GEOLOGIC HAZARDS EVALUATION AND PRELIMINARY GEOTECHNICAL INVESTIGATION WOODMOOR BEACH/SOUTH BEACH SUBDIVISION LAKE WOODMOOR DRIVE AND LOWER LAKE ROAD MONUMENT, COLORADO

Prepared For:

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December 13, 2016

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SCOPE

This report presents the results of our Geologic Hazards Evaluation and Preliminary Geotechnical Investigation for Woodmoor Beach/South Beach Subdivision located west of the intersection of Lake Woodmoor Drive and Lower Lake Road in Monument, Colorado. The investigated parcels are planned for development of single-family lots. Our purpose was to evaluate the properties for the occurrence of geologic hazards and assess their potential effect on the planned development. This report includes our interpretation of site geology, engineering analysis of the potential impact of geologic conditions on development, a description of subsurface and groundwater conditions found in exploratory borings, and our opinion of the potential influence of these conditions on site development.

The report was prepared based on conditions interpreted from field reconnaissance mapping of the site, conditions found in our exploratory borings, results of laboratory tests, engineering analysis, review of previous reports in our possession, and our experience. Observations made during grading or construction may indicate conditions that require revision or re-evaluation of some of the criteria presented in this report. The criteria presented are for the development as described. Revision in the scope of the project could influence our recommendations. If changes occur, we should review the development plans and their effect on our recommended design criteria. Evaluation of the property for the possible presence of potentially hazardous materials (environmental site assessment) is beyond the scope of our investigation. Assessment of the site for the potential for wildfire hazards, corrosive soils, erosion problems, or flooding are also beyond the scope of this investigation.

The following section summarizes the report. A more complete description of the conditions found, our interpretations, and our recommendations are included in the report.

SUMMARY

1. We identified no geologic hazards we believe preclude development of the site for single-family residences. Expansive bedrock, shallow groundwater, and regional issues of seismicity and naturally-occurring radioactive materials are conditions that may affect the proposed development. These conditions can be mitigated with engineering design and construction methods commonly employed in the area.

2. Subsurface conditions found in 10 exploratory borings drilled at the site consisted of silty to clayey sand underlain by sandstone and interbedded claystone and sandstone bedrock. Claystone samples exhibited low to moderate swell. The sand and sandstone are considered to be non-expansive. Our experience suggests highly expansive claystone layers could be encountered within Woodmoor Beach/South Beach development area.

3. At the time of drilling, groundwater was encountered in two of the borings at about 28 feet below existing ground surface. When checked eight days later, groundwater was measured in seven of the borings at depths between 10.5 and 28.5 feet. The presence of shallow bedrock is favorable for the formation of perched groundwater after development and installation of irrigated landscaping.

4. We believe site grading and utility installation across the parcel can be accomplished using conventional, heavy-duty construction equipment. Some of the sandstone is very hard and may be partially cemented.

5. We believe conventional spread footing foundations and slab-on-grade floors will be appropriate for most of the dwellings constructed within the Woodmoor Beach/South Beach parcel. Where expansive soils occur, removal and replacement of a zone of expansive material from beneath spread footing foundations or use of straight-shaft, drilled-pier foundations and structurally supported floors may be appropriate.

6. Irrigation of landscaping should be minimized to reduce problems associated with expansive soils. Overall plans should provide for the rapid conveyance of surface runoff to the storm sewer system and centralized drainage channels.

SITE CONDITIONS

Woodmoor Beach is located northwest of the intersection of Lake Woodmoor Drive and Lower Lake Road and South Beach is located southwest of the intersection in Monument, Colorado (northern half of Section 14, Township 11 South, Range 67 West of the 6th Principal Meridian). The development plan is shown on Fig. 1.

The subject parcels are undeveloped. Lower Lake Road forms the east boundary. The embankment for the southeast side of Lake Woodmoor occupies the land to the north of Woodmoor Beach. A spillway is located as the western boundary of Woodmoor Beach. Existing houses are to the south of the proposed South Beach. The ground surface slopes gently downward to the southwest. Elevations range from approximately 7,137 feet in the northeast area of Woodmoor Beach to approximately 7,100 feet in the southwest area of South Beach. Vegetation consists of grasses and weeds with occasional trees. A small drainage is located in the east portion of South Beach. A dirt road is located as the east boundary of South Beach.

PROPOSED DEVELOPMENT

Plans for Woodmoor Beach/South Beach include approximately 40 single-family lots, paved access roads, and open space areas. We anticipate the residences will be wood-frame structures with basements and attached garages. No grading plans were supplied to our office for review. We anticipate the dwellings will be serviced by a centralized water and sanitary sewer systems.

SUBSURFACE INVESTIGATION

Subsurface conditions across the two sites were investigated by drilling ten exploratory borings within Woodmoor Beach/South Beach. The approximate locations of the borings are shown on Fig. 1. Graphical logs of the conditions found in the exploratory borings, the results of field penetration resistance tests, and some laboratory data are shown in Appendix A. Swell-consolidation and gradation test results are presented in Appendix B. Laboratory test data are summarized in Table B-1.

Soil and bedrock samples obtained during this study were returned to our laboratory and visually classified. Laboratory testing was then assigned to representative samples. Testing included moisture content and dry density, swell-consolidation, sieve analysis, atterberg limits and water-soluble sulfate content tests. The swell test samples were wetted under applied pressures that approximated the existing overburden pressure.

SUBSURFACE CONDITIONS

Subsurface conditions found in the ten exploratory borings drilled at the site consisted of silty to clayey sand underlain by claystone and sandstone bedrock. Some pertinent engineering characteristics of the soil and bedrock are discussed in the following paragraphs.

Sand

Between 4.5 and 26.5 feet of silty to clayey sand was encountered from the ground surface in each of the borings. Field penetration resistance test results indicated the sand was loose to dense. Seven samples of the sand contained 7 to 21 percent silt and clay-sized particles (passing the No. 200 sieve). Our experience indicates the sand is non-expansive or possibly low swelling.

Bedrock

Silty to clayey sandstone bedrock was predominant, with occasional layers of slightly sandy to very sandy claystone. Field penetration resistance test results indicated the bedrock was hard to very hard. Some of the sandstone is very hard and may be partially cemented. Seven samples of the claystone exhibited measured swell values of 0.1 to 2.6 percent when wetted under approximate overburden pressures. The claystone samples generally exhibited low to moderate swell potential. Six samples of the claystone tested contained 51 to 89 percent silt and clay-sized particles (passing the No. 200 sieve). Our experience in the Lake Woodmoor area suggests highly expansive layers of claystone could be encountered. Seven samples of the sandstone contained 14 to 39 percent silt and clay-sized particles (passing the No. 200 sieve). The sandstone is generally non-expansive.

Groundwater

At the time of drilling, groundwater was encountered in 2 test holes at depths of 28 and 28.5 feet. When checked eight days later, groundwater was measured in seven holes at depths between 10.5 and 28.5 feet. Water levels should be expected to fluctuate in response to seasonal precipitation and irrigation of landscaping commonly associated with residential development. The presence of sandy soils underlain by bedrock increases the potential for the formation of a perched water at the soil/bedrock interface.

SITE GEOLOGY

The geology of the Woodmoor Beach/South Beach parcel was evaluated through the review of published geologic maps, field reconnaissance, and the drilling of ten exploratory borings. Information from these sources was used to produce our interpretation of surficial geologic conditions. An excerpt from the "Geologic Map of the Monument Quadrangle" published by the Colorado Geologic Survey (CGS) in 2004 is presented below. The area outlined in blue identifies the approximate location of Woodmoor Beach/South Beach. Our observations imply the CGS geologic map is accurate. A list of references is included at the end of this report. The following sections discuss the mapped units.

Excerpt from CGS 2004 Geologic Map of the Monument Quadrangle.

Surficial Deposits

Our borings encountered between 4.5 and 26.5 feet of surficial deposits overlying the bedrock. The various deposits are described in more detail in the following sections.

Middle Alluvial-slope deposits (Map Unit "Qas_2"): These soils are alluvium and slopewash deposited in Quaternary-Holocene time. The soils consist primarily of poorly sorted sand, silty and clayey sand, and beds of very fine to medium pebble gravel. Total thicknesses of the alluvial deposits are up to about 5 to 40 feet.

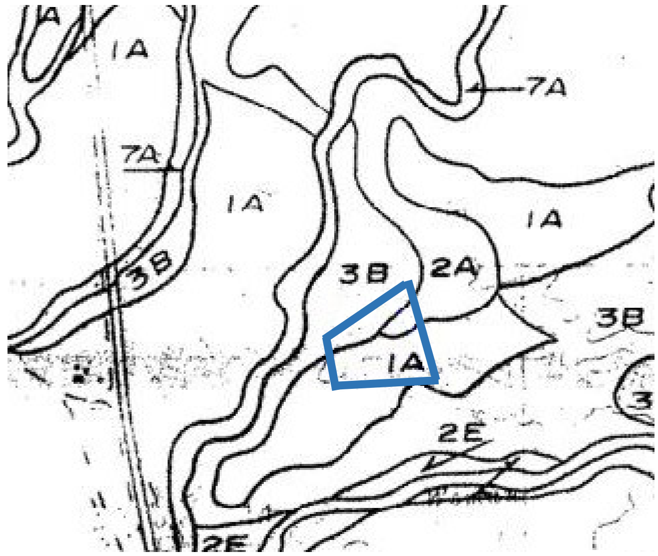
Bedrock

Upper Dawson Formation (Map Unit "Tda_4 and Tda_5"): Bedrock generally underlies the alluvium at depths 4.5 to 26.5 feet. We interpret the bedrock to be part of the Upper Dawson Formation of Paleocene to Eocene Age. This formation consists of locally cemented, interbedded sandstone and claystone. Based on the results from our exploratory borings, the bedrock at the site appears to be predominantly slightly silty to clayey, fine to coarse-grained sandstone with a few claystone lenses. Based on geologic mapping in the area, the bedrock has a gentle dip toward the north and northeast. The claystone portion of this formation can exhibit expansion potentials ranging from low to very high.

POTENTIAL GEOLOGIC HAZARDS AND ENGINEERING CONSTRAINTS

We did not identify geologic hazards that we believe preclude development of the site as planned. The conditions identified at the site that may pose hazards or constraints to development include potentially expansive bedrock and shallow bedrock, potentially shallow groundwater, and erosion. Regional geologic conditions that impact the site include seismicity and radioactivity. We believe each of these conditions can be mitigated with engineering design and construction methods commonly employed in this area. These conditions are discussed in greater detail in the sections that follow.

Our interpretation of the engineering geologic conditions that may impact development of the sites is presented in the figure below and refers to the classification system by Robinson (1977). The engineering geology conditions described below are based on our review of Robinson's "Potential Geologic Hazards and Surficial Deposits, Environmental and Engineering Geologic Maps and Tables for Land Use."



Excerpt from Robinson's Sheet 2B showing Woodmoor Beach/South Beach is within Unit 1A, Unit 2-A, and Unit 3B

Map Unit 1-A depicts stable alluvium, colluvium underlain predominantly by sandstone bedrock, with some expansive claystone lenses, on flat to gentle slopes. The South Beach parcel is within this unit.

Map Unit 2-A depicts gently sloped areas underlain predominantly by sandstone bedrock with some expansive claystone lenses. The Woodmoor Beach parcel is within this unit.

Map Unit 3-B depicts expansive and potentially expansive soil and bedrock on flat to moderate slopes. This unit lies on the northwest side of the Woodmoor Beach parcel.

Expansive Bedrock

The near-surface soils and sandstone bedrock are generally non-expansive or possibly low swelling. Some low to moderate swelling claystone bedrock is likely to be encountered. Problems associated with expansive materials can be mitigated through engineered foundation and floor slab systems, sometimes in conjunction with ground modification such as sub-excavation and replacement. Geotechnical investigations conducted for each lot should address procedures for mitigating issues associated with expansive soil and bedrock.

Shallow Bedrock

Bedrock is found at depths between 4.5 and 26.5 feet below ground surface. This condition impacts both excavation and the future development of perched groundwater. Most of the bedrock consists of weakly cemented, slightly silty to very clayey sandstone, with some sandy to very sandy claystone. The weakly cemented units can normally be excavated using conventional heavy-duty equipment and should break down to a size suitable for use as structural or overlot fill. The more cemented materials will be relatively difficult to excavate and less easily broken down.

Shallow Groundwater

The bedrock is much less permeable than the existing overlying soils. Groundwater was encountered at depths between 28 and 28.5 feet during the time of drilling and was measured at depths between 10.5 and 28.5 feet in seven holes when checked eight days later. Perched groundwater can form or rise after development due to landscape irrigation and disruption of natural drainage patterns. This condition can be mitigated through use of foundation drains and promoting good surface drainage.

Erosion

The site contains sandy surficial soils that are susceptible wind and water erosion. The surficial soils are more resistant to erosion where vegetation is established. Disturbance of the vegetative cover and exposure to the erosive power of wind and water increase the potential for erosion. Maintaining vegetative cover and providing engineered surface drainage will reduce the potential for erosion.

Economic Minerals

We found no evidence the site contains economic minerals such as coal or sand and gravel. Therefore, it is doubtful the sites have been undermined. Energy fuels in economic quantities such as uranium, oil and gas may or may not be present. The area is not expected to contain economic deposits of energy fuels or valuable minerals.

Flooding

Information presented in the "Flood Insurance Rate Map" (FIRM), Map Number 08041C0276 F, effective date March 17, 1997, indicates the proposed development within Woodmoor Beach/South Beach is outside areas mapped as prone to surface flooding. The project Civil Engineer will determine the flood potential and design surface drainage.

Seismicity

This area, like most of central Colorado, is subject to a degree of seismic activity. Geologic evidence indicates that movement along some Front Range faults (including the Rampart Range Fault) has occurred during the last two million years (Quaternary). The Rampart Range Fault is located about eight miles west of the site. We believe the property is Site Class D (stiff soil profile) according to the 2015 International Building Code (2015 IBC).

Radon and Radioactivity

We believe no unusual hazard exists from naturally occurring sources of radioactivity on this site. However, the materials found in our borings are often associated with the production of radon gas and concentrations in excess of EPA guidelines can occur. Radon tends to collect in basement areas in residences due to limited outside air exchange and interior ventilation. Passive and active mitigation procedures are commonly employed in this region to effectively reduce the buildup of radon gas. Measures that can be taken after a residence is enclosed during construction include installing a blower connected to the foundation drain and sealing the joints and cracks in concrete floors and foundation walls. If the occurrence of radon is a concern, we recommend residences be tested after they are enclosed and mitigation systems then installed to reduce the risk, as needed.

The site lies close to the contact between the Denver Formation and the overlying Dawson Formation. Rocks containing uranium have been recognized near the base of the Dawson Formation in the Black Forest region. Occurrences of low-grade, uranium-bearing rock have also been found in the Briargate area to the southwest of the site. These deposits were first recognized in a regional study for uranium in the mid-1970s. Accounts of uranium occurrences in the Denver Formation can be found in publications of the Colorado Geological Survey.

Low-level gamma radiation levels were measured in the cuttings from our exploratory borings using a LUDLUM Micro R Meter (Model 19). The meter provides readings of low-level gamma radiation in terms of micro R/Hr (micro Roentgens per hour). Background readings which represent “means” ranged between 15 and 20 micro R/Hr. Readings on the drill cuttings ranged between 15 and 20 micro R/Hr. We did not observe any of the dark brown conglomeratic sandstone at the site that is commonly associated with high radioactivity readings.

The “background” level of low-level gamma radiation in the state generally ranges from 15 to 20 micro R/Hr with the level of concern being established at about twice background. This would imply remediation should be performed for materials at this site which exceed about 30 to 40 micro R/Hr. Federal standards have been developed for uranium and thorium mill tailings which state that remediation is required when the concentration of radium-226 exceeds background levels by more than 5 pCi/g (picoCuries per gram). We understand this radium standard equates to a gamma reading of about 9 micro R/Hr above background. If the mill tailing standard is applied to the average of the background reading across the site of about 20 micro R/Hr, remediation of material exhibiting gamma readings in excess of about 30 micro R/Hr would be required. Our readings were lower than the action level.

SITE DEVELOPMENT CONSIDERATIONS

From an engineering point-of-view, the more significant subsurface conditions impacting construction are the occurrence of expansive materials and shallow bedrock. The following sections discuss the impact of these conditions on development and possible methods of mitigation.

Site Grading

We believe the majority of site grading can be accomplished using conventional heavy-duty earthmoving equipment. The presence of shallow, hard bedrock may require ripping to expedite excavation in some areas. We recommend grading plans consider long-term cut and fill slopes no steeper than 3:1 (horizontal to vertical). This ratio considers that no seepage of groundwater occurs. If groundwater seepage does occur, a drain system and flatter slopes may be appropriate.

Vegetation and organic materials should be removed from the ground surface of areas to be filled. Soft or loose soils, if encountered, should be stabilized or removed to stable material prior to placement of fill. Organic soils should be wasted in landscaped areas. If insufficient landscaped areas are planned, topsoil can be mixed with clean fill soils at a ratio of 15:1 (fill:topsoil) and placed as fill deeper than 8 feet below finished grade.

The ground surface in areas to receive fill should be scarified, moisture conditioned and compacted. The natural clay and claystone used for fill should be placed at high moisture content to help mitigate potential swell. The properties of the fill will affect the performance of foundations, slabs-on-grade, and pavements. We recommend overlot grading fill composed of the on-site sands and sandstone be placed in thin, loose lifts, moisture conditioned to within 2 percent of optimum moisture content, and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557). Clay and claystone fill should be moisture conditioned to between 1 and 4 percent above optimum moisture content and compacted in thin, loose lifts to at least 95 percent of maximum standard Proctor dry density (ASTM D 698). Placement and compaction of the grading fill should be observed and tested by our representative during construction. Guideline specifications for overlot grading are presented in Appendix C.

Buried Utilities

Over most of the site, we believe utility trench excavation can be accomplished using heavy-duty track hoes. The bedrock encountered in our borings was hard to very hard, but predominantly weakly cemented. Rock buckets and rock teeth may be needed where utility excavations extend well into the bedrock formation and the bedrock is cemented. Utility contractors should be made aware of this possibility and anticipate slower rates of pipeline installation in the very hard bedrock. Dewatering and/or stabilization of the bottom of utility trenches may be required if excavations extend to depths where groundwater is present.

Excavations for utilities should be braced or sloped to maintain stability and should meet applicable local, state, and federal safety regulations. The contractor should identify the soils and bedrock encountered in trench excavations and refer to Occupational Safety and Health Administration (OSHA) standards to determine appropriate slopes. We anticipate the near-surface soils and bedrock will classify as Type C and Type B materials, respectively. Temporary excavations in Type C and Type B materials require a maximum slope inclination of 1.5:1 and 1:1 (horizontal to vertical), respectively, unless the excavation is shored or braced. Where groundwater seepage occurs, flatter slopes will likely be required. Excavations deeper than 20 feet should be designed by a professional engineer.

Water and sewer lines are usually constructed beneath paved roads. Compaction of trench backfill will have a significant effect on the life and serviceability of pavements. We recommend trench backfill consisting of granular soils be placed in thin, loose lifts, moisture conditioned to within 2 percent of optimum moisture content and compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557). Cohesive materials should be compacted to 95 percent of maximum standard Proctor dry density (ASTM D 698) at moisture contents within 2 percent of optimum. Personnel from our firm should observe and test the placement and compaction of the trench backfill during construction.

<u>Underdrain Systems</u>

We believe use of underdrains incorporated into the design of sanitary sewer systems will provide a positive gravity outlet at individual residences for below-grade foundation drains. Where no groundwater is encountered in sanitary sewer excavations, "passive" underdrains may be used. For a passive underdrain, the drainpipe should consist of smooth, solid, rigid PVC pipe placed at a minimum slope of 0.5 percent. An active underdrain with smooth, perforated or slotted, rigid PVC pipe should be placed for a minimum distance of 10 feet upstream and downstream of the manholes. Concrete check dams should be constructed at the manhole locations to force water flowing through pipe bedding into the underdrain.

If wet conditions or active groundwater seepage are encountered in the sanitary sewer trenches, we recommend an active underdrain system with perforated or slotted pipe for these areas. A positive cutoff collar (concrete) should be constructed around the sewer pipe and underdrain pipe immediately downstream of the point the underdrain pipe exits the sewer trench or changes from active to passive. Solid pipe should be used down gradient of this cutoff collar to the point of discharge from the pipe.

The underdrain should be maintained at least 2 and preferably 3 feet below foundation elevations for buildings connected to the underdrain. The underdrain should be designed to discharge to a positive gravity outfall. A permanent concrete head wall, vent and trash rack should be provided at the underdrain discharge point to reduce risk of the drain becoming plugged and for future location of the discharge point. The discharge point should be above the high water line of any detention/retention ponds and drainage channels, and a back flow preventer valve provided at the end of the discharge pipe, if determined necessary by the civil engineer. Conceptual drain details are shown on Figs. 2 and 3.

The design of the underdrain system should consider adjacent developments that will connect to the system. If a gravity outfall will be used for this underdrain system, the outfall point should be planned to not affect developments located down gradient. As-built plans for the underdrain system should be prepared including location, elevations, and cleanouts. The entity responsible for maintenance of the underdrain system should retain the as-built plans for future reference.

The appropriate sizes of underdrain pipes are dependent upon actual alignments, area served, and gradients. We can review grading, drainage, and underground utility plans and provide suggested pipe sizing recommendations, if requested. The table below shows preliminary underdrain sizing based on number of residences and slope.

SLOPE=0.05 (0.5 PERCENT)				
Pipe Size (in)	**4**	**6**	**8**	**10**
Maximum Number of Residences	**50**	**100**	**200**	**400**
SLOPE=0.01 (1.0 PERCENT)				
Pipe Size (in)	**4**	**6**	**8**	**10**
Maximum Number of Residences	**75**	**150**	**300**	**600**
SLOPE=0.02 (2 PERCENT)				
Pipe Size (in)	**4**	**6**	**8**	**10**
Maximum Number of Residences	**100**	**300**	**600**	**1200**

FOUNDATION AND FLOOR SYSTEM CONCEPTS

We anticipate conventional spread footing foundation systems will be appropriate for residences constructed across the site. The occurrence of expansive materials may make the use of spread footings with minimum deadloads or removal of a zone of expansive material and replacement with non-expansive fill below the footings appropriate. Straight-shaft, drilled pier foundations may be an appropriate alternative if thicker zones of expansive bedrock occur at shallow depth.

Slab-on-grade floors will probably perform satisfactorily across most of the site where granular soils and/or sandstone occurs. Overall, risk of poor slab performance and cracking is believed to be low except where moderately to highly expansive bedrock occurs at or near floor slab elevation. Where moderately to highly expansive soils are present at or near finished floor elevations after overlot grading, structurally supported floors or removal of a zone of expansive material and replacement with non-expansive fill below the slab may be appropriate alternatives to enhance floor system performance. Soil and foundation investigation reports prepared after completion of overlot grading should address appropriate foundation systems and floor system alternatives on a lot-by-lot basis.

PAVEMENTS

Near surface soils predominately consist of silty to clayey sand and sandstone bedrock. These soils will most likely classify as A-2-4 and A-2-6 under the AASHTO system. Depths of overlot grading cuts and fills were not provided. For the onsite materials, we anticipate composite asphalt concrete and aggregate base course pavement sections on the order of 4 inches of asphalt over 6 inches of base course for local, low volume residential streets. These pavement thicknesses may not be sufficient for construction traffic and some maintenance and repair work may be needed prior to completion of the project. A subgrade investigation and pavement design should be performed after overlot grading and utility installation are complete.

CONCRETE

Concrete in contact with soils can be subject to sulfate attack. We measured negligible water-soluble sulfate concentrations in two samples from this site. Sulfate concentrations less than 0.1 percent indicate Class 0 exposure to sulfate attack for concrete in contact with the subsoils, according to the American Concrete Institute (ACI) *Guide To Durable Concrete (ACI 201.2R-01)*. For this level of sulfate concentration, ACI indicates any type of cement can be used for concrete in contact with the subsoils. In our experience, superficial damage may occur to the exposed surfaces of highly permeable concrete, even though sulfate levels are relatively low. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious material ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist. Concrete should have a total air content of 6 percent ± 1.5 percent. We recommend all basement walls in contact with the subsoils be damp-proofed.

SURFACE DRAINAGE AND IRRIGATION

The performance of structures, flatwork, and roads within Woodmoor Beach/ South Beach will be influenced by surface drainage. When developing an overall drainage scheme, consideration should be given to drainage around each structure and pavement areas. Drainage should be planned such that surface runoff is directed away from foundations and is not allowed to pond adjacent to or between structures or over pavements. Ideally, slopes of at least 6 inches in the first 10 feet should be planned for the areas surrounding buildings, where possible. Roof downspouts and other water collection systems should discharge well beyond the limits of all backfill around the structures. Proper control of surface runoff is also important to prevent the erosion of surface soils. Concentrated flows should not be directed over unprotected slopes. Permanent overlot slopes should be seeded or mulched to reduce the potential for erosion. The embankment slopes of the detention pond should be protected from erosion with vegetation and/or a man-made liner. Backfill soils behind the curb and gutter adjacent to streets and in utility trenches within individual lots should be compacted. If surface drainage between preliminary development and construction phases is neglected, performance of the roadways, flatwork, and foundations may be compromised.

RECOMMENDED FUTURE INVESTIGATIONS

Based on the results of this study, we recommend the following investigations and services be provided by our firm:

1. Construction materials testing and observation services during site development and construction
2. Subgrade Investigation and Pavement Design for on-site pavements.
3. Individual structure geotechnical investigations.

LIMITATIONS

The recommendations and conclusions presented in this report were prepared based on conditions disclosed by our exploratory borings, geologic reconnaissance, engineering analyses, and our experience. Variations in the subsurface conditions not indicated by the borings are possible and should be expected.

We believe this report was prepared with that level of skill and care ordinarily used by geologists and geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made.

Should you have any questions regarding the contents of this report or the project from a geotechnical engineering point-of-view, please call.

CTL | THOMPSON, INC.

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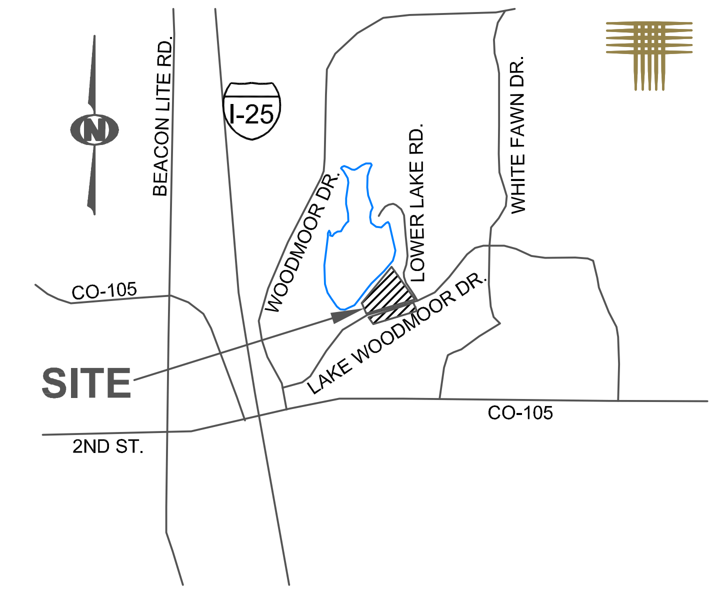

VICINITY MAP

(NOT TO SCALE)

LEGEND:

TH-1 ●	APPROXIMATE LOCATION OF EXPLORATORY BORING.
①	LOT NUMBER.
— — —	PROJECT BOUNDARY
⁓ ⁓	EXISTING TOPOGRAPHY

NOTE:
BASE DRAWING WAS PROVIDED BY CLARK LAND SURVEYING, INC.
(PROJECT NO. 5489, DATED NOVEMBER 17, 2006).

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WOODMOOR BEACH / SOUTH BEACH
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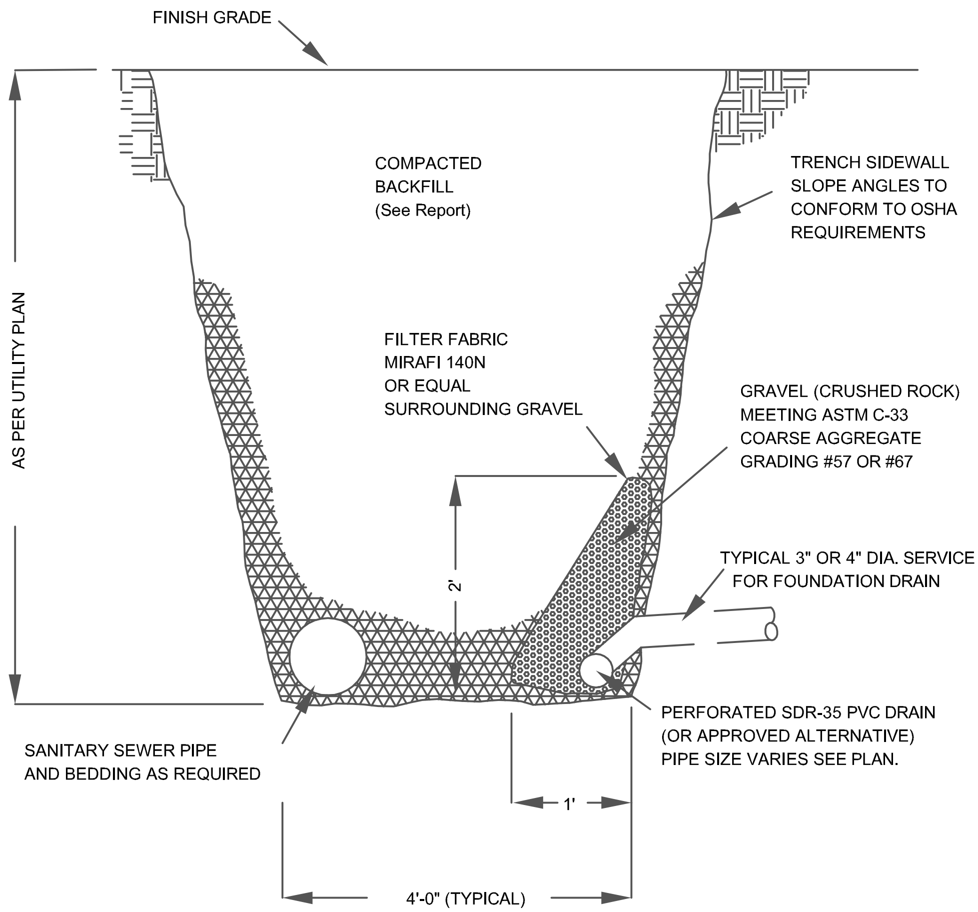
Location of Exploratory Borings

FIG. 1



Grading Requirements for Coarse Aggregates per ASTM C-33								
Size Number	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square Openings), Weight Percent						
		1 1/2 in. (37.5 mm)	1 in. (25.0 mm)	3/4 in. (19.0 mm)	1/2 in. (12.5 mm)	3/8 in. (9.5 mm)	No. 4 (4.5 mm)	No. 8 (2.36 mm)
67	3/4 in. to No. 4 (19.0 to 4.75 mm)	- -	100	90 to 100	- -	20 to 55	0 to 10	0 to 5
57	1 in. to No. 4 (25.0 to 9.5 mm)	100	95 to 100	- -	25 to 60	- -	0 to 10	0 to 5

NOTE:
TO BE USED IN CASES WHERE GROUND WATER IS FOUND DURING TRENCHING OR WHERE SHALLOW GROUND WATER IS KNOWN TO EXIST.

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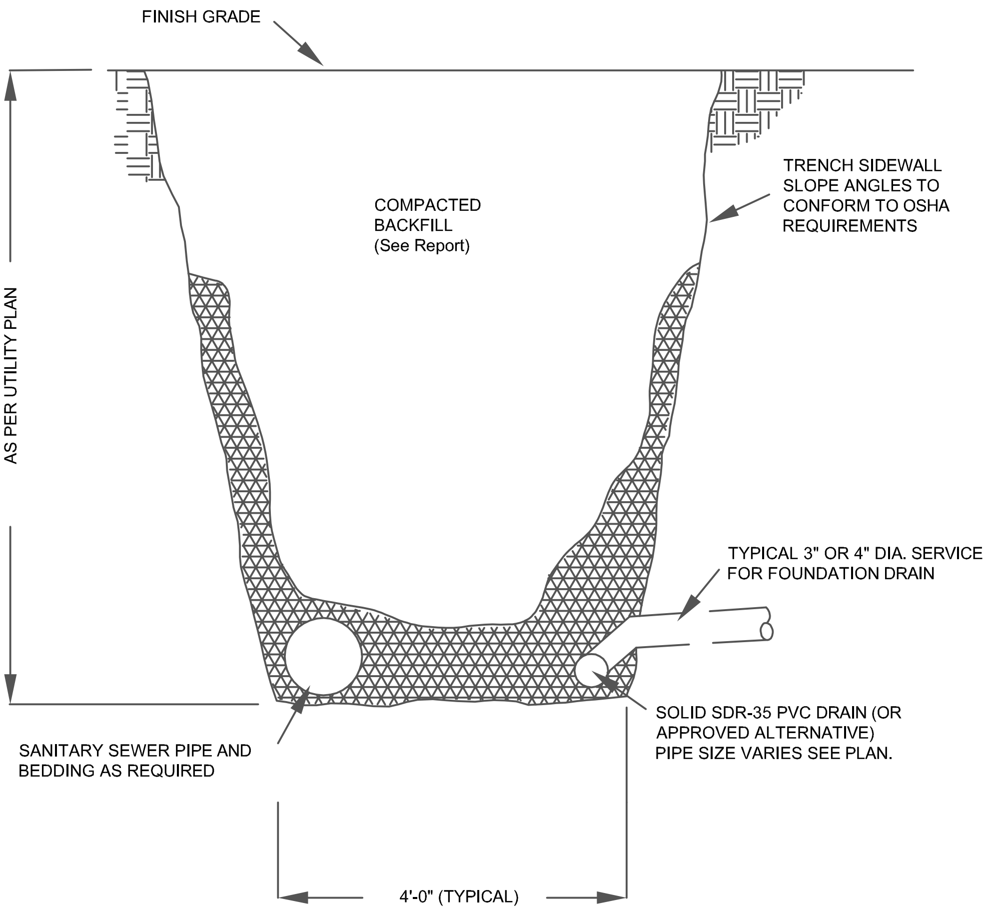
Active Drain Beside Sewer

FIG. 2



NOTE:
TO BE USED IN CASES WHERE NO
GROUND WATER IS KNOWN TO EXIST.

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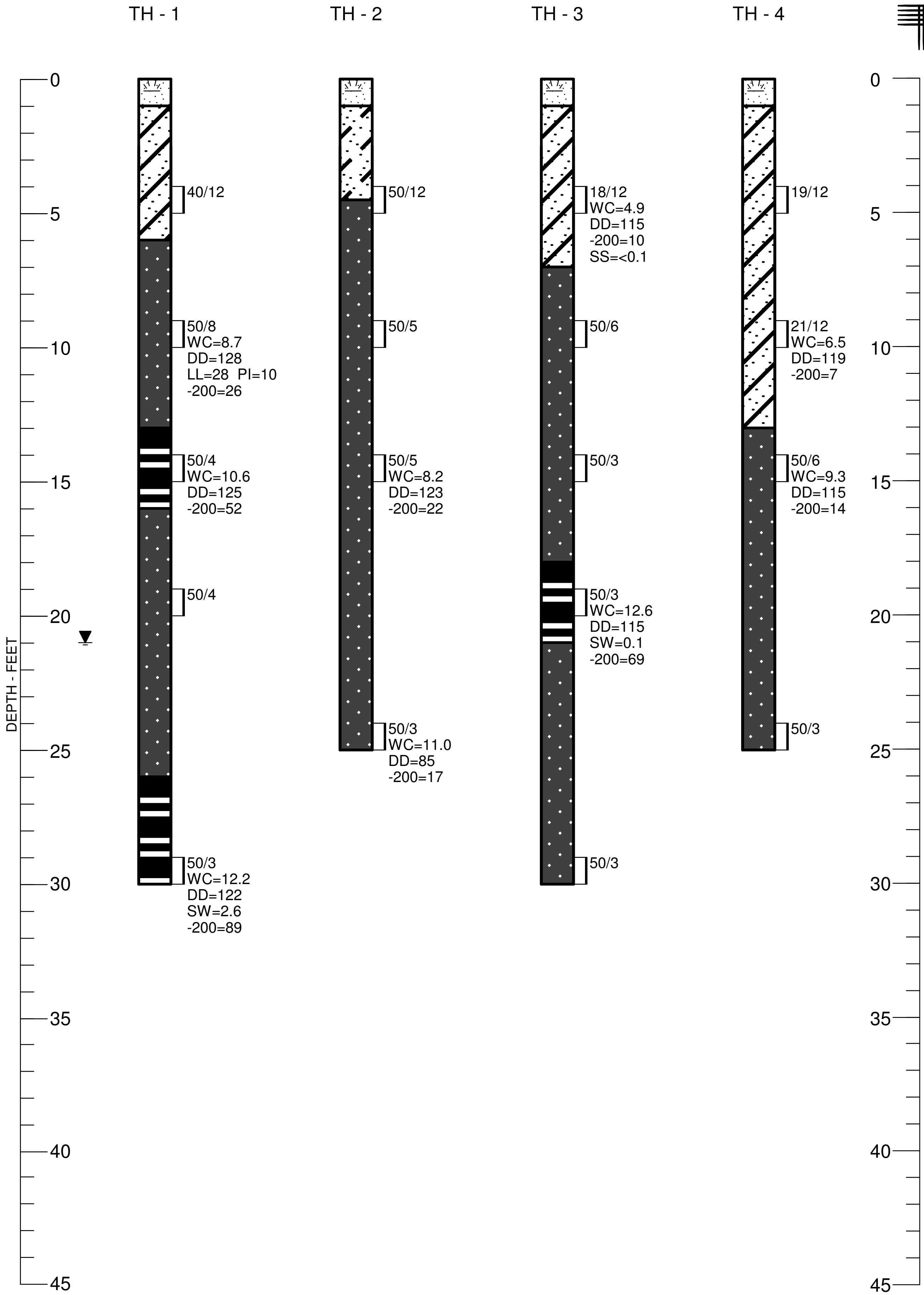
Passive Drain Beside Sewer

FIG. 3

APPENDIX A

SUMMARY LOGS OF EXPLORATORY BORINGS



LAKE WOODMOOR DEVELOPMENT
WOODMOOR BEACH / SOUTH BEACH
CTL|T PROJECT NO. CS18677-115
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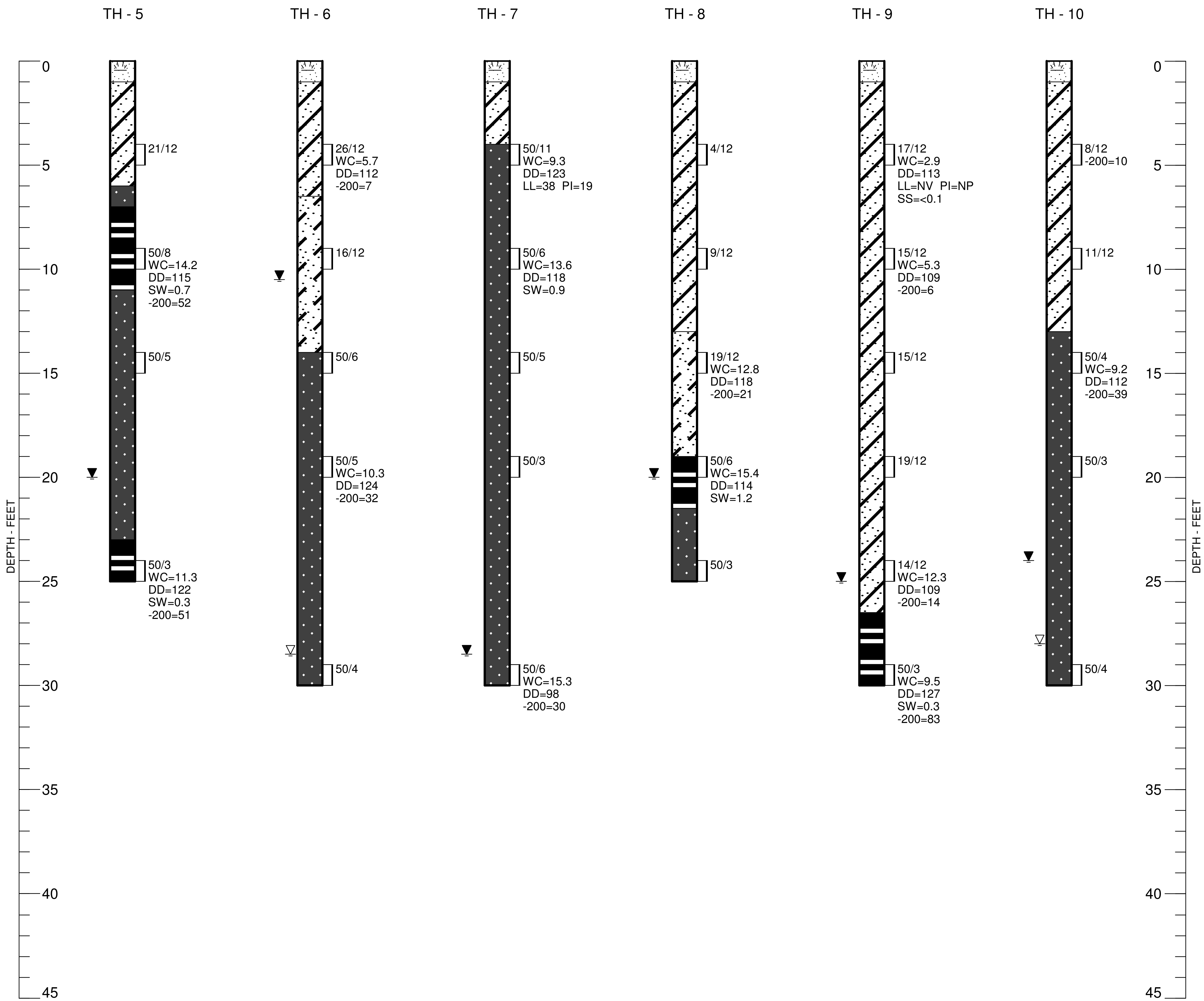
Summary Logs of Exploratory Borings

FIG. A-1



LEGEND:

TOPSOIL, SAND, CLAYEY, MOIST, DARK BROWN.

SAND, SLIGHTLY SILTY TO SILTY, MOIST, LOOSE TO VERY DENSE, LIGHT BROWN. (SP, SP-SM, SM)

SAND, CLAYEY, MOIST, MEDIUM DENSE, GRAY. (SC)

BEDROCK. SANDSTONE, CLAY TO VERY CLAYEY, MOIST, HARD, TO VERY HARD, YELLOWISH BROWN, MEDIUM BROWN, GRAY.

BEDROCK. CLAYSTONE, SANDY TO VERY SANDY, MOIST, HARD TO VERY HARD, GRAY TO DARK GRAY.

DRIVE SAMPLE. THE SYMBOL 40/12 INDICATES 40 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 12 INCHES.

∇ GROUNDWATER LEVEL MEASURED AT TIME OF DRILLING.

▼ GROUNDWATER LEVEL MEASURED EIGHT DAYS AFTER DRILLING.

NOTES:

1. THE BORINGS WERE DRILLED NOVEMBER 4, 2016 USING A 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A CME-55, TRUCK-MOUNTED DRILL RIG.
2. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS, AND CONCLUSIONS AS CONTAINED IN THIS REPORT.
3. WC - INDICATES MOISTURE CONTENT. (%)
   DD - INDICATES DRY DENSITY. (PCF)
   SW - INDICATES SWELL WHEN WETTED UNDER ESTIMATED OVERBURDEN PRESSURE. (%)
   LL - INDICATES LIQUID LIMIT. (%) (NV : NO VALUE)
   PI - INDICATES PLASTICITY INDEX. (%) (NP : NON-PLASTIC)
   -200 - INDICATES PASSING NO. 200 SIEVE. (%)
   SS - INDICATES WATER-SOLUBLE SULFATE CONTENT. (%)

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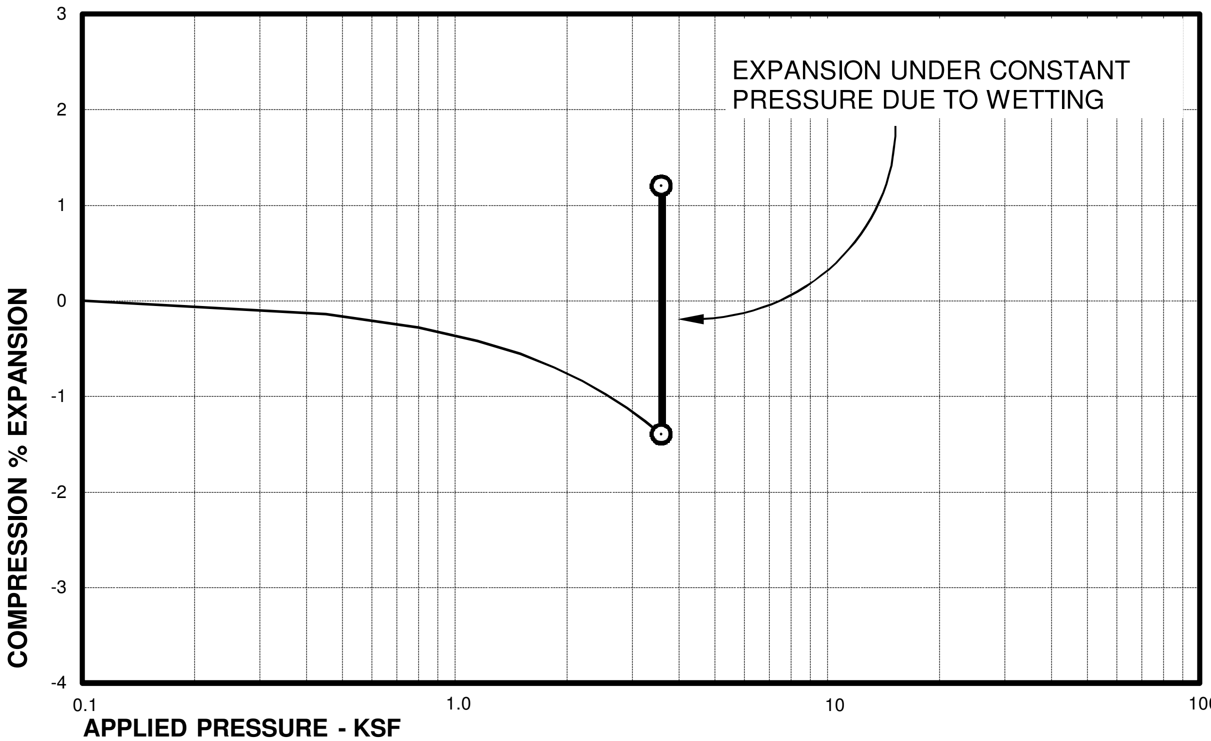
Summary Logs of Exploratory Borings

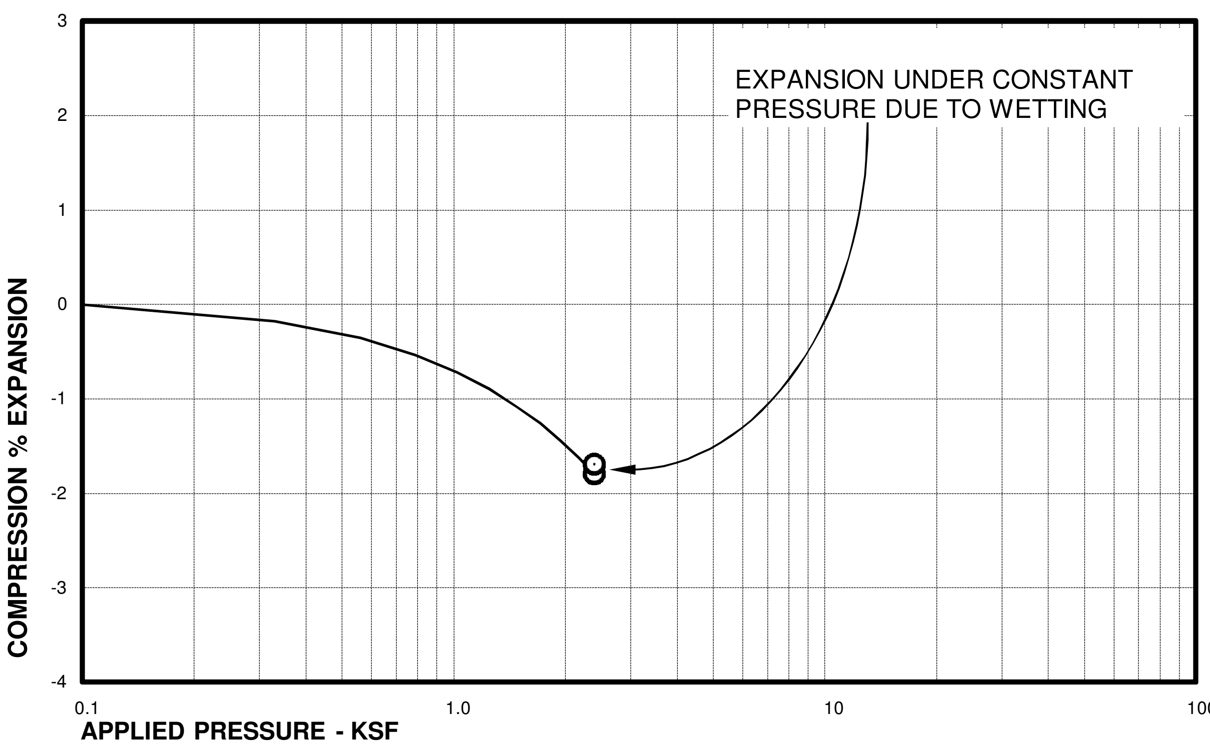
FIG. A-2

APPENDIX B

LABORATORY TEST RESULTS
TABLE B-1 – SUMMARY OF LABORATORY TESTING



Sample of	CLAYSTONE, SLIGHTLY SANDY	DRY UNIT WEIGHT=	122	PCF
From	TH-1 AT 29 FEET	MOISTURE CONTENT=	12.2	%



Sample of	CLAYSTONE, SANDY	DRY UNIT WEIGHT=	115	PCF
From	TH-3 AT 19 FEET	MOISTURE CONTENT=	12.6	%

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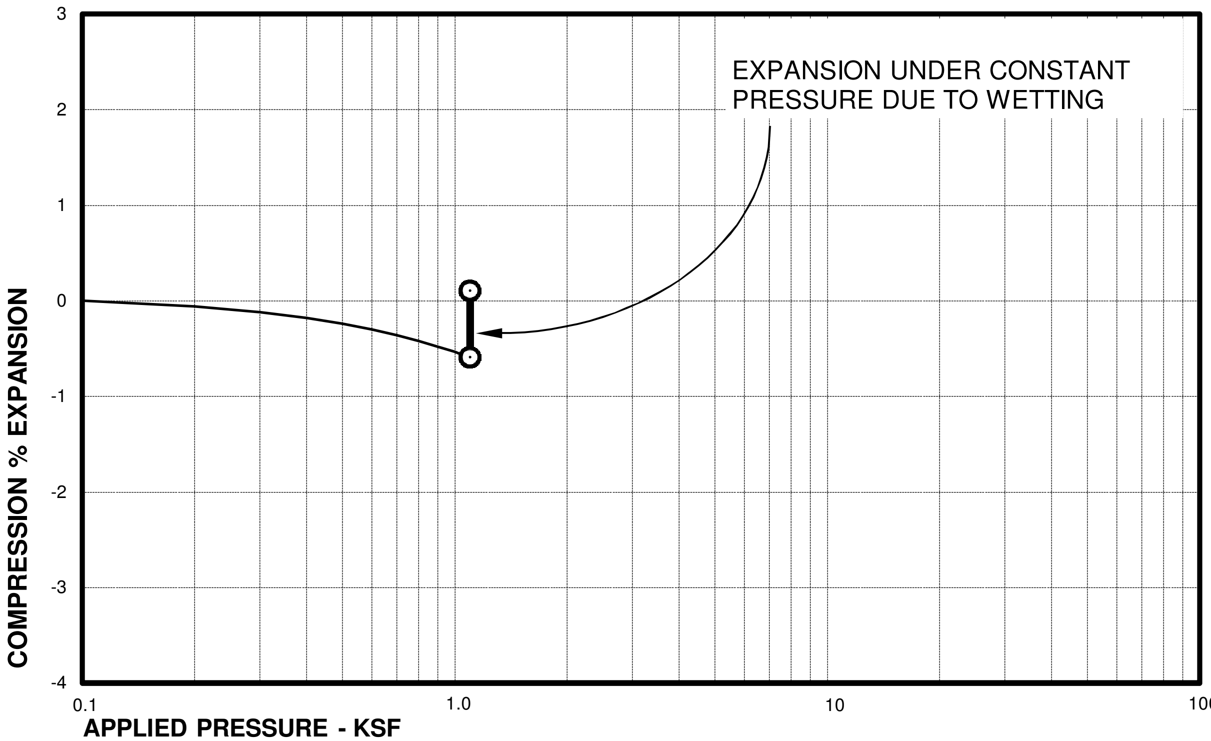
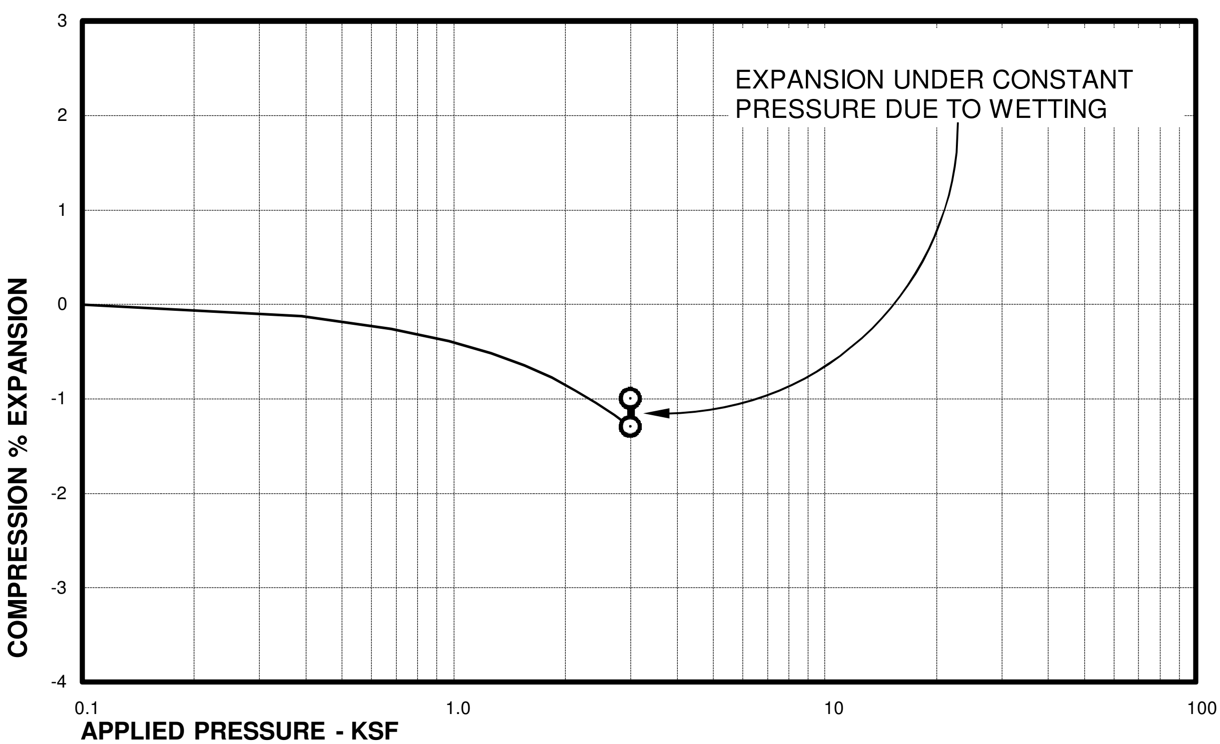
Swell Consolidation Test Results

FIG. B-1



Sample of	CLAYSTONE, VERY SANDY	DRY UNIT WEIGHT=	115	PCF
From	TH-5 AT 9 FEET	MOISTURE CONTENT=	14.2	%



Sample of	CLAYSTONE, VERY SANDY	DRY UNIT WEIGHT=	122	PCF
From	TH-5 AT 24 FEET	MOISTURE CONTENT=	11.3	%

LAKE WOODMOOR DEVELOPMENT
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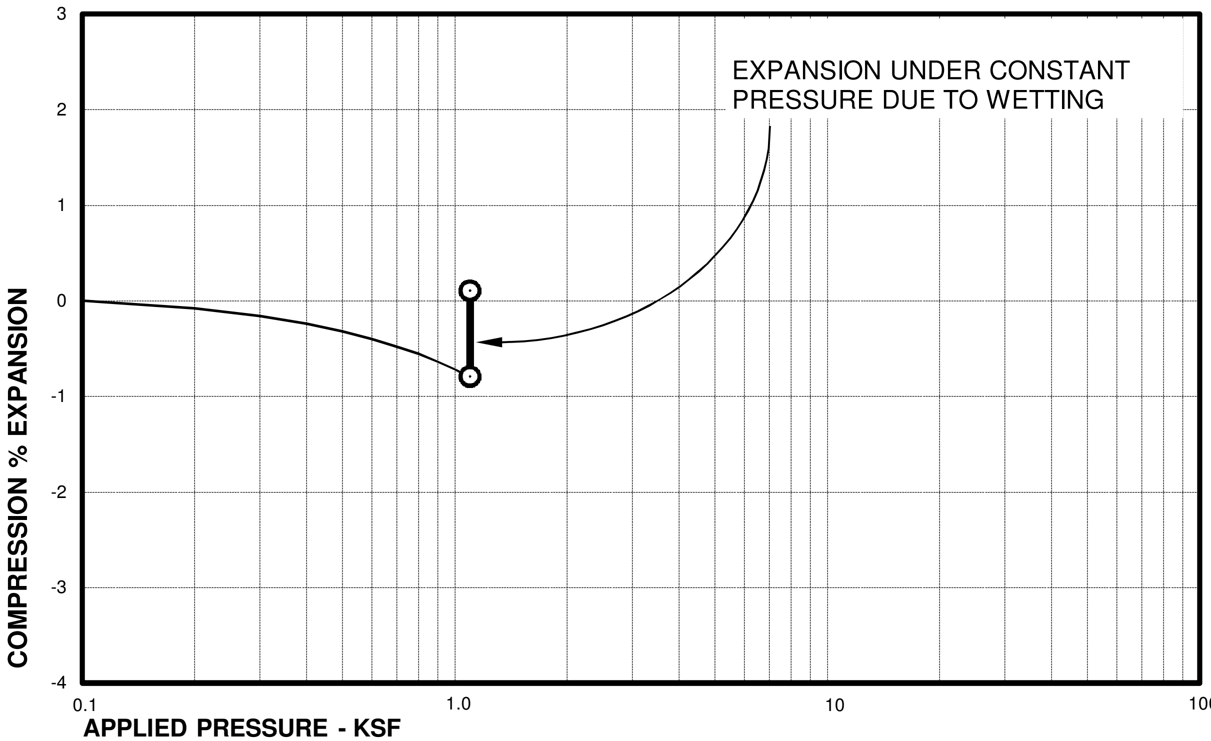
Swell Consolidation Test Results

FIG. B-2

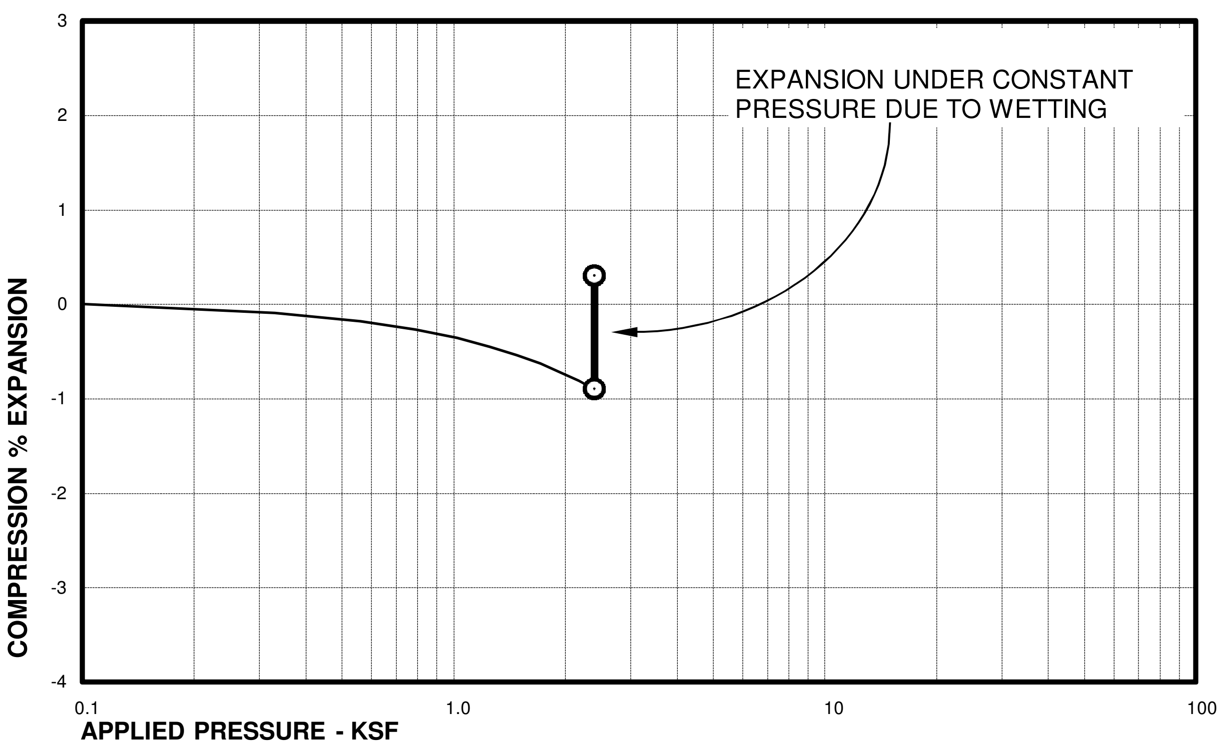


Sample of SANDSTONE, VERY CLAYEY

From TH-7 AT 9 FEET

DRY UNIT WEIGHT= 118 PCF

MOISTURE CONTENT= 13.6 %



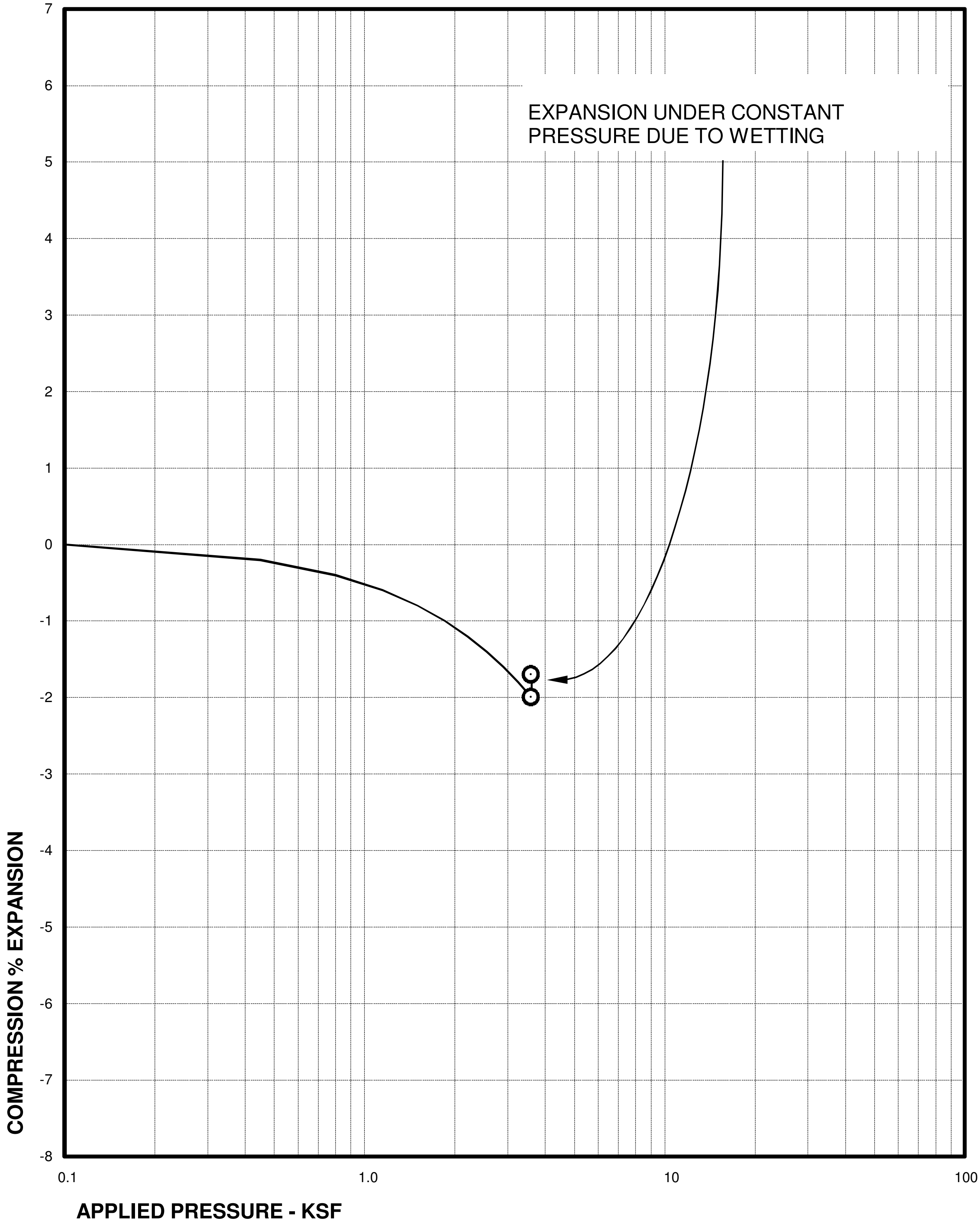
Sample of CLAYSTONE, VERY SANDY

From TH-8 AT 19 FEET

DRY UNIT WEIGHT= 114 PCF

MOISTURE CONTENT= 15.4 %

Swell Consolidation Test Results



Sample of CLAYSTONE, SANDY

From TH-9 AT 29 FEET

DRY UNIT WEIGHT= 127 PCF

MOISTURE CONTENT= 9.5 %

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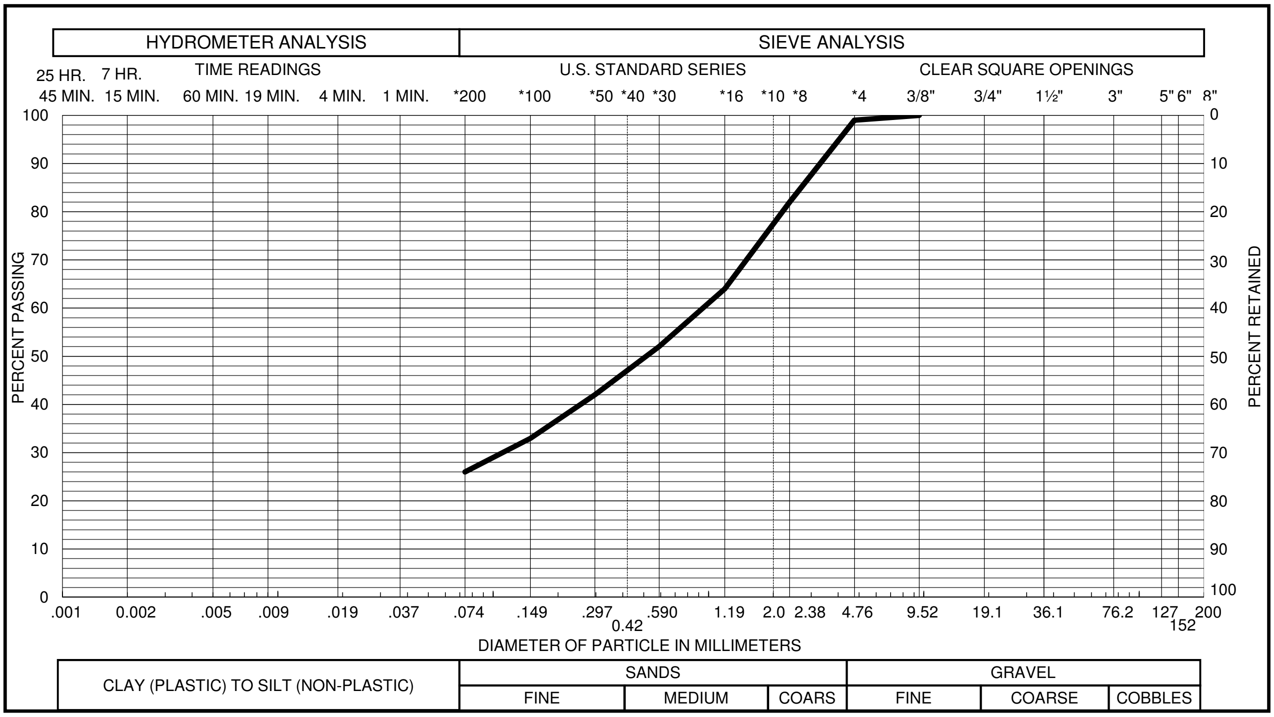
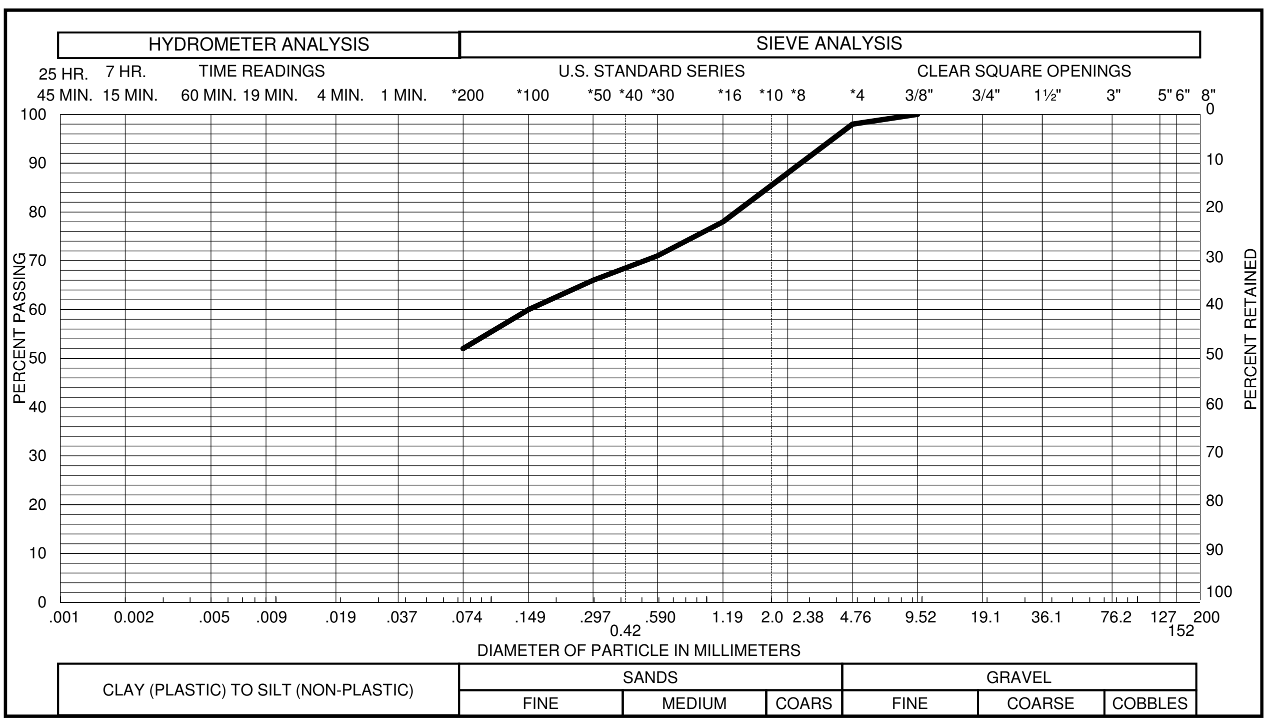
Swell Consolidation Test Results

FIG. B-4



Sample of SAND, SILTY (SM)
From TH - 1 AT 9 FEET

GRAVEL 1 % SAND 73 %
SILT & CLAY 26 % LIQUID LIMIT 28 %
PLASTICITY INDEX 10 %



Sample of CLAYSTONE, VERY SANDY
From TH - 1 AT 14 FEET

GRAVEL 2 % SAND 46 %
SILT & CLAY 52 % LIQUID LIMIT %
PLASTICITY INDEX %

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WOODMOOR BEACH/SOUTH BEACH
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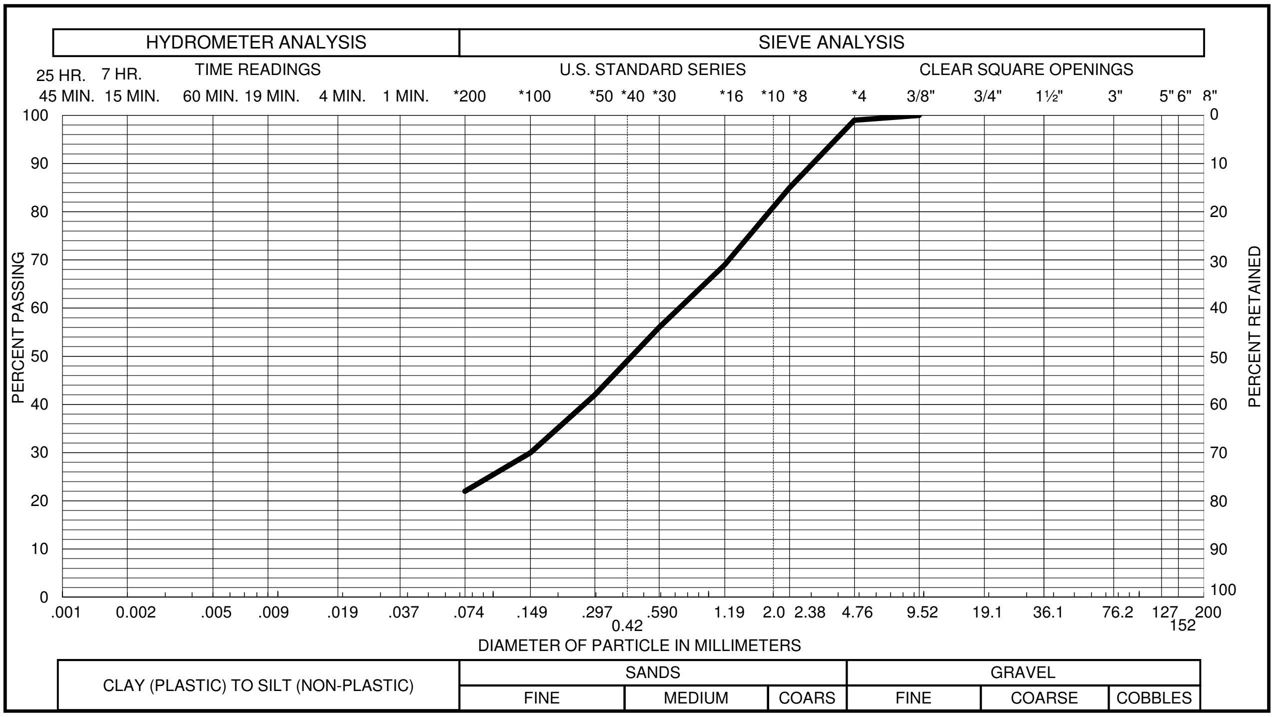
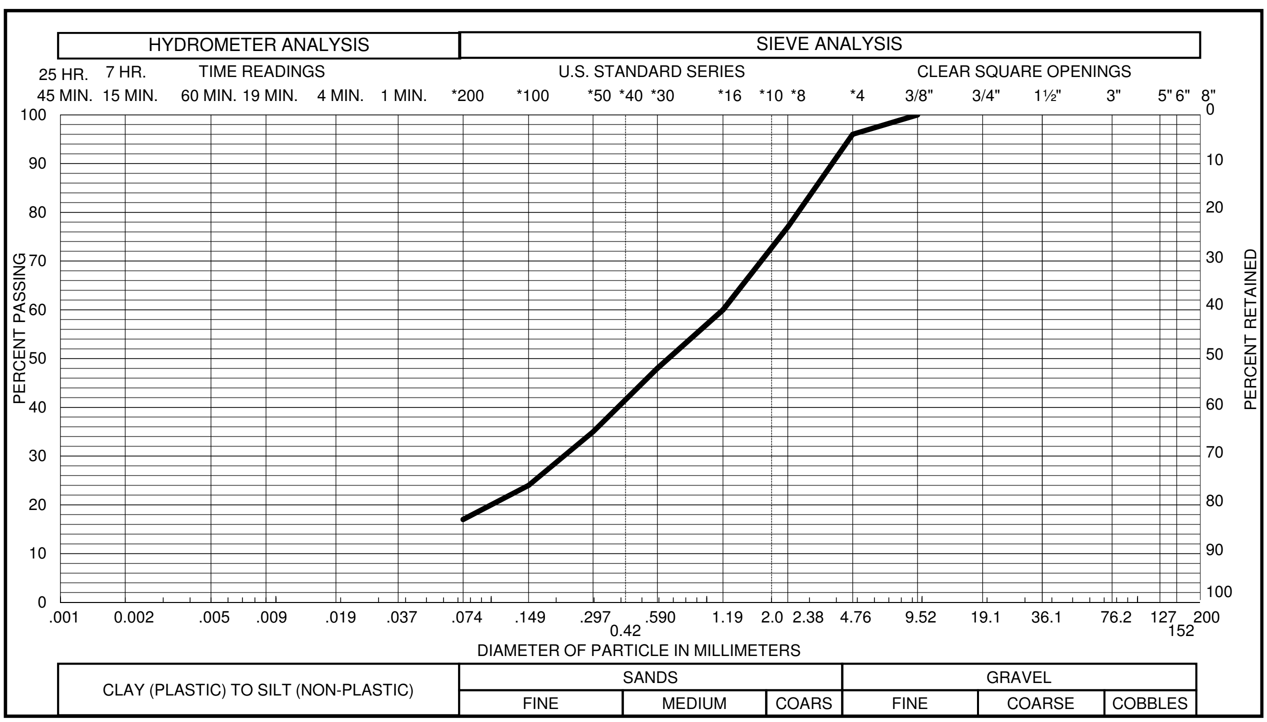
Gradation Test Results

FIG. B-5



Sample of SANDSTONE, CLAYEY
From TH - 2 AT 14 FEET

GRAVEL 1 % SAND 77 %
SILT & CLAY 22 % LIQUID LIMIT %
PLASTICITY INDEX %



Sample of SANDSTONE, CLAYEY
From TH - 2 AT 24 FEET

GRAVEL 4 % SAND 79 %
SILT & CLAY 17 % LIQUID LIMIT %
PLASTICITY INDEX %

LAKE WOODMOOR DEVELOPMENT
WOODMOOR BEACH/SOUTH BEACH
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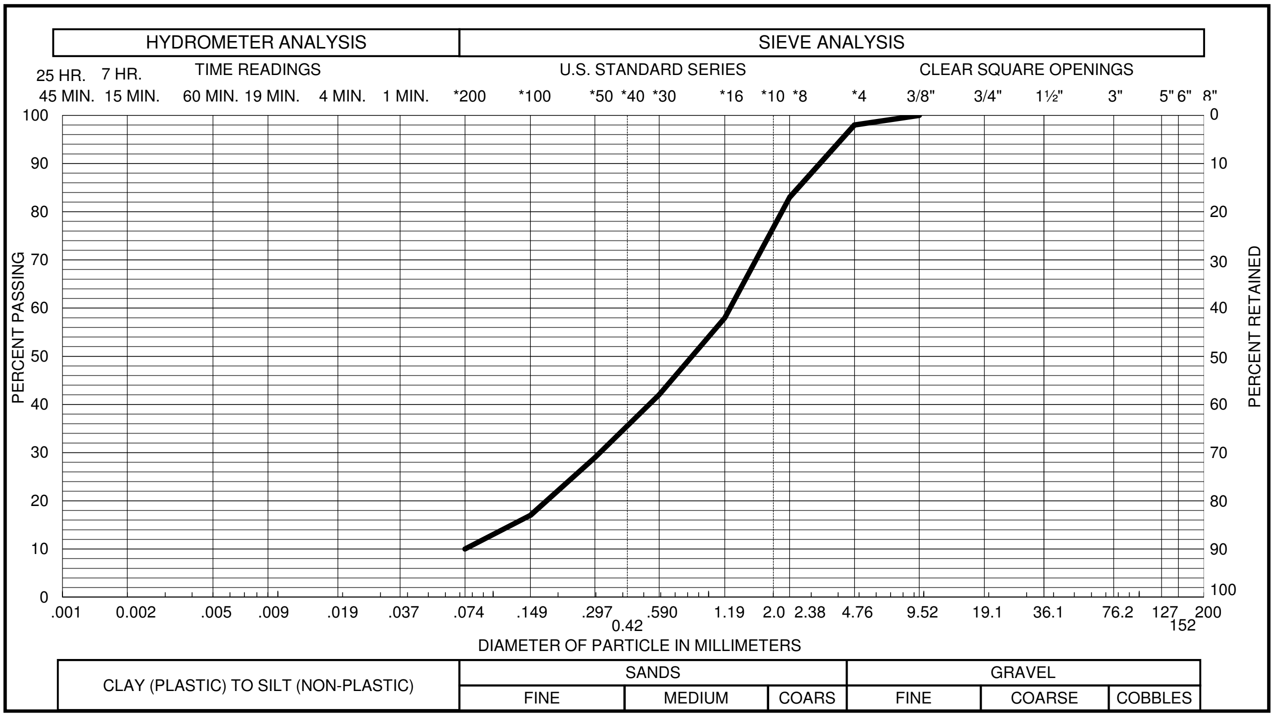
Gradation Test Results

FIG. B-6



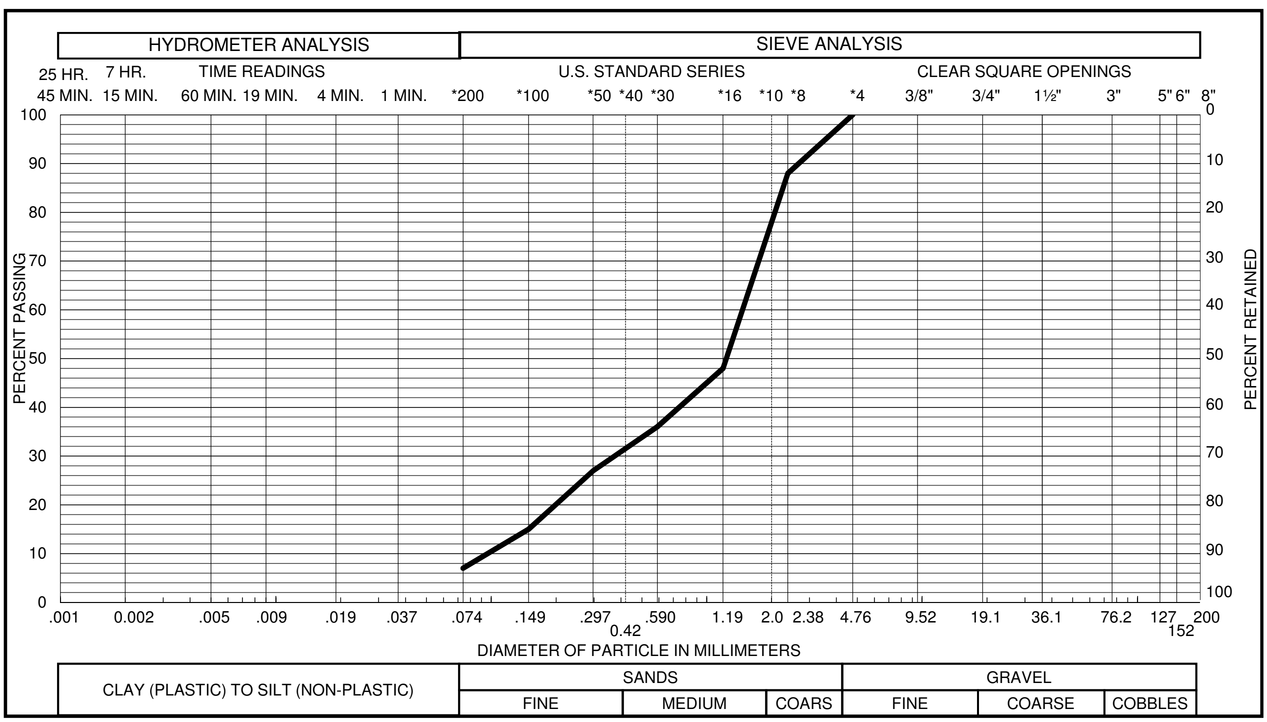
Sample of SAND, SLIGHTLY SILTY (SP-SM)

From TH - 3 AT 4 FEET

GRAVEL 2 % SAND 88 %

SILT & CLAY 10 % LIQUID LIMIT %

PLASTICITY INDEX %



Sample of SAND, SLIGHTLY SILTY (SP-SM)

From TH - 4 AT 9 FEET

GRAVEL 0 % SAND 93 %

SILT & CLAY 7 % LIQUID LIMIT %

PLASTICITY INDEX %

LAKE WOODMOOR DEVELOPMENT
WOODMOOR BEACH/SOUTH BEACH
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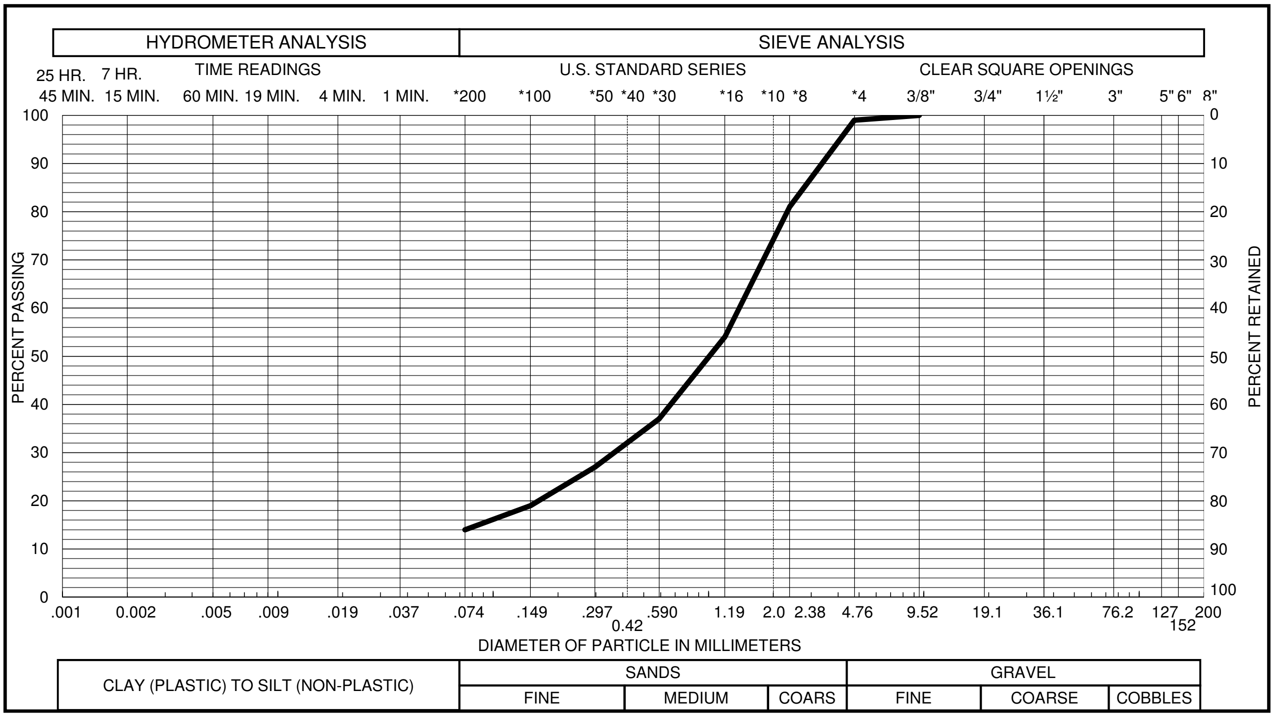
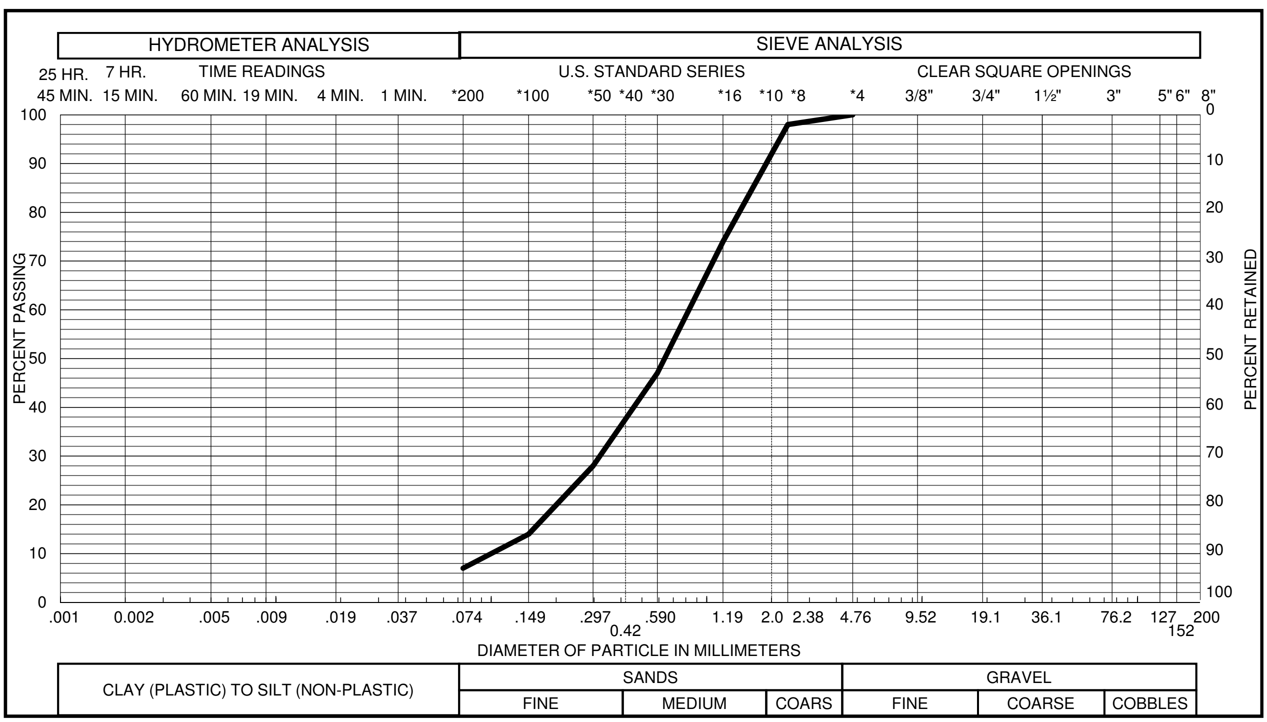
Gradation Test Results

FIG. B-7



Sample of SANDSTONE, CLAYEY
From TH - 4 AT 14 FEET

GRAVEL 1 %
SAND 85 %
SILT & CLAY 14 %
LIQUID LIMIT %
PLASTICITY INDEX %



Sample of SAND, SLIGHTLY SILTY (SP-SM)
From TH - 6 AT 4 FEET

GRAVEL 0 %
SAND 93 %
SILT & CLAY 7 %
LIQUID LIMIT %
PLASTICITY INDEX %

LAKE WOODMOOR DEVELOPMENT
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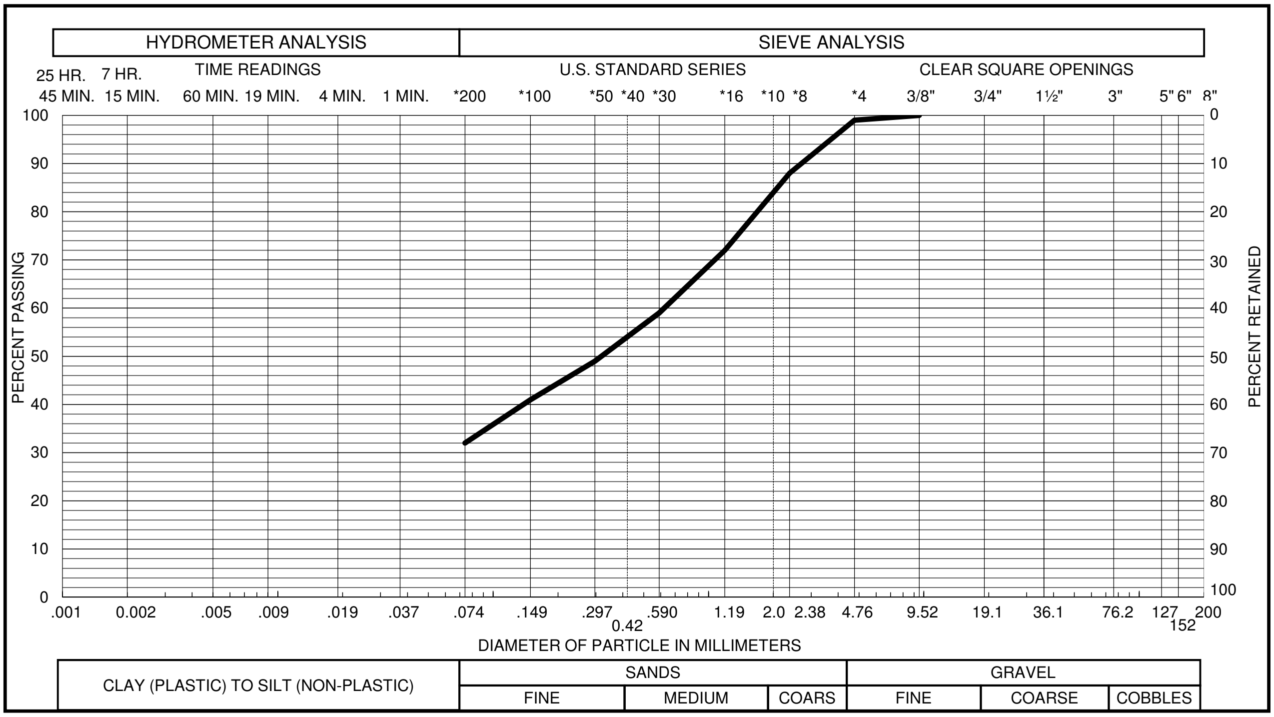
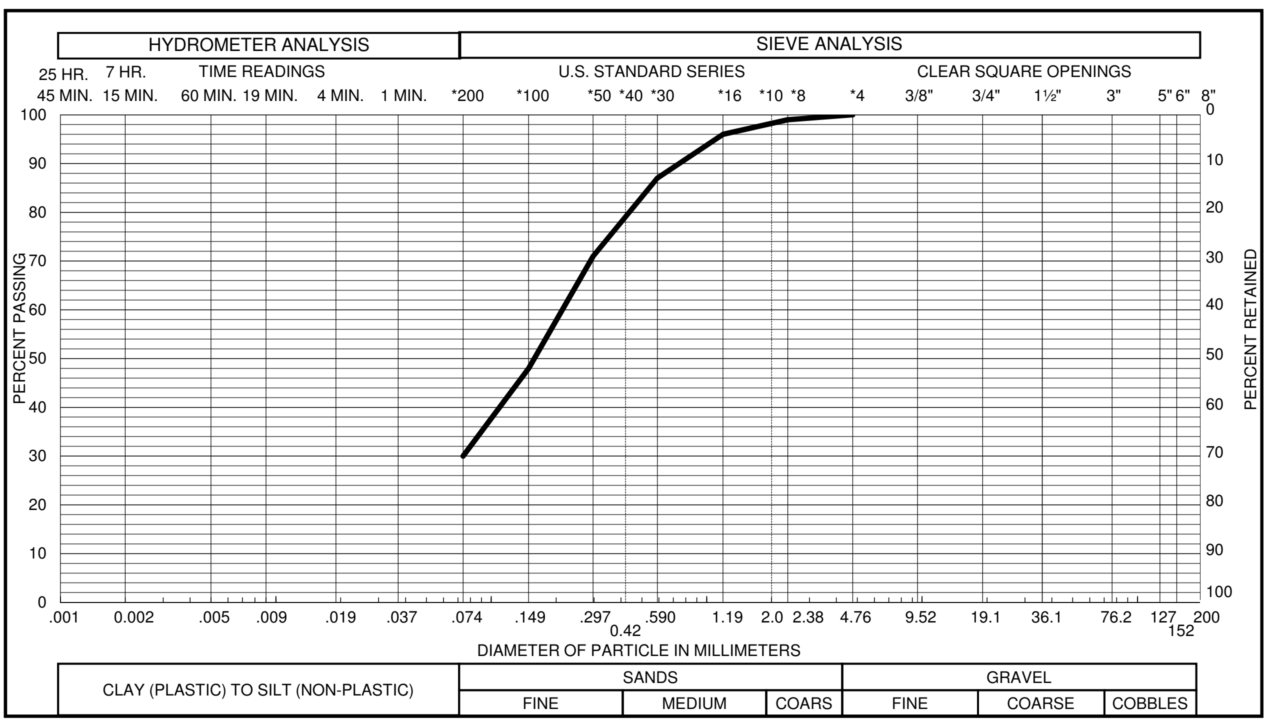
Gradation Test Results

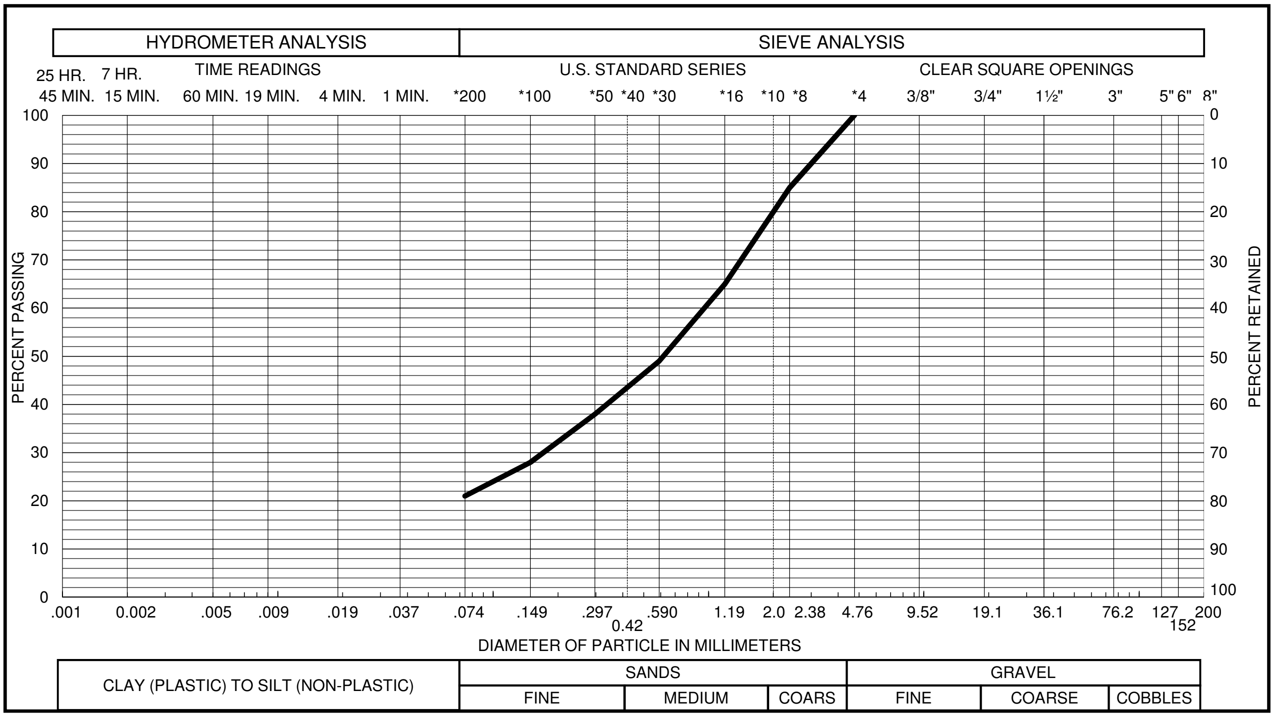


Sample of	SANDSTONE, CLAYEY	GRAVEL	1 %	SAND	67 %
From	TH - 6 AT 19 FEET	SILT & CLAY	32 %	LIQUID LIMIT	%
		PLASTICITY INDEX			%



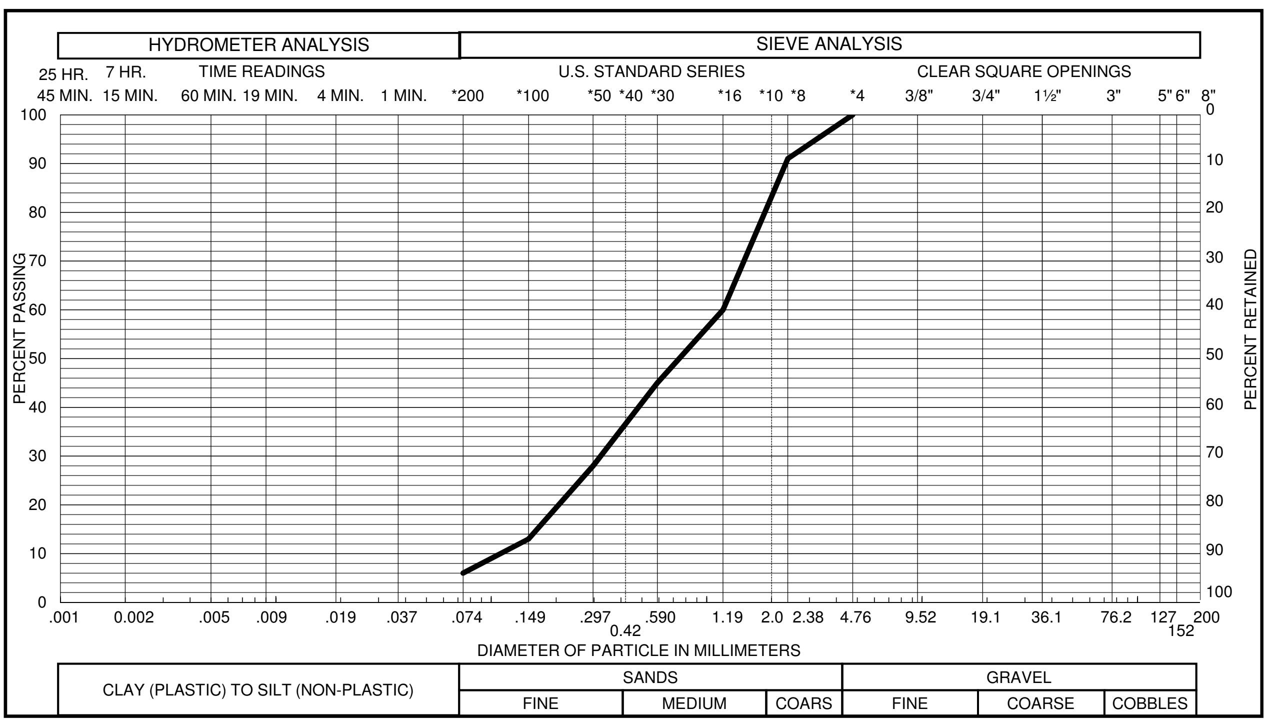
Sample of	SANDSTONE, CLAYEY	GRAVEL	0 %	SAND	70 %
From	TH - 7 AT 29 FEET	SILT & CLAY	30 %	LIQUID LIMIT	%
		PLASTICITY INDEX			%

Gradation Test Results



Sample of SAND, CLAYEY (SC)
From TH - 8 AT 14 FEET

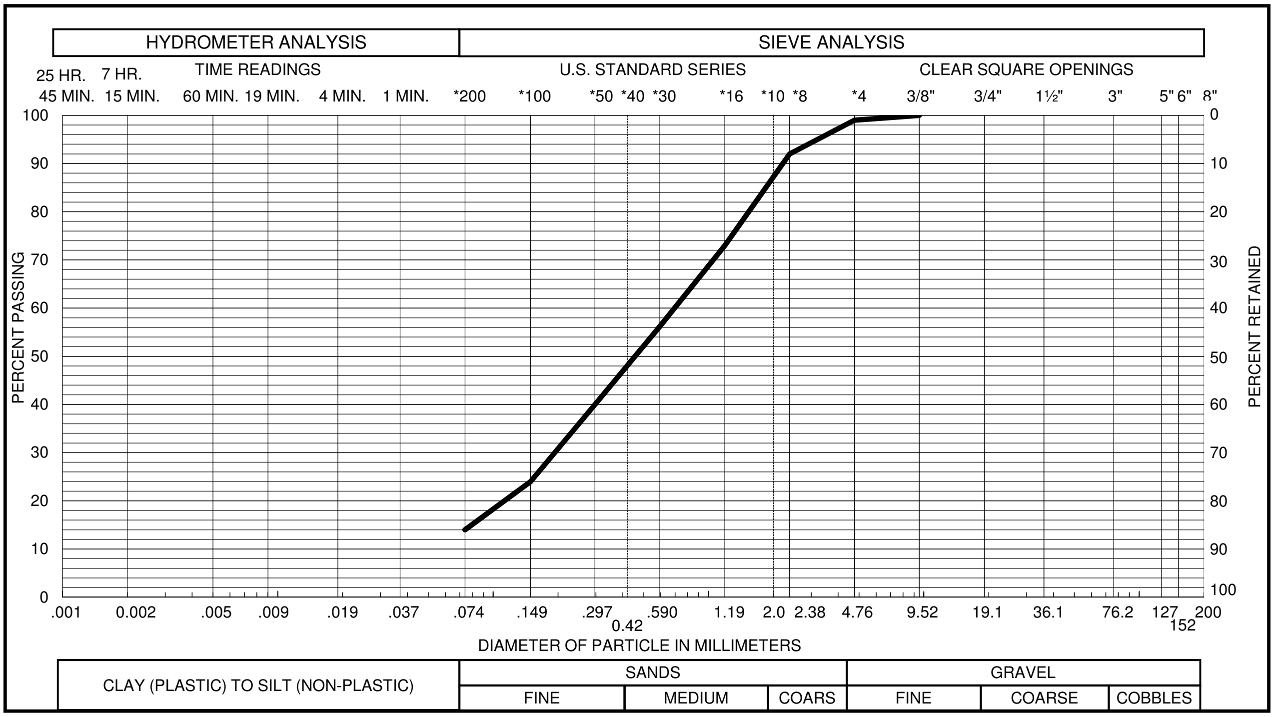
GRAVEL 0 % SAND 79 %
SILT & CLAY 21 % LIQUID LIMIT %
PLASTICITY INDEX %



Sample of SAND, SILTY (SM)
From TH - 9 AT 9 FEET

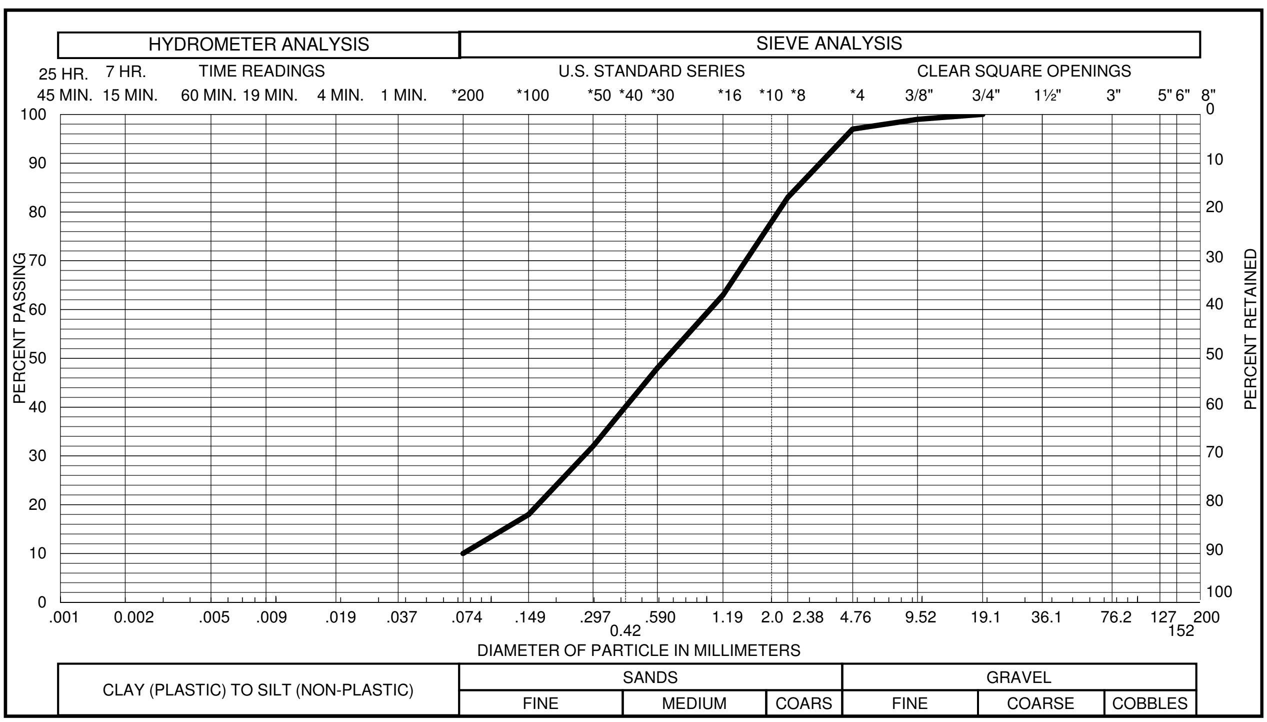
GRAVEL 0 % SAND 94 %
SILT & CLAY 6 % LIQUID LIMIT %
PLASTICITY INDEX %

Gradation Test Results



Sample of SAND, CLAYEY (SC)
From TH - 9 AT 24 FEET

GRAVEL 1 % SAND 85 %
SILT & CLAY 14 % LIQUID LIMIT %
PLASTICITY INDEX %



Sample of SAND, SLIGHTLY SILTY (SP-SM)
From TH - 10 AT 4 FEET

GRAVEL 3 % SAND 87 %
SILT & CLAY 10 % LIQUID LIMIT %
PLASTICITY INDEX %

LAKE WOODMOOR DEVELOPMENT
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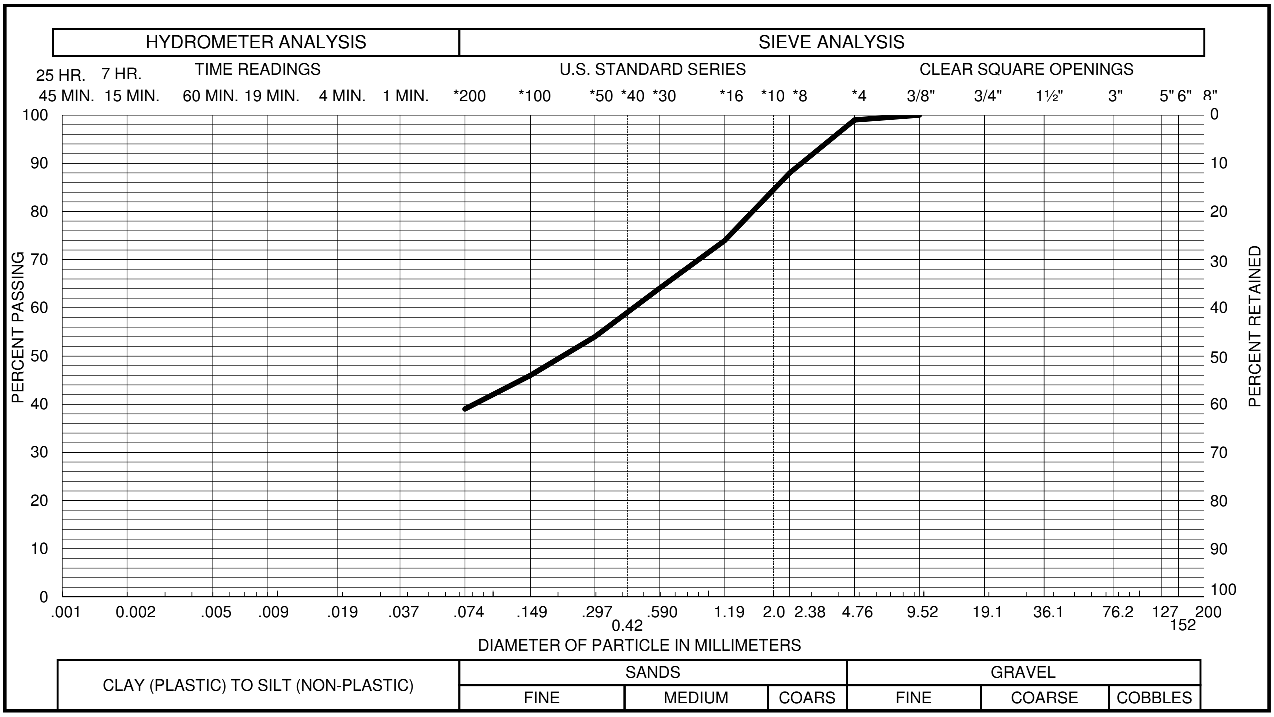
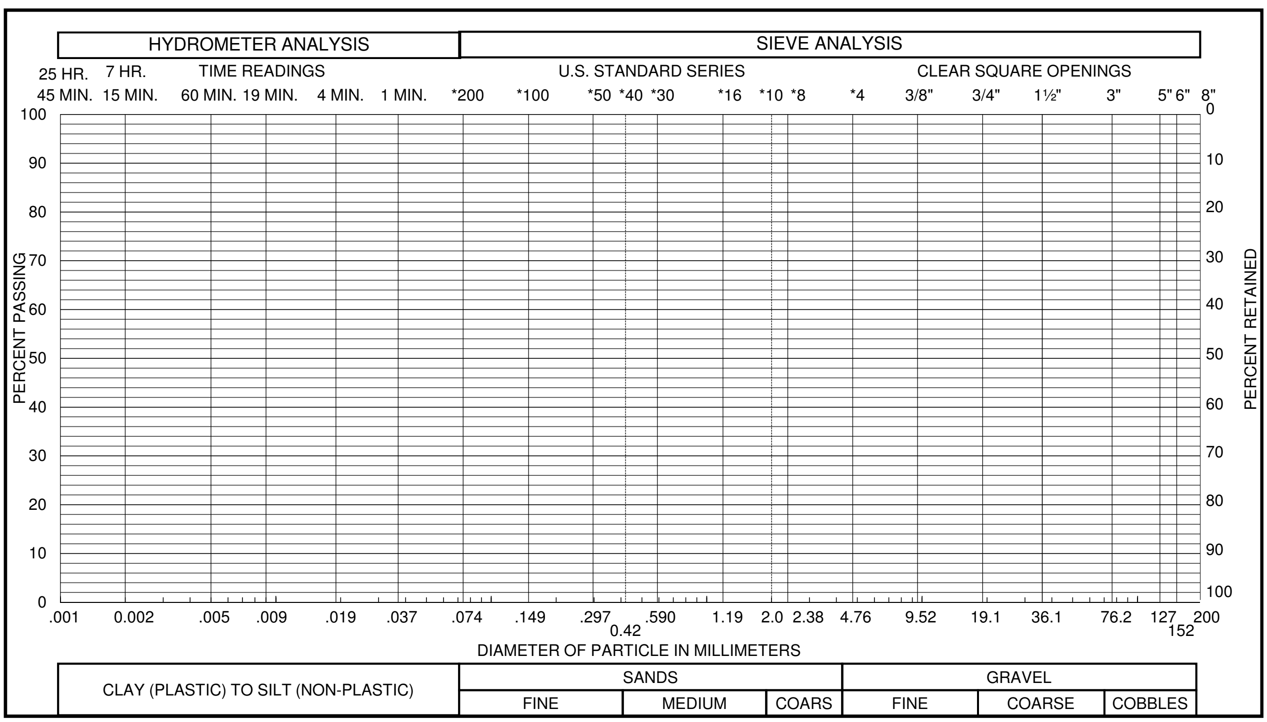
Gradation Test Results

FIG. B-11



Sample of SANDSTONE, VERY CLAYEY
From TH - 10 AT 14 FEET

GRAVEL 1 % SAND 60 %
SILT & CLAY 39 % LIQUID LIMIT %
PLASTICITY INDEX %



Sample of
From

GRAVEL % SAND %
SILT & CLAY % LIQUID LIMIT %
PLASTICITY INDEX %

LAKE WOODMOOR DEVELOPMENT
WOODMOOR BEACH/SOUTH BEACH
CTL|T PROJECT NO. CS18677-115
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Gradation Test Results

FIG. B-12

TABLE B-I

SUMMARY OF LABORATORY TESTING
CTL|T PROJECT NO. CS18677-115

				ATTERBERG LIMITS		SWELL TEST RESULTS*		PASSING	WATER	
BORING	DEPTH (FEET)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SWELL (%)	SWELL PRESSURE (PSF)	NO. 200 SIEVE (%)	SOLUBLE SULFATES (%)	DESCRIPTION
TH-1	9	8.7	128	28	10			26		SAND, SILTY (SM)
TH-1	14	10.6	125					52		CLAYSTONE, VERY SANDY
TH-1	29	12.2	122			2.6		89		CLAYSTONE, SLIGHTLY SANDY
TH-2	14	8.2	123					22		SANDSTONE, CLAYEY
TH-2	24	11.0	85					17		SANDSTONE, CLAYEY
TH-3	4	4.9	115					10	<0.1	SAND, SLIGHTLY SILTY (SP-SM)
TH-3	19	12.6	115			0.1		69		CLAYSTONE, SANDY
TH-4	9	6.5	119					7		SAND, SLIGHTLY SILTY (SP-SM)
TH-4	14	9.3	115					14		SANDSTONE, CLAYEY
TH-5	9	14.2	115			0.7		52		CLAYSTONE, VERY SANDY
TH-5	24	11.3	122			0.3		51		CLAYSTONE, VERY SANDY
TH-6	4	5.7	112					7		SAND, SLIGHTLY SILTY (SP-SM)
TH-6	19	10.3	124					32		SANDSTONE, CLAYEY
TH-7	4	9.3	123	38	19					SANDSTONE, CLAYEY
TH-7	9	13.6	118			0.9				SANDSTONE, VERY CLAYEY
TH-7	29	15.3	98					30		SANDSTONE, CLAYEY
TH-8	14	12.8	118					21		SAND, CLAYEY (SC)
TH-8	19	15.4	114			1.2				CLAYSTONE, VERY SANDY
TH-9	4	2.9	113	NV	NP				<0.1	SAND, SILTY (SM)
TH-9	9	5.3	109					6		SAND, SLIGHTLY SILTY (SP-SM)
TH-9	24	12.3	109					14		SAND, CLAYEY (SC)
TH-9	29	9.5	127			0.3		83		CLAYSTONE, SANDY
TH-10	4							10		SAND, SLIGHTLY SILTY (SP-SM)
TH-10	14	9.2	112					39		SANDSTONE, VERY CLAYEY

* SWELL MEASURED WITH 1000 PSF APPLIED PRESSURE, OR ESTIMATED IN-SITU OVERBURDEN PRESSURE.
NEGATIVE VALUE INDICATES COMPRESSION.

APPENDIX C

GUIDELINE SITE GRADING SPECIFICATIONS
WOODMOOR BEACH/SOUTH BEACH
MONUMENT, COLORADO

GUIDELINE SITE GRADING SPECIFICATIONS
WOODMOOR BEACH/SOUTH BEACH
MONUMENT, COLORADO

1. DESCRIPTION

This item consists of the excavation, transportation, placement and compaction of materials from locations indicated on the plans, or staked by the Engineer, as necessary to achieve preliminary pavement and building pad elevations. These specifications also apply to compaction of materials that may be placed outside of the project.

2. GENERAL

The Soils Engineer will be the Owner's representative. The Soils Engineer will approve fill materials, method of placement, moisture contents and percent compaction.

3. CLEARING JOB SITE

The Contractor shall remove all trees, brush and rubbish before excavation or fill placement is begun. The Contractor shall dispose of the cleared material to provide the Owner with a clean, neat appearing job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures of any kind.

4. SCARIFYING AREA TO BE FILLED

All topsoil, vegetable matter, and existing fill shall be removed from the ground surface upon which fill is to be placed. The surface shall then be plowed or scarified until the surface is free from ruts, hummocks or other uneven features that would prevent uniform compaction by the equipment to be used.

5. PLACEMENT OF FILL ON NATURAL SLOPES

Where natural slopes are steeper than 20 percent (5:1, horizontal to vertical) and fill placement is required, horizontal benches shall be cut into the hillside. The benches shall be at least 12 feet wide or 1-1/2 times the width of the compaction equipment and be provided at a vertical spacing of not more than 5 feet (minimum of two benches). Larger bench widths may be required by the Engineer. Fill shall be placed on completed benches as outlined within this specification.

6. COMPACTING AREA TO BE FILLED

After the foundation for the fill has been cleared and scarified, it shall be disced or bladed until it is free from large clods, brought to a workable moisture content and compacted.

7. FILL MATERIALS

Fill soils shall be free from vegetable matter or other deleterious substances and shall not contain rocks or lumps having a diameter greater than six (6) inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer or imported to the site.

8. MOISTURE CONTENT

For fill material classifying as SC, GC, CH or CL (cohesive soils), the fill shall be moisture treated to between 1 and 4 percent above optimum moisture content as determined by ASTM D 698 if it is to be placed within 15 feet of the final grade. For deep cohesive fill (greater than 15 feet below final grade) it shall be moisture conditioned to within ±2 percent of optimum. Soils classifying as SM, SW, SP, GP, and GM (non-cohesive soils) shall be moisture treated to within 2 percent of optimum moisture content as determined by ASTM D 1557. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas.

The Contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Soils Engineer, it is not possible to obtain uniform moisture content by adding water on the fill surface. The Contractor may be required to rake or disc the fill soils to provide uniform moisture content throughout the soils.

The application of water to embankment materials shall be made with any type of watering equipment approved by the Soils Engineer, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are washed out.

Should too much water be added to any part of the fill, such that the material is too wet to permit the desired compaction to be obtained, all work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework wet material in an approved manner to hasten its drying.

9. COMPACTION OF FILL AREAS

Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Non-cohesive fill placed less than 15 feet below final grade shall be compacted to at least 95 percent of maximum dry density as determined in accordance with ASTM D 1557. Cohesive fills placed less than 15 feet below final grade shall be compacted to at least 95 percent of maximum dry density as determined in accordance with ASTM D 698. For deep, cohesive fill (to be placed 15 feet or deeper below final grade), the material shall be compacted to at least 98 percent of maximum standard Proctor dry density (ASTM D 698). Granular fill placed more than 15 feet below final grade shall be compacted to at least 95 percent of maximum modified Proctor dry density (ASTM D 1557). Deep fills shall be placed within 2 percent of optimum moisture content. Fill materials shall be placed such that the thickness of loose materials does not exceed 10 inches and the compacted lift thickness does not exceed 6 inches.

Compaction, as specified above, shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Soils Engineer for soils classifying as claystone, CL, CH or SC. Granular fill shall be compacted using vibratory equipment or other equipment approved by the Soils Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area. Compaction equipment shall make sufficient trips to insure that the required density is obtained.

10. COMPACTION OF SLOPES

Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and there is no appreciable amount of loose soil on the slopes. Compaction of slopes may be done progressively in increments of 3 to 5 feet in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

11. DENSITY TESTS

Field density tests will be made by the Soils Engineer at locations and depths of his/her choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests will be taken in compacted material below the disturbed surface. When density tests indicate the density or moisture content of any layer of fill or portion thereof is below that required, the particular layer or portion shall be reworked until the required density or moisture content has been achieved. The criteria for acceptance of fill shall be:

A. Moisture

The allowable ranges for moisture content of the fill materials specified above in "Moisture Content" are based on design considerations. The moisture shall be controlled by the Contractor so that moisture content of the compacted earth fill, as determined by tests performed by the Soils Engineer, shall be within the limits given.

The Soils Engineer will inform the Contractor when the placement moisture is less than or exceeds the limits specified above and the Contractor shall immediately make adjustments in procedures as necessary to maintain placement moisture content within the specified limits.

B. Density

1. The average dry density of all material shall not be less than the dry density specified.

2. No more than 20 percent of the material represented by the samples tested shall be at dry densities less than the dry density specified.

3. Material represented by samples tested having a dry density more than 2 percent below the specified dry density will be rejected. Such rejected materials shall be reworked until a dry density equal to or greater than the specified dry density is obtained.

12. SEASONAL LIMITS

No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Soils Engineer indicates the moisture content and density of previously placed materials are as specified.

13. NOTICE REGARDING START OF GRADING

The Contractor shall submit notification to the Soils Engineer and owner advising them of the start of grading operations at least three (3) days in advance of the starting date. Notification shall also be submitted at least three days in advance of any resumption dates when grading operations have been stopped for any reason other than adverse weather conditions.

14. REPORTING OF FIELD DENSITY TESTS

Density tests made by the Soils Engineer, as specified under “Density Tests” above, will be submitted progressively to the Owner. Dry density, moisture content and percent compaction will be reported for each test taken.