GEOTECHNICAL ENGINEERING STUDY
Proposed Autoclave Installation
NASA Building 4707
FWR 1286-5.R
Marshall Space Flight Center, Alabama

OMI Job No. 96-297

December 5, 1996

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December 5, 1996

AJT & Associates
P. O. Box 9261
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ATTN: Mr. David Sellers

SUBJECT: Report of Geotechnical Engineering Study
Proposed Autoclave Installation
NASA Building 4707
FWR 1286-5.R
MSFC, AL
OMI Job No. 96-297

Gentlemen:

OMI, Inc., has completed a subsurface exploration and geotechnical engineering study for the referenced project. Enclosed is the report of the findings as well as recommendations for foundation design and construction, site preparation, and other geotechnically related site activities. This work was authorized on October 21, 1996, by Mr. Arthur Hargrove, Jr., of AJT & Associates.

OMI, Inc., appreciates the opportunity to be of service to AJT & Associates and NASA, and looks forward to continued involvement with the construction monitoring phase of this project. Please direct any questions concerning this report to the undersigned.

Respectfully submitted,

OMI, Inc.

John M. Ozier, P. E.
Senior Engineer

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Senior Engineer

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Distribution: 3 Copies to Addressee

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1.0 EXECUTIVE SUMMARY

The subsurface studies indicate the site for the proposed autoclave is suitable for the support of the proposed development. Soil conditions are favorable; however, there are two large storm sewers and several other utilities located beneath the autoclave and the building. These buried utilities pose the greatest concern and obstacle to successful construction of the foundations for this project. In general, heavy foundations should bear below the sewer lines which are about 10-ft below the present pavement surface. During this exploration, OMI has stated the risks associated with leaving the storm drains beneath the building and based upon the information available, NASA representatives do not want to move the storm drains.

Specific recommendations for foundation design and site earthwork are given in the body of this report.

2.0 INTRODUCTION

OMI, Inc., has completed a design geotechnical engineering study for the proposed autoclave for Building 4707. This report outlines the scope of services provided and presents comments and recommendations developed based on professional opinions formed during the course of this study. This work was authorized on October 21, 1996, by Mr. Arthur Hargrove, Jr., for AJT & Associates.

Any assessment of the environmental aspects of this site, including previous land use or the determination of the presence of any chemical, industrial, or hazardous waste is beyond the scope of this study. However OMI can provide these services if desired.

3.0 EXPLORATION METHODS

The procedures used by OMI for field and laboratory testing are in general accordance with ASTM procedures and established engineering practice. Brief descriptions of the procedures used in this exploration are contained in the Appendix of this report.

Two soil test borings were performed during this study at the locations shown on the appended Boring Location Plan. Each boring was drilled to auger refusal which was 41 and 42-ft. A member of OMI's professional staff directed the drilling and logged the soils. Each sample was sealed and transported to the office. Selected samples were tested to determine the natural moisture content and Atterberg limits of the soil. These tests assist in confirming the visual classifications as well as provide an index of certain engineering properties. The soil classifications, field testing data, and the results of the laboratory tests are provided on the Soil Boring Records in the Appendix of this report.

4.0 SITE CONDITIONS

The site is located at the southeast corner of Building 4707. The building presently has an overhead door in this area which will provide access to the proposed addition. Furthermore, underground utilities, including two large storm drains, cross from the northeast toward the southwest beneath the proposed addition. A large nitrogen tank and carbon dioxide tank are located just north of the proposed addition, with the carbon dioxide tank being located within a few feet of the proposed addition. Additional utilities, including a de-ionized water line and an 8-in industrial water line are located beneath the autoclave location. A 2-in natural gas line may be located east of the proposed addition.

Asphalt pavement covers the area of the planned construction. Elevations slope 1 to 2-ft from the finished floor slab of Building 4707 downward toward the east.

5.0 SUBSURFACE CONDITIONS

The two borings encountered very similar conditions. First, the borings encountered asphalt pavement over river gravel base. Beneath the pavement, a stiff to very stiff dark red silty sandy clay was encountered. This stratum extended to 13-ft. Penetration values ranged from 12 to 26 blows per foot (bpf) and pocket penetrometer values ranged from 2.5 to 4.25 tsf. Atterberg limits tests were performed on two samples collected in this stratum. The tests showed liquid limits values of 44 and 53 and plastic limit values of 24 and 21. These indicate a medium plastic clay.

The second stratum extended from 13 to 18-ft and was light red silty sandy clay. Penetration values were 30 and 37 bpf, indicating a hard soil.

The third stratum extended from 18-ft to auger refusal at 41 and 42-ft. This layer consisted of a highly plastic hard tan, light red, and gray sandy silty clay with chert. The chert content generally increased with depth.

Groundwater level readings taken upon completion of the borings indicated that the groundwater was observed to be between 38 and 40-ft below the ground surface. Subsequent groundwater level readings taken on October 31, 1996, showed the borings to be dry and caved at 21.7 and 19.5-ft below the ground surface. Because of the geology of this region, the groundwater levels are generally a function of seasonal precipitation and locally heavy rainfall events. Consequently, the groundwater levels can and do fluctuate with time.

6.0 SITE GEOLOGY

Published geologic information indicates the proposed site is underlain by the Tuscumbia Limestone. The Tuscumbia Limestone formation is of Mississippian age (310-345 million years). In the vicinity of the site, the Tuscumbia limestone is composed of light gray to light brownish-gray, fine to coarse grained, fossiliferous limestone containing chert lenses and nodules. Soils derived from the in-place weathering of the Tuscumbia limestone are moderately red to reddish-orange clay with variable amounts of chert.

Sinkhole Activity

Sinkholes have occurred in this formation within the vicinity of this site. However, surface observations and the subsurface exploration did not disclose evidence of sinkhole activity on this site. This exploration does not, nor was it intended to, address the possibility of future sinkhole development.

7.0 PROJECT INFORMATION

The National Aeronautics and Space Administration (NASA) Marshall Space Flight Center is planning to install an autoclave pressure vessel at Building 4707. The autoclave is a very large

pressure vessel that weighs approximately 400 kips. Outside dimensions are 50-ft in length by 26-ft in width by 24-ft in height. The autoclave appears to be supported on two saddle type foundations. In addition, a building addition will be added to Building 4707. The new structure will measure approximately 40-ft north/south by 50-ft east/west. The autoclave will extend beyond the eastern edge of the proposed building. The addition to Building 4707 will be a pre-engineered metal structure with a slab-on-grade. There will be a lift table in front of the autoclave. The lift table will measure about 12-ft by 23-ft in plan dimensions and will recess into a 3.5-ft deep pit in the floor. Four hydraulic jacks will be recessed into the base of the pit; each jack will have a lifting capacity of 30,000 pounds. The total weight of the pit, lift table, and live load is 320 kips. The pit is planned to be supported on a strip footing at each end. The footings will bear below the sewer lines which are about 10-ft below the existing ground surface. The door hinge of the autoclave will be supported by an independent footing; the load on this footing is 36 kips.

Column loads for the pre-engineered metal building addition are expected to be less than 50 kips per column and wall loads will probably be less than 1 to 2 kips per linear foot. OMI understands and believes that the floor loads will be about 100 psf. The autoclave weighs approximately 400 kips. The present desire is to support the structure on two strip footings which extend beneath the autoclave perpendicular to the long axis of the unit.

8.0 BASIS FOR RECOMMENDATIONS

The following recommendations are based in part on the preceding project information. This study has utilized both the subsurface data, historical information regarding the structural performance of similar structures, and past experience with similar geologic environments to develop professional opinions on which the recommendations are based. Because the structural elements of the design greatly influence the design recommendations, OMI must be provided the opportunity to review the following comments and recommendations in light of changes in building location, elevation, or structural loading.

There are two very large storm sewers that extend beneath the planned building addition and autoclave. There are risks associated with leaving the storm sewers in place. These include, among other things, loss of soil as a result of erosion into the sewers and collapse of the sewers. NASA has told AJT & Associates that they are aware of the risks and are leaving the sewers in place and in service due to budget constraints.

9.0 DESIGN RECOMMENDATIONS

9.1 Foundation Design

Autoclave and Lift Table

The autoclave and lift table may be supported by a conventional shallow foundation system bearing on residual soil below the buried storm sewers which are about 12-ft below present grade. Footings should be designed based on a maximum allowable bearing pressure of 5000 psf for the combined strip footings; these pressures include a factor of safety of at least 3 against general shear failure. To allow for minor inconsistencies in the soil subgrade, the footings should have a minimum width of 3-ft, regardless of loading.

Building

The building may be supported by a conventional shallow foundation system bearing on residual soil or engineered fill. Footings should be designed based on a maximum allowable bearing pressure of 2500 psf for individual column footings and 2000 psf for continuous footings; these pressures include a factor of safety of at least 3 against general shear failure. To allow for minor inconsistencies in the soil subgrade, individual and continuous footings should have minimum widths of 24-in and 18-in, respectively, regardless of loading. Wall footings should be reinforced with top and bottom steel to guard against collapse should a void develop beneath the foundation. The column footings should be tied to the wall footings. Perimeter footings, and those within

unheated areas, should bear at least 2-ft below finished exterior grade to provide adequate confinement and protection against frost and movement due to moisture fluctuations. Interior footings should bear at least 1-ft below the soil subgrade. The ground surface around the building area should be graded to provide positive drainage away from the building.

9.2 Floor Slabs

The slab thickness, reinforcing, and stone base thickness are all a function of the traffic weight, loading frequency, and the soil subgrade strength. Design of the system is primarily a rigid pavement design, and the use of dense graded base or open graded stone depends on design concerns. Slab thickness and reinforcement may be designed based on a modulus of subgrade reaction (k) of 150 pci.

Floor slabs which will be exposed to forklift traffic should be specifically designed for the type and frequency of the loading. Floor slabs should be placed on a 4-in thick layer of open-graded compacted gravel. The aggregate layer will distribute the floor load from the slab to the soil and provide protection against the migration of moisture upward through the floor slab. A vapor barrier may be placed beneath the floor slab stone to provide additional protection against moisture migration.

9.3 Below-Grade/Retaining Walls

All below-grade and retaining walls must be designed to withstand lateral earth pressures induced on them. OMI recommends the use of cast-in-place, reinforced concrete for these walls. The following recommendations for design may only be used if the backfill conditions are also followed.

Walls that are fixed and not allowed to deflect under lateral loads should be designed using at-rest lateral earth pressures (K_o of 0.5) or may be approximated by using an equivalent fluid weight of 50

pcf. Any loads that will be placed near the top of the wall should also be considered. Retaining walls that are free to deflect at the top should be designed using active lateral-earth pressures (K_a of 0.35) or may be approximated by using an equivalent fluid weight of 35 pcf. Surcharge loads must also be considered. Appropriate factors of safety must be applied.

The above recommendations apply only when the following backfill requirements are incorporated into the design and construction. All below-grade/retaining walls should be backfilled with uniformly-sized, free-draining crushed stone such as size No. 57, 67, or 78 as per ASTM D448. This stone interval should extend from the base of the wall up to about 2-ft below final grade and extend back from the wall at least ½ the height of the wall as measured at the top of the wall. The stone should be placed in lifts not exceeding 24-in and densified. Heavy compaction equipment should not be operated near the wall. All unsupported walls should be adequately braced during backfilling operations to prevent damage to the wall. A water collection system must be designed and installed to mitigate the build-up of hydrostatic pressures. A cap of compacted clay should be placed over the stone to limit migration of surface water into the backfill. Also, the basement walls should be adequately waterproofed.

If alternative backfill methods are desired, recommendations can be provided in response to specific requirements. Please be aware that the use of "drainboards" and impervious backfill may significantly increase the actual load on the wall.

9.4 Fill Soils

Fill soils should be clayey soils free of organics, deleterious debris, or rocks larger than 3-in in diameter. The soil should have a plasticity index (PI) of less than 30 and a maximum dry density of at least 100 pcf as determined by the standard Proctor (ASTM D698) or SPMDD. The fill should be compacted to at least 95 percent of the soil's SPMDD. The top 2-ft beneath the building and pavement areas should be compacted to 98 percent SPMDD. The on-site soil interval meets the guideline set forth above.

10.0 CONSTRUCTION CONSIDERATIONS

10.1 Site Preparation

Very little site preparation is planned. To prepare the site for construction, the construction area should be stripped of pavement as required. Stripping should extend at least 5-ft beyond the limits of construction fill. Subsequently, the areas which are approximately at grade or are to receive fill should be proofrolled in the presence of a geotechnical engineer. Proofrolling is performed by repeated passes of a heavy rubber-tired vehicle, such as a loaded dump truck. Any areas judged to deflect excessively during proofrolling should be undercut to a stable soil horizon. Such over-excavation must be backfilled with structural fill placed as described below. Upon reaching subgrade elevation in cut areas, the exposed soil subgrade should be similarly proofrolled and repaired.

10.2 Fill Placement

After proofrolling is complete, placement of structural fill may begin, as necessary. Specific requirements of the soil properties are discussed previously. The soil should be placed in loose lifts, not exceeding 8-in in thickness, and systematically compacted to at least 98 percent of the soil's standard Proctor maximum dry density (ASTM D698).

10.3 Density Testing

Field density testing should be performed on each lift prior to placement of additional lifts. Test locations should be evenly distributed throughout the fill area and should be performed at the frequencies shown on the following table.

AREA	METHOD OF PLACEMENT AND COMPACTION	INITIAL TEST FREQUENCY	RETEST FREQUENCY
General Site	Large self-propelled equipment	Minimum of 3 tests per lift	1 test per failed test
Isolated Areas	Hand-guided equipment	1 test per lift	1 test per failed test
Trench backfill and behind retaining walls	Hand-guided equipment	1 test per 50 linear feet per 6-in of fill	1 test per failed test

Test frequencies may be increased during the early stages of earthwork construction. Compaction requirements should apply to all excavation/backfill operations conducted on the proposed development property.

10.4 Footing Observations

The footing excavation process generates a disturbed layer of soft soil in the excavation bottoms. This soft compressible layer should be removed prior to placement of concrete. Each foundation excavation should be observed by a member of OMI's professional staff to check for local variations in the soil strength as well as the removal of the disturbed layer.

10.5 Construction Monitoring

The foundation and site preparation recommendations contained in this report are based on the conditions encountered during the subsurface exploration and past experience in this geologic setting. Because subsurface conditions may vary from the anticipated, it is important to have a well rounded quality control program. Construction monitoring on a project of this nature can serve as an economical means to achieve the best possible foundation system and reduce the potential for

future problems. The involvement in the subsurface exploration portion of this project uniquely qualifies OMI, Inc., to provide these services as a party responsible to the Owner. OMI, Inc., strongly recommends that all construction monitoring be performed under contract with the Owner or the Owner's representative.

APPENDICES

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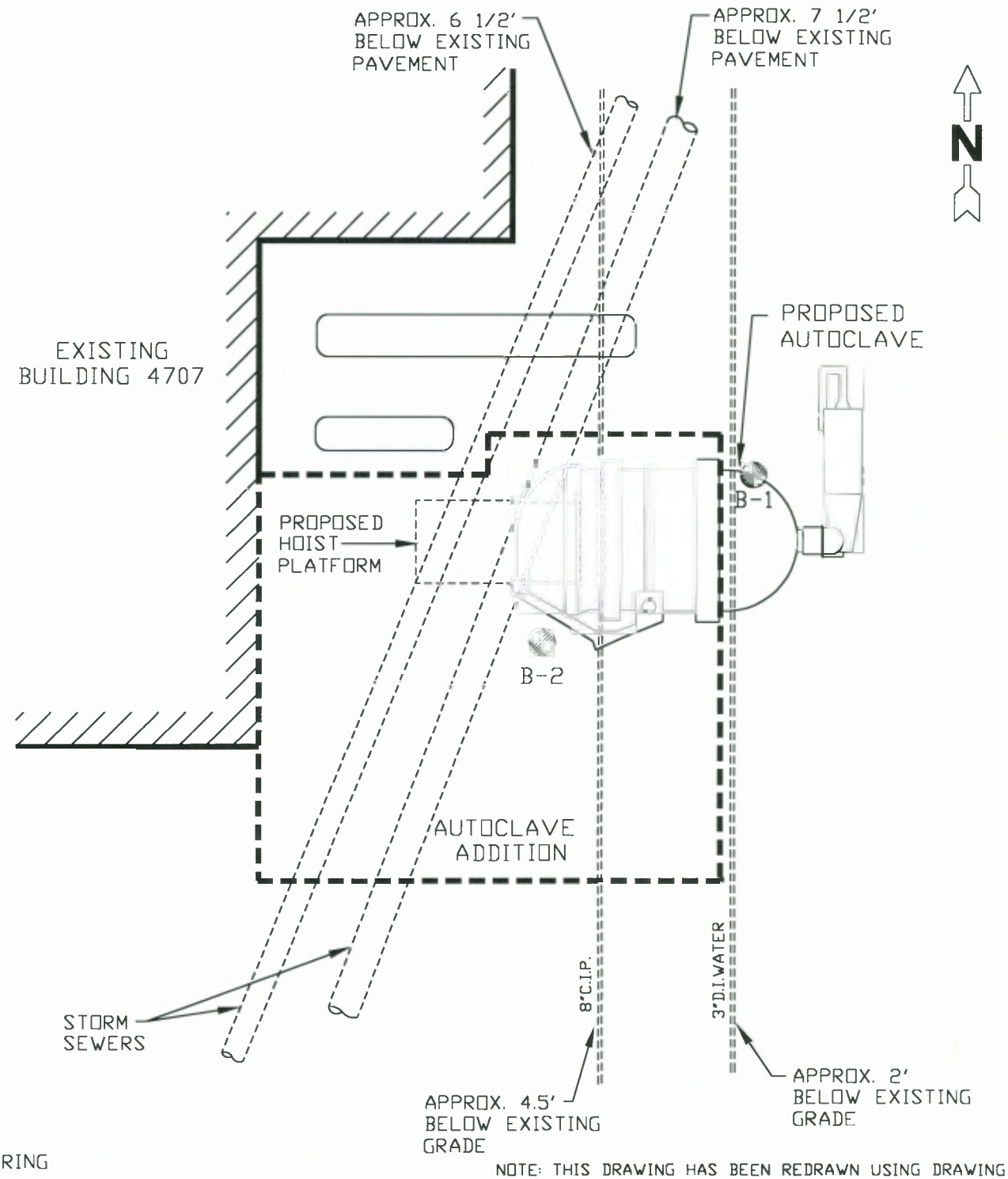


NOTE: THIS DRAWING HAS BEEN REDRAWN USING DRAWING PROVIDED BY NASA

JOB NAME: NASA BLDG 4707 AUTOCLAVE ADDITION MSFC, ALABAMA	BORING PLAN	JOB NO: 96-297 DATE: 11-20-96 SCALE: 1"=20' DRAWN BY: SRG

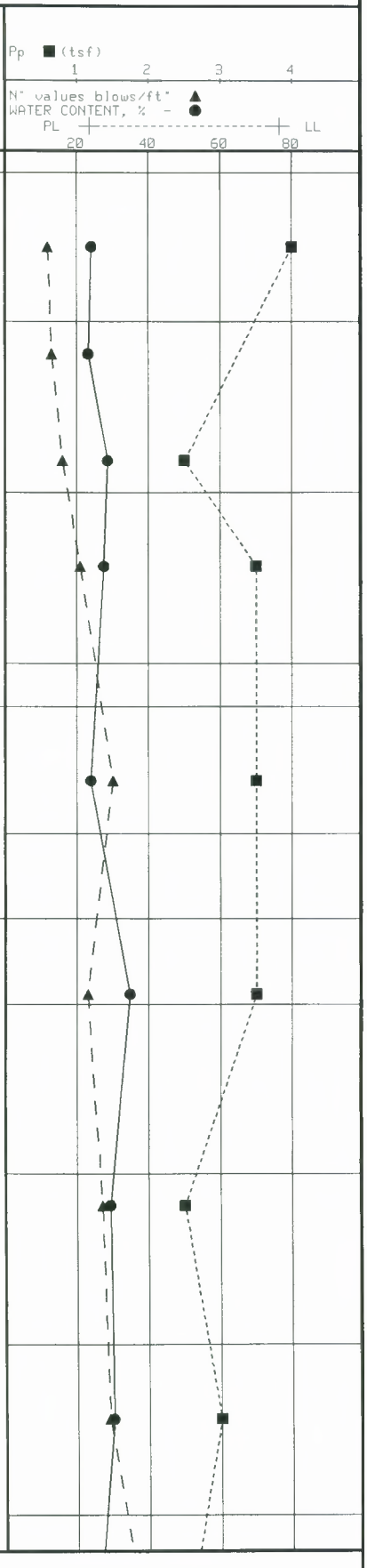
OMI, Inc.

3006 11th AVENUE, S.W. HUNTSVILLE, AL 35805

JOB NO.: 96-297 JOB: NASA BUILDING 4707 AUTOCLAVE LOG OF BORING: B-2

JOB LOCATION: MSFC REDSTONE ARSENAL, AL BORING LOCATION:

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	NATURAL MOISTURE	POCKET PENT TSF
			Elevation=N/A			
0			3" PAVEMENT 3" RIVER GRAVEL BASE			
			SILTY CLAY, slightly sandy, 10% fine sand, 90% fines, medium plasticity, dark red, stiff to very stiff, moist, residuum CL	12	24.1	4.0
4				13	23.2	--
				16	28.6	2.5
8				21	27.6	3.5
12						
			SILTY SANDY CLAY, 30% fine to medium sand, 70% fines, medium plasticity, light red, very stiff, moist, residuum CH	30	23.9	3.5
16						
			SILTY SANDY CLAY with weathered chert, 30% gravel size weathered chert, 20% fine to coarse sand, 50% fines, high plasticity, tan to light red and gray, hard, moist, residuum CH	23*	34.7	3.5
20						
24				27*	29.2	2.5
28				29*	30.0	3.0
32						



COMPLETION DEPTH: 42 DEPTH TO WATER INITIAL: 40' OMI,Inc.

DATE: 10/28/96 DEPTH TO WATER FINAL: Dry to 19.5' 10/31

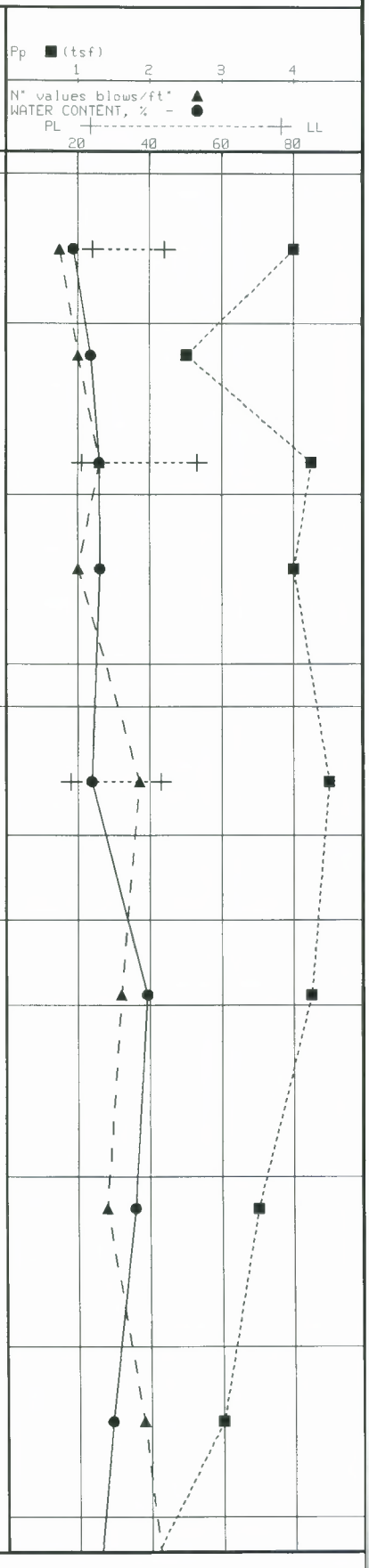
OMI, Inc.

3006 11th AVENUE, S.W. HUNTSVILLE, AL 35805

JOB NO.: 96-297 JOB: NASA BUILDING 4707 AUTOCLAVE LOG OF BORING: B-1

JOB LOCATION: MSFC REDSTONE ARSENAL, AL BORING LOCATION:

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	NATURAL MOISTURE	POCKET PENT TSF
			Elevation=N/A			
0			3.5" PAVEMENT 3" RIVER GRAVEL BASE			
			SILTY SANDY CLAY, 35% fine to medium sand, 65% fines, medium plasticity, dark red, very stiff, moist, residuum CL	15	18.7	4.0
4				20	23.5	2.5
				26	25.9	4.25
8				20	26.1	4.0
12						
			SILTY SANDY CLAY, 30% fine to medium sand, 70% fines, medium plasticity, light red, very stiff, moist, residuum CL	37	23.8	4.5
16						
			SILTY SANDY CLAY with weathered chert, 30% gravel size weathered chert, 20% fine to coarse sand, 50% fines, high plasticity, tan to light red and gray, hard, moist, residuum CH	32*	39.2	4.25
20						
24				28*	35.8	3.5
28				38*	29.3	3.0
32						



COMPLETION DEPTH: 41 DEPTH TO WATER INITIAL: 38' OMI,Inc.

DATE: 10/28/96 DEPTH TO WATER FINAL: Dry to 21.7' 10/31

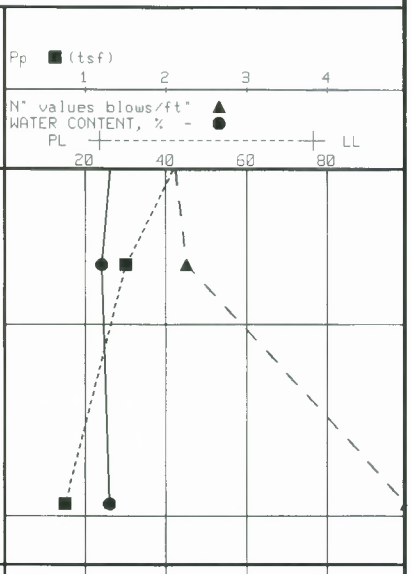
OMI, Inc.

3006 11th AVENUE, S.W. HUNTSVILLE, AL 35805

JOB NO.: 96-297 JOB: NASA BUILDING 4707 AUTOCLAVE LOG OF BORING: B-1

JOB LOCATION: MSFC REDSTONE ARSENAL, AL BORING LOCATION:

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	NATURAL MOISTURE	POCKET PENT TSF
			Elevation=N/A			
36				45*	24.1	1.5
40				100+*	26.0	0.75
			Auger refusal at 41-ft			
44			*standard penetration values inflated by chert			
48			Note: Boring grouted with concrete on 10/31/96			
52						
56						
60						
64						



COMPLETION DEPTH: 41 DEPTH TO WATER INITIAL: 38' OMI,Inc.

DATE: 10/28/96 DEPTH TO WATER FINAL: Dry to 21.7' 10/31