

FINAL DESIGN ANALYSIS

90312R02

Part 1

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CUTOFF WALLS AND CAP FOR LIME AND M-1 SETTLING BASINS

ROCKY MOUNTAIN ARSENAL
COLORADO



OCTOBER 1990

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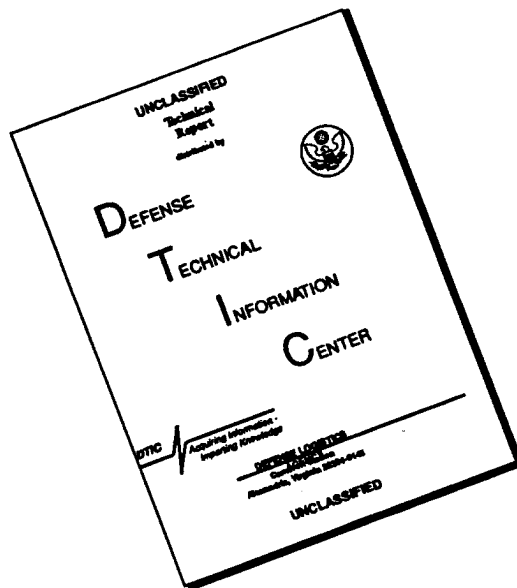


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Form Approved
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 10/00/90	3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE CUTOFF WALLS AND CAP FOR LIME AND M-1 SETTLING BASINS, ROCKY MOUNTAIN ARSENAL, COLORADO - <i>Part 1</i>			5. FUNDING NUMBERS	
6. AUTHOR(S)				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) ARMY CORPS OF ENGINEERS. OMAHA DISTRICT OMAHA, NE			8. PERFORMING ORGANIZATION REPORT NUMBER 90312R02	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) ROCKY MOUNTAIN ARSENAL (CO.). PMRMA COMMERCE CITY, CO			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) THIS DOCUMENT CONSISTS OF 2 PARTS: FINAL DESIGN ANALYSIS, AND SPECIFICATIONS. <div style="text-align: right; margin-top: 20px;">DTIC QUALITY INSPECTED 5</div>				
14. SUBJECT TERMS SPECIFICATIONS, DESIGN, CONSTRUCTION, HEALTH AND SAFETY			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT	

FINAL DESIGN ANALYSIS
FOR

CUTOFF WALLS AND CAP FOR LIME AND M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO

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PART 1 - GENERAL DESCRIPTION

1. **PURPOSE.** The purpose of the project was to develop a design for the Interim Response Actions (IRA) at the Lime and M-1 Settling Basins at Rocky Mountain Arsenal (RMA), Commerce City, Colorado. The purpose of the IRA at the Lime and M-1 Settling Basins is to mitigate the threat of release from the Basins on an interim basis, pending determination of the final remedy in the Onpost Record of Decision (ROD). The IRA for the M-1 Basins also includes treatment of the waste materials in the basins with in-situ vitrification (ISV), which is being designed by contract with Woodward-Clyde Consultants.

2. AUTHORIZATION.

2.1 **AUTHORITY.** This project was authorized by DD Form 448 from Program Manager for Rocky Mountain Arsenal.

2.2 **DECISION DOCUMENTS.** Based on RMA's evaluation of the proposed alternatives, the Decision Documents were determined as shown in appendix C. The IRA for the Lime Settling Basins consists of relocation of sludge material, which has been deposited around the Lime Settling Basins, to the Lime Settling Basins area; construction of a 360-degree subsurface barrier around the basins; construction of a soil and vegetative cover over the material; and installation of a ground-water extraction system. The IRA for the M-1 Settling Basins consists of construction of a temporary 360-degree subsurface barrier such as a slurry wall or sheet pilings around the M-1 Settling Basins area, and the treatment of the waste materials in the basins with in-situ vitrification.

3. **CRITERIA.** Criteria used in the remedial design are referenced in Part 2 of this report, and are based on applicable local, state, and federal regulations.

4. **PROJECT DESCRIPTION.** The following is the project description as quoted from applicable portions of the Decision Documents for the Lime Settling Basins and M-1 Settling Basins at Rocky Mountain Arsenal.

4.1. SITE NAME, LOCATION AND DESCRIPTION.

4.1.1. **LIME SETTLING BASINS.** The Lime Settling Basins are located north of the South Plants area, just north of December 7th Avenue along the southern edge of the southwest quarter of section 36. The Lime Settling Basins occupy about 5 acres. For the purpose of the alternatives assessment, it was estimated that approximately 80,000 cubic yards of sludge within the basins, plus approximately 26,000 cubic yards of sludge that had been placed adjacent to the basins for drying, would be addressed by the IRA.

4.1.2. **M-1 SETTLING BASINS.** The M-1 Settling Basins are located in the South Plants area, just south of December 7th Avenue along the northern edge of the northwest quarter of Section 1. The basins and the berms surrounding them, all of which are now buried and partially built upon, occupy an area of approximately 34,500 square feet. For the purpose of the alternatives assessment it was estimated that approximately 6,400 cubic yards of sludge plus 2,600 cubic yards of overburden would be addressed by the IRA.

4.2. SITE HISTORY.

4.2.1. LIME SETTLING BASINS.

4.2.1.1. During the 1940's and 1950's, wastewater from the production of Army agents was routinely treated prior to discharge to unlined evaporation ponds. This treatment involved the addition of lime to the wastewater to precipitate metals and reduce the arsenic concentration. Wastewaters produced in the South Plants were channeled through the Lime Settling Basins prior to gravity discharge to Basin A, just to the north. The precipitation process produced a lime sludge that contained elevated levels of heavy metals, arsenic, and mercury. Subsequent discharges of pesticide production wastewater resulted in the addition of pesticide to the Lime Settling Basins sludge. The Lime Settling Basins were taken out of service in 1957.

4.2.1.2. A number of studies have been completed to characterize the nature and extent of contamination in the soil, sludge, and ground-water in the vicinity of the Lime Settling Basins. These studies are referenced in the Decision Document and the results are consistent with the site history. The soil and sludge contain elevated levels of organochlorine pesticides, organosulfur compounds, arsenic, mercury, and ICP metals (cadmium, chromium, copper, lead, and zinc).

4.2.2. M-1 SETTLING BASINS.

4.2.2.1. The M-1 Settling Basins were constructed to treat fluids from the lewisite facility. Two basins were constructed in 1942, and a third was constructed in 1943 when the original two filled with solids. All three were unlined, and each measured approximately 90 feet wide, 115 feet long, and 7 feet deep. In addition to the waste fluids from the lewisite disposal facility, the basins may have contained lesser amounts of waste materials from alleged spills within the acetylene generation building, the thionyl chloride plant, and the arsenic trichloride plant, which may have been routed through floor drains and the connecting piping to the basins. The basins also received a considerable amount of mercury chloride catalyst, possibly from a spill.

4.2.2.2. The liquids discharged into the basins first passed through a set of reactor towers where calcium carbonate was added, then through a wood trough into the M-1 Settling Basins where the arsenic precipitated out of solution. The liquid from the settling basins was decanted through an 18 inch diameter pipe to the Lime Settling Basins where final treatment occurred, before being routed to Basin A. The M-1 Settling Basins were backfilled, probably in 1947, and are now covered with soil. Portions of the basins are covered with structures. These structures will be relocated as part of this IRA before implementation of the ISV treatment.

4.2.2.3. Based on several investigations, the contaminants in the waste material in the M-1 Settling Basins are primarily arsenic (about 8 percent) and mercury (about 0.5 percent), with the bulk of the material being oxides or carbonated of calcium. Organochlorine pesticides and other organics have also been found in the near-surface soils. The bottoms of the basins appear to be about 7 feet below ground surface, based on as-built drawings and field investigations.

PART 2 - DESIGN REQUIREMENTS AND PROVISIONS

1. GEOLOGY.

1.1 GENERAL GEOLOGY.

1.1.1 Physiography. The Rocky Mountain Arsenal (RMA) lies within the Colorado Piedmont section of the Great Plains physiographic province. This area is characterized by surface deposits of wind-blown and alluvial materials. The Arsenal lies near the eastern edge of the valley along the South Platte River. The topography of the Rocky Mountain Arsenal area consists of gently rolling hills with occasional prominent hills which contain bedrock outcrops.

1.1.2 Description of Overburden. Overburden in the Rocky Mountain Arsenal area consists of both alluvial and eolian deposits of silts, clays, sands, gravels and a few cobbles.

1.1.2.1 There are several distinct deposits that make up the overburden that have been identified in the Rocky Mountain Arsenal area. The Quaternary units, from oldest to youngest, include the Verdos, Slocum, Louviers, Broadway, unnamed loess, unnamed eolian, Piney Creek, and Post Piney Creek. The older alluvium is primarily coarse-grained sands and gravels whereas the younger alluvium and the eolian deposits are primarily finer grained materials. The alluvial materials were deposited in irregular, braided channel environments creating typical lenticular deposits. The eolian materials are generally silts and fine sands. The thickness of these deposits in the vicinity of the Rocky Mountain Arsenal varies from 130 feet thick to less than 20 feet. These materials are generally unconsolidated and lie unconformably on the Cretaceous-Tertiary Denver Formation.

1.1.3 Bedrock Stratigraphy. The bedrock unit lying directly below the Quaternary alluvium is the Denver Formation. Immediately underlying the Denver Formation is the Arapahoe Formation. The thickness of the Denver Formation in the vicinity of the Rocky Mountain Arsenal varies from 200 to 500 feet. The Denver Formation was derived from the erosion of basaltic and aesthetic material and was deposited by fluvial processes. The Denver Formation consists of units of interbedded siltstones, claystones, sandstones and lignite. A low permeability volcanoclastic layer is present in the upper portion of the Denver Formation. This volcanoclastic layer contains lithic fragments and minerals in a bentonitic clay matrix which probably is the product of a weathered volcanic ash deposit. Sandstone layers of the Denver Formation are usually discontinuous, lense-shaped and generally grade laterally and vertically into shales and siltstones. The lignite layers are more continuous than the sandstone layers and are usually fractured.

1.1.4 Bedrock Structure. The Rocky Mountain Arsenal facility lies in the northwestern portion of the Denver Basin. The Denver Basin is an extensive, oval-shaped, structural depression extending from eastern Colorado and eastern Wyoming into western Kansas and western Nebraska. The sedimentary rocks that fill the Denver Basin are predominantly shales, sandstones, conglomerates and occasionally some limestones. The gently dipping slope of

shallow bedrock formations of the Denver Basin is one degree or less in the vicinity of the Rocky Mountain Arsenal and is predominantly to the southeast.

1.2 INVESTIGATIONS SUMMARY.

1.2.1 General. Pre-design investigations consisted of review of IR and IRA reports and field investigations of both the Lime and M-1 Basin areas. The field investigations included topographic surveys, drilling, sampling, and permeability testing for geotechnical and chemical testing. Corps personnel visited the Arsenal to observe, photograph, and quality check the Contractor.

1.2.2 Topographic Surveys. In order to develop existing site conditions, a topographical survey was conducted to establish horizontal and vertical control. Subsequent mapping was prepared. The mapping, which contains all topographic features, was drawn at 1"=50' for the Lime Basins Area, and at 1"=20' for the M-1 area. A 1 foot contour interval was used. The survey was also used to determine the field locations of the Lime Settling and M-1 Basins. Since the M-1 Basins are buried, stakes were placed at the boundaries. The locations were determined from as-built drawings and reviewing aerial photography.

1.2.3 Exploration Drilling for Lime Settling Basins.

1.2.3.1 Equipment and Personnel.

1.2.3.2 Boring Locations and Purpose.

1.2.3.3 Slug Tests.

1.2.3.4 Backfilling Holes.

1.2.4 Exploration Drilling for M-1 Basins.

1.2.4.1 Equipment and Personnel.

1.2.4.2 Boring Locations and Purpose.

1.2.4.3 Backfilling Holes.

1.3 SITE GEOLOGY.

1.3.1 Lime Settling Basins.

1.3.1.1 Bedrock. Bedrock beneath the Lime Settling Basins area is the Cretaceous-Tertiary Denver Formation. The unconformable contact between the bedrock and the overlying surficial deposits is irregular due to erosion of the surface of the bedrock prior to the deposition of the surficial material. The uppermost portions of the Denver Formation are weathered and often fractured.

1.3.1.1.1 Lithology. The Denver Formation in the vicinity of the Lime Settling Basins consists of claystone and sandstone. The claystone

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Changes for the 90% Design Analysis, dated October 1990: See page 2-2, delete paragraph 1.2 in its entirety and substitute the following.

1.2 INVESTIGATIONS SUMMARY.

1.2.1 General. Pre-design investigations consisted of review of IR and IRA reports and field investigations of both the Lime Settling Basins and M-1 Basin areas. The field investigations included topographic surveys, drilling, and sampling, for geotechnical and chemical testing and in-situ permeability testing. Topographic surveys were conducted by Government personnel. Drilling, sampling and permeability testing was accomplished under contract with Woodward Clyde Consultants (WCC). Omaha District personnel visited the work site to oversee the work of the contractor. The discussion of the drilling, sampling, and permeability testing is a summary of the work done by WCC. A complete discussion of the field investigations performed by WCC is included in their report "Field Investigation, Lime and M-1 Settling Basins Slurry Walls, Rocky Mountain Arsenal, Commerce City, Colorado" dated September, 1990, Volumes I and II.

1.2.2 Topographic Surveys. In order to develop existing site conditions, a topographical survey was conducted to establish horizontal and vertical control. Subsequent mapping was prepared. The mapping, which contains all topographic features, was drawn at 1"=50' for the Lime Basins Area, and at 1"=20' for the M-1 area. A 1 foot contour interval was used. The survey was also used to determine the field locations of the Lime Settling and M-1 Basins. Since the M-1 Basins are buried, stakes were placed at the boundaries. The locations were determined from as-built drawings and reviewing aerial photography.

1.2.3 Exploration Drilling for Lime Settling Basins. Field investigations for the Lime Settling Basins were conducted by WCC during June and July 1990. Field investigations consisted of electro-magnetic surveys for locating buried metallic objects, exploratory drilling, slug tests for hydraulic conductivity analysis, ground-water sampling, soil sampling and analyses, and bulk sampling for compatibility testing and borrow area analysis. All drilling except the borrow investigations was conducted in level B protection.

1.2.3.1 Equipment and Personnel. Drilling was accomplished by Layne-Western Co. under contract to WCC. Drilling and sampling was accomplished by drilling with 6 1/4-inch OD hollow stem augers using a CME 75 or CME 750 drilling rig. The majority of samples were obtained by a 3-inch OD, stainless steel split spoon driven by a 140-pound hammer. Continuous auger cores were taken of bedrock in polybutyrate tubes. Logging and sampling of borings were done by WCC personnel.

1.2.3.2 Boring Locations and Purpose. A total of 30 borings were drilled for the investigation of the Lime Settling Basins Project. Nineteen borings were drilled along the alignment of the slurry trench to identify the subsurface materials and to determine the consistency density and moisture content of the overburden, and the nature and characteristics of bedrock including degree of weathering, fracturing, and cementation, and relative hardness. Eight borings were drilled outside the slurry trench area to determine the extent of waste material that had been removed from the Lime Settling Basins. Three wells were installed inside the slurry trench area for slug tests to determine the hydraulic conductivity of the overburden aquifer. Samples were taken from all borings for geotechnical analyses; compatibility testing; and chemical analyses.

1.2.3.3 Slug Tests. Slug tests were conducted in wells installed in borings LSB-15, LSB-34, and LSB-35 on 24 and 25 July 1990. These slug tests were conducted to ascertain the hydraulic conductivity of the overburden aquifer within the isolation cell, particularly for the design of the ground-water extraction system. The wells were constructed of 4-inch ID PVC riser pipe and 10 feet of slotted PVC casing used for the well screen. The bottom of the screens were placed at the top of bedrock. The screens were sand packed to the top of the aquifer then sealed with hydrated bentonite pellets and bentonite grout to the ground surface. The wells were developed with a 3-inch diameter steel surge block. After development the wells were allowed to recover two weeks before initiation of the slug tests. Slug tests were conducted using an automated data logger, 10-psi range pressure transducer probe, and a 5-foot long slug constructed of PCV pipe filled with sand and capped at each end. A falling head slug test and a rising head slug test were conducted in each well. The tests were continued until 90 percent of the induced head change was dissipated. Data and analysis of the slug tests are included in appendix A.

1.2.3.4 Backfilling Holes. All holes were backfilled with grout after completion.

1.2.4 Exploration Drilling for M-1 Basins. Field investigations were also conducted in July 1990. With the exception of slug tests, field investigations were identical to those conducted at the Lime Settling Basins.

1.2.4.1 Equipment and Personnel. Equipment and personnel involved in field investigations for the M-1 Basins were essentially the same as those at the Lime Settling Basins.

1.2.4.2 Boring Locations and Purpose. A total of 29 borings were drilled for the investigation of the M-1 Basins. Of these 12 were drilled for the design of the sheet pile wall, 2 were drilled for background geological information, and 15 were drilled within the basins to obtain data for the design of the in-situ soil vitrification project, primarily to characterize the waste sludge. As for the Lime Settling basins borings, borings drilled along the alignment of the sheet pile wall were drilled to determine the nature and character of the overburden and bedrock materials.

1.2.4.3 Backfilling Holes. All exploratory borings were backfilled with grout after completion.

is generally soft to moderately hard, brown, and blocky and is occasionally silty. Sandstone lenses are also frequently encountered. The sandstone units are fine-grained and vary from soft to hard, depending upon the degree of cementation and weathering, and fine grained. These sandstones also contain silt, thus making them less pervious. A thick, up to 15 feet, fine-grained sandstone lense occurs in the northern section of the isolation cell.

1.3.1.1.2 Bedrock Topography and Structure. The Denver Formation bedrock lies at depths of 13.5 to 27.5 feet below the surface in the Lime Settling Basins area. The local slope of the surface of the bedrock is very gentle, about two degrees, to the north-northeast. It also displays paleochannel valleys and benches. This type of paleotopography is due to stream erosion. The dip of the Denver Formation has not been determined, but it is probably the same as the regional dip, about one degree or less to the southeast. A bedrock contour map is included in Appendix A.

1.3.1.2 Overburden. The overburden in the Lime Settling Basins area is of Quaternary age and is the result of deposition by the ancient Platte River drainage network and eolian processes.

1.3.1.2.1 Lithology. The thickness of the overburden ranges between 13.5 and 27.5 feet in the Lime Settling Basins area. The soils consist mostly of poorly graded, silty, fine-grained sand with moderate amounts of sandy, silty clay and minor amounts of clayey sand, sandy clay, silty clay, and clay. The sand ranges from loose to dense and the clay ranges from soft to very stiff. The overburden soil ranges from dry to saturated with moisture content increasing with depth.

1.3.1.2.2 Alluvial Aquifer Material. The aquifer material is generally unconsolidated, fine-grained sand or silty, fine-grained sand, and clayey fine-grained sand overlying the top of bedrock. The saturated thickness ranges from 9.5 to 21.0 feet.

1.3.2 M-1 Basins.

1.3.2.1 Bedrock. The bedrock beneath the M-1 Settling Basins area is the Cretaceous-Tertiary Denver Formation. The unconformable contact between the bedrock and the overlying surficial deposits is irregular due to erosion of bedrock prior to the deposition of the surficial material. The uppermost portions of bedrock are weathered and often fractured.

1.3.2.1.1 Lithology. The upper portion of the bedrock is weathered, soft to moderately hard, dark brown claystone occasionally interbedded with moderately hard to hard, fine-grained sandstone and sandy siltstone.

1.3.2.1.2 Bedrock Topography and Structure. The Denver Formation bedrock is located at depths of 9.0 to 14.5 feet below the surface in the M-1 Settling Basins area. The slope of the surface of the bedrock is very gentle, less than one degree to the north. The bedrock surface was shaped by stream erosion. As at the Lime Settling Basins, the dip of the Denver Formation probably coincides with the regional dip of one degree or less to the southeast.

1.3.2.2 Overburden. The overburden material in the M-1 Settling Basins area is of Quaternary age and is the result of deposition by the ancient Platte River drainage network and eolian processes.

1.3.2.2.1 Lithology. The overburden in the M-1 Basins area is 9.0 to 14.5 feet in thick. The material consists mostly of unconsolidated, fine-grained, yellowish to grayish brown sand and silty sand with silt and clay of alluvial or eolian origin; surficial fill material; and chemical waste sludge. The fill extends from the ground surface downward, ranges from 2 to 11 feet thick and consists mostly of a mixture of clay, sand, and gravel occasionally mixed with sandstone and claystone. The chemical waste sludge ranges from 3.0 to 6.5 feet thick. Overburden ranges from dry to saturated with moisture content increasing with depth.

1.3.2.2.2 Aquifer Material. The aquifer material in the M-1 Basins consists of alluvial and eolian materials which are unconsolidated, poorly graded, fine grained sand and occasional silt. Saturated thickness ranges from 3.0 to 4.5 feet.

1.4 HYDROLOGY.

1.4.1 Regional Hydrology. The Rocky Mountain Arsenal lies within the drainage basin of the South Platte River. The South Platte River is approximately 3 miles west and northwest of the Arsenal. Ground-water flow in the Arsenal area is from southeast to northwest eventually discharging into the South Platte River. Ground water in the overburden is generally unconfined while ground-water in the bedrock units is confined. Ground water is unconfined where permeable bedrock units are exposed at the surface or in contact with the overburden. The aquifer units of greatest concern in the Rocky Mountain Arsenal vicinity are in the surficial Quaternary overburden deposits and permeable sandstones of the underlying Denver Formation. The bottom portion of the Denver Formation is a "buffer zone" of shale. This buffer zone is approximately 75 to 200 feet thick and acts as an aquitard between the Denver Formation and the lower bedrock formations of Arapahoe, Laramie Formation, Fox Hills Sandstone and the Pierre Shale.

1.4.1.1 Bedrock. Confined aquifers in the Denver Formation exist in the more permeable sandstones and lignite beds. These beds are separated from the overlying alluvial aquifer by shale or claystone. The Arapahoe Formation underlies the Arsenal area at a depth of 200 to 500 feet below the ground surface. Due to high-volume ground water withdrawals from the Arapahoe Formation over the past 100 years, the vertical gradient between the Denver and Arapahoe Formations in the vicinity of the Rocky Mountain Arsenal has changed from upward to downward. Recharge of the bedrock aquifers occurs from vertical leakage from the alluvial aquifers.

1.4.1.2 Overburden. Unconfined ground-water occurs in unconsolidated surficial alluvium or eolian deposits of sand. Ground-water flow in the alluvium is most rapid through coarse materials found in paleochannels, however, flow does occur throughout the saturated thickness of the overburden deposits. Thick, saturated alluvial deposits are capable of yielding large volumes of water.

1.4.2 Site Hydrology.

1.4.2.1 Lime Settling Basins.

1.4.2.1.1 Bedrock. The Denver Formation is saturated below the Lime Settling Basins and contains some confined aquifers. The most conductive units are generally subhorizontal layers of sandstones and siltstones confined by less permeable claystones. The ground-water flow in the bedrock aquifers is believed to be due north.

1.4.2.1.1.1 Hydraulic Analysis. Hydraulic conductivities for the Denver Formation aquifers vary both vertically and horizontally based on lithology and the degree of weathering and fracturing. Shales and claystones have a reported hydraulic conductivity ranging from 3.53×10^{-6} to 3.53×10^{-8} cm/sec. Unfractured claystones may be as low as 3.53×10^{-12} cm/sec (Stollar and Assoc. 1989). A conservative value of 1.0×10^{-8} cm/sec for the vertical hydraulic conductivity for the claystone was used in calculations for this project. The hydraulic conductivities of the various sandstones have been reported to range from 1.06×10^{-5} to 1.41×10^{-3} cm/sec (Stollar and Assoc. 1989).

1.4.2.1.2 Overburden. The Lime Settling Basins are situated in a local topographic low area. The Lime Settling Basins are hydrogeologically downgradient from the M-1 Settling Basins and the South Plants area. The ground-water flow direction is about due north with a gradient of 0.023 ft/ft. There is ponded water inside the lime settling basins and it has been determined that the ponded water reflects the water table.

1.4.2.1.2.1 Hydraulic Analysis. Slug tests were conducted to determine the hydraulic conductivity for the fine-grained materials in the overburden at the Lime Settling Basins. Three slug tests were conducted, with one test conducted near the center of the isolation cell and the other two conducted 100 feet south of the north wall of the isolation cell. The hydraulic conductivity near the center of the isolation cell was determined to be 2.0×10^{-3} cm/sec. The two tests 100 feet south of the north wall indicated hydraulic conductivities of 1.0×10^{-4} cm/sec and 2.0×10^{-4} cm/sec. In order to perform conservative analyses for the design of the project the lowest hydraulic conductivity was used in all calculations. Review of boring logs and mechanical analyses of samples obtained during the exploration program support the use of the smallest value obtained from the slug tests. Data and analysis of the slug test are included in Appendix A.

1.4.2.2 M-1 Basins.

1.4.2.2.1 Bedrock. The Denver Formation is saturated below the M-1 Basins and may contain some confined aquifers. Subhorizontal layers of sandstones and siltstones, confined by less permeable claystones, are generally the most permeable units of the Denver Formation. Ground-water flow within these aquifer units is generally due north.

1.4.2.2.1.1 Hydraulic Analysis. The aquifers within the Denver Formation have hydraulic conductivities that vary both vertically and horizontally based on lithology. The claystones and shales have reported hydraulic conductivities ranging from 3.53×10^{-6} to 3.53×10^{-8} cm/sec. The sandstones have a reported hydraulic conductivity ranging from 1.06×10^{-5} to 1.41×10^{-3} cm/sec. The uppermost unit of the Denver Formation below the M-1 Basins is claystone.

1.4.2.2.2 Overburden. Paleotopographic influences and localized mounding of ground-water direct the flow of ground-water in the M-1 Basins area due north to slightly northwest. The ground-water gradient ranges from 0.008 to 0.011 ft/ft. The water table varies seasonally between 5 and 10 feet below ground surface. Current water levels range from 7.8 to 10.0 feet below ground surface. The thickness of the saturated zone ranges from about 3.0 to 4.5 feet.

1.4.2.2.2.1 Hydraulic Analysis. The hydraulic conductivities for the overburden aquifer has been reported as ranging from 6.0×10^{-3} cm/sec to 2.4×10^{-3} cm/sec.

1.5 CONTAMINATION.

1.5.1 Lime Settling Basins.

1.5.1.1 Soils. Soil contamination at the Lime Settling Basins has been investigated previously. Contaminants detected have included raw materials, such as mustard agent-related compounds, manufacturing by-products, such as volatile aromatic solvents, and degradation products from the synthesis of insecticides. Previous borings indicate detectable concentrations of organochlorine pesticides (OCP's). The following OCP's were detected: dieldrin, with concentrations from 0.6 to 70 $\mu\text{g/g}$, aldrin, with concentrations up to 600 $\mu\text{g/g}$, endrin, with concentrations up to 200 $\mu\text{g/g}$, and isodrin, with concentrations up to 300 $\mu\text{g/g}$. Other contaminants found were organosulphur compounds of chlorophenylmethyl sulfide, chlorophenylmethyl sulfoxide, and chlorophenylmethyl sulfone with concentrations up to 50 $\mu\text{g/g}$. DDT was also found in an isolated area with a concentration of 7 $\mu\text{g/g}$. Volatile organic compounds (VOC's) were detected in some of the previous deeper borings. Chloroform was detected at concentrations ranging from 2 to 7 $\mu\text{g/g}$. Benzene was detected at concentrations ranging from 5 to 6 $\mu\text{g/g}$ and chlorobenzene was detected at a concentration of 2 $\mu\text{g/g}$. The most prevalent metals were arsenic and mercury. Arsenic concentrations were detected as high as 370 $\mu\text{g/g}$. Mercury was detected at concentrations of 0.159 $\mu\text{g/g}$. Elevated concentrations of copper, lead, zinc, cadmium, and chromium were also detected. Tetrachloroethene was also detected at a concentration of 0.25 $\mu\text{g/g}$.

1.5.1.2 Ground Water. Ground-water contaminants in the alluvial aquifer have been detected at the Lime Settling Basins site during previous investigations. These contaminants include VOC's (volatile organic compounds), aromatics, metals, and OCP's (organochlorine pesticides). High concentrations of various VOC's were detected. Arsenic, mercury, chromium, and copper were metals that were detected from previous monitoring well samples.

1.5.2 M-1 Basins.

1.5.2.1 Soils. High concentrations of arsenic and mercury were found in and around the M-1 Basins from depths of 0.5 to 7.0 feet. The concentrations within the basins ranged from 0.01% to 11%. These concentrations generally decreased below the 7-foot depth. Dieldrin, DCPD and BCPD have also been reported in significant concentrations.

1.5.2.2 Ground water. Previous investigations indicate high concentrations of arsenic and mercury are present in the ground water downgradient of the M-1 Settling Basins.

2. SLURRY TRENCH CUTOFF WALL (LIME SETTLING BASINS).

2.1 Criteria. The Decision Document for the Lime Settling Basins requires the containment system consist of a 360 degree subsurface barrier, vegetative cover, ground-water removal system to maintain a negative head in the isolation cell, evaluation of ground-water diversion, and evaluation of potential contamination of bedrock aquifers.

2.2 References. The following references were used during the design process:

EPA-540/2-84-001, Slurry Trench Construction for Pollution Migration Control.

EPA 600/2-87-063, Investigation of Slurry Wall Design and Construction Methods for Containment of Hazardous Waste.

Millet and Perez, "Current USA Practice: Slurry Wall Specifications", ASCE Journal of Geotechnical Engineering, August 1981.

D'Appolonia, "Soil-Bentonite Slurry Trench Cutoffs", ASCE Journal of Geotechnical Engineering, April 1980.

ASTM STP 874, Hydraulic Barriers in Soil and Rock, 1985.

Xanthakos, Slurry Walls, 1979.

Zappi, Shafer, and Adrian, "Compatibility of Soil- Bentonite Slurry Wall Backfill Mixtures With Contaminated Ground-water", Proceedings of Superfund '89 Conference, HMCRI, November 27-29, 1989.

Schulze, Barvenik, and Ayres, "Design of Soil-Bentonite Backfill Mix for the First Environmental Protection Agency Superfund Cutoff Wall".

API RP 13B-1, API Recommended Practice: Standard Procedure for Testing Drilling Fluids.

API Spec. 13A, API Specification for Oil Well Drilling Fluid Materials.

Plans and Specifications, Helen Kramer Landfill Superfund Site, Mantua Township, New Jersey, prepared by the Kansas City District

Plans and Specifications, Kane and Lombard Superfund Site, East Baltimore, Maryland, prepared by EA Engineering Science and Technology Inc.

2.3 Compatibility Study. The presence of chemical contaminants in soil and/or ground-water may significantly alter the rate of water movement through a soil medium. The purpose of compatibility testing is to find the mixture of backfill soil, bentonite, and tap water which will produce the lowest permeability of contaminated ground water over time. The Missouri River Division

(MRD) Laboratory in Omaha will perform the compatibility studies. The lab test request is included in Appendix A. The original request is dated 23 August 1990. On 1 October 1990, MRD lab personnel proposed changes in the testing procedure based on preliminary results of a similar compatibility study presently being conducted for the Forest Waste Superfund Site. The updated test request (dated 10 October) reflects the changes. The updated procedure is described here. After selection of a bentonite source using the free swell and filter cake compatibility tests, optimization testing (one or two-day fixed wall permeability tests) determines the most economical combination of bentonite, backfill soil, and water which yields a permeability of 1×10^{-7} cm/sec or less. That combination is used in permeameter tests utilizing both contaminated ground-water and tap water.

2.3.1 Bentonite Sources. Several drillers supply companies in Colorado and two out-of-state companies were contacted to identify potential bentonite suppliers and to obtain samples for conducting compatibility studies. Samples from the following companies were sent to the MRD Laboratory:

Golden Drilling Fluids and Supplies Inc.
Golden, CO
Regular

Dean Bennett Supply Company
Denver, CO
Mudgel

H & H Bentonite and Mud Inc.
Grand Junction, CO
BH-Natural and AS 85

Black Hills Bentonite Company
Palatane, IL
S-5 Natural

Wyo-Ben Inc.
Billings, MT
Hydrogel

The free swell test (EPA Report Number PB 87-229688) and filter cake compatibility test will be used to select the bentonite for this project. Two free swell tests will be performed for each bentonite sample; one using contaminated ground-water and one using RMA tap water (see following paragraph). The bentonite which exhibits the least amount of variation between the tap water and contaminated ground-water test will be selected for the backfill mixtures.

2.3.1.1 Natural vs. Treated Bentonite. The Corps slurry trench guide spec (several years old) specifies natural bentonite only. However, many slurry trench references (EPA-540/2-84-001, Millet and Perez, D'Appolonia, Xanthakos) say that practically all commercially available bentonite contains chemical additives; it is more a matter of how much is added. A memo from Geo-Con Inc., the Kane and Lombard contractor (included in Appendix A) states that most slurry trench specifications allow treated bentonites which conform to API

Spec 13A Section 4 to be used. On the Kane and Lombard project only natural bentonite which conforms to API Spec 13A Section 5 (a new section) was allowed. Geo-Con experienced some problems during construction that they attribute to the natural bentonite. He recommends not using API 13A Section 5 natural bentonites for slurry trenches. Due to time constraints in both this project and the Forest Waste project it was decided to stick with the Corps spec and use only natural bentonites. In the future when time becomes available the MRD lab may do some comparisons between natural and treated bentonites to address this question. Of the bentonites sent to the MRD lab, only 2 (H & H Bentonite's BH-Natural and Black Hill's S-5 Natural are API 13A Section 5 natural and only those two will be used for testing.

2.3.2 Water Samples. To simulate field conditions at the Arsenal site, samples of tap water and contaminated ground water were collected during the pre-design field investigations. Tap water will be used to mix the slurry and backfill materials and ground water will be used as a permanent.

2.3.3 Backfill Soil Samples. Two backfill soils will be tested; the soil to be excavated from the trench and soil from an uncontaminated borrow area on the arsenal. Soil from the trench alignment has been collected as part of the pre-design field investigations. After screening for Army agents, samples from the borings located on the northern half of the slurry trench cell were composited and tested for grain size distribution, Atterberg limits, and water content at the Arsenal. This soil was sent to the MRD Lab for compatibility studies. Prior to the pre-design field investigations it was decided to use soil from the northern boundaries of the trench for compatibility studies. This is because the groundwater flow in the area is toward the north and the highest levels of contamination found in the previous studies is to the north of the Lime Basins; therefore that soil should provide the "worst case" testing condition. The boring logs along the trench alignment are very consistent: fill or sludge overlying SM (USCS classification), overlying CL-CH, overlying claystone. The mechanical analyses of the composited samples are also very similar, containing between 17 and 40 percent fines. Due to the overall consistency and the desire to use mostly soil from the northern boundaries while also assuring representative samples, it was decided to thoroughly mix samples from the following borings into one composite: 9, 10, 17, 22, 23, 24, 25 and 26. This represent all borings along the northwest, north, and northeast boundaries of the isolation cell.

2.3.3.1 Borrow Materials. Corps personnel decided to use a clay borrow area used in the remediation of Basin F. Four test pits were excavated in this area. Approximately 150 pounds of soil was collected and sent to the MRD Lab. As there is a limited amount of this material available, this soil will be used as a possible source of fines only and not the primary borrow material. This material classifies as CL, with a liquid limit of 34.6, plastic limit of 13.5, plasticity index of 21.1, and 69.9% finer than the No. 200 sieve. (Laboratory classification data received to date are in Appendix A). Stockpiles of soil excavated from the spillway construction at the Lower Derby Dam on the Arsenal will be used as the primary alternate borrow. Samples of this material were brought to the MRD lab on August 31, 1990 and will be tested for grain size distribution, Atterberg limits and moisture content prior to optimization testing.

2.3.3.2 Chemical Screening of Borrow. Prior to compatibility studies, both borrow soils will be tested for TCLP (Toxicity Characteristics Leaching Procedure), TOC (Total Organic Carbon), sodium, calcium, magnesium, potassium, pH, and cation exchange capacity.

2.3.4 Sample Preparation. The backfill soil samples will be oven-dried at 65 degrees Celsius for 2 to 4 days. The soils will then be broken up, thoroughly mixed, and passed through a U.S. Standard Sieve No. 4. The RMA tap water shall be added to the dried and mixed samples until the original field water content is reached. These reconditioned composite samples shall then be stored for 3 to 6 days in sealed containers at room temperature. During this storage period the samples will be mixed daily.

2.3.4.1 The bentonite slurry shall be prepared by mixing the RMA tap water with the previously selected bentonite source. The slurry shall be mixed with enough water to pass through a Marsh funnel in 40 to 50 seconds. The slurry shall be tested for density, water content, pH, viscosity, and fluid loss.

2.3.5 Optimization Testing. Short-term (1 or 2 days) permeability tests will be performed to determine the most economical combination of bentonite, water, fines and coarse grained soil with a permeability of 1×10^{-7} cm/sec or less. Since tap water and backfill soil are available on the Arsenal, it is anticipated bentonite will be the highest cost item.

2.3.5.1 Three samples (two specimens each) of the insitu slurry trench soil will be prepared containing 0, 2, and 4 percent dry bentonite by weight. Bentonite slurry with a viscosity of 40 seconds (Marsh funnel) will be added to each sample to obtain an approximate 5 inch slump. Fixed wall permeability tests will be run on the 6 specimens. "Total Percent Bentonite vs. Permeability" will be plotted. If permeability values are not less than or equal to 1×10^{-7} cm/sec, the above procedure will be repeated with the addition of enough clay borrow soil to make the fines content approximately 10 percent higher than the original insitu composite. If those permeability values are not less than or equal to 1×10^{-7} cm/sec, the procedure will be repeated with the addition of clay borrow soil to make the fines content approximately 20 percent higher than the original insitu composite. If permeability values are still too high, the procedure will be repeated with the addition of clay borrow to make the fines content approximately 30 percent higher than the original insitu composite.

2.3.5.2 The optimization testing procedure will also be performed using the random fill borrow soil in place of the insitu soil. Due to the presence of contaminants in the insitu soil there is a possibility that none of the mixtures of insitu soil, fines and bentonite will produce a permeability on the order of magnitude of 10^{-7} cm/sec. If this happens and a mixture of random fill, fines, and bentonite produces an acceptable permeability then only random fill borrow will be used for construction, and long-term permeability tests will be performed using only random fill borrow as the principal soil constituent. If the desired permeability is obtained by mixtures including both insitu soil and random fill borrow then long-term permeability tests will be performed using

both principal soil constituents, and the decision of which soil to use for construction will be made based on the results of those tests.

2.3.6 Permeameter Sample Preparation. Samples for long-term permeability tests will be prepared according to subparagraph 2.3.4, Sample Preparation. The backfill mixtures shall be stored in sealed containers at room temperature until loading into the permeameters for permeability testing. Atterberg limits, fines content, porosity, density, water content, specific gravity, cation exchange capacity, and pH of the backfill mixtures will be determined. Before the backfill materials are loaded into the permeameters, comments on the general appearance, i.e. color and texture of the material before permeameter testing shall be recorded. The backfill materials and bentonite slurry shall be photographed.

2.3.7 Permeameter Testing. Permeameter testing will be conducted in accordance with the Army Corps of Engineers Manual EM 1110-2-1906 using back pressure saturation and downflow conditions. Flexible wall permeameters shall be loaded with each of the backfill mixtures and leached with RMA tap water until one porewater volume has passed through the backfill mixtures. A total of three permeameter tests shall be run on each backfill mixture. One of the three tests for each backfill mixture will serve as a control test. Control cells will be leached with only RMA tap water throughout the duration of the test, and will consist of the selected mix with the percent bentonite which produced a permeability near 1×10^{-7} cm/sec during optimization testing. The remaining two permeameters for each backfill mixture shall be leached with the contaminated ground-water, after one pore volume of RMA tap water has passed.

At least two pore volumes of contaminated ground-water will be leached through the backfill mixtures. One of these permeameters will contain the same mix and percent bentonite as the control cell. The other permeameter will contain the same mix as the control cell with a higher bentonite content that produced a permeability close to 1×10^{-8} cm/sec during optimization testing. The samples will be compressed into the cell manually in order to reduce the amount of entrapped air.

2.3.7.1 Elevated hydraulic gradients shall be used in order to complete permeameter testing within a reasonable period of time (minimum two months). A pressurized nitrogen source will be used to achieve the required hydraulic gradients. The hydraulic gradient to be applied is 28. The confining pressure to be applied is 5 psi.

2.3.7.2 The permeameter influent will be tested for TOC, specific conductivity, bromide, pH, alkalinity, sodium, calcium, chloride, VOA (Volatile Organics), and BNA (Base Neutral Acid Extractible Organics) immediately prior to permeameter testing. Effluent from the permeameters will be collected and tested for the same chemical constituents after each porewater volume has passed through the sample. This data will be used to estimate the amount of contaminant adsorption/desorption taking place.

2.3.7.3 As the permeameters are opened after completion of the tests, a visual examination of the samples will be performed. The purpose of the visual examination is to determine whether months of testing has altered the general appearance of the sample. Observations similar to those made in

the pre-test examination (color, texture) will be recorded and the samples will be photographed.

2.3.8 Selection of Backfill Mixture. Results of the compatibility study will be used to select the backfill mixture (constituents and proportions) to be used during construction. Selection will be based on:

- Permeability (lowest)
- Backfill soil alteration (lowest)
- Difference in permeability between tap water and contaminated ground-water (lowest)
- Field constructibility and quality control (greatest)
- Cost (lowest)

The MRD Lab will issue a report on the compatibility study, including all data sheets and calculations. The Final Design Analysis will reference this report and contain a discussion of the results, including the mixture selection.

2.4 Field Vs. Laboratory Permeability. For groundwater modelling purposes, a permeability of 1×10^{-7} cm/sec was assumed for the in situ slurry wall backfill. Using that permeability, a wall thickness of 3 feet, and a head differential of 3 feet across the wall, the calculated time for water to flow through the wall is 20.5 years (see calculation sheets, Appendix A). However, Darcy's Law takes into account advection of water only, while diffusion and dispersion of contaminants generally causes them migrate faster than water. At very low permeabilities, some studies have shown diffusion and dispersion predominate over advection as a means of contaminant transport. Research has been done to quantify diffusion and dispersion for individual contaminants, but the effects of multiple contaminants is largely unknown. During the life of the wall, water levels inside and outside the cell will be monitored to assure a negative head into the wall. An extraction trench near the north boundary will be used as necessary to maintain a negative head. The designers have decided not to specify a laboratory permeability an order of magnitude lower than the anticipated field permeability. With proper specification and field quality control (i.e., mix design, frequency of QA/QC testing, full mixing) the field permeability should not be severely compromised. If unexpected water flows into the cell, the extraction system will be utilized to remove it.

2.5 Control of Negative Head within Isolation Cell. Removal of ground water trapped within the isolation cell will be required in order to maintain a lower ground-water level within the cell than that outside the cell. This lower level within the cell will assure that no contaminated ground water will migrate out of the isolation cell. Additionally, ground-water recharge into the cell through the cutoff walls and floor of the cell must be considered. The ground-water level drop across the cell is 13 feet, from elevation 5250 at the south to elevation 5237 at the north. Once the cutoff walls are completed, ground water that is trapped within the cell will begin to seek equilibrium. If an equalized horizontal ground-water level were allowed to occur, this level would be at elevation 5244. The equalization process will automatically effect a negative head (a ground-water level within the cell below that outside the cell) from the south cutoff wall northward for a distance of about 250 feet. Since the soil within the cell (and without) has a low hydraulic conductivity,

ground-water flow toward the north cutoff wall will be very slow. Estimated time to reach equilibrium at elevation 5244 without ground-water withdrawal is 16.3 years (the finite difference ground-water model predicts 16 years). The graphical flow net (see discussion section 2.7, Elevation of Ground-Water Flow Diversion) indicates a slight rise in the ground-water level at the south cutoff wall, from elevation 5250 to about 5255, and a slight drop at the north cutoff wall from elevation 5237 to about 5236. Again, as in the equalization process within the cell, the rise and drop of ground-water levels will occur over many years. Because of this, calculations made for the control of the negative head within the isolation cell are based on an initial ground-water elevation of 5250 at the south cutoff wall and elevation 5237 at the north cutoff wall. Initial design ground-water elevations for the negative head are 5243 near the center of the cell and 5234 at the north cutoff wall. Final designed ground-water level is 5234 across the entire cell. Ground-water extraction is normally accomplished by wells. In this case, however, production wells are impractical. Low hydraulic conductivity, impermeable boundary effects, and well interference conditions are factors that make well extraction impractical. Analyses were made for ground-water removal by wells. The results indicate that maximum production from each well would be considerably less than 1.0 gallons per minute (gpm), about 0.08 gpm. Ground-water removal can be accomplished by a single, horizontal drain located 100 feet south of the north cutoff wall. This location of the drain is dictated by the necessity of lowering the ground-water level in the northern one-half of the isolation cell (the southern one-half will automatically adjust to a negative head). The drain is located slightly closer to the north cutoff wall to provide drawdown to elevation 5234 (about 3 feet) whereas the drawdown near the center of the cell must be at elevation 5243 (about 1 foot). Soil conditions at this location favor the emplacement of the drain at elevation 5227. Ground-water flow to the drain was calculated by quantitative methods outlined by Freeze and Cherry (1979). This method involves prediction of ground-water inflow to a vertical excavated face. The model is partially bounded by impermeable boundaries. The equations for this model are time dependent. The drain does not exactly conform to the model, i.e. vertical open face vs enclosed buried drain and impermeable boundaries at the ends of the drain. Given these conditions, estimated maximum ground-water production during the first 230 days of operation is about 19 gpm. This would result in an average drawdown of about 3.5 feet within the isolation cell. Only a minimal volume of ground-water withdrawal is required to maintain a negative head within the cell. The volume of trapped ground water within the cell above elevation 5234 (the designed ground-water level at the north cutoff wall) is 1,111,600 cubic feet. A withdrawal rate of 5 gpm for 230 days and 2.2 gpm for 396 days will lower the ground-water level to the designed elevation of 5234 at the north wall only in about 1.7 years. Since it will require about 11 years to reach elevation 5236.5 outside the cell, lowering the ground-water level in 1.7 years results in a safety factor of 6.4. Ground-water flow into the isolation cell through the cutoff walls and the floor of the cell will be negligible. The rate of flow is calculated to be about 40 cubic feet per day, about 0.2 gpm. The volume of ground water occurring between elevations 5234 and 5235 is 82,225 cubic feet. The time required to raise the ground-water level from elevation 5234 to elevation 5235 due to recharge through the cutoff walls and floor will be about 5 1/2 years.

2.6 Drain Construction. A 6-inch diameter slotted pipe drain shall be installed in a 3-foot wide trench excavated from ground surface to elevation 5228 at the east end of the drain and to elevation 5226 at the west end of the drain. The pipe drain will lead to a lift station located on the west end of the trench. Centralizers will be placed on the drain pipe to assure centering of the pipe within the trench. Fine aggregate for concrete will be used for filter sand. One foot of filter sand shall be placed in the bottom of the trench for bedding for the drain pipe. The filter sand shall be placed around and above the drain pipe to the elevation of the water table, 5239, in 3-foot lifts. Gradation of the filter sand is in accordance with EM 1110-2-1901, Seepage Analysis and Control for Drains. Random backfill shall be placed from the water table to the ground surface. A biodegradable slurry shall be used for the full depth of excavated trench to prevent sloughing of the sidewalls. The biodegradable slurry shall be clean (desanded or new) prior to the placement of the perforated drain pipe. Slurry and biodegraded slurry removed from the trench shall be considered contaminated and shall not be allowed to leave the isolation cell area and will be spread out over the surface. Design of the filter sand is included in Appendix A.

2.7 Evaluation of Ground-water Flow Diversion. Graphical representations of flow through porous media are called flow nets. Flow nets are an invaluable aid in the solution of various ground-water flow problems. Flow nets are a collection or set of flow lines intersecting a set of equipotential lines. An unlimited number of flow lines and equipotential lines may be drawn, but only a few may be selected to accurately illustrate the general flow condition for the immediate problem. The construction of flow nets involves many intuitive deductions and may be considered an art rather than a science. However, if fixed conditions are the rule at all points of a boundary of a saturated soil mass, a flow net is uniquely determined. That is to say, one and only one solution exists. If, however, there is a change in boundary conditions, a new unique solution will then exist, but it may take a long interval of time to achieve steady state conditions. One flow net and one ground-water flow diagram were constructed to determine the possibility of diversion of contaminated ground water into non-contaminated or less contaminated areas. The flow net and ground-water flow diagram are included in Appendix A. The only information a priori for the flow net were ground-water levels measured in 1989. A pre-construction flow diagram was constructed for comparison with a post-construction flow net. Although a uniform saturated thickness was assumed for the construction of the flow net, the error introduced will only have minimal effect on the study. The resultant upgradient and downgradient potentials from the post-construction flow net were estimated based on the configuration of a priori equipotential contours. The study indicates that there will be a rise in ground-water level at the south wall of the slurry trench (upgradient) of about five to six feet (elev. 5255 to 5256). Conversely there will be a drop in ground-water level at the north wall of the slurry trench (downgradient) of about one foot (elev. 5236). The finite difference ground-water flow model predicts a rise only to elevation 5252.5 south of the isolation cell, and a drop to elevation 5237 north of the cell. Flow lines of the net indicate that ground-water flow will be diverted about equally east and west of the containment cell. The ground-water flow will parallel the sides of the containment cell and then will converge north of the containment cell, again nearly following the flow path that the ground-water regime had prior

to the construction of the containment cell. It is concluded that there will be no significant diversion of the ground-water flow regime.

2.7.1 Ground-water Flow Model. A finite difference ground water flow model was used to simulate ground water flow in the alluvial aquifer of the lime settling basin area at Rocky Mountain Arsenal. Software used to develop the model is part of the Well Field Simulation Package developed by Hall Groundwater Consultants. The model is based on a finite difference computer model developed by Prickett and Lonquist (1971) which has been modified by Hall Groundwater to run on IBM PC compatible computers.

2.7.1.1 The data base used to develop the model was drawn from a bedrock elevation map and a groundwater elevation map prepared by Woodward and Clyde Consultants. Data required for the finite difference grid nodes were extrapolated from these two maps. Permeability of 2.12 gallons/day/foot² (1×10^{-4} cm/sec) was used for the model. This value was confirmed by a series of slug tests recently conducted by Woodward and Clyde Consultants. The storativity used for the model was 0.2. Modeling was conducted in three phases. Two finite difference grids were used. The first two phases of modeling were based on a symmetrical, 29x29 grid. Grid spacing varied between 200 feet, at the outer margins, to 50 feet within the area of the lime settling basin. The third phase of modeling used a 29x26 grid with a constant node spacing of 25 feet. Model configurations are included in appendix A.

2.7.1.2 Initial modeling used only data input from the groundwater elevation and bedrock elevation maps in order to calibrate the model. Boundary conditions were varied during this phase of modeling to most closely approach the current groundwater conditions at the Lime Settling Basin. The closest approximation to actual conditions at the Lime Settling Basin Site was achieved by setting up all of the boundaries as constant head boundaries. In the Hall Groundwater Model a constant head boundary is modeled by using an extremely high storativity value in the nodes which define the boundary. A value of 2×10^{12} was used for this modeling.

2.7.1.3 The model was calibrated by simulating existing head conditions in the unconfined aquifer. Results of the calibrations are included in appendix A. After the model was calibrated, the slurry wall was input into the model by reducing the permeability at the nodes which define the position of the wall by three orders of magnitude relative to background. A value of .00212 gallons/day/foot² (1×10^{-7} cm/sec) was used for the slurry wall permeability. Boundary conditions were the same as in the first phase of model runs. These model runs were used to determine the effects of the slurry wall on the local groundwater flow system and to compare the computer generated flow system with a flow net which was generated, based on hand calculations, prior to the start of computer modeling. The match between the computer generated flow system and the flow net matched over most of the model. There were slight differences between the two flow systems near the northern boundary of the slurry wall because of a minor difference in extrapolated groundwater head contours used in developing the two models. The results of the modeling of the flow overall flow regime within and surrounding the isolation cell are included in appendix A. The computer simulation indicates a slight rise in ground-water level upgradient of the isolation cell (about 2.5) feet, and a slight drop downgradient

(about 2 feet). The ground-water is shown as equalizing within the isolation cell at about elevation 5245. Total time to attain stabilized ground-water flow after construction of the isolation cell is about 11 1/4 years.

2.7.1.4 The third phase of modeling was concerned only with flow within the confines of the slurry wall. Model boundaries were determined by the position of the slurry wall over much of the model, where the boundary was set as a no flow boundary. In the northern part of the model boundaries were set up as constant head boundaries. While a constant head boundary in this location is not realistic, the relative impermeability of the slurry wall makes the effects of a constant head boundary negligible, considering it was only with the interior of the slurry wall area that this phase of modeling was concerned. Results of the modeling indicate that the groundwater will stabilize within the isolation cell at about elevation 5243 in about 19 1/2 years. This model simulation does not consider any ground-water removal from the isolation cell. Results of the modeling are included in appendix A.

2.7.1.5 A row of pumping wells was input within the slurry wall area 100 feet south of the north slurry wall to try to simulate the effects of a drain. Ten wells were simulated and at all pumping rates ground-water withdrawal was so rapid the wells were considered to be pumped dry by the model. The model run of a pumping rate of 0.10 gpm resulted in a drawdown to about elevation 5235.5 at the north wall of the isolation cell. The pumping dry of the well is a result of a combination of boundary effects and the low permeability of the material that makes up the aquifer. The results of the computer modeling of ground-water withdrawal are included in appendix A.

2.8 Evaluation of Bedrock Aquifer Contamination. A piezometer cluster is located 50 feet east of the east wall of the isolation cell at coordinates N 2,185,002; E 181,126. This cluster has separate piezometers installed in the alluvium and the Denver "A" sandstone unit which is 34.5 feet below the top of bedrock. Ground-water elevation in alluvium was measured at elevation 5248 and ground-water elevation in the Denver "A" sandstone unit was measured at elevation 5254. These measurements were made in April 1990. The measurements indicate there is a downward hydraulic gradient into the Denver formation of 0.032 ft/ft. The designed elevation of ground-water within the isolation cell to maintain negative head is 5234. This will result in an upward gradient from the Denver "A" sandstone unit into the isolation cell of 0.26 ft/ft. Since the gradient is upward into the cell, there will be no contamination of the Denver Formation from the isolation cell. Ground-water flow from the Denver Formation into the isolation cell is calculated to be about 25 cubic feet per day. Calculations concerning bedrock contaminations are included in appendix A.

2.9 Alignment of Slurry Wall. It was observed during site visits and reviews of current aerial photography and 1940's topographic maps, that the extent of sludges deposited outside the Lime Settling Basins could be possibly up to 10 feet in depth. Information from the investigative borings confirm that sludges deposited north of the Lime Settling Basins are approximately 7 to 9.5 feet in depth, approximately 1 to 2 feet in depth on the area west of the basins, and 1 to 2 feet in depth on the south side area of the basins. The option to place the slurry wall around the existing Lime Settling Basins only, did not provide enough storage capacity to contain all the excavated contaminated sludges

outside the Lime Settling Basins. It was felt that the deposited sludges outside the existing Lime Settling Basins should also be contained within the slurry wall isolation cell, as they could be considered a contaminant source. The alignment of the Slurry wall around the Lime Basins was extended to the north in order to contain more contaminated in-situ sludge material, and provide for more storage capacity of excavated contaminated soils. The area contained by the slurry wall isolation cell is directly adjacent to Basin A, and therefore the slurry wall will be constructed through contaminated soils. The slurry wall will not completely surround the contaminated area, but it will contain the contaminated source area of the Lime Settling Basins.

2.10 Slurry Trench Width and Depth. The width of the slurry trench will be 3 feet. The depth of the slurry trench was estimated to have a maximum depth of 35 feet from the ground surface and an average depth of 28 feet. The trench will be keyed into the Denver Formation claystone 2 feet. Establishment and maintenance of a negative head within the isolation cell will only require that the bottom of the trench be excavated through the overburden material. Emplacement of the slurry wall through the overburden will eliminate excessive recharge into the isolation cell. Only slight leakage, if any will occur through the claystone and into the cell when the slurry wall is keyed two feet below the top of bedrock. Whenever uncemented, loose fine-grained sandstone is encountered at the top of bedrock, it will be excavated to the depth of cemented, hard fine-grained sandstone or claystone whichever is encountered first. The cemented sandstone has a low permeability, 1.0×10^{-5} cm/sec or less, and will not appreciably affect the recharge into the isolation cell. Average depth of excavation into the Denver Formation is anticipated to be just slightly greater than two feet.

2.11 Construction.

2.11.1 Work Zones. The exclusion, contaminant reduction, support, and staging zones are shown in the drawings. The support zone is located west of the Lime Basins, north of the RMA Fire Station. The staging and contaminant reduction areas are located just east of the support zone. Arsenal personnel do not want heavy dump trucks loaded with off-site borrow soil to access the site via December 7 Avenue because the trucks might damage the pavement. Therefore a gravel access road will be built accessing the site from the east. To keep that road clean, empty trucks will exit the site via the southwest.

2.11.2 Grading. Minor grading will be necessary to provide a construction platform for the slurry wall installation. The work platform will be 40 feet wide and have a maximum slope of 1% along the slurry wall centerline. Since the existing surface soils are contaminated, the work platform will be covered with 12" of clean borrow material in order to provide a clean area on which to work.

2.11.3 Excavation. Excavation of the trench will be made with a large track mounted extended-reach backhoe or by a crane-mounted slurry-trench clamshell. The trench is kept from collapsing by the bentonite slurry. Water for slurry mixing operations is available from the water truck filling facility at the RMA Fire Station. Excavated materials will be placed in the isolation cell, if it is determined during compatibility testing that the material is

unsuitable for backfill. The Contractor will have the option of performing the overexcavation of contaminated materials on the south, north, and west of the Lime Basins either before or after construction of the slurry trench.

2.11.4 Sequential Construction Evaluation. An evaluation of sequential construction of the slurry trench has been made to determine if a significant lowering of the ground-water table will occur during the construction of the isolation cell. Once the south cutoff wall has been constructed, ground-water lowering will occur on the north side (eventually in the trapped portion of ground water within the cell). The greatest lowering (or escape out of the cell) of ground water as a result of sequential will occur if excavation is started at the north end of the east cutoff wall. The excavation must then proceed southward for excavation of the east wall thence continuing around the isolation cell until completion of the cell is made by connecting to the north end of the east wall. It is calculated that 5,310 cubic feet of ground water will escape the isolation cell because of this sequential construction. This amount is insignificant when compared to the amount that must be removed (about 1,111,600 cubic feet) for maintenance of a negative head. Since sequential construction will place a restriction on the contractor's operations, which is not cost justified, sequential construction of the slurry wall will not be specified. Calculations concerning sequential construction are included in appendix A.

2.11.5 Slurry Preparation. The Contractor will choose the method of mixing slurry. It is anticipated slurry will be mixed by a bulldozer on a concrete pad or by a high velocity mixer. The method, design, and rationale for the slurry mixing operation will be a Category I submittal.

2.11.6 Stability. The stability of a 28-foot deep (average) slurry trench is not anticipated to be a major concern, since trenches over 100 feet deep have been successfully completed by others.

2.11.7 Backfilling. Backfill material will be blended and trucked to the trench where it will be moved into the trench with a bulldozer. Blending operations are typically done with a pug mill operation or by mixing with a bulldozer on a concrete mixing pad. The Contractor will select the method of blending the backfill material. Blending operations will be done in the Contractor's staging area. The method, design, and rationale for the chosen mixing method will be a Category I submittal.

2.11.7.1 Backfill Rate. The Corps guide spec states the toe of the slope of the trench excavation shall not precede the toe of the backfill slope by less than 50 feet or more than 105 feet (although those values may be changed). Xanthakos states there is no real reason for specifying somewhat arbitrary distances, and says that the minimum distance would be the distance the Contractor would need to properly clean the bottom of the trench, which he states is approximately 30 feet. EPA-540/2-84-001 recommends the distance be minimized for stability reasons, but states it may be up to 200 feet. D'Appolonia recommends having slurry in the trench for at least 24 hours prior to placing backfill to allow for proper filter cake formation. None of the references checked listed any method or reason for specifying a maximum distance between the toe of the excavation slope and the toe of the backfill slope.

Therefore the specification states that the distance will be kept to the minimum value which will allow both cleaning of the trench bottom and a minimum 24 hours between slurry placement and soil-bentonite backfill placement. Because a formal stability study was not undertaken, it will also be specified that the distance shall not be greater than 105 feet without the approval of the Contracting Officer.

2.11.8 Bends in Alignment. The slurry trench will be overexcavated at corners to assure the full depth of the trench for at least 2 feet outside the isolation cell.

2.11.9 Compacted Clay Trench Cover. To prevent the soil-bentonite backfill mixture from desiccating, the top one foot (cut out of the work platform) will be covered with compacted clay obtained from the previously mentioned clay borrow area used during Basin F remediation. The cover will be 8 feet wide and will be placed between 2 and 4 days after backfilling. At this time it may only be compacted with a backhoe bucket or small hand-operated smooth drum roller because the soil-bentonite backfill may still be somewhat soft. Two weeks after backfilling, the cover will be recompacted with standard compaction equipment and any areas of settlement will be filled in with more clay material and compacted. At this time the Contractor will excavate two areas of the trench to be used as heavy equipment crossings during subsequent construction. The crossings consist of 2 18-inch and one 12-inch layer of compacted clay separated by geotextiles as shown on the plans. The crossing design is similar to that used on the Kane and Lombard Superfund Site. During construction of the vegetative cover, the compacted clay wall cover and the work platform will be covered by random fill, topsoiled, and vegetated.

2.11.10 Quality Assurance/Quality Control. The Quality Control program for this project is similar to that of the Helen Kramer Landfill site. QA/QC testing of materials is given in Tables 1 and 2 of specification section 02214, Soil-Bentonite Slurry Trench Cutoff. These tables are given in Appendix A. In addition, soundings to determine the top of bedrock, trench bottom, and backfill slope will be made at horizontal intervals of 20 feet. Undisturbed samples of the completed trench for permeability testing will be taken every 400 lineal feet.

2.11.11 Abandonment of Existing Wells and Piezometers. Wells and piezometers 36055A, 36055B, 36058, 36059, 36076, 36167, and 36194 in the Lime Settling Basins area and 01503 and 01504 in the M-1 Basins area will be abandoned. The abandonment is required because the wells and piezometers are located in the construction area. The abandonments will be accomplished prior to other construction activities. Abandonment will be in accordance with RMA policy. Concrete pads will be broken and removed; surface protective, steel casings will be pulled and removed; and the remaining PVC casings and screens will be overdrilled with a hollow stem auger. A cement-bentonite grout mixture of 94 pounds of Type II Portland cement, 3 pounds of powdered bentonite and a maximum 8 gallons of water. The grout will be placed in the overdrilled hole by tremie pipe beginning at the bottom and continuing to the ground surface while the auger sections are removed. A complete record of original well installation data and well abandonment procedures and data will be made for each abandoned well and piezometer.

2.12 LONG TERM MONITORING. Long term monitoring for ground-water quality and piezometric levels will be required to assure the isolation cell is performing as designed. This will be made possible by installation of monitoring wells and piezometers. Monitoring wells will be placed upgradient, and downgradient of the isolation cell and crossgradient on each side of the isolation cell. These wells will be placed near the center of the alignment of the east, south, west, and north walls of the isolation cell. One monitor well will also be placed inside the isolation cell near the center of the north wall. Piezometers will also be placed near the centers of the alignments of the walls and will be located very close to the walls. The piezometers will be inside and outside (mirror imaged) the isolation cell to closely monitor for the maintenance of the negative head within the cell. The locations of monitor wells and piezometers are shown in the Contract drawings.

2.12.1 Construction and Installation of Monitor Wells and Piezometers. Construction and installation of monitoring wells and piezometers will follow procedures outlined in MRD Policy Letter #90-001. The construction will consist of installation of 4-inch ID (for monitor wells) and 2-inch ID (for piezometers) PVC, threaded casings and continuous wire wound type screens; end caps; no grease or oils (other than vegetable oils) will be allowed. Designed sand filter packs, bentonite seals and cement-bentonite grout will be required. Well and piezometer development will be required and turbidity of the water will be measured after development has been completed. Design of the filter sand is included in appendix A. Diagrams of the monitor wells and piezometers are shown in the Contract drawings.

3. VEGETATIVE COVER (LIME SETTLING BASINS).

3.1 Design. The cover to be constructed is intended to be a vegetative cover over the Lime Settling Basins. This cover will minimize infiltration and promote drainage away from the Lime Settling Basins. The substantive standards contained in 40 CFR 264.310, specifically those requirements contained in subsections a(2)-(4), and b(1) and (4), describe the necessary standards relevant to this cover. The cover will consist of 12" of compacted fill material and topped with 6" of topsoil. The cover will have a minimum slope of 2 percent to promote drainage. The cover will be seeded with an appropriate seed mixture to minimize erosion to less than 2 tons/acre/year. The Hydrologic Evaluation of Landfill Performance (HELP) Model has been used to determine rainfall infiltration rates through the vegetative cover. Infiltration rates are currently estimated to be less than 0.012 inches/year. A summary of the HELP Model Analysis is located in Appendix A.

3.2 Pond Dewatering and Filling. The Lime Settling Basins will have approximately 2 acre-feet of water removed prior to fill material placement. Pending the results of the water quality testing, the water will be drained into the drainage located to the northeast of the Lime Settling Basins, which eventually flows into Basin A. Impacts of the additional water to Basin A will be evaluated. Other options include the construction of a lined evaporative pond which could be used to store the water until evaporated. The evaporative pond would be lined with a geomembrane to prevent infiltration into the ground. Once

drained, the Lime Settling Basins will be filled with clean fill material up to the existing ground water elevation of approximately 5248.

3.3 Contaminated Excavations. Contaminated soils outside the slurry wall containment cell, located to the south, west and north, will be excavated and placed inside the containment cell. Newly placed contaminated soils will be placed above ground-water level. Dust control will be critical during all excavations.

4. SHEET PILE CUTOFF WALL (M-1 SETTLING BASINS)

4.1 Criteria. The Decision Document requires the containment system consist of a 360 degree subsurface barrier around the M-1 Settling Basins, vitrification of soil/sludge by introducing an electric current through an array of electrodes, an offgas treatment system for capture of organics, air monitoring during implementation, and ground-water monitoring to evaluate the continued effectiveness of this ISV alternative. Steel sheet piling was determined to be the preferred barrier to be installed. Sheet piling will allow quick, easy installation, and provide temporary containment of the ground-water during the ISV process. The sheet piles will be removed after vitrification.

4.2 Location and Alignment. Information supplied by Geosafe Corporation, the ISV vendor (Application and Evaluation Considerations for In Situ Vitrification Technology: A Treatment Process for Destruction and/or Permanent Immobilization of Hazardous Materials, April 1989), a very steep thermal gradient, approximately 150-200 degrees C per inch, precedes the advancing melt surfaces. Typically, the 100 degrees C isotherm is less than 1 foot away from the molten mass. It was decided to locate the sheet pile 10 feet away from the design limits of vitrification in order to provide adequate room for ISV operations.

4.3 Key Depth. The sheet piles will be driven one foot into the bedrock surface, or until refusal. The boring logs along the sheetpile alignment show bedrock at a depth of 9 to 14.5 feet, generally 9 feet on the south boundary increasing to 14.5 feet on the north boundary.

4.4 Compatibility With Contaminated Groundwater. The sheet piling is a temporary measure to reduce the flow of groundwater into the area prior to and during vitrification primarily to save electricity (and therefore money) by reducing the amount of water that is evaporated during vitrification. The Rocky Mountain Arsenal Project Manager (PMRMA) has indicated the time between sheet pile placement and vitrification will be on the order of a few months. For this reason, compatibility of the steel with the contaminated groundwater is not considered to be a problem and no compatibility testing will be done.

4.5 Pile Sizing. The pressures against the pile and bending moment of the pile are not anticipated to be major concerns, since no excavation will take place inside the cell. The vitrification process does result in a volume decrease and therefore subsidence of the ground surface, but experience at other vitrification projects has shown this to be only a few feet. Since the vitrified mass will be several feet from the sheet piling, the full amount of subsidence will not take place against the sheetpiling but several feet away from it. After

vittrification the subsided area will be filled in with clean soil to avoid leaving a depression in the area. Therefore the major consideration in pile sizing is to survive the driving process. Piles used for the cutoff wall will be PZ22 steel sheetpile.

4.6 Construction.

4.6.1 Sheet Pile Installation.

4.6.1.1 Work Zones. The work zones for construction are shown on the drawings. The Exclusion Zone extends 10 feet outside the sheet pile wall centerline. The Contractor will store his equipment and perform all operations from the inside the area to be surrounded by the sheet pile. The Arsenal does not want workers straying outside the exclusion zone since that area is also contaminated. A note has been placed on the drawings stating that workers are not to go outside of the work zones.

4.6.1.2 Vibrations. There is concern vibrations produced during pile driving may damage adjacent structures. Of major concern to the Arsenal is an underground rigid asbestos water line located just south of December 7 Avenue (about 50 feet north of the northern pile boundary). Research and experience in the field of soil dynamics has shown that peak particle velocity is the parameter most closely related to vibratory damage of structures. As long as peak particle velocity is less than 1 or 2 inches per second damage will not occur. One inch per second is about the lowest vibration most people can perceive. Vibratory hammers produce much less vibration than impact hammers, and this job will be specified as vibratory hammer only. Figure 7 of "Construction Vibrations: State-of-the-Art" (ASCE Journal of the Geotechnical Engineering Division, February 1981) shows that at a distance of 50 feet, the peak particle velocity produced by a vibratory hammer will be approximately 0.3 inches per second. The project plan calls for demolition of above ground structures inside the sheet piling and up to 10 feet outside the sheet piling. According to Figure 7, at a distance of 10 feet a vibratory hammer will produce a peak particle velocity of about 2 inches per second. It is possible structures between 10 and 25 feet away from the driving might receive some damage. However, these structures are not in use now and most probably never will be used again. Any damage that might occur would be minor concrete cracking, as the peak particle velocities are not high enough to cause adjacent structures to collapse. Therefore, it is not anticipated vibrations will be a problem beyond 10 feet. As a precaution, four settlement monuments will be installed in the area prior to driving. Two will be located near the previously mentioned water line about 50 feet north of the north side of the sheetpile, one will be located near the overhead pipe just north of tank T 66, and one will be located just north of the concrete structure 561. The latter two monuments will be approximately 15 feet from the east and south boundaries of the sheetpile respectively. These monuments shall be monitored daily for the first several days of driving and when driving is occurring close to the monuments. If settlement is observed, the Contractor may have to adjust his operations. After the sheet piles are driven and in place, the piles will be cut off to be flush with the existing ground.

4.6.2 Sheet Pile Removal. The sheet piles will not be removed under this contract, but will be removed by others in the future.

4.6.3 Abandonment of Existing Wells and Piezometers. Abandonment of existing wells and piezometers in the construction area will be in accordance with RMA Standard Operating Procedures and/or MRD Policy Letter #90-001.

4.7 LONG TERM MONITORING. Long term monitoring of the M-1 Basins will be done by others and is not required in this contract.

5. CIVIL: GRADING, PAVING, AND DRAINAGE. (LIME SETTLING BASINS)

5.1 DESIGN REFERENCES. The following references were used in preparing the grading, paving, and drainage design:

5.1.1 Department of the Army and Air Force Technical Manuals.

TM 5-820-1 Surface Drainage Facilities for
88-5, Chap 1 Airfields and Heliports (Aug 87)

TM 5-820-4 Drainage for Areas Other Than
88-5, Chap 4 Airfields (Oct 83)

TM 5-822-2 General Provisions and Geometric
88-7, Chap 5 Design for Roads, Streets, Walks,
and Open Storage Areas (July 87)

TM 5-822-5 Flexible Pavements for Roads,
88-7, Chap 3 Streets, Walks, and Open Storage
Areas (Oct 80)

5.1.2 Department of the Army Technical Manuals (TM).

5-820-3 Drainage and Erosion Control,
Structures for Airfields and
Heliports (Jan 78)

5.1.3 Engineer Manuals (EM).

1110-2-2902 Conduits, Culverts and Pipes
(Mar 69)

5.1.4 NEENAH Foundry Company Publication.

Inlet Grate Capacities for Pondered
Water

5.1.5 Engineering Technical Letter (ETL)

1110-1-140 Pavement Design for Roads, Streets, and Open
Storage Areas (July 88)

5.2 GRADING. The following criteria was used to develop site grading.

5.2.1 Crown grade of 2 percent.

5.2.2 Maximum desirable ramp grade of 7 percent. Absolute maximum ramp grade of 10 percent for short distances only.

5.2.3 Minimum grade of 1 percent for overlot grading for cohesionless sandy soils and 2 percent for cohesive soils or turfed areas.

5.2.4 Minimum ditch grade of 0.3 percent.

5.2.5 Maximum foreslopes of 1V on 4H and backslopes of 1V on 3H.

5.3 FLEXIBLE PAVEMENT. The temporary construction access road was designed for a drivable surface for construction equipment and for dust control.

5.3.1 Traffic consists of the following vehicles:

1) various construction equipment including dump trucks and earth moving equipment.

5.3.2 Strength Method. (Non-Frost Design)

Class = E

Category = IV

Design Index = 4

CBR = 7

Design Thickness = 12 inches

5.3.3 Recommended Pavement Section.

6-inches Crushed Rock Surface Course

6-inches Crushed Aggregate Base Course

6-inches Compacted Subgrade (95% maximum density)

5.4 DRAINAGE. Drainage was designed in accordance with AFM 88-5, chapter 1, TM 5-820-3, and TM 5-820-4. The existing storm drainage system was extended and routed around the lime settling basin. The 30-inch diameter Reinforced Concrete Pipe (RCP) was partially removed, to clear the slurry trench, capped, and abandoned in place. This 30-inch RCP was previously abandoned and capped upstream and carried no storm discharge. The 24-inch RCP was removed to the last down stream manhole and extended from this location. Due to the small drainage area added to this drain line no increase in pipe size was required.

5.4.1 Storm Drain Pipe. Storm drains were designed to withstand earth dead loads as well as H-20 or HS-20 highway live loads.

5.4.1.1 Pipe Materials. Reinforced Concrete Pipe (RCP) was chosen to match the existing storm drainage system.

5.4.1.2 Pipe Joints. Watertight pipe joints were required to prevent infiltration of soils through the joints due to the presence of ground water at or above the pipelines and the use of erodible backfill materials.

5.4.2 Inlet Capacity.

5.4.2.1 Area Inlets. The capacity of area inlets in a sump condition was determined using the nomograph in the NEENAH Foundry Company publication entitled "Inlet Grate Capacities for Poned Water" for a NEENAH type R-6118 catch basin frame and grate.

6. WATER SUPPLY AND WASTEWATER COLLECTION. (LIME SETTLING BASINS)

6.1 DESIGN REFERENCES. The following references were used in preparing the water supply and wastewater disposal design:

6.1.1 Department of the Army Technical Manuals (TM).

TM 5-814-1	Sanitary and Industrial Wastewater Collection-Gravity Sewers and Appurtenances (Mar 85)
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TM 5-814-2	Sanitary and Industrial Wastewater Collection-Pumping Stations and Force Mains (Mar 85)
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6.1.2 National Standard Plumbing Code (1983).

6.1.3 Recommended Standards for Sewage Works by the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers (1978 Edition).

6.2 GENERAL. The work under this project consists of containing and pumping contaminated water from within the perimeter of the slurry wall at the Lime Settling Basins. It was determined that the ground-water should be artificially depressed within the confines of the slurry wall in order to prevent the migration of contaminated ground-water away from the project boundary.

6.2.1 The Containment and Pumping system consists of a 36-inch diameter lift station, 1 HP sump pump and 660 feet of 2-inch forcemain. The system is designed to contain the estimated flow rate of 5 gpm from the perforated groundwater collection drain and pump it to the CERCLA Water Treatment Plant. The volume to be pumped is considered a finite amount, necessary to provide a negative head/gradient within the settling basins.

6.2.2. Constructibility was the most significant consideration in the design. The collection drain is to be placed approximately 25 deep in heavily contaminated, water saturated, sandy clays which are not stable enough for normal trench excavation. Therefore, the piping will installed by a slurry method. A standard concrete type lift station would be very difficult to construct in the material at the depths required. Therefore, a 36-inch diameter polyethylene

pipe will be used for the pump chamber because it can be attached to the collection piping above ground and easily lowered into the trench through the slurry.

6.2.3. The 36-inch diameter pump chamber is 33 feet deep and is designed to provide 5 feet of storage volume between the invert of the collection drain and the bottom of the pump chamber. The 5 feet of depth amounts to 265 gallons of storage. At a inflow rate of 5 gpm, the storage volume will take approximately 50 minutes to fill allowing the pump adequate time to cool. The design requires a 1 HP sump pump to operate at 22 gpm at 52 feet of head. With the storage volume available the pump will operate for approximately 12 minutes during each pump cycle. The pump is controlled by three float switches suspended in the lift station. The lowest float switch is the pump "off" control, the second float switch located at the elevation of the collection pipe invert is the pump "on" control and the highest float switch located 1 foot above the invert of the collection pipe is the "alarm" switch. These switches will automatically control the pump operation. However, a manual lift station switch will be provided at the CERCLA Water Treatment Plant to shutdown or turn on the lift station controls. In addition, any alarms at the lift station will be monitored at the CERCLA Water Treatment Plant. The manual control and alarm monitoring will be part of the CERCLA Water Treatment Plant project, however, provisions have been made in this design to accommodate this work.

6.2.4. Approximately 1000 feet of 2-inch forcemain is needed to convey the contaminated water from the lift station to the CERCLA Water Treatment Plant. However, only 660 feet of 2-inch forcemain will be provided under this project because not enough survey is available for entire length of the pipe and the exact location for the CERCLA Plant has not been finalized. The remainder of the piping to the CERCLA Plant will be provided as part of the CERCLA Plant project. The route of the forcemain will be easily identified by new overhead power lines, required to power the lift station, running immediately parallel to the forcemain and the end of the forcemain will be identified with a marking post.

6.2.5. The lift station is designed to facilitate all maintenance without entering the pump chamber. Discharge piping is connected directly to the pump and runs directly up to a union at the top of the manhole which can be disconnected to raise pump and piping from the pump chamber during maintenance activities.

6.3 M-1 BASIN DESIGN. Also incorporated within this design package is the relocation of a fire hydrant and capping of various utilities near the M-1 Basins on the south side of December 7th Avenue to facilitate operability of the ISV process (to be designed/constructed in FY 90 thru 93).

7. CHEMISTRY. No chemical analysis is required by the Contractor other than outlined in the Site Safety and Health Plan (SSHP).

8. ELECTRICAL (LIME SETTLING BASINS)

8.1 General. The electrical design is based on the following codes, standards, publications, etc:

- 8.1.1 National Electrical Code (NEC) NFPA No. 70-1990
- 8.1.2 Life Safety Code NFPA No. 101-1990
- 8.1.3 National Electrical Safety Code (NESC) ANSI C2-1990
- 8.1.4 Architect Engineer Instruction Manual AEIM 14(Rev. July 1990)

8.2 Scope. This design will provide electrical power for the ground water waste pump located at the lime settling basins.

8.2.1 The new basin M-1 cutoff sheet pile walls will be located near existing 13800V 3-phase lines on both the north and west side of the cutoff wall. These lines will be either removed or relocated by the Rocky Mountain Arsenal's electrical distribution contractor.

8.2.2 A new aerial extension of the existing 13800V 1-phase line will be installed from the existing line west of "D" Street and routed to the west edge of the lime settling basins" cap.

8.2.3 A single phase pole mounted transformer would be provided at the end of the new aerial extension. The transformer will have fused cutoff switch and surge arresters. The transformer secondary will be 240/120V and will be routed above the cap in plastic conduit with an equipment ground. The conductor will be sized for load and distance from transformer to load (voltage drop considerations). A combination circuit breaker type motor starter with weather proof enclosure will be locate near the pump.

8.2.4 A ground fault circuit interrupter 120V, 20 ampere receptacle will be located on or near the combination motor starter.

8.3 Specifications. The following guide specifications will be edited for this project: (See Attachments)

Note that section CEGS-16415-OD would be retitled Electrical Work. In addition, section CEGS-16401-OD will be provided.

9. Health and Safety. The specifications for the remedial action will present requirements to ensure that the Contractor performs the work in compliance with applicable regulations, especially 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response". The specifications will require the Contractor to maintain a Safety and Health Program and to prepare a Site Safety and Health Plan (SSHP) covering all work to be performed under the construction contract. The paragraphs below describe background information and decision logic involved in determining specific requirements that will be included in the specifications.

9.1 Site description and contamination characterization.

9.1.1 Site description. (General) RMA occupies more than 17,000 acres (approximately 27 square miles) in Adams County, directly northeast of

metropolitan Denver, Colorado. The property was purchased by the US government in 1942 for use in World War II to manufacture and assemble chemical warfare materials, such as mustard and lewisite, and incendiary munitions. Starting in the 1950s, RMA produced the nerve agent GB (isopropyl methylphosphonofluoridate) until late 1969. A significant amount of chemical warfare materials destruction took place during the 1950s and 1960. From 1970 to the early 1980's, RMA has primarily been involved with the destruction of chemical warfare materials. In addition to these military activities, major portions of the plant facilities were leased to private industries, including Shell Oil Company, between 1947 and 1982, for the manufacture of various insecticides and herbicides.

9.1.1.1 M-1 Settling Basins Description: The M-1 Settling Basins are located in the South Plants area, just south of December 7th Avenue along the northern edge of the northwest quarter of Section 1. The basins and the berms surrounding them, all of which are now buried and partially built upon, occupy an area of approximately 34,500 square feet.

9.1.1.1.1 The M-1 Settling Basins were constructed to treat waste fluids from the lewisite facility. Two basins were constructed in 1942, and a third basin was constructed in 1943 when the original two filled with solids. All three were unlined, and each measured approximately 90 feet wide, 115 feet long, and 7 feet deep. In addition to the waste fluids from the lewisite disposal facility, the basins may have contained lesser amounts of waste materials from alleged spills within the acetylene generation building, the thionylchloride plant, and the arsenic trichloride plant, which may have been routed through floor drains and the connecting piping to the basins. The basins also received a considerable amount of mercuric chloride catalyst, possibly from a spill.

9.1.1.1.2 The liquids discharged into the basins first passed through a set of reactor towers where calcium carbonate was added, then through a wood trough into the M-1 settling basins where the arsenic precipitated out of solution. The elutriate was decanted through an 18-inch diameter pipe to the Lime Settling basins in Section 36 where final treatment occurred, prior to being routed to Basin A.

9.1.1.1.3 The M-1 Settling basins were backfilled, probably in 1947, and are now covered with soil. Portions of the basins are covered with structures. The facilities that surround the M-1 Settling Basins area were used in the manufacture of bicycloheptadiene until 1974.

9.1.1.2 Lime Settling Basins Description: The Lime Settling Basins, located in Site 36-4, are in the southwestern portion of Section 36 at RMA and consist of three unlined basins, each approximately 1 acre. The boundaries of the Lime Settling Basins include berms that surround the basins as well as associated materials that separated the basins. The total area of investigation is approximately 210,000 square feet and has an average surface elevation of 5,255 feet above mean sea level (MSL).

9.1.1.2.1 The Lime Settling basins were constructed in the early 1940's to remove arsenic from South Plants wastewater by precipitation. Wastewater was treated with lime at the site to precipitate metals and reduce

arsenic concentrations generated by the manufacture, and later the demilitarization, of lewisite. The basins were also constructed to receive wastewater from the industrial activities at the South Plants until the chemical sewer was constructed in the early 1950s. All wastewater originating from the South Plants area was channeled through the Lime Settling Basins prior to entering Basin A. This water flowed through an underground sewer and into a ditch along the south side of the basins. From the ditch, flow into the basins was controlled. Materials possibly contained within the basins include a reported spill of 500 gallons of mercury catalyst and the disposal of approximately 150 drums of mustard in the basins between 1959 and 1960. Reports also note that the mustard may have been neutralized, and that the term "drum" refers to a volume and not that the material was disposed of in drums.

9.1.2 Contamination characterization. Previous field sampling has shown contamination to be present in soil, ground-water and surface water at the Lime and M-1 Settling Basins. Classes of chemicals detected include organochlorine pesticides, organosulfur compounds, volatile organic compounds, metals, and agent degradation products. Additional field work is currently underway to further characterize the contamination at these sites. Soil and water samples are being collected and analyzed for volatiles, semi-volatiles with DBCP, organochlorine pesticides, thiodiglycol, ICP metals, arsenic and mercury. A detailed list of chemical names, concentration ranges and media in which found will be included after the latest analytical results are received.

9.2 Hazard Assessment and Risk Analysis. The remedial action for the Lime and M-1 Settling Basins will involve a number of tasks/operations. The following is a preliminary list of general tasks/operations. A more detailed description will be available later in the design process.

- Mobilization and Site preparation
- Demolition of structures
- Abandonment, installation of monitoring wells
- Construction of slurry walls
- Installation of drain/trench system
- Excavation of sludge from outside wall
- Construction of clay "cap" (cover).
- Construction of sheet pile cutoff wall
- Seeding
- Demobilization and site closeout

The following is a list of general hazards that may be encountered. As the tasks are further defined, detailed hazard analyses will be conducted for each task.

Physical Hazards

Normal outdoor work hazards: slips, trips, falls, etc.

Normal construction hazards:

Moving equipment
Use of power tools
trenching hazards
falling objects

Noise

Heat/cold stress (depending on the time of year)

Biological Hazards

Poisonous and/or thorny vegetation

Insect bites, stings

Snakes

Diseases carried and transmitted by rodents

Chemical Hazards

volatile halogenated solvents

volatile aromatic solvents

mustard agent-related organic compounds

herbicide-related organosulfur compounds

GB agent-related organic compounds

organochlorine pesticides and pesticide-related compounds

metals

9.3 Accident Prevention. The contractor will be required to follow accident prevention procedures outlined in the USACE Safety Requirements Manual (EM 385-1-1). Some of these requirements (i.e. training, hazard analysis, ...) are addressed in other sections of this Design Analysis. The SSHP prepared by the Construction Contractor will serve as the Accident Prevention Plan (APP) and Activity Hazard Analyses (phase plans) described in EM 385-1-1, thus a separate APP will not be required. Accident reporting requirements will also be addressed.

9.4 Staff organization, qualification, and responsibilities. The contractor will be required to develop an organizational structure that sets forth lines of authority, responsibility, and communication. Part of this organization will be personnel responsible for oversight and implementation of the health and safety aspects of this program. Since this site remedial action is being undertaken pursuant to CERCLA, the requirements of 29 CFR 1910.120 apply. Therefore, to ensure a "qualified" person is responsible for health and safety, the contractor will be required to utilize the services of an Industrial Hygienist certified in Comprehensive Practice by the American Board of Industrial Hygiene. The CIH will be required to:

- possess a minimum of 3 years experience in developing and implementing health and safety programs at hazardous waste sites or in the chemical industry,
- have demonstrable experience in supervising professional and technician level personnel, and
- have demonstrable experience in developing worker exposure assessment programs and ambient air monitoring programs.

The CIH will have the primary responsibility for implementation, oversight, and enforcement of the health and safety aspects of this remedial action. It will not be necessary for the CIH to be on-site for the entire duration of field work. A fully trained and experienced Site Safety and health Officer (SSHO), responsible to the Contractor and the CIH, may be delegated to implement and continually enforce the safety and health program and site-specific plan elements on-site. The SSHO will be required to possess:

- a minimum of 1 year experience in developing and implementing health and safety programs at hazardous waste sites or in the chemical industry,
- demonstrated experience in construction safety techniques and procedures,
- a working knowledge of Federal and state health and safety regulations, and
- specific training in personal and respiratory protective equipment program implementation and in the proper use of air monitoring instruments, air sampling methods, and procedures.

Each crew actively working in the contaminated areas will be required to include a fully trained and experienced Safety and Health Technician to perform monitoring and ensure compliance with the approved SSHP.

The Contractor will be required to have at least one person certified in first air/CPR by the Red Cross, or equivalent agency, on-site during all site operations.

9.5 Training. All employees working on-site with the potential for exposure to hazardous substances, health hazards, or safety hazards shall meet the minimum training requirements as specified in 29 CFR 1910.120. These employees will have completed the 40 hour hazardous waste training requirements and have three days of field experience in hazardous waste work. All supervisory personnel will have an additional 8 hours of training as specified for management of personnel and activities associated with hazardous waste site activities. Documentation of this training will be required for all personnel; in addition documentation pertinent to annual refresher courses as required in 29 CFR 1910.120 will also be required. All employees will be required to attend site-specific training covering site hazards, procedures, and all contents of the approved SSHP prior to entering the site.

9.6 Personal protective equipment (PPE). Because of the nature of this work, it is likely that engineering controls and work practices will not provide sufficient control of the hazards, therefore, the contractor will be required to provide personal protective equipment to all affected employees. This PPE shall provide dermal and respiratory protection specific to the site hazards. Selection of appropriate PPE will be based on air monitoring results (for respiratory protection) and an evaluation of the potential for dermal exposure during each task (for dermal protection). The Contractor will be required to establish a written personal protective equipment program in compliance with 29 CFR 1910.120(g)(5). Basic levels of protection will be similar to those listed below. Historical information and past field activities in the Lime and M-1 Settling Basins have indicated the possible presence of chemical agents and their breakdown products. Therefore, the level of PPE required during intrusive activities shall be Level B.

- 9.6.1 Level D Protection:
- Hard hat
 - Safety glasses with side shields or safety goggles.
 - Work clothing as prescribed by weather.
 - Steel toe work boots.
 - Hearing protection (if needed)
- 9.6.2 Modified Level D Protection (all elements of Level D above plus:)
- disposable outer coveralls (tyvek or equivalent)
 - disposable boot covers.
 - Surgical inner gloves.
 - Chemically protective outer gloves (as per PPE program).
- 9.6.3 Level C Protection:
- Hard hat
 - Work clothing as prescribed by weather.
 - Disposable outer coveralls (saranex coated tyvek or equivalent)
 - Disposable boot covers
 - Steel toe work boots.
 - Hearing protection (if needed)
 - Surgical inner gloves.
 - Chemically protective outer gloves (as per PPE program).
 - Air purifying respirator (APR) with appropriate cartridges (selected as per respiratory protection program).
- 9.6.4 Level B Protection:
all elements of Level C except air supplied respirators will be substituted for air purifying respirators.

9.7 Medical Surveillance. The contractor will be required to institute a medical surveillance program meeting the minimum requirements established by 29 CFR 1910.120. In order to ensure adequate medical surveillance for the hazards at this site, the contractor will be required utilize the services of a licensed physician who is certified in Occupational Medicine by the American Board of Preventative Medicine, or who, by necessary training and experience, is Board-eligible. The Contractor will be required to provide the physician with a copy of the employees' job descriptions, the SSHP, 29 CFR 1910.120, and Section 5.0 of NIOSH publication 85-115.

9.8 Exposure monitoring/air sampling program (personal and environmental). Because of the potential for airborne contamination, the contractor will be required to conduct air monitoring/sampling in order to establish proper levels of respiratory protection. Background conditions will be established prior to the start of work. As a minimum, real-time air monitoring for organic vapors and dust will be necessary within all work areas of an intrusive nature. Monitoring for chemical agents and arsine may also be required. This monitoring will continue throughout the duration of the activity.

9.8.1 In addition to the real-time monitoring, the contractor will be responsible for ensuring compliance with all requirements of 29 CFR 1910.120(h).

9.9 Standard operating safety procedures, engineering controls and work practices. All pertinent procedures will be addressed and implemented as described in the Contractor's SSHP.

9.10 Site control measures. Because contamination exists at this site, the Contractor will be required to establish work zones and site control measures to prevent the spread of contamination.

9.11 Personal hygiene and decontamination. Whenever employees are potentially exposed to contamination, they will be required to undergo decontamination procedures. The contractor will be required to set forth appropriate decon procedures for each level of protective clothing worn on-site. A personnel decon facility with shower facilities will be required. Details about the disposal of trash, contaminated disposable PPE and decon water will be included in the specifications.

9.12 Equipment decontamination facilities and procedures. The Contractor will be required to decontaminate all equipment that has come into contact with contamination. The Contractor will be required to establish an equipment decon pad in the CRZ.

9.13 Emergency equipment and first aid requirements. The Contractor will be required to have the following items immediately available for on-site use:

9.13.1 First aid equipment and supplies approved by the consulting physician.

9.13.2 Emergency eyewashes/showers meeting the standards of ANSI Z-358.1

9.13.3 Emergency respirators (worst-case appropriate).

9.13.4 Spill control materials and equipment.

9.13.5 Fire extinguishers.

9.14 Emergency response plan and contingency procedures (on-site and off-site). The Contractor will be required to prepare an Emergency Response Plan in compliance with 29 CFR 1910.120(1), which addresses the following elements, as a minimum:

9.14.1 Pre-emergency planning and procedures for reporting incidents to appropriate government agencies for potential chemical exposures, personal injuries, fires/explosions, environmental spills and releases.

9.14.2 Personnel roles, lines of authority, communications.

9.14.3 Posted instructions and a list of emergency contacts (physician, nearby medical facility, fire and police departments, ambulance service, federal/state/local environmental agencies, CIH, Contracting Officer).

9.14.4 Emergency recognition and prevention.

9.14.5 Site topography, layout, and prevailing weather conditions.

9.14.6 Criteria and procedures for site evacuation (emergency alerting procedures/employee alarm system, emergency PPE and equipment, safe distances, places of refuge, evacuation routes, site security and control).

9.14.7 Specific procedures for decontamination and medical treatment of injured personnel.

9.14.8 Route maps to nearest pre-notified medical facility.

9.14.9 Criteria for initiating community alert program, contacts, and responsibilities.

9.14.10 Procedures for critique of emergency responses and follow-up. The Contractor will also be required to ensure all emergency response procedures set forth by RMA are followed.

9.15 Heat/cold stress monitoring. Ambient weather conditions will dictate when heat and cold stress monitoring requirements are appropriate. Ambient temperature readings and the type of clothing worn will affect the type and extent of monitoring required. The contractor will be required to provide and implement protocols for heat and/or cold stress monitoring.

9.16 Sanitation. The Contractor will be required to provide, in the Support Zone, potable water and washing facilities consisting of hot and cold running water, towels and soap for men and women as necessary. (See also paragraph 6.11: Personal hygiene and decontamination.) At least 1 toilet, and if there are more than 20 employees, at least 1 toilet seat and 1 urinal per 40 workers will be required. A sanitary break and lunch area will be required in the Support Zone.

9.17 Logs, reports, and recordkeeping. Proper documentation will be an important part of the remedial action. The contractor will be required to keep the following records:

9.17.1 OSHA Records. Required OSHA records are listed in Table 6-1.

9.17.2 Daily log and safety inspection reports. The daily log and safety inspection report shall include practices and events that affect safety and health, safety and health discrepancies encountered and safety and health issues brought to the supervisor's attention. Each entry shall include:

9.17.2.1 Date

9.17.2.2 Work area

9.17.2.3 Employees present in work area

9.17.2.4 PPE and work equipment being used in each area.

9.17.2.5 Special health and safety issues and notes

9.17.2.6 Signature of preparer.

APPENDIX A

GEOTECHNICAL

A-1	Bedrock Contour Map
A-2	Sludge Test Information
A-3	Groundwater Flow Diagram
A-4	MRD Lab Test Request
A-5	Bentonite Memo Test From GEO-CON
A-6	Lab Classification Data
A-7	Flow Rate Calculations
A-8	Control of Negative Head Calculations
A-9	Sand Filter Design
A-10	Groundwater Flow Net
A-11	Groundwater Model Configuration
A-12	Groundwater Model Calibrations
A-13	Modeling Results
A-14	Modeling Results - Third Phase
A-15	Groundwater Withdrawal
A-16	Bedrock Contamination
A-17	Sequential Construction Calculations
A-18	Quality Assurance / Quality Control Tables
A-19	Filter Sand Design
A-20	HELP Model Results
A-21	Conversation Records
A-22	Boring Logs and Gradation Analysis
A-23	References

PROJECT RMA - LSB+M-1

SHEET NO. / OF /

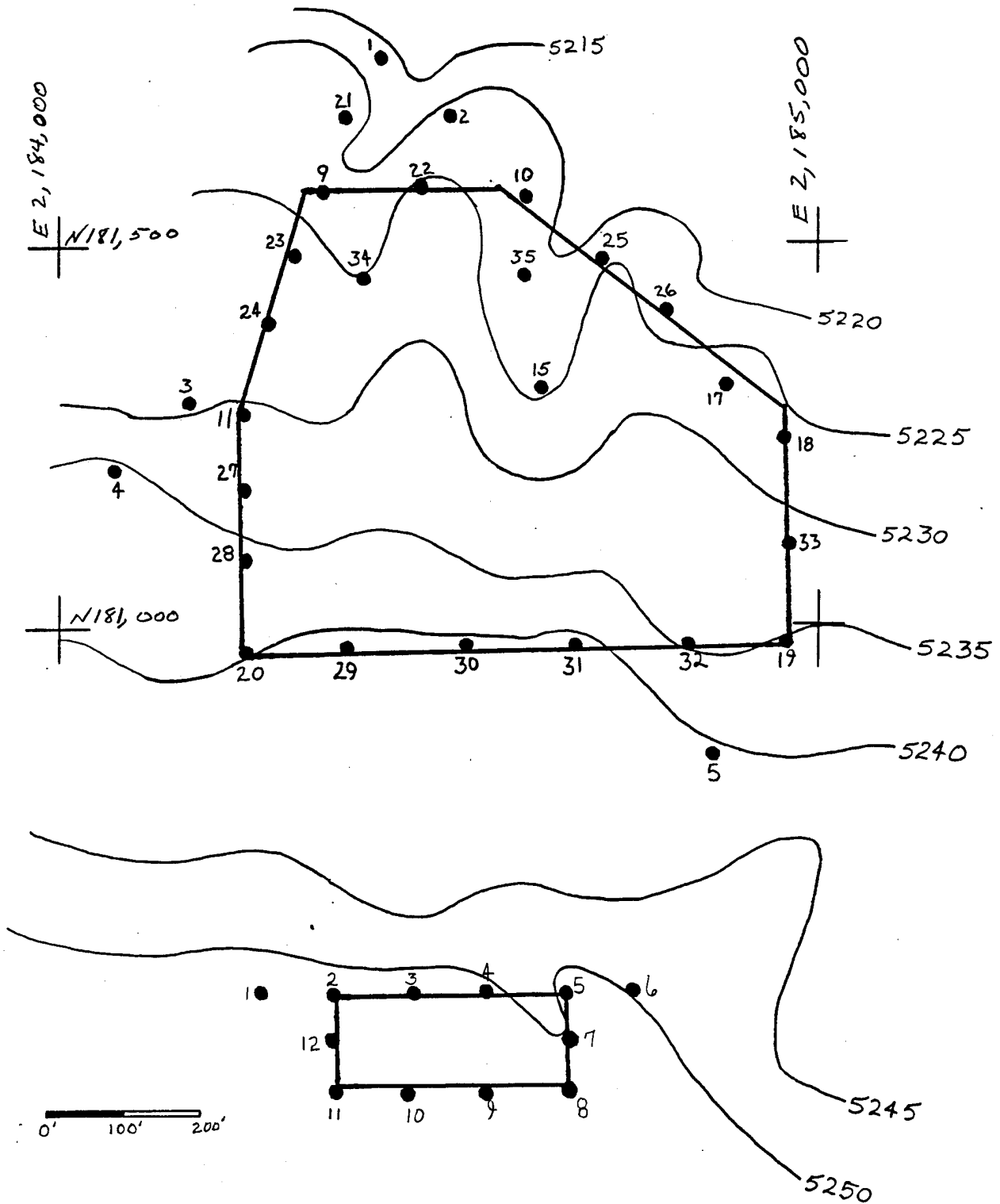
ITEM Bedrock Contour Map

BY JMC

DATE 10-12-90

CHKD. BY

DATE



HVORSLEV ANALYSISHvorslev Equation:

$$K = \frac{R^2 \ln (L/R)}{2 L T_o}$$

where: K = Hydraulic Conductivity
 R = Radius of Well Casing and Screen
 L = Length of Well Screen
 T_o = Basic Time Lag at Head Ratio = 0.37

LSB-15: Hvorslev Analysis

R = 0.17 ft
 L = 5 ft

Falling Head Test: T_o = 9.5 minutes

$$K = \frac{(0.17 \text{ ft})^2 \ln (5 \text{ ft}/0.17 \text{ ft})}{2 (5 \text{ ft}) (9.5 \text{ min})} = 1.0 \times 10^{-3} \text{ ft/min}$$

Rising Head Test: T_o = 24 minutes

$$K = \frac{(0.17 \text{ ft})^2 \ln (5 \text{ ft}/0.17 \text{ ft})}{2 (5 \text{ ft}) (24 \text{ minutes})} = 4.1 \times 10^{-4} \text{ ft/min}$$

LSB-34: Hvorslev Analysis

$$R = 0.17 \text{ ft}$$

$$L = 10 \text{ ft}$$

Falling Head Test: $T_0 = 25 \text{ minutes}$

$$K = \frac{0.17 \text{ ft})^2 \ln (10 \text{ ft}/0.17 \text{ ft})}{2(10 \text{ ft}) (25 \text{ min})} = 2.4 \times 10^{-4} \text{ ft/min}$$

Rising Head Test: $T_0 = 11.75 \text{ minutes}$

$$K = \frac{(0.17 \text{ ft})^2 \ln (10 \text{ ft}/0.17 \text{ ft})}{2(10 \text{ ft}) (11.75 \text{ min})} = 5.0 \times 10^{-4} \text{ ft/min}$$

LSB-35: Hvorslev Analysis

$$R = 0.17 \text{ ft}$$

$$L = 10 \text{ ft}$$

Falling Head Test: $T_0 = 16.5 \text{ minutes}$

$$K = \frac{(0.17 \text{ ft})^2 \ln (10 \text{ ft}/0.17 \text{ ft})}{2(10 \text{ ft}) (16.5 \text{ min})} = 3.6 \times 10^{-4} \text{ ft/min}$$

Rising Head Test: $T_0 = 39 \text{ minutes}$

$$K = \frac{(0.17 \text{ ft})^2 \ln (10 \text{ ft}/0.17 \text{ ft})}{2(10 \text{ ft}) (39 \text{ min})} = 1.5 \times 10^{-4} \text{ ft/min}$$

BOUWER AND RICE ANALYSISBouwer and Rice Equation:

$$\ln s_o - \ln s_t = \frac{2 K L t}{r_c^2 \ln(r_o/r_w)}$$

where:

s_o = initial drawdown in well due to instantaneous removal of water from well

s_t = drawdown in well at time t

L = length of well screen

r_c = radius of well casing

$\ln(r_o/r_w)$ = empirical "shape factor" determined from tables provided in Bouwer and Rice (1976)

r_o = equivalent radius over which head loss occurs

r_w = radius of well (including gravel pack)

H = static height of water in well

b = saturated thickness of aquifer

LSB-15: Bouwer and Rice Analysis

L = 5 ft

r_c = 0.17 ft

r_w = 0.42 ft

H = 14 ft

b = 14 ft

Falling Head Test: $s_o = 1.59$ ft

$$K = 6.4 \times 10^{-4} \text{ ft/min}$$

Rising Head Test: $s_o = 1.64$

$$K = 3.7 \times 10^{-4} \text{ ft/min}$$

LSB-34: Bouwer and Rice Analysis

$$\begin{aligned} L &= 10 \text{ ft} \\ r_c &= 0.17 \text{ ft} \\ r_w &= 0.42 \text{ ft} \\ H &= 13.25 \text{ ft} \\ b &= 13.25 \text{ ft} \end{aligned}$$

Falling Head Test: $s_o = 1.76$ ft

$$K = 9.6 \times 10^{-5} \text{ ft/min}$$

Rising Head Test: $s_o = 0.75$ ft

$$K = 5.2 \times 10^{-4} \text{ ft/min}$$

LSB-35: Bouwer and Rice Analysis

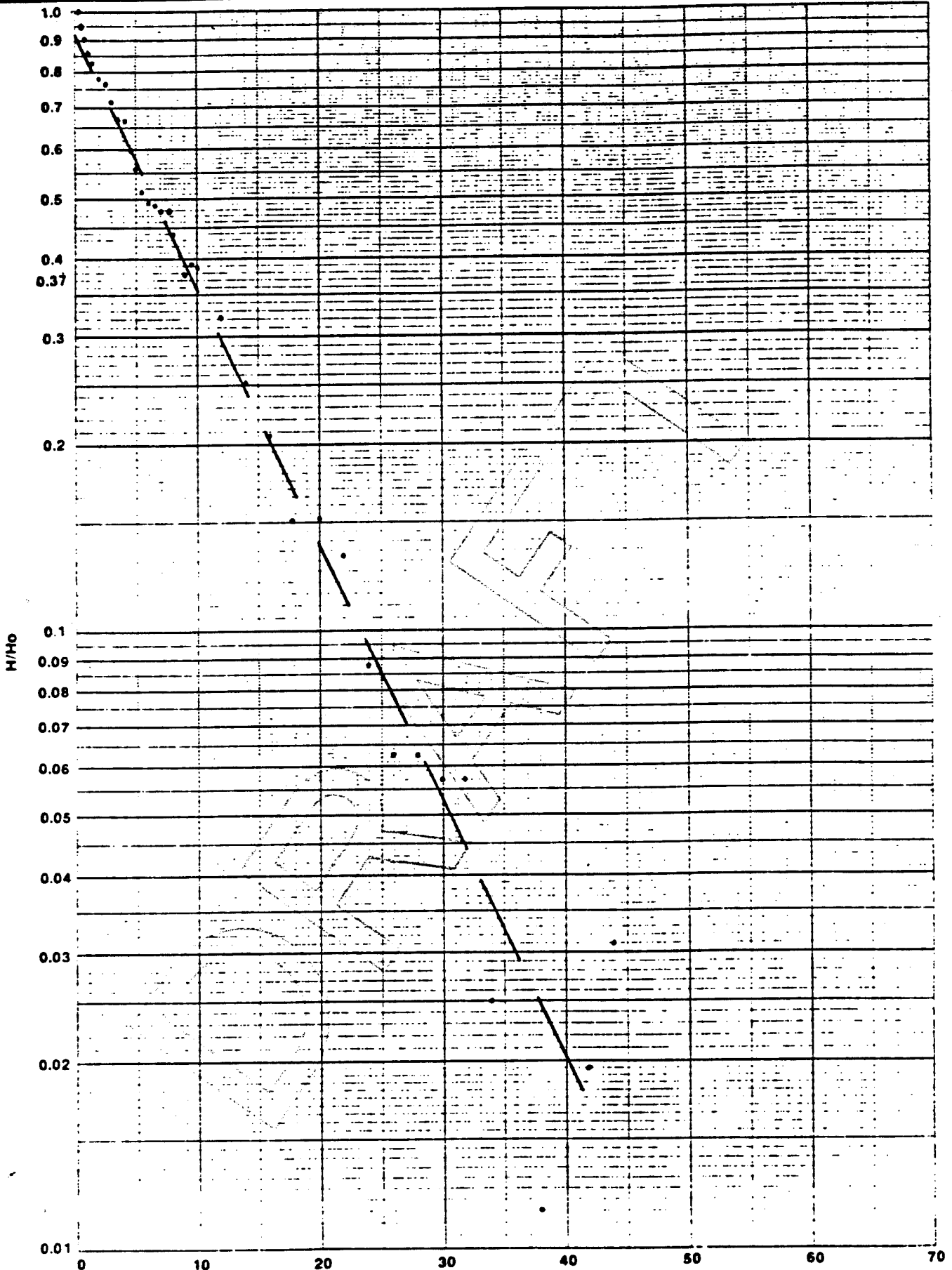
$$\begin{aligned} L &= 10 \text{ ft} \\ r_c &= 0.17 \text{ ft} \\ r_w &= 0.42 \text{ ft} \\ H &= 19.65 \text{ ft} \\ b &= 19.65 \text{ ft} \end{aligned}$$

Falling Head Test: $s_o = 1.70$ ft

$$K = 3.0 \times 10^{-4} \text{ ft/min}$$

Rising Head Test: $s_o = 1.58$ ft

$$K = 1.2 \times 10^{-4} \text{ ft/min}$$



TIME (MINUTES)

Job No. : 2050-640

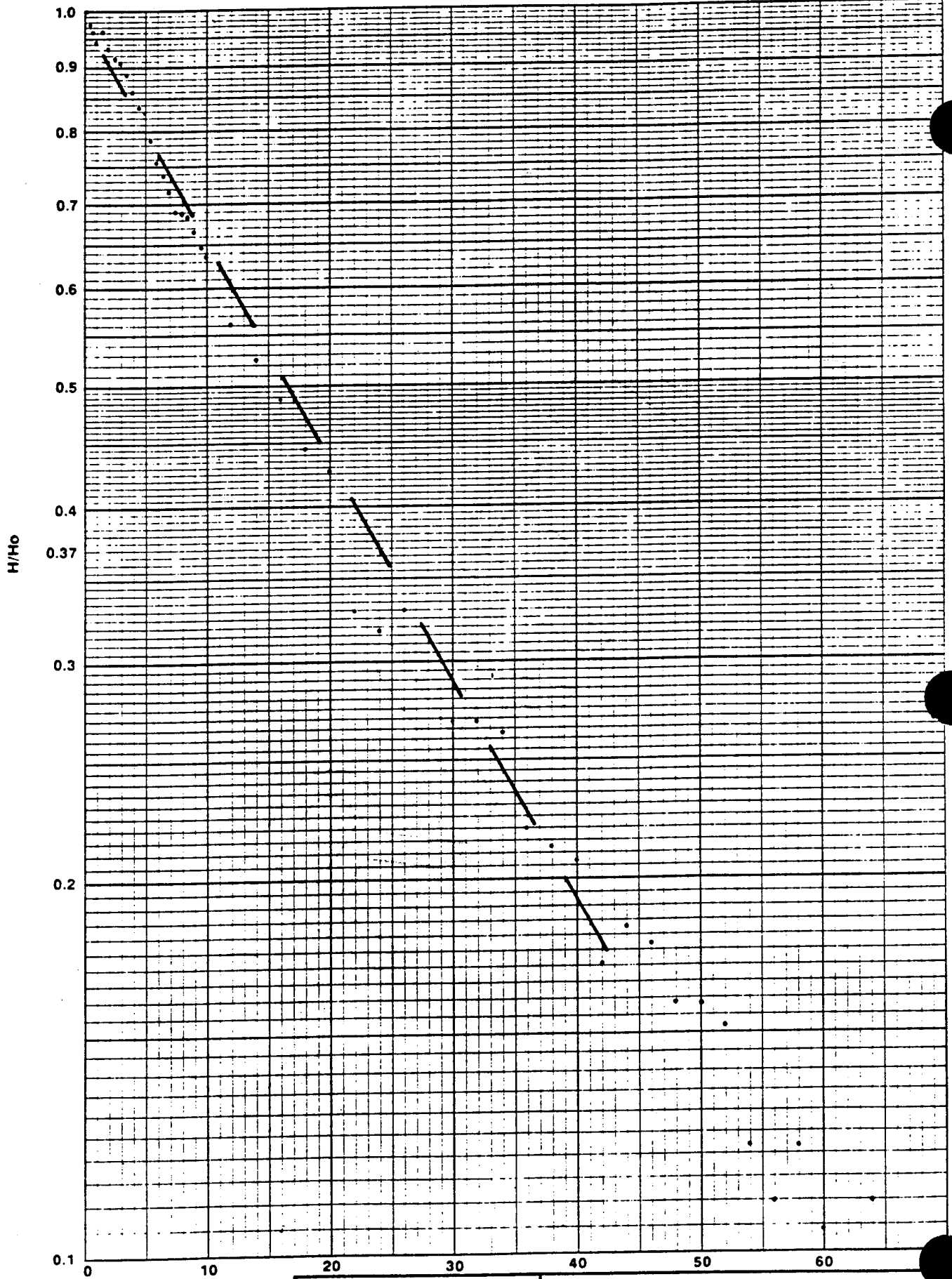
Prepared by: R.L.C.

Date: 8/23/90

FALLING HEAD TEST: HVORSLEV
LSB-15

A2-5



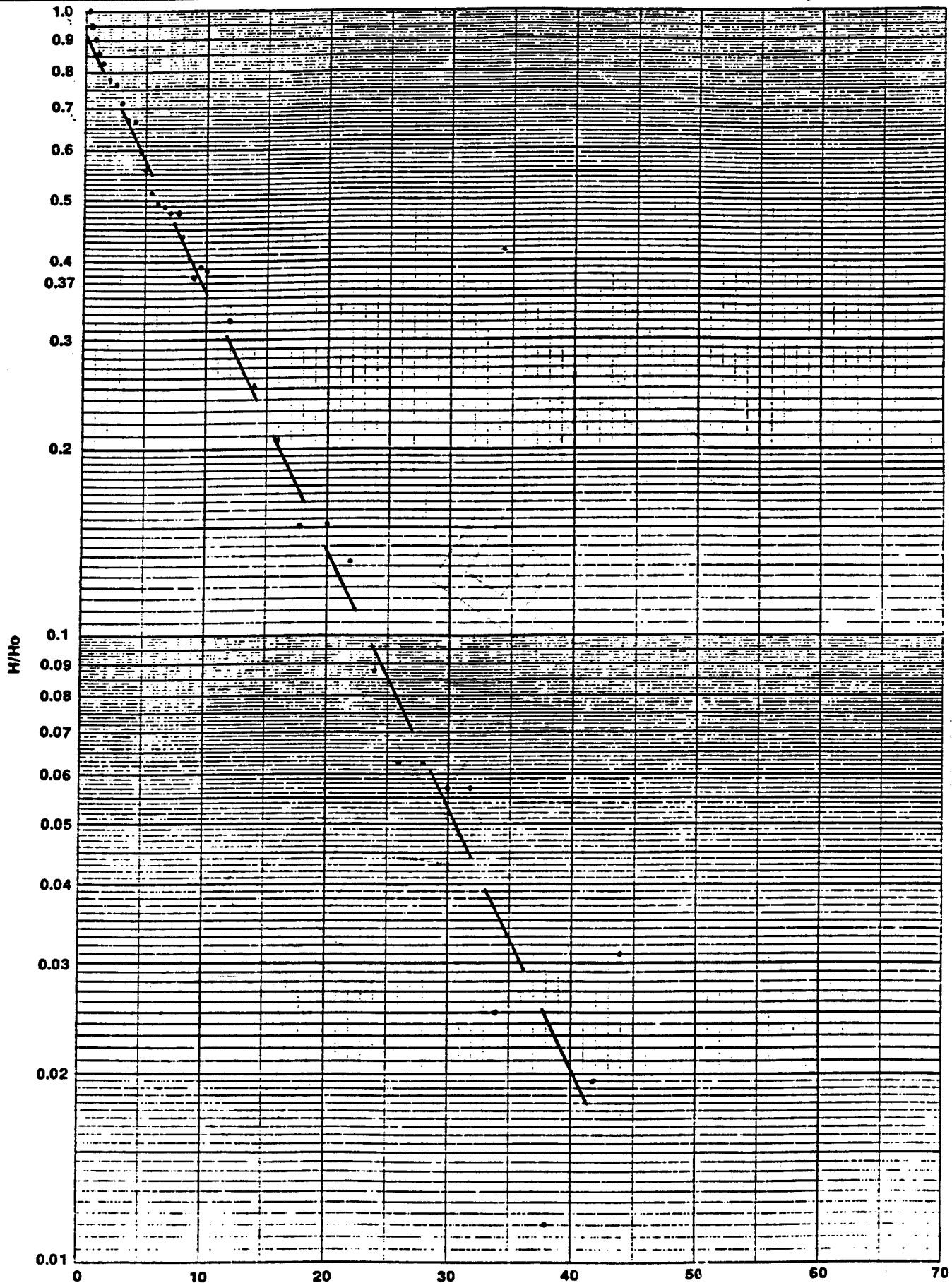


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Prepared by: R.L.C.
Date: 8/22/90

RIISING HEAD TEST: HVORSLEV
LSB-15

A2-6

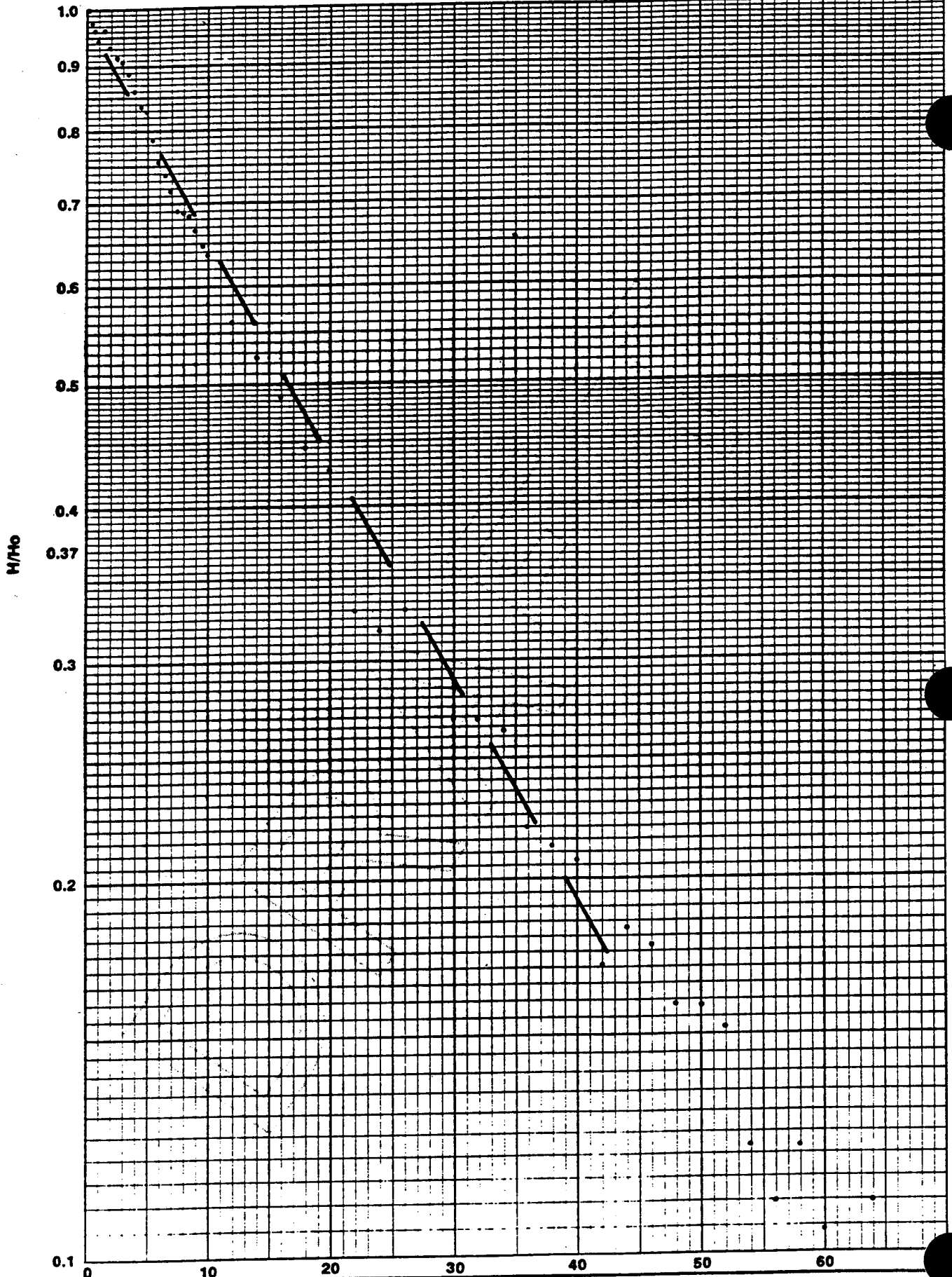


TIME (MINUTES)

Job No. : 2050-641
 Prepared by: R.L.C.
 Date: 8/23/90

FALLING HEAD TEST: HVORSLEV
 LSB-15





TIME (MINUTES)

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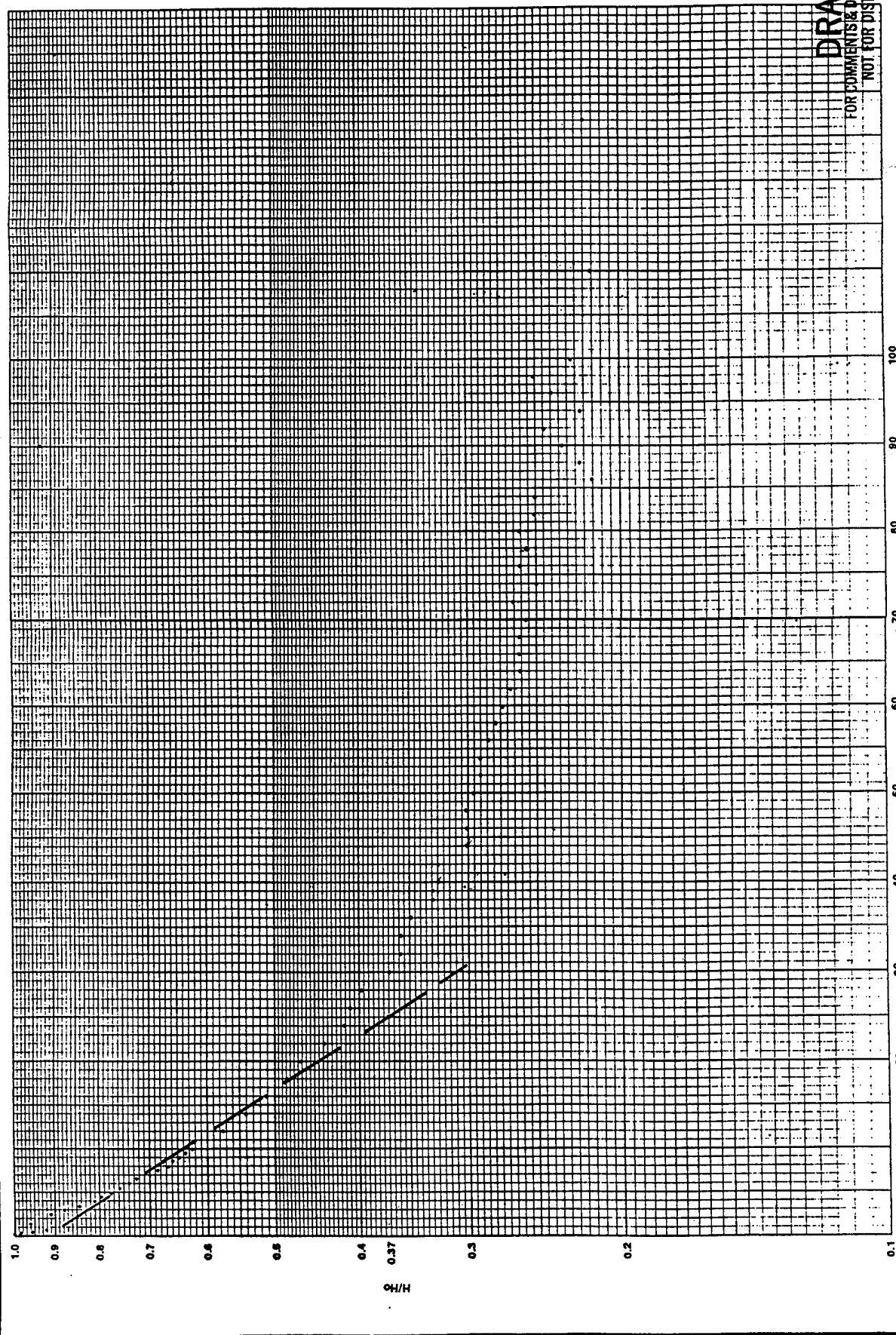
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Date: 8/22/90

**RISING HEAD TEST: HVORSLEV
LSB-15**

A2-8

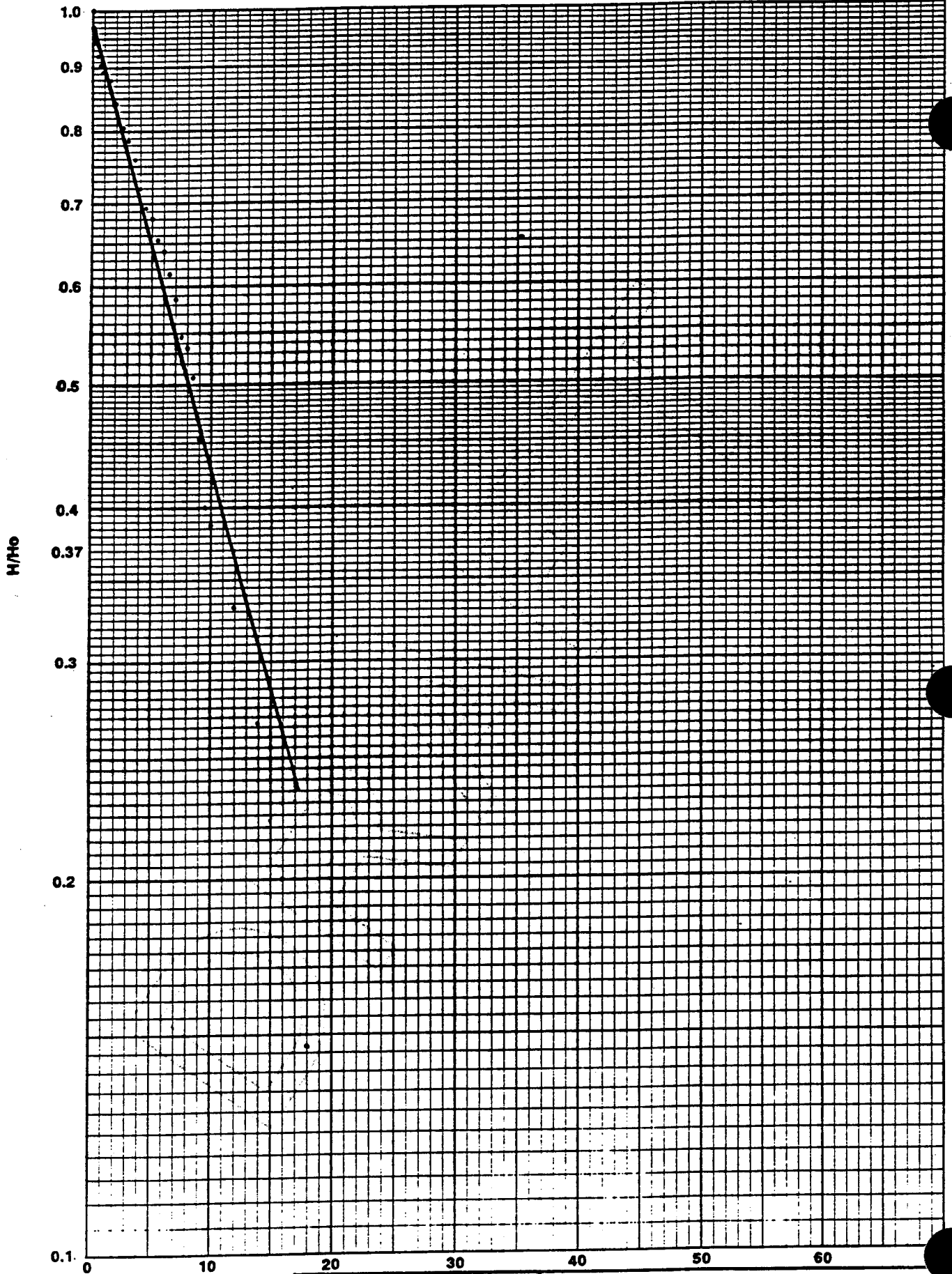




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Job No. : 2050-640
Prepared by: R.L.C.
Date : 8/23/90

FALLING HEAD TEST: HVORSLEV
LSB-34



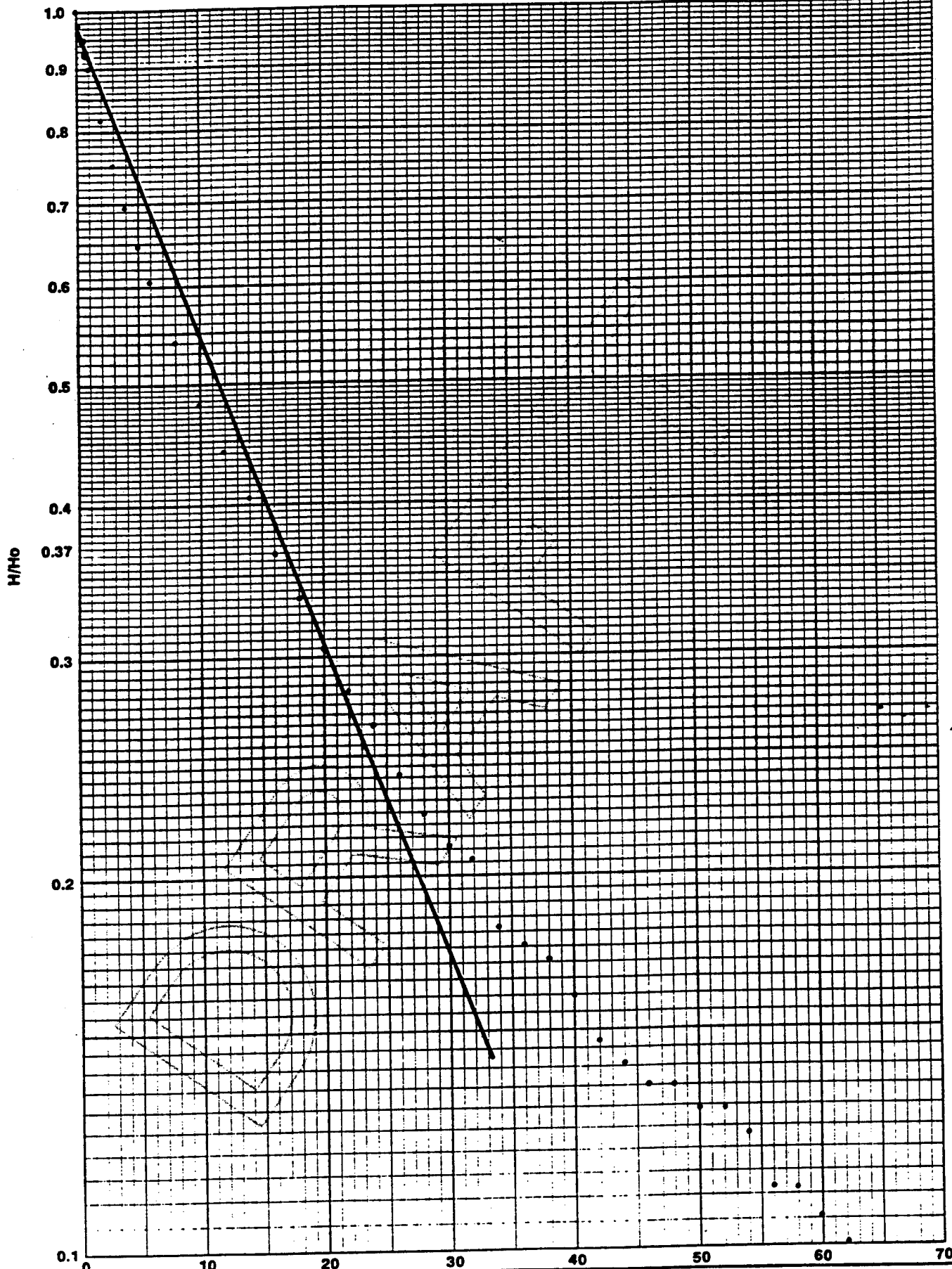
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Prepared by: R.L.C.

Date: 8/22/90

RISING HEAD TEST: HVORSLEV
LSB-34



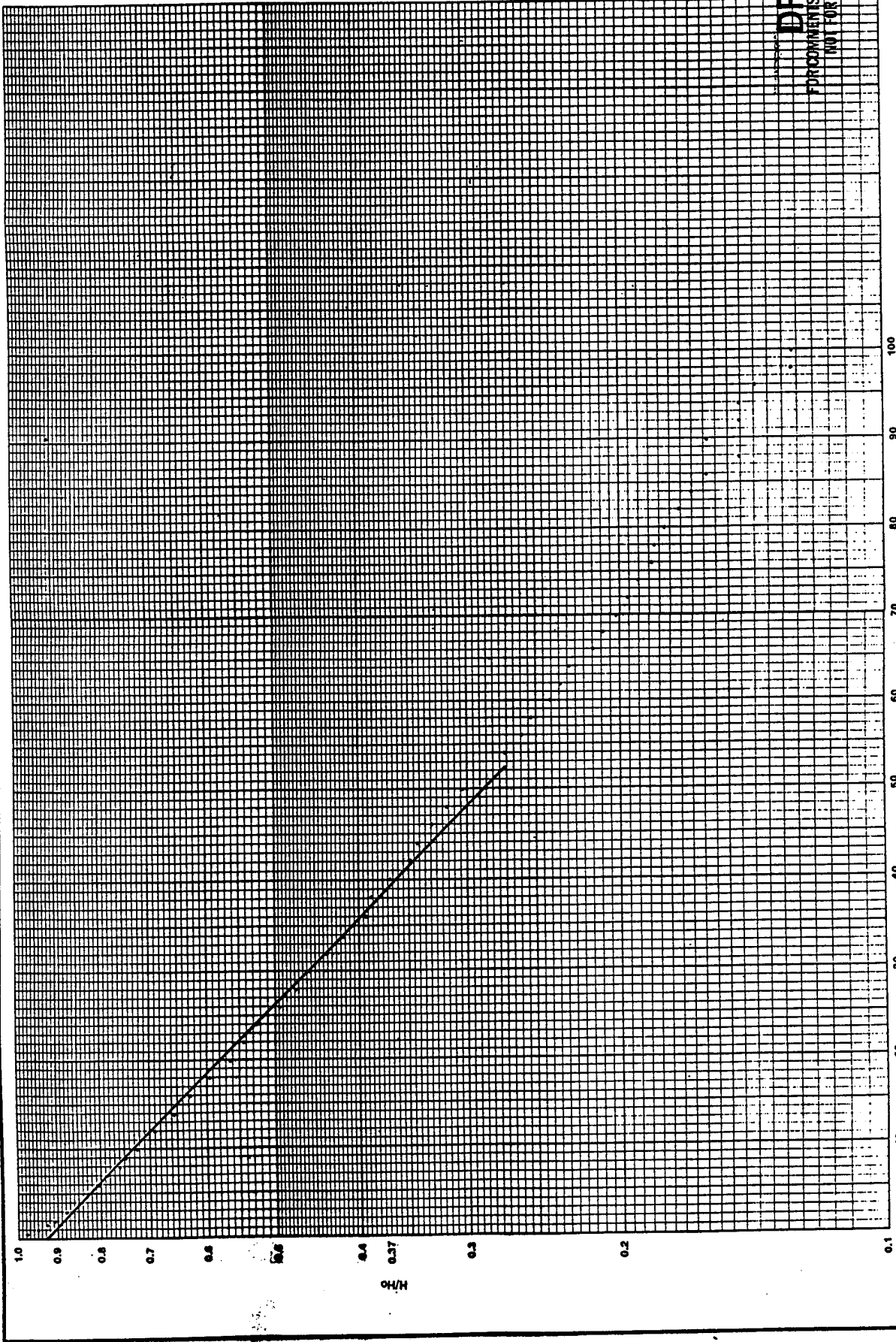
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Job No. : 2050-640

Prepared by: R.L.C.

Date: 8/22/90

FALLING HEAD TEST: HVORSLEV
LSB-35



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Job No.: 2050-640
 Prepared by: R.L.C.
 Date: 8/23/80

RISEING HEAD TEST: HVORSLEV

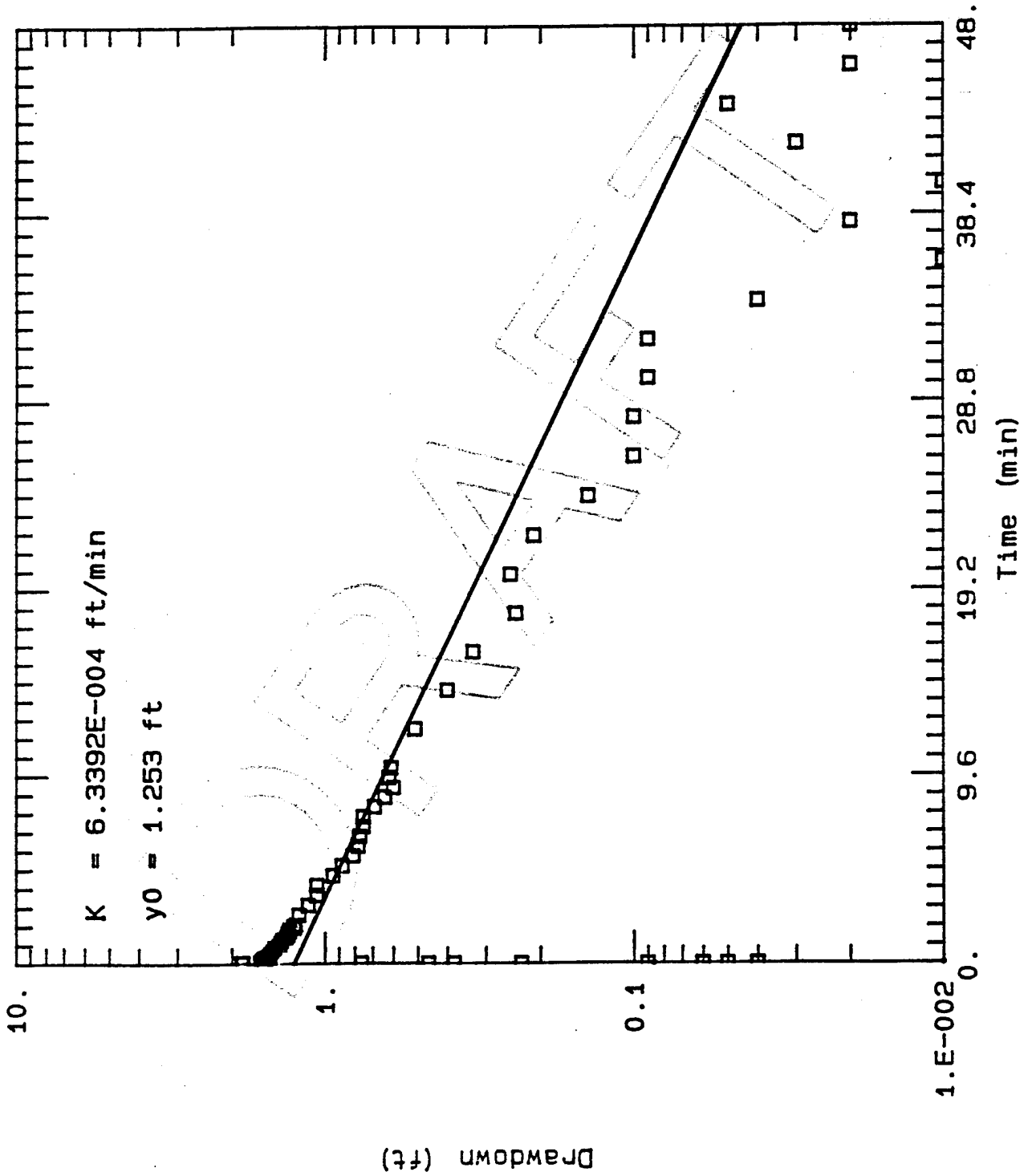
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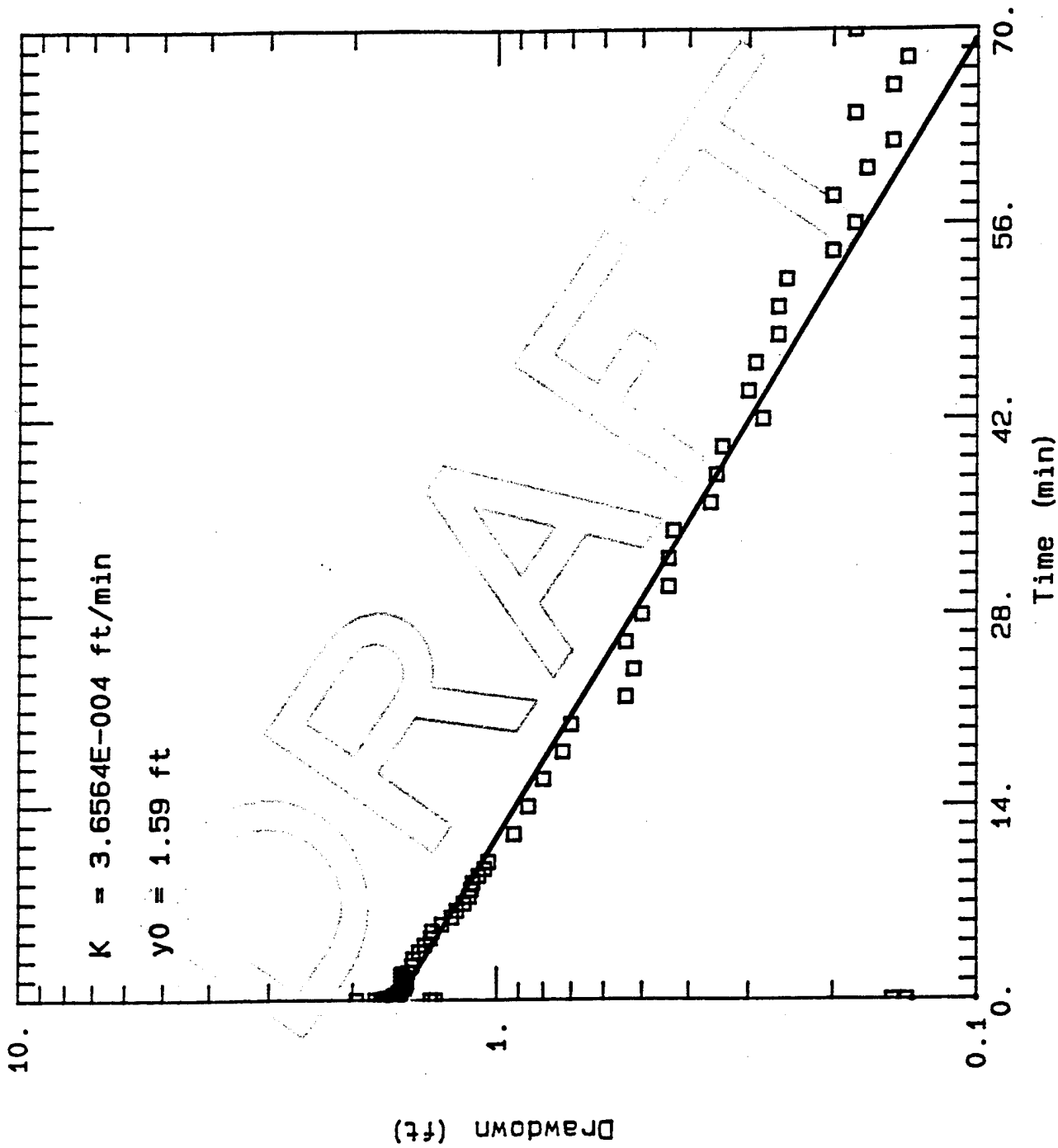
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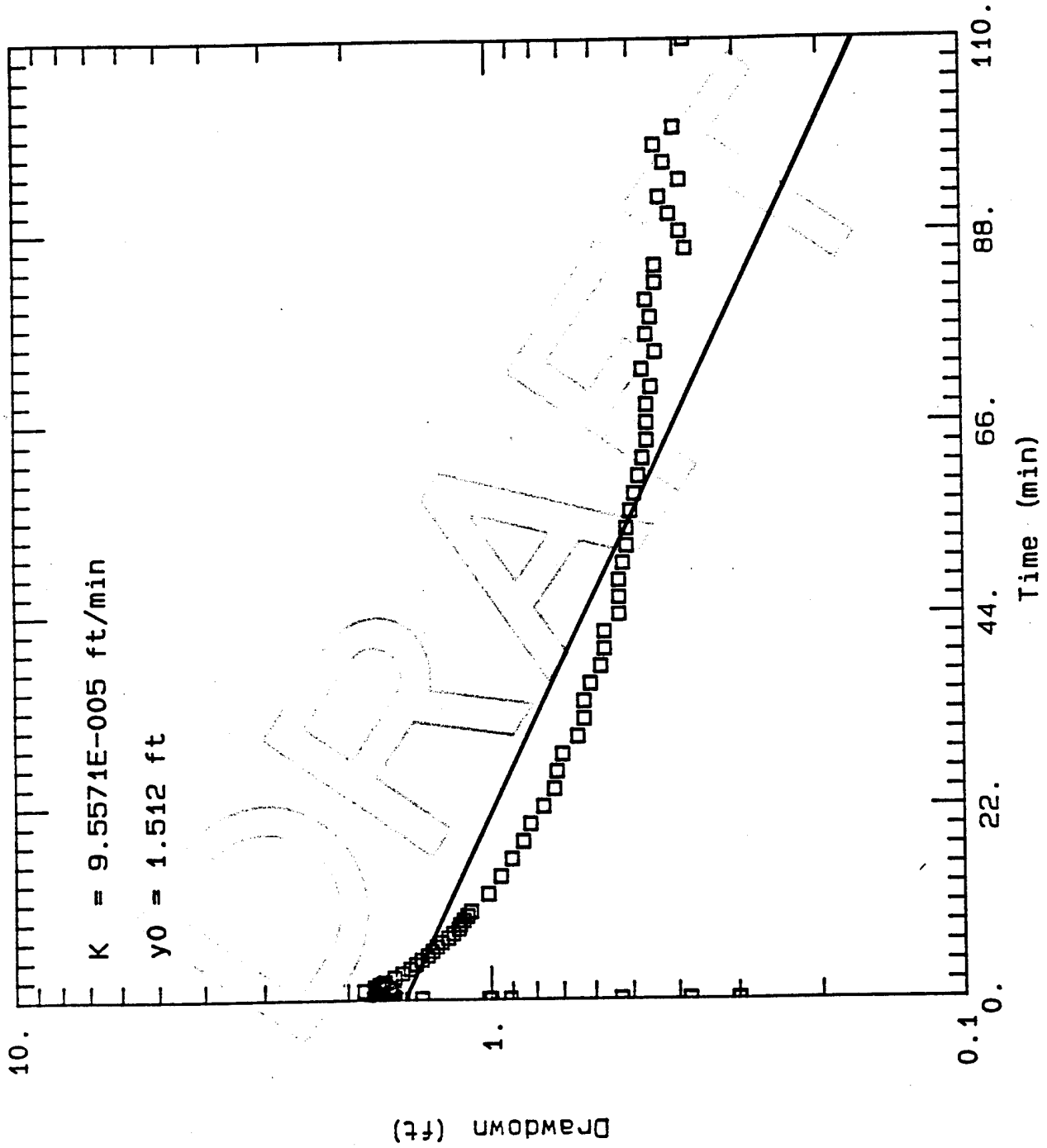
LSB-15 FALLING HEAD TEST: BOWER-RICE



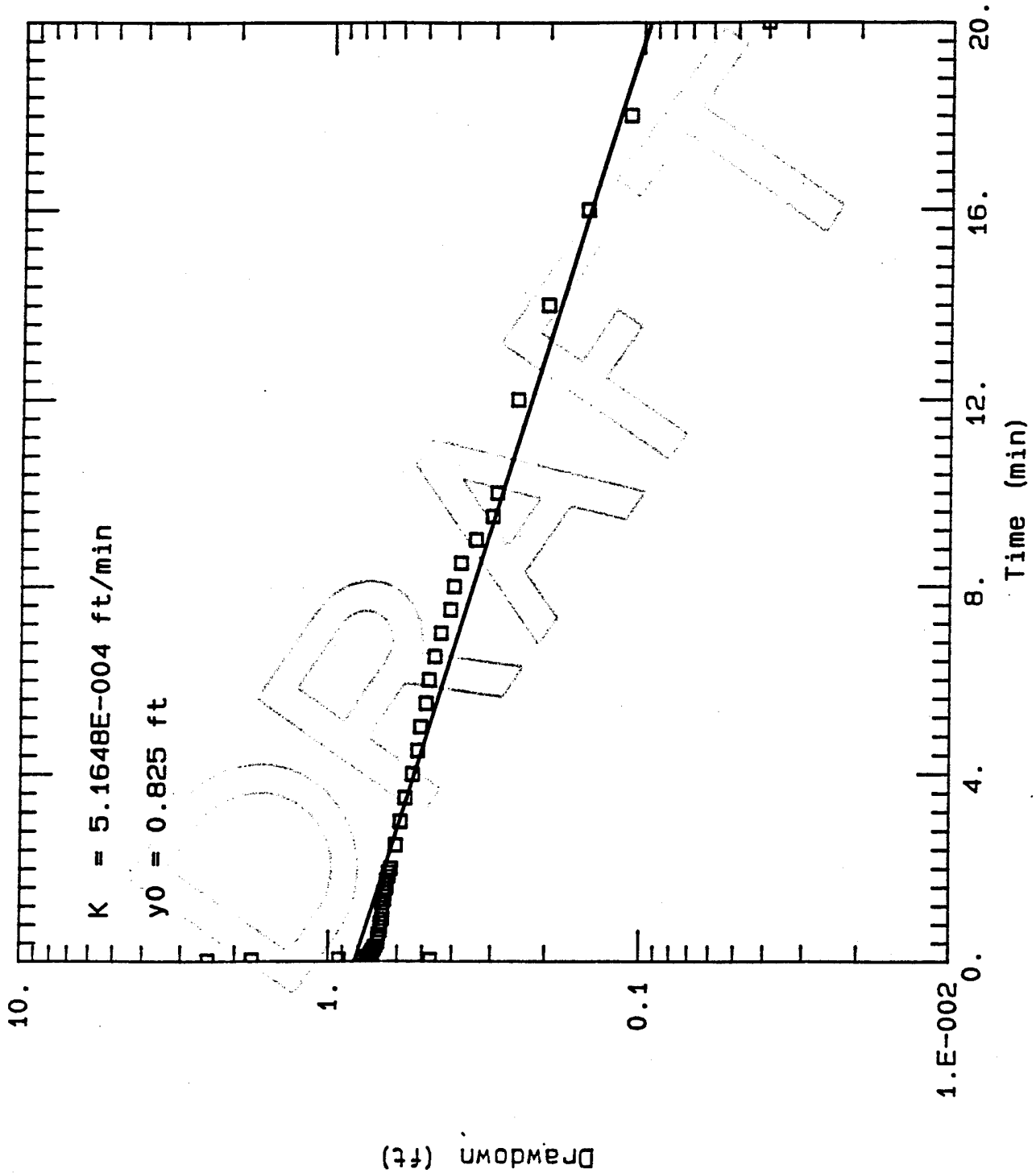
LSB-15 RISING HEAD TEST: BOUWER-RICE



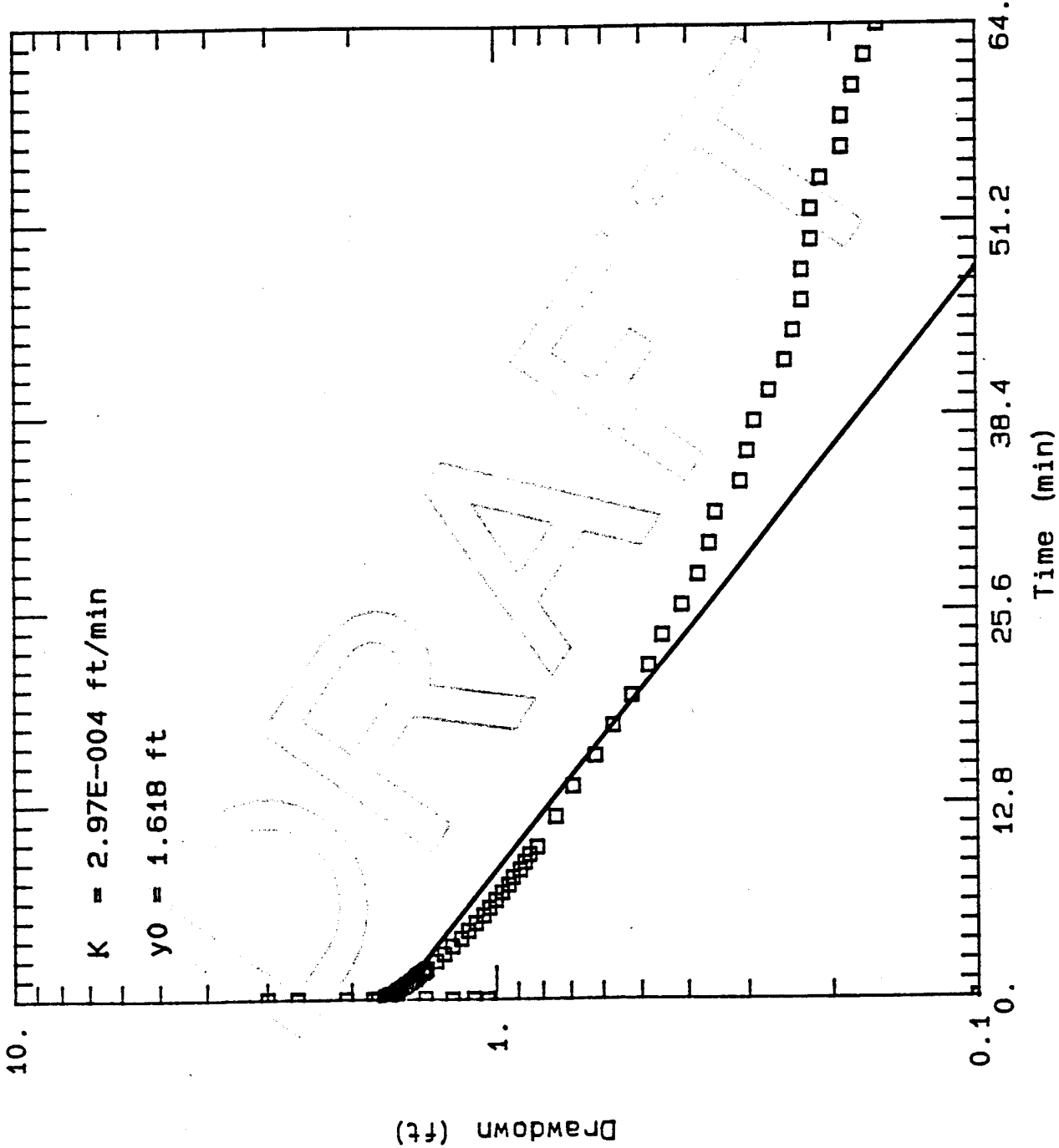
LSB-34 FALLING HEAD TEST: BOWER-RICE



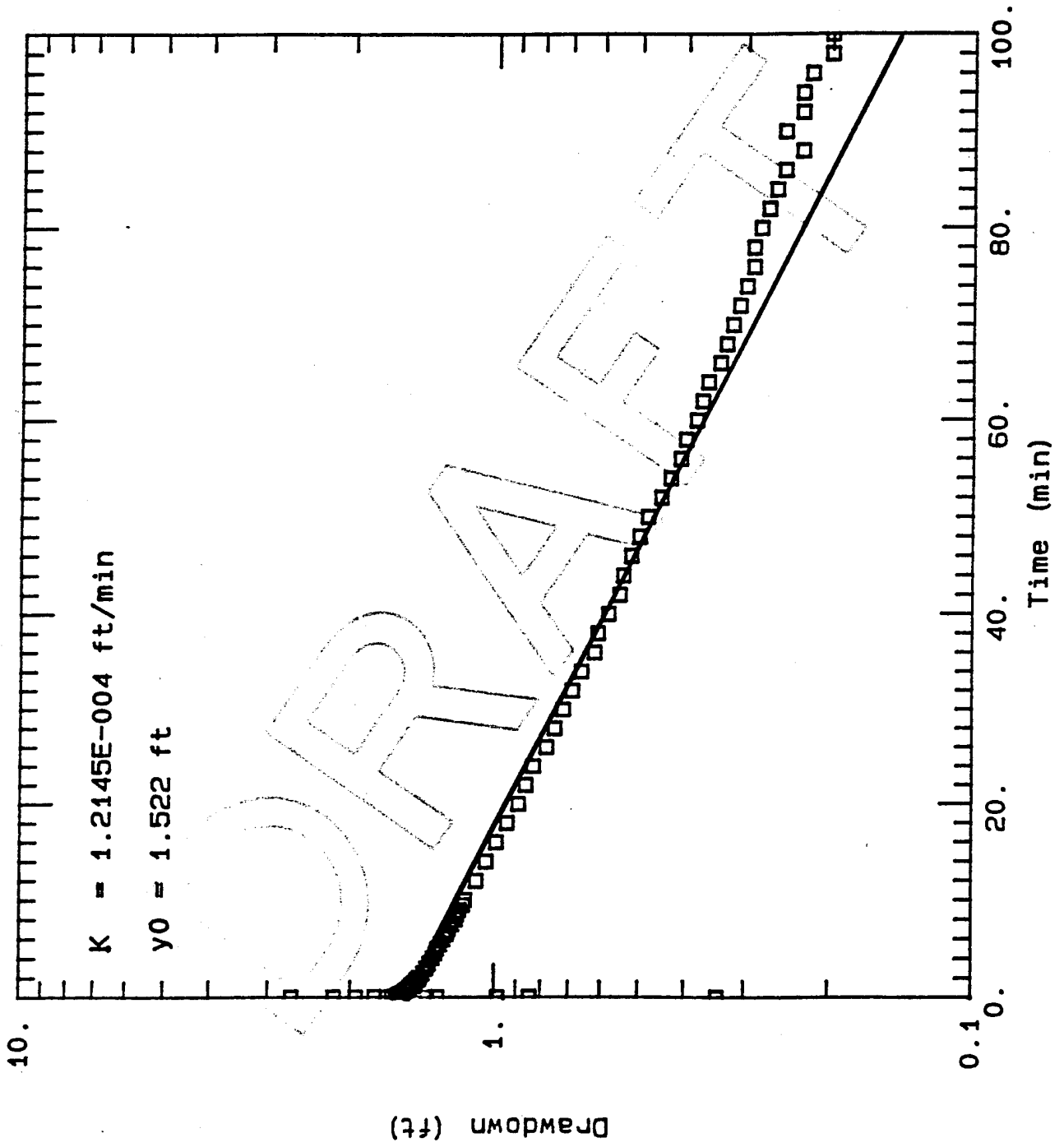
LSB-34 RISING HEAD TEST: BOUWER-RICE



LSB-35 FALLING HEAD TEST: BOUWER-RICE



LSB-35 RISING HEAD TEST: BOUWER-RICE



SLUG TEST DATA FORM

Location RMA

Name Andre Fiedler

Borehole No. LSB-15

Groundwater Elevation Before Test 11.1 btoc

Test Date 7/23/90

Total Casing Depth 23.2 ft (26.75 btoc)

Measuring Point toc

Borehole Diameter 10 in

Type of Test Falling/Rising head

Casing Diameter 4 in

Transducer Probe Serial No. 02813

Screened Interval 18.2 - 23.2

Datalogger Test Run No. 1

Sand Pack Interval 13 - 23.2

(include time and date for
identification purposes)

Lithology Tested clay, sandy

SF = 10.12
off = 0.002

step 0 Falling head
step 1 Rising head

transducer depth = 23.11 btoc
transducer = 12.01 below swl

Slug depth (bottom) = 16.5 ft btoc

DRAFT

TABLE 5
SLUG TEST DATA LSB-15

LSB-15 Falling Head Test			LSB-15 Rising Head Test		
Time(min)	Head Change(ft)	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
0	-0.07		0	1.61	
0.0033	-0.09		0.0033	0.14	
0.0066	-0.06		0.0066	0.15	
0.0099	-0.04		0.0099	1.37	
0.0133	-0.05		0.0133	1.34	
0.0166	-0.04		0.0166	1.96	
0.02	-0.06		0.02	1.7	
0.0233	-0.23		0.0233	1.79	
0.0266	-0.38		0.0266	1.74	
0.03	-0.46		0.03	1.74	
0.0333	-0.76		0.0333	1.7	
0.05	-1.86		0.05	1.7	
0.0666	-1.54		0.0666	1.69	
0.0833	-1.83		0.0833	1.71	
0.1	-1.5		0.1	1.71	
0.1166	-1.62		0.1166	1.69	
0.1333	-1.59		0.1333	1.65	
0.15	-1.58		0.15	1.66	
0.1666	-1.58		0.1666	1.66	
0.1833	-1.57		0.1833	1.61	
0.2	-1.59	1.000	0.2	1.62	
0.2166	-1.58	0.994	0.2166	1.64	1.000
0.2333	-1.58	0.994	0.2333	1.63	0.994
0.25	-1.55	0.975	0.25	1.63	0.994
0.2666	-1.56	0.981	0.2666	1.62	0.988
0.2833	-1.57	0.987	0.2833	1.62	0.988
0.3	-1.54	0.969	0.3	1.64	1.000
0.3166	-1.54	0.969	0.3166	1.63	0.994
0.3333	-1.55	0.975	0.3333	1.62	0.988
0.4167	-1.52	0.956	0.4167	1.6	0.976
0.5	-1.5	0.943	0.5	1.6	0.976
0.5833	-1.48	0.931	0.5833	1.6	0.976
0.6667	-1.47	0.925	0.6667	1.58	0.963
0.75	-1.44	0.906	0.75	1.58	0.963
0.8333	-1.45	0.912	0.8333	1.55	0.945
0.9167	-1.41	0.887	0.9167	1.58	0.963
1	-1.38	0.868	1	1.55	0.945
1.0833	-1.39	0.874	1.0833	1.54	0.939
1.1667	-1.37	0.862	1.1667	1.55	0.945
1.25	-1.37	0.862	1.25	1.54	0.939
1.3333	-1.33	0.836	1.3333	1.53	0.933
1.4166	-1.32	0.830	1.4166	1.57	0.957
1.5	-1.31	0.824	1.5	1.58	0.963
1.5833	-1.31	0.824	1.5833	1.56	0.951
1.6667	-1.29	0.811	1.6667	1.55	0.945
1.75	-1.3	0.818	1.75	1.57	0.957
1.8333	-1.25	0.786	1.8333	1.58	0.963
1.9167	-1.26	0.792	1.9167	1.57	0.957
2	-1.24	0.780	2	1.53	0.933
2.5	-1.21	0.761	2.5	1.5	0.915
3	-1.13	0.711	3	1.49	0.909
3.5	-1.06	0.667	3.5	1.45	0.884
4	-1.06	0.667	4	1.41	0.860
4.5	-0.94	0.591	4.5	1.37	0.835
5	-0.88	0.553	5	1.36	0.829
5.5	-0.81	0.509	5.5	1.3	0.793
6	-0.78	0.491	6	1.24	0.756
6.5	-0.77	0.484	6.5	1.21	0.738
7	-0.75	0.472	7	1.17	0.713
7.5	-0.75	0.472	7.5	1.14	0.695
8	-0.69	0.434	8	1.13	0.689
8.5	-0.64	0.403	8.5	1.12	0.683
9	-0.6	0.377	9	1.09	0.665
9.5	-0.62	0.390	9.5	1.06	0.646
10	-0.61	0.384	10	1.04	0.634
12	-0.51	0.321	12	0.92	0.561
14	-0.4	0.252	14	0.86	0.524
16	-0.33	0.208	16	0.8	0.488
18	-0.24	0.151	18	0.73	0.445
20	-0.25	0.157	20	0.7	0.427
22	-0.21	0.132	22	0.54	0.329
24	-0.14	0.088	24	0.52	0.317
26	-0.1	0.063	26	0.54	0.329

TABLE 5 (cont.)
SLUC TEST DATA LSB-15

LSB-15 Falling Head Test			LSB-15 Rising Head Test		
Time(min)	Head Change(ft)	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
28	-0.1	0.063	28	0.5	0.305
30	-0.09	0.057	30	0.44	0.268
32	-0.09	0.057	32	0.44	0.268
34	-0.04	0.025	34	0.43	0.262
36	-0.01	0.006	36	0.36	0.220
38	-0.02	0.013	38	0.35	0.213
40	-0.01	0.006	40	0.34	0.207
42	0.03	-0.019	42	0.28	0.171
44	0.05	-0.031	44	0.3	0.183
46	-0.02	0.013	46	0.29	0.177
48	-0.02	0.013	48	0.26	0.159
			50	0.26	0.159
			52	0.25	0.152
			54	0.2	0.122
			56	0.18	0.110
			58	0.2	0.122
			60	0.17	0.104
			62	0.15	0.091
			64	0.18	0.110
			66	0.15	0.091
			68	0.14	0.085
			70	0.18	0.110

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SLUG TEST DATA FORM

Location RMA

Name Andre Fiedler

Borehole No. LSB-34

Groundwater Elevation Before Test 14.75btoc

Test Date 7/24/90

Total Casing Depth 28.3 ft btoc

Measuring Point toc

Borehole Diameter 10 in

Type of Test Falling/Rising head

Casing Diameter 4 in

Transducer Probe Serial No. 02813

Screened Interval 18 - 28 ft

Datalogger Test Run No. 2
(include time and date for identification purposes)

Sand Pack Interval 15.4 - 28.4 ft

Lithology Tested sand, silty to clay and sand

SF = 10.12 step 0 Falling head
off = 0.002 step 1 Rising head

transducer depth = 26 ft btoc
s_o = 12.01 below swl

Slug depth (bottom) = 20 ft btoc

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TABLE 6
SLUG TEST DATA LSB-34

LSB-34 Falling Head Test			LSB-34 Rising Head Test		
Time(min)	Head Change(ft)	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
0	0		0	-1.06	
0.0033	0		0.0033	-1.06	
0.0066	0		0.0066	-1.06	
0.0099	-0.3		0.0099	-1.15	
0.0133	-0.3		0.0133	2.44	
0.0166	-0.53		0.0166	-0.28	
0.02	-0.91		0.02	-1.79	
0.0233	-0.38		0.0233	-0.02	
0.0266	-1.01		0.0266	-0.64	
0.03	-1		0.03	1.76	
0.0333	-1.75		0.0333	0.47	
0.05	-1.73		0.05	0.92	
0.0666	-1.54		0.0666	0.72	
0.0833	-1.4		0.0833	0.75	1.000
0.1	-1.73		0.1	0.75	1.000
0.1166	-1.77		0.1166	0.74	0.987
0.1333	-1.74		0.1333	0.73	0.973
0.15	-1.71		0.15	0.73	0.973
0.1666	-1.76	1.000	0.1666	0.73	0.973
0.1833	-1.75	0.994	0.1833	0.72	0.960
0.2	-1.74	0.989	0.2	0.72	0.960
0.2166	-1.74	0.989	0.2166	0.72	0.960
0.2333	-1.73	0.983	0.2333	0.72	0.960
0.25	-1.73	0.983	0.25	0.71	0.947
0.2666	-1.72	0.977	0.2666	0.71	0.947
0.2833	-1.72	0.977	0.2833	0.71	0.947
0.3	-1.72	0.977	0.3	0.71	0.947
0.3166	-1.71	0.972	0.3166	0.71	0.947
0.3333	-1.71	0.972	0.3333	0.7	0.933
0.4167	-1.7	0.966	0.4167	0.69	0.920
0.5	-1.68	0.955	0.5	0.69	0.920
0.5833	-1.65	0.938	0.5833	0.69	0.920
0.6667	-1.63	0.926	0.6667	0.68	0.907
0.75	-1.62	0.920	0.75	0.68	0.907
0.8333	-1.6	0.909	0.8333	0.68	0.907
0.9167	-1.73	0.983	0.9167	0.67	0.893
1	-1.85	1.051	1	0.67	0.893
1.0833	-1.6	0.909	1.0833	0.67	0.893
1.1667	-1.64	0.932	1.1667	0.67	0.893
1.25	-1.63	0.926	1.25	0.67	0.893
1.3333	-1.65	0.938	1.3333	0.66	0.880
1.4166	-1.76	1.000	1.4166	0.66	0.880
1.5	-1.69	0.960	1.5	0.66	0.880
1.5833	-1.72	0.977	1.5833	0.65	0.867
1.6667	-1.72	0.977	1.6667	0.65	0.867
1.75	-1.7	0.966	1.75	0.65	0.867
1.8333	-1.69	0.960	1.8333	0.64	0.853
1.9167	-1.68	0.955	1.9167	0.64	0.853
2	-1.67	0.949	2	0.63	0.840
2.5	-1.6	0.909	2.5	0.61	0.813
3	-1.54	0.875	3	0.59	0.787
3.5	-1.48	0.841	3.5	0.57	0.760
4	-1.44	0.818	4	0.54	0.720
4.5	-1.4	0.795	4.5	0.52	0.693
5	-1.36	0.773	5	0.51	0.680
5.5	-1.33	0.756	5.5	0.49	0.653
6	-1.3	0.739	6	0.48	0.640
6.5	-1.27	0.722	6.5	0.46	0.613
7	-1.23	0.699	7	0.44	0.587
7.5	-1.2	0.682	7.5	0.41	0.547
8	-1.17	0.665	8	0.4	0.533
8.5	-1.16	0.659	8.5	0.38	0.507
9	-1.14	0.648	9	0.34	0.453
9.5	-1.12	0.636	9.5	0.3	0.400
10	-1.1	0.625	10	0.29	0.387
12	-1.01	0.574	12	0.25	0.333
14	-0.95	0.540	14	0.2	0.267
16	-0.9	0.511	16	0.15	0.200
18	-0.85	0.483	18	0.11	0.147
20	-0.82	0.466	20	0.04	0.053
22	-0.77	0.438	22	0	0.000
24	-0.73	0.415	24	-0.06	-0.080
26	-0.72	0.409	26	-0.09	-0.120

TABLE 6 (cont.)
SLUG TEST DATA LSB-34

LSB-34 Falling Head Test			LSB-34 Rising Head Test		
Time(min)	Head Change(ft)	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
28	-0.7	0.398	28	-0.15	-0.200
30	-0.65	0.369	30	-0.18	-0.240
32	-0.63	0.358	32	-0.22	-0.293
34	-0.63	0.358	34	-0.25	-0.333
36	-0.61	0.347	36	-0.3	-0.400
38	-0.58	0.330	38	-0.31	-0.413
40	-0.57	0.324	40	-0.34	-0.453
42	-0.57	0.324	42	-0.39	-0.520
44	-0.53	0.301	44	-0.42	-0.560
46	-0.53	0.301	46	-0.43	-0.573
48	-0.53	0.301	48	-0.47	-0.627
50	-0.52	0.295	50	-0.49	-0.653
52	-0.51	0.290			
54	-0.51	0.290			
56	-0.5	0.284			
58	-0.49	0.278			
60	-0.48	0.273			
62	-0.47	0.267			
64	-0.46	0.261			
66	-0.46	0.261			
68	-0.46	0.261			
70	-0.45	0.256			
72	-0.47	0.267			
74	-0.44	0.250			
76	-0.46	0.261			
78	-0.45	0.256			
80	-0.46	0.261			
82	-0.44	0.250			
84	-0.44	0.250			
86	-0.38	0.216			
88	-0.39	0.222			
90	-0.41	0.233			
92	-0.43	0.244			
94	-0.39	0.222			
96	-0.42	0.239			
98	-0.44	0.250			
100	-0.4	0.227			
110	-0.38	0.216			

SLUG TEST DATA FORM

Location RMA

Name Andre Fiedler

Borehole No. LSB-35

Groundwater Elevation Before Test 10.25btoc

Test Date 7/23/90

Total Casing Depth 30.2 ft btoc

Measuring Point toc

Borehole Diameter 10 in

Type of Test Falling/Rising head

Casing Diameter 4 in

Transducer Probe Serial No. 02813

Screened Interval 19.9 - 29.9 ft

Datalogger Test Run No. 0
(include time and date for identification purposes)

Sand Pack Interval 14 - 31 ft

Lithology Tested clay, verry sandy to clay silty sandy

SF = 10.12 step 0 Falling head
off = 0.002 step 1 Rising head

transducer depth = 25 ft btoc
 Δs_0 = 13.85 below swl

Slug depth (bottom) = 16.5 ft btoc

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TABLE 7
SLUG TEST DATA LSB-35

LSB-35 Falling Head Test			LSB-35 Rising Head Test		
Time(min)	Head Change(ft)	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
0	-2.32		0	1.04	
0.0033	-1.8		0.0033	0.98	
0.0066	-1.04		0.0066	-0.48	
0.0099	-1.7		0.0099	0.34	
0.0133	-2.59		0.0133	2.66	
0.0166	-1.23		0.0166	1.94	
0.02	-0.1		0.02	0.84	
0.0233	-2.05		0.0233	1.67	
0.0266	-2.99		0.0266	2.16	
0.03	-1.71		0.03	1.37	
0.0333	-1.76		0.0333	1.31	
0.05	-1.11		0.05	1.77	
0.0666	-1.4		0.0666	1.52	
0.0833	-1.61		0.0833	1.63	
0.1	-1.7	1.000	0.1	1.58	
0.1166	-1.7	1.000	0.1166	1.6	
0.1333	-1.7	1.000	0.1333	1.58	1.000
0.15	-1.69	0.994	0.15	1.58	1.000
0.1666	-1.66	0.976	0.1666	1.58	1.000
0.1833	-1.67	0.982	0.1833	1.58	1.000
0.2	-1.67	0.982	0.2	1.57	0.994
0.2166	-1.67	0.982	0.2166	1.57	0.994
0.2333	-1.66	0.976	0.2333	1.57	0.994
0.25	-1.66	0.976	0.25	1.57	0.994
0.2666	-1.65	0.971	0.2666	1.56	0.987
0.2833	-1.65	0.971	0.2833	1.56	0.987
0.3	-1.65	0.971	0.3	1.56	0.987
0.3166	-1.64	0.965	0.3166	1.56	0.987
0.3333	-1.64	0.965	0.3333	1.55	0.981
0.4167	-1.62	0.953	0.4167	1.55	0.981
0.5	-1.61	0.947	0.5	1.54	0.975
0.5833	-1.6	0.941	0.5833	1.53	0.968
0.6667	-1.58	0.929	0.6667	1.53	0.968
0.75	-1.57	0.924	0.75	1.52	0.962
0.8333	-1.55	0.912	0.8333	1.51	0.956
0.9167	-1.54	0.906	0.9167	1.5	0.949
1	-1.53	0.900	1	1.5	0.949
1.0833	-1.51	0.888	1.0833	1.49	0.943
1.1667	-1.5	0.882	1.1667	1.48	0.937
1.25	-1.49	0.876	1.25	1.48	0.937
1.3333	-1.47	0.865	1.3333	1.47	0.930
1.4166	-1.47	0.865	1.4166	1.47	0.930
1.5	-1.46	0.859	1.5	1.46	0.924
1.5833	-1.45	0.853	1.5833	1.45	0.918
1.6667	-1.44	0.847	1.6667	1.45	0.918
1.75	-1.42	0.835	1.75	1.44	0.911
1.8333	-1.41	0.829	1.8333	1.44	0.911
1.9167	-1.4	0.824	1.9167	1.43	0.905
2	-1.39	0.818	2	1.43	0.905
2.5	-1.33	0.782	2.5	1.4	0.886
3	-1.28	0.753	3	1.38	0.873
3.5	-1.23	0.724	3.5	1.36	0.861
4	-1.18	0.694	4	1.34	0.848
4.5	-1.14	0.671	4.5	1.32	0.835
5	-1.1	0.647	5	1.31	0.829
5.5	-1.06	0.624	5.5	1.29	0.816
6	-1.03	0.606	6	1.27	0.804
6.5	-1	0.588	6.5	1.25	0.791
7	-0.97	0.571	7	1.24	0.785
7.5	-0.94	0.553	7.5	1.22	0.772
8	-0.92	0.541	8	1.2	0.759
8.5	-0.89	0.524	8.5	1.19	0.753
9	-0.87	0.512	9	1.18	0.747
9.5	-0.85	0.500	9.5	1.16	0.734
10	-0.82	0.482	10	1.15	0.728
12	-0.75	0.441	12	1.09	0.690
14	-0.69	0.406	14	1.04	0.658
16	-0.62	0.365	16	0.99	0.627
18	-0.57	0.335	18	0.94	0.595
20	-0.52	0.306	20	0.89	0.563
22	-0.48	0.282	22	0.86	0.544
24	-0.45	0.265	24	0.83	0.525
26	-0.41	0.241	26	0.78	0.494

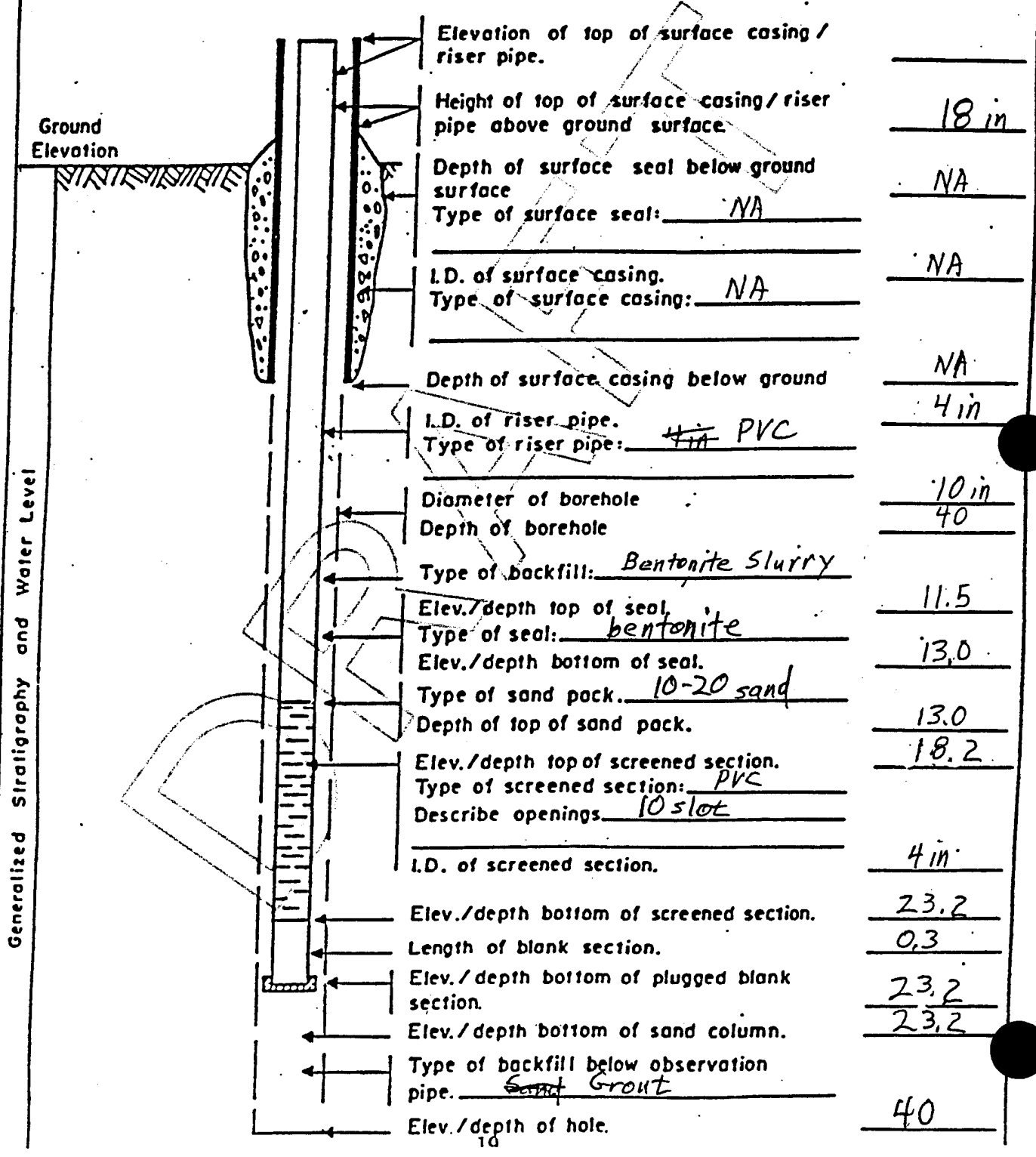
TABLE 7 (cont.)
SLUG TEST DATA LSB-35

LSB-35 Falling Head Test			LSB-35 Rising Head Test		
Time(min)	Head Change(ft)	Head Ratio	Time(min)	Head Change(ft)	Head Ratio
28	-0.38	0.224	28	0.75	0.475
30	-0.36	0.212	30	0.72	0.456
32	-0.35	0.206	32	0.69	0.437
34	-0.31	0.182	34	0.66	0.418
36	-0.3	0.176	36	0.62	0.392
38	-0.29	0.171	38	0.61	0.386
40	-0.27	0.159	40	0.58	0.367
42	-0.25	0.147	42	0.55	0.348
44	-0.24	0.141	44	0.54	0.342
46	-0.23	0.135	46	0.52	0.329
48	-0.23	0.135	48	0.5	0.316
50	-0.22	0.129	50	0.48	0.304
52	-0.22	0.129	52	0.45	0.285
54	-0.21	0.124	54	0.43	0.272
56	-0.19	0.112	56	0.41	0.259
58	-0.19	0.112	58	0.4	0.253
60	-0.18	0.106	60	0.38	0.241
62	-0.17	0.100	62	0.37	0.234
64	-0.16	0.094	64	0.36	0.228
			66	0.34	0.215
			68	0.33	0.209
			70	0.32	0.203
			72	0.31	0.196
			74	0.3	0.190
			76	0.29	0.184
			78	0.29	0.184
			80	0.28	0.177
			82	0.27	0.171
			84	0.26	0.165
			86	0.25	0.158
			88	0.23	0.146
			90	0.25	0.158
			92	0.23	0.146
			94	0.23	0.146
			96	0.22	0.139
			98	0.2	0.127
			100	0.2	0.127

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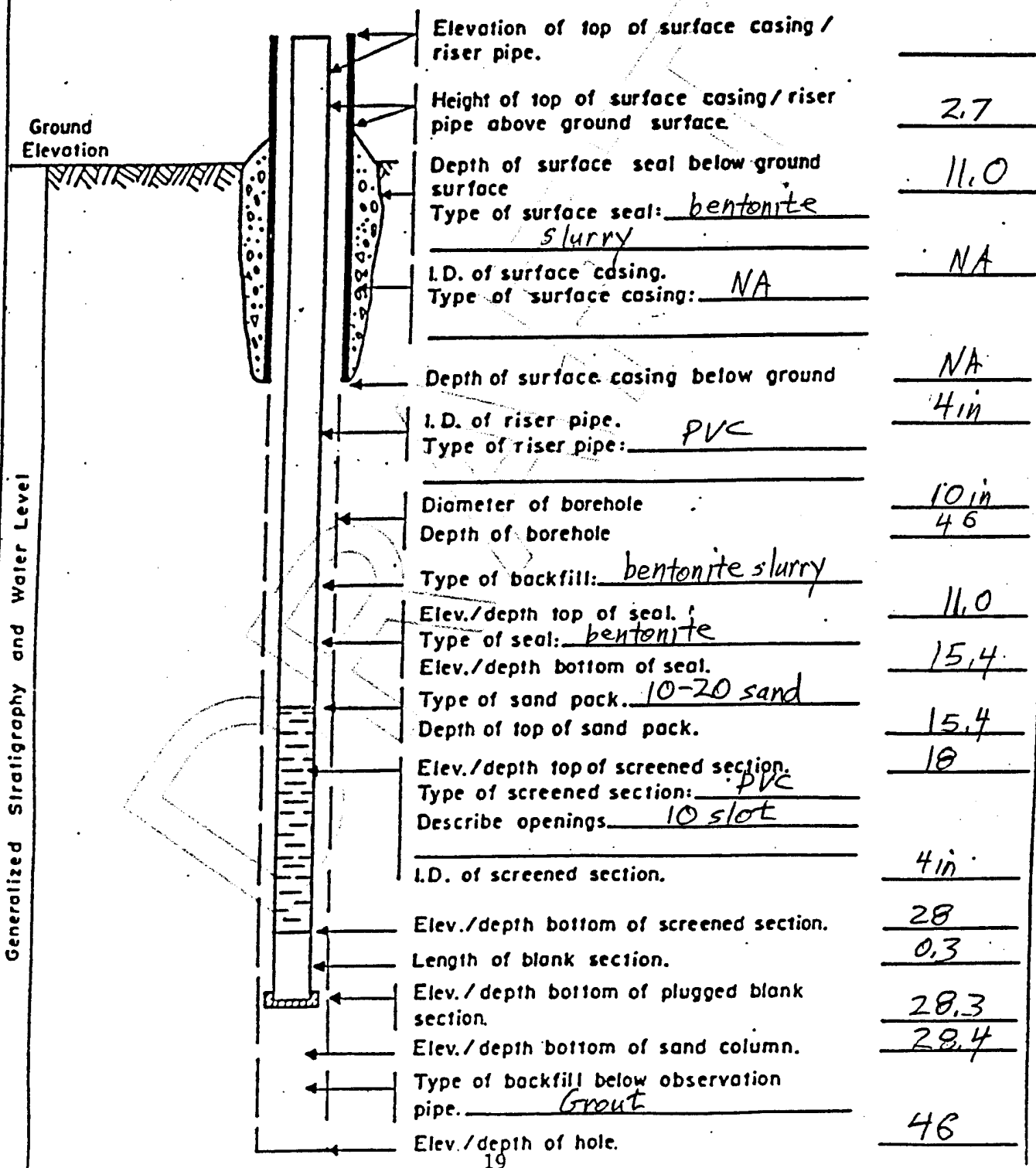
GROUND WATER OBSERVATION WELL REPORT

PROJECT	<u>RMA COE</u>	<u>89MC114A</u>
LOCATION	<u>Sec 36</u>	
Date Completed	<u>6-25-90</u>	Original Depth _____
Inspected By	<u>T. Terry</u>	Date <u>6-28-90</u>
Checked By	_____	Date _____
		Page <u>1</u> of <u>1</u>
		Well No. <u>LSB-15</u>
		Aquifer <u>Alluvial</u>
		Depth Interval _____



GROUND WATER OBSERVATION WELL REPORT

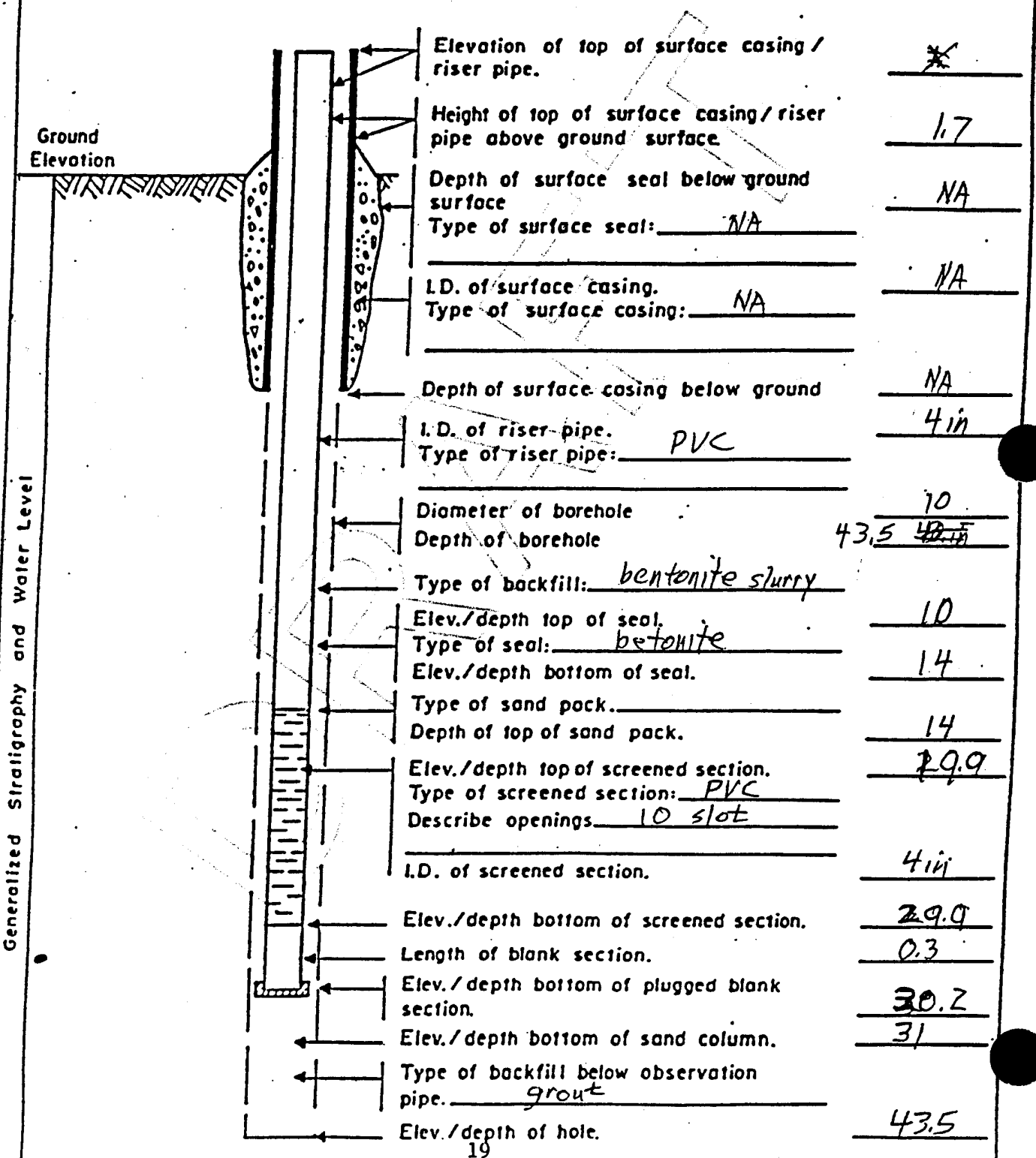
PROJECT	<u>RMA COE</u>	<u>89MC114A</u>	Page	<u>1</u>	of	<u>1</u>
LOCATION	<u>Sec. 36</u>		Well No.	<u>LSB-34</u>		
Date Completed	<u>5-27-90</u>	Original Depth	<u>28.4</u>			
Inspected By	<u>T. Terry</u>	Date	<u>6-27-90</u>			
Checked By	_____	Date	_____			
			Depth Interval	_____		



Generalized Stratigraphy and Water Level

GROUND WATER OBSERVATION WELL REPORT

PROJECT <u>RMA COE</u>	<u>B9MC114A</u>	Page <u>1</u> of <u>1</u>
LOCATION <u>SEC 36</u>		Well No. <u>LSB-35</u>
Date Completed <u>6-29-90</u>	Original Depth <u>30.2</u>	Aquifer <u>Alluvial</u>
Inspected By <u>TAT</u>	Date <u>6-29-90</u>	
Checked By _____	Date _____	Depth Interval _____



Elevation of top of surface casing / riser pipe.	<u>X</u>
Height of top of surface casing / riser pipe above ground surface.	<u>1.7</u>
Depth of surface seal below ground surface	<u>NA</u>
Type of surface seal: <u>NA</u>	
I.D. of surface casing.	<u>NA</u>
Type of surface casing: <u>NA</u>	
Depth of surface casing below ground	<u>NA</u>
I.D. of riser pipe.	<u>4 in</u>
Type of riser pipe: <u>PVC</u>	
Diameter of borehole	<u>70</u>
Depth of borehole	<u>43.5</u> 42.5
Type of backfill: <u>bentonite slurry</u>	
Elev./depth top of seal.	<u>10</u>
Type of seal: <u>bentonite</u>	
Elev./depth bottom of seal.	<u>14</u>
Type of sand pack.	
Depth of top of sand pack.	<u>14</u>
Elev./depth top of screened section.	<u>29.9</u>
Type of screened section: <u>PVC</u>	
Describe openings: <u>10 slot</u>	
I.D. of screened section.	<u>4 in</u>
Elev./depth bottom of screened section.	<u>29.0</u>
Length of blank section.	<u>0.3</u>
Elev./depth bottom of plugged blank section.	<u>30.2</u>
Elev./depth bottom of sand column.	<u>31</u>
Type of backfill below observation pipe: <u>grout</u>	
Elev./depth of hole.	<u>43.5</u>

PROJECT AMA-LIME SETTLING BASINS

SHEET NO. 1 OF 1

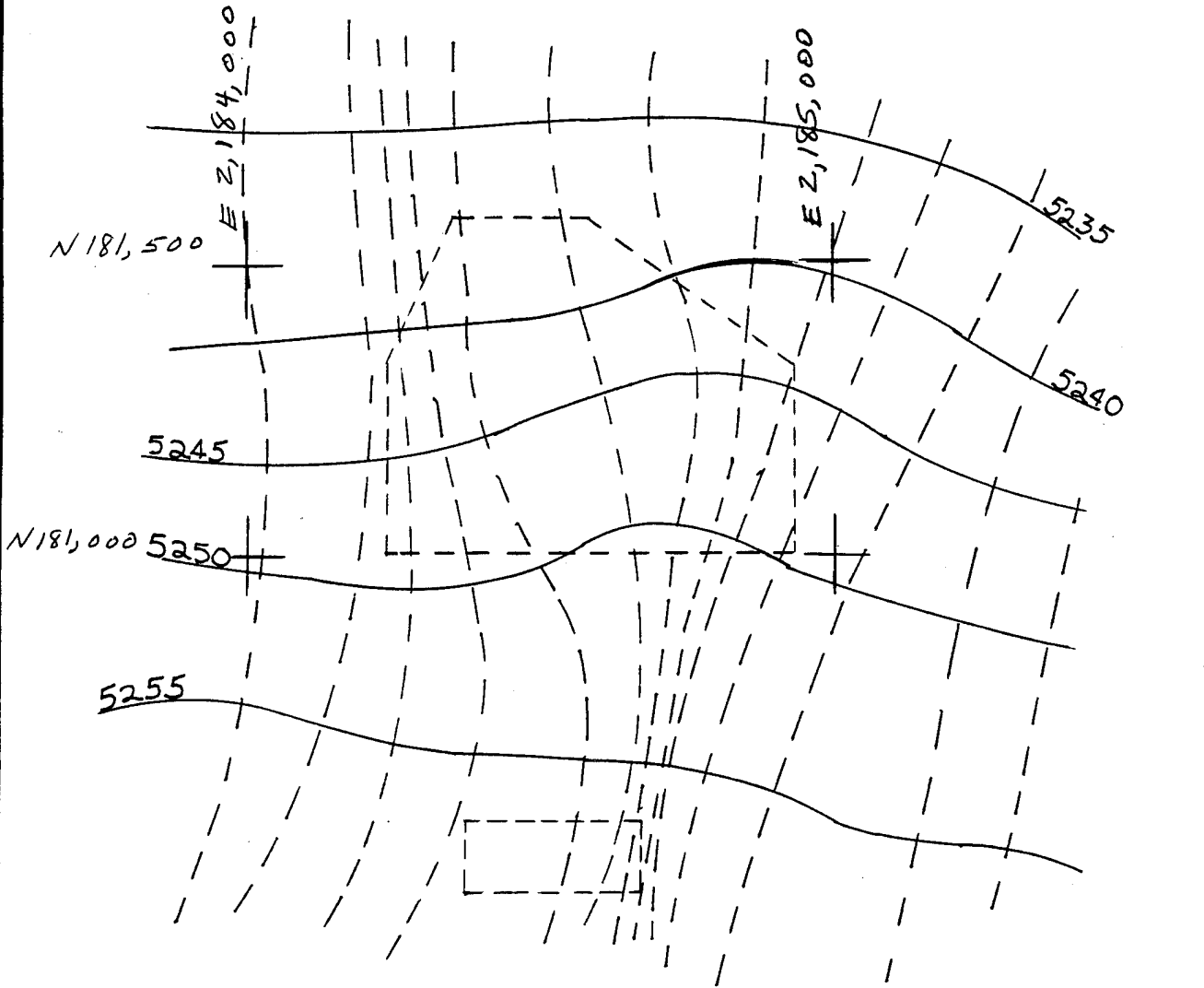
ITEM Flow Diagram PRIOR TO ISOLATION CELL

BY JMC

DATE 8-10-90

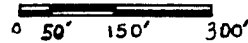
CHKD. BY

DATE



————— EQUIPOTENTIAL LINES

- - - - - FLOW LINES



CEMRO-ED-GF

23 August 1990

MEMORANDUM FOR Director, Missouri River Division Laboratory

SUBJECT: Request for Laboratory Services - Serial No. M-1045(Mil), Lime Settling Basins Slurry Wall, Rocky Mountain Arsenal, Denver, Colorado

1. The purpose of this request for services is to determine the permeability of a proposed slurry wall at the Lime Settling Basins Site when exposed to contaminants in the groundwater at the site.
2. Funds were sent to the MRD Laboratory on MIPR number ENE 0544, dated 25 April 1990. The cost code to be used is RJ0027052780099.
3. It is requested that the tests designated on the enclosed Laboratory Test Request be performed and that one copy of the testing report be sent to this office Attention: (CEMRO-ED-GF). In addition, a copy of all soil classification results should be sent to CEMRO-ED-GC.

FOR THE COMMANDER:

Encl

JOHN W. MONZINGO, P.E.
Chief, Geotechnical Branch
Engineering Division

MOSES/CEMRO-ED-GF
MONZINGO/CEMRO-ED-G

CF (wo/encl):
CEMRO-ED-MA

TEST REQUEST
ROCKY MOUNTAIN ARSENAL
TREATABILITY STUDY

1. Introduction. The following is an outline of the test procedures to be used for the Rocky Mountain Arsenal Lime Settling Basins Compatibility Study. Borrow material, slurry mix water, contaminated leachate, soil from the slurry wall borings and bentonite are already at the Lab. A schematic of the compatibility testing program is attached.

1.1. Geotechnical Test Methods. Where applicable, geotechnical testing shall be conducted in accordance with the Army Corps of Engineers Manual EM 1110-2-1906.

2. Determination of Bentonite Source. Potential bentonite sources must be premium-grade, ultrafine, natural sodium cation-based montmorillonite powders (Wyoming-type bentonite) that conforms to standards set forth in API Specification 13A, Sections 4, 8, and 9. Chemically treated bentonite will not be allowed. The bentonite samples at the Lab shall be tested for free swell using groundwater samples selected by the District. In addition, as a control, one free swell test shall be run on each bentonite sample using the anticipated slurry mix water. The free swell test method is described in EPA Report Number PB 87-229688 (EPA, 1987). The bentonite source which exhibits the least amount of variation between the control and contaminated groundwater free swell test will be used as the bentonite source for the backfill mixtures.

2.1. Bentonite Slurry Preparation. The bentonite slurry shall be prepared by mixing the slurry mix water with the previously selected bentonite source. The slurry shall be mixed with enough water to pass through a Marsh funnel in 40 to 50 seconds. The slurry shall be tested for density, moisture content, pH, and viscosity.

3. Borrow Sources. The borrow samples shall be stored in separate containers. All potential borrow material shall be tested for natural moisture content, Atterberg limits, grain size analysis (sieve and hydrometer methods), and specific gravity. No deleterious material will be allowed in any borrow material.

3.1 Chemical Analysis. The borrow material must be tested to verify it is free of contamination as determined by TCLP, TOC (Total Organic Carbon), sodium, calcium, magnesium, potassium, pH, and cation exchange capacity.

3.2. Preparation of Borrow Materials. The selected borrow will be oven-dried at 65 degrees Celsius for 2 to 4 days. The clays shall then be broken up, thoroughly mixed, and passed through a U.S. Standard Sieve No. 4. A sufficient quantity of oven dried material shall be retained for the optimization testing. The anticipated slurry mix tap water shall be added to the remainder of the dried and mixed materials until the original field water content is reached. The reconditioned borrow shall then be stored for 3 to 6 days in sealed containers at room temperature. During this storage period the samples should be mixed daily.

4. In Situ Slurry Wall Soil. Samples from the following Lime Settling Basins borings shall be thoroughly mixed to form one large sample: 11, 24, 9, 10, 26, and 18. This large sample shall be divided into two composite samples. Grain size analysis (sieve and hydrometer methods), Atterberg limits, and moisture content shall be run on each composite sample. Due to the consistency of the boring logs and field sieve analyses of the area, results of these two composite samples are expected to be very similar. One composite sample shall be used for optimization testing. Both samples will be used during permeameter testing (see paragraph 6).

5. Optimization Testing. Optimization tests will be performed to determine the most economical combination of materials for the backfill mixture. The percentage of fines, bentonite, coarse grained material, and water will be varied to produce the most economical backfill mixture which meets the 1×10^{-7} cm/sec permeability criteria.

The optimization test procedure shall consist of the following steps:

- Add sufficient oven dried (65 degrees Centigrade) borrow material to the selected oven dried composite sample so that the sample contains 20 % fines.
- Add sufficient oven dried borrow material to produce 4 additional samples which contain 30, 40, 50, and 60 % fines respectively.
- Place each sample in a constant volume mold and determine the respective dry densities. Plot percent fines vs. dry density.
- Slurry mix water shall be added to each composite sample until the anticipated field water content is reached.
- Run fixed wall permeability tests on each of these samples. The permeability tests shall be run at a differential head of 2 psi. Each permeability specimen shall be sluiced with tap water to obtain a 3 to 6 inch slump prior to being placed in the fixed wall permeameter. The length of test should be 8 to 24 hours.
- Based on the permeability test results, the District shall select a single mix which will most economically provide a permeability of 1×10^{-7} cm/sec or less after the addition of bentonite.
- The selected mix shall then be split into 3 samples. Two, 4, and 6 percent bentonite by dry weight shall be added to each of the 3 moist samples respectively. Each sample shall be sluiced with bentonite slurry to obtain a 3 to 6 inch slump. Each sample shall then be split into 2 specimens and fixed wall permeability tests run on each using the same test procedures outlined previously in this section. The length of test should be 24 to 48 hours. From this data, a plot of permeability vs. total percent bentonite will be made.
- A mixture which most economically meets or exceeds the permeability requirements will then be selected by the District for further evaluation as the backfill mixture.

5.1. Borrow Soil Optimization Testing. Optimization tests shall also be performed on the borrow material only. In this situation only the amounts of bentonite and water shall be varied. The last two steps of the above procedure shall also be carried out on the borrow material.

6. Preparation of Backfill Mixture For Compatibility Testing. One composite sample shall be permeameter tested at two percent higher bentonite content than selected during the optimization testing phase. The other composite sample will be permeameter tested at twice that percent bentonite. Two sets of compatibility tests (optimum+2% and twice [optimum+2%] bentonite)

also will be performed with the borrow soil only. Enough bentonite slurry shall be added to the reconditioned backfill mixture to achieve a slump in the range of 3 to 6 inches according to ASTM Test Method C 143-71 for determining concrete slump. The backfill mixture shall be stored in sealed containers at room temperature until loading into the permeameters for permeability testing.

7. Testing of Backfill Mixture. Atterberg limits, grain size analysis (mechanical analysis and hydrometer), moisture content, and specific gravity shall be run on the selected backfill mixture. A chemical analyses shall be performed on the selected backfill mixture as outlined in paragraph 3.1.

7.1. Initial Permeability Tests. One fixed wall permeability test shall be performed on each of the final backfill mixtures (borrow soil only and borrow soil plus in situ slurry wall soil) at optimum+2% bentonite using slurry mix water as the permeant to provide an initial estimate of the permeability. The length of this test shall be 24 to 48 hours.

8. Evaluate Permeant Effects. Three flexible wall permeameters shall be loaded with the selected backfill mixture, backpressure saturated, and leached with slurry mix water until one pore volume has passed through. Then two of the the backfill mixtures shall be leached with the contaminated groundwater samples until at least two pore volumes have passed through. The third specimen shall serve as a control test. It will be leached with only slurry mix water throughout the duration of the test. The time taken for each pore volume of fluid to move through the specimens shall be noted.

The following hydraulic gradients shall be applied to the specimens:
- 28 for the control sample which uses only slurry mix water as the permeant. Confining pressure = 5 psi.
- 28 for one of the samples using ground water as the permeant. Confining pressure = 5 psi.
- 56 for the other sample using groundwater as the permeant. Confining pressure = 5 psi.

The specimens shall be placed into the cells manually in order to reduce the amount of entrapped air. Porous stones (25 to 50 micron opening), with glass fiber filter paper (Whatman type 2), placed on the sample side of the stones will allow undisturbed flow of the permeant through the backfill samples. Effluent from the permeameters will be tested for chemical constituents after each pore water volume has passed through each specimen. The following chemical constituents will be tested for: TOC, specific conductivity, bromide, pH, alkalinity, sodium, calcium, chloride, VOA (Volatile Organics), and BNA (Base Neutral Acid Extractible Organics). The latter two methods should check for chemicals on the Priority Pollutant list. These same tests should also be performed on the groundwater prior to permeameter testing. This data will be used to estimate the amount of contaminant adsorption/desorption taking place.

9. Pre-test and Post-test Sample Examinations and Photo Documentation. Before the backfill mixture is loaded into the permeameters, comments on the general appearance, i.e. color and texture, of the material shall be recorded. The backfill mixture, before loading into the permeameters, shall be photographed. Photographs of the bentonite slurry shall also be taken.

As the permeameters are opened after completion of the tests, a visual examination of the samples shall be performed. The purpose of the visual examination is to determine whether months of testing has altered the general appearance of the sample. Similar comments to those mentioned above in the pre-test examination shall be recorded upon visual examination of the post-test backfill materials. Photographs of the backfill materials after testing shall be taken.

10. Reporting of Test Results. The results of the compatibility testing shall be presented to the Omaha District. The reported results should include the following:

- Evaluation of bentonite sources.
- Summary of bentonite slurry preparation.
- Chemical and physical test results of borrow sources.
- Summary of optimization testing performed and results of optimization testing.
- Summary of backfill preparation procedures and results from tests performed on backfill mixture.
- Results of all permeability tests performed on backfill mixtures including chemical analyses of the effluent. Permeabilities should be computed for each pore volume of fluid passing through each specimen.
- Test results of permeability tests performed on the aquitard soil.
- Pre-test and post-test sample examinations.

TREATABILITY STUDY FLOW CHART
 ROCKY MOUNTAIN ARSENAL
IN SITU AND BORROW SOILS

GROUNDWATER
 CHEMICAL TESTS
 (PARA. 8)

BENTONITE
 (PARA. 2)
 FREE SWELL TESTS

CHOOSE 1
 ↓

SLURRY PREPARATION
 (PARA. 2.1)
 CHARACTERIZATION TESTS

BORROW SOIL
 SEE BOX ①, BORROW
 SOILS ONLY CHART

IN SITU SOILS
 (PARA. 4)
 COMBINE SOILS FROM FOLLOWING
 BORINGS: 11, 24, 9, 10, 26, 18
 DIVIDE INTO 2 COMPOSITE SAMPLES
 GRAIN SIZE, A.L., W% OF EACH
 COMPOSITE

OPTIMIZATION TESTING (1)
 (PARA. 5)
 OVEN DRY BORROW AND 1 COMPOSITE
 MIX BORROW AND IN SITU SOIL TO
 PRODUCE SAMPLES WITH, 20,
 30, 40, 50, AND 60% FINES
 PLOT DRY DENSITY VS. % FINES
 FIXED WALL PERMEABILITY TESTS
 8-24 HRS, TAP WATER
 SELECT MOST ECONOMICAL MIX

OPTIMIZATION TESTING (2)
 (PARA. 5)
 ADD BENTONITE SLURRY (2, 4, AND 6%
 BENTONITE, 3 TO 6 INCH SLUMP)
 RUN 2 FIXED WALL PERMEAMETER
 TESTS FOR EACH % BENTONITE,
 24-48 HRS.
 PLOT k VS. % BENTONITE

SELECT LOWEST % BENTONITE WITH
 $k \leq 1 \times 10^{-7}$ CM/SEC

BACKFILL MIXTURE(S)
 ONE COMPOSITE: OPTIMUM + 2% BENTONITE
 ONE COMPOSITE: TWICE [OPTIMUM + 2%]
 BENTONITE
 CHEMICAL & CHARACTERIZATION TESTS
 (PARA. 7)
 INITIAL FIXED WALL PERMEABILITY
 TEST (PARA. 7.1)

CONT.

PERMEAMETER TESTS
(PARA. 8)

FOR BOTH MIXTURES:

CONTROL + MIX WATER ONLY, $i = 28$

GROUNDWATER PERMEANT, $i = 28$

GROUNDWATER PERMEANT, $i = 56$

CHEMICAL TESTS ON EFFLUENTS

REPORT (PARA. 10)

TREATABILITY STUDY FLOW CHART
 ROCKY MOUNTAIN ARSENAL
BORROW SOIL ONLY

① CHARACTERIZATION TESTS (PARA. 3)
 CHEMICAL TESTING (PARA 3.1)
 SAMPLE PREPARATION (PARA. 3.2)

② OPTIMIZATION TESTING
 (PARA. 5.1)
 24-48 HR. PERMEABILITY TESTS
 2, 4, AND 6 PERCENT BENTONITE

LOWEST % BENTONITE WITH
 $k \leq 1 \times 10^{-7}$ CM/SEC

③ BACKFILL MIXTURE TESTING
 CHEMICAL AND CHARACTERIZATION
 (PARA 7.) OPTIMUM + 2% BENTONITE
 TWICE OPTIMUM + 2% BENTONITE
 INITIAL PERMEABILITY TEST
 24-48 HR. OPTIMUM + 2% BENTONITE
 (PARA. 7.1)

④ PERMEAMETER TESTING
 (PARA. 8)

<u>OPTIMUM + 2% BENTONITE</u>	<u>TWICE OPTIMUM + 2% BENTONITE</u>
CONTROL - MIX WATER ONLY $\lambda = 28$	CONTROL - MIX WATER ONLY $\lambda = 28$
GROUNDWATER PERMEANT $\lambda = 28$	GROUNDWATER PERMEANT $\lambda = 28$
GROUNDWATER PERMEANT $\lambda = 56$	GROUNDWATER PERMEANT $\lambda = 56$

REPORT (PARA, 10)

RMA LIME SETTLING BASINS COMPATIBILITY STUDY (PROPOSED REVISION)

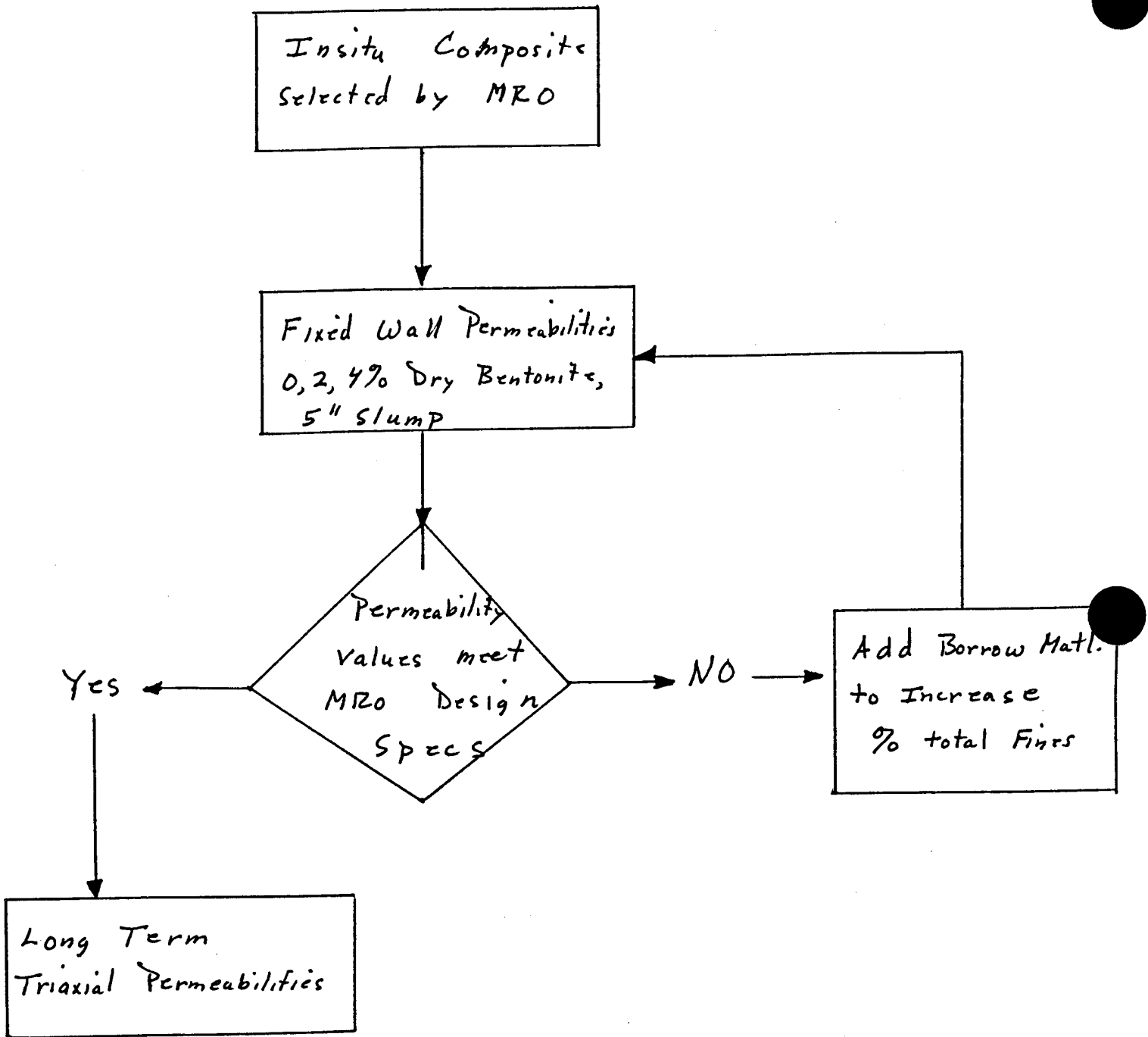
1. Compare bentonites using free swell test and filter cake compatibility test (Use fixed wall permeameters for filter cake test.)
2. Thoroughly composite samples from LSB0009, LSB 0024, LSB 0026, LSB 0023, LSB 0010, LSB 0017, LSB0022, LSB 0025).
3. Skip the "Dry Density vs % Fines" step using the constant volume molds due to poor correlations.
4. Skip the fixed wall permeability tests using non-bentonite mixes
5. Make up 3 samples (2 specimens each) using the composite insitu material (from step 2) and 0, 2, and 4% dry bentonite. Adjust composite moisture content to simulate field moisture prior to adding the dry bentonite. MRO geotech will provide the MRD Lab with the required field moisture content value.
6. Add 40 second march funnel viscosity bentonite slurry to each of the 3 soil bentonite mixes (from step 5) to obtain an approximate 5" slump.
7. Run fixed wall permeability tests on the 3 soil-bentonite mixes (6 tests total).
8. Plot "Total % Bentonite vs. Permeability." If the permeability values meet MRO design requirements, proceed with step 13. If not, go to step 9. A4-9

9. Repeat steps 2 thru 7 using the composite insitu material plus the selected borrow material to obtain a new composite with approximately 10% more fines than the original insitu composite. Adjust moisture contents of insitu and borrow material to simulate field moistures prior to adding dry bentonite. MRO geotech will provide input into which borrow matl. will be used along with the appropriate field moisture contents.
10. Plot "Total % Bentonite vs Permeability." If the permeability values meet MRO design requirements, proceed with step 13. If not, go to step 11.
1. Repeat steps 2 thru 7 using the composite insitu material plus borrow material to obtain a new composite with approximately 20% more fines than the original insitu composite.
2. Plot "Total % Bentonite vs Permeability." If the permeability values meet MRO design requirements, proceed with step 13. If not, repeat steps 2 thru 7 using a new composite with approximately 30% more fines than the original insitu composite.
3. Run 3 triaxial long term permeabilities on the selected mix:
 - Control test (Site water only) - Use selected mix w/ % bentonite resulting in a permeability near the upper limit of the design permeability. (e.g. 1×10^{-7} cm/sec @ 2% bentonite)
4. Run the second permeability test using the same mix as the control test but with leachate.

c) Run the third test using the selected mix w/ % bentonite resulting in a permeability near the lower end of the permeability range for that mix. (e.g. 1×10^{-8} cm/sec @ 4% bentonite). Run the test with leachate.

The intent of the above revisions is to provide a more logical and hopefully more economical approach to selecting permeability mixes which better simulate actual slurry wall construction mixes. It assumes we start with a ~~best~~ worst case insitu material and add up to 4% dry bentonite. Obviously, this should provide the most economical mix if design permeability requirements are met. The 4% cutoff is an arbitrary upper limit whereby we assume it would be more economical to add borrow fines rather than additional dry bentonite above this limit. If you agree with this revision, please submit a new test request with these ~~new~~ changes to the MRD Lab as soon as possible.

Dave Jones



UPDATED TEST REQUEST
ROCKY MOUNTAIN ARSENAL
TREATABILITY STUDY

OCTOBER 10, 1990

1. Introduction. The following is an outline of the test procedures to be used for the Rocky Mountain Arsenal Lime Settling Basins Compatibility Study. Borrow material, slurry mix water, contaminated leachate, soil from the slurry wall borings and bentonite are already at the Lab. A schematic of the compatibility testing program is attached.

1.1. Geotechnical Test Methods. Where applicable, geotechnical testing shall be conducted in accordance with the Army Corps of Engineers Manual EM 1110-2-1906.

2. Determination of Bentonite Source. Potential bentonite sources must be premium-grade, ultrafine, natural sodium cation-based montmorillonite powders (Wyoming-type bentonite) that conforms to standards set forth in API Specification 13A, Sections 4, 8, and 9. Chemically treated bentonite will not be allowed. The bentonite samples at the Lab shall be tested for free swell and filter cake compatibility testing using groundwater samples selected by the District. In addition, as a control, one free swell test shall be run on each bentonite sample using the anticipated slurry mix water. The free swell test method is described in EPA Report Number PB 87-229688 (EPA, 1987). A bentonite source will be chosen for further testing based on free swell and filter cake compatibility results.

2.1. Bentonite Slurry Preparation. The bentonite slurry shall be prepared by mixing the slurry mix water with the previously selected bentonite source. The slurry shall be mixed with enough water to pass through a Marsh funnel in 40 to 50 seconds. The slurry shall be tested for density, moisture content, pH, and viscosity.

3. Borrow Sources. The borrow samples shall be stored in separate containers. All potential borrow material shall be tested for natural moisture content, Atterberg limits, grain size analysis (sieve and hydrometer methods), and specific gravity. No deleterious material will be allowed in any borrow material.

3.1 Chemical Analysis. The borrow material must be tested to verify it is free of contamination as determined by TCLP, TOC (Total Organic Carbon), sodium, calcium, magnesium, potassium, pH, and cation exchange capacity.

3.2. Preparation of Borrow Materials. Enough borrow (clay and random fill) for optimization testing will be oven-dried at 65 degrees Celsius for 2 to 4 days. The clays shall then be broken up, thoroughly mixed, and passed through a U.S. Standard Sieve No. 4. The anticipated slurry mix tap water shall be added to the dried and mixed materials until the original field water content is reached. The reconditioned borrow shall then be stored for 3 to 6 days in sealed containers at room temperature. During this storage period the samples should be mixed daily.

4. In Situ Slurry Wall Soil. Samples from the following Lime Settling Basins borings shall be thoroughly mixed to form one composite sample: 11, 24, 9, 10, 26, and 18. Grain size analysis (sieve and hydrometer methods), Atterberg limits, and moisture content shall be run on this composite sample.

5. Optimization Testing. Optimization tests will be performed to determine the most economical combination of materials for the backfill mixture. The percentage of fines, bentonite, coarse grained material, and water will be varied to produce the most economical backfill mixture which meets the 1×10^{-7} cm/sec permeability criteria.

The optimization test procedure shall consist of the following steps:

- a. Prepare 3 samples (2 specimens each) using the composite insitu material. If additional water is necessary to simulate field moisture content, RMA tap water will be added at this time. Dry bentonite will be added to the samples to obtain 0, 2, and 4% bentonite by weight.
- b. Add bentonite slurry with a viscosity of 40 seconds (Marsh funnel) to each sample (from step a) to obtain an approximate 5 inch slump.
- c. Run fixed wall permeability tests on the 3 soil-bentonite mixtures (6 tests total). Test length will be 24 to 48 hours.
- d. Plot "Total Percent Bentonite vs. Permeability". If the permeability values are not less than or equal to 1×10^{-7} cm/sec, proceed with step e. Otherwise go on to paragraph 5.1.
- e. Repeat steps a through c using the composite insitu material plus the clay borrow material to obtain a new composite with approximately 10% more fines than the original insitu composite. Adjust moisture contents as necessary to simulate field moisture conditions.
- f. Plot "Total Percent Bentonite vs. Permeability". If permeability values are not less than or equal to 1×10^{-7} cm/sec proceed with step g. Otherwise go on to paragraph 5.1.
- g. Repeat steps a through c using the composite insitu material plus the clay borrow material to obtain a new composite with approximately 20% more fines than the original insitu composite. Adjust moisture contents as necessary to simulate field moisture conditions.
- h. Plot "Total Percent Bentonite vs. Permeability". If permeability values are not less than or equal to 1×10^{-7} cm/sec proceed with step i. Otherwise go on to paragraph 5.1.
- i. Repeat steps a through c using the composite insitu material plus the clay borrow material to obtain a new composite with approximately 30% more fines than the original insitu composite. Adjust moisture contents as necessary to simulate field moisture conditions.
- j. Plot "Total Percent Bentonite vs. Permeability". If permeability values are not less than or equal to 1×10^{-7} cm/sec notify MRD-GF.

5.1. Borrow Soil Optimization Testing. Optimization tests shall also be performed using the random fill borrow material in place of the insitu soil.

5.2. If none of the insitu soil-fines-bentonite mixtures results in a permeability on the order of magnitude of 10^{-7} cm/sec while mixture(s) of random fill borrow-fines-bentonite do, then long-term permeability tests will be performed using only random fill borrow as the principal soil constituent. If the desired permeability is obtained by mixtures including insitu soil and

random fill borrow, long-term permeability tests will be performed using both principal soil constituents.

6. Preparation of Backfill Mixture For Compatibility Testing.

Soils to be used for long-term permeability tests shall be prepared as specified in paragraph 3.2, Preparation of Borrow Materials. Prepared backfill mixtures shall be stored in sealed containers at room temperature until loading into the permeameters for permeability testing.

7. Testing of Backfill Mixture. Atterberg limits, grain size analysis (mechanical analysis and hydrometer), moisture content, and specific gravity shall be run on the selected backfill mixtures.

8. Evaluate Permeant Effects. Three flexible wall permeameters shall be loaded with the backfill mixture, backpressure saturated, and leached with slurry mix water until one pore volume has passed through. Then two of the the backfill mixtures shall be leached with the contaminated groundwater samples until at least two pore volumes have passed through. The third specimen shall serve as a control test. It will be leached with only slurry mix water throughout the duration of the test. The time taken for each pore volume of fluid to move through the specimens shall be noted. The hydraulic gradient will be 28 with a confining pressure of 5 psi. The mixtures shall be as follows:

- a. Control (tap water only) - the selected mix with the percent bentonite which produced a permeability near 1×10^{-7} cm/sec during optimization testing.
- b. Same mix and percent bentonite as control with contaminated groundwater as permeant after the first pore volume.
- c. Same mix as control with a higher bentonite content that produces a permeability close to 1×10^{-8} cm/sec, with contaminated groundwater as permeant after the first pore volume.

The specimens shall be placed into the cells manually in order to reduce the amount of entrapped air. Porous stones (25 to 50 micron opening), with glass fiber filter paper (Whatman type 2), placed on the sample side of the stones will allow undisturbed flow of the permeant through the backfill samples. Effluent from the permeameters will be tested for chemical constituents after each pore water volume has passed through each specimen. The following chemical constituents will be tested for: TOC, specific conductivity, bromide, pH, alkalinity, sodium, calcium, chloride, VOA (Volatile Organics), and BNA (Base Neutral Acid Extractible Organics). The latter two methods should check for chemicals on the Priority Pollutant list. These same tests should also be performed on the groundwater prior to permeameter testing. This data will be used to estimate the amount of contaminant adsorption/desorption taking place.

9. Pre-test and Post-test Sample Examinations and Photo Documentation. Before the backfill mixtures are loaded into the permeameters, comments on the general appearance, i.e. color and texture, of the material shall be recorded. The backfill mixture, before loading into the permeameters, shall be photographed. Photographs of the bentonite slurry shall also be taken.

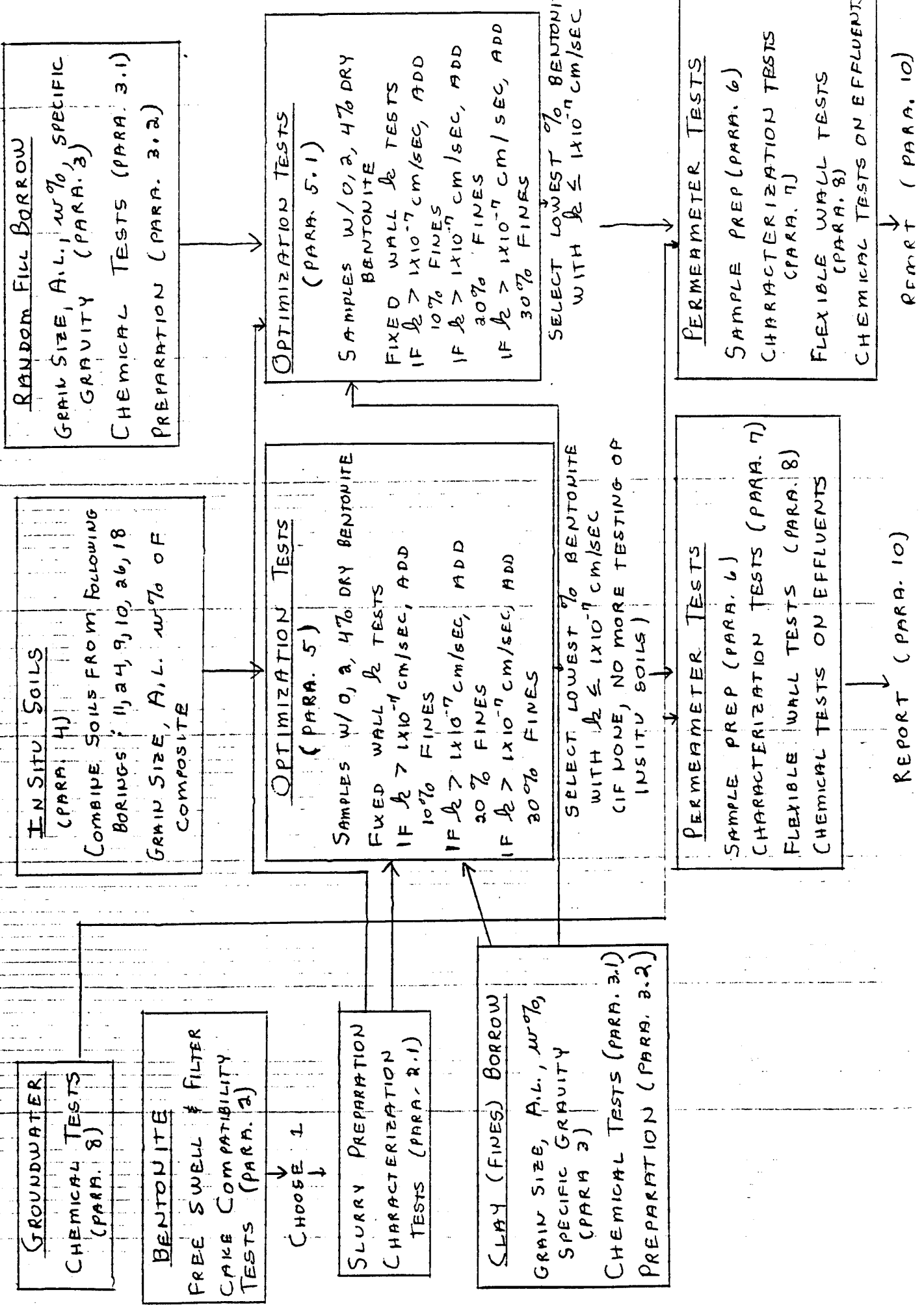
As the permeameters are opened after completion of the tests, a visual examination of the samples shall be performed. The purpose of the

visual examination is to determine whether months of testing has altered the general appearance of the sample. Similar comments to those mentioned above in the pre-test examination shall be recorded upon visual examination of the post-test backfill materials. Photographs of the backfill materials after testing shall be taken.

10. Reporting of Test Results. The results of the compatibility testing shall be presented to the Omaha District. The reported results should include the following:

- Evaluation of bentonite sources.
- Summary of bentonite slurry preparation.
- Chemical and physical test results of borrow sources.
- Summary of optimization testing performed and results of optimization testing.
- Summary of backfill preparation procedures and results from tests performed on backfill mixture.
- Results of all permeability tests performed on backfill mixtures including chemical analyses of the effluent. Permeabilities should be computed for each pore volume of fluid passing through each specimen.
- Pre-test and post-test sample examinations.

ROCKY MOUNTAIN ARSENAL UPDATED TREATABILITY STUDY FLOW CHART



GROUNDWATER
CHEMICAL TESTS
(PARA. 8)

BENTONITE
FREE SWELL & FILTER
CAKE COMPATIBILITY
TESTS (PARA. 2)

CHOOSE 1
↓

SLURRY PREPARATION
CHARACTERIZATION
TESTS (PARA. 2.1)

CLAY (FINES) BORROW
GRAIN SIZE, A.L., W%,
SPECIFIC GRAVITY
(PARA. 3)
CHEMICAL TESTS (PARA. 3.1)
PREPARATION (PARA. 3.2)

IN SITU SOILS
(PARA. 4)
COMBINE SOILS FROM FOLLOWING
BORINGS: 11, 24, 9, 10, 26, 18
GRAIN SIZE, A.L. W% OF
COMPOSITE

OPTIMIZATION TESTS
(PARA. 5)
SAMPLES W/O, 2, 4% DRY BENTONITE
FIXED WALL k_f TESTS
IF $k_f > 1 \times 10^{-7}$ CM/SEC, ADD
10% FINES
IF $k_f > 1 \times 10^{-7}$ CM/SEC, ADD
20% FINES
IF $k_f > 1 \times 10^{-7}$ CM/SEC, ADD
30% FINES
SELECT LOWEST % BENTONITE
WITH $k_f \leq 1 \times 10^{-7}$ CM/SEC
(IF NONE, NO MORE TESTING OF
INSITU SOILS)

OPTIMIZATION TESTS
(PARA. 5.1)
SAMPLES W/O, 2, 4% DRY
BENTONITE
FIXED WALL k_f TESTS
IF $k_f > 1 \times 10^{-7}$ CM/SEC, ADD
10% FINES
IF $k_f > 1 \times 10^{-7}$ CM/SEC, ADD
20% FINES
IF $k_f > 1 \times 10^{-7}$ CM/SEC, ADD
30% FINES
SELECT LOWEST % BENTONITE
WITH $k_f \leq 1 \times 10^{-7}$ CM/SEC

RANDOM FILL BORROW
GRAIN SIZE, A.L., W%, SPECIFIC
GRAVITY (PARA. 3)
CHEMICAL TESTS (PARA. 3.1)
PREPARATION (PARA. 3.2)

PERMEAMETER TESTS
SAMPLE PREP (PARA. 6)
CHARACTERIZATION TESTS (PARA. 7)
FLEXIBLE WALL TESTS (PARA. 8)
CHEMICAL TESTS ON EFFLUENTS

REPORT (PARA. 10)

PERMEAMETER TESTS
SAMPLE PREP (PARA. 6)
CHARACTERIZATION TESTS
(PARA. 7)
FLEXIBLE WALL TESTS
(PARA. 8)
CHEMICAL TESTS ON EFFLUENTS

REPORT (PARA. 10)



EA ENGINEERING,
SCIENCE, AND
TECHNOLOGY, INC.

15 Loveton Circle
Sparks, MD 21152
(301) 771-4950

Atlanta • Baltimore • Chicago • Dallas • Lincoln

Angeles • New Jersey • New York • San Francisco

LETTER OF TRANSMITTAL

DATE 24 August 1990	JOB NO. 10424.03
ATTENTION Mr. Dave Jaros	
RE: Kane & Lombard Superfund	

TO USACE
MRD Laboratories
420 South 18th Street
Omaha, NE 68102-2586

WE ARE SENDING YOU Attached Under separate cover via _____ the following items:
 Shop drawings Prints Plans Samples Specifications
 Copy of letter Change order _____

COPIES	DATE	NO.	DESCRIPTION
1			Memo from Geo Con

THESE ARE TRANSMITTED as checked below:
 For approval Approved as submitted Resubmit _____ copies for approval
 For your use Approved as noted Submit _____ copies for distribution
 As requested Returned for corrections Return _____ corrected prints
 For review and comment _____
 FOR BIDS DUE _____, 19____ PRINTS RETURNED AFTER LOAN TO US

REMARKS Dave,
I received a copy of this memo from Geo Con concerning bentonite specified
for use at K&L. This may be of interest to you in considering revisions to
USACE guide specs for hazardous waste slurry wall construction.

COPY TO File SIGNED Gregory E. Johnson, P.E., CHMM
 Project Manager

AE-1

GEO·CON[®] INC.

GEOTECHNICAL CONTRACTING

S9-H029 Letter No. 045

August 8, 1990

Department of the Army
Baltimore District, Corps of Engineers
P. O. Box 242
Fort George G. Meade, MD 20755-0242



Attn: Mr. Bob Craig

Bentonite Clay
API 13A Section 5
Slurry Wall
Kane and Lombard Superfund Site
Contract DACW45-89-C-0507
Baltimore, Maryland

Dear Mr. Craig:

As you know a new bentonite product was specified for use in the slurry wall on the above referenced project. This new product is tentatively specified by the American Petroleum Institute (API) under Specification 13A, Section 5: Nontreated Bentonite (Tentative). The usual product is premium grade, 90 bbl/ton yield, API 13A Section 4 bentonite clay. This letter presents our evaluation of this product based on our experience at the Kane and Lombard project.

At the Kane and Lombard project we mixed the bentonite slurry to a 40 MFV in our 5 cy colloidal mixer. This mixer fully hydrates the slurry during the retention time of the plant. Our excavations encountered two different areas; 1) a 15 ft. deep excavation through primarily clay, and 2) a 30 ft. deep excavation through primarily refuse. Typically, we would expect a usage factor of 4-5 pounds of bentonite per square foot in the clay excavation and 10-15 pounds per square foot in the refuse. On this project our usage was 10-12 pounds per square foot in both areas. In addition, in the refuse our filtrate loss in the trench occasionally exceeded 40 cc, however, our trench was stable and we had no cave-ins. All permeability tests were acceptable and a high quality slurry wall is now in place.

We find two areas of concern with the performance of this new bentonite product. First, in the area of normal slurry trenching, the usage was excessive and unexpected. Second, in the refuse area the usage did not respond adequately to the refuse conditions; i.e. our filtrate was excessive and a cave-in was only avoided by our extra efforts. Considering the premium price of this new product, the results described above were very disappointing.

A review of the Section 5 specification may provide some of the answers. This clay is treated with a deflocculant (sodium hexametaphosphate) prior to testing the yield. This technique results in erroneous and misleading results and is totally different from any other API test. In our opinion, the Section 5 product performed like a sub-API 13A product normally used in the foundry industry (yield = 50-80 bbl/ton).

P.O. Box 17380 • Pittsburgh, PA 15235 • Tel (412) 856-7700 • FAX (412) 373-3357

Texas Office (817) 383-1400
California Office (408) 453-3587

Florida Office (813) 647-5888
New Jersey Office (609) 848-2220

GEO·CON® INC.

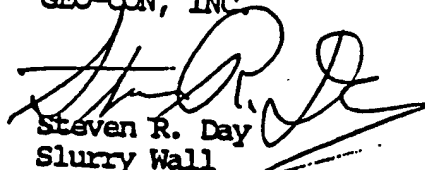
August 8, 1990
Page 2

We would not recommend this product for slurry trenching. If the aim of this new specification is a better product, the specification has failed. If bentonite/leachate compatibility is a concern, it is recommended engineering practice to test the compatibility of various bentonite products prior to specifying the bentonite. Therefore, an adequate testing program will determine what type of bentonite is acceptable. Our solution to buying quality bentonite has been to rely on a limited number of vendors with a proven product and perform regular testing of our own. Our suppliers of API 13A, Section 4 bentonite have a high quality base clay and add only about 0.5 pounds of polymer additive per ton of bentonite (0.025%). This generally results in a much more predictable product. We do not recommend that so called "contaminate resistant" bentonites with proprietary treatments. As slurry specialists we cannot recommend bentonite with excessive polymer treatment, however, bentonite is, after all, only soil and some limited treatment can be beneficial. In the end it takes qualified slurry specialists in the field and knowledgeable engineers to produce quality installations.

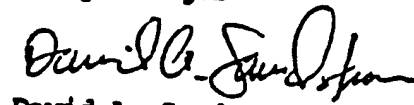
This letter is provided to you for informational purposes only, no response is necessary. We do, however, wish to register our dissatisfaction with this new product and specification so that the Corps of Engineers and API can take appropriate measures in the future.

Sincerely,

GEO·CON, INC.



Steven R. Day
Slurry Wall
Group Manager



David A. Sandstrom
Liner Division
Group Manager

SRD/DAS/lmw

cc: American Petroleum Institute
Production Department
2531 One Muir Place
Dallas, TX 75202-3904
Attn: Mike Laudermilk

J. Kohli

ZERO ACCIDENTS

SECTION 02214

SOIL-BENTONITE SLURRY CUTOFF WALL

INDEX

- | | |
|---|---------------------------------|
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| 2. APPLICABLE PUBLICATIONS. | 9. MATERIALS. |
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| 4. DEFINITIONS. | 11. SLURRY TRENCH CONSTRUCTION. |
| 5. SUBMITTALS. | 12. QUALITY CONTROL. |
| 6. QUALIFICATIONS FOR SLURRY TRENCH CONSTRUCTION. | 13. QUALITY ASSURANCE. |
| 7. SUBSURFACE INVESTIGATIONS. | 14. MEASUREMENT. |
| | 15. PAYMENT. |

1. SCOPE. The work covered by this section of the Specifications consists of furnishing all parts, labor, equipment, and materials and of performing all operations in connection with constructing the soil-bentonite slurry cutoff wall, hereinafter referred to as the slurry trench, in accordance with these specifications and contract drawings.

2. APPLICABLE PUBLICATIONS. The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the reference thereto.

- 2.1. AMERICAN PETROLEUM INSTITUTE (API) STANDARD SPECIFICATIONS.
- | | |
|--------------------|--|
| Code RP13B | Recommended Practice Standard Procedures for |
| 12th Ed. Sept 1988 | Testing Drilling Fluids; and Supplements |
| Spec. 13A | Specification for Oil-Well Drilling Fluid |
| Sections 3,5,6, | Materials |
| 7, and 8 | |
| 12th Ed. Sept 1988 | |
- 2.2. AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS.
- | | |
|-----------|--|
| D 1140-57 | Materials Finer than 75 μm (No. 200) Sieve in |
| | Mineral Aggregates by Washing |
| C 136-83 | Sieve Analysis of Fine and Coarse Aggregates |
| D 2217-66 | Wet Preparation Method |
| C 143-78 | Slump of Portland Cement Concrete |
| D 698-78 | Test for Moisture-Density Relations of Soils and |
| | Soil-Aggregate Mixture, Using 5.5-pound Hammer |
| | and 12-inch Drop |
| D 422-63 | Particle-Size Analysis of Soils |
| D 1586-67 | Standard Penetration Test |
| D 1587-83 | Thin Walled Tube Sampling of Soils |
| D 4318-84 | Liquid Limit, Plastic Limit, and Plasticity |
| | Index of Soils |
- 2.3. CORPS OF ENGINEERS MANUALS.
- | | |
|---------------------------------|--------------------------|
| EM 1110-2-1906 | Laboratory Soils Testing |
| Appendix VI | |
| (Dated 20 August with Change 2) | |
| EM 1110-2-3506 | Grouting Technology |

7.6. DISPOSAL OF DRILL CUTTINGS. All drill cuttings will be handled and disposed in accordance with SECTION: HANDLING AND DISPOSAL OF CONTAMINATED MATERIALS.

8. NOT USED.

9. MATERIALS. The requirements for the materials to be utilized in the slurry trench construction are as follows.

9.1. BENTONITE. The bentonite shall be sodium cation base montmorillonite powder (Premium Grade Wyoming-type bentonite) that conforms to the standards set forth in API Specification 13A, Section 3, 5, 6, 7, and 8 as last revised. No chemically treated bentonite will be allowed. The Contractor shall furnish to the Contracting Officer a certificate of compliance and a copy of the test reports from the bentonite manufacturer for each lot of bentonite shipped to the site stating that the bentonite complies with all applicable standards. No bentonite from the bentonite manufacturer shall be used prior to acceptance by the Contracting Officer. All bentonite will be subject to inspection, sampling, and verification of quality of testing by or under the supervision of the Government. Bentonite not meeting specifications shall be promptly removed from the site of the work and replaced with bentonite conforming to specifications requirements at the Contractor's expense. Bentonite shall be protected from moisture during transit and storage.

9.2. WATER. The Contractor shall supply all water required for mixing with bentonite to produce slurry. The water shall be clean, fresh, and comply with the standards specified below.

- a. A pH equal to 7.0 ± 1.0 .
- b. Total dissolved solids not greater than 500 parts per million.
- c. Oil, organics, acids, alkali, or other deleterious substances not greater than 50 ppm each.
- d. Hardness less than or equal to 50 ppm.
- e. Ground water from the site is specifically excluded from use.

The Contractor shall furnish water quality test results for water used for mixing the bentonite slurry to assure conformance with the above limits.

9.3. BENTONITE SLURRY. The bentonite slurry for supporting the sides of the trench and that mixed with the backfill shall consist of a stable colloidal suspension of powdered, premium-grade natural bentonite in water. It is the responsibility of the Contractor that the slurry meets the necessary properties. The properties of the slurry used in all construction sequences shall be in accordance with the testing procedures described in API Code RP13B and shall conform to the following requirements:

9.3.1. Initial Bentonite Slurry Mixture. At the time of introducing bentonite slurry into the trench excavation, the slurry mixture shall have a minimum apparent viscosity of 40 seconds as measured by the Marsh funnel. The slurry density shall be a minimum of 65 pounds per cubic foot. The water loss shall not be greater than 30 cubic centimeters in 30 minutes as measured by a filter press at 100 psi. The pH shall not be less than 8.0. Mixture adjustment shall conform to the requirements in subparagraph: Additional Bentonite.

9.3.2. Trench Bentonite Slurry Mixture. The minimum apparent viscosity of the bentonite slurry mixture in the trench at any time shall be 40 seconds as measured by the Marsh funnel and the maximum shall be low enough to flow through the Marsh funnel. The density of the slurry mixture at the time

MOISTURE DETERMINATIONS

Project **RMA**
 Location Samples **(SAVE SOIL)**
 Lab. Serial No. _____ Date Tested _____

Type of Test	COELSB 0025	25 BORE 007	25 BORE 006	COELSB 0010	COELSB 0022	COELSB 0023	COELSB 0026	COELSB 0024
Pan No.	P-67	P-65	P-64	P-63	P-62	P-66	P-69	P-50
Weight of Pan and Wet Soil	122.5	129.8	131.9	113.2	154.9	186.7	127.1	134.6
Weight of Pan and Dry Soil	106.6	119.4	123.1	99.9	138.3	159.5	111.8	124.0
Weight of Pan	53.0	53.3	53.8	53.0	53.0	53.0	52.4	53.0
Weight of Dry Soil								
Weight of Moisture								
Percent Moisture	29.7	15.7	12.7	28.4	19.5	25.5	25.8	14.9
Average Moisture								

Type of Test	COELSB 0017	COELSB 0009	25 BORE 008	25 BORE 009				
Pan No.	P-58	P-57	P-56	P-55				
Weight of Pan and Wet Soil	147.0	150.1	153.1	140.2				
Weight of Pan and Dry Soil	129.3	132.6	141.2	129.2				
Weight of Pan	52.5	53.7	53.8	53.2				
Weight of Dry Soil								
Weight of Moisture								
Percent Moisture	23.0	22.2	13.6	14.5				
Average Moisture								

Remarks: _____

Tested by: _____ Date: _____

Computed by: _____ Date: _____

Checked by: _____ Date: _____

NR Form 464
 (29 Jul 46)

Replaces Lab. Form No. 8

MOISTURE DETERMINATIONS

Project RMA							
Location Samples Random Fill Samples 1 + 2							
Lab. Serial No.				Date Tested			
Type of Test	Sample 1		Bag				
Pan No.	7		8				
Weight of Pan and Wet Soil	188.0		247.6				
Weight of Pan and Dry Soil	165.8		237.1				
Weight of Pan	56.8		56.8				
Weight of Dry Soil							
Weight of Moisture							
Percent Moisture	20.4		5.8				
Average Moisture							
Type of Test	Sample 2		Bag				
Pan No.	9		10				
Weight of Pan and Wet Soil	180.0		230.1				
Weight of Pan and Dry Soil	164.2		213.6				
Weight of Pan	56.8		56.8				
Weight of Dry Soil							
Weight of Moisture							
Percent Moisture	14.7		10.5				
Average Moisture							
Remarks:				Tested by:		Date:	
				Computed by:		Date:	
				Checked by:		Date:	

NRH Form 464
(29 Jul 46)

Replaces Lab. Form No. 8

M-43 78

LIQUID AND PLASTIC LIMIT TESTS
For use of this form, see EM 11102-1906.

(A)

DATE 9-20-90

PROJECT ROCKY MOUNTAIN ARSENAL

BORING NO. COFLSB 0025

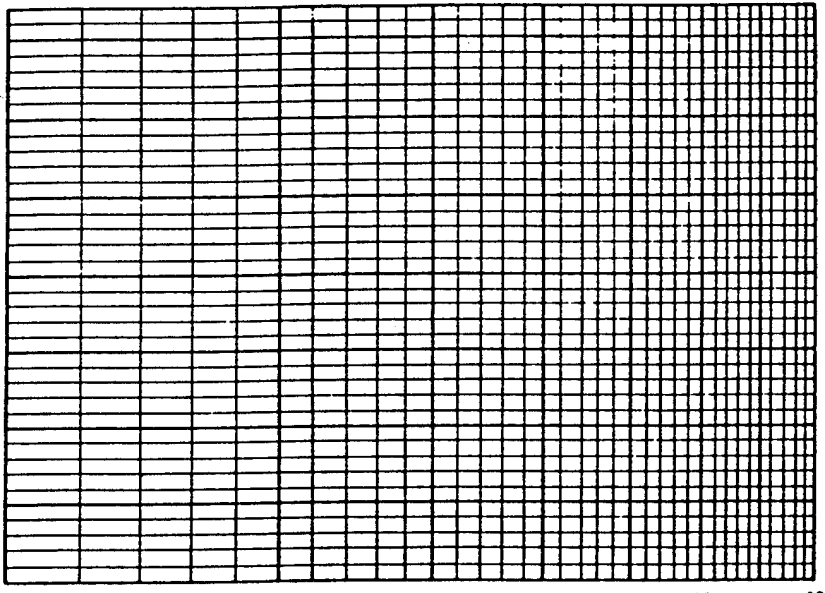
SAMPLE NO. COMPOSITE

LIQUID LIMIT

RUN NO.		1	2	3	4	5	6
WEIGHT IN GRAMS	TARE NO.	5	6				
	TARE PLUS WET SOIL	7.718	5.641				
	TARE PLUS DRY SOIL	5.774	4.36				
	WATER W_w						
	TARE	1.505	1.53				
	DRY SOIL W_s						
WATER CONTENT, % w		45.5	45.3				
NUMBER OF BLOWS		22	25				

(SAVE ^{4.8} H₂O & SOIL)

WATER CONTENT, w, %



LL 45.3
 PL 27.4
 PI 17.9

Symbol from plasticity chart

ML

NUMBER OF BLOWS

PLASTIC LIMIT

PLASTIC LIMIT						NATURAL WATER CONTENT
RUN NO.		1	2	3	4	5
WEIGHT IN GRAMS	TARE NO.	7	8			
	TARE PLUS WET SOIL	3.145	3.280			
	TARE PLUS DRY SOIL	2.792	2.914			
	WATER W_w					
	TARE	1.522	1.531			
	DRY SOIL W_s					
WATER CONTENT, % w		27.8	27.0			
PLASTIC LIMIT						

REMARKS

TECHNICIAN

COMPUTED BY

CHECKED BY

221

GRAIN SIZE ANALYSIS

(A)

Date: 9-20-90

Project No.: _____

Project: ROCKY MOUNTAIN ARSENAL

Location of Sample: COELSB 0025

Sample Description: MOTTLED LIGHT BROWN & GRAY

USCS: _____ AASHTO: _____

Liquid Limit: _____ Plastic Index: _____

Remarks: COMPOSITE 2.5', 5', 7.5', 10', 15', & 20'
(SAVE H2O & SOIL)

- Mechanical analysis
- Hydrometer analysis

Data Sheet 1 - Mechanical

	Initial Sample	After Wash
Dry Sample and Tare=	_____	_____
Tare=	_____	_____
Dry Sample Weight=	<u>105.8</u>	_____
Calculated -200=	_____	_____
Tare For Cumulative Weight Retained=	_____	_____

MECHANICAL ANALYSIS

U.S. STANDARD SIEVE SIZE (MM)

SIEVE NO.

SIEVE NO.	SAMPLE WT. % COARSER	% FINER
76.2	0.0	100.0
38.1	0.0	100.0
19.1	0.0	100.0
9.52	0.0	100.0
4.76	0.0	100.0
PAN	0.0	100.0
TOTAL	0.0	100.0
CTOR	0.0	100.0
.10	0.9452	
.20	5.1	
.40	8.7	95.2
.80	13.8	91.8
.200	35.5	87.0
PAN	69.7	66.4
	105.8	34.1
		100.0
		0.0

er:
ue: 105.8
keheet: mech2

Log: 29805

D-35 10 5 B

LIQUID AND PLASTIC LIMIT TESTS
For use of this form, see EM 11102-1906.

DATE 9-26-90

PROJECT ROCKY MOUNTAIN ARSENAL

BORING NO. COELSB 023

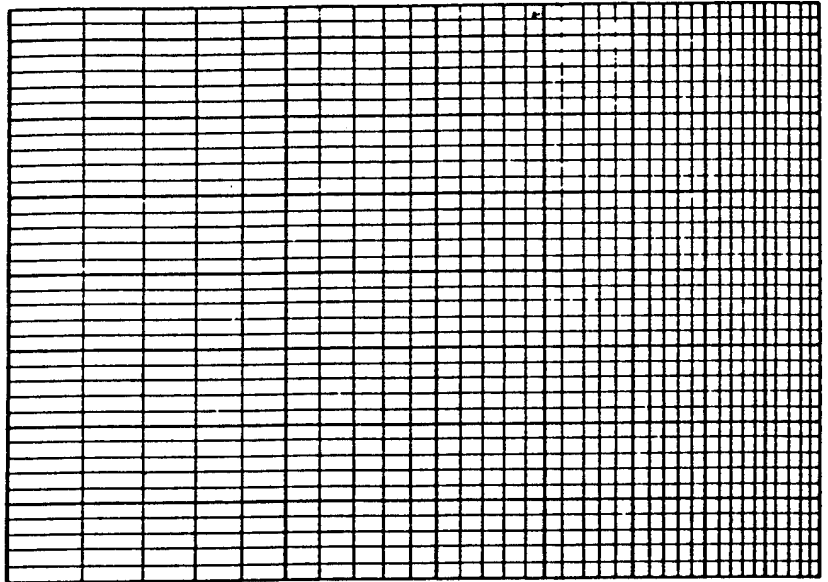
SAMPLE NO. COMPOSITE

LIQUID LIMIT

RUN NO.		1	2	3	4	5	6
TARE NO.		13	14				
WEIGHT IN GRAMS	TARE PLUS WET SOIL	7.902	8.998				
	TARE PLUS DRY SOIL	6.301	7.133				
	WATER	W	W				
	TARE	1.505	1.533				
	DRY SOIL	W	W				
WATER CONTENT, %		w	33.4	33.3			
NUMBER OF BLOWS		23	25				

33.1

WATER CONTENT, w, %



LL 33.0

PL 14.7

PI 18.3

Symbol from
plasticity chart

U
Med
tough

NUMBER OF BLOWS

PLASTIC LIMIT

RUN NO.		1	2	3	4	5	NATURAL WATER CONTENT
TARE NO.		15	16				
WEIGHT IN GRAMS	TARE PLUS WET SOIL	4.350	4.594				
	TARE PLUS DRY SOIL	3.993	4.199				
	WATER	W	W				
	TARE	1.506	1.525				
	DRY SOIL	W	W				
WATER CONTENT, %		w	14.6	14.8			
PLASTIC LIMIT							

REMARKS _____

TECHNICIAN _____

COMPUTED BY _____

CHECKED BY _____

E-67

GRAIN SIZE ANALYSIS

(B)

Date: 9-26-90

Project No.: _____

Project: ROCKY MOUNTAIN ARSENAL

B

Location of Sample: COELSB #23

COMPOSITE

Sample Description: BROWN

USCS: _____

AASHTO: _____

Liquid Limit: _____

Plastic Index: _____

Remarks: _____

Mechanical analysis

Hydrometer analysis

Data Sheet 1 - Mechanical

Initial Sample

After Wash

Dry Sample and Tare= _____

Tare= _____

Dry Sample Weight= 113.0

Calculated -200= _____

Tare For Cumulative Weight Retained= _____

U.S. STANDARD SIEVE SIZE (MM)	SIEVE NO.	Sample Weight	Tare	Cum.	%
-------------------------------	-----------	---------------	------	------	---

MECHANICAL ANALYSIS

U.S. STANDARD SIEVE SIZE (MM)

SIEVE NO.

76.2
38.1
19.1
9.52
4.76
PAN
TOTAL
FACTOR
10.10
10.20
10.40
0.80
0.200
PAN

3 INCH
1 1/2 INCH
3/4 INCH
3/8 INCH
NO. 4

2.00
0.84
0.42
0.177
0.074

SAMPLE WT. % COARSER	% FINER
0.0	100.0
0.0	100.0
0.0	100.0
0.0	100.0
0.0	100.0
0.0	100.0
0.0	100.0
0.0	100.0
0.8850	
0.0	100.0
1.4	98.8
11.0	90.3
43.2	61.8
79.9	29.3
113.0	0.0

ater:
alue: 113

orksheet: mech2

Loc: r28c5

A6-6

M-36 3/8

LIQUID AND PLASTIC LIMIT TESTS
For use of this form, see EM 1110-2-1906.

(C)

PROJECT Rocky Mountain Arsenal
BORING NO. COELSR 0022

DATE 9-20-90

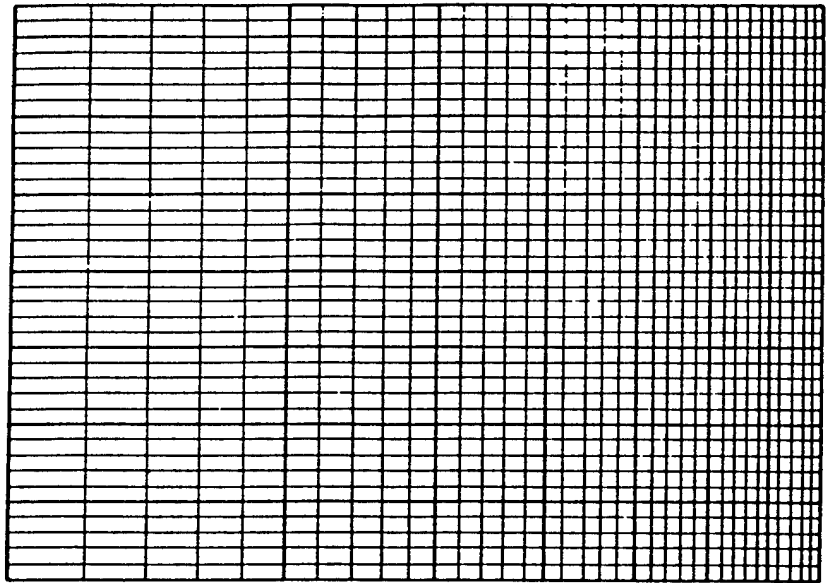
SAMPLE NO. COMPOSITE

LIQUID LIMIT

RUN NO.		1	2	3	4	5	6
TARE NO.		9	10				
WEIGHT IN GRAMS	TARE PLUS WET SOIL	6.503	7.178				
	TARE PLUS DRY SOIL	5.383	5.915				
	WATER						
	TARE	1.528	1.538				
	DRY SOIL						
WATER CONTENT, %		29.1	28.9				
NUMBER OF BLOWS		23	27				

(SAVE H₂O & SOIL)
28.8 29.1

WATER CONTENT, w, %



LL 29.0
 PL 16.1
 PI 12.9

Symbol from plasticity chart

Cl
Med tough

NUMBER OF BLOWS

PLASTIC LIMIT

RUN NO.		1	2	3	4	5	NATURAL WATER CONTENT
TARE NO.		11	12				
WEIGHT IN GRAMS	TARE PLUS WET SOIL	3.631	3.77				
	TARE PLUS DRY SOIL	3.336	3.459				
	WATER						
	TARE	1.502	1.516				
	DRY SOIL						
WATER CONTENT, %		16.1	16.0				
PLASTIC LIMIT							

REMARKS _____

TECHNICIAN _____

COMPUTED BY _____

CHECKED BY _____

14
M-15

GRAIN SIZE ANALYSIS

(C)

Date: 9-20-90

Project No.: _____

Project: ROCKY MOUNTAIN ARSENAL

Location of Sample: COELSB 0022

Sample Description: LIGHT BROWN

USCS: _____ AASHTO: _____

Liquid Limit: _____ Plastic Index: _____

Remarks: COMPOSITE 2.5', 5', 7.5', 10', 15', 20', 25', & 30'
(SAVE H₂O & SOIL)

- Mechanical analysis
- Hydrometer analysis

Data Sheet 1 - Mechanical

	Initial Sample	After Wash
Dry Sample and Tare =	_____	_____
Tare =	_____	_____
Dry Sample Weight =	<u>104.2</u>	_____
Calculated -200 =	_____	_____
Tare For Cumulative Weight Retained =	_____	_____

FN: 0 Font: %
 enter a formula, a value or text into the current cell
 %
 ssins

MECHANICAL ANALYSIS

U.S. STANDARD SIEVE
SIZE (MM)

SIEVE NO.

SIEVE NO.	SAMPLE WT. % COARSER	% FINER
3 INCH	0.0	100.0
1 1/2 INCH	0.0	100.0
3/4 INCH	0.0	100.0
3/8 INCH	0.0	100.0
NO. 4	0.0	100.0
	0.0	0.0
	0.0	0.0
	0.9597	
2.00	0.0	100.0
0.84	1.0	99.0
0.42	4.7	95.5
0.177	16.7	84.0
0.074	42.3	59.4
PAN	104.2	100.0
PAN		0.0

er:

ue: 104.2

ksheet: mech2

Loc: r28c5

FN: 0

Font: Standard

TER - enter a formula, a value or text into the current cell

19-A

LIQUID AND PLASTIC LIMIT TESTS
For use of this form, see EM 111021906.

BORROW #1 (A)

PROJECT ROCKY MOUNTAIN ARSENAL
BORING NO. 25 BORE 007 1'-6'

DATE 9-20-90

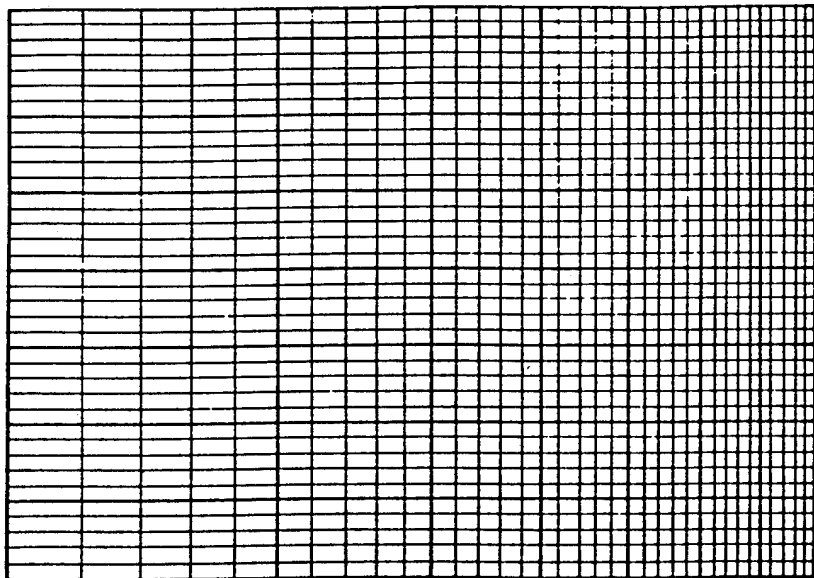
SAMPLE NO. _____

LIQUID LIMIT

RUN NO.		1	2	3	4	5	6
TARE NO.		1	2				
WEIGHT IN GRAMS	TARE PLUS WET SOIL	6.135	8.161				
	TARE PLUS DRY SOIL	4.948	6.464				
	WATER	W_w 7					
	TARE	1.524	1.54				
	DRY SOIL	W_s					
WATER CONTENT, %		w 34.7	34.6				
NUMBER OF BLOWS		23	20				

(SAVE ^{34.3} H₂O & ^{24.2} SOIL)

WATER CONTENT, w, %



LL 34.6
 PL 13.5
 PI 21.1

Symbol from plasticity chart

Cl
Med
tough

NUMBER OF BLOWS

PLASTIC LIMIT

RUN NO.		1	2	3	4	5	NATURAL WATER CONTENT
TARE NO.		3	4				
WEIGHT IN GRAMS	TARE PLUS WET SOIL	3.486	3.053				
	TARE PLUS DRY SOIL	3.253	2.871				
	WATER	W_w					
	TARE	1.526	1.513				
	DRY SOIL	W_s					
WATER CONTENT, %		w 13.5	13.4				
PLASTIC LIMIT							

REMARKS _____

TECHNICIAN _____

COMPUTED BY _____

CHECKED BY _____

1-8-41
M-6

GRAIN SIZE ANALYSIS

BORROW # 1

(A)

Date: 9-20-90

Project No.: _____

Project: ROCKY MOUNTAIN ARSENAL

Location of Sample: 25 BORE 007 1'-6'

Sample Description: BROWN

USCS: _____

AASHTO: _____

Liquid Limit: _____

Plastic Index: _____

Remarks: (SAVE H₂O & SOIL)

Mechanical analysis

Hydrometer analysis

Data Sheet 1 - Mechanical

Initial Sample

After Wash

Dry Sample and Tare= _____

Tare= _____

Dry Sample Weight= 113.9

Calculated -200= _____

Tare For Cumulative Weight Retained= _____

MECHANICAL ANALYSIS

U.S. STANDARD SIEVE
SIZE (MM)

SIEVE NO.

SAMPLE WT. % COARSER

% FINER

76.2	3 INCH	0.0	0.0	100.0
38.1	1 1/2 INCH	0.0	0.0	100.0
19.1	3/4 INCH	0.0	0.0	100.0
9.52	3/8 INCH	0.0	0.0	100.0
4.76	NO. 4	0.0	0.0	100.0
PAN		0.0	0.0	100.0
TOTAL		0.0	0.0	
FACTOR		0.0		
NO. 10	2.00	0.8780		
NO. 20	0.84	1.0	0.9	99.1
NO. 40	0.42	6.2	5.4	94.6
NO. 80	0.177	15.3	13.4	86.6
NO. 200	0.074	23.4	20.5	79.5
PAN		34.3	30.1	69.9
		113.9	100.0	0.0

Enter:

Value: 1

Worksheet: mech2

Loc: r23c5

FN: 0

Font: Standard

into the current cell

PROJECT - RMA - LIME SETTLING BASINS	SHEET NO. 1	OF 2
ITEM - GROUND WATER INFILTRATION THRU SLURRY WALL TIME CALCULATION	BY - JMB	DATE 9/4/90
	CHKD. BY	DATE

REFS.: McWHORTER & SUNADA, GROUND-WATER HYDROLOGY AND HYDRAULICS, 198

EQUATIONS

FLOW VOLUME CALCS. BY JMC ON
5/18/90 - 5/21/90
GRADIENTS AND VOLUMES.

$$Q = k n A$$

Q = FLOW VOLUME
k = PERMEABILITY
n = GRADIENT
A = AREA OF FLOW

$$N = \frac{Q}{n A} = \frac{\text{DISTANCE}}{\text{TIME}}$$

N = SEEPAGE VELOCITY
n = POROSITY

SEEPAGE VELOCITY N IS USED TO CALCULATE THE TIME OF WATER MOVEMENT.

n OF BACKFILL NOT KNOWN BECAUSE COMPATABILITY TESTING NOT COMPLETE. TABLE 4-2 OF HOLTZ AND KOVACS

AN INTRO. TO GEOTECHNICAL ENGINEERING (1981) LISTS TYPICAL n FOR SILTY SAND AS 47% (LOOSE) TO 23% (DENSE)

$$\text{USE AVG. } n = \frac{47 + 23}{2} = 35\% = 0.35$$

PROJECT _____ SHEET NO. 1 OF 2

ITEM _____ BY JMB DATE 9/4/90
 _____ CHKD. BY _____ DATE _____

SOUTH WALL

AVG. WATER LEVEL OUTSIDE WALL = 5250

AVG. WATER LEVEL INSIDE WALL = 5247

AVG. HEAD = $\frac{3}{2} = 1.5'$

$h = \frac{1.5}{3} = 0.50$

$A = 9100 \text{ FT}^2$ $k = .00028 \text{ FT/DAY}$

$Q = .00028 (.50) (9100) = 1.274 \text{ FT}^3/\text{DAY}$

$n = \frac{Q}{nA} = \frac{1.274}{(.35)(9100)} = .0004 \text{ FT/DAY}$

$t = \frac{3}{.0004 \text{ FT/DAY}} = 7,500 \text{ DAYS}$

$= 20.5 \text{ YEARS}$

PROJECT RMA LIME SETTLING BASINS

SHEET NO. 1 OF 2

ITEM CALCULATION OF INITIAL WATER
LEVEL & PORE WATER VOLUMES

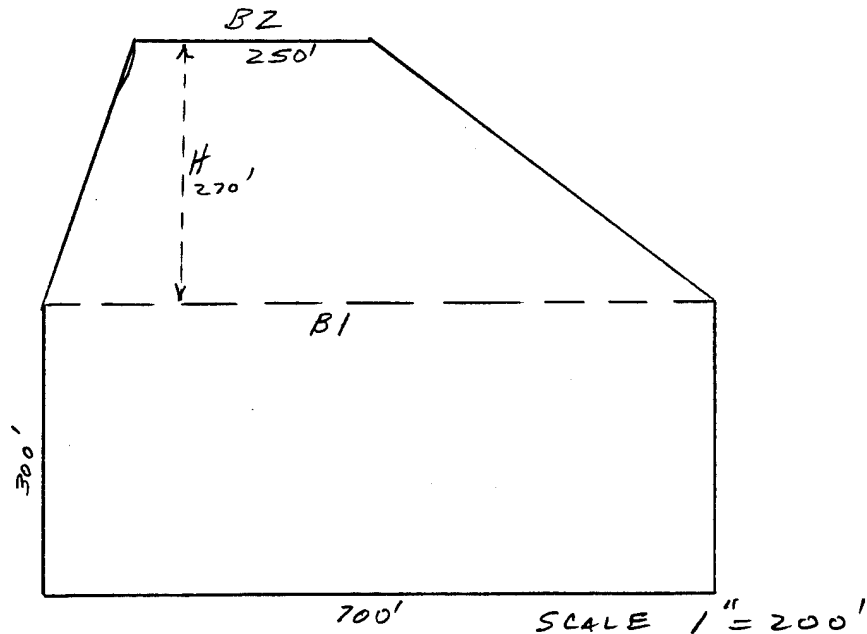
BY JMZ

DATE 5/18/90

CHKD. BY

DATE

WITHIN ISOLATION CELL



$$\begin{aligned} \text{AREA TRAPAZOID} &= \frac{B_1 + B_2}{2} \times H \\ &= \frac{700' + 250'}{2} \times 270' \\ &= 128,250 \text{ ft}^2 \end{aligned}$$

$$\begin{aligned} \text{AREA RECTANGLE} &= L \times W \\ &= 700' \times 300' \\ &= 210,000 \text{ ft}^2 \end{aligned}$$

$$\begin{aligned} \text{TOTAL AREA OF CELL} &= 128,250 \text{ ft}^2 + 210,000 \text{ ft}^2 \\ &= 338,250 \text{ ft}^2 \end{aligned}$$

PROJECT RMA LIME SETTLING BASINS

SHEET NO. 2 OF 2

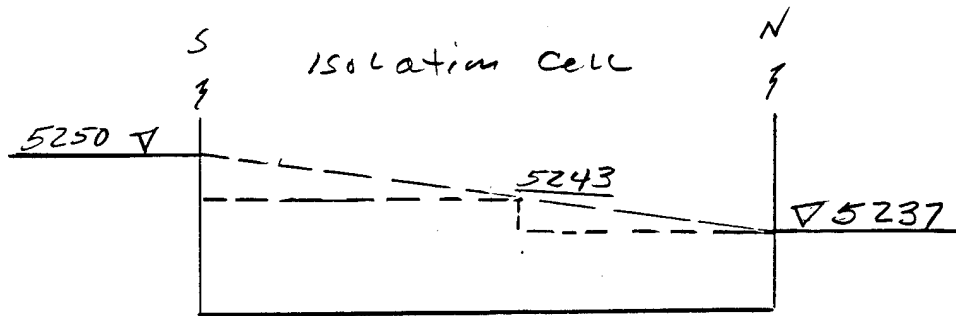
ITEM CALCULATION OF STABILIZED
WATER LEVEL WITHIN CELL AFTER

BY JMZ

DATE 5/18/90

CHKD. BY

DATE



Estimated porosity = 35%

$$\begin{aligned} \text{VOLUME VOIDS TRAP SECTION} &= 0.35 \times (128,250) \left(\frac{6}{2}\right) \\ &= 134,663 \text{ ft}^3 \end{aligned}$$

$$\begin{aligned} \text{VOLUME VOIDS RECTANGLE} &= 0.35 \times (210,000) \left(\frac{7}{2}\right) \\ &= 257,250 \text{ ft}^3 \end{aligned}$$

$$\text{EXCESS VOL VOIDS RECT-TRAP} = 122,587$$

$$\begin{aligned} \text{TOTAL VOL VOIDS PER 1' DEPTH IN CELL} \\ &= 0.35 \times (338,250) (1) \\ &= 118,388 \text{ ft}^3 \end{aligned}$$

$$\begin{aligned} \text{TOTAL RISE ABOVE EL 5243} \\ &= \frac{122,587}{118,388} \\ &= 1.04 \text{ ft ROUND TO 1.0'} \end{aligned}$$

$$\begin{aligned} \text{EL STABILIZED WL IN CELL} &= 5243 + 1 \\ &= 5244 \end{aligned}$$

PROJECT RMA - Lime Settling Basins

SHEET NO. 1 OF 8

ITEM Ground Water Infiltration through
Slurry Wall - Volume Calculation

BY JMC

DATE 5-21-90

CHKD. BY

DATE

Formula for Volume Calculations

$$Q = K I A$$

Q = volume of seepage through bentonite slurry wall

K = hydraulic conductivity of slurry wall

I = gradient

A = area of slurry wall

PROJECT RMA Lime Settling Basins

SHEET NO. 2 OF 8

ITEM Ground Water Infiltration through Slurry Walls - Volume Calculations

BY JMC

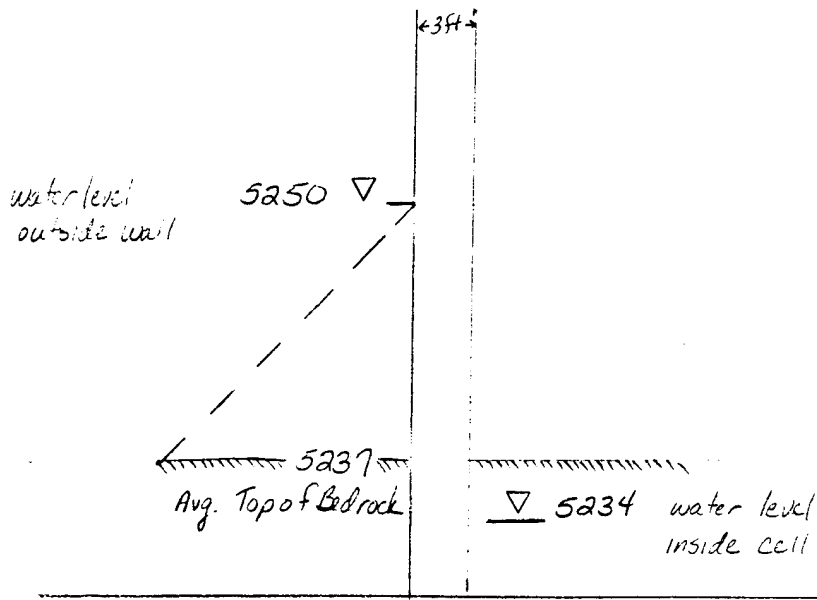
DATE 5-18-90

CHKD. BY

DATE

1" = 10'

South Wall



$$Q = KI \cdot H$$

$$K = .00028 \text{ ft/day} = 10^{-7} \text{ cm/sec}$$

$$I = \frac{13}{2} \div 3 = 2.17$$

$$A = 13 \times 700 = 9100 \text{ ft}^2$$

$$Q_s = .00028 \times 2.17 \times 9100 = 5.53 \text{ ft}^3/\text{day}$$

PROJECT *RMA - Lime Settling Basins*

SHEET NO. *3* OF *8*

ITEM *Ground Water Infiltration through Slurry Walls - Volume Calculations*

BY *JMC*

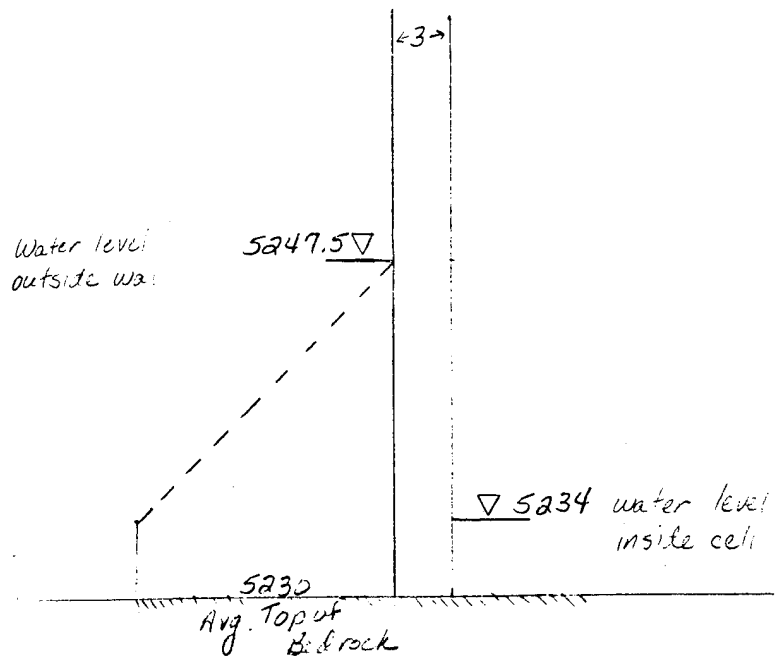
DATE *5-18-90*

CHKD. BY

DATE

1" = 10'

East Wall



$$Q = KIA$$

$$K = .00028 \text{ ft/day} = 10^{-7} \text{ cm/sec}$$

$$I = \frac{13.5}{2} \div 3 = 2.25$$

$$A = 17.5 \times 300 = 5250 \text{ ft}^2$$

$$Q_E = .00028 \times 2.25 \times 5250 = 3.31 \text{ ft}^3/\text{day}$$

PROJECT *RMA - Lime Settling Basins*

SHEET NO. *4* OF *8*

ITEM *Ground Water Infiltration through Slurry Wall - Volume Calculations*

BY *JMC*

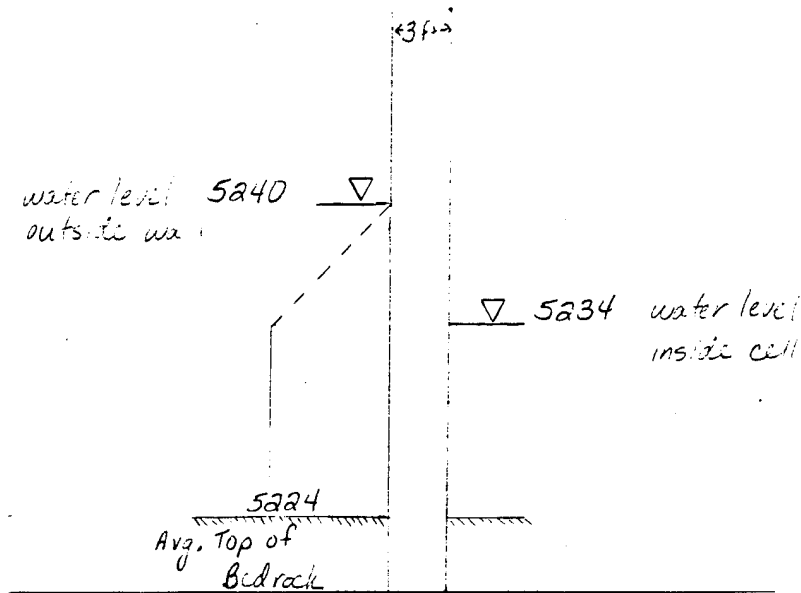
DATE *5-18-90*

CHKD. BY

DATE

1" = 10'

North East Wall



$$Q = KIA$$

$$K = .00028 \text{ ft/day} = 10^{-7} \text{ cm/sec}$$

$$I = \frac{6}{2} \div 3 = 1$$

$$A = 16 \times 460 = 7360 \text{ ft}^2$$

$$Q_{NE} = .00028 \times 1 \times 7360 = 2.06 \text{ ft}^3/\text{day}$$

PROJECT RMA - Lime Settling Basins

SHEET NO. 5 OF 8

ITEM Ground Water Infiltration through
Slurry Wall - Volume Calculations

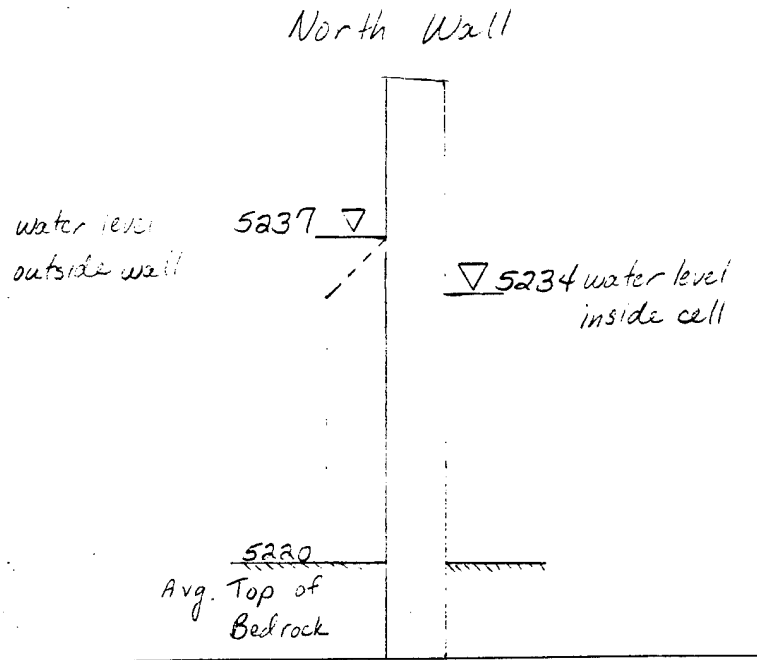
BY JMC

DATE 5-18-90

CHKD. BY

DATE

1" = 10'



$$Q = KIA$$

$$K = .00028 \text{ ft/day} = 10^{-7} \text{ cm/sec}$$

$$I = \frac{3}{2} \div 3 = 0.5$$

$$A = 17 \times 250 = 4250 \text{ ft}^2$$

$$Q_N = .00028 \times .5 \times 4250 = .595 \text{ ft}^3/\text{day}$$

PROJECT RMA - Lime Settling Basins

SHEET NO. 6 OF 8

ITEM Ground Water Infiltration through
Slurry Walls - Volume Calculations

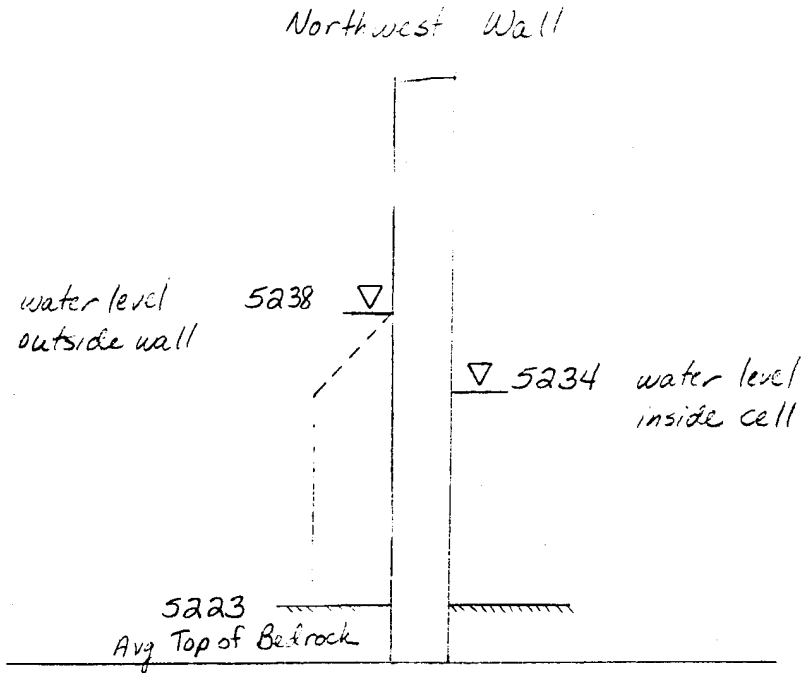
BY JMC

DATE 5-18-90

CHKD. BY

DATE

1" = 10'



$$Q = KIA$$

$$K = .00028 \text{ ft/day} = 10^{-7} \text{ cm/sec}$$

$$I = \frac{4}{2} \div 3 = .66$$

$$A = 15 \times 290 = 4350 \text{ ft}^2$$

$$Q_{NW} = .00028 \times 0.66 \times 4350 = 0.812 \text{ ft}^3/\text{day}$$

PROJECT RMA - Lime Settling Basins

SHEET NO. 7 OF 8

ITEM Ground Water Infiltration through
Slurry Wall - Volume Calculations

BY JMC

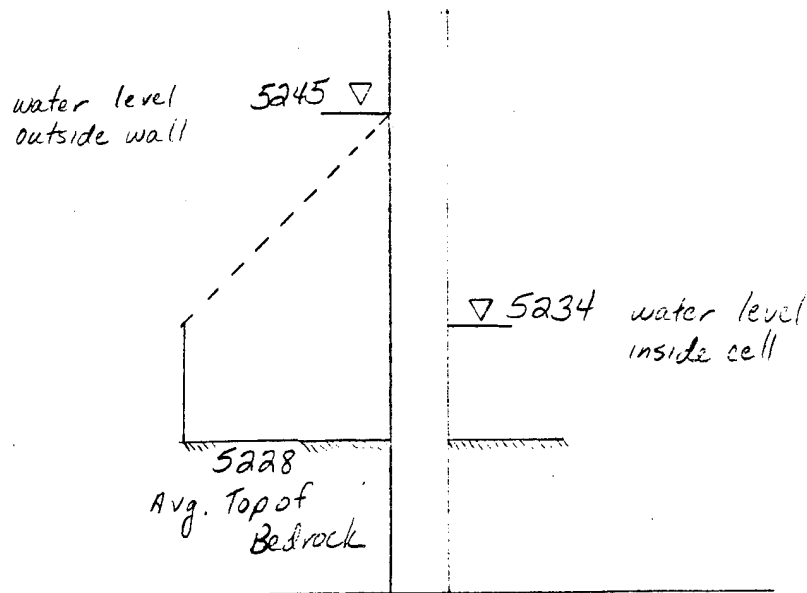
DATE 5-18-90

CHKD. BY

DATE

1" = 10'

West Wall



$$Q = KIA$$

$$K = .00028 \text{ ft/day} = 10^{-7} \text{ cm/sec}$$

$$I = \frac{H}{L} \div 3 = 1.83$$

$$A = 17 \times 300 = 5100 \text{ ft}^2$$

$$Q_w = .00028 \times 5100 \times 1.83 = 2.62 \text{ ft}^3/\text{day}$$

PROJECT RMA - Lime Settling Basins

SHEET NO. 8 OF 8

ITEM Ground Water Infiltration through
Slurry Wall - Volume Concentrations

BY JMC

DATE 5-21-90

CHKD. BY

DATE

$$Q_{TOT} = Q_S + Q_E + Q_{NE} + Q_N + Q_{NW} + Q_W$$

$$Q_S = 5.53 \text{ ft}^3/\text{day}$$

$$Q_E = 3.31 \text{ ft}^3/\text{day}$$

$$Q_{NE} = 2.06 \text{ ft}^3/\text{day}$$

$$Q_N = 0.60 \text{ ft}^3/\text{day}$$

$$Q_{NW} = 0.81 \text{ ft}^3/\text{day}$$

$$Q_W = 2.62 \text{ ft}^3/\text{day}$$

$$Q_{TOT} = 14.93 \text{ ft}^3/\text{day}$$

$$14.93 \text{ ft}^3/\text{day} = 0.42 \text{ m}^3/\text{day} = 111.68 \text{ gal}/\text{day} = .08 \text{ gal}/\text{min}$$

PROJECT *RMA - Lime Settling Basins*

SHEET NO. *1* OF *4*

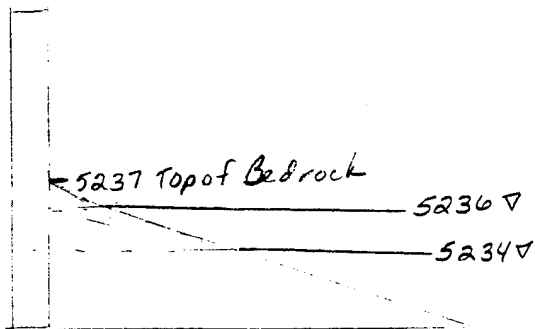
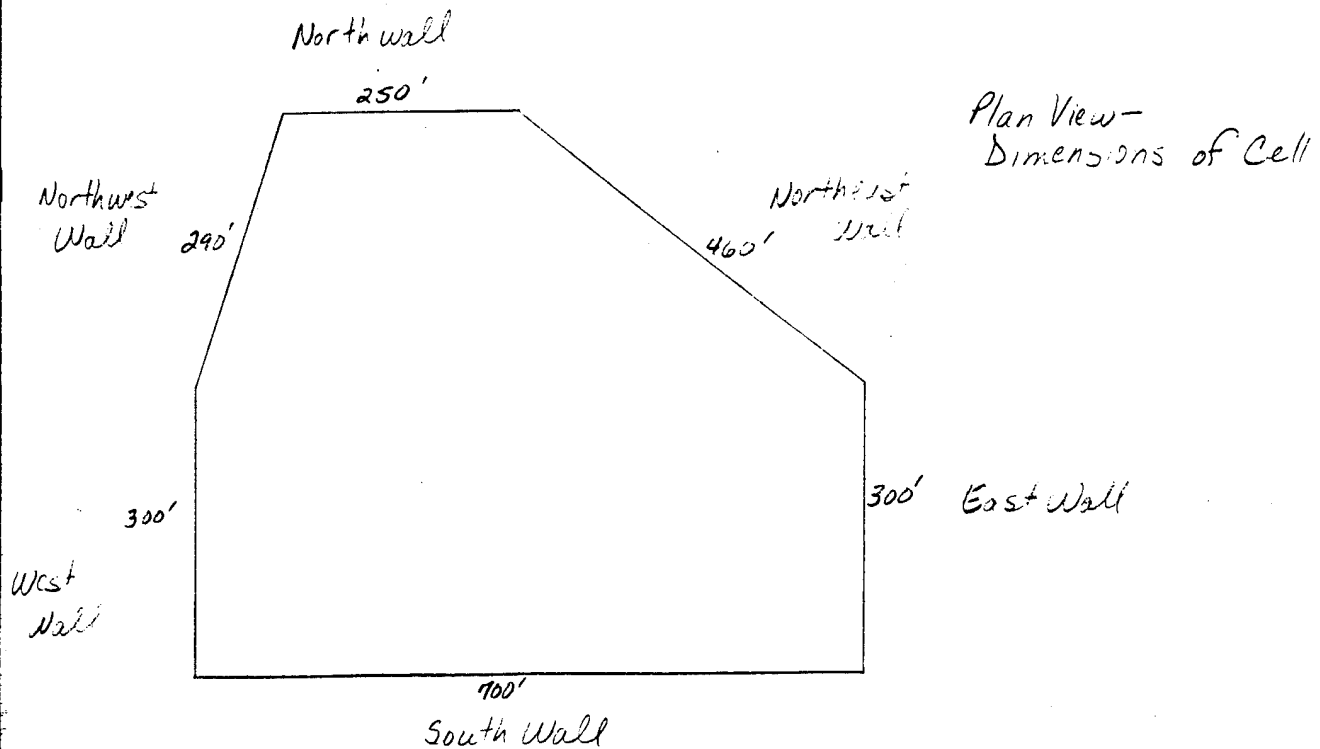
ITEM *Dimensions used to Calculate Surface Area of Cell at Elevations 5236 + 5234*

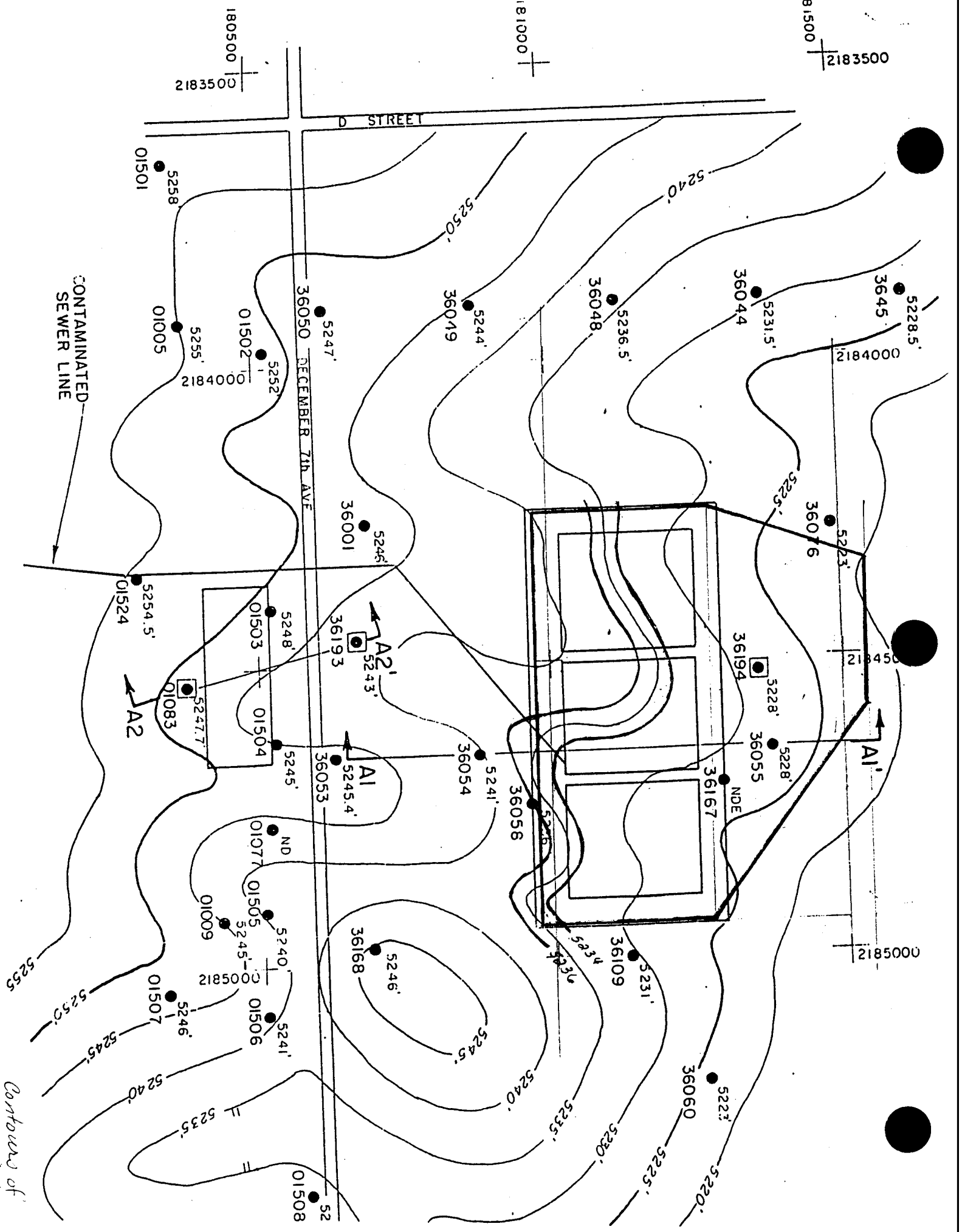
BY *JMC*

DATE *5-21-90*

CHKD. BY

DATE





Contours of
T. A. L. 11-11

PROJECT *RMA - LIMBE SETTLING BASINS.*

SHEET NO. *2* OF *4*

ITEM *SURFACE AREA OF CELL AT 5236 & 5234*
(SCALE FACTOR - 200x200 = 40,000)

BY *RME*

DATE *5/21/90*

CHKD. BY

DATE

$$EL. 5234 = 6.35' \times 40,000 = 174,000'$$

$$EL. 5236 = 7.40' \times 40,000 = 296,000'$$

PROJECT RMA - LIME SETTLING BASINS

SHEET NO. 3 OF 4

ITEM Volume Calculations from surface areas
at Elevations 5236 & 5234

BY JMC

DATE 5-21-90

CHKD. BY

DATE

At Elevation 5234 \rightarrow Surface Area = length \times width = $174,000 \text{ ft}^2$

$$\text{Volume} = 174,000 \text{ ft}^2 \times 2 \text{ ft} = 348,000 \text{ ft}^3$$

$$\text{Pore Volume} = 348,000 \text{ ft}^3 \times 35\% = 121,800 \text{ ft}^3$$

At Elevation 5236 \rightarrow Surface Area = length \times width = $296,000 \text{ ft}^2$

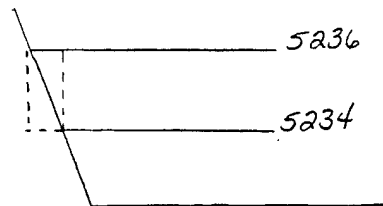
$$\text{Volume} = 296,000 \text{ ft}^2 \times 2 \text{ ft} = 592,000 \text{ ft}^3$$

$$\text{Pore Volume} = 592,000 \text{ ft}^3 \times 35\% = 207,200 \text{ ft}^3$$

PROJECT *RMA - Lime Settling Basins*SHEET NO. *4* OF *4*ITEM *Average Volume between 5236 + 5234 Elevations*BY *JMC*DATE *5-21-90*

CHKD. BY

DATE



$$\text{Volume at } 5236' = 296,000 \text{ ft}^2 \times 2 \text{ ft} = 592,000 \text{ ft}^3$$

$$\text{Volume at } 5234' = 174,000 \text{ ft}^2 \times 2 \text{ ft} = 348,000 \text{ ft}^3$$

$$\begin{array}{r} \text{Average Volume} = 592,000 \\ + 348,000 \\ \hline 940,000 \div 2 = 470,000 \text{ ft}^3 \end{array}$$

$$\text{Average Pore Volume} = 470,000 \text{ ft}^3 \times 35\% = 164,500 \text{ ft}^3$$

PROJECT *LIME SETTLING BASINS*

SHEET NO. *1* OF *3*

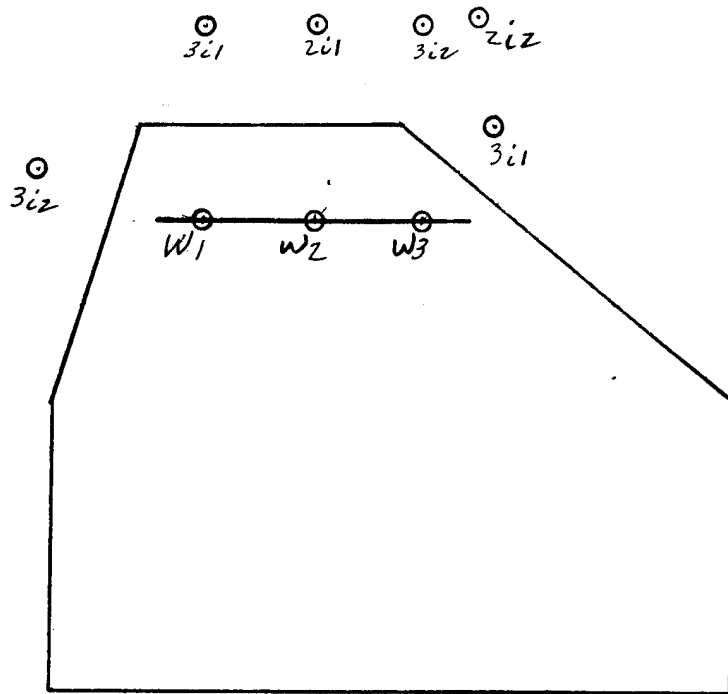
ITEM *ANALYSIS OF G.W. WITHDRAWAL BY WELLS.*

BY *JMZ*

DATE

CHKD. BY

DATE



SCALE 1" = 200'

BOTTOM OF AQUIFER EL = 5227
 G.W. EL = 5239
 HYD. COND = 1×10^{-4} cm/sec = 0.283'/day.

$$Q = \frac{\pi K (H^2 - h_w^2)}{ln_e \frac{R}{r}}$$

Where Q = PUMPING RATE ft^3 /DAY
 K = HYD. COND. FT/DAY
 H = SATURATED THICKNESS FT
 h_w = HEIGHT OF WATER IN WELL FT
 R = ASSUMED RADIUS OF INFLUENCE FT
 r = RADIUS OF WELL FT

PROJECT LSB

SHEET NO. 2 OF 3

ITEM ANAL. GW WITHDRAWAL
BY WELLS

BY JMZ

DATE

CHKD. BY

DATE

$$H = 12.0'$$

$$h_w = 12.0 - [(12.0) \times 60\%] = 4.8$$

$$Q = \frac{(3.14)(0.283)(12.0^2 - 4.8^2)}{\ln_e \frac{500}{0.5}}$$

$$Q = 15.6 \text{ FT}^3/\text{DAY} = 0.08 \text{ gpm}$$

THIS VOLUME IS TOO SMALL TO PUMP EVEN DISREGARDING BOUNDARY AND INTERFERENCE EFFECTS

CALCULATION OF THEORETICAL DRAWDOWN FOR WELL #3 INCLUDING BOUNDARY AND INTERFERENCE EFFECTS.

$$h_{w3} = \sqrt{H^2 - \left[\frac{Q \ln_e \frac{R}{r}}{\pi K} \right]}$$

$$\text{Let } C = \frac{Q}{\pi K} = \frac{15.6}{(3.14)(0.283)} = 17.6$$

FOR BOUNDARY EFFECT NE OF W_3 FOR IMAGE WELL W_{3i} AT $r = 120'$

$$h_{w_{3i}} = \sqrt{144 - \left[(17.6) \ln_e \frac{500}{120} \right]} = \sqrt{144 - 25.1} = 10.9'$$

$$\therefore \text{DD DUE TO NE BOUNDARY} = 12.0' - 10.9' = 1.1'$$

PROJECT

LSB

SHEET NO. 3

OF 3

ITEM

ANAL G.W. WITHDRAWAL
BY WELLS

BY JMZ

DATE

CHKD. BY

DATE

FOR BOUNDARY EFFECT N. OF W_3 FOR IMAGE
WELL W_{3i2} AT $r = 200'$

$$h_{w_{3i2}} = \sqrt{144 - \left[(17.6) \ln_e \frac{500}{200} \right]} = \sqrt{144 - 16.1} = 11.3'$$

$$\therefore DD \text{ DUE TO N. BOUNDARY} = 12.0' - 11.3' = 0.7'$$

FOR WELL INTERFERENCE FROM W_2 AT $r = 112.5'$

$$h_{w_2} = \sqrt{144 - \left[(17.6) \ln_e \frac{500}{112.5} \right]} = \sqrt{144 - 26.3} = 10.8'$$

$$\therefore DD \text{ DUE TO } W_2 \text{ INTERFERENCE} = 12.0' - 10.8' = 1.2'$$

FOR WELL INTERFERENCE FROM W_1 AT $r = 225'$

$$h_{w_1} = \sqrt{144 - \left[(17.6) \ln_e \frac{500}{225} \right]} = \sqrt{144 - 14.1} = 11.4'$$

$$\therefore DD \text{ DUE TO } W_1 \text{ INTERFERENCE} = 12.0' - 11.4' = 0.6'$$

$$\text{TOTAL DD} = 7.2' + 1.1' + 0.7' + 1.2' + 0.6' = 10.8'$$

$$\text{ASSUME } 80\% \text{ WELL EFFICIENCY} = \frac{10.8}{.8} = 13.5'$$

AVAILABLE DD $12.0' <$ CALCULATED DD $13.5'$

\therefore NOT SUFFICIENT AVAILABLE DD TO PRODUCE

0.08 gpm

PROJECT LSB

SHEET NO. 1 OF 1

ITEM HYDRAULIC CONDUCTIVITY
DETERMINATION

BY JNZ DATE

CHKD. BY DATE

FROM SLUG TESTS

HOLE # 34 AVE 3.4×10^{-4} FT/MIN" 35 " 2.3×10^{-4} " 5.7×10^{-4} "AVE OF AVE $\frac{5.7 \times 10^{-4}}{2}$ FT/MIN = 2.8×10^{-4} FT/MIN 2.8×10^{-4} FT/MIN $\times 12$ IN/FT $\times 2.54$ CM/IN $\div 60$ SEC/MIN =
 1.4×10^{-4} CM/SECFor conservative approach use 1.0×10^{-4} 1.0×10^{-4} CM/SEC $\div 2.54$ CM/IN $\div 12$ IN/FT $\times 60$ SEC/MIN
 $\times 1440$ MIN/DAY = 0.283 FT/DAY

PROJECT LIME SETTLING BASINS

SHEET NO. 1 OF 4

ITEM CALCULATION OF FLOW FROM
HORIZONTAL DRAIN

BY JME

DATE

CHKD. BY

DATE

1. Utilizing Ibrahim and Brutsaert (1965) equations as discussed by Freeze and Cherry (1979). See graphs and diagrams by Freeze and Cherry as reproduced in this appendix. Construction of the graph for average flows from the drain utilize these graphs and diagram, and equations shown in the appendix.

For a horizontal drain located at an average depth below the water table of 11 feet, a length of 325 feet, the following equations are used.

$$\tau = \frac{KH}{S_g L^2} t$$

where τ = dimensionless time
 K = hydraulic conductivity
 H = depth of impermeable base below water table
 S_g = specific yield
 L = distance of drain (seepage face) from impermeable barrier.
 t = time

and
$$\gamma = \frac{S_g L}{KH^2} q$$

where γ = dimensionless discharge
 q = rate of flow from one side of the drain at time t .

Solving for q

$$q = \frac{\gamma KH^2}{S_g L}$$

PROJECT *LSB*

SHEET NO. *2* OF *4*

ITEM *Calculation of flow from horiz. drain*

BY *Jmz*

DATE

CHKD. BY

DATE

From equation $\bar{c} = \frac{KH}{S_y L^2} t$ For North side

Let $C = \frac{KH}{S_y L^2}$ For $K = 0.283$ ft/day.
 $H = 11$ ft
 $L = 100$ ft
 $S_y = 0.2$ (dimensionless)

then $\bar{c} = Ct$

Determine values of \bar{c} and γ for various time intervals

$$C = \frac{(0.283)(11)}{(0.2)(100)^2} = 0.0016$$

	FROM GRAPH
$\bar{c} = (0.0016)(10) = 0.016$	$\gamma = 4.9$ (est)
$\bar{c} = (0.0016)(20) = 0.032$	$\gamma = 3.0$ (est)
$\bar{c} = (0.0016)(100) = 0.16$	$\gamma = 0.85$
$\bar{c} = (0.0016)(200) = 0.32$	$\gamma = 0.56$
$\bar{c} = (0.0016)(500) = 0.80$	$\gamma = 0.27$
$\bar{c} = (0.0016)(1000) = 1.6$	$\gamma = 0.13$
$\bar{c} = (0.0016)(1500) = 2.4$	$\gamma = 0.076$
$\bar{c} = (0.0016)(2000) = 3.2$	$\gamma = 0.047$

Determine values of q at time intervals $\frac{1}{2} t$

$$q = \frac{\gamma K H^2}{S_y L} \quad \text{Let } C = \frac{KH^2}{S_y L} = \frac{(0.283)(11)^2}{(0.2)(100)} = 1.7$$

$q = (4.9)(1.7) = 8.33$ ft ³ /day/ft	10 days
$q = (3.0)(1.7) = 5.10$ " " "	20 "
$q = (0.85)(1.7) = 1.45$ " " "	100 "

PROJECT LSB

SHEET NO. 3 OF 4

ITEM Calculation of Flow from Horizontal drain

BY JMZ

DATE

CHKD. BY

DATE

$$\begin{aligned}
 q &= (0.56)(1.7) = 0.95 \text{ ft}^3/\text{day}/\text{ft} && 200 \text{ days} \\
 q &= (0.27)(1.7) = 0.46 \text{ "} && 500 \text{ "} \\
 q &= (0.13)(1.7) = 0.02 \text{ "} && 1000 \text{ "} \\
 q &= (0.076)(1.7) = 0.13 \text{ "} && 1500 \text{ "} \\
 q &= (0.047)(1.7) = 0.08 \text{ "} && 2000 \text{ "}
 \end{aligned}$$

Time to reach el 5234 at North wall.

$$H = 5237 - 5225 = 12'$$

$$h = 5234 - 5225 = 9$$

$$\frac{h}{H} = \frac{9}{12} = 0.75$$

$$\frac{x}{L} = 1 \quad \text{From graph} = 0.39$$

$$t = \frac{2.5yL^2}{KH} = \frac{(0.39)(0.2)(100)^2}{(0.283)(12)} = 230 \text{ days}$$

Ave Flow For 230 days (from graph) North side

# days	Flow Rate	Total AVE FLOW
10	12.0 (EST)	120
10	6.7	67
80	3.3	264
100	1.2	120
30	0.9	27
<u>230</u>		<u>598</u> ft ³ /ft of drain

$$\frac{598}{230} = 2.6 \text{ ft}^3/\text{day}/\text{ft of drain Ave Flow}$$

From NORTH side

PROJECT *LSB*

SHEET NO. *4* OF *4*

ITEM Calculation of flow from
Horiz drain

BY *JMZ*

DATE

CHKD. BY

DATE

For total average flow from the drain multiply flow from north side by 2 and length of drain.

$$2.6 \text{ ft}^3/\text{day}/\text{ft} \times 2 \times 325 \text{ ft} = 1690 \text{ ft}^3/\text{day}$$

This is equivalent to:

$$1690 \text{ ft}^3/\text{day} \times 7.48 \text{ gal}/\text{ft}^3 \div 1440 \text{ min}/\text{day} = 8.8 \text{ gpm}$$

Since boundary effects are not considered at the ends of the drain, and equations model flow from a free face, the flow rate from the drain will be less than 8.8 gpm. Recommend initial pumping rate from extraction system be 5.0 gpm.

Initial time required to reach elev 5234 at North wall pumping at 5 gpm:

$$\text{Volume to be pumped} = 1690 \text{ ft}^3/\text{day} \times 230 \text{ days} = 388,700 \text{ ft}^3$$

$$\begin{array}{r} 230 \text{ days @ } 5 \text{ gpm} = 221,000 \text{ ft}^3 \text{ (rounded)} \\ 396 \text{ days @ } 2.2 \text{ gpm} = \underline{167,700} \\ 626 \end{array}$$

Time to reach elev 5234 @ North wall:

$$\frac{626 \text{ days}}{365 \text{ days/yr}} = 1.7 \text{ years}$$

Total volume remaining in cell above elev 5234

$$\begin{array}{r} = 164,500 \text{ between EL } 5234 \text{ \& } 5236 \\ + 947,104 \text{ between EL } 5236 \text{ \& } 5244 \\ - \underline{388,700} \text{ amount drained in 1.7 years} \\ 722,904 \end{array}$$

Total time to drain at ave. $0.36 \text{ ft}^3/\text{day}/\text{ft} \times 325 \text{ ft}$.

$$= \frac{722,904}{117} = 6179 \text{ days} = \frac{6179}{365} = 16.9 \approx 17 \text{ years}$$

PROJECT *LSB*

SHEET NO. *1* OF *1*

ITEM *EQUATIONS, GRAPHS AND DIAGRAM FOR DRAIN FLOW CALCULATIONS FROM FROEZE AND CHERRY (1979)*

BY _____ DATE _____

CHKD. BY _____ DATE _____

495

Groundwater and Geotechnical Problems / Ch. 10

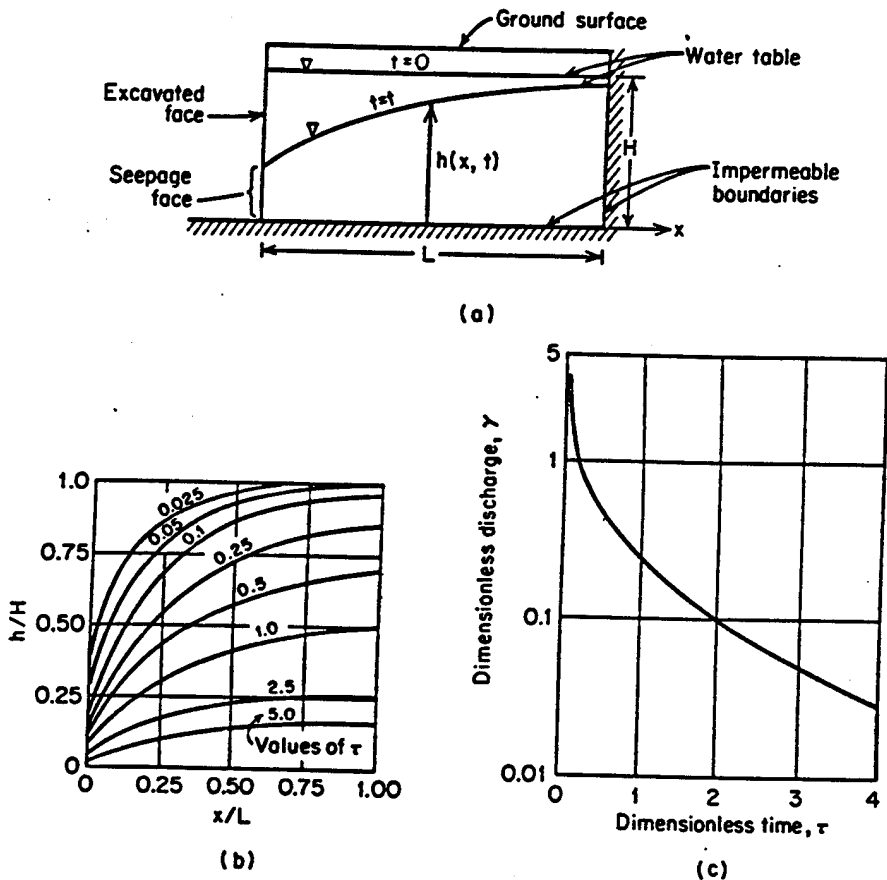


Figure 10.18 Prediction of groundwater inflows into an excavation (after Ibrahim and Brutsaert, 1965).

Figure 10.18(b) shows the transient response of the water table, plotted as dimensionless drawdown, h/H , versus dimensionless distance, x/L . The parameter τ is a dimensionless time given by

$$\tau = \frac{KH}{S L^2} t \tag{10.19}$$

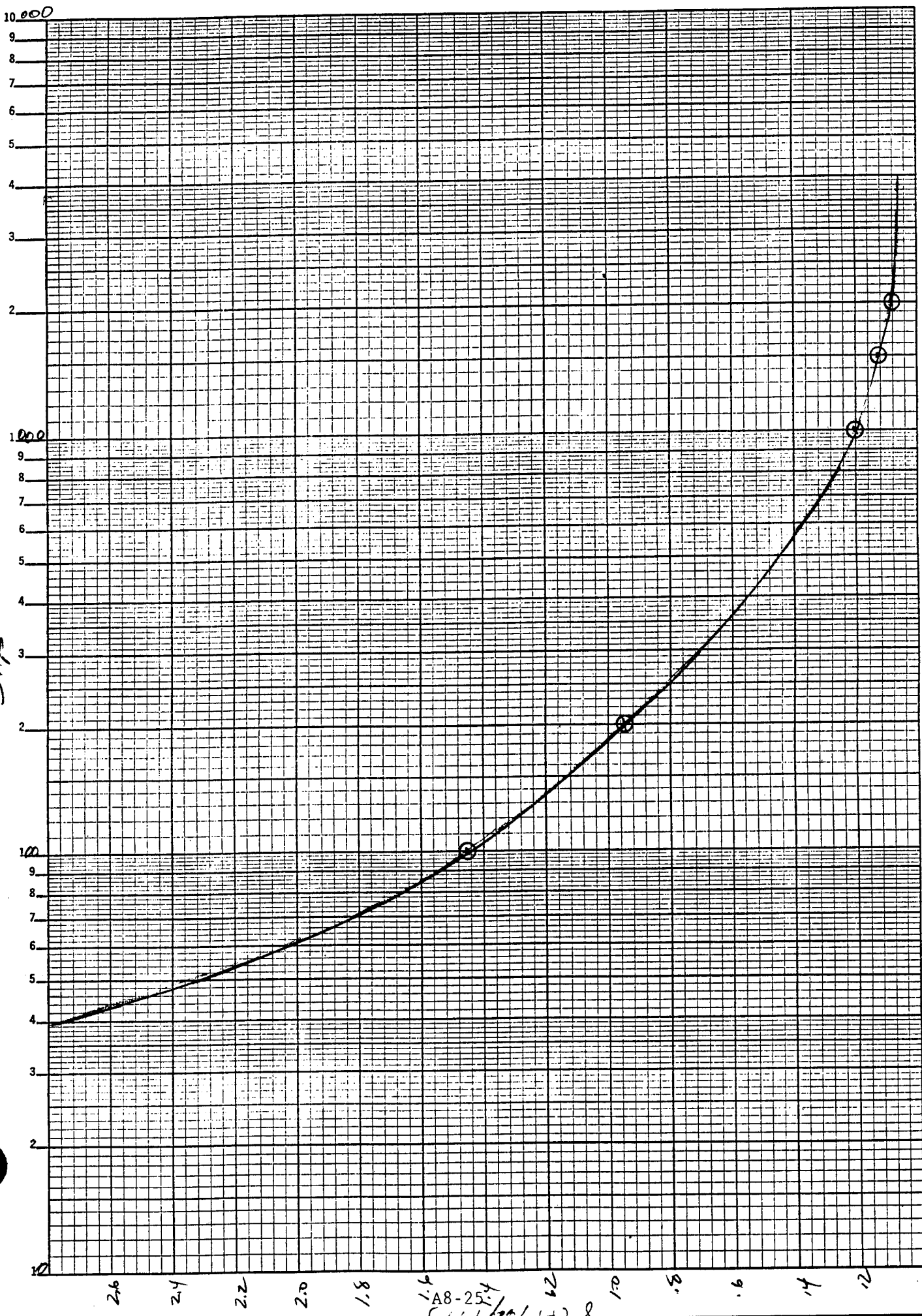
where H and L are defined by Figure 10.18(a), K and S , are the hydraulic conductivity and specific yield of the aquifer, and t is time. In Figure 10.18(c), the dimensionless discharge γ , defined by

$$\gamma = \frac{S L}{K H^2} q \tag{10.20}$$

is plotted against τ . The outflow $q = q(t)$ is the rate of flow (with dimensions L^3/T) into the excavation from the seepage face, per unit length of excavated face per-

KE SEMI-LOGARITHMIC 46 5493
3 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.

DATA



For Drain @ El. AVE 5228 (NORTH SIDE)

A8-25.4
1.6
1.2
1.0
0.8
0.6
0.4
0.2

OMAHA DISTRICT		COMPUTATION SHEET		CORPS OF ENGINEERS	
PROJECT <u>LSB</u>			SHEET NO. <u>1</u>		OF <u>1</u>
ITEM <u>Calculated time to reach stabilized (non-pumping) water level within the cell</u>			BY <u>JMZ</u>		DATE
			CHKD. BY		DATE

$Q = KIA$
 $K = 1 \times 10^{-4} \text{ cm/sec} = 0.283 \text{ ft/day}$
 $I = \frac{6 - 0}{300}$

A = Area of discharging aquifer = 700' width x 14' depth at midpoint = 9800 ft²

V = Volume to be filled per 1' depth (essentially confined to trapezoidal section) = $\frac{128,250}{2} \times 35\% \text{ porosity} = 22,444 \text{ ft}^3$

a) $Q = (0.283) \left(\frac{6}{300}\right) (9800) = 55.5 \text{ ft}^3/\text{day}$
 $t = \frac{V}{Q} = \frac{22,444}{55.5} = 404 \text{ days}$

b) $Q = (0.283) \left(\frac{5}{300}\right) (9800) = 46 \text{ ft}^3/\text{day}$
 $t = \frac{22,444}{46} = 488 \text{ days}$

c) $Q = (0.283) \left(\frac{4}{300}\right) (9800) = 37 \text{ ft}^3/\text{day}$
 $t = \frac{22,444}{37} = 606 \text{ days}$

d) $Q = (0.283) \left(\frac{3}{300}\right) (9800) = 27.7 \text{ ft}^3/\text{day}$
 $t = \frac{22,444}{27.7} = 810 \text{ days}$

e) $Q = (0.283) \left(\frac{2}{300}\right) (9800) = 18.5 \text{ ft}^3/\text{day}$
 $t = \frac{22,444}{18.5} = 1,213 \text{ days}$

f) $Q = (0.283) \left(\frac{1}{300}\right) (9800) = 9.2 \text{ ft}^3/\text{day}$
 $t = \frac{22,444}{9.2} = 2,440 \text{ days}$
 $\frac{5961}{365} = 16.3 \text{ years}$

PROJECT L S B

SHEET NO. 1 OF

ITEM SAND FILTER DESIGN FOR
DRAIN EM 1110-2-1901

BY J M Z

DATE

CHKD. BY

DATE

Calculated Filter

FM = Filter Material

PS = Protected Soil

Piping

$$\text{Max } \frac{D_{15\text{FM}}}{D_{85\text{PS}}} = \frac{1.6}{0.42} = 3.8 < 5$$

$$\text{Min } \frac{D_{15\text{FM}}}{D_{85\text{PS}}} = \frac{0.24}{0.17} = 1.4 < 5$$

$$\text{Max } \frac{D_{50\text{FM}}}{D_{50\text{PS}}} = \frac{3.4}{0.17} = 20 < 25$$

$$\text{Min } \frac{D_{50\text{FM}}}{D_{50\text{PS}}} = \frac{0.5}{0.03} = 17 < 25$$

Permeability

$$\text{Max } \frac{D_{15\text{FM}}}{D_{15\text{PS}}} = \frac{1.6}{0.04} = 40 > 5$$

$$\text{Min } \frac{D_{15\text{FM}}}{D_{15\text{PS}}} = \frac{0.24}{0.005} = 48 > 5$$

SLOT SIZE FOR THE DRAIN

$$\frac{D_{50\text{FM(AVE)}}}{\text{SLOT WIDTH}} = \frac{2.0}{0.5} = 4 > 1.2$$

0.5 mm is equivalent to a # 20 SLOT = 0.020"

PROJECT LSBSHEET NO. 2 OFITEM SAND FILTER DESIGN FOR
DRAIN EM 1110-2-1901BY JMZ

DATE

CHKD. BY

DATE

ASTM C-33 FINE AGGREGATE FOR CONCRETE
PIPING

$$\text{Max } \frac{D_{15FM}}{D_{85PS}} = \frac{0.38}{0.42} = 0.9 < 5$$

$$\text{Min } \frac{D_{15FM}}{D_{85PS}} = \frac{0.17}{0.17} = 1.0 < 5$$

$$\text{Max } \frac{D_{50FM}}{D_{50PS}} = \frac{1.3}{0.17} = 7.6 < 25$$

$$\text{Min } \frac{D_{50FM}}{D_{50PS}} = \frac{0.48}{0.03} = 16 < 25$$

Permeability

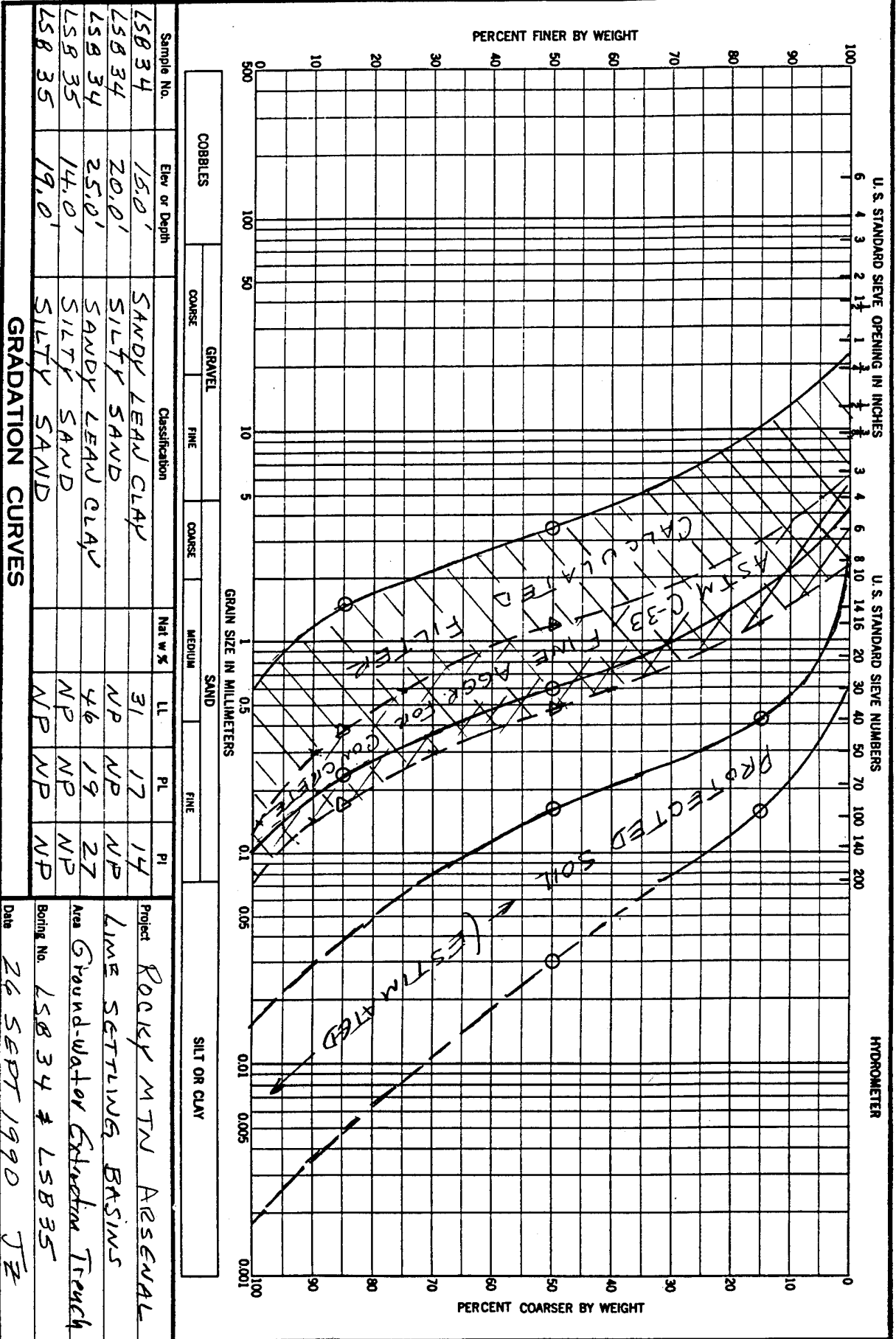
$$\text{Max } \frac{D_{15FM}}{D_{15PS}} = \frac{0.38}{0.04} = 9.5 > 5$$

$$\text{Min } \frac{D_{15FM}}{D_{15PS}} = \frac{0.17}{0.0005} = 34 > 5$$

SLOT SIZE

$$\frac{D_{50FM(AVE)}}{\text{SLOT WIDTH}} = \frac{0.9}{0.5} = 1.8 > 1.2$$

0.5 mm is equivalent to a #20 slot = 0.020"



PROJECT *AMA - LIME SETTLING BASINS*

SHEET NO. *1* OF *1*

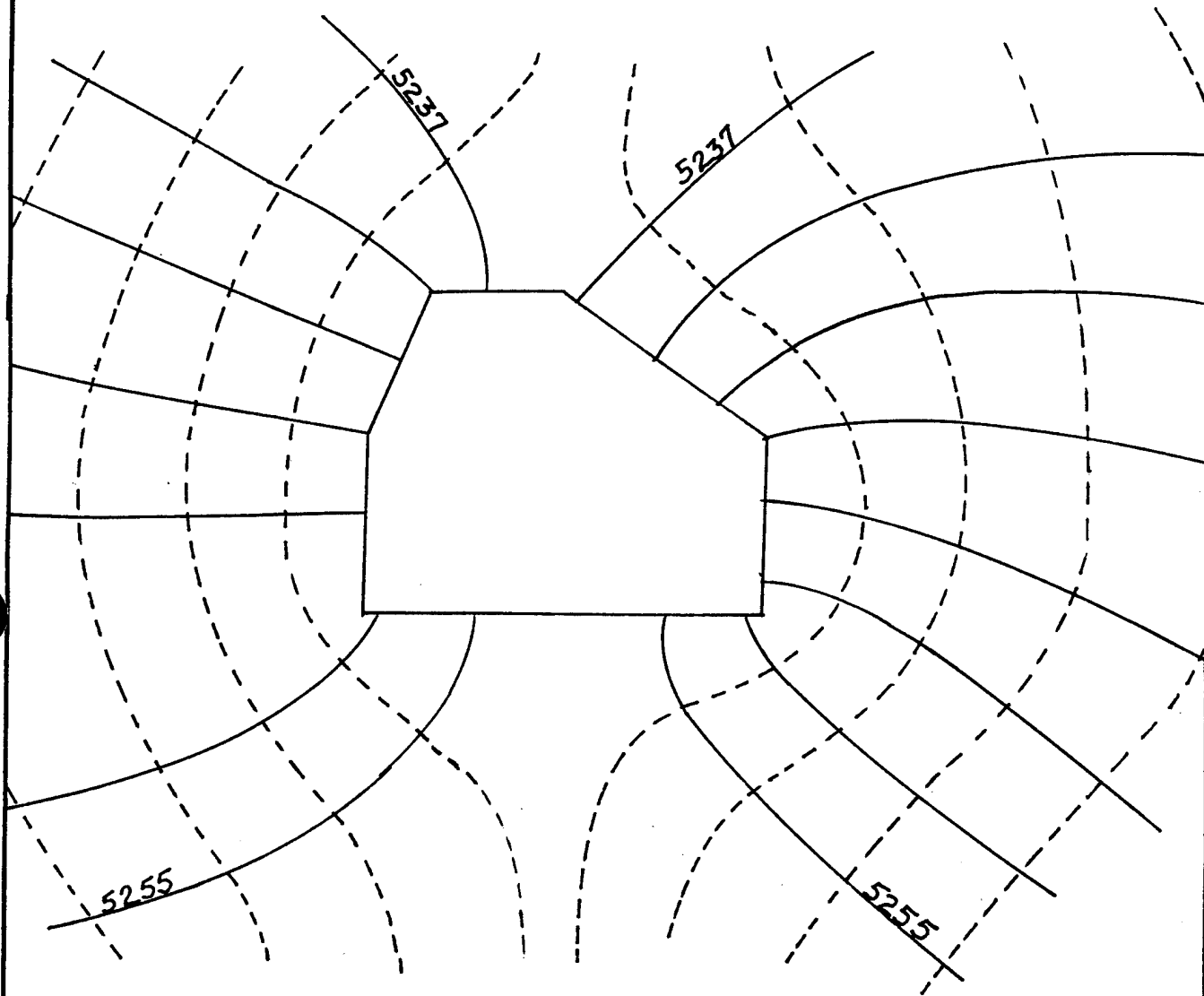
ITEM *Flow Diagram AFTER ISOLATION CELL*

BY *JMC*

DATE *8-10-90*

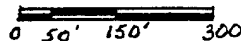
CHKD: BY

DATE



————— EQUIPOTENTIAL LINES

----- FLOW LINES



PROJECT *RMA Lime Settling basin (LSB)*

SHEET NO. *1* OF *2*

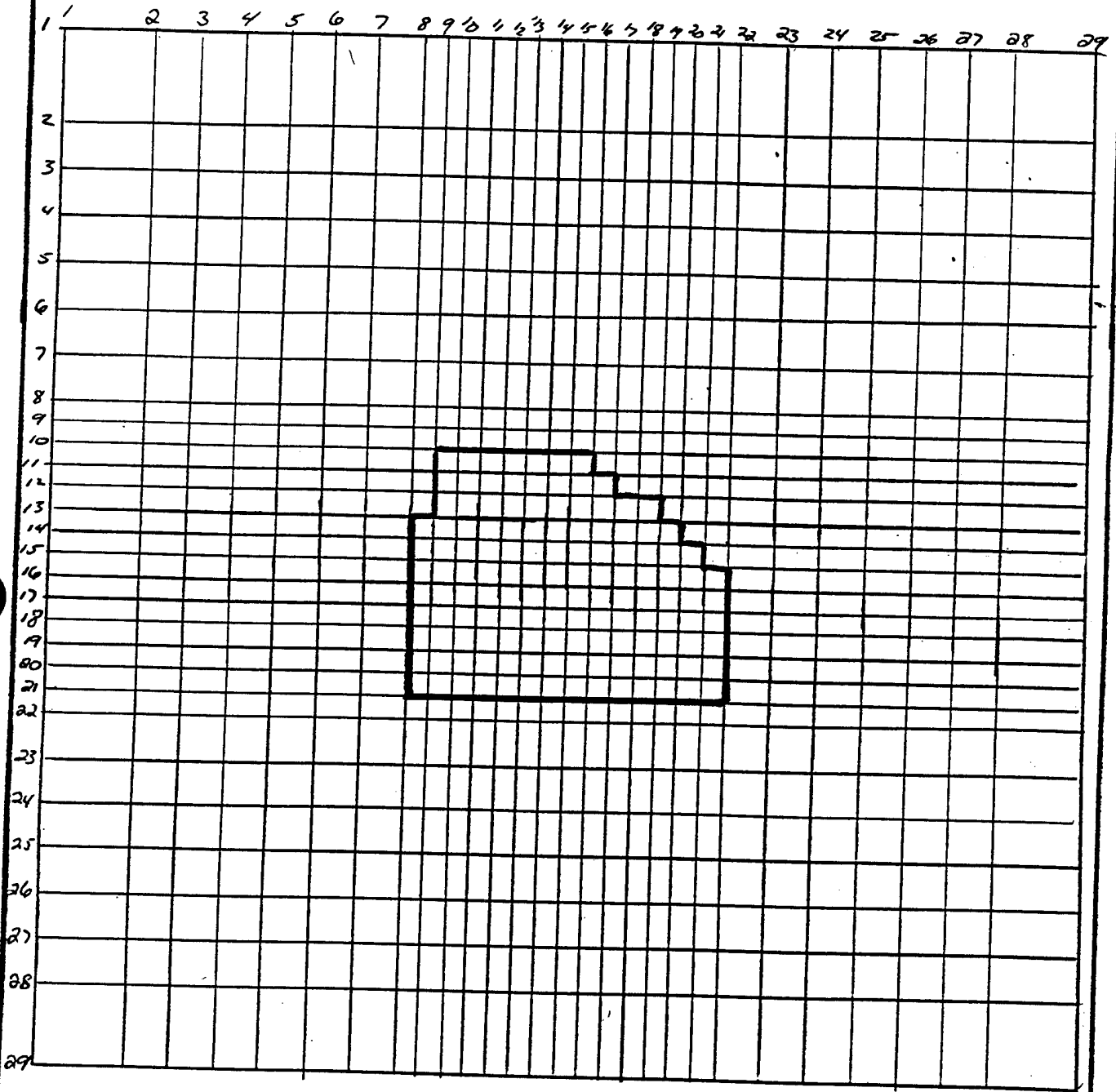
ITEM *Finite difference Grid for LSB flow Model*
Regional

BY *John Hartley*

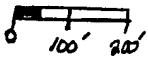
DATE *9-10-90*

CHKD. BY

DATE



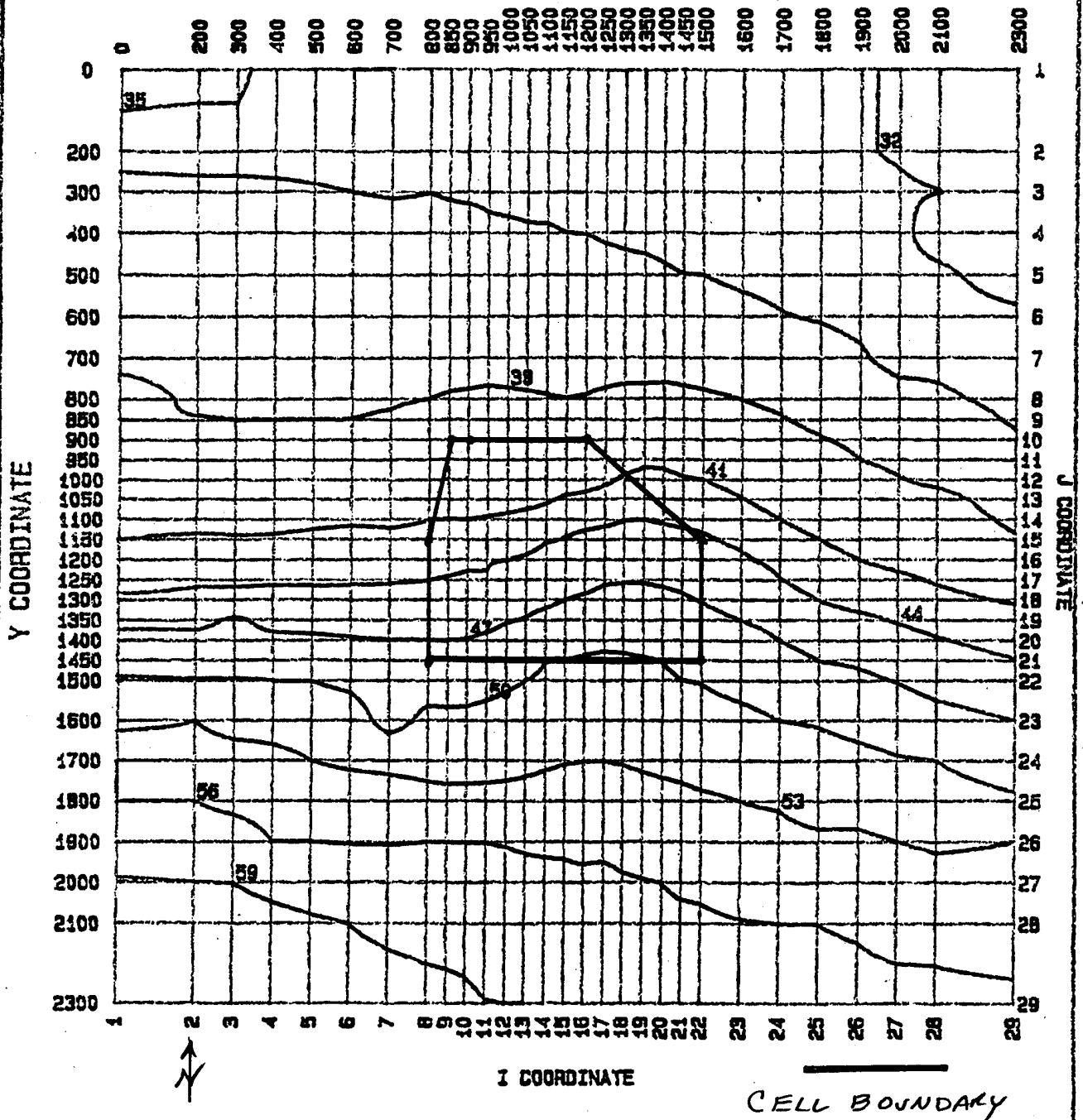
scale



Bold line designates
Location of slurry wall

All boundaries modeled
using constant head
conditions

INTERPOLATED CONTOURS
X COORDINATE DISTANCE (FT)



BASE EL 5200

CALIBRATION

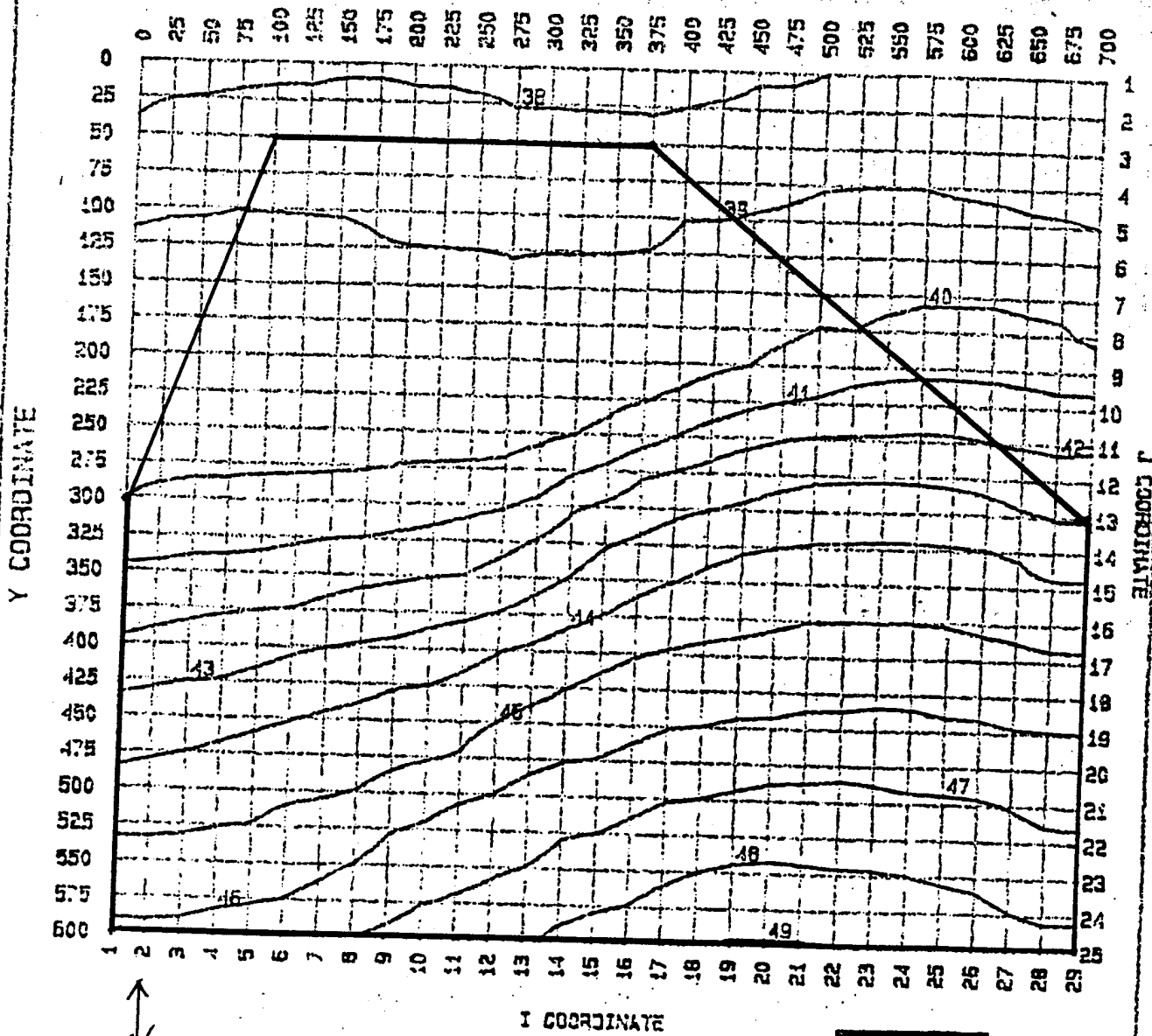
PROJECT: RMA
FILE: 1
LOCATION: DENVER

HEAD CONTOURS
AFTER 5 DAYS OF SIMULATION

U.S. ARMY CORPS. ENGINEERS

FIGURE 7

INTERPOLATED CONTOURS
X COORDINATE DISTANCE (FT)



CELL BOUNDARY

BASE EL 5200

CALIBRATION

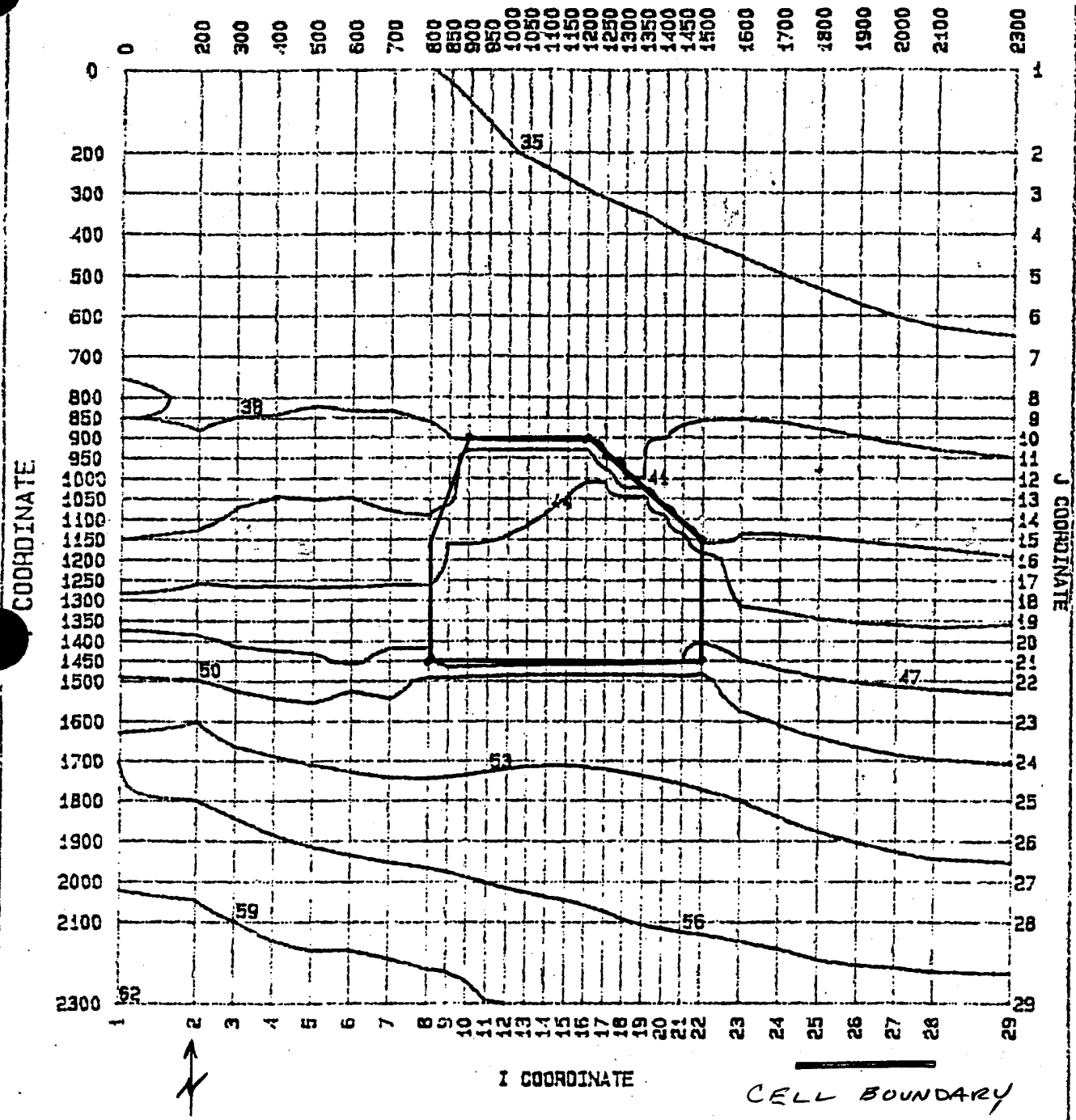
PROJECT: RMA CELL
FILE: C1
LOCATION: DENVER

HEAD CONTOURS
AFTER 5 DAYS OF SIMULATION

U.S. ARMY CORPS. ENGINEERS

FIGURE 2

INTERPOLATED CONTOURS
X COORDINATE DISTANCE (FT)

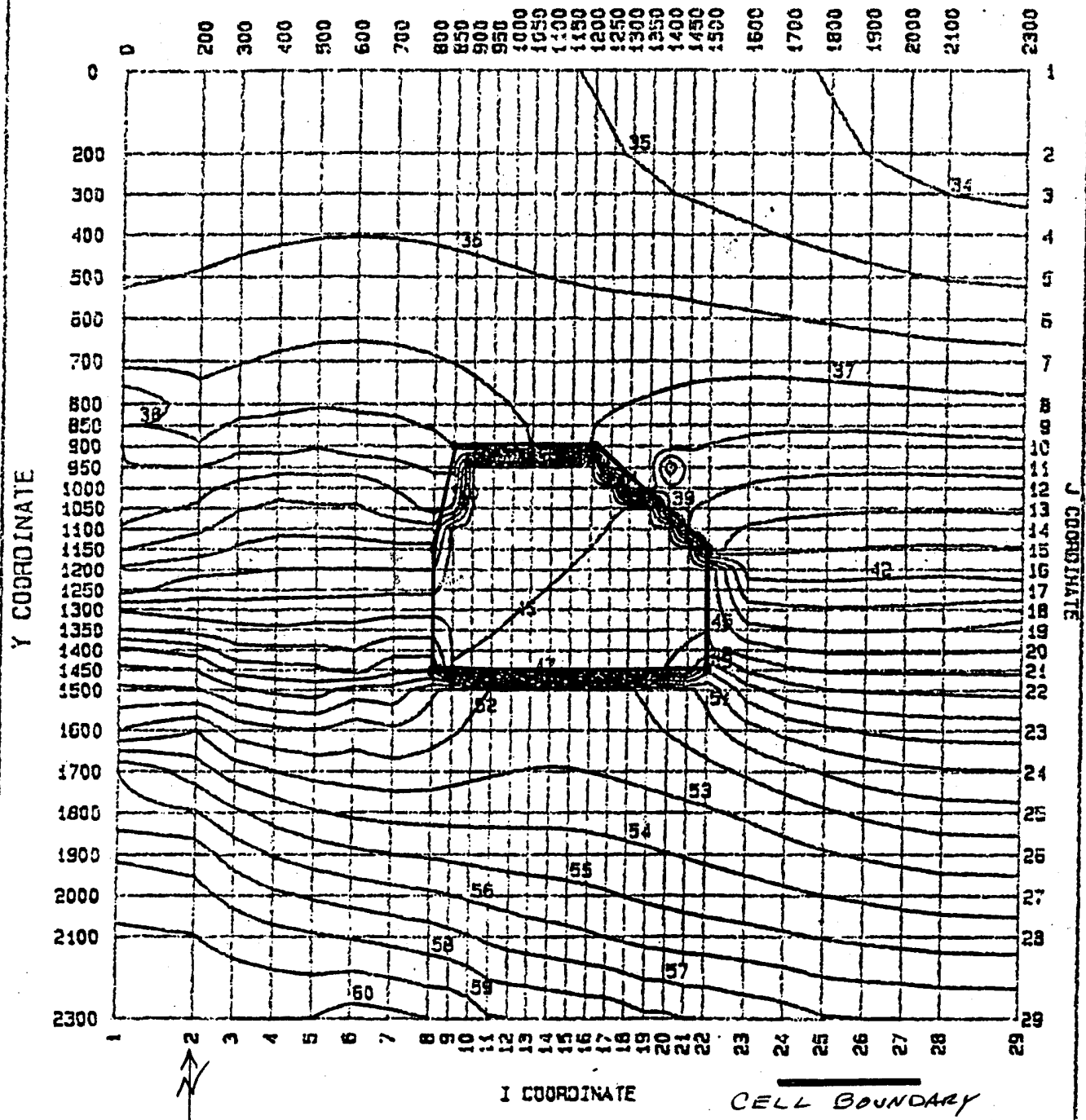


BASE EL 5200 NONPUMPING EQUALIZATION

PROJECT: rma	HEAD CONTOURS
FILE: 1	AFTER 2359.907 DAYS OF SIMULATION
LOCATION: denver	~ 6 1/2 YEARS

U.S. ARMY CORPS. ENGINEERS | FIGURE 3

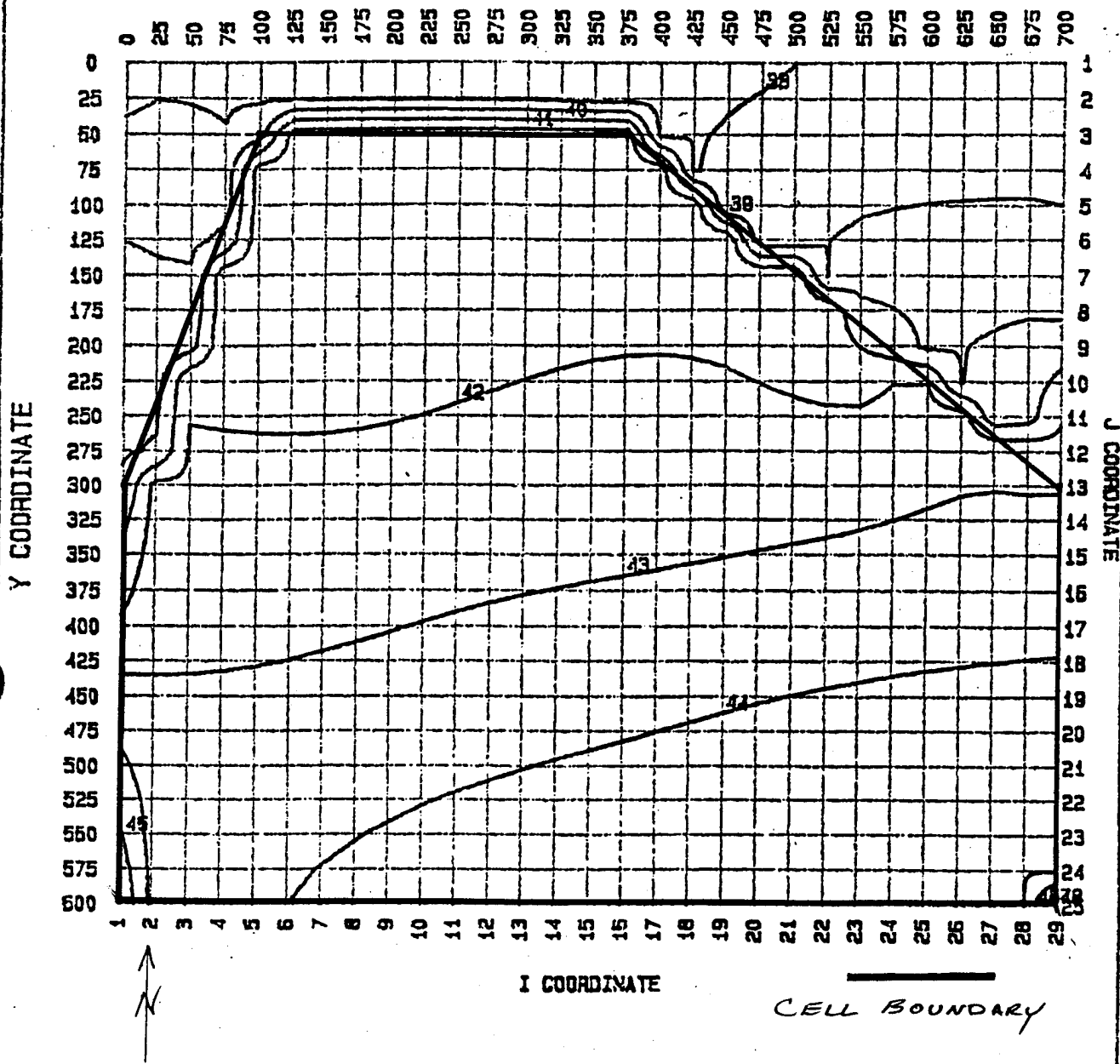
INTERPOLATED CONTOURS
X COORDINATE DISTANCE (FT)



NON PUMPING STABILIZATION

PROJECT: RMA "REGIONAL" FILE: 1 LOCATION: DENVER	HEAD CONTOURS AFTER 4096.12 DAYS OF SIMULATION ~ 11 1/4 YEARS
U.S. ARMY CORPS. ENGINEERS	FIGURE 7

INTERPOLATED CONTOURS
X COORDINATE DISTANCE (FT)



BASE EL. 5200

NONPUMPING EQUALIZATION

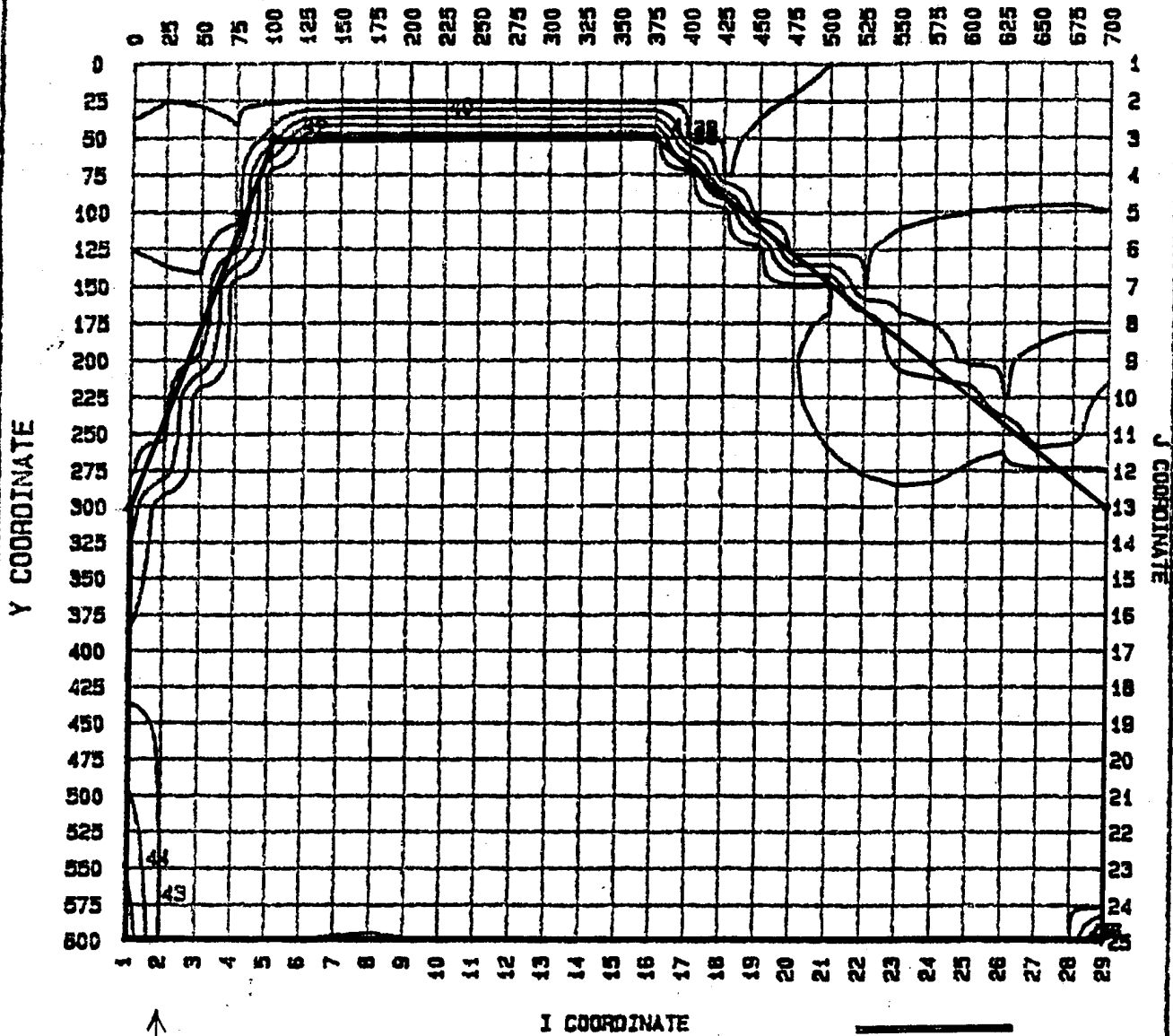
PROJECT: RMA CELL
FILE: C1
LOCATION: DENVER

HEAD CONTOURS
AFTER 2359.907 DAYS OF SIMULATION
~ 6 1/2 YEARS

U.S. ARMY CORPS. ENGINEERS

FIGURE 2

INTERPOLATED CONTOURS
X COORDINATE DISTANCE (FT)



CELL BOUNDARY

BASE EL 5200

NON PUMPING STABILIZATION

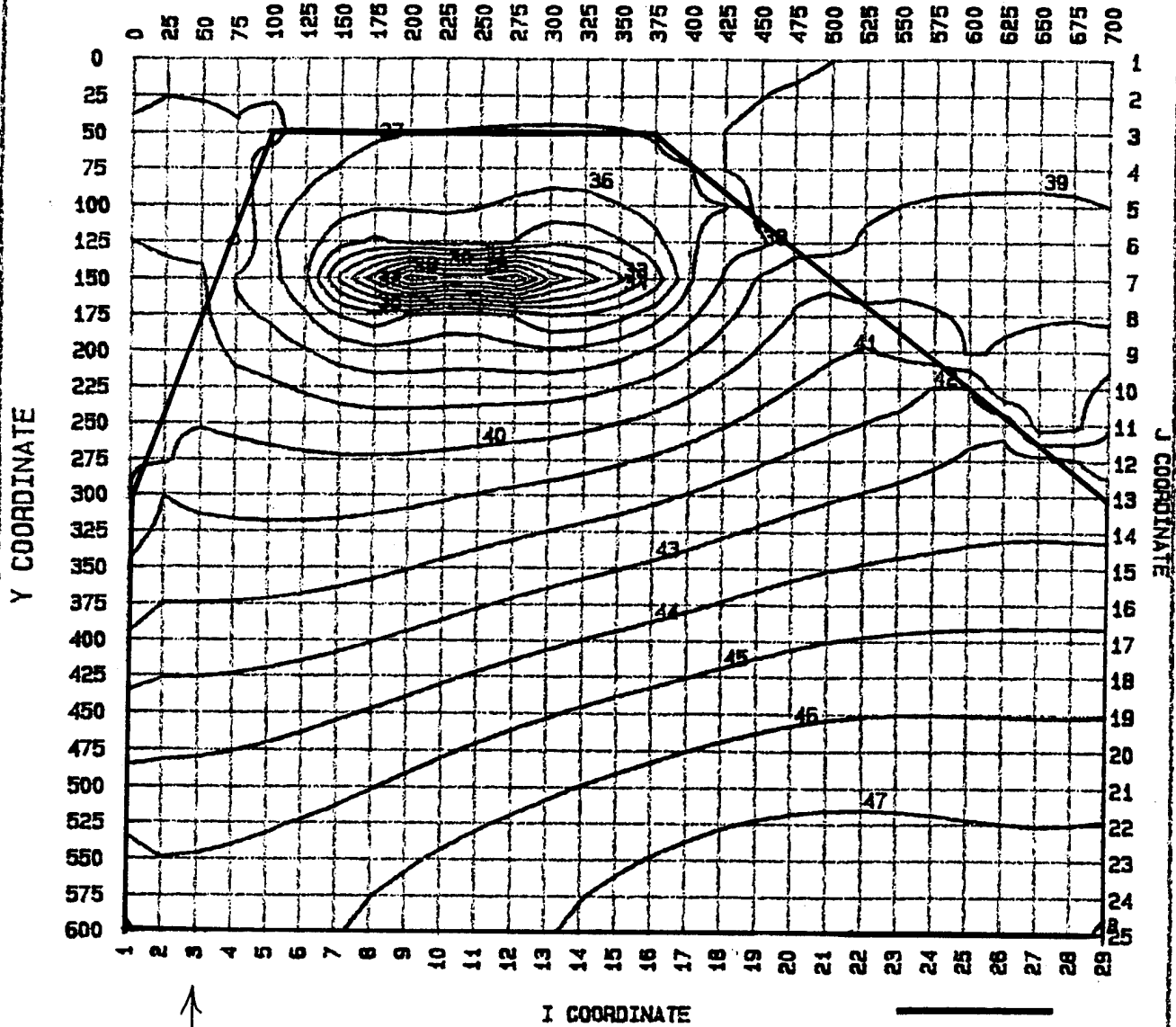
PROJECT: RMA CELL
FILE: C1
LOCATION: DENVER

HEAD CONTOURS
AFTER 7096.295 DAYS OF SIMULATION
~ 19 1/2 YEARS

U.S. ARMY CORPS. ENGINEERS

FIGURE 5

INTERPOLATED CONTOURS
X COORDINATE DISTANCE (FT)



CELL BOUNDARY

BASE EL. 5200

DRAIN SIMULATION
10 PUMPING WELLS
0.10 GPM EACH = 1.0 GPM TOTAL

PROJECT: RMA CELL
FILE: C1
LOCATION: DENVER

HEAD CONTOURS
AFTER 295.9797 DAYS OF SIMULATION

U.S. ARMY CORPS. ENGINEERS

FIGURE 5

PROJECT *RMA - Lime Settling Basins*

SHEET NO. *1* OF *3*

ITEM *Ground Water Flow thru Bedrock
(Denver Fm)*

BY *LMC*

DATE *5-24-90*

CHKD. BY

DATE

Data obtained from boring log for monitoring well 36109

DEPTH TO A SAND → 61.6 ft.

THICKNESS OF OVERBURDEN → -27.1 ft.

THICKNESS OF CLAYSTONE → 34.5 ft.

GRADIENT OF CLAYSTONE:

<i>5243 ft.</i>	<i>Elevation of top of A Sand (head)</i>
<i>-5234 ft.</i>	<i>Elevation of head to be maintained in cell</i>
<i>9 ft.</i>	

$$\frac{9 \text{ ft.}}{34.5 \text{ ft.}} = .26 = \text{Hydraulic Gradient of Claystone}$$

PROJECT RMA - Lime Settling Basins

SHEET NO. 2 OF 3

ITEM Ground Water Flow Thru Bedrock

BY JMC

DATE 5-24-90

CHKD: BY

DATE

Conservative K value for bedrock = 10^{-7} cm/sec

conversion to ft/day:

$$10^{-7} \frac{\text{cm}}{\text{sec}} = .0000001 \frac{\text{cm}}{\text{sec}} \times 2835 \frac{\text{ft}}{\text{day}} = .0002835 \frac{\text{ft}}{\text{day}}$$

Volume of flow:

gradient x K x surface area:

$$.26 \times .0002835 \frac{\text{ft}}{\text{day}} \times 338,250 \text{ft}^2 = 24.93 \frac{\text{ft}^3}{\text{day}}$$

Assumptions:

$$K \text{ value} = 10^{-9} \text{ cm/sec} = .000000001$$

conversion to ft³/day:

$$.000000001 \frac{\text{cm}}{\text{sec}} \times 2835 \frac{\text{ft}}{\text{day}} \times .26 \times 338,250 \text{ft}^2 = .25 \frac{\text{ft}^3}{\text{day}}$$

$$K \text{ value} = 10^{-8} \text{ cm/sec} = .00000001$$

conversion to ft³/day:

$$.00000001 \frac{\text{cm}}{\text{sec}} \times 2835 \frac{\text{ft}}{\text{day}} \times .26 \times 338,250 \text{ft}^2 = 2.49 \frac{\text{ft}^3}{\text{day}}$$

PROJECT RMA - Lime Settling Basins

SHEET NO. 3

OF 3

ITEM Total Ground Water Flow thru slurry wall
AND bedrock

BY JMC

DATE 5-24-90

CHKD. BY

DATE

$$Q_{Tot} = 14.93 \frac{ft^3}{day} = \text{total GW flow thru isolation cell}$$

(see previous calculations)

$$Q = 24.93 \frac{ft^3}{day} = \text{total GW flow thru bedrock when } K = 10^{-7} \frac{cm}{sec}$$

$$\begin{array}{r} 14.93 \text{ ft}^3/\text{day} \\ + 24.93 \text{ ft}^3/\text{day} \\ \hline 39.86 \text{ ft}^3/\text{day} \end{array}$$

$\sim 40 \text{ ft}^3/\text{day}$ = conservative / maximum estimate of total
groundwater flow

$$Q_{Tot} = 14.93 \text{ ft}^3/\text{day} = \text{total GW flow thru isolation cell}$$

$$Q = 2.49 \text{ ft}^3/\text{day} = \text{total GW flow thru bedrock when } K = 10^{-8} \frac{cm}{sec}$$

$$\begin{array}{r} 14.93 \text{ ft}^3/\text{day} \\ + 2.49 \text{ ft}^3/\text{day} \\ \hline 17.42 \text{ ft}^3/\text{day} \end{array}$$

$\sim 17 \text{ ft}^3/\text{day}$ = estimated total of groundwater flow

ESTIMATES OF GROUNDWATER FLOW RANGE FROM ~ 17 TO $40 \frac{ft^3}{day}$

PROJECT RMA Lime Settling Basins

SHEET NO. 1 OF 4

ITEM flow during sequential construction

BY JMC

DATE 20 July 90

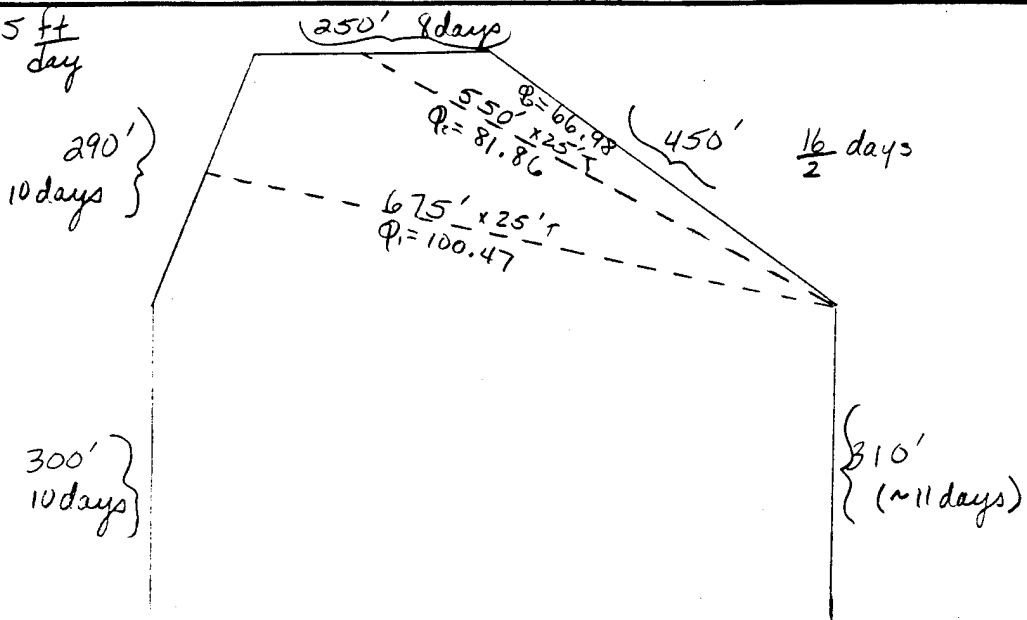
CHKD. BY

DATE

$K = 10^{-4} \frac{cm}{sec} = 0.2835 \frac{ft}{day}$

$I = 0.021$

$Q = KIA$



700' x 14' (thickness of saturated aquifer material)
 $\frac{24}{2}$ days

$Q_1 = 0.2835 \frac{ft}{day} \times 0.021 \times (675' \times 25') = 100.47 \frac{ft^3}{day}$

$32 \text{ days} \times Q (100.47 \frac{ft^3}{day}) = 3215.04 \text{ ft}^3$
 (S, W, + NW walls)

$Q_2 = 0.2835 \frac{ft}{day} \times 0.021 \times (550' \times 25') = 81.86 \frac{ft^3}{day}$

$8 \text{ days} \times 81.86 \text{ ft} = 654.88 \text{ ft}^3$
 (N wall)

$Q_3 = 0.2835 \times 0.021 \times (450' \times 25') = 66.98 \frac{ft^3}{day}$
 (NE wall)

$8 \text{ days} \times 66.98 \frac{ft^3}{day} = 535.84 \text{ ft}^3$

Total Days = 48 days (+ East Wall (11 days)) = 59 days

Total $Q_t = Q_1 + Q_2 + Q_3 = 4405.76 \text{ ft}^3$

($\approx 4406 \text{ ft}^3$)

PROJECT

SHEET NO. 2 OF 4

ITEM

BY LMC

DATE 20 July 90

CHKD. BY

DATE

East Wall - no significant Q

South Wall - $700' \div 30' = 23.3 \text{ days} \div 2 = 11.67$

$$\frac{.2835 \text{ ft}}{\text{day}} \times .021 \times (700' \times 14') \text{ ft}^2 = 58.34 \frac{\text{ft}^3}{\text{day}}$$

$$11.67 \text{ days} \times 58.34 \frac{\text{ft}^3}{\text{day}} = 680.83 \frac{\text{ft}^3}{\text{day/day}}$$

(12 days \times 58.34 = 700.08 ft³/day)

West Wall - $300' \div 30' = 10 \text{ days}$

$$.2835 \times .021 \times (300 \times 25) = 44.65 \text{ ft}^3/\text{day}$$

$$10 \text{ days} \times 44.65 \frac{\text{ft}^3}{\text{day}} = 446.51$$

North West Wall $290' \div 30 = 9.67 \text{ days}$

$$.2835 \times .021 \times (290' \times 25') = 43.16 \text{ ft}^3/\text{day}$$

$$9.67 \text{ days} \times 43.16 = 417.39$$

$$10 \text{ days} \times 43.16 = 431.60$$

North Wall $250' \div 30' = 8.33 \div 2 = 4.17 \text{ days}$

$$.2835 \times .021 \times (250' \times 25') = 37.21$$

$$4.17 \text{ days} \times 37.21 \text{ ft}^3/\text{day} = 155.16$$

$$4 \text{ days} \times 37.21 = 148.84$$

North East Wall $450' \div 30 = 15 \div 2 = 7.5 \text{ days}$

$$.2835 \times .021 \times (450' \times 25') = 66.98$$

$$7.5 \times 66.98 = 502.33$$

$$8 \times 66.98 = 535.84$$

PROJECT

SHEET NO. 3 OF 4

ITEM

BY JMC

DATE 20 July 90

CHKD: BY

DATE

midpoint from NW Wall $675 \text{ ft} \div 30 \text{ ft/day} = 22.5 \text{ days}$

$$Q = .2835 \times .021 \times (675 \times 25) = 100.47$$

(SW+NW way)
by days

$$22.5 \text{ days} \times 100.47 = 2260.47$$

$$23 \times 100.47 = 2310.81$$

midpoint from N wall $550 \text{ ft} \div 30 \text{ ft/day} = 18.3 \div 2 = 9.17$

$$.2835 \times .021 \times (550 \times 25) = 81.86$$

$$9.17 \times 81.86 = 750.66$$

$$9 \times 81.86 = 736.74$$

PROJECT

SHEET NO. 4 OF 4

ITEM

BY JMC

DATE 20 July 90

CHKD. BY

DATE

Sequential Construction

Days

East Wall	11
South Wall	12
West Wall	10
Northwest Wall	10
North Wall	4
Northeast Wall	8
midpoint from NW Wall	23
midpoint from N wall	<u>9</u>
	87 days

Q

East Wall	~0
South Wall	100.08
West Wall	446.51
Northwest Wall	431.60
North Wall	148.84
Northeast Wall	535.84
midpoint from NW wall	2310.81
midpoint from N Wall	<u>736.74</u>

$Q_T = 5310.43 \text{ ft}^3$

Total Q during construction

TABLE 1
SOIL-BENTONITE SLURRY TRENCH QUALITY CONTROL TESTING

<u>Subject</u>	<u>Test</u>		
	<u>Standard</u>	<u>Specific Test</u>	<u>Frequency</u>
Bentonite Powder	API STD-13A	a. YP/PV Ratio b. Plastic Viscosity c. Filtrate d. Record: d1. Wet Screen Analysis d2. Moisture Content	1 per truck shipment (100 bags)
Chemical Analysis of Water	API RP 13B-1	a. pH b. Hardness c. Total Dissolved Solids d. Oil, Organics etc.	Initially and monthly thereafter
	ASTM D152	Chloride	1 per water supply source or if changes occur
Initial Soil Bentonite Slurry Properties	API RP 13B-1	a. Viscosity b. Density c. pH	3 per shift (see Note 1)
In-Trench Soil Bentonite Slurry Properties	API RP 13B-1	a. Viscosity b. Density c. Sand Content	3 per shift (see Note 1)
Backfill Material	ASTM D 422	Grain Size	1 per 500 cubic yds
	ASTM D 4318	Atterberg limits	
Soil-Bentonite Backfill Material	ASTM C 143	Slump Cone	3 per shift (see Note 1)
	API RP 13B-1	Density	
	ASTM D 422	Grain Size	1 per 2000 cubic yds
	ASTM D 2216 EM 1110-2-1906	Moisture Permeability	1 per 100 ft. length or per new batch (see Note 2)
Compacted Clay	ASTM D 422	Grain Size	1 per 2000 cubic yds
	ASTM D 2922	Density (Nuclear)	5 per lift
	ASTM D 3017	Moisture (Nuclear)	5 per lift

02214-21

A 18-1

Notes:

- 1) If more than one (1) batching plant is being used, these frequencies shall apply to each batching plant separately.
- 2) Permeability test may be performed using fixed wall permeameter except that for every five such tests, there shall be performed one test using flexible wall permeameter.
- 3) Requirements of permeability on completed soil-bentonite cutoff wall are specified in Subparagraph: Slurry Trench.

02214-22

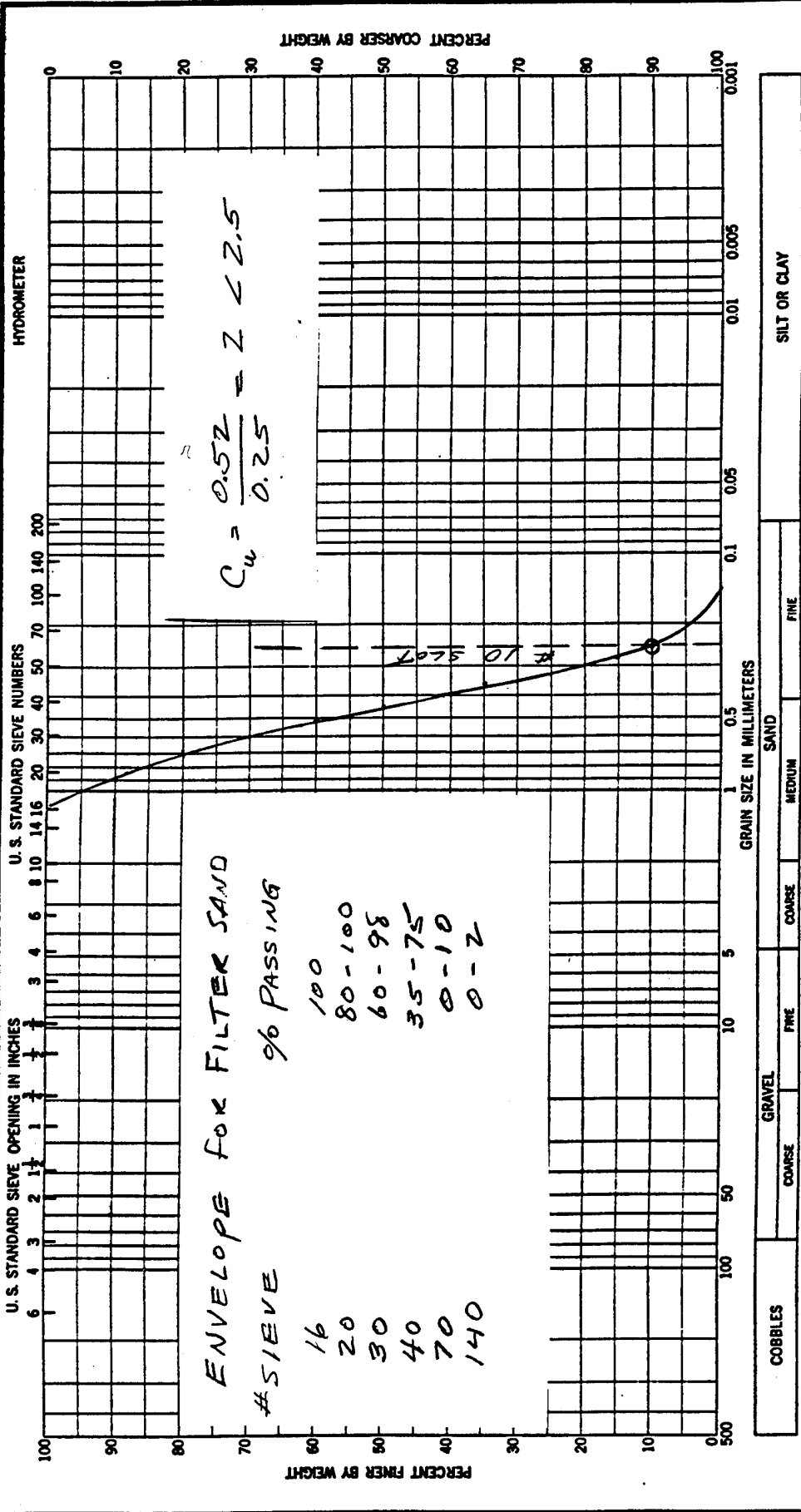
A 18-7

TABLE 2
SOIL-BENTONITE SLURRY TRENCH QUALITY ASSURANCE TESTING

<u>Subject</u>	<u>Test</u>		
	<u>Standard</u>	<u>Specific Test</u>	<u>Frequency</u>
Initial Soil Bentonite Slurry Properties	API RP 13B-1	a. Viscosity b. Density c. pH	1 per 3 shifts (Note 1)
In-Trench Soil Bentonite Slurry Properties	API RP 13B-1	a. Viscosity b. Density c. Sand Content	1 per 3 shifts (Note 1)
Backfill Material	ASTM D 422 ASTM D 4318	Grain Size Atterberg limits	1 per 5000 cubic yds
Soil-Bentonite Backfill Material	ASTM C 143 API RP 13B-1	Slump Cone Density	1 per 3 shifts (Note 1)
	ASTM D 422	Grain Size	1 per 10000 cubic yds
	ASTM D 2216 EM 1110-2-1906	Moisture Permeability	1 per 500 ft. length or per new batch (Note 2)

Notes:

- 1) If more than one (1) batching plant is being used, these frequencies shall apply to each batching plant separately.
- 2) Permeability test may be performed using fixed wall permeameter except that for every five such tests, there shall be performed one test using flexible wall permeameter.
- 3) Requirements of permeability on completed soil-bentonite cutoff wall are specified in Subparagraph: Slurry Trench.



Sample No.	Elev or Depth	Classification	Net w %	LL	PL	PI
		SILTY SAND, CLAYEY SAND SANDY CLAY				
		FILTER DESIGN BASED ON #10 SLOT SCREEN WITH UNIFORMITY COEFFICIENT ≤ 2.5				

Project: ROCKY MTN ARSENAL

Area: LIME SETTLING BASINS

Boring No.: GENERAL

Date:

GRADATION CURVES

A 19-1

VEGETATIVE COVER FOR LIME SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO
OCTOBER 12, 1990

POOR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0815 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.003060000017 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3394 VOL/VOL
FIELD CAPACITY	=	0.0906 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0771 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000085000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	73.68
TOTAL AREA OF COVER	=	385000. SQ FT
EVAPORATIVE ZONE DEPTH	=	14.00 INCHES
UPPER LIMIT VEG. STORAGE	=	5.3372 INCHES
INITIAL VEG. STORAGE	=	0.9741 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR DENVER COLORADO

MAXIMUM LEAF AREA INDEX = 1.00
START OF GROWING SEASON (JULIAN DATE) = 128
END OF GROWING SEASON (JULIAN DATE) = 284

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.50	33.60	38.00	47.40	57.20	67.00
73.30	71.40	62.60	51.90	38.70	32.60

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 76

JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC

PRECIPITATION

TOTALS	0.48	0.58	1.28	1.56	1.40	1.58
	2.48	1.55	1.03	0.97	1.09	0.31
STD. DEVIATIONS	0.47	0.23	0.08	0.62	1.37	0.83
	0.26	1.23	0.82	0.69	0.78	0.16

RUNOFF

TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

EVAPOTRANSPIRATION

TOTALS	0.589	0.561	1.116	1.512	1.378	1.971
	2.442	1.788	0.850	0.931	0.863	0.353
STD. DEVIATIONS	0.431	0.316	0.231	0.503	0.811	0.967
	0.161	1.131	0.584	0.720	0.478	0.142

PERCOLATION FROM LAYER 2

TOTALS	0.0009	0.0008	0.0008	0.0008	0.0008	0.0009
	0.0012	0.0012	0.0011	0.0011	0.0010	0.0010
STD. DEVIATIONS	0.0005	0.0005	0.0005	0.0005	0.0005	0.0003
	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 76

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	14.32 (1.079)	459327.	100.00
RUNOFF	0.000 (0.000)	0.	0.00
EVAPOTRANSPIRATION	14.353 (0.604)	460508.	100.26
PERCOLATION FROM LAYER 2	0.0115 (0.0018)	369.	0.08
CHANGE IN WATER STORAGE	-0.048 (0.550)	-1551.	-0.34

PEAK DAILY VALUES FOR YEARS 74 THROUGH 76

	(INCHES)	(CU. FT.)
PRECIPITATION	1.79	57429.2
RUNOFF	0.000	0.0
PERCOLATION FROM LAYER 2	0.0001	1.7
SNOW WATER	0.47	15079.2
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1686	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0463	

FINAL WATER STORAGE AT END OF YEAR 76

LAYER	(INCHES)	(VOL/VOL)
1	0.42	0.0695
2	0.85	0.0710
SNOW WATER	0.00	

CONVERSATION RECORD

TIME
10:00 am

DATE
6 FEB. 1990

TYPE
 VISIT
 CONFERENCE
 TELEPHONE
 INCOMING
 OUTGOING

ROUTING	
NAME/SYMBOL	INT

Location of Visit/Conference:

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU: **MARK ZAPPI**
 ORGANIZATION (Office, dept., bureau, etc.): **CEWES-EE-5**
 TELEPHONE NO.: **(601) 634-2854**

SUBJECT
**SLURRY WALL COMPATIBILITY TESTING,
 ROCKY MOUNTAIN ARSENAL**

SUMMARY
 OUR BASIC PLAN FOR SLURRY WALL COMPATIBILITY TESTING IS OK BUT NEEDS SOME FINE TUNING. HE RECOMMENDED USING MOSTLY FLEXIBLE WALL PERMEAMETERS BUT A FEW REPLICATE SAMPLES IN RIGID WALL SINCE FLEXIBLE WALLS DON'T SHOW SAMPLE SHRINKAGE. HE ALSO SUGGESTED RUNNING EACH SAMPLE IN TRIPLICATE. MARK SAID RUN AT LEAST ONE PORE VOLUME OF TAP WATER THROUGH THE SAMPLES FOLLOWED BY AT LEAST 2 PORE VOLUMES OF CONTAMINATED GROUND WATER. HE AGREED CALCIUM IN THE SOILS (LIME SETTLING BASINS) COULD EXCHANGE WITH SODIUM IN BENTONITE TO INCREASE PERMEABILITY AND SUGGESTED ~~RUNNING~~ ^{TRACKING} SODIUM AND CALCIUM INTO AND OUT OF THE SYSTEM. HE SUGGESTED USING WES LAB TO RUN THE TESTS IF MRD LAB COULD NOT DO TESTING. MARK SAID TRYING TO DETERMINE ^{CONTAMINANT} BREAKTHROUGH TIME IS A GOOD IDEA BUT NOT ^{2 PRACTICAL WITH PERMEAMETERS}

ACTION REQUIRED
 UPDATE SCOPE OF SERVICES INCORPORATING ABOVE INFORMATION. LOOK FURTHER INTO USING WES LAB FOR TESTING.

NAME OF PERSON DOCUMENTING CONVERSATION JANE M. BOLTON	SIGNATURE <i>Jane M. Bolton</i>	DATE 6 FEB. 1990
--	------------------------------------	----------------------------

ACTION TAKEN
 SCOPE UPDATED. MRD LAB, NOT WES, WILL DO TESTING

SIGNATURE <i>Jane M. Bolton</i>	TITLE CIVIL ENGINEER	DATE 20 FEB. 1990
------------------------------------	--------------------------------	-----------------------------

CONVERSATION RECORD

TIME
12:45

DATE
9/5/90

TYPE

VISIT

CONFERENCE

TELEPHONE

INCOMING

OUTGOING

ROUTING

NAME/SYMBOL

INITIALS

Location of Visit/Conference:

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU

ORGANIZATION (Office, dept., bureau, etc.)

TELEPHONE NO:

DR. WAYNE CHARLIE P. E.

COLORADO STATE UNIV.

(303)
491-8584

SUBJECT

ROCKY MTN. ARSENAL - M-1 BASINS

SHEET PILE DESIGN

SUMMARY

DR. CHARLIE WAS INFORMED THAT WE WERE DESIGNING A SHEET PILE WALL AT RMA TO PREVENT MIGRATION OF GROUNDWATER INTO THE AREA TO BE VITRIFIED, AND WE NEEDED INFORMATION ABOUT WHAT TYPE OF SHEET PILE TO SPECIFY BASED ON BLOW COUNTS DURING EXPLORATORY DRILLING. HE SAID THERE IS INFO. IN THE NAVY DESIGN MANUAL 7.2 EARTH & EARTH RETAINING STRUCTURES. HE ALSO HAS SOME INFO. THAT HE WILL FAX ME. HE SAID THE BLOW COUNTS USING 3" DIAMETER SPLIT SPOONS ^{INSTEAD OF 2" DIAM.} WOULD BE HIGHER THAN WITH SPT 2' SPLIT SPOONS. I ALSO EXPRESSED CONCERNS ABOUT VIBRATIONS CAUSING PROBLEMS WITH ADJACENT STRUCTURES LEFT IN PLACE (> 20 FT. AWAY). HE SAID AN ASCE ARTICLE ABOUT CONSTRUCTION VIBRATIONS PASSED OUT IN HIS SOIL DYNAMICS CLASS WOULD HAVE INFO, BUT THAT PROBABLY IF PEAK VIBRATIONS WERE BELOW 1 OR 2 INCHES/SEC. THINGS WOULD BE O.K. HE ALSO RECOMMENDED USING A VIBRATORY HAMMER INSTEAD OF A DRIVING HAMMER AND ACTION REQUIRED

LOCATE REFERENCES AND USE IN DESIGN.

NAME OF PERSON DOCUMENTING CONVERSATION

SIGNATURE

DATE

JANE BOLTON

Jane Bolton

9/5/90

ACTION TAKEN

REFERENCES LOCATED, VIBRATORY HAMMER AND SETTLEMENT MONUMENTS PUT IN PLANS & SPECS. SIZING OF PILE GIVEN TO CEMRO-ED-DF

SIGNATURE

TITLE

DATE

Jane Bolton

CIVIL ENGINEER

9/25/90

CONVERSATION RECORD

TIME

DATE

TYPE

VISIT

CONFERENCE

TELEPHONE

INCOMING

OUTGOING

ROUTING

NAME/SYMBOL

INT

Location of Visit/Conference:

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU

ORGANIZATION (Office, dept., bureau, etc.)

TELEPHONE NO.

SUBJECT

SUMMARY

CONT.

MAYBE PUTTING A FEW SETTLEMENT MARKERS NEAR SOME STRUCTURES AND MONITORING THEM ONCE A DAY AT THE BEGINNING OF DRIVING TO SEE IF THERE ARE ANY PROBLEMS.

CIVIL ENGINEERING

(DR. CHARLIE IS AN ASSOCIATE PROFESSOR AT CSU SPECIALIZING IN SOIL DYNAMICS AND FOUNDATIONS. HE WAS MY GRADUATE PROGRAM ADVISOR)

ACTION REQUIRED

NAME OF PERSON DOCUMENTING CONVERSATION

SIGNATURE

DATE

ACTION TAKEN

SIGNATURE

TITLE

DATE

CONVERSATION RECORD

TIME
8:30 pmDATE
10/2/90

TYPE

 VISIT CONFERENCE TELEPHONE INCOMING OUTGOING

ROUTING

NAME/SYMBOL

INT

Location of Visit/Conference:

NAME OF PERSON(S) CONTACTED OR IN CONTACT WITH YOU

MIKE SNEIDER

ORGANIZATION (Office, dept., bureau, etc.)

TELEPHONE NO:

(301)
962-4772

SUBJECT

SLURRY TRENCH "SET-UP" TIME

SUMMARY

MR. SNEIDER WAS INFORMED OF MY QUESTIONS AND CONCERNS ABOUT THE NUMBER OF DAYS FOLLOWING SLURRY WALL BACKFILL INSTALLATION BEFORE HEAVY EQUIPMENT CAN CROSS THE WALL WITHOUT DAMAGE. HE SAID ON KANE AND LOMBARD THE SOIL-BENTONITE BACKFILL DID A LOT OF HARDENING WITHIN 2-3 DAYS AFTER INSTALLATION. HE RECOMMENDED PLACING THE CLAY COVER ^{ABOUT} 2-3 DAYS AFTER BACKFILLING. WHEN ASKED ABOUT HEAVY EQUIPMENT CROSSING THE WALL HE RECOMMENDED AT LEAST 3' OF COMPACTED CLAY AT THE CROSSING LOCATION.

ACTION REQUIRED

INCORPORATE INFO. INTO PLANS & SPECS

NAME OF PERSON DOCUMENTING CONVERSATION

JANE BOLTON

SIGNATURE

Jane Bolton

DATE

10/2/90

ACTION TAKEN

INFO. INCORPORATED

SIGNATURE

Jane Bolton

TITLE



CIVIL ENGINEER

DATE

10/3/90

BORING LOCATION <u>Sec. 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>K. Cross</u>	DATE STARTED <u>7-9-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME75</u>		COMPLETION DEPTH <u>32</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST <u>10</u>
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	<u>T. Terry</u>	PID PPM
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>35</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Porewater Data	SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.)		
		Lithology	Pneumometer Installation			Type No.	Recovery (Feet/Min)			
1	Fill, sand, grayish white chunks and crystals, moist, appears to be lime, brown, light gray, dark brown							PID PPM REMARKS (Drill Rate, Fluid loss, Odor, etc.)		
2										
3										
4										
5										
6										
7	Sand, very moist to wet, loose, light brownish gray, 10YR5/2 (SP) silty							0 PPM		
8										
9										
10										
11								0 PPM		
12										
13										
14										

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Piezometer Data	SAMPLES		PID PPM REMARKS (Drill Rate, Field loss, Odor, etc)
		Lithology	Piezometer Installation			Type No.	Depth (ft)	
14								
15							5	24.9
16	Sand, very silty, grayish brown, wet, medium dense, iron oxide staining (SM) 10YR6/2					7		
17						8		
18								
19								
20							4	
21	Clay, trace sand and silt, wet, brown, stiff to very stiff (CL) 10YR5/3					6		
22						11		
23								
24								
25							4	
26							6	
27							7	
28								
29								
30							6	
31							10	
32							38	

DRAWN



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Grth Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Approx. Depth (ft)	
32	Claystone, silty, firm to hard fractured, iron oxide staining (CH) 10YR 5/3, 10YR 4/2 DENVER FORMATION	[Diagonal hatching]				C		
33								
34								
35								

DRAFT

DRILLING LOCATION <u>Sec. 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-9-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>EME 75</u>		COMPLETION DEPTH <u>32.5</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST <u>10</u>
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.		
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>32.5 FT</u>		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			PID PPM REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	TYPE NO	RECYCL	PERCENT RISK (0.01% to 0.1%)	
1	Fill, Sand, lime, moist, white, brown, trace gravel, 10YR8/1, 10YR4/3	[Cross-hatched pattern]							ND
2									
3									
4									
5									
6									
7									
8									
9	Sand, little silt, very moist, wet, loose, dark grayish brown, (SP) 10YR4/2	[Dotted pattern]							ND
10									
11									
12	Sand, silty, wet, medium dense to dense, yellowish brown, (SM), 10YR5/4	[Dotted pattern]							ND
13									
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			P.I.D. PPM REMARKS (Drill Rate, Fluid loss, Odor, etc)	
		Lithology	Piezometer Installation	Water Content	Piezometer Depth	Type No.	RIEGLER #	WATER CONTENT (Below 6 in)		
14										
15							7		37.2	
16							8			
17							10			
18	Clay (Weathered Claystone) very stiff, pale brown, yellowish brown, fractured, blocky, (CL) 10YR 6/3, 10YR 5/4									
19										
20								8		85.4
21								11		
22								15		
23										
24										
25							5		1.4	
26							11			
27							13			
28	Claystone, siltstone, hard to very hard, yellowish brown, iron oxide staining, (CH), 10YR 5/4									
29										
30								23		11.9
31								30		
32										4.7


BORING LOCATION <u>LYME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>M. WALKER</u>	DATE STARTED <u>7-10-70</u>	DATE FINISHED
DRILLING EQUIPMENT <u>ONE 750 w/ 6-7/8" HSA</u>		COMPLETION DEPTH <u>37.5</u>	SAMPLES <u>3⁴⁰ split sp...</u>
DRILLING METHOD <u>Hollow stem augers</u>	DRILL BIT	NO. OF SAMPLES <u>7</u>	DIST. <u>1</u>
SIZE AND TYPE OF CASING		WATER ELEV. <u>13</u>	FIRST <u>15</u>
TYPE OF PERFORATION	FROM - TO FT.	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK	FROM - TO FT.	<u>S. MORRISSETTE</u>	
TYPE OF SEAL	FROM <u>0</u> TO <u>37.5</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Pycnometer Installation	Water Content	Plasticity Index	Type No.	Recovery	Penetration (lb/in)	
0	(SM) gravelly silty SAND, very fine grained, poorly graded, medium dense, dry, 10y2/3 brown to dark brown								Topsoil
1	(SM) silty SAND, fine-grained, poorly graded, medium dense, dry, 10y2/3 brown to dark brown								
2									
3						SS 14	9	8	PI=ND
4									
5									
6	becomes slightly clayey					SS 9	12	10	PI=2.0 ppm
7	becomes 10y2/4 light yellowish brown								
8						SS 14	5	5	PI=ND
9									
10	(SC) clayey SAND, fine-grained, poorly graded, medium dense, very moist, 10y2/4 light yellowish brown								Alluvium
11						SS 17	6	5	PI=3.0 ppm
12									
13									Water enters ATD
14	(SM) silty SAND, fine-grained, poorly graded, medium dense, wet, 10y2/5/4 yellowish-brown								Alluvium



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Plasticity Data	SAMPLES			REMARKS (Drill Rate, Field Test, Odor, etc)		
		Lithology	Parameter Indication			Type No.	Depth (ft)	Depth (ft)			
14	SAME: (SM) silty SAND, fine-grained, poorly graded, medium dense, wet, loys/4 yellowish-brown							7	Alluvium PID = 29 ppm		
15								SS 14		12	
16										13	
17											
18											
19											
20	(CL) sandy silty CLAY, low to medium plastic, stiff to very stiff, very moist, loys/3 brown to loys 7/3 very pale brown							6	Alluvium reworked shale bedrock PID = 15 ppm		
21								SS 17		9	
22										11	
23											
24											
25											
25	(CH) silty clay SHALE, highly plastic, firm, very moist, loys 2/2 very dark brown, iron oxide stains, carbonaceous							9	Denver fm. slightly weathered PID = 17 ppm		
26	SS 15							12			
27								17			
28	becoming unweathered								drilling becomes stiff		
29	claystone										
30											
31									Core run #1		
32											

X 9 11 11 11

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Field loss, Odor, etc)
		Lithology	Porometer Installation	Water Content	Porosimeter Data	Type No.	Depth (ft)	Pressure (psi)	Time (min)	
32	(CH) silty clay stone , highly plastic, medium hard, very moist, 10% R 2/2 very dark brown, iron oxide stains, carbonaceous					CORE	32			Denser than unweathered
33										
34	Claystone									Bottom of logging at 33.5 feet
35										
36										
37										
38										
39										
40										
41										
42										
43										
44										
45										
46										
47										
48										
49										
50										

DRAFT

BORING LOCATION		ELEVATION AND DATUM							
DRILLING AGENCY		DATE STARTED							
DRILLING EQUIPMENT		COMPLETION DEPTH							
DRILLING METHOD		NO. OF SAMPLES							
SIZE AND TYPE OF CASING		WATER ELEV.							
TYPE OF PERFORATION		LOGGED BY							
SIZE AND TYPE OF PACK		CHECKED BY							
TYPE OF SEAL									
LIME SETTLING BASINS									
CAYNE - WESTERN		7-9-90							
M. WALKER		29.0							
ONE 7SD W/6-5/8" OD HSA		7							
Hollow stem augers		1							
		7.0							
		ND							
		24 HRS.							
		S. MORRISSETTE							
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE NO.	RESULTS	Particle Resist. (lb/sq. in.)	
0	(SC) clayey silty SAND, fine-grained, poorly graded, very stiff, moist, loys/3 brown, organic, with roots								Topsoil Alluvium
1	(SM) silty SAND, fine-grained, poorly-graded, subangular to subrounded, dense, moist, loys/4 yellowish-brown								
2									
3									PID=ND
4									
5									
6									PID=ND
7	becomes loys/6/3 and wet								water enters ATD
8									PID=ND
9									
10									
11									PID=ND-8ppm
12									
13									
14									

DRAWING

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Plasticity Index	SAMPLES			REMARKS (Drift Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation			Type No.	Blow Count	Blow Count (ft)	
14	SAME: silty SAND (sm), fine-grained, poorly graded, subangular to subrounded, dense, wet, 10yr 6/3	[Lithology symbols]	[Piezometer symbols]						Alluvium
15									
16	(CL) sandy silty CLAY, low plastic, very stiff, fine grained sand wet, 10yr 5/3 brown with 10yr 8/2 white mottling	[Lithology symbols]	[Piezometer symbols]						PID=ND
17									
18	(CH) sandy silty CLAY, highly plastic, medium hard, very moist, 10yr 6/4 light yellowish-brown	[Lithology symbols]	[Piezometer symbols]						Denver fm weathered
19									
20		[Lithology symbols]	[Piezometer symbols]						PID=ND
21									
22		[Lithology symbols]	[Piezometer symbols]						
23									
24	(CH) silty CLAY SHALE, highly plastic, hard, very moist, 10yr 6/4 light yellowish-brown to 10yr 2/1 dark gray, slightly carbonaceous	[Lithology symbols]	[Piezometer symbols]						Denver fm unweathered
25									
26		[Lithology symbols]	[Piezometer symbols]						CORE RUN #1
27									
28		[Lithology symbols]	[Piezometer symbols]						
29									
30									Bottom of boring at 29.0 FEET
31									
32									

BORING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE WESTERN</u>	DRILLER <u>M. WALKER</u>	DATE STARTED <u>7-9-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>ONE 750 w/ 6-5/8" OD HSA</u>		COMPLETION DEPTH <u>36.5</u>	SAMPLER <u>3" OD split spoon</u>
DRILLING METHOD <u>Hollow stem augers</u>	DRILL BIT	NO. OF SAMPLES <u>8</u>	DIST. <u>1</u>
SIZE AND TYPE OF CASING <u>-</u>		WATER ELEV. <u>FIRST 4.5</u>	COMPL. <u>NO. 24 HRS.</u>
TYPE OF PERFORATION <u>-</u>		LOGGED BY <u>S. MORRISSETTE</u>	
TYPE AND TYPE OF PACK <u>-</u>		CHECKED BY	
TYPE OF SEAL <u>6 POINT</u>		FROM <u>0</u> TO <u>36.5</u> FT.	

DEPTH (FEET)	DESCRIPTION	GRAIATIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Weight Corral	Piezometer Date	TYPE NO.	RECORDS	Particle Size, No. of Grains (in)	
0	(Sm) silty SAND, fine-grained, poorly graded, subangular to subrounded, medium dense, dry, 10 yrs/4 yellowish-brown								alluvial sand/silt or fill (?)
1									
2									
3	becomes moist							SS 6 S 5 4	PIO=ND
4									
5									
6								SS 18 S 5 4	PIO=ND Alluvium
7	(sm to med) silty SAND to sandy silt, fine-grained, poorly-graded, medium dense, moist, 10 yrs/2 grayish-brown								Alluvium
8	(Sm) silty SAND, fine-grained, poorly-graded, subangular to subrounded, medium dense, moist, 10 yrs/4 yellowish-brown							SS 14 S 6 3	PIO=ND
9									
10								SS 14 S 5 18	water enters ATD PIO=ND
11									
12									
13									
14									



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Orn. Rate, Fluid loss, Odor, etc)	
		Lithology	Mozometer Installation	Water Content	Piezometer Data	Type No.	Recon. #	PILOT POINT	DEPTH (ft)		
14	SAME: (SM) silty SAND, fine-grained, poorly-graded, subangular to subrounded, medium dense, moist, 10yr 5/4 yellowish-brown							7	8	9	Alluvium
15											PIID=ND
16	(MC) slightly sandy silt, non-plastic, medium dense, very fine grained sand, wet, 10yr 5/3 brown. silty sand										Alluvium
17											
18	(SM) slightly clayey silty SAND, fine-grained, poorly graded, medium dense, wet, 10yr 4/4 dark yellowish-brown										Alluvium
19											
20	(CL) sandy silty CLAY, low plastic, stiff, fine-grained SAND, very moist, 10yr 8/2 white to 10yr 8/3 very pale brown							5	7	10	PIID=ND Alluvium reworked shale
21											
22	(CH) sandy silty clay, highly plastic, hard, fine-grained sand, blocky, 10yr 8/3 brown, carbonaceous weathered claystone										Denser fm weathered
23											
24	(CH) slightly sandy silty CLAY, highly plastic, very hard, moist, 10yr 5/3 brown, iron oxide stains claystone										Denser fm unweathered
25											
26								12	24	32	PIID=ND
27											
28											
29											
30											
31											
32											



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Field Test, Odor, etc)
		Lithology	Micrometer Insulation	Water Content	Plasticity Index	Type No.	Pres. (1)	Moist. (2)	
32	SAMS: (CH) slightly sandy silty clay, highly plastic, very hard, moisty layers/3 brown iron oxide stains	[Hatched pattern]				C	1	32	Denver Fm unweathered
33									
34									
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									
45									
46									
47									
48									
49									
50									Bottom of boring at 36.5 ft.

DRAFT

86mc114A

BORING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. Albritton</u>	DATE STARTED <u>6-20-90</u>	DATE FINISHED <u>6-21-90</u>
DRILLING EQUIPMENT <u>CME SS with 6-1/8" OD HSA</u>		COMPLETION DEPTH <u>47.5</u>	SAMPLER <u>3.00 SS</u>
DRILLING METHOD <u>Hollow stem augers</u>	DRILL BIT	NO. OF SAMPLES	DIST. <u>10</u> UNDIST. <u>2</u>
SIZE AND TYPE OF CASING		WATER ELEV.	FIRST <u>8.5</u> COMPL <u>22</u> 24 HRS.
TYPE OF PERFORATION	FROM TO FT.	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK	FROM TO FT.	<u>S. MORRISSETTE</u>	
TYPE OF SEAL	FROM TO FT.		
	<u>Grout</u>	<u>0</u>	<u>47.5</u>

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)								
		Lithology	Plazometer Installation	Water Content	Piezometer Date	Type No	Recovery	Penetration (lb/ft ²)									
0	<p>Silty SAND, fine-grained, poorly graded, medium dense, moist, 10yr 4/4 dark yellowish brown, *</p> <p>becomes siltier and more moist</p>	SM							Aeolian sand & silt								
1																	
2																	
3																	PID=ND
4																	
5																	
6																	
7	<p>sandy silt, non-plastic, soft, very moist, 10yr 4/4 dark yellowish-brown</p> <p>becomes wet silty sand (SM)</p>	SM							Alluvium								
8																PID=ND	
9										← water enters ATD							
10																	
11	<p>Silty SAND, fine-grained, poorly graded, medium dense, wet, 10yr 5/4 yellowish-brown</p>	SM															
12																PID=ND	
13										Alluvium							
14																	






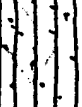
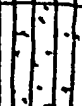
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drift Note, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Notes Content	Piezometer Depth	Type No.	Depth (ft) From Piezometer (ft)	
14	SAME: silty SAND, fine-grained, poorly graded, medium dense, wet, 10YR 5/4 yellowish-brown with some siltier zones	SM						Alluvium
15								
16								
17								
18								
19								
20								
21	With some thin seams (1/2") of SILT, 10YR 8/3 very pale brown							
22								
23								
24								
25								
26	Silty CLAY, highly plastic, hard, wet, 10YR 3/1 very dark gray, with trace of coarse grained gravel	CH						
27	Silty SAND, fine-grained, poorly graded, very dense, wet, 10YR 4/6 dk. yellowish brown with some 2.5YR 5/4 mottling	SM						
28								
29								
30								
31								
32								

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Depth	TYPE NO.	
32.5	SAME: silty SAND, fine-grained, poorly graded, very dense, wet, 10 yr 4/6 with some 2.5 yr S/4 mottling						Alluvium
33							
34							
35							
36							PID=ND
37							
38	SHALE: silty CLAY, highly plastic, hard, very moist, 10 yr 4/2 dark grayish-brown with some iron-oxide staining, carbonaceous Claystone						Denver fm
39							
40							
41							PID=ND Core run #1
42							
43							
44							
45							
46							
47							
48							
49							
50							

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SHEET 3 OF 3

BORING LOCATION <u>LIME SETTLING BASINS.</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. PARKER</u>	DATE STARTED <u>6-21-90</u>	DATE FINISHED <u>6-22-90</u>
DRILLING EQUIPMENT <u>CME SS with 6-5/8" OD HSA</u>		COMPLETION DEPTH <u>47.5</u>	SAMPLER <u>3" OD split spoon</u>
DRILLING METHOD <u>Hollow stem augers</u>	DRILL BIT	NO. OF SAMPLES <u>9</u>	DIST. <u>9</u>
SIZE AND TYPE OF CASING		WATER ELEV. <u>10.5</u>	UNDIST. <u>2</u>
TYPE OF PERFORATION		LOGGED BY <u>S. MORRISSETTE</u>	
TYPE OF SEAL <u>Grout</u>		CHECKED BY	

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE NO.	RECORD #	PARALLEL TO LOG (ft/in)	
0	<u>Grout</u> Silty SAND, fine grained, poorly graded, medium dense, dry, 10YR5/6 yellowish-brown								alluvial sand & silt / fill (?)
1	<u>Fill</u>								Fill/sludge
2	<u>Fill</u> Sandy silty CLAY, low to medium plastic, stiff, very moist, 10YR6/1 gray to light gray with trace of medium gravel and some wood chips								PIID=ND
3	<u>Fill</u>								Sludge
4	<u>Fill</u>								PIID=ND
5	<u>Fill</u> Silty CLAY, low to medium plastic, medium stiff, very moist, 10YR 2.5 YR 6/N6 gray								PIID=ND
6	<u>Fill</u>								PIID=ND
7	<u>SM</u> Silty SAND, very fine grained, poorly graded, medium dense, very moist, 10YR 4/2 dark grayish-brown or sandy SILT								Alluvium/colian sand/silt PIID=ND
8	<u>SM</u> Silty SAND, very fine grained, poorly graded, loose, wet, 10YR 5/2 grayish brown								Alluvium ← water enters ATD PIID=ND
9									
10									
11									
12									
13									
14									

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SHEET 1 OF 3

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Field test, Odor, etc)	
		Lithology	Piezometer Installation	Water Content	PH	Date	TYPE NO.		DEPTH (ft)
14	(Sm) SAME: silty SAND, very fine grained, poorly graded, loose, wet, 10 YRS/2 greyish brown								Alluvium
15									
16							SS 67	13	PIID=ND
17									
18									
19									
20	becomes less silty								
21							SS 511	14	PIID=3.0ppm
22									
23	(Sm) sandy silt, non-plastic, wet, 10 YRS/2 dark greyish-brown or silty SAND								Alluvium
24	silty sand								
25							SS 511	15	PIID=1.2ppm
26									
27									
28	(Sm) silty SAND, very fine grained, poorly graded, medium dense, wet, 10 YRS/3 brown to dark brown								Alluvium
29									
30							SS 17	15	PIID=ND
31									
32									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Field loss, Odor, etc)
		Lithology	Pneumometer Installation	Water Content	Plazometer Data	Type No.	Depth (ft)	
32	(sw) SAME: silty SAND, very fine-grained, poorly graded, medium to coarse, wet, 10YR 4/3 brown to dark brown	[Lithology symbol]						alluvium
33	(CL to CH) WEATHERED SHALE: silty CLAY, medium to highly plastic, hard, very moist, 10YR 5/4 yellowish-brown with trace of fine grained SAND, blocky texture Claystone	[Lithology symbol]						Denver fm
34		[Lithology symbol]						
35		[Lithology symbol]						PI=ND stopped drilling 6-21-92
36		[Lithology symbol]						resumed drilling 6-22-92
37	(CA) WEATHERED SHALE: silty CLAY, highly plastic, hard, very moist, 10YR 6/1 light gray to gray with iron oxide staining and iron nodules Claystone	[Lithology symbol]						best Denver fm
38		[Lithology symbol]						
39		[Lithology symbol]						
40		[Lithology symbol]						core run #1
41		[Lithology symbol]						
42	WEATHERED SANDSTONE: silty SAND, fine-grained, poorly graded, wet, 10YR 7/1 light gray with iron oxide staining and iron nodules	[Lithology symbol]						Denver fm
43	(CA) WEATHERED SHALE: silty CLAY, highly plastic, hard, very moist, 10YR 6/1 light gray to gray with iron oxide staining and iron nodules Claystone	[Lithology symbol]						Denver fm
44		[Lithology symbol]						core run #2
45	(CA) SHALE: silty CLAY, highly plastic, hard, very moist, medium to fine grained silty SAND seams, 10YR 4/1 dark gray Claystone	[Lithology symbol]						Denver fm
46		[Lithology symbol]						
47		[Lithology symbol]						
48		[Lithology symbol]						
49		[Lithology symbol]						
50		[Lithology symbol]						Bottom of boring at 47.5 feet

DRILLING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. Albritton</u>	DATE STARTED <u>6-28-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CWESS with 6-5/8" HSA</u>	COMPLETION DEPTH <u>29.5</u>	SAMPLER <u>3" Split spoon</u>	
DRILLING METHOD <u>HOLLOW STEM AUGERS</u>	DRILL BIT	NO. OF SAMPLES <u>7</u>	UNDIST. <u>1</u>
SIZE AND TYPE OF CASING	WATER ELEV. <u>13</u>	FIIST <u>13</u>	COMPL <u>17</u> <u>24-INS. 5 TWS.</u>
TYPE OF PERFORATION	FROM — TO FT.	LOGGED BY <u>S. MORRISSETTE</u>	CHECKED BY
SIZE AND TYPE OF PACK	FROM — TO FT.		
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>29.0</u> FT.		


DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drift Rate, Field loss, Odor, etc.)	
		Lithology	Pneumometer Installation	Weight Corient	Pneumometer Data	Type No	Recovery	Passing (Pass/Retain) (in)		
0	(Sm) silty SAND, fine-grained, poorly graded, medium-dense, dry, 10yr 6/6 brownish-yellow								Aeolian sand/silt	
1										
2										
3	with some 10yr 8/1 white mottling					SS 14	9	11	PID=ND	
4										
5	with some 10yr 8/1 white mottling					SS 15	6	15	PID=ND	
6										
7	(Sm) silty SAND, fine-grained, poorly graded, medium-dense, moist, 10yr 5/8 yellowish-brown color changes to 10yr 5/8 yellowish-brown, and becomes very moist					SS 15	6	13	Alluvium PID=ND	
8										
9	with some siltier zones color changes to 10yr 6/8 brownish-yellow, and becomes very moist					SS 16	9	12	PID=ND	
10										
11	with some siltier zones color changes to 10yr 6/8 brownish-yellow, and becomes very moist					SS 16	10	10	PID=ND	
12										
13	Water enters ATD								Water enters ATD	
14										

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Field logs, etc)			
		Lithology	Piezometer Installation	Well Control	Piezometer Data	Type No.	Depth (ft)				
14	SAME: (Sm) silty SAND, fine-grained, poorly-sorted, medium-dense, wet, 10YR 6/8 brownish-yellow							Alluvium			
15									SS 18	7	12
16										15	
17	(CL) sandy silty clay SHALE, low to medium plastic, very stiff, very moist, 10YR 8/2 white to 10YR 8/3 very pale brown							Water level noted on drill rods as of 1100.			
18									SS 10	4	11
19										13	
20									Weathered Claystone		
21	SS 12	8	17								
22		16		PID=ND-0.9 ppm							
23	(CH) silty clay SHALE, highly plastic, hard, 10YR 5/1 gray with some iron oxide staining							Denver Fm CORE RUN #1			
24									C O RC30"	E	
25											
26	Claystone						Bottom of boring at 29.5 FEET				
27											
28											
29											
30											
31											
32											

BORING LOCATION <u>Sec 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>6/25/90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>38</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Stem</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>4 in PVC</u>		WATER ELEV.	FIRST <u>13 ft</u> COMPL. <u>24 hrs.</u>
TYPE OF PERFORATION <u>10 slot</u>	FROM <u>18</u> TO <u>23</u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>10-20 sand</u>	FROM <u>13</u> TO <u>23</u> FT.	CHECKED BY	
TYPE OF SEAL <u>Bentonite</u>	FROM <u>11</u> TO <u>13</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recovery	Positive Result (lb/ft ³ @ 6 in)	
1	Gravel, sandy, dry, dense, brown, 10 YR 5/3 (GP)								
2	Sand, dry to slightly moist, loose to medium dense, medium to fine sand, brownish yellow 10 YR 5/3 to 10 YR 4/4 (SP) silty SM							5	ND
3								4	
4								4	
5									
6	Slightly clayey, Sand, medium to fine sand, dense, brownish yellow (SC) 10 YR 4/4 silty							3	ND
7								4	
8								13	
9	Very moist to wet							8	ND
10								14	
11								15	
12	(Next page)							4	ND
13								12	
14								10	Bentonite

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Piezometer Date	SAMPLES		PID PPM REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation			Type No.	Recon. (1) Pore Pressure Below 6 in	
14	Clay, sandy, medium to fine sand, wet to moist, stiff, olive to light olive brown, iron oxide staining, layered (CL), 5Y 5Y 5/4, 2.5Y 5/4 clayey sand							ND
15						5		
16						9		
17						10		
18								
19								3.0
20						3		
21						8		
22						11		
23								
24	Clay, slightly sandy, v. moist to dry, color varies from very pale brown to dark brown, medium stiff to stiff (CL) 10YR 7/4, 10YR 4/3							ND
25						5		
26						7		
27	weathered claystone, stiff to very stiff, moist to dry, pale olive 5Y 6/3 to olive gray, blocky, crumbly, (CH) 5Y 6/3, 5Y 4/2							ND
28						6		
29						13		
30						12		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			Piezometer Date	SAMPLES		PID PPM REMARKS (Drift Rate, Fluid loss, Odor, etc)		
		Lithology	Piezometer Installation	Water Content		Type No.	REC'D. II PITING PITING SLUG (ft in)			
32	Claystone, firm, moist, weak red, gray, black, (CH) 10 R 4/2				CORE					
33										
34										
35									13	73
36				16						
37				18						
38						78				

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SHEET 3 OF 3



BORING LOCATION LIME SETTLING BASINS		ELEVATION AND DATUM	
DRILLING AGENCY LAYNE-WESTERN	DRILLER R. Albritton	DATE STARTED 7-3-90 / DATE FINISHED 7-5-90	
DRILLING EQUIPMENT CME 75 w/6-5/8" #5A		COMPLETION DEPTH 31.5	SAMPLES 3" split spoon
DRILLING METHOD HOLLOW STEM AUGERS	DRILL BIT	NO. OF SAMPLES 7	DIST. 1
SIZE AND TYPE OF CASING -		WATER ELEV. 7.0	COMPL ND 24 HRS.
TYPE OF PERFORATION -	FROM - TO - FT.	LOGGED BY S. MORRISSETTE	
SIZE AND TYPE OF PACK -	FROM - TO - FT.	CHECKED BY	
TYPE OF SEAL - GROUT	FROM 0 TO 31.5 FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		WEIGHT CORRECTED	PIEZOMETER DATA	SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation			TYPE No	REMARKS PIEZOMETER READING (FEET) (G.P.H.)	
0	(SM) silty SAND, fine grained, poorly graded, dense, moist, 10yr 5/3 brown							Fill (?)
1	Fill							
2								
3						SS 17	9 17 16	PID=ND
4								
5								
6	becomes very moist and loose to very loose					SS 18	2 1 3	PID=ND
7	(SM) silty SAND or sandy SILT, very loose, fine grained, poorly graded, very loose, wet, 10yr 5/3 brown,							Alluvium water enters ATD
8	becomes 10yr 5/1 gray					SS 16	1 1 1	PID=ND
9								
10	(SM) silty SAND, fine grained, poorly graded, medium dense, wet, 10yr 6/2 light brownish-gray					SS 17	8 12 16	Alluvium PID=ND
11								
12								
13								
14								

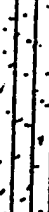

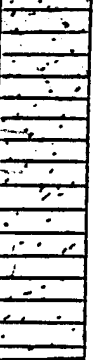

DEPTH (Feet)	DESCRIPTION	GRAPHIC LOG		WATER CONTENT (%)	FLUID LOSS (%)	SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Permeometer Installation			TYPE NO.	DEPTH (ft)	
14-15	(Sm) silty SAND, fine grained, poorly graded, medium dense, 10% AS/3 brown							Alluvium
16						SS 8	5 10 15	PID=ND
19-21	(CL) sandy silty CLAY, low to medium plastic, stiff to very stiff, very moist, 10% 4/4 dark yellowish-brown, fine grained SAND							Alluvium reworked shale
21						SS 13	5 9 11	PID=3ppm
23-24	(CH) silty clay SHALE, highly plastic, very stiff, very moist, 2-5% 6/4 light yellowish-brown							Denver Fm. weathered
24-25	Weathered lay stone							
26						SS 12	7 11 13	PID=34ppm
27						C		CORE RUN #1
28	becoming less weathered					O		
29						CC	48"	
29-31	(CH) silty clay SHALE, highly plastic, very stiff to hard, very moist, 10% 2/1 gray to 10% 2/1 very dark gray, iron oxide stains, aragonite crystals							Denver Fm.
31	claystone							
32								Bottom of boring @ 31.5 FT.

DRILLING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. Albritton</u>	DATE STARTED <u>7-2-90</u>	DATE FINISHED <u>7-3-90</u>
DRILLING EQUIPMENT <u>CME 750 w/ 6-5/8" USA</u>		COMPLETION DEPTH <u>39</u>	SAMPLES <u>3" splitspoon</u>
DRILLING METHOD <u>HOLLOW STEM AUGERS</u>	DRILL BIT	NO. OF SAMPLES <u>8</u>	UNDIST. <u>2</u>
SIZE AND TYPE OF CASING <u>—</u>		WATER ELEV. <u>7.0</u>	COMPL. <u>0.0</u> 24 HRS.
TYPE OF PENFORATION <u>—</u>	FROM <u>—</u> TO <u>—</u> FT.	LOGGED BY <u>S. MORRISSETTE</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>—</u>	FROM <u>—</u> TO <u>—</u> FT.		
TYPE OF SEAL <u>— Grout</u>	FROM <u>0</u> TO <u>39</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	WEIGHT CORRECTED	Piezometer Data	TYPE NO.	RECENT	PREVIOUS (DATE)	DEPTH (ft)	
0										Fill
1	(SM) silty SAND, fine-grained, poorly-graded, medium dense, moist, 10YR 6/6 brownish-yellow with trace of 10YR 7/1 light gray silty CLAY									
2	Fill									
3										
4										
5										
6	with wood fragments and trace of bright yellow s/s stains, becomes loose									PID=ND
7										
8	(SM) silty SAND, fine-grained, poorly-graded, medium-dense, wet, 10YR 5/4 yellowish-brown									water enters ATD Alluvium water at 8.0 FT w/s of obs 7-3-90 PID=ND
9										
10	(SM) slightly silty SAND, fine to medium grained, poorly graded, medium dense, wet, 10YR 5/2 grayish-brown									Alluvium PID=ND
11										
12										
13										
14										

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SHEET 1 OF 2

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Orth Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	Depth (ft)	
14	SAME: (SM) silty SAND, fine to medium grained, poorly graded, dense, wet, 10YR5/2 grayish-brown becomes 10YR5/3 brown with 10YR5/1 gray mottling					SS 18	11	Alluvium P=0=627ppm
15							16	
16							24	
17	(ML) STIFF, nonplastic, stiff to very stiff, very moist to wet, 10YR5/3 brown with trace of very fine SAND and iron oxide stains Clay, low plasticity						4	Alluvium P=0=114
18							10	
19							11	
20								
21	(CL to SC) sandy silty CLAY to clayey SAND, low to medium plastic, very stiff, very moist, 10YR5/3 brown with 10YR8/1 white mottling						4	Denver fm. Alluvium reworked shale P=0=8ppm
22							10	
23							11	
24							14	
25								
26	(CH) silty clay SHALE, hard, highly plastic, very moist, 10YR5/2 grayish-brown with thin fine grained sand seams, iron oxide stains, and blocky texture, carbonaceous Weathered Claystone						16	Denver fm. WEATHERED P=0=124ppm Core run #1
27							28	
28							34	
29								
30								
31								
32	CC							

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Field loss, Odor, etc)
		Lithology	Plazometer Installation	Moist Content	Plazometer Depth	TYPE NO.	DEPTH (FEET)	DEPTH (FEET)	
32	SAME: (CH) silty clay stone , hard, highly plastic, very moist, 10yr 2/2 grayish-brown with thin fine grained sand seams, iron oxide stains, and blacky texture, carbonaceous weathered claystone								Core run #1 Denver fm. WEATHERED
33									
34									
35	(CH) silty clay stone , hard, highly plastic, very moist, 10yr 4/2 dark grayish-brown, iron oxide stains, carbonaceous, becomes 10yr 2/2 very dark brown at 36 FEET becomes 10yr 4/1 dark gray claystone								Core run #2 Denver fm. Seam of white crystalline material at a 37 FEET
36									
37									
38	becomes 10yr 6/1 light gray to gray								Bottom of Boring @ 39.0 FEET.
39									
40									
41									
42									
43									
44									
45									
46									
47									
48									
49									
50									

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Woodward-Clyde Consultants PROJECT NAME

COE D.O. 1

BORING LOCATION		ELEVATION AND DATUM	
Lime Settling Basins			
DRILLING AGENCY	DRILLER	DATE STARTED	DATE FINISHED
Layne-Western	M. Walker	7-11-90	7-12-90
DRILLING EQUIPMENT	DRILL BIT	COMPLETION DEPTH	SAMPLER
CME 7SD w/6-5/8" OD HSA		29.5	3 split spoon
DRILLING METHOD		NO. OF SAMPLES	DIST.
Hollow stem Augers		7	7
SIZE AND TYPE OF CASING		WATER ELEV.	FIRST
-		10.0	14
TYPE OF PERFORATION	FROM TO FT.	LOGGED BY	CHECKED BY
-		S. MORRISSETTE	
TYPE OF SEAL	FROM TO FT.		
Grout	0 TO 29.5		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No	Recovery	Prove Return (Flow & In)	
0	(Sm) slightly clayey silty SAND, fine grained, poorly graded, medium dense, moist, 10YR5/3 brown, upper 6 inches gravelly								Medium sand/silt
1									
2									
3								SS 17 5 3 3	PID = ND
4	(Sc) silty clayey SAND, fine grained, poorly graded, medium dense, moist, 10YR5/3 brown								Alluvium
5	(SM) poorly graded, medium dense, moist, 10YR5/3 brown							SS 18 3 4 4	PID = ND
6									
7	(Sm) silty SAND, fine grained, poorly graded, very dense, moist to very moist, 10YR5/4 yellowish-brown								Alluvium
8								SS 17 12 20 31	PID = ND
9	(Se) silty clayey SAND, fine-grained, (SM) poorly graded								Alluvium
10								SS 16 12 11 11	water enters ATD PID = ND
11									
12									
13									
14									water @ 14.0' on drill rods as of 0600 on 7-12-90

PROJECT NO. 89MC114A

SHEET 1 OF 2






DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)					
		Lithology	Permeometer Installation	Water Content	Pressure	Date	Type No.		Pressure (psi)	Permeability (Darcy)			
14	SAME: (SM) silty clay SAND, fine-grained, poor / graded, medium dense, moist, 10YR5/3 brown							Alluvium					
15									SS 18	7	10	12	PID = 1 ppm
16													
17	(CL or SC) sandy silty clay or clayey SAND, very stiff, low plastic, very moist, 10YR 1/2 grayish-brown to 10YR 8/2 white							Alluvium / Denver fm.					
18													
19													
20	with some hard, blocky shale starting at 20 feet							Denver fm. weathered					
21									SS 17	11	15	23	PID = ND weak positive response on MIB blue band test
22													
23	(CH) silty clay SHALE, highly plastic, hard, very moist, 10YR 6/2 light brownish-gray claystone							Drilling becomes stiffer at 23.0' Denver fm					
24													
25									SS 16	16	32	44	weak positive response on MIB blue band test PID = ND
26													
27	Bottom of boring @ 29.5 feet							Drilling stopped 7-11-90 Core run #1 Drilling resumed 7-12-90					
28													
29													
30													
31													
32													

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CORRECTION 0.75 ft

BORING LOCATION <u>Sec. 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>K Cross</u>	DATE STARTED <u>7-6-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>	DRILL BIT	COMPLETION DEPTH	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>		NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST <u>11</u>
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	<u>T. Terry</u>	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>30</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Oder, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	TYPE NO.	RECYCLE	PERCENT RECYCLE (By Wt/ 8 in)	
1	Clay, very sandy, silty, fine sand, moist, stiff to very stiff, yellowish brown 10YR5/4 (CL)								12.6
2									
3									
4									
5									
6									
7									
8	Sand, silty, clayey, medium to fine sand, very moist to wet, medium dense to dense, yellowish brown to brown. 10YR5/4, 10YR5/3 (SP, SM)								0.2
9									
10									
11									
12									
13									
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	Reqs. (1)	Prima. Point (ft) (6 in)	
14									
15								6	
16								9	32.8
17	Clay, very sandy, stiff, very moist to wet, very dark grayish brown, 10YR 3/2 (CL)							13	
18									
19									
20								6	
21	Weathered claystone, sandy, moist, stiff to very stiff, pale brown, blocky. 10YR 6/3 (CH)							16	47.4
22									
23									
24									
25								9	
26	Claystone, moist, firm, pale brown 10YR 6/3 (CH)							14	51.6
27									
28									
29								20	
30									5.7

PROJECT NO. 89MC114A

SHEET 2 OF 2

BORING LOCATION		ELEVATION AND DATUM	
LIME SETTLING BASINS			
DRILLING AGENCY	DRILLER	DATE STARTED	DATE FINISHED
LAME - WESTERN	M. WALKER	7-10-90	
DRILLING EQUIPMENT		COMPLETION DEPTH	SAMPLES
CME 7SD w/6-5/8" HSA		50.5	3 00 split spoon
DRILLING METHOD	DRILL BIT	NO. OF SAMPLES	DIST.
Hollow stem augers		11	UNDIST. 1
SIZE AND TYPE OF CASING		WATER ELEV.	FIRST
-		9.5	COMPL 11 2 HRS
TYPE OF PERFORATION	FROM - TO FT.	LOGGED BY	
-	- - -	S. MORRISSETTE	
SIZE AND TYPE OF PACK	FROM - TO FT.	CHECKED BY	
-	- - -		
TYPE OF SEAL	FROM - TO FT.		
G-PORT	0 TO 50.5 FT		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Oder, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometric Date	Typ No	Reconst.	Porosity (Lab/8 in)	
0	(SC) slightly clayey to clayey silty SM SAND, fine-grained, poorly-graded, medium dense, moist, 10YR 4/2 dark grayish-brown								Road fill
1									
2									
3									PID=ND
4									
5	(SM) silty SAND, fine-grained, poorly-graded, medium dense, moist, 10YR 6/4								A action sand/silt(?) PID=ND
6									
7									
8	(MC) sandy silt, non-plastic, med. dense, v. fine grained sand, wet, 10YR 5/3 brown								PID=ND Alluvium
9	(SM) Sandy Silt								water enters ATD
10									PID=4 ppm water noted on drill rods @ 1138
11									
12									
13	(SM) silty SAND, fine-grained, poorly-graded, medium dense, wet, 10YR 5/3 brown								Alluvium
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Field Test, Odor, etc)				
		Lithology	Permeometer Installation	Water Content	Porosity Data	Type No.	Depth (ft)	Depth (ft)	Depth (ft)					
14	(Sm) silty SAND, fine-grained, poorly graded, medium dense, wet, 10YR 5/3 brown					SS 17	8	16	PID=ND					
15							14							
16														
17														
18														
19														
20						SS 18	4	7	PID=ND					
21							10							
22														
23														
24	(SC or CL) clayey SAND or sandy silty CLAY, fine-grained, poorly graded, medium dense, very moist, 10YR 5/4 yellowish-brown								Alluvium					
25														
26						SS 16	6	8	PID=ND					
27							10							
28	SANDSTONE: very fine grained, poorly graded, hard to very hard, very moist, 10YR 5/3 brown with iron oxide stains, clayey in zones								Denver fm. weathered					
29														
30														
31						SS 16	16	31	PID=ND					
32							50							

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drift Rate, Field loss, Odor, etc)	
		Lithology	Piezometer Installation	Water Content	Piezometric Data	Type No.	Depth (ft)	Remarks		
32	SAME: SANDSTONE: very fine-grained, poorly graded, hard to very hard, very moist, layers brown with iron oxide stains, clayey in zones with some thin seams of highly plastic, silty clay, 10yr 4/1 dark gray								Denver Fm. weathered	
33									Denver Fm.	
34										
35									SS 17 33 50	PID=ND
36									C	CORE RUN #1
37		O								
38		R								
39		E								
40										
41										
42										
43										
44				SS 4 3/4	PID=ND					
45										
46										
47										
48	(CH) silty clay stone, highly plastic, hard, moist, 10yr 5/1 gray to 10yr 4/1 dark gray Claystone								unweathered Denver Fm Drilling becomes smoother and stiffer @ 48 ft.	
49									SS 15 26 36	PID=ND
50										

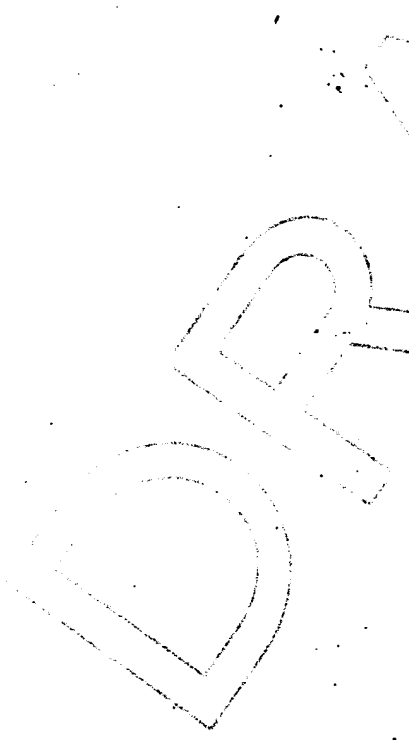



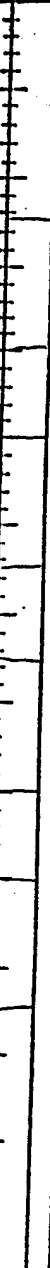



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DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Orn Rate, Field loss, Odor, etc)
		Lithology	Porometer Installation	Water Content	Prep Date	Type No.	Pressure (psi)	
52	SAME: (CH) silty clay shale, highly plastic, hard, moist, layers/1 gray to 10yr 4/1 dark gray claystone	[Blank]	[Blank]	[Blank]	[Blank]	[Blank]	[Blank]	Denser Fr. unweathered
51								
52								
53								
54								
55								
56								
57								
58								
59								
60								
61								
62								
63								
64								
65								
66								
67								
68								

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BORING LOCATION <u>Sec 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>07/03/90</u>	
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST. UNDIST.
SIZE AND TYPE OF CASING <u>NA</u>	WATER ELEV.	FIRST	COMPL. 24 HRS.
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>46</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Oder, etc.)	
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recon. J.	Positive Sample (8 in)	(8 in)		
1	Sand, silty, dry to wet, medium to fine sand, medium dense to dense, light yellowish brown to brown 10YR 6/4 10YR 5/4 10YR 5/3 										
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

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SHEET 1 OF 3

DEPTH FEET	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recon. # Pore # Pore # Below (in)	
14								
15							8	
16							9	
17							11	
18								
19								
20							4	
21							6	
22	Clay, silty, sandy, moist, stiff, very pale brown, (CL) 10 YR 7/4							
23								
24								
25							4	49.7
26	Sandstone, weathered, silty sand, hard to very hard, yellowish brown (SM)							
27								
28								
29								
30							35	10.7
31							50/4	
32								

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			PID. PPM REMARKS (Drift Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recovery (%)	
32								
33								
34								
35							35 50/4	7.4
36								
37								
38	claystone, hard, silty, dry, blocky, olive (CH)							
39	5Y5/4							
40								
41							25 35 47	8.2
42								
43								
44								
45	sandstone, hard, silty, moist, yellowish brown, (SM) 5Y5/4							
46								

CORE

DRILLING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. Albritton</u>	DATE STARTED <u>6-29-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 55 with 6-5/8" HSA</u>	DRILL BIT	COMPLETION DEPTH <u>44.0</u>	SAMPLER <u>SPLIT SPON</u>
DRILLING METHOD <u>HOLLOW STEM AUGERS</u>	DRILL BIT	NO. OF SAMPLES	DISC <u>7</u> UNDIST.
SIZE AND TYPE OF CASING		WATER ELEV. FIRST <u>14</u>	COMPL <u>11</u> 24 INCH.
TYPE OF PERFORATION	FROM TO FT.	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK	FROM TO FT.	<u>S. MORRISSETTE</u>	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>44</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Control	Piezometer Date	TYPE NO.	RESIDUAL	PRELIMINARY (6 in)	
0	(SM) silty SAND, fine-grained, poorly-graded, medium-dense, dry, 10YR 6/8 yellowish-brown								Residual sand/silt
1									
2									
3						SS 15	4 7 7	PID=ND	
4									
5									
6						SS 15	3 4 7	PID=ND	
7	becomes moist								
8						SS 15	6 6 7	PID=ND	
9									
10	color changes to 10YR 5/4 yellowish-brown, and becomes very moist and loose								
11	(SM) silty SAND, fine-grained, poorly graded, loose, very moist, 10YR 5/4 yellowish-brown					SS 16	3 4 3	PID=ND Water level noted on drill rods @ 09:30	
12									
13									
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES				REMARKS (Drill Rate, Field loss, Odor, etc)	
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	Depth (ft)	Sample No.		
14	SAME: (Sm) silty SAND, fine-grained, poorly-graded, medium-dense, wet, 10yrs/4 yellowish-brown							SS 15	9 12 12	PID=ND
15										
16										
17										
18										
19										
20										
21								SS 14	7 14 14	PID=ND
22										
23										
24	sandy									
25	(CL) silty clay SAND , low to medium plastic, weathered, 10yrs/3 brown claystone							SSH 4	8 11	Denver Fm. PID=17 ppm
26	(CL & CH) silty clay SAND low, medium, highly plastic, weathered, with some fine grained sand seams, 10yrs/1 gray claystone									Denver Fm.
27										
28										
29	(SP) slightly silty SANDSTONE, very fine grained, poorly graded, very dense, 10yrs/4 yellowish-brown							CC 18		Denver Fm CORE RUN #1 PID=ND
30										
31	With hard, calcareous concretions at 30.5 feet							SS	7 90	SAMPLER MET RETRIAL AT 30.5 FT
32										



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	Depth (ft)	
32	SAME: (SP) slightly silty SANDSTONE, very fine to fine grained, poorly graded, very dense, 10 yr 5/4 yellowish-brown							Denver fm
33								
34								Attempt to core at 34.0 feet met with auger refusal.
35								
36								
37								
38								
39								COE RUN #2
40								C
41								O
42	R							
43	E							
44	(CH) silty clay SHALE, highly plastic, hard, 10 yr 4/1 dark gray claystone							Denver fm
45								Bottom of boring at 44.0 feet
46								
47								
48								
49								
50								


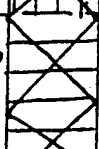
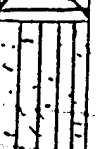
WORKING LOCATION <u>LIME SETTLING BASINS</u>				ELEVATION AND DATUM			
DRILLING AGENCY <u>LAYNE-WESTERN</u>		DRILLER <u>Kevin Cross</u>		DATE STARTED <u>6-25-90</u>		DATE FINISHED <u>6-26-90</u>	
DRILLING EQUIPMENT <u>CMESS with 6-5/8" OD HSA</u>				COMPLETION DEPTH <u>29.5</u>		SAMPLER <u>3" 00 split spoon</u>	
DRILLING METHOD <u>Hollow stem augers</u>		DRILL BIT		NO. OF SAMPLES <u>7</u>		UNDIST. <u>1</u>	
SIZE AND TYPE OF CASING				WATER ELEV.		COMPL <u>13</u> 24 HRS.	
TYPE OF PERFORATION		FROM — TO FT.		LOGGED BY		CHECKED BY	
SIZE AND TYPE OF PACK		FROM — TO FT.		<u>S. MORRISSETTE</u>			
TYPE OF SEAL <u>Grout</u>		FROM <u>0</u> TO <u>29.5</u> FT.					

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE NO.	RECYCL. PARTIC. RECAL. (Bore/8 in)		
0	(SM) Silty SAND, fine-grained, poorly graded, medium dense, dry, 10YR 6/4 light yellowish-brown								Medium SAND & SILT
1									
2									
3									PID=ND
4									
5									
6									PID=ND
7									
8	becomes moist								PID=ND
9									
10	becomes 10YR 5/3 yellowish-brown								Alluvial
11	(SM) silty SAND, fine-grained, poorly graded, medium dense, moist to very moist, 10YR 5/3 yellowish-brown								PID=ND
12									
13									
14									



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)		
		Lithology	Plazometer Metallog	Water Content	Phasometer Data	Type No.	Pres. (psi)		Water Puff Blow (in)	
14	(SM) SAME: silty SAND, fine-grained, poorly graded, medium dense, wet, 10YR5/3 yellowish-brown							Alluvium		
15								SS 13	8	PIO=ND
16									11	
17									17	
20	SS 18	4	PIO=2.0ppm							
21		10								
22										
23										
24										
25										
26	(CH) WEATHERED SHALE: silty CLAY, highly plastic, hard, very moist, 10YR5/1 gray with 10YR5/8 yellowish brown mottling with trace of very fine grained SAND sh Claystone							PIO = 3.2 ppm PIO in HSA = 10ppm		
27								SS 12	10	Denver Fm core run #1
28									12	
29										
30								Bottom of boring at 29.5		
31										
32										

BORING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. Albritton</u>	DATE STARTED <u>7-6-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CMF 750 w/6-5/8" OD HSA</u>		COMPLETION DEPTH <u>43.5</u>	SAMPLES <u>3" 00 split spore</u>
DRILLING METHOD <u>HOLLOW STEM AUGERS</u>	DRILL BIT	NO. OF SAMPLES	DIST. <u>10</u> UNDIST. <u>2</u>
SIZE AND TYPE OF CASING		WATER ELEV. <u>7.0</u>	COMPL. <u>24 HRS.</u>
TYPE OF PERFORATION	FROM — TO FT.	LOGGED BY <u>S. MORRISSETTE</u>	
SIZE AND TYPE OF PACK	FROM — TO FT.	CHECKED BY	
TYPE OF SEAL <u>GRout</u>	FROM <u>0</u> TO <u>43.5</u> FT.		

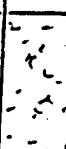
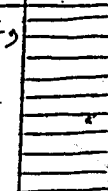
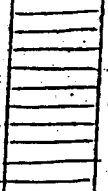
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
		Lithology	Planimeter Installation	Moist Content	Piezometer Data	TYPE NO.	RECOVERED	REMARKS (lb/ft ³ / 6 in)		
0	(SM) silty SAND, fine grained, poorly graded, medium-dense, dry to moist, 10yr 3 brown, upper 0.5 feet gravelly								Fill	
1	Fill									
2	(CL) silty CLAY, low to medium plastic, medium stiff, moist, 10yr 7/1 light gray								Fill/sludge(?)	
3						SS 17	3	2	3	PI0=ND
4	Fill									
5										
6						SS 18	2	2	2	PI0=ND
7										water enters
8	(SM) silty SAND, very fine-grained, poorly-graded, very loose, with 10yr 3/6 dark yellowish-brown									ATD Alluvium
9						SS 18	1	1	1	PI0=ND
10	becomes 10yr 5/4 yellowish-brown and medium-dense									
11						SS 15	4	4	5	PI0=ND
12										
13										
14										



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Orth Rate, Fluid loss, Odor, etc)				
		Lithology	Merometer Installation	Water Content	Piezometer Date	TYPE NO.	DEPTH (ft)		DEPTH (ft)			
14	(SM) silty SAND, fine-grained, poorly-graded, medium dense, wet, 10YR 5/3 brown							Alluvium PID=19 ppm				
15									SS 18	6	7	6
16												
17	(CL) sandy silty CLAY, low plastic, stiff to very stiff, very moist, 10YR 5/3 brown							PID=7 ppm Alluvium reworked state claystone				
21									SS 17	6	9	11
22												
23	(CC to CH) slightly sandy silty clay, STIFF, low to highly plastic, firm, very moist, 10YR 4/1 dark gray with trace of 10YR 8/1 white mottling, iron oxide stains, slightly weathered Claystone, weathered							PID=ND Denver fm. weathered				
6									SS 18	7	11	15
7												
8	Core run #1 no recovery, sampler encounters refusal at 31.5 feet	CORRE						Denver Fm weathered PID=ND				
9												
1												
L	(SP) slightly clayey SANDSTONE, v. fine-grained, poorly graded, hard to very hard, very moist, 10YR 5/3 brown, iron oxide stains											

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SHEET 2 OF 3

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)			
		Lithology	Piezometer Installation	Water Content	Plasticity Data	TYPE NO.	DEPTH (ft)	DEPTH (ft)				
32	SAME: (SP) slightly clayey SANDSTONE, fine-grained, poorly graded, hard to very hard, very moist, 10yr 5/3 brown, iron oxide stains					SS	9	53	Denver fm weathered			
33												
34												
35						becomes very hard						
36												
37												
38	(CH) silty CLAY STATE, highly plastic, hard, very moist, 10yr 5/2 grayish-brown to 10yr 4/1 dark gray, carbonaceous claystone								Drilling becomes spindlier at 37.5 feet Denver fm			
39												
40												
41												
42	becomes 10yr 5/3 brown with iron oxide stains					SS	16	22	PIO = 72 ppm CORE RUN #2			
43												
44												
45												
46												
47												
48												
49												
50	50ft											

BORING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. PARKER</u>	DATE STARTED <u>6-25-90</u> / 6-26-90 / 6-27-90	
DRILLING EQUIPMENT <u>CME SS with 6-5/8" HSA</u>		COMPLETION DEPTH <u>34</u>	SAMPLER <u>31 split spoon</u>
DRILLING METHOD <u>HOLLOW STEM AUGERS</u>	DRILL BIT	NO. OF SAMPLES <u>8</u>	UNDIST. <u>1</u>
SIZE AND TYPE OF CASING <u>-</u>		WATER ELEV. FIRST <u>10</u>	COMPL. <u>7.5</u> 24 HRS.
TYPE OF PERFORATION <u>-</u>	FROM <u>-</u> TO <u>10</u> FT.	LOGGED BY <u>S. MORRISSETTE</u>	
SIZE AND TYPE OF PACK <u>-</u>	FROM <u>-</u> TO <u>10</u> FT.	CHECKED BY	
TYPE OF SEAL <u>-</u>	FROM <u>0</u> TO <u>34</u> FT.		

DEPTH (FEET)	DESCRIPTION	GEOPHYSIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Plasticity Data	SSA No.	Recon. Points (Feet) (6 in)	PI	
0	(SM) silty SAND, fine-grained, poorly graded, medium dense, dry to moist, 10yrs/4 yellowish brown								Fill
1	Fill								
2	Fill								
3							5		
4							12		PI=ND
5	(CF) silty CLAY, low to medium plastic, medium to stiff, 10yrs/1 white, moist								Sludge
6	Fill						4		PI=ND
7									Water as of 0545 on 6-27-90. Alluvium
8	(SM) silty SAND, fine-grained, poorly-graded, medium dense, very moist, 10yr 4/4 dark yellowish-brown						4		
9							4		PI=4.0 ppm
10	becomes wet						3		Water enters ATD (10 ft)
11							4		PI=ND
12							6		
13									
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)				
		Lithology	Piezometer Installation	Water Content	Pressure	TYPE NO.	DEPTH (ft)		PIED (ft)			
14	(Sm or ML) silty SAND to sandy SILT, very fine grained, poorly graded, or non-plastic, medium dense, 10yr S/3 brown, wet							Alluvium				
15								SS 18	7	10	14	PIED=ND
16												
18	(ML to CL) slightly sandy SILT to silty CLAY, non-plastic to low to medium plastic, stiff, wet, 10yr 4/3 brown to dark brown							Alluvium				
19								SS 11	3	5	10	PIED=7.0 ppm
20												
24	(CL) slightly sandy silty CLAY, low to medium plastic, stiff to very stiff, wet, 10yr 5/3 brown							Claystone Reworked shale Denver fm (?)				
25								SS 14	5	10	10	PIED=10 ppm
26												
30	(CH) slightly sandy silty CLAY, highly plastic, medium hard, very moist, 10yr 4/1 dark gray with some iron oxide staining claystone							Denver fm.				
31								SS 13	8	16	22	CORE RUN#1
32												
32	becomes 10yr 5/3 brown and siltier at 31.5 feet to 32.5 feet											

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SHEET 2 OF 3

DEPTH (feet)	DESCRIPTION	GRAPHIC LOG			SAMPLES		REMARKS (Drill Rate, Field loss, Odor, etc)
		Lithology	Photometer Installation	Water Content	Preparator Data	TYPE NO.	
32	SAME: (CH) slightly sandy silty clay, highly plastic, medium hard, very moist, 10yr 5/3 brown with some iron oxide staining becomes 10yr 6/2 brownish-gray from 32.5 to 34.0 feet						Denver fm. core run #1
33						CC 24	
34							
35	Claystone						Bottom of boring at 34.0 feet
36							
37							
38							
39							
40							

DRAFT



BORING LOCATION <u>Sec 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-6-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>35</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST <u>10</u> COMPL. <u>24 HRS.</u>
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.		
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>35</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
		Lithology	Piezometer Installation	Water Control	Piezometer Date	Type No.	Recovery Pressure (Lbs/In)		
1	Sand, medium to fine sand, trace silt, trace clay, loose to medium dense, dry to wet, yellowish brown to brown, (SP) 10YR 5/6, 10YR 5/3 SM						PID PPM		
2								4	0.2
3								4	
4								4	
5								4	0.2
6								5	
7								5	
8								4	
9								3	
10								5	
11								3	17.4
12								4	
13								2	
14									



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc)	
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recon. (S)	Probe Depth (ft)	Probe Depth (in)		
14											
15	Clay, slightly sandy, medium stiff, wet, yellowish brown (CL) 10YR 5/4	[Hatched pattern]						5	5	9	22.6
16											
17											
18											
19											
20											
21	Weathered claystone, blocky, fractured, moist, very stiff to hard, light brownish gray, grayish brown, dark grayish brown (CH) 10YR 6/2, 10YR 5/2 10YR 4/2	[Hatched pattern]						7	11	15	32.4
22											
23											
24											
25											
26											
27											
28											
29											
30											
1	Claystone, moist, hard, very dark grayish brown, grayish brown (CH) 10YR 3/2, 2.5Y 5/2	[Hatched pattern]									

CORE




DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Pisometer Date	Type No.	Recon. # Pore Pressure (psi) Grain (lb/in ²)	
32						CORE		
33								
34								
35								

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DRILLING LOCATION <u>Sec 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-2-90</u>	
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>36</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV. <u>9.0</u>	UNDIST.
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.		
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>36</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Orbit Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recovery	Penetration (Blow/ft)	
1	Sand, silty, clayey, dry, medium dense, brown, (SP) 10YR4/3 (SM)								5.0
2									
3									
4									
5									
6	Sand, slightly silty, trace clay, dry, loose, wet, fine sand, yellowish brown (SP) 10YR5/4, 10YR6/4 (SM)								0.8
7									
8									
9									
10	[Large 'D' or 'Q' symbol]								
11									
12									
13									
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	REMARKS (Penetration, Per cent Blow, etc)	
14								
15							5	49.7
16	Clay, sandy, very stiff, light yellowish brown, moist to very moist, 10YR6/4 (CL)					11		
17								
18								
19								
20	Weathered claystone, very stiff, moist, light brownish gray, blocky, fractured,						6	32.6
21	10YR6/2						13	
22							18	
23								
24								
25							15	32.6
26							37	
27							39	
28								
29								
30							15	32.6
31							20	
32							20	

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Hole, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Depth (ft)	
32	slightly weathered claystone, hard, moist, dark grayish brown, iron oxide staining, 10YR 4/2							
33								
34								
35								
36								

CORE

DRAFT

BORING LOCATION <u>Sec 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>K. Cross</u>	DATE STARTED <u>7-5-90</u> DATE FINISHED	
DRILLING EQUIPMENT <u>CME 75</u>	COMPLETION DEPTH <u>25</u>		SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>	WATER ELEV.	FIRST	COMPL. 24 HRS.
TYPE OF PERFORATION <u>NA</u>	FROM	TO	FT.
SIZE AND TYPE OF PACK <u>NA</u>	FROM	TO	FT.
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u>	TO <u>25</u>	FT.

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recovery	Particle Size (No. 20/60)	
1	Clay, very sandy, very moist, fine sand, dark yellowish brown stiff to very stiff (CL) 10YR 4/4								
2									
3									
4									
5	Sand, silty, wet, mostly fine sand, medium dense to dense, dark grayish brown, brown (SP, SM) 10YR 4/2, 10YR 6/4, 10YR 5/3								3.8
6									
7									
8									
9									
10									
11								64.3	
12									
13									
14									



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Piezometer	SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation			Type No.	Recon. Ct.	Penetration Resist. (Blow 6 in)	
14	Weathered claystone, silty, sandy, stiff, dry to moist, pale brown (CH) 10YR 6/3								91.4
15									
16									
17									
18	Claystone, siltstone, little sand, moist, hard, pale brown (CH) 10YR 4/6 10YR 4/6								72.4
19									
20									
21									
22									
23									
24									
25									
26									








BORING LOCATION <u>LIME SETTLING BASINS</u>				ELEVATION AND DATUM			
DRILLING AGENCY <u>CLAYCO-WESTERN</u>		DRILLER <u>M. WALKER</u>		DATE STARTED <u>7-11-90</u>		DATE FINISHED	
DRILLING EQUIPMENT <u>ONE 750 w/ 6-5/8" HSA</u>				COMPLETION DEPTH <u>25.5</u>		SAMPLES <u>3" @ 5 ft</u>	
DRILLING METHOD <u>Hollow stem augers</u>		DRILL BIT		NO. OF SAMPLES		DIST. <u>5</u> UNDIST. <u>1</u>	
SIZE AND TYPE OF CASING <u>---</u>				WATER ELEV. <u>7.0</u>		COMPL <u>11</u> <u>AD</u>	
TYPE OF PERFORATION <u>---</u>		FROM <u>---</u> TO <u>---</u> FT.		LOGGED BY <u>S. MORRISSETTE</u>			
SIZE AND TYPE OF PACK <u>---</u>		FROM <u>---</u> TO <u>---</u> FT.		CHECKED BY			
TYPE OF SEAL <u>6/802T</u>		FROM <u>0</u> TO <u>25.5</u> FT.					



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	TYPE NO.	RESIDUAL	PERCENT LOSS (G IN)	
0	(SE) clayey silty SAND, fine-grained, poorly graded, medium dense, moist, 10YR 5/3 brown to 10YR 6/3 pale brown								
1									
2	(SM) "								
3						SS 18	5	5	PID=ND
4								6	
5	becomes 10YR 5/6 yellowish-brown					SS 18	5	6	PID=ND
6								7	
7									Water enters ATD
8									NOTE: 7.5 FOOT SAMPLE WAS INADEQUATELY SKIPPED BY DRILLER. WILL NOT ATTEMPT TO RESAMPLE AS TO BOD CLARK'S INSTRUCTIONS.
9									
10									
11	becomes 10YR 5/4 yellowish-brown and less clayey in zones.					SS 18	6	8	PID=6ppm
12								11	
13									
14									Drilling becomes rougher at 14.0 feet



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Porometer Installation	Water Content	Piezometer Data	Type No.	Depth (ft)	Depth (in)	
14	(CH) sandy silty clay, medium to highly plastic, medium hard, very moist to wet, 10YR 3/2 very dark grayish-brown to 10YR 6/4 light yellowish-brown, very blocky and crumbly, with some seams of very fine grained SANDSTONE.								Danner fm weathered PID = 7 ppm
15						SS	8	12	
16								26	
17									
18									
19									
20	(CH) silty clay shale, highly plastic, medium hard to hard, very moist, 10YR 6/3 pale brown to 10YR 6/4 light yellowish-brown Claystone								PID = 59 ppm Danner fm unweathered, core run #1
21						SS	30	24	
22								24	
23									
24									
25									
26									Bottom of boring @ 25.5 FEET
27									
28									
29									
30									
31									
32									

BORING LOCATION <u>Sec. 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-5-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>30</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>30</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)																		
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE No.	Resist. (ohm-ft)	Porosity (%)	Grain Size (in)																			
1	<u>Clay, sandy, silty, very moist, soft, yellowish brown, 10YR 5/4 (CL) (SM)</u>									ND																		
2											<u>silty sand with clay</u>																	
3																				<u>Sand, silty, clayey, wet, medium dense, yellowish brown, (10YR 5/4) (SP) (SM)</u>								38.1
4																												
5																												
6																												
7																												
8																												
9																												
10																												
11																												
12																												
13																												
14																												

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Plazometer Installation	Water Content	Piezometer Data	Type No.	PROG. (1)	PROG. (2)	
14	weathered Claystone, dry little to trace sand, very stiff, dark brown to pale olive (CH) 10YR3/3, 5Y6/3								
15									
16									
17									
18									
19									
20									
21									
22									
23									
24	Claystone, dry to moist, trace sand, grayish brown, very stiff, (CH) 2.5Y5/2								
25									
26									
27									
28									
29									
30									

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SHEET 2 OF 2



BORING LOCATION		ELEVATION AND DATUM	
LIME SETTLING BASINS			
DRILLING AGENCY	DRILLER	DATE STARTED	DATE FINISHED
Layne-Western	M. Walker	7-6-90	7-9-90
DRILLING EQUIPMENT		COMPLETION DEPTH	SAMPLER
AME 750 w/ 6-5/8" HSA		30 FT.	3" split spoon
DRILLING METHOD	DRILL BIT	NO. OF SAMPLES	DIST.
Hollow stem augers		7	7
SIZE AND TYPE OF CASING		WATER ELEV.	FIRST
		3.5	3.5
TYPE OF PERFORATION	FROM	TO	FT.
SIZE AND TYPE OF PACK	FROM	TO	FT.
TYPE OF SEAL	FROM	TO	FT.
6 feet	0	30.0	
		LOGGED BY	CHECKED BY
		S. MERRISSETTE	

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No	Recovery	Position (Above/Below 8 in)	
0	(SM) silty SAND, fine-grained, poorly graded, med. dense, moist, 10yr 5/3 brown								Fill / aeolian sandy silt
1									
2									
3	becomes very loose								PID=ND water enters ATD
4									
5									
6									
7									
8	becomes siltier in zones								PID=ND
9	(MC) slightly sandy silt, non-plastic, medium dense, very moist, 10yr 5/3 brown								Alluvium
10	(SM) silty sand								
11									
12									
13	(SC to CL) clayey sand to sandy silty clay, med. dense to stiff, fine grained, poorly graded, very moist, 10yr 8/2 white								Alluvium reworked shale
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Resp. #	Gravimetric Moist. Ratio (%)	Grain Size (in)	
14	SAME: (SC to CL) clayey SAND to sandy silty CLAY, med. dense to stiff, fine grained, poorly graded, very moist, 10YR 8/2 white									Alluvium reworked shale
15										
16										
17										
18	SANDSTONE: (SP) fine grained, poorly graded, very hard, very moist, 10YR 4/2 dark grayish-brown.									Denver fm weathered PID=ND drilling becomes harder at 19.5 ft.
20										
21										
22	(CL) silty clay shale, low to med plastic, very stiff to hard, very moist, 10YR 6/4 light yellowish-brown Weathered Claystone									Denver fm weathered drilling becomes smoother at 23 feet
23										
24										
25										
26	(CH) silty clay shale, highly plastic, very stiff to hard, very moist, 10YR 6/4 light yellowish-brown to 10YR 5/1 gray Claystone									Denver fm COC run #1
27										
28										
29										Bottom of boring at 30 feet
30										
31										
32										

BORING LOCATION <u>LIME SETTLING BASINS</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>LAYNE-WESTERN</u>	DRILLER <u>R. Albritton</u>	DATE STARTED <u>7-5-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CWE 750 w/6-5/8" OD HSA</u>		COMPLETION DEPTH <u>41.5</u>	SAMPLES <u>3" OD split spoon</u>
DRILLING METHOD <u>HOLLOW STEM AUGERS</u>	DRILL BIT	NO. OF SAMPLES <u>8</u>	DIST. <u>2</u>
SIZE AND TYPE OF CASING		WATER ELEV. <u>7.0</u>	COMPL. <u>24 HRS.</u>
TYPE OF PERFORATION	FROM — TO FT.	LOGGED BY <u>S. MORRISSETTE</u>	CHECKED BY
SIZE AND TYPE OF PACK	FROM — TO FT.		
TYPE OF SEAL <u>6 foot</u>	FROM <u>0</u> TO <u>41.5</u> FT.		

DEPTH (feet)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Well Control	Piezometer Date	TYPE NO.	RECOVERED	PIED (feet & in)	
0	(SM) silty SAND, fine-grained, poorly-graded, subangular to subrounded, med. dense, moist, 10yr S/3 brown, gravelly from 0.0 to 0.5 ft.							Median sand/silt	
1									
2									
3									
4									
5									
6	becomes 10yr 4/6 dark yellowish-brown and slightly less silty								
7									
8	(SP) SAND, fine-grained, poorly SM graded, subrounded, medium dense, wet, 10yr S/3 brown, with a trace of silt							water enters ATD Alluvium	
9									
10	(SM) silty SAND, fine-grained, poorly-graded, dense, wet, 10yr S/3 brown							Alluvium	
11									
12									
13									
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Field loss, Odor, etc)					
		Lithology	Piezometer Installation	Well Contact	Filtermeter	TEST NO.	DEPTH (ft)						
14	(LT or SM) sandy SILTY or silty SAND, non-plastic, fine-grained, poorly graded SAND, medium dense, wet, 10YR 5/3 brown, with trace of clay.						7 10 9	Alluvium					
15													PID=ND
16													
17													
18	(ML) slightly sandy SILTY, non-plastic, very fine grained, poorly graded SAND, medium dense, very moist, 10YR 5/3 brown, iron oxide stains							Alluvium					
19													
20													
21													
22	(SM) silty SAND, fine-grained, poorly-graded, medium-dense, very moist to wet, 10YR 4/6 dark yellowish-brown							Alluvium					
23													
24													
25	(CL to CH) slightly sandy silty clay SHALE, very stiff to hard, low to medium plastic, very highly moist, 2.5Y 6/4 light yellowish-brown							Denver Fm.					
26													slightly weathered
27													
28													
29													
30													
31	becomes 2.5Y 6/2 light brownish gray, highly plastic, with iron oxide stains, weathered & blocky							PID=ND					
32													


















DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Photometer Installation	Water Content	Shrinkage	Type No.	Pressure	Temp.	Other	
32	SAME: (CH) silty clay shale, highly plastic, very stiff to hard, very moist, 2.5y 6/2 light brownish gray, highly weathered blocky, iron oxide stains Weathered Claystone									Denver fm. weathered
33										
34										
35										
36										
37	Core run #2									
38										
39										
40	(CH) silty clay shale, highly plastic, hard, very moist, 10yR3/1 dark gray, iron oxide stains									Denver fm.
41	becomes 10yR5/4 yellowish-brown									
42	claystone									
43										
44										
45										
46										Bottom of boring at 41.5 feet
47										
48										
49										
50										

BORING LOCATION <u>Sec. 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>6/26/90</u>	DATE FINISHED <u>6/27/90</u>
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>46</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Stem</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>4 in PVC</u>		WATER ELEV.	FIRST
TYPE OF PERFORATION <u>10 slot</u>	FROM <u>15.7 TO 25.7 FT.</u>	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK <u>10-20</u>	FROM <u>15.4 TO 25.7 FT.</u>	<u>T. Terry</u>	
TYPE OF SEAL <u>Bentonite</u>	FROM <u>11.5 TO 15.4 FT.</u>		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)	
		Lithology	Piezometer Installation	Water Content	Piston No.	Type No.	Record #		
1	Sand, slightly clayey, medium to fine sand, medium dense, moist, dark yellowish brown (SC) 10YR 4/4 SM Silty							PID PPM ND	
2									6
3									8
4									5
5									
6	Sand, medium to fine sand, silty, loose to medium dense, slightly moist, yellowish brown (SP) 10YR 5/4							ND	
7									4
8									3
9									
10	Clay, very sandy, medium stiff, slightly moist, yellowish brown, (SP) 10YR 5/4 (SP) 10YR 4/3							ND	
11									4
12									6
13									
14									





DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES		REMARKS (Drill Rate, Field loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	
14							
15							
16						6	ND
17						8	
18						8	
19	Sand, silty, wet, dense to very dense, grayish brown, 10YR 5/2 (SP)						
20						5	ND
21						11	
22						14	
23							
24							
25	Clay, sand, very moist, stiff, yellowish brown 10YR 5/4 (CL)						
26						3	ND
27						7	
28						9	
29	Weathered Sandstone, clayey, silty, medium to fine sand, layered, hard to very hard, thin interbedded siltstones < 1 inch, grayish brown, 10YR 5/2 (SC)						
30						6	ND
31						24	
32	Denver Formation					50/4	7.8
















DEPTH FEET	DESCRIPTION	GRAPHIC LOG		Water Content	Piezometer Date	SAMPLES			REMARKS PPM (Drill Rate, Field loss, Odor, etc)
		Lithology	Piezometer Installation			TYPE NO.	DEPTH FEET	DEPTH FEET	
32									
33									
34									
35									
36									
37									
38									
39									
40									
41								20	
42	Claystone, sandy, silty, slightly moist, slightly blocky, hard, interbedded siltstones and sandstones, dark grayish brown, 10YR 4/2 (CL-CH)							33	5.7
43								38	
44	Denver Formation								ND
45									
46									

BORING LOCATION <u>Sec 36</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>06/28/30</u>	DATE FINISHED <u>06/29/30</u>
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>43.5</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Stem</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>4 in PVC</u>		WATER ELEV.	FIRST <u>9.5</u>
TYPE OF PERFORATION <u>10 slot</u>	FROM <u>19.9</u> TO <u>29.9</u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>10-20 Sand</u>	FROM <u>14</u> TO <u>31</u> FT.	CHECKED BY	
TYPE OF SEAL <u>Bentonite</u>	FROM <u>10</u> TO <u>14</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			P.I.D. PPM REMARKS (Drill Rate, Fluid loss, Odor, etc.)					
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE No.	RECYL PACER LABY (in)							
1	Sand, very clayey, slightly moist, brown, stiff, (SC) 10YR 4/3 silty													
2														
3														ND
4	Sand, silty, clayey, moist, medium dense, brown, loose, (SP), 10YR 4/3, wet, yellowish brown 10YR 5/4 (SM)													
5														ND
6														
7														
8														67
9														
10														
11														
12														
13	(Next Page)													
14														

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Piezometer Data	SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Pneumometer Installation			Type No.	Depth (ft)	
14	Clay, very sandy, very stiff, wet, grayish brown, wet, (CL), sand zones, 10YR5/2, pale brown 10YR6/3						12	ND
15							17	
16							14	
17								
18								
19							7	ND
20							13	
21							13	
22								
23								
24	Clay, sandy, silty, very stiff; moist, light yellowish brown (CL) 10YR6/4						7	ND
25							11	
26							12	
27								
28								
29							9	ND
30	Weathered Claystone, very stiff, moist, dark reddish brown, (CH)						13	
31							17	
32								

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			P.I.D. PPM REMARKS (Drill Rate, Fluid loss, Odor, etc)		
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	Recon. (1)	Probe Point (Flow @ ft)			
32	Sandstone, siltstone, interbedded, gray, moist, hard, wet zones 10YR 6/1 (SP)										
33											
34										50/3	37
35										C	29
36										O	
37										R	
38										E	
39											
40										C	
41										O	
42	Claystone, yellowish brown moist, hard, 10YR 5/4 (CL)										
43											

BORING LOCATION <u>LIME SETTLING BASINS</u>				ELEVATION AND DATUM				
DRILLING AGENCY <u>LAYNE WESTERN</u>		DRILLER <u>M. WALKER</u>		DATE STARTED <u>7-12-90</u>		DATE FINISHED		
DRILLING EQUIPMENT <u>OME 750 w/ 6-5/8" HSA</u>		DRILL BIT		COMPLETION DEPTH <u>15.5</u>		SAMPLER <u>3" OD split spoon</u>		
DRILLING METHOD <u>Hollow stem auger</u>		DRILL BIT		NO. OF SAMPLES <u>4</u>		UNDIST. <u>-</u>		
SIZE AND TYPE OF CASING <u>-</u>		WATER ELEV.		FIRST <u>13</u>		COMPL. NO. <u>24</u> INIS.		
TYPE OF PERFORATION <u>-</u>		FROM <u>-</u> TO <u>-</u> FT.		LOGGED BY <u>S. Maffisette</u>		CHECKED BY		
SIZE AND TYPE OF PACK <u>-</u>		FROM <u>-</u> TO <u>-</u> FT.						
TYPE OF SEAL <u>6 foot</u>		FROM <u>0</u> TO <u>155</u> FT.						
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Oder, etc.)
		Lithology	Piezometer installation	Water Control	Piezometer Case	TYPE NO.	DEPTH (FEET)	
0	(Sm) silty SAND, fine-grained, poorly graded, medium dense, moist, 10YR5/3 brown					SS 17	3 3 5	Fill
1	(Sh and CL) clayey silty SAND to sandy silty CLAY, fine-grained, poorly graded, medium dense, moist, 5Y7/1 light gray to 5Y6/1 gray							Fill/sludge PID=ND
2	Fill							
3	(Sm) silty SAND, fine-grained, poorly graded, medium dense, moist, 10YR4/3 brown to dark brown							Fill
4						SS 15	3 6 9	PID=ND
5								
6								
7								
8								
9						SS 17	7 9 6	PID=ND
10								
11								
12	becomes 10YR5/4 yellowish-brown							
13								water enters ATD
14								




DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Moisture Dens	TYPE NO.	DEPTH (ft)	DEPTH (ft)	
14	SAME: (sm) silty SAND, fine-grained, poorly graded, very loose to loose, wet, 10 yr 5/4 yellowish-brown	[Hand-drawn lithology symbols]	[Blank]	[Blank]	[Blank]	SS	2		Fill (?)
15							1/3	P=0=2.0 ppm	
16									Bottom of boring at 15.5 FEET
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									

DRAFT



BORING LOCATION LIME SETTLING BASINS		ELEVATION AND DATUM	
DRILLING AGENCY Layne Western	DRILLER M. WALKER	DATE STARTED 7-12-90	DATE FINISHED
DRILLING EQUIPMENT CME 750 w/6-5/8" HSA	COMPLETION DEPTH 15.5	SAMPLER 3" DD split spoon	
DRILLING METHOD Hollow stem augers	DRILL BIT	NO. OF SAMPLES 4	DIST. —
SIZE AND TYPE OF CASING —	WATER ELEV. 12.5	UNDIST. —	COMPL. 24 HRS.
TYPE OF PERFORATION —	FROM — TO — FT.	LOGGED BY S. MORRISSETTE	
SIZE AND TYPE OF PACK —	FROM — TO — FT.	CHECKED BY	
TYPE OF SEAL GROUT	FROM 0 TO 15.5 FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Plasometer Installation	Water Content	Plasometer Date	TYPE NO.	Penetration Resist. (lb/ft ²)	DEPTH (ft)	
0	(Sm) clayey silty SAND, fine grained, poorly graded, medium dense, moist, 5/7/1							5	Fill/sludge
1	light gray Fill							10	PIED=ND
2	(Sm to SC) silty SAND to clayey SAND, fine grained, poorly graded, medium dense, moist, 10YR 4/3 brown to dark brown							7	Fill
3	Fill								
4								7	
5								5	PIED=ND
6								4	
7									
8									
9									
10								6	PIED=ND
11								8	
12	(Sm) silty SAND, fine grained, poorly graded, medium dense, wet, 10YR 5/4 yellowish brown							8	Alluvium
13									water enters ATD (12.5)
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)	
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Depth (ft)		Depth (ft)
14	SAME: (Sm) silty SAND, fine-grained, poor 1/4 graded, medium dense, wet, 10% R 5/4 yellowish-brown						9	Alluvium PID=ND	
15									SS 10
16									10
17								Bottom of boring at 15.5 feet	
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									

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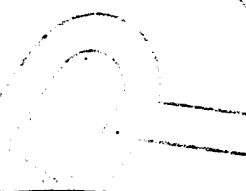



BORING LOCATION		ELEVATION AND DATUM	
Sec 01			
DRILLING AGENCY	Layne Western	DRILLER	R. McKay
DRILLING EQUIPMENT	CME 75	DATE STARTED	7-13-90
DRILLING METHOD	Hollow Auger	DATE FINISHED	
SIZE AND TYPE OF CASING	NA	COMPLETION DEPTH	
TYPE OF PERFORATION	NA	NO. OF SAMPLES	
SIZE AND TYPE OF PACK	NA	WATER ELEV.	FIIST NE
TYPE OF SEAL	Grout	LOGGED BY	T. Terry
		CHECKED BY	
			COMPL. 24 HRS.

DEPTH (FEET)	DESCRIPTION	GEOLOGIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Oder, etc.)
		Lithology	Piezometer Installation	Water Content	Plasticity	Type No.	Quantity (Lbs/ft ³ & In)	
1	Fill, clay, sandy, gravel, bricks, asphalt, very moist, brown	[Cross-hatched pattern]						ND
2								
3								
4								
5								
6								
7								
8								
9	Sand, silty, clayey, brown, very moist to wet, medium dense	[Dotted pattern]					Drop	ND
10								
11	Weathered Claystone, siltstone and sandstone, blocky, stiff crumbly, dark olive gray, dry	[Diagonal lines pattern]						610
12								
13								
14								

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			PID PPM REMARKS (Drift Note, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE NO.	RESQ. II Pore Ratio @ 1 in	
14								
15							648	769
16								
17	Claystone, siltstone, sandstone, hard, dry, layered, brown, green							
19								
20							36 50/5	34
21								
22								0.2
23								
24								
25								

CORE

DRILLING LOCATION <u>Sec 01</u>				ELEVATION AND DATUM			
DRILLING AGENCY <u>Layne Western</u>		DRILLER <u>M. Walker</u>		DATE STARTED <u>7-16-90</u>		DATE FINISHED	
DRILLING EQUIPMENT <u>CME 750</u>				COMPLETION DEPTH		SAMPLER <u>T. Terry</u>	
DRILLING METHOD <u>Hollow Auger</u>		DRILL BIT		NO. OF SAMPLES		DIST.	
SIZE AND TYPE OF CASING <u>NA</u>				WATER ELEV.		FINISH <u>NE</u>	
TYPE OF PERFORATION <u>NA</u>		FROM TO FT.		LOGGED BY <u>T. Terry</u>		CHECKED BY	
SIZE AND TYPE OF PACK <u>IVA</u>		FROM TO FT.					
TYPE OF SEAL <u>Grout</u>		FROM <u>0</u> TO <u>30</u> FT.					

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)			
		Lithology	Piezometer Installation	Water Control	Piezometer Date	TYPE NO.	RESIDUAL PRESSURE (PSI)	DEPTH (ft)				
1	Clay, little to some sand, dry to moist, brown to yellowish brown, stiff to very stiff											
2												
3												ND
4												
5												
6												
7												
8												ND
9												
10	Sand; silty, trace clay, moist, very dense, yellowish brown											
11												ND
12	Weathered Claystone, very stiff, moist, blocky, fractured, calcareous, dark yellowish brown, olive gray, olive brown, brown											
13												
14												


DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS P.P.M. (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Depth	Type No.	RESQ. (1) P.P.M. Below (ft)	
14								
15								
16							16	1.0
17							20	
18							22	
19								
20							11	1.0
21							12	
22							21	
23	Claystone, hard, moist, olive brown, brown							
24								
25								8.5
26								
27								
28								
29								
30								

BORING LOCATION <u>Sec 01</u>		ELEVATION AND DATUM						
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. Allbrighton</u>	DATE STARTED <u>7-16-90</u>						
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH						
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	SAMPLER <u>T. Terry</u>					
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	UNOIST.					
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	FIIST <u>8</u>	COMPL <u>24 hrs.</u>					
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>						
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>24</u> FT.			CHECKED BY				
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE NO.	ANALYSE (ASTM 6.11)	
1	Clay, sandy, fine sand, moist, medium stiff, dark grayish brown (CL)							
2	10YR 4/2, 10YR							
3							3	
4						4		22
5								
6	Sand, silty, medium to fine sand, moist, loose, dark yellowish brown (SM)						2	
7	10YR 5/3						1	
							2	
8	Clay, sandy, moist, very stiff, dark yellowish						12	
9	brown, brown, olive, trace sand, calcareous (CL)						12	
							13	
10	10YR 4/4, 10YR 5/3, 5Y 5/3						9	
11							12	
							17	
12								
13	Weathered claystone, very stiff to hard, moist; trace sand, blocky, fractured, olive dark brown, layered (CH)							
14	5Y 4/3							

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc) <u>PI0 PPM</u>
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Pressure Point (ft) (in)	
14								
15							20	
16							36	25
17							50 1/2	
18	Claystone, hard, moist, slightly fractured, trace sand, dark brown, layered (CH) 5Y4/3, 10YR3/3							
19								
20							38	ND
21							50 1/2	
22								19
23								
24								

BORING LOCATION <u>Sec 01</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-12-90</u>	DATE FINISHED <u>7-13-90</u>
DRILLING EQUIPMENT <u>CME 75</u>	COMPLETION DEPTH	SAMPLER <u>T. Terry</u>	
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	UNOIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	COMPL. <u>24 HRS.</u>
TYPE OF PERFORATION <u>NA</u>	FROM <u>10</u> FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>10</u> FT.		
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>19.5</u> FT.		



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)		
		Lithology	Platometer Installation	Water Content	Platometer Date	TYPE No.	RECORDS	PERCENT MOISTURE (g/g)			
1	Clay, sandy, dry to moist, stiff, brown to dark brown (CL) 10YR 3/3, 10YR 4/3								PID PPM		
2											
3										3	ND
4										8	
5										7	
6	Clay, sandy, calcareous, dry, stiff to very stiff, brown, eolian, CL 10YR 5/3								ND		
7											
8										5, 4	
9										7	
10										13	
11	13			4000-Auger							
12	Claystone, little to trace sand, hard, moist to very moist, stratified, mostly, very dark grayish brown, also green, blue, olive, dusky, red								345 Head Space Lewisite Indication		
13										4	
14										8	
									13		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Pressure, Permittivity, etc. (if any)	
14								PID PPM
15						15	769	
16						28		
17						40		
18								
19							34	
20								
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SHEET 2 OF 2

BORING LOCATION <u>Sec 01</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-17-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>	COMPLETION DEPTH <u>25</u>	SAMPLER <u>T. Terry</u>	
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>	WATER ELEV.	FIRST	COMPL. 24 HRS.
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>25</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)		
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE No.	REGUL	GRAVITY (g/in)	PPM			
1	Sand, clayey, silty, dry to wet, medium dense to very dense, brown, yellowish brown (SP) 10YR 4/3, 10YR 5/8 10YR 5/4									PID PPM		
2												
3											9	10 PPM
4											11	
5											14	
6											4	18 PPM
7											4, 6	
8											6	
9											8	
10											15	
11	13	133 PPM										
12	19											
13	16											
14												
	Weathered claystone with interbedded siltstones and sandstones, very stiff, moist to very moist, light olive gray, light grayish brown (CH), 5Y 6/2, 2.5Y 4/2											

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drift Rate, Field loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	PROV. #1 Prove. Resist Glb. (in)	
14								
15							11	
16							16	677 PPM
17							22	
18	Claystone with thin interbedded sandstones and siltstones, hard, moist, grayish brown (CH) 2.5 Y 5/2							
19								
20							18	30 PPM
21							25	
22							35	31 PPM
23								
24								
25								

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CORE

BORING LOCATION		ELEVATION AND DATUM						
DRILLING AGENCY		DATE STARTED						
DRILLING EQUIPMENT		COMPLETION DEPTH						
DRILLING METHOD		NO. OF SAMPLES						
SIZE AND TYPE OF CASING		WATER ELEV.						
TYPE OF PERFORATION		LOGGED BY						
SIZE AND TYPE OF PACK		CHECKED BY						
TYPE OF SEAL								
M-1 POND								
Layne - Western		7-13-90						
CME 750 w/ 6-5/8" HSA		28.0						
Hollow Stem Augers		7						
-		9.0						
-		S. MORRISSETTE						
-		-						
6 PAULT		-						
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE NO.	DEPTH (ft)	
0	(Sm) gravelly silty SAND, fine-grained, poorly graded, medium dense, dry							Topsail
1	(Sm) slightly clayey silty SAND, very fine-grained, poorly graded, medium dense, dry to moist, 10yr 4/2 dark grayish-brown							Fill (?)
2								
3							13	
4							9	PID = ND
5							8	
6								
7							5	PID = ND
8	(SP or Sm) slightly silty or silty SAND, fine-grained, poorly graded, subangular to subrounded, medium dense, moist, 10yr 6/4 light yellowish-brown						4	
9							4	Reaction sand/silt
10							9	PID = ND
11	(SC or CL) clayey SAND or sandy silty CLAY, fine-grained, poorly graded, medium dense, moist to very moist, 10yr 5/4 yellowish-brown with 10yr 8/1 white mottling						8	water enters ATD (measured)
12							7	Alluvium
13							10	PID = ND to 1pp
14	(CL) sandy silty CLAY, low plastic, very stiff, moist to very moist, 10yr 6/2 light brownish-gray with 10yr 8/1 white mottling						10	Alluvium (weathered bedrock)

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Plazometer	SAMPLES			REMARKS (Drill Rate, Field loss, Odor, etc)	
		Lithology	Installation			Type No.	Depth (ft)	PIID		
14	(CL) sandy silty clay shales, low plastic, hard, moist to very moist, 10/RS/1 gray, very blocky and crumbly, with a trace of coarse gravel Weathered Claystone								Denver fm (weathered) PIID = ND	
15							11			
16							SS 18	20		
17								31		
18										
19	becomes 10yr 4/2 dark grayish-brown with less sand and no gravel								PIID = 15 ppm	
20							28			
21							SS 18	34		50
22	(CL) slightly sandy silty clay shales, low-medium plastic, moist, very hard, 10yr 4/2 dark grayish-brown and 2.5y 4/14 dark gray, with iron oxide staining Claystone								becoming stiffer to drill Denver fm (unweathered) PIID = 67-213 ppm ASH3 = 0.5 ppm Driller = ND, Core run #1	
23										
24							SS 10	28		50/51
25										
26										
27										
28										
29										
30										
31										
32									Bottom of boring at 28.0 feet	



BORING LOCATION		ELEVATION AND DATUM	
M-1 ponds			
DRILLING AGENCY	DRILLER	DATE STARTED	DATE FINISHED
LAYNE-WESTERN	R. Albritton	7-13-90	
DRILLING EQUIPMENT	DRILL BIT	COMPLETION DEPTH	SAMPLER
CME 750 w/ 6-5/8" HSA		26.0	3" cone pit sampler
DRILLING METHOD		NO. OF SAMPLES	DIST.
Hollow stem Augers		6	6
SIZE AND TYPE OF CASING		WATER ELEV.	FIRST
			24
TYPE OF PERFORATION	FROM TO FT.	LOGGED BY	
		S. MORRISSETTE	
SIZE AND TYPE OF PACK	FROM TO FT.	CHECKED BY	
TYPE OF SEAL	FROM TO FT.		
	GROUT 0 TO 26.0 FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Case	TYPE NO.	REMARKS	PERCENT FINE (No. 200)	
0	(SM) gravelly silty SAND, fine-grained, poorly graded, medium dense, dry								Fill
1	(SE) clayey silty SAND, fine-grained, poorly graded, medium dense, moist, 10yr 4/2 dark grayish-brown								Fill
2	Fill								
3						SS 5	8	9	PID = ND
4								8	
5	becomes 10yr 3/2 very dark grayish-brown					SS 18	4	4	PID = ND
6								7	
7	(CH) slightly sandy silty CLAY, highly plastic, stiff, very moist, 10yr 2/2 very dark brown with trace of fine grained SAND								Fill
8						SS 18	5	6	PID = 0.5 ppm
9	Fill							7	
10	(SC) clayey silty SAND, fine-grained, poorly graded, medium dense, moist, 10yr 5/3 brown with								Alluvium water
11	10yr 8/2 white mottling					SS 18	16	16	PID = ND
12									
13	Becomes more clayey to 14.5 ft.								
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Plazometer Data	SAMPLES			REMARKS (Drill Rate, Field loss, Odor, etc)
		Lithology	Piezometer Installation			TYPE NO.	DEPTH (ft)	PIED (ppm)	
14	SAME: (see previous page)								Alluvium
15	(SANDSTONE and SC) fine-grained, poorly graded, medium hard, moist, 10YR5/1 gray, slightly silty SANDSTONE with clayey silty SAND								Denver Fm (weathered) PIED=0.8 ppm
16						SS 18	8 14 19		
17									
18									
19									
20									
21						SS 17	20 25 22		PIED=ND
22									
23	(CL w/ML) silty clay stone and slightly sandy SILTSTONE, low-mold plastic, hard, moist, 10YR5/1 gray and 10YR5/3 brown, with trace of very fine-grained SAND								Core run #1 Denver Fm (unweathered)
24	claystone								
25									
26									
27									Bottom of boring at 26.0 feet
28									
29									
30									
31									
32									

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DRILLING LOCATION <u>Sec 01</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-19-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Coring</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRES
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	<u>T. Terry</u>	
TYPE OF SEAL <u>Grout</u>	FROM 0 TO 20 FT.		



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)		
		Lithology	Piezometer Installation	Water Content	Piezometric Coefficient	TYPE NO.	DEPTH (FEET)	PERCENT (GRAV)			
1	Fill, clay, sandstone, claystone, blocky, mixed, wet, olive gray, grayish brown, 5Y4/2, 10YR5/2, 10YR4/2								P10 PPM		
2											
3										7	31.6
4										10	
5										23	
6										11	12.6
7										10	
8										10	
9										5	16.1
10										10	
11	8	21.9									
12	13										
13	18										
14	Claystone with thin interbedded sandstone lenses, hard, moist, grayish brown, green, reddish yellow, yellow, light gray, stratified, gravelly										


DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	Recon. (ft)	
14		[Diagonal Hatching]						221
15								
16								
17								
18								
19								
20								
21	[Large 'DRAFT' watermark]							36.8
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

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SHEET 2 OF 2



DRILLING LOCATION <u>Sec. 01</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7/17/90</u>	DATE FINISHED <u>7/18/90</u>
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>HOLLOW AUGER</u>	DRILL BIT	NO. OF SAMPLES	UNOIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	COMPL. <u>24 HRS.</u>
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.		
TYPE OF SEAL <u>AA Grout</u>	FROM <u>0</u> TO <u>19.5</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.) <u>PID PPM</u>		
		Lithology	Piezometer Installation	Water Control	Piezometer Casing	TYPE No.	RECYCL. PRESSURE (PSI) (500/6 in)			
1	Clay, little to some sand, moist, stiff to very stiff, dark yellowish brown, light yellowish brown, pale brown (CL) 10YR 3/4, 10YR 6/4, 10YR 6/3									
2										
3									6	1533
4									7	
5									8	
6									4	202
7									4	
8									6	
9									6	2525 Lewisite
10									9	
11									11	73000 2525 Lewisite Indication
12	7									
13	10									
14	12									
	Weathered claystone, moist, very stiff to hard, grayish brown, layered (CH) to 2.5YR 5/2									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	TYPE NO.	DEPTH (FEET)	
14	Claystone, moist, hard to very hard, grayish brown, layered (CH) 2.5YR 5/2				CORE		27	73000 314
15							37	
16							50/5	
17								
18								
19								
20								


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BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-11-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>20</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PERFORATION <u>NA</u>	FROM	TO	FT.
SIZE AND TYPE OF PACK <u>NA</u>	FROM	TO	FT.
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u>	TO <u>20</u>	FT.
LOGGED BY <u>T. Terry</u>		CHECKED BY	

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	Type No.	Recovery	Pressure (lb/sq. in.)	Depth (ft. in.)	
1	Fill Clay, little sand, gravel in 10 ft. sample, moist to very moist, very dark gray to dark brown, 10YR3/1, 10YR3/2, 10YR3/3									72
2										
3										
4										
5										
6										
7										
8										
9										
10										
11	Claystone, moist to very moist, firm to hard, weathered in top 1 foot									767
12										
13										
14										

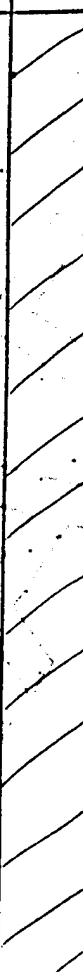
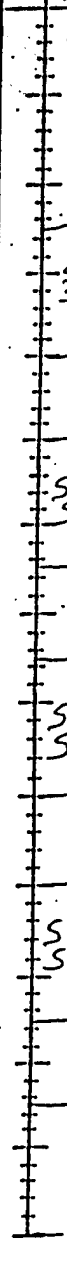


BORING LOCATION		ELEVATION AND DATUM	
Sec 1			
DRILLING AGENCY	Layne Western	DRILLER	R. McKay
DRILLING EQUIPMENT	CME 75	DATE STARTED	7-11-90
DRILLING METHOD	Hollow Auger	DATE FINISHED	
SIZE AND TYPE OF CASING	NA	COMPLETION DEPTH	28 19
TYPE OF PERFORATION	NA	NO. OF SAMPLES	1
SIZE AND TYPE OF PACK	NA	WATER ELEV.	
TYPE OF SEAL	Grout	LOGGED BY	T. Terry
		CHECKED BY	


DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Date	TYPE No	Depth (Feet) (6 in)	
1	Fill, clay, sandy moist to very moist, very dark grayish brown to dark gray 10 YR 3/2, 10 YR 3/1	[Cross-hatched pattern]					4	230
2								
3								
4								
5								
6								
7								
8	Clay, sandy, calcareous, dry to moist, stiff to very stiff, yellowish brown 10 YR 5/4, 2.5 Y 5/4	[Diagonal lines]					5	57
9								
10								
11	Claystone, trace silt, trace to little sand, firm to very hard dark olive gray, blueish 5 Y 3/2	[Solid black]					6	24.4
12								
13								
14								

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc)	
		Lithology	Piezometer Installation	Water Content	Phenometer Data	Type No.	Recon. #	Sample Depth (ft)		
14					CORE				P10 PPM	
15										
16									20	6.3
17									40	
18									50/5	
19										

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DRILLING LOCATION		ELEVATION AND DATUM	
Sec 1			
DRILLING AGENCY	DRILLER	DATE STARTED	DATE FINISHED
Layne Western	B. McKay	7-12-90	
DRILLING EQUIPMENT		COMPLETION DEPTH	SAMPLER
CME 75			T. Terry
DRILLING METHOD	DRILL BIT	NO. OF SAMPLES	DIST.
Hollow Auger			
SIZE AND TYPE OF CASING		WATER ELEV.	FIHST
NA			
TYPE OF PERFORATION	FROM TO FT.	LOGGED BY	
NA		T. Terry	
SIZE AND TYPE OF PACK	FROM TO FT.	CHECKED BY	
NA			
TYPE OF SEAL	FROM TO FT.		
Grout	0 TO 201.5		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Photometer Insulation	Water Content	Plasticity Index	TYPE NO.	RESULTS	Particle Analysis (% by Weight)		
1	Clay, sandy, moist, stiff to very stiff, brown, dark grayish brown, dark yellowish brown (CL) 10YR4/3, 10YR4/2, 10YR4/4, 10YR5/4					S	S	S	S	0.4
2										
3										
4										
5										
6										
7										
8										
9										
10										
11	weathered claystone, very stiff, moist to dry, yellowish brown, light olive brown 10YR5/4 2.5Y4/4 (CH)					S	S	S	S	27
12										
13										
14										

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES		REMARKS (Drift Note, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	TYPE NO.	
14	Claystone, hard to very hard, dry to moist; olive brown (CH), 2.5 Y 4/4				CORE		PID PPM
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

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SHEET 2 OF 2

BORING LOCATION		ELEVATION AND DATUM	
Sec 1			
DRILLING AGENCY	Layne Western	DRILLER	R. Albritton
DRILLING EQUIPMENT	CME 750	DATE STARTED	7-18-90
DRILLING METHOD	Continuous CORE	DATE FINISHED	7-19-90
SIZE AND TYPE OF CASING	NA	COMPLETION DEPTH	
TYPE OF PENFORATION	NA	SAMPLER	T. Terry
SIZE AND TYPE OF PACK	NA	NO. OF SAMPLES	
TYPE OF SEAL	Grout	DIST.	
		UNDIST.	
		WATER ELEV.	
		FIIST	
		COMPL.	24 HRS.
		LOGGED BY	T. Terry
		CHECKED BY	







DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Planimeter Installation	Water Content	Plasticity	TYPE NO.	DEPTH (ft)	DEPTH (ft)	DEPTH (ft)	
1	Fill, clay, gravelly, moist brown 10YR6/4	[Cross-hatched]								31.6
2						GT	GS			
3	Sludge, light gray, layered white, black, wet, 10YR7/1	[Cross-hatched]								12.6
4										
5										
6	Clay, light yellowish brown, wet, 10YR6/4 (CL)	[Cross-hatched]								16.1
7						GS	C			
8	Weathered claystone, blocky, dark yellowish brown (CH) 10YR4/4	[Diagonal lines]								21.9
9						GS	C			
10						GT				
11										
12										
13										
14										

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	Type No.	
14							PID PPM
15							221 Mustard Indication
16	Claystone, hard, moist, brown, layered, 10YR 4/3 Sheared in Tube						36.8
17							
18							
19							
20							Core Samples GT - Geotech GS - Geosafe C - Chemical

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BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-28-90</u>	DATE FINISHED <u>7-25-90</u>
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>20</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	DISL.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PENETRATION <u>NA</u>	FROM TO FL	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FL	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM 0 TO 20 FT		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Oder, etc.)
		Lithology	Piezometer Installation	WATER SAMPLED	PIEZOMETER DATA	TYPE NO.	DEPTH (FEET)	ANALYSIS	
1	Fill, Gravel, clay, moist, brown; 10YR4/3	[Cross-hatched]							
2									
3									
4	Sludge, moist, gray, white, black;	[Cross-hatched]							2727 PPM 292 PPM Lewisite Indication
5									
6									
7									
8	Clay, moist, sandy, gravelly, light brownish gray, (CL) 10YR6/2	[Diagonal lines]							30 PPM Lewisite Indication
9									
10									
11	Weathered Claystone, moist to dry, calcareous, blocky, fractured, (CH); 10YR3/3	[Diagonal lines]							5798 PPM 919 PPM
12									
13									
14									

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		Water Content	Piezometer Data	SAMPLES		REMARKS (Drift Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation			TYPE NO.	DEPTH (ft) & IN.	
14						A		
15						C		2052 PPM
16								
17	Claystone, brown, moist, slightly fractured, very dark grayish brown. 10YR 3/2							
18								
19						T		919 PPM
20								Core Samples T-Geotech A-Army G-Geosafe C-Chemical

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BORING LOCATION <u>Sec. 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-19-90</u>	DATE FINISHED <u>7-23-90</u>
DRILLING EQUIPMENT <u>CME 750</u>	DRILL BIT	COMPLETION DEPTH <u>20</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Continuous Core</u>		NO. OF SAMPLES	UNDIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>20</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Oder, etc.)
		Lithology	Piezometer Installation	Water Control	Piezometer Data	TYPE NO.	RESIST.	GRAVITY (Gross/Net) (G/IN)	
1	Fill, gravel, clayey, dark yellowish brown, moist 10 YR 3/4								
2									
3									
4									
5	Sludge, wet, gray, black, white, red								14.5 PPM.
6									
7									
8									
9	Clay, wet to moist, brown								1736 PPM Lewisite Indication 919 PPM
10									
11									
12	Weathered claystone, wet to moist, brown, highly fractured, blocky								
13									
14									

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SHEET 1 OF 2

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Dell Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometer Data	TYPE NO.	DEPTH (ft)	
14						A		2052
15						C		
16								
17	Claystone, moist, brown, sl. fractured							
18								
19						G		919
20						Geot		
								<u>Core Samples</u> Army - A Geosafe - G Chemical - C Geotech - Geot

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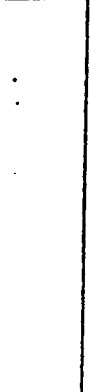
DRILLING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-26-90</u>	
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>8</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	UNDIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	COMPL. <u>24 hrs.</u>
TYPE OF PENFORATION <u>NA</u>	FROM <u> </u> TO <u> </u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u> </u> TO <u> </u> FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>8</u> FT.		





DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		WELL CASE	PISTON	DATE	SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Platometer Indication				TYPE NO.	RESULTS	PARASITIC ORGANISM (#/ft)	
1	Roadbase, Gravel Sandy, brown , dry very dark gray	00 00					A			
2	clay, very moist, brown, stiff						G			
3										
4	Sludge, gray, very moist,									0.3 PPM
5							A			
6							G			
7										
8	sand, clayey, moist, very dense						A			611 PPM Rig Refusal
9										
10										

BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-26-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PERFORATION <u>NA</u>	FROM <u>10</u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>10</u> FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>10</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		WATER	TEMPERATURE	SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation			TYPE	DEPTH (FEET)	
1	Fill, clay, gravel, sandy moist; very dark grayish brown 10YR3/2	[Cross-hatched]				A	G	
2								
3	Sludge, gray, white, brown very moist	[Cross-hatched]				G	A	93 PPM
4								
5								
6	Clay, moist, stiff, (CL) dark yellowish brown 10YR4/4	[Cross-hatched]				A	G	2683 PPM Lewisite Indication
7								
8								
9								
10								

DRILLING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-26-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PENETRATION <u>NA</u>	FROM <u> </u> TO <u> </u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u> </u> TO <u> </u> FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>10</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Platometer Installation	Water Control	Pneum. Device	TYPE	RESULTS	ANALYSIS	
1	Clay, dry to moist, stiff, dark yellowish brown, 10YR 4/4 (CL)								
2									
3									
4	Clay, very sandy, moist to very moist, brown 10YR 5/3, (CL)								77 PPM
5									
6									
7									349 PPM
8									
9									
10									

BORING LOCATION		ELEVATION AND DATUM						
Sec 1								
DRILLING AGENCY	Layne Western	DRILLER	M. Walker					
DRILLING EQUIPMENT	CME 750	DATE STARTED	7-23-90					
DRILLING METHOD	Cont. Core	DATE FINISHED						
SIZE AND TYPE OF CASING	NA	COMPLETION DEPTH	SAMPLES					
TYPE OF PERFORATION	NA	NO. OF SAMPLES	DIST.					
SIZE AND TYPE OF PACK	NA	WATCH ELEV.	FIRST					
TYPE OF SEAL	Grout	FROM 0 TO 15 FT	COMPL. 24 HRS.					
LOGGED BY		CHECKED BY						
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Platometer Indication	Water Content	Plasticity Data	TYPE NO.	REMARKS (Type, Size, etc.)	
1	Clay, moist, sandy, soft to stiff					A G		
2								
3								
4	Sand, silty, clayey, wet, loose, brown					A G		947 PPM
5								
6								
7	Clay, sandy, moist to wet, calcareous (aeolian), stiff to very stiff, brown, pale brown					A G		2054 PPM Lewisite Indication
8								
9								
10	Sand, silty, wet, trace clay, medium dense, brown							
11								
12								
13								
14								

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SHEET 1 OF 2

DEPTH FEET DOWN	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc)
		Lithology	Piezometer Installation	Water Content	Piezometric Data	Type No.	DEPTH FROM TOP (ft. in)	
14								
15								605 PPM

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SHEET 2 OF 2

BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-27-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PENETRATION <u>NA</u>	FROM TO FL	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FL		
TYPE OF SEAL <u>Grout</u>	FROM 0 TO 10 FT		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES		REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Drill Collar	Drill Pipe	TYPE	DEPTH (ft)	
1	Fill, clay, gravelly, moist, stiff, dark, yellowish brown 10YR 4/4	[Cross-hatched]						
2								
3	Sludge, gray gray, soft, white, brown, moist	[Cross-hatched]						47 PPM
4								
5		[Cross-hatched]						
6								
7	Clay, sandy, stiff, moist yellowish brown 10YR 5/4	[Cross-hatched]						189 PPM
8								
9		[Cross-hatched]						
10								


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SHEET 1 OF 1

BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-27-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	UNDIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATCH ELEV.	FIRST
TYPE OF PENETRATION <u>NA</u>	FROM <u>10</u> TO <u>FL</u>	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>10</u> TO <u>FL</u>	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>10</u> FT		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Pneumometer Installation	WATER	PIEZOMETER	TPA NA	RESISTANCE	PERCENT LOSS	WATER LOSS (in)	
1	Road base, gravel, sand, clayey, very dense, dry Fill									
2	Fill ^{Gravelly} sandy, clayey, dry to moist, brown (GP)									
3	10YR 4/3							A G		
4										
5	Sludge, gray, brown, moist, soft									50PPM
6										
7								A G		
8	Clay, very stiff, dry, dark brown, (CL) 10YR 3/3							G A		
9										
10										137PPM Core Sample G - Geosafe A - Army

BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-27-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	DISL.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST <u>4.5</u>
TYPE OF PERFORATION <u>NA</u>	FROM <u>10</u> FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>10</u> FT.		
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>10</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)			
		Lithology	Piezometer Installation	Water Level	Pneumatics	TYPE	DEPTH (FEET)	DEPTH (IN)				
1	Fill, sand, clean, to gravelly, to clayey, loose, moist to wet, brown, medium to fine sand, poorly graded (SP) 10YR4/3 very loose								140 PPM			
2										A	G	T
3												
4												
5												
6												
7												
8												
9												
10												

Core Sample
G - Geosafe
A - Army
T - Western

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BORING LOCATION <u>Sec 1</u>				ELEVATION AND DATUM			
DRILLING AGENCY <u>Layne Western</u>		DRILLER <u>M. Walker</u>		DATE STARTED <u>7-23-90</u>		DATE FINISHED	
DRILLING EQUIPMENT <u>CME 750</u>		DRILL BIT		COMPLETION DEPTH <u>10</u>		SAMPLER <u>T. Terry</u>	
DRILLING METHOD <u>Cont. Core</u>		SIZE AND TYPE OF CASING <u>NA</u>		NO. OF SAMPLES		UNDIST.	
TYPE OF PERFORATION <u>NA</u>		FROM <u>0</u> TO <u>10</u> FT.		WATER ELEV.		COMPL. <u>24 HRS.</u>	
SIZE AND TYPE OF PACK <u>NA</u>		FROM <u>0</u> TO <u>10</u> FT.		LOGGED BY <u>T. Terry</u>		CHECKED BY	
TYPE OF SEAL <u>Grout</u>		FROM <u>0</u> TO <u>10</u> FT.					

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Control	Pressure Data	TYPE NO.	ANALYSIS (PPM) (6 in)	
1	Fill Gravel, clayey, moist, light yellowish brown, 10YR6/4 (GL)							
2	Fill, Clay, moist, sandy, brown 10YR4/3 (CL)					A G		4 PPM
3								
4								
5								10 PPM
6	Sludge, gray, black, white, blocky, moist, soft					A G		
7								
8								
9	Clay, dark brown, moist 10YR3/3 (CL)					A G		13 5 PPM
10								Core Samples G-Geosafe A-Armylab




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SHEET 1 OF 1





BORING LOCATION <u>Sec 1</u>				ELEVATION AND DATUM			
DRILLING AGENCY <u>Layne Western</u>		DRILLER <u>M. Walker</u>		DATE STARTED <u>7-25-90</u>		DATE FINISHED	
DRILLING EQUIPMENT <u>CME 750</u>		DRILL BIT		COMPLETION DEPTH <u>10</u>		SAMPLER <u>T. Terry</u>	
DRILLING METHOD <u>Cont. Core</u>		DRILL BIT		NO. OF SAMPLES		DISC.	
SIZE AND TYPE OF CASING <u>NA</u>		DRILL BIT		WATER ELEV.		UNDIST.	
TYPE OF PERFORATION <u>NA</u>		FROM TO FT.		LOGGED BY		CHECKED BY	
SIZE AND TYPE OF PACK <u>NA</u>		FROM TO FT.		<u>T. Terry</u>			
TYPE OF SEAL <u>Grout</u>		FROM 0 TO 10 FT.					

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Platometer Installation	WATER CONTENT	PHREATIC DEPTH	TYPE NO.	RESULTS	ANALYSIS	
1	Fill, Gravel, clay, moist, dark brown, 10YR3/3	06				A			
2	Sludge, gray, white, black, moist to dry, soft	00				G			
3		00							
4		00							
5		00				T			0 PPM
6		00				A			
7		00				A			
8		00				G			
9	Clay, sandy, moist, stiff, yellowish brown, (CL) 10YR 5/6	00				A			130 PPM
10		00				G			CORE Samples G - Geosafe A - Army T - Geotech

DRILLING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-24-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>	COMPLETION DEPTH	SAMPLER <u>T. Terry</u>	
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>	TYPE OF PERFORATION <u>NA</u>	WATER ELEV.	FIRST
TYPE OF PERFORATION <u>NA</u>	FROM <u>10</u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>10</u> FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Orbit Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	NEUT. CURVE	PURITY DATA	TYPE NO.	RESULTS	ANALYSIS	
1	Fill, Gravel, clayey, sandy, moist, brown, 10YR4/3					A			
2	Sludge, gray, brown, white dry to moist					G			
3						A			
4						G			
5	Clay, little to trace sand, moist, dark gray, 10YR4/1					A			292 PPM
6						G			
7						A			
8						G			
9									
10									5798 PPM CORE samples G - Geosafe A - Army

BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-25-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PENETRATION <u>NA</u>	FROM <u>10</u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>10</u> FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>10</u> FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Planimeter Installation	WATER LEVEL	Pressure	TYPE NO.	DEPTH	PACKING	REMARKS	
1	Fill, gravel, sand, clay, brown 10YR5/3					A	G			
2	Sludge, moist, gray, white, black									
3										
4										
5	clay, sandy, brown, moist 10YR5/3									0 PPM
6										
7										
8										767 PPM Lewisite Indication
9										
10										

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SHEET 1 OF 1



BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-27-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>	COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>	
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	UNDIST.
SIZE AND TYPE OF CASING <u>NA</u>	FROM <u>10</u> FT.	WATER ELEV.	FIRST
TYPE OF PERFORATION <u>NA</u>	FROM <u>10</u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>0</u> TO <u>10</u> FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>			

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Pneumometer Installation	WATER LEVEL	Pressure Data	TYPE NO.	DEPTH	DEPTH	DEPTH	
1	Fill, gravel, clayey, brown 10YR4/3									
2	Sludge, gray, soft, moist									
3										
4										
5										25 PPM
6	Clay, very stiff, moist, olive brown, olive, (CH)									
7	2.5Y4/4, 5Y4/3									
8										
9										
10										103 PPM

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SHEET 1 OF 1



BORING LOCATION <u>Sec 1</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>M. Walker</u>	DATE STARTED <u>7-26-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 750</u>		COMPLETION DEPTH <u>10</u>	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Cont. Core</u>	DRILL BIT	NO. OF SAMPLES	UNDIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIRST
TYPE OF PENETRATION <u>NA</u>	FROM TO FT.	LOGGED BY	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.	<u>T. Terry</u>	
TYPE OF SEAL <u>Grout</u>	FROM 0 TO 10 FT.		

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		WATER LEVEL	PIEZOMETER	SAMPLES		REMARKS (Drill rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation			TYPE	DEPTH (FEET)	
1	Fill, gravel, clay, moist, sandy, light, yellowish brown, 10YR6/4					G		
2						A		
3								
4	Clay, sandy, calcareous, moist, dark grayish brown 10YR4/2 (CL)					G		0 PPM
5						A		
6								
7								
8								
9								
10								
								229 PPM
								Core Samples G - Geosafe A - Army



BORING LOCATION <u>Sec 1</u>				ELEVATION AND DATUM				
DRILLING AGENCY <u>Layne Western</u>		DRILLER <u>M. Walker</u>		DATE STARTED <u>7-24-90</u>		DATE FINISHED <u>7-24-90</u>		
DRILLING EQUIPMENT <u>CME 750</u>		DRILL BIT		COMPLETION DEPTH <u>10</u>		SAMPLER <u>T. Terry</u>		
DRILLING METHOD <u>Cont. Core</u>		DRILL BIT		NO. OF SAMPLES		DIST.		
SIZE AND TYPE OF CASING <u>NA</u>		DRILL BIT		WATER ELEV.		FIRST		
TYPE OF PERFORATION <u>NA</u>		FROM <u>10</u> FT.		LOGGED BY <u>T. Terry</u>		CHECKED BY		
SIZE AND TYPE OF PACK <u>NA</u>		FROM <u>10</u> FT.						
TYPE OF SEAL <u>Grout</u>		FROM <u>0</u> TO <u>10</u> FT.						
DEPTH (FEET)	DESCRIPTION	GEOPHYSIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Plasometer Installation	WATER CONTENT	PIEZOMETER DEPTH	TYPE NO.	DEPTH (FEET)	
1	Fill, gravel, little clay, moist to wet	00						
2		00						
3		00						
4		00						
5		00						0.6 PPM
6	Clay, moist to wet, stiff, brown 10YR4/3							
7					A	G		
8	Clay, sandy, wet, very stiff, dark grayish brown							
9	7.5Y4/2				A	G		
10								111 PPM Core Samples G - Geosafe A - Army

WORKING LOCATION <u>Sec. 25</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-10-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH <u>6</u>	SAMPLEN <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES <u>1</u>	DIST. <u>1</u>
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIIST <u>24 HRS.</u>
TYPE OF PERFORATION <u>NA</u>	FROM <u> </u> TO <u> </u> FT.	LOGGED BY <u>T. Terry</u>	
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u> </u> TO <u> </u> FT.	CHECKED BY	
TYPE OF SEAL <u>Grout</u>	FROM <u>0</u> TO <u>6</u> FT.		



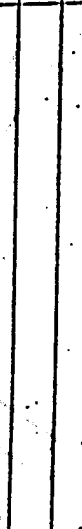
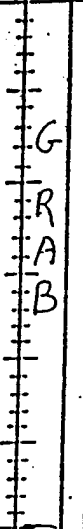



DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG			SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Control	Piezometer Date	TYPE NO.	ANALYSIS (ASTM/USDA/8 In)	
1	Clay, moist to very moist, brown, (CH), 10YR 4/3							
2								
3								
4								
5								
6	Sand, clayey, medium to fine sand, very moist, (SC) brown, 10YR 4/3							




DRILLING LOCATION <u>Layne Western Sec. 25</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-10-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>		COMPLETION DEPTH	SAMPLER <u>T Terry</u>
DRILLING METHOD <u>Hollow Auger</u>	DRILL BIT	NO. OF SAMPLES	WATER ELEV.
SIZE AND TYPE OF CASING <u>NA</u>		DISC.	UNMOIST.
TYPE OF PERFORATION <u>NA</u>	FROM TO FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM TO FT.		
TYPE OF SEAL <u>GROUT</u>	FROM 0 TO 6 FT.		

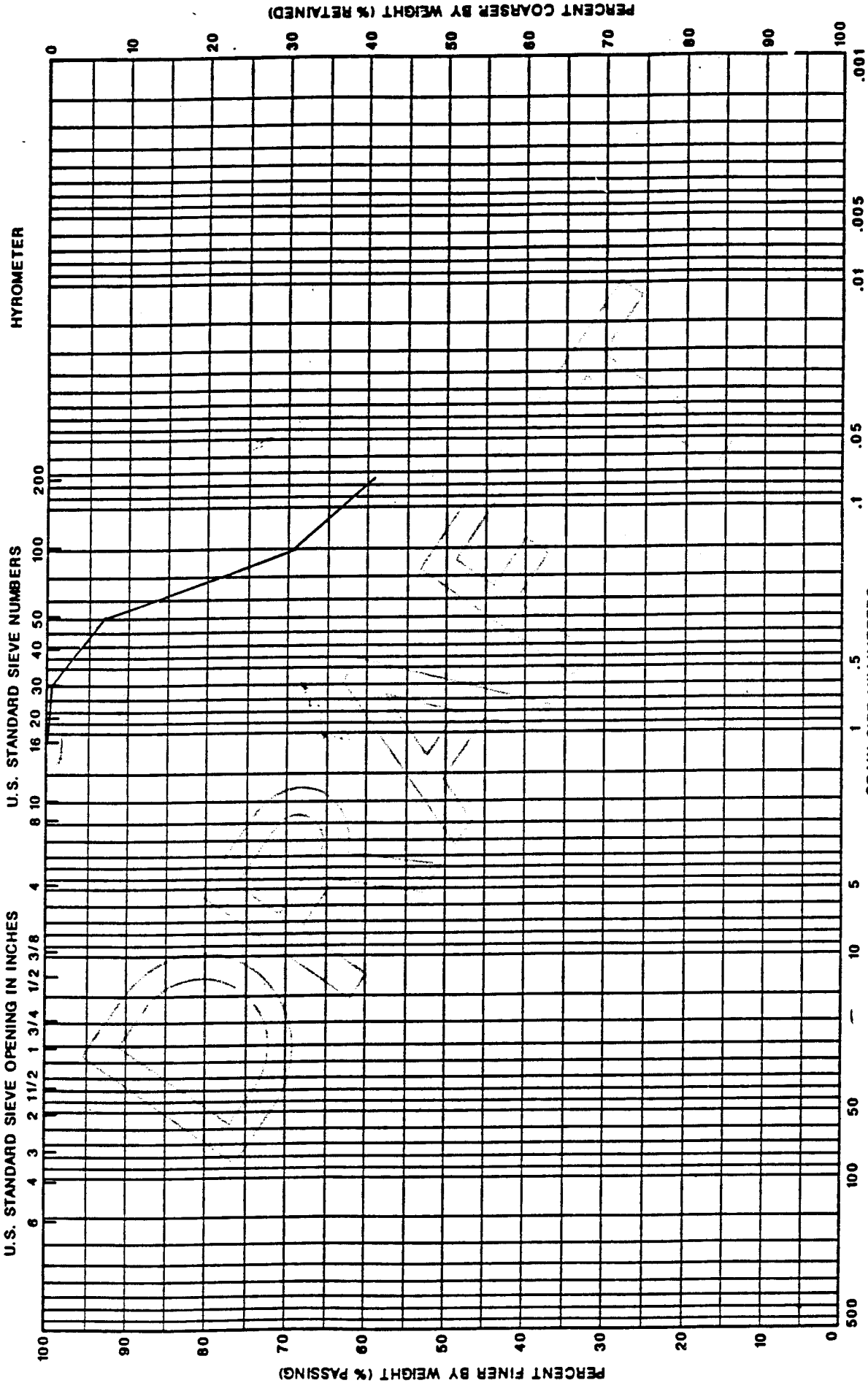
DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG		WEIGHT CORRECT	PISTON Dia	SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Pictometer Installation			TYPE NO.	DEPTH (ft)	DEPTH (in)	
1	Clay, moist to very moist, brown, (CH) 10YR 4/3	[Hatched pattern]	[Pictometer]	[Weight]	[Piston]	GRA	[Sample]	[Sample]	[Sample]
2									
3									
4									
5									
6									

DRILLING LOCATION <u>Sec. 25</u>		ELEVATION AND DATUM	
DRILLING AGENCY <u>Layne Western</u>	DRILLER <u>R. McKay</u>	DATE STARTED <u>7-10-90</u>	DATE FINISHED
DRILLING EQUIPMENT <u>CME 75</u>	DRILL BIT	COMPLETION DEPTH	SAMPLER <u>T. Terry</u>
DRILLING METHOD <u>Hollow Auger</u>		NO. OF SAMPLES	DIST.
SIZE AND TYPE OF CASING <u>NA</u>		WATER ELEV.	FIIST
TYPE OF PERFORATION <u>NA</u>	FROM <u>10</u> TO <u>10</u> FT.	LOGGED BY <u>T. Terry</u>	CHECKED BY
SIZE AND TYPE OF PACK <u>NA</u>	FROM <u>0</u> TO <u>6</u> FT.		
TYPE OF SEAL <u>Grout</u>			

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES			REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Water Content	Piezometer	GRA No.	RECENT	PIESOMETER (GRAV) (6 in)	
1	Clay, moist to very moist, brown (CL) 10YR 4/3								
2									
3									
4									
5									
6									

BORING LOCATION <u>Sec 25</u>		ELEVATION AND DATUM <u>7-10</u>	
DRILLING AGENCY <u>Layne Western</u>		DRILLER <u>R. McKay</u>	
DRILLING EQUIPMENT <u>ZME 75</u>		DATE STARTED <u>7-10-90</u>	
DRILLING METHOD <u>Hollow Auger</u>		DATE FINISHED	
SIZE AND TYPE OF CASING <u>NA</u>		COMPLETION DEPTH <u>6</u>	
TYPE OF PENFORATION <u>NA</u>		NO. OF SAMPLES	
SIZE AND TYPE OF PACK <u>NA</u>		DIST.	
TYPE OF SEAL <u>Grout</u>		WATER ELEV.	
FROM <u>10</u> TO <u>6</u> FT.		FIIST	
FROM <u>0</u> TO <u>6</u> FT.		COMPL. <u>24 hrs.</u>	
LOGGED BY <u>T. Terry</u>		CHECKED BY	

DEPTH (FEET)	DESCRIPTION	GRAPHIC LOG				SAMPLES				REMARKS (Drill Rate, Fluid loss, Odor, etc.)
		Lithology	Piezometer Installation	Well Casing	Piezometer Depth	Type No.	Depth (ft.)	Depth (ft.)	Depth (ft.)	
1	Clay, moist, brown (CL) 10YR 4/3									
2										
3										
4										
5										
6										



COBBLES GRAVEL FINE COARSE COARSE MEDIUM FINE SILT OR CLAY

FILE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	W	LL	PL	PI
0009	7.5'-9.0'	CL	SANDY LEAN CLAY	8	26	10	16

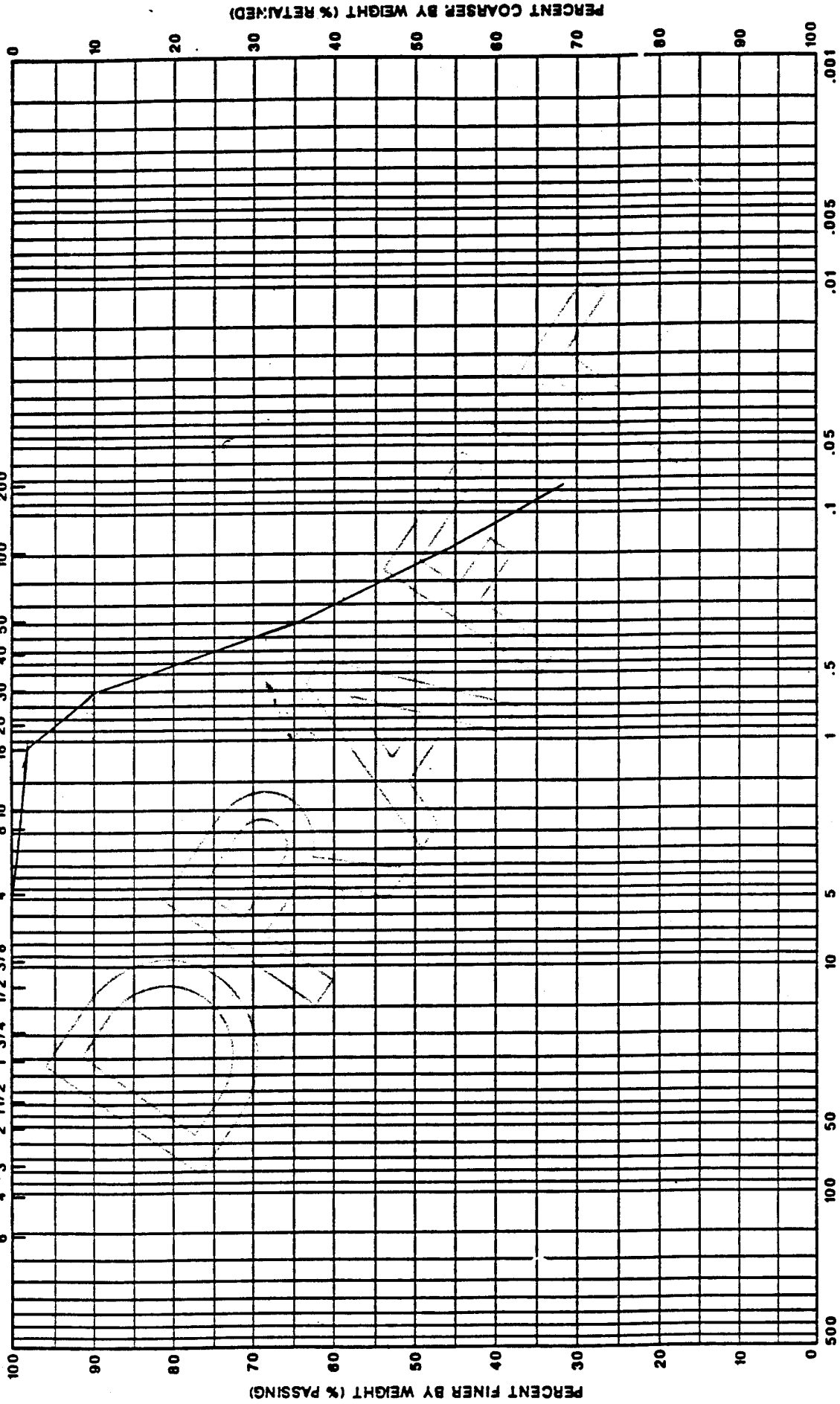


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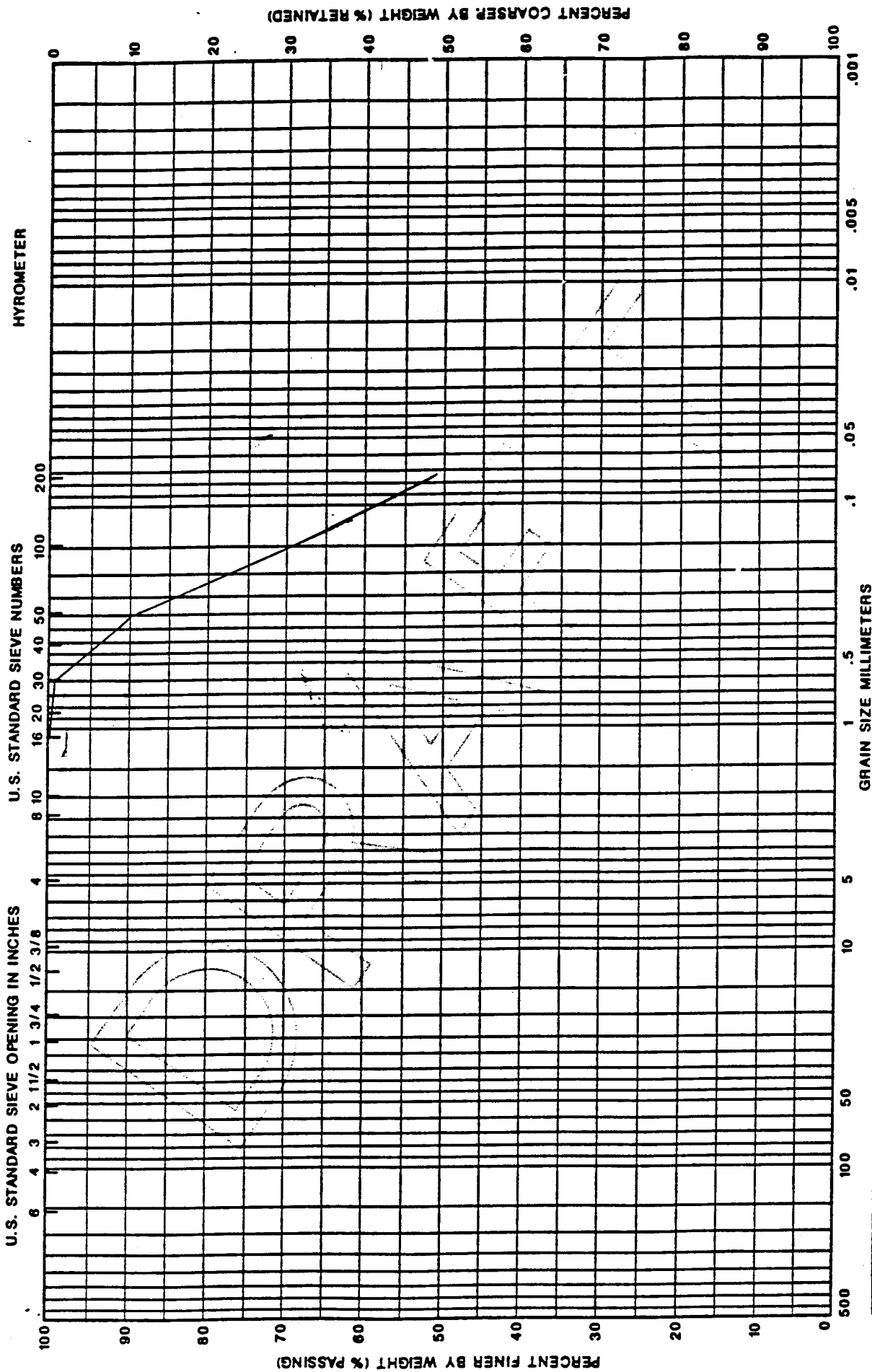
U.S. STANDARD SIEVE NUMBERS

U.S. STANDARD SIEVE OPENING IN INCHES



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

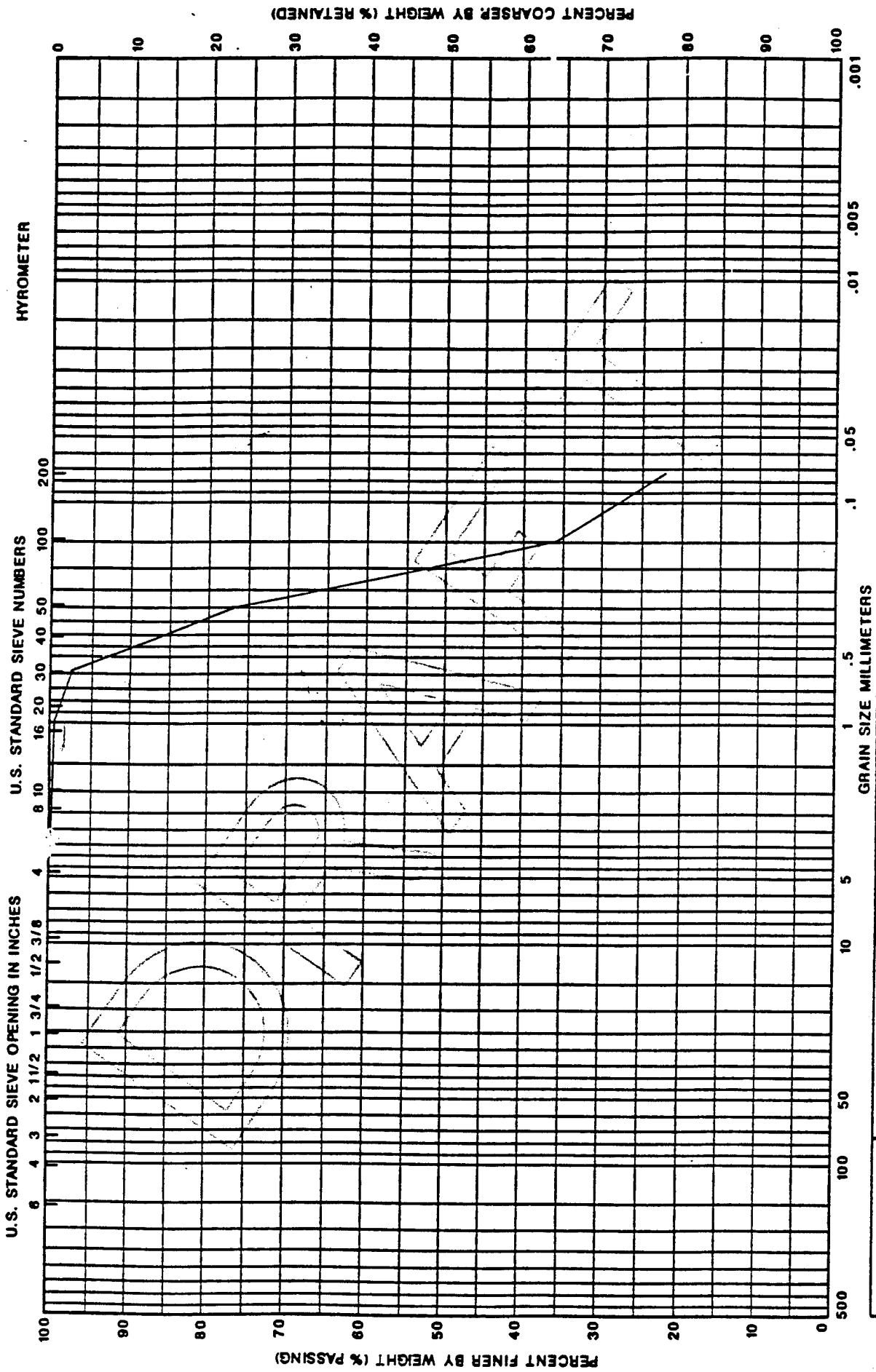
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
SB-0010	2.5'	SM	SILTY SAND	10.5	N.P.	N.P.	N.P.



COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE		FINE		MEDIUM		FINE	

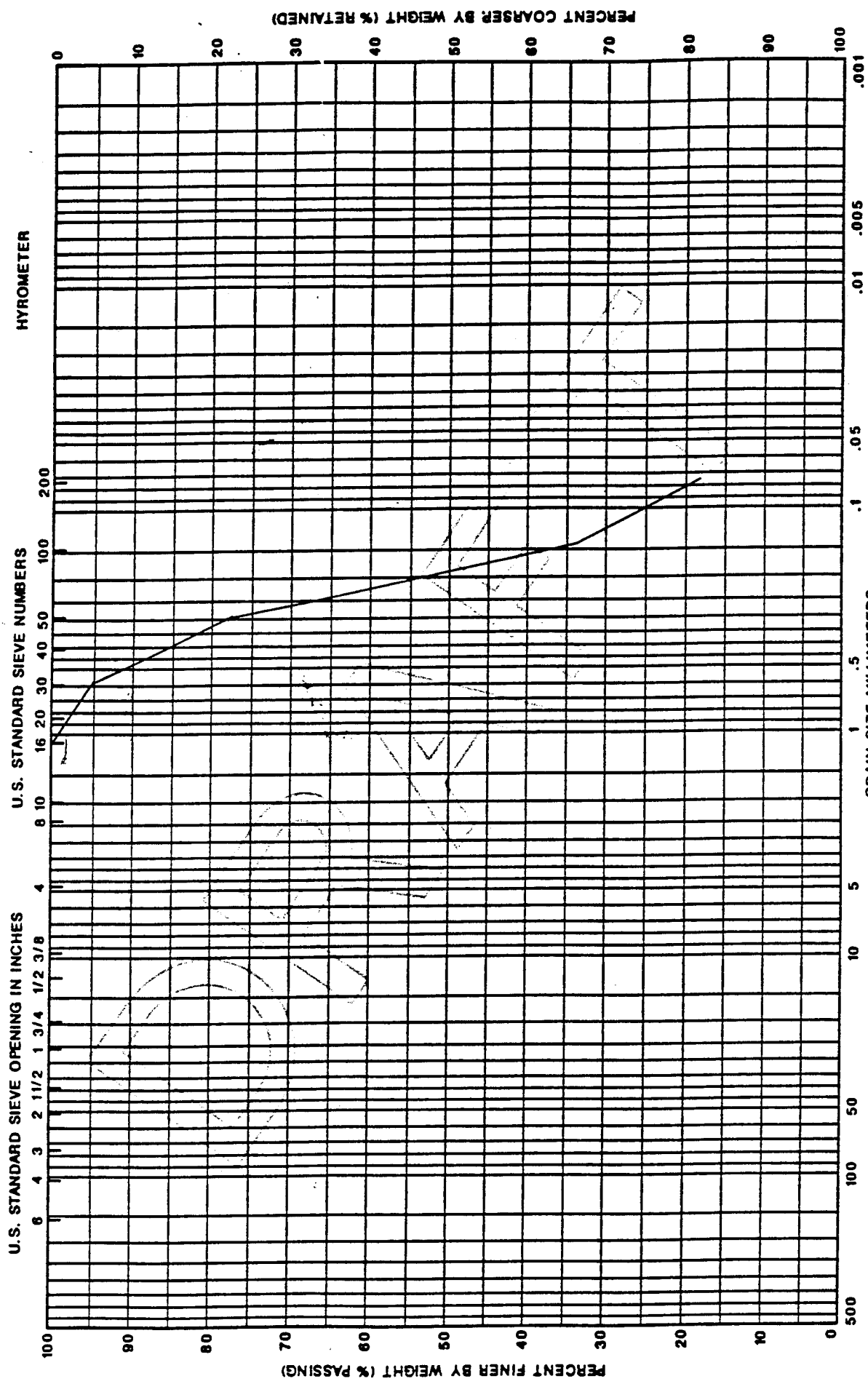
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION		
			MC	W	PI
010	2.5'-6.5'	CL	SANDY LEAN CLAY	41	19

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COBBLES		GRAVEL		SAND		SILT OR CLAY	
		COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION		LL	PL	PI
COEL SB-0010	7.5'-9.0'	SM	SILTY SAND	NAT W	N.P.	N.P.	N.P.
				2.8			

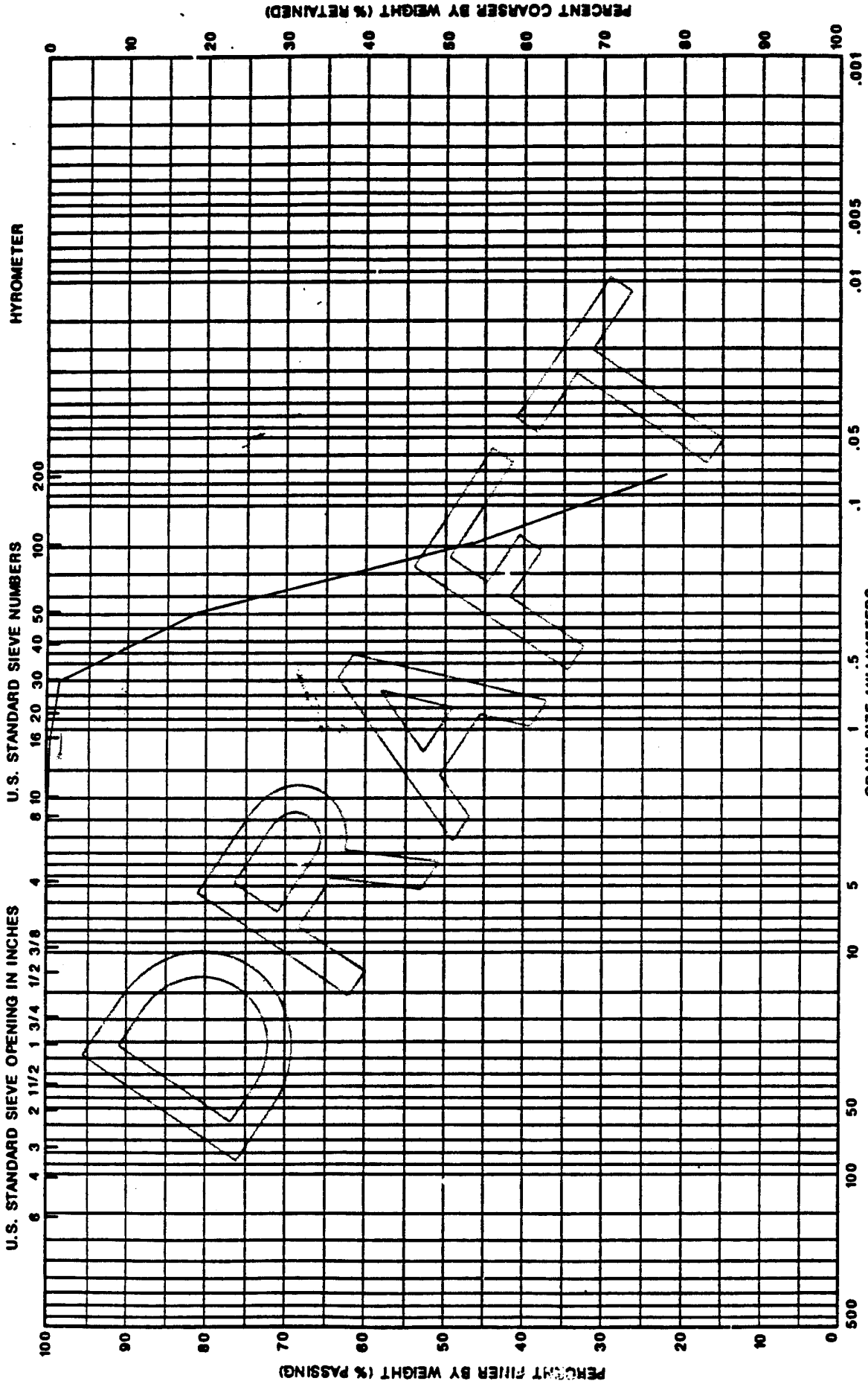


COBBLES COARSE FINE GRAVEL FINE COARSE MEDIUM FINE SAND FINE SILT OR CLAY

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION			
			SM SILTY SAND	LL	PL	PI
0015	2.5'	SM	N.P.	N.P.	N.P.	

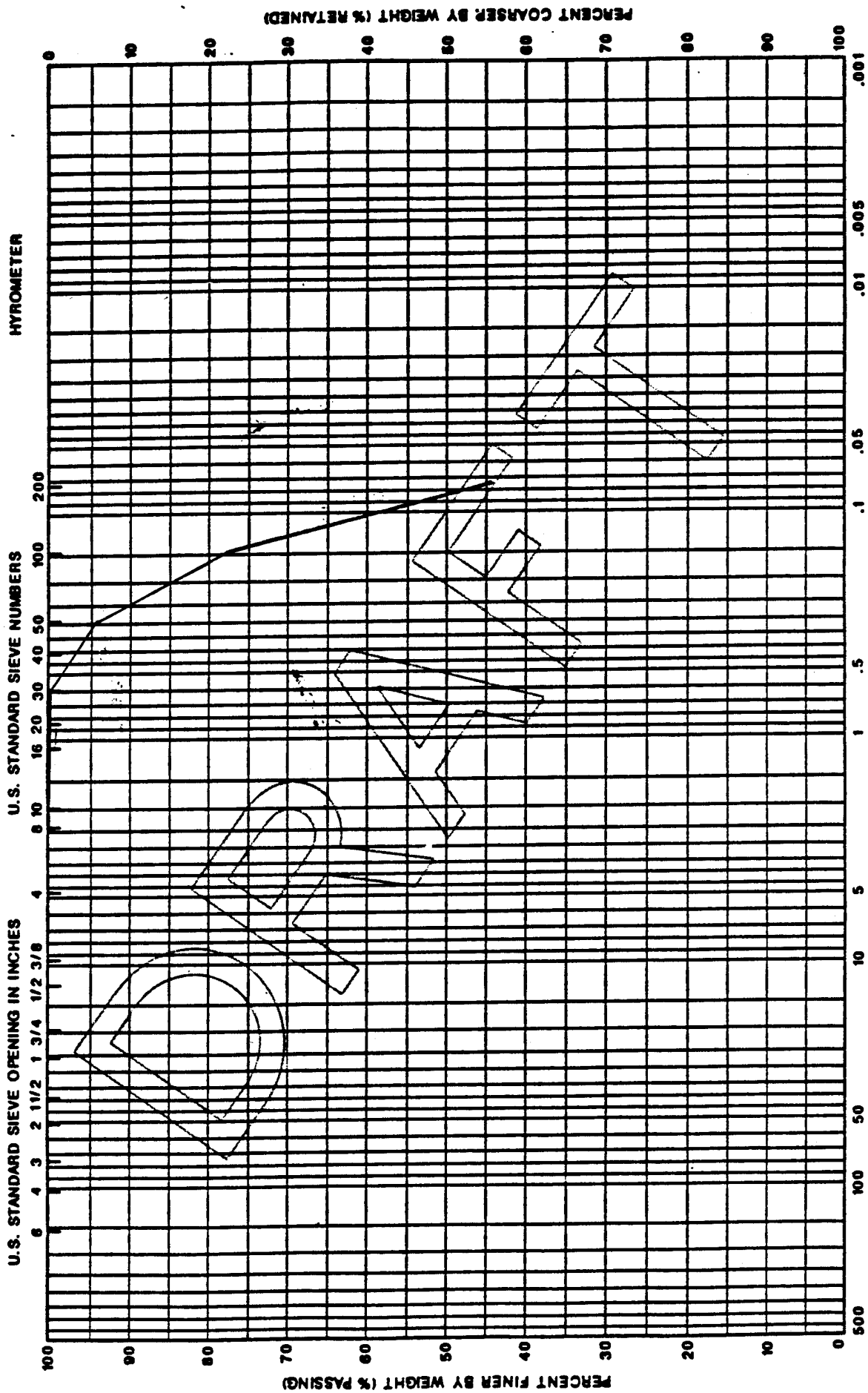
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COBBLES	GRAVEL		SAND			SILT OR CLAY			
	COARSE	FINE	COARSE	MEDIUM	FINE	LL	PL	PI	
SAMPLE NO.	CLASSIFICATION		NAT W	LL	PL	PI			
SB-0015	SM	SAND WITH SILT	16.7	N.P.	N.P.	N.P.			
ELEV. OR DEPTH									
10'									

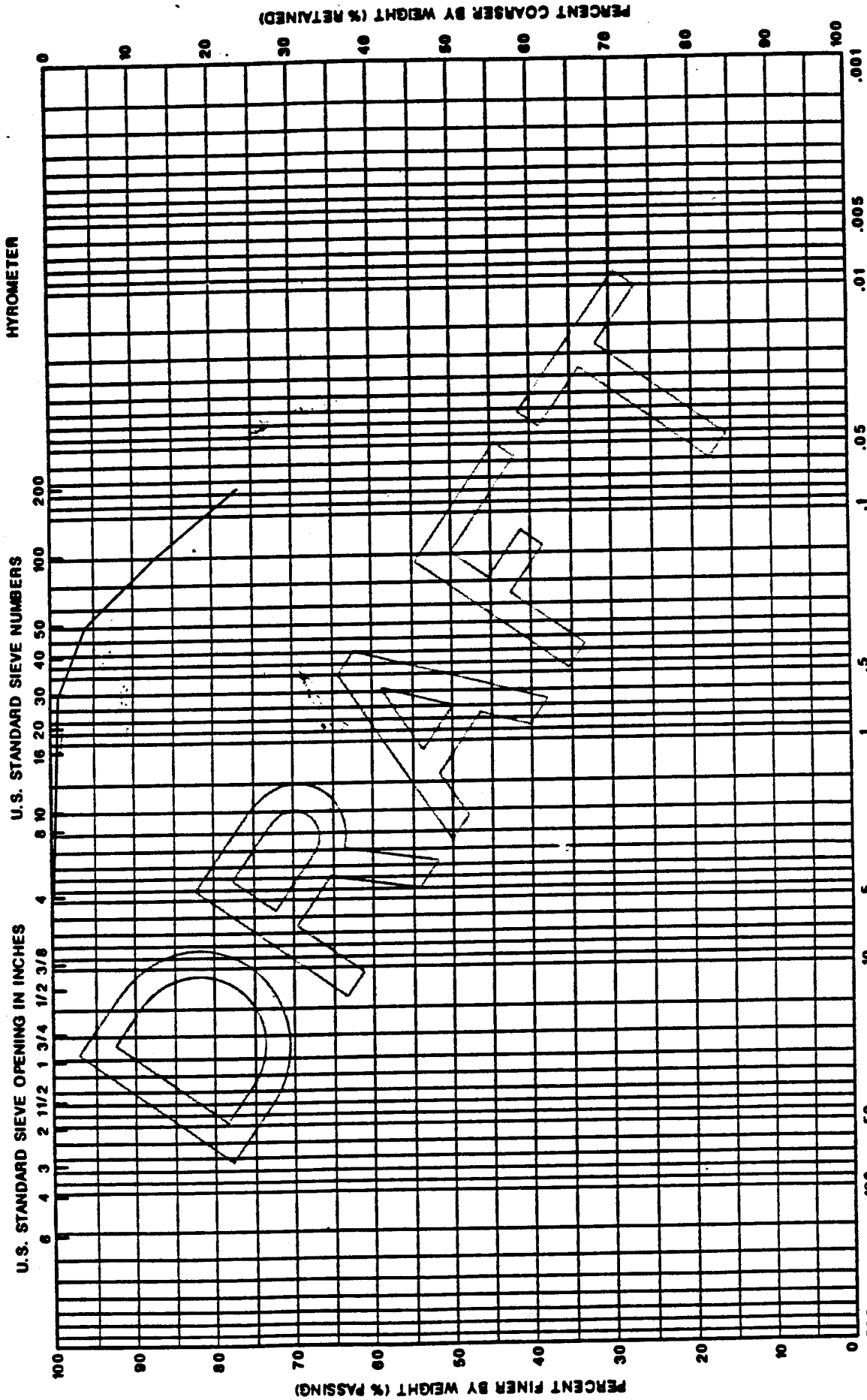
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COBBLES COARSE FINE GRAVEL FINE COARSE MEDIUM FINE SAND FINE SILT OR CLAY

PILE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	LL	PL	P1
0015	15'	SM	SILTY SAND	N.P.	N.P.	N.P.



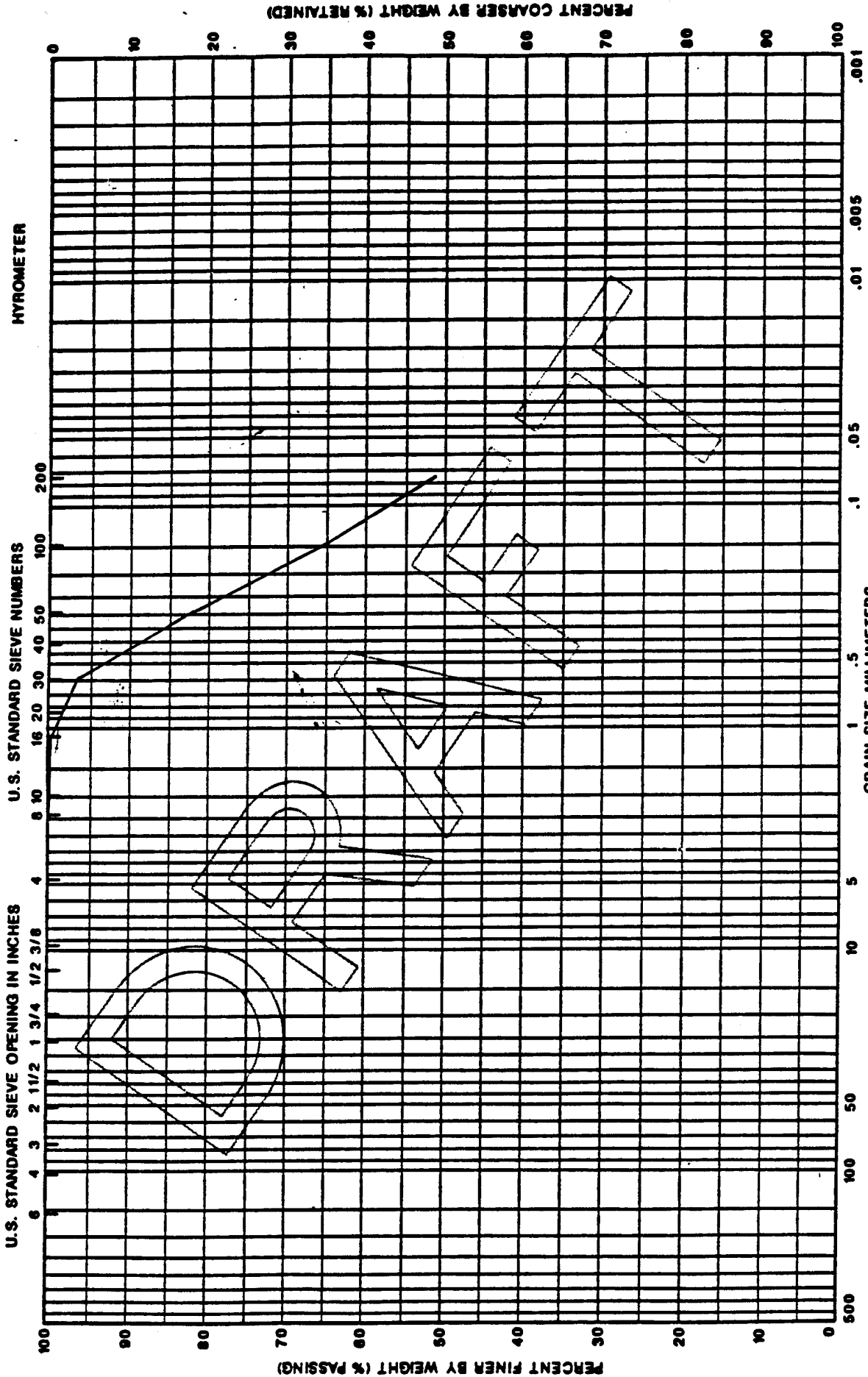


COBBLES		GRAVEL		SAND			SILT OR CLAY	
		COARSE	FINE	COARSE	MEDIUM	FINE		

COEL	SB-0015	ELEV. OR DEPTH	20'	SYM.	CL	CLASSIFICATION	LEAN CLAY WITH SAND	
				NAT W	LL	PL	P1	
				34	19	15		

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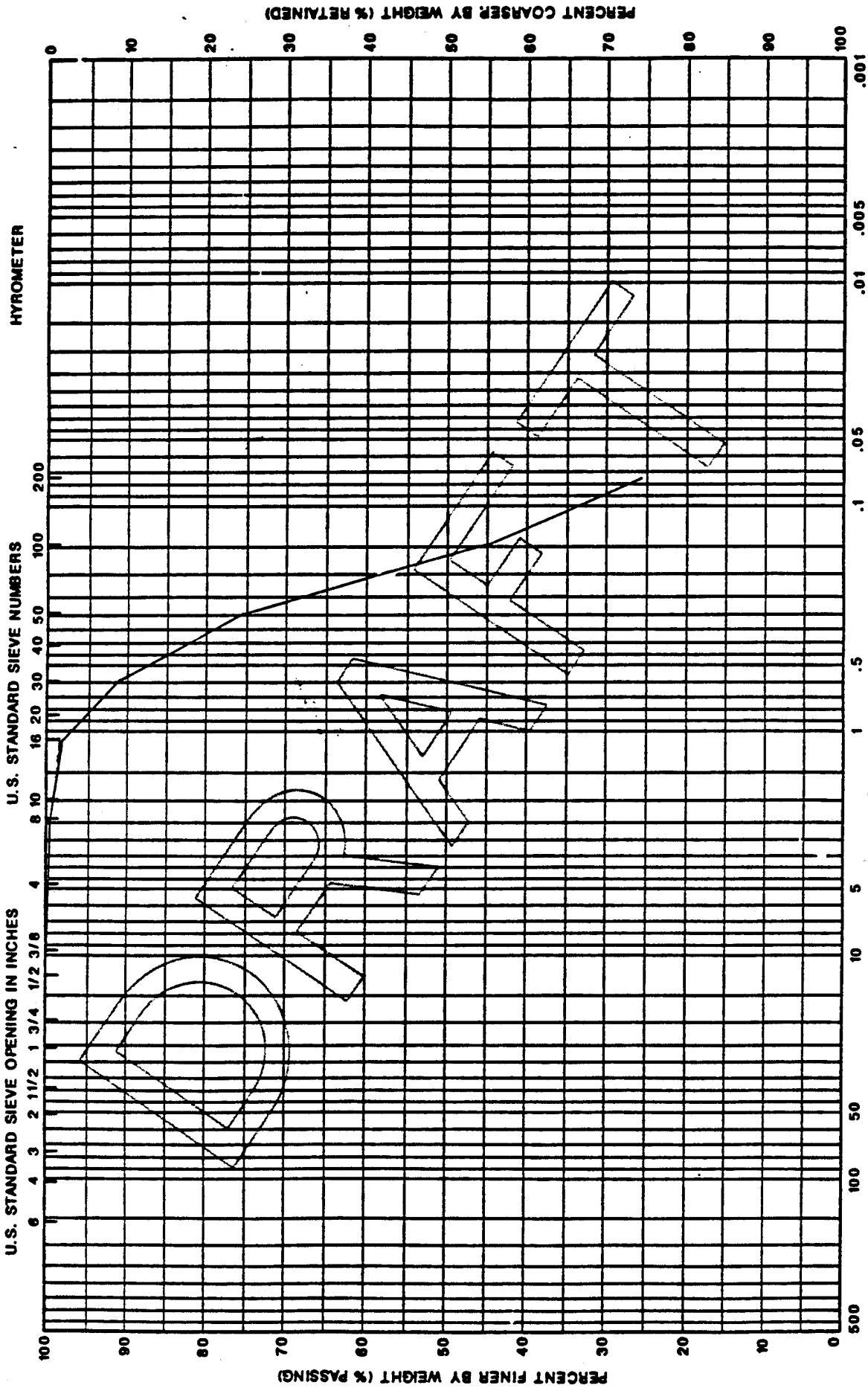
8



COBBLES	GRAVEL		SAND			SILT OR CLAY		
	COARSE	FINE	COARSE	MEDIUM	FINE			

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION			NAT W	LL	PL	PI
-0015	25'	CL	SANDY LEAN CLAY				42	24	18

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891



HYROMETER

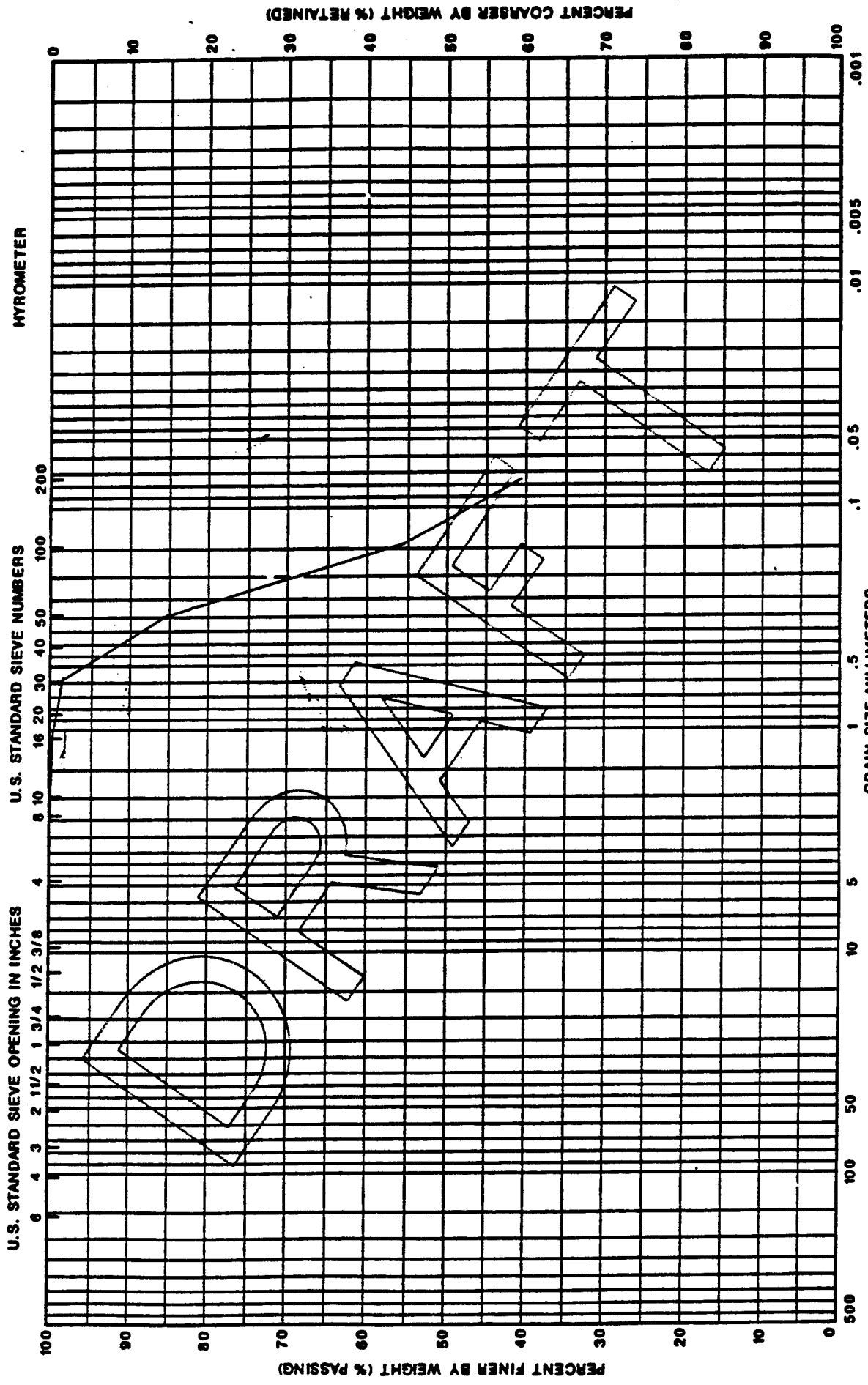
U.S. STANDARD SIEVE NUMBERS

U.S. STANDARD SIEVE OPENING IN INCHES

PERCENT COARSER BY WEIGHT (% RETAINED)

PERCENT FINER BY WEIGHT (% PASSING)

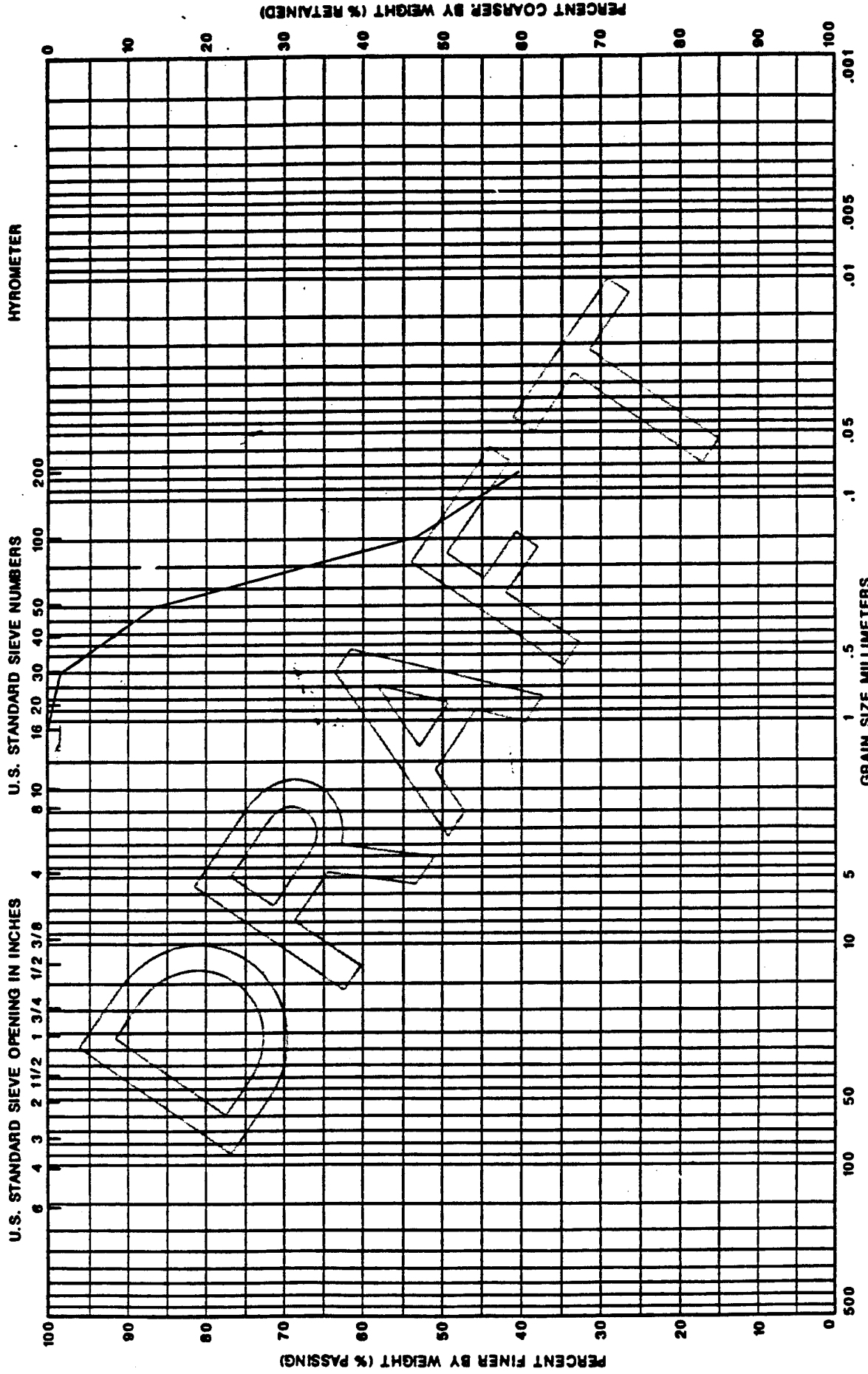
COBBLES		GRAVEL		SAND			SILT OR CLAY		
COARSE		FINE		COARSE	MEDIUM	FINE			
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION		NAT W	LL	PL	P1	
COEL SB-0017	2.5'-4.0'	SM	SILTY SAND		13.1	N.P.	N.P.	N.P.	



COBBLES	GRAVEL		SAND			SILT OR CLAY	
	COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION		PL		PI	
			SC	CLAYEY SAND	NAT W	LL	PL	PI
B-0017	7.5'			23	15	8		

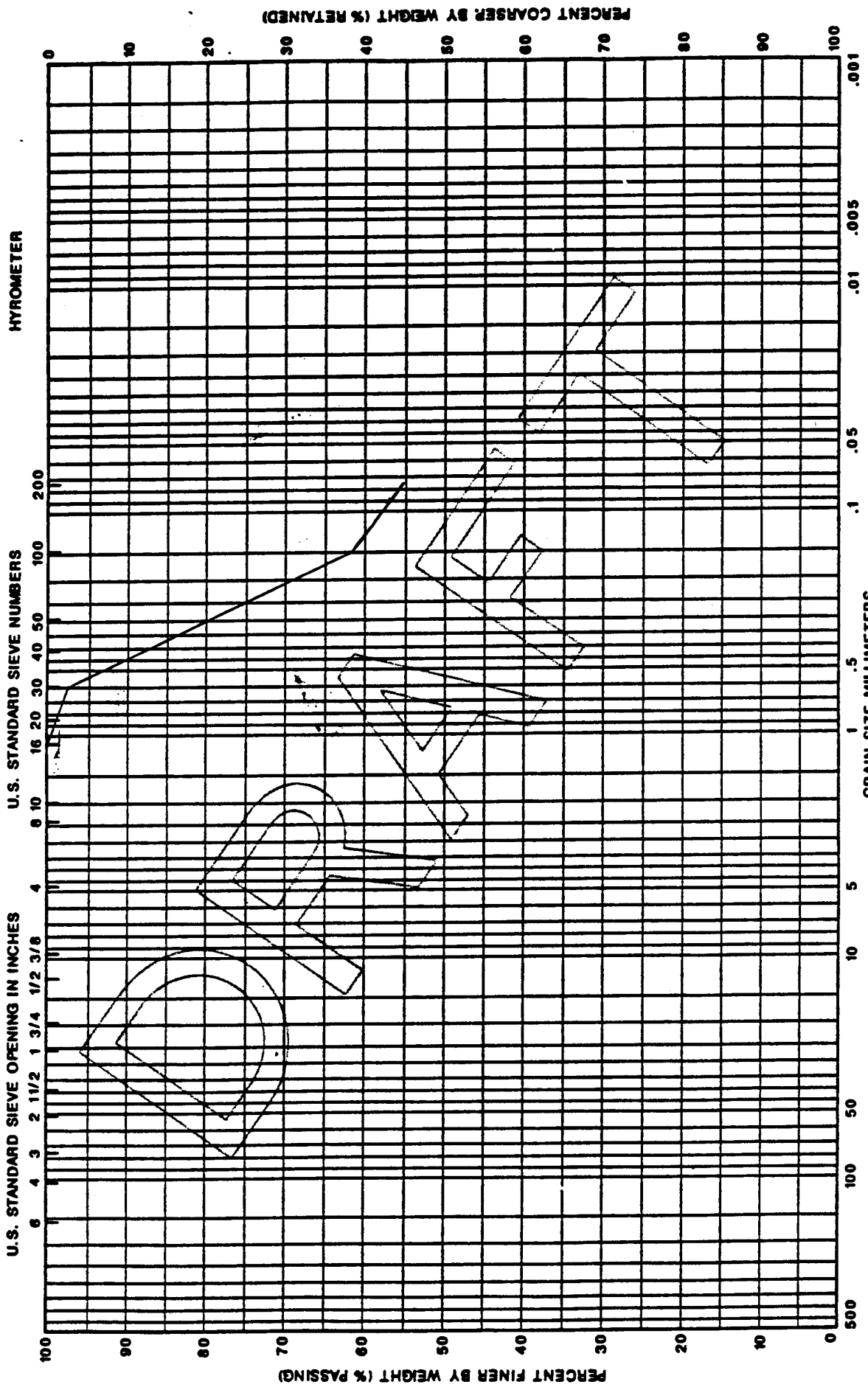
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COBBLES	GRAVEL		SAND			SILT OR CLAY		
	COARSE	FINE	COARSE	MEDIUM	FINE			

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
COEL SB-0017	15.0'-16.5'	SC	CLAYEY SAND	21.2	24	11	13

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HYROMETER

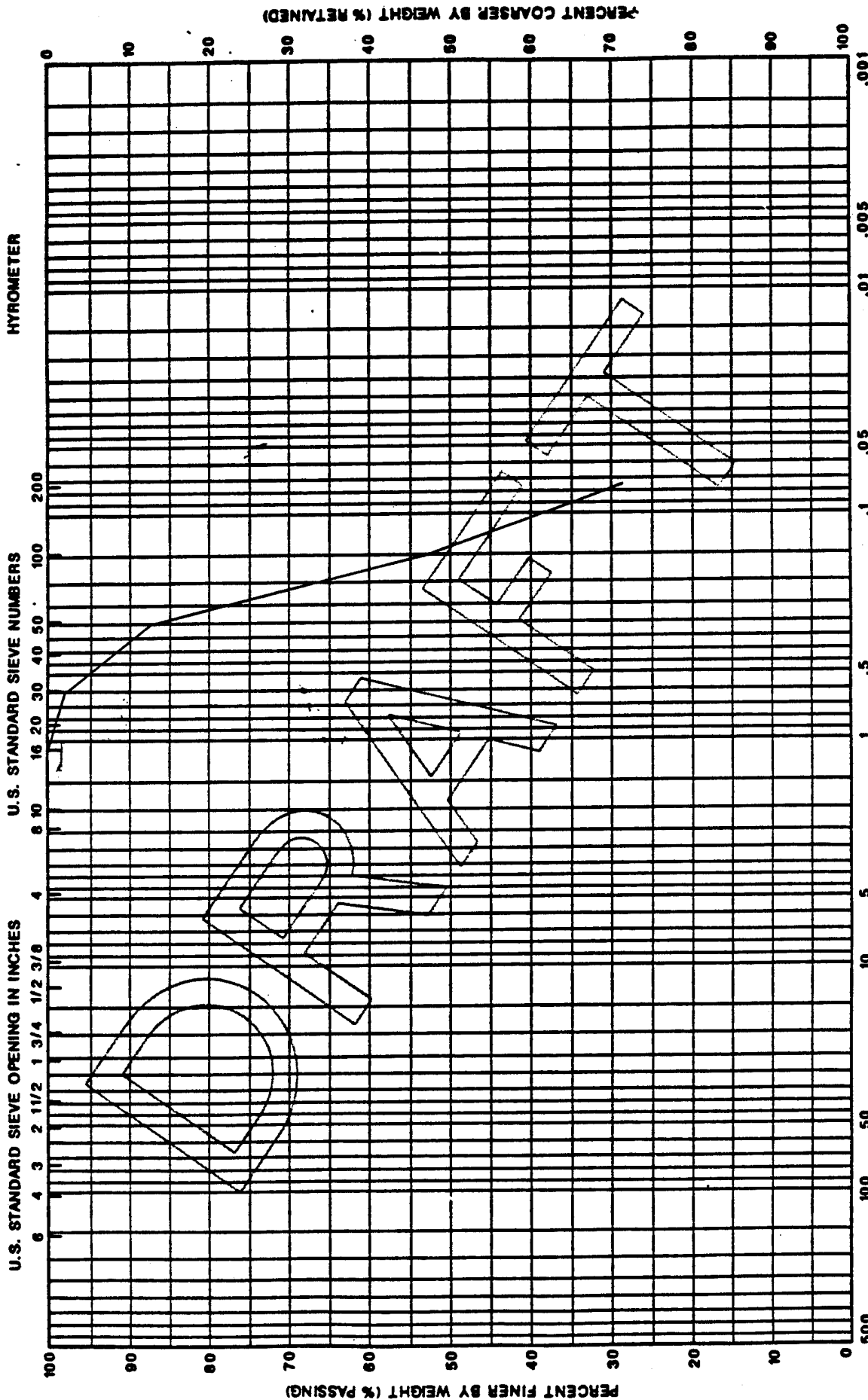
U.S. STANDARD SIEVE NUMBERS

U.S. STANDARD SIEVE OPENING IN INCHES

COBBLES		GRAVEL		SAND		SILT OR CLAY	
		COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
0017	20'-21.5'	CL	SANDY LEAN CLAY	1	38	13	25

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U.S. STANDARD SIEVE OPENING IN INCHES

U.S. STANDARD SIEVE NUMBERS

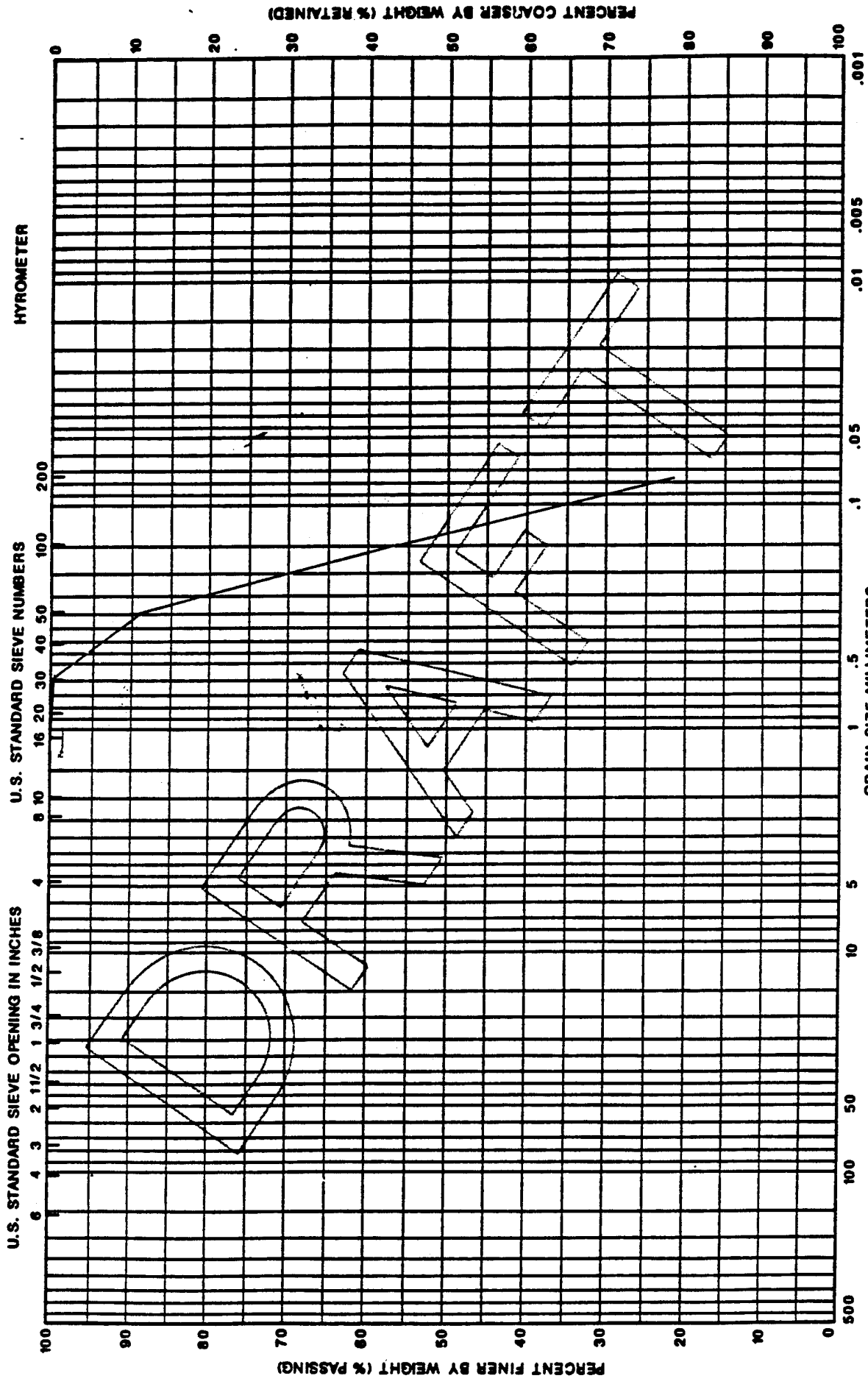
HYDROMETER

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

COEL	SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
	SB-0022	5'	SM	SILTY SAND	0.4	N.P.	N.P.	N.P.

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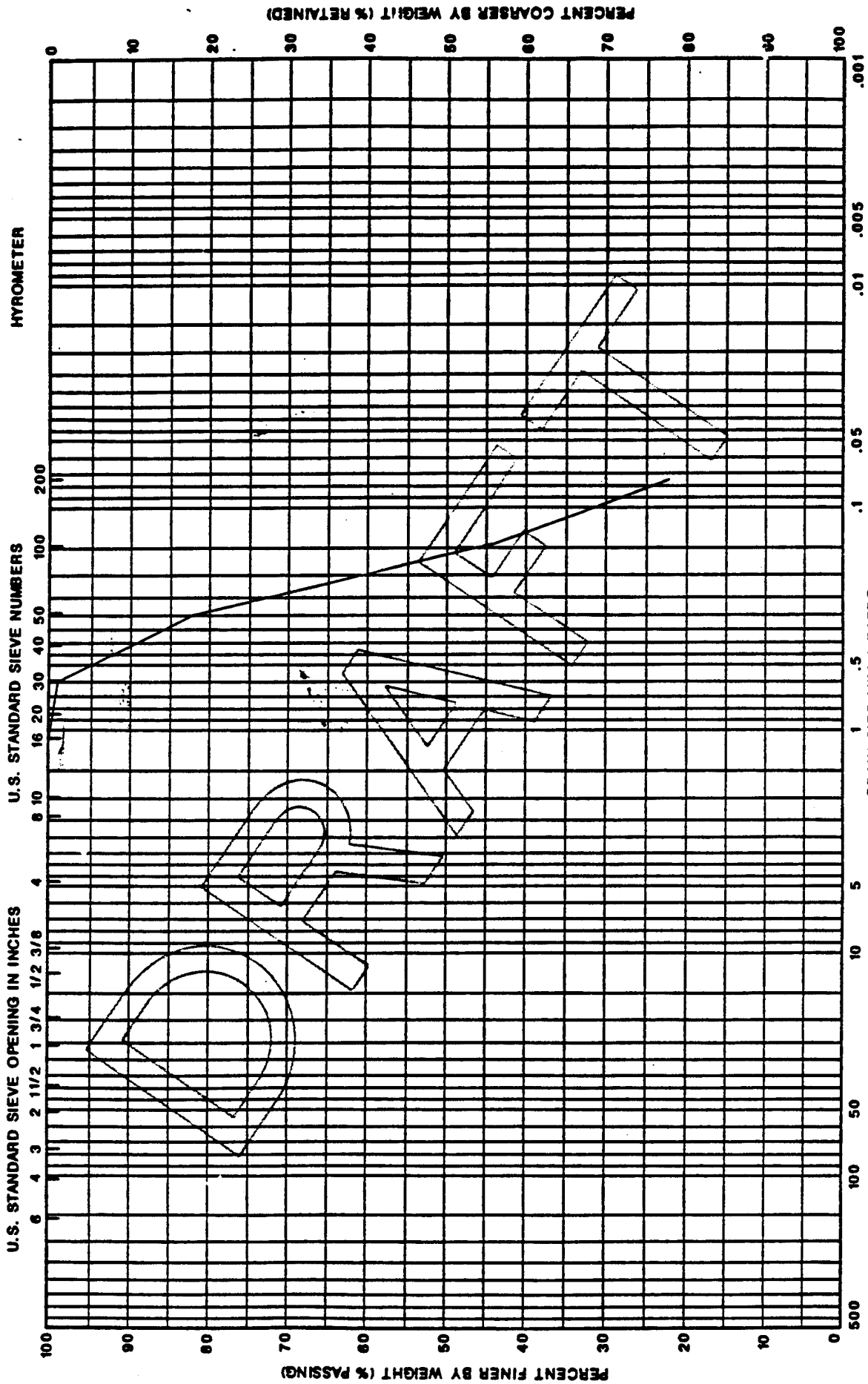
ROMC 114A



COBBLES	GRAVEL		SAND			SILT OR CLAY		
	COARSE	FINE	COARSE	MEDIUM	FINE			

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION			PI
			SM SILTY SAND	NAT W	LL	
0024	10'			5	N.P.	N.P.



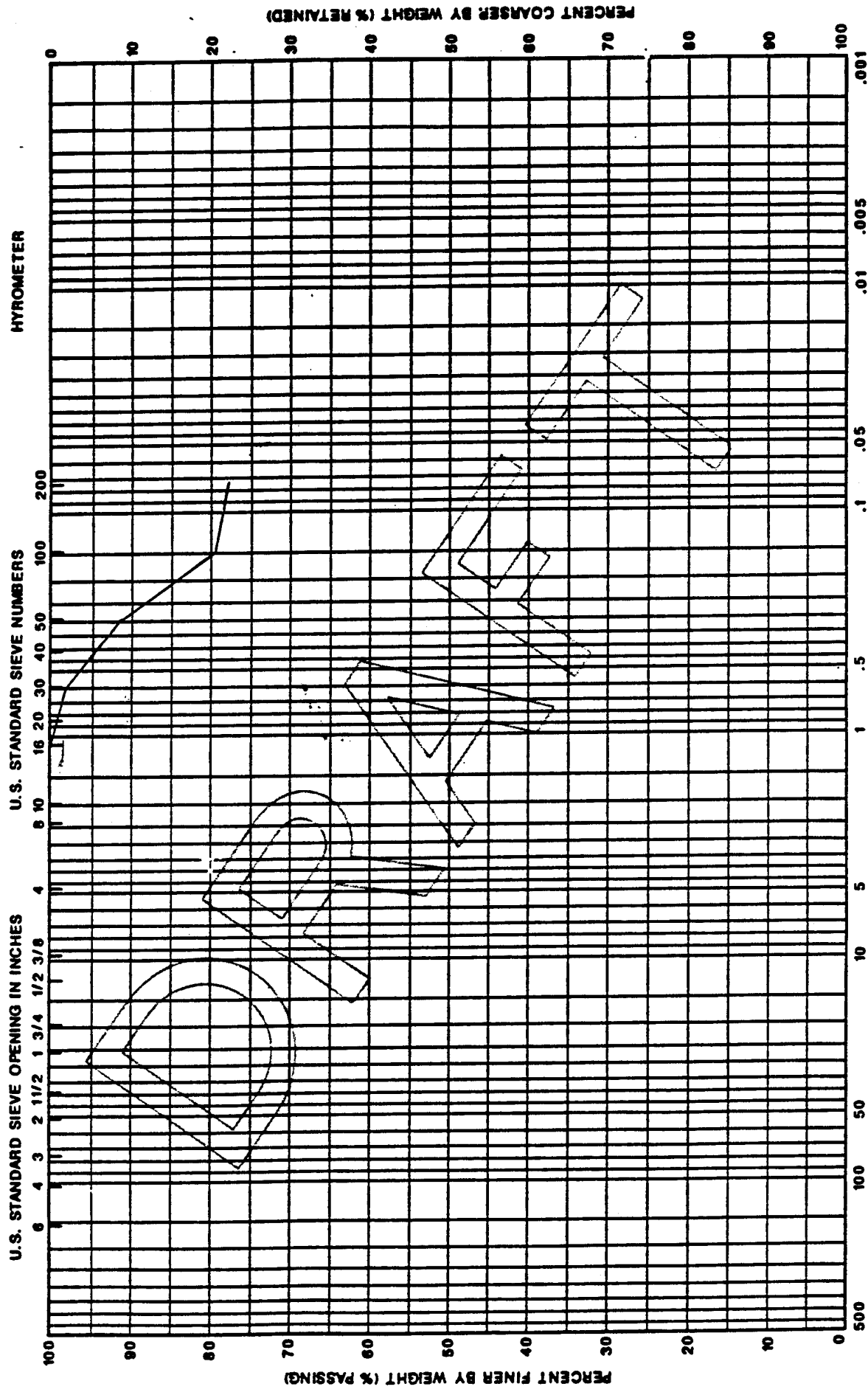


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

COEL	SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	P1
	SB-0024	20'	SM	SILTY SAND	16.3	N.P.	N.P.	N.P.

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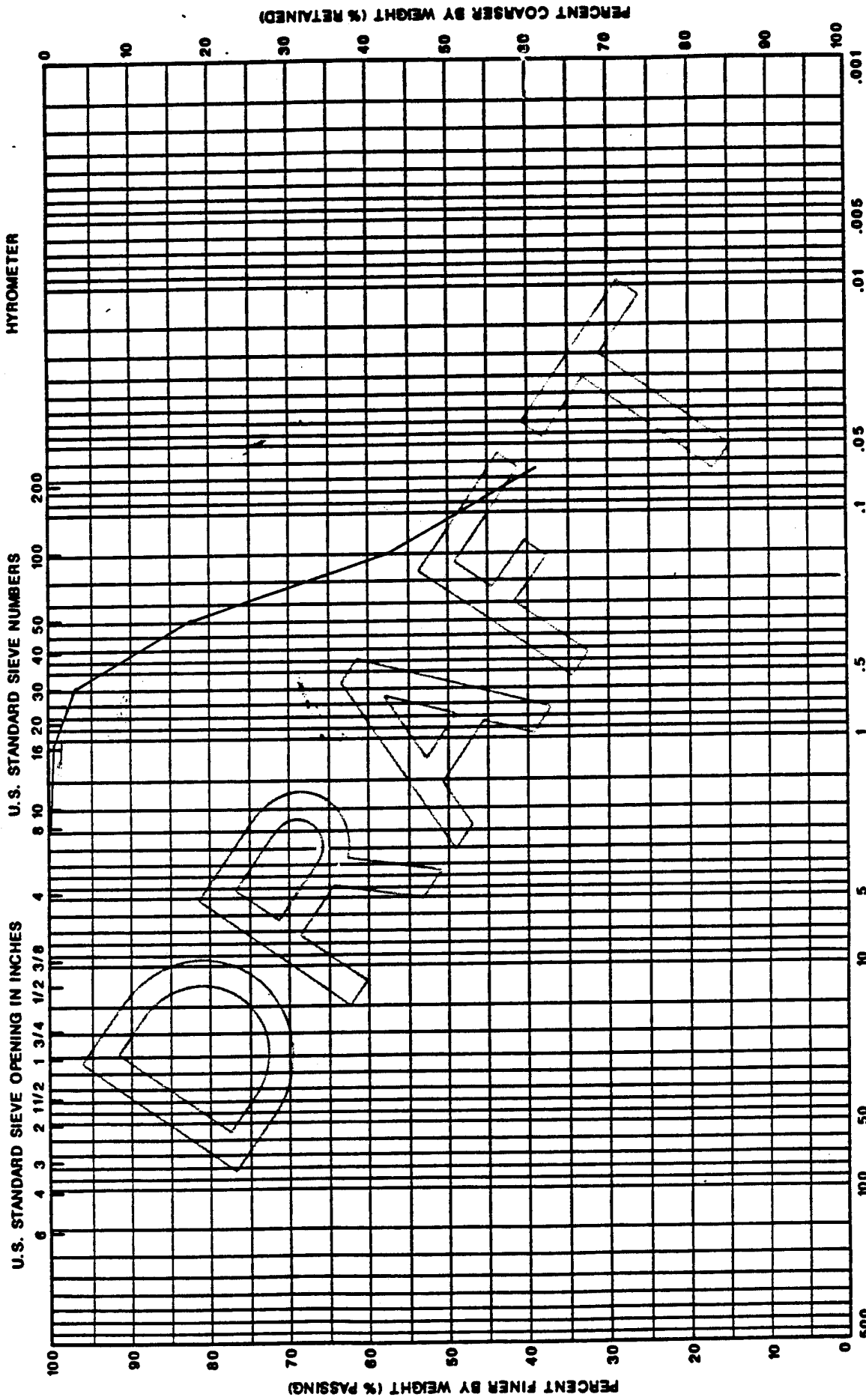
001011111



COBBLES		GRAVEL		SAND			SILT OR CLAY		
	COARSE	FINE	COARSE	MEDIUM	FINE				

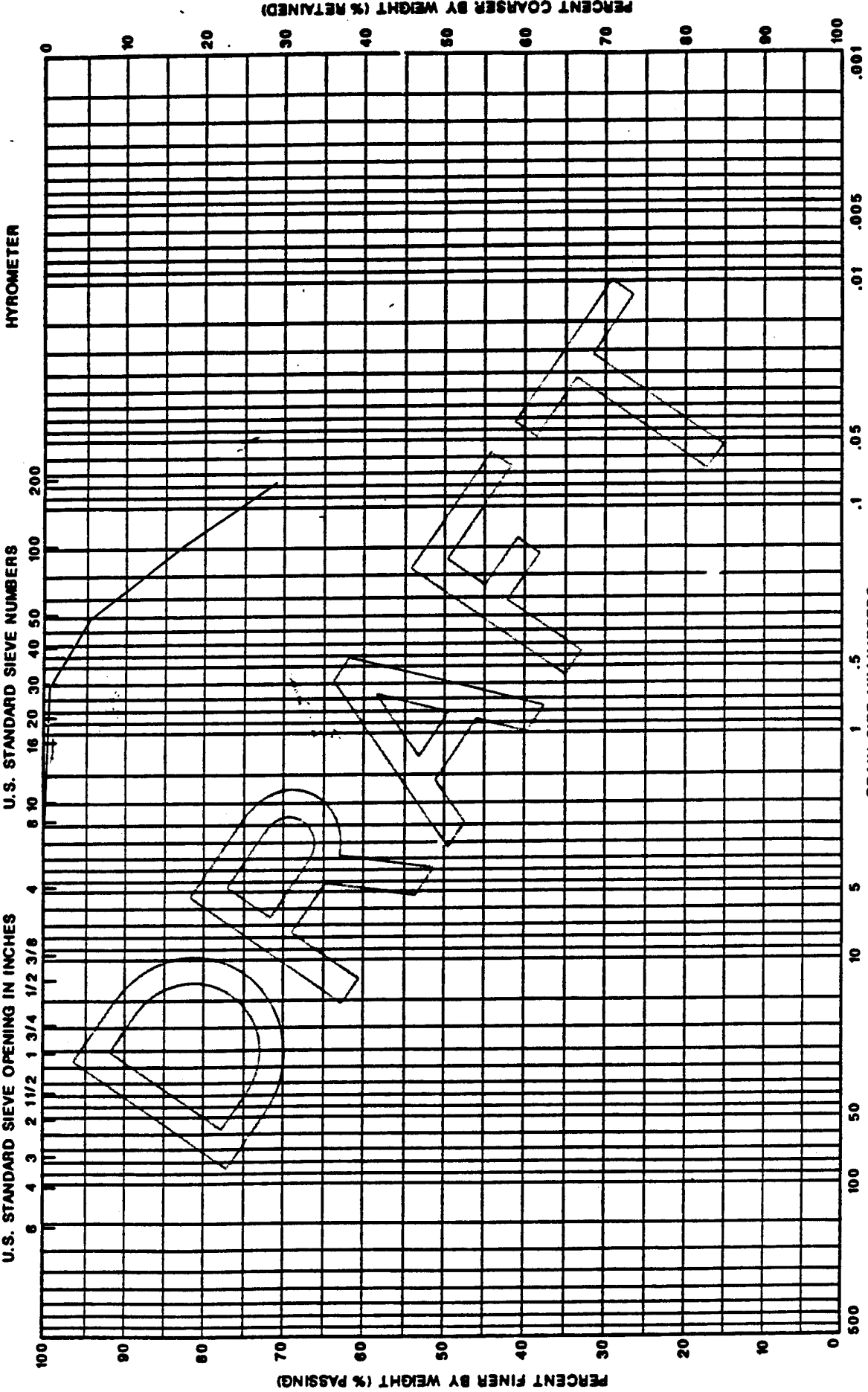
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
0025	2.5'-4.0'	ML	SILT		N.P.	N.P.	N.P.





COBBLES		GRAVEL		SAND			SILT OR CLAY	
		COARSE	FINE	COARSE	MEDIUM	FINE		
SAMPLE NO.	ELEV. OR DEPTH	SYM.			CLASSIFICATION			
SB-0025	10'	SC-SM		SILTY, CLAYEY SAND	NAT W	LL	PL	PI
					20.1	23	7	16

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COBBLES	GRAVEL		SAND		SILT OR CLAY	
	COARSE	FINE	MEDIUM	FINE		

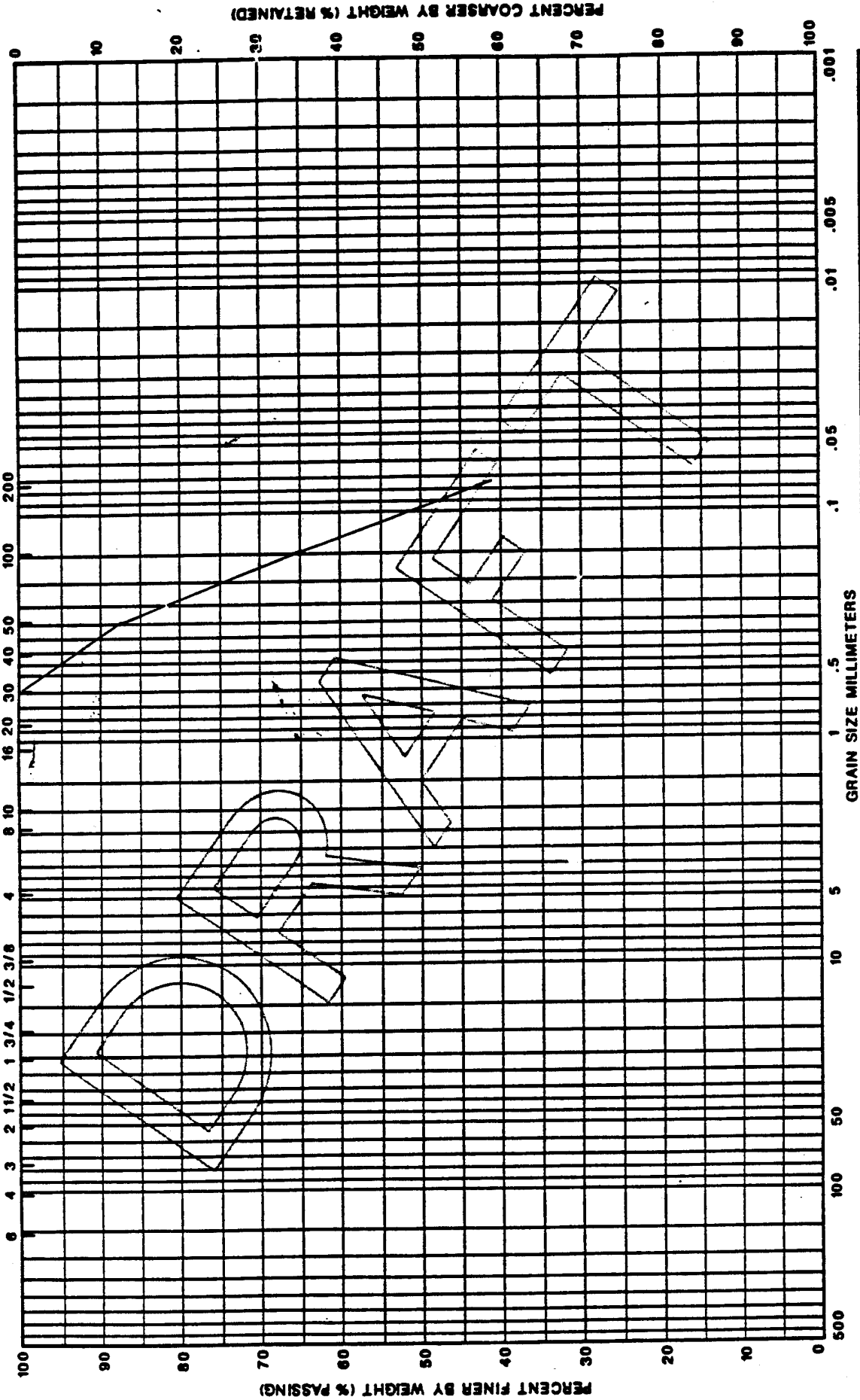
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION		NAT W	LL	PL	P1
B-0025	20'	CL	LEAN CLAY WITH SAND		2	39	18	21

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HYGROMETER

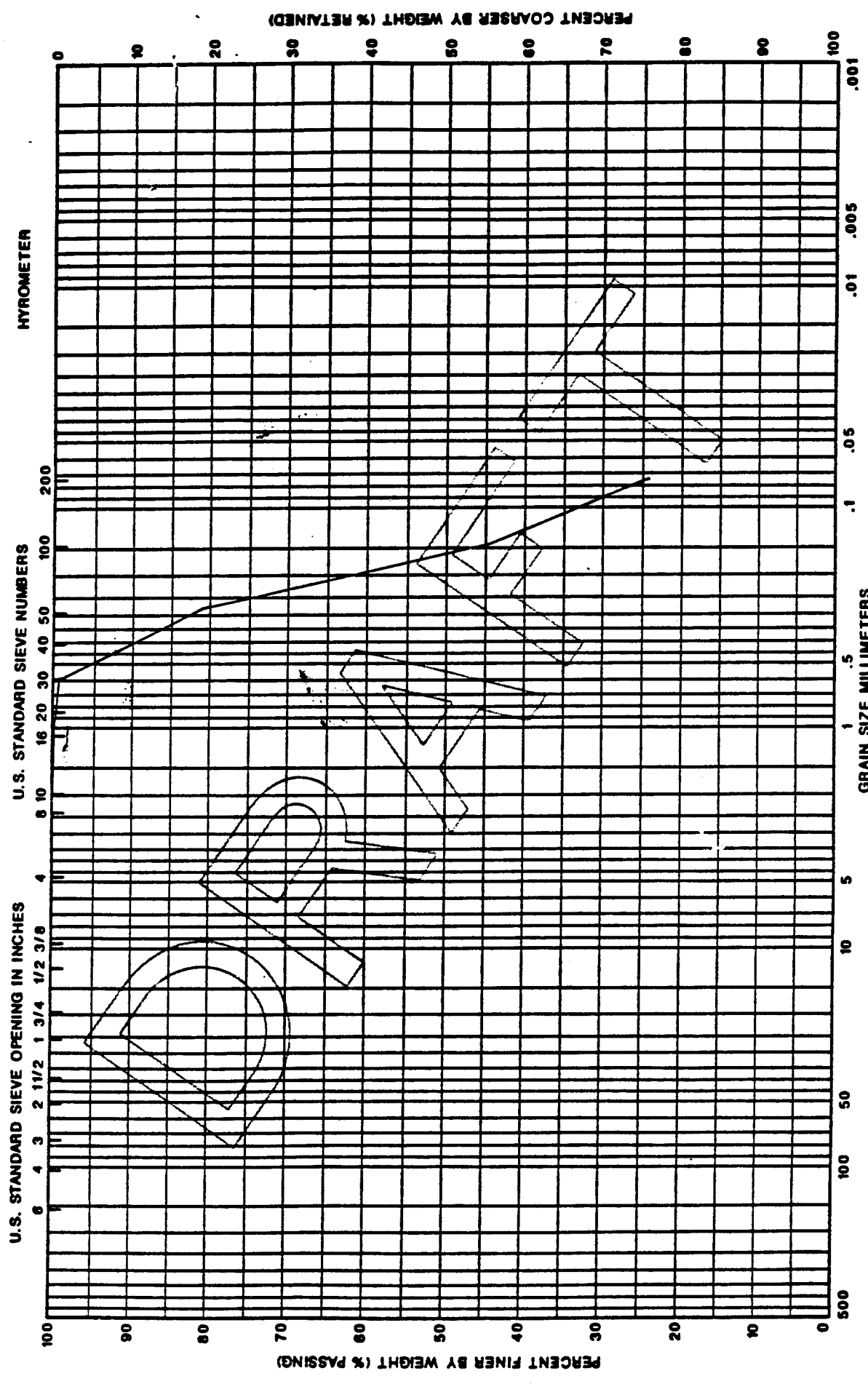
U.S. STANDARD SIEVE NUMBERS

U.S. STANDARD SIEVE OPENING IN INCHES



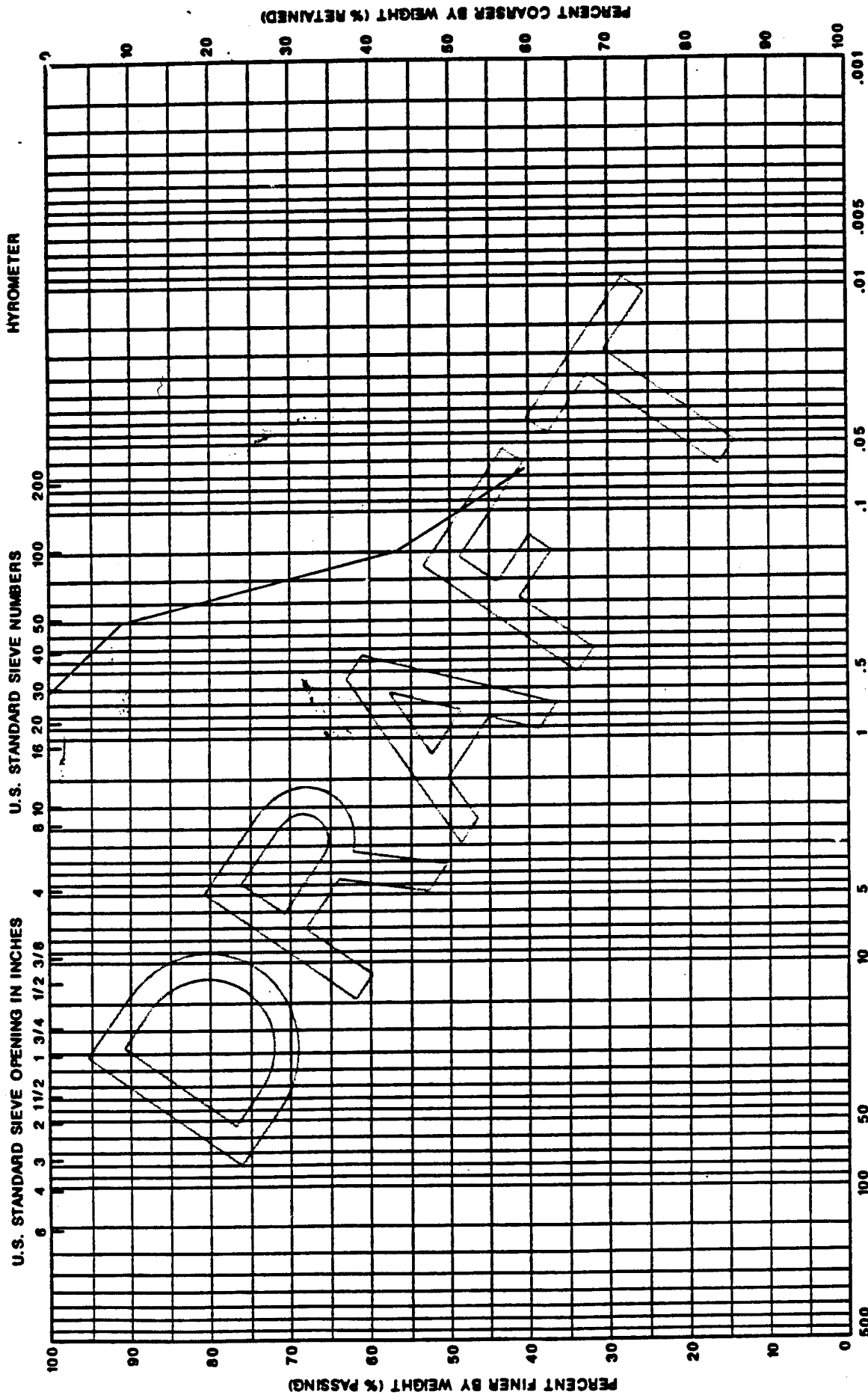
COBBLES	GRAVEL		SAND			SILT OR CLAY			
	COARSE	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	
SAMPLE NO.	ELEV. OR DEPTH		SYM.			CLASSIFICATION			
SB-0026	5'		SM	SILTY SAND			NAT W	5.8	5.8
COEL						LL	N.P.	N.P.	
						PL	N.P.	N.P.	
						PI	N.P.	N.P.	

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COBBLES		GRAVEL		SAND			SILT OR CLAY		
COARSE		FINE		COARSE		MEDIUM	FINE		
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION			NAT W	LL	PL	PI
0028	7.5'	SM	SILTY SAND			6	N.P.	N.P.	N.P.

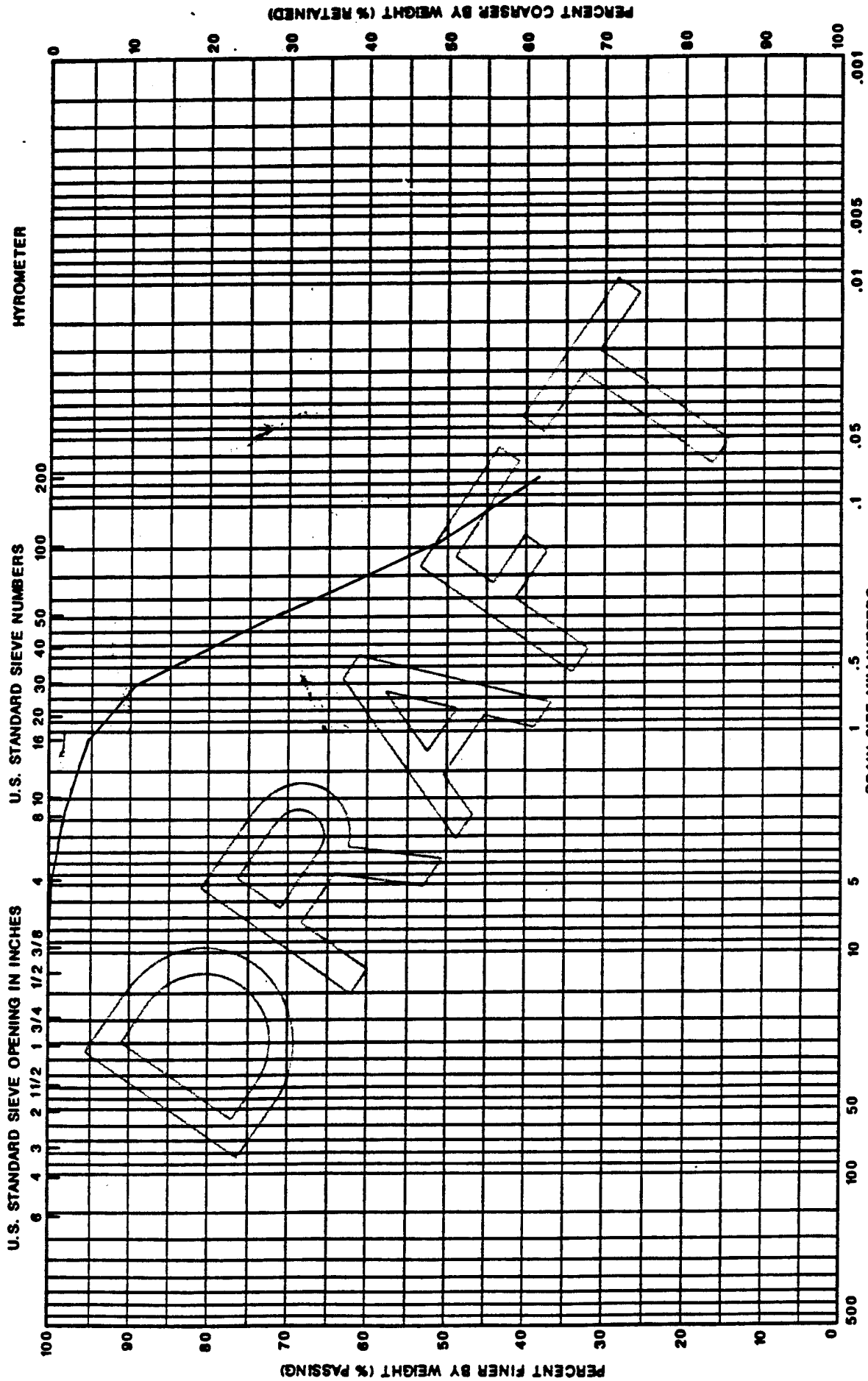
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COBBLES COARSE FINE GRAVEL FINE COARSE MEDIUM FINE SAND SILT OR CLAY

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION			PI	
			NAT W	LL	PL		
COEL SB-0029	7.5'	SC	CLAYEY SAND	19.5	25	11	13

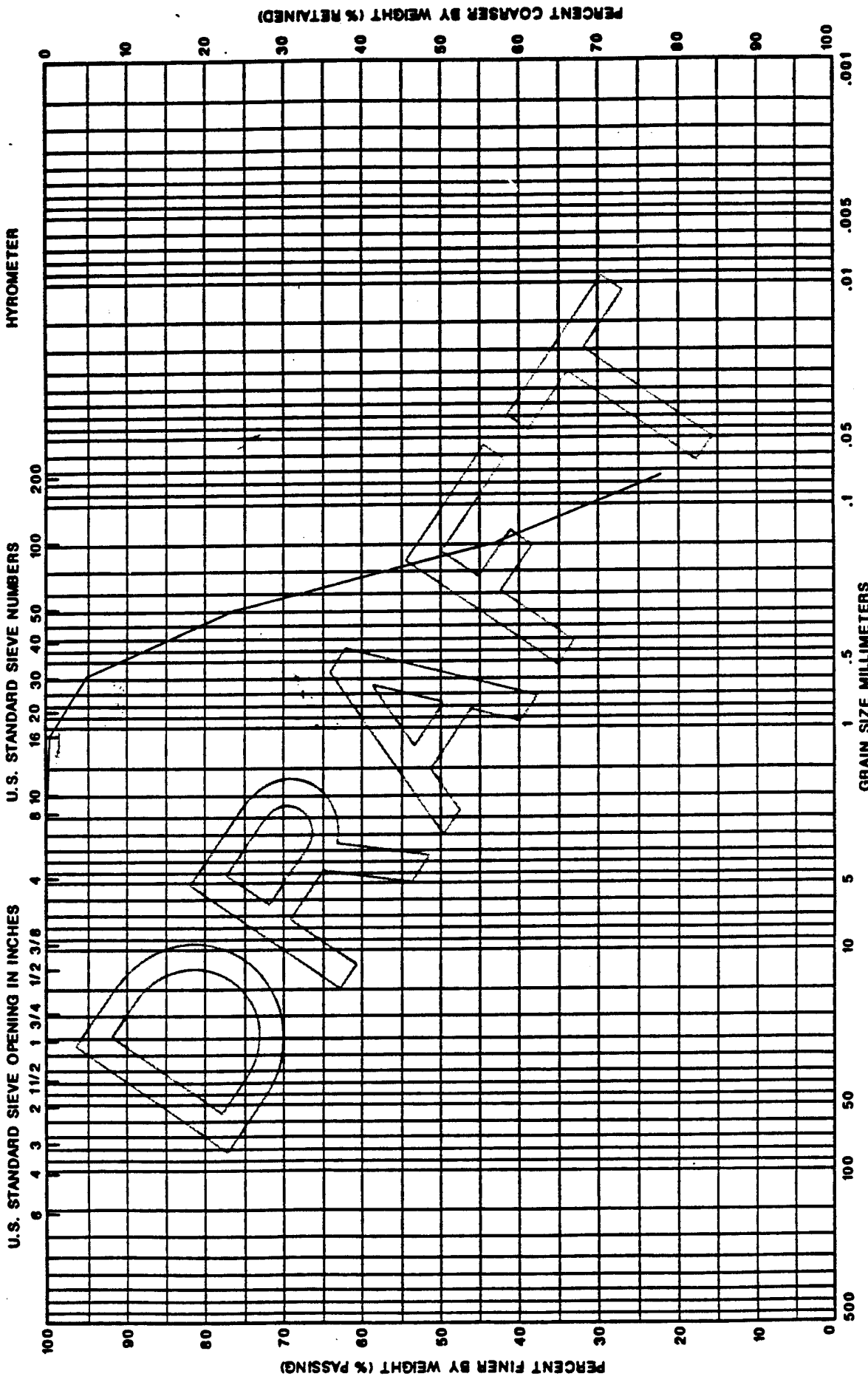
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COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE		FINE		MEDIUM		FINE	

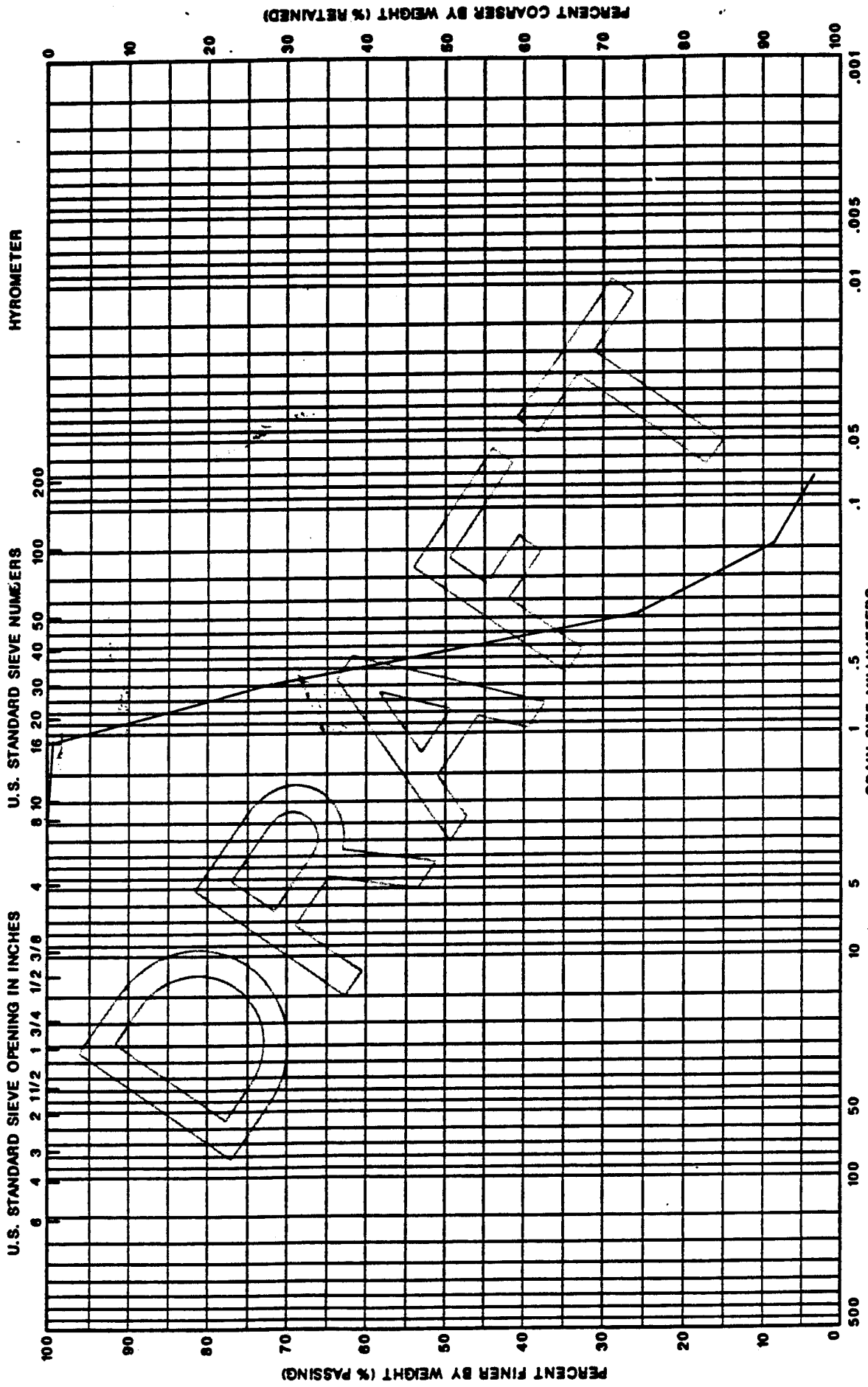
SAMPLE NO. B-0029	ELEV. OR DEPTH 20'	SYM. SC	CLASSIFICATION			
			CLAYEY SAND			
			NAT W	LL	PL	P1
			8	47	20	27

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COBBLES		GRAVEL		SAND		SILT OR CLAY			
		COARSE	FINE	COARSE	MEDIUM	FINE			
SAMPLE NO.	ELEV. OR DEPTH	SYM.		CLASSIFICATION		NAT W	LL	PL	PI
SB-0031	2.5'	CL-MI		SILTY CLAY WITH SAND		8.0	22	15	7

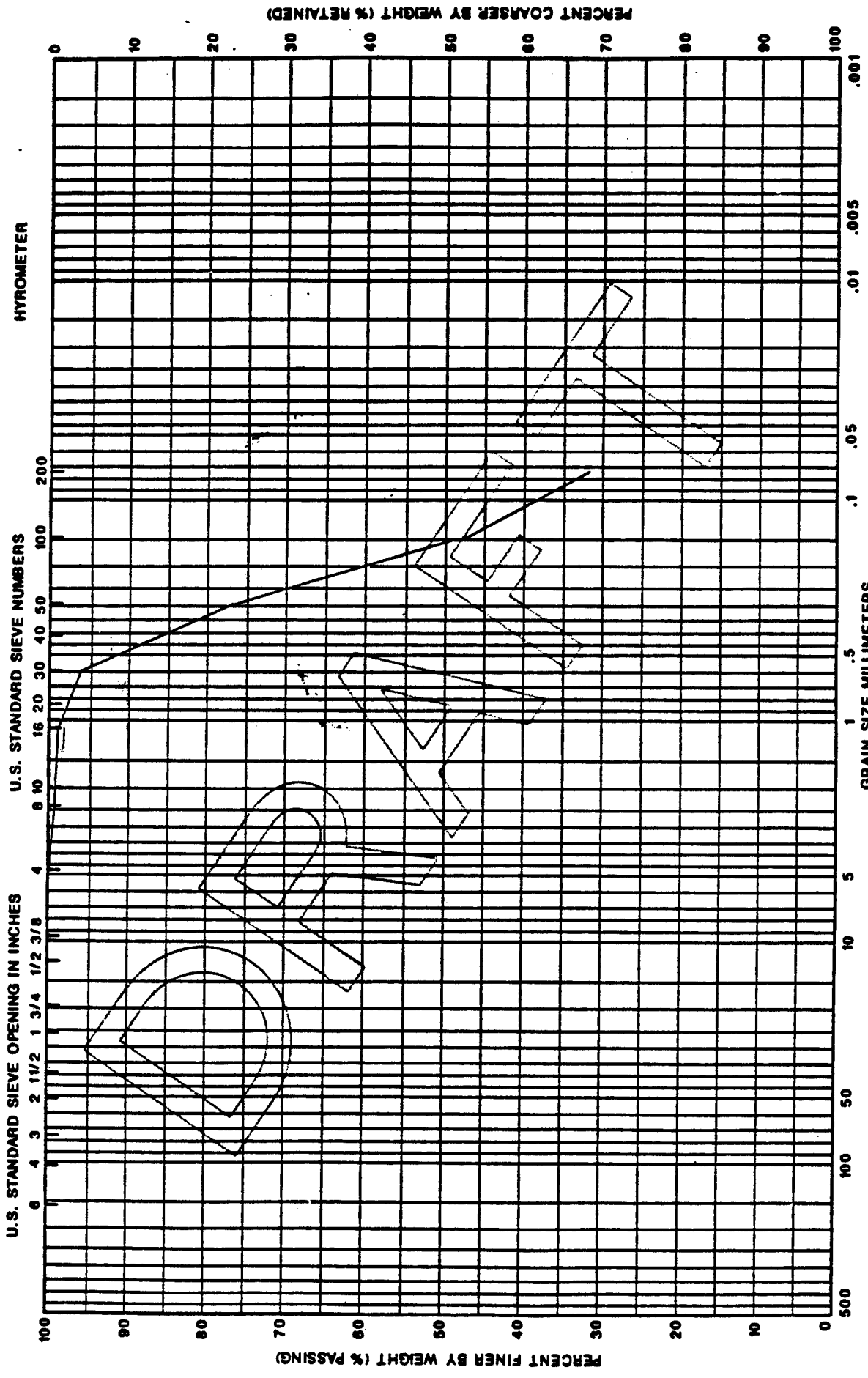
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COBBLES		GRAVEL		SAND			SILT OR CLAY	
		COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
0-0033	2.5'	SP	POORLY GRADED SAND	6	N.P.	N.P.	N.P.

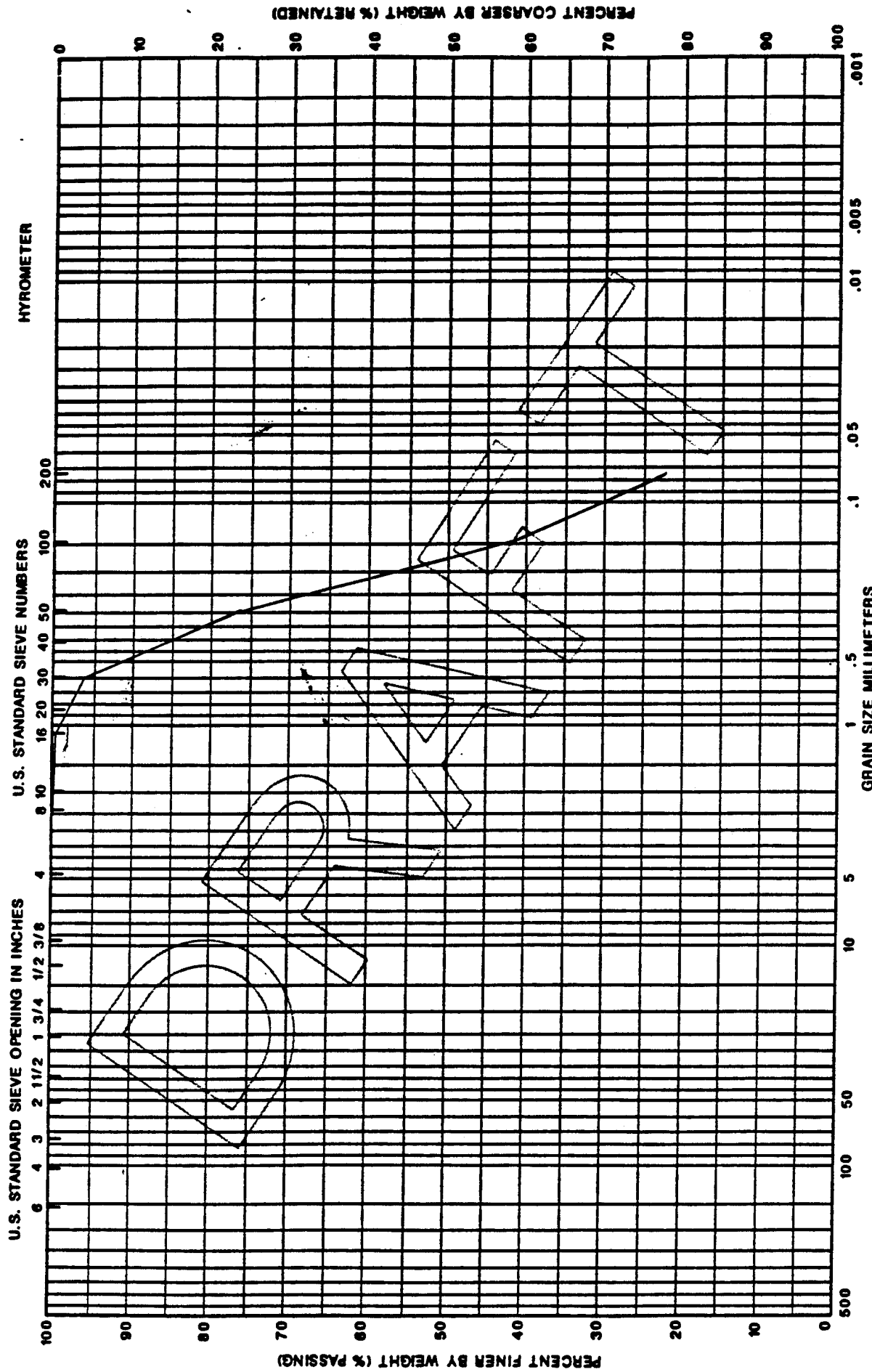
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COBBLES COARSE FINE GRAVEL FINE COARSE MEDIUM FINE SAND FINE SILT OR CLAY

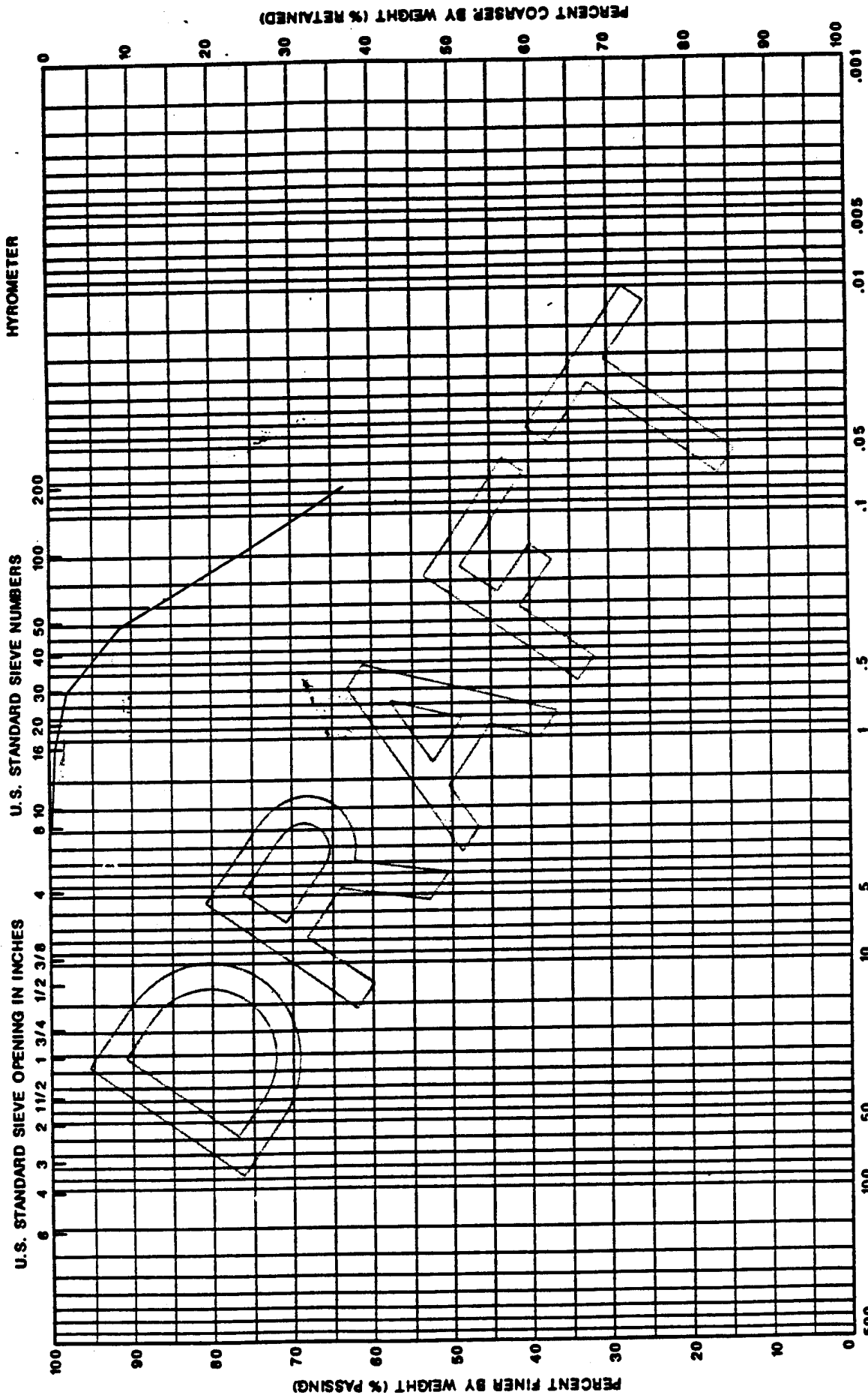
COEL SB-0034	ELEV. OR DEPTH 2.5'	SYM. SM	CLASSIFICATION SILTY SAND	NAT W	LL N.P.	PL N.P.	PI N.P.
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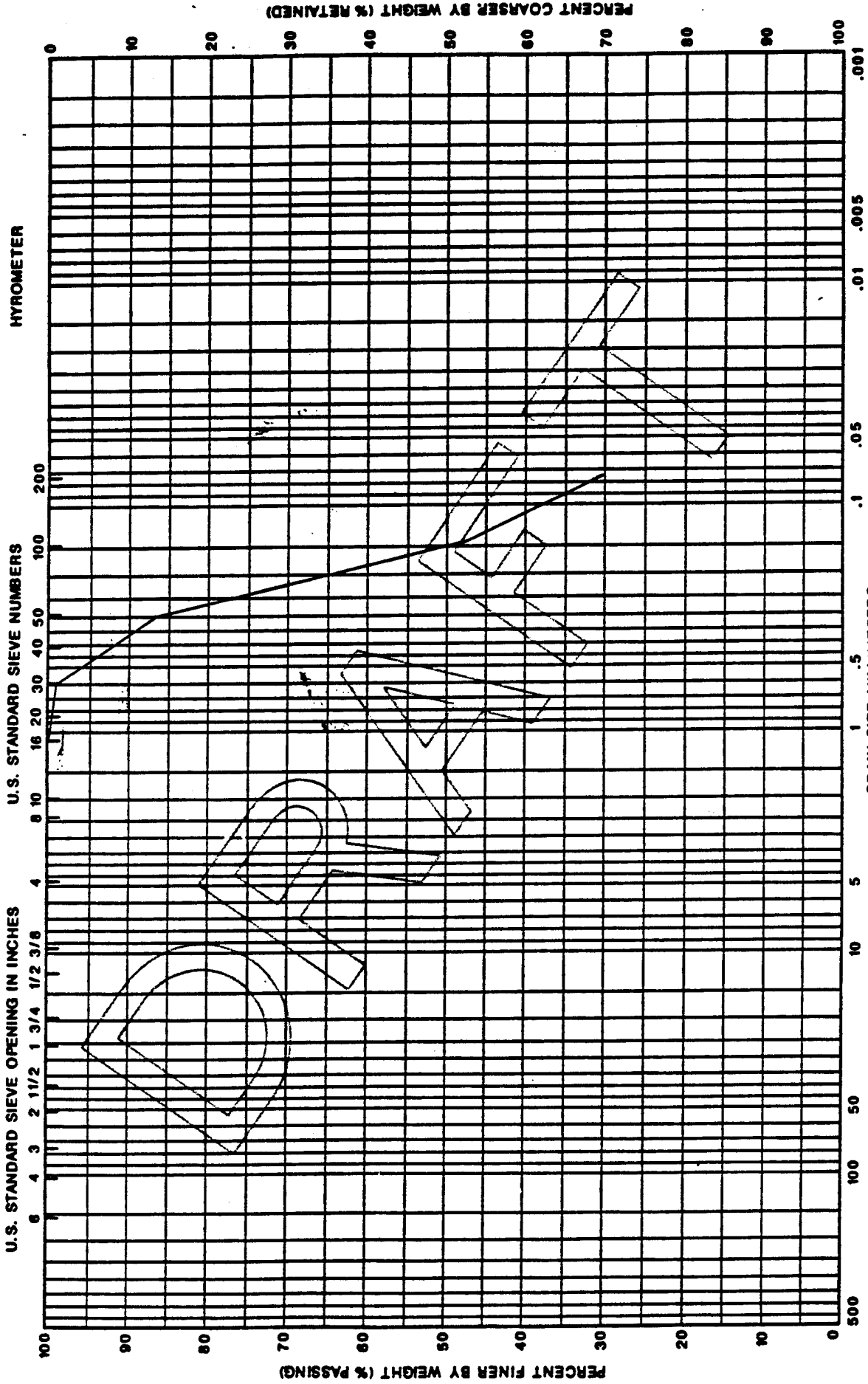
COFF	SAMPLE NO.	0034	SYM.	SM	CLASSIFICATION	SAND			PI
	ELEV. OR DEPTH	7.5'				COARSE	MEDIUM	FINE	
					SILTY SAND	NAT W	LL	N.P.	N.P.





COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE		FINE		MEDIUM		FINE	
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
SB-0034	15'	CL	SANDY LEAN CLAY		31	17	14
COEL							

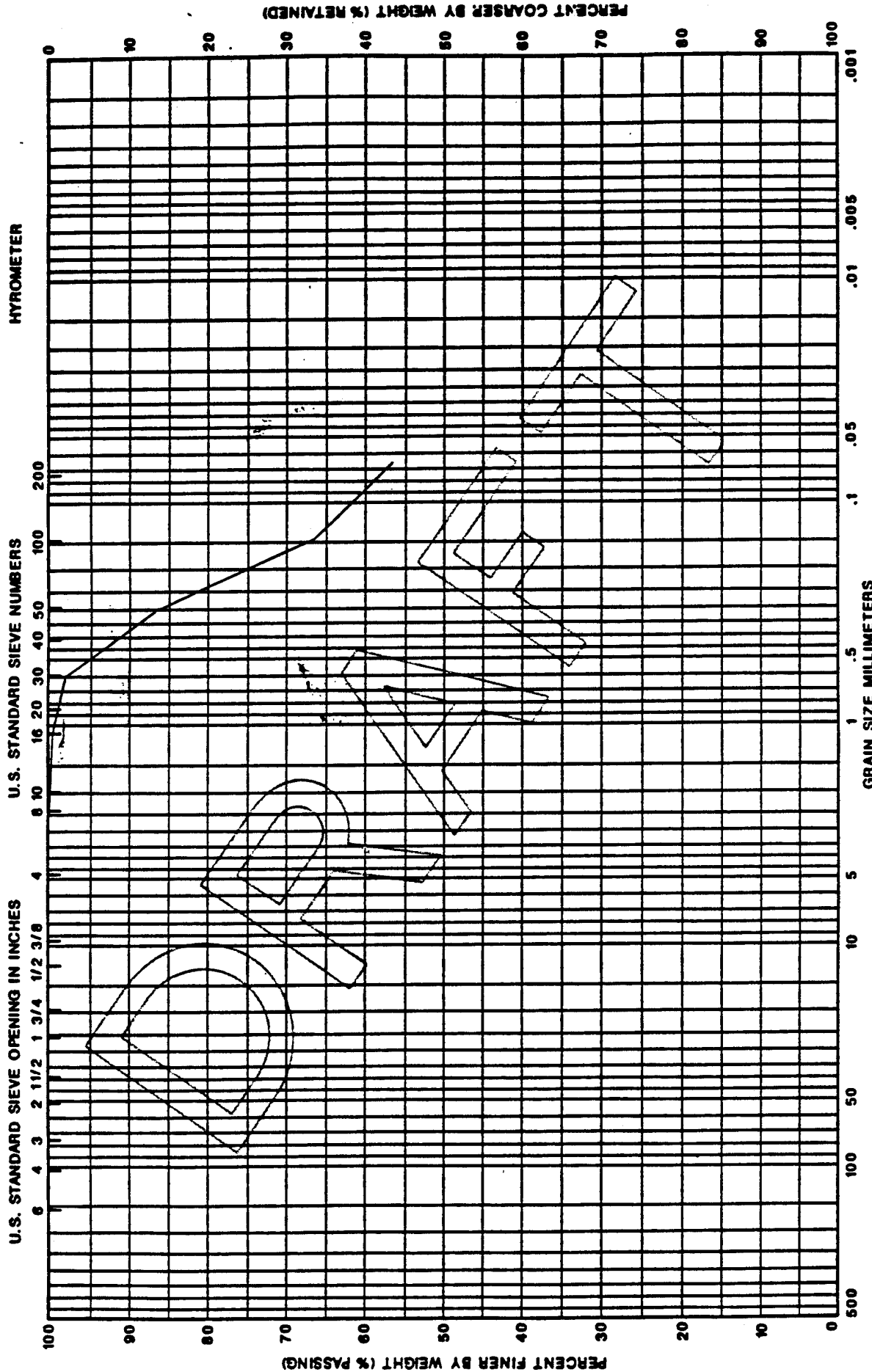
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COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE		FINE		COARSE		FINE	

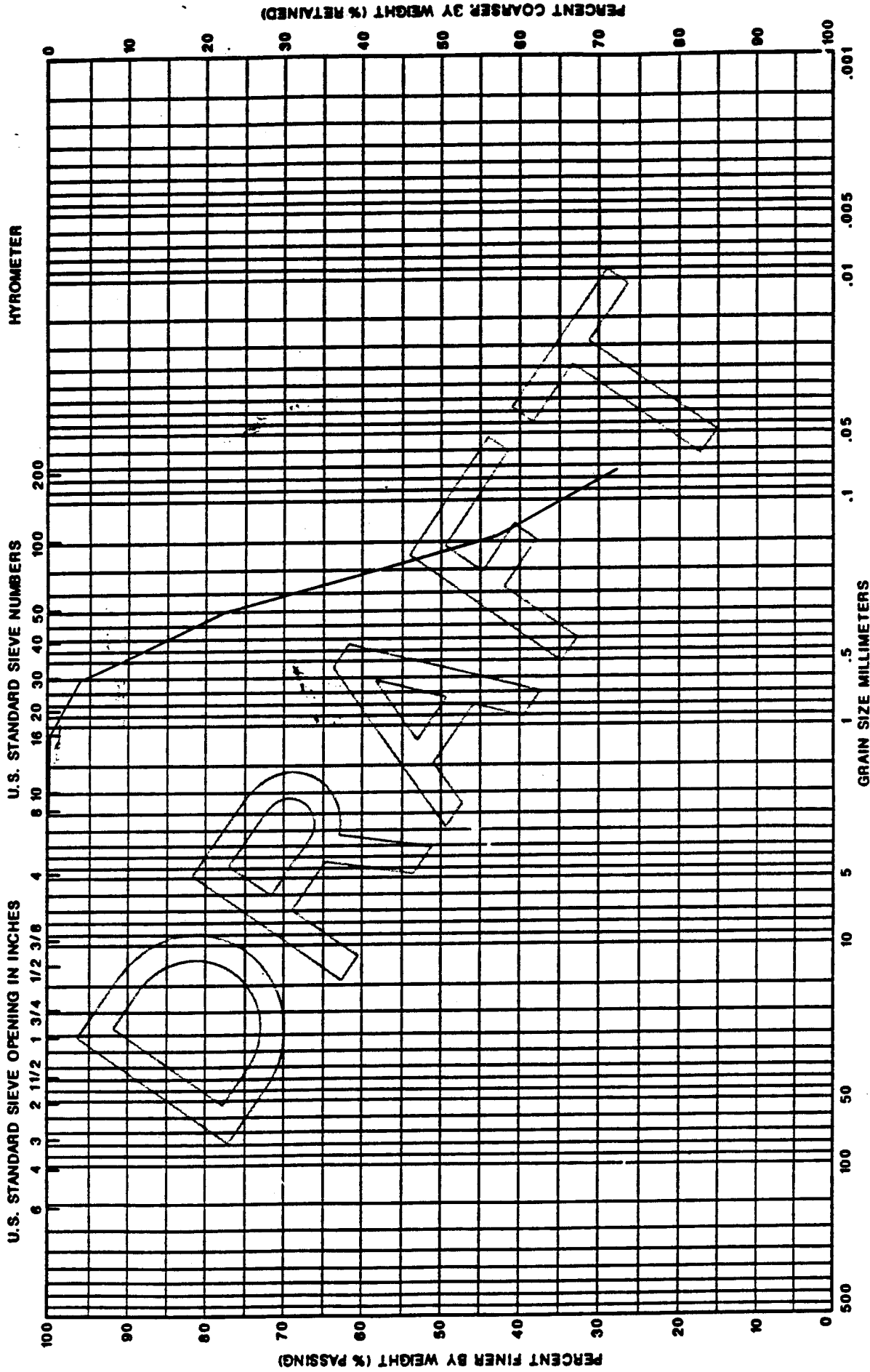
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION			PI
			NAT W	LL	PL	
0034	20'	SM	SILTY SAND	N.P.	N.P.	N.P.

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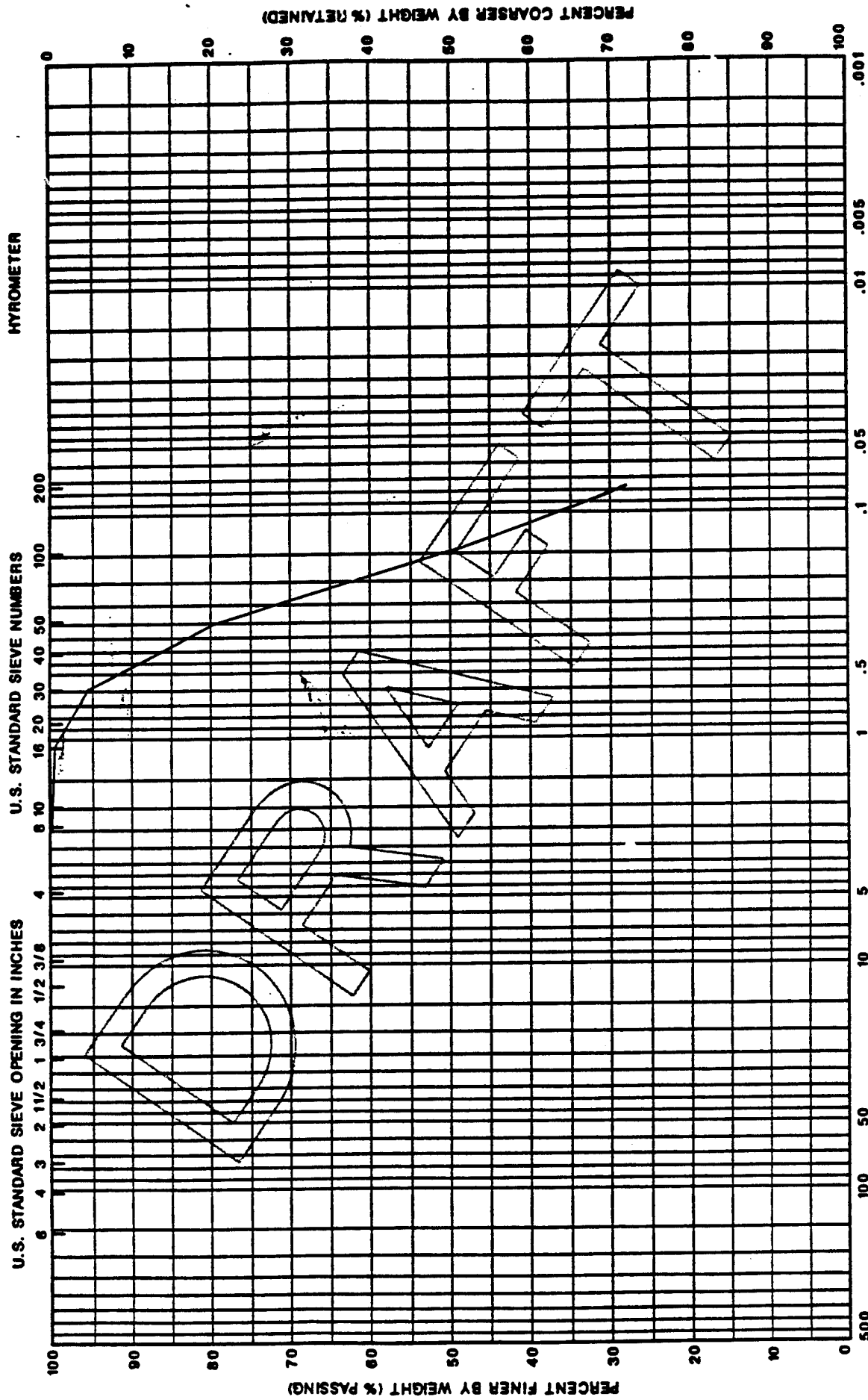


COEL	SB-0034	ELEV. OR DEPTH 25'	SYM. CL	CLASSIFICATION SANDY LEAN CLAY	NAT W	LL	PL	P1
						46	19	27

Woodward-Clyde Consultants
89MC114A

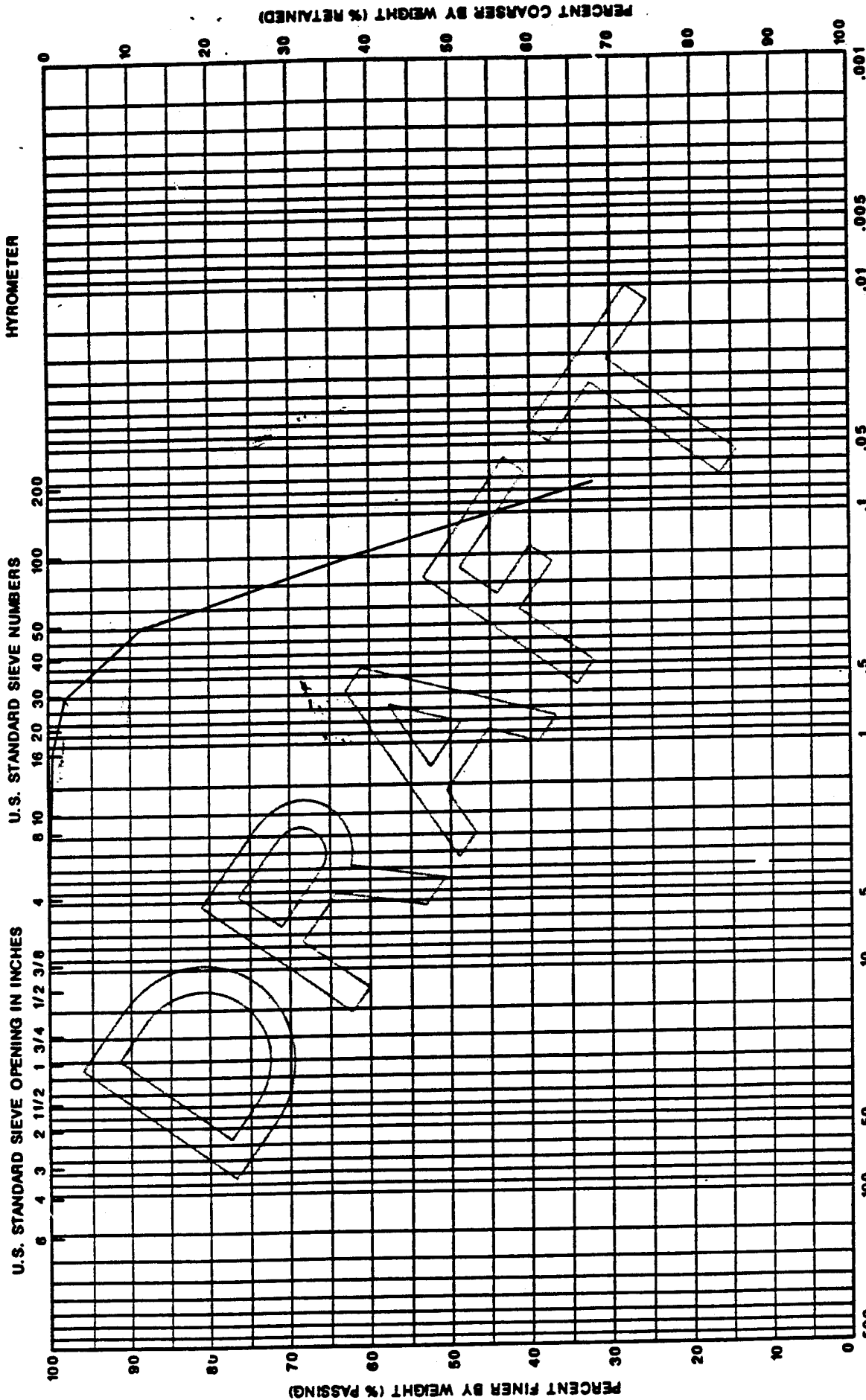


SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION			PI
			LEAN CLAY WITH SAND	NAT W	LL	
-0035	2.5'	CL		26	18	8



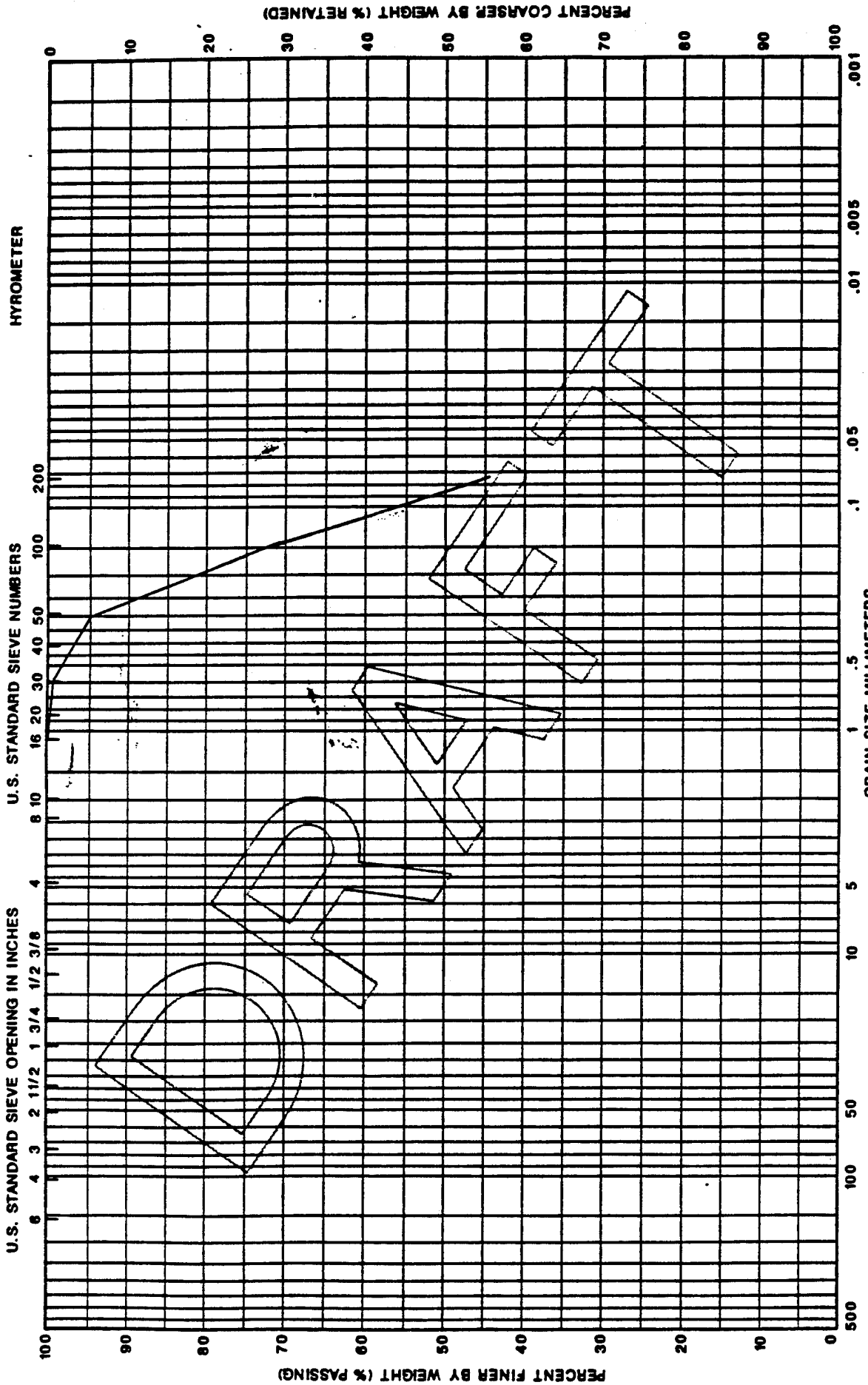
COBBLES		GRAVEL		SAND			SILT OR CLAY		
COARSE		FINE		COARSE	MEDIUM	FINE			
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI		
SB-0035	7'	SM	SILTY SAND		N.P.	N.P.	N.P.		

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89MC114A



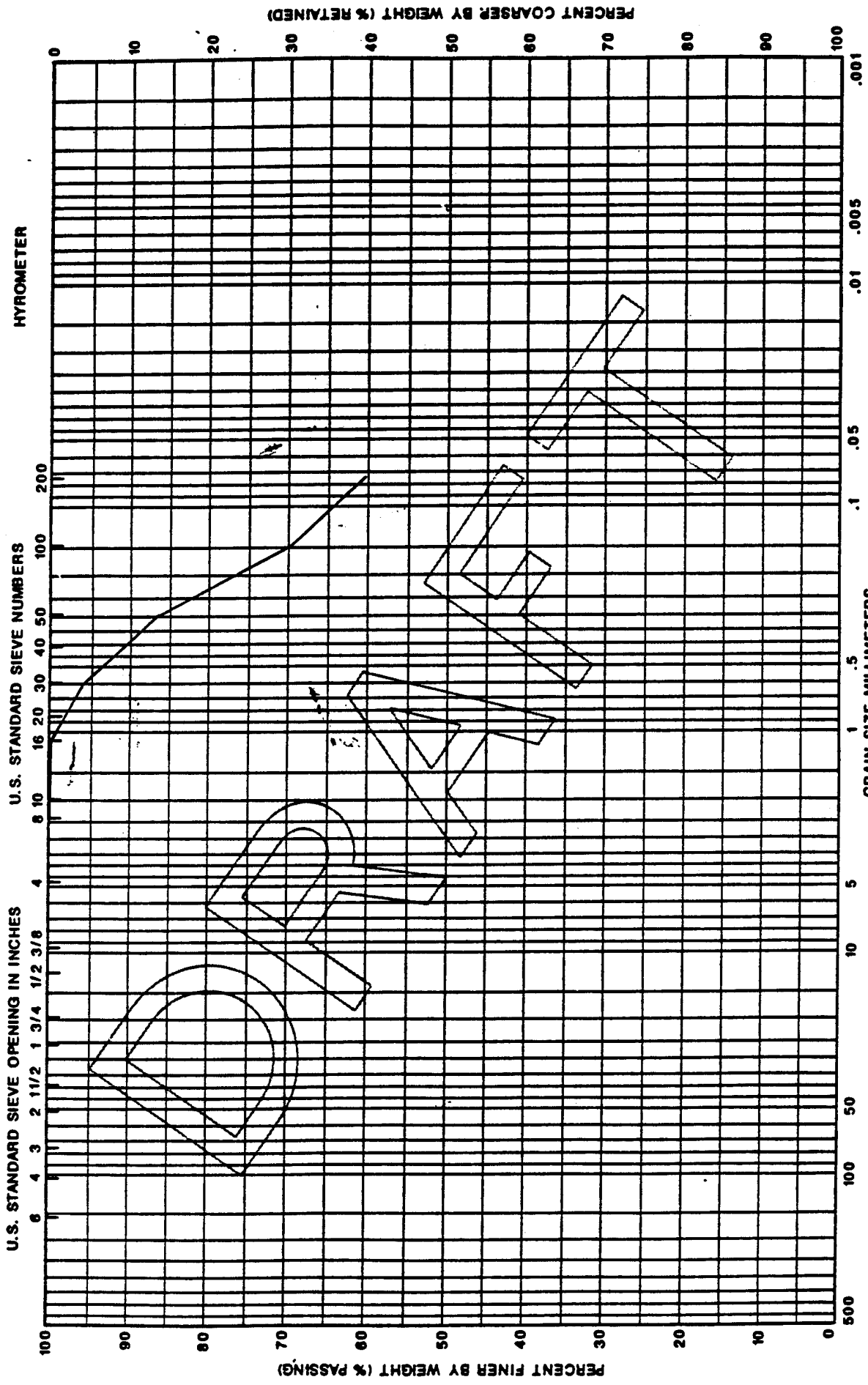
COBBLES COARSE FINE SAND MEDIUM FINE SILT OR CLAY

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	P1
B-0035	14'	SM	SILTY SAND		N.P.	N.P.	N.P.



COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE	FINE	COARSE	MEDIUM	FINE			
SAMPLE NO.		CLASSIFICATION		NAT W	LL	PL	P1
SB-0035		SM SILTY SAND			N.P.	N.P.	N.P.
ELEV. OR DEPTH		SYM.					
19'		SM					
COEL							

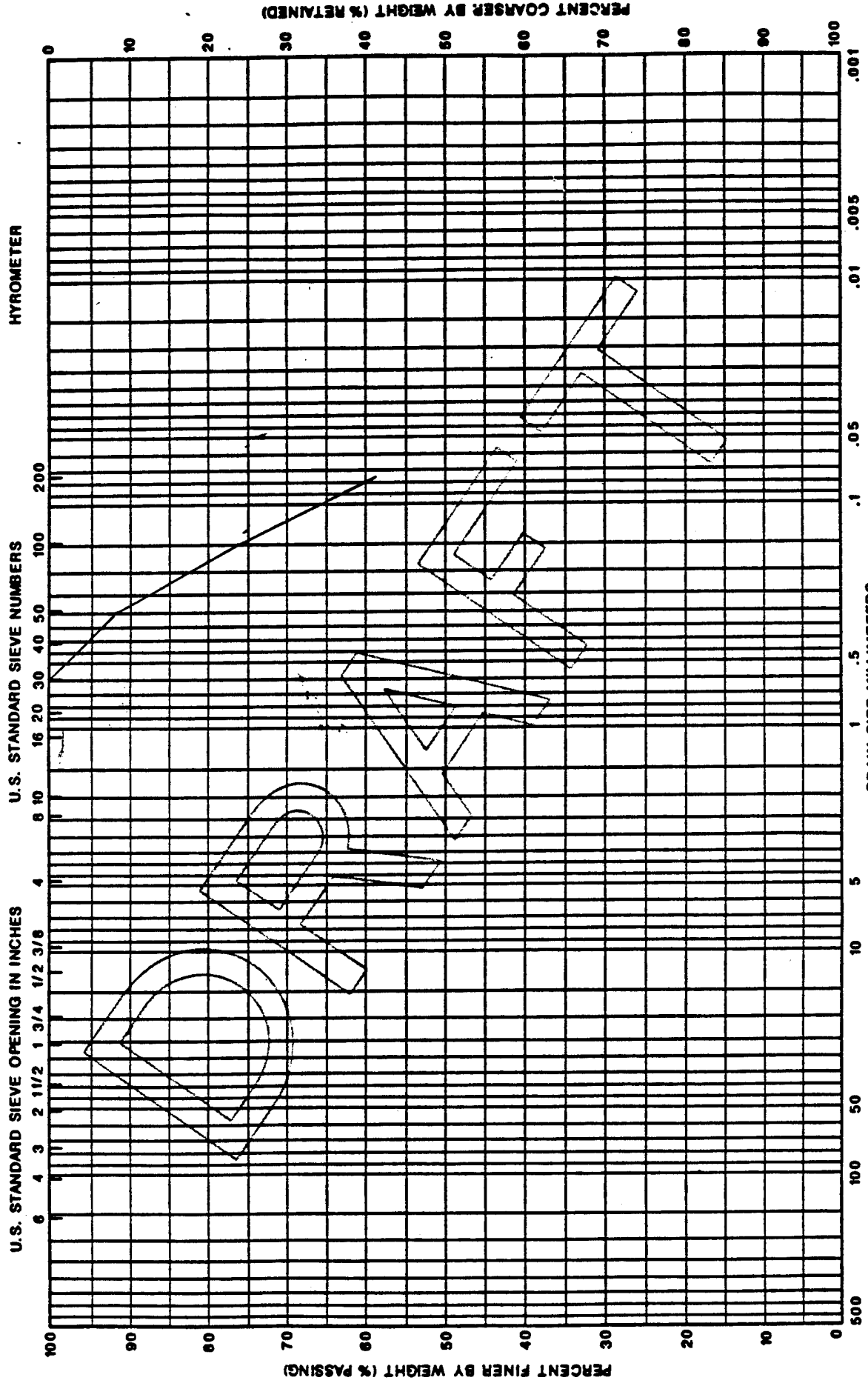
Woodward-Clyde Consultants
89MC114A

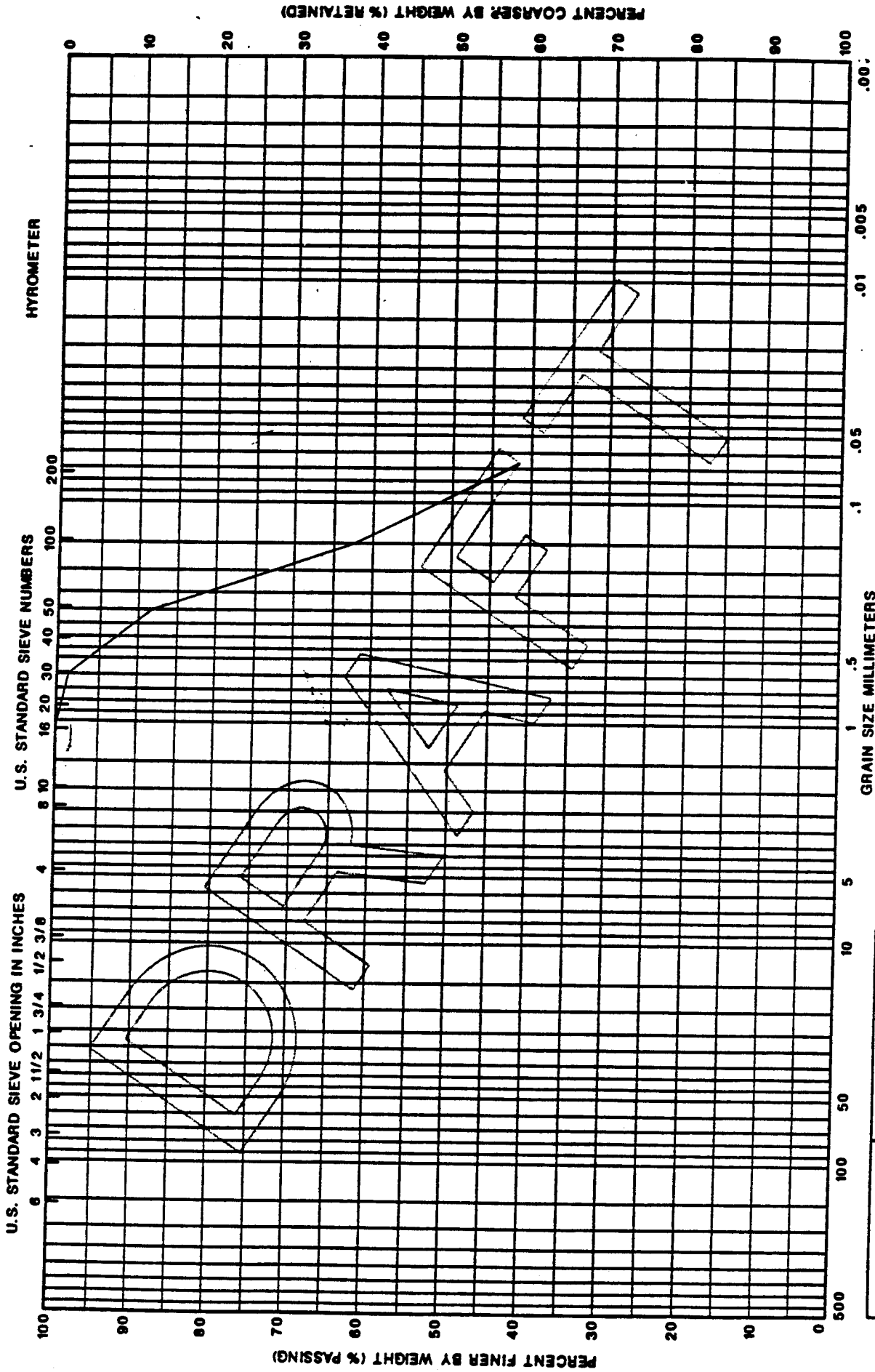


COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE		FINE		MEDIUM		FINE	

SAMPLE NO. CB-0035	ELEV. OR DEPTH 24'	SYM. CH	CLASSIFICATION		NAT W	LL	PL	PI
			SANDY FAT CLAY			50	23	27

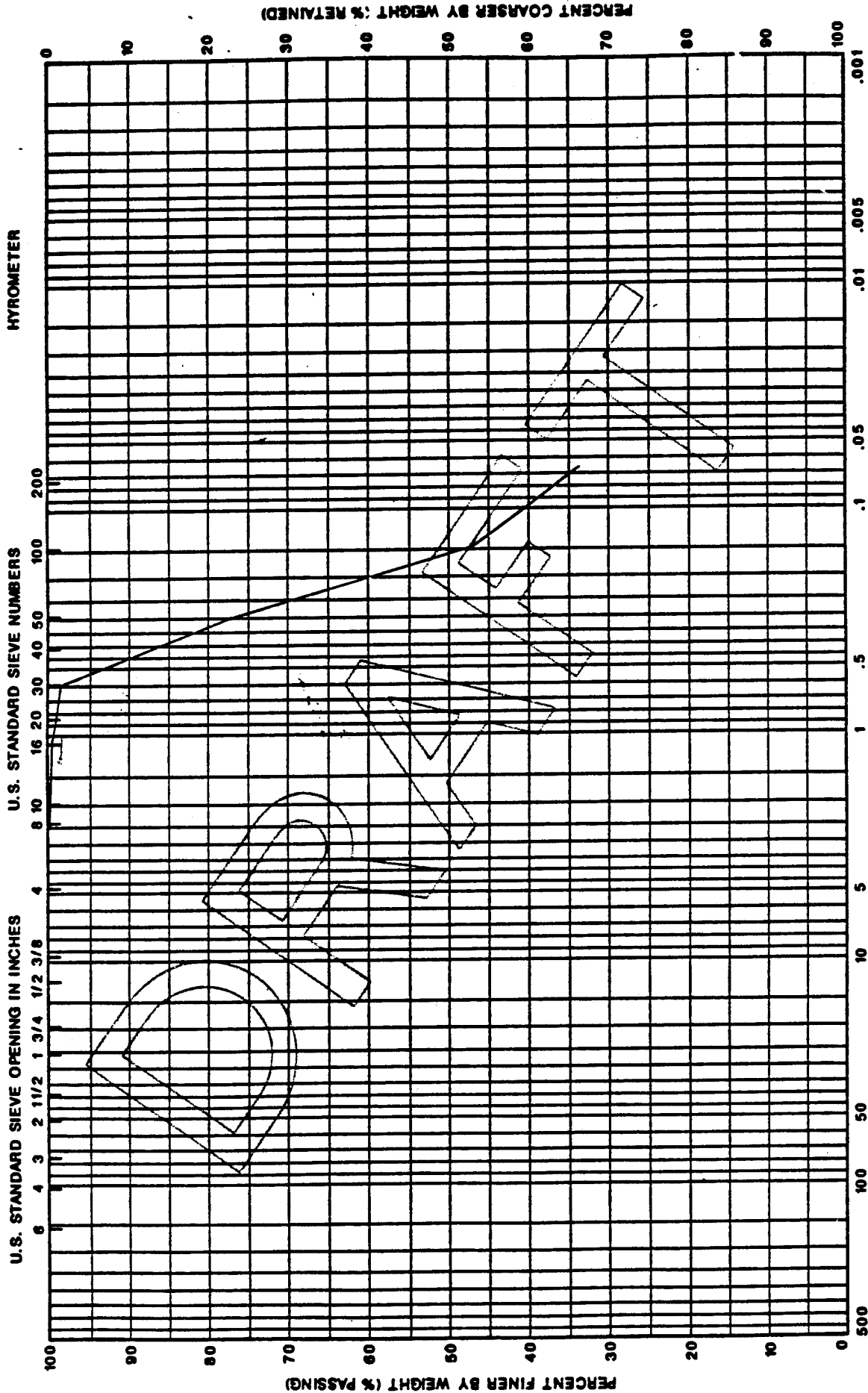
Woodward-Clyde Consultants
8





COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE		FINE		COARSE		FINE	
COARSE		FINE		MEDIUM		FINE	
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	P1
M10003	2.5'	SC	CLAYEY SAND		28	15	13

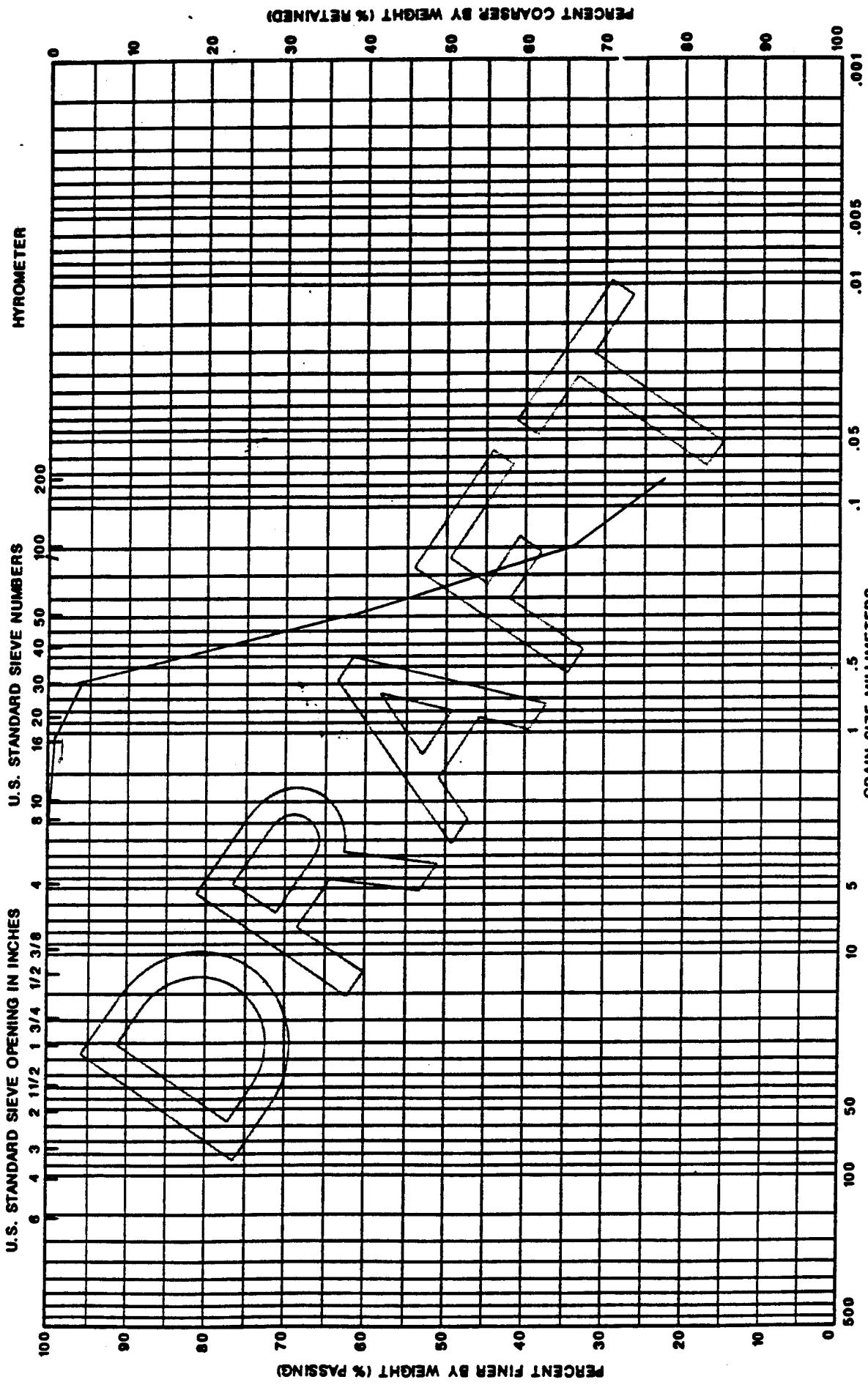




COBBLES		GRAVEL		SAND			SILT OR CLAY		
COARSE		FINE		COARSE			FINE		
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI		
M-10004	5'	SC	CLAYEY SAND	4.7	26	11	15		

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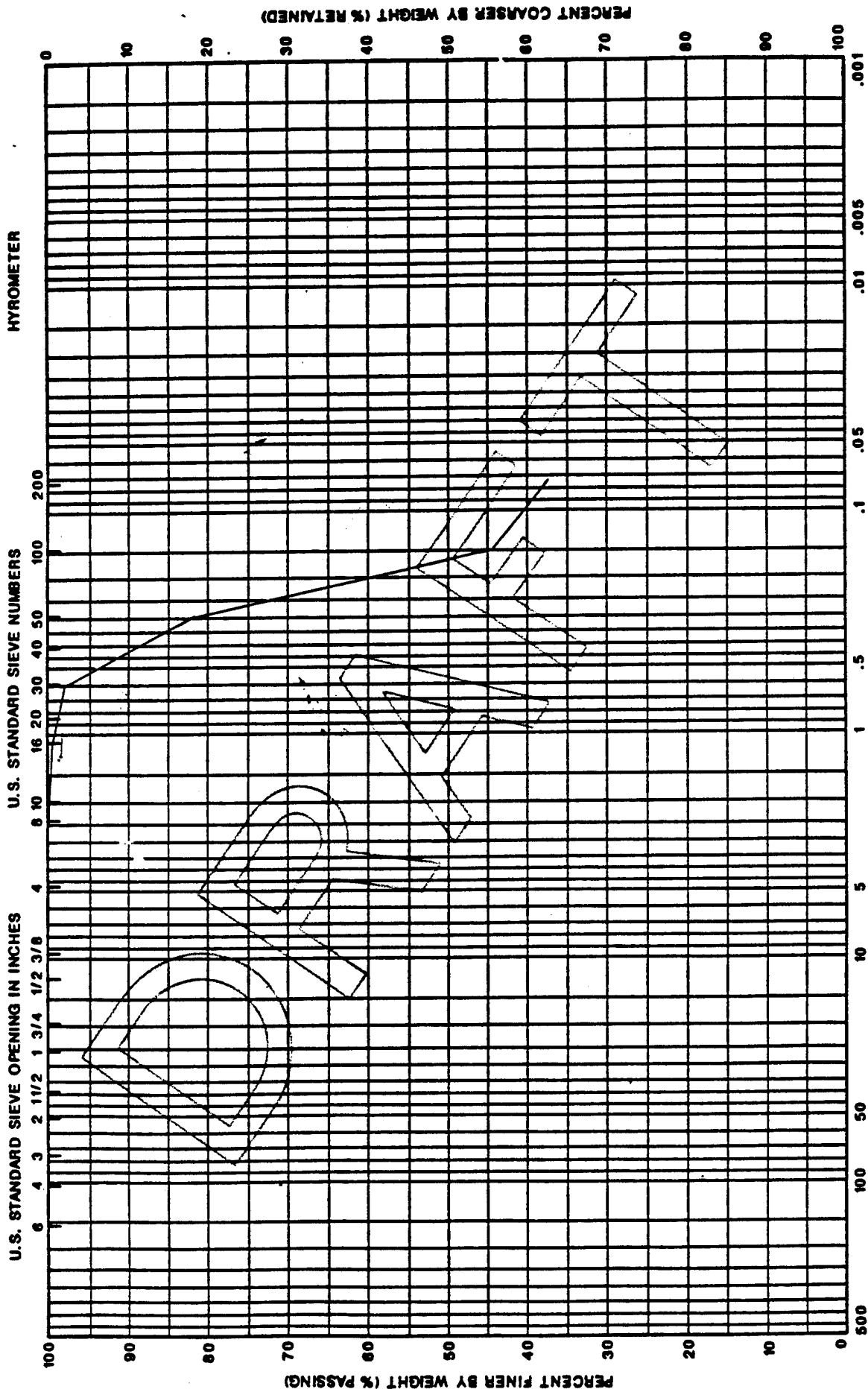
RONAC 11A



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

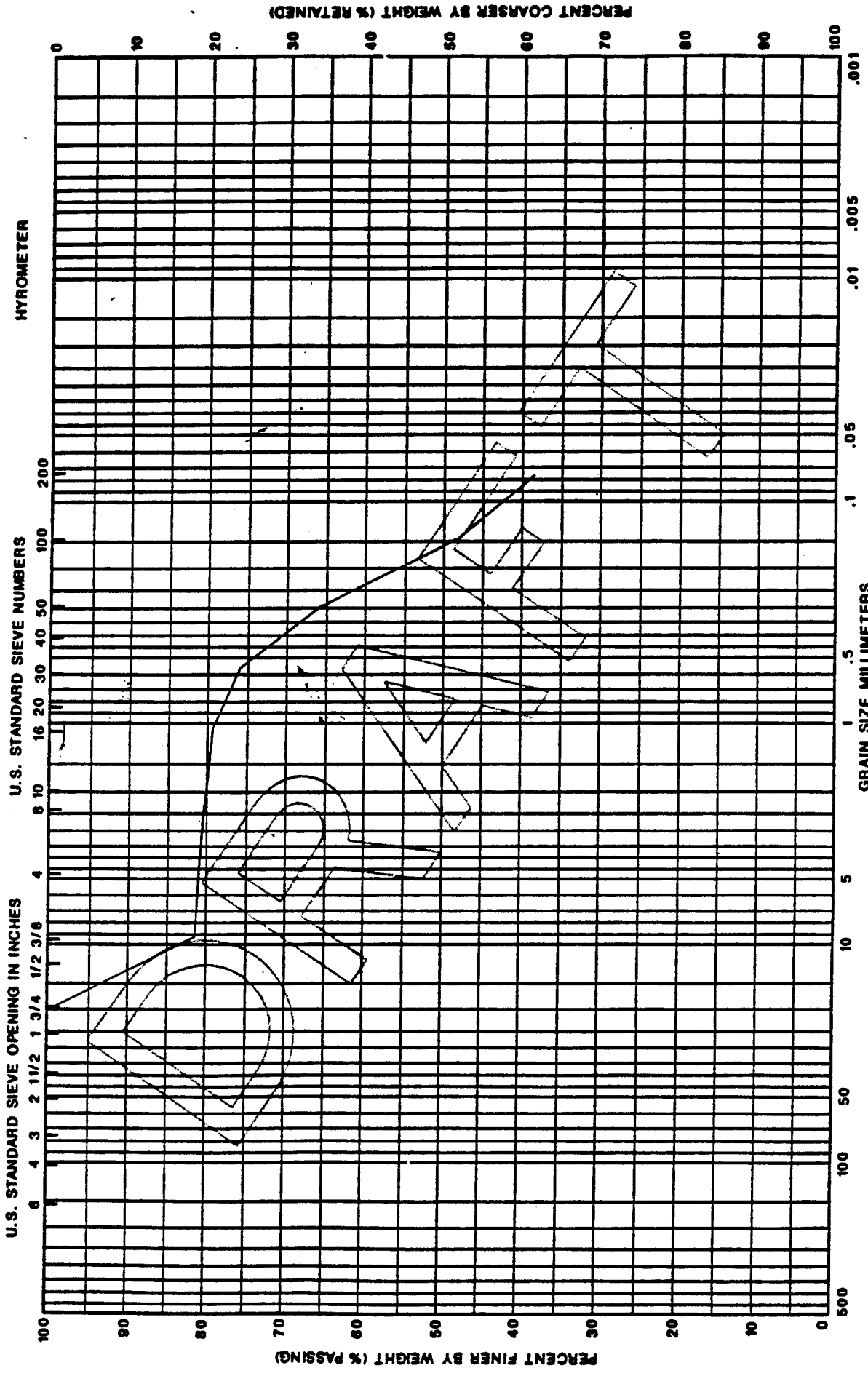
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	P1
10005	7.5'	SC-SM	SILTY, CLAYEY SAND	3	26	20	6

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COBBLES		GRAVEL		SAND		SILT OR CLAY	
COARSE		FINE		COARSE		FINE	
COARSE		MEDIUM		FINE		FINE	
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	P1
M-10008	7.5'	SC	CLAYEY SAND	20.1	46	13	33

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COBBLES		GRAVEL		SAND			SILT OR CLAY	
COARSE		FINE		COARSE		MEDIUM		FINE

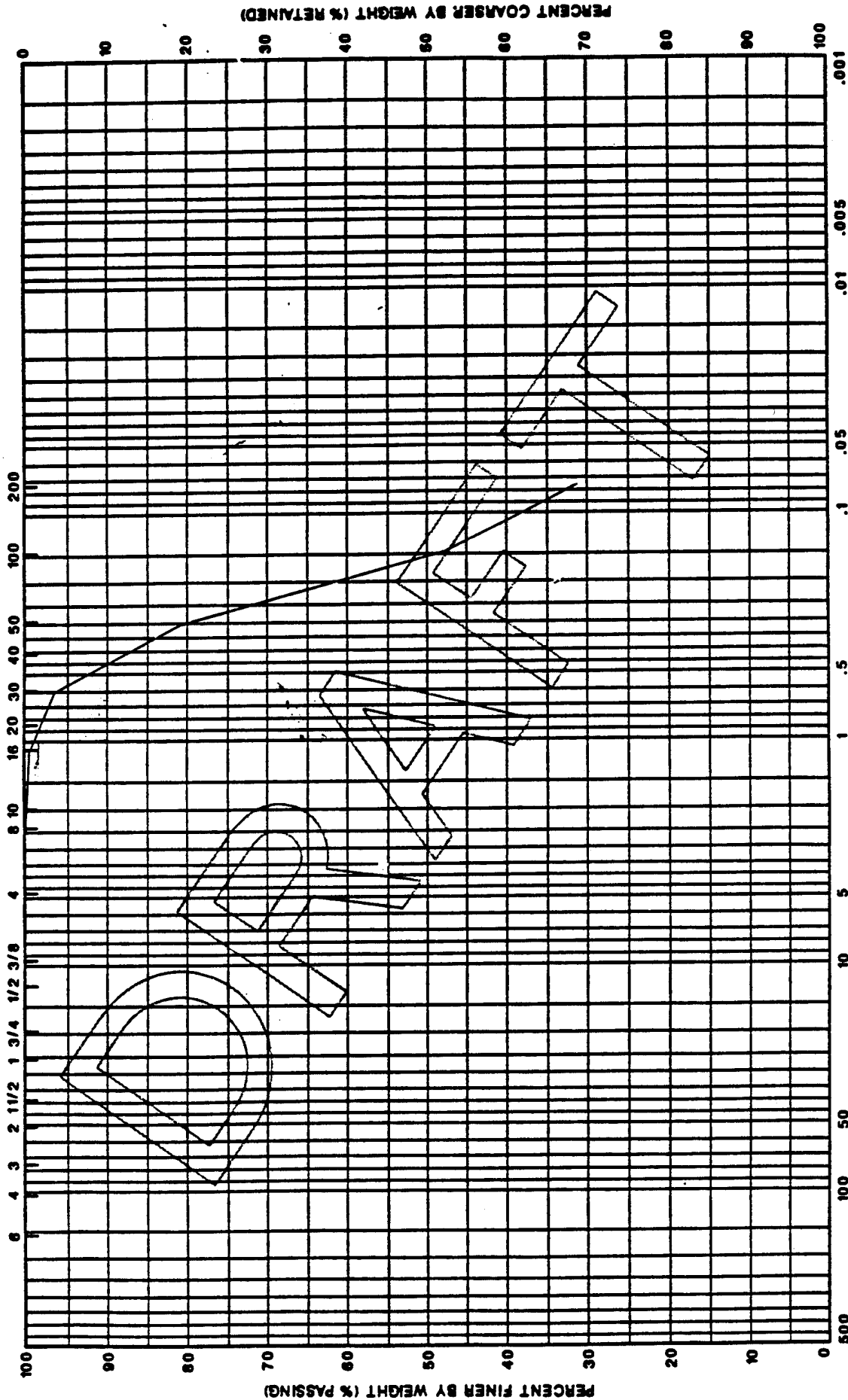
SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
10010	10'	SC	CLAYEY SAND WITH GRAVEL	8	47	23	24

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HYROMETER

U.S. STANDARD SIEVE NUMBERS

U.S. STANDARD SIEVE OPENING IN INCHES

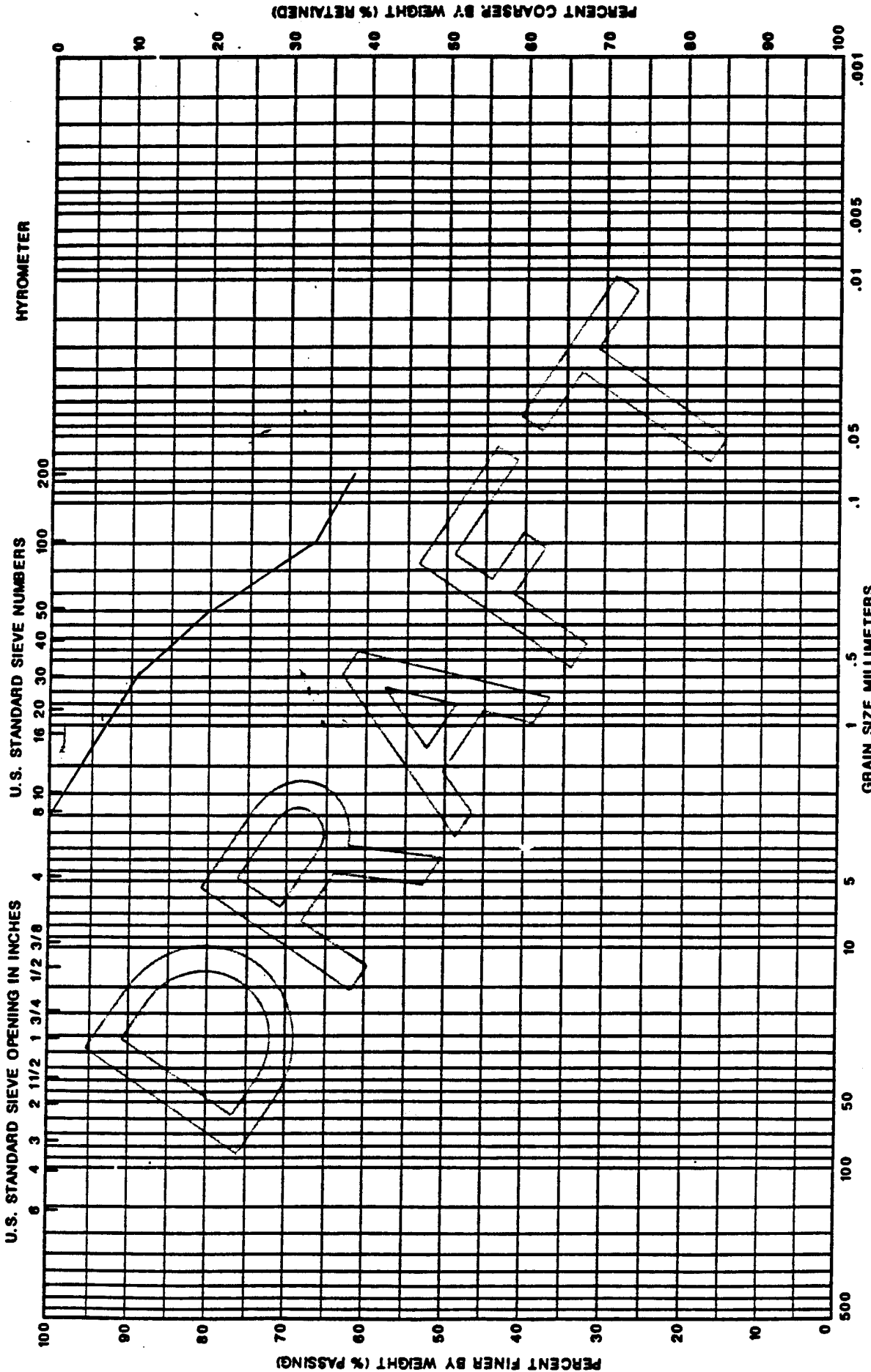


COBBLES		GRAVEL		SAND			SILT OR CLAY	
		COARSE	FINE	COARSE	MEDIUM	FINE		

SAMPLE NO.	ELEV. OR DEPTH	SYM.	CLASSIFICATION	NAT W	LL	PL	PI
M-10022	2.5'	SM	SILTY SAND	10.1	N.P.	N.P.	N.P.

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WOODWARD-CLYDE



SAMPLE NO.		ELEV. OR DEPTH		SYM.		CLASSIFICATION		NAT W		PI	
M-10026		5'		ML		SANDY SILT		40.5		NP	

Woodward-Clyde Consultants

REFERENCES

- Environmental Science Engineering, Inc., 1987, Contamination Assessment Report Lime Settling Basins, Rocky Mountain Arsenal, Vols I and II.
- Freeze, R. Allen and John A. Cherry, 1979, Groundwater, Prentice-Hall, Inc. New Jersey, 604 pp.
- May, James H., 1982, Regional Groundwater Study of Rocky Mountain Arsenal, Denver, Colorado, U.S. Army Engineer Waterways Equipment Station, Vicksburg, Miss., Report 1 of a Series.
- Stollar, R.L. and Assoc., 1989, Comprehensive Monitoring Program, Annual Ground Water Report for 1988, Vols I and II, Rocky Mountain Arsenal, Commerce City, Colorado.
- U.S. Army Corps of Engineers, EM 1110-2-1901 dated 30 Sep 86, Seepage Analysis and Control for Dams.
- Woodward Clyde Consultants, 1989, Results of field and Laboratory Investigations Conducted for the Remediation of Other Contamination Sources, Interim Response Action, Rocky Mountain Arsenal, Vols I and II.
- _____, 1989, Final Alternative Assessment of Interim Response Actions for Other Contamination Sources, Lime Settling Basins, Rocky Mountain Arsenal, Commerce City, Colorado.
- _____, 1989, Final Alternative Assessment of Interim Response Actions for Other Contamination Sources, M-1 Settling Basins, Rocky Mountain Arsenal, Commerce City, Colorado.
- _____, 1990, Final Decision Document for the Interim Response Action at the Lime Settling Basins, Rocky Mountain Arsenal, Commerce City, Colorado.
- _____, 1990, Final Decision Document for the Interim Response Action at the M-1 Settling Basins, Rocky Mountain Arsenal, Commerce City, Colorado.
- _____, 1990, Field Investigation, Lime and M-1 Settling Basins Slurry Walls, Rocky Mountain Arsenal, Commerce City, Colorado, Vols I and II.

APPENDIX B

WATER SUPPLY & WASTEWATER COLLECTION

PROJECT

SHEET NO. 1 OF 3

ITEM

Cutoff Walls and Cap for Lime and
M-1 Settling Basins - Lift Station Design

BY TCB

DATE 9/28/90

CHKD. BY RAK

DATE 10-10-90

Collection Trench Drain to Pump StationAssume: Trench Drain flow rate = 5 gpm

$$5 \text{ gpm} \times 60 \frac{\text{min}}{\text{hr}} \times 24 \frac{\text{hr}}{\text{day}} = 7,200 \text{ gal/day}$$

Size Lift Station

Trench Depth @ 24 ft.

∴ Minimum Depth of Lift Station = 24 ft

$$\text{Check Volume} \Rightarrow \text{I.D.} = 3 \text{ ft} \quad V = \pi (1.5)^2 (1) \times 7.481 \text{ gal/ft}^3$$

$$V = 53 \text{ gal/ft depth}$$

depth of sump = 5 ft

$$\text{Storage Vol.} = 5 \times 53 = 265 \text{ gallons}$$

Use depth = 33 ft. @ diam. = 3 ft.

PROJECT	SHEET NO. 2 OF 3	
ITEM	BY <i>VLB</i>	DATE <i>9/28/90</i>
	CHKD. BY <i>RAK</i>	DATE <i>10-10-90</i>

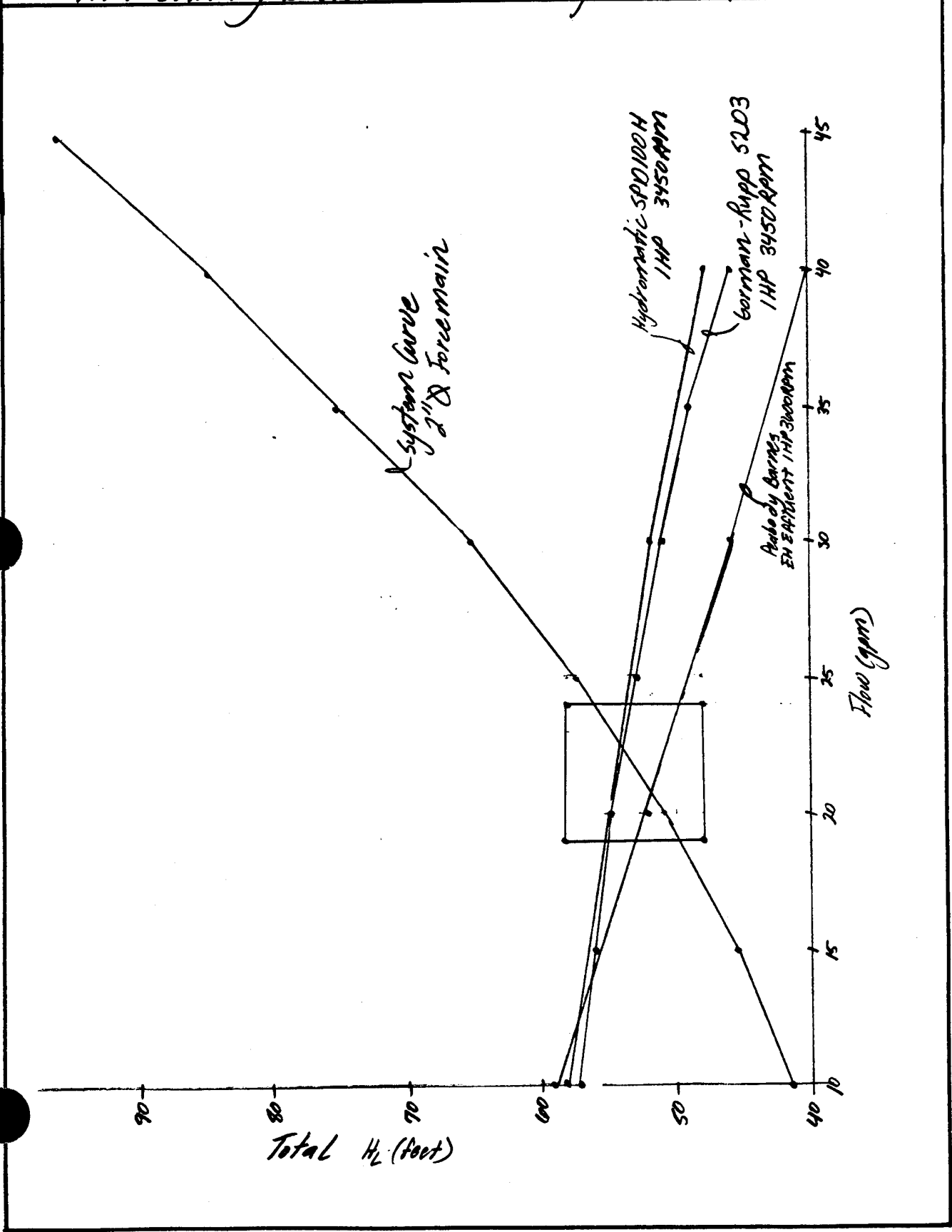
Sizing of Force Main and Pump

Length = 1000 ft.

Friction $H_f = 5XL$ $S = \left(\frac{3.5519 Q}{C D^{2.63}} \right)^{1.852}$ Hazen-Williams $Q = \text{gpm}$
 $C = 120$
 $D = \text{diam. in.}$
 $S = \text{Slope ft/ft.}$

Static Head = CERCLA Floor EL - Lift Station Floor
 5260 - 5222 = 38 ft.

<u>Q</u>	<u>Friction H_f (ft)</u>	<u>Static H (ft)</u>	<u>Total Head (ft)</u>
	<u>2"</u>		
10	3.6	38	41.6
15	7.6	38	45.6
20	12.9	38	50.9
25	19.6	38	57.6
30	27.4	38	65.4
35	36.5	38	74.5
40	46.7	38	84.7
45	58.1	38	96.1



APPENDIX C
ELECTRICAL COLLECTIONS

OMAHA DISTRICT		COMPUTATION SHEET		CORPS OF ENGINEERS	
PROJECT	Rocky Mountain Aerial Lime Basin	SHEET NO.	1	OF	1
ITEM	Voltage Drop for pump	BY	RTL	DATE	Oct 1990
		CHKD. BY	LDO	DATE	OCT 1990

Distance 100 feet
 Load 2Hp motor 1 ϕ , 240V, 12A

$$\text{Amp-feet} = 12 \text{ A} \times 100 \text{ ft} = 1200 \text{ A-ft}$$

using table 5-7-1 in Buss Bulletin SPD81
 Electrical Protection Handbook

for #10 AWG copper in plastic conduit
 80% power factor 1 ϕ from table 1978

Volt drop multiply A-ft x table and move decimal point 6
 places

$$V_{\text{drop}} = 1200 \times 1978 = 2.373600 = 2.4 \text{ Volts}$$

$$2.4 \text{ volts} / 240 \text{ volts} = 0.01 = 1\% \text{ drop}$$

1% is less than 5% maximum and is acceptable.

Use #10 AWG copper for 2HP motor

APPENDIX D

LIST OF PROSPECTIVE GUIDE SPECIFICATIONS

LIST OF PROSPECTIVE GUIDE SPECS

TABLE OF CONTENTS

DIVISION 1 GENERAL REQUIREMENTS

01100 Special Clauses
01200 Warranty of Construction
01300 Environment Protection
01400 Special Safety Requirements

DIVISION 2 SITE WORK

02050 Demolition
02060 Well Abandonment
02100 Clearing and Grubbing
02150 Hazardous Material Excavation and Handling
02210 Grading
02214 Soil- Bentonite Slurry Trench Cutoffs
02215 Geotextile Filter
02221 Excavation, Trenching, and Backfilling for Utilities Systems
02243 Crushed Rock Surfacing
02244 Low Permeability Cap (Compacted Clay)
02420 Extraction Trench
02480 Seeding
02710 Sewers; Sanitary, Gravity
02713 Water Lines
02724 Force Mains & Extraction Well Piping
02730 Extraction Wells
02910 Monitoring Wells

DIVISIONS 3 & 4 NOT USED.

DIVISION 5 METALS

05120 Structural Steel
05500 Miscellaneous Metal

DIVISIONS 6 THRU 10 NOT USED.

DIVISION 11 EQUIPMENT

11303 Guide-Mounted Sewage Lift Stations

DIVISIONS 12 THRU 15 NOT USED.

DIVISION 16 ELECTRICAL

16401 Electrical Distribution System, Aerial
16415 Electrical Work, Interior