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GEOTECHNICAL ENGINEERING STUDY
PROPOSED FORCED SANITARY SEWER PIPELINE
ROXBOROUGH WASTEWATER
REGIONALIZATION PROJECT
C-470 TO WATERTON CANYON
JEFFERSON/DOUGLAS COUNTY, COLORADO

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Project No. 05-1-205B

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SUMMARY

1. Based on the subsurface exploration, laboratory testing and field study performed for the sewer pipeline, there appear to be no potential geotechnical and geologic hazards that would preclude or significantly impact the pipeline construction. The majority of the project alignment falls within the Designated Dipping Bedrock Area (DDBA) of Jefferson County. Recommendations associated with reducing the potential for heave of the pipeline from expansive bedrock within the DDBA alignment are provided in the report.

2. Subsurface conditions encountered in the exploratory borings, primarily within the trench excavation zone and at pipe bearing elevation, consisted of roadway man-placed fill, natural soils consisting of clays to gravels, and bedrock. Bedrock was generally encountered in 24 of the 57 exploratory borings drilled along the alignment. Ground water was encountered in 13 of the 57 exploratory borings at depths ranging from approximately 6 to 22.5 feet at the time of drilling and/or when measurements were taken up to 51 days after completion of the drilling.

3. Recommendations for excavation and backfill, pipe bedding and geotechnical parameters for the design of the pipeline are presented in the report.

PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical engineering study for the proposed forced sanitary sewer line section for the Roxborough Park Wastewater Regionalization Project, located between the north side of State Highway C-470 (C-470) at Platte Canyon Road and the existing treatment plant at Waterton Canyon. The alignment traverses through Section 36, Township 5 South (T5S), Range 69 West (R69W) of the 6th Principal Meridian (P.M.); and portions of Sections 1, 2, 10, 11, 15, 23, 27 and 34 of T6S, R69W of the 6th P.M. The project alignment is shown on Figs. 1 and 1A. The subsurface study was performed to provide recommendations for pipeline design parameters, pipe backfilling, and trench excavation. This study was conducted in general accordance with the scope of work in our Proposal No. P-05-218 to Roxborough Park Metropolitan District dated March 11, 2005.

This study was performed in conjunction with the remaining portion of the project which consists of a gravity section of the pipeline located between the intersection of C-470 and Platte Canyon on the south and the intersection of State Highway 85 (Santa Fe Drive) and Belleview Avenue. This portion of the alignment generally follows the west side of the South Platte River. The recommendations for this portion of the alignment were previously provided in a report under Kumar & Associates' Project No. 05-1-205 dated July 24, 2006.

A field exploration program consisting of exploratory borings was conducted to obtain information on subsurface conditions along the pipeline alignment. Samples of the soils and bedrock obtained during field exploration were tested in the laboratory to determine their classification and engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations and construction considerations for the pipeline.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical

engineering considerations related to construction of the proposed pipeline are included in the report.

PROPOSED CONSTRUCTION

The proposed 16-inch diameter PVC forced sewer line is approximately 7.2 miles in length with its limits between C-470 at Platte Canyon Road and the existing treatment plant at Waterton Canyon. The pipeline will be crossing C-470, two different locations of Wadsworth Boulevard (State Highway 121), and the South Platte River. The depth of burial for the pipeline will generally be within the range of 4 to 11 feet. It is assumed that open trench excavation will be used for installation of the pipeline; however trenchless methods such as microtunneling, and/or jack and bore methods will be used when crossing the major roads and the South Platte River.

If the proposed construction varies significantly from that described above or depicted in this report, we should be notified to reevaluate the recommendations provided in this report.

FIELD EXPLORATION AND LABORATORY TESTING

A field exploration program for the project was conducted from July 22, 2005 through May 23, 2006. Fifty-seven (57) borings were drilled along the proposed pipeline alignment to the explored depths of 15 to 40 feet. The majority of the borings were drilled to 15 feet. Of the 50 borings, 6 borings were performed at locations of potential trenchless crossings along the alignment. These borings were drilled to depths ranging from 20 to 40 feet and were performed to obtain localized subsurface information at these critical areas. The logs of the exploratory borings are presented in Figs. 2 through 7.

Measurements of the water levels were made in the borings shortly after completion of drilling and within a few weeks subsequent to drilling. The depths of the water levels measured and the number of days subsequent to drilling are shown on the Logs of Exploratory Borings.

The results of laboratory tests performed on selected soil and bedrock samples obtained from the borings are shown to the right of the logs on Figs. 2 to 7, and are summarized in

Table I. The results of 15 swell-consolidation tests performed on clayey soil and bedrock samples are presented on Figs. 9 to 18, and gradation test results for 22 samples of granular soil are presented on Figs. 19 to 30.

PIPELINE SITE AND SUBSURFACE CONDITIONS

Station 387+89 to Station 275+00 (Borings 44A through 57): This portion of the alignment generally occurs along the south side of C-470 after crossing C-470, just east of Platte Canyon Road, to the east side of Wadsworth Boulevard, then following the east side of Wadsworth Boulevard to the entrance into the U.S. Army Corps of Engineers facility/Dear Creek Canyon Road. This portion of the alignment is on gently to moderately sloping terrain, which slopes down to Chatfield Reservoir and is vegetated with natural grasses and weeds, and random small to medium size trees.

Subsurface conditions encountered beneath approximately 4 to 6 inches of topsoil generally consisted of variable sequences and thicknesses of medium dense to dense, well to poorly-graded sands with silt/clay, clayey sands, silty sands, and occasionally sandy lean clays and poorly-graded gravels with clay. Five of the borings encountered medium hard to very hard claystone and/or sandstone bedrock between approximately 1 and 14.5 feet, while the remaining borings did not encounter bedrock within the explored depths of 15 feet. Approximately 4.5 feet of fill material was encountered in Boring 47. Three borings encountered ground water at depths ranging from 7.5 to 12 feet when measured at the completion of drilling.

Station 275+00 to Station 219+00 (Borings 58 through 65): This portion of the alignment generally occurs along the east side of Wadsworth Boulevard at the entrance into the U.S. Army Corps of Engineers facility/Dear Creek Canyon Road and continues southwest to where it crosses Wadsworth Boulevard at Trailmark Parkway. A significant portion of the alignment is adjacent to or within a highly vegetated zone of deciduous trees on the toe of the Wadsworth Boulevard embankment slope. The remaining portion of the alignment is on gently to moderately sloping terrain, vegetated with natural grasses and weeds.

Subsurface conditions encountered beneath approximately 4 to 6 inches of topsoil generally consisted of nil to 15 feet of stiff to very stiff, clayey sand, sandy lean clay, or fat clay. Approximately 6 to 15 feet of fill material was encountered in Borings 58 through 61 (on the Wadsworth Boulevard embankment) within the explored depths of 15 feet. Firm to hard, claystone bedrock was encountered in Borings 63 through 65 at depths ranging from 3 to 6.5 feet. Ground water was not observed in any of the borings during the time of drilling. Ground water was encountered at depths ranging from approximately 5 to 15 feet at the Wadsworth Boulevard crossing when measurements were taken 29 to 51 days subsequent to completion of the drilling.

Station 219+00 to Station 44+00 (Borings 66 through 88): This portion of the alignment generally occurs along the western side of Wadsworth Boulevard from Trailmark Parkway continuing south to another crossing of Wadsworth Boulevard at the entrance into the Lockheed Martin facility. This portion of the alignment is generally on gently sloping to moderately steep terrain with hills and gullies, vegetated mainly by native grasses and weeds. The areas of moderately steep terrain are located along the eastern flank of west to east trending ridges originating from the Dakota Hogback. The portion of the alignment crosses several intermittent drainages.

Subsurface conditions encountered beneath approximately 4 to 6 inches of topsoil generally consisted of variable sequences and thicknesses of medium dense to very dense, well to poorly-graded gravels with silt/clay and sand, clayey sands, clayey silty sands, and stiff to hard sandy lean clays and fat clays. Approximately one half of the borings encountered firm to very hard, claystone and/or sandstone bedrock between nil and 10 feet, while the remaining borings did not encounter bedrock within the explored depths of 15 feet. Approximately 8.5 feet of fill material was encountered in Boring 68. Borings 82 and 86 encountered ground water at the time of drilling at depths of 13 and 23 feet, respectively.

Station 0+00 to Station 44+00 (Borings 89 through 96): This portion of the alignment generally occurs south of Wadsworth Boulevard within the vicinity of Waterton Canyon and the South Platte River. The first 700 feet of alignment transects moderately steep

terrain associated with a west to east trending ridge. The remaining portion of the alignment occurs within the gentle to moderately sloping topography of the South Platte River flood plain. A portion of the alignment also follows an existing aggregate surface road associated with the Denver Water facility. The vegetation at the site generally consists of natural grasses and weeds with small to large deciduous trees scattered through the alignment.

Subsurface conditions encountered beneath approximately 4 to 6 inches of topsoil generally consisted of medium dense to dense, well to poorly-graded gravel with sand, well to poorly-graded sand with gravel, well to poorly-graded sand with silt/clay and gravel, silty sand, clayey sand, and occasional sandy lean clay. Very hard, sandstone bedrock was encountered in Boring 91 at a depth of 3.5 feet where drill rig refusal was encountered. Drill rig refusal was also encountered at a depth of 10 feet in Boring 93 which was drilled at approximately the northern bank of the South Platte River crossing. Several borings encountered ground water at depths ranging from 7 to 14 feet.

SUBSURFACE CONDITIONS AT TRENCHLESS CROSSINGS

C-470 Crossing (Borings 44A & 44B): Subsurface conditions encountered beneath the topsoil on the roadway shoulders of C-470 generally consisted of 1.5 to 17 feet of sandy lean clay fill. This fill material was in turn underlain by interbedded, medium dense to dense, clayey sands and sandy lean clays to the explored depths of 35 feet. Bedrock was not encountered in the borings within the explored depth of 35 feet.

Ground water was not encountered in the borings during the time of drilling.

Wadsworth Boulevard Crossing at Trailmark Parkway (Borings 64A & 65A): Subsurface conditions encountered beneath the topsoil on the roadway shoulders of this section of Wadsworth Boulevard generally consisted of nil to 12 feet of clayey sand and fat clay with sand fill. This fill material was in turn underlain by nil to 5 feet of medium dense, clayey silty sand. This material was then underlain by 5 to 6 feet of very stiff, sandy lean clay to sandy fat clay. Firm to hard, claystone bedrock was encountered at depths of 18 and 28 feet below the ground surface.

Ground water was encountered in Boring 64A at 28 feet during the time of drilling.

Wadsworth Boulevard Crossing at Lockheed Martin Entrance (Borings 88A & 88B): Subsurface conditions encountered beneath the roadway shoulders of this section of Wadsworth Boulevard generally consisted of 3 to 13 feet of clayey sand fill. This fill material was in turn underlain by 10 to 12 feet of medium dense to dense, silty sand to poorly-graded sand with silt. This material was then underlain by dense to very dense, clayey gravel with sand to the explored depths of 22 and 25 feet. Bedrock was not encountered in the borings within the explored depths.

Ground water was not encountered in the borings during the time of drilling.

South Platte River Crossing (Borings 93 & 94): Subsurface conditions encountered beneath approximately 6 inches of topsoil generally consisted of approximately 7 feet of well to poorly graded sand with varying concentrations of silt and gravel overlaying poorly graded gravel with clay and sand with cobbles and boulders. Drill rig refusal was encountered in the very dense cobbles and boulders at a depth of approximately 9 feet in Boring 93.

Ground water was encountered at a depth of approximately 7 to 8 feet in the borings during the time of drilling.

PIPELINE RECOMMENDATIONS

Pipe Backfill: Backfill materials for the buried pipe system should be placed and compacted so the pipe and soil act together to carry the applied loads without excessive strains from pipe deflections or localized wall distortions. Bedding material supporting the pipe bottom should consist of a layer of granular soil with a maximum size of 1½ inches, less than 25% passing the No. 50 sieve, and less than 5% passing the No. 200 sieve. The materials should also have a plasticity index of 8 or less. Based on a proposed pipe diameter of 18 inches and AWWA guidelines, we recommend a bedding thickness of 6 inches be used. The surface of the 6-inch layer should be compacted with a smooth vibratory plate. It is assumed that the pipe will seat within the bedding material during installation, and shaping of the bedding material will not be needed prior to installation of the pipe.

The pipe-zone material placed above the bedding and surrounding the pipe should consist of the same material described above for pipe bedding, and should be compacted to at least 70% relative density (ASTM D 4253 and ASTM D 4254), and in accordance with requirements of the pipe manufacturer, to provide the required support around the pipe. Special care should be taken to provide adequate compaction below the haunches of the pipe using a concrete vibrator, vibratory plates or other light compaction equipment as needed. Pipe-zone material should be placed and compacted in equal lifts on both sides of the pipe during construction before the addition of the next lift. In confined areas of the pipeline where compaction is difficult, placement of a cementitious flow fill around the pipe should be considered.

Based on the subsurface conditions encountered in the borings and the results of the laboratory testing program, it appears that essentially all of the bedding material and pipe zone backfill material will be required to be imported to the site. Areas of the pipeline will encounter natural soils that will meet this requirement; however, the material quantities will require selective excavation and stockpiling.

Backfill placed above the pipe-zone materials to the surface should consist of suitable on-site soil obtained from the pipeline excavation having a plasticity index of less than 25 and a liquid limit of less than 50, and should be generally free of claystone fragments, organics, wood, or other deleterious material that could decay over time. The backfill should be compacted to at least 95% of the maximum standard Proctor dry density (ASTM D 698) at a moisture content within 2 percentage points of optimum. It is anticipated that backfill material for above the pipe-zone will not need to be imported, and that there will be sufficient excavated material within the alignment segment that will fit these requirements.

A path for water flow along the pipe can exist, because the bedding and pipe-zone fill consist of free-draining, cohesionless material. In areas where shallow ground water conditions exist, where the pipe crosses natural drainages, aquifers or streams, or areas where the natural ground water flows could be affected by the pipeline, trench plugs should be constructed.

The trench plug should consist of properly compacted cohesive soil having at least 30% passing the No. 200 sieve and a plasticity index between 10 and 20. The trench plug should extend from the bottom of the pipe trench to the top of the pipe-zone fill surrounding the pipe. The minimum thickness of the plug, measured at the top, should equal the outside diameter of the pipe, and the front and the back of the plug should be sloped 1:1 (horizontal:vertical) downward and outward to the bottom of the trench.

The trench plug fill should be compacted to at least 95% of the maximum standard Proctor density. Trench-plug fill placed within the bedding zone beneath the pipe should be compacted at a relatively high moisture content to allow the pipe settlement on the cohesive bedding to approximately match that on the uncompacted, cohesionless soil. We recommend that the trench-plug fill located within the bedding zone be compacted at a moisture content between 2 and 4 percentage points above the optimum moisture content, and that trench-plug fill placed within the pipe zone be placed at a moisture content within 2 percentage points of the optimum moisture content.

Variable moisture contents were indicated for the soils encountered in the exploratory borings. The contractor should anticipate that moisture conditioning of the fill, or allowing time for the material to dry out, will likely be required. Based on the exploratory borings, the overburden soils are generally dry to wet. Ground water encountered within the borings was generally perched water within the overburden soils located above the bedrock.

It is anticipated that pipeline construction may take place during the winter months when colder temperatures could freeze the ground surface and any stockpiled material. Material that is frozen, or contains frost, should not be placed as bedding, pipe-zone, or backfill material.

The pipe should be buried an adequate depth below the surface to limit pipe deflections caused by traffic loading, particularly below roadway areas. The minimum burial depth required for the pipe will depend on the material and physical properties of the pipe, the soil/structure interaction between the pipe and the backfill material, and traffic loading conditions. We understand that the minimum pipe burial depth will be 4 feet.

Pipeline Design Parameters: A compacted moist unit weight of 125 pcf, a Rankine's ratio of 0.30 for compacted, on-site trench-zone fill, and a coefficient of friction between the on-site backfill and in-place soils exposed on the trench walls of 0.30 should be used for the evaluating backfill loading above the pipe for design.

Thrust Bocks: Lateral resistance against the sides of thrust blocks placed against undisturbed natural soil and/or bedrock should be designed using the passive pressure condition of the soil. In general thrust blocks placed less than 8 feet below finished grade should be designed using an equivalent fluid pressure of 250 psf per foot of depth. Thrust blocks placed greater than 8 feet below finished grade should be designed for an allowable soil bearing pressure of 2,000 psf. These values are working values and are based on the weaker soil conditions.

Excavation and Dewatering Considerations: The pipe trench should be excavated in accordance with all OSHA requirements, and other applicable local and state requirements. Based on the OSHA excavation guidelines, sandy silt, clayey sand, silty sand, clayey gravel, clayey gravel with sand, sand with gravel, and sand with silt and gravel encountered in the borings generally classify as Type C soil; sandy lean clay and sandstone bedrock generally classify as a Type B soil; and lean clay, claystone, and siltstone classify as a Type A soil.

Based on the auger drilling conditions, it appears that the soils and most of the bedrock at the site can be excavated during utility installation with heavy duty, conventional excavators. During soils exploration, occasional lenses of well-cemented sandstone were encountered that appeared to be less. This material may be encountered during excavation and it may not be uncommon that the thickness of the cemented layers approach several feet. Loosening of very hard sandstone bedrock in a trench situation is significantly more difficult to accomplish than loosening the same materials in an open excavation. Therefore, a pneumatic chisel and/or light controlled blasting may be required for excavation of the sandstone bedrock in areas, especially in isolated areas along the Denver Water access road north of the South Platte River.

Ground water was encountered in some of borings at the time of exploration, and at depths within the anticipated excavations. If ground water is encountered during

excavation, we believe that in general, dewatering can be effectively handled using narrow trenches at the sides of the excavation and sumps.

Surface water runoff into the excavations can erode and potentially destabilize the trench slopes and result in soft ground conditions along the trench bottom, and should not be allowed. Diversion berms and other measures should be used to prevent surface water runoff into the trenches.

Swelling Bedrock Considerations: The majority of the alignment falls within the Designated Dipping Bedrock Area (DDBA) of Jefferson County. The portion of the alignment which falls within the DDBA generally occurs between the intersection of C-470 and Wadsworth Boulevard on the north and just north of the Wadsworth Boulevard intersection at the Lockheed Martin entrance on the south.

The current DDBA details for sanitary sewer and waterline construction were developed for several water and sanitation districts in the mid 1980s. The detail for sanitary sewer construction in the DDBA requires 18 inches of ¾-inch crushed rock bedding material beneath the pipe and 12 inches over the pipe versus typical AWWA recommendations. In addition, the required pipe for the sanitary sewer consists of C-900 thick-walled pipe versus using standard SDR35 thin-walled pipe. We understand that this detail has been generally successful in reducing distress to the pipe to an acceptable level. Over the last 10 to 15 years, overexcavation of the expansive claystone beneath the trench bottom and placement of the moisture-density conditioned backfill has also been performed to reduce potential for heave of the pipe.

Swell-consolidation tests performed on selected samples of the claystone bedrock along this portion of the alignment indicated a low to very high expansive potential with swell potentials ranging from less than 1% to approximately 8.5% when wetted under a surcharge pressure of 1,000 psf.

Increasing moisture content to the claystone bedrock is generally the main cause for the expansive nature of the bedrock to occur. Water which accumulates in the bedding material will be the main source of the moisture increase. Therefore, placement of an

underdrain system in the trench bottom should be considered where claystone bedrock is present at pipe invert elevation in this portion of the alignment. The underdrain system should consist of a 4-inch perforated PVC pipe encased in a geotextile fabric sock.

An additional measure to reduced potential for pipe movement where claystone bedrock is present at pipeline invert elevation, the claystone bedrock can be overexcavated and replaced with soils and/or bedrock which possess a plasticity index of less than 30. The fill material replaced in the overexcavated zone should be compacted to at least 95% of the maximum standard Proctor dry density (ASTM D 698) at a moisture content between optimum and 4 percentage points above optimum. The greater the depth of overexcavation, the greater the reduction in potential for heave of the pipeline.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications so that comments can be made regarding interpretation and implementation of our geotechnical engineering recommendations before these contract documents are finalized. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies if necessary to accommodate possible changes in the proposed construction after the completion of our study. We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services during construction to document that the intent of this report and the requirements of the plans and specifications are being followed during construction, and to identify possible variations in foundation conditions from that encountered in this study so that we can re-evaluate our recommendations if needed.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practice in this area for exclusive use of the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Figs. 1 and 1A, and the proposed type of construction. This report does not reflect subsurface variations that may occur between the exploratory borings, and the nature and extent of variations across the

site may not become evident until site grading and excavations are performed. If during construction, fill, soil, bedrock or ground water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

The scope of services for this project does not include any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

JJW/mj

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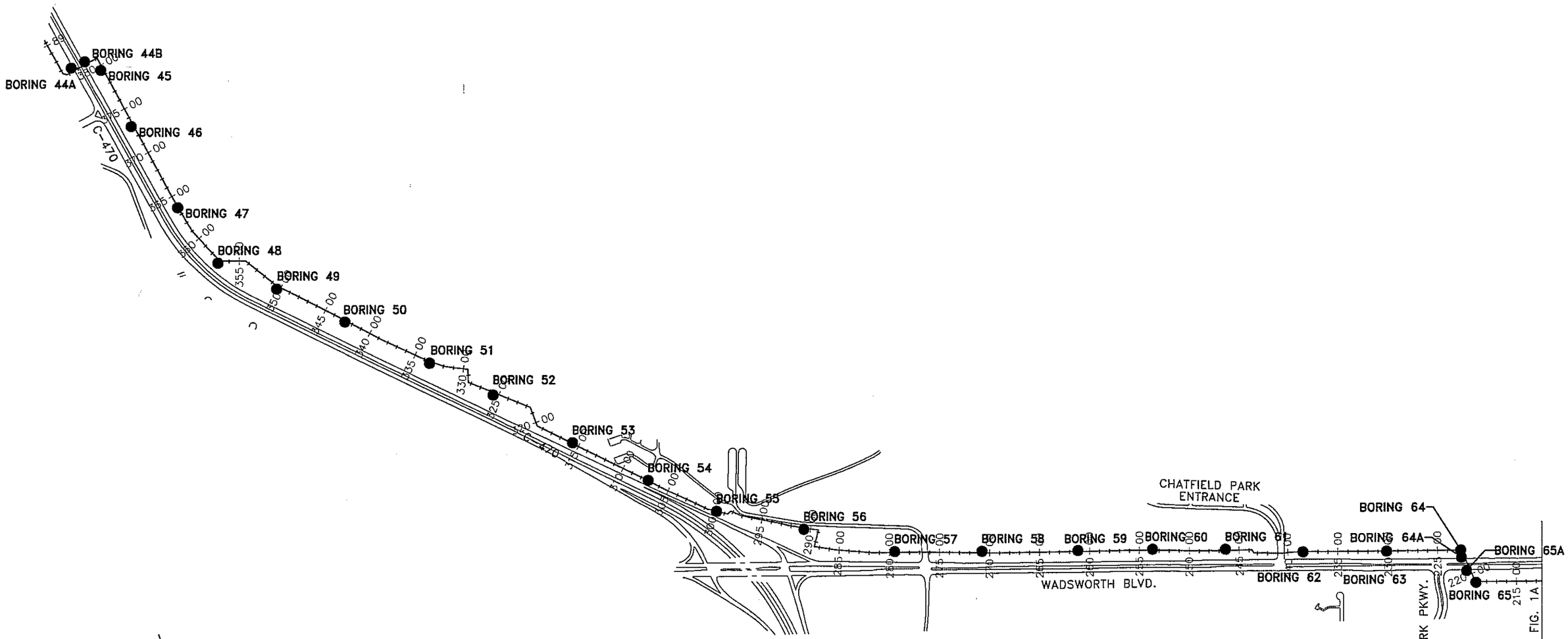

05-1-205B	Kumar & Associates	ROXBOROUGH PARK WASTEWATER REGIONALIZATION PROJECT FORCE MAIN ALIGNMENT	LOCATIONS OF EXPLORATORY BORINGS	Fig. 1

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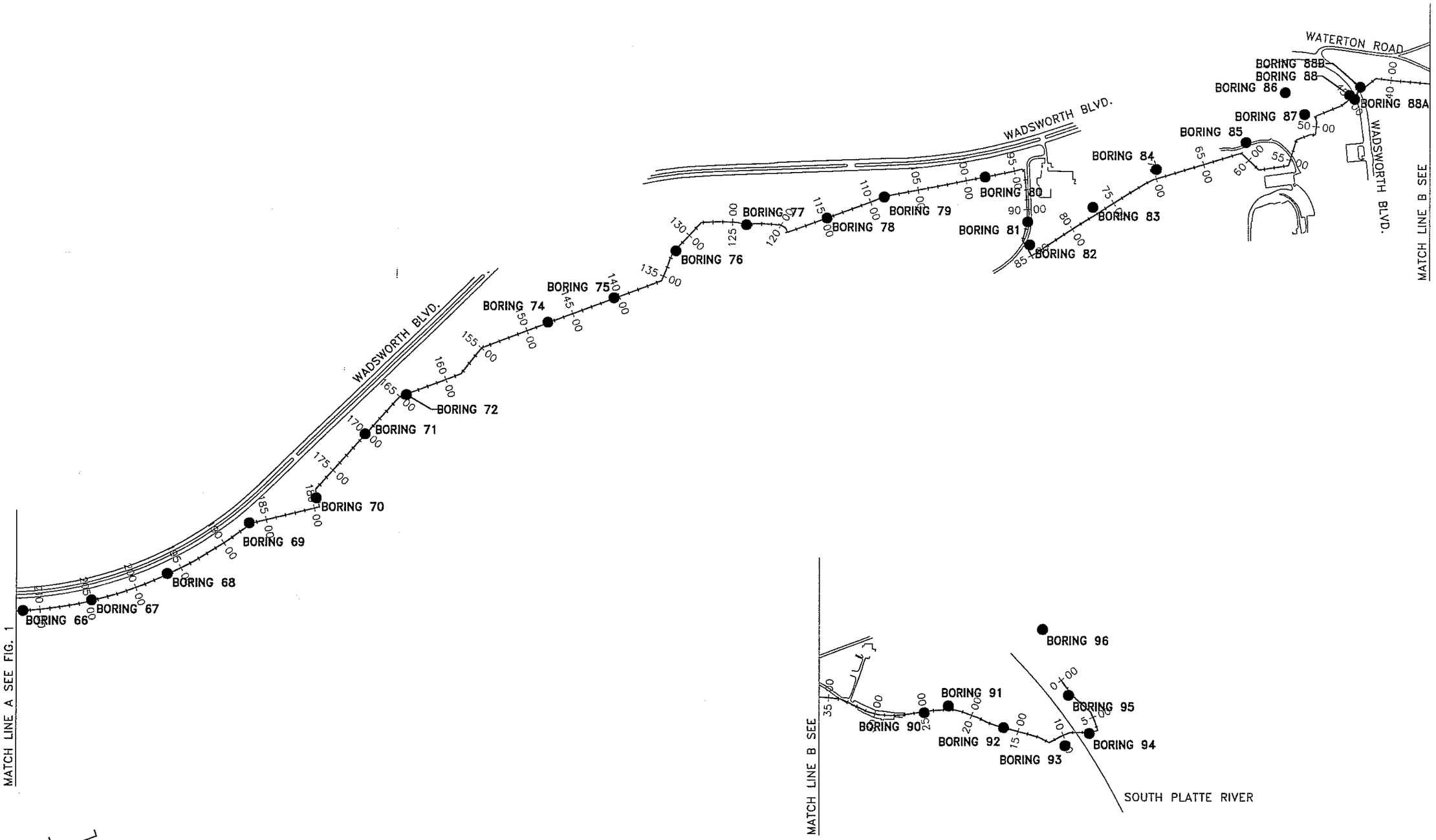

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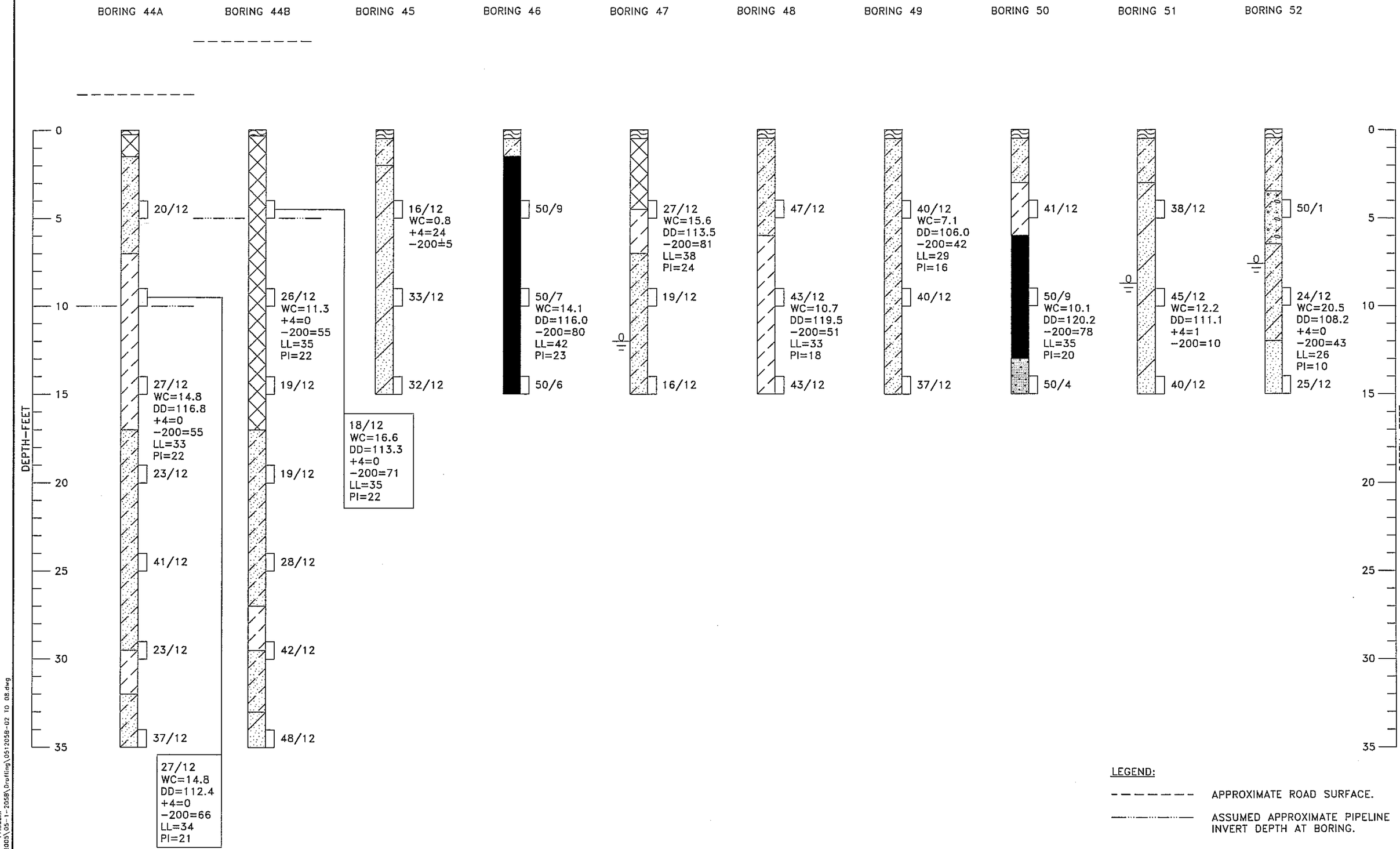
05–1–205B	Kumar & Associates	ROXBOROUGH PARK WASTEWATER REGIONALIZATION PROJECT FORCE MAIN ALIGNMENT	LOCATIONS OF EXPLORATORY BORINGS	Fig. 1A



05-1-205B	Kumar & Associates	ROXBOROUGH PARK WASTEWATER REGIONALIZATION PROJECT FORCE MAIN ALIGNMENT	LOGS OF EXPLORATORY BORINGS	Fig. 2

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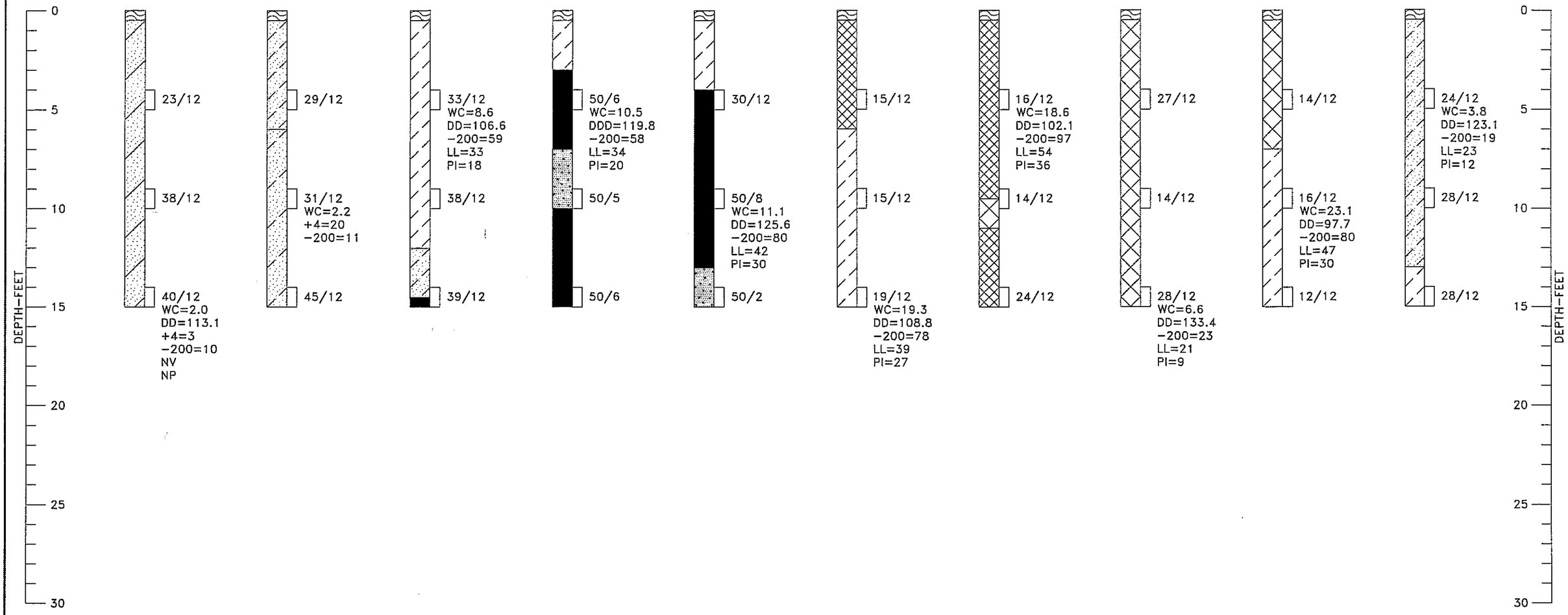

05-1-205B	Kumar & Associates	ROXBOROUGH PARK WASTEWATER REGIONALIZATION PROJECT FORCE MAIN ALIGNMENT	LOGS OF EXPLORATORY BORINGS	Fig. 3

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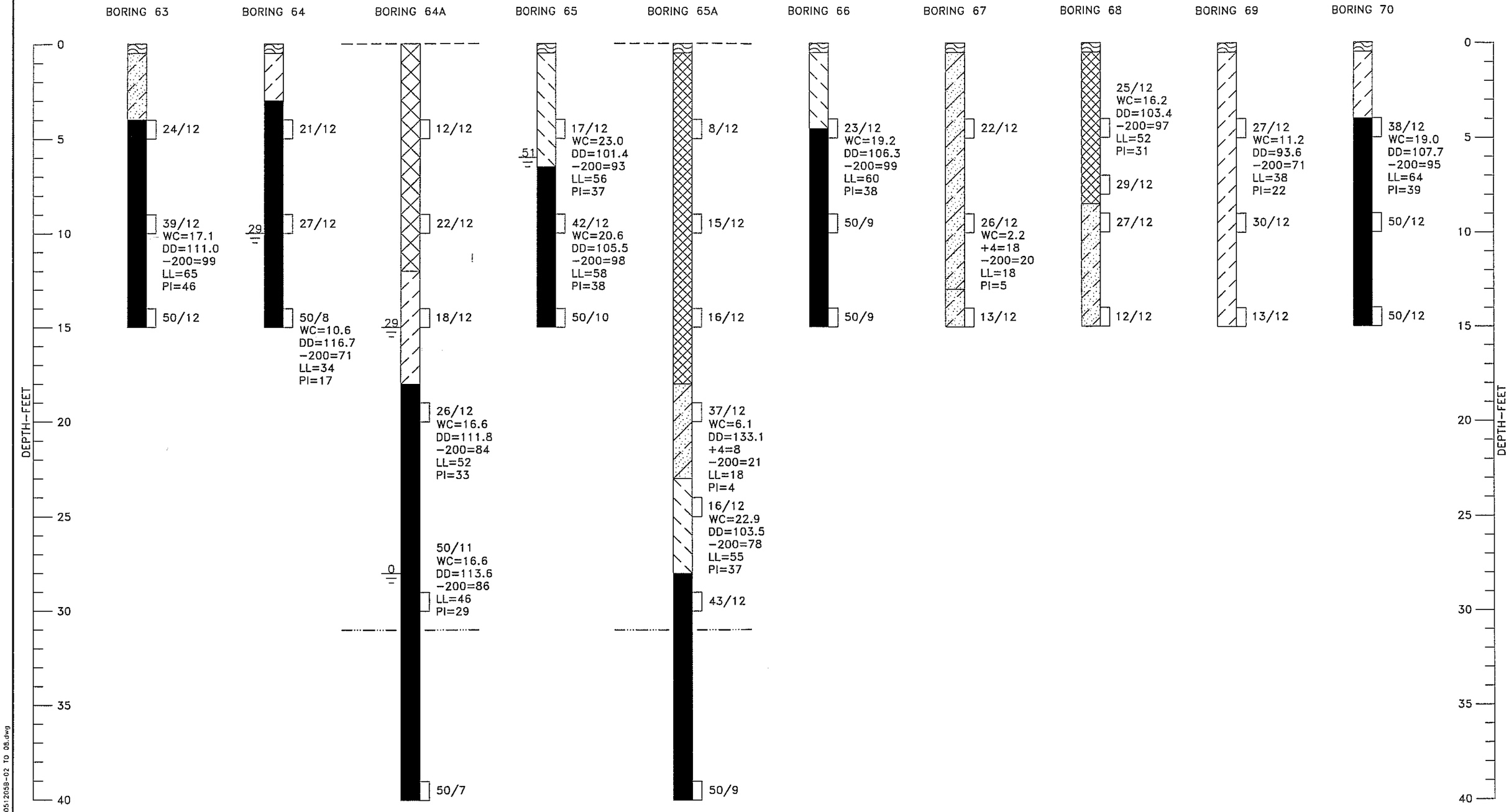

LEGEND:

- - - - - - - - APPROXIMATE ROAD SURFACE.

———·———·——— ASSUMED APPROXIMATE PIPELINE INVERT DEPTH AT BORING.

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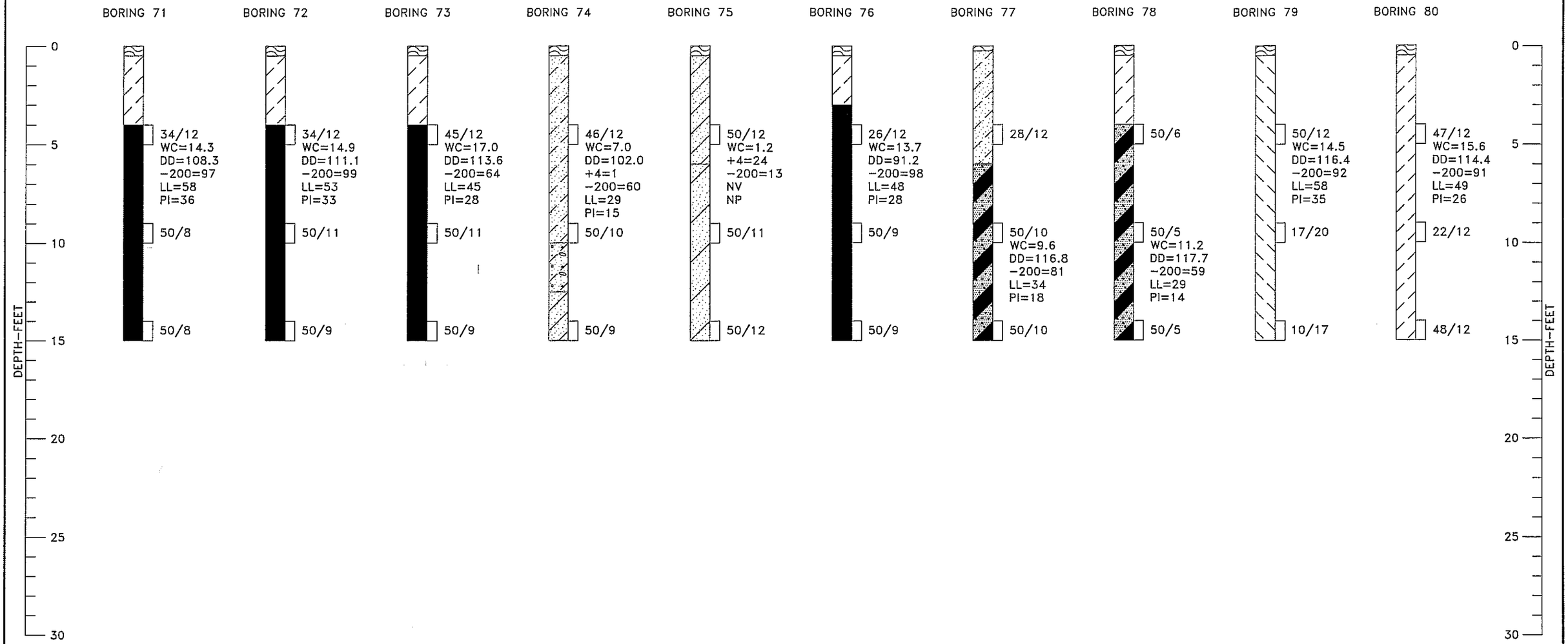

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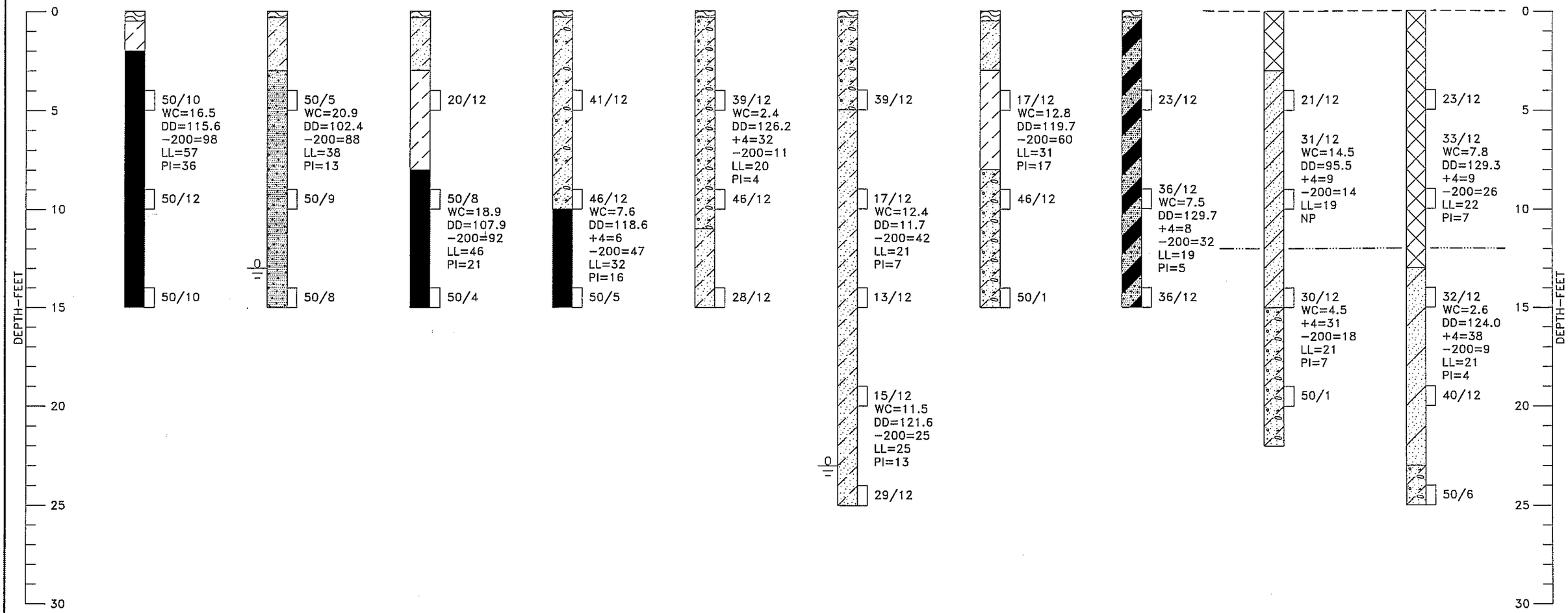
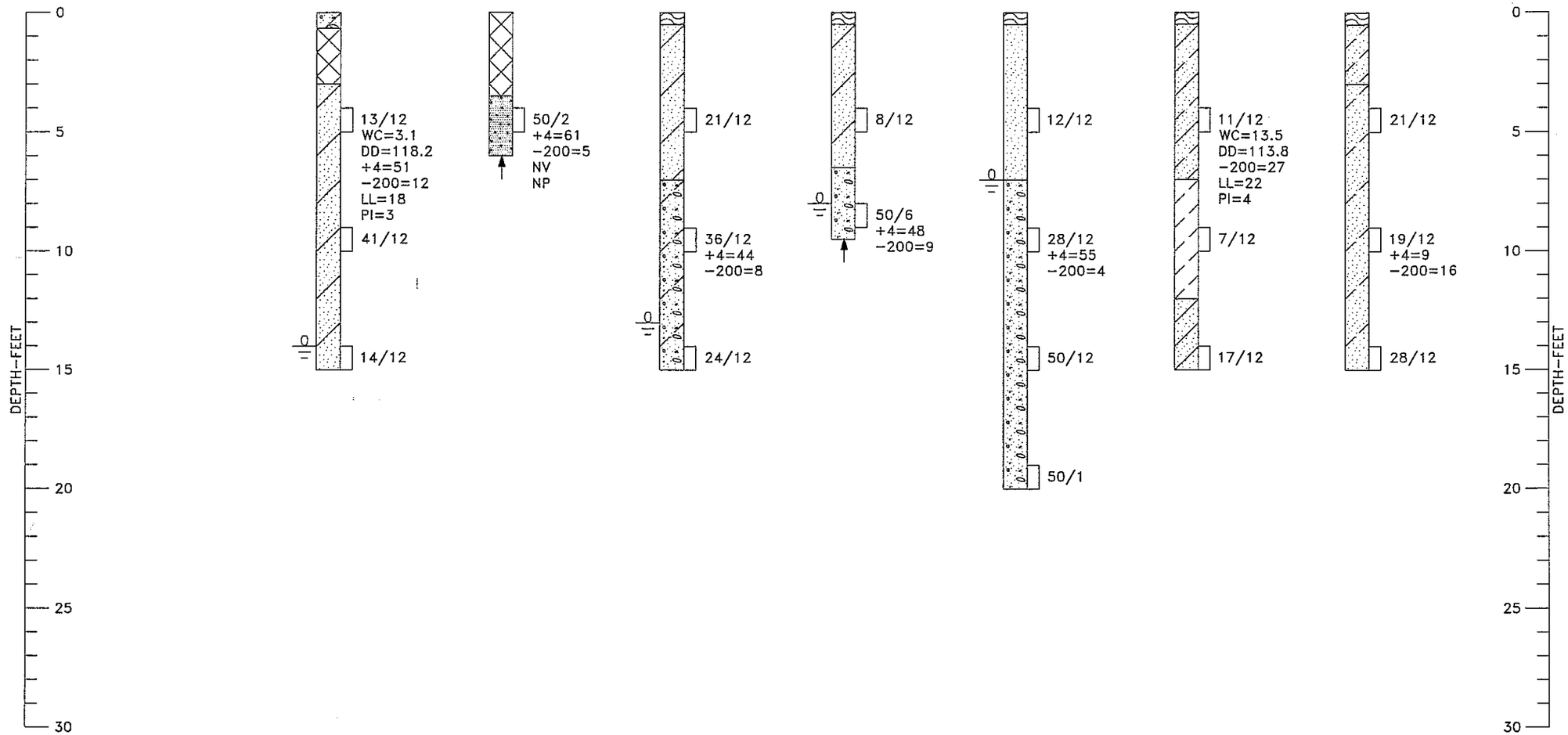


LEGEND:

- - - - - - - - APPROXIMATE ROAD SURFACE.

———·——·——— ASSUMED APPROXIMATE PIPELINE INVERT DEPTH AT BORING.

05-1-205B	Kumar & Associates	ROXBOROUGH PARK WASTEWATER REGIONALIZATION PROJECT FORCE MAIN ALIGNMENT	LOGS OF EXPLORATORY BORINGS	Fig. 6



05-1-205B	Kumar & Associates	ROXBOROUGH PARK WASTEWATER REGIONALIZATION PROJECT FORCE MAIN ALIGNMENT	LOGS OF EXPLORATORY BORINGS	Fig. 7

LEGEND

TOPSOIL, ROOTED CLAYEY SAND TO CLAY.

FILL: LEAN CLAY TO CLAYEY SAND, OCCASIONALLY VERY SANDY AND/OR GRAVELLY AND/OR CONTAINING POCKETS OF ORGANIC MATERIAL, MEDIUM TO HIGH PLASTICITY, MOIST, BROWN TO TAN–GRAY.

FILL: FAT CLAY TO FAT CLAY WITH SAND, OCCASIONALLY SANDY AND/OR GRAVELLY, CONTAINING CLAYSTONE CLASTS, HIGH PLASTICITY, MOIST, REDDISH–BROWN TO BROWN.

FAT CLAY (CH), HIGH PLASTICITY, VERY STIFF, MOIST, BROWN.

SANDY LEAN CLAY TO LEAN CLAY (CL), MEDIUM TO HIGH PLASTICITY, STIFF TO HARD, SLIGHTLY MOIST TO MOIST, BROWN TO REDDISH–BROWN, OCCASIONALLY CALCAREOUS.

CLAYEY SAND (SC), OCCASIONALLY GRAVELLY, FINE TO COARSE–GRAINED, MEDIUM DENSE TO DENSE, SLIGHTLY MOIST TO WET, TAN TO BROWN TO RED, OCCASIONALLY CALCAREOUS.

SILTY SAND (SM), FINE TO COARSE–GRAINED, MEDIUM DENSE TO DENSE, SLIGHTLY MOIST TO MOIST, RED.

CLAYEY SILTY SAND (SC–SM), FINE TO COARSE–GRAINED, LOW PLASTICITY, MEDIUM DENSE, MOIST TO WET, TAN.

POORLY–GRADED SAND WITH CLAY (SP–SC), OCCASIONALLY GRAVELLY, FINE TO COARSE–GRAINED SAND, MEDIUM DENSE TO DENSE, SLIGHTLY MOIST TO MOIST, RED.

WELL TO POORLY–GRADED SAND WITH SILT (SP–SM), OCCASIONALLY GRAVELLY, FINE TO COARSE–GRAINED, MEIDUM DENSE TO DENSE, SLIGHTLY MOIST TO WET, TAN TO PINK TO RED.

POORLY–GRADED SAND (SP), OCCASIONALLY GRAVELLY, FINE TO COARSE–GRAINED SAND, MEDIUM DENSE, SLIGHTLY MOIST TO WET, TAN TO RED.

POORLY–GRADED GRAVELS WITH CLAY AND SAND (GP–GC), OCCASIONAL COBBLES, FINE TO COARSE–GRAINED SANDS, APPARENTLY MEDIUM DENSE TO DENSE, MOIST, TAN.

SANDSTONE TO SILTSTONE BEDROCK, FINE–GRAINED, LOW PLASTICITY, HARD TO VERY HARD, MOIST, MEDIUM GRAY TO ORANGE.

CLAYSTONE BEDROCK, HIGH PLASTICITY, FIRM TO VERY HARD, SLIGHTLY MOIST TO MOIST, LIGHT GRAY TO MEDIUM GRAY TO GRAY ORANGE.

INTERBEDDED CLAYSTONE AND SANDSTONE BEDROCK, LOW TO HIGH PLASTICITY, FINE–GRAINED, HARD, SLIGHTLY MOIST, GRAY TO ORANGE–GRAY.

DRIVE SAMPLE, 2–INCH I.D. CALIFORNIA LINER SAMPLE.

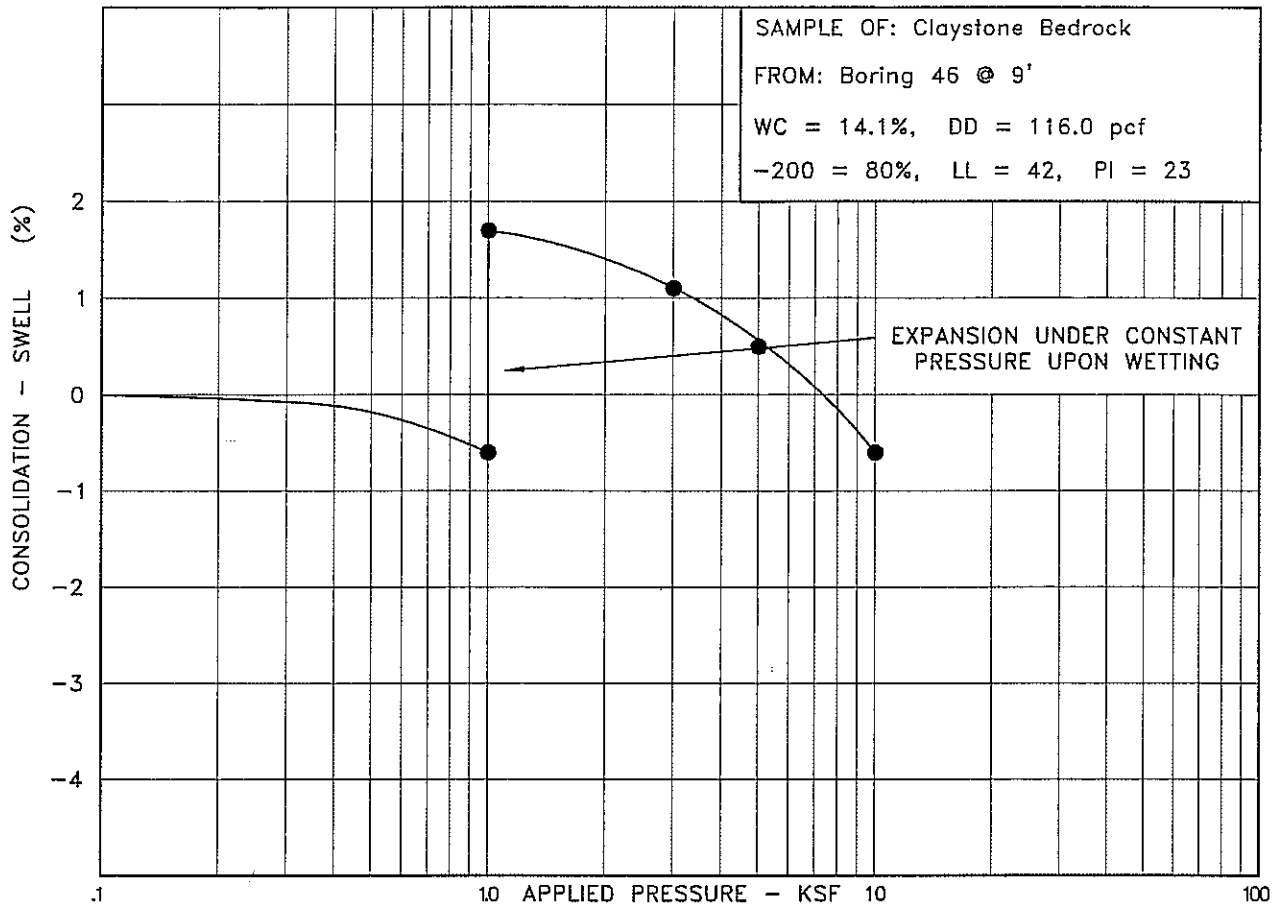
16/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 16 BLOWS OF A 140–POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

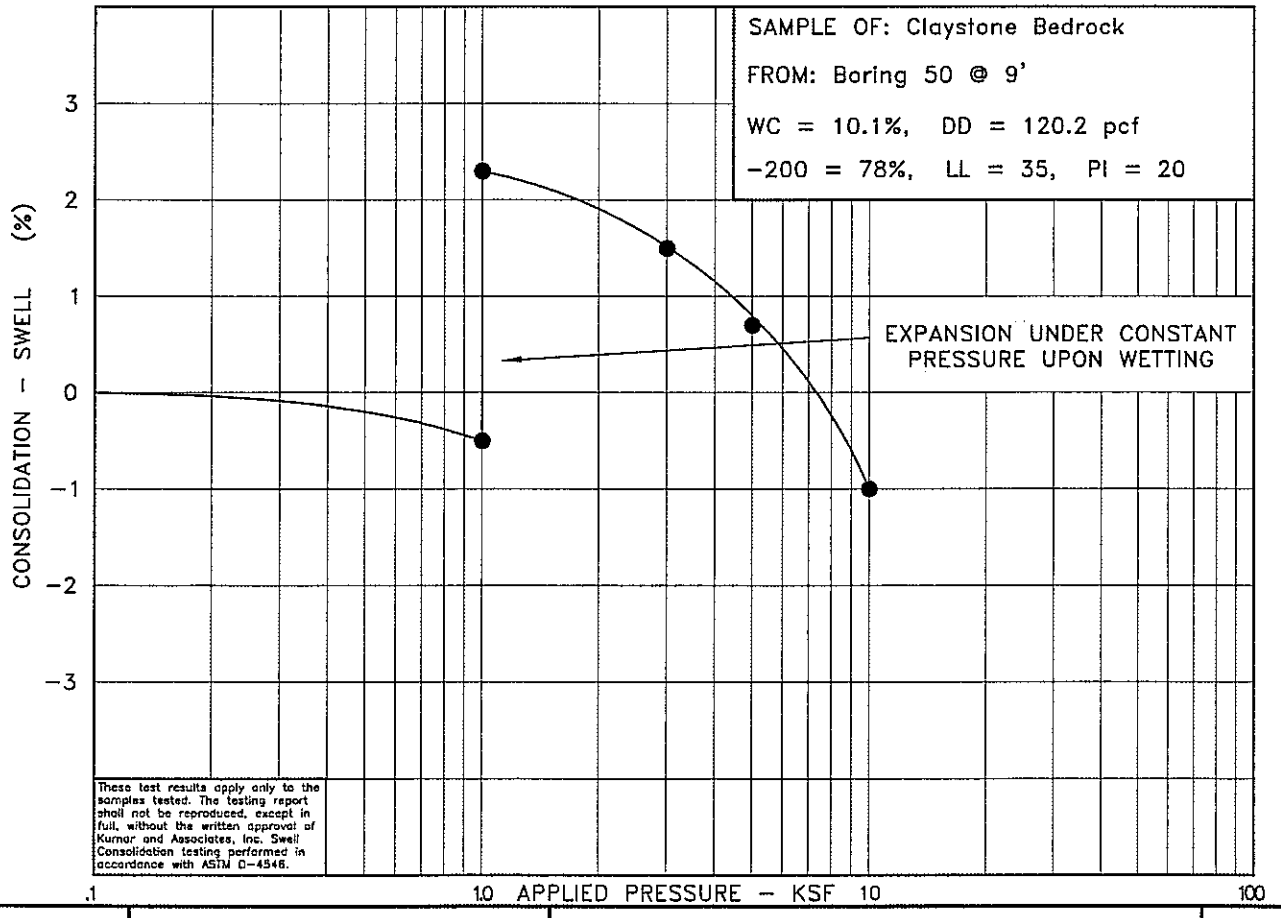
▽ DEPTH TO WATER LEVEL ENCOUNTERED AT THE TIME OF DRILLING.

PRACTICAL AUGER REFUSAL.

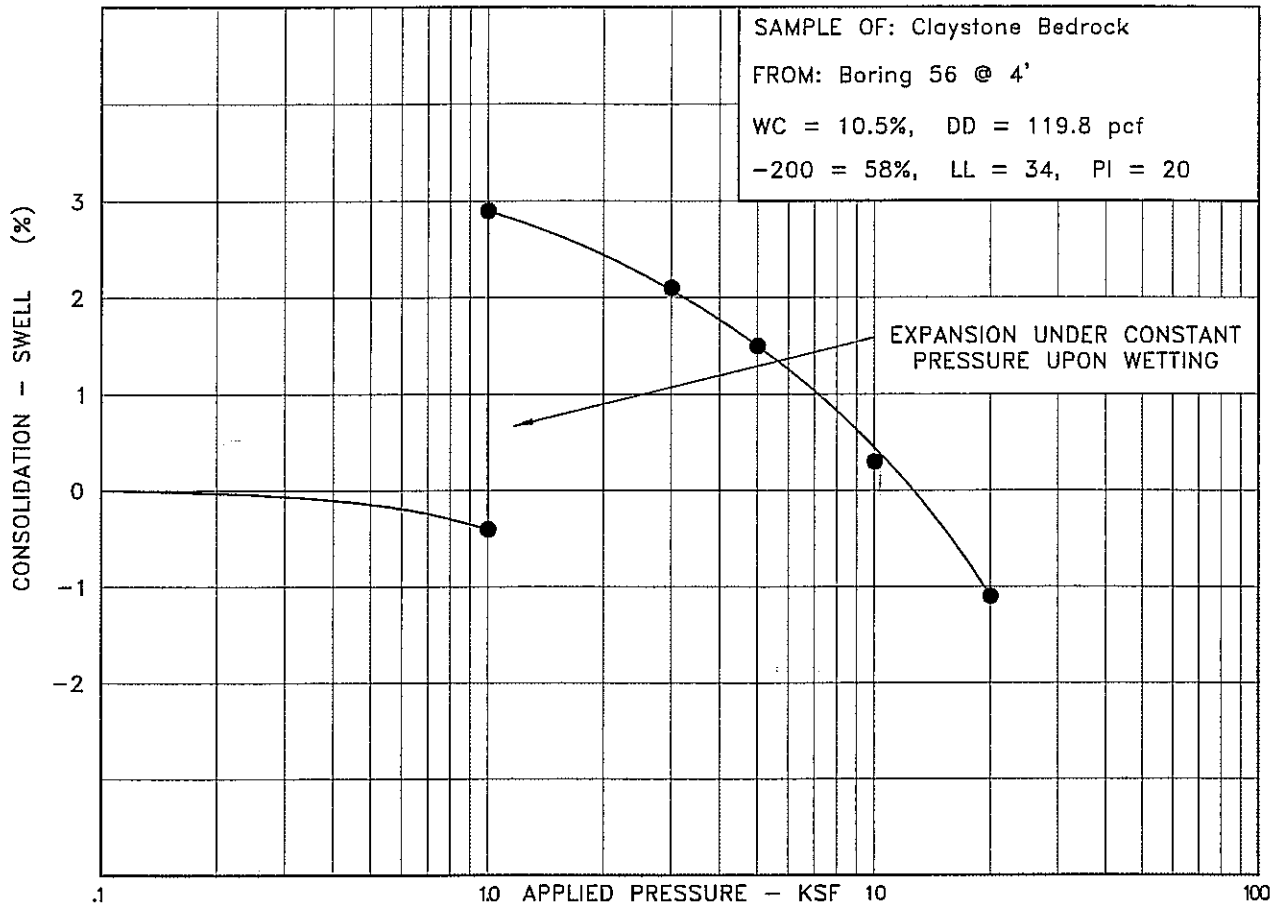
NOTES

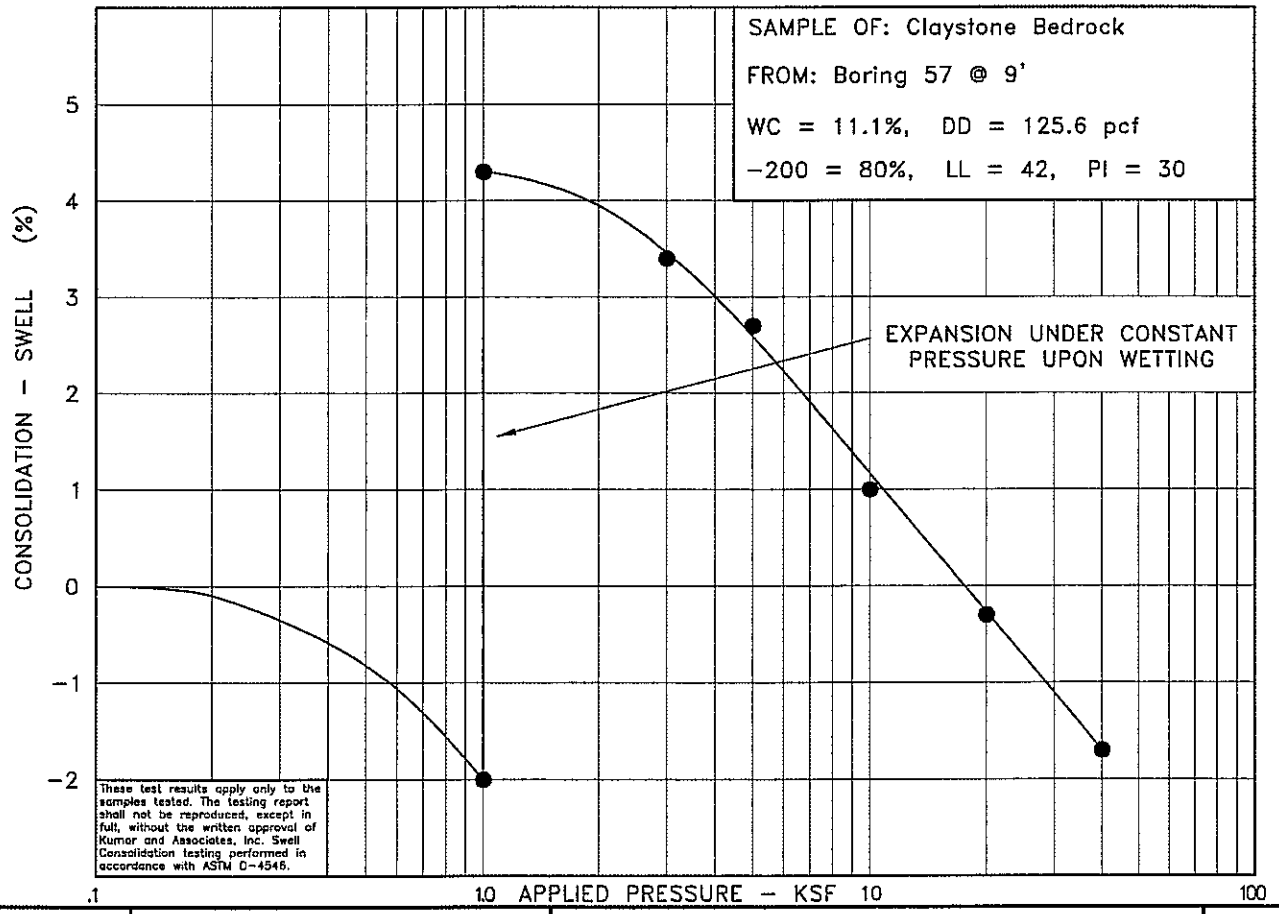
1. THE EXPLORATORY BORINGS WERE DRILLED ON APRIL 10, APRIL 11, APRIL 18, MAY 2 MAY 8, MAY 18, MAY 23, 2006 AND JULY 22, 2005 WITH A 4–INCH DIAMETER CONTINUOUS FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED BY INSTRUMENT SURVEY FROM THE CLIENT.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE NOT MEASURED AND THE LOGS OF THE EXPLORATORY BORINGS ARE PLOTTED TO DEPTH.
4. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
5. GROUND WATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
6. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D 2216);
   DD = DRY DENSITY (pcf) (ASTM D 2216);
   +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D 422);
   –200 = PERCENTAGE PASSING NO. 200 SIEVE (ASTM D 1140);
   LL = LIQUID LIMIT (ASTM D 4318);
   PI = PLASTICITY INDEX (ASTM D 4318);
   NP = NON–PLASTIC (ASTM D 4318);
   NV = NO LIQUID LIMIT VALUE (ASTM D 4318).





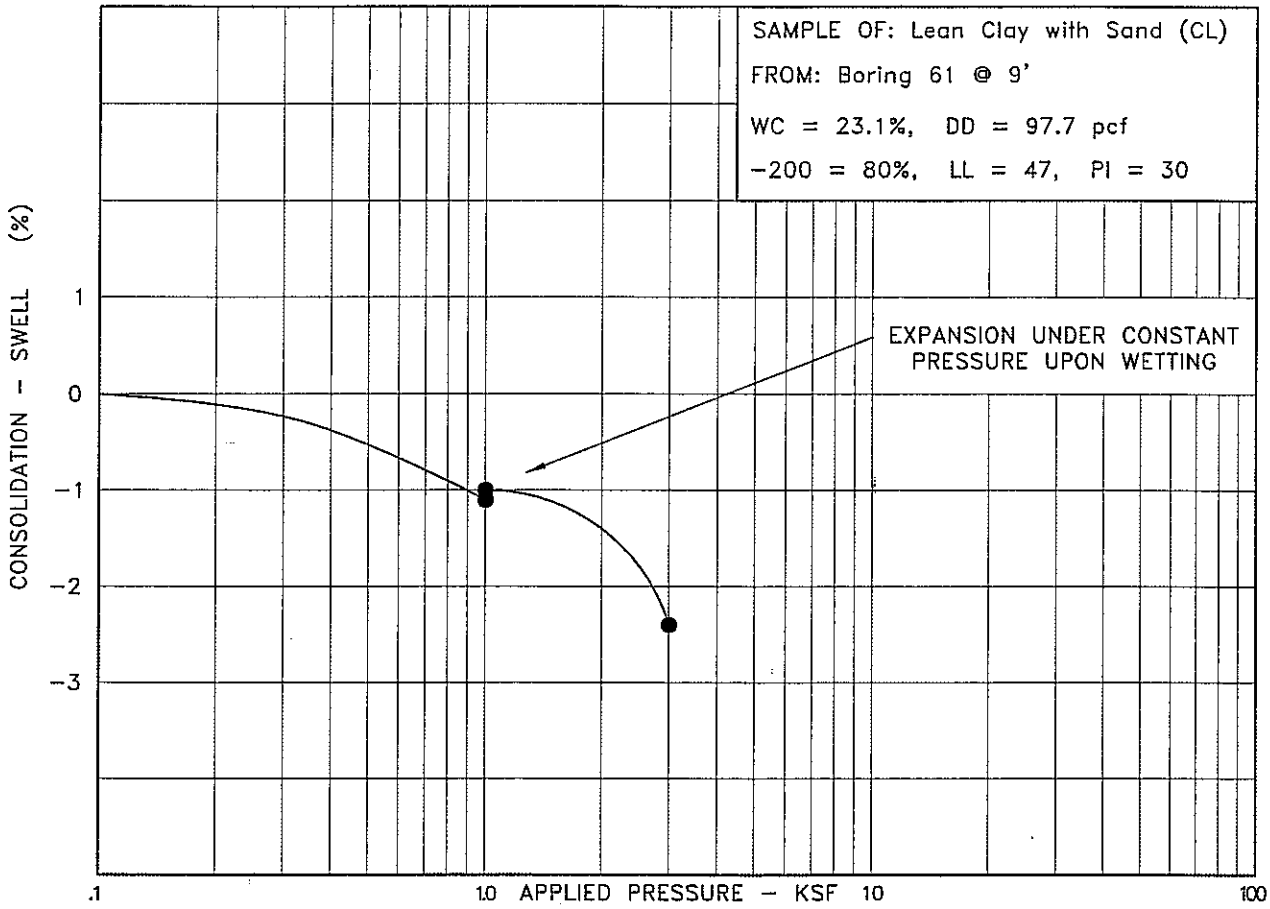
05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 9

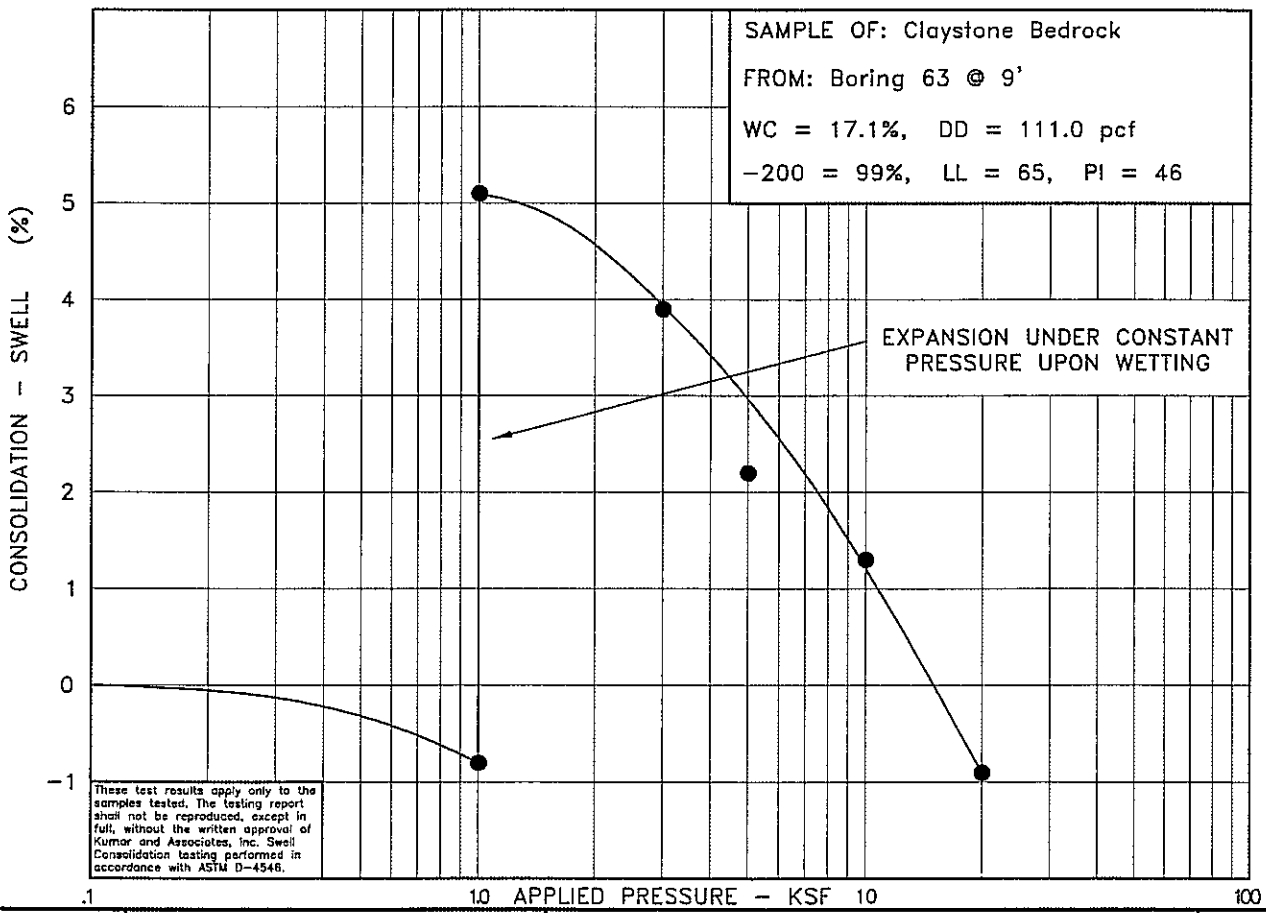




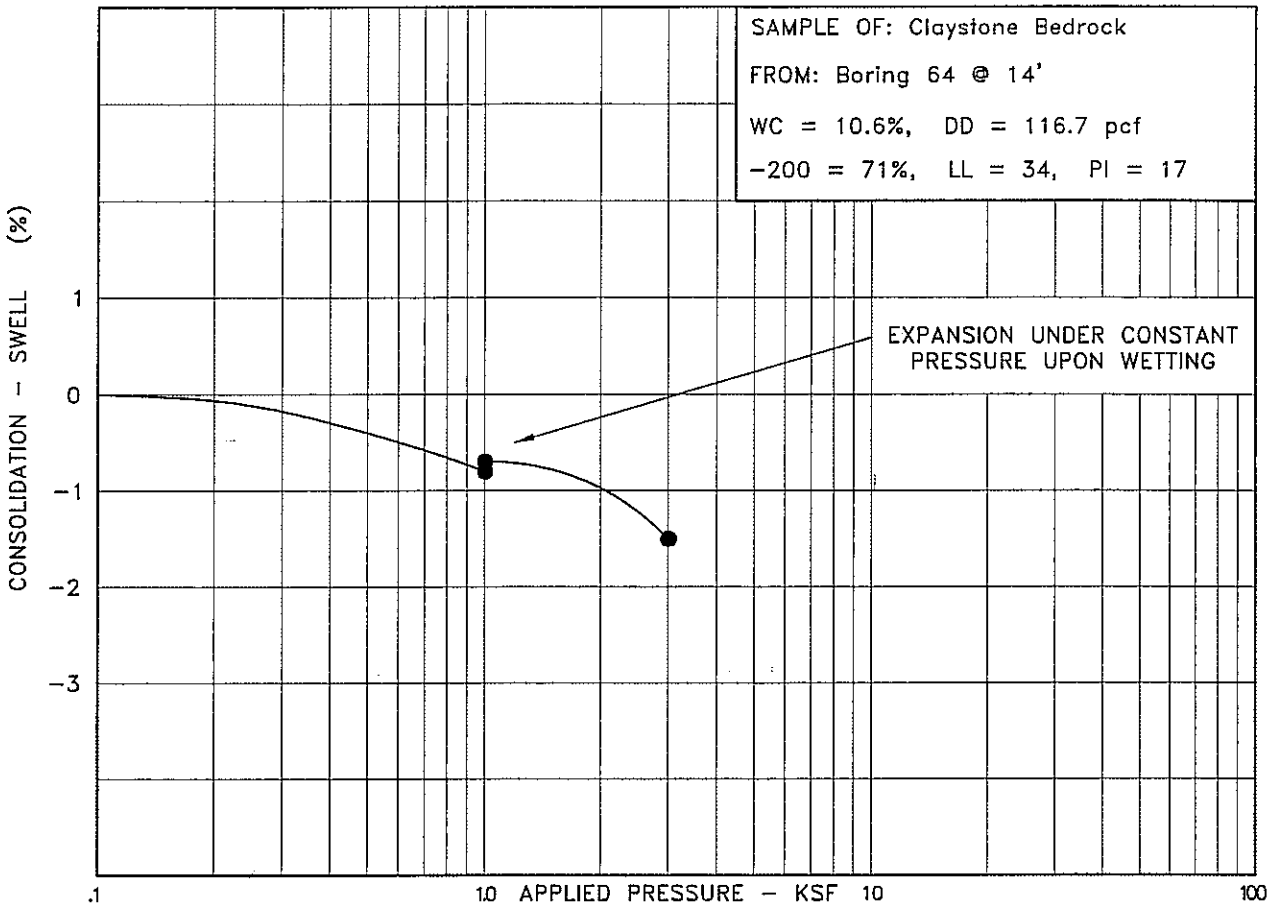
These test results apply only to the samples tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar and Associates, Inc. Swell Consolidation testing performed in accordance with ASTM D-4546.

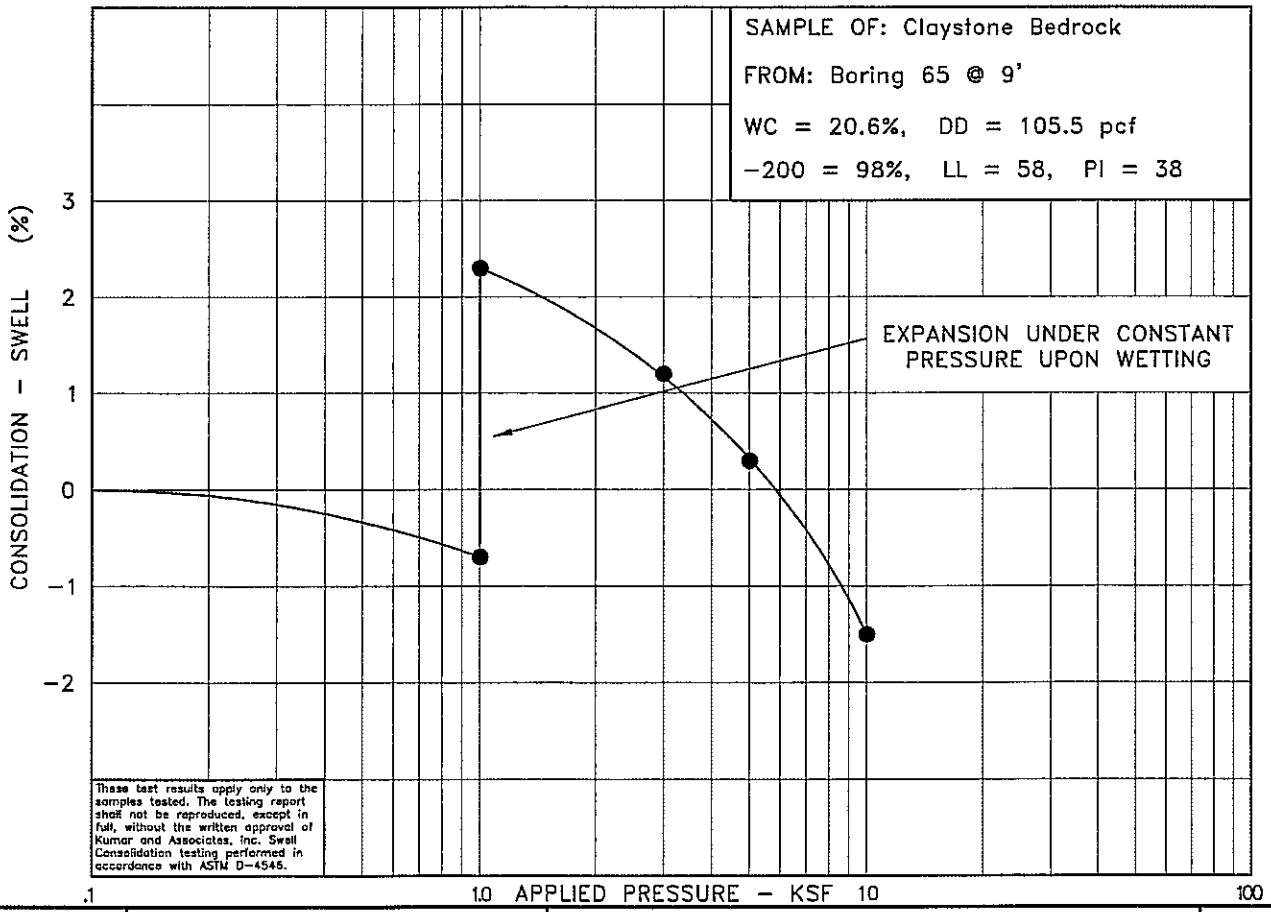
05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 10



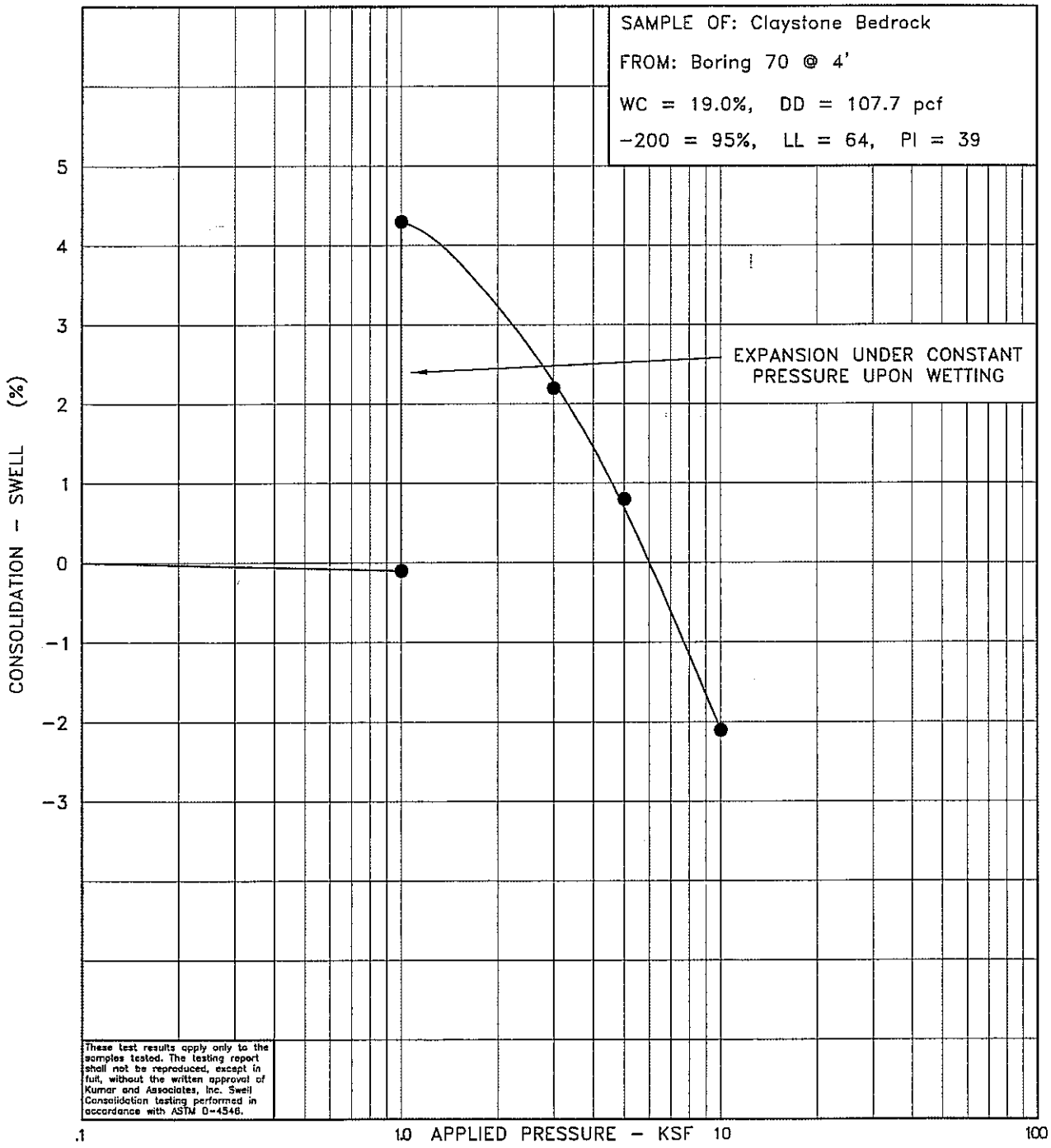


05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 11



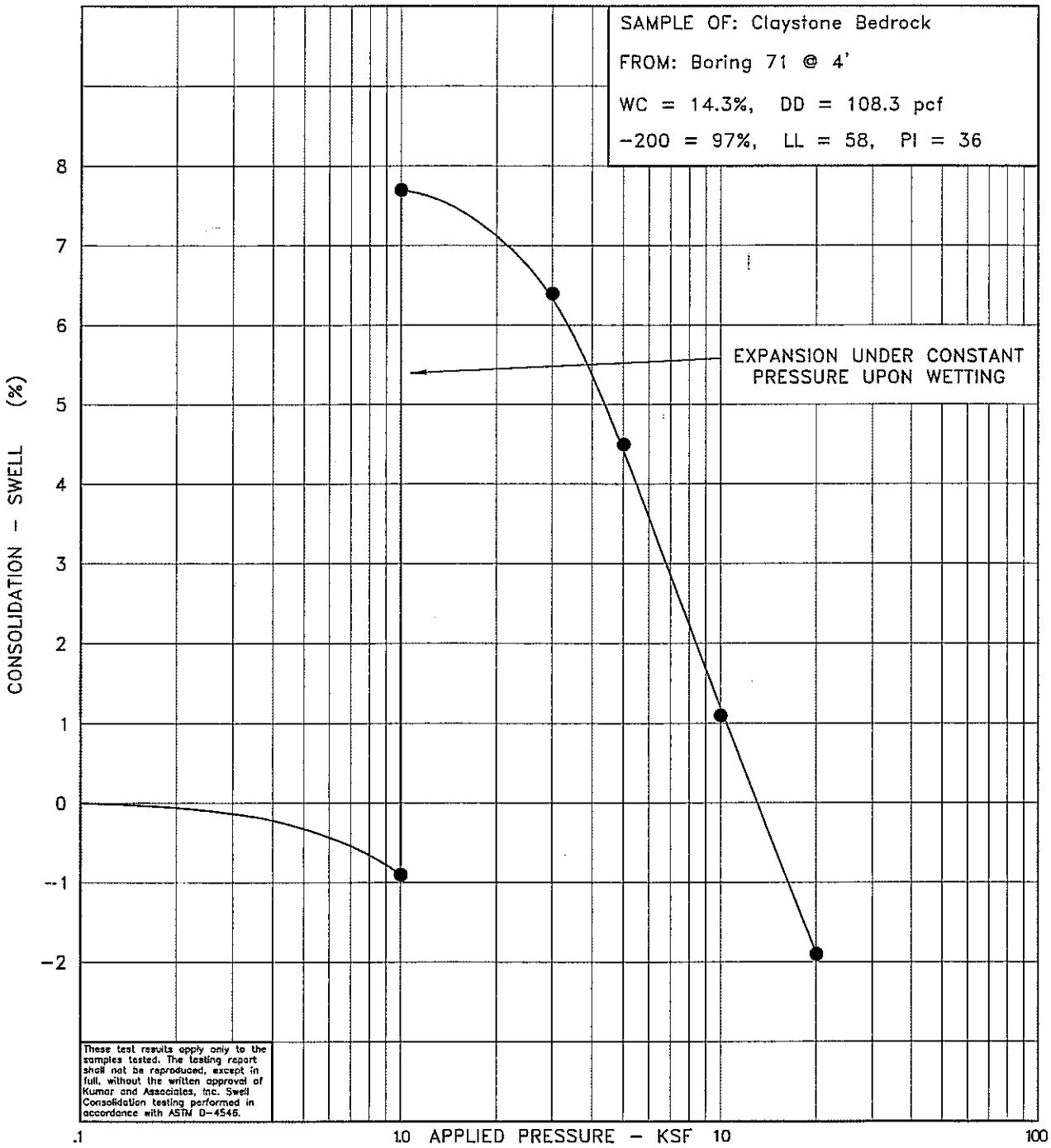


05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 12

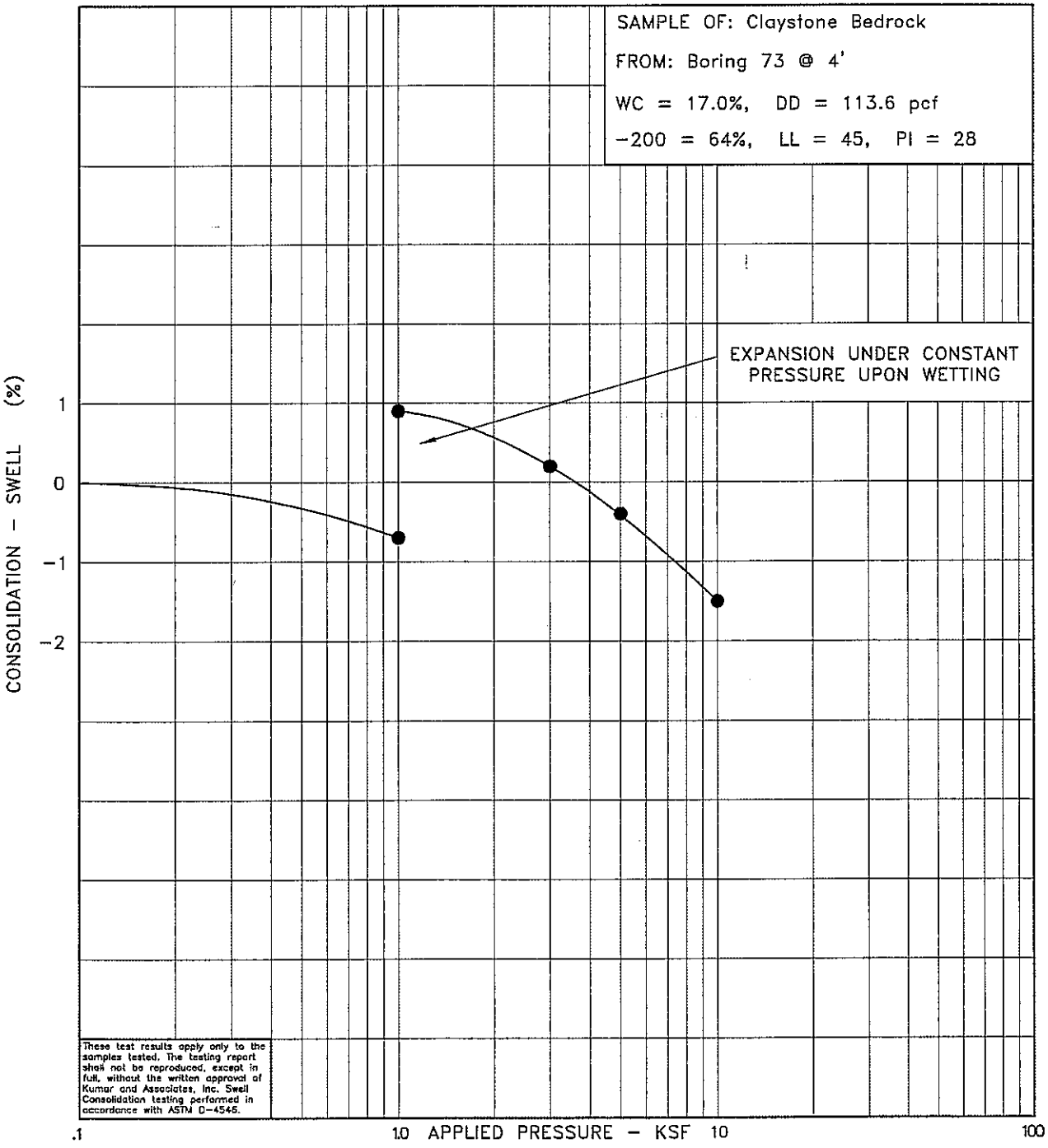


Jun 23, 06Y - 15:48pm
Y:\Projects\2005\05-1-205B\Drafting\05120SB-09 10 .18.dwg

05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 13



05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 14



05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 15

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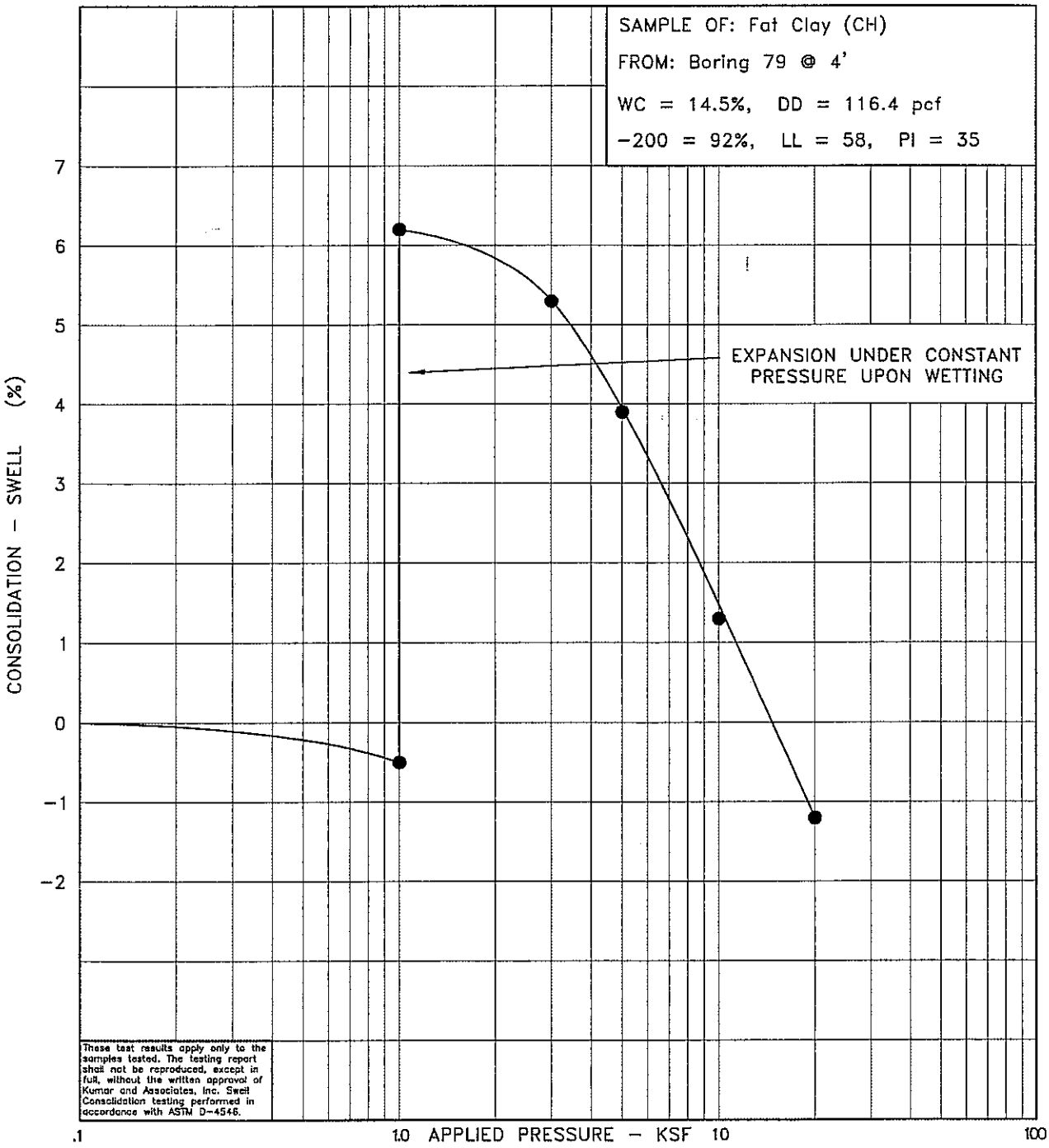

05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 16

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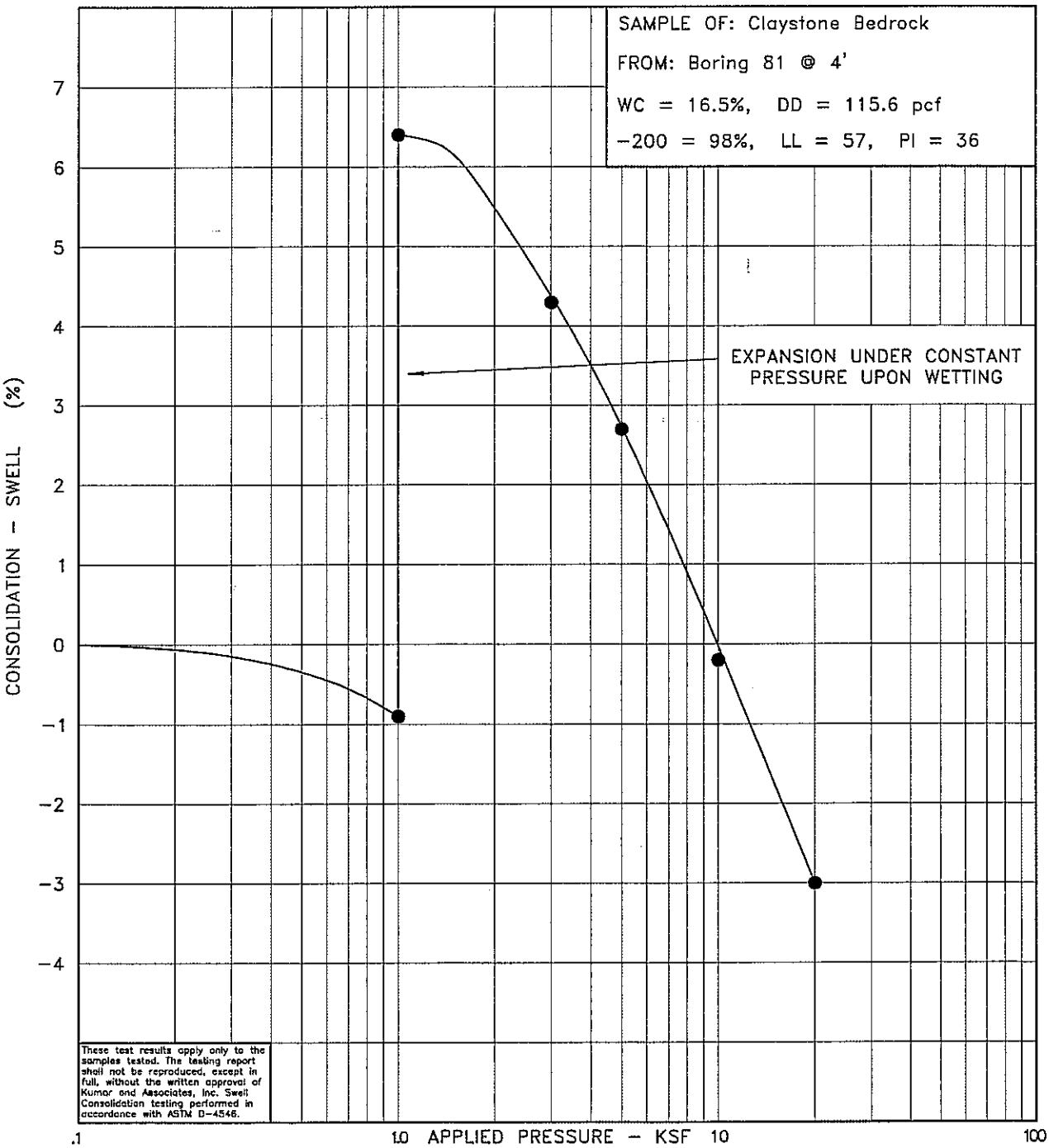
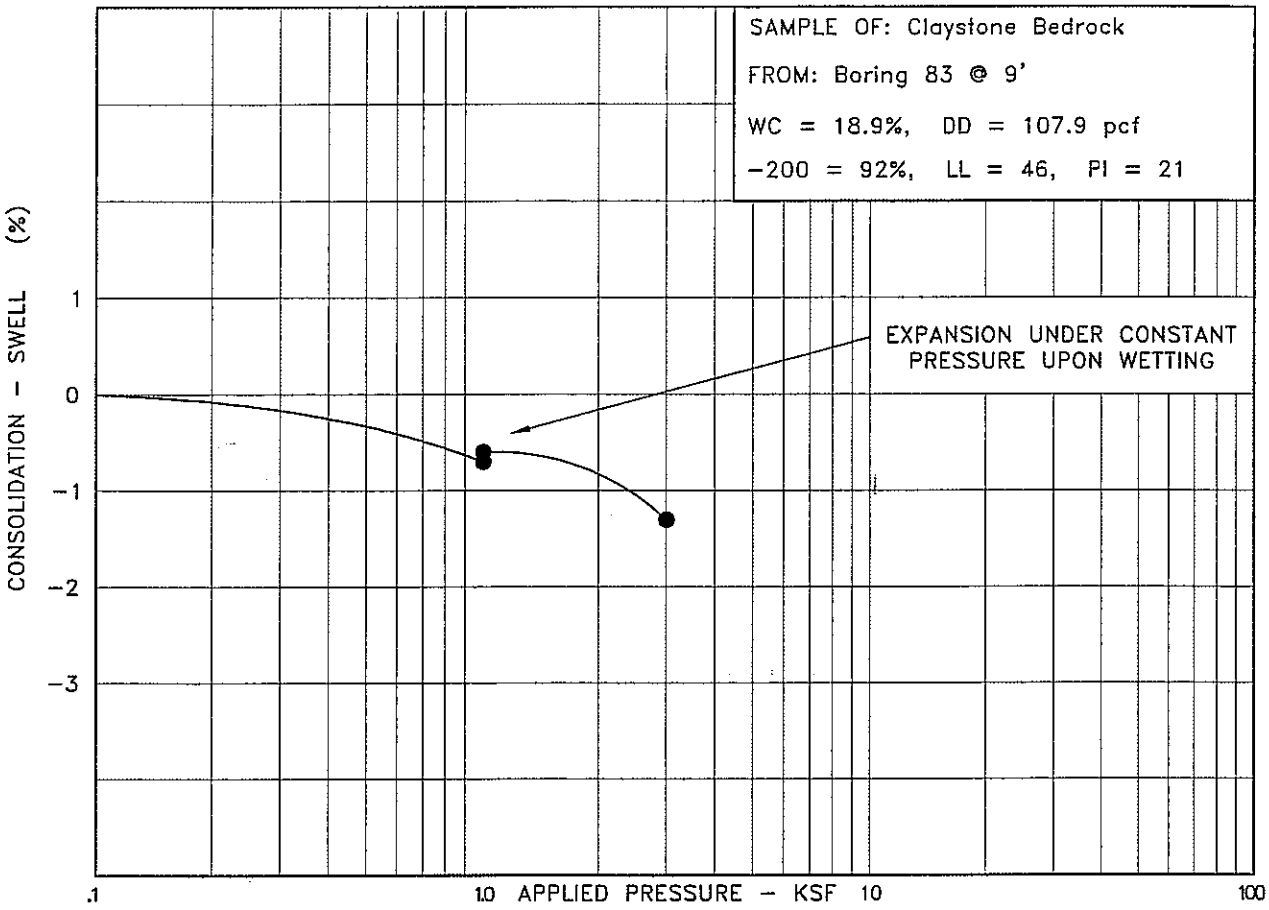
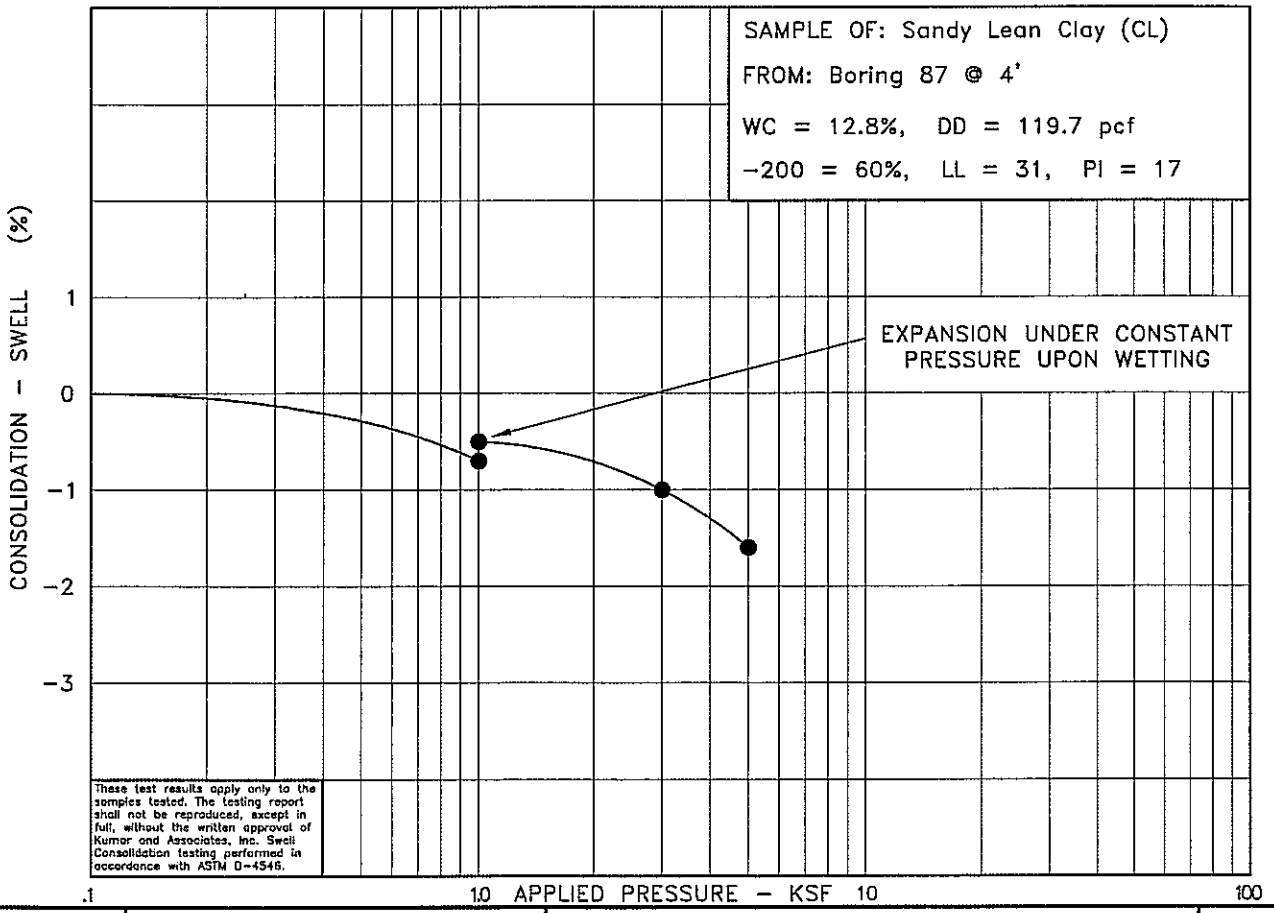
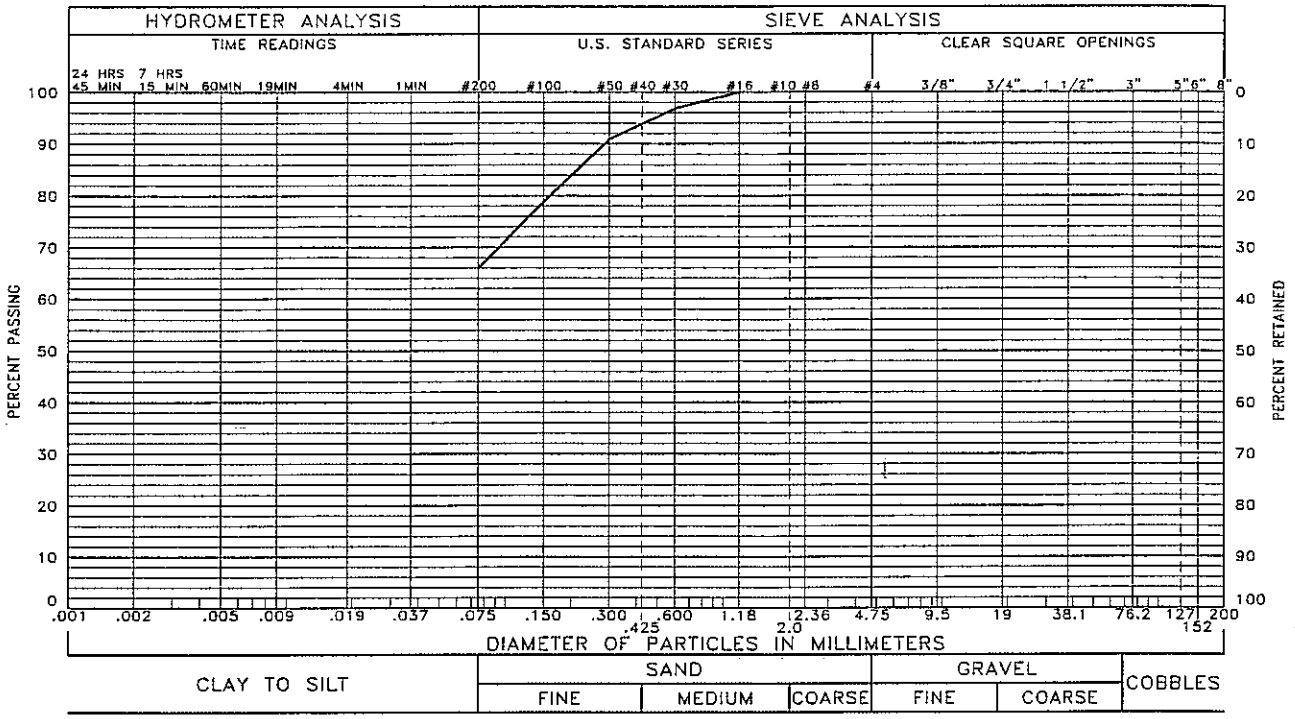


05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 17





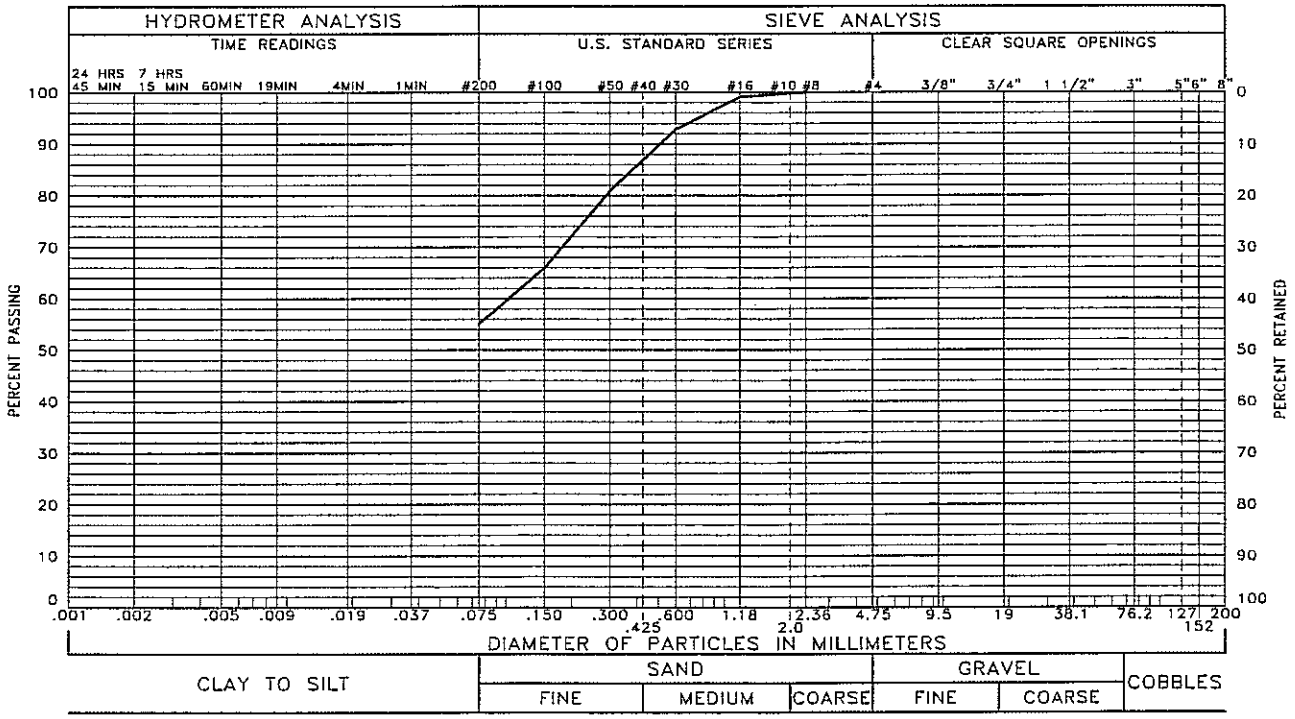
05-1-205B	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 18



GRAVEL 0% SAND 34% SILT AND CLAY 66%

LIQUID LIMIT 34 PLASTICITY INDEX 21

SAMPLE OF: Sandy Lean Clay (CL) FROM: Boring 44A @ 9'

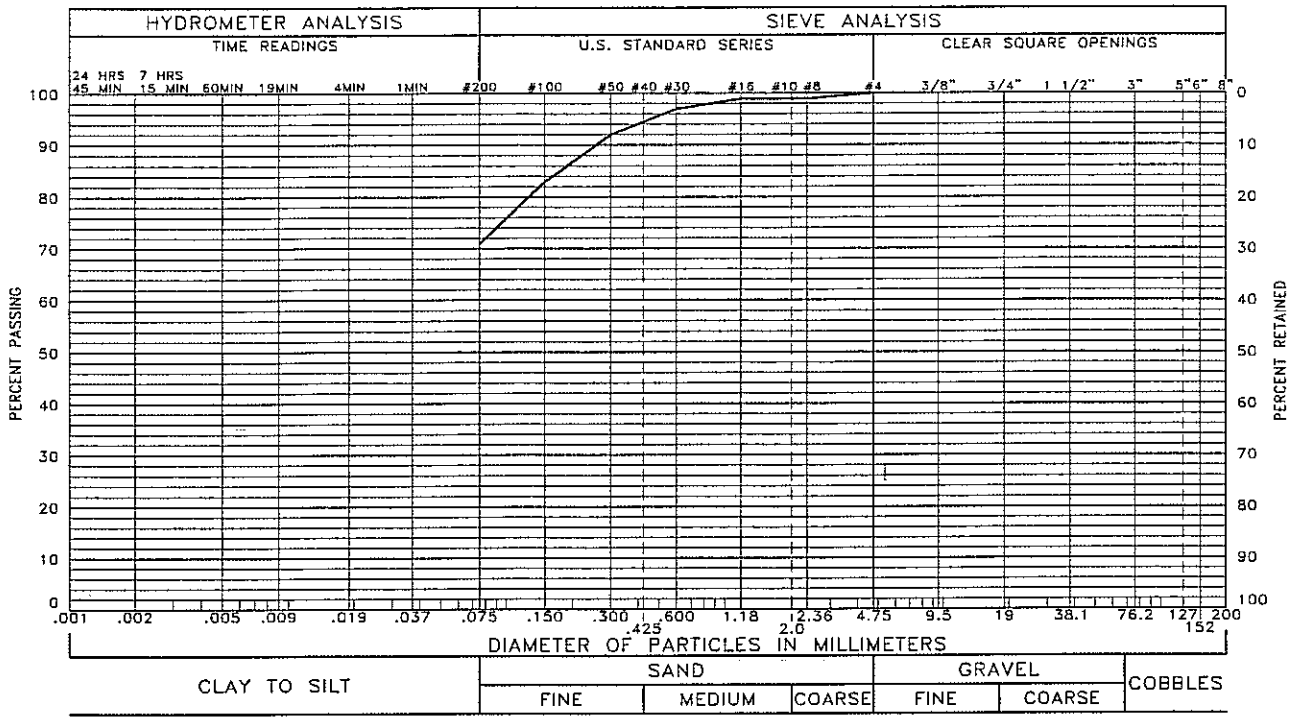


GRAVEL 0% SAND 45% SILT AND CLAY 55%

LIQUID LIMIT 33 PLASTICITY INDEX 22

SAMPLE OF: Sandy Lean Clay (CL) FROM: Boring 44A @ 14'

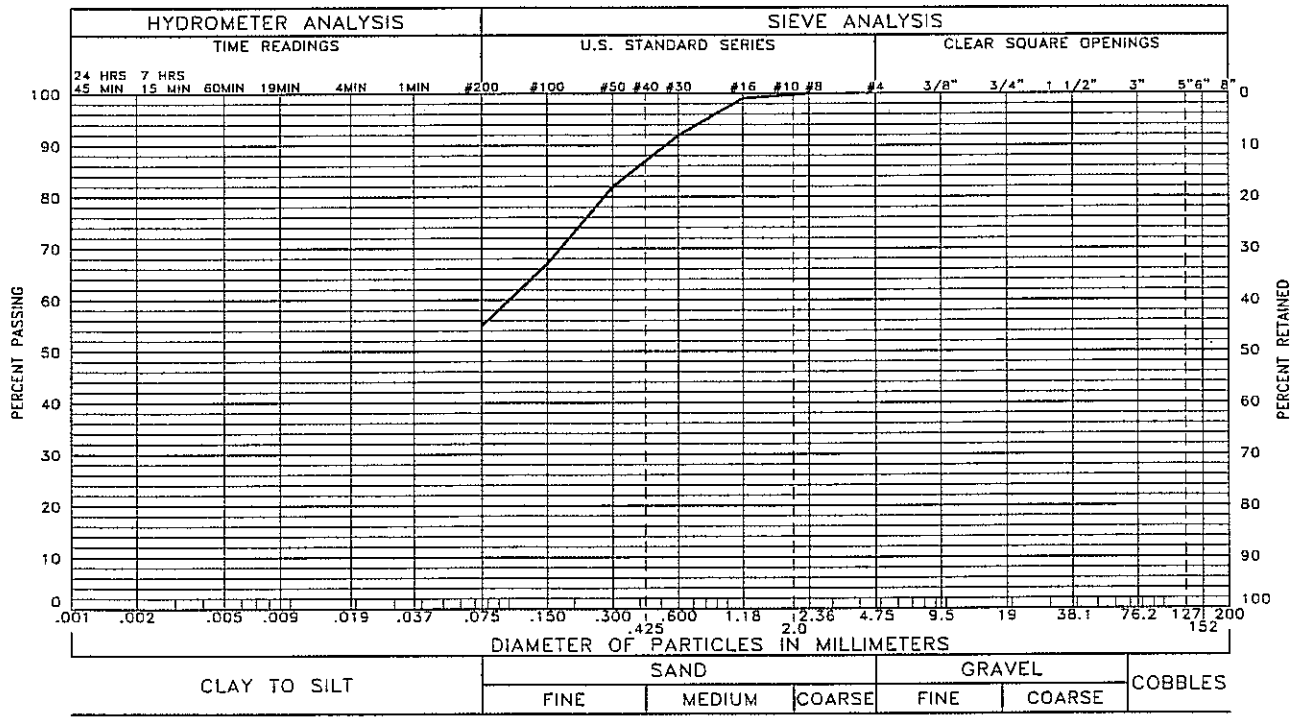
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 19



GRAVEL 0% SAND 29% SILT AND CLAY 71%

LIQUID LIMIT 35 PLASTICITY INDEX 22

SAMPLE OF: Fill: Lean Clay with Sand (CL) FROM: Boring 44B @ 4'

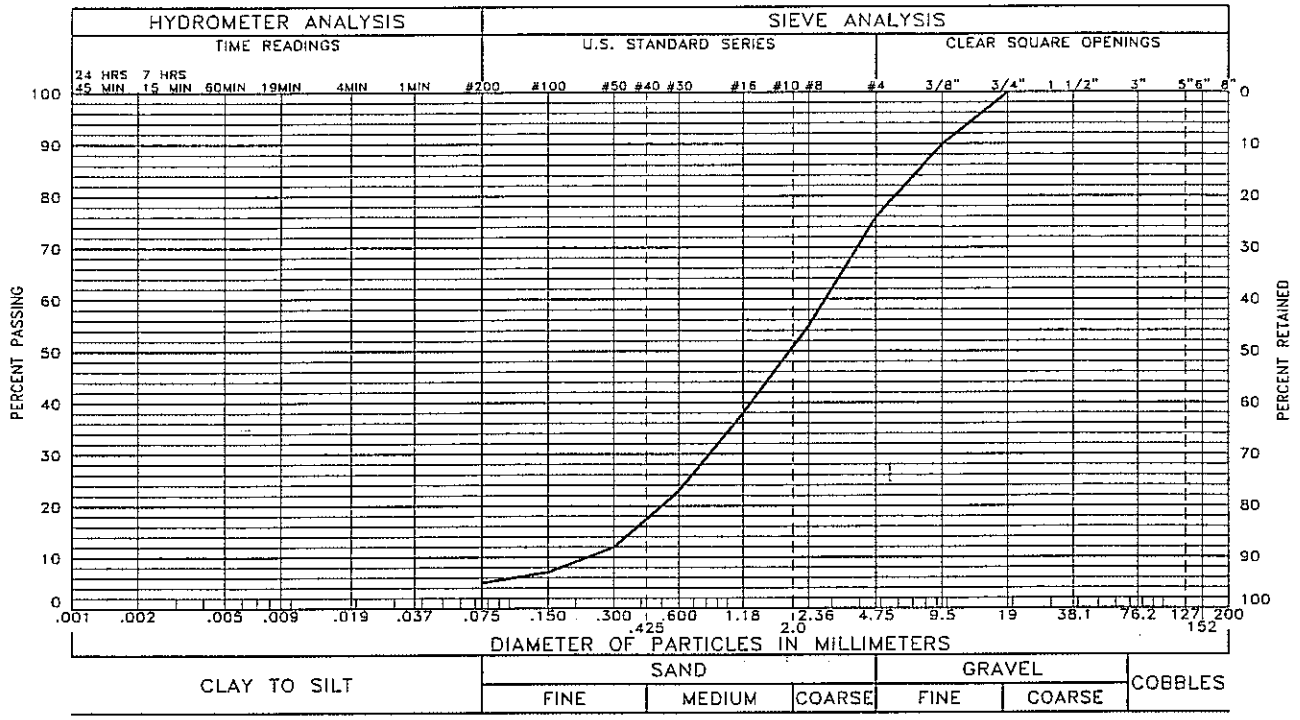


GRAVEL 0% SAND 45% SILT AND CLAY 55%

LIQUID LIMIT 35 PLASTICITY INDEX 22

SAMPLE OF: Fill: Sandy Lean Clay FROM: Boring 44B @ 9'

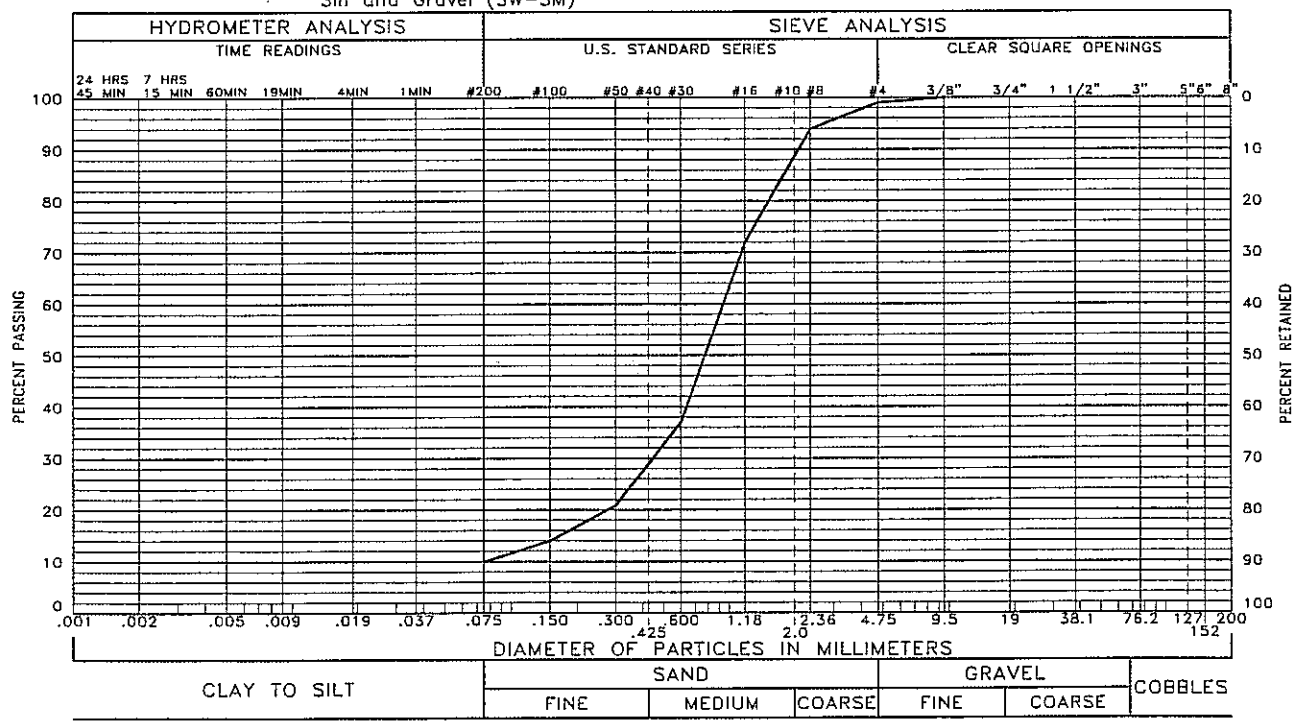
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 20



GRAVEL 24% SAND 71% SILT AND CLAY 5%

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Well-Graded Sand with Silt and Gravel (SW-SM) FROM: Boring 45 @ 4'

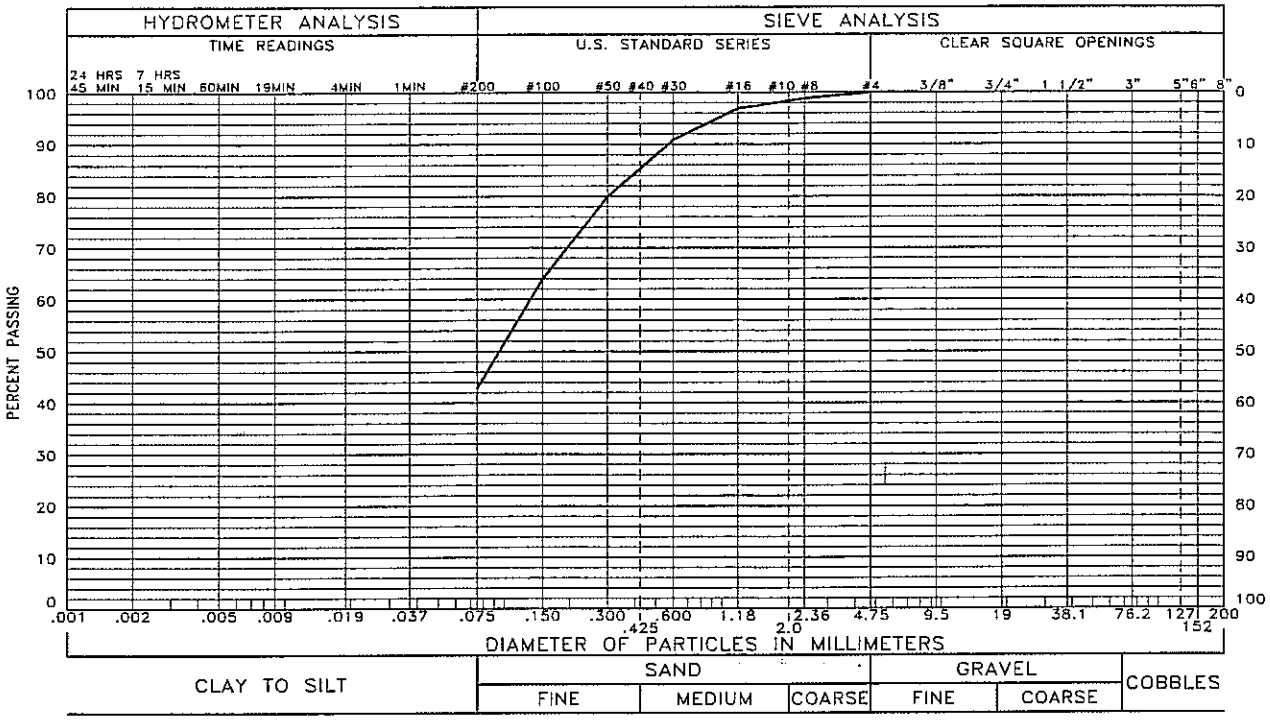


GRAVEL 1% SAND 89% SILT AND CLAY 10%

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Well-Graded Sand with Silt (SW-SM) FROM: Boring 51 @ 9'

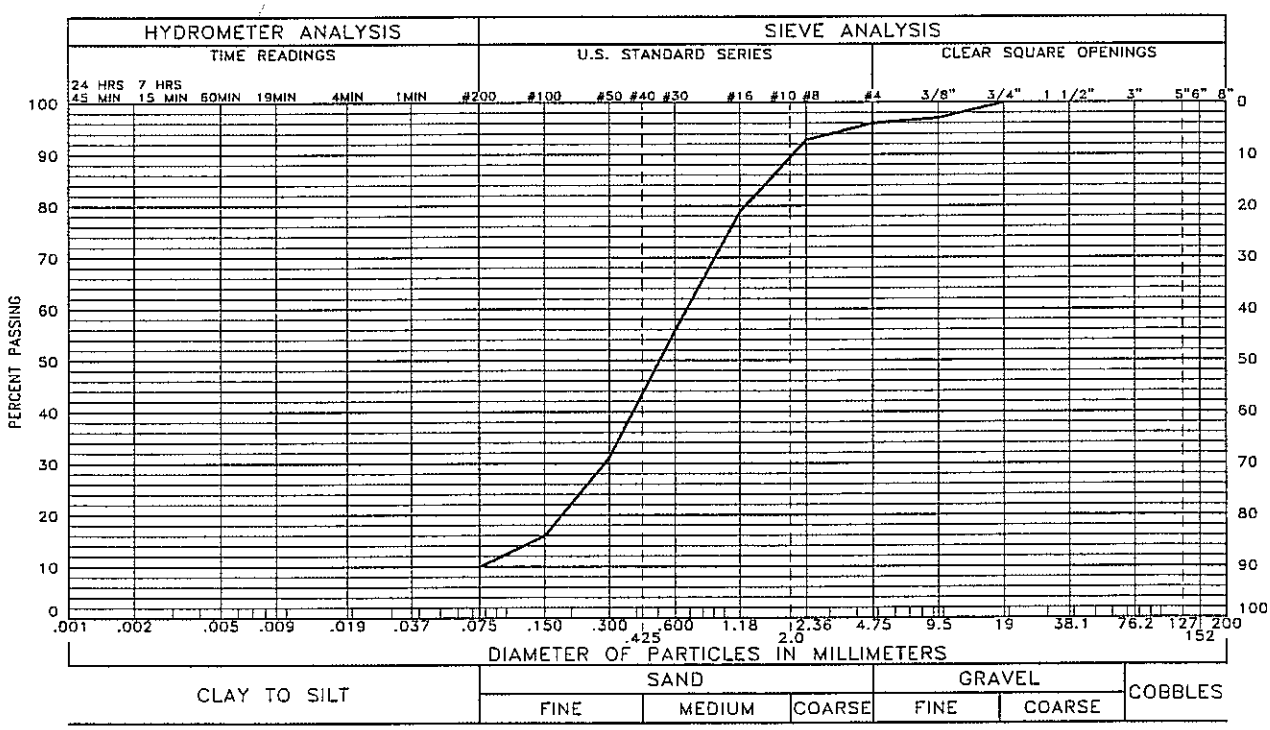
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 21



GRAVEL 0% SAND 57% SILT AND CLAY 43%

LIQUID LIMIT 26 PLASTICITY INDEX 10

SAMPLE OF: Clayey Sand (SC) FROM: Boring 52 @ 9'

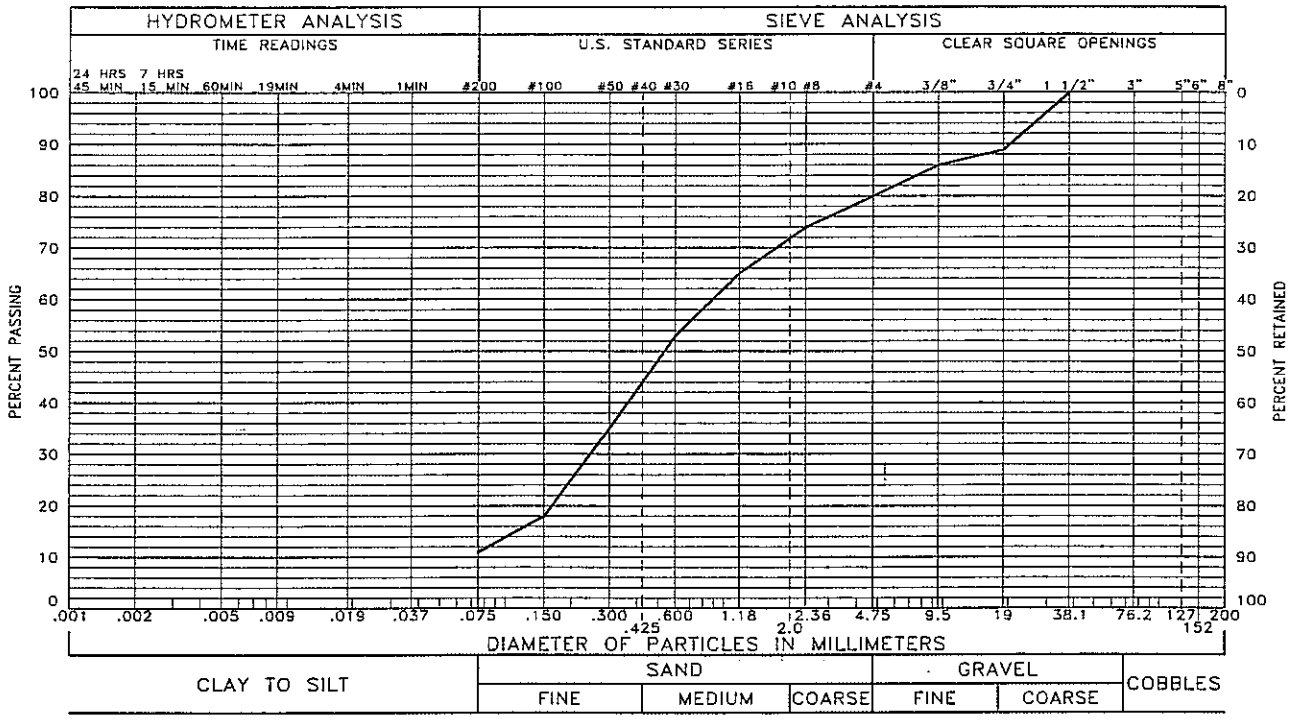


0.7
0.29
0.75

GRAVEL 4% SAND 86% SILT AND CLAY 10%

LIQUID LIMIT NV PLASTICITY INDEX NP

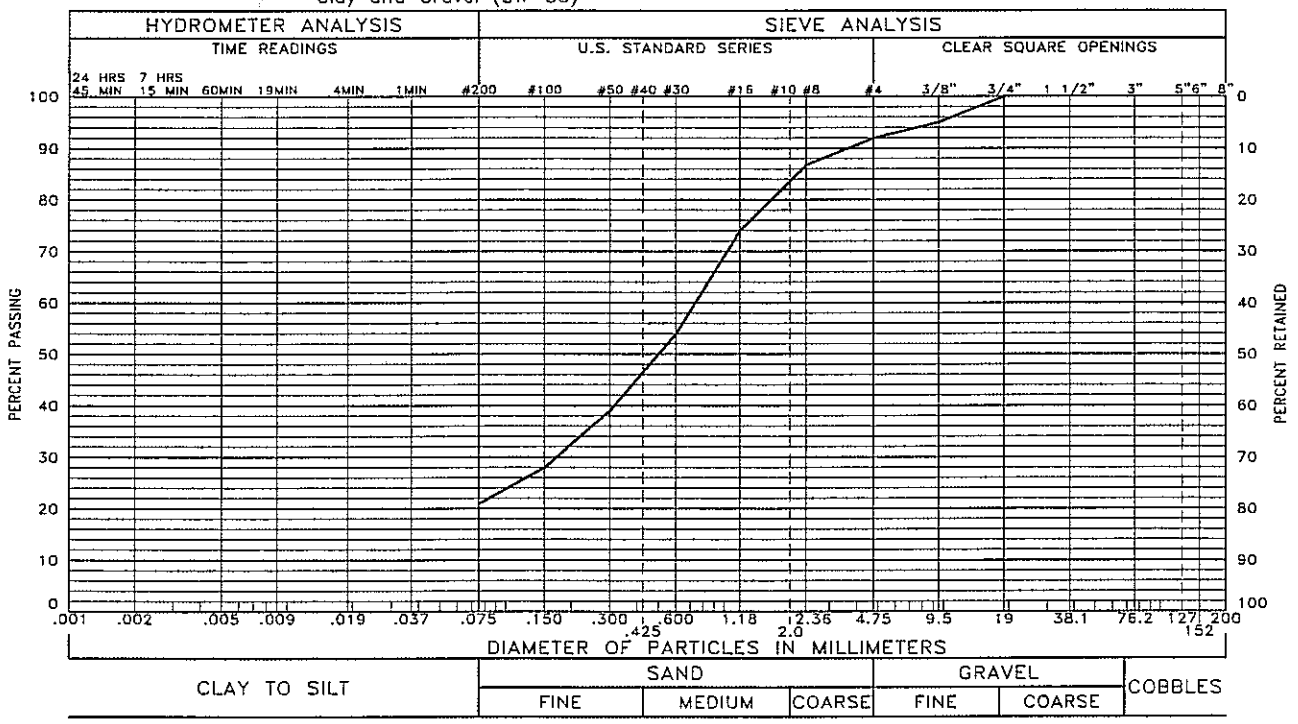
SAMPLE OF: Well-Graded Sand with Silt (SW-SM) FROM: Boring 53 @ 14'



GRAVEL 20% SAND 69% SILT AND CLAY 11%

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Well-Graded Sand with Clay and Gravel (SW-SC) FROM: Boring 54 @ 9'

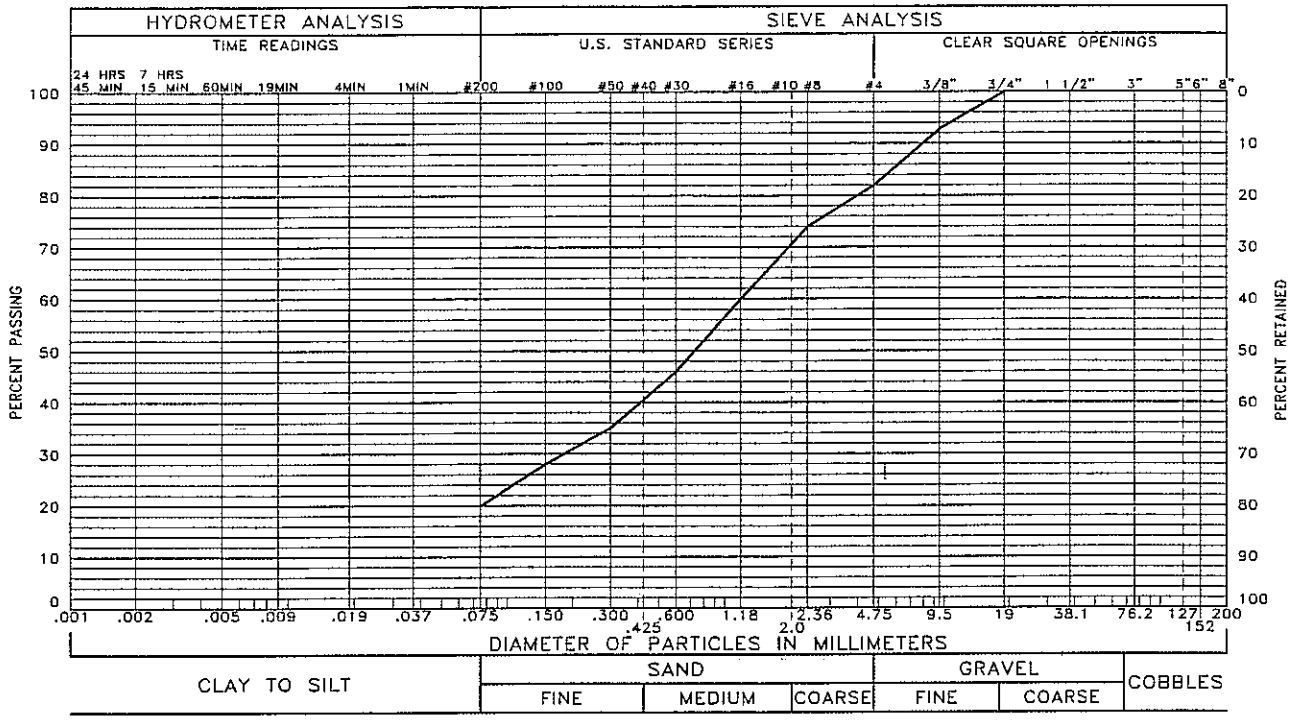


GRAVEL 8% SAND 71% SILT AND CLAY 21%

LIQUID LIMIT 18 PLASTICITY INDEX 4

SAMPLE OF: Clayey Silty Sand (SC-SM) FROM: Boring 65A @ 19'

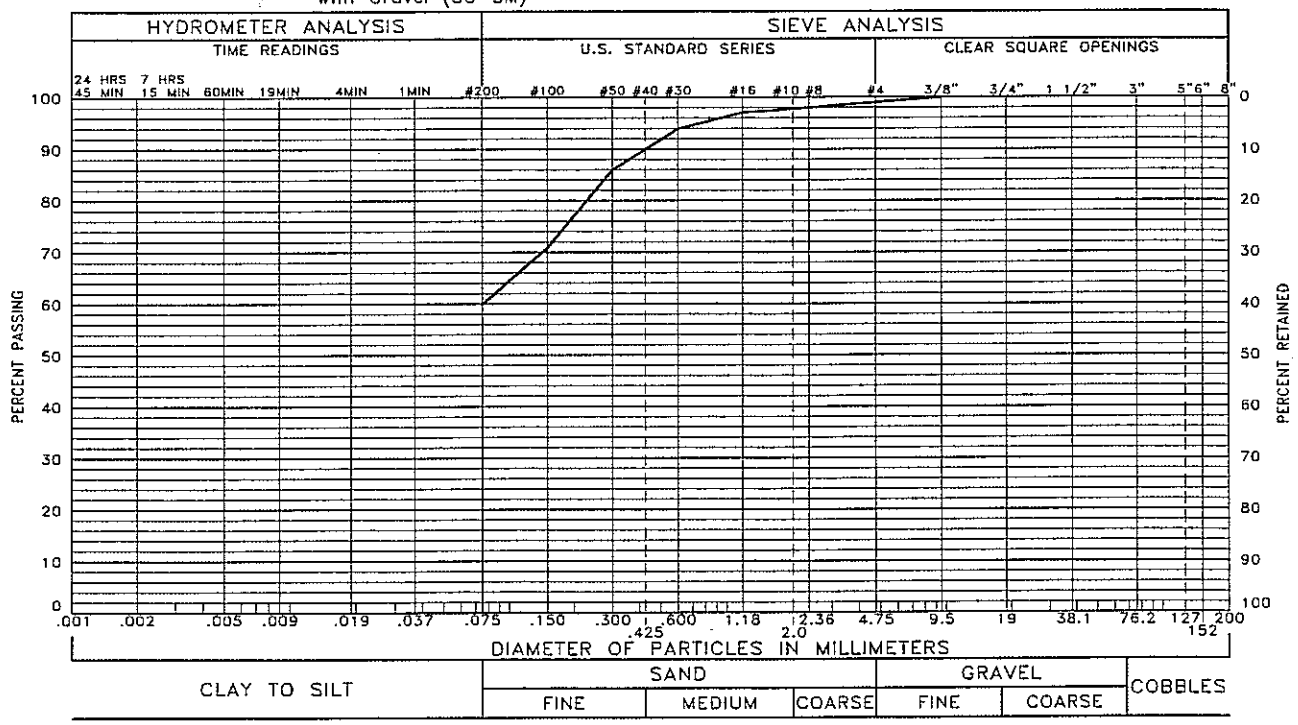
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 23



GRAVEL 18% SAND 62% SILT AND CLAY 20%

LIQUID LIMIT 18 PLASTICITY INDEX 5

SAMPLE OF: Clayey, Silty Sand with Gravel (SC-SM) FROM: Boring 67 @ 9'

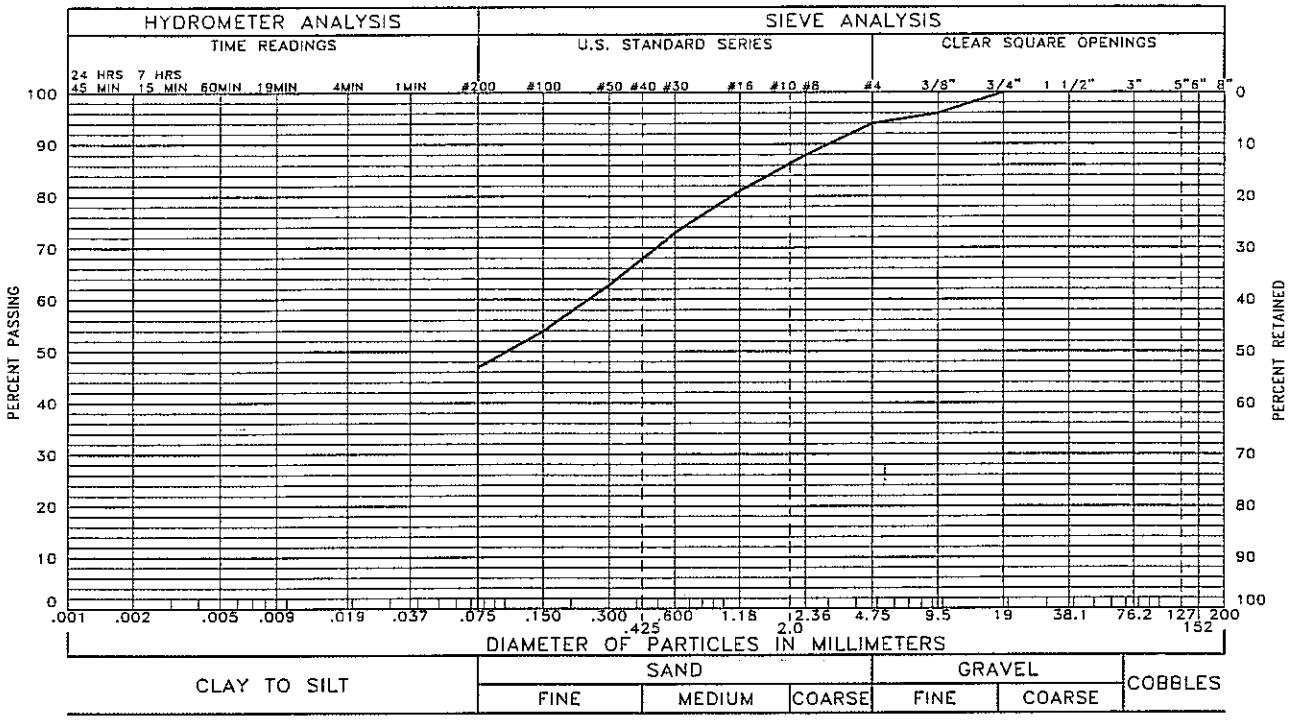


GRAVEL 1% SAND 39% SILT AND CLAY 60%

LIQUID LIMIT 29 PLASTICITY INDEX 15

SAMPLE OF: Sandy Lean Clay (CL) FROM: Boring 74 @ 4'

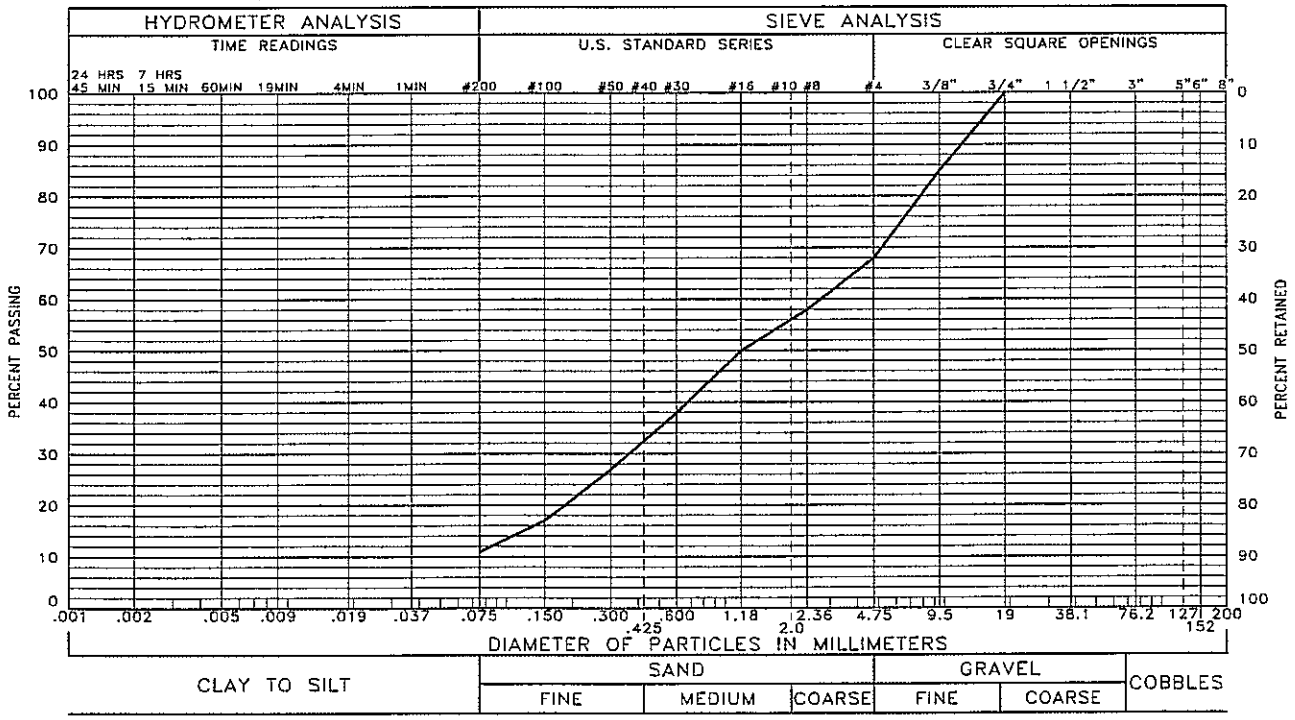
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 24



GRAVEL 6% SAND 47% SILT AND CLAY 47%

LIQUID LIMIT 32 PLASTICITY INDEX 16

SAMPLE OF: Clayey Sand (SC) FROM: Boring 84 @ 9'

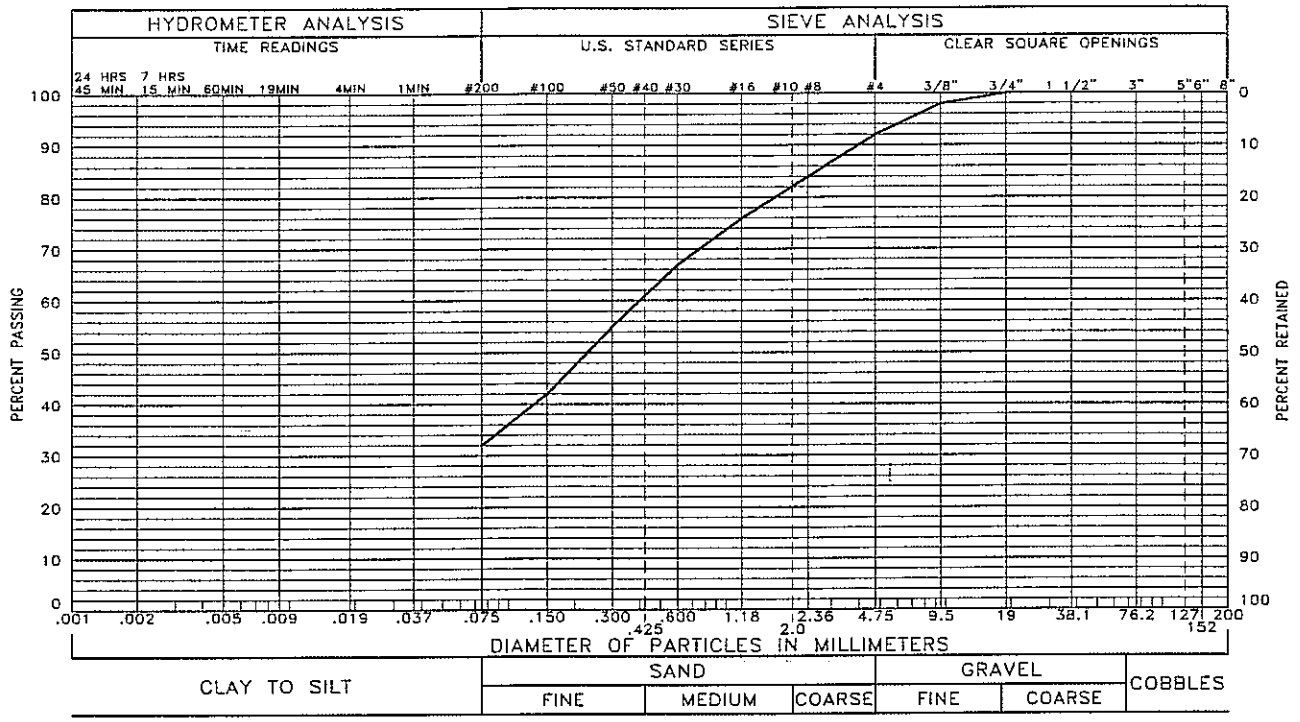


GRAVEL 32% SAND 57% SILT AND CLAY 11%

LIQUID LIMIT 20 PLASTICITY INDEX 4

SAMPLE OF: Poorly-Graded Sand with Silt and Gravel (SP-SM) FROM: Boring 85 @ 4'

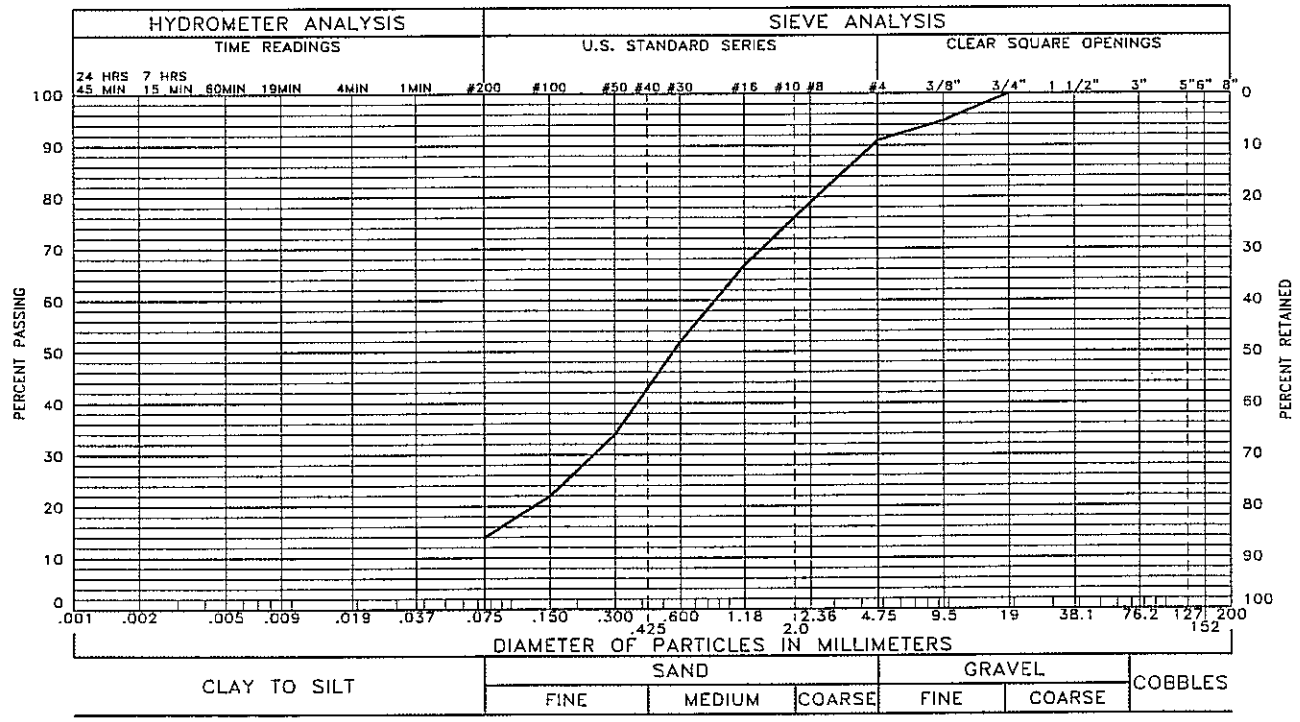
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 25



GRAVEL 8% SAND 60% SILT AND CLAY 32%

LIQUID LIMIT 19 PLASTICITY INDEX 5

SAMPLE OF: Clayey Silty Sand (SC-SM) FROM: Boring 88 @ 9'

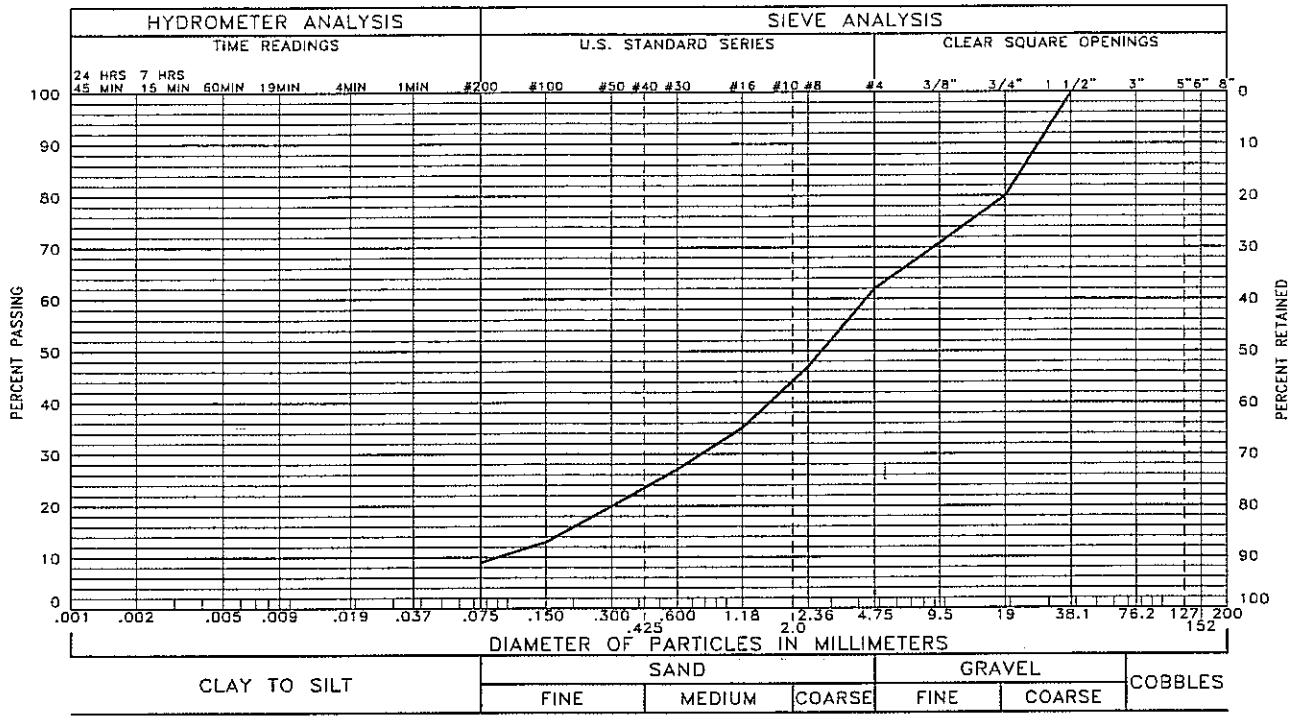


GRAVEL 9% SAND 77% SILT AND CLAY 14%

LIQUID LIMIT 19 PLASTICITY INDEX NP

SAMPLE OF: Silty Sand (SM) FROM: Boring 88A @ 9'

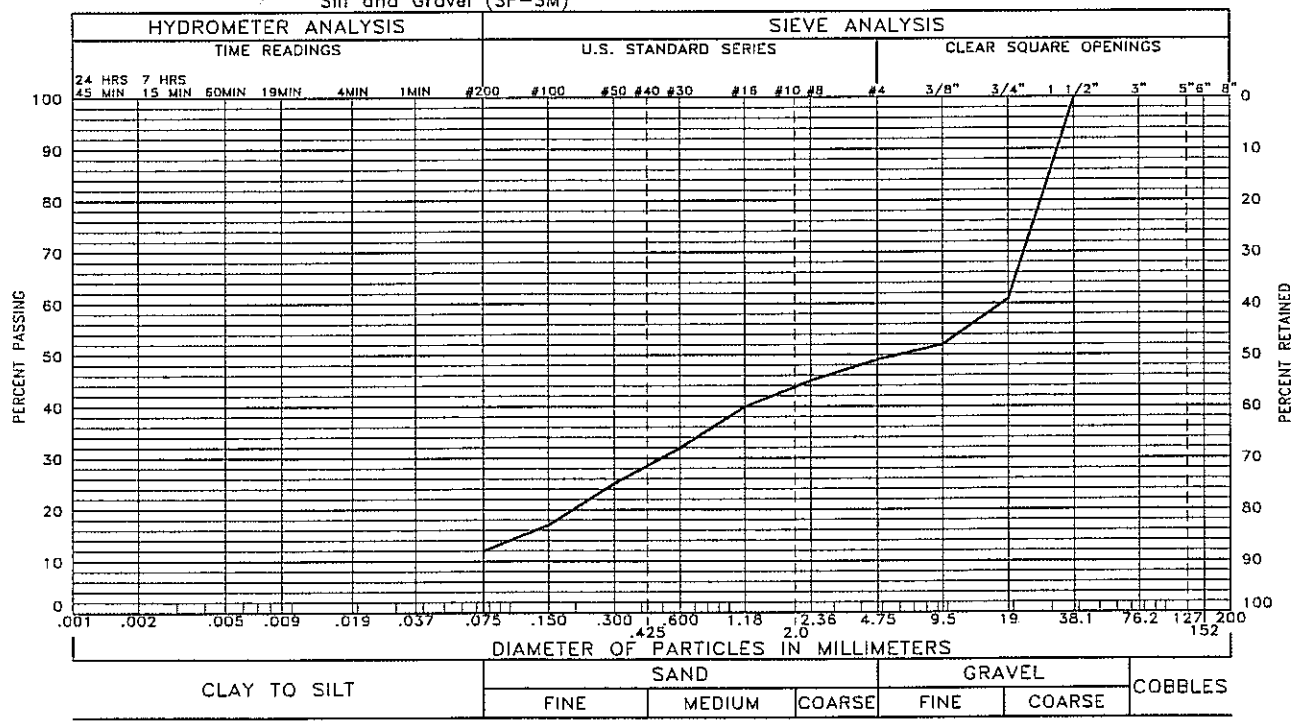
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 26



GRAVEL 38% SAND 53% SILT AND CLAY 9%

LIQUID LIMIT 21 PLASTICITY INDEX 4

SAMPLE OF: Poorly-Graded Sand with Silt and Gravel (SP-SM) FROM: Boring 88B @ 14'

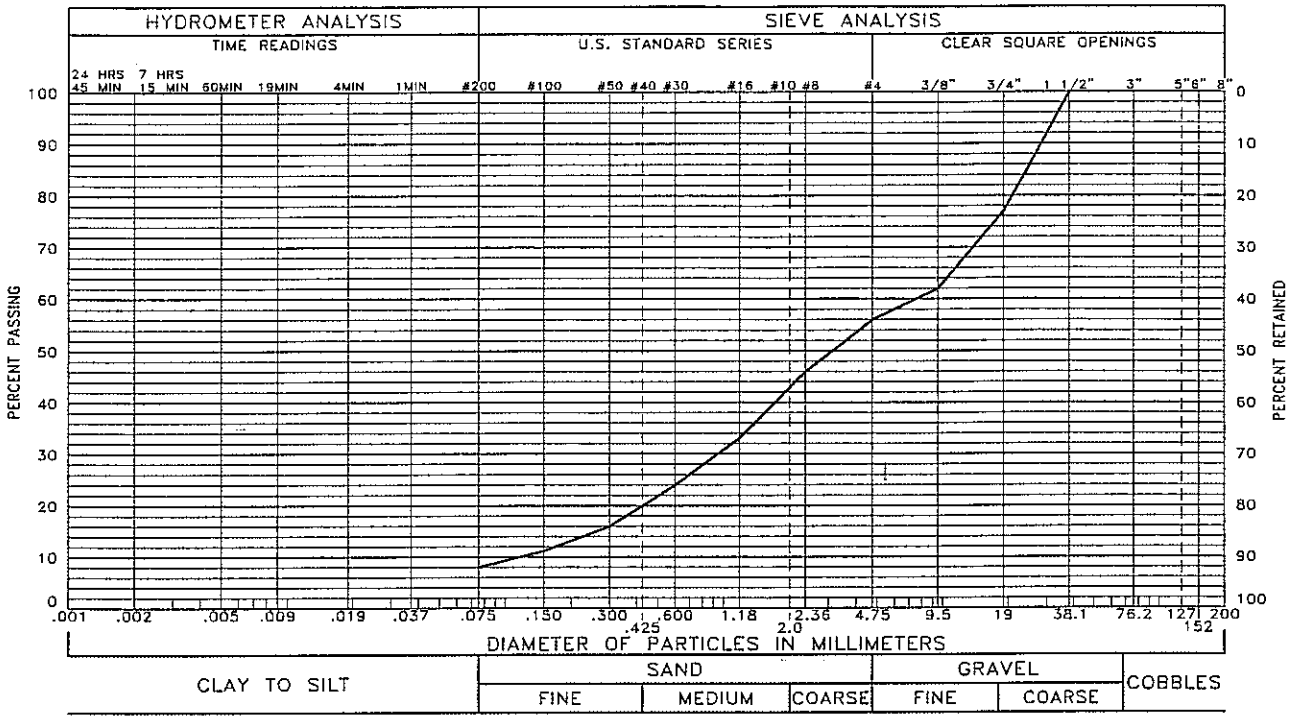


GRAVEL 51% SAND 37% SILT AND CLAY 12%

LIQUID LIMIT 18 PLASTICITY INDEX 3

SAMPLE OF: Poorly-Graded Gravel with Silt and Sand (GP-GM) FROM: Boring 90 @ 4'

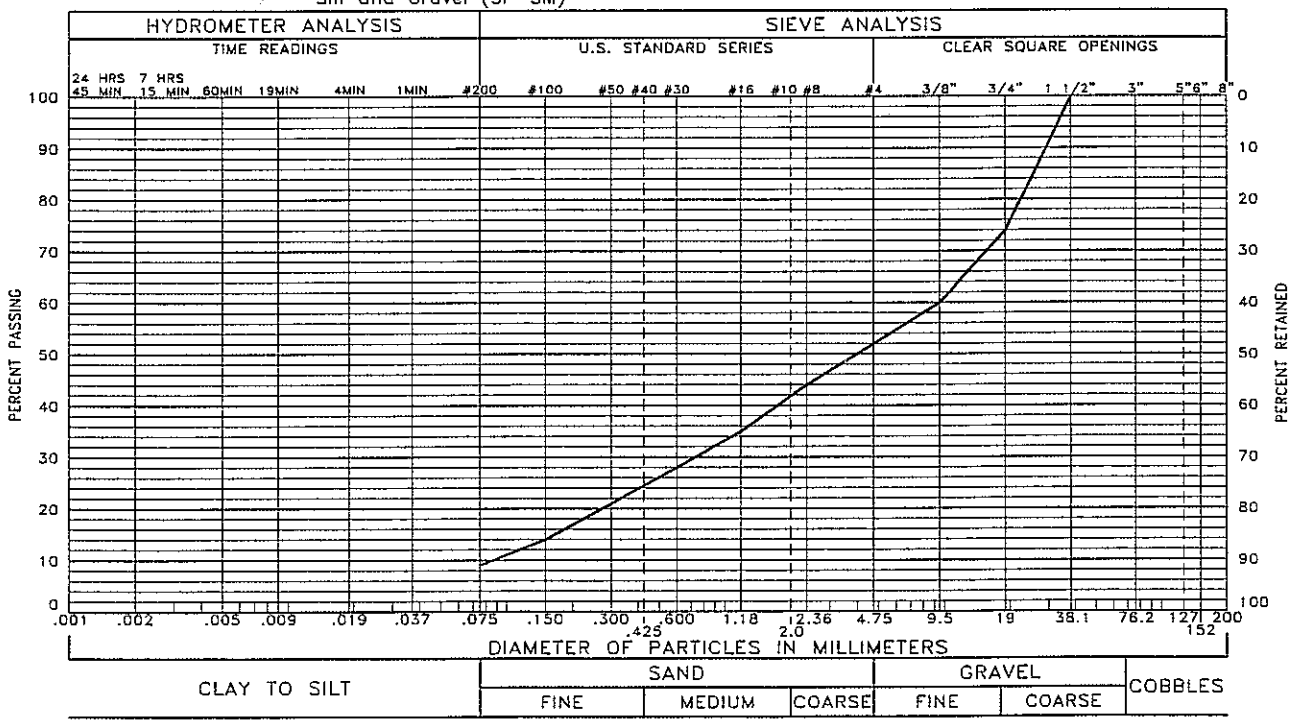
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 28



GRAVEL 44% SAND 48% SILT AND CLAY 8%

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly-Graded Sand with Silt and Gravel (SP-SM) FROM: Boring 92 @ 9'

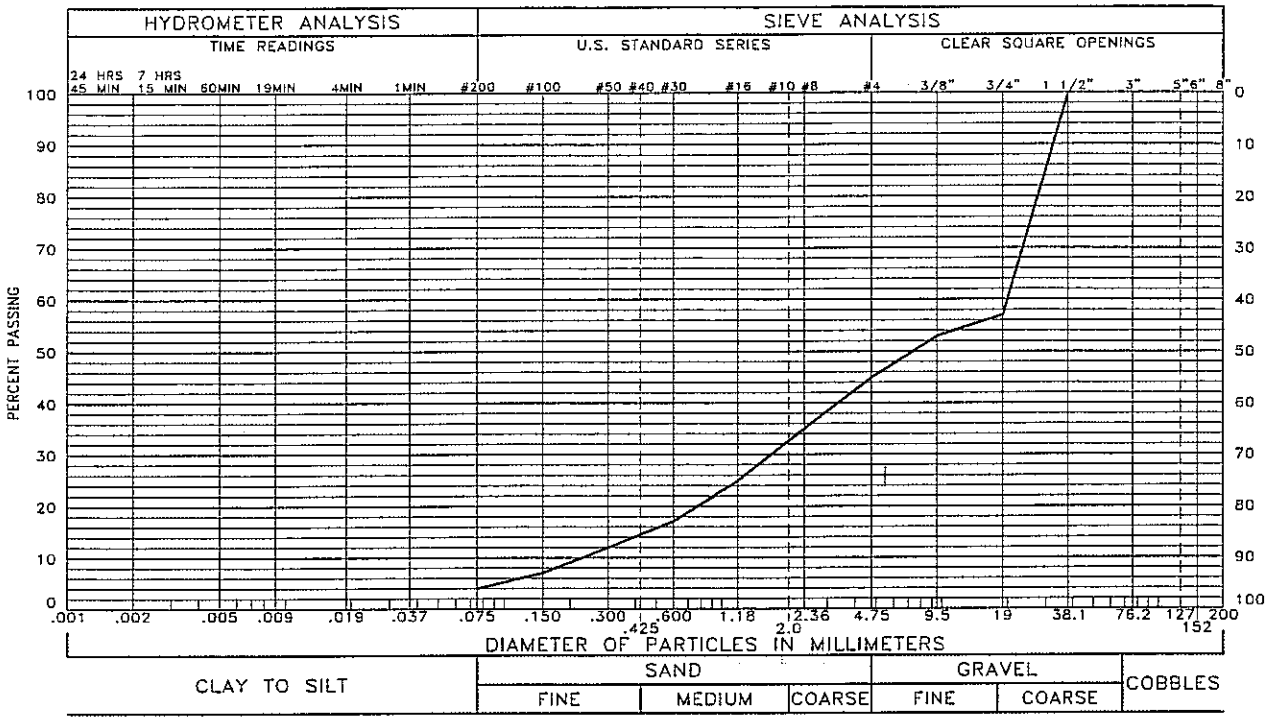


GRAVEL 48% SAND 43% SILT AND CLAY 9%

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly-Graded Gravel with Silt and Sand (GP-SM) FROM: Boring 93 @ 8'

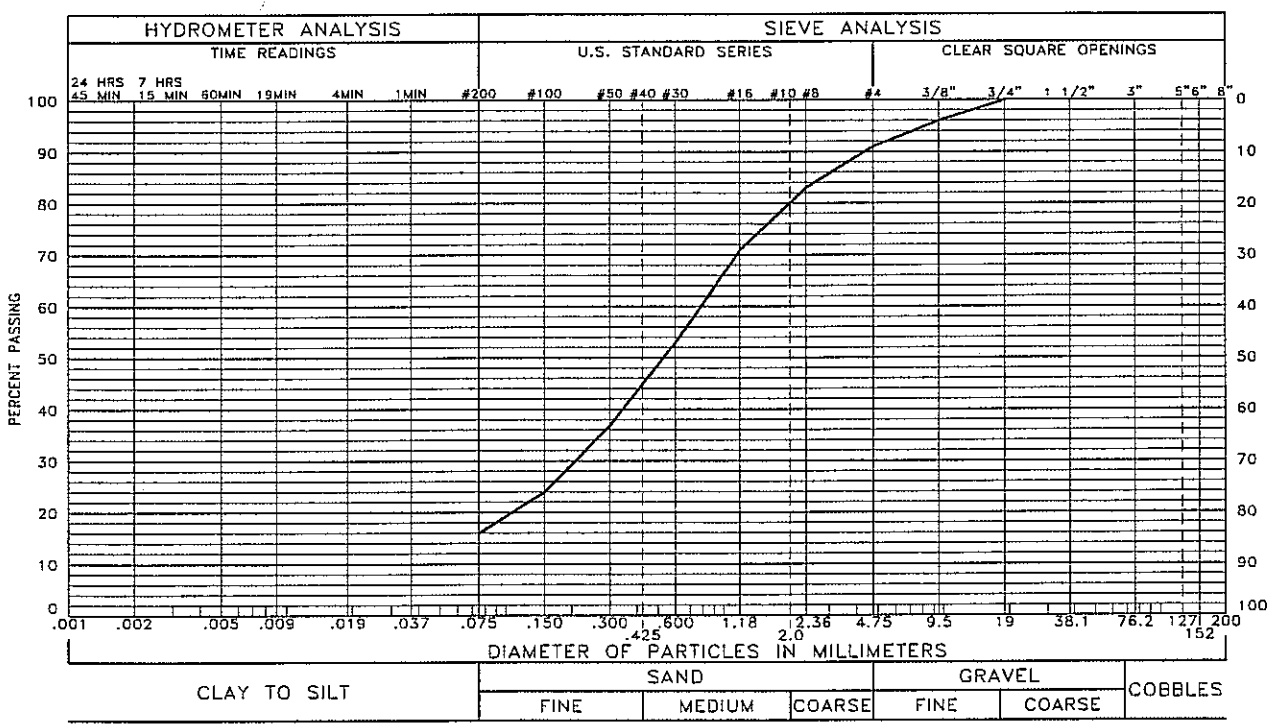
05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 29



GRAVEL 55% SAND 41% SILT AND CLAY 4%

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Poorly Graded Gravel with Sand (GP) FROM: Boring 94 @ 9'



GRAVEL 9% SAND 75% SILT AND CLAY 16%

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Clayey Sand (SC) FROM: Boring 96 @ 9'

05-1-205B	Kumar & Associates	GRADATION TEST RESULTS	Fig. 30

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NO.: 05-1-205B
PROJECT NAME: Roxborough Park Wastewater Regionalization Project
DATE SAMPLED: 3-22-05 to 4-4-05, 12-14-05 to 5-09-06
DATE RECEIVED: 4-8-05, 12-16-05, 6-7-06

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		SOIL OR BEDROCK TYPE
BORING	DEPTH (feet)				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
44A	9	6-8-06	14.8	112.4	0	34	66	34	21	Sandy Lean Clay (CL)
44A	14	6-8-06	14.8	116.8	0	45	55	33	22	Sandy Lean Clay (CL)
44B	4	6-8-06	16.6	113.3	0	29	71	35	22	Fill: Lean Clay with Sand (CL)
44B	9	6-8-06	11.3		0	45	55	35	22	Fill: Sandy Lean Clay
45	4	4-21-06	0.8		24	71	5			Well-Graded Sand with Silt and Gravel (SW-SM)
46	9	4-21-06	14.1	116.0			80	42	23	Claystone Bedrock
47	4	4-21-06	15.6	113.5			81	38	24	Fill: Lean Clay with Sand
48	9	4-21-06	10.7	119.5			51	33	18	Sandy Lean Clay (CL)
49	4	4-21-06	7.1	106.0			42	29	16	Clayey Sand (SC)
50	9	4-21-06	10.1	120.2			78	35	20	Claystone Bedrock
51	9	4-21-06	12.2	111.1	1	89	10			Well-Graded Sand with Silt (SW-SM)
52	9	4-21-06	20.5	108.2	0	57	43	26	10	Clayey Sand (SC)
53	14	5-15-06	2.0	113.1	4	86	10	NV	NP	Poorly-Graded Sand with Silt (SP-SM)
54	9	5-15-06	2.2		20	69	11			Well-Graded Sand with Clay and Gravel (SW-SC)
55	4	5-15-06	8.6	106.6			59	33	18	Sandy Lean Clay (CL)
56	4	4-21-06	10.5	119.8			58	34	20	Claystone Bedrock
57	9	5-15-06	11.1	125.6			80	42	30	Claystone Bedrock
58	14	5-15-06	19.3	108.8			78	39	27	Lean Clay with Sand (CL)
59	4	5-15-06	18.6	102.1			97	54	36	Fill: Fat Clay
60	14	5-15-06	6.6	133.4			23	21	9	Fill: Clayey Sand
61	9	5-15-06	23.1	97.7			80	47	30	Lean Clay with Sand (CL)
62	4	5-15-06	3.8	123.1			19	23	12	Clayey Sand (SC)
63	9	5-15-06	17.1	111.0			99	65	46	Claystone Bedrock
64	14	5-15-06	10.6	116.7			71	34	17	Claystone Bedrock
64A	19	6-8-06	16.6	111.8			84	52	33	Claystone Bedrock

TABLE I
SUMMARY OF LABORA4TORY TEST RESULTS

PROJECT NO.: 05-1-205B
PROJECT NAME: Roxborough Park Wastewater Regionalization Project
DATE SAMPLED: 3-22-05 to 4-4-05, 12-14-05 to 5-09-06
DATE RECEIVED: 4-8-05, 12-16-05, 6-7-06

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		SOIL OR BEDROCK TYPE
BORING	DEPTH (feet)				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
64A	29	6-8-06	16.6	113.6			86	46	29	Claystone Bedrock
65	4	4-21-06	23.0	101.4			93	56	37	Fat Clay (CH)
65	9	4-21-06	20.6	105.5			98	58	38	Claystone Bedrock
65A	19	6-8-06	6.1	133.1	8	71	21	18	4	Clayey Silty Sand (SC-SM)
65A	24	6-8-06	22.9	103.5			78	55	37	Fat Clay with Sand (CH)
66	4	4-21-06	19.2	106.3			99	60	38	Fat Clay (CH)
67	9	4-21-06	2.2		18	62	20	18	5	Clayey Silty Sand with Gravel (SC-SM)
68	4	4-21-06	16.2	103.4			97	52	31	Fill: Fat Clay (CH)
69	4	4-21-06	11.2	93.6			71	38	22	Lean Clay with Sand (CL)
70	4	5-10-06	19.0	107.7			95	64	39	Claystone Bedrock
71	4	5-10-06	14.3	108.3			97	58	36	Claystone Bedrock
72	4	5-10-06	14.9	111.1			99	53	33	Claystone Bedrock
73	4	5-10-06	17.0	113.6			64	45	28	Claystone Becrock
74	4	5-10-06	7.0	102.0	1	39	60	29	15	Sandy Lean Clay (CL)
75	4	5-10-06	1.2		24	63	13	NV	NP	Silty Sand with Gravel (SM)
76	4	4-21-06	13.7	91.2			98	48	28	Claystone Bedrock
77	9	4-21-06	9.6	116.8			81	34	18	Claystone Bedrock
78	9	5-10-06	11.2	117.7			59	29	14	Claystone Bedrock
79	4	5-10-06	14.5	116.4			92	58	35	Fat Clay (CH)
80	4	5-10-06	15.6	114.4			91	49	26	Lean Clay (CL)
81	4	5-10-06	16.5	115.6			98	57	36	Claystone Bedrock
82	4	5-10-06	20.9	102.4			88	38	13	Siltstone Bedrock
83	9	8-5-05	18.9	107.9			92	46	21	Claystone Bedrock
84	9	8-5-05	7.6	118.6	6	47	47	32	16	Clayey Sand (SC)
85	4	8-5-05	2.4	126.2	32	57	11	20	4	Poorly-Graded Sand with Silt and Gravel (SP-SM)

TABLE I
SUMMARY OF LABORATORY TEST RESULTS

PROJECT NO.: 05-1-205B
PROJECT NAME: Roxborough Park Wastewater Regionalization Project
DATE SAMPLED: 3-22-05 to 4-4-05, 12-14-05 to 5-09-06
DATE RECEIVED: 4-8-05, 12-16-05, 6-7-06

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		SOIL OR BEDROCK TYPE
BORING	DEPTH (feet)				GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTICITY INDEX (%)	
86	9	8-5-05	12.4	117.7			42	21	7	Clayey Silty Sand (SC-SM)
86	19	8-5-05	11.5	121.6			25	25	13	Clayey Sand (SC)
87	4	8-5-05	12.8	119.7			60	31	17	Sandy Lean Clay (CL)
88	9	8-5-05	7.5	129.7	8	60	32	19	5	Clayey Silty Sand (SC-SM)
88A	9	6-8-06	14.5	95.5	9	77	14	19	NP	Silty Sand (SM)
88A	14	6-8-06	4.5		31	51	18	21	7	Clayey Silty Sand with Gravel (SC-SM)
88B	9	6-8-06	7.8	129.3	9	65	26	22	7	Fill: Clayey Sand (SC)
88B	14	6-8-06	2.6	124.0	38	53	9	21	4	Poorly-Graded Sand with Silt and Gravel (SP-SM)
90	4	8-5-05	3.1	118.2	51	37	12	18	3	Poorly-Graded Gravel with Silt and Sand (GP-GM)
91	4	8-5-05			61	34	5	NV	NP	Poorly-Graded Gravel with Silt and Sand (GP-GM)
92	9	8-5-05			44	48	8			Poorly-Graded Sand with Silt and Gravel (SP-SM)
93	8	8-5-05			48	43	9			Poorly-Graded Gravel with Silt and Sand (GP-GM)
94	9	8-5-05			55	41	4			Poorly Graded Gravel with Sand (GP)
95	4	8-5-05	13.5	113.8			27	22	4	Clayey Silty Sand (SC-SM)
96	9	8-5-05			9	75	16			Clayey Sand (SC)