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NSA CRANE
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FINAL SAMPLING AND ANALYSIS PLAN RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION WITH RISK ASSESSMENT SOLID WASTE MANAGEMENT UNIT 25 (SWMU 25) HIGHWAY 58 DUMP SITE A NSA CRANE IN
06/01/2011
TETRA TECH NUS INC

# FINAL
# SAMPLING AND ANALYSIS PLAN
# JUNE 2011

# RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION WITH RISK ASSESSMENT
# SWMU 25 - HIGHWAY 58 DUMP SITE A

## NAVAL SUPPORT ACTIVITY CRANE
## CRANE, INDIANA

**Naval Facilities Engineering Command Midwest**

**Contract Number N62470-08-D-1001**

**Contract Task Order F27L**

**June 2011**

## SAP Worksheet #1 -- Title and Approval Page
(UFP-QAPP Manual Section 2.1)

**FINAL**
**SAMPLING AND ANALYSIS PLAN**
**(FIELD SAMPLING PLAN AND QUALITY ASSURANCE PROJECT PLAN)**
**JUNE 2011**

# RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION WITH RISK ASSESSMENT
# SWMU 25 - HIGHWAY 58 DUMP SITE A
# NAVAL SUPPORT ACTIVITY CRANE
# CRANE, INDIANA

**Prepared for:**
Naval Facilities Engineering Command Midwest
201 Decatur Avenue, Building 1A
Great Lakes, Illinois 60088

**Prepared by:**
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406
610-491-9688

**Prepared under:**
Contract No. N62470-08-D-1001
Contract Task Order F27L

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Signature/Date
Joseph H. Lucas, QEP, Tetra Tech NUS, Inc.

**Investigative Organization's Project Quality Assurance Manager:**
T.E. Johnston 7-8-11
Signature/Date
Tom Johnston, PhD, Tetra Tech NUS, Inc.

Approval Signatures:

_____
Signature/Date
Thomas J. Brent/NAVFAC PWD Crane ERSM/Date
NSA Crane Remedial Project Manager

_____
Signature/Date
Doug Griffin/RPM
Indiana Department of Environmental Management

_____
Signature/Date
Ken Bowers/Navy Chemist
NAVFAC QA Review

## SAP Worksheet #1 -- Title and Approval Page
(UFP-QAPP Manual Section 2.1)

DRAFT

# SAMPLING AND ANALYSIS PLAN
# (FIELD SAMPLING PLAN AND QUALITY ASSURANCE PROJECT PLAN)
# APRIL 2011

## RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION WITH RISK ASSESSMENT
## SWMU 25 - HIGHWAY 58 DUMP SITE A
## NAVAL SUPPORT ACTIVITY CRANE
## CRANE, INDIANA

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Signature/Date
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Approval Signatures:

Signature/Date
Thomas J. Brent/NAVFAC PWD Crane ERSM/Date
NSA Crane Environmental Restoration Site Manager

Signature/Date
Doug Griffin/RPM
Indiana Department of Environmental Management
BOWERS.KENNETH.A.12300924 74 Digitally signed by BOWERS.KENNETH.A.12300924 74
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USN, cn=BOWERS.KENNETH.A.12300924 74
Date: 2011.04.21 14:19:34 -04'00'

Signature/Date
Ken Bowers/Navy Chemist
NAVFAC QA Review

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# EXECUTIVE SUMMARY

Tetra Tech NUS, Inc. (Tetra Tech) has prepared this Sampling and Analysis Plan (SAP) for a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 25 (Highway 58 Dump Site A) at Naval Support Activity (NSA) Crane, located in Crane, Indiana. The SAP for the SWMU 25 RFI was developed under Contract Task Order (CTO) F27L, Contract N62470-08-D-1001, Comprehensive Long-term Environmental Action Navy (CLEAN). SWMU 25 is contained within the boundary of NSA Crane and is located in the central-northwest portion of the base. Figure ES-1 shows the locations of the NSA Crane installation and of SWMU 25 within the installation perimeter. For the purposes of this SAP, SWMU 25 is assumed to encompass two dump areas: (1) the larger area was approximately 39 feet by 150 feet, and (2) the smaller area to the southeast was about 25 feet by 10 feet and is located across Highway 58 from Building 2167 (see Figure ES-2). The dump site area is adjacent to Highway 58 along a hillside with an intermittent stream outside the SWMU boundary located at the base of the hill.

The RFI consists of soil and groundwater sampling. Soil samples will be collected to characterize the conditions in an area adjacent to Highway 58 where debris was reportedly left in place after an interim measure (IM) was conducted for the larger dump area in 1995 and 1996. The debris was left in place because it appeared to serve as backfill to support Highway 58. All debris at the smaller dump area was removed during the interim measure.

In designing this SAP, consideration was given to the potential impact to local traffic if soil borings are collected directly beneath Highway 58. The IMA recommendation to "conduct further sampling under the road" is interpreted to be a general description and include not only the road but the portion of soil located between the road and the most western extent of the previous IM soil removal. This narrow area of soil was not sampled in the IMA and is shown in Figure 4-1. Based on the IMA report, this area represents the general location of the additional debris left in place during the IMA since it may have been used as backfill to support Highway 58. It is possible that this additional debris contains contamination and should be the initial focus of the investigation. Based on the sampling results, the project team will review the need to conduct further investigation directly under the road in an effort to minimize the potential impact to local traffic.

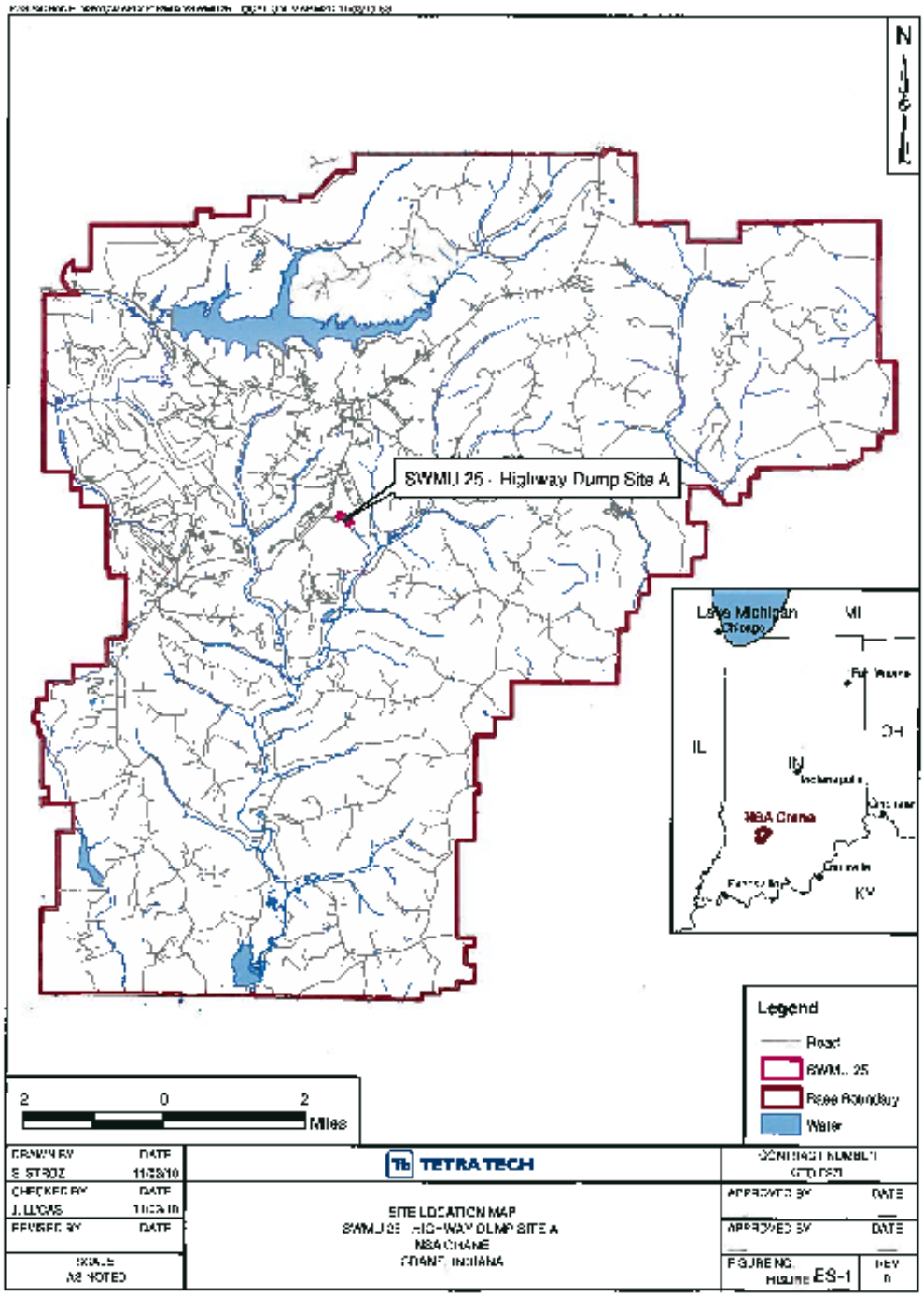
Soil will be analyzed for contaminants that may be present as a result of the buried debris. The existing monitoring wells at SWMU 25 have not been sampled in several years and as a result will be redeveloped for this RFI investigation and groundwater samples will be collected to determine if contamination from Dump Site A has migrated into groundwater. The data from the soil and groundwater samples will also be used in human health and ecological risk assessments.

The RFI includes analysis of environmental samples for metals and semi-volatile organic compounds (SVOCs) [including low level polycyclic aromatic hydrocarbons (PAHs)], to determine general risks or hazards posed by the debris disposed at SWMU 25. This newly collected RFI information will be presented in the RFI Report and will be used to update and refine the conceptual site models (CSMs) as developed and presented in this RFI Uniform Federal Policy for Sampling and Analysis Plans (UFP-SAP) format. The RFI Report will use the supplemental information to define and delineate potential contamination sources to determine the nature and extent of contamination releases to the environment, to describe the pathways/mechanisms for contaminant migration, to identify potential human receptors if contamination has migrated off-site above Project Screening Levels (PSLs), and to conclude whether a determination for No Further Action (NFA), a removal action (RA), or a Corrective Measures Study (CMS) is warranted for SWMU 25.

This UFP-SAP was prepared in accordance with the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP). This document contains the work plan, field standard operating procedures, sample analysis, and quality assurance (QA) procedures in one document.

Some worksheets are supplemented by pages of explanatory text to clearly describe the activities and procedures to be undertaken during this project. In other cases, worksheet text may present introductory discussions on the plan elements as required by the worksheet and reference an appendix of this UFP-SAP for more detailed explanations. A summary of project tasks is presented in Worksheet #14.

The appendices to this UFP-SAP include the following: Appendix A - SWMU 25 Historical Information, Appendix B - Site-Specific Field Standard Operating Procedures, Appendix C – Laboratory Standard Operating Procedures, Appendix D - Data Quality Objectives Meeting Minutes, Appendix E - SWMU 25 Monitoring Well Construction Diagrams, and Appendix F - PSL Backup Documentation.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SWMU 25 - Highway Dump Site A
Lake Michigan
MI
IL
IN
OH
KY
NSA Crane
Legend
Road
SWMU 25
Rose Roundup
Water
2
0
2
Miles
TETRA TECH
SITE LOCATION MAP
SWMU 25 - HIGHWAY DUMP SITE A
NSA CRANE
CRANE, INDIANA
DRAWN BY
S. STROZ
DATE
CHECKED BY
J. LUCAS
DATE
REVIEWED BY
DATE
SCALE
AS NOTED
APPROVED BY
DATE
APPROVED BY
DATE
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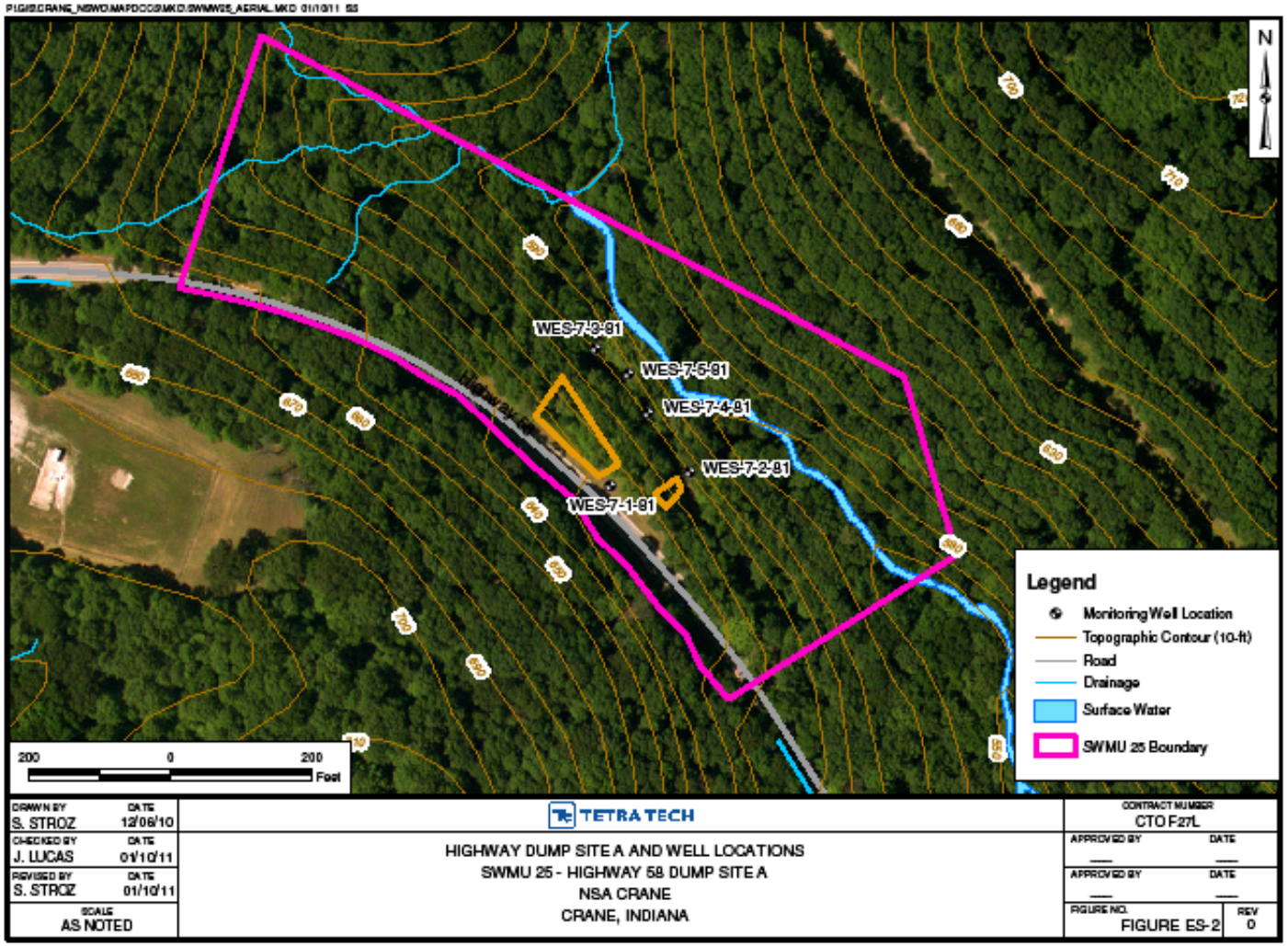
N
WES-7-3-91
WES-7-5-91
WES-7-4-91
WES-7-2-91
WES-7-1-91
Legend
Monitoring Well Location
Topographic Contour (10-ft)
Road
Drainage
Surface Water
SWMU 25 Boundary
200 0 200
Feet
DRAWN BY S. STROZ DATE 12/06/10
CHECKED BY J. LUCAS DATE 01/10/11
REVISED BY S. STROZ DATE 01/10/11
SCALE AS NOTED
TETRA TECH
HIGHWAY DUMP SITE A AND WELL LOCATIONS
SWMU 25 - HIGHWAY 58 DUMP SITE A
NSA CRANE
CRANE, INDIANA
CONTRACT NUMBER CTO F27L
APPROVED BY
DATE
FIGURE NO. FIGURE ES-2
REV 0

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17-1 Highway 58 Dump Site A and Soil Sampling and Well Locations

## Appendices

A – SWMU 25 Historical Information
B – Data Quality Objectives Meeting Minutes
C – Laboratory Standard Operating Procedures
D – Specific Field Standard Operating Procedures
E – SWMU 25 Monitoring Well Construction Diagrams
F – PSL Backup Documentation

# ACRONYMS

| | |
|---|---|
| amu | atomic mass unit |
| AR | Administrative Record |
| bgs | below ground surface |
| ºC | degrees Celsius |
| CA | Corrective Action |
| CAS | Chemical Abstracts Service |
| CCV | continuing calibration verification |
| CFR | Code of Federal Regulations |
| CLEAN | Comprehensive Long-term Environmental Action Navy |
| CMS | Corrective Measures Study |
| COC | contaminant of concern |
| COPC | chemical of potential concern |
| CSM | conceptual site model |
| CTO | Contract Task Order |
| CVAA | Cold Vapor Atomic Absorption |
| CWAP | Comprehensive Work Approval Process |
| %D | percent difference or percent drift |
| DFTPP | decafluorotriphenylphosphine |
| DL | Detection limit |
| DO | dissolved oxygen |
| DoD | Department of Defense |
| DPT | direct-push technology |
| DQI | Data Quality Indicator |
| DQO | Data Quality Objective |
| DVM | Data Validation Manager |
| ECO-SSL | Ecological Soil Screening Levels |
| EDD | Electronic Data Deliverable |
| ELAP | Environmental Laboratory Accreditation Program |
| ERSM | Environmental Restoration Site Manager |
| ESL | Ecological Screening Level |
| FOL | Field Operations Leader |
| FTMR | Field Task Modification Request |
| G-DCL | Groundwater Default Closure Level |
| GC/MS | Gas Chromatography/Mass Spectroscopy |
| GPS | Global Positioning System |

| | |
|---|---|
| HASP | Health and Safety Plan |
| HAZWOPER | Hazardous Waste Operations and Emergency Response |
| HDOP | horizontal dilution of precision |
| HHRA | human health risk assessment |
| HI | hazard index |
| HSM | Health and Safety Manager |
| ICAL | Initial Calibration |
| ICP-MS | Inductively coupled plasma mass spectroscopy |
| ICV | Initial Calibration Verification |
| IDEM | Indiana Department of Environmental Management |
| IDW | investigation-derived waste |
| ILCR | incremental lifetime cancer risk |
| IM | Interim measure |
| IS | Internal Standards |
| LCS | laboratory control sample |
| LCSD | laboratory control sample duplicate |
| LOD | Limit of Detection |
| LOQ | Limit of Quantitation |
| MPC | Measurement Performance Criterion |
| MS | matrix spike |
| MSD | matrix spike duplicate |
| NAVFAC | Naval Facilities Engineering Command |
| NEESA | Naval Energy and Environmental Support Activity |
| NFA | No Further Action |
| NIRIS | Naval Installation Restoration Information Solution |
| NSA | Naval Support Activity |
| NSWC | Naval Support Warfare Center |
| NTU | Nephelometric Turbidity Unit |
| ORP | oxidation-reduction potential |
| OSHA | Occupational Safety and Health Administration |
| PAH | Polycyclic Aromatic Hydrocarbon |
| PID | photoionization detector |
| PM | Project Manager |
| POC | Point of Contact |
| PPE | personal protective equipment |
| PQO | project quality objective |
| PSL | Project Screening Level |

| | |
|---|---|
| PWD | Public Works Department |
| QA | quality assurance |
| QAM | Quality Assurance Manager |
| QC | quality control |
| QSM | Quality Systems Manual |
| r | linear regression correlation coefficient |
| $r^2$ | non-linear coefficient of determination |
| %R | percent recovery |
| RCRA | Resource Conservation and Recovery Act |
| RF | response factor |
| RFI | RCRA Facility Investigation |
| RPD | Relative Percent Difference |
| RPM | Remedial Project Manager |
| R-RSL | Residential Regional Screening Level |
| RRT | Relative Retention Time |
| RSD | relative standard deviation |
| RSL | Regional Screening Level |
| RT | retention time |
| RTI | RTI Laboratories, Inc. |
| SAP | Sampling and Analysis Plan |
| SD | serial dilution |
| SDG | Sample Delivery Group |
| SOP | Standard Operating Procedure |
| SPCC | System Performance Check Compounds |
| SSO | Site Safety Officer |
| SVOC | Semivolatile Organic Compound |
| SWMU | Solid Waste Management Unit |
| TBD | to be determined |
| Tetra Tech | Tetra Tech NUS, Inc. |
| UCL | Upper Confidence Limit |
| UFP-QAPP | Uniform Federal Policy for Quality Assurance Project Plans |
| UFP-SAP | Uniform Federal Policy for Sampling and Analysis Plan |
| USCS | Unified Soil Classification System |
| USEPA | United States Environmental Protection Agency |
| UXO | Unexploded Ordnance |

## SAP Worksheet #2 -- SAP Identifying Information
(UFP-QAPP Manual Section 2.2.4)

| | |
|---|---|
| **Site Name/Number:** | Naval Support Activity (NSA) Crane, Solid Waste Management Unit (SWMU) 25 – Highway 58 Dump Site A |
| **Operable Unit:** | Not Applicable (NA) |
| **Contractor Name:** | Tetra Tech NUS, Inc. (Tetra Tech) |
| **Contract Number:** | N62470-08-D-1001 |
| **Contract Title:** | Comprehensive Long-term Environmental Action Navy (CLEAN) |
| **Work Assignment Number:** | Contract Task Order (CTO) F27L |

1. This SAP was prepared in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP)* (USEPA, 2005) and *EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5, QAMS* (USEPA, 2002).

2. Identify regulatory program: The Indiana Department of Environmental Management (IDEM) Hazardous Waste Closure and Corrective Action Programs, which implement and enforce the Resource Conservation and Recovery Act (RCRA), and related state laws and rules.

3. This SAP is a project-specific SAP.

4. List dates of scoping sessions that were held:

| Scoping Session | Date |
|---|---|
| Data Quality Objective (DQO) Meeting – Participants included Tetra Tech, NSA Crane, and IDEM | 12/15/2010 |

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

| Title | Date |
|---|---|
| Interim Measures Final Report, SWMU - 25/070, Highway 58 Dump Site A, NSWC Crane, Crane, Indiana; Contract No. N62467 -93-D-11 06. (Appendix A) | November, 1999 |
| Hydrogeologic Investigation of Waste Disposal Sites at The Naval Weapons Support Center Crane, Crane, Indiana, USAE Waterways Experiment Station, April 1982. (Appendix A) | April, 1982 |

6. List organizational partners (stakeholders) and connection with lead organization:

IDEM (regulatory oversight), USEPA Region 5 (regulatory oversight), Naval Facilities Engineering Command (NAVFAC) Midwest (property owner), Tetra Tech (Navy contractor)

7. Lead organization: NAVFAC Midwest

8. If any required SAP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:

NA, as there are no exclusions.

## SAP Worksheet #3 -- Distribution List
(UFP-QAPP Manual Section 2.3.1)

| Name of SAP Recipients | Title/Role | Organization | Telephone Number | E-mail Address or Mailing Address |
|---|---|---|---|---|
| Howard Hickey | Technical Representative Manages project activities for NAVFAC | NAVFAC Midwest | 847-688-2600 X243 | howard.hickey@navy.mil |
| Tom Brent | Environmental Restoration Site Manager (ERSM)/Remedial Project Manager (RPM)/Provides support and manages this project and serves as the NSA Crane Point of Contact (POC) | NAVFAC Public Works Department (PWD) NSA Crane | 812-854-6160 | tom.brent@navy.mil |
| Bonnie Capito (Final Letter Only) | Administrative Record (AR) Librarian/ Manages AR for NAVFAC | NAVFAC Atlantic | 757-322-4785 | bonnie.capito@navy.mil |
| Peter Ramanauskas | USEPA RPM/ Provides USEPA oversight | USEPA Region 5 | 312-866-7890 | ramanauskas.peter@epa.gov |
| Doug Griffin | State RPM/ Provides state input | IDEM | 317-233-2710 | dgriffin@idem.in.gov |
| Joseph Lucas, QEP | Tetra Tech Project Manager (PM)/ Manages project for Tetra Tech | Tetra Tech | 412-921-8882 | joe.lucas@tetratech.com |
| Ralph Basinski | Crane Activity Coordinator/ Coordinates Tetra Tech activities at NSA Crane | Tetra Tech | 412-921-8308 | ralph.basinski@tetratech.com |
| TBD | Field Operations Leader (FOL)/ Manages Field Operation | Tetra Tech | TBD | TBD |
| Matt Soltis | Project Health and Safety Manager | Tetra Tech | 412-921-8912 | matt.soltis@tetratech.com |
| Joe Samchuck | Data Validation Manager (DVM) | Tetra Tech | 412-921-8856 | joe.samchuck@tetratech.com |
| Edward Sedlmyer | Project Chemist | Tetra Tech | 412-921-8704 | ed.sedlmyer@tetratech.com |
| TBD | Site Safety Officer (SSO)/ Oversees site activities to ensure that safety requirements are met | Tetra Tech | TBD | TBD |

| Name of SAP Recipients | Title/Role | Organization | Telephone Number | E-mail Address or Mailing Address |
|---|---|---|---|---|
| TBD | Field Operations Technician/ Performs field sampling activities | Tetra Tech | TBD | TBD |
| Fred Hoitash | Laboratory PM/ Representative for laboratory and analytical issues | RTI Laboratories, Inc. (RTI) | 734-422-8000 | fhoitash@rtilab.com |

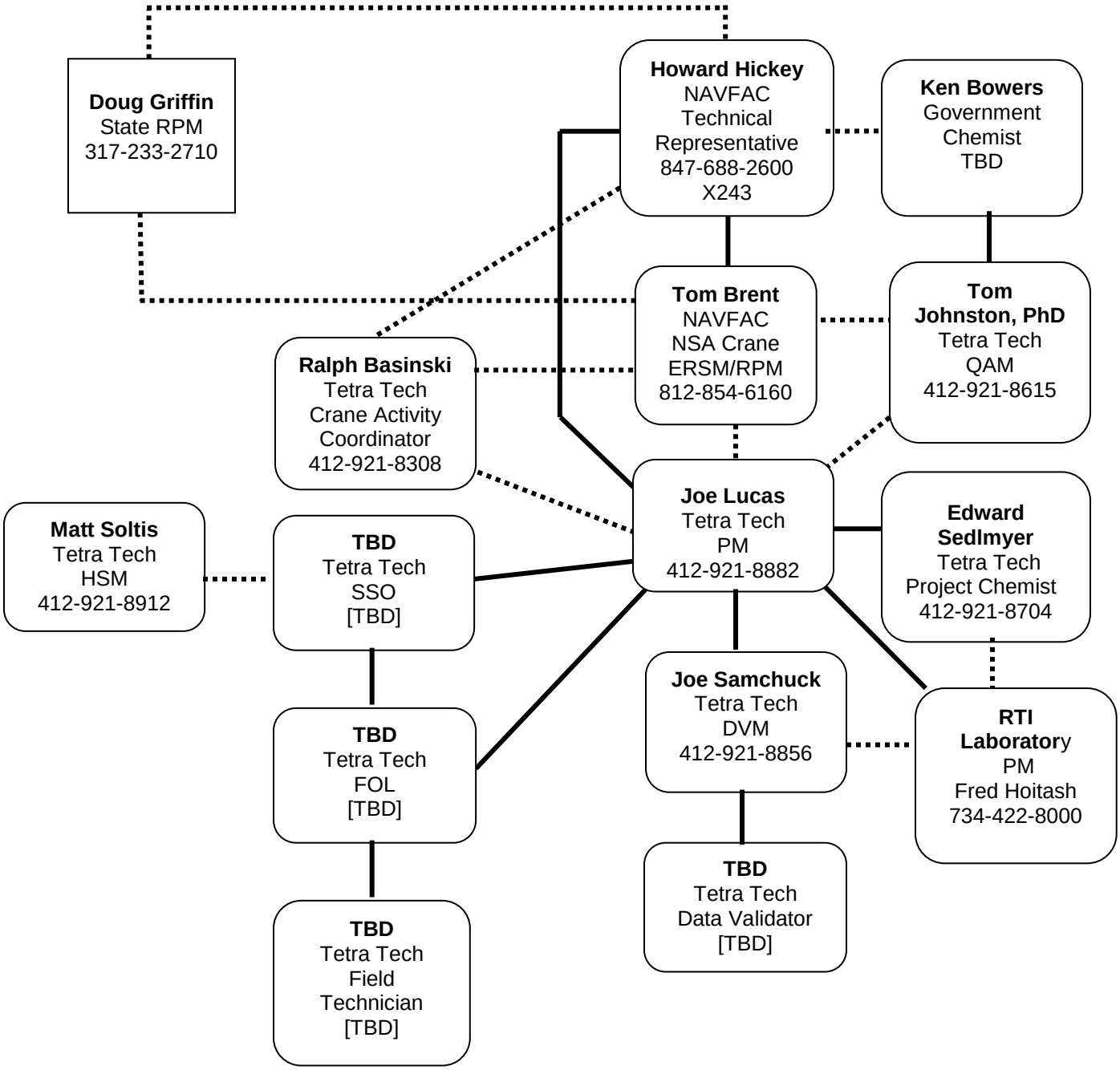
## SAP Worksheet #4 -- Project Personnel Sign-Off Sheet
(UFP-QAPP Manual Section 2.3.2)

Key personnel will be instructed to read the SAP prior to attending an internal site-specific kick-off meeting for field activities. The Tetra Tech PM will track when the reviews have been completed, obtain signatures, and ensure that the completed sign-off sheet is included in the central project file.

| Name | Organization/Title/Role | Telephone Number | Signature/E-mail Receipt | SAP Section Reviewed | Date SAP Read |
|---|---|---|---|---|---|
| TBD | Tetra Tech Field Operations Leader (FOL) | TBD | | All | |
| TBD | Tetra Tech Site Safety Officer (SSO) | TBD | | All | |
| Ralph Basinski | Crane Activity Coordinator/ Coordinates Tetra Tech activities at NSA Crane | 412-921-8308 | | All | |
| Edward Sedlmyer (Electronic copy only) | Tetra Tech Project Chemist/ Conducts data validation and reporting and provides support for laboratory- related issues | 412-921-8704 | | All | |
| Matt Soltis, CIH, CSP[Health and Safety Plan (HASP) only] | Tetra Tech Project Health and Safety Manager (HSM)/ Oversees health and safety activities | 412-921-8912 | | HASP | |
| Joe Samchuck (Electronic copy only) | Tetra Tech Data Validation Manager (DVM)/ Oversees data validation activities | 412-921-8510 | | Worksheet #s 12, 14, 15, 19, 20, 23-28, 30, and 34 to 37 | |
| Fred Hoitash (Electronic copy only) | Laboratory PM/ Manages project for Laboratory | 734-422-8000 | | Worksheet #s 12, 14, 15, 19, 20, 23-28, 30, and 34 to 36 | |

## SAP Worksheet #5 -- Project Organizational Chart
(UFP-QAPP Manual Section 2.4.1)

Lines of Authority ——— Lines of Communication ·····



## SAP Worksheet #6 -- Communication Pathways
(UFP-QAPP Manual Section 2.4.2)

| Communication Drivers | Responsible Affiliation | Name | Phone Number and/or E-Mail | Procedure |
|---|---|---|---|---|
| SAP amendments | Tetra Tech PM<br>Tetra Tech FOL<br><br>NAVFAC /Technical Representative | Joseph Lucas<br>TBD<br><br>Howard Hickey | 412-921-8882<br>TBD<br><br>847-688-2600 x243 | Tetra Tech FOL will verbally inform Tetra Tech PM within 24 hours of realizing a need for an amendment/addendum.<br>Tetra Tech PM will document the proposed changes via a Field Task Modification Request (FTMR) form within 5 days and send the Navy RPM a concurrence letter within 7 days of identifying the need for change.<br>UFP-SAP amendments will be submitted by Tetra Tech PM to NAVFAC RPM for review and approval.<br>Tetra Tech PM will send scope changes to Project Team via e-mail within 1 business day. |
| Schedule changes | Tetra Tech PM<br>NAVFAC PWD<br>NSA Crane/ERSM/RMP<br>NAVFAC/Technical Representative<br>Tetra Tech FOL | Joseph Lucas<br><br>Tom Brent<br>Howard Hickey<br><br>TBD | 412-921-8882<br><br>812-854-6160<br><br>847-688-2600 x243<br><br>TBD | Tetra Tech FOL will verbally inform Tetra Tech PM on the day that the issue is discovered.<br>Tetra Tech PM will verbally inform Navy RPM within 1 business day of discovery.<br>Navy RPM will inform IDEM RPM within 1 business day of discovery.<br>Navy RPM will issue scope change (verbally or via e-mail), if warranted; scope change to be implemented before further work is executed.<br>Tetra Tech PM will document the change via a FTMR form within 2 days of identifying the need for change and obtain required approvals within 5 days of initiating the form. |

| Communication Drivers | Responsible Affiliation | Name | Phone Number and/or E-Mail | Procedure |
|---|---|---|---|---|
| Field issues that require changes in field tasks | Tetra Tech FOL<br>Tetra Tech PM<br>NAVFAC PWD NSA Crane/ERSM/RPM<br>NAVFAC/Technical Representative | TBD<br>Joseph Lucas<br><br>Tom Brent<br>Howard Hickey | TBD<br>412-921-8882<br><br>812-854-6160<br>847-688-2600 x243 | Tetra Tech FOL informs PM verbally the day the issue is realized. PM informs the NAVFAC RPM of the issue verbally within 1 day of the FOL's notification. PM also sends a concurrence letter to NAVFAC within 7 days, if project scope is affected. The NAVFAC RPM will sign the letter within 5 days of receipt. Document changes on a FTMR form. Place the form in the project file, with signatures as determined by the PM. |
| Field issues that require changes in scope of field work | Tetra Tech FOL<br>Tetra Tech PM<br>NAVFAC PWD NSA Crane /ERSM/RPM<br>NAVFAC/Technical Representative | TBD<br>Joseph Lucas<br><br>Tom Brent<br><br>Howard Hickey | TBD<br>412-921-8882<br><br>812-854-6160<br>847-688-2600 x243 | Tetra Tech FOL informs PM verbally the day the issue is realized. PM informs the NAVFAC RPM of the issue verbally within 1 day of the FOL's notification. PM also sends a concurrence letter to the NAVFAC RPM within 7 days, if project scope is affected. The NAVFAC RPM will sign the letter within 5 days of receipt. Document changes on an FTMR form. Place the form in the project file, with signatures as determined by the PM. |
| Recommendations to stop work and then to initiate work upon corrective action implementation | Tetra Tech FOL<br>Tetra Tech PM<br>NAVFAC RPM/Technical Representative<br>NAVFAC PWD NSA Crane /ERSM<br>Tetra Tech HSM<br>Tetra Tech QAM<br>Tetra Tech Project Chemist | TBD<br>Joseph Lucas<br>Howard Hickey<br><br>Tom Brent<br><br>Matt Soltis<br>Tom Johnston, PhD<br><br>Ed Sedlmyer | TBD<br>412-921-8882<br>847-688-2600 x243<br><br>812-854-6160<br><br>412-921-8912<br><br>412-921-8615<br><br>412-921-8704 | If Tetra Tech is the responsible party for a stop-work command, the Tetra Tech person recognizing the need to stop work will inform the PM who will inform the project personnel, including subcontractor(s), the Navy RPM and base POC, and the identified Project Team members within 1 hour (verbally or by e-mail). If a subcontractor is the responsible party, the subcontractor PM must inform the Tetra Tech FOL within 15 minutes, and the Tetra Tech FOL will then follow the procedure listed above. |

| Communication Drivers | Responsible Affiliation | Name | Phone Number and/or E-Mail | Procedure |
|---|---|---|---|---|
| Field or laboratory data quality issues | RTI Laboratory PM<br>Tetra Tech FOL<br>Tetra Tech PM<br>Tetra Tech Project Chemist<br>Tetra Tech DVM | Fred Hoitash<br>TBD<br>Joseph Lucas,<br>Ed Sedlmyer<br>Joe Samchuck | 734-422-8000<br>TBD<br>412-921-8882<br>412-921-8704<br>412-921-8510 | The Laboratory PM will notify (verbally or via e-mail) the Tetra Tech Project Chemist within one business day of when an issue related to laboratory data is discovered.<br><br>The Tetra Tech Project Chemist will notify (verbally or via e-mail) the data validation staff and the Tetra Tech PM within one business day.<br><br>Tetra Tech DVM or Project Chemist notifies Tetra Tech PM or Tetra Tech FOL verbally or via e-mail within 48 hrs of validation completion that a non-routine and significant laboratory quality deficiency has been detected that could affect this project and/or other projects. The Tetra Tech PM verbally advises the NAVFAC RPM within 24 hours of notification from the project chemist or DVM. The NAVFAC RPM takes corrective action that is appropriate for the identified deficiency. Examples of significant laboratory deficiencies include data reported that has a corresponding failed tune or initial calibration verification. Corrective actions may include a consult with the NAVFAC Navy Chemist. |
| Corrective action for field program | Tetra Tech QAM<br>Tetra Tech PM | Tom Johnston, PhD<br>Joseph Lucas | 412-921-8615<br>412-921-8882 | Tetra Tech Quality Assurance Manager (QAM) will notify (verbally or via e-mail) Tetra Tech PM within one business day that the corrective action has been completed. The Tetra Tech PM will then notify (verbally or via e-mail) the NSA Crane RPM within 1 business day. |

## SAP Worksheet #7 -- Personnel Responsibilities and Qualifications Table
(UFP-QAPP Manual Section 2.4.3)`

| Name | Title/Role | Organizational Affiliation | Responsibilities |
|---|---|---|---|
| Howard Hickey | NAVFAC Technical Representative/RPM/Manages project activities for NAVFAC | NAVFAC Midwest | Oversees project scoping and implementation, including data review and evaluation. |
| Doug Griffin | IDEM RPM/Provides state input | IDEM | Participates in project scoping and implementation, including data review and evaluation, and approves the SAP. |
| Tom Brent | NAVFAC PWD NSA Crane /ERSM/Provides support and manages this environmental project as the base Point of Contact (POC) | NAVFAC NSA Crane | Oversees and coordinates site activities, participates in scoping, data review, and evaluation, and approves the SAP. |
| Joseph Lucas | Tetra Tech PM/Manages project activities on a daily basis | Tetra Tech | Oversees project, financial, schedule, and technical day-to-day management of the project. |
| Ralph Basinski | Crane Activity Coordinator/ Coordinates activities at NSA Crane | Tetra Tech | Coordinates Tetra Tech activities at NSA Crane. |
| TBD | FOL/Manages field operations | Tetra Tech | Supervises, coordinates, and performs field sampling activities. |
| TBD | SSO Oversees site activities to ensure that safety requirements are met | Tetra Tech | Responsible for training and monitoring site conditions. The SSO reports to the HSM and Tetra Tech PM. Details of the SSO's responsibilities are presented in the HASP. |
| Tom Johnston, PhD | QAM/Oversees program and project QA activities | Tetra Tech | Reviews SAP, oversees preparation of laboratory scope, and conducts data quality reviews. Ensures quality aspects of the CLEAN program. |

| Name | Title/Role | Organizational Affiliation | Responsibilities |
|---|---|---|---|
| Joseph Samchuck | DVM/Oversees data validation activities | Tetra Tech | Manages data validation activities within Tetra Tech, including ensuring QA of data validation deliverables, providing technical advice on data usability, and coordinating and maintaining the data validation review schedule. |
| Matt Soltis | HSM/Oversees health and safety activities | Tetra Tech | Oversees CLEAN Program Health and Safety Program. |
| Ed Sedlmyer | Project Chemist/ Coordinates laboratory-related functions and conducts data validation and reporting | Tetra Tech | Participates in project scoping, prepares laboratory scopes of work, and coordinates laboratory-related functions with laboratory. Conducts data quality reviews and QA of data validation deliverables. |
| Fred Hoitash | Laboratory PM/Manages project for RTI | RTI | Coordinates analyses with laboratory chemists, ensures that scope of work is followed, provides QA of data packages, and communicates with Tetra Tech project staff. |

## SAP Worksheet #8 -- Special Personnel Training Requirements Table
(UFP-QAPP Manual Section 2.4.4)

Each site worker will be required to have completed a 40-hour course (and 8-hour refresher, if applicable) in Health and Safety Training as described under Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120(b)(4). Safety requirements are addressed in greater detail in the SWMU 25 RFI HASP.

Ammunition shells were found at SWMU 25 during the interim measure (IM) activity conducted in 1995 and 1996. The shells were inert (concrete filled) and apparently used to support Highway 58. At the time the shells were discovered, the Explosives Safety Officer indicated that in reviewing the way materials were disposed of through the years, there is no strong evidence to suggest that live ordnance was "dumped" as opposed to being processed through the Demolition Range. This is because the NSA Crane Detonation Range has been a viable alternative for the destruction of ordnance materials since 1946. It is important to note that inert (concrete filled) hardware has been dumped at various other sites throughout the years because no other alternative was available. Such hardware as inert 12.75-inch warheads (Hedgehog) were found dumped near some of the buildings and used as filler to prevent land erosion. Based on this information, it is not necessary to use unexploded ordnance (UXO) personnel or to practice UXO avoidance during the field investigation.

## SAP Worksheet #9 -- Project Scoping Session Participants Sheet
(UFP-QAPP Manual Section 2.5.1)

| | |
|---|---|
| Project Name: SWMU 25<br>Projected Date(s) of Sampling: June, 2011<br><br>Project Manager: Joseph Lucas | Site Name: SWMU 25 - Highway 58 Dump Site A<br><br>Site Location: NSA Crane, Crane, Indiana |

**Date of Session:** December 15, 2010
**Scoping Session Purpose:** Data Quality Objective (DQO) Meeting

| Name | Title | Affiliation | Phone # | E-mail Address | Project Role |
|---|---|---|---|---|---|
| Joseph Lucas | PM | Tetra Tech | 412-921-8882 | joe.lucas@tetratech.com | Management |
| Tom Brent | NAVFAC PWD NSA Crane ERSM | NAVFAC PWD | 812-854-6160 | thomas.brent@navy.mil | Management |
| Doug Griffin | IDEM RPM | IDEM | 317-233-2710 | dgriffin@idem.in.gov | State RPM |
| Ralph Basinski | Crane Activity Coordinator | Tetra Tech | 412-921-8308 | ralph.basinski@tetratech.com | Management/ Oversight |

**Comments/Decisions:**

During the meeting there was discussion regarding the metals that were found to be at concentrations exceeding cleanup levels in the IM confirmation samples, particularly beryllium, which Doug Griffin of IDEM considered not to be characteristic of metals common to Crane soil. There is no historical information regarding beryllium-containing materials that may have been placed in Dump Site A. The SAP will include analysis for beryllium.

All monitoring wells will be redeveloped and one sample will be collected from each well, including stabilization parameters. It was recommended that groundwater samples be analyzed for metals (filtered and unfiltered) and semi-volatile organic compounds (SVOCs).

**Action Items:**

Tetra Tech will submit the draft SAP for simultaneous review to both Navy Crane and the Navy Chemist.

**Consensus Decisions:**

Proceed with preparation of the draft UFP-SAP as discussed and implement recommendations presented at the meeting.

## SAP Worksheet #10 -- Conceptual Site Model
(UFP-QAPP Manual Section 2.5.2)

An alternate format has been created for Worksheet #10 to breakout the primary components of the Conceptual Site Model (CSM) into a tabular presentation for easily identification of the background information used in the development of the CSM.

**Table 10-1: Conceptual Site Model Information Profiles – SWMU 25 Highway 58 Dump Site A**

| Type | Information Needs | Preliminary Assessment Findings |
|---|---|---|
| Range/Site Profile | Installation Name | NSA Crane |
| | Installation Location | Crane, Indiana |
| | Site Name | SWMU 25 Highway 58 Dump Site A |
| | Site Location | See Figures 10-1 and 10-2 |
| | Site History | Dump Site A was a disposal area that received paper, concrete, pipe, scrap metal, paint thinners, and oil. In 1995 and 1996, an Interim Measure (IM) was conducted at SWMU 25 Dump Site A. The Final IM Report is presented in Appendix A. The objective of the IM was to remove debris and incidental soil excavated with the debris. SWMU 25 Dump Site A had two dump areas. The larger area was approximately 39 feet by 150 feet, and the second area was approximately 25 feet by 10 feet. Visual inspection of Dump Site A indicated scattered debris consisting of transite siding and pipe, various sizes of concrete pipe and block, metal cans, caps, drums, blocks of roofing tar, chunks of cast concrete, metal pipe, cast metal drains, and electrical porcelain insulators. There were no detectable odors or smells noted in the dump area during the initial walk of the site. During debris clean-up, workers scanned the completed areas with metal detectors to confirm the removal of metallic cans, drums, and debris. Metal debris as deep as two feet below ground surface was detected and removed during initial site activities. At the larger dump area, inert (concrete-filled) hardware, such as 12.75 inch warheads (Hedgehogs), had been used as filler apparently to prevent land erosion adjacent to Highway 58. Confirmation sampling indicated that contaminants were removed to less than RCRA Corrective Action Guidance Human Data Quality Levels for RFI Projects (USEPA, |

**Table 10-1: Conceptual Site Model Information Profiles – SWMU 25 Highway 58 Dump Site A**

| Type | Information Needs | Preliminary Assessment Findings |
|---|---|---|
| | | 1994),cleanup levels except for arsenic, beryllium, and cobalt. Samples collected from off-site virgin soil borrow confirmed that levels of arsenic, beryllium, and cobalt greater than cleanup levels are naturally present in soils in the surrounding area. The target cleanup levels for this IM were taken from "RCRA Corrective Action Guidance Human Data Quality Levels for RFI Projects," June 18, 1994, as site-specific risk-based cleanup levels had not been developed for NSWC Crane. One confirmation sample from the smaller dump area had concentrations of benzo(a)pyrene, benzo(g,h)perylene, dibenz(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and chrysene in excess of the interim cleanup levels.<br>All debris was removed from the smaller dump site area. However, additional debris discovered during the IM at the larger dump site area was left in place because it may have been used as backfill to support Highway 58. A photograph of the removal activity at the larger dump site during the IM is shown in Figure 10-3. It was recommended that SWMU 25 revert back to the RFI process beginning with soil borings under the road to determine the need for further remediation.<br>In designing the sampling program, consideration was given to the potential impact to local traffic if soil borings are collected directly beneath Highway 58. The IMA recommendation to "conduct further sampling under the road" is assumed to be a general description and include not only the road but the portion of soil located between the road and the most western extent of the previous IM soil removal and the opposite side berm of Highway 58. This narrow area of soil was not sampled in the IMA and is shown in Figure 4-1. Based on the IMA report, this area represents the general location of the additional debris left in place during the IMA since it may have been used as backfill to support Highway 58. It is possible that this additional debris may contain potential contamination and should |

**Table 10-1: Conceptual Site Model Information Profiles – SWMU 25 Highway 58 Dump Site A**

| Type | Information Needs | Preliminary Assessment Findings |
|---|---|---|
| | | be the initial focus of the investigation. Based on the sampling results, the project team will review the need to conduct further investigation directly under the road in an effort to minimize the potential impact to local traffic. |
| | Selection of Target Analytes | The chemicals of potential concern (COPCs) for this SAP were developed on the basis of initial characterization and confirmation samples from the IM conducted in 1997. The target analytes for the IM included an extensive list of Appendix IX compounds (> 200) associated with VOCs, SVOCs, pesticides, PCBs, metals, dioxins, and furans. The selection of the COPCs for this SAP has been pared down to a list of compounds that appear to be most prevalent and that have a history of exceeding Cleanup Levels at this site.<br>The initial soil characterization samples collected during the IM indicated that IM Cleanup Levels were exceeded only for metals (see Table 3-2 of the IM report). There were also reported detections for some VOCs, SVOCs, PAHs, and dioxins/furans. The reported in-soil concentrations for all of these compounds were in most cases well below the IM Cleanup Levels.<br>Table 3-3 of the IM report presents confirmation sampling results and indicates that IM Cleanup levels for metals were exceeded in all samples and for PAHs in only one sample. All other detections for VOCs and pesticides were in most cases well below IM Cleanup Levels.<br>Based on soil results for this site, it appears that the compounds found most consistently in soil and associated with exceedances of the IM Cleanup Levels are metals, PAHs and potentially SVOCs. These three groups of compounds were selected a COPCs for this SAP. |

**Table 10-1: Conceptual Site Model Information Profiles – SWMU 25 Highway 58 Dump Site A**

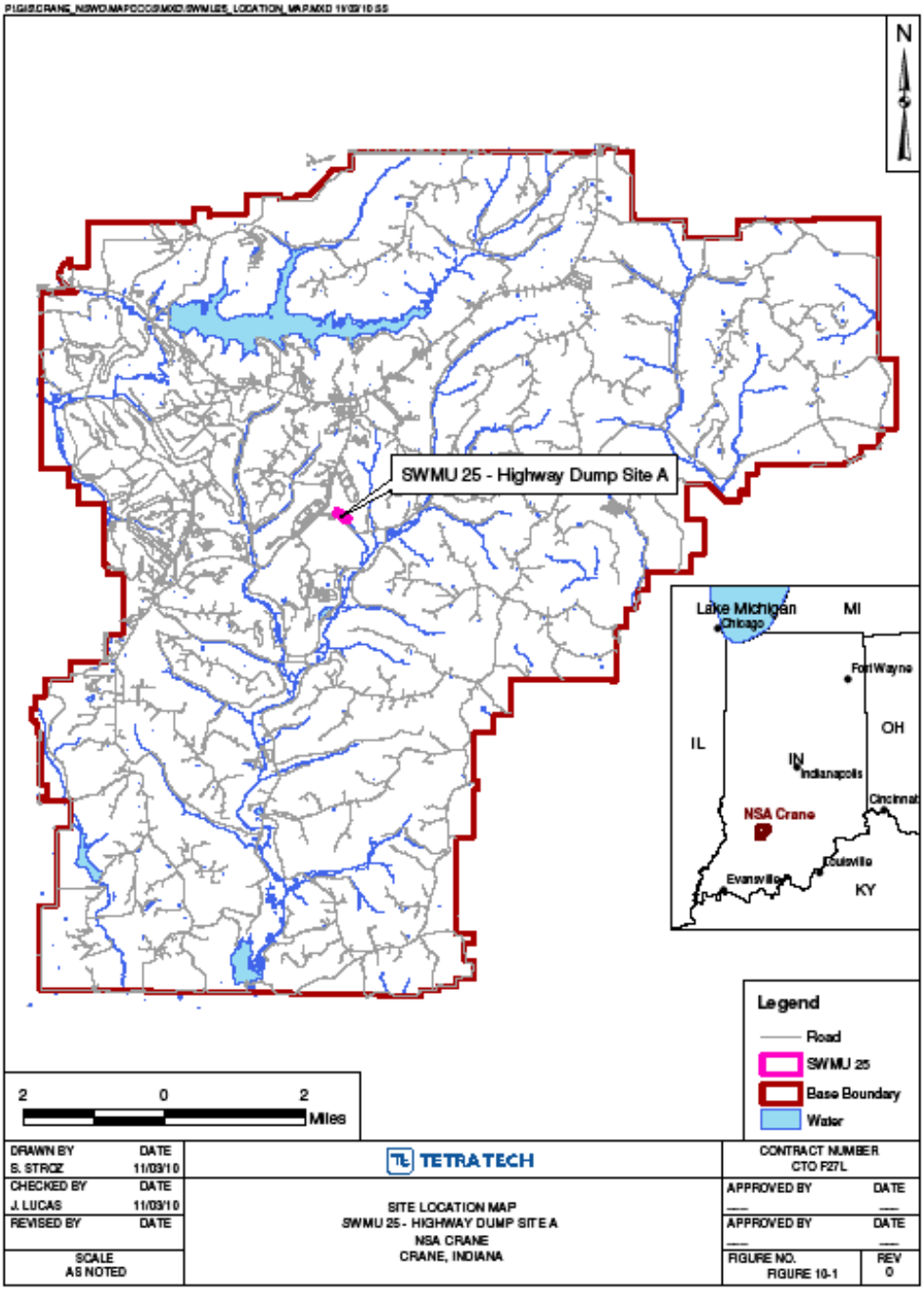
| Type | Information Needs | Preliminary Assessment Findings |
|---|---|---|
| | Site Area and Layout | SWMU 25 is located in a heavy wooded area with trees and shrubs. The dumping took place in two areas: a larger area approximately 39 feet by 150 feet and a smaller area approximately 25 feet by 10 feet. |
| | Site Structures | The only structure located at SWMU 25 is Highway 58. The site located in a heavy wooded area with trees and shrubs. |
| | Site Boundaries | The SWMU 25 boundaries are shown in Figure 10-2. |
| | Site Security | SWMU 25 is located within the boundary of NSA Crane and there are no access restrictions to Highway 58 or SWMU 25. |
| | Migration Routes/Release Mechanisms | Remaining contamination in soil and groundwater (metals, SVOCs, including low level PAHs) could result from debris left in place after the 1995/1996 IM. Contamination could also have been released from excavated material to surface and subsurface soil. After release to the soil, contamination may have leached into groundwater and possibly result in a complete exposure pathway to human receptors in the future who would work or live at this site and consume groundwater. Contaminated surface soil could impact ecological receptors, primarily plants and invertebrates. A schematic illustration of the conceptual site model (CSM) for SWMU 25 is shown in Figure 10-4. |
| **Physical Profile** | Climate | NSA Crane is located in a warm temperate climate zone. In general, summers are warm and humid, while winters are mild with cold periods of short duration. Temperatures range from an average maximum July temperature of 89 degrees Fahrenheit (°F) to an average minimum January temperature of 26°F. Precipitation is nearly evenly distributed throughout the year with maximum precipitation occurring during the spring and early summer. The average precipitation is 44 inches with 42 inches of rain and 15 inches of snow. Average humidity ranges from 40 to 90 percent in the summer and 60 to 90 percent in the winter. |

**Table 10-1: Conceptual Site Model Information Profiles – SWMU 25 Highway 58 Dump Site A**

| Type | Information Needs | Preliminary Assessment Findings |
|---|---|---|
| | Geology | Soil encountered in borings advanced at SWMU 25 during a 1981 hydrogeological investigation ranged from clayey sand-gravel to clay. Soil below 2 feet is classified as clay. The permeability of a clay sample from 5 to 6.7 feet was calculated to be 0.0 centimeters per second. The overburden at SWMU 25 ranges in thickness from less than 2 to 18.5 feet. Beneath the overburden is a layer of very stiff, dense weathered gravelly clay shale. This clay shale grades into a soft weathered occasionally limonitic shale. Bedrock consists of limestone, sandstone, and shale from the Mansfield Formation of the Raccoon Creek Group. From a depth of 20 feet, sandstone and shale are thinly interbedded in nearly equal proportions. The shale content declines to about 10 percent. |
| | Soil and Vegetation | SWMU 25 is located in a heavy wooded area with trees and shrubs. |
| | Hydrogeology | SWMU 25 wells installed in 1981 (see Appendix A) indicate that groundwater is encountered in fractures in sandstone. Groundwater flow is to the northeast. All wells appear to be screened in the same aquifer. The depth of the groundwater table is about 30 feet. |
| | Hydrology | A small creek is located approximately 200 feet east of SWMU 25 that drains into Turkey Creek, which eventually drains into the East Fork of the White River. |
| Land Use and Exposure Profile | Current Water Use | Ground water is not used at this location. |
| | Current Human Receptors | The only current human receptors at the SWMU are NSA Crane personnel and potential construction workers, utility workers. |
| | Current Activities | There are no known activities associated with SWMU 25, although traffic does traverse Highway 58, which is adjacent to SWMU 25. |
| | Potential Future Water Use | The RFI will assume future residential groundwater use. |
| | Potential Future Receptors | The RFI receptors will include current and future construction workers, future residential receptors and ecological receptors (invertebrates and plants) |

**Table 10-1: Conceptual Site Model Information Profiles – SWMU 25 Highway 58 Dump Site A**

| Type | Information Needs | Preliminary Assessment Findings |
|---|---|---|
| | Potential Future Water Use Related Activities | Potential future water will assume residential groundwater use. |
| | Zoning/Land Use Restrictions | There are no zoning restrictions at SWMU 25. |
| Ecological Profile | Degree of Disturbance | Disturbance at SWMU 25 is expected to be low. |
| | Ecological Receptors and Species of Special Concern | Ecological receptors expected to be impacted by contamination in surface soil at SWMU 25 include plants and invertebrates. There are no species of special concern at SWMU 25. |


N
SWMU 25 - Highway Dump Site A
Lake Michigan
Chicago
MI
Fort Wayne
OH
IL
IN
Indianapolis
Cincinnati
NSA Crane
Louisville
Evansville
KY
Legend
Road
SWMU 25
Base Boundary
Water
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2
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DRAWN BY S. STROZ DATE 11/03/10
CHECKED BY J. LUCAS DATE 11/03/10
REVISED BY DATE
SCALE AS NOTED
TETRA TECH
SITE LOCATION MAP
SWMU 25 - HIGHWAY DUMP SITE A
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CRANE, INDIANA
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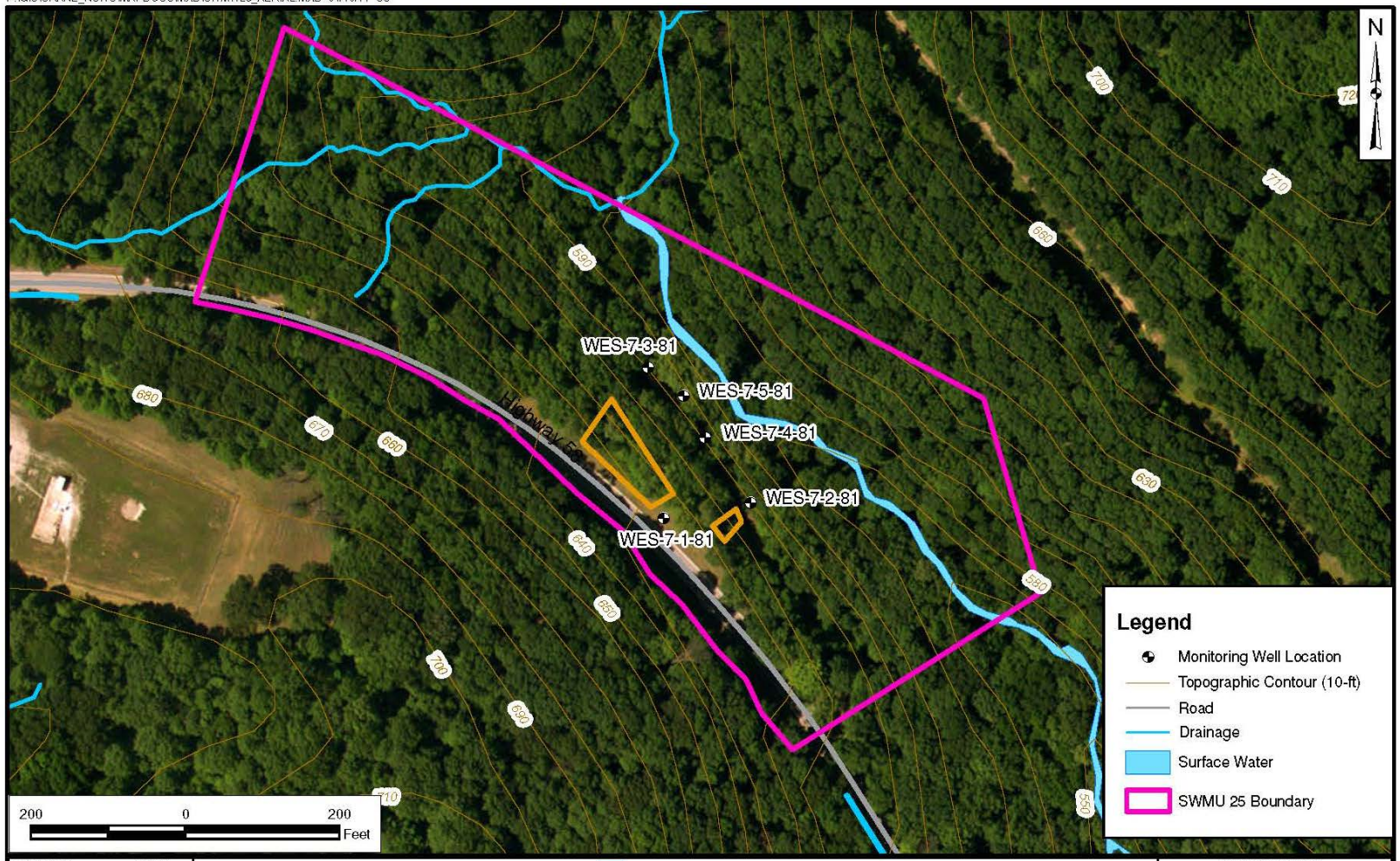


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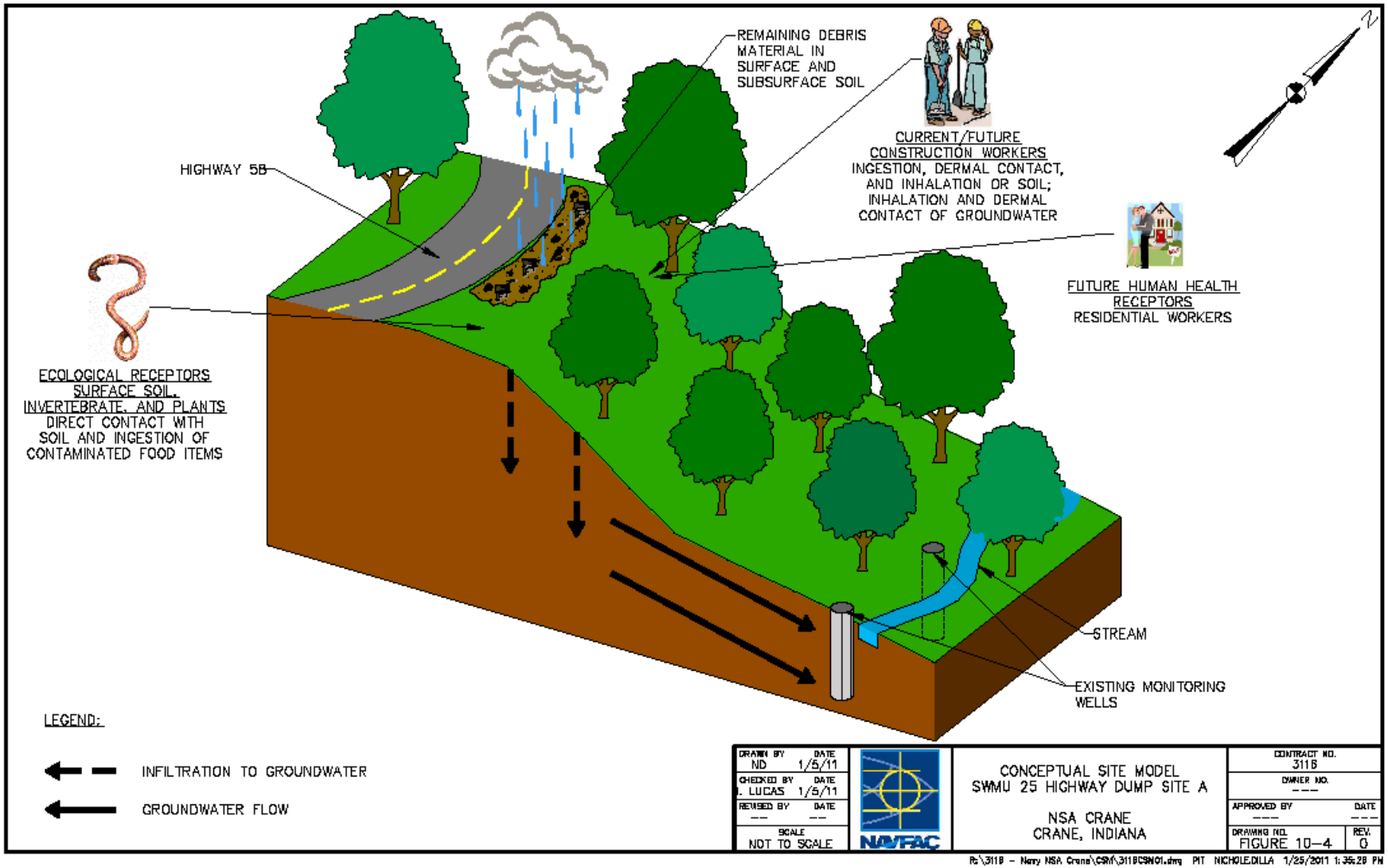
|---|---|---|---|
| DRAWN BY S. STROZ | DATE 12/06/10 | TETRA TECH | CONTRACT NUMBER CTO F27L |
| CHECKED BY J. LUCAS | DATE 01/10/11 | HIGHWAY DUMP SITE A AND WELL LOCATIONS<br>SWMU 25 - HIGHWAY 58 DUMP SITE A<br>NSA CRANE<br>CRANE, INDIANA | APPROVED BY ___ DATE ___ |
| REVISED BY S. STROZ | DATE 01/10/11 | | APPROVED BY ___ DATE ___ |
| SCALE AS NOTED | | | FIGURE NO. FIGURE 10-2 REV 0 |

**FIGURE 10-3 SWMU 25 INTERIM MEASURE EXCAVATION AT THE LARGER DUMP AREA**


REMAINING DEBRIS MATERIAL IN SURFACE AND SUBSURFACE SOIL
CURRENT/FUTURE CONSTRUCTION WORKERS
INGESTION, DERMAL CONTACT, AND INHALATION OR SOIL; INHALATION AND DERMAL CONTACT OF GROUNDWATER
HIGHWAY 58
FUTURE HUMAN HEALTH RECEPTORS
RESIDENTIAL WORKERS
ECOLOGICAL RECEPTORS
SURFACE SOIL, INVERTEBRATE, AND PLANTS
DIRECT CONTACT WITH SOIL AND INGESTION OF CONTAMINATED FOOD ITEMS
STREAM
EXISTING MONITORING WELLS
LEGEND:
INFILTRATION TO GROUNDWATER
GROUNDWATER FLOW
DRAWN BY ND DATE 1/5/11
CHECKED BY L. LUCAS DATE 1/5/11
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SCALE NOT TO SCALE
NAVFAC
CONCEPTUAL SITE MODEL
SWMU 25 HIGHWAY DUMP SITE A
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OWNER NO. ---
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# SAP Worksheet #11 -- Project Quality Objectives/Systematic Planning Process Statements

(UFP-QAPP Manual Section 2.6.1)

This section describes the development of PQOs using USEPA's seven-step DQO/Systematic Planning Process.

## 11.1 PROBLEM DEFINITION

Because debris remains in the larger dump area under Highway 58 and potential soil contamination remaining after the 1995/1996 IM, this contamination may have migrated/be migrating to groundwater. Additional surface and subsurface soil data and data from existing wells are required to determine if soil and/or groundwater concentrations may result in unacceptable risks to current and future human and ecological receptors.

Based on recommendations from the Project Team and the CSM, soil underneath the road must be further investigated to determine if there is a need for additional remediation. Groundwater at the base of the hill below the dump must also be investigated to determine if soil contamination has migrated to groundwater over time. If contamination is identified at levels that exceed screening criteria (see Worksheet #15), then additional investigation will be required in order to delineate contamination and to conduct a human health risk and ecological risk assessment. The Project team will use the data to decide if corrective measures are warranted.

## 11.2 INFORMATION INPUTS

The following chemical and physical data are needed to attain project objectives:

- Target Analyte Concentrations: Soil concentrations of metals and SVOCs (including low level PAHs) measured in a fixed-base laboratory are needed to determine if contamination is present in the remaining debris directly below Highway 58 and if contamination from the debris has migrated to groundwater. The list of target analytes and associated Project Screening Levels (PSLs) for each matrix are presented in Worksheet #15. The sampling rationale is presented in Worksheet #17. The list of samples to be collected is presented in Worksheet #18, and the analytical methods are presented in Worksheet #19.

- PSLs: The SWMU 25 RFI requires chemical data for characterizing the site and, if required, for conducting human health and ecological risk assessments. The surface and subsurface soil, and groundwater PSLs are set at the lowest matrix-specific risk-based or regulatory human health criteria

appropriate for the site to support selection of chemicals of potential concern (COPCs), which are evaluated in the risk assessments. The applicable risk-based and regulatory criteria are:

- USEPA Regions 3, 6 and 9 Residential Regional Screening Levels (R-RSLs)
- USEPA Regions 3, 6 and 9 risk-based migration-to-groundwater Soil Screening Levels (SSLs) for human health risk screening and for use in a Human Health Risk Assessment (HHRA)
- IDEM Residential Default Closure Levels (R-DCLs).
- USEPA and IDEM Ecological Screening Levels (ESLs)

Analytical data reported by the laboratory will use the following reporting conventions: All results less than Detection Limits (DLs) will be considered non-detections and will be reported with as the Limits of Detection (LOD) with "U" qualifiers; results reported at concentrations between the DLs and Limits of Quantitation (LOQs) will be reported with “J” qualifiers. In cases where the laboratory LODs are greater than the PSLs, if the analyte is not detected, the LOD will be reported and "U" qualified. This is consistent with the USEPA Risk Assessment Guidance for Superfund, Part A (USEPA, 1989). An evaluation of these analytes will also be presented in a data quality report.

- Physical: Water quality parameters, including pH, specific conductance, oxidation-reduction potential (ORP), temperature, dissolved oxygen (DO), and turbidity at all groundwater sample locations. These field measurements (excluding turbidity) will be made using a YSI 600-Series Environmental Monitoring System or equivalent type of instrument. Turbidity measurements will be made using a LaMotte 2020 turbidity meter or equivalent.

- Background Target Analyte Concentrations: The background data set for soils at NSA Crane will be used to determine whether concentrations of metals present on site are from naturally occurring sources or are potentially site related. Background data for the various soil types identified at NSA Crane are described in the Final Base-Wide Background Soil Investigation Report for NSWC Crane (Tetra Tech, 2001). The background data set for groundwater will come from the existing upgradient well sample collected at SWMU 25. This well and the associated downgradient wells will be sampled during the RFI field investigation. Data comparisons described in Tetra Tech (2001) will be used for evaluating site concentrations.

  Additionally, groundwater data between the background (upgradient) and downgradient wells will be compared to determine if groundwater concentrations in the downgradient wells are greater than the concentrations in the upgradient wells. Decision rules for the use of this data are presented in Section 11.4.

## 11.3 STUDY AREA BOUNDARIES

The populations of primary interest are surface and subsurface soil directly below Highway 58 associated with the larger dump area as shown on Figure 10-2 and groundwater, all of which are potentially contaminated by wastes at SWMU 25. To delineate contaminated soil and groundwater, potentially uncontaminated soil and groundwater are also of interest.

The following items address the horizontal, vertical, and temporal boundaries for field study:

1. Horizontal: The initial horizontal boundary of the study is defined as a portion of the area adjacent to Highway 58 that coincides with the location of the debris that was left in place at the larger dump area after the IM. This area has been located based on information provided in the IM report for the larger dump site. Lateral expansion of this horizontal study boundary may be required if any chemical concentrations exceed PSLs and if further delineation of contamination is necessary.

2. Vertical: The vertical boundary of the study includes the surface (0 to 2 foot below ground) and subsurface (2 to 10 feet below ground surface) soil directly adjacent to Highway 58 as shown in Figure 17-1. Data from surface and subsurface soil are considered representative of soil that may have been impacted due to the buried debris not removed during the IM. The depth to groundwater is approximately 30 feet.

3. Temporal: All target analyte concentrations are anticipated to be relatively unchanged (stable) over the course of time needed to conduct the RFI and into the foreseeable future and other no temporal constraints exist. However, it is recommended that groundwater be collected in spring or early summer because at least one well has gone dry during sampling when the groundwater table is low.

Five monitoring wells (one upgradient and four downgradient) were installed around the perimeter of the dump site and are shown on Figure 10-2. Groundwater samples will be collected from these existing SWMU 25 monitoring wells, which will most likely require redevelopment because they were installed in 1981.

## 11.4 ANALYTIC APPROACH

The decision rules governing data use for the RFI are as follows:

**<u>RFI Field Investigation</u>**

During the field investigation, determine whether target analyte concentrations in surface and subsurface soil below Highway 58 and in SWMU 25 groundwater exceed applicable PSLs:

- If all target analyte concentrations in site media are less than PSLs and the metals are less than background upper tolerance limits (UTLs), then the Project Team will recommend no further action (NFA) for the site.

- If the Project Team agrees that soil concentrations indicate that contamination has been satisfactorily delineated, then stop delineation. Otherwise, continue with delineation. Ideally, "step-out" samples for delineation will be collected until perimeter sample concentrations are less than PSLs; however, it may be appropriate to cease the step-out process if only marginal exceedances of PSLs are observed and continued investigation appears to provide no significant benefit as judged by the Project Team. Factors considered will include the environmental media (soil and groundwater) specific target analytes, magnitude of the exceedance(s), spatial distribution, and overall estimated risk level. If "step-out" samples are deemed necessary, collect additional samples as necessary to delineate the nature and extent of contamination and to support the screening level HHRA and ERA.

- If any downgradient groundwater target analyte concentration exceeds its PSL and the upgradient groundwater concentrations, then recommend further investigation. This assumes upgradient groundwater data has been collected. If the upgradient well has not been sampled, then a new well will be installed and sampled so that downgradient concentrations can be used for comparison.

  Further investigation would include development of a regional groundwater background data set using available data (if possible) that could be used in a data set to data set comparison to additional rounds of data collected from the downgradient wells to determine if identified contaminants are site related. The additional investigation if needed, would be designed to complete the delineation of potentially unacceptable contamination and to ensure that enough data have been collected to support a risk assessment.

  If the mean background data set concentrations are greater than any target analyte PSL, the mean background concentration will replace the PSL for that target analyte for future comparisons and decision making. Any decision rules for data collected during future investigations will be presented in an Addendum to this SAP.

**Risk Assessment**

The human health receptors will be residential receptors living at the site that use groundwater. This assumption is used for conservative screening purposes. The existing land use for SWMU 29 is not anticipated to change. The ecological receptors are expected to be invertebrates and plants.

Unacceptable human health risk is defined for this project as an incremental lifetime cancer risk (ILCR) exceeding $1x10^{-4}$ or a non-cancer hazard (i.e., hazard index [HI]) exceeding 1 (on a target-organ-specific basis).

For the HHRA, if the maximum detected concentrations of a chemical in surface soil, subsurface soil, or groundwater exceeds its PSL, then that chemical will be retained as a COPC. If any COPCs are selected, the site risk assessor will evaluate the human health risks. For each chemical, the 95% Upper Confidence Limit (UCL) on the mean will be used as the exposure point concentrations in the risk assessment.

For the ecological risk assessment, chemical concentrations in surface soil will be compared to the conservative generic screening values chosen as PSLs. USEPA Ecological Soil Screening Levels (Eco-SSLs) (2005) will be used to identify concentrations that may be harmful to ecological receptors (invertebrates and plants). If the maximum detected concentrations of a chemical in surface soil, exceeds its PSL, then that chemical will be retained as a COPC.

The exposure unit for the risk assessment will be the extent of the study area boundary.

If unacceptable risk is identified at the site, then the project team will evaluate response actions in a CMS. If site risks are acceptable, then the Project team will recommend no further action for the site.

## 11.5 PERFORMANCE OR ACCEPTANCE CRITERIA

Soil sampling locations were strategically selected to locate potential contamination based on former use of the larger dump area and information provided in the IM report. Simple comparisons of measured concentrations to PSLs are initially being used. The Project Team will use the measured results to determine whether the amount and type of data collected are sufficient to support the attainment of project objectives. This will involve an evaluation of contaminant concentrations and an evaluation of uncertainty for contaminants that have PSLs less than the LODs to ensure that contaminants are likely to have been detected if present. If all data have been collected as planned and no data points are missing or rejected for quality reasons, the sampling event completeness will be considered satisfactory. If any data gaps are identified, including missing or rejected data, the Project Team will assess whether project objectives have been achieved. This assessment will depend on the number and type of identified data gaps and will be situation dependent. All Project Team stakeholders will be involved in rendering the final conclusion regarding adequacy of the data.

## 11.6 SAMPLING STRATEGY

The sampling design and rationale for the RFI field investigation samples to be collected are provided in Worksheet #17. The sampling design and rationale for follow-up sampling, if required, will be developed by the Project Team, as necessary, based on the results of the initial sampling phase and presented in addenda to this document.

## SAP Worksheet #12 -- Measurement Performance Criteria Table
(UFP-QAPP Manual Section 2.6.2)

### Field Quality Control (QC) Samples

| QC Sample | Analytical Group | Frequency | Data Quality Indicators (DQIs) | Measurement Performance Criteria (MPCs) | QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A) |
|---|---|---|---|---|---|
| Equipment Rinsate Blank[1] | All analytical groups (metals and SVOCs) | One per 20 field samples per matrix per type of sampling equipment | Bias/ Contamination | No analytes ≥½ LOQ, except common laboratory contaminants, which must be < LOQ. | S & A |
| Field Duplicate (FD) | All analytical groups | One per 20 field samples per matrix | Precision | Values > 5x LOQ: Relative Percent Difference (RPD) ≤30% (aqueous) [2,3] ; ≤50% (solids) [2,3]. | S & A |
| Cooler Temperature Indicator | All analytical groups | One per cooler | Representativeness | Temperature must be less than or equal to 6 degrees Celsius (ºC). | S |
| Filtered Rinsate Blank[4] | Dissolved Metals (if necessary due to high turbidity) | One per filter brand | Bias/ Contamination | No analytes ≥½ LOQ, except common laboratory contaminants, which must be < LOQ. | S & A |

1 Equipment rinsate blanks will be collected if non-dedicated submersible pumps or other equipment are used. For disposable equipment, one sample per batch of disposable equipment will be collected.
2 If duplicate values are less than five times the LOQ for aqueous samples, the absolute difference should be less than two times the LOQ.
3 If duplicate values are less than five times the LOQ for solid samples, the absolute difference should be less than four times the LOQ.
4 A filtered rinsate blank will be collected if filtered samples (e.g., Dissolved Metals) are collected.

## SAP Worksheet #13 -- Secondary Data Criteria and Limitations Table
(UFP-QAPP Manual Section 2.7)

| Secondary Data | Data Source (originating organization, report title and date) | Data Generator(s) (originating organization, data types, data generation / collection dates) | How Data Will Be Used | Limitations on Data Use |
|---|---|---|---|---|
| 1 | United States Army Engineer (USAE) Waterways Experiment Station Hydrogeologic Investigation of Waste Disposal Site at the Naval Weapons Support Center, Crane, Indiana, April 1982 | USAE Waterways Experiment Station PO Box 631, Vicksburg, HS 39180. Field boring logs, graphic field logs, well completion diagrams, groundwater elevations, and soil test results | Field crew will use existing monitoring well diagrams to redevelop wells and confirm groundwater flow direction. Upgradient well will provide background levels for metals and SVOCs. | Only groundwater level data is presented from this investigation with limited chemical data regarding soil characteristics. There are no analytical results for the collected groundwater samples. |
| 2 | Tetra Tech Final Base-Wide Background Soil Investigation Report for Naval Surface Warfare Center Crane, Crane, Indiana. January. 2001 | Tetra Tech. Soil types, analytical results, recommendations for using the background data for comparison to future site data. Sampling performed in November 1999 and October 2000. | For comparing SWMU 25 soil sample analytical results to background data. | No limitations. |
| 3 | Morrison Knudsen Corporation Interim Measures Report SWMU - 25/070 Highway 58 Dump Site A, November, 1999 | Southern Division NSWC CRANE Naval Facilities Engineering Command North Charleston, South Carolina. Site Background, Work Execution, Sampling and Analysis, Photographs, Analytical Results, QC Data and Waste Manifests. Interim measure conducted in 1995 and 1996. | Confirmation sampling results from the IM will be used in conjunction with sample results from the sampling investigation described in this SAP for use in the HHRA. | No limitations. |

# SAP Worksheet #14 -- Summary of Project Tasks
(UFP-QAPP Manual Section 2.8.1)

## 14.1 FIELD INVESTIGATION TASK PLAN

SWMU 25 RFI field tasks are listed and then briefly described below.

- Mobilization/demobilization
- Site-specific health and safety training
- Utility clearance
- Drilling, direct-push technology (DPT) boring, and other intrusive activities work
- Monitoring equipment calibration
- Sample collection
- Surface and subsurface soil sampling
- Groundwater well redevelopment*
- Groundwater level measurement
- Groundwater sampling
- Investigation-derived waste (IDW) management
- Global Positioning System (GPS) locating (see Standard Operating Procedure [SOP]-15)
- Field decontamination
- Field documentation
- Sample custody and shipment
- Quality Control (QC)

**Mobilization/Demobilization**

Mobilization will consist of the delivery of all equipment, materials, and supplies to the site, complete assembly in satisfactory working order of all such equipment at the site, and satisfactory storage at the site of all such materials and supplies. Tetra Tech will coordinate with the Navy to identify appropriate locations for the storage of equipment and supplies. Site-specific health and safety training for field team will be provided as part of site mobilization.

Demobilization will consist of the prompt and timely removal of all equipment, materials, and supplies from the site following completion of the work.

**Site-Specific Health and Safety Training**

There are no specialized/non-routine project-specific training requirements or certifications needed by personnel to successfully complete the swum 25 project. All field personnel will have appropriate training to conduct the field activities to which they are assigned. Safety requirements are addressed in greater detail in the site-specific HASP.

**Utility Clearance**

One week prior to the commencement of any subsurface intrusive activities, the Tetra Tech FOL or designee will contact Indiana Underground Plant Protection Services (IUPPS) to complete a utility clearance ticket for the areas under investigation. Work permits, if required by the facility, will be obtained prior to conducting field activities. The Tetra Tech FOL will be responsible for coordinating these activities.

**Drilling, DPT Boring, and Other Intrusive Activities Work**

DPT (e.g., Geoprobe®) will be used to collect surface and subsurface soil cores from the unconsolidated overburden in accordance with SOP-05. A new acetate liner will be used for each 2-foot section of soil core. Each removed soil core will be scanned for SVOCs in accordance with SOP-05. The soil core will be visually inspected and logged by the FOL, and the soil texture, grain size (sand, silt, or clay), color (and any unusual discoloration), moisture content, and soil type will be identified based on the Unified Soil Classification System (USCS) in accordance with SOP-07.

Soil borings will be backfilled with soil cuttings not required for sampling.

**Monitoring Equipment Calibration**

Monitoring equipment calibration procedures are described in Worksheet #22. All monitoring equipment will be calibrated prior to use either by the manufacturer or, by the field team in accordance with manufacturer's instructions.

**Soil Sample Collection**

Site-specific SOPs have been developed for field activities at NSA Crane, including sample collection tasks (see Appendix D). All soil sample locations shall be marked with either a pin flags or wooden lathes. Coordinates will be determined by a handheld sub-meter accuracy GPS at each individual sample location, which will allow for future studies and guide in any removal action. Pre-determined Geographic

Information System (GIS)-grade sample coordinates may be utilized in locating proposed sample locations (see SOP-03).

Surface soil samples (from 0 to 2 feet bgs) will be collected from the soil coring, and sample jars will be filled using a decontaminated stainless-steel spoon. Subsurface soil samples (between 2 and 10 feet bgs) will be collected using a DPT, DPT rig with augering capabilities, concrete coring device, backhoe, or stainless- steel hand auger and plastic disposable trowel. The subsurface soil borings will be described by the FOL Geologist in accordance with SOP-07 (Soil Sample Logging) and will be screened for evidence of contamination with a PID. Use of the PID will be in accordance with the manufacturer's instructions. Sample labeling will be in accordance with SOP-01 (Sample Labeling), and the sample numbering scheme will be in accordance with SOP-02 (Sample Identification and Nomenclature).

The SVOC samples will be collected in accordance with SOP 05 from the point along the soil core that had the greatest photoionization detector (PID) reading. If no PID readings are greater than background, the SVOC sample will be collected from any discolored area of the soil or, if there is no discoloration, from the midpoint of the core. The sample will be placed in a decontaminated stainless-steel mixing bowl, rocks, gravel, and other coarse debris will be removed, and the sample will be mixed to uniform texture and color (or as close to as possible) using a decontaminated stainless-steel spoon.

Methods for recording data will be in accordance with SOP-03 (Sample Custody and Documentation of Field Activities), and the selection of sample containers and sample preservation, packaging, and shipping will be in accordance with SOP-08 (Sample Preservation, Packaging, and Shipping). Field and laboratory QC samples will also be collected as outlined in Worksheet #20."

**Groundwater Well Redevelopment**

Five monitoring wells currently exist at SWMU 25. Because the wells were installed in 1987, they will require redevelopment before they can be sampled. No new wells will be installed. The groundwater development procedure discussed in SOP-12 (Monitoring Well Development) will be followed.

**Groundwater Level Measurements**

One synoptic round of water level measurements and total well depth soundings will be obtained at all of the existing monitoring wells at the SWMU 25. The groundwater sampling procedures discussed in SOP-10 (Measurement of Water Levels) will be followed. All water-level measurements will be taken within an 8-hour period using an electronic water-level meter. If a rain event occurs during the field investigation, water levels will be measured 24-hours after the rain event. Water-level elevations will be recorded to within 0.01-foot accuracy from a marked reference point on the well riser pipe. Water levels will be

recorded on a Tetra Tech water-level form. The water-level meter will be decontaminated between each well.

**Groundwater Sampling**

The groundwater sampling procedures given in SOP-13 (Low Flow Well Purging and Stabilization), SOP-14 (Monitoring Well Sampling), and SOP-09 (Calibration and Care of Water Quality Meters) will be followed.

**Investigation-Derived Waste Management**

It is not anticipated that significant volumes of solid or semi-solid IDW in the form of soil or sediment will be generated during field activities, including well redevelopment, the collection of subsurface samples using DPT or backhoe excavations or the redevelopment of existing groundwater monitoring wells at SWMU 25. However, there may be significant volumes of purge water from well sampling.

IDW that is generated, including personal protective equipment (PPE) and decontamination fluids, will be handled in accordance with SOP-06 (Management of Investigation-Derived Waste).

Any encounters with metallic objects or other objects that indicate a potential contaminant source or hazard shall be reported to the FOL and SSO, and appropriate actions will be taken as specified in this UFP-SAP and associated HASP.

**Global Positioning System Locating**

A GPS unit will be used to locate all sampling points in accordance with SOP-15 (Global Positioning System Data Collection and Transfer). The GPS equipment will be checked on control monuments before and after each day's use, and these checks will be documented in the field notebook.

**Field Decontamination Procedures**

Decontamination requirements outlined in this section will apply. Decontamination of reusable sampling equipment (e.g., non-disposable hand trowels, hand augers, or DPT or backhoe equipment) will be conducted prior to sampling and between samples at each location. Decontamination of equipment will be conducted according to the sequence established in SOP-04 (Decontamination of Field Sampling Equipment).

**Field Documentation Procedures**

Field documentation will be performed in accordance with SOP-03 (Sample Custody and Documentation of Field Activity), which is presented in Appendix D.

A summary of all field activities will be properly recorded in a bound logbook with consecutively number pages that cannot be removed. Logbooks will be assigned to field personnel and will be stored in a secured area when not in use.

All logbook entries will be written in ink, and no erasures will be made. If an incorrect entry is made, striking a single line through the incorrect information will make the correction, and the person making the correction will initial and date the change.

**Sample Custody and Shipment Tasks**

Sample custody and shipment tasks are defined in SOP-08 (Sample Preservation, Packaging, and Shipping) and are discussed in Worksheet #27.

**Quality Control Tasks**

QA/QC samples will be collected at the frequencies listed in Worksheet #12.

## 14.2 ADDITIONAL PROJECT-RELATED TASKS

Additional project-related tasks include:

- Analytical tasks
- Data generation procedures
- Data handling and management
- Data tracking and control
- Assessment and oversight
- Data review
- Project reports

**Analytical Tasks**

RTI Laboratories, Inc., is a current Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accredited laboratory. A copy of the laboratory certification for RTI can be found in Appendix C. Analyses will be performed in accordance with the analytical methods identified in

Worksheet #19. RTI is expected to meet the PSLs to the extent identified in Worksheet #15. RTI will perform chemical analysis following laboratory-specific SOPs (Worksheets #19 and #23) developed based on the analytical methods listed in Worksheet #19 and #30. Copies of the laboratory SOPs are included in Appendix C.

All solid results will be reported by the laboratory on a dry-weight basis. Results of percent moisture will be reported in each analytical data package and electronic data deliverable (EDD) files. This information will also be captured in the project database that will eventually be uploaded to the Naval Installation Restoration Information Solution (NIRIS).

The analytical data packages provided by RTI will be in a Contract Laboratory Program (CLP)-like format and will be fully validatable and contain raw data, summary forms for all sample and laboratory method blank data, and summary forms containing all method-specific QC (results, recoveries, RPDs, relative standard deviations, and/or percent differences etc.).

**Data Generation Procedures**

- Project documentation and records include the following:
  - Field sample collection and field measurement records as described in Worksheet #s 27 and 29.
  - Laboratory data package deliverables as described in the analytical specifications.
  - Data assessment documents and records as listed in Worksheet #29.
- Data recording formats are described in Worksheet #27.

**Data Handling and Management**

After the RFI is completed, the field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after the completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity.

The laboratory data handling procedures to be followed by RTI will meet the requirements of the technical specifications. The electronic data results will be automatically downloaded into the Tetra Tech database in accordance with the proprietary Tetra Tech processes.

**Data Tracking and Control**

The Tetra Tech PM (or designee) is responsible for the overall tracking and control of data generated for the project. Data Tracking and Control procedures are contained in Worksheet #29 and summarized as follows:

- **Data Tracking**. Data are tracked from generation to archiving in the Tetra Tech project-specific files. The Tetra Tech Project Chemist (or designee) is responsible for tracking the samples collected and shipped to RTI. Upon receipt of the data packages from RTI, the Tetra Tech Project Chemist will oversee the data validation effort, which includes verifying that the data packages are complete and that results for all samples have been delivered by RTI.

- **Data Storage, Archiving, and Retrieval**. The data packages received from RTI are tracked in the data validation logbook. After the data are validated, the data packages are entered into the Tetra Tech Navy CLEAN file system and archived in secure files. The field records including field logbooks, sample log sheets, chain-of-custody records, and field calibration logs will be submitted by the Tetra Tech FOL to be entered into the Navy CLEAN file system prior to archiving in secure project files. The project files are audited for accuracy and completeness. At the completion of the Navy contract, the records will be stored by Tetra Tech.

- **Data Security**. Access to Tetra Tech project files is restricted to designated personnel only. Records can only be borrowed temporarily from the project file using a sign-out system. The Tetra Tech Data Manager maintains the electronic data files, and access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

**Assessment and Oversight**

Refer to Worksheet #32 for assessment findings and corrective actions and to Worksheet #33 for QA Management Reports.

**Data Review**

Data verification is described in Worksheet #34, data validation is described in Worksheet #s 35 and 36, and the usability assessment is described in Worksheet #37.

**Project Reports**

Draft and final versions of project reports will be prepared and submitted to the Navy and IDEM for review. The reports will include the following sections:

- Executive Summary, which will include a brief description of the work conducted and the findings.

- Introduction and Background, which will include a description of the history of operations and activities at the site and a summary of any previous investigations and removal actions.

- Description of Field Investigations, which will include a summary of the work performed in accordance with the approved SAP, any approved SAP addenda, and any field modifications as documented by the Tetra Tech FOL. This section will include maps showing the sampling locations and tables summarizing the data collected.

- Data Quality, which will include a summary of quantitative analytical performance indicators such as completeness, precision, bias, and sensitivity and qualitative indicators such as representativeness and comparability. This section will also include a reconciliation of project data with the DQOs and identification of deviations from this SAP.

  A data usability assessment will be used to identify significant deviations in analytical performance that could affect the ability to meet project objectives. The elements of this review are presented in Worksheet #37.

- Nature and Extent of Contamination – will include a discussion of the contamination detected in each medium sampled in relation to the CSM of the site. This section will note the removals previously conducted, contamination addressed, and any additional contaminants found during this field effort. Detected contaminant concentrations will be tabulated for each medium and depicted on maps.

- Contaminant Fate and Transport, which will include a description of the contaminants detected and their behavior in soil and groundwater, particularly with emphasis on the future migration of these contaminants to any possible exposure areas.

- Human Health Risk Assessment – includes a comparison of data collected to PSLs to identify COPCs. If COPCs are identified they will be assessed in accordance with Risk Assessment for Superfund (RAGS) and contaminants of concern (COCs) will be identified if risk is unacceptable.

- Ecological Risk Assessment, which includes a comparison of data collected to PSLs to identify COPCs. If COPCs are identified they will be assessed and COCs will be identified if risk is unacceptable.

- Summary and Conclusions, which will include a summary of the findings, conclusions as to whether delineation of contamination is adequate, and recommendations for further investigations, if needed.

The final version of the report will submitted in hardcopy and electronic format to the project stakeholders.

## SAP Worksheet #15 -- Reference Limits and Evaluation Table
(UFP-QAPP Manual Section 2.8.1)

**Matrix:** Soil
**Analytical Group:** SVOCs (including Low Level PAHs)

| Analyte | CAS Number | PSL (mg/kg) | | PSL Reference[1] | | PQLG (mg/kg) | RTI | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HHRA | ERA | HHRA | ERA | | LOQ (mg/kg) | LOD (mg/kg) | DL (mg/kg) |
| 1,1'-Biphenyl | 92-52-4 | 380 | NC | RBSSL | None | 130 | TBD | TBD | TBD |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | 1.0 | 2.02 | RBSSL | R5 ESL-S | 0.33 | 0.16 | 0.0167 | 0.01 |
| **2,2'-Oxybis(1-chloropropane)** | **108-60-1** | **0.0024** | 19.9 | **RBSSL** | R5 ESL-S | **0.00080** | **0.16** | **0.017** | **0.004757** |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | 130 | 0.199 | RBSSL | R5 ESL-S | 0.066 | 0.16 | 0.0167 | 0.01 |
| 2,4,5-Trichlorophenol | 95-95-4 | 250 | 14.1 | R-DCL | R5 ESL-S | 4.7 | 0.16 | 0.017 | 0.010885 |
| **2,4,6-Trichlorophenol** | **88-06-2** | **0.07** | 9.94 | **R-DCL** | R5 ESL-S | **0.023** | **0.16** | **0.017** | **0.012329** |
| 2,4-Dichlorophenol | 120-83-2 | 1.1 | 87.5 | R-DCL | R5 ESL-S | 0.37 | 0.16 | 0.017 | 0.011311 |
| **2,4-Dimethylphenol** | **105-67-9** | 9 | **0.01** | R-DCL | **R5 ESL-S** | **0.0033** | **0.16** | **0.017** | **0.022911** |
| **2,4-Dinitrophenol** | **51-28-5** | 0.29 | **0.0609** | R-DCL | **R5 ESL-S** | **0.020** | **0.83** | **0.083** | **0.164852** |
| **2,4-Dinitrotoluene** | **121-14-2** | **0.0058** | 1.28 | **RBSSL** | R5 ESL-S | **0.0019** | **0.16** | **0.017** | **0.007401** |
| **2,6-Dinitrotoluene** | **606-20-2** | 1.0 | **0.0328** | RBSSL | **R5 ESL-S** | **0.011** | **0.16** | **0.017** | **0.009168** |
| **2-Chloronaphthalene** | **91-58-7** | 42 | **0.0122** | R-DCL | **R5 ESL-S** | **0.0041** | **0.16** | **0.017** | **0.006673** |
| **2-Chlorophenol** | **95-57-8** | 0.75 | **0.243** | R-DCL | **R5 ESL-S** | **0.081** | 0.16 | 0.017 | 0.006646 |
| 2-Methylphenol (o-Cresol) | 95-48-7 | 14 | 40.4 | R-DCL | R5 ESL-S | 4.7 | 0.16 | 0.017 | 0.006527 |
| 2-Nitroaniline | 88-74-4 | 0.67 | 74.1 | R-DCL | R5 ESL-S | 0.22 | 0.32 | 0.017 | 0.008112 |
| 2-Nitrophenol | 88-75-5 | 1.6 | 1.6 | RBSSL | R5 ESL-S | 0.53 | 0.16 | 0.017 | 0.005376 |
| **3,3'-Dichlorobenzidine** | **91-94-1** | **0.020** | 0.646 | **RBSSL** | R5 ESL-S | **0.0067** | **1** | **0.33** | **0.229616** |

| Analyte | CAS Number | PSL (mg/kg) | | PSL Reference[1] | | PQLG (mg/kg) | RTI | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HHRA | ERA | HHRA | ERA | | LOQ (mg/kg) | LOD (mg/kg) | DL (mg/kg) |
| 3-Methylphenol (m-Cresol) | 108-39-4 | 9.8 | 3.49 | R-DCL | R5 ESL-S | 1.2 | 0.16 | 0.033 | 0.01189 |
| 3-Nitroaniline | 99-09-2 | NC | 3.16 | None | R5 ESL-S | 1.05 | 0.32 | 0.017 | 0.011657 |
| **4,6-Dinitro-2-methylphenol** | **534-52-1** | **0.10** | 0.144 | **RBSSL** | R5 ESL-S | **0.033** | **0.32** | **0.083** | **0.042594** |
| 4-Chloro-3-methyl phenol | 59-50-7 | 86 | 7.95 | RBSSL | R5 ESL-S | 2.6 | 0.16 | 0.017 | 0.005733 |
| **4-Chloroanaline** | **106-47-8** | **0.0028** | 1.1 | **RBSSL** | R5 ESL-S | **0.00093** | **0.16** | **0.017** | **0.008925** |
| 4-Methylphenol (p-Cresol) | 106-44-5 | 1.1 | 163 | R-DCL | R5 ESL-S | 0.37 | 0.16 | 0.033 | 0.01189 |
| **4-Nitroaniline** | **100-01-6** | **0.028** | 21.9 | **RBSSL** | R5 ESL-S | **0.0093** | **0.32** | **0.017** | **0.006499** |
| 4-Nitrophenol | 100-02-7 | NC | 5.12 | None | R5 ESL-S | 1.7 | 0.83 | 0.33 | 0.106398 |
| Acetophenone | 98-86-2 | 22 | 300 | RBSSL | R5 ESL-S | 7.3 | TBD | TBD | TBD |
| **Atrazine** | **1912-24-9** | **0.0038** | NC | **RBSSL** | None | **0.0013** | **TBD** | **TBD** | **TBD** |
| Benzaldehyde | 100-52-7 | 16.2 | NC | RBSSL | None | 5.4 | TBD | TBD | TBD |
| Bis(2-chloroethoxy)methane | 111-91-1 | 0.50 | 0.302 | RBSSL | R5 ESL-S | 0.10 | 0.1 | 0.017 | 0.004166 |
| **Bis(2-chloroethyl)ether** | **111-44-4** | **0.000062** | 23.7 | **RBSSL** | R5 ESL-S | **0.000021** | **0.16** | **0.033** | **0.017897** |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 22 | 0.925 | RBSSL | R5 ESL-S | 0.31 | 0.16 | 0.017 | 0.008893 |
| Butyl benzyl phthalate | 85-68-7 | 10 | 0.239 | RBSSL | R5 ESL-S | 0.080 | 0.16 | 0.017 | 0.007294 |
| Caprolactam | 105-60-2 | 90 | NC | RBSSL | None | 30 | TBD | TBD | TBD |
| Carbazole | 86-74-8 | 5.9 | NC | R-DCL | None | 2.0 | 0.16 | 0.017 | 0.006414 |
| Dibenzofuran | 132-64-9 | 4.9 | NC | R-DCL | None | 1.6 | 0.16 | 0.017 | 0.004209 |
| Diethyl phthalate | 84-66-2 | 240 | 24.8 | RBSSL | R5 ESL-S | 8.3 | 0.16 | 0.017 | 0.003715 |
| Dimethyl phthalate | 131-11-3 | 240 | 734 | RBSSL | R5 ESL-S | 80 | 0.16 | 0.017 | 0.00468 |
| **Di-n-butyl phthalate** | **84-74-2** | 184 | **0.15** | **RBSSL** | **R5 ESL-S** | **0.050** | **0.16** | **0.017** | **0.006356** |
| Di-n-octyl phthalate | 117-84-0 | 2,000 | 709 | R-DCL | R5 ESL-S | 240 | 0.16 | 0.017 | 0.005949 |
| **Hexachlorobenzene** | **118-74-1** | **0.011** | 0.199 | **RBSSL** | R5 ESL-S | **0.0037** | **0.16** | **0.017** | **0.007128** |

| Analyte | CAS Number | PSL (mg/kg) | | PSL Reference[1] | | PQLG (mg/kg) | RTI | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HHRA | ERA | HHRA | ERA | | LOQ (mg/kg) | LOD (mg/kg) | DL (mg/kg) |
| **Hexachlorobutadiene** | **87-68-3** | **0.034** | 0.0398 | **RBSSL** | R5 ESL-S | **0.011** | **0.05** | **0.017** | **0.005263** |
| Hexachlorocyclopentadiene | 77-47-4 | 14 | 0.755 | RBSSL | R5 ESL-S | 0.25 | 0.16 | 0.083 | 0.017738 |
| **Hexachloroethane** | **67-72-1** | **0.058** | 0.596 | **RBSSL** | R5 ESL-S | **0.019** | **0.16** | **0.017** | **0.005366** |
| Isophorone | 78-59-1 | 0.46 | 139 | RBSSL | R5 ESL-S | 0.15 | 0.16 | 0.017 | 0.003564 |
| **Nitrobenzene** | **98-95-3** | **0.0016** | 1.31 | **RBSSL** | R5 ESL-S | **0.00053** | **0.16** | **0.017** | **0.010349** |
| **N-Nitrosodi-n-propylamine** | **621-64-7** | **0.00014** | 0.544 | **RBSSL** | R5 ESL-S | **0.00047** | **0.16** | **0.017** | **0.009264** |
| N-Nitrosodiphenylamine | 86-30-6 | 1.5 | 0.545 | RBSSL | R5 ESL-S | 0.18 | 0.16 | 0.017 | 0.00464 |
| **Pentachlorophenol** | **87-86-5** | **0.028** | 2.1 | **R-DCL** | Eco-SSL | **0.0093** | **0.16** | **0.083** | **0.038587** |
| Phenol | 108-95-2 | 56 | 120 | R-DCL | R5 ESL-S | 19 | 0.16 | 0.017 | 0.008863 |
| **PAHs[2]** | | | | | | | | | |
| 2-Methylnaphthalene | 91-57-6 | 3.1 | 29 | R-DCL | Eco-SSL | 1.0 | 0.0067 | 0.0067 | 0.0033 |
| Acenaphthene | 83-32-9 | 130 | 29 | R-DCL | Eco-SSL | 9.7 | 0.0067 | 0.0067 | 0.0033 |
| Acenaphthylene | 208-96-8 | 18 | 29 | R-DCL | Eco-SSL | 6.0 | 0.0067 | 0.0067 | 0.0033 |
| Anthracene | 120-12-7 | 1,700 | 29 | R-RSL | Eco-SSL | 9.7 | 0.0067 | 0.0067 | 0.0033 |
| Benzo(a)anthracene | 56-55-3 | 0.15 | 1.1 | R-RSL | Eco-SSL | 0.050 | 0.0067 | 0.0067 | 0.0033 |
| Benzo(a)pyrene | 50-32-8 | 0.015 | 1.1 | R-RSL | Eco-SSL | 0.0050 | 0.0067 | 0.0067 | 0.0033 |
| Benzo(b)fluoranthene | 205-99-2 | 0.15 | 1.1 | R-RSL | Eco-SSL | 0.050 | 0.0067 | 0.0067 | 0.0033 |
| Benzo(g,h,i)perylene | 191-24-2 | 170 | 1.1 | R-RSL | Eco-SSL | 0.37 | 0.0067 | 0.0067 | 0.0033 |
| Benzo(k)fluoranthene | 207-08-9 | 1.5 | 1.1 | R-RSL | Eco-SSL | 0.37 | 0.0067 | 0.0067 | 0.0033 |
| Chrysene | 218-01-9 | 15 | 1.1 | R-RSL | Eco-SSL | 0.37 | 0.0067 | 0.0067 | 0.0033 |
| Dibenzo(a,h)anthracene | 53-70-3 | 0.015 | 1.1 | R-RSL | Eco-SSL | 0.0050 | 0.0067 | 0.0033 | 0.0033 |
| Fluoranthene | 206-44-0 | 230 | 29 | R-RSL | Eco-SSL | 9.7 | 0.0067 | 0.0067 | 0.0033 |
| Fluorene | 86-73-7 | 170 | 29 | R-DCL | Eco-SSL | 9.7 | 0.0067 | 0.0067 | 0.0033 |

| Analyte | CAS Number | PSL (mg/kg) | | PSL Reference[1] | | PQLG (mg/kg) | RTI | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HHRA | ERA | HHRA | ERA | | LOQ (mg/kg) | LOD (mg/kg) | DL (mg/kg) |
| Indeno(1,2,3-c,d)pyrene | 193-39-5 | 0.15 | 1.1 | R-RSL | Eco-SSL | 0.050 | 0.0067 | 0.0067 | 0.0033 |
| Naphthalene | 91-20-3 | 0.0094 | 29 | RBSSL | Eco-SSL | 0.0031 | 0.0067 | 0.0067 | 0.0033 |
| Phenanthrene | 85-01-8 | 13 | 29 | R-DCL | Eco-SSL | 4.3 | 0.0067 | 0.0067 | 0.0033 |
| Pyrene | 129-00-0 | 170 | 1.1 | R-RSL | Eco-SSL | 0.37 | 0.0067 | 0.0067 | 0.0033 |

Notes:

CAS – Chemical Abstracts Service
mg/kg – milligrams per kilogram
PQLG – Project Quantitation Limit Goal
NC – No Criteria

1 The PSL references for surface and subsurface soil are: RBSSL - USEPA Regions 3, 6, and 9 Risk-Based Soil Screening Level, Migration to Groundwater, DAF = 20 (November, 2010); R-RSL - USEPA Regions 3, 6, and 9 Regional Screening Level for Soil, Residential Direct Contact, adjusted to 1/10 of value for noncarcinogens (November, 2010); R-DCL – IDEM Residential Default Closure Level (May, 2009); Eco-SSL – USEPA Ecological Soil Screening Levels (2005-2008); R5 ESL-S – USEPA Region 5 Ecological Screening Level, Soil (August, 2003). Refer to Appendix F for further explanation and justification of PSLs.
2 The low level PAHs will be analyzed by SW-846 Method 8270C Selected Ion Monitoring (SIM) to obtain lower detection limits.

**Bolded** rows indicate that the PSL is between the laboratory LOQ and LOD. The Project Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the uncertainties section of the Risk Assessment.

**Bolded and Shaded** rows indicate the PSL is less than the LOD; therefore, the Project Team has agreed to report non-detected results at the LOD and any limitations on data use that result from having detection limits that are greater than PSLs will be described in the RFI Report.

**Matrix:** Soil
**Analytical Group:** Metals

| Analyte | CAS Number | PSL (mg/kg) | | PSL Reference[1] | | PQLG (mg/kg) | RTI | | |
|---|---|---|---|---|---|---|---|---|---|
| | | HHRA | ERA | HHRA | ERA | | LOQ (mg/kg) | LOD (mg/kg) | DL (mg/kg) |
| Aluminum | 7429-90-5 | 7,700 | NC | R-RSL | None | 2,600 | 0.5 | 0.05 | 0.00565 |
| Antimony | 7440-36-0 | 3.1 | 0.27 | R-RSL | Eco-SSL | 0.090 | 0.025 | 0.005 | 0.0027 |
| Arsenic | 7440-38-2 | 0.026 | 18 | RBSSL | Eco-SSL | 0.0087 | 0.015 | 0.005 | 0.0047 |
| Barium | 7440-39-3 | 1,500 | 330 | R-RSL | Eco-SSL | 110 | 0.25 | 0.005 | 0.00215 |
| Beryllium | 7440-41-7 | 16 | 21 | R-RSL | Eco-SSL | 5.3 | 0.01 | 0.005 | 0.0014 |
| Cadmium | 7440-43-9 | 7.0 | 0.36 | R-RSL | Eco-SSL | 0.12 | 0.01 | 0.005 | 0.0021 |
| **Chromium** | **7440-47-3** | **0.017** | 26 | **RBSSL** | Eco-SSL | **0.0057** | **0.1** | **0.005** | **0.00325** |
| Cobalt | 7440-48-4 | 2.3 | 13 | R-RSL | Eco-SSL | 0.77 | 0.05 | 0.005 | 0.0047 |
| Copper | 7440-50-8 | 310 | 28 | R-RSL | Eco-SSL | 9.3 | 0.05 | 0.025 | 0.00625 |
| Iron | 7439-89-6 | 5,500 | NC | R-RSL | None | 1,800 | 1 | 0.25 | 0.15955 |
| Lead | 7439-92-1 | 81 | 11 | R-DCL | Eco-SSL | 3.7 | 0.01 | 0.005 | 0.00115 |
| Manganese | 7439-96-5 | 180 | 220 | R-RSL | Eco-SSL | 60 | 0.05 | 0.025 | 0.0056 |
| Mercury | 7439-97-6 | 2.3 | 0.10 | R-RSL | R5 ESL-S | 0.033 | 0.03 | 0.01 | 0.001493 |
| Nickel | 7440-02-0 | 150 | 38 | R-RSL | Eco-SSL | 13 | 0.1 | 0.025 | 0.0044 |
| Selenium | 7782-49-2 | 5.2 | 0.52 | R-DCL | Eco-SSL | 0.17 | 0.05 | 0.025 | 0.0102 |
| Silver | 7440-22-4 | 31 | 4.2 | R-DCL | Eco-SSL | 1.4 | 0.015 | 0.005 | 0.0032 |
| Thallium | 7440-28-0 | 2.8 | 0.0569 | R-DCL | R5 ESL-S | 0.019 | 0.02 | 0.05 | 0.008 |
| Vanadium | 7440-62-2 | 39 | 7.8 | R-RSL | Eco-SSL | 2.6 | 0.02 | 0.005 | 0.00405 |
| Zinc | 7440-66-6 | 2,300 | 46 | R-RSL | Eco-SSL | 15 | 0.5 | 0.05 | 0.02395 |

Notes:

1 The PSL references for surface and subsurface soil are: RBSSL - USEPA Regions 3, 6, and 9 Risk-Based Soil Screening Level, Migration to Groundwater, DAF = 20 (November, 2010); R-RSL - USEPA Regions 3, 6, and 9 Regional Screening Level for Soil, Residential Direct Contact, adjusted to 1/10 of value for noncarcinogens (November, 2010); R-DCL – IDEM Residential Default Closure Level (May, 2009); Eco-SSL – USEPA Ecological Soil Screening Levels (2005-2008); R5 ESL-S – USEPA Region 5 Ecological Screening Level, Soil (August, 2003). Refer to Appendix F for further explanation and justification of PSLs.

**Bolded** rows indicate that the PSL is between the laboratory LOQ and LOD. The Project Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the uncertainties section of the Risk Assessment.

**Bolded and Shaded** rows indicate the PSL is less than the LOD; therefore, the Project Team has agreed to report non-detected results at the LOD and any limitations on data use that result from having detection limits that are greater than PSLs will be described in the RFI Report.

**Matrix:** Groundwater
**Analytical Group:** SVOCs (including Low Level PAHs)

| Analyte | CAS Number | PSL (µg/L) | PSL Reference[1] | PQLG (µg/L) | RTI | | |
|---|---|---|---|---|---|---|---|
| | | HHRA | HHRA | | LOQ (µg/L) | LOD (µg/L) | DL (µg/L) |
| 1,1'-Biphenyl | 92-52-4 | 180 | T-RSL | 60 | 5 | 2.5 | 1 |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | 1.1 | T-RSL | 0.37 | TBD | TBD | TBD |
| **2,2'-Oxybis(1-chloropropane)** | **108-60-1** | **0.32** | **T-RSL** | **0.11** | **5** | **0.5** | **0.148** |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | 110 | T-RSL | 37 | 5 | 2.5 | 1.3 |
| 2,4,5-Trichlorophenol | 95-95-4 | 370 | T-RSL | 120 | 5 | 0.5 | 0.325 |
| **2,4,6-Trichlorophenol** | **88-06-2** | **3.6** | **G-DCL** | **1.2** | **4** | **0.5** | **0.295** |
| 2,4-Dichlorophenol | 120-83-2 | 11 | T-RSL | 3.7 | 5 | 0.5 | 0.306 |
| 2,4-Dimethylphenol | 105-67-9 | 73 | T-RSL | 24 | 5 | 1 | 0.553 |
| **2,4-Dinitrophenol** | **51-28-5** | **7.3** | **T-RSL** | **2.4** | **25** | **10** | **7.068** |
| **2,4-Dinitrotoluene** | **121-14-2** | **0.22** | **T-RSL** | **0.073** | **5** | **0.5** | **0.393** |
| **2,6-Dinitrotoluene** | **606-20-2** | **3.7** | **T-RSL** | **1.2** | **5** | **0.5** | **0.404** |
| 2-Chloronaphthalene | 91-58-7 | 290 | T-RSL | 97 | 5 | 1 | 0.692 |
| 2-Chlorophenol | 95-57-8 | 18 | T-RSL | 6.0 | 5 | 0.5 | 0.179 |
| 2-Methylphenol (o-Cresol) | 95-48-7 | 180 | T-RSL | 60 | 5 | 0.5 | 0.303 |
| 2-Nitroaniline | 88-74-4 | 37 | T-RSL | 12 | 5 | 0.5 | 0.246 |
| 2-Nitrophenol | 88-75-5 | 7.3 | T-RSL | 2.4 | 5 | 0.5 | 0.27 |
| **3,3'-Dichlorobenzidine** | **91-94-1** | **0.15** | **T-RSL** | **0.050** | **20** | **10** | **5.538** |
| 3-Methylphenol (m-Cresol) | 108-39-4 | 180 | T-RSL | 60 | 10 | 1 | 0.311 |
| **4,6-Dinitro-2-methylphenol** | **534-52-1** | **0.29** | **T-RSL** | **0.097** | **10** | **2.5** | **1.574** |
| 4-Chloro-3-methyl phenol | 59-50-7 | 370 | T-RSL | 120 | 5 | 0.5 | 0.318 |
| **4-Chloroanaline** | **106-47-8** | **0.34** | **T-RSL** | **0.11** | **10** | **0.5** | **0.342** |

| Analyte | CAS Number | PSL (µg/L) | PSL Reference[1] | PQLG (µg/L) | RTI | | |
|---|---|---|---|---|---|---|---|
| | | HHRA | HHRA | | LOQ (µg/L) | LOD (µg/L) | DL (µg/L) |
| 4-Methylphenol (p-Cresol) | 106-44-5 | 18 | T-RSL | 6.0 | 10 | 1 | 0.311 |
| **4-Nitroaniline** | **100-01-6** | **3.4** | **T-RSL** | **1.1** | **10** | **0.5** | **0.434** |
| Acetophenone | 98-86-2 | 370 | T-RSL | 120 | TBD | TBD | TBD |
| **Atrazine** | **1912-24-9** | **0.29** | **T-RSL** | **0.097** | **TBD** | **TBD** | **TBD** |
| Benzaldehyde | 100-52-7 | 370 | T-RSL | 120 | TBD | TBD | TBD |
| Bis(2-chloroethoxy)methane | 111-91-1 | 11 | T-RSL | 3.7 | 5 | 0.5 | 0.247 |
| **Bis(2-chloroethyl)ether** | **111-44-4** | **0.012** | **T-RSL** | **0.0040** | **1** | **0.5** | **0.232** |
| **Bis(2-ethylhexyl)phthalate** | **117-81-7** | **4.8** | **T-RSL** | **1.6** | **5** | **0.5** | **0.372** |
| Butyl benzyl phthalate | 85-68-7 | 35 | T-RSL | 12 | 5 | 0.5 | 0.243 |
| Caprolactam | 105-60-2 | 1,800 | T-RSL | 600 | TBD | TBD | TBD |
| Carbazole | 86-74-8 | 43 | G-DCL | 14 | 5 | 0.5 | 0.393 |
| **Dibenzofuran** | **132-64-9** | **3.7** | **T-RSL** | **1.2** | **4** | **0.5** | **0.315** |
| Diethyl phthalate | 84-66-2 | 2,900 | T-RSL | 970 | 5 | 0.5 | 0.339 |
| Dimethyl phthalate | 131-11-3 | 2,900 | T-RSL | 970 | 5 | 0.5 | 0.182 |
| Di-n-butyl phthalate | 84-74-2 | 370 | T-RSL | 120 | 5 | 0.5 | 0.416 |
| Di-n-octyl phthalate | 117-84-0 | 20 | G-DCL | 6.7 | 5 | 0.5 | 0.213 |
| **Hexachlorobenzene** | **118-74-1** | **0.042** | **T-RSL** | **0.014** | **1** | **0.5** | **0.236** |
| **Hexachlorobutadiene** | **87-68-3** | **0.86** | **T-RSL** | **0.29** | **1** | **0.5** | **0.313** |
| **Hexachlorocyclopentadiene** | **77-47-4** | **0.019** | **VAPOR** | **0.0063** | **5** | **2.5** | **0.684** |
| **Hexachloroethane** | **67-72-1** | **3.7** | **T-RSL** | **1.2** | **5** | **0.5** | **0.23** |
| Isophorone | 78-59-1 | 71 | T-RSL | 24 | 5 | 1 | 0.97 |
| **Nitrobenzene** | **98-95-3** | **0.12** | **T-RSL** | **0.040** | **3** | **0.5** | **0.263** |
| **N-Nitrosodi-n-propylamine** | **621-64-7** | **0.0096** | **T-RSL** | **0.0032** | **5** | **0.5** | **0.318** |

| Analyte | CAS Number | PSL (µg/L) | PSL Reference[1] | PQLG (µg/L) | RTI | | |
|---|---|---|---|---|---|---|---|
| | | HHRA | HHRA | | LOQ (µg/L) | LOD (µg/L) | DL (µg/L) |
| N-Nitrosodiphenylamine | 86-30-6 | 14 | T-RSL | 4.7 | 5 | 0.5 | 0.363 |
| **Pentachlorophenol** | **87-86-5** | **0.17** | **T-RSL** | **0.057** | **5** | **2.5** | **1.635** |
| Phenol | 108-95-2 | 1,100 | T-RSL | 370 | 5 | 0.5 | 0.14 |
| **PAHs[2]** | | | | | | | |
| 2-Methylnaphthalene | 91-57-6 | 15 | T-RSL | 5.0 | 0.2 | 0.2 | 0.1 |
| Acenaphthene | 83-32-9 | 220 | T-RSL | 73 | 0.2 | 0.2 | 0.1 |
| Acenaphthylene | 208-96-8 | 71 | G-DCL | 24 | 0.2 | 0.2 | 0.1 |
| Anthracene | 120-12-7 | 1,100 | T-RSL | 370 | 0.2 | 0.2 | 0.1 |
| **Benzo(a)anthracene** | **56-55-3** | **0.029** | **T-RSL** | **0.0097** | **0.2** | **0.2** | **0.1** |
| **Benzo(a)pyrene** | **50-32-8** | **0.0029** | **T-RSL** | **0.00097** | **0.2** | **0.2** | **0.1** |
| **Benzo(b)fluoranthene** | **205-99-2** | **0.029** | **T-RSL** | **0.0097** | **0.2** | **0.2** | **0.1** |
| Benzo(g,h,i)perylene | 191-24-2 | 110 | T-RSL | 37 | 0.2 | 0.2 | 0.1 |
| Benzo(k)fluoranthene | 207-08-9 | 0.29 | T-RSL | 0.097 | 0.2 | 0.2 | 0.1 |
| Chrysene | 218-01-9 | 2.9 | T-RSL | 0.97 | 0.2 | 0.2 | 0.1 |
| **Dibenzo(a,h)anthracene** | **53-70-3** | **0.0029** | **T-RSL** | **0.00097** | **0.2** | **0.2** | **0.1** |
| Fluoranthene | 206-44-0 | 150 | T-RSL | 50 | 0.2 | 0.2 | 0.1 |
| Fluorene | 86-73-7 | 150 | T-RSL | 50 | 0.2 | 0.2 | 0.1 |
| **Indeno(1,2,3-c,d)pyrene** | **193-39-5** | **0.029** | **T-RSL** | **0.0097** | **0.2** | **0.2** | **0.1** |
| **Naphthalene** | **91-20-3** | **0.14** | **T-RSL** | **0.047** | **0.2** | **0.2** | **0.1** |
| Phenanthrene | 85-01-8 | 23 | G-DCL | 7.7 | 0.2 | 0.2 | 0.1 |
| Pyrene | 129-00-0 | 110 | T-RSL | 37 | 0.2 | 0.2 | 0.1 |

Notes:

1 The PSL references for groundwater are: T-RSL - USEPA Regions 3, 6, and 9 Regional Screening Level for Soil, Tapwater, adjusted to 1/10 of value for noncarcinogens (November, 2010); MCL – USEPA Maximum Contaminant Level (December, 2009); VAPOR – USEPA vapor screening values calculated from 2002 Vapor guidance and 2010 toxicity factors (November, 2002; November, 2010); G-DCL – IDEM Groundwater Default Closure Level (May, 2009). Refer to Appendix F for further explanation and justification of PSLs.

2 The low level PAHs will be analyzed by SW-846 Method 8270C SIM to obtain lower detection limits.

**Bolded** rows indicate that the PSL is between the laboratory LOQ and LOD. The Project Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the uncertainties section of the Risk Assessment.

**Bolded and Shaded** rows indicated the PSL is less than the LOD; therefore, the Project Team has agreed to report non-detected results at the LOD and any limitations on data use that result from having detection limits that are greater than PSLs will be described in the RFI Report.

**Matrix:** Groundwater
**Analytical Group:** Metals (Total and Dissolved)

| Analyte | CAS Number | PSL (µg/L) | PSL Reference[1] | PQLG (µg/L) | RTI | | |
|---|---|---|---|---|---|---|---|
| | | HHRA | HHRA | | LOQ (µg/L) | LOD (µg/L) | DL (µg/L) |
| Aluminum | 7429-90-5 | 3,700 | T-RSL | 1,200 | 10 | 1 | 0.41 |
| Antimony | 7440-36-0 | 1.5 | T-RSL | 0.50 | 0.5 | 0.1 | 0.054 |
| **Arsenic** | **7440-38-2** | **0.045** | **T-RSL** | **0.015** | **0.3** | **0.2** | **0.12** |
| Barium | 7440-39-3 | 730 | T-RSL | 240 | 5 | 0.1 | 0.087 |
| Beryllium | 7440-41-7 | 4.0 | G-DCL | 1.3 | 0.2 | 0.2 | 0.138 |
| Cadmium | 7440-43-9 | 1.8 | T-RSL | 0.60 | 0.2 | 0.1 | 0.077 |
| **Chromium** | **7440-47-3** | **0.043** | **T-RSL** | **0.014** | **2** | **0.5** | **0.363** |
| Cobalt | 7440-48-4 | 1.1 | T-RSL | 0.37 | 1 | 0.1 | 0.083 |
| Copper | 7440-50-8 | 150 | T-RSL | 50 | 1 | 0.5 | 0.205 |
| Iron | 7439-89-6 | 2,600 | T-RSL | 870 | 40 | 30 | 27.966 |
| Lead | 7439-92-1 | 15 | T-RSL | 5.0 | 0.2 | 0.1 | 0.071 |
| Manganese | 7439-96-5 | 88 | T-RSL | 29 | 1 | 0.5 | 0.197 |
| Mercury | 7439-97-6 | 1.1 | T-RSL | 0.37 | 0.2 | 0.1 | 0.027 |
| Nickel | 7440-02-0 | 73 | T-RSL | 24 | 2 | 0.5 | 0.126 |
| Selenium | 7782-49-2 | 18 | T-RSL | 6.0 | 1 | 0.75 | 0.577 |
| Silver | 7440-22-4 | 18 | T-RSL | 6.0 | 0.3 | 0.1 | 0.064 |
| Thallium | 7440-28-0 | 2.0 | G-DCL | 0.67 | 0.4 | 0.1 | 0.069 |
| Vanadium | 7440-62-2 | 18 | T-RSL | 6.0 | 0.8 | 0.5 | 0.113 |
| Zinc | 7440-66-6 | 1,100 | T-RSL | 370 | 10 | 1 | 0.32 |

Notes:

1 The PSL references for groundwater are: T-RSL - USEPA Regions 3, 6, and 9 Regional Screening Level for Soil, Tapwater, adjusted to 1/10 of value for noncarcinogens (November, 2010); MCL – USEPA Maximum Contaminant Level (December, 2009); VAPOR – USEPA vapor screening values calculated from 2002 Vapor guidance and 2010 toxicity factors (November, 2002; November, 2010); G-DCL – IDEM Groundwater Default Closure Level (May, 2009). Refer to Appendix F for further explanation and justification of PSLs.

**Bolded** rows indicate that the PSL is between the laboratory LOQ and LOD. The Project Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the uncertainties section of the Risk Assessment.

**Bolded and Shaded** rows indicate the PSL is less than the LOD; therefore, the Project Team has agreed to report non-detected results at the LOD and any limitations on data use that result from having detection limits that are greater than PSLs will be described in the RFI Report.

## SAP Worksheet #16 -- Project Schedule / Timeline Table
(UFP-QAPP Manual Section 2.8.2)

| Activities | Organization | Dates (MM/DD/YYYY) | | Deliverable | Deliverable Due Date |
|---|---|---|---|---|---|
| | | Anticipated Date(s) of Initiation | Anticipated Date of Completion | | |
| DQO Meeting/Site Visit | Tetra Tech, Navy, IDEM | 12/15/2010 | 12/15/2010 | Meeting Minutes | 01/03/2011 |
| Draft UFP-SAP | Tetra Tech | 09/30/2010 | 01/26/2011 | Draft SAP | 01/13/2011 |
| Final UFP-SAP | Tetra Tech | 05/06/2011 | 06/06/2011 | Final SAP | 06/06/2011 |
| Draft HASP | Tetra Tech | 09/30/2010 | 03/07/2011 | Draft HASP | 30/07/2011 |
| Final HASP | Tetra Tech | 04/21/2011 | 05/04/2011 | Final HASP | 05/04/2011 |
| Field Work – Soil and Groundwater Sampling | Tetra Tech | 06/20/2011 | 09/30/2011 | NA | NA |
| Draft RFI Report | Tetra Tech | 12/30/2011 | 04/24/2012 | Draft RFI Report | 04/24/2012 |
| Final RFI Report | Tetra Tech | 08/16/2012 | 09/07/2012 | Final RFI Report | 09/07/2012 |

## SAP Worksheet #17 -- Sampling Design and Rationale
(UFP-QAPP Manual Section 3.1.1)

This section describes sampling locations, methods, and rationale for the planned soil and groundwater sampling activities to be conducted in support of the field investigation at SWMU 25 - Highway 58 former Dump Site A located at NSA Crane, Indiana. This field plan was developed utilizing historical information from previous groundwater and IM investigations.

The design is a biased sampling design with soil and groundwater sampling locations selected to identify the presence of potentially unacceptable levels of Appendix IX metals and SVOCs (and low level PAHs) to delineate contamination in soil and groundwater if contamination is found, and to conduct baseline human health and ecological risk assessments to determine whether a corrective measures study (CMS) is required to evaluate corrective measures designed to prevent unacceptable exposure or whether additional sampling is necessary to complete the investigation. The sampling design and rationale will gather the necessary information to determine whether specific Appendix IX metals and SVOCs (including low level PAHs) associated with the debris placed into Dump Site A are present in soil and groundwater as a result of contaminants leaching from debris.

| | |
|---|---|
| Sample Locations: | See Figure 17-1. |
| Matrix and sample numbers: | Existing Monitoring Wells - Groundwater: 5 groundwater samples will be collected for laboratory analysis.<br>DPT - Soil: 33 soil samples will be collected from eleven boreholes and sent to the fixed based laboratory (FBL). |
| Field Parameters: | Measurement of field stabilization parameters is required for groundwater samples. No field parameters are required for soil samples. |
| Chemical Analyte Groups: | Groundwater: SVOCs (including low level PAHs) and Metals.<br>Soil: SVOCs (including low level PAHs) and Appendix IX Metals. |
| Analytical Method/SOPs: | See Worksheet #23. |
| Number of QC Samples: | See Worksheet #20. |
| Sample Dates: | See Worksheet #16. Field team mobilization will be scheduled within 45 days of state approval of this SAP. The soil and groundwater sampling activities will occur over eight days, followed by demobilization activities. |

**Soil Sampling Strategy**

The soil investigation will be conducted primarily to determine if any debris remains beneath or adjacent to the highway. Soil will be analyzed for contaminants that may be present as a result of the buried debris. The eleven proposed DPT soil sample locations were chosen to delineate the potential extension of fill from the larger area under Highway 58 (Figure 17-1). The soil samples locations are staggered along the north side berm of Highway 58 at 30 foot intervals and along the south side berm of Highway 58 at 60 foot intervals to determine whether remaining debris and contamination at the larger dump area exists beneath Highway 58.

Boring logs from the hydrogeological investigation indicate that the major soil type is a 2- to 3-inch-thick surface layer of brown to tan organic clay loam underlain by clay intermixed with silts and sand. Occasionally, a clay hardpan occurs between 25 and 32 inches below the surface (NEESA 1983). Surface soil samples will be collected from the 0 to 2 foot below ground surface (bgs) interval and subsurface samples will be collected from two intervals: 2 to 6 feet bgs and 6 to 10 feet bgs at each sampling location shown on Figure 17-1. All samples for fix-based laboratory will be prepared and analyzed according to the normal laboratory protocol as identified on Worksheet #30. All referenced field SOPs are presented in Appendix D.

The chosen sampling strategy employs a design to target the portion of the larger dump area most likely to contain remaining debris based on the CSMs presented in Worksheet #10. After reviewing the analytical results from the initial sampling, additional step-out samples may be collected to delineate contamination. The data collected under this conservative strategy is expected to represent concentrations to which human or ecological receptors would actually be exposed. The sampling strategy is designed to ensure that a potential unacceptable human health or ecological risk is not overlooked for the remaining debris material at the larger dump area. Details regarding soil sampling equipment and procedures are included in Worksheet #14 and the SOPs which are contained in Appendix D.

The total number of soil analyses for each analyte group are tabulated in Worksheet #18 and summarized in Worksheet #20. Soil QA/QC samples will be collected at the frequencies listed in Worksheet #20. Worksheet #19 presents a summary of the sample analyses, container types and volumes, preservation requirements, and holding times for the samples to be collected. In accordance with Worksheet #18, all samples will be analyzed for metals and SVOCs (including low level PAHs).

Sample boring locations are presented in a staggered line pattern in Figure 17-1 the east side berm of Highway 58 to cover the entire area suspected to contain the remaining debris.. The soil sampling

locations are identified as 25SB01, 25SB02 25SB03, 25SB04, 25SB05, 25SB06, 25SB07, 25SB08, 25SB09, 25SB10, and 25SB11.

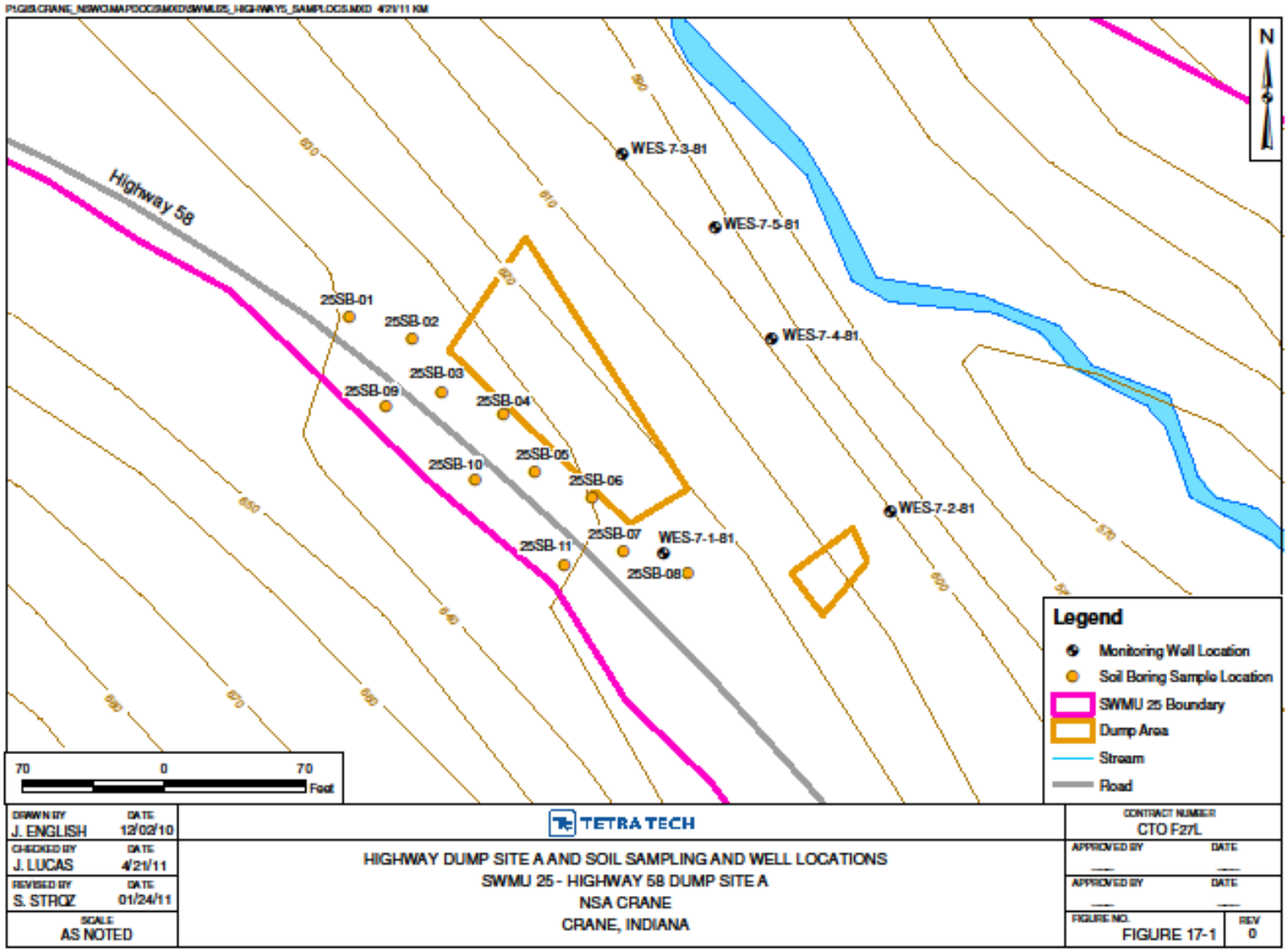
**Groundwater Sampling Strategy**

Monitoring wells at SWMU 25 are set in the groundwater in fractures of sedimentary rocks. The wells should will be re-developed and allowed to recharge. Re-development and purge water will be drummed and disposal will be based on the fixed-based laboratory results.

The chosen sampling groundwater strategy includes collection of samples from existing monitoring wells. The wells are all located downgradient of the former Dump Site A. The data collected under this conservative strategy are expected to represent concentrations to which human receptors would actually be exposed. Ecological receptors are not expected to be exposed to groundwater. The strategy, therefore, ensures that a potential unacceptable human health risk is not overlooked. Details regarding groundwater sampling equipment and procedures are included in Worksheet #14 and the SOPs contained in Appendix D.

The total number of groundwater analyses for each analyte group are tabulated in Worksheet #18 and summarized in Worksheet #20. Groundwater QA/QC samples will be collected at the frequencies listed in Worksheet #20. Worksheet #19 presents a summary of the sample analyses, container types and volumes, preservation requirements, and holding times for the samples to be collected.

Five groundwater samples are proposed for submittal to the fixed-base laboratory for analysis of Appendix IX metals and SVOCs as presented in Worksheet #18. All samples selected for fixed-base laboratory analyses will be prepared and analyzed according to the normal laboratory protocol as identified in Worksheet #30. All proposed groundwater sample at SWMU 25 will be collected in accordance with SOP-14 **(**Appendix D).


N
Highway 58
WES-7-3-81
WES-7-5-81
WES-7-4-81
WES-7-2-81
WES-7-1-81
25SB-01
25SB-02
25SB-03
25SB-04
25SB-05
25SB-06
25SB-07
25SB-08
25SB-09
25SB-10
25SB-11
Legend
Monitoring Well Location
Soil Boring Sample Location
SWMU 25 Boundary
Dump Area
Stream
Road
70 0 70
Feet
DRAWN BY J. ENGLISH DATE 12/02/10
CHECKED BY J. LUCAS DATE 4/21/11
REVISED BY S. STROZ DATE 01/24/11
SCALE AS NOTED
TETRA TECH
HIGHWAY DUMP SITE A AND SOIL SAMPLING AND WELL LOCATIONS
SWMU 25 - HIGHWAY 58 DUMP SITE A
NSA CRANE
CRANE, INDIANA
CONTRACT NUMBER CTO F27L
APPROVED BY DATE
APPROVED BY DATE
FIGURE NO. FIGURE 17-1
REV 0

## SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table
(UFP-QAPP Manual Section 3.1.1)

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| Sampling Location | ID Number | Matrix | Depth (feet bgs) | Analytical Group | Number of Samples (identify field duplicates) | Sampling SOP Reference[1] |
|---|---|---|---|---|---|---|
| **Soil Locations** | | | | | | |
| Soil Location 25SB01 | 25SS010002 and 25SS-DUP-01[2] | Soil | 0 - 2 | Metals | 1 + 1 FD | SOP-07, SOP-08 |
| | | | | SVOCs | 1 + 1 FD | |
| | 25SB010206 and 25SB-DUP-01[2] | Soil | 2 - 6 | Metals | 1 + 1 FD | |
| | | | | SVOCs | 1 + 1 FD | |
| | 25SB010610 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB02 | 25SS020002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SB020206 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SS020610 | Soil | 6 – 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB03 | 25SS030002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SB030206 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SB030610 | Soil | 6 – 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB04 | 25SS040002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SB040206 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SB040610 | Soil | 6 – 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB05 | 25SS050002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SB050206 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SB050610 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |

| Sampling Location | ID Number | Matrix | Depth (feet bgs) | Analytical Group | Number of Samples (identify field duplicates) | Sampling SOP Reference[1] |
|---|---|---|---|---|---|---|
| Soil Location 25SB06 | 25SS060002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SB060206 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SB060610 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB07 | 25SS070002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SB070206 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SB070610 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB08 | 25SS080002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SB080206 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SB080610 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB09 | 25SS090002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SS090002 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SS090002 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB10 | 25SS100002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SS100002 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SS100002 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| Soil Location 25SB11 | 25SS110002 | Soil | 0 - 2 | Metals | 1 | SOP-07, SOP-08 |
| | | | | SVOCs | 1 | |
| | 25SS110002 | Soil | 2 - 6 | Metals | 1 | |
| | | | | SVOCs | 1 | |
| | 25SS110002 | Soil | 6 - 10 | Metals | 1 | |
| | | | | SVOCs | 1 | |

| Sampling Location | ID Number | Matrix | Depth (feet bgs) | Analytical Group | Number of Samples (identify field duplicates) | Sampling SOP Reference[1] |
|---|---|---|---|---|---|---|
| **Groundwater Locations** | | | | | | |
| Groundwater GW7181 | 25GW718101) | Groundwater | Water Depth | Metals | 1 | SOP-10, SOP-13, and SOP-14 |
| | | | | SVOCs | 1 | |
| Groundwater GW7281 | 25GW728101 | Groundwater | Water Depth | Metals | 1 | SOP-10, SOP-13, and SOP-14 |
| | | | | SVOCs | 1 | |
| Groundwater GW7381 | 25GW738101 | Groundwater | Water Depth | Metals | 1 | SOP-10, SOP-13, and SOP-14 |
| | | | | SVOCs | 1 | |
| Groundwater GW7481 | 25GW748101 | Groundwater | Water Depth | Metals | 1 | SOP-10, SOP-13, and SOP-14 |
| | | | | SVOCs | 1 | |
| Groundwater GW7581 | 25GW-58101 and 25GW-DUP-01[2] | Groundwater | Water Depth | Metals | 1+ 1 FD | SOP-10, SOP-13, and SOP-14 |
| | | | | SVOCs | 1+ 1 FD | |

1 SOP or worksheet that describes the sample collection procedures (Worksheet #21). SOPs are in Appendix D.
2 Field duplicate locations may change in the field based on visual and olfactory observations and PID readings, “XXXXXX” represents date collected.

## SAP Worksheet #19 -- Analytical SOP Requirements Table
(UFP-QAPP Manual Section 3.1.1)

| **Matrix** | **Analytical Group** | **Analytical and Preparation Method / SOP Reference[1]** | **Containers** (number, size, and type) | **Sample Volume** (units) | **Preservation Requirements** (chemical, temperature, light protected) | **Maximum Holding Time** (preparation / analysis) |
|---|---|---|---|---|---|---|
| Soil | SVOCs (including Low Level PAHs) | SW-846 3550B/8270D (and 8270D SIM)<br>RTI SOP-3550B_031010_R6.1, 8270D_092310_R11 | One 4-ounce (oz) amber glass jar | 30 grams | Light protected, Cool to ≤ 6 °C | 14 days until extraction, 40 days to analysis |
| Groundwater and aqueous QC samples | SVOCs (including Low Level PAHs) | SW-846 3510C/8270D (and 8270D SIM)<br>RTI SOP-3510C_110909_R7, 8270D_092310_R11 | Two 1 - liter (L) glass amber bottles | 1,000 milliliter | Light protected, Cool to ≤ 6 °C | 7 days until extraction, 40 days to analysis |
| Soil | Metals (including Mercury) | SW-846 3050B/ 6020A, 7471B<br>RTI SOP-3050_091410_R9, 6020_072810_R8, 7470A_7471B_092310_R6 | One 4-oz glass jar | 1 to 2 grams/ 0.3 grams for mercury | Cool to ≤ 6 °C | 180 days to analysis except mercury, 28 days for mercury |
| Groundwater and aqueous QC samples | Metals (Total and Dissolved) (including Mercury) | SW-846 3020B/ 6020A, 7470A<br>RTI SOP-3020A_091510_R10, 6020_072810_R8, 7470A_7471B_092310_R6 | 1 – 1L high density polyethylene (HDPE) bottle (1 for total, 1 for dissolved if necessary) | 50 milliliter / 30 milliliter for mercury | Nitric acid to pH <2; Cool to ≤ 6 °C | 180 days to analysis except mercury, 28 days for mercury |

## SAP Worksheet #20 -- Field Quality Control Sample Summary Table
(UFP-QAPP Manual Section 3.1.1)

| Matrix | Analytical Group | No. of Sampling Locations[1] | No. of Field Duplicates | No. of MS/MSDs[2] | No. of Field Blanks | No. of Equip. Blanks | No. of Trip Blanks | Total No. of Samples to Lab |
|---|---|---|---|---|---|---|---|---|
| Surface Soil | Metals | 8 | 1 | 1/1 | 0 | 1 | 0 | 10 |
| Subsurface Soil | Metals | 16 | 1 | 1/1 | 0 | 1 | 0 | 18 |
| Surface Soil | SVOCs | 8 | 1 | 1/1 | 0 | 1 | 0 | 10 |
| Subsurface Soil | SVOCs | 16 | 1 | 1/1 | 0 | 1 | 0 | 18 |
| Groundwater | Total Metals | 5 | 1 | 1/1 | 0 | 1 | 0 | 7 |
| Groundwater | Dissolved Metals | 0 minimum; 5 maximum | 1 | 1/1 | 0 | 1* | 0 | 0 minimum; 7 maximum |
| Groundwater | SVOCs | 5 | 1 | 1/1 | 0 | 1 | 0 | 7 |

1 Samples collected at different depths at the same location are counted as separate sampling locations.
2 Although the MS/MSD is not typically considered a field QC, it is included here because location determination is often established in the field.
* - The equipment blank for the Dissolved Metals, if collected, will be obtained by passing rinse water through a 0.45-micron filter.

## SAP Worksheet #21 -- Project Sampling SOP References Table
(UFP-QAPP Manual Section 3.1.2)

| Reference Number | Title, Revision Date and / or Number | Originating Organization of Sampling SOP | Equipment Type | Modified for Project Work? (Y/N) | Comments |
|---|---|---|---|---|---|
| SOP-01 | Sample Labeling, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-02 | Sample Identification Nomenclature, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-03 | Sample Custody and Documentation of Field Activities, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-04 | Decontamination of Field Sampling Equipment, December 2010 | Tetra Tech | Decontamination equipment, scrub brushes, 5-gallon buckets, spray bottles, phosphate free detergent, deionized water | Y | Contained in Appendix D |
| SOP-05 | Borehole Advancement and Soil Coring for Soil Sampling Using Direct-Push Technology, December 2010 | Tetra Tech | DPT Rig | Y | Contained in Appendix D |
| SOP-06 | Management of Investigation-Derived Waste, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-07 | Borehole and Soil Sample Logging, December 2010 | Tetra Tech | Field logbook, sample log sheets, boring logs | Y | Contained in Appendix D |
| SOP-08 | Sample Preservation, Packaging, and Shipping, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-09 | Calibration and Care of Water Quality Meter, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-10 | Measurement of Water Levels in Monitoring Wells, December 2010 | Tetra Tech | Water Level Meter | Y | Contained in Appendix D |
| SOP-11 | Well Inspection, January 2011 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-12 | Monitoring Well Development, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-13 | Low-Flow Well Purging and Stabilization, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-14 | Groundwater Sampling, December 2010 | Tetra Tech | NA | Y | Contained in Appendix D |
| SOP-15 | Global Positioning, December 2010 | Tetra Tech | GPS unit | Y | Contained in Appendix D |

## SAP Worksheet #22 -- Field Equipment Calibration, Maintenance, Testing, and Inspection Table
(UFP-QAPP Manual Section 3.1.2.4)

| Field Equipment | Activity[1] | Frequency | Acceptance Criteria | Corrective Action | Resp. Person | SOP Reference[2] | Comments |
|---|---|---|---|---|---|---|---|
| PID | Calibration and Visual Inspection | Daily | Manufacturer's guidance. | Replace | Tetra Tech FOL or designee | Manufacturer's guidance | To be used to determine the subsurface soil depth that is most impacted for biased sample collection. |
| GPS | Positioning | Beginning and end of each day used | Accuracy: sub-meter horizontal dilution of precision (HDOP) <3, number of satellites at least six. | Wait for better signal, replace unit, or choose alternate location technique | Tetra Tech FOL or designee | SOP-15 | SOP located in Appendix D |
| DPT Rig | Inspection | Daily | Equipment inspection sheet criteria. | Replace | Tetra Tech FOL or designee | SOP-05 | SOP located in Appendix D. |
| Disposable Hand Trowel | Inspection | Per use | NA. | Replace | Tetra Tech FOL or designee | SOP-06 | SOP located in Appendix D. |
| Multi-Parameter Water Quality Meter | Visual Inspection, Calibration | Daily | Manufacturer's guidance. | Replace | Tetra Tech FOL or designee | SOP-09 | SOP located in Appendix D. |
| Turbidity Meter | Visual Inspection, Calibration | Daily | Manufacturer's guidance; Calibrations must bracket expected values.<br>Initial Calibration Verification (ICV) must be <10 Nephelometric Turbidity Units (NTUs). | Replace | Tetra Tech FOL or designee | SOP-10 | SOP located in Appendix D |

1 Activities may include: calibration, verification, testing, and maintenance.
2 Specify the appropriate reference letter or number from the Project Sampling SOP References table (Worksheet #21).

## SAP Worksheet #23 -- Analytical SOP References Table
(UFP-QAPP Manual Section 3.2.1)

| Laboratory SOP Number* | Title, Revision Date, and / or Number | Definitive or Screening Data | Matrix and Analytical Group | Instrument | Organization Performing Analysis | Modified for Project Work? (Y/N) |
|---|---|---|---|---|---|---|
| 8270D_092310_R11 | Analysis of Semivolatile Organic Compounds Revision 11, 09/23/10 | Definitive | Soil, groundwater, and aqueous QC samples/ SVOCs | Gas Chromatography/ Mass Spectrometery (GC/MS) | RTI | N |
| 6020_072810_R8 | Analysis of Elements by Inductively Coupled Plasma-Mass Spectrometry Revision 8, 07/28/10 | Definitive | Soil, groundwater, and aqueous QC samples/ Metals | Inductively Coupled Plasma-Mass Spectrometry (ICP/MS) | RTI | N |
| 7470A_7471B_092310_R6 | Analysis for Mercury Revision 6, 09/23/10 | Definitive | Soil, groundwater, and aqueous QC samples/ Mercury | Cold Vapor Atomic Absorption (CVAA) | RTI | N |
| 3020A_091510_R10 | Acid Digestion of Aqueous Samples for the Analysis of Total Metals Revision 10, 09/15/10 | Definitive | Groundwater and aqueous QC samples/ Metals digestion | NA/Digestion | RTI | N |
| 3050_091510_R10 | Acid Digestion of Solid Samples for the Analysis of Total Metals Revision 10, 09/15/10 | Definitive | Soil samples/ Metals digestion | NA/Digestion | RTI | N |
| 3550B_031010_R6.1 | Sonication Extraction Procedure for Semivolatile Organics Revision 6.1, 03/10/10 | Definitive | Soil samples/ SVOC extraction | NA/Extraction | RTI | N |
| 3510C_110909_R7 | Liquid-Liquid Extraction Procedure for Semivolatile Organics Revision 7, 11/09/09 | Definitive | Groundwater and aqueous QC samples/ SVOC extraction | NA/Extraction | RTI | N |

Copies of laboratory SOPs listed are included in Appendix C.

## SAP Worksheet #24 -- Analytical Instrument Calibration Table
(UFP-QAPP Manual Section 3.2.2)

| Instrument | Calibration Procedure | Frequency of Calibration | Acceptance Criteria | Corrective Action (CA) | Person Responsible for CA | SOP Reference |
|---|---|---|---|---|---|---|
| GC/MS SVOCs (including Low Level PAHs) | Breakdown Check (DDT only) | At the beginning of each 12-hour analytical sequence. | The degradation must be ≤ 20% for DDT to verify inertness of the injection port. | Correct the problem then repeat breakdown check. No samples shall be run until degradation is ≤20% for DDT. | Analyst/ Supervisor | RTI SOP 8270D_092310_R11 |
| | Tune Verification – decafluoro-triphenyl-phosphine (DFTPP). | Prior to each ICAL and at the beginning of each 12-hour analytical sequence. | Must meet the ion abundance criteria required by the method (SW-846 8270D; Table 3), DDT degradation must be ≤20%. | Retune and/or clean or replace source. No samples may be accepted without a valid tune. | Analyst/ Supervisor | |
| | Initial Calibration (ICAL) – a minimum of a five-point calibration is prepared for all target analytes. | Upon instrument receipt, for major instrument changes, or when continuing calibration verification (CCV) does not meet criteria. | All ICAL compounds must pass using one of three types of criteria: The percent relative standard deviation (RSD) for average response factor (RF) must be less than 20%, or a linear regression model where the linear regression correlation coefficient (r) must be ≥0.99, or a non-linear (quadratic) regression, which must include 6 data points (minimum of 3 statistical degrees of freedom) and must have a non-linear coefficient of determination ($r^2$) ≥0.99.<br><br>The minimum average RF for the System Performance Check Compounds (SPCC) are set by the method (see Section 8.7.3). For compounds that exceed 20% RSD, the linear regression function of the data system will be used for analyte quantification provided r is ≥0.99. | Correct problem then repeat ICAL. Samples cannot be analyzed until ICAL has passed. | Analyst/ Supervisor | |
| | Retention Time (RT) Window Position Establishment | Once per ICAL for each analyte and surrogate. | Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used. | None | Analyst / Supervisor | |

| Instrument | Calibration Procedure | Frequency of Calibration | Acceptance Criteria | Corrective Action (CA) | Person Responsible for CA | SOP Reference |
|---|---|---|---|---|---|---|
| | Evaluation of Relative Retention Times (RRTs) | With each sample. | RRT of each target analyte must be within ± 0.06 RRT units. | Correct problem, then rerun ICAL. | Analyst / Supervisor | |
| | Initial Calibration Verification (ICV) – Second Source | Once after each ICAL, prior to beginning a sample run. | The percent recovery (%R) for all target analytes must be within 75-125% of the true value. | Correct problem and verify ICV. If that fails, correct problem and repeat ICAL. Samples cannot be analyzed until the ICV has been verified. | Analyst/ Supervisor | |
| | CCV | Perform one per 12-hour analysis period after tune and before sample analysis. | Percent difference or drift (%D) must be ≤ 20% for all project compounds.<br><br>SPCCs RFs must be >0.050. | Correct problem and rerun CCV. If that fails, repeat ICAL and reanalyze all samples analyzed since the last successful CCV. | Analyst/ Supervisor | |
| ICP-MS Metals | Tune | Daily prior to calibration. | Mass calibration must be within 0.1 atomic mass unit (amu) from the true value. Resolution must be <0.9 amu full width at 10% peak height. For stability, on five replicate injections - %RSD must be ≤5%. | Perform necessary equipment maintenance. | Analyst/ Supervisor | RTI SOP 6020_072810_R8 |
| | ICAL - a 1-point calibration per manufacturer's guidelines is prepared for all target analytes | At the beginning of each day, or if the QC is out of criteria, prior to sample analysis. | None; only one high standard and a calibration blank must be analyzed. If more than one calibration standard is used, r must be ≥ 0.995. | Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data. | Analyst/ Supervisor | |
| | ICV – Second Source | Following ICAL, prior to the analysis of samples. | The %R of all target analytes must be within 90-110% of the true value. | Investigate reasons for failure, reanalyze once. If still unacceptable, correct problem and repeat ICAL. | Analyst/ Supervisor | |
| | CCV | At the beginning and end of the sequence and after every 10 samples. | The %R of all target analytes must be within 90-110% of the true value. | Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze all affected samples. | Analyst/ Supervisor | |
| | Initial Calibration Blank (ICB) | Before beginning a sample sequence. | No analytes detected > LOD. | Correct the problem, then reprepare and reanalyze. | Analyst / Supervisor | |

| Instrument | Calibration Procedure | Frequency of Calibration | Acceptance Criteria | Corrective Action (CA) | Person Responsible for CA | SOP Reference |
|---|---|---|---|---|---|---|
| | Continuing Calibration Blank (CCB) | After the initial CCV, after every 10 samples, and at the end of the sequence. | No analytes detected > LOD. | Correct the problem, then reprepare and reanalyze calibration blank and all affected samples. | Analyst / Supervisor | |
| | Low-Level Check Standard (if using one-point ICAL) | Daily after 1-point ICAL and before samples. | The %R of all target analytes must be within 80-120% of the true value. | Investigate and perform necessary equipment maintenance. Recalibrate and reanalyze all affected samples. | Analyst / Supervisor | |
| | Interference Check Standards (ICS – ICS A and ICS B) | At the beginning of an analytical run. | ICS A %Rs must be within the absolute value of the LOD; and ICS B %Rs must be within 80-120 % of the true value. | Terminate analysis; locate and correct problem; reanalyze ICS. | Analyst / Supervisor | |
| CVAA Mercury | ICAL - 5 points plus a calibration blank. | Upon instrument receipt, major instrument change, at the start of each day. | r must be ≥ 0.995. | Recalibrate and/or perform necessary equipment maintenance. Check calibration standards. | Analyst / Supervisor | RTI SOP 7470A_7471B_092310_R6 |
| | ICV (Second Source) | Once after each ICAL, prior to beginning a sample run. | %R of mercury must be within 90-110% of the true value. | Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL. | Analyst / Supervisor | |
| | Calibration Blank | Before beginning a sample sequence, after every 10 samples and at end of the analysis sequence. | No mercury detected > LOD. For negative blank results, absolute value must be < LOD. | Correct problem. Re-prepare and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed. | Analyst / Supervisor | |
| | CCV | Beginning and end of each run sequence and every 10 samples. | %R of mercury must be within 80-120% of the true value. | Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification. | Analyst / Supervisor | |

## SAP Worksheet #25 -- Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table
(UFP-QAPP Manual Section 3.2.3)

| Instrument/ Equipment | Maintenance Activity | Testing Activity | Inspection Activity | Frequency | Acceptance Criteria | CA | Responsible Person | SOP Reference(1) |
|---|---|---|---|---|---|---|---|---|
| GC/MS | Check pressure and gas supply daily. Manual tune if DFTPP not in criteria, change septa as needed, change liner as needed, cut column as needed. Other maintenance specified in Equipment Maintenance section of SOP. | SVOCs (including Low Level PAHs) | Ion source, injector liner, column, column flow. | Prior to ICAL and/or as necessary. | Acceptable ICAL or CCV | Correct the problem and repeat ICAL or CCV. Recalibrate or stop for service on repeat failure. | Analyst, Department Manager | RTI SOP 8270D_092310_R11 |
| ICP-MS | Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, and replace peristaltic pump tubing as needed. Other maintenance specified in Equipment Maintenance section of SOP. | Metals | Torch, nebulizer, spray chamber, pump tubing. | Prior to ICAL and as necessary | Acceptable ICAL or CCV | Correct the problem and repeat ICAL or CCV. Recalibrate or stop for service on repeat failure | Analyst, Department Manager | RTI SOP 6020_072810_R8 |
| CVAA | Replace peristaltic pump tubing, replace mercury lamp, replace drying tube, clean optical cell and/or clean liquid/gas separator as needed. Other maintenance specified in Equipment Maintenance section of SOP. | Mercury | Tubing, sample probe, optical cell. | Prior to ICAL and as necessary | Acceptable ICAL or CCV | Correct the problem and repeat ICAL or CCV. Recalibrate or stop for service on repeat failure | Analyst, Department Manager | RTI SOP 7470A_7471B_092310_R6 |

1 Laboratory SOPs are provided in Appendix C.

## SAP Worksheet #26 -- Sample Handling System
## (UFP-QAPP Manual Appendix A)

| SAMPLE HANDLING SYSTEM |
|---|
| **SAMPLE COLLECTION, PACKAGING, AND SHIPMENT** |
| Sample Collection (Personnel/Organization): FOL, Tetra Tech |
| Sample Packaging (Personnel/Organization): FOL, Tetra Tech |
| Coordination of Shipment (Personnel/Organization): FOL, Tetra Tech |
| Type of Shipment/Carrier: Overnight courier service (FedEx) |
| **SAMPLE RECEIPT AND ANALYSIS** |
| Sample Receipt (Personnel/Organization): RTI Sample custodians |
| Sample Custody and Storage (Personnel/Organization): RTI Sample custodians |
| Sample Preparation (Personnel/Organization): RTI Extraction and metals preparation laboratory analysts |
| Sample Determinative Analysis (Personnel/Organization):GC/MS, ICP-MS, mercury laboratory analysts |
| **SAMPLE ARCHIVING** |
| Field Sample Storage (No. of days from sample collection): 60 days. |
| Sample Extract/Digestate Storage (No. of days from extraction/digestion): 60 days |
| Biological Sample Storage (No. of days from sample collection): Not applicable |
| **SAMPLE DISPOSAL** |
| Personnel/Organization: RTI Sample Custodians |

## SAP Worksheet #27 – Sample Custody Requirements Table
(UFP-QAPP Manual Section 3.3.3)

**Field Sample Custody Procedures**

The laboratories will provide pre-preserved sample containers for sample collection. Following sample collection into the appropriate bottle ware, all samples will be immediately placed on ice in a cooler. Glass sample containers will be enclosed in bubble-wrap in order to protect the bottle ware during shipment. The cooler will be secured using strapping tape along with a signed custody seal. Sample coolers will be delivered to a local courier location for priority overnight delivery to the selected laboratory for analysis. Samples will be preserved as appropriate based on the analytical method. Samples will be maintained at <6 °C until delivery to the laboratory. Proper custody procedures will be followed throughout sample collection and handling.

Chain-of-custody protocols will be used throughout sample handling to establish the evidentiary integrity of samples. These protocols will be used to demonstrate that the samples were handled and transferred in a manner that would eliminate possible tampering. Samples for the laboratory will be packaged and shipped in accordance with Tetra Tech SOP-08 (Appendix D).

**Chain-of-Custody Procedures**

After collection, each sample will be maintained in the sampler's custody until formally transferred to another party (e.g., Federal Express). For all samples collected, chain-of-custody forms will document the date and time of sample collection, the sampler's name, and the names of all others who subsequently held custody of the sample. Specifications for chemical analyses will also be documented on the chain-of-custody form. Tetra Tech SOP-03 provides further details on the chain-of-custody procedure (Appendix D). Chain-of-custody requirements are also documented with instructions contained in each shipment from the laboratory.

**Sample Designation System**

Each sample collected for analysis will be assigned a unique sample tracking number that will consist of a multi-segment alphanumeric code that identifies the site, sample location, sample type (sample medium or QC sample designation), sample location, and sample depth. SOP-02 addresses sample identification nomenclature (Appendix D).

**Sample Location**

Each soil sampling location will be assigned a two digit consecutive number in the order of installation. Groundwater sampling locations are assigned a four digit number based on their initial well identification. All sample locations are identified in Worksheet #18.

**QC Sample Number**

All QC samples will be assigned a sequential sample number. The FD, MS, and MSD/sample duplicate samples will be collected from the same station. For example, the first equipment rinsate blank will be assigned the tracking number 25RB-01.

The FD will be given the same type of sample designation as the samples so that it will be “blind” to the laboratory. The sampling time recorded on the chain-of-custody form, labels and tags for the duplicate samples will be 0000. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory).

All pertinent information regarding sample identification will be recorded in the field logbooks and on sample log sheets where appropriate.

**Laboratory Custody Procedures**

The analytical laboratory’s sample receipt and chain-of-custody procedure are detailed in RTI’s SOP SRC001-A_R5 (see Appendix C). The laboratory sample custodian will inspect the integrity of each cooler’s custody seals and measure the temperature of the samples received using the temperature blank container included in each cooler. The samples will be checked against the chain-of-custody form for holding times, sample identification, and integrity. The samples will be logged into the laboratory management system. Custody of the samples will be maintained and recorded in the laboratory, from receipt to analysis, and this record will be included with the data package deliverables.

## SAP Worksheet #28 -- Laboratory QC Samples Table
(UFP-QAPP Manual Section 3.4)

| | |
|---|---|
| **Matrix** | Soil, groundwater, and aqueous QC samples |
| **Analytical Group** | SVOCs (including Low Level PAHs) |
| **Analytical Method/ SOP Reference** | SW-846 8270D (and SIM)/ RTI SOP-8270D_092310_R11 |

| QC Sample | Frequency/ Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | Data Quality Indicator (DQI) | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| Method Blank | One per batch of 20 or less samples. | No target analytes ≥ ½ the LOQ. | Correct problem, then see criteria in DoD Quality Systems Manual (QSM) 4.1, Box D-1. If required, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. | Laboratory Analyst, Supervisor, Data Validator | Bias/ Contamination | Same as QC Acceptance Limits. |
| Laboratory Control Spike (LCS) | One per batch of 20 or less samples. | %Rs must meet the DoD QSM Version 4.1 limits per Appendix G of the DoD QSM. | Correct problem, re-prepare and re-analyze affected samples. | Laboratory Analyst, Supervisor, Data Validator | Accuracy/Bias | Same as QC Acceptance Limits. |
| Matrix Spike (MS) | One per batch of 20 or less samples. | %Rs should meet the DoD QSM Version 4.1 limits as per Appendix G of the DoD QSM. | Investigate, consult with client, and record matrix issues in case narrative. | Laboratory Analyst, Supervisor, Data Validator | Accuracy / Bias | Same as QC Acceptance Limits. |
| Matrix Spike Duplicate (MSD) | One per batch of 20 or less samples. | The RPD between MS and MSD should be ≤ 30%. | Investigate and record in case narrative. | Laboratory Analyst, Supervisor, Data Validator | Precision/ Accuracy/ Bias | Same as QC Acceptance Limits. |
| Surrogates | All field and QC samples<br>Six per sample:<br>2-Fluorophenol<br>Phenol-d6<br>Nitrobenzene-d5<br>2-Fluorobiphenyl<br>2,4,6-Tribromophenol<br>Terphenyl-d14 | %Rs must meet the DoD QSM Version 4.1 limits as per Appendix G of the DoD QSM. | Evaluate for matrix interference. Re-prepare and re-analyze samples. | Laboratory Analyst, Supervisor, Data Validator | Accuracy/ Bias | Same as QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Soil, groundwater, and aqueous QC samples |
| **Analytical Group** | SVOCs (including Low Level PAHs) |
| **Analytical Method/ SOP Reference** | SW-846 8270D (and SIM)/ RTI SOP-8270D_092310_R11 |

| QC Sample | Frequency/ Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | Data Quality Indicator (DQI) | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| Internal Standards (IS) | Every field sample, standard, and QC sample.<br>Six per sample – 1,4-Dichlorobenzene-d4<br>Naphthalene-d8<br>Acenaphthene-d10<br>Phenanthrene-d10<br>Chrysene-d12<br>Perylene-d12 | RTs must be within ± 30 seconds and the response areas must be within -50% to +100% of the ICAL midpoint standard for each IS. | Re-analyze to confirm matrix interference with IS. | Laboratory Analyst, Supervisor, Data Validator | Accuracy/ Bias | Same as QC Acceptance Limits. |
| Results between DL and LOQ | NA | Apply “J” qualifier to results detected between DL and LOQ. | NA. | Analyst, Supervisor, Data Validator | Accuracy | Same as QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Soil, groundwater, and aqueous QC samples |
| **Analytical Group** | Metals (Including Mercury) |
| **Analytical Method/SOP Reference** | SW-846 6020A, 7470A, 7471B/ 6020_072810_R8, 7470A_7471B_092310 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | Data Quality Indicator (DQI) | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| Method Blank | One per batch of 20 or less samples. | No analytes detected ≥ ½ the LOQ. | Correct problem, then see criteria in DoD QSM 4.2, Box D-1. If required, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. | Analyst, Supervisor, Data Validator | Bias / Contamination | Same as QC Acceptance Limits. |
| LCS | One per batch of 20 or less samples. | %R must be within 80-120% of true value. | Correct problem, re-prepare and re-analyze affected samples. | Analyst, Supervisor, Data Validator | Accuracy / Bias | Same as QC Acceptance Limits. |
| Laboratory Duplicate (not applicable for rinsate blanks) | One sample duplicate is performed for each batch of 20 samples of the same matrix. | The RPD should be within ≤20% for duplicate samples for both water and soils. | Flag results for affected analytes for all associated samples. | Analyst, Supervisor, Data Validator | Precision | Same as QC Acceptance Limits. |
| MS (not applicable for rinsate blanks) | One per batch of 20 or less samples. | The %R should be within 80-120%, if sample < 4x spike added. | Investigate, consult with client and record matrix issues in case narrative | Analyst, Supervisor, Data Validator | Accuracy/Bias | Same as QC Acceptance Limits. |
| Serial Dilution (SD) (for ICP only, and not applicable for rinsate blanks) | One SD (5x) is performed for each batch of 20 samples of the same matrix for unacceptable MS/MSD results. | If original sample result is at least 50x LOQ, 5-fold dilution must agree within ± 10% of the original result. | Flag data as possible matrix interference. | Analyst, Supervisor, Data Validator | Accuracy/Bias | Same as QC Acceptance Limits. |
| Post-Digestion Spike (for ICP only, and not applicable for rinsate blanks) | Analyte concentration in samples < 50x LOD for unacceptable MS/MSD results. | %R must be within 75-125% of expected value to verify the absence of an interference. Spike addition should produce a concentration of 10-100x LOQ. | Flag data as possible matrix interference. | Analyst, Supervisor, Data Validator | Precision | Same as QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Soil, groundwater, and aqueous QC samples |
| **Analytical Group** | Metals (Including Mercury) |
| **Analytical Method/SOP Reference** | SW-846 6020A, 7470A, 7471B/ 6020_072810_R8, 7470A_7471B_092310 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | Data Quality Indicator (DQI) | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| IS (ICP-MS only) | Appropriate IS required for all analytes in all samples. Mass of IS must be <50 amu different from that of analyte. | For each sample, IS intensity must be 70-120% of that of initial calibration standard. | Reanalyze the sample at 5-fold dilution with addition of appropriate amounts of internal standards. | Analyst, Supervisor, Data Validator | Accuracy/Bias | Same as QC Acceptance Limits. |
| Results between DL and LOQ | NA | Apply “J” qualifier to results detected between DL and LOQ. | NA. | Analyst, Supervisor, Data Validator | Accuracy | Same as QC Acceptance Limits. |

## SAP Worksheet #29 -- Project Documents and Records Table
(UFP-QAPP Manual Section 3.5.1)

| DOCUMENT | LOCATION MAINTAINED |
|---|---|
| Sample Collection Documents and Records:<br>• Field logbook (and sampling notes)<br>• Field sample forms (e.g., boring logs, sample log sheets, drilling logs, etc.)<br>• Chain-of-custody records<br>• Sample shipment air bills<br>• Equipment calibration logs<br>• Photographs<br>• Field Task Modification Request forms<br>• SAP<br>• Field Sampling SOPs | Tetra Tech project file; results will be discussed in subject document |
| Laboratory Documents and Records in the form of analytical data package:<br>• Sample receipt/login form<br>• Equipment calibration logs<br>• Sample analysis run logs<br>• Reported results for standards, QC checks, and QC samples<br>• Data completeness checklists<br>• Raw data<br>• Electronic Data Deliverables (EDDs) | Tetra Tech project file; long-term data package storage at third-party commercial document storage firm. |
| Other Documents<br>• HASP<br>• All letter and e-mail correspondence with regulatory agencies, including approvals and comments<br>• Telephone logs<br>• Field investigation data packages<br>• All versions of project reports | Tetra Tech project file. |

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## SAP Worksheet #30 -- Analytical Services Table
(UFP-QAPP Manual Section 3.5.2.3)

| **Matrix** | **Analytical Group** | **Sample Locations/ ID Number** | **Analytical Method** | **Data Package Turnaround Time** | **Laboratory / Organization** (name and address, contact person and telephone number) | **Backup Laboratory / Organization** (name and address, contact person and telephone number) |
|---|---|---|---|---|---|---|
| Soil, Groundwater, and Aqueous QC samples | SVOCs | See Worksheet #18 | SW-846 8270D | 21 calendar days | Fred Hoitash<br>Project Manager<br><br>RTI Laboratories, Inc.<br>31627 Glendale Street<br>Livonia, MI 48150<br>734-422-8000<br>fhoitash@rtilab.com | None |
| | Low Level PAHs | | SW-846 8270D SIM | | | |
| | Metals (total) | | SW-846 6020A | | | |
| | Mercury | | SW-846 7470 (aqueous), 7471B (solid) | | | |
| Groundwater and Aqueous QC samples | Metals (Dissolved) | See Worksheet #18 | SW-846 6020A | 21 calendar days | | |

## SAP Worksheet #31 -- Planned Project Assessments Table
(UFP-QAPP Manual Section 4.1.1)

| **Assessment Type** | **Frequency** | **Internal or External** | **Organization Performing Assessment** | **Person(s) Responsible for Performing Assessment** (title and organizational affiliation) | **Person(s) Responsible for Responding to Assessment Findings** (title and organizational affiliation) | **Person(s) Responsible for Identifying and Implementing Corrective Actions** (title and organizational affiliation) | **Person(s) Responsible for Monitoring Effectiveness of Corrective Action** (title and organizational affiliation) |
|---|---|---|---|---|---|---|---|
| Laboratory System Audit(1) | Every two years | External | DoD ELAP Accrediting Body | DoD ELAP Accrediting Body Auditor | Laboratory QAM or Laboratory Manager, RTI | Laboratory QAM or Laboratory Manager, RTI | Laboratory QAM or Laboratory Manager, RTI |

1 RTI is DoD ELAP accredited. The DoD ELAP accreditation letter is included in Appendix C.

## SAP Worksheet #32 -- Assessment Findings and Corrective Action Responses
(UFP-QAPP Manual Section 4.1.2)

| **Assessment Type** | **Nature of Deficiencies Documentation** | **Individual(s) Notified of Findings** (name, title, organization) | **Timeframe of Notification** | **Nature of Corrective Action Response Documentation** | **Individual(s) Receiving Corrective Action Response** (name, title, organization) | **Timeframe for Response** |
|---|---|---|---|---|---|---|
| Laboratory System Audit | Written audit report | Charles Obrien, Laboratory QAM, RTI | Specified by DoD ELAP Accrediting Body | Letter | DoD ELAP Accrediting Body | Specified by DoD ELAP Accrediting Body |

## SAP Worksheet #33 -- QA Management Reports Table
(UFP QAPP Manual Section 4.2)

| **Type of Report** | **Frequency** (daily, weekly monthly, quarterly, annually, etc.) | **Projected Delivery Date(s)** | **Person(s) Responsible for Report Preparation** (title and organizational affiliation) | **Report Recipient(s)** (title and organizational affiliation) |
|---|---|---|---|---|
| Data validation report | Per Sample Delivery Group (SDG) | Within 3 weeks of receipt of laboratory data | DVM or designee, Tetra Tech | PM and project file, Tetra Tech |
| Major analysis problem identification (Internal Tetra Tech Memorandum) | When persistent analysis problems are detected by Tetra Tech that may impact data usability | Immediately upon detection of problem (on the same day) | Tetra Tech QAM | PM, CLEAN QAM, Program Manager, and project file, Tetra Tech |
| Project monthly progress report | Monthly for duration of the project | Monthly | PM, Tetra Tech | Navy RPM, Navy; CLEAN QAM, Program Manager, and project file, Tetra Tech |
| Laboratory QA Report | When significant plan deviations result from unanticipated circumstances | Immediately upon detection of problem (on the same day) | Laboratory PM, RTI | PM and project file, Tetra Tech |

## SAP Worksheet #34 -- Verification (Step I) Process Table
(UFP-QAPP Manual Section 5.2.1)

| Verification Input | Description | Internal / External | Responsible for Verification (name, organization) |
|---|---|---|---|
| Chain-of-Custody Forms | The Tetra Tech FOL or designee will review and sign the chain-of-custody form to verify that the samples listed are included in the shipment to the laboratory and that the sample information is accurate. The forms will be signed by the sampler, and a copy will be retained for the project file, Tetra Tech PM, and Tetra Tech Data Validators. | Internal | Sampler and FOL, Tetra Tech |
| | The Laboratory Sample Custodian will review the sample shipment for completeness and integrity and will sign accepting the shipment. The Tetra Tech Data Validators will check that the chain-of-custody form was signed and dated by the Tetra Tech FOL or designee relinquishing the samples and also by the Laboratory Sample Custodian receiving the samples for analyses. | Internal/ External | 1 - Laboratory Sample Custodian, RTI<br>2 - Data Validators, Tetra Tech |
| UFP-SAP Sample Tables/ Chain-of-Custody Forms | Verify that all proposed samples listed in the UFP-SAP tables have been collected. | Internal | FOL or designee, Tetra Tech |
| Sample Log Sheets | Verify that information recorded in the log sheets is accurate and complete. | Internal | FOL or designee, Tetra Tech |
| UFP-SAP/ Field Logs/ Analytical Data Packages | Ensure that all sampling SOPs were followed. Verify that deviations have been documented and MPCs have been achieved. Particular attention should be given to verify that samples were correctly identified, that sampling location coordinates are accurate, and that documentation establishes an unbroken trail of documented chain of custody from sample collection to report generation. Verify that the correct sampling and analytical methods/SOPs were applied. Verify that the sampling plan was implemented and carried out as written and that any deviations are documented. | Internal | PM or designee, Tetra Tech |
| UFP-SAP/ Analytical SOPs/ Analytical Data Packages | Ensure that all laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied. | Internal | Laboratory QAM, RTI |
| UFP-SAP/ Laboratory SOPs/ Raw Data/ Applicable Control Limits Tables | Establish that all method QC samples were analyzed and in control as listed in the analytical SOPs. If method QA is not in control, the Laboratory QAM will contact the Tetra Tech PM verbally or via e-mail for guidance prior to report preparation. | Internal | Laboratory QAM, RTI |
| UFP-SAP/ Chain-of-Custody Forms | Check that field QC samples listed in Worksheet #20 were collected as required. | Internal | FOL or designee, Tetra Tech |

| Verification Input | Description | Internal / External | Responsible for Verification (name, organization) |
|---|---|---|---|
| EDDs/Analytical Data Packages | Each EDD will be verified against the chain-of-custody form and hard copy data package for accuracy and completeness. Laboratory analytical results will be verified and compared to the electronic analytical results for accuracy. Sample results will be evaluated for laboratory contamination and will be qualified for false positives using the laboratory method/preparation blank summaries. Positive results reported between the DL and the LOQ will be qualified as estimated. Extraneous laboratory qualifiers will be removed from the validation qualifier. | External | Data Validators, Tetra Tech |
| Analytical Data Packages | All analytical data packages will be verified internally for completeness by the laboratory performing the work. The Laboratory QAM will sign the case narrative for each data package. | Internal | Laboratory QAM, RTI, CFA, and TA-Pitt |
| | Each data package will be verified for completeness by the Tetra Tech Data Validator. Missing information will be requested by the Tetra Tech Data Validator from the Laboratory PM. | External | Data Validators, Tetra Tech |

Notes: Verification includes field data verification and laboratory data verification. Verification inputs as per Worksheet #34 will be checked.

## SAP Worksheet #35 -- Validation (Steps IIa and IIb) Process Table

(UFP-QAPP Manual Section 5.2.2) (Figure 37 UFP-QAPP Manual) (Table 9 UFP-QAPP Manual)

| Step IIa / IIb | Validation Input | Description | Responsible for Validation (name, organization) |
|---|---|---|---|
| IIa | SAP/ Sample Log Sheets | Ensure that sample locations are correct and in accordance with the SAP proposed locations. Document any discrepancies in the final report. | PM, FOL, or designee, Tetra Tech |
| IIa | Chain-of-Custody Forms | Ensure that the custody and integrity of the samples was maintained from collection to analysis and the custody records are complete and any deviations are recorded. Review that the samples were shipped and store at the required temperature and sample pH for chemically-preserved samples meet the requirements listed in Worksheet #19. Ensure that the analyses were performed within the holding times listed in Worksheet #19. | Project Chemist or Data Validators, Tetra Tech |
| IIa/IIb | SAP/ Laboratory Data Packages/ EDDs | Ensure that the laboratory QC samples listed in Worksheet #28 were analyzed and that the MPCs listed in Worksheet #12 were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed and that the analytical QC criteria set up for this project were met. | Project Chemist or Data Validators, Tetra Tech |
| | | Check the field sampling precision by calculating the RPD for field duplicate samples. Check the laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses; MS/matrix spike duplicate (MSD) samples; and LCS/laboratory control sample duplicate (LCSD) samples, if available. | |
| | | Check that the laboratory recorded the temperature at sample receipt and the pH of chemically preserved samples to ensure sample integrity from sample collection to analysis. | |
| | | Review the chain-of-custody forms generated in the field to ensure that the required analytical samples have been collected, appropriate sample identifications have been used, and correct analytical methods have been applied. The Tetra Tech Data Validator will verify that elements of the data package required for validation are present, and if not, the laboratory will be contacted and the missing information will be requested. Validation will be performed as per Worksheet #36. | |

| Step IIa / IIb | Validation Input | Description | Responsible for Validation (name, organization) |
|---|---|---|---|
| IIb | SAP/ Laboratory Data Packages/ EDDs | Ensure that the LOQs listed in Worksheet #15 were achieved. | Project Chemist or Data Validators, Tetra Tech |
| | | Discuss the impact of matrix interferences or sample dilutions performed because of the high concentration of one or more other contaminants, on the other target compounds reported as non-detected. | |
| | | Summarize deviations from methods, procedures, or contracts in the Data Validation Report. If possible determine the impact of any deviation from sampling or analytical methods and SOPs requirements and matrix interferences effect on the analytical results. Qualify data results based on method or QC deviation and explain all the data qualifications. | |

## SAP Worksheet #36 –Analytical Data Validation (Steps IIa and IIb) Summary Table
(UFP-QAPP Manual Section 5.2.2.1)

| Step IIa / IIb | Matrix | Analytical Group | Validation Criteria | Data Validator (title and organizational affiliation) |
|---|---|---|---|---|
| IIa and IIb | Soil, Groundwater, and Aqueous Field QC Samples | SVOCs (including Low Level PAHs) | A full data validation will be performed using criteria for SW-846 Methods 8270D and 8270D SIM listed in Worksheets #12, #15, #24, and #28 will be used. If not included in the aforementioned, then the logic outlined in the USEPA CLP "National Functional Guidelines for Organic Data Review" EPA-540/R-99-008 (October 1999) will be used to apply qualifiers to data. | Data Validation Specialist, Tetra Tech |
| IIa and IIb | Soil, Groundwater, and Aqueous Field QC Samples | Total and Dissolved Metals (Including Mercury) | A full data validation will be performed using criteria for SW-846 Methods 6020A, 7470A, and 7471B listed in Worksheets #12, #15, #24, and #28 will be used. If not included in the aforementioned, then the logic outlined in USEPA CLP "National Functional Guidelines for Inorganic Data Review" EPA 540-R-04-004 (October 2004) will be used to apply qualifiers to data. | Data Validation Specialist, Tetra Tech |

## SAP Worksheet #37 -- Usability Assessment
## (UFP-QAPP Manual Section 5.2.3)

**Data Usability Assessment**

The usability of the data directly affects whether project objectives can be achieved. The following characteristics will be evaluated at a minimum. The results of these evaluations will be included in the project report. The characteristics will be evaluated for multiple concentration levels if the assessors determine that this is necessary. To the extent required by the type of data being reviewed, the assessors will consult with other technically competent individuals to render sound technical assessments of these DQI characteristics:

**Completeness**

- For each matrix that was scheduled to be sampled, the Tetra Tech FOL (or other person designated by the Tetra Tech PM) acting on behalf of the Project Team will prepare a table listing planned samples/analyses compared to collected samples/analyses. If deviations from the scheduled sample collection or analyses are identified the Tetra Tech PM and Project Risk Assessor will determine whether the deviations compromise the ability to meet project objectives. If they do, the Tetra Tech PM will consult with the Navy RPM and other Project Team members, as necessary (determined by the Navy RPM), to develop appropriate corrective actions.

**Precision**

- The Tetra Tech Project Chemist acting on behalf of the Project Team will determine whether precision goals for field duplicates and laboratory duplicates were met. This will be accomplished by comparing duplicate results to precision goals identified in Worksheets #12 and #28. This will also include a comparison of field and laboratory precision with the expectation that laboratory duplicate results will be no less precise than field duplicate results. If the goals are not met, or data have been flagged as estimated (J qualifier), limitations on the use of the data will be described in the project report.

**Accuracy**

- The Tetra Tech Project Chemist acting on behalf of the project team will determine whether the accuracy/bias goals were met for project data. This will be accomplished by comparing percent recoveries of LCS, LCSD, MS, MSD, and surrogate compounds to accuracy goals identified in Worksheet #28. This assessment will include an evaluation of field and laboratory contamination; instrument calibration variability; and analyte recoveries for surrogates, matrix spike, and laboratory control samples. If the goals are not met, limitations on the use of the data will be described in the project report. Bias of the qualified results and a description of the impact of identified non-compliances on a specific data package or on the overall project data will be described in the project report.

**Representativeness**

- A Project Scientist identified by the Tetra Tech PM and acting on behalf of the Project Team will determine whether the data are adequately representative of intended populations, both spatially and temporally. This will be accomplished by verifying that samples were collected and processed for analysis in accordance with the SAP, by reviewing spatial and temporal data variations, and by comparing these characteristics to expectations. The usability report will describe the representativeness of the data for each matrix and analytical fraction. This will not require quantitative comparisons unless the Project Scientist indicates that a quantitative analysis is required.

**Comparability**

- The Tetra Tech Project Chemist acting on behalf of the Project Team will determine whether the data generated under this project are sufficiently comparable to historical site data generated by different methods and for samples collected using different procedures and under different site conditions. This will be accomplished by comparing overall precision and bias among data sets for each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the Tetra Tech Project Chemist indicates that such quantitative analysis is required.

**Sensitivity**

- The Tetra Tech Project Chemist acting on behalf of the Project Team will determine whether project sensitivity goals listed in Worksheet #15 were achieved. The overall sensitivity and quantitation limits from multiple data sets for each matrix and analysis will be compared. If sensitivity goals are not achieved, the limitations on the data will be described. The Tetra Tech Project Chemist will enlist the help of the Tetra Tech Risk Assessor to evaluate deviations from planned sensitivity goals.

**Project Assumptions and Data Outliers**

- The Tetra Tech PM and designated team members will evaluate whether project assumptions are valid. This will typically be a qualitative evaluation but may be supported by quantitative evaluations. The type of evaluation depends on the assumption being tested. Quantitative assumptions include assumptions related to data distributions (e.g., normal or log-normal) and estimates of data variability. Potential outliers will be removed if a review of the associated data indicates that the results have an assignable cause the renders them inconsistent with the rest of the data. During this evaluation, the team will consider whether outliers could be indications of unanticipated site conditions. Consideration will be given to whether outliers represent an unanticipated site condition.

**Describe the evaluative procedures used to assess overall measurement error associated with the project:**

After completion of the data validation, the data and data quality will be reviewed to determine whether sufficient data of acceptable quality are available for decision making. In addition to the evaluations described above, a series of inspections and statistical analyses will be performed to estimate these characteristics. The statistical evaluations will include simple summary statistics for target analytes, such as maximum concentration, minimum concentration, number of samples exhibiting non-detected results, number of samples exhibiting detectable results, and the proportion of samples with detected and non-detected results. The project team members identified by the Tetra Tech PM will assess whether the data collectively support the attainment of project objectives. They will consider whether any missing or rejected data have compromised the ability to make decisions or to make the decisions with the desired level of confidence. The data will be evaluated to determine whether missing or rejected data can be compensated by other data. Although rejected data will generally not be used, there may be reason to use them in a weight of evidence argument, especially when they supplement data that have not been rejected. If rejected data are used, their use will be supported by technically defensible rationales.

For statistical comparisons and mathematical manipulations, non-detected values will be represented by a concentration equal to the sample-specific limit of detection. Duplicate results will be averaged for the purpose of representing the range of concentrations, and the average of the original sample will be used to represent the concentration at a particular sampled location.

**Identify the personnel responsible for performing the usability assessment:**

The Tetra Tech PM, Project Chemist, FOL, and Project Scientist will be responsible for conducting the listed data usability assessments. The data usability assessment will be reviewed with the Navy RPM and the IDEM RPM. If deficiencies affecting the attainment of project objectives are identified, the review will take place either in a face to face meeting or a teleconference depending on the extent of identified deficiencies. If no significant deficiencies are identified, the data usability assessment will simply be documented in the project report and reviewed during the normal document review cycle.

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# APPENDIX A

# SWMU 25 HISTORICAL INFORMATION

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# HYDROGEOLOGIC INVESTIGATION OF WASTE DISPOSAL SITES AT THE NAVAL WEAPONS SUPPORT CENTER, CRANE, INDIANA

by

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Prepared for
Naval Weapons Support Center
Crane, Indiana

April 1982

## Summary

The Naval Weapons Support Center (NWSC) identified areas on its installation where contaminated materials have been buried and determined that a groundwater monitoring network at each area was required to identify any subsurface contamination which might have resulted from these disposal areas. The NWSC requested the Waterways Experiment Station (WES) to install a groundwater monitoring system around each identified disposal site. A total of 13 groundwater monitoring networks; 83 monitoring wells; were installed in 11 sites throughout the NWSC. Each site contained from 5 to 15 monitoring wells with the number of wells dependent on the area of each site, the number of groundwater flow patterns encountered, or the number of disposal areas per site.

The WES conducted a soil sampling and drilling program to define the hydrogeologic characteristics and to locate and install the monitoring wells at each site. The sampling and drilling program identified two sites where the water table was encountered in the unconsolidated overburden and in the remaining sites, the water table was encountered in fractures in sedimentary rocks at depths of less than 10 ft to a maximum depth of 121 ft. The direction of groundwater flow varied, but generally conformed with the surface flow at each site. Overburden thickness at the sites ranges from less than 1 ft to more than 40 ft with soil types of predominantly clay, silt, and sand. The rock underlying the overburden consists of sandstone, shale, limestone, and interbedded coal seams of Pennsylvanian and Mississippian age.




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## PREFACE

This study was performed by personnel of the Geotechnical Laboratory (GL) of the U. S. Army Engineer Waterways Experiment Station. Funding for this study was authorized by Military Interdepartmental Purchase Request (MIPR) Number N00164-IMP-04575 dated 6 June 1981 and amended 22 October 1981.

The field work was conducted during the period 17 August 1981 to 1 December 1981. Soil testing and data reduction were performed from January 1982 to April 1982 and report preparation was accomplished during this same period. The drilling was performed by the Exploration Group (EG), Engineering Geology and Rock Mechanics Division (EGRMD), GL, under the supervision of Mr. Joseph B. Dunbar, Engineering Geology Applications Group (EGAG) of the EGRMD. The physical soil tests were performed by the Soil Testing Facility, GL. Messrs. Jerald D. Broughton and Dale L. Barefoot, EGAG, assisted in data compilation and analysis. Mr. Dunbar prepared the report.

The study was conducted under the direct supervision of Mr. John H. Shamburger, Chief, EGAG, and Mr. Mark A. Vispi, Chief, EG, and under the general supervision of Dr. Don C. Banks, Chief, EGRMD, and Drs. William F. Marcuson III and Paul F. Hadala, Chief and Assistant Chief, GL, respectively.

Special acknowledgment is extended to Mrs. Cathy Andrews and Mr. Eric Foster of the Naval Weapons Support Center for their assistance during the study.

Commander and Director of WES during the conduct of the study was COL Tilford C. Creel, CE. The Technical Director was Mr. F. R. Brown.



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# PART I: INTRODUCTION

## Background

The Naval Weapons Support Center (NWSC) has located areas on its premises that might contain buried hazardous waste. These hazardous waste areas resulted from landfill dumping operations and the production and disposal of military ordnance. The NWSC determined these waste sites required a groundwater monitoring network to help ascertain any subsurface contamination problems which might result from these areas.

## Purpose and Scope

The purpose of this investigation was to define the hydrogeological characteristics of each buried waste site and design and install groundwater monitoring networks around these buried waste sites which would conform with state and Federal requirements.

This study was performed at 11 predesignated areas on the NWSC where subsurface contaminations were suspected. Activities during the study included field exploration, soil sampling, well installation, and physical soil testing. Chemical analysis of soil and water samples was conducted by the NWSC and are not presented in this report.



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## PART II: ENVIRONMENTAL SETTING

### Geographic Location

The NWSC is located in southwestern Indiana in the northern half of Martin County and extends into portions of Greene, Daviess, and Lawrence Counties. It is situated approximately 75 miles southwest of Indianapolis and approximately 45 miles southwest of Bloomington, the nearest metropolitan area. The NWSC covers more than 60,000 acres or an area roughly ten miles by ten miles. Figure 1 shows the NWSC and surrounding area which is predominantly rural.

### Climate

The NWSC is located in a warm temperate climate zone. In general, summers are warm and humid while winters are mild with cold periods of short duration. Temperature ranges from an average maximum July temperature of 89°F to an average minimum January temperature of 26°F. Precipitation is nearly evenly distributed throughout the year with maximum precipitation occurring during spring and early summer. The NWSC averages 44 inches of precipitation yearly with 42 inches of rain and 15 inches of snow. Average humidity ranges from 40 to 90 percent in summer and 60 to 90 percent in winter.

### Topography

Surface relief at the NWSC consists of gently rolling hills and steep sided ridges which are dissected by numerous well-defined drainageways. Elevations at the NWSC are higher in the east and decline towards the west. The highest elevation occurs in the extreme eastern portion with an elevation of 860 feet (ft) mean sea level (MSL) while the lowest elevation of 491 ft MSL occurs in the southwestern portion of the installation.



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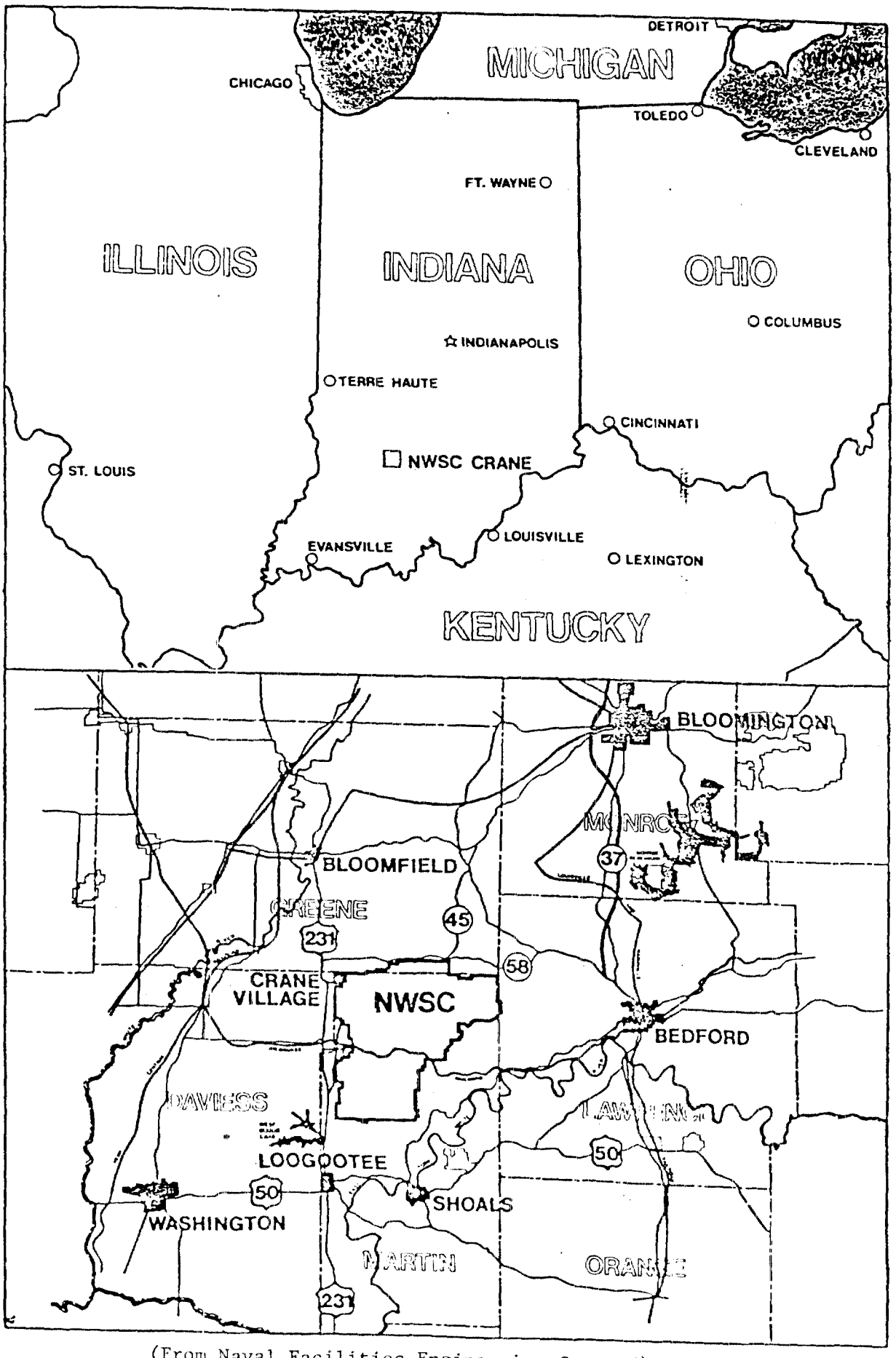


(From Naval Facilities Engineering Command)

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Figure 1. Naval Weapons Support Center and Vicinity

## Soils

The United States Department of Agriculture identifies three-fourths of Martin County which contains the major portion of the NWSC as belonging to the Zanesville and Muskingum soil series. These series are identified as a dark brown organic silt loam at the surface, underlain by 48 inches of mottled tan, grey, and yellow clay with varying percentages of sand and silt. Occasionally, a clay hardpan occurs between 25 and 32 inches below surface. WES borings encountered soil thickness at the NWSC from less than 1 ft to an excess of 40 ft. These borings identified a surficial organic layer underlain by clay, silt, or sand.

## Geology

The NWSC lies in a region of Indiana which was not covered by Pleistocene glacial deposits. The surface deposits are divided into two types; unconsolidated deposits of Recent and Pleistocene age and residual soils formed from the underlying rock. Recent and Pleistocene deposits occur in the many small floodplains throughout the NWSC and are composed of alluvial, colluvial, and paludal silt, sand, and gravel; and lacustrine clay, silt, and sand. Residual soils at the NWSC were derived from the underlying sedimentary rocks of the lower Pennsylvanian Raccoon Creek Group and the upper Mississippian Stephensport and the West Baden Groups. These soils are clay, silt, and sand. Lower Pennsylvanian rock at the NWSC consists of shale, sandstone, and coal beds while upper Mississippian rock consists of limestone, shale, and sandstone. Since the NWSC lies on the eastern edge of the Illinois Structural Basin, the Pennsylvanian and Mississippian sedimentary rocks dip west-southwest between 30 and 35 ft per mile into the basin. Table 1 presents the stratigraphic column of units underlying the NWSC and Figure 2 shows the distribution of these units on the installation.



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COLUMNAR SECTION SHOWING BEDROCK UNITS

| TIME UNIT: PERIOD | TIME UNIT: EPOCH | MAP UNIT | THICKNESS (FEET) | LITHOLOGY | ROCK UNIT *: SIGNIFICANT MEMBER | ROCK UNIT *: FORMATION | | ROCK UNIT *: GROUP |
|---|---|---|---|---|---|---|---|---|
| PENNSYLVANIAN | CONEMAUGHIAN | $P_5$ | 175+ | | MEROM Ss. | MATTOON Fm. | MATTOON Fm. (FORMATIONS MAPPED IN ILLINOIS) | MCLEANSBORO |
| | | $P_4$ | 150 to 200 | | LIVINGSTON Ls.<br>SHOAL CREEK Ls. | BOND Fm. | BOND Fm. | |
| | | $P_3$ WF | 200 to 350 | | WEST FRANKLIN Ls. | *PATOKA Fm.* | MODESTO Fm. | |
| | | | | | | SHELBURN Fm. | | |
| | ALLEGHENIAN | $P_2$ | 300 to 400 | | DANVILLE COAL (VII) | DUGGER Fm. | | CARBONDALE |
| | | | | | SPRINGFIELD COAL (V) | PETERSBURG Fm. | | |
| | | | | | SURVANT COAL (IV) | LINTON Fm. | | |
| | | B | 250 to 500 | | SEELYVILLE COAL (III) | STAUNTON Fm. | | *RACCOON CREEK* |
| | POTTSVILLIAN | $P_1$ | | | BUFFALOVILLE COAL<br>LOWER BLOCK COAL | BRAZIL Fm. | | |
| | | | | | | MANSFIELD Fm. | | |

* ROCK-UNIT NAMES FOR PENNYSLVANIAN ROCKS IN INDIANA FOLLOW THE USAGE PROPOSED BY WIER (IN PREPARATION), STRATIGRAPHY OF MIDDLE AND UPPER PENNSYLVANIAN ROCKS IN SOUTHWESTERN INDIANA. NEW NAMES ARE SHOWN IN ITALICS AND ARE TENTATIVE UNTIL FORMAL PRESENTATION.
(After Grey, Wayne, and Wier)

Table 1. Stratigraphy of Naval Weapons Support Center
(Continued)

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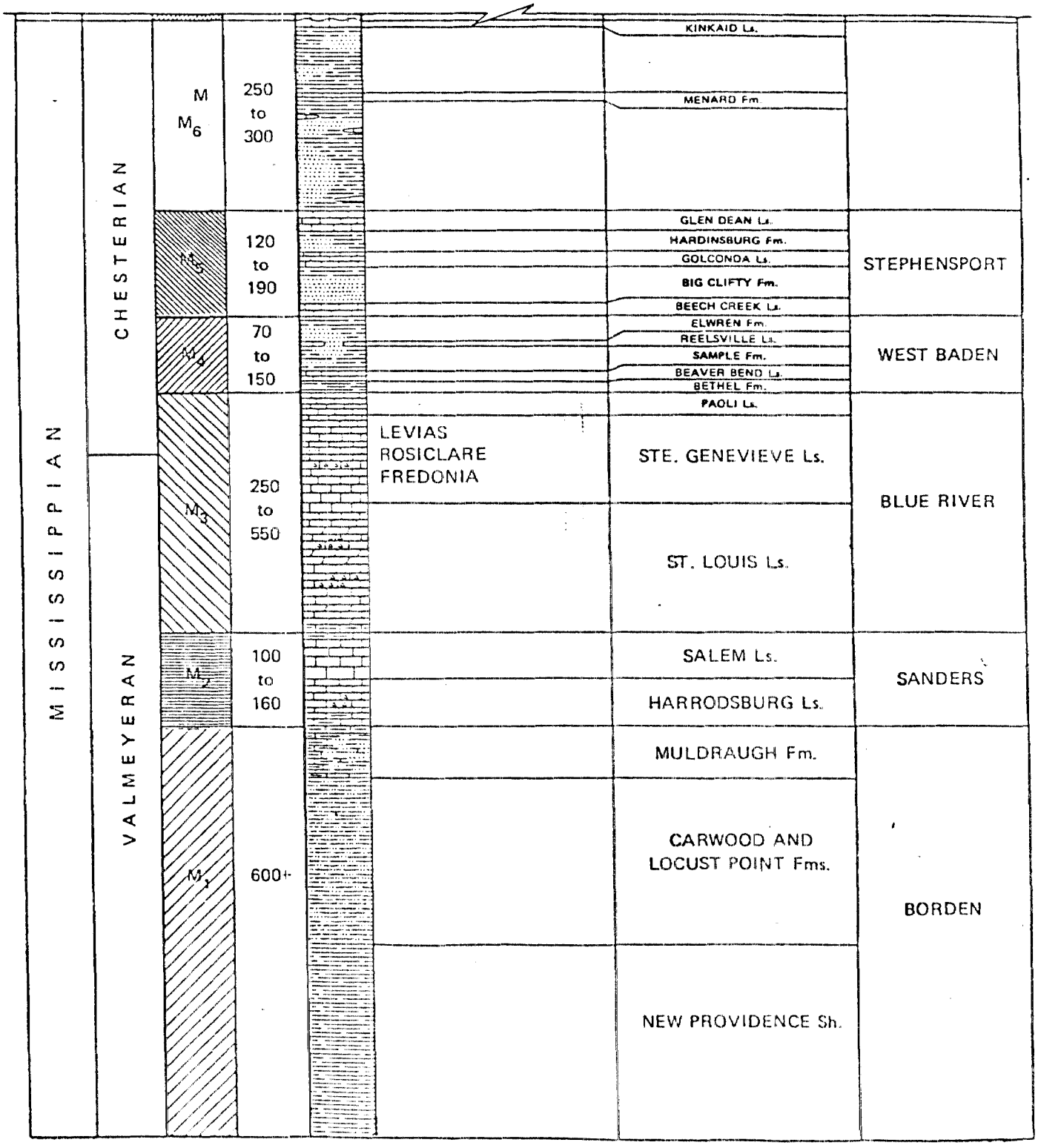
COLUMNAR SECTION SHOWING BEDROCK UNITS (CONT.)




* ROCK-UNIT NAMES FOR PENNSYLVANIAN ROCKS IN INDIANA FOLLOW THE USAGE PROPOSED BY WIER (IN PREPARATION), STRATIGRAPHY OF MIDDLE AND UPPER PENNSYLVANIAN ROCKS IN SOUTHWESTERN INDIANA. NEW NAMES ARE SHOWN IN ITALICS AND ARE TENTATIVE UNTIL FORMAL PRESENTATION.

Table 1 (Concluded)

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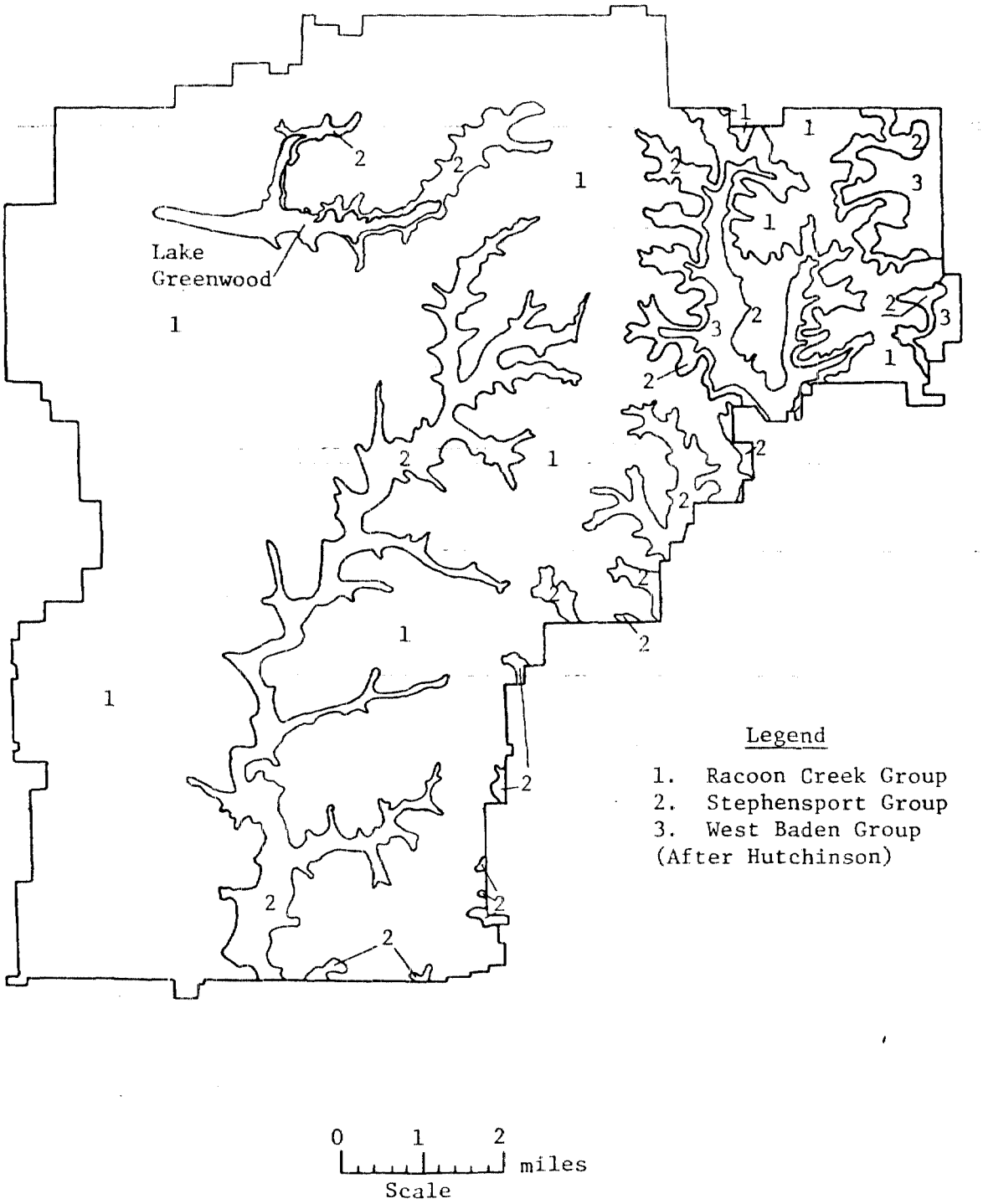


Figure 2. Distribution of Geological Groups at the NWSC.



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## Surface Water

The surface drainage at the NWSC has formed a dense dendritic pattern throughout the installation that flows in a general southerly or southwesterly direction. Seven creeks in five drainage basins carry surface water off the installation where it eventually drains into the East Fork of the White River. Figure 3 shows the basins and drainages of the NWSC. Drainage Basin IV consists of Boggs and Turkey Creeks which are the primary drainageways for the installation and drain the majority of the area. The north and northwest section (Basin I) is drained by Furst Creek, the eastern portion (Basin III) is drained by the Sulphur Creek Complex, the extreme eastern portion (Basin II) is drained by Indiana Creek, and the southwestern section (Basin V) is drained by Seed Tick Creek. Also located within the installation are several small ponds and Lake Greenwood, an 800 acre spring-fed lake in the northwestern portion of the installation.

## Groundwater

Detailed groundwater information at the NWSC is lacking since potable water is derived primarily from Lake Greenwood. Regionally, groundwater flow is expected to conform with the westward dipping bedrock with a gradient approaching the dip while locally, groundwater flow is likely to parallel the surface drainage on the installation. Wells installed by WES for the groundwater monitoring network generally showed groundwater flow agreed with local drainage. Seasonal fluctuations in the water table are expected to be slight since precipitation is well distributed throughout the year.



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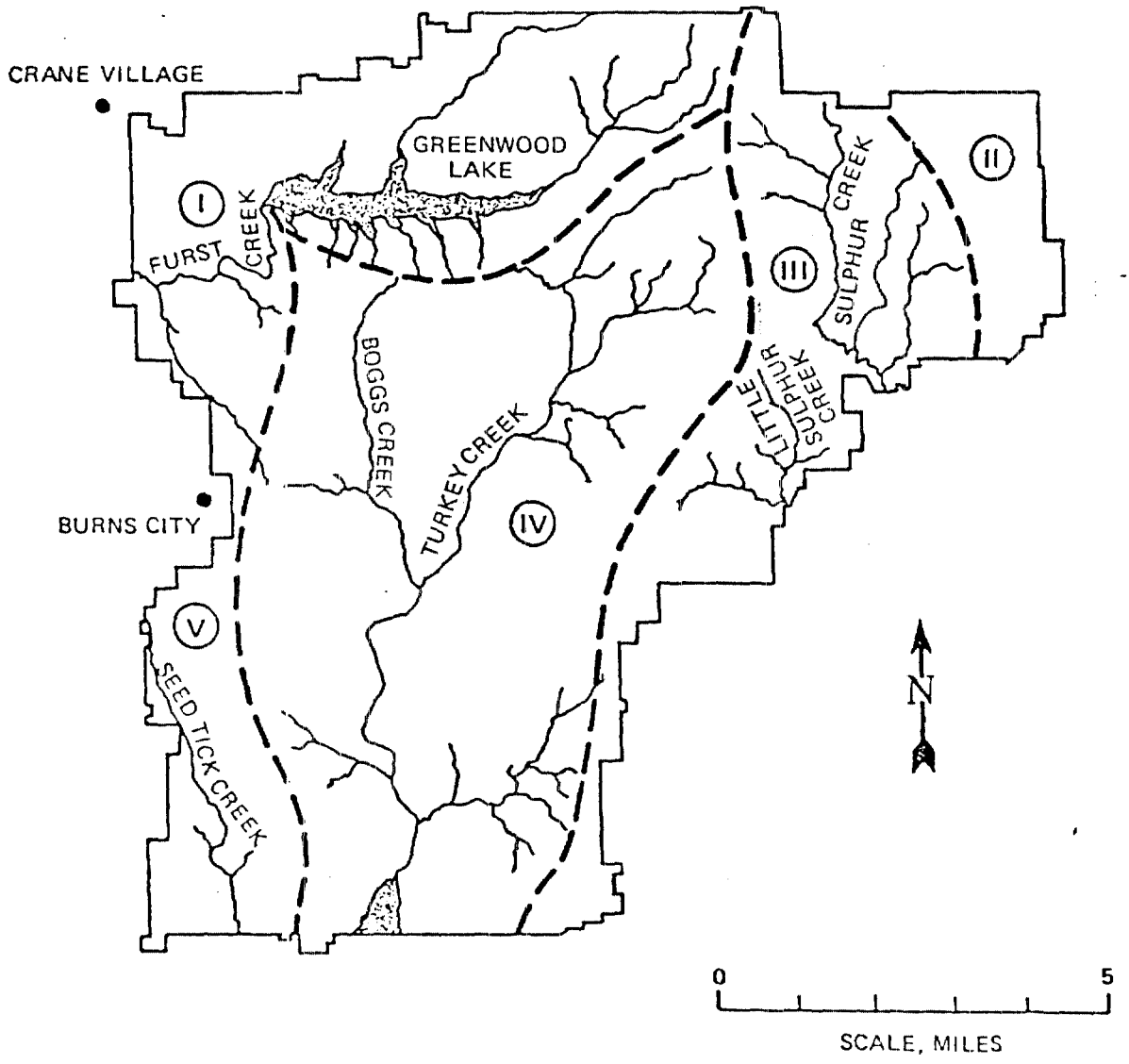


Figure 3. Surface Drainage at the NWSC.



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## PART III: DATA COLLECTION

### Field Exploration

The WES began installation of a groundwater monitoring system around each buried waste site in August 1981 and concluded work in December 1981. Thirteen groundwater monitoring networks (containing a total of 83 monitoring wells) were installed at 11 sites on the NWSC. Figure 4 identifies and locates the disposal sites on the NWSC. The installation of each network involved a soil sampling and drilling program to help define the hydrogeological characteristics at each site. The NWSC was responsible for the sampling and chemical analysis of water samples from each monitoring site, with the WES assisting the NWSC in obtaining water samples from the Demolition Area, the Old Rifle Range, the Ammunition Burning Grounds, and the Dye Burial Grounds. The NWSC initiated, prepared, and monitored all safety aspects of the drilling and sampling operations. Necessary support equipment, facilities, and personnel were also provided by the NWSC.

#### Field procedure

The installation of a monitoring network around each site was conducted in two phases. Phase one was concerned with determining depth to groundwater and the direction of groundwater flow by installing three monitoring wells around each disposal area. Well locations were based on the site topography and estimated water table gradient, and wells were located 25 to 75 ft from the site perimeter. When installed, the wells formed an approximate equilateral triangle around each area with one well up gradient and the remaining two wells down gradient of each disposal site. Water level measurements were recorded daily for seven days and weekly thereafter following each well installation (water levels were measured with an M-scope, a device similar to a volt-ohm meter). The NWSC surveyed all well locations and riser pipe elevations prior to implementation of the second phase. Groundwater elevations from the three initial wells were used to determine the direction of flow and the plane of the water table for each disposal site.



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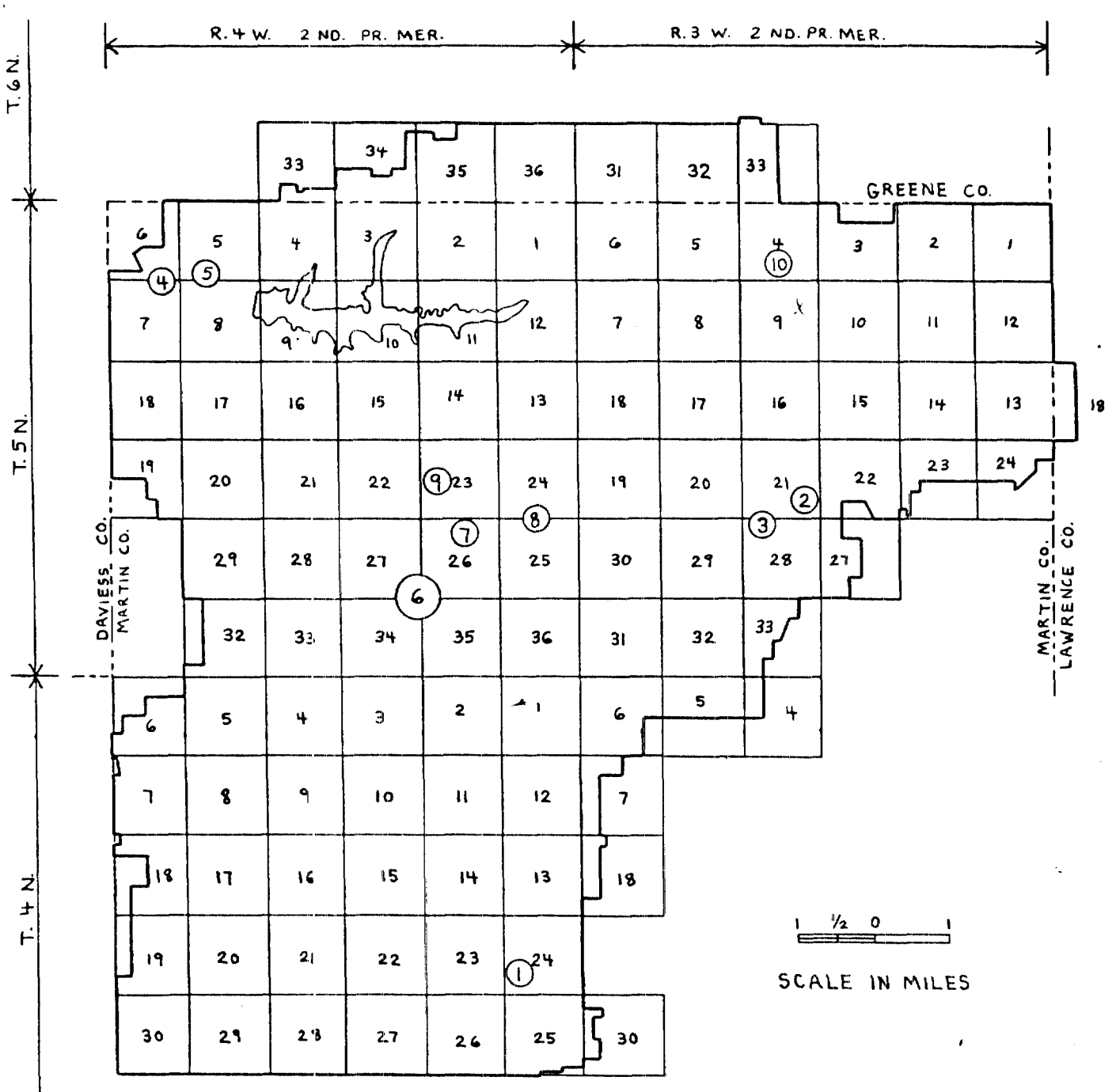


| Site Number | Site Name |
|---|---|
| 1 | Mustard Gas Burial Grounds |
| 2 | Dye Burial Grounds |
| 3 | Ammunition Burning Grounds |
| 4 | McComish Gorge |
| 5 | Old Burning Pit |
| 6 | Demolition Area and Old Rifle Range (included under Site 6 but separate area) |
| 7 | Highway 58 Dump Site A |
| 8 | Highway 58 Dump Site B |
| 9 | Pest Control Area |
| 10 | Rockeye Site |

Figure 4. Location of Groundwater Monitoring Systems

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Phase two consisted of installing a sufficient number of wells to obtain a minimum of three monitoring wells along the down gradient perimeter of each disposal site. These wells were located 25 to 75 ft from the site perimeter and equally spaced along the down gradient length to insure optimum subsurface coverage. Additional monitoring wells were installed where more than one direction of flow was encountered or where the down gradient perimeter was large. Prior to drilling the down gradient wells, a surveyed ground elevation was obtained where possible, if not, an estimate of the ground elevation was made to predict the depth where groundwater would be encountered. If the water table was as predicted, the remaining down gradient wells were installed. If the water table was not at the predicted depth, the completed well was given time to stabilize and the new three point problems solved with the next well located accordingly.

Soil sampling procedure

Undisturbed and disturbed soil samples were obtained using two truck-mounted Failing 1500 drilling rigs. An undisturbed soil sample is defined as a sample of minimal disturbance suitable for laboratory testing. The primary method used in obtaining undisturbed soil samples was with a 3-inch (in.) -diameter (diam), fixed piston sampler or Hvorslev sampler (Figure 5). A 3-in. Shelby tube, mounted to the sampler head, was pushed with hydraulic pressure into the stratum being sampled. The sampler was retrieved from its position and the tube removed from the sampler head. Approximately 3 inches of the soil sample was removed from the bottom of the tube for field classification and then sealed into a jar and labeled. Field classification consisted of identifying soil type, color, consistency, water content, and any other visible physical characteristics. Packers were inserted in each end of the sample tube and the sample tube labeled for storage at the NWSC for later shipment to WES for physical testing.

Additional undisturbed sampling methods were employed using a Pitcher sampler (Figure 6) or Dennison barrel. Both sample techniques use an inner sample tube and outer barrel with bit which is drilled into the sample interval. These methods were primarily used with hard soils or weathered rock and very coarse soils where the Hvorslev sampler was not effective.



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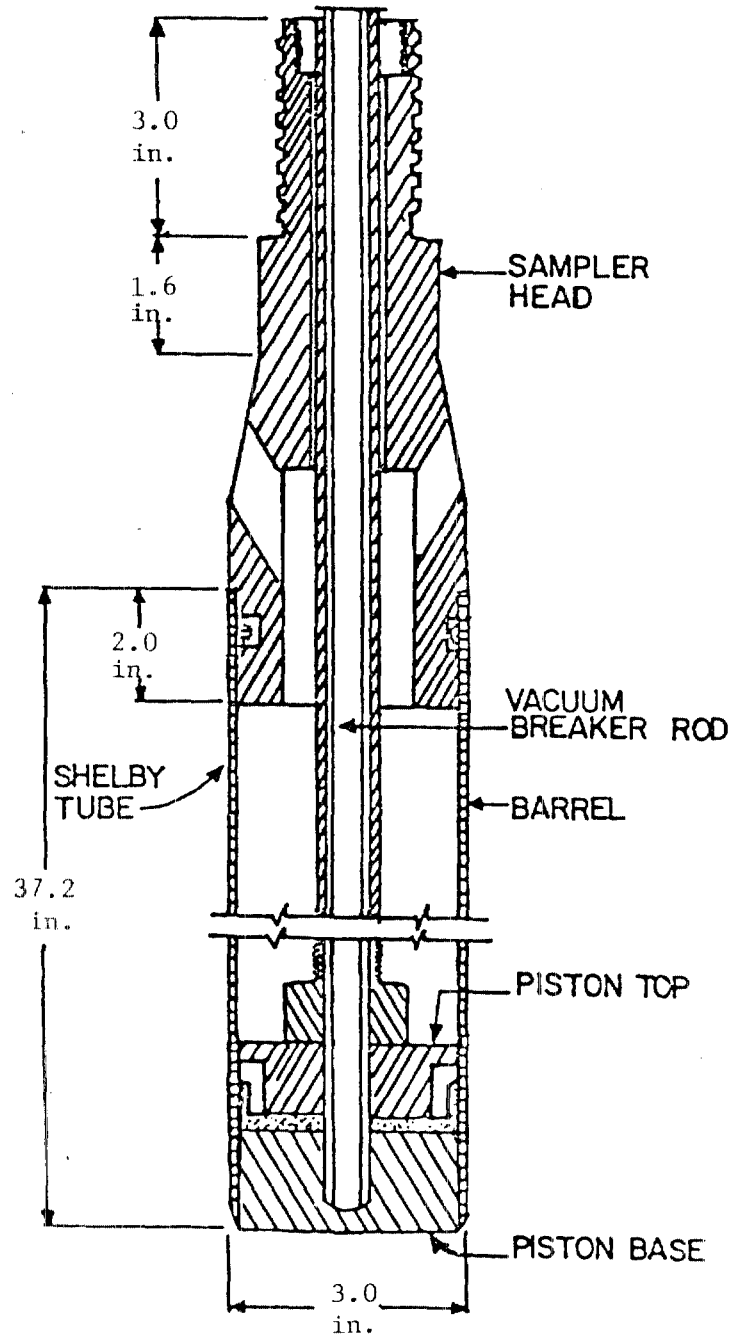


Figure 5. Sketch of Hvorslev Sampler or 3-in. Fixed Piston Sampler



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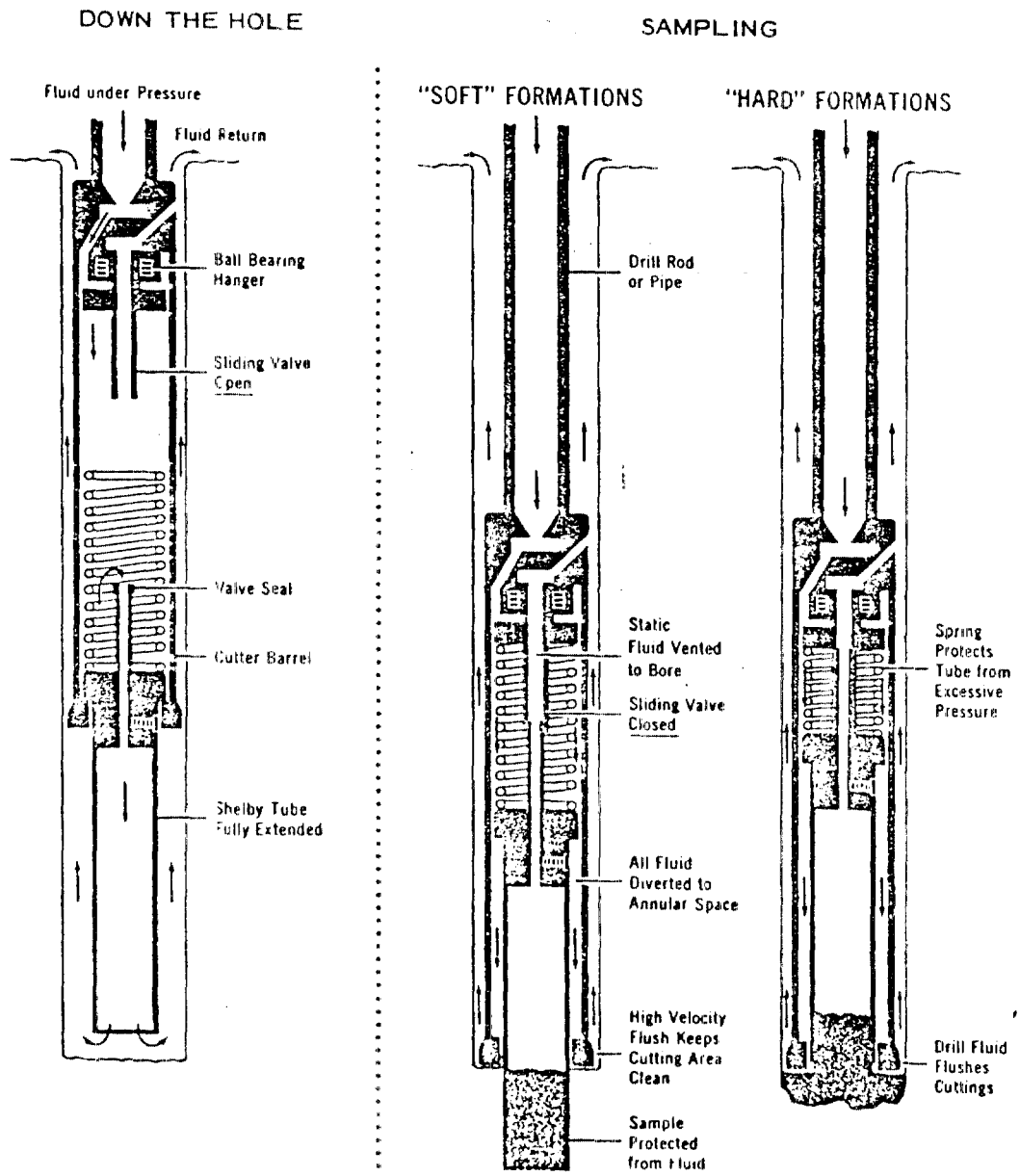


Figure 6. Sketch and Operation of Pitcher Sampler.



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Disturbed soil samples were obtained with a split-spoon sampler (Figure 7). A disturbed soil sample contains all the constituents of a particular stratum, but the original structure has been altered. The split-spoon sampler was pushed with hydraulic pressure into the same interval where the Hvorslev sampler failed to obtain a sample. This sample loss generally occurred in very moist or wet sands. The split-spoon sampler was retrieved from its position, disassembled, and the sample removed from the barrel portion where it was classified, sealed into a jar, and labeled for later shipment to WES for laboratory testing.

Additional disturbed soil samples were requested by the NWSC from the Dye Burial Grounds and an ash pile at the Ammunition Burning Grounds. These soil samples were obtained with a folding auger and composite jar samples were made for every 5 ft of material sampled. The NWSC required these samples to conduct chemical analysis on the soil and ash from these areas.

Sampling frequency

The sampling program called for 3-in. fixed piston undisturbed soil samples to be taken at 5-ft intervals - 0, 5, 10 ... ft - until either the water table or rock was encountered. If water was encountered in the overburden, two additional soil samples were taken at 5-ft and 10-ft below the depth where water was first encountered. If bedrock was encountered, boring advance was changed to rock drilling.

Boring advance between sample intervals was made with either a hollow stem auger or folding-solid auger. The hollow stem auger is a combination casing and auger which is used in soils where the boring will collapse when not supported. The folding or solid auger was used primarily in boring advance where soil borings tended to remain open. The hollow stem auger was used only at McComish Gorge and the Old Burning Pit where soils were predominantly coarser-grained.

Drilling

Drilling was initiated where rock was encountered. Rock drilling at the NWSC was done either with a 5-5/8-in. rock bit or 4-in. inside diameter (I.D.) x 5½-in. outside diameter (O.D.) core barrel with diamond bit (Figure 8). At least one boring per site was drilled with the core barrel



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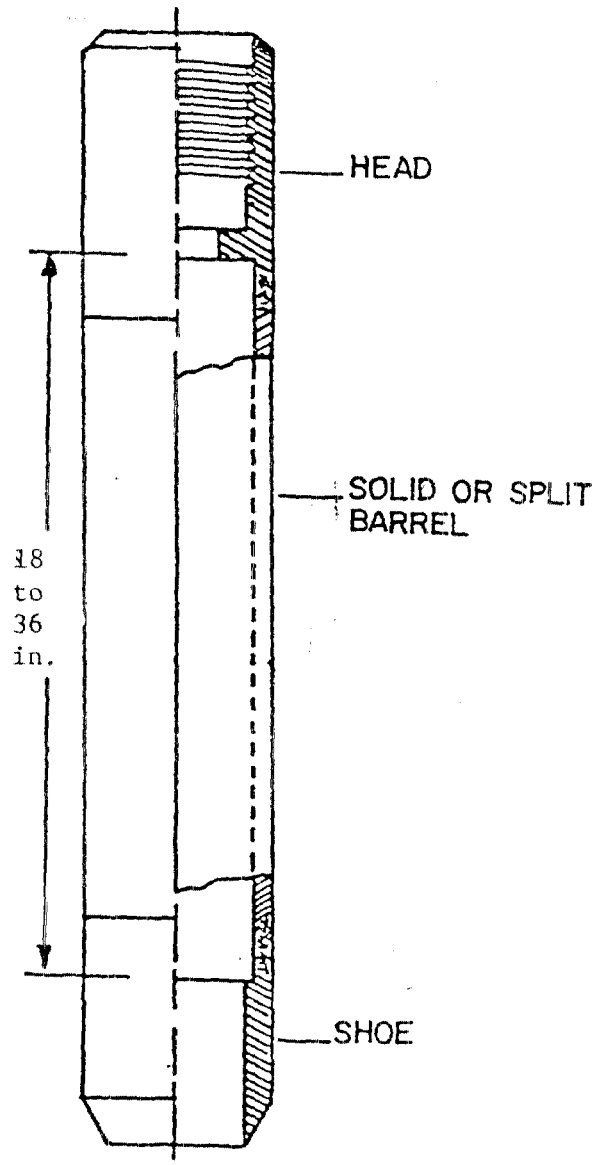


O.D. 2 in., 2.5 in., 3 in., 3.5 in.
I.D. 1.5 in., 2 in., 2.5 in., 3 in.

Figure 7. Sketch of Split-Spoon Sampler.



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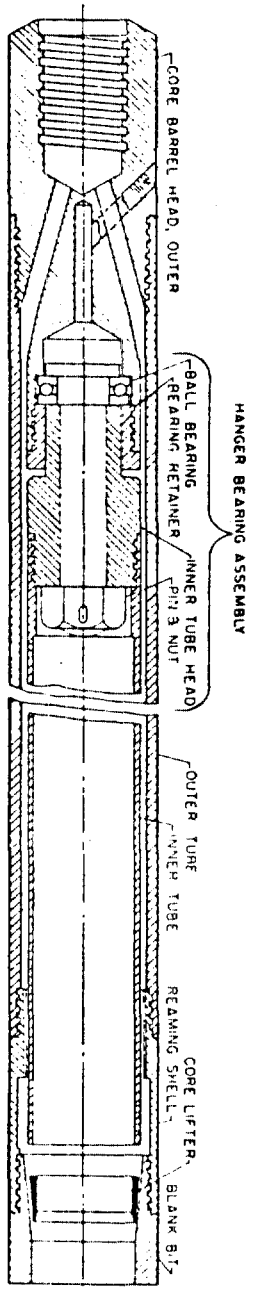


Figure 8. Sketch of 4-in. I.D. x 5-1/2-in. O.D. Core Barrel.



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to provide detailed lithologic information and the remaining borings were drilled with a rock bit. Boring advance was ended when the boring was 10 ft below the water table.

Air was used as a medium during rock drilling. A 650 cubic feet per minute air compressor furnished the necessary pressure to remove cuttings from the boring and lubricate the rock bit. During the coring operation it was occasionally necessary for water to be used as a drilling medium instead of air. This occurred when the boring was too deep for cuttings to be efficiently removed by air or the water table prevented the cuttings from reaching the surface. The preferred medium was air because water could mask the water table.

Samples from core borings were not saved, but detailed lithological logs and photographs were made from rock samples. Lithological classification from rock bit borings was made on drill cuttings which identified type, color, grain-size, water content, and drilling resistance of the material. Appendix A contains the field boring logs and Appendix B graphically summarizes the information from the field boring logs.

Well installation

Well installation for each boring was dependent on the site geology. If the water table was encountered in the overburden, one of three situations could occur which was easily determined during the soil sampling operation by pushing two undisturbed soil samples below the depth where water was encountered. Where the saturated zone was found to equal or exceed 12.5 ft, well installation would correspond to Figure 9 and where the saturated zone was less than 12.5 ft, well installation would correspond to Figure 10. The third type of overburden well installation is illustrated in Figure 11 and occurs where the saturated zone is less than 12.5 ft and overlies rock. Figure 12 illustrates installation where the water table is in rock which represents the majority of wells installed at the NWSC.

A well string was made from 2-in. schedule 40 PVC pipe after the depth of the monitoring well was determined. All well strings consisted of a bottom capped silt trap, a slotted section of PVC screen (preconstructed 10-ft



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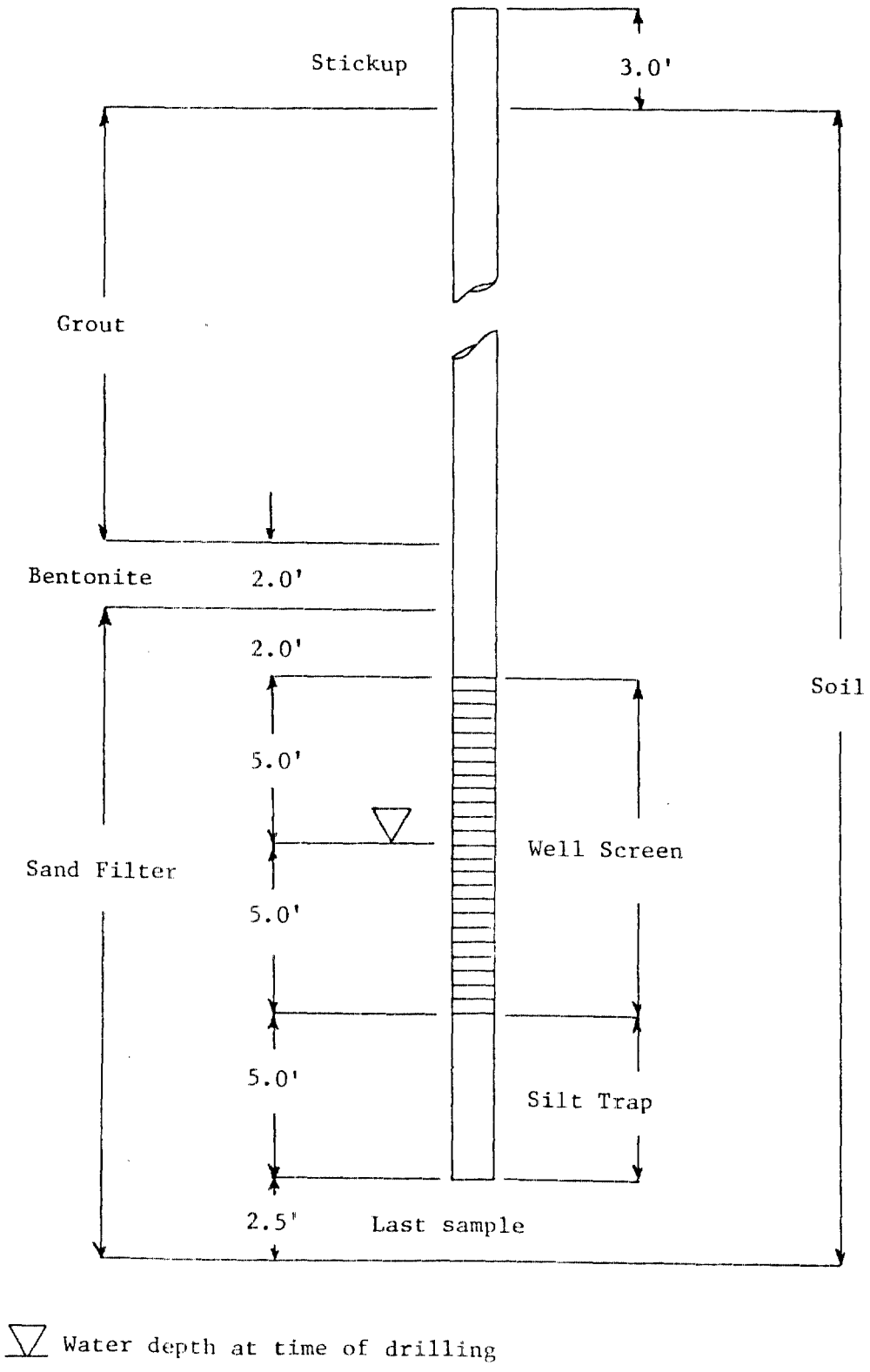


Figure 9. Monitoring Well When Saturated Zone Equals or Exceeds 12.5 ft.



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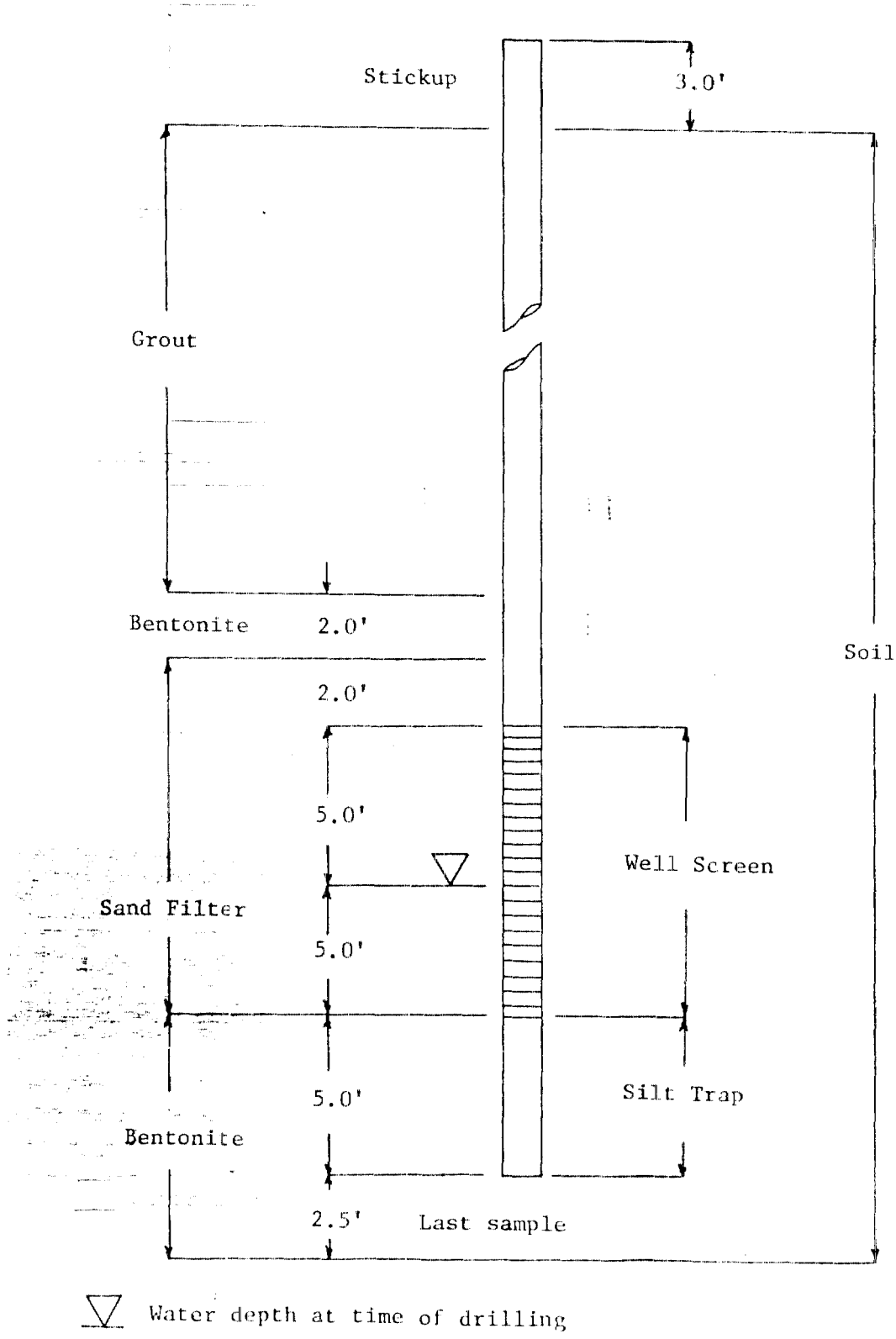


Figure 10. Monitoring Well When Saturated Zone is Less Than 12.5 ft Thick and Overlies Dry Soil.

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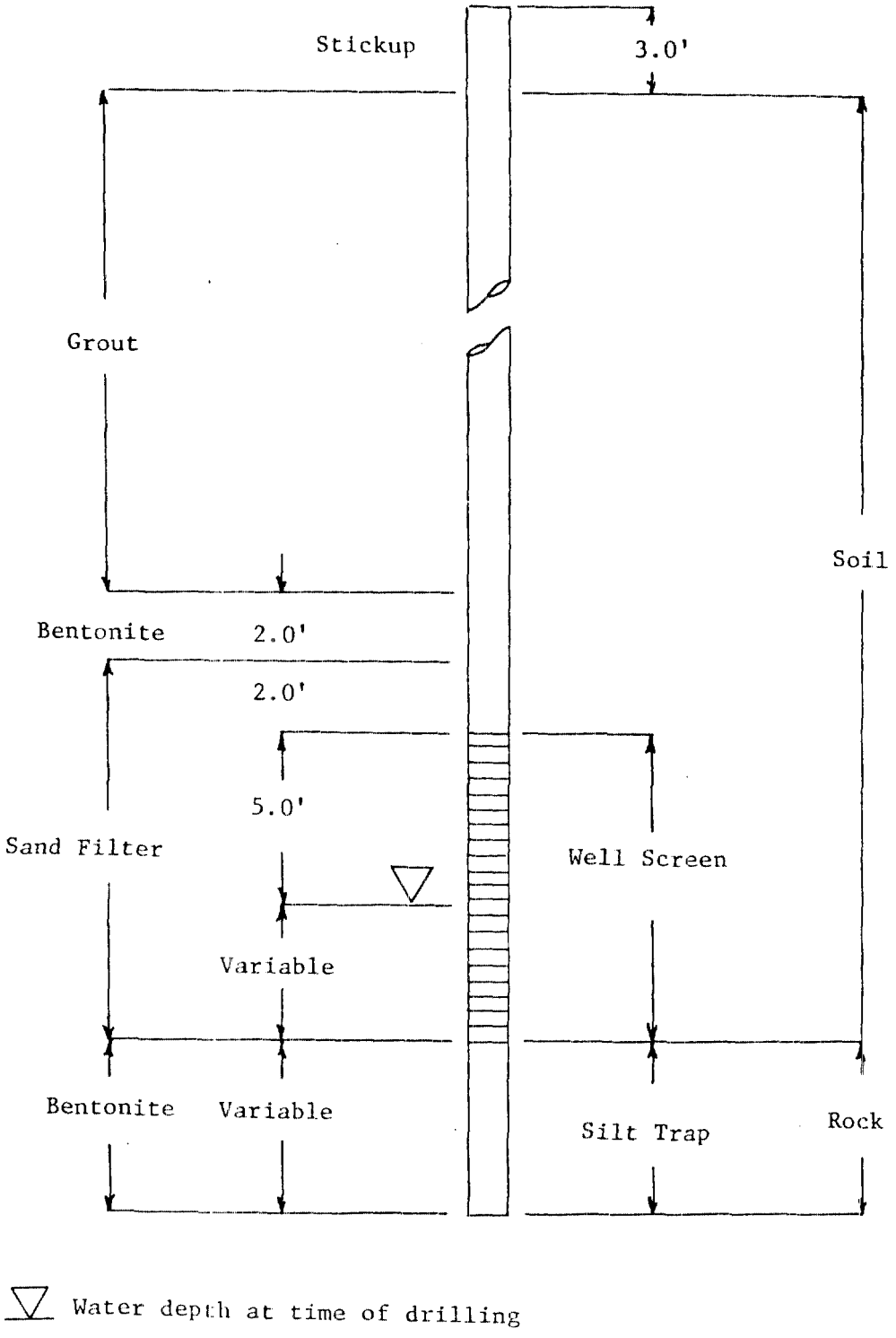


Figure 11. Monitoring Well When Saturated Zone is Less Than 12.5 ft Thick and Overlies Rock.



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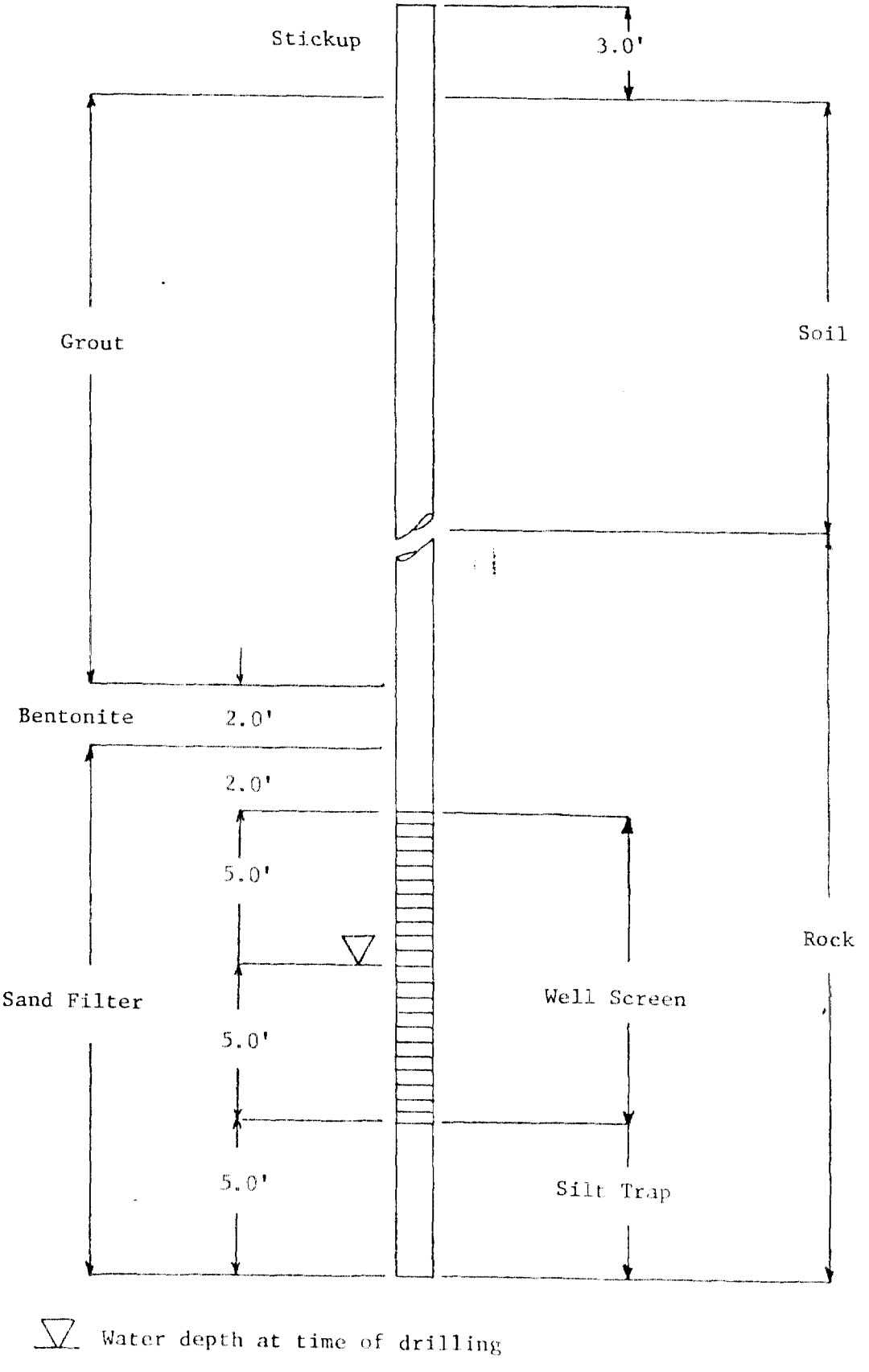


Figure 12. Monitoring Well with Water Table in Rock.

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sections with slot width opening of 0.020 in.) and a solid riser pipe extending 3 ft above ground surface. All joints were sealed with PVC cement to prevent leakage and a small vent was sawed into the riser pipe cap to allow equalization of pressure. In shallow borings the well string was lowered as a complete unit while in deeper borings it was necessary to glue the well string in sections when lowering to the desired depth. If the hollow stem auger was used in boring advance (McComish Gorge and Old Burning Pit), the well string was lowered through the hollow stem auger and the hollow stem auger removed.

Well completion was dependent on the applicable geological condition in Figures 9 through 12. If the saturated zone was less than 12.5 ft and was underlain by soil (Figure 10) or bedrock (Figure 11), a bentonite seal was placed around the silt trap to prevent possible contamination of the underlying material from the water table. If the saturated zone was greater than 12.5 ft (Figure 9) or the water table was found in bedrock (Figure 12), a washed filter sand was placed around the silt trap. In all constructions, the annulus between the well screen and boring wall was filled with a washed filter sand (laboratory test results on the filter sand are contained in Appendix E) to a level approximately 2 ft above the top of the screen, followed by approximately 2 ft of bentonite. The remaining annulus was grouted using a water, cement, and bentonite mixture. The bentonite was added to the grout to prevent shrinking and cracking during the curing process. Surface depressions caused by settling of the grout mixtures were later filled with a similar mixture.

In certain locations additional protection to the well was supplied by a 3-in.-diam, steel pipe with screw cap. All wells in the Demolition Area and the Old Rifle Range were fitted with protector pipes. Those locations where the possibility of damage might result from snow removal or high vehicle trafficked areas were also fitted with protector pipes. These protector pipes were cemented 2 ft below ground surface, vented in the cap, and contained a drain hole at the base. The drain hole prevented trapped water from freezing during the colder months and possible damage to the inner PVC riser pipe. Each monitoring well was labeled and Appendix C contains diagrams of all wells installed. Appendix D contains the water level measurements on all monitoring wells installed.


WORKING DRAFT

## Physical Test and Cation Exchange Capacity

### Physical test

Standard soil test procedures as specified by Engineering Manual 1110-2-1906 "Laboratory Soil Testing" were followed during testing. Classification tests (Atterberg limits and grain size distribution of soils), water content, and density tests were performed on all tube samples. Classification tests and water content were performed on all jar samples where no tube samples existed. Permeability tests were performed on selected samples from each site. Detailed testing procedures are presented in Appendix E with laboratory soil test data.

Classification of soils was made according to the Unified Soil Classification System (USCS) which depends on the grain size distribution and Atterberg limits. Grain size distribution was determined with standard sieves and the Atterberg limits (liquid and plastic limits) were determined with standard devices. The liquid and plastic limits are the water contents at the boundaries between the semiliquid and plastic state and the plastic and semisolid state, respectively. Figure 13 shows the USCS with which the NWSC soil samples were described.

Water content and soil density are important engineering relationships and are useful correlations among samples for which a full suite of test data are not available. Water content is the amount of free water in a soil and soil density is the dry weight per soil volume.

Permeability tests were performed on one to three representative samples from each site to evaluate the hydrogeological conditions at each disposal site. The samples above bedrock and the water table furnished an approximate measure of possible migration of contaminants.

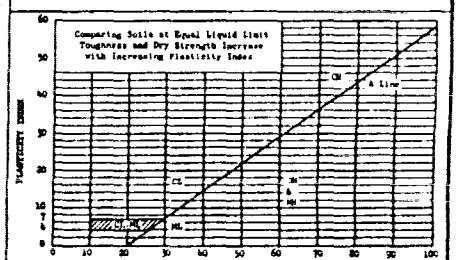
### Cation exchange capacity

Cation Exchange Capacity (CEC) test procedures as specified by Technical Report EPA/CE 81-1 "Procedures for Handling and Chemical Analysis of Sediment and Water Samples" were followed during testing. The CEC of a soil is a measure of the cations (positive charged ions) reversibility capacity from the surface of the crystalline matrix of a mineral. These cations may be released into the water table under appropriate conditions. CEC tests were generally performed on the jar sample from the first sample tube in each boring. Detailed chemical test procedures and results are included in Appendix E.

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

| Major Divisions | | | Group Symbols | Typical Names | Field Identification Procedures (Excluding particles larger than 3 in and basing fractions on estimated weights) | Information Required for Describing Soils | Laboratory Classification Criteria |
|---|---|---|---|---|---|---|---|
| 1 | 2 | | 3 | 4 | 5 | 6 | 7 |
| Coarse-grained Soils: More than half of material is larger than No. 200 sieve size. | Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size) | Clean Gravels (Little or no fines) | GW | Well-graded gravels, gravel-sand mixtures, little or no fines. | Wide range in grain sizes and substantial amounts of all intermediate particle sizes. | For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics. | $C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | GP | Poorly graded gravels or gravel-sand mixtures, little or no fines. | Predominantly one size or a range of sizes with some intermediate sizes missing. | | Not meeting all gradation requirements for GW |
| | | Gravels with Fines (Appreciable amount of fines) | GM | Silty gravels, gravel-sand-silt mixtures. | Nonplastic fines or fines with low plasticity (for identification procedures see ML below). | Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses. | Atterberg limits below "A" line or PI less than 4 |
| | | | GC | Clayey gravels, gravel-sand-clay mixtures. | Plastic fines (for identification procedures see CL below). | | Atterberg limits above "A" line with PI greater than 7 |
| | Sands: More than half of coarse fraction is smaller than No. 4 sieve size | Clean Sands (Little or no fines) | SW | Well-graded sands, gravelly sands, little or no fines. | Wide range in grain size and substantial amounts of all intermediate particle sizes. | Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM). | $C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | SP | Poorly graded sands or gravelly sands, little or no fines. | Predominantly one size or a range of sizes with some intermediate sizes missing. | | Not meeting all gradation requirements for SW |
| | | Sands with Fines (Appreciable amount of fines) | SM | Silty sands, sand-silt mixtures. | Nonplastic fines or fines with low plasticity (for identification procedures see ML below). | | Atterberg limits below "A" line or PI less than 4 |
| | | | SC | Clayey sands, sand-clay mixtures. | Plastic fines (for identification procedures see CL below). | | Atterberg limits above "A" line with PI greater than 7 |
| | | | | | Identification Procedures on Fraction Smaller than No. 40 Sieve Size: Dry Strength (Crushing characteristics) / Dilatancy (Reaction to shaking) / Toughness (Consistency near PL) | | |
| Fine-grained Soils: More than half of material is smaller than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye. | Silts and Clays: Liquid limit is less than 50 | | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. | None to slight / Quick to slow / None | For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions. | Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5% GW, GP, SW, SP; More than 12% GM, GC, SM, SC; 5% to 12% Borderline cases requiring use of dual symbols. |
| | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. | Medium to high / None to very slow / Medium | | |
| | | | OL | Organic silts and organic silty clays of low plasticity. | Slight to medium / Slow / Slight | | |
| | Silts and Clays: Liquid limit is greater than 50 | | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. | Slight to medium / Slow to none / Slight to medium | Give typical name; indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses. | |
| | | | CH | Inorganic clays of high plasticity, fat clays. | High to very high / None / High | | |
| | | | OH | Organic clays of medium to high plasticity, organic silts. | Medium to high / None to very slow / Slight to medium | Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML). | |
| Highly Organic Soils | | | Pt | Peat and other highly organic soils. | Readily identified by color, odor, spongy feel and frequently by fibrous texture. | | |

Use grain-size curve in identifying the fractions as given under field identification.




PLASTICITY CHART

For laboratory classification of fine-grained soils

(2) All sieve sizes on this chart are U. S. standard

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the sieve No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

**Dilatancy (reaction to shaking)**

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil stiff but not sticky.

While the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

**Dry Strength (crushing characteristics)**

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

**Toughness (consistency near plastic limit)**

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line. Highly organic clays have a very weak and spongy feel at the plastic limit.

Figure 13. Unified Soil Classification System (USCS)

## PART IV: DISPOSAL SITES

### Mustard Gas Burial Grounds

#### Location

The Mustard Gas Burial Grounds are located in the SE¼ NW¼ SW¼, Sec. 24, T4N, R4W (Figure 4). The area is enclosed by a fence and lies on a slight northwesterly slope. Five monitoring wells were installed around the Mustard Gas Burial Grounds and their locations are shown in Figure 14.

#### Geology

Overburden at this site ranges in thickness from 1 to 10 ft. The underlying rock consists of sandstone and shale from the Mansfield Formation of the Raccoon Creek Group (Table 1). Boring WES-1-2-81 was drilled to a depth of 22.8 ft and, underlying the overburden, encountered 14.5 ft of a light brown, uniform, fine-grained, quartz sandstone which changes to a very fine-grained, grey sandstone with shale lenses at a depth of about 16 ft. This material gradually grades into a dark grey to black, soft, sandy shale with sandstone lenses at a depth of 19 ft. Cross section A-A' (Figure 15) shows boring and groundwater data from three borings. The boring logs are presented in Appendixes A and B.

#### Groundwater

Groundwater at the Mustard Gas Burial Grounds was encountered in fractures in the sandstone. Between the up gradient and down gradient monitoring wells, groundwater elevations range from 658 to 652 ft MSL, a difference of 6 ft. A groundwater contour map constructed from water measurements of 29 November 1981, shows flow to be in a northerly direction (see Figure 16). Groundwater data are presented in Appendix D.

#### Physical and chemical test

Laboratory classification of soil samples ranged from clayey sand (SC) to clay (CL). These soils are brown to reddish brown. Soil permeability for a clay soil (sample 1, boring 5) was calculated to be $1.72 \times 10^{-4}$ cm/sec and this soil composes 86 percent of the soil samples obtained from this site. Appendix E presents the physical and chemical tests results.

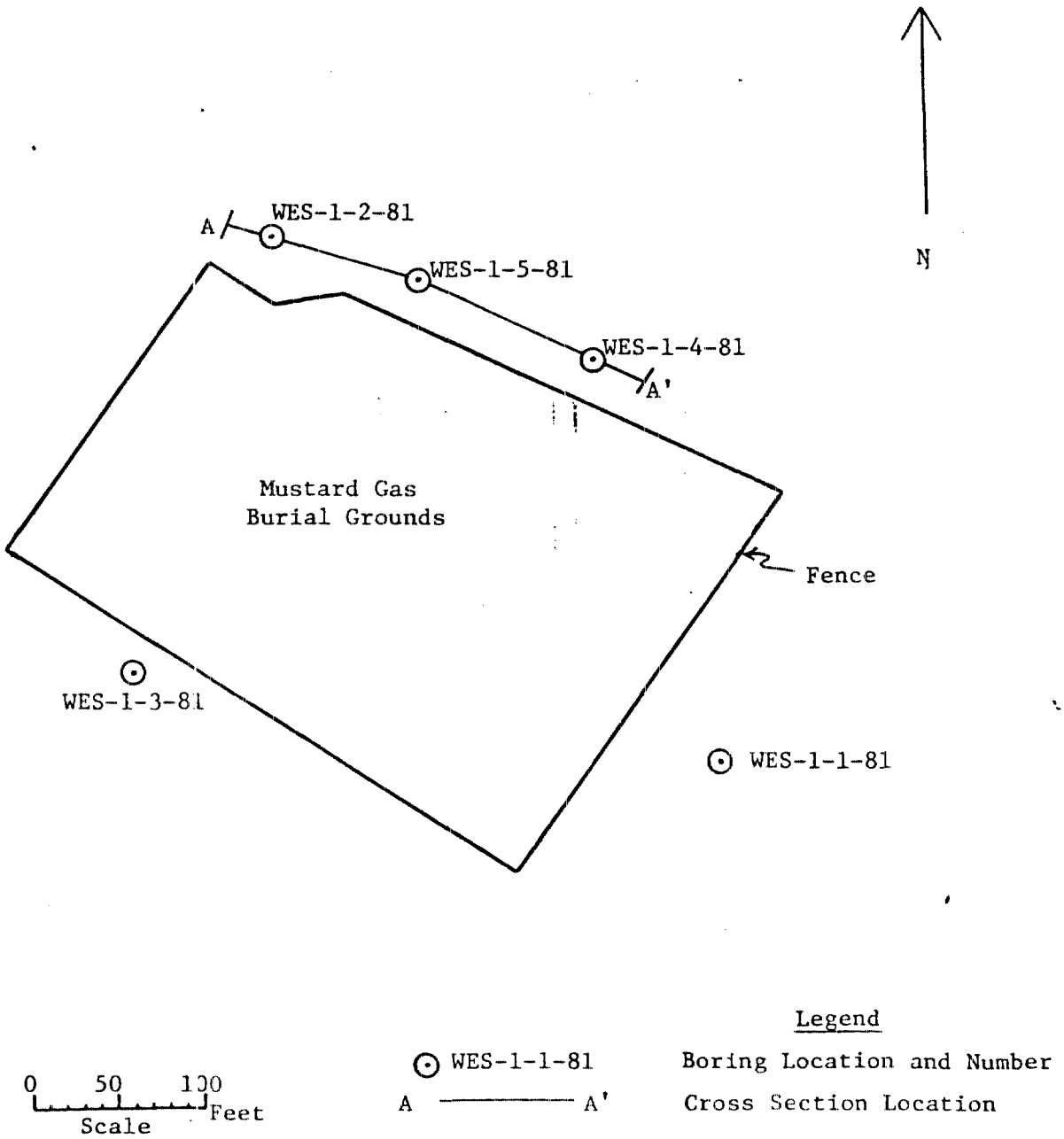



Figure 14. Well Locations and Cross Section Location of Mustard Gas Burial Grounds.

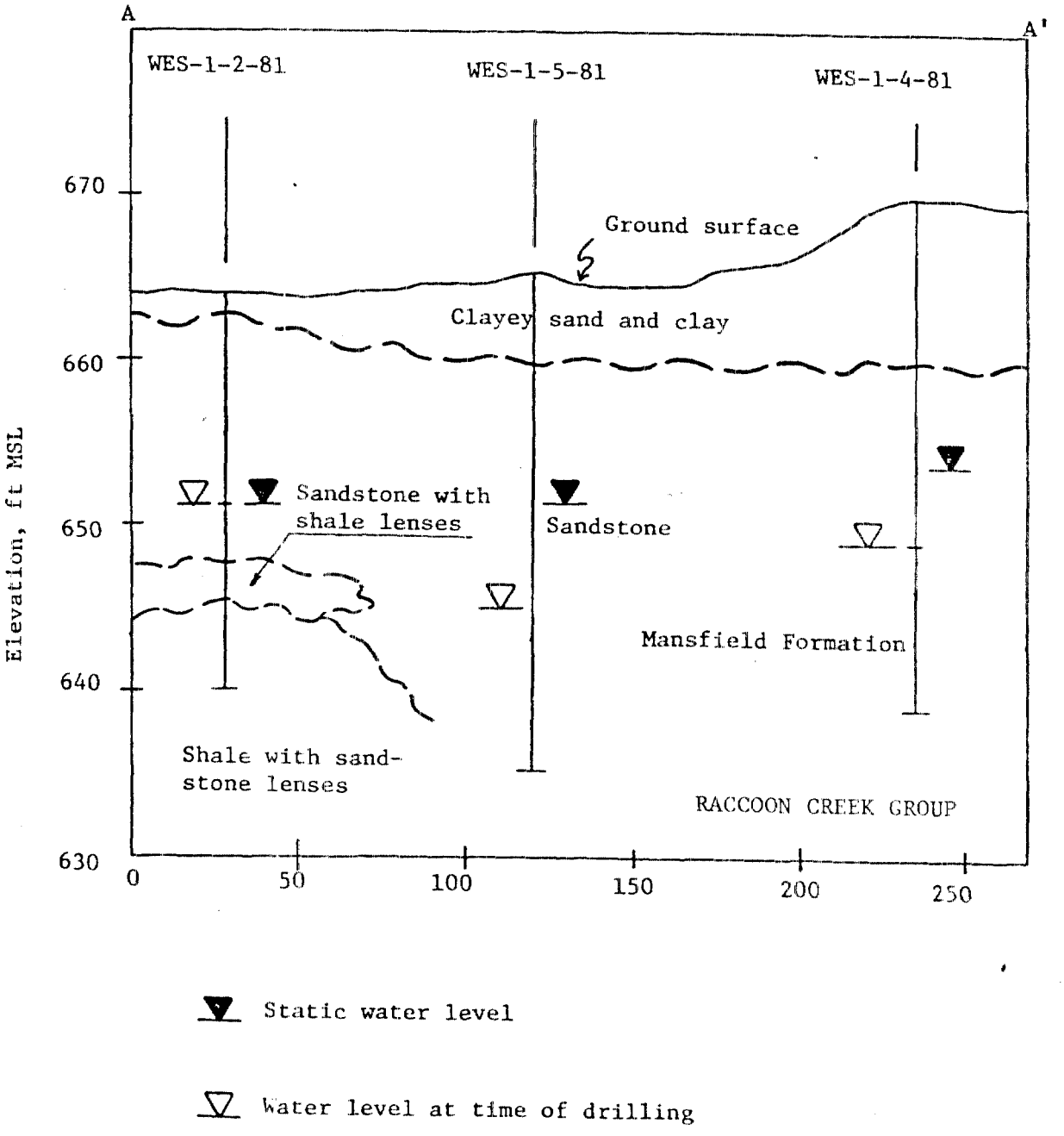



Figure 15. Geological Cross Section A-A' of Mustard Gas Burial Grounds.

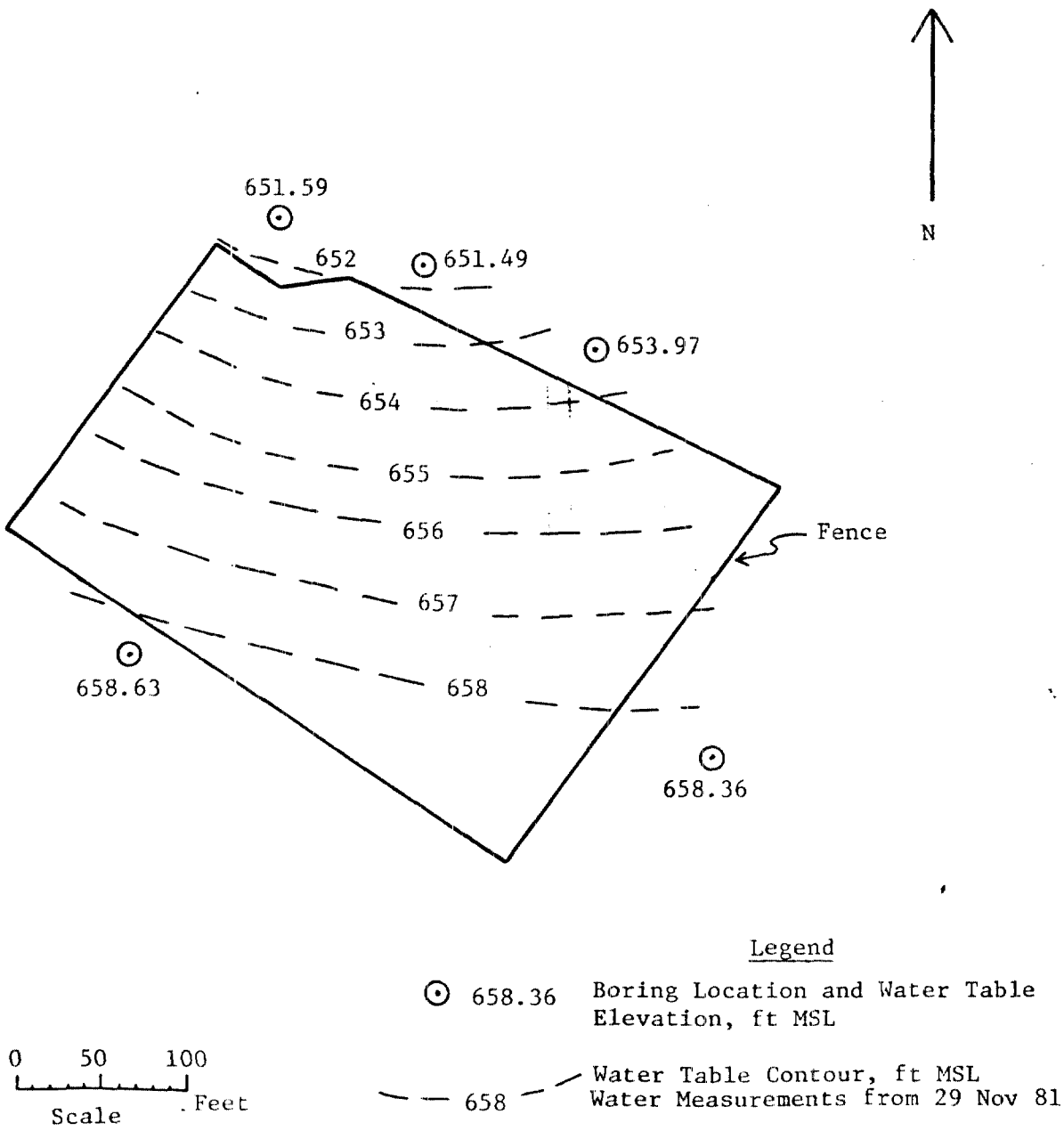



Figure 16. Water Table Contour Map of Mustard Gas Burial Grounds.

## Dye Burial Grounds

### Location

The Dye Burial Grounds are located in the SW¼ SE¼, Sec. 21, T5N, R3W (Figure 4). They are located on a ridgetop southwest of Magazine 1518 where eight monitoring wells were installed around the perimeter of the disposal site. Well locations and the approximate limits of the burial site are shown in Figure 17.

### Geology

Overburden at the Dye Burial Grounds ranges in thickness from 2 to 10 ft. The underlying rock consists of interbedded shale and sandstone from the Mansfield Formation of the Raccoon Creek Group and the Glen Dean Limestone of the Stephensport Group (Table 1). Boring WES-2-2-81 was drilled to a depth of 54.5 ft and, underlying the overburden, encountered approximately 42 ft of sandstone ranging from brown, orange, and red to various shades of grey. This sandstone unit was composed of a very fine to fine-grained quartz sand thinly bedded with seams and lenses of dark grey, soft shale and minor amounts of clay and lignite. The shale content gradually increases with depth beginning around 35 ft and grades into a green, uniform, soft, brittle shale at a depth of around 51 ft. Boring WES-2-3-81 drilled through this shale unit which was 12 ft thick and encountered 8 ft of red to purple, fine-grained sandstone underlain by the Glen Dean Limestone. This limestone was very hard and grey. Cross section A-A' (Figure 18) shows boring and groundwater data from six borings. The boring logs are presented in Appendixes A and B.

### Groundwater

Groundwater at the Dye Burial Grounds was encountered in fractures in the upper sandstone unit in all borings except boring WES-2-3-81. Groundwater in this boring was encountered near the shale and lower sandstone contact. Boring WES-2-1-81 encountered a perched water table in the upper sandstone unit. This perched water table resulted from either a localized lithological change or from little to no fracturing in the underlying rock. Between the up gradient and down gradient monitoring wells, groundwater elevations range from 684 to 678 ft MSL, a difference of 6 ft. A groundwater contour map constructed from water measurements of 11 November 1981, shows flow to be in a westerly direction (see Figure 19). Monitoring well WES-2-1-81 was not used in constructing the water table map. Groundwater data are presented in Appendix D.

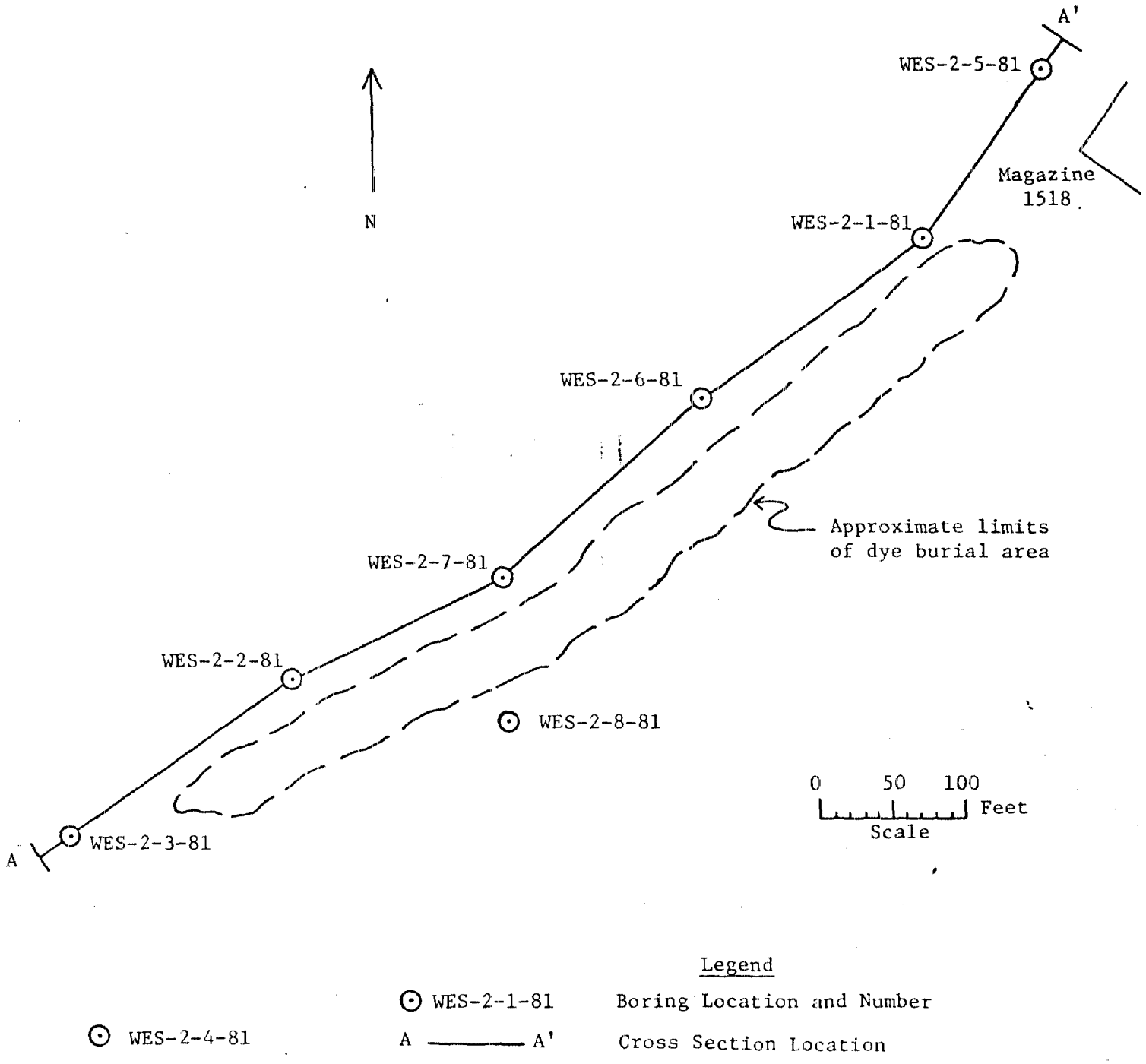



Figure 17. Well Locations and Cross Section Location of Dye Burial Area.

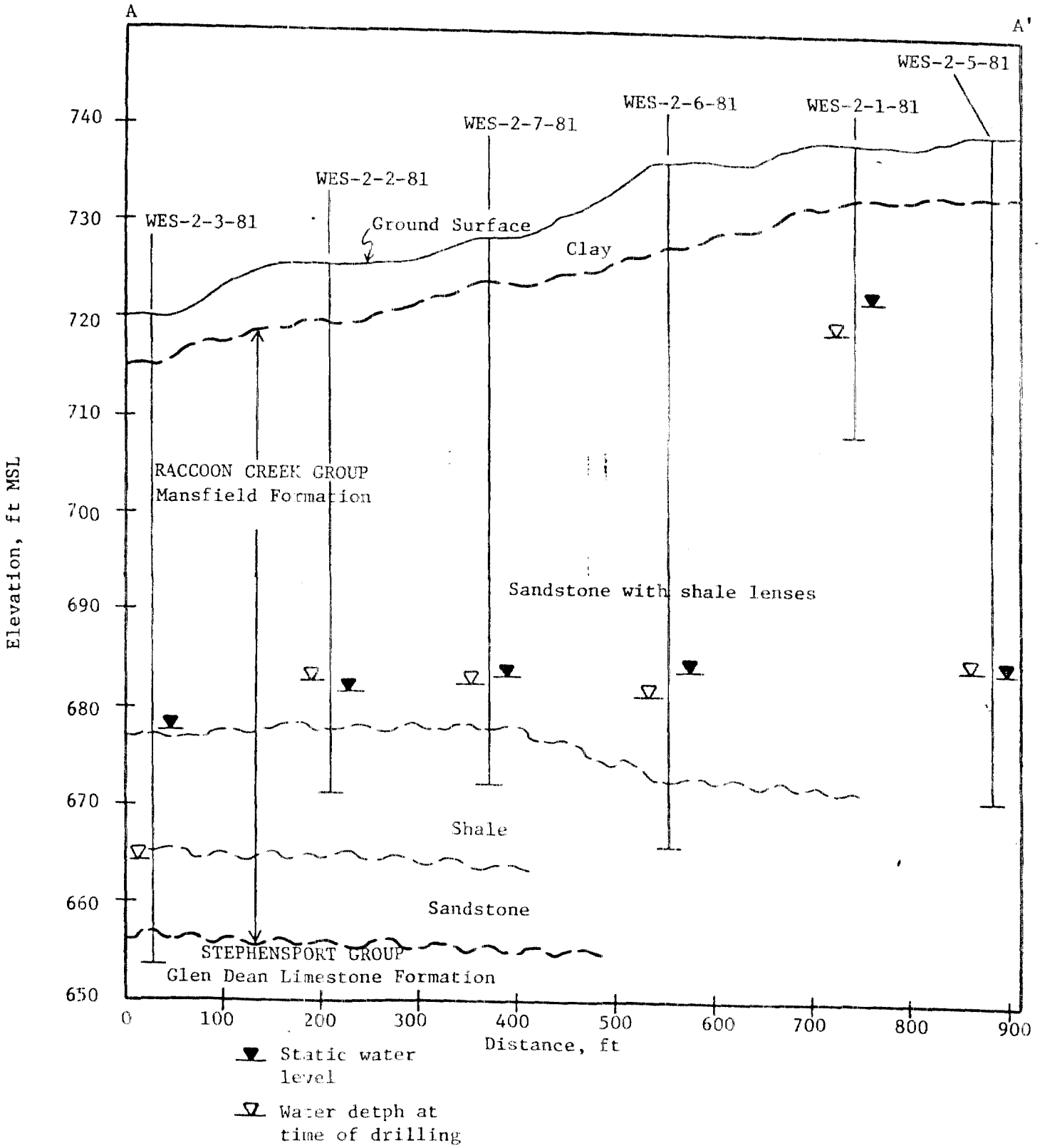



Figure 18. Geological Cross Section A-A' of Dye Burial Grounds

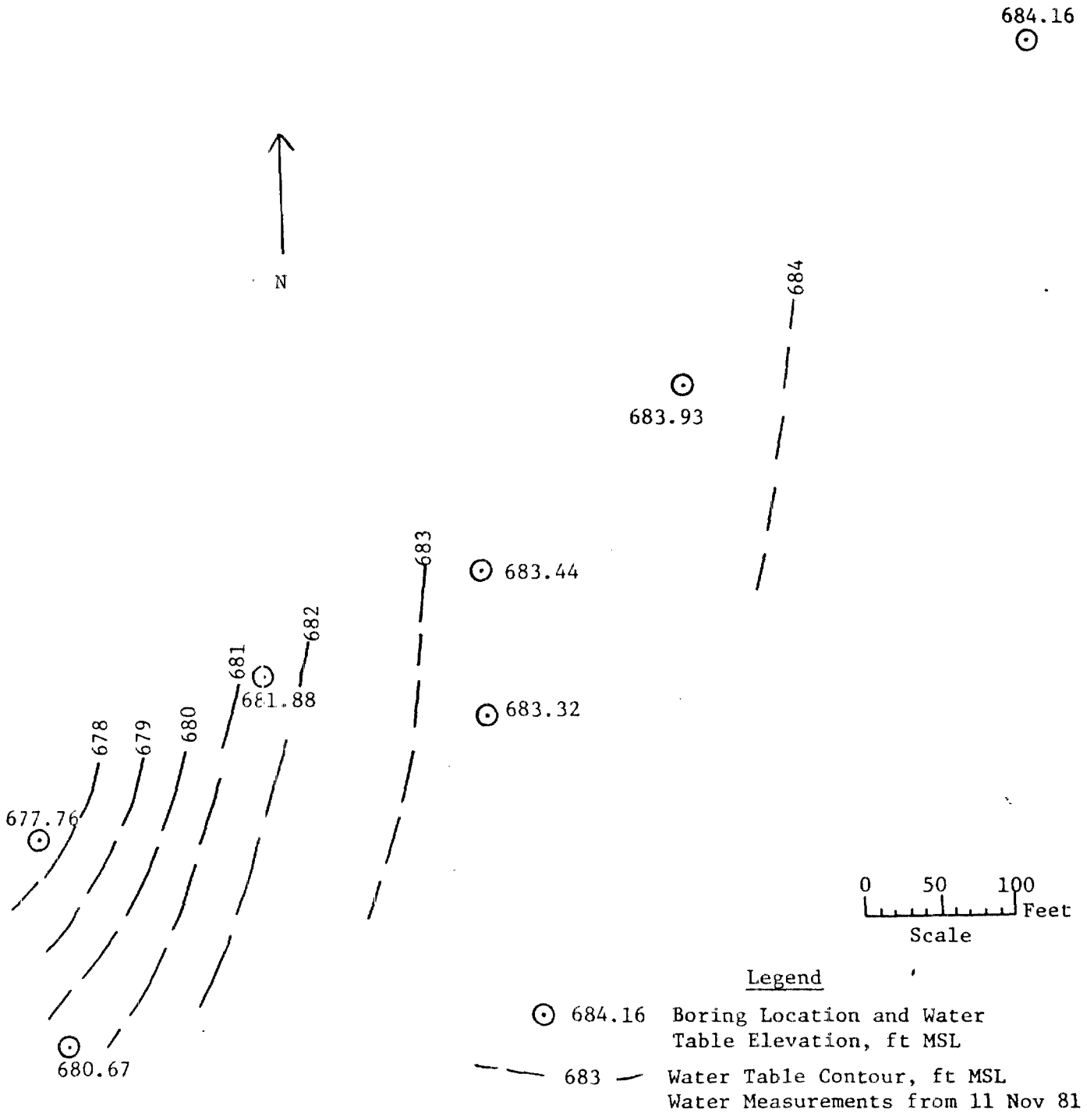



Figure 19. Water Table Contour Map of Dye Burial Grounds.

Physical and chemical test

Laboratory classification of soil samples yielded a clay (CL) soil type for the entire disposal site. This soil ranges from shades of brown to tan. Permeability tests on samples 1, 2, and 2 from borings 2, 6, and 8, respectively, yielded a permeability value ranging from $3.86 \times 10^{-5}$ to $5.98 \times 10^{-8}$ cm/sec. Appendix E presents the physical and chemical test results.

## Ammunition Burning Grounds

Location

The Ammunition Burning Grounds are located in the N½ NW¼ NW¼, Sec. 28, T5N, R3W (Figure 4). Eight monitoring wells were installed within the Ammunition Burning Grounds Valley (Figure 20) and monitoring well WES-3-7-81 was installed approximately ½ mile southeast of Building 2908 (Ammunition Burning Grounds Field Office) along Jeep Trail 25 (Figure 21). Monitoring well WES-3-7-81 is located in an area reported to have been used for disposal operations and lies adjacent to a small stream draining into the Little Sulphur Creek further south.

Geology

Overburden at the Ammunition Burning Grounds ranges in thickness from 3 to around 11 ft. The underlying rock consists of sandstone, limestone, and shale from the Hardinsburg, Golconda Limestone, Big Clifty, and Beech Creek Limestone Formations of the Stephensport Group; and shale and sand lenses from the Elwren Formation of the West Baden Group (Table 1). Boring WES-3-3-81 was drilled to a depth of 100.6 ft and underlying the overburden encountered approximately 30 ft of weathered sandstone (Hardinsburg Formation). This sandstone is brown to grey and composed of fine-grained quartz sand containing very small iron nodules and lenses of clay. No core was recovered from a depth of 27 to 35 ft. Material from this interval was either a loose sand or a very weathered sandstone. At a depth of 35 ft, the core changes to a hard, grey, dense, fine-grained, fossiliferous limestone (Golconda Limestone Formation) which grades into a green to dark grey, soft shale (Big Clifty Formation) at a depth of 46 ft. This shale unit at a depth of 60 ft changes to a grey, hard, dense limestone (Beech Creek Limestone Formation) which is thinly bedded

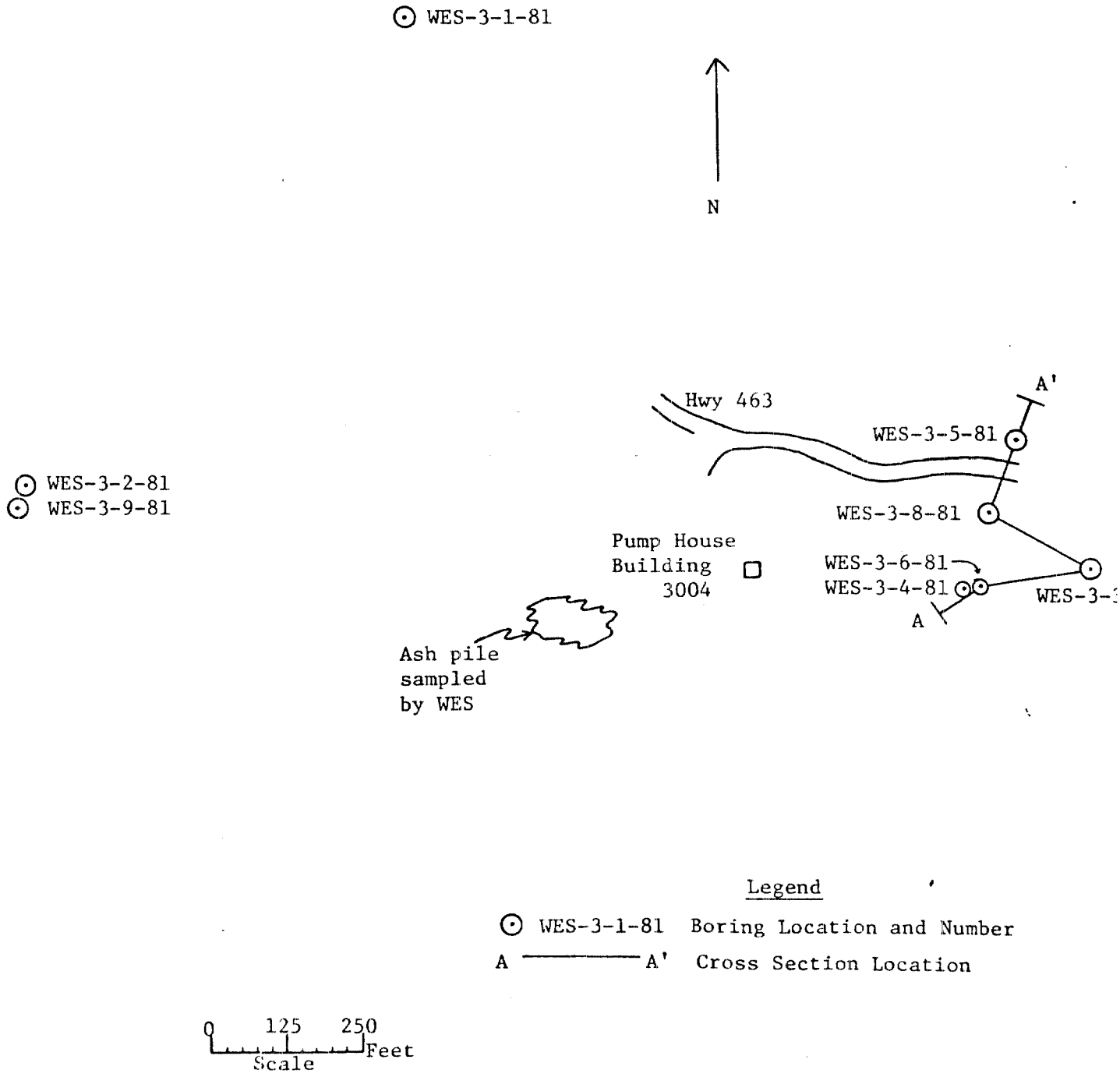



Figure 20. Well Locations and Cross Section Location of Ammunition Burning Grounds

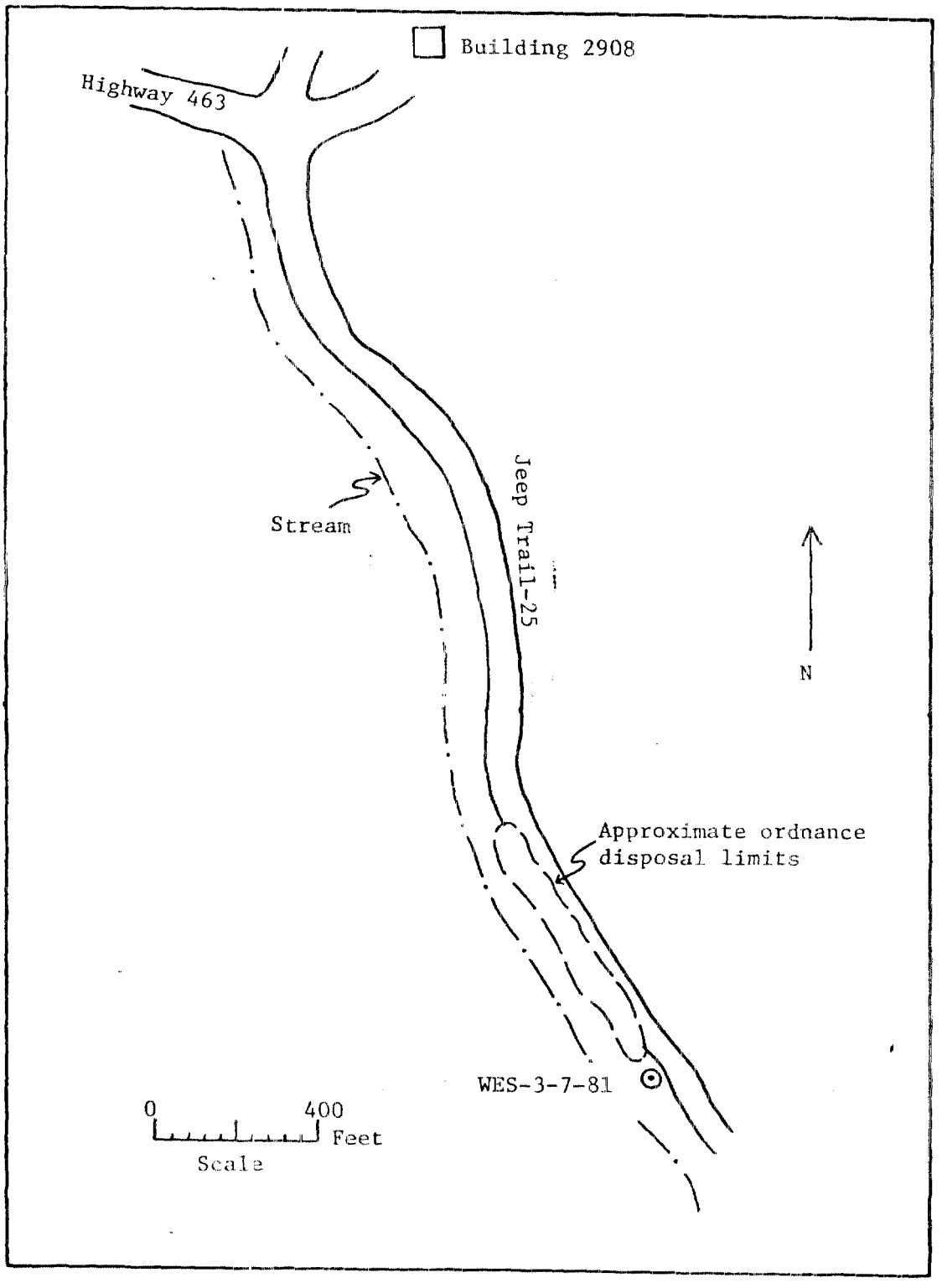



Figure 21. Ordnance Disposal Well Location Map for Boring WES-3-7-81

with soft, grey to green shale. At a depth of 71 ft, the core changes to a soft, uniform, dark grey to green shale which is interbedded with fine to medium-grained sand lenses beginning at a depth of 89 ft. Cross section A-A' (Figure 22) shows boring and groundwater data from four borings. The boring logs are presented in Appendixes A and B.

Groundwater

Groundwater at the Ammunition Burning Grounds was encountered in fractures near the contact of the Hardinsburg and Golconda Limestone Formations in all borings except WES-3-2-81 and WES-3-3-81. Boring WES-3-2-81 encountered water near the overburden-rock contact. Boring WES-3-9-81, located next to WES-3-2-81, was drilled through this perched water table and into the next saturated zone. Groundwater elevations between the up gradient and down gradient monitoring wells ranges from 559 to 546 ft MSL, a difference of 13 ft. A groundwater contour map constructed from water measurements of 29 November 1981, shows flow to be in a southeasterly direction (see Figure 23). Monitoring well WES-3-2-81 and WES-3-3-81 were not used in map construction because they were either above or below the primary saturated zone. Monitoring well WES-3-4-81 experienced problems during installation and was omitted from the groundwater contour map (see Appendix A and Appendix D for details). Groundwater data are presented in Appendix D.

Physical and chemical test

Laboratory classification of soil samples yielded the following soil types: clay sand-gravel (GC), clayey sand (SC) and clay (CL). These soils are brown to tan. Permeability tests were conducted on a clayey sand-gravel (sample 1, boring 5) and a clayey sand (sample 1, boring 4) and yielded permeability values ranging from $5.04 \times 10^{-5}$ to $4.69 \times 10^{-6}$ cm/sec for these respective soil types. Appendix E presents the physical and chemical tests results.

## McComish Gorge

Location

McComish Gorge is located a short distance from the Crane Gate at the northwest corner of the installation in NE¼ NE¼ NE¼, Sec. 7, T5N, R4W (Figure 4). Six monitoring wells were located along the perimeter of the disposal site and are shown in Figure 24.

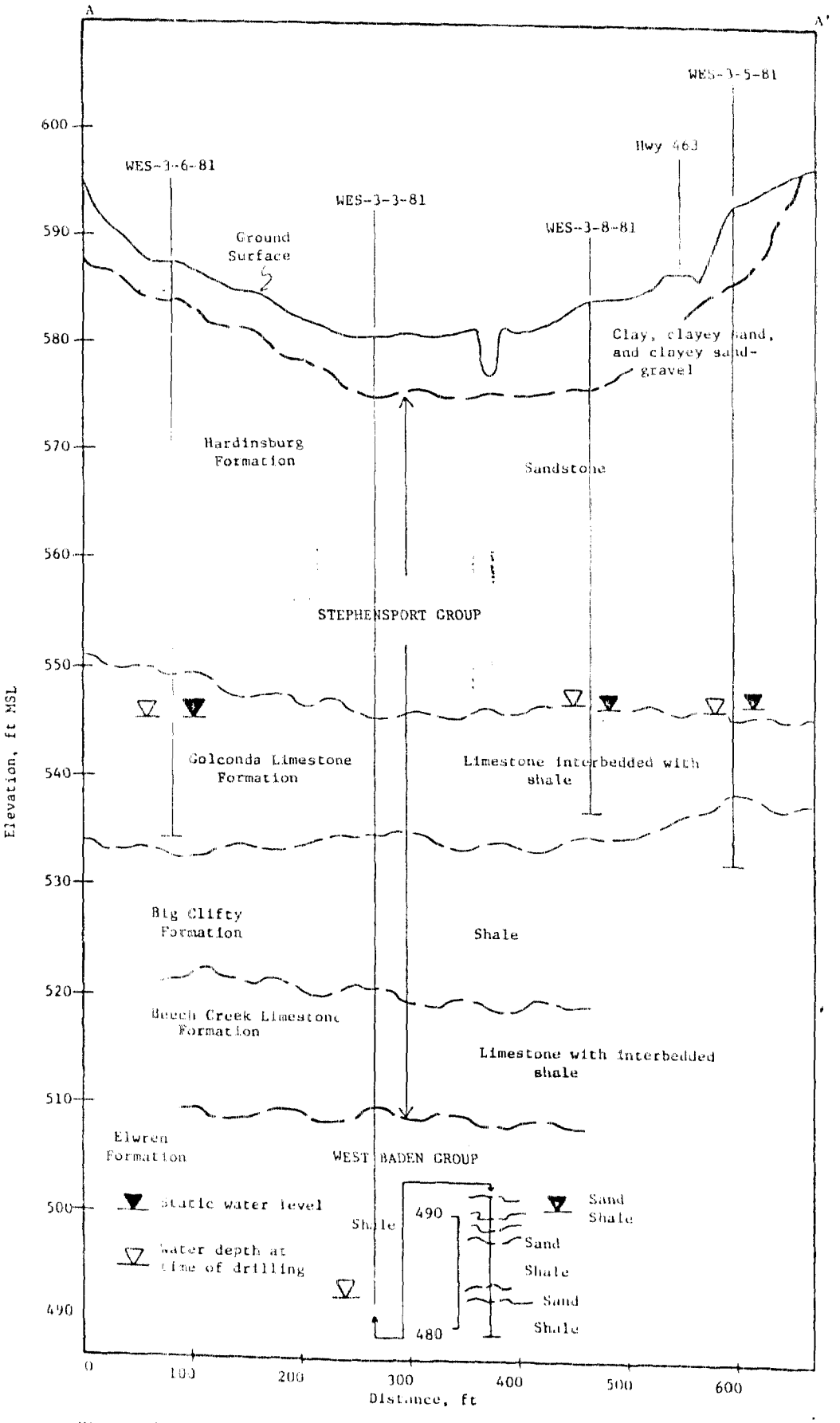
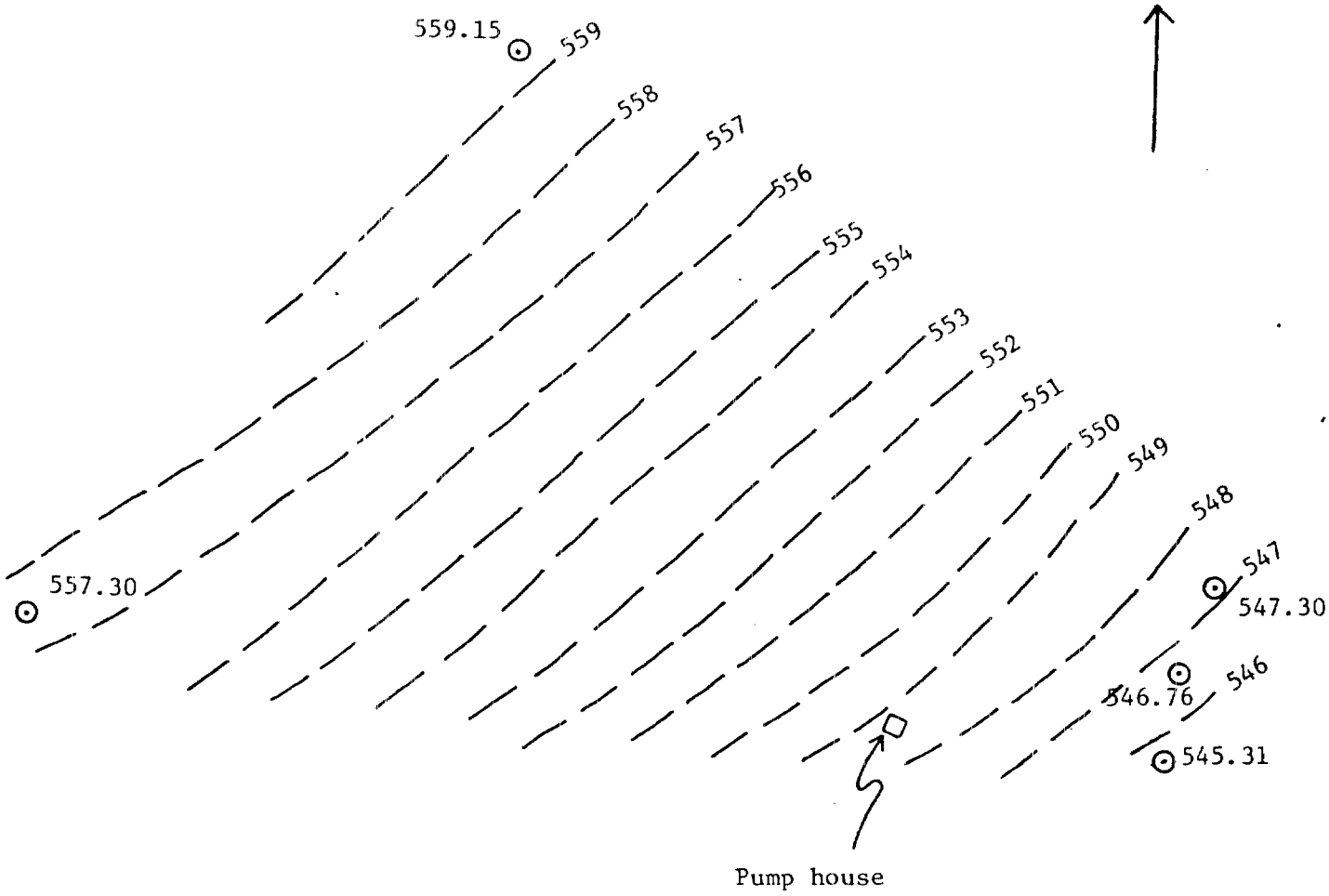



Figure 22. Geological Cross Section A-A' of Ammunition Burning Grounds



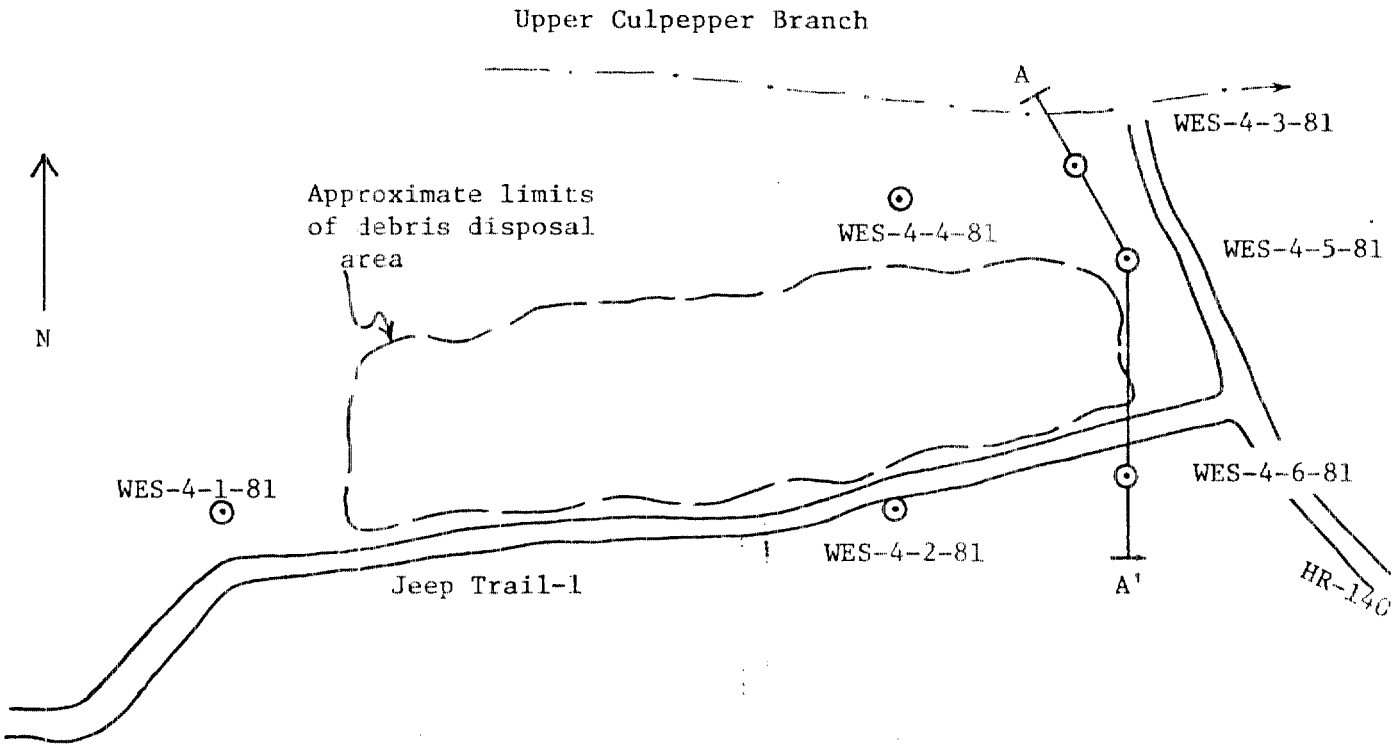

0 125 250 Feet
Scale

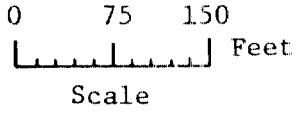
Legend

559.15 Boring Location and Water Table Elevation, ft MSL

551 Water Table Contour, ft MSL
Water Measurements from 29 Nov 81

Figure 23. Water Table Contour Map of Ammunition Burning Grounds




Legend

⊙ WES-4-1-81 Boring Location and Number

A ———— A' Cross Section Location

Figure 24. Well Locations and Cross Section Location of McComish Gorge

## Geology

McComish Gorge is composed of unconsolidated lacustrine deposits of clay, silt, and sand which are included in the Atherton Formation of the Illinoian and Wisconsinan Stage of the Pleistocene Series (Grey, Wayne, Wier, 1970). Cross section A-A' (Figure 25) shows boring and groundwater data from three borings. The boring logs are presented in Appendixes A and B.

## Groundwater

Groundwater at McComish Gorge was encountered in the overburden at relatively shallow depths. Between the up gradient and down gradient monitoring wells, groundwater elevations range from 573 to 563 ft MSL, a difference of 10 ft. A groundwater contour map constructed from water measurements of 29 November 1981, shows flow to be towards the northeast and east (see Figure 26). Groundwater data are presented in Appendix D.

## Physical and chemical test

Laboratory classification of 39 soil samples from McComish Gorge resulted in the following distribution: 23.1 percent clay (CL), 12.8 percent silt (ML), 20.5 percent clayey sand (SC), 28.2 percent silty sand (SM), 10.3 percent silty sand-sand (SP-SM), 2.6 percent sand-clayey sand (SP-SC), and 2.6 percent sand (SP). These soils are brown to reddish brown. Soil permeability for a silty sand (sample 7, boring 4) was calculated to be $3.99 \times 10^{-5}$ cm/sec. Appendix E presents the physical and chemical tests results.

# Old Burning Pit

## Location

The Old Burning Pit is located just north of the NWSC truck weigh station on Highway 5 and lies along the section line between Sec. 5 and 8, T5N, R4W (Figure 4). Eight monitoring wells were installed along the perimeter of the Old Burning Pit and the disposal area to the north as shown in Figure 27.

## Geology

The Old Burning Pit and adjacent dumping grounds are also included in the tongue of lacustrine deposits which comprise McComish Gorge (Grey, Wayne, Wier, 1970). These Pleistocene deposits consist of clay, silt, and sand. Boring and groundwater data are shown in cross section A-A' (Figure 28) from six borings. Boring information is presented in Appendixes A and B.

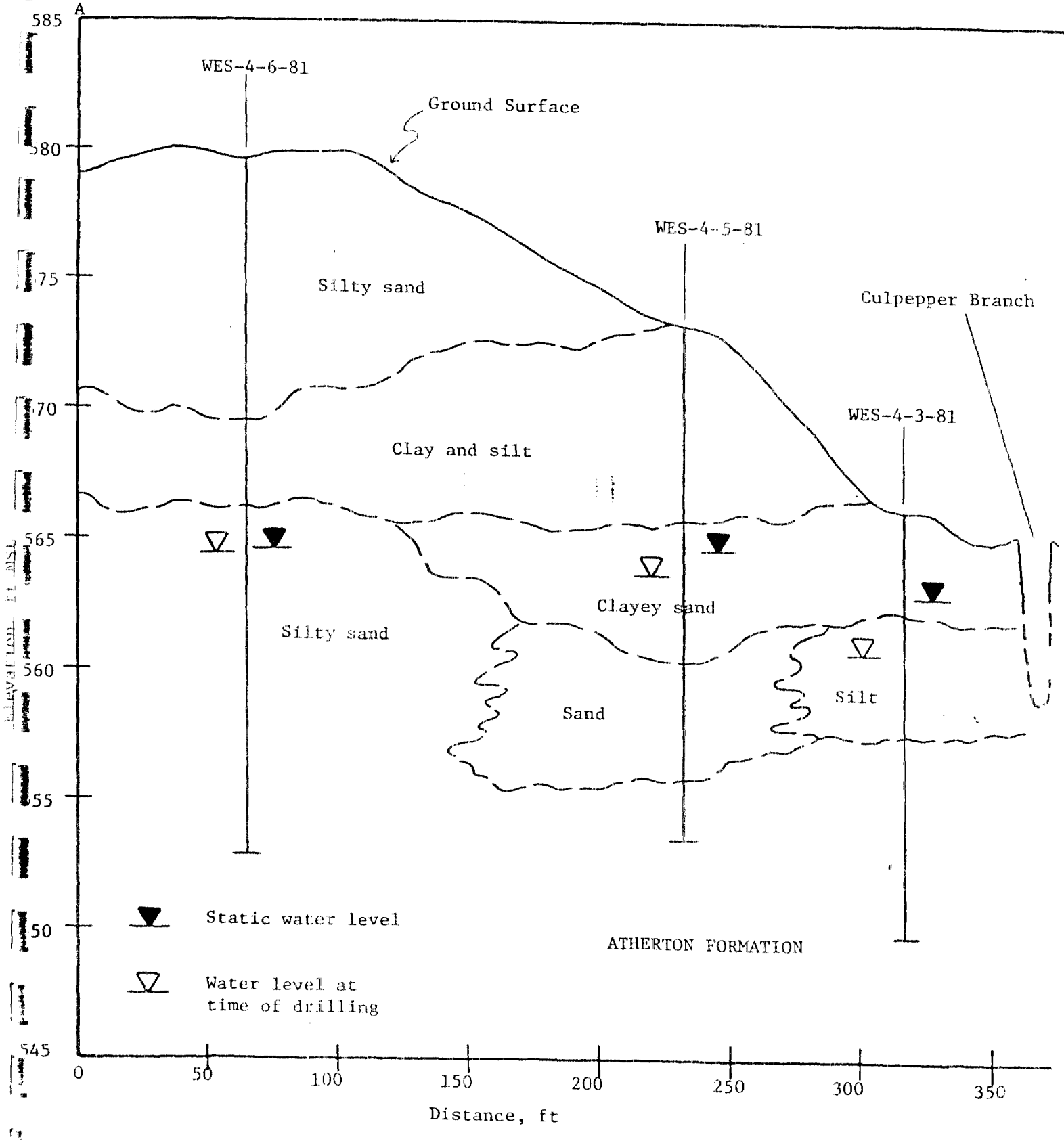



Figure 25. Geological Cross Section A-A' of McComish Gorge

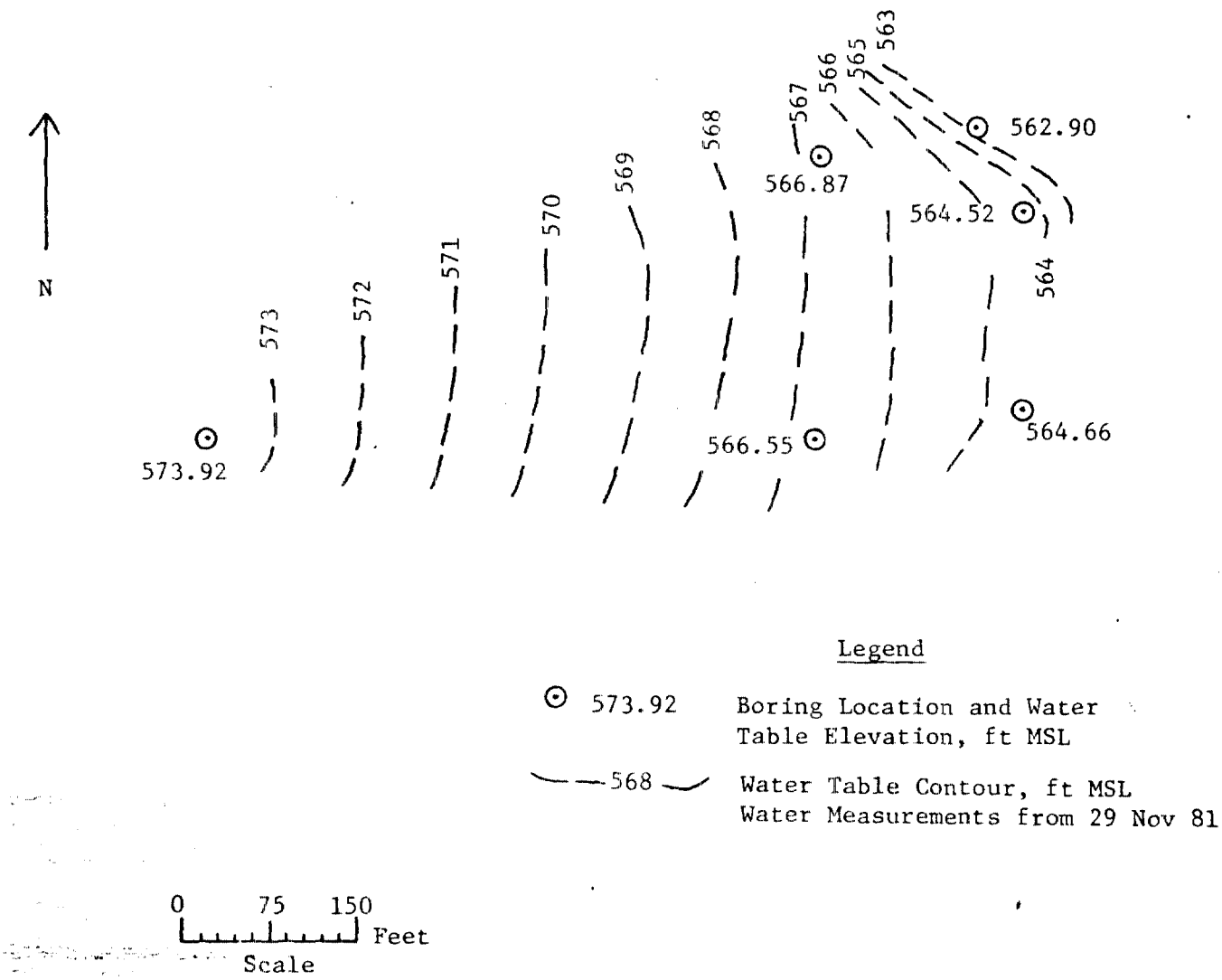



Figure 26. Water Table Contour Map of McComish Gorge

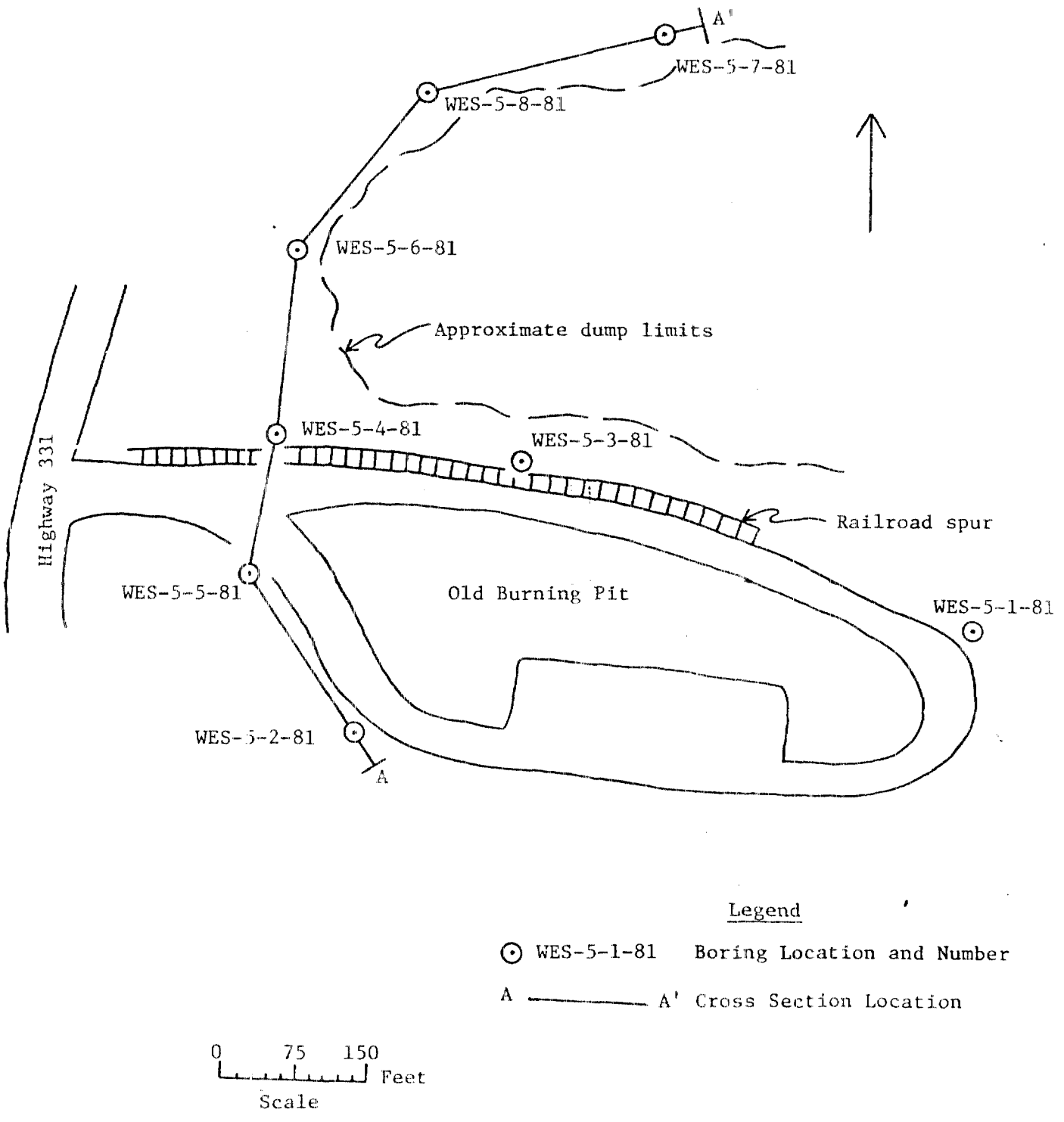



Figure 27. Well Locations and Cross Section Location of Old Burning Pit

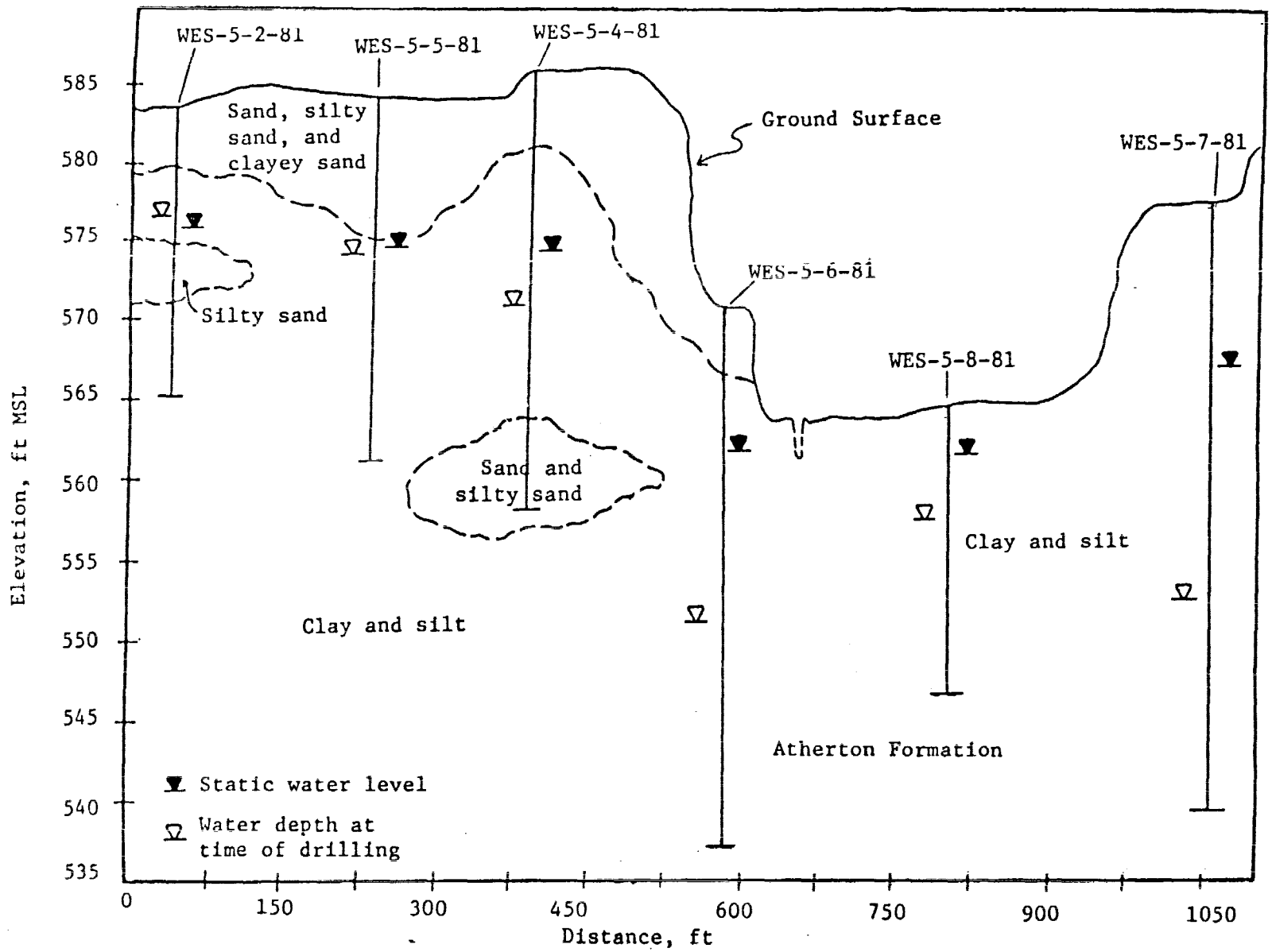



Figure 28. Geological Cross Section A-A' of Old Burning Pit

## Groundwater

Groundwater at the Old Burning Pit and adjacent dumping grounds was encountered at shallow depths. Between the up gradient and down gradient monitoring wells, groundwater elevations range from 591 to 561 ft MSL, a difference of 30 ft. A groundwater contour map constructed from water measurements of 29 November 1981, shows flow to be in a northwesterly direction (see Figure 29). Groundwater data are presented in Appendix D.

## Physical and chemical test

Laboratory classification of 40 soil samples resulted in the following soil distribution: 35 percent clay (CL), 22.5 percent clay-silt (CL-ML), 12.5 percent silt (ML), 12.5 percent clayey sand (SC), 5 percent silty sand (SM), 7.5 percent silty sand-sand (SP-SM) and 2.5 percent clayey sand-sand (SP-SC). These soils are brown to reddish brown. Soil permeability was calculated from samples 3, 6, and 3 of borings 3, 7, and 8, respectively, and ranged from $2.35 \times 10^{-5}$ to $8.05 \times 10^{-6}$ cm/sec. Appendix E presents the physical and chemical tests results.

# Demolition Area

## Location

The Demolition Area lies on two steep-sided ridgetops in SW¼, Sec. 26; SE¼, Sec. 27; NE¼, Sec. 34; and NW¼, Sec. 35; T5N, R4W (Figure 4). A total of 15 monitoring wells were installed at the Demolition Area with 7 monitoring wells along the south ridge, 5 monitoring wells along the east ridge, and 3 monitoring wells at the intersection of the two ridges as shown in Figure 30. The south ridge is used for disposal of military ordnance and contaminated insulation from production facilities was reported to have been buried along the east ridge.

## Geology

Overburden at the Demolition Area ranges in thickness from 2 to 13 ft. The underlying rock on both the south and east ridges consists of interfingered and interbedded sandstone, shale, and coal seams from the Mansfield Formation of the Raccoon Creek Group (Table 1). Core boring WES-6-2-81 along the south ridge was drilled to a depth of 39 ft and, underlying the overburden, encountered 3 ft of a weathered, brown, friable, fine-grained sandstone of which

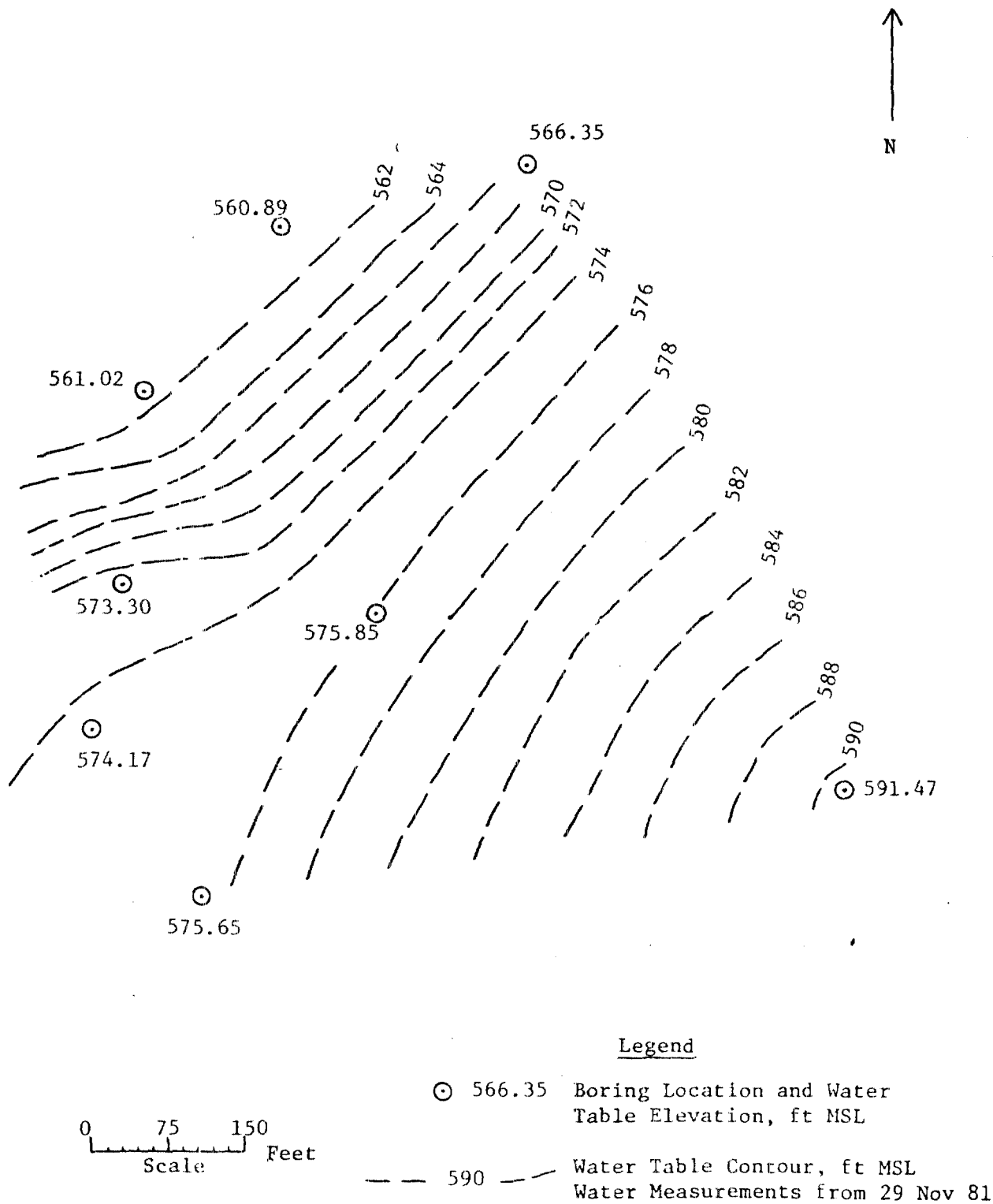



Figure 29. Water Table Contour Map of Old Burning Pit

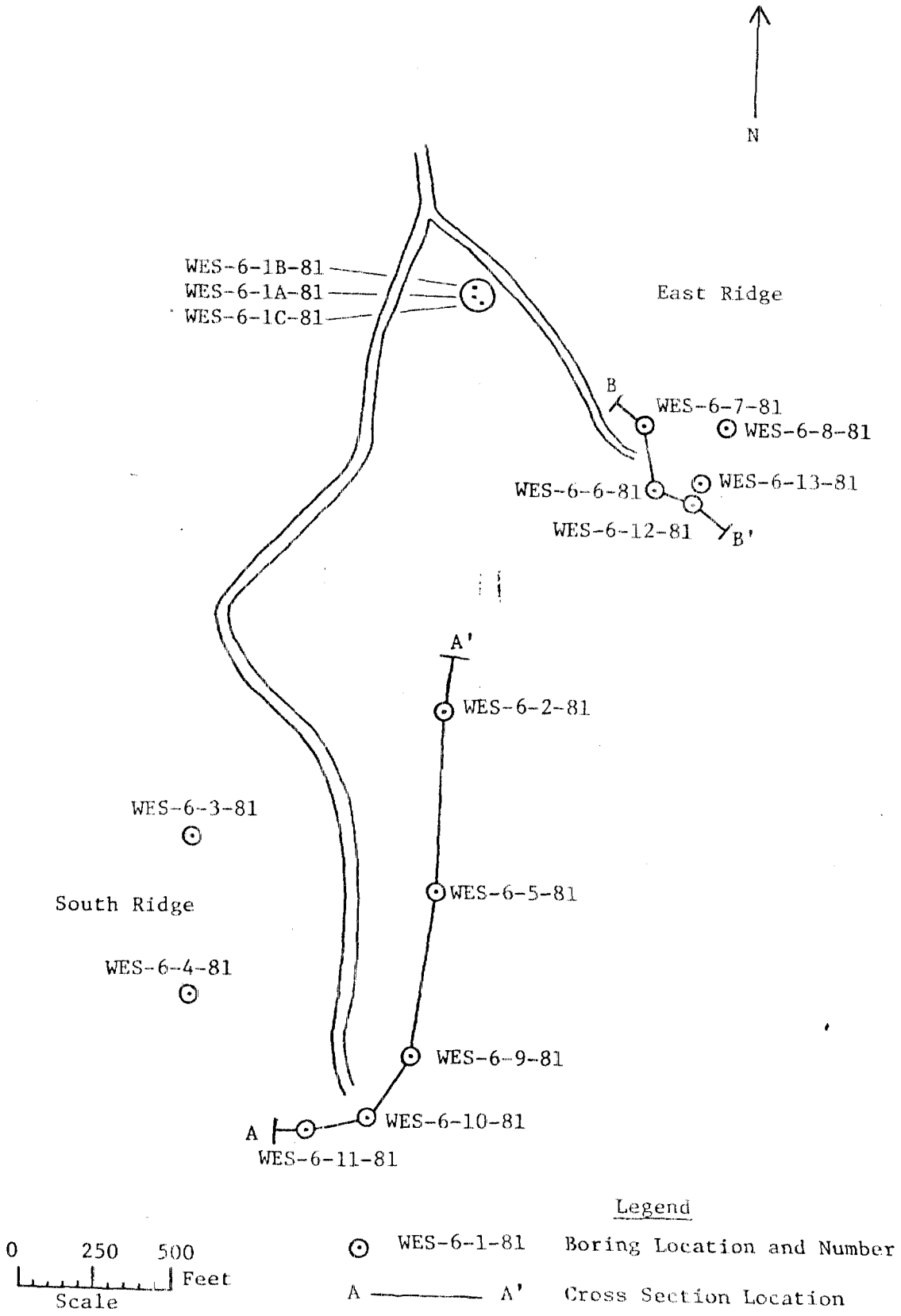



Figure 30. Well Locations and Cross Section Locations of Demolition Area

only partial sample recovery was made. This sandstone unit was underlain by about 2 ft of soft, grey to dark grey, partially organic shale which overlies 2.5 ft of brown, fine-grained, weathered, moderately friable sandstone containing approximately 20 percent thinly bedded shale seams. At a depth of 14 ft, the core grades into a 1-ft-thick bed of dark grey, soft, weathered, organic shale which is underlain by 18 ft of brown to grey, fine-grained, moderately hard sandstone containing 10 to 20 percent soft, black shale seams. At a depth of 34 ft, shale and sandstone are thinly interbedded in equal proportions. Core boring WES-6-7-81 along the east ridge was drilled to a depth of 29 ft and encountered a similar sequence of sedimentary materials. Beneath the overburden, 2 ft of brown to orange brown, weathered, friable, fine-grained quartz sandstone was encountered. This sandstone unit at a depth of 12 ft was underlain by 5 ft of soft, uniform, black shale which is underlain by approximately 1.5 ft of a black, soft, jointed coal. This coal seam was underlain by 10 ft of light to dark grey, very fine-grained shaley sandstone containing approximately 20 to 40 percent interbedded shale seams and lenses. Boring and groundwater data for the south ridge are shown in cross section A-A' (Figure 31) and for the east ridge, boring and groundwater data are shown in cross section B-B' (Figure 32). The boring logs are presented in Appendixes A and B.

Groundwater

Groundwater at the Demolition Area is flowing through fractures in a variety of rock types (see Figures 31 and 32). Groundwater elevations along the south ridge range from 648 to 595 ft MSL, a difference of 53 ft, while along the east ridge, groundwater elevations range from 645 to 630 ft MSL, a difference of 15 ft. Groundwater contour maps constructed from water measurements of 27 November 1981, shows flow on the south ridge to be in opposite directions off the ridge (Figure 33), while on the east ridge, flow is towards the southeast (Figure 34). Monitoring wells WES-6-1A, 1B, and 1C-81 were not used in contouring because all three wells are dry. The groundwater dropped below the screens in monitoring wells WES-6-1A and 1C-81 after several weeks after installation. Monitoring well WES-6-1B-81 never produced water even though water was present at time of drilling. The above three wells represent a nearly continuous screened interval from a depth of 4 ft to a depth of 39 ft. Groundwater data are presented in Appendix D.

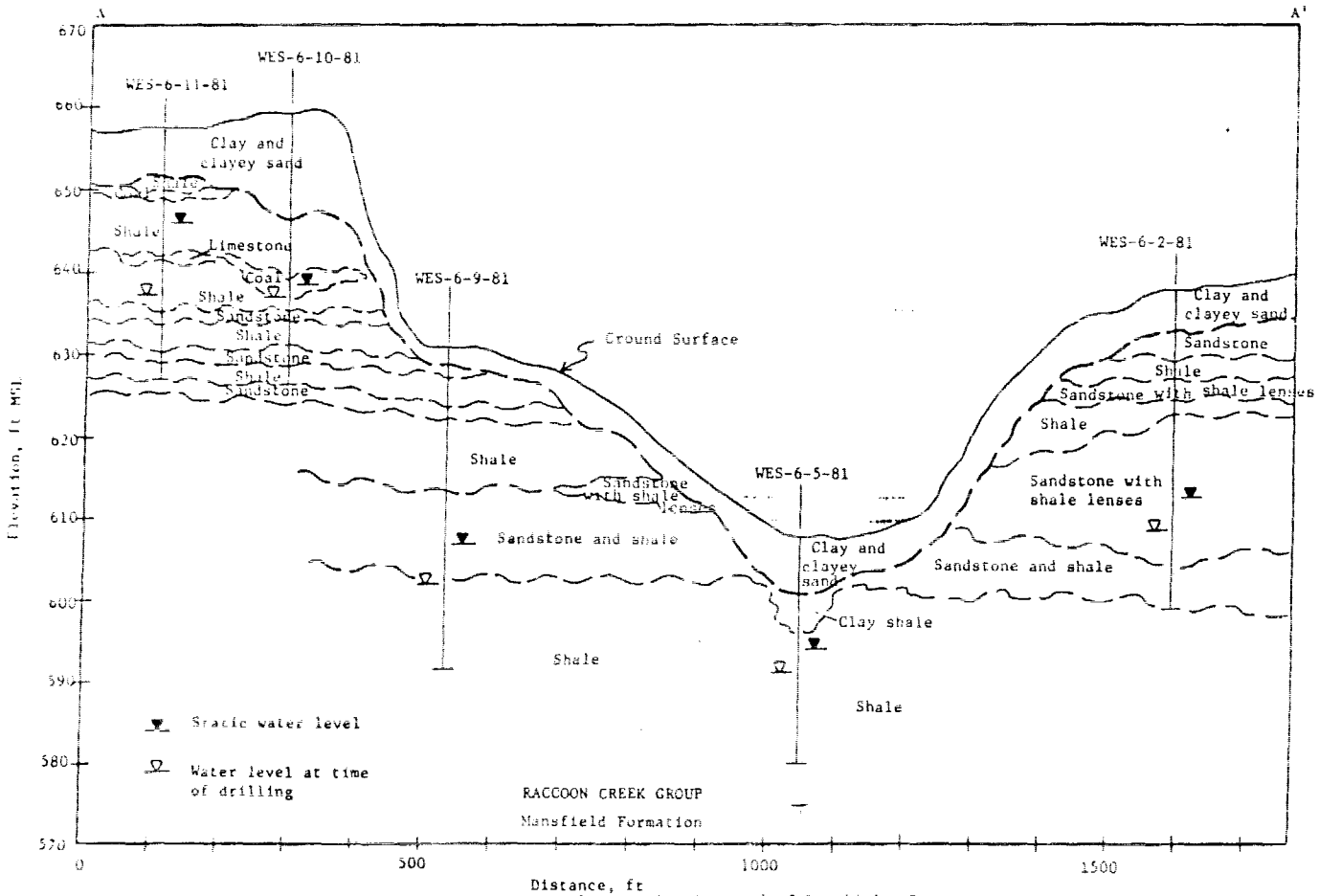



Figure 31. Geological Cross Section A-A' of Demolition Range.

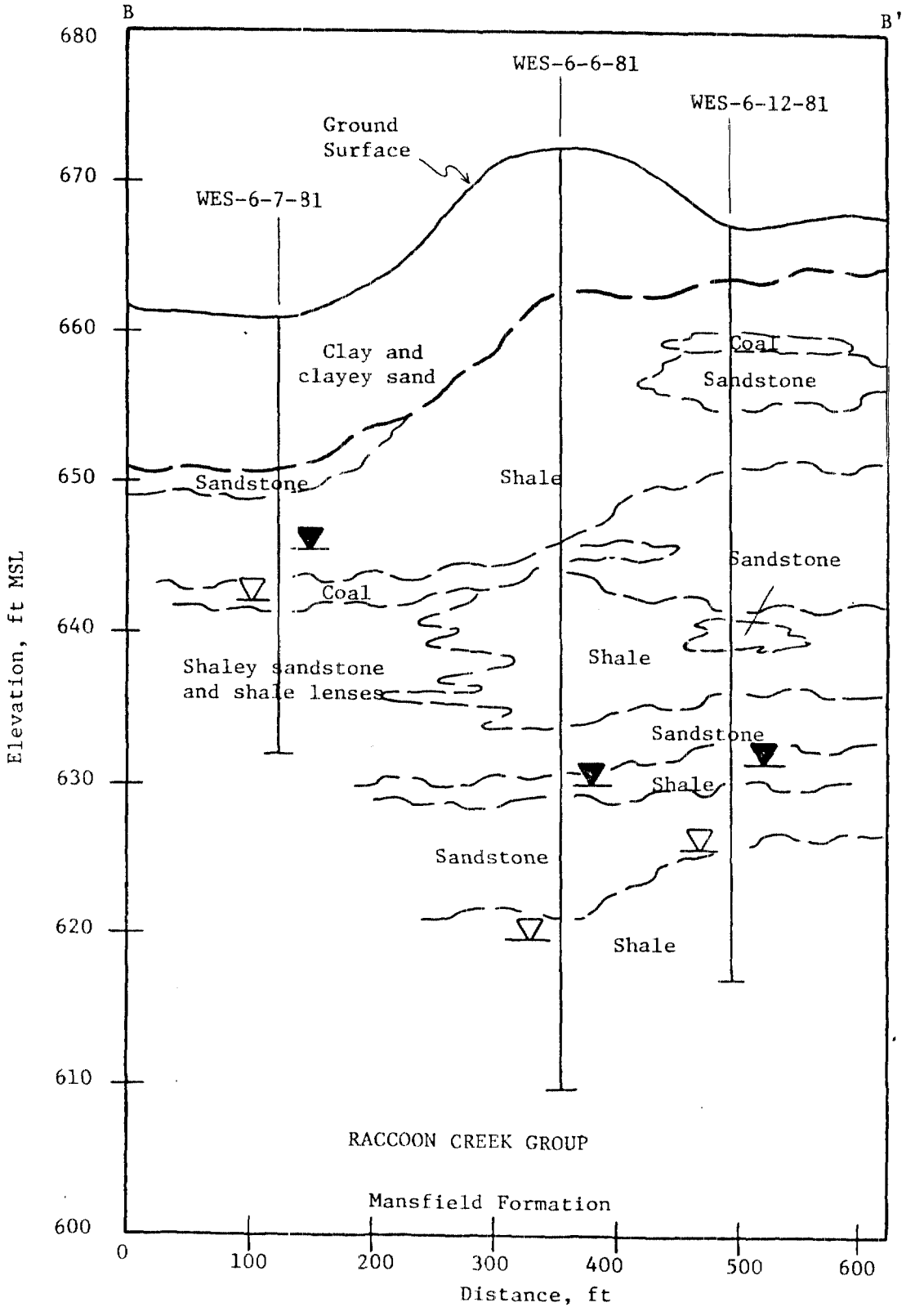



Figure 32. Geological Cross Section B-B' of Demolition Area

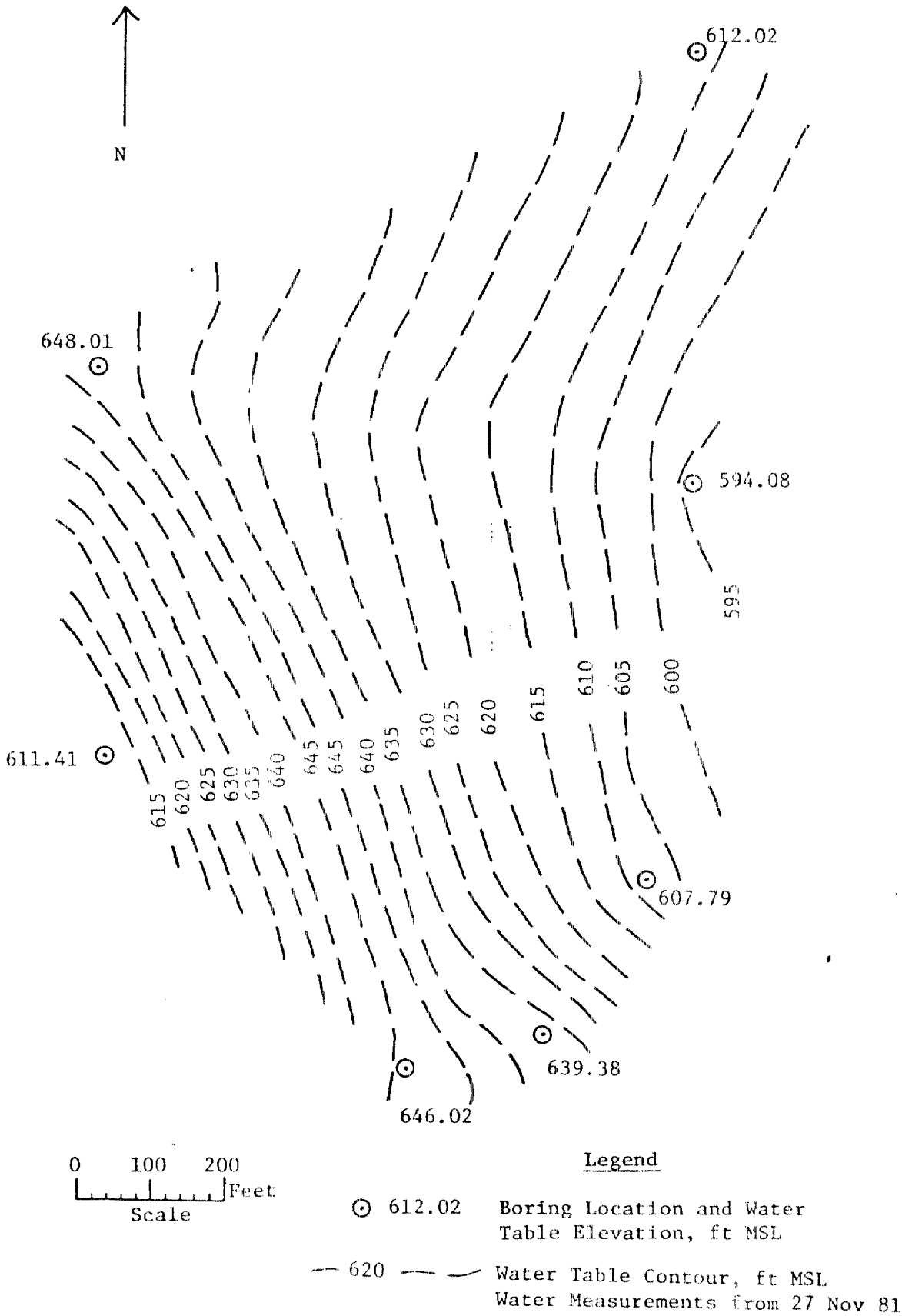



Figure 33. Water Table Contour Map of South Ridge of Demolition Area

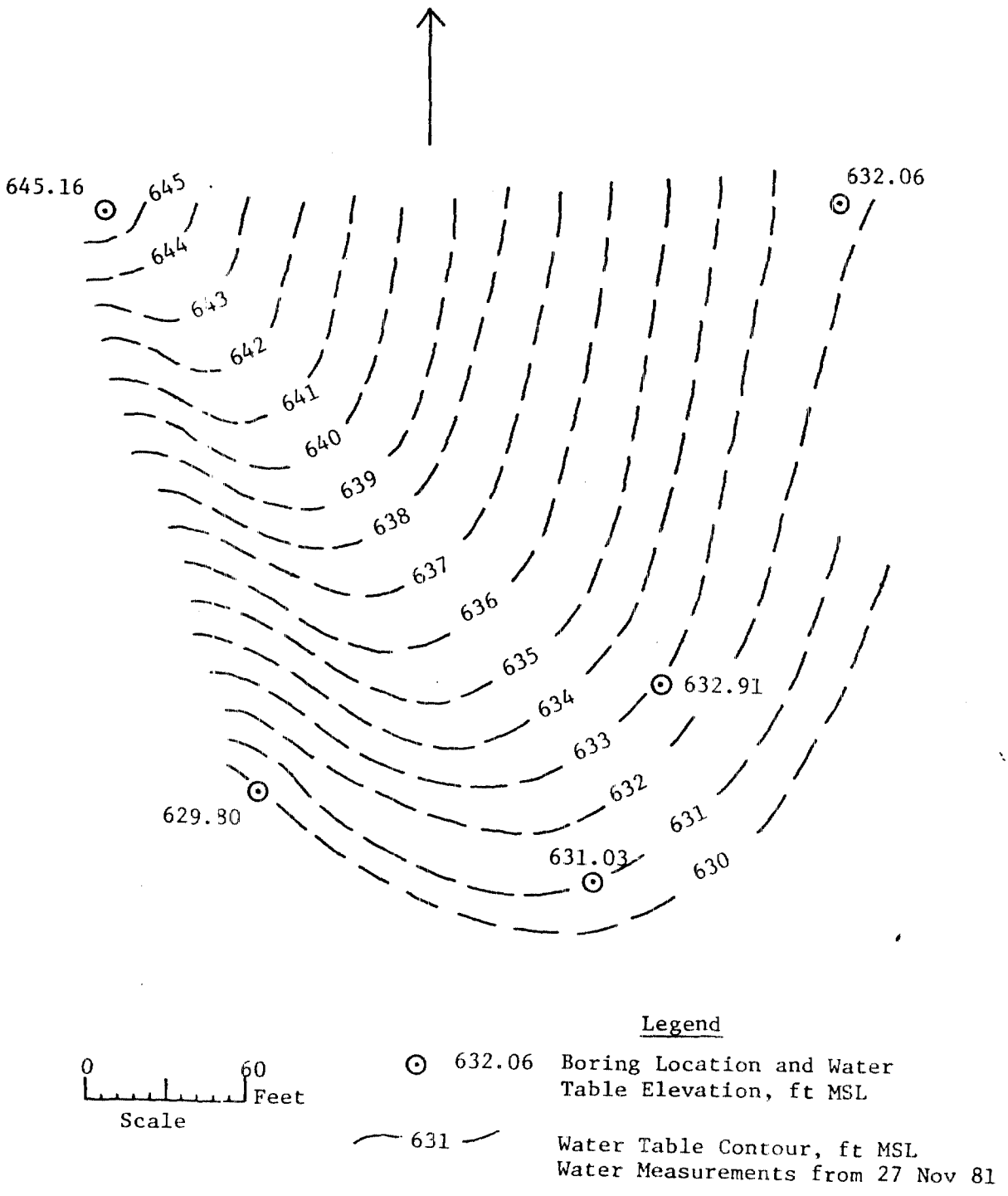



Figure 34. Water Table Contour Map of East Ridge of Demolition Area

Physical and chemical test

Laboratory classification of soil samples ranged from clay (CL and CH) to clayey sand (SC). These soils are light brown to greyish brown. Soil permeability ranges from 0.0 to $3.01 \times 10^{-8}$ cm/sec for a clay (CL) soil (sample 2, boring 10, and sample 1, boring 6) and this soil composes 79 percent of the soil samples from this site. Appendix E presents the physical and the chemical tests results.

## Old Rifle Range

Location

The Old Rifle Range is located within the confines of the Demolition Area in the N½, NW¼, Sec. 35, T5N, R4W (Figure 4). Seven monitoring wells were installed along either side of the gravel road as shown in Figure 35. Disposal operations involving military ordnance were reported to have been conducted several feet deep along either side of this north-south trending gravel road.

Geology

Overburden at the Old Rifle Range varies in thickness from less than 2 ft at the northern end to more than 20 ft at the southern end. The thick fine-grained deposits at the southern end are probably a former alluvial channel during Recent and Pleistocene times. The underlying rock in borings WES-6-15-81 and WES-6-17-81 consists of a fine-grained, uniform, well cemented, brown to reddish brown sandstone from the Hardinsburg Formation of the Stephensport Group (Table 1). Boring and groundwater data from 5 borings are shown in cross section A-A' (Figure 36). Boring logs are presented in Appendixes A and B.

Groundwater

Groundwater was encountered in fractures in the sandstone at the northern end and in the overburden at the southern end. Groundwater elevations between the up gradient and down gradient wells range from 504 to 498 ft MSL, a difference of 6 ft. A groundwater contour map constructed from water measurements of 29-30 November 1981, shows that flow is from the northwest and southwest with the direction of flow towards the east (see Figure 37). Monitoring well

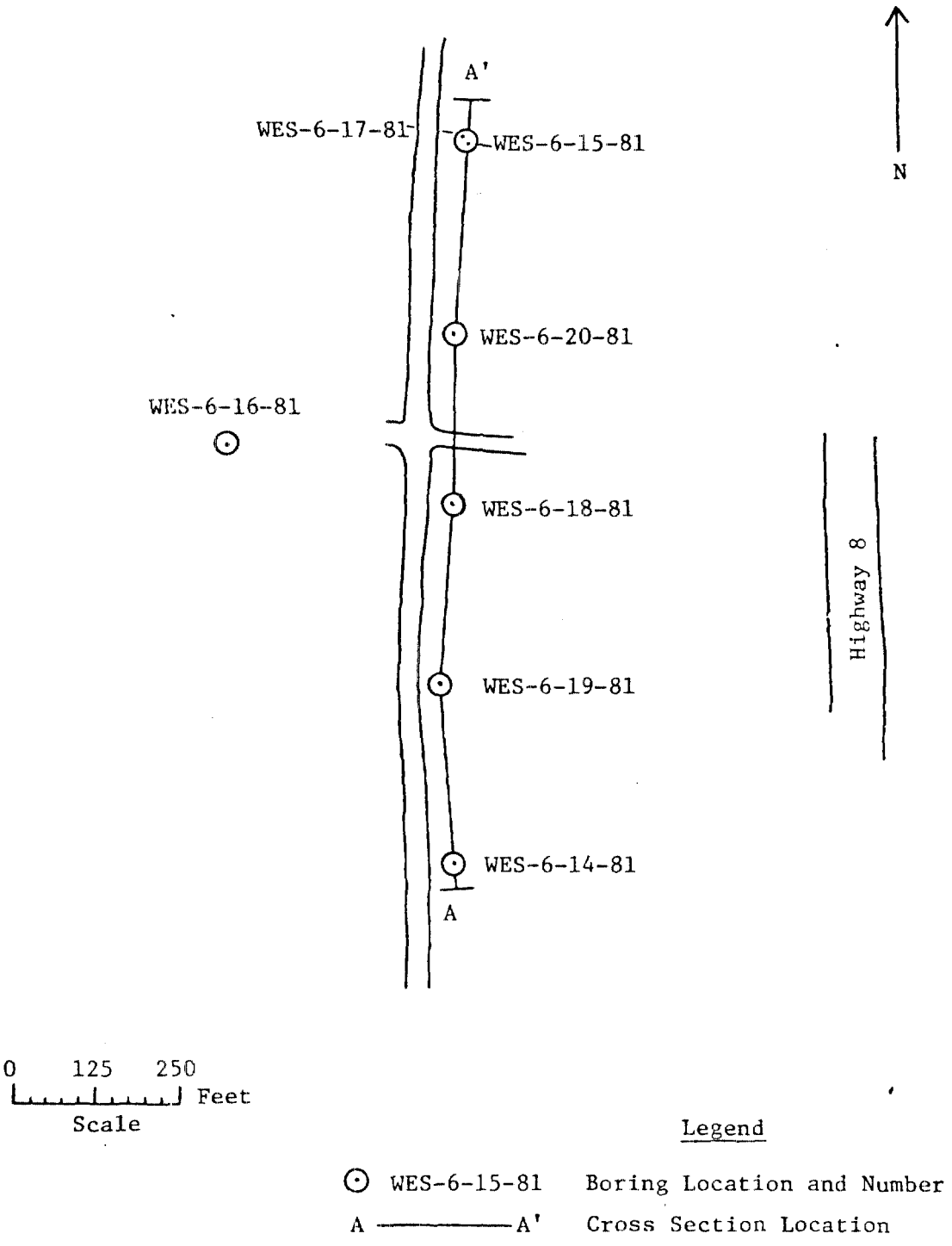



Figure 35. Well Locations and Cross Section Locations of Old Rifle Range

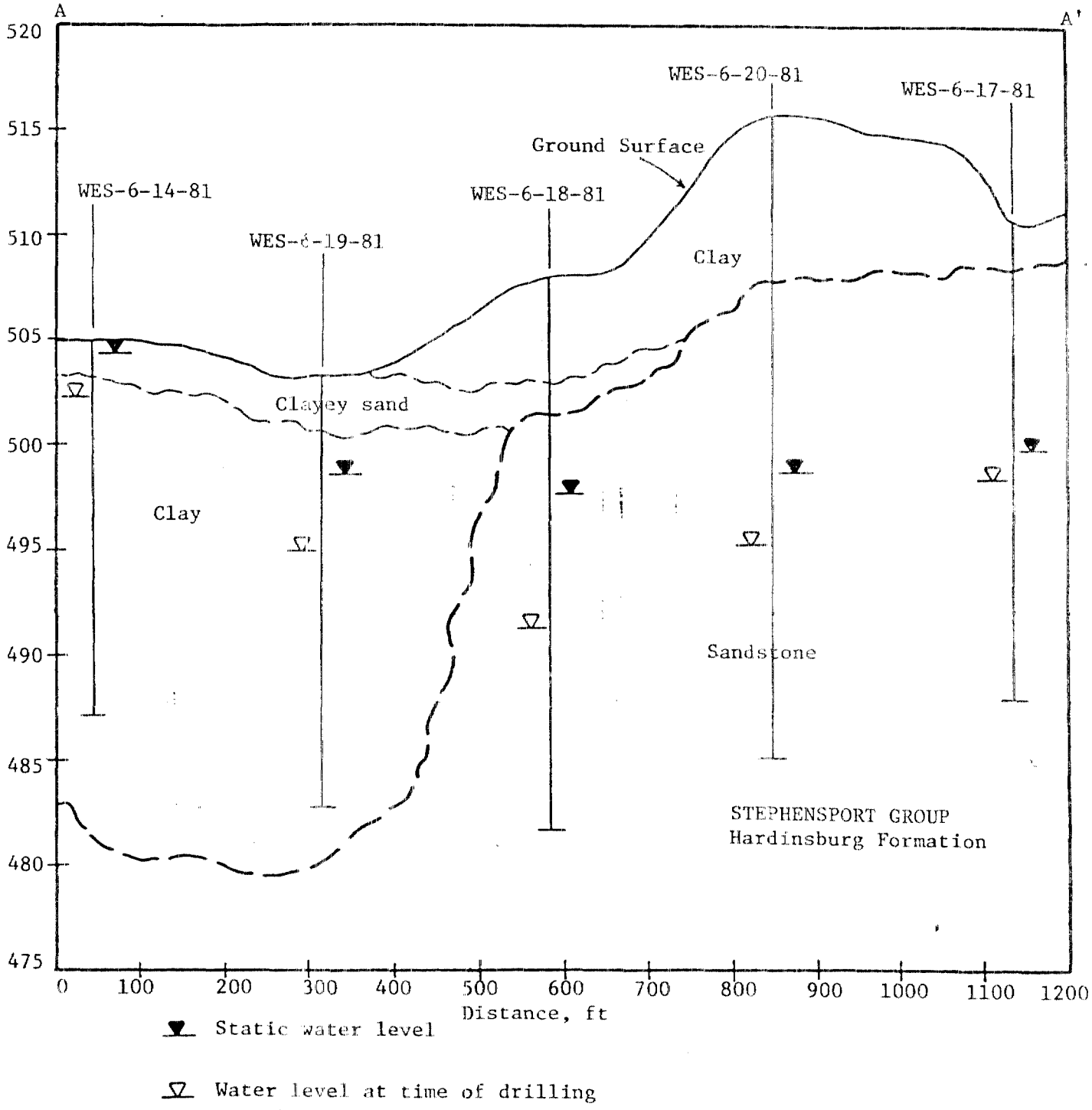



Figure 36. Geological Cross Section A-A' of Old Rifle Range.

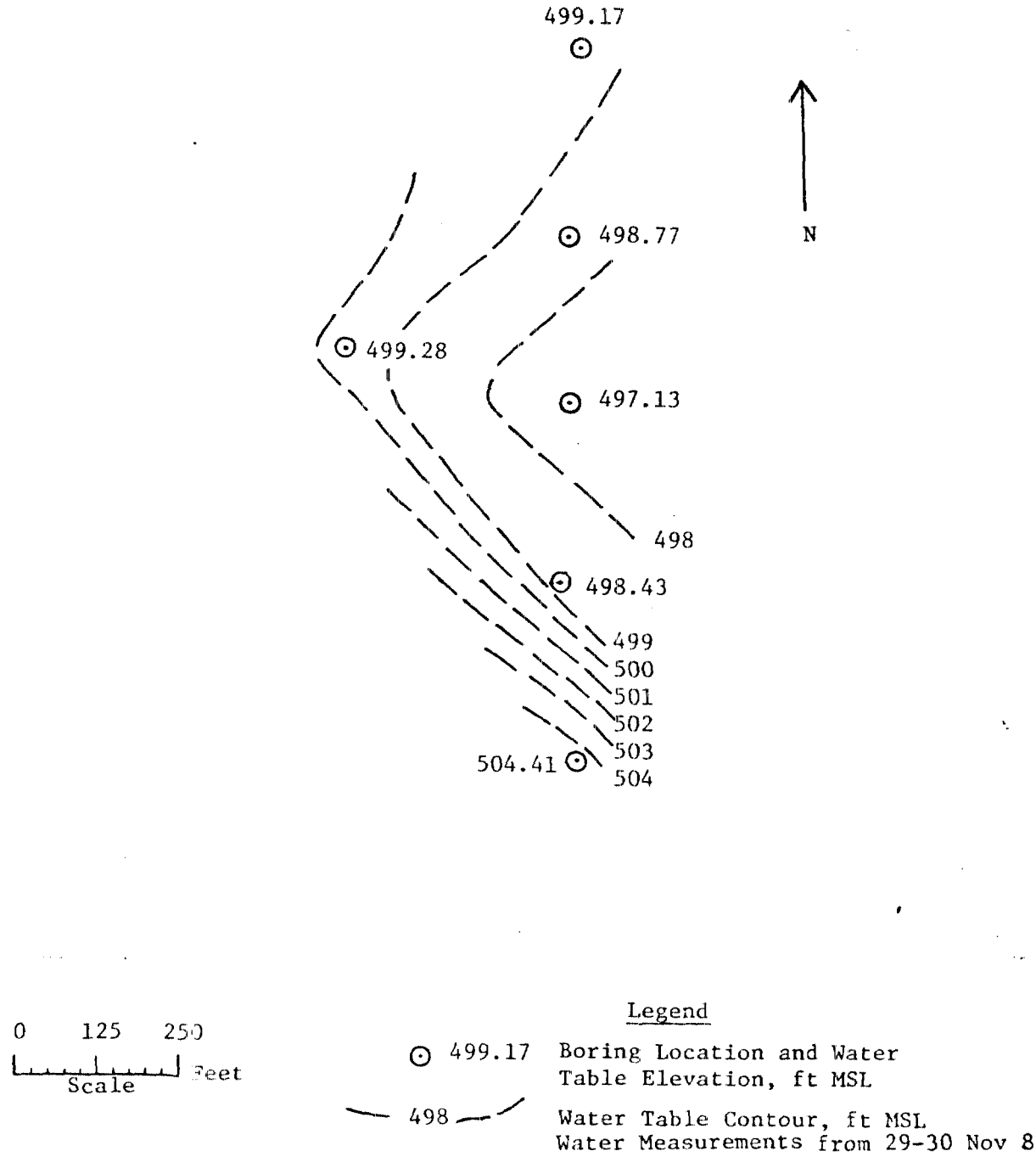



Figure 37. Water Table Contour Map of Old Rifle Range.

WES-6-15-81 was not used in contour construction since the water level fell below the screened portion shortly after installation. Groundwater data for this site are presented in Appendix D.

Physical and chemical test

Laboratory classification of soil samples ranged from clayey sand (SC) to clay (CL and CH). These soils are brown to tan. Soil permeability for a clay (CL) soil (sample 2, boring 14) was calculated to be $2.77 \times 10^{-6}$ cm/sec and this soil composes 79 percent of the samples from this site. Appendix E presents the physical and chemical tests results.

## Highway 58 Dump Site A

Location

The Highway 58 Dump Site A is located slightly north of the center of Sec. 26, T5N, R4W (Figure 4) and lies between Highway 45 and the NWSC Salvage Yard on Highway 58. Five monitoring wells were installed around the dump perimeter as shown in Figure 38.

Geology

Overburden at the Highway 58 Dump Site A ranges in thickness from less than 2 ft to 18.5 ft. Limestone, sandstone, and shale from the Mansfield Formation of the Raccoon Creek Group (Table 1) underlie the overburden. Boring WES-7-2-81 was drilled to a depth of 35 ft and beneath the overburden encountered 12 ft of a reddish brown, very stiff, dense, weathered gravelly clay shale. This clay shale at a depth of 15.5 ft grades into a soft, weathered, brown to dark grey, occasionally limonitic shale. From a depth of 20 ft, sandstone and shale are thinly interbedded in nearly equal proportions and at the end of the boring, the shale content declines to around 10 percent. The sandstone is light grey to dark grey, fine-grained, and moderately hard while the shale is dark grey to black and soft. Cross section A-A' (Figure 39) presents boring and groundwater data from 4 borings. Boring logs are presented in Appendixes A and B.

Groundwater

Groundwater at the Highway 58 Dump Site A was encountered in fractures in the sandstone. Groundwater elevations between the up gradient and the down gradient monitoring wells range from 606 to 570 ft MSL, a difference of 36 ft.

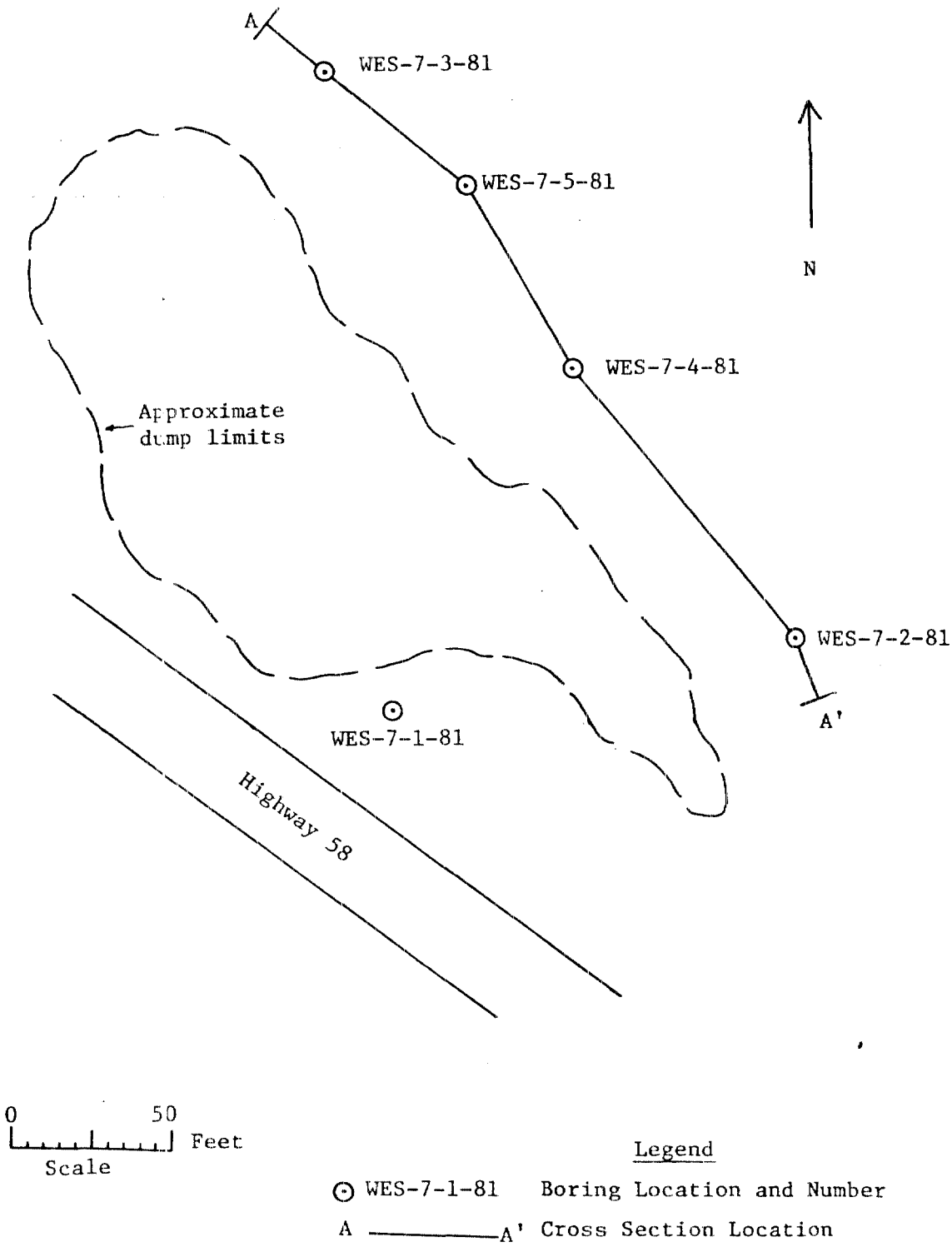



Figure 38. Well Locations and Cross Section Locations of Highway 58 Dump Site A

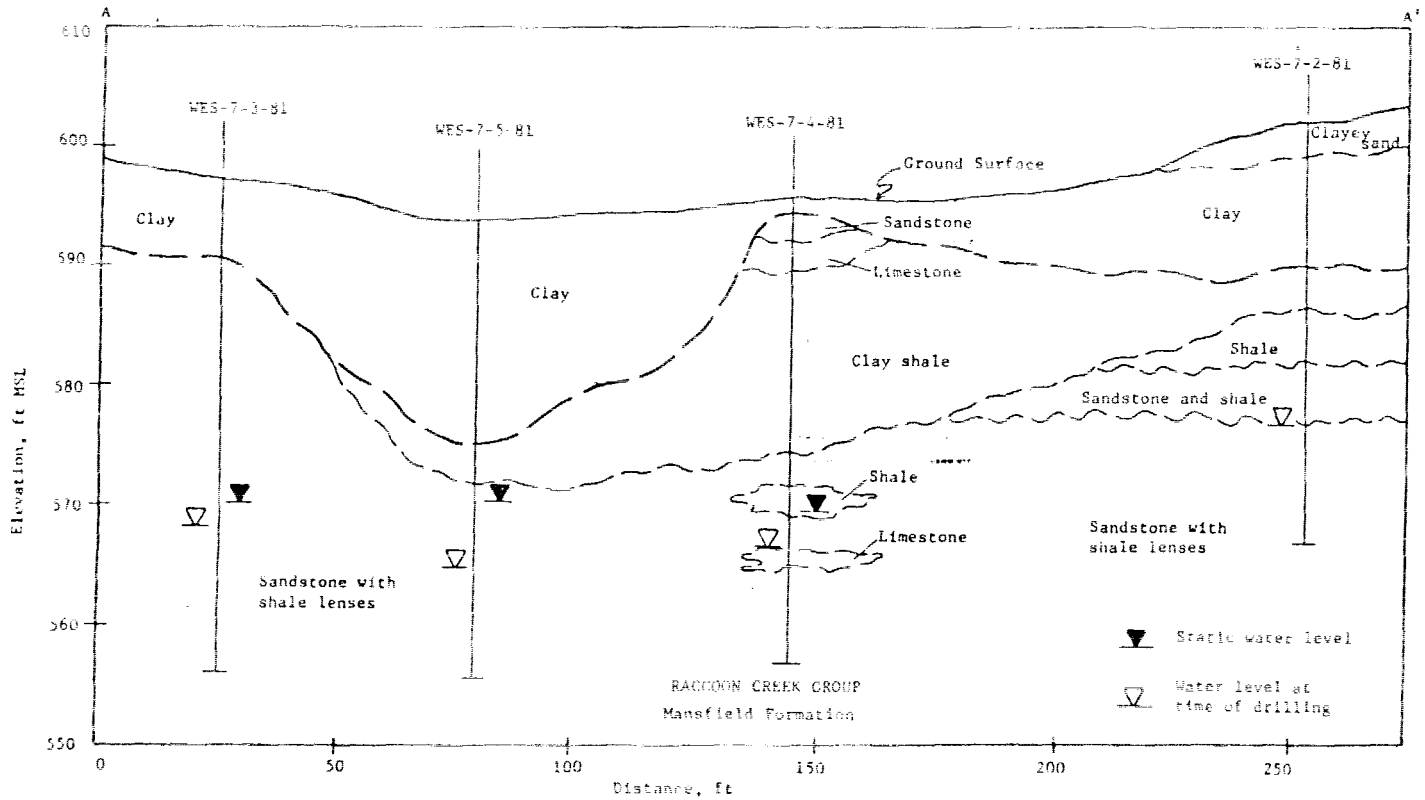



Figure 39. Geological Cross Section A-A' of Highway 58 Dump Site A

A groundwater contour map constructed from water levels of 29 November 1981, shows the flow to be in a northeasterly direction (see Figure 40). Monitoring well WES-7-2-81 was not used in map construction because the water level fell below the bottom of the well screen several weeks after installation. Groundwater data are presented in Appendix D.

Physical and chemical test

Laboratory classification of soil samples ranged from clayey sand-gravel (GC) to clay (CL). Soil permeability for a clay (sample 2, boring 1), was calculated to be 0.0 cm/sec and this soil composes 83 percent of the samples from this site. Appendix E presents the chemical and physical tests results.

## Highway 58 Dump Site B

Location

The Highway 58 Dump Site B is located in the NW¼ NE¼ NW¼, Sec. 25, T5N, R4W (Figure 4). This site is located midway on a ridge overlooking Highway 58 and Turkey Creek and is approximately ¼ mile south of Magazine 871. Nine monitoring wells were installed at this site (see Figure 41).

Geology

Overburden at the Highway 58 Dump Site B ranges in thickness from less than 1 ft to 13 ft. Underlying the overburden is shale, sandstone, and limestone from the Hardinsburg and Golconda Limestones Formations of the Stephensport Group (Table 1). Two core borings were drilled below the dump site. Boring WES-8-2-81 was drilled to a depth of 26.4 ft and boring WES-8-5-81 continued from this depth to a final depth of 70.8 ft. Only partial sample recovery was made of a highly weathered, yellowish brown clay shale from the base of the overburden to a depth of 13 ft. This clay shale grades into a weathered, soft, brittle shale which ranges from brown to dark grey and contains approximately 30 to 40 percent thinly bedded, brown sandstone beginning at a depth of 30 ft. From about 32 ft to 66 ft, a brown, well cemented, fine-grained quartz sandstone was encountered and was underlain by a light grey, moderately hard, fine-grained, fossiliferous limestone. Boring and groundwater data from 5 borings are shown in cross section A-A' (Figure 42). The boring logs are presented in Appendixes A and B.

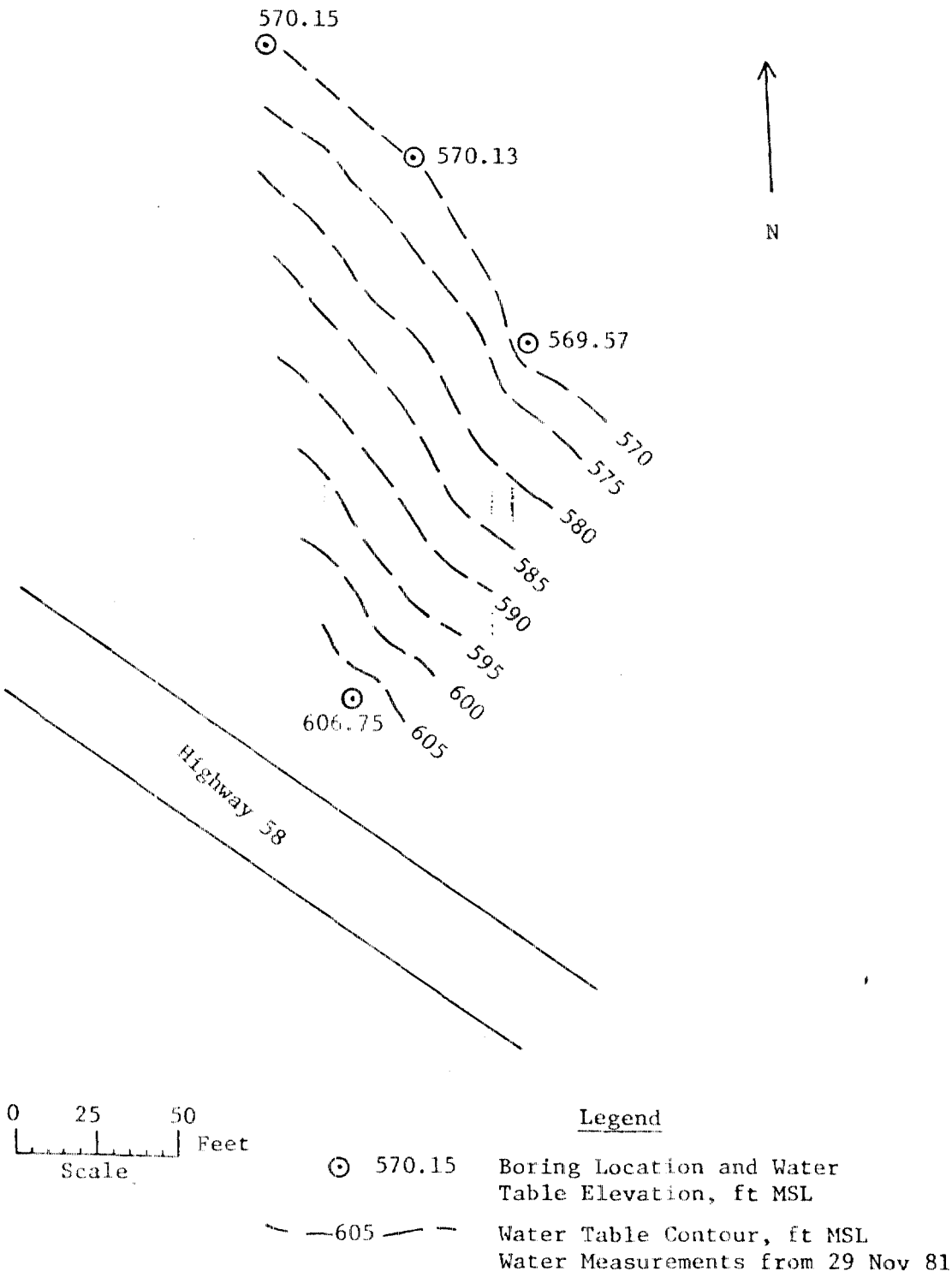



Figure 40. Water Table Contour Map of Highway 58 Dump Site A

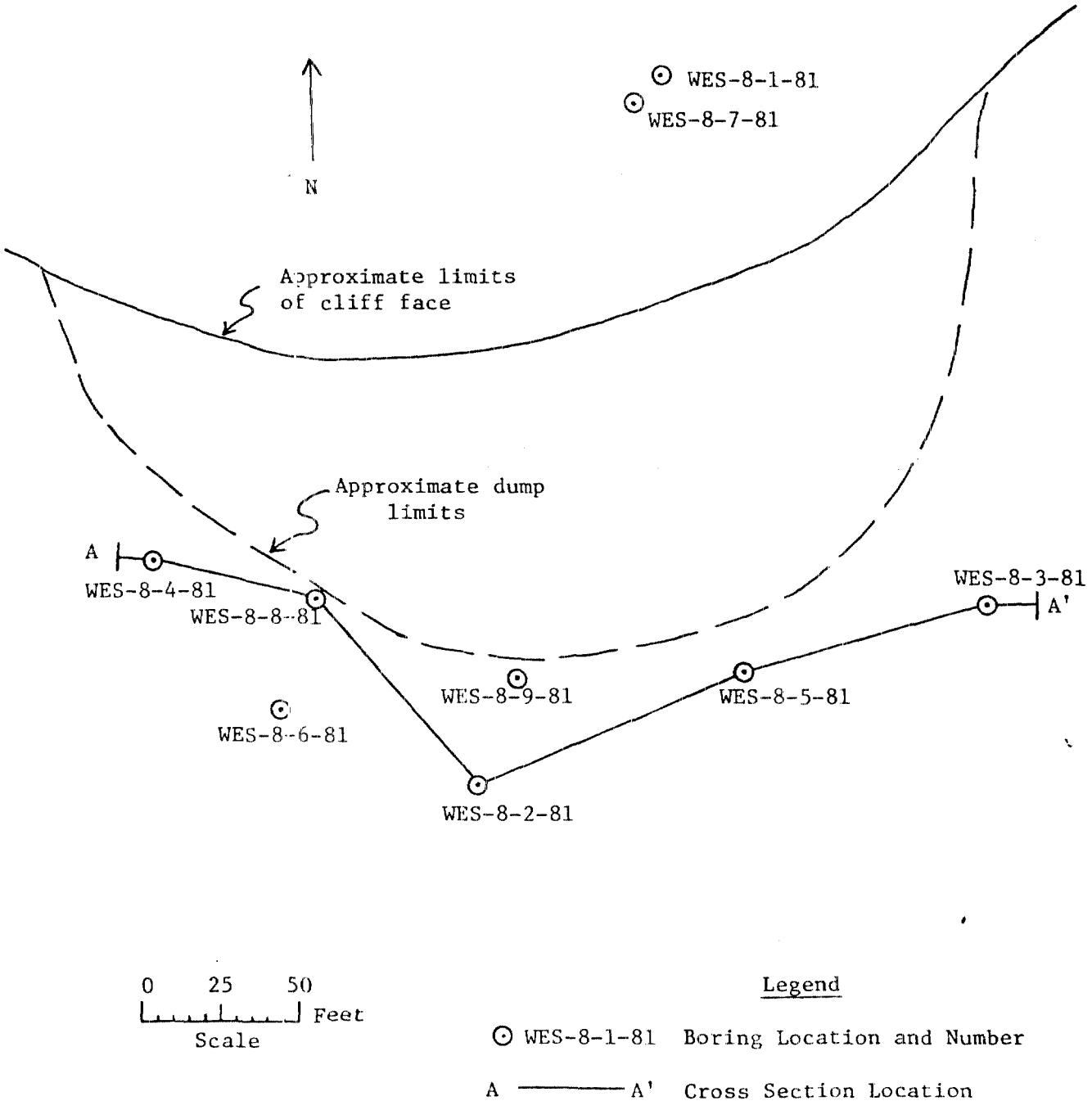



Figure 41. Well Locations and Cross Section Location of Highway 58 Dump Site B.

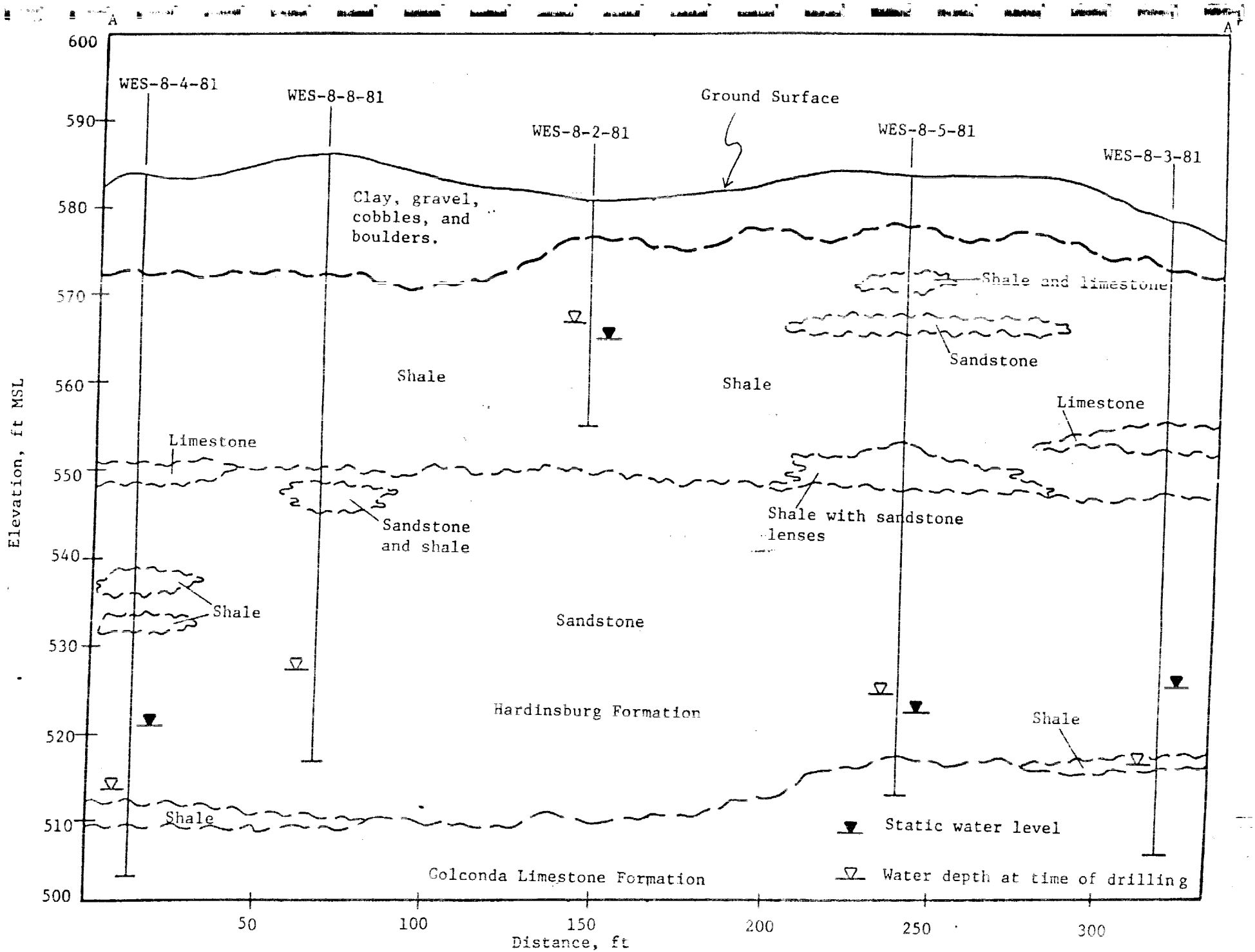



Figure 42. Geological Cross Section A-A' Highway 58 Dump Site B

Groundwater

Groundwater at the Highway 58 Dump Site B was encountered in fractures near the base of the sandstone unit. Borings WES-8-1-81, WES-8-2-81, and WES-8-6-81 encountered a perched water table in the fractured shale near surface. Between the up gradient and down gradient monitoring wells, groundwater elevations range from 525 to 521 ft MSL, a difference of 4 ft. A contour map constructed from water measurements of 29 November 1981, shows flow to be in a westerly direction (Figure 43). Monitoring well WES-8-8-81 is not shown in the water table contour map since it is a dry well. Croundwater data are presented in Appendix D.

Physical and chemical test

Laboratory classification of 3 soil samples ranged from clay (CL) to clayey sand-gravel (GC). Sampling methods at this site were not effective since the overburden consists of clay with sandstone and limestone gravel, cobbles, and boulders. Soil permeability for a clay (CL) soil was calculated to be $2.07 \times 10^{-8}$ cm/sec. Appendix E presents the chemical and physical tests results.

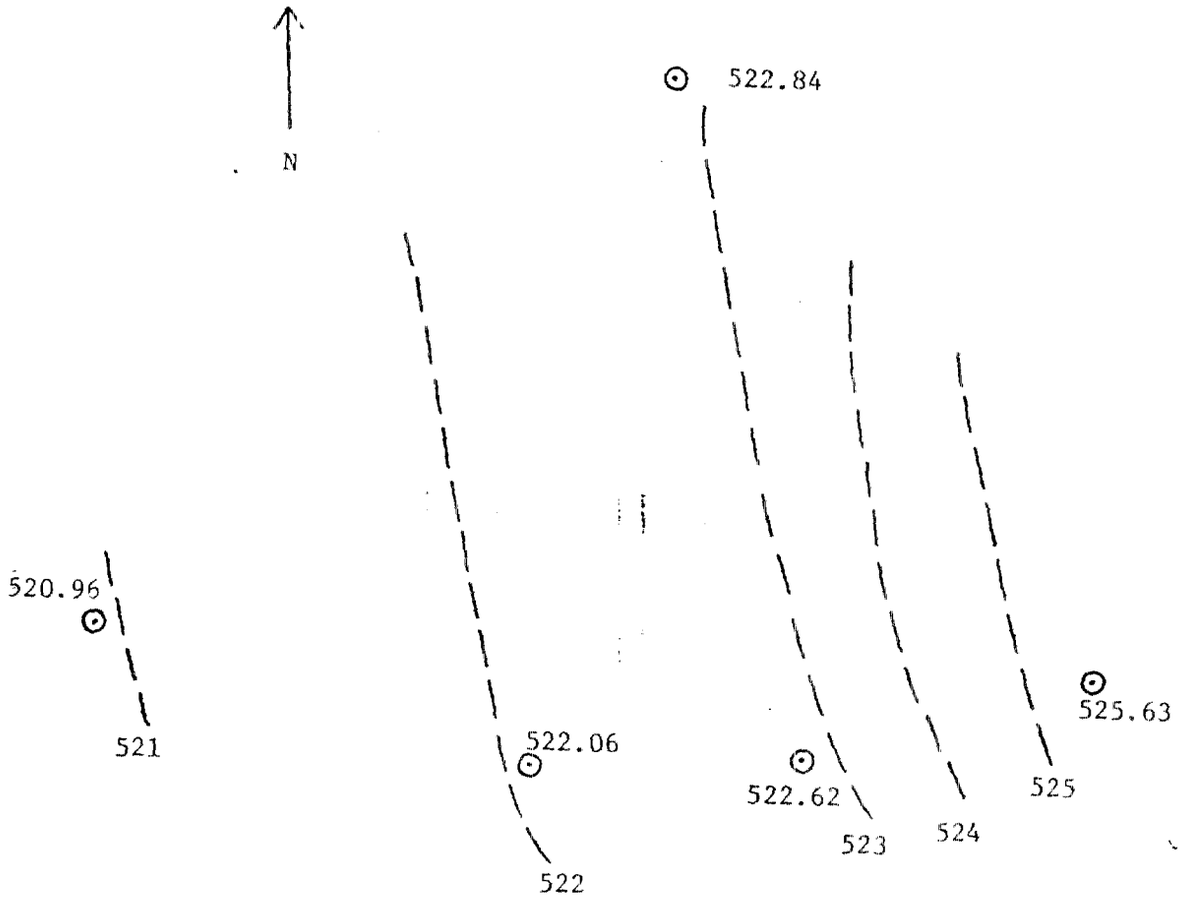
## Pest Control Area

Location

The Pest Control Area is located in the E½ NW¼ SW¼, Sec. 23, T5N, R4W (Figure 4). This site consists of a waste storage tank buried in a gravel parking lot north of Highway 349 and an area west-northwest of Building 2189 (Pest Control) where materials were reported to have been dumped and buried. Two groundwater monitoring networks consisting of nine wells were installed and are shown in Figure 44.

Geology

Overburden at the Pest Control Area ranges in thickness from 2 to 10 ft and is underlain by interfingered and interbedded sandstone, shale, limestone, and coal from the Mansfield Formation of the Raccoon Creek Group (Table 1). Boring WES-9-8-81 was drilled to a depth of 25.1 ft and under the overburden was 11.5 ft of brown, weathered, fine-grained quartz sandstone interbedded with approximately 30 percent soft, brown clay seams and lenses. At a depth




Legend

0 25 50 Feet
Scale

522.84 Boring Location and Water Table Elevation, ft MSL

522 Water Table Contour, ft MSL

Water Measurements from 29 Nov 81

Figure 43. Water Table Contour Map of Highway 58 Dump Site B.

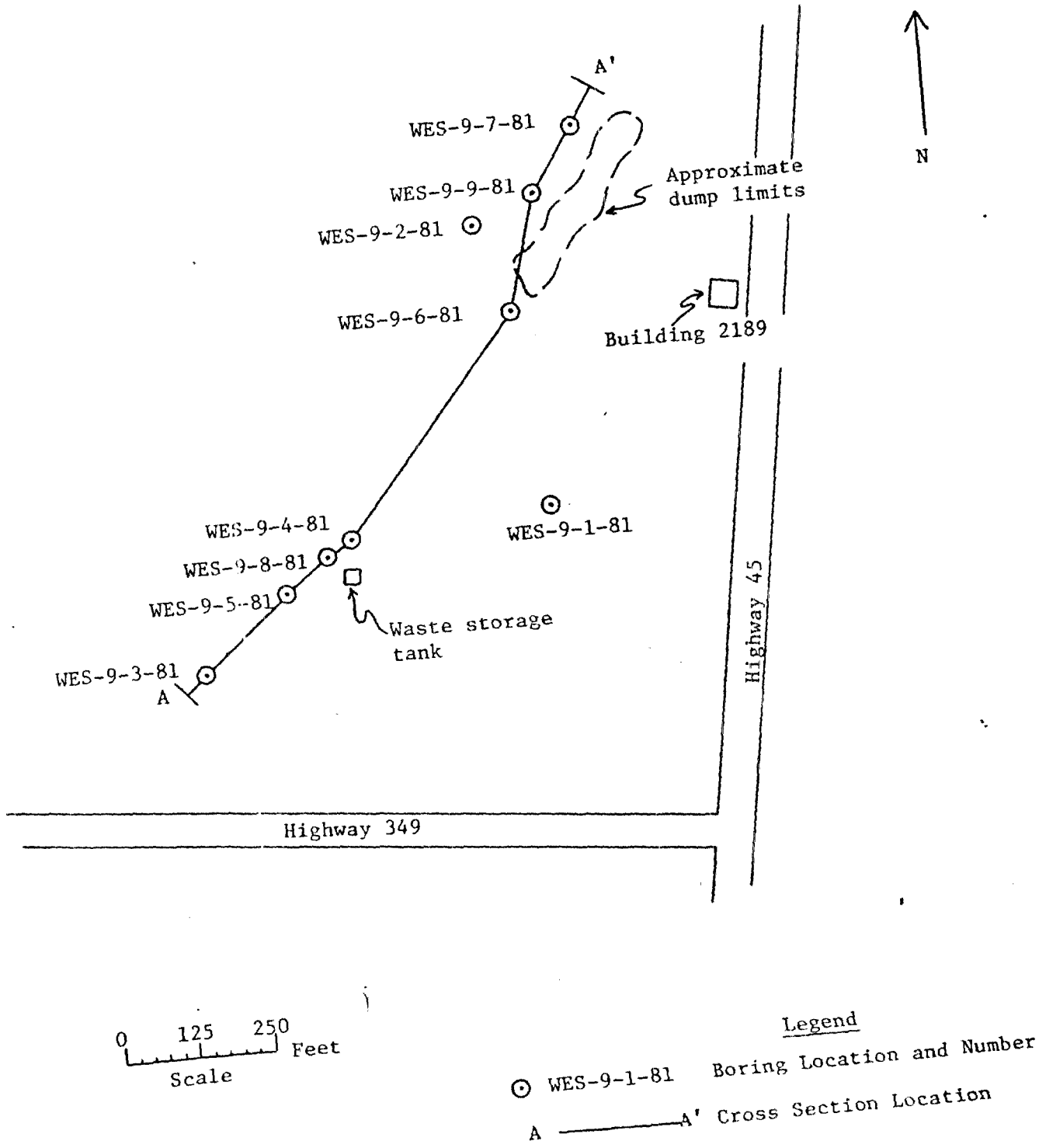



Figure 44. Well Locations and Cross Section Location of Pest Control Area.

of 18.5 ft, the sandstone is interbedded with a grey to dark grey shale with the shale content increasing with depth. At 23.5 ft, core changes to a black, soft, uniform shale. Cross section A-A' (Figure 45) shows boring and groundwater data from 7 borings. Boring logs are presented in Appendixes A and B.

Groundwater

Groundwater at the Pest Control Area was encountered in the overburden and in fractures in the underlying sandstone. Between the up gradient and down gradient monitoring wells, groundwater elevations range from 719 to 705 ft MSL, a difference of 14 ft. A contour map constructed from water measurements of 13 December 1981, shows groundwater flow to be towards the west behind Building 2189 and towards the west-northwest at the buried waste storage tank (see Figure 46). The groundwater data are presented in Appendix D.

Physical and chemical test

Laboratory classification of the soil samples ranged from clay (CL) to clayey sand (SC). These soils are tan, brown, and reddish brown. Soil permeability for a clay (CL) soil (sample 1, boring 3) was calculated to be $3.52 \times 10^{-7}$ cm/sec and this soil composes 68 percent of the samples from this site. Appendix E presents the physical and chemical tests results.

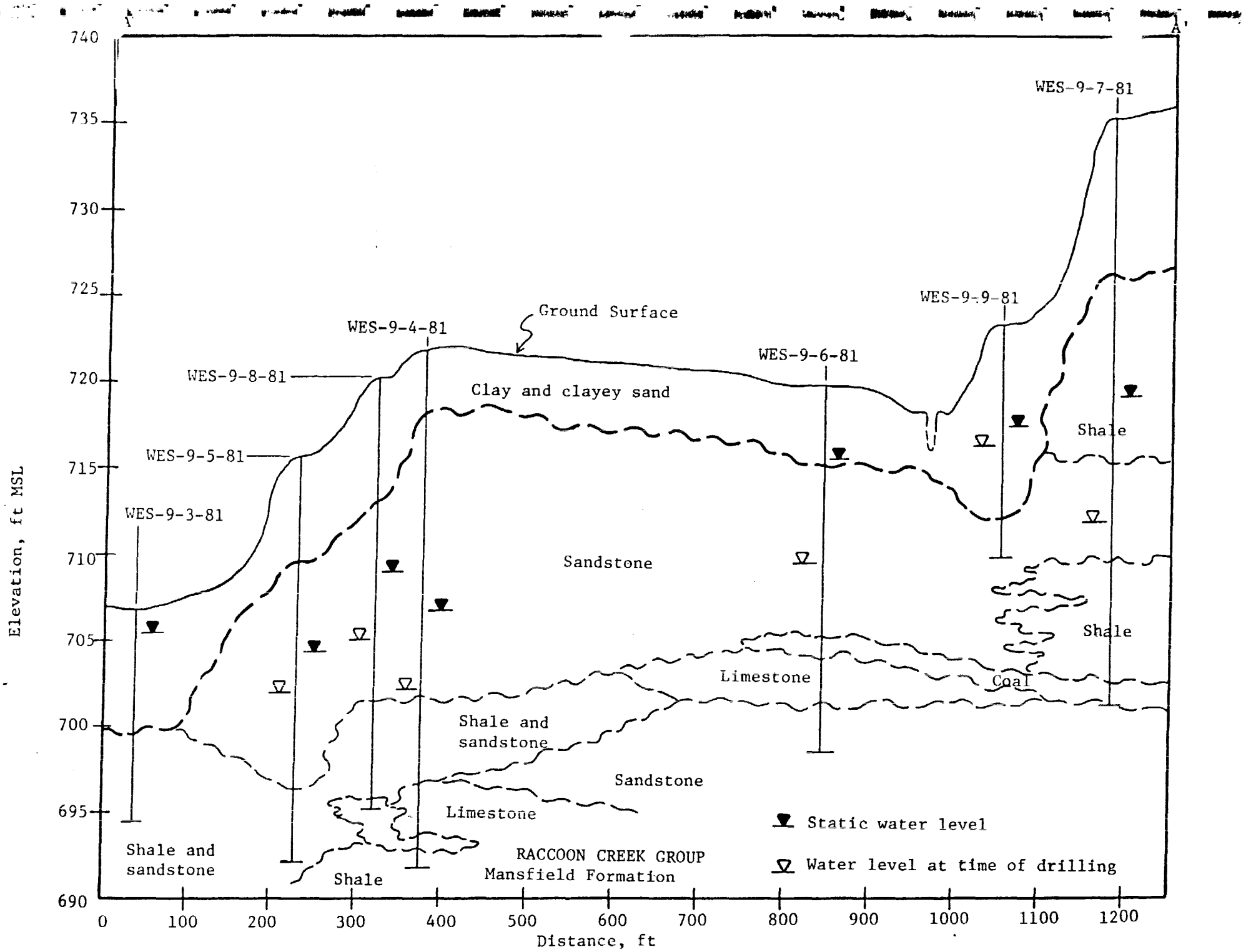
## Rockeye Site

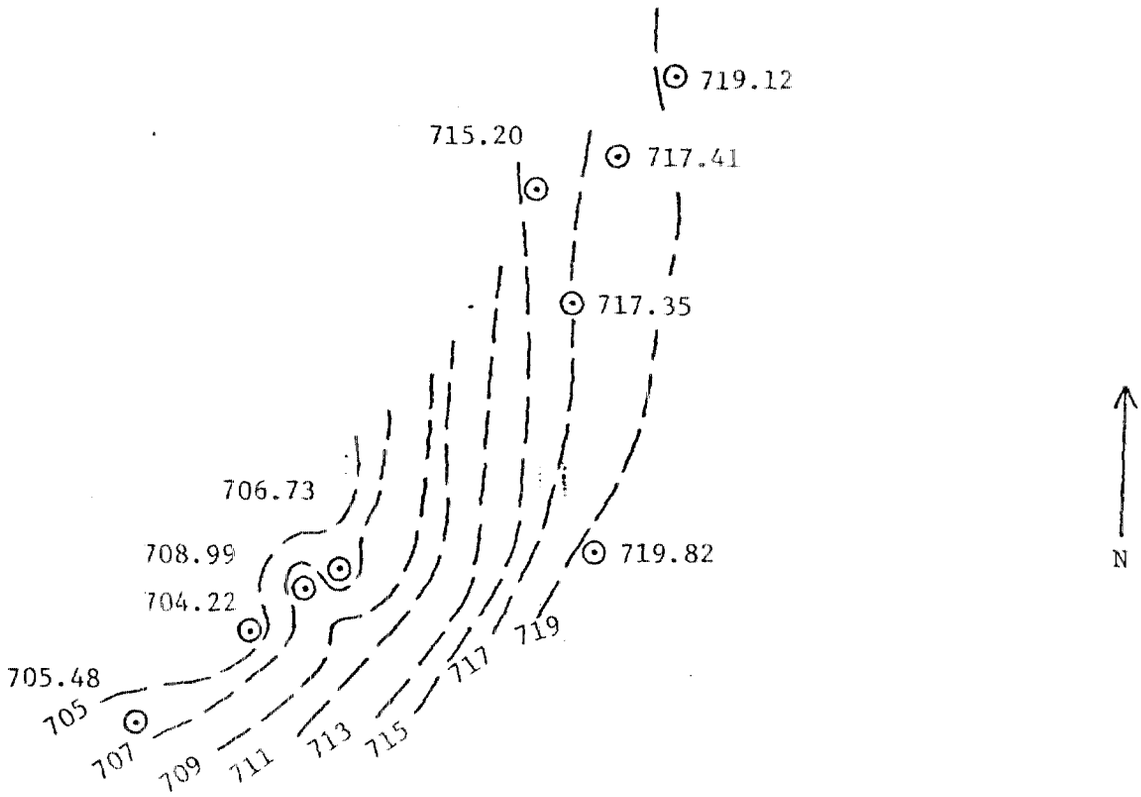
Location

The Rockeye Site is located in the SW¼ NW¼ SE¼, Sec. 4, T5N, R3W (Figure 4). It consists of two wells located along each bank of the stream approximately 200 to 250 ft from Magazine 1569 along Highway 165. Figure 47 shows well locations and the approximate stream course. The NWSC requested two wells to monitor surface discharge from the Rockeye Facility which was reported seeping into the stream bed at this location.

Geology

Overburden along each bank of the stream was around 7 ft thick and was underlain by a brown, fine-grained, quartz sandstone from the Mansfield Formation of the Raccoon Creek Group and a grey, moderately hard limestone from the


A
A'
740
735
730
725
720
715
710
705
700
695
690
Elevation, ft MSL
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Distance, ft
WES-9-3-81
WES-9-5-81
WES-9-8-81
WES-9-4-81
WES-9-6-81
WES-9-9-81
WES-9-7-81
Ground Surface
Clay and clayey sand
Sandstone
Shale
Shale
Coal
Limestone
Shale and sandstone
Sandstone
Limestone
Shale and sandstone
Shale
RACCOON CREEK GROUP
Mansfield Formation
Static water level
Water level at time of drilling




Legend

0 125 250 Feet
Scale

719.2 Boring Location and Water Table Elevation, ft MSL

719 Water Table Contour, ft MSL
Water Measurements from 13 Dec 81

Figure 46. Water Table Contour Map of Pest Control Area.

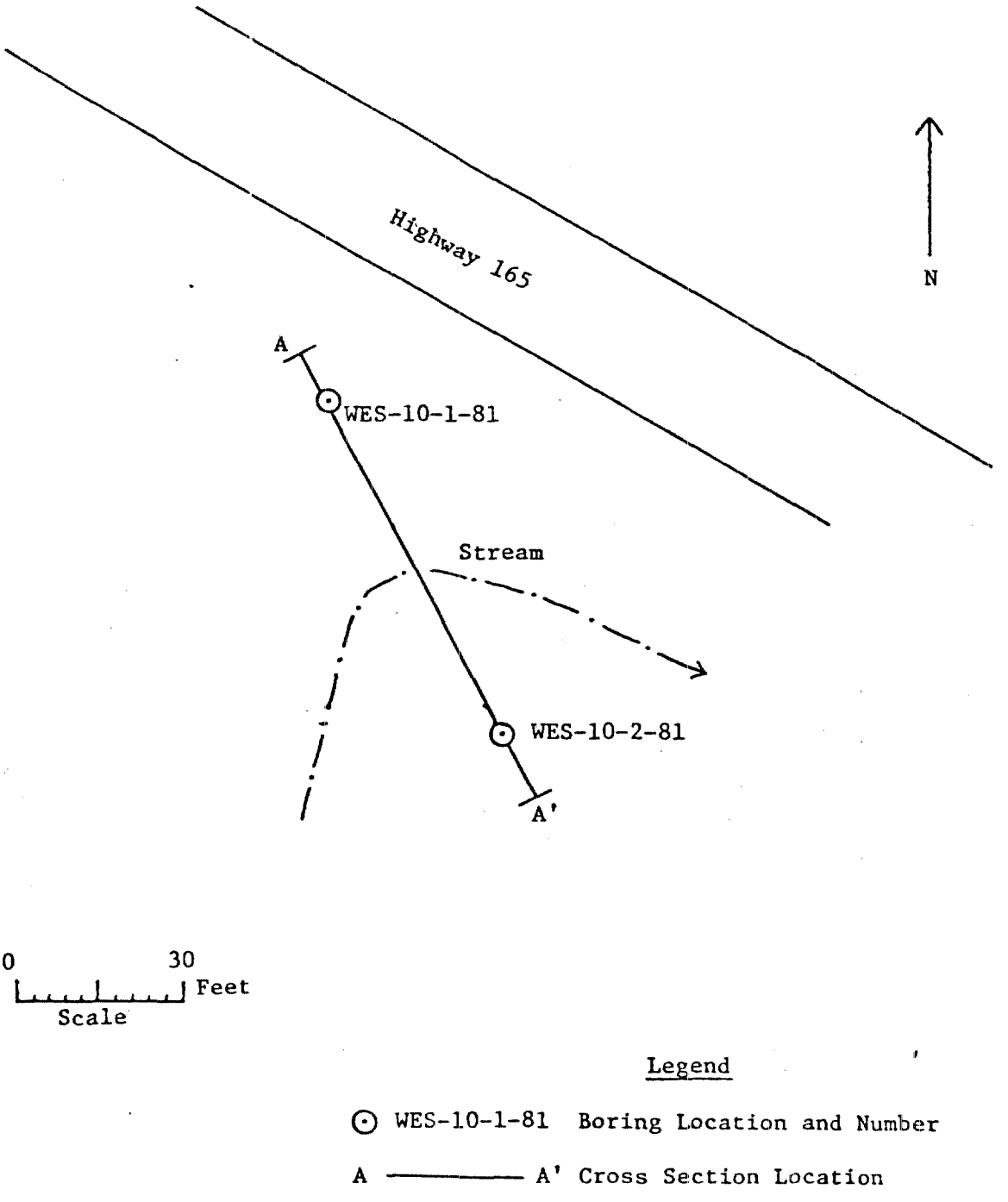



Figure 47. Well Locations and Cross Section Location of Rockeye Site.

Glen Dean Limestone Formation of the Stephensport Group (Table 1). Cross section A-A' (Figure 48) shows boring and groundwater data. Boring logs are presented in Appendixes A and B.

Groundwater

Groundwater at this location was encountered in fractures in the sandstone. Since only two wells were installed, the direction of groundwater flow cannot be determined, but in all probability conforms with the surface drainage.

Physical and chemical test

Laboratory classification of three soil samples were silty sand (SM), clayey sand-gravel (GC), and clay (CL). These soils are brown. Soil permeability for a clay soil (sample 1, boring 1), was calculated to be $5.20 \times 10^{-6}$ cm/sec. Appendix E shows the chemical and the physical tests results.

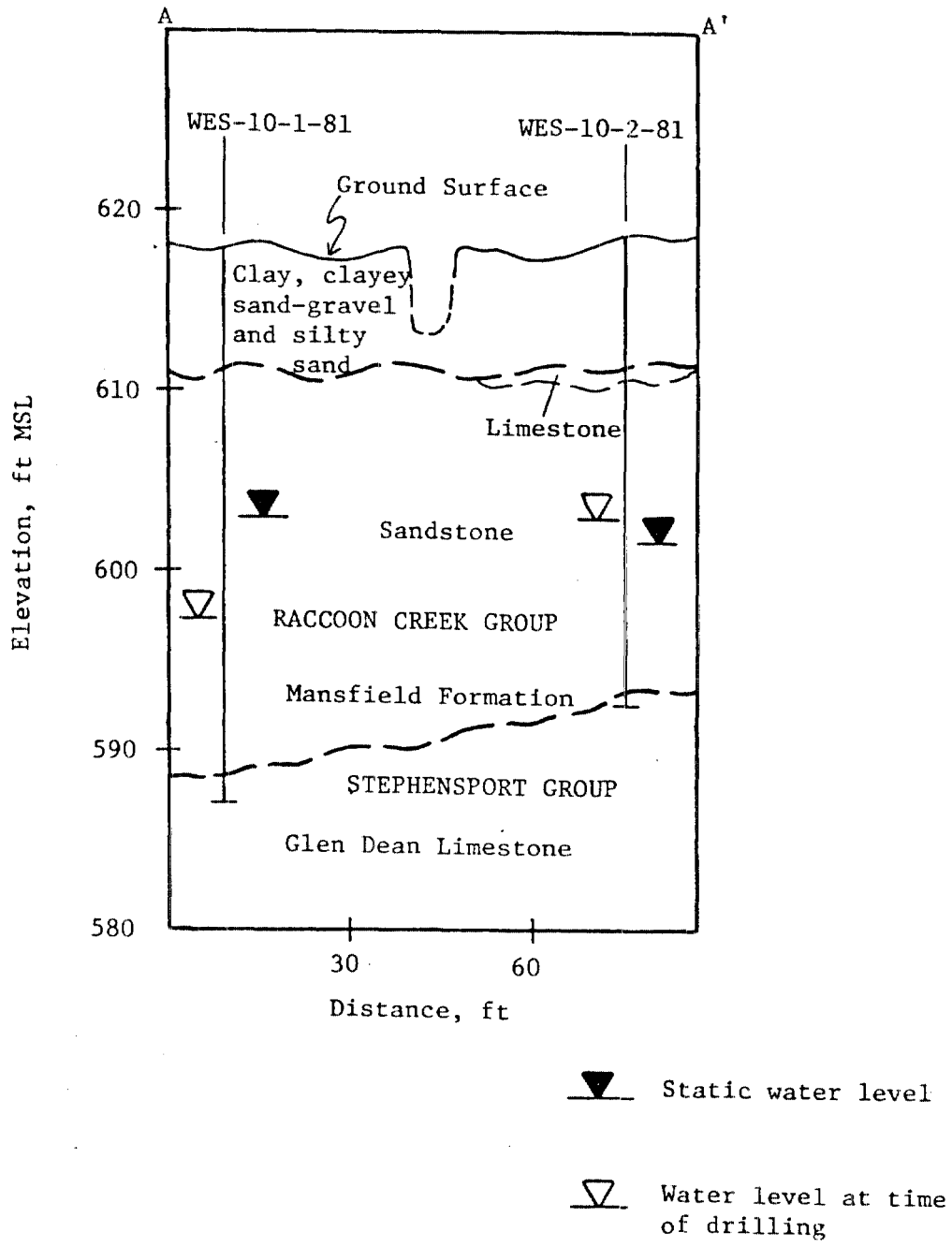



Figure 48. Geological Cross Section A-A' of Rockeye Site.

## PART V: CONCLUSIONS

The installation of groundwater monitoring networks around identified buried waste sites has been completed. A total of 13 groundwater monitoring networks (containing a total of 83 monitoring wells) were installed in 11 locations throughout the NWSC (Figure 4). With the exception of the Rockeye site, each groundwater monitoring network consists of three down gradient monitoring wells. Additional down gradient monitoring wells were installed in areas where groundwater flow was in more than one direction or where the down gradient disposal site perimeter was a large area. Overburden at the various disposal sites ranges in thickness from less than 1 ft to more than 40 ft with soils of clay, silt, and sand. Rock underlying the overburden consists of sandstone, shale, limestone, and coal seams of Pennsylvanian and Mississippian age. The water table was encountered in the unconsolidated overburden at two sites and in the remaining sites, the water table was encountered in the sedimentary rock at an average depth of 29.2 ft. The average groundwater gradient among the 11 sites was 0.06. The direction of groundwater flow varied, but generally conformed with the surface flow at each site.

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10

Admin Records
095

1C

# HYDROGEOLOGIC INVESTIGATION OF WASTE DISPOSAL SITES AT THE NAVAL WEAPONS SUPPORT CENTER, CRANE, INDIANA

APPENDIXES A AND B

by

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Prepared for
Naval Weapons Support Center
Crane, Indiana

April 1982

APPENDIX A: FIELD BORING LOGS

APPENDIX B: GRAPHIC FIELD LOGS

**WORKING DRAFT**

# APPENDIX A

# FIELD BORING LOGS

WORKING DRAFT

# BORING LOG
## FIELD DATA

Project N W S C Groundwater Study Site Crane, Indiana Date 20 August 1981
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 683.14 ft Boring No. WES-1-1-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 Aug | 0.0 | | 0.0 | 0.5 | 0.0 | 1.85 | 3"ShelbyTube | 0 | S.T. | Clay(CL): light brown to grey in |
| 1A | | | | 0.5 | 1.0 | 1.85 | 2.15 | | 160 | Jar | color, soft to slightly stiff, low |
| | | | | 1.0 | 1.5 | | | | 280 | | plasticity. |
| | | | | 1.5 | 2.0 | | | | 360 | | Sample length: 2.15' |
| | | | | 2.0 | 2.5 | | | | 420 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 20 Aug | | 5.0 | 5.0 | 5.5 | 5.0 | 6.37 | *3"Fixed Piston Sampler | 0 | S.T. | Sand (SP): light brown to grey in |
| 2A | | 5.0 | | 5.5 | 6.0 | 6.37 | 6.67 | | 20 | Jar | color, v. fine-grained, uniform, |
| | | | | 6.0 | 6.5 | 6.37 | 6.67 | | 300 | | with thin zones of moderately hard |
| | | | 7.05 | 6.5 | 7.05 | | | | 750 | | cemented sand. |
| | | | | | | | | | | | Sample length: 1.67' |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | 20 Aug | 7.05 | | 7.05 | 14.5 | | | 5-5/8" Rock Bit | | | Cleanout |
| | | | | | | | | | | | Sandstone: brown to darkbrown in |

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Sheet 1 of 2 Sheets

*3" Fixed Piston Sampler = 3" F.P.S.

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES 1-1-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | color and fine-grained. |
| 3A | 21 Aug | | | 14.5 | 14.75 | 14.5 | 14.75 | 3"F.P.S. | 750 | Jar | Sandstone: same as above. |
| | | | | | | | | | | | |
| | 21 Aug | | 48.0 | 14.5 | 48.0 | | | 5-5/8" Rock | Bit | | Sandstone |
| | | | | | | | | | | | Water encountered at 38 ft. |
| | | | | | | | | | | | Blew hole of cuttings and fall-in |
| | | | | | | | | | | | with air. Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, Indiana Date 20 August 1981
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 664.04 ft Boring No. WES-1-2-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 22 Aug | 0.0 | | 0.0 | 0.5 | 0.0 | 0.65 | 3"ShelbyTube | 180 | Jar | Sandy silt(SM): lt. brown in color, |
| | | | 1.2 | 0.5 | 0.65 | | | | 700 | | dry, very fine-grained, with frag- |
| | | | | | | | | | | | ments of weathered sandstone. |
| | | | | | | | | | | | |
| | | | | 0.0 | 2.2 | ---- | ------ | 5-5/8 " Rock Bit | | ---- | Cleanout for core barrel. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | Continued on Eng Form 1836, page 2. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-1-2-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION N.W.S.C., Crane, Indiana | SHEET 2 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT .N.W.S.C. Groundwater Study | 10. SIZE AND TYPE OF BIT 4"x5-1/2" |
| 2. LOCATION (Coordinates or Station) Mustard Gas Burial Grounds | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) M.S.L. |
| 3. DRILLING AGENCY C.E.W.E.S. | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-1-2-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED one |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 22 August 1981; COMPLETED 22 August 81 |
| 7. THICKNESS OF OVERBURDEN 1.2 | 17. ELEVATION TOP OF HOLE 664.04 |
| 8. DEPTH DRILLED INTO ROCK 21.6 | 18. TOTAL CORE RECOVERY FOR BORING 63% % |
| 9. TOTAL DEPTH OF HOLE 22.8 | 19. SIGNATURE OF INSPECTOR Joseph P. Dunbar |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 664.04 | 0.0 | | Overburden - See page one for soil information. | | | |
| 663.04 | 1.0 | | | | | |
| 662.04 | 2.0 | | No recovery | | | |
| 661.04 | 3.0 | | Sandstone: light brown, very fine-grained with 85% uniform quartz sand and 15% misc. materials. Sandstone is dry, weathered, very friable to moderately friable, and bedding is distinct with zones o oxidation. | | | Run 1<br>Began 1:30 Rec 1.9'<br>End 1:50 Loss 3.1'<br>Time 20min. Gain__<br>Drl time 20min.<br>Hyd press 200 psi<br>Water press -<br>RPM 100±<br>Drl Action Smooth<br>Cuttings Red Brown |
| 660.04 | 4.0 | | | | | |
| | | | Fractured | | | Used carbide bit. |
| 559.04 | 5.0 | | | | | |
| 558.04 | 6.0 | | No recovery | | | |
| 557.04 | 7.0 | | Run 1 | 38% | - | |
| | | | No recovery | | | Run 2<br>Began 2:15 Rec 1.5'<br>End 2:45 Loss 3.5'<br>Time 30min Gain -<br>Drl time 30min<br>Hyd press 150-200psi<br>Water press -<br>RPM 100±<br>Drl Action Smooth<br>Cuttings Red Brown<br>Remarks |
| 556.04 | 8.0 | | | | | |
| 555.04 | 9.0 | | Sandstone: same - Core loss appears to occur in areas of unconsolidated sands or very weathered sandstone. | | | |
| | | | Fractured | | | |
| 554.04 | 10.0 | | No recovery | | | |

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Hole No. WES-1-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 554.04 | 10.0 | | | | | |
| 553.04 | 11.0 | | No recovery | | | |
| 552.04 | 12.0 | | Run 2 | 30% | - | |
| | | | No recovery | | | |
| | | | Water at 12.8 ft. | | | |
| 551.04 | 13.0 | | | | | Run 3<br>Began 3:00 Run 4.33'<br>End 3:30 Loss 0.4'<br>Time 30min Gain -<br>Drl time 30min<br>Hyd press 100psi<br>Water press -<br>RPM 75±<br>Drl Action Smooth<br>Water Ret Brown |
| 550.04 | 14.0 | | Sandstone: same | | | |
| 549.04 | 15.0 | | | | | Remarks<br>Switched from carbide to to diamond bit. |
| | | | Water at 15.7 ft. | | | |
| 548.04 | 16.0 | | Highly oxidized | | | |
| | | | Run 3 | 91% | - | |
| | | | Contact from brown to grey colored sandstone. | | | |
| 547.04 | 17.0 | | Shale seam - 3/4" | | | Run 4<br>Began 4:00 Run 3.37'<br>End 4:30 Loss -<br>Time 30min Gain -<br>Drl time 30min<br>Hyd press 100psi<br>Water press -<br>RPM 75±<br>Drl Action Smooth<br>Water Ret Grey |
| 546.04 | 18.0 | | Sandstone and interbedded shale: sandstone is grey, uniform, fine-grained quartz sands with numerous dark grey shale lamina interbedded. | | | |
| 545.04 | 19.0 | | Shale ranges in thickness from 1/16" to 1/2" and controls rock breaks. Shale is fairly soft and sandstone is moderately friable. | | | Bit blocked off. |
| | | | Shale seam - 1/2" | | | |
| 544.04 | 20.0 | | Run 4 | 100% | - | |

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PROJECT HOLE NO.

Hole No. MES-1-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 544.04 | 20.0 | | 19.9' contact between sandstone and shale<br>0.2' black shale(pure)<br>0.05' black shale(pure) | | | |
| 543.04 | 21.0 | | Sandy shale: recovered core indicates 60% soft, black sandy shale interbedded with a fine-grained, grey sandstone. Individual lamina range in thickness from 1/16" to 2".<br>No recovery - Left in hole | | | Run 5<br>Began 4:30 Rec 1.0'<br>End 4:50 Loss 1.95'<br>Time 20min Gain<br>Drl time 20min<br>Hyd press 100psi.<br>Water press -<br>RPM 75<br>Drl Action smooth<br>Water rot -<br>Remarks |
| 542.04 | 22.0 | | | | | |
| 541.04 | 23.0 | | Run 5 | 34% | - | |
| | | | Went back in with 5-5/8" rock bit to remove fall-in and core left in hole.<br>Slight "oily" oder was smelled when pulling core barrel on last run. Had test run for mustard gas and negative results on test. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, Indiana Date 25 August 1981
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 667.43 ft Boring No. WES-1-3-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 Aug | 0.0 | | 0.0 | 0.5 | 0.0 | 2.3 | 3"ShelbyTube | 0 | S.T. | Silt(ML): brown in color, soft |
| 1A | | | | 0.5 | 1.0 | 2.3 | 2.5 | | 20 | Jar | organic matter, low plasticity. |
| | | | | 1.0 | 1.5 | | | | 95 | | |
| | | | | 1.5 | 2.0 | | | | 180 | | |
| | | | 4.0 | 2.0 | 2.5 | | | | 220 | | Sample length: 2.5 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | ------ | ------ | 7" Folding | Auger | --- | Cleanout: assumed change at 4.0 ft |
| | | | | | | | | | | | |
| 2 | 25 Aug | 4.0 | | 5.0 | 5.5 | 5.0 | 6.02 | 3" FixedPis- | 0 | S.T. | Clayey sand(SC) with fragments of |
| 2A | | | | 5.5 | 6.0 | 6.02 | 6.27 | ton Sampler | 40 | Jar | weathered sandstone: reddish brown |
| | | | 6.45 | 6.0 | 6.45 | | | | 280 | | in color, dry, and uniform fine- |
| | | | | | | | | | | | grained sand. |
| | | | | | | | | | | | Sample length: 1.27 ft |
| | | | | | | | | | | | |
| | 25 Aug | | | 5.0 | 6.5 | ------ | ------ | 7" Folding | Auger | ---- | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

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# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-3-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 Aug | 6.45 | | 6.5 | 6.7 | ------ | ------ | 3"Pitcher Sampler | 200-300 | | Sandstone: lt. brown to reddish brown in color, very fine to fine-grained, weathered, moderate to very friable. |
| | 25 Aug | | | 6.7 | 8.6 | ------ | ------ | 4x5-1/2" core bbl. | | --- | Sandstone: lt. grey to reddish brown in color, weathered, moderate to slightly friable, bedding is distinct with three breaks in run. Recovered to 6.25 ft. Water at 8.6 ft. |
| | 25 Aug | | -- | 8.6 | 18.6 | ------ | ------ | 5-5/8" rock bit | | --- | Cleanout |
| | | | | | | | | | | | ~~Sandstone: same as above.~~ |
| | | | | | | | | | | | Blew hole clean of cuttings and fall-in. Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, Indiana Date 22 Sep 81
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 669.95 ft Boring No. WES-1-4-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| 1 | 22 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 2.43 | 3" Shelby Tube | 40 | S.T. | Sandy silt (SM): brown to grey in |
| 1A | | | | 0.5 | 1.0 | 2.43 | 2.6 | | 60 | | color, moderate cohesion, dry, |
| | | | | 1.0 | 1.5 | | | | 80 | | with approx. 20-30% fine-grained |
| | | | | 1.5 | 2.0 | | | | 120 | | sand. |
| | | | 3.80 | 2.0 | 2.6 | | | | 200 | | Sample length: 2.6 ft |
| | | | | | | | | | | | |
| | 22 Sep | | | 0.0 | 5.0 | ---------- | | 7" Solid Auger | ---------- | | Cleanout |
| | | | | | | | | | | | |
| 2 | 22 Sep | 3.80 | | 5.0 | 5.5 | 5.0 | 6.35 | 3" Fixed Piston Sampler | 100 | S.T. | Sandy silt (SM): brown to lt. |
| 2A | | | | 5.5 | 6.0 | 6.35 | 6.55 | | 140 | Jar | grey in color (mostly grey), v. |
| | | | | 6.0 | 6.5 | | | | 200 | | stiff, layered, dry, with approx. |
| | | | | 6.5 | 7.0 | | | | 260 | | 20-30% fine sand. |
| | | | | 7.0 | 7.5 | | | | 300 | | Sample length: 1.55 ft |
| | | | | | | | | | | | |
| | 22 Sep | | | 5.0 | 10.0 | ---------- | | 7" Solid Auger | ---------- | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-1-4-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| 3A | 22 Sep | | 10.3 | 10.0 | 10.3 | 10.0 | 10.3 | 3" Fixed Piston Sampler | 800 | Jar | Sandy silt (SM) and weathered sandstone: grey to brown in color, dry, with sandstone reddish brown in color, fine-grained, and friable. |
| | 22 Sep | 10.3 | 31.0 | 10.0 | 31.0 | ------ | ------ | 5-5/8" Rock Bit | ------ | ------ | Water at 21 ft. Drilled to 31.0 ft. Water on 23 Sep 81 at 21 ft. Blew hole and installed well. |
| | | | | | | | | | | | Sandstone: reddish brown in color, fine-grained and weathered. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, Indiana Date 23 Sep 81
Location Mustard Gas Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 665.69 ft Boring No. WES-1-5-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 2.28 | 3" Shelby Tube | 60 | S.T. | Clay (CL): brown in color, dry, |
| 1A | | | | 0.5 | 1.0 | 2.28 | 2.48 | | 80 | Jar | little cohesion, uniform. Approx- |
| | | | | 1.0 | 1.5 | | | | 100 | | imately 5% sand and gravel. |
| | | | | 1.5 | 2.0 | | | | 120 | | |
| | | | | 2.0 | 2.5 | | | | 120 | | Sample length: 2.48 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | ------ | ------ | 7" Solid Auger | ---- | ---- | Cleanout |
| | | | | | | | | | | | |
| 2A | 23 Sep | | 5.2 | 5.0 | 5.5 | 5.0 | 5.5 | 3" Fixed Piston Sampler | 800 | Jar | Sandstone: brown in color, layered, |
| | | | | | | | | | | | v. fine-grained, dry, weathered, |
| | | | | | | | | | | | friable. |
| | | | | | | | | | | | |
| | 23 Sep | 5.2 | 30.63 | 5.5 | 18.0 | ------ | ------ | 5-5/8" Rock Bit | ---- | ---- | At 18.0 ft, monitored hole for |
| | | | | 18.0 | 30.63 | ------ | ------ | 5-5/8" Rock Bit | ---- | ---- | water, negative results. Water at |
| | | | | | | | | | | | 20.5 ft. Sandstone: brown in |
| | | | | | | | | | | | color with interbedded grey shale. |
| | | | | | | | | | | | Installed well on 24 Sep 81. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 26 Aug 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 738.66 Boring No. WES-2-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 26 Aug | 0.0 | | 0.0 | 0.5 | 0.0 | 0.92 | 3" Shelby Tube | 0 | Jar | Clay (CL): Brown in color, soft, |
| 1 | | | | 0.5 | 1.0 | 0.92 | 1.87 | | 0 | S.T. | low plasticity, & slight organic |
| | | | | 1.0 | 1.5 | | | | 10 | | matter. |
| | | | | 1.5 | 2.0 | | | | 30 | | Sample length: 1.97 ft |
| | | | 6.0 | 2.0 | 2.5 | | | | 100 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | -------- | | 7" Folding Auger | ------ | | Cleanout |
| | | | | | | | | | | | |
| 2A | 26 Aug | 6.0 | 7.17 | 5.0 | 5.5 | 5.0 | 6.0 | 3" Fixed Piston Sampler | 0 | Jar | Sandy silt (SM) & sandstone frag- |
| 2 | | | | 5.5 | 6.0 | 6.0 | 6.95 | | 20 | S.T. | ments: brown in color, slightly |
| | | | | 6.0 | 6.5 | | | | 380 | | sticky, & contains 25% weathered |
| | | | | 6.5 | 7.0 | | | | 700 | | sandstone. Sandstone is light |
| | | | | 7.0 | 7.17 | | | | 800 | | brown to grey in color, uniform, |
| | | | | | | | | | | | fine-grained, dry, & friable. |
| | | | | | | | | | | | Sample length: 1.95 ft |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

NOTE: Extra jar sample made for NWSC

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-1-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 26 Aug | 7.17 | 11.5 | 5.0 | 7.17 | ------- | ------- | 7" Folding Auger | ------- | ------- | Cleanout: weathered sandstone starts at 7.17 ft |
| | 26 Aug | 11.5 | 30.0 | 7.17 | 30.0 | ------- | ------- | 5-5/8" Rock Bit | ------- | ------- | Hard sandstone at 11.5 ft. Water at approximately 20 ft. Cleanout to 10 ft below water, blew hole dry of water & cuttings. Installed well screen. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 26 Aug 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 725.46 Boring No. WES-2-2-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26 Aug | 0.0 | | 0.0 | 0.5 | 0.0 | 1.65 | 3" Shelby Tube | 40 | S.T. | Silt (ML): brown in color, soft, |
| 1A | | | | 0.5 | 1.0 | 1.65 | 2.5 | | 75 | Jar | slightly sticky, dry, & contains |
| | | | | 1.0 | 1.5 | | | | 140 | | organic matter. |
| | | | | 1.5 | 2.0 | | | | 180 | | Sample length: 2.5 ft |
| | | | 5.0 | 2.0 | 2.5 | | | | 230 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | ---------- | | 7" Folding Auger | ------ | | Cleanout |
| | | | | | | | | | | | |
| 2A | 26 Aug | 5.0 | | 5.0 | 5.5 | 5.0 | 6.05 | 3" Fixed Piston Sampler | 40 | Jar | Silt (ML) & weathered sandstone: |
| | | | | 5.5 | 6.0 | | | | 700 | | brown to brownish white in color |
| | | | 6.05 | 6.0 | 6.05 | | | | 800 | | & dry. Sandstone is fine-grained, |
| | | | | | | | | | | | uniform, & friable. Slight dry |
| | | | | | | | | | | | green film found on soil sample. |
| | | | | | | | | | | | Sample length: — |
| | | | | | | | | | | | |
| | 26 Aug | 6.05 | | 5.0 | 6.1 | ---------- | | 5-5/8" Rock Bit | ------ | | Cleanout |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 8 Sheets

NOTE: Extra jar sample made for NWSC

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-2-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 26 Aug | 6.05 | | 6.1 | 6.7 | ---------- | | 3" Pitcher Sam. | 200 | -- | Fragments of weathered sandstone |
| | | | | | | | | | | | |
| | | | | | | | | | | | Continued on Eng Form 1836, page 3. |
| | | | | | | | | | | | Will use 4x5-1/2 in. core barrel. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 8 Sheets

Hole No. WES-2-2-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION NWSC, Crane, Indiana | SHEET 3 OF 8 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4x5-1/2 in. diamond |
| 2. LOCATION (Coordinates or Station) Dye burial Grounds | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-2-2-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED two |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 26 August 81; COMPLETED 2 September 1 |
| 7. THICKNESS OF OVERBURDEN 6.1 ft | 17. ELEVATION TOP OF HOLE 725.46 ft |
| 8. DEPTH DRILLED INTO ROCK 48.4 ft | 18. TOTAL CORE RECOVERY FOR BORING 87.8% |
| 9. TOTAL DEPTH OF HOLE 54.5 ft | 19. SIGNATURE OF INSPECTOR [illegible] |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 725.46 | 0.0 | | | | | |
| 724.46 | 1.0 | | | | | |
| 723.46 | 2.0 | | | | | |
| 722.46 | 3.0 | | See page one for over-burden information. | | | |
| 721.46 | 4.0 | | | | | |
| 720.46 | 5.0 | | | | | |
| 719.46 | 6.0 | | | | | 26 August 1981 |
| 718.46 | 7.0 | | No recovery - highly weathered sandstone | | | Run 1<br>Rec 4.3'<br>Long 0.8'<br>Gain-<br>50 min<br>100 psi<br>Action Smooth<br>Brown |
| 717.46 | 8.0 | | ½" clay seam-soft | | | |
| 716.46 | 9.0 | | ½" clay seam-soft<br>Sandstone | 81.4% | -- | Remarks |
| 715.46 | 10.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES -2-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 8 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 715.46 | 10.0 | | Sandstone: see below | | | |
| 714.46 | 11.0 | | | | | |
| | | | Run 1 | | | 27 August 1981 |
| 713.46 | 12.0 | | | | | WL - Run 2<br>Began 9:15 Rec 3.65'<br>End 10:20 Loss -<br>Time 65 min Gain -<br>Drl time 40 min<br>Hyd press 100-120 psi<br>Water press -<br>RPM 75±<br>Drl Action Smooth<br>Water rot Brown |
| | | | closed break | | | |
| 712.46 | 13.0 | | Sandstone interbedded with seams of clay, siltstone, limonite, lignite, and peat. Core ranges in color from shades of brown, orange, and red to various shades of grey. Grain size is uniform and ranges from very fine to fine with quartz grains predominating. Material is dry, friable, and weathered. Bedding is distinct with thickness ranging from ½ in. to 8 in. maximum. | | | |
| 711.46 | 14.0 | | | | | Bit blocked off. |
| 710.46 | 15.0 | | | 100% | -- | |
| | | | Run 2 | | | |
| | | | fractured | | | |
| 709.46 | 16.0 | | | | | - Run 3<br>Began 10:40 Rec 4.15'<br>End 11:10 Loss -<br>Time 30 min Gain -<br>Drl time 30 min<br>Hyd press 100-200 psi<br>Water press -<br>RPM 75±<br>Drl Action Smooth<br>Water rot Brown |
| 708.46 | 17.0 | | Sandstone: same | 100% | -- | Remarks - |
| 707.46 | 18.0 | | closed break | | | |
| 706.46 | 19.0 | | | | | |
| | | | Run 3 | | | |
| 705.46 | 20.0 | | No recovery | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

Hole No. WES-2-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 5 OF 8 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 705.46 | 20.0 | | Run 4 | | | WL - Run 4<br>Began 12:05 Rec 0.0'<br>End 12:30 Loss 0.6'<br>Time 25 min Gain -<br>Drl time 25 min<br>Hyd press 100-120 psi<br>Water press -<br>RPM 50 ±<br>Drl Action Smooth<br>Water ret - |
| 704.46 | 21.0 | | No recovery | | | |
| 703.46 | 22.0 | | | 62.0% | -- | Remarks<br>Bit blocked off. |
| | | | -fractured siltsone<br>Siltstone: brown, dry, and breaks very easily. | | | |
| 702.46 | 23.0 | | | | | WL - Run 5<br>Began 12:50 Rec 3.1'<br>End 1:45 Loss 1.9'<br>Time 55 min Gain -<br>Drl time 50 min<br>Hyd press 100-200 psi<br>Water press -<br>RPM 50-75 ±<br>Drl Action Semi-rough<br>Water ret -<br>Remarks - |
| 701.46 | 24.0 | | Sandstone with lignite: same | | | |
| 700.46 | 25.0 | | Run 5 | | | |
| | | | -fractured<br>Run 6 | 100.0% | -- | WL - Run 6<br>Began 2:05 Rec ≈0.6'<br>End 2:30 Loss -<br>Time 25 min Gain -<br>Drl time 20 min<br>Hyd press 200 psi<br>Water press -<br>RPM 50 ±<br>Drl Action Rough<br>Water ret -<br>Remarks - |
| 699.46 | 26.0 | | Limonite with pyrite and chalcopyrite: red, blue, black in color, very hard, and has high specific gravity. | | | |
| | | | No recovery | 0.0% | -- | |
| 698.46 | 27.0 | | Run 7 | | | |
| 697.46 | 28.0 | | fractured sandstone and clay | 69.0 | -- | WL - Run 7<br>Began 2:50 Rec 0.0'<br>End 3:15 Loss 1.6'<br>Time 25 min Gain -<br>Drl time 15 min<br>Hyd press 200 psi<br>Water press -<br>RPM 50 ±<br>Drl Action Rough<br>Water ret - |
| 696.46 | 29.0 | | Sandstone: same | | | |
| 695.46 | 30.0 | | Run 8 | | | Remarks Bit blocked off |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-2-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 6 OF 8 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| | 17. ELEVATION TOP OF HOLE |
| 7. THICKNESS OF OVERBURDEN | 18. TOTAL CORE RECOVERY FOR BORING % |
| 8. DEPTH DRILLED INTO ROCK | 19. SIGNATURE OF INSPECTOR |
| 9. TOTAL DEPTH OF HOLE | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 695.46 | 30.0 | | fractured | | | NL - Run 8<br>Began 3:30 Rec 2.0'<br>End 4:15 Loss 0.9'<br>Time 45min Gain -<br>Drl time 40 min<br>Hyd press 150 psi<br>Water press -<br>RPM 50±<br>Drl Action Very rough<br>Water ret - |
| 694.46 | 31.0 | | Sandstone: same except very hard. | 83.0% | -- | |
| | | | clay/silt: grey and soft<br>Run 9 | | | |
| 693.46 | 32.0 | | From 32.0 to 32.25 - grey sandstone | | | Remarks<br>Bit blocked off. |
| 692.46 | 33.0 | | Sandstone interbedded with seams of grey shale(1/32 to 1/2 in.). Sandstone is grey to orange brown in color, hard, and fine-grained. | | | NL - Run 9<br>Began 4:20 Rec 1.7'<br>End 4:40 Loss 0.35'<br>Time 20 min Gain -<br>Drl time 20 min<br>Hyd press 200 psi<br>Water press -<br>RPM 50-100 ±<br>Drl Action Smooth<br>Water ret - |
| 691.46 | 34.0 | | Sandstone from 34.0 to 35.0 is dark grey in color. | | | |
| 690.46 | 35.0 | | Sandstone from 35.0 to 37.8 is light brown to orange brown and contains no shale seams. | | | Remarks<br>Bit blocked off.<br>28 August 1981 |
| 689.46 | 36.0 | | | 100.0% | -- | NL - Run 10<br>Began 9:26 Rec 4.85'<br>End 11:06 Loss<br>Time 100 min Gain -<br>Drl time 90 min<br>Hyd press 80-100<br>Water press-<br>RPM 35 ±<br>Drl Action Smooth<br>Water ret - |
| | | | Run 10 | | | |
| 688.46 | 37.0 | | | | | Remarks - |
| 687.46 | 38.0 | | fractured | 100.0% | -- | NL - Run 11<br>Began 11:20 Rec 4.2'<br>End 1:30 Loss -<br>Time 130 min Gain -<br>Drl time 120 min<br>Hyd press 100-150 psi<br>Water press -<br>RPM 35 ±<br>Drl Action Smooth<br>Water ret - |
| 686.46 | 39.0 | | 1/16 in. lignite | | | Remarks - |
| 685.46 | 40.0 | | Sandstone and shale: orange brown sandstone from 1/16 to 3 in. and grey shale from 1/16 to 1 in. thickness.<br>fractured | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO

Hole No. WBS-2-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 7 OF 8 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 685.46 | 40.0 | | 3/4 in. shale seam<br>Run 11 | 100.0% | -- | Switched over to water coring due to long drill times. Lost water at 27 ft - sandstone is too fractured for drilling mud to prevent water loss. Will drop casing into hole after reaming hole out with 6-3/4 in. rock bit for 6-1/2 in. casing. Bottom of casing is at 39.0 ft. |
| 684.46 | 41.0 | | | | | |
| 683.46 | 42.0 | | fractured<br>Sandstone with interbedded shale seams. Sandstone is various shades of brown, uniform, fine-grained, and quartz grains predominating. | | | |
| 682.46 | 43.0 | | | | | 29 August 1981 |
| 681.46 | 44.0 | | Run 12 | | | WL - Run 12<br>Began 11:30 Rec 2.95'<br>End 12:15 Loss -<br>Time 45 min Gain -<br>Drl time 45 min<br>Hyd press 150 psi<br>Water press-<br>RPM 50±<br>Drl Action Smooth<br>Water ret Brown<br>Remarks- |
| 680.46 | 45.0 | | Sandstone: same<br>From 45.5 to 48.2 alternating grey sandstone and shale with brown sandstone. Bedding thickness averages between 1/16 to 1/2 in. Sandstone is fine-grained and moderately friable and core breaks occur in shale seams. | | | |
| 679.46 | 46.0 | | | | | |
| 678.46 | 47.0 | | | 100.0% | -- | [illegible] - Run 13<br>[illegible] 12:45 Rec 4.2'<br>[illegible] 1:35 Loss -<br>[illegible] 50 min Gain -<br>[illegible] 50 min<br>[illegible] 150 psi<br>[illegible] press<br>[illegible] 50±<br>[illegible] Action Smooth<br>Water ret Brown<br>Remarks - |
| 677.46 | 48.0 | | Run 13 | | | |
| 676.46 | 49.0 | | machine/mechanical fracture<br>Brown sandstone<br>From 49.0 to 51.1 ft grey to dark grey shale(70%) interbedded with fine-grained, grey sandstone(30%). | | | |
| 675.46 | 50.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

Hole No. WES-2-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 8 OF 8 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 675.46 | 50.0 | | Shale(70%) with interbedded sandstone(30%) | | | |
| 674.46 | 51.0 | | 0.15 ft dark grey shale | | | |
| | | | Shale: green in color, uniform, brittle, and soft. | | | |
| 673.46 | 52.0 | | | 81.8% | -- | |
| | | | Highly fractured - possibly mechanical/ machine fractured. | | | |
| 672.46 | 53.0 | | | | | |
| | | | Run 14 | | | |
| | | | Recovered core to approximately 53.5 ft. | | | |
| 671.46 | 54.0 | | | | | |
| | | | End depth is 54.5 ft | | | |
| 670.46 | 55.0 | | Blew hole dry of all water. Ran air for approximately one hour to remove water. Will monitor in morning to see if water is coming in. Water level rose to 43.0 ft overnight. Blew hole and installed well screen. | | | |

Run 14
Begun 2:00 Rec 4.5'
End 3:40 Loss 1.0'
Time 90 min Gain -
Drl time 90 min
Hyd press 300 psi
Water press -
RPM 70
Drl Action Smooth
Water retBrown

Remarks-

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 3 Sep 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 720.02 Boring No. WES-2-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 1.15 | 3" Shelby Tube | 0 | S.T. | Clay (CL): Brown in color, dry, |
| 1A | | | | 0.5 | 1.0 | 1.15 | 1.45 | | 20 | Jar | crumbles easily, & contains frag- |
| | | | | 1.0 | 1.5 | | | | 150 | | ments of weathered sandstone. |
| | | | | 1.5 | 2.0 | | | | 300 | | Sample length: 1.45 ft |
| | | | 2.5 | 2.0 | 2.5 | | | | 350 | | Tube damaged in push. |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | ---------- | | 7" Folding Auger | ------ | | Cleanout: assumed change at 2.5' |
| | | | | | | | | | | | |
| 2A | 3 Sep | 2.5 | 5.65 | 50. | 5.65 | 5.0 | 5.65 | 3" Pitcher Sampler | 700 | Jar | Clayey sand (SC) & fragments of |
| | | | | | | | | | | | sandstone: brown in color, dry, |
| | | | | | | | | | | | friable, uniform, & very fine-grained. |
| | | | | | | | | | | | |
| | 3 Sep | | | 5.0 | 66.2 | ---------- | | 5-5/8" Rock Bit | ------ | | Cleanout: possible moisture at |
| | | | | | | | | | | | 19.4 ft. Drilling indicates 0.2 |
| | | | | | | | | | | | to 0.4 ft cavity at this depth. |
| | | | | | | | | | | | Checked hole for water and negative |
| | | | | | | | | | | | results. Removed small root from rock bit. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

NOTE: Extra jar sample made for NWSC

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-3-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 5.65 | 43.7 | | | | | | | | Sandstone: brown, fine-grained |
| | | 43.7 | 54.7 | | | | | | | | Shale: grey/green color |
| | | 54.7 | 64.2 | | | | | | | | Sandstone: red/purple, fine-grained |
| | | | | | | | | | | | Limestone: grey, very hard |
| | | 64.2 | 66.2 | | | | | | | | |
| | | | | | | | | | | | Water level overnight rose to |
| | | | | | | | | | | | 55.8 ft. Suspect water coming in |
| | | | | | | | | | | | at 54.7 ft. Blew hole dry and in- |
| | | | | | | | | | | | stalled well screen. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 4 Sep 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 716.66 Boring No. WES-2-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 2.2 | 3" Shelby Tube | 20 | S.T. | Silt (ML): brown to grey, no |
| 1A | | | | 0.5 | 1.0 | 2.2 | 2.5 | | 20 | Jar | cohesion, dry, very uniform in |
| | | | | 1.0 | 1.5 | | | | 70 | | grain size, texture, & composition |
| | | | | 1.5 | 2.0 | | | | 150 | | Sample length: 2.5 ft |
| | | | 3.75 | 2.0 | 2.5 | | | | 300 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | ----- | ----- | 7" Folding Auger | ----- | ----- | Cleanout |
| | | | | | | | | | | | |
| 2A | 4 Sep | 3.75 | | 5.0 | 5.5 | 5.0 | 5.65 | 3" Fixed Piston Samp. | 150 | Jar | Silt (ML) & fragments of sand- |
| | | | 5.65 | 5.5 | 5.65 | | | | 700 | | stone: silt is same as above. |
| | | | | | | | | | | | Sandstone is friable, fine- |
| | | | | | | | | | | | grained, light brown in color. |
| | | | | | | | | | | | |
| | 4 Sep | 5.65 | 41.5 | 5.0 | 31.0 | ----- | ----- | 5-5/8" Rock Bit | ----- | ----- | Sandstone: brown & fine-grained |
| | | | | | | | | | | | |
| | 5 Sep | 41.5 | 43.0 | 31.0 | 50.5 | ----- | ----- | 5-5/8" Rock Bit | ----- | ----- | Shale: green, soft & weathered |
| | | 43.0 | 50.5 | | | | | | | | Shale: green & hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

NOTE: Extra jar sample made for NWSC

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-4-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | Encountered water at 40.5 ft. |
| | | | | | | | | | | | Drilled 10.0 ft below water. |
| | | | | | | | | | | | Blew cuttings & water from hole. |
| | | | | | | | | | | | Installed well screen. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 5 Sep 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 739.24 Boring No. WES-2-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 1.55 | 3" Shelby Tube | 20 | S.T. | Clay (CL): brown in color, soft, |
| 1A | | | | 0.5 | 1.0 | 1.55 | 1.90 | | 20 | Jar | dry, moderately cohesive, & con- |
| | | | | 1.0 | 1.5 | | | | 50 | | tains organic matter. |
| | | | | 1.5 | 2.0 | | | | 150 | | Sample length: 1.9 ft |
| | | | | 2.0 | 2.5 | | | | 300 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | ---------- | | 7" Folding Auger | ---------- | | Cleanout |
| | | | | | | | | | | | |
| 2 | 5 Sep | | | 5.0 | 5.5 | 5.0 | 6.1 | 3" Fixed Piston Sam. | 100 | S.T. | Clay (CL) & sandstone: clay same |
| 2A | | | | 5.5 | 6.0 | 6.1 | 6.45 | | 350 | Jar | as above. Sandstone is red in |
| | | | 6.45 | 6.0 | 6.45 | | | | 750 | | color, very friable, & fine-grained. |
| | | | | | | | | | | | Sample length: 1.45 ft |
| | | | | | | | | | | | |
| | 5 Sep | 6.45 | 28.0 | 5.0 | 68.8 | ---------- | | 5-5/8" Rock Bit | ---------- | | Sandstone: red to brown, fine- |
| | | 28.0 | 68.8 | | | | | | | | grained. Alternating small seams |
| | | | | | | | | | | | of sandstone, shale, & limestone. |
| | | | | | | | | | | | Slightly moist at 30 ft but no water. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

NOTE: Extra jar sample was made for NWSC

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-5-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | Water level rose overnight to |
| | | | | | | | | | | | 55.8 ft. Blew hole of water & |
| | | | | | | | | | | | cuttings. Installed well screen. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 23 Sep 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 736.58 Boring No. WES-2-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 2.2 | 3" Shelby Tube | 0 | S.T. | Clay (CL) - brown to grey in color, |
| 1A | | | | 0.5 | 1.0 | 2.2 | 2.45 | | 0 | Jar | dry, little cohesion, material |
| | | | | 1.0 | 1.5 | | | | 10 | | disturbed by dozer. |
| | | | | 1.5 | 2.0 | | | | 100 | | Sample length: 2.45 ft |
| | | | | 2.0 | 2.5 | | | | 140 | | |
| | | | | | | | | | | | |
| 1B | 23 Sep | | | 0.0 | 5.0 | 0.0 | 5.0 | 7" Folding Auger | -- | Jar | Cleanout: Sample for NWSC - |
| | | | | | | | | | | | material same as above |
| | | | | | | | | | | | |
| 2 | 23 Sep | | | 5.0 | 5.5 | 5.0 | 6.33 | 3" Fixed Piston Sam. | 0 | S.T. | Clay (CL): same as above. |
| 2A | | | | 5.5 | 6.0 | 6.33 | 6.55 | | 20 | Jar | Sample length: 1.55 ft |
| | | | | 6.0 | 6.55 | | | | 550 | | |
| | | | | | | | | | | | |
| 2B | 23 Sep | | 9.0 | 5.0 | 9.0 | 5.0 | 9.0 | 7" Folding Auger | | Jar | Cleanout: Sample for NWSC - |
| | | | | | | | | | | | material same as above |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-6-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 23 Sep | 9.0 | 64.0 | 9.0 | 50.0 | ---- | ---- | 5-5/8" Rock Bit | ---- | ---- | Sandstone & interbedded shale: |
| | | | | | | | | | | | weathered, brown & dark grey in |
| | | | | | | | | | | | color, soft spot at 37 ft. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Monitored hole for water at 50 ft |
| | | | | | | | | | | | for 40 min. & negative results. |
| | | | | | | | | | | | |
| | 23 Sep | 64.0 | 70.63 | 50.0 | 70.63 | ---- | ---- | 5-5/8" Rock Bit | ---- | ---- | Continued drilling & between 55 |
| | | | | | | | | | | | & 60 ft encountered water. |
| | | | | | | | | | | | Shale: dark grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 24 Sep 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 728.73 Boring No. WES-2-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 2.0 | 3" Shelby Tube | 0 | S.T. | Sandy silt (SM): brown, dry, hard, |
| 1A | | | | 0.5 | 1.0 | 2.0 | 2.15 | | 0 | Jar | & contains 5% very fine gravel. |
| | | | | 1.0 | 1.5 | | | | 0 | | Possible dozer fill. |
| | | | | 1.5 | 2.0 | | | | 20 | | Sample length: 2.15 ft |
| | | | 4.0 | 2.0 | 2.5 | | | | 100 | | |
| | | | | | | | | | | | |
| 1B | 24 Sep | | | 0.0 | 5.0 | 0.0 | 5.0 | 7" Folding Auger | | Jar | Cleanout: Material same as above. |
| | | | | | | | | | | | Sample for NWSC. |
| | | | | | | | | | | | |
| | 24 Sep | 4.0 | 9.0 | 5.0 | 40.0 | ------ | ------ | 5-5/8" Rock Bit | ------ | | Sandstone: brown, weathered |
| | | 9.0 | 51.2 | | | | | | | | Sandstone & interbedded dark grey |
| | | | | | | | | | | | shale. Sandstone is brown, tan, |
| | | | | | | | | | | | grey & white, hardness varies from |
| | | | | | | | | | | | soft to very hard. |
| | | | | | | | | | | | Slight damp area at 31.3 ft. Drilled |
| | | | | | | | | | | | to 40 ft and monitored hole for |
| | | | | | | | | | | | 60 min. with negative results. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-7-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 24 Sep | 51.2 | 57.3 | 40.0 | 57.3 | ---------- | | 5-5/8" Rock Bit | ------- | | Water at approximately 46 ft. |
| | | | | | | | | | | | Material changes to dark grey |
| | | | | | | | | | | | shale with interbedded sandstone |
| | | | | | | | | | | | at 51.2 ft. |
| | | | | | | | | | | | Blew hole of water & cuttings. |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 25 Sep 81
Location Dye Burial Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 730.22 Boring No. WES-2-8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press. | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25 Sep | 0.0 | | 0.0 | 0.5 | 0.0 | 2.25 | 3" Shelby Tube | 0 | S.T. | Silty clay (CL): light brown-brown |
| 1A | | | | 0.5 | 1.0 | 2.25 | 2.45 | | 0 | Jar | in color, dry, moderate cohesion, |
| | | | | 1.0 | 1.5 | | | | 0 | | uniform, slightly stiff. |
| | | | | 1.5 | 2.0 | | | | 40 | | Sample length: 2.45 ft |
| | | | | 2.0 | 2.5 | | | | 60 | | |
| | | | | | | | | | | | |
| 1B | 25 Sep | | | 0.0 | 5.0 | 0.0 | 5.0 | 7" Folding Auger | | Jar | Cleanout: Sample for NWSC - |
| | | | | | | | | | | | material same as above. |
| | | | | | | | | | | | |
| 2 | 25 Sep | | | 5.0 | 5.5 | 5.0 | 6.69 | 3" Fixed Piston Sam. | 0 | S.T. | Silty clay (CL): lt. brown to |
| 2A | | | | 5.5 | 6.0 | 6.69 | 6.84 | | 10 | Jar | brown, dry, stiff, moderate co- |
| | | | | 6.0 | 6.5 | | | | 180 | | hesion, uniform. |
| | | | | 6.5 | 6.84 | | | | 800 | | Sample length: 1.84 ft |
| | | | | | | | | | | | |
| 1B | 25 Sep | | 6.84 | 5.0 | 6.84 | 5.0 | 6.84 | 7" Folding Auger | | Jar | Cleanout: sample for NWSC - |
| | | | | | | | | | | | material same as above |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-2-8-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 Sep | 6.84 | 58.0 | 6.84 | 40.0 | ---- | ---- | 5-5/8" Rock Bit | ---- | ---- | Sandstone & interbedded dark grey |
| | | | | | | | | | | | shale: sandstone varies from |
| | | | | | | | | | | | white, grey, brown to reddish |
| | | | | | | | | | | | brown. |
| | | | | | | | | | | | From 30 to 35.7 ft soft and slightly |
| | | | | | | | | | | | damp. Monitored for water at |
| | | | | | | | | | | | 40 ft for 40 min. & negative |
| | | | | | | | | | | | results. |
| | | | | | | | | | | | |
| | 25 Sep | 58.0 | 60.1 | 40.0 | 60.1 | ---- | ---- | 5-5/8" Rock Bit | ---- | ---- | Shale: dark grey |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 4 Sept. 1982
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 602.45 Boring No. WES-3-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.35 | 3" Shelby Tube | 40 | ST | Sandy clay (SC): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.35 | 1.60 | | 60 | Jar | dry, moderately cohesive with |
| | | | | 1.0 | 1.5 | | | | 100 | | approximately 30 to 40% sand |
| | | | | 1.5 | 2.0 | | | | 120 | | which ranges from fine to very |
| | | | | 2.0 | 2.5 | | | | 160 | | coarse. |
| | | | | | | | | | | | Sample length: 1.6 ft |
| | | | | | | | | | | | |
| | | | 4.5 | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 4 Sept | 4.5 | | 5.0 | 5.5 | 5.0 | 5.79 | 3"Fixed Piston Sampler | 100 | ST | Clay (CL): dark grey to black in |
| 2A | | | | 5.5 | 6.0 | 5.79 | 6.04 | | 300 | Jar | color, uniform composition, brittle, |
| | | | | 6.0 | | | | | 400 | | and very cohesive. Sample is |
| | | | | | | | | | | | disturbed. |
| | | | | | | | | | | | Sample length: 1.04 ft |
| | | | | | | | | | | | |
| | | | 8.02 | 5.0 | 10.0 | | | 7" Solid Auger | | | Cleanout |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4 Sept | 8.02 | | 10.0 | 10.5 | 10.0 | 10.85 | 3"Fixed Piston Sampler | 300 | ST | Clay shale: dark grey-black in |
| 3A | | | 11.5 | 10.5 | 11.0 | 10.85 | 11.0 | | 500 | Jar | color, soft (crumbles easily), |
| | | | | | | | | | | | uniform in composition |
| | | | | | | | | | | | Slight moisture at 10.5 ft |
| | 4 Sept | 11.5 | 13.0 | 11.0 | 21.5 | | | 5-5/8" Rock Bit | | | Limestone: grey, fossiliferous, |
| | | | | | | | | | | | and fine-grained |
| | | 13.0 | | | | | | | | | Sandstone: fine-grained, uniform |
| | | | | | | | | | | | composition (quartz grains), and |
| | | | | | | | | | | | friable. |
| | | | | | | | | | | | Stopped drilling at 21.5 ft to see |
| | | | | | | | | | | | if water came in overnight from |
| | | | | | | | | | | | damp spot at 10.5 ft-negative |
| | | | | | | | | | | | results on water from above inter- |
| | | | | | | | | | | | val. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 Sept | | 56.2 | 21.5 | 56.2 | — | — | 5-5/8" Rock | Bit | — | Sandstone: Same |
| | | | | | | | | | | | Encountered water at 46 ft |
| | | | | | | | | | | | and drilled 10 ft below this |
| | | | | | | | | | | | depth. Blew hole of water & |
| | | | | | | | | | | | cuttings. Installed well screen. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 7 Sept. 1981
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 620.68 Boring No. WES-3-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 Sept | 0.0 | | 0.0 | 1.8 | 0.0 | 1.5 | 3" Shelby Tube | | ST | Sandy silt (SM): brown in color, |
| 1A | | | | | | 1.5 | 1.8 | | | Jar | dry, no cohesion with 20 to 50% |
| | | | | | | | | | | | sand and sandstone fragments. |
| | | | | | | | | | | | Sandstone is brown to red in color |
| | | | Hydrallic gauge is broken. | | | | | | | | and friable. |
| | | | | | | | | | | | Sample length: 1.8 ft |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | 5.0 | 0.0 | 5.0' | | | 7" Solid Auger | | | Cleanout: |
| | | | | | | | | | | | |
| 2 | 7 Sept | 5.0 | | 5.0 | 7.5 | 5.0 | 7.4 | 5 x 6- 1/4" Dennison Barrel | | ST | Sandy clay (SC) and sandstone |
| 2A | | | 8.25 | | | 7.4 | 7.5 | | | Jar | fragments: Sandstone is brown |
| | | | | | | | | | | | to red in color, fine-grained, |
| | | | | | | | | | | | friable, and fragments range in |
| | | | | | | | | | | | size from 1/2" to 2-1/2". |
| | | | | | | | | | | | Encountered water at 7.5 ft |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 8.25 | | 5.0 | 9.0 | | | 7" Solid Auger | | | Cleanout: Water from 7.5 to 9.2 ft |
| | | | | 9.0 | | | | 3"Fixed Piston Sampler | | | Would not push |
| 3A | 7 Sept | | 9.2 | 9.0 | 9.2 | 9.0 | 9.2 | 7" Solid Auger | | Jar | Weathered brown and grey sandstone with sandy clay (SC). |
| 4A | 7 Sept | 9.2 | 14.0 | 9.2 | 16.0 | 9.2 | 9.8 | 5-5/8" Rock | Bit | | Limestone: grey, very hard, fine-grained. |
| | | 14.0 | 16.0 | | | | | | | | Sandstone/Limestone: drill change at 14 ft, unable to determine. |
| | | | | | | | | | | | Blew hole dry of water & cuttings. Installed well screen. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 8 Sept. 1981
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 580.78 Boring No. WES-3-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.23 | 3" Shelby Tube | 120 | ST | Gravelly clay (CL): dark brown |
| 1A | | | | 0.5 | 1.0 | 1.23 | 1.43 | | 120 | Jar | in color, moderate cohesion, |
| | | | | 1.0 | 1.5 | | | | 80 | | soft, and contains 10% gravel |
| | | | | 1.5 | 2.0 | | | | 60 | | ranging from 1/6-3/4 in. |
| | | | | 2.0 | 2.5 | | | | 60 | | Sample length: 1.43 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2A | 8 Sept | | 5.5 | 5.0 | 5.5 | 5.0 | 5.5 | 3"Fixed Piston Sampler | -500 | Jar | Clay (CL): and weathered sandstone; |
| | | | | | | | | | | | clay is same as above. Sandstone |
| | | | | | | | | | | | is brown in color, friable, and |
| | | | | | | | | | | | very fine-grained. |
| | | | | | | | | | | | |
| | | | | | | | | | | | See Engineer Form 1836 for core |
| | | | | | | | | | | | log- page 2 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 2 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5-1/2 in. Diamond bit |
| 2. LOCATION (Coordinates or Station) Ammunition Burning Grounds | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-3-3-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED two |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES zero |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE: STARTED 8 Sept. 81; COMPLETED 17 Sept. 81 |
| 7. THICKNESS OF OVERBURDEN 5.5 ft | 17. ELEVATION TOP OF HOLE 580.78 ft |
| 8. DEPTH DRILLED INTO ROCK 95.0 ft | 18. TOTAL CORE RECOVERY FOR BORING 77.3% % |
| 9. TOTAL DEPTH OF HOLE 100.5 ft | 19. SIGNATURE OF INSPECTOR Joseph B. Rinaldi |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 575.78 | 5.0 | | Overburden information on page 1 | | | |
| 574.78 | 6.0 | | orange brown clay | | | 8 September 81<br>WL -<br>Began 3:30<br>End 4:15<br>Time 45 min<br>Drl time 48 min<br>Hyd press 150-200psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water rot -<br>Run 1<br>Rec 4.6'<br>Loss -<br>Gain - |
| 573.78 | 7.0 | | orange brown in color | | | |
| 572.78 | 8.0 | | Sandstone: brown in color, very uniform, fine-grained, predominately quartz grains, and moderately friable. | | | Remarks<br>Cored with water. |
| 571.78 | 9.0 | | | | | |
| 570.78 | 10.0 | | Run 1 | | | |
| 569.78 | 11.0 | | | | | WL -<br>Began 4:20<br>End 5:10<br>Time 40 min<br>Drl time 40 min<br>Hyd press 150-200psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water rot<br>Run 2<br>Rec 5.05'<br>Loss -<br>Gain - |
| | | | From 11.9 to 21.85 ft, reddish brown color-iron staining. | | | |
| 568.78 | 12.0 | | fractured | 100% | - | |
| 567.78 | 13.0 | | Sandstone: same as above. | | | Remarks<br>Blew hole dry and monitored for water-negative results. |
| 566.78 | 14.0 | | | | | |
| 565.78 | 15.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| | 17. ELEVATION TOP OF HOLE |
| 7. THICKNESS OF OVERBURDEN | 18. TOTAL CORE RECOVERY FOR BORING % |
| 8. DEPTH DRILLED INTO ROCK | 19. SIGNATURE OF INSPECTOR |
| 9. TOTAL DEPTH OF HOLE | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 565.78 | 15.0 | | Run 2 | | | |
| | | | fractured and clay filled | | | |
| 564.78 | 16.0 | | | | | |
| | | | fractured and clay filled | | | 9 Sept, 81 |
| | | | | | | WL - Run 3 |
| | | | | | | Began 8:35 Rec 5.0' |
| 563.78 | 17.0 | | At 16.3 to 16.4 ft, interbedded organic matter. | | | End 9:10 Loss - |
| | | | | | | Time 35 min Gain - |
| | | | | | | Drl time 35 min |
| | | | Sandstone: grey in color (begins at 16.34 ft), uniform, fine-grained quartz sand, and slightly friable. | | | Hyd press 100psi |
| | | | | | | Water press - |
| | | | | | | RPM 50-75 |
| 562.78 | 18.0 | | | | | Drl Action Smooth |
| | | | | | | Water ret Brown |
| | | | | | | Remarks - |
| | | | closed break with clay | | | |
| 561.78 | 19.0 | | | 100% | - | |
| | | | Run 3 | | | |
| 560.78 | 20.0 | | | | | |
| 559.78 | 21.0 | | | | | |
| | | | | | | WL - Run 4 |
| | | | | | | Began 9:20 Rec 4.85' |
| | | | Sandstone; grey in color, very uniform, clean, fine-grained quartz sand, and slightly friable | | | End 10:00 Loss - |
| | | | | | | Time 40 min Gain - |
| 558.78 | 22.0 | | | | | Drl time 35 min |
| | | | | | | Hyd press 100psi |
| | | | | 100% | - | Water press - |
| | | | | | | RPM 50-75 |
| | | | | | | Drl Action Smooth |
| | | | | | | Water ret Brown |
| 557.78 | 23.0 | | | | | Remarks - |
| 556.78 | 24.0 | | | | | |
| | | | closed break | | | |
| | | | Run 4 | | | |
| 555.78 | 25.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

Hole No. UTS-1-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 555.78 | 25.0 | | closed break | | | |
| 554.78 | 26.0 | | Grey sandstone | | | ML - Run 5<br>Began 11:05 Rec 2.5'<br>End 11:20 Loss 2.5'<br>Time 15 min Gain -<br>Drl time 15 min<br>Hyd press 150psi<br>Water press -<br>RPM 50-70<br>Drl Action Smooth<br>Water ret -<br><br>Remarks<br><br>Lost water at approximately 26 ft. |
| 553.78 | 27.0 | | From 26.0 to 27.3 ft, iron nodules from 1/16 to 1/8 in. diameter. | | | |
| 552.78 | 28.0 | | no recovery-possible unconsolidated sand or very weathered sandstone. | | | |
| 551.78 | 29.0 | | | | | |
| | | | Run 5 | | | |
| 550.78 | 30.0 | | | | | |
| 549.78 | 31.0 | | | 0% | - | ML- Run 6<br>Began 11:30 Rec 0.0<br>End 11:35 Loss 5.0'<br>Time 5 min Gain -<br>Drl time 5 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-70<br>Drl Action Smooth<br>Water ret -<br><br>Remarks<br><br>Lost water-very quick drill time |
| 548.78 | 32.0 | | no recovery- possible unconsolidated sand or very weathered sandstone. | | | |
| 547.78 | 33.0 | | | | | |
| 546.78 | 34.0 | | | | | |
| | | | Run 6 | | | |
| 545.78 | 35.0 | | fractured | | | |

ENG FORM 1836 MAR 61 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 5 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 545.78 | 35.0 | | Fractured sandstone | | | |
| 544.78 | 36.0 | | | | | Wl. - Run 7<br>Begun 12:30 Rec 4.6'<br>End 1:25 Loss -<br>Time 55 min Gain -<br>Drl time 55 min<br>Hyd press 100psi<br>water press -<br>RPM 70<br>Drl Action Smooth<br>Water ret - |
| 543.78 | 37.0 | | Limestone: grey brown in color, hard, dense, fine-grained, fossiliferous, and uniform texture | | | |
| 542.78 | 38.0 | | | 100% | - | Remarks<br>Refilled water tank |
| 541.78 | 39.0 | | Run 7 | | | |
| 540.78 | 40.0 | | | | | |
| 539.78 | 41.0 | | grey clay/shale | 100% | - | Wl. - Run 8<br>Begun 3:30 Rec 5.1'<br>End 4:20 Loss -<br>Time 50 min Gain -<br>Drl time 50 min<br>Hyd press 400psi<br>water press -<br>RPM 70+<br>Drl Action Smooth<br>Water ret - |
| 538.78 | 42.0 | | Limestone and interbedded grey shale: very hard, and possibly an argillaceous or shaley limestone. | | | |
| 537.78 | 43.0 | | | | | Remarks - |
| 536.78 | 44.0 | | Run 8 | | | |
| 535.78 | 45.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 6 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE: STARTED / COMPLETED |
| | 17. ELEVATION TOP OF HOLE |
| 7. THICKNESS OF OVERBURDEN | 18. TOTAL CORE RECOVERY FOR BORING % |
| 8. DEPTH DRILLED INTO ROCK | 19. SIGNATURE OF INSPECTOR |
| 9. TOTAL DEPTH OF HOLE | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 535.78 | 45.0 | | Limestone | 100% | - | |
| 534.78 | 46.0 | | Run 9 | | | |
| | | | - fractured | | | |
| 533.78 | 47.0 | | | | | 10 Sept. 81 |
| | | | fractured | | | NL - Run 9<br>Begun 9:00 Rec 1.7'<br>End 9:30 Loss -<br>Time 30 min Gain -<br>Drl time 25 min<br>Hyd press 400psi<br>Water press -<br>RPM 50-70<br>Drl Action Smooth<br>Water rot - |
| 532.78 | 48.0 | | | | | |
| | | | Shale: greyish green color (change occurs at 46.2 ft), soft, uniform, and dry. | | | |
| 531.78 | 49.0 | | | | | Remarks<br>Bit blocked off. |
| 530.78 | 50.0 | | | 100% | - | |
| | | | fractured | | | |
| 529.78 | 51.0 | | Run 10 | | | |
| | | | Green color from 51.5 to 51.6 ft | | | |
| 528.78 | 52.0 | | | | | NL - Run 10<br>Begun 10:00 Rec 5.0'<br>End 10:50 Loss -<br>Time 50 min Gain -<br>Drl time 50 min<br>Hyd press 350-400psi<br>Water press -<br>RPM 50<br>Drl Action Rough<br>Water rot - |
| | | | Shale: brownish grey color (change occurs at 50.25 ft), soft, uniform, and dry. | | | |
| 527.78 | 53.0 | | | | | |
| 526.78 | 54.0 | | | 48.6% | - | Remarks<br>Kept blocking off. |
| | | | no recovery | | | Jetted hole dry and monitored for 1 hr- no water. |
| 525.78 | 55.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 7 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| | 17. ELEVATION TOP OF HOLE |
| 7. THICKNESS OF OVERBURDEN | 18. TOTAL CORE RECOVERY FOR BORING % |
| 8. DEPTH DRILLED INTO ROCK | 19. SIGNATURE OF INSPECTOR |
| 9. TOTAL DEPTH OF HOLE | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 525.78 | 55.0 | | | | | |
| 524.78 | 56.0 | | no recovery<br>Run 11 | 48.6% | - | WL - Run 11<br>Began 1:15 Rec 2.60'<br>End 2:20 Loss 2.75'<br>Time 65 min Gain -<br>Drl time 65 min<br>Hyd press 200-360psi<br>Water press -<br>RPM 70<br>Drl Action Rough<br>Water ret - |
| 523.78 | 57.0 | | | | | |
| 522.78 | 58.0 | | Shale: green in color, soft, dry, uniform, texture, and uniform composition. | | | Remarks<br>Bit kept blocking off. Load of water. |
| | | | - fractured | | | 11 Sept. 81 |
| 521.78 | 59.0 | | ---------- | 100% | - | WL - Run 12<br>Began 8:40 Rec 4.75'<br>End 9:50 Loss -<br>Time 65 min Gain -<br>Drl time 65 min<br>Hyd press 400psi<br>Water press -<br>RPM 75 - 100<br>Drl Action Rough<br>Water ret - |
| 520.78 | 60.0 | | Alternating lamina of green shale and grey limestone. Individual thickness is from 1/64 in to 1/8 in. | | | Remarks - |
| 519.78 | 61.0 | | Run 12 | | | |
| 518.78 | 62.0 | | From 61.3 to 61.7 ft, greenish grey shale and brownish grey limestone. | | | |
| 517.78 | 63.0 | | Limestone: grey, hard, dense, fine-grained, and sugary texture. Microcrystals of calcite visible | | | WL - Run 13<br>Began 10:30 Rec 4.1'<br>End 11:20 Loss -<br>Time 70 min Gain -<br>Drl time 45 min<br>Hyd press 400psi<br>Water press -<br>RPM 75-100<br>Drl Action Rough<br>Water ret - |
| | | | ---------- | | | |
| 516.78 | 64.0 | | Grey brown limestone and interbedded green shale with thickness of 1/64 to 1/4 in. | | | Remarks - |
| | | | ---------- | 100% | - | |
| 515.78 | 65.0 | | Grey limestone:<br>2 vertical cracks show weathering | | | |

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 8 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 515.78 | 65.0 | | Run 13 | | | |
| 514.78 | 66.0 | | fractured-stuck in core barrel-hammered out. | | | WL - Run 14<br>Began 11:35 Rec 4.8'<br>End 12:10 Loss -<br>Time 35 min Gain -<br>Drl time 35 min<br>Hyd press 400psi<br>Water press -<br>RPM 75-100<br>Drl Action Rough<br>~~Water~~ ret -<br>Remarks - |
| 513.78 | 67.0 | | | | | |
| 512.78 | 68.0 | | Shale and limestone;<br>Complete run is fine-lamina of green shale and grey limestone. Material is moderately hard, dense, and dry. | 100% | - | |
| 511.78 | 69.0 | | | | | WL - Run 15<br>Began 1:00 Rec 3.2'<br>End 1:35 Loss -<br>Time 35 min Gain -<br>Drl time 35 min<br>Hyd press 350-400psi<br>Water press -<br>RPM 75-100<br>Drl Action Rough<br>~~Water~~ ret - |
| 510.78 | 70.0 | | Run 14 | | | |
| 509.78 | 71.0 | | | 100% | - | Remarks<br>Blocked off-<br>Jetted hole dry and monitored for water-no water. |
| 508.78 | 72.0 | | Shale: green, soft, dry, uniform texture, and uniform composition. | | | WL - Run 16<br>Began 3:05 Rec 1.5'<br>End 3:35 Loss 0.6'<br>Time 30 min Gain -<br>Drl time 30 min<br>Hyd press 400psi<br>Water press -<br>RPM 50-75<br>Drl Action Rough<br>~~Water~~ ret - |
| 507.78 | 73.0 | | Run 15 | | | |
| 506.78 | 74.0 | | Shale: same as above | | | Remarks<br>Blocked off-<br>Went for another load of water. |
| 505.78 | 75.0 | | fractured | 71.4% | - | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 9 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 505.78 | 75.0 | | fractured Run 16 | | | 12 Sept 81 Al. - Run 17 Began 9:30 Rec 10' End 10:05 Loss - Time 35 min Gain - Drl time 35 min Hyd press 280-440psi Water press - RPM 50-75 Drl Action Rough Water ret - |
| 504.78 | 76.0 | | Shale: same as above Run 17 | 100% | - | |
| 503.78 | 77.0 | | Shale: same as above | | | Remarks Blocked off-used carbaloid bit |
| 502.78 | 78.0 | | fractured | | | Al. - Run 18 Began 10:35 Rec 2.0' End 12:05 Loss 3.0' Time 90 min Gain - Drl time 80 min Hyd press 350-400psi Water press - RPM 50-75 Drl Action Rough Water ret - |
| 501.78 | 79.0 | | | 100% | - | |
| 500.78 | 80.0 | | no recovery | | | Remarks Went back with diamond bit Al. - Run 19 Began 1:00 Rec 1.0' End 2:00 Loss 1.7' Time 60 min Gain - Drl time 40 min Hyd press 300-400psi Water press - RPM 70 Drl Action Rough Water ret - |
| 499.78 | 81.0 | | Run 18 | | | |
| 498.78 | 82.0 | | fractured Shale: same as above | | | Remarks Broke drill stem. Recovered with fishing tool. Al. - Run 19 Began 3:00 Rec 1.7' End 3:25 Loss - Time 25 min Gain - Drl time 20 min Hyd press 300-400psi Water press - RPM 50-75 Drl Action Smooth Water ret - |
| 497.78 | 83.0 | | no recovery | 37.0% | - | |
| 496.78 | 84.0 | | Run 19 | | | |
| 495.78 | 85.0 | | Shale: dark grey in color. | 100% | - | Remarks Used 3 in. Pitcher Sampler |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO.

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 10 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 495.78 | 85.0 | | Shale: dark grey in color, soft, uniform, and dry. Run 20 | | | Wl. - Run 21<br>Begun 3:40 Rec 1.3'<br>End 3:50 Loss -<br>Time 10 min Gain -<br>Drl time 8 min<br>Hyd press 300-400psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret - |
| 494.78 | 86.0 | | Shale: same | 100% | | |
| 493.78 | 87.0 | | Run 21 Hole fell in, cleanout with rock bit. | | | Remarks Hard rock at 86.9 ft. Used Pitcher Sampler. |
| | | | | | | 14 Sept, 81 |
| 492.78 | 88.0 | | no recovery Run 22 | 0.0% | - | Wl. - Run 22<br>Begun 12:25 Rec 0.0'<br>End 1:50 Loss 1.8'<br>Time 105 min Gain -<br>Drl time 80 min<br>Hyd press 300-450psi<br>Water press -<br>RPM 50<br>Drl Action Smooth<br>Water ret - |
| 491.78 | 89.0 | | Run 23 | 70% | - | Remarks Blocked off. Pitcher Sampler. |
| 490.78 | 90.0 | | From 89.35 to 91.0, sand: brown, fine-grained, uniform unconsolidated, with approximately 70 % quartz and 30% miscellaneous grains | | | Wl. - Run 23<br>Begun 2:45 Rec 0.7'<br>End 3:30 Loss 0.3'<br>Time 45 min Gain -<br>Drl time 30 min<br>Hyd press 400psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret - |
| 489.78 | 91.0 | | Shale: grey, uniform, dry Run 24 | 100% | - | |
| 488.78 | 92.0 | | From 92.0 to 92.5, sand: brown, fine-grained, and unconsolidated. From 92.5 to 92.9, sand: grey, coarse-grained, and unconsolidated. | | | Remarks Pitcher Sampler |
| 487.78 | 93.0 | | Shale: grey, uniform, and dry | | | Wl. - Run 24<br>Begun 4:15 Rec 2.0'<br>End 4:50 Loss -<br>Time 30 min Gain -<br>Drl time 30 min<br>Hyd press 400psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret - |
| 486.78 | 94.0 | | Run 25 | | | |
| 485.78 | 95.0 | | no recovery | | | Remarks Pitcher Sampler |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-3-3-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 11 OF 11 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 485.78 | 95.0 | | Fractured | | | 15 Sept, 81<br>Wl. -<br>Began 8:50<br>End 9:20<br>Time 30 min<br>Drl time 20 min<br>Hyd press 400psi<br>Water press -<br>RPM 75<br>Drl Action Smooth<br>Water ret -<br>Remarks Pitcher Sampler |
| | | | Grey shale | | | |
| 484.78 | 96.0 | | Run 26 | | | |
| 483.78 | 97.0 | | no recovery | 52.0% | - | Wl. -<br>Began 9:35<br>End 10:00<br>Time 25 min<br>Drl time 25 min<br>Hyd press 400psi<br>Water press -<br>RPM 70<br>Drl Action Smooth<br>Water ret -<br>Remarks Pitcher Sampler |
| | | | Sand: grey to brown, fine to medium grained, and unconsolidated | | | |
| 482.78 | 98.0 | | Grey shale | | | |
| | | | Run 27 | | | |
| 481.78 | 99.0 | | no recovery: drill action indicated shale: | 16.6% | - | Wl. -<br>Began 10:20<br>End 10:50<br>Time 30 min<br>Drl time 28 min<br>Hyd press 400psi<br>Water press -<br>RPM 70<br>Drl Action Smooth<br>Water ret -<br>Remarks Pitcher Sampler |
| 480.78 | 100 | | Grey shale<br>Run 28 | | | |
| | | | Ran rock bit to bottom and cleaned out hole. Jetted hole dry after making repairs to jet. Installed well screen. | | | Wl. -<br>Began 11:15<br>End 11:45<br>Time 30 min<br>Drl time 20 min<br>Hyd press 400psi<br>Water press -<br>RPM 50-70<br>Drl Action Smooth<br>Water ret -<br>Remarks Pitcher Sampler |

Run 25: Rec 1.8', Loss 0.5', Gain -
Run 26: Rec 1.3', Loss 0.7', Gain -
Run 27: Rec 1.3', Loss 1.2', Gain -
Run 28: Rec 0.3', Loss 1.5', Gain -

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 24 Sept. 1981
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 592.12 Boring No. WES-3-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.3 | 3" Shelby Tube | 240 | ST | Sandy silt (SM) and gravel: brown |
| 1A | | | | 0.5 | 1.0 | 1.3 | 1.5 | | 320 | Jar | in color, dry, with hard fragments |
| | | | | 1.0 | 1.5 | | | | 460 | | of sandstone and silt. Composition |
| | | | | | | | | | | | is varied. |
| | | | | | | | | | | | Sample length: 1.5 ft |
| | | | 5.0 | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout: Hardness increasing |
| | | | | | | | | | | | with depth. |
| | | | | | | | | | | | |
| | 24 Sept | 5.0 | 11.0 | 5.0 | 20.5 | | | 5-5/8" Rock Bit | | | Gravel, sand, and weathered sand- |
| | | | | | | | | | | | stone |
| | | 11.0 | 21.0 | | | | | | | | Sandstone |
| | | 21.0 | 23.5 | | | | | | | | Limestone: white in color and |
| | | | | | | | | | | | hard |
| | | | | | | | | | | | |
| | 25 Sept | 23.5 | 34.2 | 20.5 | 70.0 | | | 5-5/8" Rock Bit | | | Sandstone: Reddish brown and |
| | | | | | | | | | | | weathered |
| | | 34.2 | 49.5 | | | | | | | | Sandstone: Hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-4-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Slightly softer from 40.5 to 42 ft |
| | | 49.5 | 59.0 | | | | | | | | Limestone: very hard cutting |
| | | 59.0 | 70.0 | | | | | | | | Sandstone or shale. Material is |
| | | | | | | | | | | | soft-easy drilling. |
| | | | | | | | | | | | |
| | 26Sept | | | | | | | | | | Water in hole to depth of 45.55 ft |
| | | | | | | | | | | | |
| | 26Sept | | No indication of moisture or water was noted during | | | | | | | | drilling. Blew hole dry and |
| | | | attempted to determine the depth at which water is | | | | | | | | entering boring. Was unable to |
| | | | see where water is coming from. Packed boring with | | | | | | | | sand to depth of 60 ft and |
| | | | bentonite to depth of 57 ft. Sealed lower portion | | | | | | | | of boring to determine if water is |
| | | | coming in above 57 ft. On 28 September 81, no water was noted. Drilled sand and | | | | | | | | |
| | | | bentonite plug from boring and installed well on bottom of hole. | | | | | | | | |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 29 Sept. 1981
Location Ammunition Burning Grounds Job No 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 593.25 Boring No. WES-3-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 29Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.25 | 3" Shelby Tube | 120 | ST | Sandy silt(SM): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.25 | 1.50 | | 240 | Jar | dry, slight cohesion and 30% fine |
| | | | 7.0 | 1.0 | 1.5 | | | | 400 | | to coarse sand. |
| | | | | | | | | | | | |
| | 29Sept | | | 0.0 | 47.0 | — | — | 5-5/8" Rock | Bit | — | |
| | | 7.0 | 12.0 | | | | | | | | Sandstone: soft & brown |
| | | 12.0 | 16.5 | | | | | | | | Sandstone: Moderately hard & brown |
| | | 16.5 | 20.0 | | | | | | | | Sandstone: reddish brown & soft |
| | | 20.0 | 32.0 | | | | | | | | Sandstone & Shale: medium hard & |
| | | | | | | | | | | | brown to grey |
| | | 32.0 | 34.0 | | | | | | | | Sandstone & Shale: very hard |
| | 30Sept | | | 47.0 | 60.0 | — | — | 5-5/8" Rock | Bit | — | Water rose overnight to depth of |
| | | | | | | | | | | | 46.5 ft. |
| | | 34.0 | 47.0 | | | | | | | | Sandstone & Shale: med. hard |
| | | 47.0 | 55.0 | | | | | | | | Sandstone/Limestone: very hard |
| | | 55.0 | 60.0 | | | | | | | | Shale: grey to green color & soft |
| | | | | | | | | | | | Monitored hole for 2 hours and |

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# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-5-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | water came up 0.7 ft. Water was |
| | | | | | | | | | | | visible in bottom of boring and |
| | | | | | | | | | | | bubbling. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 6 Oct. 1981
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 587.60 Boring No. WES-3-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.75 | 3" Shelby Tube | 60 | ST | Sandy clay(CL); brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.73 | 1.98 | | 60 | Jar | stiff, dry, and 1-10% fine gravel |
| | | | | 1.0 | 1.5 | | | | 100 | | and 30-40% sand. |
| | | | | 1.5 | 2.0 | | | | 180 | | Sample length: 1.98 |
| | | | | 2.0 | 2.5 | | | | 280 | | |
| | | | | | | | | | | | |
| | 6 Oct | | 3.4 | 0.0 | 3.4 | — | — | 7" Solid Auger | — | — | Cleanout: Hard rock at indicated |
| | | | | | | | | | | | depth. |
| | 7 Oct | 3.4 | 8.5 | 3.4 | 52.7 | — | — | 5-5/8" Rock | Bit | — | Sandstone: soft, brown |
| | | 8.5 | 9.5 | | | | | | | | Sandstone: soft, red |
| | | 9.5 | 13.2 | | | | | | | | Sandstone: soft, brown |
| | | 13.2 | 14.5 | | | | | | | | Sandstone: soft, red |
| | | 14.5 | 22.5 | | | | | | | | Sandstone: soft, brown |
| | | 22.5 | 24.0 | | | | | | | | Sandstone: soft, red |
| | | 24.0 | 37.5 | | | | | | | | Sandstone: soft, brown |
| | | 37.5 | 52.7 | | | | | | | | Limestone: Hard & possibly fractured |
| | | | | | | | | | | | from 39.0'. Water encountered |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____

Location _____ Job No _____

Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES3-6-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | around 42 ft. Installed well |
| | | | | | | | | | | | screen. |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 8 Oct, 1981
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 554.65 Boring No. WES-3-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 0.72 | 3" Shelby Tube | 100 | ST | Sandy clay (CL): dark brown in |
| 1A | | | | 0.5 | 1.0 | 0.72 | 0.90 | | 140 | Jar | color, low plasticity, soft, and |
| | | | | 1.0 | 1.5 | | | | 180 | | with 20 to 30% fine to coarse sand |
| | | | | 1.5 | 2.0 | | | | 220 | | & fine gravel. |
| | | | | 2.0 | 2.5 | | | | 300 | | Sample length: 0.90 ft |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout: |
| | | | | | | | | | | | |
| 2 | 8 Oct | | | 5.0 | 5.5 | 5.0 | 6.24* | 3"Fixed Piston Sampler | 50 | ST | Sandy clay (CL): same as above. |
| 2A | | | | 5.5 | 6.0 | 6.24 | 6.44 | | 50 | Jar | |
| | | | | 6.0 | 6.5 | | | | 100 | | |
| | | | | 6.5 | 7.0 | | | | 140 | | Sample length: 1.44 ft |
| | | | | 7.0 | 7.5 | | | | 200 | | |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | 7" Solid Auger | | | Cleanout: |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 8 Oct | | | 10.0 | 10.5 | 10.0 | 11.57 | 3" F.P.S. | 25 | ST | Sandy clay (CL): same except sand |
| 3A | | | | 10.5 | 11.0 | 11.57 | 11.77 | | 50 | Jar | & gravel content increased to |
| | | | | 11.0 | 11.5 | | | | 75 | | approx. 40 to 50%. |
| | | | | 11.5 | 12.0 | | | | 140 | | Sample length: 1.77 ft |
| | | | 13.0 | 12.0 | 12.5 | | | | 180 | | |
| | | | | | | | | | | | |
| | | 13.0 | | 10.0 | 15.0 | — | — | 7" Solid Auger | — | — | Cleanout: stratum change assumed |
| | | | | | | | | | | | |
| 4 | 8 Oct | | | 15.0 | 15.5 | 15.0 | 16.33 | 3" F.P.S. | 50 | ST | Sandy gravel (GC): brown in color |
| 4A | | | | 15.5 | 16.0 | 16.33 | 16.59 | | 120 | Jar | with 50% fine to coarse sandstone |
| | | | | 16.0 | 16.5 | | | | 260 | | fragments and 50% sand and clay. |
| | | | 17.0 | 16.5 | 17.0 | | | | 300-500 | | |
| | | | | | | | | | | | Sample length: 1.59 ft |
| | 8 Oct | | | 15.0 | 28.0 | — | — | 5-5/8" Rock | Bit | — | Water at 17.5-18.0 ft |
| | | 17.0 | 22.2 | | | | | | | | Sandstone: weathered, brown, & soft |
| | | 22.2 | 24.0 | | | | | | | | Limestone: grey, hard, & fine- |
| | | | | | | | | | | | grained |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 3 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-7-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 24.0 | 28.0 | | | | | | | | Shale: dark grey & moderately |
| | | | | | | | | | | | soft |
| | 9 Oct | | | | | | | | | | Installed well after blowing hole |
| | | | | | | | | | | | of water & fall in. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 9 Oct. 1981
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 584.26 Boring No. WES-3 8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.86 | 3" Shelby Tube | 50 | ST | Clay (CL): grey brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.86 | 2.06 | | 100 | Jar | soft, low plasticity, uniform, |
| | | | | 1.0 | 1.5 | | | | 120 | | organic matter, and dry. |
| | | | | 1.5 | 2.0 | | | | 140 | | Sample length: 2.06 ft |
| | | | 3.0 | 2.0 | 2.5 | | | | 180 | | |
| | | 3.0 | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Solid Auger | — | — | Cleanout |
| | | | | | | | | | | | |
| 2 | 9 Oct | | | 5.0 | 5.5 | 5.0 | 6.01 | 3" Fixed Piston Samp | 100 | ST | Gravelly sand (SW): brown in color |
| 2A | | | | 5.5 | 6.0 | 6.01 | 6.21 | | 180 | Jar | with fine to coarse grained sand |
| | | | 6.5 | 6.0 | 6.5 | | | | 300-540 | | and sandstone fragments & dry. |
| | | | | | | | | | | | Sample length: 1.21 ft |
| | | | | | | | | | | | |
| | 9 Oct | 6.5 | 14.3 | 5.0 | 48.0 | — | — | 5-5/5" Rock | Bit | — | Weathered brown sandstone inter- |
| | | | | | | | | | | | bedded with shale. |
| | | 14.3 | 17.0 | | | | | | | | Sandstone: brown, soft |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location Job No.
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-8-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 17.0 | 24.3 | | | | | | | | Sandstone: hard, brown |
| | | 24.3 | 36.0 | | | | | | | | Sandstone: light tan, moderately |
| | | | | | | | | | | | hard |
| | | 36.0 | 48.0 | | | | | | | | Limestone: hard, grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | Encountered water between 37 & 38 |
| | | | | | | | | | | | ft. Blew hole dry & installed |
| | | | | | | | | | | | well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Note: Water in this hole is very |
| | | | | | | | | | | | slow. Not similar to well no. |
| | | | | | | | | | | | 6 & 5 where boring made water |
| | | | | | | | | | | | at faster rate. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 28 Oct. 1981
Location Ammunition Burning Grounds Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 625.25 Boring No. WES-3-9-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 0.89 | 3" Shelby Tube | 50 | ST | Sandy clay (CL) and sandstone |
| 1A | | | | 0.5 | 1.0 | 0.89 | 1.14 | | 120 | Jar | fragments: brown in color, dry, |
| | | | | 1.0 | 1.5 | | | | 160 | | and low plasticity. Sand ranges |
| | | | | 1.5 | 2.0 | | | | 160 | | from fine to coarse-grained. |
| | | | | 2.0 | 2.5 | | | | 180 | | Sample length: 1.14 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2A | 28 Oct | | 5.8 | 5.0 | 5.5 | 5.0 | 5.8 | 3"Fixed Piston Sampler | 200 | Jar | Sandy clay (CL) and sandstone. |
| | | | | 5.5 | 5.8 | | | | 700 | | |
| | | | | | | | | | | | |
| | 28 Oct | 5.8 | 8.5 | 0.0 | 18.7 | | | 6 3/4" Rock Bit | | | Sandstone: brown, soft, weathered. |
| | 29 Oct | 8.5 | 11.0 | 0.0 | 18.7 | | | 8 3/4" Rock Bit | | | Sandstone: brown, rough drilling- |
| | | | | Cemented 8" schedule 40 PVC Pipe to | | | | | | | contains boulders, clay, and water. |
| | | 11.0 | 11.8 | depth of 11.9 ft. Telescoped 6" thin- | | | | | | | Sandstone: brown and hard. |
| | | 11.8 | 16.8 | wall casing to 18.7 ft and cemented in | | | | | | | Limestone: light grey and hard. |
| | | 16.8 | 17.5 | place. Casing, will seal off water | | | | | | | Shale: grey and soft. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-3-9-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | found in overburden. | | | | | | | |
| | | 17.5 | 20.0 | | | | | | | | Limestone: light grey and hard |
| | 31 Oct | | | 18.7 | 59.5 | | | 5-5/8" Rock Bit | | | Drilled through grout in 6 and 8" |
| | | | | | | | | | | | Casing. |
| | | 20.0 | 39.8 | | | | | | | | Shale: grey and medium hard |
| | | 39.8 | 45.3 | | | | | | | | Sandstone: light grey and hard |
| | | 45.3 | 47.7 | | | | | | | | Limestone: light grey and hard |
| | | 47.7 | 48.0 | | | | | | | | Sandstone: light brown |
| | | 48.0 | 49.2 | | | | 48.5 | ft slight moisture- | | | Shale: dark grey and medium hard |
| | | 49.2 | 51.3 | | | | no water after 90 min | | | | Sandstone: light grey |
| | | 51.3 | 52.0 | | | | | | | | Shale: dark grey |
| | | 52.0 | 63.7 | | | | | | | | Sandstone: brown and hard |
| | | 63.7 | 65.0 | | | | | | | | Limestone: grey and hard |
| | | 65.0 | 70.0 | | | | | | | | Sandstone: light grey and hard |
| | | 70.0 | 73.5 | | | | 70.5 | ft encountered water | | | Sandstone: light grey and soft |
| | | 73.5 | 80.5 | | | | | | | | Sandstone: light grey and hard |
| | | | | | | | | | | | Installed well screen. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

Pump House (Bld. 3004) - Ammunition Burning Grounds

1. Driller: W. W. Mardis
2. Date Drilled: Jan. 9, 1942
3. Depth of Well: 141 ft
4. Casing Depth: 102 ft Diameter: 8 in
5. Elevation of Casing Plate: 594.79 ft
6. Water Depth: 120 ft
7. Remarks:

   8-in. hole to 100 ft - reduced to 7-in.

   Water height in well - 20 ft
8. Well Log:

   0 to 90 ft - No information

   90 to 141 ft - Sandstone

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 9 Sept. 1981
Location McComish Gorge Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 603.49 Boring No. WES-4-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9 Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 2.08 | 3" Shelby Tube | 0 | ST | Silt (ML): brown in color, slightly |
| 1A | | | | 0.5 | 1.0 | 2.08 | 2.23 | | 0 | Jar | moist, little cohesion, slight |
| | | | | 1.0 | 1.5 | | | | 0 | | gritty feal, and contains organic |
| | | | | 1.5 | 2.0 | | | | 20 | | matter. |
| | | | | 2.0 | 2.5 | | | | 120 | | Sample length: 2.23 ft |
| | | | | | | | | | | | |
| | | | 5.0 | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 9 Sept | 5.0 | | 5.0 | 5.5 | 5.0 | 6.55 | *3"Fixed Piston Sampler | 0 | ST | Silty sand (SM): reddish brown in |
| 2A | | | | 5.5 | 6.0 | 6.55 | 6.75 | | 0 | Jar | color, very uniform, fine-grained, |
| | | | | 6.0 | 6.5 | | | | 0 | | little cohesion, and dry. |
| | | | | 6.5 | 7.0 | | | | 20 | | |
| | | | | 7.0 | 7.4 | | | | 80 | | Sample length: 1.75 ft |
| | | | | | | | | | | | |
| | | | | 5.0 | 70.0 | | | *7" Hollow-stem Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 9 Sept | | | 10.0 | 10.5 | 10.0 | 10.3 | 3" F.P.S. | 0 | ST | Silty sand (SM): reddish brown in |
| 3A | | | | 10.5 | 11.0 | 10.3 | 10.6 | | 20 | Jar | color, uniform, fine-grained (pre- |
| | | | | 11.0 | 11.5 | | | | 40 | | dominately quartz), little cohesion, |
| | | | | 11.5 | 12.0 | | | | 50 | | and dry. |
| | | | | 12.0 | 12.5 | | | | 700 | | Sample length: 0.6 ft- Sample fell |
| | | | | | | | | | | | back into hole. |
| | | | | | | | | | | | |
| | | | 14.0 | 70.0 | 15.0 | — | — | 7" H.S. Auger | | — | Cleanout: assumed stratum change. |
| | | | | | | | | | | | |
| 4 | 9 Sept | 14.0 | | 15.0 | 15.5 | 15.0 | 16.97 | 3" F.P.S. | 0 | ST | Gravelly sand (SP): reddish brown |
| 4A | | | | 15.5 | 16.0 | 16.97 | 17.20 | | 20 | Jar | in color, fine to coarse-grained |
| | | | | 16.0 | 16.5 | | | | 80 | | sand, very fine gravel, slightly |
| | | | | 16.5 | 17.0 | | | | 120 | | moist, and no cohesion. |
| | | | | 17.0 | 17.5 | | | | 140 | | Sample length: 2.2 ft |
| | | | | | | | | | | | |
| | | | 19.0 | 15.0 | 20.0 | — | — | 7" H.S. Auger | | — | Cleanout: assumed stratum change. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 9 Sept | 19.0 | | 20.0 | 20.5 | 20.0 | 22.05 | 3" F.P.S | 0 | ST | Sand (SP): brown in color, fine |
| 5A | | | | 20.5 | 21.0 | 22.05 | 22.3 | | 10 | Jar | to medium grained, slight moisture, |
| | | | | 21.0 | 21.5 | | | | 30 | | very little cohesion, and 80-90% |
| | | | | 21.5 | 22.0 | | | | 60 | | quartz sand. |
| | | | | 22.0 | 22.5 | | | | 90 | | Sample length: 2.3 ft |
| | | | | | | | | | | | |
| | | | 24.0 | 20.0 | 25.0 | — | — | 7" H.S. Auger | | — | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 6 | 9 Sept | 24.0 | | 25.0 | 25.5 | 25.0 | 27.08 | 3" F.P.S. | 0 | ST | Silty sand (SM): brown in color, |
| | | | | 25.5 | 26.0 | 27.08 | 27.3 | | 50 | Jar | fine-grained, slight moisture, little |
| | | | | 26.0 | 26.5 | | | | 100 | | cohesion, and contains 30% silt. |
| | | | | 26.5 | 27.0 | | | | 160 | | |
| | | | | 27.0 | 27.5 | | | | 180 | | Sample length: 2.3 ft |
| | | | | | | | | | | | |
| | | | 30.0 | 25.0 | 30.0 | — | — | 7" H.S. Auger | | — | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7A | 9 Sept | 30.0 | | 30.0 | 30.5 | 30.0 | 30.3 | 3" F.P.S. | 0 | Jar | Recovered 0.3 ft of very moist |
| | | | | 30.5 | 31.0 | | | | 10 | | sand/silt: brown in color, very |
| | | | | 31.0 | 31.5 | | | | 20 | | fine-grained, and slight cohesion. |
| | | | | 31.5 | 32.0 | | | | 50 | | Will attempt again at 32.5 ft. |
| | | | | 32.0 | 32.5 | | | | 80 | | |
| | | | | | | | | | | | |
| | | | | 30.0 | 32.5 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| 8 | 9 Sept | | | 32.5 | 33.0 | 32.5 | 33.3 | 3" F.P.S. | 0 | ST | Silt (ML): very moist, brown in |
| 8A | | | | 33.0 | 33.5 | 33.3 | 33.6' | | 20 | Jar | color, moderately cohesive, and |
| | | | | 33.5 | 34.0 | | | | 30 | | contains 1-2% very fine gravel. |
| | | | | 34.0 | 34.5 | | | | 40 | | Sample length: 1.1 ft |
| | | | | 34.5 | 35.0 | | | | 80 | | Lost 1.4 ft |
| | | | | | | | | | | | |
| | | | 37.5 | 32.5 | 37.5 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 9 Sept | 37.5 | | 37.5 | 38.0 | 37.5 | 39.55 | 3" F.P.S. | 0 | | Clay silt: grey in color, moist |
| 9A | | | | 38.0 | 38.5 | 39.55 | 39.8 | | 40 | | and moderately cohesive. |
| | | | | 38.5 | 39.0 | | | | 190 | | |
| | | | | 39.0 | 39.5 | | | | 230 | | Sample length: 2.3 ft |
| | | | | 39.5 | 39.85 | | | | 300 | | |
| | | | | | | | | | | | |
| | | | | 37.5 | 40.0 | — | — | 7" H.S. Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 10 | 10Sept | | | 40.3 | 40.8 | 40.3 | 42.48 | 3" F.P.S. | 0 | ST | Clay silt: same moist |
| 10A | | | | 40.8 | 41.3 | 42.48 | 42.63 | | 0 | Jar | |
| | | | | 41.3 | 41.8 | | | | 0 | | |
| | | | | 41.8 | 42.3 | | | | 10 | | Sample length: 2.33 ft |
| | | | 42.7 | 42.3 | 42.7 | | | | 20 | | |
| | | | | | | | | | | | |
| | 10Sept | | | | | | | | | | Pulled auger and installed well |
| | | | | | | | | | | | screen. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 5 of 5 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 10 Sept. 1981
Location McComish Gorge Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 585.69 Boring No. WES-4-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.27 | 3"Shelby Tube | 280 | ST | Gravelly sand (SP): brown in |
| 1A | | | | 0.5 | 1.0 | 1.27 | 1.47 | | 240 | Jar | color, dry, fine to coarse |
| | | | | 1.0 | 1.5 | | | | 300 | | grained with 20% fine to medium |
| | | | | 1.5 | 2.0 | | | | 330 | | gravel, and no cohesion. |
| | | | | 2.0 | 2.5 | | | | 350 | | Sample length: 1.47 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 10Sept | | | 5.0 | 5.5 | 5.0 | 5.9 | *3"Fixed Piston Sampler | 0 | ST | Gravelly sand (SP): brown in |
| 2A | | | | 5.5 | 6.0 | 5.9 | 6.1 | | 20 | Jar | color, dry, fine to medium |
| | | | | 6.0 | 6.5 | | | | 40 | | grained with 10% fine gravel and |
| | | | | 6.5 | 7.0 | | | | 60 | | little cohesion. |
| | | | | | | | | | | | Sample length: 1.1 ft- suspect |
| | | | | | | | | | | | loss |
| | | | | | | | | | | | |
| | | | 8.0 | 5.0 | 10.0 | | | *7"Hollow Stem Auger | | | Cleanout |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 10Sept | 8.0 | | 10.0 | 10.5 | 10.0 | 11.97 | 3" F.P.S. | 12 | ST | Silty sand (SM): brown in color, |
| 3A | | | | 10.5 | 11.0 | 11.97 | 12.23 | | 20 | Jar | slight moisture, and slight |
| | | | | 11.0 | 11.5 | | | | 30 | | cohesion. |
| | | | | 11.5 | 12.0 | | | | 90 | | Last foot is fine-grained. |
| | | | | 12.0 | 12.5 | | | | 150 | | Sample length: 2.23 ft |
| | | | | | | | | | | | |
| | | | | 70.0 | 15.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| 4 | 11Sept | | 15.0 | 15.0 | 15.5 | 15.0 | 16.60 | 3" F.P.S. | 0 | ST | Clay silt (ML): brown in color, |
| 4A | | 15.0 | | 15.5 | 16.0 | 16.60 | 16.85 | | 20 | Jar | moderately cohesive, and slight |
| | | | | 16.0 | 16.5 | | | | 40 | | moisture. Lost last 0.4 ft |
| | | | | 16.5 | 17.0 | | | | 100 | | Sample length: 1.85 ft |
| | | | | 17.0 | 17.5 | | | | 180 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 11Sept | | | 20.0 | 20.5 | See below | | 3" F.P.S. | 20 | | Lost sample. |
| | | | | 20.5 | 21.0 | | | | 20 | | |
| | | | | 21.0 | 21.5 | | | | 50 | | |
| | | | | 21.5 | 22.0 | | | | 70 | | |
| | | | | 22.0 | 22.5 | | | | 130 | | |
| | | | | | | | | | | | |
| 5A | 11Sept | | | 20.0 | 21.5 | 20.0 | 21.5 | Standard Splitspoon | — | Jar | Pushed splitspoon-clay silt (ML) |
| | | | | | | | | | | | brown in color, moderately |
| | | | | | | | | | | | cohesive, and moist. Water was |
| | | | | | | | | | | | visible in bottom of hole. |
| | | | | | | | | | | | |
| | | | 22.0 | 20.0 | 25.0 | — | — | 7" H.S. Auger | | — | Cleanout: stratum change assumed |
| | | | | | | | | | | | |
| 6 | 11Sept | 22.0 | | 20.0 | 25.5 | 25.0 | 27.05 | 3" F.P.S. | 0 | ST | Silty sand (SM): grey in color, |
| 6A | | | | 25.5 | 26.0 | 27.05 | 27.35 | | 10 | Jar | very fine-grained sand, uniform, |
| | | | | 26.0 | 26.5 | | | | 50 | | moderately cohesive, and moist. |
| | | | | 26.5 | 27.0 | | | | 100 | | Sample length: 2.35 ft |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 27.0 | 27.4 | | | | 160 | | |
| | | | | | | | | | | | |
| | | | | 25.0 | 30.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| 7 | 11Sept | | | 30.0 | 30.5 | 30.0 | 32.05 | 3" F.P.S. | 10 | ST | Silty sand (SM): brown in color, |
| 7A | | | | 30.5 | 31.0 | 32.05 | 32.35 | | 20 | Jar | very fine-grained, moderate |
| | | | | 31.0 | 31.5 | | | | 80 | | cohesion, and moist. |
| | | | | 31.5 | 32.0 | | | | 120 | | Sample length: 2.35 ft |
| | | | 32.4 | 32.0 | 32.4 | | | | 170 | | |
| | | | | | | | | | | | Left hole open overnight to |
| | | | | | | | | | | | monitor water level. Water on |
| | | | | | | | | | | | 12 Sept. 81, was at 19.9 ft. |
| | | | | | | | | | | | Installed well through auger. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 4 of 4 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 12 Sept. 1981
Location McComish Gorge Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 566.22 Boring No. WES-4-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press Wt. Kelly | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 2.08 | 3" Shelby Tube | | ST | Silty sand (SM): brown in color, |
| 1A | | | | 0.5 | 1.0 | 2.08 | 2.28 | | 0 | Jar | damp, fine-grained, and moderate |
| | | | | 1.0 | 1.5 | | | | 20 | | cohesion. Sand equals 60 to 70% |
| | | | | 1.5 | 2.0 | | | | 60 | | and silt equals 30 to 40%. |
| | | | | 2.0 | 2.5 | | | | 120 | | Sample length: 2.28 ft |
| | | | | | | | | | | | |
| | | | 4.5 | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 12Sept | 4.5 | | 5.0 | 5.5 | 5.0 | 7.13 | *3"Fixed Piston Sampler | 0 | ST | Silty sand (SM): grey in color, |
| 2A | | | | 5.5 | 6.0 | 7.13 | 7.38 | | 10 | Jar | damp to moist, fine-grained, and |
| | | | | 6.0 | 6.5 | | | | 20 | | moderate cohesion. Sand equals |
| | | | | 6.5 | 7.0 | | | | 20 | | 60%-70% and silt equals 30%-40%. |
| | | | | 7.0 | 7.5 | | | | 20 | | Believe water starts at 5.5 ft. |
| | | | | | | | | | | | Sample length: 2.38 ft |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | *7" Hollow Stem Auger | | | Cleanout |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 12Sept | | | 10.0 | 10.5 | 10.0 | 12.3 | 3" F.P.S | 0 | ST | Silty sand (SM): same as in no.2 |
| 3 | | | | 10.5 | 11.0 | 11.83 | 12.13 | | 10 | Jar | except for more moisture. |
| | | | | 11.0 | 11.5 | | | | 50 | | |
| | | | | 11.5 | 12.0 | | | | 120 | | Sample length: 2.28 ft |
| | | | | 12.0 | 12.4 | | | | 160 | | |
| | | | | | | | | | | | |
| | | | 15.0 | 10.0 | 15.0 | — | — | 7" H.S. Auger | | — | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | When pulling weight out of hollow |
| | | | | | | | | | | | stem auger, acted as piston and |
| | | | | | | | | | | | sucked sand in behind. Cleaned |
| | | | | | | | | | | | out several times with same result. |
| | | | | | | | | | | | Used splitspoon to get sample of |
| | | | | | | | | | | | material and confirm if sample |
| | | | | | | | | | | | was wet. |
| 4A | 12Sept | 15.00 | 17.0 | 15.0 | 17.0 | 15.0 | 17.0 | *Splitspoon | | | Silty sand (SM): grey in color, |
| | | | | | | | | | | | saturated, and fine-grained. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*Splitspoon = 1-7/8" I.D. x 2 1/2" O.D.

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-3-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | Installed well through auger. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 28 Sept. 1981
Location McComish Gorge Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 593.14 Boring No. WES-4-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 2.26 | 3" Shelby Tube | 0 | ST | Clay (CL): brown in color, dry, |
| 1A | | | | 0.5 | 1.0 | 2.26 | 2.45 | | 0 | Jar | uniform, slightly stiff, with |
| | | | | 1.0 | 1.5 | | | | 0 | | slight to moderate cohesion. |
| | | | | 1.5 | 2.0 | | | | 0 | | Sample length: 2.45 ft |
| | | | | 2.0 | 2.5 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 28Sept | | | 5.0 | 5.5 | 5.0 | 6.64 | *3"Fixed Piston Sampler | 0 | ST | Clay (CL): same as above. |
| | | | | 5.5 | 6.0 | 6.64 | 6.82 | | 20 | Jar | |
| | | | | 6.0 | 6.5 | | | | 90 | | Sample length: 1.82 ft |
| | | | | 6.5 | 7.0 | | | | 130 | | |
| | | | | 7.0 | 7.35 | | | | 200 | | |
| | | | | | | | | | | | |
| | | | 10.0 | 5.0 | 10.00 | | | *7"Hollow Stem Auger | | | Cleanout: stratum change assumed |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 28Sept | 10.0 | | 10.0 | 10.5 | 10.0 | 12.19 | 3" F.P.S | 0 | ST | Silt (ML): brown, uniform, dry, |
| 3A | | | | 10.5 | 11.0 | 12.19 | 12.36 | | 0 | Jar | and slight cohesion. |
| | | | | 11.0 | 11.5 | | | | 140 | | Sample length: 2.36 ft |
| | | | | 11.5 | 12.0 | | | | 160 | | |
| | | | | 12.0 | 12.38 | | | | 210 | | |
| | | | | | | | | | | | |
| | | | 13.5 | 10.0 | 15.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| 4 | 28Sept | 13.5 | | 15.0 | 15.5 | 15.0 | 16.7 | 3" F.P.S. | 0 | ST | Sand (SP): reddish brown in |
| | | | | 15.5 | 16.0 | 16.7 | 17.0 | | 10 | Jar | color, dry, fine-grained, and |
| | | | | 16.0 | 16.5 | | | | 20 | | no cohesion. |
| | | | | 16.5 | 17.0 | | | | 60 | | Sample length: 2.00 ft |
| | | | | 17.0 | 17.5 | | | | 90 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 28Sept | | | 20.0 | 20.5 | 20.0 | 22.08 | 3" F.P.S. | 0 | ST | Sand (SP): brown in color, fine- |
| 5A | | | | 20.5 | 21.0 | 22.08 | 22.4 | | 0 | Jar | grained, dry, and very uniform |
| | | | | 21.0 | 20.5 | | | | 0 | | quartz sand. |
| | | | | 20.5 | 22.0 | | | | 10 | | Sample length: 2.35 ft |
| | | | | 22.0 | 22.4 | | | | 120 | | |
| | | | | | | | | | | | |
| | | | | 20.0 | 25.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| 6 | | | | 25.0 | 25.5 | 25.0 | 26.50 | 3" F.P.S. | 0 | ST | Sand (SP): brown in color, very |
| 6A | 28Sept | | | 25.5 | 26.0 | 26.50 | 26.80 | | 0 | Jar | fine-grained, wet, and uniform. |
| | | | | 26.0 | 26.5 | | | | 10 | | Water in hollow stem auger at |
| | | | | 26.5 | 27.0 | | | | 30 | | 26.89 ft. |
| | | | | 27.0 | 27.41 | | | | 70 | | Sample length: 1.8 ft |
| | | | | | | | | | | | |
| | | | | 25.0 | 30.0 | | | 7" H.S. Auger | | | Cleanout: when pulling plug |
| | | | | | | | | | | | from auger, sand came in. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 28Sept | | | 27.8 | 28.3 | 27.8 | 29.90 | 3" F.P.S. | 0 | ST | Sand (SP): brown, fine-grained, |
| | | | | 28.3 | 28.8 | 29.90 | 30.40 | | 0 | Jar | and wet. |
| | | | | 28.8 | 29.3 | | | | 0 | | Sample length: 2.40 ft |
| | | | | 29.3 | 29.8 | | | | 0 | | |
| | | | | 29.8 | 30.3 | | | | 40 | | |
| | | | | | | | | | | | |
| | | | | 30.0 | 35.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| 8 | 28Sept | | 36.25 | 35.0 | 35.5 | 35.0 | 37.05 | 3" F.P.S. | 30 | ST | Clay (CL): grey in color, soft, |
| 8A | | 36.25 | | 35.5 | 36.0 | 37.05 | 37.30 | | 70 | Jar | very uniform in texture, and |
| | | | | 36.0 | 36.5 | | | | 100 | | uniform consistency. |
| | | | | 36.5 | 37.0 | | | | 120 | | Sample length: 2.30 ft |
| | | | 37.4 | 37.0 | 37.4 | | | | 120 | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well through auger. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 4 of 4 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 30 Sept. 1981
Location McComish Gorge Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 573.39 Boring No. WES-4-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd, Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.8 | 3" Shelby Tube | 0 | ST | Sandy clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.8 | 1.95 | | 0 | Jar | moderate cohesion, soft, and |
| | | | | 1.0 | 1.5 | | | | 0 | | contains 20-30% fine-grained sand. |
| | | | | 1.5 | 2.0 | | | | 10 | | Sample length: 1.95 ft |
| | | | | 2.0 | 2.55 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 30Sept | | | 5.0 | 5.5 | 5.0 | 6.36 | *3"Fixed Piston Sampler | 0 | ST | Sandy clay (CL): brown in color, |
| | | | | 5.5 | 6.0 | 6.36 | 6.56 | | 0 | Jar | moderate cohesion, soft, and con- |
| | | | | 6.0 | 6.5 | | | | 0 | | tains 40% fine to coarse-grained |
| | | | | 6.5 | 7.0 | | | | 0 | | sand. |
| | | | | 7.0 | 7.41 | | | | 10 | | Sample length: 1.56 ft |
| | | | | | | | | | | | |
| | | | 7.5 | 5.0 | 70.0 | | | *7" Hollow Stem Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

Sheet 1 of 3 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 30Sept | 7.5 | | 10.0 | 10.5 | 10.0 | 11.10 | 3" F.P.S. | 0 | ST | Silty sand (SM): dark grey to |
| 3A | | | | 10.5 | 11.0 | 11.10 | 11.70 | | 0 | Jar | black in color, wet, slight cohesion, |
| | | | | 11.0 | 11.5 | | | | 0 | | and trace of odor (organic/oily). |
| | | | | 11.5 | 12.0 | | | | 10 | | Sample length: 2.21 ft |
| | | | | 12.0 | 12.42 | | | | 10 | | Water at 9.5 ft after 30 min |
| | | | | | | | | | | | |
| | | | 13.5 | 10.0 | 15.0 | | | 7" H.S. Auger | | | Cleanout: material came in when |
| | | | | | | | | | | | pulling plug from auger. |
| | | 13.5 | | 14.3 | 14.8 | 14.3 | 16.0 | 3" F.P.S. | 80 | ST | Sandy gravel (GW): grey in color, |
| | | | | 14.8 | 15.3 | 16.0 | 16.35 | | 110 | Jar | wet, coarse sand (30%) and fine |
| | | | | 15.3 | 15.8 | | | | 115 | | to medium angular to rounded, |
| | | | | 15.8 | 16.3 | | | | 130 | | unsorted gravel. |
| | | | 15.0 | 16.3 | 16.71 | | | | 130 | | Sample length: 2.35 ft |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | | | 7" H.S. Auger | | | Cleanout: material came in when |
| | | | | | | | | | | | pulling plug from auger. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 30Sept | 15.0 | | 18.6 | 19.1 | 18.6 | 20.05 | 3" F.P.S. | 70 | ST | Silty sand (SM): grey in color, |
| 5A | | | | 19.1 | 19.6 | 20.05 | 20.35 | | 210 | Jar | wet, no cohesion, and uniform. |
| | | | | 19.6 | 20.1 | | | | 220 | | Sample length: 1.75 ft |
| | | | | 20.1 | 20.6 | | | | 380 | | |
| | | | 20.91 | 20.6 | 20.91 | | | | 450 | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well through auger. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 8 Oct. 1981
Location McComish Gorge Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 579.54 Boring No. WES-4-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.14 | 3" Shelby Tube | 0 | ST | Sand (SP): reddish brown in color, |
| 1A | | | | 0.5 | 1.0 | 2.14 | 2.36 | | 0 | Jar | slight cohesion, dry, uniform, and |
| | | | | 1.0 | 1.5 | | | | 0 | | fine-grained. |
| | | | | 1.5 | 2.0 | | | | 50 | | Sample length: 2.36 ft |
| | | | | 2.0 | 2.5 | | | | 140 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 8 Oct | | | 5.0 | 5.5 | 5.0 | 7.08 | *3"Fixed Piston Sampler | 0 | ST | Sand (SP): brown in color, slight |
| 2A | | | | 5.5 | 6.0 | 7.08 | 7.34 | | 0 | Jar | cohesion, dry, uniform, and fine |
| | | | | 6.0 | 6.5 | | | | 0 | | to medium (10-15%) grained. |
| | | | | 6.5 | 7.0 | | | | 0 | | Sample length: 2.34 ft |
| | | | 10.0 | 7.0 | 7.4 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | *7" Hollow Stem Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 8 Oct | 10.0 | | 10.0 | 10.5 | 10.0 | 11.71 | 3" F.P.S. | 0 | ST | Silty sand (SM): brown in color, |
| 3A | | | | 10.5 | 11.0 | 11.71 | 12.31 | | 0 | Jar | very fine-grained, uniform, slightly |
| | | | | 11.0 | 11.5 | | | | 0 | | damp, and little cohesion. |
| | | | | 11.5 | 12.0 | | | | 0 | | Sample length: 2.31 ft |
| | | | | 12.0 | 12.4 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 10.0 | 15.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| 4 | 8 Oct | | | 15.0 | 15.5 | 15.0 | 17.17 | 3" F.P.S. | 0 | ST | Silty sand (SM): brown in color, |
| 4A | | | | 15.5 | 16.0 | 17.17 | 17.38 | | 0 | Jar | very fine-grained, moist, uniform, |
| | | | | 16.0 | 16.5 | | Water | at 17.35 | 0 | | and slight cohesion, |
| | | | | 16.5 | 17.0 | | | | 0 | | Sample length: 2.38 ft |
| | | | | 17.0 | 17.38 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | | | 7" H.S. Auger | | | Cleanout: material came in when |
| | | | | | | | | | | | pulling plug from auger. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-4-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 8 Oct | | | 19.5 | 20.0 | 19.5 | 20.35 | 3" F.P.S. | 0 | ST | Silty sand (SM): same as in pre- |
| 5A | | | | 20.0 | 20.5 | 20.35 | 20,6 | | 0 | Jar | vious sample-moist. |
| | | | | 20.5 | 21.0 | | | | 0 | | Sample length: 1.1 ft |
| | | | | 21.0 | 21.5 | | | | 0 | | |
| | | | | 21.5 | 21.9 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 20.0 | 25.0 | | | 7" H.S. Auger | | | Cleanout: material came in when |
| | | | | | | | | | | | pulling plug from auger. |
| | | | | | | | | | | | |
| 6 | 8 Oct | | | 24.2 | 24.7 | 24.2 | 26.36 | 3" F.P.S. | 0 | ST | Silty sand (SM): brown to grey in |
| 6A | | | | 24.7 | 25.2 | 26.36 | 26.56 | | 20 | Jar | color, fine-grained, slight cohesion, |
| | | | | 25.2 | 25.7 | | | | 50 | | uniform, and damp. |
| | | | | 25.7 | 26.2 | | | | 100 | | Sample length: 2.36 ft |
| | | | 26.59 | 26.2 | 26.59 | | | | 130 | | |
| | | | | | | | | | | | Installed well through auger. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 14 Sept. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 596.52 Boring No. WES-5-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.55 | 3" Shelby Tube | 0 | ST | Silty sand (SM): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.55 | 1.85 | | 0 | Jar | slightly damp, fine-grained, and |
| | | | | | | | | | | | slight cohesion. |
| | | | | 1.0 | 1.5 | | | | 0 | | Sample length: 1.85 ft |
| | | | | 1.5 | 2.0 | | | | 10 | | |
| | | | | 2.0 | 2.5 | | | | 20 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 14Sept | | | 5.0 | 5.5 | 5.0 | 6.59 | *3"Fixed Piston Sampler | 0 | ST | Silty sand (SM): brown in color, |
| 2A | | | | 5.5 | 6.0 | 6.59 | 6.89 | | 0 | Jar | damp, fine-grained, slight cohesion, |
| | | | | 6.0 | 6.5 | | | | 10 | | and contains 5% very fine gravel. |
| | | | | 6.5 | 7.0 | | | | 20 | | Sample length: 1.89 ft |
| | | | | 7.0 | 7.4 | | | | 30 | | |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | *7" Hollow stem Auger | | | Cleanout |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 14Sept | | | 10.0 | 10.5 | 10.0 | 11.81 | 3" F.P.S. | 10 | ST | Silty sand (SM): brown in color, |
| 3A | | | | 10.5 | 11.0 | 11.81 | 12.01 | | 20 | Jar | moderate cohesion, and dry. |
| | | | | 11.0 | 11.5 | | | | 50 | | |
| | | | | 11.5 | 12.0 | | | | 130 | | Sample length: 2.01 ft |
| | | | 12.0 | 12.0 | 12.35 | | | | 400 | | |
| | | | | | | | | | | | |
| | | 12.0 | | 10.0 | 15.0 | — | — | 7" H.S. Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 4 | 14Sept | | | 15.0 | 15.5 | 15.0 | 15.65 | 3" F.P.S. | 0 | ST | Silt (ML): brown to grey in color, |
| 4A | | | | 15.5 | 15.9 | 15.65 | 15.90 | | 800 | Jar | hard, cohesive, and dry. |
| | | | | | | | | | | | |
| | | | 16.0 | 15.0 | 17.5 | — | — | 7" H.S. Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 5A | 14Sept | 16.0 | 17.80 | 17.5 | 18.0 | 17.5 | 17.80 | 3" F.P.S. | 850 | Jar | Shale: grey to black in color, |
| | | | | | | | | | | | uniform, and dry. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | Water in hole on 15 September, |
| | | | | | | | | | | | at 10.5 ft. |
| | | | | | | | | | | | Set well through auger. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 15 Sept. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 585.43 Boring No. WES-5-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.75 | 3" Shelby | 0 | ST | Sand (SP): reddish brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.75 | 2.0 | | 0 | Jar | dry, slight cohesion, fine to |
| | | | | 1.0 | 1.5 | | | | 50 | | medium grained, and contains ash |
| | | | | 1.5 | 2.0 | | | | 280 | | and other burned materials. |
| | | | | 2.0 | 2.5 | | | | 460 | | Sample length: 2.0 ft |
| | | | | | | | | | | | |
| | | | 4.5 | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 15Sept | 4.5 | | 5.0 | 5.5 | 5.0 | 7.15 | *3"Fixed Pis- | 0 | ST | Sandy silt (SM): brown in color, |
| 2A | | | | 5.5 | 6.0 | 7.15 | 7.35 | ton Sampler | 20 | Jar | damp, slight cohesion, and contains |
| | | | | 6.0 | 6.5 | | | | 30 | | 20% fine-grained sand. |
| | | | | 6.5 | 7.0 | | | | 40 | | Sample length: 2.35 ft |
| | | | | 7.0 | 7.4 | | | | 50 | | |
| | | | | | | | | | | | |
| | | | 8.68 | 5.0 | 10.0 | | | 7" Folding Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *3" Fixed Piston Sampler = 3" F.P.S. Sheet 1 of 3 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 15Sept | 8.68 | | 10.0 | 10.5 | 10.0 | 11.46 | 3" F.P.S. | 0 | ST | Silt (ML): brown in color, slight |
| 3A | | | | 10.5 | 11.0 | 11.46 | 12.0 | | 0 | Jar | cohesion, and wet. |
| | | | | 11.0 | 11.5 | | | | 20 | | |
| | | | | 11.5 | 12.0 | | | | 20 | | Sample length: 2.16 ft |
| | | | | 12.0 | 12.5 | | | | 20 | | |
| | | | | | | | | | | | |
| | | | | 10.0 | 15.0 | | | 7" Hollow stem Auger | | | Cleanout; water at 7.4 ft |
| | | | | | | | | | | | |
| | 15Sept | | | 15.0 | 15.5 | | | 3" F.P.S. | 0 | | No sample |
| | | | | 15.5 | 16.0 | | | | 0 | | |
| | | | | 16.0 | 16.5 | | | | 20 | | |
| | | | | 16.5 | 17.0 | | | | 20 | | |
| | | | | 17.0 | 17.5 | | | | 40 | | |
| | | | | | | | | | | | |
| 4A | 15Sept | | 18.2 | 15.0 | 18.2 | 15.0 | 18.2 | *Splitspoon | | Jar | Weight of rods carried splitspoon |
| | | | | | | | | | | | to 17.0 ft. Pushed to 18.2 ft. |
| | | | | | | | | | | | Silt (ML): same as above |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *Splitspoon = 1 7/8" I.D. x 2 1/2" O.D. Sheet 2 of 3 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 16Sept | | | | | | | | | | Installed well through auger. |
| | | | | | | | | | | | Water overnight to 7.1 ft. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 16 Sept. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 589.78 Boring No. WES-5-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.75 | 3" Shelby Tube | 0 | ST | Sand (SW): brown in color, fine |
| 1A | | | | 0.5 | 1.0 | 1.75 | 2.0 | | 20 | Jar | to very coarse grained with majority |
| | | | | 1.0 | 1.5 | | | | 20 | | of sand being medium, dry, and |
| | | | | 1.5 | 2.0 | | | | 200 | | no cohesion. |
| | | | | 2.0 | 2.5 | | | | 360 | | Sample length: 2.0 ft |
| | | | | | | | | | | | |
| | | | 3.0 | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 16Sept | 3.0 | | 5.0 | 5.5 | 5.0 | 6.76 | *3"Fixed Piston Sampler | 0 | ST | Sand (SP): brown in color, uniform, |
| 2A | | | | 5.5 | 6.0 | 6.76 | 7.41 | | 10 | Jar | fine-grained, slightly moist, and |
| | | | | 6.0 | 6.5 | | | | 10 | | no cohesion. |
| | | | | 6.5 | 7.0 | | | | 20 | | |
| | | | | 7.0 | 7.41 | | | | 20 | | Sample length: 2.41 ft |
| | | | | | | | | | | | |
| | | | 10.0 | 5.0 | 10.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 16Sept | 10.0 | | 10.0 | 10.5 | 10.0 | 11.95 | 3" F.P.S. | 0 | ST | Sand silt (ML): brown in color, |
| 3A | | | | 10.5 | 11.0 | 11.95 | 12.25 | | 0 | Jar | slight cohesion, wet, and uniform. |
| | | | | 11.0 | 11.5 | | | | 0 | | |
| | | | | 11.5 | 12.0 | | | | 10 | | Sample length: 2.25 ft |
| | | | | 12.0 | 12.4 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | 13.73 | 10.0 | 15.0 | — | — | 7" Folding Auger | — | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 4 | 16Sept | 13.73 | | 15.0 | 15.5 | 15.0 | 17.15 | 3" F.P.S. | 0 | ST | Silt (ML): brown in color, moderate |
| 4A | | | | 15.5 | 16.0 | 17.15 | 17.35 | | 0 | Jar | to highly cohesive, wet, and uniform. |
| | | | | 16.0 | 16.5 | | | | 10 | | |
| | | | | 16.5 | 17.0 | | | | 10 | | Sample length: 2.35 ft |
| | | | | 17.0 | 17.4 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | — | — | 7" Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 3 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| 5 | 16Sept | | | 20.0 | 20.5 | 20.0 | 21.38 | 3" F.P.S. | 0 | ST | Silt (ML): wet, same as previous |
| 5A | | | | 20.5 | 21.0 | 21.38 | 21.68 | | 0 | Jar | sample. |
| | | | | 21.0 | 21.5 | | | | 10 | | |
| | | | | 21.5 | 22.0 | | | | 10 | | Sample length: 2.03 ft |
| | | | 22.4 | 22.0 | 22.4 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | Water came in overnight to 11.35 ft. |
| | | | | | | | | | | | Set well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 1 Oct. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 585.33 Boring No. WES-5-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.04 | 3" Shelby | 0 | ST | Sand (SP): brown in color, uniform, |
| 1A | | | | 0.5 | 1.0 | 2.04 | 2.34 | | 0 | Jar | very fine-grained quartz sand, and |
| | | | | 1.0 | 1.5 | | | | 20 | | no cohesion. |
| | | | | 1.5 | 2.0 | | | | 150 | | |
| | | | | 2.0 | 2.5 | | | | 290 | | Sample length: 2.34 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 1 Oct | | | 5.0 | 5.5 | 5.0 | 6.78 | *3"Fixed Pis- | 0 | ST | Sand (SP): brown in color, uniform, |
| 2A | | | | 5.5 | 6.0 | 6.0 | 6.98 | ton Sampler | 0 | Jar | very fine-grained quartz sand, |
| | | | | 6.0 | 6.5 | | | | 10 | | slight cohesion, and slightly damp. |
| | | | | 6.5 | 7.0 | | | | 15 | | |
| | | | | 7.0 | 7.38 | | | | 20 | | Sample length: 1.98 ft |
| | | | | | | | | | | | |
| | | | 6.0 | 5.0 | 10.0 | | | *7" Hollow | | | Cleanout |
| | | | | | | | | stem Auger | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3"F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6.0 | | 10.0 | 10.5 | | | 3" F.P.S. | 0 | | No sample; used splitspoon to get |
| | | | | 10.5 | 11.0 | | | | 0 | | sample-see below. |
| | | | | 11.0 | 11.5 | | | | 0 | | |
| | | | | 11.5 | 12.0 | | | | 10 | | |
| | | | | 12.0 | 12.4 | | | | 20 | | |
| | | | | | | | | | | | |
| 3A | 1 Oct | | | 10.0 | 12.0 | 10.0 | 12.0 | *Splitspoon | | Jar | Silt/sand (SP-SM); brown in color, |
| | | | | | | | | | | | very fine-grained, moist, and |
| | | | | | | | | | | | little cohesion. Monitored hole |
| | | | | | | | | | | | for 30 min and no water. |
| | | | | | | | | | | | |
| | | | | 10.0 | 15.0 | | | 7" H.S. Auger | | | Cleanout |
| | | | | | | | | | | | |
| | 1 Oct | | | 15.0 | 15.5 | | | 3" F.P.S. | 0 | | No sample; used splitspoon to get |
| | | | | 15.5 | 16.0 | | | | 0 | | sample-see below. |
| | | | | 16.0 | 16.5 | | | | 10 | | |
| | | | | 16.5 | 17.0 | | | | 20 | | Water in hole at 15.0 ft |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *Splitspoon = 1 7/8" I.D. x 2 1/2" O.D. Sheet 2 of 4 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 17.0 | 17.41 | | | | 80 | | |
| | | | | | | | | | | | |
| 4A | 1 Oct | | | 15.0 | 17.0 | 15.0 | 17.0 | Splitspoon | | Jar | Silt/sand (SP-SM): same as in |
| | | | | | | | | | | | previous sample. |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | — | — | 7" H.S. Auger | | — | Cleanout |
| | | | | | | | | | | | |
| | | | | 20.0 | 20.5 | | | 3" F.P.S. | 0 | | No sample: used splitspoon to get |
| | | | | 20.5 | 21.0 | | | | 0 | | sample-see below. |
| | | | | 21.0 | 21.5 | | | | 20 | | |
| | | | | 21.5 | 22.0 | | | | 20 | | |
| | | | | 22.0 | 22.42 | | | | 60 | | |
| | | | | | | | | | | | |
| 5A | 1 Oct | | 22.5 | 20.0 | 23.0 | 22.0 | 22.5 | Splitspoon | | Jar | Silt/sand (SP-SM): same as previous |
| 5B | | 22.5 | | | | 22.5 | 23.0 | | | Jar | sample. |
| | | | | | | | | | | | Clay (CL): light grey to brown in |
| | | | | | | | | | | | color, soft, low plasticity, and |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | slightly moist. |
| | | | | | | | | | | | |
| | | | | 20.0 | 25.0 | | | 7" H.S. Auger | | | |
| | | | | | | | | | | | |
| 6 | 1 Oct | | | 25.0 | 25.5 | 25.0 | 27.18 | 3" F.P.S. | 0 | ST | Clay (CL): grey in color, uniform, |
| 6A | | | | 25.5 | 26.0 | 27.18 | 27.38 | | 0 | Jar | low plasticity, soft, and moist. |
| | | | | 26.0 | 26.5 | | | | 0 | | |
| | | | | 26.5 | 27.0 | | | | 0 | | Sample length: 2.38 ft |
| | | | 27.42 | 27.0 | 27.42 | | | | 15 | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well through hollow stem |
| | | | | | | | | | | | auger. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 2 Oct. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 583.78 Boring No. WES-5-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.12 | 3" Shelby Tube | 10 | ST | Sand (SP): brown in color, uniform, |
| 1A | | | | 0.5 | 1.0 | 2.12 | 2.42 | | 10 | Jar | fine-grained quartz sand, dry, and |
| | | | | 1.0 | 1.5 | | | | 20 | | no cohesion. |
| | | | | 1.5 | 2.0 | | | | 80 | | |
| | | | | 2.0 | 2.5 | | | | 160 | | Sample length: 2.42 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| 2 | 2 Oct | | | 5.0 | 5.5 | 5.0 | 6.81 | *3"Fixed Piston Sampler | 0 | ST | Sand (SP): same as above. |
| 2A | | | | 5.5 | 6.0 | 6.81 | 7.25 | | 0 | Jar | |
| | | | | 6.0 | 6.5 | | | | 0 | | |
| | | | | 6.5 | 7.0 | | | | 0 | | Sample length: 2.25 ft |
| | | | | 7.0 | 7.39 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | 9.0 | 5.0 | 10.0 | — | — | *7"Hollow stem Auger | — | | Cleanout: when pulling plug, auger |
| | | | | | | | | | | | fell to 10.5 ft. Assumed stratum |
| | | | | | | | | | | | change. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston = 3"F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 2 Oct | 9.0 | | 10.5 | 11.0 | 10.5 | 12.02 | 3" F.P.S. | 0 | ST | Silt/sand (SP-SM): brown in |
| 3A | | | | 11.0 | 11.5 | 12.02 | 12.36 | | 0 | Jar | color, very fine-grained, soft, |
| | | | | 11.5 | 12.0 | | | | 0 | | wet, uniform, and slight cohesion. |
| | | | | 12.0 | 12.5 | | | | 0 | | Water in hole at 10.1 ft. |
| | | | | 12.5 | 12.9 | | | | 0 | | Sample length: 2.36 ft |
| | | | | | | | | | | | |
| | | | | 10.5 | 15.0 | — | — | 7" H.S. Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 4 | 2 Oct | | | 15.0 | 15.5 | 15.0 | 16.85 | 3" F.P.S. | 0 | ST | Silt/sand (SP-SM): same as in |
| 4A | | | | 15.5 | 16.0 | 16.85 | 17.20 | | 0 | Jar | previous sample |
| | | | | 16.0 | 16.5 | | | | 0 | | |
| | | | | 16.5 | 17.0 | | | | 0 | | Sample length: 2.20 ft |
| | | | | 17.0 | 17.4 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | — | — | 7" H.S. Auger | | — | Cleanout: auger fell to 20.4 ft |
| | | | | | | | | | | | when pulling plug. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| 5 | 2 Oct | | | 20.4 | 20.9 | 20.4 | 22.15 | 3" F.P.S. | 0 | ST | Silt/sand (SP-SM): same |
| 5A | | | | 20.9 | 21.4 | 22.15 | 22.45 | | 0 | Jar | |
| | | | | 21.4 | 21.9 | | | | 0 | | |
| | | | | 21.9 | 22.4 | | | | 0 | | Sample length: 2.36 ft |
| | | | 22.78 | 22.4 | 22.78 | | | | 0 | | |
| | | | | | | | | | | | |
| | 3 Oct | | | | | | | | | | Set well through hollow stem auger. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 10 Oct. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 570.27 Boring No. WES-5-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.03 | 3" Shelby Tube | 0 | ST | Sandy silt (ML): reddish brown in |
| 1A | | | | 0.5 | 1.0 | 2.03 | 2.23 | | 10 | Jar | color, dry, uniform, low plasticity, |
| | | | | 1.0 | 1.5 | | | | 20 | | and organic matter. |
| | | | | 1.5 | 2.0 | | | | 60 | | |
| | | | | 2.0 | 2.5 | | | | 120 | | Sample length: 2.23 ft |
| | | | | | | | | | | | |
| | | | 3.62 | 0.0 | 5.0 | — | — | 7" Folding Auger | — | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 2 | 10 Oct | 3.62 | | 5.0 | 5.5 | 5.0 | 7.17 | 3"Fixed Piston Sampler | 0 | ST | Silt (ML): light brown in color, |
| 2A | | | | 5.5 | 6.0 | 7.17 | 7.37 | | 0 | Jar | soft, low plasticity, uniform, and |
| | | | | 6.0 | 6.5 | | | | 10 | | dry. |
| | | | | 6.5 | 7.0 | | | | 40 | | |
| | | | | 7.0 | 7.38 | | | | 110 | | Sample length: 2.37 ft |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | — | — | 7" Hollow Stem Auger | — | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S.
*7" Hollow Stem Auger = 7" H.S. Auger

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 10 Oct | | | 10.0 | 10.5 | 10.0 | 12.09 | 3" F.P.S. | 10 | ST | Silt (ML): brown in color, soft, |
| 3A | | | | 10.5 | 11.0 | 12.09 | 12.32 | | 10 | Jar | low plasticity, dry, and contains |
| | | | | 11.0 | 11.5 | | | | 10 | | trace of clay. |
| | | | | 11.5 | 12.0 | | | | 20 | | |
| | | | | 12.0 | 12.4 | | | | 30 | | Sample length: 2.32 ft |
| | | | | | | | | | | | |
| | | | 13.5 | 10.0 | 15.0 | | | 7" H.S. Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 4 | 10 Oct | 13.5 | | 15.0 | 15.5 | 15.0 | 17.15 | 3" F.P.S. | 0 | ST | Silt (ML): grey in color, soft, |
| 4A | | | | 15.5 | 16.0 | 17.15 | 17.57 | | 0 | Jar | low plasticity, and slightly damp. |
| | | | | 16.0 | 16.5 | | | | 0 | | |
| | | | | 16.5 | 17.0 | | | | 0 | | Sample length: 2.37 ft |
| | | | | 17.0 | 17.41 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | | | 7" H.S. Auger | | | Cleanout: water at 19.5 ft |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 10 Oct | | | 20.0 | 20.5 | 20.0 | 21.19 | 3" F.P.S. | 0 | ST | Silt (ML): dark grey in color, |
| 5A | | | | 20.5 | 21.0 | 21.19 | 21.50 | | 0 | Jar | sticky, wet, soft, and low plasti- |
| | | | | 21.0 | 21.5 | | | | 0 | | city. Lost some sample when pulling. |
| | | | | 21.5 | 22.0 | | | | 0 | | |
| | | | | 22.0 | 22.41 | | | | 0 | | Sample length: 1.19 ft |
| | | | | | | | | | | | |
| | | | | 20.0 | 25.0 | — | — | 7" H.S. Auger | | — | Cleanout |
| | | | | | | | | | | | |
| | 10 Oct | | | 25.0 | 25.5 | — | — | 3" F.P.S. | 0 | — | No sample-see below |
| | | | | 25.5 | 26.0 | | | | 0 | — | |
| | | | | 26.0 | 26.5 | | | | 0 | | |
| | | | | 26.5 | 27.0 | | | | 0 | | |
| | | | | 27.0 | 27.39 | | | | 0 | | |
| | | | | | | | | | | | |
| 6A | 10 Oct | | | 25.0 | 27.5 | | | Splitspoon | — | Jar | Silt (ML): dark grey in color, |
| | | | | | | | | | | | sticky, wet, soft, and low plasti- |
| | | | | | | | | | | | city. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No WES-5-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 25.0 | 30.0 | — | — | 7"H.S. Auger | — | — | Cleanout |
| | | | | | | | | | | | |
| | 10 Oct | | | 30.0 | 30.5 | — | — | 3" F.P.S. | 0 | — | No sample-see below |
| | | | | 30.5 | 31.0 | | | | 0 | | |
| | | | | 31.0 | 31.5 | | | | 0 | | |
| | | | | 31.5 | 32.0 | | | | 0 | | |
| | | | | 32.0 | 32.41 | | | | 0 | | |
| | | | | | | | | | | | |
| 7A | 10 Oct | | 33.5 | 30.0 | 33.5 | 30.0 | 33.5 | Splitspoon | — | Jar | Silt (ML): dark grey in color, |
| | | | | | | | | | | | very soupy, soft, and low plasticity. |
| | | | | | | | | | | | |
| | | | | | Installed well screen through hollow stem auger. When pulling auger from | | | | | | |
| | | | | | hole, natural material, silt, caved-in to depth of 13 ft. There is a good | | | | | | |
| | | | | | possibility that well screen would plug without sand filter. Will redrill | | | | | | |
| | | | | | with water to prevent cave-in, and backfill well screen with sand to | | | | | | |
| | | | | | prevent plugging off. | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 20 Oct. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 576.70 Boring No. WES-5-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.89 | 3" Shelby Tube | 0 | ST | Silt (ML): brown in color, dry, |
| 1A | | | | 0.5 | 1.0 | 1.89 | 2.04 | | 10 | Jar | uniform, and low plasticity. |
| | | | | 1.0 | 1.5 | | | | 10 | | |
| | | | | 1.5 | 2.0 | | | | 250 | | |
| | | | | 2.0 | 2.5 | | | | 350 | | Sample length: 2.04 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 20 Oct | | | 5.0 | 5.5 | 5.0 | 6.99 | *3"Fixed Piston Sampler | 0 | ST | Silt (ML): same as above. |
| 2A | | | | 5.5 | 6.0 | 6.99 | 7.37 | | 0 | Jar | |
| | | | | 6.0 | 6.5 | | | | 0 | | |
| | | | | 6.5 | 7.0 | | | | 20 | | |
| | | | 7.3 | 7.0 | 7.38 | | | | 30 | | Sample length: 2.37 ft |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *3" Fixed Piston Sampler = 3"F.P.S. Sheet 1 of 5 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 20 Oct | 7.3 | | 10.0 | 10.5 | 10.0 | 11.91 | 3"F.P.S. | 0 | ST | Silt (ML): grey in color, moist, |
| 3A | | | | 10.5 | 11.0 | 11.91 | 12.16 | | 0 | Jar | uniform, and low plasticity. |
| | | | | 11.0 | 11.5 | | | | 20 | | |
| | | | | 11.5 | 12.0 | | | | 100 | | |
| | | | | 12.0 | 12.4 | | | | 140 | | Sample length: 2.16 ft |
| | | | | | | | | | | | |
| | | | | 10.0 | 15.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 4 | 20 Oct | | | 15.0 | 15.5 | 15.0 | 16.36 | 3" F.P.S. | 0 | ST | Silt (ML): same as above |
| | | | | 15.5 | 16.0 | 16.36 | 16.66 | | 0 | Jar | |
| | | | | 16.0 | 16.5 | | | | 0 | | |
| | | | | 16.5 | 17.0 | | | | 0 | | Sample length: 1.66 ft |
| | | | | 17.0 | 17.4 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 20.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 Oct | | | 20.0 | 20.5 | | | 3" F.P.S. | 0 | | No sample- see below |
| | | | | 20.5 | 21.0 | | | | 0 | | |
| | | | | 21.0 | 21.5 | | | | 0 | | |
| | | | | 21.5 | 22.0 | | | | 0 | | |
| | | | | 22.0 | 22.41 | | | | 10 | | |
| | | | | | | | | | | | |
| 5A | 20 Oct | | | 20.0 | 22.5 | 20.0 | 22.5 | *Splitspoon | | Jar | Silt (ML): grey in color, moist, |
| | | | | | | | | | | | uniform, and low plasticity. |
| | | | | | | | | | | | |
| | | | | 20.0 | 25.0 | | | 7" Folding Auger | | | Cleanout: water at bottom of hole |
| | | | | | | | | | | | |
| 6 | 20 Oct | | | 25.0 | 25.5 | 25.0 | 27.05 | 3" F.P.S. | 0 | ST | Silt (ML): grey in color, wet, |
| 6A | | | | 25.5 | 26.0 | 27.05 | 27.35 | | 0 | Jar | uniform, and low plasticity, |
| | | | | 26.0 | 26.5 | | | | 0 | | |
| | | | | 26.5 | 27.0 | | | | 0 | | Sample length: 2.35 ft |
| | | | | 27.0 | 27.40 | | | | 0 | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *Splitspoon = 1 7/8" I.D. x 2 1/2" O.D. Sheet 3 of 5 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 21 Oct | | | | | | | | Water came to 12.4 ft overnight. Jetted | | |
| | | | | | | | | | water from hole and continued advance with | | |
| | | | | | | | | | folding auger. Hole started to fall-in and | | |
| | | | | | | | | | went to 5 1/2 in. fishtail bit and water. | | |
| | | | | | | | | | | | |
| | | | | | 30.0 | | | 5 1/2" Baffled Fish- | | | Cleanout |
| | | | | | | | | tail | | | |
| 7 | 21 Oct | | | 30.0 | 30.5 | 30.0 | 32.07 | 3" F.P.S. | 0 | ST | Silt (ML): same as above |
| 7A | | | | 30.5 | 31.0 | 32.07 | 32.35 | | 0 | Jar | |
| | | | | 31.0 | 31.5 | | | | 0 | | |
| | | | | 31.5 | 32.0 | | | | 20 | | Sample length: 2.35 ft |
| | | | | 32.0 | 32.39 | | | | 40 | | |
| | | | | | | | | | | | |
| | | | | 30.0 | 35.0 | | | 5 1/2"Baffled Fish- | | | Cleanout |
| | | | | | | | | tail | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 4 of 5 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| 8 | 21 Oct | | | 35.0 | 35.5 | 35.0 | 37.08 | 3" F.P.S. | 0 | ST | Silt (ML): same as above |
| 8A | | | | 35.5 | 36.0 | 37.08 | 37,35 | | 0 | Jar | |
| | | | | 36.0 | 36.5 | | | | 20 | | |
| | | | | 36.5 | 37.0 | | | | 150 | | Sample length: 2.35 ft |
| | | | | 37.0 | 37.38 | | | | 200 | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | Pumped hole untill water return was |
| | | | | | | | | | | | fairly clear, then installed well |
| | | | | | | | | | | | screen. Blew well dry on 22 Oct, |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 5 of 5 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 4 Nov. 1981
Location Old Burning Pit Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 563.78 Boring No. WES-5-8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 0.8 | 3" Shelby Tube | 0 | ST | Sandy clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 0.8 | 1.1 | | 0 | Jar | slightly moist, soft, and organic |
| | | | | 1.0 | 1.5 | | | | 0 | | matter. Material is possibly |
| | | | | 1.5 | 2.0 | | | | 0 | | dozer fill. |
| | | | | 2.0 | 2.5 | | | | 10 | | Sample length: 1.1 ft |
| | | | | | | | | | | | |
| | | | 4.0 | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 4 Nov | 4.0 | | 5.0 | 5.5 | 5.0 | 7.08 | *3"Fixed Piston Sampler | 0 | ST | Silt (ML): brownish grey in |
| 2A | | | | 5.5 | 6.0 | 7.08 | 7.33 | | 0 | Jar | color, moist, and uniform. |
| | | | | 6.0 | 6.5 | | | | 0 | | Water at end of push. Water |
| | | | | 6.5 | 7.0 | | | | 0 | | came up to 4.1 ft after a few |
| | | | | 7.0 | 7.4 | | | | 0 | | minutes. |
| | | | | | | | | | | | Sample length: 2.33 ft |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3"F.P.S.

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-5-8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4 Nov | | | 10.0 | 10.5 | 10.0 | 12.15 | 3" F.P.S. | 0 | ST | Silt (ML): grey in color, wet, |
| 3A | | | | 10.5 | 11.0 | 12.15 | 12.40 | | 0 | Jar | and uniform. |
| | | | | 11.0 | 11.5 | | | | 0 | | |
| | | | | 11.5 | 12.0 | | | | 0 | | |
| | | | | 12.0 | 12.41 | | | | 0 | | Sample length: 2.40 ft |
| | | | | | | | | | | | |
| | | | | 10.0 | 15.0 | | | 7" Folding | Auger | | Cleanout |
| | | | | | | | | | | | |
| 4 | 4 Nov | | | 15.0 | 15.5 | 15.0 | 17.1 | 3" F.P.S. | 0 | ST | Silt (ML): same as above |
| 4A | | | | 15.5 | 16.0 | 17.1 | 17.40 | | 0 | Jar | |
| | | | | 16.0 | 16.5 | | | | 0 | | |
| | | | | 16.5 | 17.0 | | | | 0 | | Sample length: 2.40 ft |
| | | | | 17.0 | 17.4 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | | 15.0 | 17.5 | | | 7" Folding | Auger | | Cleanout: bailed water out of |
| | | | | | | | | | | | hole with bailer. |
| | | | | | | | | | | | Installed well |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 17 Sept. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 682.63 Boring No. WES-6-1A-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 2.17 | 3" Shelby Tube | 0 | ST | Clay (CL): brown to grey in color, |
| 1A | | | | 0.5 | 1.0 | 2.17 | 2.32 | | 0 | Jar | dry, moderate, cohesion, and uniform |
| | | | | 1.0 | 1.5 | | | | 80 | | organic matter first foot. |
| | | | | 1.5 | 2.0 | | | | 250 | | |
| | | | | 2.0 | 2.5 | | | | 480 | | Sample length: 2.32 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 17Sept | | | 5.0 | 5.5 | 5.0 | 6.21 | 3"Fixed Piston Sampler | | ST | Clay (CL): orange brown in color, |
| 2A | | | | 5.5 | 6.0 | 6.21 | 6.36 | | | Jar | dry, stiff, hard, and contains |
| | | | | 6.0 | 6.5 | | | | | | 5-10% very fine, angular to rounded |
| | | | | 6.5 | 7.0 | | | | | | gravel. |
| | | | | 7.0 | 7.5 | | | | | | Sample length: 1.36 ft |
| | | | | | | | | | | | |
| | | | 8.3 | 5.0 | 8.30 | | | 7"Hollow Stem Auger | | | Cleanout: bedrock at 8.3 ft, |
| | | 8.3 | 19.0 | 8.30 | 19.0 | | | 5 5/8" Rock Bit | | | Sandstone: reddish color and fine- |
| | | | | | | | | | | | grained. Water around 9 ft. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 6 Nov. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 683.27 Boring No. WES-6-1B-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 Nov | 0.0 | | 0.0 | 2.5 | 0.0 | 1.14 | 3" Shelby Tube | | ST | Clay (CL): brown in color, very |
| 1A | | | | | | 1.14 | 1.27 | | | Jar | stiff, dry, and low plasticity. |
| | | | | | | | | | | | Sample length: 1.27 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Solid Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 2 | | | 7.0 | 5.0 | 7.0 | 5.0 | 6.14 | 3"Fixed Piston Sampler | | ST | Sandy clay (CL): brown in color, |
| 2A | | | | | | 6.14 | 6.29 | | | Jar | very stiff, dry, and low plasticity. |
| | | | | | | | | | | | Sample length: 1.27 ft |
| | | | | | | | | | | | |
| | 6 Nov | 7.0 | 8.6 | 5.0 | 29.0 | — | — | 5 5/8" Rock Bit | | — | Clay/shale: reddish brown |
| | | 8.6 | 12.6 | | | | | | | | Sandstone: light grey and hard |
| | | 12.6 | 13.2 | | | | | | | | Shale: brown |
| | | 13.2 | 14.0 | | | | | | | | Shale: grey |
| | | 14.0 | 15.2 | | | | | | | | Sandstone: reddish brown |
| | | 15.2 | 15.6 | | | | | | | | Shale: light grey |
| | | 15.6 | 16.3 | | | | | | | | Sandstone: light grey |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-1B-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 16.3 | 20.5 | | | | | | | | Shale: grey and hard |
| | | 20.5 | 24.5 | | | | | | | | Sandstone: light grey, very hard, |
| | | | | | | | | | | | and fine-grained. |
| | | 24.5 | 28.0 | | | | | | | | Sandstone: light grey and extremely |
| | | | | | | | | | | | hard. |
| | | 28.0 | 31.0 | | | | | | | | Shale: dark grey |
| | 6 Nov | | | 29.7 | 29.0 | — | — | 5 5/8" Rock | Bit | — | No water untill 29.3 ft (very slow). |
| | | | | | | | | | | | Drilled to 39.0 and will leave |
| | | | | | | | | | | | open overnight. |
| | 7 Nov | | | | | | | | | | Water at 8:05 a.m. 34.65 ft. |
| | | | | 39.0 | 44.7 | — | — | 5 5/8" Rock | Bit | — | Drilled 10 ft below water. |
| | | 31.0 | 44.7 | | | | | | | | Sandstone: brown and fine-grained. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 11 Nov. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 682.60 Boring No. WES-6-1C-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.34 | 3" Shelby Tube | 0 | ST | Sandy clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.34 | 1.51 | | 40 | Jar | dry, soft, and slight cohesion. |
| | | | | 1.0 | 1.5 | | | | 140 | | |
| | | | | 1.5 | 2 0 | | | | 280 | | Sample length: 1.51 ft |
| | | | | 2.0 | 2.5 | | | | 320 | | |
| | | | | | | | | | | | |
| | | | 4.0 | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 2 | 11 Nov | 4.0 | | 5.0 | 5.5 | 5.0 | 6.25 | 3"Fixed Piston Sampler | 0 | ST | Clay (CH): brown in color, dry, |
| 2A | | | | 5.5 | 6.0 | 6.25 | 6.40 | | 0 | Jar | very stiff, hard, and high plasti- |
| | | | | 6.0 | 6.5 | | | | 20 | | city. |
| | | | | 6.5 | 7.0 | | | | 180 | | Sample length: 1.40 ft |
| | | | 7.5 | 7.0 | 7.31 | | | | 320 | | |
| | | | | | | | | | | | |
| | | 7.5 | 8.2 | 5.0 | 8.3 | | | 7" Folding Auger | | | Sand and weathered sandstone; |
| | | | | | | | | | | | brown and fine-grained |
| | | 8.2 | 8.3 | | | | | | | | Sand and weathered sandstone; |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-1C-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | light grey and fine-grained. |
| | 11 Nov | 8.3 | 10.0 | 8.3 | 38.0 | — | — | 5 5/8" Rock | Bit | — | Sandstone: brown and fine-grained. |
| | | | | | | | | | | | |
| | | 10.0 | 12.3 | | | | | | | | Sandstone: grey with grey shale |
| | | | | | | | | | | | lenses |
| | | 12.3 | 12.5 | | | | | | | | Sandstone: dark brown |
| | | 12.5 | 15.1 | | | | | | | | Sandstone: brown |
| | | 15.1 | 17.2 | | | | | | | | Sandstone: brown with grey shale |
| | | | | | | | | | | | lenses |
| | | 17.2 | 23.7 | | | | | | | | Sandstone: soft, brown, and weathered |
| | | 23.7 | 27.8 | | | | | | | | Sandstone: hard and brown |
| | | 27.8 | 31.4 | | | | | | | | Shale and sandstone lenses |
| | | 31.4 | 35.7 | | | | | | | | Sandstone: brown and soft |
| | | 35.7 | 38.1 | | | | | | | | Sandstone: hard |
| | 12 Nov | | | | | | | | | | Water overnight at 9:20 a.m. at |
| | | | | | | | | | | | 36.52 ft, water at 2:10 p.m. at |
| | | | | | | | | | | | 36.20 ft. Blew wells 6-1A and |

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-1C-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 18 Nov | | | 0.0 | 38.1 | | | 1 3/4" Rock | Bit | | 6-1B with air to see if there was |
| | | | | | | | | | | | any communication between these borings |
| | | | | | | | | | | | and 6-1C. No communications was |
| | | | | | | | | | | | noticeable. Allowed hole to set |
| | | | | | | | | | | | untill 19 Nov. 1981, Jetted well |
| | | | | | | | | | | | several times and each time its |
| | | | | | | | | | | | making water. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 18 Sept. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 637.53 Boring No. WES-6-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.58 | 3" Shelby Tube | 0 | ST | Clay (CL): brown in color, soft, |
| 1A | | | | 0.5 | 1.0 | 1.58 | 1.78 | | 0 | Jar | little cohesion, uniform, slightly |
| | | | | 1.0 | 1.5 | | | | 0 | | damp, and organic matter. |
| | | | | 1.5 | 2.0 | | | | 0 | | Sample length: 1.78 ft |
| | | | | 2.0 | 2.5 | | | | 20 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Solid Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 2A | 18Sept | | 5.38 | 5.0 | 5.38 | | | 3"Fixed Piston Sampler | 800 | Jar | Clay (CL) and sandstone fragments: |
| | | | | | | | | | | | same as above |
| | | | | | | | | | | | |
| | 19Sept | | | 5.4 | — | | | 4 x 5-1/2"Core Barrel | | | See page two for log of core. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-6-2-81

| DRILLING LOG | DIVISION U.S Navy | INSTALLATION Crane, IN | SHEET 2 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5-1/2' Diamond bit |
| 2. LOCATION (Coordinates or Station) Demolition Area | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-6-2-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED two |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 18 Sept. 81; COMPLETED 21 Sept. 81 |
| 7. THICKNESS OF OVERBURDEN 5.38 ft | 17. ELEVATION TOP OF HOLE 657.53 |
| 8. DEPTH DRILLED INTO ROCK 33.62 ft | 18. TOTAL CORE RECOVERY FOR BORING 93.4 % |
| 9. TOTAL DEPTH OF HOLE 39.0 ft | 19. SIGNATURE OF INSPECTOR Joseph B. Dunbar |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 632.53 | 5.0 | | See page one for overburden information. | | | |
| 631.53 | 6.0 | | No recovery | | | |
| 630.53 | 7.0 | | | | | 19 Sept.81<br>WL - Run 1<br>Began 8:10 Rec 2.8'<br>End 9:05 Loss 2 2'<br>Time 55 min Gain -<br>Drl time 55 min<br>Hyd press 150psi<br>Water press -<br>RPM 75<br>Drl Action Smooth<br>Water ret - |
| 629.53 | 8.0 | | Sandstone; brown, fine-grained, weathered, and friable.<br>fractured | | | |
| 628.53 | 9.0 | | Clay shale; grey and soft.<br>closed | | | Remarks<br>Used air |
| 627.53 | 10.0 | | Shale: dark grey to brown, soft, and dry.<br>Run 1 | 56% | - | |
| 626.53 | 11.0 | | Shale: dark grey to black and highly organic | | | |
| 625.53 | 12.0 | | Sandstone and interbedded Shale: sandstone is brown in color, fine-grained, moderately friable, and weathered. Shale averages around 20% of interval and thickness 1/16-1/4 in. with frequency increasing with depth. | | | WL - Run 2<br>Began 9:20 Rec 4.65'<br>End 10:45 Loss -<br>Time 25 min Gain -<br>Drl time 25 min<br>Hyd press 100-150psi<br>Water press -<br>RPM -<br>Drl Action Smooth<br>Water ret - |
| 624.53 | 13.0 | | closed | | | Remarks - |
| 623.53 | 14.0 | | Shale: dark grey in color, soft, organic, slightly moist, and weathered. | | | |
| 622.53 | 15.0 | | | 100% | - | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO.

Hole No. WES-6-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 6 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 622.53 | 15.0 | | Run 2 | | | |
| | | | Sandstone and interbedded shale: sandstone is grey to brown and moderately hard. Shale runs at 15% and is grey to dark grey in color. | | | AL - Run 3<br>Began 11:05 Rec 4.8<br>End 11:50 Loss -<br>Time 45 min Gain -<br>Drl time 45 min<br>Hyd press 150psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret -<br>Remarks - |
| 621.53 | 16.0 | | | | | |
| 620.53 | 17.0 | | Shale: black and soft | | | |
| | | | ← closed | | | |
| 619.53 | 18.0 | | | | | |
| | | | Sandstone: light grey to brown, fine-grained, and moderately hard. | | | |
| 618.53 | 19.0 | | recemented breaks-iron | | | |
| | | | Run 3 | 100% | - | |
| 617.53 | 20.0 | | | | | |
| 616.53 | 21.0 | | ← 1/4 in. black shale | | | |
| | | | ← 1/4 in. black shale | | | AL - Run 4<br>Began 12:40 Rec 4.7<br>End 1:30 Loss -<br>Time 50 min Gain -<br>Drl time 50 min<br>Hyd press 100-150psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret -<br>Remarks - |
| | | | Sandstone: grey to brown, fine-grained, and moderately hard to hard. Run contains 1-5% shale. Oxidized from 21.5-22.0 and 23.5-24.1 ft. | | | |
| 615.53 | 22.0 | | | | | |
| 614.53 | 23.0 | | ← 1/4 in. black shale | | | |
| | | | Shale seams in fractured sandstone | | | |
| 613.53 | 24.0 | | | | | |
| | | | Run 4 | 100% | - | |
| 612.52 | 25.0 | | | | | |

Hole No. WES-6-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 612.53 | 25.0 | | | | | |
| 611.53 | 26.0 | | 1/2 in. black shale<br>3/4 in. black shale | | | WL - Run 5<br>Began 1:50 Rec 4.8<br>End 2:25 Loss -<br>Time 35 min Gain -<br>Drl time 35 min<br>Hyd press 150psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret - |
| 610.53 | 27.0 | | closed | | | |
| 609.53 | 28.0 | | Sandstone: grey in color, fine-grained, moderately hard, and inter-bedded with 10-20% black shale ranging in thickness from 1/8-3/4 in. | | | Remarks<br>Water in hole at 29 ft |
| 608.53 | 29.0 | | Run 5 | 100% | - | |
| 607.53 | 30.0 | | | | | |
| 606.53 | 31.0 | | Sandstone: same-oxidized from 29.3-30.5 ft<br>1/4 in. shale | | | WL - Run 6<br>Began 2.50 Rec 5.1<br>End 3:24 Loss -<br>Time 34 min Gain -<br>Drl time 34 min<br>Hyd press 150psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret - |
| 605.53 | 32.0 | | 1/4 in. shale | | | Remarks - |
| 604.53 | 33.0 | | ripple marks | | | |
| 603.53 | 34.0 | | Run 6 | 100% | - | |
| 602.53 | 35.0 | | Sandstone and shale:<br>closed | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

Hole No. WES-6-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 5 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 602.53 | 35.0 | | | | | |
| 601.53 | 36.0 | | Sandstone (50%) and shale (50%); sandstone is fine-grained, grey to dark grey and hard; shale is black and contains sand. Thickness ranges from 1/8 to 1-1/2 in. and averages runs 1-in. | | | AL - Run 7<br>Began 3:50 Rec 4.6<br>End 4:50 Loss -<br>Time 60 min Gain -<br>Drl time 55 min<br>Hyd press 150<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret -<br>Remarks - |
| 600.53 | 37.0 | | | | | |
| | 38.0 | | | | | |
| | | | Shale: black, soft, uniform and slakes on drying. | | | |
| | 39.0 | | Run 7 | 100% | - | |
| | | | Installed well on 21 Sept. 81 | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 21 Sept. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 659.77 Boring No. WES-6-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21Sept | 0.0 | | 0.0 | 0.5 | 0.0 | 1.74 | 3" Shelby Tube | 0 | ST | Clay (CL): dark brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.74 | 1.94 | | 10 | Jar | uniform, slight cohesion, organic |
| | | | | 1.0 | 1.5 | | | | 50 | | matter, and very slight moisture. |
| | | | | 1.5 | 2.0 | | | | 120 | | Sample length: 1.94 ft |
| | | | 4.0 | 2.0 | 2.5 | | | | 150 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Folding Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 2 | 21Sept | 4.0 | 5.3 | 5.0 | 5.3 | 5.0 | 5.3 | 3"Fixed Piston Sampler | 800 | Jar | Sandy clay (CL): light brown in |
| | | | | | | | | | | | color, very stiff, dry, and contains |
| | | | | | | | | | | | 10-20% sand. |
| | | | | | | | | | | | |
| | 21Sept | 5.3 | 8.0 | 5.3 | 20.3 | — | — | 5 5/8" Rock Bit | | — | Cleanout: at 8.0 ft rock is harder, |
| | | | | | | | | | | | less weathered. Moisture between |
| | | | | | | | | | | | 10-11 ft |
| | | 8.0 | 18.0 | | | | | | | | Sandstone |
| | | 18.0 | 20.3 | | | | | | | | Shale |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-3-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 21Sept | | | | | | | | | | Water at 10.6 ft at 9:01 a.m. |
| | | | | | | | | | | | Blew hole and installed well. |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 1 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 632.89 Boring No. WES-6-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| 1 | 1 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.46 | 3" Shelby Tube | 40 | ST | Gravelly clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.46 | 1.66 | | 40 | Jar | soft to slightly stiff, and dry. |
| | | | | 1.0 | 1.5 | | | | 60 | | Gravel is fine-grained, friable |
| | | | | 1.5 | 2.0 | | | | 80 | | sandstone. |
| | | | | 2.0 | 2.5 | | | | 100 | | Sample length: 1.66 ft |
| | | | | | | | | | | | |
| | | | 4.8 | 0.0 | 4.8 | — | — | 7" Solid Auger | | — | Cleanout: bedrock at 4.8 ft |
| | | | | | | | | | | | |
| | 2 Oct | 4.8 | 6.5 | 4.8 | 30.0 | — | — | 5 5/8" Rock Bit | | — | Weathered sandstone and clay: brown |
| | | 6.5 | 23.0 | | | | | | | | Sandstone and shale: light grey |
| | | | | | | | | | | | to green in color, and moderately |
| | | | | | | | | | | | hard |
| | | 23.0 | 26.0 | | | | | | | | Sandstone: greenish grey and hard |
| | | 26.0 | 27.8 | | | | | | | | Shale: hard and green |
| | | 27.8 | 30.0 | | | | | | | | Sandstone: hard and light grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | Water at 19.5 ft |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 2 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 607.89 Boring No. WES-6-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.8 | 3" Shelby Tube | 100 | ST | Clay (CL): brown to reddish brown |
| 1A | | | | 0.5 | 1.0 | 1.8 | 2.0 | | 100 | Jar | in color, soft to moderately stiff, |
| | | | | 1.0 | 1.5 | | | | 160 | | dry, and contains 20-25% fine gravel. |
| | | | | 1.5 | 2.0 | | | | 220 | | |
| | | | | 2.0 | 2.5 | | | | 220 | | Sample length: 2.00 ft |
| | | | | | | | | | | | |
| | | | 6.5 | 0.0 | 5.0 | — | — | 7" Solid Auger | | — | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 2 | 3 Oct | 6.5 | | 5.0 | 5.5 | 5.0 | 6.85 | 3"Fixed Piston Sampler | 160 | ST | Clay shale: brown to grey, soft, |
| 2A | | | | 5.5 | 6.0 | 6.85 | 7.05 | | 220 | Jar | and dry. |
| | | | | 6.0 | 6.5 | | | | 240 | | |
| | | | | 6.5 | 7.0 | | | | 260 | | Sample length: 2.05 ft |
| | | | | 7.0 | 7.5 | | | | 300 | | |
| | | | | | | | | | | | |
| | | | 11.5 | 7.5 | 27.0 | — | — | 5 5/8" Rock Bit | | — | Clay shale: see above |
| | | 11.5 | 13.0 | | | | | | | | Shale: red in color |
| | | 13.0 | 27.0 | | | | | | | | Shale: grey in color and harder |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-5-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | at 26 ft. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Hole making water at fairly good |
| | | | | | | | | | | | rate between 16.5 and 17.0 ft. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Blew hole and installed well. |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 13 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 672.06 Boring No. WES-6-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.41 | 3" Shelby Tube | 200 | ST | Clay (CL): brown in color, very |
| 1A | | | | 0.5 | 1.0 | 1.41 | 1.58 | | 160 | Jar | stiff, dry, variable composition, |
| | | | | 1.0 | 1.5 | | | | 240 | | and thinly bedded. |
| | | | | 1.5 | 2.0 | | | | 300 | | |
| | | | | 2.0 | 2.5 | | | | 460 | | Sample length: 1.58 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Solid Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 2 | 13Oct | | | 5.0 | 5.5 | 5.0 | 6.27 | *3"Fixed Piston Sampler | -160 | ST | Clay (CL): same as above except |
| 2A | | | | 5.5 | 6.0 | 6.27 | 6.45 | | 240 | Jar | not as stiff. |
| | | | | 6.0 | 6.5 | | | | 300 | | |
| | | | | 6.5 | 7.0 | | | | 400 | | |
| | | | | 7.0 | 7.5 | | | | 500 | | Sample length: 1.45 ft |
| | | | | | | | | | | | |
| | | | 9.0 | 5.0 | 10.0 | — | — | 7" Solid Auger | | — | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

*3" Fixed Piston Sampler = 3" F.P.S

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 13Oct | 9.0 | | 10.0 | 10.5 | 10.0 | 11.30 | 3" F.P.S. | 200 | ST | Shale: brown and dark grey, dry, |
| 3A | | | | 10.5 | 11.0 | 11.30 | 11.45 | | 340 | Jar | stiff, varied composition, and |
| | | | 11.8 | 11.0 | 11.5 | | | | 500 | | varied texture. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Sample length: 1.45 ft |
| | | | | | | | | | | | |
| | 13Oct | 11.8 | 14.0 | 11.8 | 60.0 | — | — | 5 5/8" Rock | Bit | — | Shale: grey and medium hard |
| | | 14.0 | 15.2 | | | | | | | | Shale: brown and medium hard |
| | | 15.2 | 16.8 | | | | | | | | Shale: reddish brown and medium hard |
| | | 16.8 | 26.6 | | | | | | | | Shale: greyish brown and medium hard |
| | | 26.6 | 27.3 | | | | | | | | Coal: black and medium to hard |
| | | 27.3 | 36.0 | | | | | | | | Shale: grey and soft |
| | | 36.0 | 37.2 | | | | | | | | Shale: brown |
| | | 37.2 | 38.0 | | | | | | | | Shale: grey |
| | | 38.0 | 41.0 | | | | | | | | Sandstone: grey and hard |
| | | 41.0 | 42.2 | | | | | | | | Shale: grey and medium hard |
| | | 42.2 | 46.3 | | | | | | | | Sandstone: brown and medium hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-6-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 46.3 | 48.7 | | | | | | | | Sandstone: grey and hard |
| | | 48.7 | 51.0 | | | | | | | | Sandstone: light grey-grey and |
| | | | | | | | | | | | medium hard |
| | | 51.0 | 62.3 | | | | | | | | Shale: grey |
| | | | | | | | | | | | |
| | 14Oct | | | 60.0 | 62.3 | | | 5 5/8" Rock | Bit | — | Water level rose to 50.5 ft over- |
| | | | | | | | | | | | night. M-scope wouldn't give |
| | | | | | | | | | | | reading, water level measured on |
| | | | | | | | | | | | drill rods and estimate 2 ft |
| | | | | | | | | | | | displacement. Set well after |
| | | | | | | | | | | | blowing hole. |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 14 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator A. McNamara Surface El 660.92 Boring No. WES-6-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.22 | 3" Shelby Tube | 20 | ST | Clay (CL): brown in color, soft |
| 1A | | | | 0.5 | 1.0 | 2.22 | 2.40 | | 100 | Jar | to slightly stiff, dry, and low |
| | | | | 1.0 | 1.5 | | | | 250 | | plasticity- fill material |
| | | | | 1.5 | 2.0 | | | | 300 | | Sample length: 2.40 ft |
| | | | 4.5 | 2.0 | 2.5 | | | | 300 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| 2 | 14Oct | 4.5 | | 5.0 | 5.5 | 5.0 | 6.45 | *3"Fixed Pis- | 0 | ST | Sandy clay (CL): orange brown in |
| 2A | | | | 5.5 | 6.0 | 6.45 | 6.65 | ton Sampler | 80 | Jar | color, dry, variable composition, |
| | | | | 6.0 | 6.5 | | | | 500 | | and contains 10-20% fine-grained |
| | | | | 6.5 | 7.0 | | | | 550 | | sand. Possible black powder |
| | | | 7.5 | 7.0 | 7.38 | | | | — | | intermixed in sample. |
| | | | | | | | | | | | Sample length: 1.65 ft- chucks |
| | | | | | | | | | | | slipped |
| | | | | | | | | | | | |
| | | 7.5 | 10.0 | 5.0 | 10.0 | — | — | 7" Folding Auger | — | | Cleanout: clay and weathered sandstone. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *3" Fixed Piston Sampler = 3"F.P.S. Sheet 1 of 4 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____

Location _____ Job No

Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3A | 14Oct | 10.0 | | 10.0 | 10.5 | 10.0 | 10.5 | 3"F.P.S. | 700 | Jar | Sandstone: grey brown in color, |
| | | | | | | | | | | | dry, weathered, and very fine- |
| | | | | | | | | | | | grained. |
| | | | | | | | | | | | |
| | | | | 10.7 | ——— | | | 4 x 5-1/2"Core Barrel | | | See page 3 (Engineer Form 1836) |
| | | | | | | | | | | | for log of core. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 4 Sheets

Hole No. WES-6-7-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 3 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5 1/2' Diamond bit |
| 2. LOCATION (Coordinates or Station) Demolition Area | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-6-7-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED three; UNDISTURBED two |
| 5. NAME OF DRILLER A. McNamara | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 14 Oct. 81; COMPLETED 15 Oct. 81 |
| 7. THICKNESS OF OVERBURDEN 10.0 ft | 17. ELEVATION TOP OF HOLE 660.92 |
| 8. DEPTH DRILLED INTO ROCK 19.15 ft | 18. TOTAL CORE RECOVERY FOR BORING 100% % |
| 9. TOTAL DEPTH OF HOLE 29.15 ft | 19. SIGNATURE OF INSPECTOR [signature] |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 650.92 | 10.0 | | See pages 1 and 2 for | | | |
| 649.92 | 11.0 | | Sandstone: brown to orange brown in color, fine-grained quartz and miscellaneous sand, weathered, dry, thinly bedded, and friable. | | | 14 Oct. 81<br>WL -<br>Began 2:05<br>End 3:00<br>Time 55 min<br>Drl time 58 min<br>Hyd press 100psi<br>Water press -<br>RPM 50±<br>Drl Action Smooth<br>~~Water~~ rot<br>Reddish brown and grey<br>Remarks<br>Cored with air<br>Run 1<br>Rec 4.15'<br>Loss -<br>Gain - |
| 648.92 | 12.0 | | fractured | | | |
| 647.92 | 13.0 | | Shale: black, dry, soft, and uniform, except for small, irregular seams and lenses of yellow, dry, and earthy oxidation product or precipitate. | | | |
| | | | fractured | | | |
| 646.92 | 14.0 | | | | | |
| | | | Run 1 | 100% | - | |
| 645.92 | 15.0 | | Shale: same as above | | | |
| 644.92 | 16.0 | | closed | | | WL -<br>Began 3:45<br>End 4:50<br>Time 65 min<br>Drl time 65 min<br>Hyd press -<br>Water press<br>RPM 50-60±<br>Drl Action Smooth<br>~~Water~~ rot<br>Dark black/dark grey<br>Remarks<br>Cored with air. Water began bubbling in at bottom of run. Checked water level 15 Oct. 81, at 8:00 and read 15.56 ft.<br>Run 2<br>Rec 4.75<br>Loss -<br>Gain - |
| 643.92 | 17.0 | | | 100% | - | |
| 642.92 | 18.0 | | Coal: black in color, brilliant luster, brittle, soft, and jointed with irregular pattern. From 17.9-18.1 ft, slight, earthy, orange brown crust. From 18.6-19.0 ft, material is more shale like in nature and softer. | | | |
| 641.92 | 19.0 | | Run 2 | | | |
| 640.92 | 20.0 | | Shaley sandstone | | - | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-6-7-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| | 17. ELEVATION TOP OF HOLE |
| 7. THICKNESS OF OVERBURDEN | 18. TOTAL CORE RECOVERY FOR BORING % |
| 8. DEPTH DRILLED INTO ROCK | 19. SIGNATURE OF INSPECTOR |
| 9. TOTAL DEPTH OF HOLE | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 640.92 | 20.0 | | From 20-20.5 ft, soft, black shale. | | | 15 Oct, 81 |
| 639.92 | 21.0 | | Shaley sandstone: light to dark grey in color, moderately hard, very fine-grained, and contains 30-40% interbedded dark grey shale. Sandstone and shale is interbedded in irregular seams, lenses, and thin beds. | | | WL - Run 3<br>Began 9:30 Rec 0.0'<br>End 9:45 Loss 0.8'<br>Time 15 min Gain -<br>Drl time 15 min<br>Hyd press 100psi<br>Water press -<br>RPM 50<br>Drl Action Smooth<br>~~Water~~ ret Black<br>Remarks Blocked off |
| 638.92 | 22.0 | | | | | |
| 637.92 | 23.0 | | | | | |
| 636.92 | 24.0 | | Run 4 | 118% | - | WL - Run 4<br>Began 10:08 Rec 4.55'<br>End 11:33 Loss -<br>Time 85 min Gain 0.8<br>Drl time 85 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-70<br>Drl Action Smooth<br>~~Water~~ ret Black-dark grey<br>Remarks - |
| 635.92 | 25.0 | | | | | |
| 634.92 | 26.0 | | coal (1/4-1/2 in.) | | | |
| | | | shale (1/2 in.) | | | |
| 633.92 | 27.0 | | | | | |
| 632.92 | 28.0 | | Shaley sandstone and interbedded shale:<br>20-30% shale<br>70-80% sandstone | | | WL - Run 5<br>Began 12:18 Rec 5.05<br>End 2:00 Loss -<br>Time 102 min Gain -<br>Drl time 102 min<br>Hyd press 100psi<br>Water press -<br>RPM 50<br>Drl Action Smooth<br>~~Water~~ ret Black<br>Remarks - |
| 631.92 | 29.0 | | Run 5 | 100% | - | |
| | | | Cleaned mud and cuttings from hole with water. Jetted hole of water and installed well screen. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 14 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 638.72 Boring No. WES-6-8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.55 | 3" Shelby Tube | 80 | ST | Clay (CL): brown in color, soft, |
| 1A | | | | 0.5 | 1.0 | 1.55 | 1.75 | | 100 | Jar | low plasticity, and uniform. |
| | | | | 1.0 | 1.5 | | | | 120 | | Material is fill from dozer. |
| | | | | 1.5 | 2.0 | | | | 120 | | Sample length: 1.75 ft |
| | | | 4.2 | 2.0 | 2.5 | | | | 140 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Solid Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 2 | 14Oct | 4.2 | | 5.0 | 5.5 | 5.0 | 5.99 | 3"Fixed Piston Sampler | 700 | ST | Sandstone: brown in color, weathered, |
| 2A | | | | 5.5 | 6.0 | 5.99 | 6.19 | | 400 | Jar | very fine-grained, crumbles easily, |
| | | | | | | | | | | | and dry. |
| | | | 6.3 | 6.0 | — | | | | 700 | | Sample length: 1.19 ft |
| | | | | | | | | | | | |
| | 14Oct | 6.3 | 8.4 | 6.3 | 20.0 | — | — | 5 5/8" Rock Bit | | — | Sandstone: weathered and brown |
| | | 8.4 | 9.2 | | | | | | | | Shale: reddish grey and soft |
| | | 9.2 | 11.4 | | | | | | | | Sandstone: grey |
| | | 11.4 | 17.3 | | | | | | | | Shale: grey and hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-8-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 15Oct | 17.3 | 27.5 | 20.0 | 27.5 | — | — | 5 5/8" Rock | Bit | — | Shale: dark grey and hard |
| | | | | | | | | | | | |
| | | | | | | | | | | | Encountered water around 17.5 ft. |
| | | | | | | | | | | | Drilled to 27.5 ft. Water came up |
| | | | | | | | | | | | overnight to depth of 8 ft (reading |
| | | | | | | | | | | | taken on 15 Oct. 81 at 8:10 a.m. |
| | | | | | | | | | | | Blew hole and installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 16 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 631.04 Boring No. WES-6-9-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | | 0.0 | | 0.0 | 0.5 | 0.0 | 1.7 | 3" Shelby Tube | 260 | Jar | Sand (SP) and sandstone fragments: |
| | | | | 0.5 | 1.0 | | | | 500 | | brown in color, dry, fine-grained |
| | | | | 1.0 | 1.5 | | | | 700 | | quartz sand, and uniform. Tube |
| | | | 1.7 | 1.5 | 1.7 | | | | 700 | | was damaged in push. |
| | | | | | | | | | | | |
| | | 1.7 | 3.2 | 0.0 | 39.7 | — | — | 5 5/8" Rock | Bit | — | Sandstone: brown and weathered |
| | | 3.2 | 6.6 | | | | | | | | Clay shale: brown |
| | | 6.6 | 7.5 | | | | | | | | Shale: grey |
| | | 7.5 | 8.6 | | | | | | | | Sandstone |
| | | 8.6 | 17.9 | | | | | | | | Shale: changing often from brown, |
| | | | | | | | | | | | to red, and to grey. |
| | | 17.9 | 19.7 | | | | | | | | Sandstone: rust colored |
| | | 19.7 | 23.2 | | | | | | | | Shale: grey |
| | | 23.2 | 24.2 | | | | | | | | Sandstone: brown |
| | | 24.2 | 25.0 | | | | | | | | Shale: grey |
| | | 25.0 | 27.5 | | | | | | | | Sandstone: brown |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-9-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 27.5 | 39.7 | | | | | | | | Shale: grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | Water at 29 ft. Installed well |
| | | | | | | | | | | | after blowing hole. |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 17 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator A. McNamara Surface El 659.10 Boring No. WES-6-10-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.08 | 3" Shelby Tube | 0 | ST | Clay (CL): brown in color, dry, |
| 1A | | | | 0.5 | 1.0 | 2 08 | 2.28 | | 0 | Jar | no cohesion, and organic matter. |
| | | | | 1.0 | 1.5 | | | | 0 | | Material is fill from dozer. |
| | | | | 1.5 | 2.0 | | | | 20 | | Sample length: 2.28 ft |
| | | | 4.0 | 2.0 | 2.5 | | | | 40 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Folding Auger | — | | Cleanout: fill ends at 4.0 ft |
| | | | | | | | | | | | |
| 2 | 17Oct | 4.0 | | 5.0 | 5.5 | 5.0 | 6.99 | 3"Fixed Piston Sampler | 40 | ST | Clay (C ): grey brown in color, |
| 2A | | | | 5.5 | 6.0 | 6.99 | 7.14 | | 100 | Jar | uniform, stiff, dry, and high plas- |
| | | | | 6.0 | 6.5 | | | | 150 | | ticity. |
| | | | | 6.5 | 7.0 | | | | 250 | | Sample length: 2.14 ft |
| | | | | 7.0 | 7.35 | | | | 400 | | |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | — | — | 7" Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED 3" Fixed Piston Sampler = 3" F.P.S. Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-10-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 17 Oct | | | 10.0 | 10.5 | 10.0 | 11.49 | 3" F.P.S. | 0 | ST | Clay (CH): dark grey brown in color, |
| 3A | | | | 10.5 | 11.0 | 11.49 | 11.68 | | 20 | Jar | dry, stiff, uniform, and high plas- |
| | | | | 11.0 | 11.5 | | | | 50 | | ticity. |
| | | | | 11.5 | 12.0 | | | | 400 | | Sample length: 1.68 ft |
| | | | | 12.0 | 12.40 | | | | 500 | | |
| | | | | | | | | | | | |
| | | | 13.34 | 10.0 | 15.0 | | | 7" Folding Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 4A | 17 Oct | 13.34 | 15.5 | 15.0 | 15.5 | 15.0 | 15.5 | 3" F.P.S. | 700 | Jar | Sandy shale: brownish dark grey |
| | | | | | | | | | | | in color, dry, and stiff to hard. |
| | | | | | | | | | | | |
| | 17 Oct | 15.5 | 20.0 | 15.0 | 32.7 | | | 5 5/8" Rock Bit | | | Shale: brown to dark grey |
| | | 20.0 | 22.0 | | | | | | | | Coal: black- water at 22 ft |
| | | 22.0 | 32.7 | | | | | | | | Shale and interbedded sandstone |
| | | | | | | | | | | | |
| | | | | | | | | | | | Blew hole dry and installed well. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 17 Oct. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 657.43 Boring No. WES-6-11-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.39 | 3" Shelby Tube | 50 | ST | Sandy silt (SM): brown in color, |
| 1A | | | | 0.5 | 1.0 | 2.39 | 2.62 | | 75 | Jar | dry, no cohesion, and contains 5-10% |
| | | | | 1.0 | 1.5 | | | | 120 | | sandstone and limonite gravel. |
| | | | | 1.5 | 2.0 | | | | 140 | | |
| | | | 3.5 | 2.0 | 2.62 | | | | 160 | | Sample length: 2.62 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 17Oct | 3.5 | 6.0 | 5.0 | 5.5 | 5.0 | 5.71 | 3"Fixed Pis- | 100 | ST | Clay (CL) and shale: brown in color, |
| 2A | | | | 5.5 | 5.9 | 5.71 | 5.90 | ton Sampler | 500 | Jar | low plasticity, dry, and contains |
| | | | | | | | | | | | 30% hard shale fragments. |
| | | | | | | | | | | | |
| | 17Oct | 6.0 | 7.8 | 5.0 | 30.5 | | | 5 5/8" Rock | Bit | | Shale: grey |
| | | 7.8 | 8.5 | | | | | | | | Coal: black |
| | | 8.5 | 10.5 | | | | | | | | Shale: brown and grey mixed |
| | | 10.5 | 15.3 | | | | | | | | Shale: light brown |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-11-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 15.3 | 16.0 | | | | | | | | Limestone: light grey |
| | | 16.0 | 17.0 | | | | | | | | Shale: grey |
| | | 17.0 | 22.2 | | | | | | | | Shale: dark grey with water between |
| | | | | | | | | | | | 20-20.5 ft |
| | | 22.2 | 23.0 | | | | | | | | Sandstone: brown and hard |
| | | 23.0 | 27.0 | | | | | | | | Shale: hard and grey |
| | | 27.0 | 27.8 | | | | | | | | Sandstone: hard |
| | | 27.8 | 30.5 | | | | | | | | Shale: grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | Blew hole dry and installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 3 Nov. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 667.28 Boring No. WES-6-12-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0 | | 0.0 | 1.1 | | | | | | Disturbed when setting up rig. |
| | | | 1.5 | | | | | | | | Clay (CH): brown, soft, and slight |
| | | | | | | | | | | | moisture |
| | | | | | | | | | | | |
| 1 | 3 Nov | 1.5 | 2.8 | 1.1 | 3.6 | 1.10 | 2.20 | 3"Shelby Tube | | ST | Clay (CH): brick red in color, dry, |
| 1A | | | | | | 2.20 | 2.35 | | | Jar | uniform, stiff, and high plasticity. |
| | | 2.8 | 3.1 | | | Pressure gauge is broken | | | | | Sandy clay (CL): brown in color, |
| | | | | | | | | | | | dry, stiff, and brittle. |
| | | | | | | | | | | | Sample length: 1.25 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 3 Nov | 3.1 | 7.6 | 5.0 | 6.7 | 5.0 | 6.01 | 3"Fixed Piston Sampler | | ST | Clay shale: brown to grey brown in |
| | | | | | | 6.01 | 6.15 | | | Jar | color, dry, and stiff. |
| | | | | | | | | | | | Sample length: 1.15 ft |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-12-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 Nov | 7.6 | 8.3 | 5.0 | 45.4 | | | 5 5/8" Rock | Bit | | Coal: black |
| | | 8.3 | 12.0 | | | | | | | | Sandstone: light grey and medium |
| | | | | | | | | | | | hard |
| | | 12.0 | 16.3 | | | | | | | | Shale: dark grey |
| | | 16.3 | 26.0 | | | | | | | | Sandstone: light brown |
| | | 26.0 | 27.3 | | | | | | | | Shale: dark grey and hard |
| | | 27.3 | 28.5 | | | | | | | | Sandstone: brown |
| | | 28.5 | 31.8 | | | | | | | | Shale: dark grey |
| | | 31.8 | 34.5 | | | | | | | | Sandstone: grey and hard |
| | | 34.5 | 37.0 | | | | | | | | Shale: light grey |
| | | 37.0 | 41.8 | | | Slight moisture at 37 ft | | | | | Sandstone: light grey |
| | | 41.8 | 51.7 | | | | | | | | Shale: grey |
| | | | | | | | | | | | |
| | 4 Nov | | | 45.4 | 51.7 | | | 5 5/8" Rock | Bit | | Water came up to depth of 41.5 ft |
| | | | | | | | | | | | overnight. Drilled to 51.7 ft and |
| | | | | | | | | | | | set well. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 5 Nov. 1981
Location Demolition Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 660.41 Boring No. WES-6-13-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 Nov | 0.0 | 3.7 | 0.0 | 2.5 | 0.0 | 1.29 | 3"Shelby Tube | | ST | Clay (CL): reddish brown in color, |
| 1A | | | | | | 1.29 | 1.44 | | | Jar | slightly moist, stiff, and low |
| | | | | | | | | | | | plasticity. |
| | | | | | | | | | | | Sample length: 1.44 ft |
| | | | | | | | | | | | |
| 2 | 5 Nov | 3.7 | 5.7 | 0.0 | 5.0 | 3.7 | 5.0 | 7" Solid Auger | | Jar | Clay shale: dark black in color, |
| | | | | | | | | | | | soft, dry, and highly organic. |
| | | | | | | | | | | | |
| | | 5.7 | 8.0 | 5.0 | 52.0 | — | — | 5 5/8" Rock Bit | | — | Shale: mixture of grey and brown |
| | | 8.0 | 13.3 | | | | | | | | Shale: grey and soft |
| | | 13.3 | 14.4 | | | | | | | | Shale: brown and soft |
| | | 14.4 | 16.1 | | | | | | | | Sandstone: grey and hard |
| | | 16.1 | 18.2 | | | | | | | | Sandstone: brown |
| | | 18.2 | 23.7 | | | | | | | | Shale: grey and hard |
| | | 23.7 | 24.8 | | | | | | | | Sandstone: light grey |
| | | 24.8 | 27.7 | | | | | | | | Shale: grey and hard |
| | | 27.7 | 31.8 | | | | | | | | Sandstone: grey and hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-13-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 31.8 | 32.3 | | | | | | | | Sandstone: brown |
| | | 32.3 | 35.7 | | | | | | | | Sandstone: grey and hard |
| | | 35.7 | 50.2 | | | | | | | | Shale: dark grey and hard |
| | | 50.2 | 52.0 | | | | | | | | Sandstone: light grey and hard |
| | | | | | | | | | | | |
| | | | | | | | | | | | Water at 40.5 ft coming in very |
| | | | | | | | | | | | slow. Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 27 Oct. 1981
Location Old Rifle Range Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 505.06 Boring No. WES-6-14-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 27Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.61 | 3" Shelby Tube | 0 | ST | Sandy clay (CL) and sandstone gravel: |
| 1A | | | | 0.5 | 1.0 | 1.61 | 1.89 | | 0 | Jar | brown in color, moist, and low |
| | | | | 1.0 | 1.5 | | | | 0 | | plasticity. |
| | | | | 1.5 | 2.0 | | | | 0 | | |
| | | | | 2.0 | 2.5 | | | | | | Sample length: 1.89 ft |
| | | | | | | | | | | | |
| | | | 3.44 | 0.0 | 5.0 | — | — | 7" Folding Auger | — | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 2 | 27Oct | 3.44 | | 5.0 | 5.5 | 5.0 | 7.06 | 3"Fixed Piston Sampler | 0 | ST | Sandy clay (CL): grey to brown in |
| 2A | | | | 5.5 | 6.0 | 7.06 | 7.30 | | 0 | Jar | color, moist, and low plasticity. |
| | | | | 6.0 | 6.5 | | | | 0 | | Water level at 4.0 ft, ten minutes |
| | | | | 6.5 | 7.0 | | | | 0 | | later, water level at 3.4 ft. |
| | | | | 7.0 | 7.4 | | | | 10 | | Sample length: 2.30 ft |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | — | — | 7" Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED 3" Fixed Piston Sampler = 3" F.P.S. Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-14-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 27 Oct | 11.8 | | 10.0 | 10.5 | 10.0 | 11.67 | 3" F.P.S. | 0 | ST | Clay (CH): dark grey in color, |
| 3A | | | | 10.5 | 11.0 | 11.67 | 11.89 | | 0 | Jar | uniform, soft, and high plasticity. |
| | | | | 11.0 | 11.5 | | | | 10 | | |
| | | | | 11.5 | 12.0 | | | | 30 | | |
| | | | | 12.0 | 12.4 | | | | 70 | | Sample length: 1.89 ft |
| | | | | | | | | | | | |
| | | | | 10.0 | 15.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 4 | 27 Oct | | | 15.0 | 15.5 | 15.0 | 17.07 | 3" F.P.S. | 0 | ST | Clay (CH): same as above- water |
| 4A | | | | 15.5 | 16.0 | 17.07 | 17.32 | | 0 | Jar | level rose to 2.6 ft after lunch. |
| | | | | 16.0 | 16.5 | | | | 0 | | |
| | | | | 16.5 | 17.0 | | | | 0 | | |
| | | | | 17.0 | 17.39 | | | | 0 | | Sample length: 2.32 ft |
| | | | | | | | | | | | |
| | | | 17.5 | 15.0 | 17.5 | | | 7" Folding Auger | | | Cleanout: installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 30 Oct. 1981
Location Old Rifle Range Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 510.42 Boring No. WES-6-15-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.35 | 3"Shelby Tube | 0 | ST | Sand (SP) and sandstone fragments. |
| 1A | | | | 0.5 | 1.0 | 1.35 | 1.55 | | 0 | Jar | brown to orange brown in color, very |
| | | | | 1.0 | 1.5 | | | | 50 | | fine to fine-grained, and dry. |
| | | | | 1.5 | 2.0 | | | | 120 | | |
| | | | 2.4 | 2.0 | 2.5 | | | | 700 | | Sample length: 1.55 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 2.75 | | | 7" Folding Auger | | | Cleanout; bedrock starts at 2.4 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 2.8 | | | 5 5/8" Rock Bit | | | Cleanout |
| | | | | | | | | | | | |
| | 31 Oct | | | 2.8 | | | | 4 x 5 1/2"Core Barrel | | | See page two for core log. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-6-15-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 2 OF 3 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | NWSC Groundwater Study |
| 2. LOCATION (Coordinates or Station) | Old Rifle Range |
| 3. DRILLING AGENCY | CEWES |
| 4. HOLE NO. (As shown on drawing title and file number) | WES-6-15-81 |
| 5. NAME OF DRILLER | C. Drake |
| 6. DIRECTION OF HOLE | [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. |
| 7. THICKNESS OF OVERBURDEN | 2.75 ft |
| 8. DEPTH DRILLED INTO ROCK | 14.50 ft |
| 9. TOTAL DEPTH OF HOLE | 17.25 ft |
| 10. SIZE AND TYPE OF BIT | 4 x 5 1/2 in. Diamond bit |
| 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) | MSL |
| 12. MANUFACTURER'S DESIGNATION OF DRILL | Failing 1500 |
| 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED: zero; UNDISTURBED: two |
| 14. TOTAL NUMBER CORE BOXES | zero |
| 15. ELEVATION GROUND WATER | |
| 16. DATE HOLE | STARTED: 30 Oct. 81; COMPLETED: 31 Oct. 81 |
| 17. ELEVATION TOP OF HOLE | 510.42 |
| 18. TOTAL CORE RECOVERY FOR BORING | 95.2% % |
| 19. SIGNATURE OF INSPECTOR | Joseph E. Wierbra |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 510.42 | 0.0 | | | | | |
| 509.42 | 1.0 | | See page one for over-burden information. | | | |
| 508.42 | 2.0 | | | | | 30 Oct. 81<br>WL -<br>Run 1<br>Began 2:35<br>Rec 4.55'<br>End 2:55<br>Loss -<br>Time 20 min<br>Gain -<br>Drl time 20 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>~~Water~~ ret<br>Brown<br>Remarks<br>Cored with air. Stuck core bbl-drilled 6" Cs around to break out. |
| 507.42 | 3.0 | | | | | |
| 506.43 | 4.0 | | Sandstone: brown to rusty brown in color, uniform, fine-grained quartz sand, moderately hard, and oxidized. Bedding ranges from thinly bedded to around one foot maximum thickness and horizontal to sub-horizontal in attitude. | | | |
| 505.42 | 5.0 | | | | | |
| 504.42 | 6.0 | | | | | |
| | | | Solution cavity. | | | |
| 503.42 | 7.0 | | Water at end of run. | | | 31 Oct. 81<br>WL -<br>Run 2<br>Began 9:42<br>Rec 3.85'<br>End 10:15<br>Loss -<br>Time 33 min<br>Gain -<br>Drl time 33 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret<br>Slight return-brown<br>Remarks<br>Stuck core bbl-Drilled 6" Cs around to break out. |
| | | | Run 1 | 100% | - | |
| 502.42 | 8.0 | | | | | |
| 501.42 | 9.0 | | Sandstone: same | | | |
| 500.42 | 10.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-6-15-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 3 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 500.42 | 10.0 | | | | | |
| 499.42 | 11.0 | | Run 2 | | | |
| 498.42 | 12.0 | | | | | AL - Run 3<br>Logan 1:09 Rec 4.1'<br>End 1:39 Loss -<br>Time 30 min Gain -<br>Drl time 30 min<br>Hyd press 100psi<br>Water press -<br>RPM 50<br>Drl Action Smooth<br>~~Water~~ ret<br>Slight-brown<br>Remarks<br>Water more pronounced after second run. |
| 497.42 | 13.0 | | Sandstone: same | 100% | - | |
| | | | small cavity-1/2 x 1/2 x 1 in. | | | |
| 496.42 | 14.0 | | | | | |
| 495.42 | 15.0 | | Run 3 | | | |
| 494.42 | 16.0 | | Sandstone: same | 64.1% | - | AL - Run 4<br>Logan 2:00 Rec 1.25<br>End 2:30 Loss 0.70<br>Time 30 min Gain -<br>Drl time 30 min<br>Hyd press 100+<br>Water press -<br>RPM 50<br>Drl Action Smooth<br>~~Water~~ ret<br>Slight-brown<br>Remarks - |
| | | | Recovered to 16.55 ft | | | |
| 493.42 | 17.0 | | Hole rodded at 17.25 ft<br>Run 4 | | | |
| | | | Blew hole dry and installed well. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 2 Nov, 1981
Location Old Rifle Range Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 527.88 Boring No. WES-6-16-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.37 | 3" Shelby Tube | 0 | ST | Silt (ML), brown in color, uniform, |
| 1A | | | | 0.5 | 1.0 | 1.37 | 1.52 | | 0 | Jar | dry, and stiff. |
| | | | | 1.0 | 1.5 | | | | 200 | | |
| | | | | 1.5 | 2.0 | | | | 480 | | |
| | | | | 2.0 | 2.5 | | | | 620 | | Sample length: 1.52 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 3.0 | | | 7" Folding Auger | | | Cleanout: very hard |
| | | | | | | | | | | | |
| | | | 4.5 | 3.0 | 5.0 | | | 5 5/8" Rock Bit | | | Cleanout: softer at 4.5 ft |
| | | | | | | | | | | | |
| 2A | 2 Nov | 4.5 | 10.0 | 5.0 | 5.4 | 5.0 | 5.4 | 3"Fixed Piston Sampler | 700 | Jar | Sandy silt (ML): brown in color, |
| | | | | | | | | | | | dry, low plasticity, and contains |
| | | | | | | | | | | | 5-10% fine to medium sand. |
| | | | | | | | | | | | |
| | | 10.0 | 27.0 | 5.0 | 45.15 | | | 5 5/8" Rock Bit | | | Clay shale: brown in color, very |
| | | | | | | | | | | | stiff to hard, weathered, and |
| | | | | | | | | | | | slightly moist in regions, |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-16-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 27.0 | 45.15 | | | | | | | | Sandstone: brown in color, medium |
| | | | | | | | | | | | hard, and fine-grained. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Encountered water between 35 and 37ft. |
| | | | | | | | | | | | Meausred water level after 49 |
| | | | | | | | | | | | minutes and it rose to 31.97 ft. |
| | | | | | | | | | | | Drilled to 45.15 ft and blew water |
| | | | | | | | | | | | from hole. Rinsed hole three times |
| | | | | | | | | | | | with clean water to remove mud, |
| | | | | | | | | | | | Installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 10 Nov. 1981
Location Old Rifle Range Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 510.73 Boring No. WES-6-17-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.39 | 3" Shelby Tube | 0 | ST | Clay (CL): brown in color, soft, |
| 1A | | | | 0.5 | 1.0 | 1.39 | 1.57 | | 0 | Jar | slightly moist, and low plasticity. |
| | | | | 1.0 | 1.5 | | | | 30 | | Sample length: 1.57 ft |
| | | | 2.0 | 1.5 | 2.0 | | | | 700 | | |
| | | | | | | | | | | | |
| | 10 Nov | 2.0 | | 0.0 | 17.5 | — | — | 6 3/4" Rock | Bit | — | Sandstone: brown, fine-grained, |
| | | | | | | | | | | | and medium hard. Checked hole for |
| | | | | | | | | | | | water at 6.8 ft, 10.0 ft, and |
| | | | | | | | | | | | 12.4 ft. Moisture at 12.4 ft, |
| | | | | | | | | | | | Water visible from 12.4 to 17.5 ft |
| | | | | | | | | | | | coming in from sidewalls. |
| | | | | | | | | | | | |
| | 10 Nov | | 22.5 | 17.5 | 22.55 | — | — | 4 x 5 1/2" Core Barrel | | — | Sandstone: see page two for log |
| | | | | | | | | | | | of core. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-6-17-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5 1/2 in Diamond |
| 2. LOCATION (Coordinates or Station) Old Rifle Range | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-6-17-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED one |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 10 Nov. 81; COMPLETED 10 Nov. 81 |
| 7. THICKNESS OF OVERBURDEN 2.0 ft | 17. ELEVATION TOP OF HOLE 510.73 |
| 8. DEPTH DRILLED INTO ROCK 20.55 ft | 18. TOTAL CORE RECOVERY FOR BORING 24.6% % |
| 9. TOTAL DEPTH OF HOLE 22.55 ft | 19. SIGNATURE OF INSPECTOR Joseph B. Rinehart |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 493.73 | 17.0 | | | | | |
| 492.73 | 18.0 | | From 17.5 to 18.0 ft, 1/4-3/4 in. alternating layers of rusty brown to dark brown sandstone. | | | 10 Nov. 81<br>NL -<br>Run 1<br>Begin 1:13<br>Rec 5:05<br>End 1:56<br>Loss -<br>Time 43 min<br>Gain -<br>Drl time 43 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret Brown<br>- |
| 491.73 | 19.0 | | Sandstone: brown in color, uniform, fine-grained quartz sand, and medium hard. Pyrite crystals with oxidation rims from 21.65-21.9 ft and at 22.35 ft. | | | |
| 490.73 | 20.0 | | | | | |
| 489.73 | 21.0 | | | | | |
| 488.73 | 22.0 | | | | | |
| | | | Run 1 | 100% | - | |
| 487.73 | 23.0 | | Reamed hole out with 6-3/4 in rock bit and rinsed hole with clean water. Water level came up overnight to 12.7 ft. Blew dry and installed well. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 13 Nov. 1981
Location Old Rifle Range Job No 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 508.03 Boring No. WES-6-18-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.63 | 3" Shelby Tube | 0 | ST | Silty sand (SM): brown to rusty |
| 1A | | | | 0.5 | 1.0 | 1.63 | 1.78 | | 0 | Jar | brown in color, fine-grained, and |
| | | | | 1.0 | 1.5 | | | | 20 | | little cohesion. |
| | | | | 1.5 | 2.0 | | | | 280 | | |
| | | | 5.0 | 2.0 | 2.5 | | | | 380 | | Sample length: 1.78 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 13 Nov | 5.0 | | 5.0 | 5.5 | 5.0 | 6.58 | 3"Fixed Piston Sampler | 0 | ST | Sand (SP): brown in color, uniform, |
| 2A | | | | 5.5 | 6.0 | 6.58 | 6.78 | | 20 | Jar | fine-grained quartz sand, and |
| | | | | 6.0 | 6.5 | | | | 320 | | slightly damp. |
| | | | 6.5 | 6.5 | 6.75 | | | | 720 | | Sample length: 1.78 ft |
| | | | | | | | | | | | |
| | | 6.5 | 10.0 | 5.0 | 26.6 | | | 5 5/8" Rock Bit | | | Sandstone: brown, weathered, and |
| | | | | | | | | | | | fine-grained |
| | | 10.0 | 11.5 | | | | | | | | Sandstone with clay/shale lenses. |
| | | 11.5 | 14.4 | | | | | | | | Sandstone: brown, fine-grained, |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-18-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | and soft. |
| | | 14.4 | 26.6 | | | | | | | | Sandstone: brown, fine-grained, |
| | | | | | | | | | | | and hard. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Water at 16.6 ft. |
| | | | | | | | | | | | Jetted hole twice to clear water |
| | | | | | | | | | | | and installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 23 Nov, 1981
Location Old Rifle Range Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 503.42 Boring No. WES-6-19-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.0 | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout: 0.0 to 5.0 ft is disturbed |
| | | | | | | | | | | | from setting up. Had to dump load |
| | | | 3.0 | | | | | | | | of gravel to firm up area. |
| | | | | | | | | | | | |
| 1 | 23 Nov | 3.0 | | 5.0 | 5.5 | 5.0 | 6.88 | *3"Fixed Piston Sampler | 0 | ST | Clay (CH): grey with streaks of |
| 1A | | | | 5.5 | 6.0 | 6.88 | 7.13 | | 0 | Jar | brown, soft, and high plasticity. |
| | | | | 6.0 | 6.5 | | | | 0 | | Water in hole after cleanout- 8 ft. |
| | | | | 6.5 | 7.0 | | | | 0 | | Sample length: 2.13 ft |
| | | | | 7.0 | 7.5 | | | | 10 | | |
| | | | | | | | | | | | |
| | | | 11.75 | 5.0 | 10.0 | | | 7" Folding Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 2 | 23 Nov | 11.75 | | 10.0 | 10.5 | 10.0 | 11.66 | 3" F.P.S. | 0 | ST | Sandy clay (CL): dark grey in color, |
| 2A | | | | 10.5 | 11.0 | 11.66 | 11.96 | | 0 | Jar | soft, low to medium plasticity, and |
| | | | | 11.0 | 11.5 | | | | 0 | | contains 20% very fine-grained sand. |
| | | | | 11.5 | 12.0 | | | | 0 | | |
| | | | | 12.0 | 12.39 | | | | 0 | | Sample length: 1.96 ft |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

* 3" Fixed Piston Sampler = 3"F.P.S.

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-19-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 16.75 | 10.0 | 15.0 | | | 7" Folding Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 3 | 23 Nov | 16.75 | | 15.0 | 15.5 | 15.0 | 17.06 | 3" F.P.S. | 0 | ST | Gravelly clay (CL): brown to grey |
| 3A | | | | 15.5 | 16.0 | 17.06 | 17.36 | | 0 | Jar | with traces of red and green, fine |
| | | | | 16.0 | 16.5 | | | | 0 | | to medium sized gravel, soft, and |
| | | | | 16.5 | 17.0 | | | | 0 | | low plasticity. |
| | | | | 17.0 | 17.40 | | | | 0 | | Sample length: 2.36 ft |
| | | | | | | | | | | | |
| | | | 20.0 | 15.0 | 20.0 | | | 7" Folding Auger | | | Went additional few ft to provide |
| | | | | | | | | | | | better seal at surface. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 24 Nov. 1981
Location Old Rifle Range Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 515.68 Boring No. WES-6-20-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.78 | 3" Shelby Tube | 0 | ST | Silt (ML), brown in color, soft, |
| | | | | 0.5 | 1.0 | 1.78 | 1.95 | | 0 | Jar | low plasticity, and dry. |
| | | | | 1.0 | 1.5 | | | | 25 | | |
| | | | | 1.5 | 2.0 | | | | 75 | | Sample length: 1.95 ft |
| | | | | 2.0 | 2.5 | | | | 380 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 24 Nov | | | 5.0 | 5.5 | 5.0 | 6.75 | 3"Fixed Piston Sampler | 0 | ST | Silt (ML): brown in color with |
| 2A | | | | 5.5 | 6.0 | 6.75 | 6.95 | | 0 | Jar | traces of grey, soft, and low |
| | | | | 6.0 | 6.5 | | | | 10 | | plasticity. |
| | | | | 6.5 | 7.0 | | | | 230 | | Sample length: 1.95 ft- chucks slipped |
| | | | | 7.0 | 7.5 | | | | 380 | | |
| | | | | | | | | | | | |
| | 25 Nov | | 8.0 | 5.0 | 8.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-6-20-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 25 Nov | 8.0 | 30.5 | 8.0 | 30.5 | | | 5 5/8" Rock | Bit | | Sandstone; brown in color, fine-grained, and weathered. Water encountered around 20.5 ft. Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 3 Oct. 1981
Location Highway 58 Dump Site A Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 629.54 Boring No. WES-7-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.05 | 3" Shelby | 40 | ST | Gravelly clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.05 | 1.25 | Tube | 40 | Jar | soft to moderately stiff, dry, and |
| | | | | 1.0 | 1.5 | | | | 100 | | contains 20% gravel fragments. |
| | | | | 1.5 | 2.0 | | | | 160 | | |
| | | | 4.0 | 2.0 | 2.5 | | | | 300 | | Sample length: 1.25 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7" Solid Auger | | — | Cleanout |
| | | | | | | | | | | | |
| 2 | 3 Oct | 4.0 | | 5.0 | 5.5 | 5.0 | 6.79 | 3"Fixed Pis- | 40 | ST | Clay (CL): brown to grey, stiff, |
| 2A | | | | 5.5 | 6.0 | 6.79 | 6.97 | | 60 | Jar | and fairly uniform. |
| | | | | 6.0 | 6.5 | | | | 120 | | |
| | | | | 6.5 | 7.0 | | | | 180 | | Sample length: 1.97 ft |
| | | | 8.0 | 7.0 | 7.5 | | | | 240 | | |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | — | — | 7" Solid Auger | | — | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *3" Fixed Piston Sampler = 3"F.P.S. Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-7-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 5 Oct | 8.0 | | 10.0 | 10.5 | 10.0 | 11.44 | 3" F.P.S. | 160 | ST | Clay shale: grey in color, dry, |
| 3A | | | | 10.5 | 11.0 | 11.44 | 11.59 | | 240 | Jar | very stiff, and uniform. |
| | | | | 11.0 | 11.5 | | | | 380 | | |
| | | | | 11.5 | 12.0 | | | | 420 | | Sample length: 1.59 ft |
| | | | | 12.0 | 12.5 | | | | 520 | | |
| | | | | | | | | | | | |
| | | | 13.0 | 10.0 | 13.0 | — | — | 7" Solid Auger | | — | Cleanout: auger required 600 psi, |
| | | | | | | | | | | | will go to rock bit |
| | | | | | | | | | | | |
| | 5 Oct | 13.0 | 17.5 | 13.0 | 41.5 | — | — | 5 5/8" Rock | Bit | — | Shale: brownish red |
| | | 17.5 | 31.0 | | | | | | | | Shale: grey |
| | | | | | | | | | | | Encountered water between 30-31 ft |
| | | 31.0 | 32.2 | | | | | | | | Coal: black |
| | | 32.2 | 41.5 | | | | | | | | Shale: grey and becoming harder |
| | | | | | | | | | | | at 39 ft |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well after blowing hole clear. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 3 Oct. 1981
Location Highway 58 Dump Site A Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 601.89 Boring No. WES-7-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.55 | 3" Shelby Tube | 0 | ST | Gravelly clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.55 | 1.80 | | 10 | | dry, stiff, and contains 10-15% |
| | | | | 1.0 | 1.5 | | | | 150 | | sandstone gravel. |
| | | | | 1.5 | 2.0 | | | | 250 | | |
| | | | | 2.0 | 2.5 | | | | 360 | | Sample length: 1.7 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 3 Oct | | | 5.0 | 5.5 | 5.0 | 7.06 | 3"Fixed Piston Sampler | 0 | ST | Gravelly clay (CL): brownish grey |
| 2A | | | | 5.5 | 6.0 | 7.06 | 7.21 | | 0 | Jar | in color, very stiff, dry, and con- |
| | | | | 6.0 | 6.5 | | | | 40 | | tains 10-15%, fine to medium sand- |
| | | | | 6.5 | 7.0 | | | | 220 | | stone gravel. |
| | | | | 7.0 | 7.4 | | | | 400 | | Sample length: 2.21 ft |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-7-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3A | 3 Oct | | | 10.0 | 10.5 | 10.5 | 11.5 | 3" F.P.S. | 0 | Jar | Gravelly clay (CL); same as in |
| | | | | 10.5 | 11.0 | | | | 400 | | previous sample except 25-30% gravel. |
| | | | 11.8 | 11.0 | 11.5 | | | | 800 | | Tube bent on rock. |
| | | | | | | | | | | | |
| | | 11.8 | | 10.0 | 11.8 | | | 7" Folding Auger | | | Cleanout: 800 psi on auger. |
| | | | | | | | | | | | |
| | | | | | | | | | | | For core log page 3. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 5 Sheets

Hole No. WES-7-2-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 3 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5-1/2 in. Diamond bit |
| 2. LOCATION (Coordinates or Station) Highway 58 Dump Site A | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-7-2-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED three |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 3 Oct. 1981; COMPLETED 5 Oct. 1981 |
| 7. THICKNESS OF OVERBURDEN 11.8 ft | 17. ELEVATION TOP OF HOLE 601.89 |
| 8. DEPTH DRILLED INTO ROCK 23.2 ft | 18. TOTAL CORE RECOVERY FOR BORING 98.5% % |
| 9. TOTAL DEPTH OF HOLE 35.0 ft | 19. SIGNATURE OF INSPECTOR Joseph E. Dunbar |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 590.89 | 11.0 | | For overburden see page one and two. | | | |
| 589.89 | 12.0 | | | | | 3 Oct. 1981<br>WL -<br>Run 1<br>Began 3:18<br>Rec 3.70'<br>End 3:44<br>Loss -<br>Time 26 min<br>Gain -<br>Drl time 26 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>~~Water~~ rot<br>Brownish red<br>Remarks<br>Cored with air |
| 588.89 | 13.0 | | | | | |
| | | | Gravelly clay shale; reddish brown in color, dry, very stiff, dense, weathered, and contains 20-30% fine to medium sized gravel. | | | |
| 587.89 | 14.0 | | | | | |
| 586.89 | 15.0 | | | | | 5 Oct. 1981<br>WL -<br>Run 2<br>Began 8:59<br>Rec 4.0'<br>End 9:17<br>Loss 0.45'<br>Time 18 min<br>Gain -<br>Drl time 18 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>~~Water~~ rot<br>Dark grey<br>Remarks - |
| | | | Run 1 | 100% | - | |
| | | | Fractured black shale | | | |
| 585.89 | 16.0 | | Fine-grained shaley sandstone from 16.0 to 16.5 ft | | | |
| | | | Shale: brown to orange brown, weathered, soft, dry, and contains interbedded limonite lenses. | | | |
| 584.89 | 17.0 | | | | | |
| 583.89 | 18.0 | | Shale: dark grey and soft | | | |
| | | | Limonite; orange brown, earthly texture, and crumbles easily. | | | WL -<br>Run 3<br>Began 10:03<br>Rec 0.35'<br>End 10:08<br>Loss -<br>Time 5 min<br>Gain -<br>Drl time 5 min<br>Hyd press 100psi<br>Water press -<br>RPM 50+<br>Drl Action Smooth<br>~~Water~~ rot<br>Dark grey<br>Remarks<br>Blocked off |
| 582.89 | 19.0 | | Shale: dark grey and soft<br>Shaley sandstone: dark grey and fine-grained | | | |
| | | | Fractured black, soft shale. | | | |
| 581.89 | 20.0 | | Run 2 | 89.8% | - | |
| | | | Run 3 Black shale | 100% | - | |
| 580.89 | 21.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-7-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 580.89 | 21.0 | | | | | |
| 579.89 | 22.0 | | Shale (50%) and sandstone (50%): light grey to dark grey in color, very soft to soft, and very irregular bedding. Sandstone and shale in irregular seams and lenses which are random in orientation and attitude. | | | WL - Run 4<br>Began 10:37 Rec 4.65'<br>End 10:59 Loss -<br>Time 22 min Gain -<br>Drl time 22 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>~~Water~~ ret -<br><br>Remarks<br>Encountered water at 25 ft-lost cuttings. |
| 578.89 | 23.0 | | | | | |
| 577.89 | 24.0 | | | | | |
| 576.89 | 25.0 | | Run 4 | 100% | - | |
| 575.89 | 26.0 | | Sandstone (80%) and shale (20%): light grey to dark grey, fine-grained sandstone, moderately hard, traces of organic matter, and thickness of black shale is between 1/16-1/4 in. | | | WL - Run 5<br>Began 11:30 Rec 3.45'<br>End 11:56 Loss -<br>Time 26 min Gain -<br>Drl time 26 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>~~Water~~ ret -<br><br>Remarks - |
| 574.89 | 27.0 | | | | | |
| 573.89 | 28.0 | | Run 5 | 100% | - | |
| 572.89 | 29.0 | | Sandstone (85-90%) and shale (10-15%): same as above, breaks in shale seams, and 1-3% black coal between 1/16-1/8-in. thickness. | | | WL - Run 6<br>Began 12:42 Rec 3.85'<br>End 12:55 Loss -<br>Time 13 min Gain -<br>Drl time 13 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>~~Water~~ ret -<br><br>Remarks - |
| 571.89 | 30.0 | | | | | |
| 570.89 | 31.0 | | closed break | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-7-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 5 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN | 16. DATE HOLE — STARTED — COMPLETED |
| 8. DEPTH DRILLED INTO ROCK | 17. ELEVATION TOP OF HOLE |
| 9. TOTAL DEPTH OF HOLE | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| | 31.0 | | closed break | | | |
| | 32.0 | | Run 6 | | | |
| | | | Sandstone (90-95%)<br>Shale (5-10%) | | | WL - Run 7<br>Began 1:15 Rec 2.7'<br>End 1:40 Loss -<br>Time 25 min Gain -<br>Drl time 25 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water ret -<br><br>Remarks - |
| | 33.0 | | 1/2 in coal lens | | | |
| | 34.0 | | 1/2 in coal lens | | | |
| | 35.0 | | Run 7 | 100% | - | |
| | | | Rinsed boring with water to remove mud and cuttings untill water cleared up. Jetted water from boring prior to installing well on 6 Oct. 81. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 6 Oct. 1981
Location Highway 58 Dump Site A Job No. 441-G150,11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 597.02 Boring No. WES-7-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.77 | 3" Shelby Tube | 0 | ST | Gravelly clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.77 | 1.97 | | 0 | Jar | very stiff, dry, and contains fine |
| | | | | 1.0 | 1.5 | | | | 0 | | to medium sandstone gravel. |
| | | | | 1.5 | 2.0 | | | | 150 | | Sample length: 1.97 ft |
| | | | | 2.0 | 2.5 | | | | 280 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | | | | 5.0 | 5.5 | 5.0 | 6.14 | 3"Fixed Piston Sampler | 20 | ST | Gravelly clay (CL): same as above. |
| 2A | 6 Oct | | | 5.5 | 6.0 | 6.14 | 6.39 | | 340 | Jar | |
| | | | | 6.0 | 6.5 | | | | 440 | | |
| | | | | 6.5 | 7.0 | | | | 480 | | Sample length: 1.39 ft |
| | | | 6.39 | 7.0 | 7.5 | | | | 750 | | |
| | | | | | | | | | | | |
| | 6 Oct | 6.39 | 40.1 | 5.0 | 40.1 | | | 5 5/8" Rock Bit | | | Water encountered between 28-30 ft. |
| | | | | | | | | | | | Material drilled was shale and |
| | | | | | | | | | | | sandstone. Lost cuttings at 30 ft. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 12 Oct. 1981
Location Highway 58 Dump Site A Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 595.80 Boring No WES-7-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 Oct | 0.0 | 1.5 | 0.0 | 0.3 | | | 3" Shelby | 500 | | Clay, coal, and fragments of bed- |
| | | | | | | | | | | | rock, material is fill. |
| | 12 Oct | 1.5 | 3.7 | 0.0 | 36.5 | | | 5 5/8" Rock | Bit | | Sandstone: brown and soft |
| | | 3.7 | 6.3 | | | | | | | | Limestone: grey, fine-grained, |
| | | | | | | | | | | | and fossiliferous. |
| | | 6.3 | 11.7 | | | | | | | | Clay shale: reddish brown and soft |
| | | 11.7 | 21.5 | | | | | | | | Clay shale: dark brownish grey |
| | | | | | | | | | | | and soft |
| | | 21.5 | 23.7 | | | | | | | | Sandstone and interbedded shale: |
| | | | | | | | | | | | grey to brown and moderately hard. |
| | | 23.7 | 25.0 | | | | | | | | Shale: grey and soft |
| | | 25.0 | 29.3 | | | | | | | | Sandstone and shale: grey and |
| | | | | | | | | | | | moderately hard. Slight moisture |
| | | | | | | | | | | | at 29 ft. |
| | | 29.3 | 30.8 | | | | | | | | Limestone: |
| | | 30.8 | 39.5 | | | | | | | | Sandstone and shale |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-7-4-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 12 Oct | | | 36.5 | 39.5 | | | 5 5/8" Rock | Bit | | Stopped st 36.5 ft and allowed |
| | | | | | | | | | | | water level to stabalize. Measured |
| | | | | | | | | | | | after 60 min and depth was 31.75 ft. |
| | | | | | | | | | | | Will drill to 39.0 ft, which should |
| | | | | | | | | | | | put boring 10 ft below where water |
| | | | | | | | | | | | starts. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 5 Nov. 1981
Location Highway 58 Dump Site A Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 593.73 Boring No. WES-7-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 0.95 | 3" Shelby Tube | 0 | ST | Clay (CL): dark brownish grey in |
| 1A | | | | 0.5 | 1.0 | 0.95 | 1.18 | | 0 | Jar | color, slightly damp, soft, and low |
| | | | | 1.0 | 1.5 | | | | 0 | | plasticity. |
| | | | | 1.5 | 2.0 | | | | 0 | | Sample length: 1.18 ft |
| | | | | 2.0 | 2.5 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7" Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 5 Nov | | | 5.0 | 5.5 | 5.0 | 7.07 | *3"Fixed Piston Sampler | 0 | ST | Clay (CL): brown in color, dry, |
| 2A | | | | 5.5 | 6.0 | 7.07 | 7.37 | | 0 | Jar | very stiff, brittle, and low |
| | | | | 6.0 | 6.5 | | | | 0 | | plasticity. |
| | | | | 6.5 | 7.0 | | | | 0 | | Sample length: 2.37 ft |
| | | | | 7.0 | 7.39 | | | | 30 | | |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | 7" Folding Auger | | | Cleanout: material is lighter in |
| | | | | | | | | | | | color from 9 ft. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED *3" Fixed Piston Sampler = 3" F.P.S. Sheet 1 of 3 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-7-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 5 Nov | | | 10.0 | 10.5 | 10.0 | 11.39 | 3" F.P.S. | 0 | ST | Clay (CL): brown in color, dry, |
| 3A | | | | 10.5 | 11.0 | 11.39 | 11.57 | | 0 | Jar | stiff, brittle, and low plasticity |
| | | | | 11.0 | 11.5 | | | | 0 | | |
| | | | | 11.5 | 12.0 | | | | 30 | | |
| | | | | 12.0 | | | | | 500 | | Sample length: 1.57 ft |
| | | | | | | | | | | | |
| | | | 13.28 | 10.0 | 15.0 | | | 7" Folding Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 4 | 5 Nov | 13.28 | | 15.0 | 15.5 | 15.0 | 16.39 | 3" F.P.S. | 0 | ST | Sandy clay (CL): brown in color, |
| 4A | | | | 15.5 | 16.0 | 16.39 | 16.59 | | 0 | Jar | slightly damp, moderately stiff, |
| | | | | 16.0 | 16.5 | | | | 0 | | low plasticity, and contains 5-10% |
| | | | | 16.5 | 17.0 | | | | 90 | | fine to medium grained sand. |
| | | | 17.0 | 17.0 | 17.38 | | | | 200 | | Sample length: 1.59 ft |
| | | | | | | | | | | | |
| | | 17.0 | 18.3 | 15.0 | 18.3 | | | 7" Folding Auger | | | Cleanout: from 17 to 18.3 ft, |
| | | | | | | | | | | | gravelly clay (CL)- brown and stiff. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-7-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 Nov | | | 18.3 | 22.0 | — | — | 5 5/8" Rock | Bit | — | Clay shale: brown and medium hard |
| | | | | 22.0 | 39.0 | | | | | | Sandstone: grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | Water at 28.7 ft- drilled to 39 ft. |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 24 Oct, 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 641.26 Boring No. WES-8-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 24Oct | 0.0 | 1.5 | 0.0 | 0.5 | 0.0 | 0.7 | 3" Shelby Tube | 50 | Jar | Sandy clay (CL): brown in color, |
| | | | | 0.5 | 1.0 | | | | 500 | | dry, and contains fine to coarse |
| | | | | 1.0 | 1.5 | | | | 700 | | grained sand. |
| | | | | | | | | | | | |
| | 24Oct | 1.5 | 18.3 | 0.0 | 35.0 | — | — | 5 5/8" Rock | Bit | — | Sandstone: horizontal cracks at |
| | | | | | | | | | | | 3.3, 7.5, and 8.3 ft. Sandstone |
| | | | | | | | | | | | is brown, soft, and weathered to |
| | | | | | | | | | | | 8.3 ft, moderately hard after 8.3 ft. |
| | | 18.3 | 19.2 | | | | | | | | Clay shale: soft and grey |
| | | 19.2 | 23.3 | | | | | | | | Limestone: very hard and light grey |
| | | 23.3 | 24.7 | | | | | | | | Shale: brown and soft |
| | | 24.7 | 31.6 | | | | | | | | Sandstone: brown to 27.3 ft and |
| | | | | | | | | | | | light grey to 31.6 ft |
| | | 31.6 | 32.0 | | | | | | | | Shale: dark grey and soft |
| | | 32.0 | 34.3 | | | | | | | | Limestone: light grey and hard |
| | | 34.3 | 35.0 | | | | | | | | Shale: brown |
| | 26Oct | 35.0 | 37.7 | 35.0 | 68.0 | — | — | 5 5/8" Rock | Bit | — | Limestone: light grey and hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 37.7 | 38.3 | | | | | | | | Shale: brown |
| | | 38.3 | 44.2 | | | | | | | | Limestone: light grey and hard |
| | | 44.2 | 45.0 | | | | | | | | Sandstone: grey, soft, and clayey |
| | | 45.0 | 54.3 | | | | | | | | Limestone: grey and hard |
| | | 54.3 | 56.3 | | | | | | | | Shale: dark grey and soft |
| | | 56.3 | 57.5 | | | | | | | | Sandstone: grey and medium hard |
| | | 57.5 | 59.3 | | | | | | | | Clay: brown, soft, and damp |
| | | 59.3 | 65.5 | | | | | | | | Shale: hard and grey |
| | | 65.5 | 67.3 | | | | | | | | Sandstone: brown |
| | | 67.3 | 71.6 | | | | | | | | Limestone |
| | 27Oct | 71.6 | 74.0 | 6.8 | 74.0 | — | — | 5 5/8" Rock | Bit | — | Shale |
| | | | | | | | | | | | Water level at 9:14 on 27 Oct, 1981 |
| | | | | | | | | | | | was at 63.95 ft. Drilled 10 ft |
| | | | | | | | | | | | below and installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 20 Oct. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 580.99 Boring No. WES-8-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 Oct | 0.0 | | 0.0 | 0.5 | | | 3" Shelby Tube | | | No sample: clay (CL), boulders, |
| | | | | 0.5 | 1.0 | | | | | | and cobbles. Hydrallic guage is |
| | | | | 1.0 | 1.5 | | | | | | broken. |
| | | | | 1.5 | 1.7 | | | | | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 3.2 | | | 7" Solid Auger | | | Clay with sandstone cobbles and |
| | | | | | | | | | | | boulders. |
| | | | | | | | | | | | |
| | 20 Oct | | | 3.2 | 4.8 | | | 5 5/8" Rock Bit | | | Made room for 4-5-1/2 in. core |
| | | | | | | | | | | | barrel. |
| | | | | | | | | | | | |
| | 20 Oct | | 4.2 | 4.8 | 9.8 | | | 4 x 5 1/2" Core Barrel | | | No sample-clay shale: yellow |
| | | 4.2 | | | | | | | | | brown in color and highly weathered. |
| | | | | | | | | | | | |
| | 20 Oct | | | 9.8 | 11.4 | | | 4 x 5 1/2" Core Barrel | | | No sample-clay shale; same-cored |
| | | | | | | | | | | | with low hyd. and low air press. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-2-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20Oct | 13.4 | 15.5 | 13.4 | 15.9 | 13.4 | 15.9 | 5" Dennison | Barrel | | Shale: highly weathered, brittle, |
| | | | | | | | | | | | soft, and light brown to brown |
| | | | | | | | | | | | in color-partial recovery |
| | | 15.5 | | | | | | | | | Shale: brittle, soft, weathered, |
| | | | | | | | | | | | and dark grey to brownish grey. |
| | | | | | | | | | | | |
| | 20Oct | | | 15.9 | 17.0 | 15.9 | 17.0 | 5" Dennison | Barrel | | Shale: dark grey and oxidized. |
| | | | | | | | | | | | Water at 16 ft. |
| | | | | | | | | | | | |
| | 21Oct | | | 17.0 | 17.5 | 17.0 | 18.7 | 3"Fixed Pis- Sampler | 240 | | Shale: dark grey, brittle, soft, |
| | | | | 17.5 | 18.0 | | | | 300 | | weathered, and oxidized. Water |
| | | | | 18.0 | 18.5 | | | | 420 | | marks visible from iron staining |
| | | | | 18.5 | 18.7 | | | | 500 | | on core. |
| | | | | | | | | | | | |
| | 21Oct | | | 18.7 | 2.12 | 18.7 | 21.2 | 5" Dennison | Barrel | | Shale: dark black and no oxidation. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 5 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-2-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 21Oct | | | 21.2 | 23.7 | 21.2 | 23.7 | Dennison Barrel | | | Shale: dark greenish grey, soft, |
| | | | | | | | | | | | uniform and brittle. |
| | | | | | | | | | | | |
| | 21Oct | | | 23.7 | 26.2 | 23.7 | 26.2 | Dennison Barrel | | | Shale: same |
| | | | | | | | | | | | oxidized from 24.2 to 24.5 ft and |
| | | | | | | | | | | | 25.0 to 25.2 ft. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Blew hole dry and installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 5 Sheets

Hole No. WES-8-2-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 4 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT – |
| 2. LOCATION (Coordinates or Station) Highway 58 Dump Site B | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-8-2-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED seven |
| 5. NAME OF DRILLER D. Taylor | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 20 Oct. 1981; COMPLETED 21 Oct. 1981 |
| 7. THICKNESS OF OVERBURDEN 0.0 | 17. ELEVATION TOP OF HOLE 58099 |
| 8. DEPTH DRILLED INTO ROCK 26.2 ft | 18. TOTAL CORE RECOVERY FOR BORING – % |
| 9. TOTAL DEPTH OF HOLE 26.2 ft | 19. SIGNATURE OF INSPECTOR [signature] |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 567.99 | 13.0 | | Partial recovery of shale; very weathered, brittle, and fractured | | | |
| 566.99 | 14.0 | | fractured<br>Shale: light brown to brown in color, highly weathered, brittle, and soft | | | Dennison Barrel |
| 565.99 | 15.0 | | Shale: dark grey to brownish grey, oxidized, brittle, and soft. | | | |
| 564.99 | 16.0 | | fractured<br>Shale: dark grey and oxidized | | | Dennison Barrel<br>Encountered water at 16 ft |
| 563.99 | 17.0 | | Shale: dark grey, brittle, soft, and oxidized. Water marks visible from iron staining on core. | | | 21 Oct. 81<br>Water overnight to 15 ft<br>Fixed Piston Sampler |
| 562.99 | 81.0 | | | | | |
| 561.99 | 18.0 | | fractured | | | Dennison Barrel |
| 560.99 | 20.0 | | Shale: dark grey to black, soft, and very brittle. | | | |
| 559.99 | 21.0 | | | | | |
| 558.99 | 22.0 | | Shale: dark greenish grey, soft, uniform, and brittle. | | | Dennison Barrel |
| 557.99 | 23.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO.

Hole No. WES-8-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 5 OF 5 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 557.99 | 23.0 | | | | | |
| 556.99 | 24.0 | | oxidized | | | Dennison Barrel |
| 555.99 | 25.0 | | oxidized | | | |
| 554.99 | 26.0 | | Shale: dark greenish grey, soft, uniform, and brittle. | | | |
| | | | Machine breaks to 23.7 ft. Natural break from 23.7 | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 22 Oct. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 578.90 Boring No. WES 8-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 22 Oct | 0.0 | | 0.0 | 2.5 | | | 3" Shelby Tube | | | No sample-push bent tube-clay (CL), |
| | | | | | | | | | | | cobbles, and boulders. |
| | | | | | | | | | | | |
| | | | 5.3 | 0.0 | 5.5 | | | 7" Solid Auger | | | Cleanout: clay, cobbles, and |
| | | | | | | | | | | | boulders. |
| | | | | | | | | | | | |
| | | 5.3 | 8.0 | 5.5 | 35.0 | | | 5 5/8" Rock Bit | | | Shale: brown, weathered, and soft |
| | | 8.0 | 14.3 | | | | | | | | Shale: dark grey and medium hard |
| | | 14.3 | 23.0 | | | | | | | | Shale: light grey and medium hard |
| | | 23.0 | 26.3 | | | | | | | | Limestone: grey and hard |
| | | 26.3 | 27.5 | | | | | | | | Shale: light grey and medium hard |
| | | 27.5 | 31.3 | | | | | | | | Shale: brown |
| | | 31.3 | 35.0 | | | | | | | | Sandstone: brown and medium hard. |
| | | | | | | | | | | | Let hole sit overnight-no water |
| | | | | | | | | | | | on 23 Oct. 1981. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 23Oct | 35.0 | 61.0 | 35.0 | 73.0 | — | — | 5 5/8" Rock | Bit | — | Sandstone: brown and medium hard. |
| | | 61.0 | 62.1 | | | | | | | | Shale: dark grey and water |
| | | 62.1 | 73.0 | | | | | | | | Limestone: grey and hard. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Blew hole and installed well. |
| | | | | | | | | | | | Water coming in very slowly. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 10 Nov. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 583.66 Boring No. WES-8-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A | 10Nov | 0.0 | | 0.0 | 2.5 | 0.0 | 0.8 | 3" Shelby Tube | | Jar | Gravelly clay (CL): brown, soft, |
| 1A | | | | | | | | | | | low plasticity, and contains 25-30% |
| | | | | | | | | | | | limestone and sandstone fragments. |
| | | | | | | | | | | | Tube damaged in push. |
| | | | | | | | | | | | |
| | | | | 0.0 | 4.0 | — | — | 7" Solid Auger | | — | Cleanout |
| | | | | | | | | | | | |
| | 10Nov | | 9.0 | 4.0 | 39.0 | — | — | 5 5/8" Rock | Bit | — | Overburden: clay, gravel, cobbles, |
| | | | | | | | | | | | and boulders. Rock portion is |
| | | | | | | | | | | | primarily limestone. |
| | | 9.0 | 11.6 | | | | | | | | Sandy clay shale: soft and red |
| | | 11.6 | 15.8 | | | | | | | | Sandy clay shale: soft and brown |
| | | 15.8 | 33.2 | | | | | | | | Shale: grey-soft and sandy between |
| | | | | | | | | | | | 29-30 ft |
| | | 33.2 | 35.5 | | | | | | | | Limestone: grey and hard |
| | 11Nov | | | 39.0 | 70.0 | — | — | 5 5/8" Rock | Bit | — | No water in hole overnight. |
| | | 35.5 | 45.2 | | | | | | | | Sandstone: brown and hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 45.2 | 48.1 | | | | | | | | Shale: grey |
| | | 48.1 | 50.0 | | | | | | | | Sandstone: hard and brown |
| | | 50.0 | 52.3 | | | | | | | | Shale: grey and hard |
| | | 52.3 | 71.6 | | | | | | | | Sandstone: brown and hard |
| | | | | 70.0 | 80.0 | | | 5 5/8" Rock | Bit | | Water at 70 ft, waited 60 min and |
| | | | | | | | | | | | water rose 1.5 ft |
| | | 71.6 | 73.8 | | | | | | | | Shale: grey and hard |
| | | 73.8 | 80.0 | | | | | | | | Limestone: grey and hard |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 11 Nov. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 583.84 Boring No. WES-8-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11Nov | 0.0 | | 0.0 | 2.5 | 0.0 | 0.94 | 3" Shelby Tube | | ST | Clay (CH): brown to dark brown in |
| 1A | | | | | | 0.94 | 1.29 | | | Jar | color, soft, and high plasticity. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Sample length: 1.29 ft-Tube bent |
| | | | | | | | | | | | in push |
| | | | | | | | | | | | |
| | | | | 0.0 | 3.3 | — | — | 7" Solid Auger | | — | Cleanout: clay, cobbles, and boulders |
| | | | | | | | | | | | |
| | 11Nov | | 5.1 | 3.3 | 26.0 | — | — | 6 3/4" Rock Bit | | — | Clay, cobbles, and boulders |
| | | 5.1 | 10.5 | | | | | | | | Shale: brown and soft |
| | | 10.5 | 11.3 | | | | | | | | Shale: grey and soft |
| | | 11.3 | 12.3 | | | | | | | | Limestone: grey and hard |
| | | 12.3 | 15.8 | | | | | | | | Shale: grey and medium |
| | | 15.8 | 17.0 | | | | | | | | Sandstone: brown and soft |
| | | 17.0 | 30.1 | | | | | | | | Shale: dark grey and soft |
| | 12Nov | | | 26.0 | 28.2 | — | — | Dennison Barrel | | | For core log see page 3. |
| | | | | 28.2 | 30.4 | — | — | Dennison Barrel | | | Core information above 26 ft is |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 30.4 | 35.2 | | | 4 x 5 1/2" Core Barrel | | | found on boring WES-8-2-81. |
| | | | | 35.2 | 36.0 | | | Dennison Barrel | | | |
| | | | | 36.0 | 37.8 | | | 4 x 5 1/2" Core Barrel | | | |
| | | | | 37.8 | 38.3 | | | Dennison Barrel | | | |
| | | | | 38.3 | 43.1 | | | 4 x 5 1/2" Core Barrel | | | |
| | | | | 43.1 | 47.8 | | | 4 x 5 1/2" Core Barrel | | | |
| | 13Nov | | | 47.8 | 52.5 | | | 4 x 5 1/2" Core Barrel | | | |
| | | | | 52.5 | 57.2 | | | 4 x 5 1/2" Core Barrel | | | |
| | | | | 57.2 | 61.9 | | | 4 x 5 1/2" Core Barrel | | | |
| | | | | 61.9 | 65.75 | | | 4 x 5 1/2" Core Barrel | | | |
| | | | | 65.75 | 70.75 | | | 4 x 5 1/2" Core Barrel | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-8-5-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 3 OF 7 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5-1/2 in Diamond |
| 2. LOCATION (Coordinates or Station) Highway 58 Dump Site B | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-8-5-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED one |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| 7. THICKNESS OF OVERBURDEN 5.1 ft | 16. DATE HOLE: STARTED 11 Nov. 1981; COMPLETED 13 Nov. 1981 |
| 8. DEPTH DRILLED INTO ROCK 65.65 ft | 17. ELEVATION TOP OF HOLE 583.84 |
| 9. TOTAL DEPTH OF HOLE 70.75 ft | 18. TOTAL CORE RECOVERY FOR BORING % |
| | 19. SIGNATURE OF INSPECTOR Joseph B. Drake |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 558.84 | 25.0 | | | | | |
| 557.84 | 26.0 | | | | | |
| | | | Shale; dark greenish grey, soft, brittle, and uniform | | | |
| 556.84 | 27.0 | | fractured | | | |
| | | | Breaks occured when drilling and pushing sample | | | |
| 555.84 | 28.0 | | Run 1 | 100% | - | Dennison Barrel |
| 554.84 | 29.0 | | | | | |
| | | | Shale; same | | | |
| | | | Breaks ocurred when drilling and pushing sample. | | | |
| 553.84 | 30.0 | | Run 2 | 100% | - | Dennison Barrel |
| | | | fractured | | | |
| 552.84 | 31.0 | | | | | |
| | | | Shale (60-70%) and sandstone lenses (30-40%): highly weathered, orange brown in color, brittle, and very soft. | | | AL - Run 3<br>Began - Rec 4.6'<br>End - Loss 0.2'<br>Time - Gain -<br>Drl time -<br>Hyd press 100psi<br>Water press -<br>RPM 50-75<br>Drl Action Smooth<br>Water rot<br>Brown<br>Remarks<br>Partial recovery |
| 551.84 | 32.0 | | | | | |
| 550.84 | 33.0 | | | | | |
| 549.84 | 34.0 | | | | | |
| | | | | 80% | - | |
| 548.84 | 35.0 | | Recovered to about 35 ft | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-8-5-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 7 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 2. LOCATION (Coordinates or Station) | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 3. DRILLING AGENCY | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 4. HOLE NO. (As shown on drawing title and file number) | 14. TOTAL NUMBER CORE BOXES |
| 5. NAME OF DRILLER | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 548.84 | 35.0 | | Run 3 | | | |
| | | | Sandstone: brown, fine-grained, and friable-recovered several fragments. | | | AL - Run 5<br>Begun - Rec 0.0<br>End - Loss 1.8<br>Time - Gain - |
| 547.84 | 36.0 | | Run 4 | | | |
| | | | Sandstone: no recovery | 0% | - | Drl time -<br>Hyd press 100psi<br>Water press<br>RPM 50-75<br>Drl Action Smooth<br>Water-ret<br>Brown<br>Remarks<br>Used Dennsion Barrel |
| 546.84 | 37.0 | | | | | |
| | | | Run 5 Dennison Barrel | | | |
| 545.84 | 38.0 | | Sandstone | | | |
| | | | Run 6 Dennison Barrel | | | |
| 544.84 | 39.0 | | | | | AL - Run 7<br>Begun - Rec 4.9<br>End - Loss -<br>Time - Gain -<br>Drl time -<br>Hyd press 50-100psi<br>Water press<br>RPM 100<br>Drl Action Smooth<br>Water ret<br>Brown<br>Remarks - |
| 543.84 | 40.0 | | | | | |
| | | | Sandstone: brown in color, fine-grained quartz sand, friable to moderately hard, very uniform in composition, and massive to thinly bedded. | | | |
| 542.84 | 41.0 | | | | | |
| 541.84 | 42.0 | | | | | AL - Run 8<br>Begun - Rec 4.7<br>End - Loss -<br>Time - Gain -<br>Drl time -<br>Hyd press 100-240<br>Water press -<br>RPM 100<br>Drl Action Smooth<br>Water ret<br>Brown<br>Remarks<br>Slight moisture at 43 ft, but no water. |
| 540.84 | 43.0 | | Run 7 | 100% | - | |
| 539.84 | 44.0 | | Sandstone: same | 100% | - | |
| 538.84 | 45.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-8-5-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 5 OF 7 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 538.84 | 45.0 | | | | | |
| 537.84 | 46.0 | | | | | |
| 536.84 | 47.0 | | Sandstone | 100% | - | WL - Run 9<br>Began - Rec 4.7<br>End - Loss -<br>Time - Gain -<br>Drl time -<br>Hyd press 100-200<br>Water press -<br>RPM 100<br>Drl Action Smooth<br>Water ret<br>Brown<br>Sample -<br>Sligth moisture causing barrel to block |
| 535.84 | 48.0 | | machine fracture | | | |
| 534.84 | 49.0 | | | | | |
| 533.84 | 50.0 | | Sandstone | 100% | - | WL - Run 10<br>Began - Rec 4.7<br>End - Loss -<br>Time - Gain -<br>Drl time -<br>Hyd press 100-200psi<br>Water press -<br>RPM 70<br>Drl Action Smooth<br>Water ret<br>Brown<br>Sample - |
| 532.84 | 51.0 | | oxidized and friable | | | |
| 531.84 | 52.0 | | Run 9 | | | |
| 530.84 | 53.0 | | Sandstone: orange brown to brown, fine-grained quartz sand, hard, and very uniform. | | | |
| 529.84 | 54.0 | | | | | |
| 528.84 | 55.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-8-5-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 6 OF 7 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| | 17. ELEVATION TOP OF HOLE |
| 7. THICKNESS OF OVERBURDEN | 18. TOTAL CORE RECOVERY FOR BORING % |
| 8. DEPTH DRILLED INTO ROCK | 19. SIGNATURE OF INSPECTOR |
| 9. TOTAL DEPTH OF HOLE | |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 528.84 | 55.0 | | | | | |
| 527.84 | 56.0 | | Sandstone: same | 100% | - | |
| 526.84 | 57.0 | | Run 10 | | | |
| | | | | | | WL - Run 11<br>Began - Rec 4.7<br>End - Loss -<br>Time - Gain -<br>Drl time -<br>Hyd press 100-200psi<br>Water press -<br>RPM 70-100psi<br>Drl Action Smooth<br>~~Water~~ rot<br>Slight-brown<br>Remarks |
| 525.84 | 58.0 | | | | | |
| 524.84 | 59.0 | | | | | |
| 523.84 | 60.0 | | Sandstone: same<br>black discoloration | | | More difficult to drill, slight moisture water at 59 ft. |
| 522.84 | 61.0 | | | 100% | - | WL - Run 12<br>Began - Rec 3.85<br>End - Loss -<br>Time - Gain -<br>Drl time -<br>Hyd press 100-200psi<br>Water press -<br>RPM 50-100<br>Drl Action Smooth<br>Water rot<br>Slight-brown<br>Remarks - |
| 521.84 | 62.0 | | Run 11 | | | |
| 520.84 | 63.0 | | Sandstone: brown, uniform, very fine-grained, hard and slight reaction with HCL. | 100% | - | |
| 519.84 | 64.0 | | | | | |
| 518.84 | 65.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-B-5-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 7 OF 7 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 2. LOCATION (Coordinates or Station) | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 3. DRILLING AGENCY | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: ; UNDISTURBED: |
| 4. HOLE NO. (As shown on drawing title and file number) | 14. TOTAL NUMBER CORE BOXES |
| 5. NAME OF DRILLER | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED: ; COMPLETED: |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 518.84 | 65.0 | | Sandstone | | | |
| | | | Run 12 | | | |
| 517.84 | 66.0 | | | | | |
| 516.84 | 67.0 | | black discoloration | | | dL - Run 13<br>Began - Rec 5.0<br>End - Loss -<br>Time - Gain -<br>Drl time -<br>Hyd press 100-200psi<br>Water press -<br>RPM 700-100<br>Drl Action Smooth<br>Water Jet - |
| 515.84 | 68.0 | | Limestone: light grey to pinkish grey in color, fine-grained, moderately hard, and massive to thinly bedded. | 100% | | |
| 514.84 | 69.0 | | | | | |
| 513.84 | 70.0 | | | | | |
| | | | Run 13 | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 19 Nov. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 582.70 Boring No. WES-8-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 17 Nov | 0.0 | 6.0 | 0.0 | 30.0 | — | — | 5 5/8" Rock | Bit | — | Clay, gravel, cobbles, and boulders |
| | | 6.0 | 11.0 | | | | | | | | Clay shale: reddish brown and soft |
| | | 11.0 | 14.0 | | | | | | | | Clay shale: same, moisture-water |
| | | 14.0 | 30.0 | | | | | | | | Clay shale: soft to 22 ft and |
| | | | | | | | | | | | medium hard to 30 ft |
| | | | | | | | | | | | |
| | | | | | | | | | | | Hole to remain open for several |
| | | | | | | | | | | | days to monitor water-moisture. |
| | | | | | | | | | | | Water level steady around 18 ft. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Blew hole and installed well on |
| | | | | | | | | | | | 26 Nov. 1981. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 20 Nov. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 640.75 Boring No. WES-8.7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20Nov | 0.0 | 4.7 | 0.0 | 52.2 | — | — | 5 5/8" Rock | Bit | — | Sandstone: brown, hard, and fine- |
| | | | | | | | | | | | grained |
| | | 4.7 | 5 8 | | | | | | | | Shale: grey and medium |
| | | 5.8 | 17.6 | | | | | | | | Sandstone: brown and medium |
| | | 17.6 | 18.4 | | | | | | | | Clay shale: red |
| | | 18.4 | 23.1 | | | | | | | | Limestone: light grey and hard |
| | | 23.1 | 33.2 | | | | | | | | Sandstone: hard and brown |
| | | 33.2 | 37.4 | | | | | | | | Limestone: light grey and hard |
| | | 37.4 | 40.6 | | | | | | | | Sandstone: hard |
| | | 40.6 | 52.2 | | | | | | | | Limestone: light grey and medium |
| | | | | | | | | | | | hard |
| | 21Nov | 52.2 | 54.3 | 52.2 | 120.0 | | | | | | Sandstone: hard |
| | | 54.3 | 55.6 | | | | | | | | Shale: grey and medium hard |
| | | 55.6 | 57.4 | | | | | | | | Limestone: very hard and light grey |
| | | 57.4 | 66.3 | | | | | | | | Shale and sandstone |
| | | 66.3 | 70.2 | | | Water | between | 66.3 and | 70.2 | | Limestone: grey and hard |
| | | 70.2 | 90.0 | | | | | | | | Shale: grey and medium hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 90.0 | 91.7 | | | | | | | | Limestone, light grey and hard |
| | | 91.7 | 92.3 | | | | | | | | Shale: grey |
| | | 92.3 | 93.2 | | | | | | | | Limestone: light grey and hard |
| | | 93.2 | 94.2 | | | | | | | | Shale: grey |
| | | 94.2 | 96.3 | | | | | | | | Sandstone: brown, hard and fine- |
| | | | | | | | | | | | grained |
| | | 96.3 | 125.7 | | | | | | | | Sandstone: brown, soft and fine- |
| | | | | | | | | | | | grained |
| | | 125.7 | 131.2 | | | | | | | | Limestone: hard and light grey |
| | | | | | | | | | | | Water sticking rock bit- grouted |
| | | | | | | | | | | | hole to 70.0 ft |
| | | | | | | | | | | | |
| | 22Nov | | | 0.0 | 45.0 | — | — | 8 3/4" Rock | Bit | — | Cleanout for 6" casing to seal off |
| | | | | | | | | | | | water from 66.3-70.2 ft. |
| | | | | | | | | | | | |
| | 23Nov | | | 45.0 | 78.0 | — | — | 8 3/4" Rock | Bit | — | Cleanout: continued |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 24Nov | | | | | | | | | | Grouted 6" casing into hole. |
| | | | | | | | | | | | Bottom at 78 ft with 2 ft stickup. |
| | | | | | | | | | | | |
| | 25Nov | | | 62.0 | 131.2 | | | 5 5/8" Rock | Bit | | Drilled grout from 62 to 120 ft. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 3 of 3 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 26 Nov. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 586.31 Boring No. WES-8-8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26Nov | 0.0 | 1.25 | 0.0 | 1.05 | 0.0 | 9.0 | 3" Shelby Tube | — | ST | Sandy clay (CL): brown in color, |
| 1A | | | | | | 9.0 | 1.05 | | | Jar | soft, slightly moist, and low |
| | | | | | | | | | | | plasticity. |
| | | | | | | | | | | | |
| | 26Nov | 1.25 | 14.0 | 0.0 | 14.0 | — | — | 5 5/8" Rock | Bit | — | Clay, gravel, cobbles, and boulders |
| | 27Nov | | | 14.0 | 69.87 | — | — | 5 5/8" Rock | Bit | — | Limestone to 9 ft, sandstone to 14 ft |
| | | 14.0 | 27.0 | | | | | | | | Clay shale: grey, soft, and slightly |
| | | | | | | | | | | | damp |
| | | 27.0 | 36.0 | | | | | | | | Shale: grey and soft |
| | | 36.0 | 37.5 | | | | | | | | Sandstone: brown and fine-grained |
| | | 37.5 | 41.0 | | | | | | | | Sandstone and shale |
| | | 41.0 | 44.5 | | | | | | | | Sandstone: brown and hard |
| | | 44.5 | 53.5 | | | | | | | | Sandstone: brown and soft |
| | | 53.5 | 58.0 | | | | | | | | Sandstone: brown and very soft |
| | | 58.0 | 66.8 | | | | | | | | Sandstone: brown, very soft, and |
| | | | | | | | | | | | damp |
| | | 66.8 | 69.87 | | | | | | | | Sandstone: brown, hard, and dry. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No WES-8-8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 26 Nov. 1981
Location Highway 58 Dump Site B Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 586.33 Boring No. WES-8-9-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26Nov | 0.0 | | 0.0 | 0.8 | 0.0 | 0.65 | 3" Shelby Tube | | ST | Gravelly clay (CL): brown in color, |
| 1A | | | | | | 0.65 | 0.80 | | | Jar | soft, slightly moist, and contains |
| | | | | | | | | | | | 5% fine to medium gravel, |
| | | | | | | | | | | | |
| | | | | | | | | | | | Sample length: 0.80 ft |
| | | | | | | | | | | | |
| | 27Nov | | 4.8 | 0.0 | 80.0 | | | 5 5/8" Rock | Bit | | Clay (CL), gravel, cobbles, and boulders |
| | | 4.8 | 9.6 | | | | | | | | Shale, grey with cobbles and boulders |
| | | 9.6 | 11.3 | | | | | | | | Limestone: grey and hard. |
| | | 11.3 | 12.1 | | | | | | | | Shale: grey |
| | | 12.1 | 13.5 | | | | | | | | Limestone: light grey and hard. |
| | | 13.5 | 15.0 | | | | | | | | Shale: brown |
| | | 15.0 | 32.0 | | | | | | | | Shale: grey and medium hard. |
| | | 32.0 | 34.5 | | | | | | | | Sandstone: brown and fine-grained |
| | | 34.5 | 35.3 | | | | | | | | Limestone: light grey and hard. |
| | | 35.3 | 53.6 | | | | | | | | Sandstone: brown, hard and fine-grained. |
| | | 53.6 | 69.3 | | | | | | | | Sandstone: brown, medium and fine-grained. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____

Location _____ Job No. _____

Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-8-9-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 69.3 | 72.7 | | | | | | | | Sandstone: brownish grey, hard, |
| | | | | | | | | | | | and fine-grained. |
| | | 72.7 | 80.0 | | | | | | | | Limestone: light grey and hard |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 22 Oct. 1981
Location Pest Control Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 734.32 Boring No. WES-9-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 1.75 | 3" Shelby Tube | 0 | ST | Clay (CL): brown, soft, dry, and |
| 1A | | | | 0.5 | 1.0 | 1.75 | 1.90 | | 0 | Jar | contains organic matter. |
| | | | | 1.0 | 1.5 | | | | 5 | | |
| | | | | 1.5 | 2.0 | | | | 150 | | Sample length: 1.90 ft |
| | | | 4.5 | 2.0 | 2.5 | | | | 480 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7"Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| 2 | 22Oct | 4.5 | | 5.0 | 5.5 | 5.0 | 7.09 | *3"Fixed Piston Sampler | 0 | ST | Silty sand (SM): brown in color, |
| 2A | | | | 5.5 | 6.0 | 7.09 | 7.26 | | 30 | Jar | fine-grained sand, dry, and slight |
| | | | | 6.0 | 6.5 | | | | 210 | | cohesion. |
| | | | | 6.5 | 7.0 | | | | 320 | | Sample length: 2.26 ft |
| | | | | 7.0 | 7.38 | | | | 410 | | |
| | | | | | | | | | | | |
| | | | 8.63 | 5.0 | 10.0 | — | — | 7"Folding Auger | — | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED 3" Fixed Piston Sampler = 3" F.P.S. Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-9-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 22Oct | 8.63 | | 10.0 | 10.5 | 10.0 | 11.33 | 3"F.P.S. | 0 | | Sand (SM) and sandstone fragments: |
| 3A | | | | 10.5 | 11.0 | 11.33 | 11.51 | | 10 | | brown to reddish brown, fine grained, |
| | | | | 11.0 | 11.55 | | | | 340 | | friable, and weathered. |
| | | | 11.0 | 11.55 | 12.0 | | | | 700 | | |
| | | | | | | | | | | | Sample length: 1.51 ft |
| | | | | | | | | | | | |
| | | 11.0 | 23.6 | 0.0 | 11.49 | — | — | 5 5/8" Rock | Bit | — | Sandstone with interbedded shale |
| | 23Oct | 23.6 | 24.6 | 11.49 | 33.8 | — | — | 5 5/8" Rock | Bit | — | Coal: black, soft, and water |
| | | 24.6 | 29.5 | | | | | | | | Shale: grey and medium hard |
| | | 29.5 | 33.8 | | | | | | | | Limestone: hard and grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well 24 Oct. 1981. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 23 Oct. 1981
Location Pest Control Area Job No 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 723.80 Boring No. WES-9-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.28 | 3" Shelby Tube | 0 | ST | Sand (SW), brown in color, dry, |
| 1A | | | | 0.5 | 1.0 | 2.28 | 2.45 | | 0 | Jar | and fine to coarse grained. |
| | | | | 1.0 | 1.5 | | | | 0 | | |
| | | | | 1.5 | 2.0 | | | | 70 | | |
| | | | 4.5 | 2.0 | 2.5 | | | | 180 | | Sample length: 2.45 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout: |
| | | | | | | | | | | | |
| 2 | 23Oct | 4.5 | | 5.0 | 5.5 | 5.0 | 6.16 | *3"Fixed Piston Sampler | 0 | ST | Sandy clay (CL): brown in color, |
| 2A | | | | 5.5 | 6.0 | 6.16 | 6.36 | | 0 | Jar | slight cohesion, and contains 20% |
| | | | | 6.0 | 6.5 | | | | 0 | | fine to medium-grained sand. |
| | | | | 6.5 | 7.0 | | | | 0 | | |
| | | | | 7.0 | 7.38 | | | | 10 | | Sample length: 1.36 ft |
| | | | | | | | | | | | |
| | | | 8.0 | 5.0 | 10.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

*3" Fixed Piston Sampler = 3" F.P.S.

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 2 Sheets

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-9-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 23Oct | | | 10.0 | 11.5 | 10.0 | 12.08 | 3" F.P.S. | 0 | ST | Sandy clay (CL): grey to dark grey |
| 3A | | | | 11.5 | 11.0 | 12.08 | 12.33 | | 0 | Jar | in color, and wet-water in hole |
| | | | | 11.0 | 11.5 | | | | 0 | | at 10 ft. |
| | | | | 11.5 | 12.0 | | | | 0 | | |
| | | | | 12.0 | 12.4 | | | | 0 | | Sample length: 2.33 ft |
| | | | | | | | | | | | |
| | | | 14.0 | 10.0 | 14.0 | — | — | 7"Folding Auger | — | | Bedrock starts at 14 ft-sandstone. |
| | | | | | | | | | | | |
| | | 14.0 | 19.0 | 14.0 | 19.0 | — | — | 5 5/8" Rock Bit | — | | Drilled 5 ft into bedrock to make |
| | | | | | | | | | | | room for silt trap. |
| | | | | | | | | | | | Installed well screen and filled |
| | | | | | | | | | | | hole with bentonite to depth of |
| | | | | | | | | | | | 14 ft (around silt trap). |
| | | | | | | | | | | | |
| | | | | | | | | | | | Strong odor was noticed with water |
| | | | | | | | | | | | when drilling. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 24 Oct. 1981
Location Pest Control Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 706.78 Boring No. WES-9-3-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 24Oct | 0.0 | | 0.0 | 0.5 | 0.0 | 2.29 | 3" Shelby Tube | 0 | ST | Sandy clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 2.29 | 2.44 | | 0 | Jar | dry, low plasticity, and contains |
| | | | | 1.0 | 1.5 | | | | 20 | | fine to coarse-grained sand. |
| | | | | 1.5 | 2.0 | | | | 180 | | |
| | | | | 2.0 | 2.5 | | | | 400 | | Sample length: 2.44 ft |
| | | | | | | | | | | | |
| | | | 3.72 | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout: assumed stratum change |
| | | | | | | | | | | | |
| 2 | 24Oct | 3 72 | | 5.0 | 5.5 | 6.0 | 6.40 | 3"Fixed Piston Sampler | 0 | ST | Sand (SP) and sandstone: brown to |
| 2A | | | | 5.5 | 6.0 | 6.40 | 6.62 | | 0 | Jar | white in color, fine-grained, and |
| | | | | 6.0 | 6.5 | | | | 30 | | weathered. |
| | | | | 6.5 | 7.0 | | | | 500 | | |
| | | | 7.19 | 7.0 | 7.19 | | | | 700 | | Sample length: 1.62 ft |
| | | | | | | | | | | | |
| | 25Oct | | | 7.19 | 12.1 | | | 4 x 5 1/2"Core Barrel | | | See ENGR FORM 1836 (page 2) |
| | | | | | | | | | | | for log of core. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-9-3-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 2 OF 2 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5 1/2" in Diamonel |
| 2. LOCATION (Coordinates or Station) Pest Control Area | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-9-3-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED two |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 24 Oct. 1981; COMPLETED 25 Oct. 1981 |
| 7. THICKNESS OF OVERBURDEN 7.19 ft | 17. ELEVATION TOP OF HOLE 706.78 |
| 8. DEPTH DRILLED INTO ROCK 4.91 ft | 18. TOTAL CORE RECOVERY FOR BORING 100% % |
| 9. TOTAL DEPTH OF HOLE 12.1 ft | 19. SIGNATURE OF INSPECTOR Joseph B. Dunham |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 699.78 | 7.0 | | | | | |
| 698.78 | 8.0 | | fractured and black discoloration | | | |
| 697.78 | 9.0 | | Sandstone: white to orange brown in color, very fine-grained, thinly bedded, and contains clay lenses. | | | WL - Run 1<br>Began 10.11 Rec 4.91'<br>End 10.41 Loss -<br>Time 30 min Gain -<br>Drl time 30 min<br>Hyd press loopsi<br>Water press -<br>RPM 50<br>Drl Action Smooth<br>~~Water~~ ret Brown to black<br>Cored with air-air bubbled up 25 ft around rig in all directions. |
| 696.78 | 10.0 | | fractured<br>closed break<br>Sandstone (70%) and interbedded Shale (30%): orange brown, light grey, and dark grey | 100% | - | |
| 695.78 | 11.0 | | Sandstone (50%) and shale (50%) thickness ranges from 1/64-1/4 in, light grey to dark grey, and fine-grained sandstone | | | |
| 694.78 | 12.0 | | Run 1<br>Installed well screen on 25 Oct. 1981. Did not go deeper because of the possibility of encountering deeper zone of water. | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 6 Nov. 1981
Location Pest Control Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 721.93 Boring No. WES-9-4-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 2.15 | 3"Shelby | 20 | ST | Sandy clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 2 15 | 2.30 | | 40 | Jar | very stiff, dry, and low plasticity. |
| | | | | 1.0 | 1.5 | | | | 250 | | |
| | | | | 1.5 | 2.0 | | | | 380 | | |
| | | | 3.5 | 2.0 | 2.5 | | | | 500 | | Sample length: 2.30 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 6 Nov | 3.5 | | 5.0 | 5.5 | 5.0 | 6.43 | 3"Fixed Piston Sampler | 0 | ST | Clay shale and interbedded sandstone: |
| 2A | | | | 5.5 | 6.0 | 6.43 | 6.63 | | 20 | Jar | grey, brown, reddish brown in color, |
| | | | | 6.0 | 6.5 | | | | 490 | | very stiff, hard, and dry. |
| | | | 6.63 | 6.5 | ---- | | | | 700 | | Sample length: 1.63 ft |
| | | | | | | | | | | | |
| | 6 Nov | 6.63 | 15.5 | 5.0 | 20.15 | | | 5 5/8" Rock Bit | | | Sandstone: brown, fine-grained, weathered |
| | | 15.5 | 20.15 | | | | | | | | Sandstone: light grey, very fine- |
| | | | | | | | | | | | grained, and hard. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-9-4-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7 Nov | | | 20.15 | 30.15 | | | 5 5/8" Rock | Bit | | Water overnight at depth of 19.6 ft |
| | | 20.15 | 25.0 | | | | | | | | Shale: dark grey in color. |
| | | 25.0 | 28.0 | | | | | | | | Limestone: light grey and hard. |
| | | 28.0 | 28.7 | | | | | | | | Shale: grey |
| | | 28.7 | 30.15 | | | | | | | | Limestone: light grey |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 7 Nov. 1981
Location Pest Control Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 715.52 Boring No. WES-9-5-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.54 | 3" Shelby Tube | 0 | ST | Clayey sand (SC): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.54 | 1.69 | | 0 | Jar | dry, fine-grained, and moderate |
| | | | | 1.0 | 1.5 | | | | 40 | | cohesion. |
| | | | | 1.5 | 2.0 | | | | 480 | | |
| | | | | 2.0 | 2.5 | | | | 640 | | Sample length: 1.69 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 7 Nov | | | 5.0 | 5.5 | 5.0 | 6.17 | 3"Fixed Pis- | 0 | ST | Clayey sand (SC) and weathered sandstone: |
| 2A | | | | 5.5 | 6.0 | 6.17 | 6.32 | ton Sampler | 20 | Jar | brown, fine-grained, brittle, and |
| | | | 6.33 | 6.0 | 6.5 | | | | 730 | | friable. |
| | | | | | | | | | | | Sample length: 1.32 ft |
| | | | | | | | | | | | |
| | 7 Nov | 6.33 | 9.0 | 6.33 | 23.5 | | | 5 5/8" Rock Bit | | | Sandstone: brown, fine-grained, |
| | | | | | | | | | | | and weathered. |
| | | 9.0 | 12.0 | | | | | | | | Sandstone: light brown |
| | | 12.0 | 13.5 | | Water | in bottom of hole | | | | | Sandstone, light grey to dark brown |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No.
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-9-5-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 13.5 | 17.5 | | | | | | | | Sandstone: light brown and fine- |
| | | | | | | | | | | | grained. |
| | | 17.5 | 18.5 | | | | | | | | Sandstone: light grey |
| | | 18.5 | 23.5 | | | | | | | | Sandstone: darker in color, shale |
| | | | | | | | | | | | content increases. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 7 Nov. 1981
Location Pest Control Area Job No. 441-G150,11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 719.65 Boring No. WES-9-6-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 Nov | 0.0 | | 0.0 | 2.57 | 0.0 | 2.37 | 3" Shelby Tube | | ST | Sandy silt (ML), brown, soft, and |
| 1A | | | | | | 2.37 | 2.57 | | | Jar | little cohesion. |
| | | | | | | | | | | | Sample length: 2 57 ft |
| | | | | | | | | | | | |
| | | | 4.5 | 0.0 | 4.5 | — | — | 7" Solid Auger | — | | Cleanout |
| | | | | | | | | | | | |
| | 7 Nov | 4.5 | 14.3 | 4.5 | 11.0 | — | — | 5 5/8" Rock Bit | — | | Sandstone: brown with slight moisture |
| | | | | | | | | | | | at 10.2 ft |
| | 7 Nov | 14.3 | 15.4 | 11.0 | 21.0 | — | — | 5 5/8" Rock Bit | — | | Coal: black, soft, and wet |
| | | 15.4 | 18.1 | | | | | | | | Limestone: light grey and moderately |
| | | | | | | | | | | | hard. |
| | | 18.1 | 21.0 | | | | | | | | Sandstone: brown and medium hard |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 1 of 1 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 18 Nov. 1981
Location Pest Control Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator D. Taylor Surface El 735.32 Boring No. WES-9-7-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18Nov | 0.0 | | 0.0 | 2.5 | 0.0 | 1.58 | 3"Shelby Tube | | ST | Clay (CL): brown in color, dry, |
| 1A | | | | | | 1.58 | 1.78 | | | Jar | moderately stiff, and low plasticity. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Sample length: 1.78 ft |
| | | | | | | | | | | | |
| | | | 4.3 | 0.0 | 5.0 | | | 7" Solid Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 18Nov | 4.3 | 7.5 | 5.0 | 7.5 | 5.0 | 7.10 | 3"Fixed Piston Sampler | | ST | Silty sand (SM): brown in color, |
| 2A | | | | | | 7.10 | 7.35 | | | Jar | dry, moderate cohesion, and fine- |
| | | | | | | | | | | | grained. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Sample length: 2.35 ft |
| | | | | | | | | | | | |
| | 18Nov | 7.5 | 9.0 | 5.0 | 34.2 | | | 5 5/8" Rock Bit | | | Clay and sandstone gravel |
| | | 9.0 | 13.5 | | | | | | | | Shale: soft and brown |
| | | 13.5 | 19.9 | | | | | | | | Shale. soft and grey |
| | | 19.9 | 23.2 | | | | | | | | Sandstone: brown, fine-grained, |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-9-7-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | | | | | | | | and water beginning at 23.2 ft |
| | | 23.2 | 25.5 | | | | | | | | Sandstone: brown, fine-grained, |
| | | | | | | | | | | | and medium hard. |
| | | 25.5 | 33.2 | | | | | | | | Shale: grey and hard |
| | | 33.2 | 34.2 | | | | | | | | Coal: black and soft |
| | | | | | | | | | | | |
| | | | | | | | | | | | Blew water from hole and installed |
| | | | | | | | | | | | well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 18 Nov. 1981
Location Pest Control Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 720.19 Boring No. WES-9-8-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.39 | 3" Shelby Tube | 0 | ST | Clay (CL): brown in color, organic |
| 1A | | | | 0.5 | 1.0 | 1.39 | 1.59 | | 10 | Jar | matter, very stiff, dry, and low |
| | | | | 1.0 | 1.5 | | | | 30 | | plasticity. |
| | | | | 1.5 | 2.0 | | | | 200 | | |
| | | | | 2.0 | 2.5 | | | | 420 | | Sample length: 1.59 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7"Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| 2 | 18Nov | | 7.0 | 5.0 | 5.5 | 5.0 | 6.38 | 3"Fixed Piston Sampler | 0 | ST | Sandstone: brown to reddish brown, |
| 2A | | | | 5.5 | 6.0 | 6.38 | 6.53 | | 10 | Jar | weathered, fine-grained, slightly |
| | | | | 6.0 | 6.5 | | | | 220 | | friable, and dry. |
| | | | | 6.5 | 7.0 | | | | 640 | | |
| | | | | 7.0 | 7.5 | | | | 730 | | Sample length: 1.53 ft |
| | | | | | | | | | | | |
| | | 7.0 | 18.6 | 5.0 | 10.0 | — | — | 7"Folding Auger | — | | Sandstone: brown, fine-grained, |
| | | | | | | | | | | | weathered, and contains clay lenses. |
| | | 18.6 | 23.5 | 10.0 | 25.0 | — | — | 4 x 5-1/2"Core Barrel | | | Shale and sandstone: shale increases |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-9-8-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | 18Nov | | | 0.0 | 25.1 | — | — | 6-3/4" Rock | Bit | | with depth. |
| | | 23.5 | 25.1 | | | | | | | | Shale: black, soft, and uniform. |
| | | | | | | | | | | | |
| | | | | | | | | | | | For core log see page three. |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-9-8-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 3 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5 1/2" Diamond Bit |
| 2. LOCATION (Coordinates or Station) Pest Control Area | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-9-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED two |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 18 Nov. 1981; COMPLETED 18 Nov. 1981 |
| 7. THICKNESS OF OVERBURDEN 7.0 ft | 17. ELEVATION TOP OF HOLE 720.19 |
| 8. DEPTH DRILLED INTO ROCK 18.1 ft | 18. TOTAL CORE RECOVERY FOR BORING 100% % |
| 9. TOTAL DEPTH OF HOLE 25.1 ft | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 710.19 | 10.0 | | Sandstone: brown in color with interbedded clay lenses. | | | |
| 709.19 | 11.0 | | | | | |
| 708.19 | 12.0 | | Sandstone (70%) and clay lenses (30%): light brown to brown, fine-grained quartz sand, and very weathered. Clay is brown, soft, and in lenses which are irregular in shape. Lenses are nearly horizontal in attitude and range in shape from angular to rounded with average thickness of 1 in. | | | WL - Run 1<br>Began 10:54 Rec 5.0'<br>End 11:13 Loss -<br>Time 19 min Gain -<br>Drl time 19 min<br>Hyd press 100psi<br>Water press -<br>RPM 70-100<br>Drl Action Smooth<br>~~Water~~ Wet<br>Brown<br>Remarks<br>Reamed hole with 6-3/4 in bit. |
| 707.19 | 13.0 | | | | | |
| 706.19 | 14.0 | | | | | Water at 14.89 ft |
| | | | Sandstone: brown and clean | | | |
| 705.19 | 15.0 | | Clay shale: brown | 100% | - | |
| 704.19 | 16.0 | | Run 1<br>Fractured sandstone and clay shale lenses. | | | |
| 703.19 | 17.0 | | 80% light grey and orange brown sandstone and 20% brown clay shale lenses | | | WL - Run 2<br>Began 12:09 Rec 5.0'<br>End 12:15 Loss -<br>Time 6 min Gain -<br>Drl time 6 min<br>Hyd press 100psi<br>Water press -<br>RPM 50-100<br>Drl Action Smooth<br>~~Water~~ Wet<br>Brown-dark grey<br>Remarks<br>Reamed hole with 6-3/4 in bit. |
| | | | closed breaks | | | |
| 702.19 | 18.0 | | dark brown shale from 8.3 to 18.6 ft | | | |
| 701.19 | 19.0 | | 50% Sandstone: brown-dark grey<br>50% Shale: grey to dark grey alternating lamina and thin beds-1/16 to 1/4 in. | | | |
| 700.19 | 20.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-9-8-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 700.19 | 20.0 | | | | | |
| 699.19 | 21.0 | | fractured | | | |
| | | | 85% Dark grey shale | | | |
| 698.19 | 22.0 | | 15% Grey sandstone | | | WL - Run 3<br>Began 1:06 Run 5.1'<br>End 1:22 Loss -<br>Time 16 min Gain -<br>Drl time 16 min<br>Hyd press 100psi<br>Water press -<br>RPM 100<br>Drl Action Smooth<br>~~Water~~ rot<br>Black-dark grey<br>marks<br>Reamed hole with 6-3/4 in bit. |
| 697.19 | 23.0 | | closed | | | |
| 696.19 | 24.0 | | closed breaks | | | |
| | | | Shale; black, soft, and uniform | | | |
| 695.19 | 25.0 | | Run 3 | 100% | - | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT HOLE NO.

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 25 Nov. 1981
Location Pest Control Area Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 723.21 Boring No. WES-9-9-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 25Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.75 | 3"Shelby Tube | 0 | ST | Sandy clay (CL): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.75 | 1.90 | | 0 | Jar | soft, low plasticity, dry, and |
| | | | | 1.0 | 1.5 | | | | 0 | | contains fragments of brown sandstone. |
| | | | | 1.5 | 2.0 | | | | 0 | | |
| | | | | 2.0 | 2 5 | | | | 175 | | Sample length: 1.90 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| 2 | 25Nov | | 6.8 | 5.0 | 5.5 | 5.0 | 6.28 | 3"Fixed Piston Sampler | 0 | ST | Clay (CL): dark brown to black, |
| 2A | | 6.8 | | 5.5 | 6.0 | 6.28 | 6.48 | | 0 | Jar | moist, soft, and low plasticity. |
| | | | | 6.0 | 6.5 | | | | 0 | | |
| | | | | 6.5 | 7.0 | | | | 0 | | Sample length: 1.48 ft |
| | | | | 7.0 | 7.39 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 5.0 | 10.0 | | | 7"Folding Auger | | | Cleanout: water at 7 ft and more |
| | | | | | | | | | | | water at 9 ft. |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-9-9-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | | | 10.0 | 10.5 | 10.0 | 10.65 | 3"Fixed Piston Sampler | 10 | ST | Sandstone: brown to light grey |
| | | | 11.0 | 10.5 | 11.0 | 10.65 | 10.8 | | 700 | Jar | in color, weathered, friable, and |
| | | | | | | | | | | | very fine-grained. |
| | | | | | | | | | | | Sample length: 0.8 ft |
| | | | | | | | | | | | |
| | | | | 10.0 | 11.0 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | 11.0 | 13.5 | 11.0 | 13.5 | | | 5 5/8" Rock Bit | | | Sandstone: brown, fine-grained, |
| | | | | | | | | | | | soft, and weathered. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Sheet 2 of 2 Sheets

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 20 Nov. 1981
Location Rockeye Site Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 617.80 Boring No. WES-10-1-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont. | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.84 | 3" Shelby Tube | 0 | ST | Gravelly sand (SN): brown in color, |
| 1A | | | | 0.5 | 1.0 | 1.84 | 2.0 | | 10 | Jar | dry, fine to coarse sand, and fine |
| | | | | 1.0 | 1.5 | | | | 10 | | to coarse, angular to rounded gravel. |
| | | | | 1.5 | 2.0 | | | | 30 | | |
| | | | 4.1 | 2.0 | 2.5 | | | | 50 | | Sample length: 2.00 ft |
| | | | | | | | | | | | |
| | | | | 0.0 | 5.0 | — | — | 7"Folding Auger | — | | Cleanout |
| | | | | | | | | | | | |
| 2 | 20Nov | 4.1 | | 5.0 | 5.5 | 5.0 | 6.16 | 3"Fixed Piston Sampler | 20 | ST | Sand (SP): orange brown in color, |
| 2A | | | | 5.5 | 6.0 | 6.16 | 6.41 | | 20 | Jar | fine-grained, moderate to little |
| | | | | 6.0 | 6.5 | | | | 30 | | cohesion, and dry. |
| | | | | 6.5 | 7.0 | | | | 200 | | |
| | | | 7.19 | 7.0 | 7.19 | | | | 460 | | Sample length: 1.41 ft |
| | | | | | | | | | | | |
| | 20Nov | 7.19 | 17.3 | 5.0 | 30.5 | — | — | 5 5/8" Rock Bit | — | | Sandstone: reddish brown-brown and |
| | | | | | | | | | | | soft. |
| | | 17.3 | 19.0 | | | | | | | | Sandstone: brown and medium hard |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project _____ Site _____ Date _____
Location _____ Job No. _____
Drill Rig _____ Inspector _____ Operator _____ Surface El _____ Boring No. WES-10-1-81

| SAMPLE NUMBER | DATE TAKEN | STRATUM | | DRIVE | | SAMPLE | | TYPE OF SAMPLER | | | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FROM | TO | FROM | TO | FROM | TO | | | | |
| | | 19.0 | 20.5 | | | | | | | | Sandstone: brown and soft |
| | | 20.5 | 26.3 | | | | | | | | Sandstone: brown and soft to medium |
| | | 26.3 | 28.8 | | | | | | | | Sandstone: brown and hard |
| | | 28.8 | 29.5 | | | | | | | | Sandstone: red colored water. |
| | | 29.5 | 30.5 | | | | | | | | Limestone: grey colored water and |
| | | | | | | | | | | | hard drilling. |
| | | | | | | | | | | | |
| | | | | | | | | | | | Bailed and washed hole to remove |
| | | | | | | | | | | | mud and cuttings. Water began at |
| | | | | | | | | | | | 20.5 ft and was red in color to |
| | | | | | | | | | | | indicated depth. Lost cuttings |
| | | | | | | | | | | | at 28.8 ft with slight water return. |
| | | | | | | | | | | | Installed well. |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

# BORING LOG
## FIELD DATA

Project NWSC Groundwater Study Site Crane, IN Date 22 Nov. 1981
Location Rockeye Site Job No. 441-G150.11GR21/22
Drill Rig Failing Inspector J. Dunbar Operator C. Drake Surface El 618.51 Boring No. WES-10-2-81

| SAMPLE NUMBER | DATE TAKEN 1981 | STRATUM FROM | STRATUM TO | DRIVE FROM | DRIVE TO | SAMPLE FROM | SAMPLE TO | TYPE OF SAMPLER | Hyd. Press | Cont | CLASSIFICATION AND REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22Nov | 0.0 | | 0.0 | 0.5 | 0.0 | 1.29 | 3" Shelby Tube | 0 | ST | Silty sand (SM), dark brown in |
| 1A | | | | 0.5 | 1.0 | 1.29 | 1.46 | | 0 | Jar | color, dry, soft, very fine-grained, |
| | | | | 1.0 | 1.5 | | | | 0 | | and slight cohesion. |
| | | | | 1.5 | 2.0 | | | | 0 | | Sample length: 1.46 ft |
| | | | 4.4 | 2.0 | 2.5 | | | | 0 | | |
| | | | | | | | | | | | |
| | | | | 0.0 | 4.4 | | | 7"Folding Auger | | | Cleanout |
| | | | | | | | | | | | |
| | | 4.4 | 7.1 | 4.4 | 9.6 | | | 4 x 5 1/2"Core Barrel | | | For core log see page 2. |
| | | 7.1 | 25.0 | 4.4 | 9.6 | | | 6 3/4" Rock Bit | | | |
| | | 25.0 | 25.8 | 9.6 | 15.8 | | | 4 x 5 1/2"Core Barrel | | | |
| | | | | 9.6 | 15.8 | | | 6 3/4" Rock Bit | | | |
| | | | | 15.8 | 20.8 | | | 4 x 5 1/2"Core Barrel | | | |
| | | | | 15.8 | 20.8 | | | 6 3/4" Rock Bit | | | |
| | | | | 20.8 | 25.8 | | | 4 x 5 1/2"Core Barrel | | | |
| | | | | 20.8 | 25.8 | | | 6 3/4" Rock Bit | | | |
| | | | | | | | | | | | |

WES FORM JAN 74 819 EDITION OF NOV 1971 MAY BE USED

Hole No. WES-10-2-81

| DRILLING LOG | DIVISION U.S. Navy | INSTALLATION Crane, IN | SHEET 2 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT NWSC Groundwater Study | 10. SIZE AND TYPE OF BIT 4 x 5-1/2 in. Diamond Bit |
| 2. LOCATION (Coordinates or Station) Rockeye Site | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL |
| 3. DRILLING AGENCY CEWES | 12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500 |
| 4. HOLE NO. (As shown on drawing title and file number) WES-10-2-81 | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED zero; UNDISTURBED one |
| 5. NAME OF DRILLER C. Drake | 14. TOTAL NUMBER CORE BOXES zero |
| 6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT. | 15. ELEVATION GROUND WATER |
| | 16. DATE HOLE: STARTED 22 Nov. 1981; COMPLETED 22 Nov. 1981 |
| 7. THICKNESS OF OVERBURDEN 4.4 ft | 17. ELEVATION TOP OF HOLE 618.51 |
| 8. DEPTH DRILLED INTO ROCK 21.4 ft | 18. TOTAL CORE RECOVERY FOR BORING 47.7 % |
| 9. TOTAL DEPTH OF HOLE 25.8 ft | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 614.51 | 4.0 | | | | | |
| 613.51 | 5.0 | | Loose sandstone gravel: fine to coarse fragments, brown, and fine-grained. | | | WL - Run 1 Began 9:40 Rec 5.2' End 9:53 Loss - Time 13 min Gain - Drl time 13 min Hyd press 100psi Water press - RPM 70 ± Drl Action Smooth Water ret Brown Remarks Cored with air |
| 612.51 | 6.0 | | Gravelly clay: 60% brown, stiff clay and 40% fine to coarse, rounded gravel<br>Loose sandstone gravel. | | | |
| 611.51 | 7.0 | | Sandstone: brown, very weathered, fine-grained, and friable. | | | |
| | | | Limestone: grey with clay seam | | | |
| 610.51 | 8.0 | | | | | |
| 609.51 | 9.0 | | Sandstone: brown, very weathered, uniform, fine-grained quartz sand, and friable. | | | |
| | | | fractured | 100% | - | |
| 608.51 | 10.0 | | Run 1 | | | |
| 607.51 | 11.0 | | closed break | | | Run 2 Rec 3.4' Loss 2.8' Gain - Time 13 min 100psi 50-100 Water ret Brown |
| 606.51 | 12.0 | | fractured | 54.8% | - | |
| 605.51 | 13.0 | | Sandstone: same | | | Water at end of run-15.8 ft |
| 604.51 | 14.0 | | No recovery | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) PROJECT HOLE NO.

Hole No. WES-10-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 2. LOCATION (Coordinates or Station) | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 3. DRILLING AGENCY | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 4. HOLE NO. (As shown on drawing title and file number) | 14. TOTAL NUMBER CORE BOXES |
| 5. NAME OF DRILLER | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 604.51 | 14.0 | | | | | |
| 603.51 | 15.0 | | Run 2 | | | |
| 602.51 | 16.0 | | | | | Run 3<br>Began 11:22 Rec 0.8'<br>End 11:25 Loss 3.7'<br>Time 3 min Gain -<br>Drl time 3 min<br>Hyd press 100psi<br>Water press -<br>RPM 100+<br>Drl Action Smooth<br>~~Water~~ ret<br>Brown<br>Remarks - |
| 601.51 | 17.0 | | Sandstone | 17.8% | - | |
| 600.51 | 18.0 | | No recovery except for approximately 0.8 ft of weathered, brown, fine-grained quartz sandstone. | | | |
| 599.15 | 19.0 | | | | | |
| 598.51 | 20.0 | | Run 3 | | | |
| 597.51 | 21.0 | | | | | Run 4<br>Began 11:57 Rec 0.8'<br>End 12:05 Loss 4.7'<br>Time 8 min Gain -<br>Drl time 8 min<br>Hyd press 100psi<br>Water press -<br>RPM 100<br>Drl Action Smooth<br>~~Water~~ ret<br>Brown<br>Remarks - |
| | | | Sandstone | | | |
| 596.51 | 22.0 | | No recovery | 14.5% | - | |
| 595.51 | 23.0 | | | | | |
| 594.51 | 24.0 | | | | | |

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

Hole No. WES-10-2-81

| DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 4 SHEETS |
|---|---|---|---|

| | |
|---|---|
| 1. PROJECT | 10. SIZE AND TYPE OF BIT |
| 2. LOCATION (Coordinates or Station) | 11. DATUM FOR ELEVATION SHOWN (TBM or MSL) |
| 3. DRILLING AGENCY | 12. MANUFACTURER'S DESIGNATION OF DRILL |
| 4. HOLE NO. (As shown on drawing title and file number) | 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED |
| 5. NAME OF DRILLER | 14. TOTAL NUMBER CORE BOXES |
| | 15. ELEVATION GROUND WATER |
| 6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT. | 16. DATE HOLE — STARTED — COMPLETED |
| 7. THICKNESS OF OVERBURDEN | 17. ELEVATION TOP OF HOLE |
| 8. DEPTH DRILLED INTO ROCK | 18. TOTAL CORE RECOVERY FOR BORING % |
| 9. TOTAL DEPTH OF HOLE | 19. SIGNATURE OF INSPECTOR |

| ELEVATION a | DEPTH b | LEGEND c | CLASSIFICATION OF MATERIALS (Description) d | % CORE RECOVERY e | BOX OR SAMPLE NO. f | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g |
|---|---|---|---|---|---|---|
| 594.51 | 24.0 | | No recovery | | | |
| 593.51 | 25.0 | | Limestone: light grey, moderately hard, and fine-grained. | | | |
| | | | Bailed water from hole and set well. Boring fell in 0.9 ft. | | | |

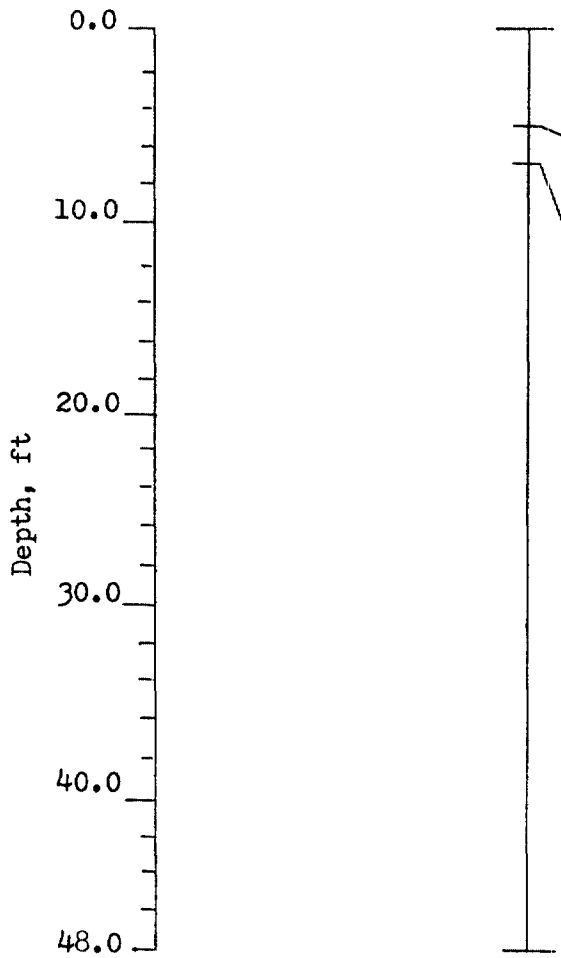
ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO.

APPENDIX B

GRAPHIC FIELD LOGS

WORKING DRAFT




686.14' MSL

Clay (CL): light brown to grey in color, soft to slightly stiff, and low plasticity.

Sand (SP): light brown to grey in color, very fine-grained, uniform, and contains thin zones of moderately hard cemented sand.

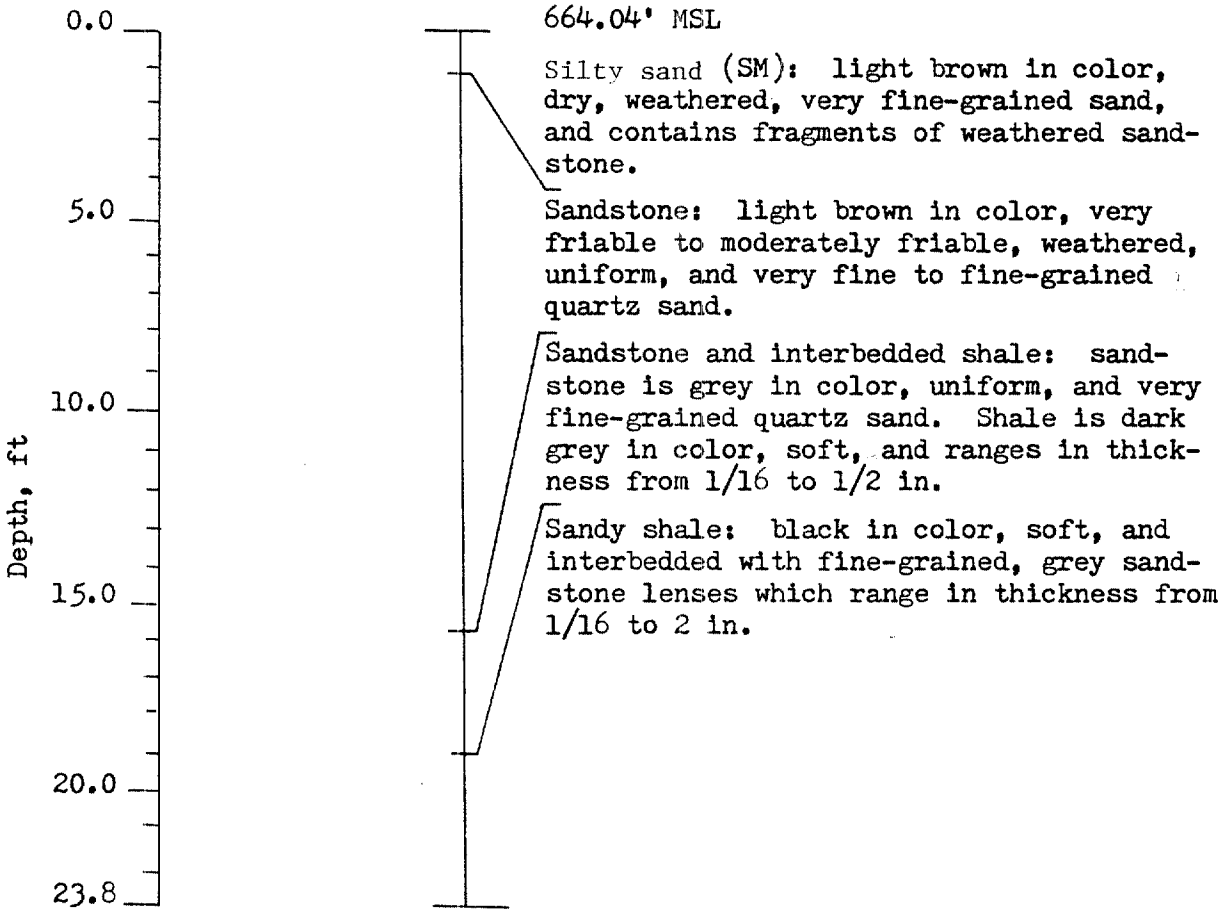
Sandstone: brown to dark brown in color and very fine-grained.

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-1-81

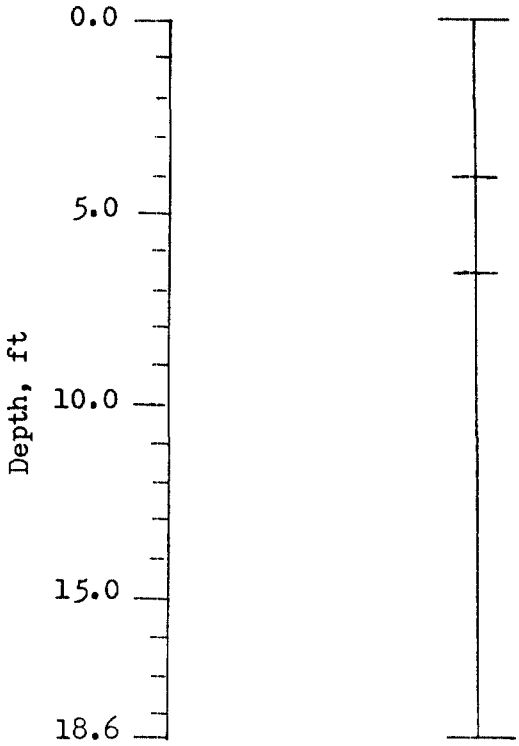



NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-2-81




667.43' MSL

Silt(ML): brown in color, soft, organic matter, and low plasticity.

Clayey sand(SC): reddish brown in color, dry, uniform, and fine-grained sand and sandstone fragments.

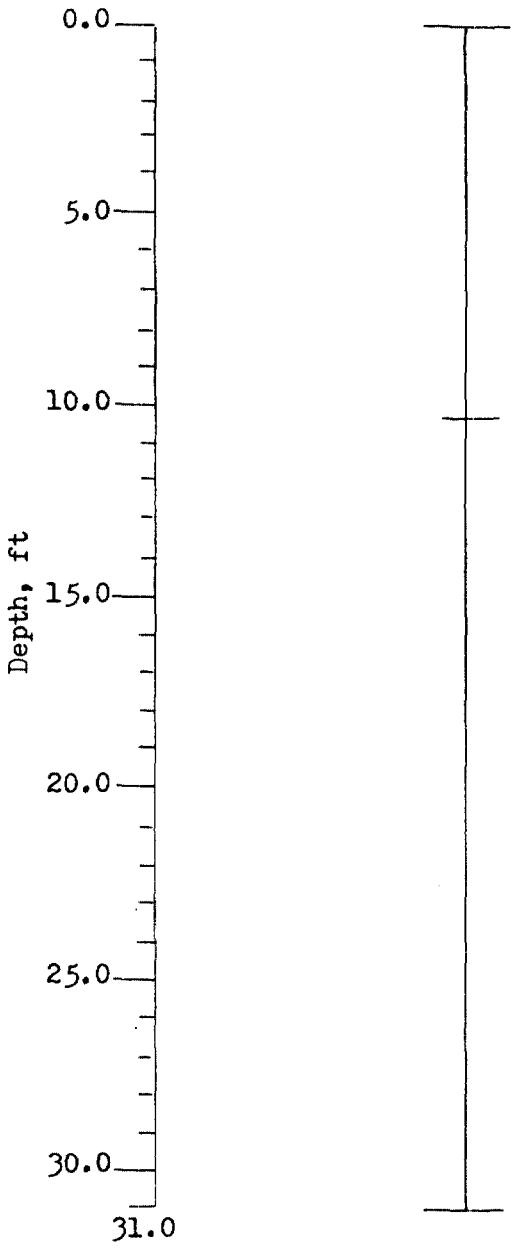
Sandstone: light brown to reddish brown and light grey in color, very friable to slightly friable, weathered, and very fine to fine-grained.

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-3-81




669.95' MSL

Sandy silt(ML): brown to grey in color, moderate cohesion, dry, stiff, and contains 20 to 30% fine-grained sand.

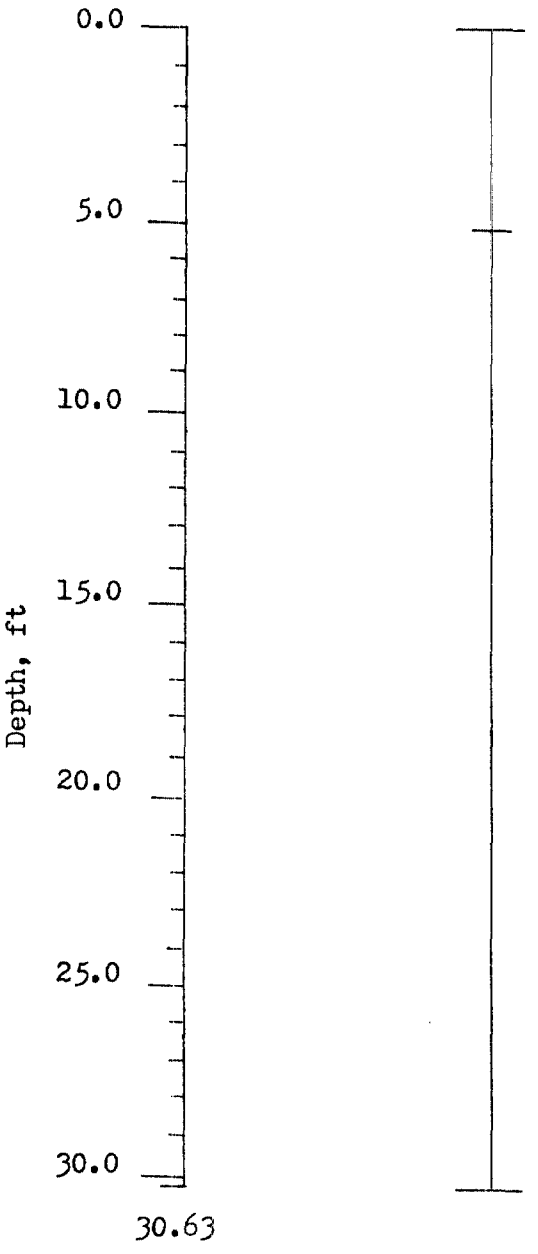
Sandstone: reddish brown in color, fine-grained, and weathered.

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-4-81




665.69' MSL

Clay (CL): brown in color, dry, little cohesion, uniform, and contains 5% sand and gravel.

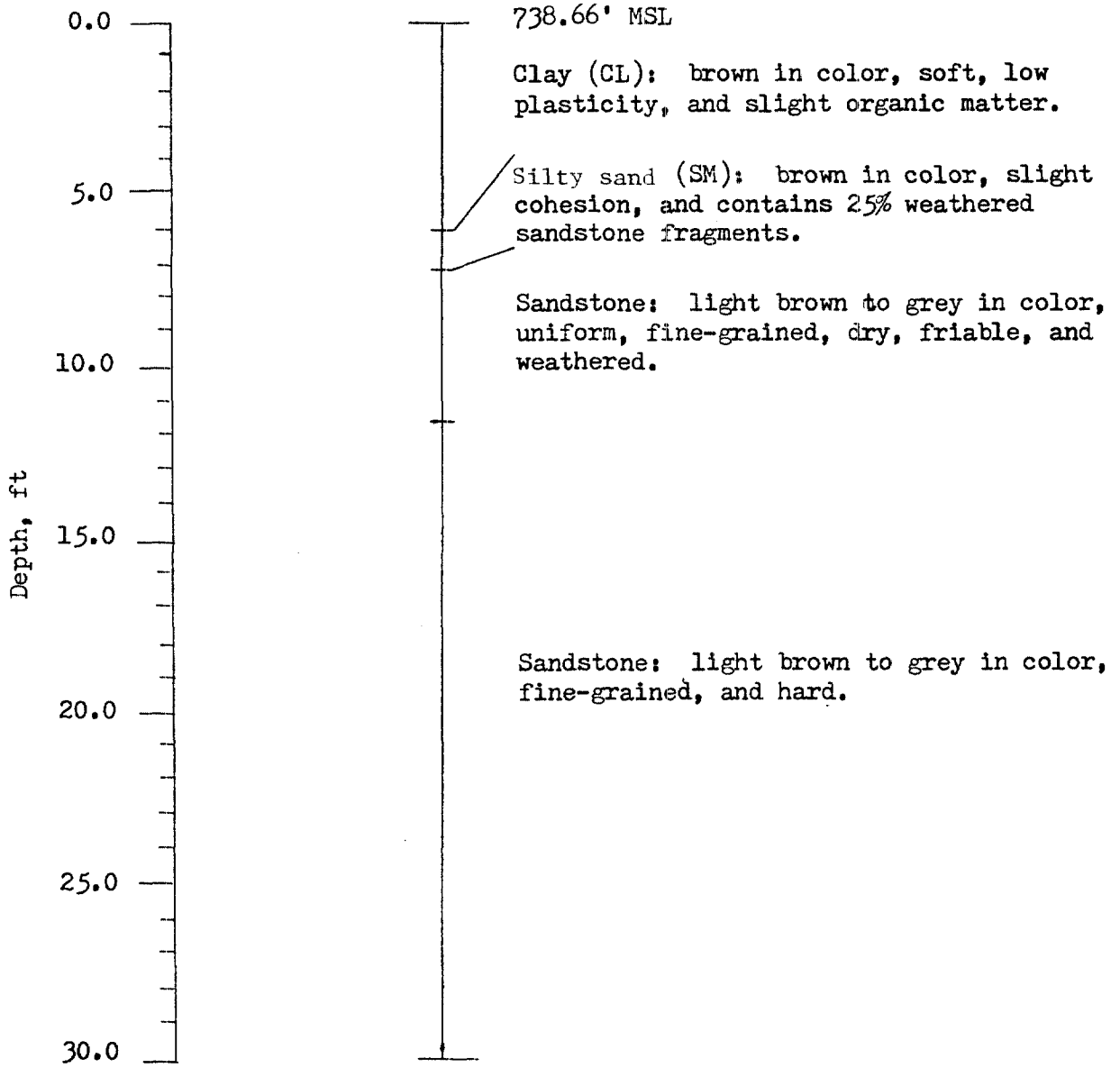
Brown sandstone and interbedded grey shale

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Lithology

Boring Number: WES-1-5-81

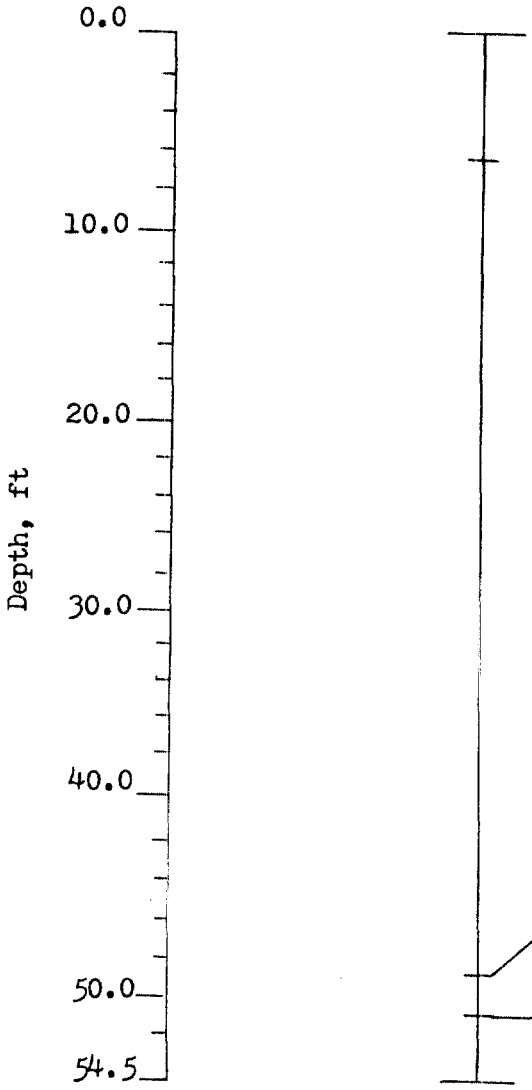



NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-1-81




725.46' MSL

Silt (ML): brown in color, soft, dry, and contains slight organic matter. Sandstone fragments begin at 5 ft.

Sandstone: color ranges from shades of brown, orange, and red to various shades of grey, uniform, very fine to fine-grained quartz sand, dry, friable, weathered, and interbedded with numerous small seams of clay, shale, siltstone, peat, and lignite. Shale is dark grey to grey in color, soft, and frequency increases with depth beginning around 35 ft.

Shale(70%) interbedded with sandstone(30%): grey to dark grey in color, soft, and thinly bedded.

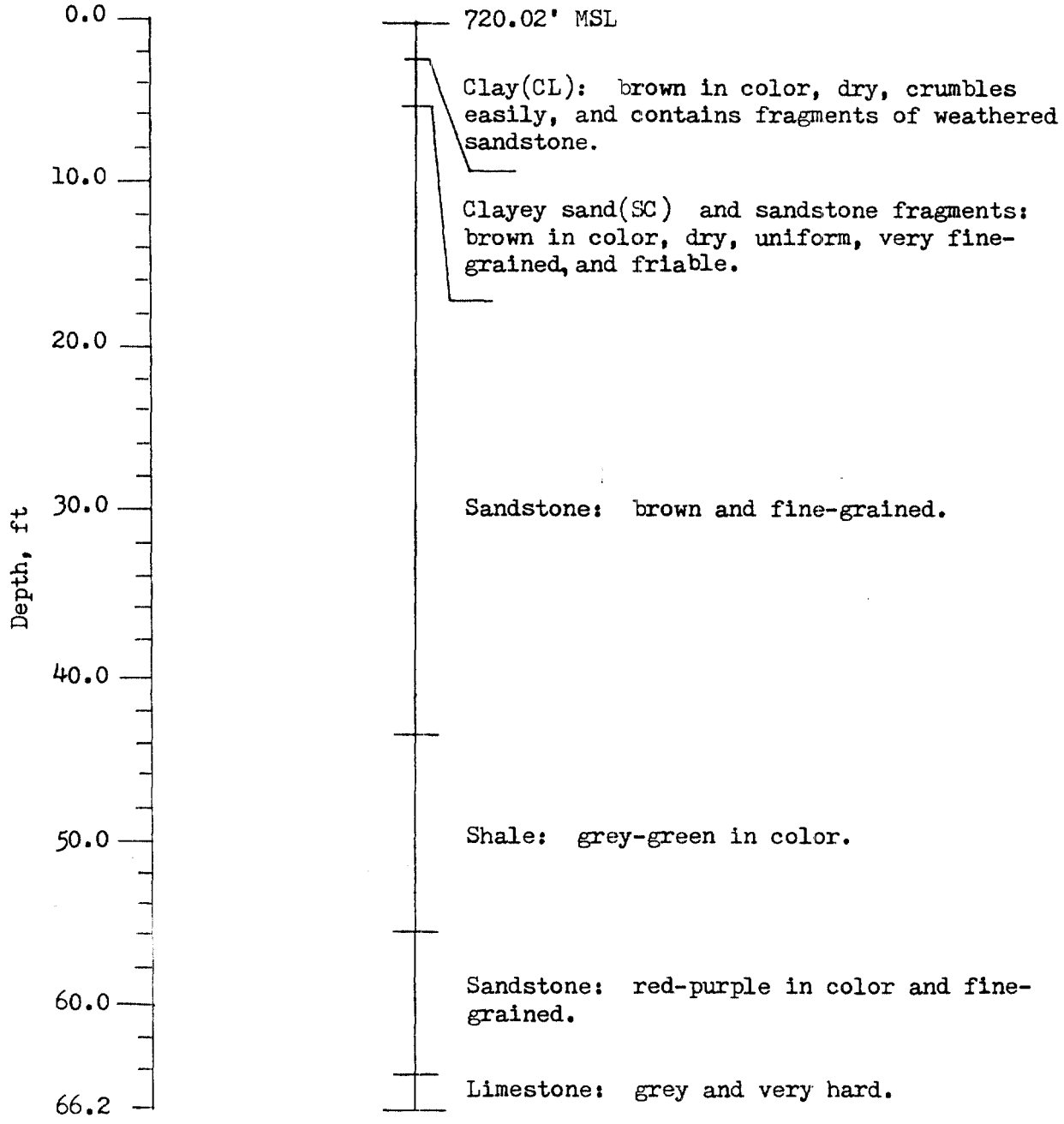
Shale: green, uniform, soft, and brittle.

NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-2-81

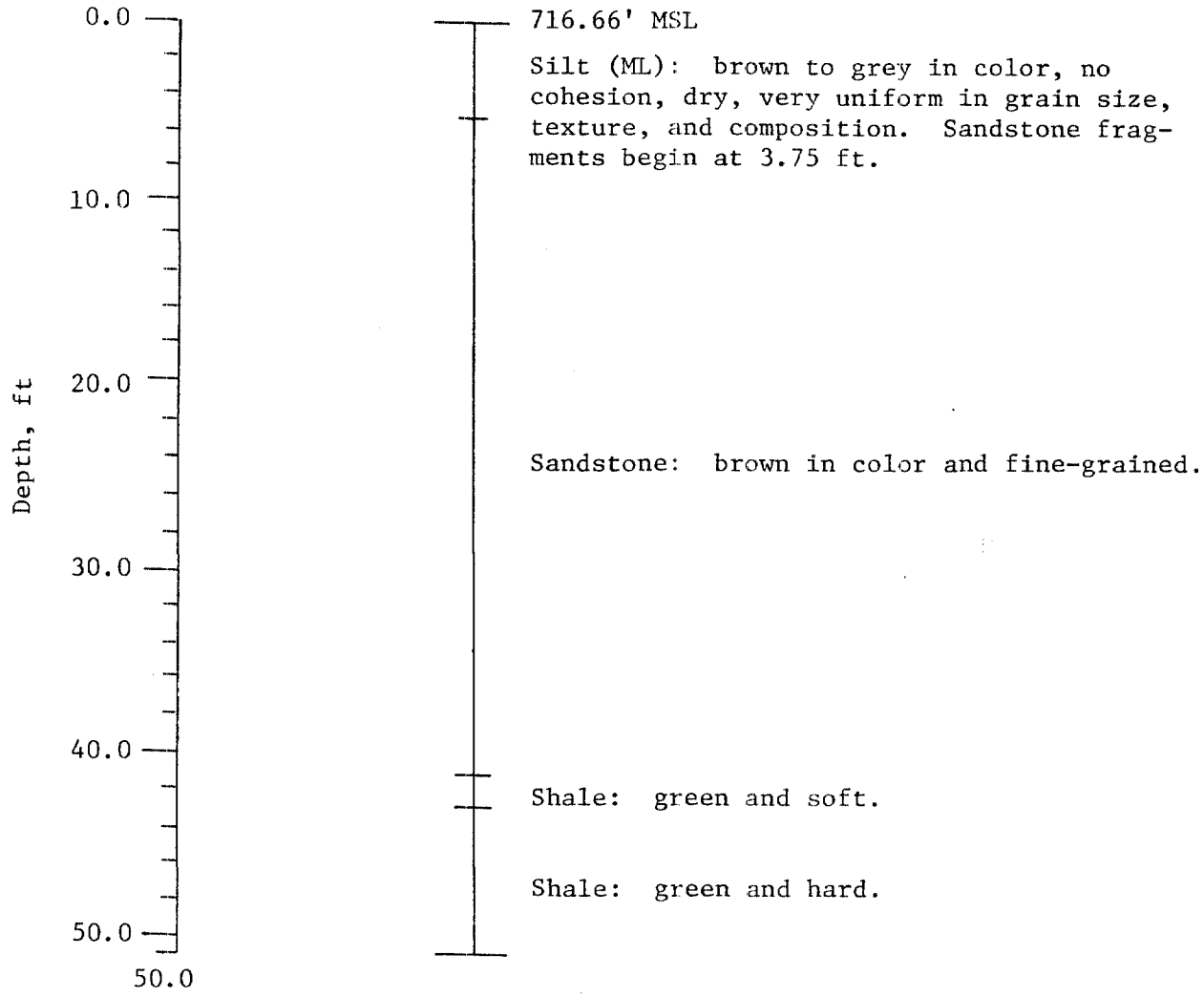



NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-3-81

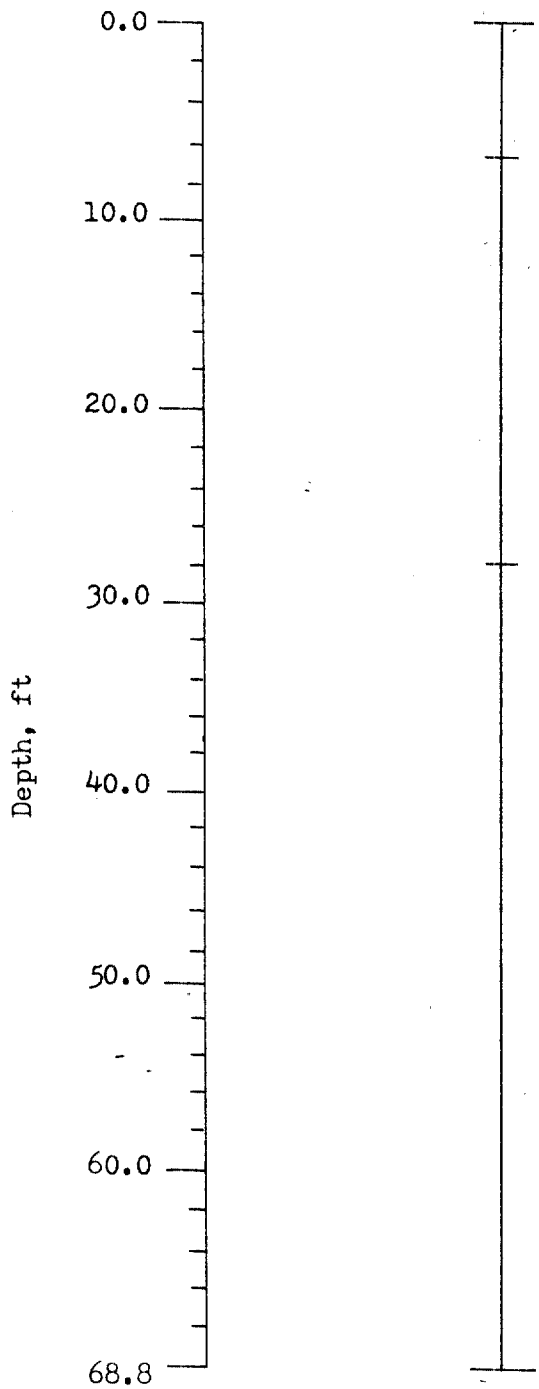



NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-4-81




739.24' MSL

Clay (CL): brown in color, soft, dry, moderately cohesive, and slight organic matter. Sandstone fragments begin at 5 ft.

Sandstone: red to brown in color and fine-grained.

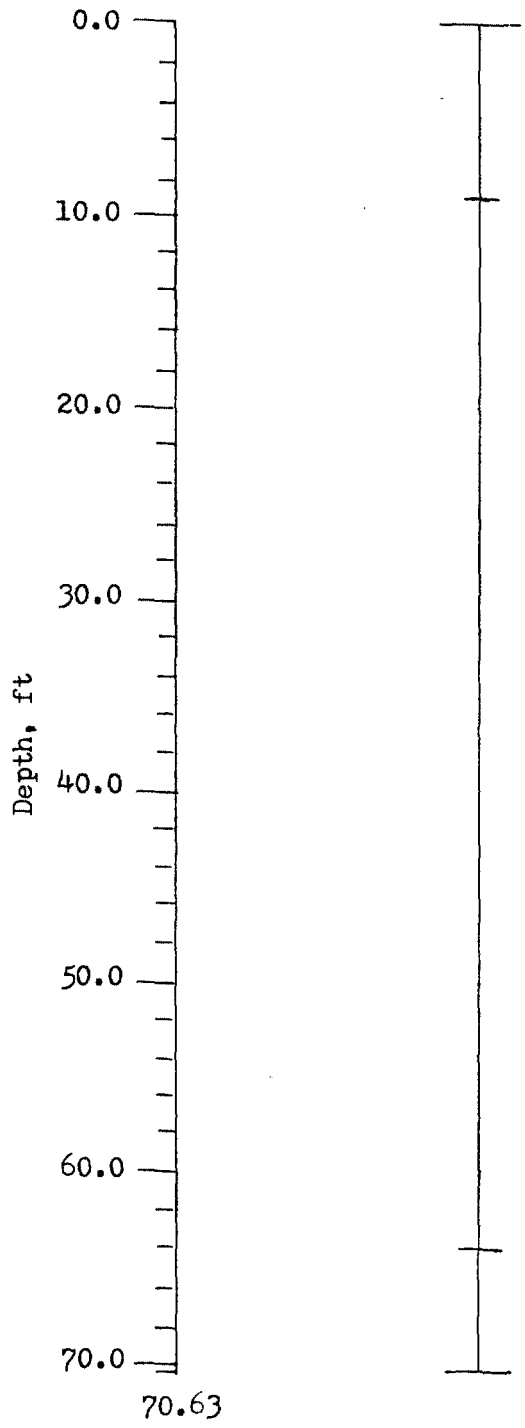
Interbedded sandstone, shale, and limestone.

NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-5-81




736.58' MSL

Clay(CL): brown to grey in color, dry, and little cohesion.

Sandstone and interbedded shale: brown to dark grey in color.

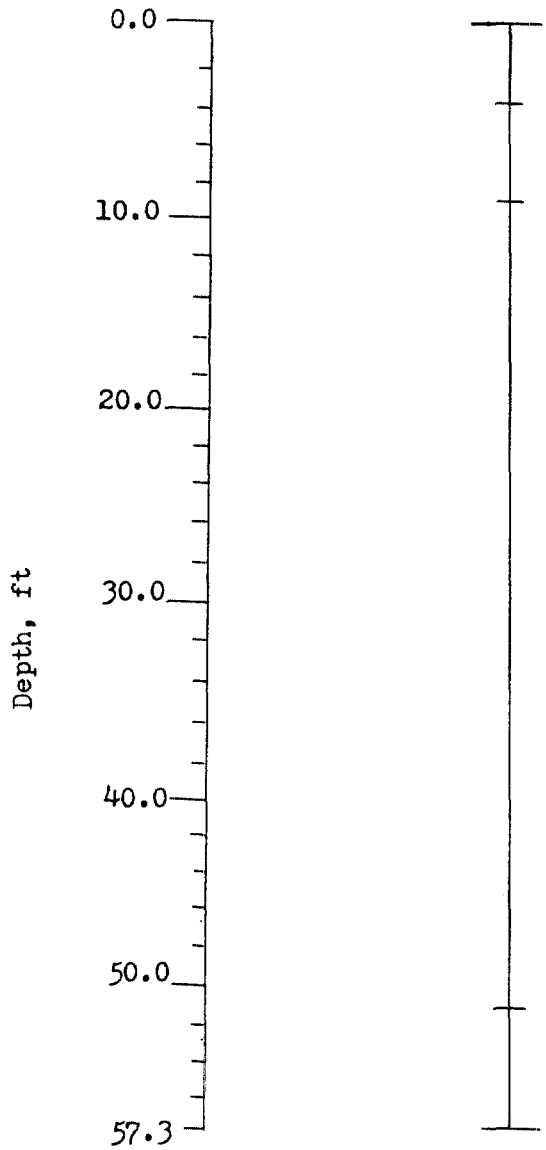
Shale: dark grey in color.

NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-6-81




728.73' MSL

Silty sand (SM): brown, dry, hard, and contains 5% very fine gravel.

Sandstone: brown in color and weathered.

Sandstone and interbedded dark grey shale: brown, tan, grey, and white in color, soft to very hard.

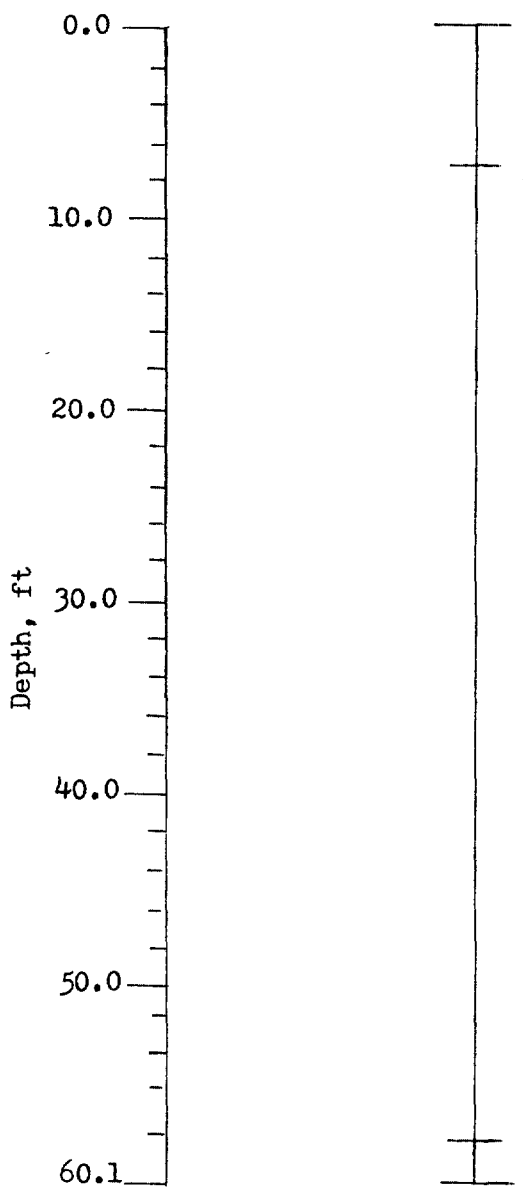
Shale and interbedded sandstone: dark grey in color.

NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-7-81




730.29' MSL

Silty clay(CL): light brown to brown, dry, moderate cohesion, uniform, and slightly stiff.

Sandstone and interbedded dark grey shale: color ranges from white, grey, brown, and reddish brown.

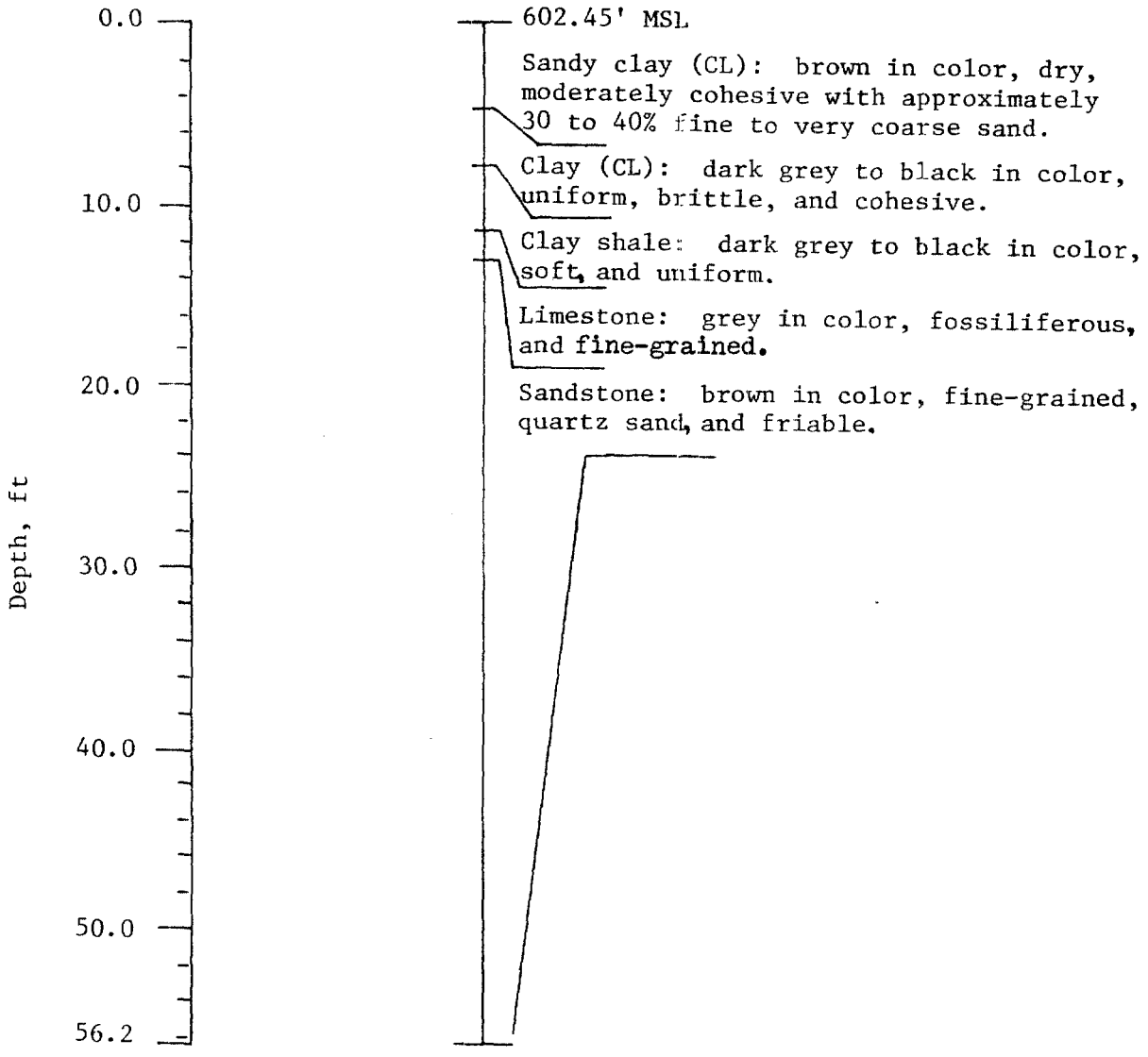
Shale: dark grey in color.

NWSC, Crane, Indiana

Dye Burial Grounds

Lithology

Boring Number: WES-2-8-81

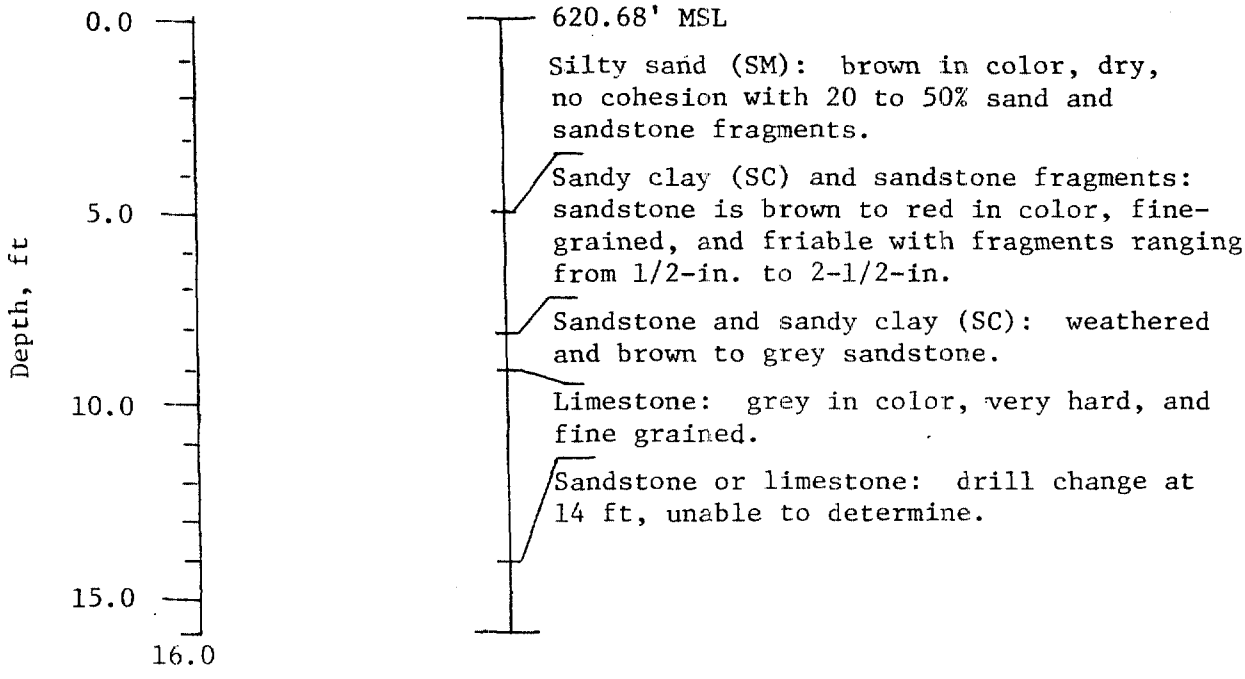



NWSC, Crane, Indiana

Ammunition Burning Grounds

Lithology

Boring Number: WES-3-1-81

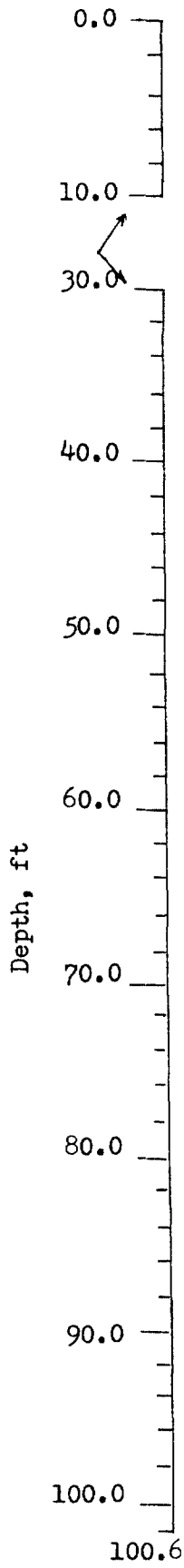



NWSC, Crane, Indiana

Ammunition Burning Grounds

Lithology

Boring Number: WES-3-2-81




580.87' MSL

Gravelly clay (CL): dark brown in color, moderately cohesive, soft, and contains 10% gravel from 1/16 to 3/4-in.

Sandstone: brown (to 16.35 ft) and grey in color, uniform, fine-grained quartz sand, and contains iron nodules and fine seams of lignite. Sandstone is very friable near surface, weathered in areas, and predominantly thinly bedded.

Limestone: grey brown in color, hard, dense, fine-grained, fossiliferous, and thinly bedded with grey shale.

Shale: brownish grey to greenish grey, soft, and uniform.

Limestone with interbedded shale: grey brown to grey, hard, dense, and contains soft, greenish grey shale.

Shale: green to dark grey in color, soft, and fairly uniform.

Sand (SP): brown, fine-grained, uniform, unconsolidated, and approximately 70% quartz grains.

Shale: grey and uniform.

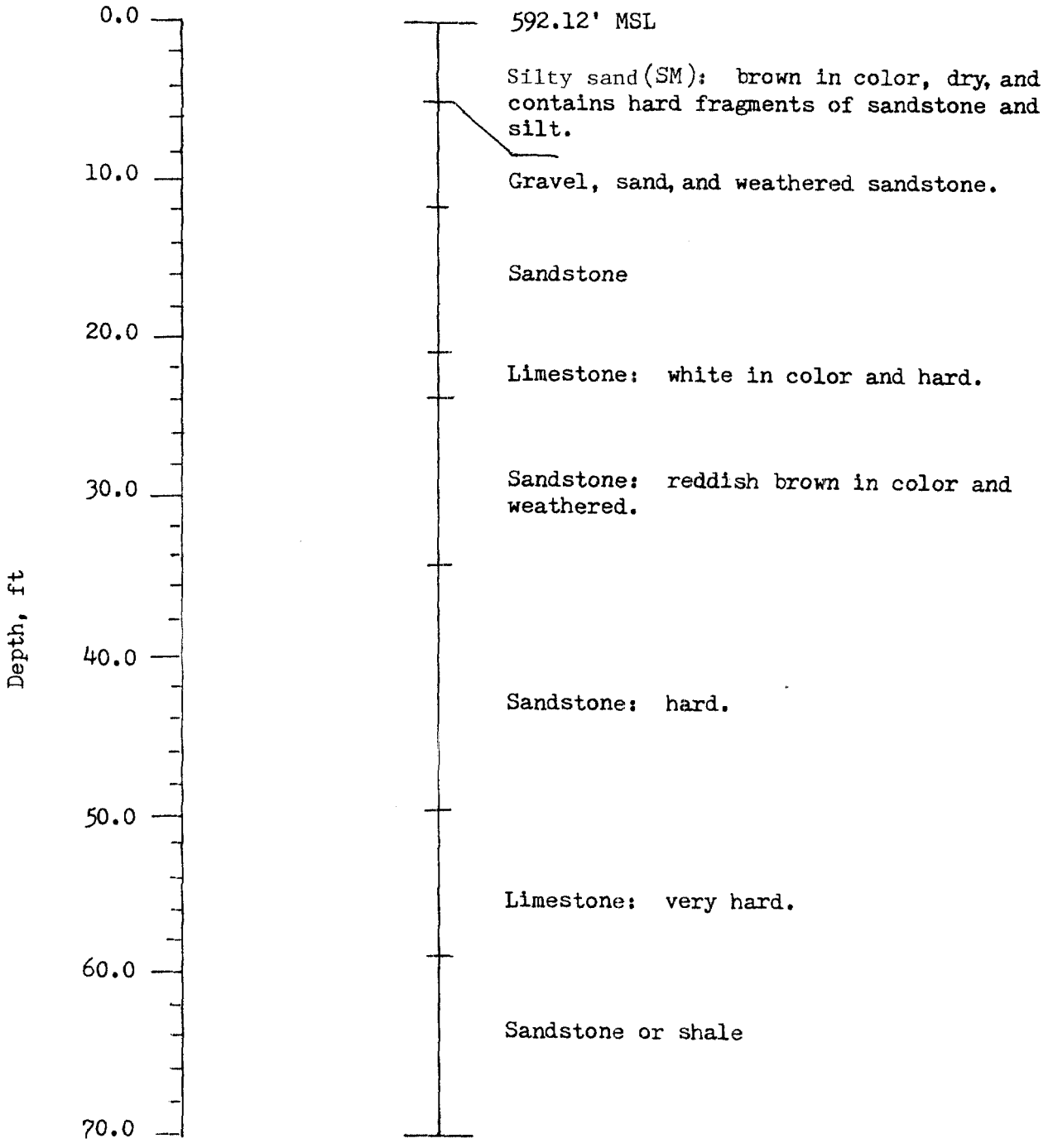
Sand (SP): brown to grey, fine-coarse, and unconsolidated.

Shale: same as above.

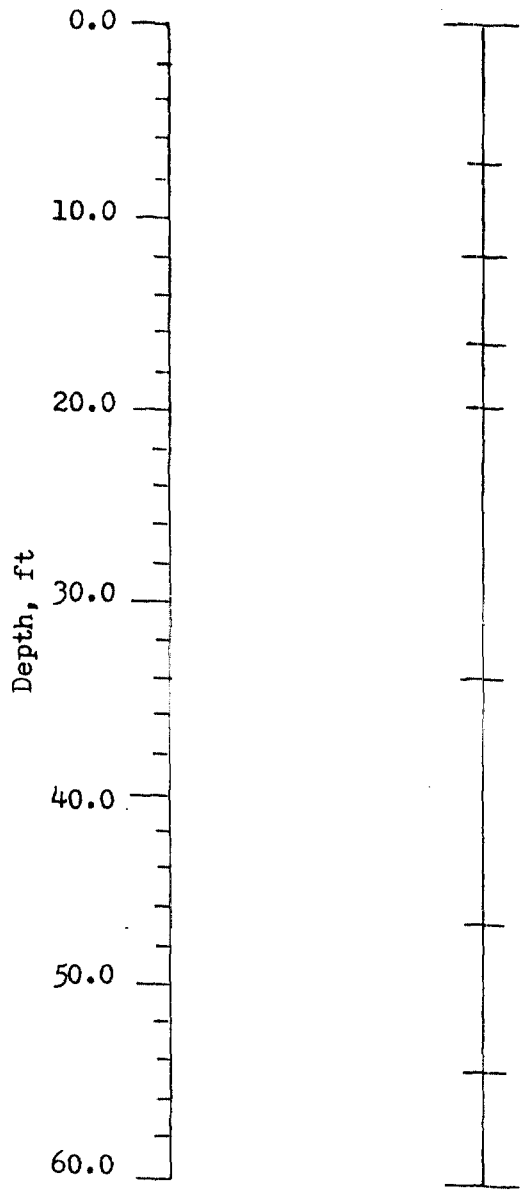
Sand (SP): same as above.

Shale: same as above.

NWSC, Crane, Indiana
Ammunition Burning Grounds
Lithology
Boring Number: WES-3-3-81




NWSC, Crane, Indiana
Ammunition Burning Grounds
Lithology
Boring Number: WES-3-4-81




593.25' MSL

Silty sand (SM): brown in color, dry, slight cohesion, and 30% fine to coarse sand.

Sandstone: brown in color and soft.

Sandstone: brown in color and moderately hard.

Sandstone: reddish brown in color and soft.

Sandstone and shale: brown to grey in color and medium hard. Very hard spot from 32 to 34 ft.

Sandstone and shale: brown to grey in color and medium hard.

Sandstone or limestone: very hard.

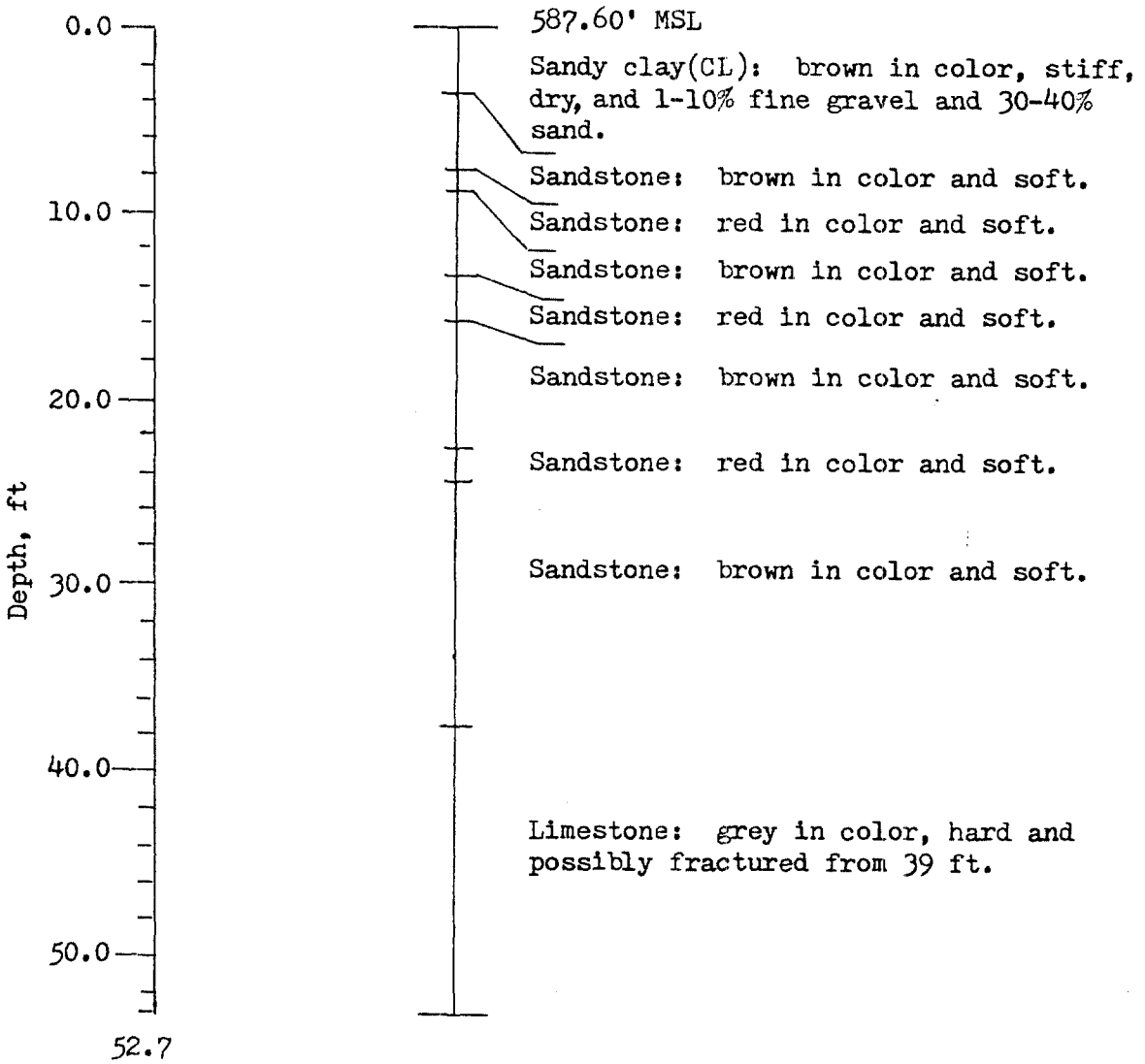
Shale: grey to green in color and soft.

NWSC, Crane, Indiana

Ammunition Burning Grounds

Lithology

Boring Number: WES-3-5-81

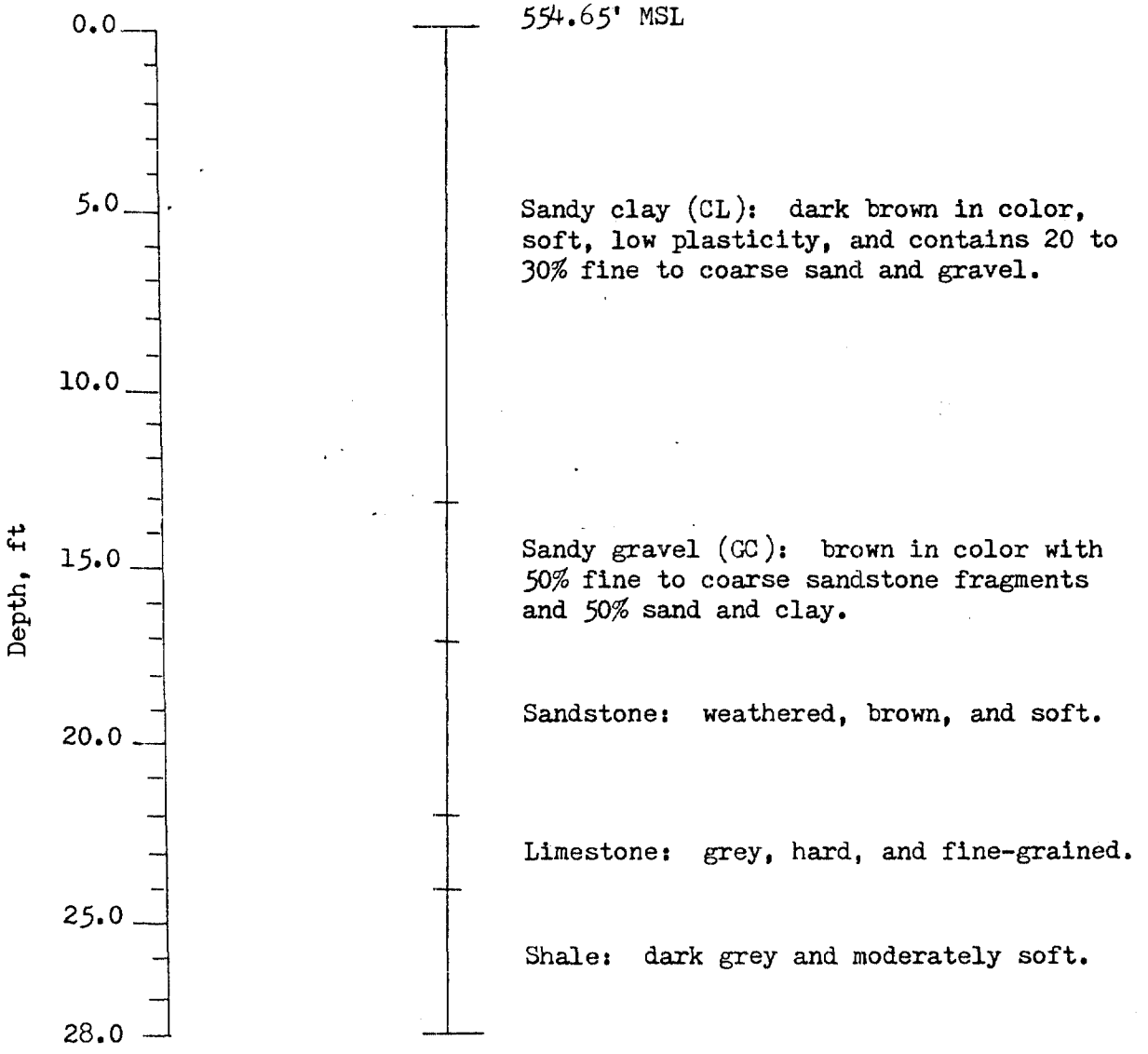



NWSC, Crane, Indiana

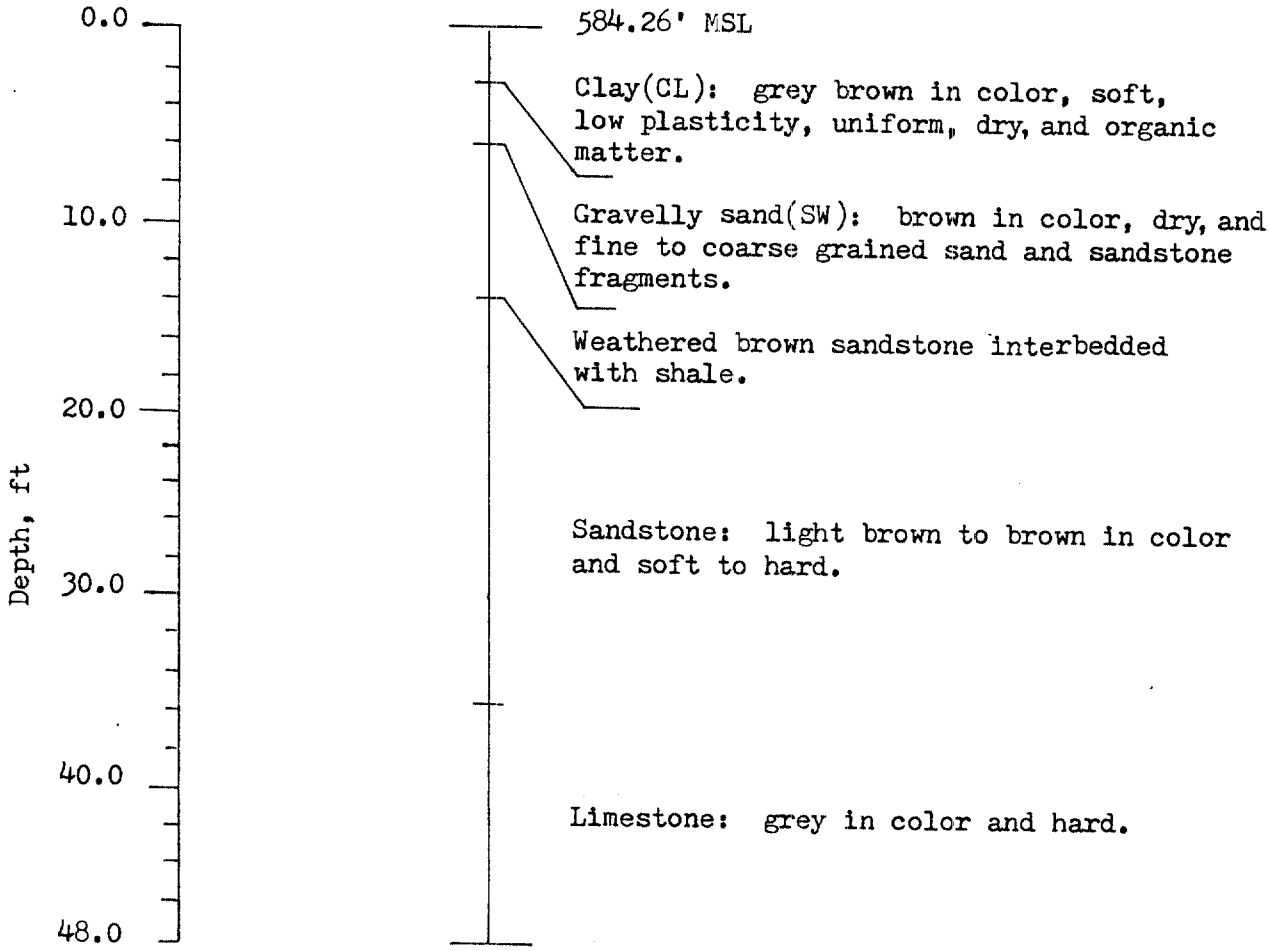
Ammunition Burning Grounds

Lithology

Boring Number: WES-3-6-81




NWSC, Crane, Indiana
Ammunition Burning Grounds
Lithology
Boring Number: WES-3-7-81

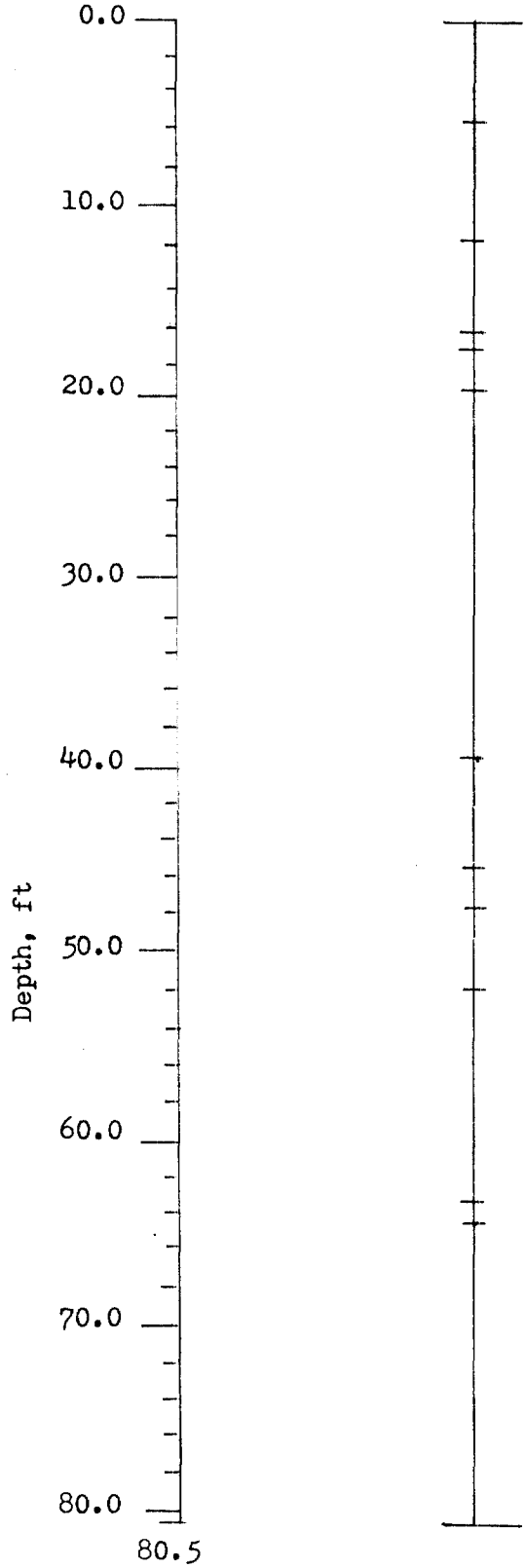



NWSC, Crane, Indiana

Ammunition Burning Grounds

Lithology

Boring Number: WES-3-8-81




625.25' MSL

Sandy clay (CL): brown in color, dry, low plasticity, and contains fine to coarse-grained sand and sandstone fragments.

Sandstone: brown in color, soft, highly weathered, and wet.

Limestone: light grey in color and hard.

Shale: grey in color and soft.
Limestone: light grey in color and hard.

Shale: grey in color and medium hard.

Sandstone: light grey in color and hard.

Limestone: light grey in color and hard.

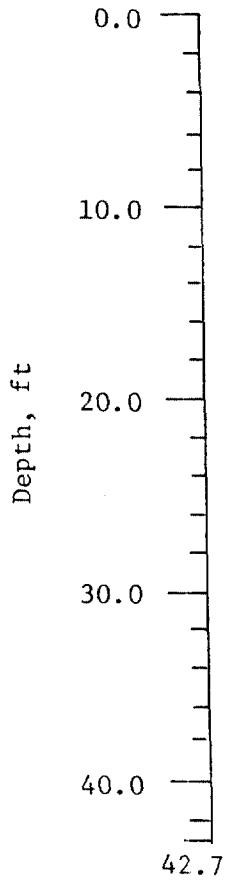
Shale, sandstone, and limestone

Sandstone: brown in color and hard.

Limestone: grey in color and hard.

Sandstone: light grey in color and hard.
Soft spot from 70.0 to 73.5 ft.

NWSC, Crane, Indiana
Ammunition Burning Grounds
Lithology
Boring Number: WES-3-9-81




603.49' MSL

Silt (ML): brown in color, slightly moist, little cohesion, slightly gritty, and contains organic matter.

Silty sand (SM): reddish brown in color, very uniform, fine-grained, little cohesion, and dry.

Gravelly sand (SP): reddish brown in color, fine to coarse-grained sand, very fine gravel, slightly moist, and no cohesion.

Sand (SP): brown in color, fine to medium quartz sand, slight moisture, and very little cohesion.

Silty sand (SM): brown in color, fine-grained quartz sand, slight moisture, little cohesion, and 30% silt.

Silt (ML): brown in color, very moist, moderately cohesive, and contains 1-2% very fine gravel.

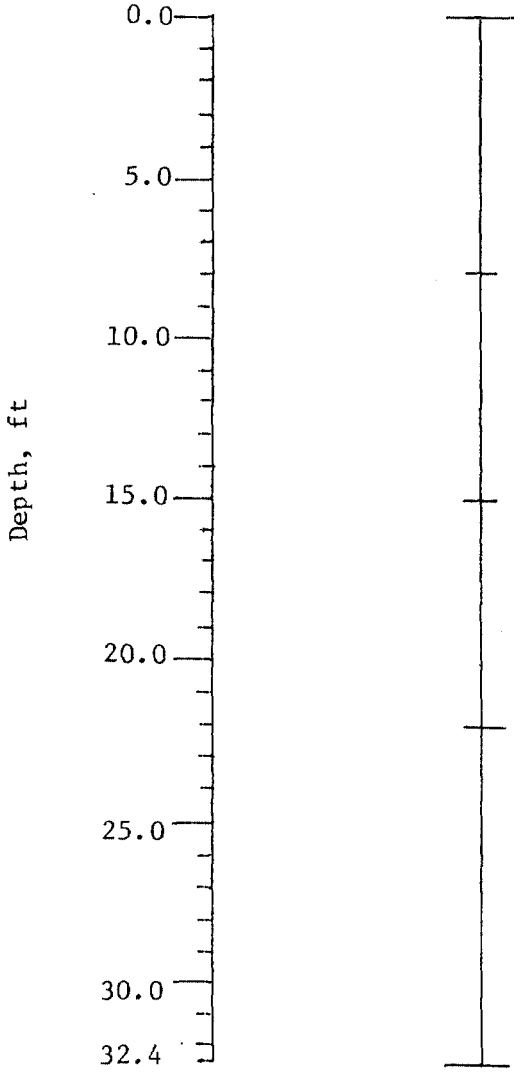
Clay silt (ML): grey in color, moist, and moderately cohesive.

NWSC, Crane, Indiana

McComish Gorge

Lithology

Boring Number: WES-4-1-81




585.69' MSL

Gravelly sand (SP): brown in color, dry, no cohesion, and fine to coarse-grained sand with 10-20% fine to medium gravel.

Silty sand (SM): brown in color, slight moisture, and slight cohesion.

Clay silt (ML): brown in color, moderately cohesive, and slight moisture. Material is very moist around 20 ft.

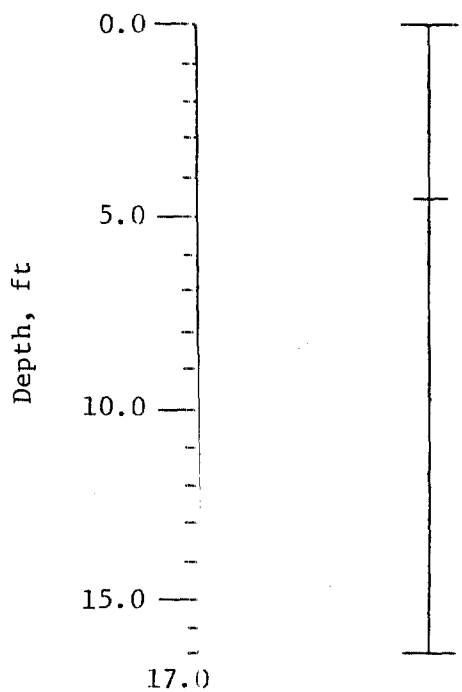
Silty sand (SM): grey in color, very fine-grained sand, uniform, moderately cohesive, and moist.

NWSC, Crane, Indiana

McComish Gorge

Lithology

Boring Number: WES-4-2-81




566.22' MSL

Silty sand (SM): brown in color, damp, fine-grained, moderate cohesion, and contains 30 to 40% silt.

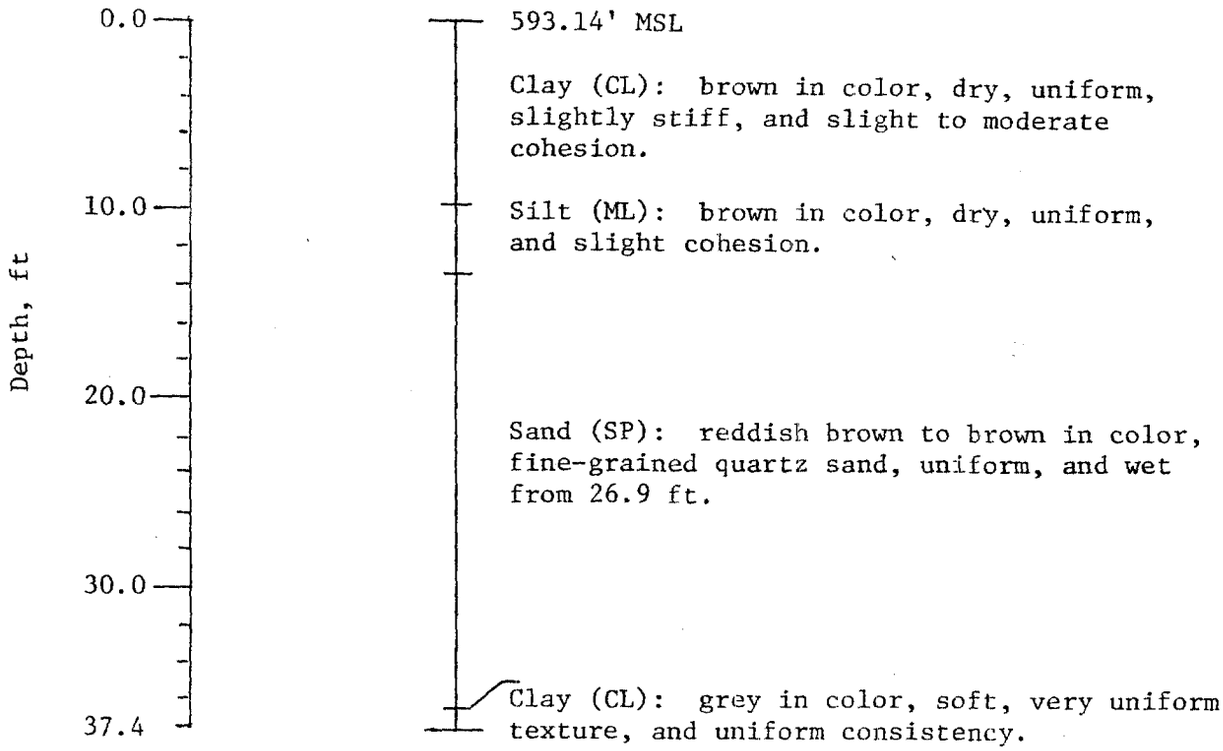
Silty sand (SM): grey in color, fine-grained, wet, moderate cohesion, and contains 30 to 40% silt.

NWSC, Crane, Indiana

McComish Gorge

Lithology

Boring Number: WES-4-3-81

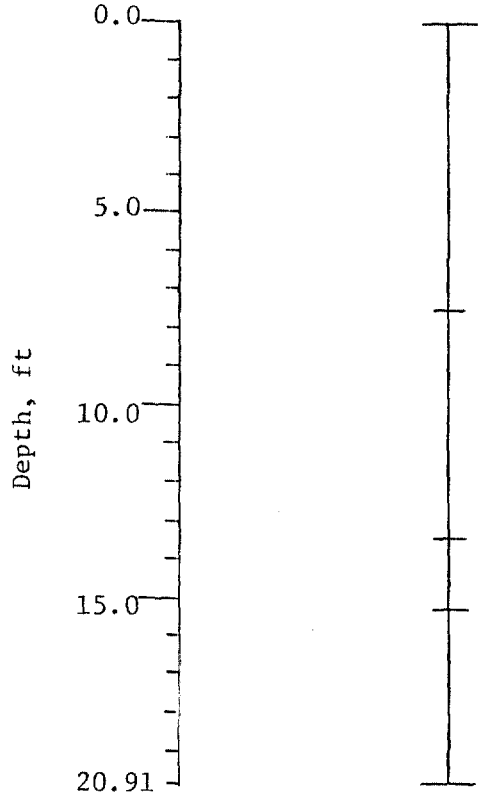



NWSC, Crane, Indiana

McComish Gorge

Lithology

Boring Number: WES-4-4-81




573.39' MSL

Sandy clay (CL): brown in color, moderate cohesion, soft, and contains 20-30% fine-grained sand.

Silty sand (SM): dark grey to black in color, wet, slight cohesion, and slight organic-oily odor.

Sandy gravel (GW): grey in color, wet, coarse sand (30%), and fine to medium, angular to rounded, unsorted gravel.

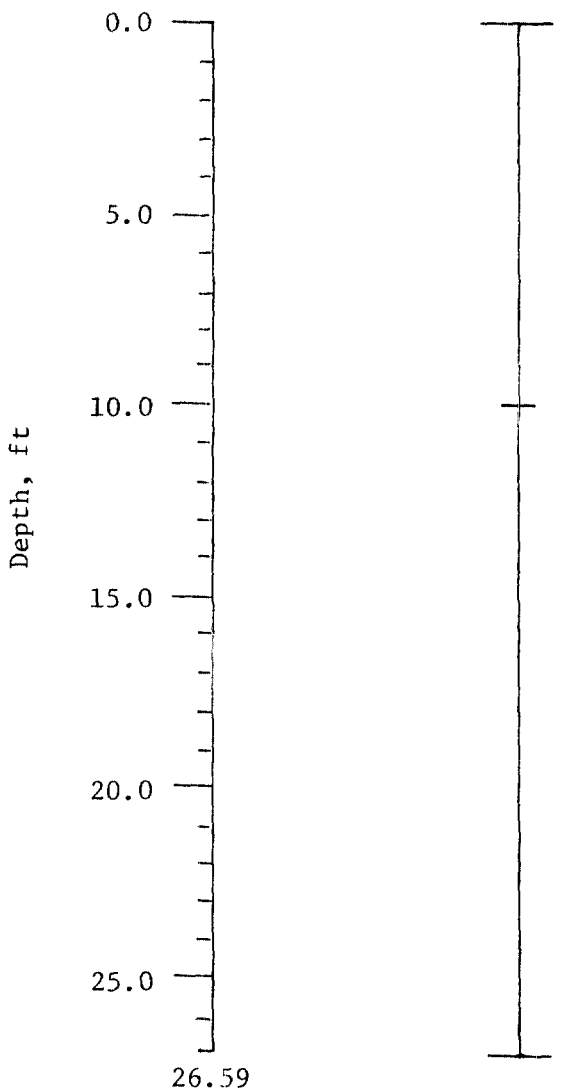
Silty sand (SM): grey in color, wet, no cohesion, and uniform.

NWSC, Crane, Indiana

McComish Gorge

Lithology

Boring Number: WES-4-5-81




579.54' MSL

Sand (SP): reddish brown to brown in color, dry, uniform, slight cohesion, and fine to medium grained.

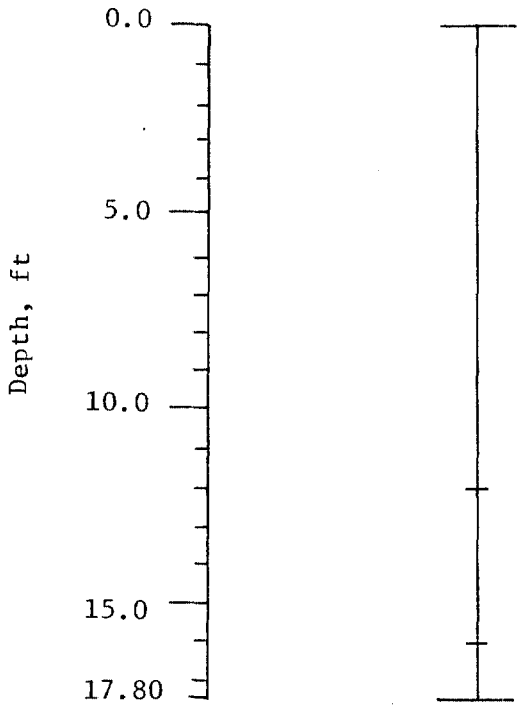
Silty sand (SM): brown in color, uniform, very fine-grained, slight cohesion, and wet from 17.35 ft. Material changes to grey color at 24.2 ft.

NWSC, Crane, Indiana

McComish Gorge

Lithology

Boring Number: WES-4-6-81




596.52' MSL

Silty sand (SM): brown in color, fine-grained, slight cohesion, and contains 5% very fine gravel. Material is moist from about 5 to 10 ft.

Silt (ML): brown to grey in color, hard, cohesive, and dry.

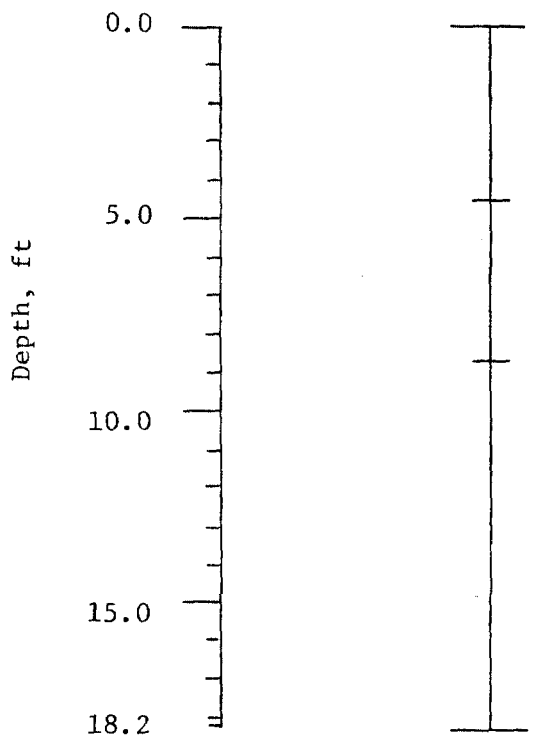
Shale: grey to black in color, uniform, and dry.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-1-81




583.43' MSL

Sand (SP): reddish brown in color, dry, slight cohesion, fine to medium grained, and contains ash and other burned materials.

Sandy silt (ML): brown in color, damp, slight cohesion, and contains 20% fine-grained sand.

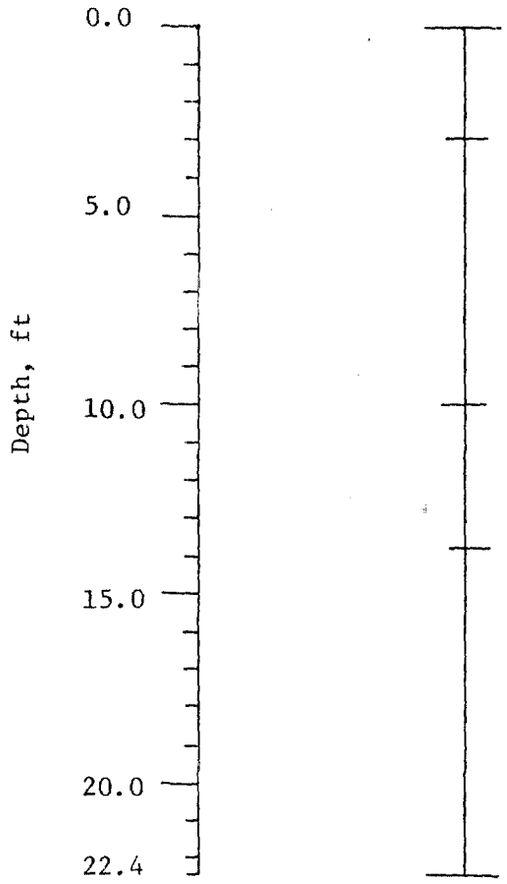
Silt (ML): brown in color, wet, and slight cohesion.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-2-81




589.78' MSL

Sand (SW): brown in color, fine to very coarse grained with majority of sand being medium, dry, and no cohesion.

Sand (SP): brown in color, uniform, fine-grained, slightly moist, and no cohesion.

Sandy silt (ML): brown in color, uniform, wet, and slight cohesion.

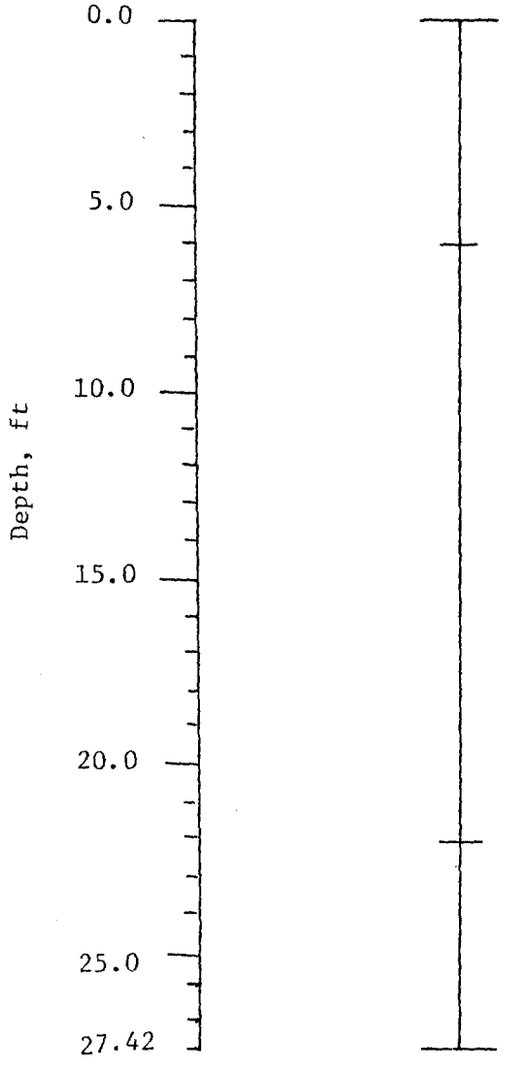
Silt (ML): brown in color, uniform, wet, moderate to highly cohesive.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-3-81




585.33' MSL

Sand (SP): brown in color, uniform, very fine-grained quartz sand, slightly damp, and slight cohesion.

Silt/Sand (SP-SM): brown in color, very fine-grained, moist to wet, and little cohesion.

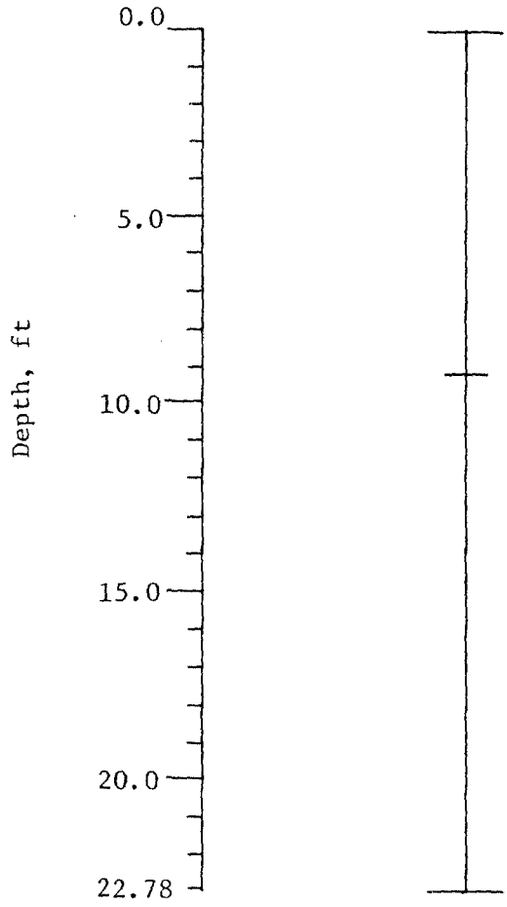
Clay (CL): brown to grey in color, soft, low plasticity, and moist.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-4-81




583.78' MSL

Sand (SP): brown in color, fine-grained quartz sand, dry, and no cohesion.

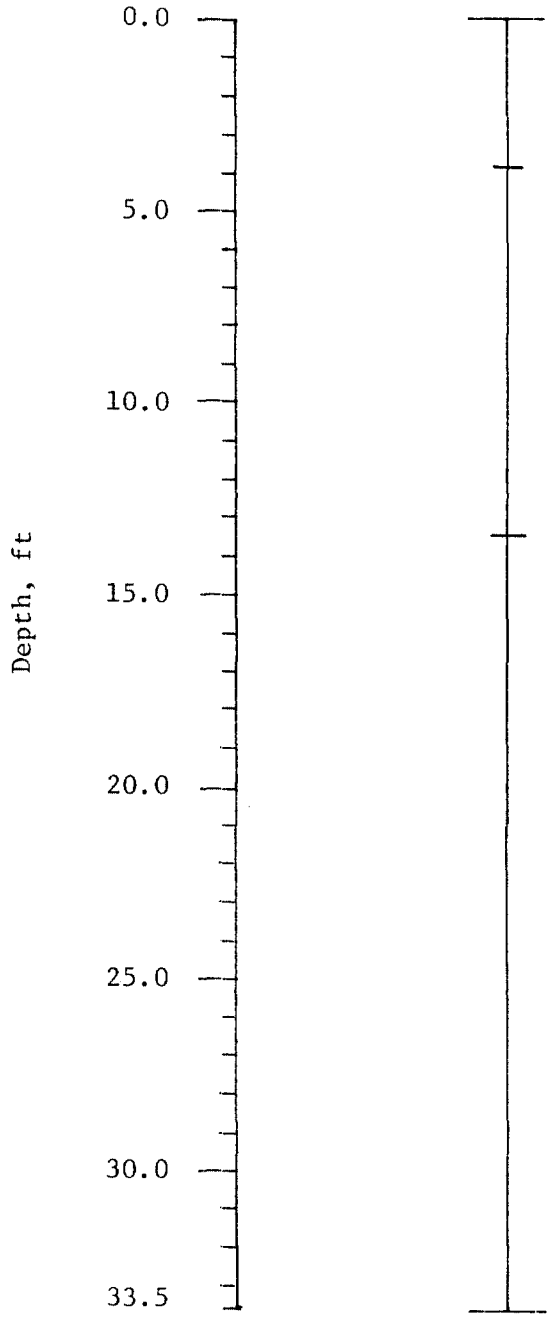
Silt/Sand (SP-SM): brown in color, very fine-grained, soft, wet, uniform, and slight cohesion.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-5-81




570.27' MSL

Sandy silt (ML): reddish brown in color, dry, uniform, low plasticity, and organic matter.

Silt (ML): light brown in color, soft, low plasticity, uniform, and dry.

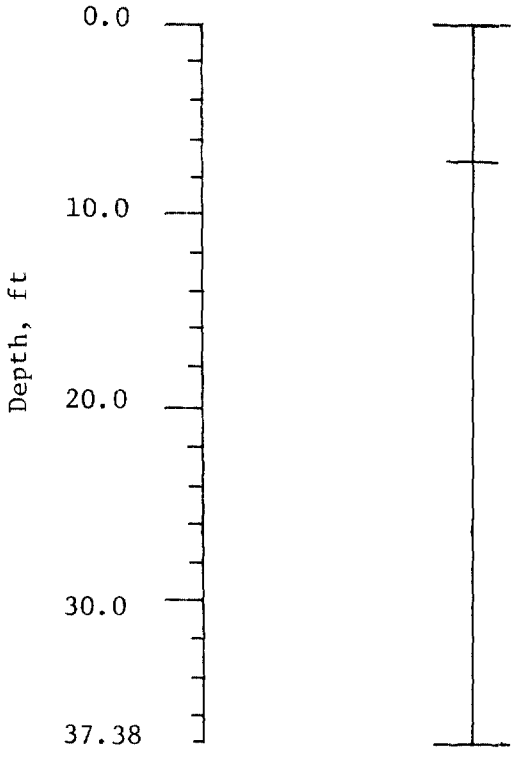
Silt (ML): grey to dark grey in color, soft, and low plasticity. Material is wet from 19.5 ft.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-6-81




576.70' MSL

Silt (ML): brown in color, dry, uniform and low plasticity.

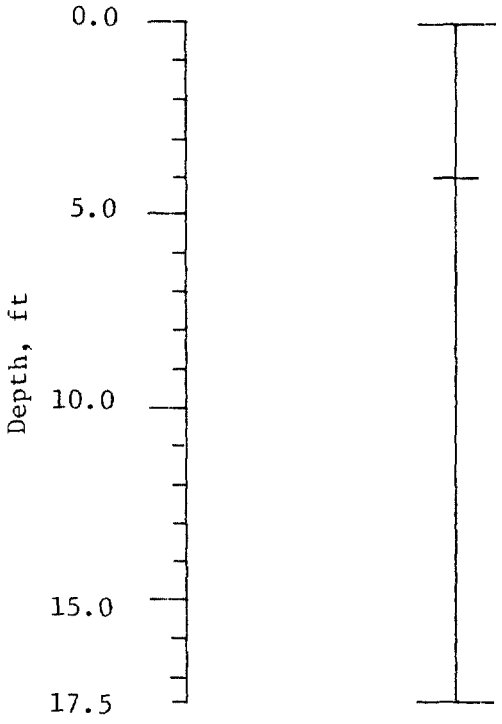
Silt (ML): grey in color, moist to very wet, uniform, soft, and low plasticity.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-7-81




563.78' MSL

Sandy clay (CL): brown in color, slightly moist, soft, and organic matter. Material is possibly dozer fill.

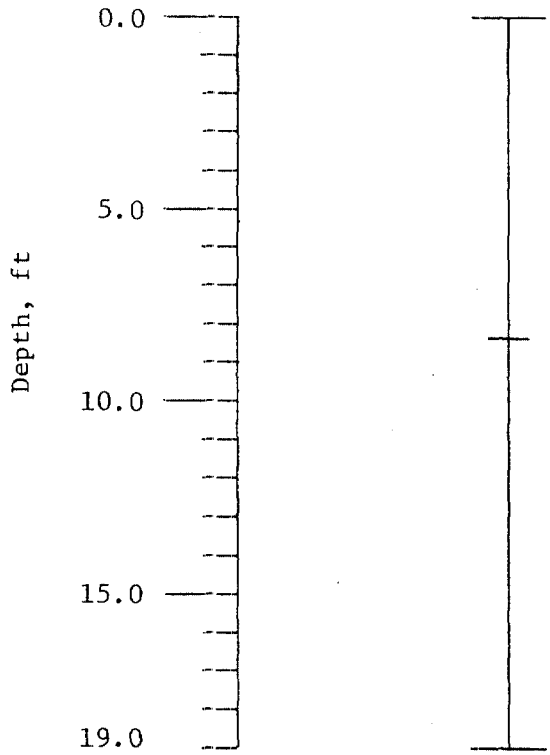
Silt (ML): brownish grey to grey in color, moist to wet, and uniform.

NWSC, Crane, Indiana

Old Burning Pit

Lithology

Boring Number: WES-5-8-81




682.63' MSL

Clay (CL): brown to grey in color, dry, moderate cohesion, organic matter, and contains 5-10% very fine, angular to rounded gravel from 5 ft.

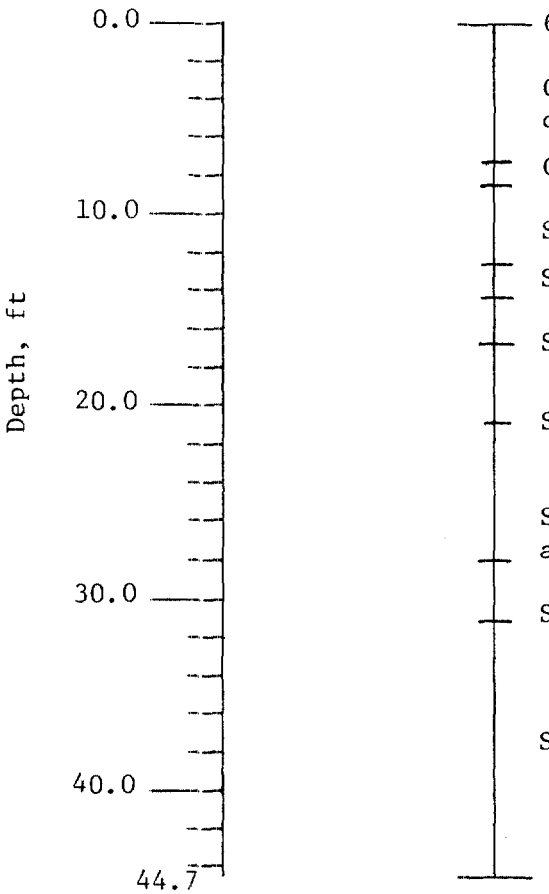
Sandstone: reddish brown in color and fine-grained.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-1A-81




683.27' MSL

Clay (CL): brown in color, very stiff, dry, and low plasticity.

Clay shale: reddish brown.

Sandstone: light grey and hard.

Shale: brown and grey.

Sandstone and shale: light grey.

Shale: grey and hard.

Sandstone: light grey, fine-grained, and very hard.

Shale: dark grey.

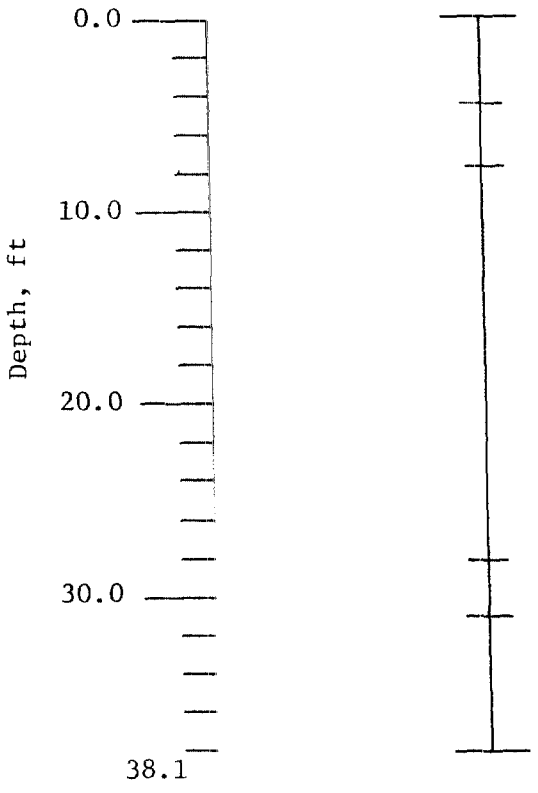
Sandstone: brown and fine-grained.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-1B-81




682.60' MSL

Sandy clay (CL): brown in color, dry, soft, and slight cohesion.

Clay (CH): brown in color, dry, hard, very stiff, and high plasticity.

Sandstone: ranges in color from brown to dark brown and light grey to grey, fine-grained, weathered, contains shale lenses, and alternates between soft and hard.

Shale with sandstone lenses.

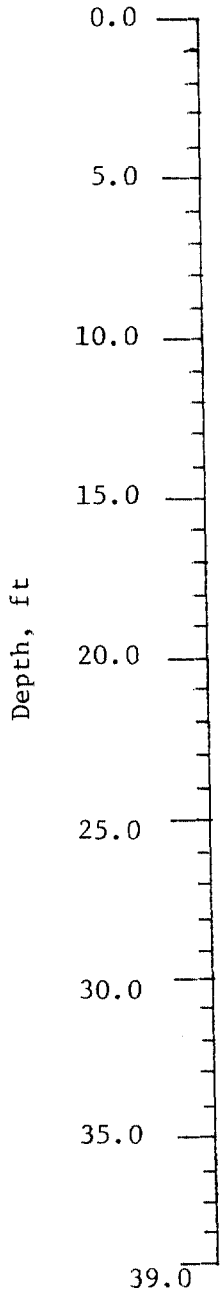
Sandstone: brown and soft, becoming harder at 35.7 ft.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-1C-81




637.53' MSL

Clay (CL): brown in color, soft, little cohesion, uniform, slightly damp, and organic matter. Sandstone fragments start around 5 ft.

Sandstone: brown fine-grained, weathered, and friable.

Shale: brown, grey to dark grey, dry, and very soft to soft.

Sandstone and interbedded shale: sandstone is brown in color, fine-grained, moderately friable, and weathered. Shale averages around 20% of interval with thickness ranging from 1/16-1/4 in. and frequency increasing with depth.

Shale: dark grey in color, soft, organic matter, slightly moist, and weathered.

Sandstone and interbedded shale: sandstone ranges from brown to grey, to light grey, fine-grained, and moderately hard to hard. Shale is grey to dark grey in color, soft, and content is about 10-20% of interval.

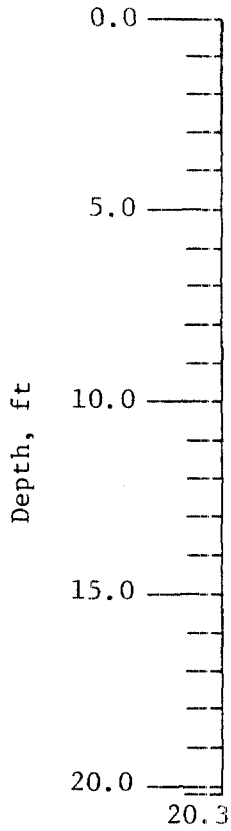
Sandstone (50%) and shale (50%): sandstone is fine-grained, grey to dark grey, and hard. Shale is black and contains sand. Bedding ranges from 1/8 to 1-1/2 in. with average at around 1 in.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-2-81




659.77' MSL

Clay (CL): dark brown in color, uniform, slight cohesion, organic matter, and slightly moist.

Sandy clay (CL): light brown in color, very stiff, dry, and contains 10-20% sand.

Sandstone: soft and weathered to 8 ft.

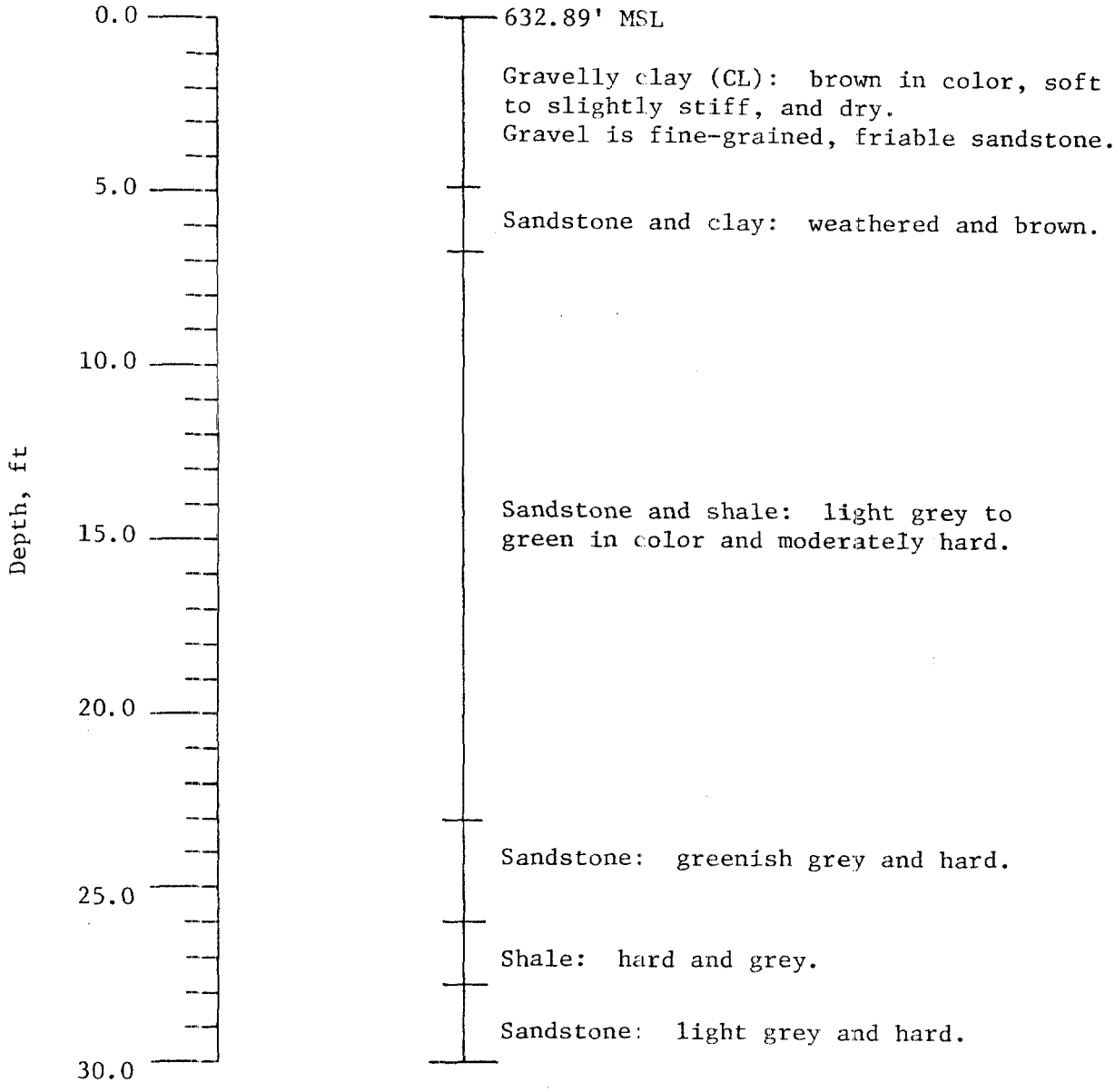
Shale

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-3-81

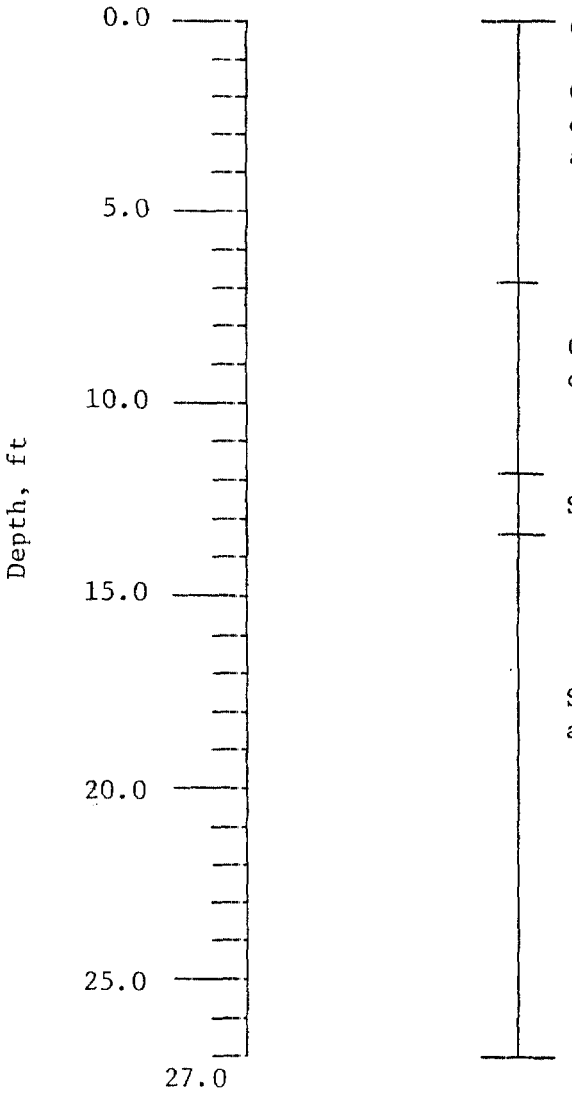



NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-4-81




607.89' MSL

Clay (CL): brown to reddish brown in color, soft to moderately stiff, dry, and contains 20-25% fine gravel.

Clay shale: brown to grey, soft, and dry.

Shale: red.

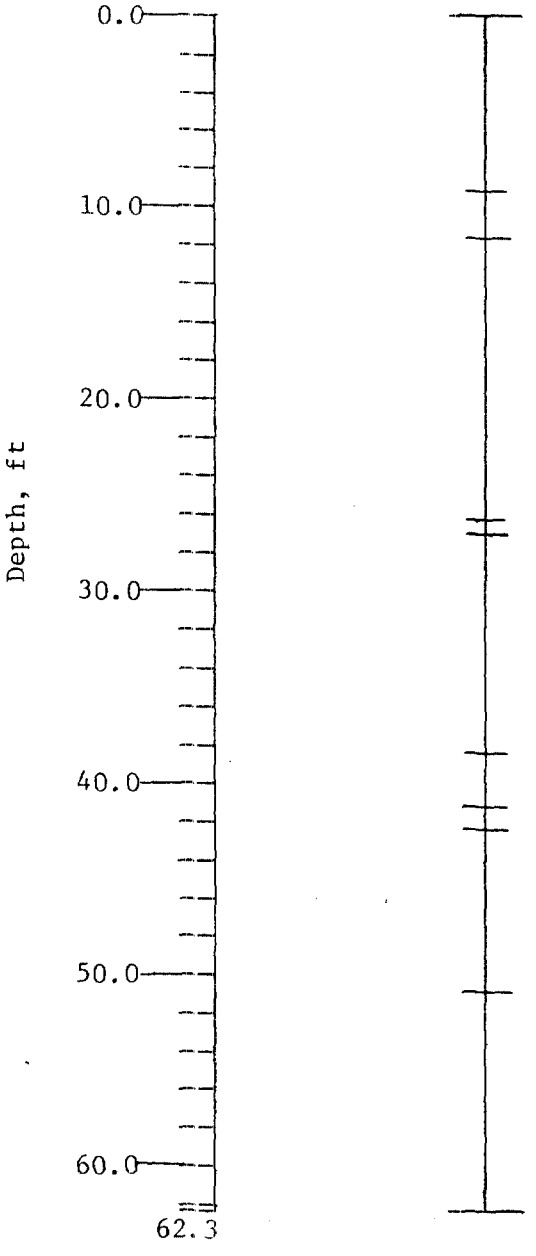
Shale: grey in color and becoming harder at 26 ft.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-5-81




672.06' MSL

Clay (CL): brown in color, stiff, thinly bedded, and dry.

Shale: brown and dark grey, dry, stiff, varied texture, and varied composition.

Shale: medium hard, grey, brown, and reddish brown in color.

Coal: black and medium hard.

Shale: grey to brown and soft.

Sandstone: grey and hard.

Shale: grey and medium hard.

Sandstone: brown to grey and medium hard to hard.

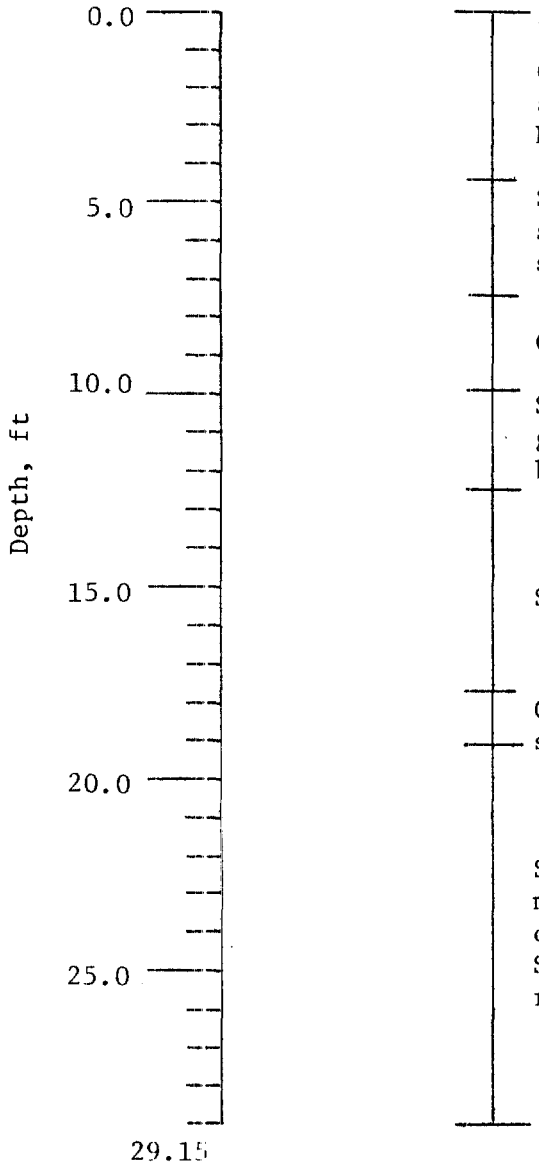
Shale: grey.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-6-81




660.92' MSL

Clay (CL): brown in color, soft to slightly stiff, dry, and low plasticity. Material is dozer fill.

Sandy clay (CL): orange brown in color, soft, dry, and contains 10-20% fine-grained sand.

Clay and weathered sandstone.

Sandstone: brown to orange brown, fine-grained quartz sand, weathered, dry, thinly bedded, and friable.

Shale: black, dry, soft, and uniform.

Coal: black, brilliant luster, brittle, soft, and jointed.

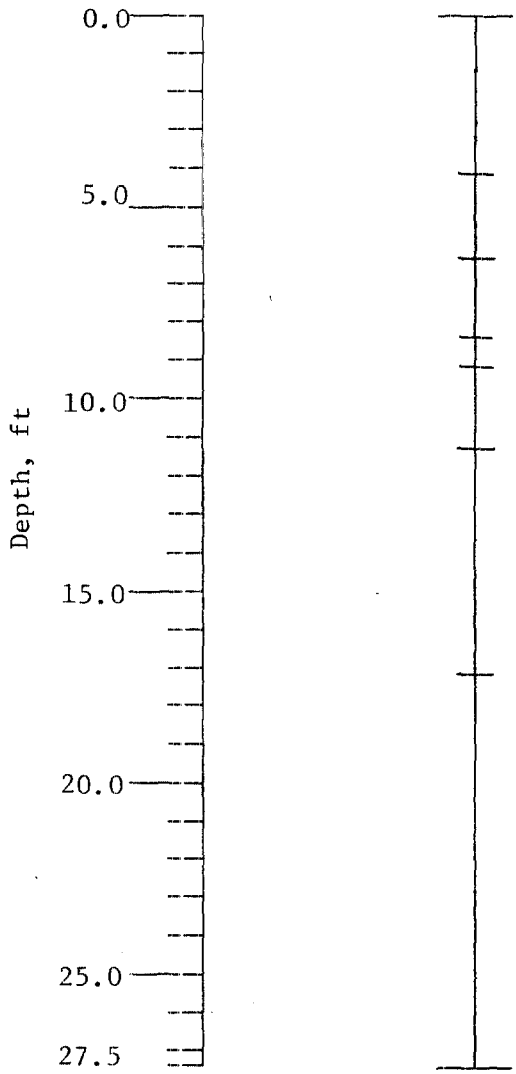
Shaley sandstone: light to dark grey, moderately hard, very fine-grained, and contains 30-40% interbedded dark grey shale. Sandstone and shale are interbedded in irregular seams, lenses, and thin beds.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-7-81




638.72' MSL

Clay (CL): brown in color, soft, low plasticity, and uniform. Material is dozer fill.

Sandstone: brown in color, weathered, very fine-grained, crumbles easily, and dry.

Sandstone: weathered and brown.

Shale: reddish grey and soft.

Sandstone: grey.

Shale: grey and hard.

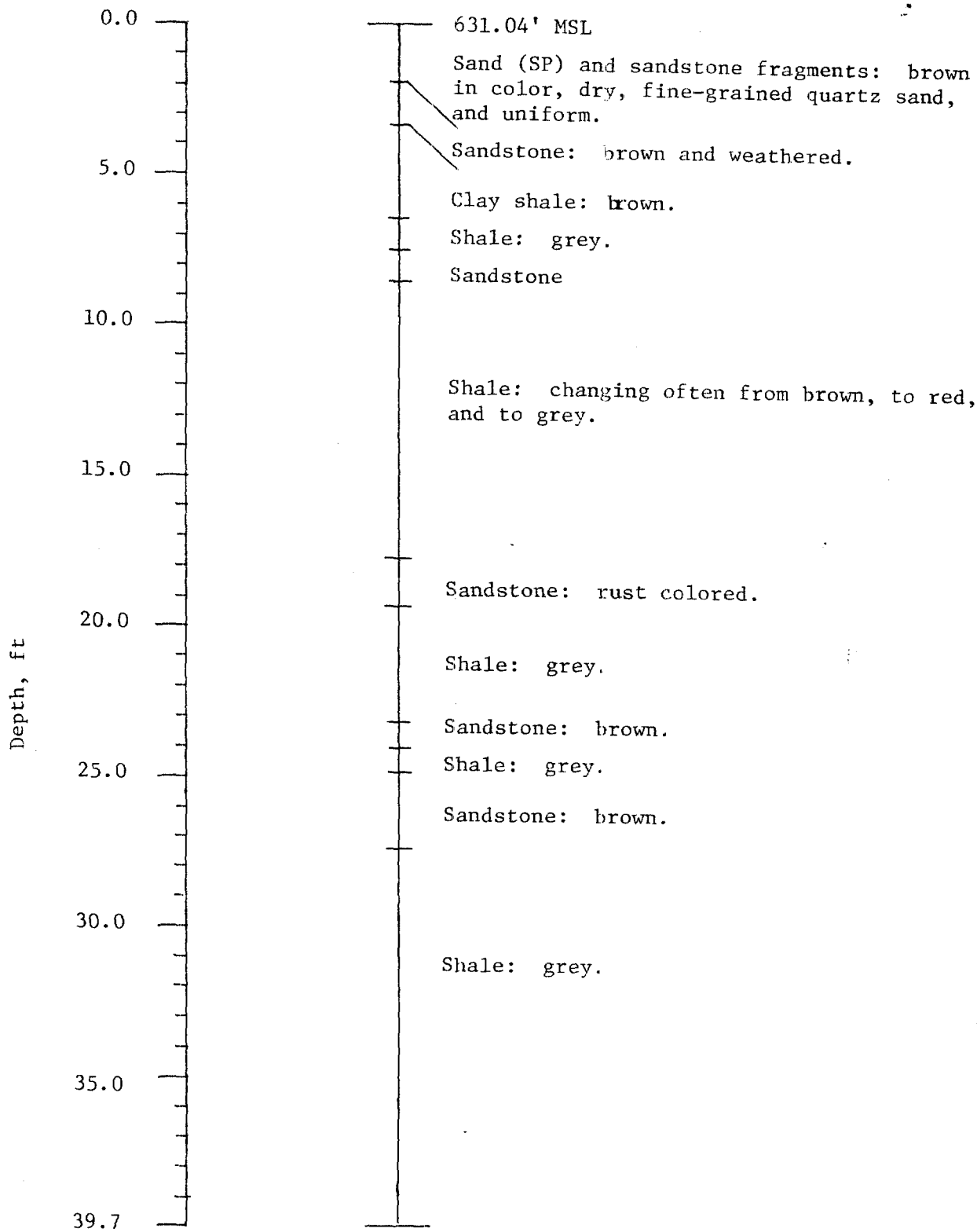
Shale: dark grey and hard.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-8-81

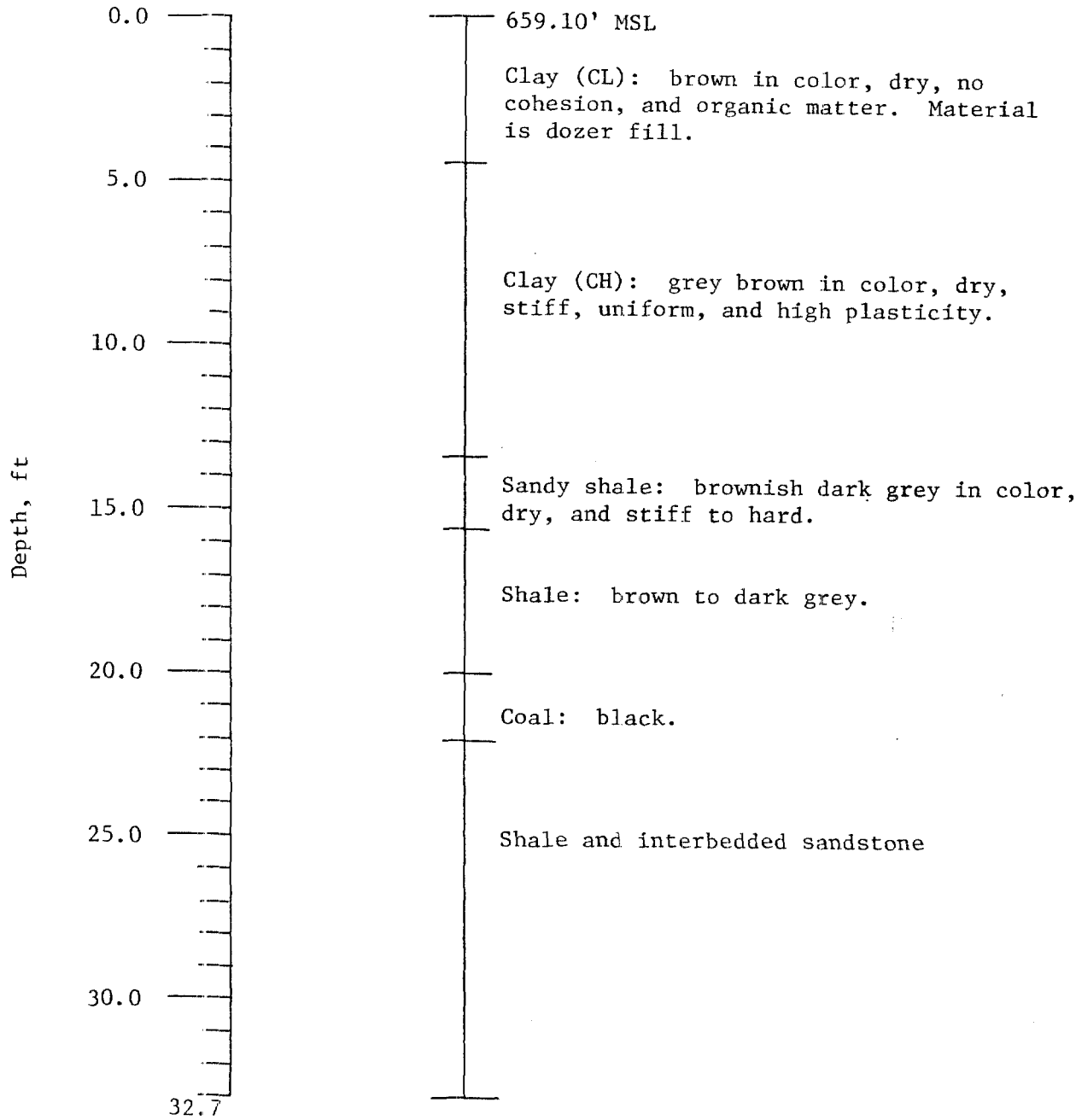



NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-9-81

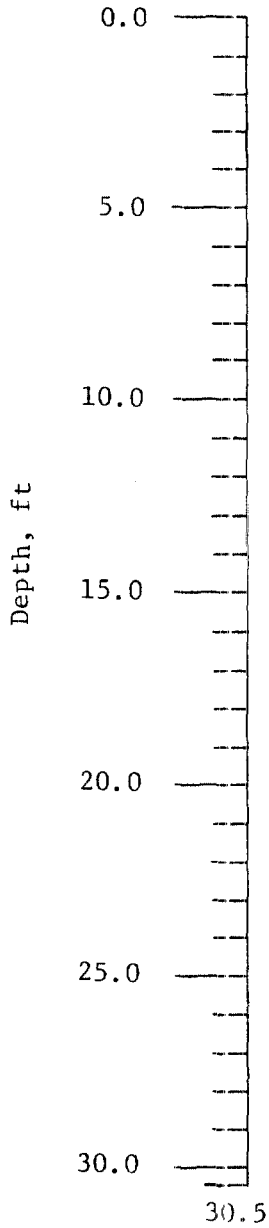



NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-10-81




657.43' MSL

Silty sand (SM): brown in color, dry, no cohesion, and contains 5-10% sandstone gravel.

Clay (CL) and shale: brown in color, low plasticity, dry, and contains 30% hard shale fragments.

Shale: grey.

Coal: black.

Shale: brown and grey mixed.

Shale: light brown.

Limestone: light grey.

Shale: grey.

Shale: dark grey.

Sandstone: brown and hard.

Shale: grey and hard.

Sandstone: hard.

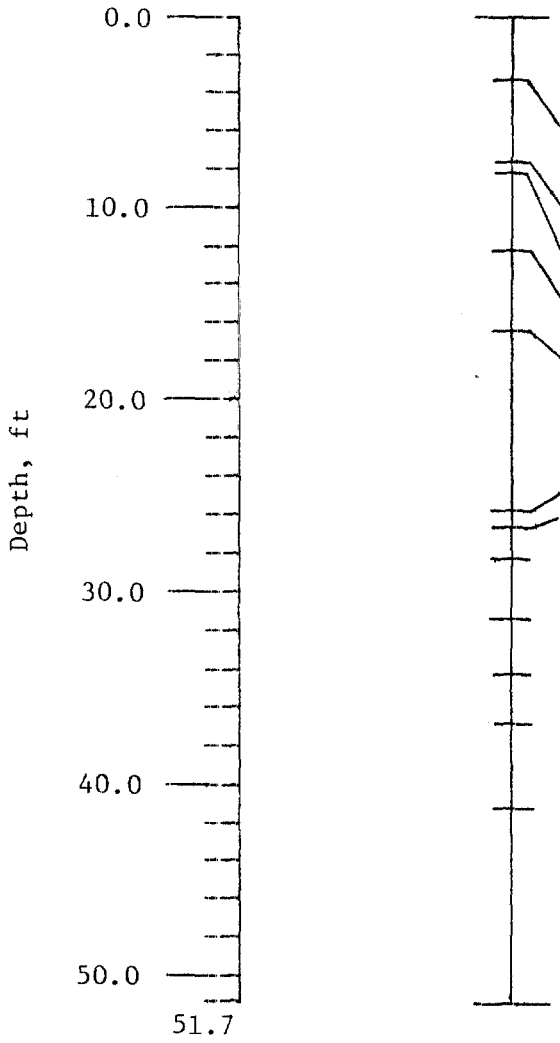
Shale: grey.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-11-81




667.28' MSL

Clay (CH): brown to red in color, slightly moist to dry, soft to stiff, and high plasticity.

Clay shale: brown to grey brown in color, dry, and stiff.

Coal: black.

Sandstone: light grey and medium hard.

Shale: dark grey.

Sandstone: light brown.

Shale: dark grey and hard.

Sandstone: brown.

Shale: dark grey.

Sandstone: grey and hard.

Shale: light grey.

Sandstone: light grey.

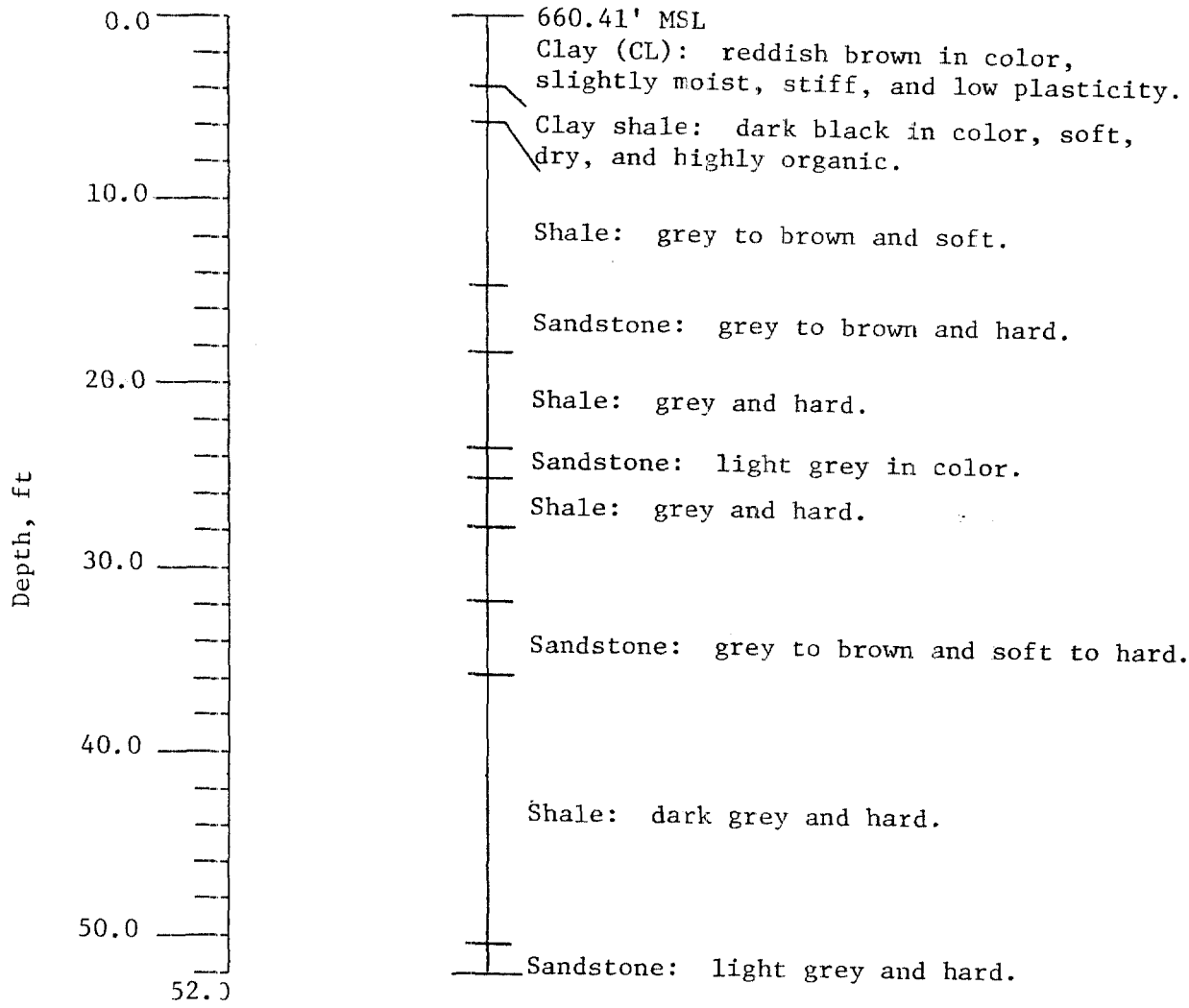
Shale: grey.

NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-12-81

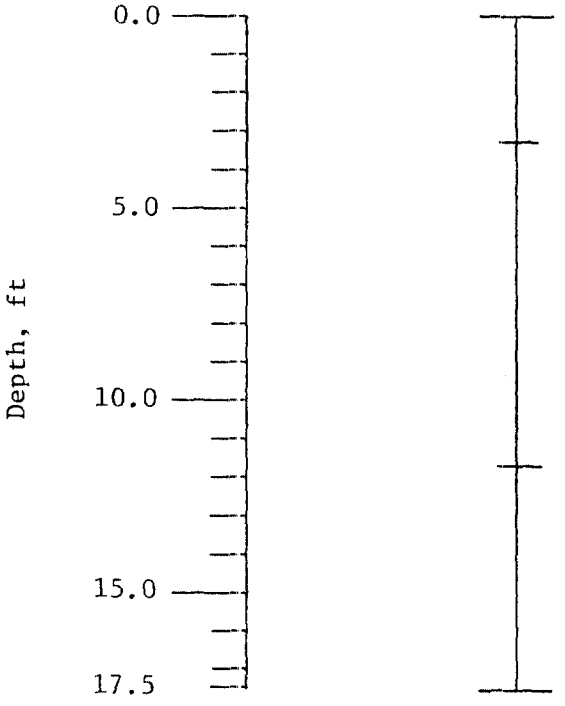



NWSC, Crane, Indiana

Demolition Area

Lithology

Boring Number: WES-6-13-81




505.06' MSL

Sandy clay (CL) and sandstone gravel: brown in color, moist, and low plasticity.

Sandy clay (CL): grey to brown in color, moist, and low plasticity.

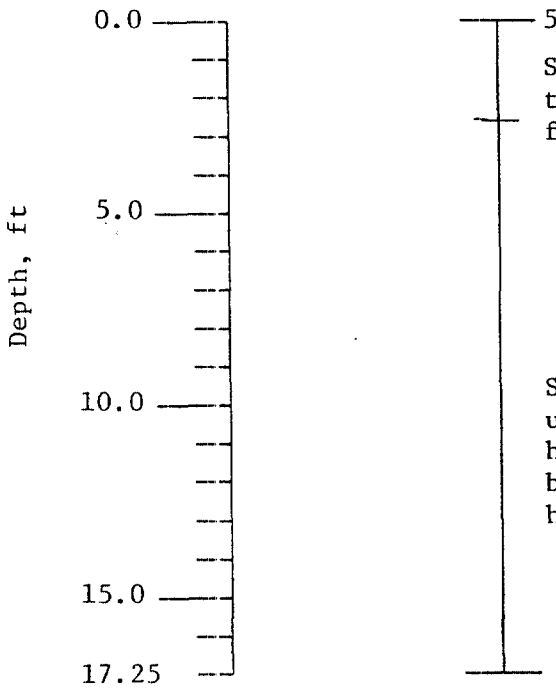
Clay (CH): dark grey in color, uniform, soft, and high plasticity.

NWSC, Crane, Indiana

Old Rifle Range

Lithology

Boring Number: WES-6-14-81




510.42' MSL

Sand (SP) and sandstone fragments: brown to orange brown in color, very fine to fine-grained, and dry.

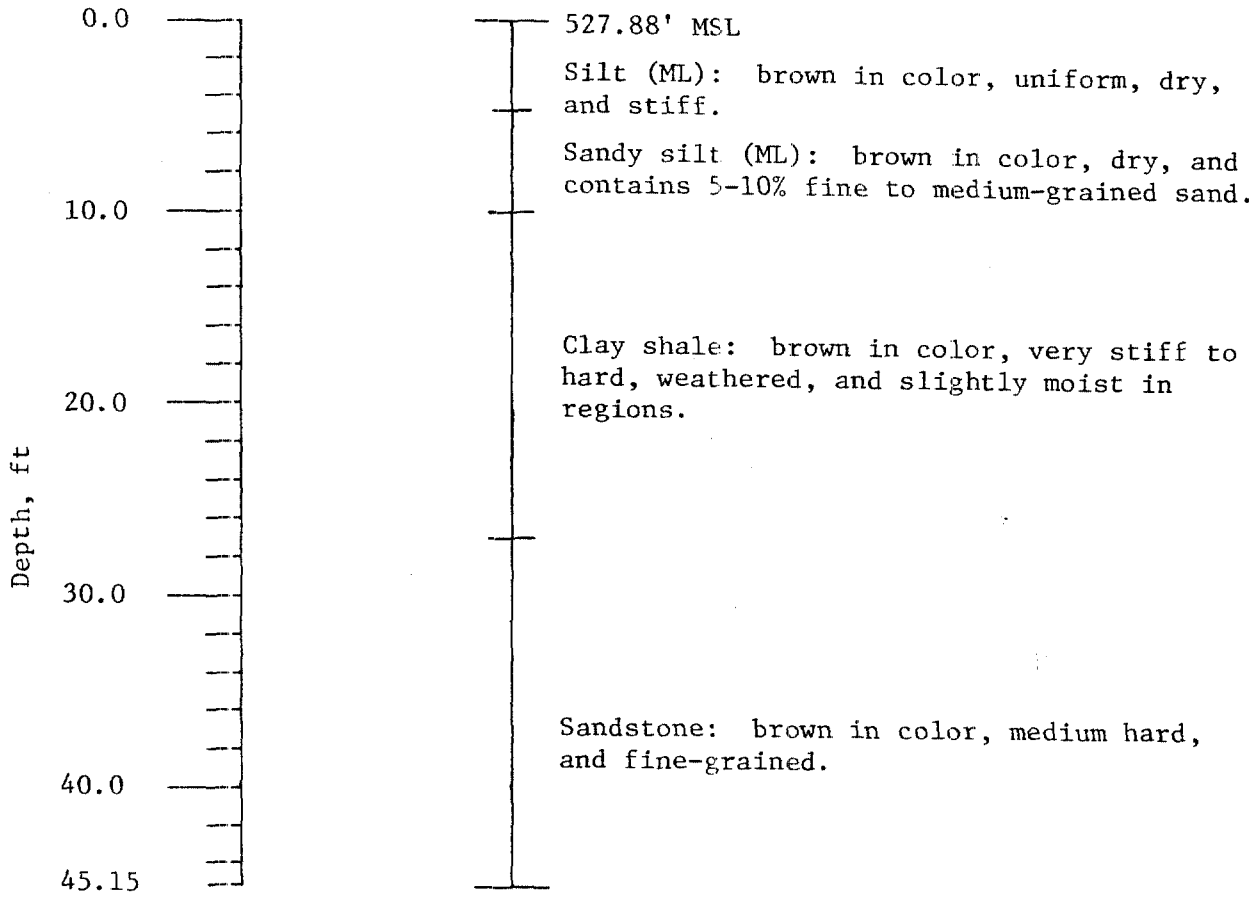
Sandstone: brown to rusty brown in color, uniform, fine-grained quartz sand, moderately hard and oxidized. Bedding ranges from thinly bedded to around one foot maximum and nearly horizontal in attitude.

NWSC, Crane, Indiana

Old Rifle Range

Lithology

Boring Number: WES-6-15-81

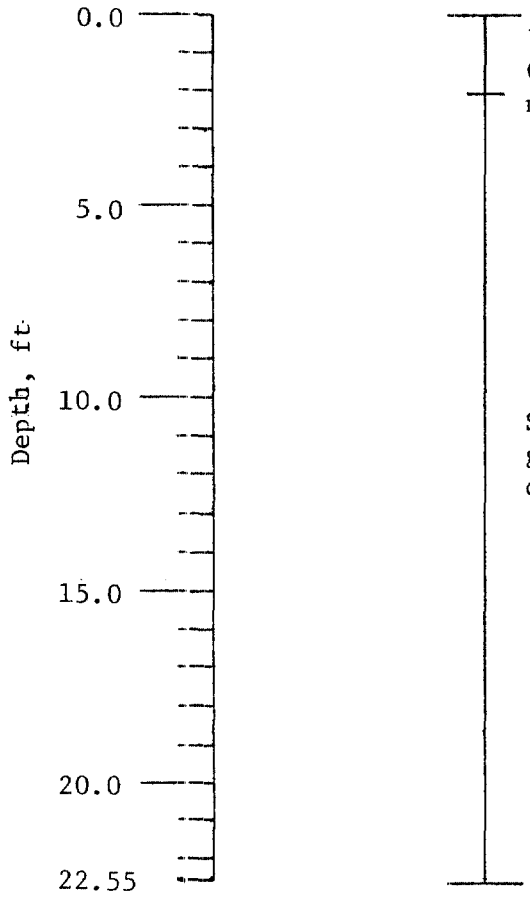



NWSC, Crane, Indiana

Old Rifle Range

Lithology

Boring Number: WES-6-16-81




510.73' MSL

Clay (CL): brown in color, soft, slightly moist, and low plasticity.

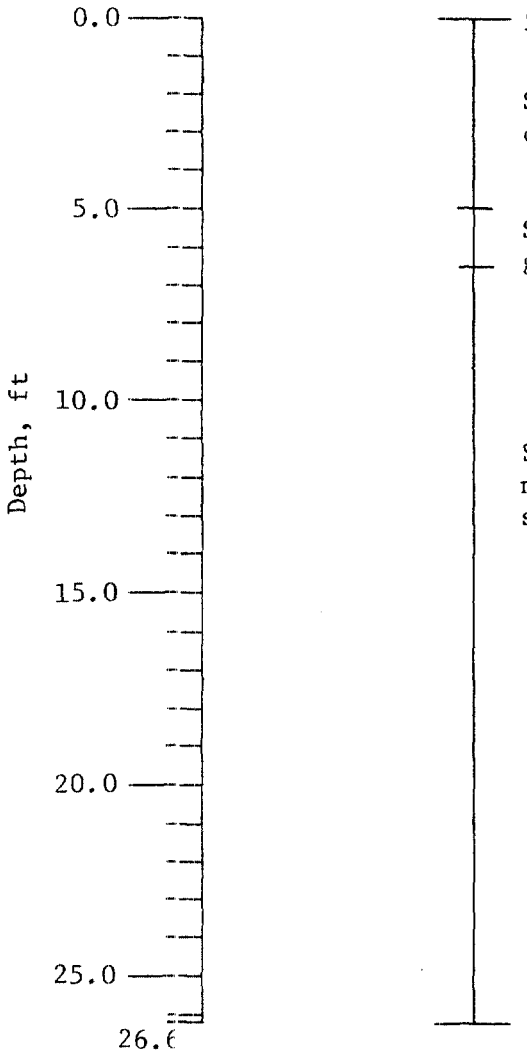
Sandstone: brown in color, uniform, fine-grained quartz sand, medium hard, and oxidized in regions.

NWSC, Crane, Indiana

Old Burning Grounds

Lithology

Boring Number: WES-6-17-81




508.03' MSL

Silty sand (SM): brown to rusty brown in color, fine-grained, and little cohesion.

Sand (SP): brown in color, uniform, fine-grained quartz sand, and slightly moist.

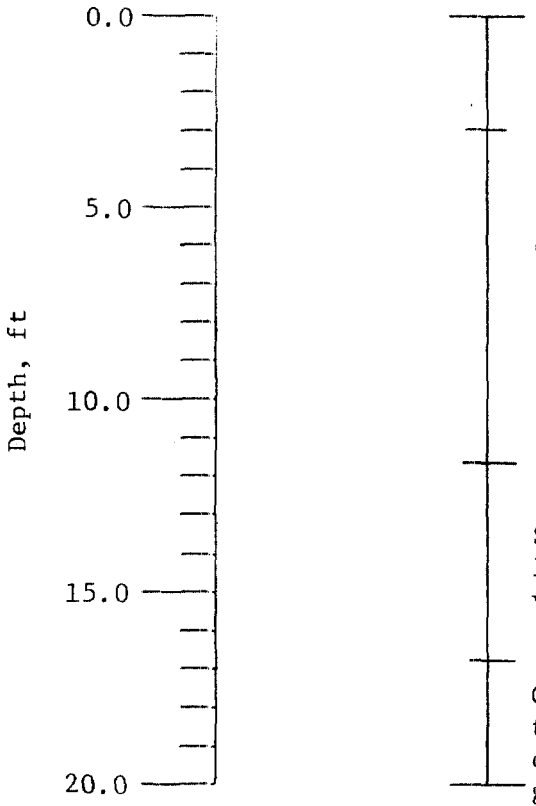
Sandstone: brown, weathered, fine-grained, medium hard to hard, and contains clay or shale lenses from 10 to 11.5 ft .

NWSC, Crane, Indiana

Old Rifle Range

Lithology

Boring Number: WES-6-18-81




503.42' MSL

Fill

Clay (CH): grey with streaks of brown, soft, and high plasticity.

Sandy clay (CL): dark grey in color, soft, low to medium plasticity, and contains 20% very fine-grained sand.

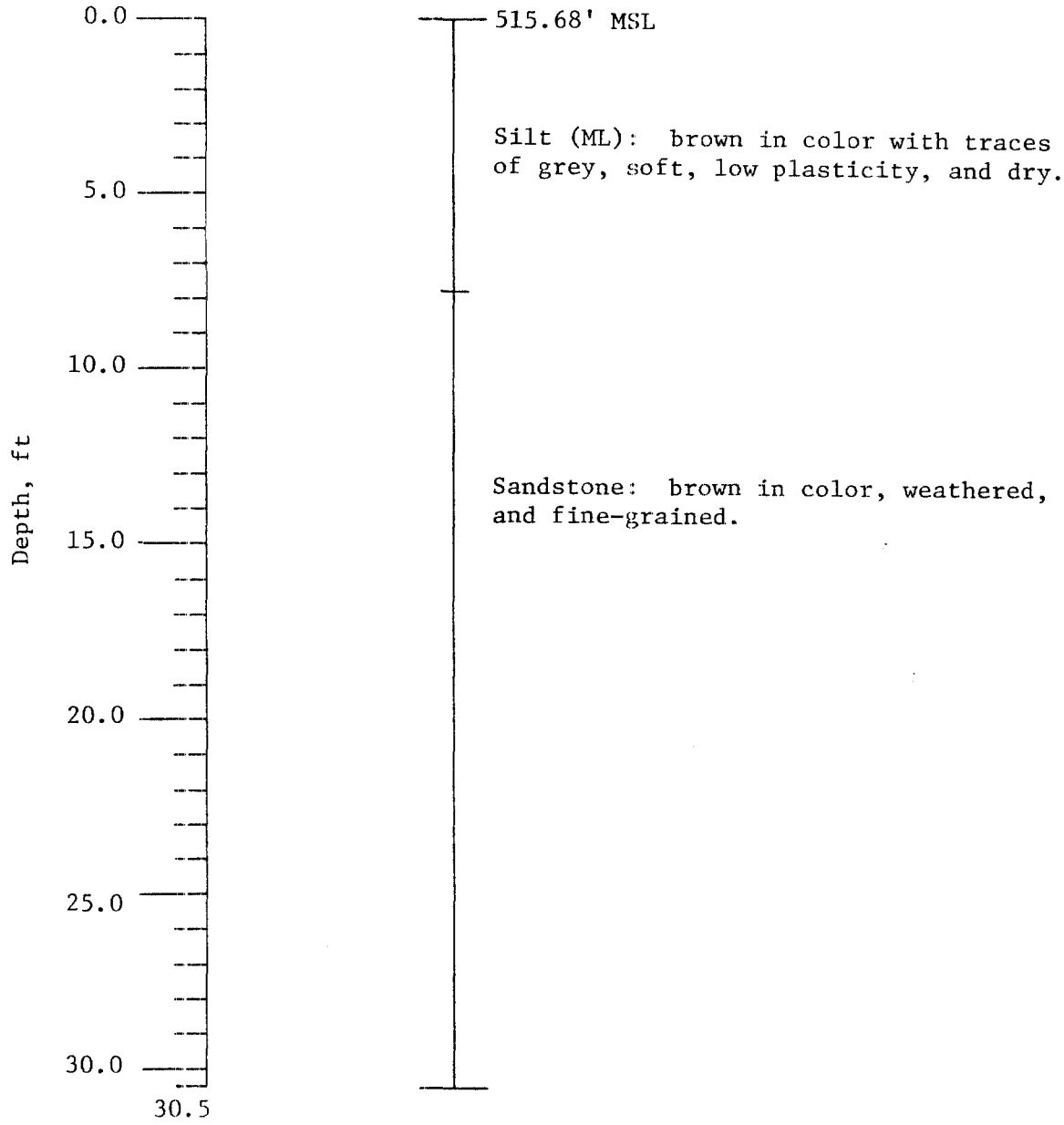
Gravelly clay (CL): brown to grey with traces of red and green, soft, low plasticity, and contains fine to medium sized gravel.

NWSC, Crane, Indiana

Old Burning Grounds

Lithology

Boring Number: WES-6-19-81

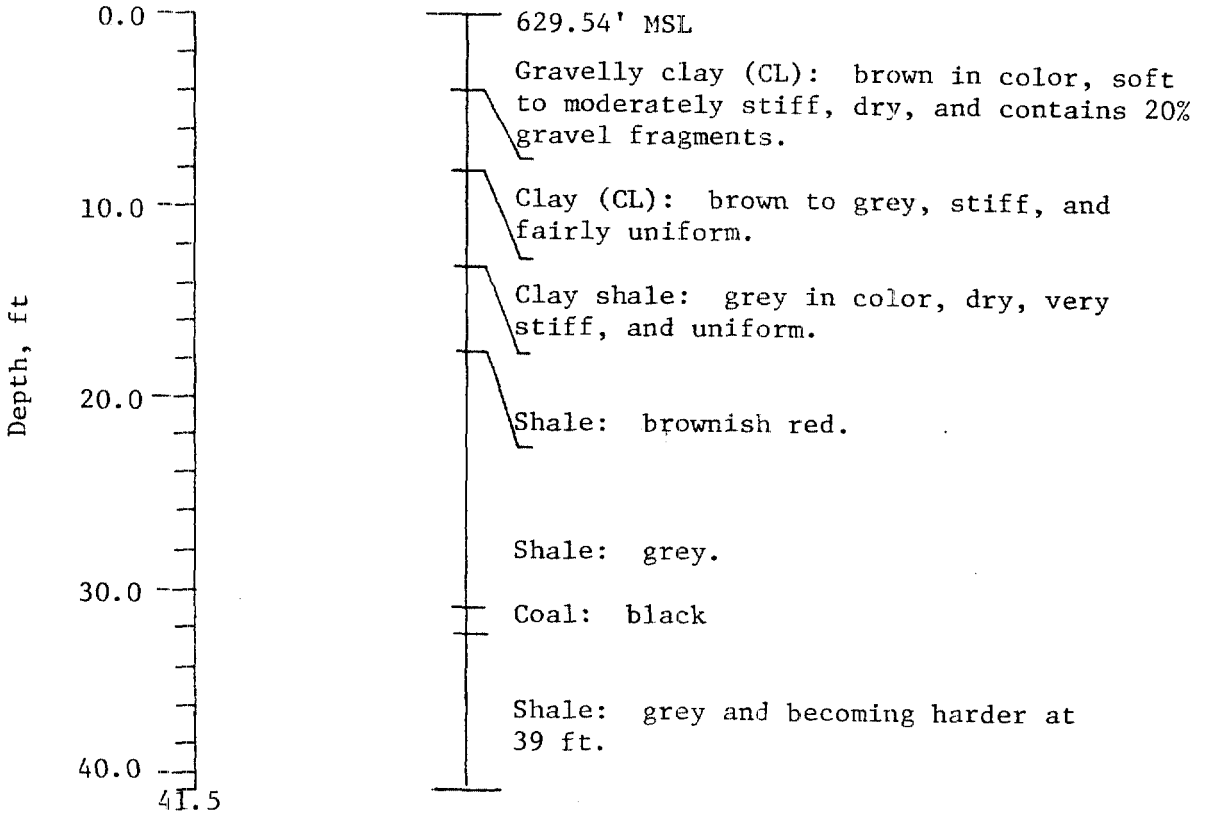



NWSC, Crane, Indiana

Old Rifle Range

Lithology

Boring Number: WES-6-20-81

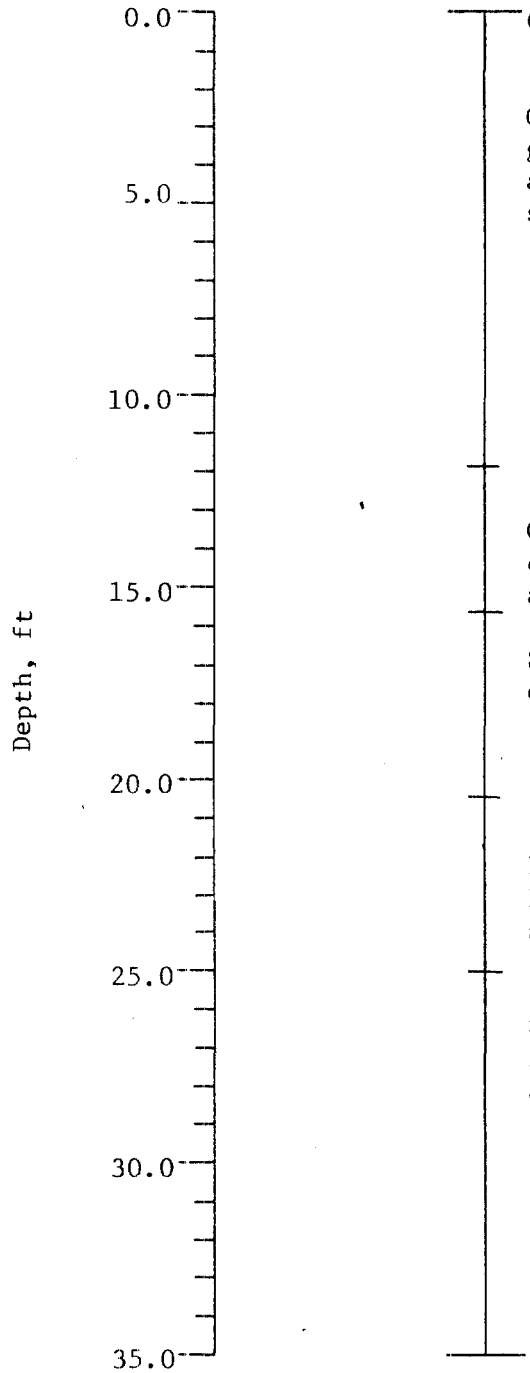



NWSC, Crane, Indiana

Highway 58 Dump Site A

Lithology

Boring Number: WES-7-1-81




601.89' MSL

Gravelly clay (CL): brown to brownish grey in color, dry, stiff to very stiff, and contains 10-15% fine to medium sandstone gravel.

Gravelly clay shale: reddish brown in color, dry, very stiff, dense, weathered, and contains 20-30% fine to medium gravel.

Shale: brown to orange brown with zones of dark grey, soft, dry, and weathered.

Interbedded sandstone (50%) and shale (50%): light grey to dark grey and very soft to soft.

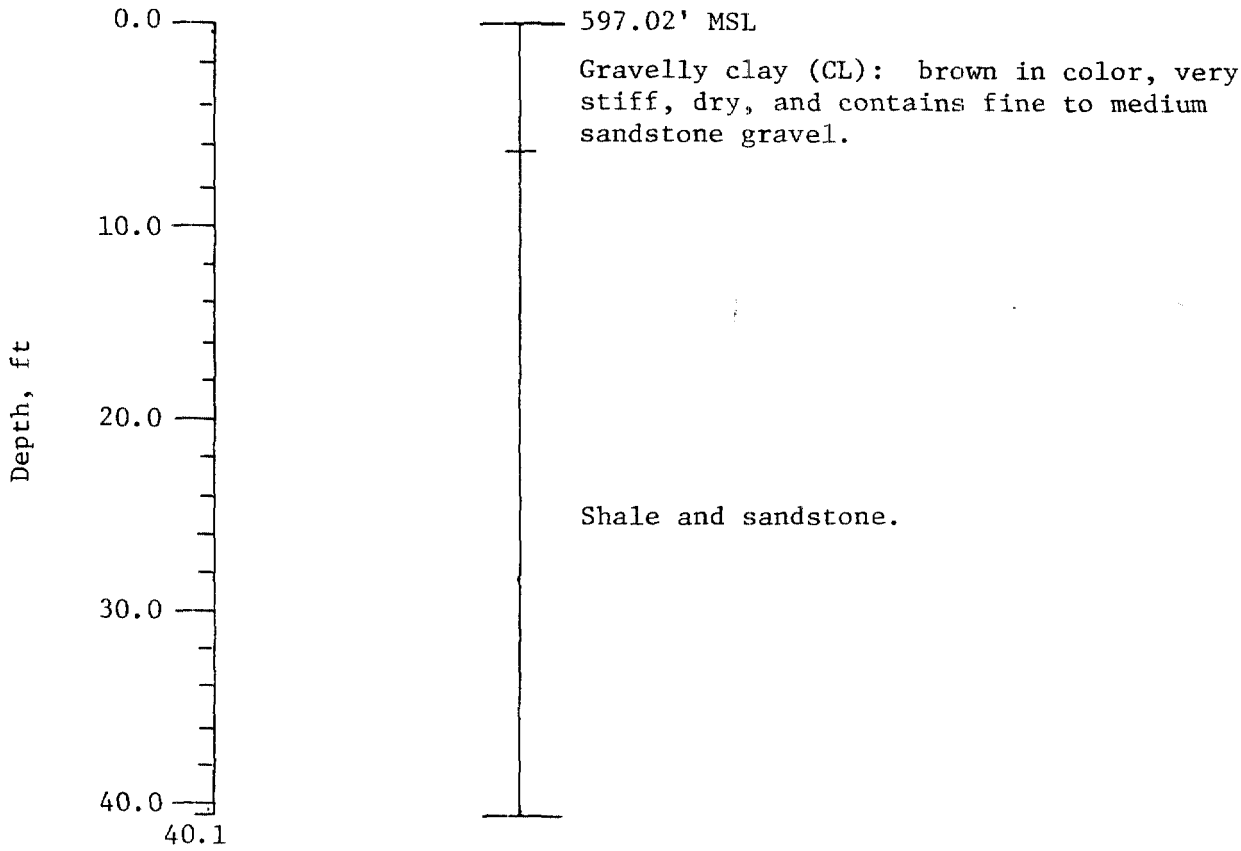
Sandstone (80%) and interbedded shale (20%): light grey to dark grey, soft to very soft, and contains 1-3% coal lenses.

NWSC, Crane, Indiana

Highway 58 Dump Site A

Lithology

Boring Number: WES-7-2-81

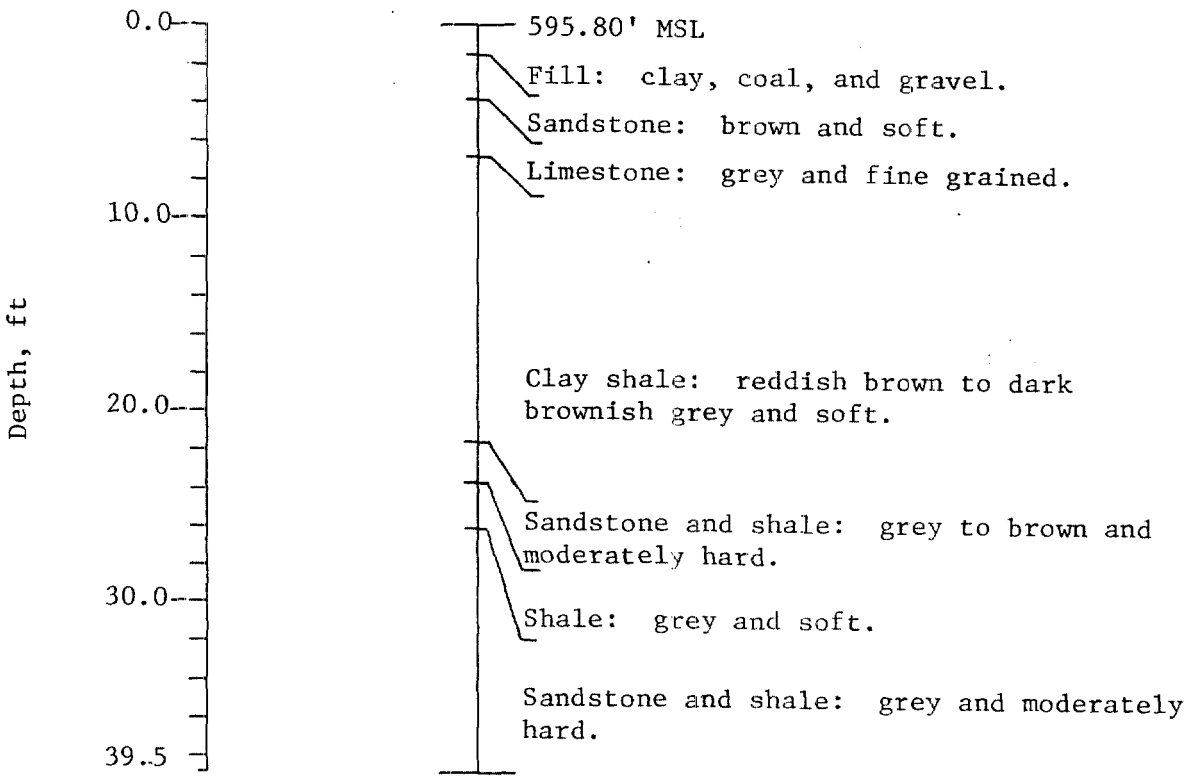



NWSC, Crane, Indiana

Highway 58 Dump Site A

Lithology

Boring Number: WES-7-3-81

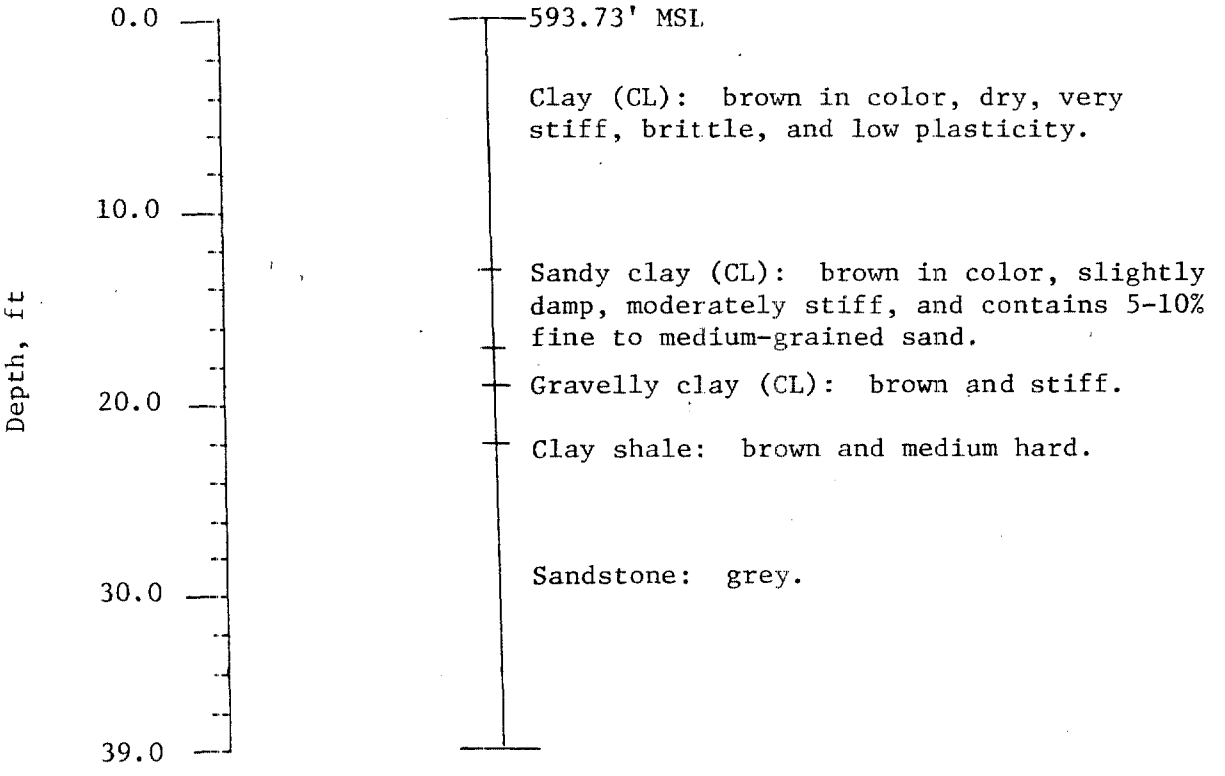



NWSC, Crane, Indiana

Highway 58 Dump Site A

Lithology

Boring Number: WES-7-4-81

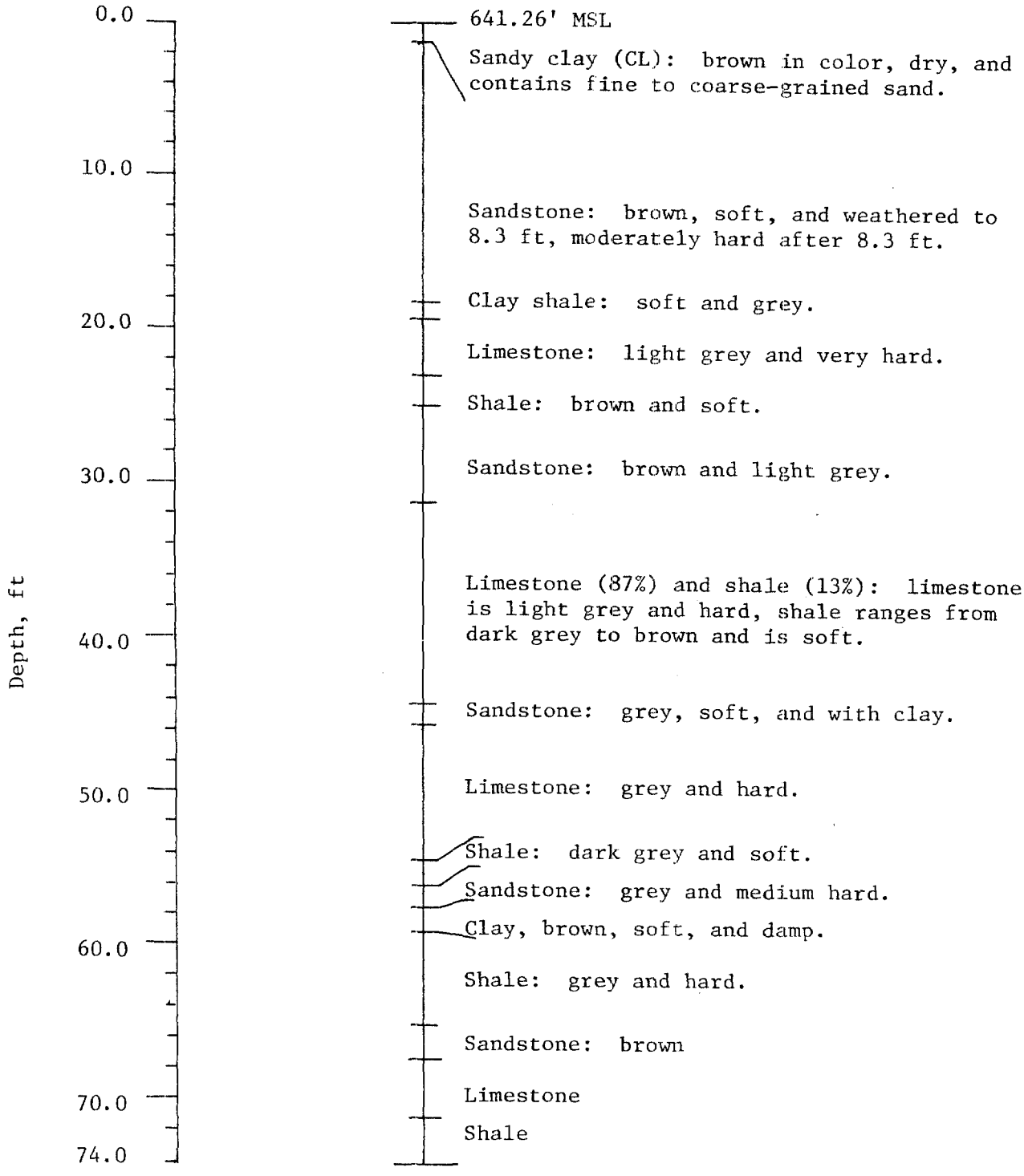



NWSC, Crane, Indiana

Highway 58 Dump Site A

Lithology

Boring Number: WES-7-5-81

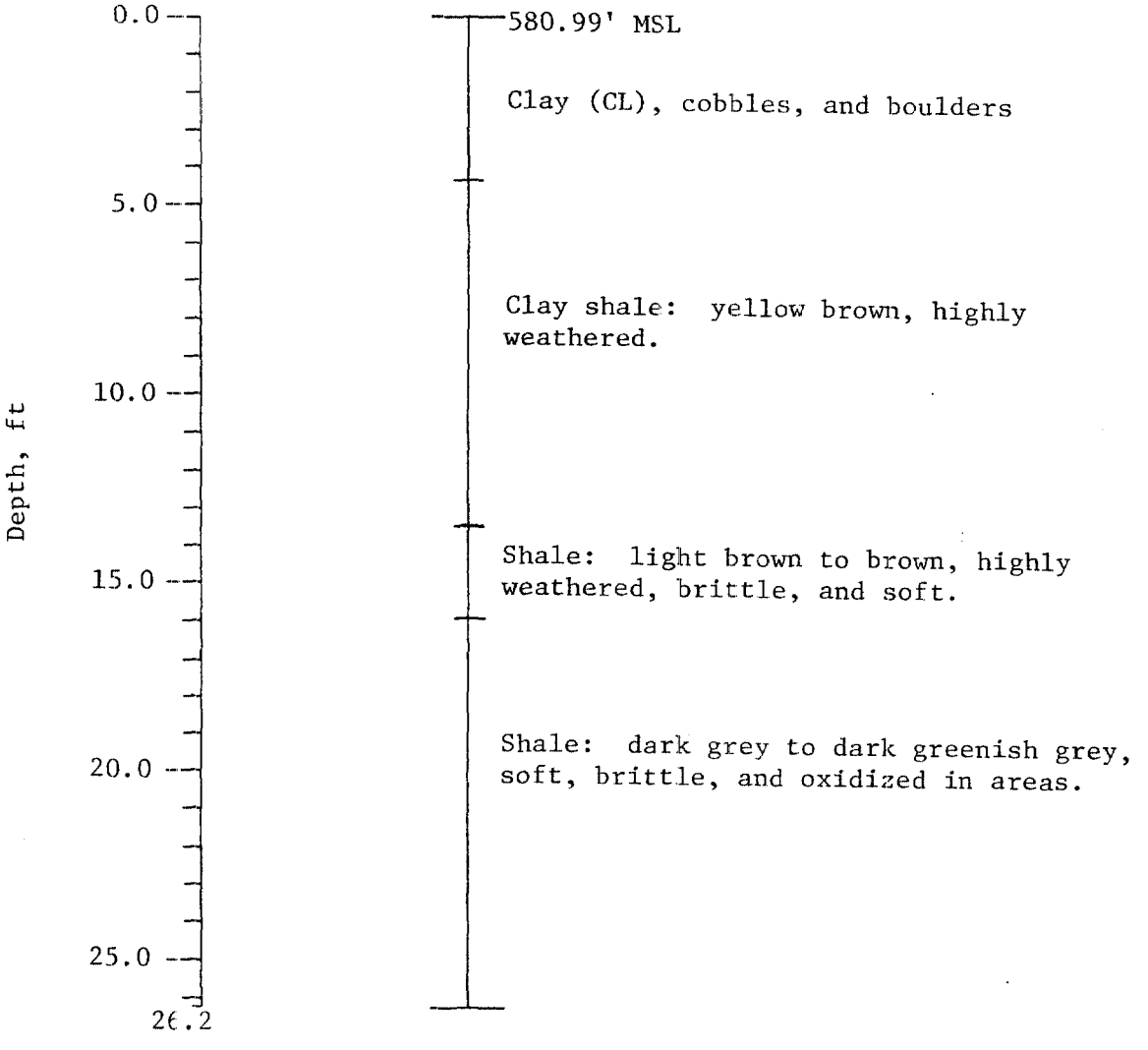



NWSC, Crane, Indiana

Highway 58 Dump Site B

Lithology

Boring Number: WES-8-1-81

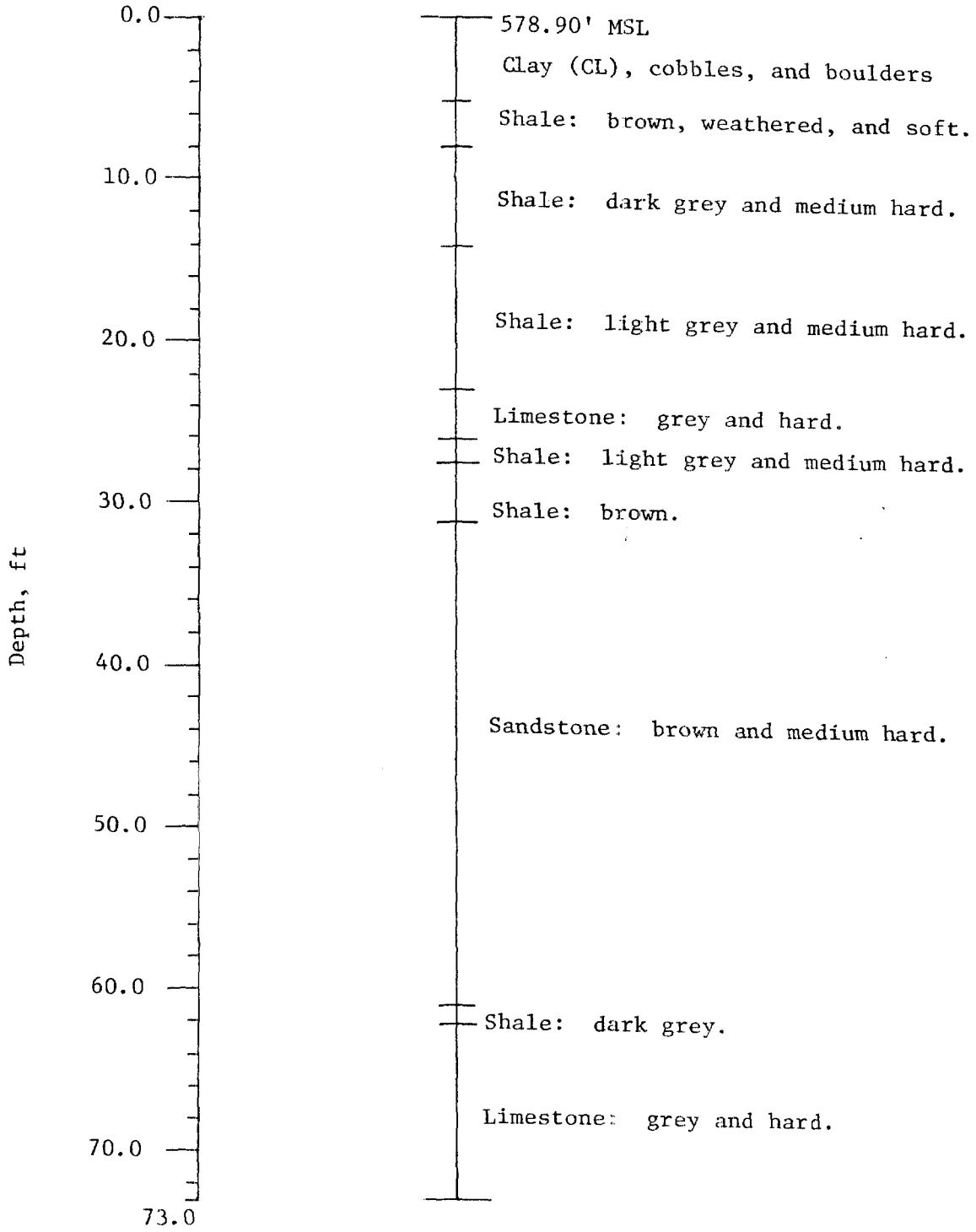



NWSC, Crane, Indiana

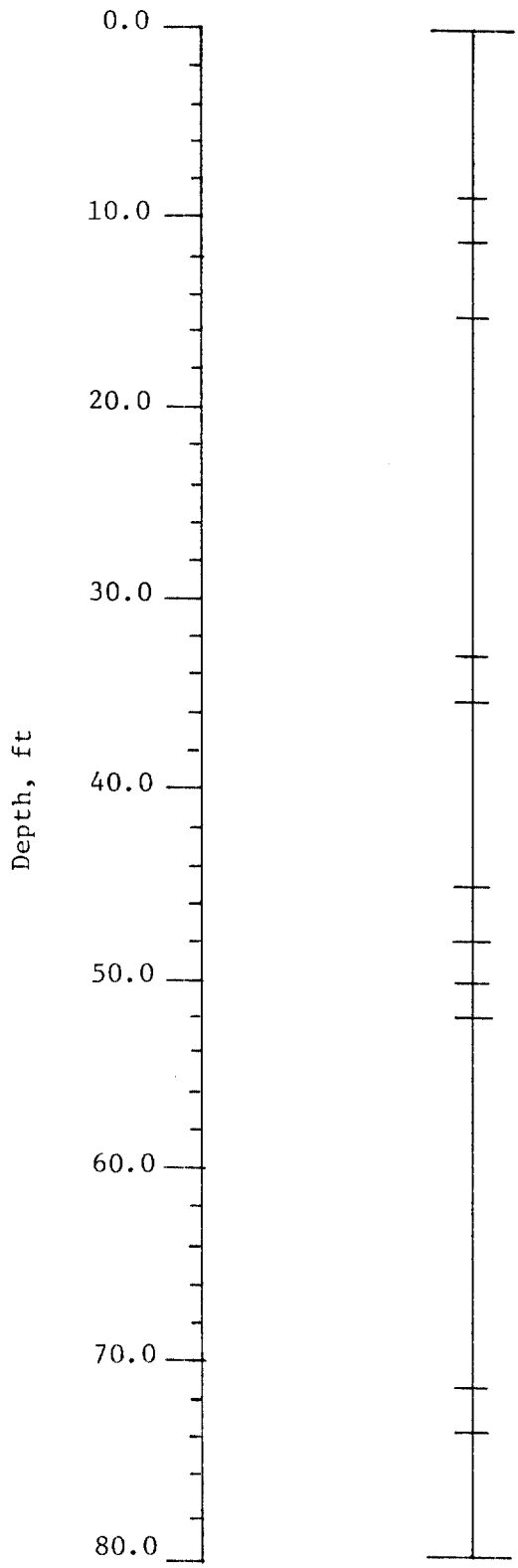
Highway 58 Dump Site B

Lithology

Boring Number: WES-8-2-81




NWSC, Crane, Indiana
Highway 58 Dump Site B
Lithology
Boring Number: WES-8-3-81




583.66' MSL

Gravelly clay (CL): brown, soft, low plasticity, and contains 25-30% limestone and sandstone fragments.

Clay (CL), gravel, cobbles, and boulders.

Sandy clay shale: red and soft.

Sandy clay shale: brown and soft.

Limestone: grey and hard.

Sandstone: brown and hard.

Shale: grey.

Sandstone: hard and brown.

Shale: grey and hard.

Sandstone: brown and hard.

Shale: grey and hard.

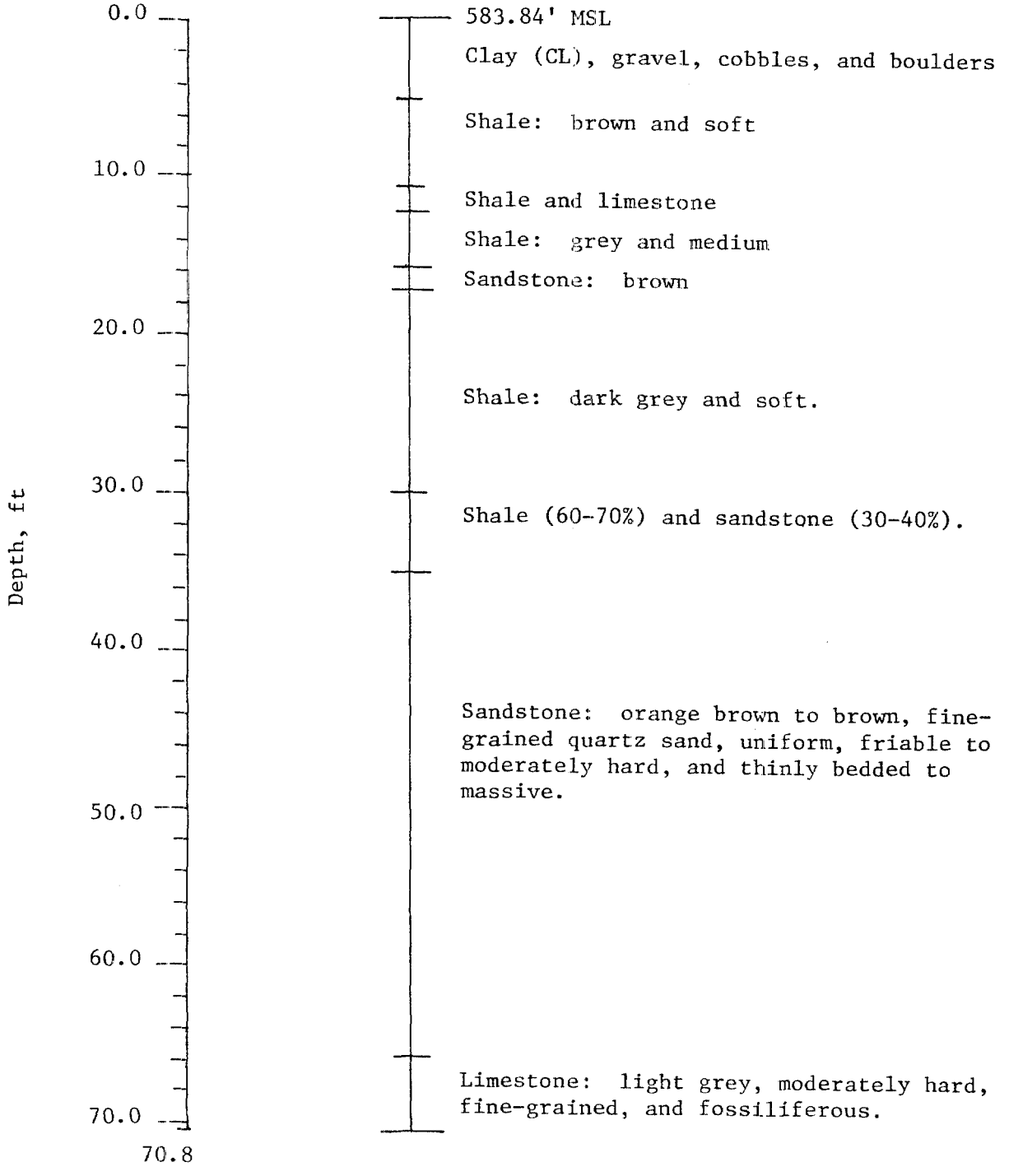
Limestone: grey and hard.

NWSC, Crane, Indiana

Highway 58 Dump Site B

Lithology

Boring Number: WES-8-4-81

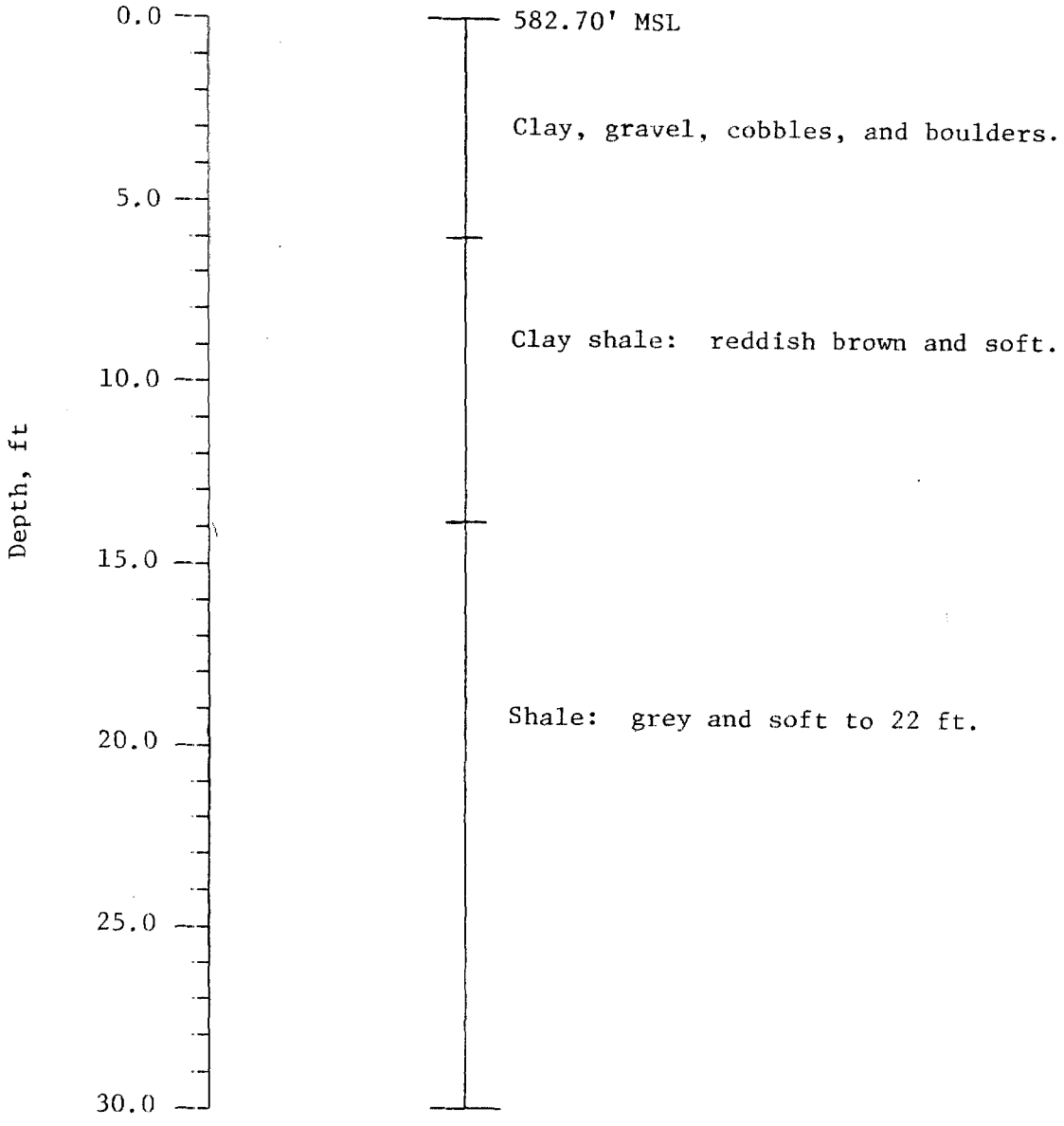



NWSC, Crane, Indiana

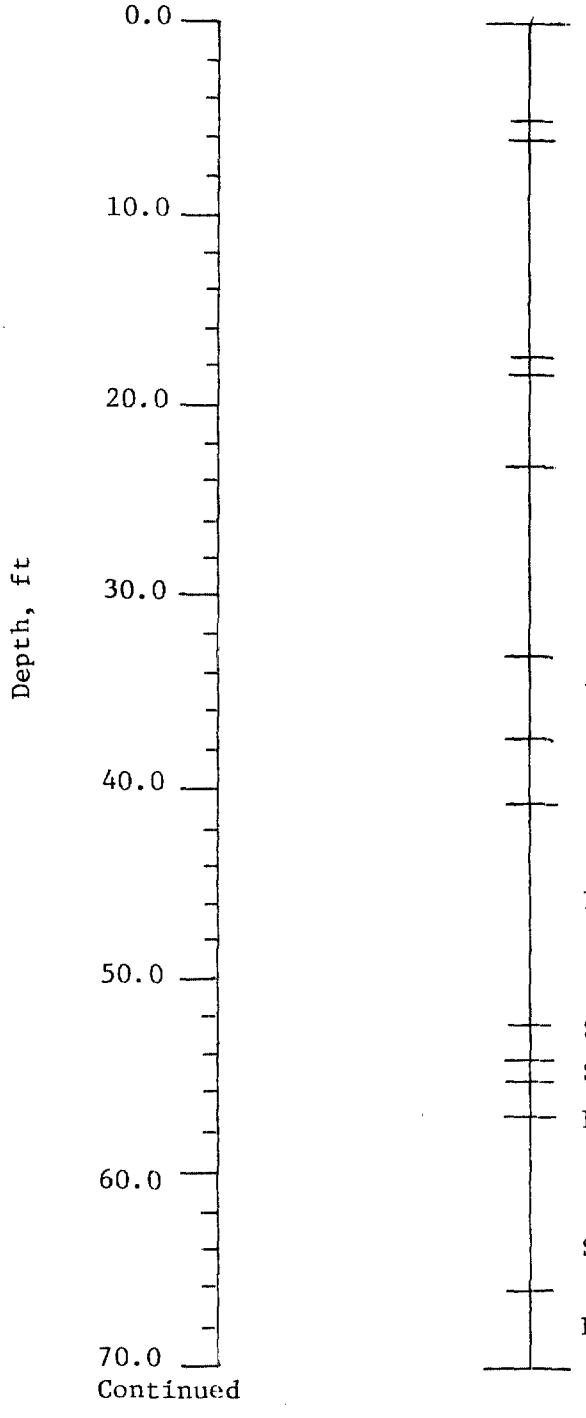
Highway 58 Dump Site B

Lithology

Boring Number: WES-8-5-81




NWSC, Crane, Indiana
Highway 58 Dump Site B
Lithology
Boring Number: WES-8-6-81




640.75' MSL

Sandstone: brown, hard, and fine-grained.

Shale: gray and medium.

Sandstone: brown and medium.

Clay shale: red in color.

Limestone: light grey and hard.

Sandstone: hard and brown.

Limestone: light grey and hard.

Sandstone: hard.

Limestone: light grey and medium hard.

Sandstone: hard.

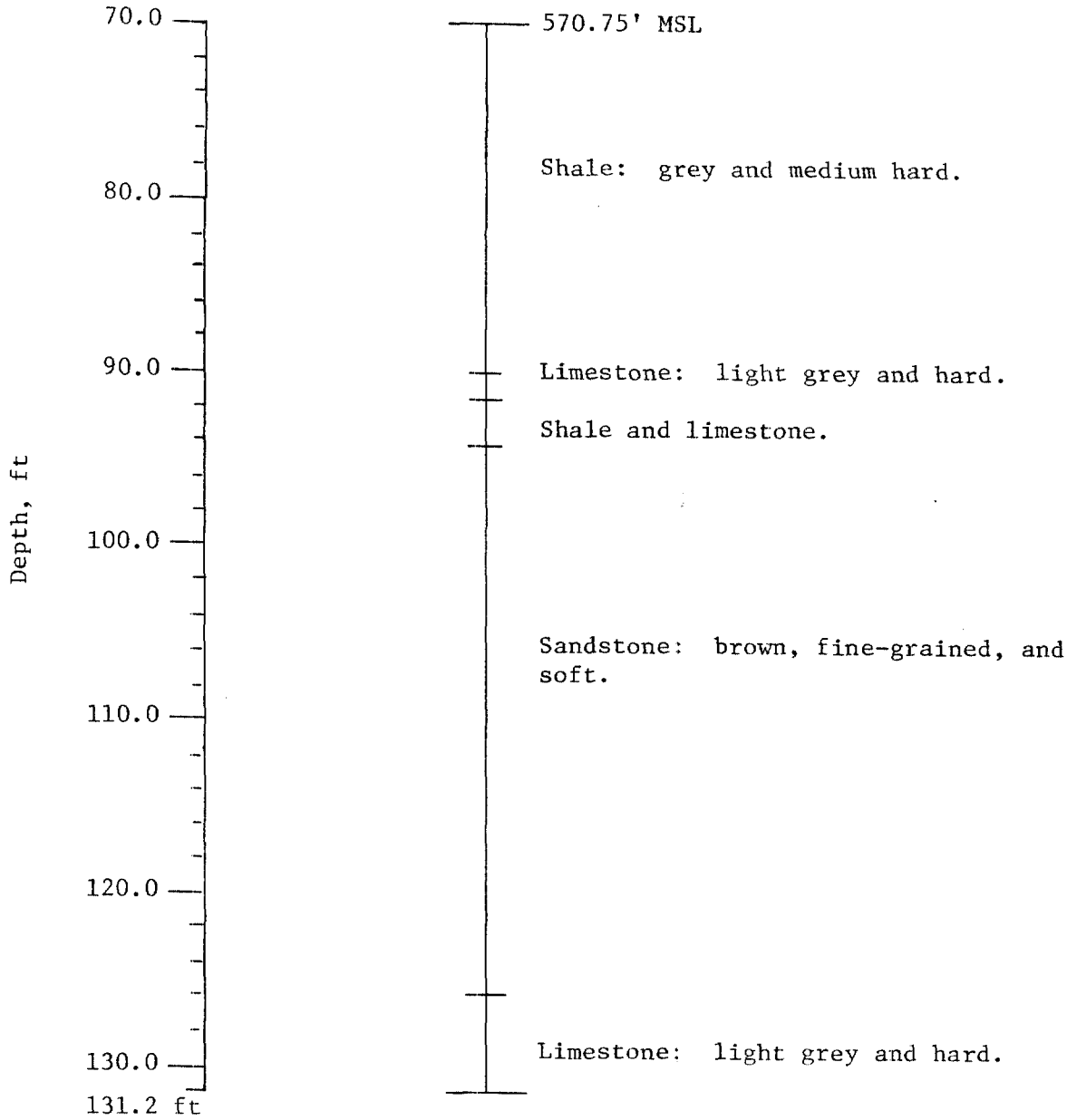
Shale: grey and medium.

Limestone: light grey and very hard.

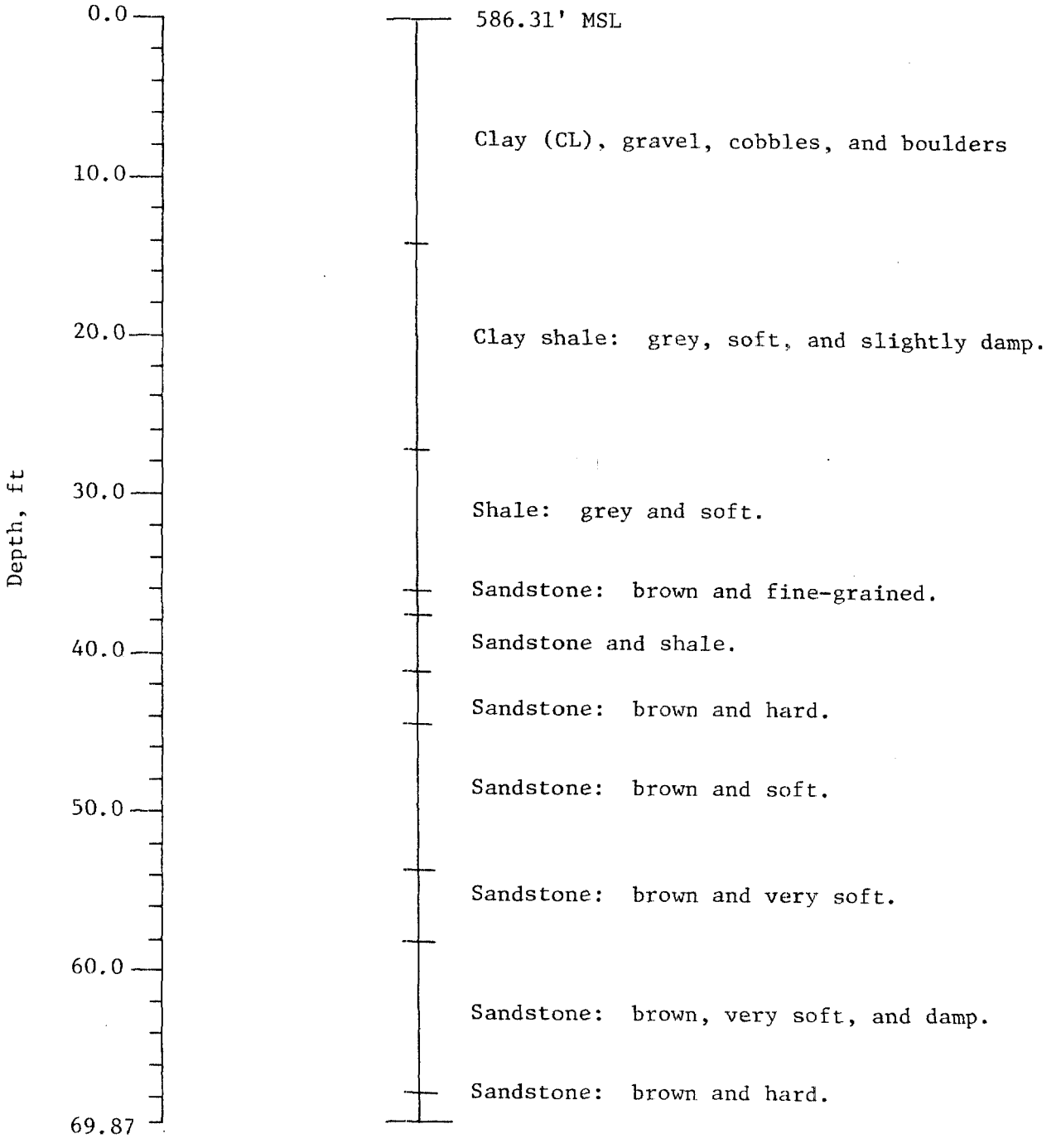
Shale and sandstone.

Limestone: grey and hard.

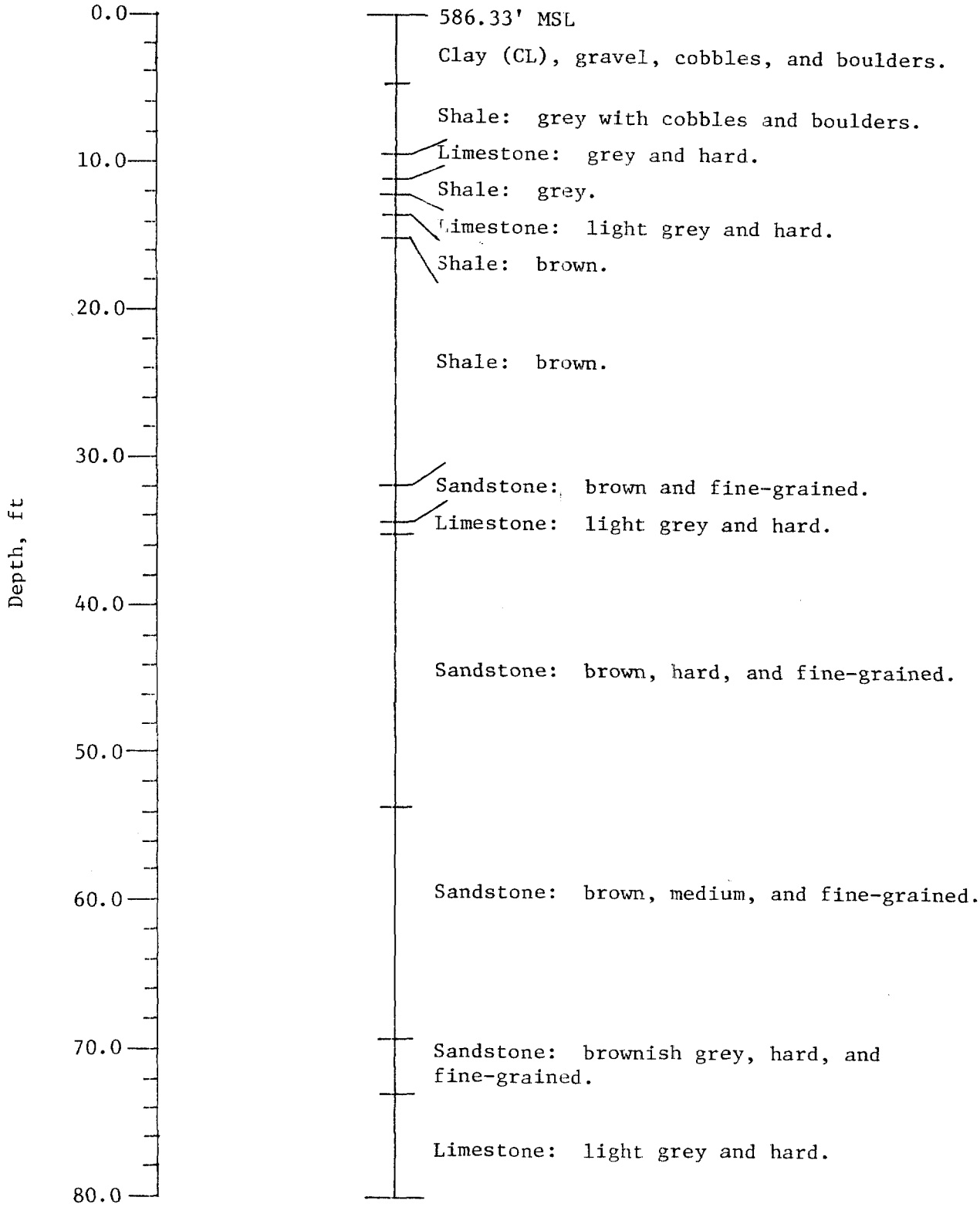
NWSC, Crane, Indiana
Highway 58 Dump Site B
Lithology
Boring Number: WES-8-7-81




NWSC, Crane, Indiana
Highway 58 Dump Site B
Lithology
Boring Number: WES-8-7-81




NWSC, Crane, Indiana
Highway 58 Dump Site B
Lithology
Boring Number: WES-8-8-81

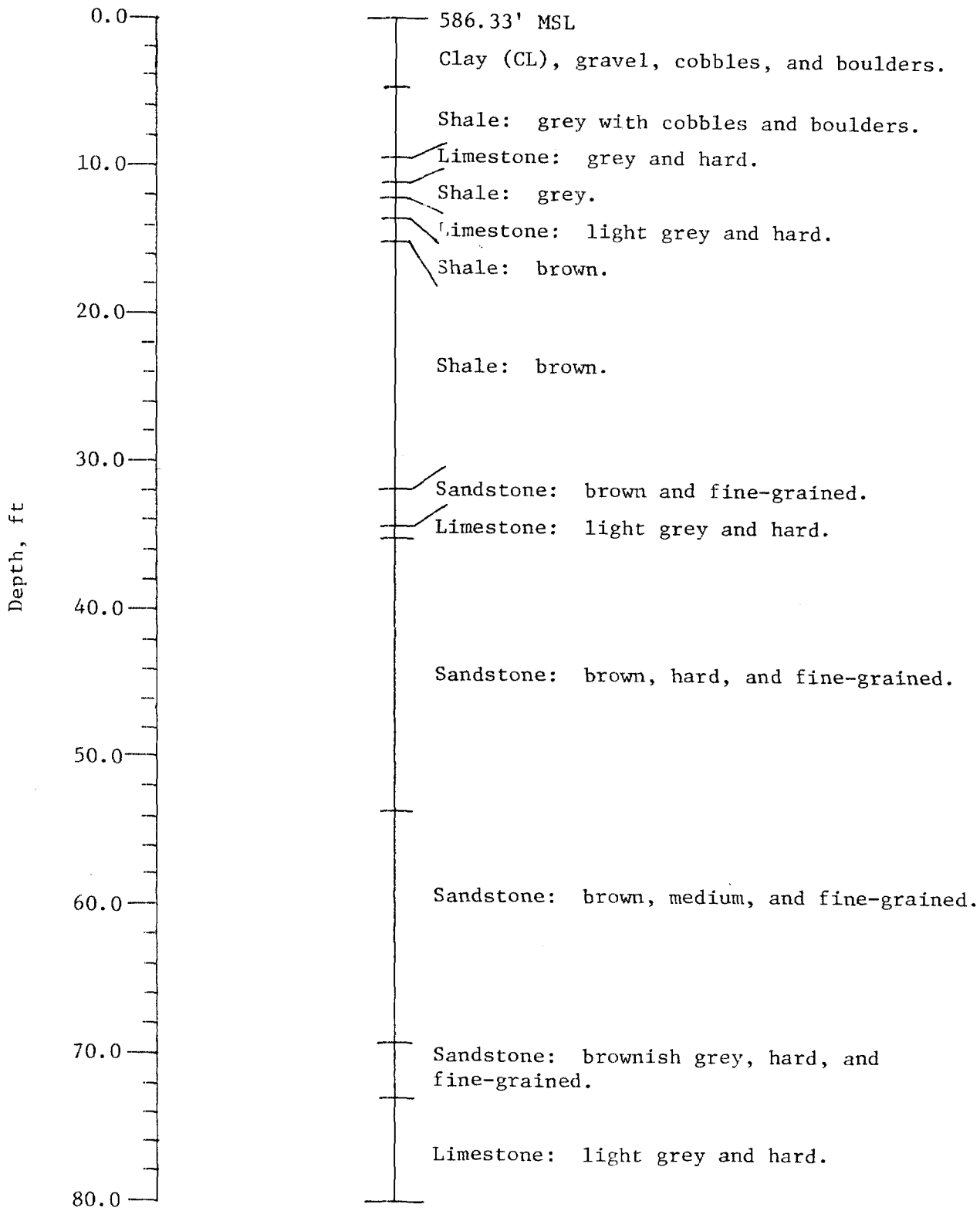



NWSC, Crane, Indiana

Highway 58 Dump Site B

Lithology

Boring Number: WES-8-9-81

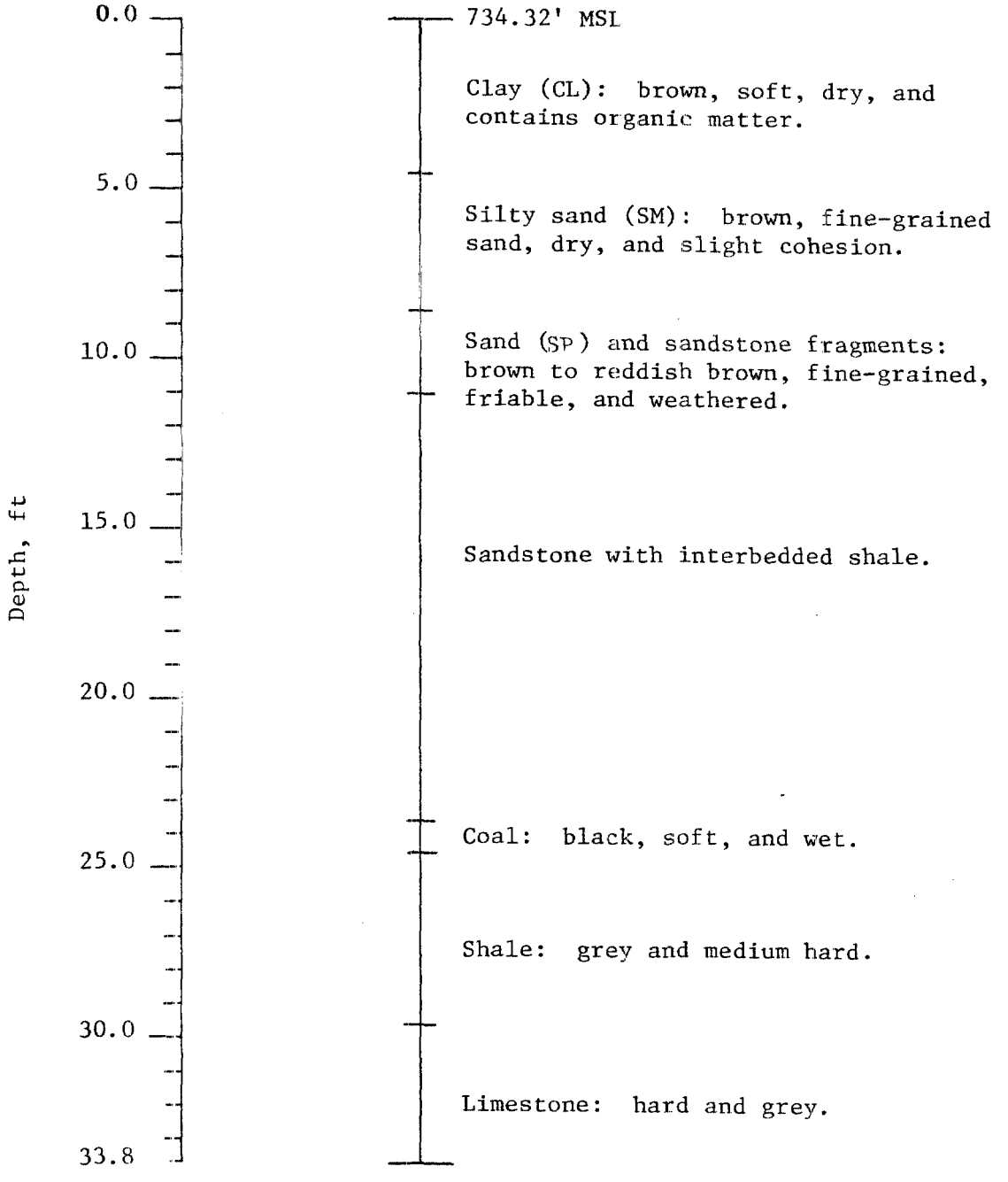



NWSC, Crane, Indiana

Highway 58 Dump Site B

Lithology

Boring Number: WES-8-9-81

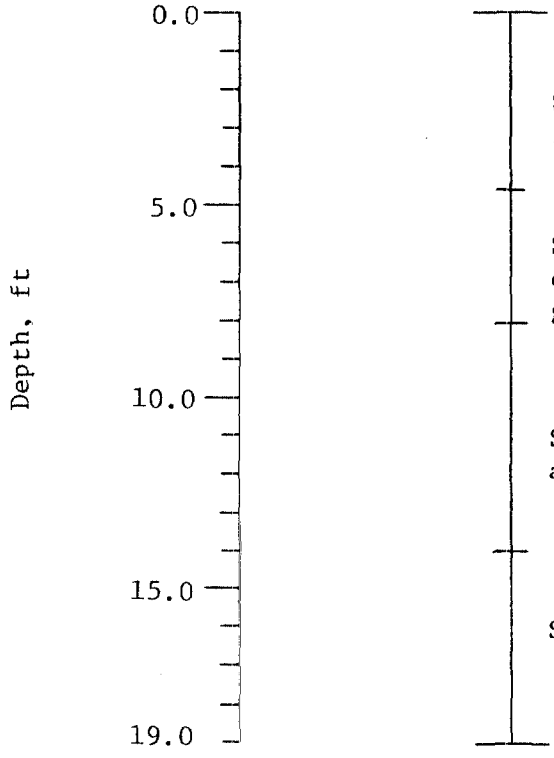



NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-1-81




723.80' MSL

Sand (SW): brown in color, dry, and fine to coarse grained.

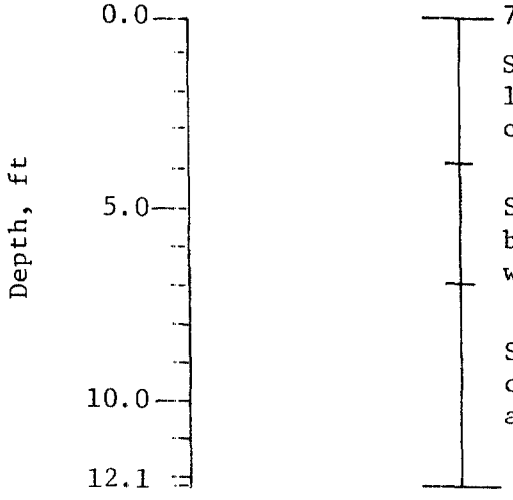
Sandy clay (CL): brown in color, slight cohesion, and contains 20% fine to medium grained sand.

Sandy clay: grey to dark grey in color and wet.

Sandstone.

NWSC, Crane, Indiana

Pest Control Area
Lithology
Boring Number: WES-9-2-81




706.78' MSL

Sandy clay (CL): brown in color, dry, low plasticity, and contains fine to coarse-grained sand.

Sand (SP) and sandstone fragments: brown to white, fine-grained, and weathered.

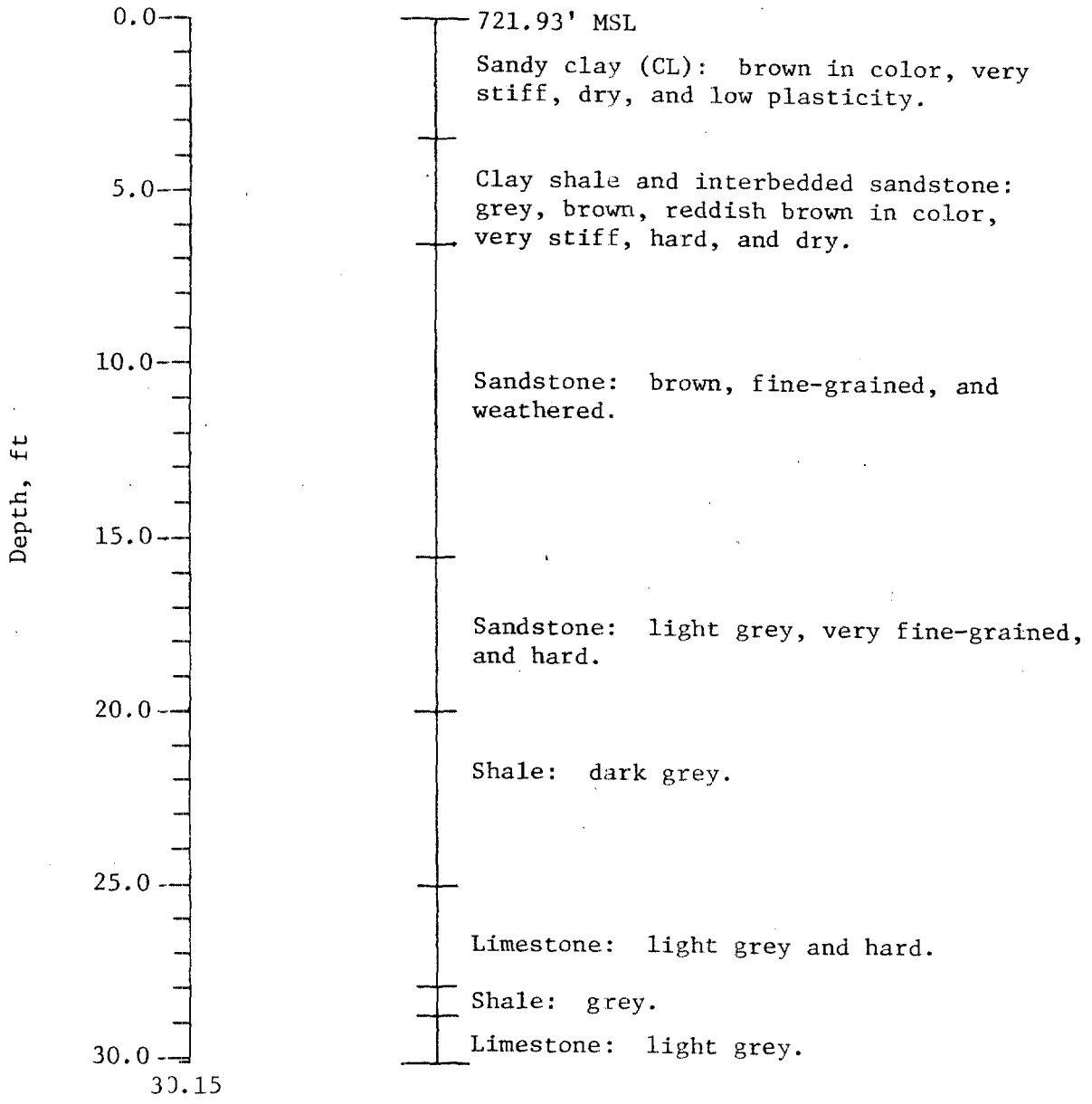
Sandstone (50-70%) and shale (30-50%): orange brown to dark grey, fine-grained, and thinly bedded.

NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-3-81

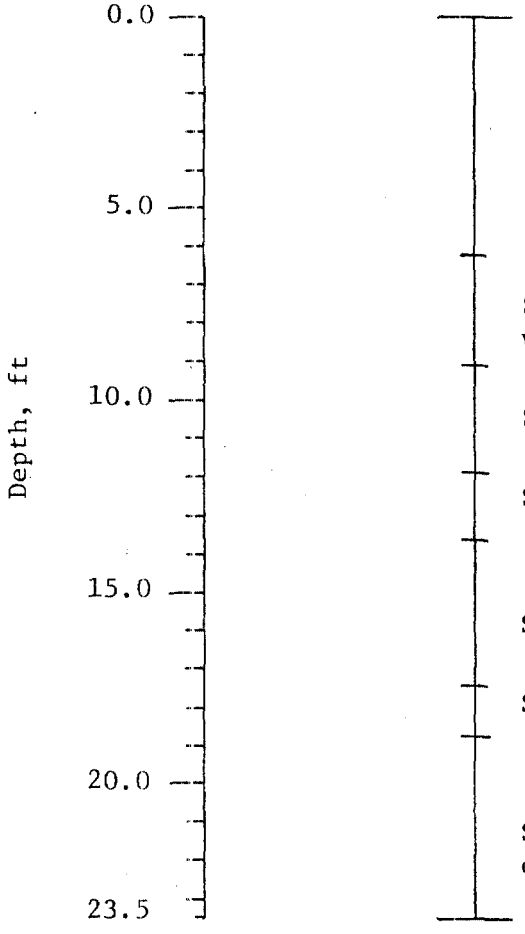



NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-4-81




715.52' MSL

Clayey sand (SC): brown in color, dry, fine-grained, moderate cohesion, and contains sandstone fragments from 5 ft.

Sandstone: brown, fine-grained, and weathered.

Sandstone: light brown.

Sandstone: light grey to dark brown.

Sandstone: light brown and fine-grained.

Sandstone: light grey.

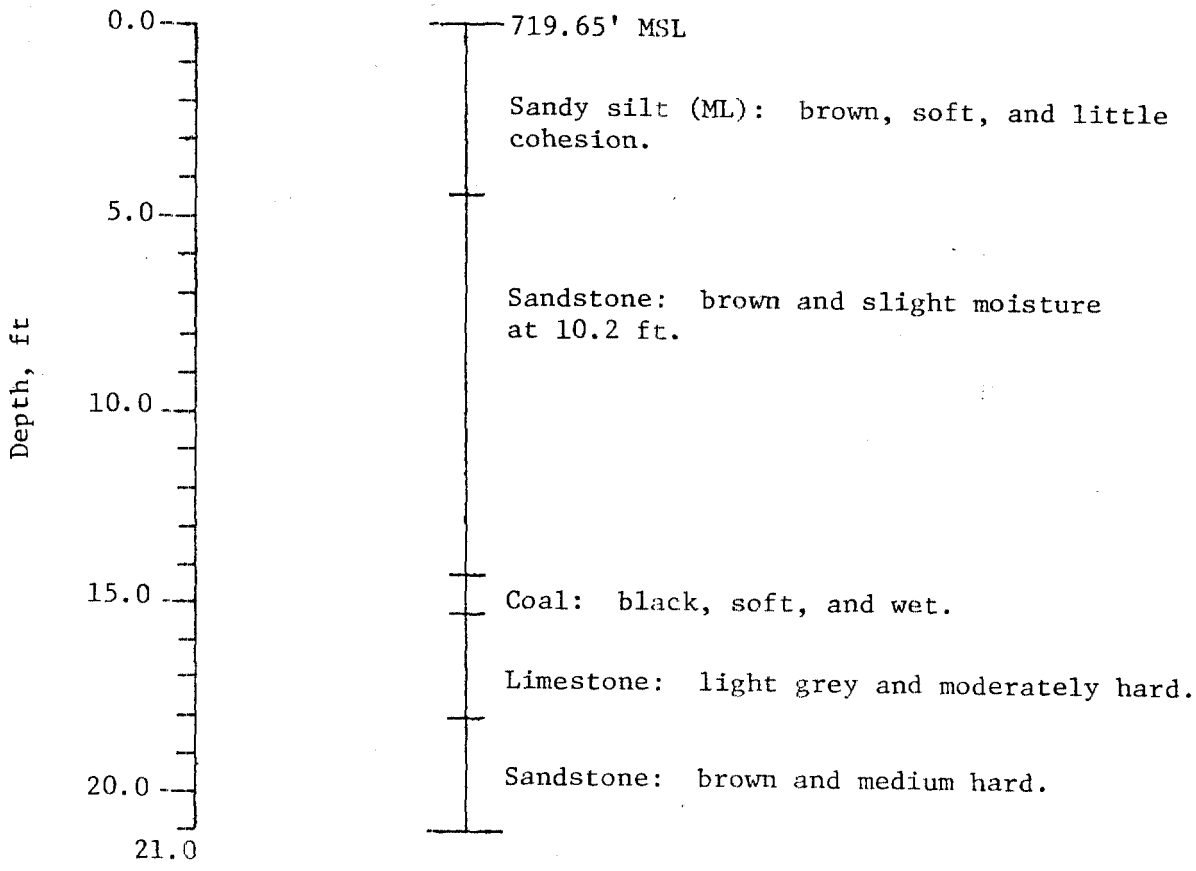
Sandstone: darker in color as shale content increases.

NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-5-81

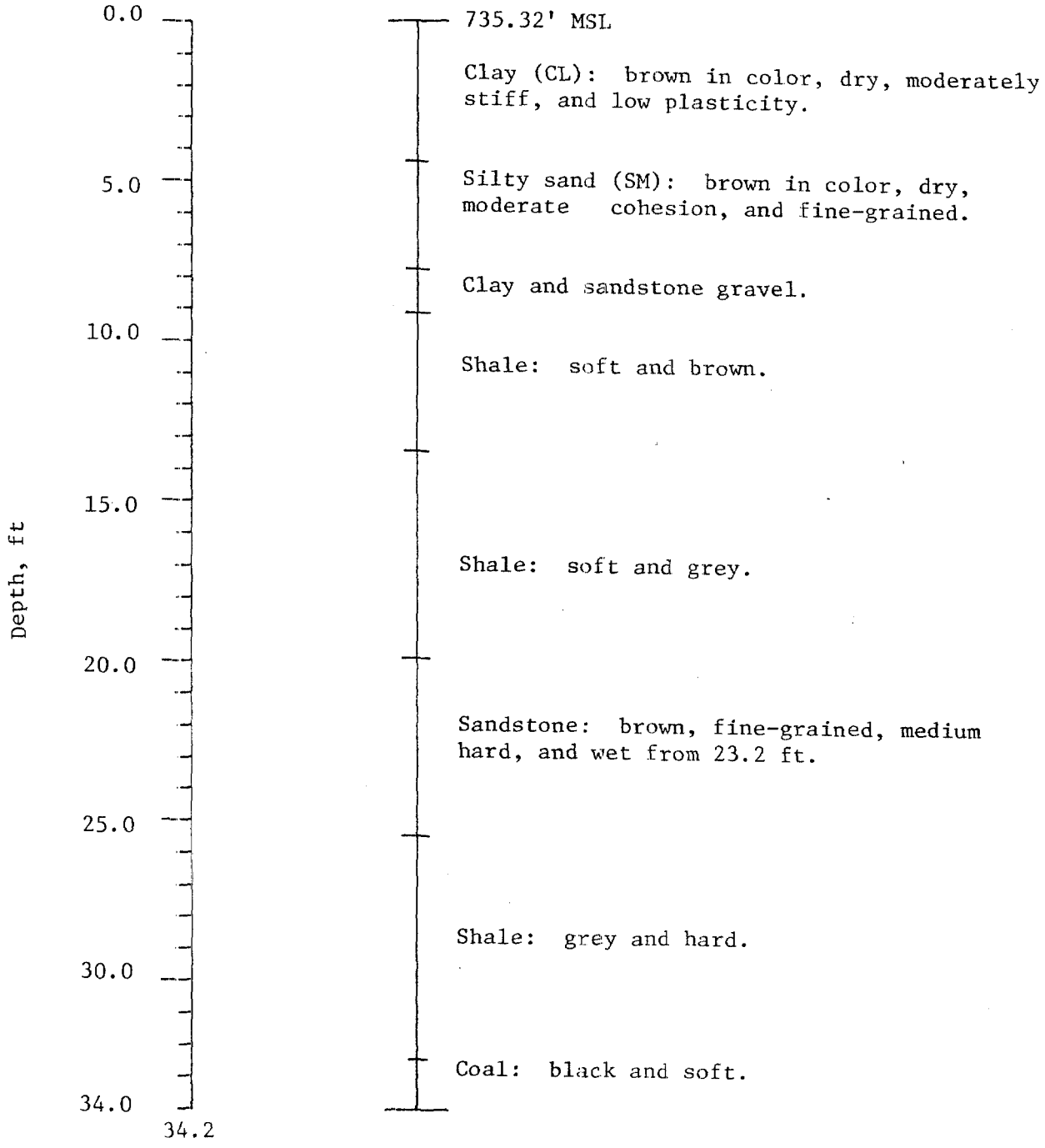



NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-6-81

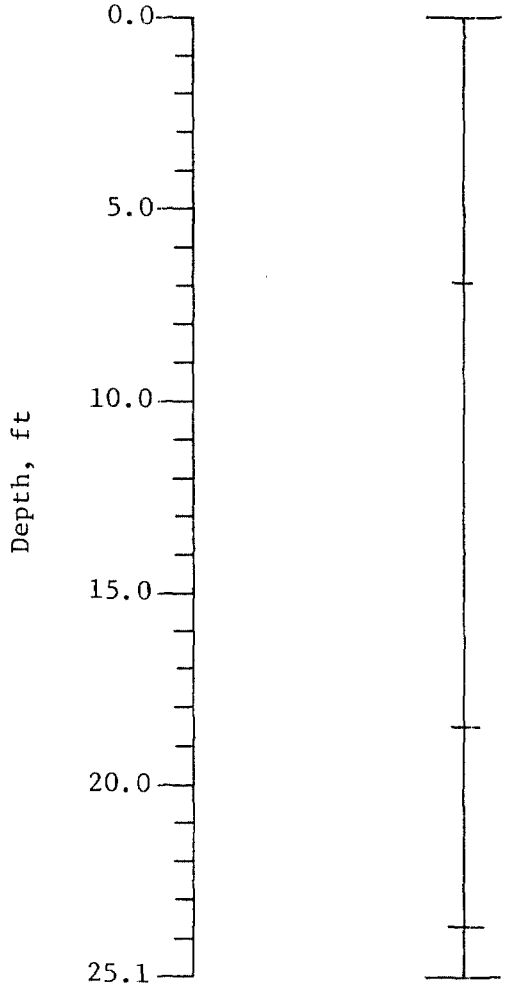



NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-7-81




720.19' MSL

Clay (CL): brown in color, organic matter, very stiff, dry, and low plasticity.

Sandstone (70%) and clay lenses (30%): brown in color, weathered, fine-grained quartz sand, and brown, soft clay lenses.

Sandstone (15-50%) and shale (50-85%): brown to dark grey, thinly bedded, and shale content increases with depth.

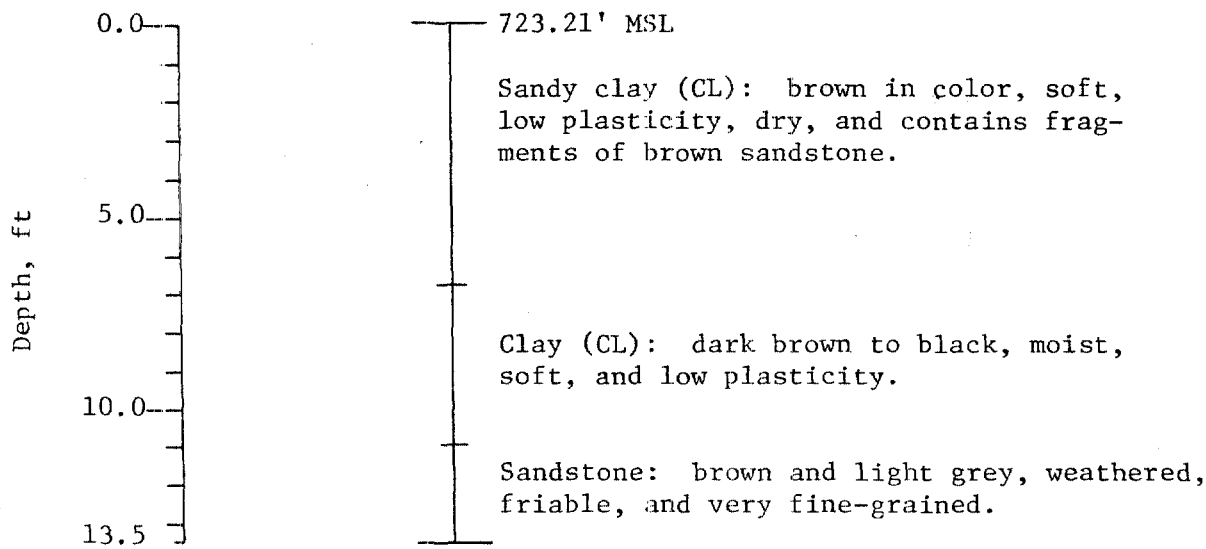
Shale: black, soft, and uniform.

NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-8-81

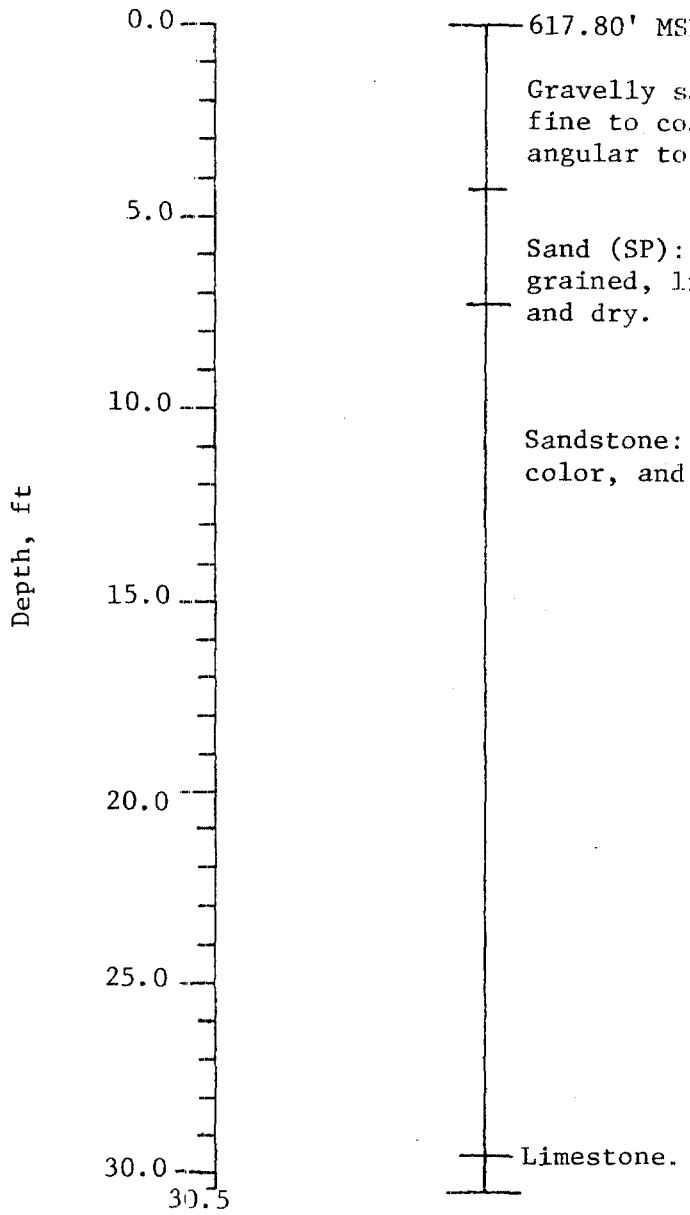



NWSC, Crane, Indiana

Pest Control Area

Lithology

Boring Number: WES-9-9-81

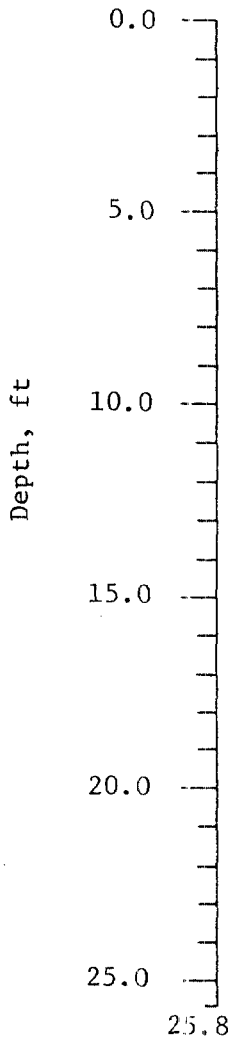



NWSC, Crane, Indiana

Rockeye Site

Lithology

Boring Number: WES-10-1-81




618.51' MSL

Silty sand (SM): dark brown in color, dry, soft, very fine-grained and slight cohesion.

Sandstone gravel: brown, fine to coarse fragments, and fine-grained sandstone.

Limestone: grey.

Sandstone: brown, fine-grained quartz sand, very weathered, and friable.

Limestone: light grey, moderately hard, fine-grained, and fossiliferous.

NWSC, Crane, Indiana

Rockeye Site

Lithology

Boring Number: WES-10-2-81

10

Admin Records 095 10

# HYDROGEOLOGIC INVESTIGATION OF WASTE DISPOSAL SITES AT THE NAVAL WEAPONS SUPPORT CENTER, CRANE, INDIANA

APPENDIXES C AND D

+ E

by

Joseph B. Dunbar

Geotechnical Laboratory
USAE Waterways Experiment Station
PO Box 631, Vicksburg, MS 39180

Prepared for
Naval Weapons Support Center
Crane, Indiana

April 1982

APPENDIX C: WELL COMPLETION DIAGRAMS

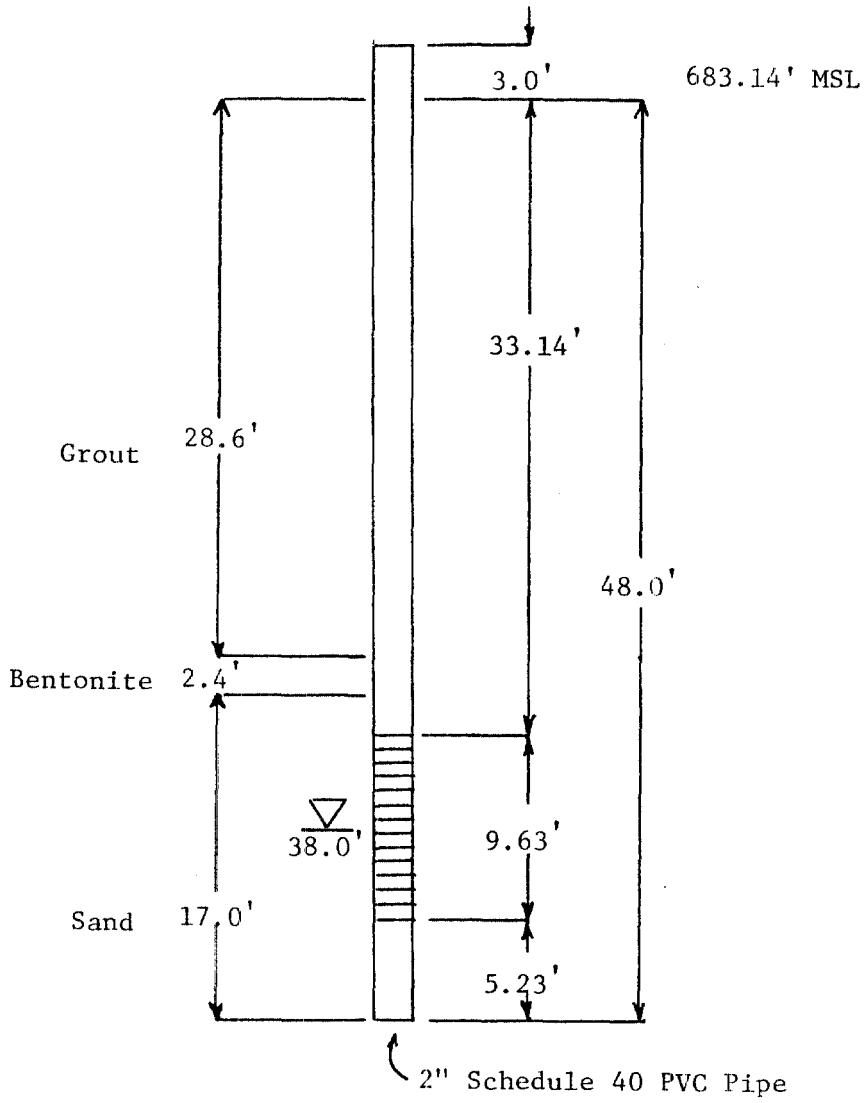
APPENDIX D: GROUNDWATER ELEVATIONS

**WORKING DRAFT**

# APPENDIX C

# WELL COMPLETION DIAGRAMS

WORKING DRAFT




Water depth at time of drilling

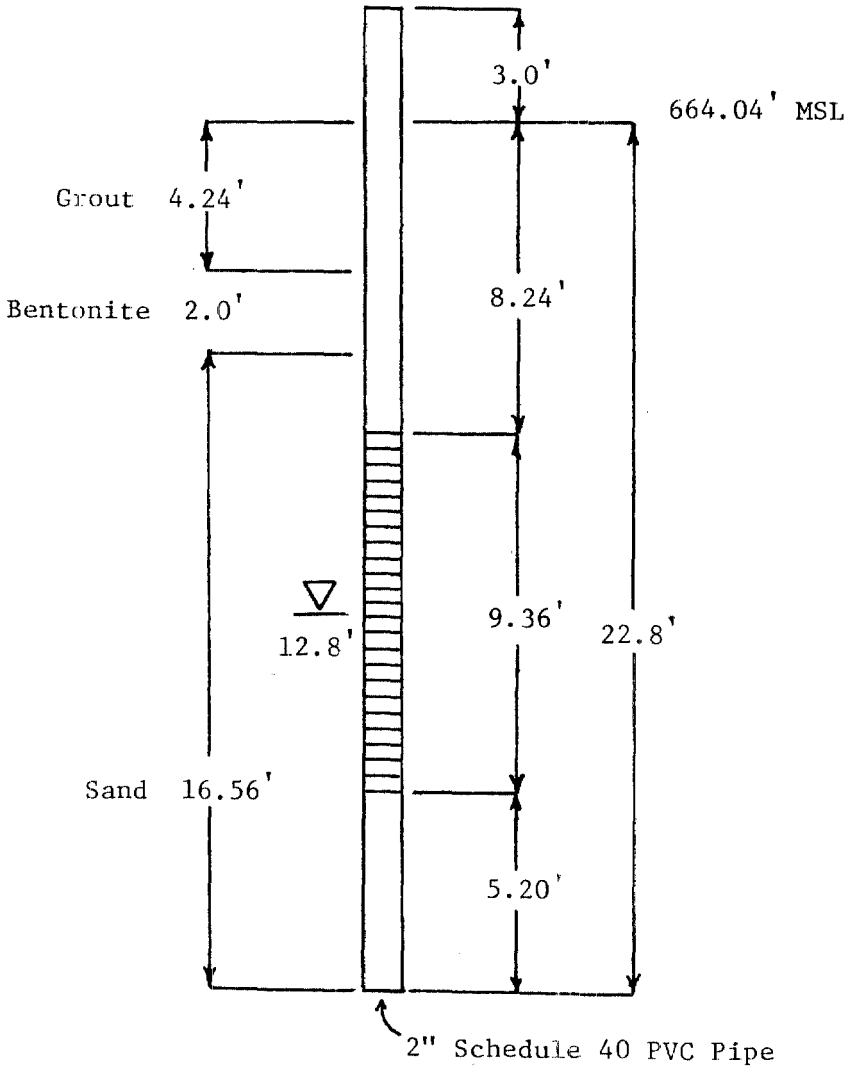
Well screen

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Well Completion

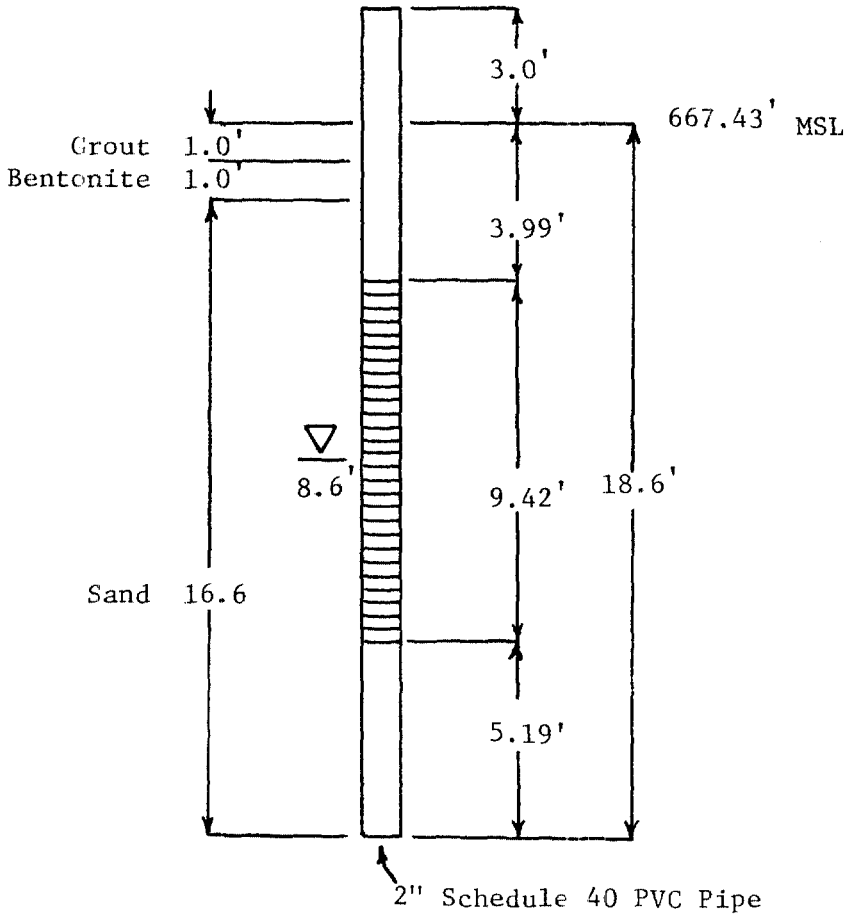
Boring Number: WES-1-1-81




Water depth at time of drilling

Well screen

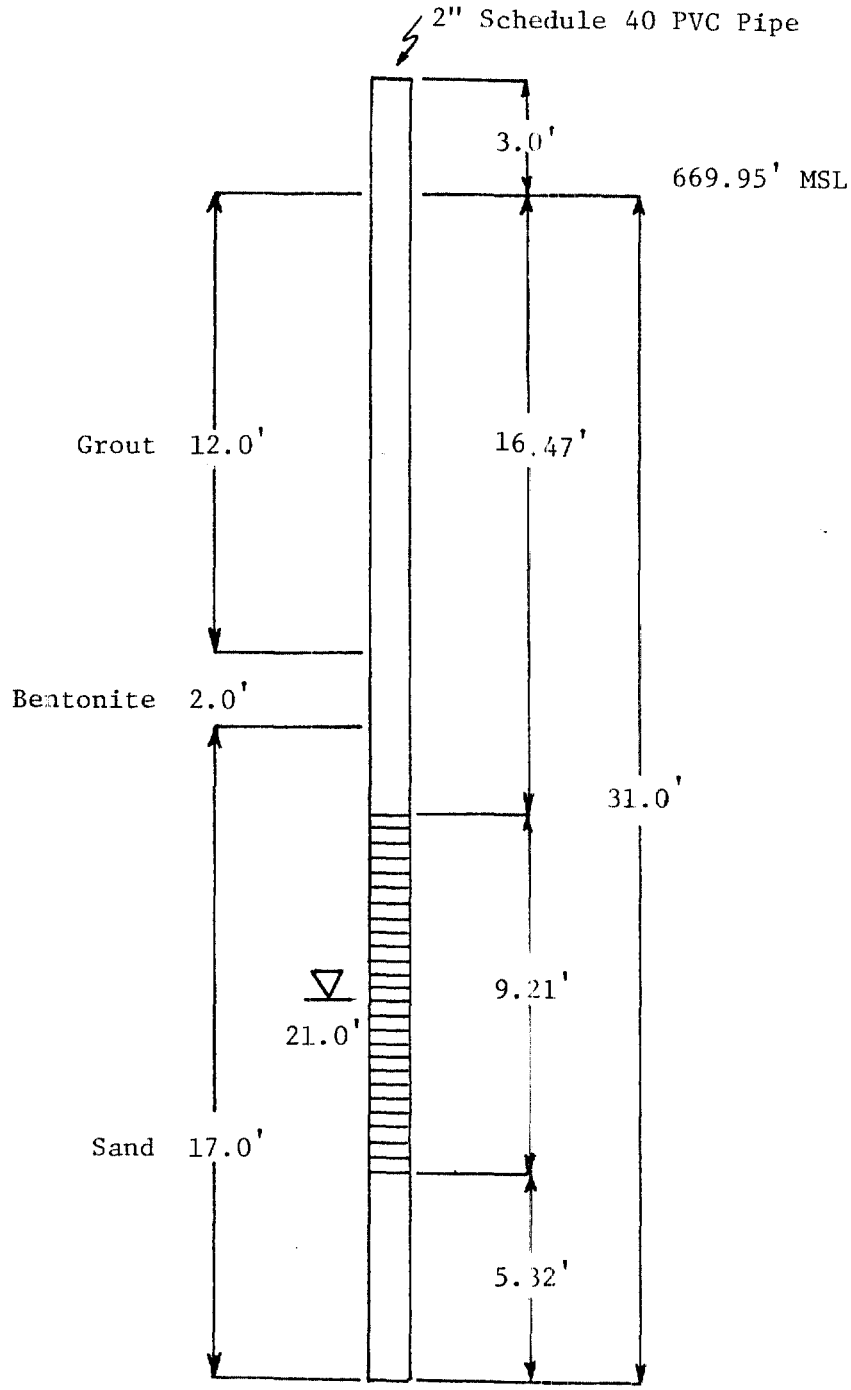
NWSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-2-81




Water depth at time of drilling

Well screen

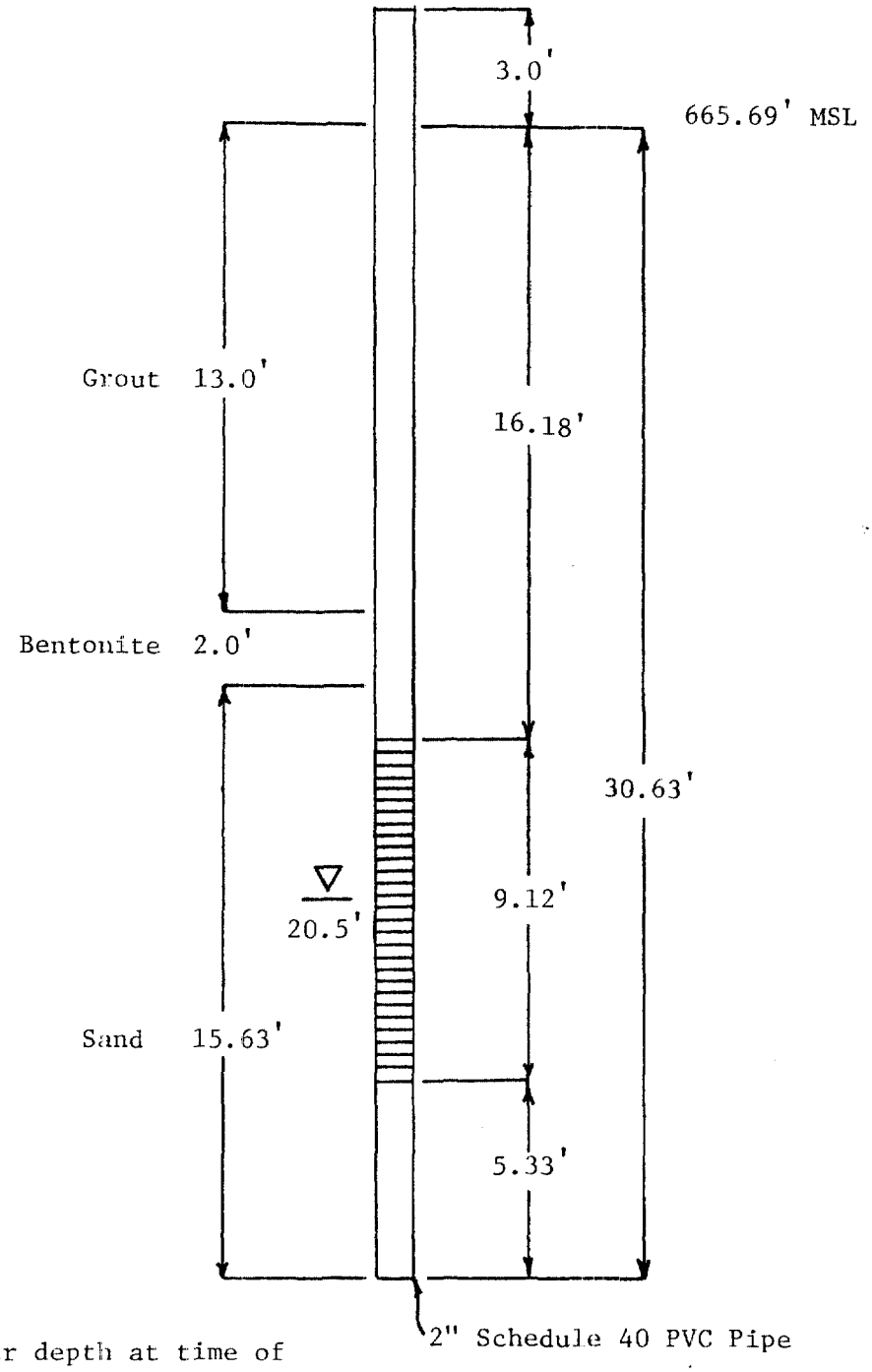
NUSC, Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-3-81




Water depth at time of drilling

Well screen

NWSC , Crane, Indiana
Mustard Gas Burial Grounds
Well Completion
Boring Number: WES-1-4-81




▽ Water depth at time of drilling

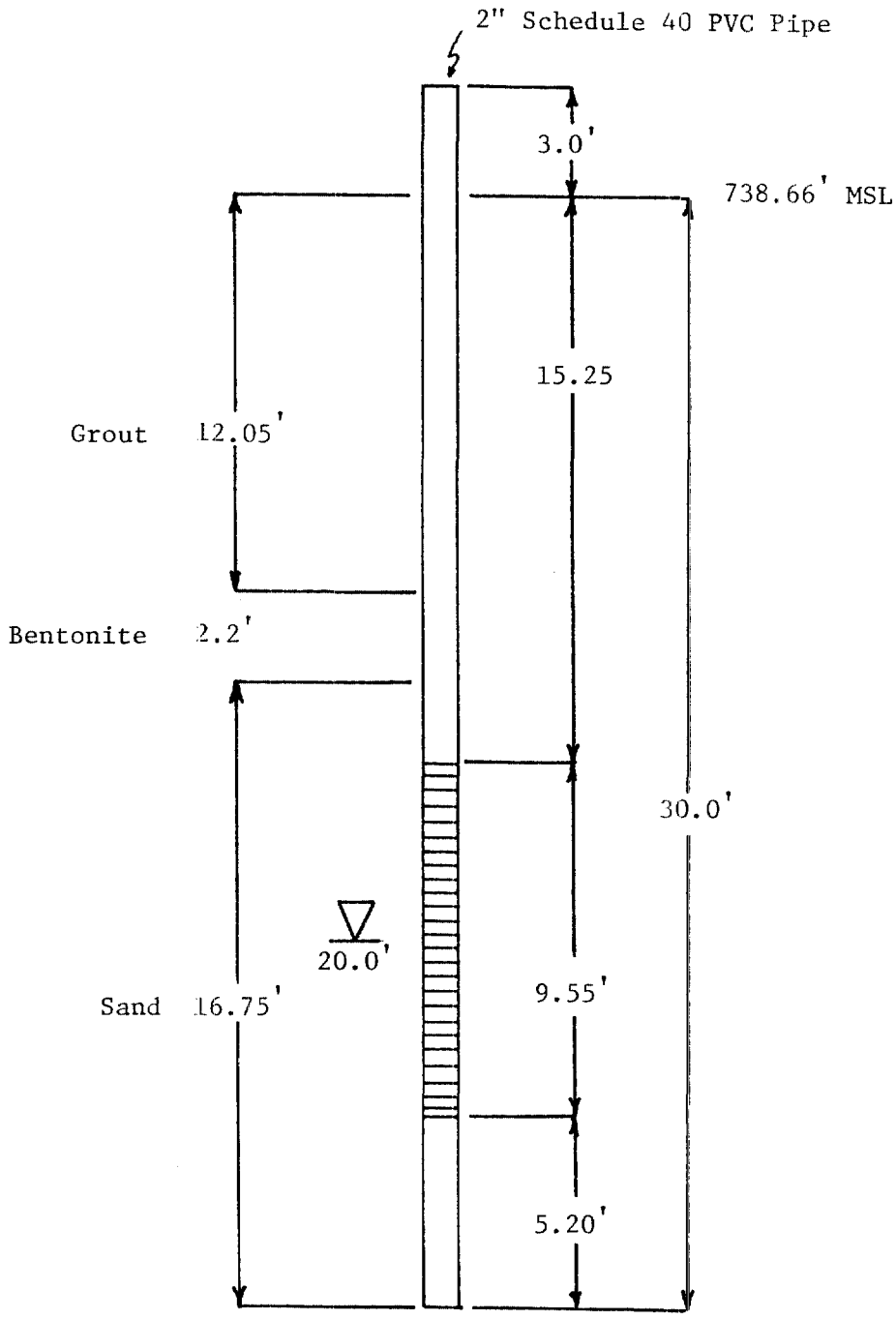
Well screen

NWSC, Crane, Indiana

Mustard Gas Burial Grounds

Well Completion

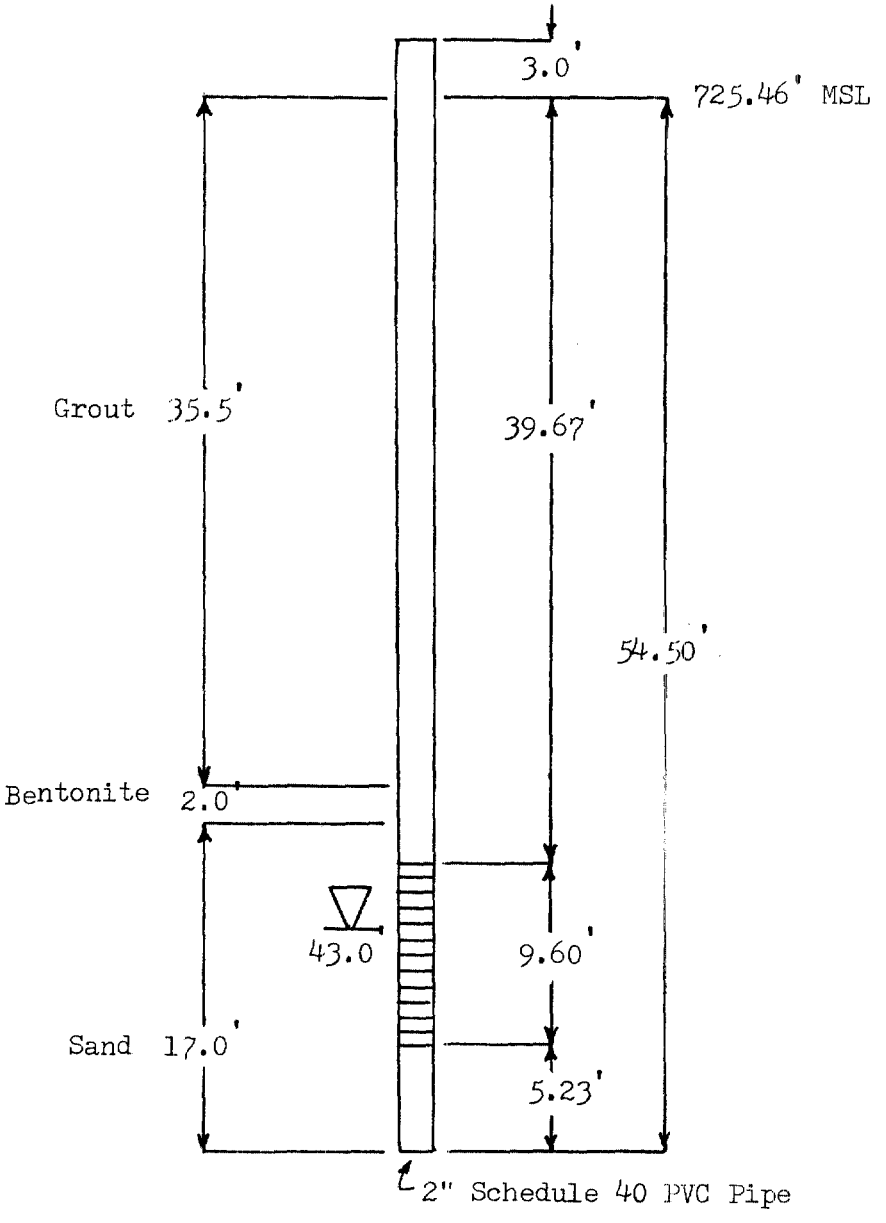
Boring Number: WES-1-5-81




Water depth at time of drilling

Well screen

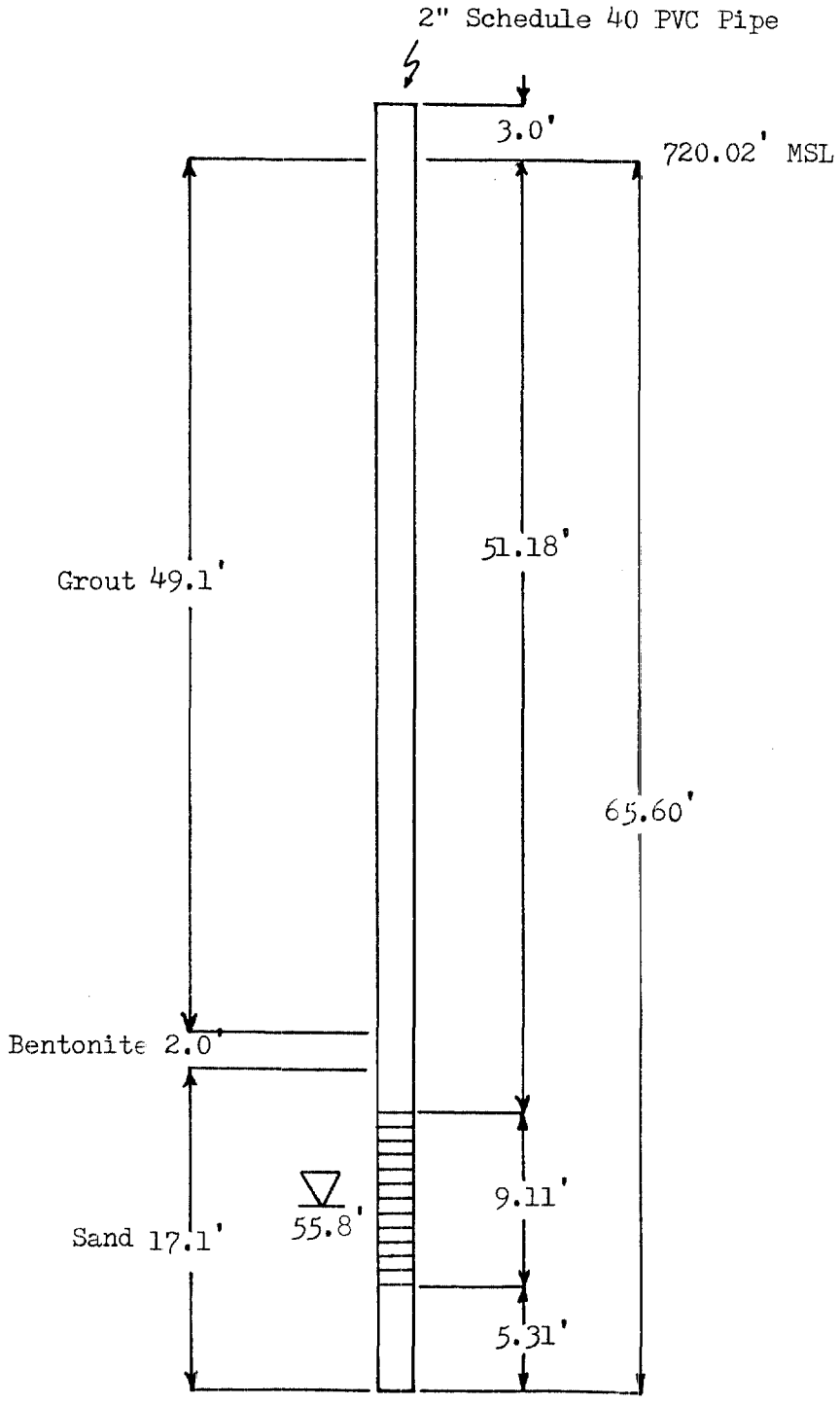
NWSC, Crane, Indiana
Dye Burial Grounds
Well Completion
Boring Number: WES-2-1-81




Water depth at time of drilling

Well screen

NWSC, Crane, Indiana
Dye Burial Grounds
Well Completion
Boring Number: WES-2-2-81




Water depth at time of drilling

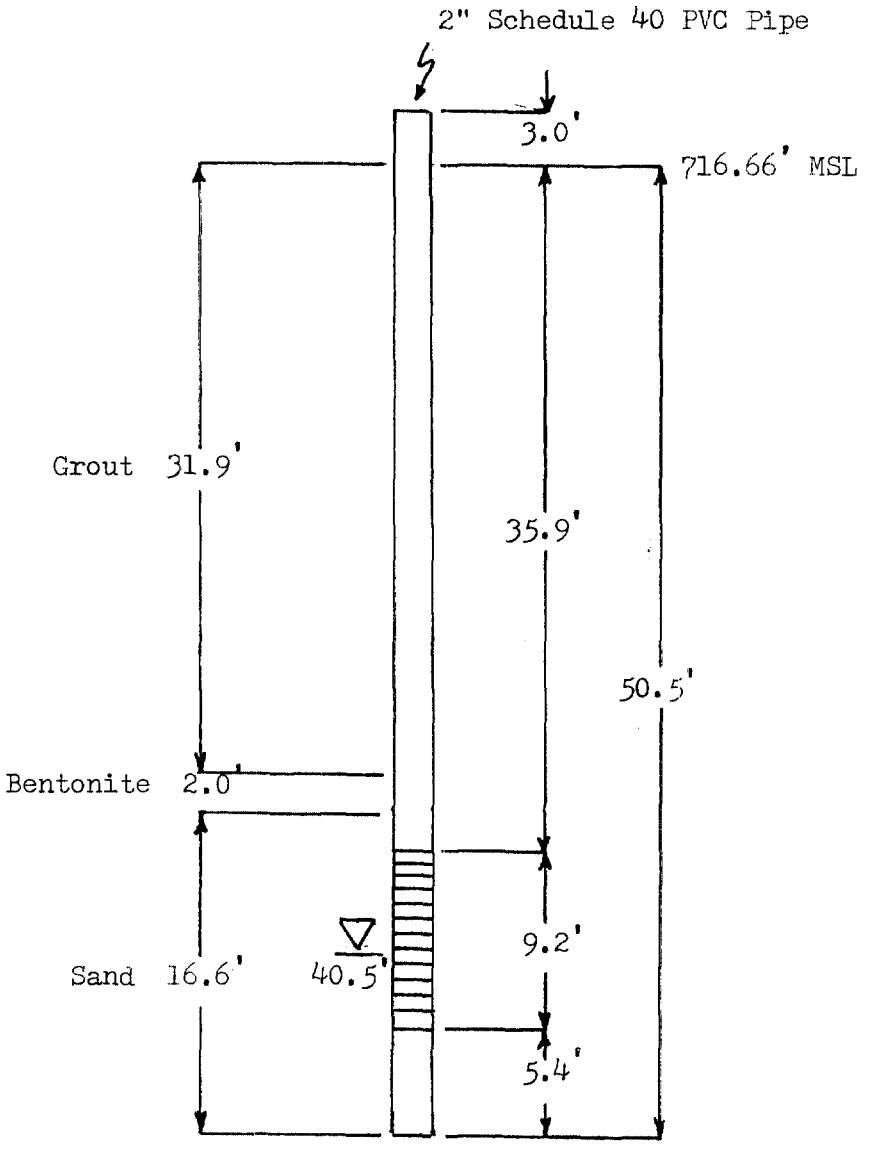
Well screen

NWSC, Crane, Indiana

Dye Burial Grounds

Well Completion

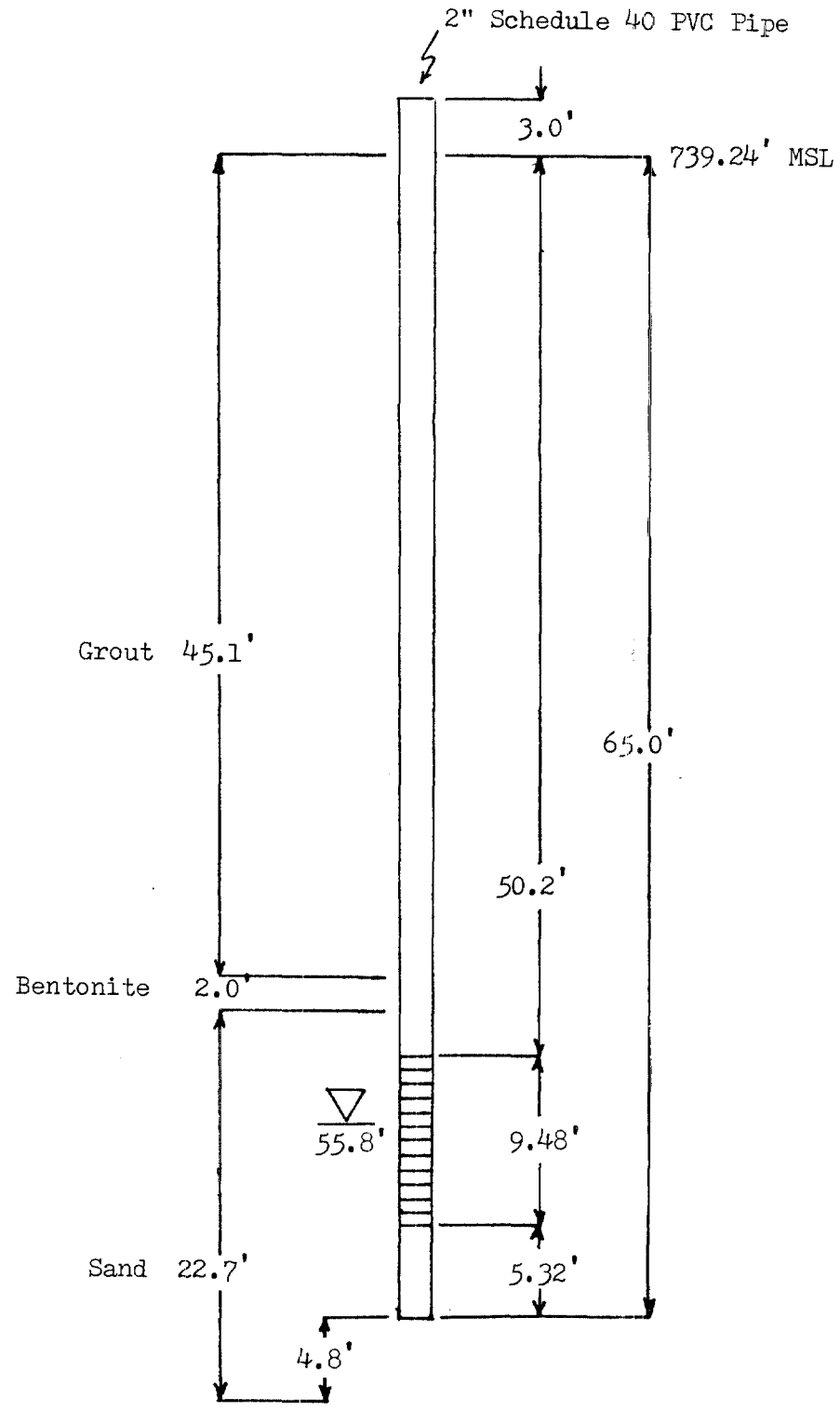
Boring Number: WES-2-3-81




Water depth at time of drilling

Well screen

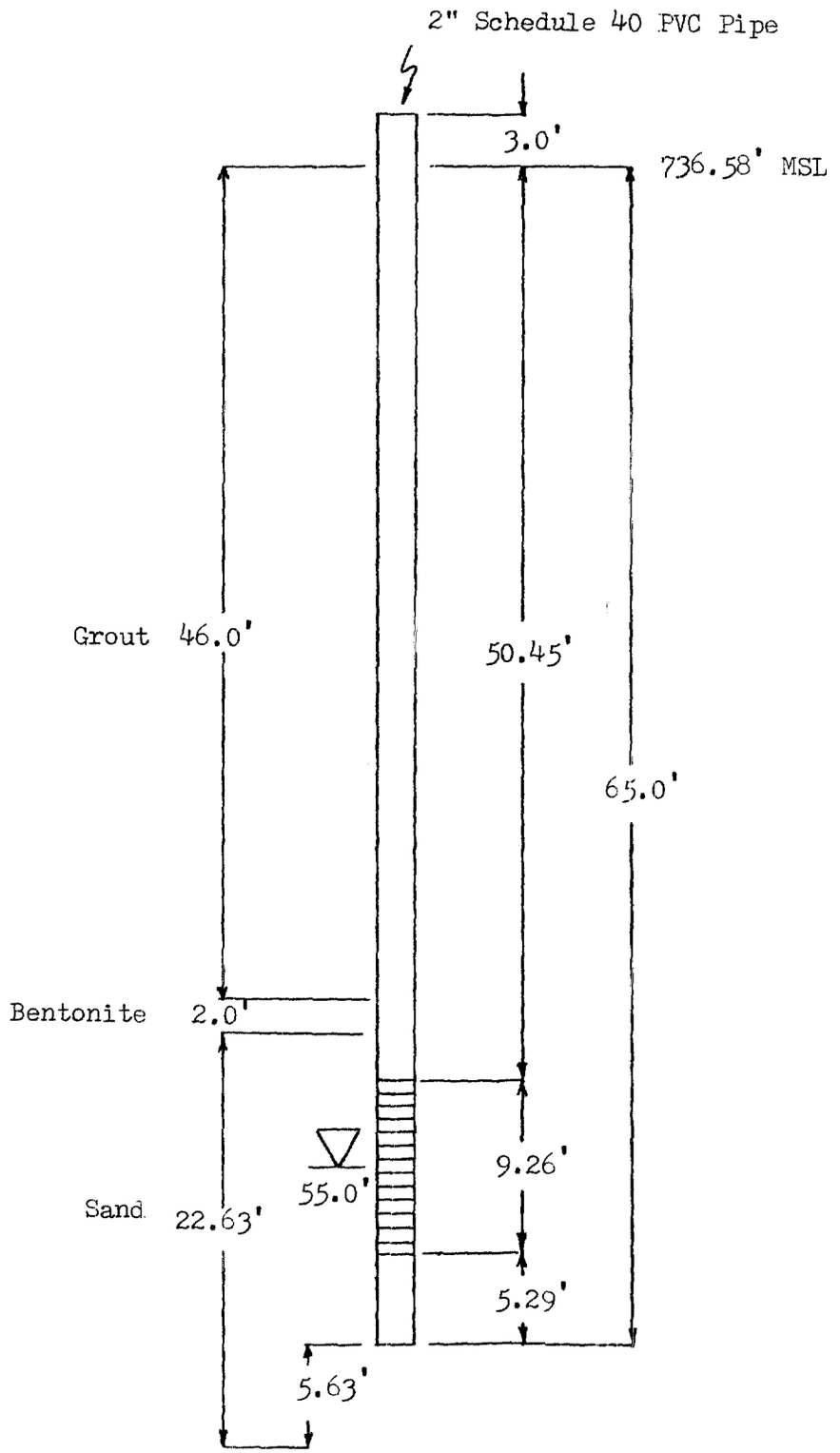
NWSC, Crane, Indiana
Dye Burial Grounds
Well Completion
Boring Number: WES-2-4-81




Water depth at time of drilling

Well screen

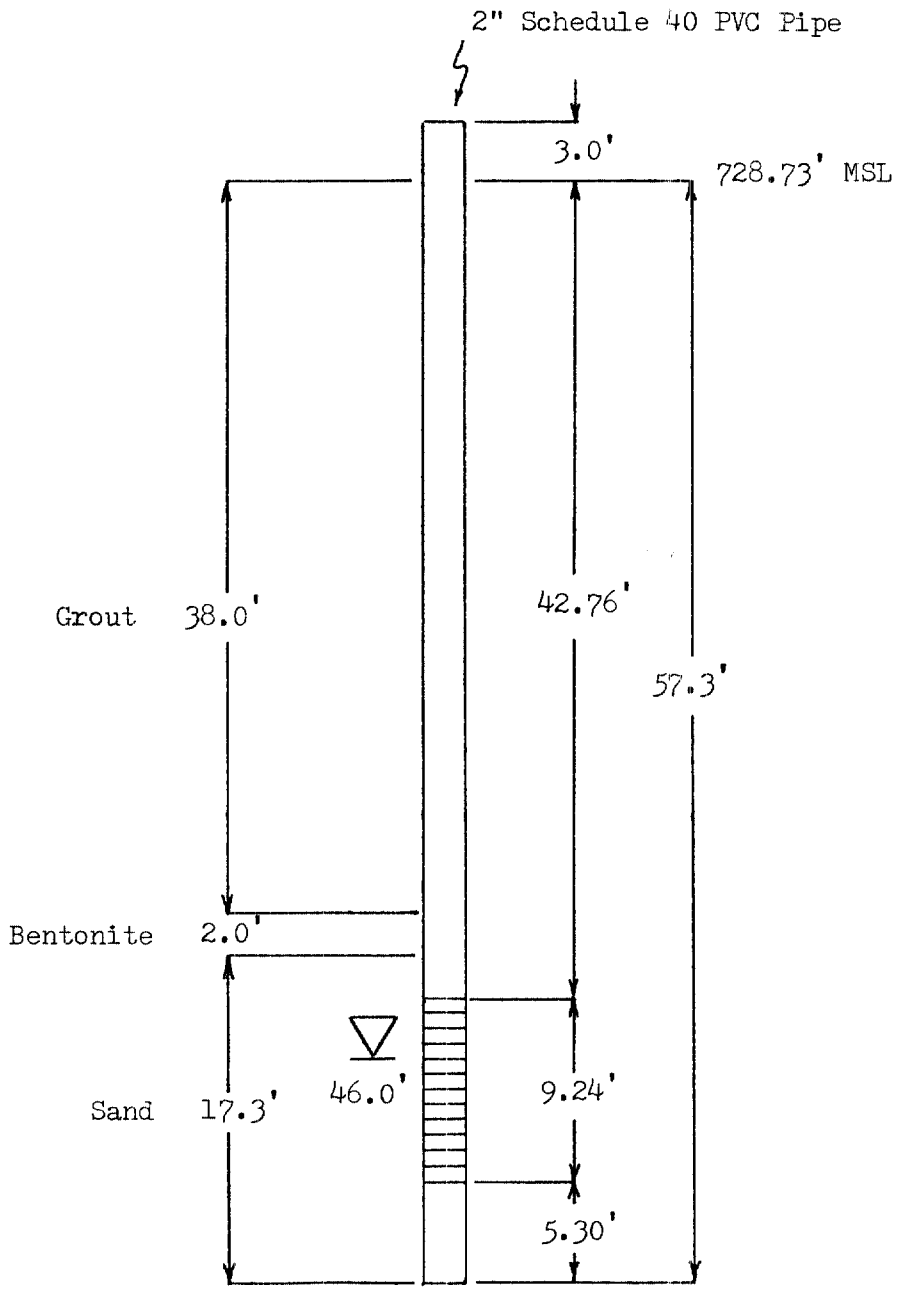
NWSC, Crane, Indiana
Dye Burial Grounds
Well Completion
Boring Number: WES-2-5-81




Water depth at time of drilling

Well screen

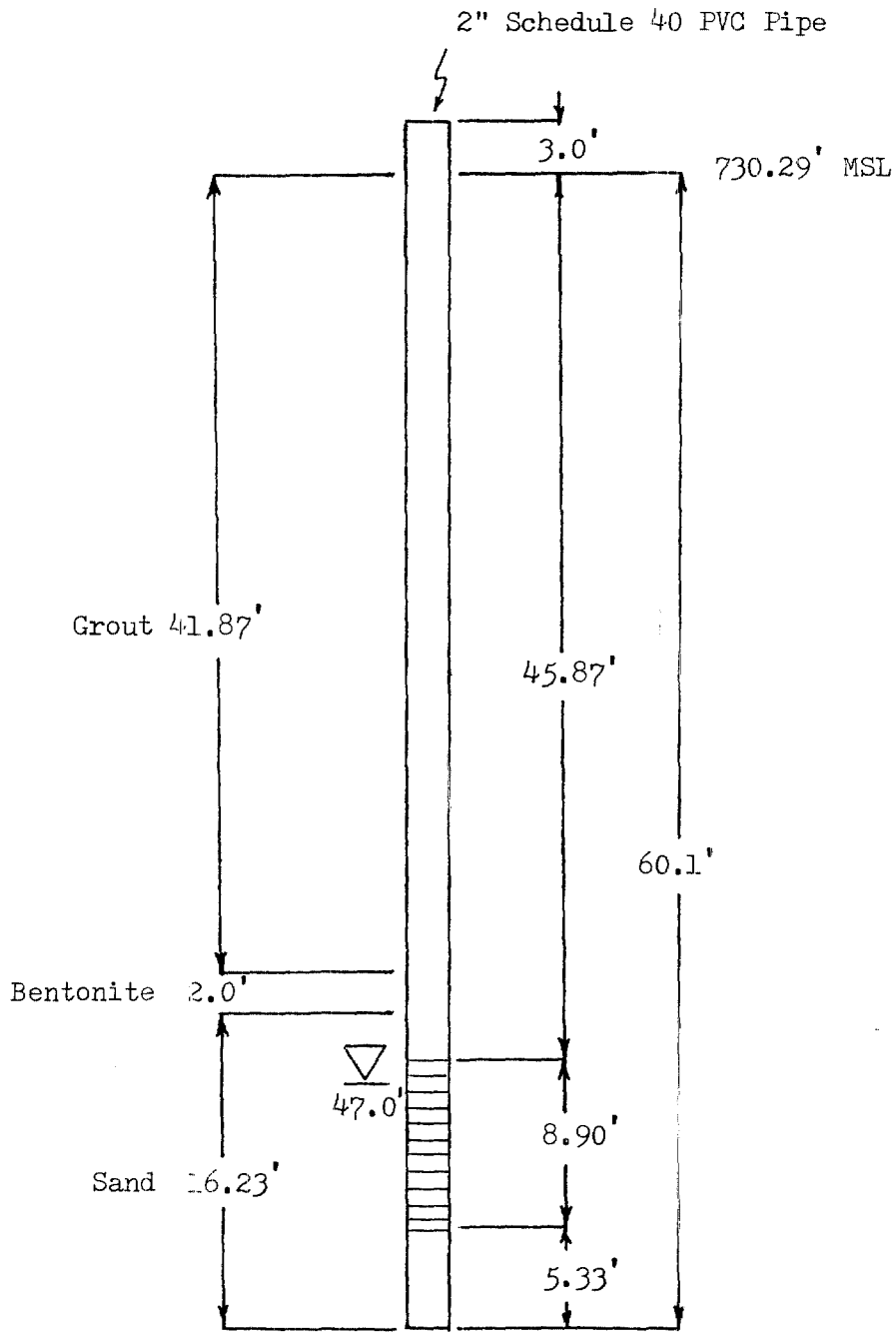
NWSC, Crane, Indiana
Dye Burial Grounds
Well Completion
Boring Number: WES-2-6-81




Water depth at time of drilling

Well screen

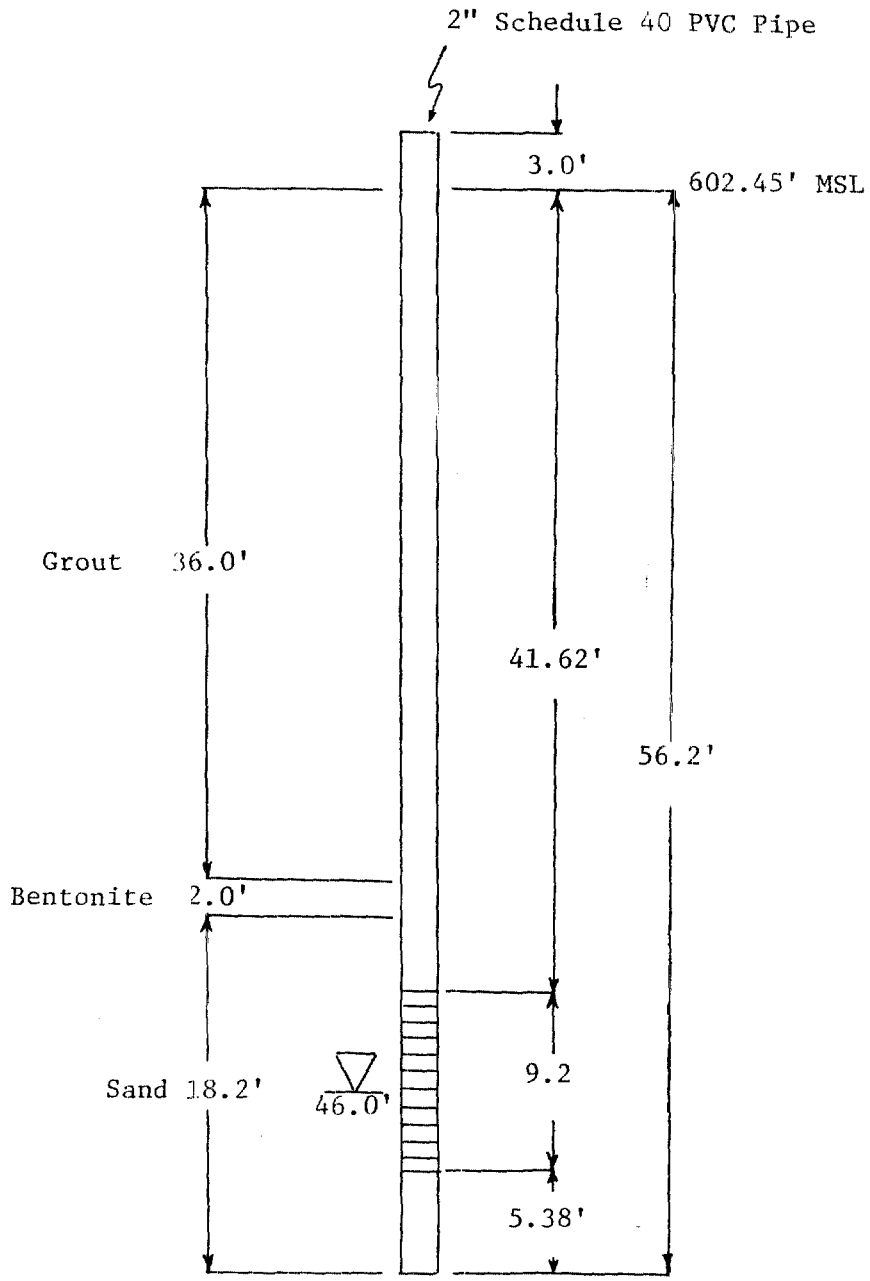
NWSC, Crane, Indiana
Dye Burial Grounds
Well Completion
Boring Number: WES-2-7-81




Water depth at time of drilling

Well screen

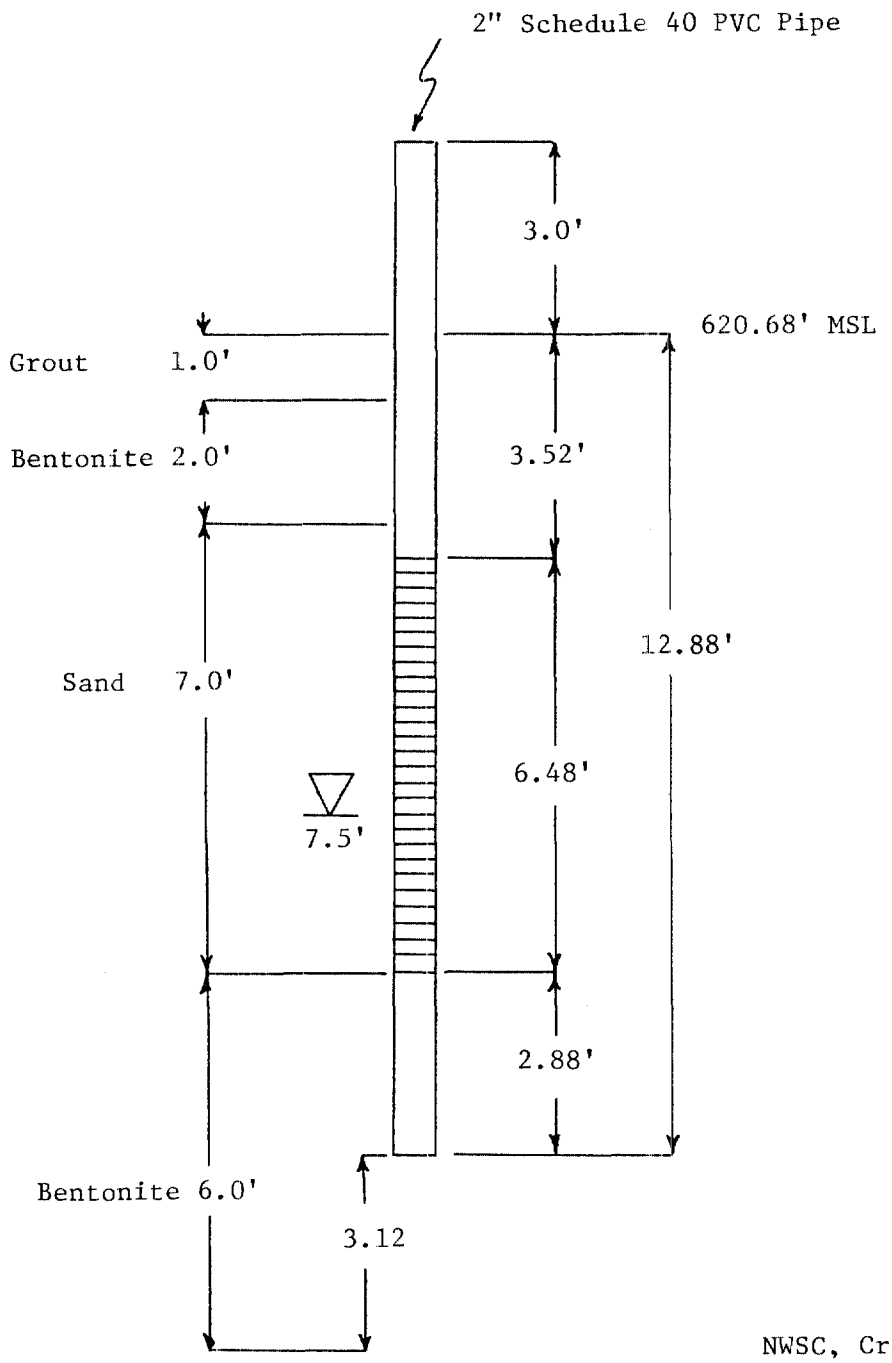
NWSC, Crane, Indiana
Dye Burial Grounds
Well Completion
Boring Number: WES-2-8-81




Water depth at time of drilling

Well screen

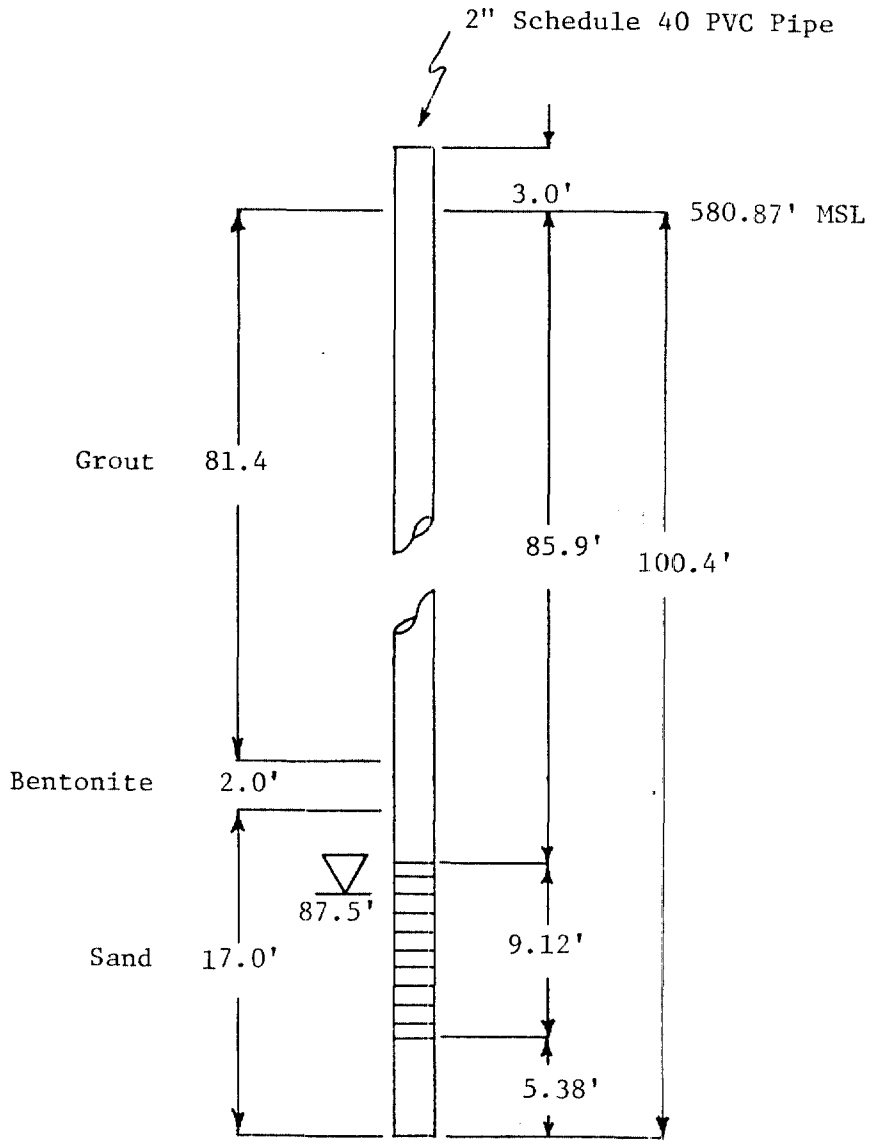
NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-1-81




NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-2-81

Water depth at time of drilling

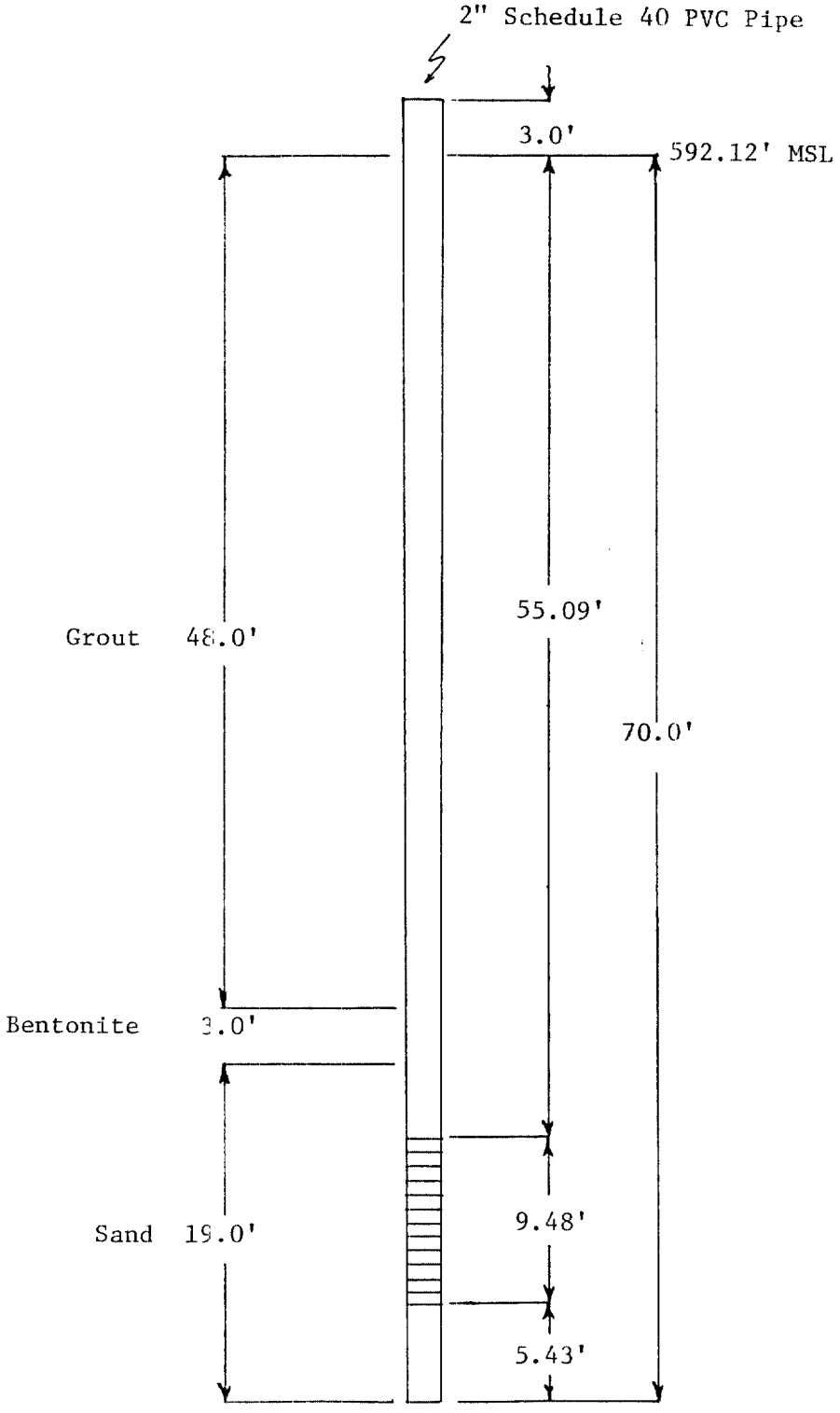
Well screen




Water depth at time of drilling

Well screen

NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-3-81




Water depth at time of drilling was unobtainable

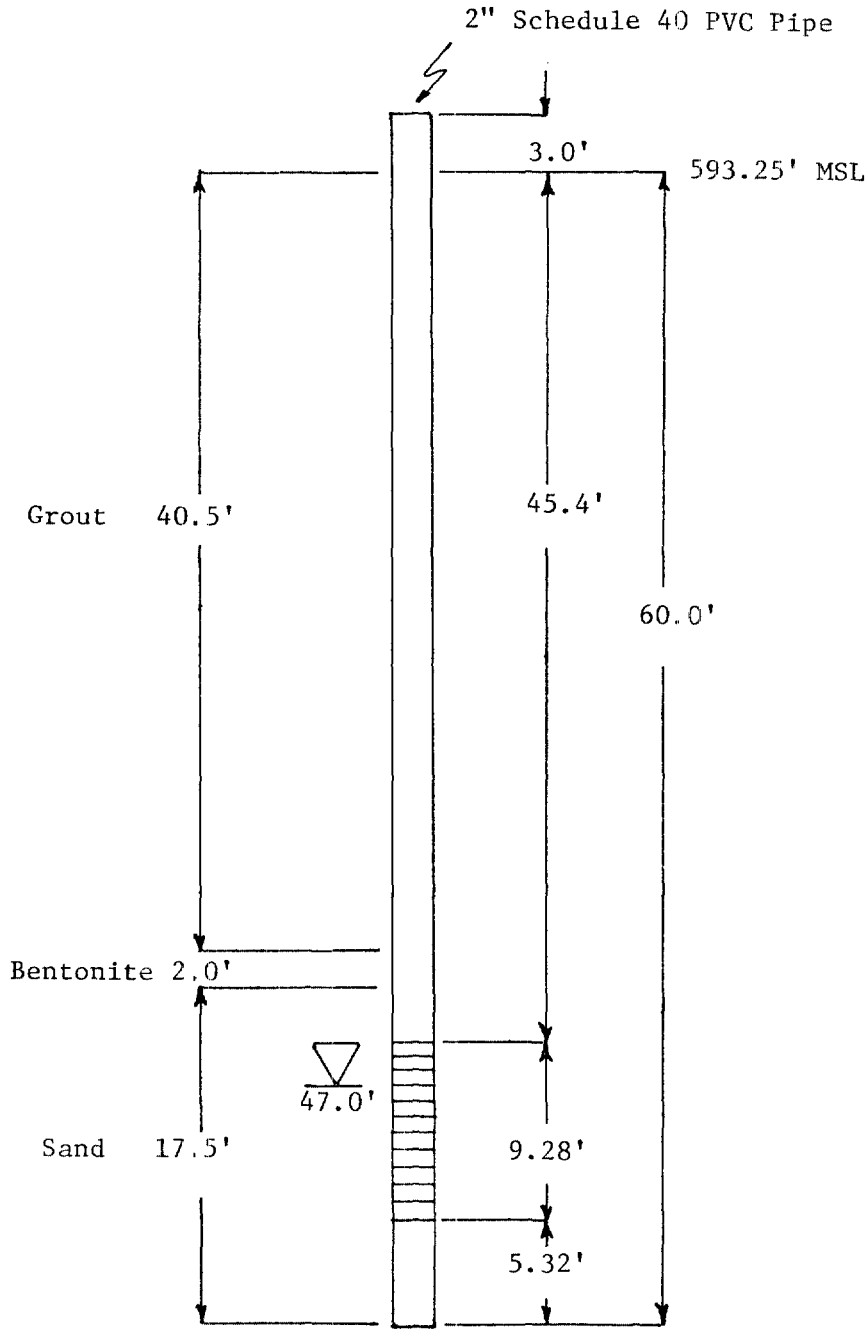
Well screen

NWSC, Crane, Indiana

Ammunition Burning Grounds

Well Completion

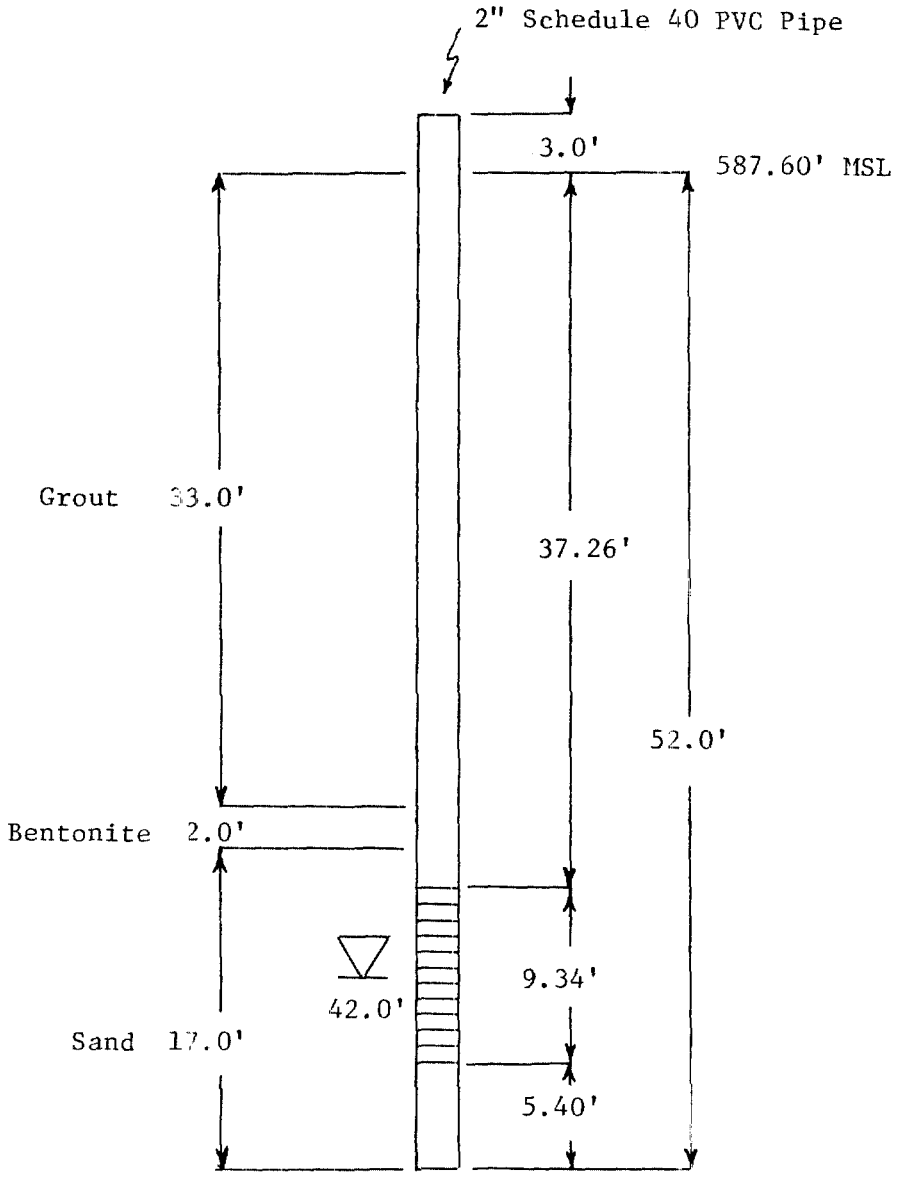
Boring Number: WES-3-4-81




Water depth at time of drilling

Well screen

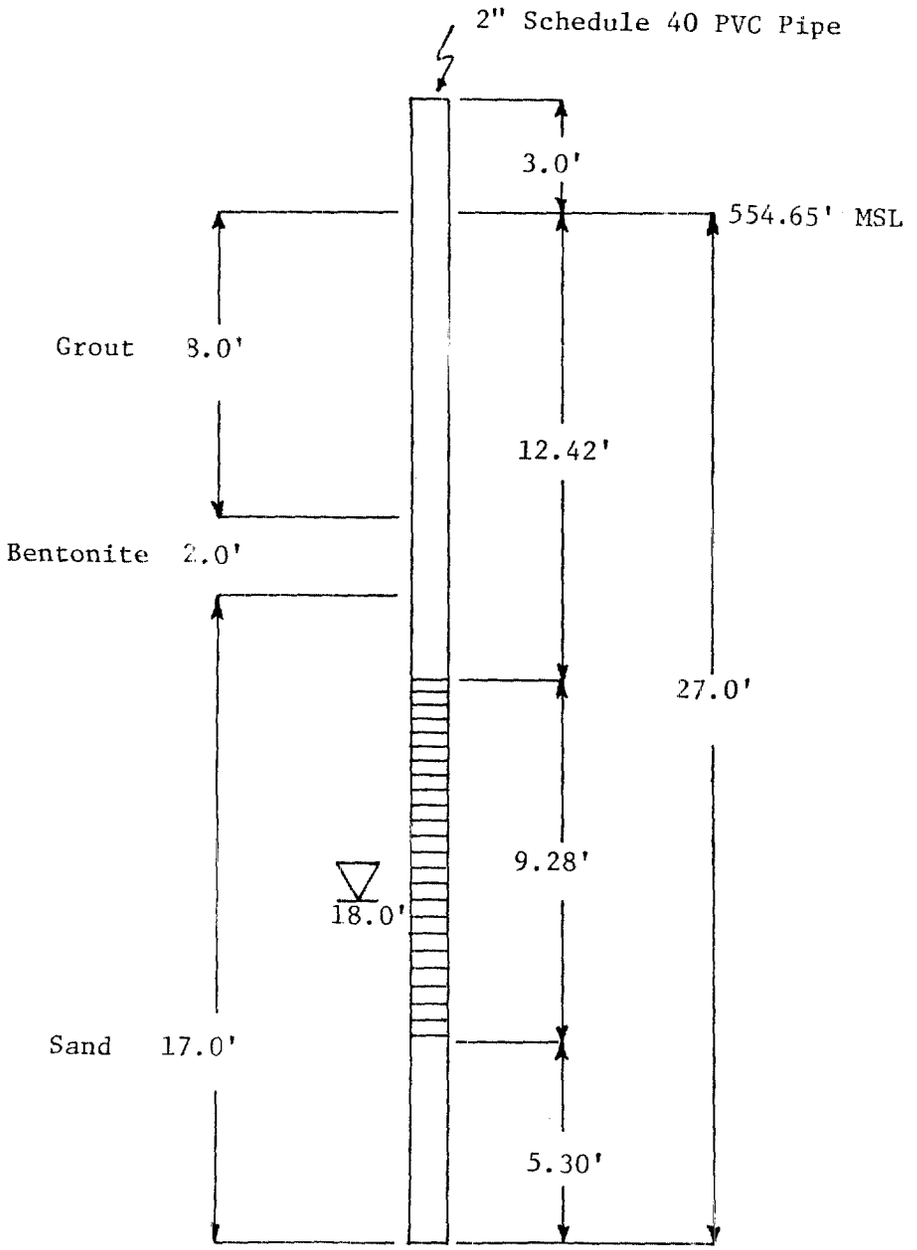
NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-5-81




Water depth at time of drilling

Well screen

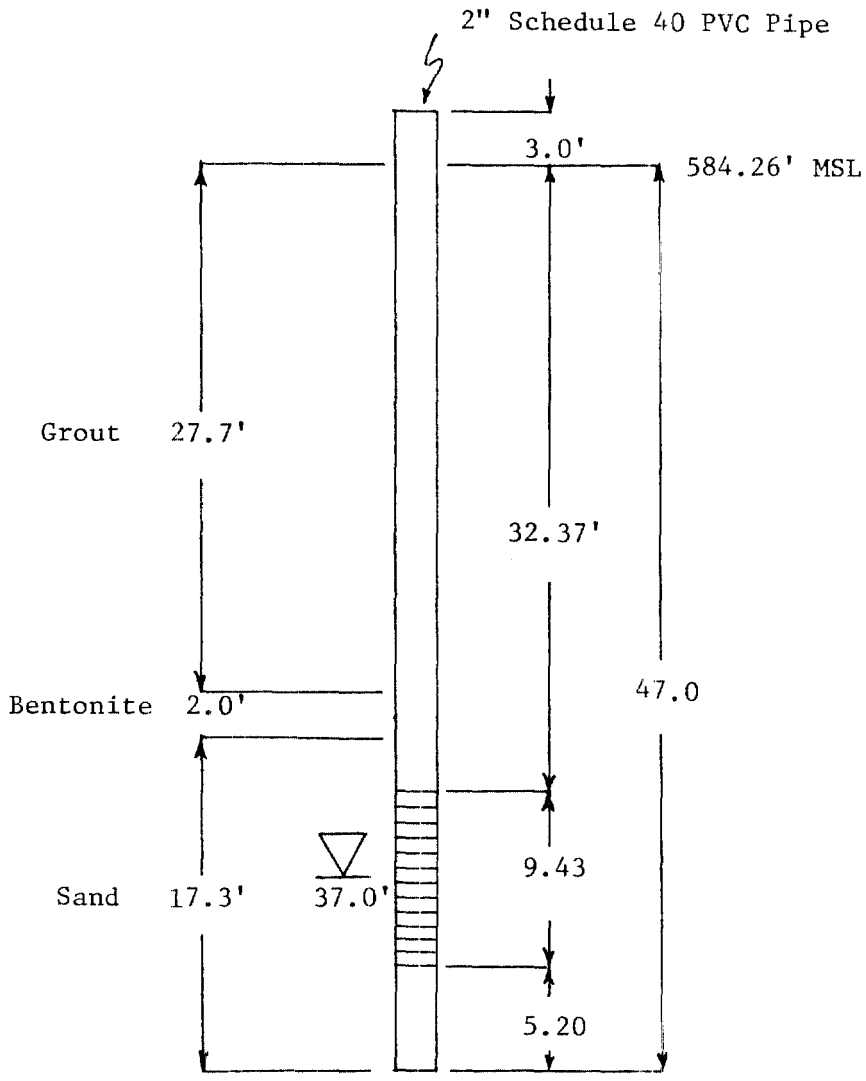
NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-6-81




Water depth at time of drilling

Well screen

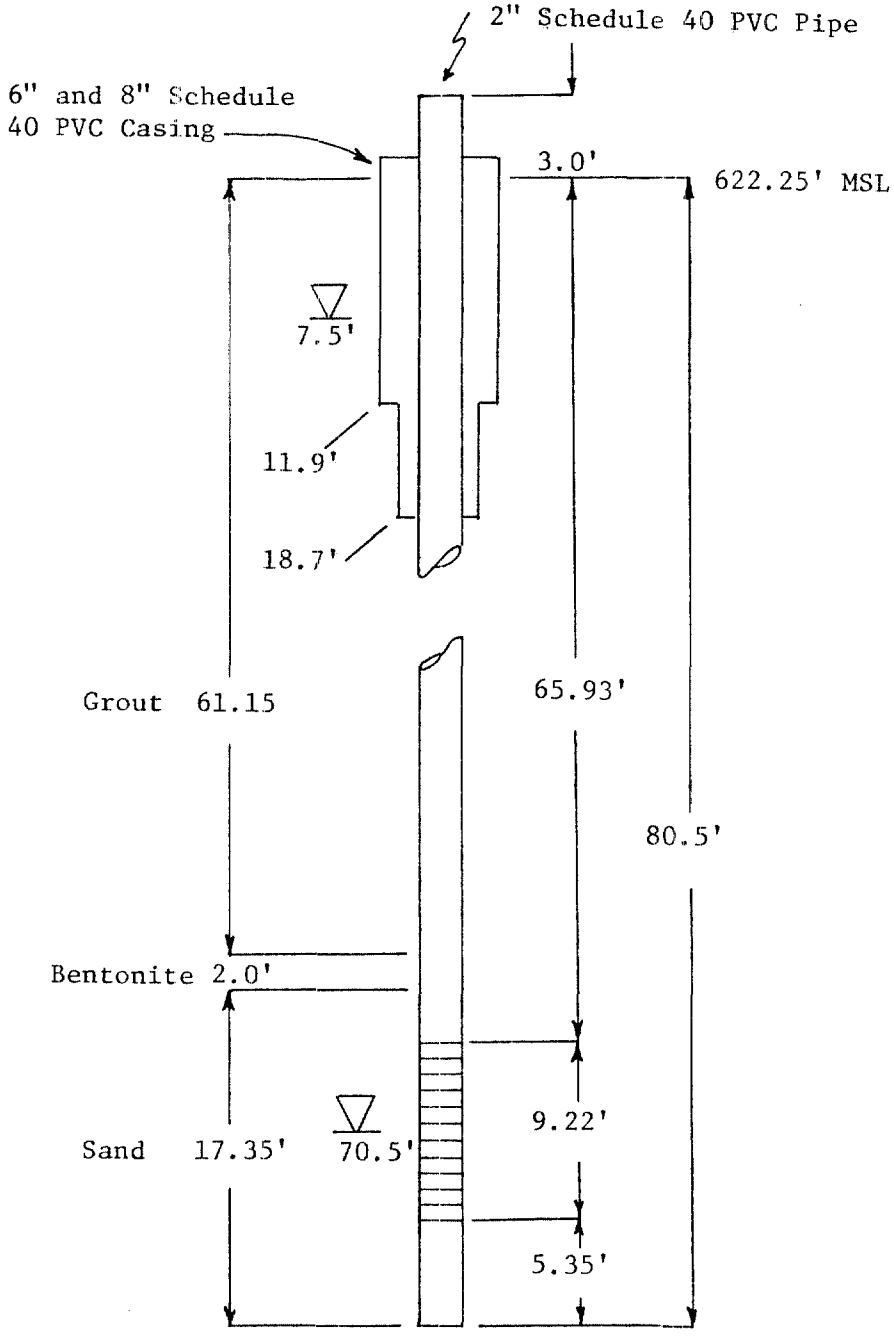
NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-7-81




Water depth at time of drilling

Well screen

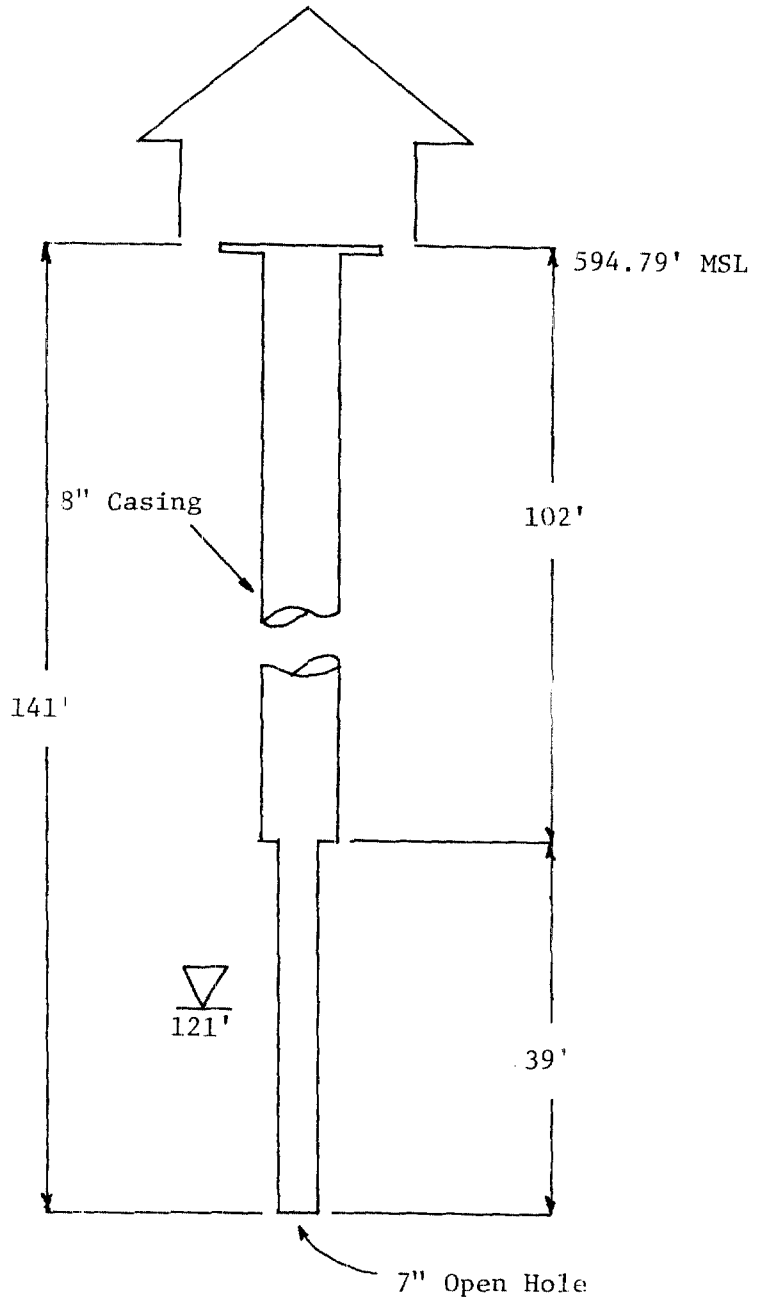
NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-8-81




Water depth at time of drilling

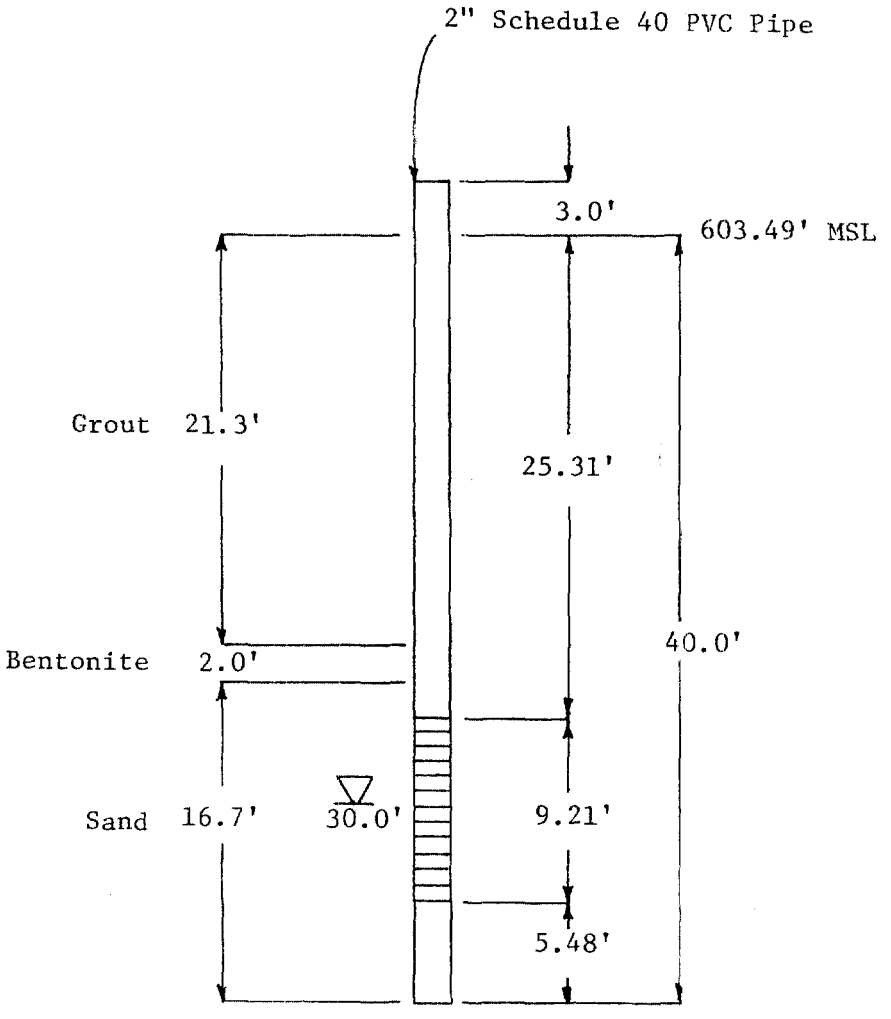
Well screen

NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Boring Number: WES-3-9-81




Water depth at
time of drilling

NWSC, Crane, Indiana
Ammunition Burning Grounds
Well Completion
Pump House-Building 3004




Water depth at time of drilling

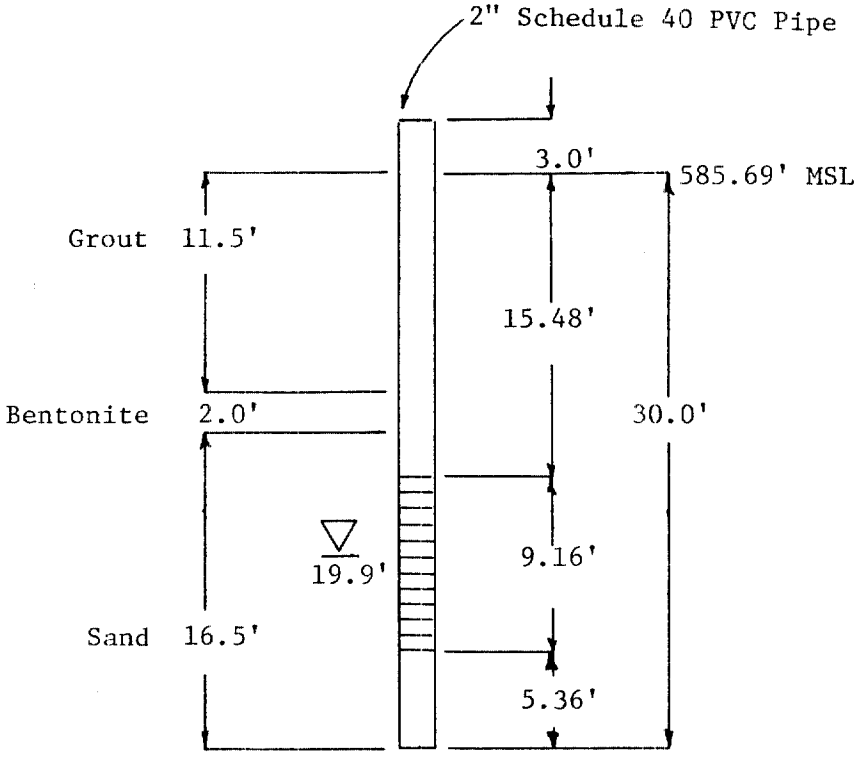
Well screen

NWSC, Crane, Indiana

McComish Gorge

Well Completion

Boring Number: WES-4-1-81




Water depth at time of drilling

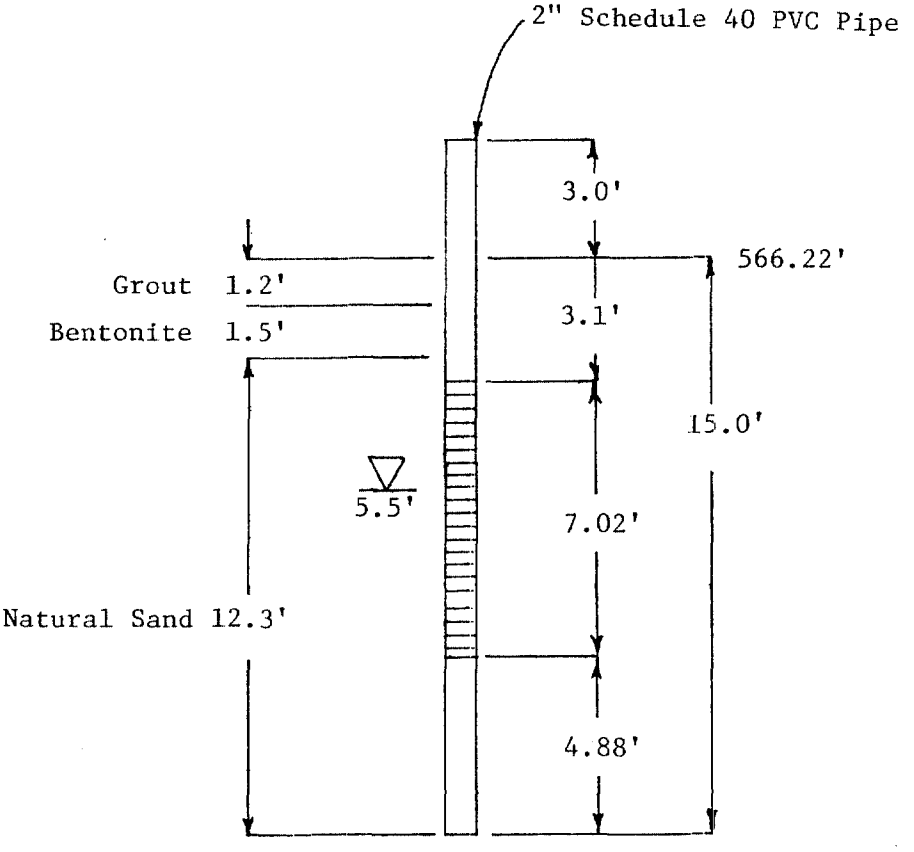
Well screen

NWSC, Crane, Indiana

McComish Gorge

Well Completion

Boring Number: WES-4-2-81




Water depth at time of drilling

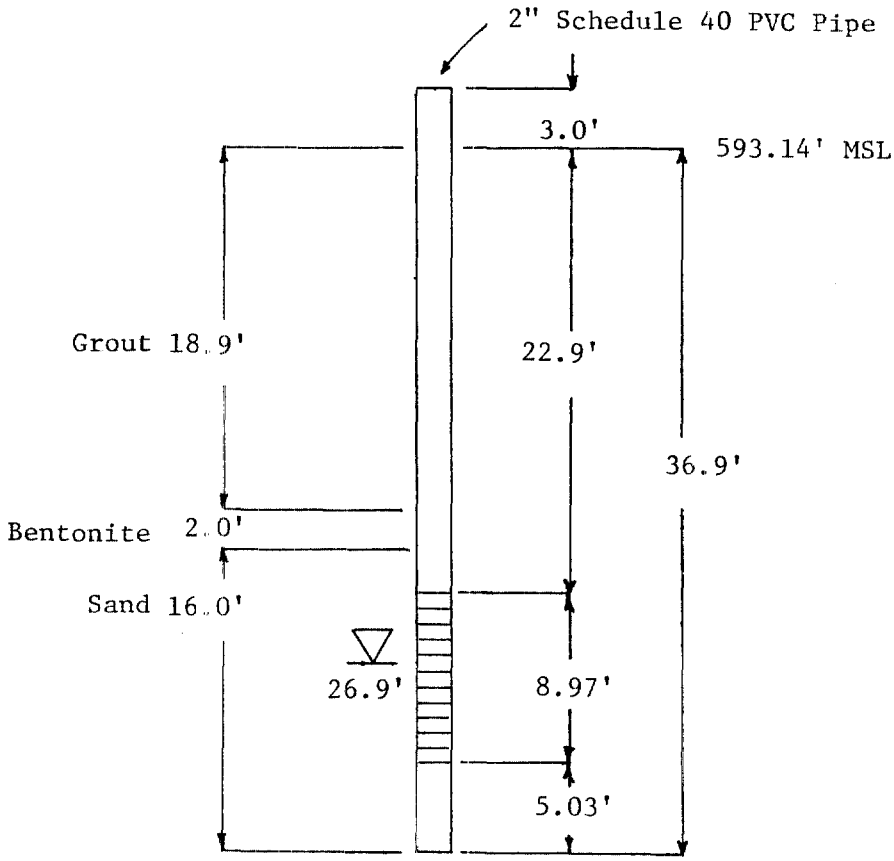
Well screen

NWSC, Crane, Indiana

McComish Gorge

Well Completion

Boring Number: WES-4-3-81




Water depth at time of drilling

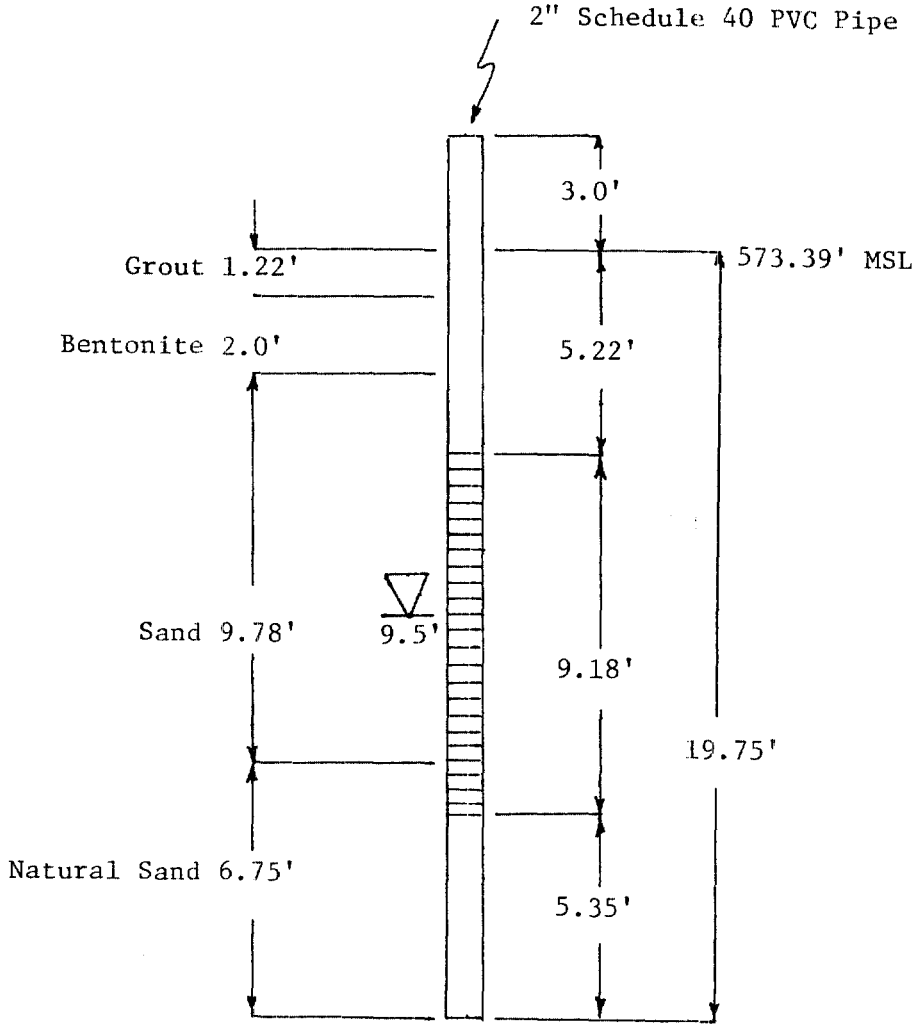
Well screen

NWSC, Crane, Indiana

McComish Gorge

Well Completion

Boring Number: WES-4-4-81




Water depth at time of drilling

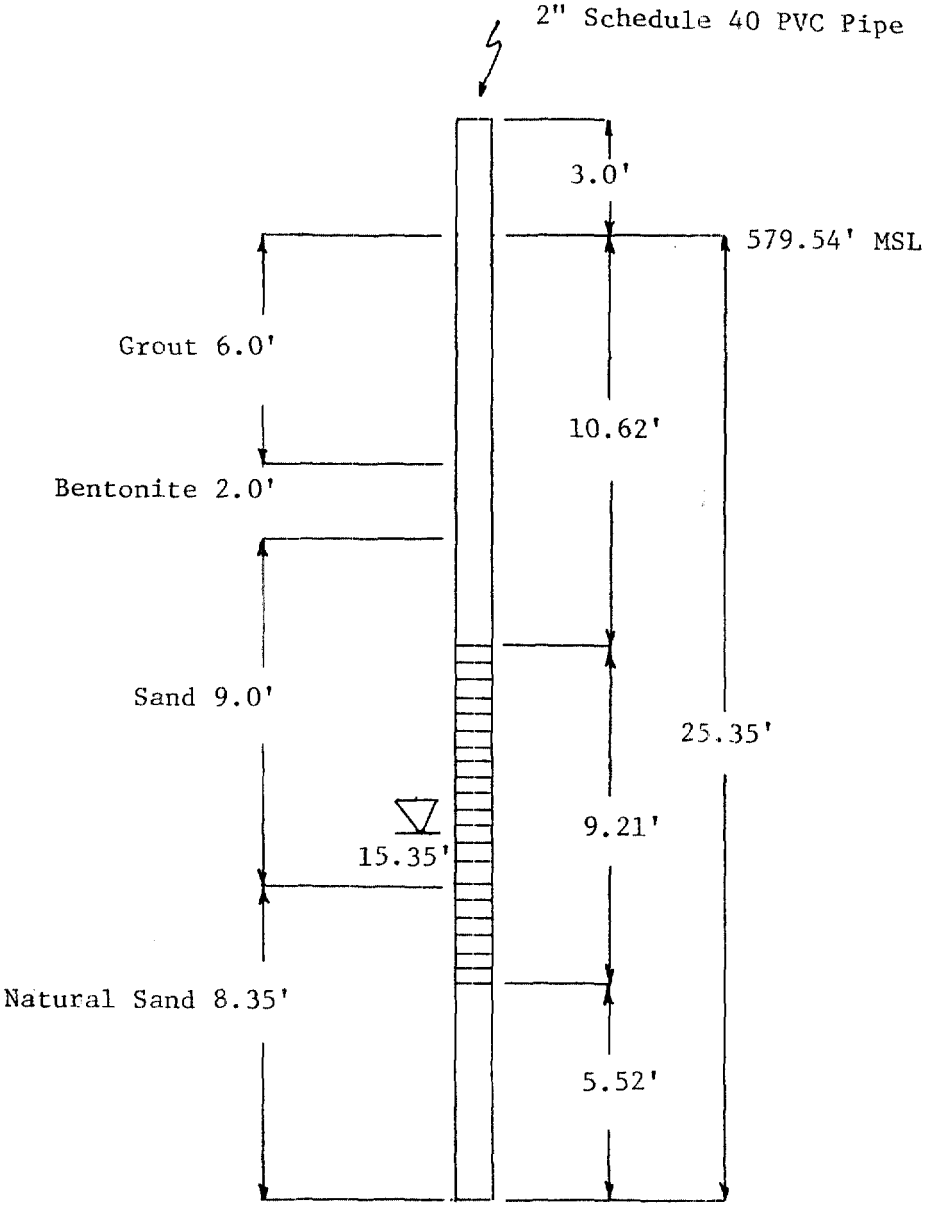
Well screen

NWSC, Crane, Indiana

McComish Gorge

Well Completion

Boring Number: WES-4-5-81




Water depth at time of drilling

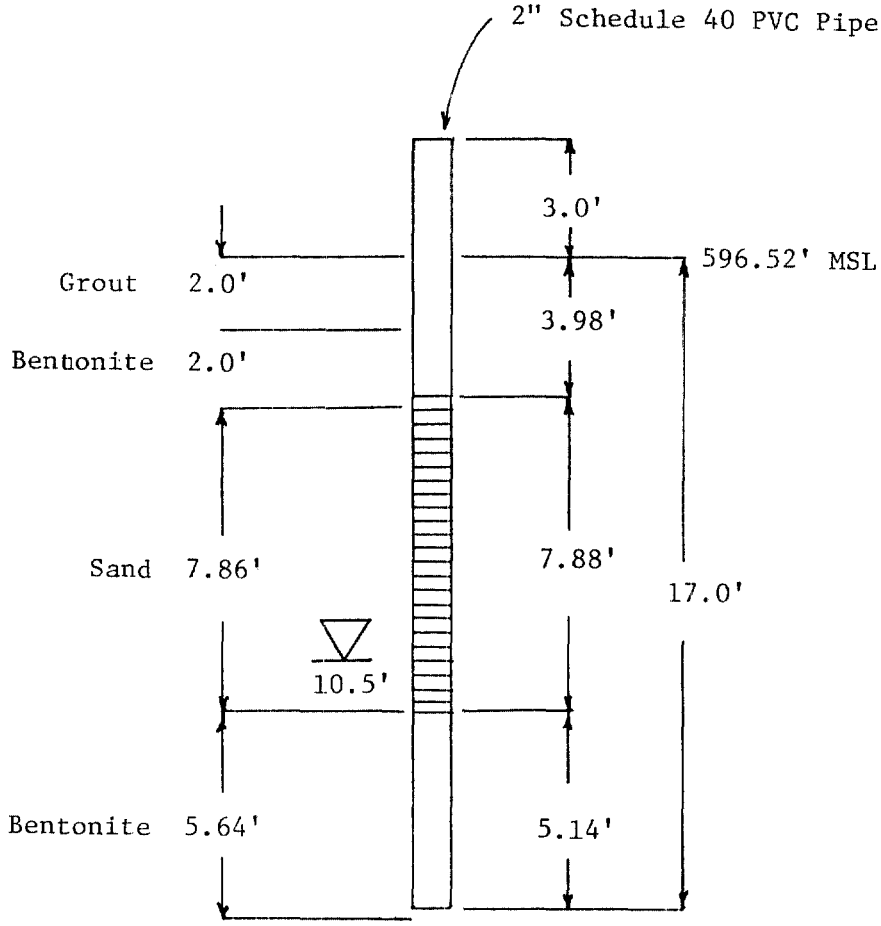
Well screen

NWSC, Crane, Indiana

McComish Gorge

Well Completion

Boring Number: WES-4-6-81




Water depth at time of drilling

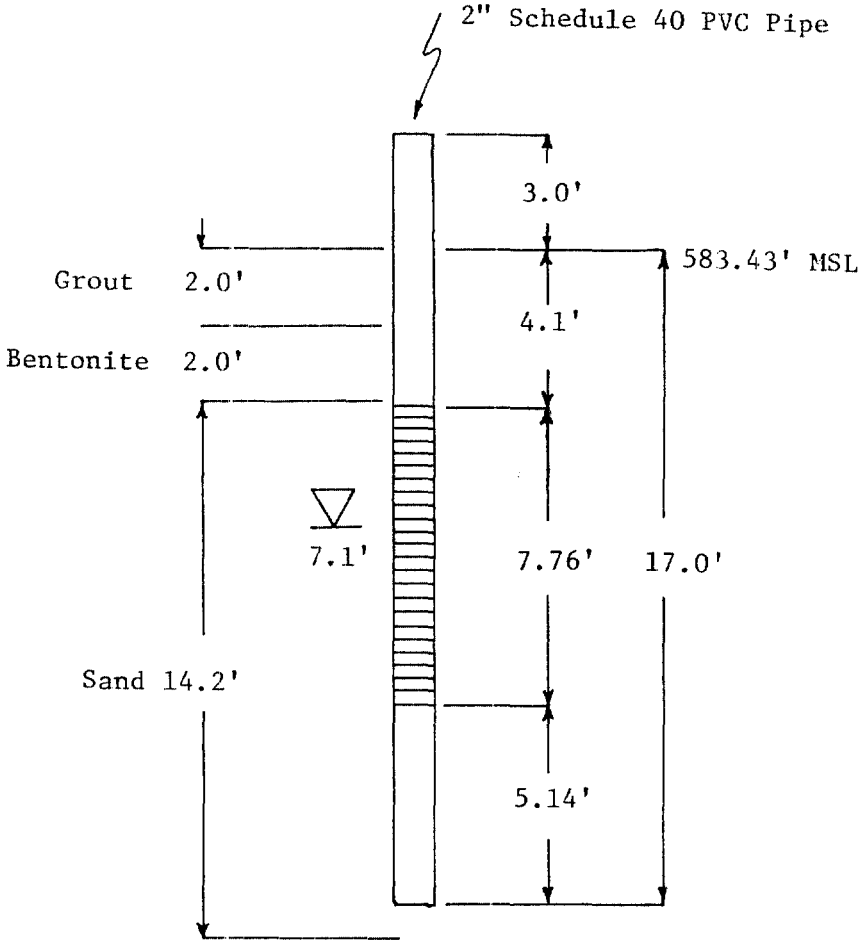
Well screen

NWSC, Crane, Indiana

Old Burning Pit

Well Completion

Boring Number: WES-5-1-81




Water depth at time of drilling

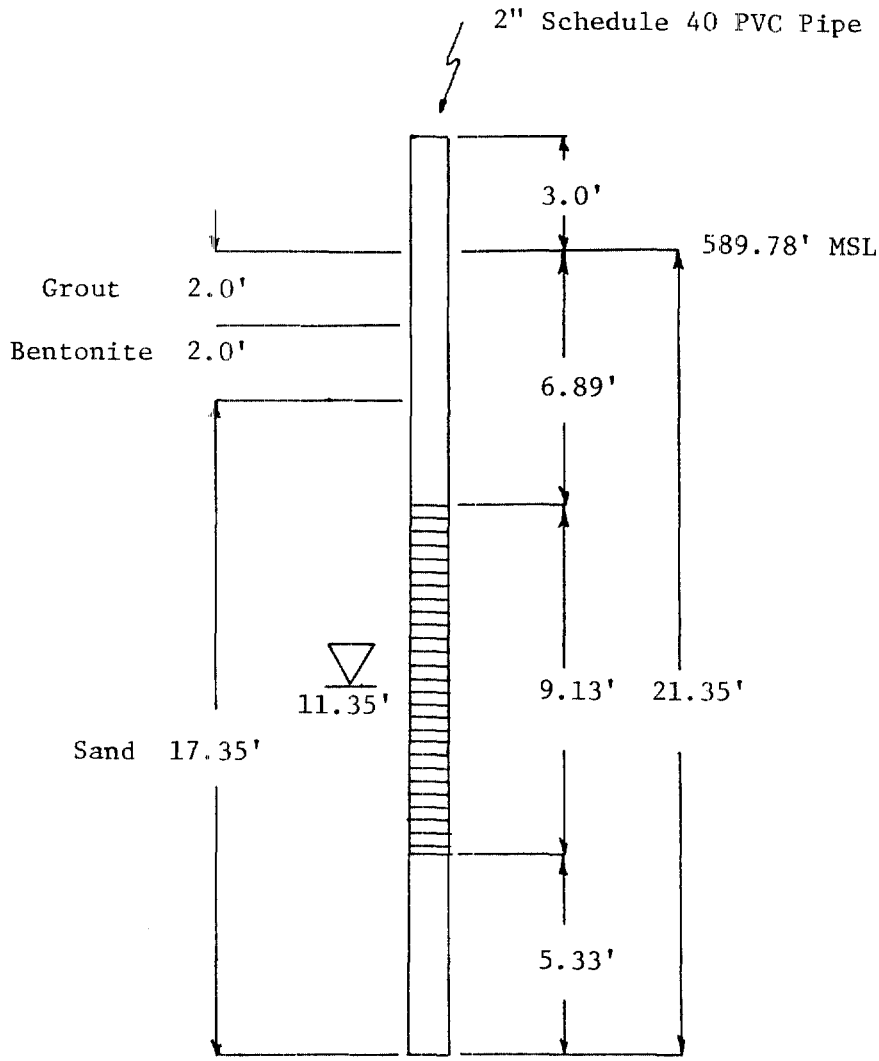
Well screen

NWSC, Crane, Indiana

Old Burning Pit

Well Completion

Boring Number: WES-5-2-81




Water depth at time of drilling

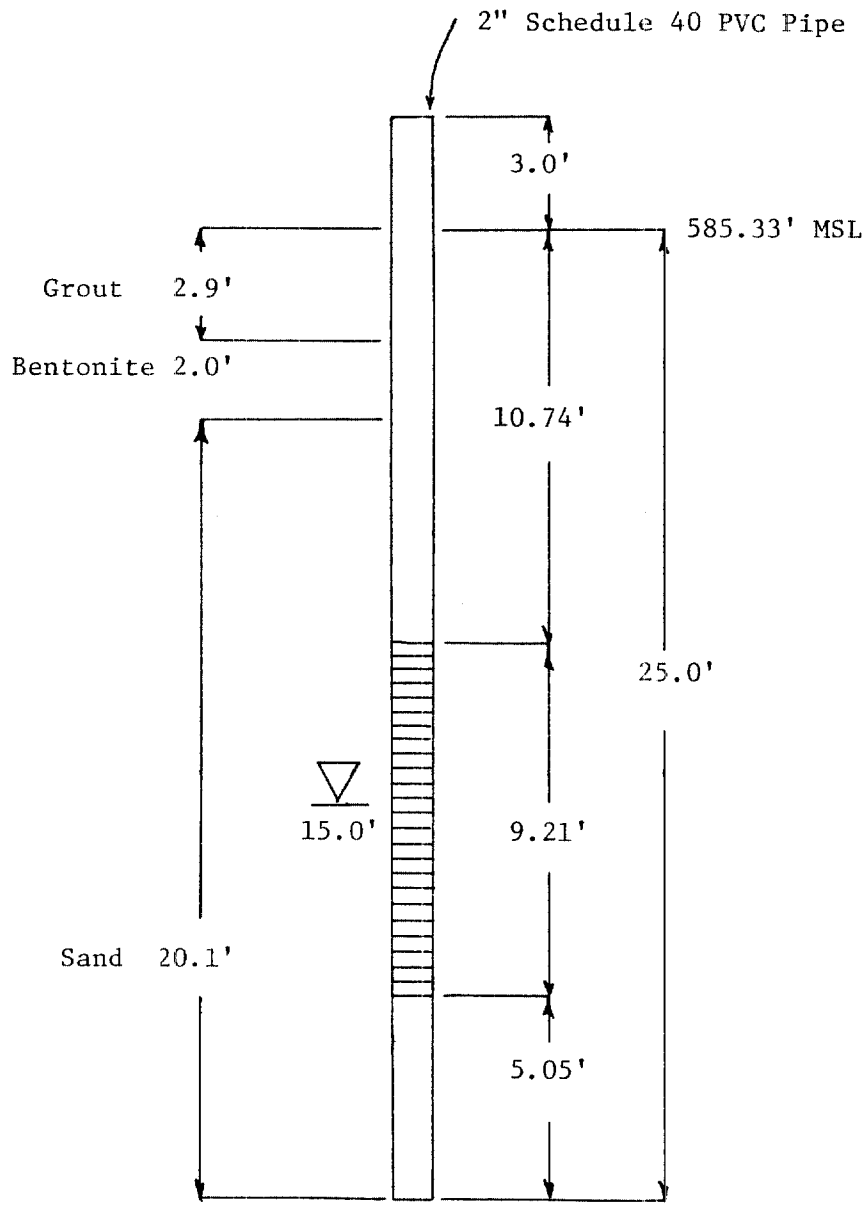
Well screen

NWSC, Crane, Indiana

Old Burning Pit

Well Completion

Boring Number: WES-5-3-81




Water depth at time of drilling

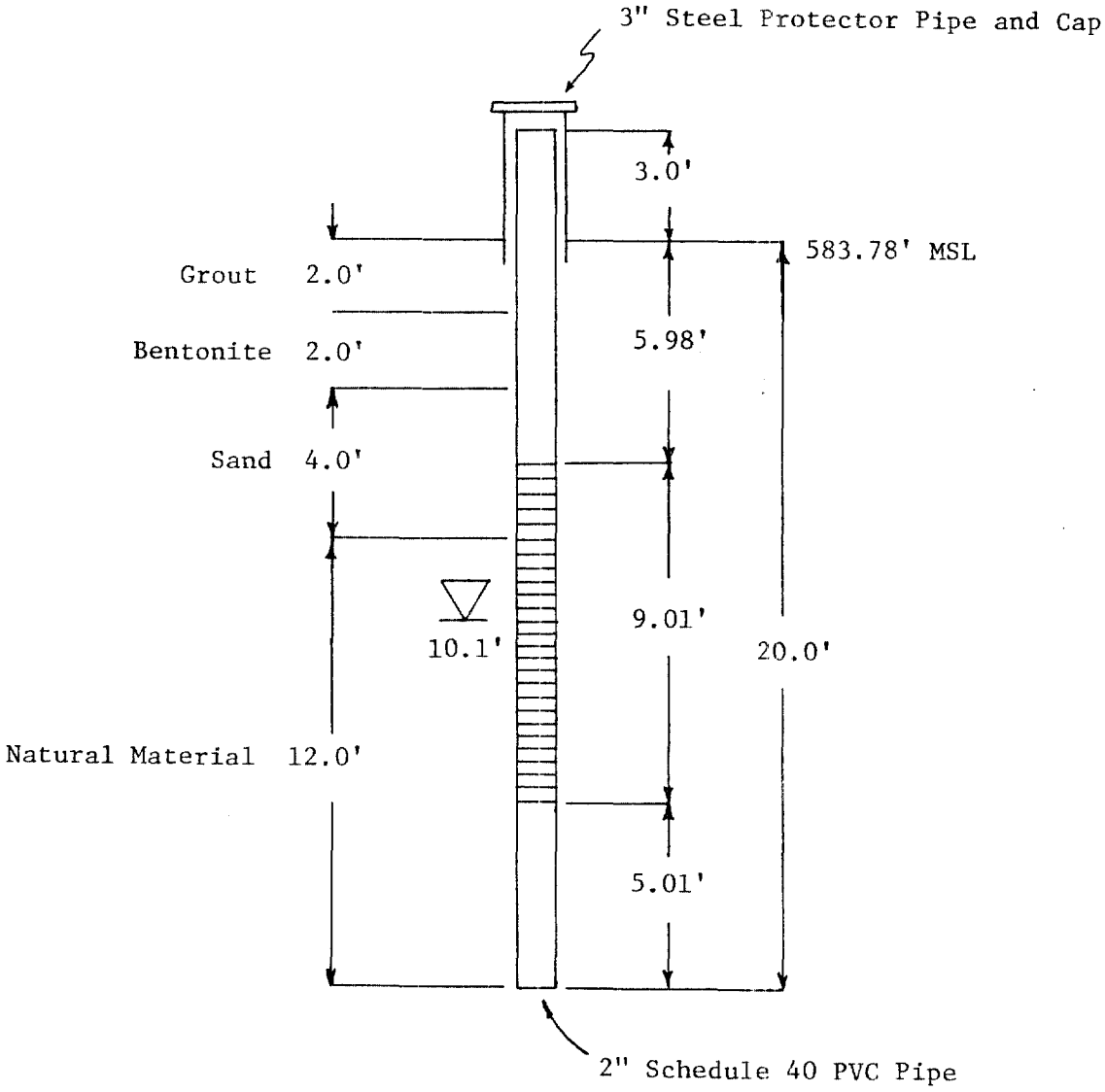
Well screen

NWSC, Crane, Indiana

Old Burning Pit

Well Completion

Boring Number: WES-5-4-81




Water depth at time of drilling

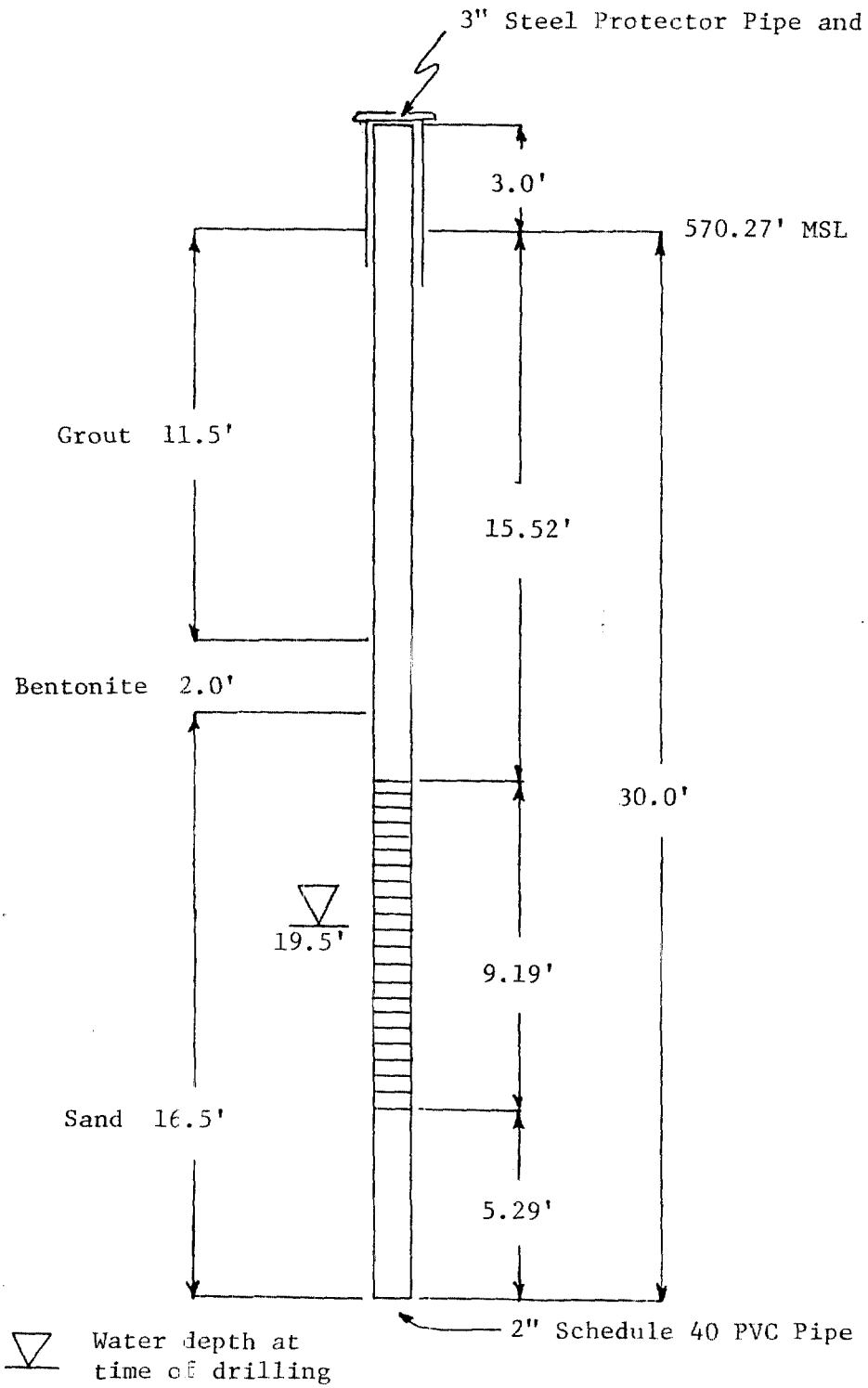
Well screen

NWSC, Crane, Indiana

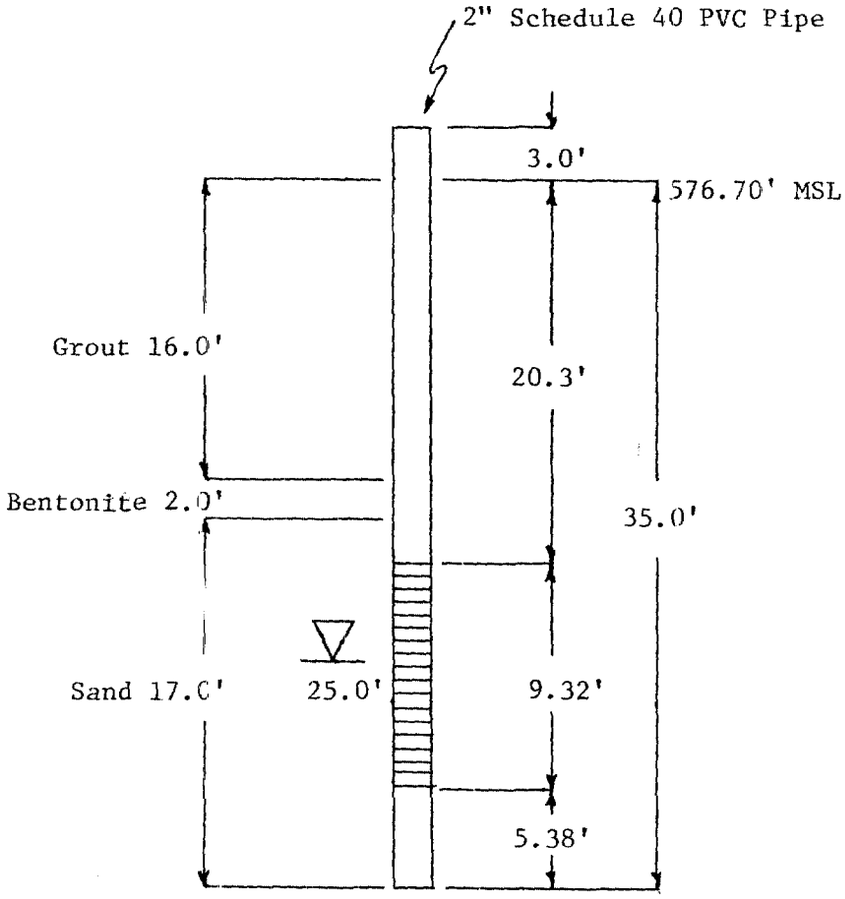
Old Burning Pit

Well Completion

Boring Number: WES-5-5-81




NWSC, Crane, Indiana
Old Burning Pit
Well Completion
Boring Number: WES-5-6-81




Water depth at time of drilling

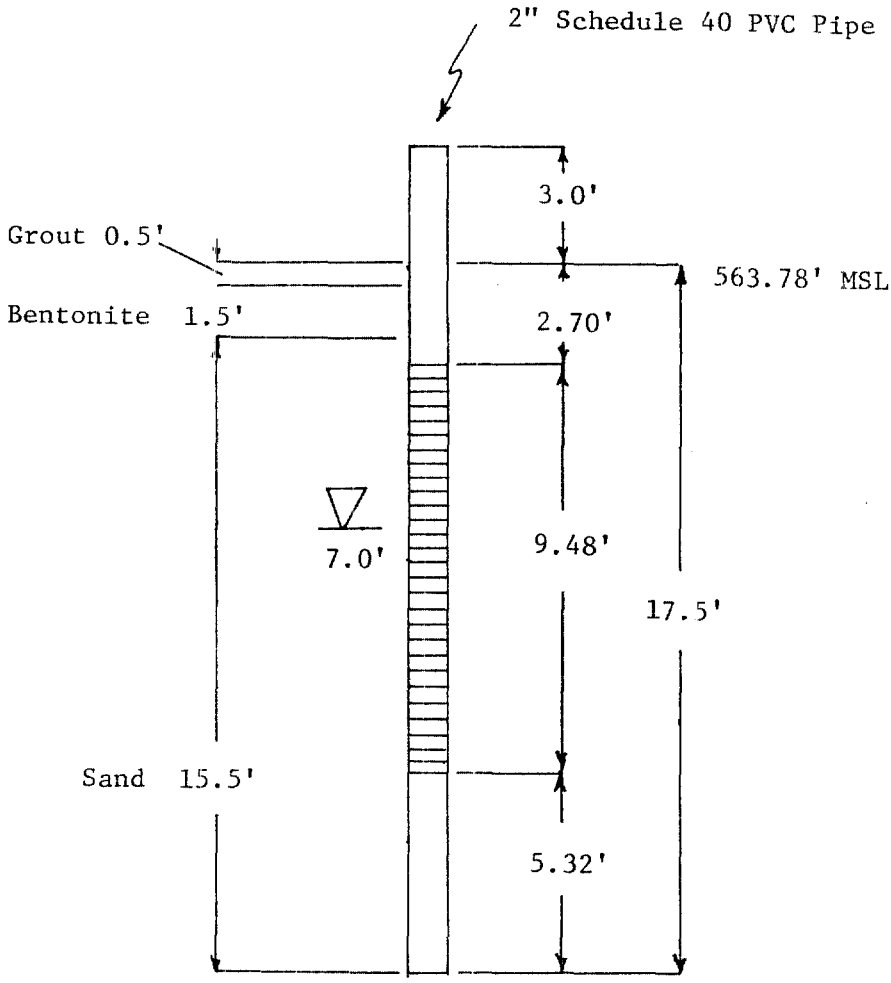
Well screen

NWSC, Crane, Indiana

Old Burning Pit

Well Completion

Boring Number: WES-5-7-81




Water depth at time of drilling

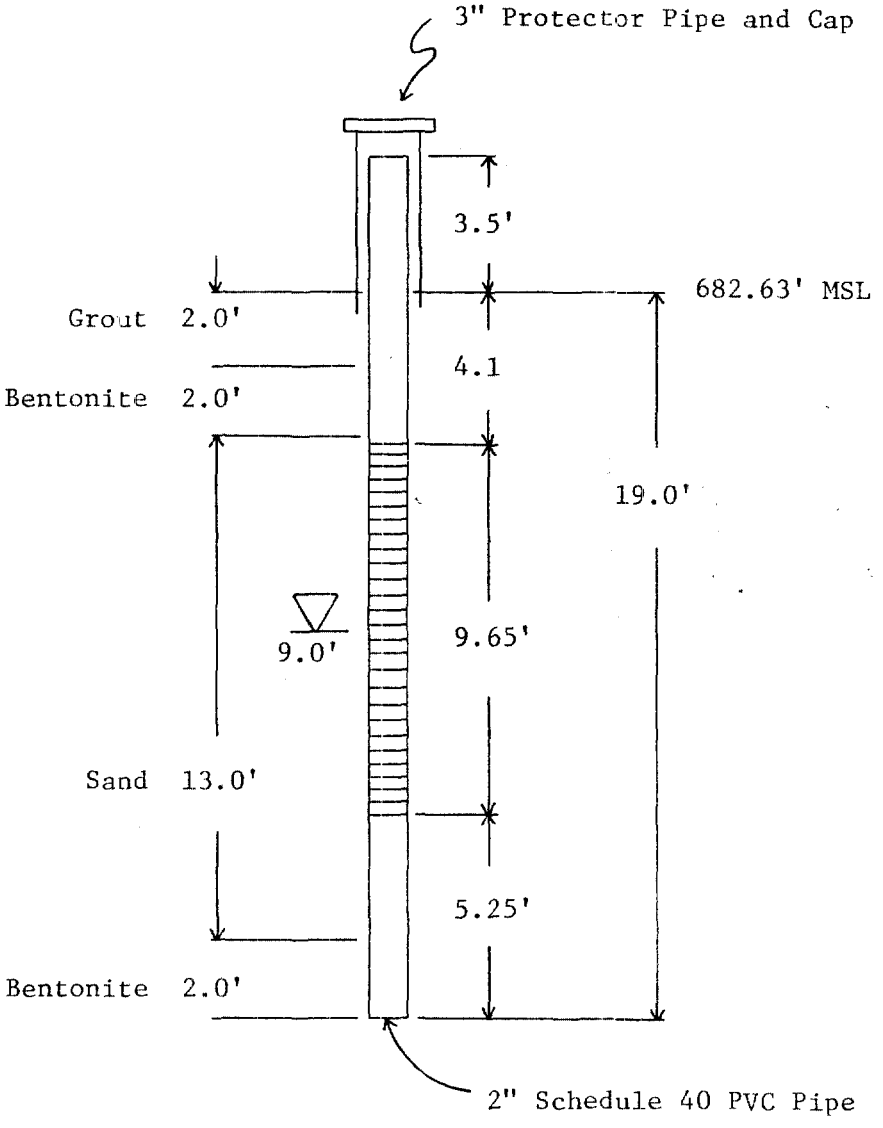
Well screen

NWSC, Crane, Indiana

Old Burning Pit

Well Completion

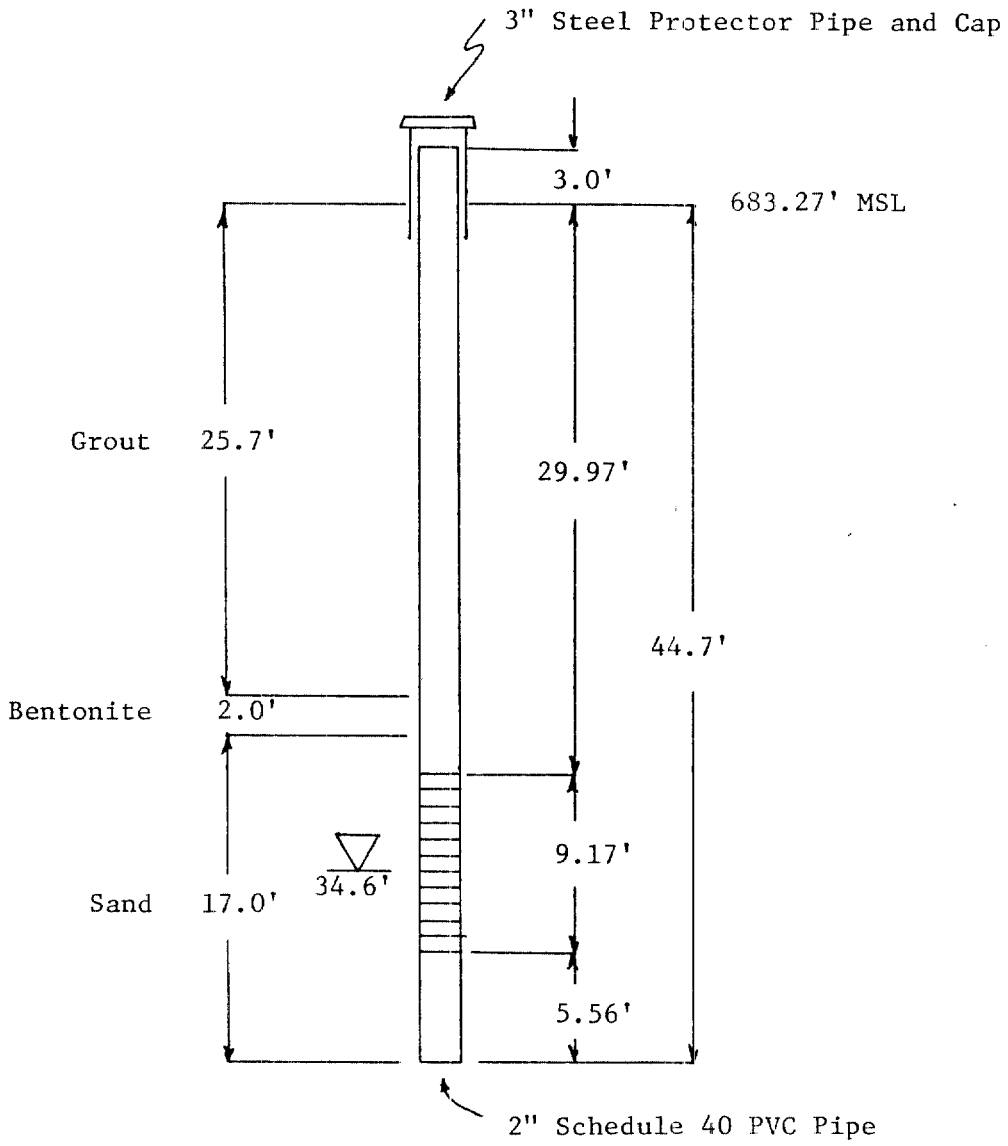
Boring Number: WES-5-8-81




Well screen

Water depth at time of drilling

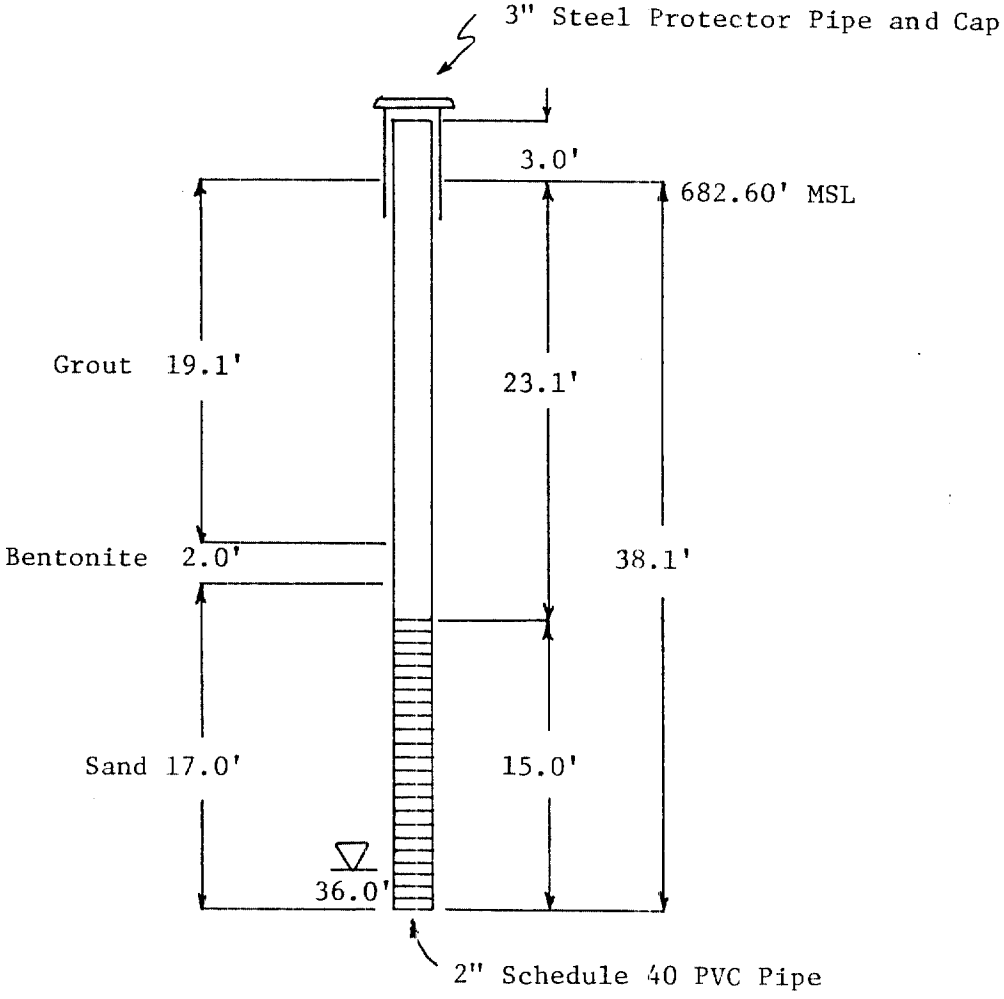
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-1A-81




Well screen

Water depth at time of drilling

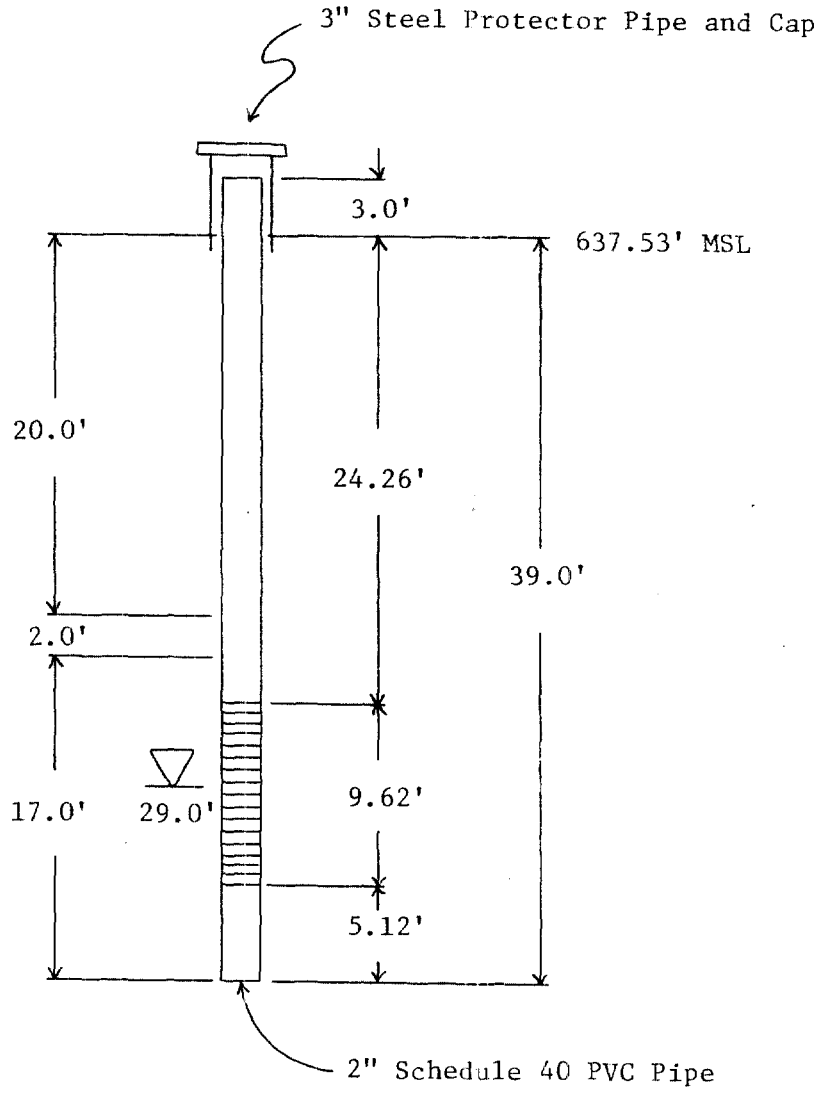
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-1B-81




Well screen

Water depth at time of drilling

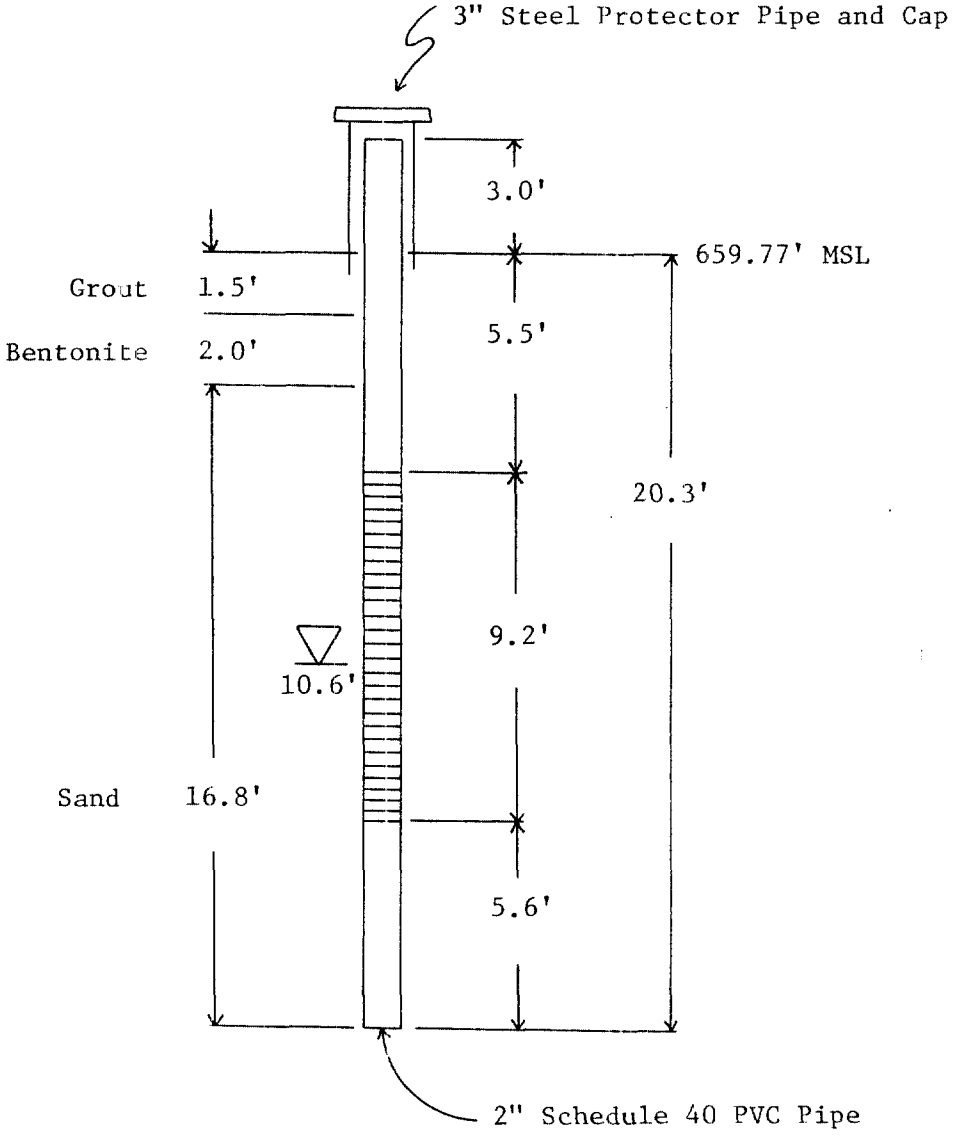
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-1C-81




Well screen

Water depth at time of drilling

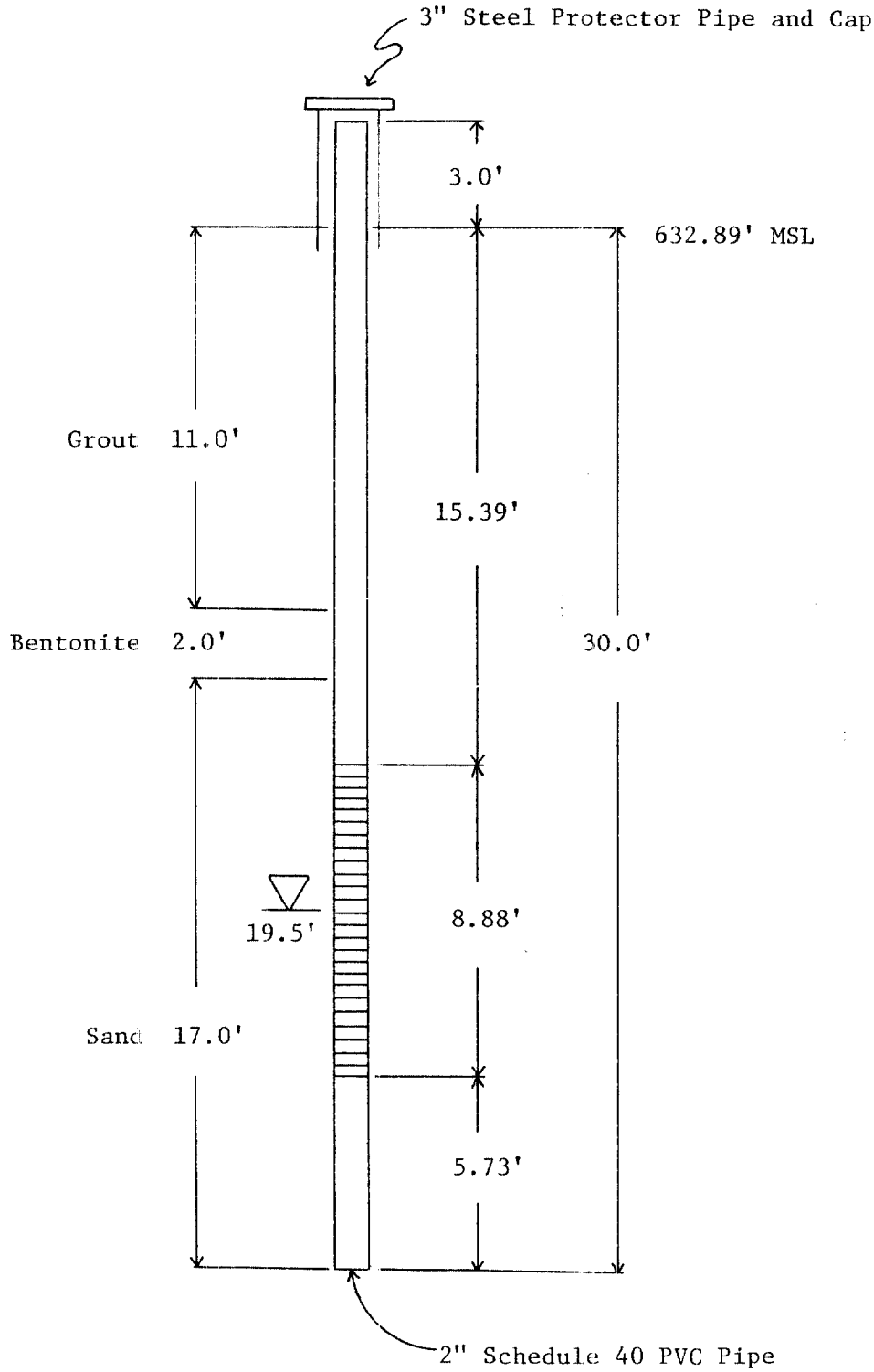
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-2-81




Well screen

Water depth at time of drilling

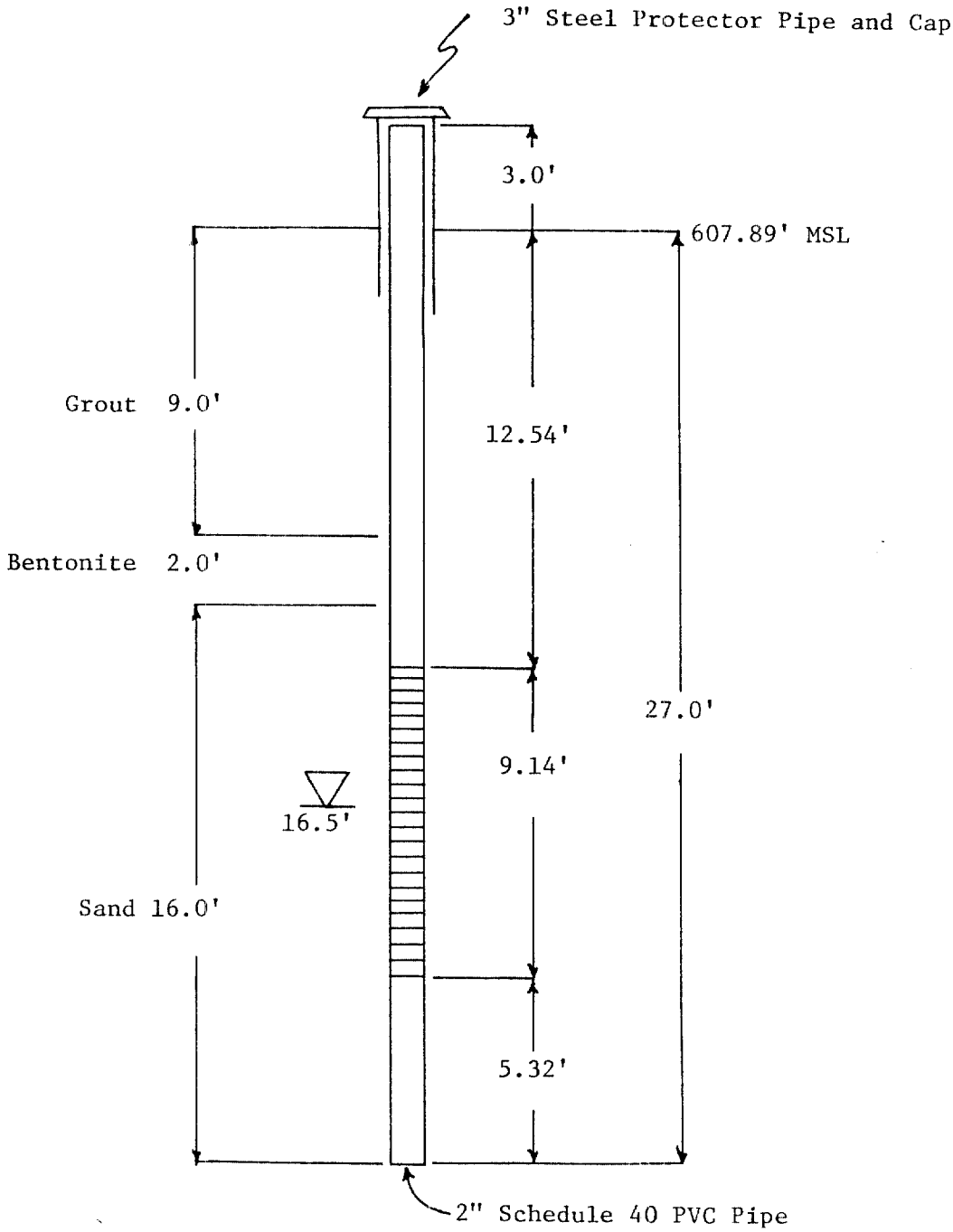
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-3-81




Well screen

Water depth at time of drilling

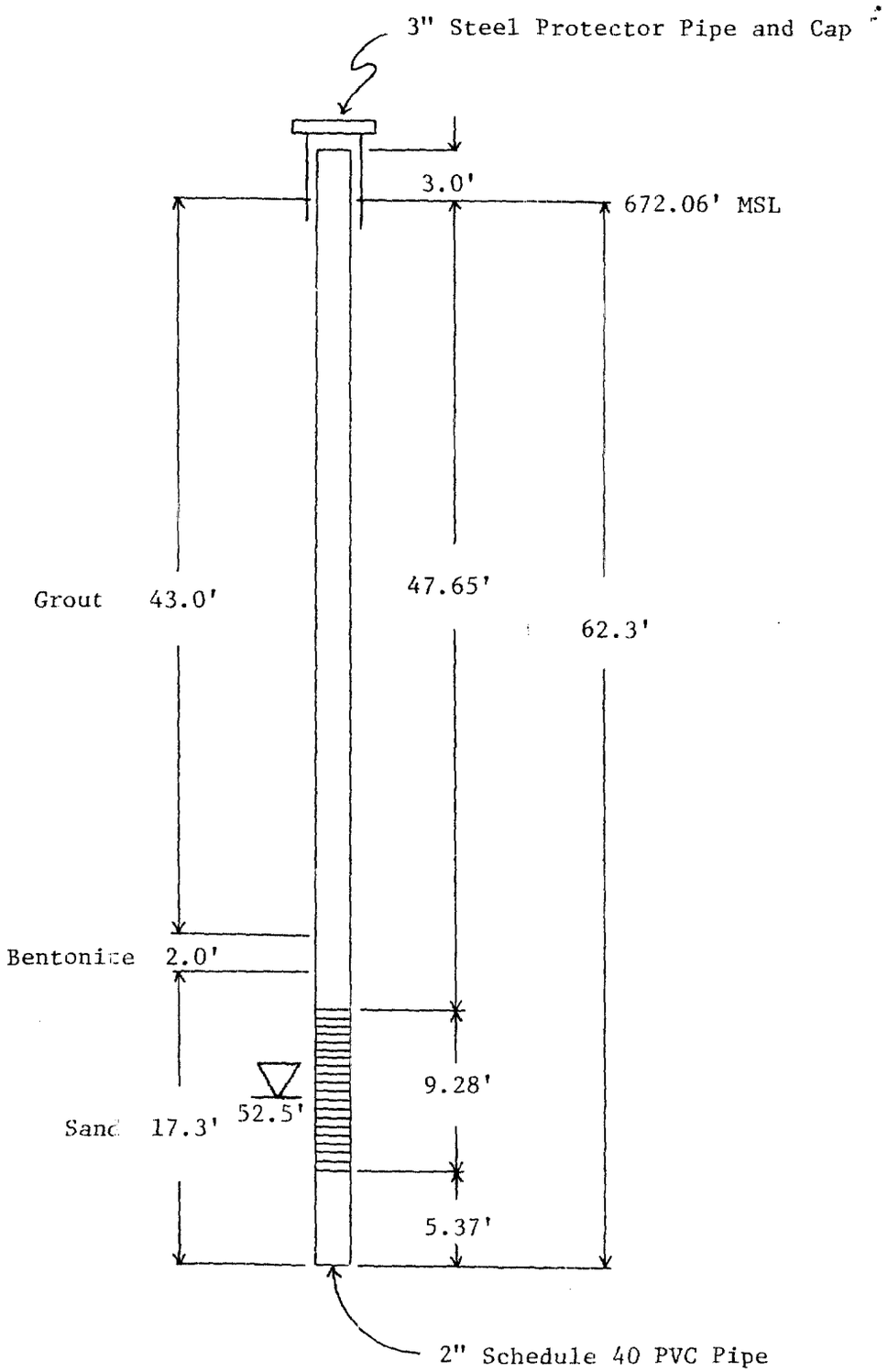
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-4-81




Well screen

Water depth at time of drilling

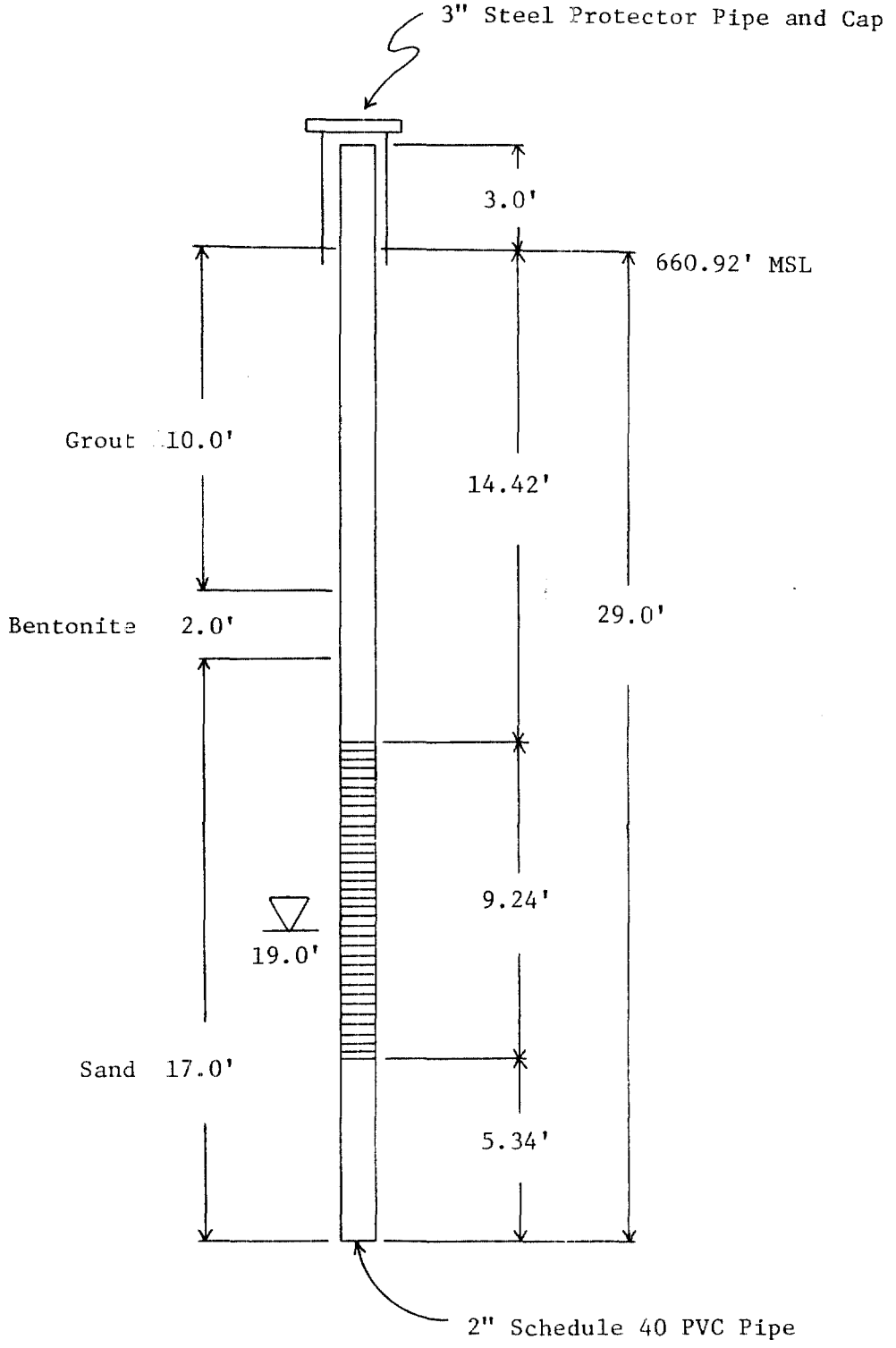
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-5-81




Well screen

Water depth at time of drilling

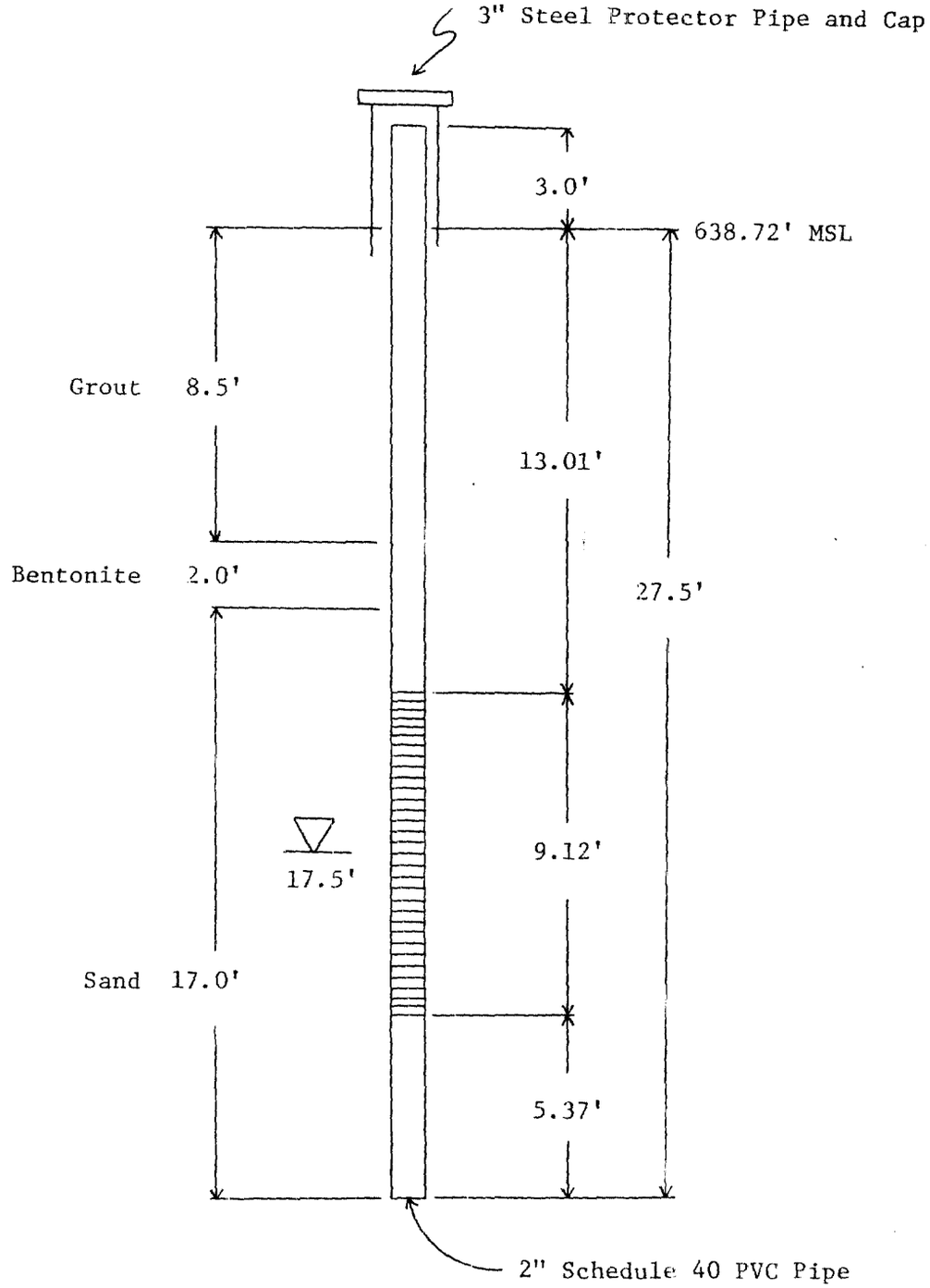
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-6-81




Well screen

Water depth at time of drilling

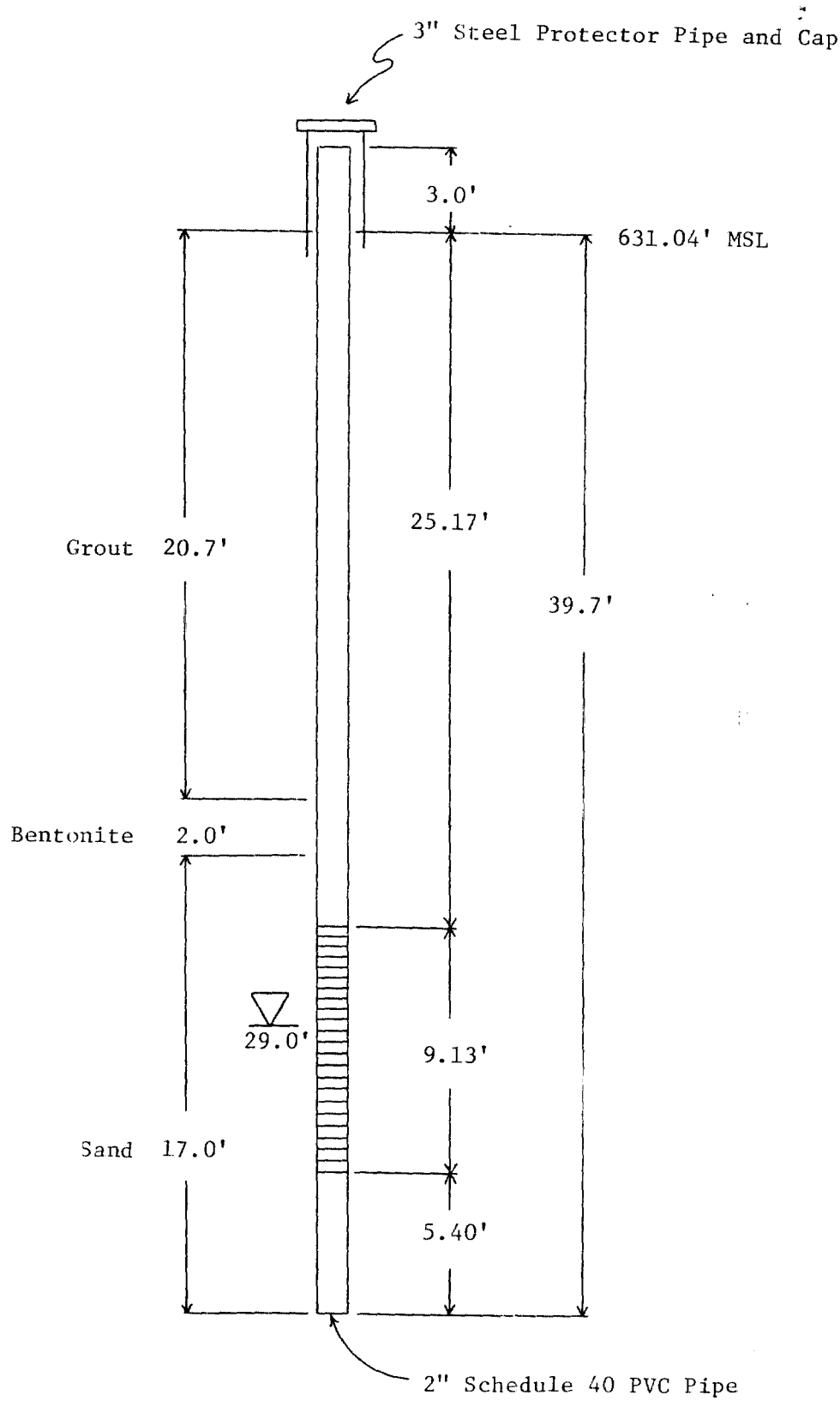
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-7-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-8-81




Well screen

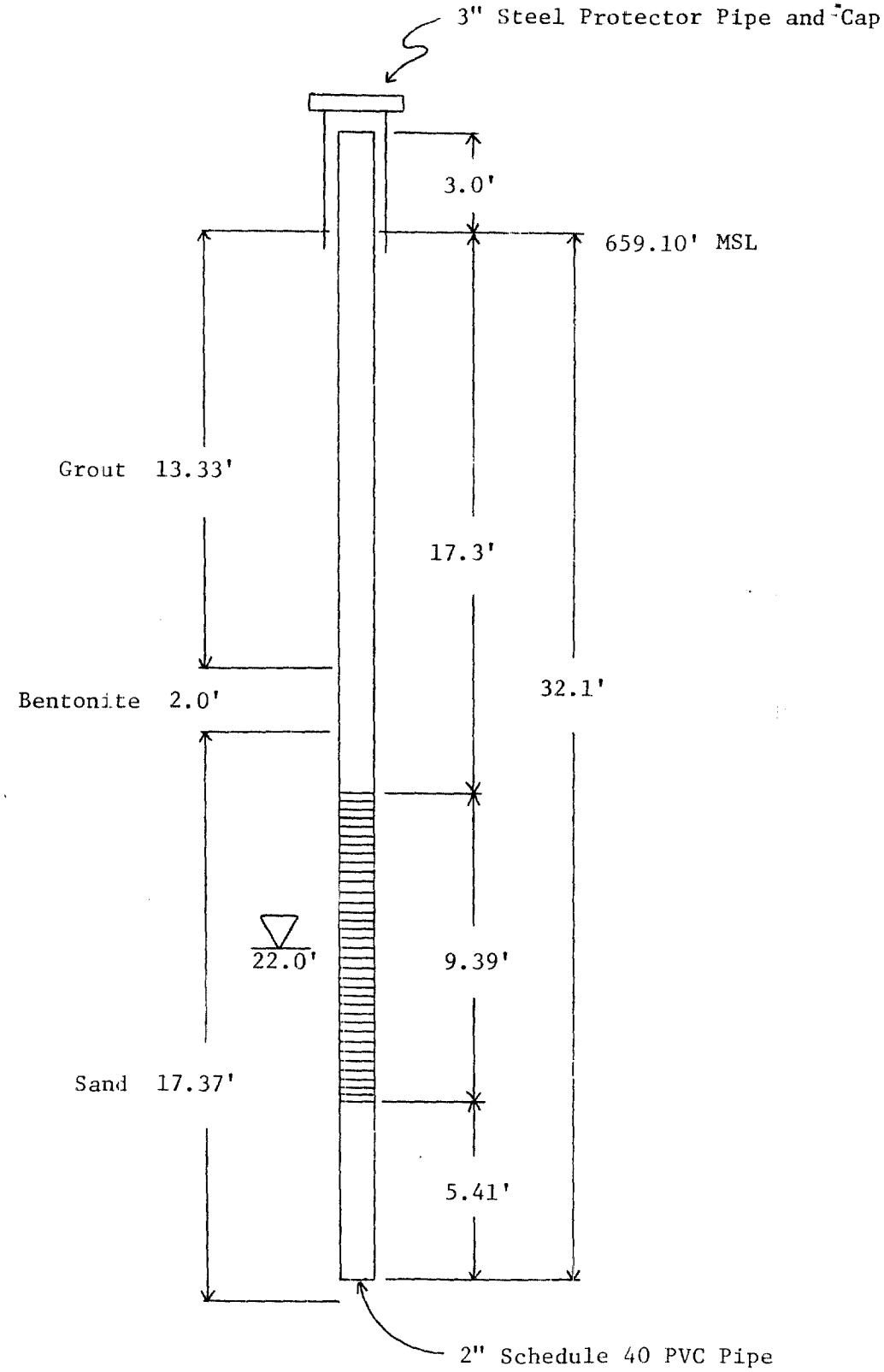
Water depth at time of drilling

NWSC, Crane, Indiana

Demolition Area

Well Completion

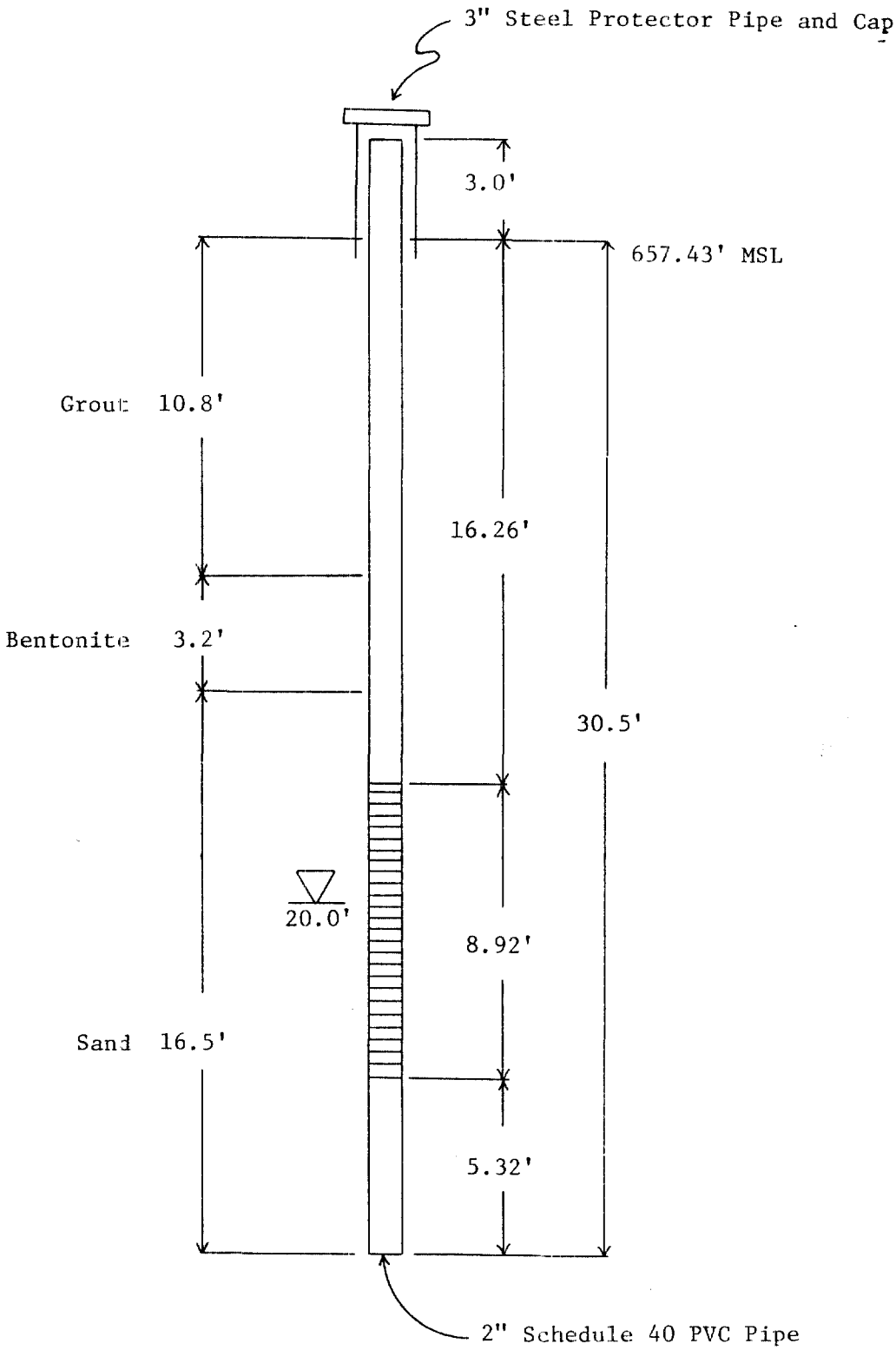
Boring Number: WES-6-9-81




Well screen

Water depth at time of drilling

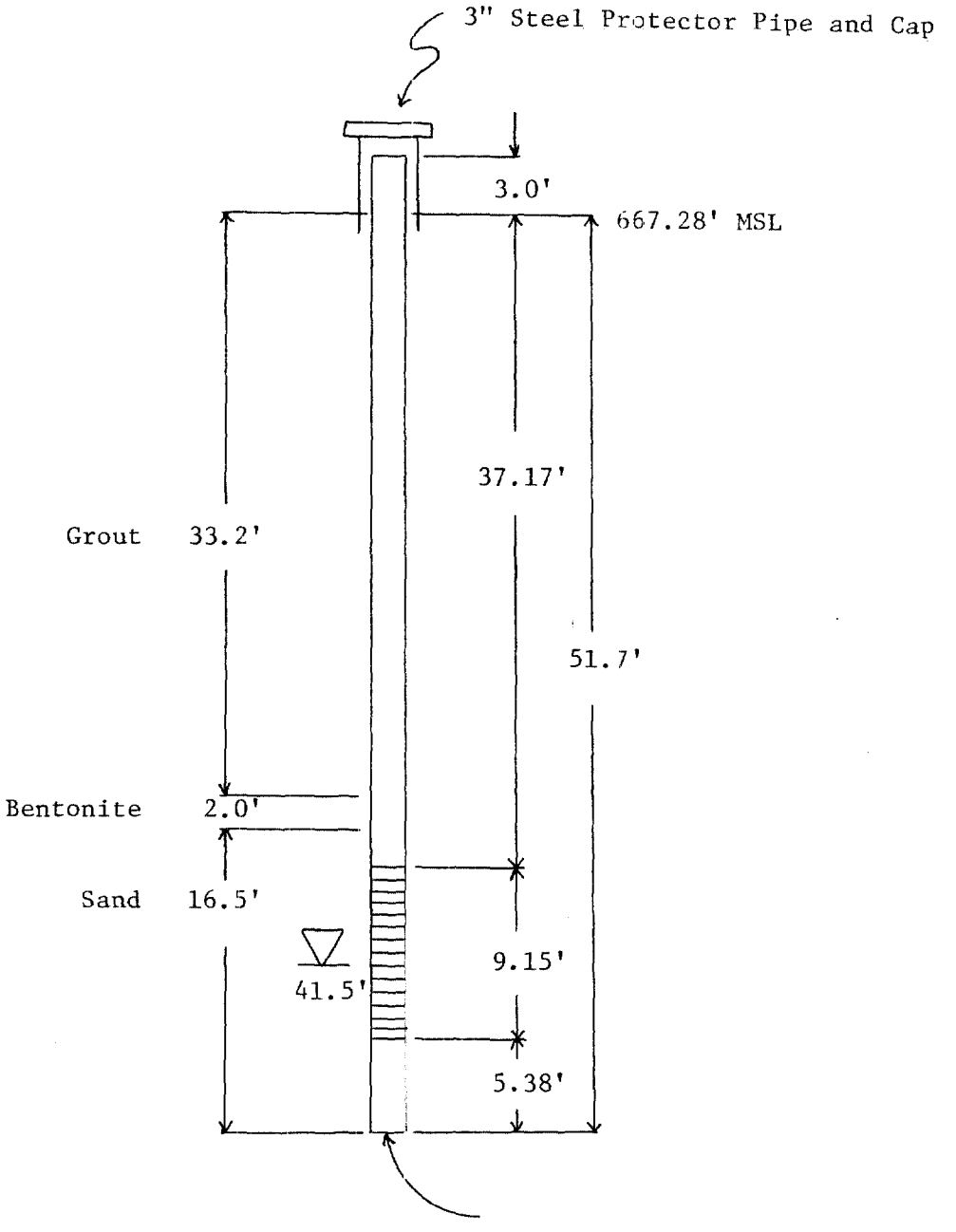
NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-10-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-11-81




Well screen

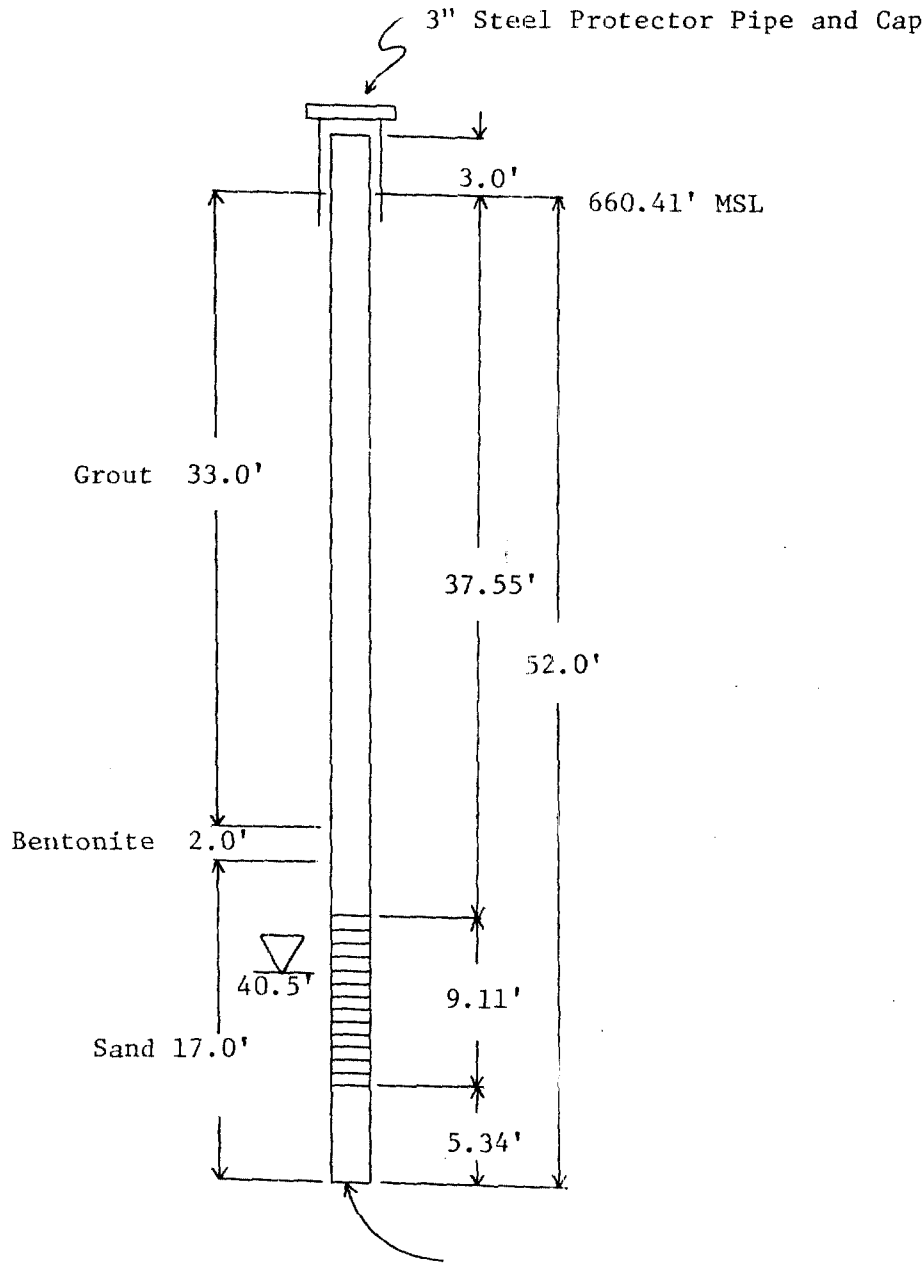
Water depth at time of drilling

NWSC, Crane, Indiana

Demolition Area

Well Completion

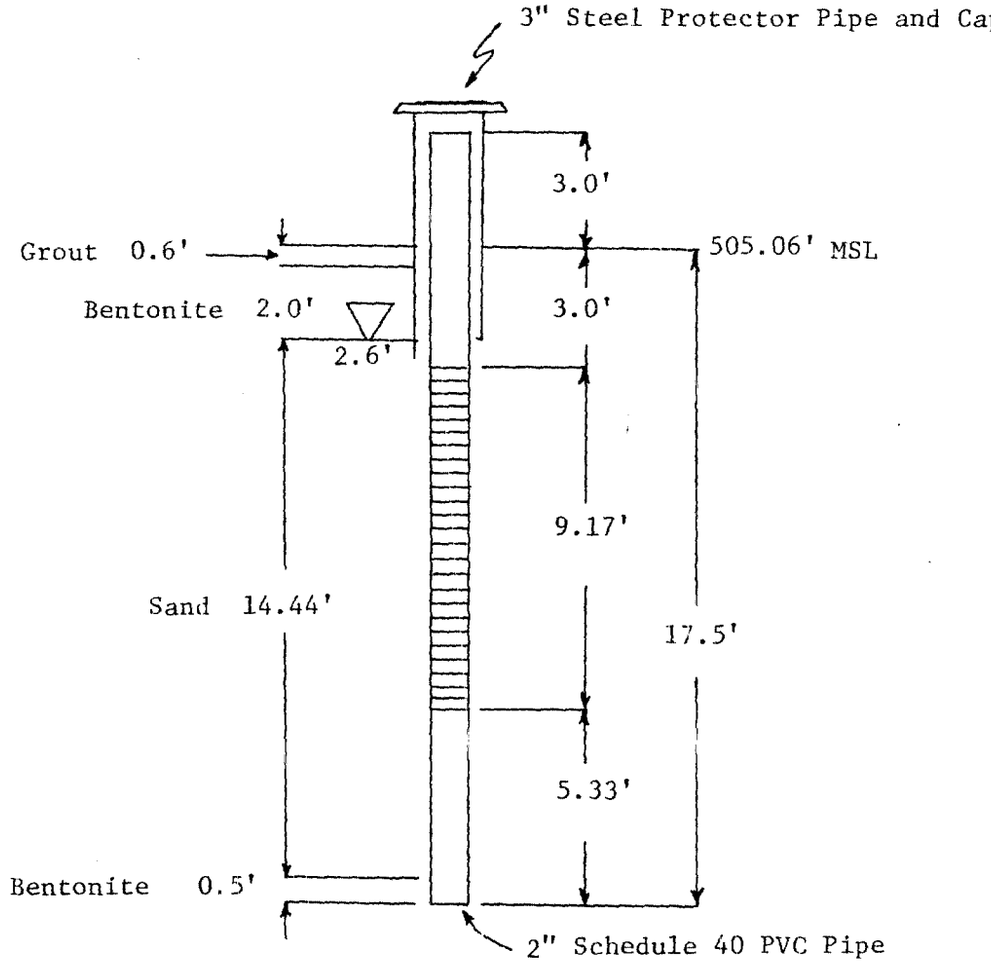
Boring Number: WES-6-12-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Demolition Area
Well Completion
Boring Number: WES-6-13-81




Well screen

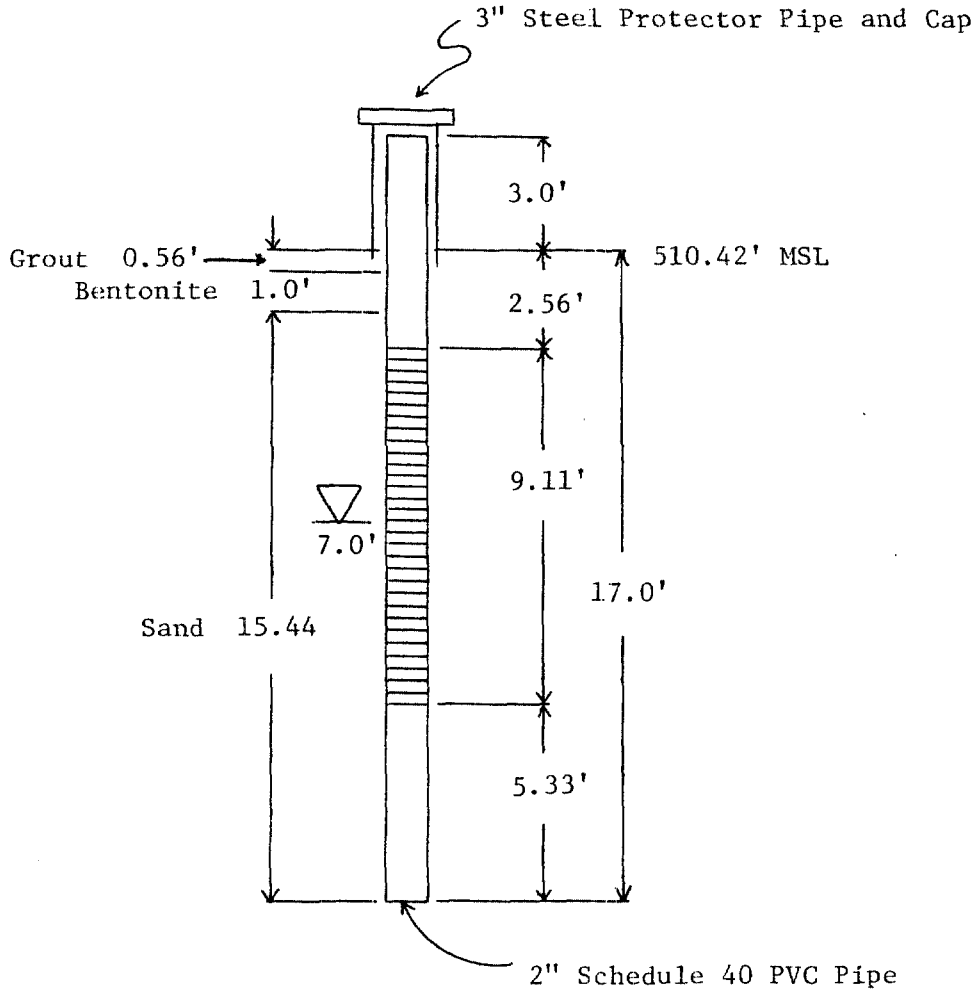
Water depth at time of drilling

NWSC, Crane, Indiana

Rifle Range

Well Completion

Boring Number: WES-6-14-81




Well screen

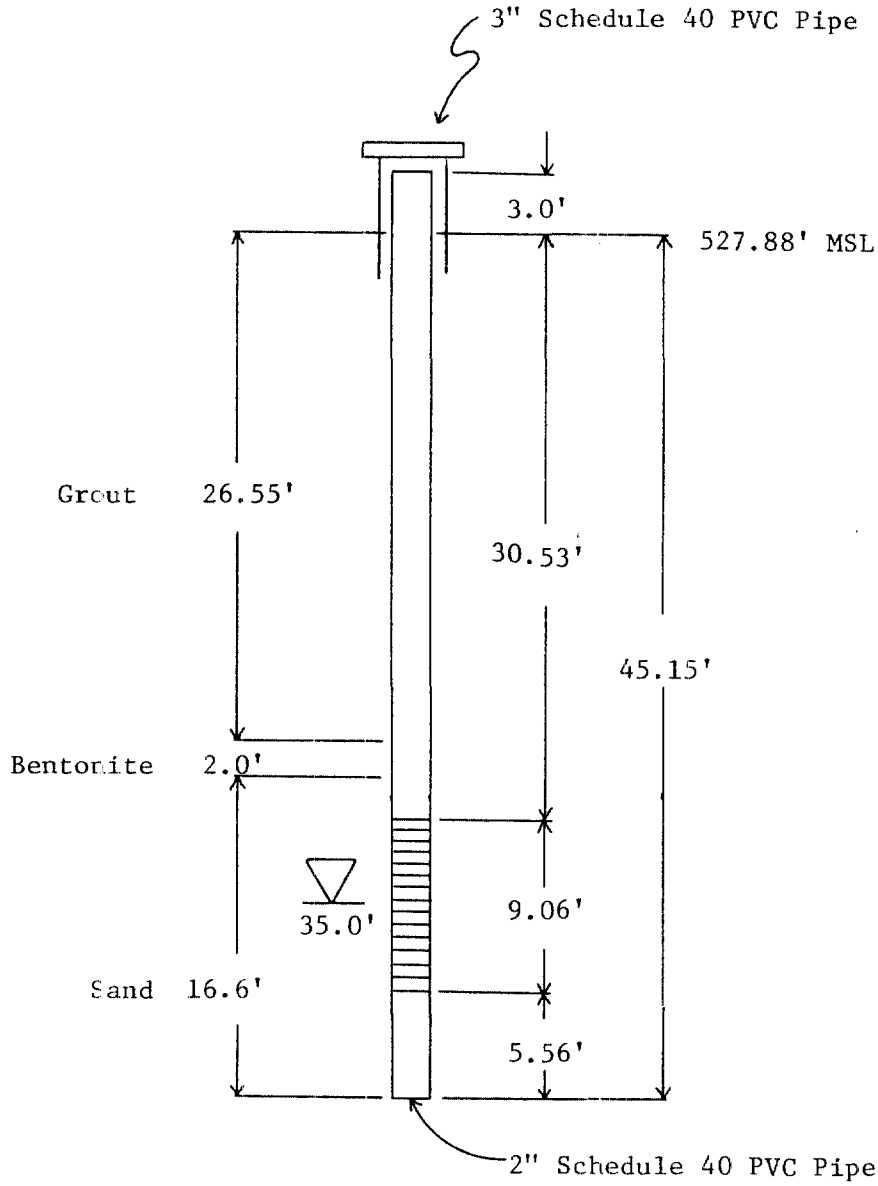
Water depth at time of drilling

NWSC, Crane, Indiana

Rifle Range

Well Completion

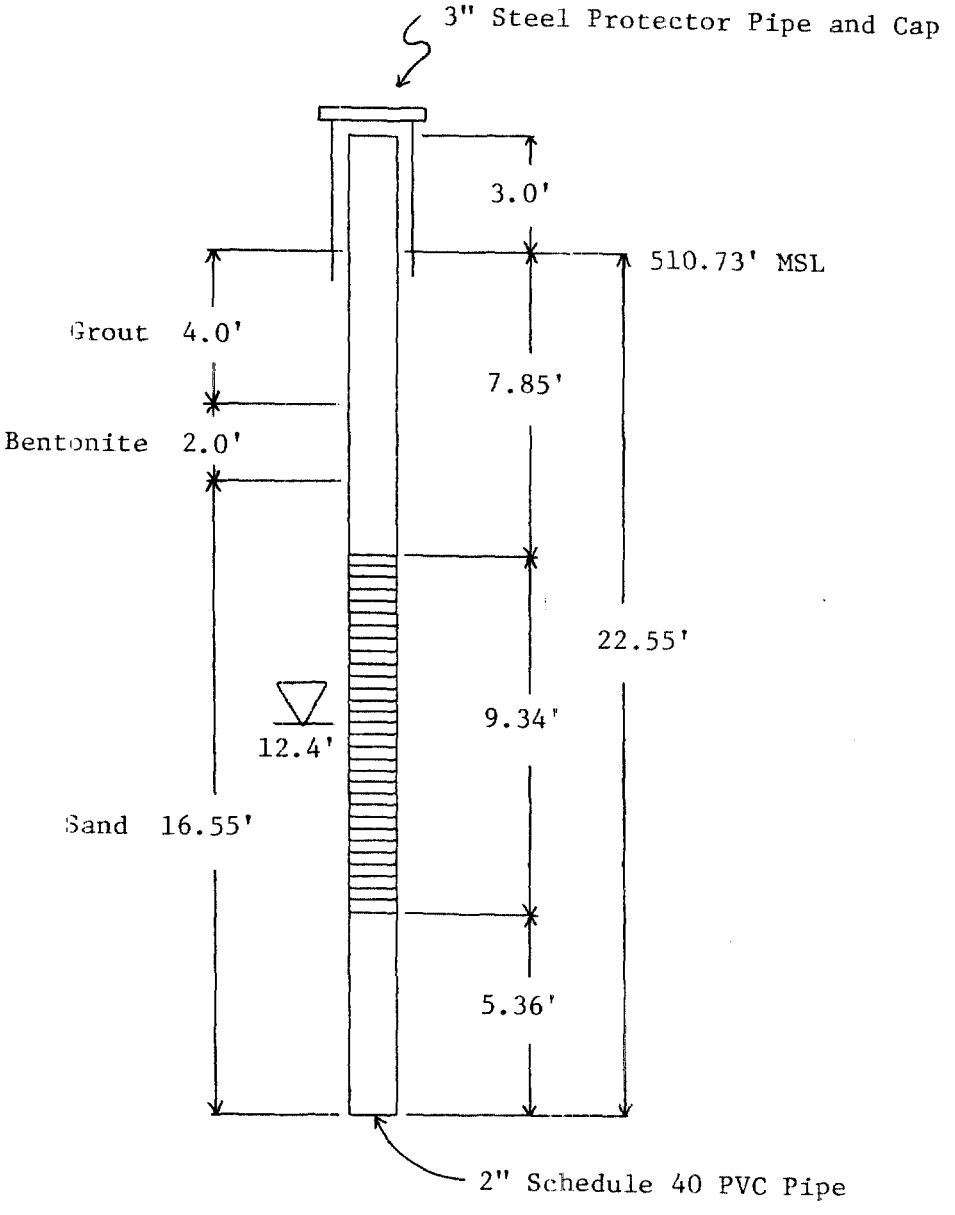
Boring Number: WES-6-15-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Rifle Range
Well Completion
Boring Number: WES-6-16-81




Well screen

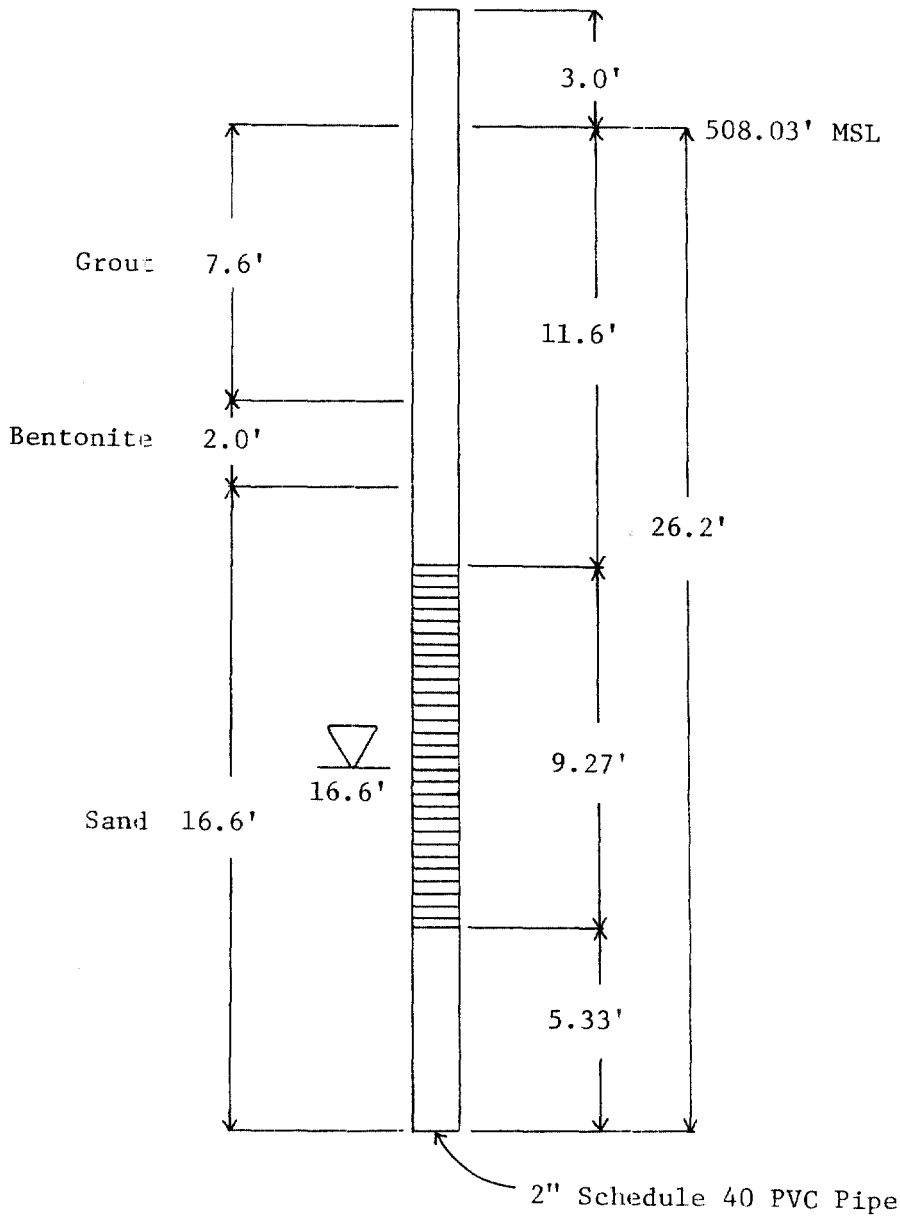
Water depth at time of drilling

NWSC, Crane, Indiana

Rifle Range

Well Completion

Boring Number: WES-6-17-81




Well screen

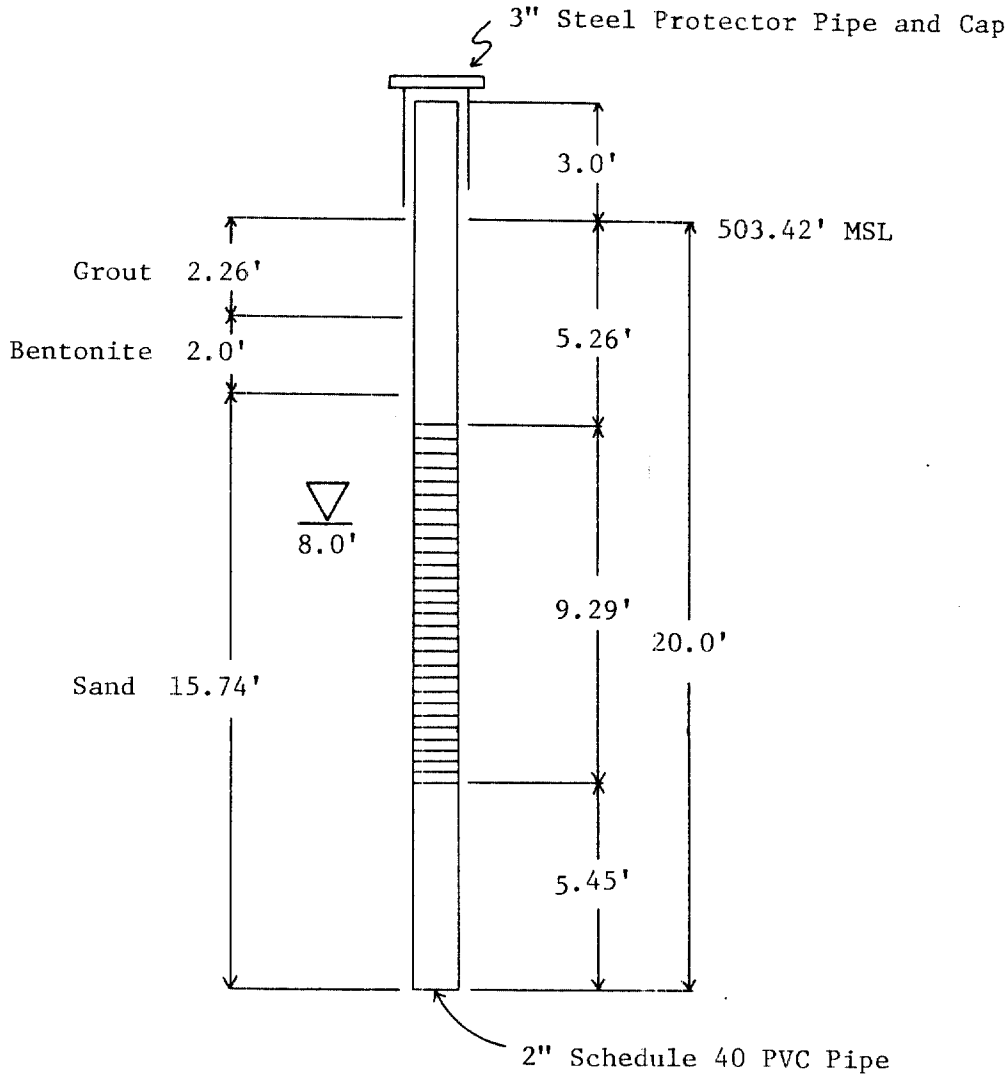
Water depth at time of drilling

NWSC, Crane, Indiana

Rifle Range

Well Completion

Boring Number: WES-6-18-81




Well screen

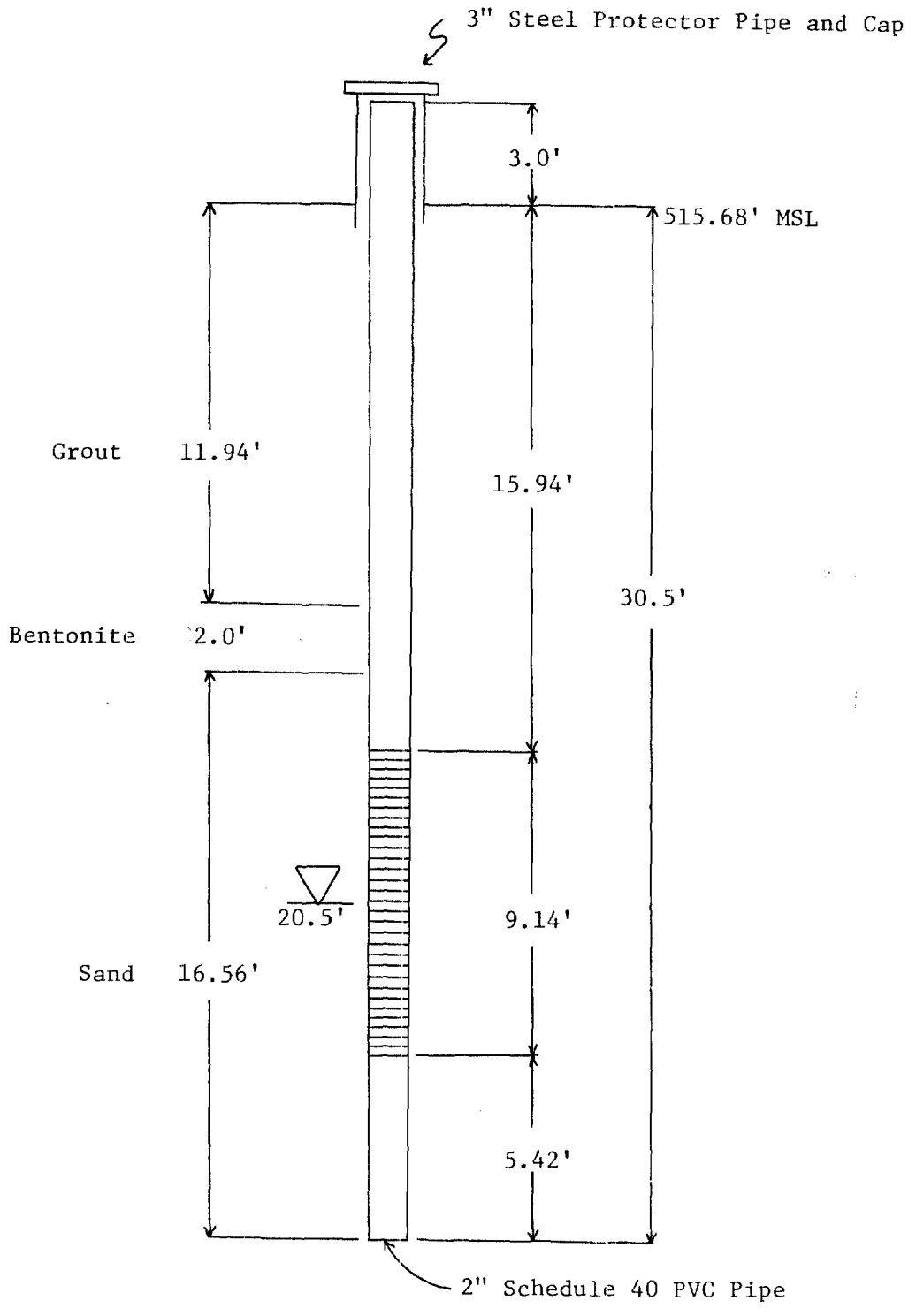
Water depth at time of drilling

NWSC, Crane, Indiana

Rifle Range

Well Completion

Boring Number: WES-6-19-81




Well screen

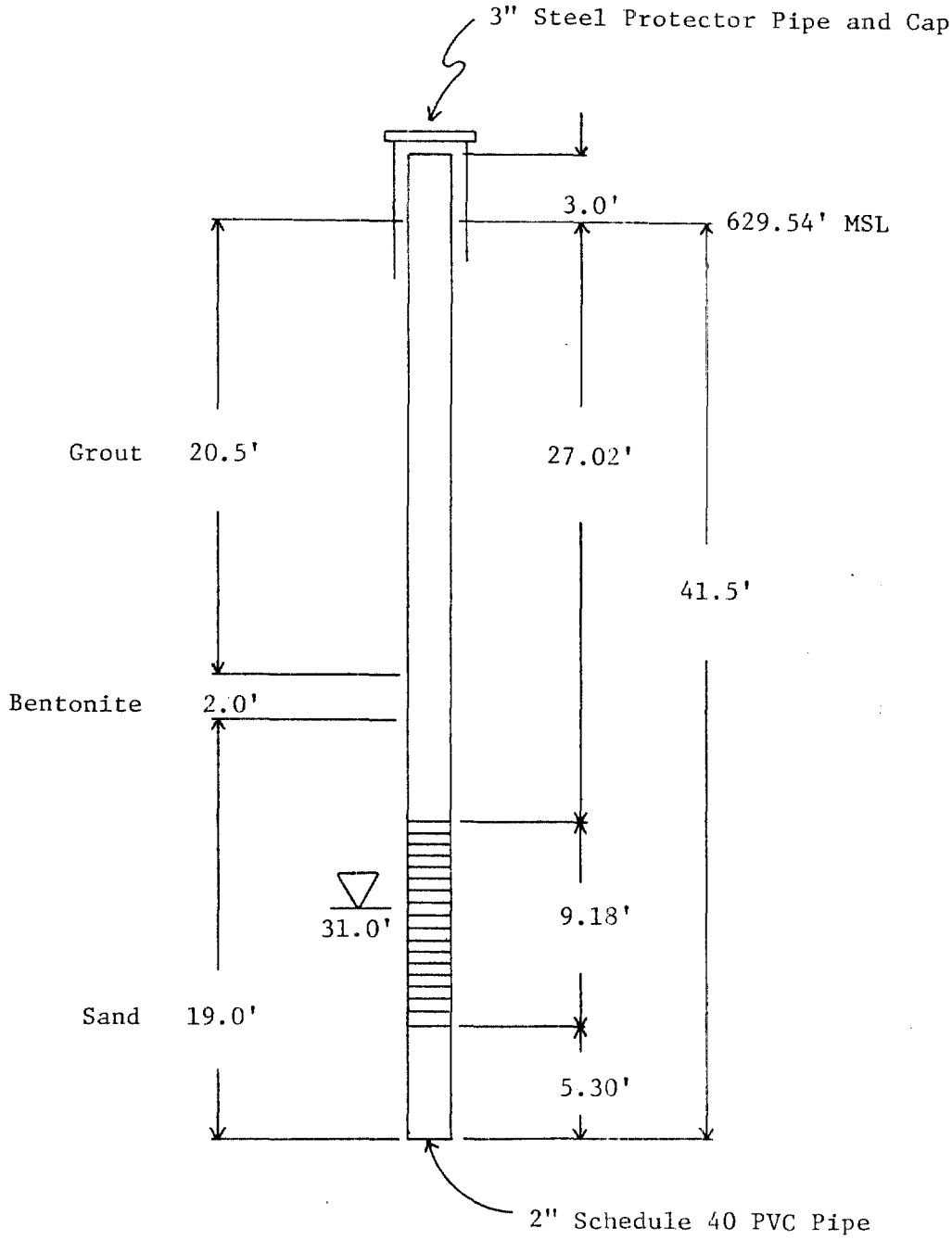
Water depth at time of drilling

NWSC, Crane, Indiana

Rifle Range

Well Completion

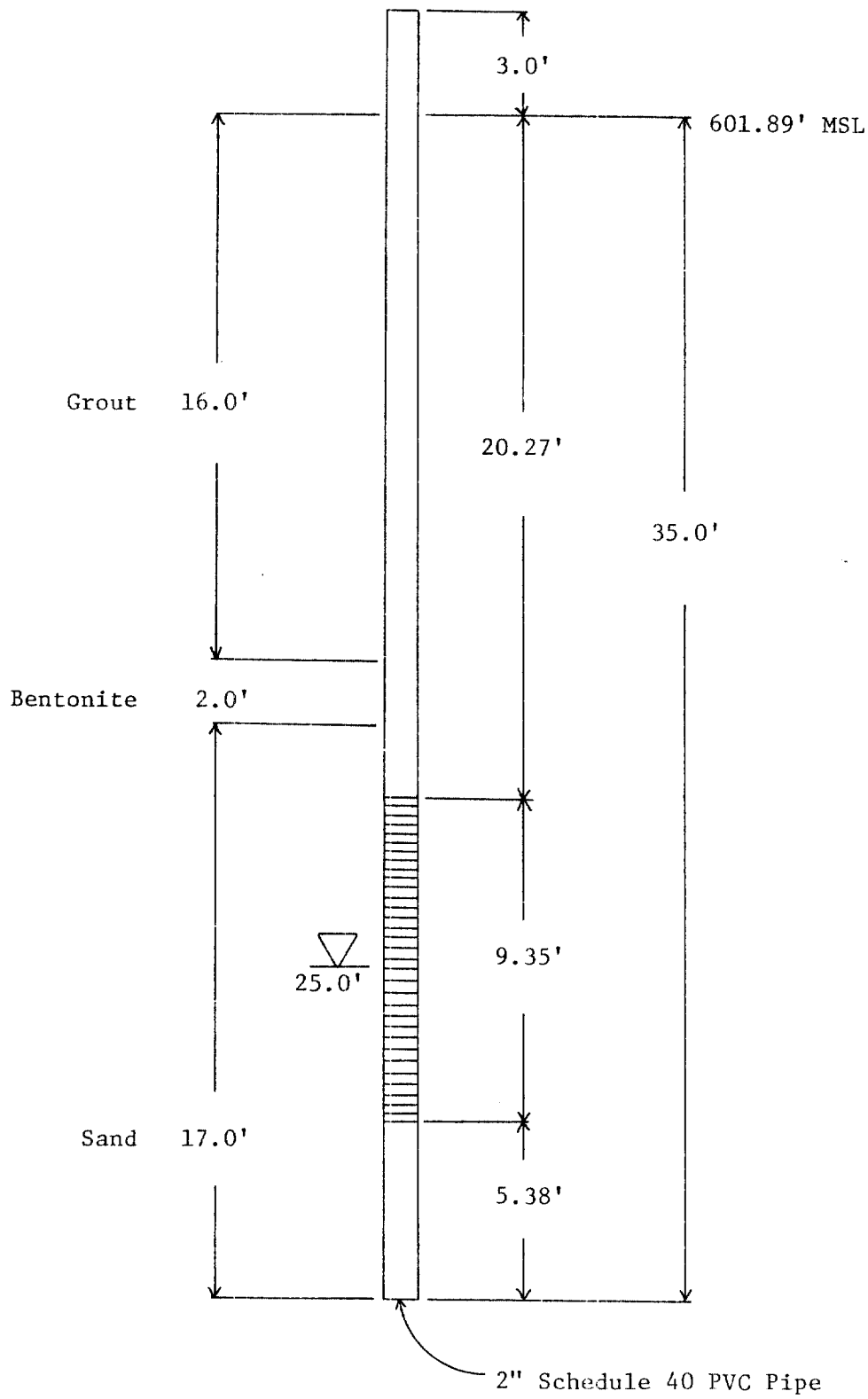
Boring Number: WES-6-20-81




Well screen

Water depth at time of drilling

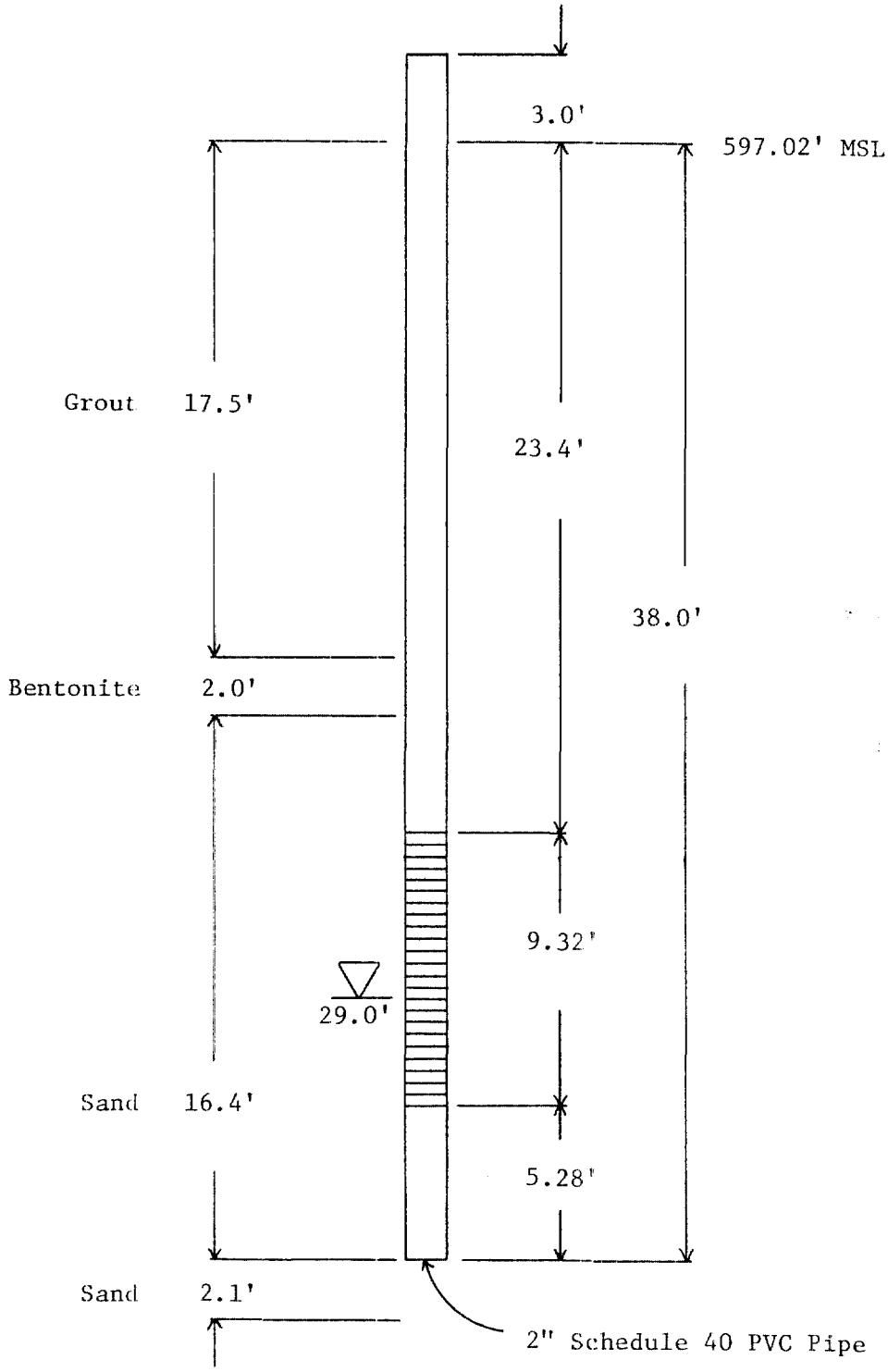
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-1-81




Well screen

Water depth at time of drilling

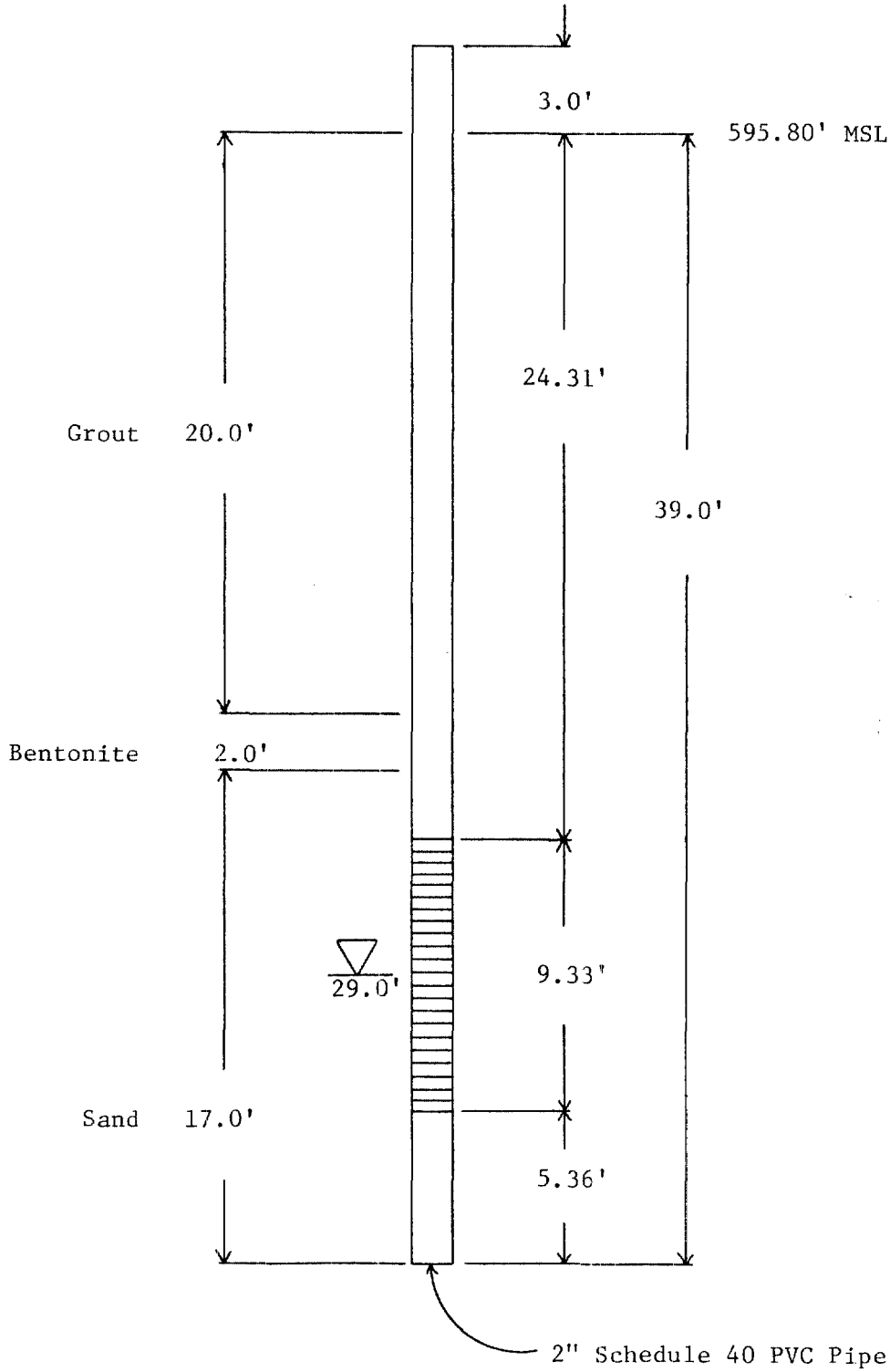
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-2-81




Well screen

Water depth at time of drilling

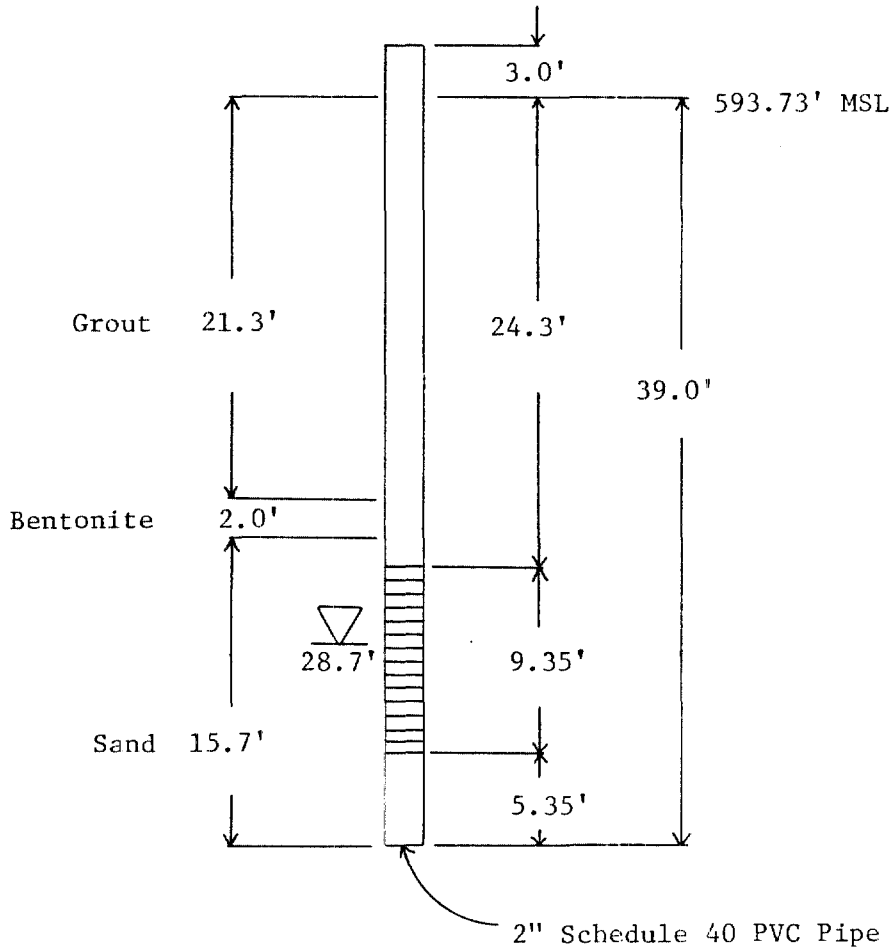
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-3-81




Well screen

Water depth at time of drilling

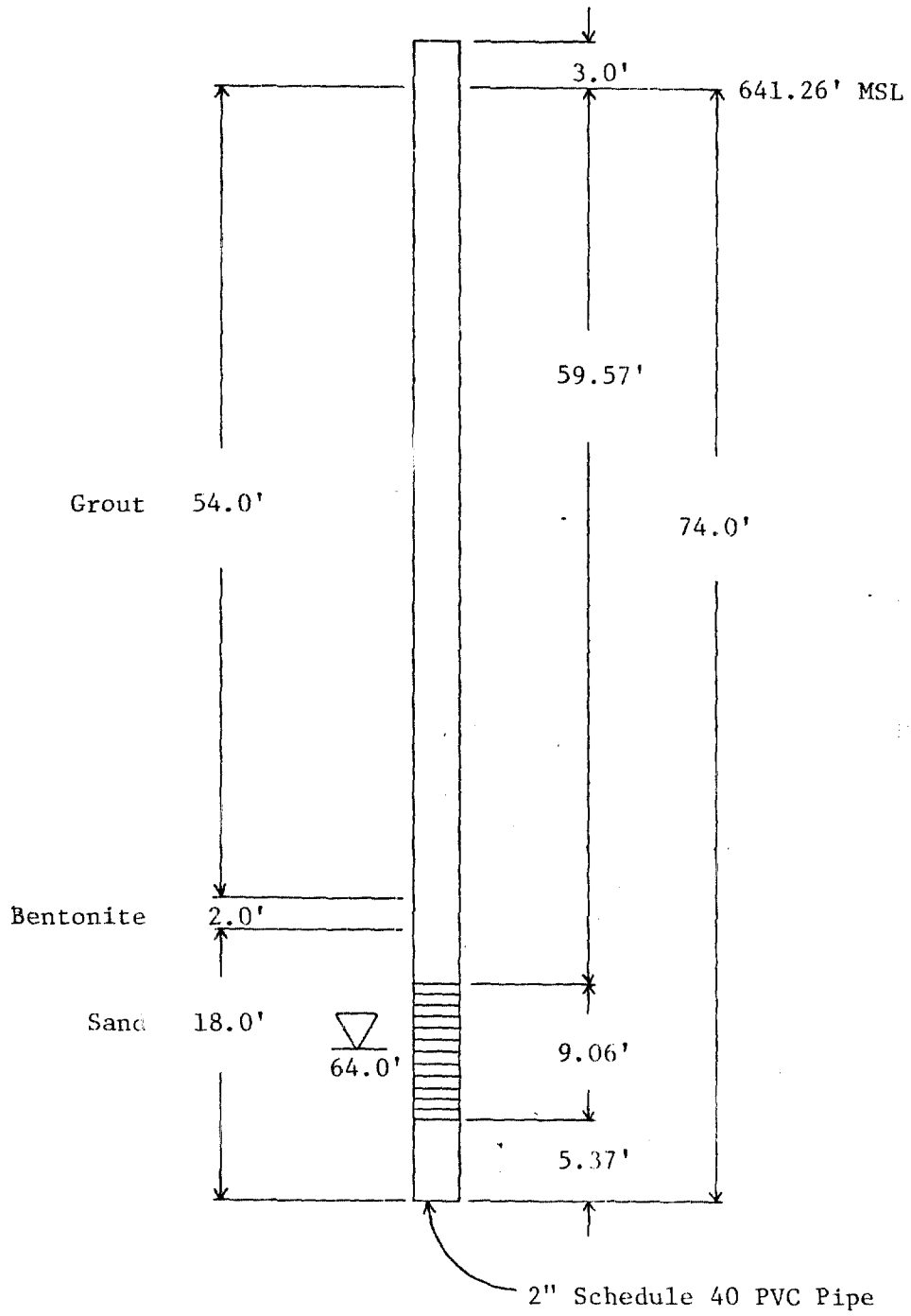
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-4-81




Well screen

Water depth at time of drilling

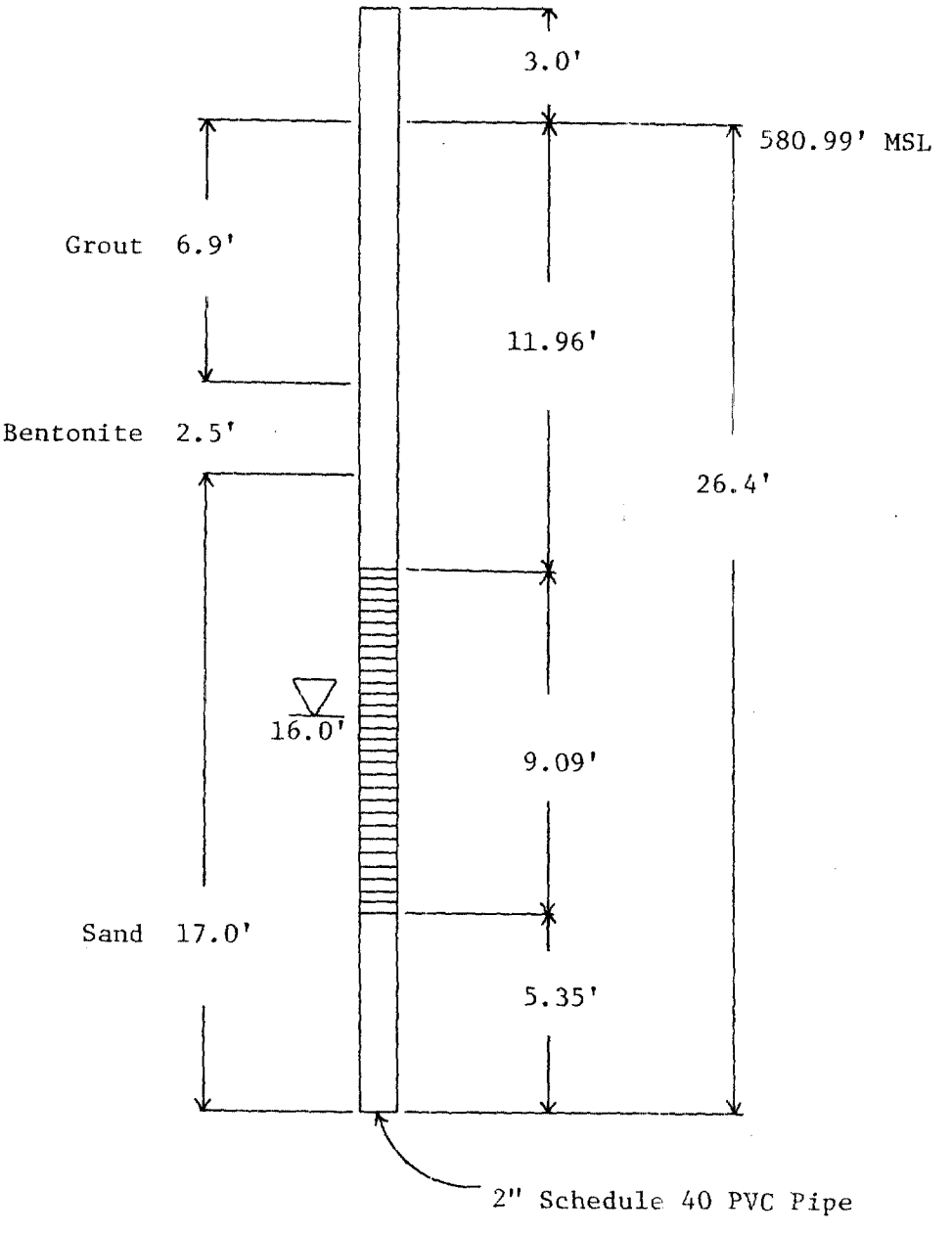
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-5-81




Well screen

Water depth at time of drilling

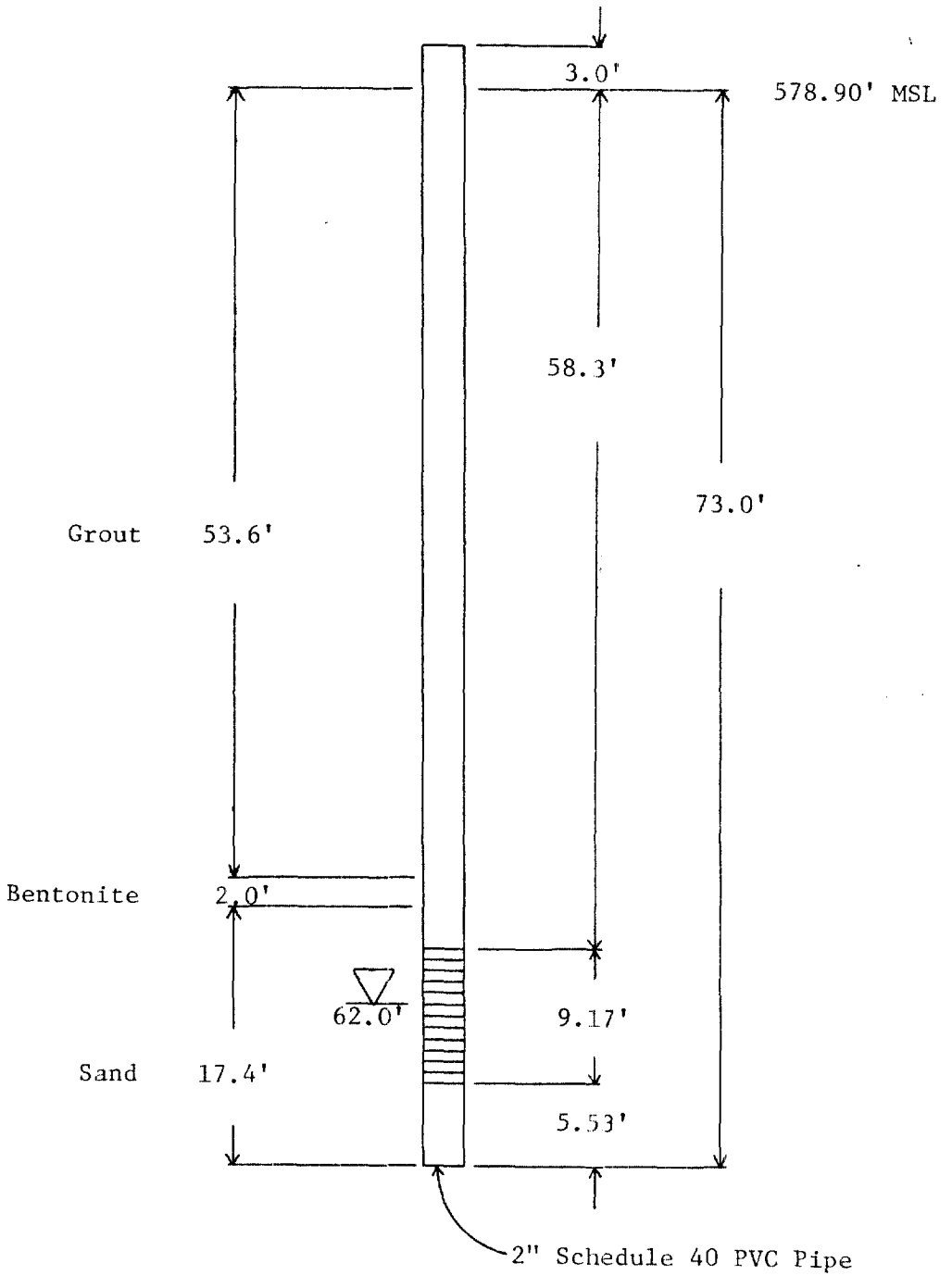
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-1-81




Well screen

Water depth at time of drilling

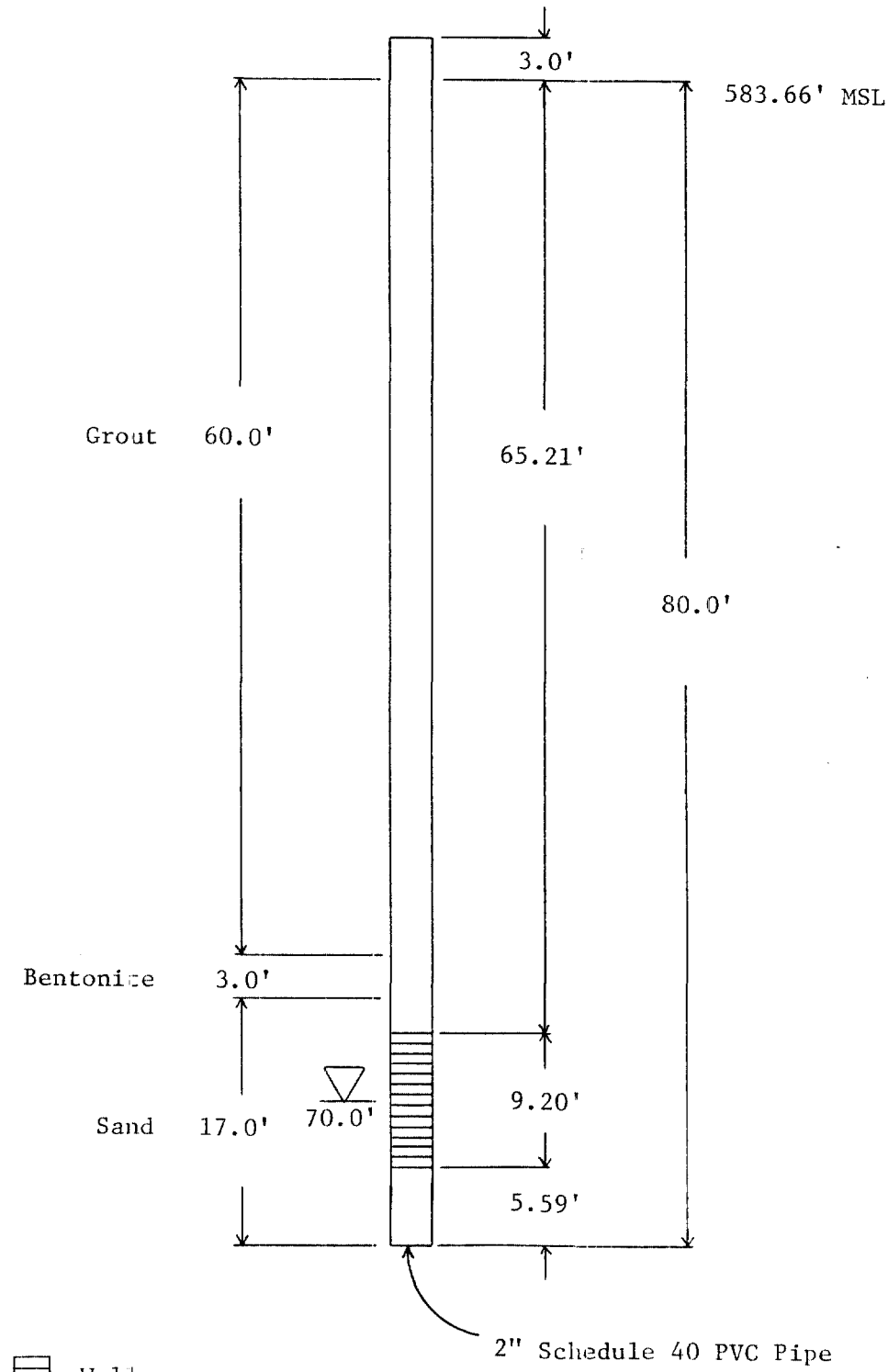
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-2-81




Well screen

Water depth at time of drilling

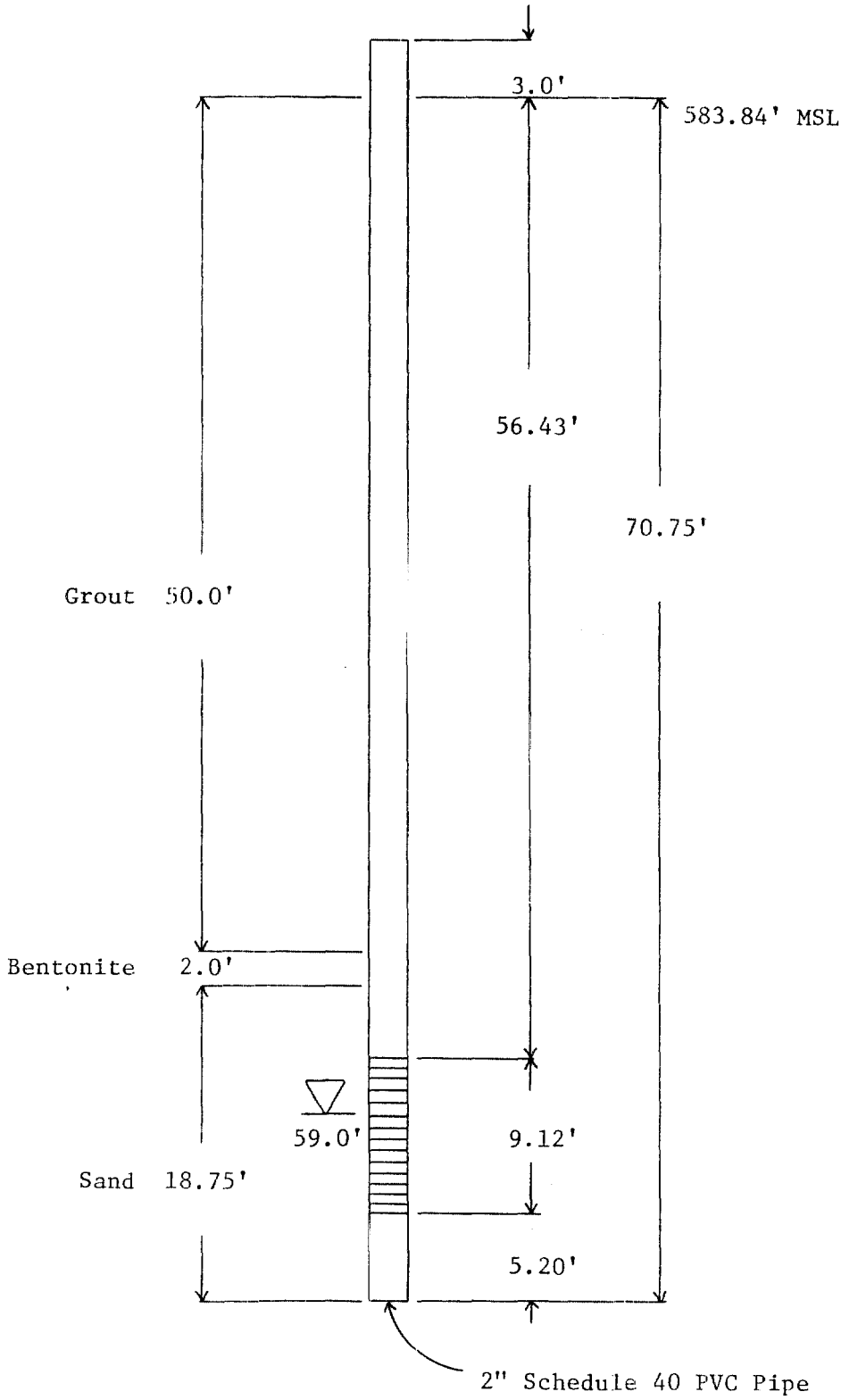
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-3-81




Well screen

Water depth at time of drilling

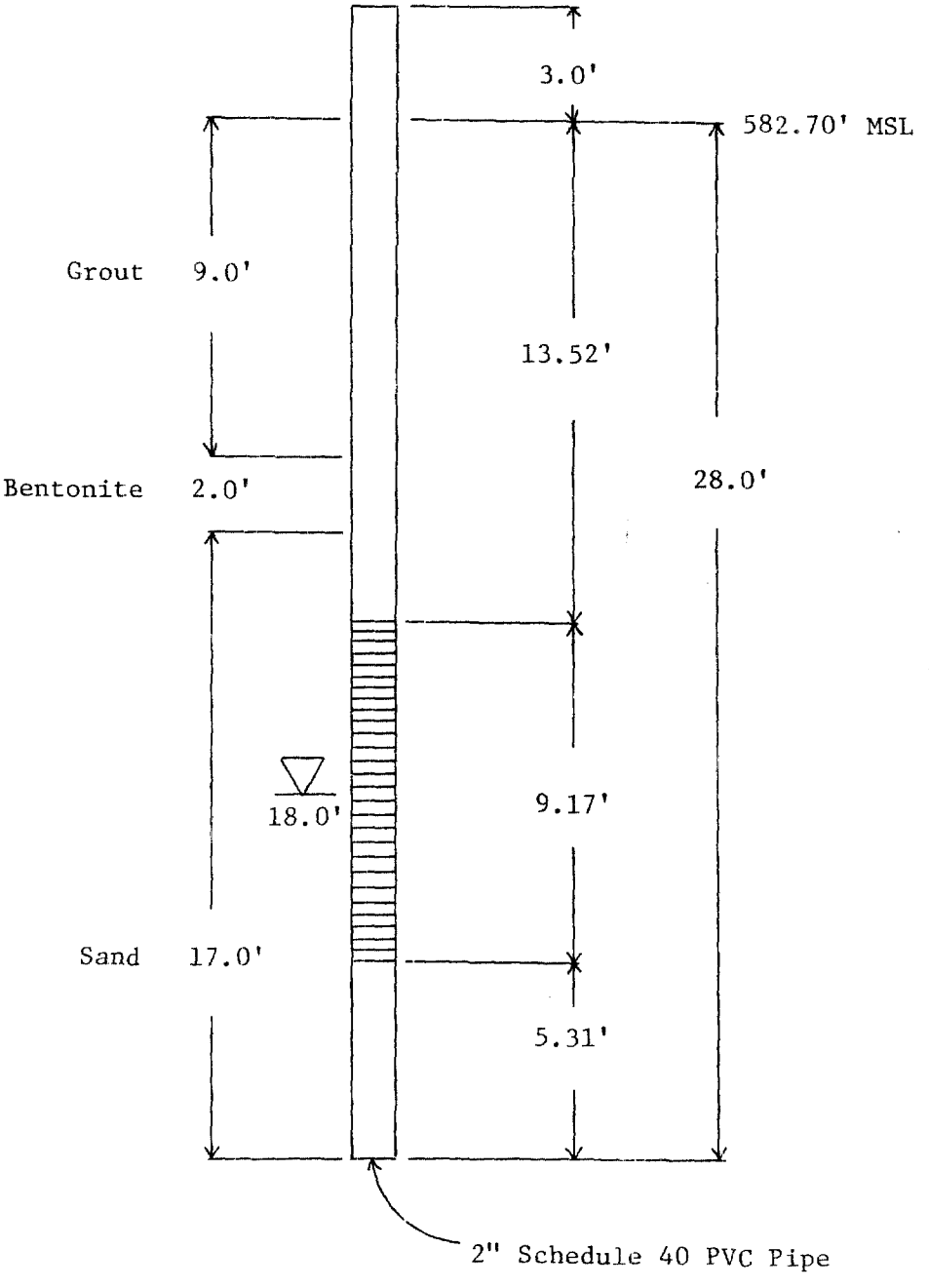
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-4-81




Well screen

Water depth at time of drilling

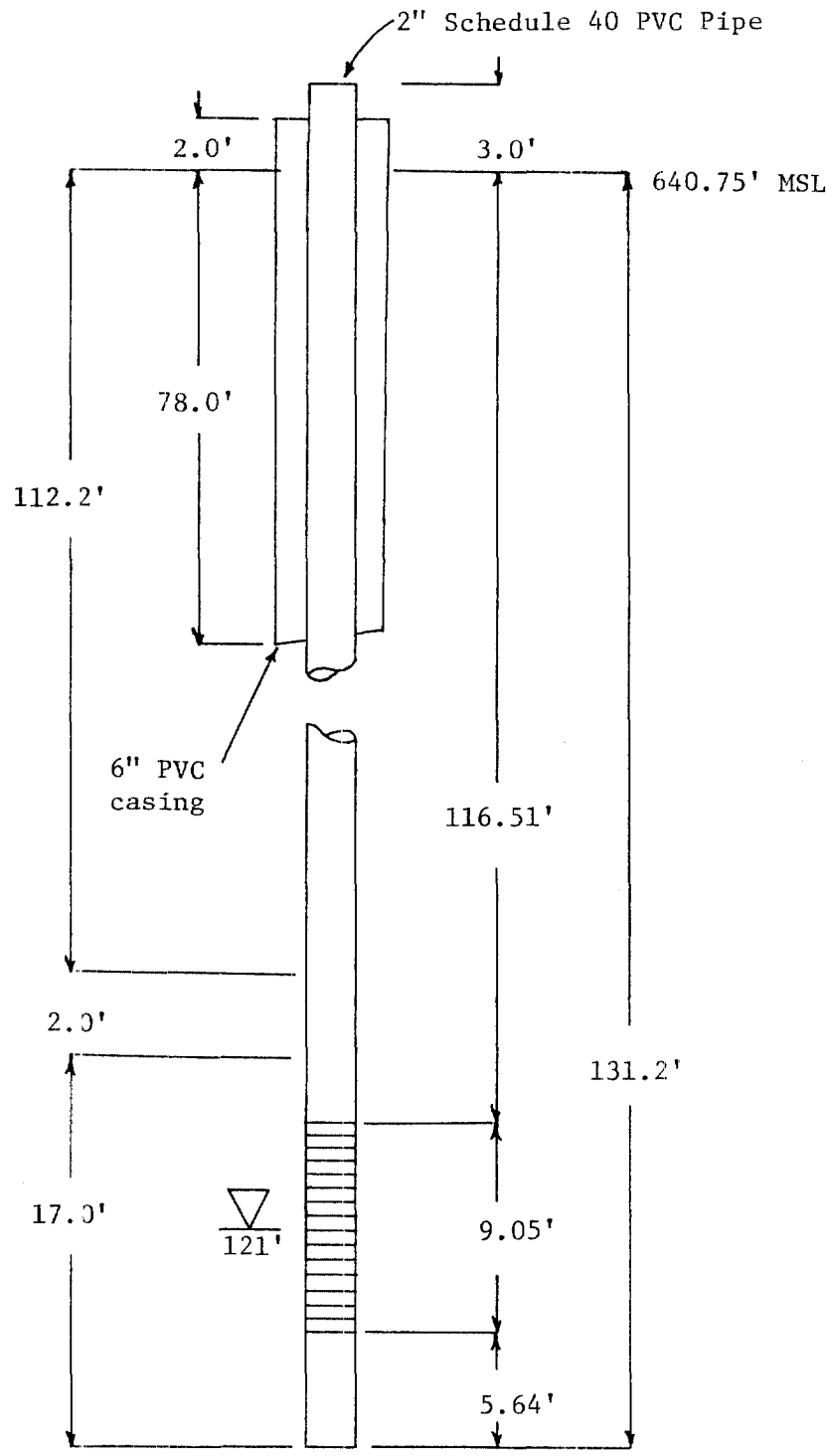
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-5-81




Well screen

Water depth at time of drilling

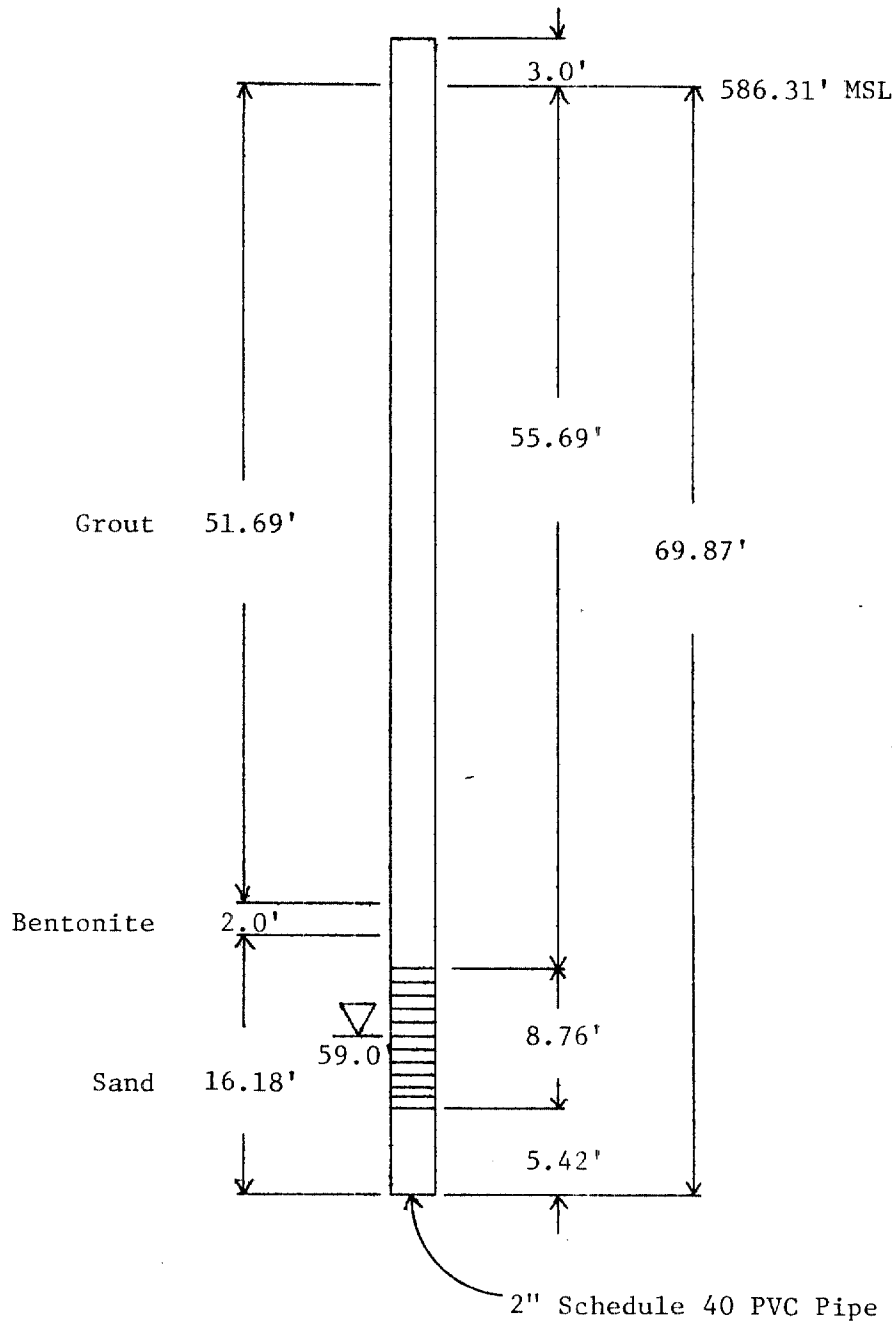
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-6-81




Water depth at time of drilling

Well screen

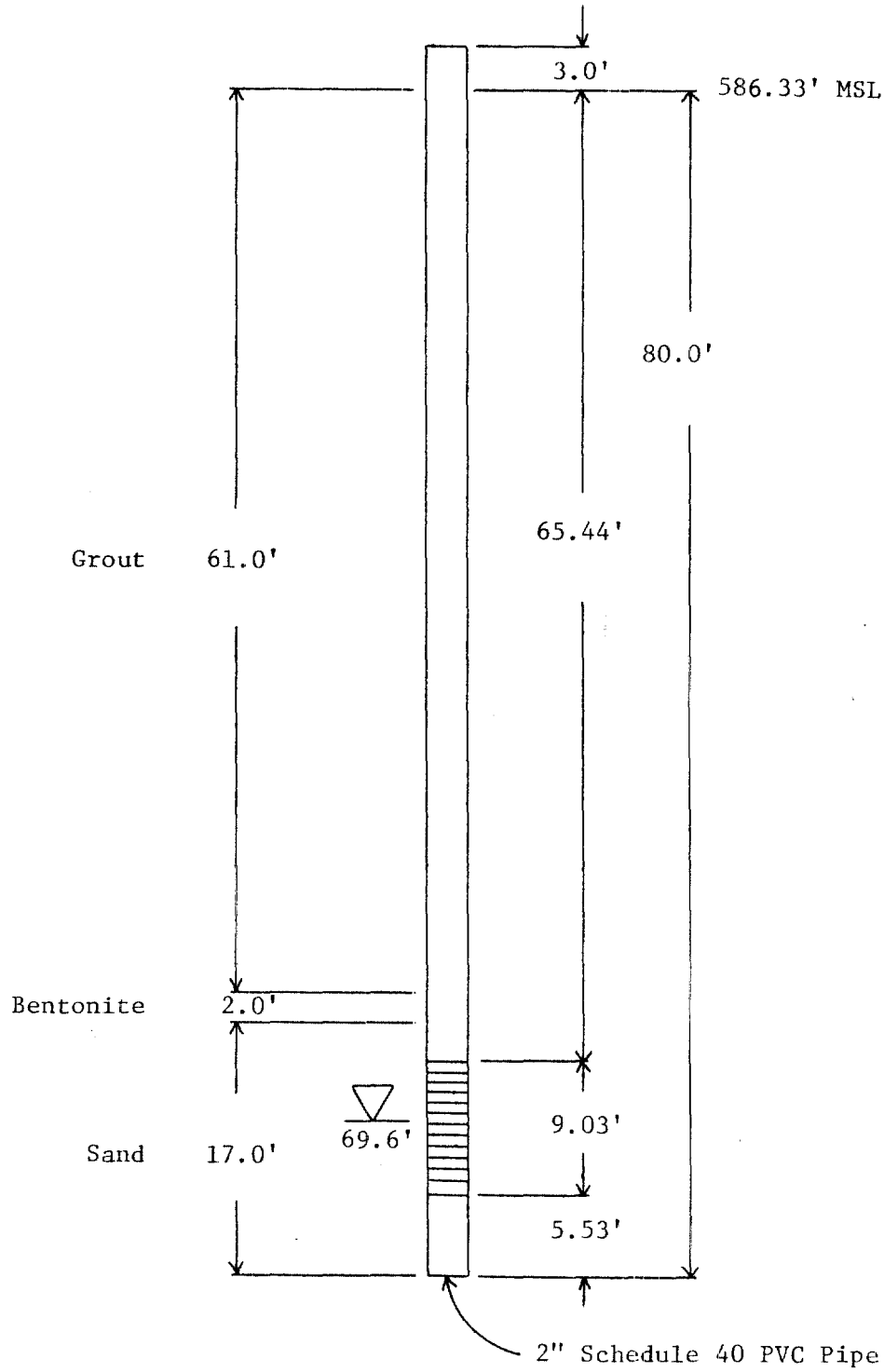
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-7-81




Well screen

Water depth at time of drilling

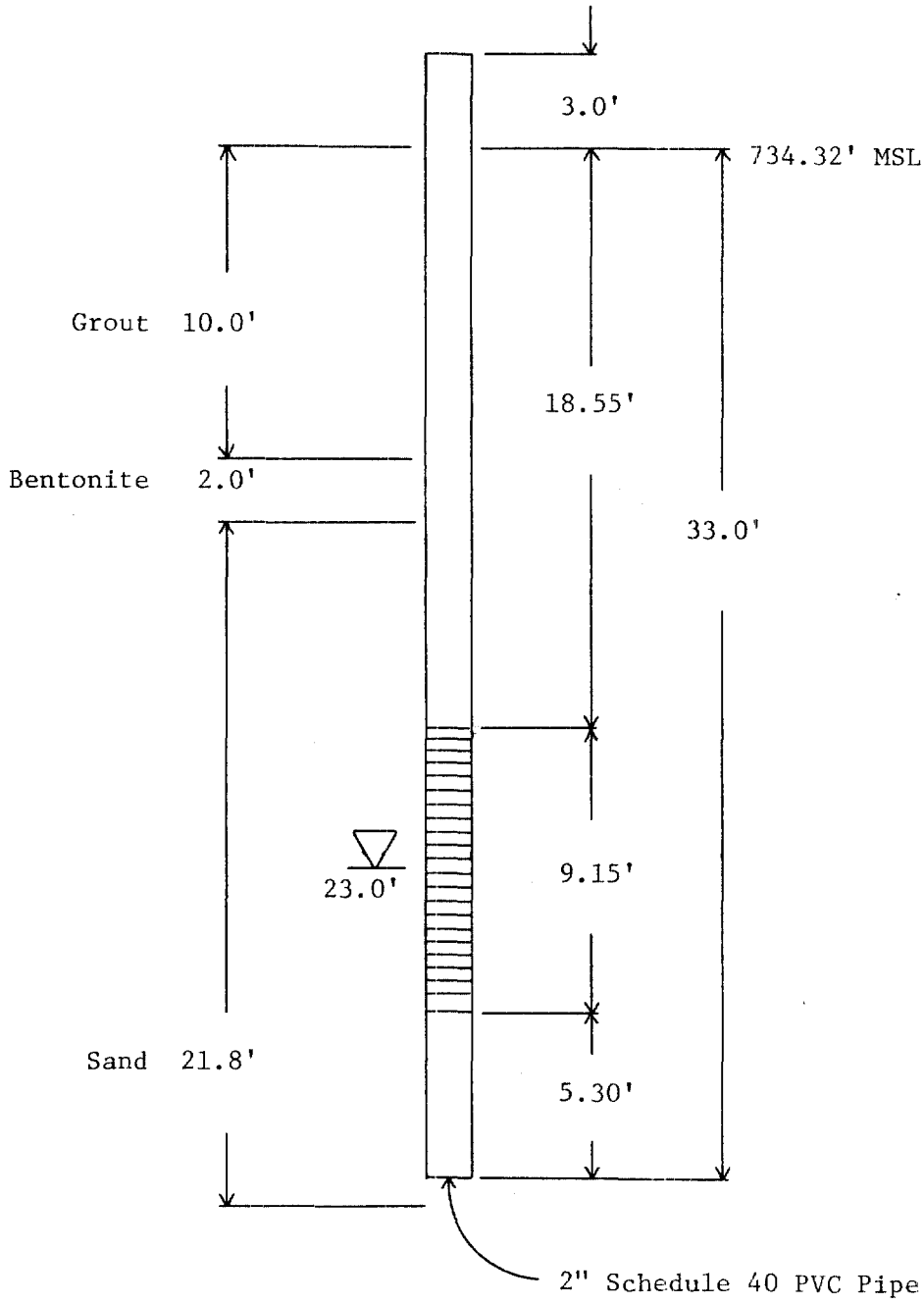
NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-8-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Highway 58 Dump Site B
Well Completion
Boring Number: WES-8-9-81




Well screen

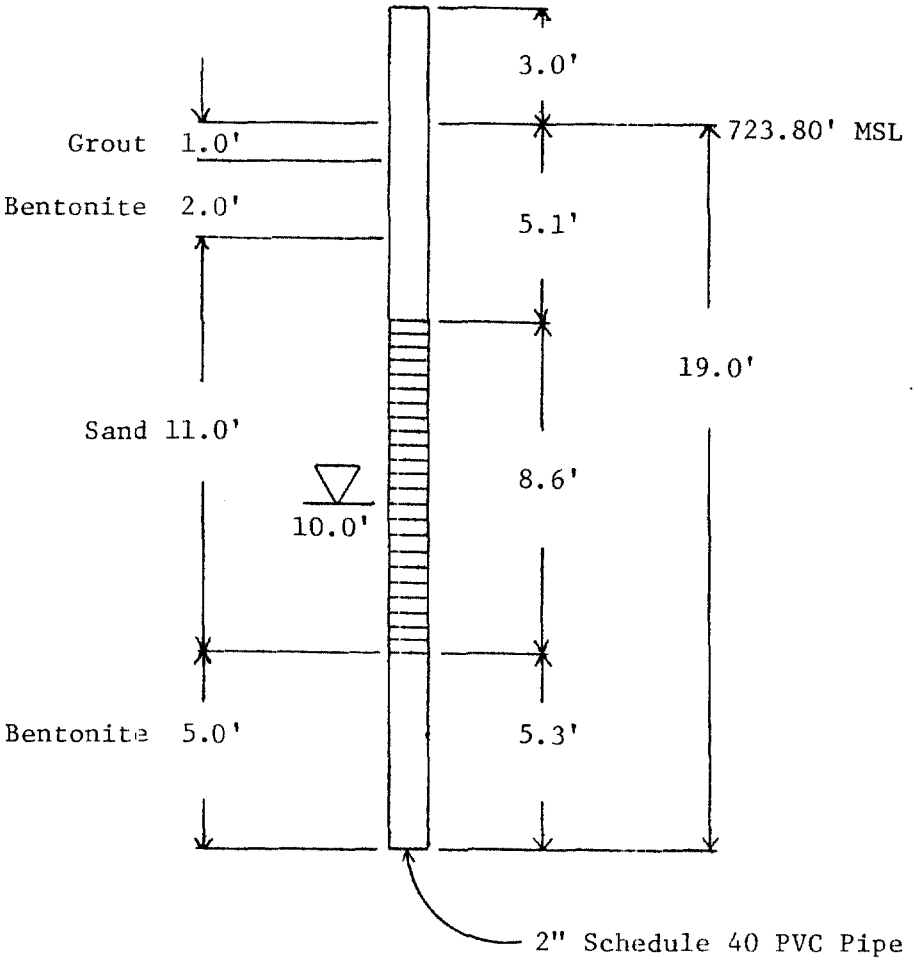
Water depth at time of drilling

NWSC, Crane, Indiana

Pest Control Area

Well Completion

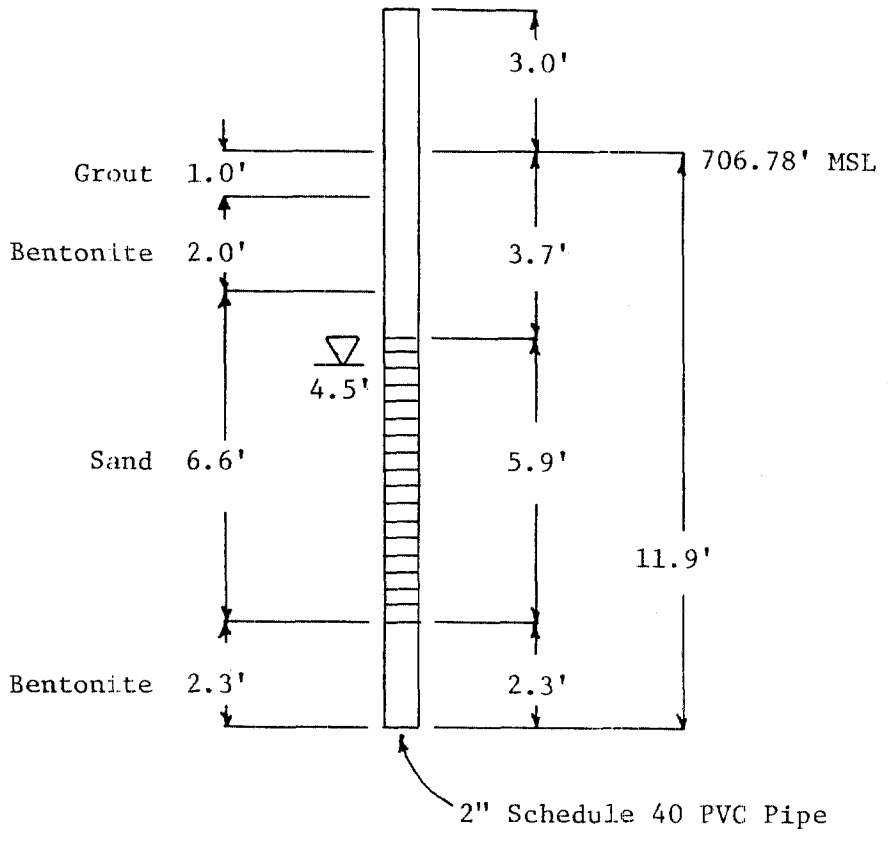
Boring Number: WES-9-1-81




Well screen

Water depth at time of drilling

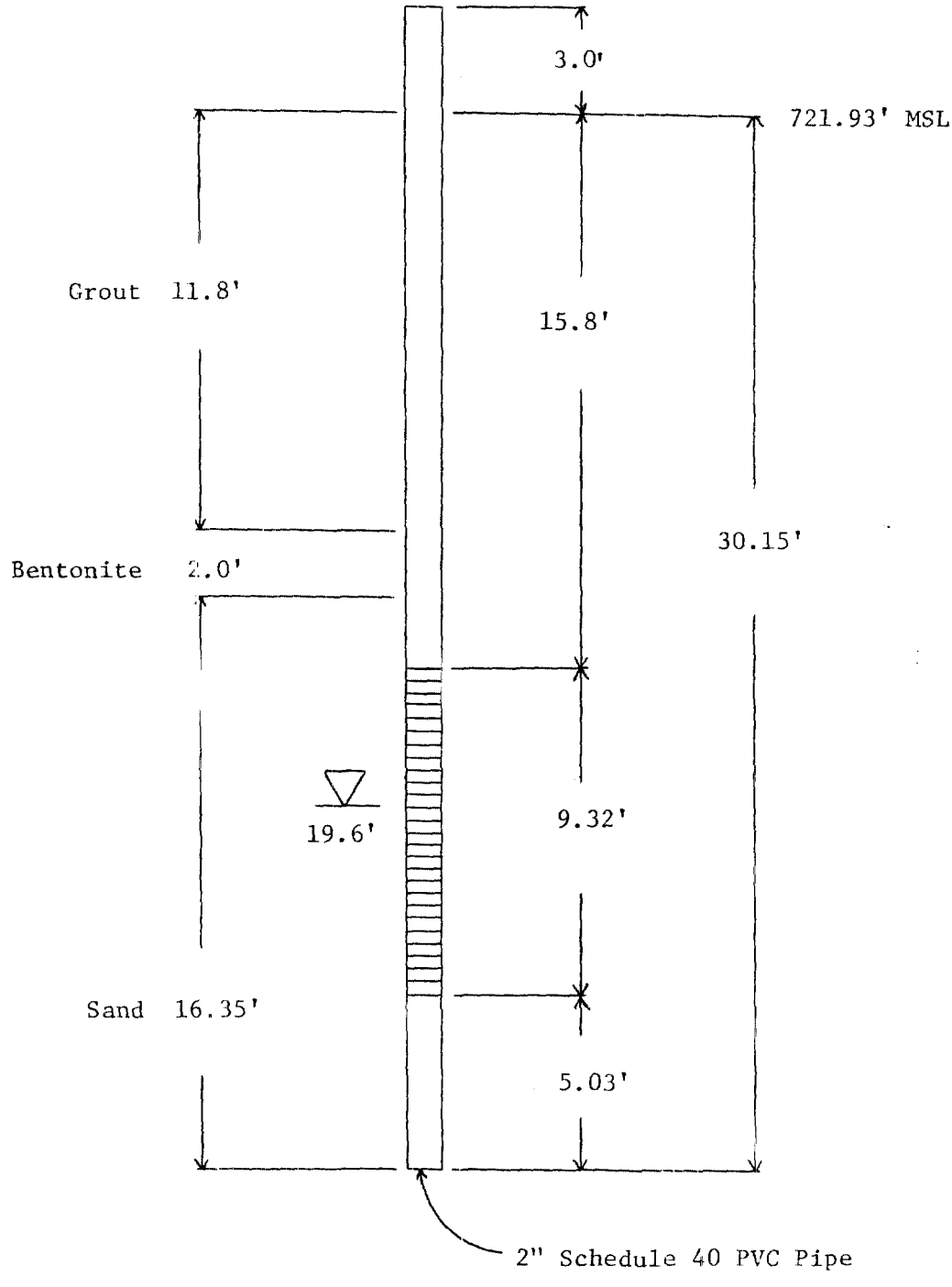
NWSC, Crane, Indiana
Pest Control Area
Well Completion
Boring Number: WES-9-2-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Pest Control Area
Well Completion
Boring Number: WES-9-3-81




Well screen

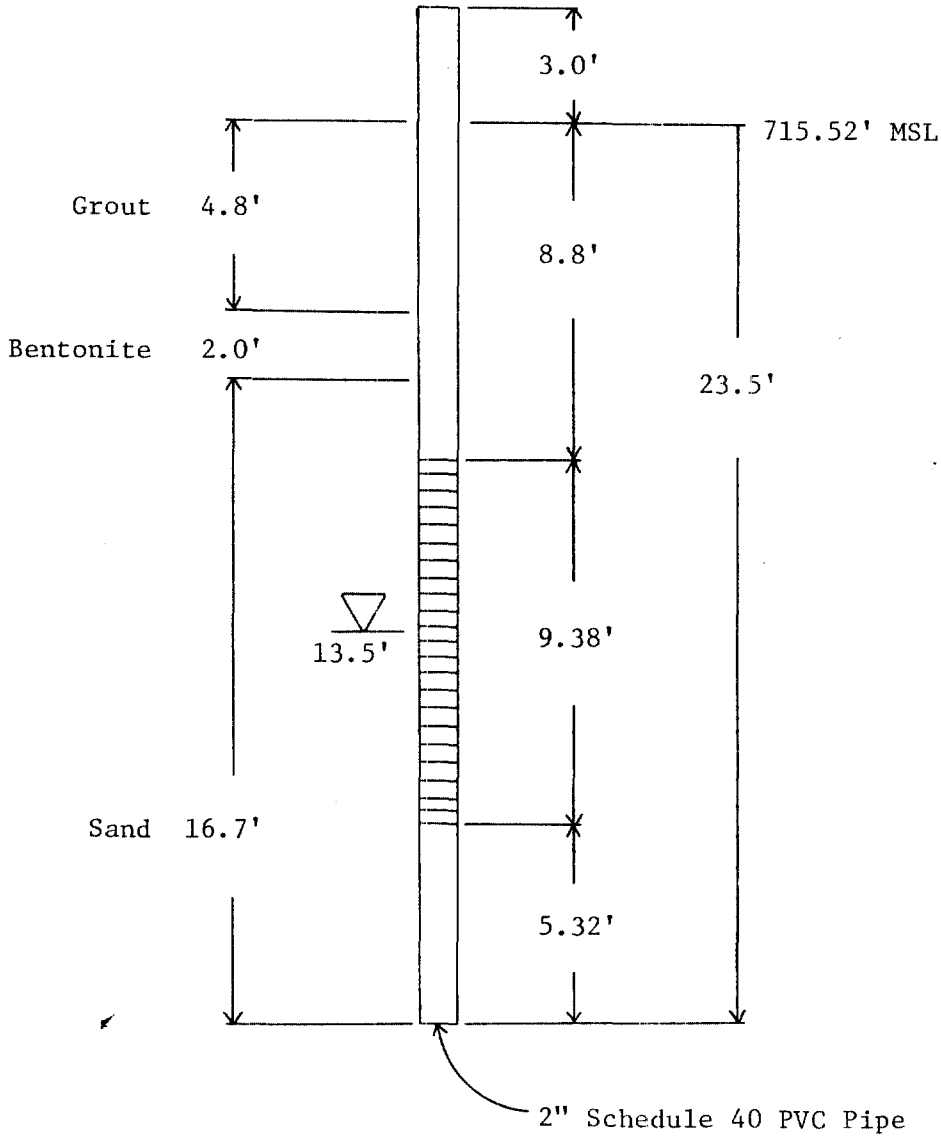
Water depth at time of drilling

NWSC, Crane, Indiana

Pest Control Area

Well Completion

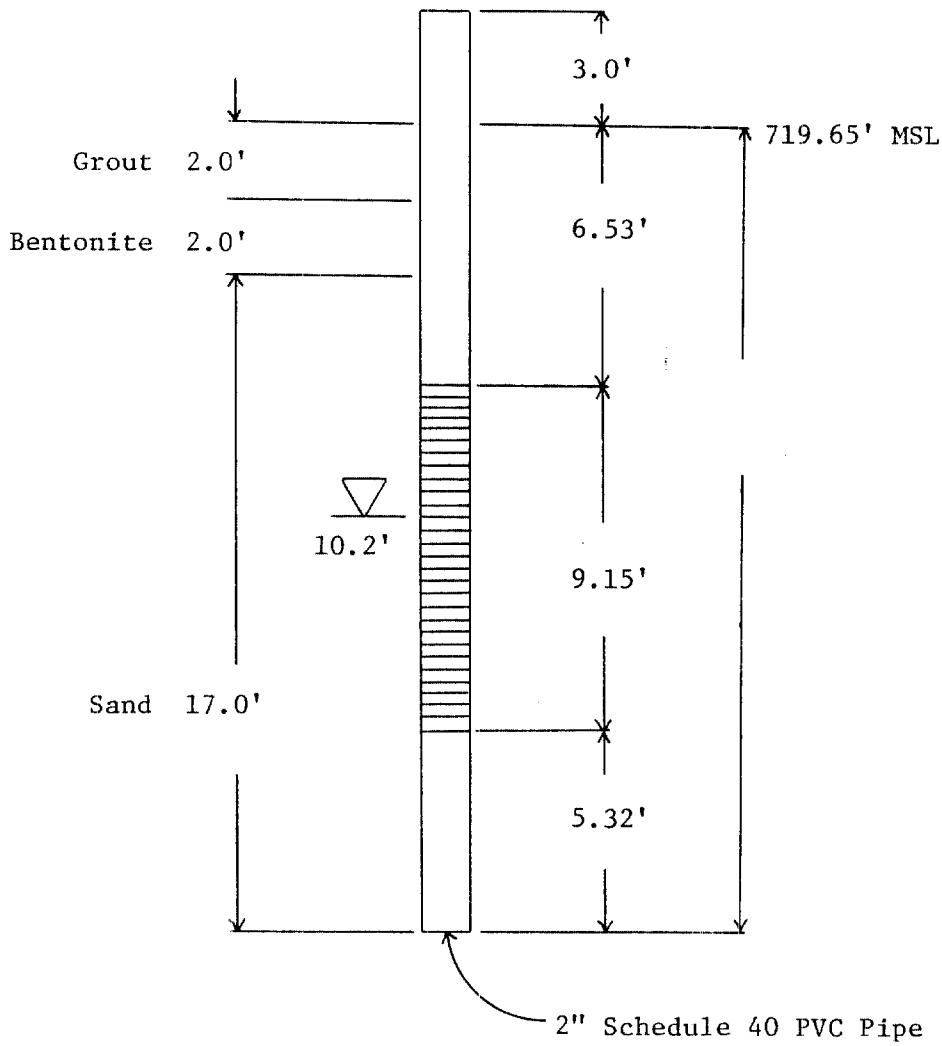
Boring Number: WES-9-4-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Pest Control Area
Well Completion
Boring Number: WES-9-5-81




Well screen

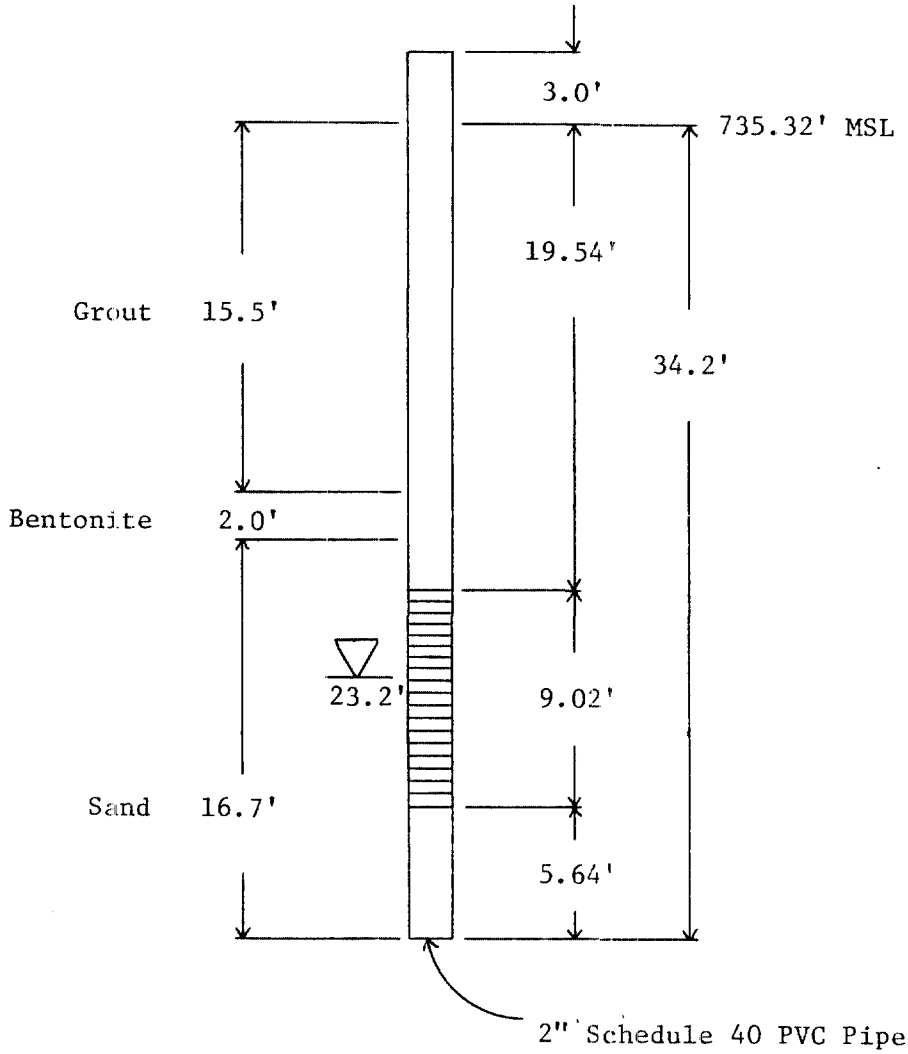
Water depth at time of drilling

NWSC, Crane, Indiana

Pest Control Area

Well Completion

Boring Number: WES-9-6-81




Well screen

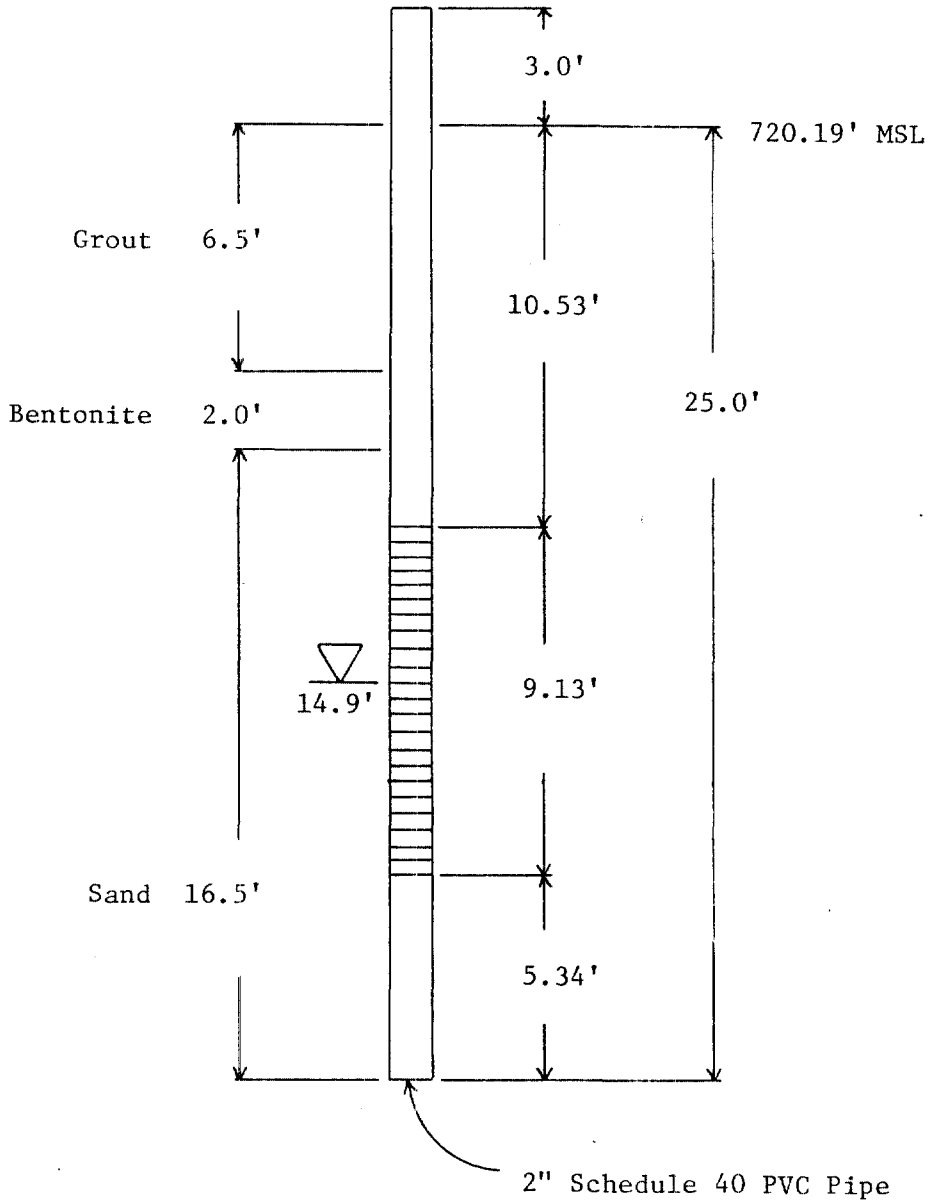
Water depth at time of drilling

NWSC, Crane, Indiana

Pest Control Area

Well Completion

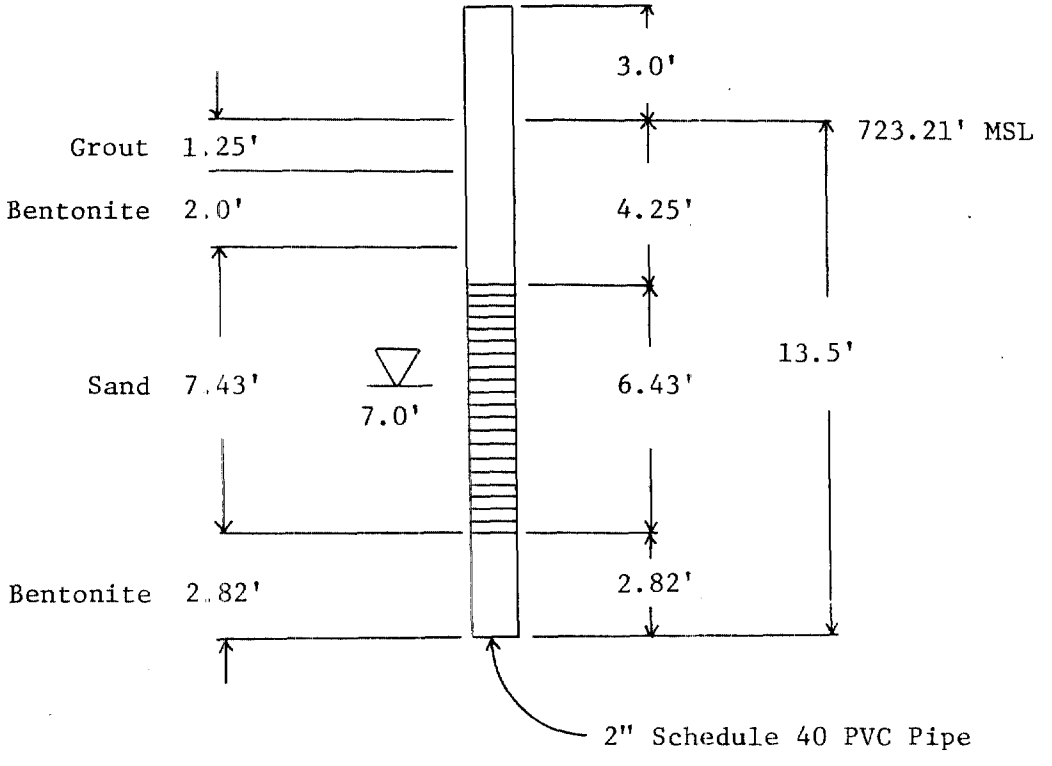
Boring Number: WES-9-7-81




Well screen

Water depth at time of drilling

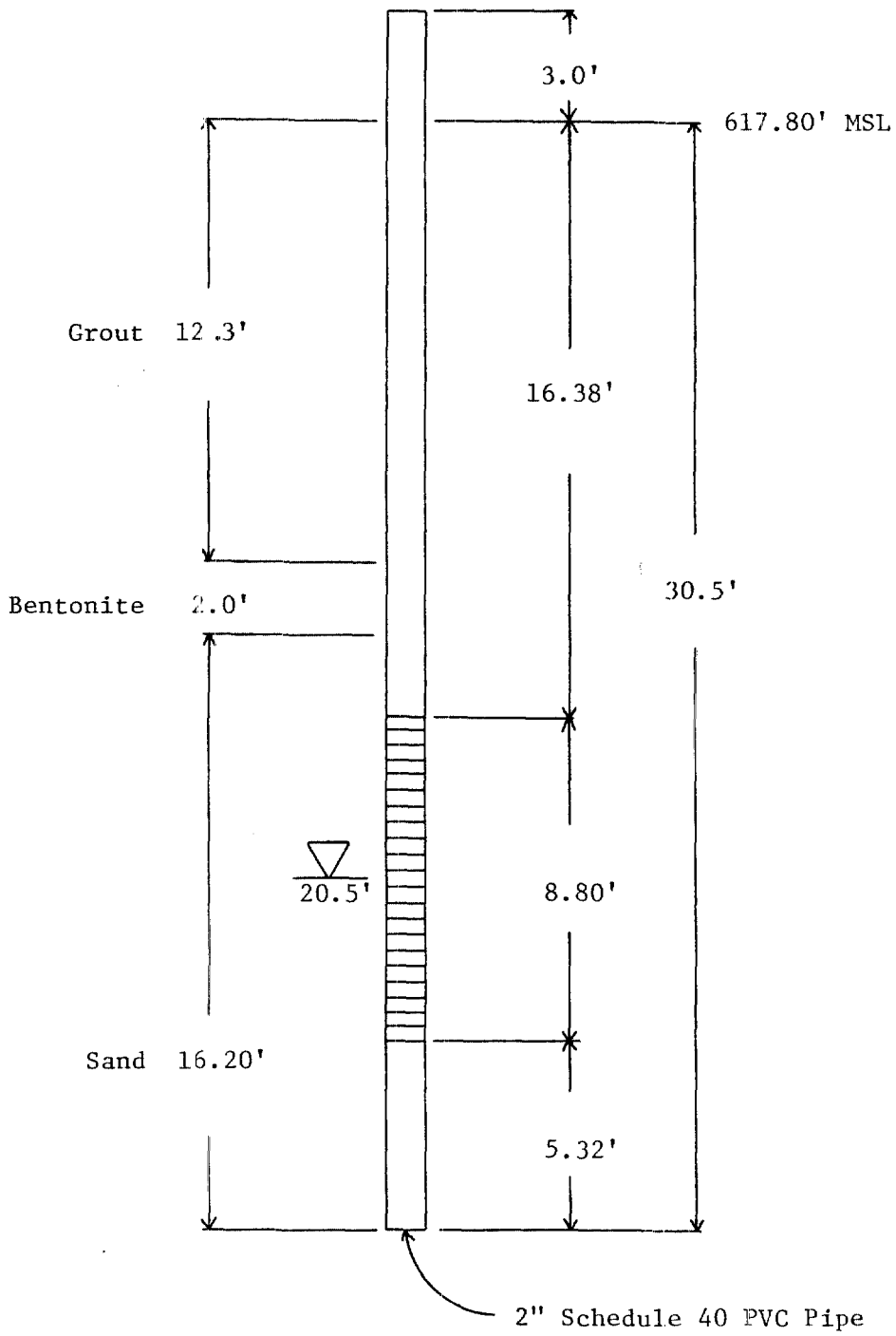
NWSC, Crane, Indiana
Pest Control Area
Well Completion
Boring Number: WES-9-8-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Pest Control Area
Well Completion
Boring Number: WES-9-9-81




Well screen

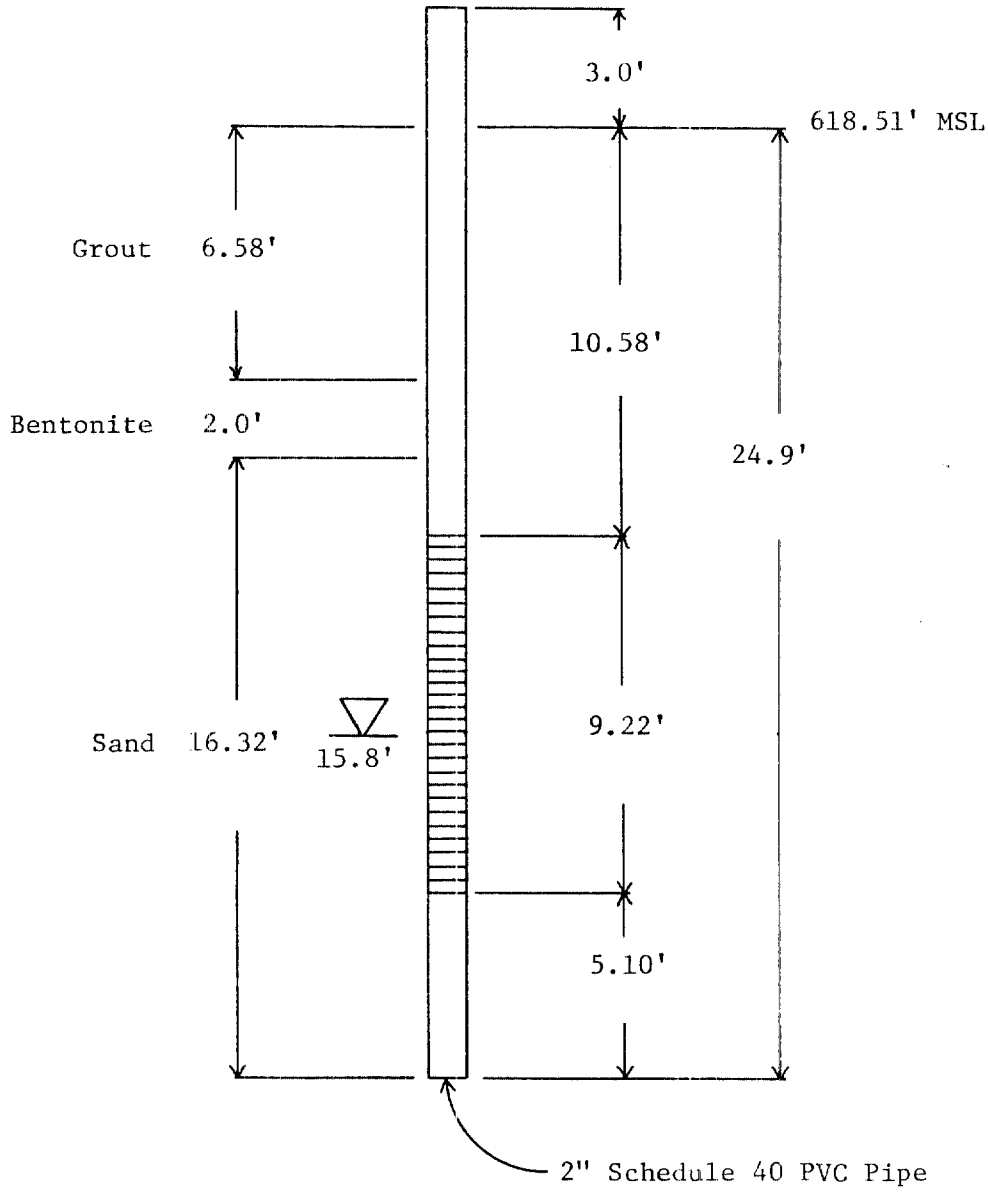
Water depth at time of drilling

NWSC, Crane, Indiana

Rockeye Site

Well Completion

Boring Number: WES-10-1-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana

Rockeye Site

Well Completion

Boring Number: WES-10-2-81

APPENDIX D

GROUNDWATER ELEVATIONS

WORKING DRAFT

Groundwater Elevations

Mustard Gas Burial Grounds

Boring Number: WES-1-1-81

Top of Pipe Elevation: 686.14 ft MSL

Screen Interval: from 650.00 to 640.37 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 22 Aug 81 | 3:10 | 27.30 | 658.84 | |
| 23 Aug 81 | 10:31 | 27.21 | 658.93 | |
| 24 Aug 81 | 4:20 | 26.99 | 659.15 | |
| 25 Aug 81 | 10:45 | 27.09 | 659.05 | |
| 26 Aug 81 | 8:39 | 26.86 | 659.28 | |
| 27 Aug 81 | 8:25 | 26.87 | 659.27 | |
| 28 Aug 81 | 7:47 | 26.91 | 659.23 | |
| 29 Aug 81 | 7:43 | 26.87 | 659.27 | |
| 5 Sep 81 | 8:45 | 26.93 | 659.21 | |
| 12 Sep 81 | 6:45 | 26.87 | 659.27 | |
| 19 Sep 81 | 9:20 | 26.97 | 659.17 | |
| 26 Sep 81 | 7:53 | 26.82 | 659.32 | |
| 3 Oct 81 | 7:45 | 27.09 | 659.05 | |
| 10 Oct 81 | 10:22 | 26.91 | 659.23 | |
| 17 Oct 81 | 8:44 | 26.98 | 659.16 | |
| 24 Oct 81 | 10:00 | 27.38 | 658.76 | |
| 31 Oct 81 | 7:55 | 27.54 | 658.60 | |
| 7 Nov 81 | 10:15 | 27.59 | 658.55 | |
| 15 Nov 81 | 3:45 | 27.18 | 658.96 | |
| 22 Nov 81 | 10:12 | 27.43 | 658.71 | |
| 29 Nov 81 | 8:22 | 27.78 | 658.36 | |

Groundwater Elevations

Mustard Gas Burial Grounds

Boring Number: WES-1-2-81

Top of Pipe Elevation: 667.04 ft MSL

Screen Interval: from 655.80 to 646.44 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 23 Aug 81 | 10:45 | 12.18 | 651.86 | Open hole |
| 24 Aug 81 | 4:00 | 13.88 | 653.16 | |
| 25 Aug 81 | 10:13 | 13.92 | 653.12 | |
| 26 Aug 81 | 8:51 | 13.49 | 653.55 | |
| 27 Aug 81 | 8:34 | 13.41 | 653.63 | |
| 28 Aug 81 | 8:00 | 13.55 | 653.49 | |
| 29 Aug 81 | 7:50 | 13.68 | 653.36 | |
| 30 Aug 81 | 12:55 | 13.60 | 653.44 | |
| 5 Sep 81 | 9:02 | 13.85 | 653.19 | |
| 12 Sep 81 | 7:06 | 13.97 | 653.07 | |
| 19 Sep 81 | 9:30 | 14.08 | 652.96 | |
| 26 Sep 81 | 7:46 | 14.13 | 652.91 | |
| 3 Oct 81 | 7:53 | 14.37 | 652.67 | |
| 10 Oct 81 | 10:31 | 14.45 | 652.59 | |
| 17 Oct 81 | 8:53 | 14.51 | 652.53 | |
| 24 Oct 81 | 10:09 | 14.93 | 652.11 | |
| 31 Oct 81 | 8:04 | 15.15 | 651.89 | |
| 7 Nov 81 | 10:25 | 15.01 | 652.03 | |
| 15 Nov 81 | 3:52 | 14.83 | 652.21 | |
| 17 Nov 81 | 10:20 | 15.24 | 651.80 | |
| 29 Nov 81 | 8:49 | 15.45 | 651.59 | |

Groundwater Elevations

Mustard Gas Burial Grounds

Boring Number: WES-1-3-81

Top of Pipe Elevation: 670.43 ft MSL

Screen Interval: from 663.44 to 654.02 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 26 Aug 81 | 8:45 | 11.02 | 659.41 | |
| 27 Aug 81 | 8:29 | 11.19 | 659.24 | |
| 28 Aug 81 | 7:51 | 11.45 | 658.98 | |
| 29 Aug 81 | 7:47 | 11.55 | 658.88 | |
| 30 Aug 81 | 12:50 | 11.56 | 658.87 | |
| 31 Aug 81 | 8:40 | 11.63 | 658.80 | |
| 1 Sep 81 | 7:47 | 11.63 | 658.80 | |
| 5 Sep 81 | 8:50 | 11.78 | 658.65 | |
| 12 Sep 81 | 7:01 | 11.87 | 658.56 | |
| 19 Sep 81 | 9:25 | 12.17 | 658.26 | |
| 26 Sep 81 | 7:50 | 12.37 | 658.06 | |
| 3 Oct 81 | 7:56 | 12.86 | 657.57 | |
| 10 Oct 81 | 10:33 | 13.02 | 657.41 | |
| 17 Oct 81 | 8:55 | 13.18 | 657.25 | |
| 24 Oct 81 | 10:12 | 13.82 | 656.61 | |
| 31 Oct 81 | 8:07 | 13.89 | 656.54 | |
| 7 Nov 81 | 10:28 | 13.87 | 656.56 | |
| 15 Nov 81 | 3:55 | 13.12 | 657.31 | |
| 22 Nov 81 | 10:23 | 12.96 | 657.47 | |
| 29 Nov 81 | 8:52 | 11.80 | 658.63 | |

Groundwater Elevations

Mustard Gas Burial Grounds

Boring Number: WES-1-4-81

Top of Pipe Elevation: 672.95 ft MSL

Screen Interval: from 653.48 to 644.27 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 23 Sep 81 | 8:50 | 21.00 | 651.95 | Open hole |
| 24 Sep 81 | 9:55 | 18.52 | 654.43 | |
| 25 Sep 81 | 8:10 | 18.04 | 654.91 | |
| 26 Sep 81 | 7:40 | 17.61 | 655.34 | |
| 27 Sep 81 | 3:01 | 17.50 | 655.45 | |
| 28 Sep 81 | 9:27 | 17.62 | 655.33 | |
| 29 Sep 81 | 11:10 | 17.70 | 655.25 | |
| 30 Sep 81 | 8:00 | 17.65 | 655.30 | |
| 3 Oct 81 | 7:48 | 17.52 | 655.43 | |
| 10 Oct 81 | 10:25 | 17.51 | 655.44 | |
| 17 Oct 81 | 8:47 | 17.74 | 655.21 | |
| 24 Oct 81 | 10:04 | 18.23 | 654.72 | |
| 31 Oct 81 | 7:59 | 18.30 | 654.65 | |
| 7 Nov 81 | 10:19 | 18.31 | 654.64 | |
| 15 Nov 81 | 3:47 | 18.46 | 654.49 | |
| 22 Nov 81 | 10:14 | 18.61 | 654.34 | |
| 29 Nov 81 | 8:43 | 18.98 | 653.97 | |

Groundwater Elevations

Mustard Gas Burial Grounds

Boring Number: WES-1-5-81

Top of Pipe Elevation: 668.69 ft MSL

Screen Interval: from 649.51 to 640.39 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 25 Sep 81 | 8:10 | 16.78 | 651.91 | |
| 26 Sep 81 | 7:43 | 16.39 | 652.30 | |
| 27 Sep 81 | 3:08 | 16.32 | 652.37 | |
| 28 Sep 81 | 9:31 | 16.44 | 652.25 | |
| 29 Sep 81 | 11:15 | 16.43 | 652.26 | |
| 30 Sep 81 | 8:07 | 16.15 | 652.54 | |
| 1 Oct 81 | 11:35 | 15.98 | 652.71 | |
| 3 Oct 81 | 7:50 | 16.22 | 652.47 | |
| 10 Oct 81 | 10:29 | 16.17 | 652.52 | |
| 17 Oct 81 | 8:50 | 16.28 | 652.41 | |
| 24 Oct 81 | 10:07 | 16.78 | 651.91 | |
| 31 Oct 81 | 8:02 | 16.81 | 651.88 | |
| 7 Nov 81 | 10:22 | 16.90 | 651.79 | |
| 15 Nov 81 | 3:50 | 16.80 | 651.89 | |
| 22 Nov 81 | 10:17 | 17.05 | 651.64 | |
| 29 Nov 81 | 8:46 | 17.20 | 651.49 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-1-81

Top of Pipe Elevation: 741.66 ft MSL

Screen Interval: from 723.41 to 713.86 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 26 Aug 81 | 5:08 | -- | -- | No water |
| 27 Aug 81 | 9:02 | 22.99 | 718.67 | |
| 28 Aug 81 | 8:25 | 20.47 | 721.19 | |
| 29 Aug 81 | 8:37 | 19.80 | 721.86 | |
| 30 Aug 81 | 12:36 | 19.25 | 722.41 | |
| 31 Aug 81 | 9:45 | 19.24 | 722.42 | |
| 1 Sep 81 | 10:00 | 19.15 | 722.51 | |
| 2 Sep 81 | 7:50 | 19.00 | 722.66 | |
| 9 Sep 81 | 12:45 | 19.08 | 722.58 | |
| 16 Sep 81 | 8:20 | 18.87 | 722.79 | |
| 23 Sep 81 | 12:45 | 19.29 | 722.37 | |
| 30 Sep 81 | 8:28 | 19.29 | 722.37 | |
| 7 Oct 81 | 10:48 | 19.23 | 722.43 | |
| 14 Oct 81 | 10:41 | 19.20 | 722.46 | |
| 21 Oct 81 | 9:24 | 19.14 | 722.52 | |
| 28 Oct 81 | 12:55 | 19.08 | 722.58 | |
| 4 Nov 81 | 11:18 | 19.30 | 722.36 | |
| 11 Nov 81 | 1:51 | 19.53 | 722.13 | |
| 16 Nov 81 | 12:00 | 19.41 | 722.25 | Blew dry |
| 18 Nov 81 | 12:57 | 19.34 | 722.32 | |
| 25 Nov 81 | 3:56 | 19.27 | 722.39 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-2-81

Top of Pipe Elevation: 728.46 ft MSL

Screen Interval: from 685.79 to 676.19 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 4 Sep 81 | 8:35 | 45.65 | 682.81 | |
| 5 Sep 81 | 8:27 | 46.10 | 682.36 | |
| 6 Sep 81 | 12:30 | 46.22 | 682.24 | |
| 7 Sep 81 | 8:50 | 46.01 | 682.45 | |
| 8 Sep 81 | 12:13 | 46.01 | 682.45 | |
| 9 Sep 81 | 12:50 | 46.13 | 682.33 | |
| 10 Sep 81 | 3:00 | 46.09 | 682.37 | |
| 16 Sep 81 | 8:27 | 46.05 | 682.41 | |
| 23 Sep 81 | 12:50 | 46.70 | 681.76 | |
| 30 Sep 81 | 8:45 | 46.33 | 682.13 | |
| 7 Oct 81 | 9:59 | 46.66 | 681.86 | |
| 14 Oct 81 | 10:52 | 46.54 | 681.92 | |
| 21 Oct 81 | 9:12 | 46.50 | 681.96 | |
| 28 Oct 81 | 12:43 | 46.62 | 681.84 | |
| 4 Nov 81 | 11:05 | 46.47 | 681.99 | |
| 11 Nov 81 | 1:40 | 46.58 | 681.88 | |
| 16 Nov 81 | 3:59 | 46.09 | 682.37 | Blew dry |
| 18 Nov 81 | 12:31 | 46.33 | 682.13 | |
| 25 Nov 81 | 3:45 | 46.41 | 682.05 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-3-81

Top of Pipe Elevation: 723.02 ft MSL

Screen Interval: from 668.84 to 659.73 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 4 Sep 81 | 9:10 | 55.80 | 664.22 | Open hole |
| 5 Sep 81 | 8:14 | 52.53 | 667.49 | Open hole |
| 6 Sep 81 | 12:25 | 40.78 | 682.24 | |
| 7 Sep 81 | 9:08 | 41.31 | 681.71 | |
| 8 Sep 81 | 12:20 | 41.78 | 681.24 | |
| 9 Sep 81 | 12:55 | 42.28 | 680.74 | |
| 10 Sep 81 | 3:05 | 42.60 | 680.42 | |
| 11 Sep 81 | 9:10 | 42.81 | 680.21 | |
| 12 Sep 81 | 7:33 | 43.20 | 679.82 | |
| 16 Sep 81 | 8:33 | 43.75 | 679.27 | |
| 23 Sep 81 | 12:57 | 44.67 | 678.35 | |
| 30 Sep 81 | 8:40 | 44.89 | 678.13 | |
| 7 Oct 81 | 9:06 | 44.91 | 678.11 | |
| 14 Oct 81 | 10:54 | 45.19 | 677.83 | |
| 21 Oct 81 | 9:07 | 45.33 | 677.69 | |
| 28 Oct 81 | 12:47 | 45.32 | 677.70 | |
| 4 Nov 81 | 11:03 | 45.29 | 677.73 | |
| 11 Nov 81 | 1:36 | 45.26 | 677.76 | |
| 16 Nov 81 | 4:43 | 45.35 | 677.67 | Blew dry |
| 18 Nov 81 | 12:38 | 55.15 | 667.87 | |
| 25 Nov 81 | 3:43 | 51.60 | 671.42 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-4-81

Top of Pipe Elevation: 719.66 ft MSL

Screen Interval: from 680.76 to 671.56 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 6 Sep 81 | 12:21 | 38.84 | 680.82 | |
| 7 Sep 81 | 9:10 | 38.62 | 681.04 | |
| 8 Sep 81 | 12:25 | 38.67 | 680.99 | |
| 9 Sep 81 | 1:00 | 38.67 | 680.99 | |
| 10 Sep 81 | 3:07 | 38.50 | 681.16 | |
| 11 Sep 81 | 9:14 | 38.68 | 680.98 | |
| 12 Sep 81 | 7:29 | 38.73 | 680.93 | |
| 16 Sep 81 | 8:40 | 38.52 | 681.14 | |
| 23 Sep 81 | 12:59 | 39.06 | 680.60 | |
| 30 Sep 81 | 8:50 | 38.65 | 681.01 | |
| 7 Oct 81 | 9:04 | 38.75 | 680.91 | |
| 14 Oct 81 | 10:57 | 38.84 | 680.82 | |
| 21 Oct 81 | 8:50 | 38.89 | 680.77 | |
| 28 Oct 81 | 12:50 | 38.96 | 680.70 | |
| 4 Nov 81 | 10:55 | 38.88 | 680.78 | |
| 11 Nov 81 | 1:32 | 38.99 | 680.67 | |
| 16 Nov 81 | 5:01 | 38.60 | 681.06 | Blew dry |
| 18 Nov 81 | 12:43 | 38.72 | 680.94 | |
| 25 Nov 81 | 3:40 | 38.95 | 680.71 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-5-81

Top of Pipe Elevation: 742.24 ft MSL

Screen Interval: from 689.04 to 679.56 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 7 Sep 81 | 8:20 | 54.5-55.0 | 684.24 | Open hole |
| 8 Sep 81 | 12:08 | 57.66 | 684.58 | |
| 9 Sep 81 | 1:10 | 57.79 | 684.45 | |
| 10 Sep 81 | 3:14 | 57.60 | 684.64 | |
| 11 Sep 81 | 8:50 | 57.84 | 684.40 | |
| 12 Sep 81 | 7:15 | 57.83 | 684.41 | |
| 13 Sep 81 | 2:01 | 57.68 | 684.56 | |
| 14 Sep 81 | 3:40 | 57.52 | 684.72 | |
| 16 Sep 81 | 8:13 | 57.68 | 684.56 | |
| 23 Sep 81 | 3:59 | 58.01 | 684.23 | |
| 30 Sep 81 | 8:25 | 57.93 | 684.31 | |
| 7 Oct 81 | 9:45 | 57.90 | 684.34 | |
| 14 Oct 81 | 10:35 | 58.00 | 684.24 | |
| 21 Oct 81 | 9:27 | 58.11 | 684.13 | |
| 28 Oct 81 | 12:59 | 58.10 | 684.14 | |
| 4 Nov 81 | 11:20 | 58.00 | 684.24 | |
| 11 Nov 81 | 1:55 | 58.08 | 684.16 | |
| 16 Nov 81 | 11:13 | 57.95 | 684.29 | Blew dry |
| 18 Nov 81 | 1:00 | 57.87 | 684.37 | |
| 25 Nov 81 | 3:58 | 57.90 | 684.34 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-6-81

Top of Pipe Elevation: 739.58 ft MSL

Screen Interval: from 686.13 to 676.87 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 24 Sep 81 | 8:00 | 55.36 | 681.22 | Open hole |
| 25 Sep 81 | 3:55 | 54.74 | 684.74 | |
| 26 Sep 81 | 9:01 | 55.32 | 684.26 | |
| 27 Sep 81 | 3:25 | 55.40 | 684.18 | |
| 28 Sep 81 | 8:55 | 55.56 | 684.02 | |
| 29 Sep 81 | 11:34 | 55.64 | 683.94 | |
| 30 Sep 81 | 8:31 | 55.36 | 684.22 | |
| 1 Oct 81 | 11:55 | 55.30 | 684.28 | |
| 7 Oct 81 | 9:49 | 55.51 | 684.07 | |
| 14 Oct 81 | 10:44 | 55.54 | 684.04 | |
| 21 Oct 81 | 9:22 | 55.60 | 683.98 | |
| 28 Oct 81 | 12:35 | 55.74 | 683.84 | |
| 4 Nov 81 | 11:16 | 55.80 | 683.78 | |
| 11 Nov 81 | 1:49 | 55.65 | 683.93 | |
| 16 Nov 81 | 12:40 | 55.18 | 684.40 | Blew dry |
| 18 Nov 81 | 12:55 | 55.48 | 684.10 | |
| 25 Nov 81 | 3:53 | 55.69 | 683.89 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-7-81

Top of Pipe Elevation: 731.73 ft MSL

Screen Interval: from 685.97 to 676.73 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 25 Sep 81 | 9:01 | 45.34 | 683.39 | Open hole |
| 26 Sep 81 | 9:00 | 48.02 | 683.71 | |
| 27 Sep 81 | 3:25 | 48.34 | 683.39 | |
| 28 Sep 81 | 9:03 | 48.31 | 683.42 | |
| 29 Sep 81 | 11:39 | 48.24 | 683.49 | |
| 30 Sep 81 | 8:35 | 48.23 | 683.50 | |
| 1 Oct 81 | 11:59 | 47.85 | 683.88 | |
| 2 Oct 81 | 8:06 | 48.06 | 683.67 | |
| 7 Oct 81 | 9:50 | 48.20 | 683.53 | |
| 14 Oct 81 | 10:45 | 48.20 | 683.53 | |
| 21 Oct 81 | 9:19 | 48.27 | 683.46 | |
| 28 Oct 81 | 12:40 | 48.32 | 683.41 | |
| 4 Nov 81 | 11:09 | 48.31 | 683.42 | |
| 11 Nov 81 | 1:43 | 48.29 | 683.44 | |
| 16 Nov 81 | 1:20 | 47.84 | 683.89 | Blew dry |
| 18 Nov 81 | 12:52 | 48.01 | 683.72 | |
| 25 Nov 81 | 3:50 | 48.00 | 683.73 | |

Groundwater Elevations

Dye Burial Grounds

Boring Number: WES-2-8-81

Top of Pipe Elevation: 733.29 ft MSL

Screen Interval: from 684.42 to 675.52 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 26 Sep 81 | 8:50 | 47.0 | 683.29 | Open hole |
| 27 Sep 81 | 3:29 | 49.75 | 683.54 | |
| 28 Sep 81 | 9:07 | 49.94 | 683.35 | |
| 29 Sep 81 | 11:43 | 49.89 | 683.40 | |
| 30 Sep 81 | 8:38 | 49.78 | 683.51 | |
| 1 Oct 81 | 12:03 | 49.52 | 683.77 | |
| 2 Oct 81 | 8:10 | 49.68 | 683.61 | |
| 3 Oct 81 | 8:15 | 49.85 | 683.44 | |
| 7 Oct 81 | 9:55 | 49.83 | 683.46 | |
| 14 Oct 81 | 10:49 | 49.88 | 683.41 | |
| 21 Oct 81 | 9:15 | 49.92 | 683.37 | |
| 28 Oct 81 | 12:30 | 50.00 | 683.29 | |
| 4 Nov 81 | 11:13 | 49.95 | 683.34 | |
| 11 Nov 81 | 1:46 | 49.97 | 683.32 | |
| 16 Nov 81 | 2:13 | 49.52 | 683.77 | Blew dry |
| 18 Nov 81 | 12:46 | 49.76 | 683.53 | |
| 25 Nov 81 | 3:47 | 49.76 | 683.53 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-1-81

Top of Pipe Elevation: 605.45 ft MSL

Screen Interval: from 560.83 to 551.63 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 6 Sep 81 | 12:10 | 45.91 | 559.54 | |
| 7 Sep 81 | 1:58 | 45.71 | 559.74 | |
| 8 Sep 81 | 11:51 | 45.80 | 559.65 | |
| 9 Sep 81 | 8:14 | 45.95 | 559.50 | |
| 10 Sep 81 | 4:08 | 45.73 | 559.72 | |
| 11 Sep 81 | 9:30 | 45.94 | 559.51 | |
| 12 Sep 81 | 10:59 | 45.86 | 559.59 | |
| 19 Sep 81 | 8:59 | 46.00 | 559.45 | |
| 26 Sep 81 | 9:18 | 45.97 | 559.48 | |
| 29 Sep 81 | 11:50 | 46.04 | 559.41 | |
| 6 Oct 81 | 4:04 | 45.76 | 559.69 | |
| 13 Oct 81 | 8:10 | 46.09 | 559.36 | |
| 20 Oct 81 | 8:31 | 46.12 | 559.33 | |
| 27 Oct 81 | 5:05 | 45.83 | 559.62 | |
| 3 Nov 81 | 8:10 | 46.06 | 559.39 | |
| 10 Nov 81 | 8:37 | 46.11 | 559.34 | |
| 15 Nov 81 | 4:16 | 45.57 | 559.88 | Blew dry |
| 17 Nov 81 | 7:54 | 45.66 | 559.79 | |
| 17 Nov 81 | 9:51 | 45.54 | 559.91 | |
| 24 Nov 81 | 9:05 | 45.72 | 559.73 | |
| 29 Nov 81 | 10:10 | 46.30 | 559.15 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-2-81

Top of Pipe Elevation: 623.68 ft MSL

Screen Interval: from 617.16 to 610.68 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 8 Sep 81 | 11:40 | 6.25 | 617.43 | |
| 9 Sep 81 | 8:18 | 6.67 | 617.01 | |
| 10 Sep 81 | 4:15 | 6.80 | 616.88 | |
| 11 Sep 81 | 9:40 | 6.81 | 616.87 | |
| 12 Sep 81 | 11:03 | 6.85 | 616.83 | |
| 13 Sep 81 | 12:55 | 7.01 | 616.67 | |
| 14 Sep 81 | 3:25 | 7.08 | 616.60 | |
| 15 Sep 81 | 4:30 | 7.20 | 616.48 | |
| 22 Sep 81 | 4:02 | 7.39 | 616.29 | |
| 29 Sep 81 | 11:55 | 7.67 | 616.01 | |
| 6 Oct 81 | 4:10 | 7.71 | 615.97 | |
| 13 Oct 81 | 8:14 | 7.84 | 615.84 | |
| 20 Oct 81 | 8:42 | 7.96 | 615.72 | |
| 27 Oct 81 | 5:00 | 7.90 | 615.78 | |
| 3 Nov 81 | 8:20 | 7.91 | 615.77 | |
| 10 Nov 81 | 8:31 | 7.89 | 615.79 | |
| 15 Nov 81 | 4:12 | 6.58 | 617.10 | Blew dry |
| 17 Nov 81 | 7:45 | 6.73 | 616.95 | |
| 17 Nov 81 | 10:25 | 10.72 | 612.95 | |
| 24 Nov 81 | 9:10 | 6.26 | 617.42 | |
| 29 Nov 81 | 10:15 | 6.15 | 617.53 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-3-81

Top of Pipe Elevation: 583.87 ft MSL

Screen Interval: from 494.97 to 485.85 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 17 Sep 81 | 8:00 | 87.5 | 493.37 | Open hole |
| 18 Sep 81 | 7:38 | 77.25 | 506.62 | |
| 19 Sep 81 | 9:05 | 77.19 | 506.68 | |
| 20 Sep 81 | 10:05 | 77.00 | 506.87 | |
| 21 Sep 81 | 9:00 | 76.75 | 507.12 | |
| 22 Sep 81 | 2:25 | 76.47 | 507.40 | |
| 23 Sep 81 | 12:35 | 76.42 | 507.45 | |
| 29 Sep 81 | 12:06 | 75.66 | 508.21 | |
| 6 Oct 81 | 4:20 | 75.00 | 508.87 | |
| 13 Oct 81 | 8:27 | 74.53 | 509.34 | |
| 20 Oct 81 | 8:54 | 74.06 | 509.81 | |
| 27 Oct 81 | 5:26 | 73.67 | 510.20 | |
| 3 Nov 81 | 8:43 | 73.40 | 510.47 | |
| 10 Nov 81 | 8:52 | 73.05 | 510.82 | |
| 15 Nov 81 | 4:28 | 72.61 | 511.26 | |
| 17 Nov 81 | 8:39 | 90.55 | 493.32 | Blew dry |
| 24 Nov 81 | 9:34 | 93.48 | 490.39 | |
| 29 Nov 81 | 10:35 | 93.19 | 490.68 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-4-81

Top of Pipe Elevation: 595.12 ft MSL

Screen Interval: from 537.03 to 527.55 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 26 Sep 81 | 9:10 | 45.55 | 546.57 | Open hole |
| 28 Sep 81 | 8:05 | -- | -- | Open hole w/plug |
| 29 Sep 81 | 12:12 | 70.00 | 525.12 | |
| 30 Sep 81 | 9:03 | 68.97 | 526.15 | |
| 1 Oct 81 | 9:05 | 67.85 | 527.25 | |
| 2 Oct 81 | 8:25 | 67.15 | 527.97 | |
| 3 Oct 81 | 8:30 | 66.67 | 528.45 | |
| 4 Oct 81 | 11:24 | 66.18 | 528.94 | |
| 5 Oct 81 | 4:10 | 65.67 | 529.45 | |
| 6 Oct 81 | 10:15 | 65.07 | 530.05 | |
| 13 Oct 81 | 8:32 | 65.40 | 529.72 | |
| 20 Oct 81 | 8:55 | 58.82 | 536.30 | |
| 27 Oct 81 | 5:21 | 54.15 | 540.97 | |
| 3 Nov 81 | 8:40 | 53.28 | 541.84 | |
| 10 Nov 81 | 8:47 | 52.18 | 542.94 | |
| 15 Nov 81 | 4:23 | 51.61 | 543.51 | Blew dry |
| 17 Nov 81 | 8:43 | 52.71 | 542.41 | |
| 24 Nov 81 | 9:28 | 51.75 | 543.37 | |
| 29 Nov 81 | 10:32 | 51.10 | 544.02 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-5-81

Top of Pipe Elevation: 596.25 ft MSL

Screen Interval: from 547.85 to 538.57 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 1 Oct 81 | 9:12 | 48.96 | 547.29 | |
| 2 Oct 81 | 8:30 | 48.92 | 547.33 | |
| 3 Oct 81 | 8:35 | 48.90 | 547.35 | |
| 4 Oct 81 | 11:34 | 49.08 | 547.17 | |
| 5 Oct 81 | 4:17 | 48.90 | 547.35 | |
| 6 Oct 81 | 10:20 | 48.94 | 547.31 | |
| 7 Oct 81 | 10:19 | 48.76 | 547.49 | |
| 13 Oct 81 | 8:22 | 48.94 | 547.31 | |
| 20 Oct 81 | 8:49 | 48.88 | 547.37 | |
| 27 Oct 81 | 5:15 | 48.90 | 547.35 | |
| 3 Nov 81 | 8:30 | 49.04 | 547.21 | |
| 10 Nov 81 | 8:39 | 49.01 | 547.24 | |
| 15 Nov 81 | 4:20 | 49.00 | 547.25 | Blew dry |
| 17 Nov 81 | 8:21 | 49.17 | 547.08 | |
| 24 Nov 81 | 9:24 | 49.04 | 547.21 | |
| 29 Nov 81 | 10:25 | 48.95 | 547.30 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-6-81

Top of Pipe Elevation: 590.60 ft MSL

Screen Interval: from 550.34 to 541.00 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 8 Oct 81 | 9:10 | 46.91 | 543.61 | |
| 9 Oct 81 | 3:19 | 45.03 | 545.57 | |
| 10 Oct 81 | 9:01 | 45.24 | 545.36 | |
| 11 Oct 81 | 12:29 | 45.12 | 545.48 | |
| 12 Oct 81 | 7:55 | 45.16 | 545.44 | |
| 13 Oct 81 | 8:31 | 45.12 | 545.48 | |
| 14 Oct 81 | 10:29 | 45.20 | 545.40 | |
| 20 Oct 81 | 8:58 | 45.31 | 545.29 | |
| 27 Oct 81 | 5:23 | 45.30 | 545.30 | |
| 3 Nov 81 | 8:36 | 45.20 | 545.40 | |
| 10 Nov 81 | 8:49 | 45.37 | 545.23 | |
| 15 Nov 81 | 4:25 | 45.43 | 545.17 | Blew dry |
| 17 Nov 81 | 8:35 | 46.50 | 544.10 | |
| 24 Nov 81 | 7:29 | 45.39 | 545.21 | |
| 29 Nov 81 | 10:30 | 45.29 | 545.31 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-7-81

Top of Pipe Elevation: 557.65 ft MSL

Screen Interval: from 542.23 to 532.95 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 9 Oct 81 | 3:24 | 22.00 | 535.65 | |
| 10 Oct 81 | 9:48 | 17.15 | 540.50 | |
| 11 Oct 81 | 12:19 | 13.30 | 544.35 | |
| 12 Oct 81 | 7:45 | 13.20 | 544.45 | |
| 13 Oct 81 | 8:39 | 13.02 | 544.63 | |
| 14 Oct 81 | 10:20 | 13.09 | 544.56 | |
| 15 Oct 81 | 2:47 | 13.05 | 544.60 | |
| 20 Oct 81 | 9:04 | 13.13 | 544.52 | |
| 27 Oct 81 | 5:35 | 11.80 | 545.85 | |
| 3 Nov 81 | 8:47 | 12.10 | 545.55 | |
| 10 Nov 81 | 9:01 | 11.40 | 546.25 | |
| 15 Nov 81 | 4:31 | 11.32 | 546.33 | Blew dry |
| 17 Nov 81 | 8:47 | 11.64 | 546.01 | |
| 24 Nov 81 | 9:41 | 10.60 | 547.05 | |
| 29 Nov 81 | 10:40 | 11.00 | 546.65 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-8-81

Top of Pipe Elevation: 587.26 ft MSL

Screen Interval: from 551.89 to 542.46 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 11 Oct 81 | 12:33 | 41.77 | 545.49 | |
| 12 Oct 81 | 7:59 | 40.50 | 546.76 | |
| 13 Oct 81 | 8:25 | 39.94 | 547.32 | |
| 14 Oct 81 | 10:33 | 40.23 | 547.03 | |
| 15 Oct 81 | 2:53 | 40.28 | 546.98 | |
| 16 Oct 81 | 3:50 | 40.39 | 546.87 | |
| 17 Oct 81 | 8:22 | 40.34 | 546.92 | |
| 20 Oct 81 | 8:52 | 40.30 | 546.96 | |
| 27 Oct 81 | 5:18 | 40.35 | 546.91 | |
| 3 Nov 81 | 8:34 | 40.40 | 546.86 | |
| 10 Nov 81 | 8:44 | 40.54 | 546.72 | |
| 15 Nov 81 | 4:22 | 40.58 | 546.68 | Blew dry |
| 17 Nov 81 | 8:30 | 40.62 | 546.64 | |
| 24 Nov 81 | 9:26 | 40.46 | 546.80 | |
| 29 Nov 81 | 10:27 | 40.50 | 546.76 | |

Groundwater Elevations

Ammunition Burning Grounds

Boring Number: WES-3-9-81

Top of Pipe Elevation: 625.25 ft MSL

Screen Interval: from 556.32 to 547.10 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 1 Nov 81 | 10:50 | 67.75 | 557.50 | |
| 2 Nov 81 | 8:08 | 67.81 | 557.44 | |
| 3 Nov 81 | 8:20 | 67.87 | 557.38 | |
| 4 Nov 81 | 11:35 | 67.70 | 557.55 | |
| 5 Nov 81 | 10:29 | 67.53 | 557.72 | |
| 6 Nov 81 | 11:09 | 67.56 | 557.69 | |
| 7 Nov 81 | 10:46 | 67.71 | 557.54 | |
| 10 Nov 81 | 8:25 | 67.95 | 557.30 | |
| 15 Nov 81 | 4:10 | 67.48 | 557.77 | |
| 17 Nov 81 | 7:43 | 67.40 | 557.85 | Blew dry |
| 17 Nov 81 | 11:00 | -- | -- | No water |
| 24 Nov 81 | 9:11 | 67.55 | 557.70 | |
| 29 Nov 81 | 10:17 | 67.95 | 557.30 | |

Groundwater Elevations

Ammunition Burning Grounds

Pump House - Building 3004

Top of Casing Plate Elevation: 594.79 ft MSL

Screen Interval: No screen, open hole from 492.79 to 453.79 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 6 Sep 81 | 9:00 | 81.66 | 513.13 | |
| 12 Sep 81 | 11:10 | 81.82 | 512.97 | |
| 13 Sep 81 | 1:45 | 81.69 | 513.10 | |
| 19 Sep 81 | 9:10 | 81.67 | 513.12 | |
| 22 Sep 81 | 4:08 | 81.85 | 512.94 | |
| 29 Sep 81 | 12:02 | 81.94 | 512.85 | |
| 6 Oct 81 | 4:16 | 81.84 | 512.95 | |
| 13 Oct 81 | 8:19 | 81.87 | 512.92 | |
| 20 Oct 81 | 8:46 | 81.89 | 512.90 | |
| 27 Oct 81 | 5:10 | 81.97 | 512.82 | |
| 24 Nov 81 | 9:20 | 81.97 | 512.82 | |
| 29 Nov 81 | 10:20 | 82.00 | 512.79 | |

Water measurements made through a ½-in. screw plug on top of casing plate.

Groundwater Elevations

McComish Gorge

Boring Number: WES-4-1-81

Top of Pipe Elevation: 606.49 ft MSL

Screen Interval: from 578.18 to 568.97 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 11 Sep 81 | 7:55 | 31.82 | 574.67 | |
| 12 Sep 81 | 9:02 | 31.83 | 574.66 | |
| 13 Sep 81 | 2:20 | 31.79 | 574.70 | |
| 14 Sep 81 | 8:15 | 31.89 | 574.60 | |
| 15 Sep 81 | 5:55 | 31.81 | 574.68 | |
| 16 Sep 81 | 9:15 | 31.94 | 574.55 | |
| 17 Sep 81 | 11:02 | 31.89 | 574.60 | |
| 24 Sep 81 | 12:50 | 32.05 | 574.44 | |
| 1 Oct 81 | 8:20 | 32.05 | 574.44 | |
| 8 Oct 81 | 2:50 | 32.05 | 574.44 | |
| 15 Oct 81 | 5:10 | 32.11 | 574.38 | |
| 22 Oct 81 | 8:34 | 32.26 | 574.23 | |
| 29 Oct 81 | 2:11 | 32.31 | 574.18 | |
| 5 Nov 81 | 9:15 | 32.55 | 573.94 | |
| 12 Nov 81 | 4:31 | 32.43 | 574.06 | |
| 19 Nov 81 | 10:58 | 32.42 | 574.07 | |
| 26 Nov 81 | 9:54 | 32.44 | 574.05 | |
| 29 Nov 81 | 1:45 | 32.57 | 573.92 | |

Groundwater Elevations

McComish Gorge

Boring Number: WES-4-2-81

Top of Pipe Elevation: 588.69 ft MSL

Screen Interval: from 570.21 to 561.05 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 12 Sep 81 | 8:35 | 19.9 | 565.79 | Open hole |
| 13 Sep 81 | 2:24 | 21.71 | 566.98 | |
| 14 Sep 81 | 8:24 | 21.71 | 566.98 | |
| 15 Sep 81 | 5:55 | 21.68 | 567.01 | |
| 16 Sep 81 | 9:21 | 21.81 | 566.88 | |
| 17 Sep 81 | 11:05 | 21.79 | 566.90 | |
| 18 Sep 81 | 11:01 | 21.73 | 566.96 | |
| 19 Sep 81 | 7:23 | 21.74 | 566.95 | |
| 24 Sep 81 | 12:53 | 21.75 | 566.94 | |
| 1 Oct 81 | 8:26 | 22.02 | 566.67 | |
| 8 Oct 81 | 2:53 | 22.13 | 566.56 | |
| 15 Oct 81 | 5:12 | 22.00 | 566.69 | |
| 22 Oct 81 | 8:37 | 22.08 | 566.61 | |
| 29 Oct 81 | 2:15 | 22.08 | 566.61 | |
| 5 Nov 81 | 9:21 | 22.15 | 566.54 | |
| 12 Nov 81 | 4:34 | 22.30 | 566.39 | |
| 19 Nov 81 | 10:59 | 22.17 | 566.52 | |
| 26 Nov 81 | 9:57 | 22.11 | 566.58 | |
| 29 Nov 81 | 1:46 | 22.14 | 566.55 | |

Groundwater Elevations

McComish Gorge

Boring Number: WES-4-3-81

Top of Pipe Elevation: 569.22 ft MSL

Screen Interval: from 563.12 to 556.10 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 13 Sep 81 | 2:29 | 6.65 | 562.57 | |
| 14 Sep 81 | 3:30 | 6.80 | 562.42 | |
| 15 Sep 81 | 5:00 | 6.57 | 562.65 | |
| 16 Sep 81 | 9:25 | 6.70 | 562.52 | |
| 17 Sep 81 | 11:14 | 6.48 | 562.74 | |
| 18 Sep 81 | 11:06 | 6.61 | 562.61 | |
| 19 Sep 81 | 7:28 | 6.54 | 562.68 | |
| 24 Sep 81 | 12:58 | 6.70 | 562.52 | |
| 1 Oct 81 | 3:36 | 6.59 | 562.63 | |
| 8 Oct 81 | 3:00 | 6.59 | 562.63 | |
| 15 Oct 81 | 5:20 | 6.74 | 562.48 | |
| 22 Oct 81 | 3:44 | 6.64 | 562.58 | |
| 29 Oct 81 | 2:23 | 6.48 | 562.74 | |
| 5 Nov 81 | 9:31 | 6.60 | 562.62 | |
| 12 Nov 81 | 4:45 | 6.49 | 562.73 | |
| 19 Nov 81 | 11:06 | 6.52 | 562.70 | |
| 26 Nov 81 | 10:06 | 6.40 | 562.82 | |
| 29 Nov 81 | 1:53 | 6.32 | 562.90 | |

Groundwater Elevations

McComish Gorge

Boring Number: WES-4-4-81

Top of Pipe Elevation: 596.14 ft MSL

Screen Interval: from 570.24 to 561.27 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 29 Sep 81 | 2:00 | 28.79 | 567.35 | |
| 30 Sep 81 | 9:40 | 28.75 | 567.39 | |
| 1 Oct 81 | 8:30 | 28.88 | 567.26 | |
| 2 Oct 81 | 3:15 | 28.64 | 567.50 | |
| 3 Oct 81 | 2:20 | 28.77 | 567.37 | |
| 4 Oct 81 | 11:53 | 28.77 | 567.37 | |
| 5 Oct 81 | 8:01 | 28.78 | 567.36 | |
| 8 Oct 81 | 2:55 | 28.82 | 567.32 | |
| 15 Oct 81 | 5:19 | 28.86 | 567.28 | |
| 22 Oct 81 | 8:42 | 28.94 | 567.20 | |
| 29 Oct 81 | 2:20 | 28.95 | 567.19 | |
| 5 Nov 81 | 9:27 | 29.09 | 567.05 | |
| 12 Nov 81 | 4:39 | 29.20 | 566.94 | |
| 19 Nov 81 | 11:05 | 29.25 | 566.89 | |
| 26 Nov 81 | 10:02 | 29.25 | 566.89 | |
| 29 Nov 81 | 1:50 | 29.27 | 566.87 | |

Groundwater Elevations

McComish Gorge

Boring Number: WES-4-5-81

Top of Pipe Elevation: 576.39 ft MSL

Screen Interval: from 568.17 to 558.99 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 1 Oct 81 | 8:33 | 11.15 | 565.24 | |
| 2 Oct 81 | 3:18 | 11.33 | 565.06 | |
| 3 Oct 81 | 2:25 | 11.41 | 564.98 | |
| 4 Oct 81 | 11:56 | 11.35 | 565.04 | |
| 5 Oct 81 | 8:09 | 11.54 | 564.85 | |
| 6 Oct 81 | 11:35 | 11.43 | 564.96 | |
| 7 Oct 81 | 8:58 | 11.47 | 564.92 | |
| 8 Oct 81 | 2:58 | 11.79 | 564.60 | |
| 15 Oct 81 | 5:22 | 12.04 | 564.35 | |
| 22 Oct 81 | 8:46 | 12.43 | 563.96 | |
| 29 Oct 81 | 2:25 | 12.58 | 563.81 | |
| 5 Nov 81 | 9:33 | 12.50 | 563.89 | |
| 12 Nov 81 | 4:43 | 12.57 | 563.82 | |
| 19 Nov 81 | 11:09 | 12.59 | 563.80 | |
| 26 Nov 81 | 10:05 | 12.11 | 564.28 | |
| 29 Nov 81 | 1:54 | 11.87 | 564.52 | |

Groundwater Elevations

McComish Gorge

Boring Number: WES-4-6-81

Top of Pipe Elevation: 582.54 ft MSL

Screen Interval: from 568.92 to 559.71 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 9 Oct 81 | 4:35 | 18.01 | 564.53 | |
| 10 Oct 81 | 4:30 | 18.06 | 564.48 | |
| 11 Oct 81 | 1:04 | 18.04 | 564.50 | |
| 12 Oct 81 | 8:55 | 18.15 | 564.39 | |
| 13 Oct 81 | 9:08 | 18.30 | 564.24 | |
| 14 Oct 81 | 9:44 | 18.03 | 564.51 | |
| 15 Oct 81 | 5:16 | 18.09 | 564.45 | |
| 22 Oct 81 | 8:39 | 18.08 | 564.46 | |
| 29 Oct 81 | 2:17 | 18.00 | 564.54 | |
| 5 Nov 81 | 9:23 | 18.01 | 564.53 | |
| 12 Nov 81 | 4:36 | 18.10 | 564.44 | |
| 19 Nov 81 | 11:02 | 17.96 | 564.58 | |
| 26 Nov 81 | 9:59 | 17.97 | 564.57 | |
| 29 Nov 81 | 1:49 | 17.88 | 564.66 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-1-81

Top of Pipe Elevation: 599.52 ft MSL

Screen Interval: from 592.54 to 584.66 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 15 Sep 81 | 5:50 | 8.39 | 591.13 | |
| 16 Sep 81 | 9:12 | 8.48 | 591.04 | |
| 17 Sep 81 | 10:45 | 8.34 | 591.18 | |
| 18 Sep 81 | 11:14 | 8.28 | 591.24 | |
| 19 Sep 81 | 7:14 | 8.26 | 591.26 | |
| 20 Sep 81 | 10:27 | 8.25 | 591.27 | |
| 21 Sep 81 | 3:22 | 8.23 | 591.29 | |
| 28 Sep 81 | 12:59 | 8.79 | 590.73 | |
| 5 Oct 81 | 8:20 | 9.55 | 589.97 | |
| 12 Oct 81 | 8:48 | 9.88 | 589.64 | |
| 19 Oct 81 | 11:29 | 10.18 | 589.34 | |
| 26 Oct 81 | 10:55 | 10.09 | 589.43 | |
| 2 Nov 81 | 9:58 | 10.19 | 589.33 | |
| 9 Nov 81 | 12:28 | 10.26 | 589.26 | |
| 16 Nov 81 | 2:22 | 10.00 | 589.52 | |
| 23 Nov 81 | 11:28 | 9.21 | 590.31 | |
| 29 Nov 81 | 2:06 | 8.05 | 591.47 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-2-81

Top of Pipe Elevation: 586.43 ft MSL

Screen Interval: from 579.33 to 571.57 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 17 Sep 81 | 10:58 | 9.77 | 576.66 | |
| 18 Sep 81 | 11:16 | 9.82 | 576.61 | |
| 19 Sep 81 | 8:17 | 9.68 | 576.75 | |
| 20 Sep 81 | 10:30 | 9.70 | 576.73 | |
| 21 Sep 81 | 3:25 | 9.62 | 576.81 | |
| 22 Sep 81 | 5:20 | 9.90 | 576.53 | |
| 23 Sep 81 | 3:15 | 9.91 | 576.52 | |
| 28 Sep 81 | 1:02 | 10.00 | 576.43 | |
| 5 Oct 81 | 8:22 | 9.90 | 576.53 | |
| 12 Oct 81 | 8:50 | 10.32 | 576.11 | |
| 19 Oct 81 | 11:32 | 10.63 | 575.80 | |
| 26 Oct 81 | 10:52 | 10.21 | 576.22 | |
| 2 Nov 81 | 10:01 | 10.68 | 575.75 | |
| 9 Nov 81 | 12:31 | 10.99 | 575.44 | |
| 16 Nov 81 | 2:25 | 10.80 | 575.63 | |
| 23 Nov 81 | 11:31 | 10.72 | 575.71 | |
| 29 Nov 81 | 2:08 | 10.78 | 575.65 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-3-81

Top of Pipe Elevation: 592.78 ft MSL

Screen Interval: from 582.89 to 573.76 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 18 Sep 81 | 11:11 | 17.62 | 575.16 | |
| 19 Sep 81 | 7:10 | 15.46 | 577.32 | |
| 20 Sep 81 | 10:24 | 15.42 | 577.36 | |
| 21 Sep 81 | 3:40 | 15.44 | 577.34 | |
| 22 Sep 81 | 5:75 | 15.50 | 577.28 | |
| 23 Sep 81 | 3:10 | 15.54 | 577.24 | |
| 24 Sep 81 | 12:42 | 15.56 | 577.22 | |
| 28 Sep 81 | 12:55 | 15.52 | 577.06 | |
| 5 Oct 81 | 8:16 | 15.76 | 577.02 | |
| 12 Oct 81 | 8:44 | 15.96 | 576.82 | |
| 19 Oct 81 | 11:26 | 16.23 | 576.55 | |
| 26 Oct 81 | 10:49 | 16.15 | 576.63 | |
| 2 Nov 81 | 10:53 | 16.49 | 576.29 | |
| 9 Nov 81 | 12:18 | 16.67 | 576.11 | |
| 16 Nov 81 | 2:12 | 16.66 | 576.12 | |
| 23 Nov 81 | 11:25 | 16.89 | 575.89 | |
| 29 Nov 81 | 1:59 | 16.93 | 575.85 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-4-81

Top of Pipe Elevation: 588.33 ft MSL

Screen Interval: from 574.59 to 565.38 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 2 Oct 81 | 3:08 | 13.38 | 574.95 | |
| 3 Oct 81 | 2:30 | 13.20 | 575.13 | |
| 4 Oct 81 | 11:59 | 13.29 | 575.04 | |
| 5 Oct 81 | 8:15 | 13.45 | 574.88 | |
| 6 Oct 81 | 11:26 | 13.44 | 574.89 | |
| 7 Oct 81 | 8:50 | 13.39 | 574.94 | |
| 8 Oct 81 | 4:06 | 13.41 | 574.92 | |
| 12 Oct 81 | 8:40 | 13.57 | 574.76 | |
| 19 Oct 81 | 11:23 | 13.94 | 574.39 | |
| 26 Oct 81 | 10:41 | 13.91 | 574.42 | |
| 2 Nov 81 | 9:48 | 14.26 | 574.07 | |
| 9 Nov 81 | 12:13 | 14.48 | 573.85 | |
| 16 Nov 81 | 2:06 | 14.61 | 573.72 | |
| 23 Nov 81 | 11:20 | 14.56 | 573.77 | |
| 29 Nov 81 | 1:58 | 14.63 | 573.70 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-5-81

Top of Pipe Elevation: 586.78 ft MSL

Screen Interval: from 577.80 to 568.79 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 3 Oct 81 | 2:32 | 11.57 | 575.21 | |
| 4 Oct 81 | 12:01 | 11.60 | 575.18 | |
| 5 Oct 81 | 8:09 | 11.64 | 575.14 | |
| 6 Oct 81 | 11:29 | 11.75 | 575.03 | |
| 7 Oct 81 | 8:53 | 11.92 | 574.86 | |
| 8 Oct 81 | 4:10 | 11.82 | 574.96 | |
| 9 Oct 81 | 4:40 | 11.82 | 574.96 | |
| 12 Oct 81 | 8:53 | 12.02 | 574.76 | |
| 19 Oct 81 | 11:35 | 12.40 | 574.38 | |
| 26 Oct 81 | 10:44 | 12.48 | 574.30 | |
| 2 Nov 81 | 9:51 | 12.66 | 574.12 | |
| 9 Nov 81 | 12:15 | 13.16 | 573.62 | |
| 16 Nov 81 | 2:09 | 12.92 | 573.86 | |
| 23 Nov 81 | 11:23 | 12.88 | 573.90 | |
| 29 Nov 81 | 2:09 | 12.61 | 574.17 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-6-81

Top of Pipe Elevation: 573.27 ft MSL

Screen Interval: from 554.75 to 545.56 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 15 Oct 81 | 5:28 | 12.56 | 560.71 | |
| 16 Oct 81 | 1:20 | 12.48 | 560.79 | |
| 17 Oct 81 | 4:45 | 12.48 | 560.79 | |
| 18 Oct 81 | -- | -- | -- | |
| 19 Oct 81 | 11:55 | 12.45 | 560.82 | |
| 20 Oct 81 | 4:45 | 12.56 | 560.71 | |
| 21 Oct 81 | 3:56 | 12.39 | 560.88 | |
| 26 Oct 81 | 11:03 | 12.40 | 560.87 | |
| 2 Nov 81 | 10:04 | 12.48 | 560.79 | |
| 9 Nov 81 | 12:40 | 12.63 | 560.64 | |
| 16 Nov 81 | 2:31 | 12.41 | 560.86 | |
| 23 Nov 81 | 11:34 | 12.37 | 560.90 | |
| 29 Nov 81 | 2:12 | 12.25 | 561.02 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-7-81

Top of Pipe Elevation: 579.70 ft MSL

Screen Interval: from 556.40 to 547.08 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 22 Oct 81 | 4:40 | 13.04 | 566.66 | Blew well |
| 23 Oct 81 | 10:21 | 13.89 | 565.81 | |
| 24 Oct 81 | 11:20 | 13.90 | 565.80 | |
| 25 Oct 81 | 4:37 | 13.96 | 565.74 | |
| 26 Oct 81 | 10:58 | 13.82 | 565.88 | |
| 27 Oct 81 | 12:58 | 13.75 | 565.95 | |
| 28 Oct 81 | 10:37 | 13.80 | 565.90 | |
| 2 Nov 81 | 9:55 | 13.86 | 565.84 | |
| 9 Nov 81 | 12:22 | 14.02 | 565.68 | |
| 16 Nov 81 | 2:17 | 13.67 | 566.03 | |
| 23 Nov 81 | 11:24 | 13.36 | 566.34 | |
| 29 Nov 81 | 2:04 | 13.35 | 566.35 | |

Groundwater Elevations

Old Burning Pit

Boring Number: WES-5-8-81

Top of Pipe Elevation: 566.78 ft MSL

Screen Interval: from 561.08 to 551.60 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 5 Nov 81 | 9:43 | 6.20 | 560.58 | |
| 6 Nov 81 | 11:50 | 6.23 | 560.55 | |
| 7 Nov 81 | 3:10 | 6.20 | 560.58 | |
| 8 Nov 81 | 11:28 | 6.13 | 560.65 | |
| 9 Nov 81 | 12:45 | 5.94 | 560.84 | |
| 10 Nov 81 | 4:35 | 6.04 | 560.74 | |
| 11 Nov 81 | 4:45 | 6.04 | 560.74 | |
| 16 Nov 81 | 2:36 | 6.01 | 560.77 | |
| 23 Nov 81 | 11:39 | 5.93 | 560.85 | |
| 29 Nov 81 | 2:15 | 5.89 | 560.89 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-1A-81

Top of Pipe Elevation: 686.13 ft MSL

Screen Interval: from 678.53 to 668.88 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 18 Sep 81 | 8:05 | 11.35 | 671.28 | Open hole |
| 19 Sep 81 | 4:00 | 14.60 | 671.53 | |
| 20 Sep 81 | 9:50 | 14.00 | 672.13 | |
| 21 Sep 81 | 12:35 | 12.59 | 673.54 | |
| 22 Sep 81 | 10:26 | 12.08 | 674.05 | |
| 23 Sep 81 | 3:30 | 12.09 | 674.04 | |
| 24 Sep 81 | 1:50 | 11.87 | 674.26 | |
| 25 Sep 81 | 7:20 | 11.76 | 674.37 | |
| 2 Oct 81 | 8:43 | 11.26 | 674.87 | |
| 9 Oct 81 | 12:08 | 11.42 | 674.70 | |
| 16 Oct 81 | 12:25 | 11.66 | 674.47 | |
| 23 Oct 81 | 3:45 | 17.60* | 668.53 | |
| 30 Oct 81 | 10:01 | 17.42* | 668.71 | |
| 6 Nov 81 | 2:20 | 17.39* | 668.74 | |
| 12 Nov 81 | | | | Blew hole and rinsed |
| 13 Nov 81 | 8:50 | -- | -- | No water |
| 16 Nov 81 | 8:40 | -- | -- | No water |
| 20 Nov 81 | 3:30 | -- | -- | No water |
| 27 Nov 81 | 9:02 | 17.02* | 669.11 | |

* Water level below screen

Groundwater Elevations

Demolition Area

Boring Number: WES-6-1B-81

Top of Pipe Elevation: 686.27 ft MSL

Screen Interval: from 653.30 to 644.13 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 8 Nov 81 | -- | -- | -- | No water |
| 9 Nov 81 | 5:25 | -- | -- | " " |
| 10 Nov 81 | 11:20 | -- | -- | " " |
| 11 Nov 81 | 2:30 | -- | -- | " " |
| 12 Nov 81 | 10:30 | -- | -- | " " |
| 13 Nov 81 | 9:00 | -- | -- | " " |
| 16 Nov 81 | 8:50 | -- | -- | " " |
| 20 Nov 81 | 8:35 | -- | -- | " " |
| 27 Nov 81 | 8:57 | -- | -- | " " |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-1C-81

Top of Pipe Elevation: 685.60 ft MSL

Screen Interval: from 659.50 to 644.50 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 16 Nov 81 | 7:34 | 29.95 | 652.65 | Open hole |
| 17 Nov 81 | | | | Open hole - jetted dry |
| 18 Nov 81 | 11:24 | 32.38 | 650.22 | Open hole - jetted dry |
| 19 Nov 81 | 10:00 | 33.52 | 652.08 | |
| 20 Nov 81 | 8:31 | 33.57 | 652.03 | |
| 22 Nov 81 | 9:04 | 35.42 | 650.18 | |
| 23 Nov 81 | 10:35 | 35.13 | 650.47 | |
| 24 Nov 81 | 10:14 | 34.26 | 651.34 | |
| 25 Nov 81 | 3:20 | 35.35 | 650.25 | |
| 27 Nov 81 | 9:00 | 35.27 | 650.33 | |
| 30 Nov 81 | 10:48 | 36.25 | 649.35 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-2-81

Top of Pipe Elevation: 640.53 ft MSL

Screen Interval: from 613.27 to 603.65 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 21 Sep 81 | 1:55 | 24.40 | 613.13 | Open hole |
| 22 Sep 81 | 10:30 | 27.31 | 613.22 | |
| 23 Sep 81 | 3:35 | 27.55 | 612.98 | |
| 24 Sep 81 | 2:50 | 27.64 | 612.89 | |
| 25 Sep 81 | 7:25 | 27.69 | 612.84 | |
| 26 Sep 81 | 7:00 | 27.49 | 613.04 | |
| 27 Sep 81 | 2:10 | 27.49 | 613.04 | |
| 2 Oct 81 | 8:50 | 27.65 | 612.88 | |
| 9 Oct 81 | 12:45 | 27.55 | 612.98 | |
| 16 Oct 81 | 11:50 | 27.95 | 612.58 | |
| 23 Oct 81 | 3:02 | 28.11 | 612.42 | |
| 30 Oct 81 | 10:31 | 28.29 | 612.24 | |
| 6 Nov 81 | 3:05 | 28.15 | 612.38 | |
| 13 Nov 81 | 9:39 | 28.54 | 611.99 | |
| 15 Nov 81 | 8:21 | 28.36 | 612.17 | Blew dry |
| 16 Nov 81 | 7:29 | 28.21 | 612.32 | |
| 20 Nov 81 | 4:14 | 28.30 | 612.23 | |
| 27 Nov 81 | 8:52 | 28.51 | 612.02 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-3-81

Top of Pipe Elevation: 662.77 ft MSL

Screen Interval: from 654.27 to 645.07 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 22 Sep 81 | 9:01 | 10.6 | 649.17 | Open hole |
| 23 Sep 81 | 3:40 | 13.57 | 649.20 | |
| 24 Sep 81 | 2:50 | 13.58 | 649.19 | |
| 25 Sep 81 | 7:30 | 13.42 | 649.35 | |
| 26 Sep 81 | 7:05 | 13.42 | 649.35 | |
| 27 Sep 81 | 2:20 | 13.50 | 649.27 | |
| 28 Sep 81 | 5:05 | 13.66 | 649.11 | |
| 2 Oct 81 | 8:55 | 13.63 | 649.14 | |
| 9 Oct 81 | 12:29 | 13.61 | 649.16 | |
| 16 Oct 81 | 12:59 | 13.83 | 648.94 | |
| 23 Oct 81 | 3:39 | 14.31 | 648.46 | |
| 30 Oct 81 | 10:09 | 14.39 | 648.38 | |
| 6 Nov 81 | 2:25 | 14.22 | 648.55 | |
| 13 Nov 81 | 5:11 | 14.50 | 648.27 | |
| 15 Nov 81 | 7:46 | 14.43 | 648.34 | Blew dry |
| 16 Nov 81 | 7:15 | 14.12 | 648.65 | |
| 20 Nov 81 | 3:40 | 14.58 | 648.19 | |
| 27 Nov 81 | 8:21 | 14.76 | 648.01 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-4-81

Top of Pipe Elevation: 635.89 ft MSL

Screen Interval: from 617.50 to 608.62 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 2 Oct 81 | 8:50 | 19.50 | 613.39 | Open hole |
| 3 Oct 81 | 9:45 | 23.45 | 612.44 | |
| 4 Oct 81 | 11:01 | 23.45 | 612.44 | |
| 5 Oct 81 | 9:20 | 23.59 | 612.30 | |
| 6 Oct 81 | 12:00 | 23.52 | 612.37 | |
| 7 Oct 81 | 4:45 | 23.67 | 612.22 | |
| 8 Oct 81 | 11:30 | 23.72 | 612.17 | |
| 9 Oct 81 | 12:40 | 23.54 | 612.35 | |
| 16 Oct 81 | 12:05 | 23.90 | 611.99 | |
| 23 Oct 81 | 3:33 | 24.25 | 611.64 | |
| 30 Oct 81 | 10:19 | 24.40 | 611.49 | |
| 6 Nov 81 | 2:30 | 24.30 | 611.59 | |
| 13 Nov 81 | 5:22 | 24.45 | 611.44 | |
| 15 Nov 81 | 7:56 | 24.30 | 611.59 | Blew dry |
| 20 Nov 81 | 3:48 | 24.35 | 611.59 | |
| 27 Nov 81 | 8:27 | 24.48 | 611.41 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-5-81

Top of Pipe Elevation: 610.89 ft MSL

Screen Interval: from 595.35 to 586.21 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 3 Oct 81 | 1:15 | 19.90 | 590.99 | |
| 4 Oct 81 | 11:08 | 17.54 | 593.35 | |
| 5 Oct 81 | 9:31 | 17.45 | 593.44 | |
| 6 Oct 81 | 12:06 | 17.25 | 593.64 | |
| 7 Oct 81 | 4:50 | 17.09 | 593.80 | |
| 8 Oct 81 | 11:35 | 17.02 | 593.87 | |
| 9 Oct 81 | 12:56 | 17.02 | 593.87 | |
| 16 Oct 81 | 11:55 | 17.00 | 593.89 | |
| 23 Oct 81 | 3:10 | 17.15 | 593.74 | |
| 30 Oct 81 | 10:32 | 17.25 | 593.64 | |
| 6 Nov 81 | 3:02 | 17.18 | 593.71 | |
| 13 Nov 81 | 5:44 | 17.17 | 593.72 | |
| 15 Nov 81 | 8:15 | 17.14 | 593.75 | Blew dry |
| 16 Nov 81 | 7:27 | 17.24 | 593.65 | |
| 20 Nov 81 | 4:10 | 17.28 | 593.61 | |
| 27 Nov 81 | 8:47 | 16.81 | 594.08 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-6-81

Top of Pipe Elevation: 675.06 ft MSL

Screen Interval: from 624.41 to 615.13 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 15 Oct 81 | 12:35 | 46.56 | 628.50 | |
| 16 Oct 81 | 12:25 | 46.10 | 628.96 | |
| 17 Oct 81 | 3:44 | 46.60 | 628.46 | |
| 18 Oct 81 | 3:38 | 45.54 | 629.52 | |
| 19 Oct 81 | 9:59 | 45.14 | 629.92 | |
| 20 Oct 81 | 9:44 | 45.79 | 629.27 | |
| 21 Oct 81 | 10:12 | 45.74 | 629.32 | |
| 23 Oct 81 | 3:53 | 45.76 | 629.30 | |
| 30 Oct 81 | 10:45 | 45.61 | 629.45 | |
| 6 Nov 81 | 3:15 | 45.48 | 629.58 | |
| 13 Nov 81 | 5:52 | 45.52 | 629.54 | |
| 15 Nov 81 | 8:41 | 45.24 | 629.82 | Blew dry |
| 16 Nov 81 | 8:10 | 45.42 | 629.64 | |
| 20 Nov 81 | 5:29 | 45.37 | 629.69 | |
| 27 Nov 81 | 9:07 | 45.26 | 629.80 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-7-81

Top of Pipe Elevation: 663.92 ft MSL

Screen Interval: from 646.50 to 637.26 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 15 Oct 81 | 12:35 | 18.10 | 645.82 | |
| 17 Oct 81 | 3:49 | 18.15 | 645.77 | |
| 18 Oct 81 | 3:45 | 18.73 | 645.19 | |
| 19 Oct 81 | 10:01 | 18.43 | 645.49 | |
| 20 Oct 81 | 9:50 | 18.44 | 645.48 | |
| 21 Oct 81 | 10:20 | 18.36 | 645.56 | |
| 22 Oct 81 | 12:59 | 18.36 | 645.56 | |
| 23 Oct 81 | 3:56 | 18.54 | 645.38 | |
| 30 Oct 81 | 10:50 | 18.81 | 645.11 | |
| 6 Nov 81 | 3:31 | 18.55 | 645.37 | |
| 13 Nov 81 | 6:04 | 18.60 | 645.32 | |
| 15 Nov 81 | 9:25 | 18.45 | 645.47 | Blew dry |
| 16 Nov 81 | 8:20 | 18.45 | 645.47 | |
| 20 Nov 81 | 5:43 | 18.42 | 645.50 | |
| 27 Nov 81 | 9:34 | 18.36 | 645.56 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-8-81

Top of Pipe Elevation: 641.72 ft MSL

Screen Interval: from 625.71 to 616.59 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 16 Oct 81 | 12:31 | 11.10 | 630.62 | |
| 17 Oct 81 | 3:52 | 11.79 | 629.93 | |
| 18 Oct 81 | 3:55 | 11.60 | 630.12 | |
| 19 Oct 81 | 10:07 | 11.23 | 630.49 | |
| 20 Oct 81 | 9:46 | 11.22 | 630.50 | |
| 21 Oct 81 | 10:15 | 11.18 | 630.54 | |
| 22 Oct 81 | 1:01 | 11.21 | 630.51 | |
| 23 Oct 81 | 3:59 | 11.31 | 630.41 | |
| 30 Oct 81 | 10:47 | 11.02 | 630.70 | |
| 6 Nov 81 | 3:23 | 10.90 | 630.82 | |
| 13 Nov 81 | 6:01 | 10.40 | 631.32 | |
| 15 Nov 81 | 9:08 | 10.34 | 631.38 | Blew dry |
| 16 Nov 81 | 8:31 | 10.12 | 631.60 | |
| 20 Nov 81 | 5:37 | 10.18 | 631.54 | |
| 27 Nov 81 | 9:39 | 9.66 | 632.06 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-9-81

Top of Pipe Elevation: 634.04 ft MSL

Screen Interval: from 605.87 to 596.74 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 17 Oct 81 | 3:33 | 25.71 | 608.33 | |
| 18 Oct 81 | 3:32 | 25.62 | 608.42 | |
| 19 Oct 81 | 9:49 | 25.79 | 608.25 | |
| 20 Oct 81 | 9:39 | 26.06 | 607.98 | |
| 21 Oct 81 | 10:04 | 25.94 | 608.10 | |
| 22 Oct 81 | 12:54 | 26.00 | 608.04 | |
| 23 Oct 81 | 3:14 | 25.98 | 608.06 | |
| 30 Oct 81 | 10:30 | 26.00 | 608.04 | |
| 6 Nov 81 | 2:58 | 26.05 | 607.99 | |
| 13 Nov 81 | 5:34 | 26.34 | 607.70 | |
| 15 Nov 81 | 8:05 | 26.16 | 607.88 | Blew dry |
| 16 Nov 81 | 7:24 | 26.19 | 607.85 | |
| 20 Nov 81 | 4:05 | 26.10 | 607.94 | |
| 27 Nov 81 | 8:44 | 26.25 | 607.79 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-10-81

Top of Pipe Elevation: 662.10 ft MSL

Screen Interval: from 641.80 to 632.41 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 20 Oct 81 | 9:31 | 22.19 | 639.91 | |
| 21 Oct 81 | 9:58 | 22.20 | 639.90 | |
| 22 Oct 81 | 12:45 | 22.26 | 639.84 | |
| 23 Oct 81 | 3:19 | 22.25 | 639.85 | |
| 24 Oct 81 | 11:04 | 22.24 | 639.86 | |
| 25 Oct 81 | 4:45 | 22.26 | 639.84 | |
| 26 Oct 81 | 8:10 | 22.28 | 639.82 | |
| 30 Oct 81 | 10:26 | 22.35 | 639.75 | |
| 6 Nov 81 | 2:53 | 22.70 | 639.40 | |
| 13 Nov 81 | 5:28 | 22.63 | 639.47 | |
| 15 Nov 81 | 8:03 | 22.59 | 639.51 | Blew dry |
| 16 Nov 81 | 7:22 | 22.56 | 639.54 | |
| 20 Nov 81 | 4:02 | 22.61 | 639.49 | |
| 27 Nov 81 | 8:40 | 22.72 | 639.38 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-11-81

Top of Pipe Elevation: 660.43 ft MSL

Screen Interval: from 641.17 to 632.25 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 18 Oct 81 | 3:20 | 14.18 | 646.25 | |
| 19 Oct 81 | 9:45 | 14.14 | 646.29 | |
| 20 Oct 81 | 9:36 | 14.12 | 646.31 | |
| 21 Oct 81 | 9:59 | 14.18 | 646.25 | |
| 22 Oct 81 | 12:48 | 14.06 | 646.37 | |
| 23 Oct 81 | 3:23 | 14.11 | 646.32 | |
| 24 Oct 81 | 11:07 | 14.15 | 646.28 | |
| 30 Oct 81 | 10:24 | 14.12 | 646.31 | |
| 6 Nov 81 | 2:55 | 14.05 | 646.38 | |
| 13 Nov 81 | 5:21 | 14.14 | 646.29 | |
| 15 Nov 81 | 7:59 | 14.10 | 646.33 | Blew dry |
| 16 Nov 81 | 7:18 | 16.26 | 644.17 | |
| 20 Nov 81 | 3:58 | 14.40 | 646.03 | |
| 27 Nov 81 | 8:34 | 14.41 | 646.02 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-12-81

Top of Pipe Elevation: 670.28 ft MSL

Screen Interval: from 630.11 to 620.96 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 5 Nov 81 | 12:55 | 39.65 | 630.63 | |
| 6 Nov 81 | 3:17 | 39.36 | 630.92 | |
| 7 Nov 81 | 8:20 | 39.60 | 630.68 | |
| 8 Nov 81 | 12:07 | 39.38 | 630.90 | |
| 9 Nov 81 | 5:05 | 39.62 | 630.66 | |
| 10 Nov 81 | 11:10 | 39.67 | 630.61 | |
| 11 Nov 81 | 2:17 | 39.50 | 630.78 | |
| 13 Nov 81 | 5:55 | 39.45 | 630.83 | |
| 15 Nov 81 | 8:59 | 39.20 | 631.08 | Blew dry |
| 16 Nov 81 | 8:23 | 39.12 | 631.16 | |
| 20 Nov 81 | 5:32 | 39.25 | 631.03 | |
| 27 Nov 81 | 9:10 | 39.25 | 631.03 | |

Groundwater Elevations

Demolition Area

Boring Number: WES-6-13-81

Top of Pipe Elevation: 663.41 ft MSL

Screen Interval: from 622.86 to 613.75 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 6 Nov 81 | 3:21 | 54.93 | 605.48 | No water |
| 7 Nov 81 | 8:25 | 47.44 | 612.97 | |
| 8 Nov 81 | 12:11 | 40.76 | 619.65 | |
| 9 Nov 81 | 5:10 | 35.90 | 624.51 | |
| 10 Nov 81 | 11:17 | 34.64 | 625.77 | |
| 11 Nov 81 | 2:20 | 34.53 | 625.88 | |
| 12 Nov 81 | 3:30 | 32.95 | 627.46 | |
| 13 Nov 81 | 5:57 | 32.18 | 628.23 | |
| 15 Nov 81 | 9:20 | 31.40 | 632.01 | Blew dry |
| 16 Nov 81 | 8:28 | 39.12 | 621.29 | |
| 20 Nov 81 | 5:35 | 32.65 | 630.76 | |
| 27 Nov 81 | 9:13 | 30.72 | 632.69 | |
| 30 Nov 81 | 10:56 | 30.50 | 632.91 | |

Groundwater Elevations

Old Rifle Range

Boring Number: WES-6-14-81

Top of Pipe Elevation: 508.06 ft MSL

Screen Interval: from 502.06 to 492.89 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 28 Oct 81 | 4:35 | 5.57 | 502.49 | |
| 29 Oct 81 | 9:21 | 5.60 | 502.46 | |
| 30 Oct 81 | 4:10 | 5.64 | 502.42 | |
| 31 Oct 81 | 7:40 | 5.70 | 502.36 | |
| 1 Nov 81 | 10:30 | 5.75 | 502.31 | |
| 2 Nov 81 | 10:59 | 5.78 | 502.28 | |
| 3 Nov 81 | 1:49 | 5.85 | 502.21 | |
| 6 Nov 81 | 10:44 | 5.90 | 502.16 | |
| 13 Nov 81 | 1:31 | 5.19 | 502.87 | |
| 15 Nov 81 | 3:34 | 5.35 | 502.71 | Blew dry |
| 16 Nov 81 | 10:53 | 5.30 | 502.76 | |
| 20 Nov 81 | 10:34 | 3.54 | 504.52 | |
| 27 Nov 81 | 10:07 | 3.65 | 504.41 | |

Groundwater Elevations

Old Rifle Range

Boring Number: WES-6-15-81

Top of Pipe Elevation: 513.42 ft MSL

Screen Interval: from 507.86 to 498.75 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 1 Nov 81 | 10:35 | 14.40 | 499.02 | |
| 2 Nov 81 | 11:25 | 14.30 | 499.12 | |
| 3 Nov 81 | 1:45 | 14.69* | 498.73 | |
| 4 Nov 81 | 10:31 | 14.77* | 498.65 | |
| 5 Nov 81 | 10:12 | 14.73* | 498.69 | |
| 6 Nov 81 | 10:55 | 14.74* | 498.68 | |
| 7 Nov 81 | 10:58 | 14.74* | 498.68 | |
| 9 Nov 81 | | | | Blew well and rinsed with clean water |
| 10 Nov 81 | 11:33 | -- | -- | No water |
| 13 Nov 81 | 4:31 | -- | -- | " " |
| 15 Nov 81 | 2:35 | -- | -- | " " |
| 17 Nov 81 | 5:15 | -- | -- | " " |
| 20 Nov 81 | 10:22 | 15.50* | 497.92 | |
| 27 Nov 81 | 10:26 | 13.51 | 499.91 | |

* Water level below screen

Groundwater Elevations

Old Rifle Range

Boring Number: WES-6-16-81

Top of Pipe Elevation: 530.88 ft MSL

Screen Interval: from 497.35 to 488.29 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 4 Nov 81 | 10:43 | 29.74 | 498.14 | Open hole |
| 5 Nov 81 | 10:07 | 32.76 | 498.12 | |
| 6 Nov 81 | 10:47 | 32.80 | 498.08 | |
| 7 Nov 81 | 11:02 | 32.95 | 497.93 | |
| 8 Nov 81 | 11:58 | 32.70 | 498.18 | |
| 9 Nov 81 | 2:42 | 32.84 | 498.04 | |
| 10 Nov 81 | 11:30 | 32.75 | 498.13 | |
| 11 Nov 81 | 2:45 | 32.80 | 498.08 | |
| 13 Nov 81 | 1:36 | 32.60 | 498.28 | |
| 15 Nov 81 | 3:30 | 32.51 | 498.37 | Blew dry |
| 16 Nov 81 | 10:45 | 32.20 | 498.68 | |
| 20 Nov 81 | 10:27 | 32.11 | 498.77 | |
| 27 Nov 81 | 10:16 | 31.60 | 499.28 | |

Groundwater Elevations

Old Rifle Range

Boring Number: WES-6-17-81

Top of Pipe Elevation: 513.73 ft MSL

Screen Interval: from 502.88 to 493.54 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 12 Nov 81 | 3:39 | 15.44 | 498.29 | |
| 13 Nov 81 | 1:35 | 15.49 | 498.24 | |
| 15 Nov 81 | 2:33 | 15.12 | 498.61 | Blew dry |
| 16 Nov 81 | 10:30 | 15.00 | 498.73 | |
| 17 Nov 81 | 5:19 | 15.15 | 498.58 | |
| 18 Nov 81 | 11:35 | 15.22 | 498.51 | |
| 19 Nov 81 | 2:35 | 14.80 | 498.93 | |
| 20 Nov 81 | 10:21 | 15.02 | 498.71 | |
| 24 Nov 81 | 10:21 | 14.27 | 499.46 | |
| 27 Nov 81 | 10:23 | 14.12 | 499.61 | |
| 29 Nov 81 | 11:25 | 13.96 | 499.77 | |

Groundwater Elevations

Old Rifle Range

Boring Number: WES-6-18-81

Top of Pipe Elevation: 511.03 ft MSL

Screen Interval: from 496.43 to 487.16 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 18 Nov 81 | 11:38 | 14.22 | 496.88 | |
| 19 Nov 81 | 2:38 | 14.00 | 497.03 | |
| 20 Nov 81 | 10:31 | 13.88 | 497.15 | |
| 22 Nov 81 | 9:13 | 13.66 | 497.37 | |
| 23 Nov 81 | 9:09 | 13.59 | 497.44 | |
| 24 Nov 81 | 10:24 | 13.38 | 497.65 | |
| 25 Nov 81 | 11:07 | 13.41 | 497.62 | |
| 27 Nov 81 | 10:13 | 13.42 | 497.61 | |
| 29 Nov 81 | 11:22 | 13.30 | 497.73 | |
| 6 Dec 81 | 9:20 | 12.75 | 498.28 | Readings by NWSC |

Groundwater Elevations

Old Rifle Range

Boring Number: WES-6-19-81

Top of Pipe Elevation: 506.42 ft MSL

Screen Interval: from 498.16 to 488.87 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 25 Nov 81 | 11:00 | 8.28 | 498.14 | |
| 26 Nov 81 | 3:59 | 7.94 | 498.48 | |
| 27 Nov 81 | 10:10 | 8.11 | 498.31 | |
| 29 Nov 81 | 11:20 | 7.85 | 498.57 | |
| 30 Nov 81 | 10:40 | 7.99 | 498.43 | |
| 6 Dec 81 | 9:25 | 8.08 | 498.34 | Readings by NWSC |
| 3 Jan 82 | 10:30 | 6.80 | 499.62 | Readings by NWSC |
| 1 Mar 82 | 10:00 | 6.50 | 499.92 | Readings by NWSC |

Groundwater Elevations

Old Rifle Range

Boring Number: WES-6-20-81

Top of Pipe Elevation: 518.68 ft MSL

Screen Interval: from 499.74 to 490.60 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 26 Nov 81 | 4:02 | 19.85 | 498.83 | |
| 27 Nov 81 | 10:20 | 20.29 | 498.39 | |
| 29 Nov 81 | 11:23 | 20.12 | 498.56 | |
| 30 Nov 81 | 10:37 | 19.91 | 498.77 | |
| 6 Dec 81 | 9:30 | 19.67 | 499.01 | Readings by NWSC |
| 3 Jan 82 | 9:55 | 18.10 | 500.58 | Readings by NWSC |
| 1 Mar 82 | 8:15 | 17.0 | 501.68 | Readings by NWSC |

Groundwater Elevations

Highway 58 Dump Site A

Boring Number: WES-7-1-81

Top of Pipe Elevation: 632.54 ft MSL

Screen Interval: 602.52 to 593.34 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 6 Oct 81 | 4:32 | 25.35 | 607.19 | |
| 7 Oct 81 | 4:55 | 25.43 | 607.11 | |
| 8 Oct 81 | 10:25 | 25.45 | 607.09 | |
| 9 Oct 81 | 3:42 | 25.35 | 607.22 | |
| 10 Oct 81 | 11:38 | 25.39 | 607.15 | |
| 11 Oct 81 | 12:43 | 25.44 | 607.10 | |
| 12 Oct 81 | 8:15 | 25.60 | 606.94 | |
| 19 Oct 81 | 10:36 | 25.53 | 607.01 | |
| 26 Oct 81 | 9:15 | 25.68 | 606.86 | |
| 2 Nov 81 | 8:46 | 25.90 | 606.64 | |
| 9 Nov 81 | 4:37 | 25.90 | 606.64 | |
| 16 Nov 81 | 12:46 | 25.73 | 606.81 | Blew dry |
| 23 Nov 81 | 12:02 | 25.73 | 606.81 | |
| 29 Nov 81 | 11:38 | 25.79 | 606.75 | |

Groundwater Elevations

Highway 58 Dump Site A

Boring Number: WES-7-2-81

Top of Pipe Elevation: 604.89 ft MSL

Screen Interval: 581.62 to 572.27 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 6 Oct 81 | 4:35 | 27.09 | 577.80 | |
| 7 Oct 81 | 5:00 | 28.63 | 576.26 | |
| 8 Oct 81 | 10:49 | 30.00 | 574.89 | |
| 9 Oct 81 | 3:49 | 30.78 | 574.11 | |
| 10 Oct 81 | 11:44 | 31.00 | 573.89 | |
| 11 Oct 81 | 12:50 | 31.70 | 573.19 | |
| 12 Oct 81 | 8:18 | 31.96 | 572.93 | |
| 19 Oct 81 | 10:41 | 32.60 | 572.29 | |
| 26 Oct 81 | 9:25 | 32.68* | 572.21 | |
| 2 Nov 81 | 8:53 | 32.85* | 572.04 | |
| 9 Nov 81 | 4:50 | 32.80* | 572.09 | |
| 16 Nov 81 | 12:55 | 33.38* | 571.51 | Blew water from well |
| 23 Nov 81 | 12:13 | 33.32* | 571.57 | |
| 29 Nov 81 | 11:42 | 33.26* | 571.63 | |

* Water level below screen

Groundwater Elevations

Highway 58 Dump Site A

Boring Number: WES-7-3-81

Top of Pipe Elevation: 600.02 ft MSL

Screen Interval: 573.62 to 564.30 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 7 Oct 81 | 4:58 | 27.99 | 572.03 | |
| 8 Oct 81 | 10:46 | 29.76 | 570.26 | |
| 9 Oct 81 | 3:44 | 29.76 | 570.26 | |
| 10 Oct 81 | 11:41 | 29.68 | 570.34 | |
| 11 Oct 81 | 12:45 | 29.89 | 570.13 | |
| 12 Oct 81 | 8:23 | 29.89 | 570.13 | |
| 13 Oct 81 | 8:51 | 29.93 | 570.09 | |
| 19 Oct 81 | 10:45 | 30.03 | 569.99 | |
| 26 Oct 81 | 9:05 | 29.65 | 570.37 | |
| 2 Nov 81 | 8:48 | 29.93 | 570.09 | |
| 9 Nov 81 | 4:39 | 30.06 | 569.96 | |
| 16 Nov 81 | 12:49 | 29.48 | 570.54 | |
| 23 Nov 81 | 12:05 | 29.55 | 570.47 | |
| 29 Nov 81 | 11:40 | 29.87 | 570.15 | |

Groundwater Elevations

Highway 58 Dump Site A

Boring Number: WES-7-4-81

Top of Pipe Elevation: 598.80 ft MSL

Screen Interval: 571.49 to 562.16 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 13 Oct 81 | 8:54 | 29.39 | 569.41 | |
| 14 Oct 81 | 11:15 | 29.55 | 569.25 | |
| 15 Oct 81 | 2:26 | 29.43 | 569.37 | |
| 16 Oct 81 | 12:45 | 29.34 | 569.46 | |
| 17 Oct 81 | 9:32 | 29.29 | 569.51 | |
| 18 Oct 81 | -- | -- | -- | |
| 19 Oct 81 | 10:31 | 29.50 | 569.30 | |
| 26 Oct 81 | 9:20 | 29.01 | 569.79 | |
| 2 Nov 81 | 8:51 | 29.30 | 569.50 | |
| 9 Nov 81 | 4:45 | 29.32 | 569.48 | |
| 16 Nov 81 | 12:53 | 28.86 | 569.94 | |
| 23 Nov 81 | 12:10 | 28.88 | 569.92 | |
| 29 Nov 81 | 11:41 | 29.23 | 569.57 | |

Groundwater Elevations

Highway 58 Dump Site A

Boring Number: WES-7-5-81

Top of Pipe Elevation: 596.73 ft MSL

Screen Interval: 569.43 to 560.08 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 6 Nov 81 | 10:36 | 26.48 | 570.25 | |
| 7 Nov 81 | 11:09 | 26.72 | 570.01 | |
| 8 Nov 81 | 11:50 | 26.61 | 570.12 | |
| 9 Nov 81 | 4:42 | 26.78 | 569.95 | |
| 10 Nov 81 | 4:01 | 26.70 | 570.03 | |
| 11 Nov 81 | 2:10 | 26.67 | 570.06 | |
| 12 Nov 81 | 4:08 | 26.51 | 570.22 | |
| 16 Nov 81 | 12:51 | 26.19 | 570.54 | |
| 23 Nov 81 | 12:08 | 26.40 | 570.33 | |
| 29 Nov 81 | 11:41 | 26.60 | 570.13 | |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-1-81

Top of Pipe Elevation: 644.26 ft MSL

Screen Interval: from 581.69 to 572.63 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 27 Oct 81 | 9:14 | 63.95 | 577.31 | Open hole |
| 28 Oct 81 | 1:21 | 67.30 | 576.96 | |
| 29 Oct 81 | 9:38 | 67.02 | 577.24 | |
| 30 Oct 81 | 11:45 | 66.94 | 577.32 | |
| 31 Oct 81 | 8:19 | 66.95 | 577.31 | |
| 1 Nov 81 | 10:00 | 66.94 | 577.32 | |
| 2 Nov 81 | 8:30 | 66.95 | 577.31 | |
| 9 Nov 81 | 4:18 | 67.04 | 577.22 | |
| 16 Nov 81 | 1:15 | 66.61 | 577.65 | |
| 23 Nov 81 | 9:32 | 66.72 | 577.54 | |
| 29 Nov 81 | 10:50 | 66.68 | 577.58 | |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-2-81

Top of Pipe Elevation: 583.99 ft MSL

Screen Interval: from 569.03 to 559.94 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 22 Oct 81 | 3:55 | 18.04 | 565.95 | |
| 23 Oct 81 | 8:30 | 18.22 | 565.77 | |
| 24 Oct 81 | 9:37 | 18.17 | 565.82 | |
| 25 Oct 81 | 4:15 | 18.05 | 565.94 | |
| 26 Oct 81 | 9:20 | 18.24 | 565.75 | |
| 27 Oct 81 | 1:15 | 18.31 | 565.68 | |
| 28 Oct 81 | 9:31 | 18.39 | 565.60 | |
| 29 Oct 81 | 11:55 | 18.42 | 565.57 | |
| 2 Nov 81 | 8:39 | 18.45 | 565.54 | |
| 9 Nov 81 | 4:11 | 18.84 | 565.15 | |
| 16 Nov 81 | 1:20 | 18.66 | 565.33 | |
| 20 Nov 81 | 10:04 | 19.13 | 564.86 | |
| 23 Nov 81 | 10:10 | 18.99 | 565.00 | |
| 29 Nov 81 | 11:05 | 18.81 | 565.18 | |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-3-81

Top of Pipe Elevation: 581.90 ft MSL

Screen Interval: from 520.60 to 511.43 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 24 Oct 81 | 9:41 | 56.07 | 525.83 | |
| 25 Oct 81 | 4:18 | 55.71 | 526.19 | |
| 26 Oct 81 | 9:45 | 55.76 | 526.14 | |
| 27 Oct 81 | 1:12 | 56.05 | 525.85 | |
| 28 Oct 81 | 9:43 | 56.02 | 525.82 | |
| 29 Oct 81 | 12:01 | 56.10 | 525.80 | |
| 30 Oct 81 | 12:05 | 56.15 | 525.75 | |
| 2 Nov 81 | 8:41 | 56.05 | 525.85 | |
| 9 Nov 81 | 4:15 | 56.16 | 525.74 | |
| 16 Nov 81 | 1:31 | 55.77 | 526.13 | |
| 23 Nov 81 | 10:16 | 56.02 | 525.88 | |
| 29 Nov 81 | 11:09 | 56.27 | 525.63 | |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-4-81

Top of Pipe Elevation: 586.66 ft MSL

Screen Interval: from 518.45 to 509.25 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 12 Nov 81 | 3:48 | 65.45 | 521.21 | |
| 13 Nov 81 | 10:04 | 65.57 | 521.09 | |
| 15 Nov 81 | 11:30 | 65.42 | 521.24 | |
| 16 Nov 81 | 1:08 | 65.35 | 521.31 | |
| 17 Nov 81 | 2:57 | 65.45 | 521.21 | |
| 18 Nov 81 | 11:50 | 65.50 | 521.16 | |
| 19 Nov 81 | 2:51 | 65.18 | 521.48 | |
| 20 Nov 81 | 10:05 | 65.56 | 521.10 | |
| 23 Nov 81 | 10:01 | 65.45 | 521.21 | |
| 29 Nov 81 | 11:00 | 65.70 | 520.96 | |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-5-81

Top of Pipe Elevation: 586.84 ft MSL

Screen Interval: from 527.41 to 518.29 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 16 Nov 81 | 1:27 | 61.90 | 521.94 | Open hole |
| 17 Nov 81 | 3:08 | 63.37 | 523.47 | |
| 18 Nov 81 | 11:54 | 63.52 | 523.32 | |
| 19 Nov 81 | 2:55 | 63.65 | 523.19 | |
| 20 Nov 81 | 10:01 | 63.77 | 523.07 | |
| 22 Nov 81 | 9:26 | 64.17 | 522.67 | |
| 23 Nov 81 | 10:13 | 64.00 | 522.84 | |
| 29 Nov 81 | 11:07 | 64.22 | 522.62 | |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-6-81

Top of Pipe Elevation: 585.70 ft MSL

Screen Interval: from 569.18 to 560.01 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 20 Nov 81 | 10:06 | 18.48 | 564.22 | Open hole |
| 22 Nov 81 | 9:23 | 18.22 | 564.48 | " " |
| 23 Nov 81 | 10:04 | 18.22 | 564.48 | " " |
| 24 Nov 81 | 10:40 | 15.85 | 566.85 | " " |
| 27 Nov 81 | 1:37 | 17.60 | 568.10 | |
| 29 Nov 81 | 10:20 | 20.08 | 565.52 | |
| 30 Nov 81 | 10:24 | 20.60 | 565.10 | |
| 3 Dec 81 | 9:15 | 24.60 | 561.10 | Readings by NWSC |
| 6 Dec 81 | 9:40 | 20.67 | 565.03 | Readings by NWSC |
| 13 Dec 81 | 10:45 | 20.42 | 565.28 | Readings by NWSC |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-7-81

Top of Pipe Elevation: 643.75 ft MSL

Screen Interval: from 524.24 to 515.19 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 27 Nov 81 | 10:57 | 121.05 | 522.70 | |
| 29 Nov 81 | 10:52 | 121.20 | 522.55 | |
| 30 Nov 81 | 9:37 | 120.91 | 522.84 | |
| 6 Dec 81 | 9:50 | 121.08 | 522.67 | Readings by NWSC |
| 13 Dec 81 | 9:42 | 120.90 | 522.85 | Readings by NWSC |

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-8-81

Top of Pipe Elevation: 589.31 ft MSL

Screen Interval: from 530.62 to 521.86 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 29 Nov 81 | 11:02 | 69.87* | 519.44 | |
| 30 Nov 81 | 10:19 | 69.92* | 519.39 | |
| 3 Dec 81 | 9:15 | 67.83* | 521.48 | Readings by NWSC |
| 6 Dec 81 | 9:45 | 67.33* | 521.98 | Readings by NWSC |
| 13 Dec 81 | 9:28 | 67.50* | 521.81 | Readings by NWSC |

* Water level below screen

Groundwater Elevations

Highway 58 Dump Site B

Boring Number: WES-8-9-81

Top of Pipe Elevation: 589.33 ft MSL

Screen Interval: from 520.89 to 511.86 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 29 Nov 81 | 11:06 | 67.57 | 521.76 | |
| 30 Nov 81 | 10:21 | 67.27 | 522.06 | |
| 3 Dec 81 | 9:30 | 67.50 | 521.83 | Readings by NWSC |
| 6 Dec 81 | 9:43 | 67.60 | 521.73 | Readings by NWSC |
| 13 Dec 81 | 9:27 | 67.50 | 521.83 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-1-81

Top of Pipe Elevation: 737.32 ft MSL

Screen Interval: from 715.77 to 706.62 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 25 Oct 81 | 4:24 | 17.48 | 719.84 | |
| 26 Oct 81 | 10:14 | 17.58 | 719.74 | |
| 27 Oct 81 | 1:50 | 17.74 | 719.58 | |
| 28 Oct 81 | 2:08 | 17.95 | 719.37 | |
| 29 Oct 81 | 9:07 | 17.81 | 719.51 | |
| 30 Oct 81 | 8:35 | 17.91 | 719.41 | |
| 31 Oct 81 | 8:35 | 18.01 | 719.31 | |
| 3 Nov 81 | 9:40 | 17.80 | 719.52 | |
| 10 Nov 81 | 9:35 | 17.91 | 719.41 | |
| 17 Nov 81 | 2:19 | 17.48 | 719.84 | |
| 24 Nov 81 | 2:41 | 17.55 | 719.77 | |
| 29 Nov 81 | 12:51 | 17.62 | 719.70 | |
| 13 Dec 81 | 8:00 | 17.50 | 719.82 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-2-81

Top of Pipe Elevation: 726.80 ft MSL

Screen Interval: from 718.70 to 710.10 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 24 Oct 81 | 7:55 | 13.35 | 713.45 | |
| 25 Oct 81 | 4:27 | 13.14 | 713.66 | |
| 26 Oct 81 | 10:09 | 13.08 | 713.72 | |
| 27 Oct 81 | 2:00 | 12.57 | 714.23 | |
| 28 Oct 81 | 2:15 | 12.51 | 714.29 | |
| 29 Oct 81 | 9:01 | 12.50 | 714.30 | |
| 30 Oct 81 | 8:40 | 12.52 | 714.28 | |
| 3 Nov 81 | 9:43 | 12.55 | 714.25 | |
| 10 Nov 81 | 9:50 | 12.38 | 714.42 | |
| 17 Nov 81 | 2:35 | 12.02 | 714.78 | |
| 24 Nov 81 | 2:29 | 11.48 | 715.32 | |
| 29 Nov 81 | 1:02 | 11.44 | 715.36 | |
| 13 Dec 81 | 7:45 | 11.60 | 715.20 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-3-81

Top of Pipe Elevation: 709.78 ft MSL

Screen Interval: from 703.08 to 697.18 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 27 Oct 81 | 1:44 | 4.45 | 705.33 | |
| 28 Oct 81 | 2:01 | 4.29 | 705.49 | |
| 29 Oct 81 | 9:13 | 4.25 | 705.53 | |
| 30 Oct 81 | 8:30 | 4.23 | 705.55 | |
| 31 Oct 81 | 8:25 | 4.25 | 705.53 | |
| 1 Nov 81 | 10:15 | 4.24 | 705.54 | |
| 2 Nov 81 | 9:35 | 4.15 | 705.63 | |
| 3 Nov 81 | 9:37 | 4.18 | 705.60 | |
| 10 Nov 81 | 9:21 | 4.35 | 705.43 | |
| 17 Nov 81 | 1:57 | 3.91 | 705.87 | Bailed well |
| 24 Nov 81 | 2:21 | 3.70 | 706.08 | |
| 29 Nov 81 | 12:43 | 3.60 | 706.18 | |
| 13 Dec 81 | 9:05 | 4.30 | 705.48 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-4-81

Top of Pipe Elevation: 724.93 ft MSL

Screen Interval: from 706.13 to 696.81 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 8 Nov 81 | 11:45 | 28.22 | 696.71 | |
| 9 Nov 81 | 3:16 | 23.07 | 701.86 | |
| 10 Nov 81 | 9:26 | 21.98 | 702.95 | |
| 11 Nov 81 | 4:00 | 19.81 | 705.12 | |
| 12 Nov 81 | 5:05 | 19.56 | 705.37 | |
| 13 Nov 81 | 5:00 | 19.01 | 705.92 | |
| 14 Nov 81 | 5:07 | 18.42 | 706.51 | |
| 17 Nov 81 | 2:15 | 17.85 | 707.08 | |
| 24 Nov 81 | 2:16 | 17.90 | 707.03 | |
| 29 Nov 81 | 12:49 | 18.08 | 706.85 | |
| 13 Dec 81 | 8:04 | 18.20 | 706.73 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-5-81

Top of Pipe Elevation: 718.52 ft MSL

Screen Interval: from 706.72 to 697.34 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 8 Nov 81 | 11:41 | 14.15 | 704.37 | |
| 9 Nov 81 | 3:13 | 14.22 | 704.30 | |
| 10 Nov 81 | 9:29 | 14.38 | 704.14 | |
| 11 Nov 81 | 4:03 | 14.04 | 704.48 | |
| 12 Nov 81 | 5:08 | 14.18 | 704.34 | |
| 13 Nov 81 | 5:03 | 14.10 | 704.42 | |
| 14 Nov 81 | 5:05 | 13.85 | 704.67 | |
| 17 Nov 81 | 2:10 | 13.88 | 704.64 | |
| 24 Nov 81 | 2:08 | 14.00 | 704.52 | |
| 29 Nov 81 | 12:46 | 14.13 | 704.39 | |
| 13 Dec 81 | 8:08 | 14.30 | 704.22 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-6-81

Top of Pipe Elevation: 722.65 ft MSL

Screen Interval: from 713.12 to 703.97 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 10 Nov 81 | 8:42 | 5.73 | 716.92 | |
| 11 Nov 81 | 4:10 | 5.54 | 717.11 | |
| 12 Nov 81 | 5:01 | 5.60 | 717.05 | |
| 13 Nov 81 | 5:07 | 5.60 | 717.05 | |
| 15 Nov 81 | 5:08 | 5.20 | 717.45 | |
| 16 Nov 81 | 12:39 | 5.10 | 717.35 | |
| 17 Nov 81 | 2:25 | 5.15 | 717.50 | |
| 24 Nov 81 | 2:37 | 5.33 | 717.32 | |
| 29 Nov 81 | 12:59 | 5.21 | 717.44 | |
| 13 Dec 81 | 7:54 | 5.30 | 717.35 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-7-81

Top of Pipe Elevation: 738.32 ft MSL

Screen Interval: from 715.78 to 706.76 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 19 Nov 81 | 8:55 | 18.58 | 719.74 | |
| 20 Nov 81 | 11:05 | 18.75 | 719.57 | |
| 22 Nov 81 | 8:39 | 19.00 | 719.32 | |
| 23 Nov 81 | 12:48 | 18.97 | 719.35 | |
| 24 Nov 81 | 2:33 | 18.81 | 719.51 | |
| 25 Nov 81 | 4:50 | 18.78 | 719.54 | |
| 26 Nov 81 | 7:50 | 18.60 | 719.72 | |
| 27 Nov 81 | 10:38 | 18.82 | 719.50 | |
| 29 Nov 81 | 12:56 | 18.90 | 719.42 | |
| 13 Dec 81 | 7:50 | 19.20 | 719.12 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-8-81

Top of Pipe Elevation: 723.19 ft MSL

Screen Interval: from 709.66 to 700.53 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 19 Nov 81 | 9:26 | 12.72 | 710.47 | |
| 20 Nov 81 | 11:09 | 13.00 | 710.19 | |
| 22 Nov 81 | 8:42 | 13.67 | 709.52 | |
| 23 Nov 81 | 12:29 | 13.77 | 709.42 | |
| 24 Nov 81 | 2:13 | 13.87 | 709.32 | |
| 25 Nov 81 | 4:00 | 13.50 | 709.69 | |
| 26 Nov 81 | 4:08 | 13.33 | 709.86 | |
| 29 Nov 81 | 12:47 | 13.95 | 709.24 | |
| 13 Dec 81 | 8:06 | 14.20 | 708.99 | Readings by NWSC |

Groundwater Elevations

Pest Control Area

Boring Number: WES-9-9-81

Top of Pipe Elevation: 726.21 ft MSL

Screen Interval: from 718.96 to 712.53 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 26 Nov 81 | 7:43 | 5.67 | 717.54 | Open hole |
| 27 Nov 81 | 10:35 | 8.61 | 717.60 | |
| 29 Nov 81 | 12:54 | 8.57 | 717.64 | |
| 30 Nov 81 | 2:00 | 8.42 | 717.79 | |
| 6 Dec 81 | 9:05 | 8.75 | 717.46 | Readings by NWSC |
| 13 Dec 81 | 7:47 | 8.80 | 717.41 | Readings by NWSC |

Groundwater Elevations

Rockeye Site

Boring Number: WES-10-1-81

Top of Pipe Elevation: 620.80 ft MSL

Screen Interval: 601.42 to 592.60 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 22 Nov 81 | 10:45 | 17.69 | 603.11 | |
| 23 Nov 81 | 3:05 | 18.00 | 602.80 | |
| 24 Nov 81 | 9:58 | 14.94 | 605.86 | |
| 25 Nov 81 | 4:15 | 18.07 | 602.73 | |
| 26 Nov 81 | 4:32 | 17.70 | 603.10 | |
| 27 Nov 81 | 3:17 | 17.66 | 603.14 | |
| 29 Nov 81 | 1:12 | 17.95 | 602.85 | |

Groundwater Elevations

Rockeye Site

Boring Number: WES-10-2-81

Top of Pipe Elevation: 621.51 ft MSL

Screen Interval: 607.93 to 598.71 ft MSL

Grid Coordinates:

| Date | Time | Depth to Water, ft | Water Elevation, ft MSL | Remarks |
|---|---|---|---|---|
| 23 Nov 81 | 3:10 | 19.46 | 602.05 | |
| 24 Nov 81 | 9:55 | 14.94 | 606.57 | |
| 25 Nov 81 | 4:12 | 19.85 | 601.66 | |
| 26 Nov 81 | 4:30 | 19.83 | 601.68 | |
| 27 Nov 81 | 3:14 | 19.85 | 601.66 | |
| 29 Nov 81 | 1:14 | 20.16 | 601.35 | |

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# HYDROGEOLOGIC INVESTIGATION OF WASTE DISPOSAL SITES AT THE NAVAL WEAPONS SUPPORT CENTER, CRANE, INDIANA

APPENDIX E

C+D

by

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April 1982

# APPENDIX E

## DEFINITION OF SOIL TESTS AND SOIL TEST RESULTS

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## APPENDIX E: DEFINITION OF SOIL TESTS AND SOIL TEST RESULTS

### Physical Test

Standard soil test procedures as specified by Engineer Manual 1110-2-1906, "Laboratory Soil Testing," were followed during testing.

#### Unified Soil Classification System

Classification of soils according to the USCS depends upon grain-size distribution and the Atterberg limits. Grain-size distribution is determined with sieves and the liquidity and plasticity limits (Atterberg limits) are determined with standard devices. The liquid and plastic limits are the water contents at the boundaries between the semiliquid and plastic state and the plastic and semisolid state, respectively. Figure E-1 shows the USCS by which the NWSC soil samples were described. Figures E-2 and E-3 present examples of the laboratory data sheets for the classification of two samples; one a coarse-grained material (SP-SM) and the other a fine-grained material (CL). Laboratory data sheets for all the NWSC soil samples are presented in the end of this Appendix.

#### Water content and density

Water content and soil density are important engineering relationships and are useful correlations among samples for which a full suite of physical test data are not available. Water content is the amount of free water in a soil and is determined by the following formula:

$$W = \frac{W_w}{W_s}$$

where

$W$ = water content

$W_w$ = weight of water

$W_s$ = dry weight of soil

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Density or dry unit weight is determined according to the following formula:

$$D = \frac{W_s}{V}$$

where

$D$ = density

$W_s$ = dry weight of soil

$V$ = volume of soil

Permeability

Permeability is a measure of a soil's ability to transmit a fluid; in the current study the fluid is water. The flow of water through a soil is governed by Darcy's law:

$$q = KiA$$

where

$q$ = rate of discharge through a soil of cross-sectional area A

$K$ = coefficient of permeability

$i$ = hydraulic gradient (the loss of hydraulic head per unit distance of flow)

$A$ = sample area perpendicular to flow

For coarse-grained materials, permeability tests are usually conducted in a constant head apparatus. In this equipment, an overflowing reservoir maintains a constant head on a soil sample of specified dimensions and the amount of water passing through the soil in a specified time is collected and measured. The permeability is then calculated according to the formula:

$$K_{20} = \frac{QLR_t}{hAt}$$

where

$K_{20}$ = coefficient of permeability, cm/sec at 20°

$Q$ = quantity of flow, cc

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L = length of specimen over which head loss is measured, cm. If piezometer taps are used, L is equal to the distance between piezometer taps.

$R_t$ = temperature correction factor for viscosity of water

h = head loss across sample or between piezometer taps, cm

## Chemical Test

### Cation Exchange Capacity

Cation Exchange Capacity (CEC) test procedures as specified by Technical Report EPA/CE 81-1, "Procedures for Handling and Chemical Analysis of Sediment and Water Samples," were followed during testing. The CEC of a soil is a measure of the cations reversibility capacity from the surface of the crystalline matrix of a mineral. The CEC is expressed in millequivalents per 100 grams and is calculated from the following formula:

$$\text{CEC/100g} = \frac{(X\ \text{mg}/\ell)\ (.05)\ (100)}{(18\ \text{mg/meq})\ (g)\ (\%\ S)}$$

where

X = ammonia concentration in NaCl leachate, mg/ℓ

.05 = volume of NaCl leachate, ℓ

18 = millequivalent weight of ammonium ion, mg/meq

g = weight of sediment sample, g

% S = percent solids in sediment sample (as decimal fraction)

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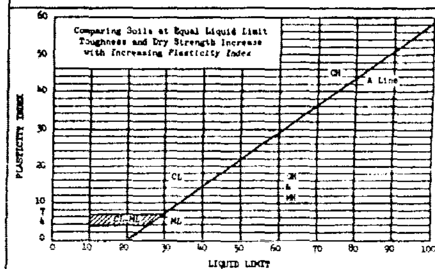
## UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

| Major Divisions (1) | Major Divisions (2) | | Group Symbols (3) | Typical Names (4) | Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights) (5) | | | Information Required for Describing Soils (6) | Laboratory Classification Criteria (7) |
|---|---|---|---|---|---|---|---|---|---|
| Coarse-grained Soils. More than half of material is larger than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye. | Gravels. More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size) | Clean Gravels (Little or no fines) | GW | Well-graded gravels, gravel-sand mixtures, little or no fines. | Wide range in grain sizes and substantial amounts of all intermediate particle sizes. | | | For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics. Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses. Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM). | Use grain-size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5% - GW, GP, SW, SP. More than 12% - GM, GC, SM, SC. 5% to 12% - Borderline cases requiring use of dual symbols. — $C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | GP | Poorly graded gravels or gravel-sand mixtures, little or no fines. | Predominantly one size or a range of sizes with some intermediate sizes missing. | | | | Not meeting all gradation requirements for GW |
| | | Gravels with Fines (Appreciable amount of fines) | GM | Silty gravels, gravel-sand-silt mixture. | Nonplastic fines or fines with low plasticity (for identification procedures see ML below) | | | | Atterberg limits below "A" line or PI less than 4. Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols. |
| | | | GC | Clayey gravels, gravel-sand-clay mixtures. | Plastic fines (for identification procedures see CL below). | | | | Atterberg limits above "A" line with PI greater than 7 |
| | Sands. More than half of coarse fraction is smaller than No. 4 sieve size. | Clean Sands (Little or no fines) | SW | Well-graded sands, gravelly sands, little or no fines. | Wide range in grain size and substantial amounts of all intermediate particle sizes. | | | | $C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 |
| | | | SP | Poorly graded sands or gravelly sands, little or no fines. | Predominantly one size or a range of sizes with some intermediate sizes missing. | | | | Not meeting all gradation requirements for SW |
| | | Sands with Fines (Appreciable amount of fines) | SM | Silty sands, sand-silt mixtures. | Nonplastic fines or fines with low plasticity (for identification procedures see ML below). | | | | Atterberg limits below "A" line or PI less than 4. Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols. |
| | | | SC | Clayey sands, sand-clay mixtures. | Plastic fines (for identification procedures see CL below). | | | | Atterberg limits above "A" line with PI greater than 7 |
| | | | | | Identification Procedures on Fraction Smaller than No. 40 Sieve Size: Dry Strength (Crushing characteristics) | Dilatancy (Reaction to shaking) | Toughness (Consistency near PL) | | |
| Fine-grained Soils. More than half of material is smaller than No. 200 sieve size. | Silts and Clays | Liquid limit is less than 50 | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. | None to slight | Quick to slow | None | For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions. Give typical name; indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet condition; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses. Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML). | Plasticity chart (see below) |
| | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. | Medium to high | None to very slow | Medium | | |
| | | | OL | Organic silts and organic silty clays of low plasticity. | Slight to medium | Slow | Slight | | |
| | Silts and Clays | Liquid limit is greater than 50 | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. | Slight to medium | Slow to none | Slight to medium | | |
| | | | CH | Inorganic clays of high plasticity, fat clays. | High to very high | None | High | | |
| | | | OH | Organic clays of medium to high plasticity, organic silts | Medium to high | None to very slow | Slight to medium | | |
| Highly Organic Soils | | | Pt | Peat and other highly organic soils. | Readily identified by color, odor, spongy feel and frequently by fibrous texture. | | | | |




PLASTICITY CHART

For laboratory classification of fine-grained soils

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

### FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

**Dilatancy (reaction to shaking)**

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

**Dry Strength (crushing characteristics)**

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

**Toughness (consistency near plastic limit)**

After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Figure E-1. Unified Soil Classification System (USCS)

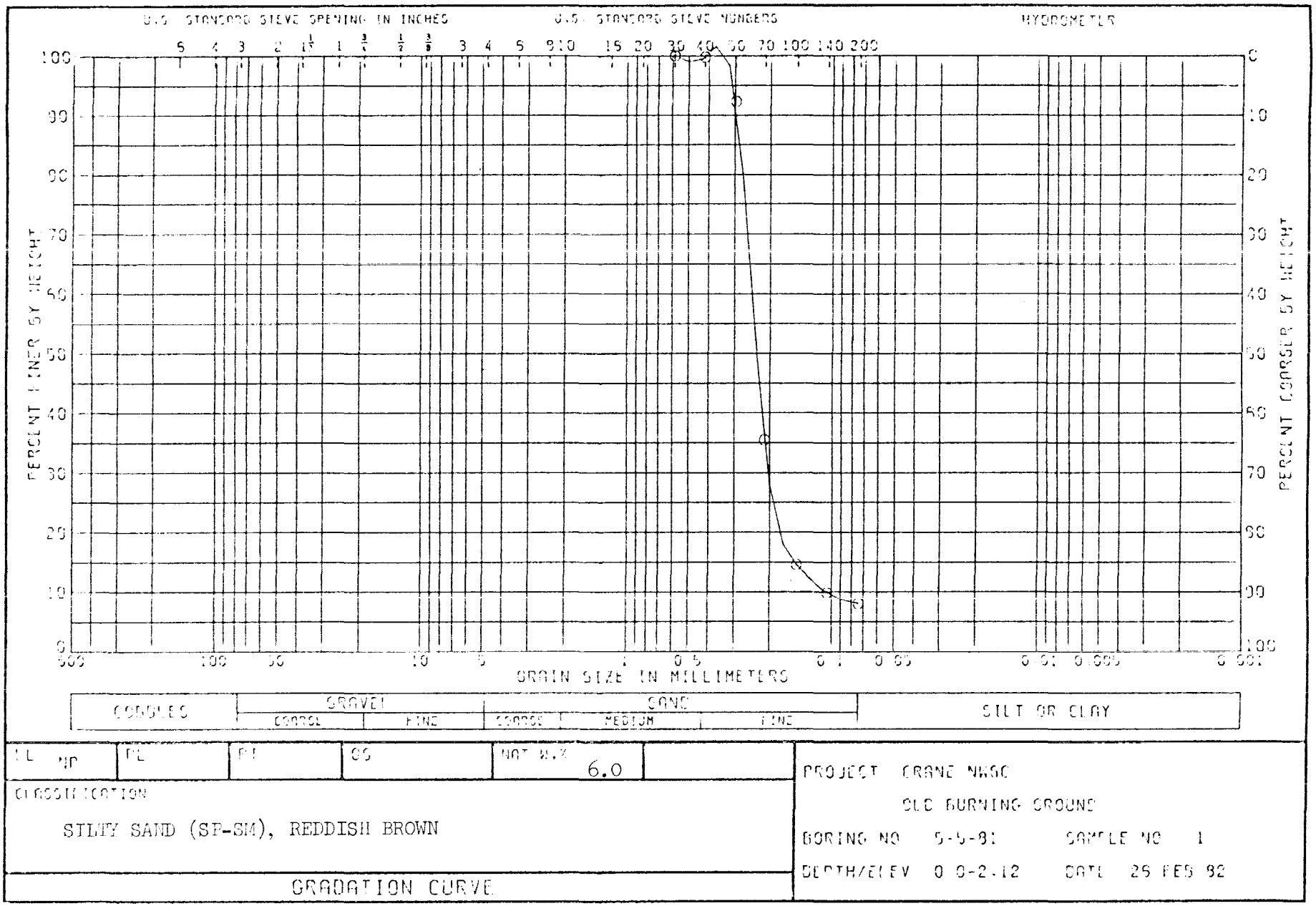



Figure E-2. Laboratory data sheet of grain size curve for a coarse-grained soil.

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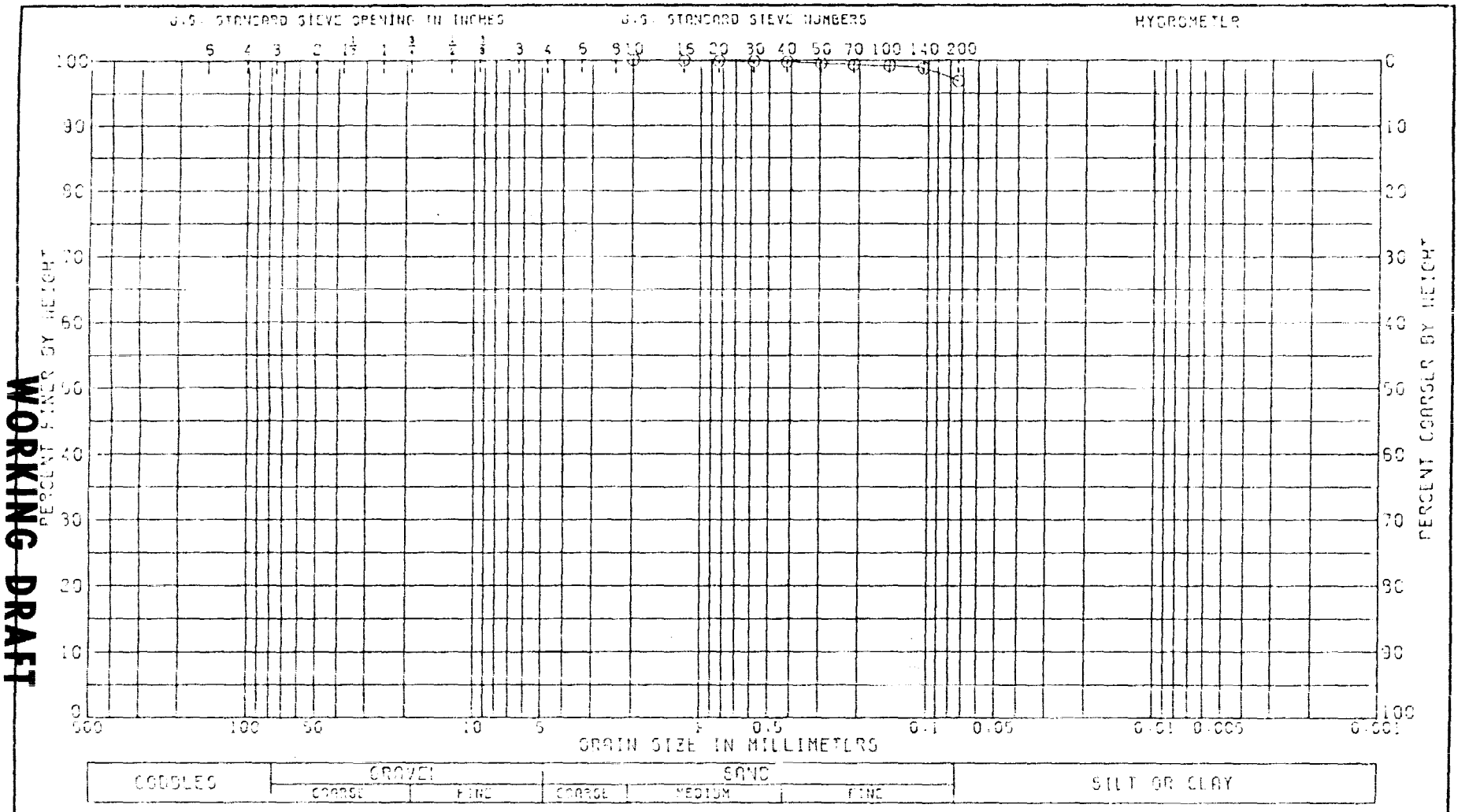


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| LL | PL | PI | GS | NAT W,% | |
|---|---|---|---|---|---|
| 31 | 19 | 12 | | 17.8 | |

CLASSIFICATION

CLAY (CL), BROWN: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-6-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.17 DATE 11 FEB 82

Figure E-3. Laboratory data sheet of grain size curve for a fine-grained soil.

Laboratory Soil Test Results

Mustard Gas Burial Grounds

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-1-81 | 1 | 0.0-1.85 | 104.6 | 21.7 | 36 | 18 | 18 | CL | | 1.30 |
| 1-1-81 | 2 | 5.0-6.37 | 121.2 | 13.6 | 27 | 14 | 13 | SC | | |
| 1-2-81 | 1A* | 0.0-0.65 | -- | 7.1 | 35 | 18 | 17 | SC | | |
| 1-3-81 | 1 | 0.0-2.3 | 114.3 | 14.2 | 28 | 13 | 15 | CL | | 6.84 |
| 1-3-81 | 2 | 5.0-6.02 | 106.5 | 17.9 | 37 | 18 | 19 | CL | | |
| 1-4-81 | 1 | 0.0-2.43 | 107.2 | 11.2 | 30 | 13 | 17 | CL | | |
| 1-4-81 | 2 | 5.0-6.35 | 120.8 | 12.8 | 32 | 19 | 13 | CL | | 0.40 |
| 1-5-81 | 1 | 0.0-2.28 | 92.2 | 11.4 | 33 | 18 | 15 | CL | $1.72 \times 10^{-4}$ | 6.42 |

* Jar sample
** See Figure E-1

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## Laboratory Soil Test Results

## Dye Burial Grounds

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 2-1-81 | 1 | 0.92-1.87 | 101.0 | 21.9 | 38 | 19 | 19 | CL | | 7.83 |
| 2-1-81 | 2 | 6.0-6.95 | 125.1 | 11.1 | 25 | 14 | 11 | CL | | |
| 2-2-81 | 1 | 0.0-1.65 | 93.3 | 21.2 | 46 | 21 | 25 | CL | $2.97 \times 10^{-7}$ | 2.54 |
| 2-3-81 | 1 | 0.0-1.15 | 108.9 | 18.4 | 44 | 23 | 21 | CL | | 4.49 |
| 2-3-81 | 2A* | 5.0-5.65 | -- | 14.3 | 38 | 14 | 24 | CL | | |
| 2-4-81 | 1 | 0.0-2.2 | 91.4 | 18.5 | 42 | 21 | 21 | CL | | 2.81 |
| 2-5-81 | 1 | 0.0-1.55 | 93.8 | 18.0 | 44 | 23 | 21 | CL | | 4.51 |
| 2-5-81 | 2 | 5.0-6.1 | 117.0 | 8.8 | 25 | 14 | 11 | CL | | |
| 2-6-81 | 1 | 0.0-2.2 | 82.7 | 15.8 | 31 | 17 | 14 | CL | | |
| 2-6-81 | 2 | 5.0-6.33 | 106.3 | 15.4 | 38 | 15 | 23 | CL | $3.86 \times 10^{-5}$ | 0.49 |
| 2-7-81 | 1 | 0.0-2.0 | 105.5 | 9.2 | 34 | 15 | 19 | CL | | 5.06 |
| 2-8-81 | 1 | 0.0-2.25 | 84.8 | 17.1 | 39 | 18 | 21 | CL | | |
| 2-8-81 | 2 | 5.0-6.69 | 117.0 | 13.4 | 39 | 16 | 23 | CL | $5.98 \times 10^{-8}$ | 6.38 |

* Jar sample
** See Figure E-1

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## Laboratory Soil Test Results

## Ammunition Burning Grounds

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 3-1-81 | 1 | 0.0-1.35 | 115.5 | 17.3 | 42 | 17 | 25 | SC | | 4.26 |
| 3-1-81 | 2 | 5.0-5.79 | 118.1 | 15.1 | 43 | 18 | 25 | CL | | |
| 3-1-81 | 3 | 10.0-10.85 | 123.3 | 10.2 | 37 | 19 | 18 | CL | | |
| 3-2-81 | 1 | 0.0-1.5 | 119.8 | 3.7 | 32 | 19 | 13 | SC | | 3.86 |
| 3-2-81 | 2 | 5.0-7.4 | 113.5 | 15.4 | 27 | 13 | 14 | SC | | |
| 3-3-81 | 1 | 0.0-1.23 | 98.9 | 19.8 | 31 | 17 | 14 | CL | | 0.97 |
| 3-4-81 | 1 | 0.0-1.3 | 115.6 | 9.8 | 31 | 16 | 15 | SC | $4.69 \times 10^{-6}$ | 3.84 |
| 3-5-81 | 1 | 0.0-1.25 | 115.1 | 12.0 | 24 | 15 | 9 | GC | $5.04 \times 10^{-5}$ | 2.46 |
| 3-6-81 | 1 | 0.0-1.73 | 115.8 | 13.7 | 27 | 16 | 11 | SC | | 4.50 |
| 3-7-81 | 1 | 0.0-0.72 | 122.4 | 12.3 | 38 | 16 | 22 | SC | | |
| 3-7-81 | 2 | 5.0-6.24 | | | | | | | | 4.28 |
| 3-7-81 | 3 | 10.0-11.57 | 114.1 | 17.9 | 24 | 13 | 11 | SC | | |
| 3-7-81 | 4 | 15.0-16.33 | 122.0 | 12.6 | 26 | 15 | 11 | SC | | |
| 3-8-81 | 1 | 0.0-1.86 | 102.1 | 18.4 | 36 | 20 | 16 | CL | | 1.31 |
| 3-8-81 | 2 | 5.0-6.01 | 112.6 | 8.0 | 23 | 14 | 9 | SC | | |
| 3-9-81 | 1 | 0.0-0.89 | 114.0 | 15.3 | 25 | 16 | 9 | CL | | 3.03 |

* Jar sample
** See Figure E-1

WORKING DRAFT

## Laboratory Soil Test Results

## McComish Gorge

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 4-1-81 | 1 | 0.0-2.08 | 115.1 | 15.0 | 29 | 15 | 14 | CL | | 4.28 |
| 4-1-81 | 2 | 5.0-6.55 | 110.8 | 17.8 | 27 | 16 | 11 | SC | | |
| 4-1-81 | 3 | 10.0-10.3 | 86.6 | 10.3 | 19 | 12 | 7 | SP-SC | | |
| 4-1-81 | 4 | 15.0-16.97 | 100.0 | 15.0 | 28 | 17 | 11 | SC | | |
| 4-1-81 | 5 | 20.0-22.05 | 87.8 | 11.3 | NP+ | NP | NP | SP-SM | | |
| 4-1-81 | 6 | 25.0-27.08 | 95.6 | 15.5 | NP | NP | NP | SM | | |
| 4-1-81 | 7A* | 30.0-30.3 | -- | 21.5 | NP | NP | NP | -- | | |
| 4-1-81 | 8 | 32.5-33.3 | 97.1 | 19.1 | 25 | 18 | 7 | CL | | |
| 4-1-81 | 9 | 37.5-39.55 | 102.4 | 23.1 | 26 | 18 | 8 | CL | | |
| 4-1-81 | 10 | 40.3-42.48 | 104.4 | 17.2 | NP | NP | NP | ML | | |
| 4-2-81 | 1 | 0.0-1.27 | 118.8 | 10.6 | 22 | 13 | 9 | SC | | |
| 4-2-81 | 2 | 5.0-5.9 | 116.7 | 12.6 | 27 | 12 | 15 | SC | | |
| 4-2-81 | 3 | 10.0-11.97 | 96.9 | 13.9 | 24 | 16 | 8 | SC | | |
| 4-2-81 | 4 | 15.0-16.60 | 101.1 | 22.9 | 29 | 24 | 5 | ML | | |
| 4-2-81 | 5A* | 20.0-21.5 | -- | 30.0 | 21 | 16 | 5 | CL-ML | | |
| 4-2-81 | 6 | 25.0-27.05 | 100.5 | 13.6 | NP | NP | NP | SM | | 2.87 |
| 4-2-81 | 7 | 30.0-32.05 | 99.7 | 14.6 | NP | NP | NP | SM | | |
| 4-3-81 | 1 | 0.0-2.08 | 105.8 | 14.1 | 25 | 13 | 12 | SC | | |
| 4-3-81 | 2 | 5.0-7.13 | 64.3 | 49.7 | NP | NP | NP | ML | | 2.93 |
| 4-3-81 | 3 | 10.0-11.83 | 97.4 | 4.9 | NP | NP | NP | SM | | |
| 4-3-81 | 4A* | 15.0-17.0 | -- | 24.3 | NP | NP | NP | SP-SM | | |

(Continued)

+ Not plastic
* Jar sample
** See Figure E-1

WORKING DRAFT

## Laboratory Soil Test Results

## McComish Gorge (Concluded)

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 4-4-81 | 1 | 0.0-2.26 | 99.0 | 20.7 | 39 | 18 | 21 | CL | | 6.58 |
| 4-4-81 | 2 | 5.0-6.64 | 103.8 | 21.8 | 45 | 20 | 25 | CL | | |
| 4-4-81 | 3 | 10.0-12.19 | 98.8 | 12.0 | 35 | 19 | 16 | CL | | |
| 4-4-81 | 4 | 15.0-16.7 | 87.7 | 9.9 | 32 | 14 | 18 | SC | | |
| 4-4-81 | 5 | 20.0-22.08 | 91.1 | 5.8 | NP | NP | NP | SP-SM | | |
| 4-4-81 | 6 | 25.0-26.50 | 93.7 | 18.4 | NP | NP | NP | SP-SM | | |
| 4-4-81 | 7 | 27.8-29.90 | 98.4 | 23.9 | NP | NP | NP | SM | $3.99 \times 10^{-5}$ | |
| 4-4-81 | 8 | 35.0-37.05 | 89.8 | 33.6 | 31 | 16 | 15 | CL | | |
| 4-5-81 | 1 | 0.0-1.8 | 100.5 | 23.6 | 35 | 16 | 19 | CL | | |
| 4-5-81 | 2 | 5.0-6.36 | 102.5 | 21.1 | 38 | 18 | 20 | CL | | |
| 4-5-81 | 3 | 10.0-11.10 | 91.8 | 22.9 | 30 | 17 | 13 | SC | | 3.36 |
| 4-5-81 | 4 | 14.3-16.0 | 96.7 | 14.7 | NP | NP | NP | SP | | |
| 4-5-81 | 5 | 18.6-20.05 | 89.8 | 22.4 | NP | NP | NP | SM | | |
| 4-6-81 | 1 | 0.0-2.14 | 115.0 | 12.4 | NP | NP | NP | SM | | 2.74 |
| 4-6-81 | 2 | 5.0-7.08 | 93.3 | 10.2 | NP | NP | NP | SM | | |
| 4-6-81 | 3 | 10.0-11.71 | 83.4 | 19.2 | NP | NP | NP | ML | | |
| 4-6-81 | 4 | 15.0-17.17 | 92.3 | 27.4 | NP | NP | NP | SM | | |
| 4-6-81 | 5 | 19.5-20.35 | 103.1 | 18.4 | NP | NP | NP | SM | | |
| 4-6-81 | 6 | 24.2-26.36 | 101.9 | 23.1 | 20 | 17 | 3 | SM | | |

* Jar sample
** See Figure E-1

WORKING DRAFT

## Laboratory Soil Test Results

## Old Burning Pit

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 5-1-81 | 1 | 0.0-1.55 | 111.1 | 9.9 | 19 | 11 | 8 | SC | | 1.96 |
| 5-1-81 | 2 | 5.0-6.59 | 105.8 | 14.4 | 26 | 12 | 14 | SC | | |
| 5-1-81 | 3 | 10.0-11.81 | 120.0 | 15.9 | 33 | 15 | 18 | CL | | |
| 5-1-81 | 4 | 15.0-15.65 | 124.2 | 10.3 | 29 | 13 | 16 | CL | | |
| 5-2-81 | 1 | 0.0-1.75 | 120.5 | 13.6 | 25 | 12 | 13 | SC | | |
| 5-2-81 | 2 | 5.0-7.15 | 97.7 | 23.0 | 21 | 16 | 5 | CL-ML | | 3.26 |
| 5-2-81 | 3 | 10.0-11.46 | 82.2 | 19.3 | NP+ | NP | NP | SM | | |
| 5-2-81 | 4A* | 15.0-18.2 | -- | 28.4 | 22 | 17 | 5 | CL-ML | | |
| 5-3-81 | 1 | 0.0-1.75 | 112.5 | 7.7 | 21 | 12 | 9 | SC | | |
| 5-3-81 | 2 | 5.0-6.76 | 89.6 | 10.4 | NP | NP | NP | SP-SM | | |
| 5-3-81 | 3 | 10.0-11.95 | 96.8 | 21.7 | 24 | 19 | 5 | CL-ML | $8.05 \times 10^{-6}$ | |
| 5-3-81 | 4 | 15.0-17.15 | 98.8 | 24.4 | 25 | 16 | 9 | CL | | 2.97 |
| 5-3-81 | 5 | 20.0-21.38 | 90.6 | 28.9 | 31 | 20 | 11 | CL | | |
| 5-4-81 | 1 | 0.0-2.04 | 112.0 | 7.6 | NP | NP | NP | SM | | 1.78 |
| 5-4-81 | 2 | 5.0-6.78 | 98.2 | 16.9 | NP | NP | NP | ML | | |
| 5-4-81 | 3A* | 10.0-12.0 | -- | 23.7 | 21 | 14 | 7 | CL | | |
| 5-4-81 | 5B* | 22.5-23.0 | -- | 33.1 | 31 | 19 | 12 | CL | | |
| 5-4-81 | 6 | 25.0-27.18 | 102.0 | 24.6 | 28 | 18 | 10 | SP-SC | | |

(Continued)

\+ Not plastic
* Jar sample
** See Figure E-1

WORKING DRAFT

WORKING DRAFT

## Laboratory Soil Test Results

## Old Burning Pit (Concluded)

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 5-5-81 | 1 | 0.0-2.12 | 100.4 | 6.0 | NP | NP | NP | SP-SM | | |
| 5-5-81 | 2 | 5.0-6.81 | 89.1 | 7.4 | NP | NP | NP | SP-SM | | 3.22 |
| 5-5-81 | 3 | 10.5-12.02 | 99.4 | 25.0 | 23 | 20 | 3 | ML | | |
| 5-5-81 | 4 | 15.0-16.85 | 96.3 | 20.6 | NP | NP | NP | ML | | |
| 5-5-81 | 5 | 20.4-22.15 | 95.5 | 25.3 | 24 | 19 | 5 | CL-ML | | |
| 5-6-81 | 1 | 0.0-2.03 | 108.4 | 14.3 | 34 | 14 | 20 | SC | | |
| 5-6-81 | 2 | 5.0-7.17 | 94.5 | 17.8 | 31 | 19 | 12 | CL | | |
| 5-6-81 | 3 | 10.0-12.09 | 102.5 | 23.6 | 28 | 19 | 9 | CL | | |
| 5-6-81 | 4 | 15.0-17.15 | 100.6 | 23.8 | 24 | 16 | 8 | CL | | |
| 5-6-81 | 5 | 20.0-21.19 | 97.0 | 20.8 | 25 | 18 | 7 | CL | | 2.37 |
| 5-6-81 | 7A* | 30.0-33.5 | | 25.8 | 19 | 15 | 4 | CL-ML | | |
| 5-7-81 | 1 | 0.0-1.89 | 101.8 | 20.3 | 25 | 19 | 6 | CL-ML | | |
| 5-7-81 | 2 | 5.0-6.99 | 97.5 | 18.2 | 38 | 20 | 18 | CL | | 2.91 |
| 5-7-81 | 3 | 10.0-11.91 | 97.3 | 21.9 | 29 | 21 | 8 | CL | | |
| 5-7-81 | 4 | 15.0-16.36 | 101.3 | 23.8 | 24 | 19 | 5 | CL-ML | | |
| 5-7-81 | 6 | 25.0-27.05 | 101.8 | 21.2 | 26 | 16 | 10 | CL | $5.39 \times 10^{-6}$ | |
| 5-7-81 | 7 | 30.0-32.07 | 101.1 | 20.9 | NP | NP | NP | ML | | |
| 5-7-81 | 8 | 35.0-37.08 | 100.2 | 21.1 | 22 | 18 | 4 | CL-ML | | |
| 5-8-81 | 1 | 0.0-0.8 | 106.7 | 18.7 | 31 | 14 | 17 | CL | | |
| 5-8-81 | 2 | 5.0-7.08 | 108.8 | 19.8 | 29 | 16 | 13 | CL | | |
| 5-8-81 | 3 | 10.0-12.15 | 98.8 | 23.1 | NP | NP | NP | ML | $2.35 \times 10^{-5}$ | |
| 5-8-81 | 4 | 15.0-17.1 | 101.8 | 23.5 | 22 | 16 | 6 | CL-ML | | |

* Jar sample
** See Figure E-1

Laboratory Soil Test Results

Demolition Area

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 6-1A-81 | 1 | 0.0-2.17 | 102.6 | 21.0 | 42 | 18 | 24 | CL | | |
| 6-1A-81 | 2 | 5.0-6.21 | 115.2 | 18.6 | 63 | 20 | 43 | CH | | |
| 6-1B-81 | 1 | 0.0-1.14 | 120.2 | 15.0 | 34 | 18 | 16 | CL | | |
| 6-1B-81 | 2 | 5.0-6.14 | 114.1 | 17.9 | 48 | 16 | 32 | CL | | 11.0 |
| 6-1C-81 | 1 | 0.0-1.34 | 111.9 | 17.8 | 49 | 19 | 30 | CL | | 20.0 |
| 6-1C-81 | 2 | 5.0-6.25 | 116.6 | 17.7 | 57 | 19 | 38 | CH | | |
| 6-2-81 | 1 | 0.0-1.58 | 98.8 | 22.8 | 35 | 20 | 15 | CL | | 8.60 |
| 6-3-81 | 1 | 0.0-1.74 | 81.0 | 26.8 | 35 | 19 | 16 | CL | | 4.60 |
| 6-3-81 | 2A* | 5.0-5.3 | -- | 15.6 | 44 | 18 | 26 | CL | | |
| 6-4-81 | 1 | 0.0-1.46 | 103.5 | 19.3 | 33 | 20 | 13 | CL | | 4.79 |
| 6-5-81 | 1 | 0.0-1.8 | 110.9 | 9.1 | 35 | 17 | 18 | CL | | 5.73 |
| 6-5-81 | 2 | 5.0-6.85 | 118.5 | 16.0 | 44 | 22 | 22 | CL | | |
| 6-6-81 | 1 | 0.0-1.41 | 110.8 | 14.1 | 40 | 16 | 24 | CL | 0 | |
| 6-6-81 | 2 | 5.0-6.27 | 119.3 | 14.5 | 43 | 17 | 26 | CL | | 5.60 |
| 6-6-81 | 3 | 10.0-11.30 | 120.4 | 14.9 | 45 | 22 | 23 | CL | | |
| 6-7-81 | 1 | 0.0-2.22 | 111.3 | 16.3 | 46 | 16 | 30 | CL | | 5.67 |
| 6-7-81 | 2 | 5.0-6.45 | 118.7 | 17.0 | 42 | 20 | 22 | CL | | |
| 6-8-81 | 1 | 0.0-1.55 | 103.8 | 21.5 | 36 | 21 | 15 | CL | | 7.72 |
| 6-8-81 | 2 | 5.0-5.99 | 122.8 | 10.8 | 25 | 15 | 10 | CL | | |

(Continued)

* Jar sample
** See Figure E-1

WORKING DRAFT

Laboratory Soil Test Results

Demolition Area (Concluded)

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 6-9-81 | 1A* | 0.0-1.7 | -- | 7.4 | 30 | 13 | 17 | SC | | |
| 6-10-81 | 1 | 0.0-2.08 | 81.6 | 14.8 | 41 | 19 | 22 | CL | | |
| 6-10-81 | 2 | 5.0-6.99 | 109.7 | 17.4 | 45 | 19 | 26 | CL | $3.01 \times 10^{-8}$ | 35.8 |
| 6-10-81 | 3 | 10.0-11.49 | 110.0 | 20.8 | 47 | 25 | 22 | CL | | |
| 6-11-81 | 1 | 0.0-2.39 | 98.5 | 13.0 | 32 | 18 | 14 | CL | | 7.19 |
| 6-11-81 | 2 | 5.0-5.71 | 101.1 | 22.0 | 36 | 19 | 17 | CL | | |
| 6-12-81 | 1 | 1.10-2.20 | 108.4 | 20.8 | 57 | 18 | 39 | CH | | 3.53 |
| 6-12-81 | 2 | 5.0-6.01 | 132.9 | 7.9 | 26 | 12 | 14 | CL | | |
| 6-13-81 | 1 | 0.0-1.29 | 113.2 | 17.3 | 50 | 17 | 33 | CH | | 10.7 |

* Jar sample

** See Figure E-1

WORKING DRAFT

## Laboratory Soil Test Results

## Old Rifle Range

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 6-14-81 | 1 | 0.0-1.61 | 115.6 | 15.8 | 27 | 16 | 11 | SC | | |
| 6-14-81 | 2 | 5.0-7.06 | 98.8 | 24.0 | 28 | 19 | 9 | CL | $2.77 \times 10^{-6}$ | 5.65 |
| 6-14-81 | 3 | 10.0-11.67 | 101.1 | 23.5 | 33 | 18 | 15 | CL | | |
| 6-14-81 | 4 | 15.0-17.07 | 87.0 | 33.3 | 61 | 24 | 37 | CH | | |
| 6-15-81 | 1 | 0.0-1.35 | 111.5 | 16.5 | 27 | 17 | 10 | CL | | |
| 6-16-81 | 1 | 0.0-1.37 | 102.4 | 13.8 | 37 | 20 | 17 | CL | | 11.2 |
| 6-16-81 | 2A* | 5.0-5.4 | --- | 10.7 | 29 | 15 | 14 | CL | | |
| 6-17-81 | 1 | 0.0-1.39 | 101.0 | 22.7 | 28 | 17 | 11 | CL | | 3.71 |
| 6-18-81 | 1 | 0.0-1.63 | 117.4 | 15.0 | 35 | 18 | 17 | CL | | |
| 6-18-81 | 2 | 5.0-6.58 | 112.9 | 13.9 | 24 | 14 | 10 | SC | | |
| 6-19-81 | 1 | 5.0-6.88 | 103.6 | 23.2 | 42 | 18 | 24 | CL | | 10.2 |
| 6-19-81 | 2 | 10.0-11.66 | 99.7 | 25.2 | 44 | 17 | 27 | CL | | |
| 6-20-81 | 1 | 0.0-1.78 | 110.8 | 19.1 | 27 | 15 | 12 | CL | | 4.65 |
| 6-20-81 | 2 | 5.0-6.75 | 109.9 | 18.9 | 35 | 14 | 21 | CL | | |

* Jar sample
** See Figure E-1

WORKING DRAFT

## Laboratory Soil Test Results

## Highway 58 Dump Site A

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 7-1-81 | 1 | 0.0-1.05 | 108.0 | 11.8 | 40 | 16 | 24 | GC | | 3.86 |
| 7-1-81 | 2 | 5.0-6.79 | 113.6 | 15.7 | 42 | 19 | 23 | CL | 0 | |
| 7-1-81 | 3 | 10.0-11.44 | 127.4 | 12.2 | 35 | 16 | 19 | CL | | |
| 7-2-81 | 1 | 0.0-1.55 | 126.0 | 8.2 | 30 | 16 | 14 | SC | | |
| 7-2-81 | 2 | 5.0-7.06 | 113.7 | 16.1 | 47 | 22 | 25 | CL | | 9.85 |
| 7-2-81 | 3A* | 10.5-11.5 | -- | 13.9 | 38 | 15 | 23 | CL | | 5.23 |
| 7-3-81 | 1 | 0.0-1.77 | 120.2 | 12.1 | 35 | 20 | 15 | CL | | 4.12 |
| 7-3-81 | 2 | 5.0-6.14 | 111.1 | 9.1 | 30 | 14 | 16 | CL | | |
| 7-5-81 | 1 | 0.0-0.95 | 108.7 | 18.2 | 41 | 16 | 25 | CL | | |
| 7-5-81 | 2 | 5.0-7.07 | 115.2 | 14.9 | 36 | 17 | 19 | CL | | 3.79 |
| 7-5-81 | 3 | 10.0-11.39 | 115.9 | 17.2 | 37 | 18 | 19 | CL | | |
| 7-5-81 | 4 | 15.0-16.39 | 113.6 | 18.1 | 35 | 18 | 17 | CL | | |

* Jar sample
** See Figure E-1

WORKING DRAFT

## Laboratory Soil Test Results

## Highway 58 Dump Site B

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 8-1-81 | 1A* | 0.0-0.7 | -- | 5.0 | 35 | 16 | 19 | CL | | |
| 8-4-81 | 1A* | 0.0-0.8 | -- | 9.1 | 32 | 15 | 17 | GC | | 8.13 |
| 8-5-81 | 1 | 0.0-0.94 | 101.0 | 8.9 | 43 | 17 | 26 | CL | $2.07 \times 10^{-8}$ | 3.58 |
| 8-8-81 | 1A* | 0.0-0.9 | -- | -- | | | | | | 2.55 |
| 8-9-81 | 1A* | 0.0-0.65 | -- | -- | | | | | | 3.83 |

* Jar sample
** See Figure E-1

WORKING DRAFT

## Laboratory Soil Test Results

## Pest Control Area

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 9-1-81 | 1 | 0.0-0.5 | 110.4 | 15.5 | 49 | 24 | 25 | CL | | 7.25 |
| 9-1-81 | 2 | 5.0-7.09 | 111.7 | 14.0 | 37 | 15 | 22 | SC | | |
| 9-1-81 | 3 | 10.0-11.33 | 120.6 | 13.3 | 32 | 19 | 13 | CL | | |
| 9-2-81 | 1 | 0.0-2.28 | 106.5 | 9.3 | 28 | 19 | 9 | SC | | |
| 9-2-81 | 2 | 5.0-6.16 | 103.0 | 19.6 | 30 | 16 | 14 | CL | | 6.48 |
| 9-2-81 | 3 | 10.0-12.08 | 86.6 | 31.3 | 37 | 21 | 16 | CL | | |
| 9-3-81 | 1 | 0.0-2.29 | 109.9 | 16.7 | 35 | 17 | 18 | CL | $3.52 \times 10^{-7}$ | 6.72 |
| 9-3-81 | 2 | 5.0-6.40 | 104.7 | 21.9 | 26 | 15 | 11 | CL | | |
| 9-4-81 | 1 | 0.0-2.15 | 103.1 | 17.9 | 41 | 16 | 25 | CL | | 2.15 |
| 9-4-81 | 2 | 5.0-6.43 | 126.2 | 8.1 | 35 | 18 | 17 | SC | | |
| 9-5-81 | 1 | 0.0-1.54 | 122.7 | 13.4 | 40 | 17 | 23 | CL | | 1.57 |
| 9-5-81 | 2 | 5.0-6.17 | 124.5 | 10.2 | 34 | 17 | 17 | CL | | |
| 9-6-81 | 1 | 0.0-2.37 | 94.4 | 12.2 | 35 | 19 | 16 | CL | | 5.25 |
| 9-7-81 | 1 | 0.0-1.58 | 116.3 | 13.0 | 38 | 20 | 18 | SC | | |
| 9-7-81 | 2 | 5.0-7.10 | 109.0 | 9.3 | 27 | 18 | 9 | SC | | 4.48 |
| 9-8-81 | 1 | 0.0-1.39 | 104.1 | 19.9 | 45 | 18 | 27 | CL | | 9.02 |
| 9-8-81 | 2 | 5.0-6.38 | 122.8 | 14.1 | 38 | 20 | 18 | CL | | |
| 9-8-81 | 3A* | | | | | | | | | 6.90 |
| 9-9-81 | 1 | 0.0-1.75 | 116.7 | 12.9 | 29 | 16 | 13 | SC | | 1.20 |
| 9-9-81 | 2 | 5.0-6.28 | 111.5 | 18.2 | 34 | 20 | 14 | CL | | |

* Jar sample

** See Figure E-1

WORKING DRAFT

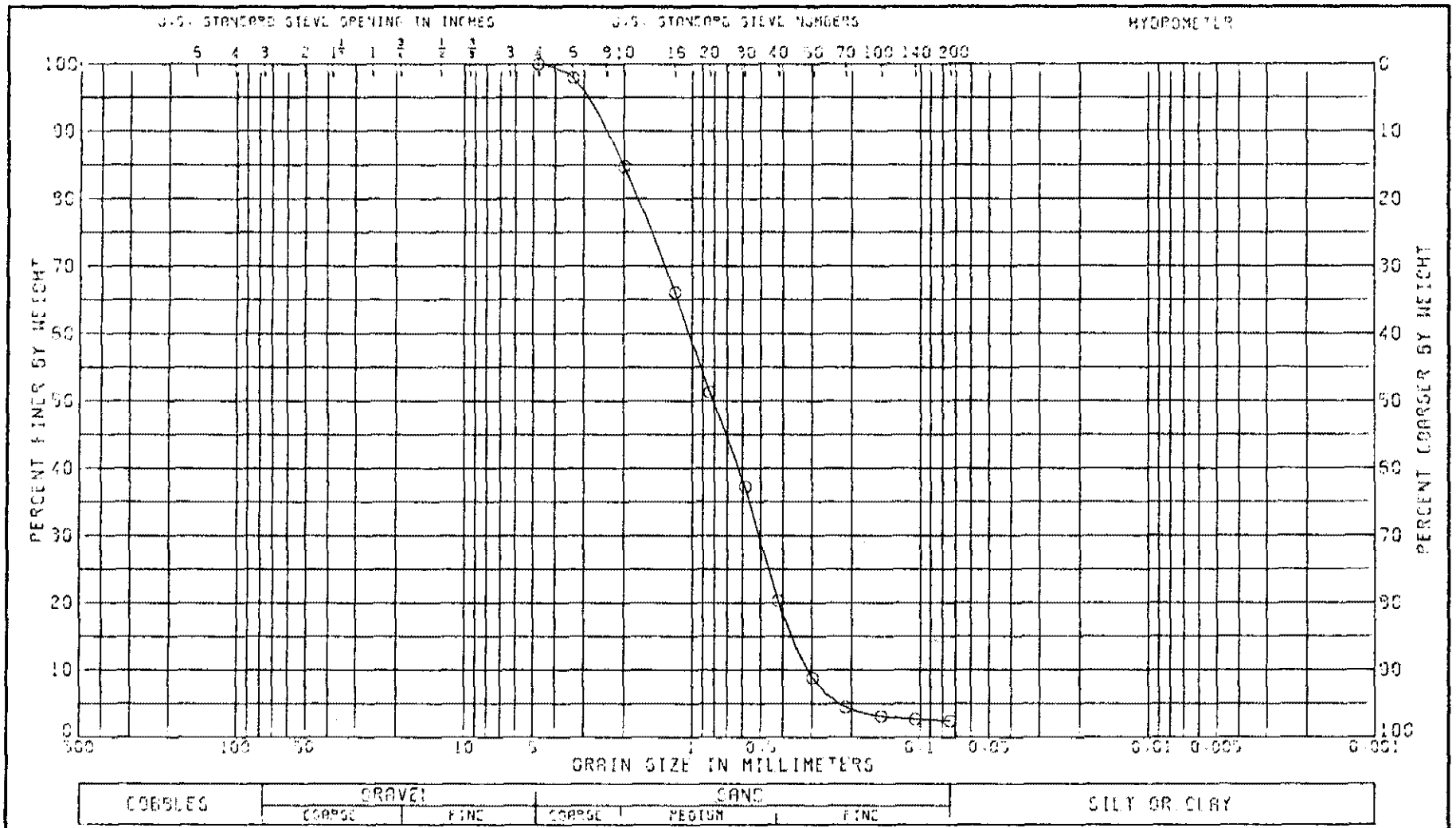
## Laboratory Soil Test Results

## Rockeye Site

| Boring Number | Sample Number | Depth ft | Dry Density lbs/cu ft | Water Content Percent | Liquid Limit Percent | Plastic Limit Percent | Plasticity Index Percent | USCS** | Permeability cm/sec | Cation Exchange Capacity meq/100 g |
|---|---|---|---|---|---|---|---|---|---|---|
| 10-1-81 | 1 | 0.0-1.84 | 116.2 | 9.6 | NP+ | NP | NP | SM | | |
| 10-1-81 | 2 | 5.0-6.16 | 118.0 | 9.6 | 24 | 15 | 9 | GC | | 1.76 |
| 10-2-81 | 1 | 0.0-1.29 | 101.4 | 18.2 | 33 | 20 | 13 | CL | $5.20 \times 10^{-6}$ | 5.98 |

\+ Not plastic
** See Figure E-1

WORKING DRAFT




| LL | PL | PI | CC | NAT W.% | |
|---|---|---|---|---|---|

CLASSIFICATION

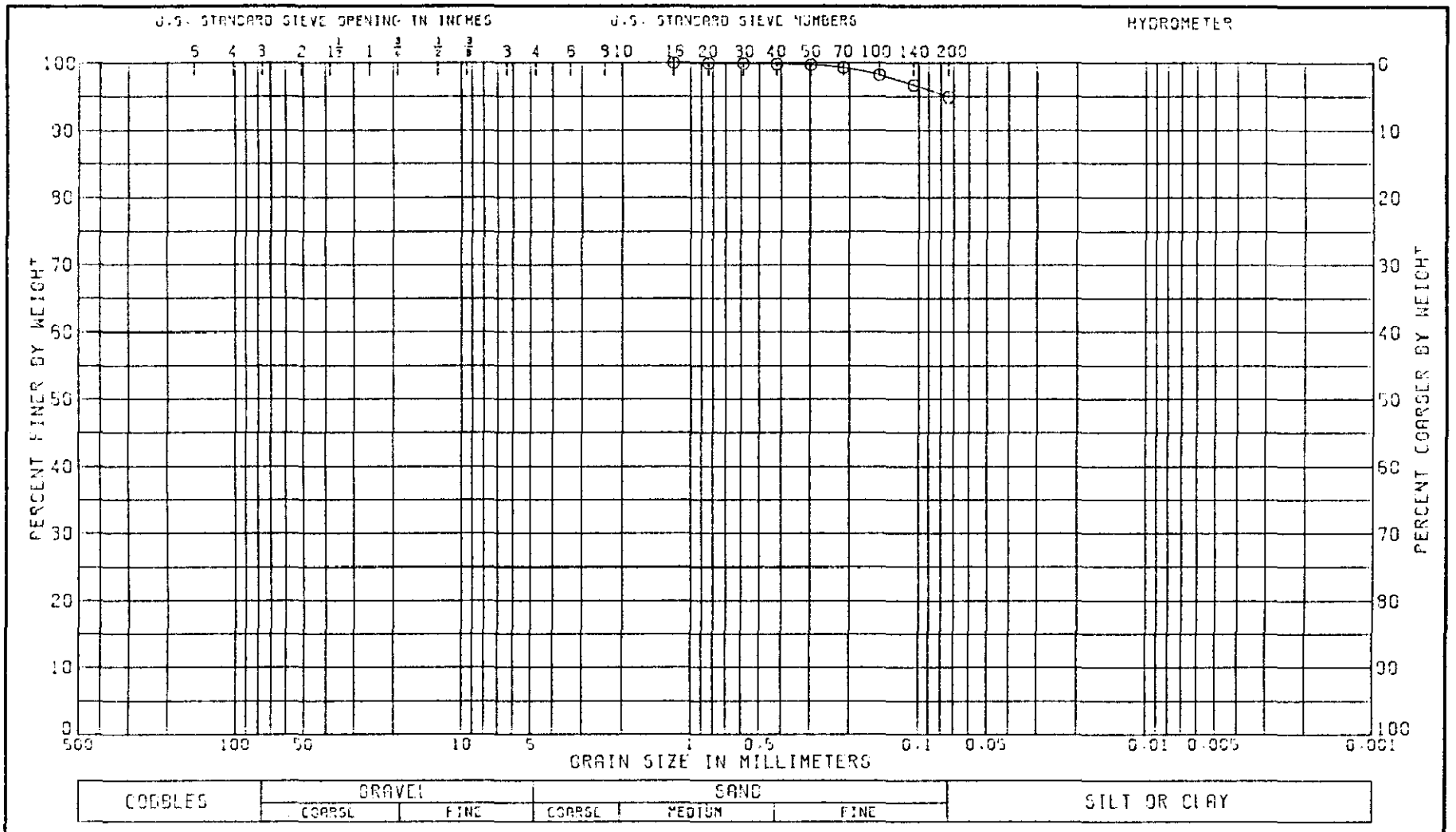
SAND (SP), GRAYISH BROWN

GRADATION CURVE

PROJECT CRANE NWSC SCREEN SAND

BORING NO. 0 SAMPLE NO. 0

DEPTH/ELEV 0 DATE 14 APR 92




| LL 36 | PL 18 | PI 18 | CS | NAT W.% 21.7 | |
|---|---|---|---|---|---|

CLASSIFICATION

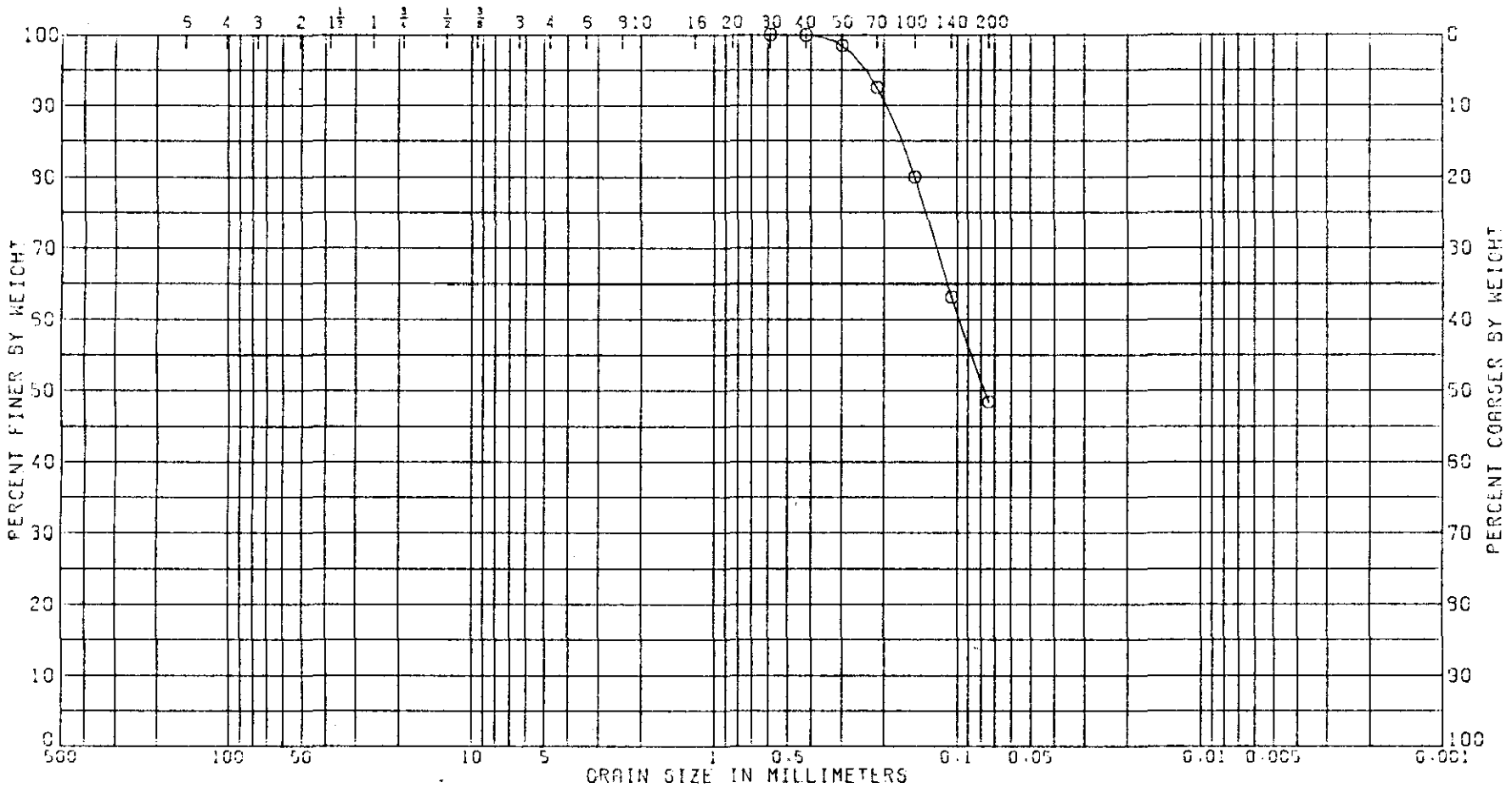
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-1-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.85 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 27 | 14 | 13 | . | 13.6 |

CLASSIFICATION

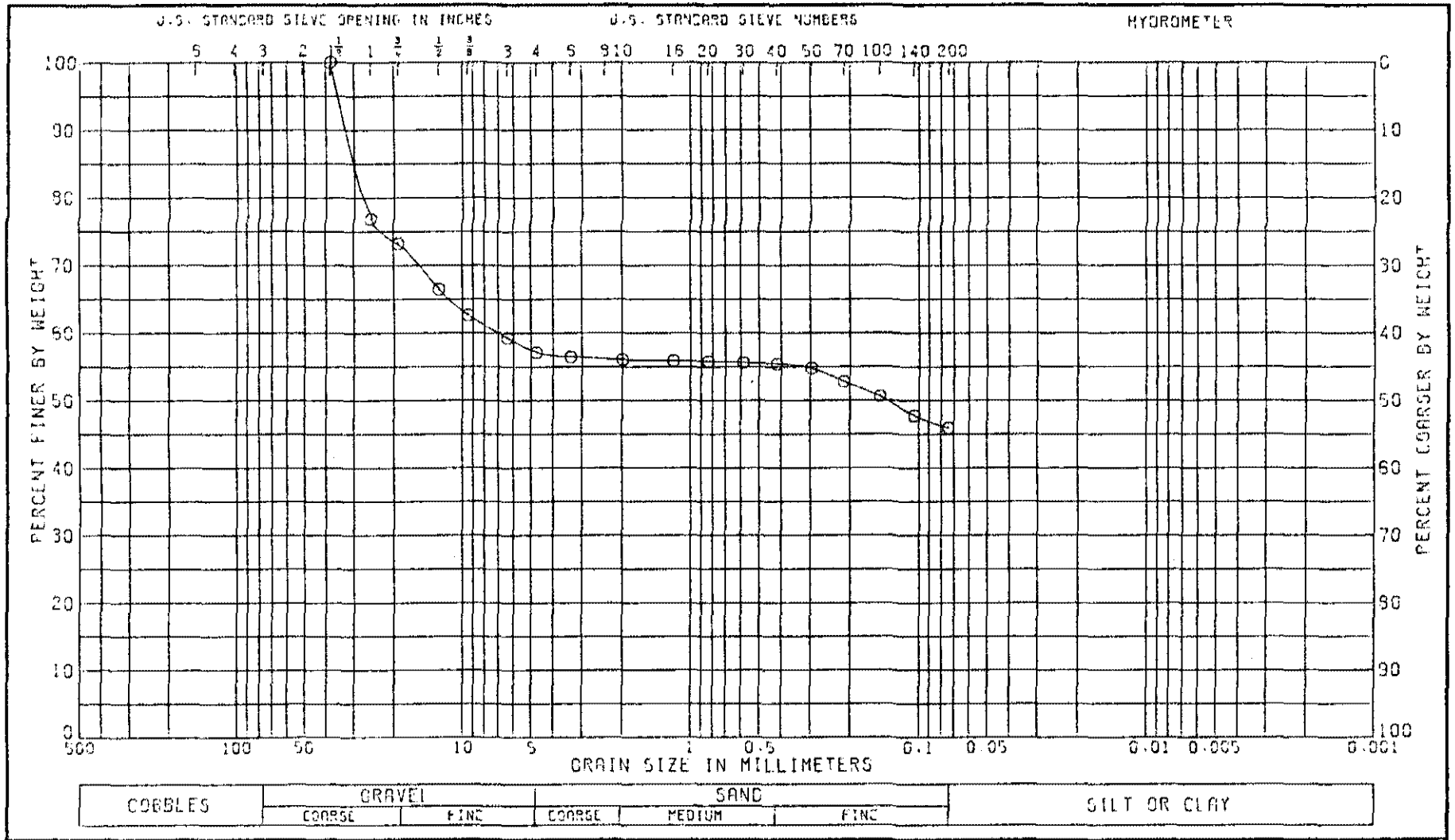
CLAYEY SAND (SC), LIGHT BROWN

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-1-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.37 DATE 30 MAR 82




| LL 35 | PL 19 | PI 17 | CS | NAT W.% 7.1 | |
|---|---|---|---|---|---|

CLASSIFICATION

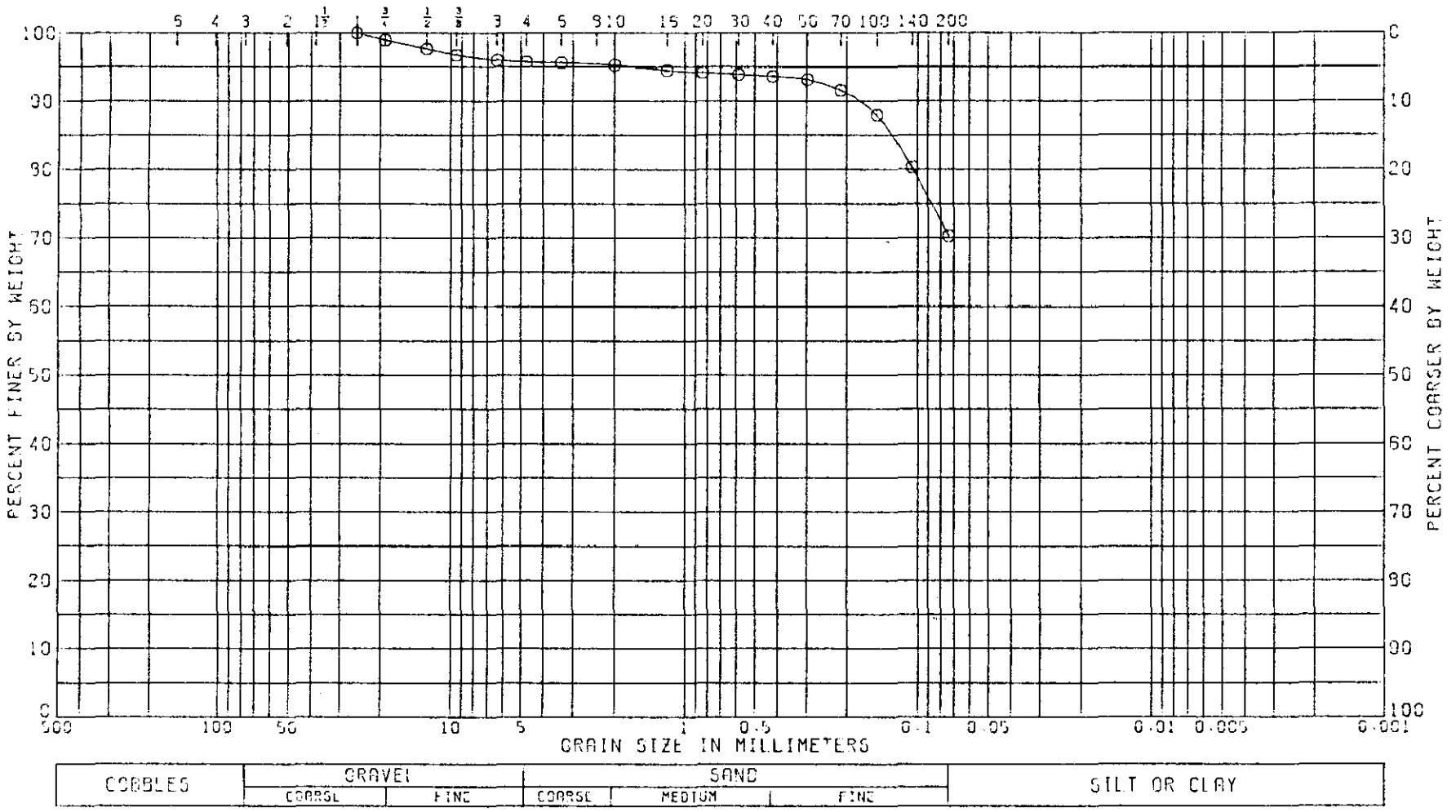
GRAVELLY CLAYEY SAND (SC), REDDISH BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-2-81 SAMPLE NO. 1A

DEPTH/ELEV 0.0-0.65 DATE 30 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 29 | 13 | 15 | | 14.2 |

CLASSIFICATION

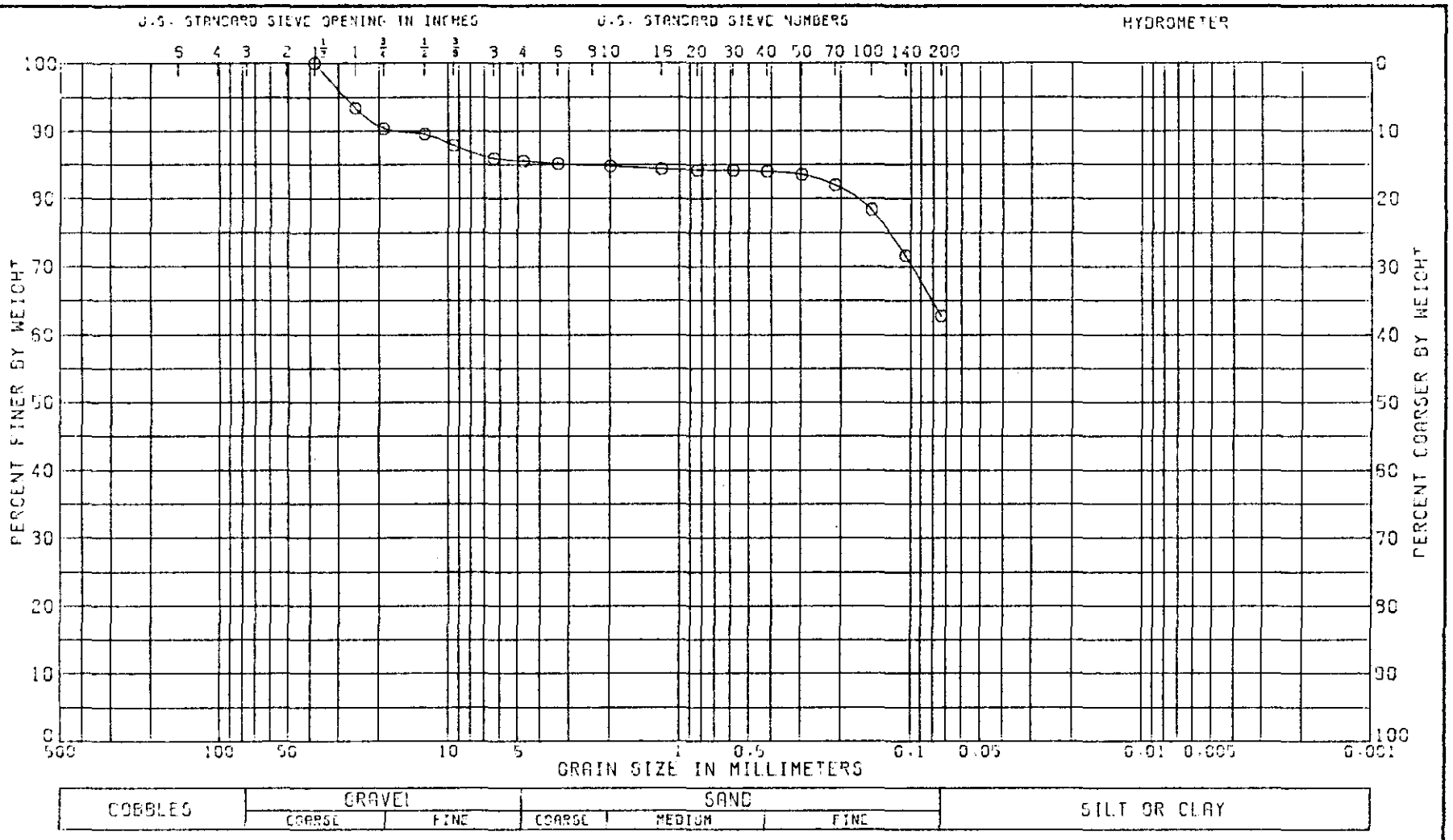
SANDY CLAY (CL), BROWN: TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-3-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.3 DATE 30 MAR 92




| LL 37 | PL 18 | PI 19 | OS | NAT W.% 17.9 | |
|---|---|---|---|---|---|

CLASSIFICATION

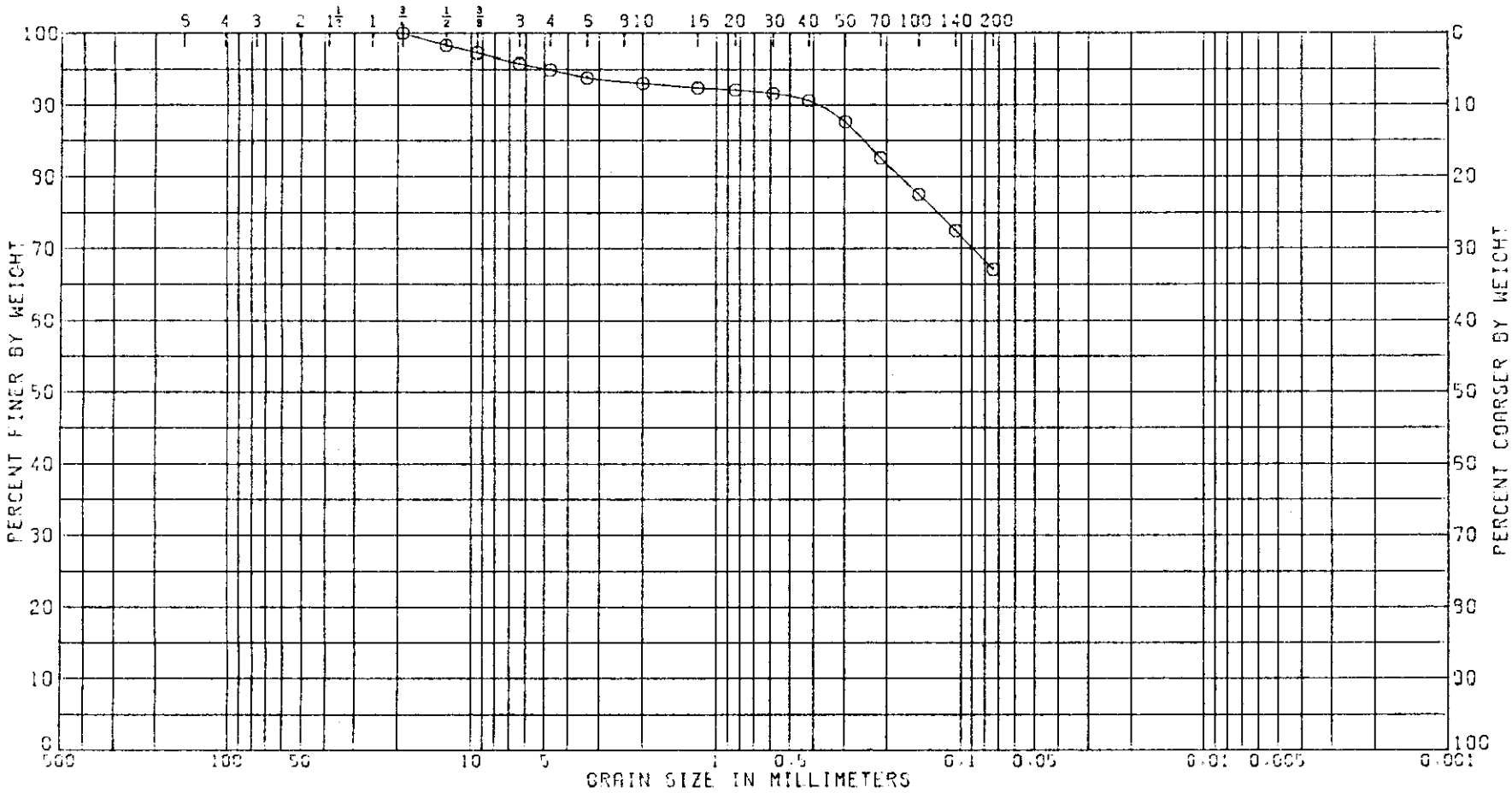
GRAVELLY SANDY CLAY (CL), TAN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-3-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.02 DATE 30 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 30 | 13 | 17 | | 11.2 |

CLASSIFICATION

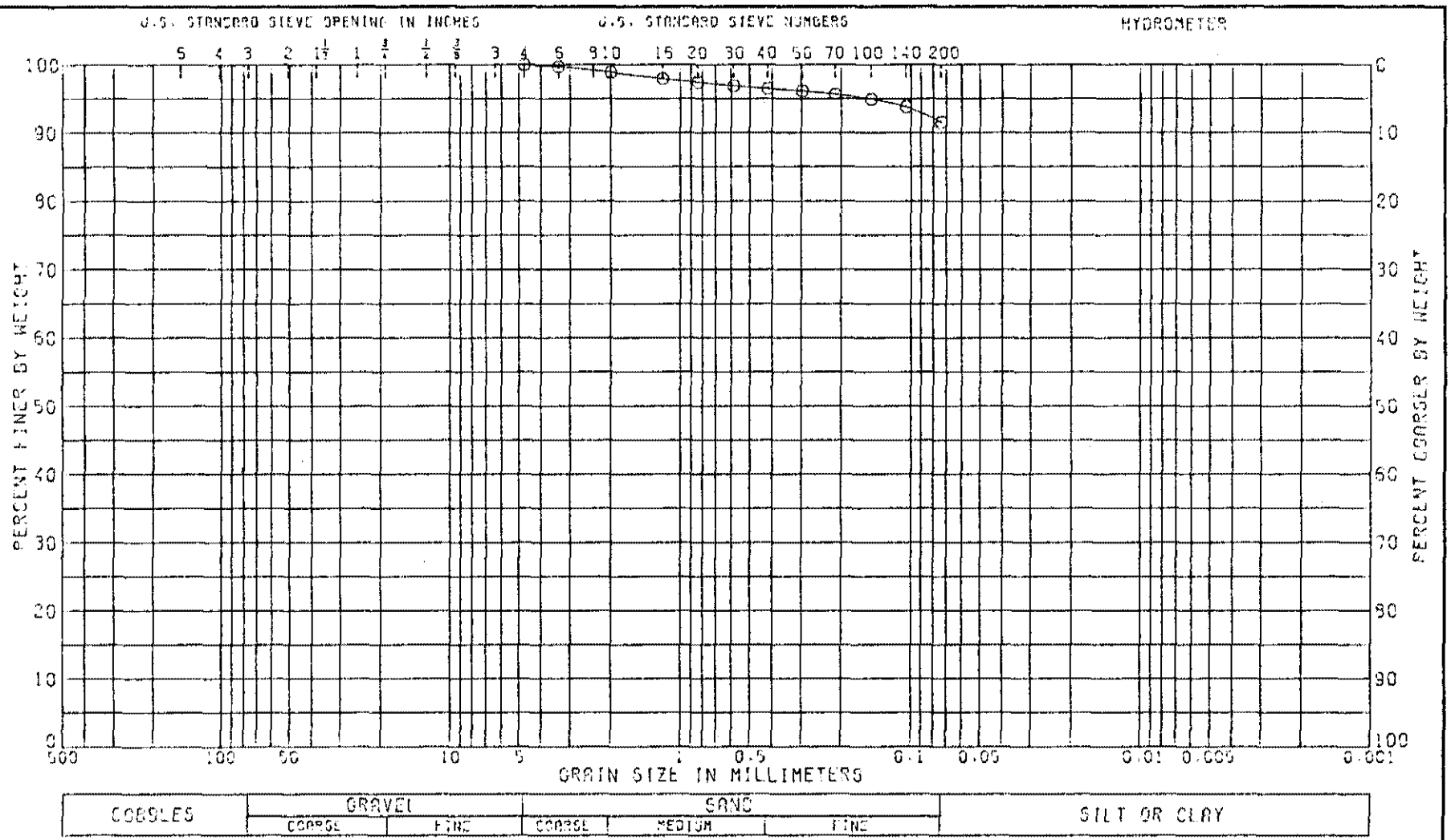
SANDY CLAY (CL) BROWN: WITH TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-4-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.43 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| 32 | 19 | 13 | | 12.8 | |

CLASSIFICATION

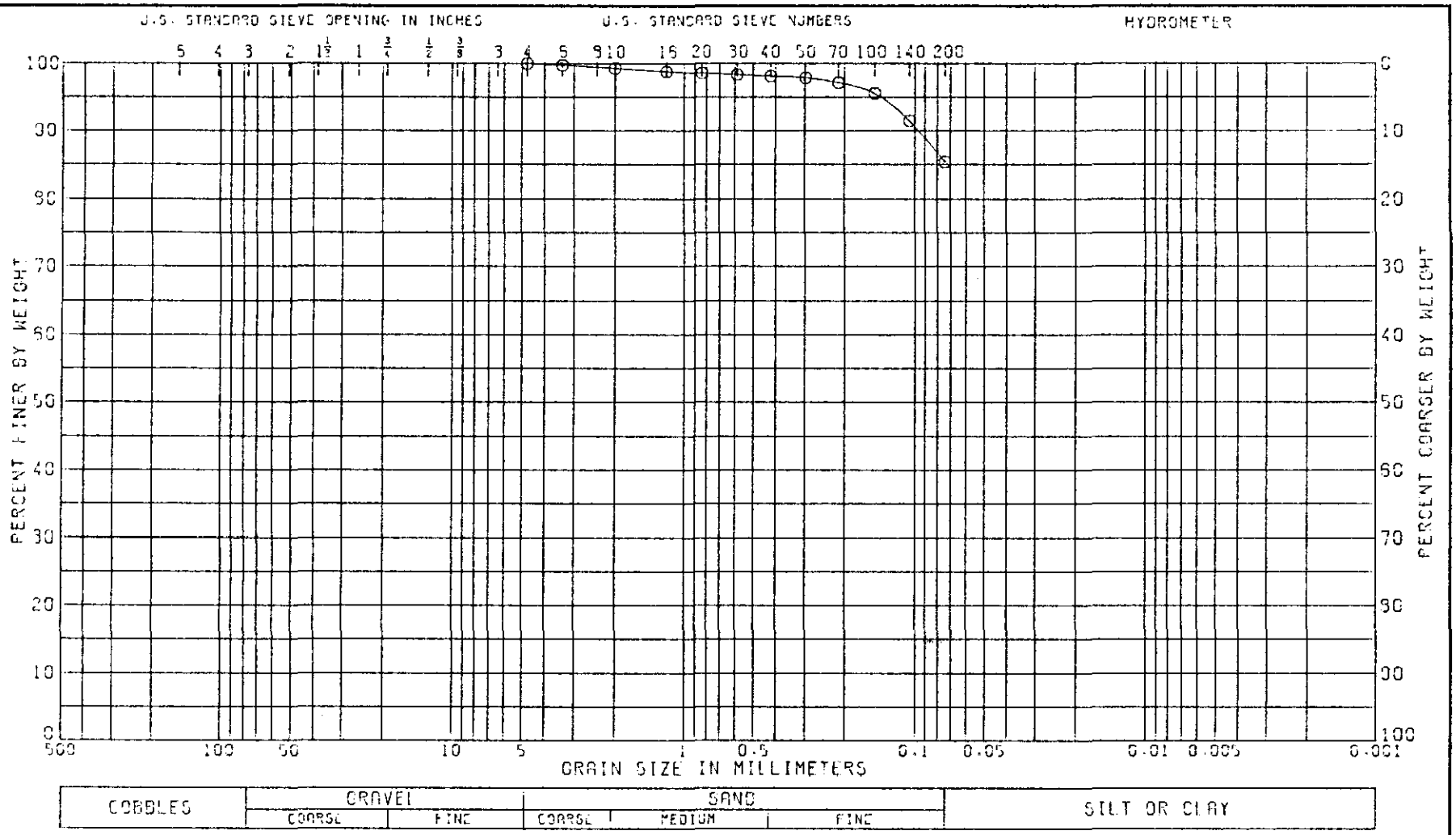
CLAY (CL), TAN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-4-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.35 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 33 | 18 | 15 | | 11.4 |

CLASSIFICATION

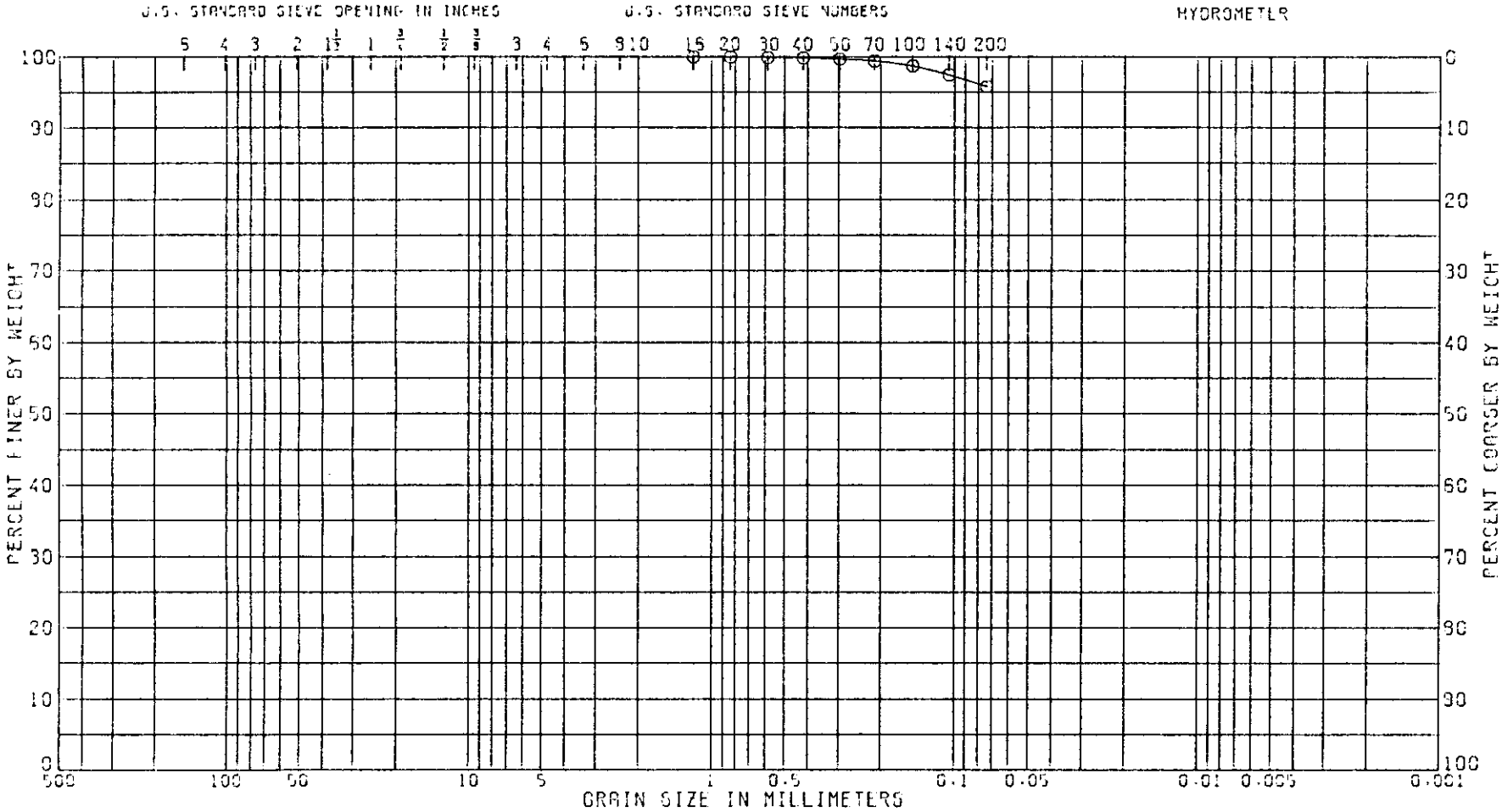
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 1-5-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.29 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 39 | 19 | 19 | | 21.9 |

CLASSIFICATION

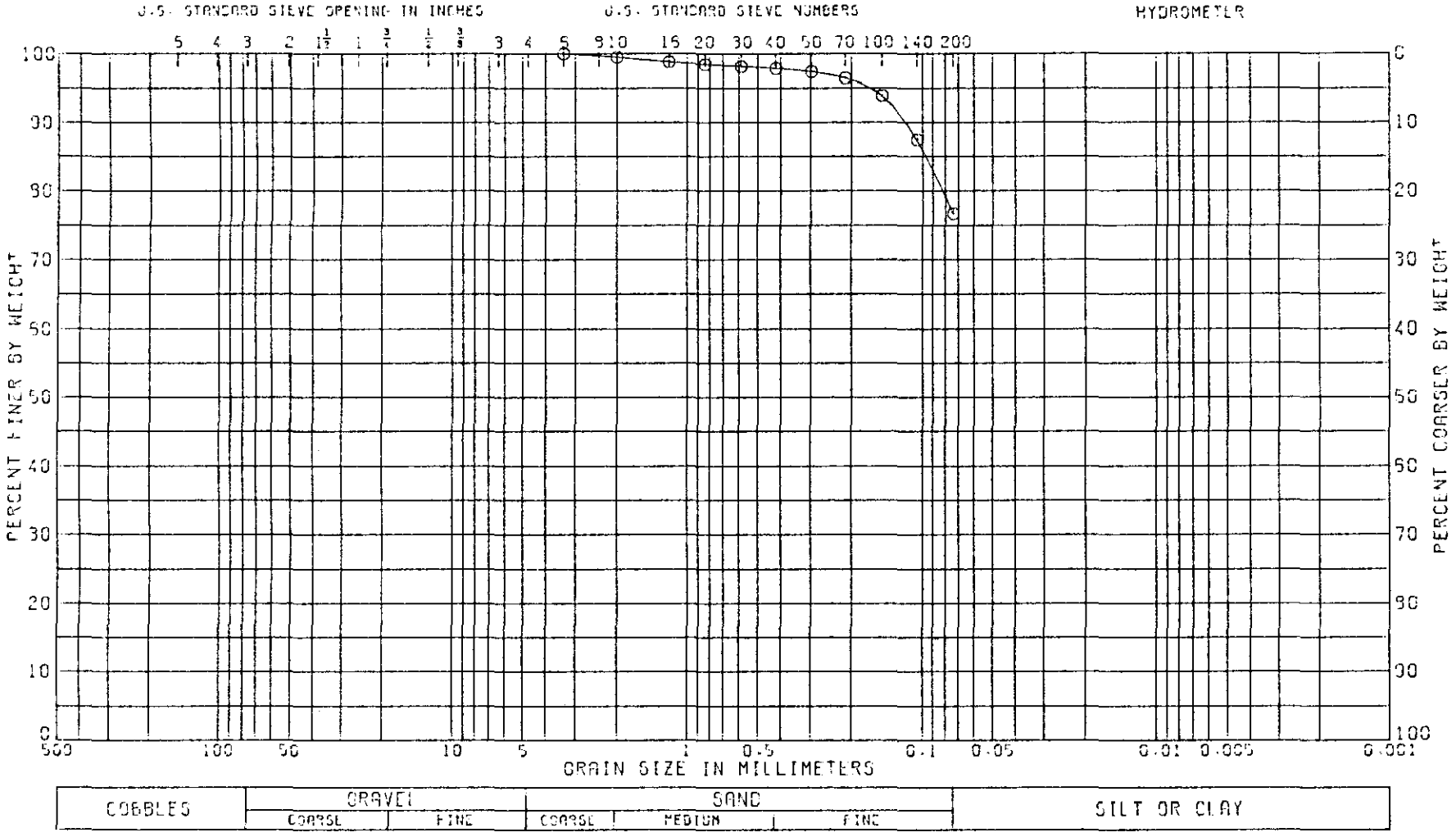
CLAY (CL), BROWN: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-1-81 SAMPLE NO. 1

DEPTH/ELEV 0.92-1.87 DATE 30 MAR 92




| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| 25 | 14 | 11 | | 11.1 | |

CLASSIFICATION

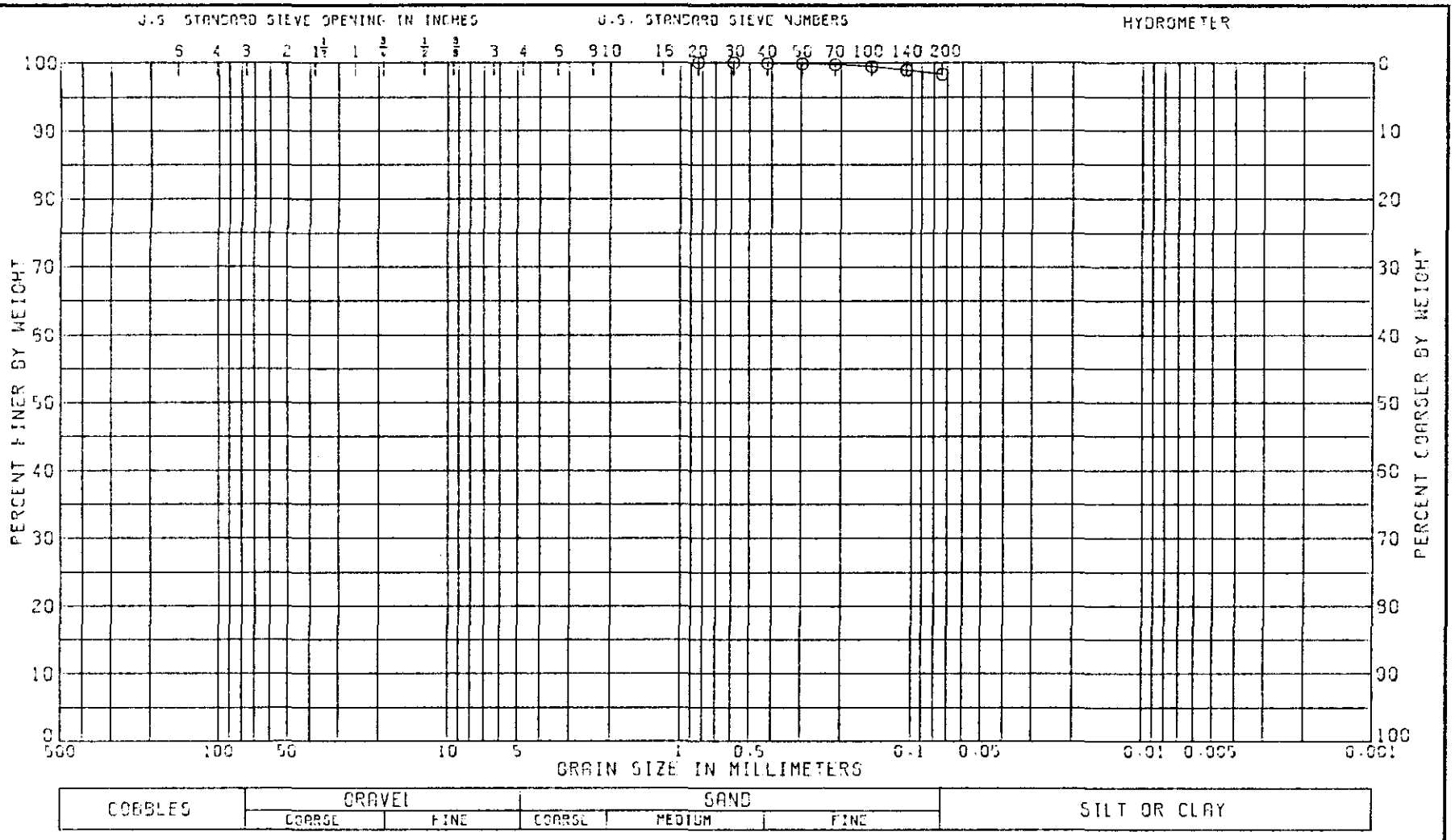
SANDY CLAY (CL), LIGHT BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-1-91 SAMPLE NO 2

DEPTH/ELEV 6.0-6.95 DATE 30 MAR 92




| LL 46 | PL 21 | PI 25 | CS | NAT W.% 21.2 | |
|---|---|---|---|---|---|

CLASSIFICATION

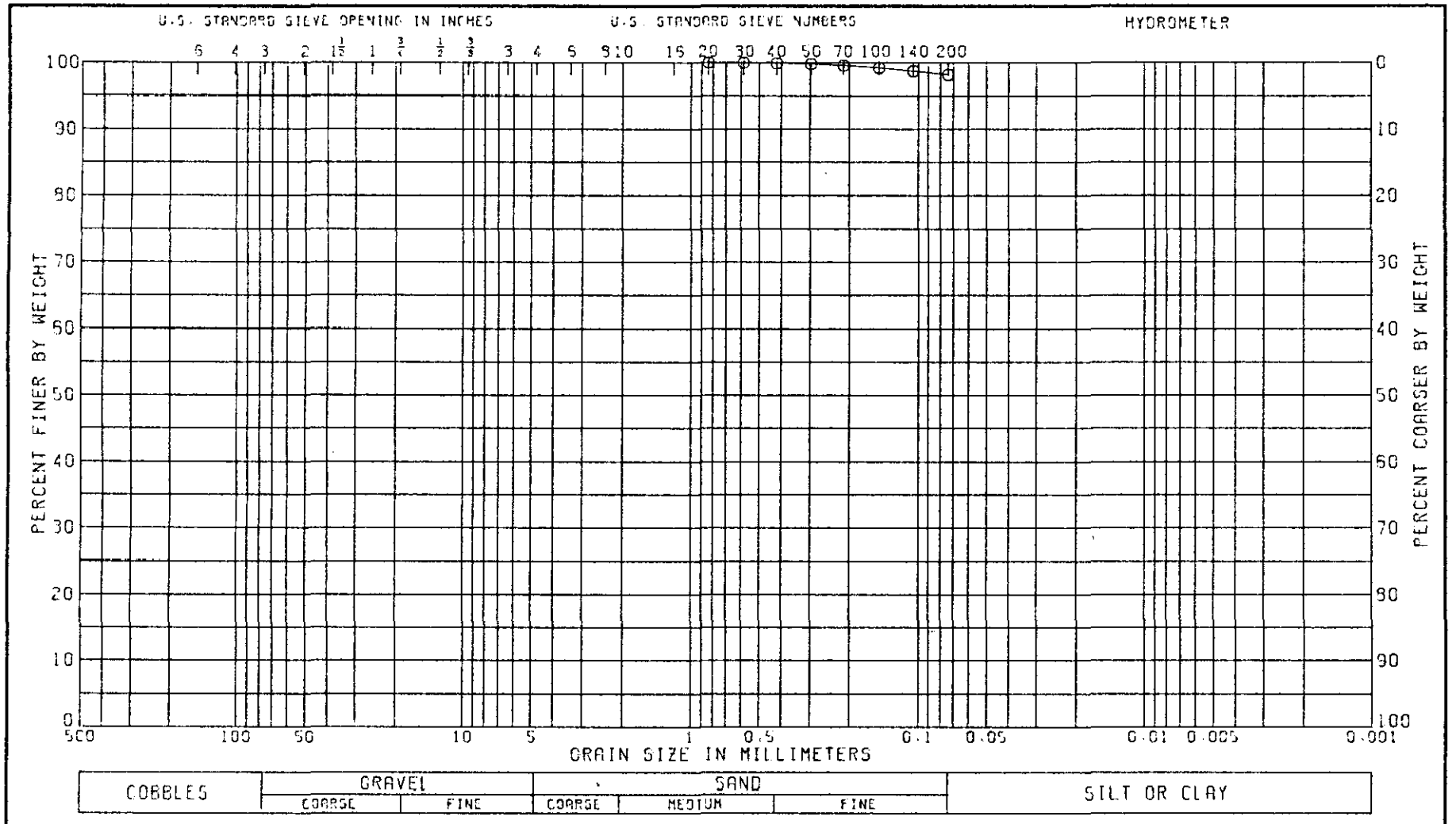
CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-2-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.65 DATE 30 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 44 | 23 | 21 | | 18.4 |

CLASSIFICATION

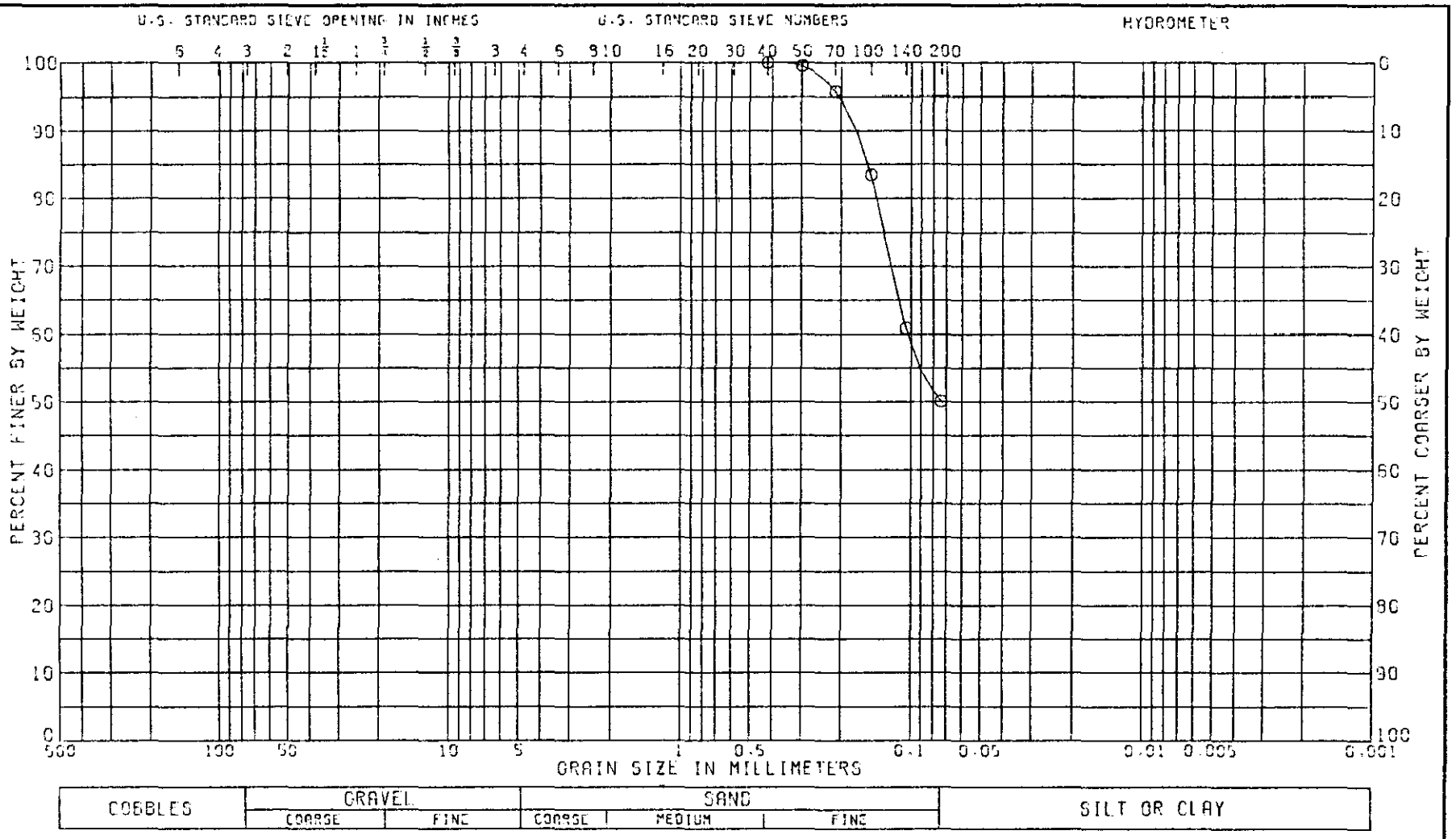
CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-3-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.15 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 38 | 14 | 24 | | 14.3 |

CLASSIFICATION

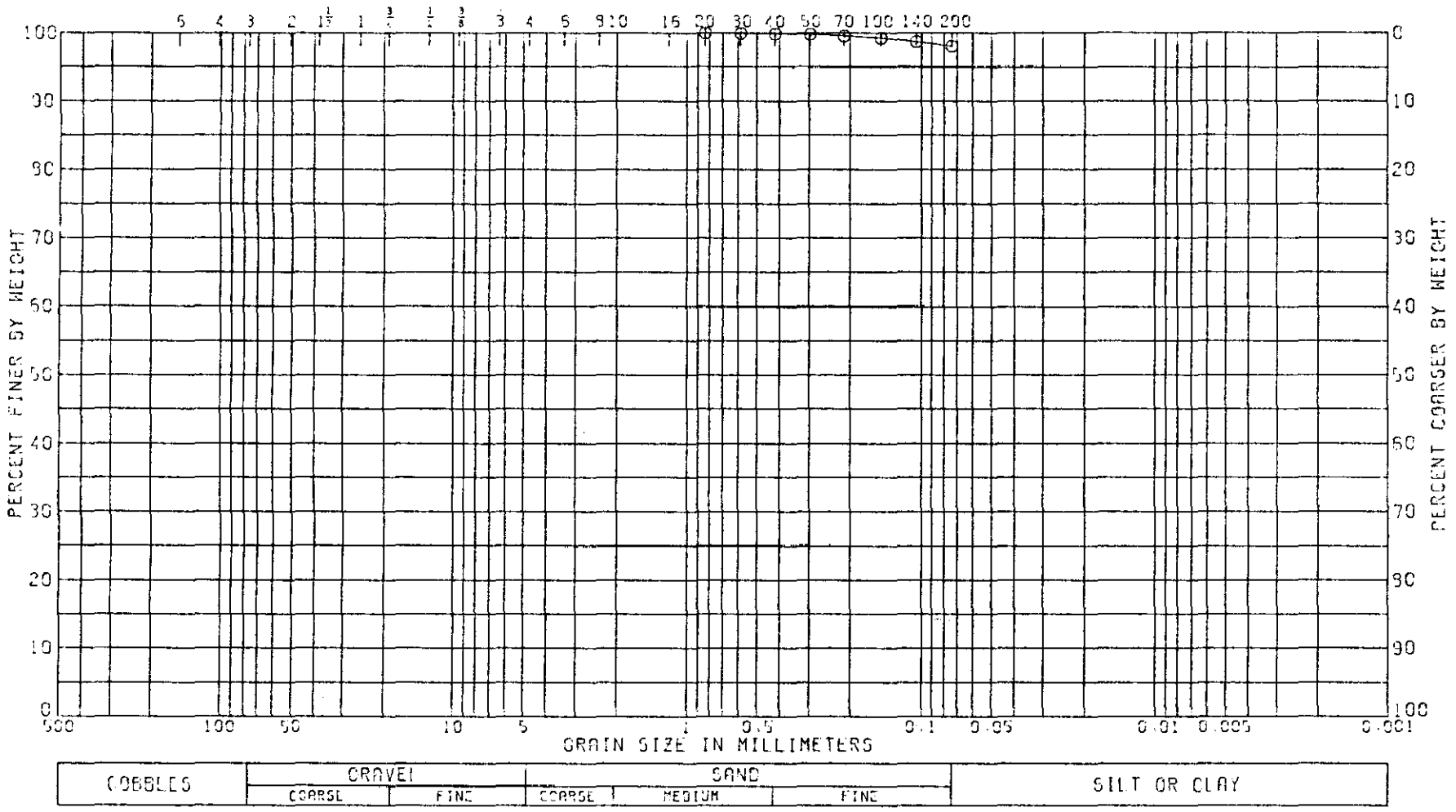
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-3-81 SAMPLE NO. 2A

DEPTH/ELEV 5.0-5.65 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 42 | 21 | 21 | | 18.5 |

CLASSIFICATION

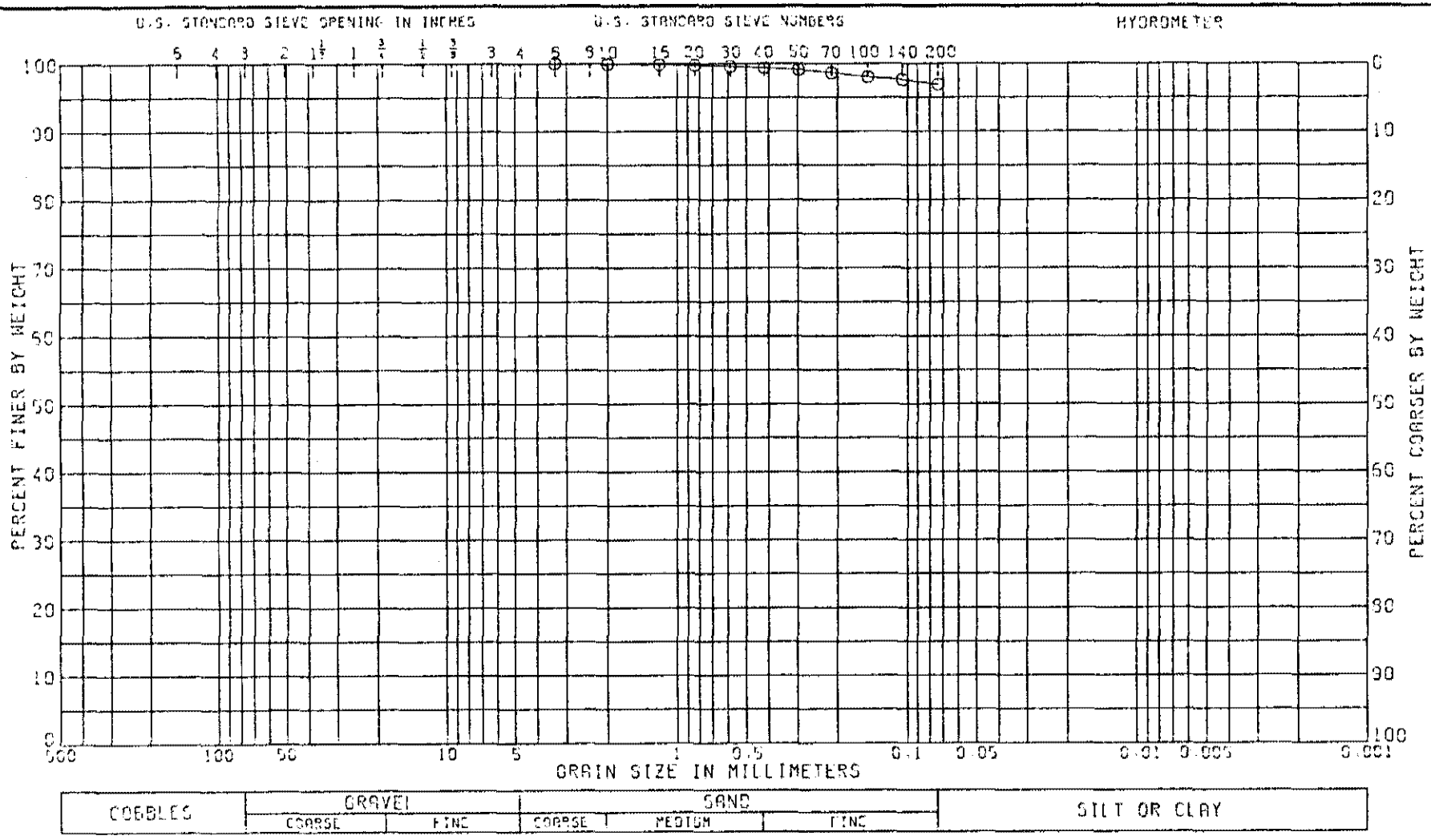
CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-4-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.2 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 44 | 23 | 21 | | 18.0 |

CLASSIFICATION

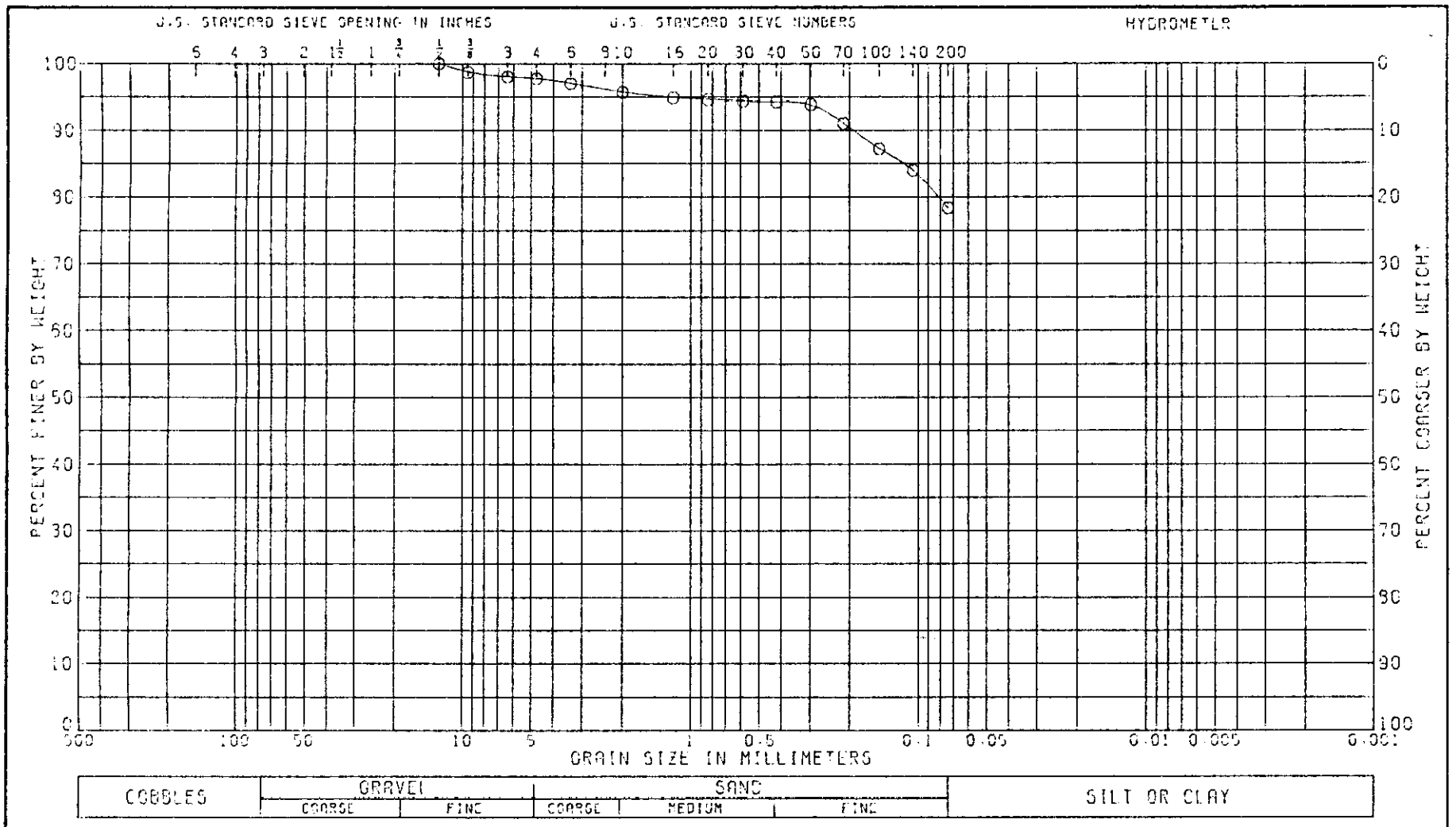
CLAY (CL), DARK TAN: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-5-91 SAMPLE NO 1

DEPTH/ELEV 0.0-1.55 DATE 30 MAR 82




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 25 | 14 | 11 | | 8.8 |

CLASSIFICATION

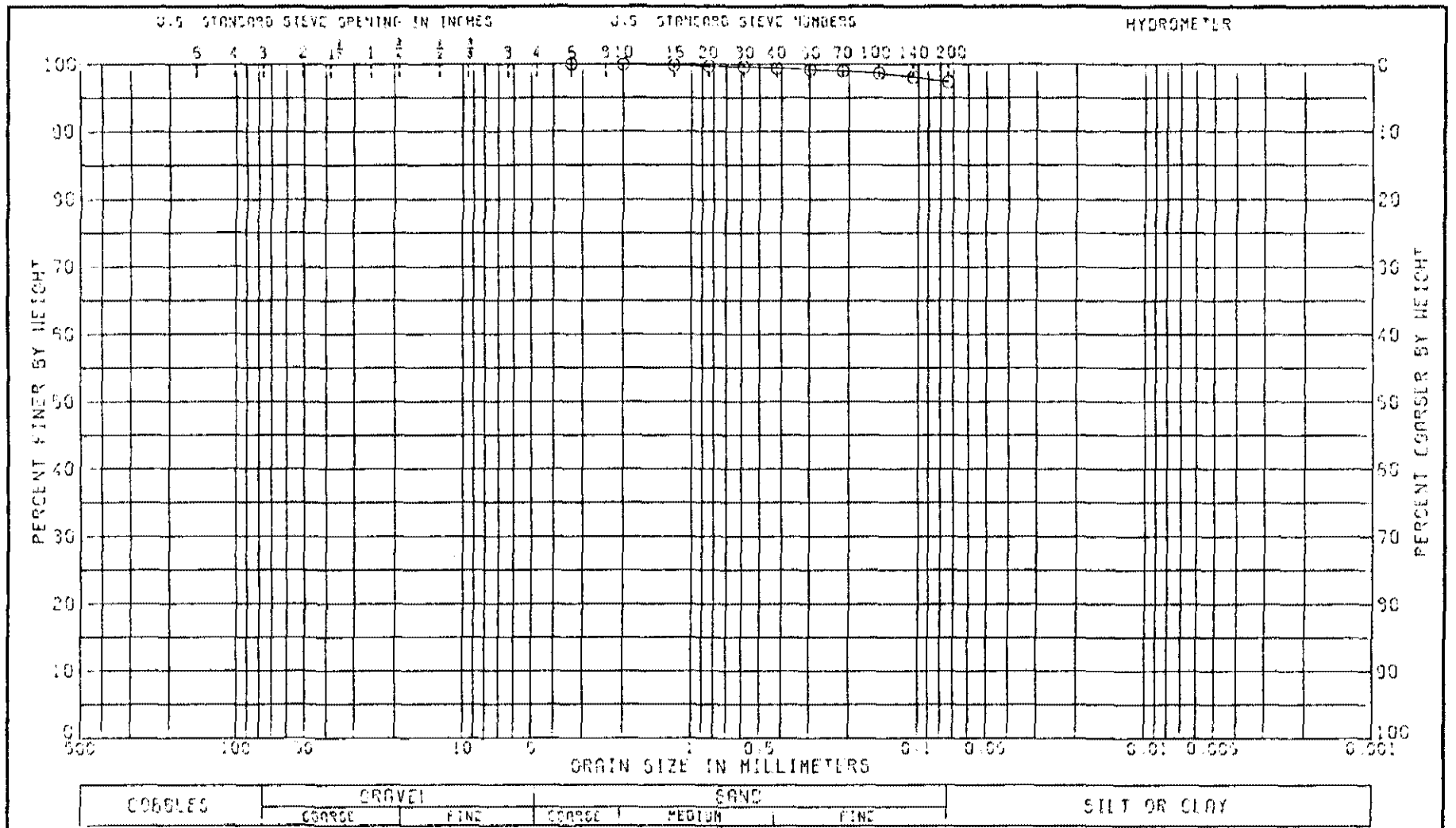
SANDY CLAY (CL), TAN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-5-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.1 DATE 11 FEB 92




| LL 31 | PL 17 | PI 14 | CS | NAT W,% 15.8 | |
|---|---|---|---|---|---|

CLASSIFICATION

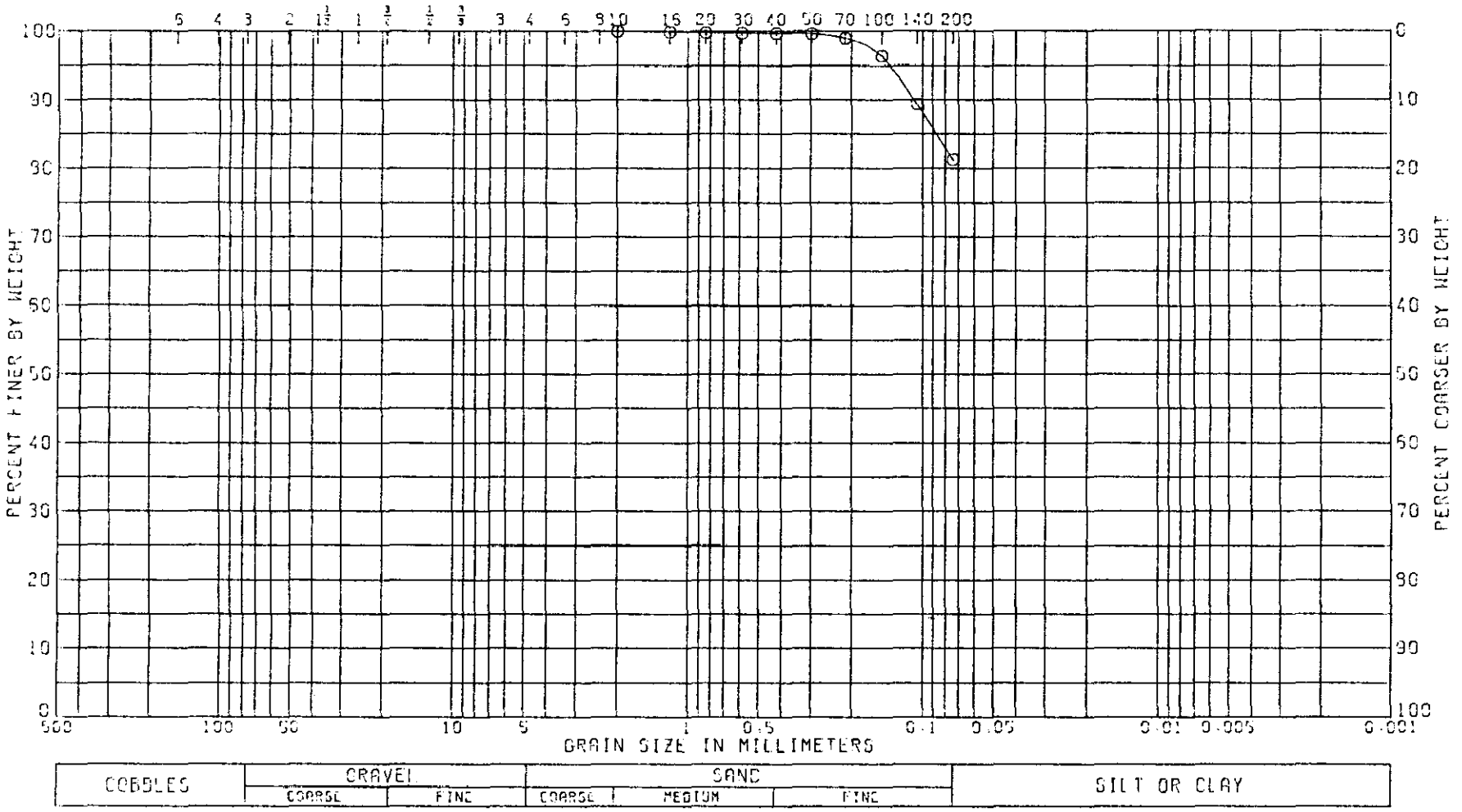
CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO 2-6-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.2 DATE 26 FEB 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 38 | 15 | 23 | | 15.4 |

CLASSIFICATION

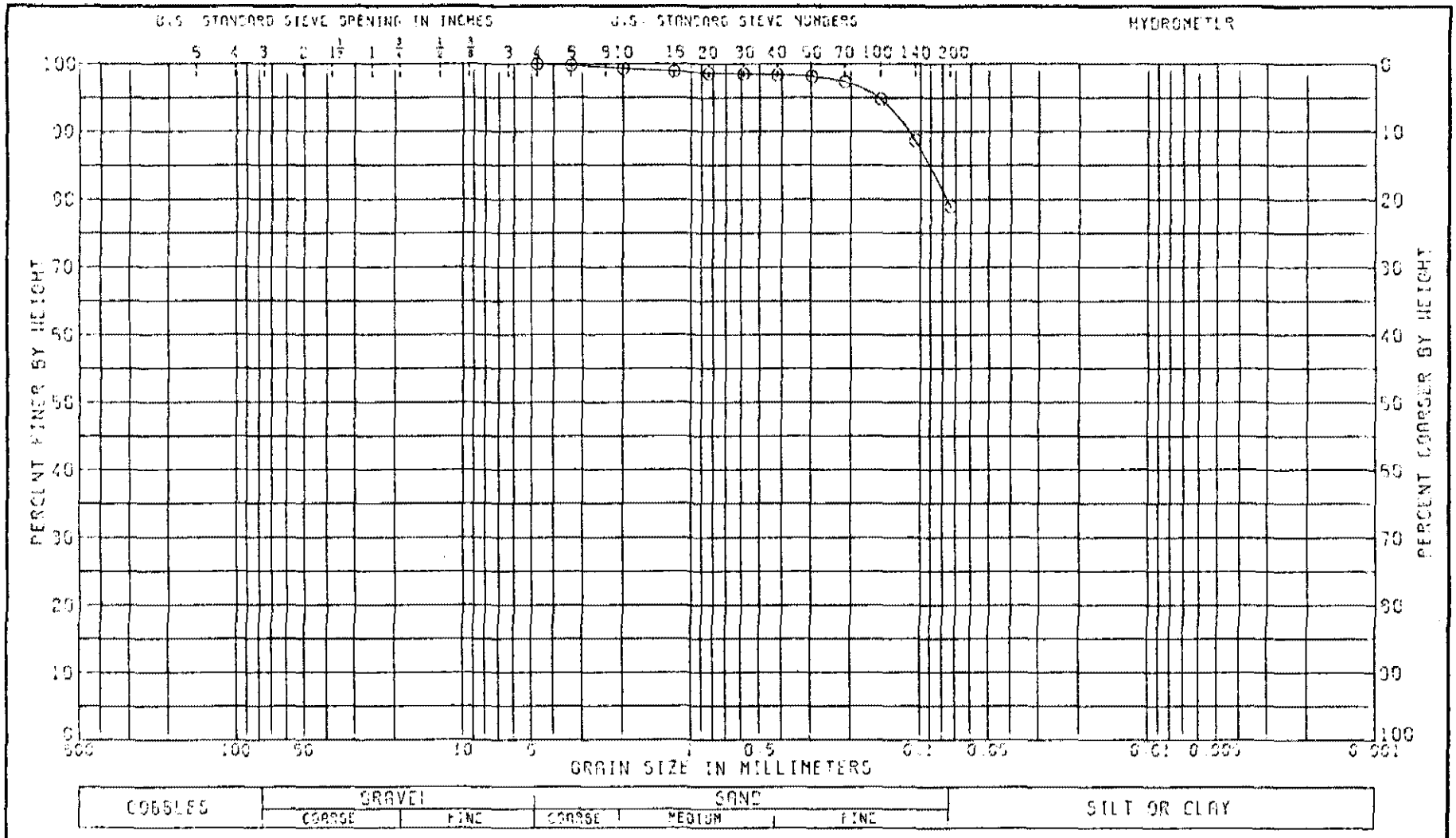
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-6-81 SAMPLE NO 2

DEPTH/ELEV 5.0-6.33 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 34 | 15 | 19 | | 9.2 |

CLASSIFICATION

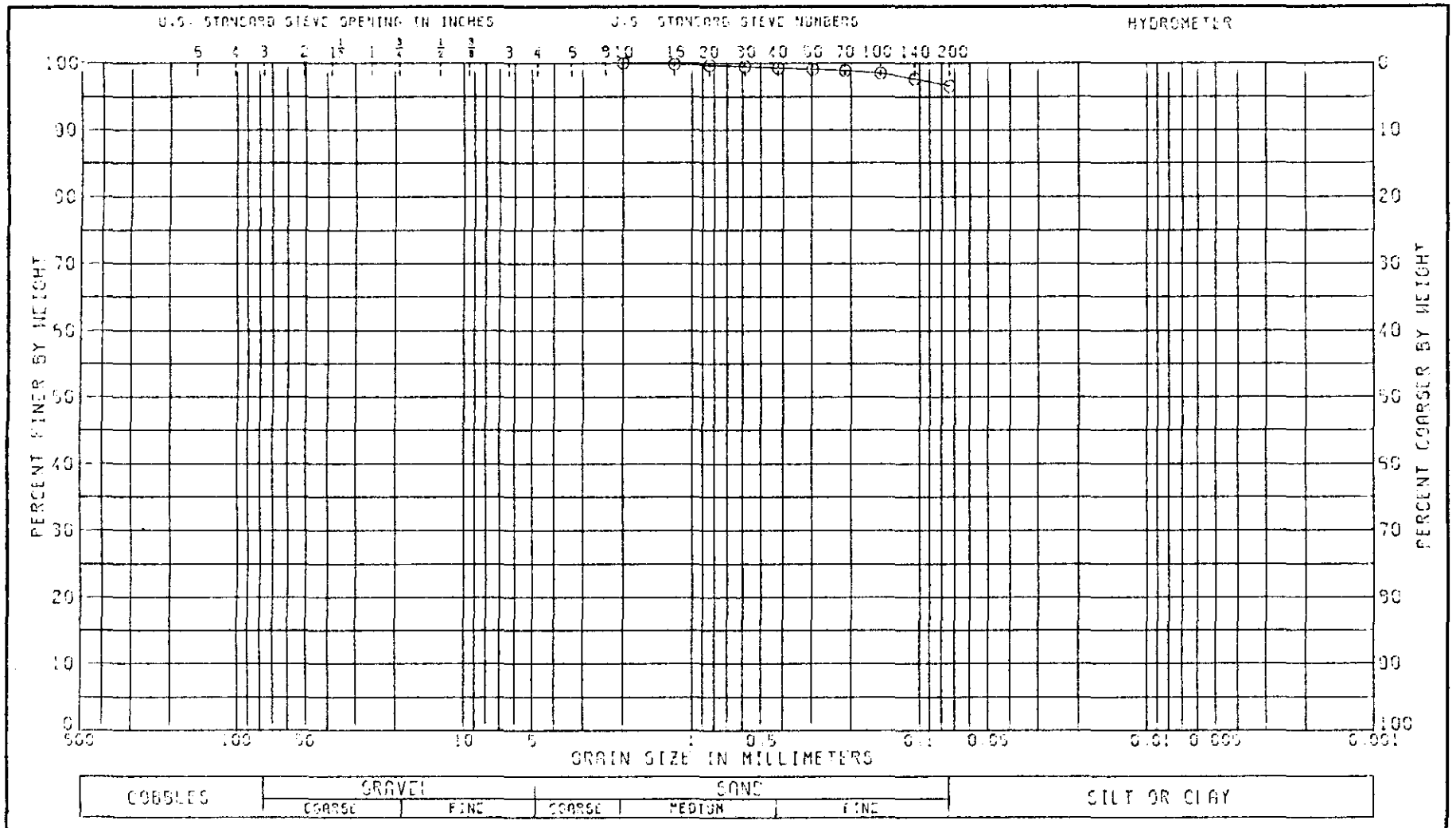
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO 2-7-91 SAMPLE NO 1

DEPTH/ELEV 0.0-2.0 DATE 25 FEB 92




| LL 39 | PL 18 | PI 21 | CS | NAT W.% 17.1 | |
|---|---|---|---|---|---|

CLASSIFICATION

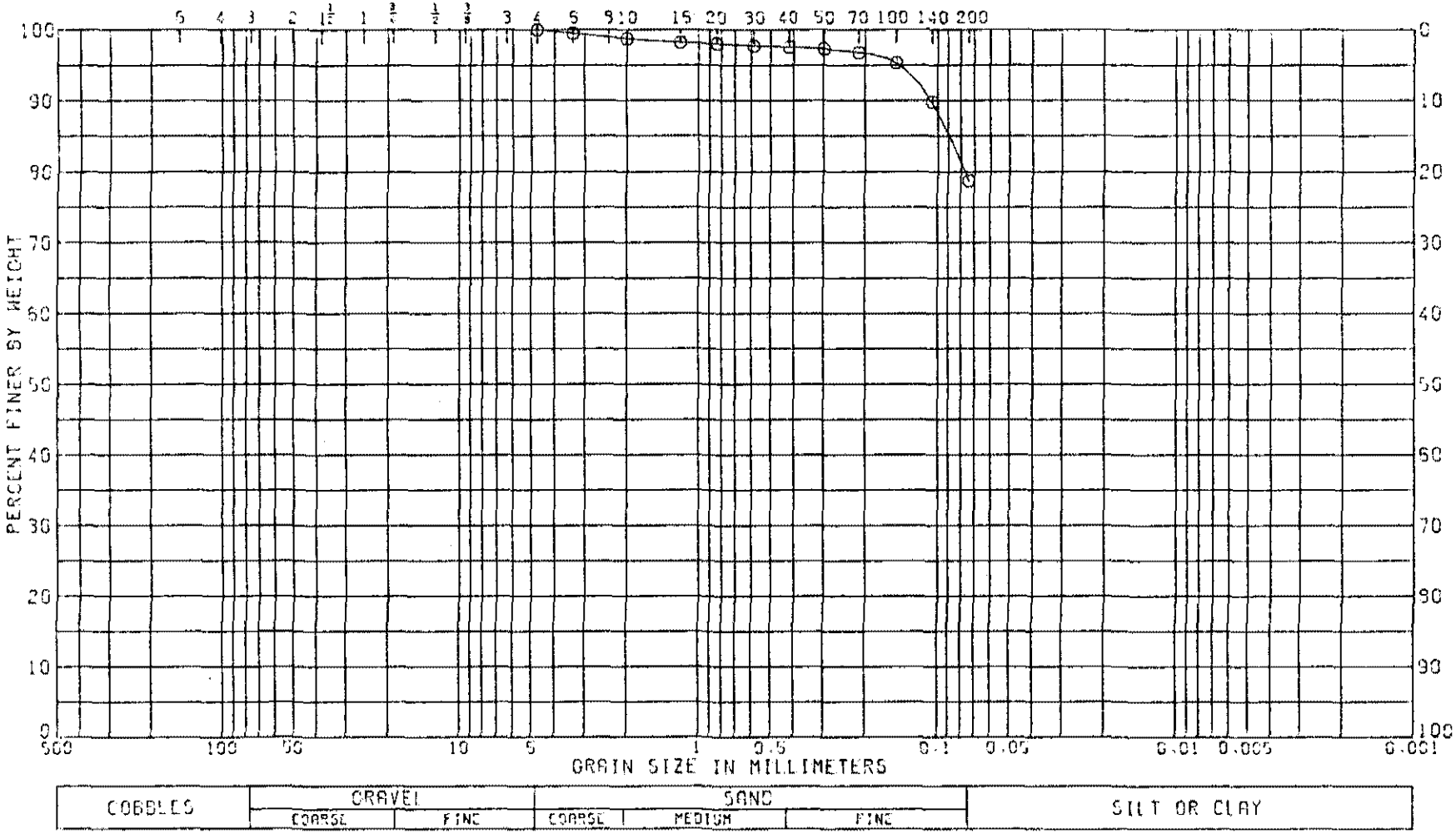
CLAY (CL), BROWN: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO 2-B-B1 SAMPLE NO 1

DEPTH/ELEV 0.0-2.25 DATE 26 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 39 | 16 | 23 | | 13.4 |

CLASSIFICATION

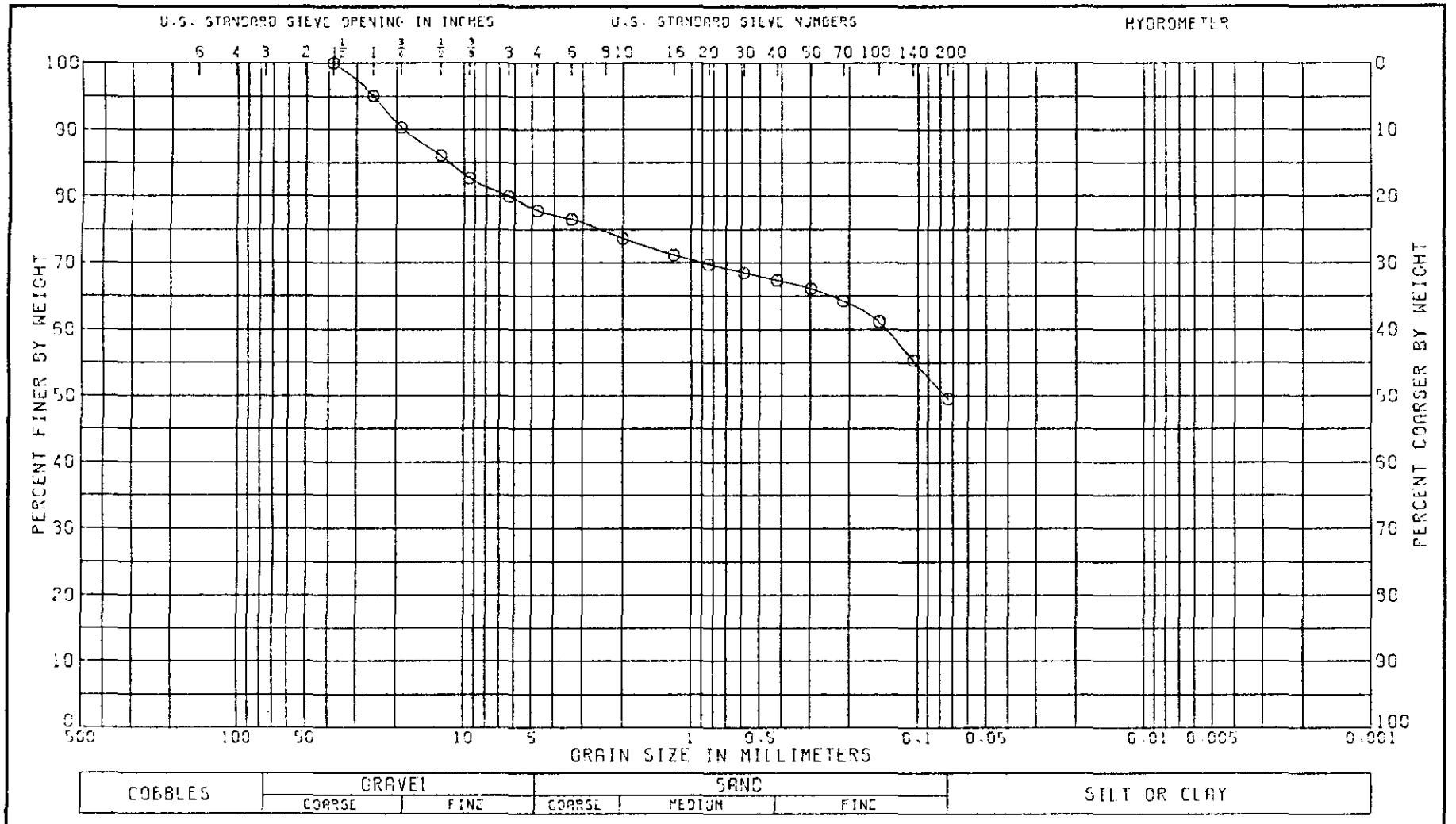
SANDY CLAY (CL), TAN

GRADATION CURVE

PROJECT CRANE NWSC DYE BURIAL

BORING NO. 2-8-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.69 DATE 30 MAR 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 42 | 17 | 25 | | 17.3 |

CLASSIFICATION

GRAVELLY CLAYEY SAND (SC), BROWN

INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

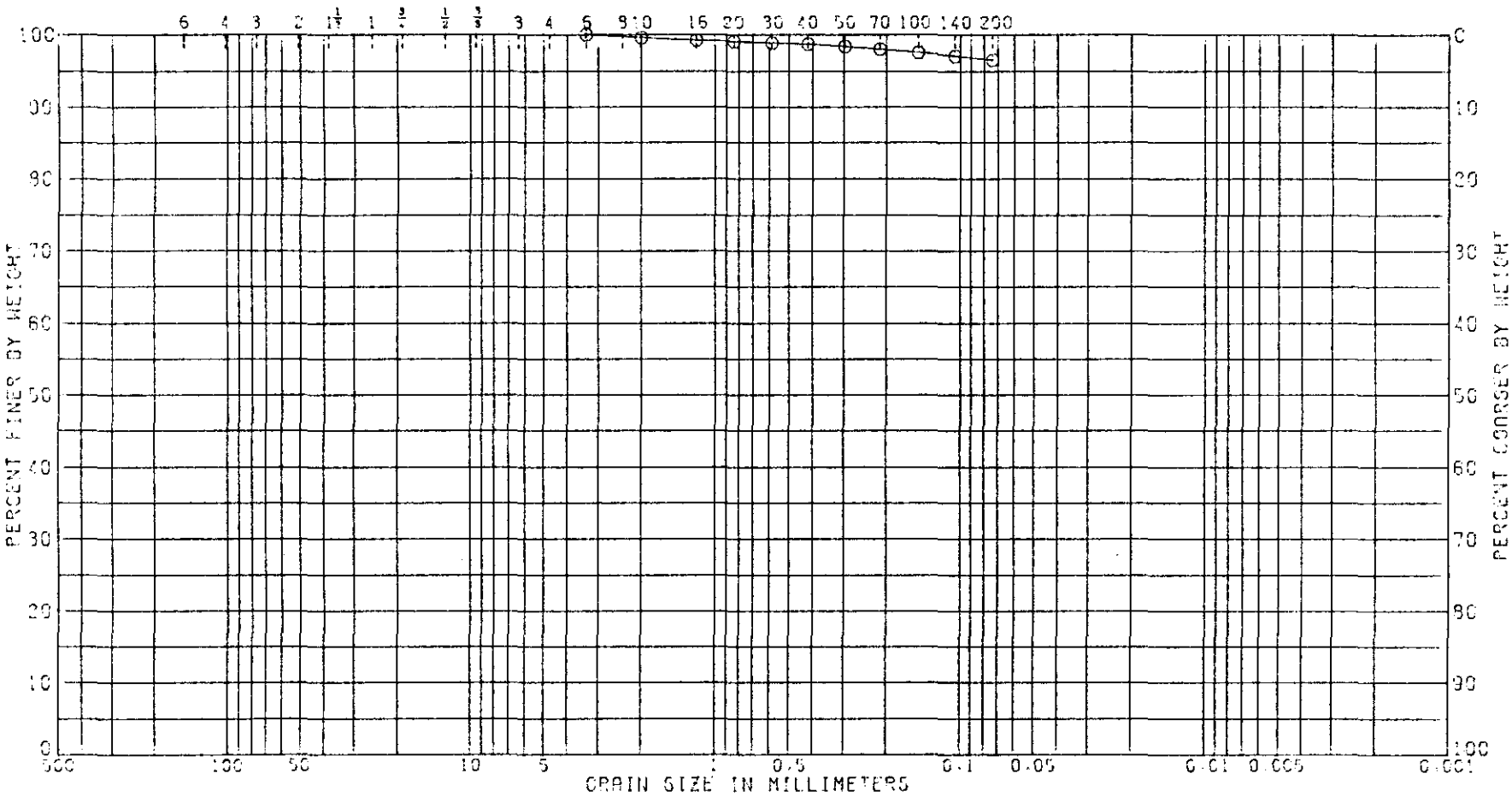
GRADATION CURVE

PROJECT CRANE NWSC

ORDANCE BURNING GROUND

BORING NO. 3-1-81 SAMPLE NO 1

DEPTH/ELEV 0.0-1.35 DATE 30 MAR 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 43 | 18 | 25 | | 15.1 |

CLASSIFICATION

CLAY (CL), GRAY; TRACE OF SAND

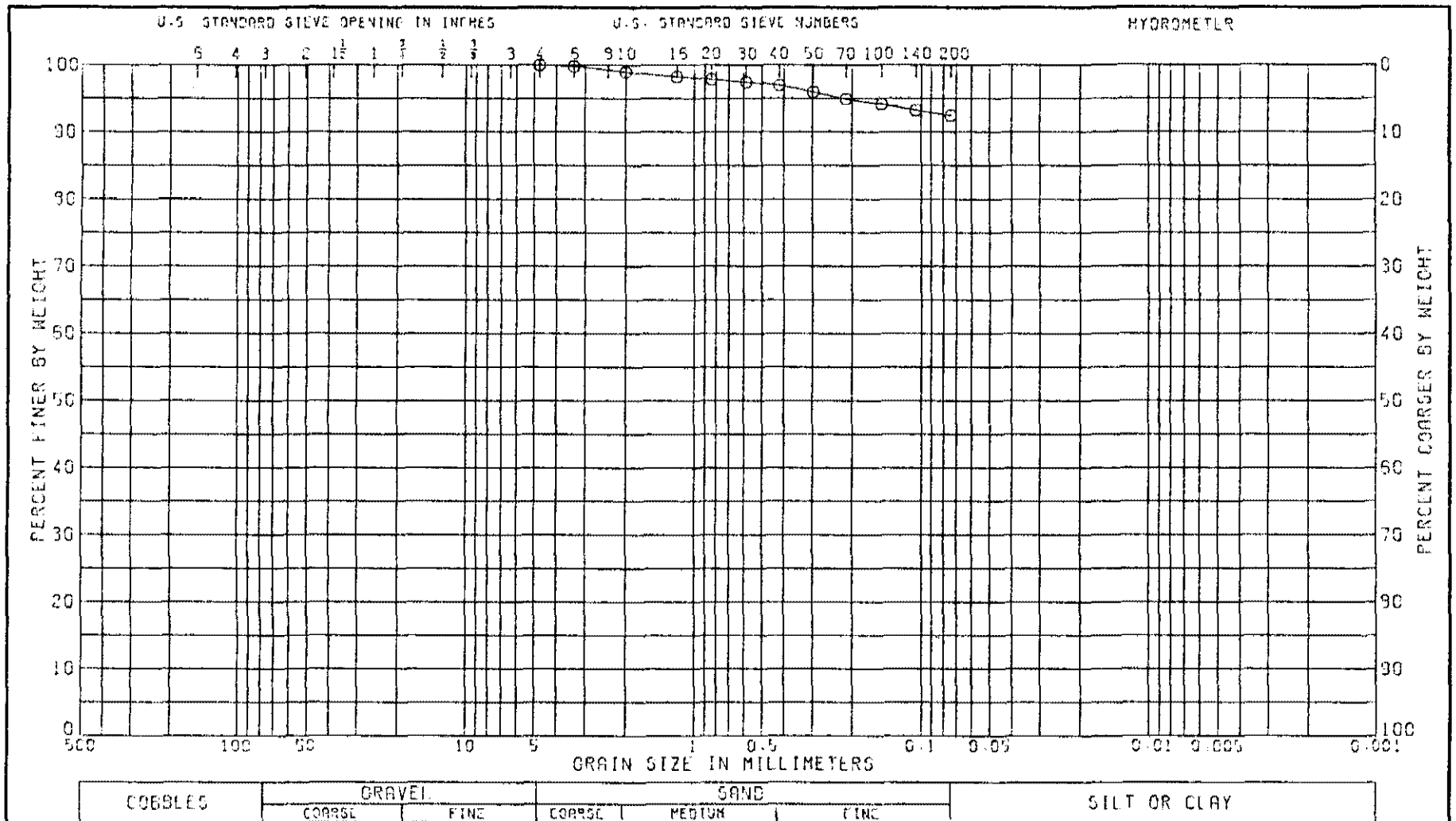
GRADATION CURVE

PROJECT CRANE NWSC

ORDNANCE BURNING GROUND

BORING NO. 3-1-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-5.71 DATE 09 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 37 | 19 | 18 | | 10.2 |

CLASSIFICATION

CLAY (CL), DARK GRAY: WITH SAND

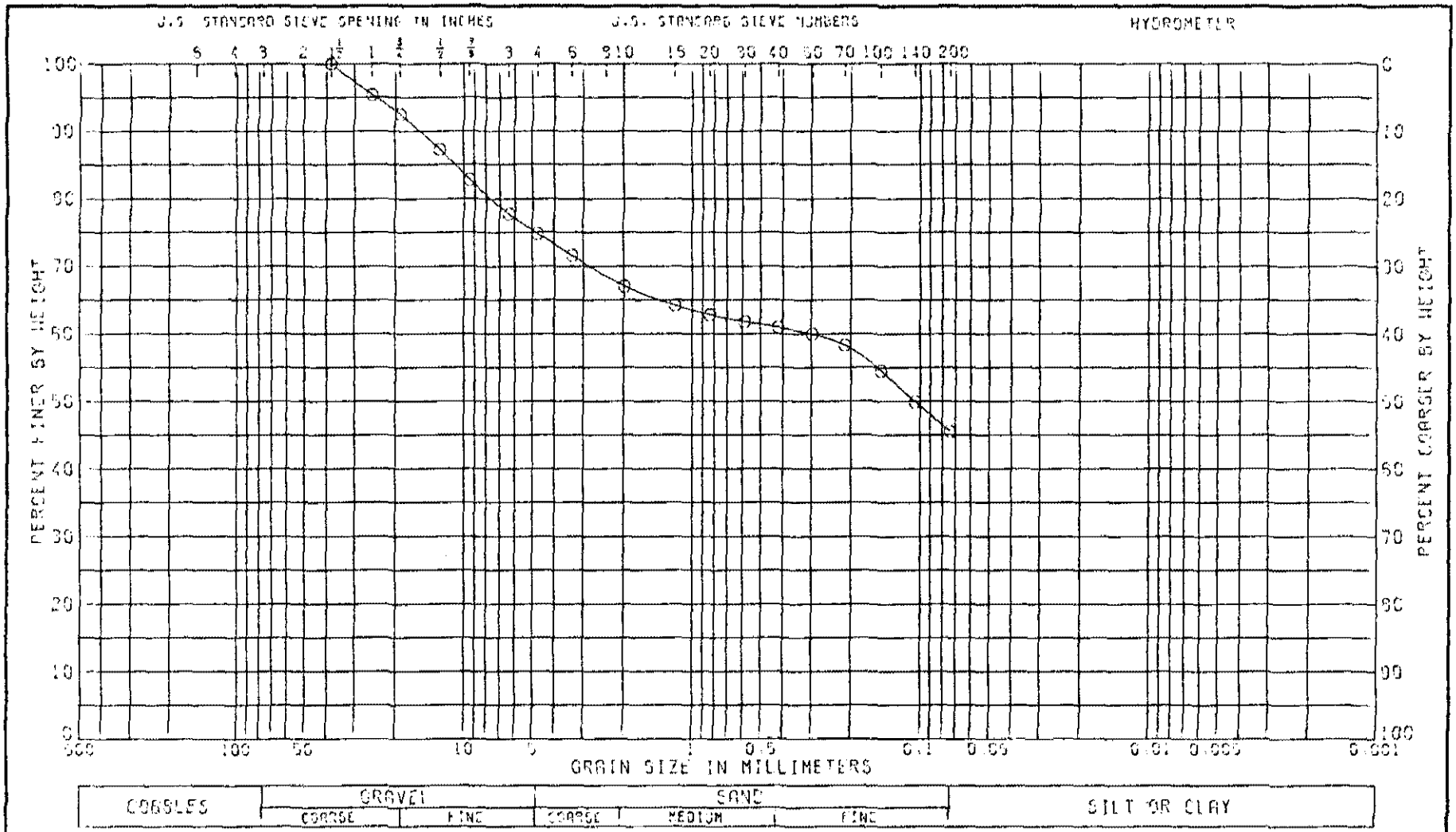
GRADATION CURVE

PROJECT CRANE NWSC

ORDANCE BURNING GROUND

BORING NO. 3-1-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-10.85 DATE 30 MAR 82




| LL 32 | PL 19 | PI 13 | GS | NAT W.% 3.7 | |
|---|---|---|---|---|---|

CLASSIFICATION

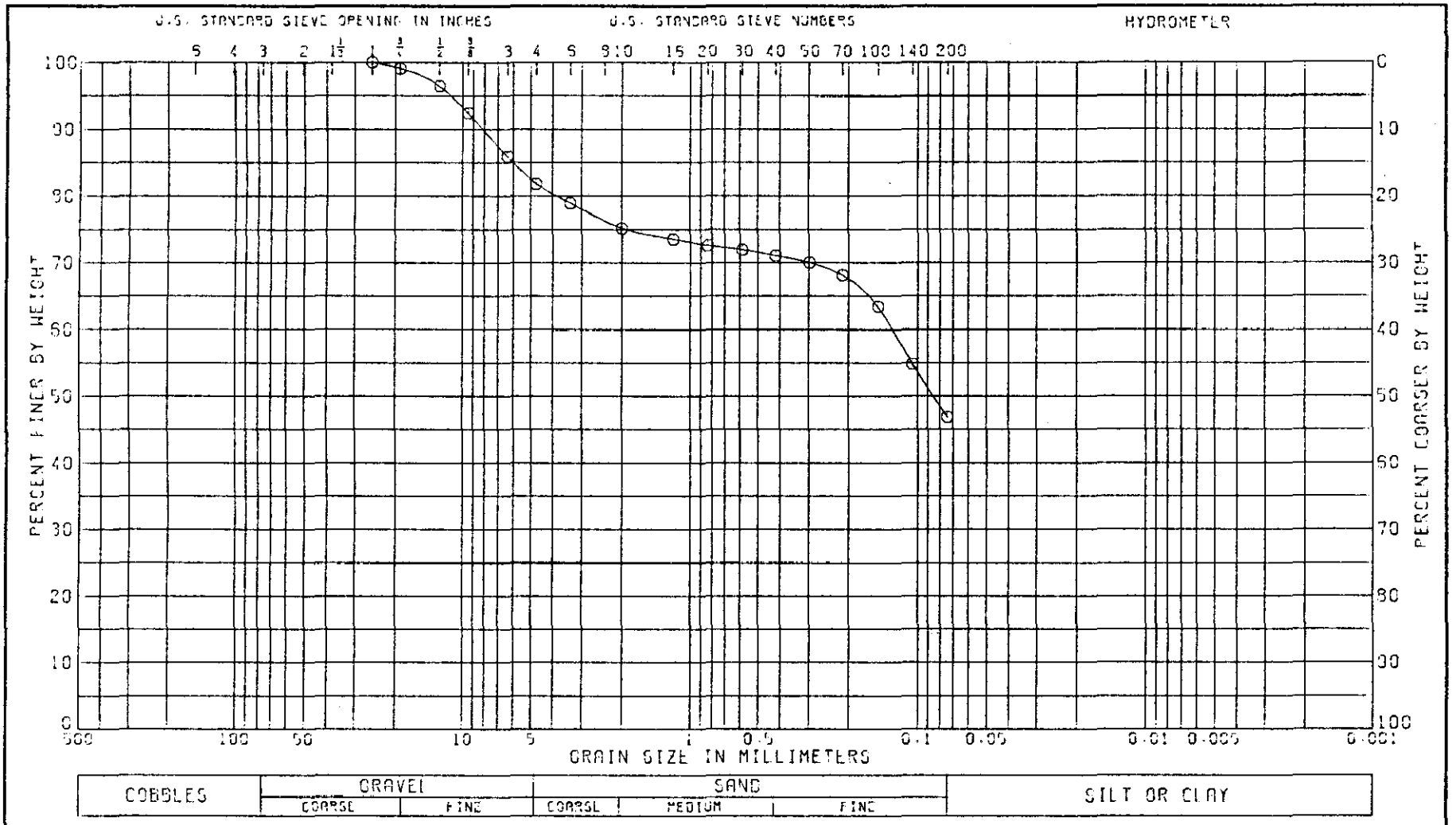
GRAVELLY CLAYEY SAND (SC), BROWN

GRADATION CURVE

PROJECT CRANE NWSC ORDNANCE BURNING GROUND

BORING NO 3-2-81 SAMPLE NO 1

DEPTH/ELEV 0.0-1.5 DATE 26 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 27 | 13 | 14 | | |

CLASSIFICATION

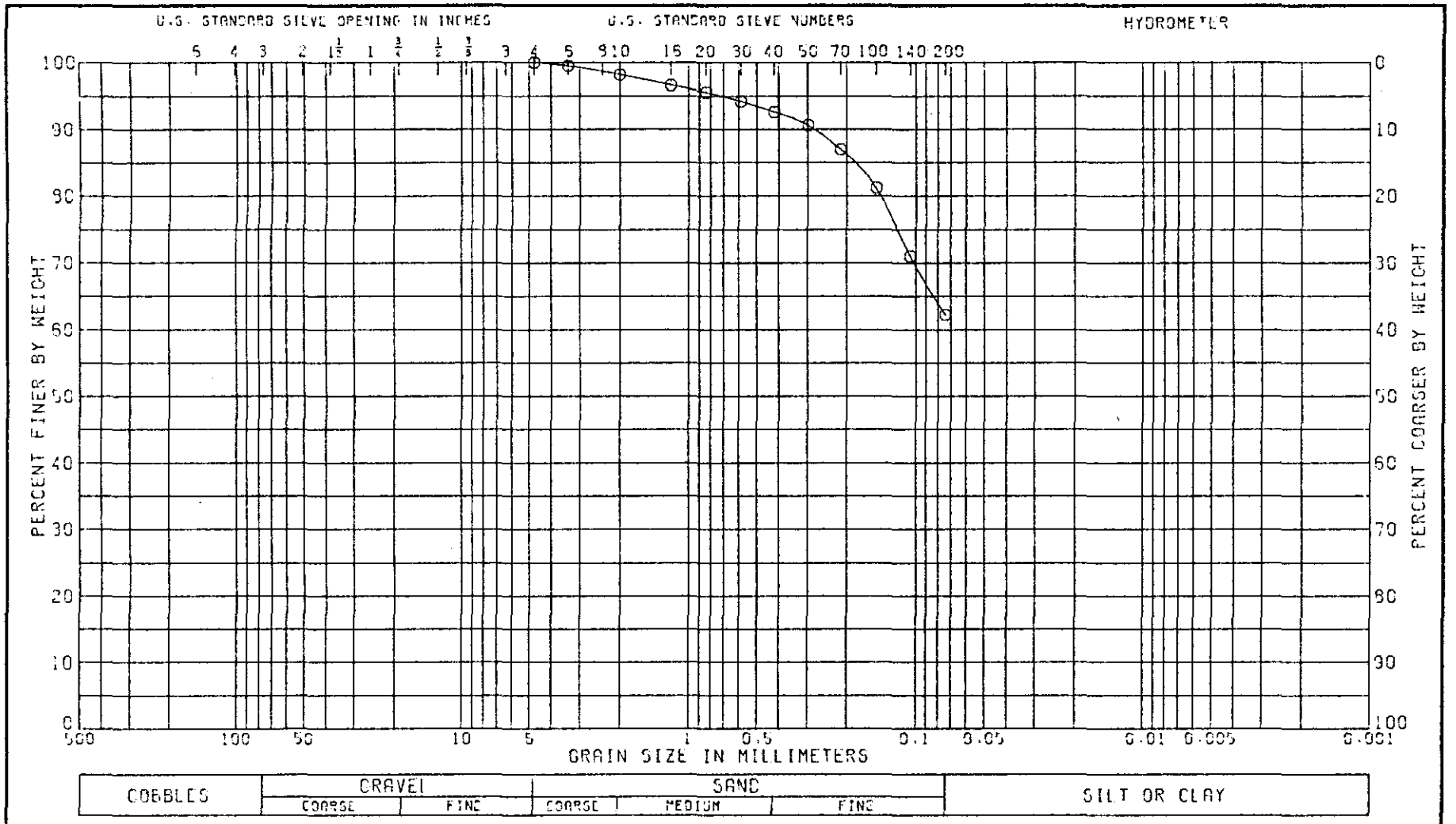
GRAVELLY CLAYEY SAND (SC), BROWN

GRADATION CURVE

PROJECT CRANE NWSC

BORING NO. 3-2--91 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.4 DATE 12 APR 92




| LL 31 | PL 17 | PI 14 | GS | NAT W.% 19.8 |
|---|---|---|---|---|

CLASSIFICATION

SANDY CLAY (CL), BROWN

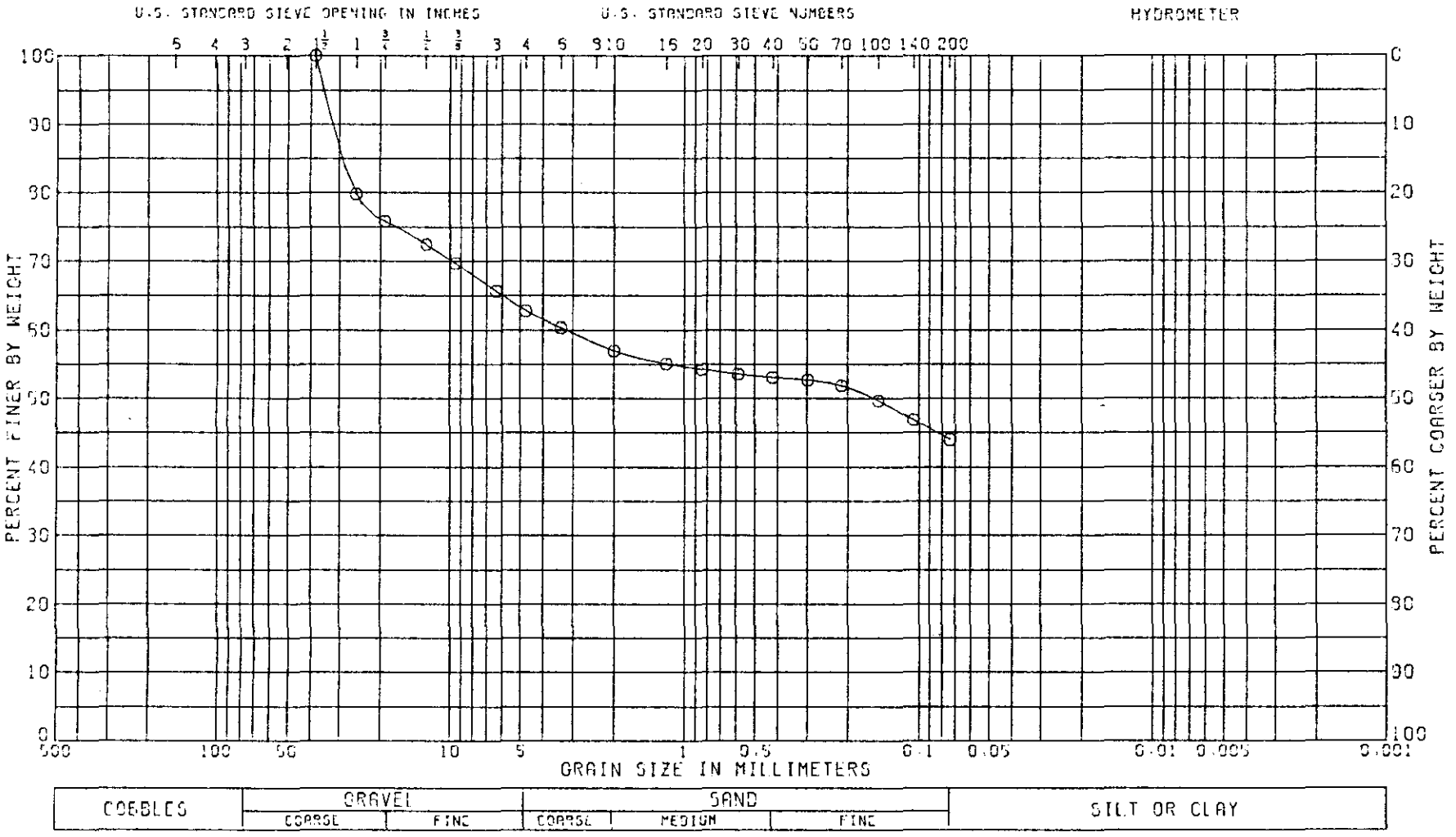
GRADATION CURVE

PROJECT CRANE NWSC

ORDANCE BURNING GROUND

BORING NO. 3-3-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.23 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 31 | 16 | 15 | | 9.8 |

CLASSIFICATION

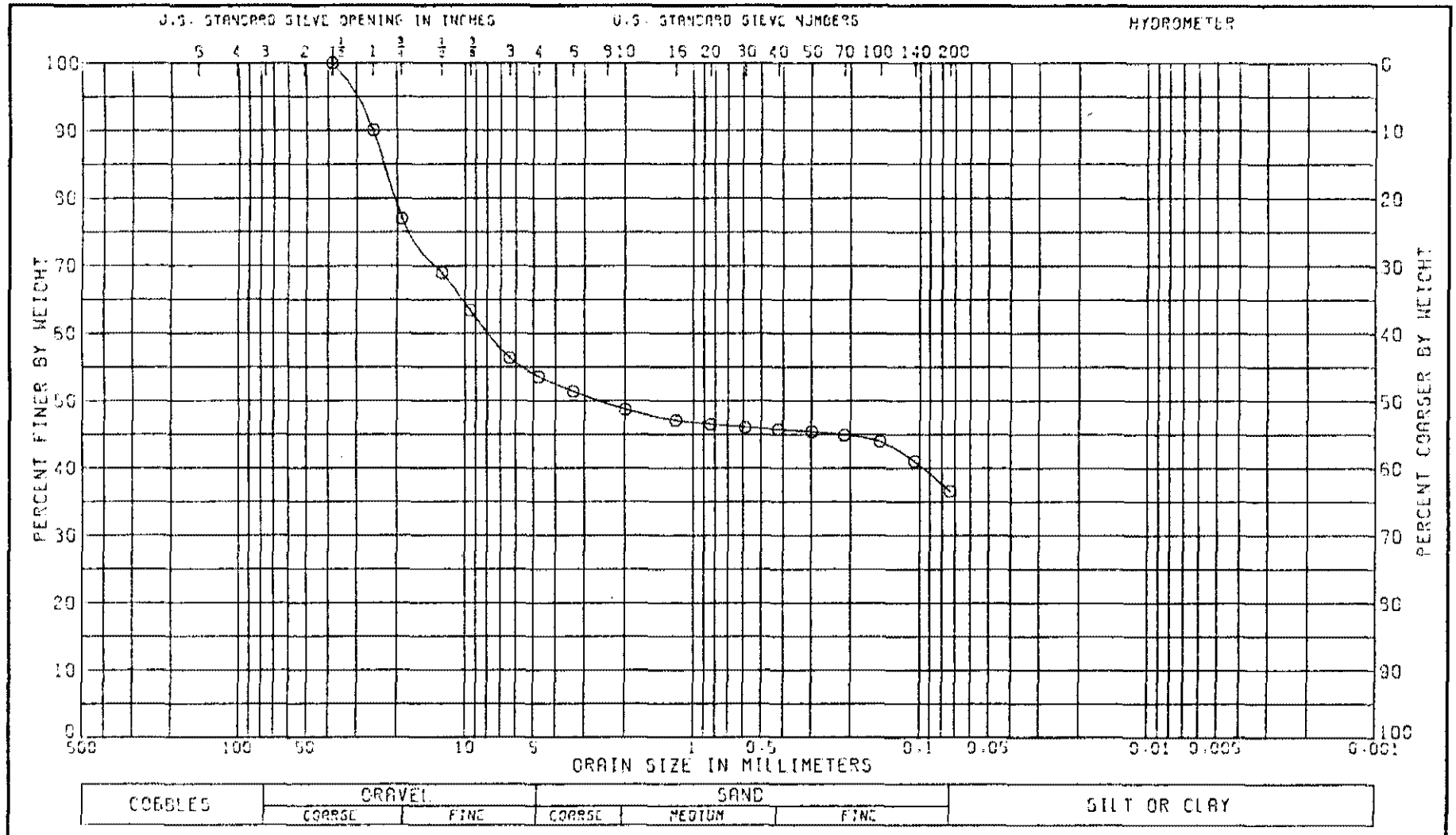
GRAVELLY CLAYEY SAND (SC), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
ORDANCE BURNING GROUND

BORING NO. 3-4-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.3 DATE 30 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 24 | 15 | 9 | | 12.0 |

CLASSIFICATION

SANDY CLAYEY GRAVEL (GC), TAN

INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

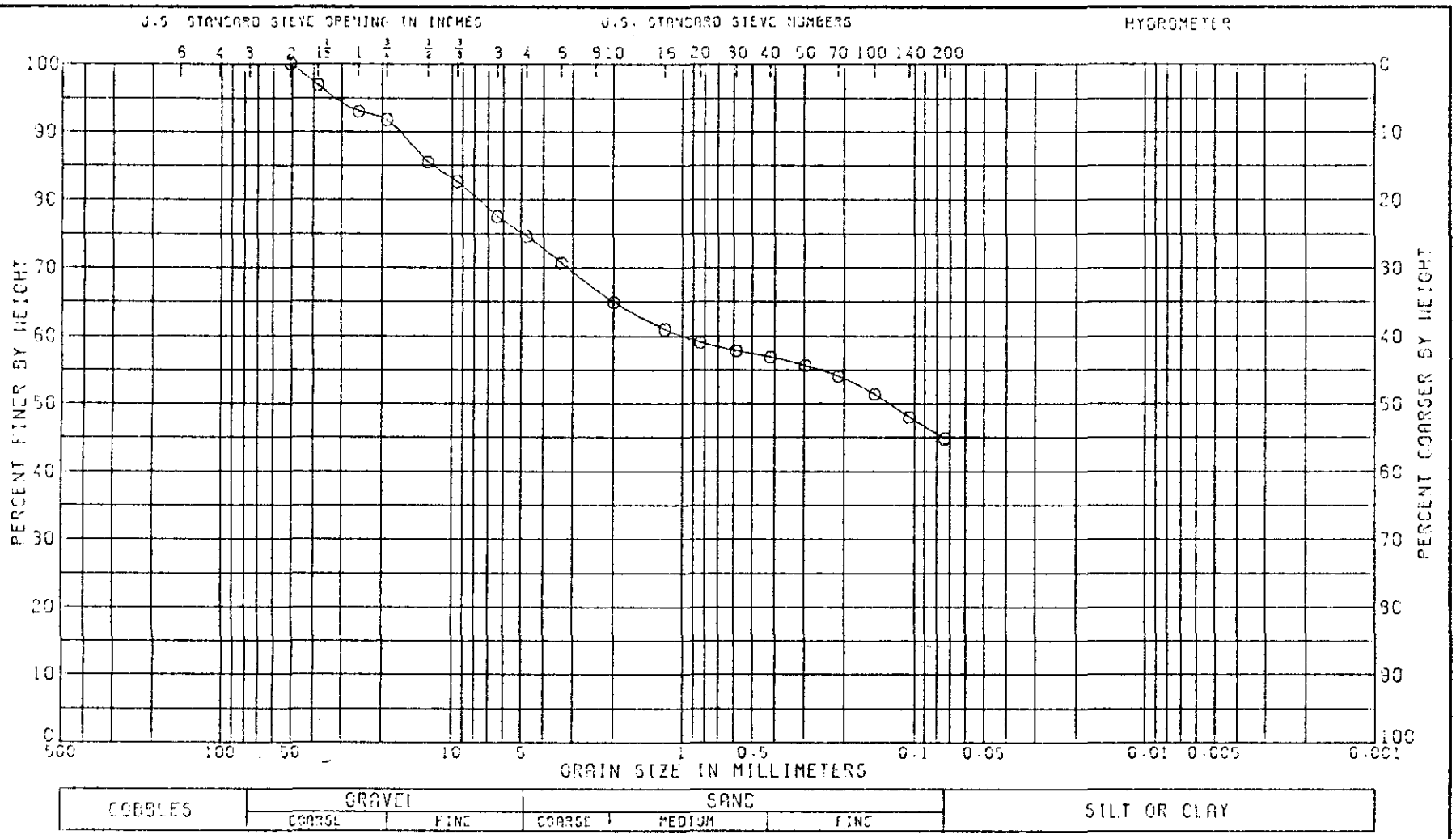
GRADATION CURVE

PROJECT CRANE NWSC

ORDANCE BURNING GROUND

BORING NO. 3-5-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.25 DATE 30 MAR 82




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 27 | 16 | 11 | | 13.7 |

CLASSIFICATION

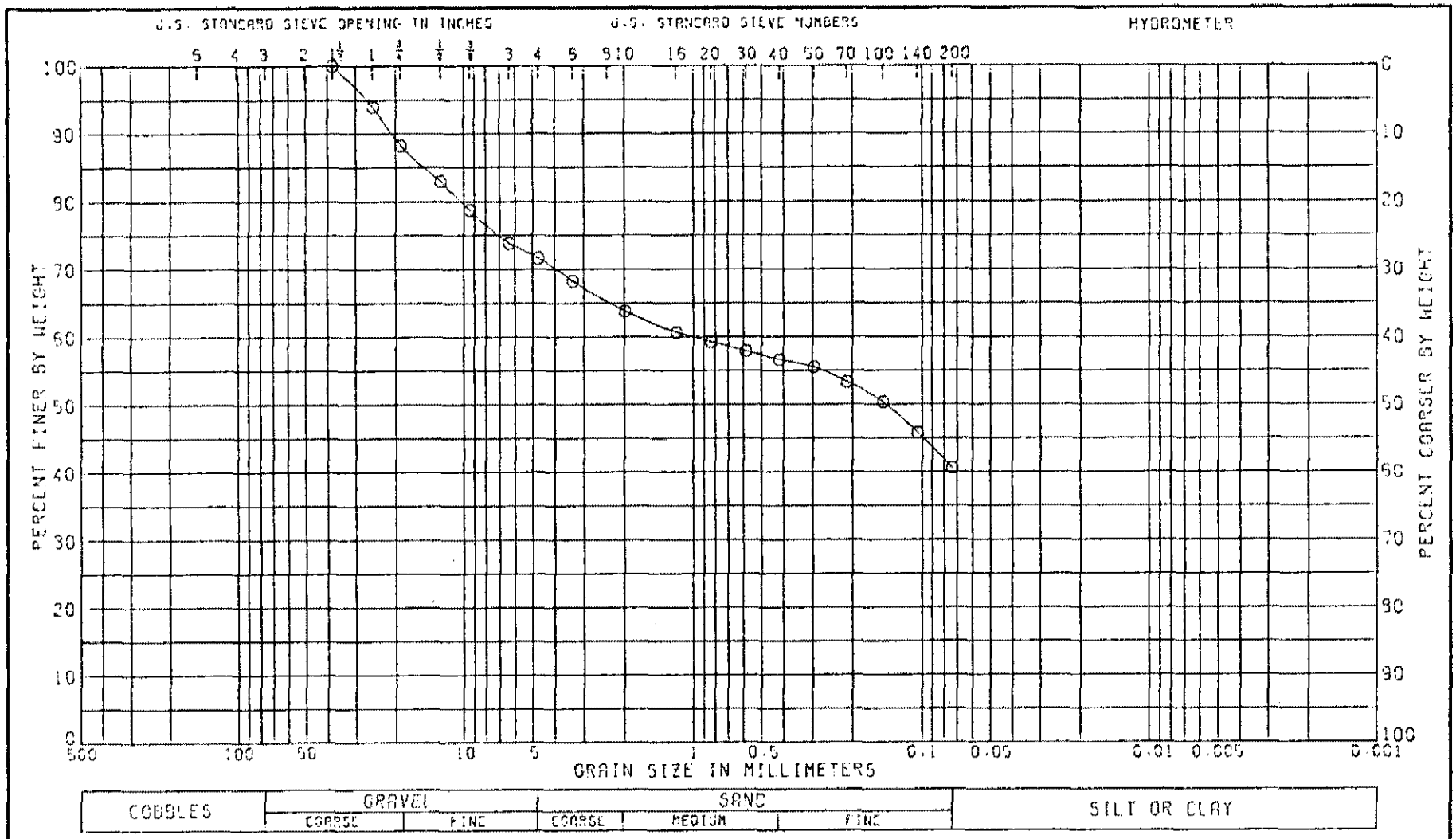
GRAVELLY CLAYEY SAND (SC), TAN

GRADATION CURVE

PROJECT CRANE NWSC ORDANCE BURING GROUND

BORING NO. 3-6-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.73 DATE 11 FEB 92




| LL 38 | PL 16 | PI 22 | GS | NAT W.% 12.3 |
|---|---|---|---|---|

CLASSIFICATION

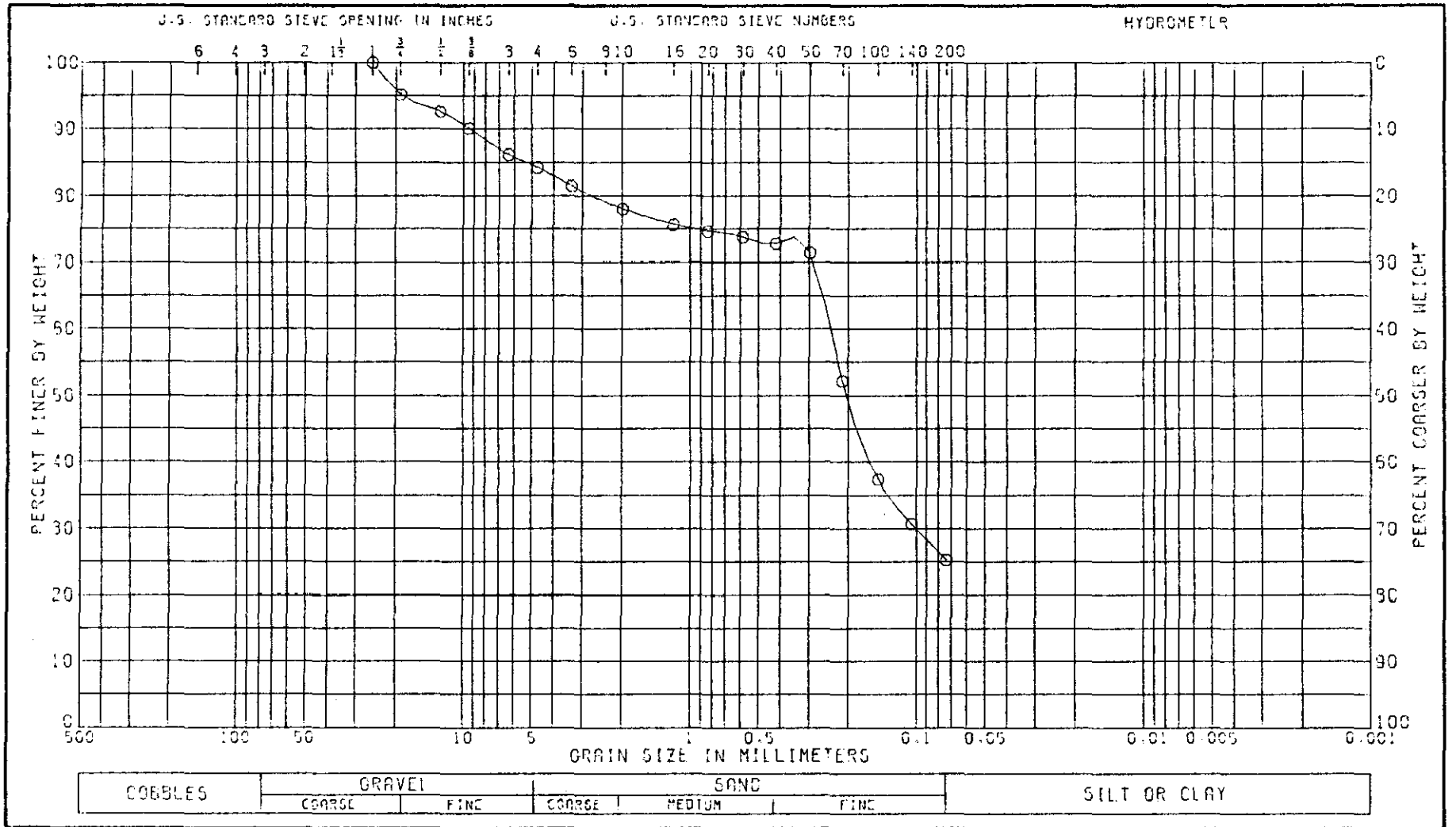
GRAVELLY CLAYEY SAND (SC), BROWN

GRADATION CURVE

PROJECT CRANE NWSC ORDANCE BURING GROUND

BORING NO. 3-7-91 SAMPLE NO. 1

DEPTH/ELEV 0.0--0.72 DATE 11 FEB 92




| LL 24 | PL 13 | PI 11 | GS | NAT W.% 17.9 |
|---|---|---|---|---|

CLASSIFICATION

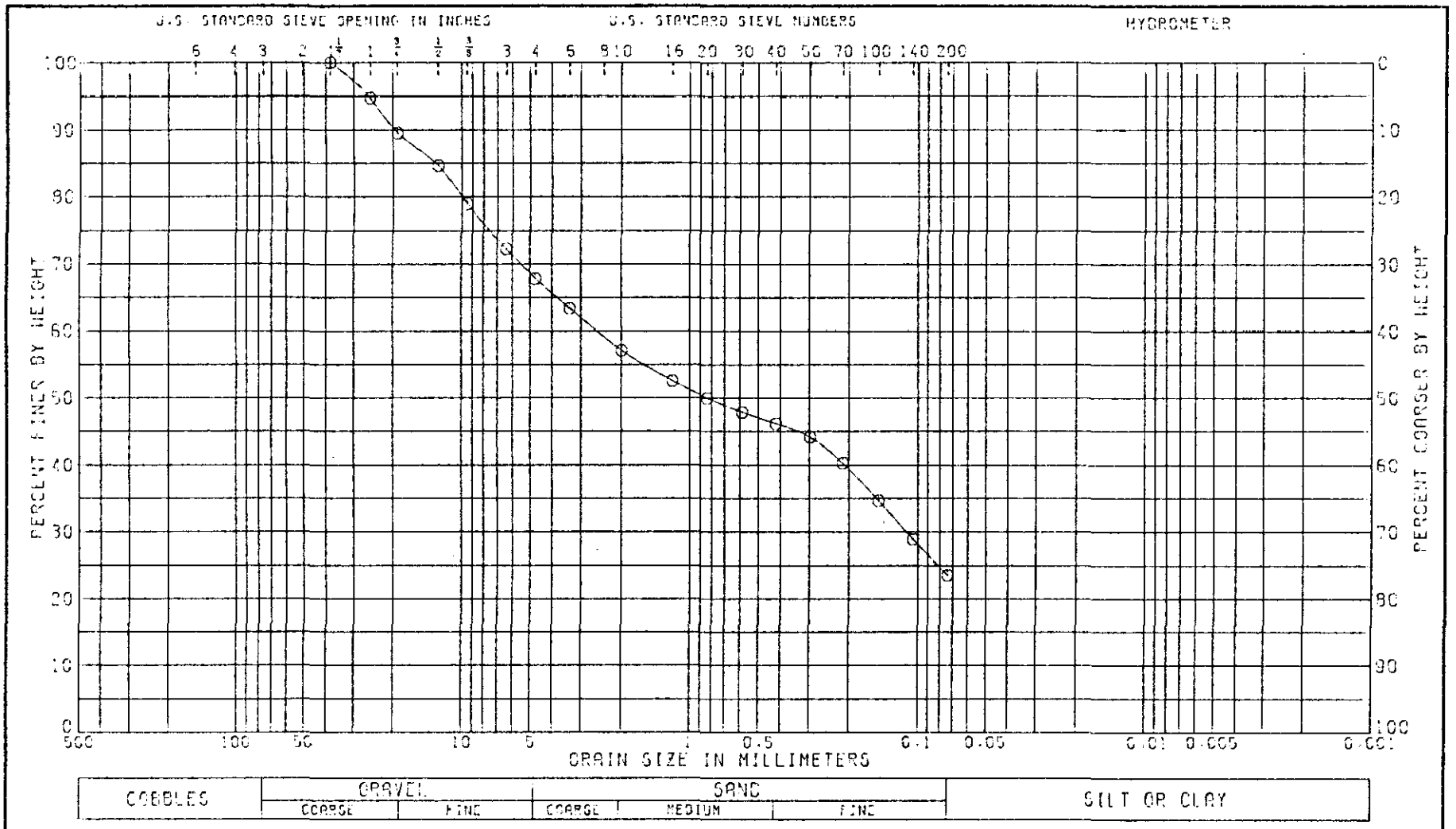
GRAVELLY CLAYEY SAND (SC), REDDISH BROWN

GRADATION CURVE

PROJECT CRANE NWSC ORDANCE BURING GROUND

BORING NO. 3-7-91 SAMPLE NO 3

DEPTH/ELEV 10.0-11.57 DATE 11 FEB 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 26 | 15 | 11 | | 12.6 |

CLASSIFICATION

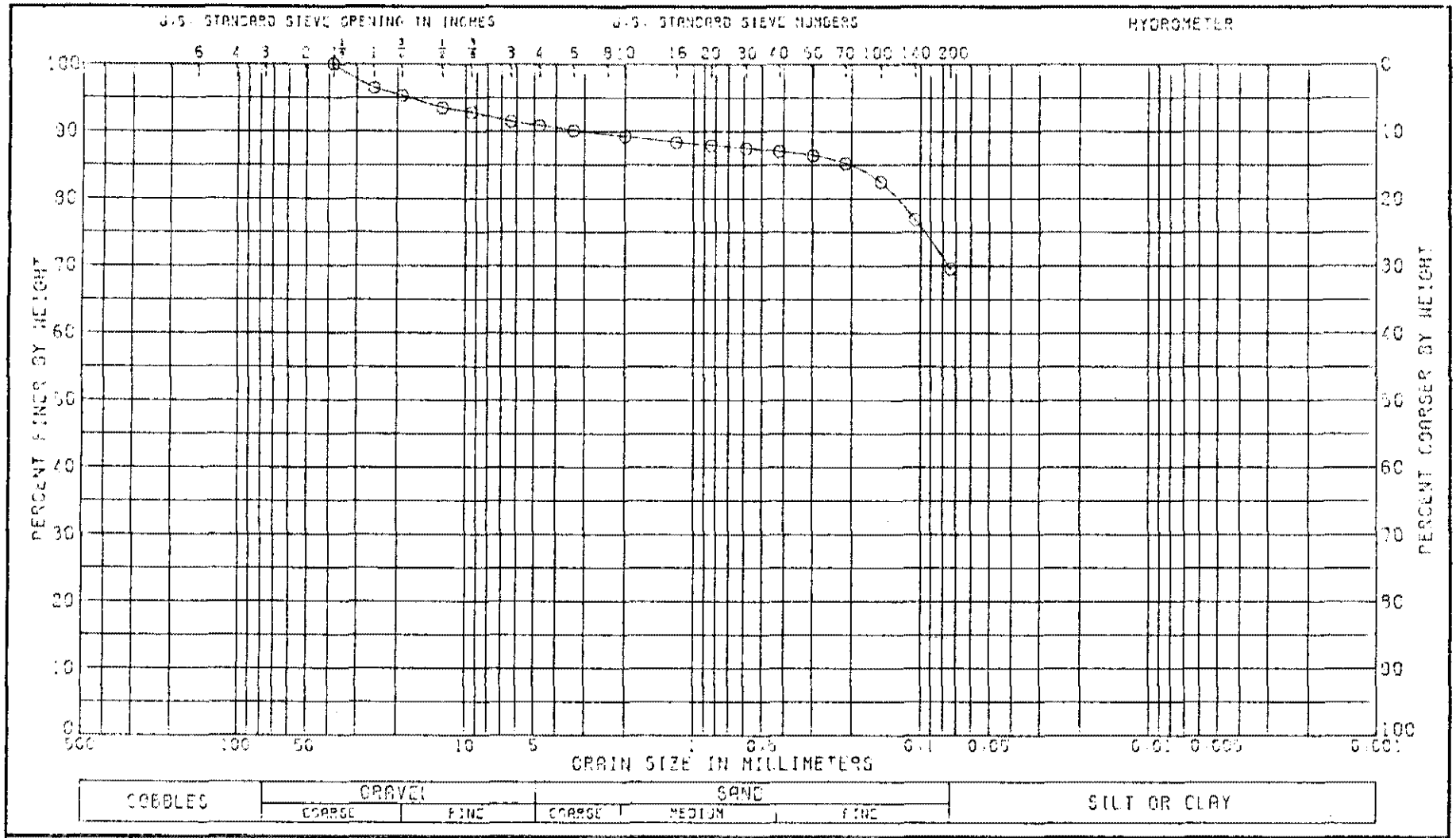
GRAVELLY CLAYEY SAND (SC), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
ORDNANCE BURNING GROUND

BORING NO. 3-7-81 SAMPLE NO. 4

DEPTH/ELEV 15.0-16.33 DATE 09 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 36 | 20 | 16 | | 18.4 |

CLASSIFICATION

SANDY CLAY (CL), BROWN: WITH GRAVEL

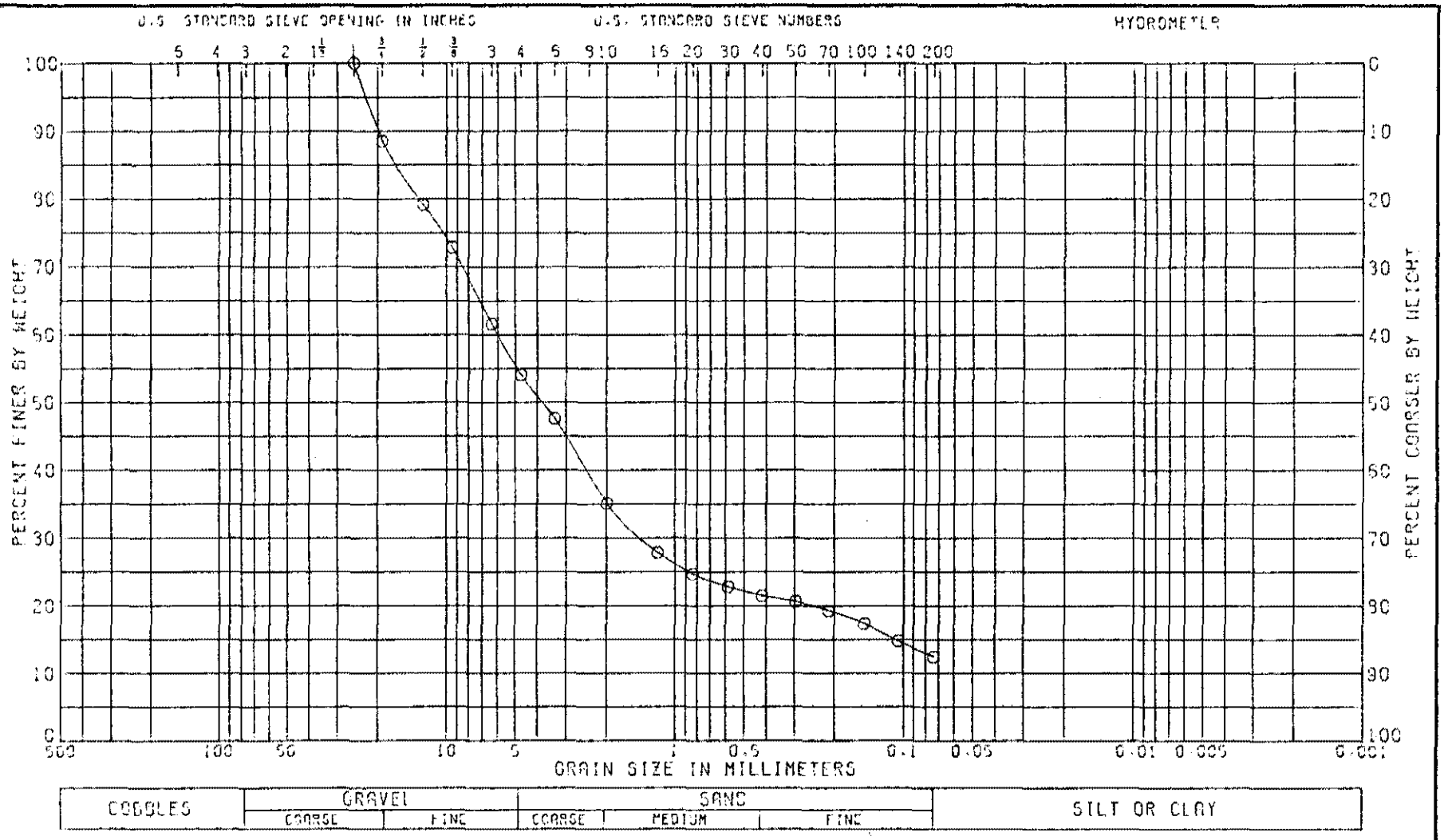
GRADATION CURVE

PROJECT CRANE NLSC

ORDNANCE BURNING GROUND

BORING NO. 3-8-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.86 DATE 20 MAR 82




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 23 | 14 | 9 | | 8.0 |

CLASSIFICATION

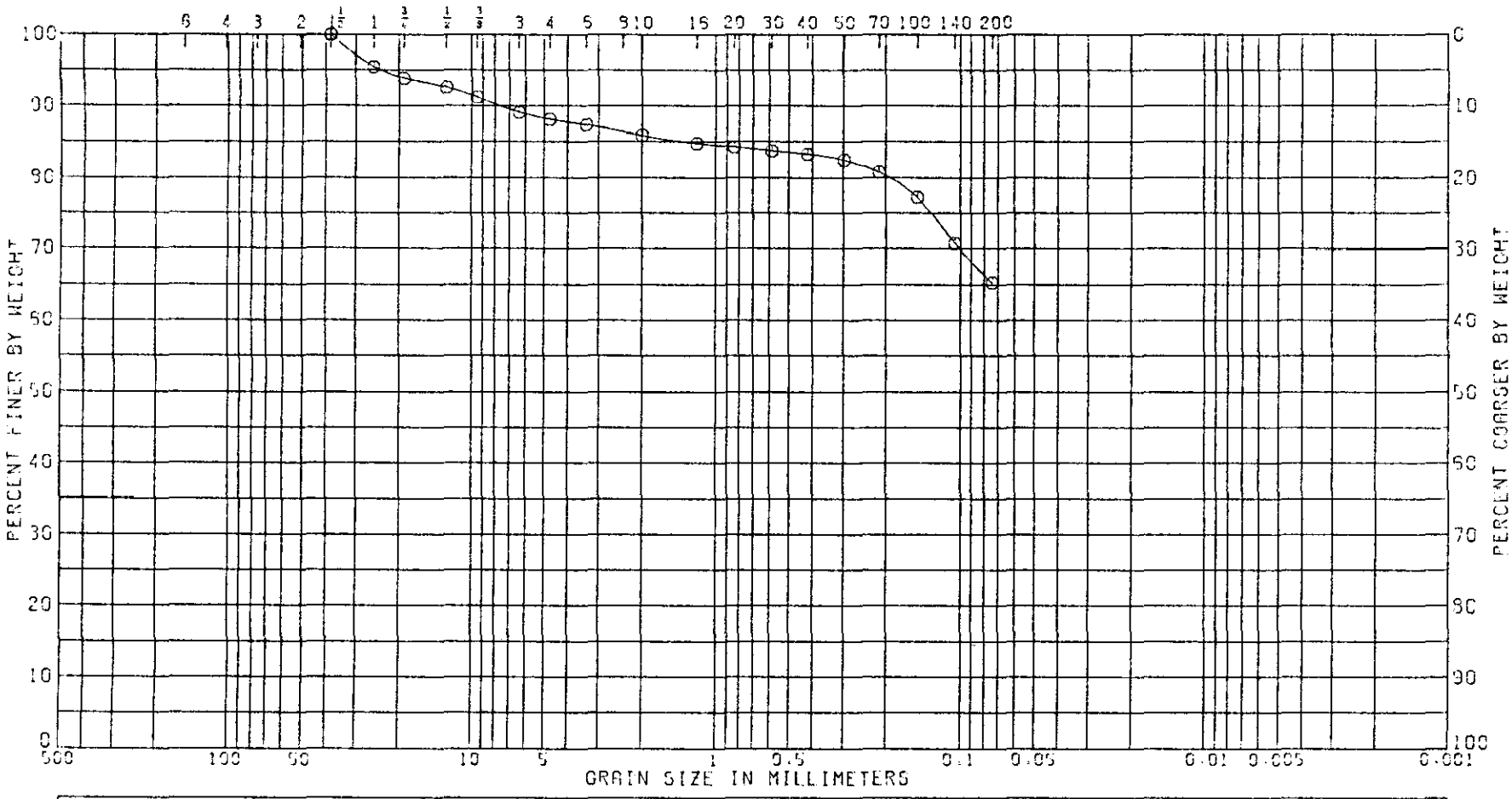
GRAVELLY CLAYEY SAND (SC), REDDISH BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC ORDANCE BURING GROUND

BORING NO. 3-B-B1 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.0' DATE 11 FEB 92




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |

| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 25 | 16 | 9 | | 15.3 |

CLASSIFICATION

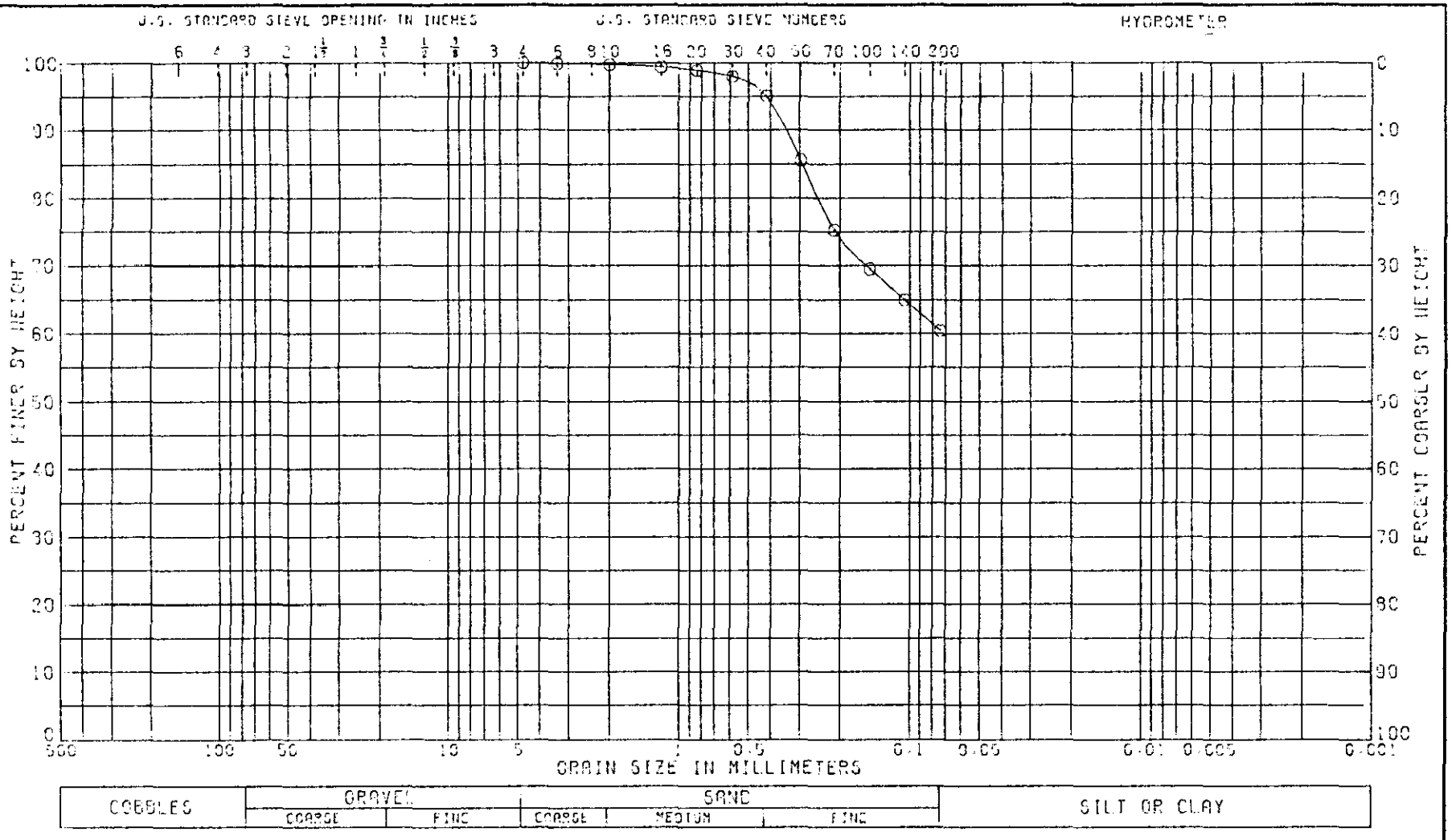
SANDY CLAY (CL), BROWN: WITH GRAVEL
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
ORDANCE BURNING GROUND

BORING NO. 3-9-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-0.99 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 29 | 15 | 14 | | 15.0 |

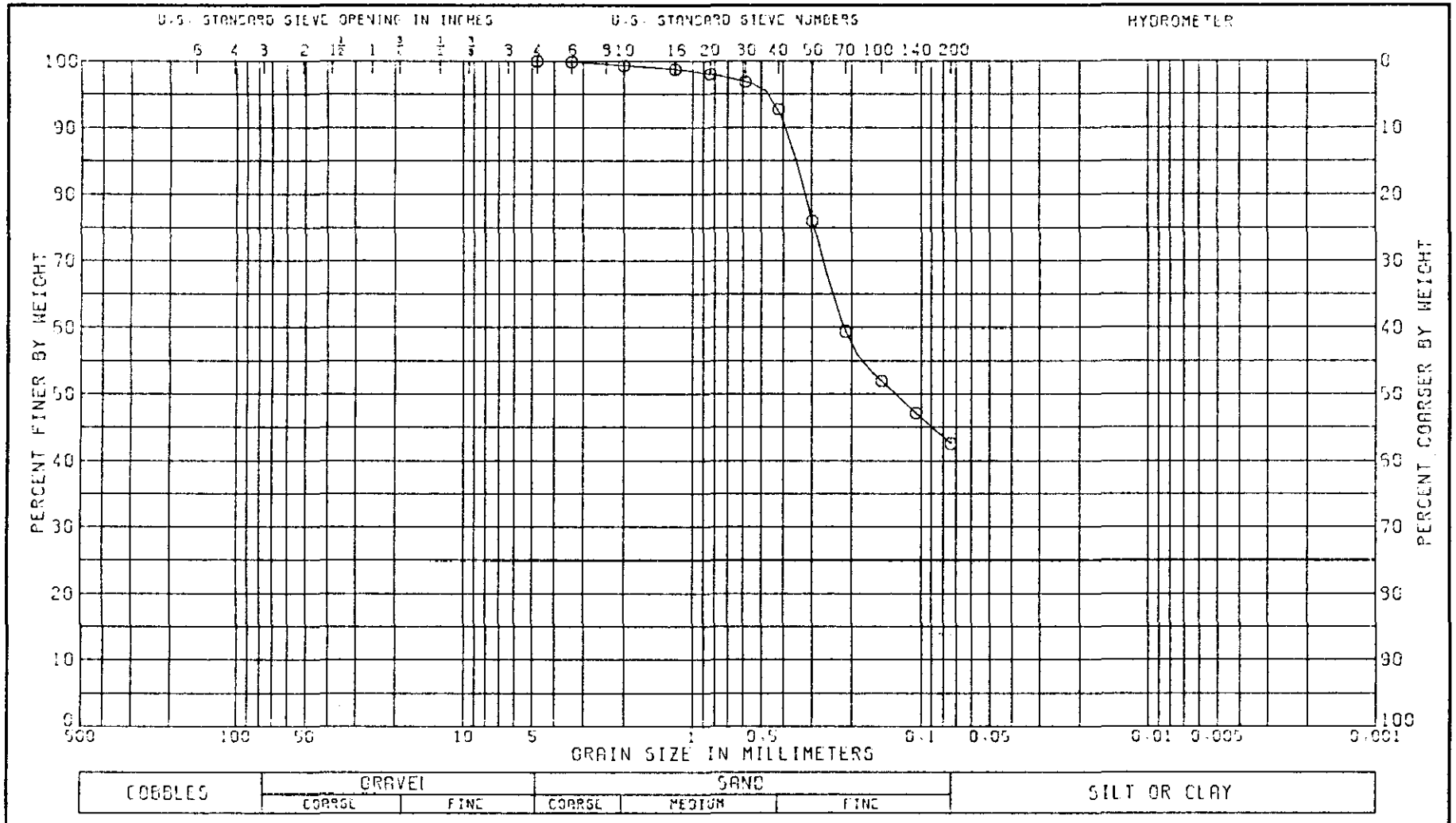
CLASSIFICATION
SANDY CLAY (CL), TAN

GRADATION CURVE

PROJECT CRANE NESC
MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.09 DATE 09 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 27 | 16 | 11 | | 17.8 |

CLASSIFICATION

CLAYEY SAND (SC), TAN

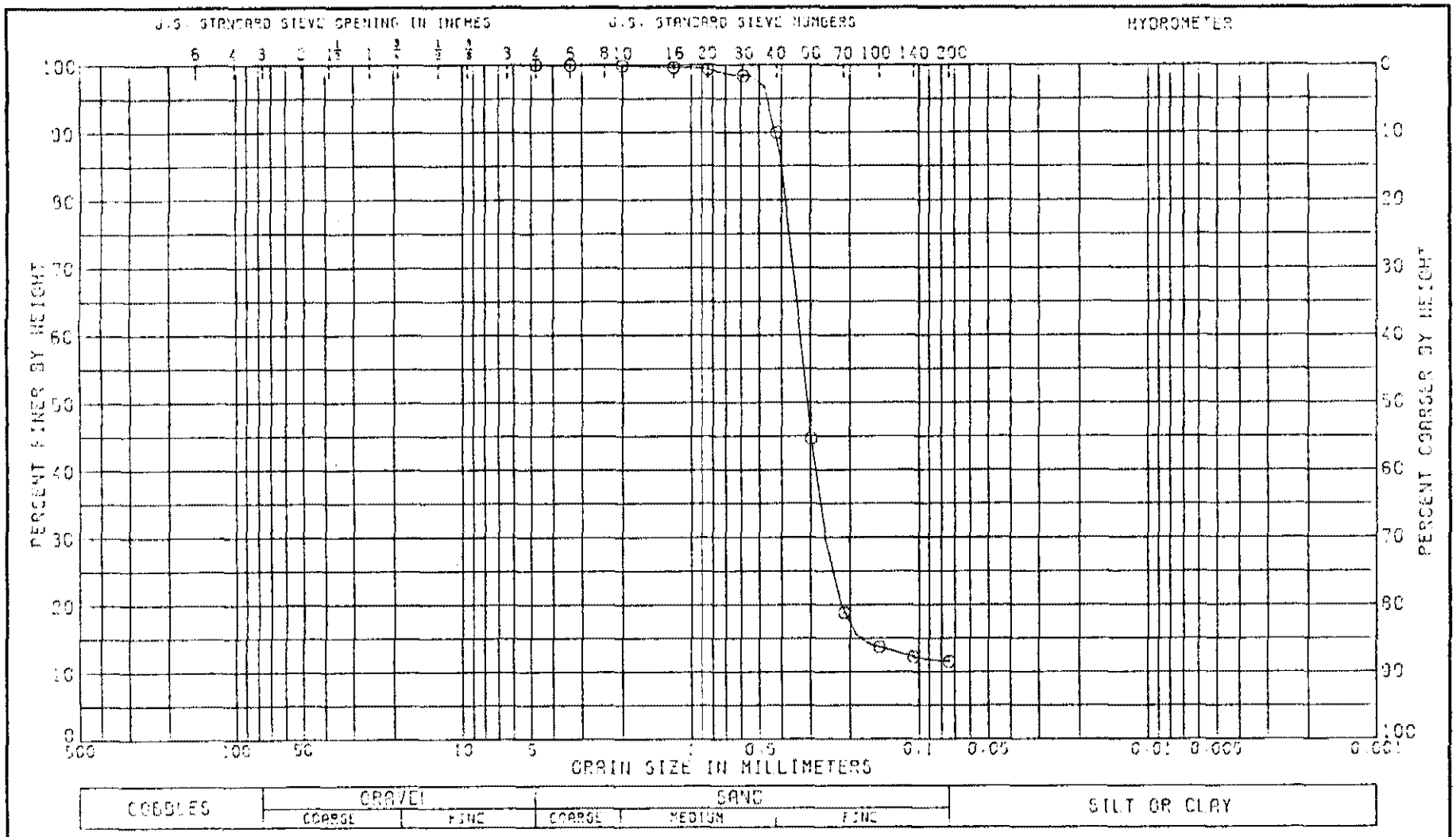
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.55 DATE 30 MAR 82




| LL 19 | PL 12 | PI 7 | GS | NAT W.% 10.3 | |
|---|---|---|---|---|---|

CLASSIFICATION

CLAYEY SAND (SP-SC), REDDISH BROWN

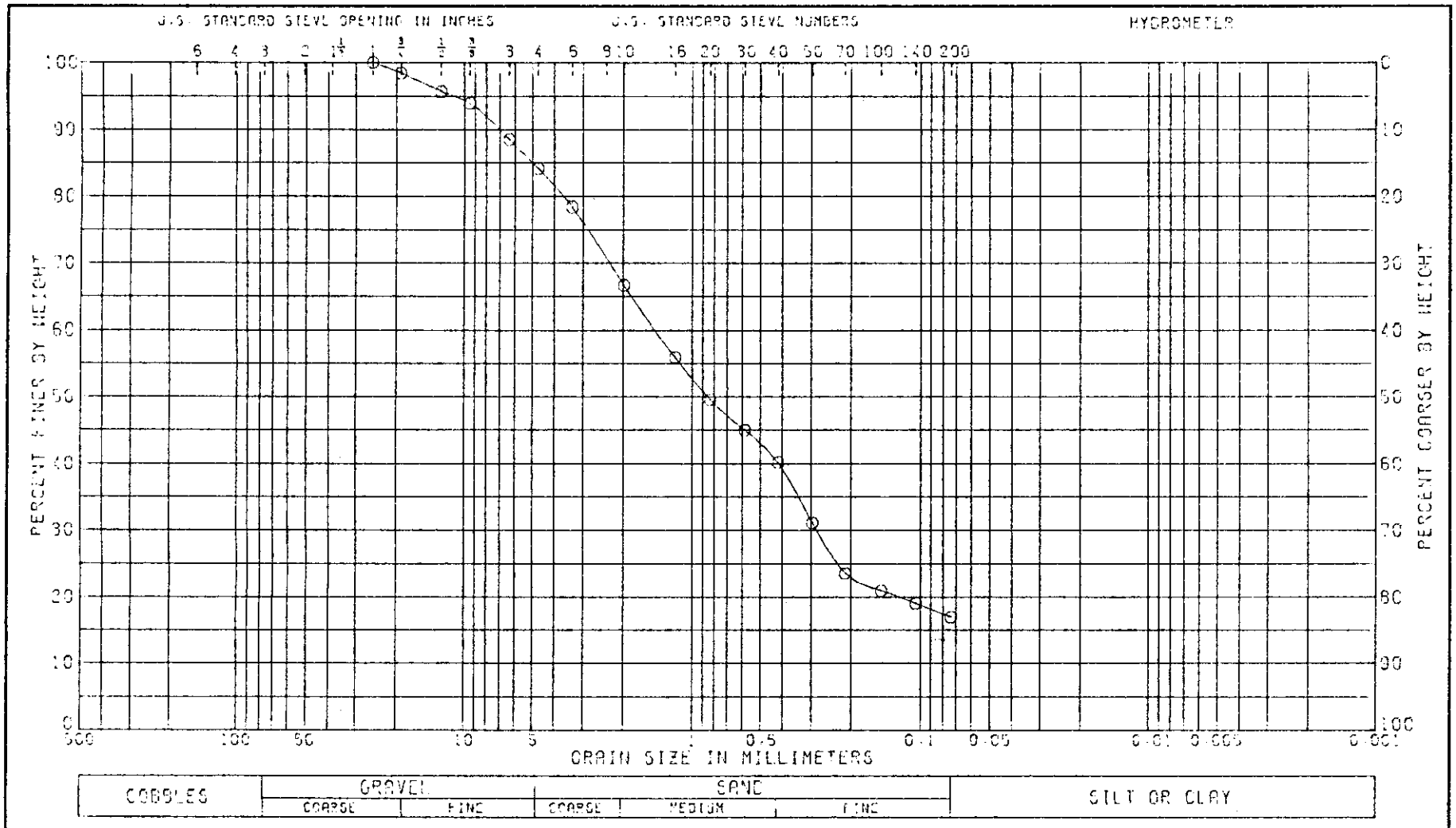
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO 3

DEPTH/ELEV 10.0-10.3 DATE 09 MAR 83




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 28 | 17 | 11 | | 15.0 |

CLASSIFICATION

GRAVELLY CLAYEY SAND (SC), BROWN

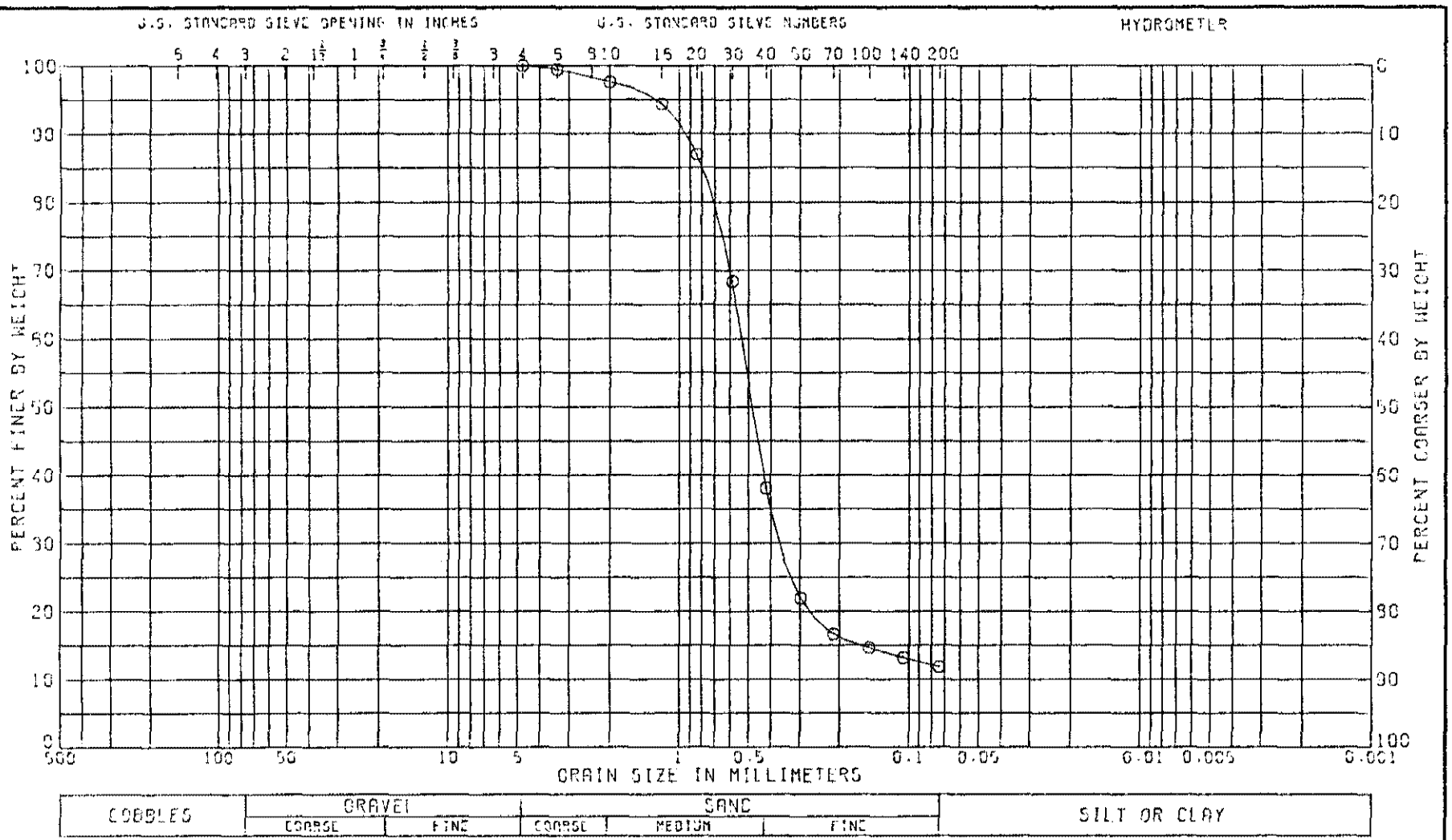
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO 4-1-81 SAMPLE NO. 4

DEPTH/ELEV 15.0-16.07 DATE 09 MAR 82




| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| NP | | | | 11.3 | |

CLASSIFICATION

SILTY SAND (SP-SM), TAN

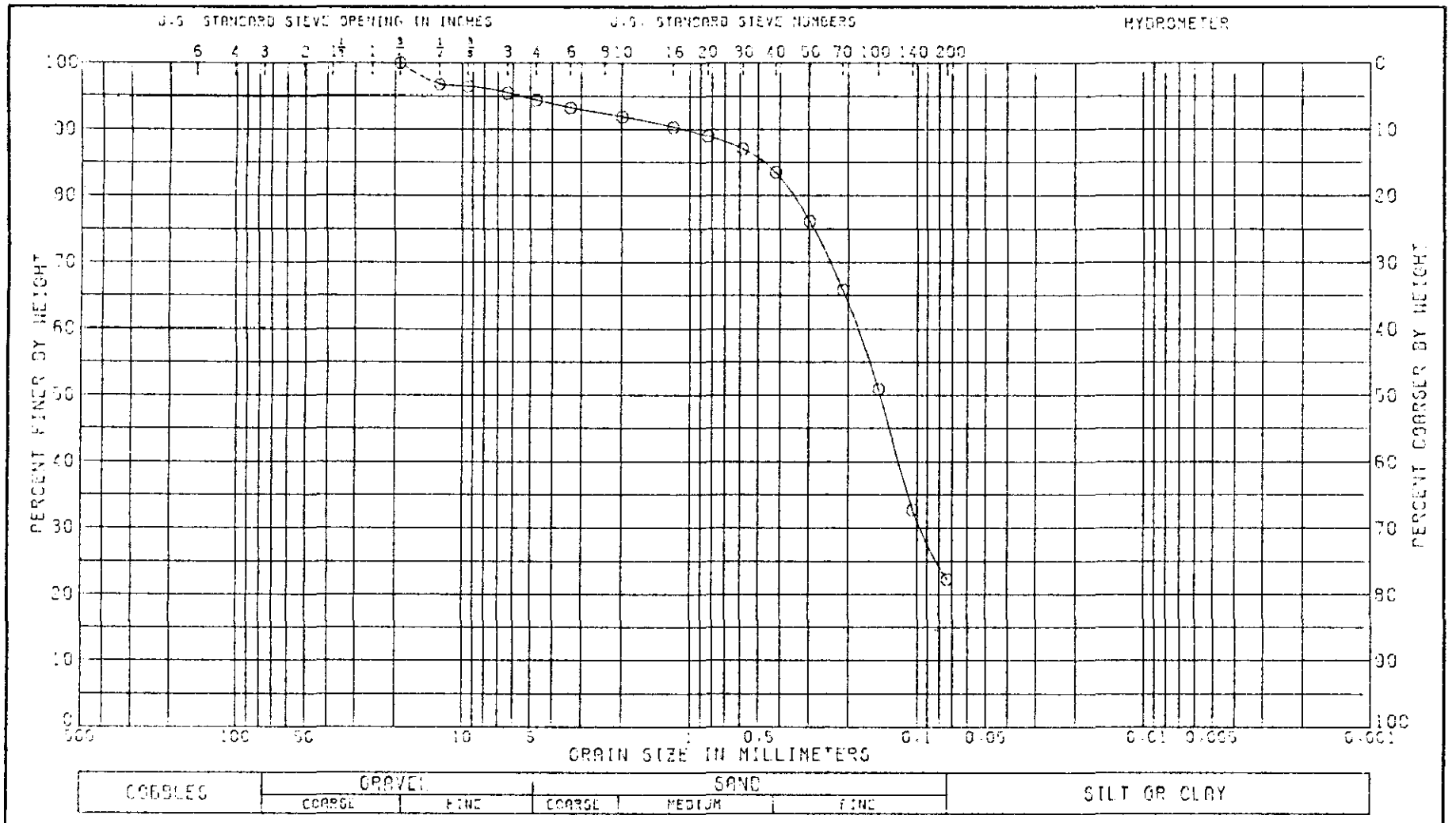
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO. 5

DEPTH/ELEV 20.0-22.05 DATE 30 MAR 82




| LL NP | PL | PI | GS | NAT W.% 15.5 | |
|---|---|---|---|---|---|

CLASSIFICATION

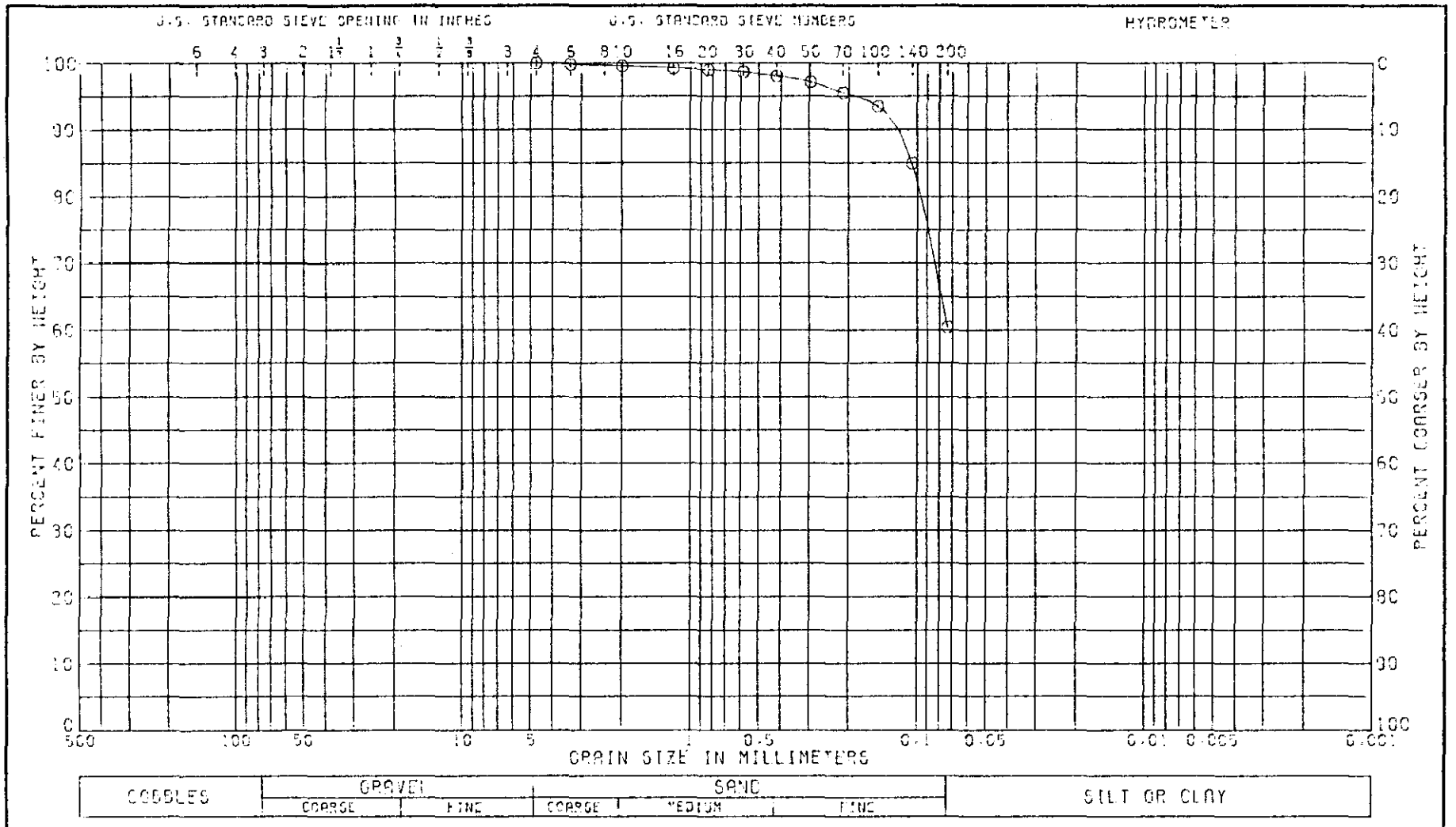
SILTY SAND (SM) BROWN: WITH GRAVEL

GRADATION CURVE

PROJECT CRANE NLSC
MCCONISH GORGE

BORING NO. 4--1-81 SAMPLE NO 6

DEPTH/ELEV 25.0-27.8 DATE 03 MAR 82




| LL 25 | PL 18 | PI 7 | GS | NAT W.% 19.1 | |
|---|---|---|---|---|---|

CLASSIFICATION

SANDY CLAY (CL), BROWN

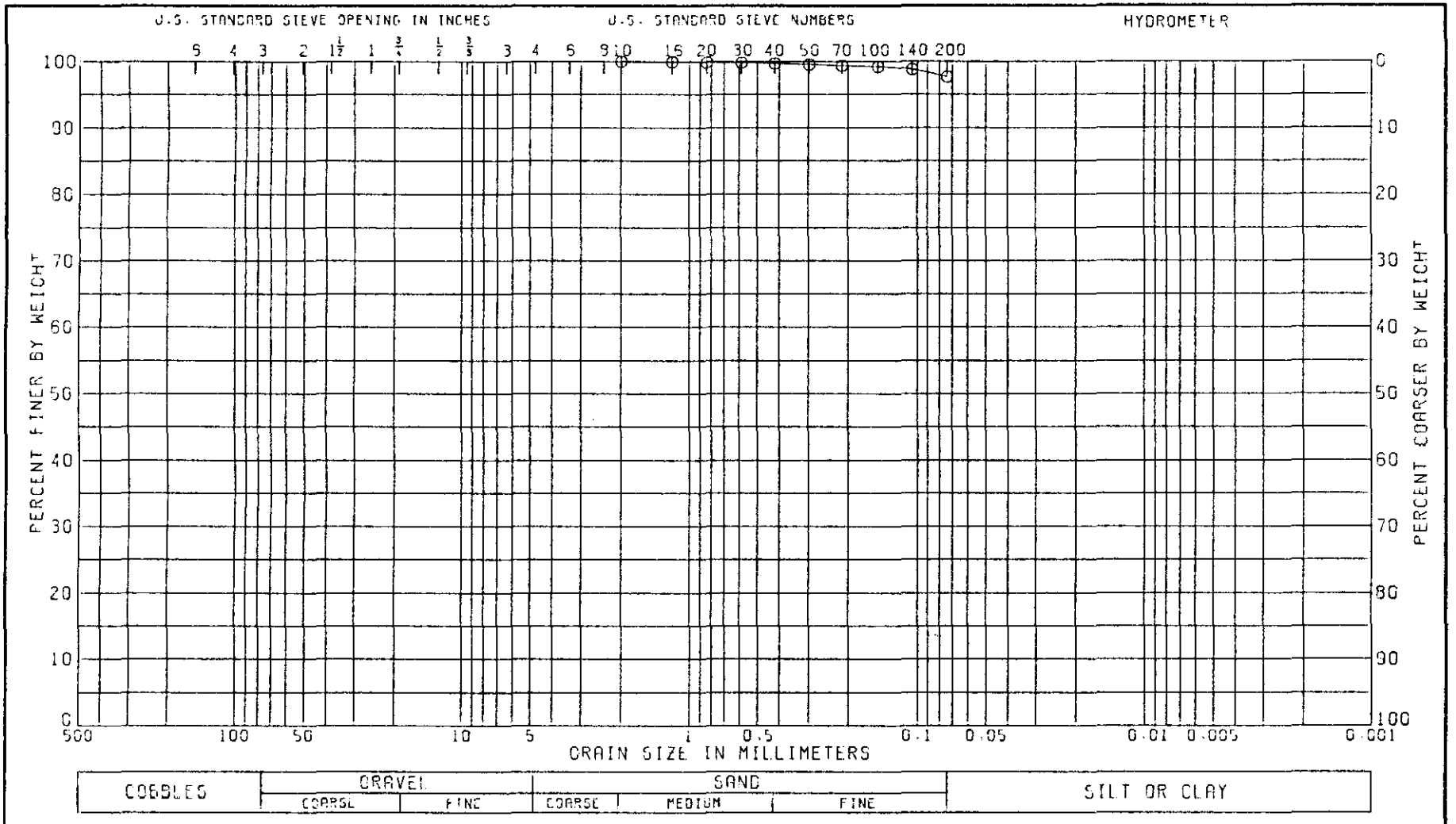
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO 8

DEPTH/ELEV 32.5-33.3 DATE 09 MAR 82




| LL 26 | PL 18 | PI 8 | CS | NAT W.% 23.1 |
|---|---|---|---|---|

CLASSIFICATION

CLAY (CL), GRAY

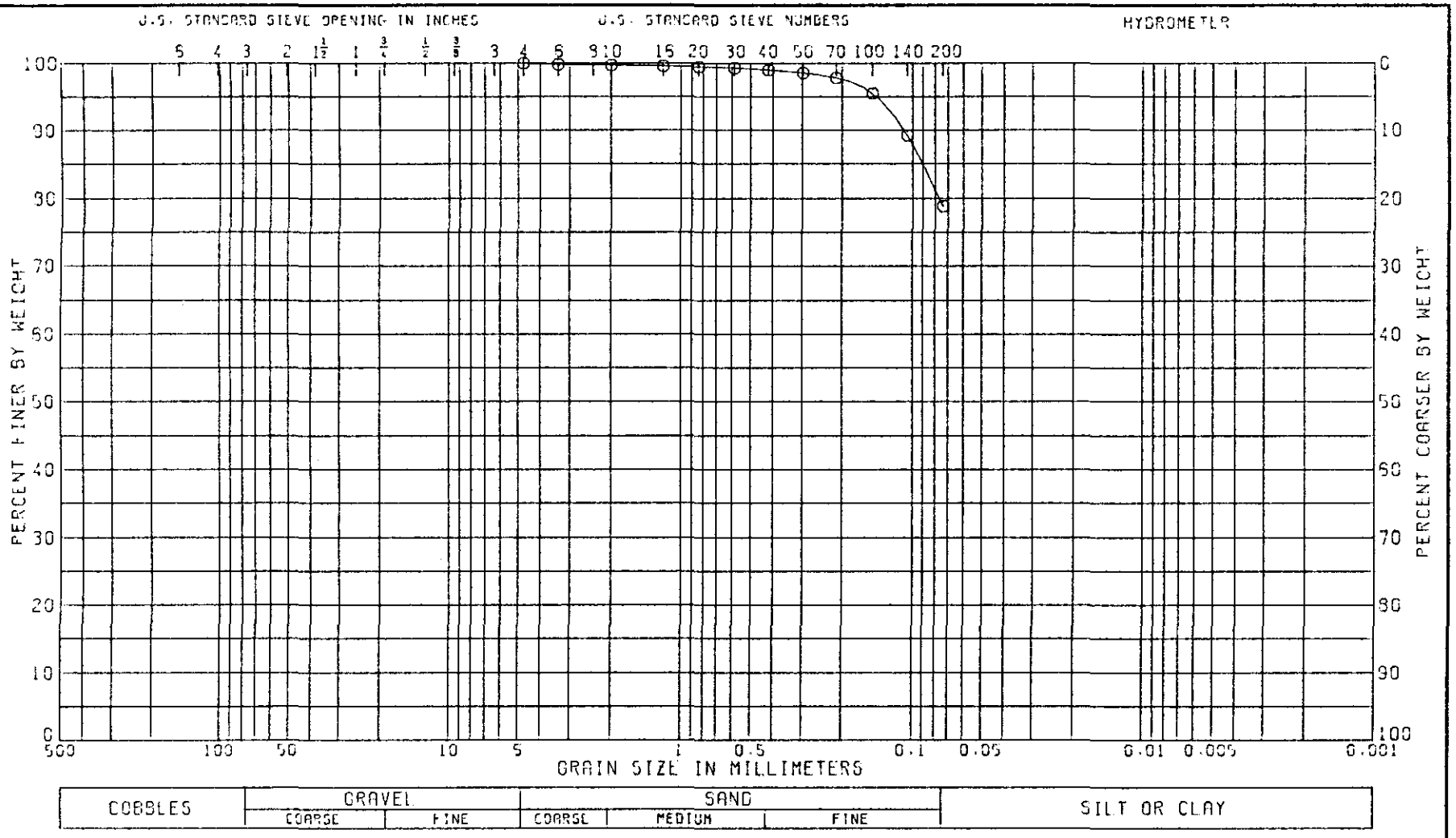
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO 9

DEPTH/ELEV 37.5-39.55 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 17.2 |

CLASSIFICATION

SANDY SILT (ML), GRAY

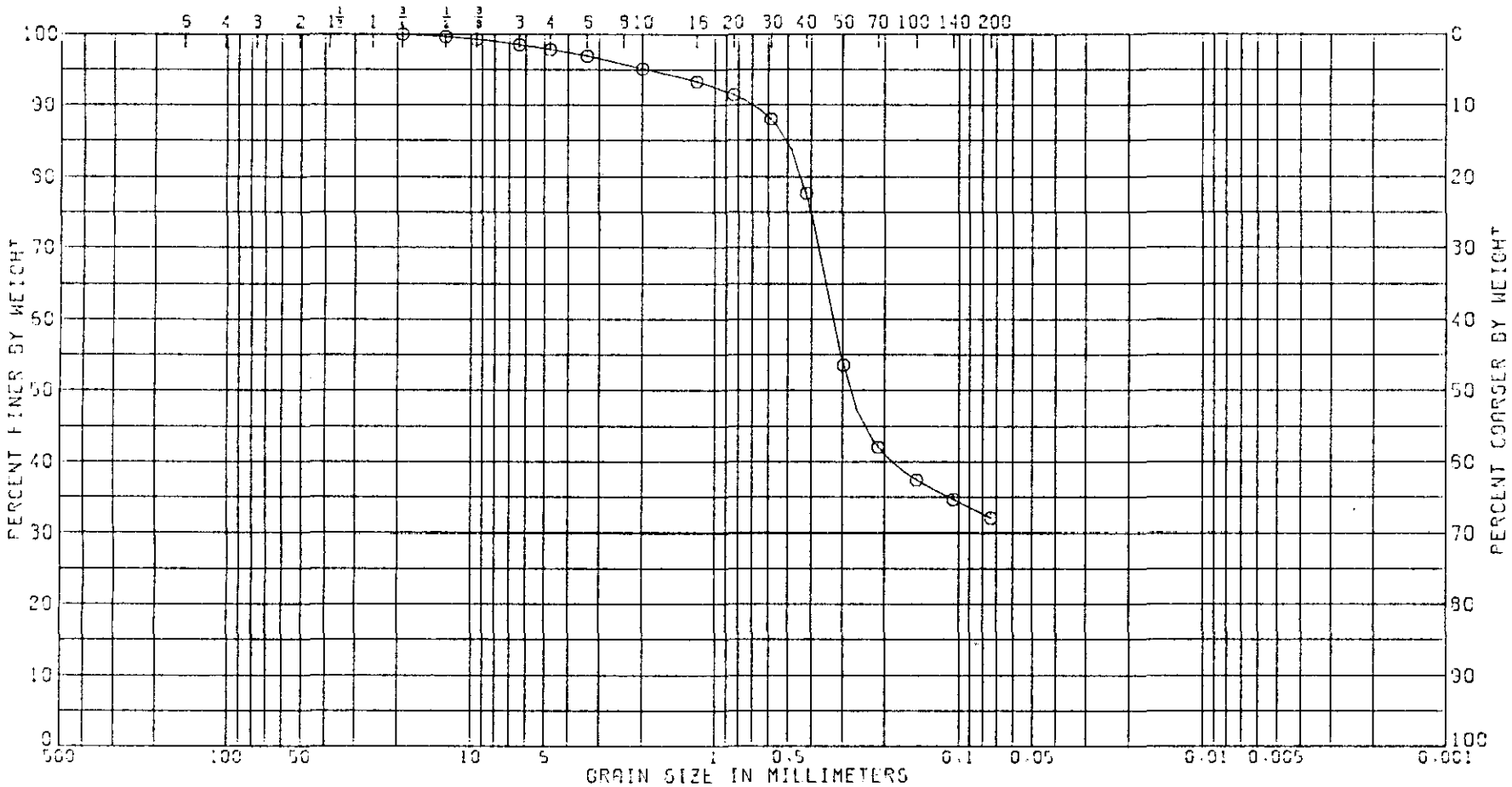
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO. 10

DEPTH/ELEV 40.3-42.48 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 22 | 13 | 9 | | 10.6 |

CLASSIFICATION

CLAYEY SAND (SC). BROWN

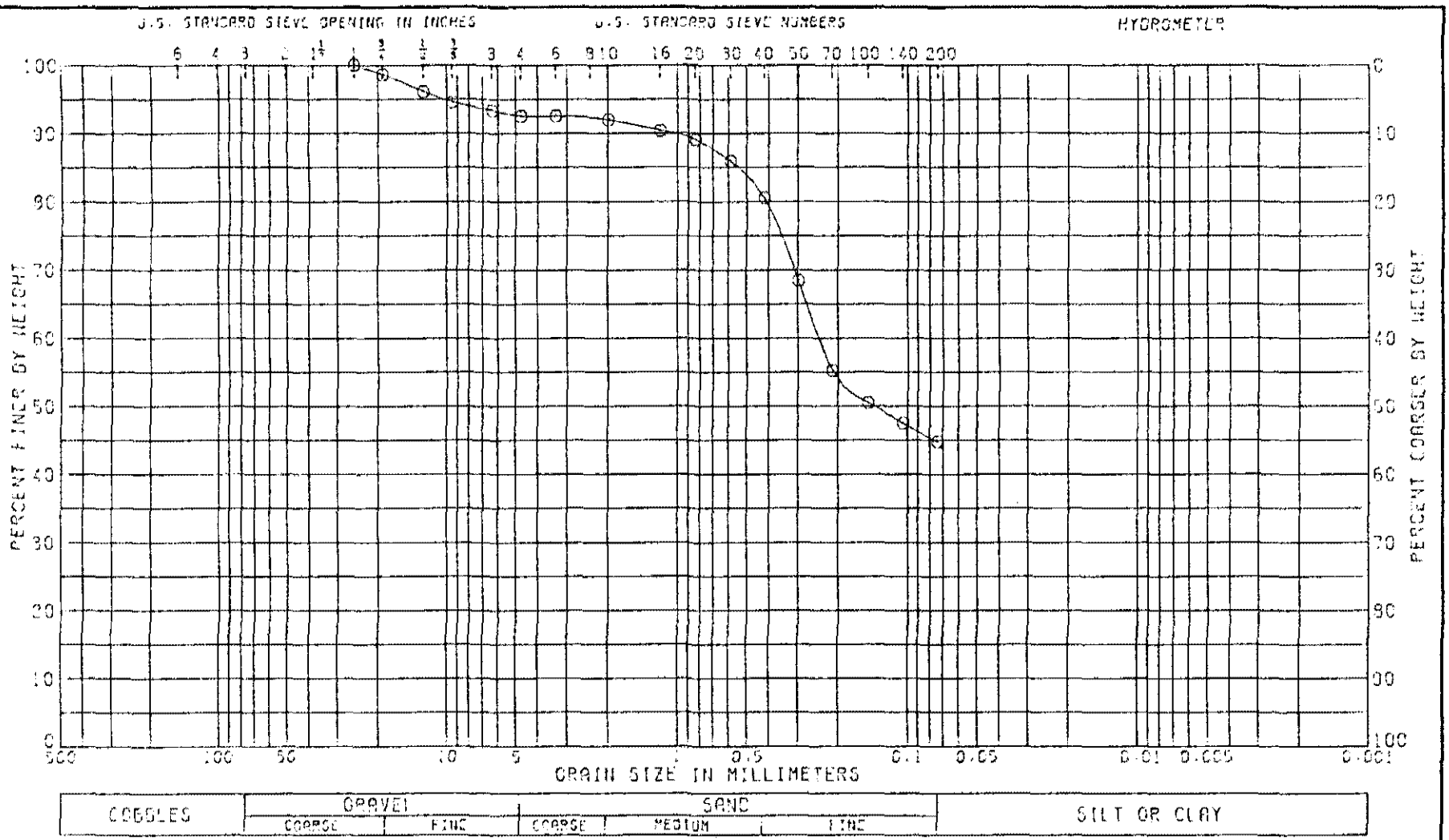
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-2-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.27 DATE 30 MAR 82




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 27 | 12 | 15 | | 12.6 |

CLASSIFICATION

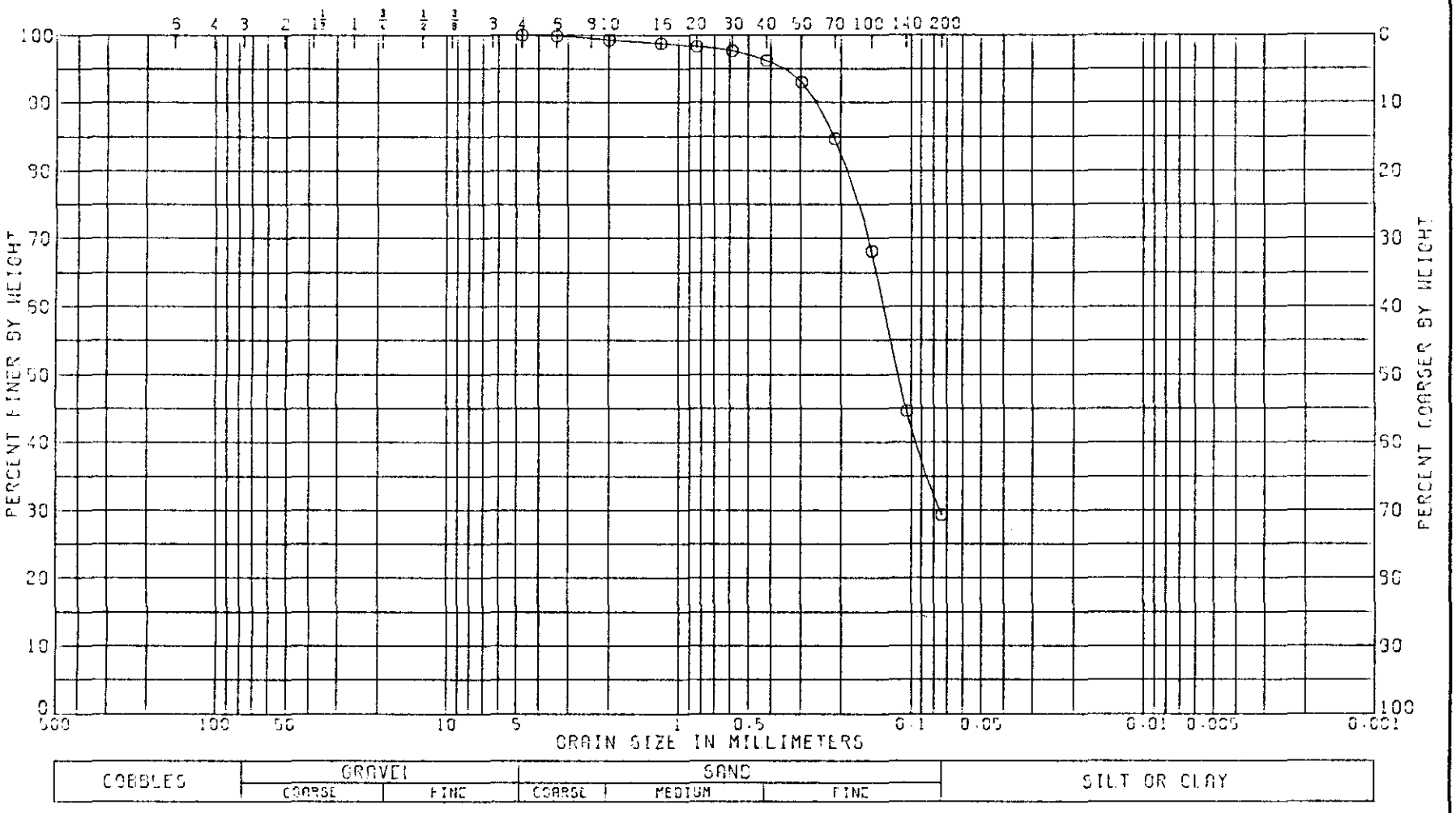
CLAYEY SAND (SC), REDDISH BROWN: WITH GRAVEL
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
MCCOMISH GORGE

BORING NO. 4-2-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-5.0 DATE 09 MAR 82




| LL 24 | PL 15 | PI 9 | GS | NAT W.% 13.9 | |
|---|---|---|---|---|---|

CLASSIFICATION

CLAYEY SAND (SC), BROWN

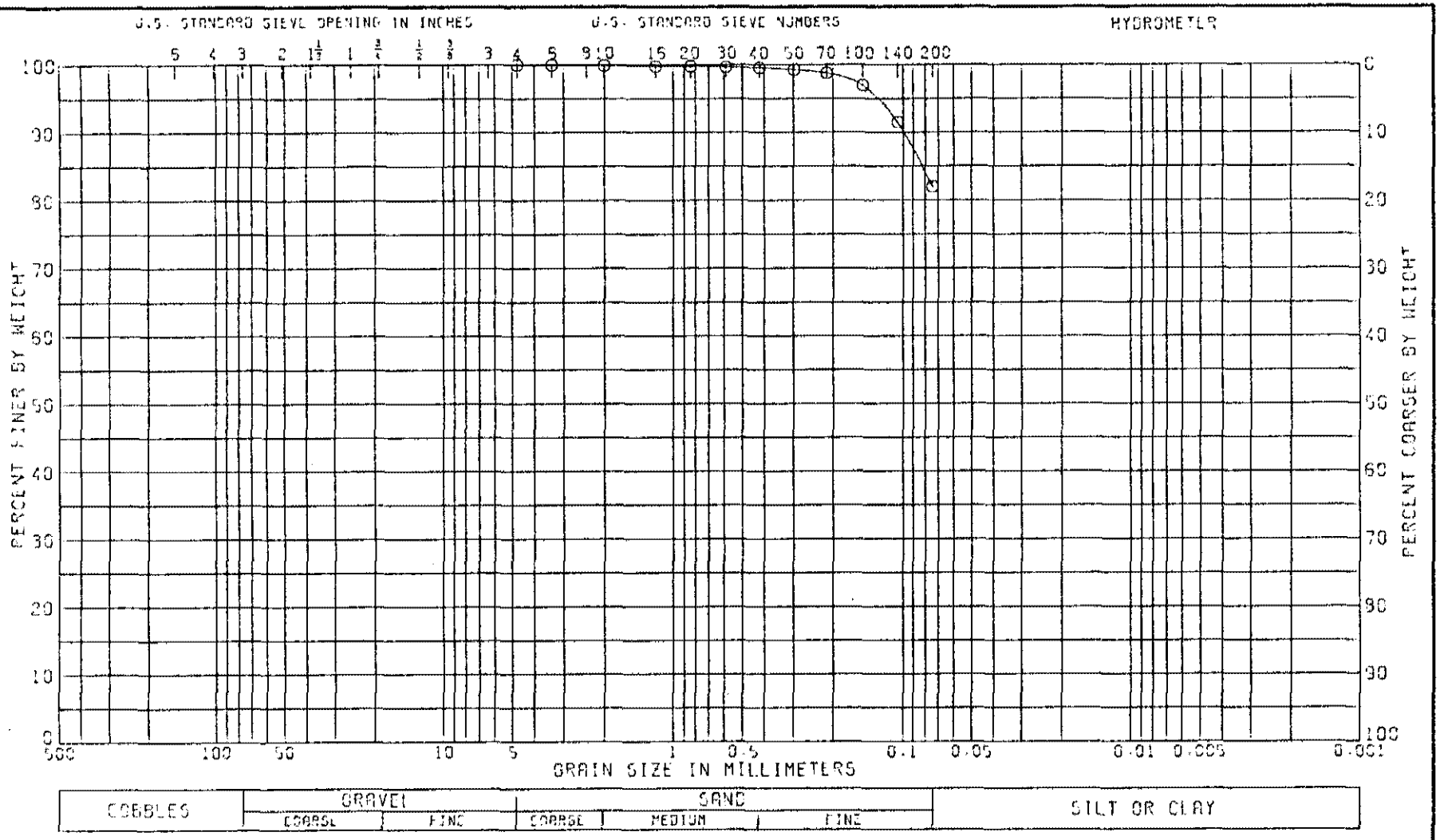
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-2-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.37 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 29 | 24 | 5 | | 22.9 |

CLASSIFICATION

SANDY SILT (ML), BROWN

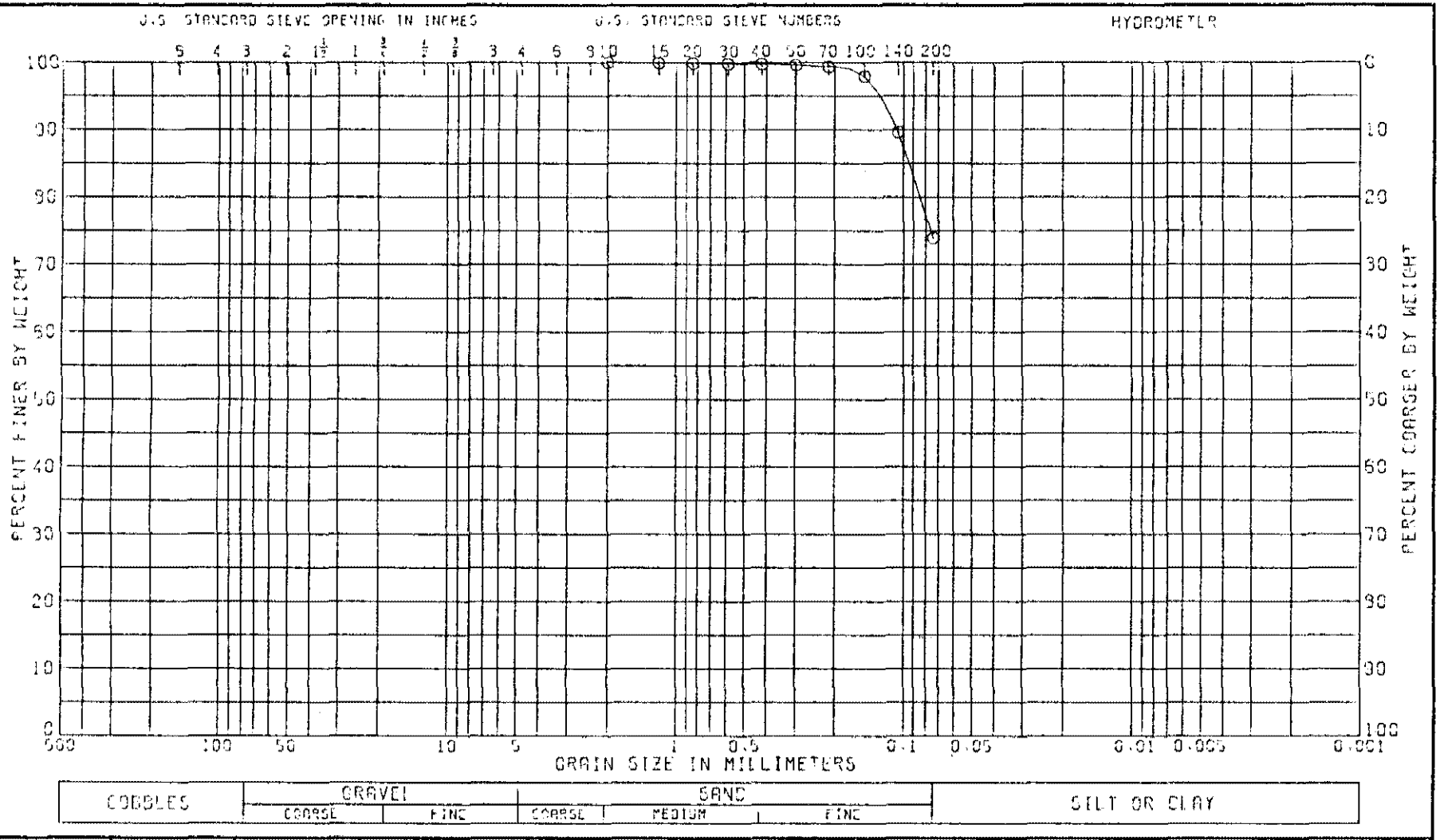
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-2-91 SAMPLE NO. 4

DEPTH/ELEV 15.0-16.60 DATE 30 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 21 | 16 | 5 | | 30.0 |

CLASSIFICATION

SANDY CLAYEY SILT (ML-CL), BROWN

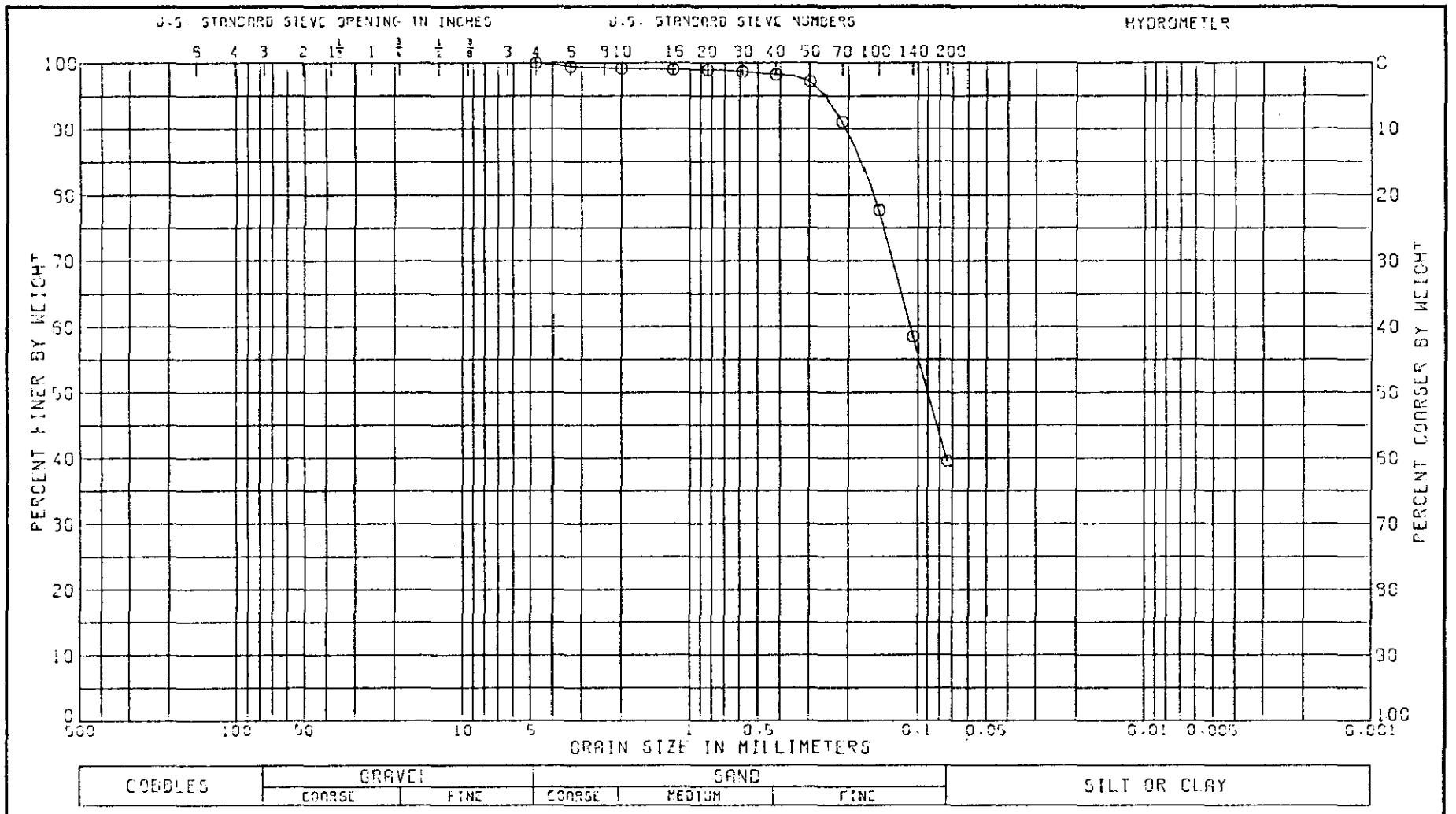
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-2-91 SAMPLE NO 5A

DEPTH/ELEV 20.0-21.5 DATE 30 MAR 92




| LL | PL | PI | CC | NAT W.% |
|---|---|---|---|---|
| NP | | | | 13.6 |

CLASSIFICATION

SILTY SAND (SM), GRAYISH BROWN

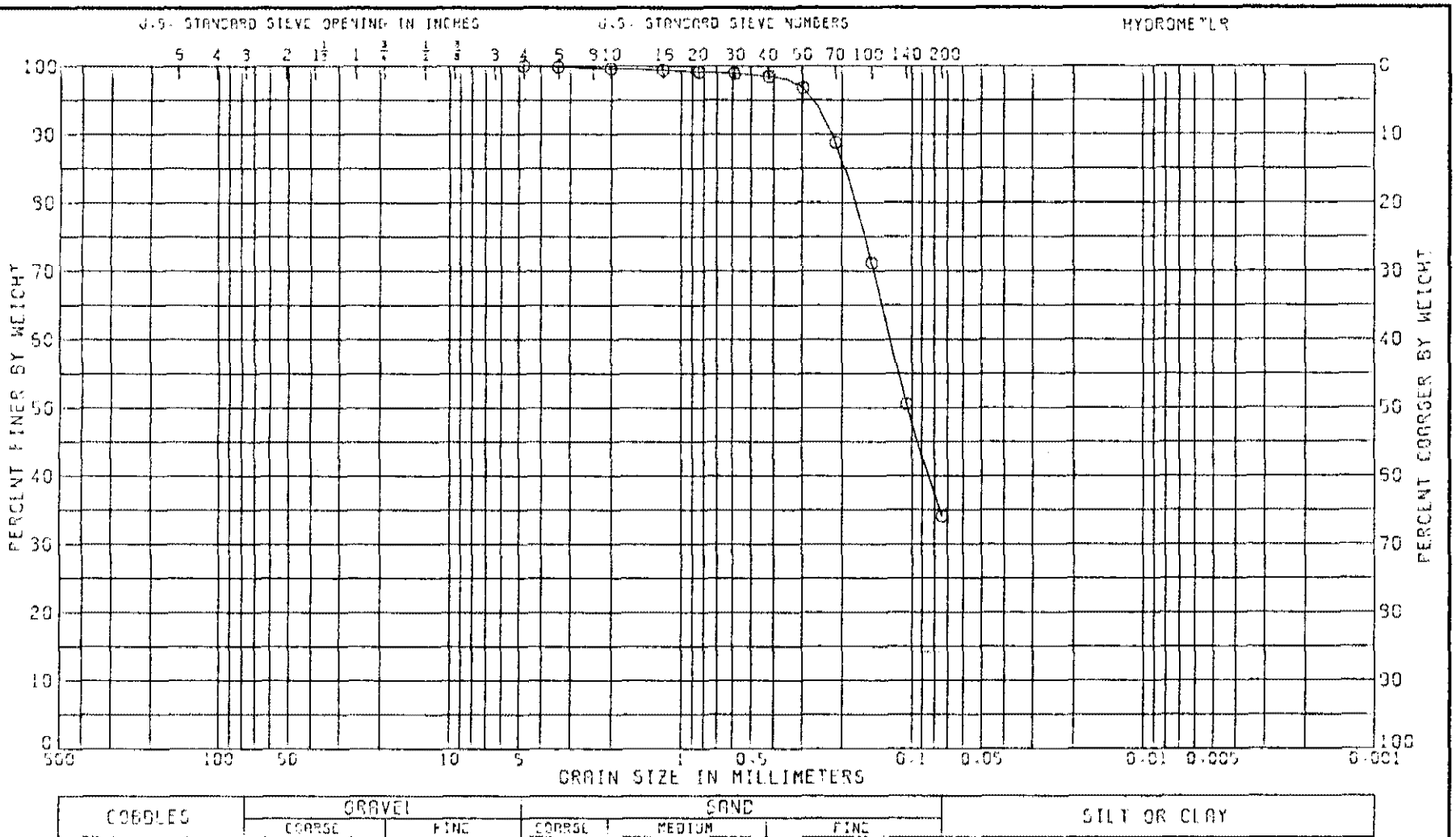
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-2-81 SAMPLE NO. 6

DEPTH/ELEV 25.0-27.05 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 14.6 |

CLASSIFICATION

SILTY SAND (SM), BROWN

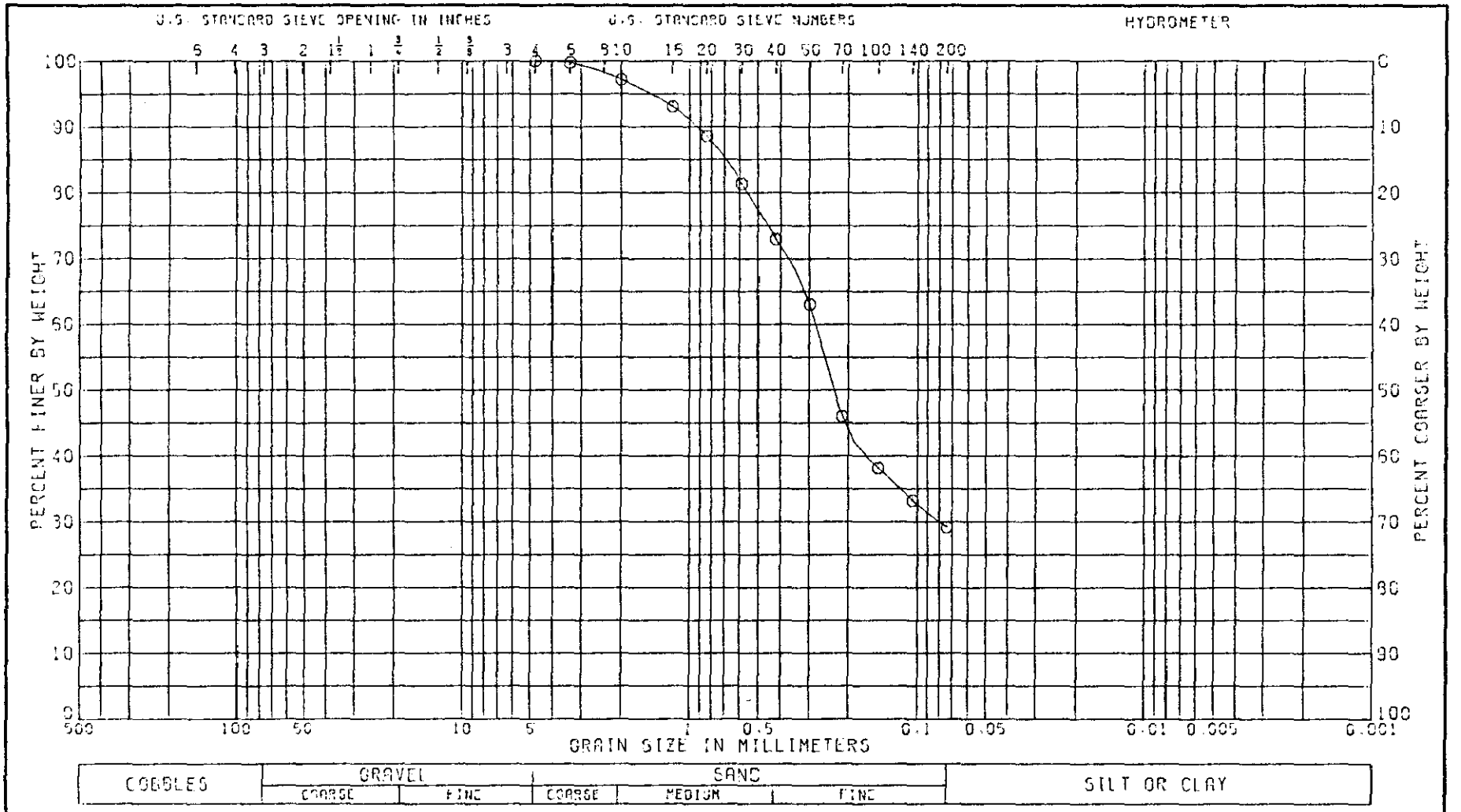
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-2-91 SAMPLE NO 7

DEPTH/ELEV 30.0-32.05 DATE 30 MAR 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 25 | 13 | 12 | | 14.1 |

CLASSIFICATION

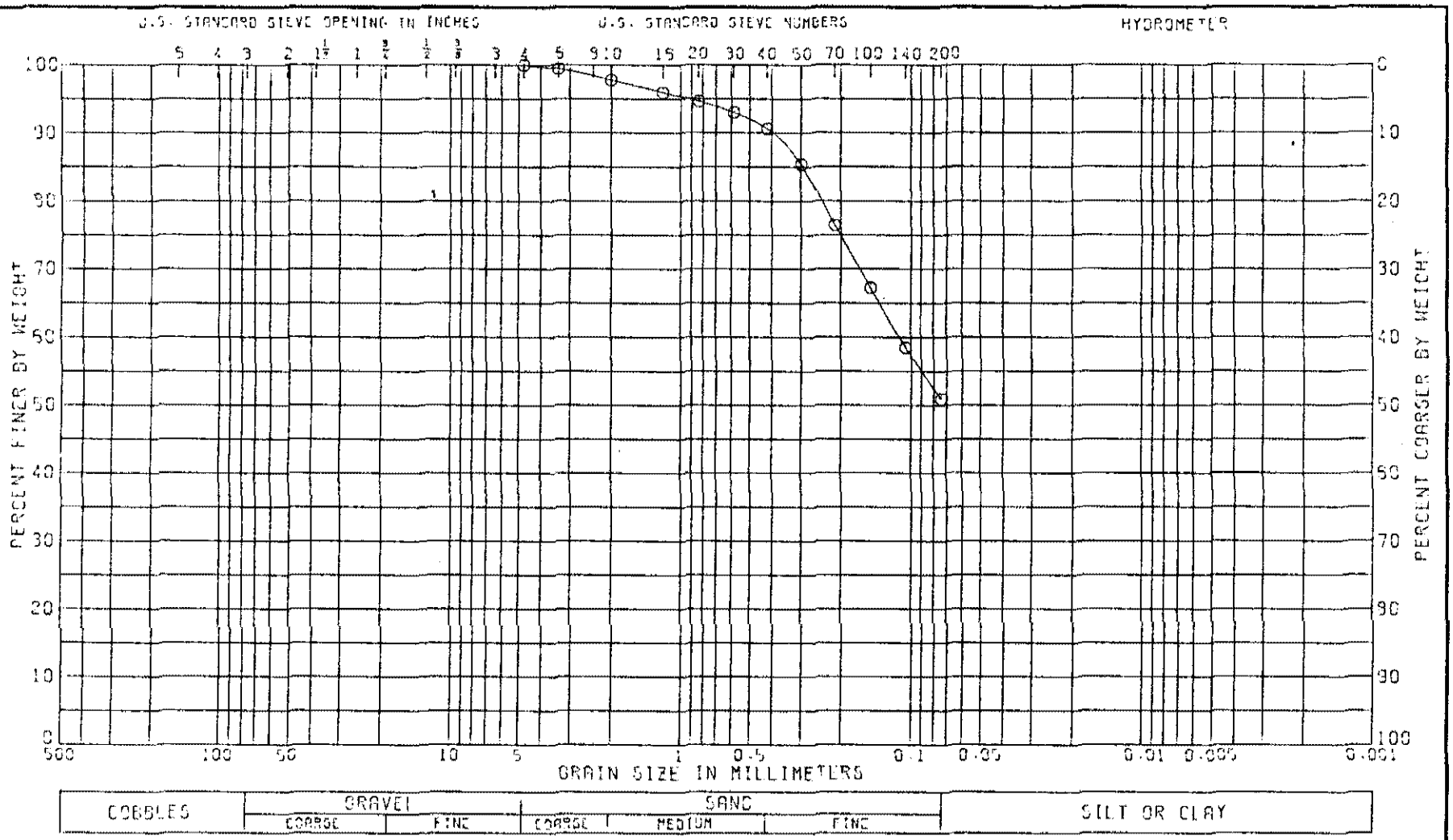
CLAYEY SAND (SC), BROWN

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-3-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.0ft DATE 11 FEB 92




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| NP | | | | 49.7 | |

CLASSIFICATION

SANDY SILT (ML), GRAYISH BROWN

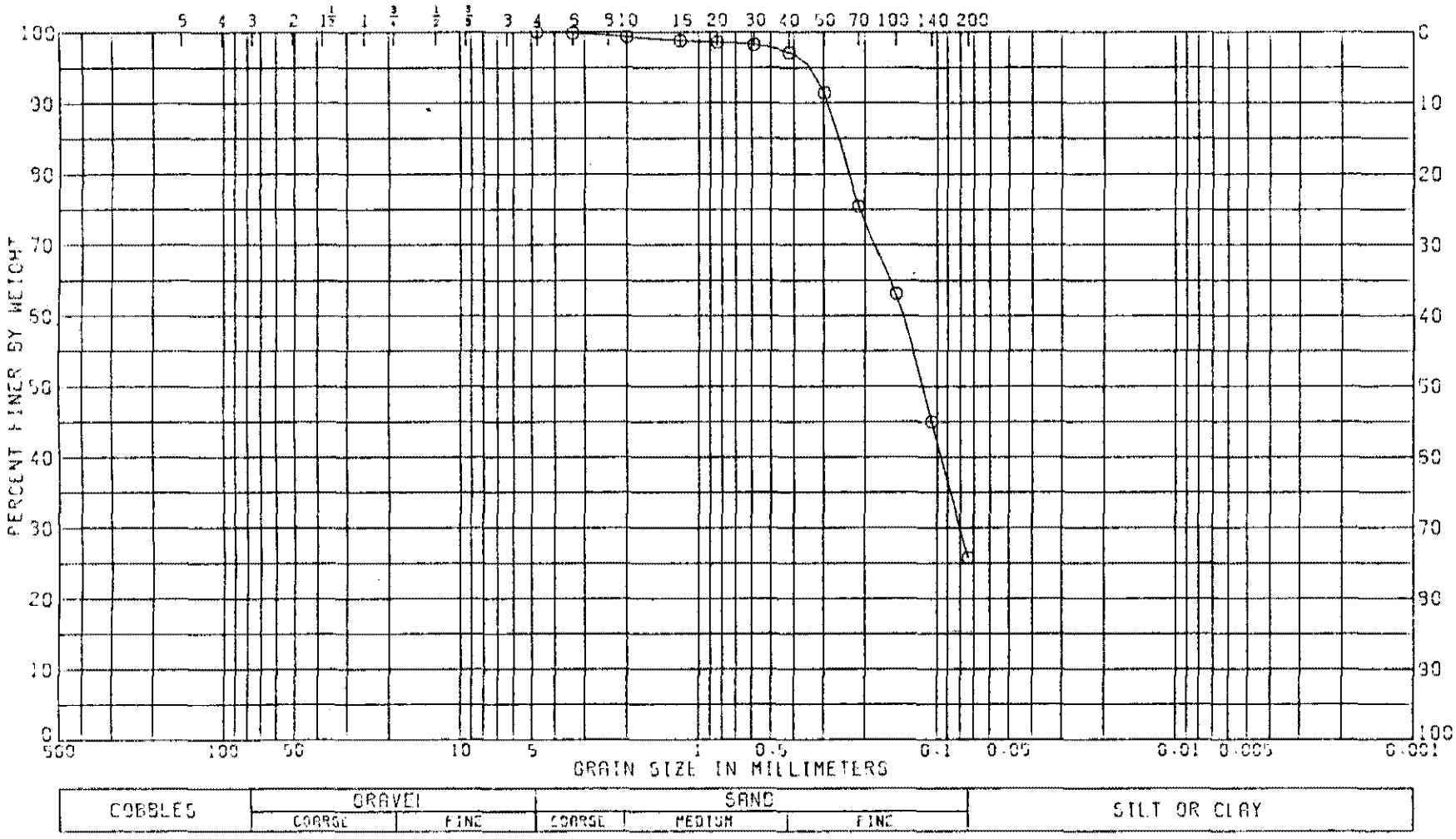
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-3-91 SAMPLE NO 2

DEPTH/ELEV 5.0-7.13 DATE 30 MAR 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 4.9 |

CLASSIFICATION

SILTY SAND (SM), BROWN

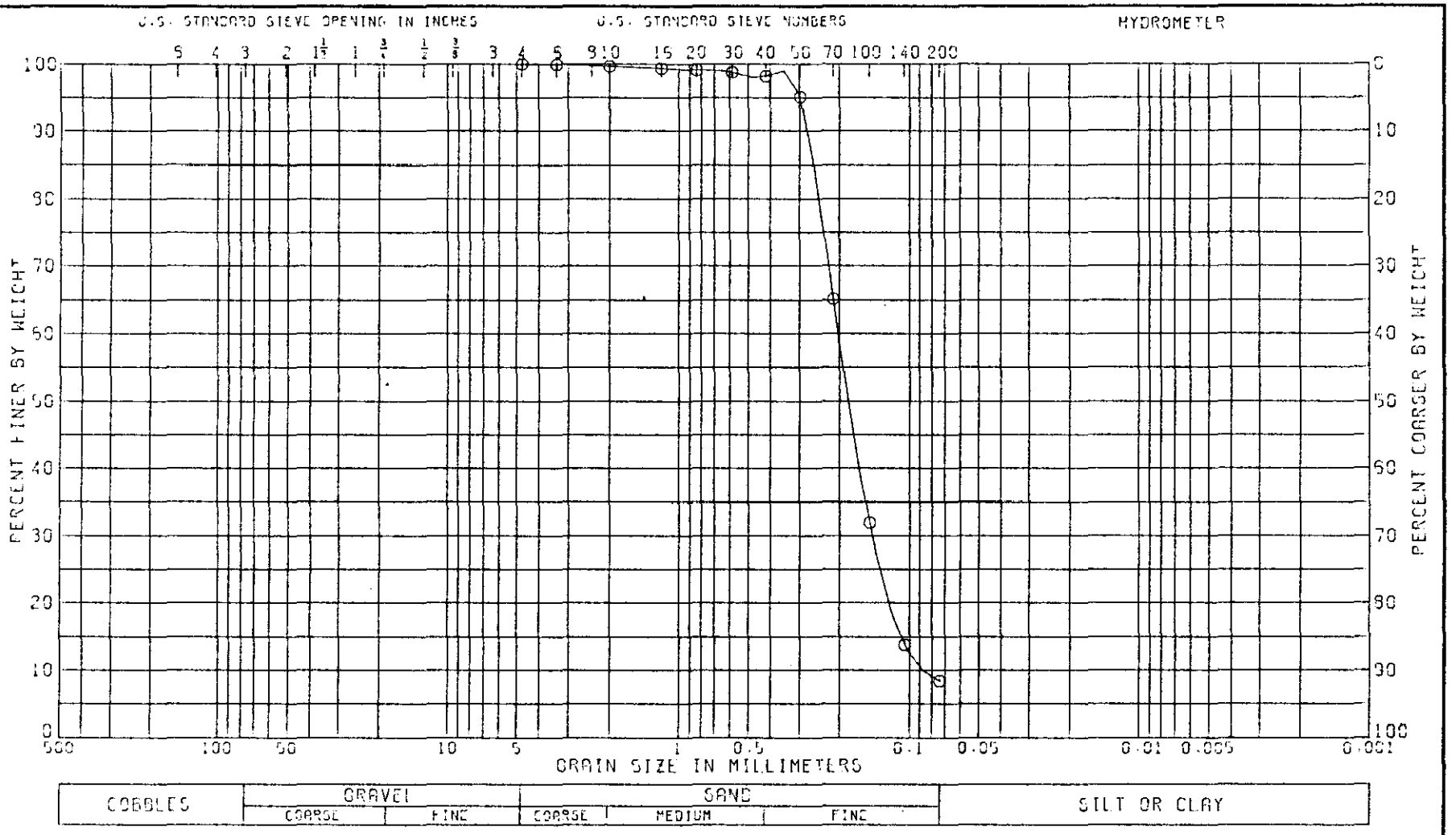
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-3-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.83 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 24.3 |

CLASSIFICATION

SILTY SAND (SP-SM), GRAY

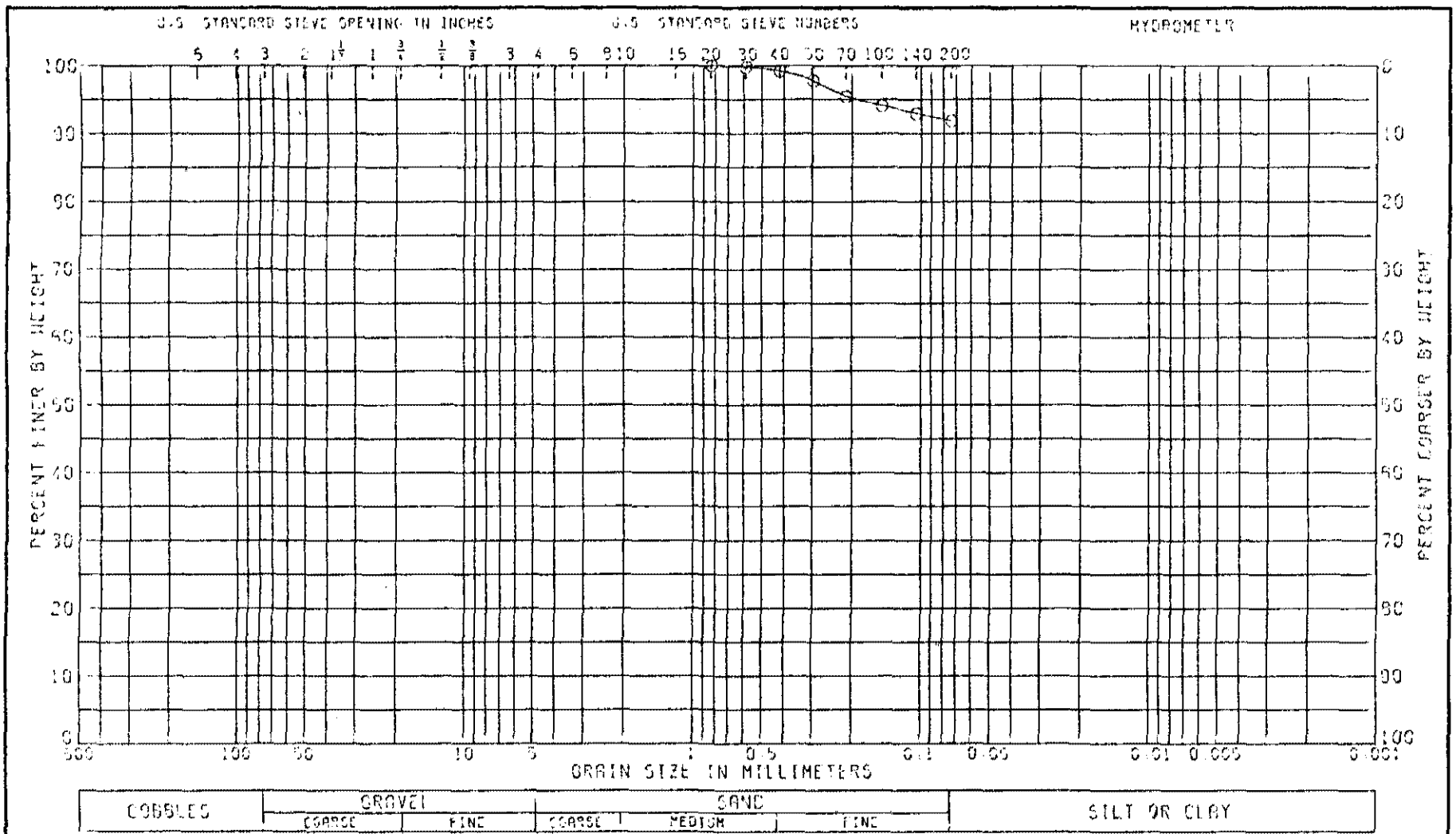
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-3-91 SAMPLE NO. 4G

DEPTH/ELEV 15.0-17.0 DATE 30 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 39 | 18 | 21 | | 20.7 |

CLASSIFICATION

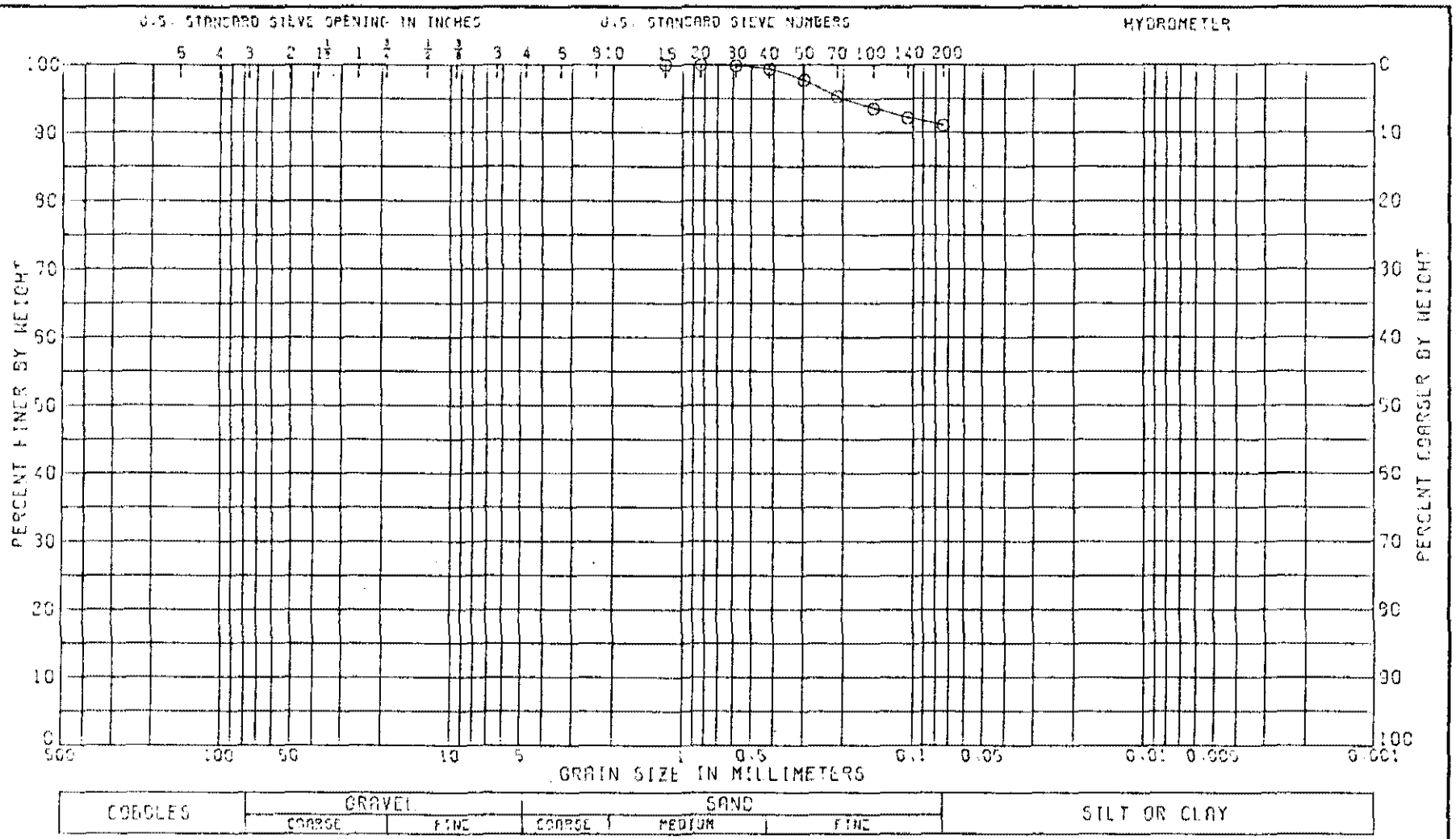
CLAY (CL), REDDISH BROWN; WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC
MCCOMISH GORGE

BORING NO 4-4-B1 SAMPLE NO 1

DEPTH/ELEV 0.0-2.26 DATE 26 FEB 82




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| 45 | 20 | 25 | | 21.8 | |

CLASSIFICATION

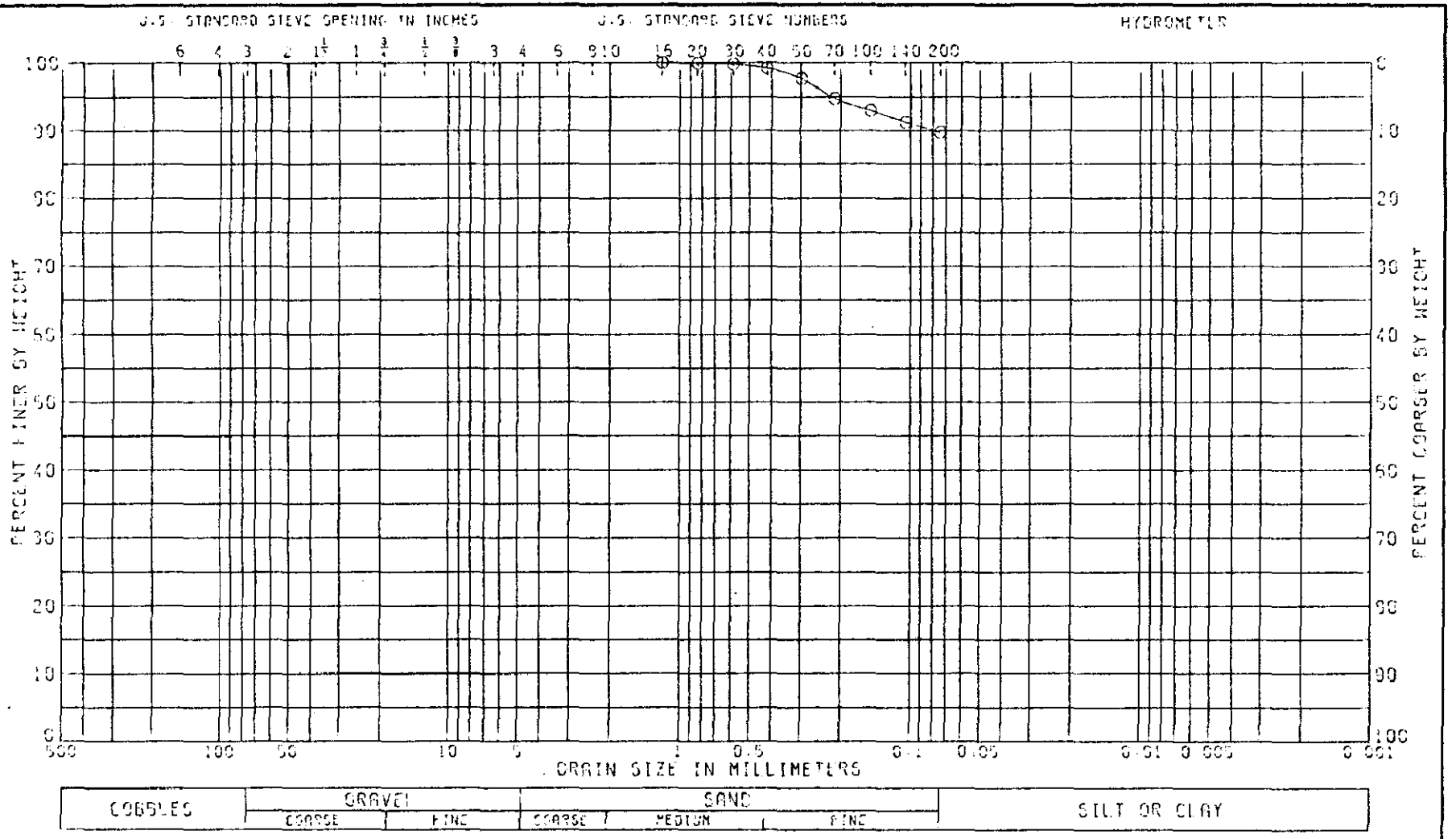
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-4-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.64 DATE 11 FEB 92




| LL | PL | PI | OS | NAT W.% | |
|---|---|---|---|---|---|
| 35 | 19 | 16 | | 12.0 | |

CLASSIFICATION

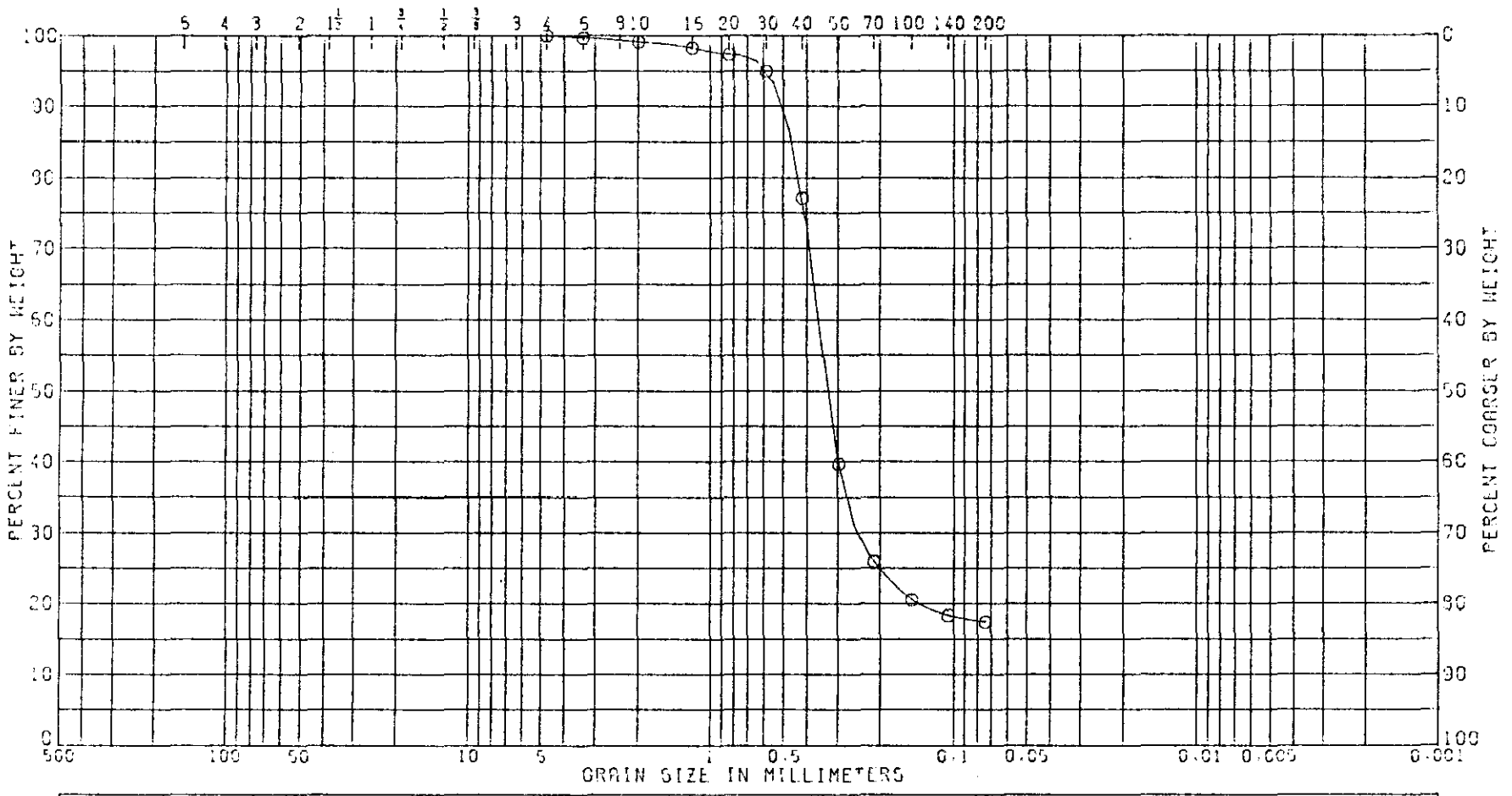
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC
MCCOMISH GORGE

BORING NO 4-4-81 SAMPLE NO 3

DEPTH/ELEV 10.0-12.10 DATE 26 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 32 | 14 | 18 | | 9.9 |

CLASSIFICATION

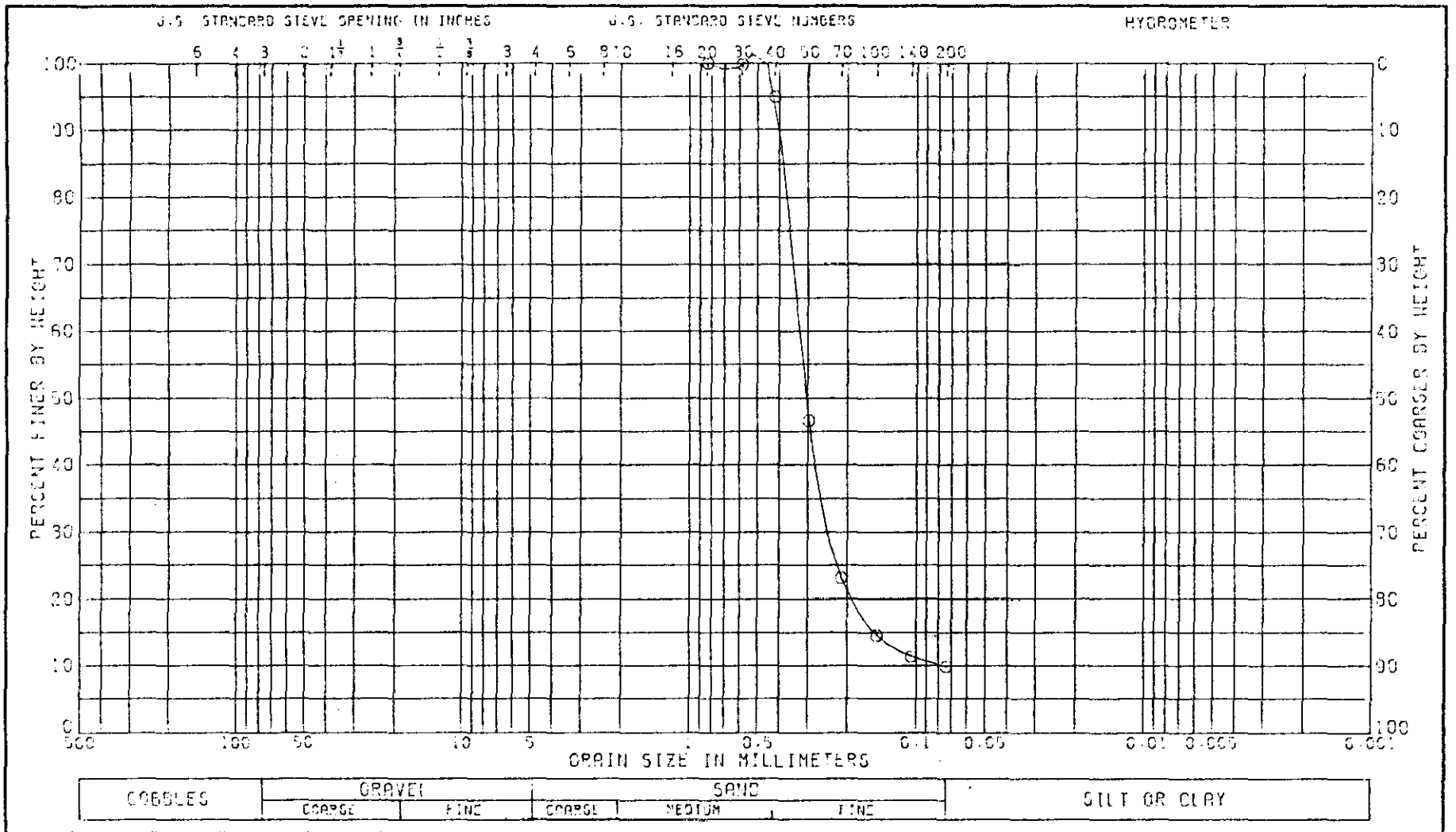
CLAYEY SAND (SC), BROWN

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-4-91 SAMPLE NO. 4

DEPTH/ELEV 15.0-16.97 DATE 11 FEB 92




| LL | PL | PI | OS | NAT M.% |
|---|---|---|---|---|
| NP | | | | 5.8 |

CLASSIFICATION

SILTY SAND (SP-SM), BROWN

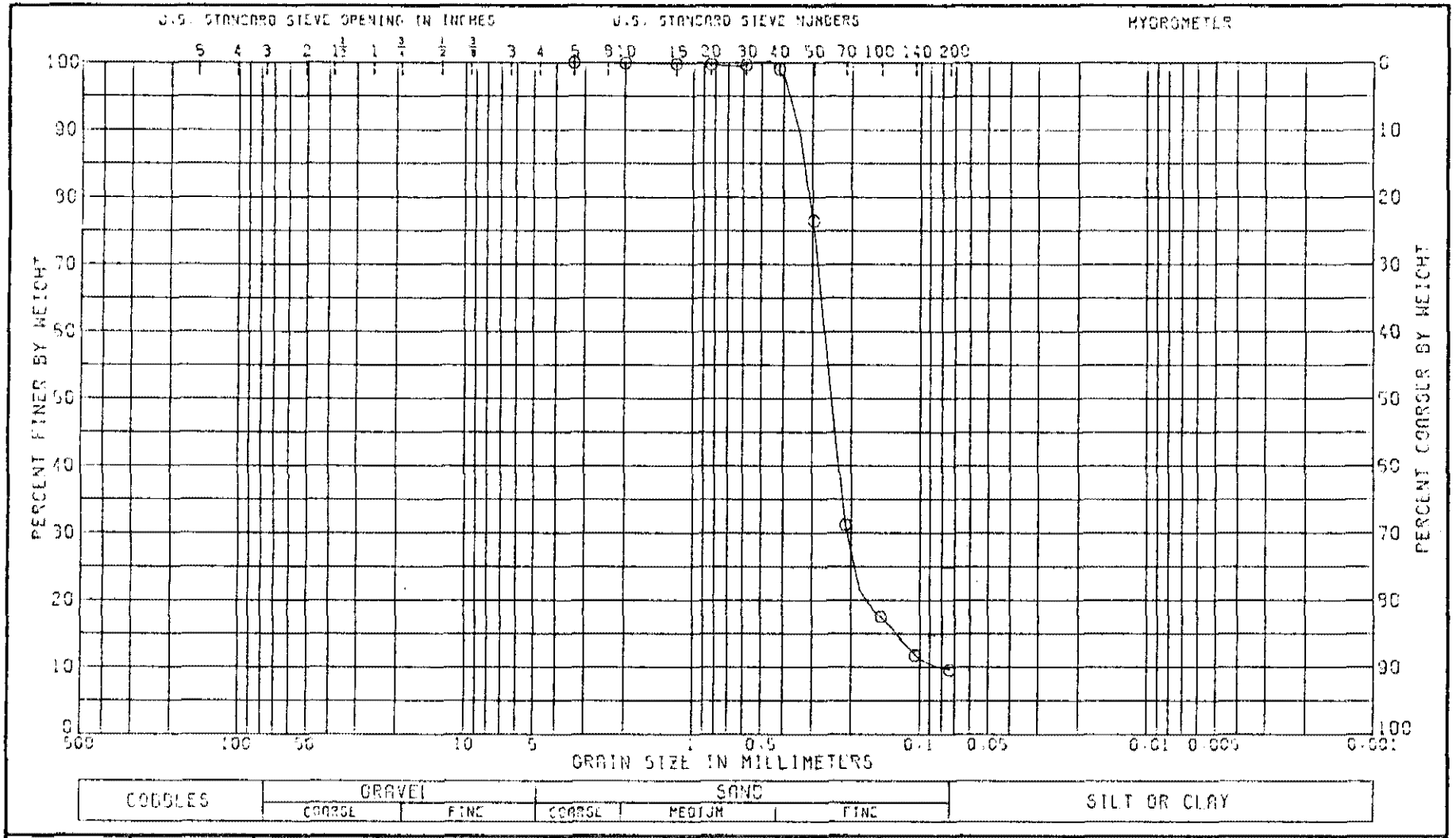
GRADATION CURVE

PROJECT CRANE NASC

MCCOMISH GORGE

BORING NO. 4-1-81 SAMPLE NO. 5

DEPTH/ELEV 20.0-22.08 DATE 03 MAR 82




| LL NP | PL | PI | GS | NAT W.% 18.4 | |
|---|---|---|---|---|---|

CLASSIFICATION

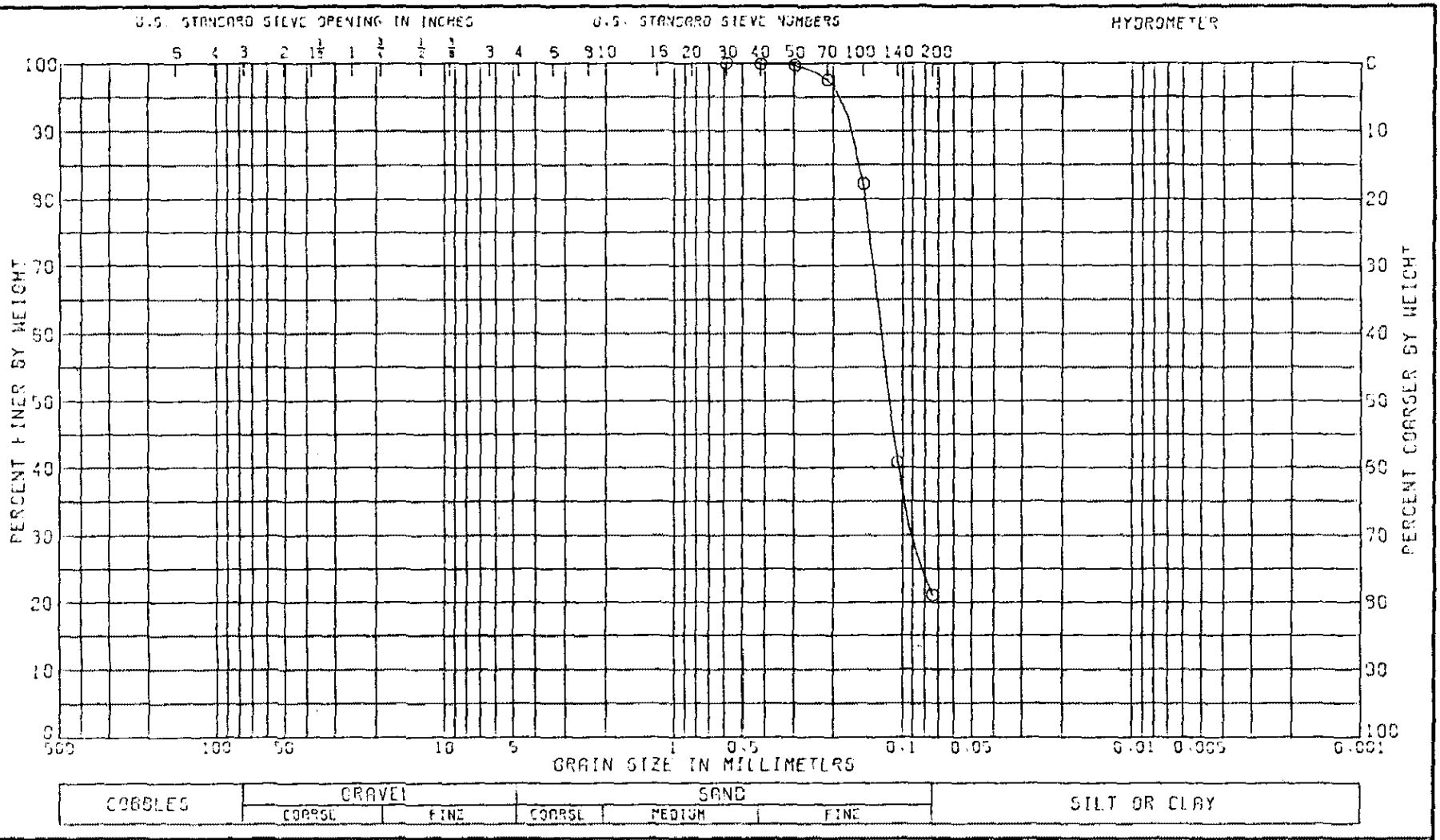
SILTY SAND (SP-SM), REDDISH BROWN

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-4-91 SAMPLE NO 5

DEPTH/ELEV 25.0-26.50 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 23.9 |

CLASSIFICATION

SILTY SAND (SM), REDDISH BROWN

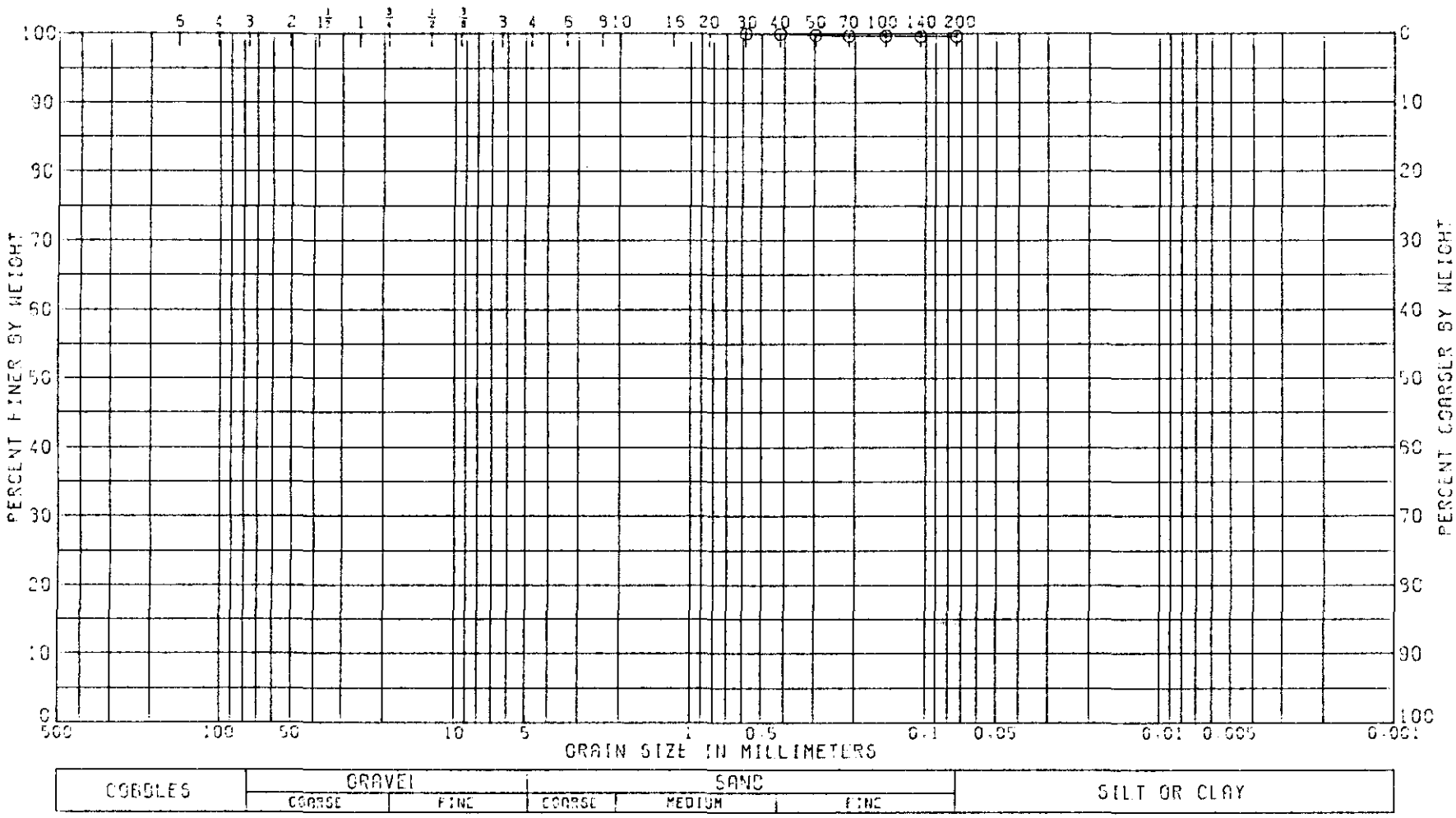
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-4-81 SAMPLE NO. 7

DEPTH/ELEV 27.8-29.30 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 31 | 16 | 15 | | 33.6 |

CLASSIFICATION

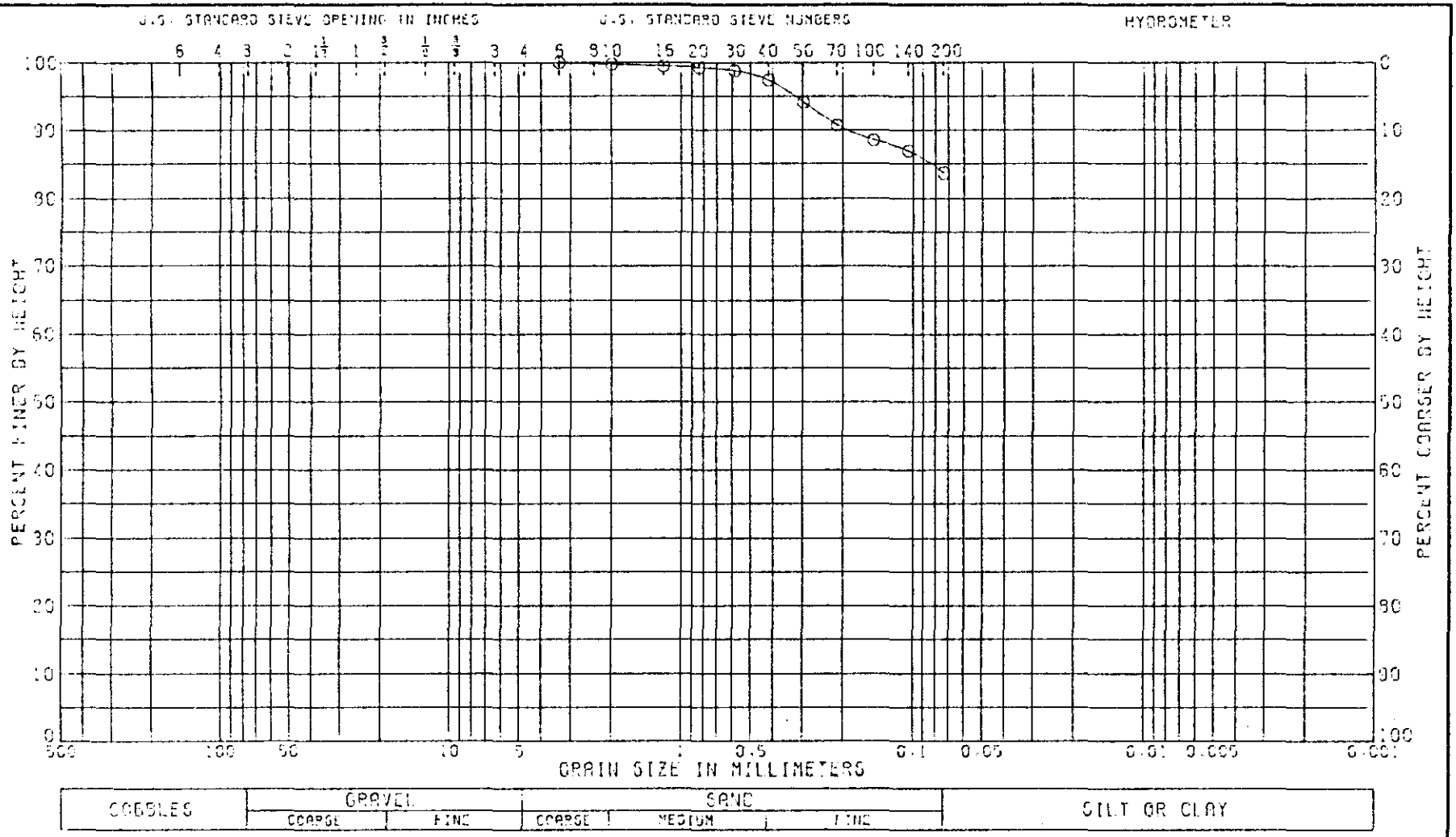
CLAY (CL), GRAY

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-4-91 SAMPLE NO 9

DEPTH/ELEV 35.0-37.05 DATE 11 FEB 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 35 | 16 | 19 | | 23.6 |

CLASSIFICATION

SANDY CLAY (CL), TAN

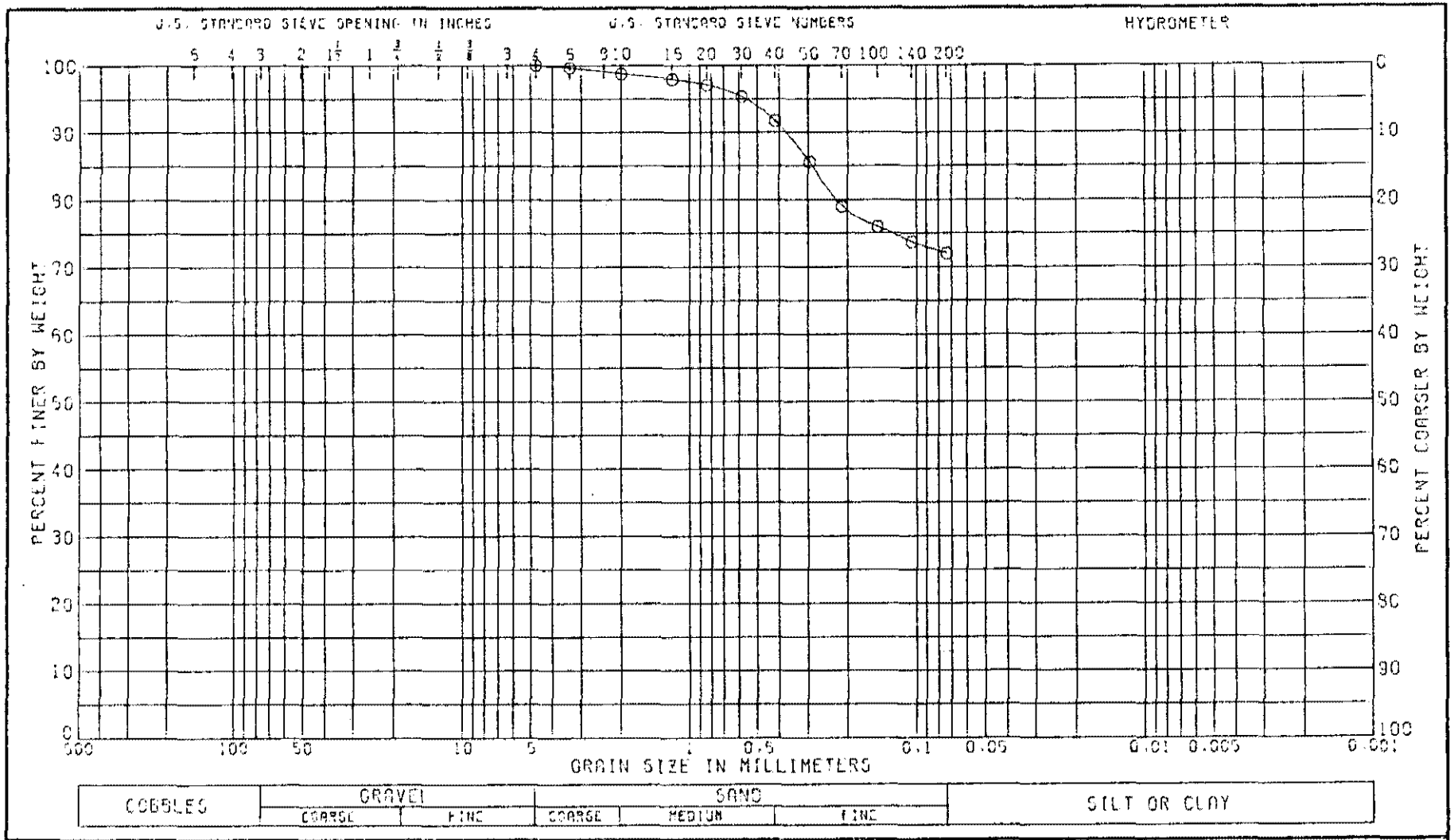
GRADATION CURVE

PROJECT CRANE NLSC

MCCOMISH GORGE

BORING NO. 4--5--81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.8 DATE 00 MAR 82




| LL 38 | PL 18 | PI 20 | GS | NAT W.% 21.1 |
|---|---|---|---|---|

CLASSIFICATION

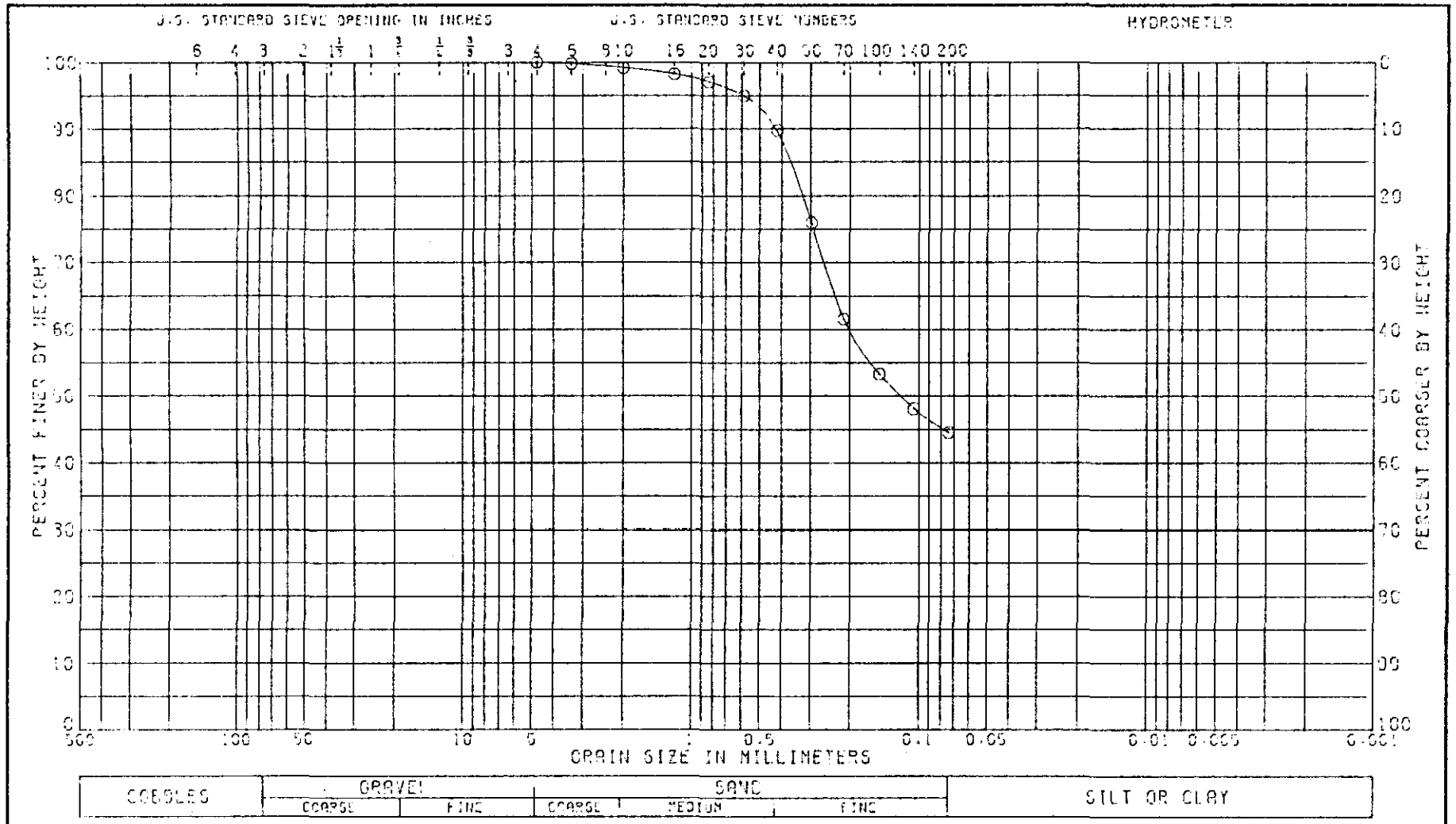
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-5-91 SAMPLE NO 2

DEPTH/ELEV 5.0-6.36 DATE 11 FEB 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 30 | 17 | 13 | | 22.9 |

CLASSIFICATION

CLAYEY SAND (SC), DARK BROWN

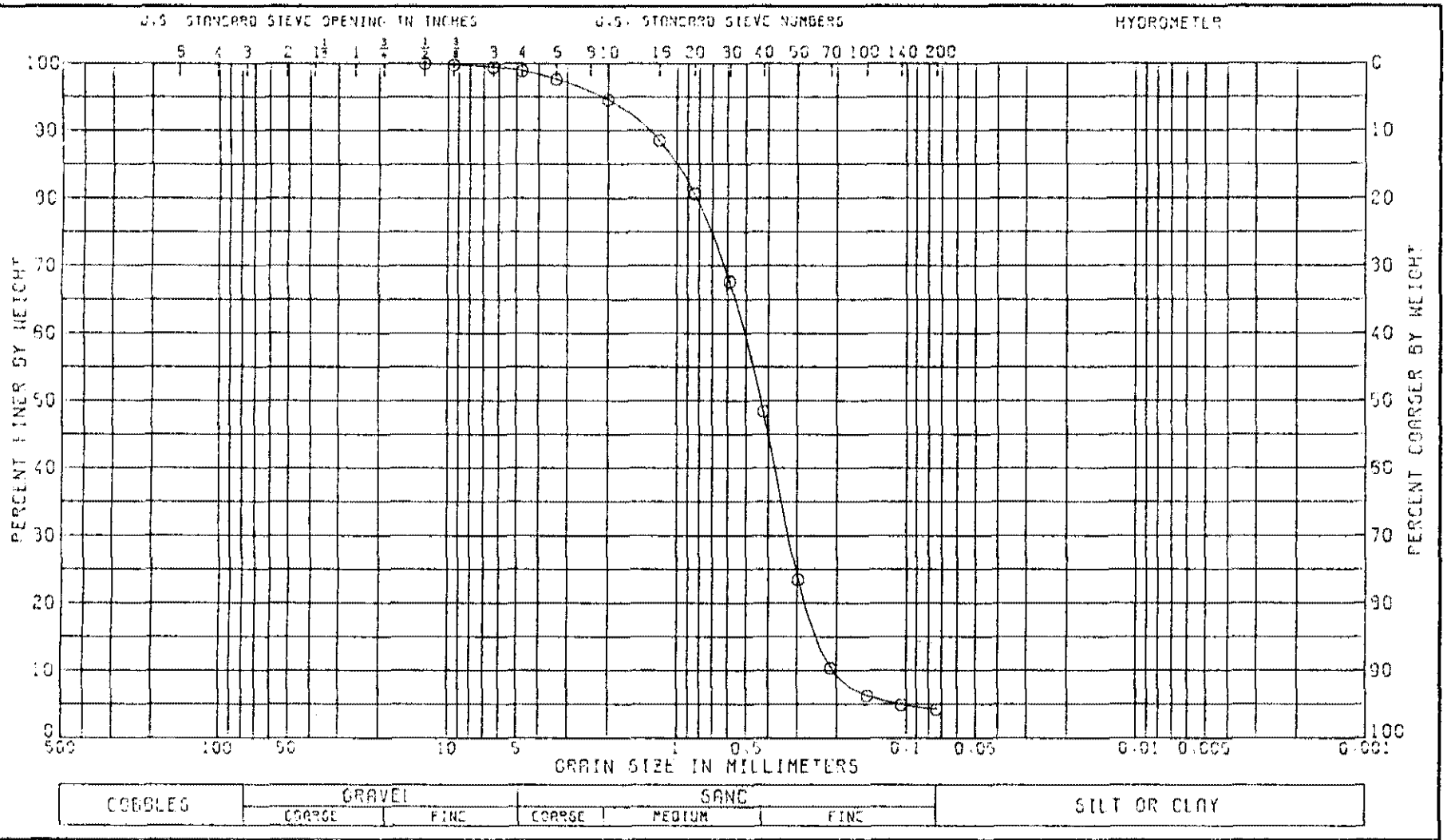
GRADATION CURVE

PROJECT CRANE MISC

MCCOMISH GORGE

BORING NO 4-5-81 SAMPLE NO 3

DEPTH/ELEV 10.0-11.10 DATE 09 MAR 82




| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| NP | | | | 14.7 | |

CLASSIFICATION

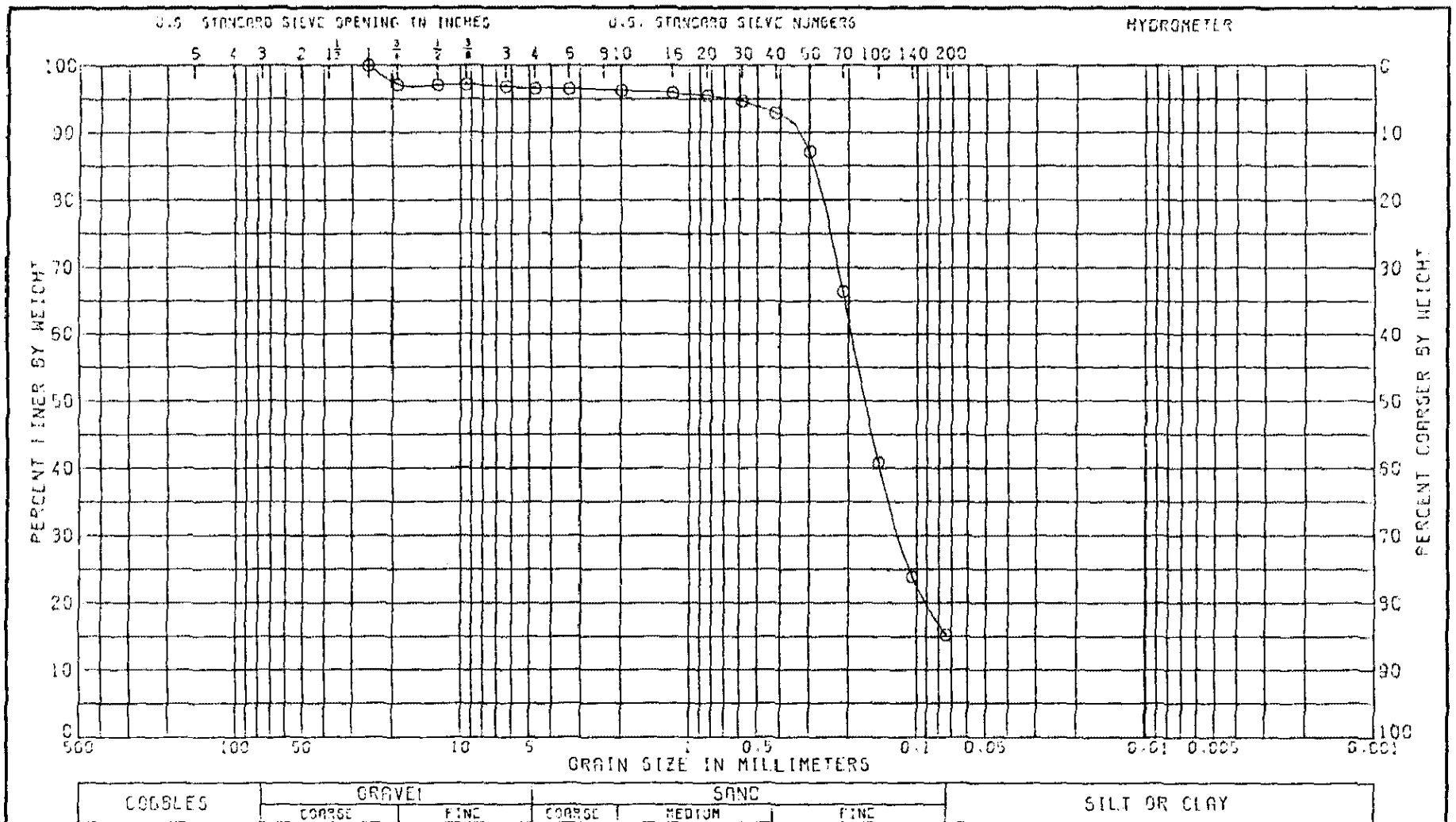
SAND (SP), GRAY

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-5-91 SAMPLE NO. 4

DEPTH/ELEV 14.3-16.0 DATE 11 FEB 92




| LL NP | PL | PI | GS | NAT W.% 22.4 | |
|---|---|---|---|---|---|

CLASSIFICATION

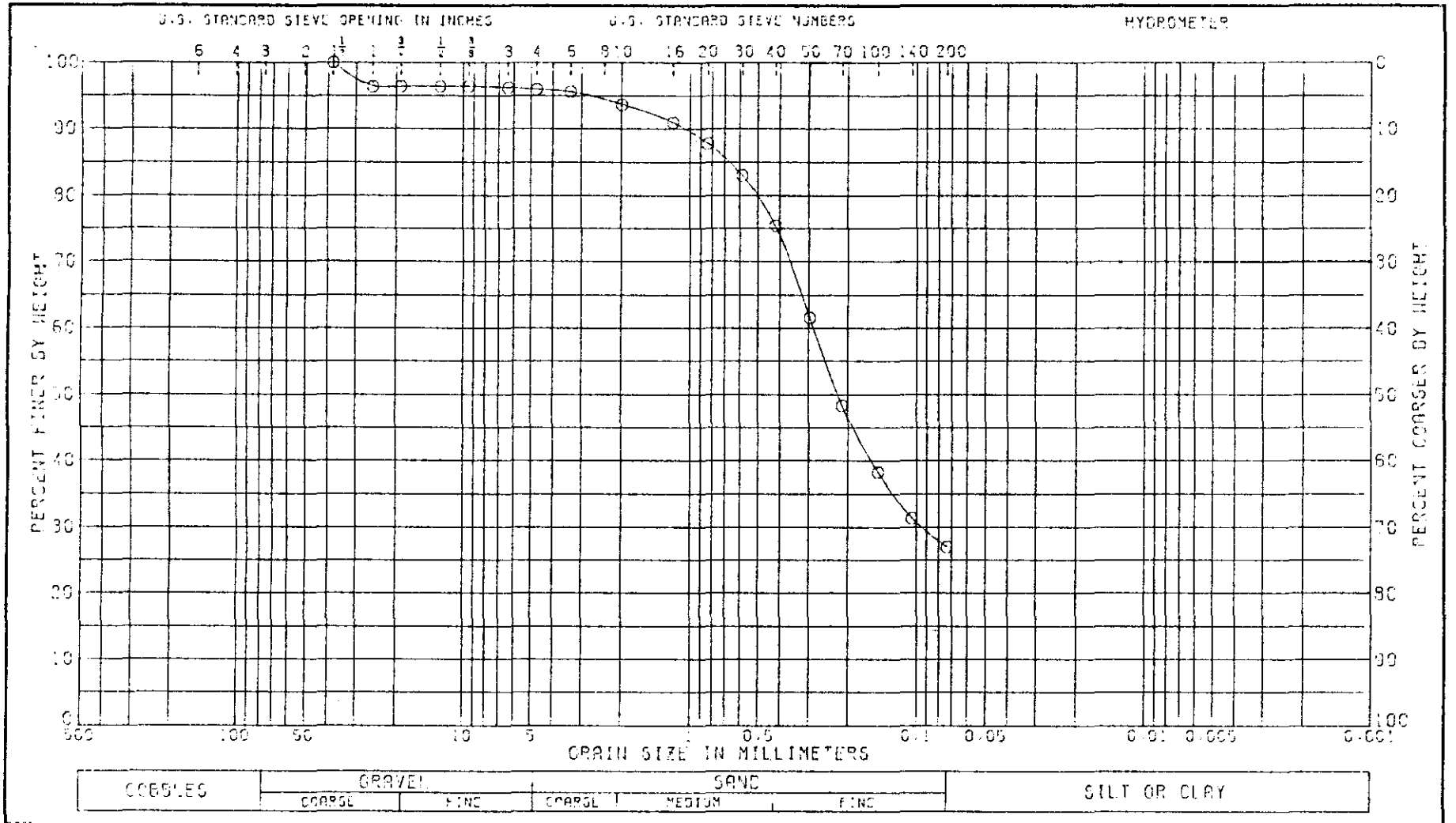
SILTY SAND (SM), BROWN: TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-5-81 SAMPLE NO 5

DEPTH/ELEV 18.6-20.05 DATE 11 FEB 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 12.4 |

CLASSIFICATION

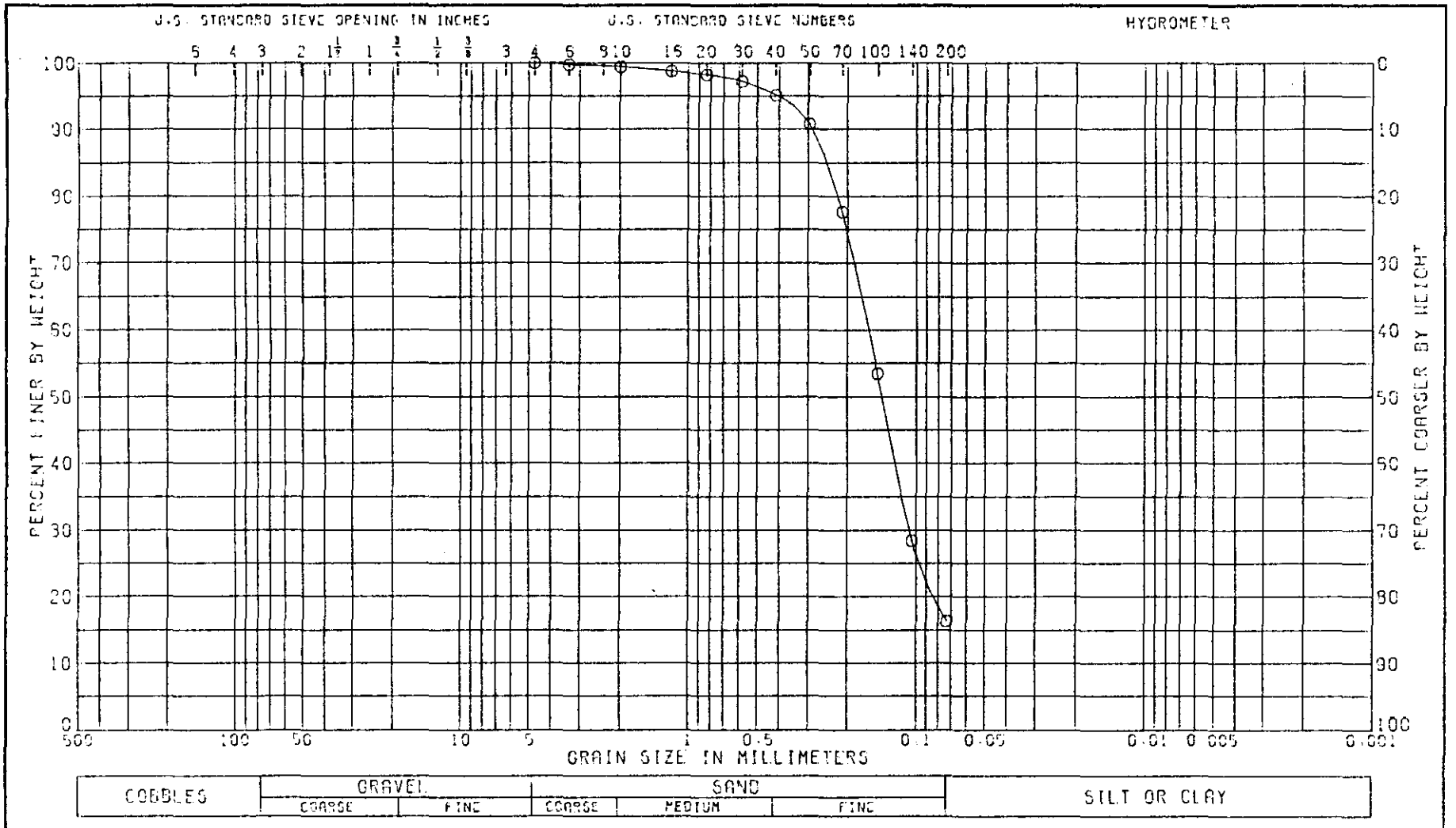
SILTY SAND (SM), LIGHT BROWN: TRACE OF GRAVEL
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NUSC
MCCOMISH GORGE

BORING NO. 4-6-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.14 DATE 00 MAR 82




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| NP | | | | 10.2 | |

CLASSIFICATION

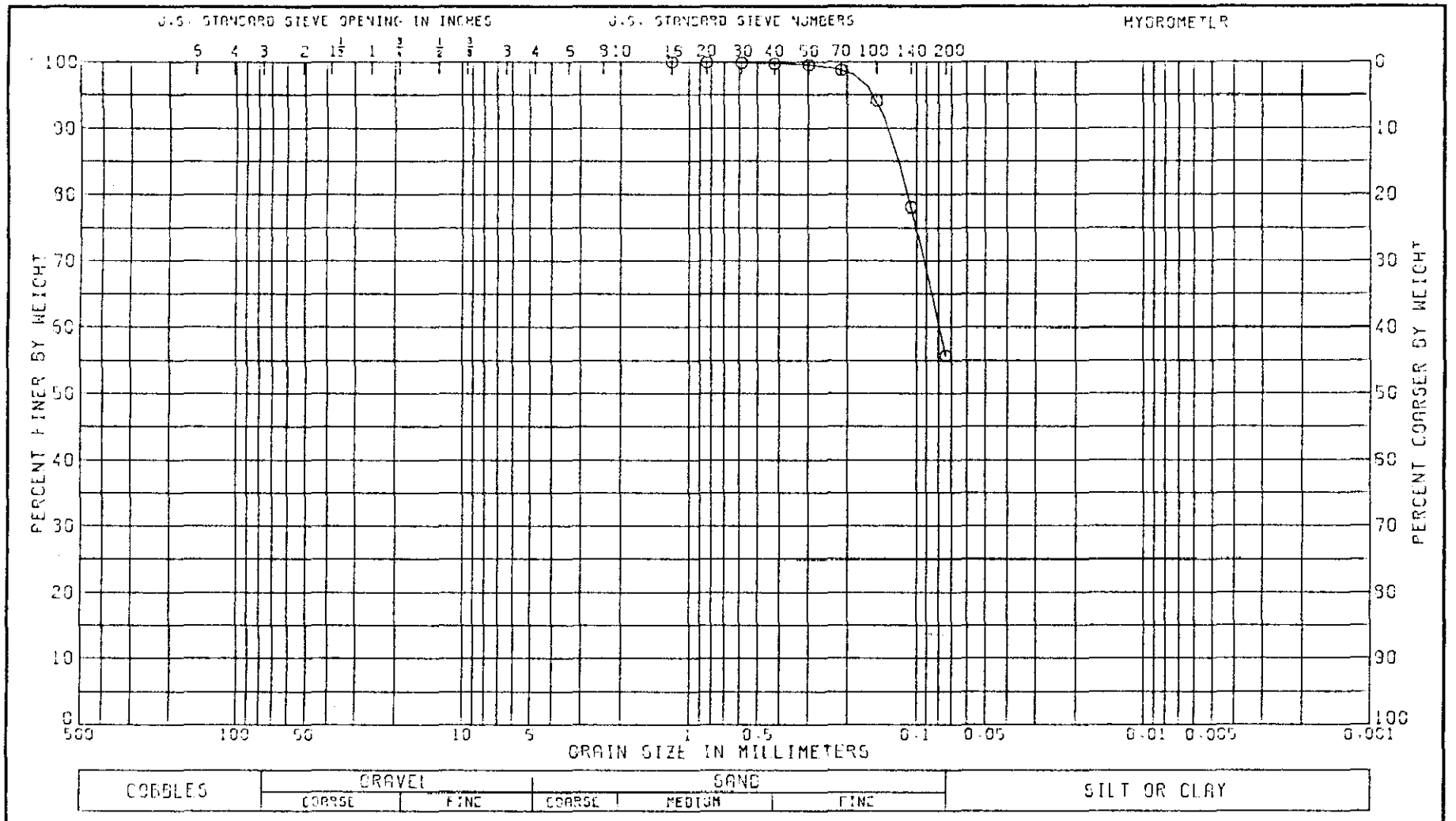
SILTY SAND (SM), DARK BROWN

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-6-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.0ft DATE 11 FEB 82




| LL NP | PL | PI | CS | NAT W.% 19.2 | |
|---|---|---|---|---|---|

CLASSIFICATION

SANDY SILT (ML), TAN

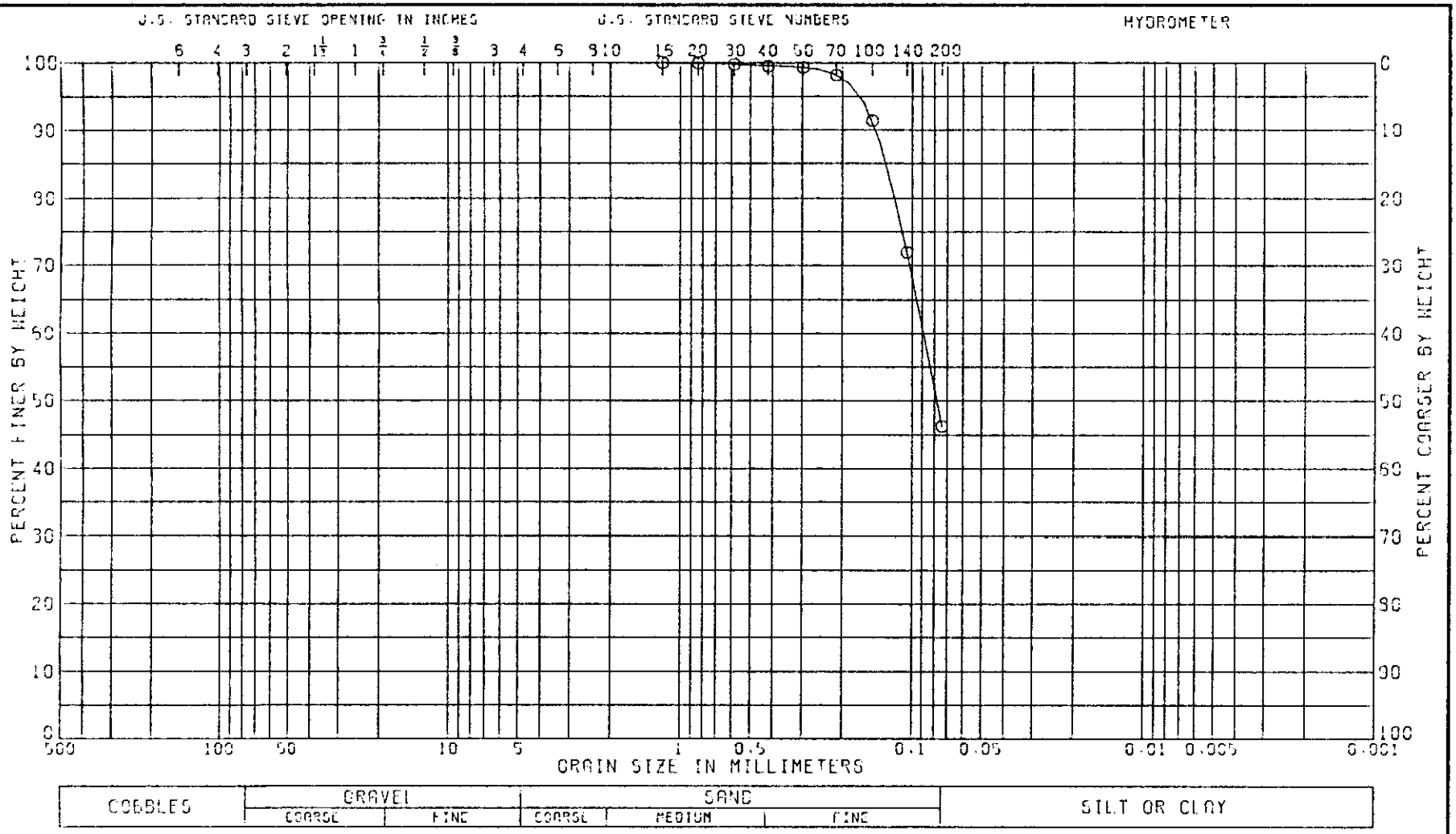
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-6-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.71 DATE 30 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 27.4 |

CLASSIFICATION

SILTY SAND (SM) GRAYISH TAN

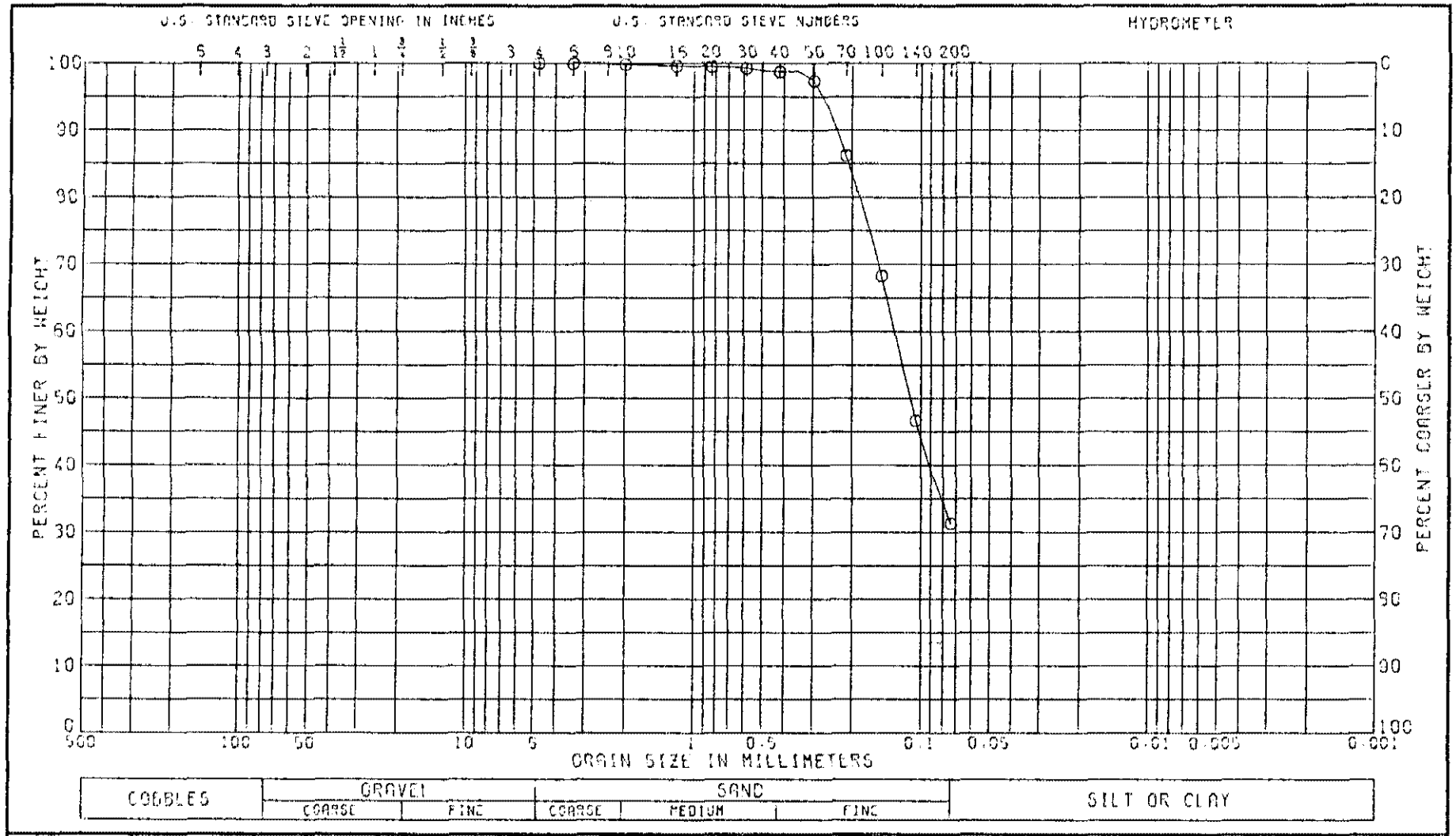
GRADATION CURVE

PROJECT CRANE NWSC

MCCOMISH GORGE

BORING NO. 4-6-81 SAMPLE NO. 4

DEPTH/ELEV 15.0-17.17 DATE 30 MAR 82




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| NP | | | | 18.4 | |

CLASSIFICATION

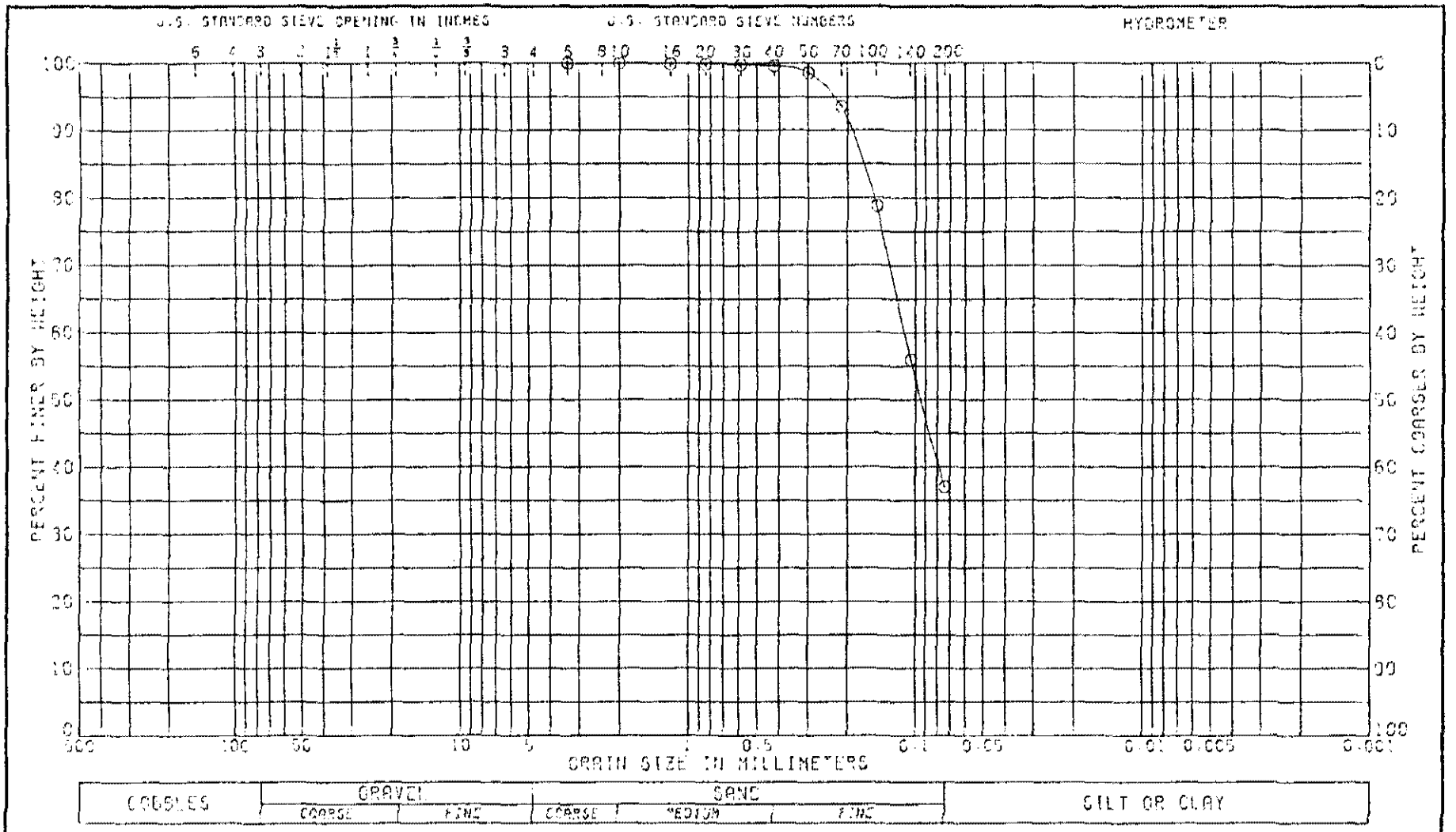
SILTY SAND (SM), BROWN

GRADATION CURVE

PROJECT CRANE NWSC MCCOMISH GORGE

BORING NO. 4-6-91 SAMPLE NO. 5

DEPTH/ELEV 19.5-20.35 DATE 11 FEB 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 20 | 17 | 3 | | 23.1 |

CLASSIFICATION

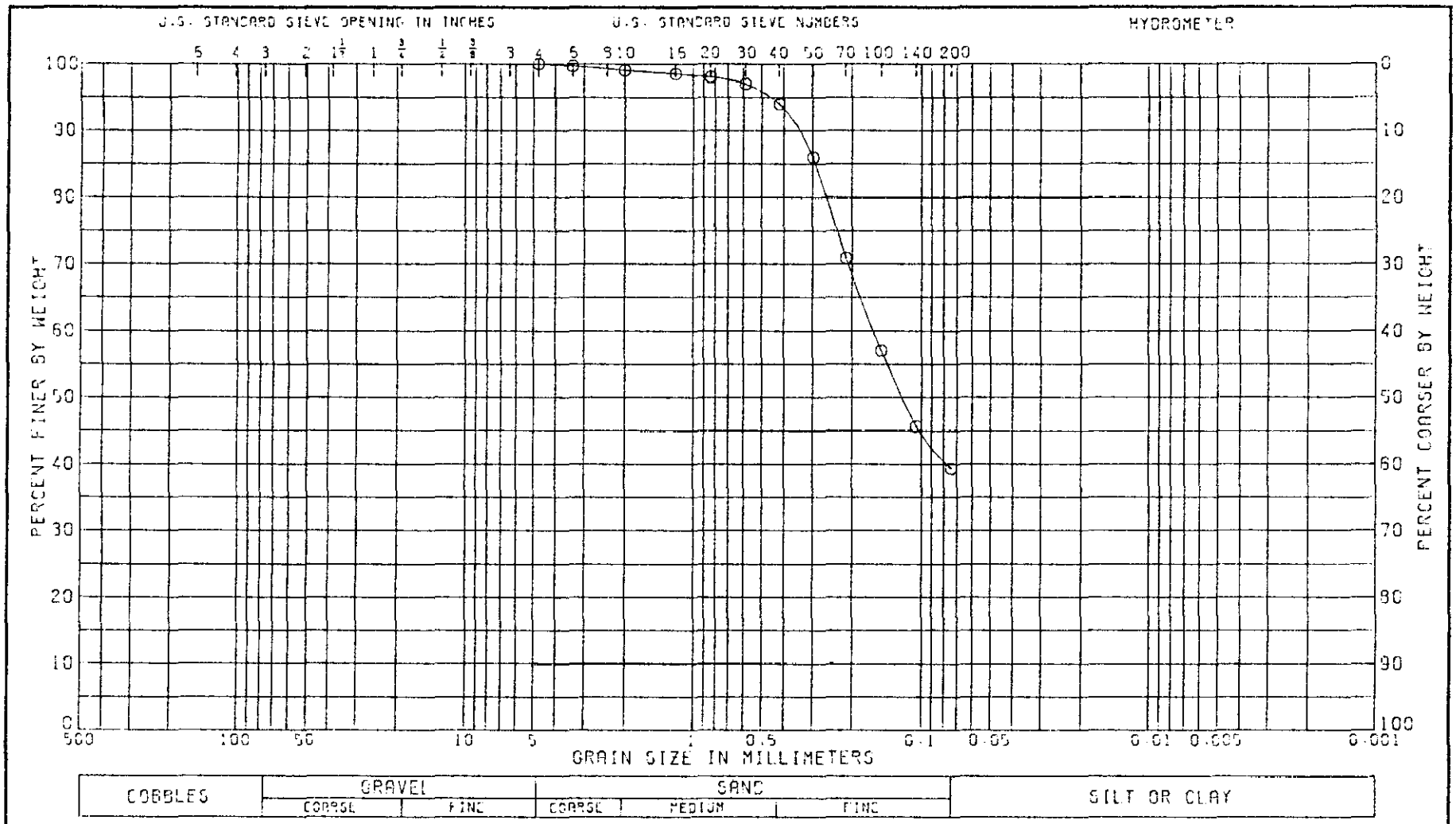
SILTY SAND (SM), BROWN

GRADATION CURVE

PROJECT CRANE MESC
MOCCASIN GORGE

BORING NO. 4-6-81 SAMPLE NO. 6

DEPTH/ELEV 24.2-26.36 DATE 09 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 19 | 11 | 8 | | 9.9 |

CLASSIFICATION

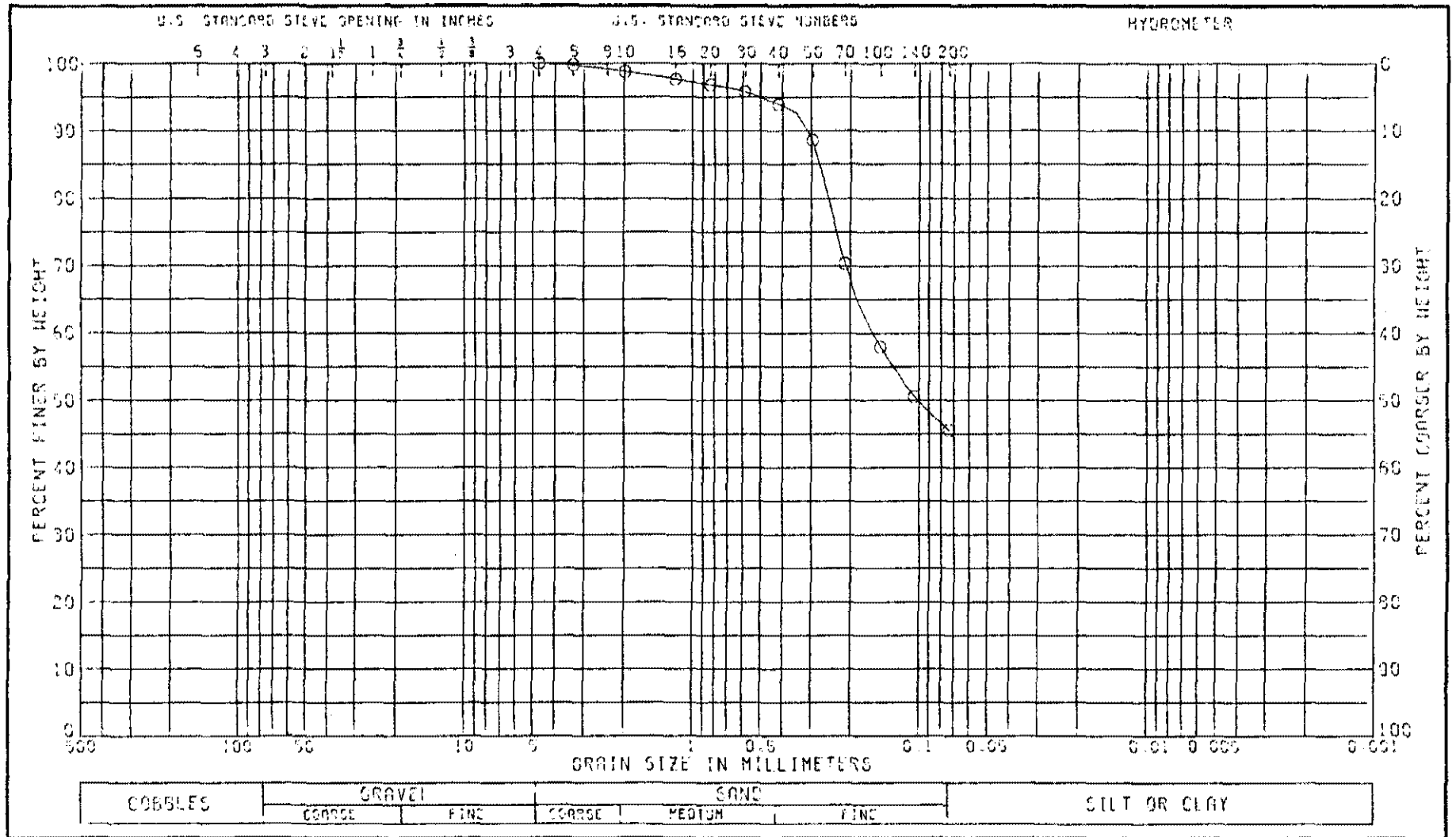
CLAYEY SAND (SC), TAN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO 5-1-91 SAMPLE NO 1

DEPTH/ELEV 0.0-1.55 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 25 | 12 | 14 | | 14.4 |

CLASSIFICATION

CLAYEY SAND (SC), BROWN

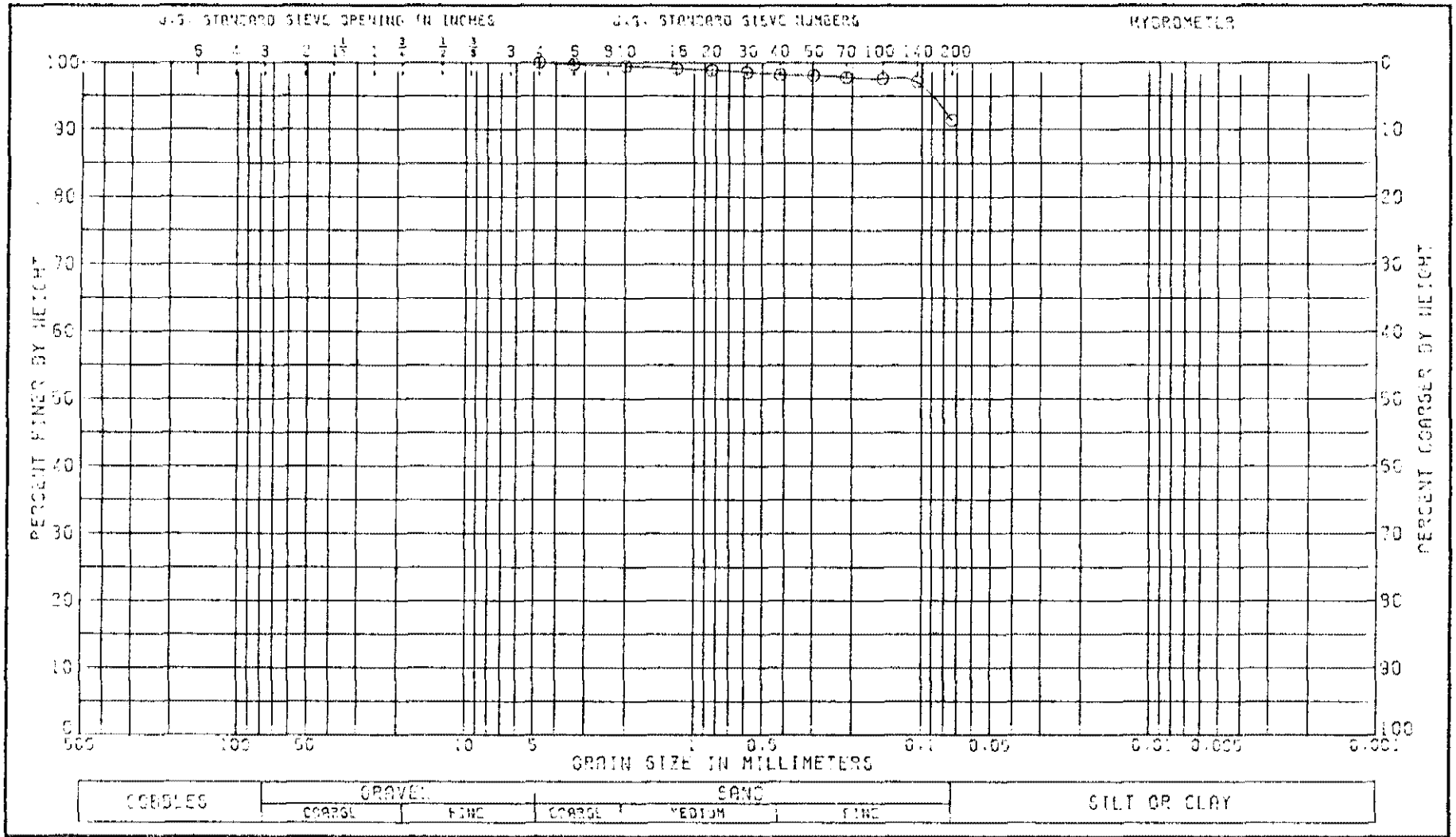
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 5-1-81 SAMPLE NO 2

DEPTH/ELEV 5.0-6.50 DATE 26 FEB 82




| LL 33 | PL 15 | PI 18 | OS | NAT W.% 15.9 |
|---|---|---|---|---|

CLASSIFICATION

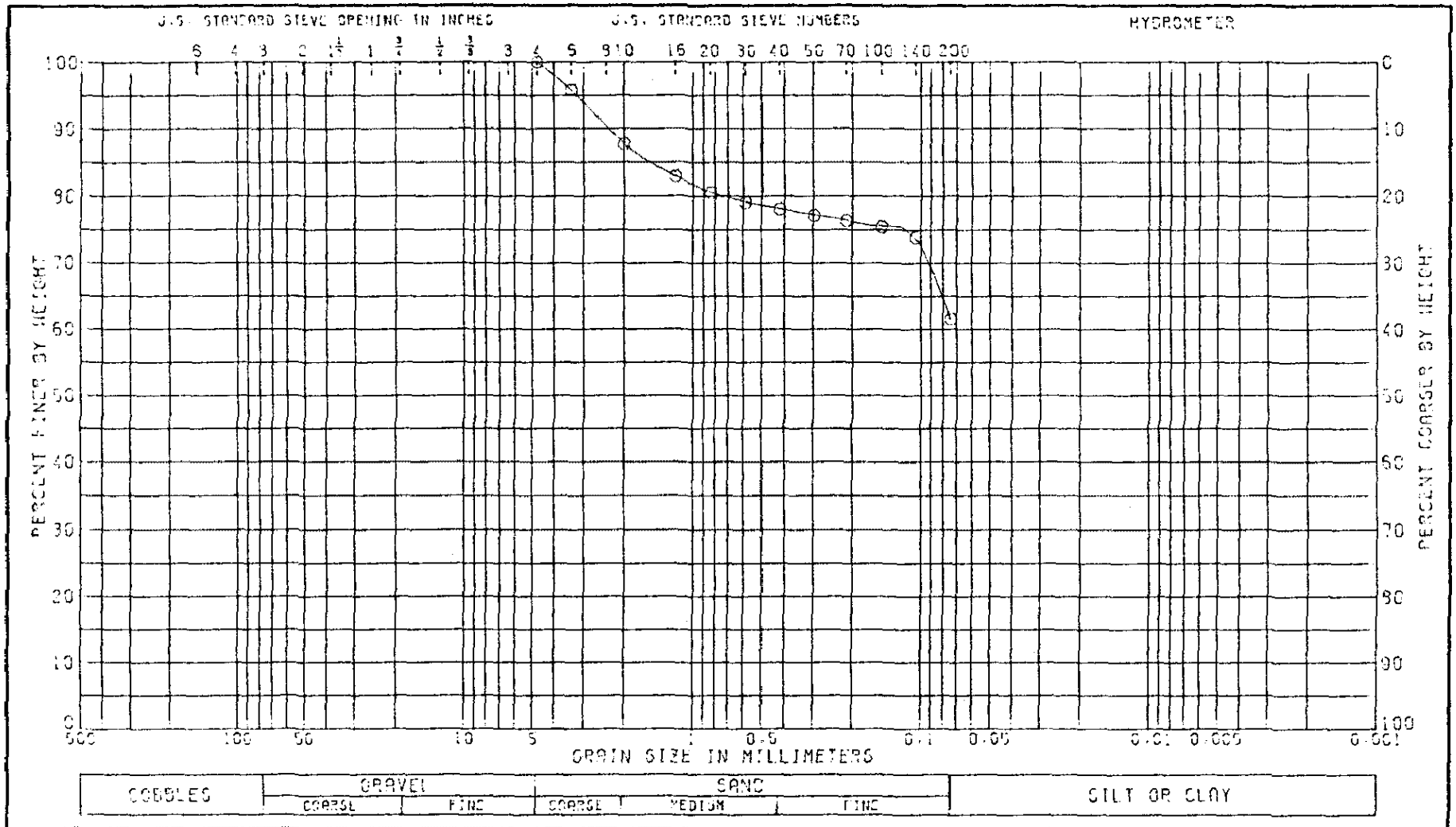
CLAY (CL), LIGHT BROWN: W/SAND

GRADATION CURVE

PROJECT CRANE NLSC OLD BURNING GROUND

BORING NO. 5-1-91 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.81 DATE 11 FEB 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 29 | 13 | 16 | | 10.3 |

CLASSIFICATION

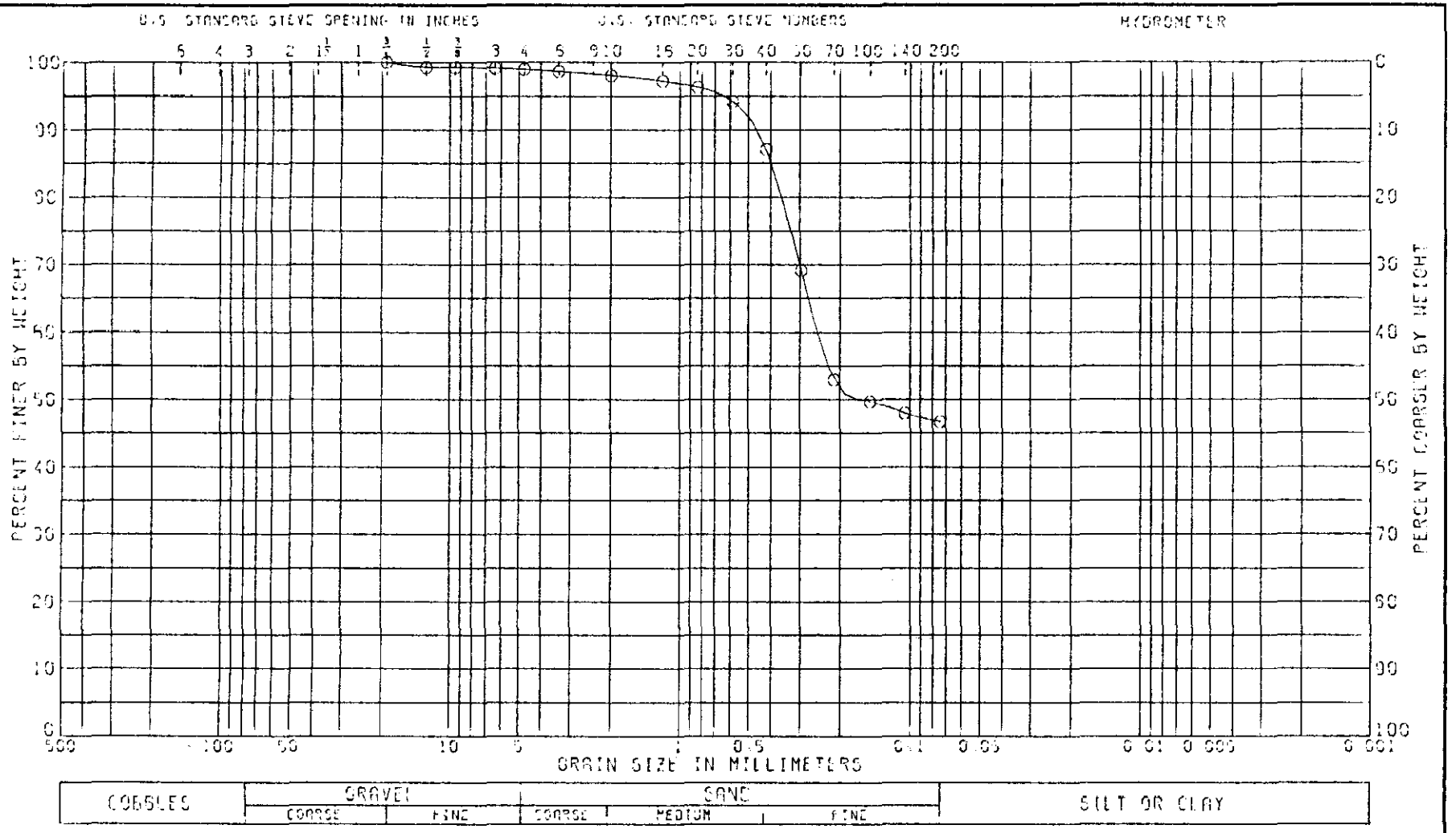
SANDY CLAY (CL), TAN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO 5-1-81 SAMPLE NO 4

DEPTH/ELEV 15.0-15.65 DATE 11 FEB 82




| LL | PL | PI | OS | NAT W.% | |
|---|---|---|---|---|---|
| 25 | 12 | 13 | | 13.6 | |

CLASSIFICATION

CLAYEY SAND (SC), REDDISH BROWN

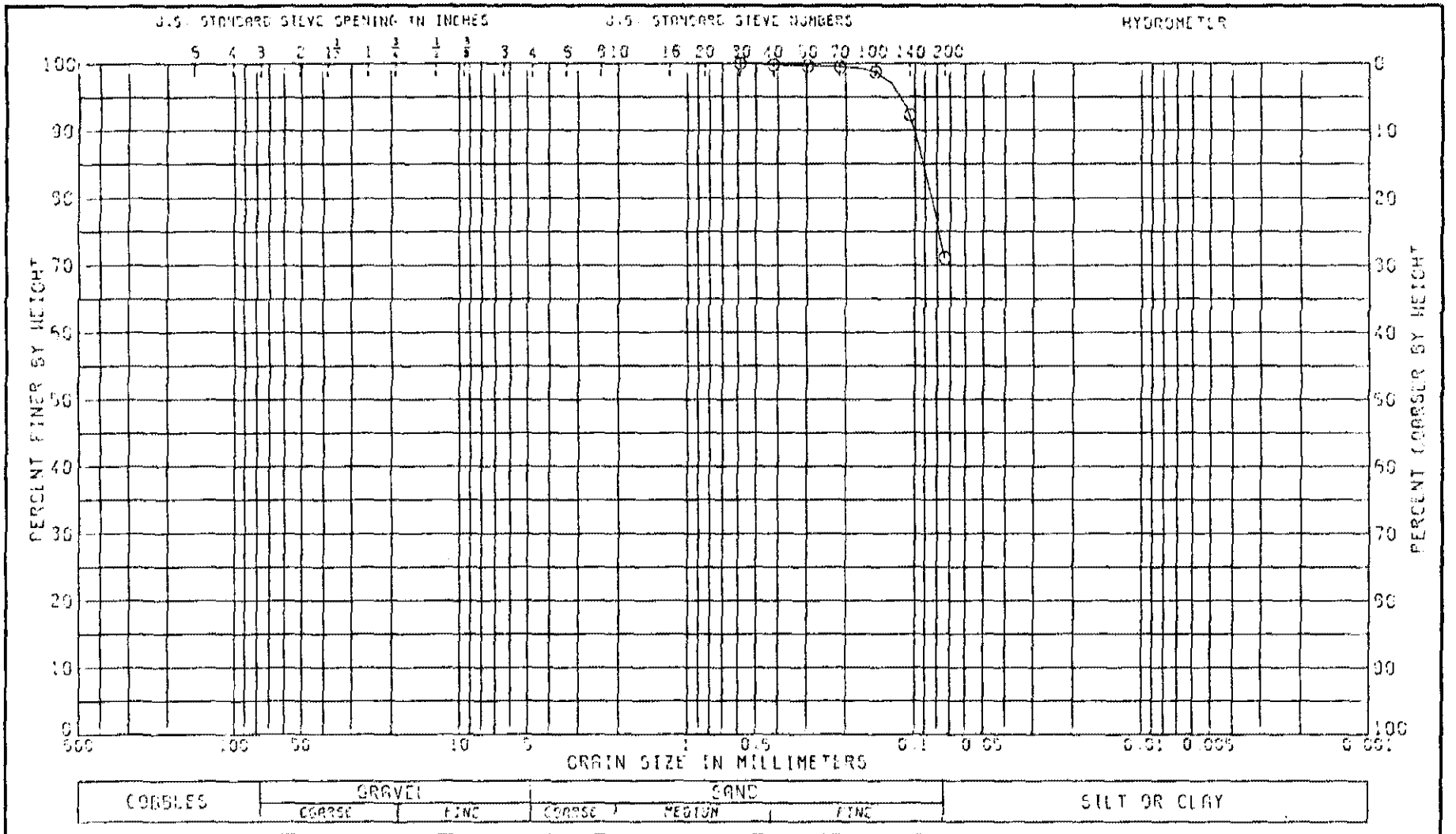
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 5-2-81 SAMPLE NO 1

DEPTH/ELEV 0.0-1.75 DATE 26 FEB 82




| LL 21 | PL 16 | PI 5 | GS | NAT W.% 23.0 | |
|---|---|---|---|---|---|

CLASSIFICATION

SANDY CLAYEY SILT (CL-ML), TAN

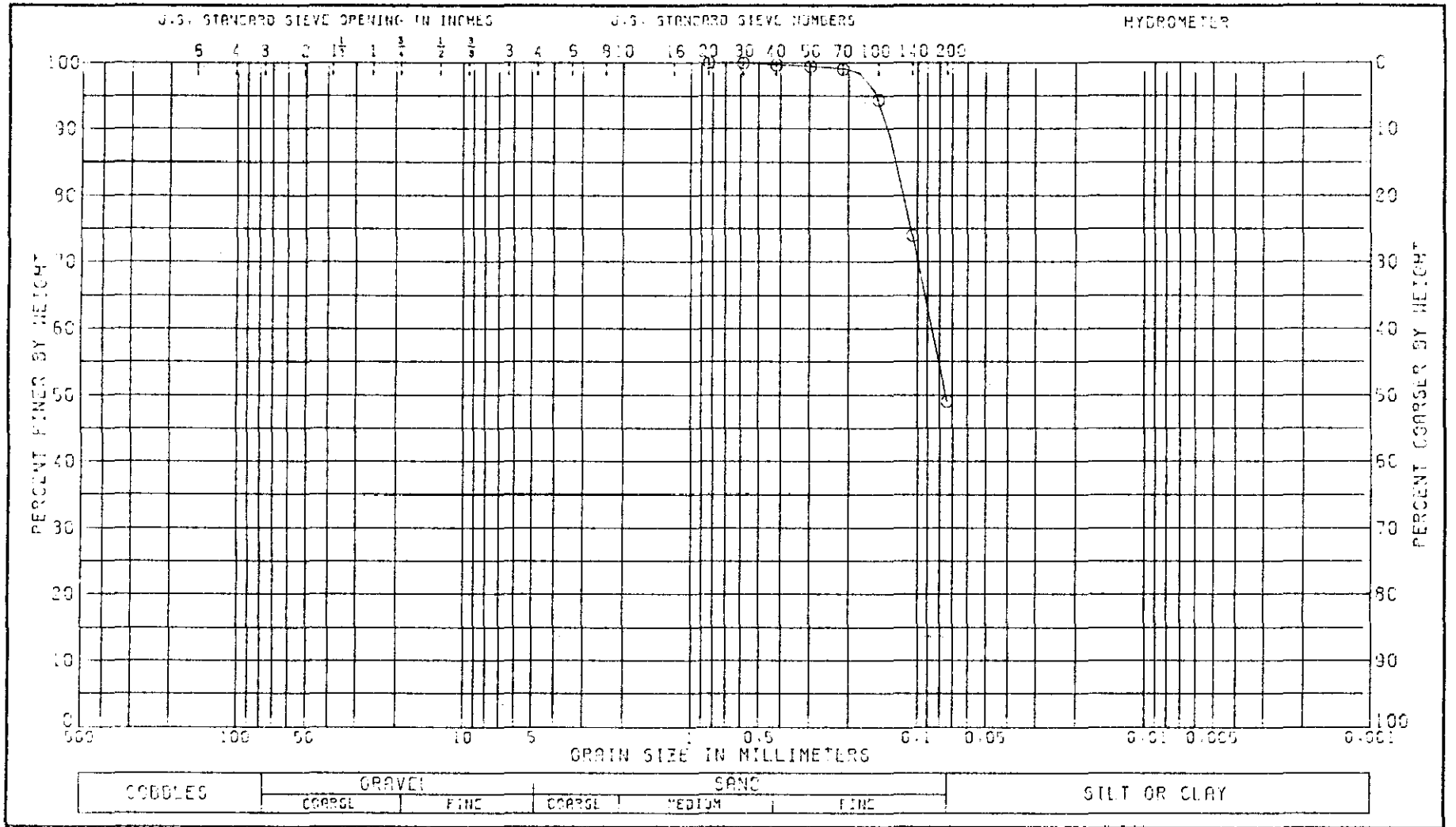
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 5-2-81 SAMPLE NO 2

DEPTH/ELEV 5.0-7.15 DATE 26 FEB 82




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| NP | | | | 19.3 | |

CLASSIFICATION

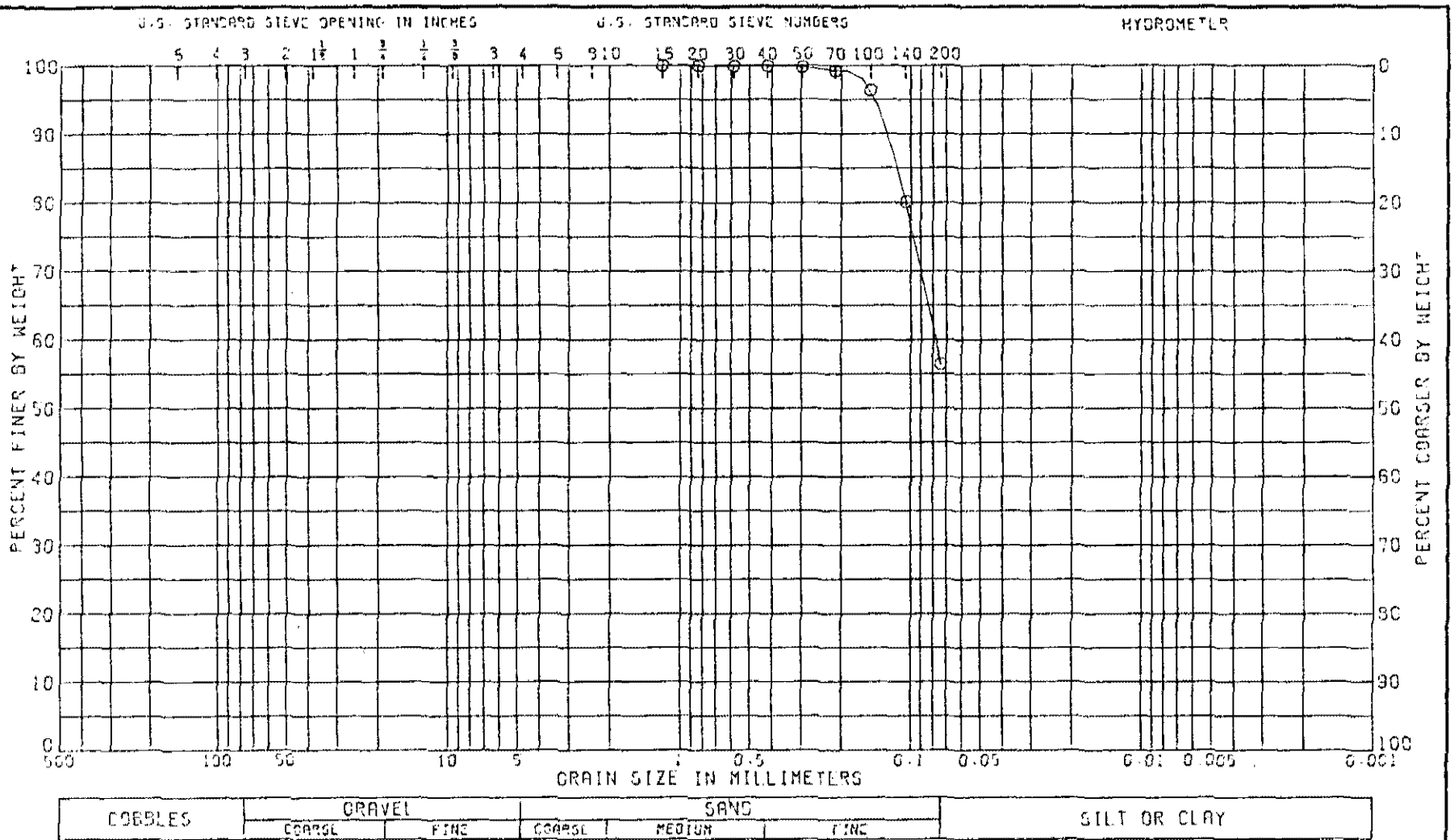
SILTY SAND (SM), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO 5-2-91 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.46 DATE 11 FEB 92




| LL | PL | PI | OS | NAT W.% | |
|---|---|---|---|---|---|
| 22 | 17 | 5 | | 28.4 | |

CLASSIFICATION

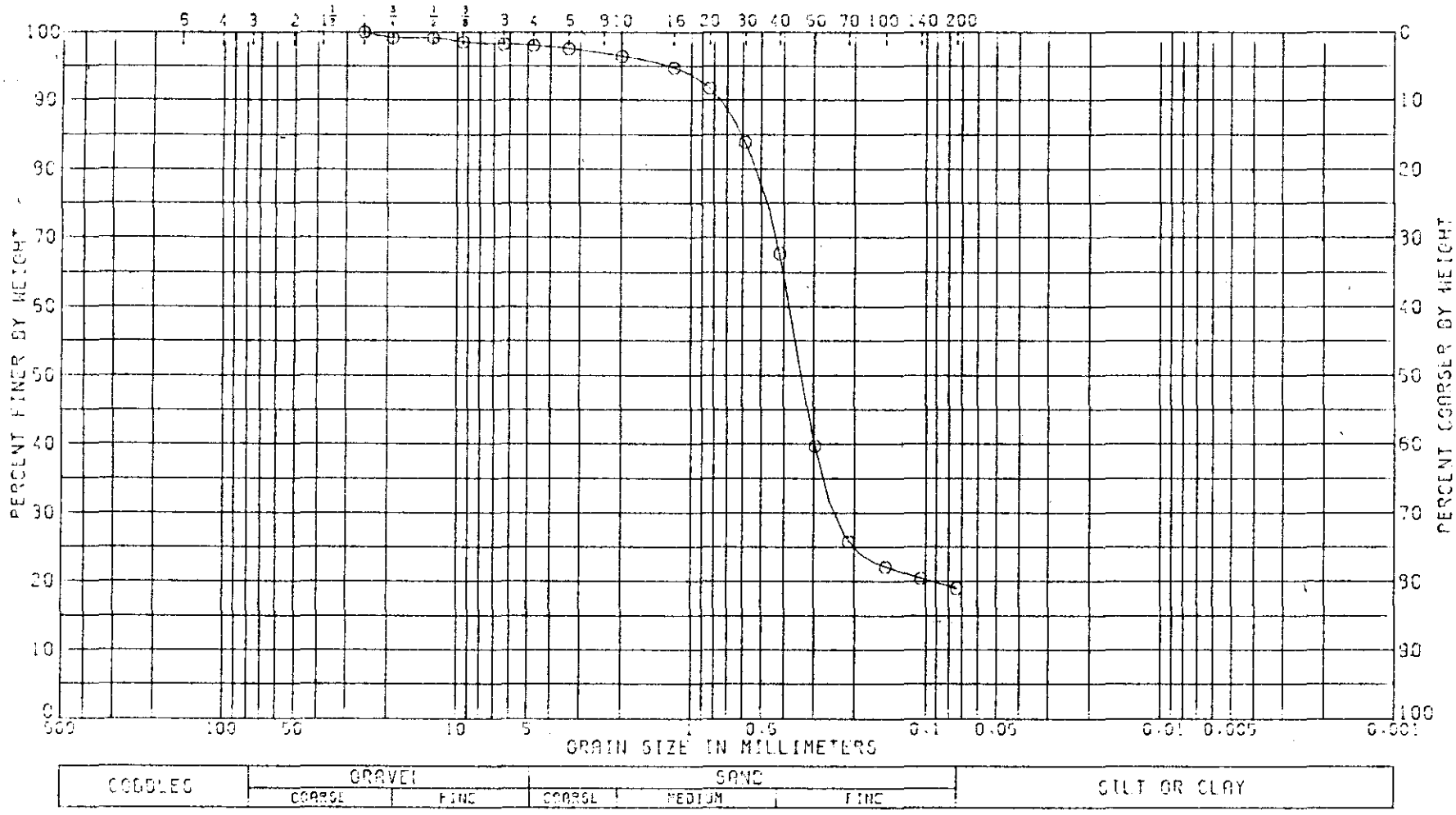
SANDY CLAYEY SILT (CL-ML), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-2-81 SAMPLE NO. 4B

DEPTH/ELEV 15.0-18.2 DATE 31 MAR 82




| LL 21 | PL 12 | PI 9 | CS | NAT W.% 7.7 | |
|---|---|---|---|---|---|

CLASSIFICATION

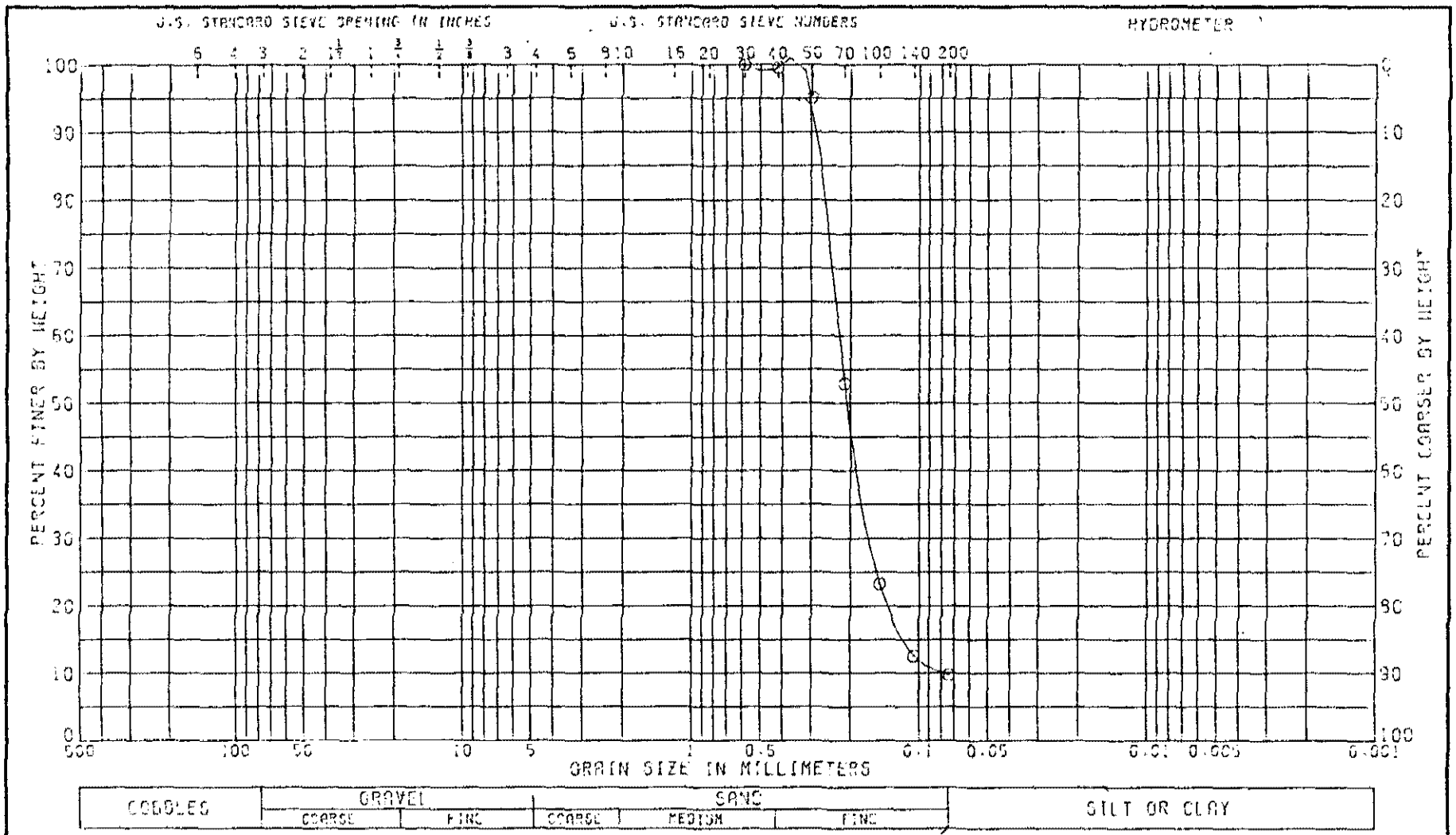
CLAYEY SAND (SC), REDDISH BROWN

GRADATION CURVE

PROJECT CRANE NESC OLD BURNING GROUND

BORING NO. 5-3-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.75 DATE 11 FEB 92




| LL NP | PL | PI | GS | NAT W.% 10.4 |
|---|---|---|---|---|

CLASSIFICATION

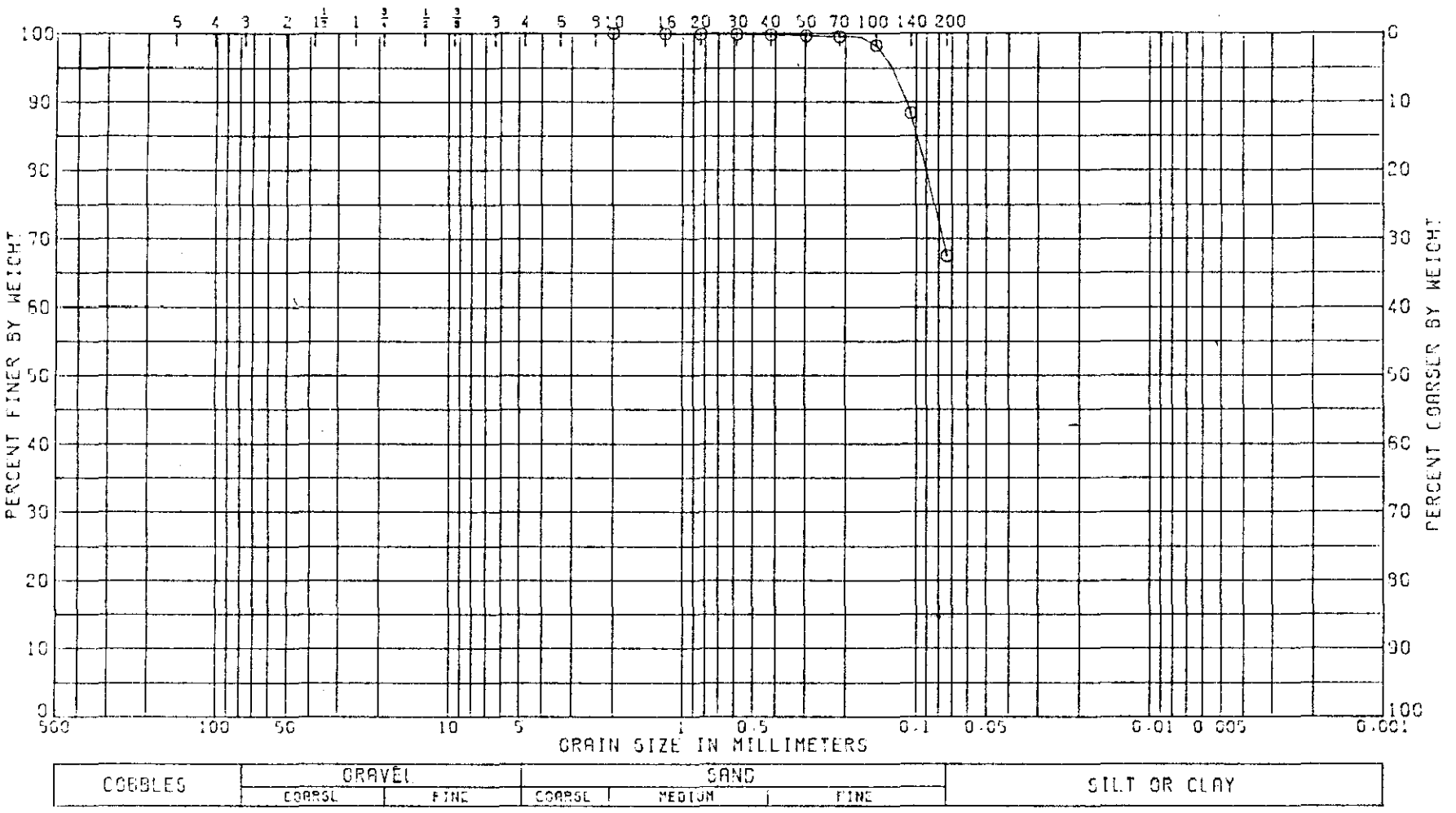
SILTY SAND (SP-SM), REDDISH BROWN

GRADATION CURVE

PROJECT CRANE NLSC OLD BURNING GROUND

BORING NO. 5-3--91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.76 DATE 11 FEB 92




| LL 24 | PL 19 | PI 5 | GS | NAT W.% 21.7 |
|---|---|---|---|---|

CLASSIFICATION

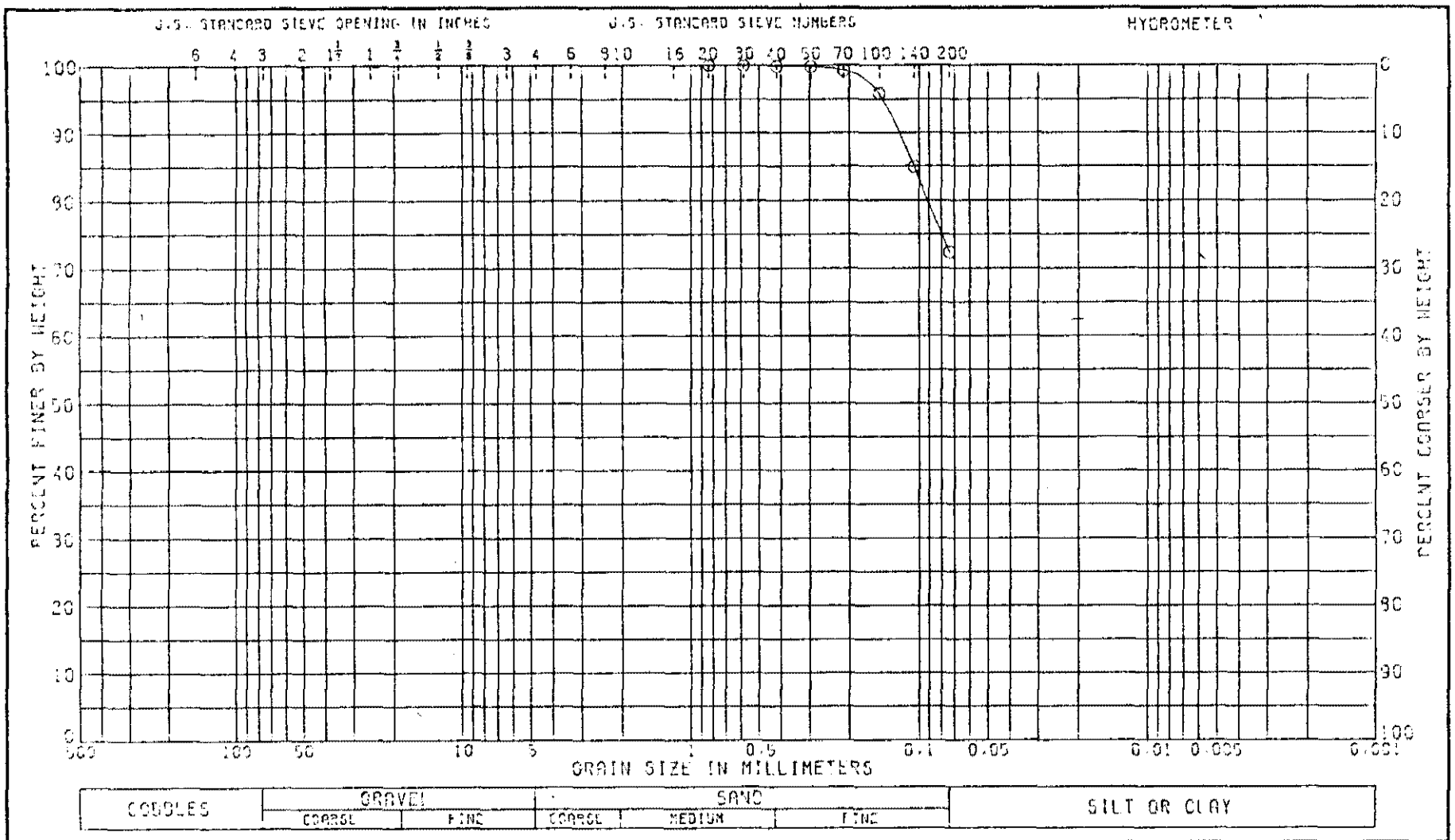
SANDY SILTY CLAY (CL-ML), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-3-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.95 DATE 31 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 25 | 16 | 9 | | 24.4 |

CLASSIFICATION

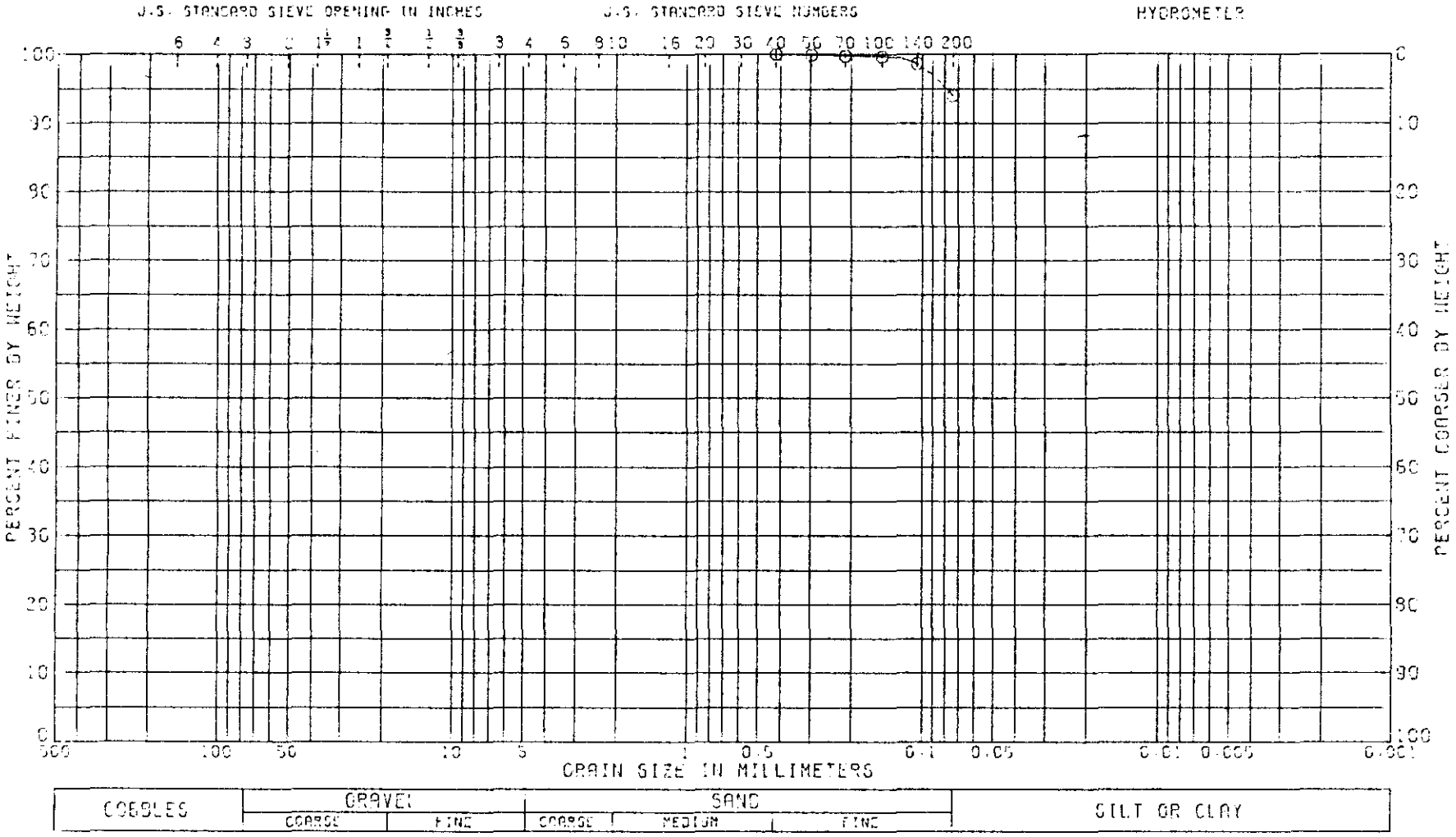
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-3-91 SAMPLE NO. 4

DEPTH/ELEV 15.0-17.15 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 31 | 20 | 11 | | 28.9 |

CLASSIFICATION

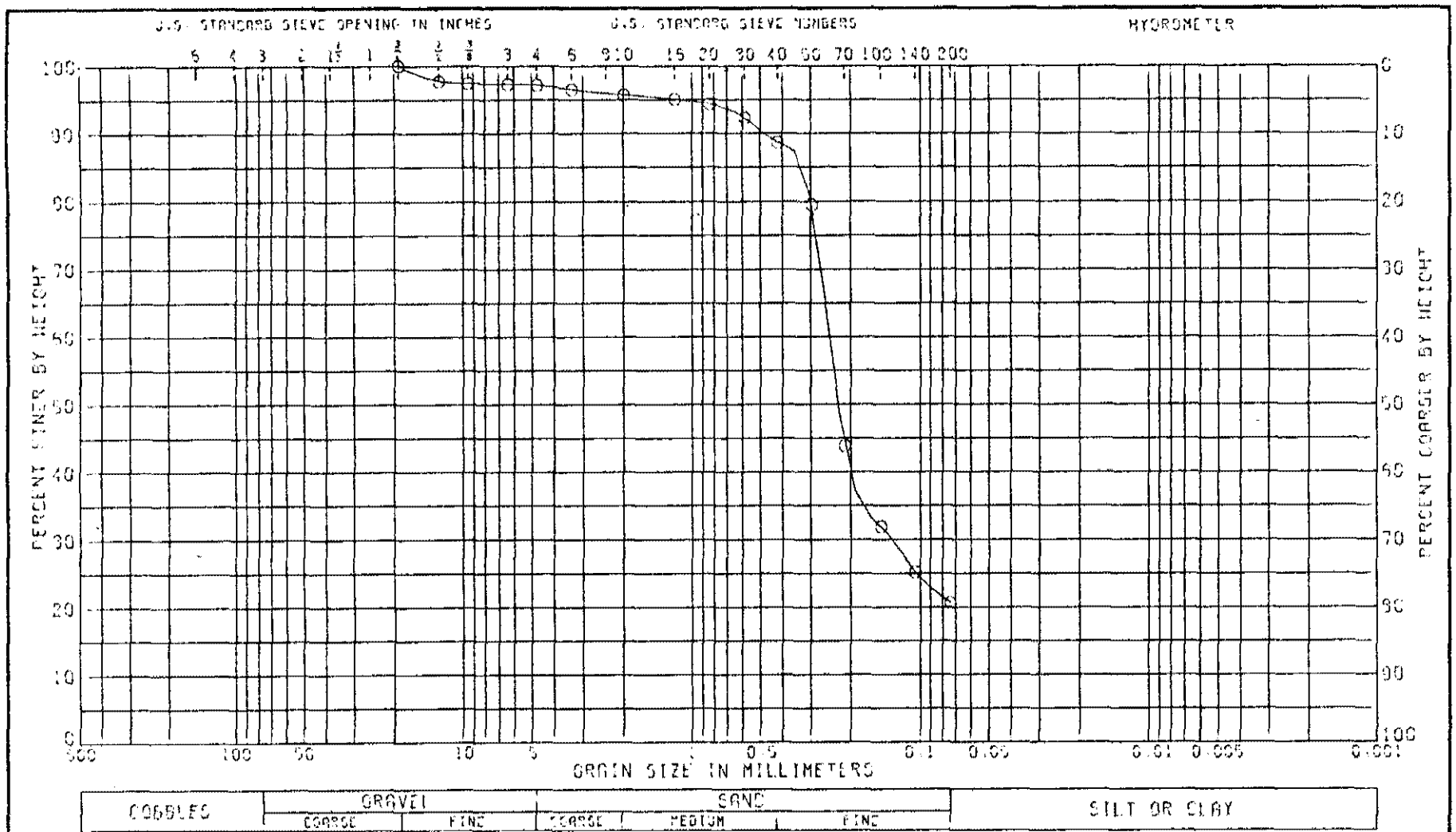
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-3-81 SAMPLE NO. 5

DEPTH/ELEV 20.0-21.39 DATE 12 MAR 82




| LL NP | PL | PI | CS | NAT W.% 7.6 | |
|---|---|---|---|---|---|

CLASSIFICATION

SILTY SAND (SM), LIGHT BROWN

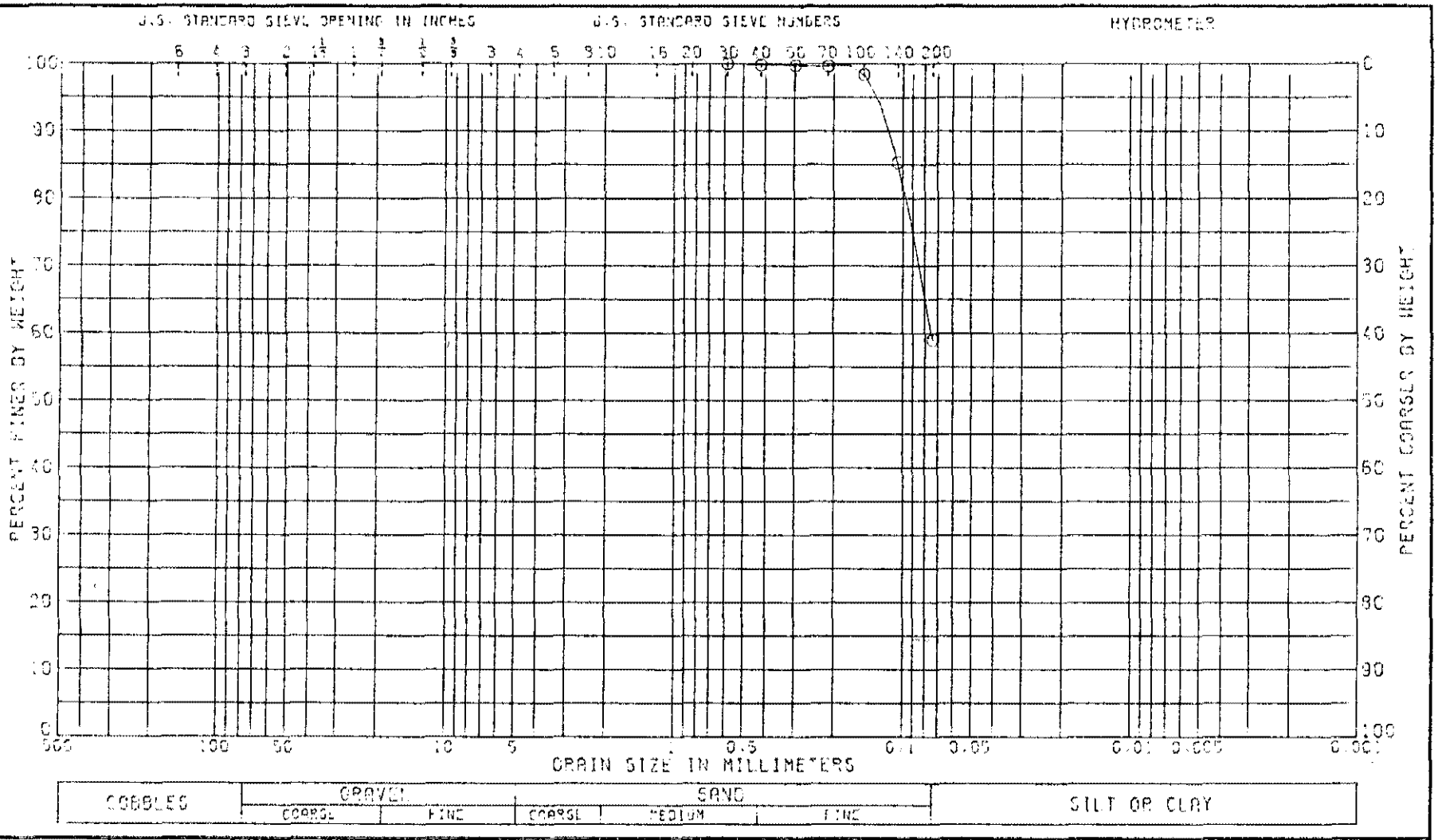
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 5-4-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.04 DATE 25 FEB 82




| LL | PL | PI | GS | NAT W.% 16.9 | |
|---|---|---|---|---|---|

CLASSIFICATION

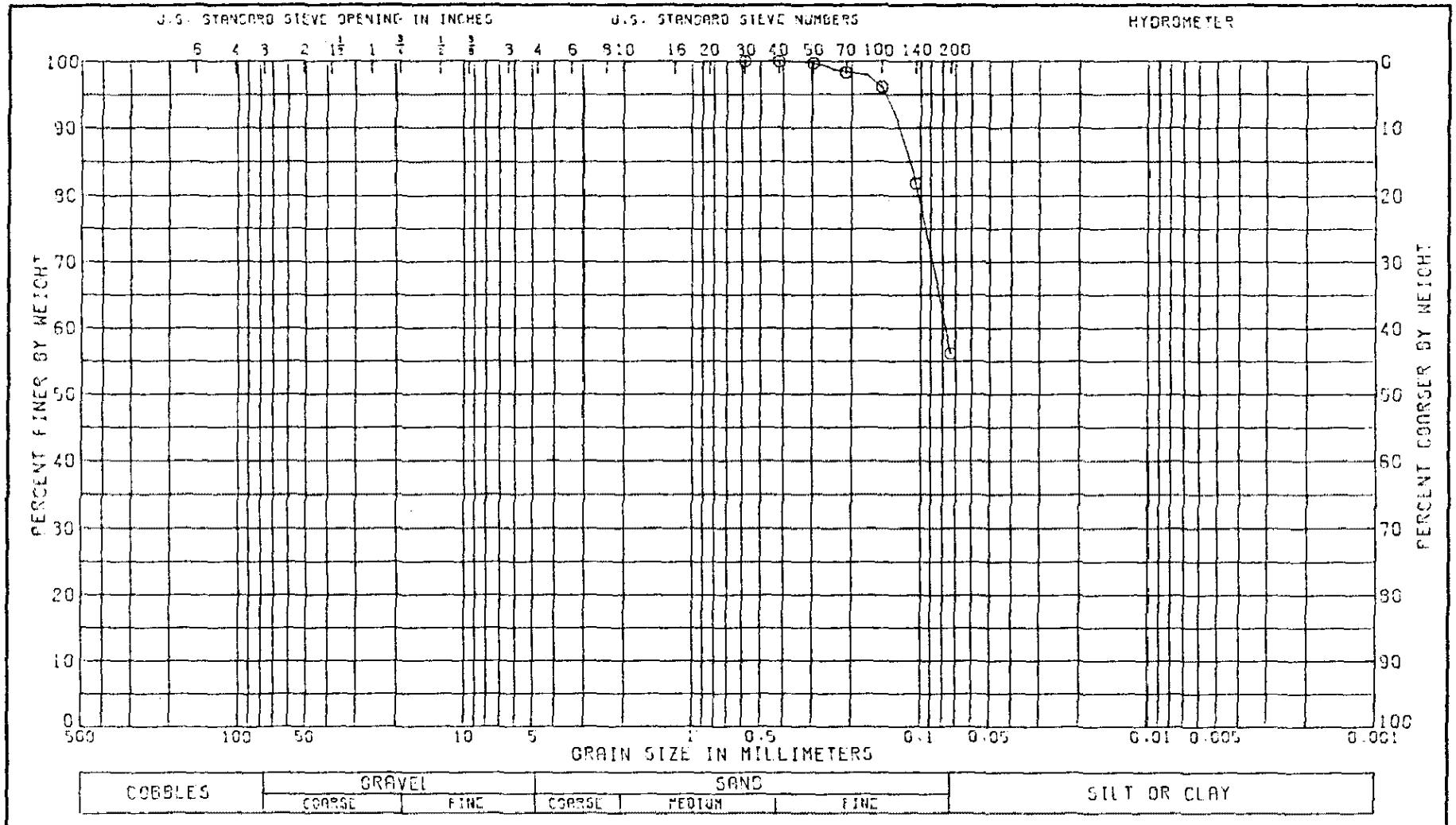
SANDY SILT (ML), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO 5-4-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.78 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 21 | 14 | 7 | | 23.7 |

CLASSIFICATION

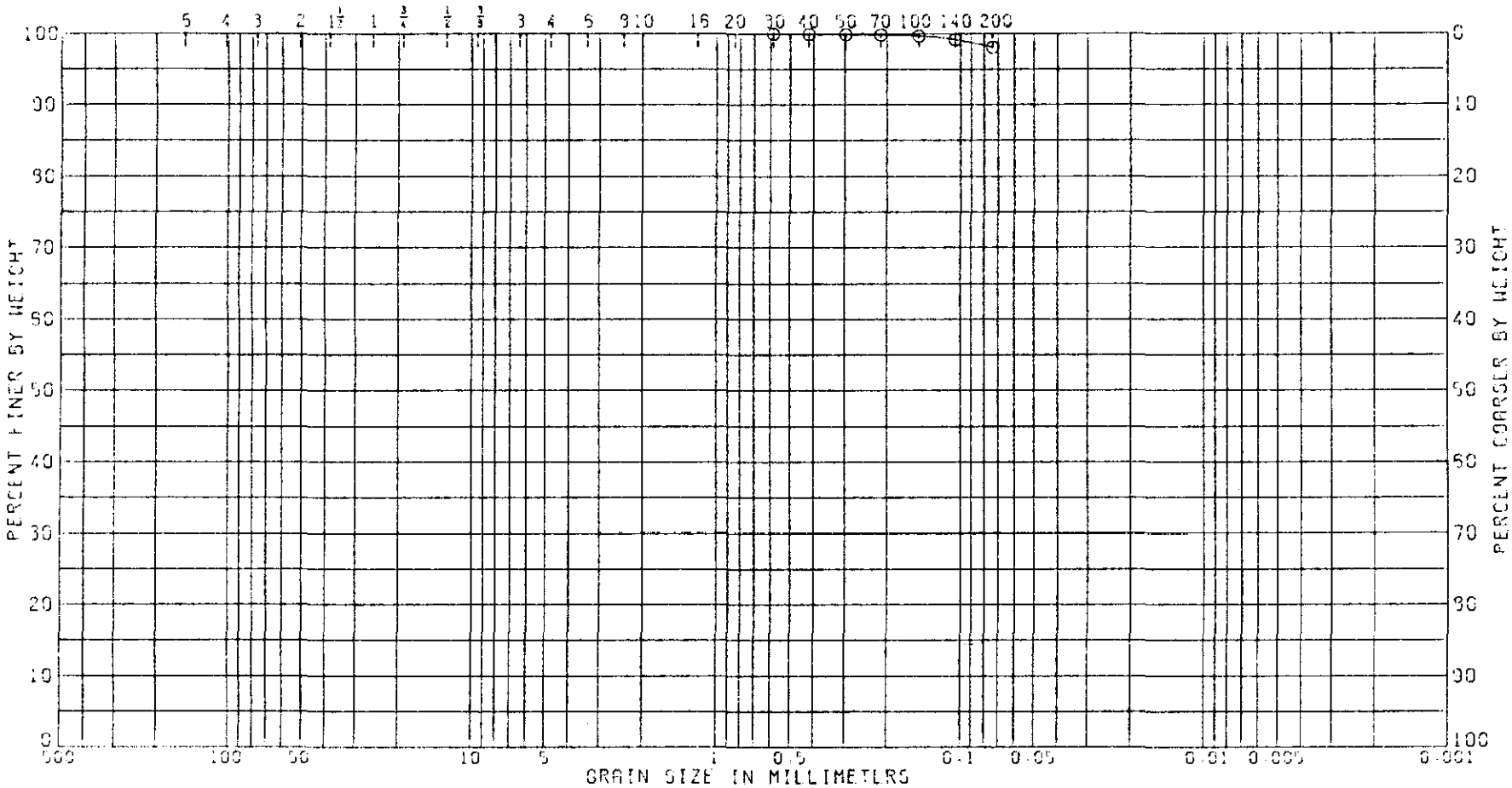
SANDY CLAY (CL) BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-4-81 SAMPLE NO. 3A

DEPTH/ELEV 10.0-12.0 DATE 31 MAR 82




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |

| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| 31 | 19 | 12 | | 33.1 | |

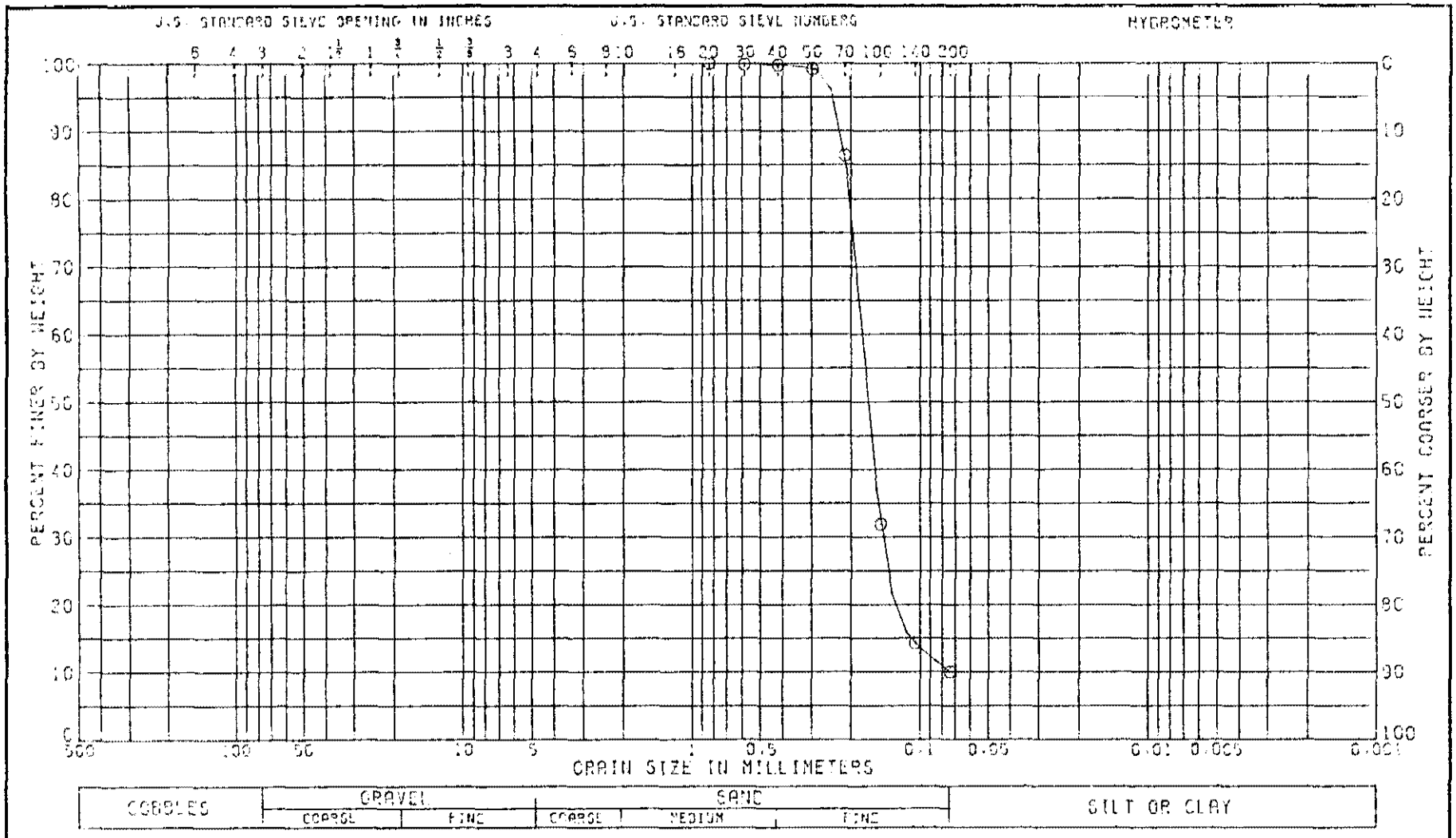
CLASSIFICATION
CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-4-91 SAMPLE NO. 5B

DEPTH/ELEV 22.5-23.0 DATE 31 MAR 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 28 | 18 | 10 | | 24.6 |

CLASSIFICATION

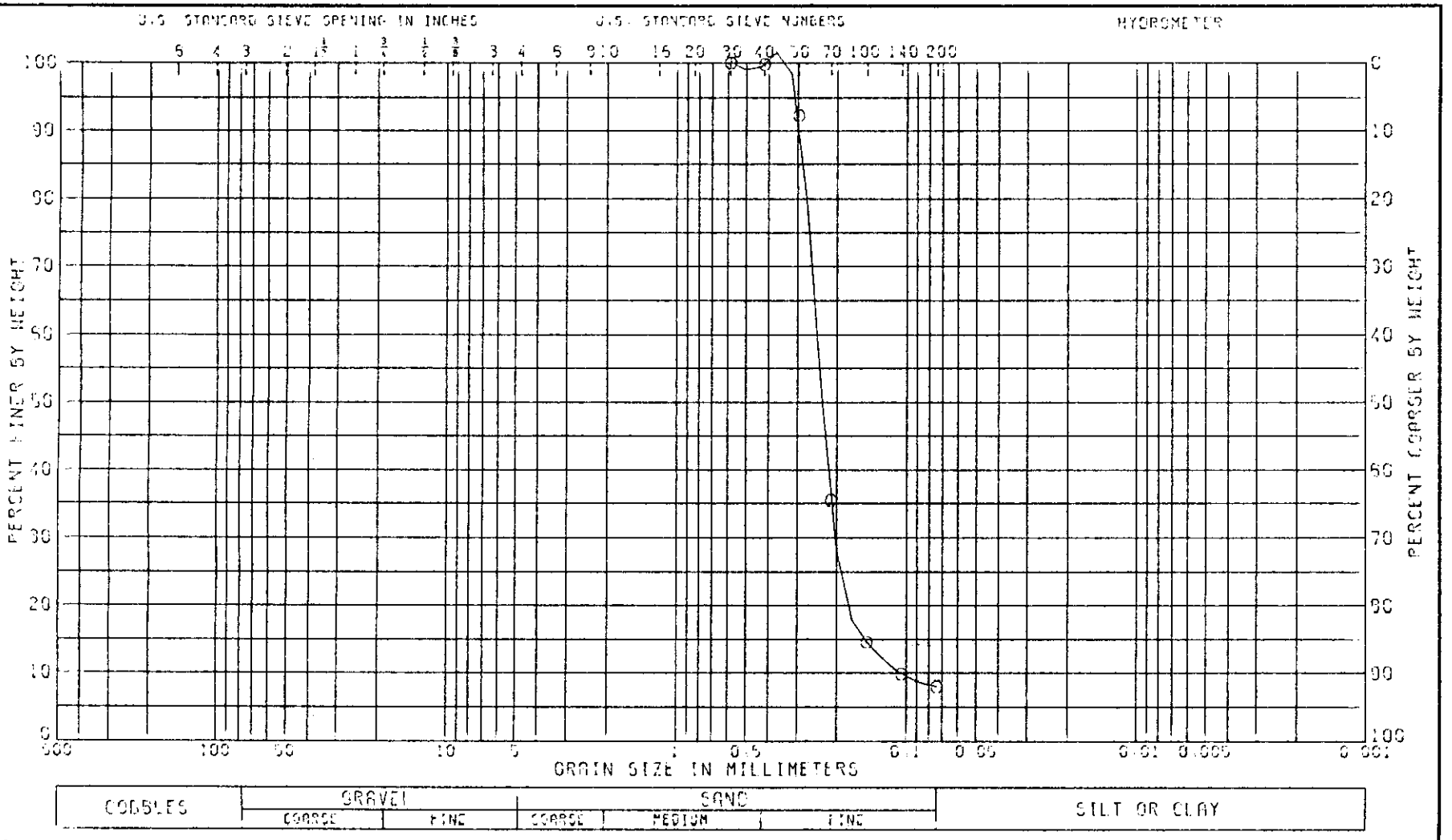
CLAYEY SAND (SP-SC), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO 5-4-81 SAMPLE NO. 6

DEPTH/ELEV 25.0-27.18 DATE 12 MAR 82




| LL NP | PL | PI | GS | NAT W.% 6.0 | |
|---|---|---|---|---|---|

CLASSIFICATION

SILTY SAND (SP-SM), REDDISH BROWN

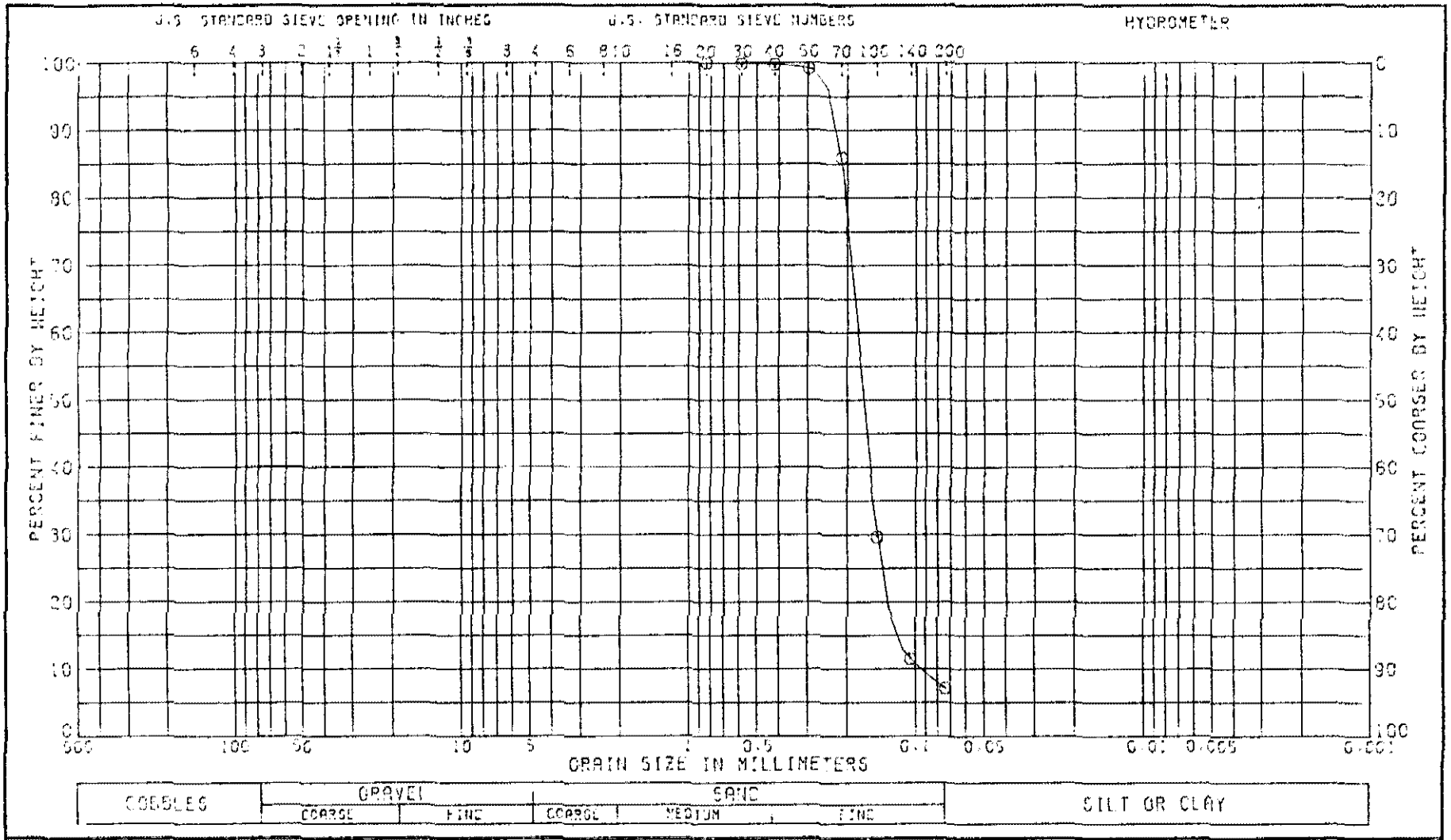
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 5-5-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.12 DATE 25 FEB 82




| LL | PL | PI | GS | NAT W,% | |
|---|---|---|---|---|---|
| NP | | | | 7.4 | |

CLASSIFICATION

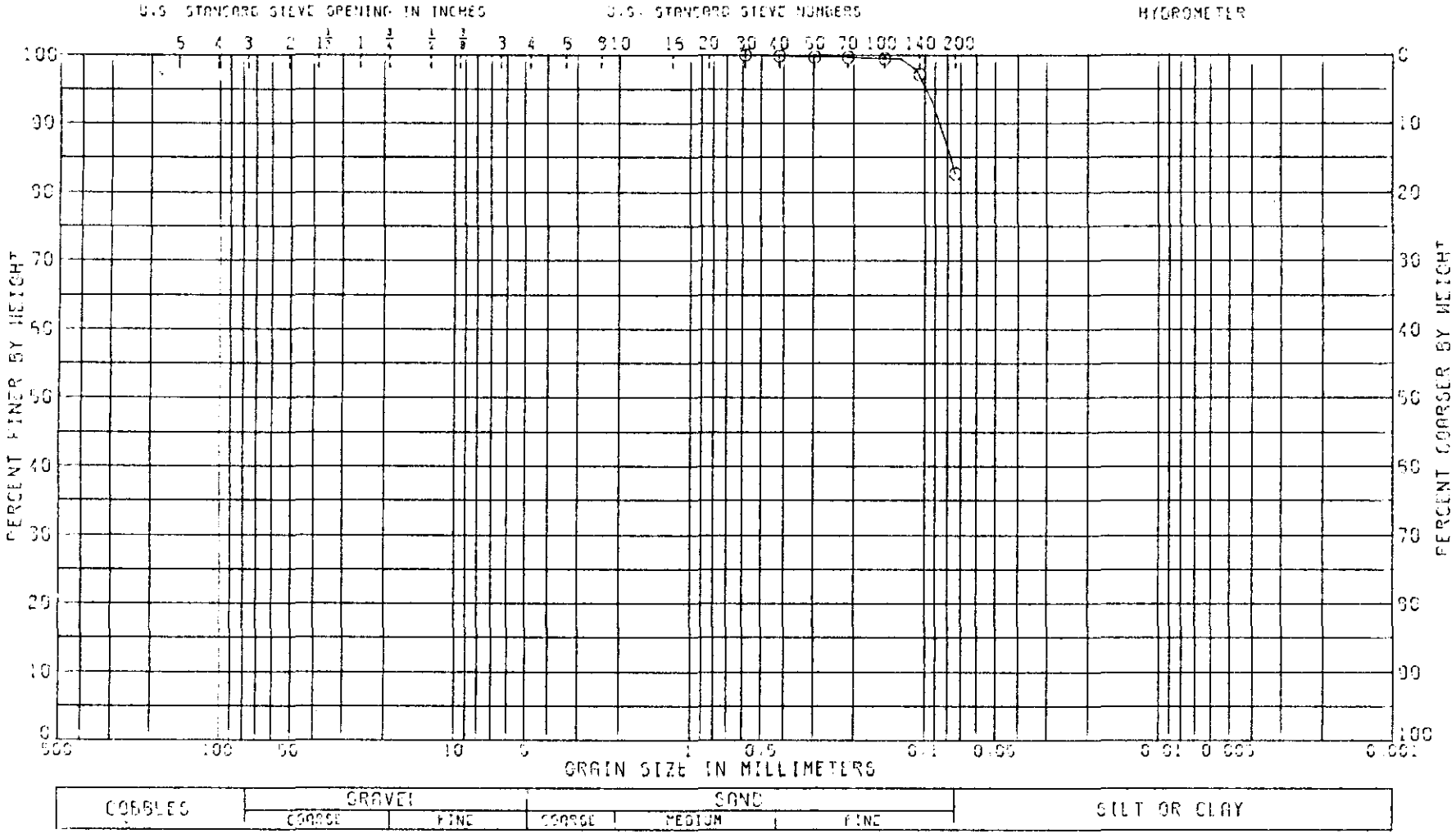
SILTY SAND (SP-SM), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO 5-5-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.81 DATE 12 MAR 82




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| 23 | 20 | 3 | | 25.0 | |

CLASSIFICATION

SANDY SILT (ML), BROWN

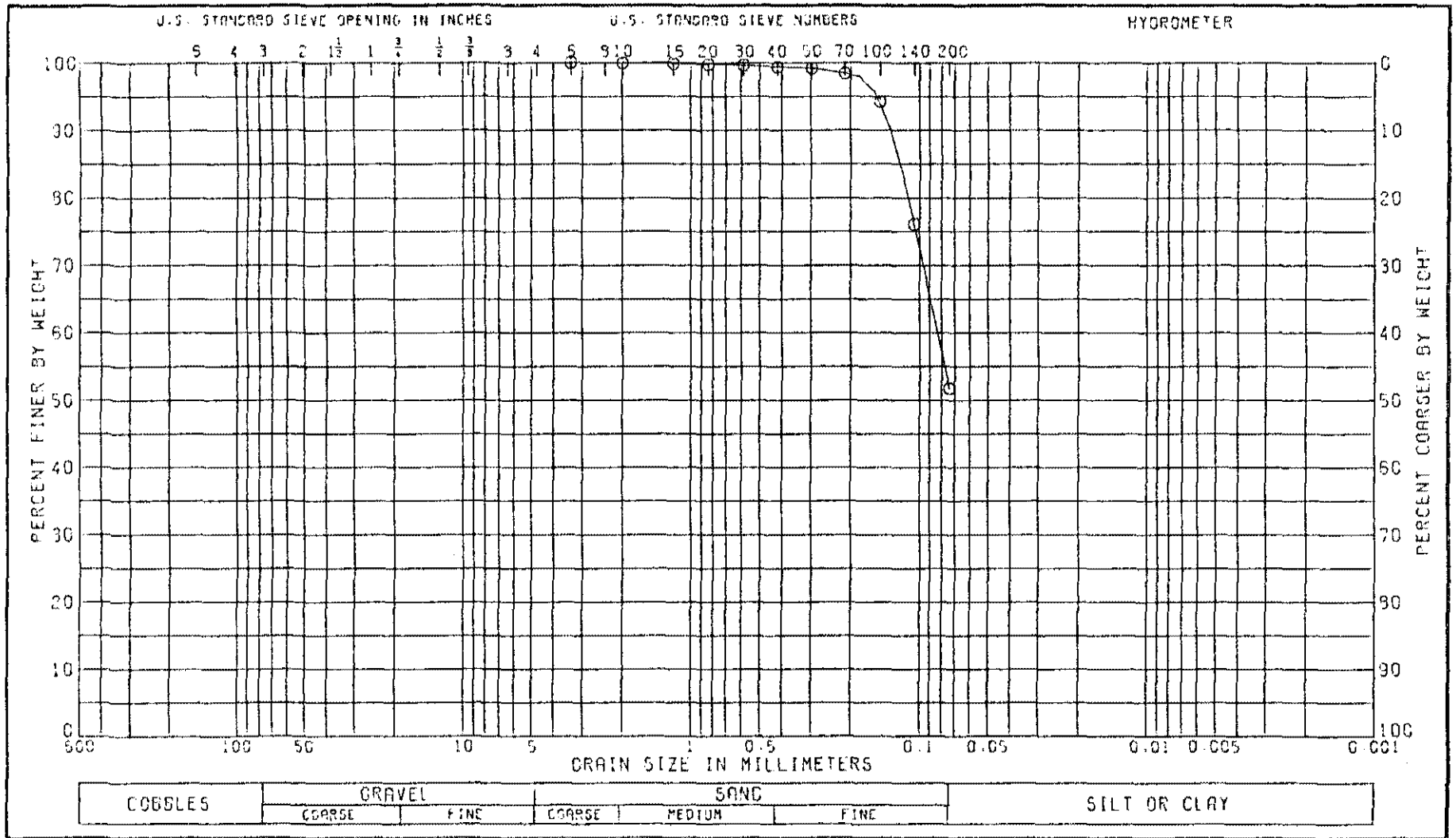
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 5-5-91 SAMPLE NO 3

DEPTH/ELEV 10.5-12.02 DATE 26 FEB 92




| LL NP | PL | PI | OS | NAT W.% 20.6 |
|---|---|---|---|---|

CLASSIFICATION

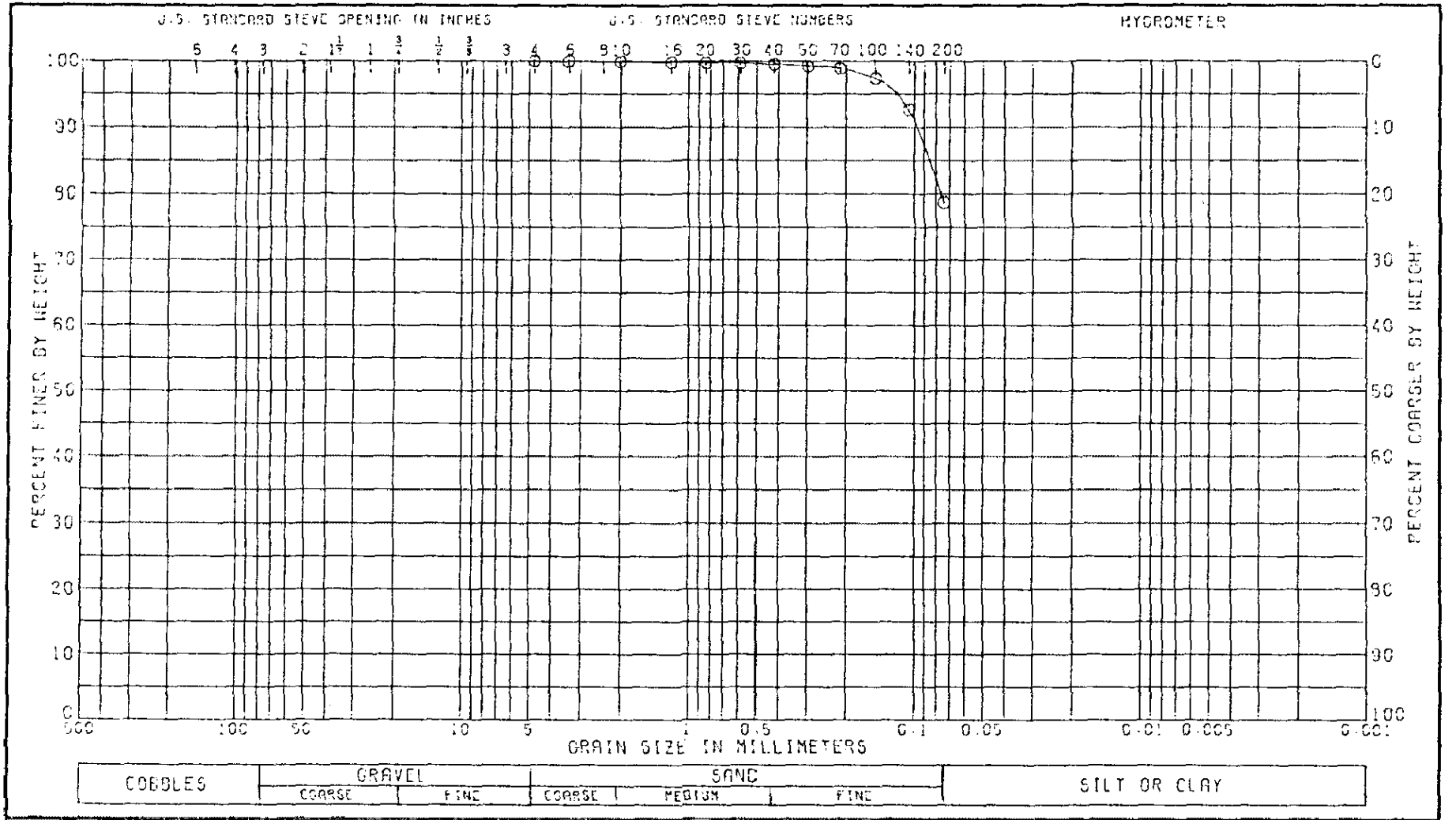
SANDY SILT (ML), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-5-81 SAMPLE NO. 4

DEPTH/ELEV 15.0-16.85 DATE 12 MAR 82




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 24 | 19 | 5 | | 25.3 |

CLASSIFICATION

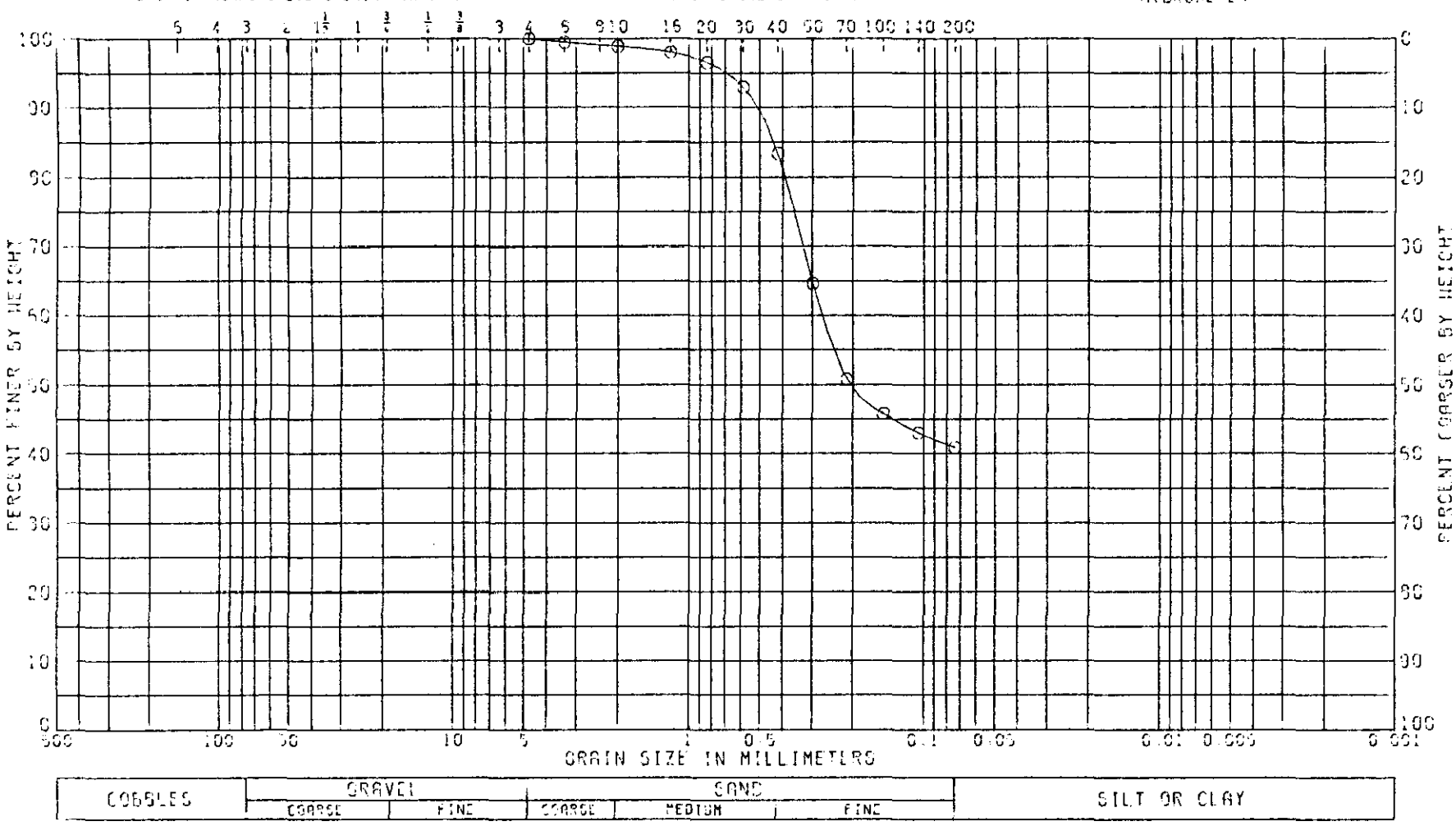
SANDY SILTY CLAY (CL-ML), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-5-81 SAMPLE NO. 5

DEPTH/ELEV 20.4-22.15 DATE 12 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 34 | 14 | 20 | | 14.3 |

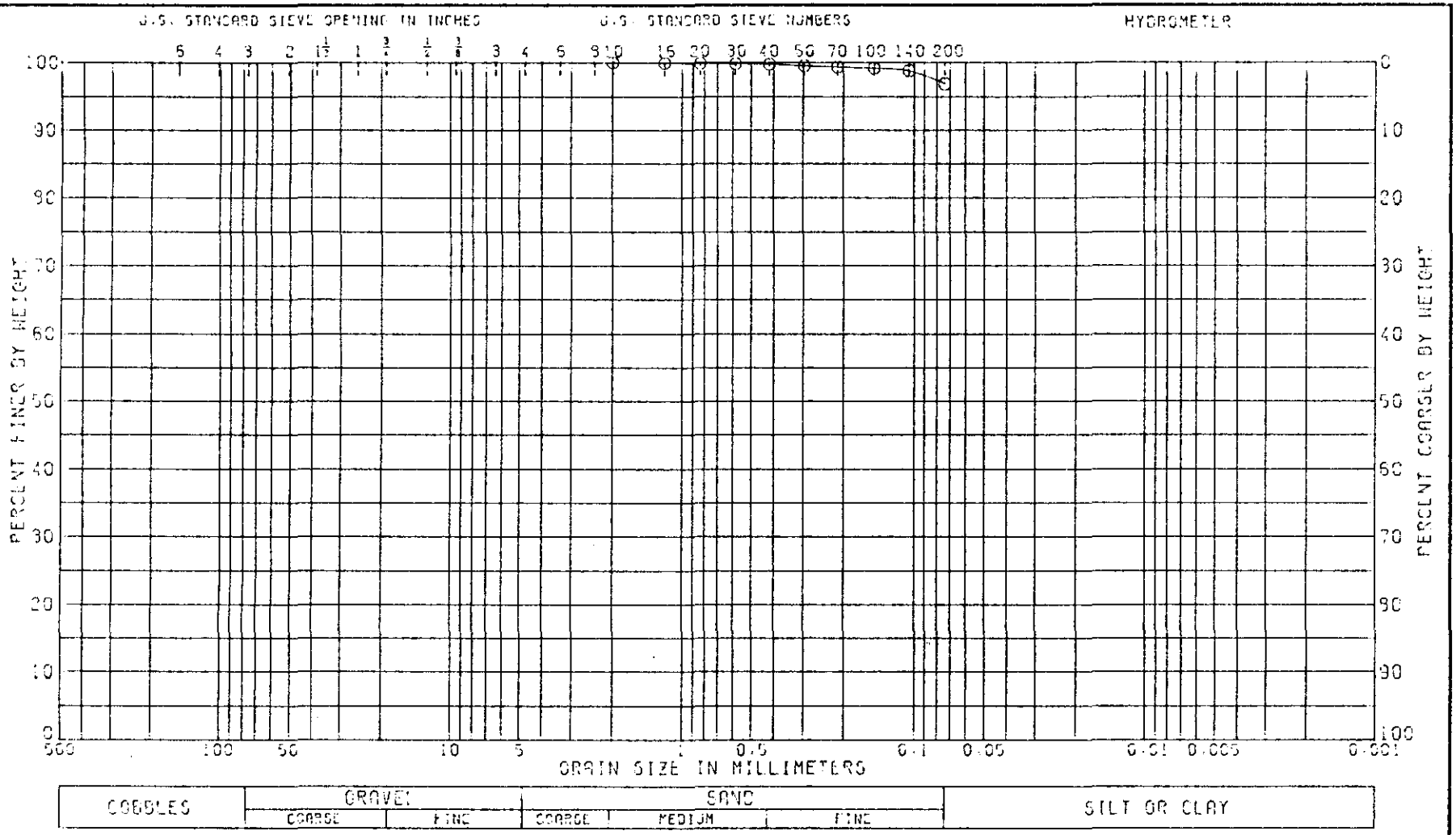
CLASSIFICATION
CLAYEY SAND (SC), REDDISH BROWN

GRADATION CURVE

PROJECT CRANE NWSC
OLD BURNING GROUND

BORING NO 5-6-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.03 DATE 26 FEB 82




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 31 | 19 | 12 | | 17.8 |

CLASSIFICATION

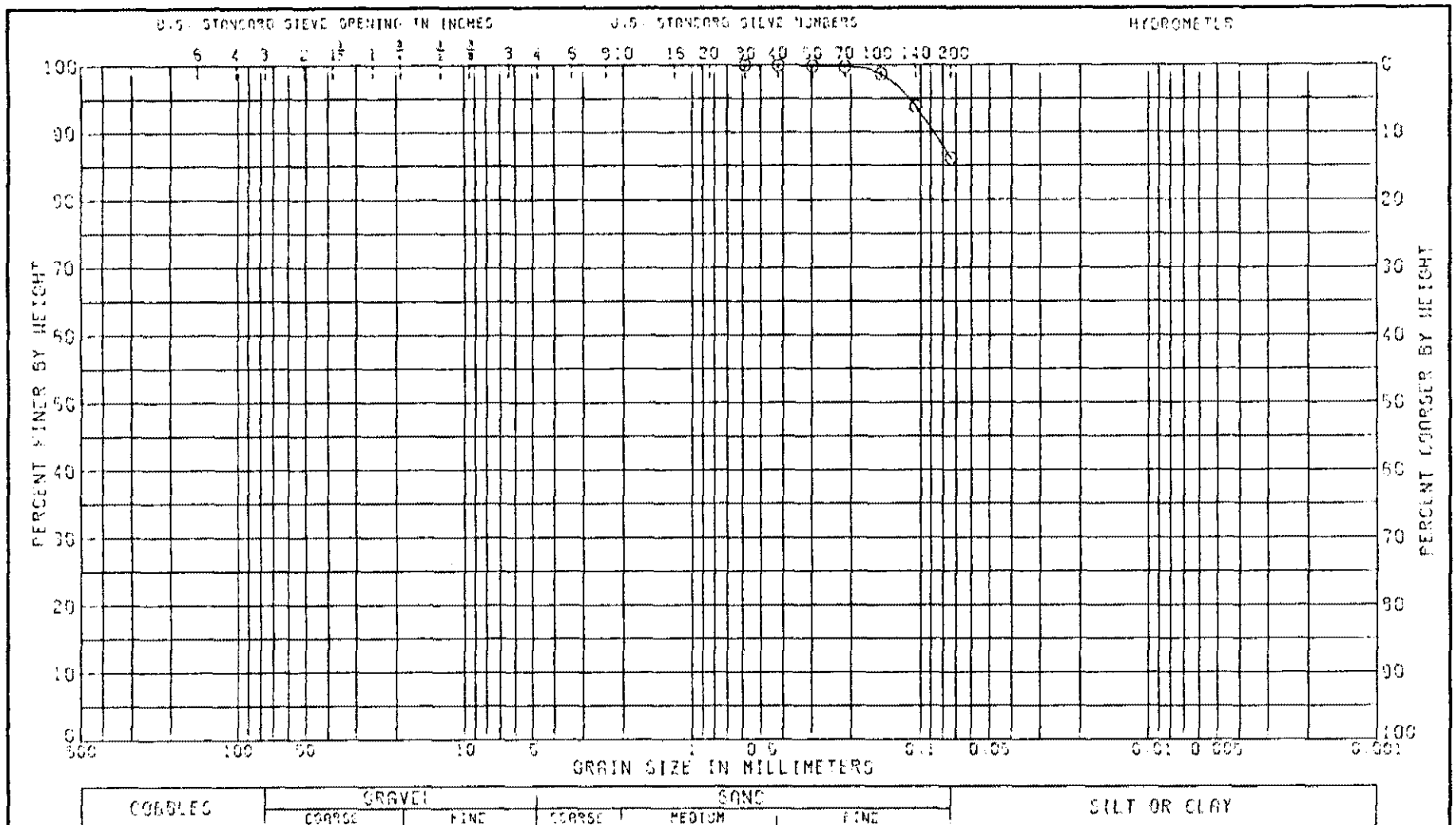
CLAY (CL), BROWN: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-6-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.17 DATE 11 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 28 | 19 | 9 | | 23.6 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

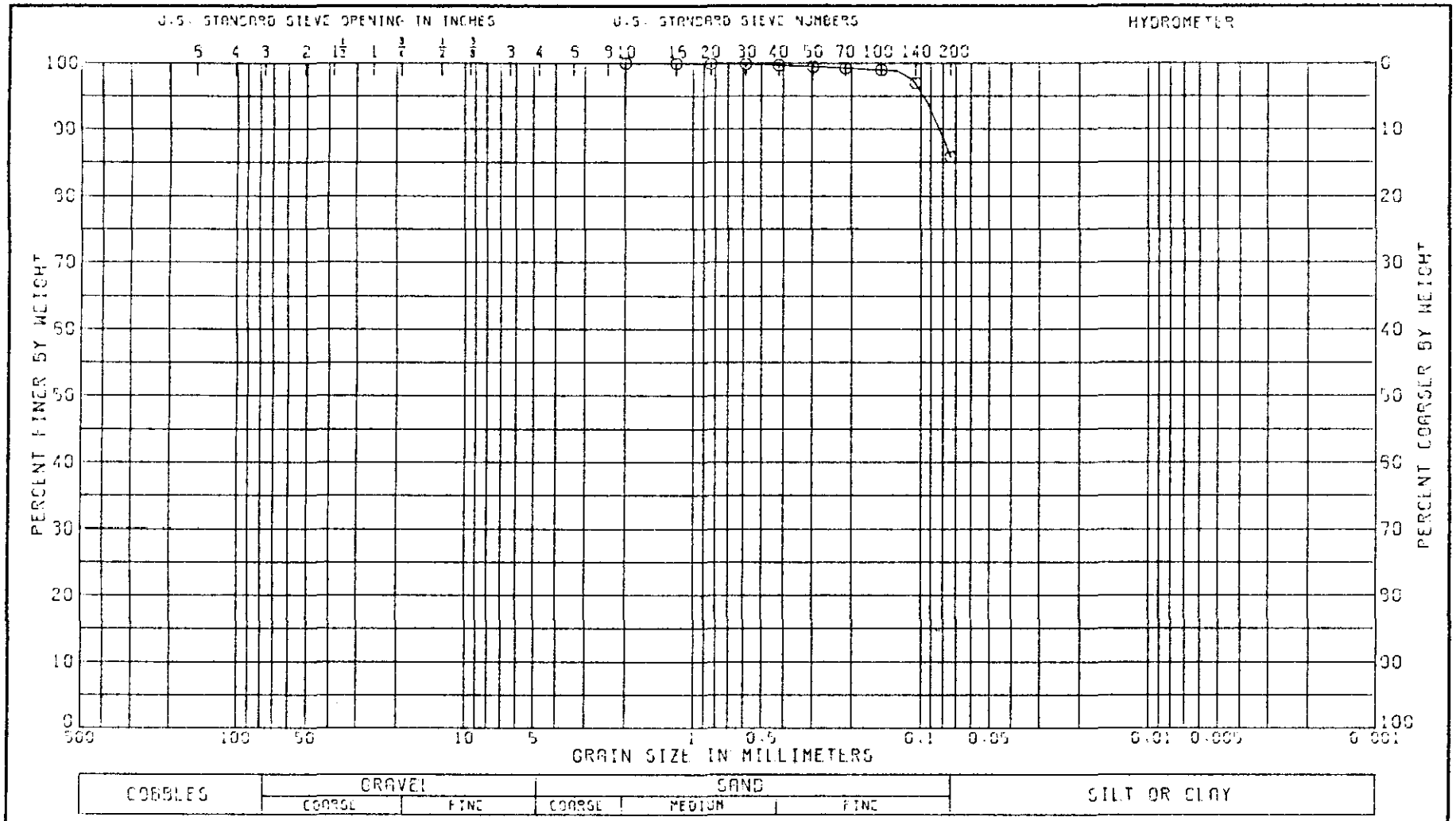
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 5-6-81 SAMPLE NO 3

DEPTH/ELEV 10.0-12.00 DATE 25 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 24 | 16 | 8 | | 23.8 |

CLASSIFICATION

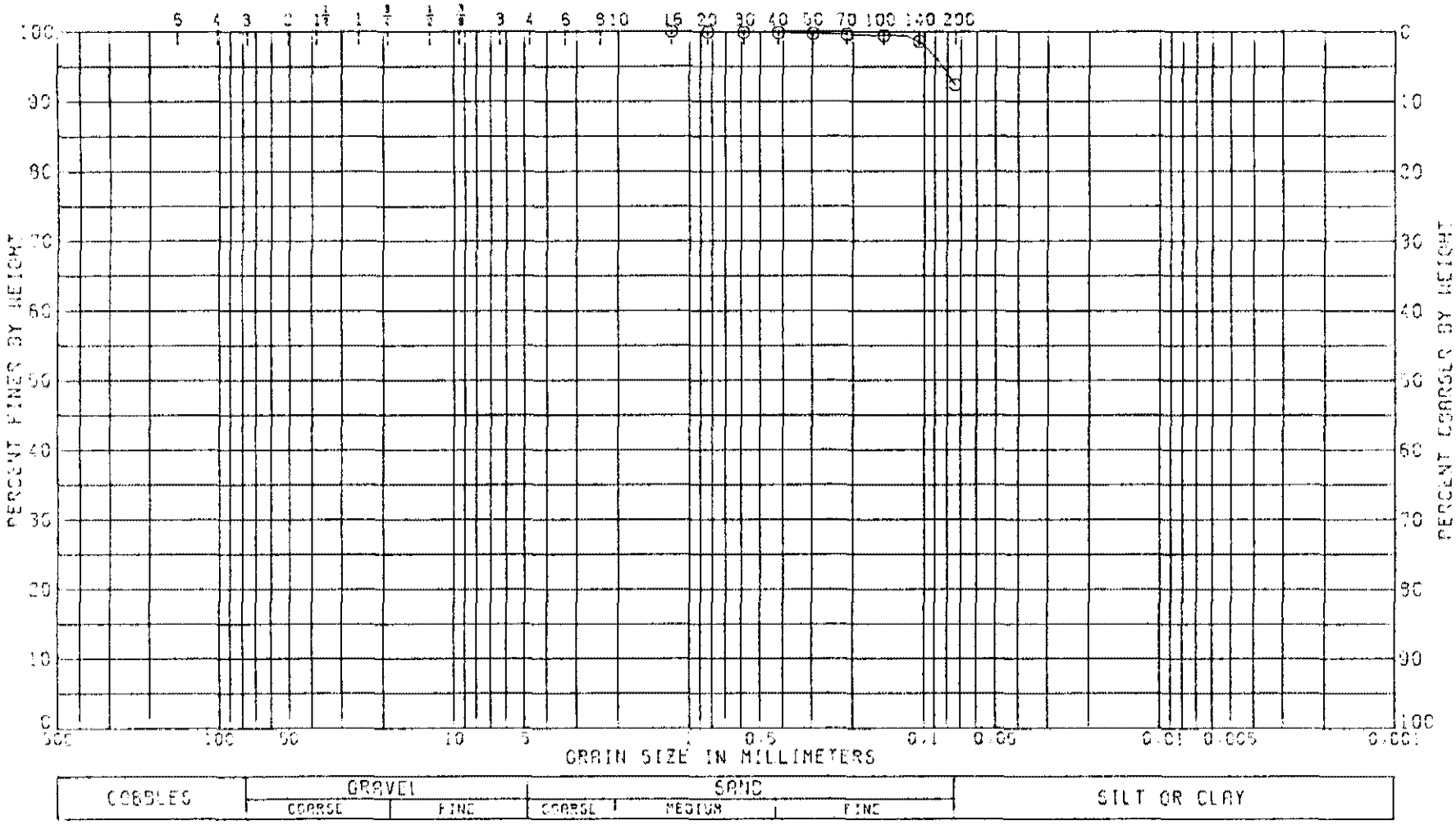
SANDY CLAY (CL), GRAY

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-6-91 SAMPLE NO 4

DEPTH/ELEV 15.0-17.15 DATE 31 MAR 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 25 | 18 | 7 | | 20.8 |

CLASSIFICATION

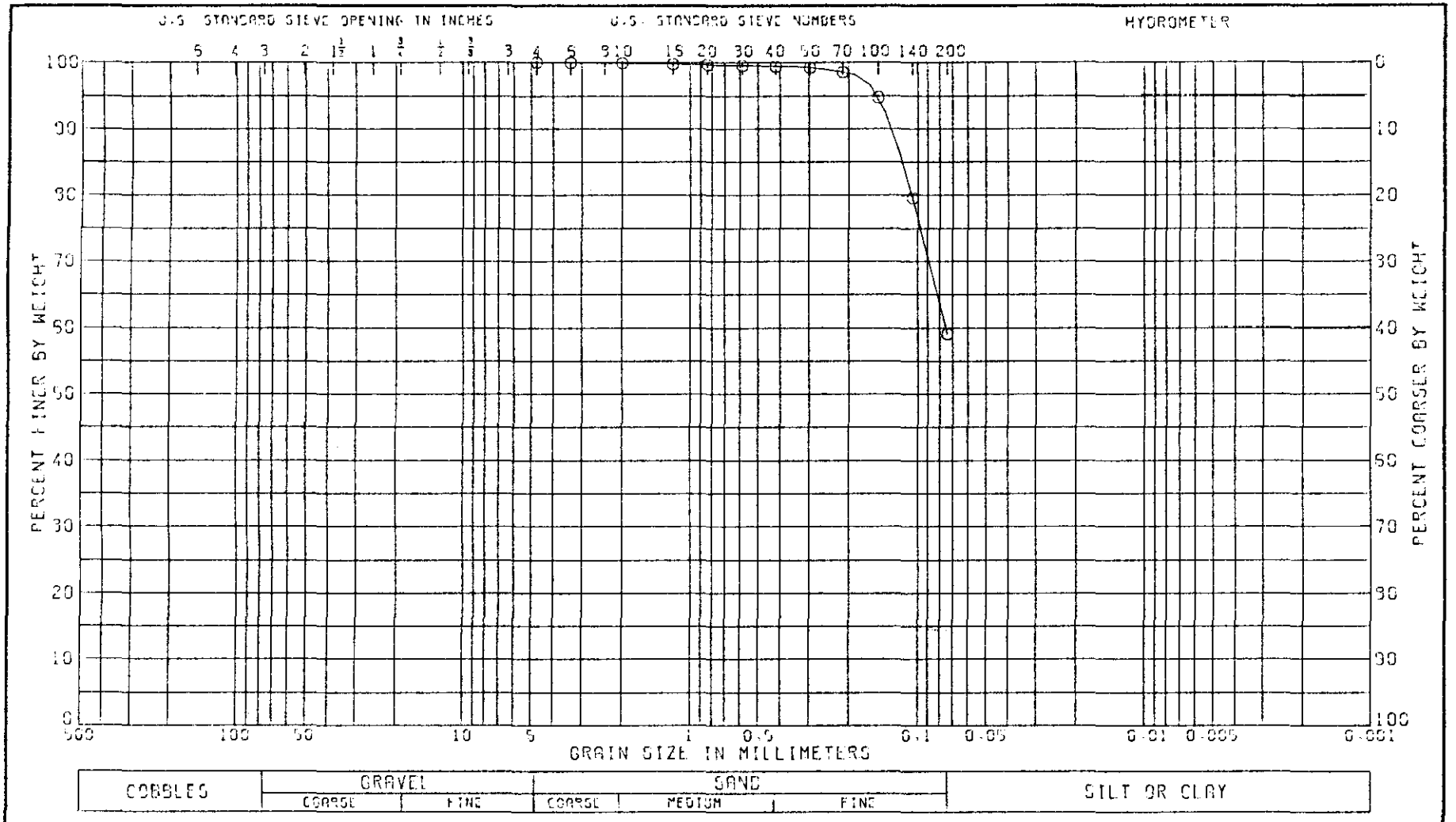
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO 5-6-91 SAMPLE NO 5

DEPTH/ELEV 20.0-21.10 DATE 12 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 19 | 15 | 4 | | 25.8 |

CLASSIFICATION

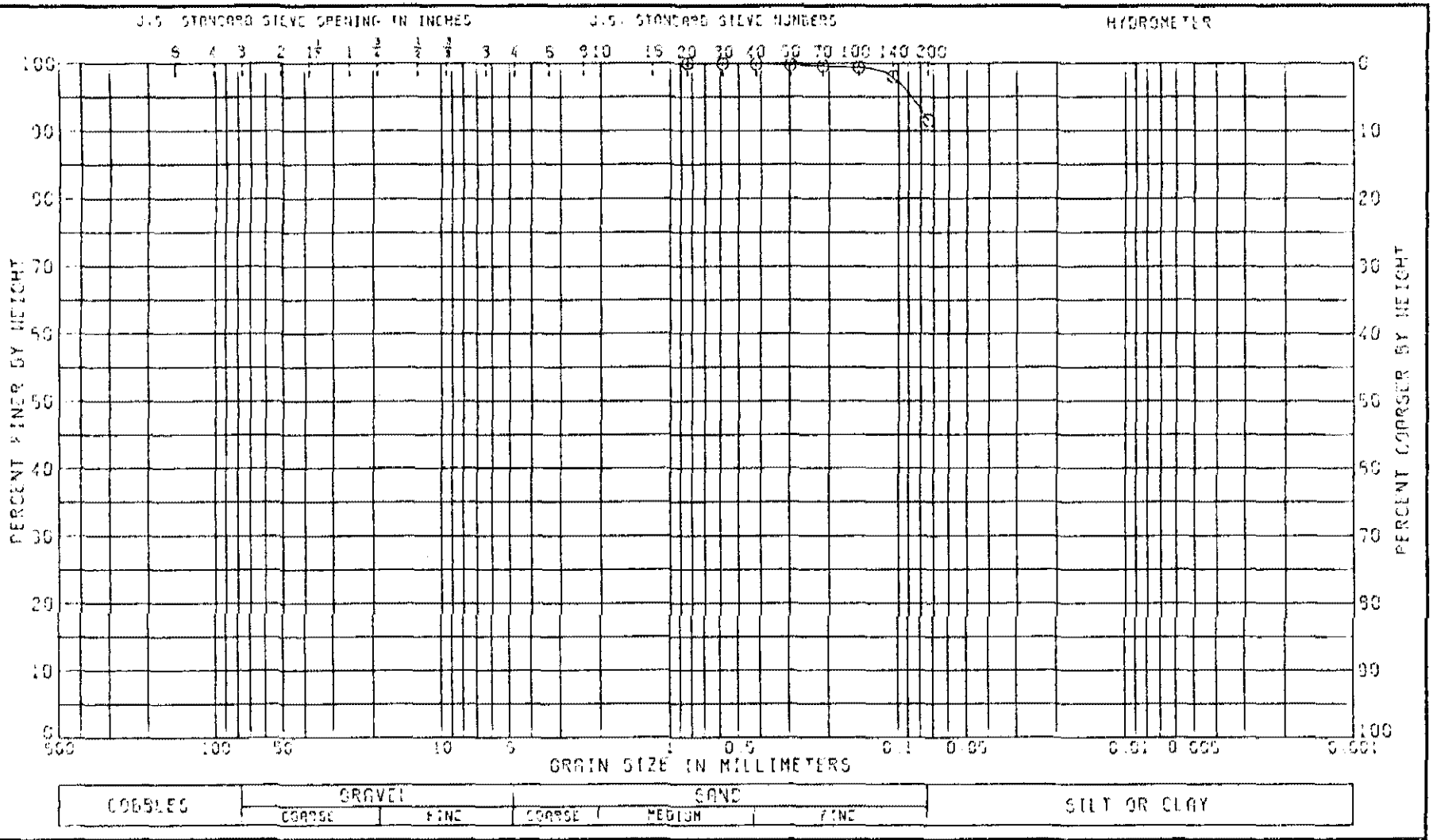
SANDY CLAYEY SILT (CL-ML), GRAY

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-6-81 SAMPLE NO. 7A

DEPTH/ELEV 30.0-33.5 DATE 31 MAR 82




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 25 | 19 | 6 | | 20.3 |

CLASSIFICATION

SILTY CLAY (CL-ML), BROWN: WITH SAND

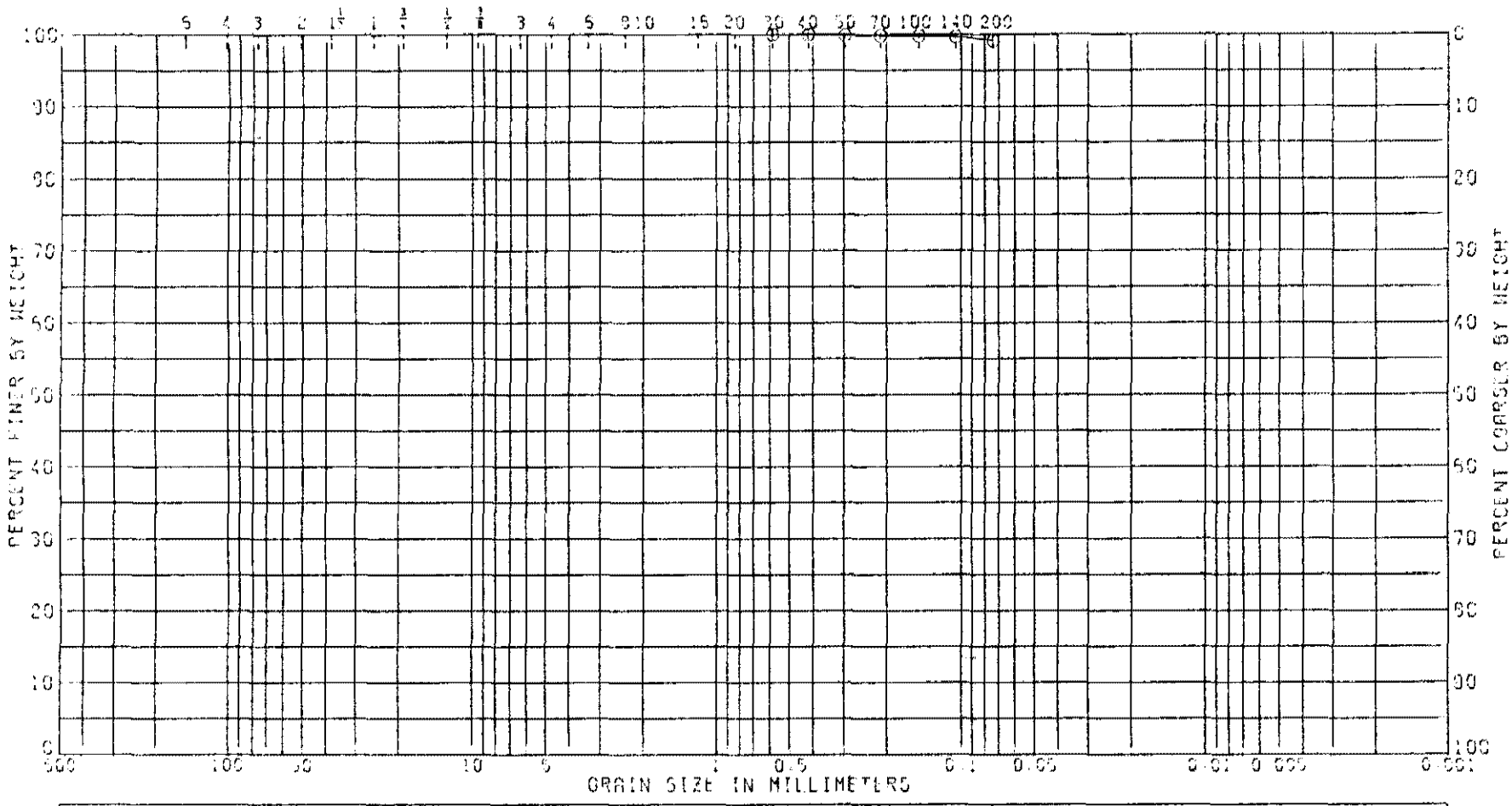
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO. 5-7-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.99 DATE 26 FEB 82




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |

| LL 39 | PL 20 | PI 19 | GS | NAT W.% 18.2 |
|---|---|---|---|---|

CLASSIFICATION

CLAY (CL), BROWN

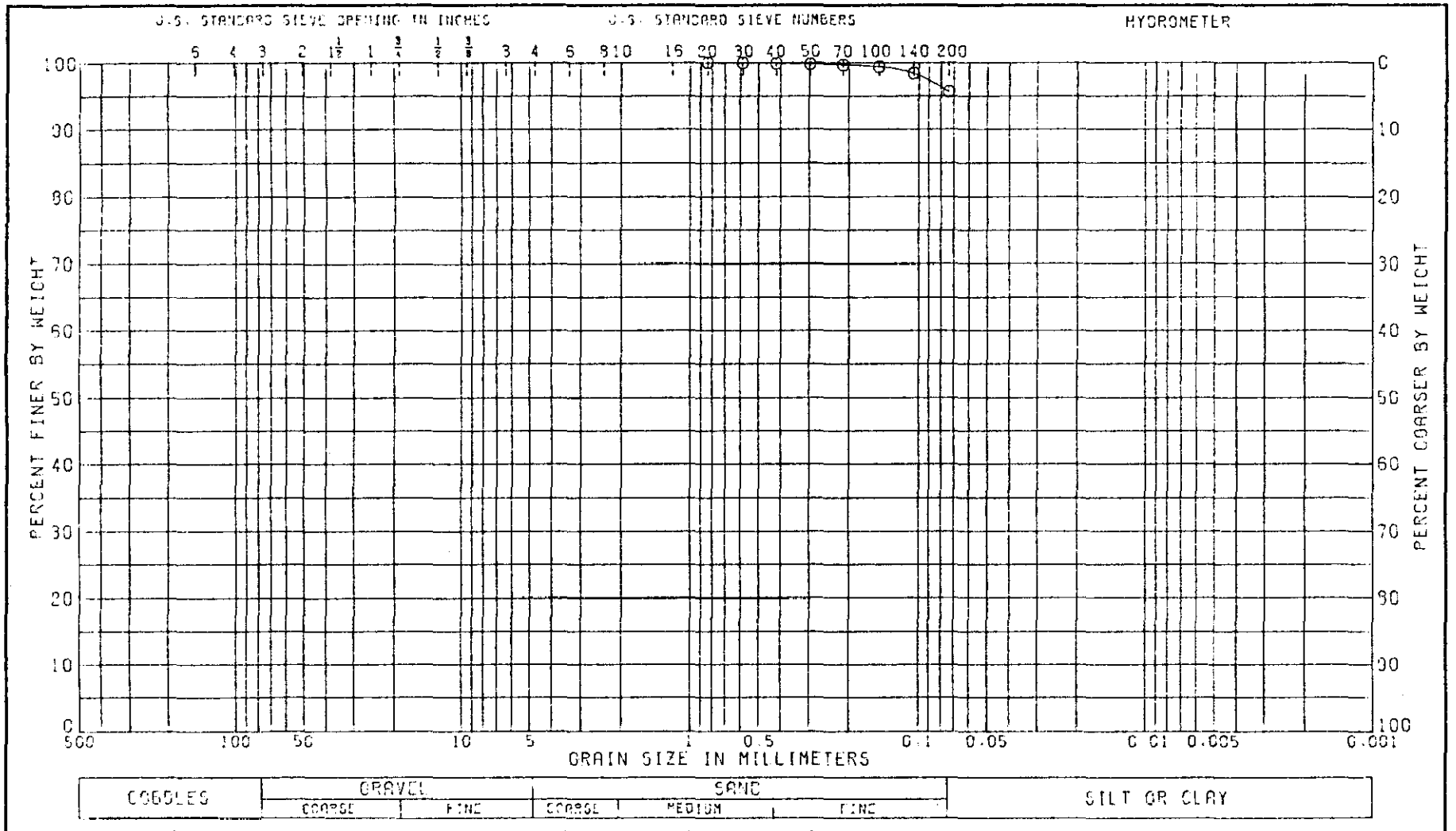
GRADATION CURVE

PROJECT CRONE NAGC

SLC BURNING GROUND

BORING NO. 5-7-81 SAMPLE NO 2

DEPTH/ELEV 5.0-5.99 DATE 25 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 29 | 21 | 8 | | 21.9 |

CLASSIFICATION

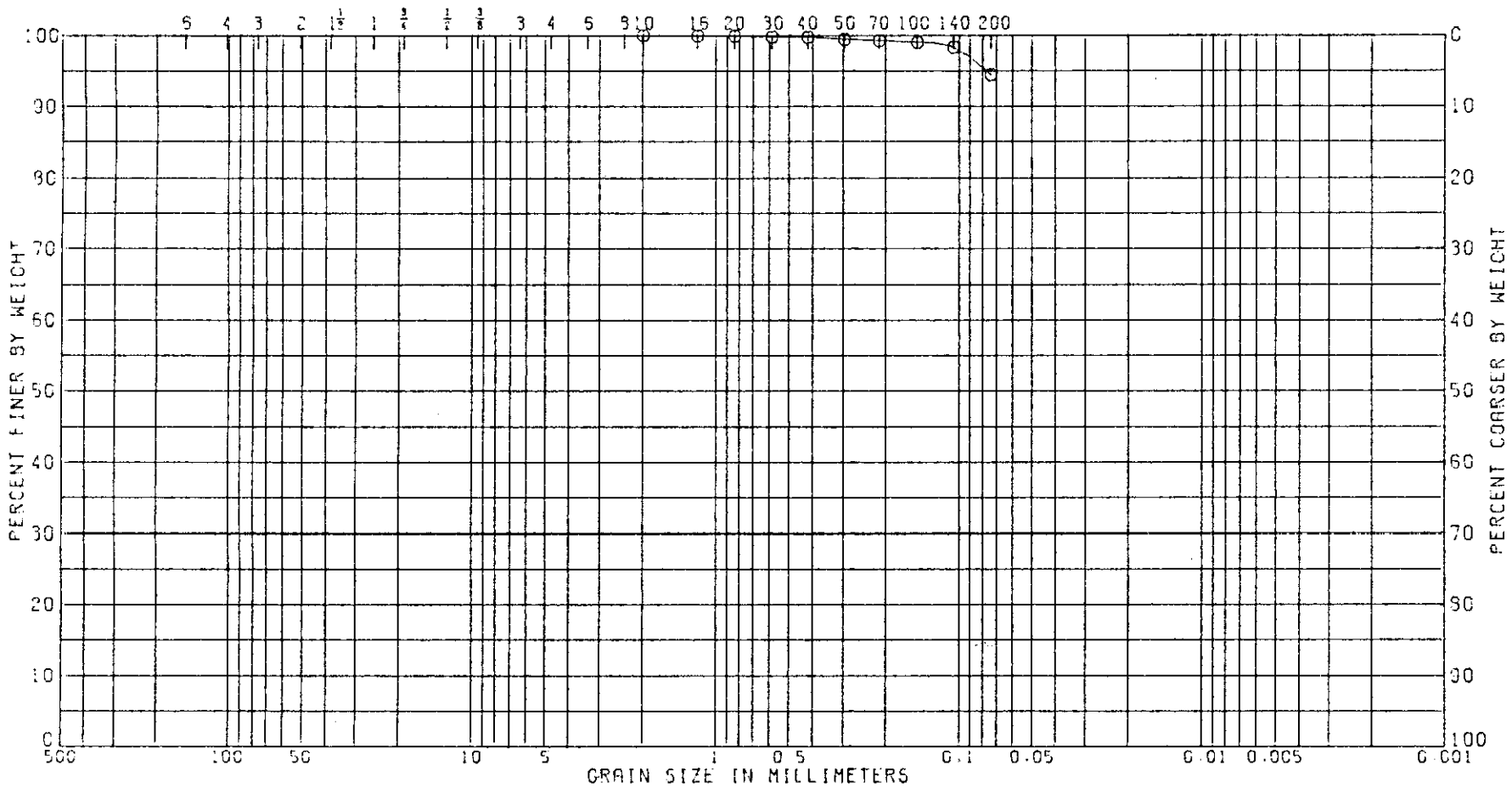
CLAY (CL), BROWN: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-7-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.91 DATE 12 MAR 82




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |

| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 24 | 19 | 5 | | 23.8 |

CLASSIFICATION

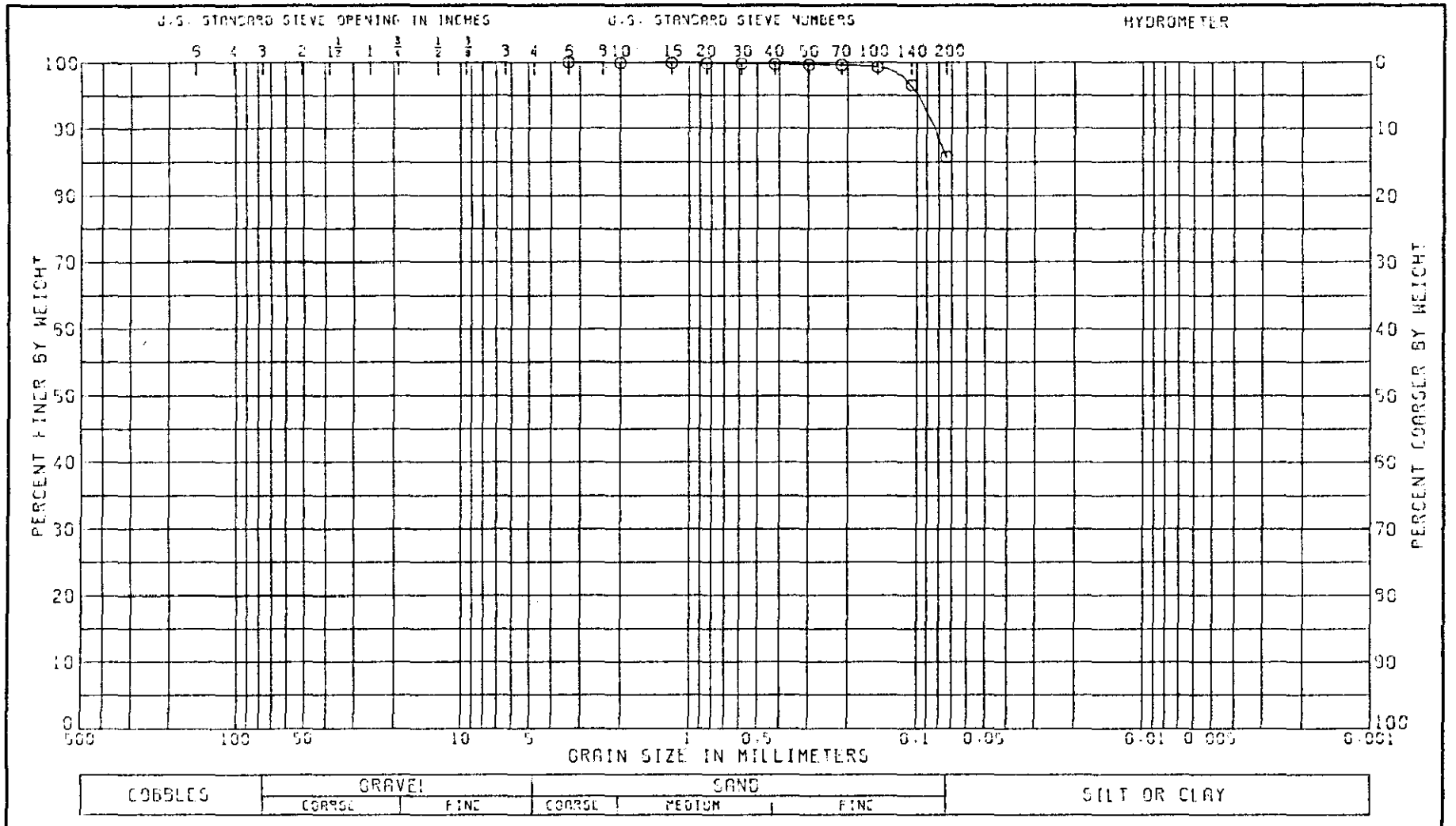
SILTY CLAY (CL-ML), GRAY: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-7-81 SAMPLE NO. 4

DEPTH/ELEV 15.0-16.36 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| 26 | 16 | 10 | | 21.2 | |

CLASSIFICATION

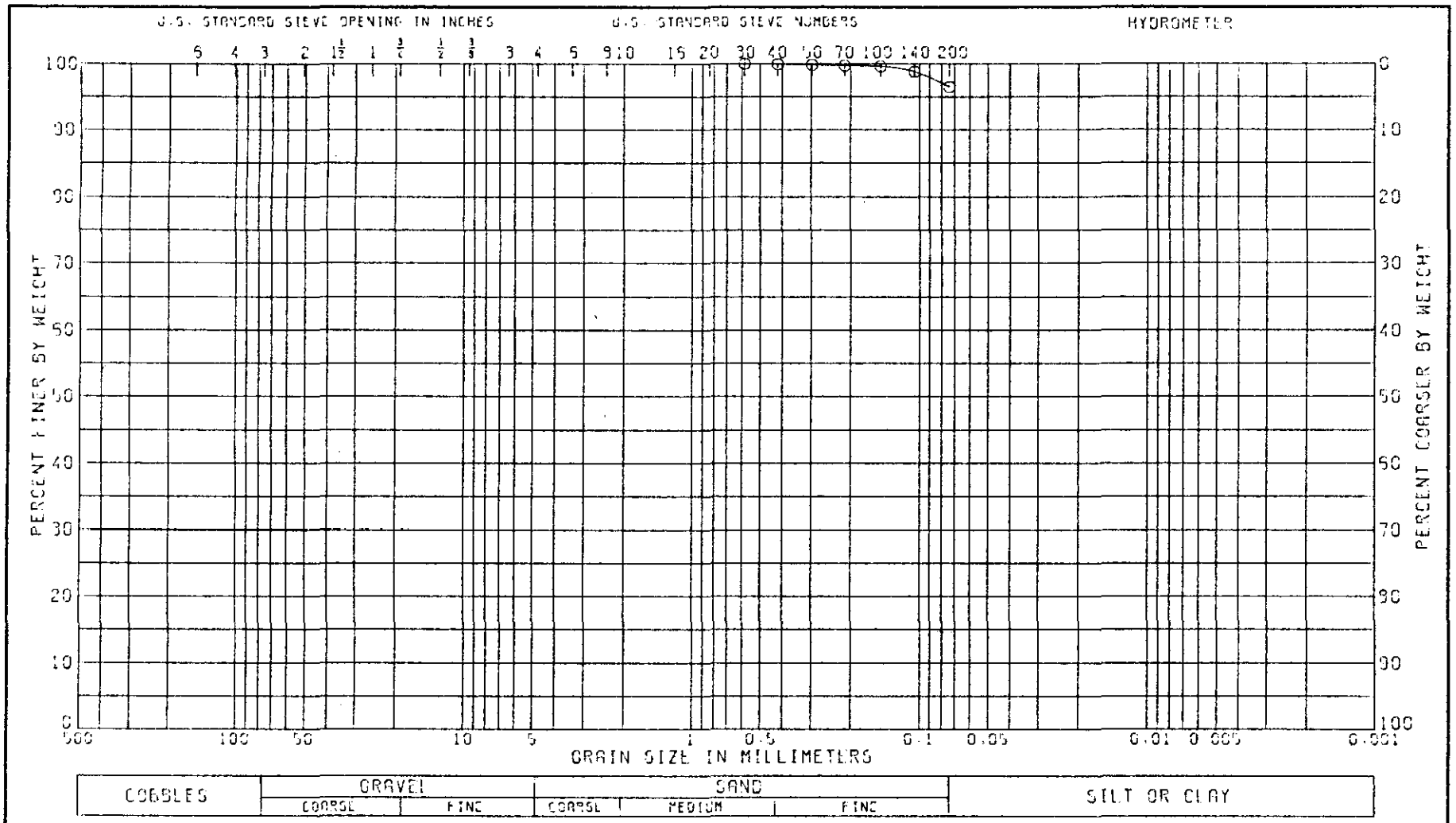
SANDY CLAY (CL), GRAY

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-7-91 SAMPLE NO. 6

DEPTH/ELEV 25.0-27.0S DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 20.9 |

CLASSIFICATION

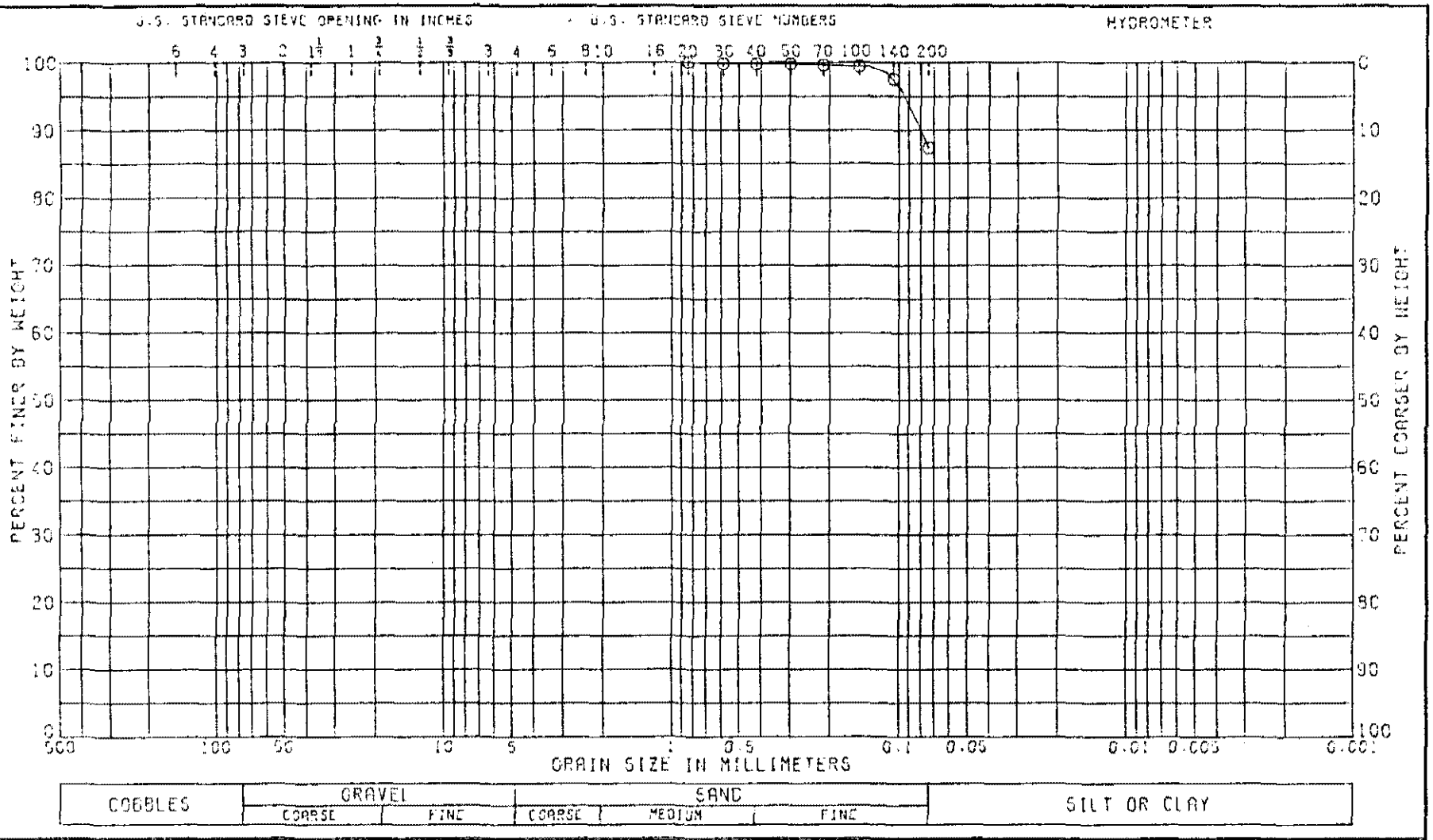
SILT (ML), GRAY: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-7-91 SAMPLE NO. 7

DEPTH/ELEV 30.0-32.07 DATE 31 MAR 92




| LL | PL | PI | GS | NAT W,% | |
|---|---|---|---|---|---|
| 22 | 18 | 4 | | 21.1 | |

CLASSIFICATION

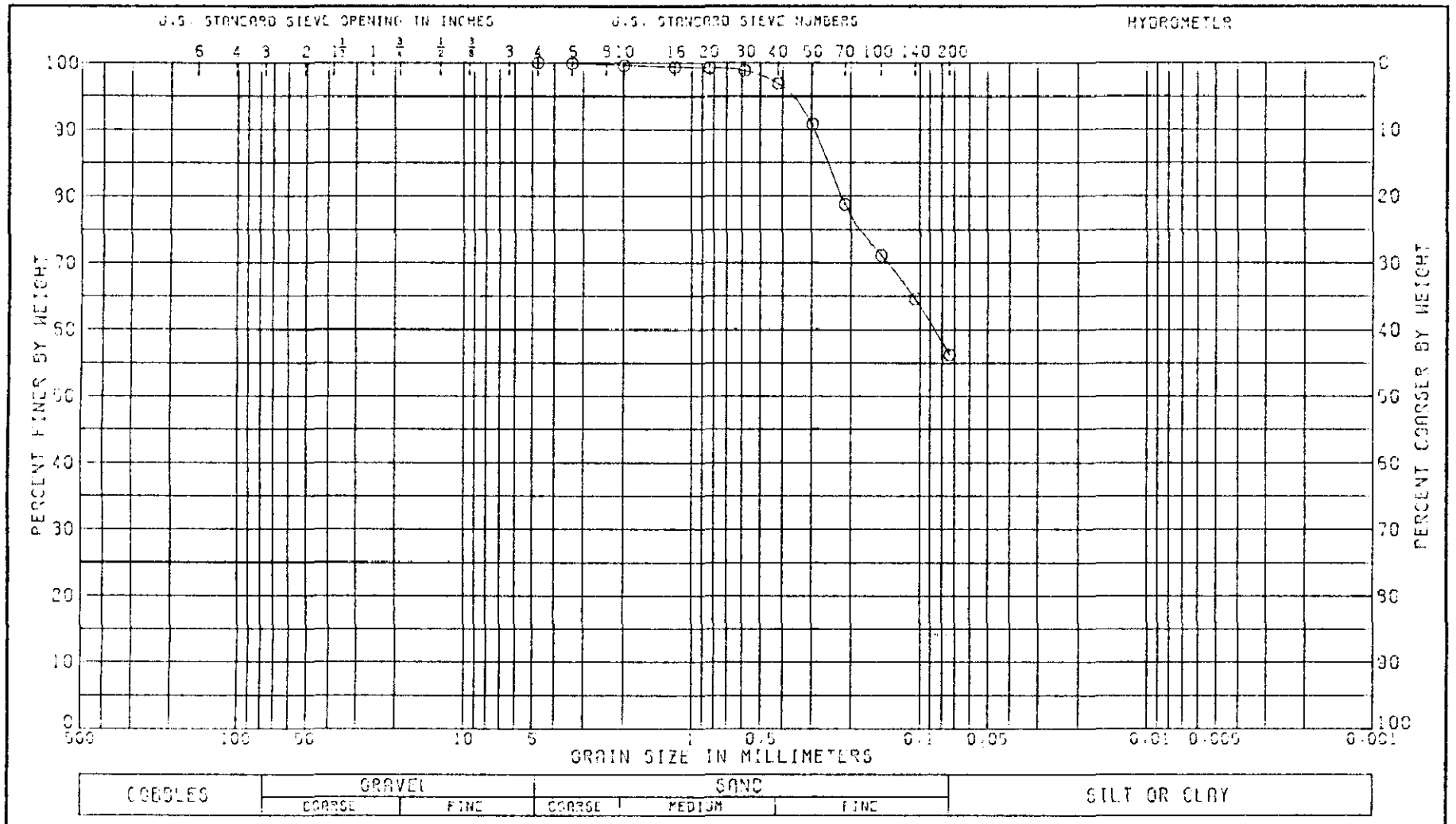
SANDY SILTY CLAY (CL-ML), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-7-81 SAMPLE NO. 8

DEPTH/ELEV 35.0-37.08 DATE 12 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 31 | 14 | 17 | | 18.7 |

CLASSIFICATION

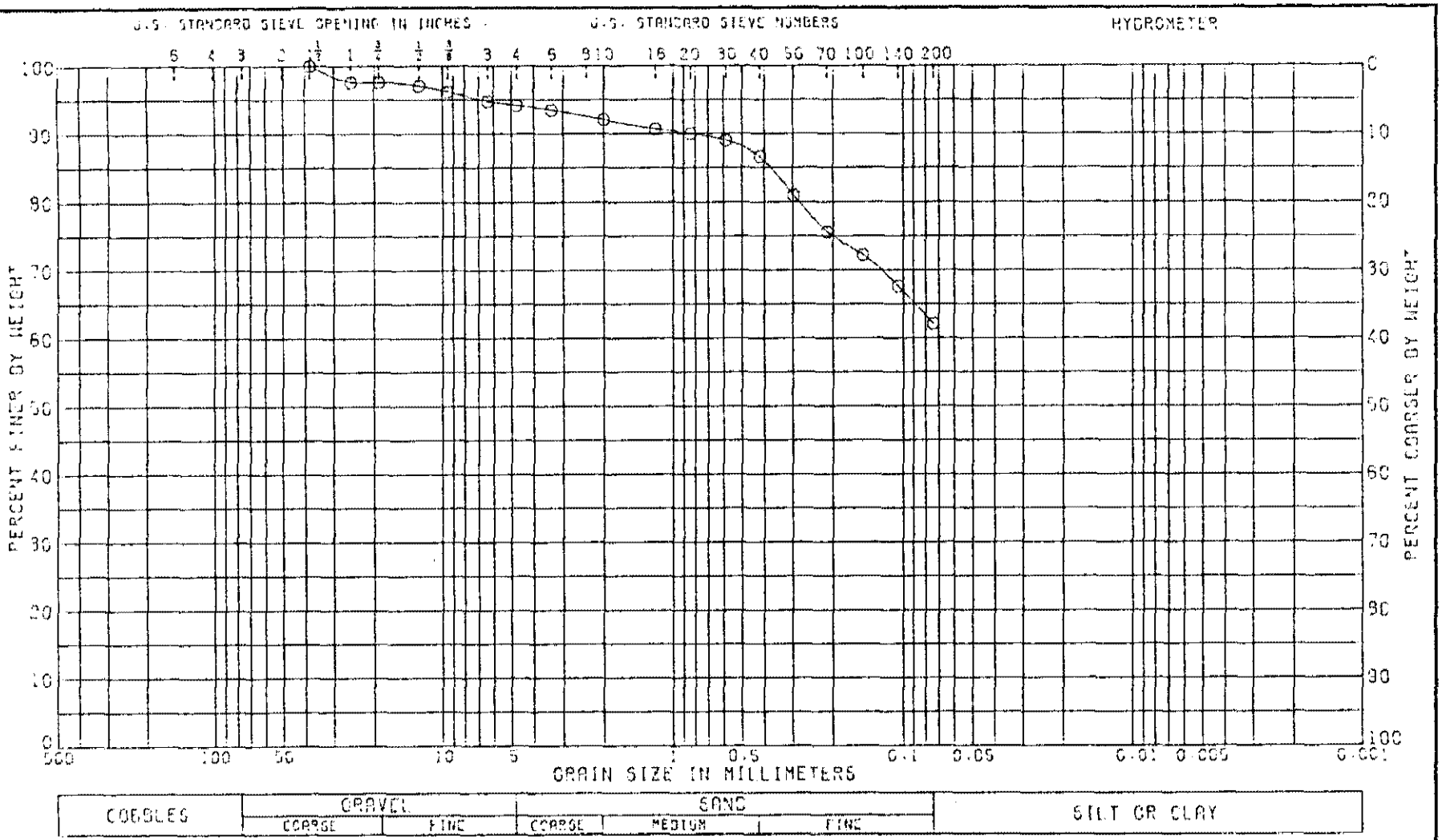
SANDY CLAY (CL), LIGHT BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-9-91 SAMPLE NO 1

DEPTH/ELEV 0.0-0.9 DATE 11 FEB 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 29 | 16 | 13 | | 19.8 |

CLASSIFICATION

SANDY CLAY (CL), DARK BROWN: WITH GRAVEL

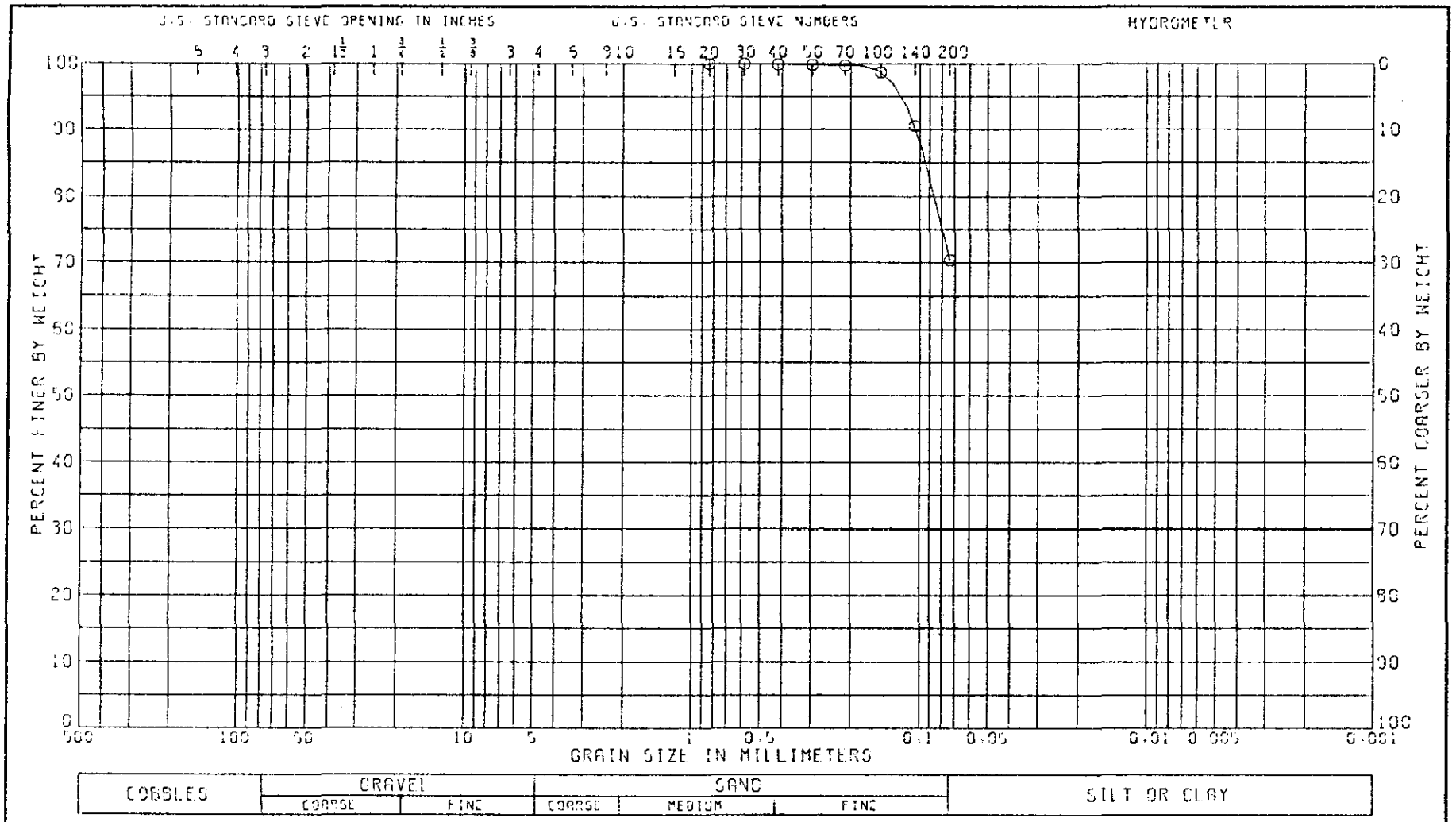
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC CLC BURNING GROUND

BORING NO. 5-8-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.08 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 23.1 |

CLASSIFICATION

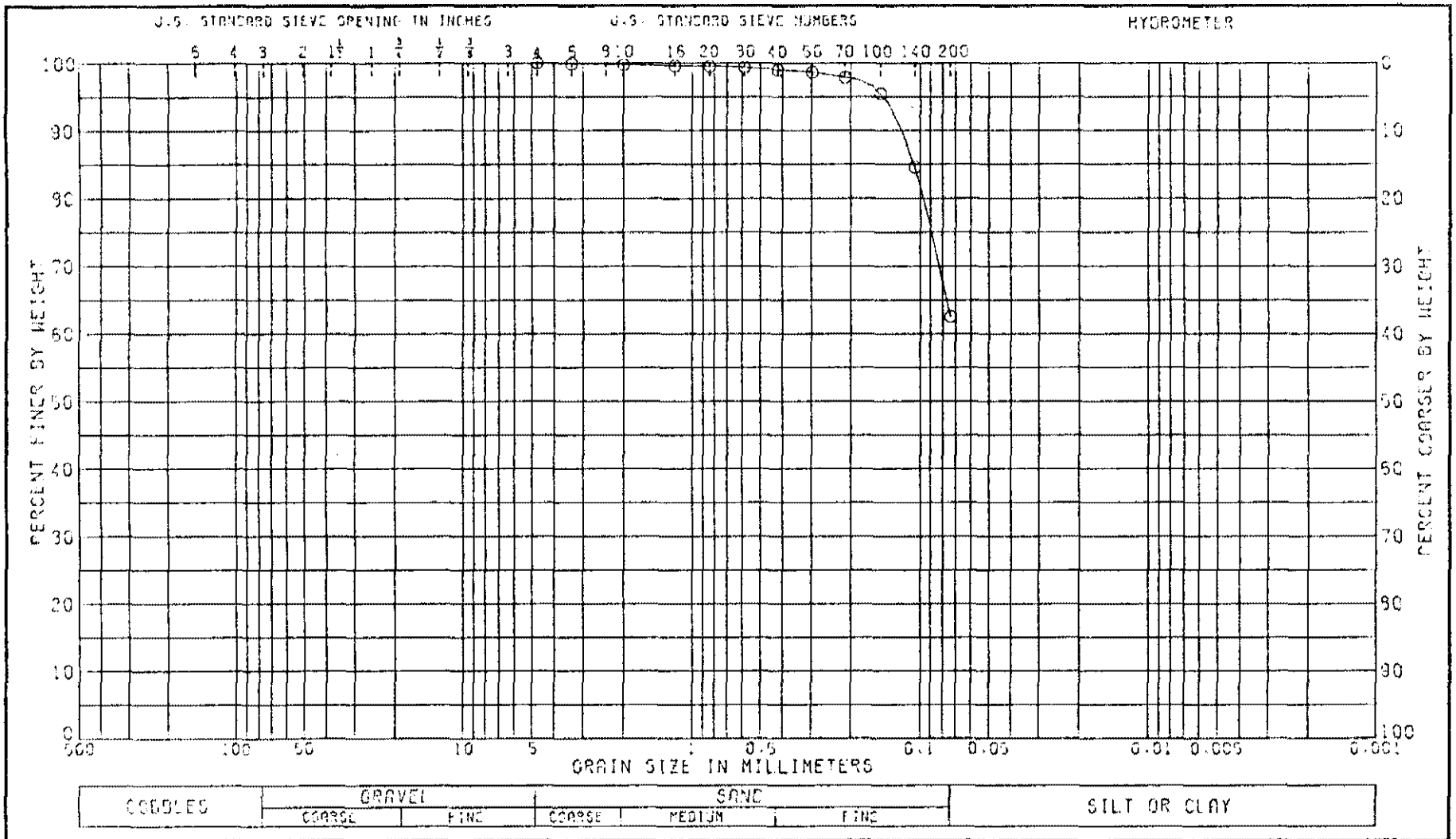
SANDY SILT (ML), GRAY

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-B-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-12.15 DATE 31 MAR 82




| LL | PL | PI | GS | NAT W.% | |
|---|---|---|---|---|---|
| 22 | 16 | 6 | | 23.5 | |

CLASSIFICATION

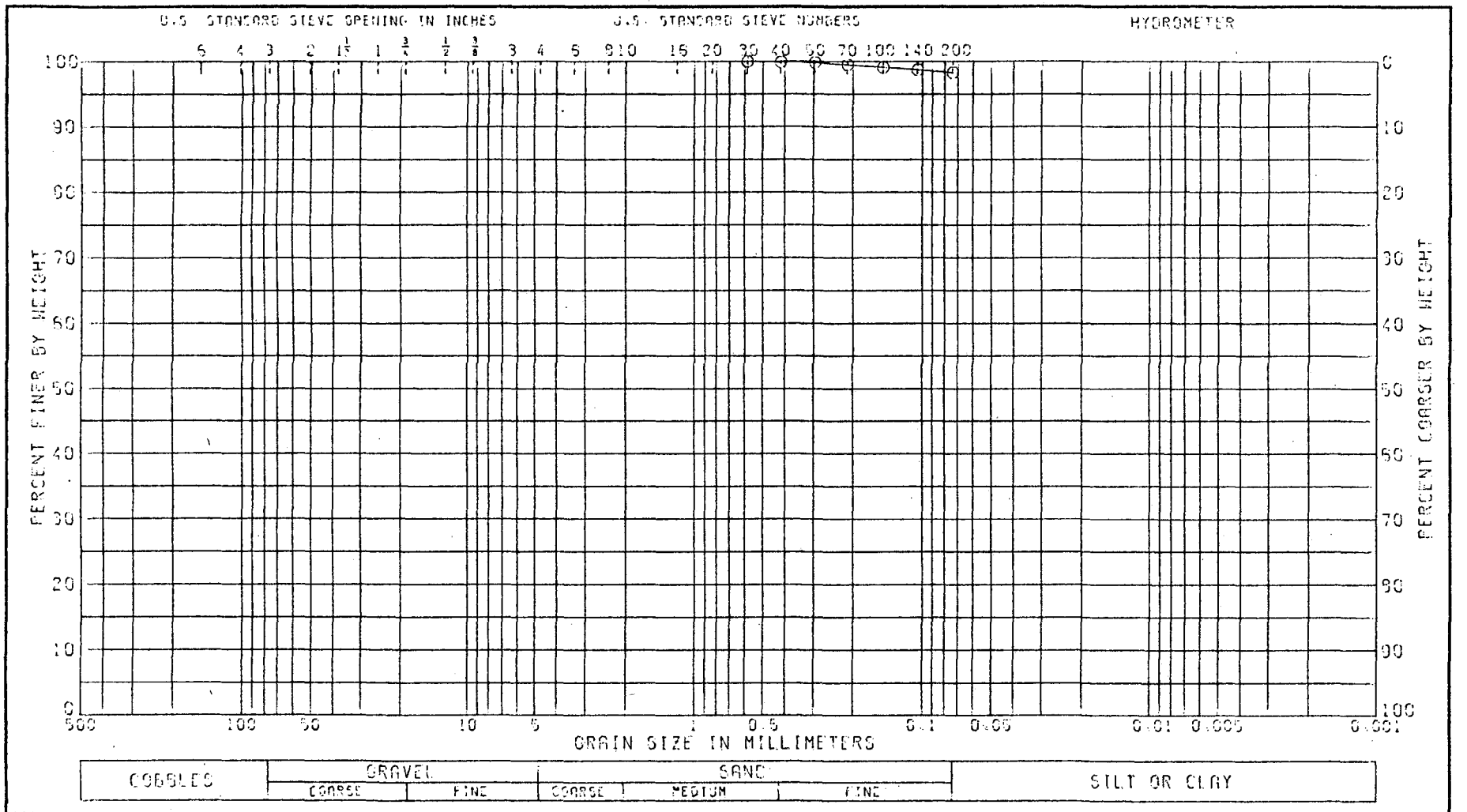
SANDY CLAYEY SILT (CL-ML), BROWN

GRADATION CURVE

PROJECT CRANE NWSC OLD BURNING GROUND

BORING NO. 5-9-91 SAMPLE NO. 4

DEPTH/ELEV 15.0-17.1 DATE 11 FEB 92




| LL 42 | PL 18 | PI 24 | GS | NAT W.% 21.0 | |
|---|---|---|---|---|---|

CLASSIFICATION

CLAY (CL), BROWN

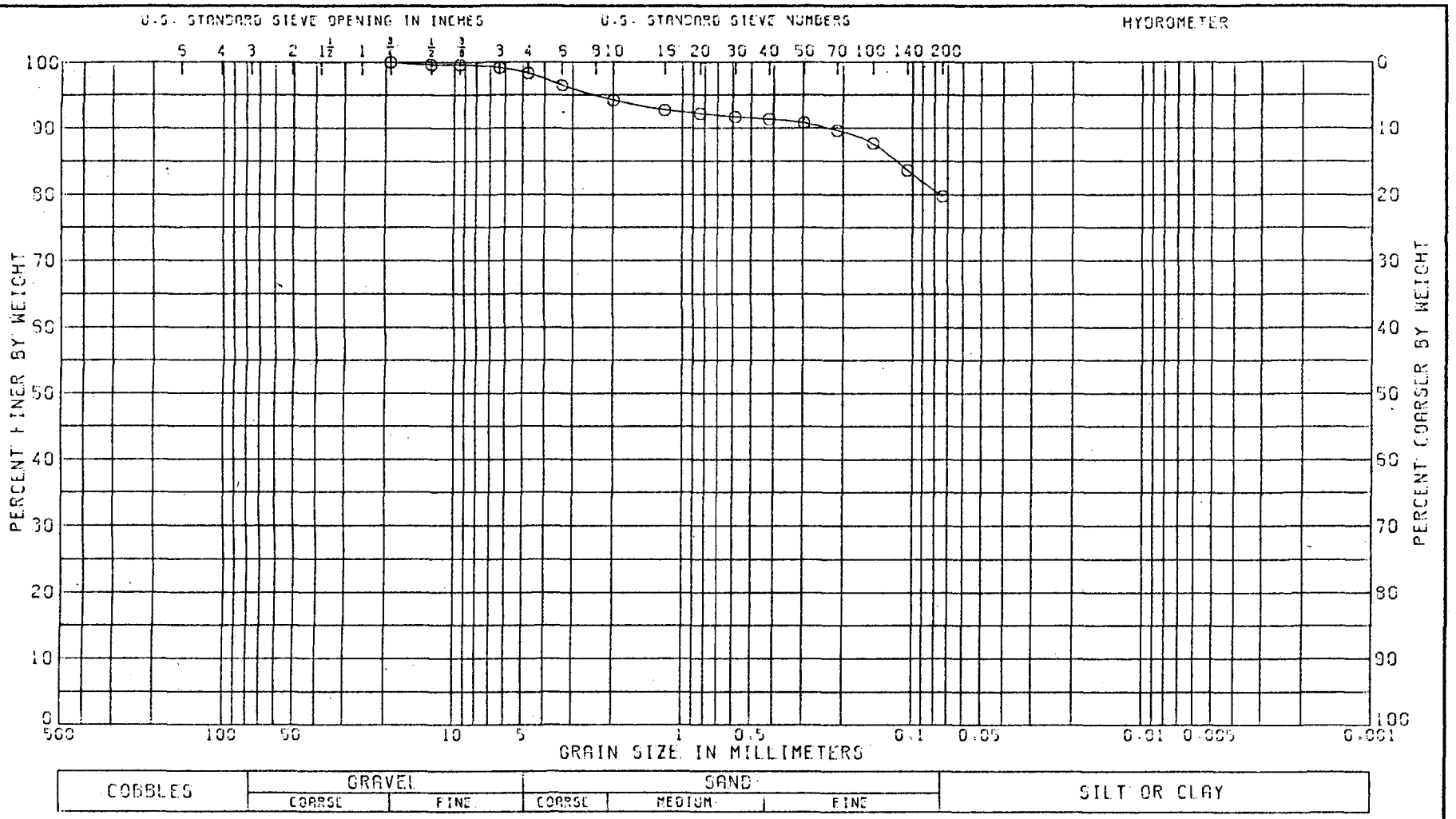
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO. 6-18-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.17 DATE 26 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 63 | 20 | 43 | | 18.6 |

CLASSIFICATION

SANDY CLAY (CH), TAN

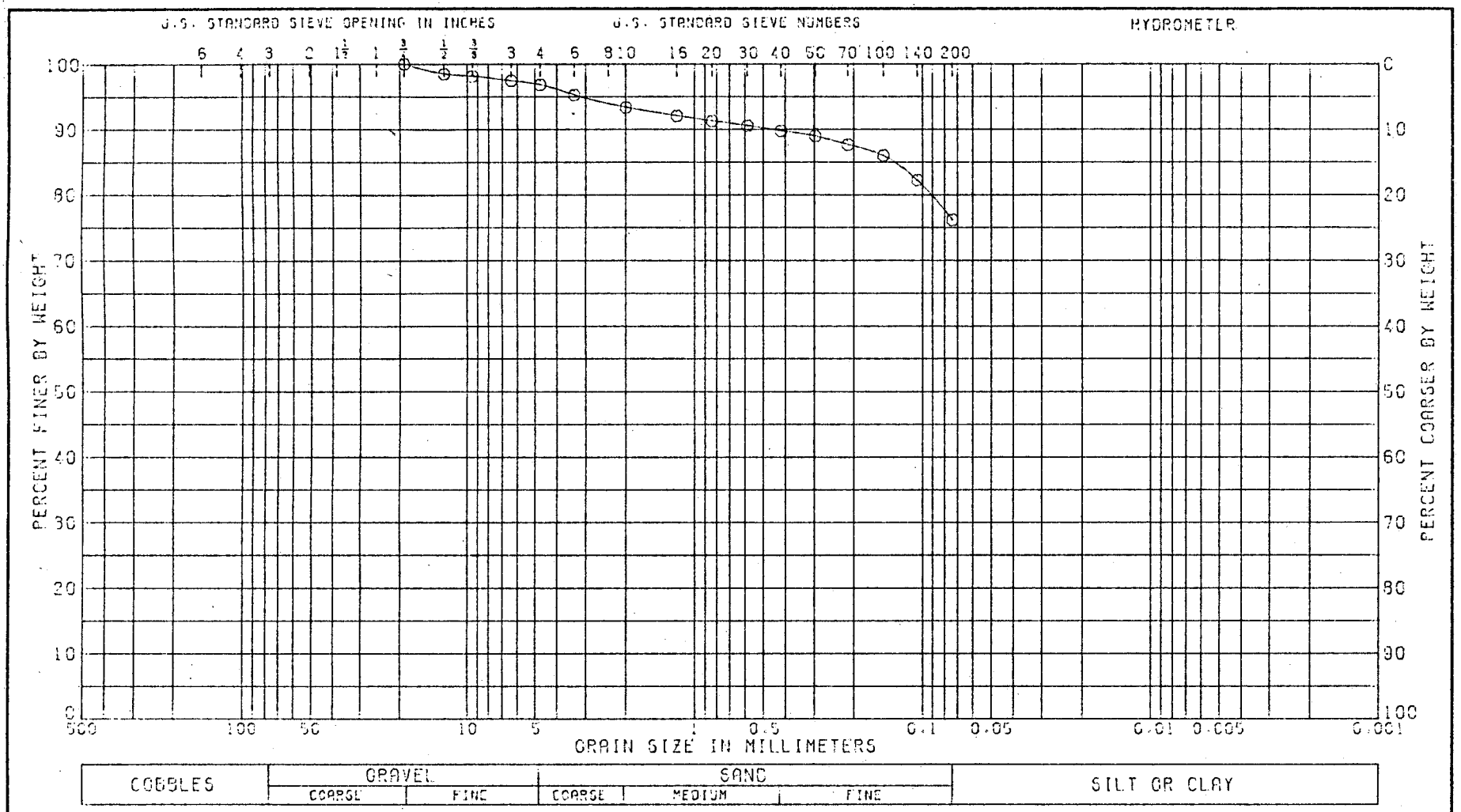
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-1A-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.21 DATE 31 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 34 | 18 | 16 | | 15.0 |

CLASSIFICATION

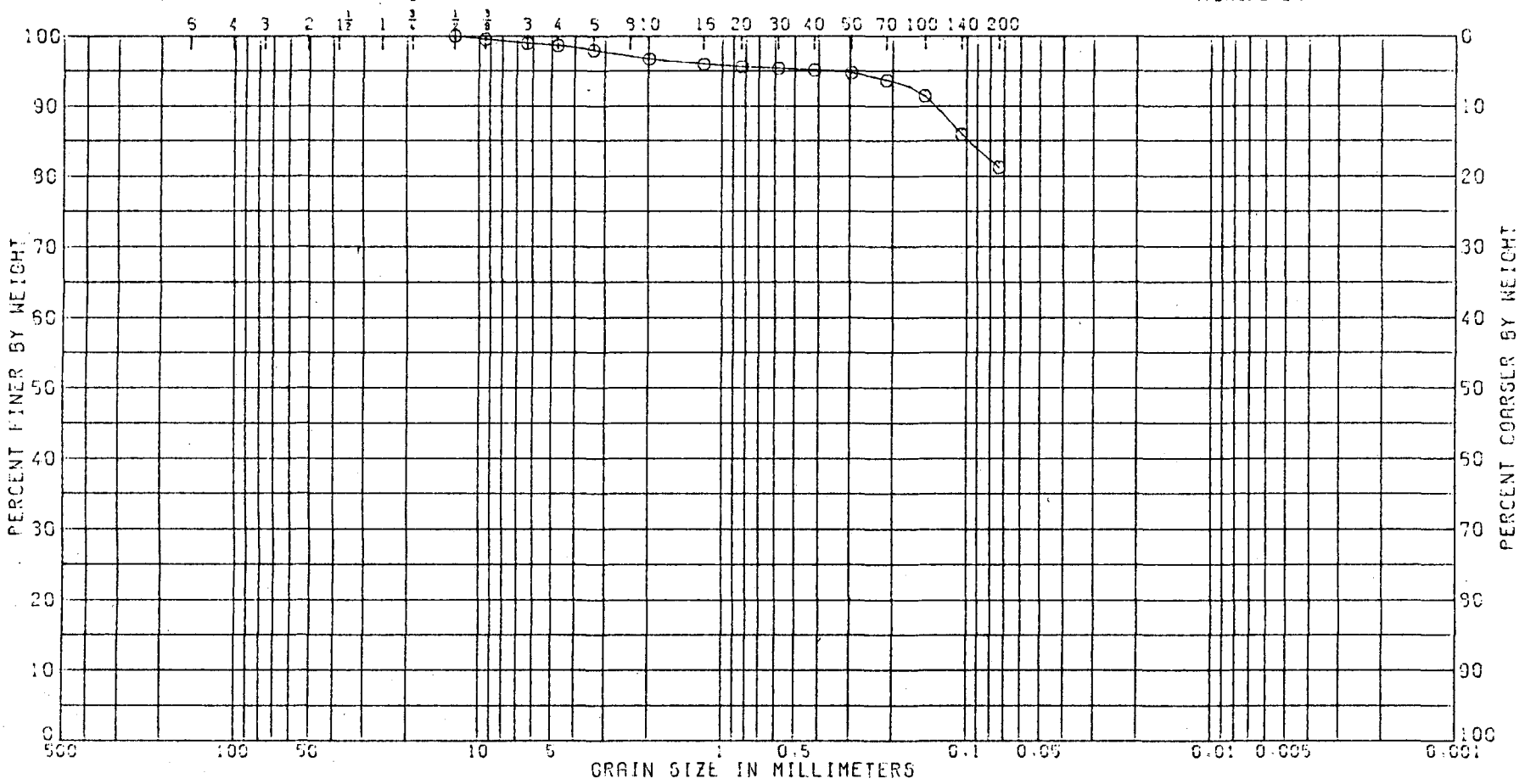
SANDY CLAY (CL), BROWN: TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-18-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.14 DATE 12 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 48 | 16 | 32 | | 17.9 |

CLASSIFICATION

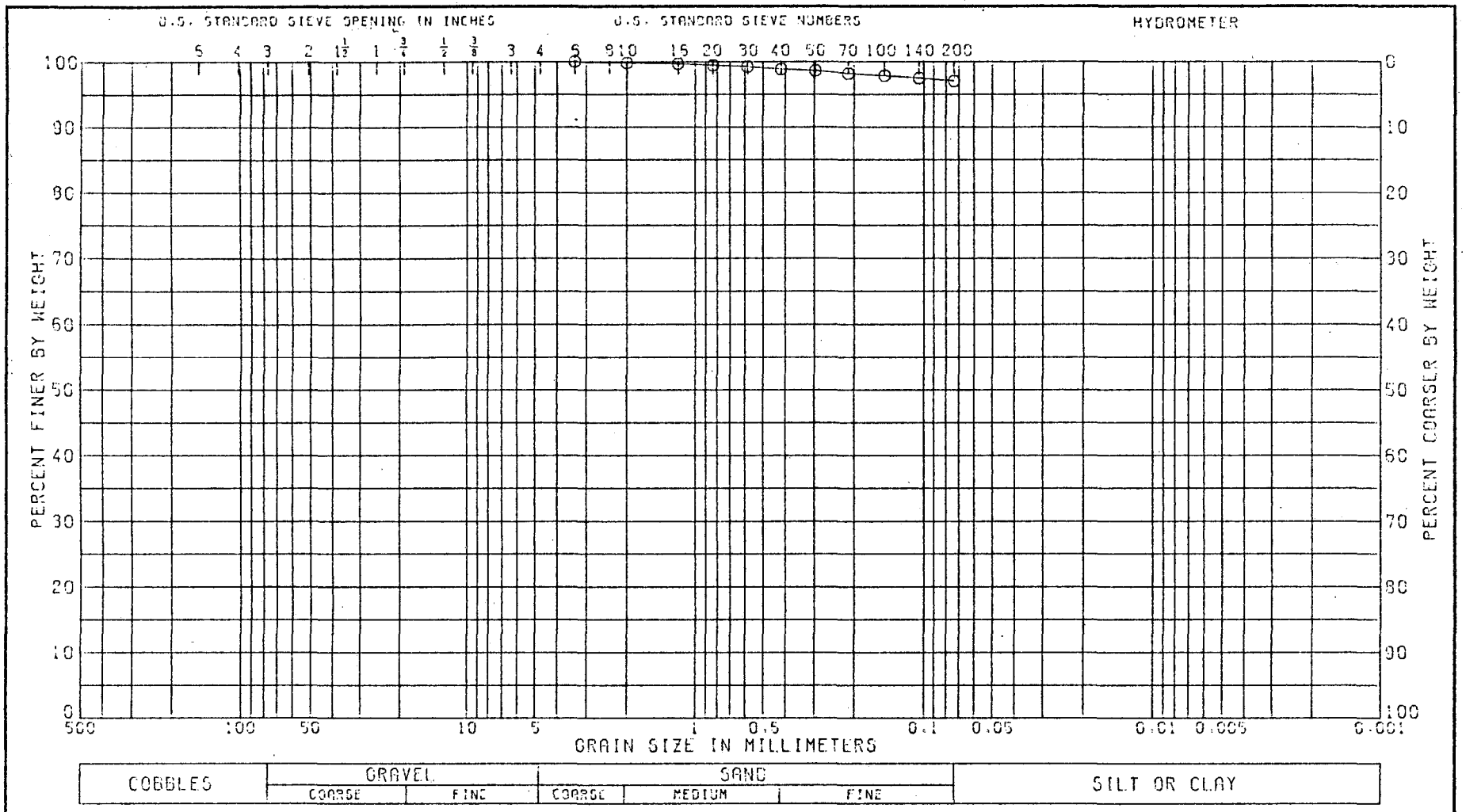
SANDY CLAY (CL), TAN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-16-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.14 DATE 11 FEB 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 49 | 19 | 30 | | 17.8 |

CLASSIFICATION

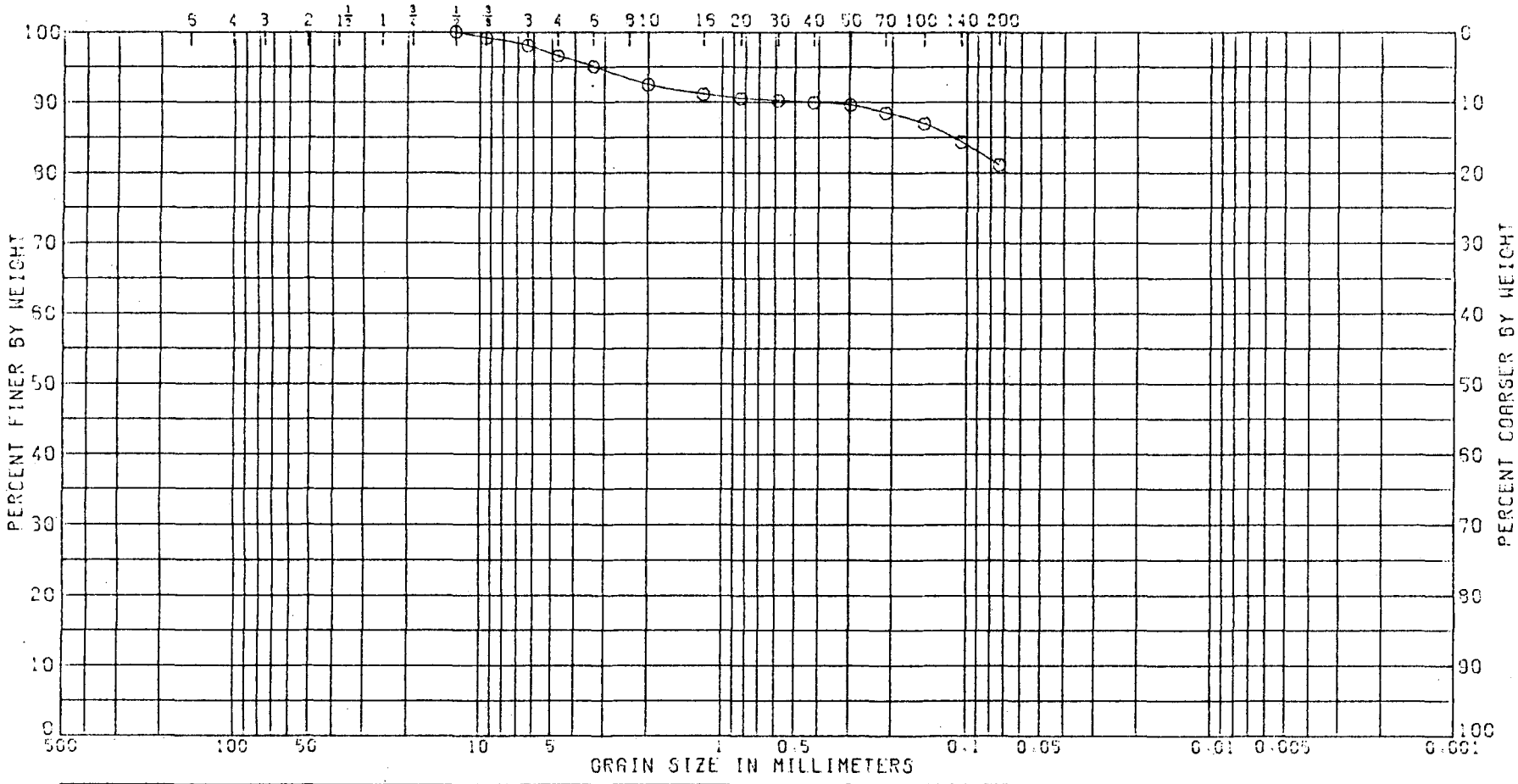
CLAY (CL), BROWN: TRACE OF SAND

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-1C-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.34 DATE 11 FEB 82




| LL 57 | PL 19 | PI 38 | GS | NAT W.% 17.7 |
|---|---|---|---|---|

CLASSIFICATION

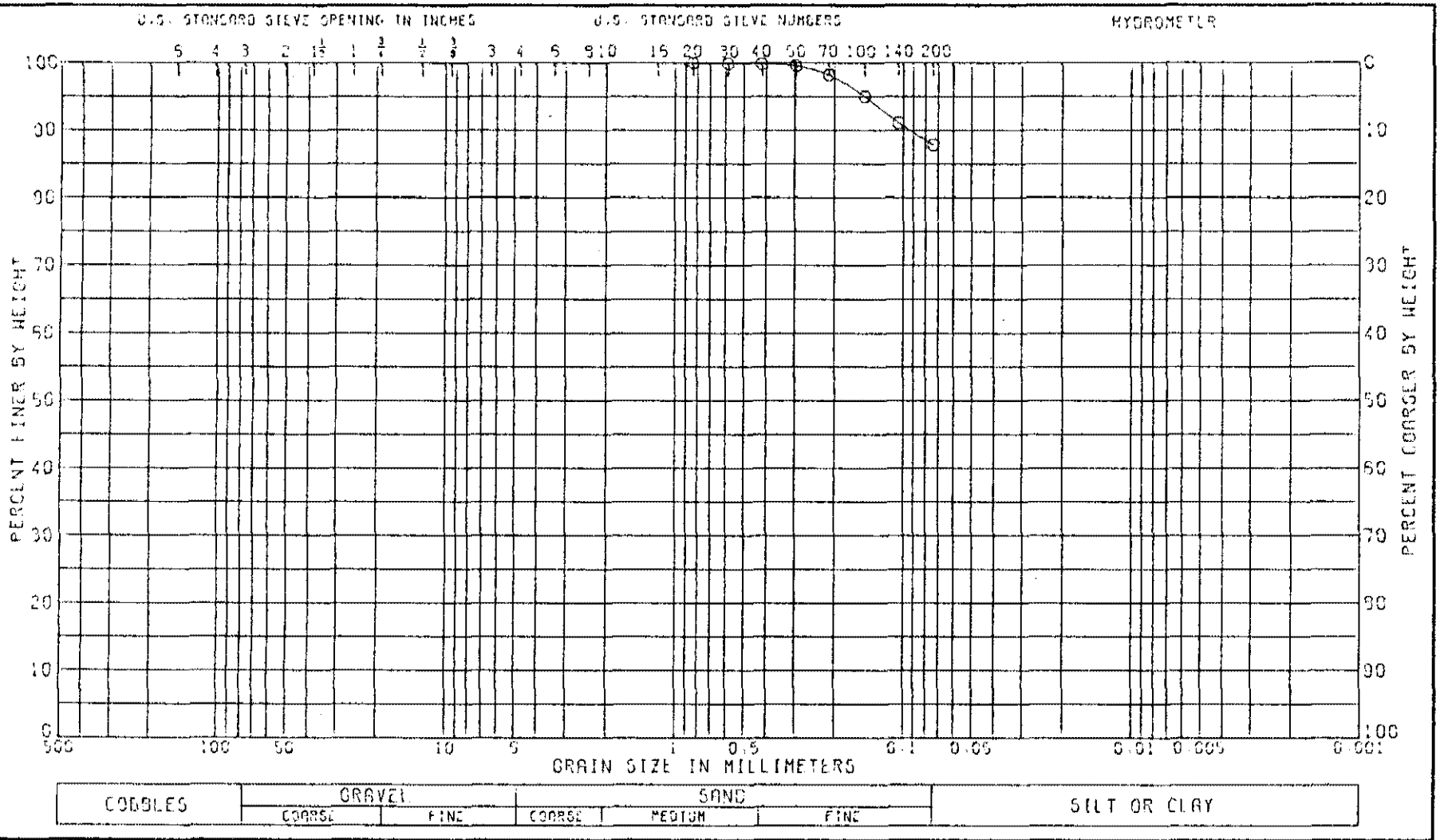
SANDY CLAY (CH), TAN: TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-1C-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.25 DATE 11 FEB 82




| LL | PL | PI | CC | NAT W.% |
|---|---|---|---|---|
| 35 | 20 | 15 | | 22.8 |

CLASSIFICATION

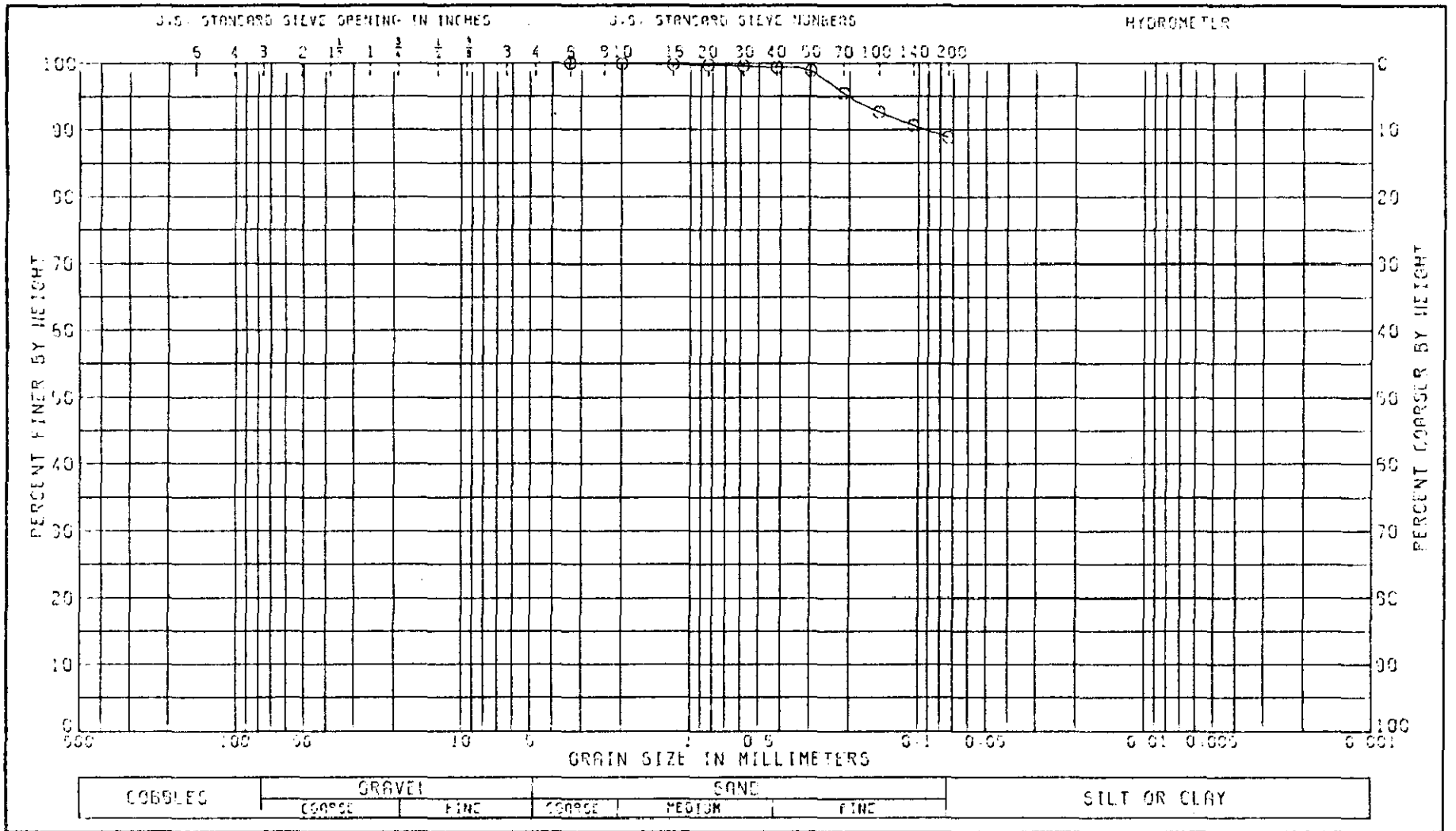
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-2-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.55 DATE 11 FEB 82




| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| 35 | 19 | 16 | | 26.8 | |

CLASSIFICATION

CLAY (CL), BROWN: WITH SAND

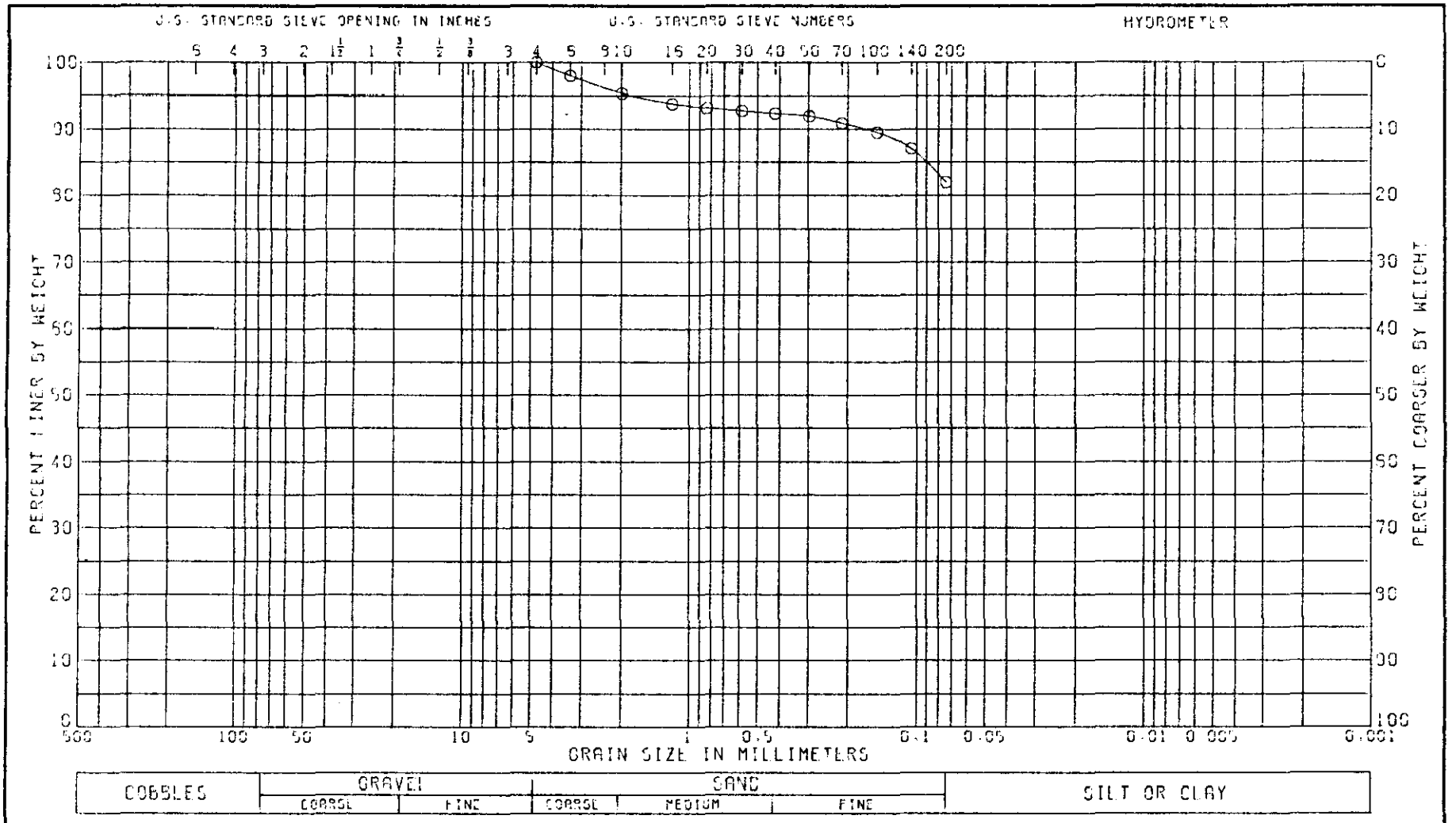
GRADATION CURVE

PROJECT CRANE NESC

OLD BURNING GROUND

BORING NO 6-3--81 SAMPLE NO 1

DEPTH/ELEV 0.0-1.74 DATE 26 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 44 | 18 | 26 | | 15.6 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

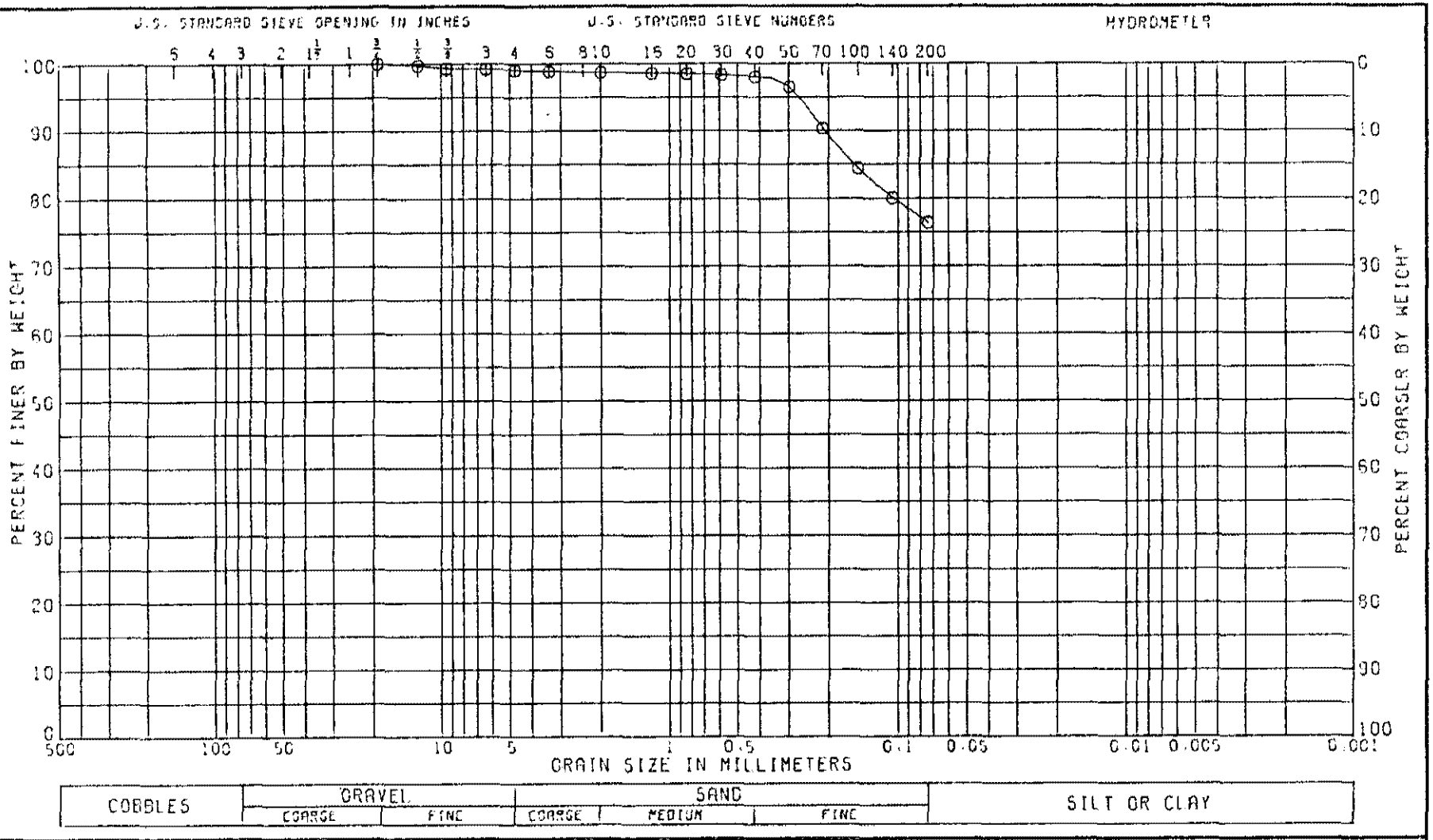
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-3-91 SAMPLE NO 2A

DEPTH/ELEV 5.0-5.3 DATE 31 MAR 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 33 | 20 | 13 | | 19.3 |

CLASSIFICATION

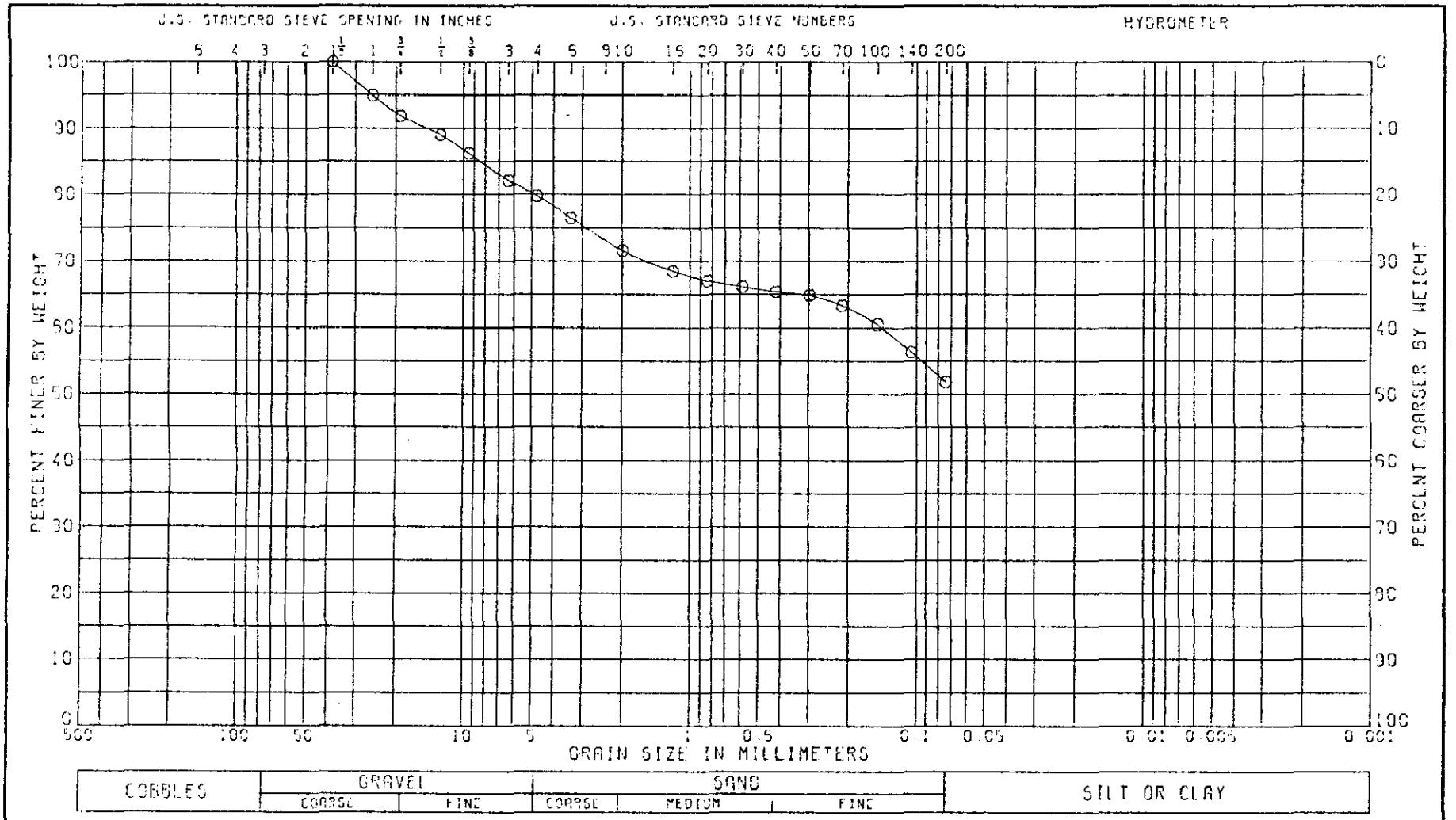
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-4-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.46 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 17 | 18 | | 9.1 |

CLASSIFICATION

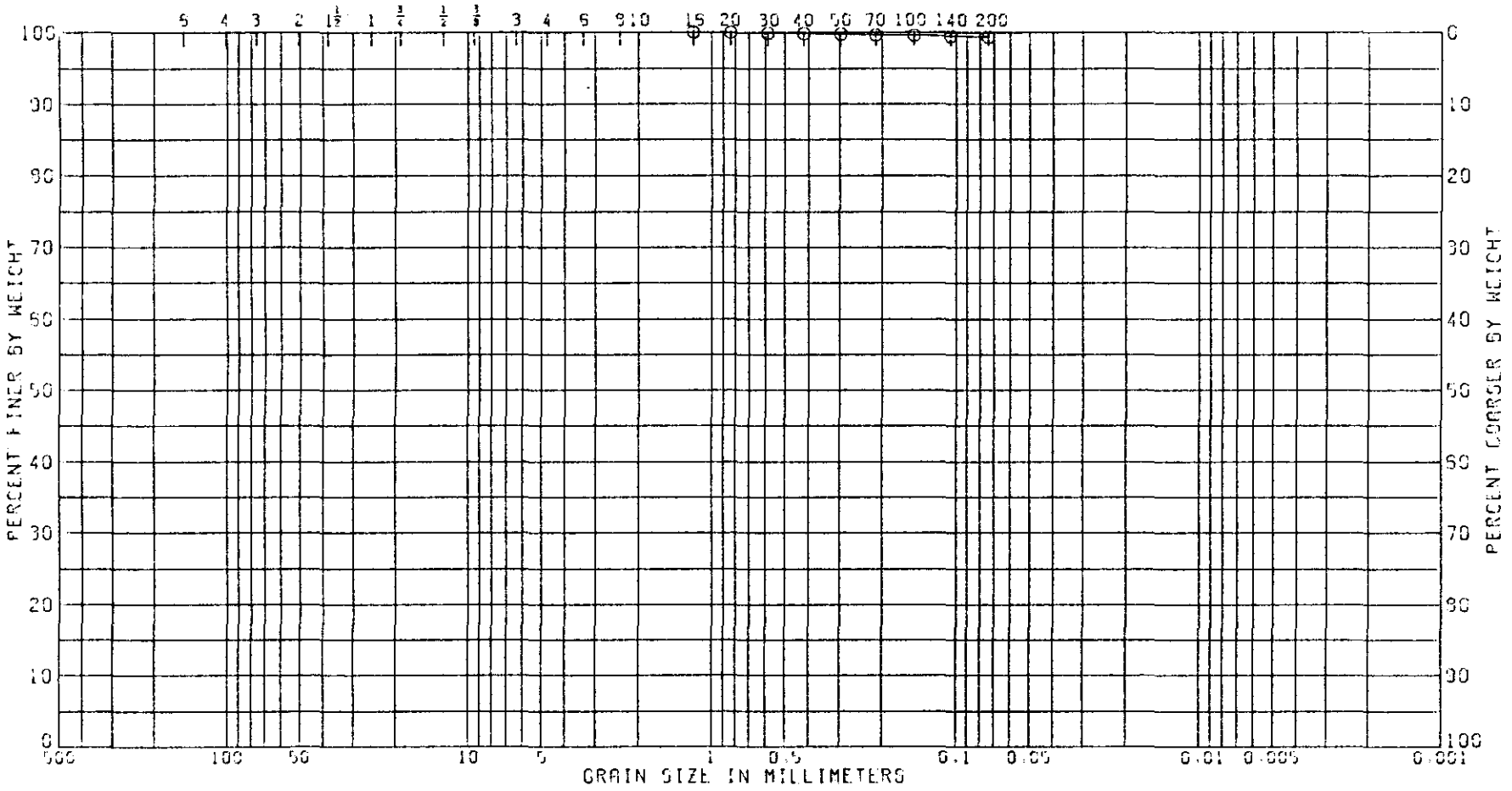
GRAVELLY SANDY CLAY (CL), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-5-91 SAMPLE NO. 1

DEPTH/ELEV 0.0.-1.8 DATE 11 FEB 92




| LL 44 | PL 22 | PI 22 | CS | NAT W.% 16.0 |
|---|---|---|---|---|

CLASSIFICATION

CLAY (CL), GRAY

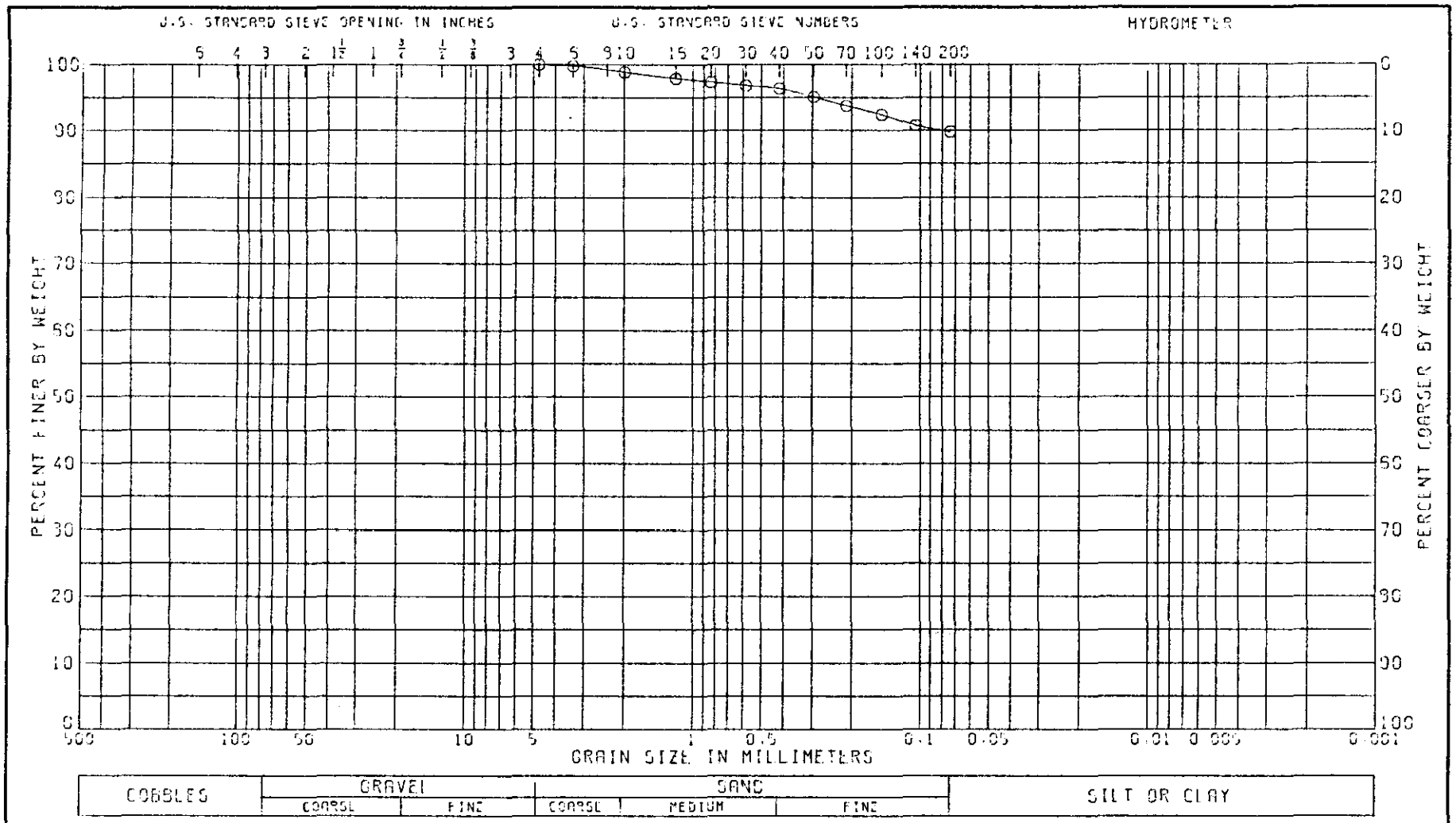
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-5-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-5.95 DATE 31 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 40 | 16 | 24 | | 14.1 |

CLASSIFICATION

CLAY (CL), BROWN: WITH SAND

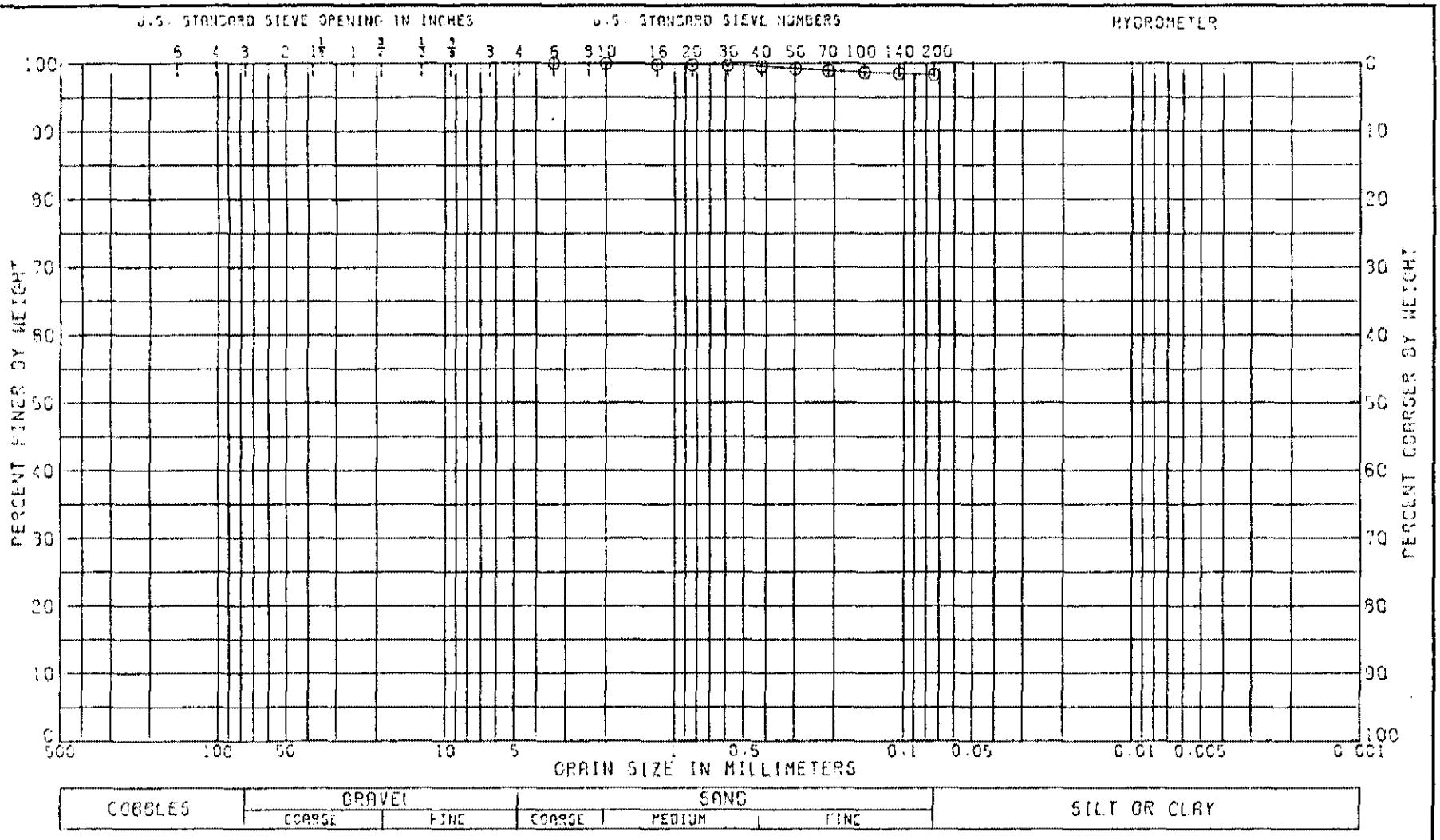
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-6-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.41 DATE 31 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 43 | 17 | 26 | | 14.5 |

CLASSIFICATION

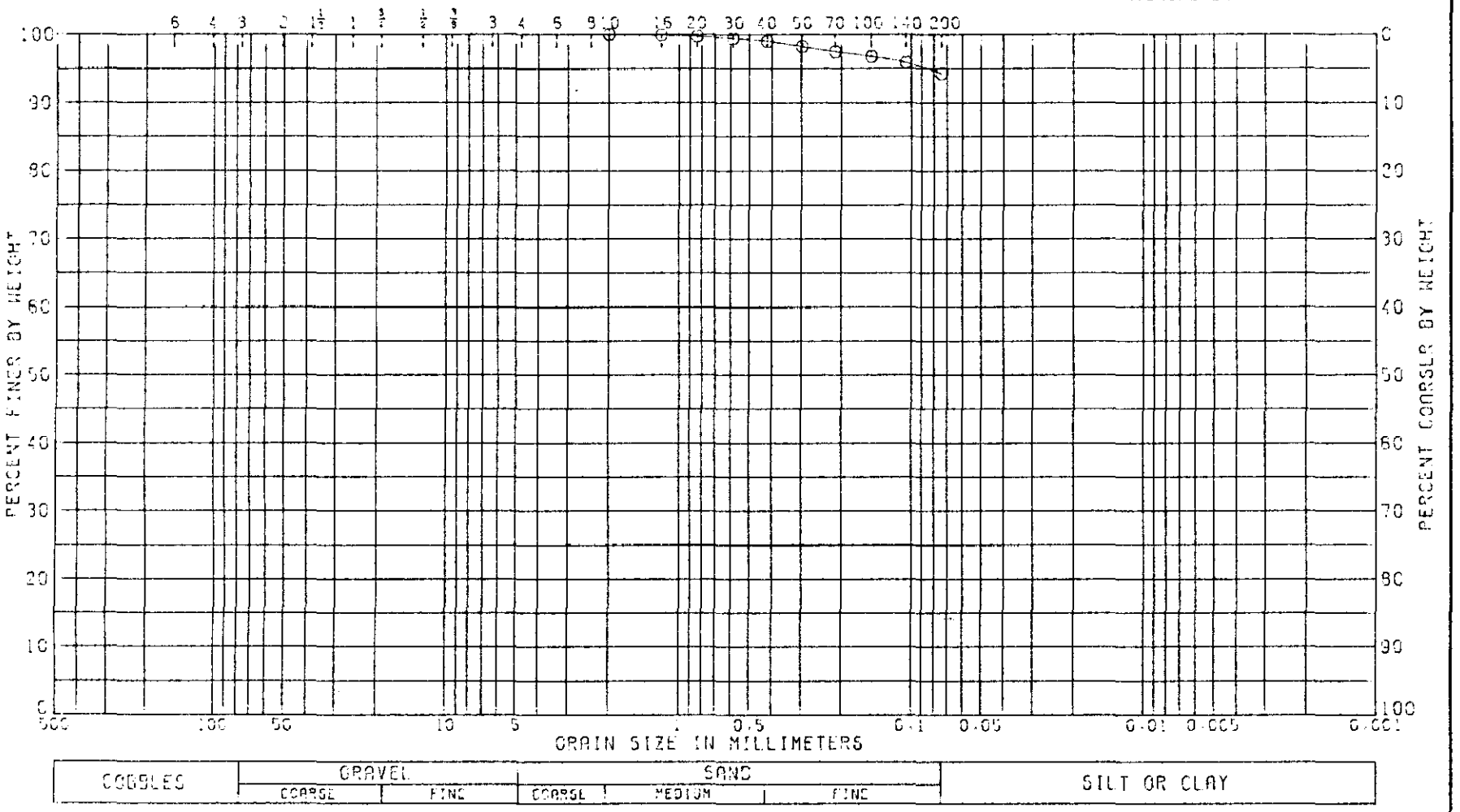
CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-6-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.27 DATE 12 MAR 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 45 | 22 | 23 | | 14.9 |

CLASSIFICATION

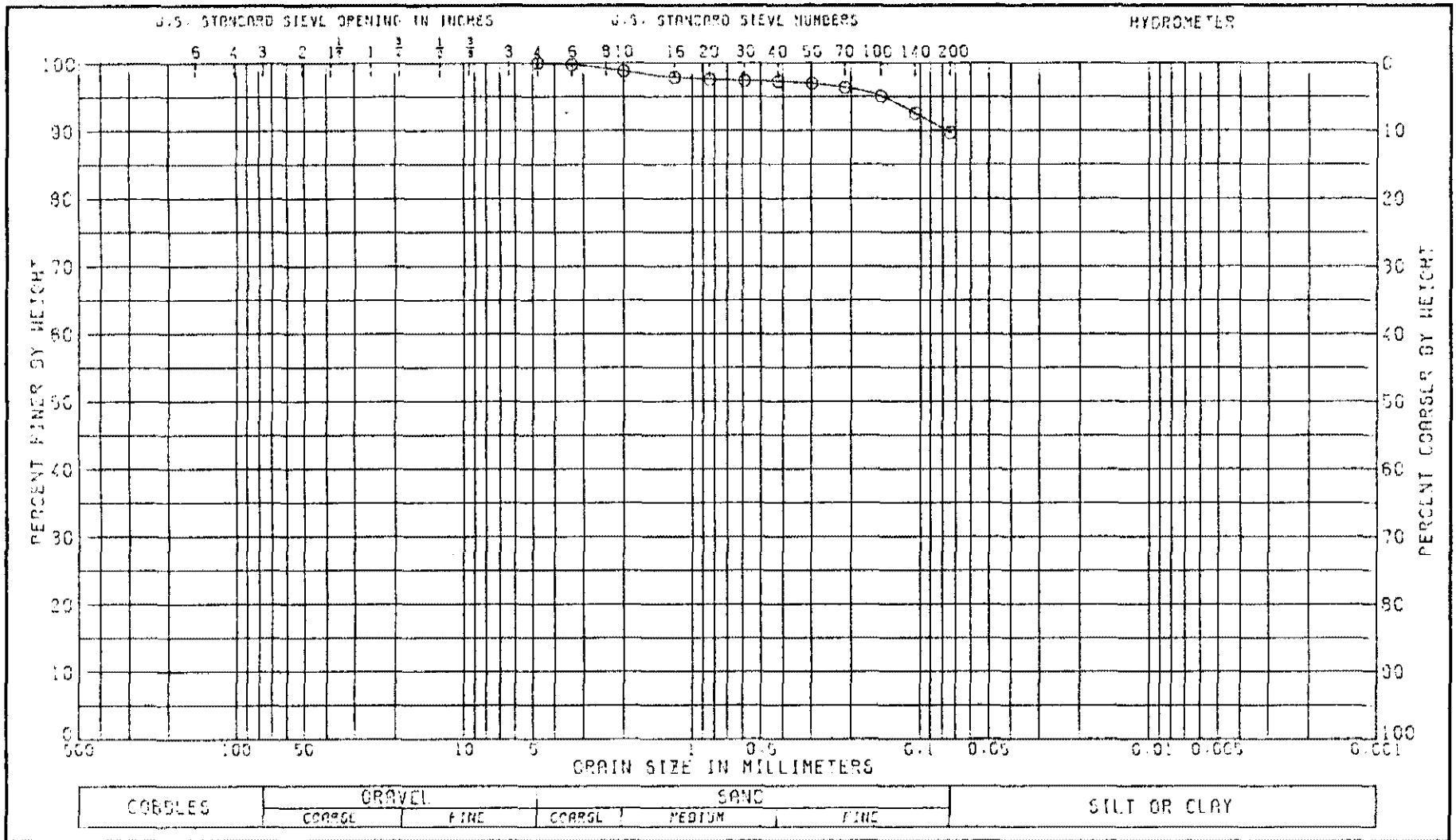
CLAY (CL), GRAYISH BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-6-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.30 DATE 12 MAR 82




| LL 46 | PL 16 | PI 30 | GS | NAT W.% 16.3 |
|---|---|---|---|---|

CLASSIFICATION

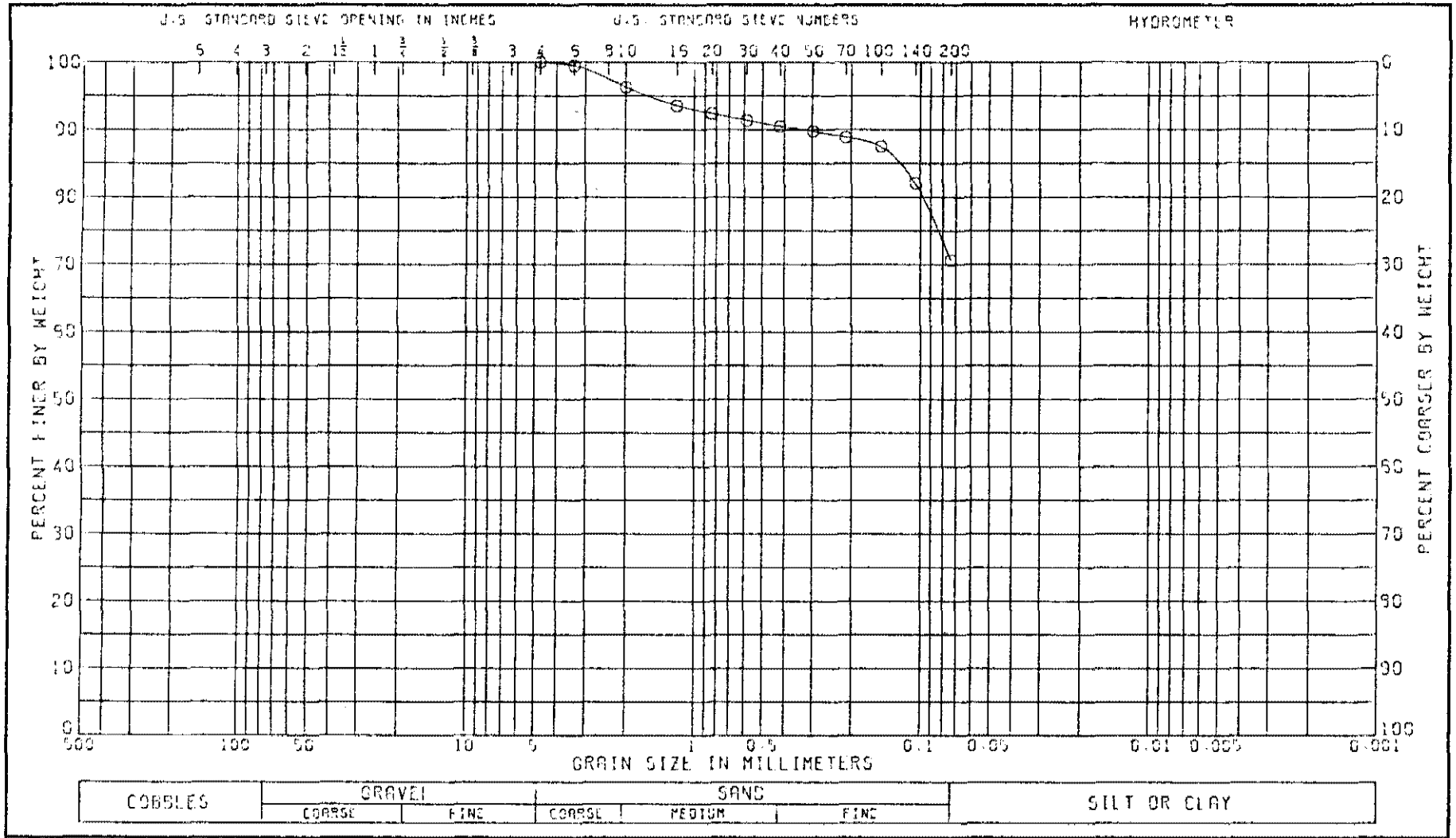
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-7-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.22 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 42 | 20 | 22 | | 17.0 |

CLASSIFICATION

SANDY CLAY (CL), TAN

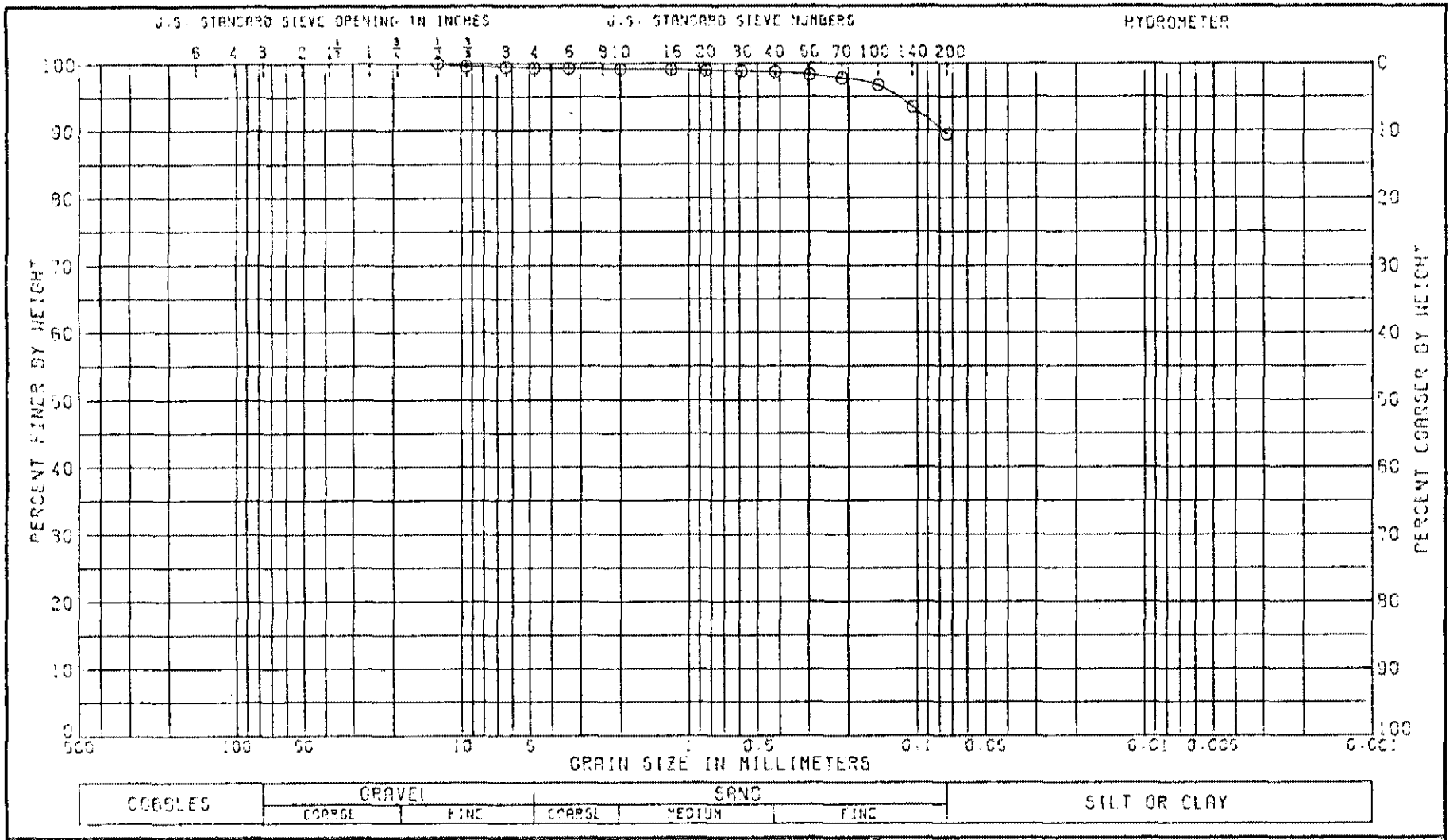
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-7-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.45 DATE 31 MAR 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 36 | 21 | 15 | | 21.5 |

CLASSIFICATION

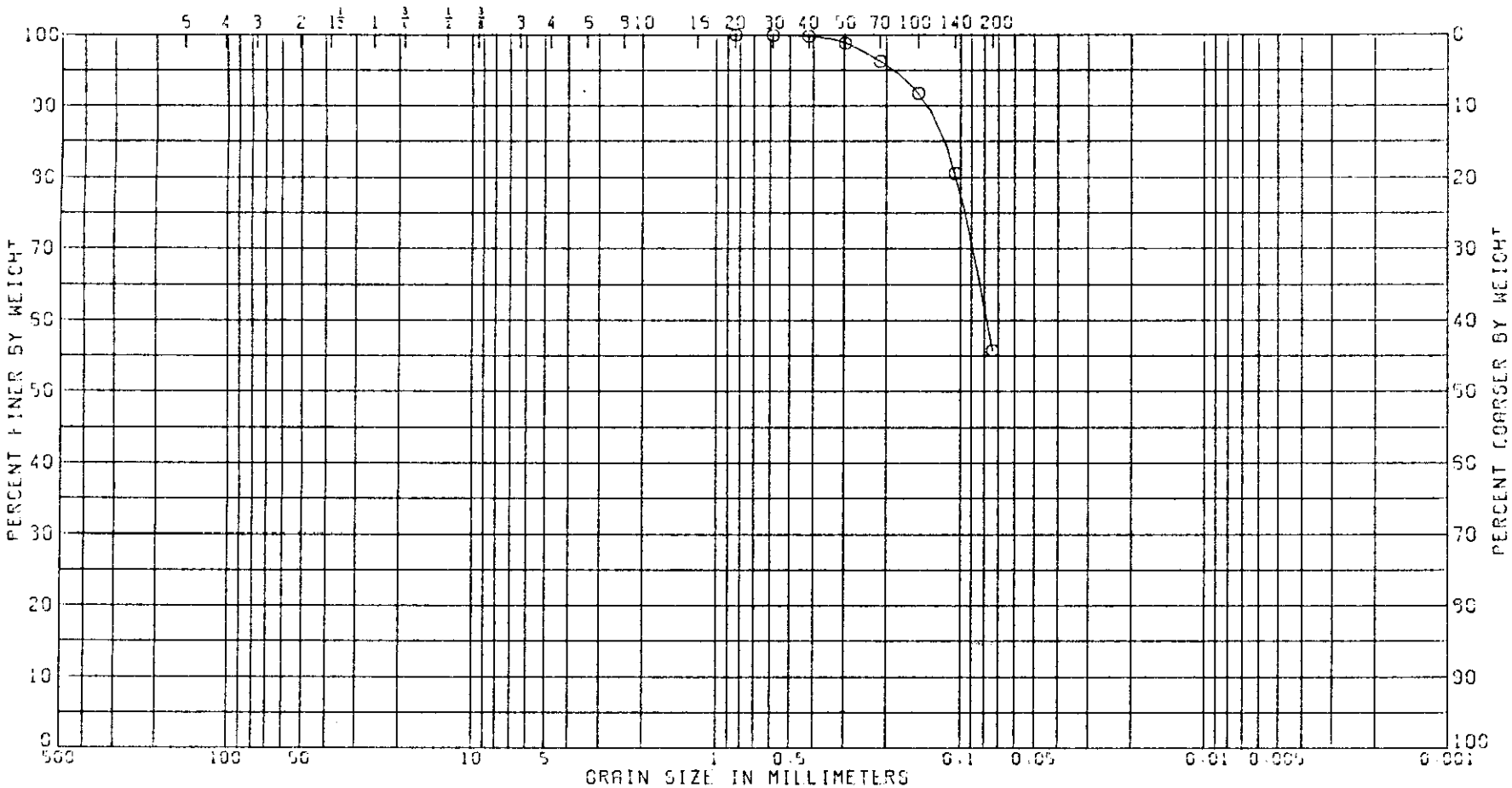
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-8-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.55 DATE 12 MAR 92




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |

| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| 25 | 15 | 10 | | 10.8 | |

CLASSIFICATION

SANDY CLAY (CL), BROWN

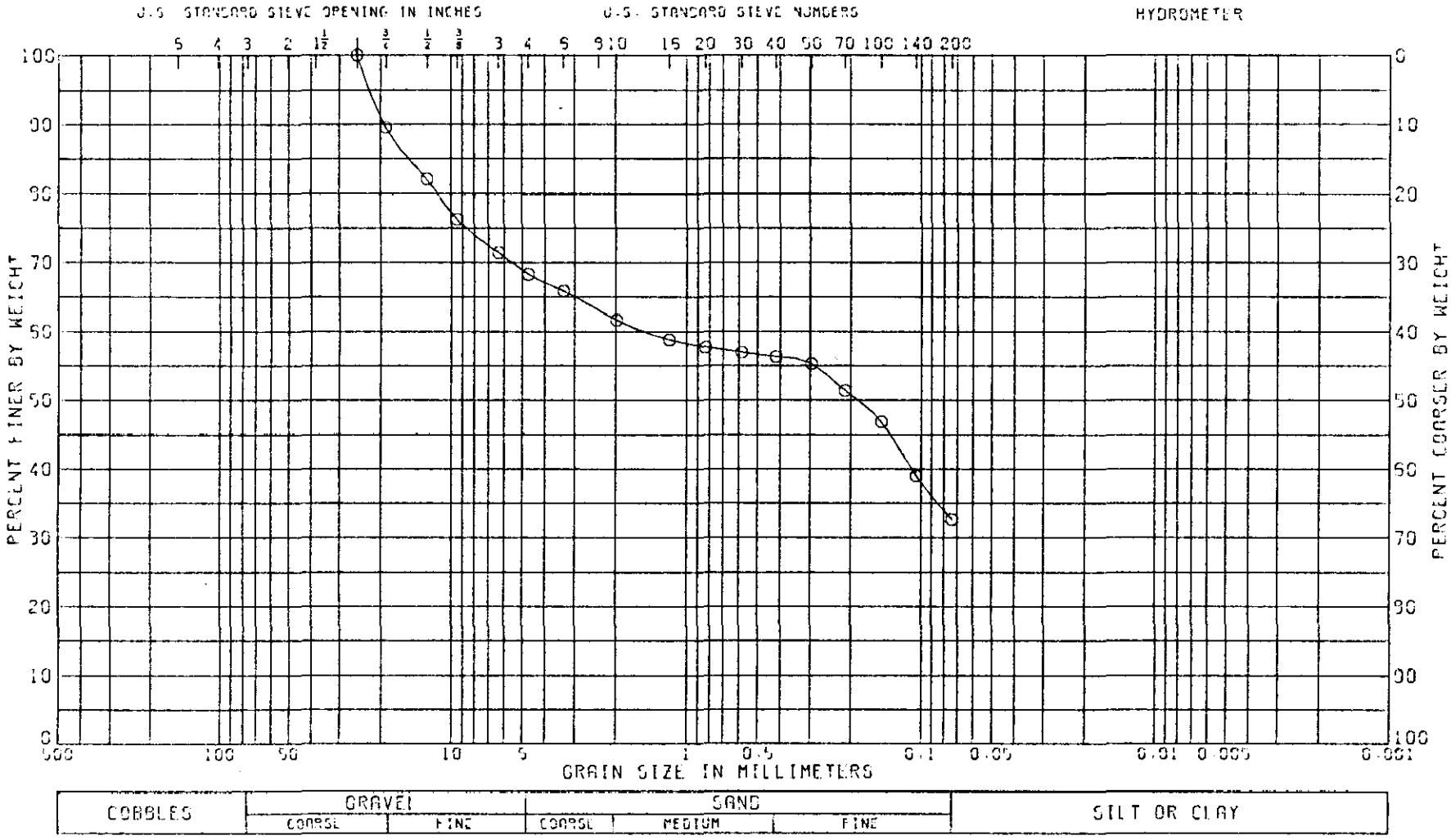
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-8-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-5.00 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 30 | 13 | 17 | | 7.4 |

CLASSIFICATION

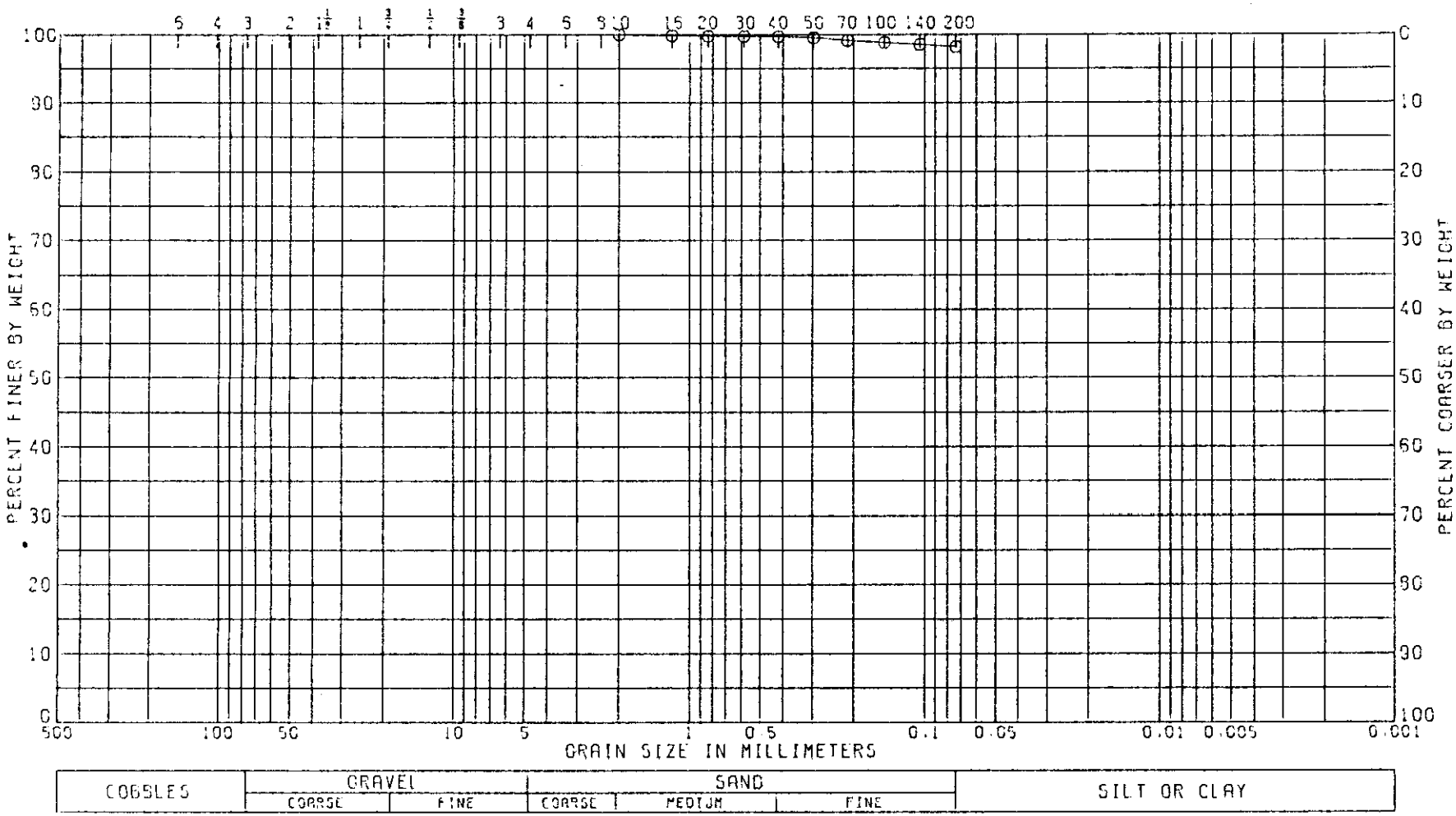
GRAVELLY CLAYEY SAND (SC), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
DEMOLITION AREA

BORING NO. 6-0-81 SAMPLE NO. 1A

DEPTH/ELEV 0.0-1.7 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 41 | 19 | 22 | | 14.8 |

CLASSIFICATION

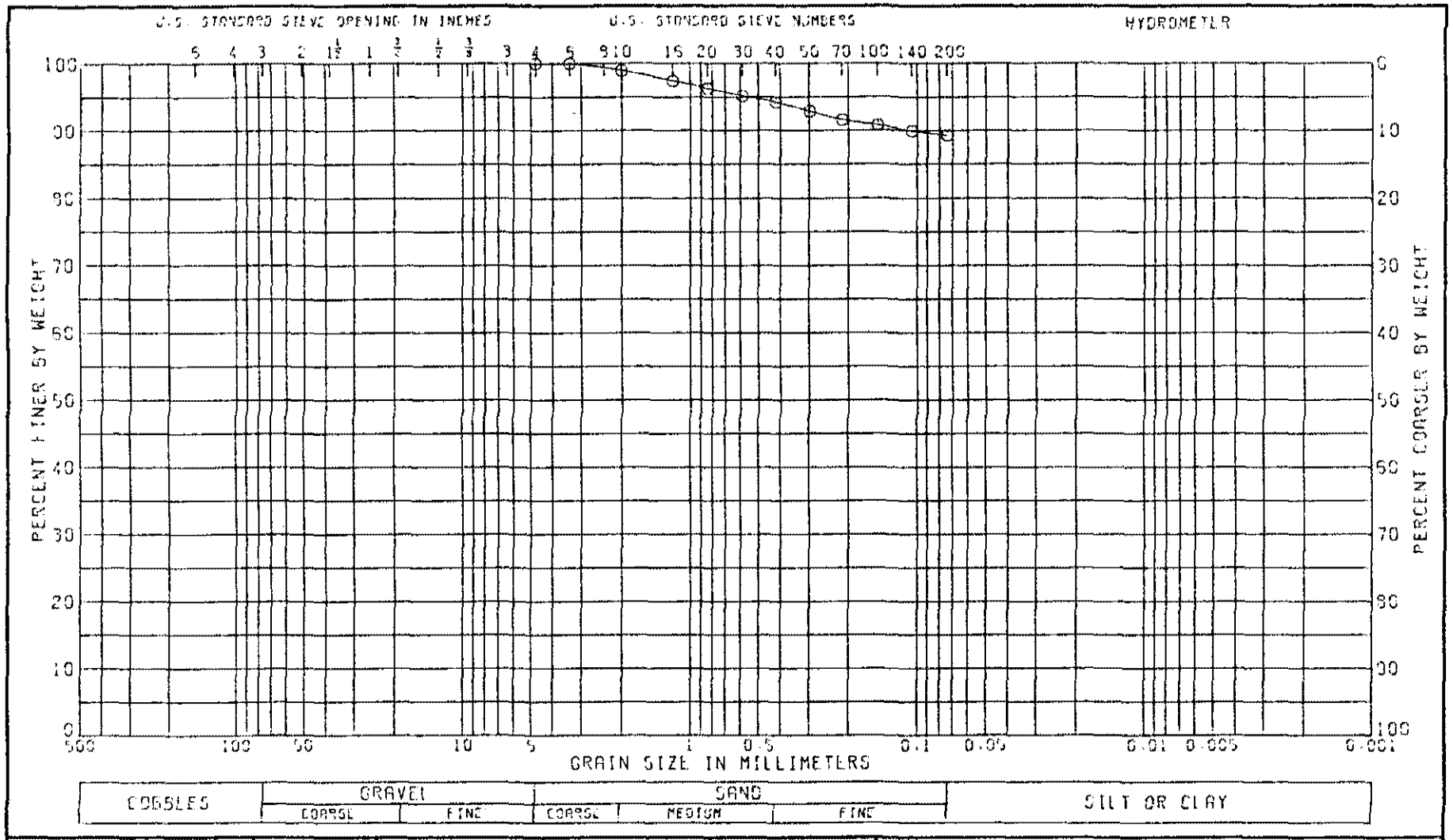
CLAY (CL) BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. S-10-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.08 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 45 | 19 | 26 | | 17.4 |

CLASSIFICATION

CLAY (CL), BROWN: WITH SAND

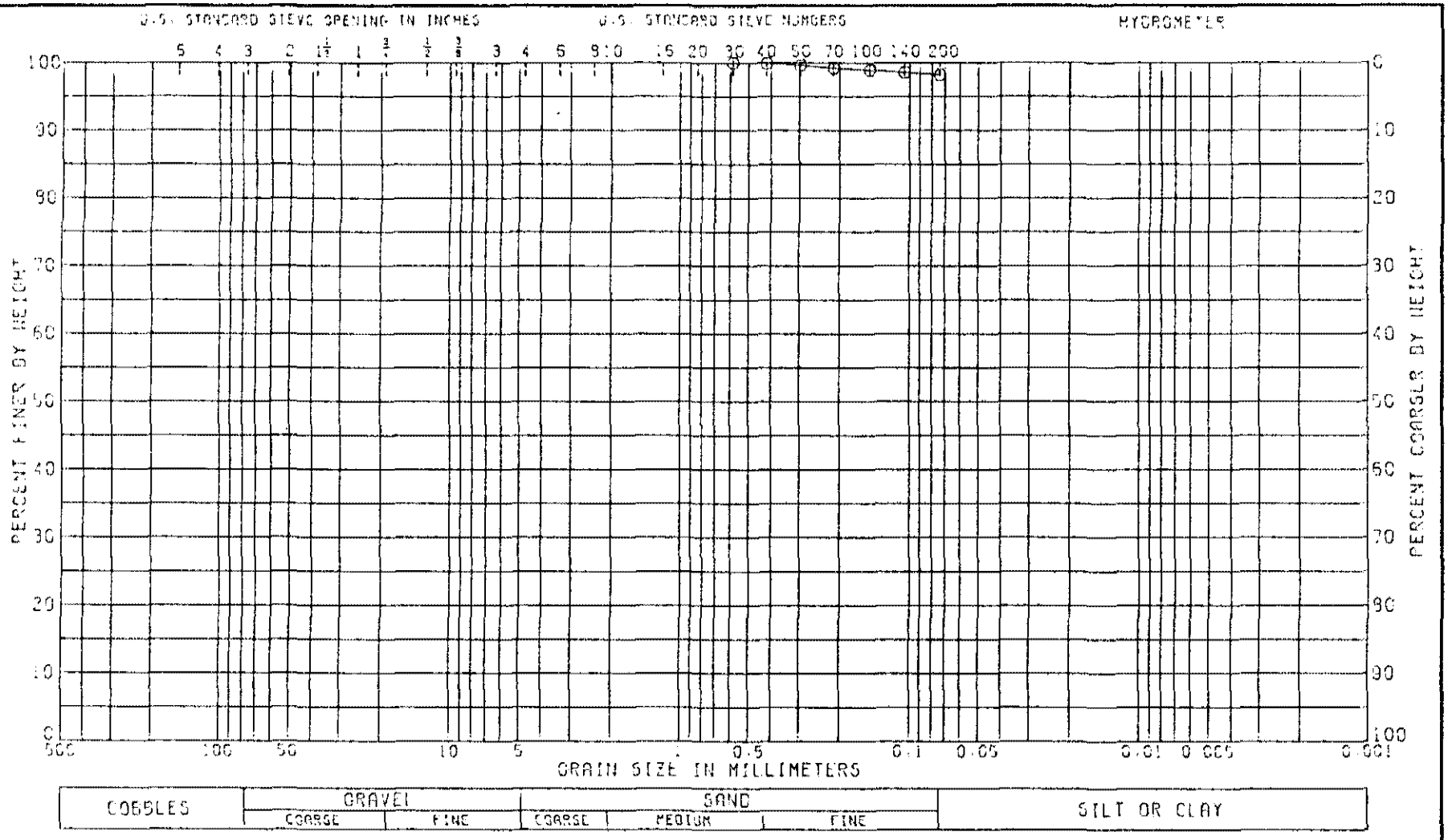
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-10-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.00 DATE 31 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 47 | 25 | 22 | | 20.8 |

CLASSIFICATION

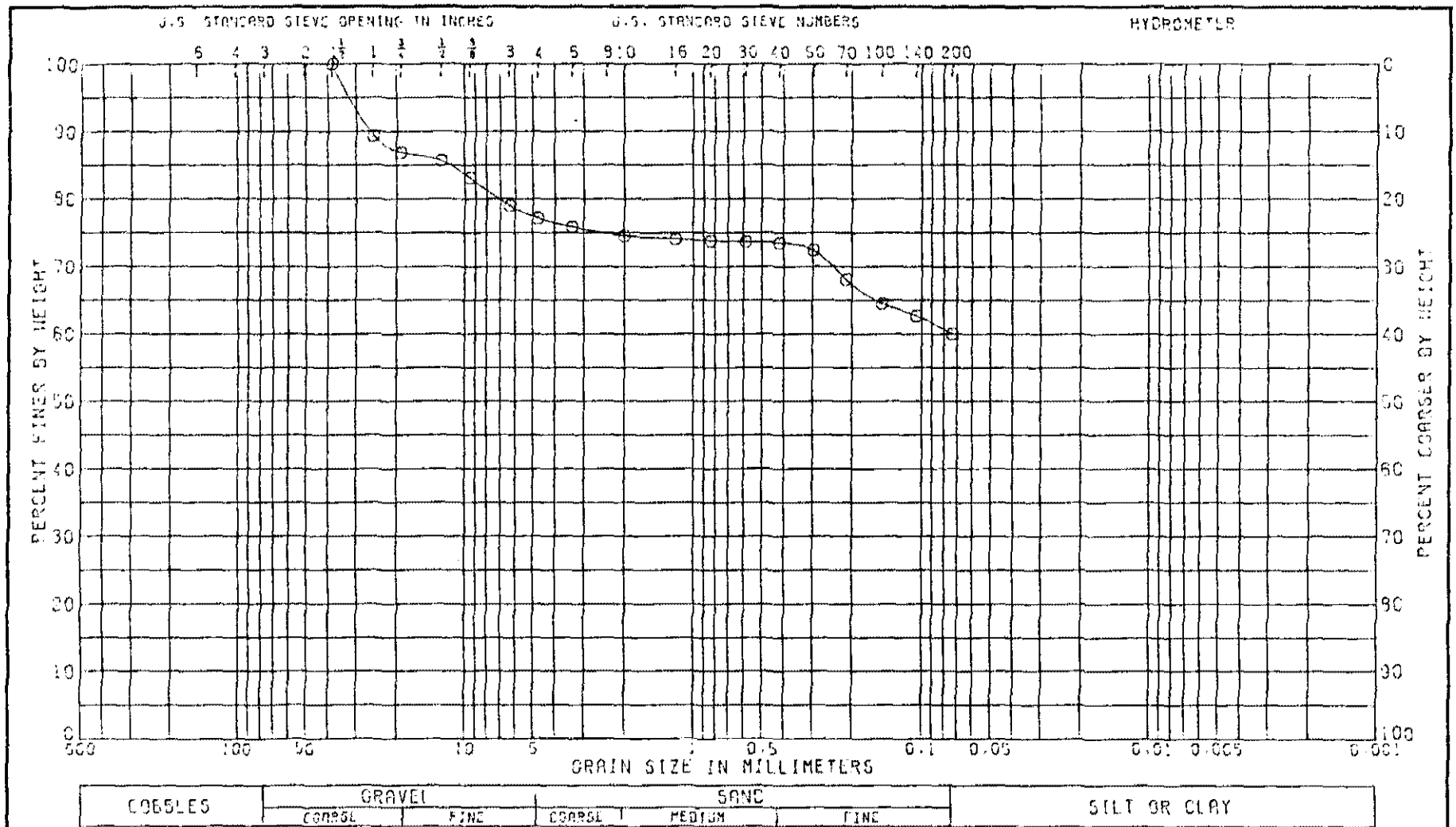
CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-10-81 SAMPLE NO 3

DEPTH/ELEV 10.0-11.40 DATE 12 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 32 | 18 | 14 | | 13.0 |

CLASSIFICATION

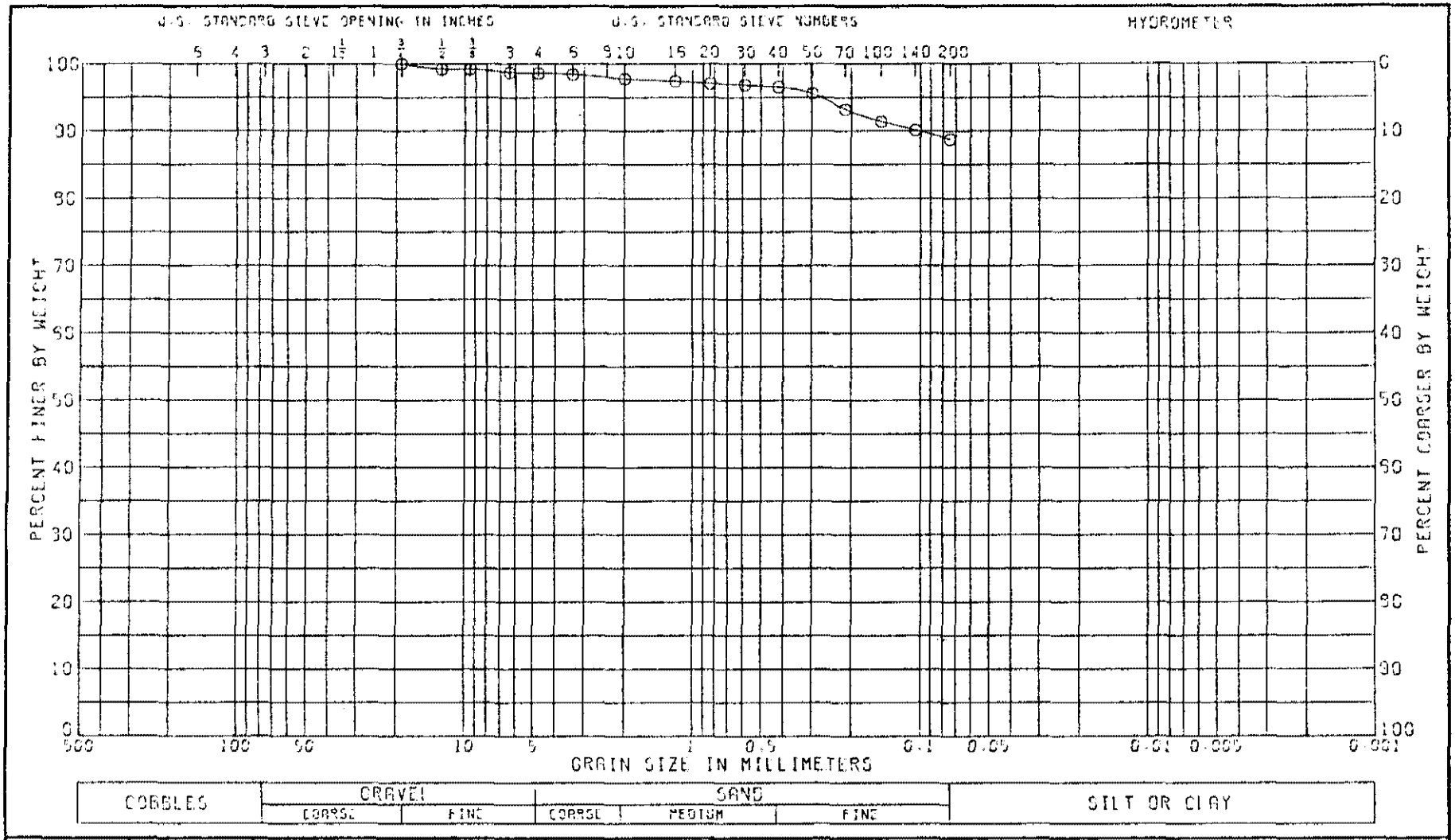
GRAVELLY SANDY CLAY (CL), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO 6-11-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.39 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 36 | 19 | 17 | | 22.0 |

CLASSIFICATION

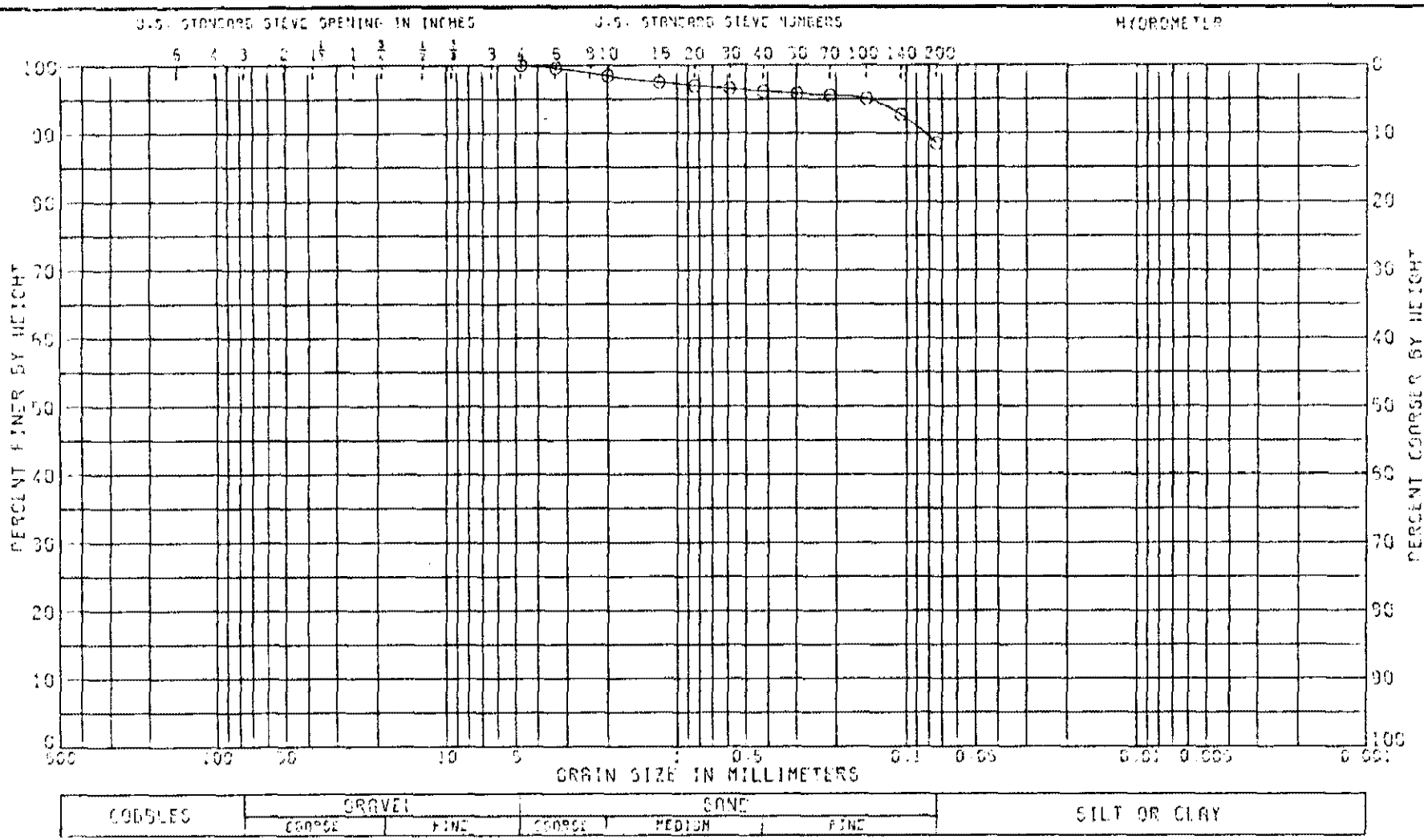
CLAY (CL), LIGHT BROWN: WITH SAND
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
DEMOLITION AREA

BORING NO. 6-11-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-5.71 DATE 31 MAR 92




| LL | PL | PI | CC | NAT W,% |
|---|---|---|---|---|
| 57 | 18 | 39 | | 20.8 |

CLASSIFICATION

CLAY (CH), REDDISH BROWN: WITH SAND

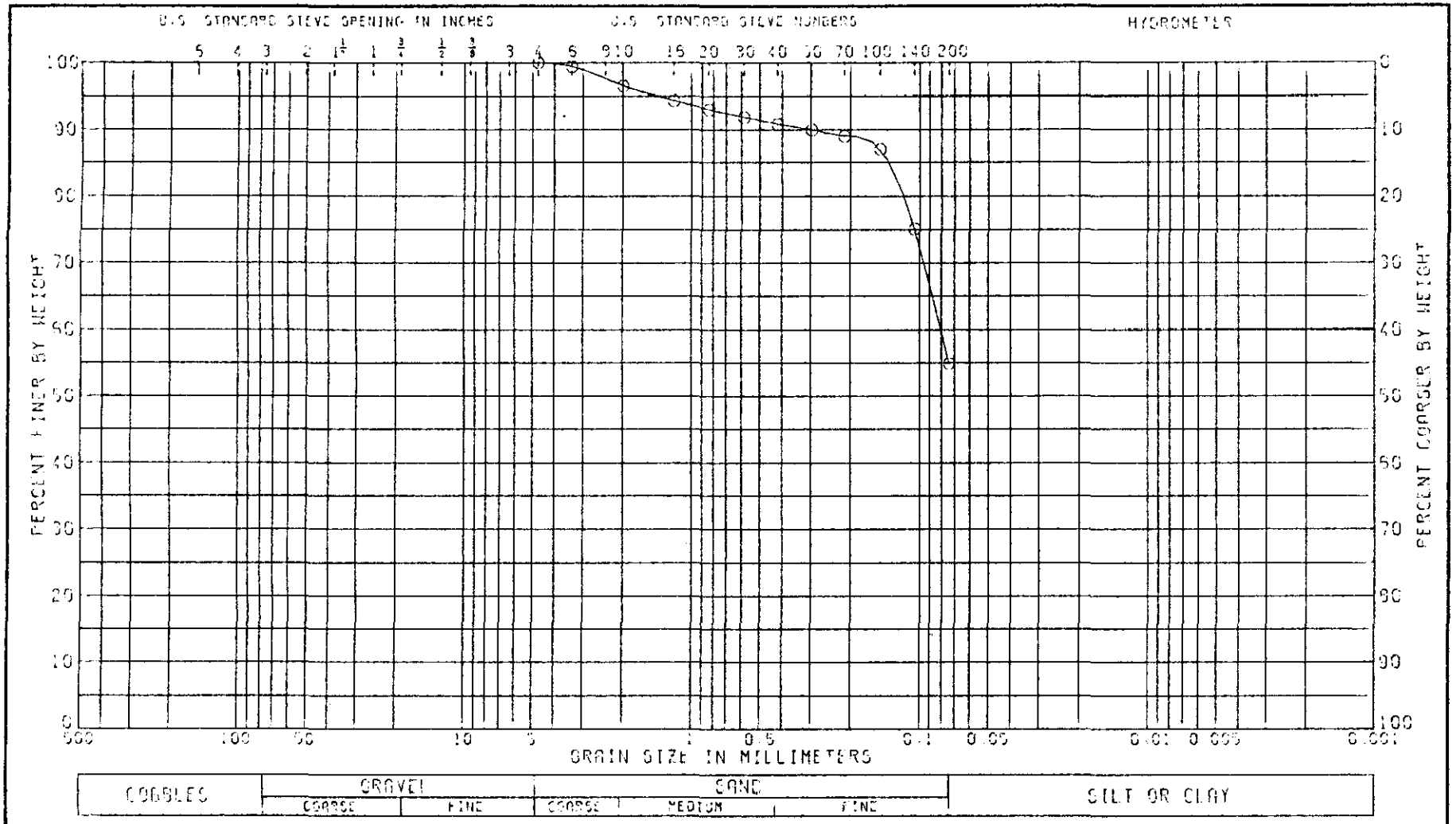
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO 6-12-81 SAMPLE NO 1

DEPTH/ELEV 1.10-2.20 DATE 26 FEB 82




| LL 26 | PL 12 | PI 14 | GS | NAT W.% 7.9 | |
|---|---|---|---|---|---|

CLASSIFICATION

SANDY CLAY (CL), GRAY

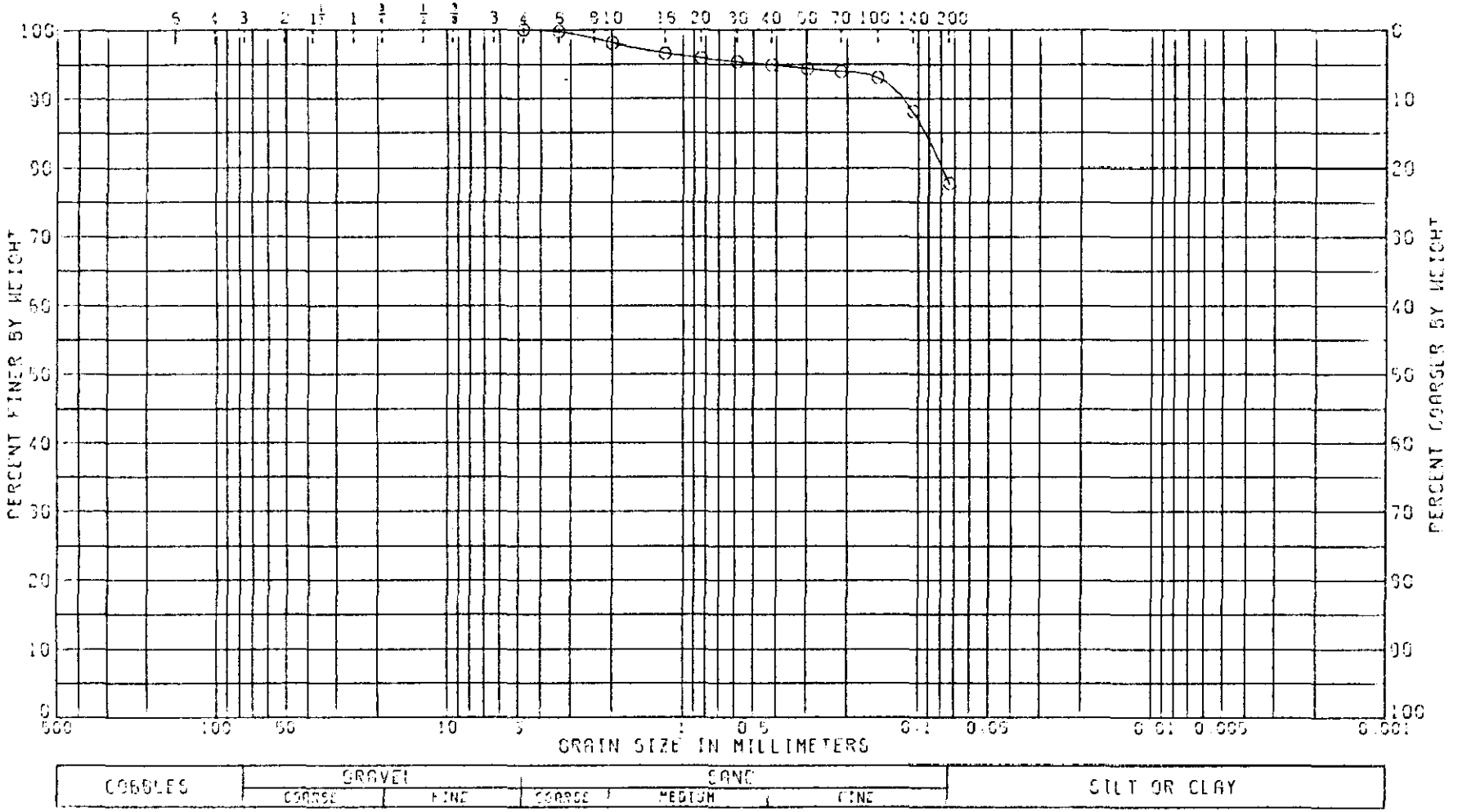
GRADATION CURVE

PROJECT CRANE NWSC

OLD BURNING GROUND

BORING NO. 6-12-81 SAMPLE NO 2

DEPTH/ELEV 5.0-6.14 DATE 25 FEB 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 50 | 17 | 33 | | 17.3 |

CLASSIFICATION

SANDY CLAY (CH) BROWN

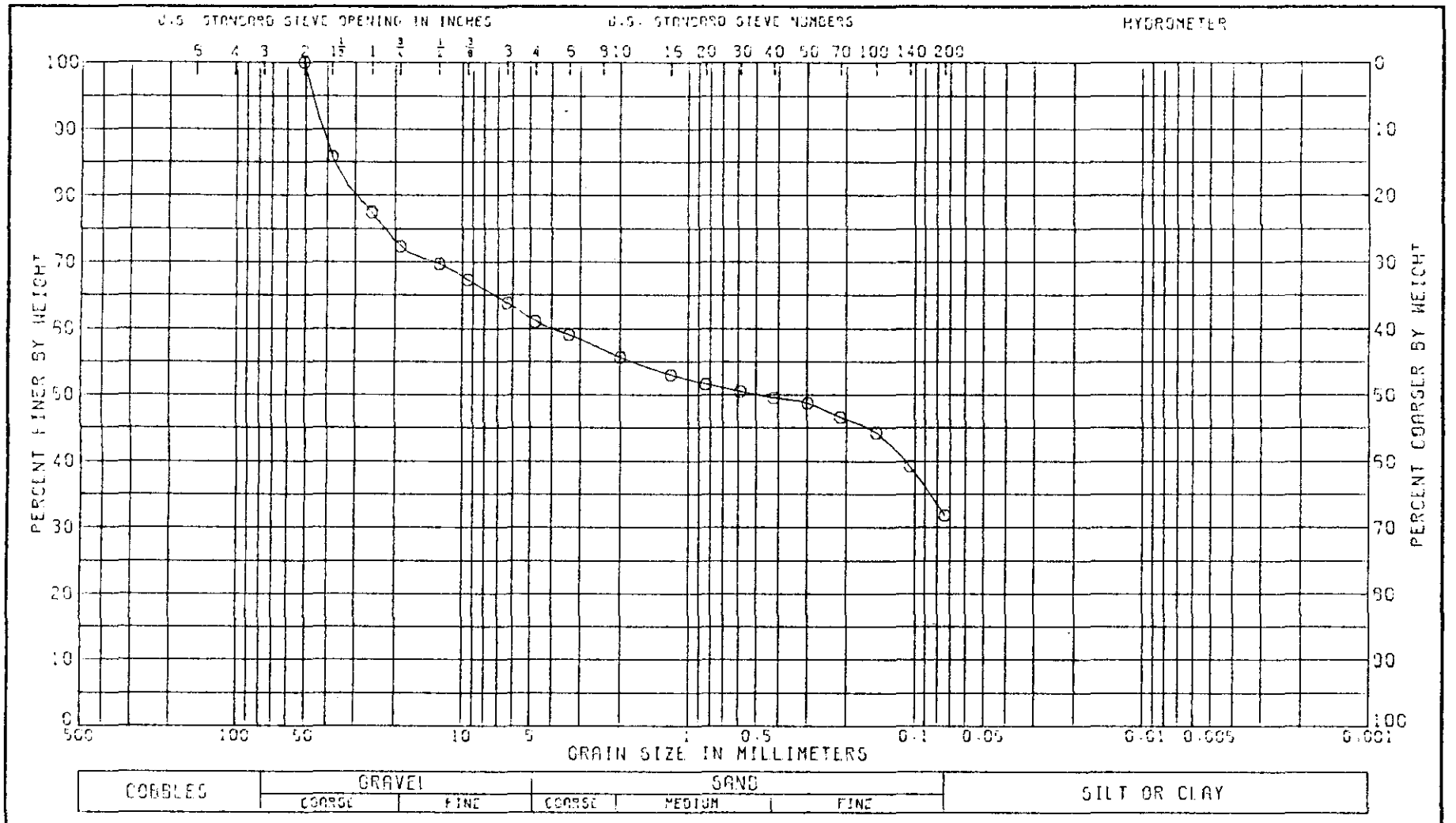
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-13-81 SAMPLE NO 1

DEPTH/ELEV 0.9-1.29 DATE 26 FEB 82




| LL 27 | PL 16 | PI 11 | GS | NAT W.% 15.8 |
|---|---|---|---|---|

CLASSIFICATION

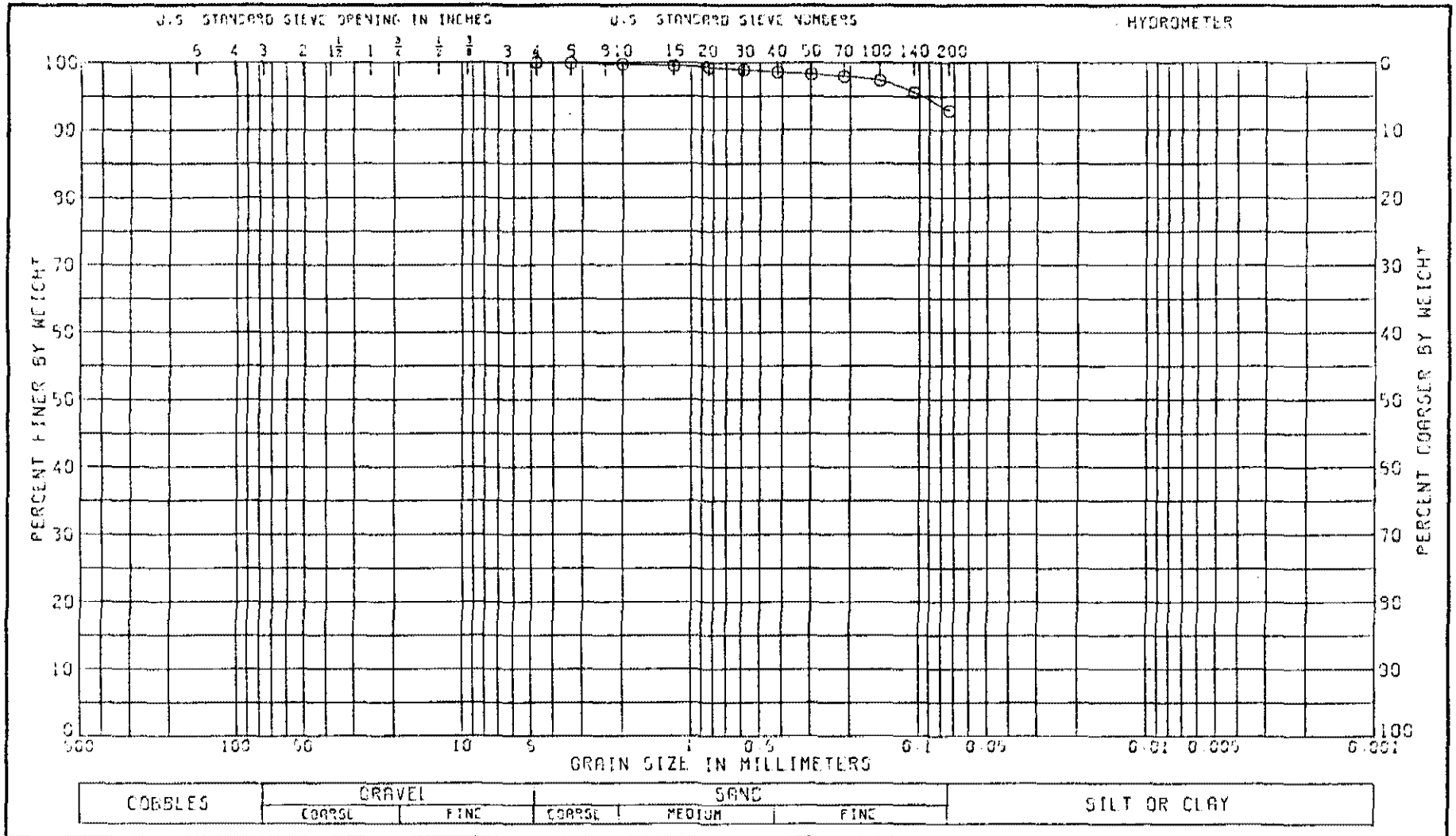
GRAVELLY CLAYEY SAND (SC), REDDISH BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. S-14-91 SAMPLE NO 1

DEPTH/ELEV 0.0-1.61 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 28 | 19 | 9 | | 24.0 |

CLASSIFICATION

CLAY (CL), BROWN: WITH SAND

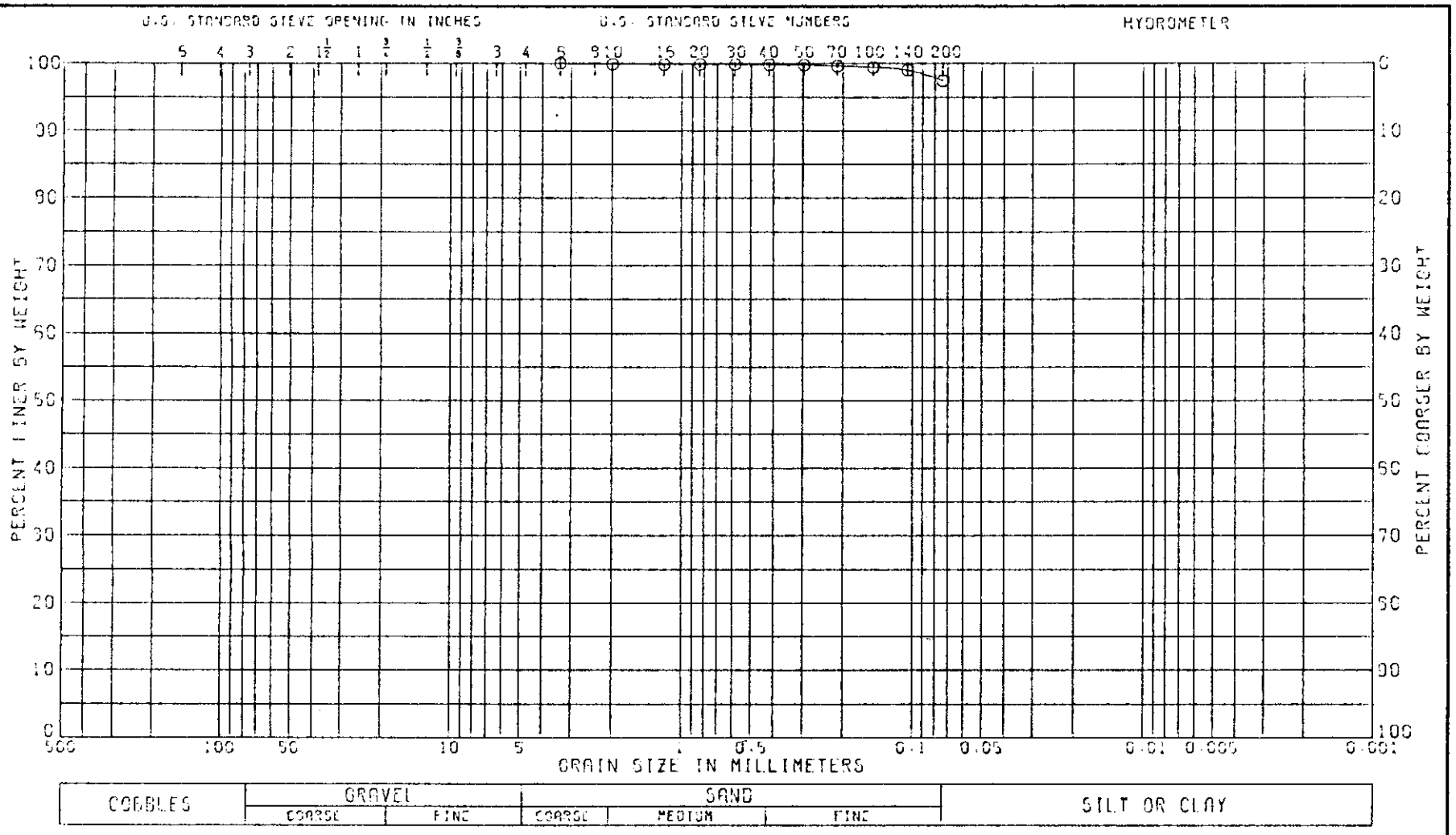
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-14-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.05 DATE 31 MAR 82




| LL 30 | PL 18 | PI 15 | OS | NAT W.% 23.5 |
|---|---|---|---|---|

CLASSIFICATION

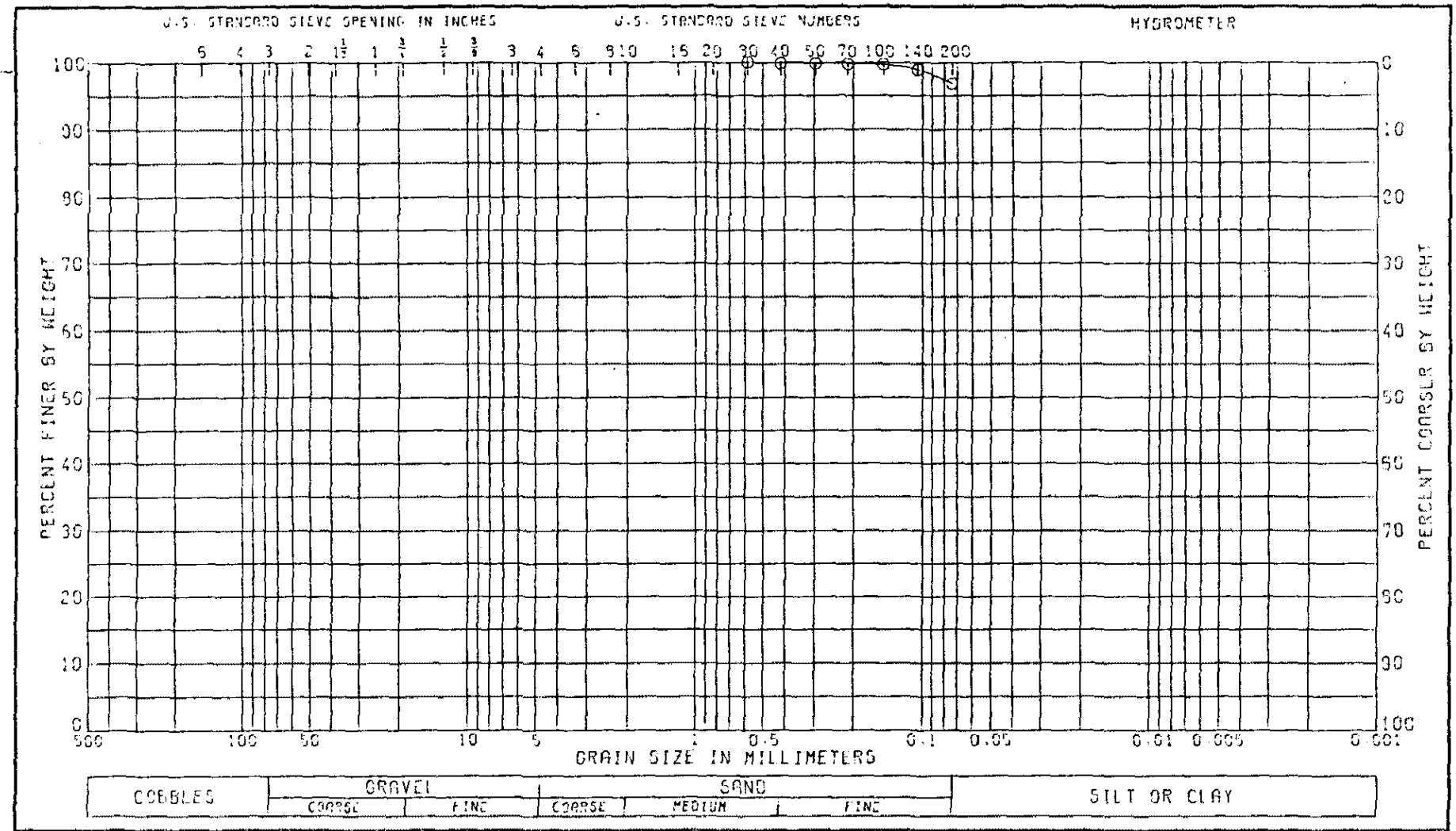
CLAY (CL), GRAY

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. S-14-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.67 DATE 11 FEB 82




| | | | | | |
|---|---|---|---|---|---|
| LL 61 | PL 24 | PI 37 | GS | NAT W.% 33.3 | |

CLASSIFICATION

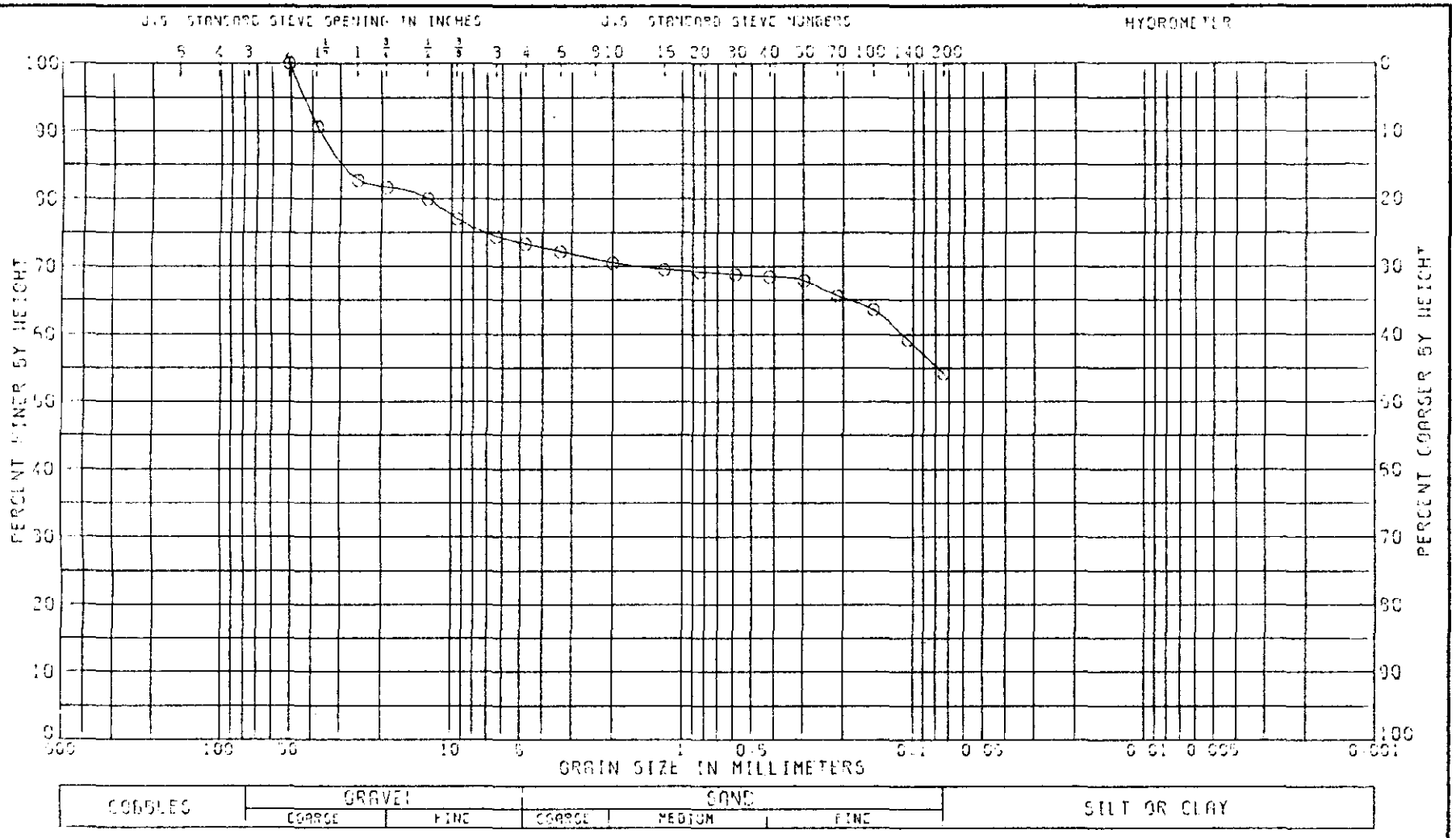
CLAY (CH), DARK BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-14-81 SAMPLE NO. 4

DEPTH/ELEV 15.0-17.07 DATE 11 FEB 82




| LL 27 | PL 17 | PI 10 | CS | NAT W.% 16.5 | |
|---|---|---|---|---|---|

CLASSIFICATION

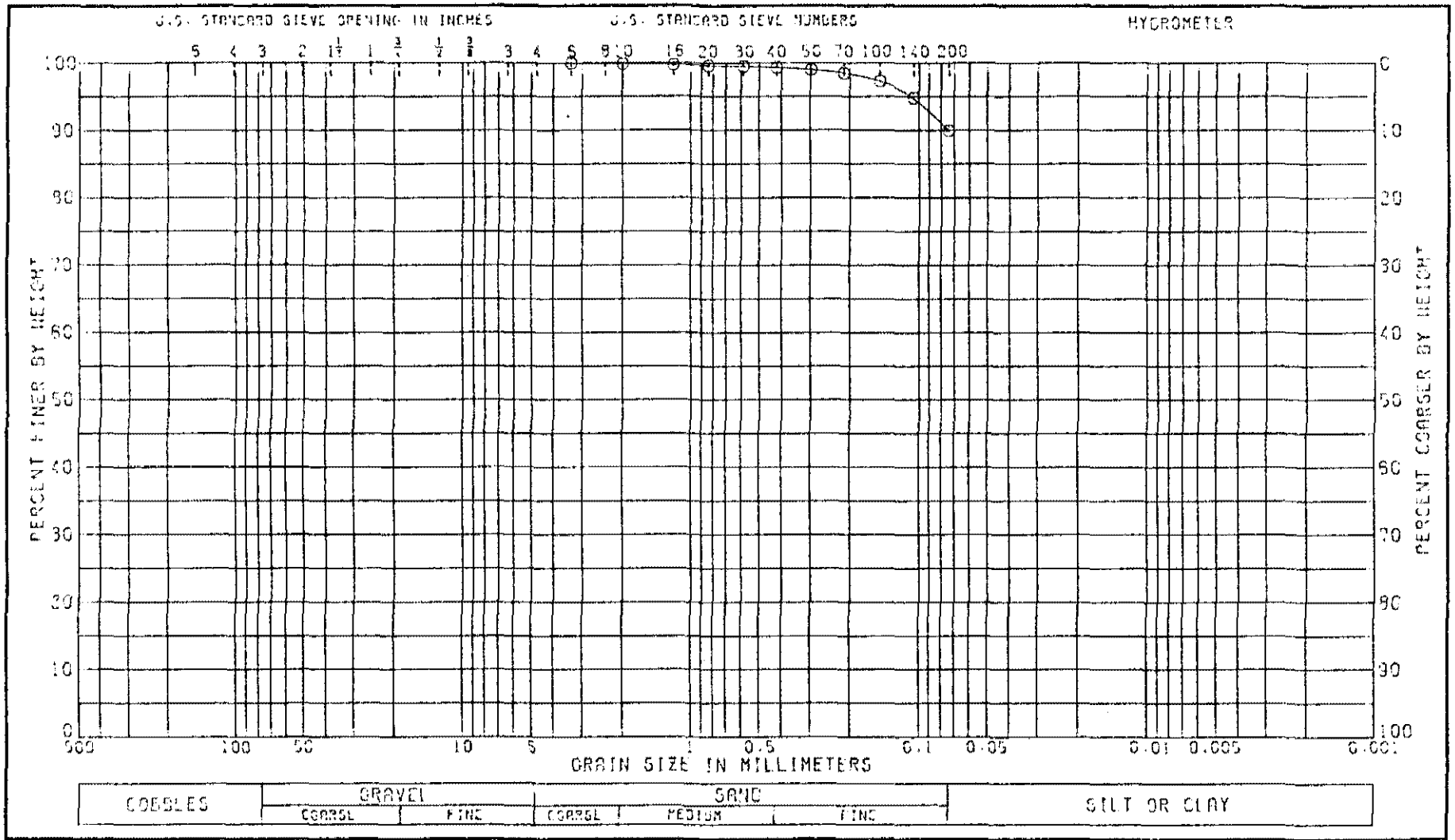
GRAVELLY SANDY CLAY (CL), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
OLD BURNING GROUND

BORING NO 6-15-91 SAMPLE NO 1

DEPTH/ELEV 0.0-1.35 DATE 26 FEB 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 37 | 20 | 17 | | 13.8 |

CLASSIFICATION

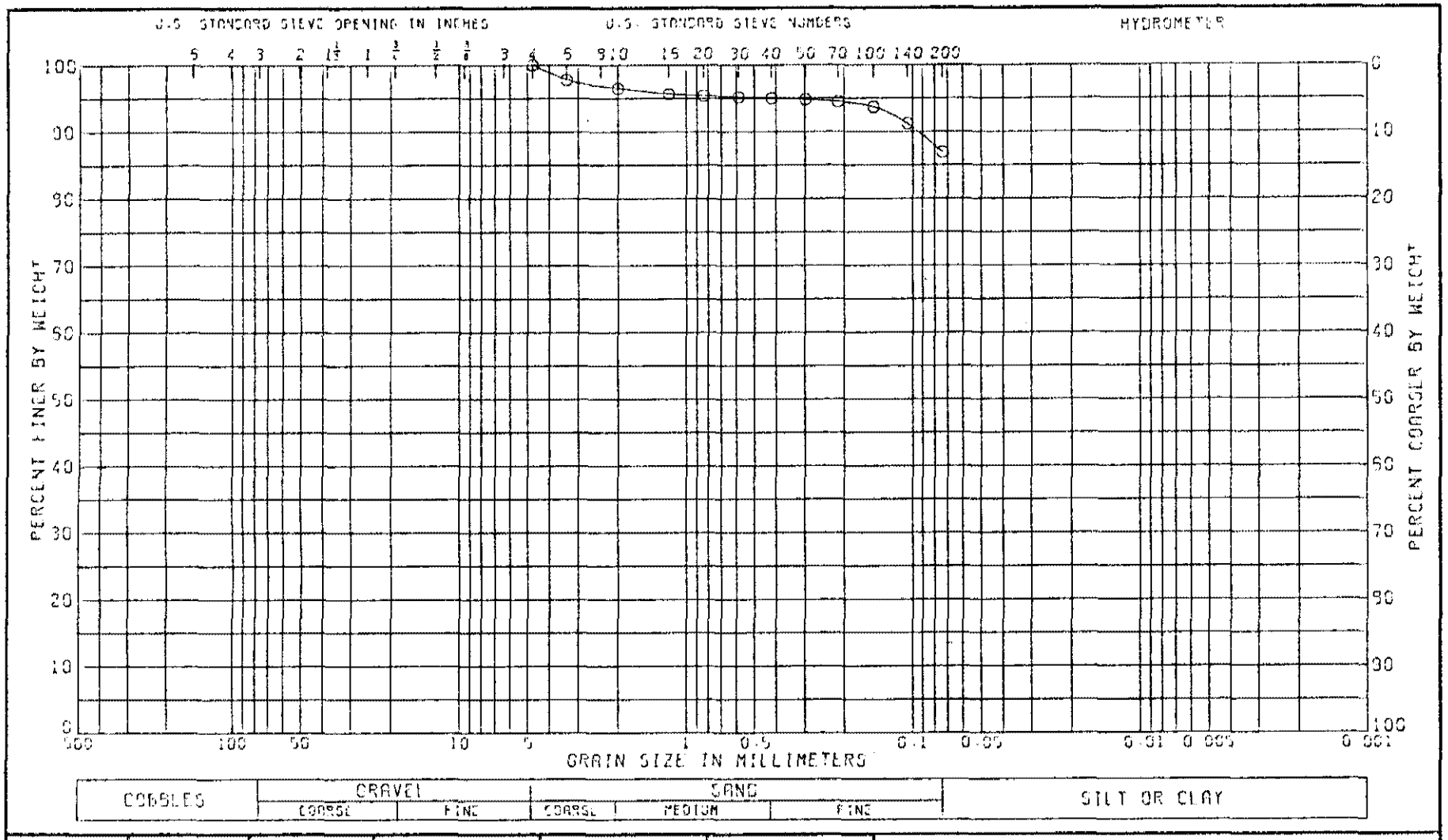
CLAY (CL), BROWN: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-18-91 SAMPLE NO 1

DEPTH/ELEV 0.0-1.37 DATE 12 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 29 | 15 | 14 | | 10.7 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

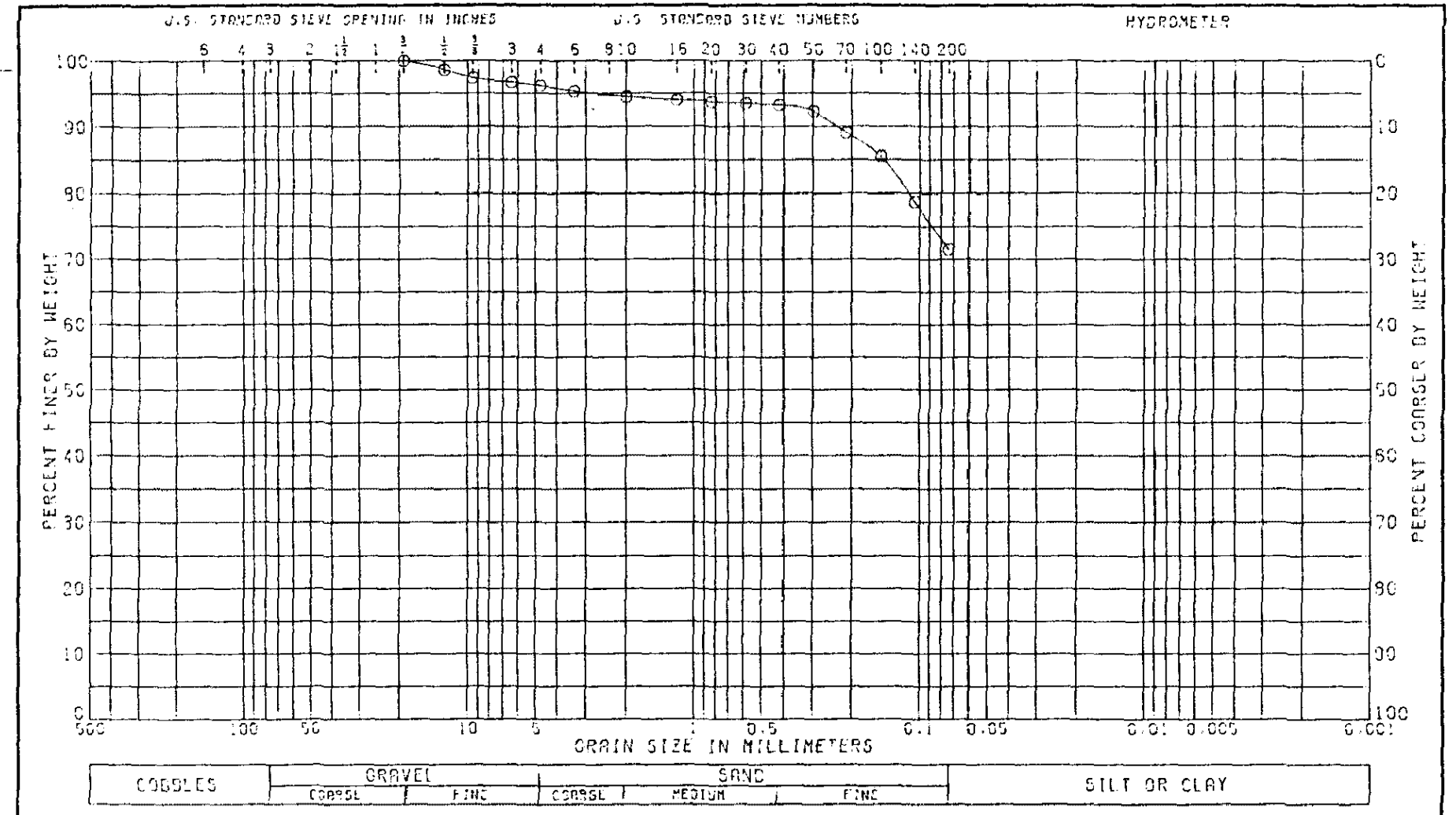
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-15-91 SAMPLE NO. 29

DEPTH/ELEV 5.0-5.4 DATE 31 MAR 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 28 | 17 | 11 | | 22.7 |

CLASSIFICATION

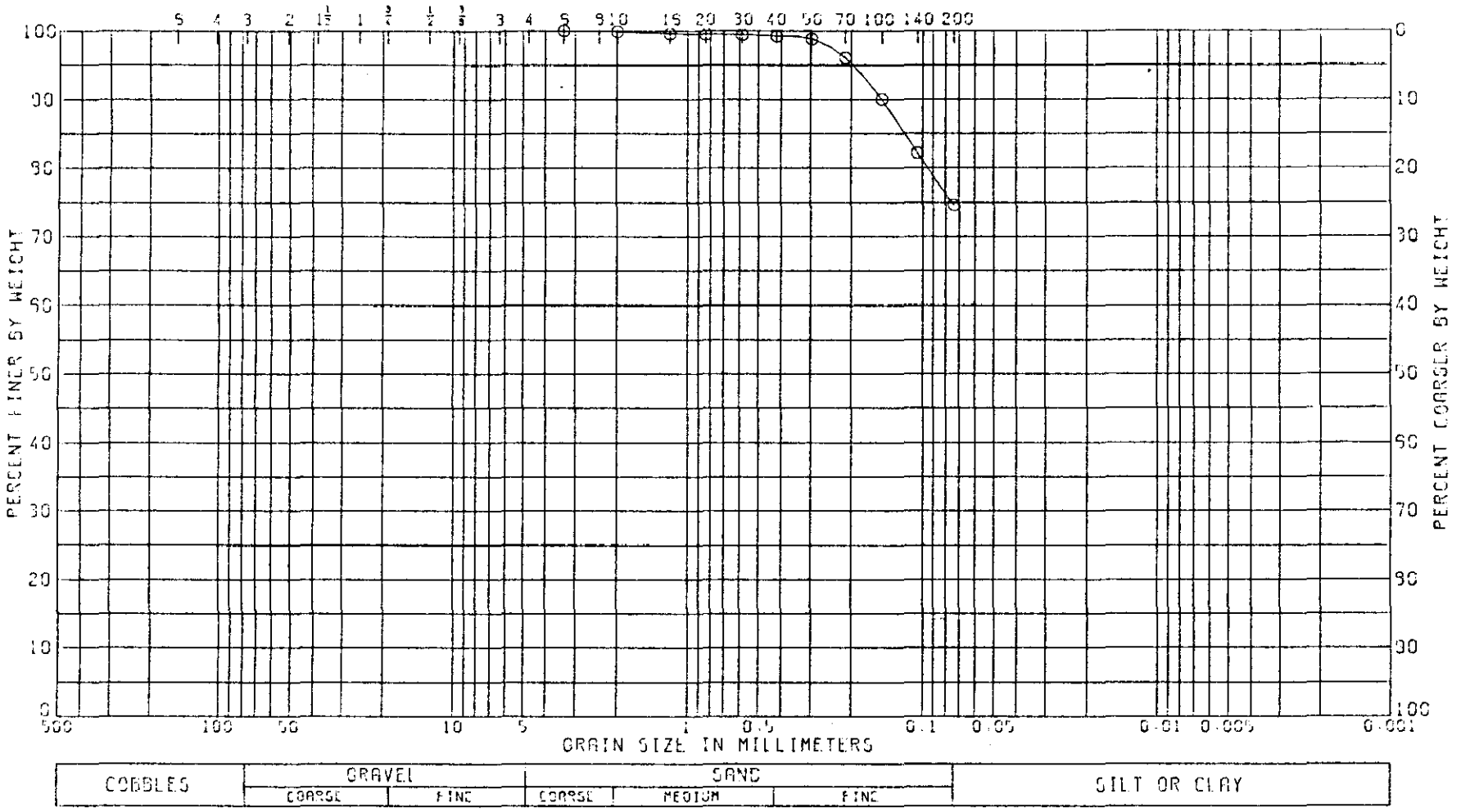
SANDY CLAY (CL), BROWN TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-17-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.33 DATE 12 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 18 | 17 | | 15.0 |

CLASSIFICATION

SANDY CLAY (CL), TAN

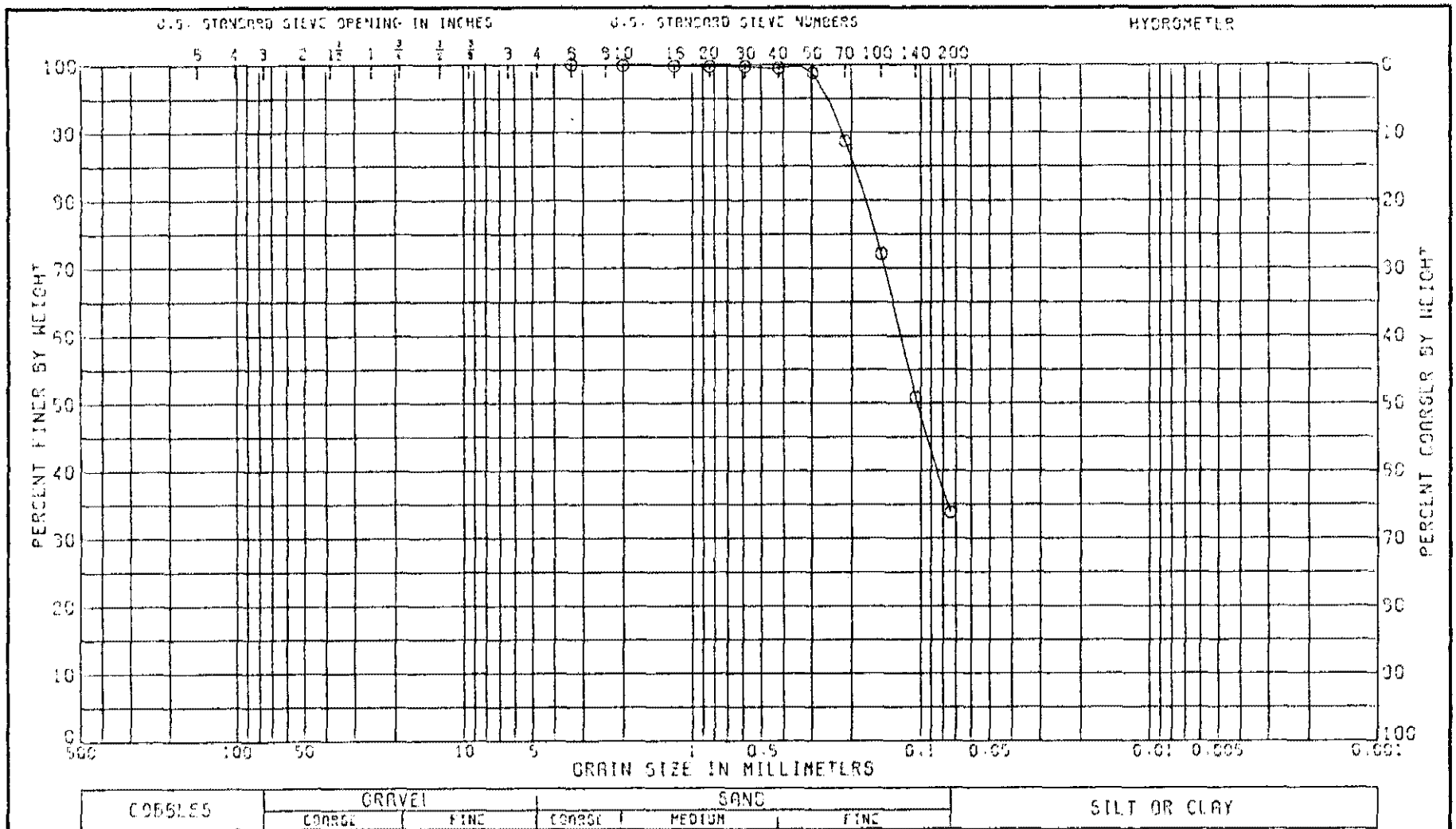
GRADATION CURVE

PROJECT CRANE NWSC

DEMOLITION AREA

BORING NO. 6-19-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.53 DATE 31 MAR 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 24 | 14 | 10 | | 13.9 |

CLASSIFICATION

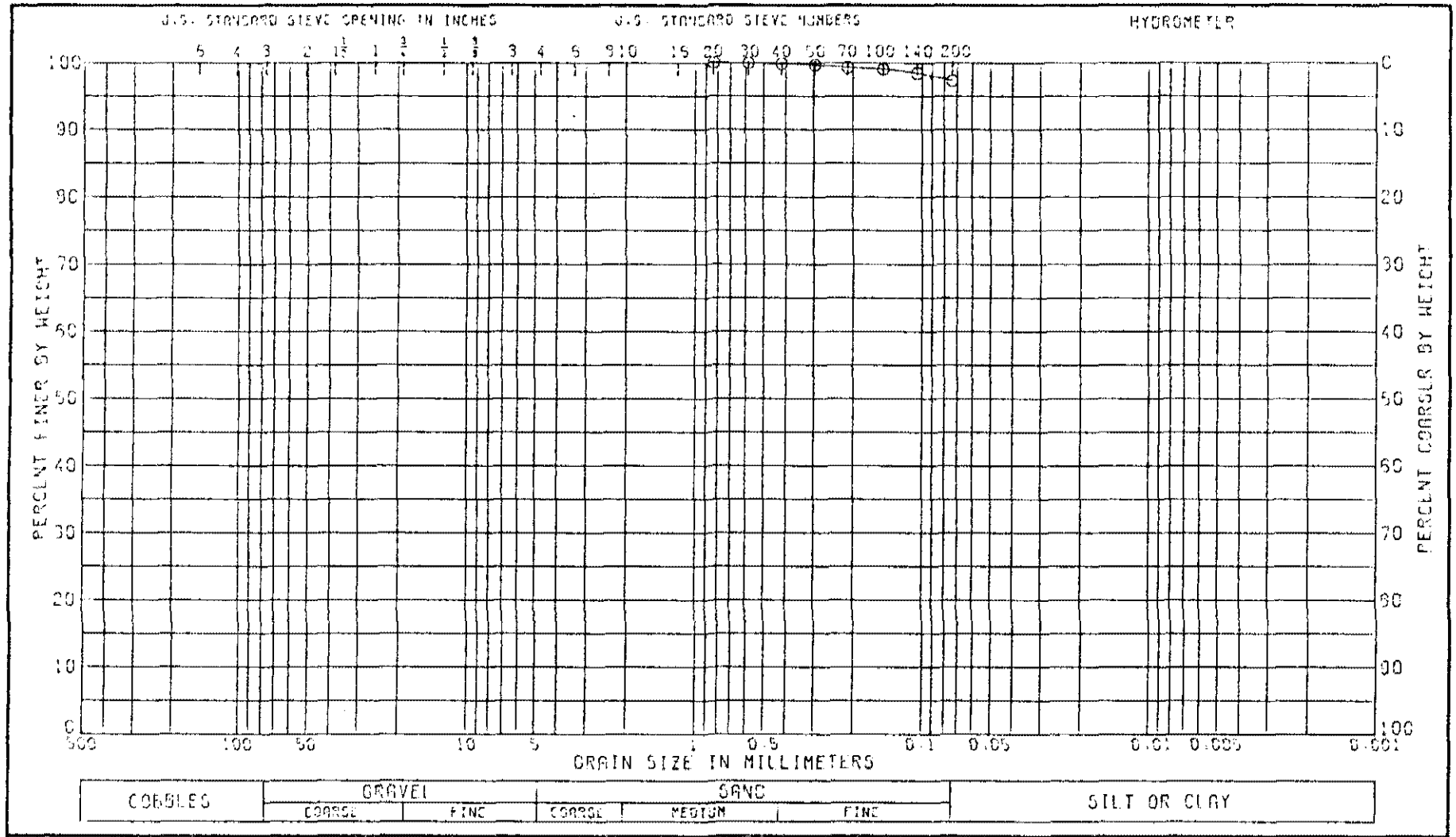
CLAYEY SAND (SC), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-18-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-5.55 DATE 11 FEB 92




| LL 42 | PL 19 | PI 24 | CS | NAT W.% 23.2 |
|---|---|---|---|---|

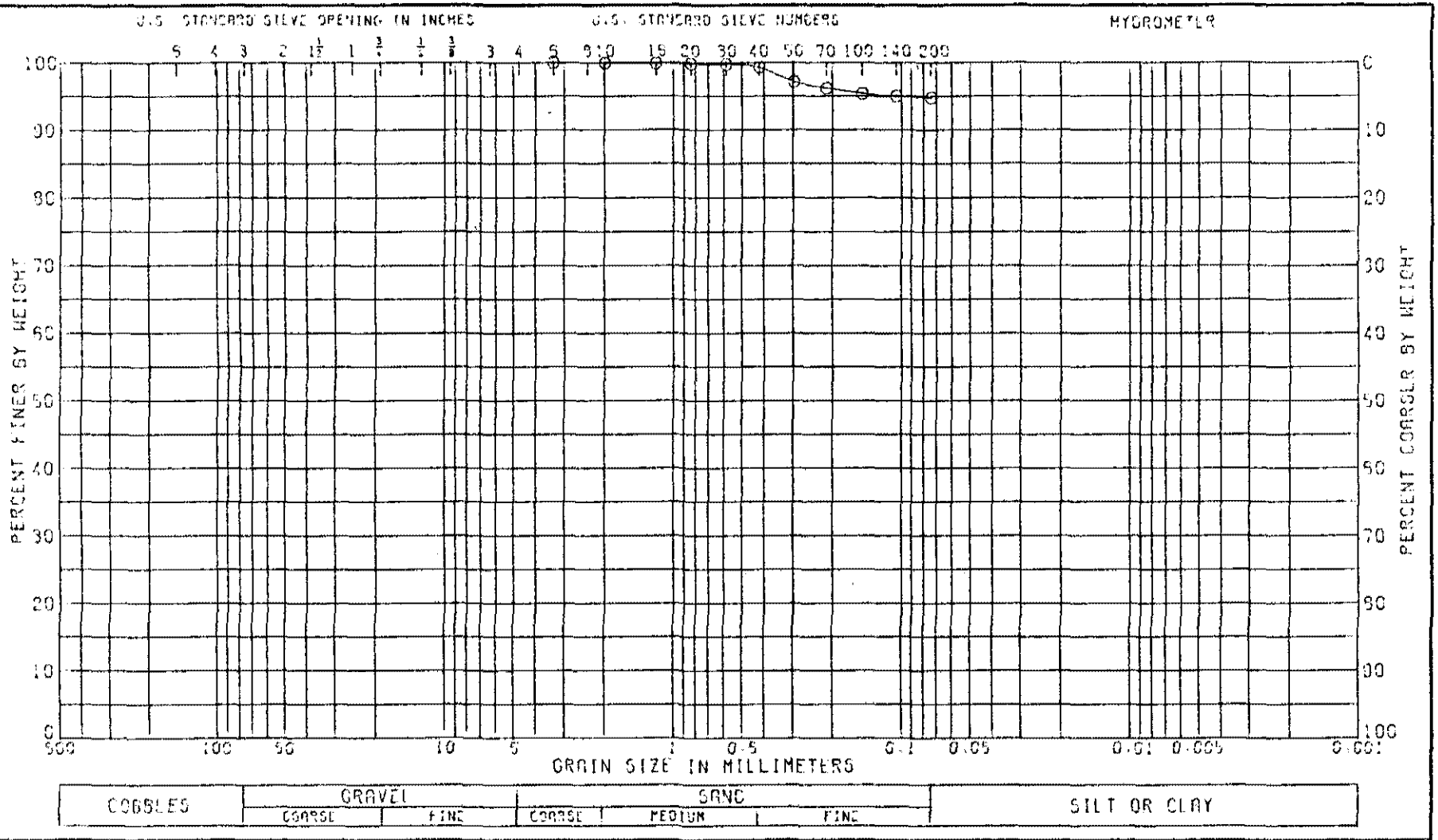
CLASSIFICATION
CLAY (CL), LIGHT BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-10-91 SAMPLE NO. 1

DEPTH/ELEV 5.0-6.85 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 44 | 17 | 27 | | 25.2 |

CLASSIFICATION

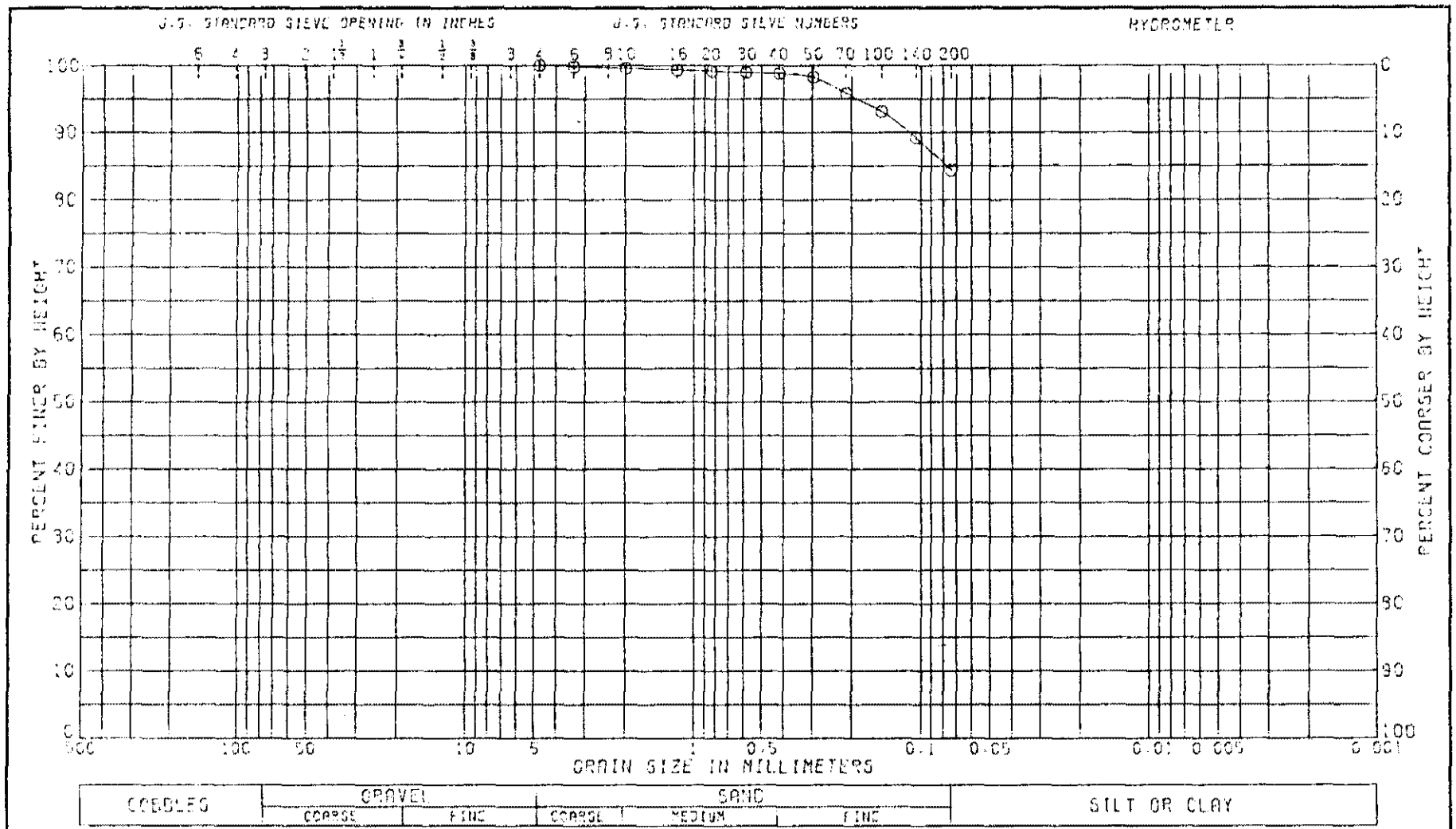
CLAY (CL), BROWNISH GRAY: WITH SAND

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. 6-19-91 SAMPLE NO. 2

DEPTH/ELEV 10.0-11.66 DATE 11 FEB 92




| LL 27 | PL 15 | PI 12 | GS | NAT W.% 19.1 | |
|---|---|---|---|---|---|

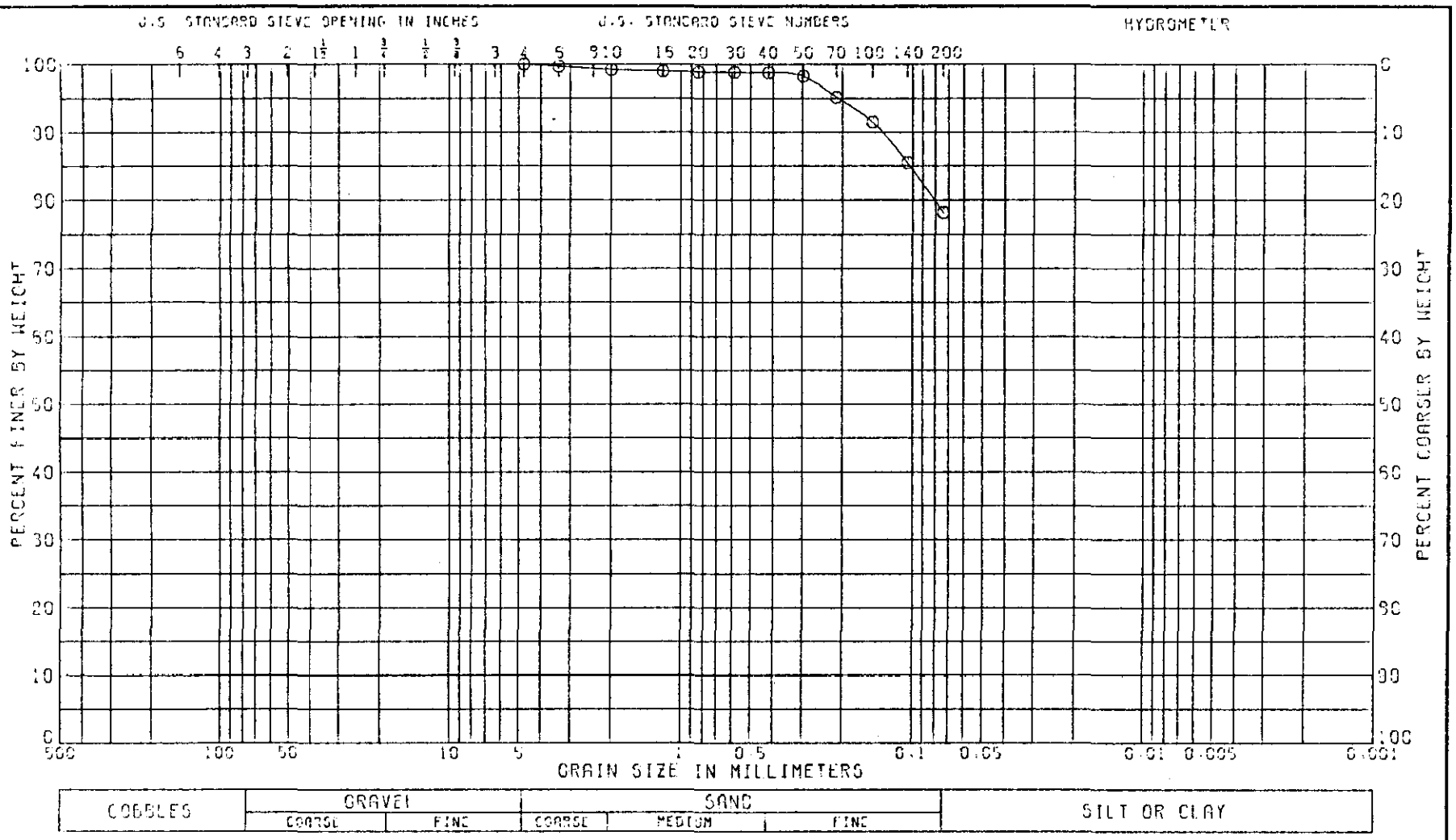
CLASSIFICATION
SANDY CLAY (CL), REDDISH BROWN

PROJECT CRANE NASC DEMOLITION AREA

BORING NO. 6-20-81 SAMPLE NO 1

DEPTH/ELEV 0.0-1.78 DATE 05 FEB 82

GRADATION CURVE




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 35 | 14 | 21 | | 18.9 |

CLASSIFICATION

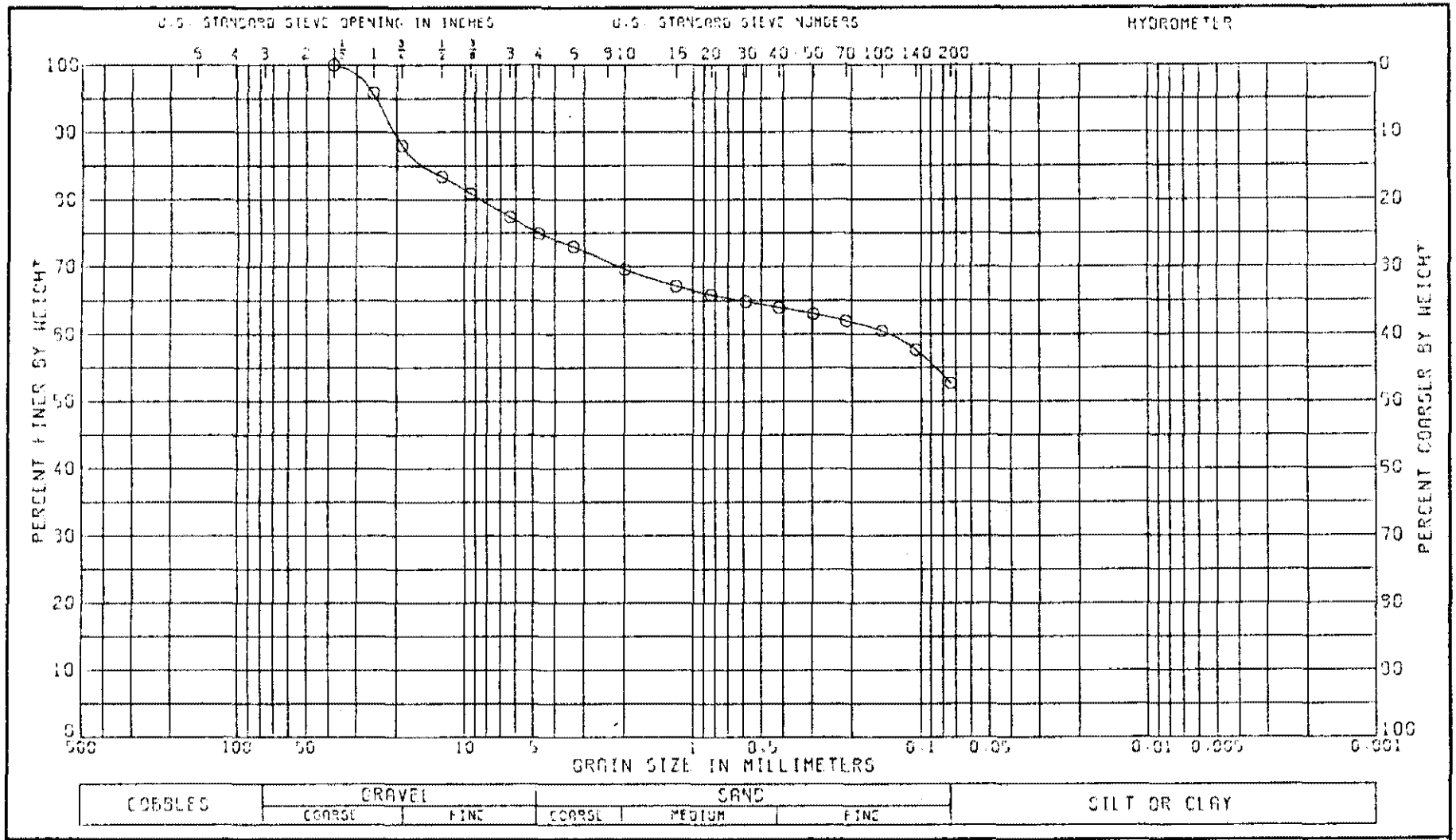
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO. S-20-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.75 DATE 11 FEB 82




| LL | PL | PI | CC | NAT W.% | |
|---|---|---|---|---|---|
| 40 | 16 | 24 | | 11.8 | |

CLASSIFICATION

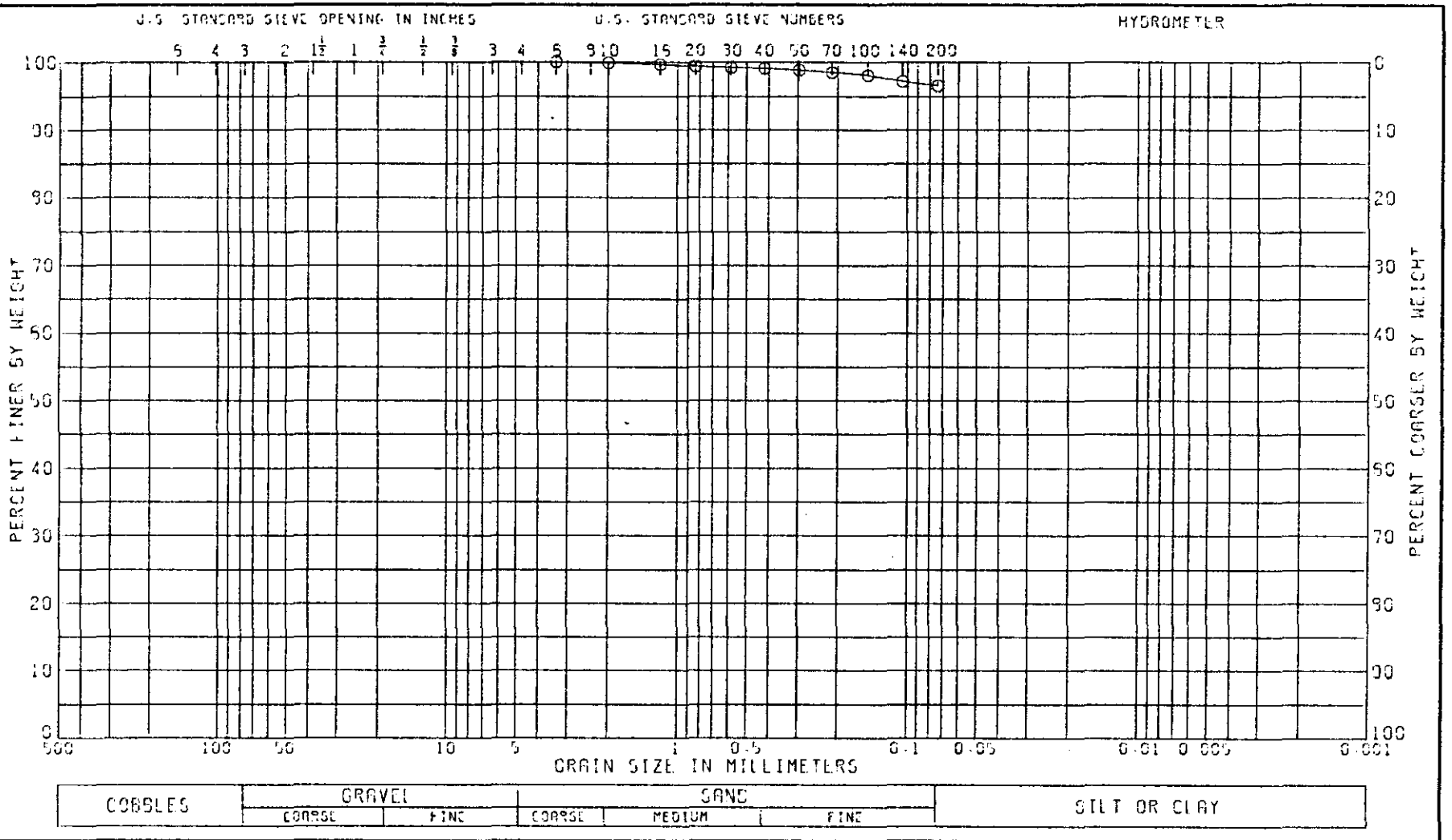
SANDY CLAYEY GRAVEL (GC), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
HWY-59 BURIAL GROUND

BORING NO. 7-1-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.05 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 42 | 19 | 23 | | 15.7 |

CLASSIFICATION

CLAY (CL), TAN: TRACE OF SAND

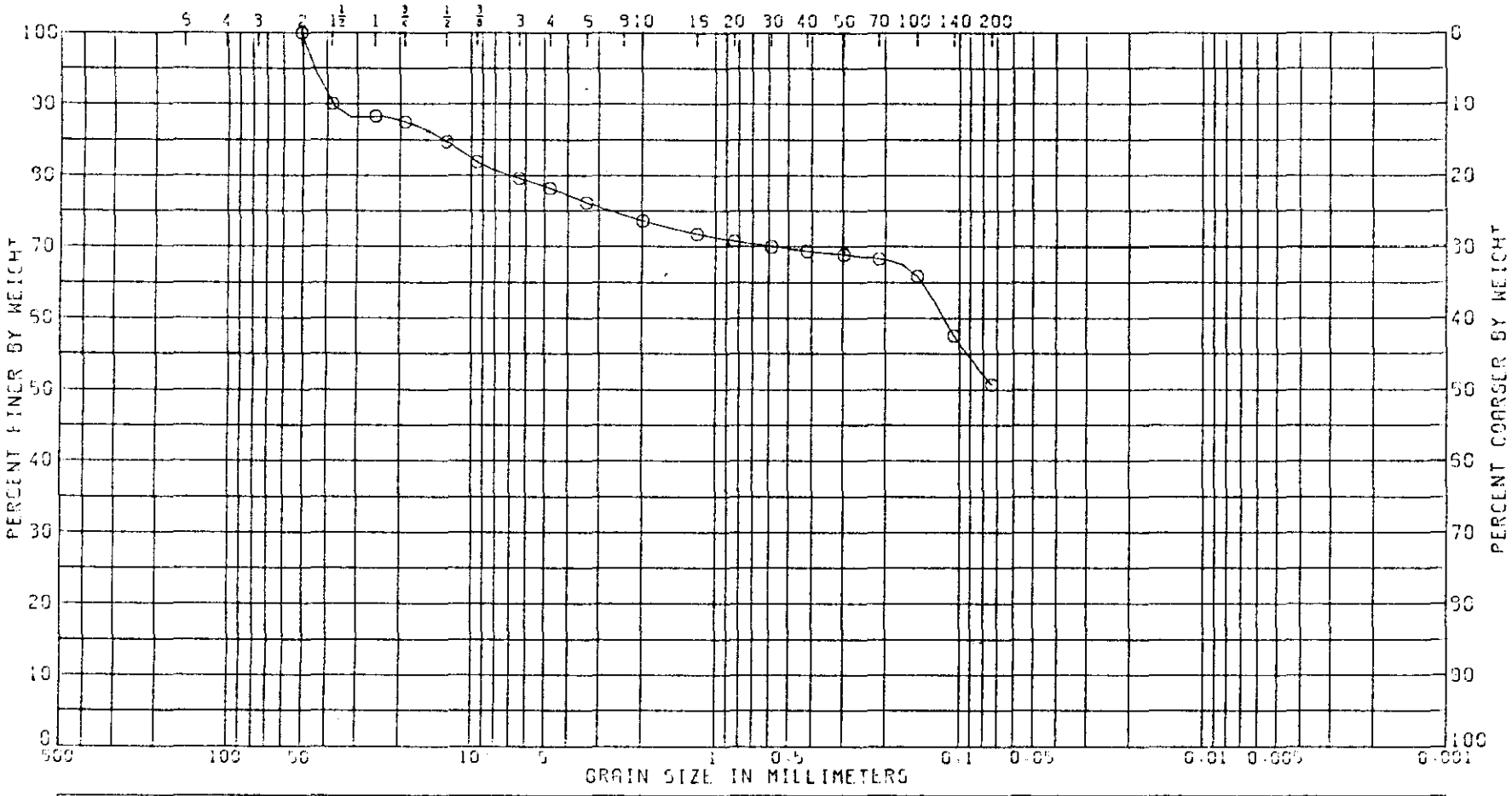
GRADATION CURVE

PROJECT CRANE NWSC

HWY-59 BURIAL GROUND

BORING NO. 7-1-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.70 DATE 31 MAR 92




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM | FINE | |

| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 16 | 19 | | 12.2 |

CLASSIFICATION

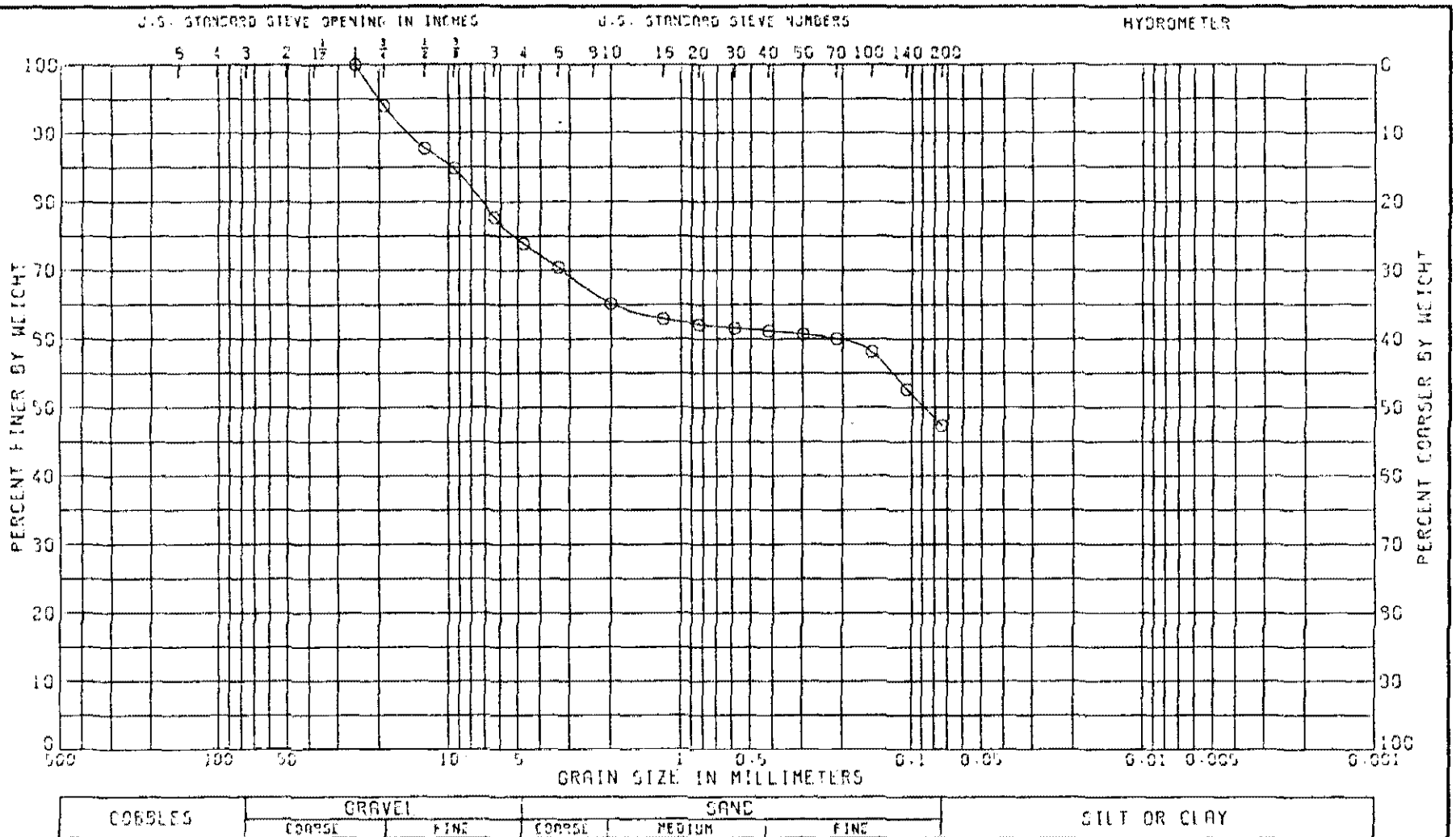
GRAVELLY SANDY CLAY (CL), GRAY
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC
HWY-59 BURIAL GROUND

BORING NO. 7-1-91 SAMPLE NO 3

DEPTH/ELEV 10.0-11.44 DATE 31 MAR 92




| LL 30 | PL 15 | PI 14 | CS | NAT W.C. 8.2 | |
|---|---|---|---|---|---|

CLASSIFICATION

GRAVELLY CLAYEY SAND (SC), BROWN

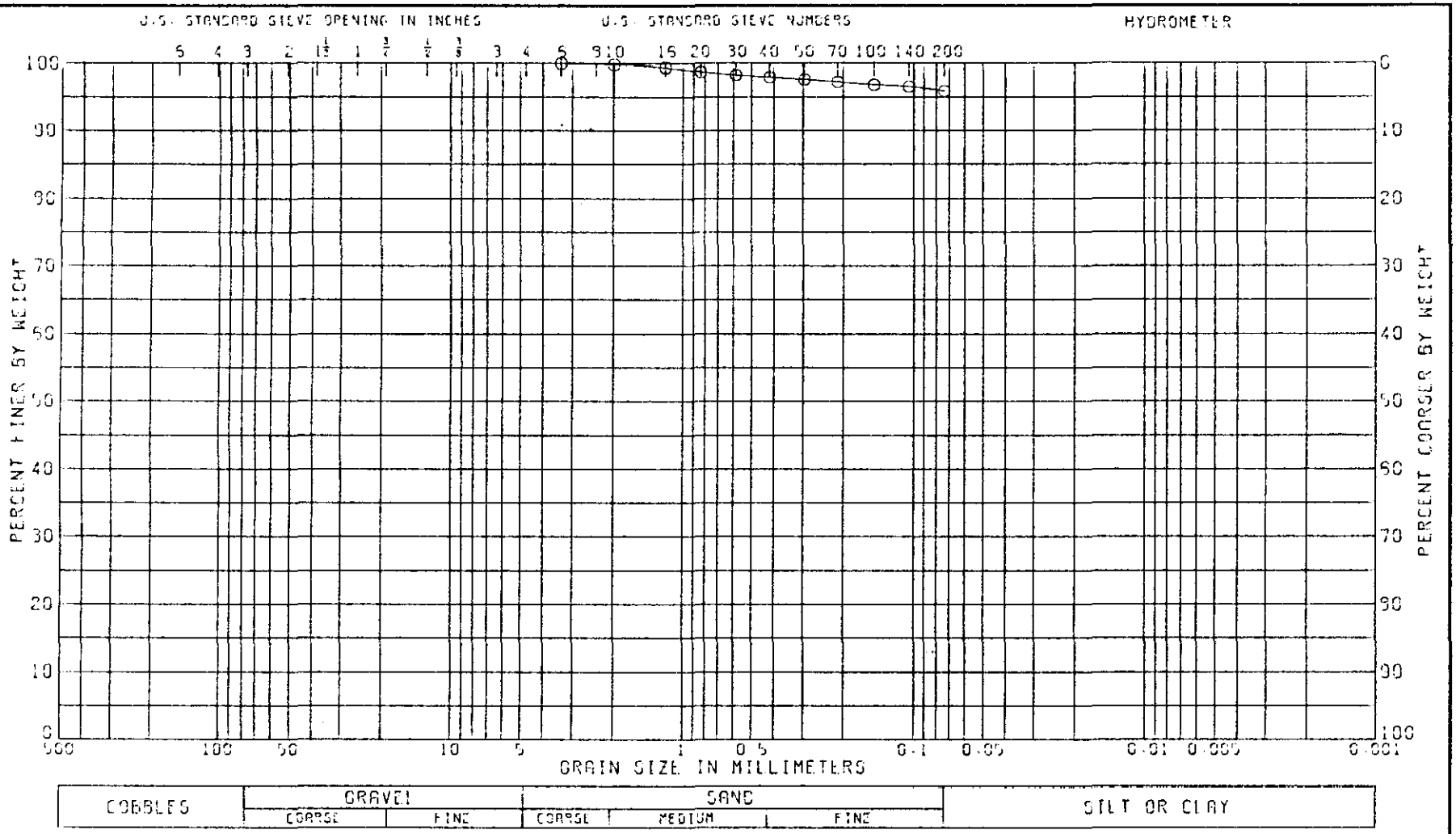
GRADATION CURVE

PROJECT CRANE NWSC

HWY-58 BURIAL GROUND

BORING NO. 7-2-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.55 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 47 | 22 | 25 | | 16.1 |

CLASSIFICATION

CLAY (CL), BROWN: TRACE OF SAND

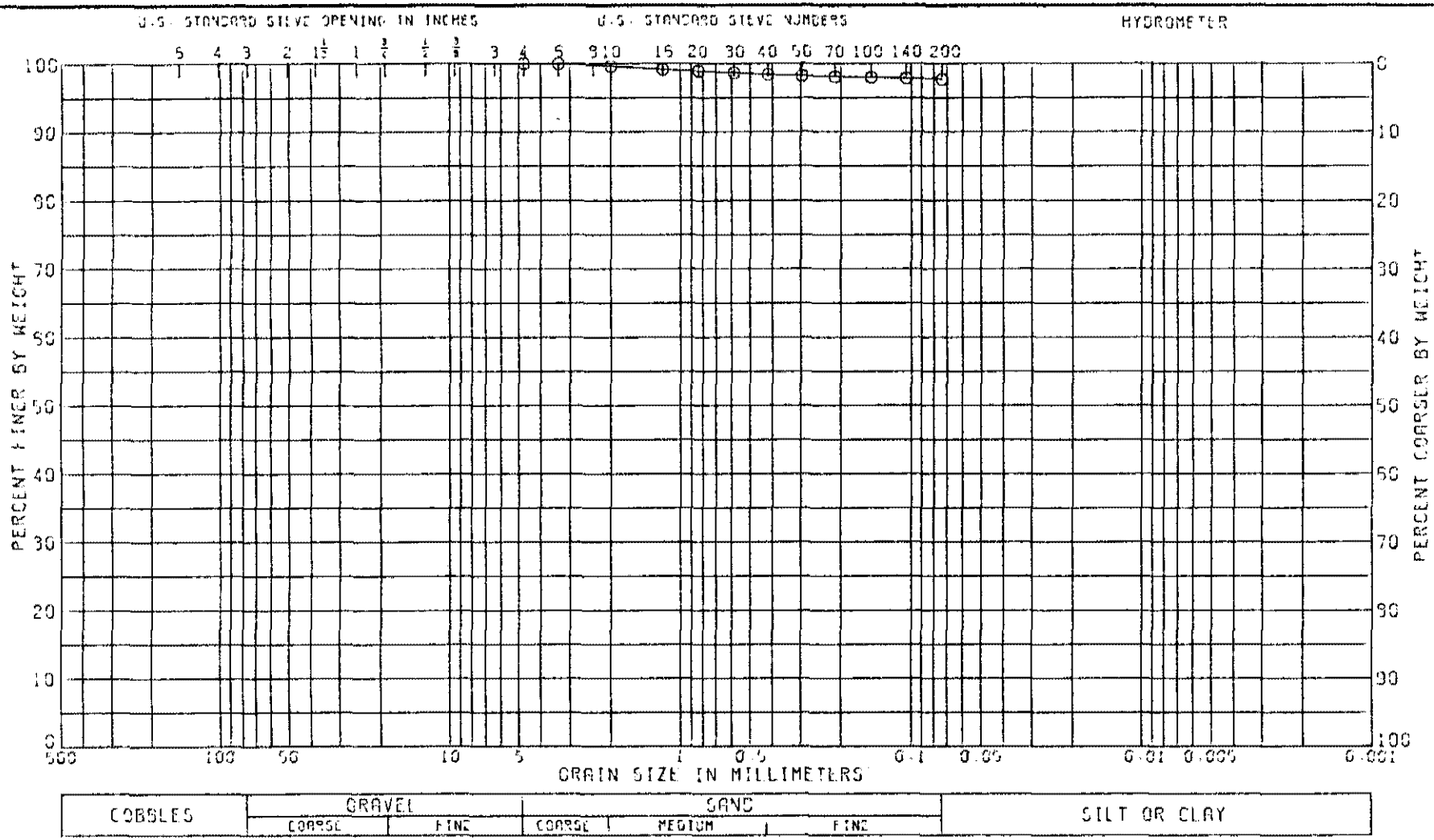
GRADATION CURVE

PROJECT CRANE NWSC

HWY-59 BURIAL GROUND

BORING NO. 7-2-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.05 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 38 | 15 | 23 | | 13.9 |

CLASSIFICATION

CLAY (CL), GRAY

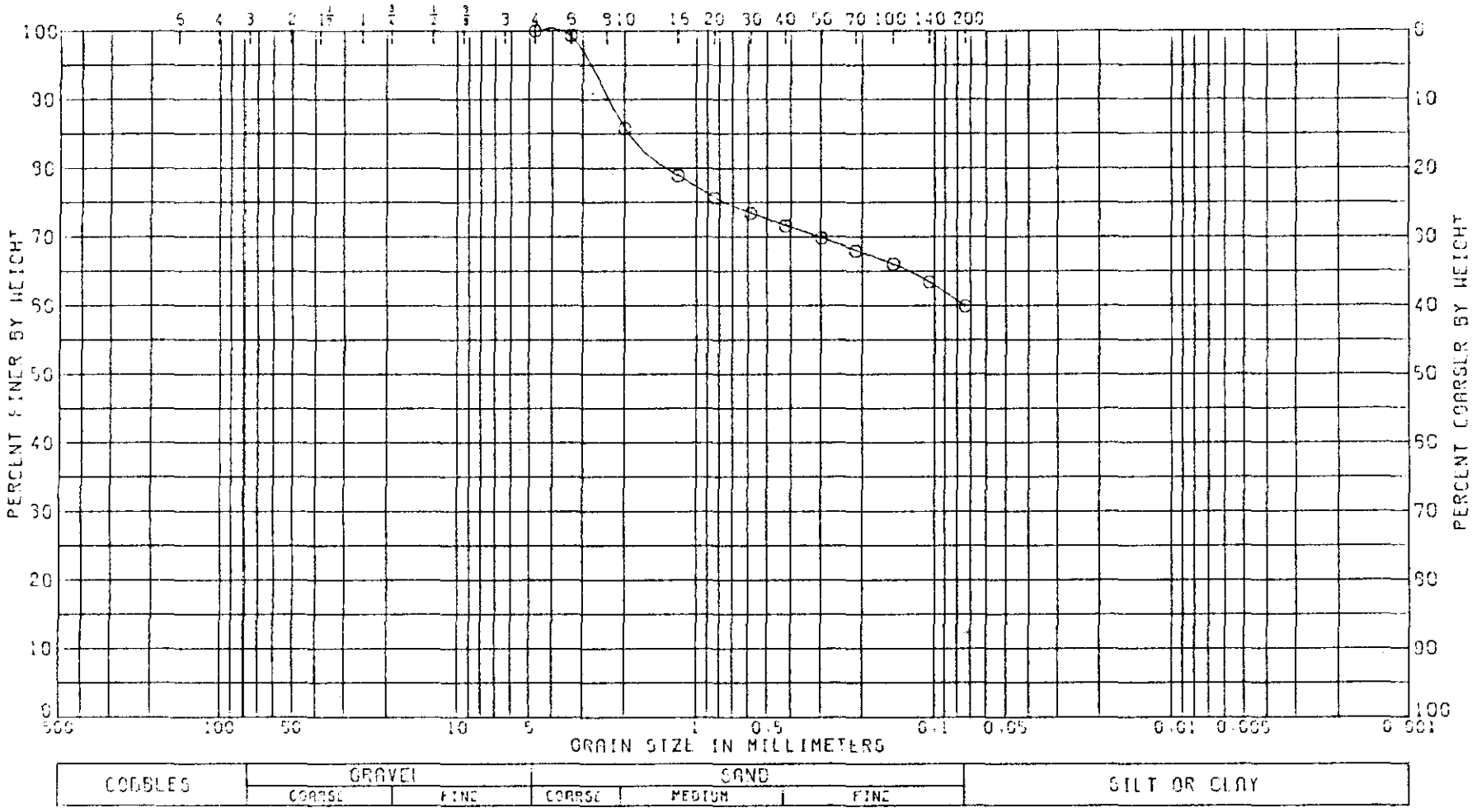
GRADATION CURVE

PROJECT CRANE NWSC

HWY-59 BURIAL GROUND

BORING NO. 7-2-91 SAMPLE NO. 39

DEPTH/ELEV 10.5-11.5 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 20 | 15 | | 12.1 |

CLASSIFICATION

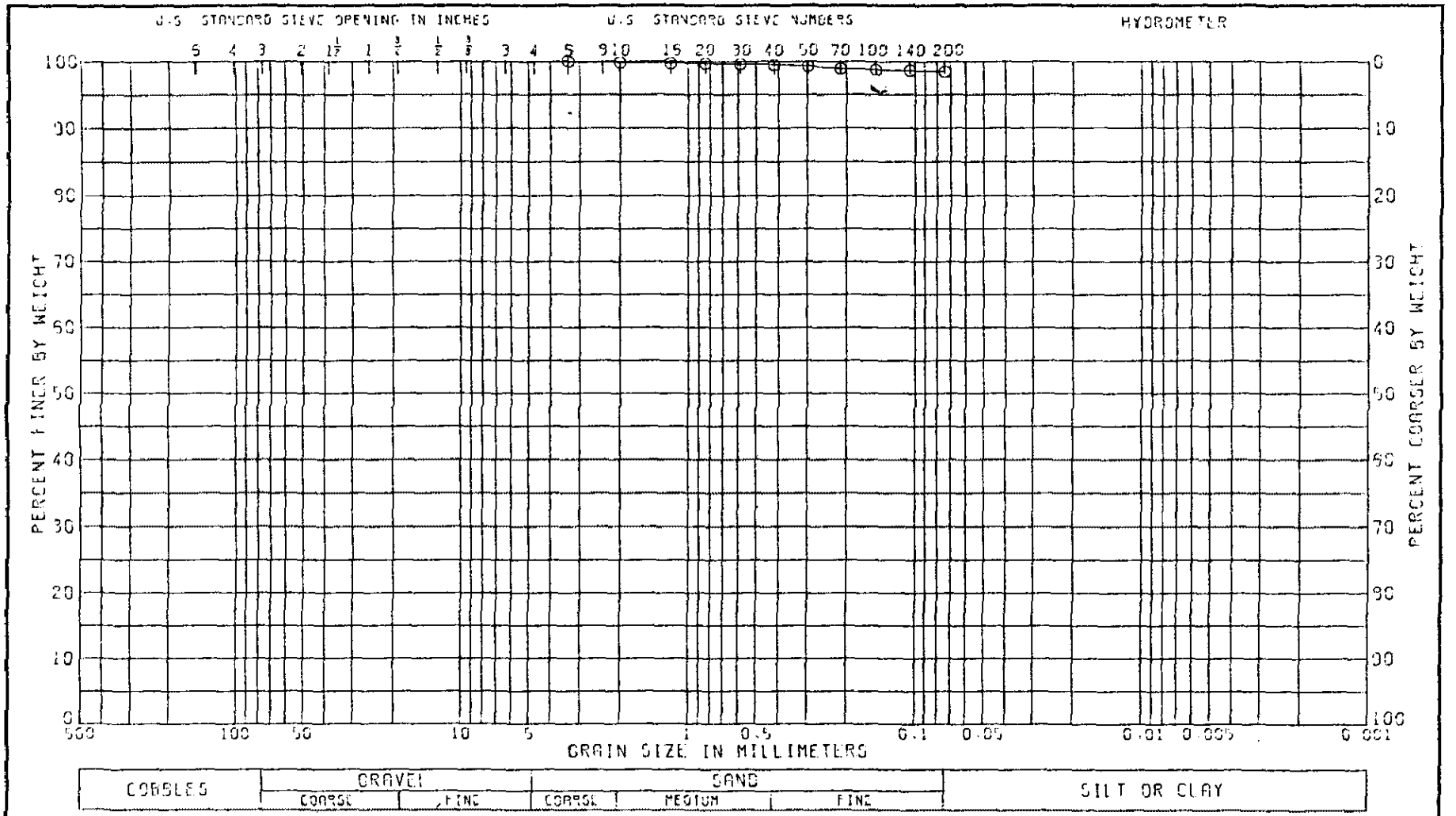
SANDY CLAY (CL), BROWN

GRADATION CURVE

PROJECT CRANE NWSC HWY 59 BURIAL GROUND

BORING NO. 7-3-91 SAMPLE NO 1

DEPTH/ELEV 0.0-1.77 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 30 | 14 | 16 | | 9.1 |

CLASSIFICATION

CLAY (CL), BROWN

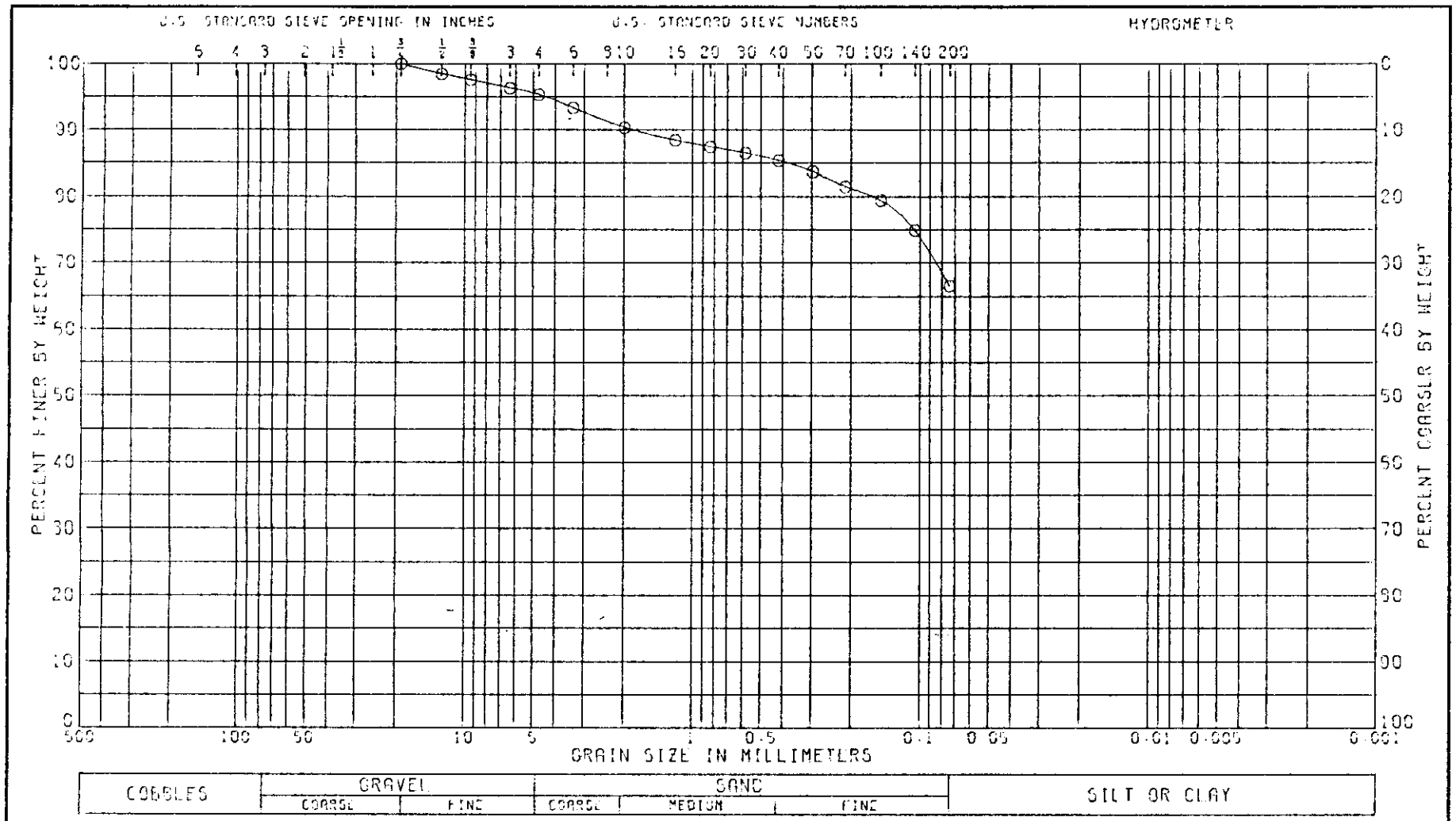
GRADATION CURVE

PROJECT CRANE NWSC

HWY-59 BURIAL GROUND

BORING NO. 7-3-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.14 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 41 | 16 | 25 | | 18.2 |

CLASSIFICATION

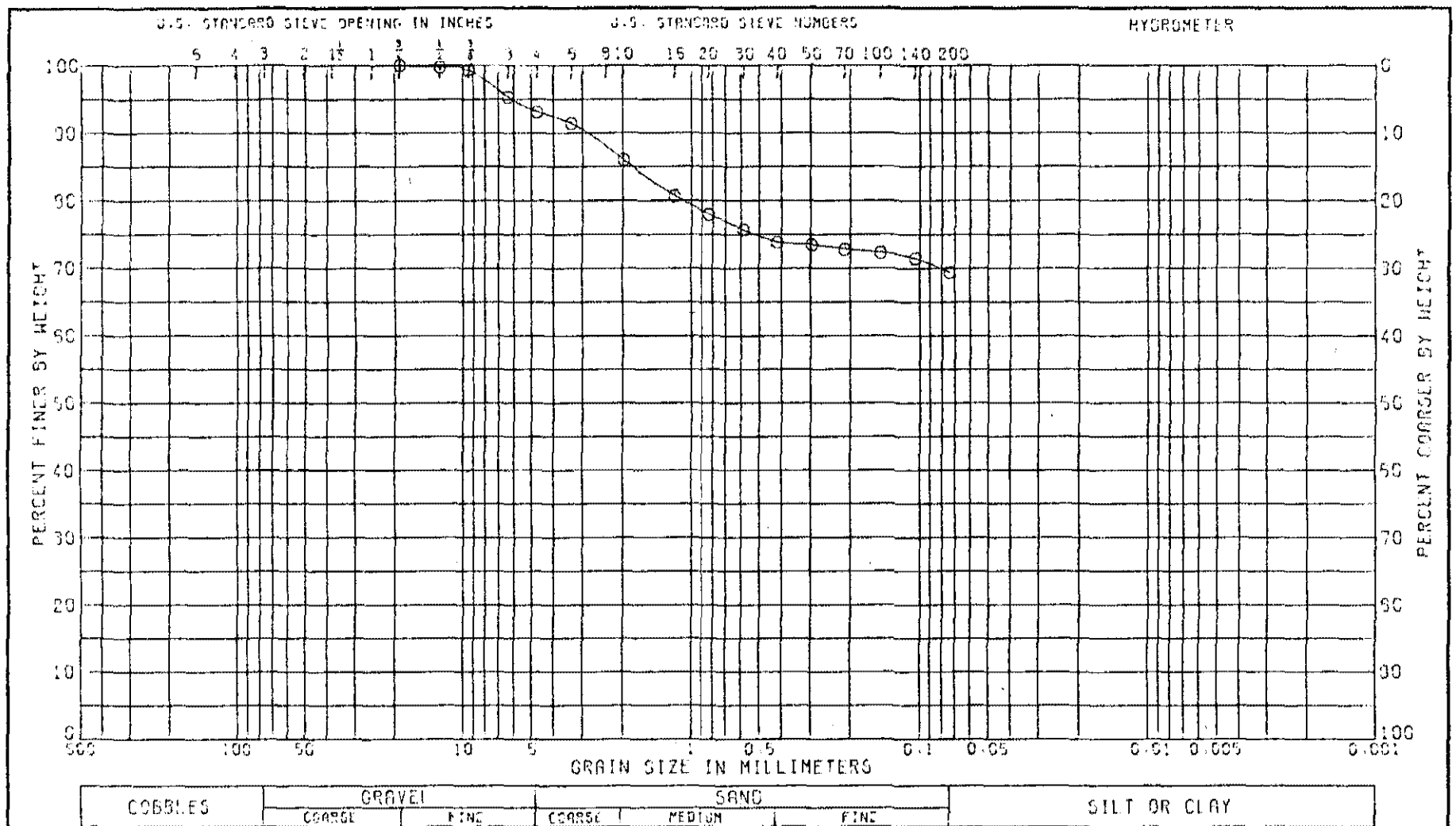
SANDY CLAY (CL), REDDISH BROWN: TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC HWY 56 BURIAL GROUND

BORING NO. 7-5-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-0.05 DATE 11 FEB 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 36 | 17 | 19 | | 14.9 |

CLASSIFICATION

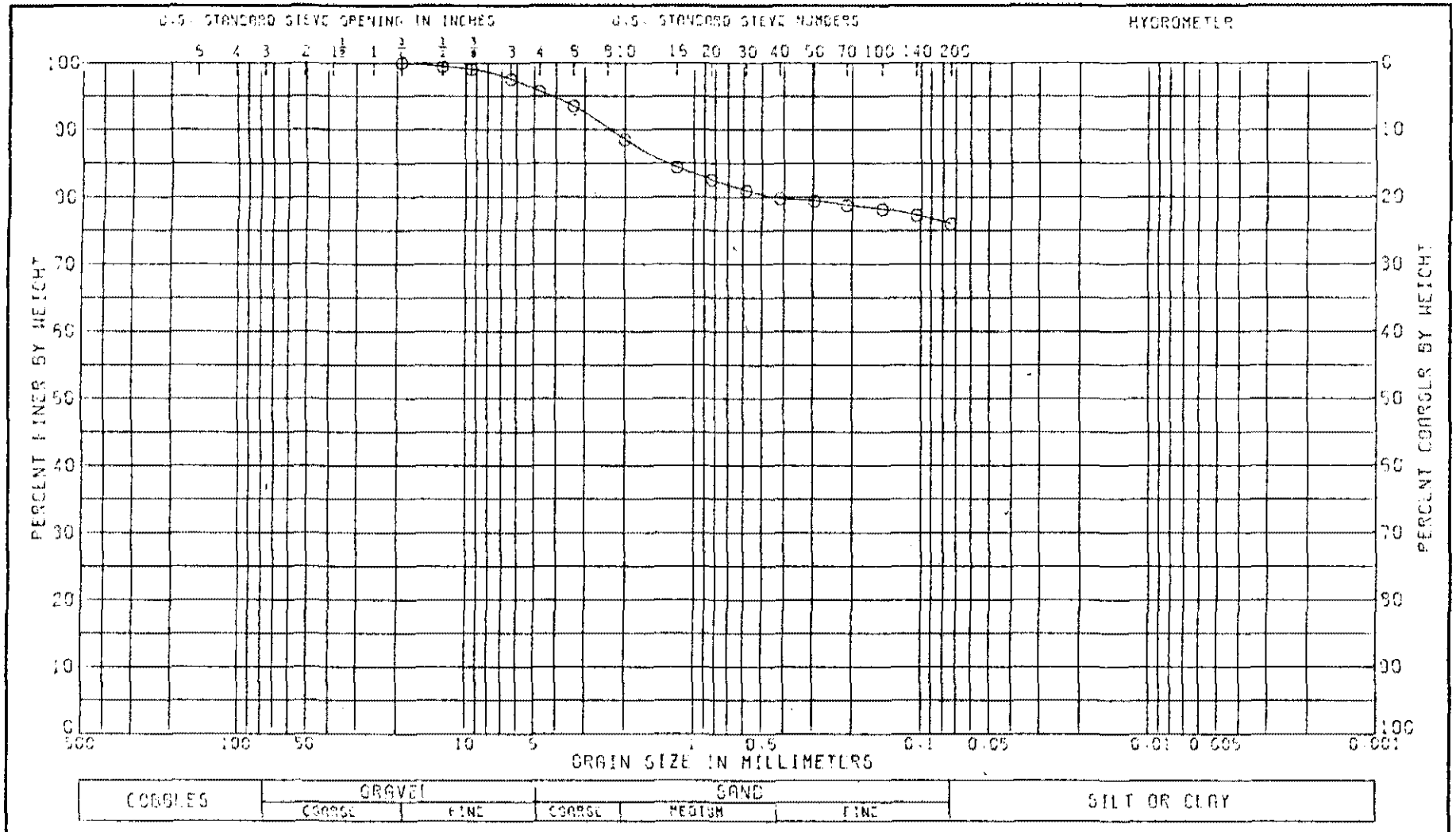
SANDY CLAY (CL), BROWN; WITH GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC HWY 50 BURIAL GROUND

BORING NO. 7-5-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.07 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 37 | 18 | 19 | | 17.2 |

CLASSIFICATION

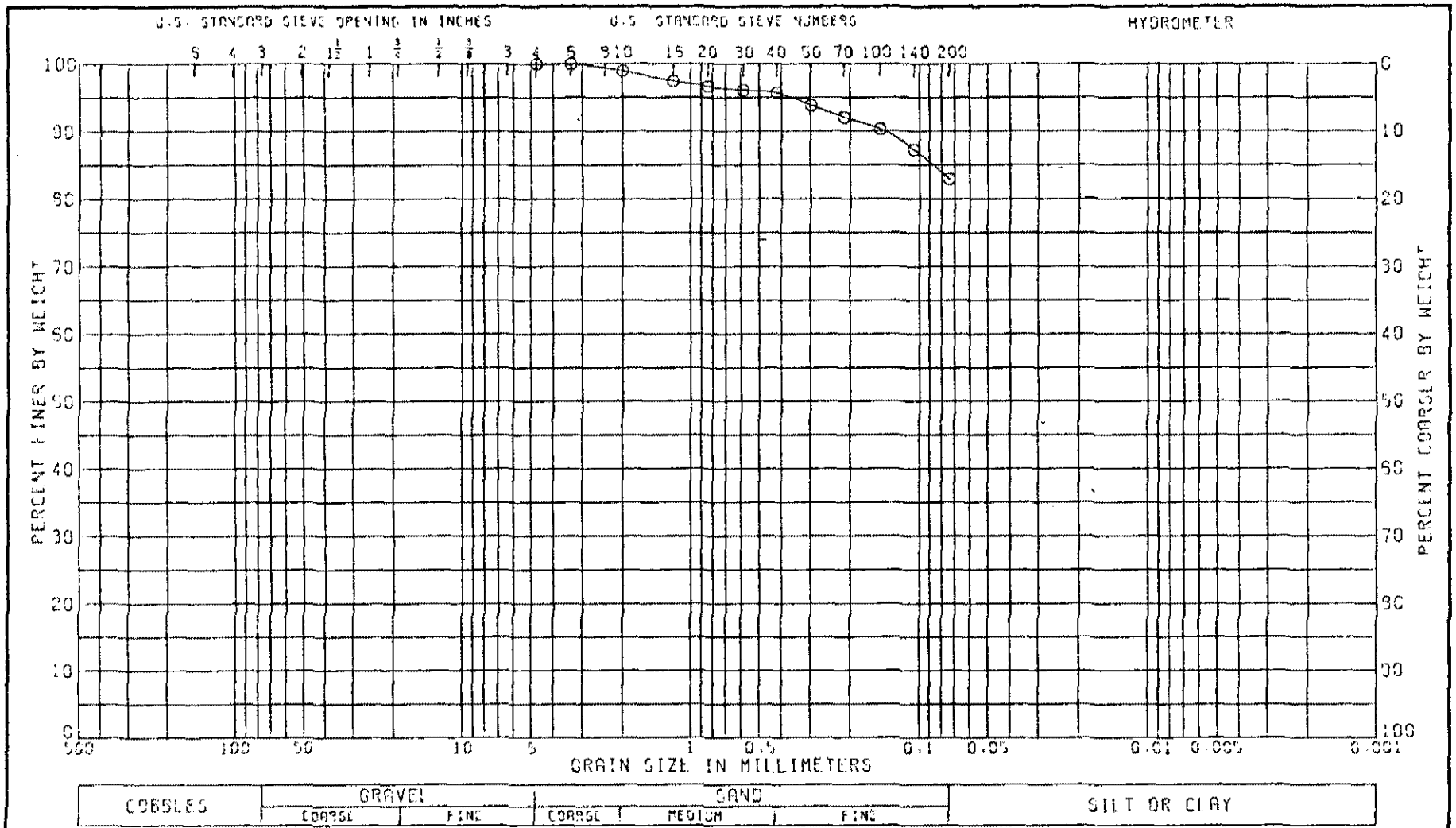
SANDY CLAY (CL), BROWN: TRACE OF GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC HWY 59 BURIAL GROUND

BORING NO. 7-5-81 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.30 DATE 11 FEB 82




| LL | PL | PI | CS | NAT W.C. |
|---|---|---|---|---|
| 35 | 18 | 17 | | 18.1 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

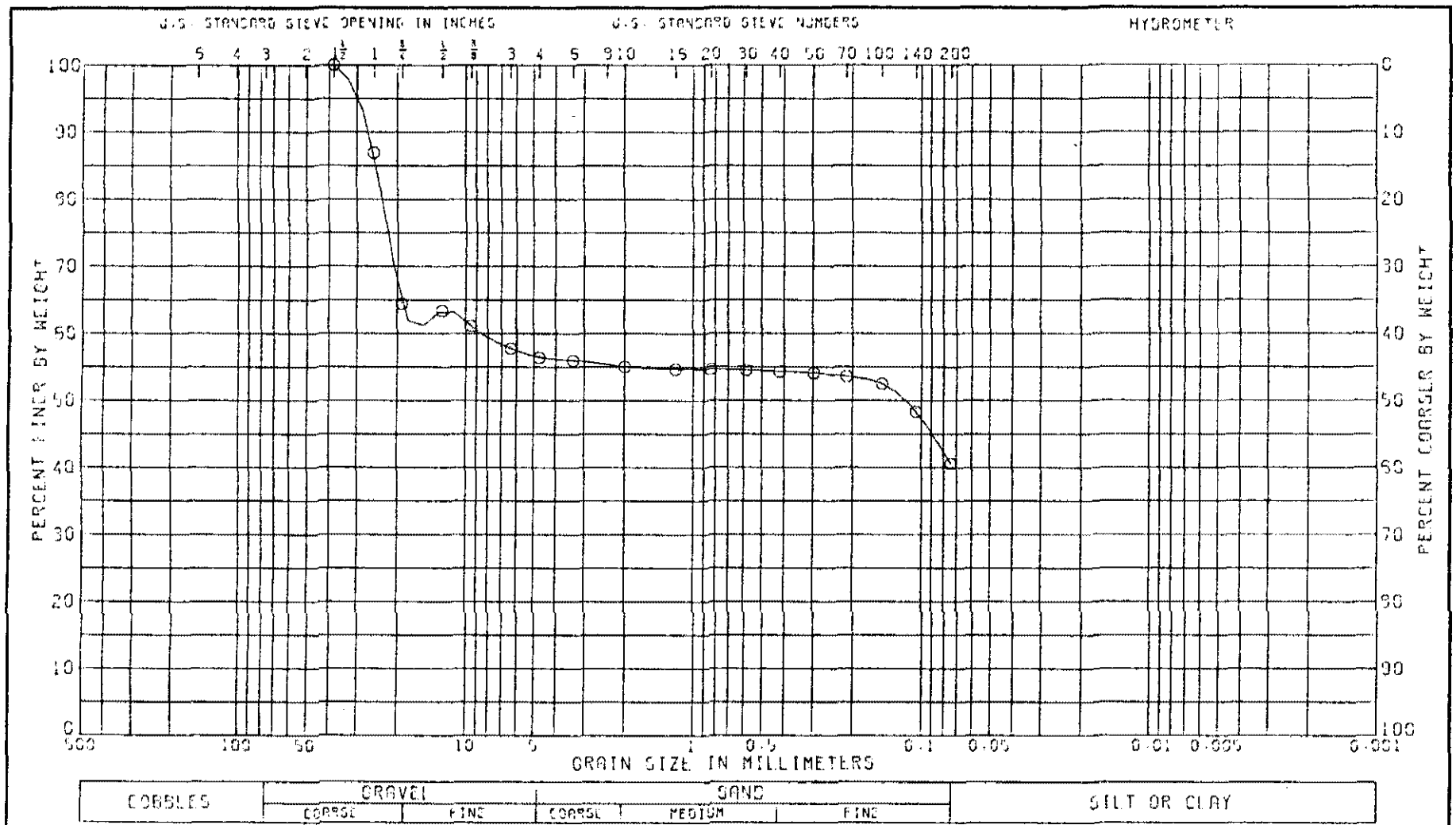
GRADATION CURVE

PROJECT CRANE NWSC

HWY-59 BURIAL GROUND

BORING NO. 7-5-81 SAMPLE NO. 4

DEPTH/ELEV 15.0-15.33 DATE 31 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 16 | 19 | | 5.0 |

CLASSIFICATION

SANDY CLAYEY GRAVEL (GC), TAN

INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

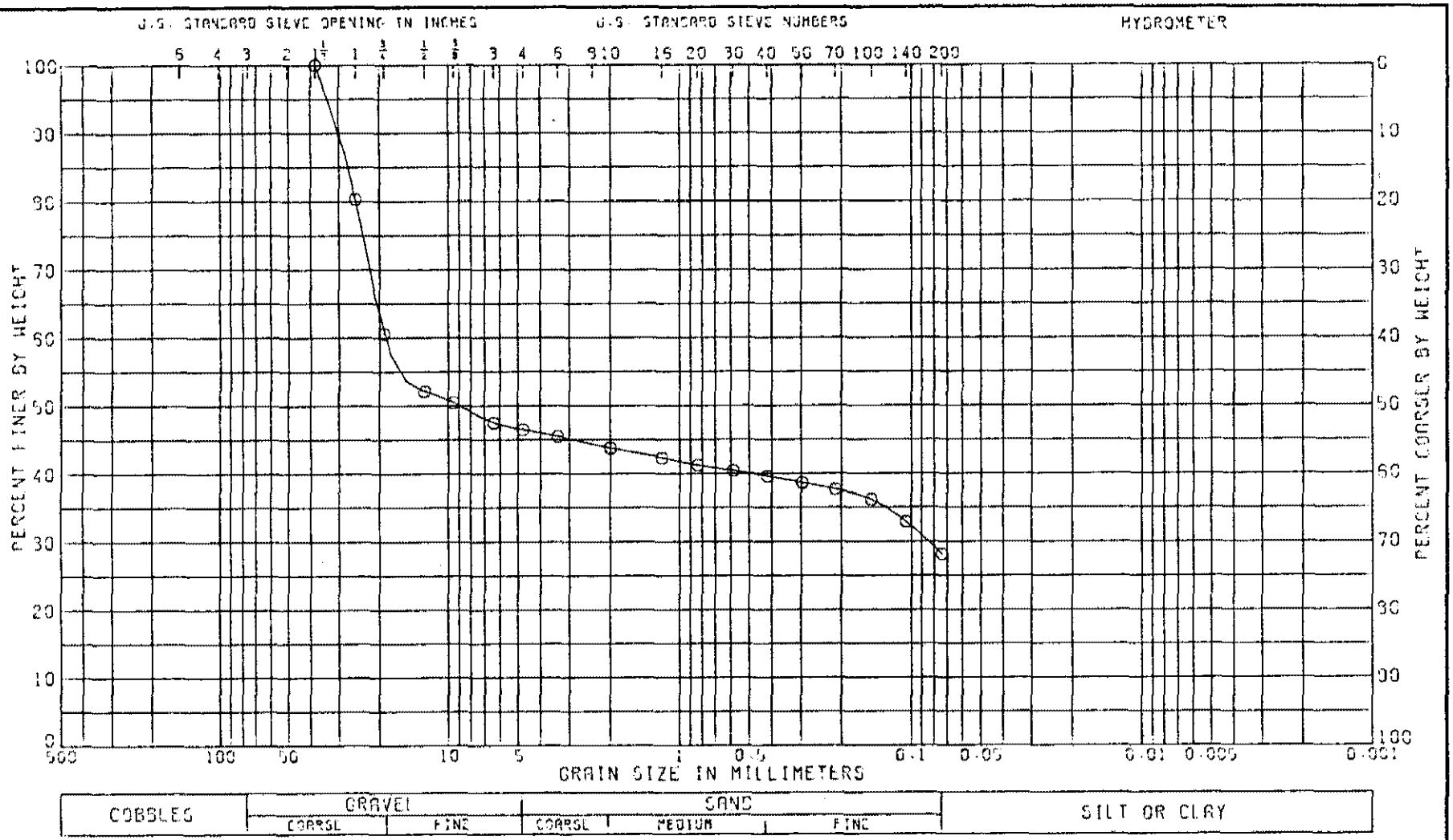
GRADATION CURVE

PROJECT CRANE NWSC

HWY-59 BURIAL GROUND

BORING NO. 9-1-81 SAMPLE NO. 1A

DEPTH/ELEV 0.0-0.7 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.C. |
|---|---|---|---|---|
| 32 | 15 | 17 | | 9.1 |

CLASSIFICATION

SANDY CLAYEY GRAVEL (GC), BROWN

INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

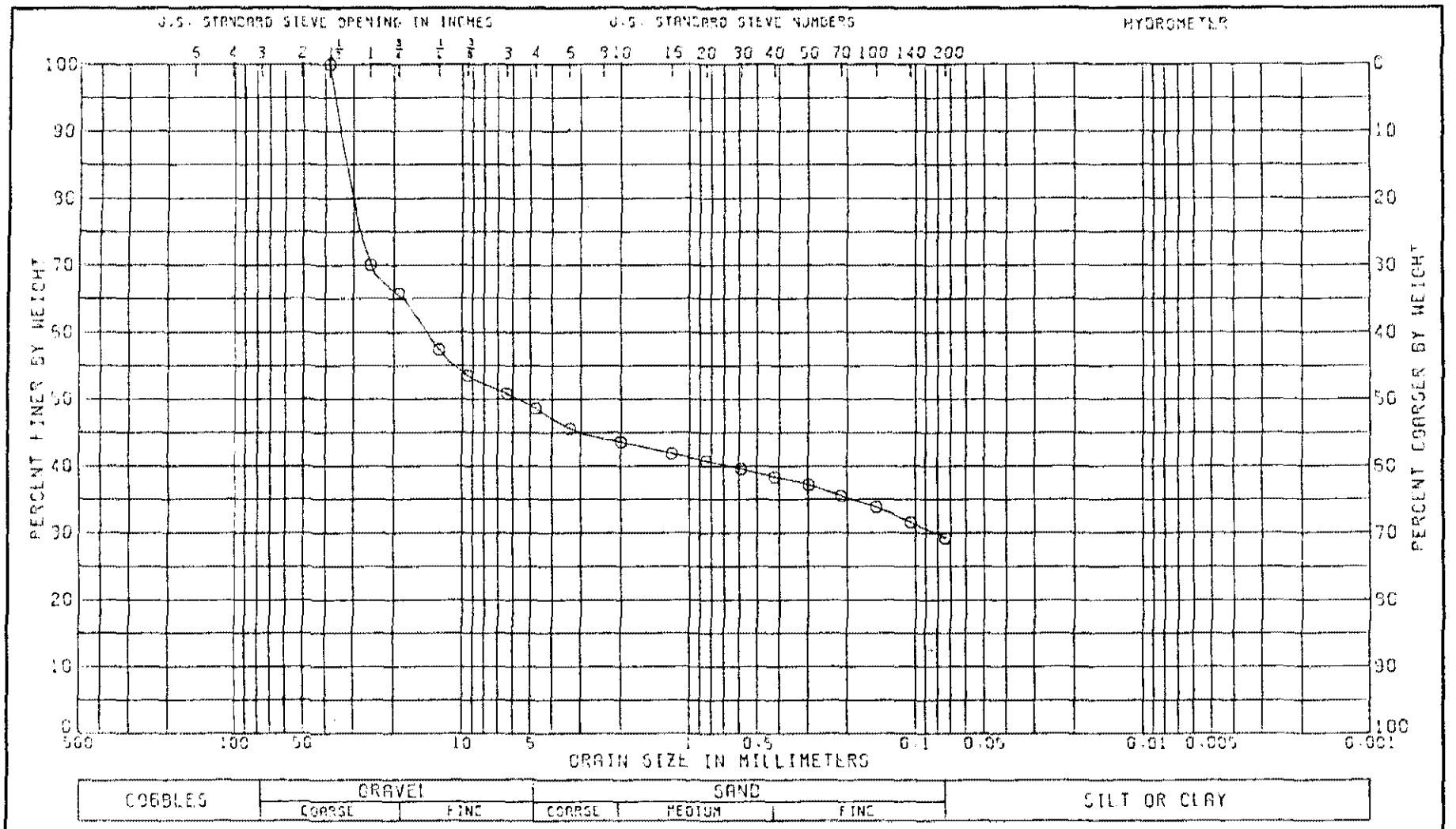
GRADATION CURVE

PROJECT CRANE NWSC HWY-59

OLD QUARRY BURIAL/BURNING GROUND

BORING NO. 8-4-81 SAMPLE NO. 1A

DEPTH/ELEV 0.0-0.8 DATE 12 APR 92




| LL | PL | PI | CS | NAT W.Y | |
|---|---|---|---|---|---|
| 43 | 17 | 26 | | 8.9 | |

CLASSIFICATION

SANDY CLAYEY GRAVEL (GC), BROWN

INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

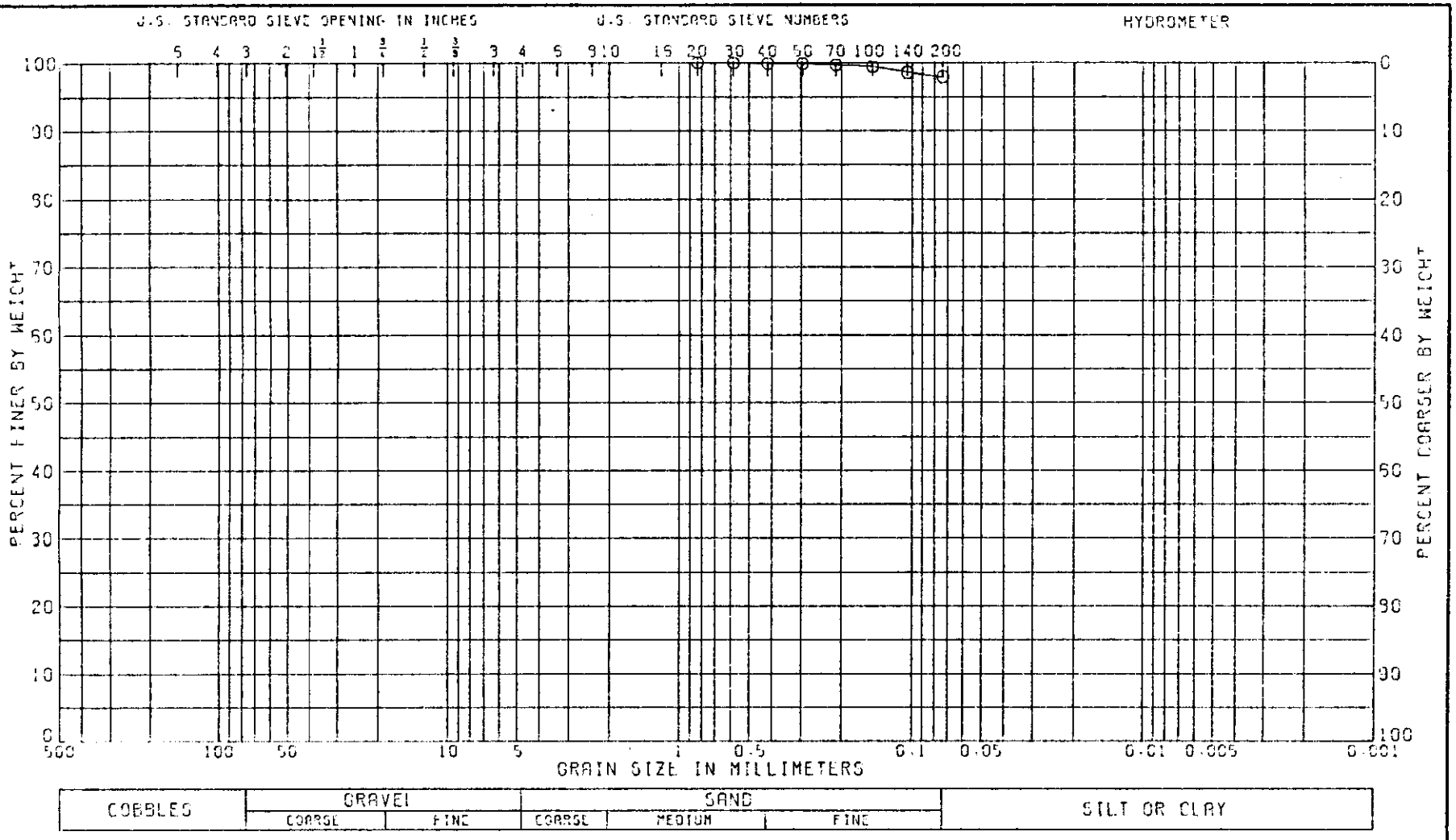
GRADATION CURVE

PROJECT CRANE NWSC HWY - 59

OLD QUARRY/BURNING GROUND

BORING NO. 9-5-91 SAMPLE NO 1

DEPTH/ELEV 0.0-0.94 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 49 | 24 | 25 | | 15.5 |

CLASSIFICATION

CLAY (CL), TAN

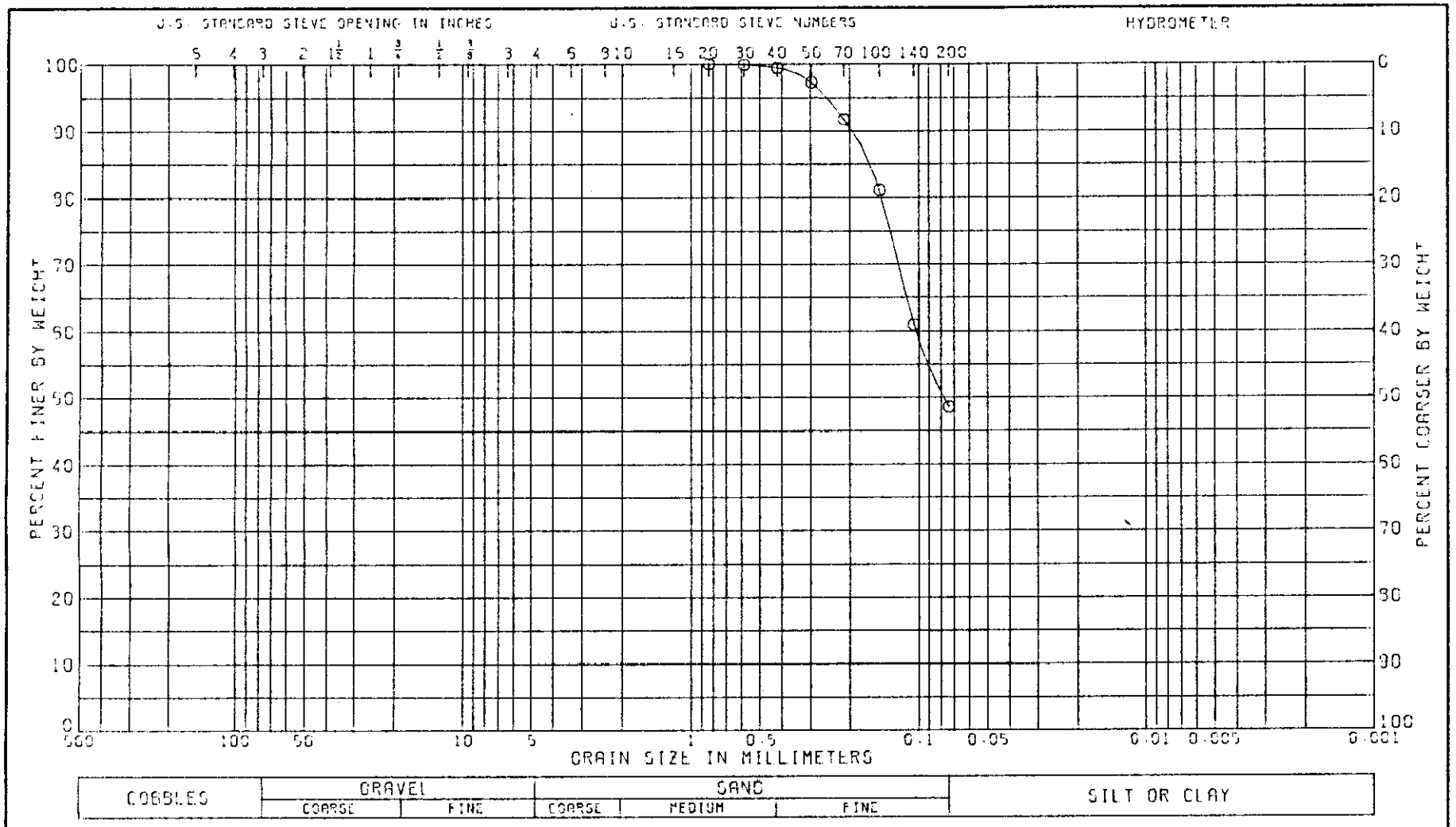
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-1-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-0.5 DATE 31 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 37 | 15 | 22 | | 14.0 |

CLASSIFICATION

CLAYEY SAND (SC), BROWN

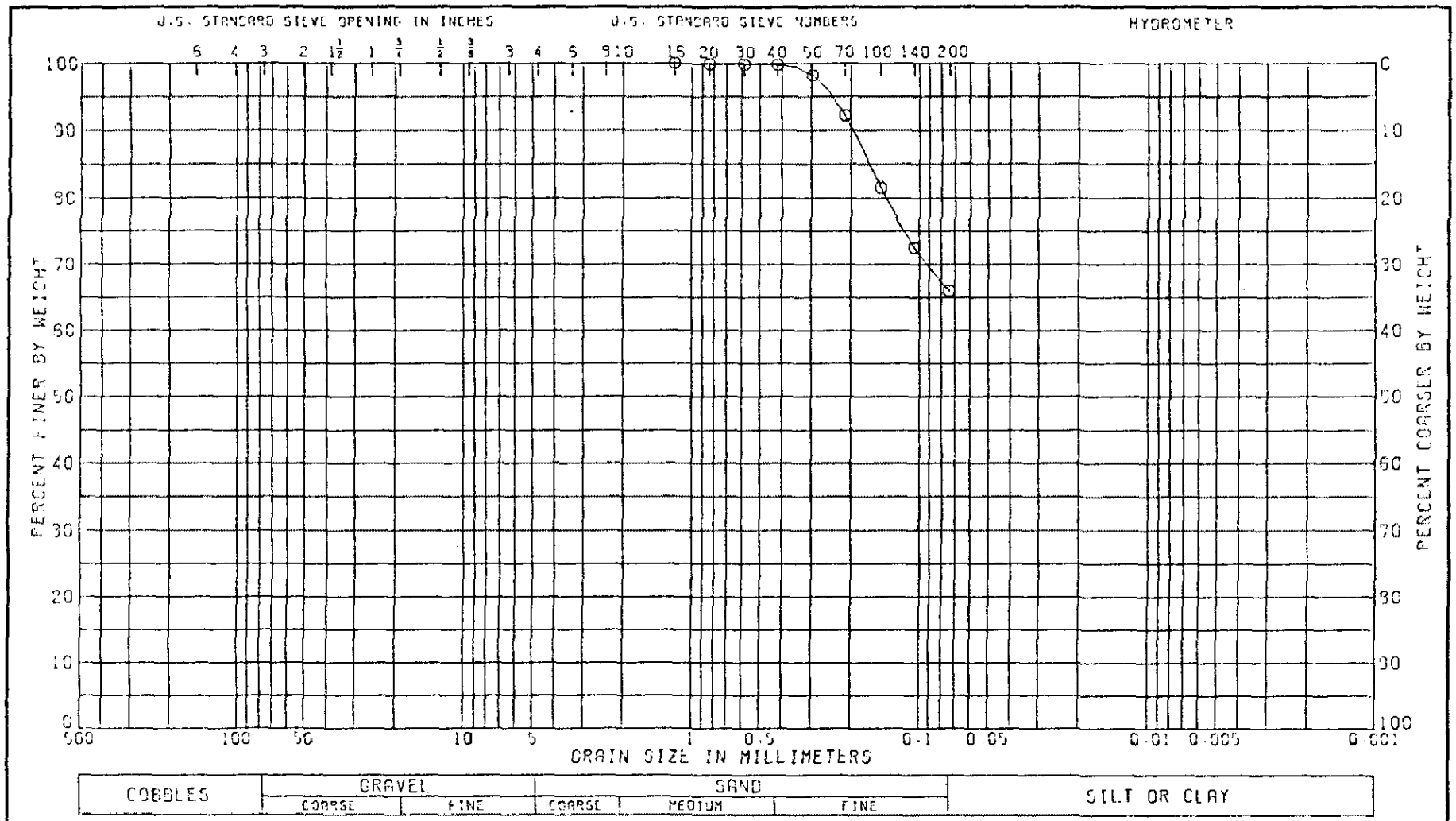
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-1-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.00 DATE 31 MAR 92




| LL 32 | PL 19 | PI 13 | CS | NAT W.C. 13.3 | |
|---|---|---|---|---|---|

CLASSIFICATION

SANDY CLAY (CL), BROWN

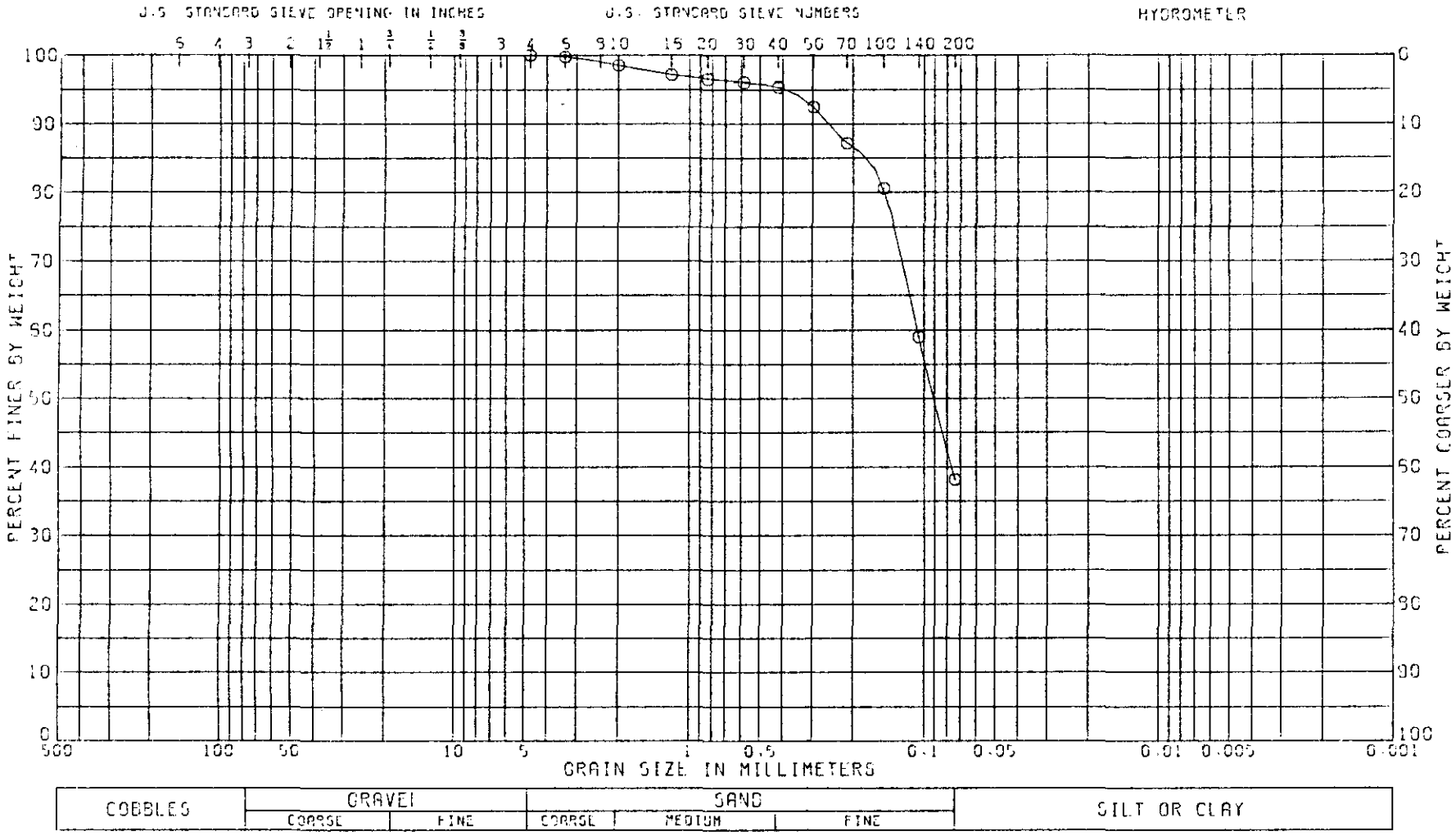
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-1-91 SAMPLE NO. 3

DEPTH/ELEV 10.0-11.33 DATE 31 MAR 92




| LL 28 | PL 19 | PI 9 | CS | NAT W.% 9.3 |
|---|---|---|---|---|

CLASSIFICATION

CLAYEY SAND (SC), TAN

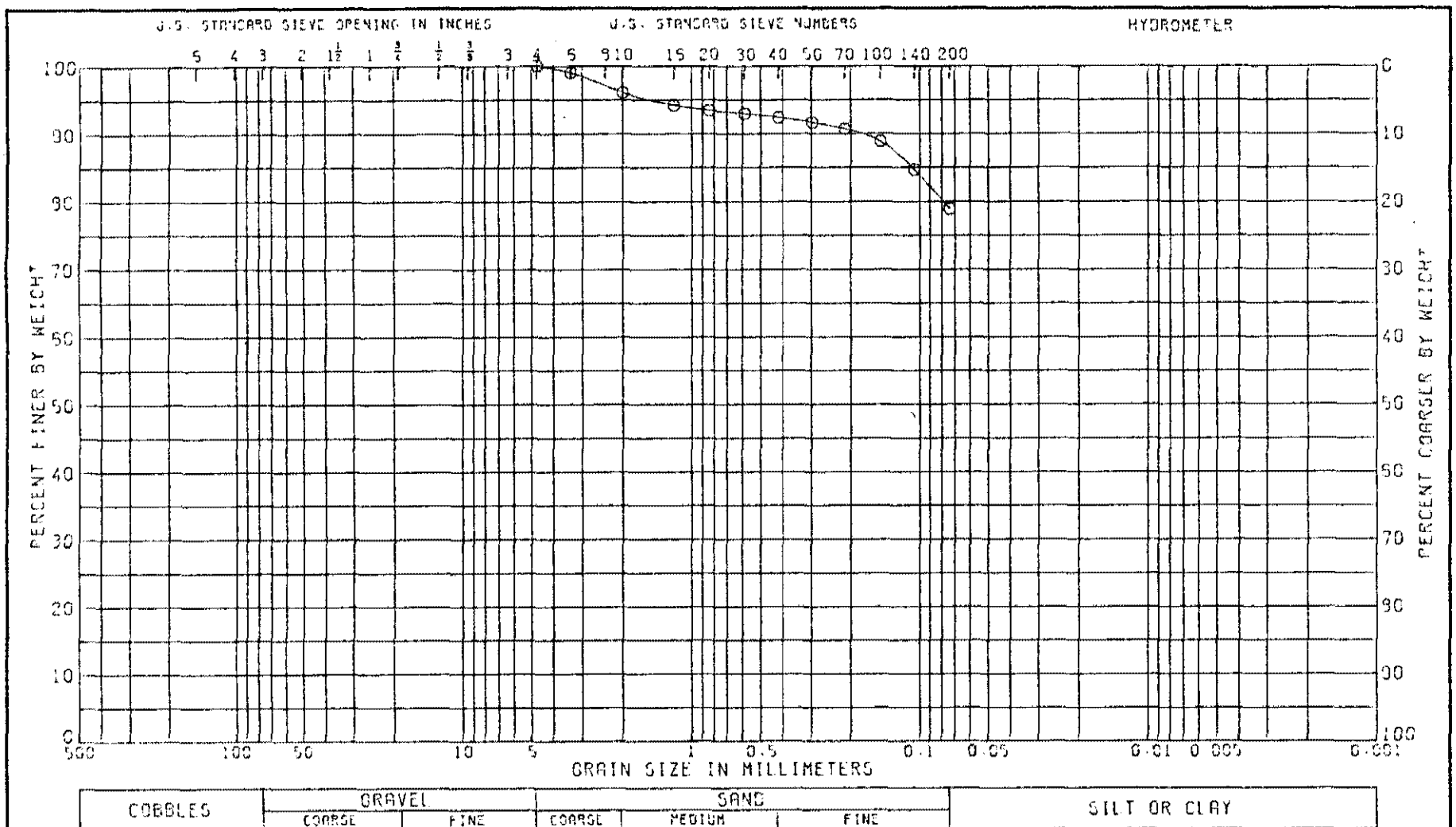
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 0-2-81 SAMPLE NO 1

DEPTH/ELEV 0.0-2.28 DATE 31 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 30 | 16 | 14 | | 19.6 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

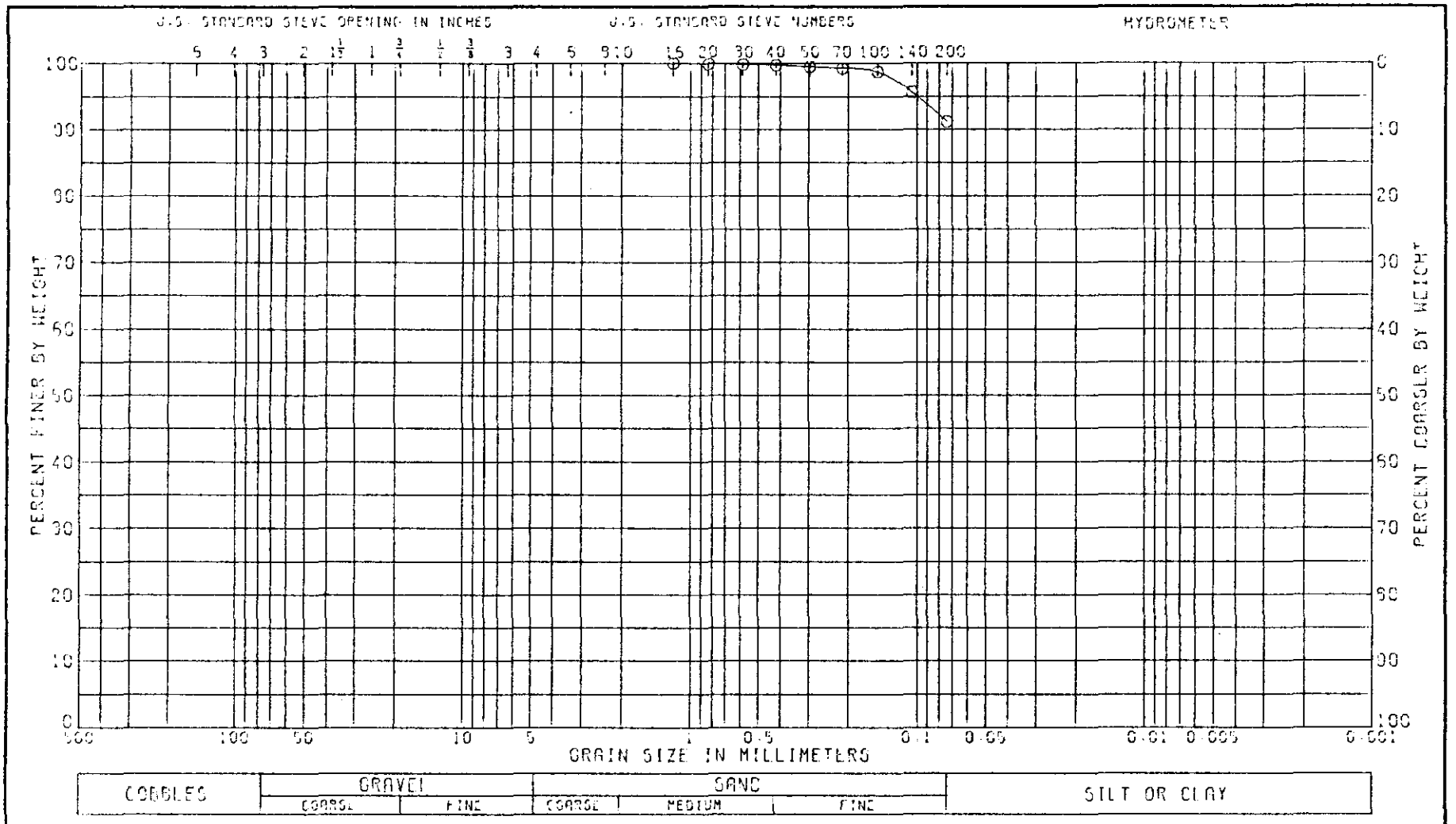
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-2-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.16 DATE 31 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 37 | 21 | 16 | | 31.3 |

CLASSIFICATION

CLAY (CL), GRAY: WITH SAND

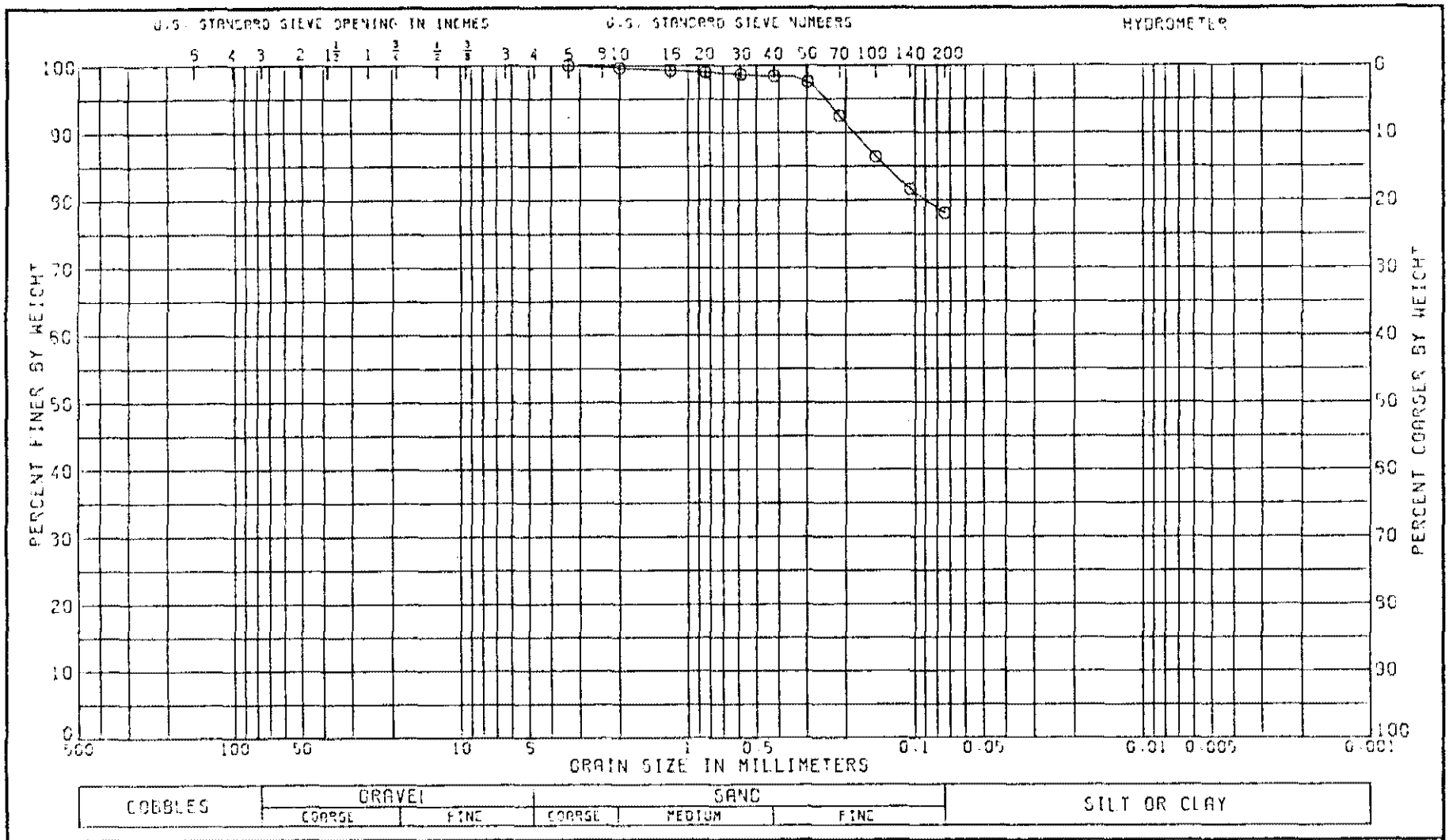
GRADATION CURVE

PROJECT CRANE NWSC HWY 45

PEST CONTROL BURRIL AREA

BORING NO. 9-2-81 SAMPLE NO 3

DEPTH/ELEV 10.0-12.00 DATE 11 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 17 | 18 | | 16.7 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

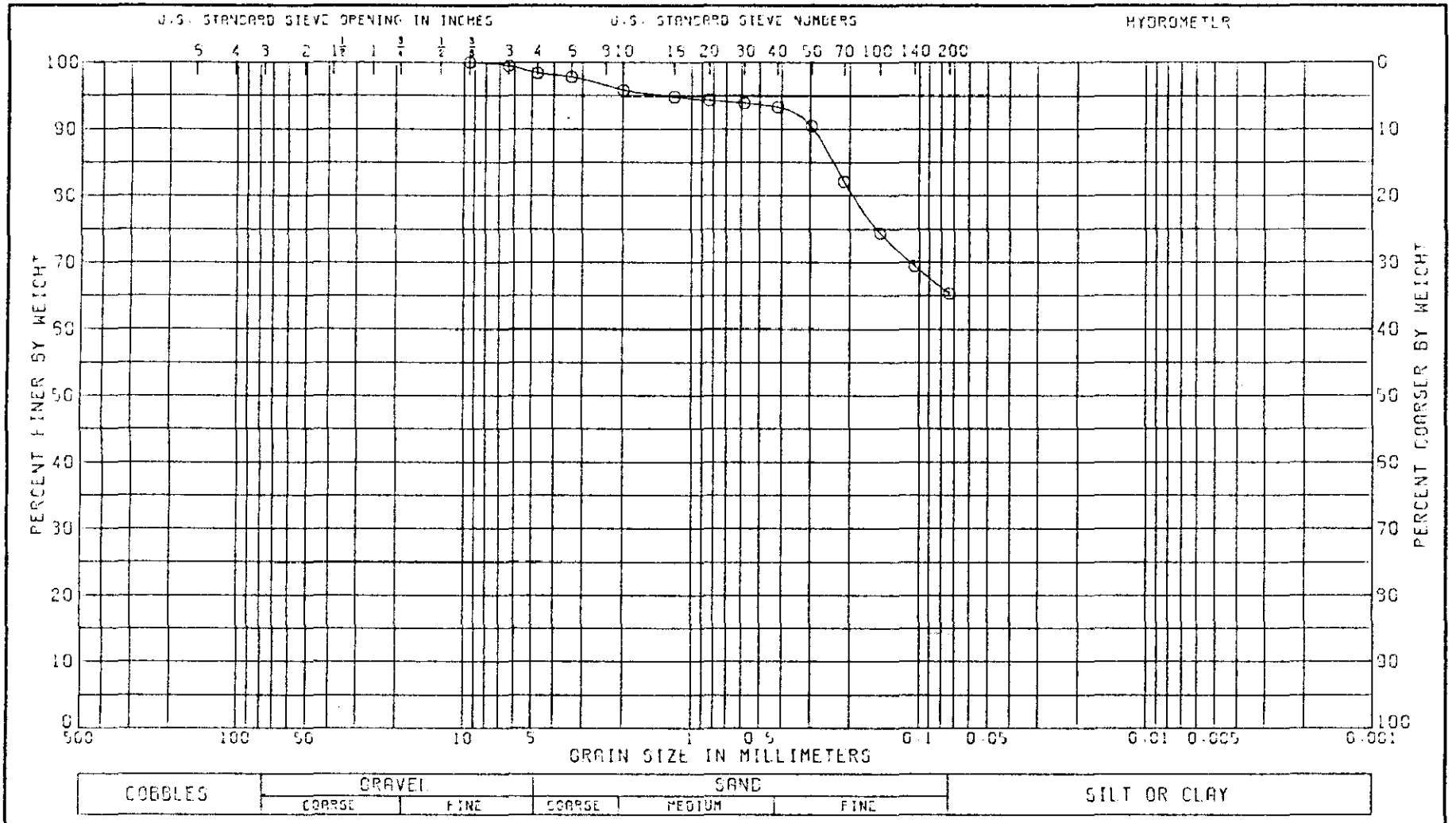
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-3-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.29 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 26 | 15 | 11 | | 21.9 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

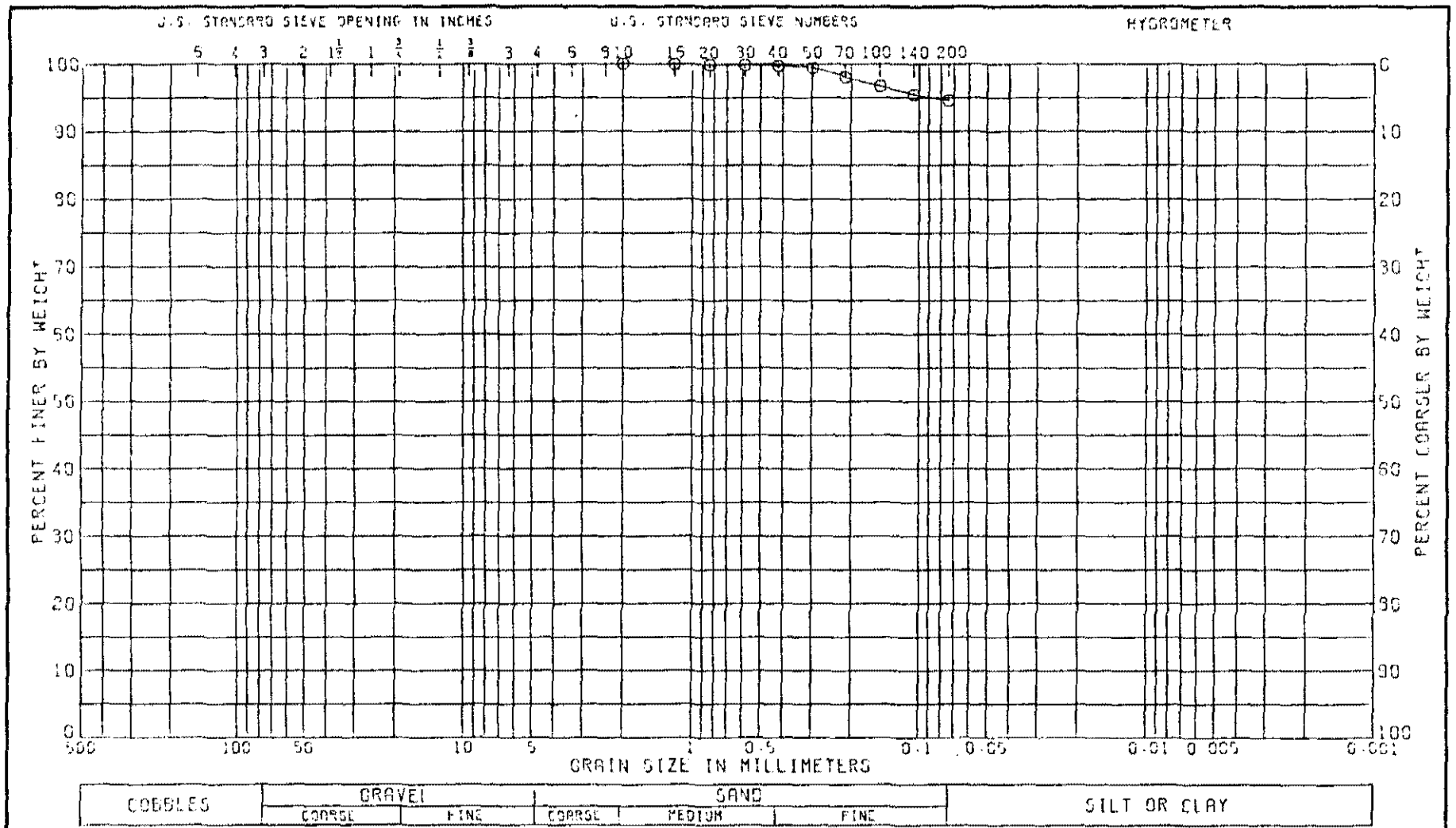
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-3-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.40 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 41 | 16 | 25 | | 17.9 |

CLASSIFICATION

CLAY (CL), BROWN: WITH SAND

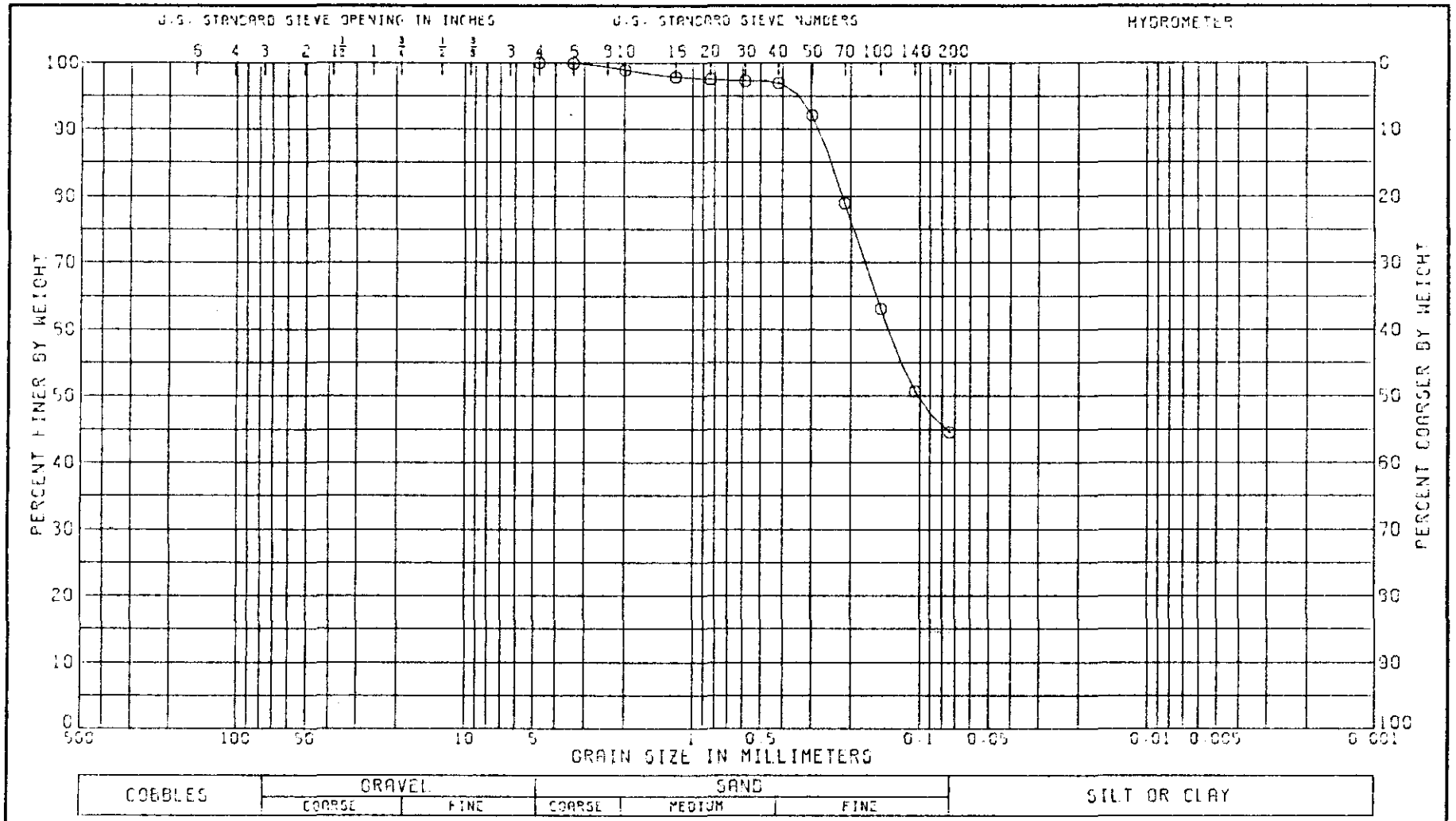
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-4-91 SAMPLE NO 1

DEPTH/ELEV 0 0-2.15 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 18 | 17 | | 8.1 |

CLASSIFICATION

CLAYEY SAND (SC), TAN

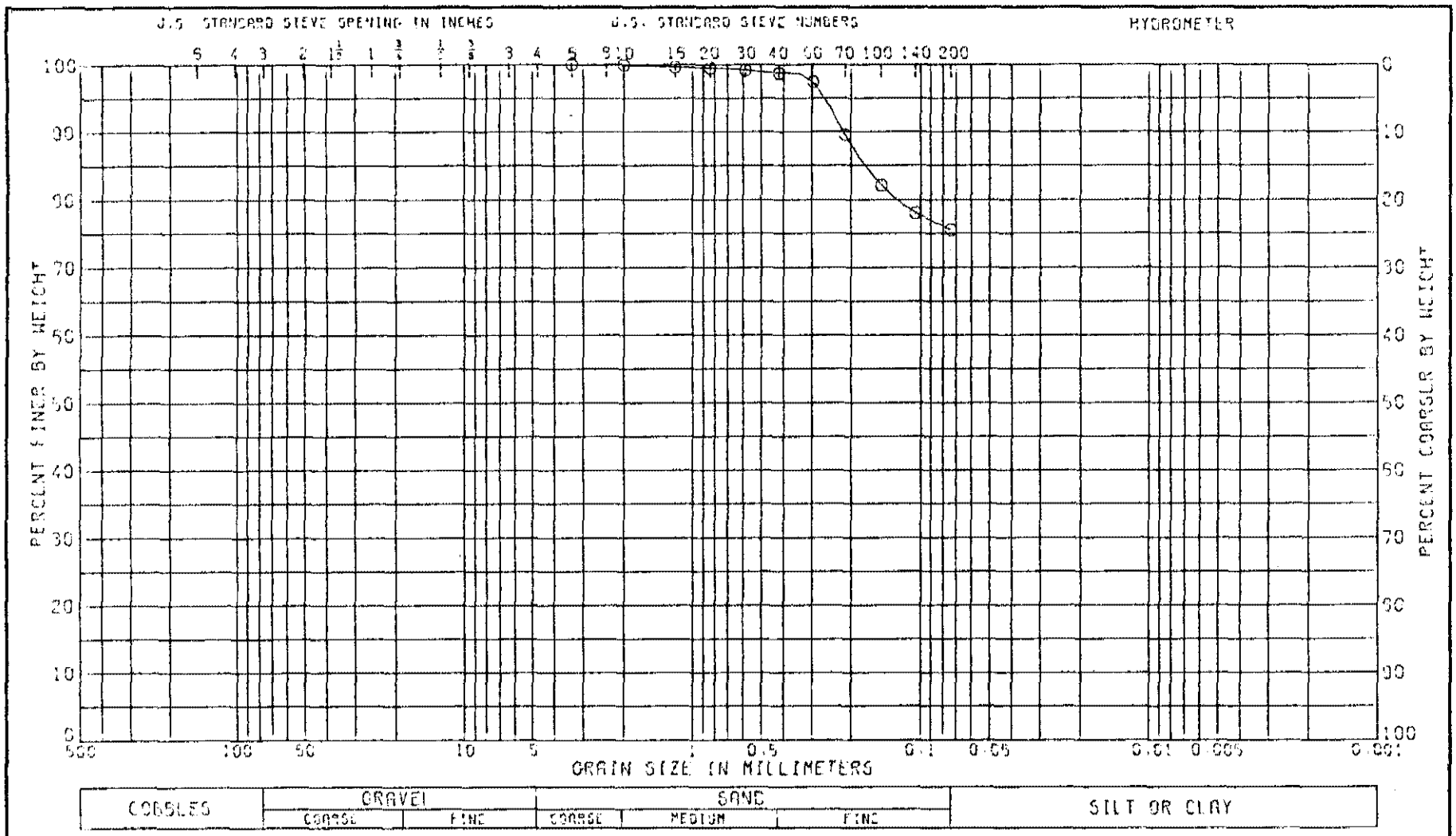
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-4-81 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.43 DATE 31 MAR 92




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 40 | 17 | 23 | | 13.4 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

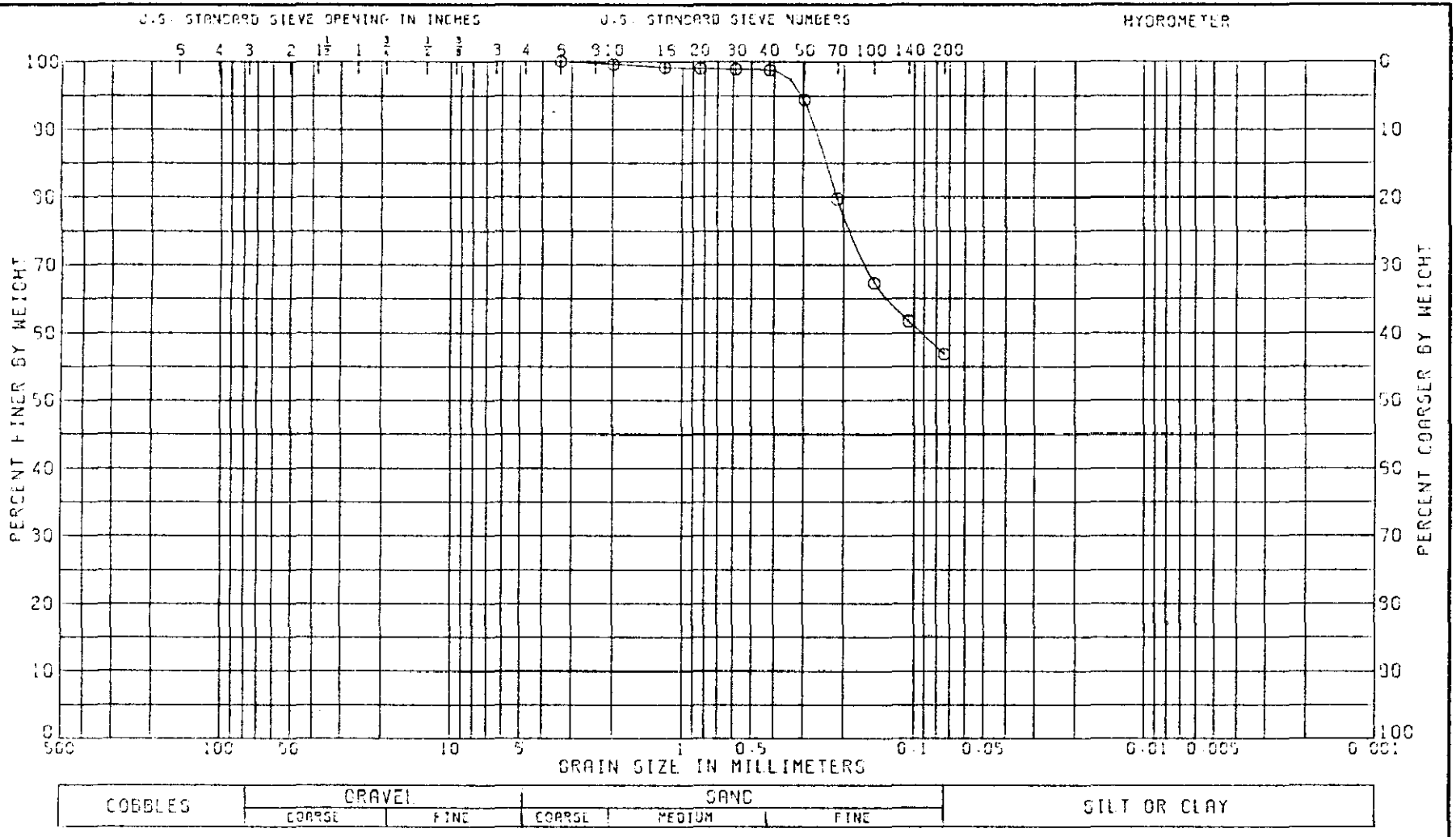
GRADATION CURVE

PROJECT CRANE NWSC HWY 45

PEST CONTROL BURRIL AREA

BORING NO. 9-5-81 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.54 DATE 11 FEB 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 34 | 17 | 17 | | 10.2 |

CLASSIFICATION

SANDY CLAY (CL) LIGHT BROWN

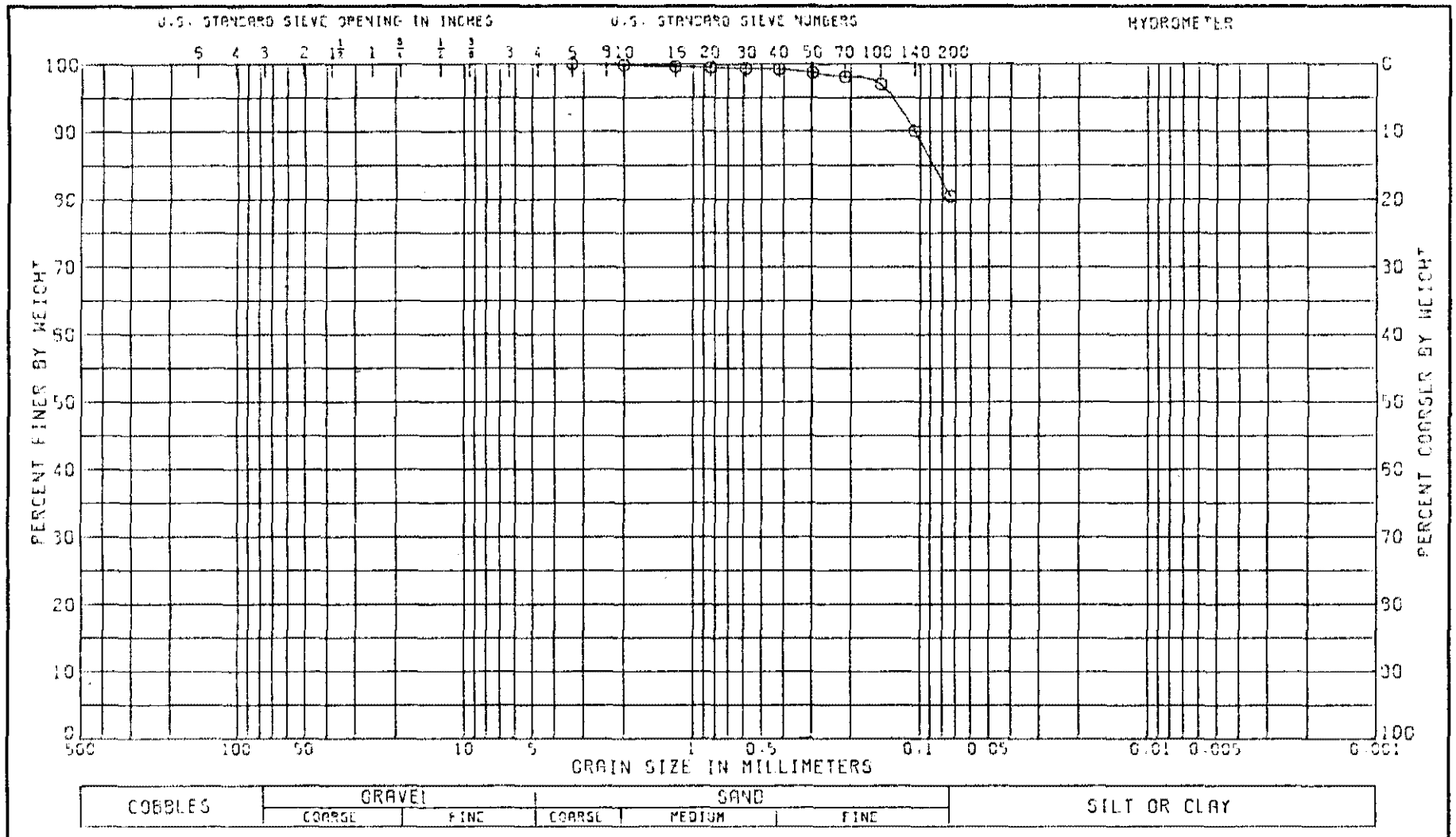
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-5-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.17 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 35 | 19 | 16 | | 12.2 |

CLASSIFICATION

SANDY CLAY (CL), BROWN

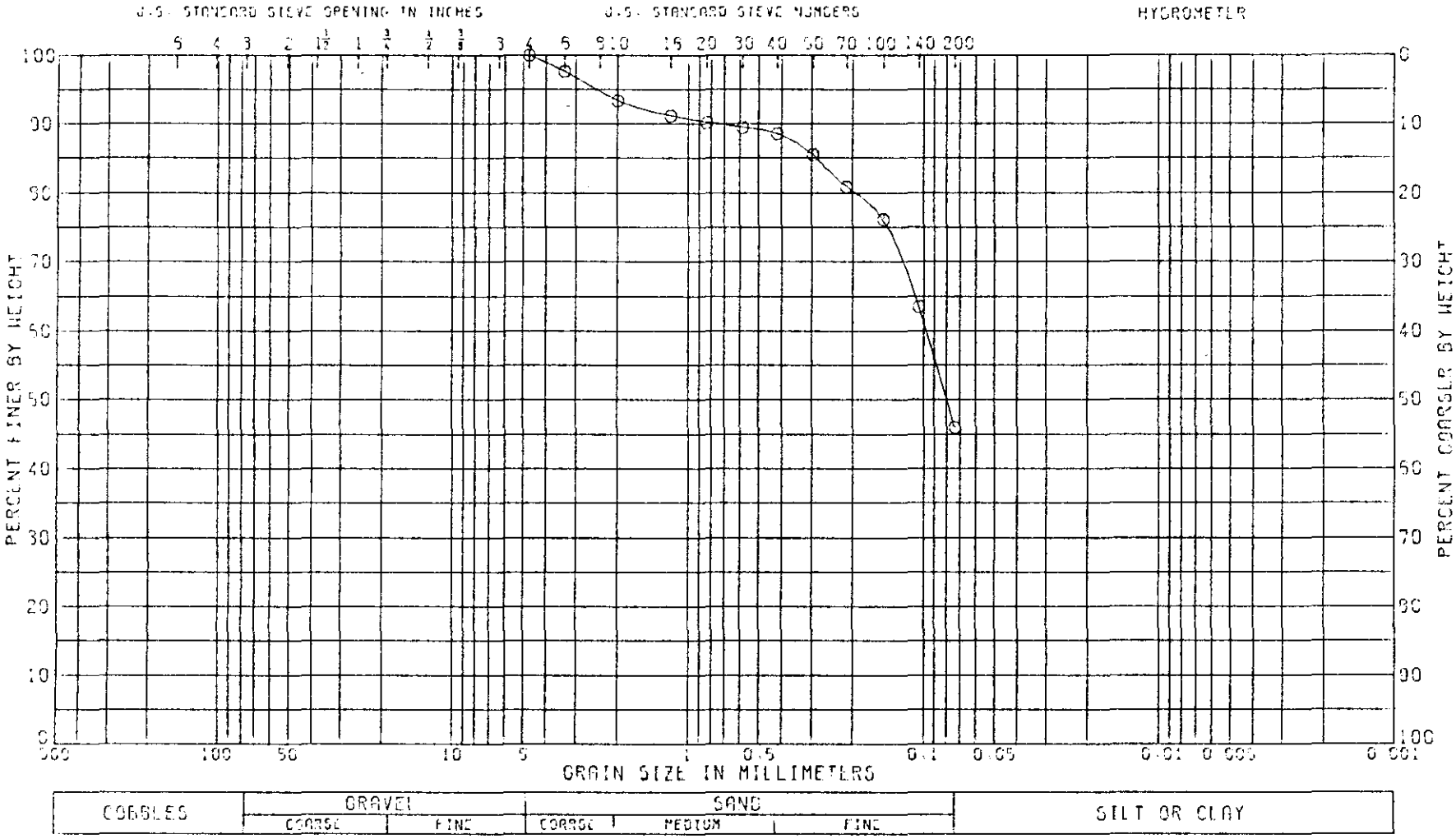
GRADATION CURVE

PROJECT CRANE NWSC HWY-45

PEST CONTROL BURIAL AREA

BORING NO. 9-6-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-2.37 DATE 31 MAR 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 39 | 20 | 19 | | 13.0 |

CLASSIFICATION

CLAYEY SAND (SC), TAN

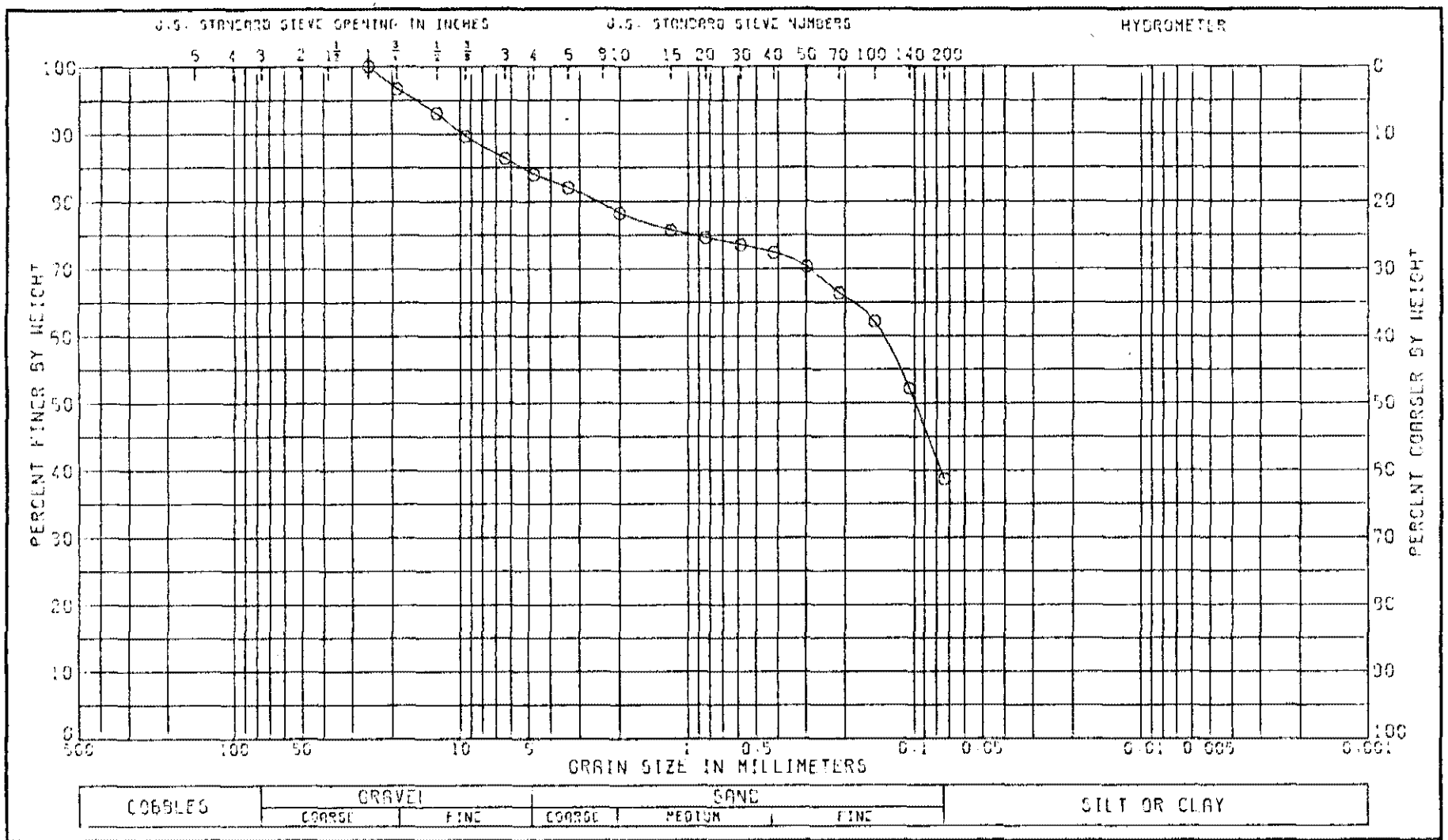
GRADATION CURVE

PROJECT CRANE NWSC HWY 45

PEST CONTROL BURRIL AREA

BORING NO. 9-7-91 SAMPLE NO 1

DEPTH/ELEV 0.0-1.59 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 27 | 18 | 9 | | 9.3 |

CLASSIFICATION

GRAVELLY CLAYEY SAND (SC), BROWN

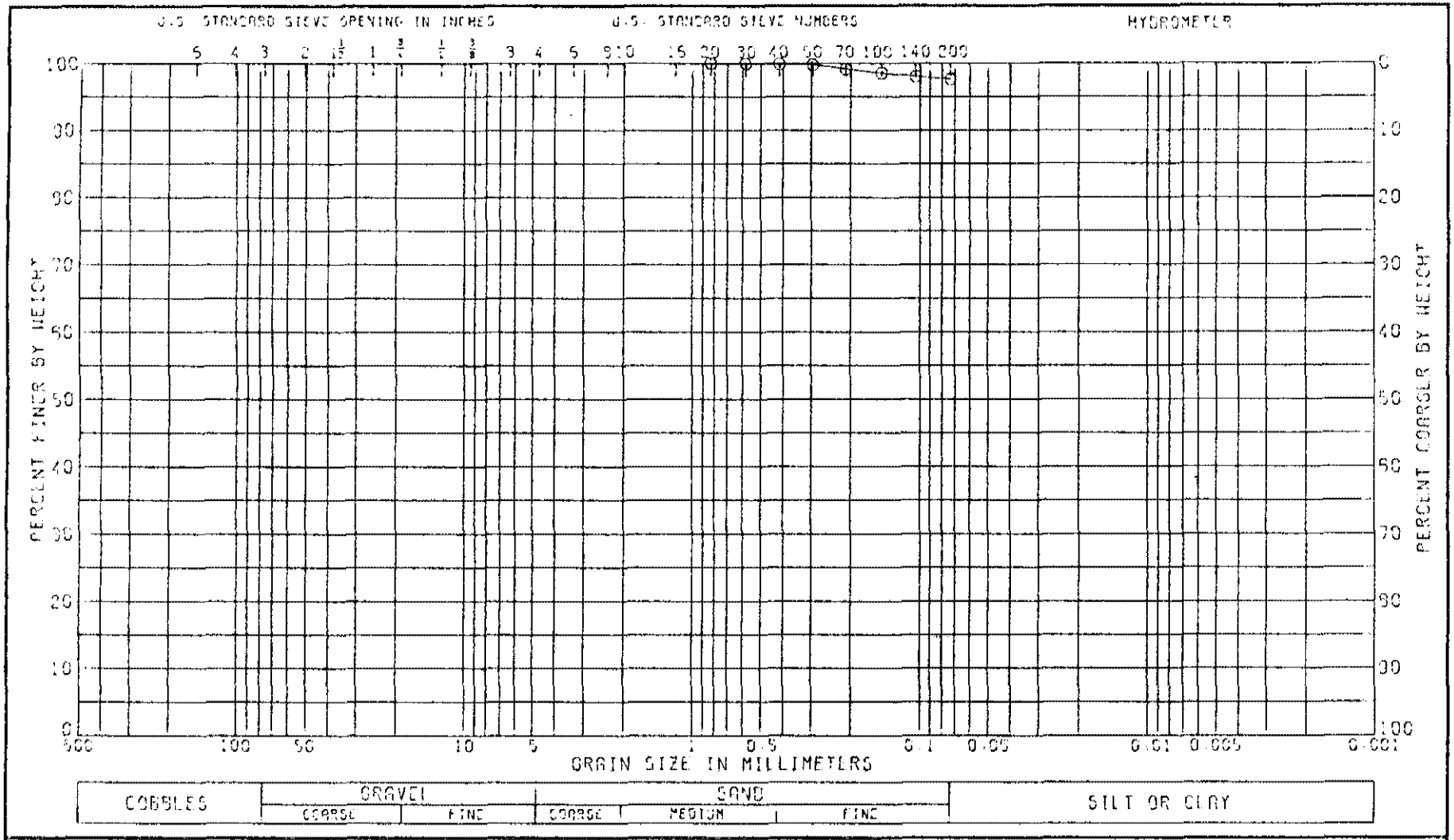
GRADATION CURVE

PROJECT CRANE NWSC HWY 45

PEST CONTROL BURRIL AREA

BORING NO. 3-7-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-7.10 DATE 11 FEB 92




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 45 | 18 | 27 | | 19.9 |

CLASSIFICATION

CLAY (CL), REDDISH BROWN

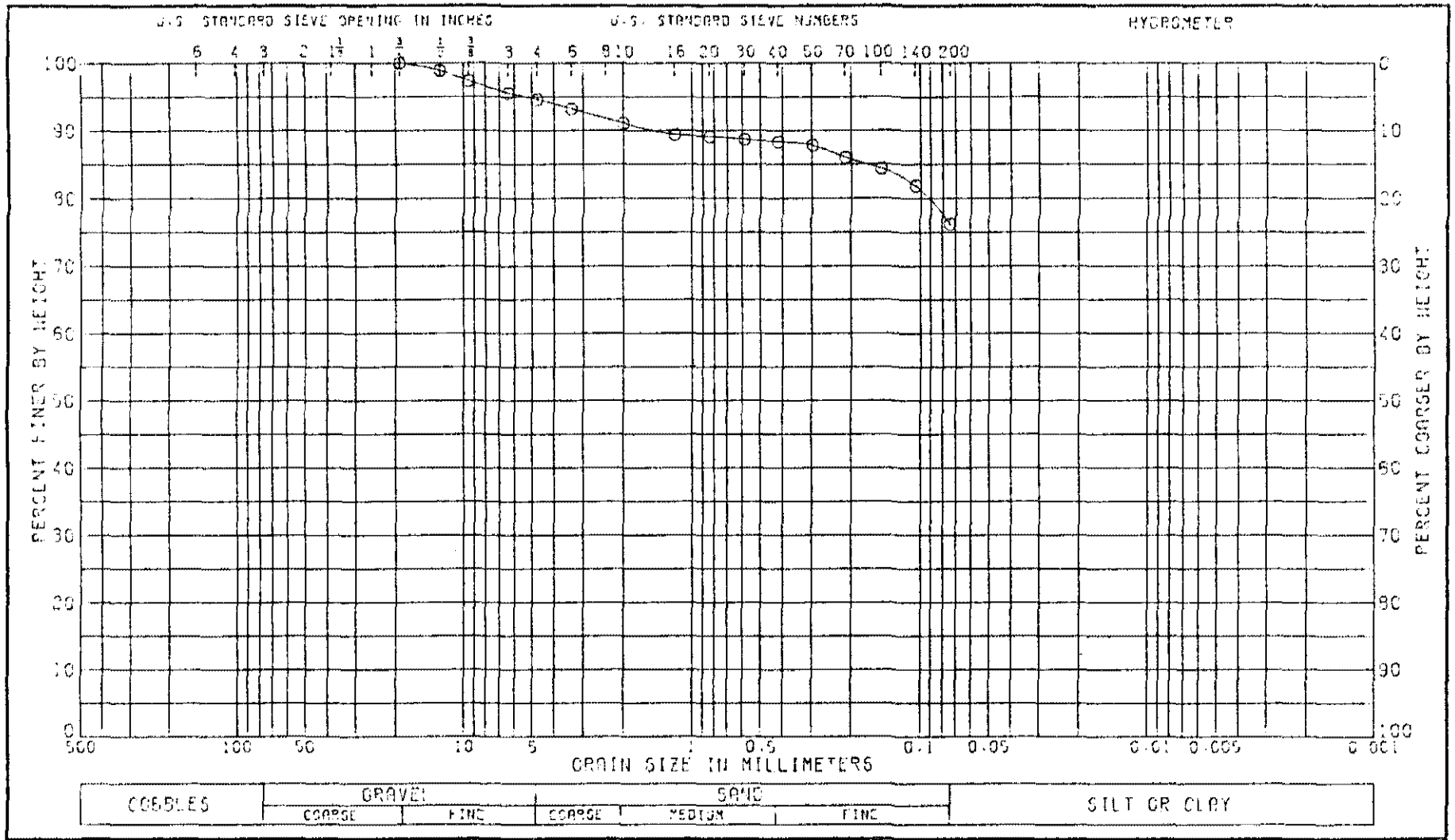
GRADATION CURVE

PROJECT CRANE NWSC HWY 45

PEST CONTROL BURRIL AREA

BORING NO. 3-B-81 SAMPLE NO 1

DEPTH/ELEV 0.0-1.30 DATE 11 FEB 82




| LL | PL | PI | GS | NAT W.% |
|---|---|---|---|---|
| 39 | 20 | 19 | | 14.1 |

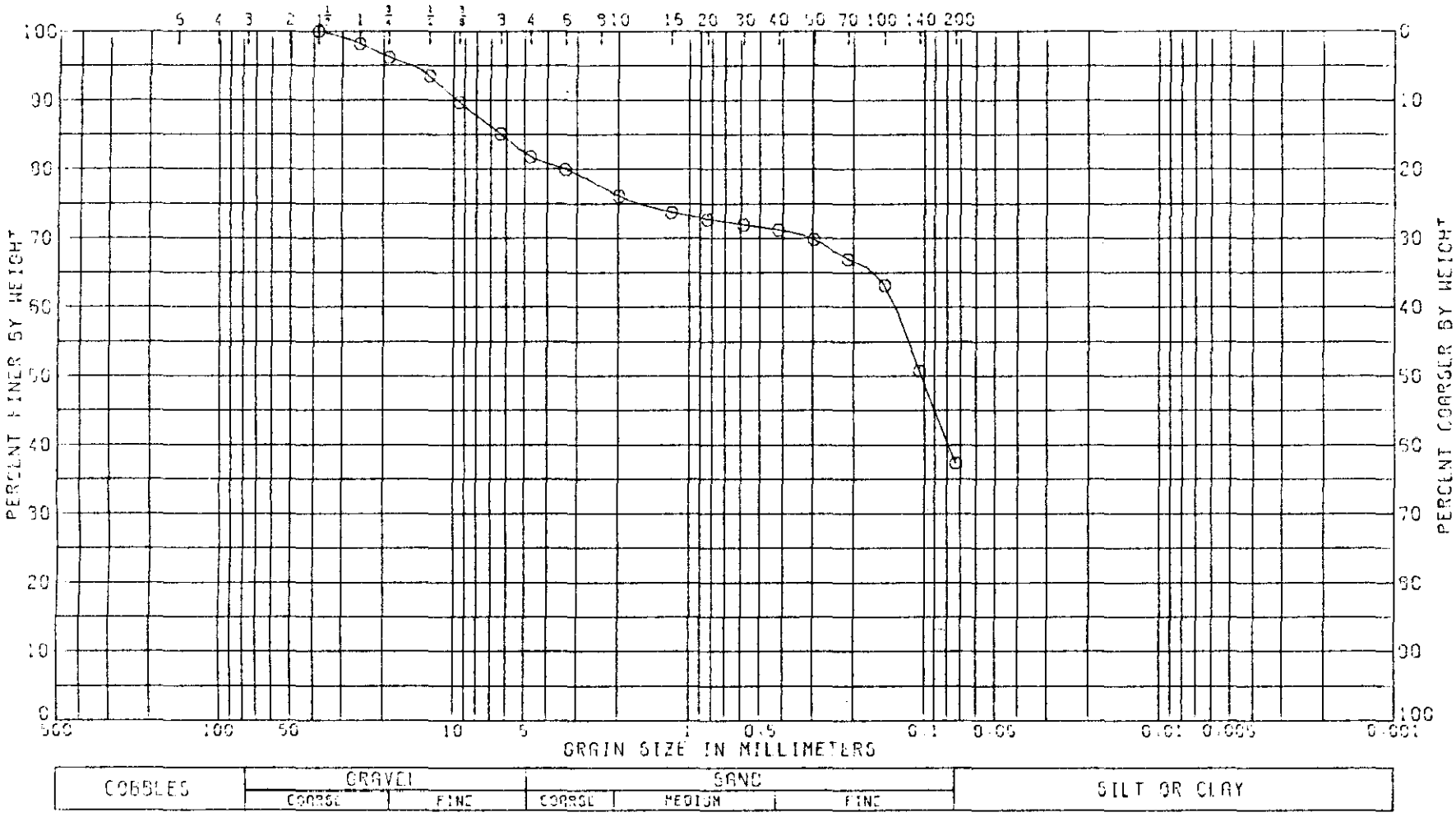
CLASSIFICATION
SANDY CLAY (CL), LIGHT BROWN, WITH GRAVEL

GRADATION CURVE

PROJECT CRANE NWSC DEMOLITION AREA

BORING NO 9-9-81 SAMPLE NO 2

DEPTH/ELEV 5.0-6.39 DATE 05 FEB 90




| LL | PL | PI | OS | NAT W.% |
|---|---|---|---|---|
| 29 | 16 | 13 | | 12.9 |

CLASSIFICATION

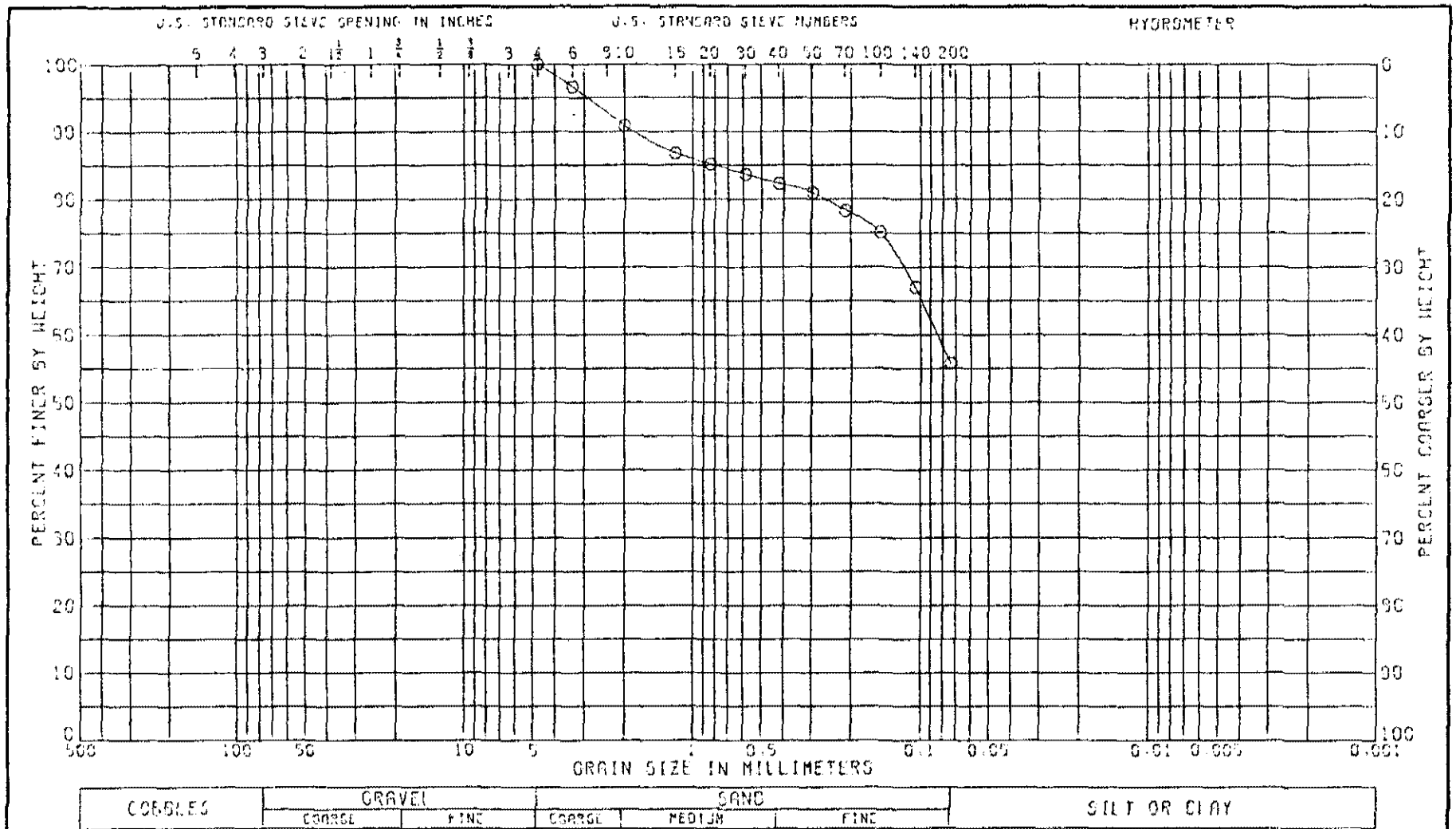
GRAVELLY CLAYEY SAND (SC), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC HWY 45
PEST CONTROL BURAIL AREA

BORING NO. 9-9-81 SAMPLE NO 1

DEPTH/ELEV 0.0-1.75 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% | |
|---|---|---|---|---|---|
| 34 | 20 | 14 | | 18.2 | |

CLASSIFICATION

SANDY CLAY (CL), BROWN

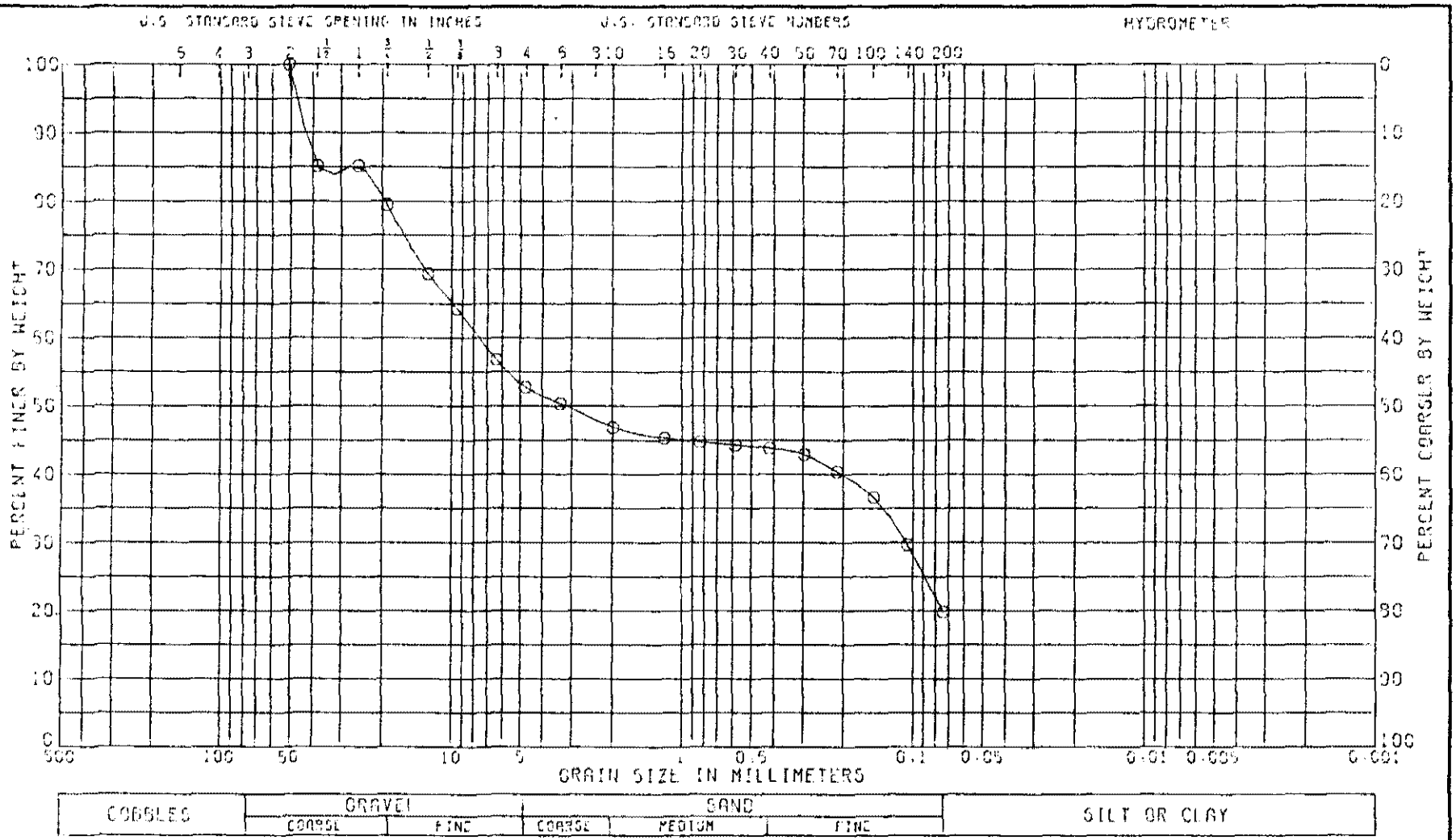
GRADATION CURVE

PROJECT CRANE NWSC HWY 45

PEST CONTROL BURIAL AREA

BORING NO. 3-9-91 SAMPLE NO. 2

DEPTH/ELEV 5.0 -6.28 DATE 11 FEB 92




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| NP | | | | 9.6 |

CLASSIFICATION

SANDY SILTY GRAVEL (GM), BROWN

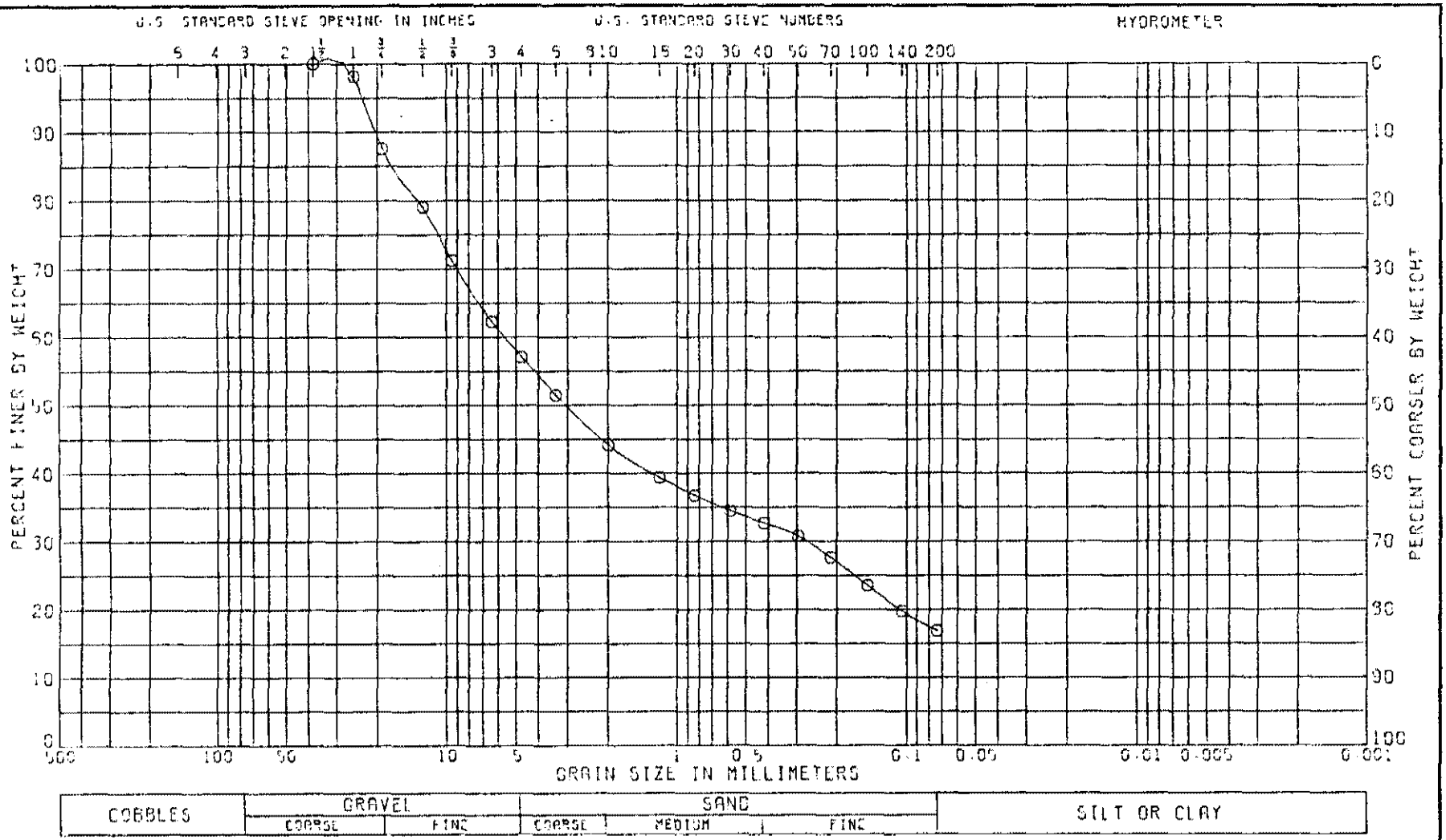
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC ROCKEYE NORTH DISCHARGE

BORING NO. 10-1-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.94 DATE 11 FEB 82




| LL | PL | PI | GS | NAT W.C. | |
|---|---|---|---|---|---|
| 24 | 15 | 9 | | 9.6 | |

CLASSIFICATION

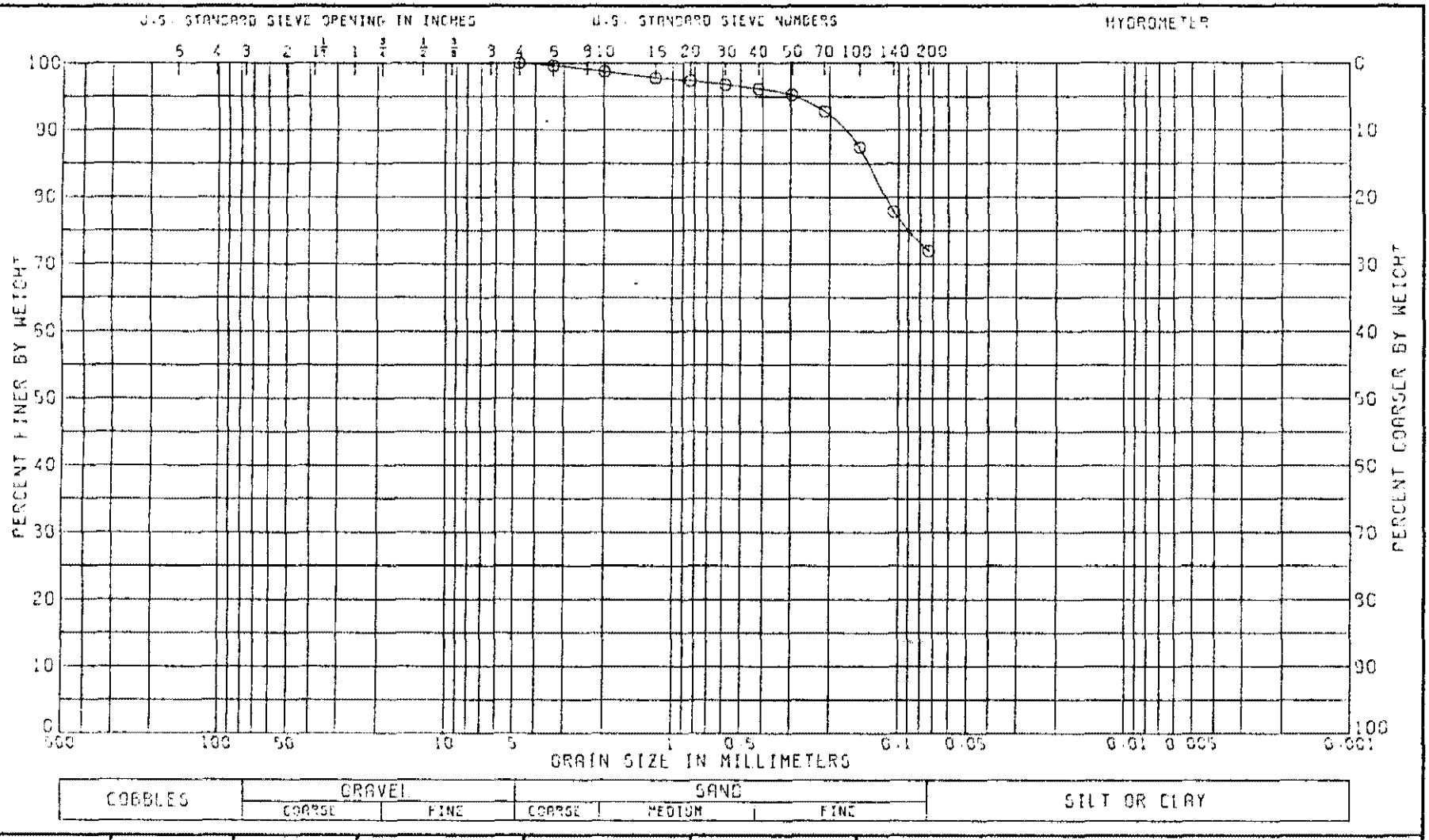
SANDY CLAYEY GRAVEL (GC), BROWN
INSUFFICIENT SAMPLE FOR ACCURATE GRADATION

GRADATION CURVE

PROJECT CRANE NWSC ROCKEYE NORTH DISCHARGE

BORING NO. 10-1-91 SAMPLE NO. 2

DEPTH/ELEV 5.0-6.15 DATE 31 MAR 82




| LL | PL | PI | CS | NAT W.% |
|---|---|---|---|---|
| 33 | 20 | 13 | | 18.2 |

CLASSIFICATION

SANDY CLAY (CL), BROWN.

GRADATION CURVE

PROJECT CRANE NWSC ROCKEYE NORTH DISCHARGE

BORING NO. 10-2-91 SAMPLE NO. 1

DEPTH/ELEV 0.0-1.20 DATE 31 MAR 92

N00164.AR.000485
NSWC CRANE
5090.3a

**FINAL**

# Interim Measures Report
# SWMU - 25/07D
# Highway 58 Dump Site A

Volume 1

NSWC Crane
Crane, Indiana

Unit Identification Code: N00164
Contract No. N62467-93-D-1106

November, 1999

**Southern Division**
**Naval Facilities Engineering Command**
**North Charleston, South Carolina**
**29419-9010**

**FINAL**

# Interim Measures Report
# SWMU - 25/07D
# Highway 58 Dump Site A

Volume 1

NSWC Crane
Crane, Indiana

Unit Identification Code: N00164
Contract No. N62467-93-D-1106

November, 1999

**Southern Division**
**Naval Facilities Engineering Command**
**North Charleston, South Carolina**
**29419-9010**

# FINAL

## INTERIM MEASURES REPORT
## SWMU - 25/07D
## Highway 58 Dump Site A

**NSWC CRANE**
**CRANE, INDIANA**

**Volume 1**

**November, 1999**

**CONTRACT N62467-93-D-1106**
**DELIVERY ORDER #0009**
**STATEMENT OF WORK #007**

***Prepared for***

**SOUTHERN DIVISION**
**NAVAL FACILITIES ENGINEERING COMMAND**
2155 Eagle Drive
P.O. Box 190010
North Charleston, South Carolina 29419-9010

***Prepared by:***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**PREPARED/APPROVED BY:**

Valarie Ann Mariola
MK Project Engineer

11/19/99
Date

**APPROVALS:**

Alan Fosdick
MK Program Manager

11/23/99
Date

# EXECUTIVE SUMMARY

This Interim Measures Report has been prepared by Morrison Knudsen (MK) for the Naval Facilities Engineering Command (NAVFACENGCOM), Southern Division pursuant to the scope of work defined in Delivery Order #0009, under Contract #N62467-93-D-1106. All remediation actions and interim measures taken at the Solid Waste Management Unit (SWMU) 25/07D, located at Highway 58 Dump Site A, Naval Surface Warfare Center, Crane, Indiana (NSWC Crane), were performed in response to the RCRA Part B Permit for NSWC Crane.

The objectives at SWMU 25/07D, Highway 58 Dump Site A, were to remove debris and incidental soil excavated with the debris. Disposal was to be either on-site or off-site depending on contaminant concentration. Soils were to be left in place and characterized for any future remediation requirements. Any excavated areas would be backfilled to original grade and restored with vegetation.

SWMU 25/07D, Dump Site A had two dump areas. The larger area was approximately 39 feet by 150 feet, and the second area was approximately 25 feet by 10 feet. Photographs taken during various working stages of the site are contained in Appendix A. This site was found to be contaminated with pieces of varying sizes of Transite (asbestos-containing material). The material was determined to be non-friable in its current state. No other contaminants were found above the TCLP limits. The primary area of removal was approximately 2000 square feet and the debris extended to depths of approximately two feet.

A small excavator and skid steer loader were used to remove the large debris and ammunition shells. Random debris was hand picked throughout the work area, where possible, with minimal disturbance to the hillside. During debris clean-up, workers scanned the completed areas with metal detectors to confirm the removal of metallic debris. All the debris collected was non-hazardous and was removed from the site by truck.

Following the completion of debris removal, confirmation sampling was performed. Eleven samples 25/07D-006 through 25/07D-016 were collected and analyzed by a laboratory for 40 CFR 264, Appendix IX criteria in accordance with the Sampling and Analysis Plan (SAP). The confirmation sample results were reviewed and accepted, and the site was restored with backfill and native ground cover.

SWMU 25/07D Acceptance and Turnover statement is dated July 12, 1996, and reflects the final inspection of SWMU 25/07D by Naval Surface Warfare Center (NSWC) personnel. The work performed at SWMU 25/07D has been accepted by the Navy.

The Interim Measure project at SWMU #25/07D was terminated. The confirmatory samples showed no contamination levels above the cleanup objectives, and all visible signs of transite and "strange" debris has been removed. Additional debris discovered during this interim measure was left in place since it may have been used as backfill to support the road (Highway 58). It is recommended that SWMU #25/07D revert back to the RFI process beginning with soil borings under the road to determine the need for further remediation.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AENI | American Environmental Network, Inc |
| CAAA | Crane Army Ammunition Activity |
| CEC | CompuChem Environmental Corporation |
| CFR | Code of Federal Regulations |
| DRMO | Defense Reutilization and Marketing Office |
| HSWA | Hazardous and Solid Waste Amendments |
| IDEM | Indiana Department of Environmental Management |
| IM | Interim Measure |
| IMR | Interim Measures Report |
| MK | Morrison Knudsen Corporation |
| MS | Matrix Spike |
| MS/MD | Matrix Spike/Matrix Duplicate |
| NAVFACENGCOM | Naval Facilities Engineering Command |
| NSWC | Naval Surface Warfare Center |
| QAPP | Quality Assurance Project Plan |
| QCP | Quality Control Plan |
| RFI | RCRA Facilities Investigation |
| RCRA | Resource Conservation and Recovery Act |
| SAP | Sampling and Analysis Plan |
| SWMU | Solid Waste Management Unit |
| USEPA | United States Environmental Protection Agency |

# 1.0
# INTRODUCTION

Morrison Knudsen Corporation (MK) was contracted by the Southern Division (SOUTHDIV), Naval Facilities Engineering Command (NAVFACENGCOM), under Contract #N62467-93-D-1106, Delivery Order #0009, Statement of Work #007 to remediate Solid Waste Management Units (SWMUs) at Naval Surface Warfare Center (NSWC) Crane, Crane, Indiana. This Interim Measures Report (IMR) summarizes the construction and environmental tasks associated with the sampling, excavation, and disposal of materials from SWMU 25/07D, Highway 58 Dump Site A, during a voluntary interim measure conducted in 1995 and 1996.

Promulgation of the United States Environmental Protection Agency's (USEPA's) regulatory program under the Resource Conservation and Recovery Act (RCRA) provided the impetus to identify and control environmental contamination from past practices at NSWC Crane. On December 23, 1989, the USEPA issued the Federal portion of the final RCRA Part B permit for NSWC Crane to the US Navy; the permit renewal, for a period of five years, was issued on July 31, 1995. This permit also contains the State permit conditions, which were issued separately by the State of Indiana RCRA program. The permit establishes the Hazardous and Solid Waste Amendment (HSWA) corrective action requirements and compliance schedules which obligate the US Navy to perform RCRA Facility Investigations (RFIs) at 30 SWMUs, to conduct Corrective Measures Studies, and to implement corrective measures if needed. Voluntary interim measures were performed at SWMU 25/07D (Highway 58 Dump Site A) as part of the RCRA Part B Permit for NSWC Crane.

MK provided project management, construction management, scientific and environmental, health and safety oversight, and quality control staff. MK's primary subcontractor, US Tech, provided debris removal and disposal, and backfilling/restoration services. American Environmental Network, Inc. (AENI) and CompuChem Environmental Corporation (CEC) provided analytical services under contract to MK.

MK prepared the following project documents which describe the procedures to be used in execution of the voluntary interim measure (IM) at SWMU 25/07D:

- *Work Plan for Interim Measures Cleanup at Solid Waste Management Units #23/00, #25/07D, and #26/08D,* Revision B, as amended, dated August 25, 1995, (MK, 1995a)

- *Task-Specific Site Safety and Health Plan, Supplement to Work Plan for Solid Waste Management Units #23/00/ #25/07D, and #26/08D,* Revision B, dated August 25, 1995, (MK, 1995b)

- *General Project Plans for Interim Measures Cleanup, Revision C*, August 18, 1995, consisting of the following plans:

    - *Quality Control Plan*, Rev. C, August 18, 1995, (MK, 1995c)
    - *Quality Assurance Project Plan*, Rev. C, December 29, 1995, (MK, 1995d)
    - *Waste Management Plan*, Rev. C, August 18, 1995, (MK, 1995e)
    - *Sampling and Analysis Plan*, Rev. C, August 18, 1995, (MK, 1995f)
    - *Environmental Protection Plan*, Rev. C, August 18, 1995, (MK, 1995g)

MK received approval of the Work Plan for SWMUs #23/00, #25/07D, and #26/08D on September 27, 1995.

The target cleanup levels for this IM were taken from "*RCRA Corrective Action Guidance Human Data Quality Levels for RFI Projects,*" June 18, 1994, (USEPA, 1994), as site-specific risk-based cleanup levels had not been developed for NSWC Crane. The target cleanup levels are presented in Volume 2, Appendix D.

# 2.0
# SITE BACKGROUND

## 2.1 SITE DESCRIPTION

NSWC Crane consists of 62,463 acres located approximately 75 miles south of Indianapolis, Indiana, as shown in Figure 2-1. The facility provides support for equipment, shipboard weapons systems, and ordnance. In addition, NSWC Crane supports the Crane Army Ammunition Activity (CAAA), including production and renovation of conventional ammunition, as well as storage, shipment, demilitarization, and disposal of conventional ammunition.

The Highway 58 Dump Site A is located west of the NSWC Crane Salvage Yard, across the road from Building 2167 as shown in Figure 2-2. The dump site is along a hillside with an intermittent stream located at the base of the hill. Access to the site is from above, via Highway 58 (H-58), or a trail below, as shown in photographs 1a and 1b provided in Appendix A of this report. There are two dump areas: the larger area is approximately 39 feet by 150 feet, and the smaller area to the southeast is about 25 feet by 10 feet. The disposal areas are heavily wooded with underbrush and a thick layer of leaves covering the ground. Visual inspection revealed that the smaller area contained primarily transite tiles of non-friable asbestos.

## 2.2 ENVIRONMENTAL SETTING

The topography of NSWC Crane consists of flat to gently rolling terrain dissected by numerous well-defined drainage ways. Surface elevation ranges from approximately 470 feet at the drainage exiting the southern boundary of Crane to 860 feet on a ridge in the west-central portion of the facility. Ridge crests generally lie at elevations of 750 to 800 feet (NEESA 1983).

Natural surface drainage at NSWC Crane is dendritic and defines four drainage basins. Dump Site A is located in Basin IV which occupies the central portion of the facility. Surface drainage in the immediate area of Dump Site A empties into Turkey Creek. All surface drainage from the NSWC empties into the East Fork of the White River south of the installation (NEESA 1983).

NSWC Crane is underlain by unconsolidated deposits of Quaternary (Pleistocene) age and residual soil derived from Pennsylvanian and Mississippian bedrock. The unconsolidated deposits are limited to the small floodplains and are composed of alluvial, colluvial, and paludal (marshland) silt, sand, and gravel; lacustrine clay, silt, and sand; and outwash plain gravel, sand, and silt. The remainder of NSWC Crane surficial deposits consist of residual clays and silt from the Pennsylvanian Raccoon Creek Group and Mississippian Stephensport and West Baden Groups with small areas of Quaternary clay, silt, and sand (Lacustrine deposits). The bedrock units beneath the facility, primarily Raccoon Creek and Stephensport Groups containing predominately sandstone and shale, reportedly dip gently from the Cincinnati Arch to the Illinois Basin in the southwest (NEESA 1983).

From boring logs collected from the facility, the major soil type is a 2- to 3-inch-thick surface layer of brown to tan organic clay loam underlain by clay intermixed with silts and sand. Occasionally, a clay hardpan occurs between 25 and 32 inches below the surface (NEESA 1983).

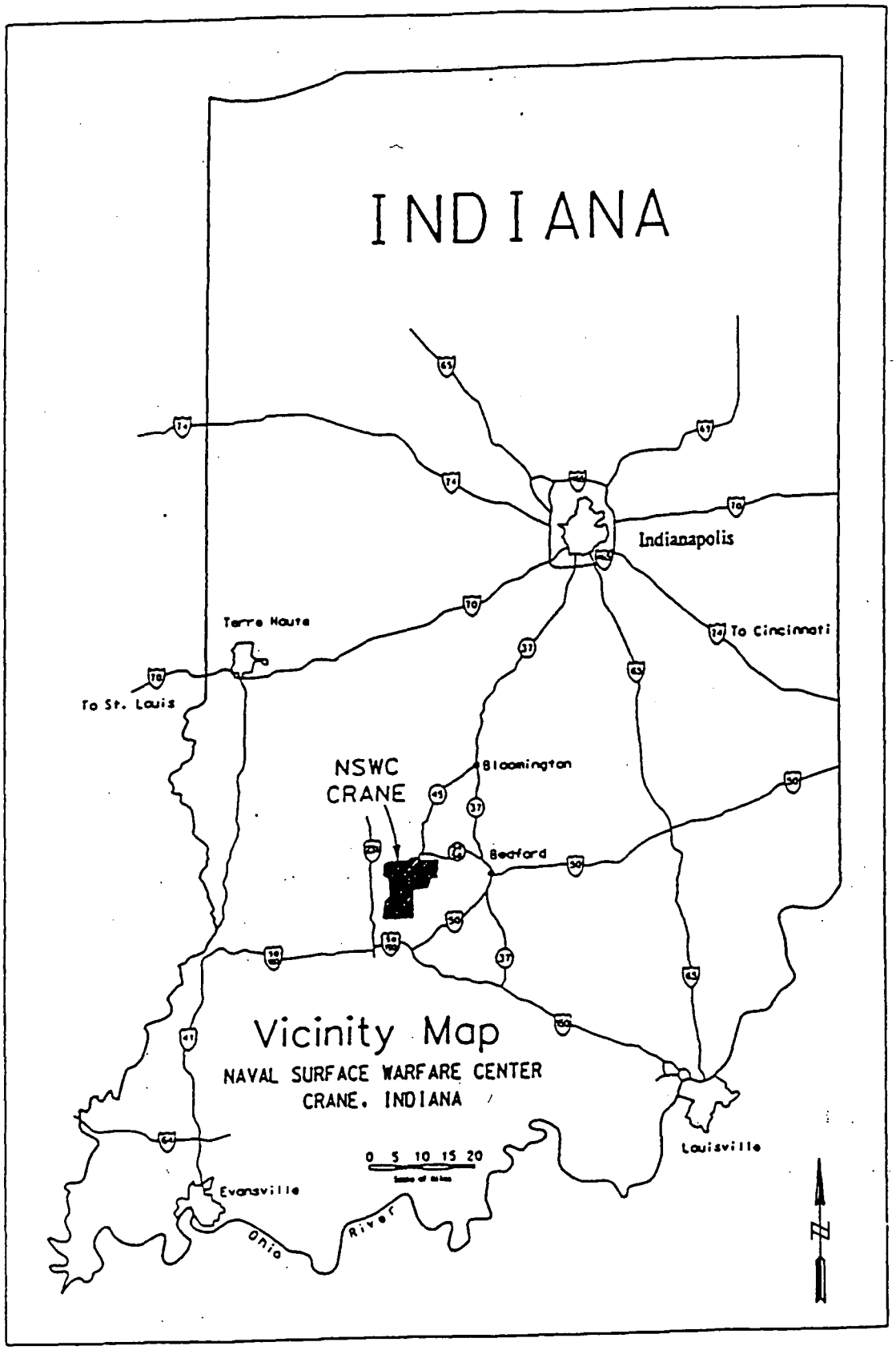



**FIGURE 2-1**
**NSWC CRANE VICINITY MAP**

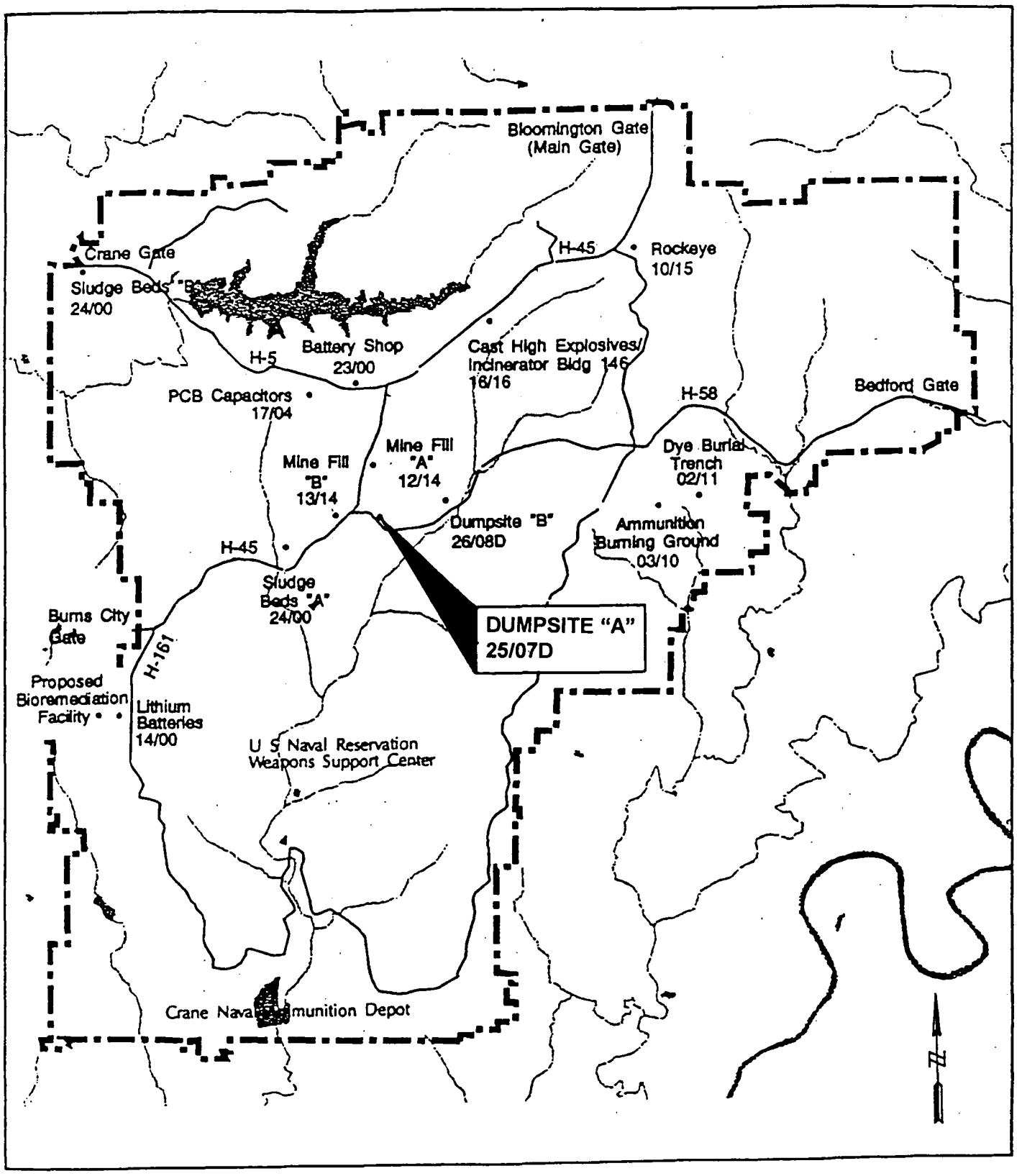



**FIGURE 2-2**
**LOCATION OF SOLID WASTE MANAGEMENT UNIT 25/07D**

FIGURE 2-2
LOCATION OF SOLID WASTE MANAGEMENT UNIT 25/07D

# 3.0 WORK EXECUTION

## 3.1 SITE CHARACTERIZATION

Visual inspection of Highway 58 Dump Site A indicated scattered debris consisting of transite siding and pipe, various sizes of concrete pipe and block, metal cans, caps, drums, blocks of roofing tar, chunks of cast concrete, metal pipe, cast metal drains, and electrical porcelain insulators. There were no detectable smells or organic vapor indications noted in the area during the initial walk downs. Inert (concrete-filled) hardware, such as 12.75 inch warheads (Hedgehog), had been used as filler to prevent land erosion. A memo dated June 5, 1995, in Appendix B, shows a sketch of the configuration of disposed ordnance buried at the site. Photographs 2a through 5b in Appendix A show the debris and heavy foliage at the dump site.

Two random soil characterization samples were initially collected for Dump Site A on July 18, 1995, (25/07D-001 and 002). The samples were analyzed for 40 CFR 264, Appendix IX analytes. Results indicate arsenic, beryllium, and cobalt above the target cleanup levels. Table 3-1 identifies the analysis requested for each sample. A summary of detected analytes is presented in Table 3-2.

As debris removal began, it became apparent that the affected depth and horizontal area was greater than originally projected. Transite tile and other debris were intermingled with the natural vegetation, soil, and humic material. Five additional characterization samples were collected on November 16 and 17, 1995, (25/07D-003 thru 007). The samples were analyzed for Appendix IX analytes and ignitability, corrosivity, and reactivity. Samples 25/07D-006 and 007 were also analyzed for TCLP metals and semi-volatile organics. These sample results indicated arsenic, beryllium, and cobalt were detected at concentrations above the cleanup levels for most samples, and the additional metals of copper, lead, and zinc above cleanup levels in one sample (25/07D-006). The established cleanup levels are shown in Table 5 of the SAP which is provided in Volume 2, Appendix D of this report. Levels of arsenic ranging from 2,600 to 201,000 ppb were detected in all of the samples collected. Beryllium and cobalt were also detected in levels as high as 820 ppb and 17,500 ppb, respectively. Previous background and backfill material sample results also indicate high levels of various metals which are shown in Table 3-4. Complete analytical results are included in Volume 2, Appendix D.

## 3.2 EXCAVATION AND REMOVAL OF DEBRIS

A small excavator and skid steer loader was used to remove the large debris and ammunition shells. Photograph 10 in Appendix A shows the excavator and triaxle dump truck. Random smaller debris was hand-picked wherever possible, with minimal disturbance to the hillside. During debris clean-up, workers scanned the completed areas with metal detectors to confirm the removal of metallic cans, drums, and debris. Metal debris as deep as two feet below ground surface was detected and removed. All the excavated debris mixed with transite material and incidental soil was removed and disposed as special waste at an approved landfill.

Following the completion of debris removal, confirmation sampling was performed. Eleven soil samples were collected and analyzed by CEC laboratory for 40 CFR 264, Appendix IX analytes in accordance with the SAP. Sampling and analytical results are discussed in Section 4.0 of this report.

## 3.3 RECONSTRUCTION AND RESTORATION

Following review of analysis on confirmation samples 25/07D-006 through 25/07D-016, the excavated area was backfilled with topsoil material from the Bioremediation Facility construction site located next to the NSWC Crane onsite landfill (see Figure 2-2). Samples NSWC-BIOF-001 through 014 were analyzed for RCRA metals. The results, shown in Table 3-4, indicate that the topsoil was acceptable for use at Dump Site A. The backfill, including topsoil, was placed and compacted in one foot increments or less until the site was restored to near original grade. The area was seeded, mulched, and subsequently monitored to ensure establishment of adequate ground cover to prevent erosion. Adequate ground cover has been re-established, and the work was accepted by the US Navy on July 12, 1996. A copy of the SWMU Acceptance and Turnover Statement is included with the regulatory documents in Appendix C.

## 3.4 WASTE DISPOSAL

The debris and incidental soils, including asbestos-containing material, removed from Dump Site A (SWMU 25/07D) were classified as non hazardous "special" wastes and were transported by truck to the Southside Landfill in Indianapolis, Indiana. Fourteen loads totaling approximately 240 tons were taken to the landfill. A copy of the Asbestos Waste Shipment/Disposal Records dated February 2, February 5, and March 11, 1995, are provided in Volume 2, Appendix F.

Table 3-1
Sample Collection Summary

| Sample No. | Medium | Sample Type | Date Sampled | Analysis | Location |
|---|---|---|---|---|---|
| | | | | | |
| 25/07D-001 | SOIL | WASTE CHARACTERIZATION | 07/18/95 | APPENDIX IX | Fig 4-1 |
| 25/07D-002 | SOIL | WASTE CHARACTERIZATION | 07/18/95 | APPENDIX IX | Fig 4-1 |
| 25/07D-003 | SOIL | WASTE CHARACTERIZATION | 11/16/95 | APPENDIX IX / ASBESTOS / RCRA | Fig 4-1 |
| 25/07D-004 | SOIL | WASTE CHARACTERIZATION | 11/16/95 | APPENDIX IX / ASBESTOS / RCRA | Fig 4-1 |
| 25/07D-005 | SOIL | WASTE CHARACTERIZATION | 11/16/95 | APPENDIX IX / ASBESTOS / RCRA | Fig 4-1 |
| 25/07D-006 | SOIL | WASTE CHARACTERIZATION | 11/17/95 | APPENDIX IX / RCRA | Fig 4-1 |
| 25/07D-007 | SOIL | WASTE CHARACTERIZATION | 11/17/95 | APPENDIX IX / RCRA | Fig 4-1 |
| 25/07D-006 | SOIL | WASTE CHARACTERIZATION | 11/17/95 | TCLP | Fig 4-1 |
| 25/07D-007 | SOIL | WASTE CHARACTERIZATION | 11/17/95 | TCLP | Fig 4-1 |
| 25/07D-006 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-007 | SOIL | CONFIRMATION D | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-008 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-009 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-010 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-011 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-012 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-013 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-014 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-015 | SOIL | CONFIRMATION | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-016 | SOIL | CONFIRMATION D | 03/12/96 | APPENDIX IX / 9002 | Fig 4-1 |
| 25/07D-T20 | LIQUID | TRIP BLANK | 03/12/96 | 8240 | N/A |
| 25/07D-T21 | LIQUID | TRIP BLANK | 03/12/96 | 8240 | N/A |
| 25/07D-T22 | LIQUID | TRIP BLANK | 03/12/96 | 8240 | N/A |
| 25/07D-T23 | LIQUID | TRIP BLANK | 03/12/96 | 8240 | N/A |
| 25/07D-T24 | LIQUID | TRIP BLANK | 03/12/96 | 8240 | N/A |

Note: A 'D' next to the Sample Type indicates a duplicate.

TABLE 3-2
Characterization Sample Analytical Results Summary

| Compound | Interim Measure Cleanup Level ug/kg | Sample ID Sample Date Medium | 25/07D-001 7/18/95 SOIL | | 25/07D-001RE 7/18/95 SOIL | | 25/07D-002 7/18/95 SOIL | | 25/07D-002RE 7/18/95 SOIL | | 25/07D-003 11/16/95 SOIL | | 25/07D-004 11/16/95 SOIL | | 25/07D-005 11/16/95 SOIL | | 25/07D-006 11/17/95 SOIL | | 25/07D-007 11/17/95 SOIL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Methylene Chloride | 22000 | | 38 | | 39 | B | 25 | B | | | 28 | | 15 | | 22 | | | | 53 | |
| Acetone | 230000 | | 110 | JB | 84 | JB | | | | | 12 | J | | | | | | | | |
| Tetrachloroethene | 22000 | | 19 | | 16 | | | | | | 34 | | | | | | 11000 | | 45 | |
| Hexachlorobenzene | 530 | | 200 | J | | | | | | | | | | | | | | | | |
| Phenanthrene | 660 | | 55 | J | | | | | | | 110 | J | | | | | | | | |
| Fluoranthene | 1600000 | | 130 | J | | | | | 65 | J | | | | | | | | | | |
| Pyrene | 1200000 | | 130 | J | | | | | 60 | J | | | | | | | | | | |
| Benzo[a]anthracene | 660 | | 140 | J | | | | | 61 | J | | | | | | | | | | |
| Chrysene | 800 | | 210 | J | | | | | 76 | J | | | | | | | | | | |
| Benzo[b]fluoranthene | 660 | | 220 | J | | | | | | | | | | | | | | | | |
| Benzo[k]fluoranthene | 660 | | 190 | J | | | | | | | | | | | | | | | | |
| Benzo[a]pyrene | 660 | | 200 | J | | | | | | | | | | | | | | | | |
| Indeno[1,2,3-cd]pyrene | 1200 | | 190 | J | | | | | | | | | | | | | | | | |
| Dibenz[a,h]anthracene | 120 | | 100 | J | | | | | | | | | | | | | | | | |
| Benzo[g,h,i]perylene | 660 | | 220 | J | | | | | | | | | | | | | | | | |
| Endosulfan I | 2000 | | | | | | | | | | | | | | | | 4.3 | P | | |
| Arsenic | 970 | | **11300** | | | | **13100** | | | | **12200** | N | **9600** | N | **7000** | N | **120000** | N | **201000** | N |
| Antimony | 31000 | | | | | | | | | | | | | | | | **32000** | N | **101000** | N |
| Barium | 5500000 | | 87700 | | | | 61900 | | | | 64300 | | 64600 | | 111000 | | 100000 | | | |
| Beryllium | 400 | | **800** | | | | **790** | | | | **750** | | **820** | | **480** | *B* | | | | |
| Cadmium | 39000 | | 1800 | N | | | | | | | 1300 | | 580 | | | | 11700 | | 1400 | |
| Chromium | 940000 | | 25300 | EN | | | 27600 | EN | | | 22100 | N* | 19500 | N* | 19200 | N* | 23300 | N* | 14400 | N* |
| Cobalt | 100 | | **15600** | | | | **8100** | | | | **12700** | | **7400** | | **6100** | *B* | **2500** | | **4800** | |
| Copper | 2900000 | | 92100 | | | | 17100 | | | | 110000 | N* | 26500 | N* | 20200 | N* | **3810000** | N* | 1190000 | N* |
| Lead | 500000 | | 22400 | | | | 24400 | | | | 19500 | EN* | 16500 | EN* | 41300 | EN* | **728000** | EN* | 119000 | EN* |
| Mercury | 23000 | | | | | | | | | | | | | | 190 | | | | 250 | |
| Nickel | 1600000 | | 45300 | | | | 21100 | | | | 34600 | N | 13700 | N | 12600 | N | 211000 | N | 55400 | N |
| Vanadium | 550000 | | 36100 | | | | 32500 | | | | 26900 | N* | 27700 | N* | 24600 | N* | | | | |
| Zinc | 23000000 | | 1360000 | E | | | 78900 | E | | | 16100000 | N | 1990000 | N | 70500 | N | **102000000** | N | 7810000 | N |
| 1,2,3,4,6,7,8,9-OCDD | | | 1.33 | | | | 1.69 | | | | | | | | | | | | | |
| 1,2,3,4,6,7,8-HpCDF | | | 0.251 | | | | | | | | | | | | | | | | | |
| *TCLP RESULTS* | | | | | | | | | | | | | | | | | | | | |
| *Hexachloroethane* | *3000 ug/l* | | | | | | | | | | | | | | | | *140 ug/l* | *D* | *29 ug/l* | *JD* |
| *Barium* | *100000 ug/l* | | | | | | | | | | | | | | | | | | *1800 ug/l* | |
| *Cadmium* | *1000 ug/l* | | | | | | | | | | | | | | | | *79.2 ug/l* | | *61.5 ug/l* | |
| *Lead* | *5000 ug/l* | | | | | | | | | | | | | | | | *347 ug/l* | | *117 ug/l* | |

Notes:
1. Outlined results in **BOLD** indicate a sample level above the Interim Measures Cleanup Level.
2. Flagcode explanations:
   - J: Estimated below reporting limit
   - B: (for Organic Analytes): Analyte also found in corresponding Blank sample(s)
   - *B: (for metals): Indicates a concentration below reporting limit.*
   - P: Value from quantitation and confirmation columns differed by more than 25%. Data flagged and lower of two values reported.
   - N: Spike recoveries outside of QC limits
   - *: For Metals, Replicate precision results outside of QC limits
   - E: Exceeded range of calibration curve
   - D: Value from dilution run
3. All sample results not shown in this table are non-detects.
4. *Samples 25/07D-006 and 25/07D-007 were re-analyzed for TCLP metals and semi-volatile analyses. Results are shown in last four rows of table. Criteria for these analytes are toxicity level criteria for TCLP.*
5. Soil sample results are reported in ug/kg.

TABLE 3-3
Confirmation Sample Analytical Results Summary

| Compound | Interim Measures Cleanup Level ug/kg | Sample ID<br>Sample Date<br>Medium | 25/07D-006<br>3/12/96<br>SOIL | | 25/07D-007<br>3/12/96<br>SOIL | | 25/07D-008<br>3/12/96<br>SOIL | | 25/07D-009<br>3/12/96<br>SOIL | | 25/07D-010<br>3/12/96<br>SOIL | | 25/07D-011<br>3/12/96<br>SOIL | | 25/07D-012<br>3/12/96<br>SOIL | | 25/07D-013<br>3/12/96<br>SOIL | | 25/07D-014<br>3/12/96<br>SOIL | | 25/07D-015<br>3/12/96<br>SOIL | | 25/07D-016<br>3/12/96<br>SOIL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Methylene Chloride | 22000 | | 8 | JB | 6 | JB | 6 | JB | 9 | JB | 11 | JB | 7 | JB | 14 | B | 12 | B | 7 | JB | 6 | JB | 8 | JB |
| Acetone | 230000 | | 14 | B | 7 | JB | 6 | JB | 12 | B | 10 | JB | 11 | JB | | | 10 | JB | 12 | B | 13 | B | 14 | B |
| Tetrachloroethene | 22000 | | | | | | 2 | J | | | 29 | | 26 | | 3 | J | | | | | | | | |
| Acenaphthylene | 660 | | | | | | | | | | | | | | | | 160 | J | | | | | | |
| Hexachloroethane | 39000 | | | | | | | | | | 8800 | E | 68 | J | | | | | | | | | | |
| Hexachlorobenzene | 530 | | | | | | | | | | 95 | J | | | | | | | | | | | | |
| Phenanthrene | 660 | | | | | | | | 46 | J | | | | | | | 260 | J | | | | | | |
| Anthracene | 1900 | | | | | | | | | | | | | | | | 120 | J | | | | | | |
| Benzo[a]anthracene | 660 | | | | | | 75 | J | 120 | J | 45 | J | | | | | 1900 | | | | | | | |
| Chrysene | 800 | | | | | | 86 | J | 120 | J | 52 | J | | | | | 2100 | | | | | | | |
| Benzo[b]fluoranthene | 660 | | | | | | 220 | XJ | 330 | XJ | 160 | JX | 92 | XJ | 78 | XJ | 3700 | X | | | | | | |
| Benzo[k]fluoranthene | 660 | | | | | | 200 | XJ | 300 | XJ | 140 | JX | 84 | XJ | 82 | XJ | 3900 | X | | | | | | |
| Fluoranthene | 1600000 | | | | | | 65 | J | 130 | J | | | | | | | 1700 | | | | | | | |
| Pyrene | 1200000 | | | | | | 70 | J | 130 | J | | | | | | | 1900 | | | | | | | |
| Indeno[1,2,3-cd]pyrene | 1200 | | | | | | 93 | J | 140 | J | 85 | J | | | | | 1800 | | | | | | | |
| Dibenz[a,h]anthracene | 120 | | | | | | | | | | | | | | | | 460 | | | | | | | |
| Benzo[g,h,i]perylene | 660 | | | | | | 150 | J | 190 | J | 100 | J | | | | | 2000 | | | | | | | |
| Aldrin | 50 | | | | | | 0.25 | JP | 0.38 | JP | 0.28 | JP | 0.068 | JP | | | | | | | 0.26 | JP | 0.45 | JP |
| beta-BHC | 4.02 | | | | | | 0.68 | JP | | | | | | | 0.22 | JP | | | | | | | 1.1 | JP |
| delta-BHC | 6.03 | | 0.15 | JP | | | 0.061 | JP | 0.16 | JP | 0.14 | J | 0.13 | JP | 0.16 | JP | 0.097 | JP | 0.14 | JP | 0.22 | J | 0.14 | JP |
| Dieldrin | 53 | | | | 3.9 | JP | 0.12 | JP | 0.23 | JP | 0.49 | JP | | | 0.098 | JP | 0.36 | JP | 0.43 | JP | 0.1 | JP | 0.13 | JP |
| Endosulfan I | 2000 | | | | | | 1.2 | JP | 3.6 | P | 2.2 | P | 0.77 | JP | 1.3 | JP | 3.1 | P | | | 1.0 | JP | 2.4 | |
| Endosulfan II | 2000 | | | | | | 0.15 | JP | 0.71 | JP | | | 0.52 | JP | 0.39 | JP | 0.97 | JP | 0.15 | JP | 1.4 | J | 0.18 | JP |
| Endosulfan Sulfate | 44.2 | | | | | | 0.66 | JBP | 0.64 | JB | 0.45 | JBP | 0.29 | JBP | | | 1.1 | JBP | | | 0.53 | JBP | 0.13 | JBP |
| Endrin | 12000 | | | | | | 3.6 | P | 0.33 | JP | 0.36 | JP | 1.5 | JP | 0.37 | J | 0.57 | JP | 0.26 | J | 0.29 | JP | 0.44 | JP |
| Endrin Aldehyde | 15.4 | | | | | | 2.0 | P | 2.3 | P | 0.36 | JP | 0.4 | JP | | | 2.6 | P | 0.95 | JP | 0.15 | JP | 0.35 | JP |
| gamma-BHC (Lindane) | 2.68 | | | | | | 0.32 | JP | | | 0.1 | JP | | | 0.071 | JP | | | 0.082 | JP | 0.10 | JP | 0.21 | JP |
| Heptachlor | 190 | | 0.11 | JP | | | 0.33 | JP | 0.69 | JP | 0.19 | JP | 0.096 | JP | 0.068 | JP | 0.15 | JP | 0.077 | JP | 0.087 | JP | 0.25 | JP |
| Heptachlor Epoxide | 94 | | | | | | | | | | 0.20 | JP | 0.097 | JP | 0.15 | JP | 0.45 | JP | 0.22 | JP | 0.28 | J | 0.19 | JP |
| Methoxychlor | 200000 | | 0.35 | JP | | | 4.5 | | 5.0 | P | 2.0 | JP | 1.8 | JP | 0.43 | JP | 0.80 | JP | | | 0.32 | JP | | |
| 4,4'-DDD | 3500 | | | | | | 0.27 | J | 0.54 | JP | 0.48 | JP | | | | | 1.2 | JP | 0.41 | JP | 0.64 | JP | 0.25 | JP |
| 4,4'-DDE | 2500 | | 0.16 | JP | | | 0.13 | JP | 0.12 | JP | 0.19 | J | 0.54 | JP | 0.23 | JP | 0.29 | J | 0.26 | JP | | | 0.078 | JP |
| 4,4'-DDT | 8 | | | | | | 0.68 | JP | 1.4 | J | 0.47 | JP | | | 0.55 | JP | 0.94 | JP | 0.16 | JP | 1.1 | JP | 0.98 | JP |
| 2,4,5-TP (Silvex) | 110 | | 2.7 | JBP | 2.8 | JBP | 1.8 | JBP | 0.69 | JBP | 10 | JBP | 2.4 | JBP | 2.4 | JBP | 4.7 | JBP | | | | | 1.6 | JBP |
| 2,4,5-T | 390000 | | 1.8 | JBP | | | | | | | 2.6 | JBP | | | 3.0 | JBP | 1.2 | JBP | 0.43 | JBP | 2.9 | JBP | 1.3 | JBP |
| Antimony | 31000 | | 900 | NB | 290 | NB | | | 400 | NB | | | | | 730 | NB | 420 | NB | 690 | NB | | | 230 | |
| Arsenic | 970 | | 22500 | | 13800 | | 2600 | | 4800 | | 8500 | | 3100 | | 8000 | | 6900 | | 4200 | | 6000 | | 6400 | |
| Barium | 5500000 | | 41500 | | 36800 | | 24200 | | 35400 | | 71500 | | 30300 | | 36700 | | 53100 | | 37600 | | 34700 | | 64500 | |
| Beryllium | 400 | | 580 | B | 420 | B | 290 | B | 370 | B | 290 | B | 280 | B | 330 | B | 480 | B | 450 | B | 380 | B | 410 | B |
| Cadmium | 39000 | | | | | | | | 330 | N | 1200 | N | | | 170 | N | | | | | | | | |
| Chromium | 940000 | | 21000 | N* | 10600 | N* | 8400 | N* | 6700 | N* | 9800 | N* | 6900 | N* | 8800 | N* | 12700 | N* | 10000 | N* | 7100 | N* | 7100 | N* |
| Cobalt | 100 | | 7000 | | 4100 | B | 3300 | B | 5200 | B | 4400 | B | 6400 | | 5900 | B | 8100 | | 5300 | B | 17500 | | 10300 | |
| Copper | 2900000 | | 12400 | | 10900 | | 8200 | | 18500 | | 117000 | | 11800 | | 70800 | | 25500 | | 92400 | | 8400 | | 9900 | |
| Lead | 500000 | | 16000 | * | 11600 | * | 6600 | * | 10500 | * | 35100 | * | 63900 | * | 38800 | * | 22000 | * | 62800 | * | 12000 | * | 15800 | * |
| Nickel | 1600000 | | 5900 | | 4300 | B | 7100 | | 10800 | | 14000 | | 10600 | | 11300 | | 12000 | | 11500 | | 12500 | | 8000 | |
| Selenium | 390000 | | 860 | N | 570 | NB | 290 | NB | | | 650 | N | | | 610 | N | 360 | NB | 370 | NB | | | 1100 | N |
| Tin | 47000000 | | | | 510 | NB | 760 | NB | 890 | NB | 2200 | NB | 4200 | NB | 2100 | NB | 1200 | NB | 1600 | NB | 820 | NB | 720 | NB |
| Vanadium | 550000 | | 20400 | | 15000 | | 6200 | | 8400 | | 9500 | | 5100 | B | 8400 | | 19100 | | 10500 | | 8700 | | 9300 | |
| Zinc | 23000000 | | 510000 | | 410000 | | 45100 | | 1630000 | | 5970000 | | 332000 | | 2110000 | | 452000 | | 472000 | | 25300 | | 27900 | |

TABLE 3-3
Confirmation Sample Analytical Results Summary

Notes:
1. Outlined results in **BOLD** indicate a sample level above the Interim Measures Cleanup Level.
2. Flagcode explanations:
   - J: Estimated below reporting limit
   - B: Analyte also found in corresponding Blank sample(s)
   - *B: (for metals): Indicates a concentration below reporting limit.*
   - P: Value from quantitation and confirmation columns differed by more than 25%. Data flagged and lower of two values reported.
   - N: Spike recoveries outside of QC limits
   - *: For Metals, Replicate precision results outside of QC limits
   - E: Exceeded range of calibration curve
   - X: Benzo(b)fluoranthene and Benzo(k)fluoranthene determined to be indistinguishable co-eluting isomers
3. All sample results not shown in this table are non-detects.
4. Trip blank samples are not shown because no detectable compounds were found.

TABLE 3-4
BACKGROUND AND BORROW PIT ANALYTICAL RESULTS SUMMARY

| Interim Measures | | | Arsenic | Barium | Beryllium | Chromium | Cobalt | Copper | Lead | Lithium | Nickel | Vanadium | Zinc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cleanup Level (ug/kg) | | | 970 | 5500000 | 400 | 940000 | 100 | 2900000 | 500000 | 1600 | 1600000 | 550000 | 23000000 |
| NSWC-BP/BF-001 | 3/16/95 | | **9400** | 62400 | **570** | 15800 | **3900** | 15300 | 13800 | **12800** | 10000 | 31200 | 395 |
| NSWC-BP/BF-002 | 3/16/95 | | **9000** | 65100 | **560** | 16900 | **4600** | 16100 | 14900 | **11700** | 10800 | 30800 | 41900 |
| NSWC-BP/BF-003 | 10/12/95 | | **7800** | 92100 | **740** | 22100 | **8600** | 15100 | 14200 | **14900** | 14500 | 39000 | 40800 |
| NSWC-BP/BF-004 | 10/12/95 | | **6300** | 83900 | **810** | 22800 | **7000** | 13900 | 13700 | **14700** | 13500 | 38200 | 40100 |
| NSWC-BP/BF-005 | 10/27/95 | | **1900** | 20600 | NR | 4600 | **2400** | 4300 | 3500 | NR | 6200 | 7300 | 16000 |
| NSWC-BP/BF-006 | 10/27/95 | | **1800** | 26700 | NR | 5600 | **3200** | 4800 | 3900 | NR | 6600 | 8600 | 17700 |
| NSWC-BIOF001 | 3/7/96 | | **9200** | 86300 | **627** | 17700 | **9200** | 14600 | 15900 | **7440** | 11100 | 30200 | 34000 |
| NSWC-BIOF002 | 3/7/96 | | **6210** | 82000 | **557** | 11100 | **10700** | 9190 | 16200 | **4690** | 8540 | 20100 | 24300 |
| NSWC-BIOF003 | 3/7/96 | | **8200** | 61200 | **417** | 15900 | **10800** | 9910 | 13500 | **6960** | 9500 | 27100 | 27000 |
| NSWC-BIOF004 | 3/7/96 | | **4950** | 123000 | **729** | 10400 | **9890** | 10300 | 16700 | **4730** | 9860 | 18300 | 27000 |
| NSWC-BIOF005 | 3/7/96 | | **7430** | 105000 | **602** | 12100 | **8690** | 10900 | 16300 | **5820** | 9050 | 24100 | 29700 |
| NSWC-BIOF006 | 3/7/96 | | **5880** | 89200 | **642** | 11300 | **10300** | 10400 | 16500 | **5100** | 9410 | 20900 | 25800 |
| NSWC-BIOF007 | 3/7/96 | | **11400** | 58300 | **546** | 17700 | **6370** | 15400 | 16400 | **8730** | 10900 | 32000 | 35700 |
| NSWC-BIOF008 | 3/7/96 | | **6130** | 91900 | **648** | 11400 | **11100** | 10400 | 17000 | **6220** | 10500 | 22300 | 29900 |
| NSWC-BIOF009 | 3/7/96 | | **2960** | 83500 | **540** | 9490 | **4860** | 10500 | 13200 | **6030** | 8990 | 17200 | 39700 |
| NSWC-BIOF010 | 3/7/96 | | **5260** | 46700 | **478** | 12400 | **8080** | 7120 | 13700 | **4430** | 7240 | 20900 | 20600 |
| NSWC-BIOF011 | 3/7/96 | | **6870** | 73000 | **542** | 38300 | **9180** | 16000 | 15200 | **45200** | 193000 | 24200 | 38700 |
| NSWC-BIOF012 | 3/7/96 | | **6730** | 54600 | **459** | 17600 | **12600** | 11200 | 14500 | **7940** | 21100 | 23500 | 31300 |
| NSWC-BIOF013 | 3/7/96 | | **2880** | 51600 | **454** | 9360 | **7820** | 8510 | 7380 | **5580** | 10600 | 14200 | 25300 |
| NSWC-BIOF014 | 3/7/96 | | **2580** | 62700 | **623** | 9480 | **12100** | 10400 | 7720 | **6520** | 17900 | 13200 | 36100 |

Notes:
1. Outlined results in **BOLD** indicate a sample level above the Interim Measures Cleanup Level.
2. NR = Not Requested
3. Analytical results are for metals only. No other analytes were present at levels near or above Interim Measures Cleanup Levels Criteria.

# 4.0
# SAMPLING AND ANALYSIS

## 4.1 SAMPLING PROCEDURES

All sample collection activities were performed in accordance with the SAP for Interim Measures Cleanup. Chain of Custody records were maintained for each sample shipment sent to the laboratory for analysis. Samples were collected and preserved per the SAP in order to maintain the sample integrity. Field duplicates and trip blanks were collected and submitted to the laboratory in order to assist in evaluating field and analytical precision, accuracy, representativeness, and comparability. The laboratory performed method blank, sample matrix spike, sample matrix spike duplicate, sample duplicate, surrogate, and standard matrix spike analyses in order to evaluate laboratory accuracy and precision.

## 4.2 SAMPLE COLLECTION

### 4.2.1 Characterization

Seven random soil characterization samples were taken for NSWC Crane SWMU 25/07D—two initially (25-07D-001 and 25-07D-002), and five additional after commencing debris removal (25-07D-003 through 25-07D-007). Soil characterization samples were collected using either a stainless steel core sampler lined with a brass sleeve that was hand driven into undisturbed soil, or a stainless trowel. These samples were placed in appropriate containers for sample analysis per the SAP. The characterization samples were marked and placed in a cooler with "blue ice" prior to shipment to maintain sample integrity. All samples were transported using proper chain of custody procedures. Copies of the chain of custody can be found in Volume 2, Appendix D of this report.

### 4.2.2 Confirmation

After excavation, 11 confirmation samples (25-07D-006 through 25-07D-016) of soil were collected and submitted to CEC Laboratory to be analyzed for Appendix IX requirements per the SAP. The number of samples collected was the cube root of the number of grid intersections, based on a 20 foot grid interval laid out over the excavated area. Eleven confirmation samples (25/07D-006 through 25/07D-016) were collected using a random number generator to determine the grid sample number location. Figure 4-1 shows the actual field location of each sample. Soil confirmation samples were collected using either a stainless steel core sampler lined with a brass sleeve that was hand driven into undisturbed soil, or a stainless trowel. These samples were placed in appropriate containers for sample analysis per the SAP. The confirmation samples were marked and placed in a cooler with "blue ice" prior to shipment to maintain sample integrity. All soil and liquid samples were transported using proper chain of custody procedures. Copies of the chain of custody can be found in Volume 2, Appendix D of this report.

## 4.3 SAMPLE ANALYSES

Two site characterization samples 25/07D-001 and -002 were analyzed for Appendix IX compounds. Five additional characterization samples (25/07D-003 through 25/07D-007) were collected to determine the method of disposal and were analyzed for RCRA characteristics, in addition to Appendix IX compounds. Analytical parameters and results are provided in Volume 2, Appendix D. Characterization sample 25/07D-001 had low internal standards during the initial volatile analysis, and sample 25/07D-002 had low internal standards during the initial semivolatile analysis. These samples were re-run with similar results, which may indicate a matrix interference. The sample matrix spikes also had low internal standards, and recovery of target analytes was acceptable. Both the original results and the re-run results (indicated by "RE" for sample 001 and "R" for sample 002) have been included. Confirmatory sampling was for

Appendix IX compounds to ensure complete removal of all contaminated material. The analytical methods employed for this SWMU were in accordance with the SAP and followed *Test Methods for Evaluating Solid Waste, SW 846, USEPA 1986,* (SW 846) methodologies. The analytical methods used for analyses associated with these interim measures activities are presented in Table 3-1 and in Volume 2, Appendix D. A summary of the sampling activity and results for SWMU-25/07D are included in Tables 3-2 through 3-4.

## 4.4 DATA QUALITY CONTROL

All soil and liquid samples collected from SWMU-25/07D were transported using proper chain-of-custody procedures. Copies of the chain of custody documents are included in Volume 2, Appendix D of this report.

### 4.4.1 Field Quality Control

Field quality control samples, which included trip blanks and field duplicate samples, were collected during the confirmation phase of the work at SWMU 25/07D. Results of the field duplicate samples are summarized in Tables 3-3 along with the sample data. Trip blanks and field duplicate analytical results from confirmation sampling events were evaluated to identify potential sources of error introduced during sampling.

Trip blank sample results were evaluated to identify any cross-contamination that may have occurred during storage and shipping of the samples to the analytical laboratory. Trip blanks were received in sealed sample containers from the laboratory and are not opened at the site. No target analytes were detected in the trip blanks for the confirmation samples.

Duplicate samples were collected from sample locations during the confirmation sampling event. Samples 25/07D-006 and 25/07D-007, as well as samples 25/07D-015 and 25/07D-016, were duplicates for the confirmation samples. Arsenic, beryllium, and cobalt were the only target analytes detected above cleanup criteria in these samples. As mentioned previously, these analytes were detected in the confirmation samples and are naturally present in soils of the surrounding area. Precision criteria for duplicate samples with results above the reporting limits differ for different analyses, and these criteria can be found in the QAPP. Field duplicate samples taken in support of the Interim Measure at SWMU 25/07D met this precision criteria for most samples.

Precision for samples 25/07D-006 and 25/07D-007 was acceptable, except for arsenic, chromium, cobalt, lead, nickel, and selenium, which had precision results ranging from 27% Relative Percent Difference (RPD) to 49.5% RPD. Precision criteria for duplicate samples 25/07D-015 and 25/07D-016 was acceptable for all analytes except Endosulfan-1, barium, cobalt, and nickel. Endosulfan-I was detected below the reporting limit at 1.0 ug/kg in 25/07D-015 and was detected at 2.4 ug/kg in sample 25/07D-016. Both of these results were well below the criteria of 2000 ug/kg for this analyte, and data is acceptable for the data quality objectives. Precision criteria were not met for barium, cobalt, and nickel, with RPD's of 46.2%, 41.1%, and 36%, respectively. Matrix interference due to the inherent heterogeneity of soils is commonly observed in soils and could be contributing to the these results.

### 4.4.2 Laboratory Quality Control

Eighteen soil samples taken for NSWC Crane SWMU 25/07D were analyzed for pesticides/PCB's, metals, organophosphorus pesticides, semi-volatiles, volatile organic compounds, herbicides, and/or dioxins. In addition, characterization samples 003-007 were analyzed for RCRA characteristics. Characterization samples 006 and 007 were re-analyzed by TCLP. The laboratory performed method blank, sample matrix spike, sample matrix spike duplicate, sample duplicate, surrogate, and standard matrix spike analyses in order to evaluate laboratory accuracy and precision. QA objectives for precision, accuracy and

completeness are established in the QAPP. MK reviewed the laboratory data received to determine whether data quality objectives were met for the sampling and analytical programs through the assessment of precision, accuracy, representativeness, comparability, and completeness.

Precision is a measure of the reproducibility of measurements under a given set of conditions. Laboratory duplicates, matrix spikes, and matrix spike duplicates were used to determine the precision of the analytical process. Accuracy is a measure of the bias in a measurement system and is defined as the closeness of the reported value to the true value. The accuracy of a measurement system was assessed by evaluating the results of quality control samples such as matrix spikes, analytical surrogates and the use of trip blanks. Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing field duplicated samples. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Analytical data are considered to be comparable when similar sampling and analytical methods are used and documented per the QAPP. Laboratory completeness is a measure of the number of valid measurements obtained from all measurements taken in the project. The laboratory completeness goal established in the QAPP is 90 percent; this goal has been met. MK's evaluation is summarized below. The QA/QC data is presented in Volume 2, Appendix E.

Method blanks were free of target compounds above the reporting limits, except for methylene chloride and acetone, which were present in several method blanks at concentrations both above and below the reporting limit. Corresponding field sample results impacted by these method blanks were qualified accordingly. All VOC surrogate recoveries fell within acceptable ranges to meet the project data quality objectives. The primary columns used for quantitation of pesticide and herbicides showed acceptable surrogate recoveries. For sample 25/07D-006, sampled on November 17,1995, all surrogates on both columns were uniformly low, which is believed to be attributed to matrix interference. Samples 25/07D-003, -004, and -005 were diluted prior to analysis, due to dark coloration and potential for damage to analytical instruments; consequently, the surrogates were diluted out of these samples. In one SVOC run, the method blank, sample 25/07D-015, and the matrix spike duplicate had low surrogate recoveries. Because the method blank in particular had been affected, all samples from this batch were re-run. Soil sample results replicated well between the two runs, and sample results were reported from the first run.

The sample matrix spikes and matrix spike duplicates (MS/MSD) had acceptable accuracy and precision, with few exceptions. The MS and MSD precision for the SVOC run mentioned above was high for all analytes on the first run. This was due to the low recoveries of all spiked analytes, including the surrogates, for the MSD. When the samples in this batch were rerun, both the MS and the MSD had acceptable recoveries for all spiked analytes. Although precision for pyrene was still high at 56% RPD on the second run, data is considered acceptable for this batch because all recoveries were acceptable.

MS/MSD recoveries for several metals were slightly low, but in all cases the post-digest spike recoveries were acceptable, and affected data was qualified appropriately. Post-digestion spikes were run for metals demonstrating unsatisfactory matrix spike recoveries. The satisfactory recoveries of post-digest spike analytes can imply interference by the required preparation procedure or in the sample matrix itself. Precision and accuracy were acceptable for MS/MSDs performed for all other types of analyses.

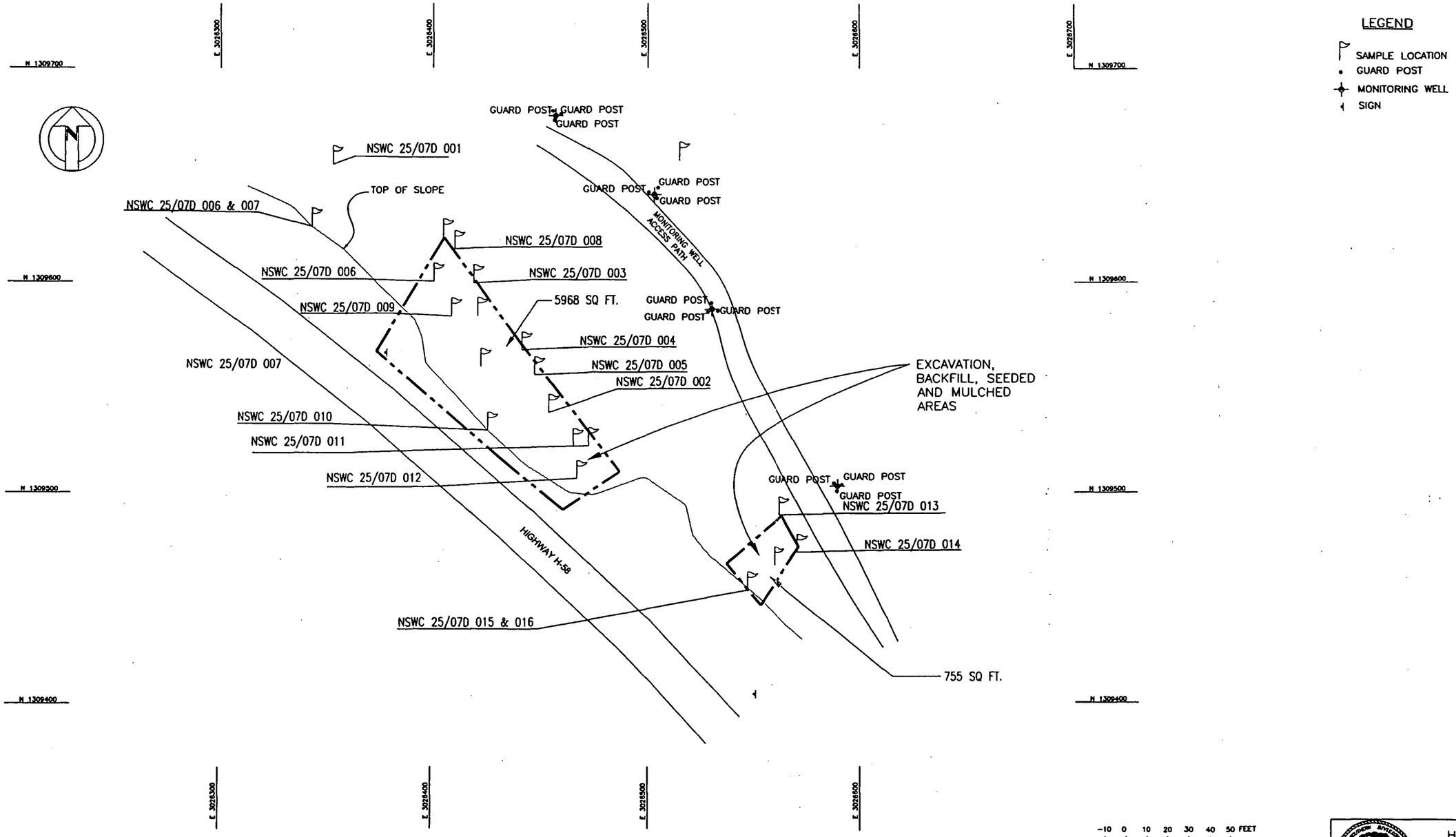
The laboratory duplicate samples analyzed had acceptable results, with few exceptions. Chromium, antimony, copper, and lead results were high for one or more metals analyses. As noted earlier, matrix interference due to the inherent heterogeneity of soils is commonly observed in soils and is likely contributing to the these results.

The laboratory control spikes (LCS's) which corresponded to the characterization and confirmation samples had acceptable accuracy and precision for all analyses performed.

Overall, data quality objectives for accuracy, precision, comparability, and completeness were met and the

data is considered to be acceptable.

A number of samples, summarized in Table 4-1, had analytes with reporting limits that exceeded the IM cleanup levels specified in Tables 5 and 6 of the Sampling and Analysis Plan. In these instances, the practical quantitation limit has been reported per the USEPA 1994 Guidance Document. The results of these samples did not show the presence of target analytes above the reporting limit.




| REV | DATE | | APPROVED |
|---|---|---|---|
| 1 | 11/17/99 | ADDED CONSTRUCTION AREA | |

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES

HIGHWAY 58
DUMPSITE A
NSWC CRANE
CRANE, INDIANA

FIGURE 4-1
SAMPLE LOCATIONS

SOURCE: MSE CORPORATION, 1996

DWG DATE: 11/20/96 | FILE NAME: DUMPA.DWG

## TABLE 4-1
## Analytes with reporting limits exceeding the Interim Measures Cleanup Levels

| SAMPLE # | INTERIM | Sample ID | 25/07D-001 | 25/07D-002 | 25/07D-003 | 25/07D-004 | 25/07D-005 | 25/07D-006 | 25/07D-007 | 25/07D-006 | 25/07D-007 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE DATE | MEASURES | Sample Date | 7/28/95 | 7/18/95 | 11/16/95 | 11/16/95 | 11/16/95 | 11/17/95 | 11/17/95 | 3/12/96 | 3/12/96 |
| TYPE | CLEANUP | Medium | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL |
| COMPOUND | LEVEL ug/kg | | | | | | | | | | |
| 1,2-Dibromoethane | 19 | | | | | | | 1100 | | | |
| 1,2-Dichloroethane | 840 | | | | | | | 1100 | | | |
| 1,4-Dioxane | 32000 | | | | | | | | | 62000 | 60000 |
| 2-Hexanone | 50 | | | | | | | 11000 | | | |
| 2-Methylnaphthalene | 660 | | | | | | | | 760 | 1000 | 980 |
| 2-Nitrophenol | 300 | | 460 | 340 | | | | | | 750 | |
| 3,3-Dimethylbenzidine | 93 | | 460 | 340 | | | | | | 550 | |
| 3-Chloropropene | 5 | | | | | | | | | | 18 |
| 4,4'-DDT | 8 | | | | 84* | 40* | 92* | | | | 41* |
| 4-Bromophenyl phenyl ether | 660 | | | | | | | | | 910 | 880 |
| 4-Chlorophenyl phenyl ether | 660 | | | | | | | | | 730 | 700 |
| 4-Nitrophenol | 190 | | 460 | 340 | | | | | | 840 | 810 |
| Acenaphthylene | 660 | | | | | | | | 760 | 810 | 790 |
| Acrylonitrile | 260 | | 1600 | 1300 | 1300 | | 1400 | 220000 | 2300 | | |
| alpha-BHC | 2.01 | | 2.6 | | 42* | 20* | 46* | 2.9 | 3.8 | | 12* |
| Aroclor 1016 | 110 | | | | 840* | 400* | 920* | | | | 230* |
| Aroclor 1221 | 110 | | | | 1700* | 790* | 1800* | | 150 | | 230* |
| Aroclor 1232 | 110 | | | | 840* | 400* | 920* | | | | 230* |
| Aroclor 1242 | 110 | | | | 840* | 400* | 920* | | | | 230* |
| Aroclor 1248 | 110 | | | | 840* | 400* | 920* | | | | 230* |
| Aroclor 1254 | 110 | | | | 840* | 400* | 920* | | | | 230* |
| Aroclor 1260 | 110 | | | | 840* | 400* | 920* | | | | 230* |
| Benzo(a)anthracene | 660 | | | | | | | | 760 | 800 | 770 |
| Benzo(a)pyrene | 660 | | | | | | | | 760 | | |
| benzo(b)fluoranthene | 660 | | | | | | | | 760 | 930 | 900 |
| Benzo(g,h,i)perylene | 660 | | | | | | | | 760 | 750 | 730 |
| Benzo(k)fluoranthene | 660 | | | | | | | | 760 | 750 | 730 |
| Beryllium | 400 | | | | | | | | 450 | | |
| beta-BHC | 4.02 | | | | 42* | 20* | 46* | | | | 12* |
| bis(2-chloroethoxy)methane | 660 | | | | | | | | | 810 | 790 |
| bis(2-Chloroethyl)ether | 150 | | 460 | 340 | | | | | | 340 | 330 |
| Carbon Tetrachloride | 920 | | | | | | | 1100 | | | |
| Chlordane | 660 | | | | 840* | | 920* | | | | |
| Chloroform | 960 | | | | | | | 1100 | | | |
| cis-1,3-Dichloropropene | 1000 | | | | | | | 1100 | | | |
| delta-BHC | 6.03 | | | | 42* | 20* | 46* | | | | 12* |
| Dibenzo(a,h)anthracene | 120 | | | 340 | 420* | 390* | 460* | 570 | 760 | 220 | 210 |
| Dibenzofuran | 660 | | | | | | | | 760 | 840 | 810 |
| Dieldrin | 53 | | | | 84* | 40* | 92* | | | | |
| Endosulfan Sulfate | 44.2 | | | | 84* | 40* | 92* | | | | |
| Endrin Aldehyde | 15.4 | | | | 84* | 40* | 92* | | | | |
| Ethyl cyanide | 100 | | | | | | | | | 720 | 690 |
| gamma-BHC (Lindane) | 2.68 | | 5.2 | 4.1 | 84* | 40* | 92* | 5.8 | 7.5 | | 12 |
| Hexachlorobenzene | 530 | | | | | | | | | 930 | 900 |
| Iodomethane | 5 | | 8.1 | 6.3 | 6.3 | 6 | 6.9 | 1100 | 11 | 12 | 12* |
| Kepone | 47 | | 52 | | 837* | 397* | 917* | 58 | 7.5 | | |
| n-Nitrosodibutylamine | 160 | | 460 | 340 | | | | | | 180 | 180 |
| n-Nitrosodiethylamine | 5.7 | | 460 | 340 | | | | | | 270 | 260 |
| n-Nitrosodimethylamine | 17 | | 460 | 340 | | | | | | 320 | 300 |
| n-Nitrosomethylethylamine | 39 | | 460 | 340 | | | | | | 290 | 280 |
| Pentachloroethane | 10 | | | | | | | 1100 | 11 | | |
| Phenanthrene | 660 | | | | | | | | 760 | 750 | 730 |
| Silvex | 100 | | | | | | | | 112 | | |
| Toxaphene | 770 | | | | 4200* | 2000* | 4600* | | | | |
| trans-1,3-Dichloropropene | 1000 | | | | | | | 1100 | | | |
| trans-1,4-Dichloro-2-butene | 15 | | | | | | | 1100 | | | 18 |

* denotes reporting limits increased due to dilutions

## TABLE 4-1
## Analytes with reporting limits exceeding the Interim Measures Cleanup Levels

| SAMPLE # | INTERIM | Sample ID | 25/07D-008 | 25/07D-009 | 25/07D-010 | 25/07D-011 | 25/07D-012 | 25/07D-013 | 25/07D-014 | 25/07D-015 | 25/07D-016 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE DATE | MEASURES | Sample Date | 3/12/96 | 3/12/96 | 3/12/96 | 3/12/96 | 3/12/96 | 3/12/96 | 3/12/96 | 3/12/96 | 3/12/96 |
| TYPE | CLEANUP | Medium | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL | SOIL |
| COMPOUND | LEVEL ug/kg | | | | | | | | | | |
| 1,2-Dibromoethane | 19 | | | | | | | | | | |
| 1,2-Dichloroethane | 840 | | | | | | | | | | |
| 1,4-Dioxane | 32000 | | 59000 | 60000 | 63000 | 59000 | 62000 | 60000 | 61000 | 60000 | 62000 |
| 2-Hexanone | 50 | | | | | | | | | | |
| 2-Methylnaphthalene | 660 | | 980 | 980 | 1000 | 970 | 1000 | 980 | 990 | 990 | 1000 |
| 2-Nitrophenol | 300 | | | | 770 | 720 | 760 | 730 | 730 | 730 | 760 |
| 3,3-Dimethylbenzidine | 93 | | | | 560 | 520 | 550 | 530 | 530 | 530 | 550 |
| 3-Chloropropene | 5 | | 18 | 18 | 19 | 17 | 18 | 18 | 18 | 18 | 18 |
| 4,4'-DDT | 8 | | | | | | | | | | |
| 4-Bromophenyl phenyl ether | 660 | | 880 | 880 | 930 | 870 | 910 | 880 | 890 | 880 | 910 |
| 4-Chlorophenyl phenyl ether | 660 | | 700 | 700 | 740 | 690 | 730 | 700 | 710 | 710 | 730 |
| 4-Nitrophenol | 190 | | 810 | 810 | 850 | 800 | 840 | 810 | 820 | 810 | 840 |
| Acenaphthylene | 660 | | 790 | 790 | 830 | 770 | 820 | | 790 | 790 | 820 |
| Acrylonitrile | 260 | | | | | | | | | | |
| alpha-BHC | 2.01 | | | | | | | | | | |
| Aroclor 1016 | 110 | | | | | | | | | | |
| Aroclor 1221 | 110 | | | | | | | | | | |
| Aroclor 1232 | 110 | | | | | | | | | | |
| Aroclor 1242 | 110 | | | | | | | | | | |
| Aroclor 1248 | 110 | | | | | | | | | | |
| Aroclor 1254 | 110 | | | | | | | | | | |
| Aroclor 1260 | 110 | | | | | | | | | | |
| Benzo(a)anthracene | 660 | | | | | 760 | 800 | | 780 | 780 | 800 |
| Benzo(a)pyrene | 660 | | | | | | | | | | |
| benzo(b)fluoranthene | 660 | | | | | | | | 910 | 910 | 940 |
| Benzo(g,h,i)perylene | 660 | | | | | 720 | 760 | | 730 | 730 | 760 |
| Benzo(k)fluoranthene | 660 | | | | | | | | 730 | 730 | 760 |
| Beryllium | 400 | | | | | | | | | | |
| beta-BHC | 4.02 | | | | | | | | | | |
| bis(2-chloroethoxy)methane | 660 | | 790 | 790 | 830 | 770 | 820 | 790 | 790 | 790 | 820 |
| bis(2-Chloroethyl)ether | 150 | | 330 | 330 | 350 | 320 | 340 | 330 | 330 | 330 | 340 |
| Carbon Tetrachloride | 920 | | | | | | | | | | |
| Chlordane | 660 | | | | | | | | | | |
| Chloroform | 960 | | | | | | | | | | |
| cis-1,3-Dichloropropene | 1000 | | | | | | | | | | |
| delta-BHC | 6.03 | | | | | | | | | | |
| Dibenzo(a,h)anthracene | 120 | | 210 | 210 | 220 | 210 | 220 | | 210 | 210 | 220 |
| Dibenzofuran | 660 | | 810 | 810 | 850 | 800 | 840 | 810 | 820 | 810 | 840 |
| Dieldrin | 53 | | | | | | | | | | |
| Endosulfan Sulfate | 44.2 | | | | | | | | | | |
| Endrin Aldehyde | 15.4 | | | | | | | | | | |
| Ethyl cyanide | 100 | | 680 | 690 | 730 | 690 | 720 | 690 | 700 | 690 | 720 |
| gamma-BHC (Lindane) | 2.68 | | | | | | | | | | |
| Hexachlorobenzene | 530 | | 900 | 900 | | 890 | 940 | | 910 | 910 | 940 |
| Iodomethane | 5 | | 11 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Kepone | 47 | | | | | | | | | | |
| n-Nitrosodibutylamine | 160 | | 180 | 180 | 190 | 170 | 180 | 180 | 180 | 180 | 180 |
| n-Nitrosodiethylamine | 5.7 | | 260 | 260 | 280 | 260 | 270 | 260 | 270 | 260 | 270 |
| n-Nitrosodimethylamine | 17 | | 300 | 300 | 320 | 300 | 320 | 300 | 310 | 310 | 320 |
| n-Nitrosomethylethylamine | 39 | | 280 | 280 | 300 | 280 | 290 | 280 | 280 | 280 | 290 |
| Pentachloroethane | 10 | | | | | | | | | | |
| Phenanthrene | 660 | | 730 | | 770 | 720 | 760 | | 730 | 730 | 760 |
| Silvex | 100 | | | | | | | | | | |
| Toxaphene | 770 | | | | | | | | | | |
| trans-1,3-Dichloropropene | 1000 | | | | | | | | | | |
| trans-1,4-Dichloro-2-butene | 15 | | 17 | 18 | 19 | 17 | 18 | 18 | 18 | 18 | 18 |

* denotes reporting limits increased due to dilutions

# 5.0
# SUMMARY AND CONCLUSIONS

Debris was removed from Dump Site A using hand and machine methods. Metal detectors were used to verify that all metallic debris was removed. Metal debris was detected and removed from depths of two feet below ground surface. Approximately 240 tons of debris, including non-friable asbestos material (transite), were removed from SWMU 25/07D. Materials were loaded into trucks using a skid steer loader and transported to the Southside Landfill in Indianapolis, Indiana. Photographs of the site before, during, and after the IM activities are provided in Appendix A.

All analyses were performed following EPA SW846 methodologies. As shown in Table 3-1, characterization samples were analyzed for Appendix IX compounds as well as RCRA/TCLP. Confirmation samples were also analyzed for the Appendix IX list to verify that all contaminants were below cleanup levels. Comparison of Table 3-3 (confirmation sample results) and Table 3-2 (characterization sample results) shows that contaminants were removed to below cleanup levels except for arsenic, beryllium, and cobalt, which appear in levels as high as 22,500 ppb, 580 ppb, and 7,000 ppb, respectively. Samples collected from off-site virgin soil borrow sources confirmed that levels of arsenic, beryllium, and cobalt above the established cleanup levels are naturally present in soils in the surrounding area. Table 3-4 summarizes the background samples BP/BF-001 thru BP/BF-004 collected at the onsite borrow pit and BP/BF-005 and -006 collected off-site. Other SWMU sites found similar heavy metal concentrations of the same metals (MK, 1996). The confirmation sampling results met the required IM cleanup criteria, and the site restoration has been accepted by NSWC Crane personnel.

The Interim Measure project at SWMU #25/07D was terminated. The confirmatory samples showed no contamination levels above the cleanup objectives, and all visible signs of transite and "strange" debris have been removed. Additional debris discovered during this interim measure was left in place since it may have been used as backfill to support the road (Highway 58). It is recommended that SWMU #25/07D revert back to the RFI process beginning with soil borings under the road to determine the need for further remediation.

# 6.0
# REFERENCES


Morrison Knudsen Corporation, (MK) 1995a. *Work Plan for Interim Measures Cleanup at Solid Waste Management Units #23/00, #25/07D, and #26/08D,* Revision B, as amended, dated August 25, 1995.

Morrison Knudsen Corporation, (MK) 1995b. *Task-Specific Site Safety and Health Plan, Supplement to Work Plan for Solid Waste Management Units #23/00/ #25/07D, and #26/08D,* Revision B, dated August 25, 1995.

Morrison Knudsen Corporation, (MK) 1995c. *Quality Control Plan for Interim Measures Cleanup, NSWC Crane, Crane, Indiana,* Revision C, August 1995.

Morrison Knudsen Corporation, (MK) 1995d. *Quality Assurance Project Plan for RCRA Corrective Action Interim Measures Cleanup, NSWC Crane, Crane, Indiana,* Revision C, August 1995.

Morrison Knudsen Corporation, (MK) 1995e. *Waste Management Plan for Interim Measures Cleanup, NSWC Crane, Crane, Indiana,* Revision C, August 1995.

Morrison Knudsen Corporation, (MK) 1995f. *Sampling and Analysis Plan for Interim Measures Cleanup, NSWC Crane, Crane, Indiana,* Revision C, August 1995.

Morrison Knudsen Corporation, (MK) 1995g. *Environmental Protection Plan Interim Measures Cleanup, NSWC Crane, Crane, Indiana,* Revision C, August 1995.

Morrison Knudsen Corporation, (MK) 1996. *Interim Measure Report, SWMU 23/00 Battery Shop, Naval Surface Warfare Center Crane, Crane, Indiana,* Draft, September 1996.

Naval Energy and Environmental Support Activity, (NEESA) 1983. *Initial Assessment Study of Naval Weapons Support Center Crane, Indiana.* NEESA 13-003, May.

U. S. Environmental Protection Agency (USEPA) 1994. *RCRA Corrective Action Guidance Human Data Quality Levels for RFI Projects.* June 18, 1994.

# APPENDIX A

# PHOTOGRAPHS

ROLL: 1
FRAME: 3
DATE: 11 MAY 95
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Possible access along the sampling wells north and bottom of the dump site hill.**

ROLL: 3
FRAME: 7A
DATE: 12 MAY 95
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Access from highway H58 that passes by the above sampling wells.**

**PHOTO 1a & 1b**

ROLL: 1
FRAME: 1
DATE: 11 MAY 95
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Example of trash; transite siding.**

ROLL: 1
FRAME: 4
DATE: 11 MAY 95
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Example of trash; transite pipe.**

**PHOTO 2a & 2b**

ROLL: 1
FRAME: 8A
DATE: 11 MAY 95
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Concrete blocks various thickness 8' to 10".**

ROLL: 1
FRAME: 9A
DATE: 11 MAY 95
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Concrete pipe, cinder blocks, electrical porcelain insulators, metal pipe metal sheeting.**

**PHOTO 3a & 3b**

ROLL: **1**
FRAME: **6A**
DATE: **11 MAY 95**
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Roofing tar blocks with smaller pieces below leaves.**

ROLL: **1**
FRAME: **7A**
DATE: **11 MAY 95**
PHOTOGRAPHER: **J. SMITH**
DESCRIPTION: **Buried metal cylinders.**

**PHOTO 4a & 4b**

ROLL: 1
FRAME: 4A
DATE: 11 MAY 95
PHOTOGRAPHER: J. SMITH
DESCRIPTION: **Concrete pipe attached to 10' of concrete header.**

ROLL: 1
FRAME: 5A
DATE: 11 MAY 95
PHOTOGRAPHER: J. SMITH
DESCRIPTION: **Metal caps with more covered by dead leaves.**

**PHOTO 5a & 5b**

ROLL: 23
FRAME: 06
DATE: 2/ 5/96
SWMU: 25/07D
BY: B. Kemp
TIME: 10:05
DESCRIPTION:
Looking south, road above into bank.

ROLL: 23
FRAME: 17
DATE: 2/ 5/96
SWMU: 25/07D
BY: B. Kemp
TIME: 10:10
DESCRIPTION:
Looking down and north from the road.

**PHOTO 6a & 6b**

ROLL: 23
FRAME: 09
DATE: 2/ 5/96
SWMU: 25/07D
BY: B. Kemp
TIME: 10:06
DESCRIPTION:
Looking north down at excavation

ROLL: 23
FRAME: 10
DATE: 2/ 5/96
SWMU: 25/07D
BY: B. Kemp
TIME: 10:07
DESCRIPTION:
Looking north down at excavation

**PHOTO 7a & 7b**

PHOTO 8

PHOTO 9

PHOTO 10

# APPENDIX B

# CORRESPONDENCE

# APPENDIX B

# CORRESPONDENCE

- Construction Interface Documents (CIDs) and backup (7 pages)
- Inter-Office Correspondence from John Berggren to the file, concerning Explosive Ordinance Buried at Dump Site "A" (2 pages)
- Letter from Robert Brown of Brown Associates to MK's Contract Administrator Willard McCumbers regarding close-out of their contract (1 page).

# CONSTRUCTION INTERFACE DOCUMENTS (CIDS)

# NAVY AND EPA CORRESPONDENCE

# CONSTRUCTION INTERFACE DOCUMENT

| | |
|---|---|
| MORRISON KNUDSEN CORPORATION<br>ENGINEERING, CONSTRUCTION & ENVIRONMENTAL GROUP | DATE: 1/16/96<br>MK CID NO: 034-009 |
| DELIVERY ORDER NO.<br>4324-0024-031-30 | SUBCONTRACT NO.<br>SC-4324-034 |
| ORIGINATOR PROBLEM NO.<br>MK-016 | SUBCONTRACTOR:<br>U.S. Tech Group Inc. |
| TO:<br>Steve Downey | PROJECT DESCRIPTION:<br>NSWC Crane - SWMU #25/07 D |
| FROM:<br>Marvin G. Chidester Jr. | REFERENCE: WORK PLAN/DRAWINGS/SPECIFICATIONS<br>N/A |
| SUBJECT:<br>Excavation and Removal of Special Waste | ATTACHMENTS: YES [X] NO [ ]<br>Dump Sites "A" & "B" Scope of Additional Remediation<br>CID-033-001 |

COPY

**PROBLEM / DEFICIENCY** CLARIFICATION [ ] CHANGE [X] INFORMATION [ ]

CID-033-001 was written to Contract SC-4324-033 for pricing of out of scope work. This work was also issued to another contractor for competitive pricing. The successful pricing contractor is working under Contract SC-4324-034. The original CID has to be replaced or superceeded.

| ADDITIONAL COSTS | SCHEDULE CHANGE | PROPOSAL |
|---|---|---|
| YES [X] NO [ ] | YES [X] NO [ ] | YES [X] NO [ ] |

**RECOMMENDED SOLUTION**

The original CID is attached along with the detailed scope of work. The subcontractor shall price the work described in the scope of work in accordance with the specifications attached. This CID is written to superceed the previously issued CID.

# CONSTRUCTION INTERFACE DOCUMENT

MORRISON KNUDSEN CORPORATION
ENGINEERING, CONSTRUCTION & ENVIRONMENTAL GROUP

DATE: 12/22/95

MK CID NO: 033-001

COPY

| | |
|---|---|
| DELIVERY ORDER NO.<br>4324-0009-007-30 | SUBCONTRACT NO.<br>SC-4324-033 |
| ORIGINATOR PROBLEM NO.<br>MK-011 | SUBCONTRACTOR:<br>R.J. Brown Associates |
| TO:<br>Steve Downey | PROJECT DESCRIPTION:<br>NSWC Crane - SWMU #25/07 D |
| FROM:<br>Marvin G. Chidester Jr. | REFERENCE: WORK PLAN/DRAWINGS/SPECIFICATIONS<br>N/A |
| SUBJECT:<br>Excavation and Removal of Special Waste | ATTACHMENTS: YES [X] NO [ ]<br>Dump Sites "A" & "B" Scope of Additional Remediation |

PROBLEM / DEFICIENCY — CLARIFICATION [ ] CHANGE [X] INFORMATION [ ]

Dump Site "A" has been found to be contaminated with pieces of varing sizes of Transite (asbestos containing material). The contamination levels found do not exceed the TCLP limits.

| ADDITIONAL COSTS | SCHEDULE CHANGE | PROPOSAL |
|---|---|---|
| YES [X] NO [ ] | YES [X] NO [ ] | YES [X] NO [ ] |

RECOMMENDED SOLUTION

An area approximately 100' x 20' will require excavation. The contamination extends to depths of approximately 2'. The removed material will be measured by weight. The total weight of the excavated material to removed and transported to an off-site disposal facility is estimated to be approximately 220 tons. If the sample analysis indicate further contamination, additional excavation may be required prior to backfill. After removal of contaminated material, the resulting hole will be backfilled to the original grade.

# CID DISPOSITION REPORT

MORRISON KNUDSEN CORPORATION
ENGINEERING, CONSTRUCTION & ENVIRONMENTAL GROUP

DATE: 12/22/95

MK CID NO: 033-001

DELIVERY ORDER NO. 4324-0009-007-30

SUBCONTRACT NO. SC-4324-033

ORIGINATOR PROBLEM NO. MK-011

SUBCONTRACTOR: R.J. Brown Associates

## DISPOSITION CATEGORIES

- [ ] Request for Info/Clarification
- [ ] Work Plan Change
- [ ] Design Change (Design Eng. Approval req'd)
- [X] Subcontract Scope Change
- [ ] Delivery Order Scope Change

- [ ] No cost/schedule impact
- [X] Cost/schedule impact
  - [X] Cost increase/decrease
  - [ ] _____ (estimate)
  - [X] Schedule impact: _____ days
  - [X] Engineering estimate attached?
    Yes [ ] No [X]
  - [ ] Requisition # _____

## DETAILED DISPOSITION

Dispositioned by: Date: Title:

## APPROVALS

| | | | |
|---|---|---|---|
| [signature] | 12/22/95 | | |
| MK Project Engineer | Date | MK Contract Admin. Mgr. | Date |
| [signature] | 12-22-95 | | |
| MK Project Manager | Date | MK Program Manager (over $5000) | Date |
| | | | |
| MK Sr. Project Manager (over $5000) | Date | MK Project Controls Manager | Date |
| | | | |
| | | MK Quality Control Manager (Work Plan or Design Changes only) | Date |

# PROPOSAL FOR COMPLETION OF ADDITIONAL REMEDIATION WORK AT SWMU's 25/07D & 26/08D DUMP SITES "A" and "B"

| ITEM # | ITEM DESCRIPTION | QUANTITY | UNITS | UNIT PRICE | TOTAL |
|---|---|---|---|---|---|
| | | | | | |
| | **SWMU #25/07D (Dump Site A)** | | | | |
| 1 | Mobilization/Demobilization | 1 | Lump sum | N/A | |
| 2 | Excavation, transportation, disposal and backfill (Special Waste) | 220 | Tons | | |
| | | | | | |
| | **SWMU #26/08D (Dump Site B)** | | | | |
| 3 | Mobilization/Demobilization | 1 | Lump sum | N/A | |
| 4 | Excavation, transportation, disposal and backfill (Hazardous Waste) | 450 | Tons | | |
| | | | | | |
| | TOTAL PRICE | | | | |

# SWMU's 25/07D and 26/08D
# DUMP SITES "A" & "B"
# SCOPE OF ADDITIONAL REMEDIATION

**SWMU #25/07D**

Dump Site "A" (SWMU #25/07D) is located along the north side of Hwy. 58, west of the Crane Salvage Yard. It has been found to be contaminated with pieces of varying sizes of Transite (asbestos containing material). This material has been determined to be non-friable in its current state. No other contaminants have been found above the TCLP limits. The primary area for removal is approximately 100' X 20' and the contamination extends to depths of approximately 2'. The removed material will be measured by weight. Total weight to be removed and transported to an off-site disposal facility is estimated to be 220 tons. After removal of contaminated material, the resulting hole will be backfilled to the original grade. The backfill material shall be placed in one foot lifts and compacted to 85% relative density. This material will be available from the Crane borrow pit located about five miles from the dump site. There may be a delay of up to two weeks between completion of excavation and approval to backfill to allow for sampling and analysis. If the sample analyses indicate further contamination, additional excavation may be required prior to backfill.

**SWMU #26/08D**

Dump Site "B" (SWMU #26/08D) is located just North of Hwy. 58, east of the Crane Salvage Yard. It has been found to be contaminated with pieces of varying sizes of Transite (asbestos containing material). This material has been determined to be non-friable in its current state. The soil in this area is also considered to be hazardous due to levels of Barium and Lead reported above TCLP limits (analysis results attached). The primary area for removal is approximately 100' X 20' and the contamination extends to depths of approximately 4'. The removed material will be measured by weight. Total weight to be removed and transported to an off-site disposal facility is estimated to be 440 tons. After removal of contaminated material, the resulting hole will be backfilled to the original grade. The backfill material shall be placed in one foot lifts and compacted to 85% relative density. This material will be available from the Crane borrow pit located about six miles from the dump site. There may be a delay of up to two weeks between completion of excavation and approval to backfill to allow for sampling and analysis. If the sample analyses indicate further contamination, additional excavation may be required prior to backfill.

| | SWMU 25/07D | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Compound | Sample Date TCLP Regulatory Level (Mg/L) | 16-Nov | 003 | 16-Nov | 004 | 16-Nov | 005 | 17-Nov | 006 | 17-Nov | 007 |
| 1,1-Dichloroethene / 1,1-Dichloroethylene | .7 | LT | .7 | LT | .7 | LT | .7 | LT | .7 | LT | .7 |
| 1,2-Dichloroethane | 0.5 | LT | 0.5 | LT | 0.5 | LT | 0.5 | LT | 0.5 | LT | 0.5 |
| 1,4-Dichlorobenzene | 7.5 | LT | 7.5 | LT | 7.5 | LT | 7.5 | LT | 7.5 | LT | 7.5 |
| 2,4,5-Trichlorophenol | 400 | LT | 400 | LT | 400 | LT | 400 | LT | 400 | LT | 400 |
| 245TP / Silvex / 2-(2,4,5-Trichlorophenoxy)propion | 1 | LT | 1 | LT | 1 | LT | 1 | LT | 1 | LT | 1 |
| 2,4,6-Trichlorophenol | 2 | LT | 2 | LT | 2 | LT | 2 | LT | 2 | LT | 2 |
| 2,4-Dichlorophenoxyacetic acid / 2,4-D | 10 | LT | 10 | LT | 10 | LT | 10 | LT | 10 | LT | 10 |
| 2,4-Dinitrotoluene | .13 | LT | .13 | LT | .13 | LT | .13 | LT | .13 | LT | .13 |
| Silver | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 |
| Arsenic | 5 | LT | 5 | LT | 5 | LT | 5 | | 6** | LT | 5 |
| Barium | 100 | LT | 100 | LT | 100 | LT | 100 | LT | 100 | LT | 100 |
| Chloroethene / Vinyl chloride | .2 | LT | .2 | LT | .2 | LT | .2 | LT | .2 | LT | .2 |
| Benzene | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 |
| Carbon tetrachloride | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 |
| Cadmium | 1 | LT | 1 | LT | 1 | LT | 1 | LT | 1 | LT | 1 |
| Chloroform | 6 | LT | 6 | LT | 6 | LT | 6 | LT | 6 | LT | 6 |
| Hexachlorobenzene | .13 | LT | .13 | LT | .13 | LT | .13 | LT | .13 | LT | .13 |
| Hexachloroethane | 3 | LT | 3 | LT | 3 | LT | 3 | LT | 3 | LT | 3 |
| Chlorobenzene / Monochlorobenzene | 100 | LT | 100 | LT | 100 | LT | 100 | LT | 100 | LT | 100 |
| Chlordane | .03 | LT | .03** | LT | .03 | LT | .03 | LT | .03 | LT | .03 |
| Chromium | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 |
| *CRESOLS | 200 | LT | 200 | LT | 200 | LT | 200 | LT | 200 | LT | 200 |
| Endrin | .02 | LT | .02 | LT | .02 | LT | .02 | LT | .02 | LT | .02 |
| FLASH POINT | | GT | 203 | GT | 203 | GT | 203 | GT | 203 | GT | 203 |
| Hexachlorobutadiene / Hexachloro-1,3-butadiene | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 |
| Mercury | .2 | LT | .2 | LT | .2 | LT | .2 | LT | .2 | LT | .2 |
| Heptachlor | .008 | LT | .008 | LT | .008 | LT | .008 | LT | .008 | LT | .008 |
| Heptachlor epoxide | .008 | LT | .008 | LT | .008 | LT | .008 | LT | .008 | LT | .008 |
| Lindane / gamma-Benzenehexachloride | .4 | LT | .4 | LT | .4 | LT | .4 | LT | .4 | LT | .4 |
| 2-Butanone / Methyl ethyl ketone | 200 | LT | 200 | LT | 200 | LT | 200 | LT | 200 | LT | 200 |
| Methoxychlor / Methoxy-DDT | 10 | LT | 10 | LT | 10 | LT | 10 | LT | 10 | LT | 10 |
| Nitrobenzene | 2 | LT | 2 | LT | 2 | LT | 2 | LT | 2 | LT | 2 |
| Lead | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 |
| Pentachlorophenol | 100 | LT | 100 | LT | 100 | LT | 100 | LT | 100 | LT | 100 |
| *PH | | | 7.6 | | 8.4 | | 8.6 | | 7.2 | | 7.7 |
| Pyridine | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 | LT | 5 |
| Selenium | 1 | LT | 1 | LT | 1 | LT | 1 | LT | 1 | LT | 1 |
| Tetrachloroethylene / Ankilostin / Ethylene tetrac | .7 | LT | .7 | LT | .7 | LT | .7 | LT | .7 | LT | .7 |
| Trichloroethylene / Algylen / Chlorylen / Gemalgen | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 |
| Toxaphene / Alltox / Chlorinated camphene / Camphe | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 | LT | .5 |

* Maximum TCLP sample analytical results are calculated from total analyses.
** Arsenic TCLP leach results will likely be below 5 Mg/L if leach is performed.
*** Sample did not have a hit, however, reporting limits above limit.

# CONSTRUCTION INTERFACE DOCUMENT

| | |
|---|---|
| MORRISON KNUDSEN CORPORATION<br>ENGINEERING, CONSTRUCTION & ENVIRONMENTAL GROUP | DATE: 2/2/96<br>MK CID NO: 034-011 |
| DELIVERY ORDER NO.<br>4324-0009-007-30 | SUBCONTRACT NO.<br>SC-4324-034 |
| ORIGINATOR PROBLEM NO.<br>MK-018 | SUBCONTRACTOR:<br>U.S. Tech Group, Inc. |
| TO:<br>Steve Downey | PROJECT DESCRIPTION:<br>NSWC Crane - SWMU #25/07 D |
| FROM:<br>Marvin G. Chidester Jr. | REFERENCE: WORK PLAN/DRAWINGS/SPECIFICATIONS<br>N/A |
| SUBJECT:<br>Excavation and Removal of Additional Special Waste | ATTACHMENTS: YES [X] NO [ ]<br>Dump Sites "A" Scope of Additional Remediation |

COPY

**PROBLEM / DEFICIENCY** CLARIFICATION [ ] CHANGE [X] INFORMATION [ ]

The amount of contaminated material will exceed the defined scope of work approved previously. The amount of material which will exceed the scope of work is estimated to be approximately 850 tons. This will bring the total amount of soil requiring removal to approximately 1070 tons.

| ADDITIONAL COSTS | SCHEDULE CHANGE | PROPOSAL |
|---|---|---|
| YES [X] NO [ ] | YES [X] NO [ ] | YES [X] NO [ ] |

**RECOMMENDED SOLUTION**

An area approximately 100' x 15' will require excavation. The contamination extends to depths of approximately 10'. The removed material will be measured by weight. The total weight of the excavated material to removed and transported to an off-site disposal facility is estimated to be approximately 850 tons. If the sample analysis indicate further contamination, additional excavation may be required prior to backfill. After removal of contaminated material, the resulting hole will be backfilled to the original grade.

10.024.C4D00061F
13.050.05F
15.350.03F

RECOMMENDED SOLUTION

# OTHER CORRESPONDENCE

MORRISON KNUDSEN CORPORATION
ENGINEERING, CONSTRUCTION & ENVIRONMENTAL GROUP

INTER-OFFICE CORRESPONDENCE

DATE: June 5, 1995

TO: File

FROM: John Berggren

LOCATION: 4324-0009

LOCATION: 4324-0009; Crane, IN

SUBJECT: EXPLOSIVE ORDNANCE BURIED AT DUMP SITE "A"

The attached sketch was received from Tom Brent, Site Representative NSWC-Crane, today at approximately 1:00PM. The sketch shows the configuration of disposed ordnance buried at Dump Site "A" (SWMU #25) along Highway H-58. The number of pallets is unknown. A detail not shown of the 7.2 P.C. Rocket Heads is that the "rockets" are without "tails." The tails were removed before buried.

File: 11.011.F
10.304.F
18.001.F

| NSWC - CRANE 4324-0009 | | | |
|---|---|---|---|
| PROJECT MEMBER | ACT | INFO | INIT |
| PROJECT MANAGER | | ✓ | |
| PROJECT ENGINEER | | | |
| GNL SUPT | HAS COPY | | |
| SAFETY AND HEALTH | HAS COPY | | |
| QA/QC SUPERVISOR | HAS COPY | | |
| PROJECT CONTROLS | | | MC |
| FIELD ENGINEERING | | | |
| PMO-CHARLESTON | | X | GOT |
| | | | |
| | | | |
| FILE: | | | |
| FILE: | | | |
| FILE: | | | |

PROCEDURE NO. CN-0000-G-241

Dump Site "A", H-58

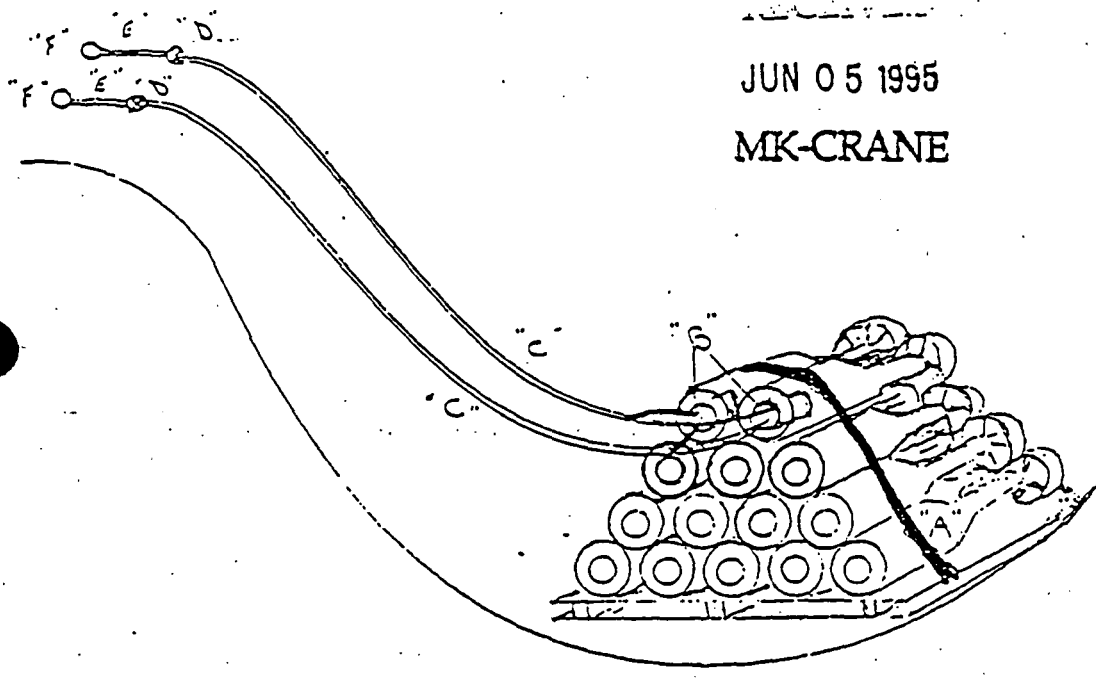
ROUTINE ORDNANCE DETONATION (ROD) ADVISORY PROCEDURE SHEET (RODAPS) SKETCH AND OR PHOTOGRAPH OF HOLE LAYOUT WITH AEDA SHOWN

DET / PRIMACORD TYPE Plastic, Type I, Class E NO. FEET REQ'D. Variable

INITIATING EXPLOSIVES (TYPE) Composition C-4 or equivalent

FUZING USED (TYPE) Time Fuse Plastic Type 3, Class 2 60 sec.; Non-Electric Blasting Caps, Fuse Igniter M2/M60

NET EXPLOSIVE WEIGHT PER SHOT (TOTAL) 426 POUNDS




JUN 05 1995

MK-CRANE

| NSWC - CRANE 4324-0009 | | | |
|---|---|---|---|
| PROJECT MEMBER | ACT | INFO | INIT |
| PROJECT MANAGER | | | |
| PROJECT ENGINEER | | | |
| GNL SUPT | | | |
| SAFETY AND HEALTH | | | |
| QA/CC SUPERVISOR | | | |
| PROJECT CONTROLS | | | |
| FIELD ENGINEERING | | | |
| PMO-CHARLESTON | | | |
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| FILE: | | | |
| FILE: | | | |

A - 7.2 P.C. Rocket Head with tails, 14 heads pyramid stacked and banded to pallet
B - Initiating Explosive - Composition C-4 or equivalent.
C - Detonating cord firing system, dual primed
D - Blasting caps, non-electric
E - Blasting Time Fuse
F - Fuse Igniter, M2/M60

NOTE: Place approximately 1-3 lbs. of C-4 into top 2 rocket heads. Place det cord into eac end of C-4 and pack into the cavity using a wooden dowel rod or equivalent. Cover rocket heads with approxmiately 6-10 feet of dirt prior to installing blasting caps.

BROWN
ASSOCIATES

OILS-LUBRICANTS-CHEMICALS
SALES-RECLAMATION-DISPOSAL

R.J. BROWN ASSOCIATES, INC.
1946 N. 13th ST.-SUITE 437
TOLEDO, OHIO 43624
OFFICE: (419) 244-0010
FAX: (419) 244-0515

RECEIVED
JAN 26 1996
MK-CRANE

January 23, 1996

Morrison Knudsen Corporation
Attn: Willard D. McCumbers
2420 Mall Drive
North Charleston, SC 29406

Reference: Subcontract No., 4324-033
Completion of project at SWMU's #23/00, #25/07D, and 26/08D
NSWC Crane, IN

As a result of the changed conditions at the project sites in Crane, it is our opinion that it would be cost effective to all parties involved to close out the project as complete. There is retainage on the contract primarily for demobilization that needs your consideration.

Any additional work would be handled through a separate line item under the new contract. We acknowledge that closing out this contract is beneficial to us and feel it makes good sense to Morrison Knudsen and the Navy. We trust this action in no way reflects negatively with Morrison Knudsen or the government.

If this is agreeable, we would prefer to complete the minimal remaining requirements of the project. Please advise.

Sincerely,

Robert J. Brown

Robert J. Brown,
President

RJB/sdc

cc: Steve Downey/MK Crane

NSWC - CRANE
4324-0009

| PROJECT MEMBER | ACT | INFO | INST |
|---|---|---|---|
| PROJECT MANAGER | | | |
| PROJECT ENGINEER | | | |
| GNL SUPT | | | |
| SAFETY AND HEALTH | | | |
| QA/QC SUPERVISOR | | | |
| PROJECT CONTROLS | | | |
| FIELD ENGINEERING | | | |
| PMO-CHARLESTON | | | |
| | | | |
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| FILE: | | | |
| FILE: | | | |

# APPENDIX C

# APPROVALS, PERMITS AND REGULATORY INFORMATION

# APPENDIX C

## APPROVALS, PERMITS AND REGULATORY INFORMATION

- Work Plan Approval/Sign-Off page for Solid Waste Management Units #23/00, #25/07D, and #26/08D, Dated: August 25,1995, Revision B (1 page)
- Letter from Brent Robertson to MK, Dated: 30May95, Contract N62467-93-D-1106, Environmental RAC Contract 4324-0009 NSWC-CRANE, Discussing EOD Clearance for the Remedial site (3 pages)
- Letter from MK Project Manager Steven Downey to Jerry Langlois at Jacobs Engineering Tech, Inc., Final Inspection and acceptance Reports D.O. #0009, S.O.W. #007 (4 pages)

# NAVAL SURFACE WARFARE CENTER
# CRANE WORK PLAN

## SOLID WASTE MANAGEMENT UNITS
## #23/00, #25/07D, AND #26/08D

**NSWC CRANE**
**CRANE, INDIANA**

**August 25, 1995**
**Revision B**

**CONTRACT N62467-93-D-1106**
**DELIVERY ORDER #0009**
**STATEMENT OF WORK #0007**

**Prepared by:**


**MORRISON KNUDSEN CORPORATION**
2420 MALL DRIVE
CORPORATE SQUARE 1 - SUITE 211
NORTH CHARLESTON, SOUTH CAROLINA 92406


**APPROVALS:**

| | |
|---|---|
| William Piispanen | 26-Sep-95 |
| MK Safety and Health Program Manager | Date |
| [illegible] | 26-Sep-95 |
| MK Quality Program Manager | Date |
| [illegible] | 26 Sep 95 |
| MK Sr. Project Manager | Date |
| [illegible] | 26 Sept 95 |
| MK Program Manager | Date |

**ACCEPTANCE**

| | |
|---|---|
| [illegible] | 27 Sept 95 |
| U.S. Navy Responsible Authority | Date |

DEPARTMENT OF THE NAVY
OFFICER IN CHARGE OF
NAVAL FACILITIES ENGINEERING COMMAND
CONTRACTS
CRANE DIVISION, NAVAL SURFACE WARFARE CENTER
BUILDING 2516
CRANE, INDIANA 47522-5082

4330
OICC
30 May 95

RECEIVED
MAY 3 1 1995
MK-CRANE

Morrison Knudsen Corp.
CTR 12
NSWC Crane In
Crane, IN 47522

Subj: Contract N62467-93-D-1106, ENVIRONMENTAL RAC CONTRACT
4324-0009 NSWC-CRANE

Encl: NSWC Memo code 067 dtd. 22 May 95.

Gentlemen:

Enclosed is the EOD clearance for the remedial sites as requested. Should you have any questions, please call me at 812-854-3318.

Sincerely,

Brent Robertson
Navy Technical Representative

cc: Caryl Hickel; SDIV Code 0514 w/o enlc.
Jimmy Jones; SDIV Code 18011 w/o encl.
Adrienne Wilson; SDIV Code 1864 w/o encl.
File

| NSWC - CRANE | | | |
|---|---|---|---|
| 4324-0009 | | | |
| PROJECT MEMBER | ACT | INFO | INIT |
| PROJECT MANAGER | | | |
| PROJECT ENGINEER | | | |
| GNL SUPT | | X | |
| SAFETY AND HEALTH | | X | |
| QA/QC SUPERVISOR | | X | |
| PROJECT CONTROLS | | | |
| FIELD ENGINEERING | | | |
| PMO-CHARLESTON | | X | |
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| FILE: 11.011.F | | | |
| FILE: | | | |
| FILE: | | | |

10.302.F
10.304.F
10.305.F
10.306.F
10.307.F

DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
CRANE, INDIANA 47522-5000

IN REPLY REFER TO:
8020
067
22 May 95

MEMORANDUM

From: Explosives Safety Officer
To: Officer in Charge of NAVFAC Contracts

Subj: CONSTRUCTION CONTRACT N62467-93-C-1106, ENVIRONMENTAL RESPONSE ACTION CONTRACT

Ref: (a) OIC for NAVFAC Contracts memo OIC 4330 of 12 May 95

1. In response to reference (a), the following information is provided regarding the known history of the sites making up the various work areas:

a. Lithium Battery Burial Site - This area has no history of ordnance dumping being only a designated land fill for inert materials.

b. PCB Capacitor Burial Site - This dump site is fairly new and no historical information exists to suggest it being used for any dumping except inert materials.

c. Battery Shop - The area and the type of work conducted in the area suggests no involvement with explosive ordnance.

d. Highway 58 Dump site A - The location of this site to ordnance functions may make the presence of "ordnance looking" material possible. In reviewing the way materials were disposed of through the years, there is no strong evidence to suggest live ordnance was "dumped" as opposed to being processed through the Detonation Range. This is so because the Detonation Range has been a viable alternative for the destruction of ordnance materials since 1946. There has been inert (concrete filled) hardware dumped at various sites throughout the years because no other alternative was available. Such hardware as 12.75" warheads (Hedgehog) were found dumped near some of the buildings and used as filler to prevent land erosion. These items caused quite a stir when first uncovered until a check was made as to their make-up and purpose.

e. Highway 58 Dump site B - Same comment as for Dump site A.

f. Dye Burial Ground - Though not much is known about this burial plot, the only evidence that exists illustrates that bulk dye was dumped in open trenches and that hardware (especially containing explosives) was not a factor.

Subj: CONSTRUCTION CONTRACT N62467-93-C-1106, ENVIRONMENTAL RESPONSE ACTION CONTRACT

g. Bioremediation Facility Area - This area was identified because of the land configuration (flat with minimal explosives safety quantity distance controls) and no record exists in this office regarding its use as a dumping ground.

h. Cast High Explosives/Incinerator Building - As a cast high explosives area, the probability of uncovering unexploded ordnance is minimal. As the Incinerator Building, there is a probability that ordnance parts (fuze bodies, small caliber projectiles etc.) can be found in the area surrounding the Building 146 facility.

i. Sludge Drying Beds A & B - There is no risk of unexploded ordnance or ordnance looking hardware being in these two beds.

j. Rockeye - There is no reason to believe unexploded ordnance exists in this area.

k. Ammunition Burning Ground - There is evidence that ordnance looking hardware could be found in this area. Of all the excavation that has been conducted for the purpose of cleaning up ash pits and so on, there has been minimal active explosive material found.

l. Mine Fill A - There is no evidence to suggest that unexploded ordnance was ever dumped in this area.

m. Mine Fill B - Same comment as for Mine Fill B.

2. Point of contact is Dale Groh, Code 067, Building 12, Extension 3601.

D. L. Groh

D. L. GROH

**MORRISON KNUDSEN CORPORATION**
**ENGINEERING, CONSTRUCTION**
**& ENVIRONMENTAL GROUP**

P.O. BOX 408
CRANE VILLAGE, IN 47522
PHONE: (812) 854-6941
FAX: (812)854-6944

31 Jul 96 4324-0009-169

Jerry Langlois
Jacobs Engineering Tech, Inc.
4949 Essen Lane
Baton Rouge, LA 70898

Subject: Final Inspection and Acceptance Reports
D.O. #0009, S.O.W. #007
Contract No. N62467-93-0-1106

Dear Jerry:

For your records and information, enclosed are Final Inspection and Acceptance Reports for SWMUs #16/16, #24/00, and #25/07.

These reports are provided for your use in completing the Interim Measures Report for these SWMUs.

Very truly yours,
**Morrison Knudsen Corporation**

for
Steven T. Downey

STD:jlw

File: 12.082.09.F
12.082.05.F
13.050.07.F

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL AND GOVERNMENT DIVISION

RECEIVED
JUL 12 1996
MK-CRANE

SWMU ACCEPTANCE AND TURNOVER

**DATE:** July 12, 19967

TO: Steven Downey, Proj. Mgr.

**FROM:** W.M. Kemp Jr., QCS

LOCATION: NSWC

LOCATION: NSWC

SUBJECT: Final inspection and acceptance by the ROICC

The final inspection for the Solid Waste Management Unit Interim Measures Cleanup for the physical work completed at SWMU-16/~~00~~ 6 was conducted on 7-11-96. The completed physical work was accepted by the ROICC on 7-11-96 establishing the beneficial date.

MORRISON KNUDSEN CORPORATION

Signature [signature] Date 7-11-96
Signature [signature] Date 7-12-96
Signature _____ Date _____

ROICC

Signature [signature] Date 7/11/96
Signature [signature] Date 7/12/96

The completion and acceptance of the Interim Measures Report will complete this closure at a later date.

cc: Greg Jones PMO
Brent Robertson ROICC
File

| NSWC - CRANE | | | |
|---|---|---|---|
| 4324-0009 | | | |
| PROJECT MENGER | ACT | INFO | INT |
| PROJECT MANAGER | | | 270 |
| PROJECT ENGINEER | | | |
| GNL SUPT | | | |
| SAFETY AND HEALTH | | | |
| DAMCO SUPERVISOR | | | |
| PROJECT CONTROLS | | | |
| FIELD ENGINEERING | | | |
| PMO-CHARLESTON | | X | |
| Jacobs | X | | |
| | | | |
| FILE: 11.096.05 | | | |
| FILE: 12.082.09.05 | | | |
| FILE: 18.900.01.05 | | | |
| 13.050.07.05 | | | |

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL AND GOVERNMENT DIVISION

RECEIVED
JUL 12 1996
MK-CRANE

SWMU ACCEPTANCE AND TURNOVER

DATE: July 12, 19967

TO: Steven Downey, Proj. Mgr.

FROM: W.M. Kemp Jr., QCS

LOCATION: NSWC

LOCATION: NSWC

SUBJECT: Final inspection and acceptance by the ROICC

___The final inspection for the Solid Waste Management Unit Interim Measures Cleanup for the physical work completed at SWMU-24/00 was conducted on 7-11-96. The completed physical work was accepted by the ROICC on 7-11-96 establishing the beneficial date.

MORRISON KNUDSEN CORPORATION

Signature W.M. Kemp Jr. Date 7-11-96
Signature Robert Porto Date 7-12-96
Signature _____ Date _____

ROICC

Signature [illegible] Date 7/11/96
Signature [illegible] Date 7/12/96

The completion and acceptance of the Interim Measures Report will complete this closure at a later date.

cc: Greg Jones PMO
Brent Robertson ROICC
File

NSWC - CRANE
4324-0009

| PROJECT MEMBER | ACT | INFO | INIT |
|---|---|---|---|
| PROJECT MANAGER | | | |
| PROJECT ENGINEER | | | |
| GNL SUPT | | | |
| SAFETY AND HEALTH | | | |
| QA/QC SUPERVISOR | | | |
| PROJECT CONTROLS | | | |
| FIELD ENGINEERING | | | |
| PMO-CHARLESTON | | | |
| Jacobs | | X | |
| | X | | |

FILE: 11.096.05
FILE: 12.092.09
FILE: 12.900.015
13.050.07

RECEIVED
JUL 12 1996
MK-CRANE

# MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL AND GOVERNMENT DIVISION

## SWMU ACCEPTANCE AND TURNOVER

**DATE:** July 12, 19967

TO: Steven Downey, Proj. Mgr.

**FROM:** W.M. Kemp Jr., QCS

LOCATION: NSWC

**LOCATION:** NSWC

SUBJECT: Final inspection and acceptance by the ROICC

____The final inspection for the Solid Waste Management Unit Interim Measures Cleanup for the physical work completed at SWMU-25/~~60~~ 81 was conducted on 7-11-96. The completed physical work was accepted by the ROICC on 7-11-96 establishing the beneficial date.

MORRISON KNUDSEN CORPORATION

Signature W.M. Kemp Date 7-11-96
Signature [illegible] Date 7-12-96
Signature _____ Date _____

ROICC

Signature [illegible] Date 7/11/96
Signature [illegible] Date 7/12/96

The completion and acceptance of the Interim Measures Report will complete this closure at a later date.

cc: Greg Jones PMO
Brent Robertson ROICC
File

| NSWC - CRANE | | | |
|---|---|---|---|
| 4324-0009 | | | |
| PROJECT MEMBER | ACT | INFO | INIT |
| PROJECT MANAGER | | | |
| PROJECT ENGINEER | | | |
| GNL SUPT | | | |
| SAFETY AND HEALTH | | | |
| QA/QC SUPERVISOR | | | |
| PROJECT CONTROLS | | | |
| FIELD ENGINEERING | | | |
| PMO-CHARLESTON | | X | |
| Jacobs | X | | |
| | | | |
| FILE: 11.0916.05 | | | |
| FILE: 12.082.05 | | | |
| FILE: 13.900.01 | | | |
| 13.050.07 | | | |

# APPENDIX B

# DATA QUALITY OBJECTIVES MEETING MINUTES

# DQO Meeting Minutes
# For Development
# Of The UFP-SAP
# For SWMU 25 Highway 58 Dump Site A

Date of Meeting: December 16, 2010 (via teleconference)

Meeting Location: Environmental Office, NSA Crane; Crane, IN and Indianapolis, IN

Attendee/Location: Tom Brent, Crane Environmental / NSA Crane
Doug Griffin, IDEM / IDEM office - Indianapolis, IN
Ralph Basinski, Tetra Tech / NSA Crane
Joe Lucas, Tetra Tech / NSA Crane

Prepared by: Joe Lucas – 412-921-8882, prepared: December 20, 2010

Tetra Tech presented background information and the proposed sampling plans for the SWMU 25 Highway 58 Dump Site A. Given below is a summary of the information and specific issues discussed during the teleconference regarding SWMU 25.

1. Site History:

    - Dump Site A was a disposal area that received paper, roofing tar, porcelain insulators, concrete, pipe, scrap metal, paint thinners and oils. Debris was dumped in two areas: one large area 39 feet by 150 feet and one small area 25 feet by 10 feet.
    - The SWMU has five monitoring wells that were installed in 1982. Four down gradient and one up gradient. Due to a long period of inactivity, these wells will most likely require redevelopment before conducting groundwater sampling. There is no historical analytical data available for groundwater samples collected in 1982. The down gradient wells appear to be located in the same aquifer.
    - Interim Measure action in 1995/1996 removed most debris from the dump site from both areas; however additional debris was discovered in the large area close to the road and was left in place since it may have been used as backfill to support Highway 58. After removal of most debris, confirmation sampling indicated that contaminants were removed below cleanup levels except for arsenic, beryllium, cobalt, and some SVOCs. It was recommended that the SWMU revert back to the RFI process beginning with soil borings near Highway 58 where the additional debris is located and determine the need for further remediation.

2. There was a discussion regarding the metals that were found to be in excess of cleanup levels in the confirmation samples, particularly beryllium, which is not characteristic of metals common to Crane soil. There is no historical information regarding beryllium containing materials that may have been placed in Dump Site A.

3. The sampling plan will include a bias sampling design for soil and groundwater. Eight soil boring locations will be spaced at about 20 foot intervals along the south side of Highway 58 in the location of the original debris left in place. There will be two samples per boring selected from the 0-2 feet bgs range and from the 4-6 feet bgs range. Soil samples will be analyzed for metals and SVOCs.

4. All monitoring wells will be redeveloped and one sample will be collected from each well, including stabilization parameters. Groundwater samples will be analyzed for metals (filtered and un-filtered) and SVOCs. Based on the analytical results, further remediation may be recommended or the site may proceed to NFA.

5. Tetra Tech will submit the draft SAP for simultaneous review to both Navy Crane and the Navy Chemist.

# APPENDIX C

# LABORATORY STANDARD OPERATING PROCEDURES

RTI Laboratories, Inc.
31628 Glendale
Livonia, Michigan 48150

# STANDARD OPERATING PROCEDURE

## ACID DIGESTION OF AQUEOUS SAMPLES FOR THE ANALYSIS OF TOTAL METALS

| | |
|---|---|
| **Analyte:** | **Metals** |
| **SOP #:** | **3020A_091510_R10** |
| **Method Reference:** | **EPA SW846/3020A** |
| **Issue Date:** | **March 11, 1998** |
| **Revision No.:** | **10** |
| **Revision Date:** | **September 15, 2010** |
| **Reviewed Date:** | **September 15, 2010** |

**Reviewed and Approved September 15, 2010 by:**

Director, Quality Management: Charles O'Bryan

Manager, Environmental Services: James Woukila

**The current controlled version of this document resides electronically on the RTI Laboratories, Inc. company server. All forms of this document, hardcopy, electronic or other must be verified as the most recent version prior to any use or reference of the document**

**ACID DIGESTION OF AQUEOUS SAMPLES**
**FOR THE ANALYSIS OF TOTAL METALS**

**SOP#: 3020A_091510_R10**

**TABLE OF CONTENTS**


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| 2.0 | Safety Precautions | 1 |
| 3.0 | Sample Requirements and Sample Handling Procedure | 1 |
| 4.0 | MDL, Linear Range, Accuracy and Precision | 2 |
| 5.0 | Interference's | 2 |
| 6.0 | Apparatus and Materials | 2 |
| 7.0 | Reagents | 3 |
| 8.0 | Preparation of Standards and Calibration Procedure | 3 |
| 9.0 | Sample Preparation | 4 |
| 10.0 | Diagram Table | 6 |
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| 12.0 | Details of Calibration and Calculations | 6 |
| 13.0 | Quality Assurance/Quality Control (QA/QC) Requirements | 6 |
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# 1.0 Scope and Application

## 1.1 Introduction

1.1.1 This SOP details the sample preparation procedures for the acid digestion of aqueous samples for total metals analysis. This SOP applies to all metals except mercury. Following digestion the samples can be analyzed for elements by ICP/MS. For definition of terms not specifically defined in this document refer to RTI QAP Section 16.

## 1.2 Method Summary

1.2.1 An aliquot of a well mixed sample is placed in a digestion tube. Appropriate acids are added and the sample heated until reduced to a low volume. The sample is evaporated to a low volume and diluted to volume with DI water.

1.2.2 Analytical procedures follow the appropriate SOP for the particular element(s) of interest.

# 2.0 Safety Precautions

2.1 Concentrated acids are corrosive. All digestions are performed in a fume hood designated for use with mineral acids. Proper safety equipment is worn when handling concentrated acids. Some metals are toxic and should be handled with care.

# 3.0 Sample Requirements and Sample Handling Procedures

3.1 Samples are received in accordance with RTI Laboratories' Standard Operating Procedure for Sample Receipt and Custody (SRC001-A). Appropriate U.S. Environmental Protection Agency (EPA) sample handling procedures and sample preservation recommendations are followed.

3.1.1 Aqueous samples are collected in pre cleaned plastic bottles preserved with approximately 2.0 ml of 1:1 high purity nitric acid (HNO3):DI water. The pH of the sample is checked on receipt and prior to sample preparation for the presence of adequate preservative. The pH of preserved samples should be < 2. Preserved samples received at pH>2 or at sample preparation are at pH>2 are adjusted to pH<2 with additional acid and held for a minimum of 16 hours until verified to be pH<2.

3.1.2 Samples received for filtration in the laboratory or samples that have been filtered prior to receipt must be preserved and held for 24 hours prior to commencing the sample preparation procedure. The pH is checked prior to analysis.

3.1.3 Samples are refrigerated until ready for analysis.

3.1.4 Maximum sample holding time is six (6) months.

## 4.0 MDL, Linear Range, Accuracy and Precision

4.1 Not applicable. See SOP corresponding to the analytical method of interest.

## 5.0 Interferences

5.1 Diverse matrix types can pose an analytical challenge. Spiked samples should be processed to aid in determining whether this digestion procedure is applicable to the samples.

5.2 All glassware and apparatus should be scrupulously cleaned before use to avoid possible source of contamination.

5.3 Further information concerning potential interference's can be found in the SOP for the particular element(s) of interest.

## 6.0 Apparatus and Materials

6.1 Apparatus

6.1.1 250 ml Griffin Beakers

6.1.2 Watch glasses

6.1.3 Drying oven

6.1.4 Thermometer

6.1.5 Filter paper - Whatman #41 or equivalent

6.1.6 Funnels

6.1.7 Oxford/Eppendorf Pipettes

6.1.8 Graduated Cylinders – Class A

6.1.9 Hot Block

6.1.10 Plastic disposable digestion vessels - 50 ml (manufacturer certified volume)

6.1.11 Plastic watch glasses

6.1.12 Analytical balance - capable of weighing to 0.1 mg with computer interface.

6.1.13 PC with Balancelink software, Microsoft Excel and Omega LIMS.

## 7.0 Reagents

7.1 Deionized Water – Crossbow DI Express, mixed bed. – Type II

7.2 High purity concentrated $HNO_3$. 1:1 solutions are prepared by adding equal volumes of the concentrated acid to DI water.

7.3 High purity concentrated HCL. 1:1 solutions are prepared by adding equal volumes of the concentrated acid to DI water.

7.4 Hydrogen peroxide ($H_2O_2$) 30%, reagent grade.

7.5 1000 ppm Stock Metal Concentrates plasma pure grade.

7.6 All reagents and standards prepared must be labeled with a minimum:

7.6.1 Identity of the material
7.6.2 Concentration of the solution
7.6.3 Date prepared
7.6.4 Initials of analyst preparing the solution
7.6.5 Expiration date.

## 8.0 Calibration Procedure

Pipette calibration procedure - All pipettes are calibrated monthly.

8.1.1 Weigh a weighing boat and record the weight.

8.1.2 Note temperature of the water at time of weighing and enter on the Pipette Calibration Check log.

8.1.3 Draw up the desired volume of water into the pipette.

8.1.4 Deliver the $H_2O$ to the tarred weighing boat.

8.1.5 Weigh the weighing boat containing the water.

8.1.6 Repeat this procedure 10 times for the maximum pipette volume and 5 times for a volume at the mid to low range of the pipette.

8.1.7 Enter result in the log.

8.1.8 Calculation: Volume = mass/density.

8.1.9 The mean of the 10 measurements at the maximum pipette volume must be within 2% of the volume setting. The mean of the 5 measurements at the mid to low range must be within 3% of the pipette setting.

8.2 All spiking solutions for preparation of LCS, MS, MSD are maintained and prepared by the instrumentation analysts. Composition and preparation of spiking solutions is specified in the applicable analytical SOP.

## 9.0 Sample Preparation

9.1 Hot Block Digestion – If silver and/or antimony are part of the analytical request prepare samples as below and using the procedure in section 9.2

9.1.1 Turn on power

9.1.2 Set temperature to 95 +/- 5 degrees C. Check temperature with calibrated thermometer placed in a digestion vessel containing DI water.

9.1.3 Mix sample thoroughly

9.1.4 Transfer a measured volume (50 ml) of a well mixed sample to a 50 ml digestion tube.

9.1.5 Add 1.5 ml concentrated $HNO_3$ and cover with a ribbed watch glass.

9.1.6 Place vessel in the hot block digestor and evaporate to approximately 5 ml.

9.1.6.1 Do not allow the sample to boil or go to dryness

9.1.7 Allow sample to cool.

9.1.8 Add another 1.5 ml of concentrated $HNO_3$.

9.1.9 Cover with watch glass (non ribbed) and increase temperature so that a gentile reflux occurs.

9.1.10 Continue heating and adding additional acid until the digestion is complete as indicated by a digestate that is light in color or does not change appearance with continued refluxing.

9.1.11 When digestion is complete evaporate to a low volume of approximately 3 ml with a ribbed watch glass. Do not allow any of the bottom of the vessel to go dry.

9.1.12 Remove the digestion vessel and add 10 ml of DI water, mix and return to hot block for 10-15 min. to allow additional residue to dissolve.

9.1.13 Wash the walls of the vessel with a small amount of DI water

9.1.13 Bring sample to final volume (50 ml) with DI water and mix.

9.1.14 Allow to settle overnight or centrifuge if samples will be analyzed sooner.

9.1.15 If suspended particulates are present filter sample through Whatman filter (6.1.6).

9.2 Hot Block Digestion – For silver and antimony. Based on the procedures specified in Method 200.8 (3020A does not adequately address the optimization of Ag and Sb recovery).

Modifications to the 200.8 procedure include:

- Use of 10 ml of 1:1 HCl/DI water based on laboratory studies that demonstrated optimal recoveries of matrix spike sample with the excess of HCl in the digestion procedure.
- Use of 25 ml sample size to accommodate digestion vessels and ensure adequate volume of HCl for samples.

9.2.1 Turn on power

9.2.2 Set temperature to 95 +/- 5 degrees C.

9.2.3 Mix sample thoroughly

9.2.4 Transfer a measured volume (25 ml) to a digestion tube.

9.2.5 Add 10 ml of 1:1 HCl/DI water and 1 ml of 1:1 HNO3/DI water. Cover with a ribbed watch glass.

9.2.6 Place vessel in the hot block and evaporate to approximately 10 ml (approximately 2 hours).

9.2.6.1 Do not allow the sample to boil or go to dryness

9.2.6.2 After the sample reaches approximately 10 ml cover with a watch glass and gently reflux for 30 min.

9.2.7 Allow sample to cool.

9.2.8 Bring sample to final volume (25 ml) with DI water and mix.

9.2.9 Allow to settle overnight or centrifuge if samples will be analyzed sooner.

9.2.10 If suspended particulates are present filter sample through Whatman filter (6.1.6)

## 10.0 Diagram/Table

10.1 Reserved

## 11.0 Analytical Procedure

11.1 See SOP corresponding to the analytical method of interest.

## 12.0 Details of Calibration and Calculations

12.1 Not applicable to this SOP.

## 13.0 Quality Assurance/Quality Control (QA/QC) Requirements

13.1 The following quality control samples are prepared with each batch of samples.

13.1.1 Method Blank

13.1.2 Matrix Spike – prepared at a frequency of not less than 10% (2 per batch of 20 samples.

13.1.3 Matrix Spike Duplicate – prepared at a 5% frequency (1 per batch of 20 samples).

13.1.4 Duplicate Sample – prepared if specified in the project quality assurance plan at the frequency required

13.1.5 Laboratory control sample

13.2 Consult with appropriate SOP for spike concentration for the individual elements.

13.3 Preparation batch information is entered into the Omega LIMS.

13.4 Digestion temperature and Spike ID information in entered in the sample preparation logbook.

## 14.0 Data Reporting Requirements

14.1 Not applicable to this SOP.

## 15.0 Preventative Maintenance and Routine Cleaning

15.1 Inspect all glassware for cracks or abrasions. Discard damaged glassware.

15.2 Clean preparation area daily.

15.3 Keep surfaces clean.

15.4 Monitor fume hood for proper face velocity quarterly and record.

## 16.0 Pollution Prevention and Waste Management

16.1 Pollution Prevention

16.1.1 Reagents are purchased and quantities used to reflect anticipated usage and minimize disposal of expired or unused chemicals.

16.1.2 Chemicals are handled in a manner that minimizes the potential for release or spill of the material.

16.2 Waste Management

16.2.1 Acidic materials (pH<2) are treated as hazardous waste and placed in the appropriate waste drum for disposal.

16.2.2 Soil samples are composited in a drum designated for incineration.

16.2.3 Disposal of materials is addressed in the laboratory QAP (Section 5.6).

## 17.0 References

17.1 EPA Test Method for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods. Method 3020A Revision 1. July 1992.

17.2 EPA Method 200.8. Determination of Trace Elements in Water and Wastes by Inductively Coupled Plasma – Mass Spectrometry. Revision 5.4. 1994.

17.2 RTI Laboratories, Inc. Quality Assurance Plan.

17.4 RTI Laboratories, Inc. SOP SRC001-A, Sample Receipt and Custody.

17.5 RTI Laboratories, Inc. Chemical Hygiene Plan.

17.6 RTI Laboratories, Inc. Employee Handbook.

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# STANDARD OPERATING PROCEDURE

## ACID DIGESTION OF SOLID SAMPLES FOR THE ANALYSIS OF TOTAL METALS

| | |
|---|---|
| **Analyte:** | **Metals** |
| **SOP #:** | **3050_091410_R9** |
| **Method Reference:** | **EPA SW846/3050B** |
| **Issue Date:** | **March 11, 1998** |
| **Revision No.:** | **9** |
| **Revision Date:** | **September 14, 2010** |
| **Reviewed Date:** | **September 14, 2010** |

**Reviewed and Approved: September 14, 2010**

Director, Quality Management: Charles O'Bryan

Manager, Environmental Services: James Woukila

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**ACID DIGESTION OF SOLID SAMPLES**
**FOR THE ANALYSIS OF TOTAL METALS**

**SOP#: 3050_091410_R9**

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# 1.0 Scope and Application

## 1.1 Introduction

1.1.1 This SOP details the sample preparation procedures for the acid digestion of solid/soil samples for total metals analysis. This SOP applies to all metals except mercury. Following digestion the samples can be analyzed for elements by ICP/MS. For definition of terms not specifically defined in this document refer to RTI QAP Section 16.

## 1.2 Method Summary

1.2.1 A representative 1-2 g aliquot of sample is digested with repeated addition of nitric acid and hydrogen peroxide. Hydrochloric acid is added to samples requiring analysis for antimony and/or silver. The digestate is reduced in volume while heating, diluted to volume with DI water and filtered.

1.2.2 Analytical procedures follow the appropriate SOP for the particular element(s) of interest. A procedure for preparing samples for the analysis of lead in fine and coarse fractions is detailed in Section 9.

# 2.0 Safety Precautions

2.1 Concentrated acids are corrosive. All digestions are performed in a fume hood designated for use with mineral acids. Proper safety equipment is worn when handling concentrated acids. Some metals are toxic and should be handled with care.

# 3.0 Sample Requirements and Sample Handling Procedures

3.1 Samples are received in accordance with RTI Laboratories' Standard Operating Procedure for Sample Log-in. Appropriate U.S. Environmental Protection Agency (EPA) sample handling procedures and sample preservation recommendations are followed.

3.1.1 Solid samples are collected in pre cleaned 4-8 oz. wide mouth glass jars.

3.1.2 Samples are refrigerated until ready for analysis.

3.1.3 Holding time for samples is 180 days from collection.

3.1.4 Minimum sample volume – 50 g.

## 4.0 MDL, Linear Range, Accuracy and Precision

4.1 Not applicable. See SOP corresponding to the analytical method of interest.

## 5.0 Interferences

5.1 Diverse matrix types can pose an analytical challenge. Spiked samples should be processed to aid in determining whether this digestion procedure is applicable to the samples.

5.2 All glassware and apparatus should be scrupulously cleaned before use to avoid possible source of contamination.

5.3 Further information concerning potential interference's can be found in the SOP for the particular element(s) of interest.

## 6.0 Apparatus and Materials

6.1 Apparatus

6.1.1 250 ml Griffin Beakers

6.1.2 Watch glasses

6.1.3 Drying oven

6.1.4 Thermometer

6.1.5 Hot Plates

6.1.6 Filter paper - Whatman #41 or equivalent

6.1.7 Funnels

6.1.8 Oxford/Eppendorf Pipettes

6.1.9 Graduated Cylinders – Class A

6.1.10 Hot Block

6.1.11 Plastic disposable digestion vessels - 50 ml (manufacturer certified volume)

6.1.12 Plastic watch glasses

6.1.13 Aluminum weighing dishes.

6.1.14 Glass beakers.

6.1.15 Sieves (stainless steel) 10 mesh (2 mm) and 60 mesh (250 micron)

6.1.16 Mortar and pestle

6.1.17 Analytical balance - capable of weighing to 0.1 mg with computer interface.

6.1.18 PC with Balancelink software, Microsoft Excel and Omega LIMS.

## 7.0 Reagents

7.1 Deionized Water – Crossbow DI Express, mixed bed. – Type II

7.2 High purity concentrated $HNO_3$. 1:1 solutions are prepared by adding equal volumes of the concentrated acid to DI water.

7.3 High purity concentrated HCL. 1:1 solutions are prepared by adding equal volumes of the concentrated acid to DI water.

7.4 Hydrogen peroxide ($H_2O_2$) 30%, reagent grade.

7.5 1000 ppm Stock Metal Concentrates plasma pure grade.

7.6 All reagents and standards prepared must be labeled with a minimum:

7.6.1 Identity of the material
7.6.2 Concentration of the solution
7.6.3 Date prepared
7.6.4 Initials of analyst preparing the solution
7.6.5 Expiration date.

## 8.0 Calibration Procedure

8.1 Pipette calibration procedure - All pipettes are calibrated monthly.

8.1.1 Weigh a weighing boat and record the weight.

8.1.2 Note temperature of the water at time of weighing and enter on the Pipette Calibration Check log.

8.1.3 Draw up the desired volume of water into the pipette.

8.1.4 Deliver the $H_2O$ to the tarred weighing boat.

8.1.5 Weigh the weighing boat containing the water.

8.1.6 Repeat this procedure 10 times for the maximum pipette volume and 5 times for a volume at the mid to low range of the pipette.

8.1.7 Enter result in the log.

8.1.8 Calculation: Volume = mass/density.

8.1.9 The mean of the 10 measurements at the maximum pipette volume must be within 2% of the volume setting. The mean of the 5 measurements at the mid to low range must be within 3% of the pipette setting.

8.2 All spiking solutions for preparation of LCS, MS, MSD are maintained and prepared by the instrumentation analysts. Composition and preparation of spiking solutions is specified in the applicable analytical SOP.

## 9.0 Sample Preparation

9.1 Hot Block Digestion – Samples not requiring the analysis of silver and antimony.

9.1.1 Turn on power

9.1.2 Set temperature to 95 +/- 5$^{o}$C. Check temperature with calibrated thermometer placed in a digestion vessel containing DI water.

9.1.3 Mix sample thoroughly to achieve homogeneity and sieve if necessary through a #10 sieve.

9.1.3.1 Transfer the entire contents of the sample container to a glass beaker.

9.1.3.2 Mix sample thoroughly with a wooded tongue depressor.

9.1.3.3 If materials such as sticks, leaves, rocks, etc. are present sieve the sample with a #10 sieve.

9.1.4 Transfer 1-2 g of the as received sample weighed to 0.01 g and place in a digestion vessel. For samples requiring analysis on dried basis prepare according to the SOP for Sub_Sampling, take a 1g aliquot and proceed with Sec 9.1.5.

9.1.5 Add 10 ml of 1:1 $HNO_3$, mix and cover with a ribbed watch glass.

9.1.6 Place sample in the hot block and heat at 95 +/- 5 $^oC$ for 10-15 minutes without boiling.

9.1.6.1 Allow the sample to cool and add 5 ml concentrated nitric acid.

9.1.6.2 Replace the cover and reflux for 30 minutes concentrating the sample to approximately 5 ml. If brown fume are generated repeat the addition of 5 ml concentrated nitric acid over and over until no brown fumes are observed

9.1.6.3 Continue heating at 95±5 degrees C for two hours or until the volume is reduced to approximately 5 ml. Do not allow to boil and maintain a covering of solution over the bottom of the vessel at all times.

9.1.6.4 Allow the sample to cool and add 2 ml DI water and 3 ml 30% hydrogen peroxide.

9.1.6.5 Cover and heat (the peroxide reaction will commence and be evident by effervescence).

9.1.6.6 Continue to add $H_2O_2$ in 1 ml aliquots until the effervescence is minimal to a maximum of 10 ml added to the sample.

9.1.6.7 Cover and continue heating without boiling at 95±5 degrees C until the volume has been reduced to approximately 5 ml or two hours. Maintain a covering of solution on the bottom of the digestion tube at all times.

9.1.7 Allow sample to cool.

9.1.8 Wash the walls of the beaker with a small amount of DI water

9.1.9 Bring sample to a final volume of 50 ml in a digestion vessel (accuracy 50 ml +/- 0.2ml – 0.4%) with DI water and mix.

9.1.10 Allow to settle overnight or centrifuge if samples will be analyzed sooner.

9.1.10 Filter sample through Whatman filter (6.1.6)

9.2 Hot Block Digestion – Samples requiring the analysis of silver and antimony.

9.2.1 Turn on power

9.2.2 Set temperature to 95 +/- 5$^{o}$C

9.2.3 Prepare samples according to Sec. 9.1.3 and 9.1.4 above.

9.2.4 Add 10 ml of concentrated HCl and 2.5 ml of concentrated $HNO_3$, mix and cover with a ribbed watch glass.

9.2.5 Place sample in the hot block and heat at 95 +/- 5 $^{o}$C for 10-15 minutes without boiling. Temperature must be verified using a calibrated thermometer.

9.2.5.1 Reflux for 30 minutes concentrating the sample to approximately 5 ml.

9.2.5.2 Remove from hot block and allow the sample to cool.

9.2.6 Wash the walls of the beaker with a small amount of DI water

9.2.7 Bring sample to a final volume of 50 ml with DI water using the graduated hot block digestion vessels (manufacturer certified volume) and mix.

9.2.8 Allow to settle overnight or centrifuge if samples will be analyzed sooner.

9.2.8 Filter sample through Whatman filter (6.1.6)

9.3 Procedure for the preparation of samples for Fine and Coarse Lead.

9.3.1 Remove large objects such as rocks, twigs, vegetation, etc.

9.3.2 Mix samples and sieve through a No 10 mesh (2 mm) sieve.

9.3.3 Homogenize the sample by mixing with a spatula (manually break up large soil clumps if necessary).

9.3.4 Weigh and record the weight of a numbered aluminum weighing dish.

9.3.5 Transfer approximately 20 g of the well mixed sample (50-100 g if high moisture content - >35%) to a clean, tared, labeled weighing dish.

9.3.6 Weigh and record the weight of the dish containing the sample.

9.3.7 Dry the sample at 105 degrees C +/-2 in a drying oven for 24 hours +/- 2.

9.3.8 Remove from the oven and place in a dessicator to cool for at least 1 hour.

9.3.9 Weigh and record the weight of the dish containing the dried sample.

9.3.10 Sieve the sample through a 60 mesh (250 micron) sieve using a mechanical shaker for 10 minutes.

9.3.11 Weigh and record the sieved portion of the sample.

9.3.12 Grind the sample with a mortar and pestle and place in a labeled plastic container. This portion of the sample represents the Fine Soil Fraction.

9.3.13 Weigh and record the portion of the sample that did not pass through the sieve.

9.3.14 Grind the sample with a mortar and pestle and place in a labeled plastic container. This portion of the sample represents the Coarse Soil Fraction.

9.3.15 Digest samples according to procedure specified in Section 9.1 above.

## 10.0 Diagram/Table

10.1 Reserved

## 11.0 Analytical Procedure

11.1 See SOP corresponding to the analytical method of interest.

## 12.0 Details of Calibration and Calculations

12.1 Calculate the percent solids as

% Total Solids = DWt/WWt x 100

DWt = weight of sample after drying at 105 deg. C
WWt = weight of sample prior to drying.

12.2 Calculation of Total Lead.

Total Lead (ug/Kg) = ((FF x WtF) + (CF x WtC)) / (WtF + WtC)

FF = Lead concentration (ug/Kg) in Fine Fraction
CF = Lead concentration (ug/Kg) in Coarse Fraction
WtF = Weight of Fine Fraction (Sec 9.4.11)
WtC = Weight of Coarse Fraction (Sec 9.4.13)

## 13.0 Quality Assurance/Quality Control (QA/QC) Requirements

13.1 The following quality control samples are prepared with each batch of samples.

13.1.1 Method Blank

13.1.2 Matrix Spike – prepared at a frequency of not less than 5% (1 per batch of 20 samples) by spiking a solid samples chosen from the batch of samples.

13.1.3 Matrix Spike Duplicate – prepared at a 5% frequency (1 per batch of 20 samples) .by again spiking the sample chosen above.

13.1.4 Duplicate Sample – prepared if specified in project quality assurance plan, at the frequency required.

13.1.5 Laboratory control sample prepared by spiking DI water.

13.1.6 SRM – Standard Reference Material. Required for analysis of Fine/Coarse lead.

13.2 Consult with appropriate SOP for spike concentration for the individual elements.

13.3 Preparation batch information is entered into the Omega LIMS including digestion temperature and spike ID information.

## 14.0 Data Reporting Requirements

14.1 Samples are reported on a dry weight basis. A percent moisture determination is performed and entered into the LIMS. Data calculations for dry weight reporting of the sample results are performed by the LIMS following analytical data entry. Refer to the analytical SOP for calculations and reporting specifications.

## 15.0 Preventative Maintenance and Routine Cleaning

15.1 Inspect all glassware for cracks or abrasions. Discard damaged glassware.

15.2 Clean preparation area daily.

15.3 Keep surfaces clean.

15.4 Monitor fume hood for proper face velocity quarterly and record.

## 16.0 Pollution Prevention and Waste Management

16.1 Pollution Prevention

16.1.1 Reagents are purchased and quantities used to reflect anticipated usage and minimize disposal of expired or unused chemicals.

16.1.2 Chemicals are handled in a manner that minimizes the potential for release or spill of the material.

16.2 Waste Management

16.2.1 Acidic materials (pH<2) are treated as hazardous waste and placed in the appropriate waste drum for disposal.

16.2.2 Soil samples are composited in a drum designated for incineration.

16.2.3 Disposal of materials is addressed in the laboratory QAP (Section 5.6).

## 17.0 References

17.1 EPA Test Method for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods. Method 3050B Revision 2. Dec. 1996.

17.2 RTI Laboratories, Inc. Quality Assurance Plan.

17.3 RTI Laboratories, Inc. SOP SRC001-A, Sample Receipt and Custody.

17.4 RTI Laboratories, Inc. Chemical Hygiene Plan.

17.5 RTI Laboratories, Inc. Employee Handbook.

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STANDARD OPERATING PROCEDURE

# LIQUID-LIQUID EXTRACTION PROCEDURE FOR SEMI – VOLATILE ORGAINC COMPOUNDS

| | |
|---|---|
| Analyte: | Semi-volatile organic compounds |
| SOP #: | 3510C_110909_R7 |
| Method Reference: | SW-846 3510C |
| Issue Date: | August 15, 2005 |
| Revision No.: | 7 |
| Revision Date: | November 9, 2009 |
| Reviewed Date: | November 9, 2009 |

Reviewed and Approved November 9, 2009 by:

Director, Quality Management: Charles O'Bryan

Manager, Environmental Services: James Wuokila

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# LIQUID-LIQUID EXTRACTION PROCEDURE FOR SEMI – VOLATILE ORGAINC COMPOUNDS

SOP#: 3510C_110909_R7

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## 1.0 Scope and Application:

### 1.1 Introduction

RTI Laboratories, Inc, has prepared this document to detail the Standard Operating Procedure (SOP) for the preparation of aqueous samples for the analysis of semi-volatile compounds by gas chromatography/mass spectrometry, pesticides and PCB's by GC/ECD, PNA's by HPLC and DRO by GC/FID. This SOP contains the procedures for manual liquid-liquid extraction (Method 3510C) for aqueous samples.

A detailed description of the instrumentation, calibration, run parameters and quality control procedures for analyses are not included in this SOP. For definition of terms not specifically defined in this document refer to RTI QAP Section 16.

### 1.2 Summary of Method

1.2.1 A measured aliquot of a sample is added to a separatory funnel. The solvent appropriate to the analysis, surrogates and spikes (where applicable) are added and shaken. The solvent extract is removed and dried with sodium sulfate. The procedure is repeated twice and the final extract is concentrated to the desired volume. This method has been modified to use 50mL aliquots instead of 60mL aliquots of extraction solvent.

## 2.0 Safety Precautions

2.1 Compounds applicable to this method are known or suspected carcinogens. Standard preparation is conducted in fume hoods designated for organic use.

2.2 Extraction solvents are flammable and/or toxic and must be handled with caution. All extractions are performed in a manner designed to minimize exposure to these chemicals using appropriate hoods and personal protection.

2.3 Sulfuric acid is extremely corrosive, poisonous and may cause severe burns to the skin and eyes. Always use with appropriate personal protective equipment.

2.4 Sodium hydroxide is extremely caustic, poisonous and a severe eye and skin irritant. Always use with appropriate personal protective equipment.

## 3.0 Sample Requirements and Sample Handling Procedures

3.1 Samples are received in accordance with RTI Laboratories' Standard Operating Procedure for sample receipt. Appropriate U. S. Environmental Protection Agency (EPA) sample handling procedures and sample preservation recommendations are followed. Water samples are received in pre-cleaned one-liter amber glass jars with Teflon lined lids.

3.1.2 For PCB water samples covered under USEPA method 608, the holding time is 1 year. For all other analytes covered in this SOP, the holding time for water samples is 7 days from collection to extraction and 40 days from extraction to analysis.

3.1.3 All samples are stored at $4^{o}$ C in the walk-in cooler.

3.1.4 All sample extracts are stored in a designated freezer.

3.1.5 Recommended minimum sample volume – 1 L.

## 4.0 MDL, Linear Range, Accuracy and Precision

4.1 Not applicable to this SOP. See the appropriate analytical SOP for details.

## 5.0 Interferences

5.1 Interferences can arise from carry over due to high sample concentrations or contamination from reagents and/or glassware. Blanks are analyzed to ensure system cleanliness in both instances. All glassware must be scrupulously cleaned before use. Phthalates are common lab contaminants and will leach from any soft plastic material used during sampling or sample preparation.

5.2 Samples containing high concentrations of non-target analytes or extremely high levels of select target analytes can result in elevated detection limits for some or all compounds. Dilution of the extract may improve the resolution and quantification of some analytes but will generally cause an elevation in the RDL. Interferences from high molecular weight organics such as oils will cause an elevated baseline. If this background is at a high concentration it will interfere with analyte identification as well as quantification.

5.3 Sample extract interferences can be cleaned up using techniques described in the SOP for sample extract cleanup (florisil cleanup, acid cleanup, sulfur cleanup or dilution (3610B, 3611A, 3620B, 3630C, 3650B, 3660B). Dilution of the extract can also be used to minimize interferences.

## 6.0 Apparatus and Materials

6.1 Analytical Balance capable of weighing to 0.1 gm.

6.2 Glass or Teflon Funnels

6.3 pH indicator paper

6.4 Test strips for residual chlorine.

6.5 Graduated cylinders. 1000mL and 100mL

6.6 Glass beakers, 250 mL size.

6.7 Separatory funnels – 2 liter glass with teflon or glass stoppers.

6.8 Microliter syringes, 50ul, 10 ul, 25ul, 1000µl, 5000µl.

6.9 Volumetric glassware

6.10 Glass vials – 2mL with Teflon lined screw caps.

6.11 Pyrex glass wool

6.12 Pasteur pipettes

6.13 TurboVap II evaporator – Zymark

6.14 200mL concentrators tubes with a 1.0mL graduated tip- available through Caliper

6.15 Mechanical shaker, Glas-Col

## 7.0 Reagents

7.1 Anhydrous sodium sulfate; cleaned and dried by muffle furnace at 400$^{o}$C for 4 hours.

7.2 Acidified anhydrous sodium sulfate- Acidify by mixing 1000 g sodium sulfate with enough diethyl ether to just cover the solid; then add 1.0 mL of concentrated sulfuric acid and mix thoroughly. Remove the ether by air drying. Mix 1 g of the resulting solid with 5 mL of organic-free reagent water and measure the pH of the mixture. It must be below a pH of 4.

7.3 Methylene chloride – pesticide grade

7.4 Hexane – pesticide grade

7.5 Acetone – pesticide grade

7.6 Sulfuric acid, concentrated – reagent grade.

7.7 1:1 Sulfuric acid: slowly add 500mL of concentrated sulfuric acid (7.6) to 500mL ASTM Type II DI water (7.8) while mixing. CAUTION! Adding sulfuric acid to water generates a significant amount of heat. Add ~100mL of acid at a time, allowing the solution to cool before adding the next volume of acid.

7.8 ASTM Type II DI water.

7.9 Reagent water and soap for cleaning, as well as acetone for rinsing.

7.10 Sodium hydroxide – reagent grade

7.11 Sodium hydroxide solution: 10N – prepared by dissolving 100 g of NaOH in 250 mL DI water.

7.12 Nitrogen gas from a liquid nitrogen dewar – for Turbovap.

7.13 Acetonitrile – HPLC grade or better.

7.14 Stock Standards

7.14.1 8270 BNA Surrogate Standard Mix, 4000µg/mL, Ultra Scientific
7.14.2 8270 LCS Mix, 200µg/mL, Cerilliant
7.14.3 Pesticide Surrogate Standard, 200µg/mL, Ultra Scientific
7.14.4 Method 8082 Calibration Mix, 1000µg/mL, Ultra Scientific
7.14.5 *p*-Terphenyl-$d_{14}$ solution, 2000µg/mL, Ultra Scientific
7.14.6 PAH Mixture (16 analytes), 500µg/mL, Ultra Scientific
7.14.7 Acenaphthalene solution, 5000µg/mL, Ultra Scientific
7.14.8 Acenaphthylene solution, 5000µg/mL, Ultra Scientific
7.14.9 Naphthalene solution, 5000µg/mL, Ultra Scientific
7.14.10 2-Methylnaphthalene, 98.5%, Sigma-Aldrich Company
7.14.11 Organochlorine pesticide mix, 2000µg/mL, Ultra Scientific

7.15 Intermediate Standards

7.15.1 10mg/mL 2-Methylnaphthalene: weigh 0.1000g of 2-methylnaphthalene (7.14.10) into a 10mL class "A" volumetric flask containing approximately 8mL methylene chloride. Mix until completely dissolved and dilute to the mark with methylene chloride and invert several times.

7.15.2 Pesticide Intermediate standard: add 50µL organochlorine pesticide mix (7.14.11) to a class "A" volumetric flask containing approximately 8mL hexane. Dilute to the mark with hexane and invert several times.

7.16 SVOC working standards. All solutions have a 6 month expiration date.

7.16.1 BNAE Surrogate spiking solution, 250µg/mL

Add 1.56mL 8270 BNA Surrogate Standard Mix (7.14.1) to a class "A" 25mL volumetric flask containing approximately 20mL acetone. Dilute to the mark with acetone and invert several times. Add 100µL to each sample and QC sample (25ug/extract).

7.16.2 BNAE MS/MSD/LCS spike mix 200µg/mL

8270 LCS Mix (7.14.2) used as received. Add 100µL to each QC sample (LCS, LCSD, MS, MSD).

7.16.3 PCB/Pesticide Surrogate spiking solution, 100ng/mL

Add 0.05mL Pesticide Surrogate Standard (7.14.3) to a class "A" 100mL volumetric flask containing approximately 90mL acetone. Dilute to the mark with acetone and invert several times. Add 1.0mL to each sample and QC sample.

7.16.4 PCB Spike solution, 500ng/mL

Add 0.05mL Method 8082 Calibration Mix (7.14.4) to a class "A" 100mL volumetric flask containing approximately 90mL acetone. Dilute to the mark with acetone and invert several times. Add 1.0mL to each QC sample (LCS, LCSD, MS, MSD).

7.16.5 PNA Surrogate solution, 5µg/mL

Add 0.25mL *p*-Terphenyl-$d_{14}$ (7.14.5) to a class "A" 100mL volumetric flask containing approximately 90mL acetone. Dilute to the mark with acetone and invert several times. Add 1.0mL to each sample and QC sample.

7.16.6 PNA Spike solution, various concentrations

Add 0.1mL PAH Mixture (7.14.6), 0.09mL Acenapthalene solution (7.14.7), 0.09mL Acenaphthylene solution (7.14.8), 0.09mL Naphthalene solution (7.14.9) and 0.0275mL 10mg/mL 2-Methylnaphthalene intermediate solution (7.15.1) to a class "A" 20mL volumetric flask containing approximately 15mL acetone. Dilute to the mark with acetone and invert several times. Add 1.0mL to each QC sample (LCS, LCSD, MS, MSD).

7.16.7 Pesticide Spike solution, 100ng/mL

Add 0.25mL Pesticide Intermediate standard (7.15.2) to a class "A" 25mL volumetric flask containing approximately 15mL acetone. Dilute to the mark with acetone and invert several times. Add 1.0mL to each QC sample (LCS, LCSD, MS, MSD).

Technical chlordane and toxaphene are not routinely part of the pesticide spike mixes.

7.17 All reagents and standards prepared must be labeled with a minimum:

7.17.1 Identity of the material
7.17.2 Concentration of the solution
7.17.3 Date prepared
7.17.4 Initials of analyst preparing the solution
7.17.5 Expiration date.

## 8.0 Preparation of Standards and Calibration Procedure

8.1 Not applicable to this SOP.

## 9.0 Sample Preparation

9.1 Allow samples to warm to ambient temperature.

9.2 With each batch of samples prepare a method blank, LCS and LCS duplicate (LCSD – if insufficient volume for MS/MSD) by adding spiking solution specified for analytical request (section 7). If sufficient volume is supplied a MS/MSD (spiked according to section 7) is prepared with the batch of samples.

9.3 For Pesticide samples check the pH. If the pH is not within 5-9 adjust to within this range using 1:1 H2SO4 or 10N NaOH. Record the pH of the sample at the time of extraction.

9.4 Add the appropriate amount of surrogate and/or spike mix (Sec. 7) directly to the sample in the container (or measuring device, such as a graduated cylinder) for the analytical request to each sample.

9.5 Mark the meniscus of the sample on the outside of the sample jar for later determination of sample volume. If the sample is a wastewater mix thoroughly and pour the entire contents of the liquid sample into the separatory funnel. If the sample is a ground water decant the liquid from the sample container into a graduated cylinder. Samples must be quantitatively transferred to the funnel by rinsing the sample container with the solvent used for extraction.

9.6 For BNA samples check the pH and adjust to the appropriate pH level for the class of compounds to be extracted using a minimum amount of acid or base.

9.6.1 Basic compounds = >10 with 10N NaOH.
9.6.2 Acidic compounds = <2 with 1:1 $H_2SO_4$.
9.6.3 Record the pH at the time of extraction.

9.7 Add 60 mL of methylene chloride to the original sample jar. Swirl the solvent in the jar for about a minute. Pour this solvent into the separatory funnel containing the aqueous sample. Be careful not to rinse a plastic lid with methylene chloride, as this may extract phthalates.

9.8 Place stopper on the funnel. If the separatory funnel is shaken by hand, shake vigorously for 2 minutes. If the mechanical shaker is used, place the separatory funnel in the shaker. The separatory funnels are then shaken for 5 minutes at 130rpm.

9.9 Allow the organic layer to separate for at least ten minutes and collect the solvent in a flask. If an emulsion forms that is greater than one third the size of the solvent layer mechanical means must be employed to achieve phase separation including stirring, filtration through glass wool, centrifugation or other physical techniques. If a least 80% of the solvent cannot be recovered using the procedures above the sample, solvent and emulsion are transferred to the extraction vessel of the continuous liquid-liquid extractor. Extraction will proceed according to the SOP for Method 3520.

9.10 Add 60 mL methylene chloride to the separatory funnel and repeat 9.7 and 9.8 two additional times combining the three extracts.

9.11 Repeat 9.7 through 9.10 for each of the classes of compounds desired, acidic or basic or neutral compounds.

9.12 If sample extract contains large amounts of water, using a pipette, remove as much water as possible without removing solvent, before filtering.

9.13 Slowly add a minimum amount of sodium sulfate to the flask. For the acid extractable fraction (if needed), only use the acidified sodium sulfate for drying. After the extract is dried, it may be combined with the other dried extract fractions.

9.14 Pour the extracts through a funnel containing filter paper and approximately ½ inch of sodium sulfate (For the acid extractable fraction (if needed), only use the acidified sodium sulfate for drying.) and collect in a TurboVap vessel.

9.15 Rinse the flask with methylene chloride, pour through the funnel and collect in the TurboVap vessel.

9.16 Rinse the sodium sulfate with methylene chloride; clumped sodium sulfate must be broken apart before rinsing.

9.17 Transfer the container to the TurboVap concentrator. Set the TurboVap to the manufacturer's instructions (use the manual setting and tank pressure at 20psi). Concentrate to 1.0 mL at 44 degrees C.

9.18 PCB and Pesticide extracts require a solvent exchange to hexane. When the methylene chloride solvent extract reaches about 1 to 2 mL add 10 mL of hexane, set the TurboVap temperature to 50 degrees C and re-concentrate to 2 mL.

9.19 PNA extracts require a solvent exchange to acetonitrile. When the methylene chloride solvent extract reaches about 1 to 2 mL add 10 mL of acetonitrile, set the TurboVap temperature to 54 degrees C and re-concentrate to 2 mL.

9.20 Transfer the concentrate to a 2-mL vial auto sampler vial. If the sample will not concentrate to 1 mL (oily waste) collect the extract in a 10 mL vial (or 40 mL vial if necessary) and record the final volume.

9.21 The analyst will decide what cleanup technique, if any will be required.

## 10.0 Diagram/Table

10.1 Reserved.

## 11.0 Analytical Procedure

11.1 This section is not applicable to this SOP

## 12.0 Details of Calibration and Calculations

12.1 This section is not applicable to this SOP.

## 13.0 Quality Assurance/Quality Control (QA/QC) Requirements

13.1 Prepare a method blank for each batch of twenty or less samples per matrix, using DI water.

13.2 Prepare a laboratory control sample (LCS) and LCSD - laboratory control sample duplicate (if insufficient sample volume for MS/MSD) for each batch of twenty or less samples by adding the appropriate amount of the spike mix to one liter of DI water.

13.3 Prepare a matrix spike (MS) and matrix spike duplicate (MSD) for each batch of twenty or less samples per matrix, if sufficient volume is available by adding the appropriate amount of the spike mix to a representative sample.

13.4 Corrective action procedures are specified in the applicable SOP's.

## 14.0 Data Reporting Requirements

14.1 In the sample preparation log in the LIMS enter initial the sample volume in liters (1 L is the default), final extract volume (1 or 2 mL is the default) and sample matrix. Additionally enter the amount of surrogate and spike solutions added in mL.

14.2 The preparation analyst must also enter date and time of start and completion as well as analyst ID and method ID.

## 15.0 Preventative Maintenance and Routine Cleaning

15.1 Daily: Balance must be checked prior to use with the certified weights and recorded.

15.2 TurboVap: Ensure that the water bath reservoir is filled to at least above the bottom of the cutout circle on the vertical portion of the interior wall. Check to make sure that the N2 tank is not empty and that the air is flowing to the sample tube.

15.3 Check the TurboVap temperature with a calibrated thermometer on each day of use.

## 16.0 Pollution Prevention and Waste Management

16.1 Pollution Prevention

16.1.1 Reagents are purchased and quantities used to reflect anticipated usage and minimize disposal of expired or unused chemicals.

16.1.2 Chemicals are handled in a manner, which minimizes the potential for release or spill of the material.

16.2 Waste Management

16.2.1 Organic solvents are treated as hazardous waste and placed in the appropriate waste drum for disposal.

16.2.2 Soil samples are composited in a drum designated for incineration.

16.2.3 Disposal of materials is addressed in the laboratory QAP (Section 5.6).

## 17.0 References

17.1 EPA Test Methods for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods, Nov, 1986, Revision 1 Sept, 1994. Method 3510C, 3610B, 3611A, 3620B, 3630C, 3650B, 3660B.

17.2 RTI Laboratories, Inc. Quality Assurance Plan.

17.3 RTI Laboratories, Inc. SOP SRC001-A, Sample Receipt and Custody.

17.4 RTI Laboratories, Inc. Chemical Hygiene Plan.

17.5 RTI Laboratories, Inc. Employee Handbook.

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# STANDARD OPERATING PROCEDURE

# SONICATION EXTRACTION PROCEDURE FOR SEMI – VOLATILE ORGANICS

| | |
|---|---|
| **Analyte:** | **Semi-volatile organic compounds** |
| **SOP #:** | **3550B_031010_R6.1** |
| **Method Reference:** | **EPA SW-846 3550** |
| **Issue Date:** | **December 2, 2005** |
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| | |
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**SONICATION EXTRACTION PROCEDURE FOR**
**SEMI – VOLATILE ORGANICS**

**SOP#: 3550B_031010_R6 .1**

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# 1.0 Scope and Application

## 1.1 Introduction

RTI Laboratories, Inc, has prepared this document to detail the Standard Operating Procedure (SOP) for the preparation of the preparation of solid samples for analysis of semi-volatile compounds by gas chromatography/mass spectrometry, pesticides and PCB's by GC/ECD, PNA's by HPLC and DRO by GC/FID. This SOP contains the procedures for sonication extraction (Method 3550B) for solid samples. Wipe samples (particularly for PCB's) are prepared using this procedure.

A detailed description of the instrumentation, calibration, run parameters and quality control procedures used for analysis are not included in this SOP. For definition of terms not specifically defined in this document refer to RTI QAP Section 16.

## 1.2 Summary of Method

1.2.1 A 25 to 30 g aliquot of sample is weighed and dried with anhydrous sodium sulfate. The solvent appropriate to the analysis, surrogates and spikes (where applicable) are added to the solid sample or wipe and sonicated for 3 minute at full power. The solvent extract is removed and filtered through anhydrous sodium sulfate. The procedure is repeated three times and the final extract is concentrated to the desired volume. This method has been modified to use 50ml aliquots instead of 100ml aliquots of extraction solvent.

# 2.0 Safety Precautions

2.1 Compounds applicable to this method are known or suspected carcinogens. Standard preparation is conducted in fume hoods designated for organic use.

2.2 Extraction solvents are flammable and/or toxic and must be handled with caution. All extractions are performed in a manner designed to minimize exposure to these chemicals using appropriate hoods and personal protection (such as, gloves, lab coat, and safety glasses.

# 3.0 Sample Requirements and Sample Handling Procedures

3.1 Samples are received in accordance with RTI's Standard Operating Procedure for Sample Receipt and Custody (SRC001-A). Appropriate U. S. Environmental Protection Agency (EPA) sample handling procedures and sample preservation recommendations are followed. Soil samples are collected in 2 to 9 oz. pre-cleaned wide mouth jars with Teflon lined lids.

3.2 The holding time for soil samples is 14 days from collection to extraction and 40 days from extraction to analysis.

3.3 All samples are stored at $4^{o}$ C in the walk-in cooler.

3.4 Minimum sample size – 30 g.

## 4.0 MDL, Linear Range, Accuracy and Precision

4.1 Not applicable to this SOP. See the appropriate analytical SOP for details

## 5.0 Interferences

5.1 Interferences can arise from carry over due to high sample concentrations or contamination from reagents and/or glassware. Method blanks are prepared to ensure system cleanliness in both instances. All glassware must be scrupulously cleaned before use. Phthalates are common lab contaminants and will leach from any soft plastic material used during sampling or during prep.

5.2 Samples containing high concentrations of non-target analytes or extremely high levels of select target analytes can result in elevated detection limits for some or all compounds. Dilution of the extract may improve the resolution and quantification of some analytes but will generally cause an elevation in the RDL. Interferences from high molecular weight organics such as oils will cause an elevated baseline. If this background is at a high concentration it will interfere with analyte identification as well as quantification.

5.3 Sample extract interferences can be cleaned up using techniques described in the SOP for sample extract cleanup (florisil cleanup, acid cleanup, sulfur cleanup or dilution (3610B, 3611A, 3620B, 3630C, 3650B, 3660B)). Dilution of the extract can also be used to minimize interferences.

## 6.0 Apparatus and Materials

6.1 Analytical Balance capable of weighing to 0.1 gm.

6.2 Glass or Teflon Funnels

6.3 pH indicator paper

6.4 Residual chlorine test strips

6.4 Graduated cylinders. 1000ml and 100ml

6.5 Glass beakers, 250 ml size.

6.6 Sonicator – Ultrasonic Processor XL or Heat Systems Virsonic 300 or equivalent.

6.7 Class A Microliter syringes, 50ul, 10 ul, 25ul, 1000µl, 5000µl.

6.8 Volumetric glassware

6.9 Glass vials – 2ml with Teflon lined screw caps.

6.10 Pyrex glass wool

6.11 Filter paper, Whatman #41 or equivalent.

6.12 Pasteur pipettes

6.13 10ml Glass graduated pipettes

6.14 TurboVap II evaporator – Zymark

6.15 200ml concentrators tubes with a 1.0ml graduated tip- available through Caliper

6.16 4" x 4" gauze pads – for wipe collection.

## ~~7.0 Reagents~~

7.1 Anhydrous Sodium sulfate- cleaned by muffle furnace for 4 hours at 400 degrees C

7.2 Methylene chloride – pesticide grade

7.3 Hexane – pesticide grade

7.4 Acetone – pesticide grade

7.5 Acetonitrile – HPLC grade or better.

7.6 Sulfuric acid – 1:1 in DI water

7.7 ASTM Type II DI.

7.8 Clean soil for Method Blank and LCS, this may be sand heated in a muffle furnace for 4 hours at 400 degrees C.

7.9 Dry Nitrogen – for TurboVap.

7.10 Stock Standards

7.10.1 Pesticide Mix 2000ug/mL, Absolute, Part No. 10013
7.10.2 TCMX/DCB Surrogate 200ug/mL, Ultra, Part No. ISM-320
7.10.3 PCB 1016/1260 1000ug/mL, Ultra, Part No. PPM-8082
7.10.4 8270 LCS Mix 200ug/mL, Cerrilliant, Part No. ERS-077
7.10.5 8270 Surrogate Mix 4000ug/mL, Ultra, Part No. ISM-331
7.10.6 n-Eicosane 99%, Ultra, Part No. RNA-011

7.10.7 SAE 30W Motor Oil 20mg/mL, Accustandard, Part No. FU-018-D-40X
7.10.8 Diesel #2 Fuel Oil 20mg/mL, Accustandard, Part No. FU-002-D-40X
7.10.9 Surrogate p-Terphenyl d14 2000ppm solution, Ultra , Part No. ATS-160
7.10.10 PNA spike mix – 500ppm each analyte, Ultra, Part No. PM-831-1
7.10.11 2-Methylnapthalene – Solid Stock Material Ultra, Part No. RAH-045
7.10.12 Acenaphthalene 5000ppm standard, Ultra, Part # EPA-1064
7.10.13 Acenaphthylene 5000ppm standard, Ultra, Part No. EPA-1065
7.10.14 Napthalene 5000ppm standard, Ultra, Part EPA-1134

7.11 SVOC working standards. All solutions have a 6-month expiration date.

7.11.1 BNAE Surrogate spiking solution 250ppm–

7.11.1.1 Working surrogate solution 25 ppm - prepared by adding 1.56ml of 8270 Surrogate Mix (7.10.5) to a 25ml class A volumetric flask and dilute to the mark with pesticide grade acetone. Add 0.1ml to each sample (25ug/extract).

7.11.2 BNA MS/MSD/LCS spike mix 200ppm –

7.11.2.1 The 8270 LCS Mix (7.10.4) is ready for use. Add 0.1ml to each LCS, MS, and MSD samples (20ug/extract).

7.12 PCB/Pesticide standards:

7.12.1 Pesticide ICV/CCV Intermediate standard 10ppm - prepared by adding 50µl of Absolute-10013 (7.10.1) to a 10ml class A volumetric flask and dilute to 10ml with pest grade Hexane

7.12.2 Working TCMX/DCB Surrogate 0.2ug/mL – prepared by adding 100µl TCMX/DCB Surrogate 200ug/mL (7.10.2) to a 100ml Class A volumetric flask and diluting to mark with pesticide grade acetone.

7.12.3 PCB MS/MSD/LCS spike mix 2ug/mL - prepared by adding 50µl of the PCB 1016/1260 1000ug/mL (7.10.3) to a 25ml Class A volumetric flask and diluting to mark with pesticide grade acetone. Add 1.0ml per MS/MSD/LCS.

7.12.4 Pesticide MS/MSD/LCS Working Spike 2ug/mL - prepared by adding 250µl of Pesticide ICV/CCV standard 10ppm (7.12.1), add 1.0ml per pesticide MS/MSD/LCS (100ng per extract).

7.12.5 Technical chlordane and toxaphene are not routinely part of the pesticide spike mixes.

7.13 PNA method 8310:

7.13.1 Surrogate spiking solution- 5ppm p-terphenyl d14 (250ul of 2000 ppm stock (7.10.9) diluted to 100ml with pesticide grade acetonitrile. Add 1mL to every sample.

7.13.2 2-Methylnapthalene 10,000ug/mL - prepare by dissolving 0.1g 2-Methylnapthalene (7.10.11) in a 10mL volumetric flask and dilute to the mark with pesticide grade methylene chloride.

7.13.3 MS/MSD/LCS Spike Mix

7.13.3.1 100ul PAH Mix 500ppm each section 7.7
7.13.3.2 90ul Acenapthalene 5000ppm section 7.10
7.13.3.3 90ul Acenapthylene 5000ppm section 7.11
7.13.3.4 90ul Napthalene 5000ppm section 7.12
7.13.3.5 27.5ul 2-methlnapthalene 10,000ppm section 7.9
7.13.3.6 Final volume 20mL Acetonitrile.
7.13.3.7 Add one ml of the working spike (7.13.2) to 30g ottowa sand to prepare LCS and 30g sample to prepare MS/MSD.

7.14 DRO/ORO.

7.14.1 DRO/ORO Surrogate Intermediate 5000ug/mL – weigh 0.05g of n-Eicosane (7.10.6) in a 10mL volumetric flask and dilute to the mark with pesticide grade methylene chloride.

7.14.2 DRO/ORO Working Surrogate 150ug/mL – prepare by adding 300uL of the DRO/ORO Surrogate Intermediate (7.14.1) to a 10mL volumetric flask and dilute to the mark with pesticide grade acetone. Add 100uL to each sample.

7.14.3 DRO/ORO MS/MSD/LCS Spike Mix 5000/10000ug/mL - add 500 ul SAE 30W Motor Oil (7.10.7) and 250uL Diesel #2 Fuel Oil (7.10.7) to a final volume of 1mL with pesticide grade acetone. Add 10uL to each MS/MSD/LCS.

7.15 All reagents and standards prepared must be labeled with a minimum:

7.15.1 Identity of the material
7.15.2 Concentration of the solution
7.15.3 Date prepared
7.15.4 Initials of analyst preparing the solution
7.15.5 Expiration date.

## 8.0 Preparation of Standards and Calibration Procedure

8.1 Ultra sonic processor tuning procedure – Heat System Model SL2015. Tune each use.

8.1.1 The probe should not be in contact with or immersed in liquid during tuning.

8.1.2 Turn the output control knob counter clockwise to zero and turn the pulsar duty cycle to off.

8.1.3 Press the power switch to the ON position. The switch will illuminate.

8.1.4 Press and hold the tune switch.

8.1.5 Turn the output control knob towards setting 3 and note the position of the needle on the % output power meter. Do not exceed 70%.

8.1.6 Rotate the tuning knob clockwise or counter clockwise until a minimum reading is obtained (usually less than 20%).

8.1.7 Turn the output control knob towards setting 7 and note the position of the needle on the % output power meter. Do not exceed 70%.

8.1.8 Rotate the tuning knob as above (8.1.6) until a minimum output power reading is obtained (usually less that 20%).

8.1.9 Repeat above steps (8.1.7 and 8.1.8) with the output control knob turned towards setting 10.

8.1.10 Release the tune switch.

8.2 Ultra sonic processor tuning procedure – Tekmar Model TM 502. Tune each use.

8.2.1 The probe should not be in contact with or immersed in liquid during the tuning procedure.

8.2.2 Set the timer to HOLD.

8.2.3 Set the output control to 10.

8.2.4 Momentarily hold down the on/off/tune switch to tune and rotate the tuning control clockwise or counter clockwise until a minimum reading (usually less that 20%) is obtained on the power monitor. If a minimum reading cannot be obtained the probe or tip may be loose or out of resonance or the power supply or converter requires servicing. A loose probe will

usually generate a loud piercing sound.

8.2.5 Set the output control to 4.

8.2.6 Release the on/off/tune switch.

## 9.0 Sample Preparation

9.1 Allow samples to warm to ambient temperature.

9.2 With each batch of samples prepare a method blank, LCS and LCS duplicate (LCSD) by adding spiking solution specified for analytical request (section 7). If sufficient volume is supplied a MS/MSD (spiked according to section 7) is prepared with the batch of samples.

9.3 Verify the calibration of the balance used and record the calibration in the logbook daily. Measure 30 gm of well-mixed soil discarding any water layer and eliminating foreign objects such as sticks, rocks, etc. or the entire wipe sample and place in a 250 ml beaker.

9.4 Add minimum amount of sodium sulfate and mix until the sample is free flowing like sand. If needed for a wet sample, add additional sodium sulfate. If sample is dry, less sodium sulfate may be used.

9.5 Add 1.0ml of the appropriate surrogate mix (section 7.12 through 7.15) then immediately add 50 ml of methylene chloride.

9.6 Place the cleaned sonicator horn approximately 3-8 mm below the surface of the solvent but not in contact with the soil and sonicate for 3 min at full power with the pulse duty set to 50%.

9.7 Decant the extracts through a funnel containing filter paper and approximately ½ inch of sodium sulfate and collect in a 200 ml TurboVap vessel. Be careful not to fill the Turbovap vessel more than 2/3 full, too much solvent in the vessel will spray out the top.

9.8 Add 50ml methylene chloride to the beaker and repeat 9.6 and 9.7 two additional times combining the extracts.

9.9 Transfer the container to the TurboVap concentrator. Set the Turbovap according to the manufacturer's instructions (use the manual setting and tank pressure at 20psi). Concentrate to 1.0 ml at 44 degrees C( for methylene chloride).

9.10 PCB and Pesticide extracts require a solvent exchange to hexane. When the methylene chloride solvent extract reaches about 1 to 2 ml add 10 ml of hexane, set the TurboVap temperature to 46-50 degrees C and re-concentrate to 2 ml using the graduated tip of the concentrator tube. Add an additional 4.0ml of Hexane (using the 5.0ml syringe) to the concentrator tube.

9.11 PNA extracts require a solvent exchange to acetonitrile. When the methylene chloride solvent extract reaches about 1 to 2 ml add 10 ml of acetonitrile, set the TurboVap to 55 degrees C and re-concentrate to 1 ml using the graduated tip of the concentrator tube. Add an additional 1.0ml of acetonitrile (using the 1.0ml syringe) to the concentrator tube.

9.12 Transfer the concentrate to a 2-ml vial auto sampler vial. If the sample will not concentrate to 1 to 2 ml (oily waste) collect the extract in a 10 ml vial (or 40 ml vial if necessary) and record the final volume.

9.13 The analyst will decide what cleanup technique, if any will be required.

9.14 In the sample preparation log in the LIMS enter initial the sample volume in ml (1000 ml is the default), final extract volume (1 ml is the default) and sample matrix. Additionally enter the amount of surrogate and spike solutions added in ml.

9.15 The preparation analyst must also enter date and time of start and completion as well as analyst ID and method I

9.16 Enter all applicable Reagents/Chemicals and Spikes/Standard information in the preparation form.

## 10.0 Diagram/Table

10.1 Reserved

## 11.0 Analytical Procedure

11.1 This section is not applicable to this SOP.

## 12.0 Details of Calibration and Calculations

12.1 This section is not applicable to this SOP.

## 13.0 Quality Assurance/Quality Control (QA/QC) Requirements

13.1 Prepare a method blank for each batch of twenty or less samples by extracting cleaned sand.

13.2 Prepare a laboratory control sample (LCS) for each batch of twenty or less samples per matrix, by adding the appropriate amount of the spike mix to 30 g of cleaned sand.

13.3 Prepare a matrix spike (MS) and matrix spike duplicate (MSD) for each batch of twenty or less samples per matrix, if sufficient volume is available by adding the appropriate amount of the spike mix to a representative sample.

13.4 Corrective action procedures are specified in the applicable SOP's.

## 14.0 Data Reporting Requirements

14.1 Refer to applicable analytical SOP.

## 15.0 Preventative Maintenance and Routine Cleaning

15.1 The sonicators are tuned according to the manufacturers instructions daily or with each use. Record tuning in the maintenance log.

15.2 At the end of the work shift, the glassware is to be cleaned and put away. The counters are to be cleaned and wiped down.

15.3 Daily: Balance must be checked prior to use with the certified weights and recorded.

15.4 TurboVap: Ensure that the water bath reservoir is filled to at least above the bottom of the cutout circle on the vertical portion of the interior wall. Check to make sure that the N2 tank is not empty and that the nitrogen is flowing to the sample tube at the proper pressures..

15.5 Check the TurboVap displayed temperature with a calibrated thermometer on each day of use.

## 16.0 Pollution Prevention and Waste Management

16.1 Pollution Prevention

16.1.1 Reagents are purchased and quantities used to reflect anticipated usage and minimize disposal of expired or unused chemicals.

16.1.2 Chemicals are handled in a manner, which minimizes the potential for release or spill of the material.

16.2 Waste Management

16.2.1 Organic solvents are treated as hazardous waste and placed in the appropriate waste drum for disposal.

16.2.2 Disposal of materials is addressed in the laboratory QAP (Section 5.6).

## 17.0 References

17.1 EPA Test Methods for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods, Nov, 1986, Revision 1 Sept, 1994. Method 3550, 3610B, 3611A, 3620B, 3630C, 3650B, 3660B.

17.2 RTI Laboratories, Inc. Quality Assurance Plan.

17.3 RTI Laboratories, Inc. SOP SRC001-A, Sample Receipt and Custody.

17.4 RTI Laboratories, Inc. Chemical Hygiene Plan.

17.5 RTI Laboratories, Inc. Employee Handbook.

RTI Laboratories, Inc.
31628 Glendale
Livonia, Michigan 48150

# STANDARD OPERATING PROCEDURE

# ANALYSIS OF ELEMENTS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY (ICP/MS)

| | |
|---|---|
| Analyte: | Elements |
| SOP#: | 6020_072810_R8 |
| Method Reference: | SW 846/3020A/3050A/6020A<br>EPA 200.8, Rev. 5.4 |
| Issue Date: | October 13, 2000 |
| Revision No.: | 8 |
| Revision Date: | July 28, 2010 |

Reviewed and Approved: July 28, 2010

Director, Quality Management: Charles O'Bryan

Manager, Environmental Services: James Woukila

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# ANALYSIS OF ELEMENTS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY (ICP/MS)

SOP#: 6020_072810_R8

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# 1.0 Scope and Application

## 1.1 Introduction

1.1.1 This Standard Operating Procedure details the daily operation, optimization, tuning of the analytical system and the analysis of samples according to the U. S. EPA Methods 6020/200.8 for the elements listed in the associated Omega LIMS test code using inductively coupled plasma/mass spectrometry (ICP/MS).

1.1.2 This method applies to ground waters, surface waters, soil, industrial wastes, and sludge.

1.1.3 Acid digestion and filtration are required prior to analysis of these samples.

1.1.4 Maintenance for the ICP-MS instruments can be found in the ELAN Hardware Manuals provided with the instrument.

1.1.5 Detailed instructions on the ICP-MS software can be found in the instrument Software Manuals.

1.1.6 For definition of terms not specifically defined in this document refer to RTI QAP Section 16.

## 1.2 Summary of Method

1.2.1 Prepared samples are nebulized into the spray chamber where a stream of argon gas carries the sample in the form of an aerosol through the quartz torch and injects it into a R.F. plasma. The sample will decompose in the plasma. The ions produced are entrained in the plasma gas and with the aid of a water-cooled, differentially pumped interface and are introduced into a high-vacuum chamber that houses the quadruple mass spectrometer. The ions are separated according to their mass-to-charge ratio, identified and quantified.

1.2.2 Samples are prepared according to the matrix by Methods 3020, 3050 or 3052. SOPs for each of these methods are on file. Samples for dissolved metals do not require additional sample preparation procedures prior to analysis.

# 2.0 Safety Precautions

2.1 Acids used in the digestion procedure are corrosive. All digestions are performed in a fume hood designated for use with mineral acids. Proper safety equipment (gloves, lab coats, etc.) is worn when handling concentrated acids. Many elements are toxic and should be handled with care.

2.2 Good laboratory technique and safety practices should be used at all times to reduce the risks associated with chemicals and potential hazards.

2.3 The ICPMS instrument is fully interlocked for safety purposes. Never attempt to disable these interlocks.

2.4 Spilled samples must be cleaned up immediately when they come in contact with the instrument. Neutralize all acid spills with sodium bicarbonate.

## 3.0 Sample Requirements and Sample Handling Procedures

3.1 Samples are received in accordance with RTI Laboratory's Standard Operating Procedure for Sample Log-in (SOP: SRC001-A_R3). Appropriate U. S. Environmental Protection Agency (EPA) sample handling procedures and sample preservation recommendations are followed.

3.1.1 Soil, sludge and solid samples are collected in pre cleaned wide mouth glass jars.

3.1.2 Aqueous samples are collected in pre cleaned plastic bottles preserved with approximately 2.0 ml of 1:1 high purity nitric acid (HNO3):DI water. The pH of the sample is checked on receipt and prior to sample preparation for the presence of adequate preservative. The pH of preserved samples should be < 2. Preserved samples received at pH>2 or at sample preparation are at pH>2 are adjusted to pH<2 with additional acid and held for a minimum of 16 hours until verified to be pH<2.

3.1.3 Maximum sample holding time is six (6) months.

3.1.4 Samples received for filtration in the laboratory or samples that have been filtered prior to receipt must be preserved and held for 24 hours prior to commencing the sample preparation procedure. The pH is checked prior to analysis and if required the procedure in Sec. 3.1.2 is followed.

## 4.0 MDL, Linear Range, Accuracy and Precision

4.1 The method detection limit (MDL) is statistically defined at the 99% confidence level according to 40 CFR Part 136 App. B. Seven replicates containing all of the analytes of interest at a concentration level of 1-5 times the estimated D.L. are analyzed and the standard deviation is calculated. The Student's T Value for the 7 replicates (3.143) is multiplied by the standard deviation of the analyte to calculate the MDL. MDL's are updated annually (or as needed) and are kept on file in the Laboratory. MDLs and reporting limits are incorporated into the applicable test code in the Omega LIMS.

4.2 The LOD (limit of detection) is determined by spiking reagent water at 1-4 times the MDL and prepared using the same procedure as samples. Analytes must be present at levels 3 times or greater than the blank response (greater than 3 times the signal to noise ratio). The concentration used is the LOD for that analyte. LOD determinations must be performed quarterly.

4.3 The LOQ (limit of quantification) is determined by spiking reagent water at the reporting limit (RL/CRQL) and prepared in the same manner as samples. Analyte recovery must be within 20% of the expected concentration. The concentration used and successfully recovered is the LOQ for that analyte. LOQ determinations must be performed quarterly.

4.4 Initially accuracy and precision at the LOQ is determined by spiking 4 aliquots of reagent water at the reporting limit (RL/CRQL) and prepared using the same procedure used for samples. The average recovery must be within 20% of the expected value and the %RSD must be less than 15%.

4.5 LOD/LOQ determinations that do not meet the specifications above require repeat analysis, adjustment to the spiking levels and/or reporting limits, repeating the MDL determination at adjusted concentrations if required and repeat LOD/LOQ determinations.

4.6 The linear range for this method is element specific. Linear ranges are addressed in Section 13. If a sample falls above the linear range dilutions of the sample digestate must be made until the concentration falls within the established calibration range.

4.7 The accuracy and precision for this method are determined by analyzing four aliquots from a Laboratory Control Sample containing the element(s) of interest at the mid-level of the calibration range. Percent recovery, standard deviation, and the relative standard deviation are calculated for each analyte. Quality control limits, mean recovery values and RPD results are incorporated in the Omega LIMS.

## 5.0 Interferences

5.1 Isobaric interference occurs during analysis when an isotope of one element is at the same nominal mass as an isotope of another element. To correct for this interference the intensity of the interfering element may be measured at another isotope. Using the natural abundance ratios to correct for its presence at the analytical mass of interest. Most commonly used corrections for isobaric interferences are already incorporated into the ELAN NT software. Make certain that the isotope used for correction purposes dose not suffer from overlap with other isotopes that maybe present in the sample.

5.2 Molecular interferences are caused when molecular species are formed in the plasma with plasma matrix ions. These interferences are corrected in the same manner as the isobaric interferences.

5.3 Reagents, glassware and other sample preparation equipment may contain artifacts that will interfere with the analysis. Method blanks are routinely analyzed to demonstrate that materials are free from contamination. Sample bottles and reagents are assayed prior to use for suitability. Glass containers cannot be used for analyses requiring determination of Boron or Silicon.

5.4 Carryover can occur when a high concentration sample is analyzed. Additional rinse time may be required when encountering an elevated concentration sample to eliminate potential memory affects.

5.5 Physical interferences associated with dissolved solids content or matrix viscosity can cause suppression or enhancement of the signal. Internal standards will correct for these types of interference. If the internal standard signal is altered by more than 70-125% of the calibration standard, dilution of the sample will usually eliminate the physical interference problem.

## 6.0 Apparatus and Materials

6.1 ICPMS3 - Perkin-Elmer ELAN DRC-e, Cetac ASX-520 auto sampler with SYS Systenax computer system (MS XP OS) and ELAN software – Version 3.4.

6.2 ICPMS2 – Perkin-Elmer Elan 6000 instrument, Cetac auto sampler, Dell OptiPlex1 computer system, and ELAN NT software – Version 2.2.

6.3 ICPMS3: Peristaltic pump tubing black/black - 0.75mm id, black/white – 0.125 id, red/orange – 0.19 id. ICPMS2: Peristaltic pump tubing black/black - 0.76mm id, black/white – 3.18 mm, yellow/orange – 0.51 mm.

6.4 Calibrated mechanical pipettes with metal free plastic pipette tips 10 – 100 ul, 100 – 1000 ul, 500 – 5000 ul, 1 – 10 ml.

6.5 50 ml plastic auto sample tubes with plastic caps.

6.6 Beakers – various sizes.

6.7 Volumetric flasks, Class A – various volumes.

## 7.0 Reagents

7.1 High purity reagents, acid and water must be used at all times. Trace metals grade purity acids must be used for this method. Nitric acid is preferred in order to minimize polyatomic interferences. Hydrochloric acid is used to maintain stability in solutions containing antimony and silver but corrections for polyatomic ion interferences must be used.

7.2 Tuning solution stock: 10 mg/L Ba, Be, Cd, Ce, Co, Cu, In, Pb, Mg, Rh, Tl, Li. Tuning solution is prepared by pipetting 1 mL of tuning stock solution into a 1 liter flask containing 200 mL deionized water, and adding 10 mL of conc. nitric then diluting to the mark with deionized water.

7.3 1:1 (vol/vol) nitric acid. Prepare by adding 50 ml of ultra pure nitric acid to a 100 ml vol. flask and dilute to the mark with deionized water.

7.4 Internal Standard. Stock: 100 ug/ml Li6, Sc, Y, In, Tb, Bi and 1000 ppm Ge.

7.4.1 Intermediate. Internal Std. A: Place 10 ml of the 100ug/ml stock solution into a 100 ml volumetric flask and dilute to volume. Internal Std. B: Dilute 5 ml of the 1000 ppm Ge standard to 100 ml final volume in a volumetric flask.

7.4.2 Working standard: Add 1 ml of internal standard A and B and dilute to 100 ml with deionized water. All samples and solution must contain internal standards. Prepare fresh daily.

7.5 Single element standards at ICP-MS grade.

7.6 Standard stock solutions:

7.6.1 AAC-STD-2: 1000 ug/ml – Al, Sb, As, B, Mo, P, Se, Si, Sn, Ti, Zr (2% absolute $HNO_3$/0.5% HF)

7.6.2 AAC-STD-4: 1000 ug/ml – Ba, Be, Bi, Cd, $Cr_3$, Co, Cu, Pb, Mn, Ni, Ag, Sr, Tl, Th, V, Zn (5% absolute $HNO_3$).

7.6.3 AAC-STD-3: 10000 ug/ml – Ca, Mg, K, Na, Fe.

7.6.4 Calibration Stock:

A1 – 2ml of AAC-STD-4 and 2ml 1:1 Nitric acid diluted to a final volume of 100 ml with DI water. Standard concentration is 20 ug/ml.

A3 – 2ml of AAC-STD-2 and 2ml 1:1 Nitric acid diluted to a final volume of 100 ml with DI water. Standard concentration is 20 ug/ml.

III – 1ml of AAC-STD-3 and 2ml 1:1 Nitric acid diluted to a final volume of 100 ml with DI water. Standard concentration is 100 ug/ml.

B – 1000 ug/ml Boron Standard

Si – 1000 ug/ml Silicon Standard

7.6.5 Second source single element standards – Lithium 1000ug/ml, Boron 1000 ug/ml, Silicon 1000 ug/ml and Strontium 1000 ug/ml

7.6.6.1 Intermediate strontium standard – dilute 100 ul of the 1000 ug/ml standard to a final volume of 50 ml DI water containing 1 ml of 1:1 nitric acid.

7.7 Independent Calibration Verification (ICV) - This solution must be from a different stock then the calibration standards and when available from a separate vendor. ICV stock AAC-CAL-1 – 50 ppm As, Sb, Al, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Sn, Ag, Ti, Tl, V, Zn. ICV stock 2 AAC-STD-1 – 5000 ppm Na, Ca, Mg, K, Fe.

7.8 Calibration Standards: These standards are prepared fresh daily.

7.8.1 Calibration Blank: Place 1 ml of 1:1 (v/v) nitric acid into a 50 ml auto sampler tube.

7.8.2 Cal Std: Place 1 ml of 1:1 (v/v) nitric into a 50 ml auto sampler tube. Add 250 ul of calibration stock standards A1 and A3, 4000 ul of calibration stock III and 50 ul of the B and Si atandards. The standard concentration is 100 ug/L for all elements (Al, Sb, As, Mo, P, Se, Sn, Ti, Ba, Be, Bi, Cd, Cr, Co, Cu, Pb, Mn, Ni, Ag, Sr, Tl, Th, V, Zn) except:

Na, Ca, Mg, K – 8000 ug/L
B, Si – 1100 ug/L
Fe – 8000 ug/L

7.9 ICV Standard: This standard must be prepared fresh daily.

7.9.1 Place 1 ml of 1:1 (v/v) nitric into a 50 ml volumetric flask. Add 50 ul of AAC-CAL-1, 50 ul of AAC-STD-1, 25 ul each of the boron and silicon standard and 125 ul of the strontium intermediate standard (20ug/ml) and dilute to volume. This solution contains the following concentrations: 50 ug/L As, Sb, Al, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Sr, Tl, V, Zn. 5000ug/L Na, Ca, Mg, K, Fe. 500 ug/L B, Si.

7.10 Dual Detector Cross – Calibration Solution: Add 0.25 ml of AAC-STD-2, 0.25 ml of AAC-STD-3, 1ml of each individual standard of Se, Ag, Li, Ge and 2.5 ml of the 100 ug/ml internal standard solution. Dilute to 1000 ml final volume with DI water. This solution contains the following concentrations: 250ug/L Al, Sb, As, B, Ba, Be, Bi, Cd, Cr, Co, Cu, In, Pb, P, Mn, Mo, Ni, Sc, Si, Sn, Sr, Tb, Ti, Tl, Th, V, Y, Zn: 2500 ug/L Na, Ca, Mg, Fe and K: 1.25 ug/ml Se, Ag, Li.

7.11 Interference Check Solution Stock OA: Contains 1000 mg/L Al, Ca, Fe, Mg, Na, P, K, and S; 2000 mg/L of C; 10000 mg/L Cl, and 20 mg/L Mo and Ti. To prepare interference check solution A (ICSA) perform a 100-fold dilution on the stock. This result in a solution containing the following concentrations: 10mg/L Al, Ca, Fe, Mg, Na, P, K, and S; 20 mg/L of C; 0.2 mg/L Mo and Ti

7.12 Interference Check Solution Stock OB: Contains 2 mg/L of As, Cd, Cr, Co, Cu, Mn, Ni, Ag, and Zn. To prepare interference check solution AB (ICSAB) add 0.5 ml of ICS stock OA to a 50 ml volumetric flask. Add 0.5 ml of ICS stock OB and dilute to the mark with deionized water.

7.13 Continuing Calibration Verification (CCV) standard: Place 1 ml of 1:1 nitric acid into a 50 ml auto sampler vial. Add 125 ul of Calibration Standards A1 and A3, 2000 ul of calibration stock III and 25 ul each of the boron and silicon standards (Section 7.6.5). This solution contains 50 ug/L of Al, Sb, As, Mo, P, Se, Sn, Ti, Zr, Ba, Be, Bi, Cd, Cr, Co, Cu, Pb, Mn, Ni, Ag, Sr, Tl, Th, V, Zn – 4000 ug/L of Na, Ca, Mg, K, Fe – 550 ug/L of B and Si.

7.14 All prepared standards and reagents are labeled with an identification number, the concentration of the standard (if not referenced to the preparation log), contents where appropriate, the expiration date and the initials of the preparer. Standard logs and reagent logs are maintained for recording the receipt, lot number and preparation information of all standards and reagents.

## 8.0 Preparation of Standards and Calibration Procedure

8.1 The ELAN 6000 must be calibrated before analysis with at blank and at least 1 standard. For specified projects, clients or programs the calibration protocol will require a blank and 3 non-zero standards with the lowest at the RL and the highest below the linear dynamic range. Sample concentrations above the highest standard used require dilution until the result is within the calibration range or a high-level check standard is analyzed with concentrations exceeding the sample concentration. Percent recovery for the check standard must be within 10% of the expected value.

8.2 Standards are prepared as specified in section 7.

8.3 All continuing calibration standards and blanks must pass criteria specified in section 13.

8.4 Initial calibration is performed using a calibration blank and calibration standard prepared at concentrations listed in Sec. 7.8. When calibration is performed using multi-level standards the cc of the calibration curve must be >0.998.

8.5 Calibration is verified with a second source standard (ICV) prepared at the concentrations listed in Sec 7.9. Element concentrations must be within 10% of the expected value.

8.6 A continuing calibration blank is analyzed following initial calibration and after every 10 samples. Results must be less that the MDL.

8.7 A reporting limit verification sample (CRQL) is analyzed following initial calibration and prior to sample analysis and at the end of each analytical sequence. The results of the CRQL must be within 20% of the expected concentration.

8.8 A continuing calibration standard (CCV) prepared according to Sec. 7.11 is analyzed before sample analysis, after every 10 analyses, and at the end of the analytical sequence. Element concentrations must be within 10% of the expected value.

8.9 Interference check solutions must be analyzed prior to sample analysis (and after 12 hr. of use, if applicable).

## 9.0 Sample Preparation

9.1 Allow samples to warm to ambient temperature prior to analyzing.

9.2 Check the pH of aqueous samples prior to beginning digestion.

9.3 Prepare samples according to the appropriate SOP for the particular matrix (3020A or 3050A).

## 10.0 Diagram/Table

10.1 Reserved.

## 11.0 Analytical Procedure

11.1 Initiate the plasma and allow 30 minutes for a warm up time.

11.2 Open the workspace Tuning 1 and optimize the following parameters using the tuning solution: set RF power level, optimize the nebulizer argon flow, optimize the static lens voltage and save the optimization file.

11.3 Monthly or as needed open the dual detector workspace. Aspirate the dual detector solution. Clear the old calibration and click on get analytes. Click on optimize and save file when complete.

11.4 Open the auto-lens workspace. Using the tuning solution clear the old calibration, click on get analytes and click on optimize. Ensure the mass calibration and resolution check meets the criteria in Sec. 13.6. Save the file

11.5 Open the Daily Performance workspace. Using the tuning solution click on analyze sample button.

11.5.1 For the ICPMS2 instrument the following conditions must be observed to proceed with analysis: BKG = <30 cps Rh >150,000 cps Mg > 20,000 cps Pb > 100,000 cps Ce/Ceo </= 0.03 Ba++/Ba </= 0.03. %RSD must be <5.

11.5.2 For the ICPMS3 instrument the following conditions must be observed to proceed with analysis: BKG = <10 cps In >250,000 cps Mg > 50,000 cps U > 200,000 cps Ce/Ceo </= 0.03 Ba++/Ba </= 0.03. %RSD must be <5.

11.6 Instrument operating conditions:

11.6.1 Nebulizer Gas Flow: 0.9
11.6.2 Lens Voltage: 8.6
11.6.3 ICP RF Power: 1300.0
11.6.4 Analog Storage Voltage: -2700.0
11.6.5 Pulse Stage Voltage: 1650.0
11.6.6 Discriminator Threshold: 70.0
11.6.7 AC Rod Offset: -3.0
11.6.8 Dual Detector Mode: Pulse
11.6.9 Replicates: 3

11.7 Open EPA6020 method. Calibrate the instrument and insert all QC samples in their proper location. Start the run.

11.8 For instances of sample matrix interference the Method of Standard Additions (Internal Calibration Quantification) may be required for sample quantification.

11.8.1 Four identical aliquots of the extract are taken.

11.8.2 Three of the aliquots are spiked with calibration standard solution at various concentrations that would approximate 50%, 100% and 150% of the expected analyte concentration.

11.8.3 The four aliquots are analyzed and the instrument signal is plotted versus the added concentration. This may be performed directly by the instrument or by using a linear regression plot (i.e. Excel spreadsheet). The y-intercept is determined which corresponds to the concentration of the analyte in the sample.

## 12.0 Details of Calibration and Calculations

12.1 The instrument will note if excessive curvature of the calibration curve occurs. A Correlation Coefficient of 0.995 is programmed into the software for multi-standard calibration protocols when used. Deviations from this will result in the run being stopped until a successful calibration is achieved.

12.2 Continuing calibration standards are evaluated by:

% Recovery = actual conc./expected conc. * 100

12.3 Percent recovery - matrix spikes, post digestion spikes and LCS

% Recovery = conc. recovered-sample conc. (MS/PDS)/conc. expected * 100

12.4 Relative Percent Difference

RPD = [result 1 - result 2]/average result1..result2) * 100

12.5 Serial Dilutions

% D = (original result - Dilution result)/original result * 100

## 13.0 Quality Assurance/Quality Control (QA/QC) Requirements

13.1 An initial demonstration of proficiency must be performed on instrument set-up, by all analysts performing the method or engaged in sample preparation or whenever substantial changes are made to the instrument or procedure. This is accomplished by preparing and analyzing four laboratory control samples. The average recovery must be within 20% of the expected concentration and the %RSD must be less that 15%.

13.2 Instrument Detection Limits (IDL) must be performed initially and after significant changes to instrumentation, personnel, test method or sample matrix by the analysis of 10 calibration blanks on three non-consecutive days.

13.3 Method Detection Limit studies (MDL) are performed initially, on failure to achieve successful LOD/LOQ results or when a new analyst is running the instrument or performing sample preparation.

13.4 LOD/LOQ determinations are performed quarterly as specified in Sec. 4.

13.5 The upper limit or the linear dynamic range must be determined initially, when a new detector is installed, detector volts change, or if a new sample introduction unit is installed and verified every six months. The upper linear limit is defined as the highest concentration where the measured value is within 10 % of the actual prepared value as quantified by the calibration. Calibrate the instrument and run a series of 3-5 increasing concentration standards close to the upper linear range of the instrument.

13.6 Prior to each use of the instrument the tuning solution is analyzed and a mass calibration and resolution check is performed. If the mass calibration differs by more that 0.1 amu from the true value the mass calibration must be adjusted to the correct value. The resolution must be verified to be less than 0.9 amu full width at 10% peak height.

13.7 Prior to each use of the instrument the ICPMS four replicates of the tuning solution are analyzed. The RSD must be <5% for each element in the solution and meet the criteria in Sec. 11.5.

13.8 ICV- must be run after a calibration. The results must be +/- 10% of the stated value. If the ICV is not within limits the analysis must be terminated.

13.9 CCV - continuing calibration verifications. This standard must be run after every 10 samples. The limits are +/- 10% of the true value. If this standard fails the problem must be corrected and the previous samples repeated.

13.10 CRQL – reporting limit verification standard, prepared at the reporting limit concentration and analyzed prior to and at the end of each analytical sample sequence. Results must be within 20% of the expected concentration. If the CRQL standard exhibits results beyond the acceptance limits sample results cannot be reported. Investigate, correct and recalibrate if necessary until acceptable CRQL results are obtained.

13.11 CCB- continuing calibration blank analyzed following every 10 samples. The result must be less than the LOD for each element. If this standard fails, correct the problem and reanalyze the samples affected.

13.12 ICSA and ICSAB: Analyze every 12 hours per analytical event. Spiked results should be within 20% of the expected value. For the ICSA solution the non-spiked elements must be less than the LOD. If acceptable results are not obtained terminate the analytical process and correct the problem before proceeding with sample analyses.

13.13 Correction equations for isotope interferences are incorporated in the instrument software. These equations are reviewed at least annually, whenever a potential interference is identified or when acceptable ICSA/ICSAB results cannot be obtained.

13.14 Internal Standards: The samples must recover the internal standards at 70 – 120 %. If these standards fail on a sample, attempt a five - fold dilution to correct the problem. Internal standards may be evaluated by data reviewers for compliance with specific method program requirements.

13.14.1 Method 200.8 requirement: 60 – 125%.
13.14.2 DoD QSM Version 4.1Table F-8: 30 – 120%
13.14.3 SW 6020: >70%

13.15 A serial dilution must be preformed when MS/MSD results exceed control limits and the sample concentration is sufficiently high - >10 times the CRQL. The serial dilution must agree within +/- 10% of the original reading.

13.16 A post digestion spike must be prepared when MS/MSD results exceed control limits and the sample result does not exceed 100 times the CRQL. The recovery should be within 80 – 120 % of the spiked value. If the MS/MSD and PDS do not produce acceptable results matrix effects are confirmed.

13.17 LCS- laboratory control sample. One LCS is required per batch. The LCS must be 80-120 % of the known value. For Method 200.8 the LCS control limits are 85-115%.

13.18 One duplicate sample may be run per every 20 samples. A control limit of 20 % RPD should not be exceeded.

13.19 Matrix Spike (MS) at a frequency of 10% - Matrix Spike Duplicate (MSD) at a frequency of 5%. For each batch of samples a MS and MSD and a second MS are prepared. The recovery and relative percent difference (RPD) are determined.

13.19.1 Acceptance Criteria Recovery 80 - 120 %

13.19.2 Acceptance Criteria RPD <20 %

13.20 Method Blank is prepared for each batch of sample. The results for each analyte must be < ½ the RL. If unacceptable results are obtained re-analyze method blank once and if unacceptable results persist terminate the analysis and correct the problem. Re-prepare sample batch if necessary.

Table 2
Quality Control Criteria

| CONTROL ITEM | FREQUENCY | CRITERIA | CORRECTIVE ACTION |
|---|---|---|---|
| Initial Calibration Std. (ICV) | Daily | 90 – 110 % | Repeat Calibration |
| ICB | After ICV | < LOD | Stop, repeat -determine cause and correct |
| CCV | After ICSAB and every 10 samples | 90 – 110 % of True Value | Repeat CCV and all samples preceding a CCV failure – recalibrate if problem persists |
| CCB | After CCV and every 10 samples | <LOD | Stop, repeat -determine cause and correct |
| CRQL | After ICB and at the end of the sample set | 80 – 120 % | Investigate, determine cause and correct. Repeat samples analyzed prior to unacceptable CRQL |
| Method Blank | At the beginning of each batch analyses. | <1/2RL | 1) Repeat once and if unacceptable terminate analysis, correct problem and repeat.<br>2) evaluate system<br>3) repeat batch digestion if necessary |
| ICS A & AB | Every 12 hours . | 80 - 120 % Non Spiked Elements <LOD | Terminate analysis and correct the problem prior to sample analysis. |
| LCS | 1 per batch | 80 – 120 %, 85-115% (200.8) | Analytes with unacceptable results cannot be reported. Investigate, repeat batch as necessary |
| MS/MSD | 5% - 1 per batch | 80 – 120 % | 1) Flag Data |
| Duplicate Samples | 5% - 1 per batch | RPD < 20% | Investigate and repeat as necessary |

## 14.0 Data Reporting Requirements

14.1 Sample results are reported as ug/L (aqueous samples) and ug/kg (solid samples).

NOTE: TCLP extracts may require analysis by the method of Standard Additions and are processed according to the instrument protocol for analysis by Standard Addition (Refer to Sec. 11.8).

14.2 Raw results are entered into Omega. Prep factors are automatically imported from sample prep logs. Dilutions are entered in the analytical sequence.

14.3 Sample results are reported as ug/L for water and ug/kg for soil as dry weight.

14.4 Raw instruments results are entered directly into the Omega LIMS direct instrument interface. All calculations to derive final result (including dry weight conversions) are performed automatically by the LIMS. Sample preparation information and percent moisture results are entered into the appropriate section of the LIMS prior to instrument data and are automatically factored into the final results.

14.5 Confirm that there are no QC flags or qualifiers in this sequence. If present, investigate and repeat or reanalyze as necessary.

## 15.0 Preventative Maintenance and Routine Cleaning

15.1 Sample waste container must be checked daily.

15.2 Visually check the torch condition and measure for alignment daily.

15.3 Visually check for acceptable roller pressure and condition of the sample introduction tubing. Correct pump rotation and the condition of the drain tubing daily.

15.4 Visually check the condition and levels of the rough pump oil daily.

15.5 Visually check the condition of each cone for cleanliness and proper orifice size weekly.

15.6 Check and replace filters as needed or monthly at a minimum.

15.7 Change pump oil every 3 months.

15.8 Check and adjust detector to proper voltage as needed.

15.9 Check argon pressure daily.

## 16.0 Waste Management and Pollution Prevention

16.1 Pollution Prevention

16.1.1 Reagents are purchased and quantities used to reflect anticipated usage and minimize disposal of expired or unused chemicals.

16.1.2 Chemicals are handled in a manner that minimizes the potential for release or spill of the material.

16.2 Waste Management

16.2.1 Acidic materials (pH<2) are treated as hazardous waste and placed in the appropriate waste drum for disposal.

16.2.2 Soil samples are composited in a drum designated for incineration.

16.2.3 Disposal of materials is addressed in the laboratory QAP (Section 5.6).

## 17.0 References

17.1 EPA Test Methods for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods, Method 6020A, Revision 1, February 2007.

17.2.1 EPA Methods for Chemical Analysis of Water and Wastewater. Method 200.8, Revision 5.4 (1994).

17.3 RTI Laboratories, Inc. SOP 3020A – Acid Digestion of Aqueous Samples.

17.4 RTI Laboratories, Inc. SOP 3050A – Acid Digestion of Solid Sample.

17.5 RTI Laboratories, Inc. Quality Assurance Plan.

17.6 RTI Laboratories, Inc. SOP SRC001-A_R3, Sample Receipt and Custody.

17.7 RTI Laboratories, Inc. Chemical Hygiene Plan.

17.8 RTI Laboratories, Inc. Employee Handbook.

# Appendix A

TABLE 3

| Element | Isotopes monitored | Correction equations |
|---|---|---|
| Al | 27 | |
| Sb | 121,123 | Sb 123 = Sb 123 - 0.127189* Te 125 |
| As | 75 | As 75 = as 75 - 3.127*[ArCl 77 - (0.815*Se 82)] |
| Ba | 135,137 | |
| Be | 9 | |
| Cd | 106,108,111,114 | Cd111 = Cd111-1.073*[MoO108-(0.712*Pd106)]<br>Cd114=Cd114-0.026826*Sn118 |
| Cr | 52,53 | |
| Co | 59 | |
| Cu | 63,65 | |
| Pb | 206,207,208 | Pb208 = Pb208 + 1*Pb206+1*Pb207 |
| Mn | 55 | |
| Ni | 60,62 | |
| Ag | 107,109 | |
| Tl | 203,205 | |
| Zn | 66,67,68 | |
| Mo | 95,97,98 | Mo98 = Mo98 - 0.110588*Ru101 |
| Se | 77,82 | Se82 = Se82 - 1.008696 * Kr83 |
| Th | 232 | |
| V | 51 | V51 = V51 - 3.127*[ClO53 - (0.113*Cr52)] |
| Ca | 44 | |
| Mg | 24 | |
| Na | 23 | |
| K | 39 | |
| Fe | 54 | Fe54 = Fe54 - 0.028226*Cr52 |
| Internal standards | | |
| Li | 6 | |
| Sc | 45 | |
| Y | 89 | |
| Rh | 103 | |
| In | 115 | |
| Bi | 209 | |
| Ge | 72 | |

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# STANDARD OPERATING PROCEDURE

# ANALYSIS FOR MERCURY

| | |
|---|---|
| **Analyte:** | **Mercury** |
| **SOP #:** | **7470A_ 7471B_092310_R6** |
| **Method Reference:** | **SW-846 7470A, 7471B** |
| **Issue Date:** | **January 22, 2006** |
| **Revision No.:** | **6** |
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| **Reviewed Date:** | **September 23, 2010** |

**Reviewed and Approved: September 23, 2010**

Director, Quality Management: Charles O'Bryan

Manager, Environmental Services: Jim Wuokila

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**ANALYSIS FOR MERCURY**
**SOP#: 7470A_ 7471B_092310_R6**

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# 1.0 Scope and Application

## 1.1 Introduction

RTI Laboratories, Inc, has prepared this document to detail the Standard Operating Procedure (SOP) for the analysis of drinking, surface, and saline waters, domestic and industrial wastes and solid materials. In addition to inorganic forms of mercury, organic mercurials may be present. These compounds do not respond to the cold vapor atomic absorption technique unless they are first broken down and converted to mercuric ions. Potassium permanganate oxidizes many of these compounds, Potassium persulfate has been found to give approximately 100% recovery when used as the oxidant with these compounds.

## 1.2 Summary of Method

The flameless AA procedure is a physical method based on the absorption of radiation at 253.7 nm by mercury vapor. The mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrometer. Absorbance (peak height) is measured as a function of mercury concentration and recorded. For definition of terms not specifically defined in this document refer to RTI QAP Section 16.

# 2.0 Safety Precautions

2.1 This method involves working with hazardous substances. Some of the toxicological properties of these substances are not known. Always wear gloves, eye protection and clothing protection.

2.2 Potassium permanganate is a strong oxidizer. Contact with other materials may cause fire. Exposure to potassium permanganate may cause severe eye, skin, and respiratory and digestive tract irritation. May cause kidney damage.

2.3 Hydroxylamine sulfate is corrosive. May cause burns to any area of contact. Harmful if swallowed or inhaled. Affects the blood and is a powerful reducing agent.

2.4 Sodium persulfate causes severe irritation. Harmful if swallowed or inhaled. Strong oxidizer. Contact with other materials may cause fire.

2.5 Stannous chloride is corrosive. May cause severe skin and eye irritation. May cause liver damage, severe respiratory tract irritation and digestive tract irritation with nausea, vomiting and diarrhea

## 3.0 Sample Requirements and Sample Handling Procedures

3.1 Samples are received in accordance with RTI's Standard Operating Procedure for Sample Receipt and Custody (SRC001-A). Appropriate U.S. Environmental Protection Agency (EPA) sample handling procedures and sample preservation recommendations are followed.

3.1.1 Soil, sludge and solid samples are collected in pre cleaned wide mouth glass jars.

3.1.2 Samples can be collected in glass or plastic bottles. Aqueous samples should be preserved with nitric acid to a pH of less than 2 and refrigerated at 4°C. Aqueous samples should have zero headspace and the bottle should not be opened until mercury is ready to be analyzed.

3.1.3 Sample volume minimum requirements: solids - 10 grams, aqueous - 100 ml.

3.1.4 Maximum sample holding time is 28 days.

## 4.0 MDL, Linear Range, Accuracy and Precision

4.1 The method detection limit (MDL) is statistically defined at the 99% confidence level according to 40 CFR Part 136 App. B. Seven replicates containing all of the analytes of interest at a concentration level of 1-5 times the estimated D.L. are analyzed and the standard deviation is calculated. The Student's T Value for the 7 replicates (3.143) is multiplied by the standard deviation of the analyte to calculate the MDL. MDLs are updated annually (or as needed) and are kept on file in the Laboratory. MDLs and reporting limits are incorporated into the applicable test code in the Omega LIMS.

4.2 The LOD (limit of detection) is determined by spiking reagent water at 1-4 times the MDL and prepared using the same procedure as samples. Analytes must be present at levels 3 times or greater than the blank response (greater than 3 times the signal to noise ratio). The concentration used is the LOD for that analyte. LOD determinations must be performed quarterly.

4.3 The LOQ (limit of quantification) is determined by spiking reagent water at the reporting limit (RL/CRQL) and prepared in the same manner as samples. Analyte recovery must be within 20% of the expected concentration. The concentration used and successfully recovered is the LOQ for that analyte. LOQ determinations must be performed quarterly.

4.4 Initially accuracy and precision at the LOQ is determined by spiking 4 aliquots of reagent water at the reporting limit (RL/CRQL) and prepared using the same procedure used for samples. The average recovery must be within 20% of the expected value and the %RSD must be less than 15%.

4.5 LOD/LOQ determinations that do not meet the specifications above require repeat analysis, adjustment to the spiking levels and/or reporting limits, repeating the MDL determination at adjusted concentrations if required and repeat LOD/LOQ determinations.

4.5 The accuracy and precision for this method are determined by analyzing four aliquots from a Laboratory Control Sample containing the element(s) of interest at the mid-level of the calculated range (diluted if above this range). Percent recovery, standard deviation, and the relative standard deviation are calculated for each analyte and documents are kept on file in the laboratory.

## 5.0 Interferences

5.1 Possible interference from sulfide is eliminated by addition of potassium permanganate. Concentrations as high as 20 mg/L of sulfide as sodium sulfide do not interfere with the recovery of added inorganic mercury from distilled waster.

5.2 Sea waters, Brines and industrial effluents high in chlorides require additional permanganate (as much as 25 mL) Care must be taken to assure that free chlorine is absent before the mercury is reduced and swept into the cell. Adding excess of hydroxylamine sulfate (25 mL) can eliminate this interference.

5.3 Copper is a reported interference. However copper concentrations up to 10 mg/L have shown no affect on recovery of mercury from spiked samples.

5.4 Volatile organic compounds that absorb at the wavelength used may interfere.

## 6.0 Apparatus and Materials

6.1 Mercury Analyzer: Cetac M-6000a

6.2 Digestion cups – plastic cups for digesting the samples with marking at 10, 25 and 50ml from Environmental Express

6.3 Water bath, capable of maintaining 95 °C

6.4 Compressed Nitrogen 99.9999%.

6.5 Volumetric glassware - Class A

6.6 Variable volume pipettes – calibrated

6.7 PC with Microsoft Windows XP, Cetac M600 Software Version 1.5.2.5 and Omega LIMS.

## 7.0 Reagents

7.1 Hydrochloric acid concentrated, trace metals grase : JT Baker # 9598-34

7.2 10% Stannous chloride, reagent grade: Dissolve 10g of stannous chloride in 100ml of 7% HCL. Store at room temperature for up to 5 days.

7.3 Sodium chloride - hydroxylamine hydrochloride, reagent grade: Dissolve 120 g of sodium chloride and 120 g of hydroxylamine hydrochloride in distilled water and dilute to 1000 ml with DI water. Stored at room temperature. Expiration date – 6 mos.

7.4 5% Potassium Permanganate ( Alfa Aesar # 36675 )(%w/v): Dissolve 5 g of potassium permanganate in 100 ml distilled water. Stored at room temperature. Expiration date – 6 mos. Stored at room temperature. Expiration date – 6 mos.

7.5 5% Potassium persulfate ( JT Baker V035-07) (%w/v): Dissolve 5 g of potassium persulfate in 100 ml of distilled water. Stored at room temperature. Expiration date – 6 mos.

7.6 Primary stock mercury standard 1000mg/L : Accutrace # A7045027. Store at room temperature until manufacturer's expiration date.

7.7 Secondary stock mercury 1000mg/L. Store at room temperature until manufacturer's expiration date.

7.8 Concentrated Sulfuric acid. – Trace metals grade

7.9 Concentrated nitric acid – Trace metals grade

7.10 Auqa regia – Combine 300 ml concentrated hydrochloric acid with 100 ml of nitric acid. Prepare for each use.

7.11 Reagent Water - Deionized Water – Crossbow DI Express, mixed bed. – Type II

7.12 All reagents and standards prepared must be logged in the appropriate standards/reagents log labeled with a minimum:

7.12.1 Identity of the material.
7.12.2 Concentration of the solution.
7.12.3 Date prepared.
7.12.4 Initials of analyst preparing the solution.
7.12.5 Expiration date.

## 8.0 Preparation of Standards and Calibration Procedure

8.1 Working Mercury Solution: 1 mg/L - prepared fresh daily. Acidity of the working standard should be maintained at 0.15% HCL. Measure 100 µL of 1000 mg/L stock standard (6) and dilute to 100 ml in a volumetric flask containing 1.5 ml nitric acid.

8.1.1 Intermediate standard for soil calibration – Volumetrically dilute 5 ml of the working standard to 50 ml DI water in a volumetric flask. Solution concentration is 100 ug/L.

8.2 Aqueous calibration standards are prepared as below in the same manner as the samples according to Section 9.0. The correlation coefficient of the calibration curve must be >0.995 to continue with the analysis of samples. If this criterion is not met the calibration standards must be re-analyzed or new standards prepared and analyzed until an acceptable cc is obtained.

8.2.1 1.0 ppb: (µg/L): Pipette 100 µL of 1 ppm(8.1) working standard into a 100ml volumetric flask that is half full of DI water and 1.5ml of concentrated $HNO_3$ and dilute to mark.

8.2.2 2.0 ppb: (µg/L): Pipette 200 µL of 1ppm(8.1) working standard into a 100ml volumetric flask that is half full of DI water and 1.5ml of concentrated $HNO_3$ and dilute to mark. For reference purposes, the abosorbance should be 8000 – 12000 for this standard.

8.2.3 5.0 ppb: (µg/L): Pipette 500 µL of 1ppm(8.1) working standard into a 100ml volumetric flask that is half full of DI water and 1.5ml of concentrated $HNO_3$ and dilute to mark.

8.2.4 8.0 ppb : (µg/L): Pipette 800 µL of 1ppm (8.1) working standard into a 100ml volumetric flask that is half full of DI water and 1.5ml of concentrated $HNO_3$ and dilute to mark.

8.2.5 0.2 ppb: (µg/L): Pipette 10 ml of 2 ppb (8.2.5) calibration standard into a 100ml volumetric flask that is half full of DI water and 1.5ml of concentrated $HNO_3$ and dilute to mark.

8.2.6 0.5 ppb: (µg/L): Pipette 10 ml of 5 ppb (8.2.6) calibration standard into a 100ml volumetric flask that is half full of DI water and 1.5ml of concentrated $HNO_3$ and dilute to mark

8.3 A calibration blank is prepared using 25 ml of DI water and is processed according to the procedure in Section 9.0.

8.4 An intermediate calibration verification standard is prepared from the second source by diluting 100 µl of the 1000 µg/ml standard to a final volume 100 ml DI water containing 1.5 ml of $HNO_3$. Prepare fresh each use.

8.4.1 The daily working CCV is prepared by dilution 200 µl of the intermediate standard (section 8.4) to 100 ml final volume DI water containing 1.5 ml $HNO_3$.

8.5 LCS and Matrix spikes are prepared from the intermediate second source standard (section 8.4).

8.5.1 The LCS is prepared by adding 25 µl of the standard to 25 ml DI water. The final concentration of this standard 1 µg/L..

8.5.2 MS/MSD samples are prepared by adding 25 µL of standard to 25 ml of a sample. The final concentration of the MS/MSD are 100 µg/Kg.

8.6 Soil calibration standards are prepared as below in the same manner as the samples according to Section 9.0. The correlation coefficient of the calibration curve must be >0.995 to continue with the analysis of samples. If this criterion is not met the calibration standards must be re-analyzed or new standards prepared and analyzed until an acceptable cc is obtained.

8.6.1 1.0 ppb: (µg/L): Pipette 30 µL of 1 ppm(8.1) working standard into a digestion cup containing 5 ml of reagent water and 5 ml of aqua regia and proceed with Sec. 9.3.3.

8.6.2 2.0 ppb: (µg/L): Pipette 60 µL of 1 ppm(8.1) working standard into a digestion cup containing 5 ml of reagent water and 5 ml of aqua regia and proceed with Sec. 9.3.3.

8.6.3 5.0 ppb: (µg/L): Pipette 150 µL of 1 ppm(8.1) working standard into a digestion cup containing 5 ml of reagent water and 5 ml of aqua regia and proceed with Sec. 9.3.3.

8.6.4 8.0 ppb: (µg/L): Pipette 240 µL of 1 ppm(8.1) working standard into a digestion cup containing 5 ml of reagent water and 5 ml of aqua regia and proceed with Sec. 9.3.3.

8.6.5 0.2 ppb: (µg/L): Pipette 60 µL of 100 ppb (8.1.1) intermediate standard into a digestion cup containing 5 ml of reagent water and 5 ml of aqua regia and proceed with Sec. 9.3.3.

8.6.6 0.5 ppb: (µg/L): Pipette 150 µL of 100 ppb (8.1.1) intermediate standard into a digestion cup containing 5 ml of reagent water and 5 ml of aqua regia and proceed with Sec. 9.3.3.

8.7 A calibration blank is prepared using 5 ml of DI water and 5 ml of aqua regia and is processed according to the procedure in Section 9.0.

8.8 An intermediate calibration verification standard is prepared from the second source by diluting 100 µl of the 1000 µg/ml standard to a final volume 100 ml DI water containing 1.5 ml of $HNO_3$. Prepare fresh each use.

8.8.1 The daily working CCV is prepared by dilution 60 µl of the intermediate standard (section 8.8) to a digestion cup containing 5 ml DI water and 5 ml aqua regia and proceed with section 9.3.3.

8.9 LCS and Matrix spikes are prepared from the intermediate second source standard (section 8.8).

8.9.1 The LCS is prepared by adding 30 µL of the standard (Sec 8.8) to 5 ml DI water and 5ml aqua regia. The final concentration of this standard is 50 µg/Kg.

8.9.2 MS/MSD samples are prepared by adding 30 µL of the standard to 0.6 g of a sample. The final concentration of the MS/MSD are 50 µg/Kg.

## 9.0 Sample Preparation

9.1 Allow samples to warm to ambient temperature.

9.2. Method 7470 sample preparation

9.2.1 Transfer 25ml of sample or an aliquot diluted to 25ml in the 50ml digestion cups.

9.2.2 Add 0.75 ml of concentrated $HNO_3$ and 1.25 ml concentrated sulfuric acid to each sample, standard and QC samples.

9.2.3 Add 3.75 ml of potassium permanganate solution (see 7.4) to each bottle and mix. Alternatively add enough crystals of potassium permanganate for the sample to turn purple and hold color for at least 15 minutes

Note: For sewage samples, additional permanganate may be required. Add potassium permanganate crystals until the purple color persists for 15 minutes.

9.2.4 Add 2.0 ml of potassium persulfate (see 7.5) to each bottle.

9.2.5 Heat for 2 hours in a water bath at 95°C.

9.2.6 Add 2.0ml hydroxyl amine hydrochloride (see 7.3) to the cups.

9.3 Method 7471 sample preparation.

9.3.1 Transfer 0.5 – 0.6g of solid sample taken as ~0.2g portions from the container.

9.3.2 Add 5 ml of reagent water and 5 ml aqua regia to each sample.

9.3.3 Heat for 2 minutes at 95 +/- 3 degrees C in a water bath.

9.3.4 Allow to cool: then add 25 ml of reagent water and 7.5 ml of potassium permanganate solution.

9.3.5 Mix thoroughly and place in the water bath at 95 degrees C for 30 minutes.

9.3.6 Cool and add 2.0ml hydroxylamine hydrochloride (see 7.3).

## 10.0 Diagram/Table

10.1 Reserved.

## 11.0 Analytical Procedure

11.1 Prepared samples are analyzed within 24 hours of sample preparation.

11.2 Turn the instrument on. (Let it warm up for at least 2 hours)

11.3 Turn the mercury lamp on (Let it warm for 10 minutes)

11.4 Turn the Gas flow on (N2, valve is behind peristaltic pump)

11.5 Connect the tensioners on the auto sampler over the rinse tubes (located behind the left corner of the auto sampler.

11.6 Connect the tubes on the peristaltic pump and engage the tensioner (also turn pump ~30° so that sample line doesn't get tangled)

11.7 Align the tensioner fingers over the tubing.

11.8 Fill reagent (10% SnCl2), diluent and rinse bottles (5%HCl+2%HNO3)

11.9 Reagent bottle-Weigh 100g of Stannous Chloride (crystal, dehydrate) and make to a final volume of 1000ml. Use deionized water with 7% HCL ( 70ml conc. HCl to 1000ml ).

11.10 Diluent and Rinse bottle-2.0% Nitric acid / 5.0% Hydrochloric acid ( 20ml conc. HNO3 + 50ml conc. HCL diluted to 100ml)

11.11 Check waste container and empty if needed.

11.12 Turn on peristaltic pump (clockwise, push down on Right).

11.13 Wet the GLS (gas liquid separator) as in the following steps

11.14 Disconnect the tube from the top right of the GLS.

11.15 Release the drain tensioners (the lower 2 tubes or pinch drain tube) on the peristaltic pump.

11.16 Allow the reagent to bubble to almost the top of the GLS. DO NOT ALLOW GLS TO OVERFLOW.

11.17 Reengage the drain tensioners (the lower two) on the peristaltic pump.

11.18 Reconnect the tube at the top right of the GLS.

11.19 Set up Worksheet for mercury analysis.

11.20 Load a new Worksheet from a template

11.21 Make label file (date, analyst, comment, sample type-QC std., QC blk., Sample ID-MB, LCS, etc.)

11.22 Turn on the rinse pump and put the autosampler tube down using the software controls (go to Auto Sampler, click “Down” for sample probe to go down to rinse).

11.23 Final sample preparation steps immediately before analysis.

11.24 Add 1.5 ml of hydroxylamine hydrochloride to 10ml of sample (1.5ml/ 10ml)

11.25 If sample contains high levels of Cl2, purge sample with nitrogen for at least 30 sec.

11.26 Decant the clear portion of the sample into the culture tubes.

11.27 Filter samples through whatman #41 filter paper if samples contain significant particulates, these will clog the sampling tube, so must be removed.

11.28 Then place the culture tubes in the sample rack.

11.29 Zero the instrument.

11.30 Calibrate the instrument following manufacturer's manual and instructions. Place calibration standards, QC check std. and QC check blank in the calibration rack (be sure to remove the caps).

11.31 After the calibration is done, make sure correlation coefficient is 0.995 or greater (remove one point from the curve to see if correlation coefficient is 0.995 or greater, if needed). The calibration must be based on at least five data points.

11.32 Run samples that are in the worksheet.
(Note: SnCl2 is added automatically by the auto sampler and peristaltic pump).

11.33 After all analysis is complete

11.34 Put instrument into standby mode.

11.35 Use a bottle of DI water to rinse all lines starting with the reagent lines.

11.36 Remove the tube from the reagent bottle and put it in the DI water bottle, and allow the pump to run for several minutes, and then turn off the pump.

11.37 Rinse the auto diluter by connecting the tubing from it to the DI water bottle and then use the software to prime using the DI water several times.

11.38 Remove the two tubes from the Rinse bottle and allow DI water to pump for several minutes, and then use the software to raise the auto sampler sipper up and stop the auto sampler pump. Then release the tension on the auto sampler rinse lines.

## 12.0 Details of Calibration and Calculations

12.1 Final results are calculated as specified in section 14.

12.2 The CCV must be analyzed at the frequency specified in Section 13 and the concentration must be within 10% of the known value for confirmation of instrument calibration.

12.3 Continuing calibration standards are evaluated by:

% Recovery = actual conc./expected conc. * 100

12.4 Percent recovery - LCS

% Recovery = conc. recovered/conc. expected * 100

12.5 Relative Percent Difference – Duplicate samples

RPD = [result 1 - result 2]/average result1.result2) * 100

12.6 Initial Calibration Equation.

$y = mx + b$
y = sample absorbance
m = slope
x = sample concentration
b = intercept

## 13.0 Quality Assurance/Quality Control (QA/QC) Requirements

13.1 A calibration verification standard (CCV) is analyzed following initial instrument calibration, after every 10 samples and at the end of the analytical sequence.

13.1.1 Acceptance Criteria **90 - 110 %**

13.1.2 Corrective Action: Repeat CCV and all samples preceding a CCV failure. Recalibrate if the problem persists.

13.2 A calibration verification blank (CCB) is analyzed following initial instrument calibration, after every 10 samples and at the end of the analytical sequence.

13.2.1 Acceptance Criteria **< MDL**

13.2.2 Corrective Action: Repeat CCB and all samples preceding a CCB failure. Evaluate system for sources of contamination and correct the problem before proceeding with sample analysis.

13.3 A Method Blank is processed with each batch of samples.

13.3.1 Acceptance Criteria **< ½ RL**

13.3.2 Corrective Action: Repeat analysis. Evaluate the systems for contamination sources and repeat the batch as necessary.

13.4 Laboratory Control Sample (LCS) – Prepared according to Section 8.5.

13.4.1 A LCS is processed with each batch of samples

13.4.3 Acceptance Criteria **80 – 120 %**

13.4.4 Corrective Action: Repeat LCS and sample batch as necessary.

13.5 Matrix Spike (MS) - Matrix Spike Duplicate (MSD) – Prepare as in Section 8.5.

13.4.1 For each batch of samples a MS/MSD is prepared. The recovery and relative percent difference (RPD) are determined. Statistical control limits are calculated in the LIMS.

13.4.2 Acceptance Criteria (% recovery) **80 - 120 %** or within laboratory established statistical control limits.

13.4.3 Corrective Action: Dilute and re-spike/re-analyze to determine if interferences can be overcome by sample dilution. If unsuccessful or if sample volume precludes re-analysis, flag data as possible matrix interference.

13.4.4 Acceptance Criteria (RPD) **<20 %** or within laboratory established statistical control limits.

13.4.5 Corrective Action: Evaluate sample homogeneity and flag data if necessary.

13.6 Duplicate Sample (DUP) prepared with each of samples

13.6.1 Acceptance Criteria (RPD) **<20%** or within laboratory established statistical control limits.

13.6.1 Corrective Action: Evaluate sample homogeneity and flag data if necessary.

13.7 One serial dilution must be preformed for every batch of samples prepared provided one of the samples has a concentration of >25 times the MDL .The dilution test is performed by making a five fold dilution of the sample. The result of the serial dilution must agree within +/- 10% of the original reading.

13.8 Reporting limit verification is assessed by analyzing the 0,2 calibration standard at the end of the analytical sequence. Recovery of this standard must be within 70 – 130 %. If the recovery fall outside of this range the analytical sequence must be repeated.

13.8 Method of Standard Additions (Internal Calibration Quantification) – performed for cases of matrix interference.

13.8.1 Four identical aliquots of the sample are taken.

13.8.2 Three of the aliquots are spiked with calibration standard solution at various concentrations that would approximate 50%, 100% and 150% of the expected analyte concentration.

13.8.3 The four aliquots are analyzed and the instrument signal is plotted versus the added concentration. This may be performed directly by the instrument or by using a linear regression plot (i.e. Excel spreadsheet). The y-intercept is determined which corresponds to the concentration of the analyte in the sample.

## 14.0 Data Reporting Requirements

14.1 Sample results are reported as µg/L (aqueous samples) and µg/kg (solid samples).

14.2 Raw results are entered into Omega. Prep factors are automatically imported from sample prep logs. Dilutions are entered in the analytical sequence.

14.3 Sample results are reported as ug/L for water and ug/kg for soil as dry weight.

ug/kg dry wt. = ug/kg wet wt.*100/percent solids

14.4 Raw instruments results are entered directly into the Omega LIMS system using excel spreadsheets, direct instrument interface or manually. All calculations to derive final result (including dry weight conversions) are performed automatically by the LIMS. Sample preparation information and percent moisture results are entered into the appropriate section of the LIMS prior to instrument data and are automatically factored into the final results.

14.5 Confirm that there is no QC flags or qualifiers in this sequence. If present, investigate and repeat or reanalyze as necessary. See section 9.2 of the QAP for more detail on qualifiers.

## 15.0 Preventative Maintenance and Routine Cleaning

15.1 Examine all tubing and replace as needed.

15.2 Clean GLS as needed.

15.3 Replace Nafion drying cartridge as needed.

## 16.0 Pollution Prevention and Waste Management

16.1 Pollution Prevention

16.1.1 All hazardous waste produced by this method is stored in a waste drum until that drum can be processed and disposed of properly by a professional waste management company

.

16.1.2 All samples are processed with the minimum quantity of reagents possible. This is to reduce the amount of waste generated by the test method, and, consequently, the amount of pollution generated by RTI.

16.2 Waste Management

16.2.1 Acidic materials (pH<2) are treated as hazardous waste and placed in the appropriate waste drum for disposal.

16.2.2 Disposal of materials is addressed in the laboratory QAP.

## 17.0 References

17.1 Standard Methods for the Examination of Water and Wastewater, 20th Edition, Method 3112 B.

17.2 USEPA Methods for Chemical Analysis of Water and Wastewater, 600/4/70/200 (Rev.3/1983), Method 245.1

17.3 EPA Test Methods for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods, Nov, 1986, Revision 1 September 1994 Method 7471A.

17.4 EPA Test Methods for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods, Method 7471B (Update IVA).

17.5 EPA Test Methods for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods, Nov, 1986, Revision 1 September 1994 Method 7470A.

17.5 RTI Laboratories, Inc. Quality Assurance Plan.

17.6 RTI Laboratories, Inc. SOP SRC001-A, Sample Receipt and Custody.

17.7 RTI Laboratories, Inc. Chemical Hygiene Plan.

17.8 RTI Laboratories, Inc. Employee Handbook.

RTI Laboratories, Inc.
31628 Glendale St.
Livionia, Michigan 48150

# STANDARD OPERATING PROCEDURE

# ANALYSIS OF SEMI-VOLATILE ORGANIC COMPOUNDS

| | |
|---|---|
| **Analyte:** | **Base Neutral & Acid Extractable (BNA's)**<br>**Semi Volatile Organics** |
| **SOP #:** | **8270D_092310_R11** |
| **Method Reference:** | **EPA SW-846 8270D** |
| **Issue Date:** | **June 1, 1996** |
| **Revision No.:** | **11** |
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**Reviewed and Approved:** **September 23, 2010**

Director, Quality Management: Charles O'Bryan

Manager, Environmental Services: James Wuokila

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**ANALYSIS OF SEMI-VOLATILE ORGANIC COMPOUNDS**

**SOP#: 8270D_092310_R11**

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# 1.0 Scope and Application

## 1.1 Introduction

RTI Lab, Inc, has prepared this document to detail the Standard Operating Procedure (SOP) for the analysis of water and soil samples for semi-volatile compounds by gas chromatography/mass spectrometry. Method 8270D can be used to quantify most neutral, acidic, and basic semi - volatile organic compounds that are soluble in methylene chloride and capable of being eluted, without requiring formation of derivatives, as sharp peaks from a GC fused-silica cap column coated with a slightly polar silicone. Such compounds include PNA's, chlorinated hydrocarbons and pesticides, phthalate esters, organophosphate esters and pesticides, nitrosamines, haloethers, aldehydes, ethers, ketones, anilines, pyridines, quinolines, aromatic nitro compounds, phenols and nitrophenols. Specific compound lists are contained in the test codes resident in the Omega LIMS.

A detailed description of the instrumentation, calibration, run parameters and quality control procedures where applicable is included in this SOP. This SOP is to be used in conjunction with the RTI QAP quality control procedures. Please review the QAP to fully implement this SOP. For definition of terms not specifically defined in this document refer to RTI QAP Section 16.

## 1.2 Summary of Method

The samples are prepared for analysis using either liquid: liquid extraction (aqueous) or sonication (solids/soils). Sample cleanup procedures are employed when necessary (See 3550B and 3510C SOPs for cleanup procedures). The semi - volatile compounds are introduced into the GC/MS by injecting an aliquot of the sample extract. The GC column is temperature programmed to separate the analytes, which are then detected with a mass spectrometer (MS). Identification of the target analytes is accomplished by comparing their mass spectra with the electron impact spectra of standard compounds. Quantification is accomplished by comparing the response of the primary quant ion relative to an internal standard using at least a five-point calibration curve.

# 2.0 Safety Precautions

2.1 Compounds applicable to this method are known or suspected carcinogens. Standard preparation is conducted in fume hoods designated for organic use.

2.2 Extraction solvents are flammable and/or toxic and must be handled with caution. All extractions are performed in a manner designed to minimize exposure to these chemicals using appropriate hoods and personal protection.

## 3.0 Sample Requirements and Sample Handling Procedures

3.1 Samples are received in accordance with the RTI Lab Standard Operating Procedure for Sample Receipt and Custody (SRC001-A). Appropriate U. S. Environmental Protection Agency (EPA) sample handling procedures and sample preservation recommendations are followed. Water samples are collected in 1L amber bottles with Teflon lined screw caps. Soil samples are received in wide mouth jars with Teflon lined lids ranging from 2 oz. to 9 oz. in size. Refer to Sample Receipt and Custody SOP (SRC001-A) and QAP section 5 for sample preservation requirements and checks.

3.2 The holding time for water samples is 7 days from collection to extraction and 40 days from extraction to analysis.

3.3 The holding time for solid samples is 14 days from collection to extraction and 40 days from extraction to analysis.

3.4 All samples are stored at $4^{o}$ C. Extracts are stored in a designated freezer at $<0^{o}$ C

## 4.0 MDL, Linear Range, Accuracy and Precision

4.1 The method detection limit (MDL) is statistically defined at the 99% confidence level according to 40 CFR Part 136 App. B. Seven replicates containing all of the analytes of interest at a concentration level of 1-5 times the estimated D.L. are analyzed and the standard deviation is calculated. The Student's T Value for the 7 replicates (3.143) is multiplied by the standard deviation of the analyte to calculate the MDL. MDLs are updated annually (or as needed) and are kept on file in the Laboratory. MDLs and reporting limits are incorporated into the applicable test code in the Omega LIMS.

4.2 The LOD (limit of detection) is determined by spiking reagent water at 1-4 times the MDL and prepared using the same procedure as samples. Analytes must be present at levels 3 times or greater than the blank response (greater than 3 times the signal to noise ratio). The concentration used is the LOD for that analyte. LOD determinations must be performed quarterly.

4.3 The LOQ (limit of quantification) is determined by spiking reagent water at the reporting limit (RL/CRQL) and prepared in the same manner as samples. Analyte recovery must be within 20% of the expected concentration. The concentration used and successfully recovered is the LOQ for that analyte. LOQ determinations must be performed quarterly.

4.4 Initially accuracy and precision at the LOQ is determined by spiking 4 aliquots of reagent water at the reporting limit (RL/CRQL) and prepared using the same procedure used for samples. The average recovery must be within 20% of the expected value and the %RSD must be less than 15%.

4.5 LOD/LOQ determinations that do not meet the specifications above require repeat analysis, adjustment to the spiking levels and/or reporting limits, repeating the MDL determination at adjusted concentrations if required and repeat LOD/LOQ determinations.

4.6 The accuracy and precision for this method are determined by analyzing four aliquots from a Laboratory Control Sample containing the element(s) of interest at the mid-level of the calculated range (diluted if above this range). Percent recovery, standard deviation, and the relative standard deviation are calculated for each analyte and documents are kept on file in the laboratory.

4.7 The analytical range used by RTI Lab, Inc is from 1.0 g/L to 50 g/L for most of the compounds determined by this method. If an analyte concentration is beyond its established calibration range, a dilution of that sample is required. Quantification of all reportable analytes must originate from a response within the established linear range.

## 5.0 Interferences

5.1 Interferences can arise from carryover due to high sample concentrations or contamination from reagents and/or glassware. Blanks are injected to ensure system cleanliness in both instances. All glassware must be scrupulously cleaned before use. Phthalates are notorious lab contaminants and will leach from any soft plastic material used during sampling or sample preparation.

5.2 Samples containing high concentrations of non-target analytes or extremely high levels of select target analytes can result in elevated detection limits for other target analytes. Dilution of the extract may improve the resolution and quantification of some analytes but will generally cause an elevation in the RDL. Interferences from high molecular weight organics such as oils will cause an elevated baseline. If this background is at a high concentration it will interfere with analyte identification as well as quantification. While RTI does not currently employ this method of clean up, GPC clean up (refer to GPC reference method for specifics) is a method available to reduce high molecular weight interference.

5.3 Benzidines may be subject of oxidative loss during solvent concentration and exhibits poor chromatographic behavior.

5.4 Hexachlorocyclopentadiene will thermally decompose in the GC inlet, chemically react is acetone solutions and is subject to photochemical decomposition.

5.5 N-nitrosodimethylamine does not separate well from the solvent.

5.6 N-nitrosodiphenylamine decomposed in the GC inlet and cannot be distinguished from diphenylamine. These compounds are reported as a combined concentration.

5.7 1,2-Diphenylhydrazine is unstable even at room temperature and converts to azobenzene. These compounds are reported as a combined concentration.

5.8 Pentachlorophenol, 2,4-Dinitrophenol, 4-Nitrophenol, Benzoic acid, 4,6-Dinitro-2-methylphenol, 4-Chloro-3-methylphenol, Niroanilines and Benzyl alcohol are subject to erratic chromatographic behavior especially if the GC system becomes contaminated with oils or other high boiling point materials.

5.9 Pyridine performs poorly with the injection temperature used for analysis. If this compound is critical to the program objectives a separate analysis may be required.

## 6.0 Apparatus and Materials

6.1 Glass Funnels or HDPE if glass in unavailable.

6.2 pH indicator paper

6.3 Graduated cylinders. 1000ml and 100ml

6.4 Glass beakers, 250 ml size.

6.5 Microliter syringes, 10ul, 25 ul, 50ul, 100µl, 500µl, and 1000µl.

6.6 Volumetric glassware, class A

6.7 Glass vials – 2ml with Teflon lined crimp caps.

6.8 Pyrex glass wool

6.9 Pasteur pipettes

6.10 HP5890 GC/5972 MS with 7673 autosampler.

6.11 HP6890 GC/5973 MS with 7673 autosampler.

6.12 GC column – RXI-5 Sil MS 20m x 0.18mmID, 0.36 film thickness.

6.13 HP Enviroquant data system.

6.14 Siltek Gooseneck Splitless Liner IP Deact., SV Wool4mm ID (Restek #20799-231.5)

6.15 2ml amber autosampler vials

6.16 250µl vial inserts

6.17 11mm aluminum auto sampler caps with Teflon lined septa

6.18 11mm crimper tool

6.19 Pasteur pipettes.

6.20 1/16”x0.5mm ID Compact Vespel/Graphite Inlet Ferrules (Restek 20248).

6.21 1/16”x0.4mm ID Vespel/Graphite GC/MS Interface Ferrules (Restek 20211).

6.22 Gold-plated Inlet Seals, 0.8mm ID (Restek 21241).

6.23 PC with Microsoft Windows, Agilent EnviroQuant Chemstation-G1701BA Ver. B.01.00 and Omega LIMS.

## 7.0 Reagents

7.1 Anhydrous Sodium sulfate, muffled at 450° C for 4 hours

7.2 Methylene chloride – pesticide grade

7.3 Acetone – pesticide grade

7.4 Methanol-purge and trap grade

7.5 8270 spiking solutions.

7.5.1 8270 LCS Spike, 200µg/mL (Cerriliant ERS-077)- Add 100µL to each LCS, MS, and MSD samples (20ug/extract).

7.5.2 Working surrogate solution 250 ppm: prepared by adding 1.56mL of Ultra Scientific ISM-331 to a 25ml class A volumetric flask and dilute to the mark with pesticide grade acetone. Add 100µl to each sample, method blank, MS/MSD and LCS (25ug/extract).

7.5.3 Internal standard mix – 4000 µg/mL (10009 from Absolute Standards), add 10 ul per 1 ml extract (40 ug/extract).

7.5.3.1 Internal standard solutions are prepared, stored and handled in a manner designed to minimize the deviation in response from the time a vial is opened until the next new vial is opened for use. Changes to the internal standard solution may occur due to evaporation of solvent into the headspace of the vial storing the solution. The repeated opening and closing of this solution over a period of several days could lead to a concentrating of the compounds with a concomitant change in response.

7.5.3.2 Transfer internal standard solution into a vial insert within a 2ml amber autosampler vial until the insert is completely filled.

7.5.3.3 Cap the vial tightly and continue transferring the remaining internal standard solution into separate vials.

7.5.3.4 Label the vials with the date transferred and a unique letter for each vial (Example JW062306A, JW062306B, etc.).

7.5.3.5 Store the vials at room temperature protected from exposure to light.

7.6 Sulfuric acid – 1:1 in DI water

7.7 ASTM Type II DI water.

7.8 Helium – UHP.

7.9 Calibration standards –

7.9.1 Semi-volatile Tuning Standard 500µg/mL, Absolute Standards, 43030.
7.9.2 Internal Standard mixture 4000µg/mL, Absolute Standards,10009.
7.9.3 Method 8270 BNA Working Standard 160-320µg/mL, Cerilliant, ERS-026.
7.9.4 4-Chlorophenol 1000µg/mL , Absolute Standards, 79061
7.9.5 Benzidine mix 1000µg/mL, Restek, 31834
7.9.6 1-Chloronapthalene 1000µg/mL, Absolute Standards, 70311
7.9.7 Benzoic Acid 1000µg/mL. Absolute Standards, 70034
7.9.8 N-Decane 1000µg/mL, Absolute Standards, 70106
7.9.9 n-Octadecane 1000µg/mL, Absolute Standards, 70971

7.10 Calibration check standard -

7.10.1 Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8270.
7.10.2 Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8271.
7.10.3 Pyridine 1000µg/mL, Absolute Standards, 79091.
7.10.4 Benzoic acid 2000µg/mL, Restek, 31879.
7.10.5 Benzidine Mixture 2000µg/mL, Restek Corp., 31834.
7.10.6 Surrogate Standard Mixture 4000µg/mL, Ultra Scientific, ISM-331.
7.10.7 4-Chlorophenol 5000µg/mL, AccuStandard, AS-E0183
7.10.8 n-Decane, 99% purity, Ultra Scientific, RNA-001.
7.10.9 n-Octadecane, 99% purity, Ultra Scientific, RNA-009.

7.11 Reporting Limit Verification Standard (RLVS)-

7.11.1 n-Octadecane 1000µg/mL, Absolute Standards, 70971
7.11.2 n-Decane 1000µg/mL, Absolute Standards, 70106
7.11.3 Pyridine 1000µg/mL, Absolute Standards, 79091
7.11.4 Benzoic Acid 1000µg/mL, Absolute Standards, 70034
7.11.5 Benzidine Mix 2000µg/mL, Restek, 31834

7.11.6 Surrogate Standard Mixture 4000µg/mL, Ultra Scientific, ISM-331.
7.11.7 1-Chloronapthalene 1000µg/mL, Absolute Standards, 70311
7.11.8 Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8270.
7.11.9 Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8271
7.11.10 Pentachlorophenol 1000µg/mL, Absolute Standards, 70243
7.11.11 4-Nitrophenol 1000µg/mL, Absolute Standards, 70231
7.11.12 Hexachlorocyclopentadiene 1000µg/mL, Absolute Standards, 70198
7.11.13 2,4-Dinitrophenol 1000µg/mL, Absolute Standards, 70159
7.11.14 2,3,4,6-Tetrachlorophenol 1000µg/mL, Absolute Standards, 70477
7.11.15 4-Bromophenyl phenyl ether 1000µg/mL, Absolute Standards, 70057
7.11.16 4,6-Dinitro-2-methylphenol 1000µg/mL, Absolute Standards, 70158
7.11.17 4-Chlorophenol 5000µg/mL, AccuStandard, AS-E0183

7.12 Standards are stored according to the manufacturer's recommendations.

7.13 All reagents and standards prepared must be logged in the appropriate standards/reagents log labeled with a minimum:

7.13.1 Identity of the material.
7.13.2 Concentration of the solution.
7.13.3 Date prepared.
7.13.4 Initials of analyst preparing the solution.
7.13.5 Expiration date.

## 8.0 Preparation of Standards and Calibration Procedure

8.1 Storage conditions of standards are found with the manufacturer instructions and must be followed. The expiration date of all standards and spikes in this method is 6 months or the shortest expiration date of any stock standard used that is less than 6 months.

8.2 Tune check standard 50ng/µl- Prepared by adding 1000µl of Semi-volatile Tuning Standard to a 10ml class A volumetric flask and diluting to the mark with pesticide grade methylene chloride.

8.3 Tune verification – A solution containing 50 ng of DFTPP, DDT, benzidine, and pentachlorophenol is injected into the GC/MS and evaluated against the criteria specified in Method 8270D. These parameters are incorporated into the data system and appear on the tune report. The tune verification must be performed prior to analyzing samples and every 12 hours of continuous instrument run time. See section 13 of this document for more information.

8.4 A pentachlorophenol, benzidine peak tailing check is performed along with the tune check on a daily basis. Peak tailing factors must be <2. DDT degradation must not exceed 20%. If results exceed the criteria, injection port maintenance must be performed. This check must be done using Enviroquant. See section 13 for more information. Peak tailing factors and DDT degredation results are captured as PDF files and stored in the data folder for the each individual sequence.

8.5 Preparation of initial calibration standards, CCV/ICV and RLVS:

8.5.1 The initial calibration standards are prepared directly from the stock standards listed in section 7.9. The CCV and MS/MSD/LCS are made from the second source standards (section 7.10).

8.5.2 The lowest standard must be at or below the reporting limit concentration.

8.5.3 An RLVS of various concentrations is prepared according to the table below in a 25mL volumetric flask and diluting to volume with pesticide grade methylene chloride.

| Standard | Volume (µl) | Final Concnetration (µg/mL) |
|---|---|---|
| n-Octadecane 1000µg/mL, Absolute Standards, 70971 | 125 | 1.0 |
| n-Decane 1000µg/mL, Absolute Standards, 70106 | 125 | 1.0 |
| Pyridine 1000µg/mL, Absolute Standards, 79091 | 125 | 1.0 |
| Benzoic Acid 1000µg/mL, Absolute Standards, 70034 | 500 | 20 |
| Benzidine Mix 2000µg/mL, Restek, 31834 | 250 | 20 |
| Surrogate Standard Mixture 4000µg/mL, Ultra Scientific, ISM-331. | 156 | 25 |
| 1-Chloronapthalene 1000µg/mL, Absolute Standards, 70311 | 25 | 1.0 |
| Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8270 | 25 | 1.0 |
| Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8271 | 25 | 1.0 |
| Pentachlorophenol 1000µg/mL, Absolute Standards, 70243 | 100 | 5 |
| 4-Nitrophenol 1000µg/mL, Absolute Standards, 70231 | 475 | 20 |
| Hexachlorocyclopentadiene 1000µg/mL, Absolute Standards, 70198 | 100 | 5 |
| 2,4-Dinitrophenol 1000µg/mL, Absolute Standards, 70159 | 475 | 20 |
| 2,3,4,6-Tetrachlorophenol 1000µg/mL, Absolute Standards, 70477 | 100 | 5 |
| 4-Bromophenyl phenyl ether 1000µg/mL, Absolute Standards, 70057 | 100 | 5 |
| 4,6-Dinitro-2-methylphenol 1000µg/mL, Absolute Standards, 70158 | 100 | 5 |

| | | |
|---|---|---|
| 4-Chlorophenol 5000µg/mL, AccuStandard, AS-E0183 | 25 | 1.0 |

8.5.4 Intermediate Standards-

5000µg/mL n-decane is prepared by adding 0.050g of neat n-decane (Sec 7.9.8) to a 10mL volumetric flask and diluting to volume with pesticide grade methylene chloride.

5000µg/mL n-octadecane is prepared by adding 0.050g of neat n-octadecane (Sec 7.9.9) to a 10mL volumetric flask and diluting to volume with pesticide grade methylene chloride

8.5.5 A 50µg/mL calibration standard is prepared according to the table below in a 25mL volumetric flask and diluting to volume with pesticide grade methylene chloride.

| Standard | Volume (mL) |
|---|---|
| Method 8270 BNA Working Standard 160-320µg/mL, Cerilliant, ERS-026 | 7.8125 |
| 4-Chlorophenol 1000µg/mL , Absolute Standards, 79061 | 1.25 |
| Benzidine mix 1000µg/mL, Restek, 31834 | 0.625 |
| 1-Chloronapthalene1000µg/mL, Absolute Standards, 70311 | 1.25 |
| Benzoic Acid 1000µg/mL. Absolute Standards, 70034 | 1.25 |
| N-Decane 1000µg/mL, Absolute Standards, 70106 | 1.25 |
| n-Octadecane 1000µg/mL, Absolute Standards, 70971 | 1.25 |

8.5.6 The calibration curve is made through a series of dilutions of the 50µg/mL calibration standard (Sec8.5.4) to encompass the range from 1.0 – 50 ug/mL. The levels of calibration are designed to incorporate the linear range of all compounds of interest. However, all levels may not actually be used to calibrate all compounds. The lowest level used for each analyte is a reflection of the lowest limit that will allow adequate identification of all compounds ions above the instrument noise level. Therefore, some compounds may have linear ranges that include 5-6 of the most concentrated standards. Some compounds become non-linear at the higher concentration range and 5-6 or the least concentrated standards may be used as the linear range. Standards chosen for the calibration will be continuous.

| Level Concentration (µg/mL) | Volume(mL) of 50µg/mL | Final Volume Methylene Chloride |
|---|---|---|
| 1 | 0.1 | 5 |
| 2.5 | 0.25 | 5 |
| 5 | 0.5 | 5 |
| 10 | 1.0 | 5 |
| 15 | 1.5 | 5 |
| 20 | 2.0 | 5 |
| 25 | 2.5 | 5 |

8.6.4 A 25µg/mL Calibration Check Standard is prepared in a 5mL volumetric flask and diluting to volume with pesticide grade methylene chloride.

| Standard | Volume (µL) |
|---|---|
| Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8270. | 125 |
| Semi-volatiles Mixture 1000µg/mL, Ultra Scientific, SVM-8271. | 125 |
| Pyridine 1000µg/mL, Absolute Standards, 79091. | 125 |
| Benzoic acid 2000µg/mL, Restek, 31879. | 62.5 |
| Benzidine Mixture 2000µg/mL, Restek Corp., 31834. | 62.5 |
| Surrogate Standard Mixture 4000µg/mL, Ultra Scientific, ISM-331. | 32 |
| 4-Chlorophenol 5000µg/mL, AccuStandard, AS-E0183 | 25 |
| n-Decane, 5000µg/mL (Sec 8.5.3) | 25 |
| n-Octadecane, 5000µg/mL (Sec 8.5.3) | 25 |

8.6.5 All ICAL compounds must pass using one of three types of criteria: <20% RSD of the RFs, a linear regression model where the correlation coefficient is >0.99, or a non-linear (quadratic) regression, which must include 6 data points (minimum of 3 statistical degrees of freedom) and have a correlation coefficient >0.99. All ICAL compounds must pass using one of these types of calibration models. The equations for these regressions can be found in the HP ChemStation software. The minimum average RF for the SPCC compounds are set by the method (see section 8.7.3). For compounds that exceed 20% RSD the linear regression function of the data system will be used for analyte quantification provided the correlation coefficient is greater than 0.99. The force through zero option may be used based on the response of the curve relative to the intercept (intercept not significantly different than zero) and with evaluation of the impact on results at the lower end of the calibration curve. Quantification of results at or slightly above the lowest standard

may be more accurate when using the force through zero option of the data system. Since the data system does not include zero in the calculation of the regression equation and merely pivots the line through zero, this procedure is consistent with the guidelines in Method 8000C. If the cc is >0.99 and the RDS exceeds 20% a non-linear model may be used.

**Note: The force through zero option may not be used for the analysis of samples submitted under DoD/QSM protocol.**

8.6.5 In situations where a sample is analyzed on an initial calibration where one or more compounds could not be calibrated to these specifications, then both non-detections and detections must be qualified as estimated if the sample cannot be re-analyzed

8.6.6 If a linear regression function is used, the lowest standard must be recalculated with that calibration curve and the concentration must be within +/-25% of the true concentration. Compounds that do not meet this criterion cannot be reported until corrective actions are undertaken. The lower quantification limit may require adjusting for these compounds.

8.6.7 Immediately following initial calibration a second source standard (Sec. 7.10) must be analyzed. The concentration of all compounds must be within 25% of the expected value. This standard is prepared at 25 g/L corresponding to the mid point of the calibration range.

8.7 Twelve (12) hour continuing calibration verification (CCV with evaluation of the SPCC compounds) standards. SPCC – system performance check compounds. See section 13 for more information.

8.7.1 The SPCC must be evaluated every 12 hours whenever samples are being analyzed or on failure of a SPCC.

8.7.2 The CCV is prepared by making a midpoint calibration standard, 25ug/ml using the protocol referenced in section 8.2.4 from the second source standard (section 7.10).

8.7.3 SPCC criteria – minimum RRF

8.7.3.1 SPCC Compounds:

Phenol, 0.800
bis(2-Chloroethyl)ether, 0.700

2-Chlorophenol, 0.800
4-Methylphenol, 0.600
N-Nitroso-di-*n*-propylamine, 0.500
Hexachloroethane, 0.300

Nirtobenzene, 0.200
Isophorone, 0.400
2,4-Dimethylphenol, 0.200
bis(2-Chloroethoxy)methane, 0.300
2,4-Dichlorophenol, 0.200
Naphthalene, 0.700
4-Chloroaniline, 0.010
Hexachlorobutadiene, 0.010
4-Chloro-3-methylphenol, 0.200
2-Methylnaphthalene, 0.400
Hexachlorocyclopentadiene, 0.050
2,4,6-Trichlorophenol, 0.200
2,4,5-Trichlorophenol, 0.200
2-Chloronaphthalene, 0.800
2-Nitroaniline, 0.010
Dimethyl phthalate, 0.010
2,6-Dinitrotoluene, 0.200
Acenaphthalene, 0.900
3-Nitroaniline, 0.010
Acenaphthene, 0.900
2,4-Dinitrophenol, 0.010
4-Nitrophenol, 0.010
Dibenzofuran, 0.800
2,4-Dinitrotoluene, 0.200
Diethyl phthalate, 0.010
1,2,4,5-Tetrachlorobenzene, 0.010
4-Chlorophenyl-phenyl ether, 0.400
Fluorene, 0.900
4-Nitroaniline, 0.010
4,6-Dinitro-2-methylphenol, 0.010
4-Bromophenyl-phenyl ether, 0.100
N-Nitrosodiphenylamine, 0.010

Hexachlorobenzene, 0.100
Pentachlorophenol, 0.050
Phenanthrene, 0.700
Anthracene, 0.700
Carbazole, 0.010
Di-*n*-butyl phthalate, 0.010
Fluoranthene, 0.600
Pyrene, 0.600
Butyl benzyl phthalate, 0.010
3,3'-Dichlorobenzidine, 0.010
Benzo(a)anthracene, 0.800

Chrysene, 0.700
bis-(2-Ethylhexyl)phthalate, 0.010
Di-*n*-octyl phthalate, 0.010

Benzo(b)fluoranthene, 0.700
Benzo(k)fluoranthene, 0.700
Benzo(a)pyrene, 0.700
Indeno(1,2,3-cd)pyrene, 0.500
Benzo(g,h,I)perylene, 0.500

Compounds not normally on RTIs list of reported analytes:
Benzaldehyde, 0.010
2,2'-Oxybis-(1-chloropropane), 0.010
Acetophenone, 0.010
Caprolactam, 0.010
1,1'-Biphenyl, 0.010
Atrazine, 0.010
2,3,4,6-Tetrachlorophenol, 0.010

8.7.4 Compounds must meet a 20% criterion. Compounds calibrated using relative response factors must exhibit less than 20% difference and those calibrated using linear regression must exhibit less than 20% drift. 80% of all compounds must meet the criteria above for analysis to proceed. If more than 20% of the compounds exceed the criteria corrective action must be taken prior to analysis.

8.7.5 Compounds present in samples that fail the 20% criterion are flagged as estimated.

## 9.0 Sample Preparation

9.1 Allow samples to warm to ambient temperature and prepare according to SOP#'s 3510C and 3550B. The only clean up procedure applicable to this method is GPC. The laboratory currently does not have this capability. Oily, viscous or samples suspected of containing high concentrations of matrix interference are diluted with methylene chloride prior to instrument introduction.

## 10.0 Diagram/Table

10.1 Reserved.

## 11.0 Analytical Procedure

11.1 Set up run sequence according to the data system software protocol using the following template after a successful tune check (Note: the below list is a guide and samples and QC samples may be loaded in any sequence within the 12 hour time frame):

11.1.1 CCV (following initial calibration if applicable).

11.1.2 RLVS
11.1.3 Method Blank
11.1.4 LCS
11.1.5 QC sample and MS/MSD
11.1.6 Continue with sample analyses up to 12 hours from time of initial CCV.
11.1.7 RLVS
11.1.8 Repeat tune check and CCV at 12 hours and proceed from 11.1.2.

11.2 Set GC conditions according to Table 1 below

**Table 1**

| **Typical GC Parameters:** | **Settings: Instrument** |
|---|---|
| Flow/Initial column temperature | Flow UHP Helium – 0.9ml/min Splitless, constant flow EPC injection at 50 degrees C |
| Initial hold time | 1.0 minutes |
| 1st ramp rate/temp. | 15 degrees/min to 110 degrees C. |
| Hold time – temp 1 | 0 minutes |
| 2nd ramp rate/temp | 30 degrees/min to 280 degrees C. |
| Hold time – temp 2 | 0 minutes |
| 3nd ramp rate/temp | 15 degrees/min to 330 degrees C. |
| Hold time – temp 3 | 3 minutes |
| Injector Temperature | 285 degrees C. |
| Detector Temperature | 280 degrees C. |

11.3 Set transfer line to 280 degrees C, and filament delay to a setting after the solvent peak has been identified.

11.4 Data interpretation, qualitative identifications and MS software specific protocol are addressed in method 8270D of SW-846, the HP GC/MS operator's and Enviroquant manual. Qualitative identifications must meet the method criteria before positive identification can be made.

11.5 Compound identification and quantification

11.5.1 Compound identification is based on relative retention time (RRT) and characteristic mass spectrum.

11.5.2 Initial identification is a compound that elutes with +/- 0.06 RRT units of the RRT of the standard compound. A minimum retention time deviation of 0.5 minutes is programmed into the data system method.

11.5.3 The mass spectrum of compounds within the RRT range is compared to the spectrum of the standard compound. Relative intensities of the characteristic ions should be within 30% of the expected relative intensities for the reference spectrum.

11.5.4 Co-eluting structural isomers whose resolution is less than 50% of the average peak heights and that have similar mass spectra are to be reported as the sum of the isomers (i.e. m,p-cresols).

11.5.5 Analyst experience in evaluating mass spectra and identifying compounds in the presence of interfering components is important in final compound identification.

11.5.6 Identified compounds are quantified from the average response factor of the initial calibration or other calibration model employed when required.

11.5.7 Compounds exhibiting concentrations above the upper calibration level are diluted into the calibration range. If insufficient sample is available for dilution the concentration is flagged as estimated ("E"). Data from all dilutions are evaluated and compound results will be reported from the lowest dilution that exhibits lack of interference.

11.5.8 Compound concentrations that are below the laboratory reporting limit or lowest calibration point but positively identified above the MDL are flagged as estimated ("J").

11.6 Manual integration guidelines and procedures

11.6.1 Situation may arise whereby the quantification provided by the data system is inappropriate. This can occur due to co-elution, baseline noise or matrix interference.

11.6.2 When manual integration of a compound is necessary the following guidelines must be followed.

11.6.2.1 Manual quantification is performed by integrating the area of the quant ion for the compound.

11.6.2.2 The integration will only include the area attributable to the compound of interest.

11.6.2.3 The area integrated shall not include baseline background noise.

11.6.2.4 The area integrated shall not extend beyond the point where the sides of the peak intersect with the baseline.

11.6.2.5 Manual integration must not be used solely to meet quality control criteria.

11.6.2.6 Manual integration must not be used as a substitute for corrective action on the GC/MS system.

11.6.2.7 Instances of manual integration are flagged with an “m” by the data system. This is sufficient for routine integrations in obvious cases of peak interference and when not required to be reported as part of the contracted laboratory report. Other cases of manual integrations are documented in the LIMS analytical sequence with an “m” in the Uqual field . For some programs (i.e. USACE) the before and after integrations are captured as PDF files, stored in the data folder for the each individual sequence, reviewed and included in the data package.

11.7 SIM Analysis.

11.7.1 Set up run sequence according to the data system software protocol using the following template after a successful tune check (Note: the below list is a guide and samples and QC samples may be loaded in any sequence within the 12 hour time frame):

11.7.1.1 CCV (following initial calibration if applicable).

11.7.1.2 RLVS

11.7.1.3 Method Blank

11.7.1.4 LCS

11.7.1.5 QC sample and MS/MSD

11.7.1.6 Continue with sample analyses up to 12 hours from time of initial CCV.

11.7.1.7 RLVS

11.7.1.8 Repeat tune check and CCV at 12 hours and proceed from

11.7.2 Set GC conditions according to Table 1 below

**Table 1**

| **Typical GC Parameters:** | **Settings: Instrument** |
|---|---|
| Flow/Initial column temperature | Flow UHP Helium – 0.9ml/min Splitless, constant flow EPC injection at 50 degrees C |
| Initial hold time | 1.0 minutes |
| 1st ramp rate/temp. | 15 degrees/min to 110 degrees C. |
| Hold time – temp 1 | 0 minutes |
| 2nd ramp rate/temp | 30 degrees/min to 280 degrees C. |
| Hold time – temp 2 | 0 minutes |
| 3nd ramp rate/temp | 15 degrees/min to 330 degrees C. |
| Hold time – temp 3 | 3 minutes |
| Injector Temperature | 280 degrees C. |
| Detector Temperature | 280 degrees C. |

11.7.3 Data interpretation, qualitative identifications and MS software specific protocol are addressed in method 8270D of SW-846, the HP GC/MS operator's and Enviroquant manual. Qualitative identifications must meet the method criteria before positive identification can be made.

11.7.4 For SIM analysis, internal standard calibration is used.

11.7.5 A SIM method containing the analytes of interest is created. The retention time of each analyte is determined by running the standard in the full scan mode. The primary (Quantitation), secondary and tertiary ions from section 13.12 are used to create an ion monitoring window that incorporates the retention time of the analyte of interest.

11.7.6 The resolution is set to high and the dwell time to 50ms.

11.7.7 Sections 11.5 and 11.6 of this document are used for data analysis.

## 12.0 Details of Calibration and Calculations

12.1 Response Factor: Rf = Ax Cis/Ais Cx

Where: Ax = Area of the characteristic ion for the compound being measured.
Ais = Area of the characteristic ion for the specific internal standard.
Cis = Amount of the specific internal standard (ng).
Cx = Concentration amount of the compound being measured (ng).

12.2 Concentration: (ug/L or ug/kg) = $\frac{(Ax)\ (Is)}{(Ais)\ (Rf)\ (Vo)}$ * Df

Where: Ax = Area of characteristic ion for compound being measured.
Is = Amount of internal standard injected (ng).
Ais = Area of characteristic ion for the internal standard.
R.F = Response factor for compound being measured.
D.F = Dilution factor (where applicable)
Vo = Sample volume in gm or ml.

12.3 Percent Relative Standard Deviation: $\%RSD = \frac{SD}{X} \times 100$

Where: RSD = Relative Standard Deviation.

X = Mean of the 3-5 initial R.F for a compound.
SD = Standard Deviation of average R.F for a compound.

12.4 Percent Difference: $\% D = \frac{RF - RFc \times 100}{RF}$

Where: RF = Average response factor from initial calibration.
RFc = Response factor from current verification check standard.

12.5 Percent Drift: % Drift = (Conc. Found – Conc. Expected)/Conc. Expected * 100

12.6 Tailing Factor = BC/AB

Where AC = Width at 10% height
DE = Peak Height
B = Height at 10% of DE

12.5 Linear Regression: y = ax + b

Where: y = Instrument response (peak area)
a = Slope of the line
x = Concentration of the calibration standard
b = The intercept

12.6 Quadratic Regression: $y = ax^2 + bx + c$

## 13.0 Quality Assurance/Quality Control (QA/QC) Requirements

13.1 Initial tune verification – 50 ng of DFTPP is injected into the GC/MS and evaluated against the criteria specified in Method 8270D. These parameters are incorporated into the data system and appear on the tune report.

13.1.1 The DFTPP tune evaluation must be performed prior to analyzing samples and every 12 hours of continuous instrument run time. Tune parameters must be within established limits.

13.1.1.1 Possible Corrective Actions

13.1.1.1.1 Retune the instrument.

13.1.1.1.2 Adjust the target values for the tuning procedure, retune and re-inject the tune solution.

13.1.1.1.3 Clean source.

13.1.2 Evaluate pentachlorophenol and benzidine tailing factors. If factors exceed 2 investigate and perform any necessary corrective actions.

13.1.2.1 Possible Corrective Actions.

13.1.2.1.1 Replace injection port liner.

13.1.2.1.2 Trim or replace guard column.

13.1.2.1.3 Trim or replace analytical column.

13.1.3 Evaluate DDT breakdown. Breakdown must be less than 20%. If breakdown exceeds 20% corrective actions must be performed.

13.1.3.1 Possible Corrective Actions.

13.1.3.1.1 Replace injection port liner.

13.1.3.1.2 Trim or replace guard column.

13.1.3.1.3 Trim or replace analytical column.

13.2 Refer to Section 8.6 for initial calibration evaluation criteria.

13.3 Following successful tuning, and valid initial calibration, the CCV/SPCC sample must be analyzed and must pass the method criteria (Section 8.7). This sample must be analyzed every 12 hours of continuous instrument run time.

13.3.1 Possible Corrective Action

13.3.1.1 Repeat CCV/SPCC sample.

13.3.1.2 Reprepare the CCV standard and repeat.

13.3.1.3 Replace injection port liner.

13.3.1.4 Trim or replace guard column.

13.3.1.5 Trim or replace analytical column.

13.3.1.6 Clean the source.

13.3.1.7 Once the problem has been identified and corrected, repeat the initial calibration procedure.

13.3.1.8 Check to be sure that there are no errors in integration of internal standards and SPCC and CCC compounds. Examine chromatograms for interfering peaks and integrated peak areas. If errors are found, recalculate the data accordingly.

13.3.1.9 Make sure certified solutions and calibration standards are not expired. Expired solutions and standards may exhibit analyte degradation. Replace all expired standards and remake all calibration standards. Recalibrate the instrument.

13.3.1.10 High variability of phenol compounds may indicate a system leak or reactive sites on the column. Leaks are noted if base line levels are high and atmospheric masses are predominant in the tune (18, 28,32, and 44). Check connections for leaks. A column that has developed active sites may need to be replaced. Typical column life expectancy is 6 months or less.

13.3.2 The CCV is further evaluated for all target analytes in the batch. Percent recovery for each should be within 80 – 120 %. Refer to Sec. 8.7.4 and 8.7.5.

13.4 For each 12 hour or less analytical event a Method Blank is analyzed prior to analysis of samples to ensure the system is free of contamination that may impact sample results. Prepare the method blank for each matrix for each batch of twenty or less samples using DI water for aqueous samples and cleaned sand (or reagents only if necessary) for solid samples.

13.4.1 Acceptance Criteria: All analytes <0.5 x RL

13.4.2 Corrective Action: Clean system, bake the trap and check for sources of contamination.

13.5 For each batch of samples a Laboratory Control Sample (LCS) at 20 ug/ml (aqueous, 1333.37 ug/Kg solid concentration) is evaluated. Prepare the laboratory control sample (LCS) for each matrix for each batch of twenty or less samples by adding 1.0ml of the spike mix (section 7.4) to one liter of DI water for aqueous samples or 30 gm of cleaned sand (or reagents only if necessary) for solid samples.

13.5.1 Acceptance Criteria: Default limits of 50 – 150 % recovery or within statistically derived control limits.

13.5.2 For a few analytes that historically exhibit wider statistical ranges, the laboratory will review the actual recovery data that often will consistently fall within project specific (i.e. QSM) ranges. In these instances, the project limits will be adopted.

13.5.3 Corrective Action: Repeat LCS, re-prepare solution and repeat LSC and repeat calibration procedure if necessary.

13.6 For each matrix batch of 20 or less samples a MS/MSD is included that contains all of the components of interest. Prepare a matrix spike (MS) for each matrix for each batch of twenty or less samples by adding 1.0ml of the spike mix (section 7.4) to a representative sample. Prepare a matrix spike duplicate (MSD) for each batch of twenty or less samples by adding 1.0ml of

the spike mix (section 7.4) to the same sample used for the MS. MS/MSD's for aqueous sample require additional material to be supplied by the client.

13.6.1 Acceptance Criteria: Within statistically derived control limits (default limits - 50 150%). MSD RDP limit not to exceed 30%. For some projects the MS/MSD recovery limits are set to the LCS control limits. Spike concentration is 20 ug/ml (aqueous (based on a 1000ml sample size and a 1ml extract final volume), 1333.37 ug/Kg solid concentration (based on a 15g sample size and a 1ml extract final volume)).

13.6.2 Corrective Action – Evaluate the sample spiked for matrix interference and flag the data as necessary.

13.7 Surrogate Control Limits

13.7.1 For each sample matrix the first 30 surrogate recoveries are used to establish control limits based on the Mean recovery +/- 3 times the standard deviation. This procedure is performed annually.

13.7.2 For samples (including QC samples) in which the surrogate recovery falls outside the established control limits, the following is required.

13.7.2.1 Check integrations for errors.

13.7.2.2 Check calculations for errors.

13.7.2.3 Check instrument performance.

13.7.2.4 Re-extract and re-analyzed the samples if the above show no problems or flag the data if sample matrix interference is present.

13.8 Internal standard responses.

13.8.1 The response for each internal standard in the CCV must be within –50% to +100% of the mid-level calibration standard.

13.8.2 Failure to achieve the above criteria requires inspection of system operation and any necessary corrective actions. Any sample associated with the CCV having internal standard failures must be re-analyzed.

13.9 The retention times of the internal standards in the calibration verification standard must be evaluated immediately after or during data acquisition. If the retention time for any internal standard changes by more than 30 seconds from the that in the mid-point standard level of the most recent initial

calibration sequence, then the chromatographic system must be inspected for malfunctions and corrections must be made, as required. When corrections are made, reanalysis of samples analyzed while the system was malfunctioning is required.

13.10 Initial demonstrations of proficiency are performed by all analysts for all instruments and methods. IDP records are kept on file in the laboratory and referenced in analyst training files. Demonstrations of proficiency are re-performed in instances of new staff or major changes in methodology or equipment.

13.11 Refer also to the RTI QAP sections 3.0, 8.0, 9.0, 12.0 and 13.0.

13.12 Table of analytes (internal standards, surrogates and target compounds), including primary (quantitation), and confirmation ions.

| | | Primary Ion | Secondary Ion | Tertiary Ion | Quaternary Ion | Internal standard used |
|---|---|---|---|---|---|---|
| Internal | 1,4-Dichlorobenzene-$d_4$ | 152 | 150 | 115 | 78 | 1,4-Dichlorobenzene-$d_4$ |
| Target | *N*-Nitrosodimethylamine | 74 | 42 | 43 | 59 | 1,4-Dichlorobenzene-$d_4$ |
| Target | Pyridine | 79 | 52 | 51 | 50 | 1,4-Dichlorobenzene-$d_4$ |
| Surrogate | 2-Fluorophenol | 112 | 64 | 92 | 57 | 1,4-Dichlorobenzene-$d_4$ |
| Target | *N*-Nitrosodiethylamine | 102 | 56 | 42 | 71 | 1,4-Dichlorobenzene-$d_4$ |
| Surrogate | Phenol-$d_5$ | 99 | 71 | 100 | 42 | 1,4-Dichlorobenzene-$d_4$ |
| Target | Phenol | 94 | 66 | 65 | 55 | 1,4-Dichlorobenzene-$d_4$ |
| Target | Aniline | 93 | 66 | 65 | | 1,4-Dichlorobenzene-$d_4$ |
| Target | bis(2-Chloroethyl) ether | 93 | 63 | 95 | | 1,4-Dichlorobenzene-$d_4$ |
| Target | n-Decane | 57 | 43 | 71 | 142 | 1,4-Dichlorobenzene-$d_4$ |
| Target | 2-Chlorophenol | 128 | 64 | 130 | 92 | 1,4-Dichlorobenzene-$d_4$ |
| Target | 1,3-Dichlorobenzene | 146 | 148 | 111 | | 1,4-Dichlorobenzene-$d_4$ |
| Target | 1,4-Dichlorobenzene | 146 | 148 | 111 | | 1,4-Dichlorobenzene-$d_4$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Target | Benzyl alcohol | 108 | 79 | 77 | 51 | 1,4-Dichlorobenzene-$d_4$ |
| Target | 1,2-Dichlorobenzene | 146 | 148 | 111 | | 1,4-Dichlorobenzene-$d_4$ |
| Target | 2-Methylphenol | 107 | 108 | 79 | 90 | 1,4-Dichlorobenzene-$d_4$ |
| Target | *bis*(2-Chloroisopropyl) ether | 45 | 77 | 121 | | 1,4-Dichlorobenzene-$d_4$ |
| Target | 4-Methylphenol | 108 | 107 | 79 | 90 | 1,4-Dichlorobenzene-$d_4$ |
| Target | *N*-Nitrosodipropylamine | 70 | 42 | 130 | 101 | 1,4-Dichlorobenzene-$d_4$ |
| Target | o-Toluidine | 106 | 107 | 79 | 77 | 1,4-Dichlorobenzene-$d_4$ |
| Target | Hexachloroethane | 117 | 201 | 199 | 166 | 1,4-Dichlorobenzene-$d_4$ |
| Internal | Naphthalene-$d_8$ | 136 | 68 | 108 | 54 | Naphthalene-$d_8$ |
| Surrogate | Nitrobenzene-$d_5$ | 82 | 54 | 128 | | Naphthalene-$d_8$ |
| Target | Nitrobenzene | 77 | 123 | 65 | 51 | Naphthalene-$d_8$ |
| Target | Isophorone | 82 | 138 | 95 | 54 | Naphthalene-$d_8$ |
| Target | 2-Nitrophenol | 139 | 109 | 65 | 81 | Naphthalene-$d_8$ |
| Target | 2,4-Dimethylphenol | 122 | 107 | 121 | 77 | Naphthalene-$d_8$ |
| Target | Benzoic acid | 122 | 105 | 77 | 51 | Naphthalene-$d_8$ |
| Target | *bis*(2-Chloroethoxy)methane | 93 | 95 | 123 | | Naphthalene-$d_8$ |
| Target | 2,4-Dichlorophenol | 162 | 164 | 98 | 63 | Naphthalene-$d_8$ |
| Target | 1,2,4-Trichlorobenzene | 180 | 182 | 145 | 109 | Naphthalene-$d_8$ |
| Target | 4-Chlorophenol | 128 | 130 | 65 | 73 | Naphthalene-$d_8$ |
| Target | Naphthalene | 128 | 129 | 127 | 63 | Naphthalene-$d_8$ |
| Target | 4-Chloroaniline | 127 | 129 | 65 | 92 | Naphthalene-$d_8$ |
| Target | 2,6-Dichlorophenol | 162 | 164 | 98 | 63 | Naphthalene-$d_8$ |
| Target | Hexachlorobutadiene | 225 | 223 | 227 | 118 | Naphthalene-$d_8$ |
| Target | 4-Chloro-3-methylphenol | 107 | 142 | 144 | | Naphthalene-$d_8$ |
| Target | 2-Methylnaphthalene | 142 | 141 | 115 | 71 | Naphthalene-$d_8$ |
| Internal | Acenaphthene-$d_{10}$ | 164 | 162 | 160 | | Acenaphthene-$d_{10}$ |
| Target | Hexachlorocyclopentadiene | 237 | 95 | 272 | 235 | Acenaphthene-$d_{10}$ |
| Target | 1,2,4,5-Tetrachlorobenzene | 216 | 108 | 214 | 179 | Acenaphthene-$d_{10}$ |
| Target | 2,4,6-Trichlorophenol | 196 | 198 | 97 | 200 | Acenaphthene-$d_{10}$ |
| Target | 2,4,5-Trichlorophenol | 196 | 198 | 97 | 132 | Acenaphthene-$d_{10}$ |
| Surrogate | 2-Fluorobiphenyl | 172 | 85 | 75 | 171 | Acenaphthene-$d_{10}$ |
| Target | 2-Chloronaphthalene | 162 | 164 | 127 | 63 | Acenaphthene-$d_{10}$ |
| Target | 1-Chloronaphthalene | 162 | 164 | 127 | 63 | Acenaphthene-$d_{10}$ |
| Target | 2-Nitroaniline | 138 | 65 | 92 | 77 | Acenaphthene-$d_{10}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Target | Dimethyl phthalate | 163 | 77 | 194 | 164 | Acenaphthene-$d_{10}$ |
| Target | 2,6-Dinitrotoluene | 165 | 89 | 63 | 121 | Acenaphthene-$d_{10}$ |
| Target | Acenaphthylene | 152 | 151 | 76 | 153 | Acenaphthene-$d_{10}$ |
| Target | 3-Nitroaniline | 65 | 138 | 92 | | Acenaphthene-$d_{10}$ |
| Target | Acenaphthene | 153 | 154 | 76 | 152 | Acenaphthene-$d_{10}$ |
| Target | 2,4-Dinitrophenol | 184 | 107 | 63 | 154 | Acenaphthene-$d_{10}$ |
| Target | 4-Nitrophenol | 65 | 109 | 81 | 139 | Acenaphthene-$d_{10}$ |
| Target | Pentachlorobenzene | 250 | 215 | 143 | 129 | Acenaphthene-$d_{10}$ |
| Target | 2,4-Dinitrotoluene | 165 | 63 | 89 | 182 | Acenaphthene-$d_{10}$ |
| Target | Dibenzofuran | 168 | 139 | 169 | 84 | Acenaphthene-$d_{10}$ |
| Target | 2,3,4,6-Tetrachlorophenol | 232 | 131 | 166 | 230 | Acenaphthene-$d_{10}$ |
| Target | Diethyl phthalate | 149 | 177 | 105 | 150 | Acenaphthene-$d_{10}$ |
| Target | 4-Chlorophenyl phenyl ether | 204 | 141 | 206 | | Acenaphthene-$d_{10}$ |
| Target | Fluorene | 166 | 165 | 167 | 139 | Acenaphthene-$d_{10}$ |
| Target | 4-Nitroaniline | 138 | 65 | 92 | 108 | Acenaphthene-$d_{10}$ |
| Surrogate | 2,4,6-Tribromophenol | 330 | 332 | 61 | 141 | Acenaphthene-$d_{10}$ |
| Internal | Phenanthrene-$d_{10}$ | 188 | 80 | 94 | | Phenanthrene-$d_{10}$ |
| Target | 4,6-Dinitro-2-methylphenol | 198 | 105 | 121 | 51 | Phenanthrene-$d_{10}$ |
| Target | *N*-Nitrosodiphenylamine | 169 | 168 | 167 | | Phenanthrene-$d_{10}$ |
| Target | Azobenzene | 77 | 182 | 105 | 152 | Phenanthrene-$d_{10}$ |
| Target | 4-Bromophenyl phenyl ether | 248 | 250 | 141 | | Phenanthrene-$d_{10}$ |
| Target | Hexachlorobenzene | 284 | 142 | 249 | | Phenanthrene-$d_{10}$ |
| Target | Pentachlorophenol | 266 | 165 | 264 | 268 | Phenanthrene-$d_{10}$ |
| Target | Pentachloronitrobenzene | 237 | 297 | 179 | 265 | Phenanthrene-$d_{10}$ |
| Target | n-Octadecane | 57 | 71 | 85 | 254 | Phenanthrene-$d_{10}$ |
| Target | Phenanthrene | 178 | 152 | 179 | 176 | Phenanthrene-$d_{10}$ |
| Target | Anthracene | 178 | 76 | 176 | 179 | Phenanthrene-$d_{10}$ |
| Target | Carbazole | 167 | 139 | 84 | 166 | Phenanthrene-$d_{10}$ |
| Target | Di-n-butyl phthalate | 149 | 150 | 104 | 278 | Phenanthrene-$d_{10}$ |
| Target | Fluoranthene | 202 | 101 | 203 | 88 | Phenanthrene-$d_{10}$ |
| Target | Benzidine | 184 | 92 | 185 | 156 | Phenanthrene-$d_{10}$ |
| Internal | Chrysene-$d_{12}$ | 240 | 236 | 120 | | Chrysene-$d_{12}$ |
| Target | Pyrene | 202 | 200 | 203 | 101 | Chrysene-$d_{12}$ |
| Internal | Terphenyl-$d_{14}$ | 244 | 122 | 245 | 212 | Chrysene-$d_{12}$ |
| Target | Butyl benzyl phthalate | 149 | 91 | 206 | 312 | Chrysene-$d_{12}$ |
| Target | 3,3'-Dichlorobenzidine | 252 | 154 | 126 | 254 | Chrysene-$d_{12}$ |
| Target | *bis*(2-Ethylhexyl) phthalate | 149 | 167 | 279 | 113 | Chrysene-$d_{12}$ |
| Target | Benz(a)anthracene | 228 | 226 | 114 | 229 | Chrysene-$d_{12}$ |
| Target | Chrysene | 228 | 226 | 114 | 229 | Chrysene-$d_{12}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Target | Di-n-octyl phthalate | 149 | 167 | 43 | 279 | Chrysene-$d_{12}$ |
| Internal | Perylene-$d_{12}$ | 264 | 132 | 260 | 265 | Perylene-$d_{12}$ |
| Target | Benzo(b)fluoranthene | 252 | 253 | 126 | 125 | Perylene-$d_{12}$ |
| Target | Benzo(k)fluoranthene | 252 | 253 | 126 | 125 | Perylene-$d_{12}$ |
| Target | Benzo(a)pyrene | 252 | 126 | 113 | 125 | Perylene-$d_{12}$ |
| Target | Indeno(1,2,3-cd)pyrene | 276 | 138 | 124 | 277 | Perylene-$d_{12}$ |
| Target | Dibenz(a,h)anthracene | 278 | 139 | 125 | 279 | Perylene-$d_{12}$ |
| Target | Benzo(g,h,i)perylene | 276 | 138 | 124 | 277 | Perylene-$d_{12}$ |

## 14.0 Data Reporting Requirements

14.1 If any compound is found in a sample at a concentration greater than that of the highest standard the sample must be re-analyzed after dilution. The sample should be diluted until all compounds of interest are within the working range of the standard curve. Data from all dilutions are evaluated and compound results will be reported from the lowest dilution that exhibits lack of interference. The LIMS is capable on accepting multiple dilutions on a sample and reporting only the applicable compounds for each dilution. The surrogate recoveries must fall within the statistical ranges (section 13.4).

14.2 Blank results are not to be subtracted from sample values.

14.3 Sample concentrations are reported in ug/ml from the Enviroquant data system.

14.4 Raw results are entered into Omega. Prep factors are automatically imported from sample prep logs. Dilutions are entered in the analytical sequence.

14.5 Sample results are reported as ug/L for water and ug/kg for soil as dry weight.

ug/kg dry wt. = ug/kg wet wt.*100/percent solids

14.6 Raw instruments results are entered directly into the Omega LIMS system using excel spreadsheets, direct instrument interface or manually. All calculations to derive final result (including dry weight conversions) are performed automatically by the LIMS. Sample preparation information and percent moisture results are entered into the appropriate section of the LIMS prior to instrument data and are automatically factored into the final results.

14.7 Confirm that there are no QC flags or qualifiers in this sequence. If present, investigate and repeat or reanalyze as necessary. See section 9.2 of the QAP for more detail on qualifiers.

## 15.0 Preventative Maintenance and Routine Cleaning

15.1 Daily: Perform air water check, tune check, monitor tank pressures, check multiplier mv, check for RT shifts by monitoring compound RT's, perform injection port monitoring and maintenance using tune verification standard as indicator.

15.2 Weekly: Change septa approximately every 100 injections, perform injection port maintenance and prepare new CCV standard.

15.3 Annual: Change pump oil.

15.4 All maintenance is recorded in the Omega LIMS for the applicable instrument.

## 16.0 Waste Management and Pollution Prevention

16.1 Pollution Prevention

16.1.1 Reagents are purchased and quantities used to reflect anticipated usage and minimize disposal of expired or unused chemicals.

16.1.2 Chemicals are handled in a manner, which minimizes the potential for release or spill of the material.

16.2 Waste Management

16.2.1 Organic solvents are treated as hazardous waste and placed in the appropriate waste drum for disposal.

16.2.2 Soil samples are composited in a drum designated for incineration.

16.2.3 Disposal of materials is addressed in the laboratory QAP (Section 5.6).

## 17.0 References

17.1 EPA Test Methods for Evaluating Solid Waste. Laboratory Manual Physical/Chemical Methods, Method 8270D Revision 4, 3550B, 3545, and 3510C.

17.2 RTI Lab SOP#'s 3510C and 3550B.

17.3 RTI Laboratories, Inc. Quality Assurance Plan, Revision 8, August 16, 2005.

17.4 RTI Laboratories, Inc. Chemical Hygiene Plan.

17.5 RTI Laboratories, Inc. SOP: SRC001-A, Sample Receipt and Custody SOP.

17.6 RTI Laboratories, Inc. Employee Handbook.

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**ADMINISTRATIVE OPERATING PROCEDURE**

# SAMPLE RECEIPT AND CUSTODY STANDARD OPERATING PROCEDURE

| | |
|---|---|
| **SOP#:** | **SRC001-A_R5** |
| **Reference:** | **RTI QAP** |
| **Issue Date:** | **August 25, 2005** |
| **Revision No.:** | **5** |
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| | |
|---|---|
| Director, Quality Management: | Charles O'Bryan |
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**SAMPLE RECEIPT AND CUSTODY STANDARD OPERATING PROCEDURE**

**SOP#: SRC001-A_R5**

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# Administrative Operating Procedure

## Sample Receiving and Custody Standard Operating Procedure

The following standard operating procedure provides guidance for the receipt, checking, logging in and distribution of samples received at RTI Laboratory. The Client Services Supervisor and/or Laboratory Manager provides supervision and checking to ensure that all of the requirements of the operating procedure are implemented for all projects.

For additional policies, procedures, and definitions refer to the RTI Quality Assurance Plan.

## 1.0 Sample Receiving

It is the policy of RTI that all samples received for analysis are handled under strict chain of custody (COC) protocols. Sample custody is defined in the RTI QAP, Section 5.1. Samples are received in the sample receiving area of the laboratory either by courier, customer delivery or from RTI personnel.

If the samples are picked up by an employee of RTI (field staff or other) it is the responsibility of that person to check that all of the bottles on the chain of custody (COC) are present before signing the COC. If no COC is present and cannot be obtained, the samples may be transported to the lab where Sample Receiving will arrange to get the documentation from the customer before proceeding.

All samples must be received with a properly completed chain of custody and properly labeled before proceeding with the log in of the samples. Sample container labels must be permanently affixed, legible and include the customer name, project name or identification, client or field sample identification number, date and time of collection, and chemical preservation used. The chain of custody and must include:

Client name, address, phone and fax number and e-mail address (where provided).
Project identification information.
Sample collection location (where provided)
Sample identifications
Date and time of collection
Sample type/matix
Analyses requested
Name of person collecting the samples
Sample preservation
Turnaround time requested
Special instructions or comments

Relinquished and received by signatures and dates.

When RTI field personnel collect samples, it is the responsibility of that person to verify that the chain of custody is properly filled out, sample containers are correctly labeled and the sample inventory matches the chain of custody before relinquishing the samples to sample receiving.

Before proceeding to sample log in, sample-receiving personnel will check the COC and bottles to determine the acceptability as described in the following sample acceptance policy and, after resolving any discrepancies, sign the COC. If there are any discrepancies, the appropriate person must be contacted for resolution.

If the client delivers the samples, sample inventory is checked against the chain of custody and any discrepancies noted for the client to correct. After the samples and COC are in agreement and the samples have been determined to be acceptable as described in the following sample acceptance policy, the client and the sample receiving person sign and date the COC and a copy is provided to the client.

If the samples are picked up by an employee of RTI (field staff or other) and a COC was provided, the delivering employee signs it. Whenever possible the inventory should be verified on site before accepting the samples. Before proceeding, sample-receiving personnel will check the COC and bottles. If no COC was provided it is the responsibility of sample receiving to contact the client to obtain the correct documentation before proceeding with log in. If at this time there are any discrepancies the client must be contacted by either sample receiving or Customer Service and any discrepancies resolved. Sample receiving determines the acceptability as described in the following sample acceptance policy and, after resolving any discrepancies, signs the COC.

Samples received by courier are treated in the same manner as those picked up by RTI employees.

Sample receiving personnel must determine the origin of the samples received. Solid or soil samples originating from foreign countries or regulated areas of the United States must processed in accordance with the United States Department of Agriculture (USDA) Compliance Agreement. Sections 3.0 and 4.0 specify the handling procedures for these samples.

All calls, conversations or correspondence with the client must be noted and become a part of the project file. This note must include the issue(s), the date and time, the client representative and the resolution reached. Where possible, a revised copy of the COC faxed from the client is desirable.

Refer also to Appendix A for instruction on receipt of listed waste samples.

## 2.0 Sample Acceptance Policy

Upon receipt of the sample, the following information will be checked at log in time and is the responsibility of RTI Laboratories, Inc. sample receiving personnel:

A sample receipt checklist is incorporated into the LIMS Work Order screen for each sample set that is logged in and documents all checks appropriate for the disposition of the sample and will be maintained as part of the project record. All discrepancies must be noted on the sample receipt checklist comments and resolved with the client. The following items are noted on the sample receipt checklist.

- Client code.
- Date and time received.
- Work Order Number.
- Mode of receipt – Carrier Name, Courier, Client.
- Received by person, person completing checklist and reviewed by.
- COC and cooler identifications, if available.
- Acceptable condition of shipping containers.
- Presence of custody seals (if provided) with seal number, date and signature.
- Presence of the COC.
- Verification of COC relinquished and received signatures.
- Agreement of COC with container labels.
- Proper containers used for samples.
- Condition of sample containers.
- Verification of sufficient sample volume for the analyses requested.
- Receipt of samples within holding time.
- Temperature of samples on receipt and method of cooling when required.
- Aqueous volatile compounds samples received without headspace.
- Acceptable pH of samples requiring preservation.

- Client contact information

## 3.0 Verification and Inspection of Samples

In completing the checklist the following procedures are performed by sample receiving personnel. Departures from acceptable documentation or sample condition are noted, brought to the attention of the sample submitter and resolved where necessary.

- Methods requested by the client must be appropriate for the sample and container submitted. Clients will be informed if methods requested are not appropriate for the sample or if a requested method is out of date for the analysis required.

- Appropriate sample containers are used as per the referenced method. Refer to RTI QAP, Section 4, Table 4-1 for method requirements for bottle, preservative and holding time.

- Adherence to holding times specified in the referenced method. Holding times are incorporated into the Omega LIMS test codes for the individual methods or procedures.

- Adequate sample volume to perform the test, provide method required quality control and meet the detection limits required by the client. Minimum sample volume are noted in the RTI QAP, Section 4, Table 4-1.

- Individual samples are evaluated for sample integrity and condition, including container damage, possible cross contamination or inadequate preservation.

- All samples that require thermal preservation at 4 deg C shall be considered acceptable if the arrival temperature is freezing to 6 deg C and that there is evidence that cooling was started (ex. samples on ice). All coolers and samples are checked for temperature with a digital thermometer and the temperature recorded on the sample receipt checklist

- Chemical preservation will be checked, when applicable, with the use of full range pH paper and free chlorine test paper. Residual chlorine will be checked at sample receiving for all samples requiring analysis for BOD (routinely checked by analyst at sample set-up), cyanide, or organic extractable compounds with starch iodide paper. For those samples exhibiting residual chlorine, sodium thiosulfate is added (0.1ml of 10% sodium thiosulfate/100ml of sample) and the residual chlorine rechecked. All samples requiring preservation by pH adjustment will be checked for pH and the pH adjusted as required for that parameter. Any adjustments made are noted on the sample receipt checklist. VOA water sample pH is checked by the VOA analyst at the time of analysis and

noted in the VOC analytical logbook. VOC samples that exceed the required pH are noted in the comments section of the sample analytical sequence and appear on the case narrative noting :"sample pH >2". These comments automatically appear on the work order Case Narrative. Preserved samples for metals analysis must be verified that at least sixteen hours have elapsed from sample preservation to pH checks. For metals samples that are preserved in the laboratory a notation of the time of preservation is made in the LIMS for that sample and the time required to hold the sample before commencing analysis. The pH of these samples will be checked after the appropriate time by the metals preparation analyst and note in the preparation log. If continued preservation of a sample is in question or deterioration of the preservative is suspected based on difficulty in achieving the desired pH or other observations, a comment is added to the sample in the work order to instruct the analyst to check the pH prior to analysis.

- For VOA soil samples, method 5035 sampling criteria must be met. Methanol preservation is required by various State agencies or programs for soil samples. Appropriate sample weight and methanol ratio is checked at log in time by taking a final weight and subtracting client sample weight and tare weight. Ideal sample to methanol ration is 1:1. If the ration exceeds 1:1 additional methanol is added to adjust the ratio. However, if the ratio exceeds 2:1 the sample if rejected, the client is notified and analysis will only proceed on authorization from the client. If the ratio is more than 10% below the target ratio the samples are flagged. If the soil is not completely submerged in the methanol solution a notation is made on the Case Narrative.

- If it is necessary to split a sample into other containers and preserved, notation must be made on the COC that this was done, that the client was informed, the person performing the splitting and preservation and the date.

- The COC must be checked for any comments or special requirements from the client. This could include sample handling (ex. filtering sample) or that the sample is high in some parameter or interference. This information is logged in the work order and will be present for the analyst to review on the applicable backlog.
- For samples received from foreign or regulated sources, the shipping container must be inspected to ensure all sample bottles were received intact. In the event of damage to sample containers any material present in the chipping cooler must be transferred to a sample bottle and placed with the sample set for disposal according to the procedures specified in the USDA Compliance Agreement (RTI QAP Section 5). Contaminated shipping containers will be cleaned with 6% bleach solution (Chlorox) prior to reuse.

## 4.0 Sample Login

Following acceptance of the samples the log in process will commence.

From the front screen of the Omega LIMS choose WORK ORDERS.

Select ADD. This will automatically generate a new and unique Work Order number for each sample set/project.

From the Client ID filed enter or choose from the drop down menu the appropriate client.

Add or change the Client Contact.

Enter the appropriate client project number and/or description into the Project Name field.

Enter the requested turnaround time in days in the TAT filed and check Work Order is Rush if applicable.

Select ChkList and enter the appropriate information as described above.

Select SAMPLE LOGIN and then ADD to begin logging in samples.

Enter the ClientSampID, Date Collected, Matrix, Bottle Type, # Containers and Storage/Status.

From Tests or Test Groups choose the appropriate Test Code/Group for the analyses requested on the chain.

Continue by adding fractions for separate containers and the appropriate Test Codes based on the request or by adding additional samples as required.

Following completion of logging in all samples choose LABELS and print the sample labels. Labels for samples received that are regulated by the USDA soil permit are colored to distinguish these samples.

Samples under the USDA Compliance Agreement are stored segregated from all other samples.

Attach the corresponding LIMS sample label to the appropriate sample container.

> The number assigned will be used by the analytical staff for tracking all preparation and testing procedures associated with this sample. Refer to RTI QAP, Section 5.4

Close the log in screen and select SUMMARY.

Print the Work Order Summary, attach this to the COC and give to the person designated for log review.

Following review of the Work Order and verification that all samples have been appropriately logged in a date will be entered into the Log Review field of the Work Order.

The status of the Work Order will change to LOCKED and subsequent changes can only be made by authorized personnel.

## 5.0 Extended/Evidentiary Chain of Custody Procedures

When required by contract or specified by client request samples will be designated for Extended Chain of Custody. The following procedures will apply in these instances.

- All sample shipping receipts will be retained and become part of the permanent record.
- Custody seals will be logged and documented as above.
- The Sample Tracker in the LIMS will be used to initiate internal chain of custody records for all samples.
- All transfers will be posted in the sample tracker.
- Sample chain of custodies will be generated from the Sample Tracker, will contain the signatures of all individuals that require possession of the samples and will account for

  the time frame that sample were in possession of any individual.
- Samples will be maintained in secured, restricted locations under control of the sample custodian.
- The sample custodian will be responsible for transfer of samples to the appropriate individuals and documentation of the transfer.
- Sample extracts, digestion solutions, etc. will be maintained in the possession of the analysts until testing is complete.
- Upon completion the extracts will be returned to the sample custodian and maintained in a designated secured location.
- Sample disposal will occur according to the instructions supplied by the responsible party and will be fully documented.

## 6.0 References

RTI Laboratories, Inc., Quality Assurance Plan.

United States Department of Agriculture, Animal & Plant Inspection Service Plant Protection and Quarantine – Compliance Agreement
United States Department of Agriculture – Soil Permit

## 7.0 Appendix A. Procedures for Listed Waste Samples

Receiving and tracking samples that are identified as listed waste.

- RTI must manage all samples, TCLP extracts, extractions, digestates, or any other process or waste that comes in contact with the samples (residual waste) as a listed waste. This appendix describes the proper method for receiving the identified waste, including notification to the client about how the residual and sample will be managed. This appendix further describes the process for properly managing all fluids associated with processing the sample throughout the lab, and return or disposal of the sample and residual waste.

Receiving samples identified by the client as “RCRA listed wastes”

- When a client submits a samples identified as a listed waste, sample receiving personnel must first determine if RTI can manage the listed waste or if it must be returned to the client. RTI can only manage F001, F002, F003, F004 and F005 (F001-5) listed wastes.

- If the waste is identified as any other listed waste, including K, P, U, or other F waste codes; the client must be informed that RTI is not capable of managing the listed waste. This would require RTI to manage the sample and residual waste as described in the “Management of RCRA listed waste sample and residual waste” section and return the sample and all residual waste to the generator with the analytical report. The client must be notified of this immediately, including any additional charges for sample management, so they have the opportunity to have the samples analyzed elsewhere.

- If the sample is identified as an F001-5 waste, RTI must manage the sample and residual waste as described in the “Management of RCRA listed waste sample and residual waste” section and at the proper time, dispose of the sample and residual wastes in the properly identified satellite collection vessel or solvent drum in the waste area.

- In either situation, the sample must be logged into the LIMS for the proper tests and go through the identical steps as any other sample. The sample login must contain a comment that the samples is a known listed waste, i.e., “Sample is a

F001 listed waste-manage residuals"

Management of RCRA listed waste sample and residual waste

- At the time of login, the sample-receiving custodian must do all of the following for each sample identified as a RCRA listed waste:

- Label the sample container with a hazardous waste label identifying the waste code for the sample. This information is in addition to the information required for standard login and tracking labels.

- Provide a one gallon container with the same information as the sample and a label indicating

  Residual Waste
  Sample number
  Login date
  Waste Code

- The sample and residual waste container are placed in a box identified with the sample number and login date, and stored in walk-in cooler 2 (W-2).

- All residuals, including TCLP residuals, generated from the preparation and analysis of the sample must be placed in the "Residual waste" container. If the digestate, extract, concentrate, etc. is already contained, that container, properly labeled with the sample number, must be placed in the box identified for that sample so that all residuals are properly managed.

- All residuals and the sample are managed as any other sample. Samples identified as listed wastes are stored in W-2 cooler until disposal or return.

Disposal/Return of RCRA listed waste sample and residual waste

- At the designated time the sample and residual waste must be returned or disposed.

- Samples for return are to be returned with the delivery of the analytical report. To facilitate this the analytical report, invoice and shipper are prepared and scheduled for delivery to the client. The sample box, sample, residual waste, reports, COC, invoice and shipper are delivered to the client. A representative from the company must sign the COC as receiving the sample and sign the shipper indicating that all residuals have been returned to the client. The signed shipper is attached and filed with the retained file papers for that work order number.

- Samples for disposal (F001-5 wastes) are disposed into the satellite collection container or waste solvent drum. All sample and residual waste containers must be triple rinsed before disposal and the rinsate must be managed in the satellite collection container or waste solvent drum. The sample disposal information must also be updated in the LIMS.

- Any situations that are not clearly understood from a sample management aspect must be addressed with either the Safety manager or the Director.

# APPENDIX D

# SPECIFIC FIELD STANDARD OPERATING PROCEDURES

# APPENDIX D

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SOP-10 Measurement of Water Levels in Monitoring Wells

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# STANDARD OPERATING PROCEDURE

# SOP-01

# SAMPLE LABELING

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used for labeling sample containers. Sample labels are used to document the sample ID, date, time, analysis to be performed, preservative, matrix, sampler, and the analytical laboratory. A sample label will be attached to each sample container.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

**Writing utensil (preferably black pen with indelible ink)**
**Disposable medical-grade gloves (e.g. latex, nitrile)**
**Sample log sheets**
**Required sample containers**: All sample containers for analysis by fix-based laboratories will be supplied and deemed certified clean by the laboratory.
**Sample labels**
**Chain-of-custody records**
**Sealable polyethylene bags**
**Heavy-duty cooler**
**Ice**

## 3.0 PROCEDURES

3.1 The following information will be electronically printed on each sample label prior to mobilizing for field activities. Additional “generic” labels will also be printed prior to mobilization to be used for field QC and backups.

- Project number (CTO F272)
- Sample location ID
- Contract Task Order number
- Sample ID

- Matrix
- Preservative
- Analysis to be performed
- Laboratory name

3.2 Select the container(s) that are appropriate for a given sample. Select the sample-specific ID label(s), complete date, time, and sampler name, and affix to the sample container(s).

3.3 Fill the appropriate containers with sample material. Securely close the container lids without overtightening.

3.4 Place the sample container in a sealable polyethylene bag and place in a cooler containing ice.

Example of a sample label is attached at the end of this SOP.

## 4.0 ATTACHMENTS

1. Sample Label

**ATTACHMENT 1**

**SAMPLE LABEL**

| | | |
|---|---|---|
| Tetra Tech NUS, Inc.<br>661 Andersen Drive<br>Pittsburgh, 15220<br>(412)921-7090 | **Project:**<br>**Location:**<br>**CTO:** | |
| **Sample No:** | | **Matrix:** |
| **Date:** | **Time:** | **Preserve:** |
| **Analysis:** | | |
| **Sampled by:** | **Laboratory** | |

# STANDARD OPERATING PROCEDURE

# SOP-02

# SAMPLE IDENTIFICATION NOMENCLATURE

## 1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish a consistent sample nomenclature system that will facilitate subsequent data management at the Naval Support Activity (NSA) Crane. The sample nomenclature system has been devised such that the following objectives can be attained.

- Sorting of data by site, location, or matrix
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints
- Ease of sample identification

The NSA Crane Environmental Protection Department must approve any deviations from this procedure.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

**Pen with indelible ink**
**Sample tags**
**Sample container labels**

## 3.0 SAMPLE IDENTIFICATION NOMENCLATURE

### 3.1 <u>Confirmation Samples</u>

All confirmation samples will be properly labeled with a sample label affixed to the sample container. Each sample will be assigned a unique sample tracking number.

### 3.1.1 Confirmation Sample numbering Scheme

The sample tracking number will consist of a four- or five-segment alpha-numeric code that identifies the sample's associated Unexploded Ordnance (UXO) site or Area of Concern (AOC), sample type, location, and sample depth. For soil samples, the final four tracking numbers will identify the depth in units of feet below ground surface (bgs) at which the sample was collected (rounded to the nearest foot). For sediment samples, the final four tracking numbers will identify the depth in units of inches bgs at which the sample was collected.

The alphanumeric coding to be used is explained in the following diagram and subsequent definitions:

| **AN** | **AA** | **NNNA** | **NNNN (Soils and Sediment only)** |
|---|---|---|---|
| UXO or AOC Number | Matrix | Sample Location Number and Grab or Composite | Sequential depth interval from freshly exposed surface |

**Character Type:**

A = Alpha
N = Numeric

**UXO Number (AN):**

X6 = UXO 6
A1 = AOC 1
A2 = AOC 2
A4 = AOC 4
A6 = AOC 6

**Matrix Code (AA):**

SS = Surface Soil Sample
SB = Subsurface Soil Sample
SD = Sediment Sample

**Location Number (NNNA):**

Sequential number beginning with “001” for each matrix, followed by a letter indicating grab (G) (or composite [C] sample, if appropriate).

**Depth Interval (NNNN):**

This code section will be used for soil and sediment samples only. For soil samples, the final four tracking numbers will identify the depth in units of feet. Surface soil samples will be collected from 0- to 2-feet bgs. Subsurface soil samples will be collected at depths greater than 2-feet bgs. For sediment samples, the final four tracking numbers will identify the depth in units of inches. Sediment samples will be collected from 0- to 6-inches below the sediment/water interface.

The depth code is used to note the depth bgs at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval of the sample depth. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet, boring log, logbook, etc. (If composite samples are collected: “location” refers to a particular sampling grid represented by a composite sample.

### 3.1.2 Examples of Confirmation Sample Nomenclature

The first grab surface soil sample collected from UXO 6, sampling location 003, at a depth of 1-foot bgs would be labeled as “X6SS003G0001”.

The composite sediment sample collected from sampling location 002 at AOC 4 would be labeled as A4SD002C0006.

## 3.3 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature

Field QA/QC samples are described in the UFP-SAP. They will be designated using a different coding system than the one used for regular field samples.

### 3.3.1 QC Sample Numbering

The QC code will consist of a four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

| AN | AA | NNNNNN | NN |
|---|---|---|---|
| UXO of AOC Number | QC Type | Date | Sequence Number (per day) |

The QC types are identified as:

RB = Rinsate Blank
FD = Field Duplicate

The sampling time recorded on the Chain-of-Custody Form, labels, and tags for duplicate samples will be “0000” so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory).

### 3.3.2 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day at AOC 2 for a surface soil sample collected on August 25, 2009 would be designated as A2FD08250901.

The third duplicate of the day taken at AOC 1 of a surface soil sample collected on September 3, 2009 would be designated as FD09030903.

The first rinsate blank associated with samples collected on September 3, 2009 would be designated as RB09030901.

# STANDARD OPERATING PROCEDURE

# SOP-03

# SAMPLE CUSTODY AND DOCUMENTATION OF FIELD ACTIVITIES

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for sample custody and documentation of field sampling and field analyses activities.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following logbooks, forms, labels, and equipment are required.

**Writing utensil (preferably black pen with indelible ink)**
**Site logbook**
**Field logbook**
**Sample label**
**Chain-of-Custody Form**
**Custody seals**
**Equipment calibration log**
**Soil and Sediment Sample Log Sheet**
**Surface Water Sample Log Sheet**

## 3.0 PROCEDURES

This section describes custody and documentation procedures. All entries made into the logbooks, custody documents, logs, and log sheets described in this SOP must be made in indelible ink (black is preferred). No erasures are permitted. If an incorrect entry is made, the entry will be crossed out with a single strike mark, initialed, and dated.

### 3.1 Site Logbook

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, the following activities and events will be recorded (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Arrival/departure of equipment
- Start or completion of sampling activities
- Daily on-site activities performed each day
- Sample pickup information
- Health and safety issues
- Weather conditions

The site logbook is initiated at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that on-site activities take place.

The following information must be recorded on the cover of each site logbook:

- Project name
- Project number
- Book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). At the completion of each day's entries, the site logbook must be signed and dated by the field operations leader (FOL).

## 3.2 Field Logbooks

The field logbook is a separate dedicated notebook used by field personnel to document his or her activities in the field. This notebook is hardbound and paginated.

## 3.3 Sample Labels

Adhesive sample container labels must be completed and applied to every sample container. Information on the label includes the project name, location, sample number, date, time,

preservative, analysis, matrix, sampler's initials, and the name of the laboratory performing the analysis.

### 3.4 Chain-of-Custody Form

The Chain-of-Custody Form (COC) is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as it is transferred from person to person. Each COC is numbered. This form must accompany any samples collected for laboratory chemical analysis. A copy of a blank COC form is attached at the end of this SOP.

The FOL must include the name of the laboratory in the upper right hand corner section to ensure that the samples are forwarded to the correct location. If more than one COC is necessary for any cooler, the FOL will indicate "Page __ of __" on each COC. The original (top) signed copy of the COC will be placed inside a sealable polyethylene bag and taped inside the lid of the shipping cooler. Once the samples are received at the laboratory, the sample custodian checks the contents of the cooler(s) against the enclosed COC(s). Any problems are noted on the enclosed COC Form (bottle breakage, discrepancies between the sample labels, COC form, etc.) and will be resolved through communication between the laboratory point-of-contact and the Task Order Manager (TOM). The COC form is signed and retained by the laboratory and becomes part of the sample's corresponding analytical data package.

### 3.5 Custody Seal

The custody seal is an adhesive-backed label, and it is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transit to the laboratory. The custody seals are signed and dated by the samplers and affixed across the opening edges of each cooler (two seals per cooler) containing environmental samples. The laboratory sample custodian will examine the custody seal for evidence of tampering and will notify the Tetra Tech TOM if evidence of tampering is observed.

### 3.6 Equipment Calibration Log

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device requiring calibration. Entries must be made for each day the equipment is used.

### 3.7 Sample Log Sheets

The Soil and Sediment Sample Log Sheets are used to document the sampling of soils and sediments (see SOPs-05, 06, and -08). The surface water sample log sheets are used to document the sampling of surface waters (see SOP-07). The groundwater sample log sheets are used to document the sampling of groundwater (see SOP-18).

## 4.0 ATTACHMENTS

1. Chain-of-Custody Record
2. Equipment Calibration Log
3. Soil and Sediment Sample Log
4. Surface water Sample Log
5. Groundwater Sample Log

# ATTACHMENT 1
## CHAIN-OF-CUSTODY RECORD

CHAIN OF CUSTODY | NUMBER | PAGE ____ OF _____

| PROJECT NO: | SITE NAME: | PROJECT MANAGER AND PHONE NUMBER | LABORATORY NAME AND CONTACT: |
|---|---|---|---|
| SAMPLERS (SIGNATURE) | | FIELD OPERATIONS LEADER AND PHONE NUMBER | ADDRESS |
| | | CARRIER/WAYBILL NUMBER | CITY, STATE |

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

| DATE YEAR ____ | TIME | SAMPLE ID | MATRIX | GRAB (G) COMP (C) | No. OF CONTAINERS | CONTAINER TYPE PLASTIC (P) or GLASS (G) | | | | | | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | PRESERVATIVE USED | | | | | | | | |
| | | | | | | TYPE OF ANALYSIS | | | | | | | | |
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COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

3/99
FORM NO. TtNUS-001

# ATTACHMENT 2
# EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

## EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

| Date of Calibration | Instrument I.D. Number | Person Performing Calibration | Instrument Settings | | Instrument Readings | | Calibration Standard (Lot No.) | Remarks and Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Pre-calibration | Post-calibration | Pre-calibration | Post-calibration | | |
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## ATTACHMENT 3

## SOIL AND SEDIMENT SAMPLE LOG SHEET

### SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

**GRAB SAMPLE DATA:**

| Date: | Depth Interval | Color | Description (Sand, Silt, Clay, Moisture, etc.) |
|---|---|---|---|
| Time: | | | |
| Method: | | | |
| Monitor Reading (ppm): | | | |

**COMPOSITE SAMPLE DATA:**

| Date: | Time | Depth Interval | Color | Description (Sand, Silt, Clay, Moisture, etc.) |
|---|---|---|---|---|
| | | | | |
| Method: | | | | |
| | | | | |
| Monitor Readings (Range in ppm): | | | | |
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**SAMPLE COLLECTION INFORMATION:**

| Analysis | Container Requirements | Collected | Other |
|---|---|---|---|
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**OBSERVATIONS / NOTES:**

**MAP:**

**Circle if Applicable:**

| MS/MSD | Duplicate ID No.: |
|---|---|

**Signature(s):**

## ATTACHMENT 4

## SURFACE WATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

**SURFACE WATER SAMPLE LOG SHEET**

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

**SAMPLING DATA:**

| | Color | pH | S.C. | Temp. | Turbidity | DO | Salinity | ORP |
|---|---|---|---|---|---|---|---|---|
| Date: | Visual | Standard | mS/cm | Degrees C | NTU | mg/l | % | mV |
| Time: | | | | | | | | |
| Depth: | | | | | | | | |
| Method: | | | | | | | | |

**SAMPLE COLLECTION INFORMATION:**

| Analysis | Preservative | Container Requirements | Collected |
|---|---|---|---|
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**OBSERVATIONS / NOTES:**

**MAP:**

**Circle if Applicable:**

| MS/MSD | Duplicate ID No.: |
|---|---|
| | |

**Signature(s):**

**ATTACHMENT 5**

# GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

## GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

**SAMPLING DATA:**

| Date: | Color | pH | S.C. | Temp. | Turbidity | DO | Salinity | Other |
|---|---|---|---|---|---|---|---|---|
| Time: | (Visual) | (S.U.) | (mS/cm) | ($^0$C) | (NTU) | (mg/l) | (%) | |
| Method: | | | | | | | | |

**PURGE DATA:**

| Date: | Volume | pH | S.C. | Temp. | Turbidity | DO | Salinity | Other |
|---|---|---|---|---|---|---|---|---|
| Method: | | | | | | | | |
| Monitor Reading (ppm): | | | | | | | | |
| Well Casing Diameter & Material | | | | | | | | |
| Type: | | | | | | | | |
| Total Well Depth (TD): | | | | | | | | |
| Static Water Level (WL): | | | | | | | | |
| One Casing Volume(gal/L): | | | | | | | | |
| Start Purge (hrs): | | | | | | | | |
| End Purge (hrs): | | | | | | | | |
| Total Purge Time (min): | | | | | | | | |
| Total Vol. Purged (gal/L): | | | | | | | | |

**SAMPLE COLLECTION INFORMATION:**

| Analysis | Preservative | Container Requirements | Collected |
|---|---|---|---|
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**OBSERVATIONS / NOTES:**

| Circle if Applicable: | | Signature(s): |
|---|---|---|
| MS/MSD | Duplicate ID No.: | |

# STANDARD OPERATING PROCEDURE

# SOP-04

# DECONTAMINATION OF FIELD SAMPLING EQUIPMENT

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures to be followed when decontaminating non-dedicated field sampling equipment during the field investigations.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

**Writing utensil (preferably black pen with indelible ink)**
**Non-latex rubber or plastic gloves**
**Cotton gloves**
**Field logbook**
**Potable water**
**Deionized water**
**Isoproponal (optional)**
**LiquiNox detergent**
**Brushes, spray bottles, paper towels, etc.**
**Container to collect and transport decontamination fluids**

## 3.0 DECONTAMINATION PROCEDURES

3.1 Don non-latex and/or cotton gloves and decontaminate sampling equipment (in accordance with the following steps) prior to field sampling and between samples.

3.2 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.3 Wash the equipment with a solution of LiquiNox detergent. Prepare the LiquiNox wash solution in accordance with the instructions on the LiquiNox container. Collect the LiquiNox wash solution into a container. Use brushes or sprays as appropriate for the equipment. If oily residue has accumulated on the sampling equipment, remove the residue with an isopropanol wash and repeat the LiquiNox wash.

3.4 Rinse the equipment with potable water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the potable water rinsate into a container.

3.5 Rinse the equipment with deionized water. Rinsing may be conducted by spraying with water from a spray bottle or by dipping. Collect the deionized water rinsate into a container.

3.6 Remove excess water by air drying, shaking, or by wiping with paper towels as necessary.

3.7 Document decontamination by recording it in the field logbook.

3.8 Containerized decontamination solutions will be managed in accordance with the procedures described in SOP-13 and this UFP SAP.

# STANDARD OPERATING PROCEDURE

# SOP-05

# BOREHOLE ADVANCEMENT AND SOIL CORING FOR SOIL SAMPLING USING DIRECT-PUSH TECHNOLOGY

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for collecting surface and subsurface soil cores from unconsolidated overburden materials using direct-push technology (DPT) and hand augering techniques at the NSWC Crane facility. For this investigation, a Geoprobe® rig with a Macrocore Sampler will be the type of DPT used.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

**Cut-resistant non-latex Impermeable Gloves**
**Cotton gloves**
**Disposable medical-grade gloves (e.g., latex, nitrile)**
**Writing utensil**
**Boring log sheets:** A copy of this form is included in SOP-07
**Geoprobe® or equivalent DPT equipment**
**Geoprobe® Macrocore Sampler or equivalent**
**Geoprobe® Sampling Kit or equivalent**
**Clear acetate liners:** one new liner for each soil core
**Stainless Steel Auger Buckets**
**Stainless Steel Extension Rods**
**Cross Handle**
**Required decontamination materials** (see SOP-04)
**Bentonite pellets**

## 3.0 BOREHOLE ADVANCEMENT AND SOIL SAMPLING USING A GEOPROBE®

DPT will be employed to collect soil cores. DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional rotary drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. Geoprobe® is a

manufacturer of a hydraulically powered, percussion/probing machine utilizing DPT to collect subsurface environmental samples.

3.1 Clear the area to be sampled of any surface debris (herbaceous vegetation, twigs, rocks, litter, etc.).

3.2 Place a new clear acetate liner in the detachable Macrocore core barrel and attach the coring device to the Geoprobe® rig.

3.3 Drive the macrocore sampler (lined with acetate) into the ground to a depth of 2 feet using hydraulic pressure. The 0- to 2-foot depth soil interval is considered to be the surface soil.

3.4 Retract the sampler from the borehole and remove the acetate liner and the soil core from the Macrocore barrel.

3.5 Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tailgate of a vehicle. If a vehicle with a tailgate is not available, secure the trough on another suitable surface.

3.6 Place the acetate liner containing the soil core in the trough.

3.7 While wearing cut-resistant gloves (constructed of non-latex over cotton), cut the acetate liner through its entire length using the double-bladed knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. **CAUTION:** Do not attempt to cut the acetate liner while holding it in your hand.

3.8 Scan the entire length of the soil core for VOCs using the PID. Record the specific depth interval and the associated PID reading on the Boring Log Sheet. Collect a soil VOC sample using Encore samplers from the soil interval that had the highest PID reading. If no above-background PID readings were detected, collect the VOC sample from an interval that is discolored or displays other visual signs of being contaminated. If no visual sign of contamination is evident, collect the soil VOC sample from the center of the core interval (i.e., 1-foot depth).

3.9 Log the soil core on the Boring Log Sheet (see SOP-07).

3.10 Place the soil core in a stainless-steel mixing bowl, homogenize, and collect the remainder of the soil sample aliquots, as described in SOP-08.

3.11 Repeat steps 3.2 through 3.11 for the next depth intervals.

3.12 The depth to bedrock should be recorded on the Boring Log and the estimated moisture content of the soil and the presence or absence of water in the boring should be noted.

3.13 If readings from the PID are all at background levels below field screening criteria, then excess soil core materials will be returned to the hole and tamped. If insufficient soil is available to fill the hole to the ground surface, then bentonite pellets mixed with the soil will be used to backfill the hole.

3.14 If screening instruments indicate that contaminants may be present in the soil materials, then all excess soil core materials will be placed in a plastic bag (or drum if larger quantities). The bag will be tagged identifying the locations and depths from where the soils came from and the date. The bag will then be placed in a 55-gallon drum and stored on site until laboratory analyses of the soil are completed and classification of the soil waste materials can be determined.

3.15 If soil materials from the boring are suspected of being contaminated (see 3.14 above), the soil boring will be backfilled with bentonite pellets up to the ground surface.

3.16 Decontaminate all soil sampling equipment in accordance with SOP-04 before collecting the next sample.

# STANDARD OPERATING PROCEDURE

# SOP-06

# MANAGEMENT OF INVESTIGATION-DERIVED WASTE

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes how investigation-derived waste (IDW) will be collected, segregated, classified, and managed during the field investigations at NSA Crane. The following types of IDW will be generated during this investigation:

- Soil sampling residues
- Monitoring well development and well purge waters
- Decontamination solutions
- Personal protective equipment and clothing (PPE)
- Miscellaneous trash and incidental items

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

**Health and safety equipment (with PPE)**
**Hand augers, plastic or stainless steel trowels**
**Bucket (**with collected development/purge water)
**Decontamination equipment**
**Field logbook**
**Writing utensil (preferably black pen with indelible ink)**
**Plastic sheeting and/or tarps**
**55-gallon drums with sealable lids**
**IDW labels for drums**
**Plastic garbage bags**

## 3.0 PROCEDURES

Management of IDW includes the collection, segregation, temporary storage, classification, final disposal, and documentation of the waste-handling activities if necessary.

### 3.1 Liquid Wastes

Liquid wastes that will be generated during the site activities include decontamination solutions from sampling equipment. These wastes will be collected and containerized in a central location at NSA Crane for proper disposal.

### 3.2 Solid Wastes

Solid wastes that may be generated during site activities include soil and sediment sampling residues. Excess soil core/sampling materials will be returned to the hole and tamped. If insufficient soil is available to fill the hole to the ground surface, then bentonite pellets mixed with the soil will be used to backfill the hole, and hydrated with potable water. Excess sediment sampling materials will be returned to the point of collection. The disposition of this materials will be carried out in a manner such as not to contribute further environmental degradation or pose a threat to public health or safety.

### 3.3 PPE and Incidental Trash

All PPE wastes and incidental trash materials (e.g., wrapping or packing materials from supply cartons, waste paper) will be decontaminated (if contaminated), double bagged, securely tied shut, and placed in a designated waste receptacle at NSA Crane.

# STANDARD OPERATING PROCEDURE

# SOP-07

# BOREHOLE AND SOIL SAMPLE LOGGING

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the standard procedures and technical guidance on the logging of soil samples.

## 2.0 FIELD FORMS AND EQUIPMENT

**Knife**
**Ruler** (marked in tenths and hundredths of feet)
**Boring Log:** An example of this form is attached.
**Writing utensil (preferably black pen with indelible ink)**

## 3.0 RESPONSIBILITIES

A field geologist or engineer is responsible for supervising all activities and assuring that each soil sample is properly and completely logged.

## 4.0 PROCEDURES FOR SAMPLE LOGGING

To maintain a consistent classification of soil, it is imperative that the field geologist understands and accurately uses the field classification system described in this SOP. This identification is based on visual examination and manual tests.

### 4.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (attached to this SOP).

This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no distinguishable size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils will be divided into categories: rock fragments, sand, or gravel. The terms "sand" and "gravel" not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term "rock fragments" will be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges that are typically observed indicate little or no transport from their source area; and therefore, the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used, it will be followed by a size designation such as "(1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

## 4.2 Color

Soil colors will be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Because color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples will be broken or split vertically to describe colors. Samplers tend to smear the sample surface, creating color variations between the sample interior and exterior.

The term "mottled" will be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

## 4.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are non-cohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in the following table.

**CONSISTENCY FOR COHESIVE SOILS**

| Consistency | Standard Penetration Resistance (Blows per Foot) | Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration) | Field Identification |
|---|---|---|---|
| Very soft | 0 to 2 | Less than 0.25 | Easily penetrated several inches by fist. |
| Soft | 2 to 4 | 0.25 to 0.50 | Easily penetrated several inches by thumb. |
| Medium stiff | 4 to 8 | 0.50 to 1.0 | Can be penetrated several inches by thumb with moderate effort. |
| Stiff | 8 to 15 | 1.0 to 2.0 | Readily indented by thumb but penetrated only with great effort. |
| Very stiff | 15 to 30 | 2.0 to 4.0 | Readily indented by thumbnail. |
| Hard | Over 30 | More than 4.0 | Indented with difficulty by thumbnail. |

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined by hand by determining the resistance to penetration by the thumb. The thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample. The sample will be broken in half and the thumb pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. One of the other methods will be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in the above-listed table.

## 4.4 Weight Percentages

In nature, soils are consist of particles of varying size and shape and are combinations of the various grain types. The following terms are useful in the description of soil:

| Terms of Identifying Proportion of the Component | Defining Range of Percentages by Weight |
|---|---|
| Trace | 0 - 10 percent |
| Some | 11 - 30 percent |
| Adjective form of the soil type (e.g., sandy) | 31 - 50 percent |

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

## 4.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the gloved hand or on a porous surface liberates water (i.e., dirties or muddies the surface). Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire field activity.

## 4.6 Classification of Soil Grain Size for Chemical Analysis

To determine the gross grain size classification (e.g., clay, silt, and sand) from the USCS classification described above, the following table will be used.

| Gross Soil Grain Size Classification | USCS Abbreviation | Description |
|---|---|---|
| Clay | CL | inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | CH | inorganic clays of high plasticity, fat clays. |
| | OH | organic clays of medium to high plasticity, organic silts. |
| Silt | ML | inorganic silts and very fine sands, rock four, silty or clayey fine sands with slight plasticity. |
| | OL | organic silts and organic silty clays of low plasticity. |
| | MH | inorganic silts, micaceous or diatomaceous fine sand or silty soils. |

| Gross Soil Grain Size Classification | USCS Abbreviation | Description |
|---|---|---|
| Sand | SW | well graded sands, gravelly sands, little or no fines. |
| | SP | poorly graded sands, gravelly sands, little or no fines. |
| | SM | silty sands, sand-silt mixtures. |
| | SC | clayey sands, sand-clay mixtures. |

### 4.7 Summary of Soil Classification

In summary, soils will be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (optional)
- Soil types
- Moisture content
- Other distinguishing features
- Grain size
- Depositional environment

## 5.0 ATTACHMENTS

1. Figure 1 - Unified Soil Classification System
2. Boring Log

## ATTACHMENT 1

## FIGURE 1 - UNIFIED SOIL CLASSIFICATION SYSTEM

### Unified Soil Classification System

| | | | |
|---|---|---|---|
| Coarse Grained Soils (more than half of soil > No. 200 sieve) | Gravels (More than half of coarse fraction > no. 4 sieve size) | GW | Well graded gravels or gravel-sand mixtures, little or no fines |
| | | GP | Poorly graded gravels or gravel-sand mixtures, little or no fines |
| | | GM | Sandy gravels, gravel-sand-silt mixtures |
| | | GC | Clayey gravels, gravel-sand-silt mixtures |
| | Sands (More than half of coarse fraction < no. 4 sieve size) | SW | Well graded sands or gravelly sands, little or no fines |
| | | SP | Poorly graded sands or gravelly sands, little or no fines |
| | | SM | Silty sands, sand-silt mixtures |
| | | SC | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity |
| Fine Grained Soils (more than half of soil < No. 200 sieve) | Silts and Clays LL = < 50 | ML | Inorganic silts and very fine sands, rock flour, silty fine sands or clayey silts with slight plasticity |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, lean clays |
| | | OL | Organic silts and organic silty clays of low plasticity |
| | Silts and Clays LL = > 50 | MH | Inorganic silts, micaceous or diatomaceous fine sand or silty soils, elastic silts |
| | | CH | Inorganic silts of high plasticity, fat clays |
| | | OH | Organic clays of high plasticity, organic silty clays, organic silts |
| Highly Organic Soils | | Pt | Peat and other highly organic soils |

### Grain Size Chart

| Classification | Range of Grain Sizes | |
|---|---|---|
| | U.S. Standard Sieve Size | Grain Size In Millimeters |
| Boulders | Above 12" | Above 305 |
| Cobbles | 12" to 3" | 305 to 76.2 |
| Gravel | 3" to No. 4 | 76.2 to 7.76 |
| coarse | 3" to 3/4" | 76.2 to 4.76 |
| fine | 3/4"to No.4 | 19.1 to 4.76 |
| Sand | No. 4 to No. 200 | 4.76 to 0.074 |
| coarse | No.4 to No. 10 | 4.76 to 2.00 |
| medium | No. 10 to No. 40 | 2.00 to 0.420 |
| fine | No. 40 to No. 200 | 0.420 to 0.074 |
| Silt and Clay | Below No. 200 | Below 0.074 |

### Relative Density (SPT)

| SANDS AND GRAVELS | BLOWS/FOOT |
|---|---|
| VERY LOOSE | 0 – 4 |
| LOOSE | 4 – 10 |
| MEDIUM DENSE | 10 – 30 |
| DENSE | 32 – 50 |
| VERY DENSE | OVER 50 |

### Consistency (SPT)

| SILTS AND CLAYS | BLOWS/FOOT |
|---|---|
| VERY SOFT | 0 – 2 |
| SOFT | 2 – 4 |
| MEDIUM STIFF | 4 – 8 |
| STIFF | 8 – 16 |
| VERY STIFF | 16 – 22 |
| HARD | OVER 32 |

## ATTACHMENT 2

## BORING LOG

Tetra Tech NUS, Inc.

**BORING LOG**

Page ___ of ___

PROJECT NAME: _____ BORING No.: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

| Sample No. and Type or RQD | Depth (Ft.) or Run No. | Blows / 6" or RQD (%) | Sample Recovery / Sample Length | Lithology Change (Depth/Ft.) or Screened Interval | MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness | MATERIAL DESCRIPTION: Color | MATERIAL DESCRIPTION: Material Classification | USCS * | Remarks | PID/FID Reading (ppm): Sample | PID/FID Reading (ppm): Sampler BZ | PID/FID Reading (ppm): Borehole** | PID/FID Reading (ppm): Driller BZ** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): _____

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

# STANDARD OPERATING PROCEDURE

# SOP-08

# SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures for sample preservation, packaging, and shipping to be used in handling soil and aqueous samples.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

**Shipping labels**
**Custody seals**
**Chain-of-custody (COC) form(s)**
**Sample containers with preservatives**: All sample containers for analysis by fixed-base laboratories will be supplied, with preservatives added (if required) and deemed certified clean by the laboratory.
**Sample shipping containers (coolers)**: All sample shipping containers are supplied by the laboratory.
**Packaging material**: Bubble wrap, sealable polyethylene bags, strapping tape, etc.

## 3.0 PROCEDURES FOR SAMPLE PRESERVATION, PACKAGING, AND SHIPPING

3.1 The laboratory provides sample containers with preservative already included (as required) for the analytical parameter for which the sample is to be analyzed. All samples will be held, stored, and shipped at 4°C. This will be accomplished through refrigeration (used to hold samples prior to shipment) and/or ice.

3.2 The sampler shall maintain custody of the samples until the samples are relinquished to another custodian or to the common carrier.

3.3 Check that each sample container is properly labeled, the container lid is securely fastened, and the container is sealed in a polyethylene bag.

3.4 If the container is glass, place the sample container into a bubble-out shipping bag and seal the bag using the self-sealing, pressure sensitive tape supplied with the bag.

3.5 Inspect the insulated shipping cooler. Check for any cracks, holes, broken handles, etc. If the cooler has a drain plug, make certain it is sealed shut, both inside and outside of the cooler. If the cooler is questionable for shipping, the cooler must be discarded.

3.6 Line the cooler with large plastic bag, and line the bottom of the cooler with a layer of bubble wrap. Place the sample containers into the shipping cooler in an upright position (containers will be upright, with the exception of any 40-ml vials). Continue filling the cooler with ice until the cooler is nearly full and the movement of the sample containers is limited.

3.7 Wrap the large plastic bag closed and secure with tape.

3.8 Place the original (top) signed copy of the COC form inside a sealable polyethylene bag. Tape the bag to the inside of the lid of the shipping cooler.

3.9 Close the cooler and seal the cooler with approximately four wraps of strapping tape at each end of the cooler. Prior to wrapping the last wrap of strapping tape, apply a signed and dated custody seal to each side of the cooler (one per side). Cover the custody seal with the last wrap of tape. This will provide a tamper evident custody seal system for the sample shipment.

3.10 Affix shipping labels to each of the coolers, ensuring all of the shipping information is filled in properly. Overnight (e.g., FedEx Priority Overnight) courier services will be used for all sample shipments.

3.11 All samples will be shipped to the laboratory no more than 72 hours after collection. Under no circumstances should sample hold times be exceeded.

# STANDARD OPERATING PROCEDURE

# SOP-09

# CALIBRATION AND CARE OF WATER QUALITY METERS

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedures for the calibration and maintenance of field instruments used to measure water quality and for the proper documentation of calibration and maintenance. The YSI 600-Series Environmental Monitoring System, or a similar system, will be used to measure pH, temperature, oxidation-reduction potential (ORP), specific conductance (SC), dissolved oxygen (DO), and turbidity in water. A LaMotte turbidity meter will be used in conjunction with the water quality meter to measure turbidity. The YSI meter has a multiprobe sensor that can be used in conjunction with a flow-through cell attached to a pump discharge tube to measure water-quality parameters in a ground water discharge or can be immersed in a surface water body such as a stream, pond, or drainage ditch. The LaMotte is a hand held meter that uses a multi-detector optical configuration to assure long term stability and minimize stray light and color interferences.

## 2.0 FIELD FORMS AND EQUIPMENT LIST

The following logbooks, forms, equipment, and supplies are required:

**Site logbook**
**Equipment calibration log sheet**
**YSI Model 600 Serien and Sonde or similar type of meter**: multi-parameter water-quality meter with flow through cell
**LaMotte Turbidity Meter**
**Equipment manual**
**Calibration kit**
**Deionized water, paper towels, spray bottle, etc.**
**Disposable medical-grade gloves (e.g., latex, nitrile)**

## 3.0 PROCEDURES

This section describes the calibration procedures for the YSI Model 600 series and the LaMotte. Each meter is supplied with an instruction manual and will be on site and will be used as the calibration guidance documents. These procedures will list requirements for frequency of calibration and checks to be performed on the meter.

### 3.1 YSI Model 600 Series

The YSI Model 600 series and Sonde is a multi-parameter, water-quality meter that may be used to measure open water bodies (streams, ponds, springs, etc.) with the probe guard installed. With the flow through cell attached, the meter has the ability to measure water-quality parameters in ground water via a pump discharge line. By performing the measurements in the discharge line coming directly from the well, the parameters are measured before the ground water comes in contact with the atmosphere. The parameters measured by the YSI for this field effort are as follows:

- DO
- SC
- Temperature
- pH
- ORP
- Turbidity

#### 3.1.1 Documentation

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including the frequency of calibration, type of standards used, and checks performed on calibration during the course of using the equipment. An Equipment Calibration Log must be maintained for each measuring device that requires calibration. Entries must be made for each day the equipment is used. A blank Equipment Calibration Log form is attached at the end of this SOP.

#### 3.1.2 Calibration

All the parameters listed in Section 3.0 must be calibrated prior to the start of each field effort. After this initial calibration, the YSI will be checked each day that it is used. If the check shows any out-of-specification readings, the specific probe will be recalibrated. Meter specifications can be found in the

equipment manual, starting on page 248. Calibration and calibration checks will be documented in the field logbook and on the Equipment Calibration Log. The name, lot number, and expiration date for all calibration buffers and standards used will be recorded on the Equipment Calibration Log. The meter's model, serial number, and name of rental company will also be recorded on the equipment calibration form.

### 3.1.3 Tips for Good Calibration

- The DO calibration is a water-saturated air calibration. Make certain to loosen the calibration cup seal to allow pressure to equilibrate before calibrating.

- Make certain that sensors are completely submersed in solution and readings are stable when calibration values are entered.

- Use a small amount of calibration solution (previously used solution may be used, then discarded for this purpose) to pre-rinse the sonde.

- Fill a bucket with ambient temperature water to rinse the sonde between calibration solutions.

- Make sure to rinse and dry the probe between calibration solutions. This will reduce carry-over contamination and increase the accuracy of the calibration.

## 3.2 Lamotte Turbidity Meter

The Lamotte turbidity meter is a hand held meter that measures the amount of suspended matter in water using the Nephelometric method.

### 3.2.1 Documentation

The Equipment Calibration Log is used to document calibration of measuring equipment used in the field. The Equipment Calibration Log documents that the manufacturer's instructions were followed for calibration of the equipment, including the frequency of calibration, type of standards used, and checks performed on calibration during the course of using the equipment. An Equipment Calibration Log must be maintained for each measuring device that requires calibration. Entries must be made for each day the equipment is used. A blank Equipment Calibration Log form is attached at the end of this SOP.

### 3.2.2 Calibration

Turbidity must be calibrated prior to the start of each field effort. After this initial calibration, the LaMotte will be calibrated each day that it is used. If the check shows any out-of-specification readings, the meter will be recalibrated. Meter specifications can be found in the equipment manual. Calibration and calibration checks will be documented in the field logbook and on the Equipment Calibration Log. The name, lot number, and expiration date for all calibration standards used will be recorded on the Equipment Calibration Log. The meter's model, serial number, and name of rental company will also be recorded on the equipment calibration form.

### 3.2.2 Tips for Good Calibration

- Thoroughly clean the standard vial with a chem wipe to remove finger prints.
- Make sure that the vial is properly aligned according the manual recommendations.

## 4.0 MAINTENANCE

The YSI Meter and LaMotte will be rented for the duration of each brief field effort. Therefore, little field maintenance will be required. For any maintenance other than the routine cleaning, calibrating, or battery charging, the instrument should be returned to the vendor and a replacement sent immediately to the job site.

### 4.1 Meter Storage for the YSI

For this field effort, the meter storage will be short term, [i.e. over night or between work shifts (4-day break)]. During these breaks, the meter will be charged. One-half inch of tap or distilled water will be placed in the meter calibration cup and the cup threaded onto the sonde. The key for short-term storage of probes is to use a minimal amount of water so the calibration cup will remain at 100 percent humidity. The water level must be low enough so that none of the probes are actually immersed. Proper storage of the sonde between usage will extend its life and will also ensure that the unit is ready for use as quickly as possible for the next application.

**Multi-parameter short term storage key points:**

- Use enough water to provide humidity but not enough to cover the probe surfaces.
- Make sure the storage vessel is sealed to minimize evaporation.
- Check periodically to make certain that water is still present.

## 4.2 Probe Cleaning

- Rinse the probe thoroughly with potable water.
- Wash the probe in a mild solution of Liquinox and water and wipe with paper towels and/or cotton swabs.
- Rinse and soak the probe in deionized water.
- If stronger cleaning is required, consult Section 2.10 on page 89 of the equipment manual.

Note: Reagents that are used to calibrate and check the YSI may be hazardous. Review the health and safety plan, Appendix A of the equipment manual, and Material Safety Data Sheets (MSDSs), all of which are on file in the field trailer.

## 4.3 Meter Storage for the LaMotte

For this field effort, the meter storage will be short term, [i.e. over night or between work shifts (4-day break)]. Proper storage of the meter between usage will extend its life and will also ensure that the unit is ready for use as quickly as possible for the next application.

**Short term storage key points:**

- Make sure the storage vessel is moisture free and sealed.

## 4.4 Sample Vial Cleaning

- Rinse the vial thoroughly with potable water to remove sediments.
- Wipe with chem.-wipes or cotton swabs.

## 5.0 ATTACHMENTS

1. Documentation of Field Calibration
2. Equipment Calibration Log

# ATTACHMENT 1
# DOCUMENTATION OF FIELD CALIBRATION

Tetra Tech NUS, Inc.

## DOCUMENTATION OF FIELD CALIBRATION

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

| Date of Calibration | Person Performing Calibration | INITIAL READINGS | | | | | | FINAL READINGS | | | | | | Calibration Standard (Lot No.) | Remarks and Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PH | COND | TURB | DO | TEMP | SAL | PH | COND | TURB | DO | TEMP | SAL | | |
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# ATTACHMENT 2
# EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

## EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

| Date of Calibration | Instrument I.D. Number | Person Performing Calibration | Instrument Settings | | Instrument Readings | | Calibration Standard (Lot No.) | Remarks and Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Pre-calibration | Post-calibration | Pre-calibration | Post-calibration | | |
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# STANDARD OPERATING PROCEDURE

# SOP-10

# MEASUREMENT OF WATER LEVELS IN MONITORING WELLS

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for determining water levels in monitoring wells.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and field forms are required for determining water levels in monitoring wells.

**Ground Water Level Measurement Form**: A copy of the Ground Water Level Measurement Form is attached.
**Bound field logbook**
**Well key**
**Writing utensil**
**Electronic water-level indicator**: The water-level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01 foot.
**Decontamination supplies**: SOP-04 describes decontamination procedures including decontamination supplies.

## 3.0 WATER-LEVEL MEASUREMENT PROCEDURES

3.1 Check the operation of the electronic water-level indicator or interface meter.

3.2 Record the well identification (ID), date, and time (using military time) on the Ground Water-Level Measurement Form.

3.3 Unlock the well and remove the well cap.

3.4 Place the well cap on a clean piece of plastic.

3.5 Ensure that the water-level indicator probe has been decontaminated before use, in accordance with the procedures outlined in SOP-04.

3.6 Slowly lower the probe into the well riser pipe until an audible and/or visible signal is produced, indicating contact with the water surface.

3.7 Read the ground water-level measurement from the top of the inner casing at the surveyed reference point to the nearest 0.01 foot.

3.10 Record the water-level measurement on the Ground Water Level Measurement Form.

3.11 Wind the meter cable measuring tape back onto the spool.

3.12 Replace the well cap and lock.

3.13 Decontaminate the meter's probe and cable following the procedures outlined in SOP-04.

3.13 Containerize any decontamination fluids and PPE in accordance with the procedures described in SOP-09.

## 4.0 ATTACHMENTS

1. Ground Water Level Measurement Sheet

## ATTACHMENT 1

## GROUND WATER LEVEL MEASUREMENT SHEET

Tetra Tech NUS, Inc.

**GROUNDWATER LEVEL MEASUREMENT SHEET**

**Project Name:** _____ **Project No.:** _____
**Location:** _____ **Personnel:** _____
**Weather Conditions:** _____ **Measuring Device:** _____
**Tidally Influenced:** Yes ___ No ___ **Remarks:** _____

| Well or Piezometer Number | Date | Time | Elevation of Reference Point (feet)* | Total Well Depth From TOC (feet)* | Water Level Indicator Reading (feet)* | Groundwater Elevation (feet)* | Comments |
|---|---|---|---|---|---|---|---|
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* All measurements to the nearest 0.01 foot

Page ____ of ____

# STANDARD OPERATING PROCEDURE

# SOP-11

# INSPECTION AND REHABILITATION OF EXISTING MONITORING WELLS

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes procedures for the inspection, field measurements, and minor repair of existing monitoring wells at the NSWC Crane facility. The inspection data for each well will be recorded on an individual electronic Monitoring Well Inspection Log, which is attached at the end of this SOP.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following equipment and supplies are needed for the inspection of monitoring wells:

**eData electronic logbook on a ToughBook field computer**
**Hand-held Global Positioning System (GPS) unit with project data**
**Magnetometer or metal detection device**
**Writing utensil with indelible ink**
**Disposable medical-grade gloves (e.g., latex, nitrile)**
**Outer work gloves (weather appropriate)**
**Well keys**
**Replacement well locks and keys**
**Heavy duty bolt cutters**
**Lock deicer/hand warmer packs**
**Flat front steel shovel**
**Stiff bristle broom**
**Pruning sheers, small limb saw, hedge clippers**
**Replacement well caps/plugs of various sizes**
**Photoionization detector (PID)**
**Electronic water-level indicator/oil-water interface probe (length for maximum depth well)**
**Engineers folding ruler (6 feet standard) with 0.01' graduations**
**Bubble level or similar device (e.g. iPhone app) for determination of level/plumb measurements**
**Steel rod (about 1 inch in diameter with eye bolt at one end)**

**200 feet of nylon rope**

**Plastic sheeting (Visqueen)**

**Internal and external PVC pipe cutters**

**Common hand tools (visegrips, screw drivers, hack saw)**

**File, v notch**

**Field camera (digital high resolution)**

**Sharpie for marking measurement location**

## 3.0 WELL LOCATION PROCEDURES

All well locations (survey coordinates) will be confirmed. Personnel will locate all monitoring wells using known and previously verified coordinates for each well. A hand-held Global Positioning System (GPS) unit will be available to each field team and facility-wide landmarks will be utilized from facility-wide aerial mapping and site features. Since most of the wells at NSWC Crane are stick-up type wells, the use of magnetometers is not planned to locate wells. Any access issues, such as fallen trees which obstruct passage to the well location, will be recorded.

## 4.0 WELL INSPECTION PROCEDURES

The well inspection procedures will include confirmation and, if applicable, updating of the main physical characteristics of the well. These categories include the well construction type, surface construction type, well identification tag, locking system, dedicated sampling equipment (if applicable), and protective devices surrounding the well. The overall condition of the well, protective casing, concrete pad or surface, well tag or identification, bollards and other protection/abutments, dust caps and plugs, and locking system will be recorded.

Specific inspection items include the following:

4.1 Navigate to each well based on survey coordinates (outlined in Section 3.0)

4.2 Confirm and record the well identification information (ID), date, time, and inspection personnel on the Monitoring Well Inspection Log. Confirm that the Well identification number as observed on the well is the same as on the Monitoring Well Inspection Log. Note any well ID “alias” information or variations, such as missing prefix, added alpha-numeric characters, etc. Record the condition of the well ID tag. Is the tag in place and legible? If not, note the discrepancies on the Monitoring Well Inspection Log. Temporary well ID markings should be placed on a visible location (e.g. outer

protective casing) using a permanent paint marker, stencil kit, metal punch kit, or similar marking procedure until a permanent well tag can be installed.

4.3 Record the condition of the protective casing, caps, and lock. Field personnel will record the physical characteristics of each monitoring well. The inspection logs will document the physical characteristics of the well and related features (i.e., well protection bollards) after any maintenance is performed. Has the casing, cap, and/or lock been tampered with or damaged? Has the well been damaged in any way or does it show signs of deterioration?

4.4 Record the condition of the concrete or gravel pad (as applicable). Check the condition of the pad (or the area around the well if no pad exists) and note any abnormalities. Are concrete pads cracking or heaving? If a gravel pad is present, is there any erosion or plant growth in the pad area? If a concrete or gravel pad is not present, or the surrounding surface is not pavement, then the ground surface should be observed for erosion, depressions, cracks or other conditions that may effect the integrity of the well.

Note – effort must be used to clear the well surface area of surface debris, leave dander, sediment or soil accumulation, snow/ice, or other material that may cover the well pad or surface. The inspection and photograph documentation must be after the pad and surface has been cleared.

4.5 Record the condition of the cement seal surrounding the protective casing. Has the seal cracked or pulled away from the protective casing? Record any visible signs of deterioration in the area of the seal. Verify any telescopic or isolation casing seals (if known or present).

4.6 Record the presence of depressions and/or standing water around the casing or pad.

4.7 Inspect and record the condition of the well protective devises (e.g. steel bollards). Note any issues such as broken or bent protective posts.

## 5.0 MEASUREMENT OF WATER LEVELS AND TOTAL DEPTH OF WELL

The measurement of water levels and total depth of the wells will be performed observing the following:

- Presence and thickness of silt at the bottom of the well
- Detection and, if applicable, thickness of any free product (both light and dense product)

Specific well measurement tasks include the following:

5.1 Inspect the outer protective casing lock, well riser cap/plug, and overall security and locking system. Unlock the well cap and open the protective cover, if one exists.

5.2 Open the well cap and use a photoionization detector (PID) to screen the air within the well opening to determine whether above-background levels of volatile organic compounds (VOCs) are present within the well. Record the PID reading in the Measurements section of the Well Inspection Log. Refer to the Health & Safety Plan (HASP) for procedures to follow for the presence of VOCs in a well.

If the well contains a dedicated bladder pump, the water level monitoring port will be opened and a PID reading will be collected by inserting the PID tip through the open port without removing the cap.

5.3 Inspect and record the condition of the polyvinyl chloride (PVC) riser pipe and the established surveyed reference point.

5.4.1 Measure the height of the protective casing and well riser pipe above the ground surface. Specific measurements include:

- distance from top of pad to top of well riser reference point (water level measurement reference point)
- distance from top of well riser to top of outer protective casing when closed
- distance from top of well riser to top of outer protective casing when open. Note that this distance may be a negative or positive, relative to the outer casing, based on the well installation and completion details
- additional measurements, as necessary, for well completions with multiple outer casings, isolation casings, or other well completion types.
- or flush-mount wells, measure the distance from the top of the well riser to the top of the outer well vault rim (or similar ground surface/pad/pavement feature as applicable)

Record these readings in the “General Notes” section of the Well Inspection Log to the nearest 0.01 foot. Note the following casing characteristics:

- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.

- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.

5.5 Check the existing well log to verify the total original depth of the monitoring well being inspected.

5.6 Measure the static water level (i.e. depth to water). When measuring groundwater levels, there should be a clearly established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well riser. The surveyed reference point is normally a V-notch on the top of the PVC riser pipe. If no mark exists to identify the reference point for elevation data the following hierarchy should be used:

- The highest portion of the well riser should be used.
- If the riser does not have a high point in the top of riser, then the northern side of the well riser should be used.
- The reference point will be noted in the applicable data field within the Well Inspection Log and the reference location will be marked on the PVC casing with a permanent marker (i.e. Sharpie).

All groundwater level measurements will be made to the nearest 0.01 foot and recorded on the Groundwater Level Measurement Log. The static water level in each well will be measured using an M-scope or similar electronic water-level meter. The measurement of the total depth of the well may be accomplished using a weighted tape measure or weighted electronic water level indicator utilizing the following methods:

- Lower the electronic water-level indicator probe down the well casing. If an obstruction is encountered, record the depth of the obstruction and whether the obstruction is partial or complete.
- A non-aqueous phase liquid (NAPL) interface probe will be used to measure depth to water and thickness of any light NAPL (LNAPL) or dense NAPL (DNAPL) layer that might be present at the top or the bottom of the water column, respectively. Note that the DNAPL measurement will be taken after the removal of any dedicated sampling equipment. Note that free product may cause problems in determining the true water level in a monitoring well.
- Equipment used for measuring static water levels, total depth, etc. will be decontaminated as required.

5.7 If no obstruction is encountered, continue lowering the water-level indicator down the well casing until ground water is encountered. Measure the depth to water to the nearest 0.01 foot (see SOP

CTO166-17) and record the depth on the Monitoring Well Inspection Log. If there is a dedicated bladder pump installed in well, the pump will be removed prior to the measurement of the total well depth and the inspector will be careful not to tangle the weighted tape with the pump, pump hanger, and tubing.

5.8 Continue lowering the indicator probe down the casing until a solid bottom is reached or an obstruction is encountered. Record the depth to the bottom of the well (from top of riser reference point) on the Inspection Log. The use of a weighted tape may be used if the water indicator is too light to provide accurate measurement of the total depth. The weighted tape will be advanced slowly near the bottom of the well if sediment is present (the presence of sediment on the weight upon removal should be noted). The depth to the bottom of well and the depth to the sediment interface will be recorded on the Well Inspection Log.

5.9 If an obstruction is encountered in the casing before the well bottom is reached, record the depth of obstruction on the Inspection Log and whether the obstruction is partial or complete.

5.10 Remove the water-level indicator from the well.

5.11 If an obstruction was encountered during steps 5.6 or 5.8, lower a heavy steel rod slowly down the well casing until the obstruction is encountered. Attempt to loosen the obstruction by raising and dropping the steel rod, letting it hit the obstruction with gradually increasing force. Record whether the obstruction could be loosened.

5.12 If step 5.11 is performed, remove the steel rod from the well and remeasure the depth to the obstruction. If the obstruction has been knocked loose and settles to the bottom, then the well may still be used as a piezometer but will not be used for ground water sampling.

5.13 Close the well cap and lock, if lock is present.

5.14 Decontaminate the water-level indicator and steel rod, if used, per SOP CTO166-16.

5.15 Make recommendations on the Well Inspection Log, if necessary, for repair of the monitoring well. Replace lock, if needed, as soon as possible.

5.16 Perform repair of well as soon as possible (See Section 7.0).

5.17 Field personnel will take digital photographs at each well location to document current conditions. At a minimum, one photograph must be taken to represent each well included in the inventory. The field personnel should be cognizant of the following while taking the photograph:

- shadows
- well ID should be visible (or use of a white board and marker to display the well ID in the photo)
- well riser, pad, and protective devices (as applicable) in the photo
- location/context of the well (if permitted by client) as possible

In the case of multiple well clusters, a photograph must be taken with each respective well as the center object within each photo. Additional photographs may be taken and included to document conditions or important observations. A photograph of each well will be attached to its respective Monitoring Well Inventory Log.

## 6.0 DEDICATED SAMPLING EQUIPMENT INSPECTION (FOR WELLS WHICH CONTAIN DEDICATED PUMPS)

If dedicated sampling equipment is installed in the well (e.g. dedicated bladder pump), the pump will be inspected and tested for operating capabilities. The following tasks will be performed:

6.1 The distance from the outer protective casing to the top of the pump cap assembly (which is seated on the top of well riser) will be measured to the nearest 0.01' and recorded.

6.2 After the static water level (as outlined in the Measurements section) has been measured and recorded, clean sheet plastic will be laid on the ground.

6.3 The dedicated pump will be carefully removed from the well, and the pump and tubing will be placed on the plastic.

6.4 The total length from the pump riser cap/connection surface to the pump intake will be measured and recorded on the Well Inspection Log.

6.5 The entire length of tubing and tubing attachment points will be inspected for cracks, leaks, and loose connections. All connections will be tightened as needed and the pump will also be inspected for external damage.

6.6 Measurements for the well total depth, depth to sediment, and presence/depth to DNAPL will be taken and recorded.

6.6 The pump and tubing assembly will be placed back into the well riser and the cap carefully positioned on the well riser. The field personnel will make sure the cap assembly is properly seated on the well riser and at the proper height with respect to the pre-removal measurement.

6.7 The pump will be connected to a controller unit (e.g., QED controller) and the compressed nitrogen tank per manufacturer's recommendations. The operational capabilities of the pump will be tested by operating the pump between 100 and 300 liters per minute for up to 10 minutes. Flow rate(s) will be measured using bucket of known capacity and a watch, a visual description of turbidity will be recorded. All purge water will be containerized in either 5 gallon buckets or 55 gallon drums (depending on vehicle used by the field team) and will be disposed of properly at the support area drain. Any noticeable odors during the testing period will also be recorded. All information, including date, field personnel present, start time, end time, and total water pumped will be recorded on a Well Inspection Log.

6.8 If the pump is pumping in an acceptable manner, then the well inspection will be considered complete and the well will be capped and locked.

6.9 Otherwise, the non-operation of the pump will be noted on the Well Inspection Log and the the pump and associated tubing/cap assembly will be removed from the well, placed in a marked plastic bag, and stored in the support trailer for future repair or replacement action. The FOL and field personnel may do field repairs to bladders or other components if possible during the inspection.

## 7.0 FIELD REPAIRS TO MONITORING WELLS

Minor monitoring well maintenance will be performed as needed during the field inspection. The type of maintenance performed during the field inspection will be noted on the Monitoring Well Inventory Log.
The overall condition of the well and other features at the well will be recorded initially and after maintenance is performed at the well (i.e., if the lock is missing and replaced, the Monitoring Well Inventory Sheet will not record the current lock condition as "missing," but rather as "present and secure." However, the Monitoring Well Inventory Log will also have an entry under "Actions Taken" to document what actions were performed (i.e. that the missing lock was replaced).

The need for major well maintenance such as repairing broken risers, welding lock, wasps on outer well casings, installing new concrete well pads, reinstalling protective bollards, significant scraping and painting outer well casings, grouting well seals, etc. will be noted on the Monitoring Well Inventory Log as appropriate. This SOP does not address major maintenance activities.

Specific minor well maintenance activities may include the following:

## 7.1 BRUSH AND VEGETATION CLEARING

The area around each well will be cleared of ground cover, heavy vegetation, debris, and other material that may be present and obstruct access to and interfere with assessment of the well. This may include cutting ground cover vines or woody overgrowth with hand tools. Any small brush, limbs, roots, vines, and other vegetation should be cleared at the well location to allow clear and unobstructed access to the well. Clearing for vehicular access to the general well location is considered major maintenance; however, major access obstructions should be noted on the Monitoring Well Inventory Log for future action. It is important that photographic documentation include an unobstructed view of the well.

## 7.2 WELL IDENTIFICATION

Well tags or other permanent identification may be missing, may be damaged, or may not be legible as found during the inspection. All wells that can be confirmed by survey coordinates and verified against the 2005/06 inventory should have at least a temporary well identification marking with the well identification, alias, or other discernable identification. A permanent paint marker or similar marking device may be used during inspection to apply the well identification in a visible and protected location until a permanent well tag can be installed. Alternatively, metal punched tag with the complete Well ID as in the database will be affixed to the outer protective casing (if present) or to the well riser.

## 7.3 WELL SECURITY

Individual locks and J-plugs will be replaced as needed. NSWC Crane personnel may be contacted to determine lock type and key number to be used. Dry graphite will be used as a lubricant for the well locks in lieu of volatile organic compound (VOC)/semivolatile organic compound (SVOC) based lubricants. Locks that cannot be opened will be cut with bolt cutters and replaced with new locks. Replacement locks will be heavy duty brass type keyed to match the existing well lock type and key number.

## 7.4 PAINTING

Wells found in deteriorated condition will be assessed by the FOL and either scheduled for immediate minor maintenance or will be noted for future maintenance action. Ambient air temperatures will be monitored by the FOL and decision to proceed with preparation and painting tasks will be made if air temperatures are favorable to performing the task. Preparation of the metal surfaces for primer and paint will be performed by the field team. Preparation will consist of grinding or sanding loose and chipping paint to a sound metal surface. The prepared surface will be cleaned with a damp cloth and air-dried prior to primer application. Paint primer will be applied to the well casing, outer protective casing, other well protective casings, and protective bollards as needed and directed by the FOL.

## 7.5 WELL RISER MAINTENANCE

Well risers may be repaired if they are found broken or in a condition that does not permit proper closing the securing of the well. If a monitoring well is damaged beyond the repair capabilities of the field crew, the NSWC Crane Environmental Department will be notified and a decision will be made to repair or replace the well using a drilling contractor (under future task).

7.5.1 Remove a short section of the top of the PVC riser that is broken, using an inside pipe cutter. Before the riser is cut, a clean rag will be inserted into the riser to just below the cut to prevent cuttings from entering the well. Insert the cutter just below the damaged area and remove only the damaged section of riser. Carefully remove the rag, measure and record the length of riser removed and mark the top of the riser for water-level measurement (filing a V notch is the preferred method).

7.5.2 If the riser damage indicates that a riser must be added, a section of PVC may be attached to the existing riser. After removing the damaged riser (see 7.5.1 above), cut a new section of riser to the needed length and attach a slip coupler to one end. In most cases, the coupler will fit securely to the pipe without the need for mechanical fasteners (pop-rivets/screws). If needed, fasteners may be used, but in no case will glue be used to attach the coupler. Attach the new coupler and PVC pipe to the existing riser, mark the top for measurement purposes, and document the length of pipe added. All new materials (pipe and couplers) will be decontaminated prior to installation.

# STANDARD OPERATING PROCEDURE
# SOP-12

# MONITORING WELL DEVELOPMENT

## 1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper development of new and existing monitoring wells. The methods described herein are specific for monitoring wells located at the NSA Crane facility. Guidelines by South Division, Naval Facilities Engineering Command, (SOUTHDIV NAVFAC, 1997) and the State of Indiana regulatory requirements in Article 16 Water Well Drillers of Chapter 310 of the Indiana Annotated Codes (310 IAC 16) should be consulted.

## 2.0 RESPONSIBILITIES

The drilling contractor will provide adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of developing monitoring wells. The drilling contractor personnel must have all the health and safety training required to perform the work, as specified in the health and safety plan (HASP).

## 3.0 REQUIRED EQUIPMENT/ITEMS

The following list includes equipment and items required for monitoring well installation:

**Health and safety equipment** as required by the HASP and the site safety officer.

**Well development equipment with associated materials** (typically supplied by the driller).

**Hydrogeologic equipment** (weighted engineer's tape, water-level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).

## 4.0 WELL DEVELOPMENT METHODS

The development of new wells will not occur until at least 48 hours after the well has been installed and grouted. This time is required so that the grout in the annulus can set and harden. The purpose of well

development is to stabilize and increase the permeability of the sand pack and the well screen and to restore the permeability of the formation that may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water, if any, is removed from the well.

Sequential measurements of pH, specific conductance, turbidity, and temperature taken during development yield information (stabilized values) that sufficient development is reached. Development should proceed until criteria are met as stated in Navy Guidelines.

A surge plunger (also called a surge block) that is approximately the same diameter as the well casing will be used to agitate the water. There are two basic types of surge plungers, solid and valved surge plungers. Site-specific conditions will dictate which type will be used. In formations with low yields, a valved surge plunger may be preferred because solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

Surging causes water to move in and out of the screens. This movement of water pulls fine materials into the well, preventing bridging of sand particles in the gravel pack. These fine materials can then be removed by any of several methods such as submersible pumps (i.e. whale pumps), bailers, or even peristaltic pumps. Whale pumps can be used to surge and sweep the well screen as it pumps. Another alternative method for development would be to utilize a waterra (i.e. check valve method). This method allows for surging and purging of the well by moving the tubing in an up and down motion. On the downward stroke, the ball in the foot valve lifts and the tubing fills with water; and on the upward stroke the ball is set and surged ground water is forced out of the tubing and into a purge bucket.

Development should proceed until the following criteria are met:

- The well water is clear to the unaided eye.

and

- A minimum removal of five times the standing water volume in the well (to include the well screen and casing plus saturated borehole annulus, assuming 30% annular porosity).

or

- When pH measurements remain constant within 0.1 Standard Units and specific conductance and temperature vary no more than plus or minus 3 percent for at least three consecutive readings. Turbidity should also show stabilization and ideally be below 10 nephelometric turbidity units (NTUs).

or

- If the well has been purged dry at least three times while waiting 15 to 20 minutes to allow the well to recharge between pumping intervals. Recharge rates will be documented while the well is allowed to recover.

If for any reason the above criteria cannot be met, the site geologist should document the event in writing and consult with the Task Order Manager regarding an alternate plan of action.

Well development must be completed at least 24 hours before well sampling. The intent of this hiatus is to provide time for the newly installed well and backfill materials to sufficiently equilibrate to their new environment and for the new environment to re-stabilize after the disturbance of drilling. All development water should be handled in accordance with SOP-06.

## 5.0 ATTACHMENTS

1. Monitoring Well Development Record

# ATTACHMENT 1

## MONITORING WELL DEVELOPMENT RECORD

Tetra Tech NUS, Inc.

**MONITORING WELL DEVELOPMENT RECORD**

Page ___ of _____

Well: _____
Site: _____
Date Installed: _____
Date Developed: _____
Dev. Method: _____
Pump Type: _____

Depth to Bottom (ft.): _____
Static Water Level Before (ft.): _____
Static Water Level After (ft.): _____
Screen Length (ft.): _____
One Well Volume (gal/L): _____
Casing ID (in.): _____

Responsible Personnel: _____
Drilling Company: _____
Project Name: _____
Project Number: _____
PID Readings: Bore Hole_____ppm
PID Readings: Breathing Zone_____ppm

| Time | Cumulative Water Volume (Gal.) | Flow Rate (mL/min.) | Water Level Readings (Ft. below TOC) | Temperature (Degrees C) | pH | Specific Conductance (Units _____) | Turbidity (NTU) | Remarks (odor, color, etc.) |
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# STANDARD OPERATING PROCEDURE
# SOP-13

# LOW-FLOW WELL PURGING AND STABILIZATION

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for well purging and stabilization utilizing low-flow techniques.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow purging.

**Low-Flow Purge Data Sheet:** A copy of this form is attached at the end of this SOP.
**Ground Water Sample Log Sheet**: A copy of this form and instructions for its completion are included in SOP-14.
**Bound field logbook**
**Writing utensil**
**Well key**
**Electronic water-level indicator:** The water-level indicator must have a cable of sufficient length to reach the water surface and be capable of measurements of 0.01 foot (see SOP-10).
**Electronic Programmable Controller, model 400:** This controller regulates air flow in a bladder pump.
**Cylinder of compressed nitrogen with regulator:** Compressed gas serves as the power source for the bladder pump.
**Multiple parameter water-quality meter:** This unit measures and displays field parameters measured in the field including pH, dissolved oxygen, oxidation-reduction potential (ORP), temperature, and specific conductance (see SOP-09).
**Flow-through cell adapter for water-quality meter**
**Purge water containers**
**Graduated cylinder and stopwatch:** Used to calculate flow rate.
**Decontamination supplies:** SOP-04 describes required decontamination supplies.
**Disposable medical-grade gloves (e.g., latex, nitrile)**

## 3.0 PROCEDURES FOR WELL PURGING

3.1 Prior to mobilizing to the site, clean, check for proper operation, and calibrate above equipment in accordance with manufacturer requirements as necessary.

3.2 Follow the steps outlined in SOP-10 to obtain a static water-level measurement of the well to be purged. Record the information on the Ground Water Sample Log Sheet and the Low-Flow Purge Data Sheet. Leave the water-level meter suspended in the well casing.

3.3 Calculate one well casing volume as follows:

1. Obtain the total depth of the well by measurement.

2. Using the static water level determined in Step 3.2 of this SOP and the total depth of the well, calculate the well casing volume using the following formula:

$$\mathbf{V = (0.163)(T)(r^2)}$$

where:

| | | |
|---|---|---|
| V | = | Static casing volume of well (in gallons). |
| T | = | Vertical height of water column (linear feet of water). |
| 0.163 | = | A constant conversion factor that compensates for the conversion of the casing radius from inches to feet, the conversion of cubic feet to gallons, and pi. |
| r | = | Inside radius of the well casing (in inches). |

Note: For wells of 1-inch radius (2-inch diameter), V = 0.163 gallons per foot of water column.

3.4 Connect the pump controller to the well pump air supply (at the well cap) by following the instructions in the pump control manual. The pump controller must be turned off when it is being connected.

3.5 Connect the nitrogen cylinder to the pump controller. The nitrogen cylinder valve must be closed and the regulator line pressure set at zero pounds per square inch (psi) when it is being connected.

3.6 Following the instructions found in the water-quality meter manual, connect the flow-through cell to the pump discharge line (at the well cap).

3.7 Place the discharge tubing from the flow-through cell to direct the purge water discharge into the graduated cylinder or purge water container.

3.8 Following the instructions in the pump controller manual, start pumping water from the well.

3.9 Start with the initial pump rate set at approximately 0.1 liters per minute. Use the graduated cylinder and stopwatch to measure the pumping rate. Adjust pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a max of 0.4 liters per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If ground water is drawn down below the top of the well screen, purging will cease and the well will be allowed to recover before purging continues. Slow recovering wells will be identified and purged at the beginning of the workday. If possible, samples will be collected from these wells within the same 8-hour workday and no later than 24 hours after the start of purging.

The time to sample any given well will vary greatly due to the many variables associated with low flow purging and sampling:

- Stabilization of parameters
- Possible drawdown
- Analytical changes from quarter to quarter
- Varying QA sample requirements from quarter to quarter
- Variable pump rates

Normally, the time from the start of purging to the end of sampling will be between 1 and 4 hours.

3.10 Measure the well water level using the water-level meter every 5 minutes. Record the well water level on the Low-Flow Purge Data Form (attached at the end of this SOP).

3.11 Every 5 to 10 minutes, record on the Low-Flow Purge Data Form the water-quality parameters (pH, specific conductance, temperature, turbidity, oxidation-reduction potential, and dissolved

oxygen) measured by the water-quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form.

3.12 Measure the flow rate using a graduated cylinder. Remeasure the flow rate any time the pump rate is adjusted.

3.13 During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections.

3.14 Stabilization is achieved and sampling can begin when a minimum of one casing volume has been removed and three consecutive readings, taken at 5- to 10-minute intervals, are within the following limits:

- pH ± 0.1 standard units
- Specific conduct ± 3%
- Temperature ± 5%
- Turbidity less than 10 NTUs
- Dissolved oxygen ± 10%
- Oxidation-Reduction Potential (ORP) ± 10 mV

If the above conditions have still not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data From onto the Ground Water Sample Log Form.

If there is a need to leave a well during purging, there are two options:

- One, if the sampler must move for 30 minutes or less but still has a clear line of sight to the well, the sampler may leave the pump running and watch the well from a distance until he or she is able to return to the well.

- Two, if for whatever reason, the sampler must stop purging for an extended period of time or a clear line of sight cannot be maintained, the pump and cell will be shut down. All equipment and supplies will be loaded into the sample vehicle, and the well will be secured before the sampler departs.

In both cases, the time purging was stopped and restarted will be noted on the Low-Flow Purge Data Form.

3.15 Rinse the flow-through cell, the water-quality meter probes, and the turbidity cell with analyte-free water and pack the cell and meters for transport.

## 4.0 ATTACHMENTS

1. Low-Flow Purge Data Sheet

**ATTACHMENT 1**

**LOW-FLOW PURGE DATA SHEET**

Tetra Tech NUS, Inc.

# LOW FLOW PURGE DATA SHEET

**PROJECT :** _____
**PROJECT NUMBER:** _____
**PROJECT SITE NAME:** _____

**WELL ID.:** _____
**DATE:** _____
**WEATHER:** _____

| Time (Hrs.) | Water Level (Ft. below TOC) | Volume (gal/L) | Flowrate (mL/min) | pH (S.U.) | Cond. (mS/cm) | Turb. (NTU) | DO (mg/L) | Temp. (Celsius) | ORP (mV) | Comments |
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Water Quality Meter (S/N) _____
Control Box Type (S/N) _____
Turbidity Meter (S/N) _____

Pump Intake Depth _____

**SIGNATURE(S):** _____

**PAGE___OF___**

# STANDARD OPERATING PROCEDURE
# SOP-14

# GROUNDWATER SAMPLING

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for collecting groundwater samples from permanent and temporary monitoring wells. Low-flow sampling techniques will be used for groundwater sampling at the NSF Indian Head and the NSF Indian Head – Stump Neck Annex facility.

## 2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for low-flow sampling of monitoring wells:

**Writing utensil** (preferably black ink)

**Stainless steel Geoprobe Screen Point Groundwater Sampler** (or equivalent)

**Groundwater Sample Log Form**: A copy of this form is attached at the end of this SOP

**Low Flow Purge Data Sheet**: A copy of this form is attached at the end of SOP-17

**Bound field log book**

**Chain-of-Custody Form**

**Bladder pump:** With accessories: twin bonded PE ¼-inch tubing, MP-10 control box, nitrogen gas cylinder, and nitrogen regulator.

**Peristaltic pump:** Silicon and ¼-inch PE tubing.

**Required sample containers with appropriate preservative**: All sample containers for analysis by fixed-base laboratories will be supplied and deemed certified clean by the laboratory.

**Surgical gloves**

**Water-level indicator**

**0.45-micron filter cartridge:** If the metal analysis requires field filtering.

**Bucket:** to collect development/purge water

**Calculator, wristwatch, and timer**

**Stainless steel clamps**

**Plastic storage bags**

**Shipping containers with ice**

## 3.0 SAMPLING PROCEDURES FOR MONITORING WELLS

3.1 Groundwater sampling may be initiated when the monitoring well has been purged and stabilized in accordance with SOP-17.

3.2 Record the sample start time (using military time) on the Groundwater Sample Log Sheet. Record the field measurements for pH, oxidation-reduction potential (ORP), specific conductance, temperature, dissolved oxygen, and turbidity.

3.3 With the pump continuing to run, disconnect the flow-through cell from the pump discharge tube and immediately start filling sample bottles directly from the pump discharge. All sample containers will be supplied by the laboratory, and the laboratory will pre-preserve all sample containers, where appropriate.

3.4 Allow the pump discharge to flow gently down the inside of the container with minimal turbulence when filling sample containers. Avoid immersing the discharge tube into the sample as the sample container is being filled. Sample containers for volatile constituents (VOCs) must be completely filled so that no headspace exists in the container. The VOC vials will be filled to the top so that a convex meniscus is formed. Gently secure the cap, turn the vial upside down, and check to see if any air has been trapped inside the vial. If so, open the cap, reform the meniscus,

and attempt again to secure the lid without trapping air in the sample. All other sample containers can have air space included when the container lid is secured.

3.5 Cap each container immediately after filling.

3.6 Record the sample time on the Groundwater Sample Log Form, the sample label, and the sample label.

3.7 Place the tagged sample container into a plastic storage bag and then into a cooler containing ice.

3.8 Enter the proper information on the Chain-of-Custody Form for each sample container (see SOP-03).

3.9 Repeat steps 3.3 through 3.9 for each sample container collected.

3.10 The pump rate should not be adjusted after sampling has commenced. If it becomes necessary to adjust the pump rate, document the change on the Groundwater Sample Log Form.

3.11 All samples will be collected into pre-preserved bottles (if required) supplied by an approved laboratory. All samples will be collected in the following sequence (where applicable):

- Volatile organic compounds (VOCs)
- Other organics
- Metals
- Other Inorganics
- Filtered Metals

3.12 Filtered aliquots of groundwater may be collected and analyzed for dissolved metals. Without turning off the pump, attach a disposable, inline, 0.45-um filter cartridge at the end of the discharge tube. Fill sample containers marked for dissolved metals so that the laboratory knows that these aliquots are distinct sample fractions and that the results should be reported as dissolved analytes.

3.13 Repeat steps 3.5 through 3.9 for the filtered sample containers.

3.14 After completion of sample collection, remove the bladder pump (if bladder pump is used for sampling) from the well and decontaminate the pump following the procedures in SOP-04. Leave dedicated tubing inside the well for possible future sampling events.

3.15 Replace the outer protective well cap and lock the well.

3.16 All equipment should be cleaned and packed into the sample vehicle, along with the sample cooler for transport. Disposable gloves and other equipment should be placed in a plastic trash bag and handled as investigation-derived waste (SOP-09).

## 4.0 SAMPLING PROCEDURES FOR TEMPORARY MONITORING WELLS

4.1 Groundwater samples shall be collected from temporary monitoring wells. Temporary monitoring wells shall be constructed as per SOP-16.

4.2 The temporary monitoring wells shall be developed as per SOP-15 prior to purging.

4.3 The temporary monitoring wells shall be purged as per SOP-17.

4.4 Samples will be collected using the peristaltic pump following procedures in Section 3.0 of this SOP.

4.5 Proceed to abandon the temporary well as per SOP-16.

## 5.0 ATTACHMENTS

1. Groundwater Sample Log Sheet
2. Low Flow Purge Data Sheet

## ATTACHMENT 1

## GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

### GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

**SAMPLING DATA:**

| Date: | Color | pH | S.C. | Temp. | Turbidity | DO | Salinity | Other |
|---|---|---|---|---|---|---|---|---|
| Time: | (Visual) | (S.U.) | (mS/cm) | ($^0$C) | (NTU) | (mg/l) | (%) | |
| Method: | | | | | | | | |

**PURGE DATA:**

| Date: | Volume | pH | S.C. | Temp. | Turbidity | DO | Salinity | Other |
|---|---|---|---|---|---|---|---|---|
| Method: | | | | | | | | |
| Monitor Reading (ppm): | | | | | | | | |
| Well Casing Diameter & Material | | | | | | | | |
| Type: | | | | | | | | |
| Total Well Depth (TD): | | | | | | | | |
| Static Water Level (WL): | | | | | | | | |
| One Casing Volume(gal/L): | | | | | | | | |
| Start Purge (hrs): | | | | | | | | |
| End Purge (hrs): | | | | | | | | |
| Total Purge Time (min): | | | | | | | | |
| Total Vol. Purged (gal/L): | | | | | | | | |

**SAMPLE COLLECTION INFORMATION:**

| Analysis | Preservative | Container Requirements | Collected |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**OBSERVATIONS / NOTES:**

| Circle If Applicable: | | Signature(s): |
|---|---|---|
| MS/MSD | Duplicate ID No.: | |

# STANDARD OPERATING PROCEDURE

# SOP-15

# GLOBAL POSITIONING SYSTEM

## 1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the Field Technicians with basic instructions for operating a handheld Global Positioning System (GPS) unit allowing them to set GPS parameters in the receiver, record GPS positions on the field device, and update existing Geographic Information System (GIS) data. This SOP is specific to GIS quality data collection for Trimble-specific hardware and software.

If possible, the Trimble GeoXM or GeoXH Operators Manual should be downloaded onto the operator's personal computer for reference before or while in the field. The manual can be downloaded at http://trl.trimble.com/docushare/dsweb/Get/Document-311749/TerraSyncReferenceManual.pdf

Unless the operator is proficient in the setup and operation of the GPS unit, the Project Manager (or designee) should have the GPS unit shipped to the project-specific contact listed below in the Pittsburgh, Pennsylvania office at least five working days prior to field mobilization so project-specific shape files, data points, background images, and correct coordinate systems can be uploaded into the unit.

Tetra Tech NUS, Inc.
Attn: John Wright
661 Anderson Drive, Bldg #7
Pittsburgh, PA 15220

## 2.0 REQUIRED EQUIPMENT

The following hardware and software should be utilized for locating and establishing GPS points in the field:

### 2.1 Required GPS Hardware

- Hand-held GPS Unit capable of sub-meter accuracy (i.e. Trimble GeoXM or Trimble GeoXH). This includes the docking cradle, a/c adapter, stylus, and USB cable for data transfer.

Optional Accessories:

- External antenna
- Range pole
- Hardware clamp (for mounting Geo to range pole)
- GeoBeacon

- Indelible marker
- Non-metallic pin flags for temporary marking of positions

## 2.2 Required GPS Software

The following software is required to transfer data from the handheld GPS unit to a personal computer:

- Trimble TerraSync version 2.6 or later (pre-loaded onto GPS unit from vendor)

- Microsoft ActiveSync version 4.2 or later. Download to personal computer from: http://www.microsoft.com/windowsmobile/en-us/downloads/eulas/eula_activesync45_1033.mspx?ProductID=76

- Trimble Data Transfer Utility (freeware version 2.1 or later). Download to personal computer from: http://www.trimble.com/datatransfer.shtml

## 3.0 START-UP PROCEDURES

Prior to utilizing the GPS in the field, ensure the unit is fully charged. The unit may come charged from the vendor, but an overnight charge is recommended prior to fieldwork.

The Geo-series GPS units require a docking cradle for both charging and data transfer. The Geo-series GPS unit is docked in the cradle by first inserting the far domed end in the top of the cradled, then gently seating the contact end into the latch. The power charger is then connected to the cradle at the back end using the twist-lock connector. Attach a USB cable as needed between the cradle (B end) and the laptop/PC (A end).

It is recommended that the user also be familiar and check various Windows Mobile settings. One critical setting is the Power Options. The backlight should be set as needed to conserve power when not in use.

Start Up:

1) Power on the GPS unit by pushing the small green button located on the lower right front of the unit.

2) Utilizing the stylus that came with the GPS unit, launch **TerraSync** from the Windows Operating System by tapping on the start icon located in the upper left hand corner of the screen and then tap on **TerraSync** from the drop-down list.

3) If the unit does not default to the Setup screen, tap the Main Menu (uppermost left tab, just below the Windows icon) and select Setup.

4) If the unit was previously shipped to the Pittsburgh office for setup, you can skip directly to Section 4.0. However, to confirm or change settings, continue on to Section 3.1.

## 3.1 Confirm Setup Settings

Use the Setup section to confirm the TerraSync software settings. To open the Setup section, tap the Main Menu and select Setup.

1) Coordinate System
   a. Tap on the Coordinate System.
   b. Verify the project specs are correct for your specific project by scrolling through the various settings. Edit as needed and then tap OK; otherwise, tap Cancel to return to Setup Menu. **Note:** It is always best to utilize the Cancel tab rather than the OK tab if no changes are made since configurations are easily changed by mistake.
   c. Tap on the Units.
   d. Verify the user preferences are correct for your specific project by scrolling through the various settings. Edit as needed and then tap OK; otherwise, tap Cancel to return to Setup Menu.
   e. Tap Real-time Settings.
   f. Verify the Real-time Settings are correct for your specific project by scrolling through the various settings. Edit as needed and then tap OK; otherwise, tap Cancel to return to Setup Menu.
   g. The GPS unit is now configured correctly for your specific project.

## 4.0 ANTENNA CONNECTION

1) If a connection has been properly made with the internal antenna, a satellite icon along with the number of usable satellites will appear at the top of the screen next to the battery icon. If no connection is made (e.g.: no satellite icon), tap on the GPS tab to connect antenna.
2) At this point the GPS unit is ready to begin collecting data.

## 5.0 COLLECTING NEW DATA IN THE FIELD

1) From the Main Menu select Data.
2) From the Sub Menu (located below the Data tab) select New which will bring up the New Data File menu.
3) An auto-generated filename appears and should be edited for your specific project. If the integral keyboard does not appear, tap the small keyboard icon at the bottom of the screen.
4) After entering the file name, tap Create to create the new file.
5) Confirm antenna height if screen appears. Antenna height is the height that the GPS unit will be held from the ground surface (Typically 3 to 4 feet).
6) The Choose Feature screen appears.

### 5.1 Collecting Features

1) If not already open, the Collect Feature screen can be opened by tapping the Main Menu and selecting Data. The Sub Menu should default to Collect.
2) **Do not begin the data logging process until you are at the specific location for which you intend to log the data.**
3) A known reference or two should be shot at the beginning and at the end of each day in which the GPS unit is being used. This allows for greater accuracy during post-processing of the data.
4) Upon arriving at the specific location, tap on Point_generic as the Feature Name.
5) Tap Create to begin data logging.
6) In the Comment Box enter sample ID or location-specific information.
7) Data logging can be confirmed by viewing the writing pencil icon in the upper part of the screen. Also, the logging counter will begin. As a Rule of Thumb, accumulate a minimum of 20 readings on the counter, per point, as indicated by the logging counter before saving the GPS data.
8) Once the counter has reached a minimum number of counts (i.e. 20), tap on OK to save the data point to the GPS unit. Confirm the feature. All data points are automatically saved within the GPS unit.
9) Repeat steps 2 through 8, giving each data point a unique name or number.

**Note:** If the small satellite icon or the pencil icon is blinking, this is an indication the GPS unit is not collecting data. A possible problem may be too few satellites. While still in data collection mode, tap on Main Menu in upper left hand corner of the screen and select Status. Skyplot will display as the default showing the number of available satellites. To increase productivity (number of usable satellites) use the stylus to move the pointer on the productivity and precision line to the left. This will decrease precision, but increase productivity. The precision and productivity of the GPS unit can be adjusted as the number of usable satellites changes throughout the day. To determine if GPS is correctly recording data, see Section 5.2.

## 5.2 Viewing Data or Entering Additional Data Points to the Current File

1) To view the stored data points in the current file, tap on the Main Menu and select Map. Stored data points for that particular file will appear. Use the +/- and <-/-> icons in lower left hand corner of screen to zoom in/out and to manipulate current view.
2) To return to data collection, tap on the Main Menu and select Data. You are now ready to continue to collect additional data points.

## 5.3 Viewing Data or Entering Data Points from an Existing File

1) To view data points from a previous file, tap on Main Menu and select Data, then select File Manager from the Sub Menu.
4) Highlight the file you want to view and select Map from the Main Menu.
5) To add data points to this file, tap on Main Menu and select Data. Continue to collect additional data points.

# 6.0 NAVIGATION

This section provides instructions on navigating to saved data points in an existing file within the GPS unit.

1) From the Main Menu select Map.
2) Using the Select tool, pick the point on the map to where you want to navigate.
3) The location you select will have a box placed around the point.
4) From the Options menu, choose the Set Nav Target (aka set navigation target).
5) The location will now have double blue flags indicating this point is you navigation target.
6) From the Main Menu select Navigation.

7) The dial and data on this page will indicate what distance and direction you need to travel to reach the desired target.
8) Follow the navigation guide until you reach the point you select.
9) Repeat as needed for any map point by going back to Step 1.

## 7.0 PULLING IN A BACKGROUND FILE

This section provides instructions on pulling in a pre-loaded background file. These files are helpful in visualizing your current location.

1) From the Main Menu select Map, then tap on Layers, select the background file from drop down list.
2) Select the project-specific background file from the list of available files.
3) Once the selected background file appears, the operator can manipulate the screen utilizing the +/- and <-/-> functions at the bottom of the screen.
4) In operating mode, the operator's location will show up on the background file as a floating "x".

## 8.0 DATA TRANSFER

This section provides instructions on how to transfer stored data on the handheld GPS unit to a personal computer. Prior to transferring data from the GPS unit to a computer, Microsoft ActiveSync and Trimble Data Transfer Utility software must be downloaded to the computer from the links provided in Section 2.2 (Required GPS Software). If a leased computer is utilized in which the operator can not download files, see the Note at the end of Section 8.0.

1) See Attachment A at the end of this SOP for instructions on how to transfer data from the GPS to a personal computer.

**Note:** If you are unable to properly transfer data from the GPS unit to a personal computer, the unit should be shipped to the project-specific contact listed in Section 1.0 where the data will be transferred and the GPS unit then shipped back to the vendor.

## 9.0 SHUTTING DOWN

This section provides instruction for properly shutting down the GPS unit.

1) When shutting down the GPS unit for the day, first click on the "X" in the upper right hand corner.

2) You will be prompted to ensure you want to exit TerraSync. Select Yes.
3) Power off the GPS unit by pushing the small green button located on the bottom face of the unit.
4) Place the GPS unit in its cradle to recharge the battery overnight. Ensure the green charge light is visible on the charging cradle.

# ATTACHMENT A

**How to Transfer Trimble GPS Data between Data Collector and PC**
original 11/21/06 (5/1/08 update) – John Wright

***Remember – Coordinate System, Datum, and Units are critical!!!***

**Trimble Data Collection Devices:**
Standard rental systems include the Trimble ProXR/XRS backpack and the newer handheld GeoXT or GeoXH units. Some of the older backpack system may come with either a RECON "PDA-style" or a TSCe or TSC1 alpha-numeric style data collector.

The software on all of the above units should be Trimble TerraSync (v 2.53 or higher – current version is 3.20) and to the user should basically look and function similar. The newer units and software versions (which should always be requested when renting) include enhancements for data processing, real-time display functions, and other features.

**Data Transfer:**
Trimble provides a free transfer utility program to aid in the transfer of GIS and field data. The Data Transfer Utility is a standalone program that will run on a standard office PC or laptop.

To connect a field data collector such as a RECON, GeoXM, GeoXT, GeoXH, or ProXH, you must first have Microsoft ActiveSync installed to allow the PC and the data collector to talk to one another. A standard USB cable is also needed to connect the two devices.

A CD or USB drive is provided with the data collector for use in data transfer. If needed, these programs are also available without charge via the web at:

• **Trimble Data Transfer Utility** (v 1.38) program to download the RECON or GeoXH field data to your PC: http://www.trimble.com/datatransfer.shtml

• **ActiveSync** from Microsoft to connect the data collector to the PC. The latest version (v4.5) can be found at: http://www.microsoft.com/windowsmobile/activesync/default.mspx
**(see page 2 for data transfer instructions)**

**To Transfer Data Collected in the Field:**

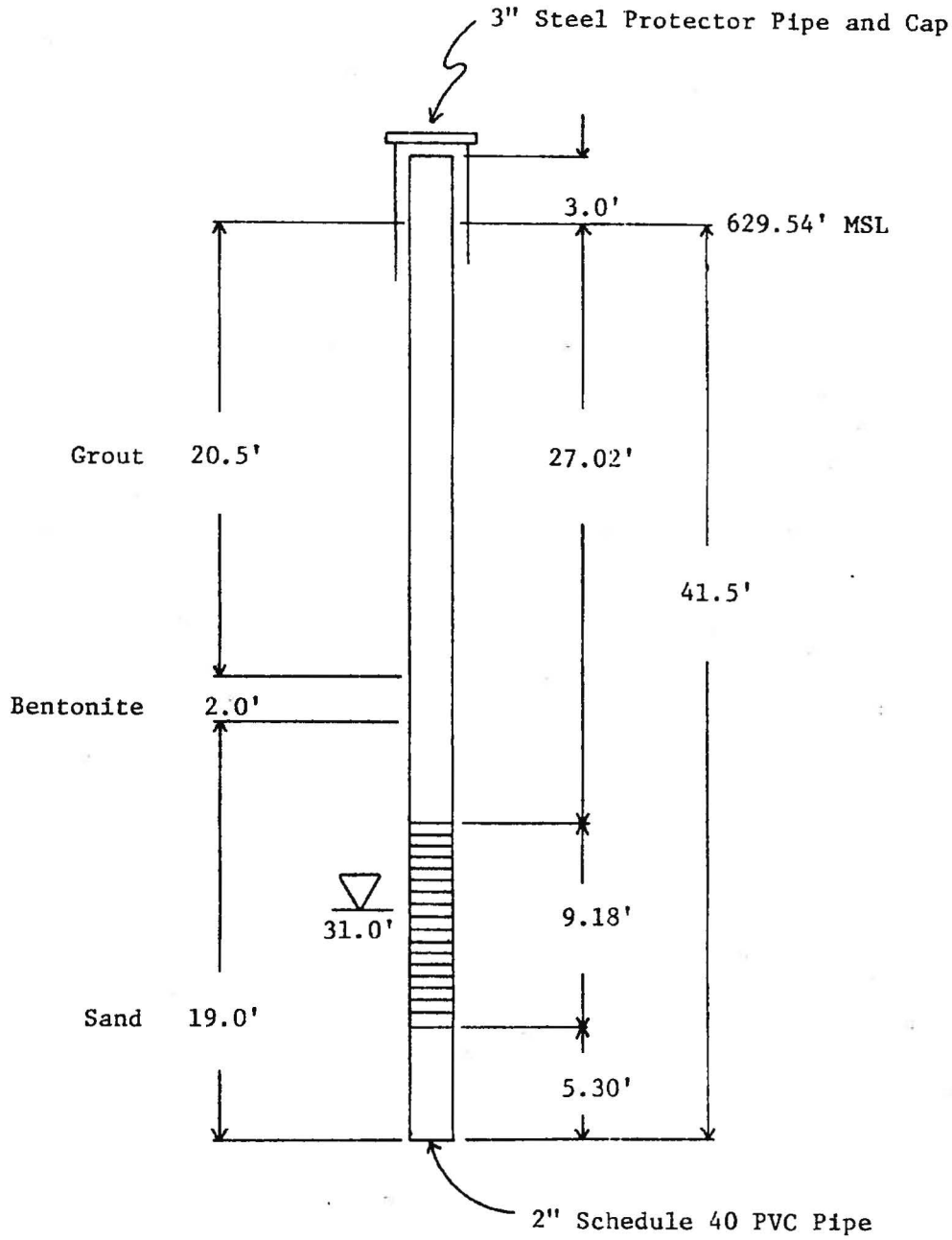
• Install the Data Transfer and ActiveSync software installed on your PC
• Connect the RECON or GeoXH to your PC via an A/B USB cable (blade end and square end type "HP printer" style)
• ActiveSync should auto-detect the connection and recognize the data collector
• Make sure the data file desired is CLOSED in TerraSync prior to transfer
• Connect via ActiveSync as a guest (not a partnership)
• Run the Trimble Data Transfer Utility program on your PC
• Select "***GIS Datalogger on Windows CE***" or similar selection
• Hit the green connect icon to the right - the far right area should say "***Connected to ....***" if successful
• Select the "***Receive***" data tab (under device)
• Select "***Data***" from file types on the right
• Find the file(s) needed for data transfer. You can sort the data files by clicking on the date/time header
• Select or browse to a C-drive folder you can put this file for emailing
• When the file appears on the list, hit the "***Transfer All***"
• Go to your Outlook or other email, send a message to: John.Wright@tetratech.com (or GIS department)
• Attach the file(s) you downloaded from your C-drive. For each TerraSync data file created you should have a packet of multiple data files. All need to be sent as a group – make sure you attach all files (the number of files may vary – examples include: ssf, obx, obs, gix, giw, gis, gip, gic, dd, and car)

**To Transfer GIS Data from PC to the Field Device (must be converted in Pathfinder Office):**

• Obtain GIS file(s) desired from GIS Department and have converted to Trimble extension
• Contact John Wright (John.Wright@tetratech.com) if needed for file conversion and upload support
• The GIS file(s) can be quickly converted if requested and sent back to the field user in the needed "Trimble xxx.imp" extension via email – then quickly downloaded from Outlook to your PC for transfer
• Install the Data Transfer and ActiveSync software installed on your PC
• Connect the RECON or GeoXH to your PC via an A/B USB cable (blade end and square end type "HP printer" style)
• ActiveSync should auto-detect the connection and recognize the data collector
• Connect via ActiveSync as a guest (not a partnership)
• Run the Trimble Data Transfer Utility program on your PC
• Select "***GIS Datalogger on Windows CE***" or similar selection
• Hit the green connect icon to the right - the far right area should say "***Connected to ....***" if successful
• Select the "**Send**" data tab (under device)
• Select "**Data**" from file types on the right (you can also send background files)
• Browse to the location of the data on your PC (obtain the file from Pathfinder Office or from the person who converted the data for field use)
• Select the options as appropriate for the name and location of the data file to go on the data collector (usually you can choose main memory or a data storage card)
• When the file(s) appears on the list, hit the "***Transfer All***"
• Run TerraSync on the field device and open the existing data files. Your transferred file should appear (make sure you have selected Main Memory, Default, or Storage Card as appropriate)

# APPENDIX E

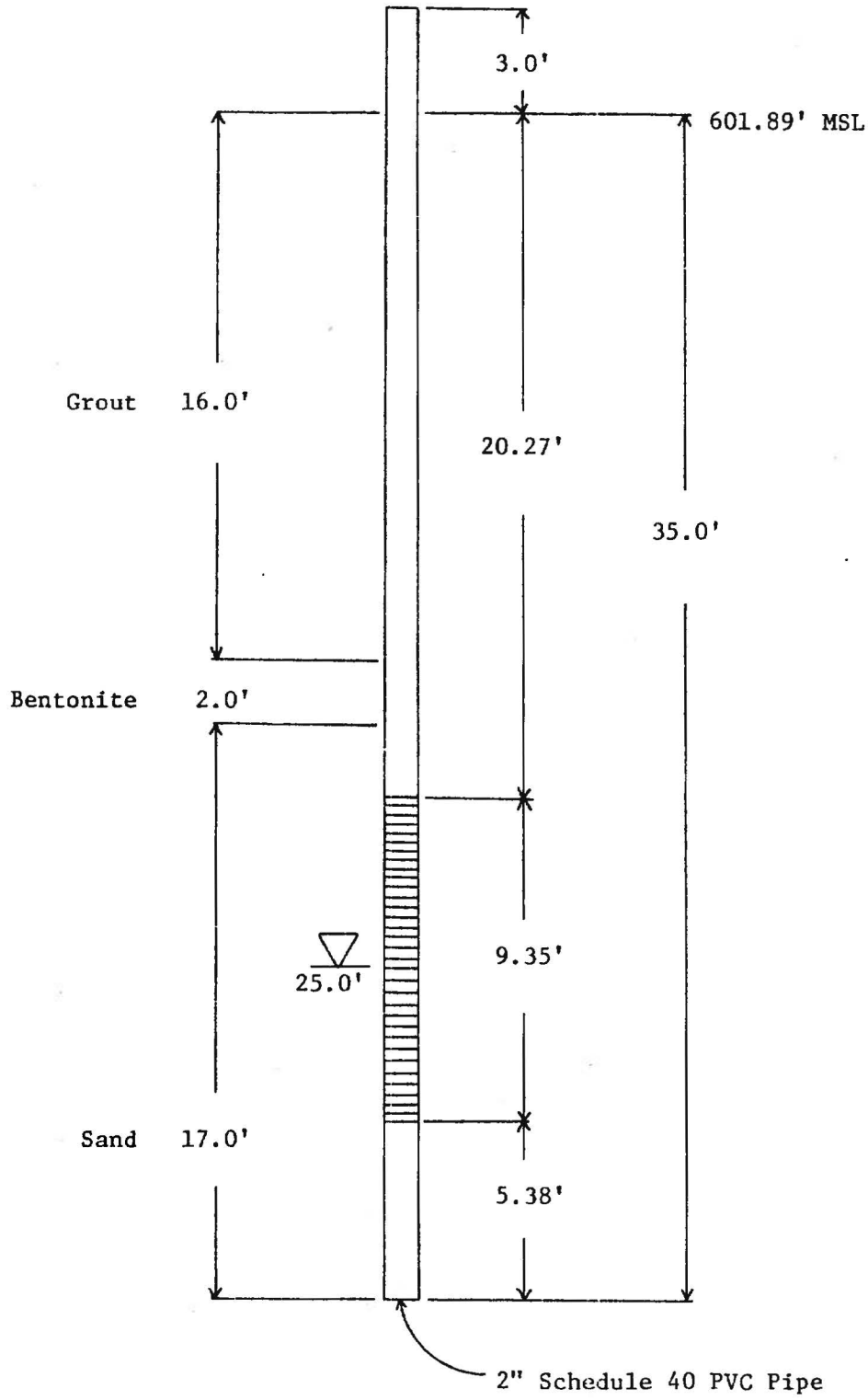
# SWMU 25 MONITORING WELL CONSTRUCTION DIAGRAMS




Well screen

Water depth at time of drilling

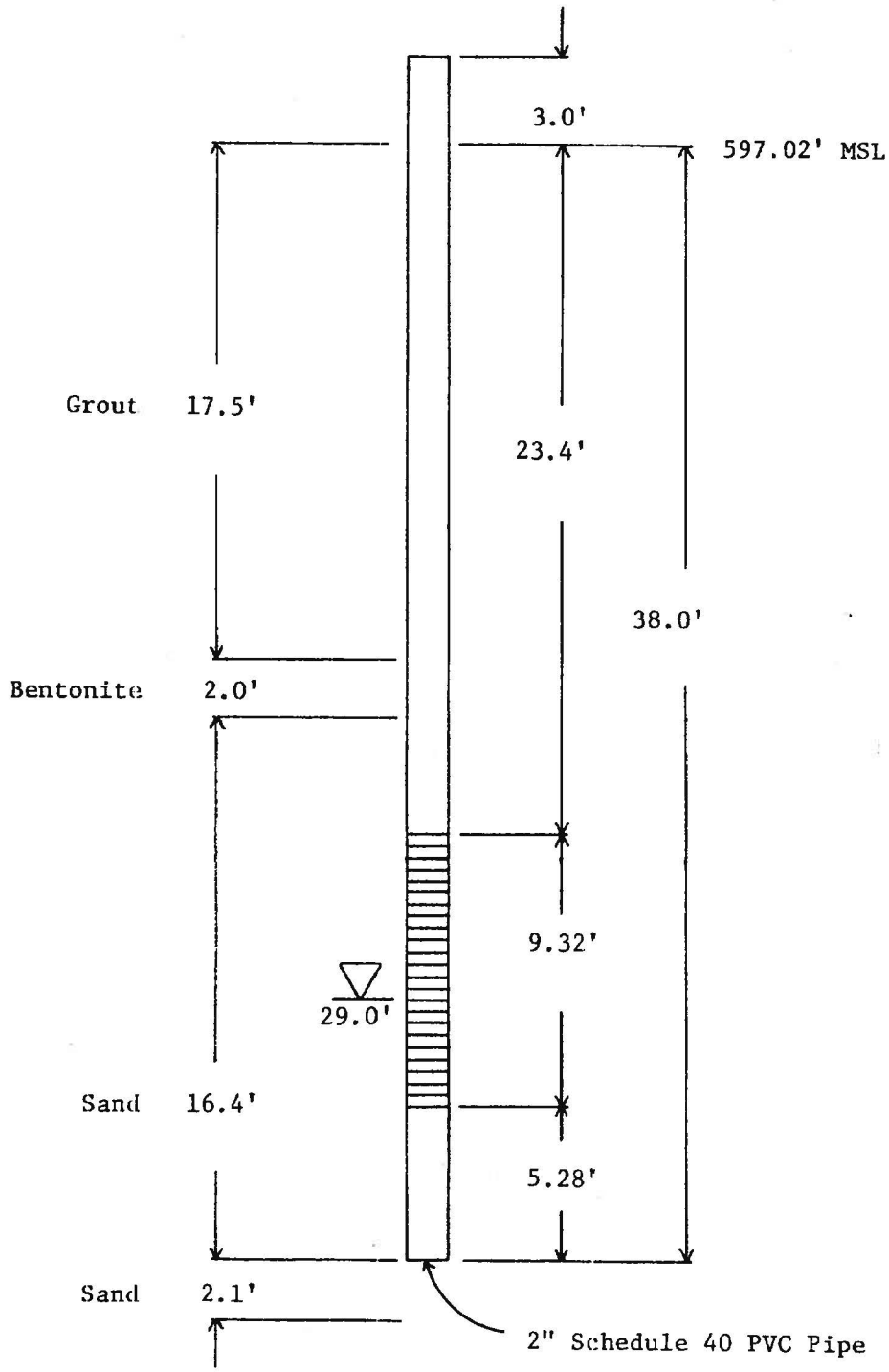
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-1-81




Well screen

Water depth at time of drilling

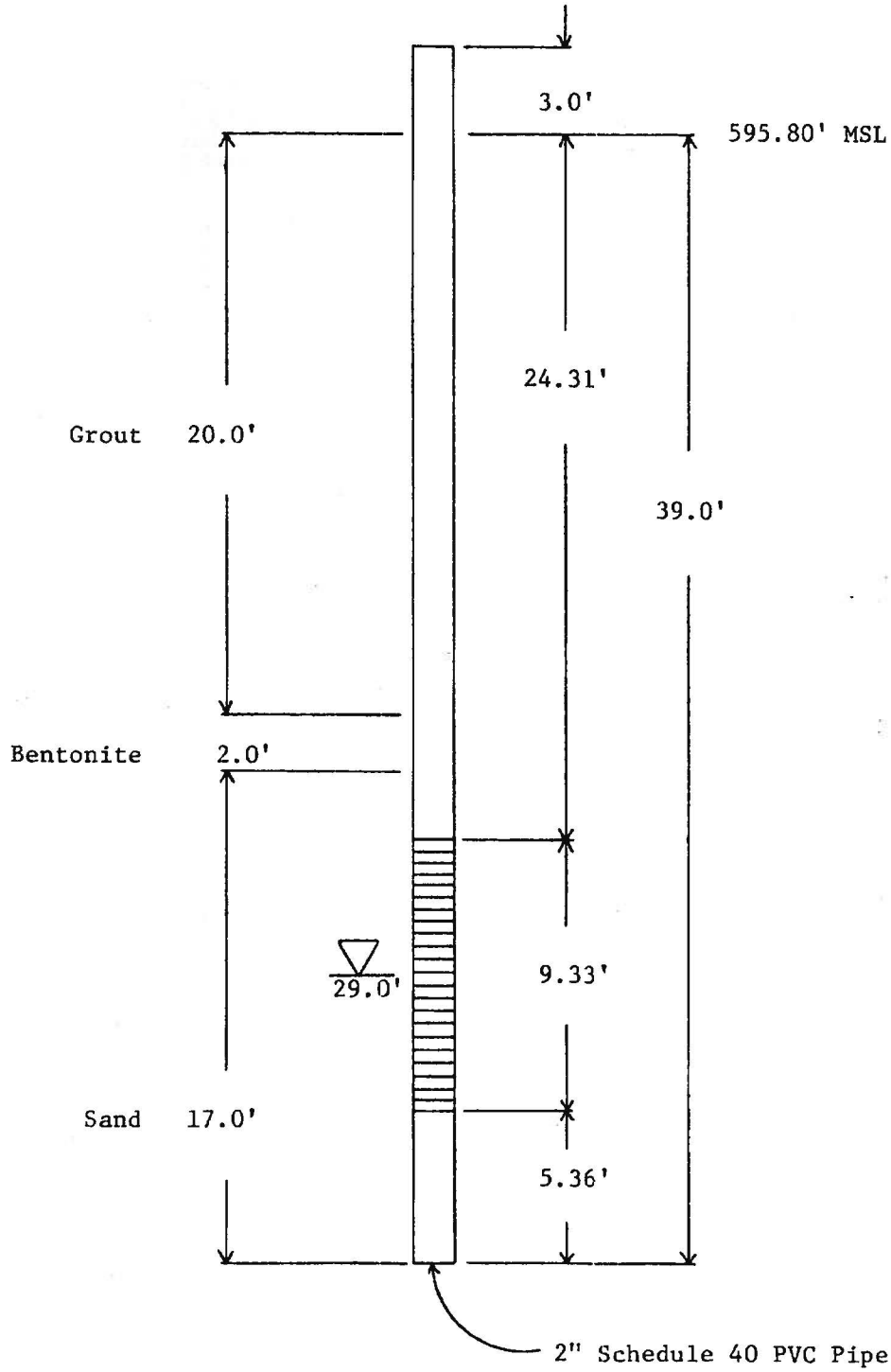
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-2-81




Well screen

Water depth at time of drilling

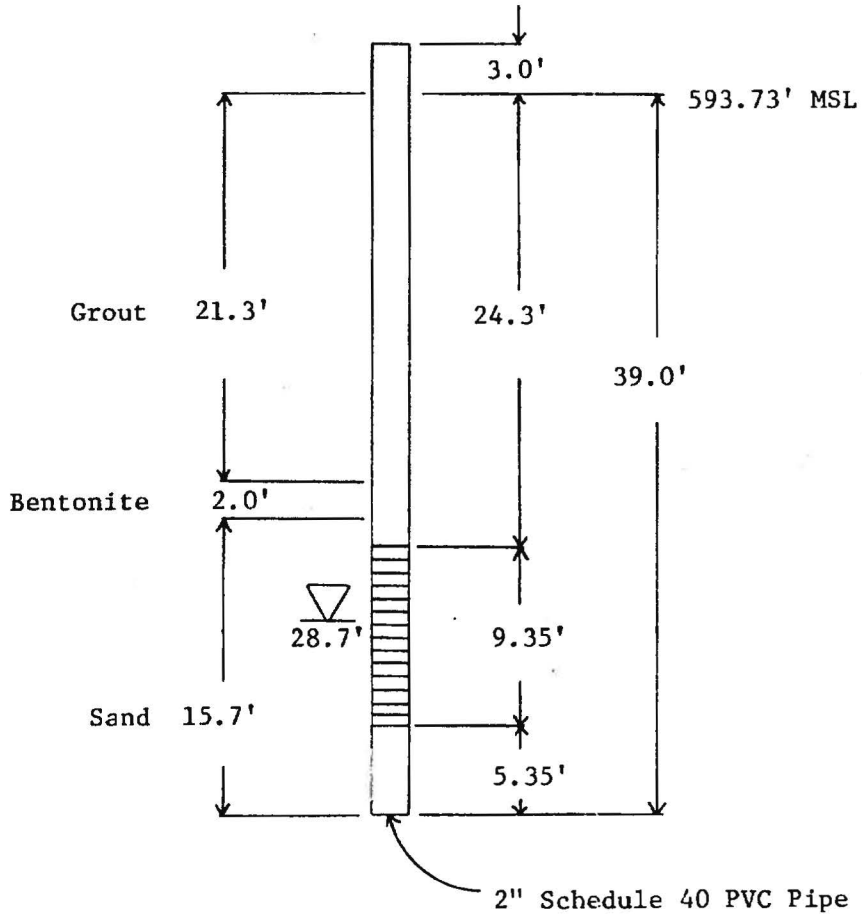
NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-3-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-4-81




Well screen

Water depth at time of drilling

NWSC, Crane, Indiana
Highway 58 Dump Site A
Well Completion
Boring Number: WES-7-5-81

# APPENDIX F

# PSL BACKUP DOCUMENTATION

## NSA Crane SWMU 25 Human Health Screening Criteria - Surface and Subsurface Soil Samples

| Analyte | CAS Number | EPA Regional Screening Level, Residential Soil [1] (mg/kg) | Adjusted EPA Regional Screening Level, Residential Soil [2] (mg/kg) | EPA Regional Screening Level, Migration to Groundwater [1] (mg/kg) | Adjusted EPA Regional Screening Level, Migration to Groundwater [2] (mg/kg) | 2009 IDEM RISC Residential Closure Levels for Soil (mg/kg) [3] | | | Lowest Human Health Criterion | Lowest Human Health Criterion Reference | EPA Regional Screening Level, Industrial Soil [1] (mg/kg) | 2009 IDEM RISC Industrial Closure Levels for Soil (mg/kg) [3] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Residential Direct Contact | Migration to Groundwater | Residential Default Closure Level | | | | Industrial Direct Contact | Migration to Groundwater | Industrial Default Closure Level |
| **Semivolatile Organic Compounds** | | | | | | | | | | | | | | |
| 1,1'-Biphenyl | 92-52-4 | 3900 N | 390 N | 19 | 380 | NA | NA | NA | 380 | RBSSL | 51000 N | NA | NA | NA |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | 18 N | 1.8 N | 0.051 | 1.0 | NA | NA | NA | 1.0 | RBSSL | 180 N | NA | NA | NA |
| 2,2'-Oxybis(1-chloropropane) | 108-60-1 | 4.6 C | 4.6 C | 0.00012 | 0.0024 | 30 | 0.027 | 0.027 | 0.0024 | RBSSL | 22 C | 61 | 0.26 | 0.26 |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | 1800 N | 180 N | 6.7 | 130 | NA | NA | NA | 130 | RBSSL | 18000 N | NA | NA | NA |
| 2,4,5-Trichlorophenol | 95-95-4 | 6100 N | 610 N | 14 | 280 | 18000 | 250 | 250 | 250 | IDEM-RDCL | 62000 N | 49000 | 690 | 690 |
| 2,4,6-Trichlorophenol | 88-06-2 | 61 N[4] | 6.1 N[4] | 0.023 [4] | 0.46 [4] | 18 | 0.07 | 0.07 | 0.07 | IDEM-RDCL | 620 N[4] | 49 | 0.2 | 0.2 |
| 2,4-Dichlorophenol | 120-83-2 | 180 N | 18 N | 0.13 | 2.6 | 550 | 1.1 | 1.1 | 1.1 | IDEM-RDCL | 1800 N | 1500 | 3 | 3 |
| 2,4-Dimethylphenol | 105-67-9 | 1200 N | 120 N | 0.86 | 17 | 3700 | 9 | 9 | 9 | IDEM-RDCL | 12000 N | 9800 | 25 | 25 |
| 2,4-Dinitrophenol | 51-28-5 | 120 N | 12 N | 0.082 | 1.6 | 370 | 0.29 | 0.29 | 0.29 | IDEM-RDCL | 1200 N | 980 | 0.82 | 0.82 |
| 2,4-Dinitrotoluene | 121-14-2 | 1.6 C | 1.6 C | 0.00029 | 0.0058 | NA | NA | NA | 0.0058 | RBSSL | 5.5 C | NA | NA | NA |
| 2,6-Dinitrotoluene | 606-20-2 | 61 N | 6.1 N | 0.050 | 1.0 | NA | NA | NA | 1.0 | RBSSL | 620 N | NA | NA | NA |
| 2-Chloronaphthalene | 91-58-7 | 6300 N | 630 N | 15 | 300 | 15000 | 42 | 42 | 42 | IDEM-RDCL | 82000 N | 39000 | 560 | 560 |
| 2-Chlorophenol | 95-57-8 | 390 N | 39 N | 0.15 | 3.0 | 360 | 0.75 | 0.75 | 0.75 | IDEM-RDCL | 5100 N | 580 | 10 | 10 |
| 2-Methylphenol (o-Cresol) | 95-48-7 | 3100 N | 310 N | 1.5 | 30 | 7500 | 14 | 14 | 14 | IDEM-RDCL | 31000 N | 17000 | 39 | 39 |
| 2-Nitroaniline | 88-74-4 | 610 N | 61 N | 0.15 | 3.0 | 550 | 0.67 | 0.67 | 0.67 | IDEM-RDCL | 6000 N | 1500 | 1.9 | 1.9 |
| 2-Nitrophenol | 88-75-5 | 120 N[5] | 12 N[5] | 0.08 [5] | 1.6 [5] | NA | NA | NA | 1.6 | RBSSL | 1200 N[5] | NA | NA | NA |
| 3,3'-Dichlorobenzidine | 91-94-1 | 1.1 C | 1.1 C | 0.0010 | 0.020 | 9.5 | 0.062 | 0.062 | 0.020 | RBSSL | 3.8 C | 31 | 0.21 | 0.21 |
| 3-Methylphenol (m-Cresol) | 108-39-4 | 3100 N | 310 N | 1.5 | 30 | 9100 | 9.8 | 9.8 | 9.8 | IDEM-RDCL | 31000 N | 25000 | 28 | 28 |
| 3-Nitroaniline | 99-09-2 | NA | NA | NA | NA | NA | NA | NA | NA | None | NA | NA | NA | NA |
| 4,6-Dinitro-2-methylphenol | 534-52-1 | 4.9 N | 0.49 N | 0.0050 | 0.10 | NA | NA | NA | 0.10 | RBSSL | 49 N | NA | NA | NA |
| 4-Bromophenyl phenyl ether | 101-55-3 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4-Chloro-3-methyl phenol | 59-50-7 | 6100 N | 610 N | 4.3 | 86 | NA | NA | NA | 86 | RBSSL | 62000 N | NA | NA | NA |
| 4-Chloroanaline | 106-47-8 | 2.4 C | 2.40 C | 0.00014 | 0.0028 | 730 | 0.97 | 0.97 | 0.0028 | RBSSL | 8.6 C | 2000 | 2.7 | 2.7 |
| 4-Chlorophenyl phenyl ether | 7005-72-3 | NA | NA | NA | NA | NA | NA | NA | NA | None | NA | NA | NA | NA |
| 4-Methylphenol (p-Cresol) | 106-44-5 | 310 N | 31 N | 0.15 | 3.0 | 910 | 1.1 | 1.1 | 1.1 | IDEM-RDCL | 3100 N | 2500 | 3 | 3 |
| 4-Nitroaniline | 100-01-6 | 24 C | 24 C | 0.0014 | 0.028 | NA | NA | NA | 0.028 | RBSSL | 86 C | NA | NA | NA |
| 4-Nitrophenol | 100-02-7 | NA | NA | NA | NA | NA | NA | NA | NA | None | NA | NA | NA | NA |
| Acetophenone | 98-86-2 | 7800 N | 780 N | 1.1 | 22 | NA | NA | NA | 22 | RBSSL | 100000 N | NA | NA | NA |
| Atrazine | 1912-24-9 | 2.1 C | 2.1 C | 0.00019 | 0.0038 | 19 | 0.048 | 0.048 | 0.0038 | RBSSL | 7.5 C | 63 | 0.21 | 0.21 |
| Benzaldehyde | 100-52-7 | 7800 N | 780 N | 0.81 | 16.2 | NA | NA | NA | 16.2 | RBSSL | 100000 N | NA | NA | NA |
| Bis(2-chloroethoxy)methane | 111-91-1 | 180 N | 18 N | 0.025 | 0.50 | NA | NA | NA | 0.50 | RBSSL | 1800 N | NA | NA | NA |
| Bis(2-chloroethyl)ether | 111-44-4 | 0.21 C | 0.21 C | 0.0000031 | 0.000062 | 1.6 | 0.0007 | 0.0007 | 0.000062 | RBSSL | 1.0 C | 3 | 0.012 | 0.012 |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 35 C | 35 C | 1.1 | 22 | 300 | 3600 | 300 | 22 | RBSSL | 120 C | 980 | 120000 | 980 |
| Butyl benzyl phthalate | 85-68-7 | 260 C | 260 C | 0.51 | 10 | 37000 | 6200 | 310 | 10 | RBSSL | 910 C | 98000 | 6200 | 310 |
| Caprolactam | 105-60-2 | 31000 N | 3100 N | 4.5 | 90 | NA | NA | NA | 90 | RBSSL | 310000 N | NA | NA | NA |
| Carbazole | 86-74-8 | NA | NA | NA | NA | 210 | 5.9 | 5.9 | 5.9 | IDEM-RDCL | NA | 690 | 20 | 20 |
| Dibenzofuran | 132-64-9 | 78 N | 7.8 N | 0.68 | 13.6 | 370 | 4.9 | 4.9 | 4.9 | IDEM-RDCL | 1000 N | 980 | 65 | 65 |
| Diethyl phthalate | 84-66-2 | 49000 N | 4900 N | 12 | 240 | 150000 | 450 | 450 | 240 | RBSSL | 490000 N | 390000 | 1300 | 840 |
| Dimethyl phthalate | 131-11-3 | 49000 N[6] | 4900 N[6] | 12 [6] | 240 [6] | 1000000 | 2000 | 1100 | 240 | RBSSL | 490000 N[6] | 1000000 | 5600 | 1100 |
| Di-n-butyl phthalate | 84-74-2 | 6100 N | 610 N | 9.2 | 184 | 18000 | 5000 | 760 | 184 | RBSSL | 62000 N | 49000 | 14000 | 760 |
| Di-n-octyl phthalate | 117-84-0 | NA | NA | NA | NA | 7300 | 67000 | 2000 | 2000 | IDEM-RDCL | NA | 20000 | 67000 | 2000 |
| Hexachlorobenzene | 118-74-1 | 0.30 C | 0.30 C | 0.00053 | 0.011 | 2.7 | 2.2 | 2.2 | 0.011 | RBSSL | 1.1 C | 8.6 | 3.9 | 3.9 |
| Hexachlorobutadiene | 87-68-3 | 61 N[4] | 6.1 N[4] | 0.0017 | 0.034 | 55 | 24 | 24 | 0.034 | RBSSL | 22 C | 150 | 66 | 66 |
| Hexachlorocyclopentadiene | 77-47-4 | 370 N | 37 N | 0.68 | 14 | 1100 | 400 | 400 | 14 | RBSSL | 3700 N | 2900 | 4900 | 720 |
| Hexachloroethane | 67-72-1 | 61 N[4] | 6.1 N[4] | 0.0029 | 0.058 | 120 | 2.8 | 2.8 | 0.058 | RBSSL | 620 N[4] | 240 | 7.7 | 7.7 |
| Isophorone | 78-59-1 | 510 C | 510 C | 0.023 | 0.46 | 4500 | 5.3 | 5.3 | 0.46 | RBSSL | 1800 C | 14000 | 18 | 18 |
| Nitrobenzene | 98-95-3 | 4.8 C | 4.8 C | 0.000079 | 0.0016 | 91 | 0.028 | 0.028 | 0.0016 | RBSSL | 24 C | 250 | 0.34 | 0.34 |
| N-Nitrosodi-n-propylamine | 621-64-7 | 0.069 C | 0.069 C | 0.0000072 | 0.00014 | 0.61 | 0.0006 | 0.0006 | 0.00014 | RBSSL | 0.25 C | 2 | 0.002 | 0.002 |
| N-Nitrosodiphenylamine | 86-30-6 | 99 C | 99 C | 0.075 | 1.5 | 870 | 9.7 | 9.7 | 1.5 | RBSSL | 350 C | 2800 | 32 | 32 |
| Pentachlorophenol | 87-86-5 | 0.89 C | 0.89 C | 0.0017 | 0.034 | 20 | 0.028 | 0.028 | 0.028 | IDEM-RDCL | 9.0 C | 54 | 0.66 | 0.66 |
| Phenol | 108-95-2 | 18000 N | 1800 N | 6.3 | 126 | 44000 | 56 | 56 | 56 | IDEM-RDCL | 180000 N | 96000 | 160 | 160 |
| **Polycyclic Aromatic Hydrocarbons** | | | | | | | | | | | | | | |
| 2-Methylnaphthalene | 91-57-6 | 310 N | 31 N | 0.75 | 15 | 630 | 3.1 | 3.1 | 3.1 | IDEM-RDCL | 4100 N | 1600 | 42 | 42 |
| Acenaphthene | 83-32-9 | 3400 N | 340 N | 22 | 440 | 9500 | 130 | 130 | 130 | IDEM-RDCL | 33000 N | 24000 | 1800 | 1800 |
| Acenaphthylene | 208-96-8 | 3400 N[7] | 340 N[7] | 360 [7] | 7200 [7] | 1100 | 18 | 18 | 18 | IDEM-RDCL | 170000 N[7] | 2800 | 180 | 180 |
| Anthracene | 120-12-7 | 17000 N | 1700 N | 360 | 7200 | 47000 | 2700 | 2000 | 1700 | R-RSL | 170000 N | 120000 | 36000 | 2000 |
| Benzo(a)anthracene | 56-55-3 | 0.15 C | 0.15 C | 0.010 | 0.20 | 5 | 19 | 5 | 0.15 | R-RSL | 2.1 C | 15 | 62 | 15 |
| Benzo(a)pyrene | 50-32-8 | 0.015 C | 0.015 C | 0.0035 | 0.070 | 0.5 | 8.2 | 0.5 | 0.015 | R-RSL | 0.21 C | 1.5 | 16 | 1.5 |
| Benzo(b)fluoranthene | 205-99-2 | 0.15 C | 0.15 C | 0.035 | 0.70 | 5 | 57 | 5 | 0.15 | R-RSL | 2.1 C | 15 | 190 | 15 |
| Benzo(g,h,i)perylene | 191-24-2 | 1700 N[8] | 170 N[8] | 120 [8] | 2400 [8] | NA | NA | NA | 170 | R-RSL | 17000 N[8] | NA | NA | NA |

## NSA Crane SWMU 25 Human Health Screening Criteria - Surface and Subsurface Soil Samples

| Analyte | CAS Number | EPA Regional Screening Level, Residential Soil [1] (mg/kg) | Adjusted EPA Regional Screening Level, Residential Soil [2] (mg/kg) | EPA Regional Screening Level, Migration to Groundwater [1] (mg/kg) | Adjusted EPA Regional Screening Level, Migration to Groundwater [2] (mg/kg) | 2009 IDEM RISC Residential Closure Levels for Soil (mg/kg) [3] | | | Lowest Human Health Criterion | Lowest Human Health Criterion Reference | EPA Regional Screening Level, Industrial Soil [1] (mg/kg) | 2009 IDEM RISC Industrial Closure Levels for Soil (mg/kg) [3] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Residential Direct Contact | Migration to Groundwater | Residential Default Closure Level | | | | Industrial Direct Contact | Migration to Groundwater | Industrial Default Closure Level |
| Benzo(k)fluoranthene | 207-08-9 | 1.5 C | 1.5 C | 0.35 | 7.0 | 50 | 570 | 50 | 1.5 | R-RSL | 21 C | 150 | 1900 | 150 |
| Chrysene | 218-01-9 | 15 C | 15 C | 1.1 | 22 | 500 | 1900 | 500 | 15 | R-RSL | 210 C | 1500 | 6200 | 1500 |
| Dibenzo(a,h)anthracene | 53-70-3 | 0.015 C | 0.015 C | 0.011 | 0.22 | 0.5 | 18 | 0.5 | 0.015 | R-RSL | 0.21 C | 1.5 | 60 | 1.5 |
| Fluoranthene | 206-44-0 | 2300 N | 230 N | 160 | 3200 | 6300 | 6300 | 2000 | 230 | R-RSL | 22000 N | 16000 | 18000 | 2000 |
| Fluorene | 86-73-7 | 2300 N | 230 N | 27 | 540 | 6300 | 170 | 170 | 170 | IDEM-RDCL | 22000 N | 16000 | 2300 | 2000 |
| Indeno(1,2,3-c,d)pyrene | 193-39-5 | 0.15 C | 0.15 C | 0.12 | 2.4 | 5 | 160 | 5 | 0.15 | R-RSL | 2.1 C | 15 | 540 | 15 |
| Naphthalene | 91-20-3 | 3.6 C | 3.60 C | 0.00047 | 0.0094 | 3200 | 0.7 | 0.7 | 0.0094 | RBSSL | 18 C | 8000 | 170 | 170 |
| Phenanthrene | 85-01-8 | 1700 N[8] | 170 N[8] | 120 [8] | 2400 [8] | 470 | 13 | 13 | 13 | IDEM-RDCL | 17000 N[8] | 1200 | 170 | 170 |
| Pyrene | 129-00-0 | 1700 N | 170 N | 120 | 2400 | 4700 | 4600 | 2000 | 170 | R-RSL | 17000 N | 12000 | 13000 | 2000 |
| **Metals** | | | | | | | | | | | | | | |
| Aluminum | 7429-90-5 | 77000 N | 7700 N | 55000 | 1100000 | NA | NA | NA | 7700 | R-RSL | 990000 NM | NA | NA | NA |
| Antimony | 7440-36-0 | 31 N | 3.1 N | 0.66 | 13 | 140 | 5.4 | 5.4 | 3.1 | R-RSL | 410 N | 620 | 37 | 37 |
| Arsenic | 7440-38-2 | 0.39 C | 0.39 C | 0.0013 | 0.026 | 3.9 | 5.8 | 3.9 | 0.026 | RBSSL | 1.6 C | 20 | 5.8 | 5.8 |
| Barium | 7440-39-3 | 15000 N | 1500 N | 300 | 6000 | 63000 | 1600 | 1600 | 1500 | R-RSL | 190000 NM | 230000 | 17000 | 10000 |
| Beryllium | 7440-41-7 | 160 N | 16 N | 58 | 1160 | 680 | 63 | 63 | 16 | R-RSL | 2000 N | 2900 | 3200 | 2300 |
| Cadmium | 7440-43-9 | 70 N | 7 N | 1.4 | 28 | 12 | 7.5 | 7.5 | 7 | R-RSL | 800 N | 990 | 77 | 77 |
| Chromium | 7440-47-3 | 0.29 C[9] | 0.29 C[9] | 0.00083 [9] | 0.017 [9] | 430[9] | 38[9] | 38[9] | 0.017 | RBSSL | 5.6 C[9] | 650 | 120 | 120 |
| Cobalt | 7440-48-4 | 23 N | 2.3 N | 0.49 | 9.8 | NA | NA | NA | 2.3 | R-RSL | 300 N | NA | NA | NA |
| Copper | 7440-50-8 | 3100 N | 310 N | 51 | 1020 | 14000 | 920 | 920 | 310 | R-RSL | 41000 N | 62000 | 2900 | 2900 |
| Iron | 7439-89-6 | 55000 N | 5500 N | 640 | 12800 | NA | NA | NA | 5500 | R-RSL | 720000 N | NA | NA | NA |
| Lead | 7439-92-1 | 400 [10] | 400 [10] | 14 [11] | 280 [11] | 400 | 81 | 81 | 81 | IDEM-RDCL | 800 [12] | 1300 | 230 | 230 |
| Manganese | 7439-96-5 | 1800 N | 180 N | 57 | 1140 | NA | NA | NA | 180 | R-RSL | 23000 N | NA | NA | NA |
| Mercury | 7439-97-6 | 23 N[13] | 2.3 N[13] | 0.57 [13] | 11.4 [13] | NA | NA | NA | 2.3 | R-RSL | 310 N[13] | NA | NA | NA |
| Nickel | 7440-02-0 | 1500 N | 150 N | 48 | 960 | 6900 | 950 | 950 | 150 | R-RSL | 20000 N | 31000 | 2700 | 2700 |
| Selenium | 7782-49-2 | 390 N | 39 N | 0.95 | 19 | 1700 | 5.2 | 5.2 | 5.2 | IDEM-RDCL | 5100 N | 7800 | 53 | 53 |
| Silver | 7440-22-4 | 390 N | 39 N | 1.6 | 32 | 1700 | 31 | 31 | 31 | IDEM-RDCL | 5100 N | 7800 | 87 | 87 |
| Thallium | 7440-28-0 | NA | NA | NA | NA | 24 | 2.8 | 2.8 | 2.8 | IDEM-RDCL | NA | 110 | 10 | 10 |
| Vanadium | 7440-62-2 | 390 N[14] | 39 N[14] | 180 [14] | 3600 [14] | NA | NA | NA | 39 | R-RSL | 5200 N[14] | NA | NA | NA |
| Zinc | 7440-66-6 | 23000 N | 2300 N | 680 | 13600 | 100000 | 14000 | 10000 | 2300 | R-RSL | 310000 N | 470000 | 38000 | 10000 |

Notes:

1 - The residential direct contact (R-RSL) and risk-based migration to groundwater soil screening levels (RBSSL) from the USEPA Regions 3, 6, and 9 Regional Screening Levels for Chemical Contaminants at Superfund Sites, November, 2010 available online at http://epa-prgs.ornl.gov/chemicals/index.shtml. The risk-based screening levels are based on a target hazard quotient of 1 for noncarcinogens (denoted with a "N" flag) or an incremental lifetime cancer risk (ILCR) of 1E-6 for carcinogens (denoted with a "C" flag). (Industrial criteria are also presented for information purposes.)

2 - The USEPA R-RSL (November, 2010) residential soil screening level for noncarcinogens adjusted by dividing by 10, equivalent to a target hazard quotient of 0.1. The residential soil screening level for carcinogens (not adjusted) is equivalent to an incremental lifetime cancer risk (ILCR) of 1E-6. The USEPA RBSSL (May, 2010) is adjusted for a dilution attenuation factor (DAF) of 20.

3 - Indiana Department of Environmental Management (IDEM) residential soil direct contact screening levels, migration to groundwater screening levels, and Residential Default Closure Levels from IDEM RISC Technical Guide, January 31, 2006, Appendix 1, revised May 1, 2009. (Industrial criteria are also presented for information purposes.)

4 - One tenth the noncarcinogenic value is less than the carinogenic value; therefore, the noncarcinogenic value is presented.

5 - Value is for 2,4-dinitrophenol.

6 - Value is for diethyl phthalate.

7 - Value is for acenapththene.

8 - Value is for pyrene.

9 - Value is for hexavalent chromium.

10 - Office of Solid Waste and Emergency Response soil screening level (EPA, 1994b)

11 - Calculated from the EPA website (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search).

12 - USEPA Technical Review Workgroup for Lead. Guidance Document. “Frequently Asked Question (FAQs) on the Adult‑Lead Model.” October 2010. http://www.epa.gov/superfund/lead/almfaq.htm

13 - Value is for mercuy, inorganic salts.

14 - Value is for vanadium and compounds.

Abbreviations:

NA - Not applicable or not available
C - Carcinogen
EPA - U.S. Environmental Protection Agency
N - Noncarcinogen
NA - Not available
SSL - Soil Screening Level

## Crane SWMU 25 Human Health Screening Criteria - Groundwater Samples

| Analyte | CAS Number | EPA Regional Screening Level, Tap Water[1] (ug/L) | Adjusted EPA Regional Screening Level, Tap Water[2] (ug/L) | EPA Regional Screening Level, Vapor[1] (ug/L) | Adjusted EPA Regional Screening Level, Vapor[2] (ug/L) | EPA Maximum Contaminant Level (ug/L)[3] | IDEM GW[4] (ug/L) | IDEM GW Default Closure Level[4] (ug/L) | Minimum Criteria (ug/L) | Minimum Criterion Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| **Semivolatile Organic Compounds** | | | | | | | | | | |
| 1,1'-Biphenyl | 92-52-4 | 1800 N | 180 N | NA | NA | NA | NA | NA | 180 | T-RSL |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | 11 N | 1.1 N | NA | NA | NA | NA | NA | 1.1 | T-RSL |
| 2,2'-Oxybis(1-chloropropane) | 108-60-1 | 0.32 C | 0.32 C | 80 C | 80 C | NA | 4.2 | 4.2 | 0.32 | T-RSL |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | 1100 N | 110 N | NA | NA | NA | NA | NA | 110 | T-RSL |
| 2,4,5-Trichlorophenol | 95-95-4 | 3700 N | 370 N | NA | NA | NA | 3600 | 3600 | 370 | T-RSL |
| 2,4,6-Trichlorophenol | 88-06-2 | 37 N[5] | 3.7 N[5] | NA | NA | NA | 3.6 | 3.6 | 3.6 | IDEM G-DCL |
| 2,4-Dichlorophenol | 120-83-2 | 110 N | 11 N | NA | NA | NA | 110 | 110 | 11 | T-RSL |
| 2,4-Dimethylphenol | 105-67-9 | 730 N | 73 N | NA | NA | NA | 730 | 730 | 73 | T-RSL |
| 2,4-Dinitrophenol | 51-28-5 | 73 N | 7.3 N | NA | NA | NA | 73 | 73 | 7.3 | T-RSL |
| 2,4-Dinitrotoluene | 121-14-2 | 0.22 C | 0.22 C | NA | NA | NA | NA | NA | 0.22 | T-RSL |
| 2,6-Dinitrotoluene | 606-20-2 | 37 N | 3.7 N | NA | NA | NA | NA | NA | 3.7 | T-RSL |
| 2-Chloronaphthalene | 91-58-7 | 2900 N | 290 N | NA | NA | NA | 610 | 610 | 290 | T-RSL |
| 2-Chlorophenol | 95-57-8 | 180 N | 18 N | NA | NA | NA | 38 | 38 | 18 | T-RSL |
| 2-Methylphenol (o-Cresol) | 95-48-7 | 1800 N | 180 N | NA | NA | NA | 1800 | 1800 | 180 | T-RSL |
| 2-Nitroaniline | 88-74-4 | 370 N | 37 N | NA | NA | NA | 110 | 110 | 37 | T-RSL |
| 2-Nitrophenol | 88-75-5 | 73 N[6] | 7.3 N[6] | NA | NA | NA | NA | NA | 7.3 | T-RSL |
| 3,3'-Dichlorobenzidine | 91-94-1 | 0.15 C | 0.15 C | NA | NA | NA | 1.9 | 1.9 | 0.15 | T-RSL |
| 3-Nitroaniline | 99-09-2 | NA | NA | NA | NA | NA | NA | NA | NA | None |
| 4,6-Dinitro-2-methylphenol | 534-52-1 | 2.9 N | 0.29 N | NA | NA | NA | NA | NA | 0.29 | T-RSL |
| 4-Bromophenyl phenyl ether | 101-55-3 | NA | NA | NA | NA | NA | NA | NA | NA | None |
| 4-Chloro-3-methyl phenol | 59-50-7 | 3700 N | 370 N | NA | NA | NA | NA | NA | 370 | T-RSL |
| 4-Chloroanaline | 106-47-8 | 0.34 C | 0.34 C | NA | NA | NA | 150 | 150 | 0.34 | T-RSL |
| 4-Chlorophenyl phenyl ether | 7005-72-3 | NA | NA | NA | NA | NA | NA | NA | NA | None |
| 4-Methylphenol (p-Cresol) | 106-44-5 | 180 N | 18 N | NA | NA | NA | 180 | 180 | 18 | T-RSL |
| 4-Nitroaniline | 100-01-6 | 3.4 C | 3.4 C | NA | NA | NA | NA | NA | 3.4 | T-RSL |
| 4-Nitrophenol | 100-02-7 | NA | NA | NA | NA | NA | NA | NA | NA | None |
| Acetophenone | 98-86-2 | 3700 N | 370 N | NA | NA | NA | NA | NA | 370 | T-RSL |
| Atrazine | 1912-24-9 | 0.29 C | 0.29 C | NA | NA | 3 | 3.9 | 3 | 0.29 | T-RSL |
| Benzaldehyde | 100-52-7 | 3700 N | 370 N | NA | NA | NA | NA | NA | 370 | T-RSL |
| Bis(2-chloroethoxy)methane | 111-91-1 | 110 N | 11 N | NA | NA | NA | NA | NA | 11 | T-RSL |
| Bis(2-chloroethyl)ether | 111-44-4 | 0.012 C | 0.012 C | 11 C | 11 C | NA | 0.15 | 0.15 | 0.012 | T-RSL |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 4.8 C | 4.8 C | NA | NA | 6 | 61 | 6 | 4.8 | T-RSL |
| Butyl benzyl phthalate | 85-68-7 | 35 C | 35 C | NA | NA | NA | 7300 | 2700 | 35 | T-RSL |
| Caprolactam | 105-60-2 | 18000 N | 1800 N | NA | NA | NA | NA | NA | 1800 | T-RSL |
| Carbazole | 86-74-8 | NA | NA | NA | NA | NA | 43 | 43 | 43 | IDEM G-DCL |
| Dibenzofuran | 132-64-9 | 37 N | 3.7 N | NA | NA | NA | 15 | 15 | 3.7 | T-RSL |
| Diethyl phthalate | 84-66-2 | 29000 N | 2900 N | NA | NA | NA | 29000 | 29000 | 2900 | T-RSL |
| Dimethyl phthalate | 131-11-3 | 29000 N[7] | 2900 N[7] | NA | NA | NA | 360000 | 360000 | 2900 | T-RSL |
| Di-n-butyl phthalate | 84-74-2 | 3700 N | 370 N | NA | NA | NA | 3600 | 3600 | 370 | T-RSL |
| Di-n-octyl phthalate | 117-84-0 | NA | NA | NA | NA | NA | 1500 | 20 | 20 | IDEM G-DCL |
| Hexachlorobenzene | 118-74-1 | 0.042 C | 0.042 C | 0.076 C | 0.076 C | 1 | 0.53 | 1 | 0.042 | T-RSL |
| Hexachlorobutadiene | 87-68-3 | 0.86 C | 0.86 C | NA | NA | NA | 11 | 11 | 0.86 | T-RSL |
| Hexachlorocyclopentadiene | 77-47-4 | 220 N | 22 N | 0.19 N | 0.019 N | 50 | 220 | 50 | 0.019 | VAPOR |
| Hexachloroethane | 67-72-1 | 37 N[5] | 3.7 N[5] | 3.8 C | 3.8 C | NA | 36 | 36 | 3.7 | T-RSL |
| Isophorone | 78-59-1 | 71 C | 71 C | NA | NA | NA | 900 | 900 | 71 | T-RSL |
| Nitrobenzene | 98-95-3 | 0.12 C | 0.12 C | 62 C | 62 C | NA | 4.3 | 4.3 | 0.12 | T-RSL |
| N-Nitrosodi-n-propylamine | 621-64-7 | 0.0096 C | 0.0096 C | NA | NA | NA | 0.12 | 0.12 | 0.0096 | T-RSL |
| N-Nitrosodiphenylamine | 86-30-6 | 14 C | 14 C | NA | NA | NA | 170 | 170 | 14 | T-RSL |
| Pentachlorophenol | 87-86-5 | 0.17 C | 0.17 C | NA | NA | 1 | 7.1 | 1 | 0.17 | T-RSL |
| Phenol | 108-95-2 | 11000 N | 1100 N | NA | NA | NA | 11000 | 11000 | 1100 | T-RSL |

## Crane SWMU 25 Human Health Screening Criteria - Groundwater Samples

| Analyte | CAS Number | EPA Regional Screening Level, Tap Water[1] (ug/L) | Adjusted EPA Regional Screening Level, Tap Water[2] (ug/L) | EPA Regional Screening Level, Vapor[1] (ug/L) | Adjusted EPA Regional Screening Level, Vapor[2] (ug/L) | EPA Maximum Contaminant Level (ug/L)[3] | IDEM GW[4] (ug/L) | IDEM GW Default Closure Level[4] (ug/L) | Minimum Criteria (ug/L) | Minimum Criterion Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| **Polycyclic Aromatic Hydrocarbons** | | | | | | | | | | |
| 2-Methylnaphthalene | 91-57-6 | 150 N | 15 N | NA | NA | NA | 31 | 31 | 15 | T-RSL |
| Acenaphthene | 83-32-9 | 2200 N | 220 N | NA | NA | NA | 460 | 460 | 220 | T-RSL |
| Acenaphthylene | 208-96-8 | 2200 N[8] | 220 N[8] | NA | NA | NA | 71 | 71 | 71 | IDEM G-DCL |
| Anthracene | 120-12-7 | 11000 N | 1100 N | NA | NA | NA | 2300 | 2300 | 1100 | T-RSL |
| Benzo(a)anthracene | 56-55-3 | 0.029 C | 0.029 C | NA | NA | NA | 1.2 | 1.2 | 0.029 | T-RSL |
| Benzo(a)pyrene | 50-32-8 | 0.0029 C | 0.0029 C | NA | NA | 0.2 | 0.12 | 0.2 | 0.0029 | T-RSL |
| Benzo(b)fluoranthene | 205-99-2 | 0.029 C | 0.029 C | 320 C | 320 C | NA | 1.2 | 1.2 | 0.029 | T-RSL |
| Benzo(g,h,i)perylene | 191-24-2 | 1100 N[9] | 110 N[9] | NA | NA | NA | NA | NA | 110 | T-RSL |
| Benzo(k)fluoranthene | 207-08-9 | 0.29 C | 0.29 C | NA | NA | NA | 12 | 12 | 0.29 | T-RSL |
| Chrysene | 218-01-9 | 2.9 C | 2.9 C | 410 C | 410 C | NA | 120 | 120 | 2.9 | T-RSL |
| Dibenzo(a,h)anthracene | 53-70-3 | 0.0029 C | 0.0029 C | NA | NA | NA | 0.12 | 0.12 | 0.0029 | T-RSL |
| Fluoranthene | 206-44-0 | 1500 N | 150 N | NA | NA | NA | 1500 | 1500 | 150 | T-RSL |
| Fluorene | 86-73-7 | 1500 N | 150 N | NA | NA | NA | 310 | 310 | 150 | T-RSL |
| Indeno(1,2,3-c,d)pyrene | 193-39-5 | 0.029 C | 0.029 C | NA | NA | NA | 1.2 | 1.2 | 0.029 | T-RSL |
| Naphthalene | 91-20-3 | 0.14 C | 0.14 C | 4.0 C | 4.0 C | NA | 8.3 | 8.3 | 0.14 | T-RSL |
| Phenanthrene | 85-01-8 | 1100 N[9] | 110 N[9] | NA | NA | NA | 23 | 23 | 23 | IDEM G-DCL |
| Pyrene | 129-00-0 | 1100 N | 110 N | NA | NA | NA | 1100 | 1100 | 110 | T-RSL |
| **Metals** | | | | | | | | | | |
| Aluminum | 7429-90-5 | 37000 N | 3700 N | NA | NA | NA | NA | NA | 3700 | T-RSL |
| Antimony | 7440-36-0 | 15 N | 1.5 N | NA | NA | 6 | 15 | 6 | 1.5 | T-RSL |
| Arsenic | 7440-38-2 | 0.045 C | 0.045 C | NA | NA | 10 | 0.57 | 10 | 0.045 | T-RSL |
| Barium | 7440-39-3 | 7300 N | 730 N | NA | NA | 2000 | 7300 | 2000 | 730 | T-RSL |
| Beryllium | 7440-41-7 | 73 N | 7.3 N | NA | NA | 4 | 73 | 4 | 4 | IDEM G-DCL |
| Cadmium | 7440-43-9 | 18 N | 1.8 N | NA | NA | 5 | 18 | 5 | 1.8 | T-RSL |
| Chromium | 7440-47-3 | 0.043 C[10] | 0.043 C[10] | NA | NA | 100 | NA | NA | 0.043 | T-RSL |
| Cobalt | 7440-48-4 | 11 N | 1.1 N | NA | NA | NA | NA | NA | 1.1 | T-RSL |
| Copper | 7440-50-8 | 1500 N | 150 N | NA | NA | 1300 | 1500 | 1300 | 150 | T-RSL |
| Iron | 7439-89-6 | 26000 N | 2600 N | NA | NA | NA | NA | NA | 2600 | T-RSL |
| Lead | 7439-92-1 | 15 [11] | 15 [11] | NA | NA | 15 | 15 | 15 | 15 | T-RSL |
| Manganese | 7439-96-5 | 880 N | 88 N | NA | NA | NA | NA | NA | 88 | T-RSL |
| Mercury | 7439-97-6 | 11 N[12] | 1.1 N[12] | NA | NA | 2 | NA | NA | 1.1 | T-RSL |
| Nickel | 7440-02-0 | 730 N | 73 N | NA | NA | NA | 730 | 730 | 73 | T-RSL |
| Selenium | 7782-49-2 | 180 N | 18 N | NA | NA | 50 | 180 | 50 | 18 | T-RSL |
| Silver | 7440-22-4 | 180 N | 18 N | NA | NA | NA | 180 | 180 | 18 | T-RSL |
| Thallium | 7440-28-0 | NA | NA | NA | NA | 2 | 2.6 | 2 | 2 | IDEM G-DCL |
| Vanadium | 7440-62-2 | 180 N[13] | 18 N[13] | NA | NA | NA | NA | NA | 18 | T-RSL |
| Zinc | 7440-66-6 | 11000 N | 1100 N | NA | NA | NA | 11000 | 11000 | 1100 | T-RSL |

Notes:

1 - The tapwater screening levels from the USEPA Regions 3, 6, and 9 Regional Screening Levels (T-RSLs) for Chemical Contaminants at Superfund Sites, May, 2010 available online at http://epa-prgs.ornl.gov/chemicals/index.shtml. The vapor screening levels (VAPOR) were calculated using USEPA guidance (November, 2002) and toxicity values from USEPA (November, 2010). The risk-based screening levels are based on a target hazard quotient of 1 for noncarcinogens (denoted with a "N" flag) or an incremental lifetime cancer risk (ILCR) of 1E-6 for carcinogens (denoted with a "C" flag).

2 - The USEPA T-RSL (November, 2010) and VAPOR (calculated using USEPA guidance [November, 2002] and toxicity criteria [May, 2010]) adjusted values from the risk-based screening level for noncarcinogens adjusted by dividing by 10, equivalent to a target hazard quotient of 0.1. The risk-based screening level for carcinogens is equivalent to an incremental lifetime cancer risk (ILCR) of 1E-6.

3 - USEPA Maximum Contaminant Levels (MCLs) from the 2009 Edition of the Drinking Water Standards and Health Advisories (USEPA, October 2009).

4 - Indiana Department of Environmental Management (IDEM) groundwater screening levels for direct contact and groundwater Default Closure Levels from IDEM RISC Technical Guide, January 31, 2006, Appendix 1, revised May 1, 2009.

5 - One tenth the noncarcinogenic value is less than the carinogenic value; therefore, the noncarcinogenic value is presented.

**Crane SWMU 25 Human Health Screening Criteria - Groundwater Samples**

| Analyte | CAS Number | EPA Regional Screening Level, Tap Water[1] (ug/L) | Adjusted EPA Regional Screening Level, Tap Water[2] (ug/L) | EPA Regional Screening Level, Vapor[1] (ug/L) | Adjusted EPA Regional Screening Level, Vapor[2] (ug/L) | EPA Maximum Contaminant Level (ug/L)[3] | IDEM GW[4] (ug/L) | IDEM GW Default Closure Level[4] (ug/L) | Minimum Criteria (ug/L) | Minimum Criterion Reference |
|---|---|---|---|---|---|---|---|---|---|---|

6 - Value is for 2,4-dinitrophenol.
7 - Value is for diethyl phthalate.
8 - Value is for acenapththene.
9 - Value is for pyrene.
10 - Value is for hexavalent chromium.
11 - Action level under Safe Drinking Water Act.
12 - Value is for mercuy, inorganic salts.
13 - Value is for vanadium and compounds.

Abbreviations:
NA - Not available or not applicable
N - Noncarcinogen
C - carcinogen

## NSA Crane SWMU 25 Ecological Screening Criteria - Surface Soil Samples

| Analyte | CAS Number | Ecological Soil Screening Level [1] (mg/kg) | Source of Ecological Soil Screening Level | EPA Eco SSL (mg/kg) | EPA R5 Eco Soil (mg/kg) | NOAA SQUIRT (mg/kg) |
|---|---|---|---|---|---|---|
| **Semivolatile Organic Compounds** | | | | | | |
| 1,1'-Biphenyl | 92-52-4 | 60 | R5 ECOS | NA | 60 | 60 |
| 1,2,4,5-Tetrachlorobenzene | 95-94-3 | 2.02 | R5 ECOS | NA | 2.02 | 2.02 |
| 2,2'-Oxybis(1-chloropropane) | 108-60-1 | 19.9 | R5 ECOS | NA | 19.9 | 19.9 |
| 2,3,4,6-Tetrachlorophenol | 58-90-2 | 0.199 | R5 ECOS | NA | 0.199 | 0.199 |
| 2,4,5-Trichlorophenol | 95-95-4 | 14.1 | R5 ECOS | NA | 14.1 | 14.1 |
| 2,4,6-Trichlorophenol | 88-06-2 | 9.94 | R5 ECOS | NA | 9.94 | 9.94 |
| 2,4-Dichlorophenol | 120-83-2 | 87.5 | R5 ECOS | NA | 87.5 | 87.5 |
| 2,4-Dimethylphenol | 105-67-9 | 0.01 | R5 ECOS | NA | 0.01 | 0.01 |
| 2,4-Dinitrophenol | 51-28-5 | 0.0609 | R5 ECOS | NA | 0.0609 | 0.0609 |
| 2,4-Dinitrotoluene | 121-14-2 | 1.28 | R5 ECOS | NA | 1.28 | 1.28 |
| 2,6-Dinitrotoluene | 606-20-2 | 0.0328 | R5 ECOS | NA | 0.0328 | 0.0328 |
| 2-Chloronaphthalene | 91-58-7 | 0.0122 | R5 ECOS | NA | 0.0122 | 0.0122 |
| 2-Chlorophenol | 95-57-8 | 0.243 | R5 ECOS | NA | 0.243 | 0.243 |
| 2-Methylphenol (o-Cresol) | 95-48-7 | 40.4 | R5 ECOS | NA | 40.4 | 40.4 |
| 2-Nitroaniline | 88-74-4 | 74.1 | R5 ECOS | NA | 74.1 | 74.1 |
| 2-Nitrophenol | 88-75-5 | 1.6 | R5 ECOS | NA | 1.6 | 1.6 |
| 3,3'-Dichlorobenzidine | 91-94-1 | 0.646 | R5 ECOS | NA | 0.646 | 0.646 |
| 3-Nitroaniline | 99-09-2 | 3.16 | R5 ECOS | NA | 3.16 | 3.16 |
| 4,6-Dinitro-2-methylphenol | 534-52-1 | 0.144 | R5 ECOS | NA | 0.144 | 0.144 |
| 4-Bromophenyl phenyl ether | 101-55-3 | -- | -- | NA | NA | NA |
| 4-Chloro-3-methyl phenol | 59-50-7 | 7.95 | R5 ECOS | NA | 7.95 | 7.95 |
| 4-Chloroanaline | 106-47-8 | 1.1 | R5 ECOS | NA | 1.1 | 1.1 |
| 4-Chlorophenyl phenyl ether | 7005-72-3 | -- | -- | NA | NA | NA |
| 4-Methylphenol (p-Cresol) | 106-44-5 | 163 | R5 ECOS | NA | 163 | 163 |
| 4-Nitroaniline | 100-01-6 | 21.9 | R5 ECOS | NA | 21.9 | 21.9 |
| 4-Nitrophenol | 100-02-7 | 5.12 | R5 ECOS | NA | 5.12 | 5.12 |
| Acetophenone | 98-86-2 | 300 | R5 ECOS | NA | 300 | 300 |
| Atrazine | 1912-24-9 | -- | -- | NA | NA | NA |
| Benzaldehyde | 100-52-7 | -- | -- | NA | NA | NA |
| Bis(2-chloroethoxy)methane | 111-91-1 | 0.302 | R5 ECOS | NA | 0.302 | 0.302 |
| Bis(2-chloroethyl)ether | 111-44-4 | 23.7 | R5 ECOS | NA | 23.7 | 23.7 |
| Bis(2-ethylhexyl)phthalate | 117-81-7 | 0.925 | R5 ECOS | NA | 0.925 | 0.925 |
| Butyl benzyl phthalate | 85-68-7 | 0.239 | R5 ECOS | NA | 0.239 | 0.239 |
| Caprolactam | 105-60-2 | -- | -- | NA | NA | NA |
| Carbazole | 86-74-8 | -- | -- | NA | NA | NA |
| Dibenzofuran | 132-64-9 | -- | -- | NA | NA | NA |
| Diethyl phthalate | 84-66-2 | 24.8 | R5 ECOS | NA | 24.8 | 24.8 |
| Dimethyl phthalate | 131-11-3 | 734 | R5 ECOS | NA | 734 | 734 |
| Di-n-butyl phthalate | 84-74-2 | 0.15 | R5 ECOS | NA | 0.15 | 0.15 |
| Di-n-octyl phthalate | 117-84-0 | 709 | R5 ECOS | NA | 709 | 709 |
| Hexachlorobenzene | 118-74-1 | 0.199 | R5 ECOS | NA | 0.199 | 0.199 |
| Hexachlorobutadiene | 87-68-3 | 0.0398 | R5 ECOS | NA | 0.0398 | 0.0398 |
| Hexachlorocyclopentadiene | 77-47-4 | 0.755 | R5 ECOS | NA | 0.755 | 0.755 |
| Hexachloroethane | 67-72-1 | 0.596 | R5 ECOS | NA | 0.596 | 0.596 |
| Isophorone | 78-59-1 | 139 | R5 ECOS | NA | 139 | 139 |
| Nitrobenzene | 98-95-3 | 1.31 | R5 ECOS | NA | 1.31 | 1.31 |
| N-Nitrosodi-n-propylamine | 621-64-7 | 0.544 | R5 ECOS | NA | 0.544 | 0.544 |
| N-Nitrosodiphenylamine | 86-30-6 | 0.545 | R5 ECOS | NA | 0.545 | 0.545 |
| Pentachlorophenol | 87-86-5 | 0.119 | R5 ECOS | NA | 0.119 | 0.119 |
| Phenol | 108-95-2 | 120 | R5 ECOS | NA | 120 | 120 |
| **Polycyclic Aromatic Hydrocarbons** | | | | | | |
| 2-Methylnaphthalene | 91-57-6 | 29 | Eco SSL | 29 | 3.24 | 3.24 |
| Acenaphthene | 83-32-9 | 29 | Eco SSL | 29 | 682 | 682 |
| Acenaphthylene | 208-96-8 | 29 | Eco SSL | 29 | 682 | 682 |
| Anthracene | 120-12-7 | 29 | Eco SSL | 29 | 1480 | 1480 |
| Benzo(a)anthracene | 56-55-3 | 1.1 | Eco SSL | 1.1 | 5.21 | 5.21 |
| Benzo(a)pyrene | 50-32-8 | 1.1 | Eco SSL | 1.1 | 1.52 | 1.52 |
| Benzo(b)fluoranthene | 205-99-2 | 1.1 | Eco SSL | 1.1 | 59.8 | 59.8 |
| Benzo(g,h,i)perylene | 191-24-2 | 1.1 | Eco SSL | 1.1 | 119 | 119 |
| Benzo(k)fluoranthene | 207-08-9 | 1.1 | Eco SSL | 1.1 | 148 | 148 |
| Chrysene | 218-01-9 | 1.1 | Eco SSL | 1.1 | 4.73 | 4.73 |
| Dibenzo(a,h)anthracene | 53-70-3 | 1.1 | Eco SSL | 1.1 | 18.4 | 18.4 |
| Fluoranthene | 206-44-0 | 29 | Eco SSL | 29 | 122 | 122 |
| Fluorene | 86-73-7 | 29 | Eco SSL | 29 | 122 | 122 |
| Indeno(1,2,3-c,d)pyrene | 193-39-5 | 1.1 | Eco SSL | 1.1 | 109 | 109 |
| Naphthalene | 91-20-3 | 29 | Eco SSL | 29 | 0.0994 | 0.0994 |
| Phenanthrene | 85-01-8 | 29 | Eco SSL | 29 | 45.7 | 45.7 |
| Pyrene | 129-00-0 | 1.1 | Eco SSL | 1.1 | 78.5 | 78.5 |
| **Metals** | | | | | | |
| Aluminum | 7429-90-5 | pH>5.5 | Eco SSL | pH>5.5 | NA | NA |
| Antimony | 7440-36-0 | 0.27 | Eco SSL | 0.27 | 0.142 | 0.142 |
| Arsenic | 7440-38-2 | 18 | Eco SSL | 18 | 5.7 | 5.7 |
| Barium | 7440-39-3 | 330 | Eco SSL | 330 | 1.04 | 1.04 |
| Beryllium | 7440-41-7 | 21 | Eco SSL | 21 | 1.06 | 1.06 |
| Cadmium | 7440-43-9 | 0.36 | Eco SSL | 0.36 | 0.00222 | 0.00222 |
| Chromium | 7440-47-3 | 26 | Eco SSL | 26 | 0.4 | 0.4 |
| Cobalt | 7440-48-4 | 13 | Eco SSL | 13 | 0.14 | 0.14 |

## NSA Crane SWMU 25 Ecological Screening Criteria - Surface Soil Samples

| Analyte | CAS Number | Ecological Soil Screening Level [1] (mg/kg) | Source of Ecological Soil Screening Level | EPA Eco SSL (mg/kg) | EPA R5 Eco Soil (mg/kg) | NOAA SQUIRT (mg/kg) |
|---|---|---|---|---|---|---|
| Copper | 7440-50-8 | 28 | Eco SSL | **28** | 5.4 | 5.4 |
| Iron | 7439-89-6 | 5<pH<8 | Eco SSL | **5<pH<8** | NA | NA |
| Lead | 7439-92-1 | 11 | Eco SSL | **11** | 0.0537 | 0.0537 |
| Manganese | 7439-96-5 | 220 | Eco SSL | **220** | **220** | **220** |
| Mercury | 7439-97-6 | 0.1 | R5 ECOS | NA | **0.1** | **0.1** |
| Nickel | 7440-02-0 | 38 | Eco SSL | **38** | 13.6 | 13.6 |
| Selenium | 7782-49-2 | 0.52 | Eco SSL | **0.52** | **0.52** | **0.52** |
| Silver | 7440-22-4 | 4.2 | Eco SSL | **4.2** | 2 | 2 |
| Thallium | 7440-28-0 | 0.0569 | R5 ECOS | NA | **0.0569** | **0.0569** |
| Vanadium | 7440-62-2 | 7.8 | Eco SSL | **7.8** | 1.59 | 1.59 |
| Zinc | 7440-66-6 | 46 | Eco SSL | **46** | 6.62 | 6.62 |

1- The following hierarchy was used for selecting the Ecological Screening level in order of preference:
USEPA Ecological Soil Screening Levels (Eco SSL) (EPA, 2003, 2005, 2006, 2007). The lower of the plant, invertebrate, or wildlife Eco SSL is selected as the screening level.
The lower of the Oak Ridge National Laboratory (ORNL) plant or invertebrate benchmarks (Efroymson, et al., 1997a, 1997b).
USEPA Region 5 Ecological Soil Screening Levels (R5 ECOS) (USEPA, 2005).
Lowest of National Oceanographic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQUIRT) surface soil benchmarks (Buchman, 2008).

Shaded cells are values that were selected as the overall ecological soil screening level.