State of California
The Resources Agency
Department of Water Resources
DIVISION OF ENGINEERING

North of the Delta
Offstream Storage Investigations

SITES RESERVOIR FEASIBILITY STUDY

Materials Investigation, Testing, and Evaluation Program

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SITES RESERVOIR FEASIBILITY STUDY
MATERIALS INVESTIGATION, TESTING, AND EVALUATION PROGRAM

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ENGINEERING CERTIFICATION

This report has been prepared under my direction as the professional engineer in direct responsible charge of the work, in accordance with the provisions of the Professional Engineers' Act of the State of California.

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1.0 EXECUTIVE SUMMARY

1.1 Objectives

The objectives of the construction materials investigation program were to identify the types of available on-site materials, examine their potential uses, and perform limited testing and evaluation to determine their suitability for use in the dams and appurtenant structures for the Sites Reservoir project. It should be pointed out that the objectives of the materials investigation program were developed using the design principal that available on-site materials dictate the design and selection of the dam sections.

The construction materials investigation program identified the following material types within or near the proposed Sites Reservoir project area:

- Impervious Materials (terrace deposits and recent alluvium)
- Venado Sandstone (fresh and weathered from the Cortina Formation)
- Mudstone (Boxer Formation)

These material types were further investigated, tested, and evaluated to explore their suitability for use as the following types of construction materials:

- Impervious Materials
- Rockfill and Riprap Materials
- Random Materials
- Filter, Drain, and Transition Materials
- Concrete Aggregate

1.2 Impervious Material

A surplus of impervious material exists within or near the Sites Reservoir project. Previous studies by USBR identified four main areas of deposits encompassing roughly 36 million cubic yards of material. Additional impervious materials are located within required excavation areas for the appurtenant structures and Funks Reservoir enlargement.

The proposed impervious materials are classified as low to medium plasticity clays (CL)[1], with lesser amounts of high plasticity clays (CH) and clayey sands (SC). Dry, moist, and saturated densities were found to be 109 pcf, 127 pcf, and 131 pcf, respectively. Permeability tests indicate the material is very impervious with results on the order of 10^{-8} to 10^{-9} cm/s. From CUE triaxial testing, total friction angle (ϕ) was

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[1] Uniform Soil Classification designation

found to be 14º with a total cohesion (C) of 650 psf. Effective friction angle (ϕ') was found to be 21.5º with an effective cohesion (C') of 600 psf.

Although only limited testing was performed as part of the feasibility level investigation, testing and evaluation indicate the impervious materials are suitable for use in the proposed embankment dams.

1.3 Rockfill and Riprap Material

The best available source of clean rockfill material within the project area is the fresh Venado sandstone, distinguishable from the weathered Venado sandstone. Four prospective sandstone quarry areas have been identified near the dam sites. Sufficient quantities of Venado sandstone are available in the proposed quarry areas for construction of the embankment sections currently under consideration.

Petrographic examination characterizes the Venado sandstone as an arkosic graywacke with fine to medium grained structure, and comprised mostly of quartz and feldspar. Test results indicate the specific gravity to be approximately 2.5, while absorption results ranged from roughly 3% to 5%. Unconfined compressive strength testing on the fresh Venado sandstone indicates strengths of about 9,600 psi for the dry material and about 7,000 psi for the saturated material. Shear strength estimations indicate a friction angle (ϕ') of 42º. Dry, moist, and saturated densities were found to be 116 pcf, 122 pcf, and 136 pcf, respectively.

Material testing and evaluation indicate the fresh Venado sandstone to be of sufficient quality for use as clean rockfill and riprap materials. In addition to the testing and evaluation performed as part of this investigation, the suitability of the Venado sandstone is evidenced by its performance at Funks Reservoir's dam. The upstream slope protection on this embankment dam is comprised of the Venado sandstone and has been performing satisfactorily since the mid 1970s. Another indicator of the suitability of the Venado sandstone is a review and comparison of particle breakage of the Venado sandstone and Pyramid Dam argillite during large-scale triaxial testing performed by UC Berkeley in the 1970s. The particle breakage of the sandstone was comparable to the argillite, which has performed satisfactorily as rockfill material in Pyramid Dam, both as riprap and shell material.

1.4 Random Material

Random embankment material will be comprised of materials unsuitable for use as clean rockfill. It will consist of weathered sandstone, mudstone, slopewash, etc from excavations for the dam foundations, appurtenant structures, and the rockfill quarries. Abundant quantities of random material are available for construction of Golden Gate, Sites, and the saddle dams.

It is anticipated that two general types of random materials will be generated during construction depending upon the source of the material. One type of random material will be comprised of predominantly weathered sandstone from the Cortina Formation, while the other type will be predominantly mudstone from the Boxer Formation. It should be pointed out that the mudstone from excavation of the Boxer Formation will tend to be “soil like”, because of its propensity to break down when exposed to air and water, and excavation and compaction operations. The weathered Cortina formation will tend to be a dirty rockfill.

Compressive strength testing indicates the mudstone and weathered sandstone have compressive strengths of approximately 3,500 psi and 5,000 psi, respectively. Warranting special note, the average compressive strength of the mudstone only included one near surface sample, while the majority of the samples were obtained at depth. That near surface sample demonstrated a compressive strength of 1,200 psi, which indicates that the material comprised of mudstone from excavation will be of low strength.

Shear strength estimations indicate an effective friction angle (ϕ’) of 40º for the material comprised of predominantly weathered sandstone. The material comprised predominantly of mudstone was estimated to have an effective friction angle (ϕ’) of 35º, a total friction angle (ϕ) of 15º, and a total cohesion of 600 psf. In-place densities for the random material as a whole were assumed to be equivalent to the rockfill densities. Dry, moist, and saturated densities were estimated to be 116 pcf, 122 pcf, and 136 pcf, respectively.

Since random materials are generally used in portions of the dam embankment where hydraulic conductivity and erosion resistant properties are not a consideration, a comprehensive evaluation of the random material’s engineering properties is generally not required. As such, the limited testing and evaluation indicate the random materials are suitable for use in the proposed embankment dams.

1.5 Filter, Drain, and Transition Material

Since sufficient deposits of sand and gravel are not available in the project area, crushed Venado sandstone was evaluated for use as filter, drain, and transition materials. Although laboratory testing indicates crushed, fresh Venado sandstone may be suitable as filter, drain, and transition materials, it was not extensively tested as part of the feasibility level investigation since an extensive particle breakage and other evaluation would have been necessary. This particle breakage evaluation would have required test quarries and fills and was considered beyond the scope of this feasibility level investigation. Since the suitability of the Venado sandstone cannot be confirmed at this level of investigation, it is assumed that filter, drain, and transition materials for the embankment dams will be imported from the closest off-site sand and gravel deposit. This off-site deposit was identified as an old abandoned channel on Stony Creek, between Orland and Willows. It is approximately 35 road miles from the project, and has an estimated material availability of 160 million cubic yards that far exceeds the construction requirement.

Both shear strength and density were estimated from published data. The filter, drain, and transition materials are estimated to have a friction angle (ϕ') of 42º. Dry, moist, and saturated densities were also estimated at 115 pcf, 121 pcf, and 135 pcf, respectively.

1.6 Concrete Aggregate

As discussed in Section 1.5, sufficient deposits of sand and gravel are not available within the project area. Therefore, crushed Venado sandstone was also evaluated for use as concrete aggregate. Sources of sandstone are identical to those identified for use in the rockfill and riprap materials. Also, off-site sand and gravel deposits were identified as alternative material sources as part of the geologic exploration program.

Quality testing was the focus of the concrete aggregate evaluation. Specific gravity was found to be roughly 2.6, while absorption ranged from approximately 2% to 6%. Los Angeles Abrasion losses were about 11% at 100 revolutions and about 47% at 500 revolutions. Clay lumps and friable particles ranged from 1% to 5%. Organic impurities had standard colors of mostly “clear”. Bulk density was estimated at roughly 88 pcf.

Since the test results indicate the crushed Venado sandstone only marginally meets the adopted concrete aggregate criteria, the suitability of the sandstone can not be confirmed without additional testing and evaluation considered beyond the scope of the feasibility level investigation. Therefore, it is assumed that concrete aggregate will be imported from the off-site sand and gravel deposit on Stony Creek presented in Section 1.5. As discussed previously, an abundance of material is available from this borrow source.

1.7 Summary of Engineering Properties for Stability Analysis

Table A presents a summary of the engineering properties recommended for use in the feasibility level embankment stability analysis.

Table A - Engineering Properties Recommended for Feasibility Level Embankment Stability Analysis

Material	Shear Strength Parameters				Density (pcf)		
	Effective		Total				
	ϕ' (deg)	C' (psf)	ϕ (deg)	C (psf)	Dry	Moist	Saturated
Impervious Material	21.5	600	14	650	109	127	131
Random, Predominately Weathered Sandstone	40	0	-	-	116	122	136
Random, Predominately Mudstone	35	0	15	600	116	122	136
Rockfill	42	0	-	-	116	122	136
Filter, Drain, & Transition	42	0	-	-	115	121	135

2.0 INTRODUCTION

2.1 Sites Reservoir Project

Sites Reservoir is one of several alternative reservoir sites being proposed for offstream storage as part of the North of the Delta Offstream Storage Investigation. The reservoir would be located in Antelope Valley, about ten miles west of Maxwell. Most of the project would lie within northern Colusa County, with portions of the reservoir extending into southern Glenn County.

The reservoir currently under investigation has a storage capacity of 1.9 MAF that would be impounded by a system of embankment dams including two major dams, named Sites and Golden Gate, and nine smaller saddle dams. The dams range in height from 15 to 310 feet. The maximum operating water surface elevation of the reservoir would be 520 feet, which would inundate 14,700 acres. The Sites Reservoir project would also include appurtenant structures such as a: spillway, pumping/generating plant, inlet/outlet works, etc..

2.2 Construction Materials

The objectives of this feasibility level investigation, testing, and evaluation program were to identify the availability of soil and rock materials within the project area and assess the suitability of these materials for use in construction of the dams and appurtenant structures. Specifically, the use and engineering properties of the soil and rock materials were sought for the purpose of preparing preliminary dam sections for development of cost estimates.

Objectives of this program were accomplished by investigating, testing, and evaluating the properties of the following material types available within the project area:

- Impervious Materials (terrace deposits and recent alluvium)
- Venado Sandstone (fresh and weathered from the Cortina Formation)
- Mudstone (Boxer Formation)

This report presents a summary and discussion of the materials investigation and laboratory testing performed on embankment materials for the Sites Reservoir project. Engineering properties presented in this report were determined directly from laboratory testing, estimated by empirical relationships, or estimated by reviewing published data. Laboratory testing performed for this investigation included: classification, compaction, in-place density, permeability, CUE triaxial compression, and quality and physical properties testing. Testing by DWR was performed at the Bryte Laboratory in Sacramento.

3.0 PREVIOUS STUDIES

Construction materials, for use in embankment dams and levee protection, have been investigated in the Sites and Antelope Valley area since the 1960s. As such, published data and reports were available for research. Previous materials investigations by USBR and USACE were used extensively for comparative purposes in this report. Figure 1 identifies USBR and USACE material investigation areas. Warranting special note are two reports by USBR dated August 1969 and March 1980. These reports summarized reconnaissance investigations of construction materials for the Sites Reservoir project and comprised the majority of comparisons.

A UC Berkeley report published by Becker et. al. (1972) proved to be an invaluable resource for the evaluation of engineering properties and suitability of the Venado sandstone. This report includes extensive shear strength testing of the Venado sandstone along with comparisons to other rockfill materials. Test results from this study were frequently used to assist the current evaluation.

4.0 CONSTRUCTION MATERIAL SOURCES

The Sites Reservoir area is on the west side of the Sacramento Valley in the foothills of the Coast Ranges. The area is underlain by Lower and Upper Cretaceous sedimentary rocks of the Great Valley Sequence. The major structural features in the region include the Sites anticline, the Fruto syncline, and the Salt Lake fault. A detailed summary of the site geology and material deposits may be found in Division of Planning and Local Assistance (DPLA) reports, included as references. DPLA figures of site geology are included as Figures 2 through 4, which also identify proposed borrow areas and sample locations for DWR and USBR.

Impervious materials for the embankment dams will be excavated from plentiful borrow deposits located within the proposed reservoir area. This impervious material is comprised of Quaternary terrace deposits and recent alluvium. Previous studies by USBR revealed four major borrow areas upstream of Golden Gate and Sites dam sites. The four areas, designated as Area 1 through Area 4 in Figure 1, were adopted by DWR who then performed similar testing within their boundaries. DWR and USBR sample locations are depicted in Figures 3 and 4. Impervious materials are also located within required excavation areas for the appurtenant structures and Funks Reservoir enlargement.

The highest quality rock available in the project area is the Venado sandstone. The sandstone is a Cretaceous marine sedimentary rock of the Cortina Formation. It is fine to medium-grained and well cemented with a variable color indicative of the state of weathering. Fresh material has a light blue gray appearance, while the weathered material has a brownish color. Collectively, DWR, USBR, and USACE identified six potential Venado sandstone quarry areas (identified in Figure 1). Sufficient quantities of sandstone exist to accommodate project requirements. Incidentally, an operational quarry is located one-quarter mile downstream of the Sites Dam site.

Mudstone, of the Boxer Formation, is a weaker, lower quality rock as compared to the Venado sandstone. Additionally, the mudstone tends to break down when exposed to air and moisture limiting its use within the dam embankments to materials that do not require “free-draining” properties (such as: random materials, semi-impervious materials, etc.). Since numerous borrow areas are available in the reservoir area and significant quantities of mudstone will be generated from required excavation for the dam foundations, its borrow locations were not specifically identified or quantified.

Since sufficient quantities of sand and gravel do not exist in near vicinity of the reservoir area, off-site sources were investigated as an alternative to processing these materials from Venado sandstone. The nearest sand and gravel borrow area was identified as an old abandoned channel on Stony Creek, about 35 road miles from the project site, between Orland and Willows. Available deposits were estimated at 160 million cubic yards, an abundance of material is available to meet the anticipated construction requirements.

5.0 IMPERVIOUS MATERIAL

5.1 Introduction

The proposed source of impervious materials for construction of the dam embankments are Quaternary terrace deposits and recent alluvium located within the project area. These materials are characterized as predominantly low to medium plasticity clays (CL), with some high plasticity clays (CH) and clayey sands (SC).

Exploration by USBR was performed in the valleys upstream of the two main dam sites in four areas, labeled as Areas 1, 2, 3, and 4 (Figure 1). These four areas contain an estimated 36 million cubic yards of impervious material with 4 million cubic yards and 3 million cubic yards of material located within 1 mile of the Golden Gate and Sites Dam sites, respectively. In addition to the four borrow areas within the reservoir, impervious materials are also located within required excavation areas for the appurtenant structures and Funks Reservoir enlargement. These required excavation areas would be utilized until exhausted.

Exploration and sampling was performed by DWR and USBR at test pits and auger holes located throughout the four areas to determine the extent and suitability of the proposed impervious materials (Figure 3 and Figure 4). Additional exploration and sampling was performed by DWR at sites located upstream of Funks Reservoir within the proposed excavation area for enlarging the reservoir. DWR sample locations are denoted by FR, GG and SC, while USBR used AP and TP to designate their sample locations. Table 1 describes the various sample locations.

Table 1 – Impervious Material Sample Locations

Sample Designation	Sampling Agency	Description	Sample Type
FR-Aug 7 through FR-Aug 9	DWR	FR = Funks Reservoir	Auger Hole
GG-1 through GG-8	DWR	GG = Golden Gate Dam site	Test Pit
SC -1 through SC-10	DWR	SC = Sites/Colusa Dam site	Test Pit
AP	USBR	AP = auger hole	Auger Hole
TP-1 and TP-2	USBR	TP = test pit	Test Pit

DWR sample locations were selected to characterize the impervious materials available within the project area. The sample locations within the reservoir were selected to compliment and confirm the exploration and testing performed previously by USBR. DWR bag samples were obtained at various depths within the test pits corresponding to visual identification of different material types. Classification testing was performed on all DWR bag samples. In addition, composite samples were prepared from the bag samples in order to perform density, permeability, and shear strength testing on samples representative of the materials within the proposed borrow areas upstream of Golden Gate and Sites Dam. The composite samples were composed of equal portions of material from test pits GG-1 through GG-8 and SC-4 through SC-10, excluding the approximate 10% finest and 10% coarsest samples. The composition of the composite samples is included in Appendix A.

5.2 Classification

The following test procedures were used by DWR to classify the proposed impervious material:

- Particle-Size Analysis of Soils (ASTM D 422)
- Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D 4318)
- Classification of Soils for Engineering Purposes (Unified Soil Classification System) (ASTM D 2487)

In addition to classification testing, the following test procedures were used by DWR to provide additional characterization of the proposed impervious materials:

- Specific Gravity of Soil Solids by Water Pycnometer (ASTM D 854)
- Moisture, Ash, and Organic Matter of Peat and Other Organic Soils (ASTM D 2974)

Test procedures used by USBR were not indicated. However, test results are presented on USBR standard forms, and test procedures were probably performed in accordance with USBR standard test designations.

Classification testing was performed on all DWR samples. Table 2 presents the classification summary, and the detailed test results are included in Appendix B. Collectively, testing performed by DWR indicate that the proposed impervious materials are predominantly low to medium plasticity clays (CL), with some high plasticity clays (CH) and clayey sands (SC). More precisely, the low to medium plasticity clays were comprised of lean clay, lean clay with sand, and sandy lean clay. Fat clay and fat clay with sand made up the high plasticity clays.

Table 2 – Classification Summary for Impervious Material

Golden Gate Sample Locations			
Group Symbol	Group Name	Number of Samples	Percentage of Total
CL	Lean Clay	6	32
CL	Lean Clay with Sand	8	42
CL	Sandy Lean Clay	2	11
CH	Fat Clay	2	11
CH	Fat Clay with Sand	1	5
	Total	19	100

Sites Sample Locations			
Group Symbol	Group Name	Number of Samples	Percentage of Total
CL	Lean Clay	5	21
CL	Lean Clay with Sand	5	21
CL	Sandy Lean Clay	4	17
CH	Fat Clay	6	25
CH	Fat Clay with Sand	2	8
SC	Clayey Sand	1	4
SC	Clayey Sand with Gravel	1	4
	Total	24	100

Funks Reservoir Sample Locations			
Group Symbol	Group Name	Number of Samples	Percentage of Total
CL	Lean Clay	1	17
CL	Lean Clay with Sand	3	50
CL	Sandy Lean Clay	1	17
SC	Clayey Sand	1	17
	Total	6	100

Testing performed by USBR indicate comparable material classifications. For reference, USBR test results are also summarized in Table 3, and detailed test results are included in Appendix C.

Table 3 – Classification Summary of USBR Samples

USBR Samples Collected Near DWR Sites Sample Locations			
Group Symbol	Group Name	Number of Samples	Percentage of Total
CL	Lean Clay with Sand	3	60
CL	Sandy Lean Clay	1	20
SC	Clayey Sand with Gravel	1	20
	Total	5	100

USBR Samples Collected Near DWR Golden Gate Sample Locations			
Group Symbol	Group Name	Number of Samples	Percentage of Total
CL	Lean Clay	2	18
CL	Lean Clay with Sand	6	55
CL-ML	Sandy Silty Clay	2	18
SM	Silty Sand with Gravel	1	9
	Total	11	100

Figure 5 presents gradation curves for the DWR samples obtained upstream of the Golden Gate Dam site. As shown, the samples are similarly graded with the exception of samples obtained from test pits GG-3 and GG-5 at depths of 10 and 15 feet, respectively. Sandy lean clay was encountered within both test pits which may be the result of their close proximity to Funks Creek. With the exception of the coarser samples obtained from test pits GG-3 and GG-5, the percent passing the No. 4 and No. 200 sieves varied from 98 to 100 percent and 77 to 91 percent, respectively. Testing performed by USBR indicates comparable material gradations and is presented in Appendix C for reference.

Figure 6 presents gradation curves for the DWR samples obtained upstream of the Sites Dam site. Again, the samples are similarly graded with the exception of a few test pits. Test pits SC-2.1, SC-6.3, SC-8.2, SC-8.3 and SC-10.3 all encountered sandy coarser materials probably resulting from their close proximity to neighboring creeks. With the exception of the coarser samples obtained from the previously mentioned test pits, the percent passing the No. 4 and No. 200 sieves varied from 98 to 100 percent and 70 to 97 percent, respectively. Testing performed by USBR indicates comparable material gradations and is presented in Appendix C for reference.

Figure 7 presents gradation curves for the DWR samples obtained upstream of Funks Reservoir. Test pit FR-Aug-7.2 is the only outlier curve, encountering clayey sand at a depth range of 15 to 25 feet. With the exception of the coarser sample obtained from test pit FR-Aug-7.2, the percent passing the No.4 and No. 200 sieves varied from 97 to 99 percent and 68 to 86 percent, respectively. USBR did not perform sampling upstream of Funks Reservoir.

Figure 8 presents a plot of the Atterberg Limits for the samples collected upstream of the Golden Gate Dam site. The Plasticity Index of the samples ranged from a low of 12 to a high of 42. The Liquid Limit of the samples ranged from a low of 30 to a high of 59. The average Liquid Limit and Plasticity Index of the samples was 39 and 22, respectively. For comparison purposes, neighboring USBR samples had an average Liquid Limit and Plasticity Index of 34 and 15, respectively.

Figure 9 presents a plot of the Atterberg Limits for the samples collected upstream of the Sites Dam site. The Plasticity Index of the samples ranged from a low of 17 to a high of 51. The Liquid Limit of the samples ranged from a low of 34 to a high of 72. The average Liquid Limit and Plasticity Index of the samples was 46 and 30, respectively. For comparison purposes, neighboring USBR samples had an average Liquid Limit and Plasticity Index of 36 and 17, respectively.

Figure 10 presents a plot of the Atterberg Limits for the samples collected upstream of Funks Reservoir. The Plasticity Index of the samples ranged from a low of 13 to a high of 25. The Liquid Limit of the samples ranged from a low of 29 to a high of 41. The average Liquid Limit and Plasticity Index of the samples was 38 and 21, respectively. Comparisons to USBR Atterberg Limits were not made because USBR did not sample upstream of Funks Reservoir.

Specific gravity testing was performed on a limited number of DWR samples, including the composite samples. Table 4 presents a summary of the DWR specific gravity test results. USBR test results are not presented in Table 4 since specific gravity testing was performed on numerous samples. However, detailed test results for both DWR and USBR specific gravity tests are included in Appendix B and Appendix C, respectively. Specific gravity values for DWR and USBR samples ranged from 2.74 to 2.80 and 2.59 to 2.74, respectively.

Table 4 – Impervious Material Specific Gravity Summary

Sample Location	Specific Gravity
SC-1.1	2.78
SC-1.2	2.79
GG-1.1	2.78
GG-1.2	2.80
GG-Composite	2.74
SC-Composite	2.74

Organic content testing was also performed on a limited number of DWR samples, including the composite samples. The organic content of the samples ranged from 3.6 to 7.2 percent. Table 5 presents a summary of the DWR organic content test results.

Table 5 – Impervious Material Organic Content

Lab No.	Sample Location	Sample Depth (ft)	Group Symbol	Organic Content (%)
98-167	GG-1.1	5	CL	4.0
98-168	GG-1.2	10	CL	5.1
98-169	GG-1.3	15	CL	5.0
98-170	GG-2.1	4	CL	3.8
98-171	GG-2.2	10	CL	4.0
98-172	GG-2.3	14	CH	7.2
98-173	GG-2.4	*	CL	6.1
98-157	SC-1.1	**	CL	4.7
98-158	SC-1.2	**	CL	3.6
98-159	SC-2.1	**	CL	3.7
98-160	SC-2.2	**	CL	4.4
98-161	SC-3.1	**	CH	4.9
98-162	SC-3.2	**	CH	5.0
99-1419	GG-Composite	N/A	CL	3.9
99-1420	SC-Composite	N/A	CL	4.2

Notes:

* Depth of sample GG-2.4 is unknown.
** Depths of SC samples are unknown. Samples taken from stream banks.

5.3 Density

Compaction testing was performed by DWR on the two composite samples to characterize the moisture-density relationship of the impervious materials. The test procedure used was ASTM D 1557, Laboratory Compaction Characteristics of Soil (modified to a compactive effort of 20,000 ft-lbs./ft^3). Compaction curves for the two composite samples can be found in Figures 11 and 12. Table 6 summarizes the compaction test results. As shown, the maximum dry density and optimum water content of the composite samples ranged from 110.0 to 111.8 pcf and 17.0 to 17.4%, respectively.

Table 6 – Compaction Test Results

Sample Location	Classification - Group Symbol	Plasticity Index	Maximum Dry Density (pcf)	Optimum Water Content (%)
GG-Composite	CL	22	111.8	17.4
SC-Composite	CL	30	110.0	17.0

Based upon the compaction testing performed on the composite samples, the following densities are recommended for use in feasibility level stability analysis: Dry Density = 109 pcf; Moist Density = 127 pcf; and Saturated Density = 131 pcf. The recommended values represent an estimation of anticipated in-place densities for compacted impervious materials using an average of the composite sample compaction test results and assuming 98% compaction at or near the optimum water content.

Compaction testing was also performed by USBR and the detailed test data sheets are included in Appendix C for reference. A summary of the USBR test results is not included for comparison, since the USBR data sheets do not indicate the compactive effort used during testing. However, the average maximum dry density and optimum water content of the USBR samples is comparable to the DWR test results indicating that a modified compactive effort of 20,000 ft-lbs./ft^3 may have been used during USBR testing. The average maximum dry density and optimum water content of the USBR tests were 108.5 pcf and 17.9 percent, respectively.

5.4 Permeability

Permeability testing was also performed on the composite samples. Testing was performed in accordance with ASTM D 5084, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter, Falling Head Test. The permeability tests were performed on the composite samples prepared for CUE triaxial testing. These samples were compacted to approximately 98% of the maximum dry density at or near the optimum water content. Table 7 summarizes the test results, and detailed test results can be found in Appendix D.

Table 7 – Permeability Test Results

Sample Description	Average Permeability (cm/s)
GG-Composite	1.0×10^{-8}
SC-Composite	2.7×10^{-9}

USBR's Earth Manual lists a range of permeability for this type of material as 10^{-5} to 10^{-8} cm/s. This indicates the tested samples are on the lower end of the permeability range, indicating the soil is very impervious. It should be noted, however, that lab technicians encountered some difficulty performing tests due to the low permeability of the impervious material.

5.5 Shear Strength

Consolidated undrained (CUE) triaxial testing was performed on the composite samples to determine and evaluate the shear strength and stress-strain characteristics of the proposed impervious material. The CUE testing was performed in accordance with ASTM D 4767, Standard Test Method for Consolidated Undrained Triaxial Compression Test on Cohesive Soils. Initial effective confining stresses, sample densities, and moisture contents were selected to approximate expected field conditions. Initial effective confining stresses were selected to range between 0.4 tsf and 12 tsf with the samples compacted to approximately 98% of the maximum dry density at or near the optimum water content.

Figures 13 through 18 present plots of deviator stress, effective stress ratio, and pore pressure versus strain. These plots were used to develop the failure envelopes (Figures 19 and 20). In addition, the detailed CUE test results are included in Appendix E. The failure criterion used to develop the total and effective stress envelopes are listed below:

- Total Stress Failure Criteria - Failure assumed to occur at either the maximum deviator stress or 10 percent strain, whichever occurred first.
- Effective Stress Failure Criteria - Failure assumed to occur at either the maximum effective stress ratio or 5 percent strain, whichever occurred first.

Table 8 illustrates the shear strength parameters estimated from the CUE testing.

Table 8 – Estimated Shear Strength Parameters

Sample Location	ϕ	C	ϕ'	C'
GG-Composite	14.5°	800 psf	23°	700 psf
SC-Composite	13.5°	500 psf	20°	500 psf

Results of the CUE testing for the two composite materials were averaged to provide an estimate of the shear strength parameters for use in the feasibility level stability analysis. Recommended shear strength parameters are: Total Friction Angle (ϕ) = 14°; Total Cohesion (C) = 650 psf; Effective Friction Angle (ϕ’) = 21.5°; and Effective Cohesion (C’) = 600 psf.

By comparison, USBR’s Earth Manual lists an average effective friction angle and effective cohesion of 28° and 300 psf, respectively for this type of material. These published average values differ from the shear strength parameters estimated from the testing performed on the composite samples. The limited triaxial testing performed on the impervious materials and difference from average published values indicates the need for additional shear strength testing and evaluation of the impervious materials as part of future design studies.

Another emphasis of the CUE triaxial testing was to evaluate the material’s stress-strain behavior. As shown in Figure 13 through Figure 18, plots of the deviator stress, effective stress ratio, and pore pressure versus strain generally do not exhibit any substantial loss of strength after reaching peak values. The only exception to this is for the effective stress ratio plots for the samples tested at the lowest confining stresses of 1.1 tsf (Figure 14) and 0.4 tsf (Figure 17). These curves may indicate possible testing errors related to the use of relatively low confining stresses on the low permeability material. Excluding these exceptions, the plotted stress-strain curves are similar at different confining pressures and show a generally smooth, plateauing behavior indicating ductile, non-brittle behavior of the impervious material.

5.6 Conclusions and Recommendations

Materials testing and evaluation indicate the impervious materials available within the project area are suitable for use in embankment dams. Sufficient quantities of impervious material exist upstream of the dam sites. Approximately 36 million cubic yards of material are available from the deposits within the reservoir area. This is roughly four times the volume required for construction of Golden Gate Dam, Sites Dam, and the nine saddle dams. Additional impervious materials are also available within the required excavation areas for the appurtenant structures and Funks Reservoir enlargement.

Preliminary and final design programs should include further exploration, testing, and evaluation of the impervious materials. This additional investigation should focus on:

- Identification of specific borrow areas within near vicinity of dams in conjunction with constructability review of the project. The selection of impervious borrow areas should be located to minimize the amount of high plasticity lean clays and fat clays utilized within the dam embankments. Additional sampling and testing should be performed to define the limits of the borrow areas to minimize use of these materials.

- Quantification of available materials within these borrow areas to assist development of the optimum dam section. This should include additional exploration to determine the anticipated in-place density and moisture conditions of impervious material within the borrow areas to assist development of borrow quantity estimates.

- Perform additional exploration, sampling, testing, and evaluation of the impervious materials within the specific borrow areas. Additional testing should include expanded evaluation of the moisture-density relationship, permeability, consolidation, and shear strength properties of the impervious materials due to the limited testing performed as part of this feasibility level investigation. Specifically, the moisture-density relationship of the impervious materials should be examined further to ensure that specified moisture and compaction requirements produce a material with desirable placement, moisture, and compaction characteristics. Shear strength and permeability testing should be performed concurrently with the moisture-density evaluation to ensure selection of engineering properties corresponding to anticipated in-place density and moisture conditions within the dam embankment. Consolidation testing should be performed to estimate the amount of consolidation or settlement expected to occur during construction. In addition, the significance of organic content and plasticity of the impervious materials should be evaluated further to assist development of specification limits.

6.0 ROCKFILL AND RIPRAP MATERIAL

6.1 Introduction

The best available source of clean rockfill and riprap material within the project area is the fresh Venado sandstone (Figure 21). The sandstone is a Cretaceous marine sedimentary rock, fine-to medium-grained, and well cemented with a variable color that is indicative of the state of weathering. The fresh material has a light blue gray appearance, and the weathered material has a brownish color. The Venado sandstone was the only rock type considered for clean rockfill and riprap. Sandstone-with-interbedded-mudstone and mudstone were not considered for rockfill and riprap since the mudstone breaks down when exposed to air and moisture and would not meet “free-draining” requirements for upstream shell material.

There are four proposed sources of the Venado sandstone for construction of the main dam embankments: two located near the Golden Gate Dam site, one near the Sites Dam site, and one near the Saddle Dam sites (Figure 22). A ridge north of the proposed Golden Gate Dam alignment constitutes the Golden Gate Dam rockfill source. The Sites Dam rockfill source is located just north of the existing Sites quarry, outside the proposed reservoir area. The proposed rockfill source for construction of the saddle dams is outside the proposed reservoir area on Logan Ridge centrally located near the saddle dam sites. The proposed quarry areas contain more than enough sandstone to satisfy the required rockfill quantities for the embankment dams.

Based upon field inspections, the proposed Golden Gate Dam rockfill source within the reservoir area is likely to produce more waste material and require more processing than adjacent quarry locations outside of the reservoir area. Therefore, future design investigations should include an evaluation of quarry locations outside of the reservoir area to identify the quarry that will produce the highest quality and yield of rockfill materials.

DWR samples of the Venado sandstone were obtained from the Sites Quarry and exploration holes. Fresh and moderately weathered samples were collected to characterize properties of sandstone with different degrees of weathering. The following types of samples were obtained for laboratory testing:

- 2.5-inch x 5-inch x 5-inch cubes from Sites Quarry
- 3-inch cube samples from Sites Quarry
- 6-inch diameter x 12-inch long cores from Sites Quarry
- 1½-inch minus crushed sandstone from Sites Quarry
- crushed sandstone from drill cores
- 2.5-inch diameter drill core samples from geologic exploration

USACE also performed limited testing on the sandstone sampled from the active Sites Quarry and the abandoned Sites Quarry south of the active quarry to determine the adequacy of the sandstone for use as riverbank slope protection. In USACE documents the active quarry is referred to as the: Old Sites Quarry, Sites Quarry (Cron), and Sites Quarry North; whereas the abandoned quarry is referred to as the Sites Quarry South and Sites Quarry (Welch). In this report, the active and abandoned quarries will be referred to as the Sites Quarry and Sites Quarry (south), respectively.

6.2 Petrography

Petrographic examinations of weathered and fresh samples of Venado sandstone were performed in 1962 and 1972 by USACE. The examinations did not reveal any significant defects and generally characterized the sandstone as an argillaceous, arkosic graywacke with fine to medium grained structure, few fractures, and comprised primarily of quartz and feldspar with a lesser percentage of biotite, chlorite, and clay. The Venado sandstone has a variable color indicative of the state of weathering. The fresh material has a light blue gray appearance, and the weathered material has a brownish color. The USACE petrographic examination reports are included for reference in Appendix G.

6.3 Quality

Laboratory testing was performed on a variety of samples obtained by DWR to provide a quantitative characterization of the quality of Venado sandstone for use as rockfill and riprap. This section summarizes the testing performed by DWR, provides a comparison to testing performed by USACE, and presents an evaluation of the Venado sandstone quality based upon a review of the test results and a comparison to published acceptable limits criteria. The following test procedures were used to characterize the Venado sandstone quality:

- Specific Gravity and Absorption of Coarse Aggregate (ASTM C 127)
- Resistance to Degradation of Small-Size Coarse Aggregates by Abrasion and Impact in the Los Angeles Machine (ASTM C 131)
- Evaluation of Durability of Rock for Erosion Control under Wetting and Drying Conditions (ASTM D 5313)

3-inch Cube Samples

Specific gravity and absorption testing were performed on the 3-inch cube samples of fresh sandstone from Sites Quarry. A summary of the test results is presented in Table 9. As shown, the average specific gravity and absorption are 2.48 and 2.6, respectively. Specific gravity values ranged from a low of 2.45 to a high of 2.52. Similarly, absorption percentages ranged from 2.3% to 3.0%. Detailed test results are included in Appendix F.

Table 9 – Specific Gravity and Absorption Test Results for 3-inch Cubes

Lab No.	Slab No.	Specimen	Specific Gravity	Percent Absorption
98-174	SSQ-1	A	2.50	2.6
"	"	B	2.48	2.6
"	"	C	2.48	2.8
98-175	SSQ-2	A	2.50	2.5
"	"	B	2.50	2.5
"	"	C	2.49	2.6
98-176	SSQ-3	A	*	*
"	"	B	*	*
"	"	C	*	*
98-177	SSQ-4	A	2.50	2.4
"	"	B	2.50	2.5
"	"	C	**	**
98-178	SSQ-5	A	2.46	3.0
"	"	B	2.45	2.8
"	"	C	2.45	2.8
98-179	SSQ-6	A	2.45	2.8
"	"	B	2.45	2.9
"	"	C	2.45	2.9
98-180	SSQ-7	A	2.52	2.5
"	"	B	2.51	2.3
"	"	C	2.50	2.7
98-181	SSQ-8	A	2.48	2.3
"	"	B	2.49	2.5
"	"	C	2.49	2.4
98-182	SSQ-9	A	2.49	2.8
"	"	B	2.49	2.6
"	"	C	2.48	2.6
98-183	SSQ-10	A	2.45	2.8
"	"	B	2.46	2.7
"	"	C	2.46	2.7
		Average	2.48	2.6

Notes:

* Unable to obtain cube samples. Slab was fractured and uneven.

** Only able to secure two cube specimens from slab.

Crushed Sandstone from Drill Cores

Specific gravity, absorption, and Los Angeles abrasion testing was performed on a sample of crushed fresh sandstone from exploration drill cores. Testing indicated a specific gravity of 2.48, absorption of 4.2%, and Los Angeles abrasion losses of 11.4% and 43.4% after 100 revolutions and 500 revolutions, respectively. Detailed test results are included in Appendix F.

1½-Minus Crushed Sandstone from Sites Quarry

The 1½-inch minus samples were prepared with random sandstone waste cobbles from the Sites Quarry operator's debris piles. Samples were segregated into fresh and moderately weathered sandstone lots, and transported for crushing to Valley Rock Products in Orland. A rock crusher processed the samples until material passed a 1-inch screen. Approximately two cubic yards of each the fresh and moderately weathered material passing the 1-inch screen, including fines, were transported to the DWR Bryte Lab in Sacramento for testing.

Specific gravity, absorption, and Los Angeles abrasion testing were performed on the 1½-inch minus samples of crushed fresh and moderately weathered sandstone from Sites Quarry. A summary of the test results is presented in Table 10. As shown, the average specific gravity values vary little between the fresh and moderately weathered samples at 2.48 and 2.46, respectively. However, there is a slight difference between the fresh and moderately weathered absorption values of 5.1% and 6.1%, respectively. Similar differences are noted when comparing the Los Angeles Abrasion values for the fresh and moderately weathered sandstone at 100 and 500 revolutions. The fresh sandstone had average losses of 10.1% and 45.7% for the 100 revolutions and 500 revolutions, respectively, while the moderately weathered sandstone had corresponding average losses of 11.8% and 51.3%. Detailed test results are included in Appendix F.

Table 10 – Specific Gravity, Absorption, and Los Angeles Abrasion Test Results for 1½-Inch Minus Crushed Sandstone from Sites Quarry

				Los Angeles Abrasion	
Lab No.	Specimen	Specific Gravity	Percent Absorption	100 Rev. (% loss)	500 Rev. (% loss)
		Fresh			
99C-113	A	2.48	4.9	11.4	50.8
99C-113	B	2.49	5.0	7.3	36.9
99C-113	C	2.48	5.4	11.5	49.5
	Average	2.48	5.1	10.1	45.7
		Moderately Weathered			
99C-114	A	2.45	6.2	13.7	56
99C-114	B	2.46	6.0	9.2	43.5
99C-114	C	2.46	6.0	12.5	54.5
	Average	2.46	6.1	11.8	51.3

2.5-Inch x 5-Inch x 5-Inch Cubes

Fresh and moderately weathered 2.5-inch x 5-inch x 5-inch cubes from Sites Quarry were tested for specific gravity, absorption, and percent loss due to 45 wetting-drying cycles. The results are presented in Table 11. Slight differences are noticed between the fresh and moderately weathered average values. The fresh sandstone had an average specific gravity of 2.49, while the moderately weathered value was 2.43. Average percent absorption for the fresh and moderately weathered materials were 3.3% and 4.7%, respectively. Wetting-drying test results were similar for both the fresh and the moderately weathered sandstone at 0.5% loss and 0.6% loss, respectively. It should be noted that neither the fresh nor the moderately weathered samples exhibited scaling, flaking, cracking, or slabbing during any part of the wetting-drying testing. Detailed test results are included in Appendix F.

Table 11 – Specific Gravity, Absorption, and Wetting-Drying Test Results
for 2.5-Inch x 5-Inch x 5-Inch Cubes

Lab No.	Specimen	Specific Gravity	Percent Absorption	Wetting-Drying (% loss)
Fresh				
99C-80	A	2.50	3.2	0.5
99C-80	B	2.49	3.3	0.5
99C-80	C	2.49	3.3	0.5
	Average	2.49	3.3	0.5
Moderately Weathered				
99C- 79	A	2.43	4.7	0.6
99C- 79	B	2.42	4.7	0.6
99C- 79	C	2.43	4.7	0.5
	Average	2.43	4.7	0.6

2.5-Inch Diameter Drill Cores from Geologic Exploration

Fresh and weathered 2.5-inch diameter drill cores from geologic exploration were tested for specific gravity and absorption. The results are presented in Table 12. As shown, the specific gravity and absorption for the fresh sandstone had an average of 2.50 and 2.9%, respectively, while the weathered sandstone had average values of 2.52 and 3.6%. Specific gravity values ranged from a low of 2.33 to a high of 2.66. Similarly, absorption percentages ranged from 0.5% to 5.4%. Detailed test results are included in Appendix F.

Table 12 – Specific Gravity and Absorption Test Results for 2.5-Inch Diameter Drill Cores from Geologic Exploration

Lab No.	Drill Hole	Start Depth (ft)	End Depth (ft)	Condition	Specific Gravity	Absorption (%)
2001-28A	GGC-LA1	75.8	77.3	Fresh	2.56	2.9
2001-28B	GGC-LA1	75.8	77.3	Fresh	2.56	2.9
2001-28C	GGC-LA1	75.8	77.3	Fresh	2.57	2.8
2001-30A	GGC-RC1	56.0	57.0	Fresh	2.49	2.9
2001-30B	GGC-RC1	56.0	57.0	Fresh	2.50	2.8
2001-33A	GGC-RC2	70.8	71.9	Fresh	2.53	2.8
2001-33B	GGC-RC2	70.8	71.9	Fresh	2.52	3.1
2001-33C	GGC-RC2	70.8	71.9	Fresh	2.55	3.0
2001-34A	GGC-RA1	59.9	61.0	Fresh	2.53	2.6
2001-34B	GGC-RA1	59.9	61.0	Fresh	2.55	2.6
2001-34C	GGC-RA1	59.9	61.0	Fresh	2.56	2.6
2001-34D	GGC-RA1	59.9	61.0	Fresh	2.56	2.8
2001-36A	GO-DHS-3	45.0	46.0	Fresh	2.48	2.3
2001-36B	GO-DHS-3	45.0	46.0	Fresh	2.48	2.2
2001-41A	GO-DHT3	71.0	72.2	Fresh	2.48	4.2
2001-41B	GO-DHT3	71.0	72.2	Fresh	2.43	3.3
2001-41C	GO-DHT3	71.0	72.2	Fresh	2.42	3.3
2001-43A	GO-DHT3	272.0	273.0	Fresh	2.45	3.7
2001-43B	GO-DHT3	272.0	273.0	Fresh	2.44	3.9
2001-43C	GO-DHT3	272.0	273.0	Fresh	2.44	3.5
2001-43D	GO-DHT3	272.0	273.0	Fresh	2.43	3.9
2001-52C	GGO-DHS4	56.0	57.0	Fresh	2.66	0.8
2001-56B	GGO-DHT1	176.0	177.2	Fresh	2.66	0.5
2001-57A	GGO-DHT3	316.3	317.7	Fresh	2.33	4.4
2001-57B	GGO-DHT3	316.3	317.7	Fresh	2.42	3.4
2001-57C	GGO-DHT3	316.3	317.7	Fresh	2.43	3.4
2001-57D	GGO-DHT3	316.3	317.7	Fresh	2.44	3.6
2001-57E	GGO-DHT3	316.3	317.7	Fresh	2.46	3.7
2001-58A	GGO-DHT3	327.7	329.0	Fresh	2.49	2.0
2001-60A	GGO-DHT4	124.5	125.5	Fresh	2.50	2.7
2001-60B	GGO-DHT4	124.5	125.5	Fresh	2.59	1.5
2001-61A	GGO-DHT5	430.5	432.0	Fresh	2.49	3.3
2001-61B	GGO-DHT5	430.5	432.0	Fresh	2.53	2.5
2001-61C	GGO-DHT5	430.5	432.0	Fresh	2.54	2.9
2001-61D	GGO-DHT5	430.5	432.0	Fresh	2.52	2.1
1999C-84A	GGLA-1	27.8	28.4	Weathered	2.52	3.7
1999C-84B	GGLA-1	27.8	28.4	Weathered	2.50	3.8
1999C-88	GGLC-1	35.6	36.3	Weathered	2.66	1.5
1999C-90	GGRA-1	16.2	17.2	Weathered	2.41	5.4
1999C-91	GGRA-1	51.0	52.3	Fresh	2.47	3.7
1999C-92A	GGRA-1	53.4	54.2	Fresh	2.50	3.5
1999C-92B	GGRA-1	53.4	54.2	Fresh	2.50	3.4
Average for Fresh Sandstone =					2.50	2.9
Average for Weathered Sandstone =					2.52	3.6

USACE Quality Testing

USACE performed similar quality testing on the Venado sandstone from Sites Quarry and Sites Quarry (south) in the early 1960s and 1970s. For comparison purposes, Table 13 through Table 16 present the USACE test results.

Sites Quarry (USACE, 1962)

Specific gravity, absorption, Los Angeles abrasion, and wetting-drying tests were performed by USACE on samples of fresh and weathered Venado sandstone obtained from Sites Quarry in 1962. As shown in Table 13, average specific gravity values for the fresh and weathered sandstone were 2.54 and 2.44, respectively. The fresh and the weathered sandstone had the same average absorption of 3.4%. Los Angeles abrasion testing indicated percent losses for the fresh and weathered sandstone at 36.6% and 45.0%, respectively. Detailed test results can be found in Appendix G.

Table 13 – Rock Quality Test Results from Sites Quarry (USACE, 1962)

Sample No.	Condition	Specific Gravity	Percent Absorption	Los Angeles Abrasion (% loss)	Wetting-Drying
*1	Weathered	2.44	3.4	** 45.0	*a*
*2	Fresh	2.58	3.3	** 39.1	*b*
*3	Fresh	2.50	3.5	** 34.1	*c*
Avg. for Fresh Sandstone =		2.54	3.4	** 36.6	
Avg. for Weathered Sandstone =		2.44	3.4	** 45.0	

Notes:

** sample No. 1 consisted of 100 lbs. of cobble sized particles, but sample types for samples No. 2 and No. 3 are unknown.*

*** number of revolutions not specified, although values are comparable to 500 revolutions*

a = after 15 cycles in fresh and salt water a noticeable softening and loosening of surface grains was evident

b = slight surface sloughing

c = not reported

Sites Quarry (South) (USACE, April 1972)

Specific gravity, absorption, Los Angeles abrasion and wetting-drying tests were performed by USACE on samples of slightly weathered Venado sandstone obtained from Sites Quarry (south) in April of 1972. As shown in Table 14, the average specific gravity and percent absorption for the slightly weathered sandstone were 2.46 and 2.2%, respectively. Percent loss during the Los Angeles Abrasion test was 27%. Detailed test results can be found in Appendix G.

Table 14 – Rock Quality Test Results from Sites Quarry (South) (USACE, April 1972)

*Sample No.	Condition	Specific Gravity	Percent Absorption	Los Angeles Abrasion (% loss)	Wetting-Drying
1	Slightly Weathered	2.47	2.3	**27	*a*
2	Slightly Weathered	2.46	2.1	-	
3	Slightly Weathered	2.45	1.9	-	
4	Slightly Weathered	2.45	2.4	-	
	Avg. for Slightly Weathered Sandstone =	2.46	2.2		

Note:

** sample types are unknown*

*** number of revolutions not specified*

a = Freshwater slab broke into three large fragments during the fifth to seventh cycles, additional flaking occurred for the duration of the test. The other specimens showed only minor flaking during the test.

Sites Quarry (South) (USACE, July 1972)

Specific gravity, absorption, Los Angeles abrasion, and wetting-drying tests were performed by USACE on samples of fresh, moderately weathered, and weathered Venado sandstone obtained from Sites Quarry (south) in July of 1972. As shown in Table 15, average specific gravity values for the fresh, moderately weathered, and weathered sandstone were 2.46, 2.43, and 2.40, respectively. Average percent absorption values were 3.4%, 4.6%, and 6.5%, respectively for the fresh, moderately weathered, and weathered sandstone. Los Angeles abrasion testing was only performed on the fresh and moderately weathered samples. As expected, the moderately weathered sandstone exhibited a greater loss than the fresh sandstone. Percent losses for the Los Angeles abrasion testing were 26% and 39% for the fresh and moderately weathered sandstone, respectively. Although the total number of wetting-drying cycles was not specified, the fresh sandstone parted along joints during the twelfth cycle, and minor flaking occurred throughout the test. The moderately weathered sandstone flaked throughout the entire test. Detailed test results are included in Appendix G.

Table 15 – Rock Quality Test Results from Sites Quarry (South) (USACE, July 1972)

Sample No.	*Specimen	Condition	Specific Gravity	Percent Absorption	Los Angeles Abrasion (% loss)	Wetting-Drying
A	1	Fresh	2.43	4.1	** 26	a
"	2	Fresh	2.50	2.9		
"	3	Fresh	2.45	3.1		
B	1	Mod. Weathered	2.44	4.8	** 39	b
"	2	Mod. Weathered	2.44	4.8		
"	3	Mod. Weathered	2.41	4.1		
C	1	Weathered	2.42	6.1	-	-
"	2	Weathered	2.37	7.0		
"	3	Weathered	2.41	6.3		
Avg. for Fresh Sandstone =			2.46	3.4		
Avg. for Mod. Weathered Sandstone =			2.43	4.6		
Avg. for Weathered Sandstone =			2.40	6.5		

Notes:

** sample types are unknown*

*** Los Angeles Abrasion testing performed on specimen 1 of each rock type. Number of revolutions not specified.*

a = Rock specimens parted along joints during the 12th cycle. Minor flaking occurred throughout the test.

b = Specimens flaked during the test.

Sites Quarry and Sites Quarry (South) (USACE, 1974)

Specific gravity, absorption, and Los Angeles abrasion testing were performed on grab samples of fresh Venado sandstone obtained from Sites Quarry and Sites Quarry (south) in 1974. As shown in Table 16, the average specific gravity values for the gradations at Sites Quarry (south) and Sites Quarry are nearly identical at 2.46 and 2.47 respectively. Average percent absorption values for the sandstone at both quarries were identical at 5.3%. Los Angeles abrasion testing, at 100 revolutions, yielded results of 18.9% for Sites Quarry (south) and 12.8% at Sites Quarry. Corresponding values, at 500 revolutions, were 52.6% and 50.2%. Detailed test results are included in Appendix G.

Table 16 – Rock Quality Test Results from Sites Quarry and Sites Quarry (South) (USACE, 1974, Tested by USBR)

				Los Angeles Abrasion	
Quarry	Gradation	Specific Gravity	Absorption (%)	100 Rev. (% loss)	500 Rev. (% loss)
Sites Quarry (south)	1½" - ¾"	2.47	4.4	18.9	52.6
Sites Quarry (south)	¾" – $^{3}/_{8}$”	2.47	5.1		
Sites Quarry (south)	$^{3}/_{8}$" - #4	2.45	6.4		
Sites Quarry	1½" - ¾"	2.48	4.4	12.8	50.2
Sites Quarry	¾" – $^{3}/_{8}$”	2.47	5.1		
Sites Quarry	$^{3}/_{8}$" - #4	2.46	6.5		
	Average Sites Quarry (south) =	2.46	5.3		
	Average Sites Quarry =	2.47	5.3		

Quality Evaluation

For ease of comparison and discussion of the Venado sandstone quality evaluation, Table 17 presents a summary of the average rock quality test results performed by DWR. This table also includes acceptable limits criteria, adopted from USBR’s Design Standards No. 13, Embankment Dams, Chapter 7, Riprap Slope Protection, 1992 and USACE’s Engineer Manual No. 1110-2-2302, Construction with Large Stone, 1990. These criteria indicate specific gravity values should be greater than 2.6, while absorption should be less than 2%. Furthermore, Los Angeles abrasion test results should be less than 10% and 40% for 100 revolutions and 500 revolutions, respectively.

Table 17 - Average Rock Quality Test Results for the Venado Sandstone

Sample Type	Weathering Characteristics	Number of Tests	ASTM Test Procedures				
			Specific Gravity C 127	Absorption C 127 (%)	Los Angeles Abrasion C 131		Wet-Dry with 45 Cycles D 5313 (% loss)
					100 Rev. (% loss)	500 Rev. (% loss)	
3-Inch Cubes from Sites Quarry	Fresh	26	2.48	2.6	-	-	-
Crushed Sandstone from Drill Cores (1½-Inch Minus)	Fresh	1	2.48	4.2	11.4	43.4	-
Crushed Sandstone from Sites Quarry (1½-Inch Minus)	Fresh	3	2.48	5.1	10.1	45.7	-
	Moderately Weathered	3	2.46	6.1	11.8	51.3	-
2½-Inch x 5-Inch x 5-Inch Cubes from Sites Quarry	Fresh	3	2.49	3.3	-	-	0.5*
	Moderately Weathered	3	2.43	4.7	-	-	0.6*
Drill Cores from Geologic Exploration	Fresh	37	2.50	2.9	-	-	-
	Moderately Weathered	5	2.51	3.6	-	-	-
Acceptable Limits**			**Should be >2.6**	**Should be <2.0%**	**Should be <10%**	**Should be <40%**	***

* Rock samples did not exhibit scaling, flaking, cracking, or slabbing during or at end of test.

** Acceptable limits criteria adopted from USBR's Design Standards No. 13, Embankment Dams, Chapter 7, Riprap Slope Protection, 1992 and USACE's Engineer Manual No. 1110-2-2302, Construction with Large Stone, 1990.

*** Rock should not exhibit progressive cracking during or at end of test.

Although a comparison of the test results to the acceptable limits indicate the quality of the Venado sandstone to be slightly unacceptable, the fresh sandstone is of sufficient quality for use as clean rockfill and riprap, provided that considerations regarding its quality are incorporated into design. The acceptable limits are generally applicable for concrete aggregates and should not be used as the only indicator of rock quality. A recent site inspection of Funks Reservoir Dam, where Venado sandstone was used for upstream slope protection, yielded perhaps the most definitive statement about the rock's quality. The dam was constructed in the mid-1970s, and the sandstone is still performing adequately today, exhibiting no significant signs of deterioration or detrimental performance. The quality testing also confirms that the fresh Venado sandstone is a better quality rock than the moderately weathered sandstone.

Based upon the test results, the following considerations should be included into the design of the rockfill material:

- Specific gravity values of less than 2.6 may indicate rock with higher potential for displacement by wave action. Larger rock sizes could be used to compensate for lower values of specific gravity.

- Absorption values greater than 2% may indicate the rock will be susceptible to deterioration from wave action or freeze thaw. Rock deterioration by wave action may necessitate the periodic maintenance of the upstream slope. Freeze-thaw damage is not a significant concern in the project area.

- Los Angeles Abrasion test results exceeding 10% for 100 revolutions and 40% for 500 revolutions may indicate the rock will be less resistant to degradation by surface abrasion and impact. Development of test quarries and fills should be performed as part of future design studies to ensure specification requirements produce clean rockfill and riprap materials with desired in-place gradations, while compensating for particle breakage during quarry, placement, and compaction operations.

6.4 Physical Properties and Rock Strength

Laboratory testing was performed on fresh and moderately weathered samples to characterize and evaluate the physical properties and strength of the Venado sandstone. The following test procedures were performed on 6-inch diameter by 12-inch long core samples from Sites Quarry and 2.5-inch diameter drill cores from geologic exploration:

- Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression (ASTM D 3148)
    - Unconfined Compressive Strength

    - Young's Modulus
    - Poisson's Ratio
- Splitting Tensile Strength of Intact Rock Core Specimens (ASTM D 3967)

6-Inch Diameter x 12-Inch Long Core Samples

Table 18 presents the physical properties and strength test results of the 6-inch diameter by 12-inch long rock cores from Sites Quarry. As shown, the average unconfined compressive strength for the fresh sandstone was 9,568 psi and 6,983 psi, respectively for the dry and wet samples, while the moderately weathered sandstone had corresponding values of 4,998 psi and 3,589 psi. The average Young's Modulus for the fresh sandstone was 1.258 x 10^6 psi and 1.180 x 10^6 psi, respectively for the dry and wet samples, while the moderately weathered sandstone had corresponding values of 0.916 x 10^6 psi and 0.735 x 10^6 psi. The average Poisson's Ratio for the fresh sandstone was 0.170 and 0.164, respectively for the dry and wet samples, while the moderately weathered sandstone had corresponding values of 0.107 and 0.120. The average Brazilian Tensile Strength for the fresh sandstone was 661 psi and 444 psi, respectively for the dry and wet samples, while the moderately weathered sandstone had corresponding values of 358 psi and 226 psi. Test results indicate that the unconfined compressive strength and Brazilian tensile strength of the fresh sandstone is approximately twice the strength of the moderately weathered sandstone. Detailed test results can be found in Appendix H.

Table 18 - Physical Properties of 6-Inch Diameter Sandstone Rock Cores from Sites Quarry

Lab No.	Weathering	Unconfined Compressive Strength (psi)		Young's Modulus (x10^6 psi)		Poisson's Ratio		Brazilian Tensile Strength (psi)		Orientation to Bedding
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	
99C-62	Mod. Weathered	5,511		0.945		0.06				
99C-55	Mod. Weathered	4,842		0.896		0.16				
99C-59	Mod. Weathered	4,640		0.906		0.10				
99C-53	Mod. Weathered		3,790		0.663		0.10			
99C-59	Mod. Weathered		3,516		0.730		0.11			
99C-61	Mod. Weathered		3,461		0.813		0.15			
99C-66	Fresh	8,994		1.303		0.22				
99C-69	Fresh	9,983		1.262		0.15				
99C-73	Fresh	9,727		1.209		0.14				
99C-70	Fresh		6,904		1.157		0.22			
99C-72	Fresh		6,818		1.188		0.14			
99C-74	Fresh		7,227		1.196		0.13			
99C-54-3A	Mod. Weathered								182	parallel
99C-54-3B	Mod. Weathered								272	perpendicular
99C-54-3C	Mod. Weathered							247		parallel
99C-54-3D	Mod. Weathered							450		perpendicular
99C-56-5A	Mod. Weathered								172	parallel
99C-56-5B	Mod. Weathered								278	perpendicular
99C-56-5C	Mod. Weathered							235		parallel
99C-56-5D	Mod. Weathered							415		perpendicular
99C-58-7A	Mod. Weathered								174	parallel
99C-58-7B	Mod. Weathered								282	perpendicular
99C-58-7C	Mod. Weathered							279		parallel
99C-58-7D	Mod. Weathered							461		perpendicular
99C-60-9A	Mod. Weathered								145	parallel
99C-60-9B	Mod. Weathered								301	perpendicular
99C-60-9C	Mod. Weathered							304		parallel
99C-60-9D	Mod. Weathered							470		perpendicular
99C-67-2A	Fresh								394	parallel
99C-67-2B	Fresh								577	perpendicular
99C-67-2C	Fresh							617		parallel
99C-67-2D	Fresh							763		perpendicular
99C-71-6A	Fresh								433	parallel
99C-71-6B	Fresh								612	perpendicular
99C-71-6C	Fresh							561		parallel
99C-71-6D	Fresh							798		perpendicular
99C-75-10A	Fresh								342	parallel
99C-75-10B	Fresh								367	perpendicular
99C-75-10C	Fresh							626		parallel
99C-75-10D	Fresh							629		perpendicular
99C-78-13A	Fresh								318	parallel
99C-78-13B	Fresh								508	perpendicular
99C-78-13C	Fresh							539		parallel
99C-78-13D	Fresh							754		perpendicular
Average for Fresh =		9,568	6,983	1.258	1.180	0.170	0.164	661	444	
Average for Mod. Weathered =		4,998	3,589	0.916	0.735	0.107	0.120	358	226	

2.5-Inch Diameter Drill Cores

Table 19 presents Brazilian tensile strength and compressive strength test results for the 2.5-inch diameter drill cores from geologic exploration. As shown, the average Brazilian tensile strength for the wet and dry, fresh samples of Venado sandstone were 524 psi and 840 psi, respectively. The average compressive strengths for the fresh samples were 6,836 psi and 10,808 psi for the wet and dry samples, respectively. The fresh, wet samples ranged from a low of 4,548 psi to a high of 17,910 psi, while the fresh, dry samples ranged from a low of 4,600 psi to a high of 16,850 psi. The weathered, dry sample had a compressive strength of 7,290 psi. Unconfined compressive strength test results on the drill cores from geologic exploration are comparable to the strength values determined for the 6-inch diameter drill cores from Sites Quarry. Detailed test results can be found in Appendix H.

Table 19 – Brazilian Tensile Strength and Compressive Strength Test Results for 2.5-Inch Diameter Drill Cores from Geologic Exploration

Lab Code	Drill Hole	Start Depth (ft)	End Depth (ft)	Weathering Condition	Moisture Condition	Compressive Strength (psi)	Brazilian Tensile Strength (psi)
Brazilian Tensile Strength							
2001-57D	GGO-DHT3	316.3	317.7	Fresh	Wet	-	467
2001-61A	GGO-DHT5	430.5	432		Wet	-	541
2001-41A	GO-DHT3	71	72.2		Wet	-	565
2001-52B	GGO-DHS4	56	57	Fresh	Dry	-	789
2001-57E	GGO-DHT3	316.3	317.7		Dry	-	890
				Average for Wet Samples		=	524
				Average for Dry Samples		=	840
Compressive Strength							
1999C-84A	GGLA-1	27.8	28.4	Fresh	Wet	4,725	-
1999C-92A	GGRA-1	53.4	54.2		Wet	7,230	-
1999C-110	LC-2	51.3	52		Wet	17,910	-
2001-58A	GGO-DHT3	327.7	329		Wet	4,548	-
2001-30A	GGC-RC1	56	57		Wet	4,693	-
2001-34B	GGC-RA1	59.9	61		Wet	4,810	-
2001-41B	GO-DHT3	71	72.2		Wet	5,226	-
2001-28B	GGC-LA1	75.8	77.3		Wet	5,703	-
2001-61B	GGO-DHT5	430.5	432		Wet	5,745	-
2001-52C	GGO-DHS4	56	57		Wet	6,861	-
2001-60B	GGO-DHT4	124.5	125.5		Wet	7,740	-
1999C-91	GGRA-1	51	52.3	Fresh	Dry	13,080	
1999C-92B	GGRA-1	53.4	54.2		Dry	13,120	
2001-58B	GGO-DHT3	327.7	329		Dry	4,600	-
2001-61C	GGO-DHT5	430.5	432		Dry	8,803	-
2001-60A	GGO-DHT4	124.5	125.5		Dry	9,264	-
2001-30B	GGC-RC1	56	57		Dry	9,791	-
2001-34C	GGC-RA1	59.9	61		Dry	9,997	-
2001-28C	GGC-LA1	75.8	77.3		Dry	10,125	-
2001-56B	GGO-DHT1	176	177.2		Dry	11,988	-
1999C-84B	GGLA-1	27.8	28.4		Dry	11,270	-
1999C-88	GGLC-1	35.6	36.3		Dry	16,850	-
1999C-90	GGRA-1	16.2	17.2	Weathered	Dry	7,290	-
			Average for Fresh, Wet Samples		=	6,836	
			Average for Fresh, Dry Samples		=	10,808	
			Average for Weathered, Dry Samples		=	7,290	

Average physical properties and strength values for the Venado sandstone presented in subsequent sections of this report will be based upon testing performed on the 6-inch diameter cores from Sites Quarry. These samples are considered to provide a better representation of the sandstone that would be obtained from quarry development for the Sites Reservoir project, since these samples were obtained from an active quarry near the surface and not at depth as in the cores obtained from exploration holes.

Comparison to Other Rockfill Materials

Table 20 presents a comparison of the average physical properties of the Venado sandstone to other rockfill materials for which physical properties, strength, and shear strength data are available. Of particular interest is a comparison to the Venado sandstone that was extensively tested as part of the UC Berkeley Report by Becker et. al. (1972). The Venado sandstone tested by DWR and UC Berkeley were obtained from the same quarry (Sites Quarry) and have similar unconfined compressive strengths of 9,568 psi and 8,845 psi, respectively. The average compressive strength of the fresh sandstone tested by DWR is higher than the sandstone tested by UC Berkeley, indicating that the use of UC Berkeley's testing for evaluation of the sandstone as part of this study is appropriate. Additionally, compressive and shear strength data for the other rockfill materials presented in Table 20 will be used to develop relationships to estimate shear strengths of the Venado sandstone for use in the feasibility level stability analysis.

Table 20 - Average Physical Properties of Rock Cores

Source	Rock Type	Unconfined Compressive Strength (psi)		Young's Modulus ($x10^6$ psi)		Poisson's Ratio		Brazilian Tensile Strength (psi)		Reference
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	
Sites Quarry	Sandstone (F)	9,568	6,983	1.258	1.180	0.170	0.164	661	444	1
Sites Quarry	Sandstone (MW)	4,998	3,589	0.916	0.735	0.107	0.120	358	226	1
Sites Quarry	Sandstone (A)	8,845	4,797	1.93	1.45	0.220		1,133		2
Newville	Sandstone	22,160	12,160	3.210	2.610	0.13	0.29	1,898	1120	3
Newville	Conglomerate	16,800	5,750	4.260	2.780	0.15	0.47	1,522	844	3
Oroville	Amphibolite	45,500	28,000	6.200	6.200			1,870		2
Oroville	Quartz Schist	48,400	29,500	10.200	6.800	0.30		2,590		2
Oroville	Granulite	17,000		2.850						2
Pyramid	Argillite	15,000		4.200				1,896		2

F-Fresh, MW-Moderately Weathered, A-Average

1. DWR's current testing and evaluation program.
2. Becker, Chan, and Seed, UC Berkeley Report No. TE 72-3 "Strength and Deformation Characteristics of Rockfill Materials in Plane Strain and Triaxial Compression Tests"
3. DWR "SWP Future Supply Program Glenn Reservoir Complex, Investigation of Rockfill Materials for Newville Dam," December 1980

Rock Strength Classification

Figure 23 presents a graphical comparison of the average compressive strength of the Venado sandstone to other rockfill materials. This figure also includes rock strength classification scales proposed by Leps and Deere. According to these scales, the sandstone would be classified as follows:

- Fresh Sandstone, Dry
  - Leps Scale = Average Strength
  - Deere Scale = Average Strength

- Fresh Sandstone, Saturated
  - Leps Scale = Average Strength
  - Deere Scale = Low Strength

- Moderately Weathered Sandstone, Dry
  - Leps Scale = Average Strength
  - Deere Scale = Low Strength

- Moderately Weather Sandstone, Saturated
  - Leps Scale = Average Strength
  - Deere Scale = Very Low Strength

These strength classifications confirm that the fresh Venado sandstone is a better quality rock than the moderately weathered sandstone.

Figure 24 presents a graphical comparison of the fresh Venado sandstone to other rockfill materials using the Deere engineering classification chart. As shown in this figure, the saturated Venado sandstone is classified as a low strength, low modulus ratio material, while the dry Venado sandstone is classified as a medium strength, low modulus ratio material.

6.5 Shear Strength

Shear strength parameters were estimated by determining the physical properties of the Venado sandstone, identifying rockfill materials with similar properties, and selecting shear strength parameters from published data for those similar rockfill materials.

Table 21 presents published data for the shear strength properties of the Venado sandstone and other rockfill materials. As shown, data was collected from 2.8-inch, 12-inch, and 36-inch triaxial tests as well as plane strain tests. Photographs of the large-scale triaxial and plane strain testing apparatus used at UC Berkeley on Oroville amphibolite, Pyramid argillite, and Venado sandstone are included for reference as

Figure 25 and Figure 26, respectively. Of particular interest is the Venado sandstone test data presented in the 1972 UC Berkeley Report by Becker et. al. The Venado sandstone examined in this report was quarried within the vicinity of the expected borrow locations for the Sites Reservoir project. As such, it is appropriate to make estimations from the published Venado sandstone data regarding the anticipated shear strength of the rockfill material for the Sites Reservoir Project. Shear strength information for the published data is included for reference in Appendix J.

Figure 27 is a comparison of confining stress to friction angle for the rockfill materials presented in Table 21. The figure was modeled after the shearing strength plot first proposed by Leps, 1970 (Appendix J) and includes Leps' rockfill strength scales for comparison. This figure also includes trendlines of confining stress versus friction angle for the 36-inch triaxial tests and plane strain tests performed on the Venado sandstone. These trendlines will be used to estimate shear strength properties of the Venado sandstone.

Table 21 - Shear Strength Properties of Rockfill Materials

Project	Rock Type	Triaxial Test Size (inches)	Maximum Particle Size (inches)	Confining Pressure (psi)	Friction Angle (degrees)	Reference
Indraratna et al. 1993	Greywacke (1.5 inch)	Information not available.	1.5	23	45	Indraratna et al, 1993
			1.5	50	39.5	
			1.5	70	37	
			1.5	90	36	
			1.5	120	34.5	
			1.5	145	32.5	
Oroville	Amphibolite (Dredger Tailings)	36	6	30	47	Marachi et al, UC Berkeley 1969
		36	6	140	43	
		36	6	420	39.5	
		36	6	650	38.5	
Newville	Sandstone	2.8	0.5	30	43.5	DWR, 1980
		2.8	0.5	85	39.5	
		2.8	0.5	140	38.5	
		2.8	0.5	300	37	
Newville	Conglomerate	2.8	0.5	30	44	DWR, 1980
		2.8	0.5	85	41	
		2.8	0.5	140	39	
		2.8	0.5	300	35	
Eastside	Quartzite BA-2	Not applicable. Eastside friction angles are design values.		30	48	Domenigoni Valley Reservoir Project, 1994
				100	44	
Pyramid	Argillite	36	6	30	47	Marachi et al, UC Berkeley 1969
		36	6	140	39.5	
		36	6	420	36	
		36	6	650	35.5	
Charles & Watts, 1980	Sandstone	Information not available.		7	59	Charles & Watts, 1980
				22	51	
				69	39	
				150	35	
Scammonden	Sandstone	12	Information not available.	15	49	Charles, 1973
		12		250	37	
UC Berkeley	Venado Sandstone	36	6	30	41	Becker et al, UC Berkeley 1972
		36	6	140	36.5	
		36	6	420	36	
		36	6	650	37	
UC Berkeley	Venado Sandstone (under plane strain conditions)	NA	4	30	44	Becker et al, UC Berkeley 1972
		NA	4	140	41	
		NA	4	420	38	
		NA	4	650	38	
Eastside	Phyllite BA-3	Not applicable. Eastside friction angles are design values.		30	46	Domenigoni Valley Reservoir Project, 1994
				100	42	

Table 22 summarizes the estimated range of friction angles for the Venado Sandstone obtained from Figure 27 at confining stresses equivalent to the average stress and maximum stress levels estimated to occur on deep sliding surfaces within the proposed Golden Gate and Sites dam embankments. The average and maximum confining stresses are estimated to be approximately 40 psi and 100 psi, respectively. As shown in Table 22, the average and maximum confining stresses correspond to triaxial friction angels of 40.5º and 39.0º and plane strain friction angles of 43.5º and 41.5º. According to the reference scale proposed by Leps, 1970, these ranges of friction angles roughly correspond to rockfill shear strength classifications of “Low” and “Average” for triaxial and plane strain conditions, respectively.

Table 22 – Estimated Shear Strength of Rockfill Materials

Confining Pressure (psi)	Triaxial Friction Angle (degrees)	Plane Strain Friction Angle (degrees)
40	40.5	43.5
100	39.0	41.5

It is customary to estimate shear strengths in terms of triaxial friction angles, but plane strain friction angles are also presented because Marachi et. al. (1969) suggested that long rockfill dams experience deformation conditions generally similar to those of plane strain. It should also be pointed out that the triaxial and plane strain data for the Venado sandstone, corresponding to a 6-inch and 4-inch maximum particle size, respectively, were intentionally chosen for their large particle size. According to the study performed by Becker et al (1972) (Appendix J), there is very little change in shear strength between the 2-inch maximum particle size triaxial tests and the 6-inch maximum particle size triaxial tests, when similar gradations are used. Furthermore, a plot in the same study suggests that little difference would be seen (in terms of shear strength) if the data were extrapolated to include the 30-inch maximum particle size expected for use in rockfill materials for Sites reservoir. In summary, it is therefore appropriate to use the shear strengths estimated from Figure 27 and presented in Table 22.

Since a lower level of evaluation is required for the feasibility level stability analysis, the shear strength for the rockfill material was estimated by adopting a friction angle corresponding to the average confining stress (40 psi) estimated to occur on deep sliding surfaces, and neglecting the effects of varying shear strength with confining stress by using the average value. Specifically, the recommended shear strength for the rockfill material was estimated by adopting the plane strain friction angle for the average confining stress, but reducing the value slightly as a conservative measure. The recommended shear strength for use in the feasibility level stability analysis is: Friction Angle (ϕ') = 42°. Since shear strength varies with confining stress, future testing and evaluation of the rockfill materials should account for this effect when recommending shear strengths for use in preliminary and final design of the dam embankments.

Subsequent tables and figures are presented as a supplemental comparison for the selection of appropriate shear strengths for the Venado sandstone.

Table 23 presents published compressive and shear strength properties of selected rockfill materials under triaxial and plane strain conditions at confining pressures of 40 psi and 100 psi. Published data was obtained from UC Berkeley and DWR reports.

Table 23 – Published Compressive and Shear Strength Properties of Selected Rockfill Materials

Project	Rock Type	Dry Unconfined Compressive Strength (psi)	Triaxial Friction Angle at 40 psi (degrees)	Triaxial Friction Angle at 100 psi (degrees)	Reference
Oroville	Amphibolite (Dredger Tailings)	45,500	46.5	44.5	1
Newville	Sandstone	22,160	43.0	39.0	2
Newville	Conglomerate	16,800	43.5	40.5	2
Pyramid	Argillite	15,500	46.5	42.0	1
Venado	Sandstone	8,845	40.5	38.0	3
Oroville	Amphibolite (Dredger Tailings)	45,500	*52.0	*49.5	3
Pyramid	Argillite	15,500	*48.5	*45.0	2,3
Venado	Sandstone	8,845	*43.5	*41.5	3

*Notes: * = friction angle under plane strain conditions*
1 = Marachi, Becker, et al (1969, 1972)
2 = DWR, 1980
3 = Becker et al, 1972

Figure 28 and Figure 29 present comparisons of dry unconfined compressive strength to friction angle, under triaxial and plane strain conditions, for the rockfill materials presented in Table 23. Figure 28 presents friction angles corresponding to a confining stress of 40 psi, while Figure 29 presents friction angles corresponding to a confining stress of 100 psi. A trendline was developed through the triaxial and plane strain rockfill data to facilitate estimation of the shear strength for the Venado sandstone. As shown in Figure 28, the average dry unconfined compressive strength of 9,568 psi indicates friction angles of approximately 42.0º and 44.5º for the triaxial and plane strain conditions, respectively at a confining stress of 40 psi. As shown in Figure 29, a dry unconfined compressive strength of 9,568 psi indicates friction angles of approximately 38.5º and 42.0º for the triaxial and plane strain conditions, respectively at a confining stress of 100 psi.

Figure 30 is another comparison between compressive strength and friction angle for rockfill materials used in embankment dams. Data was obtained from ICOLD Bulletin 92, and probably reflects design values instead of actual test results. Again, a trendline through the rockfill data, coupled with Venado sandstone's compressive strength of 9,568 psi, indicates a friction angle of approximately 39.5º.

Figures 28 through 30 are supplemental comparisons for the selection of appropriate shear strengths for the Venado sandstone for use as rockfill material in the proposed dams. These figures indicate comparable shear strengths for the Venado sandstone and confirm the selection of the shear strengths recommended previously in this section.

6.6 Density

Compacted in-place densities of the Venado sandstone to be used as rockfill and riprap materials were estimated from data published by Becker et. al. (1972) (Appendix K). In-place densities were calculated assuming a water content of 5% and a relative density of 90% for the compacted rockfill materials. The published data along with the previous assumptions indicate estimated dry, moist, and saturated densities of 116 pcf, 122 pcf, and 136 pcf, respectively.

6.7 Particle Breakage

Particle breakage refers to the phenomenon by which individual rock particles fracture and crush due to external stress concentrations. Because particle breakage can adversely affect a soil’s shear strength, it warrants consideration during design. Relevant to this report, particle breakage occurs within embankment dams and can be modeled and simulated in the laboratory by compression tests such as triaxial and plane strain testing.

As discussed in UC Berkeley reports by Marachi, Becker, et. al. (1969, 1972), Marsal (1965) quantified the amount of a soil’s particle breakage by devising the particle breakage factor “B”. The breakage factor B is calculated by comparing the percent material retained on each sieve before and after shear strength testing, and summing the same sign differences for each sieve. For clarification, a sample calculation of the particle breakage factor B is included below.

Sample Calculation of Particle Breakage Factor B

	% Retained on Sieve		
Sieve	Before Testing	After Testing	Δ (%)
3-inch	6	6	0
1½-inch	20.5	20.2	0.3
¾-inch	24.5	24.7	-0.2
$^3/_8$-inch	17.5	19.1	-1.6
#4	11.5	9.9	1.6
Pan	20	20.1	-0.1
		Particle Breakage Factor B =	1.9 %

A comparison of observed particle breakage of the Venado sandstone during shear strength testing to rockfill materials (argillite) used at Pyramid Dam was performed as a supplemental method for evaluating the suitability of the sandstone for rockfill and riprap materials. This comparison involved review of the large-scale triaxial and plane strain testing documented in UC Berkeley reports published by Marachi, Becker, et. al. (1969, 1972). It should be pointed out that both rockfill materials were composed of angular particles, and both materials had the same initial gradation for each test and/or figure discussed in the following paragraphs.

Figures 31 and 32 present particle breakage as a function of confining pressure, observed from triaxial testing, for the Venado sandstone and Pyramid Dam argillite, respectively. When directly comparing the two curves for the 6-inch maximum particle size (36-inch diameter specimen), it can be seen that the two rockfill materials exhibit comparable particle breakage. In fact, at confining pressures of 30 psi, 420 psi, and 650 psi, the Venado sandstone demonstrated less particle breakage than the Pyramid Dam argillite. Table 24 compares the Venado sandstone and Pyramid argillite particle breakage results as presented in Figures 31 and 32.

Table 24 – Summary of Particle Breakage Results for 6-Inch Maximum Particle Size Triaxial Tests for Venado Sandstone and Pyramid Argillite

	Particle Breakage (%) at Confining Pressures of:			
Rock Type	30 psi	140 psi	420 psi	650 psi
Venado Sandstone	12.5	22.5	31.5	33.5
Pyramid Argillite	13.5	21.5	35	43

Figure 33 is a comparison of particle breakage of the Venado sandstone to the Pyramid Dam argillite for plane strain testing. Particle breakage is plotted against minor principal stress. Of particular interest is the 4-inch maximum particle size curves for the two materials. Similar to the previous two figures, the Venado sandstone and Pyramid Dam argillite exhibit comparable particle breakage. Again, at certain minor principal stresses, the Venado sandstone shows slightly more resistance to particle breakage than the Pyramid Dam argillite. Table 25 compares the Venado sandstone and Pyramid argillite particle breakage results as presented in Figure 33.

Table 25 – Summary of Particle Breakage Results for 4-Inch Maximum Particle Size Plane Strain Tests for Venado Sandstone and Pyramid Argillite

	Particle Breakage (%) at Minor Principal Stresses of:			
Rock Type	30 psi	140 psi	420 psi	650 psi
Venado Sandstone	8	17	25	26.5
Pyramid Argillite	8.5	17	27.5	32.5

Figure 34 presents gradation curves for the Venado sandstone and the Pyramid Dam argillite before and after the plane strain testing at a minor principal stress of 650 psi. This figure confirms the earlier suggestion that the Venado sandstone exhibited slightly more resistance to particle breakage than the Pyramid Dam argillite. As seen in this figure, the Pyramid Dam argillite has a slightly finer gradation after testing than the Venado sandstone, indicating the Venado sandstone to be slightly more resistant to particle breakage.

Figure 31 through Figure 34 indicate the particle breakage of the Venado sandstone is comparable to the Pyramid Dam argillite. In some cases, the Venado sandstone exhibited slightly more resistance to particle breakage than the Pyramid Dam argillite. Considering that the Pyramid Dam argillite is an adequate and successfully performing rockfill material, the Venado sandstone is judged to have sufficient strength and resistance to breakage for use as clean rockfill and riprap material.

6.8 Observed Performance

Probably the greatest indicator of the quality, durability, and suitability of the Venado sandstone for use as rockfill and riprap is to evaluate its long-term performance under similar environmental and operating conditions. Venado sandstone was used as upstream slope protection on USBR's Funks Reservoir Dam, constructed during the mid 1970s. Inspection of the slope protection on Funks Reservoir Dam indicates that the Venado sandstone has not exhibited significant deterioration, has performed adequately over the last 25 years, and is of sufficient quality for use as clean rockfill and riprap materials. Figure 35 is a photograph of the upstream slope protection on Funks Reservoir Dam.

6.9 Processability

As discussed and evaluated earlier in the report, the fresh sandstone was found to be of better quality, and thus more desirable, than the moderately weathered sandstone. As such, obtaining fresh Venado sandstone for use as riprap and rockfill material is essential to the successful construction and operation of the proposed embankment dams. Past correspondence between the USACE and Teichert Construction (regarding the Venado sandstone quarrying operations at Sites Quarry (south)) indicates that separating the desired fresh Venado sandstone from the lesser quality, weathered sandstone and interbedded mudstone may be a significant task. Teichert's quarry operations at Sites Quarry (south) were producing riprap for Sacramento River bank protection projects. Consequently, further studies should include an assessment of the excavation and processing requirements to produce the desired materials. USACE inspection reports of Teichert's quarry operation are included for reference in Appendix L.

As previously mentioned, USBR's Funks Reservoir Dam also utilized Venado sandstone for use as upstream slope protection. Although USBR and USACE used the Venado sandstone for somewhat different purposes, it should be pointed out that USBR inspector, Paul Freeman, reported no difficulties in processing the sandstone for use as upstream slope protection during a phone conversation in September, 2001

Inspection of Sites Quarry indicates that obtaining the desired stone sizes for rockfill and riprap material may require additional processing. Drilling and blasting will likely produce over-sized and/or under-sized rock fragments depending upon the bedding thickness. Over-sized stones will require further processing (crushing), while under-sized stones will have to be segregated and removed from the prospective rockfill and riprap material to be used as random or possibly transition material. Quality control over the quarrying operations will be necessary to ensure specification requirements are met.

6.10 Conclusions and Recommendations

Material testing and evaluation indicate the fresh Venado sandstone is of sufficient quality for use as clean rockfill and riprap materials. Sufficient quantities of Venado sandstone can be obtained from quarries developed in near vicinity of the dam sites for the embankment dams under consideration. Although beyond the scope of this study, future design investigations should include test quarries and fills to develop the specification requirements. This will ensure that the Venado sandstone will meet design requirements for clean rockfill material, particularly related to limiting the fines content of in-place material. Future design investigations should also include additional testing and evaluation of the Venado sandstone to further define the engineering properties of the clean rockfill material such as: shear strength, hydraulic conductivity, density, etc..

Although use of the highest quality rock meeting laboratory test requirements for concrete aggregates is desirable, use of “softer” rock types (such as the Venado sandstone) is an acceptable practice if the rock is the best quality available within the project area. “Softer” or “weaker” rock types have been used successfully in many existing dams provided that conservative estimates of engineering properties are selected for design. It should be noted that the available types of material should dictate the selected dam section. Design requirements should not dictate material criteria for major embankment zones, only for zones with specific design requirements (such as filters and drains).

Physical properties, strength, and quality testing confirm the observation that the moderately weathered sandstone is a lower quality rock than the fresh sandstone. Dam design criteria generally dictate use of the best quality rock available on site for rockfill and riprap materials. To meet this requirement, it is assumed that only fresh sandstone will be used for riprap and clean rockfill materials, and weathered sandstone will be used for random rockfill material in preparing the feasibility level embankment design and cost estimates. Moderately weathered sandstone may, in fact, be suitable for clean rockfill materials. Use of weathered sandstone for rockfill materials should be investigated further in future design studies.

Although not discussed in the report, drill cores from the geologic exploration program found a north trending unit of conglomerate within the Sites Reservoir area near the proposed saddle dam sites. Preliminary review of the drill cores indicates the conglomerate may be suitable as rockfill for the saddle dams. Compressive strength tests performed towards the end of this investigation on samples from Hole No. SSD 6-1 indicate average dry and saturated compressive strengths of 5,761 psi and 3,058 psi respectively. Detailed test results are included in Appendix P. Future design investigations should include a comprehensive study of the conglomerate to determine its suitability as a rockfill source.

7.0 RANDOM MATERIALS

7.1 Introduction

Random embankment materials will be comprised of materials unsuitable for use as clean rockfill and generally do not meet the hydraulic conductivity and erosion resistant properties required for rockfill materials. These random materials would consist of weathered sandstone, sandstone with interbedded mudstone, mudstone, slopewash, colluvium, etc. from excavations for the dam foundations, appurtenant structures, and the rockfill quarries. Available quantities of random material in the project area exceed estimated quantities of 1 million cubic yards and 3 million cubic yards for Sites and Golden Gate dams, respectively. In addition, sufficient quantities of random type materials are available for construction of the saddle dams.

It is anticipated that two general types of random materials will be generated during construction depending upon the source of the material. One type of random material will be comprised of predominately weathered sandstone from the Cortina Formation. This material will be comprised of weathered sandstone, sandstone interbedded with mudstone, and fines generated during quarry excavation and processing operation for clean rockfill and riprap materials. This type of random material will also incorporate material generated during dam foundation and structure excavations in the Cortina Formation. It is anticipated that this material will be characterized as semi-pervious and generally be classified as a gravel with sand and cobbles.

The other type of random material will be comprised of predominantly mudstone generated during dam foundation and structure excavation, and from borrow excavation in the Boxer Formation. Since the mudstone is a low strength rock and tends to fall apart when exposed to air and water, this material will likely break down into a “soil like” material during excavation and compaction operations. In comparison to the random material generated from the Cortina Formation, this random material will generally have a higher fines content, smaller maximum particle size, and a lower shear strength. It is anticipated that this material will be characterized as semi-impervious to impervious and generally be classified as a silty or clayey sand with gravel. This estimation was confirmed by after compaction classification gradation tests performed on mudstone obtained from Drill Cores SSD 5-3, SSD 8-1, and SSD 8-3 (Appendix Q).

Since random materials are generally not used in areas of dam embankments that would require engineering properties such as hydraulic conductivity, erosion resistance, etc., the emphasis of this investigation is to provide an estimate of the shear strength and compacted densities for use in the feasibility level stability analysis. The engineering properties of the random materials were estimated by performing limited laboratory testing combined with a review and comparison to published data.

7.2 Compressive Strength

Compressive strength testing was performed on samples of moderately weathered sandstone and mudstone to provide an estimate of the strength of the random materials. Compressive strength testing was performed on:

- 6-inch diameter x 12-inch long core samples of weathered sandstone from Sites Quarry
- 2.5-inch diameter drill cores of mudstone from geologic exploration

Testing was performed in accordance with Elastic Moduli of Intact Rock Core Specimens in Uniaxial Compression (ASTM D 3148). Test results for the mudstone samples are presented in Table 26, and test results for the moderately weathered sandstone samples were presented in the rockfill section.

As shown in Table 26, the mudstone had an average compressive strength of 3,477 psi. The compressive strengths ranged from a low of 1,180 psi to a high of 5,390 psi. It should be pointed out that the compressive strength testing was primarily performed on samples obtained at depth, since near surface samples tended to expand and break apart and were not suitable for testing. Furthermore, mudstone samples were also tested dry since saturated samples fell apart and could not be tested. The compressive strength of 1,180 psi corresponds to the only sample tested near the surface and is an indicator that materials comprised of mudstone from dam foundation and structure excavation will be low strength. Additionally, the propensity of the mudstone to fall apart when exposed to air and water indicates that it will likely breakdown into a soil like material during excavation and compaction operations. Detailed test results are included for reference in Appendix M.

Table 26 – Compressive Strength Test Results for Dry Mudstone
(2.5-Inch Diameter Drill Cores from Geologic Exploration)

Bryte Lab Code	Drill Hole	Start Depth (ft)	End Depth (ft)	Compressive Strength (psi)
1999C-87	GGLC-1	23.2	23.8	1,180
2001-32A	GGC-RC2	140.1	141.3	3,980
2001-35A	GGC-RA1	146.3	147.5	2,184
2001-40C	SSD9-1	120.4	121.4	5,238
2001-55A	GGO-DHT1	155.7	156.7	3,170
2001-59D	GGO-DHT4	115.5	116.7	2,816
2001-63A	GGO-DHT6	556.3	557.3	3,856
1999C-89	GGLC-1	199.5	200.3	5,390
			Average =	3,477

For comparison purposes, Table 27 presents the average compressive strengths for the mudstone samples obtained from geologic exploration and the weathered sandstone samples obtained from Sites Quarry.

Table 27 – Average Compressive Strengths for Mudstone and Weathered Sandstone

Material	Source	Moisture Condition	Compressive Strength (psi)
Mudstone	2.5-Inch Diameter Drill Cores from Geologic Exploration	Dry	3,477
Weathered Sandstone	6-Inch Diameter x 12-Inch Long Cores from Sites Quarry	Dry	4,998

7.3 Rock Strength Classification

Based upon the average compressive strength results for the dry materials, the mudstone and moderately weathered sandstone would be classified as follows, according to the Leps and Deere scales previously presented in Figure 23:

- Mudstone
  - Leps = Average Strength
  - Deere = Very Low Strength

- Weathered Sandstone
  - Leps = Average Strength
  - Deere = Low Strength

7.4 Shear Strength

Material Comprised of Predominantly Weathered Sandstone (Cortina Formation)

Shear strength parameters for the random material comprised of predominately weathered sandstone were estimated using an approach similar to that detailed in Section 6.5. Figure 36 repeats the comparison of dry unconfined compressive strength to friction angles for the rockfill materials presented in Table 23 at a confining stress equivalent to the average stress level estimated to occur on deep sliding surfaces within the proposed dam embankments (40 psi). As shown in Figure 36, the average dry unconfined compressive strength of the weathered Venado sandstone of 4,998 psi indicates friction angles of 40.0° and 41.5° for the triaxial and plane strain conditions, respectively.

Similar to the approach discussed in Section 6.5, the recommended shear strength of the random material comprised predominantly of weathered sandstone was estimated by adopting the friction angle corresponding to plane strain conditions and reducing this value slightly as a conservative measure. Using this approach, the recommended shear strength for use in the feasibility level stability analysis is: Friction Angle (ϕ') = 40º.

Figure 37 repeats the supplemental comparison between compressive strength and friction angle for rockfill materials used in embankment dams for data presented in ICOLD Bulletin 92. As shown, the trendline through the rockfill data, coupled with the average compressive strength of the moderately weathered sandstone of 4,998 psi, indicates a friction angle of 38.5^{o}. This figure indicates a comparable shear strength for the weathered sandstone and confirms that the recommended shear strength is an appropriate selection. Another confirmation that the recommended shear strength is an appropriate selection is a direct comparison to Leps' "Rockfill Shearing Strength" chart included in Appendix J. According to Leps' chart, a rockfill material with low density, poorly graded, weak particles would have a friction angle of approximately 39^{o} for the confining stress level under consideration.

Material Comprised of Predominantly Mudstone (Boxer Formation)

Since it is anticipated that random material comprised of predominately mudstone will be characterized as a "soil like" material after excavation and compaction operations, estimation of the shear strength using a comparison to published data for rockfill materials is not appropriate. Therefore, shear strength parameters for this type of random material were estimated from published soil data corresponding to the anticipated classification of the in-place material after excavation and compaction operations. As discussed previously, it is anticipated that this material will generally be classified as a silty or clayey sand with gravel. Based upon a review of published data for this type of material, the recommended shear strength parameters for use in the feasibility level stability analysis are: Total Friction Angle (ϕ) = 15º; Total Cohesion (C) = 600 psf; Effective Friction Angle (ϕ') = 35^{o}; and Effective Cohesion (C') = 0 psf.

These recommended shear strength parameters represent adoption of the average shear strength parameters for SC and SM materials presented in a DWR shear strength study (1976). Published data from this study is included for reference in Appendix N.

7.5 Density

Since test results indicate the mudstone and Venado sandstone have similar specific gravities, in-place densities of the random materials are assumed to be equivalent to the rockfill densities, previously estimated in section 6.6. Recommended dry, moist, and saturated densities for the random materials are 116 pcf, 122 pcf, and 136 pcf, respectively.

7.6 Conclusions and Recommendations

Random embankment materials will be comprised of materials that are essentially unsuitable for use as clean rockfill. The random materials will include weathered sandstone, mudstone, slopewash, colluvium, and other materials from excavations for the dam foundations, appurtenant structures, and the rockfill quarries and designated borrow areas for construction of the saddle dams. Since random materials are generally used in portions of the dam embankment where hydraulic conductivity and erosion resistant properties are not a consideration, random materials do not require a comprehensive evaluation of engineering properties. As such, only shear strength and density were investigated as part of this feasibility investigation.

Sufficient quantities of random material are available within or near the proposed Sites Reservoir project area. These materials will be generated from required excavation and designated borrow-areas for construction of the saddle dams. Future design investigations should include a thorough evaluation, as part of the constructability review, to identify and quantify the type of random materials generated from required excavation. The dam embankment section should be developed to incorporate these random materials to the maximum extent possible to minimize generation of waste material.

Further studies, including the preliminary design program, should include additional testing and evaluation of the random materials. Specifically, these investigations should include a comprehensive evaluation of the composition (percent weathered sandstone, mudstone, etc.) and gradation of the random materials that are likely to be generated from required excavation at each of the dam sites. This evaluation should include construction of test fills to assist development of the specification requirements. In addition, compaction, hydraulic conductivity (if necessary), shrink/swell, and triaxial testing of the anticipated random materials should be performed to further refine the engineering properties for use in design of the dam embankments.

With specific regard to the Boxer Formation, excavated random material should be explored and laboratory tested to determine engineering properties, especially for the Sites Dam and saddle dams. In further studies, this material should be tested as a soil type material.

8.0 FILTER, DRAIN, AND TRANSITION MATERIAL

8.1 Introduction

The fresh Venado sandstone may be suitable for use as filter, drain, and transition materials. Visual observation of crushed samples for concrete aggregate testing and the aggregate quality test results indicate that the Venado sandstone may have sufficient strength and durability for use as filter, drain, and transition materials. Use of the Venado sandstone for these materials will require extensive evaluation of particle breakage characteristics during quarry, transport, placement, and compaction operations to ensure the materials meet design hydraulic conductivity and in-place gradation requirements. This particle breakage evaluation will require test quarries and fills and is considered beyond the scope of this feasibility level investigation.

Since the suitability of the sandstone for use as filter, drain, and transition materials can not be confirmed at this level of investigation, the feasibility level cost estimates should include the conservative assumption that these materials will be imported from the closest sand and gravel source identified in the geologic exploration program. This sand and gravel source was identified as an old abandoned channel on Stony Creek located approximately 35 road miles away, between Orland and Willows (Figure 38). An estimated 160 million cubic yards of material exist, which far exceed the construction requirements for the proposed structures.

8.2 Shear Strength

Shear strength parameters for the filter, drain, and transition material were estimated from published data. Specifically, the friction angle was derived from a plot of relative density verses friction angle found in USBR's Earth Manual. This plot is included as Figure 39. In this figure, the trendline corresponding to the No. 3 material (35% gravel, ¾-inch maximum size) was selected as representative of the proposed filter, drain, and transition materials. This material was selected because it is considered to be representative of an average gradation for the filter, drain, and transition materials. Assuming a relative density of 90% for compacted in-place filter, drain, and transition materials, Figure 39 indicates a friction angle for the No. 3 material of approximately 42°. Accordingly, the recommended shear strength for use in the feasibility level stability analysis is: Friction Angle (ϕ') = 42°.

8.3 Density

In-place compacted densities for the filter, drain, and transition materials were estimated in much the same way as the rockfill material. Assuming a water content of 5%, a relative density of 90% for in-place materials, and using the data published by Becker et al (1972), dry, moist, and saturated densities were estimated at 115 pcf, 121 pcf, and 135 pcf, respectively. The aforementioned published data is included in Appendix K as previously noted in the rockfill section.

8.4 Conclusions and Recommendations

Testing and evaluation of the fresh Venado sandstone presented in the rockfill and concrete aggregate sections indicate that it may be of sufficient quality for filter, drain, and transition materials. Since the quality of the sandstone for use as these materials cannot be confirmed without an extensive testing and evaluation program, feasibility level cost estimates should include the conservative assumption that material will be imported from the closest sand and gravel source identified in the geologic exploration program. This source was identified as an abandoned channel on Stony Creek, approximately 35 road miles from the project site, with an estimated sand and gravel quantity of roughly 160 million cubic yards. Additional testing and evaluation performed as part of future design studies should also include an economic comparison between importing and producing filter, drain, and transition materials to ensure selection of the most economical material source. This comparison should include a detailed examination of the costs required to produce clean filter, drain, and transition materials from the Venado sandstone, particularly related to separating the interbedded mudstone and weathered sandstone during excavation and processing operations.

Preliminary and final design programs should include placement and compaction of test fills constructed of quarried and processed sandstone materials, with gradations approximating anticipated ranges for filter, drain, and transition materials. This would allow the evaluation of whether the sandstone has sufficient strength and durability characteristics for use as filter, drain, and transition material. The evaluation should focus on the propensity of particle breakdown, which would adversely affect the hydraulic conductivity of the material.

9.0 CONCRETE AGGREGATE

9.1 Introduction

Sufficient deposits of sands and gravels for construction of the proposed project facilities are not available within the project area. Therefore, the emphasis of this program was to evaluate the suitability of crushed Venado sandstone for use as concrete aggregate.

Alternative sand and gravel sources were also identified as part of the geologic exploration program. The closest imported source is located about 35 road miles from the project site, between Orland and Willows, on an old abandoned channel of Stony Creek (Figure 38). This borrow source contains an estimated 160 million cubic yards of material, which is considerably greater than quantities required for construction of the proposed project structures.

9.2 Sampling and Testing

Samples for concrete aggregate testing were prepared from 2.5-inch diameter drill cores from geologic exploration and waste cobbles from Sites Quarry. Samples from the latter were segregated into fresh and weathered sandstone lots and then transported to a rock crushing facility. The sandstone was processed until all material passed a 1-inch screen. As a result, two cubic yards each of crushed fresh and weathered Venado sandstone were delivered to Bryte Lab for testing.

The following test procedures were used to evaluate the quality of the sandstone for use as concrete aggregate:

- Specific Gravity and Absorption of Coarse and Fine Aggregates (ASTM C 127 & 128)
- Resistance to Degradation of Small-Size Coarse Aggregates by Abrasion and Impact in the Los Angeles Machine (ASTM C 131).
- Clay Lumps and Friable Particles in Aggregate (ASTM C 142)
- Organic Impurities in Fine Aggregate (ASTM C 40)
- Bulk Density and Voids in Aggregate (ASTM C 29)

Figures 40 and 41 present gradation curves for the fresh and weathered crushed sandstone samples, respectively. The figures include an average gradation curve for each material along with the Caltrans concrete aggregate gradation envelope. As shown, the average fresh and weathered material gradations deviate only slightly from the Caltrans envelope.

9.3 Quality

Tables 28 and 29 present concrete aggregate quality test results for crushed Venado sandstone from the drill cores and Sites Quarry, respectively. Detailed test results are included for reference in Appendix O.

As shown in Table 28, the specific gravity and absorption for the fresh sandstone were 2.48 and 4.2%, respectively for the drill core sample. Additionally, Los Angeles abrasion losses were 11.4% and 43.4% for 100 revolutions and 500 revolutions, respectively.

Table 28 – Concrete Aggregate Quality Test Results for Crushed Venado Sandstone from Drill Cores

Sample Type	Degree of Weathering	Specific Gravity	Absorption (%)	Los Angeles Abrasion (% loss)	
				100 Rev.	500 Rev.
Crushed Sandstone from Drill Cores (1½"-Minus)	Fresh	2.48	4.2	11.4	43.4

As shown in Table 29, the average specific gravity for the fine and coarse fresh samples were 2.58 and 2.48, respectively, while corresponding weathered samples were 2.57 and 2.46. Average absorption for the fine and coarse fresh samples were 2.4% and 5.7%, respectively, while corresponding weathered samples were 2.7% and 6.3%. Los Angeles Abrasion losses for the fresh samples were 10.1% and 45.7% for 100 revolutions and 500 revolutions, respectively, while corresponding losses for the weathered samples were 11.8% and 51.3%.

Average percentage of clay lumps and friable particles for the fine and coarse fresh samples were 3.2% and 0.6%, respectively, while corresponding averages for the weathered samples were 5.1% and 1.2%. The average standard colors for the organic impurities for the “as received” and “washed – fines removed” fresh samples were both “clear.” Corresponding averages for the weathered samples were 3 and “clear.” The average bulk densities for the fresh and weathered samples were 88.5 pcf and 86.7 pcf, respectively.

Table 29 – Concrete Aggregate Quality Test Results for Crushed Venado Sandstone from Sites Quarry

Table 29A

Sample No.	Degree of Weathering	Specific Gravity		Absorption (%)		Los Angeles Abrasion (% loss)	
		Fine	Coarse	Fine	Coarse	100 Rev.	500 Rev.
99C-113-A	Fresh	2.57	2.48	2.4	5.6	11.4	50.8
99C-113-B		2.58	2.49	2.3	5.7	7.3	36.9
99C-113-C		2.58	2.48	2.5	5.8	11.5	49.5
99C-114-A	Weathered	2.56	2.46	2.7	6.4	13.7	56.0
99C-114-B		2.57	2.47	2.7	6.3	9.2	43.5
99C-114-C		2.57	2.46	2.7	6.3	12.5	54.5
Average for Fresh Samples =		2.58	2.48	2.4	5.7	10.1	45.7
Average for Weathered Samples =		2.57	2.46	2.7	6.3	11.8	51.3

Table 29B

Sample No.	Degree of Weathering	Clay Lumps and Friable Particles (%)		Organic Impurities (standard color)		Bulk Density and Voids (pcf)
		Fine	Coarse	As Rec'd	Washed	
99C-113-A	Fresh	6.5	1.55	clear	clear	88.3
99C-113-B		1.7	0.15	clear	clear	88.7
99C-113-C		1.3	0.15	clear	clear	88.6
99C-114-A	Weathered	8.6	2.50	2	clear	86.2
99C-114-B		3.0	0.30	3	clear	86.4
99C-114-C		3.7	0.65	3	clear	87.5
Average for Fresh Samples =		3.2	0.6	clear	clear	88.5
Average for Weathered Samples =		5.1	1.2	3	clear	86.7

Table 30 presents the average results from the concrete aggregate quality testing performed on the crushed Venado sandstone from the drill cores and Sites Quarry. This table also includes acceptable limits criteria adopted from USBR's Concrete Manual and ASTM's Test Designation C33, Standard Specification for Concrete Aggregates, for comparison and discussion purposes. As shown, average test results for both the fresh and moderately weathered samples of Venado sandstone were slightly out of the acceptable limits criteria used by USBR and ASTM. However, these test results also indicate that the crushed sandstone is generally within the range of typical values presented in ACI's Manual of Concrete Practice.

Table 30 - Average Concrete Aggregate Quality Test Results for the Venado Sandstone

Sample Type	Degree of Weathering	Number of Tests	ASTM Test Procedures										
			Specific Gravity C 127		Absorption C 127 (%)		Los Angeles Abrasion C 131		Clay Lumps and Friable Particles C 142 (%)		Organic Impurities C 40 (standard color)		Bulk Density and Voids C 29 (pcf)
			Fine	Coarse	Fine	Coarse	100 Rev. (% loss)	500 Rev. (% loss)	Fine	Coarse	As Rec.	Wash	
Crushed Sandstone from Drill Cores (1½-Inch Minus)	Fresh	1	-	2.5	-	4.2	11.4	43.4	-	-	-	-	-
Crushed Sandstone from Sites Quarry (1½-Inch Minus)	Fresh	3	2.6	2.5	2.4	5.7	10.1	45.7	3.2	0.6	Clear	Clear	89
	Moderately Weathered	3	2.6	2.5	2.7	6.3	11.8	51.3	5.1	1.2	3	Clear	87
Acceptable Limits*			**Should be >2.6**		**Not Specified**		**Should be <10%**	**Should be <40 to 50%**	**Should be <5%**		**Not Specified**		**Not Specified**
ACI Range of Typical Values for Aggregates**			**1.6 to 3.2**		**0.2 to 4.0%**		**Not Specified**	**15 to 50%**	**0.5 to 2%**		**Color 3 or less**		**75 to 110 pcf**

* Acceptable limits criteria adopted from USBR, Concrete Manual, Eighth Edition, 1988; ASTM, Designation C 33, Standard Specification for Concrete Aggregates, 2001; and Waddle, Concrete Construction Handbook, Third Edition, 1993.

** From Guide for Use of Normal Weight Aggregates in Concrete, American Concrete Institute.

9.4 Conclusions and Recommendations

Based upon the test results, the crushed sandstone is considered to marginally meet the criteria for concrete aggregate. However, since the current testing program indicates the sandstone quality is marginal, its suitability for concrete aggregate will require additional testing and evaluation (such as test batches), which is considered beyond the scope of this feasibility investigation.

Since the suitability of the sandstone for use as concrete aggregate can not be confirmed at this level of investigation, the feasibility level cost estimates should include the conservative assumption that aggregates will be imported from the closest sand and gravel source identified in the geologic exploration program. This source was identified as an abandoned channel on Stony Creek, approximately 35 road miles from the project site, with an estimated sand and gravel quantity of roughly 160 million cubic yards. Additional testing and evaluation performed as part of future design studies should also include an economic comparison between importing and producing on-site aggregates to ensure selection of the most economical material source. This comparison should include a detailed examination of the costs required to produce clean concrete aggregate from the Venado sandstone, particularly related to separating the interbedded mudstone and weathered sandstone during excavation and processing operations.

10.0 FINAL CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The construction materials investigation program identified the types of available on-site materials, examined their potential uses, and performed limited testing and evaluation of those materials to determine their suitability for use in the dams and appurtenant structures for the proposed Sites Reservoir project. This investigation was guided by the design principle that available on-site materials should dictate the design and selection of the dam sections.

The construction materials investigation program identified the following material types within or near the proposed Sites Reservoir project area:

- Impervious Materials (terrace deposits and recent alluvium)
- Venado Sandstone (fresh and weathered from the Cortina Formation)
- Mudstone (Boxer Formation)

These material types were further investigated, tested, and evaluated to explore their suitability for use as the following types of construction materials:

- Impervious Materials
- Rockfill and Riprap Materials
- Random Materials
- Filter, Drain, and Transition Materials
- Concrete Aggregate

Materials testing and evaluation indicate the impervious materials available within the project area are suitable as core material for use in embankment dams. Sufficient quantities of impervious material exist upstream of the dam sites. Approximately 36 million cubic yards of material are available from the deposits within the reservoir area. This is roughly four times the volume required for construction of Golden Gate Dam, Sites Dam, and the nine saddle dams. Additional impervious materials are also available within the required excavation areas for the appurtenant structures and Funks Reservoir enlargement.

Material testing and evaluation indicate the fresh sandstone is of sufficient quality for use as clean rockfill and riprap materials. Sufficient quantities of Venado sandstone can be obtained from quarries developed near the dam sites.

Although use of the highest quality rock meeting laboratory test requirements for concrete aggregates is desirable, use of “softer” rock types (such as the Venado sandstone) is an acceptable practice if the rock is the best quality available within the project area. “Softer” or “weaker” rock types have been used successfully in many existing dams provided that conservative estimates of engineering properties are selected for design. It should be noted that the available types of material should dictate the selected dam section. Design requirements should not dictate material criteria for major embankment zones, only for zones with specific design requirements (such as filters and drains).

Physical properties, strength, and durability testing confirm the observation that the moderately weathered sandstone is a lower quality rock than the fresh sandstone. Dam design criteria generally dictate use of the best quality rock available on site for rockfill and riprap materials. To meet this requirement, it is assumed that only fresh sandstone will be used for riprap and clean rockfill materials, and weathered sandstone will be used for random rockfill material in preparing the feasibility level embankment design and cost estimates. Moderately weathered sandstone may, in fact, be suitable for clean rockfill materials.

Random embankment materials will be comprised of materials that are essentially unsuitable for use as rockfill. The random materials will, therefore, include weathered sandstone, mudstone, slopewash, colluvium, and the like. Unlike rockfill, random materials do not require a strict engineering evaluation of properties. As such, only shear strength and density were investigated as part of this feasibility level investigation. A surplus of random material exists within or near the proposed Sites Reservoir project area. Random material will be generated from required excavation and designated borrow areas for construction of the saddle dams.

Fresh Venado sandstone may be suitable for filter, drain, and transition material as well as concrete aggregate, but feasibility level cost estimates should include the conservative assumption that material will be imported from the closest sand and gravel source identified in the geologic exploration program. This source was identified as an abandoned channel on Stony Creek, approximately 35 road miles from the project site, with an estimated sand and gravel quantity of roughly 160 million cubic yards.

10.2 Recommendations

Impervious Materials

Preliminary and final design programs should include further exploration, testing, and evaluation of the impervious materials. Additional testing should include an expanded evaluation of the in-place density, moisture-density relationship, permeability, and shear strength properties due to the limited testing performed as part of this feasibility level investigation. Impervious borrow areas should be selected to minimize the amount of high plasticity lean clays and fat clays. Also, specific borrow areas should be identified and quantified within near vicinity of the dams in conjunction with a constructability review of the project.

Rockfill and Riprap Materials

Future design investigations for the Venado sandstone should include test quarries and fills to develop specification requirements. This will ensure that the Venado sandstone will meet design requirements for clean rockfill material, particularly related to limiting the fines content of in-place material. Future design investigations should also include additional testing and evaluation of the Venado sandstone to further define the engineering properties of the clean rockfill material such as: shear strength, hydraulic conductivity, density, etc.. The suitability of weathered sandstone for use as clean rockfill material should also be investigated in future design studies.

Although not discussed in the report, drill cores from the geologic exploration program found a north trending unit of conglomerate within the proposed Sites Reservoir area near the proposed saddle dam sites. Preliminary review of the drill cores indicates the conglomerate may be suitable as rockfill for the saddle dams. Future design investigations should include a comprehensive study of the conglomerate to determine its suitability as a rockfill source.

Random Materials

Future design investigations should include a thorough evaluation, as part of the constructability review, to identify and quantify the type of random materials generated from required excavation. The dam embankment section should be developed to incorporate these random materials to the maximum extent possible to minimize generation of waste material.

Further studies, including the preliminary design program, should include additional testing and evaluation of the random materials. Specifically, these investigations should include a comprehensive evaluation of the composition (percent weathered sandstone, mudstone, etc.) and gradation of the random materials that are likely to be generated from required excavation at each of the dam sites. This evaluation should include construction of test fills to assist development of the specification requirements. In addition, compaction, hydraulic conductivity (if necessary), shrink/swell, and triaxial testing of the anticipated random materials should be performed to further refine the engineering properties for use in design of the dam embankments.

With specific regard to the Boxer Formation, excavated random material should be explored and laboratory tested to determine engineering properties, especially for the Sites Dam and saddle dams. In further studies, this material should be tested as a soil type material.

Filter, Drain, and Transition Materials

Additional testing and evaluation performed as part of future design studies should also include an economic comparison between importing and producing filter, drain, and transition materials to ensure selection of the most economical material source. This comparison should include a detailed examination of the costs required to produce clean filter, drain, and transition materials from the Venado sandstone, particularly related to separating the interbedded mudstone and weathered sandstone during excavation and processing operations.

Preliminary and final design programs should include placement and compaction of test fills constructed of quarried and processed sandstone materials, with gradations approximating anticipated ranges for filter, drain, and transition materials. This would allow the evaluation of whether the sandstone has sufficient strength and durability characteristics for use as filter, drain, and transition material. The evaluation should focus on the propensity of particle breakdown, which would adversely affect the hydraulic conductivity of the material.

Concrete Aggregate

Since the current testing program indicates the sandstone quality is marginal, its suitability for concrete aggregate will require additional testing and evaluation (such as test batches). Additional testing and evaluation performed as part of future design studies should also include an economic comparison between importing and producing on-site aggregates to ensure selection of the most economical material source. This comparison should include a detailed examination of the costs required to produce clean concrete aggregate from the Venado sandstone, particularly related to separating the interbedded mudstone and weathered sandstone during excavation and processing operations.

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23. Verigin, Bill, “Review Sites Construction Materials Sampling and Testing Report – March 2000,” Memorandum, April 24, 2000

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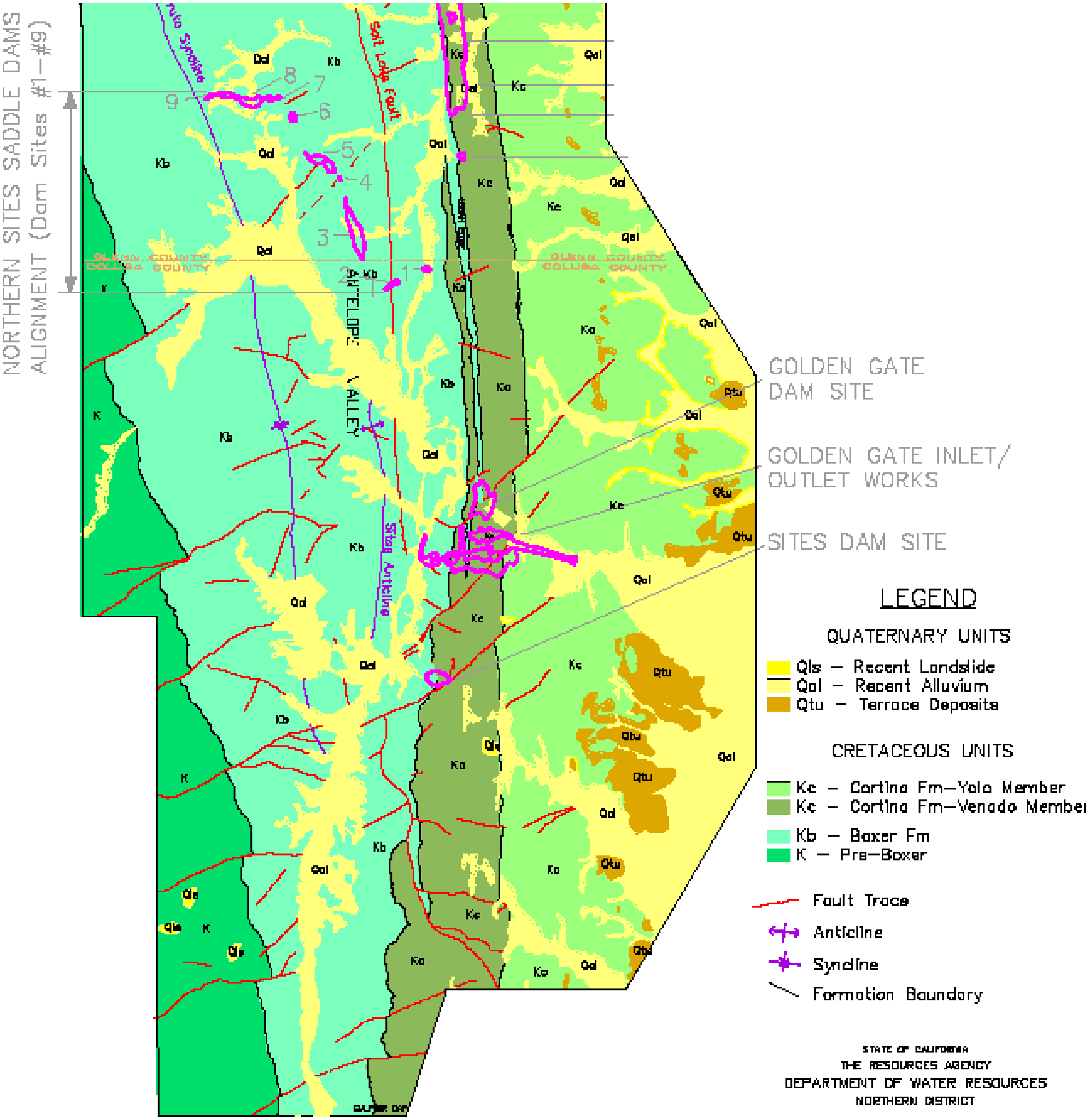
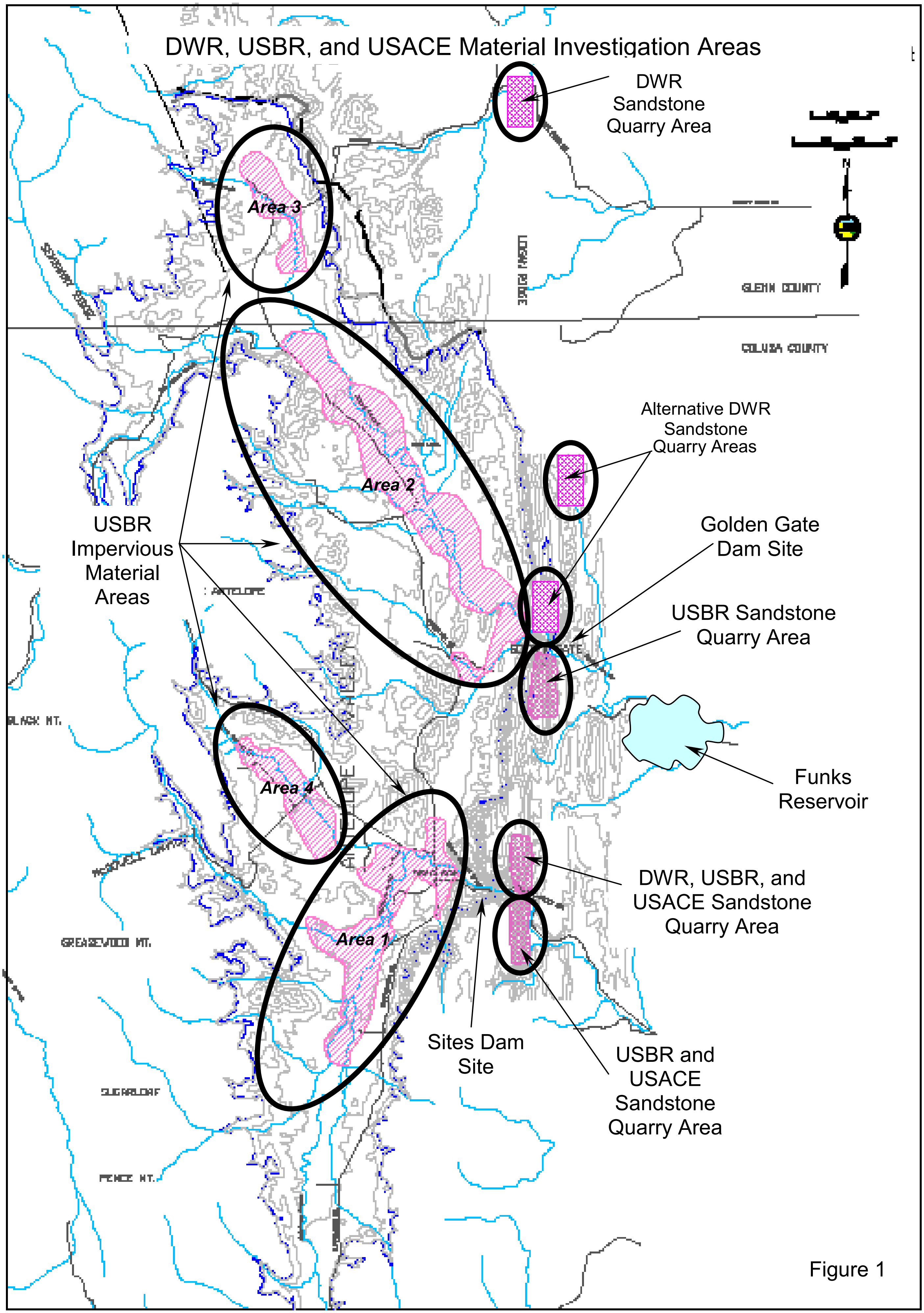
25. Verigin, Bill, Untitled Notes, January 22, 1999

Location and Geologic Map of the Sites Reservoir Project



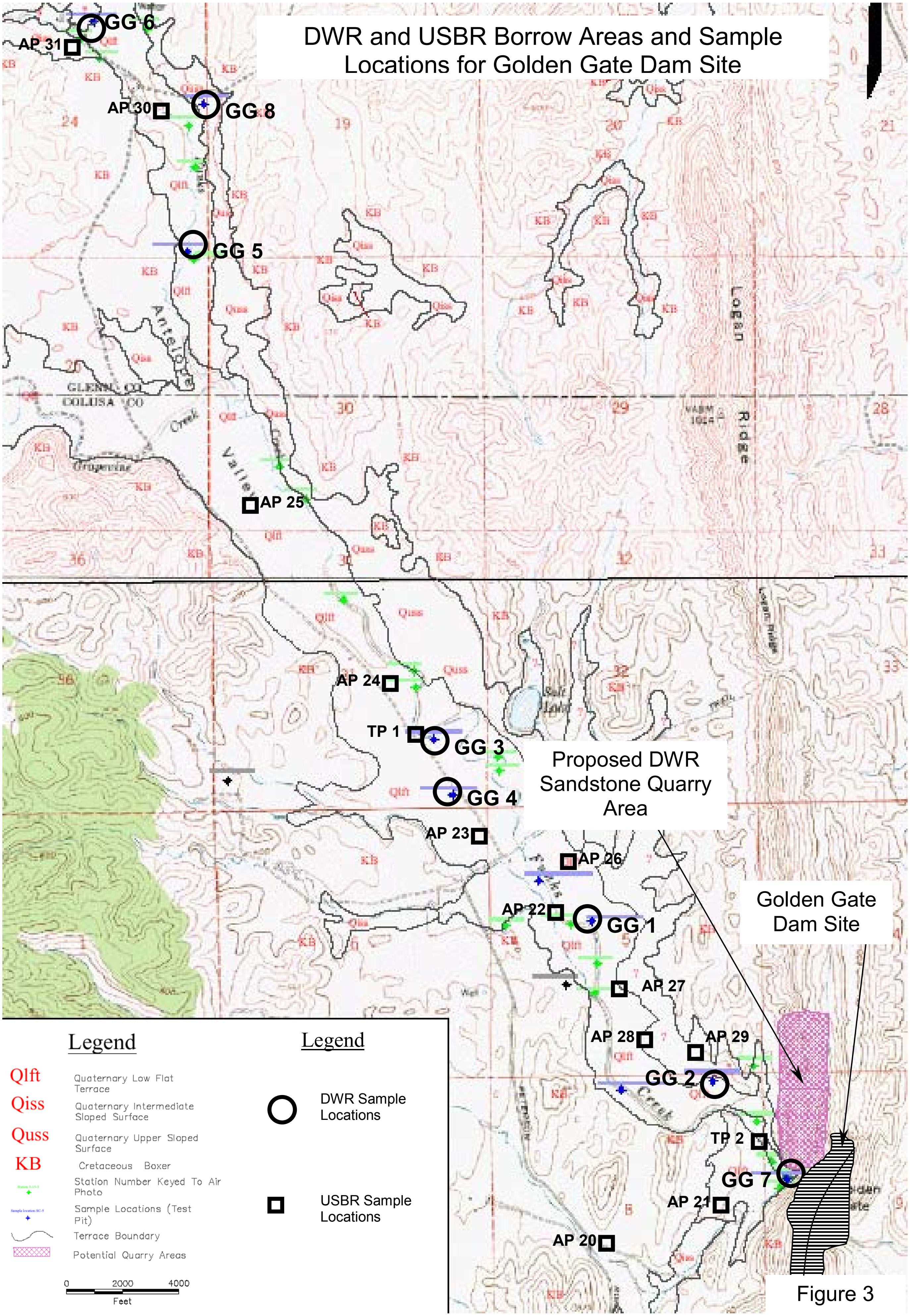
NOTES: Sources of geological data include geologic map interpretation, Brown and Rich (1961), U.S. Geological Survey (1972) and USBR (1983).

Figure 2



DWR, USBR, and USACE Material Investigation Areas

Figure 1



DWR and USBR Borrow Areas and Sample Locations for Golden Gate Dam Site

Figure 3

DWR and USBR Borrow Areas and Sample Locations for Sites Dam Site

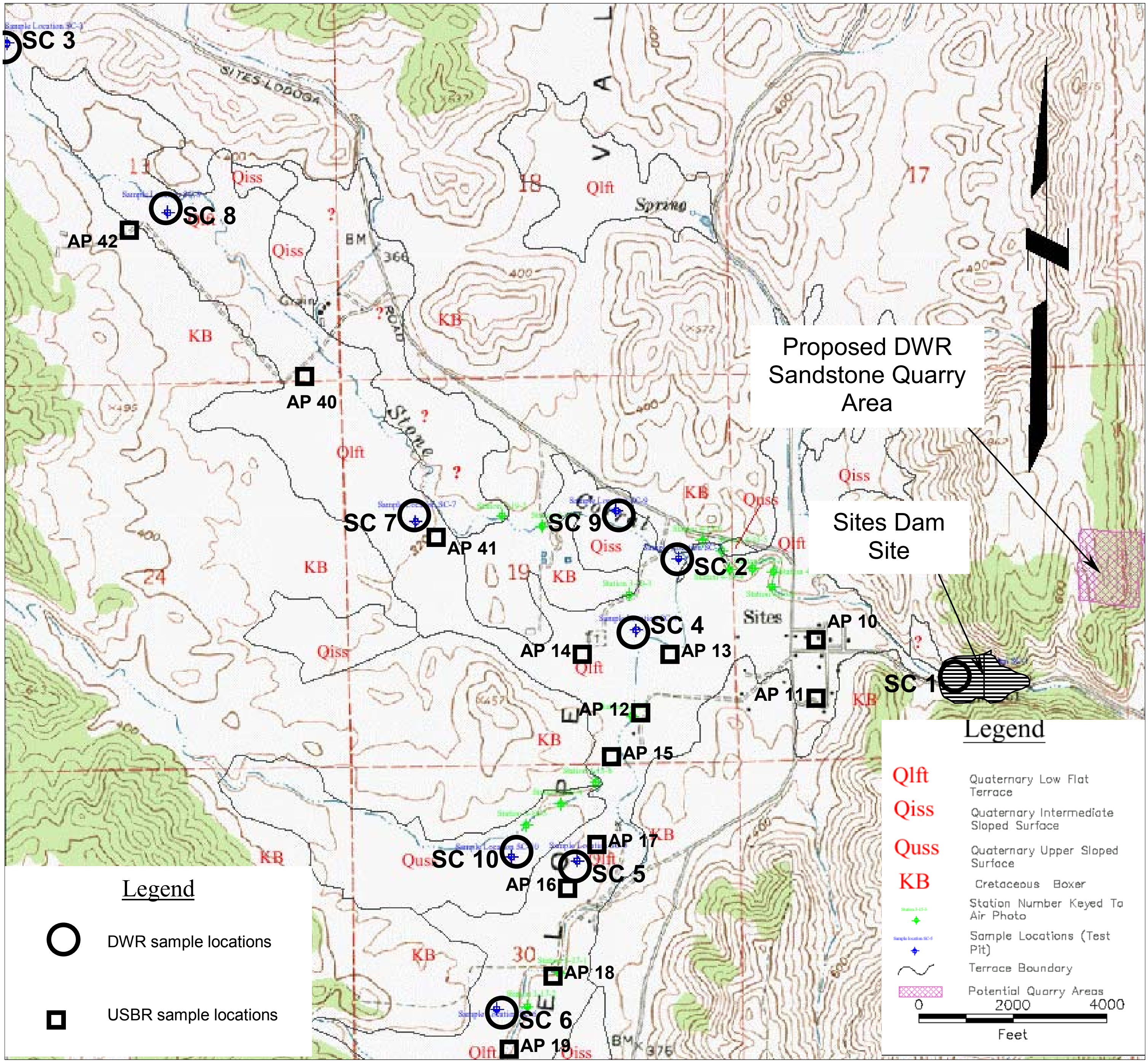


Figure 4

SITES RESERVOIR

Proposed Impervious Material (Golden Gate Samples)

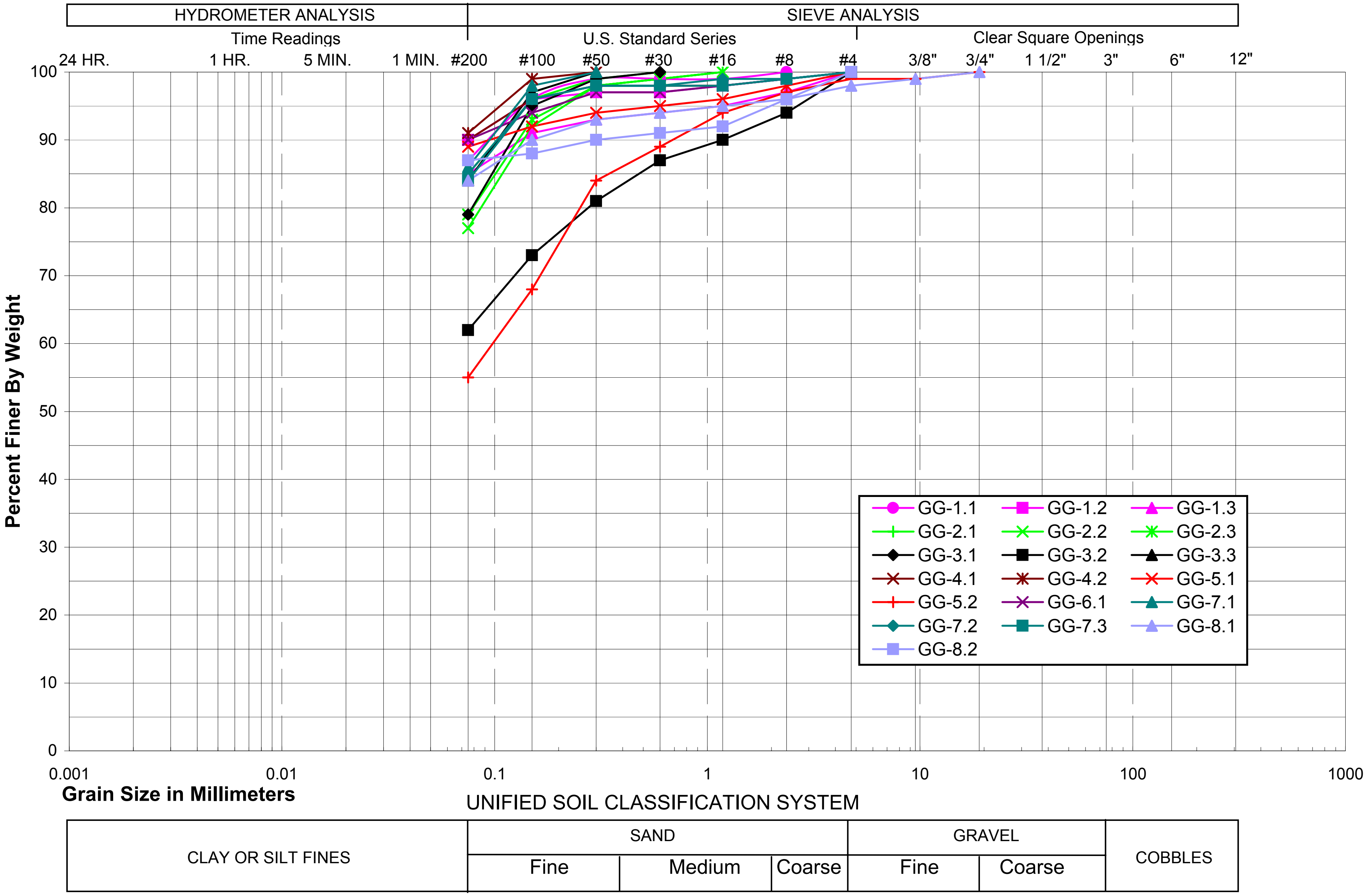


Figure 5

SITES RESERVOIR

Proposed Impervious Material (Sites Samples)

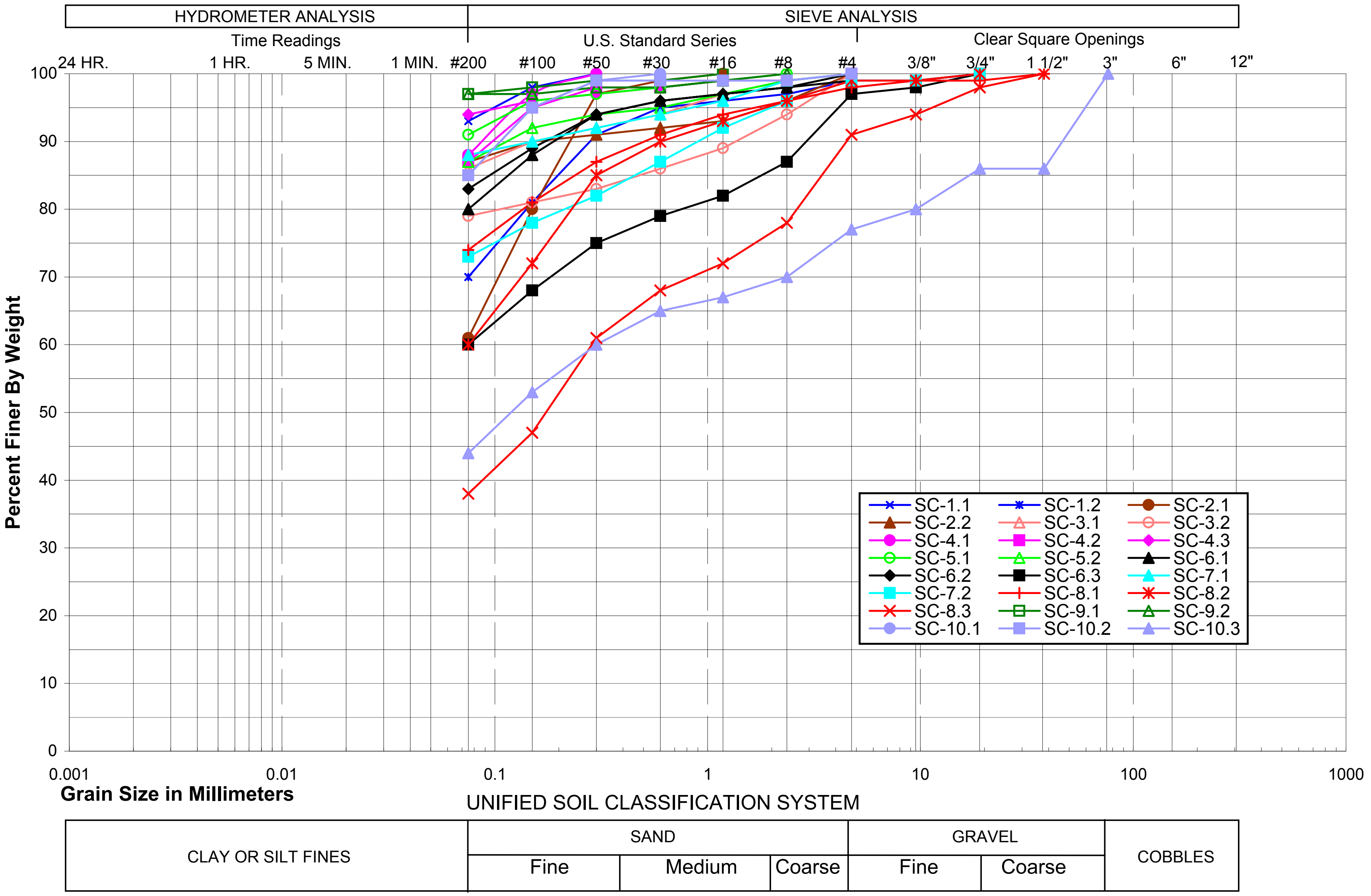


Figure 6

SITES RESERVOIR

Proposed Impervious Material (Funks Reservoir Samples)

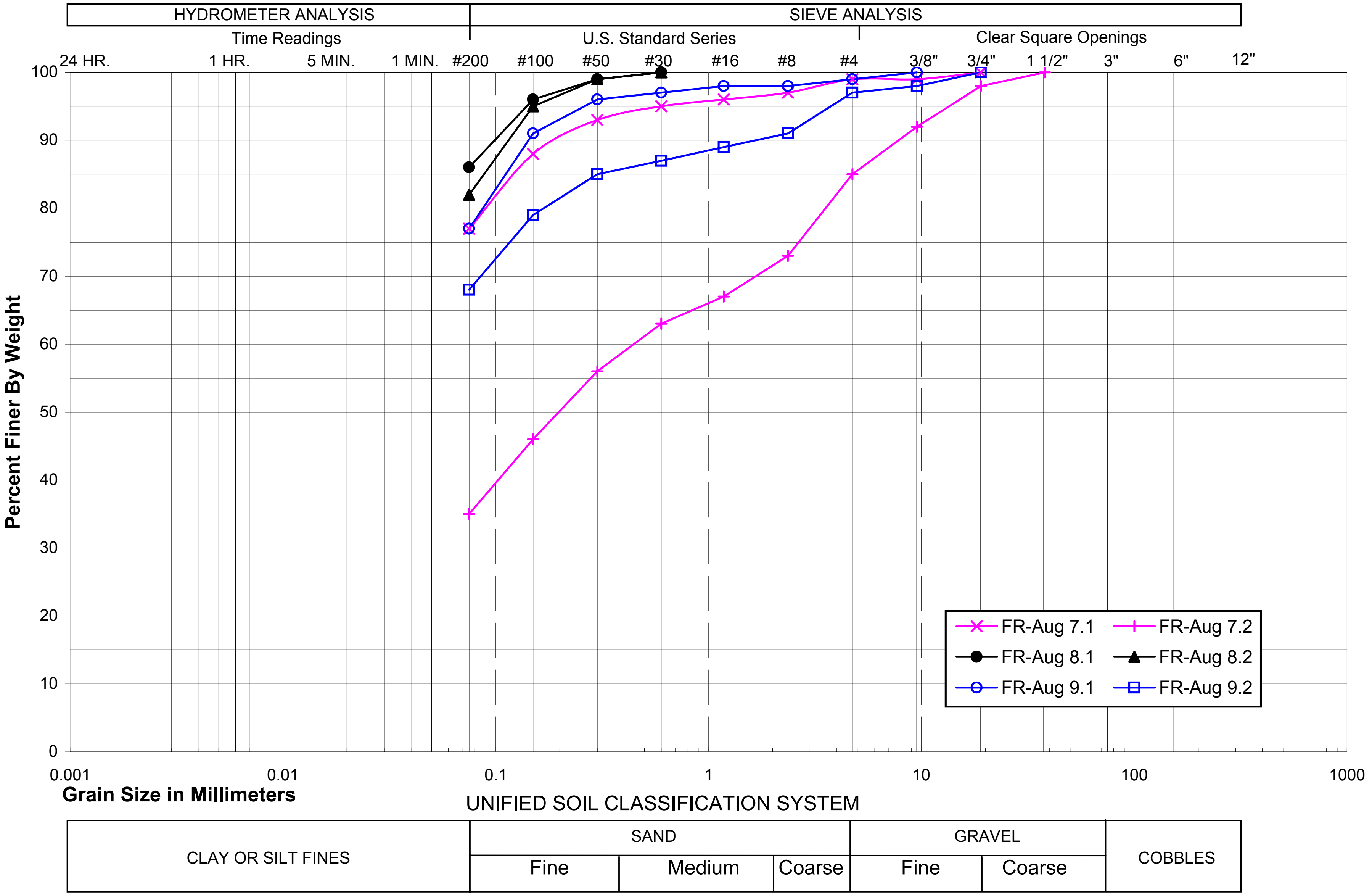


Figure 7

SITES RESERVOIR
PLASTICITY CHART
GOLDEN GATE

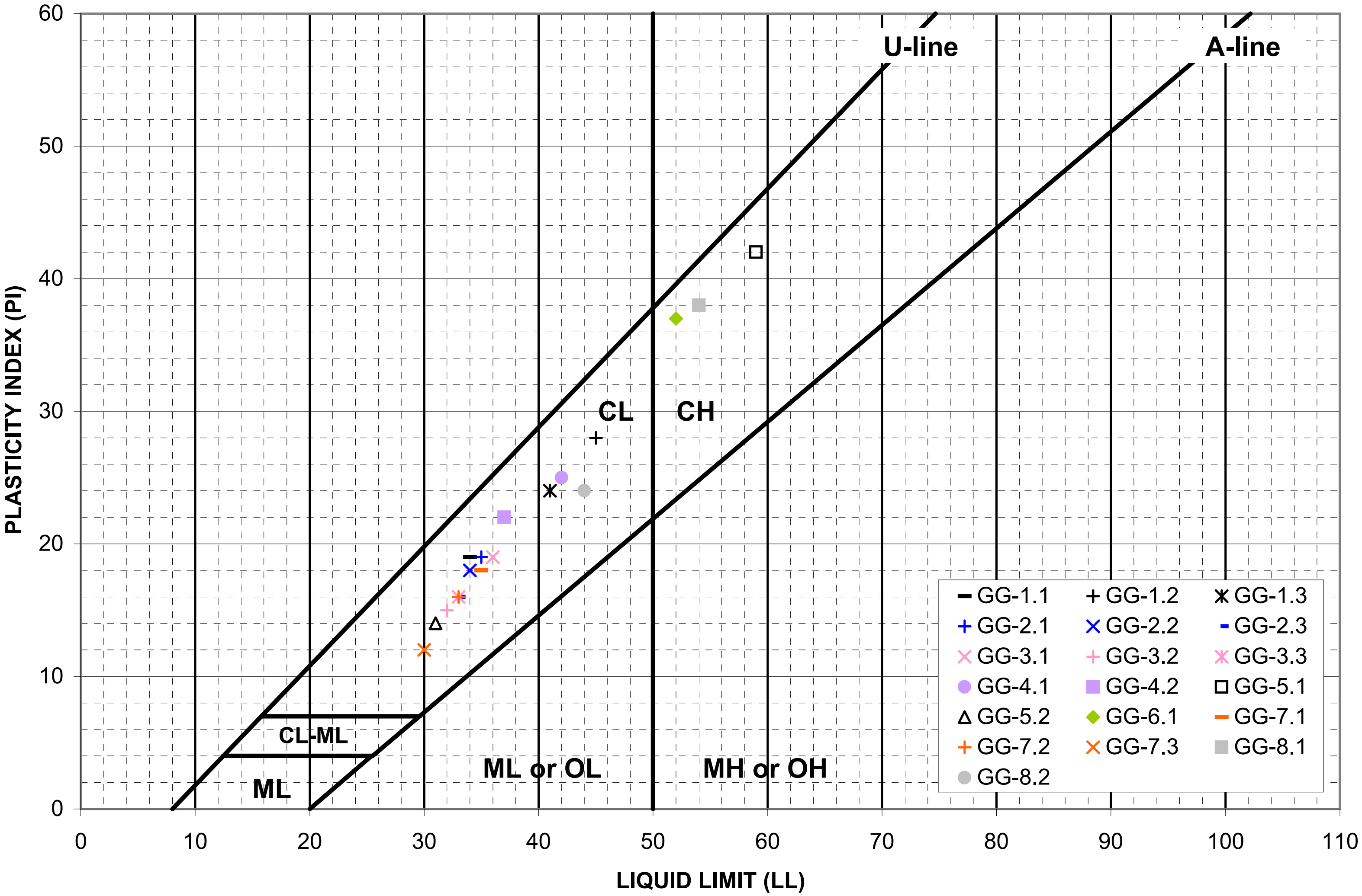


Figure 8

SITES RESERVOIR
PLASTICITY CHART
SITES

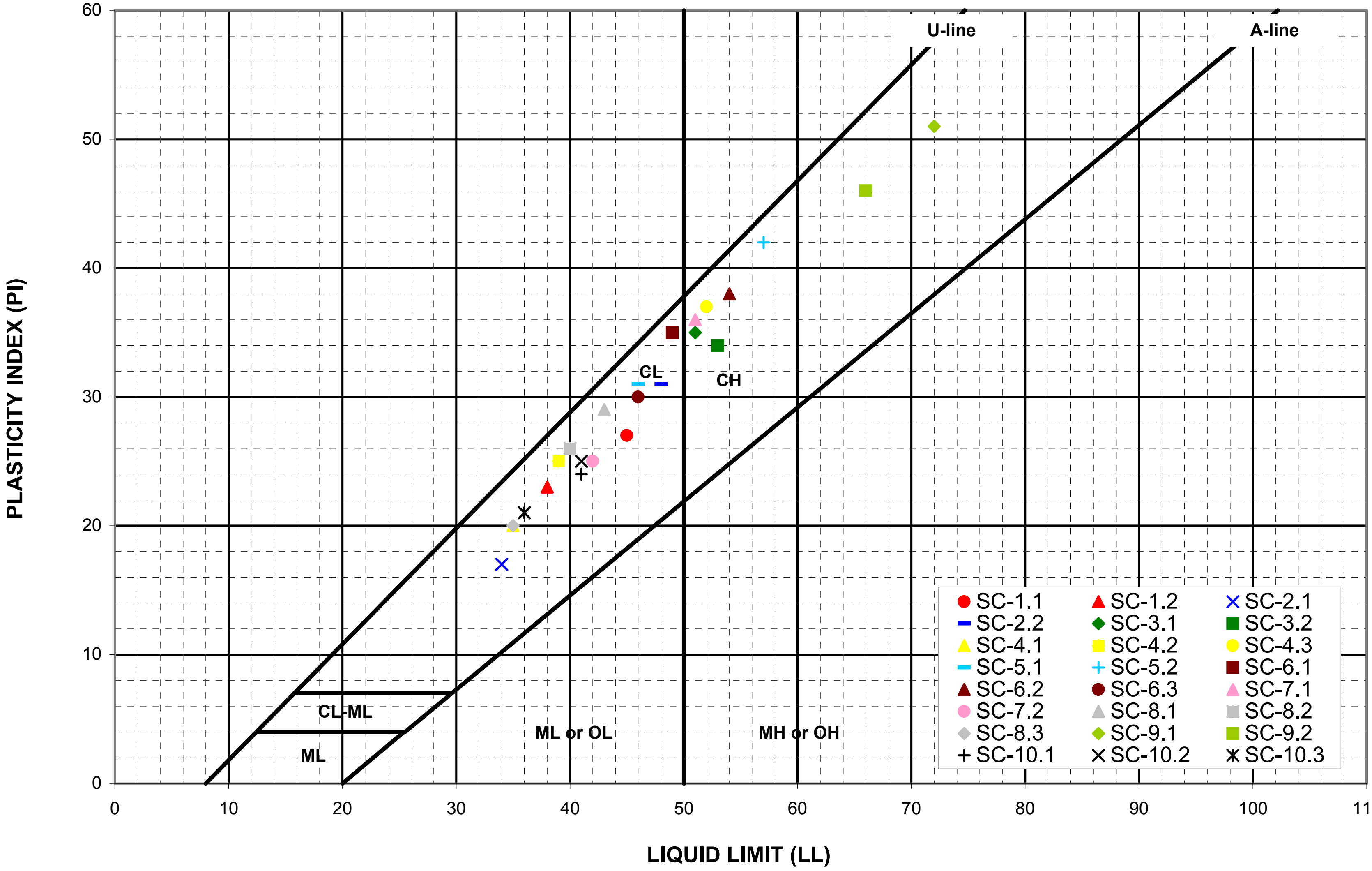


Figure 9

SITES RESERVOIR PROJECT
PLASTICITY CHART
FUNKS RESERVOIR

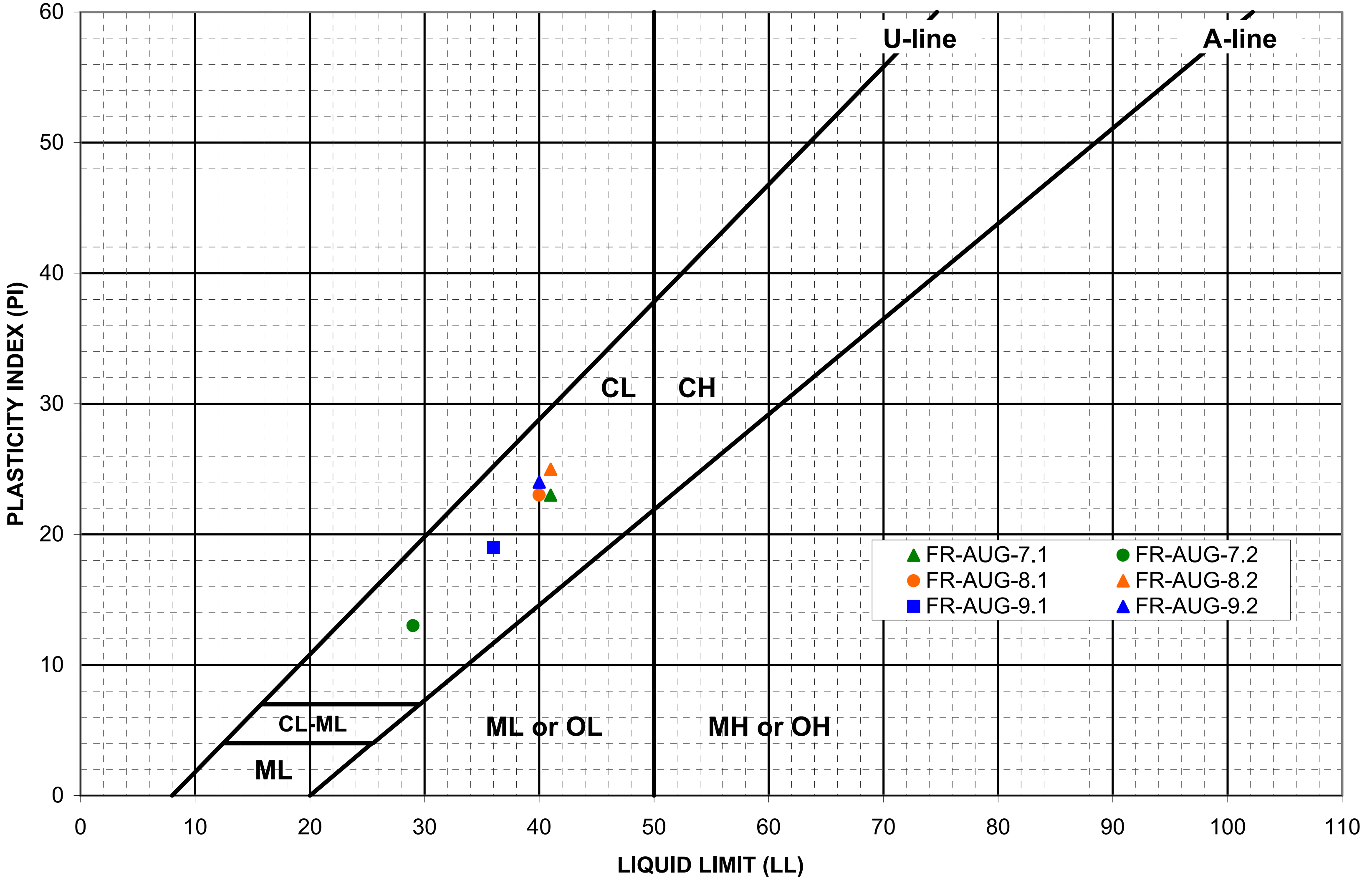
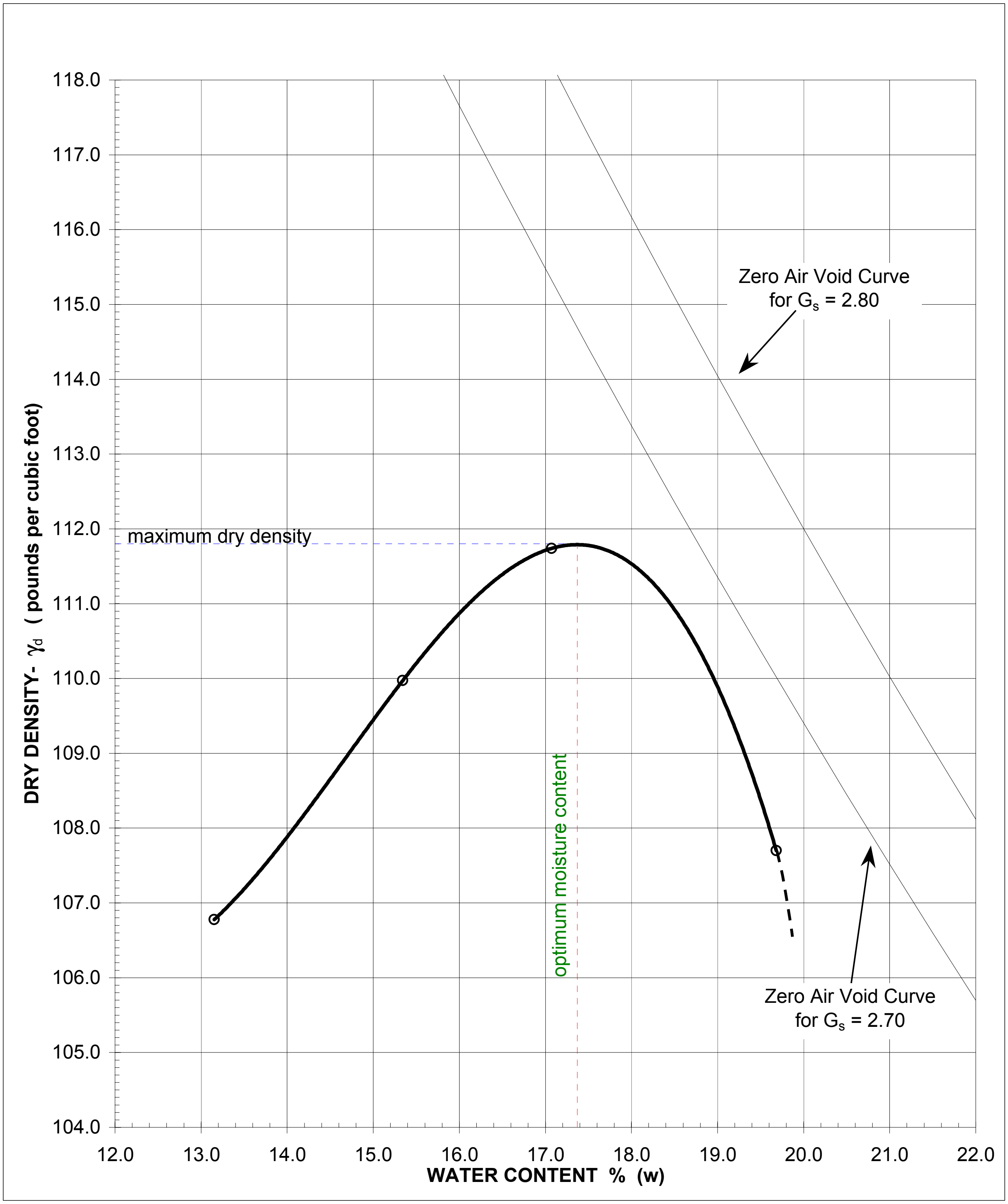


Figure 10

COMPACTION TEST

ASTM D 1557-91 : Laboratory Compaction Characteristics of Soil Modified to DWR Standard



PROJECT: Sites Reservoir - Golden Gate Dam
FEATURE: Composite Sample, Hole GG
HOLE NO. N/A
DEPTH N/A
FIELD SAMPLE NO. N/A

LAB NO. 99-1419
REQUEST NO. 99-51
DATE Sept. 9, 1999

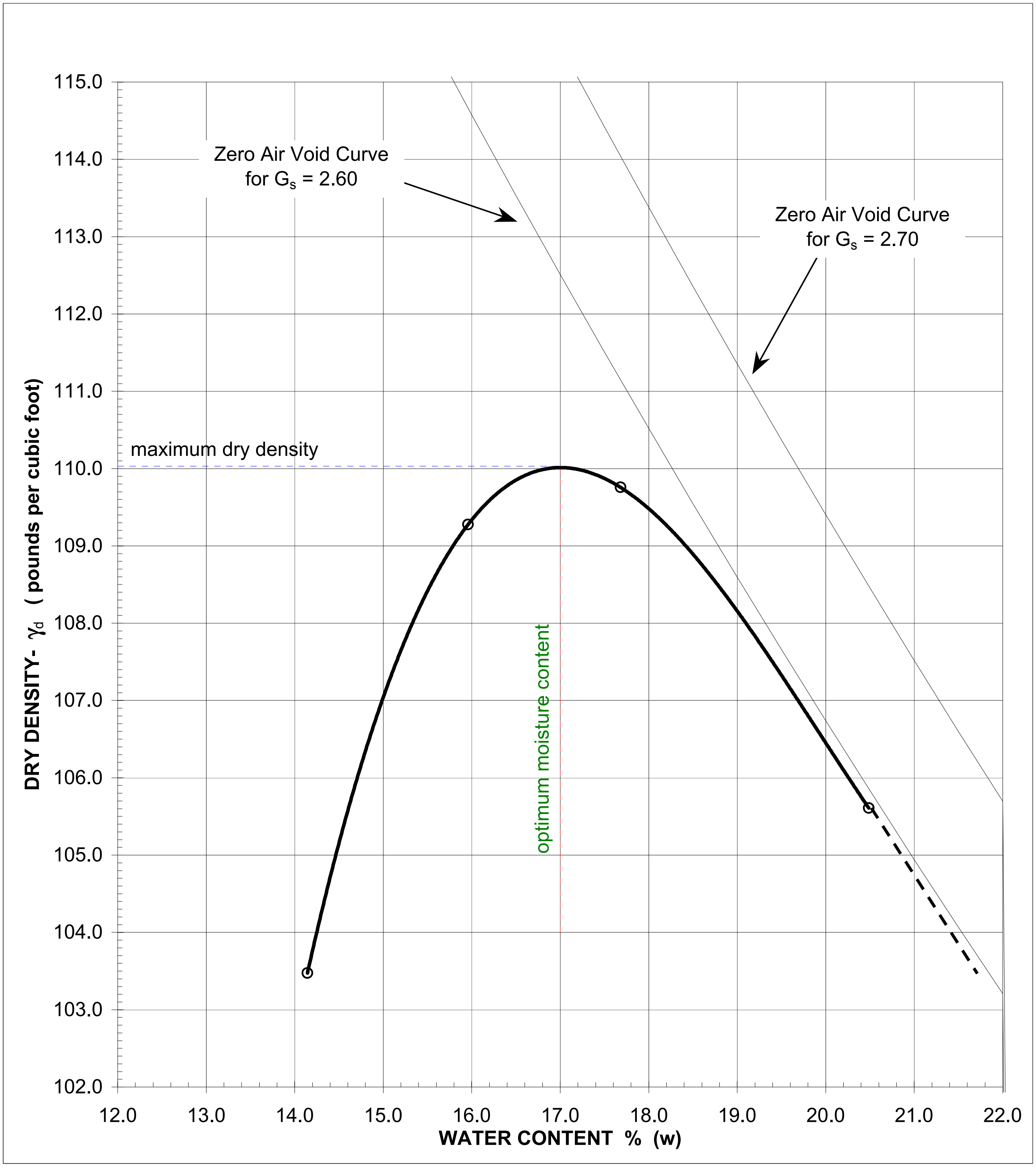
MAXIMUM DRY DENSITY 111.8 pcf
OPTIMUM WATER CONTEI 17.4 %
PENETRATION RESISTANCE psi

COMPACTIVE EFFORT 20,250 ft.lb./ft^3
MOLD SIZE 0.0333 cu. ft.
SPECIFIC GRAVITY N/A
MAX. SIZE minus No. 4
TESTED BY Dave Tully

Figure 11

COMPACTION TEST

ASTM D 1557-91 : Laboratory Compaction Characteristics of Soil Modified to DWR Standard



PROJECT: Sites Reservoir - Sites Dam
FEATURE: Composite Sample, Hole SC
HOLE NO. N/A
DEPTH N/A
FIELD SAMPLE NO. N/A

MAXIMUM DRY DENSITY 110.0 pcf
OPTIMUM WATER CONTI 17.0 %
PENETRATION RESISTANCE psi

COMPACTIVE EFFORT 20,250

Figure 12

SITES RESERVOIR - MATERIALS INVESTIGATION

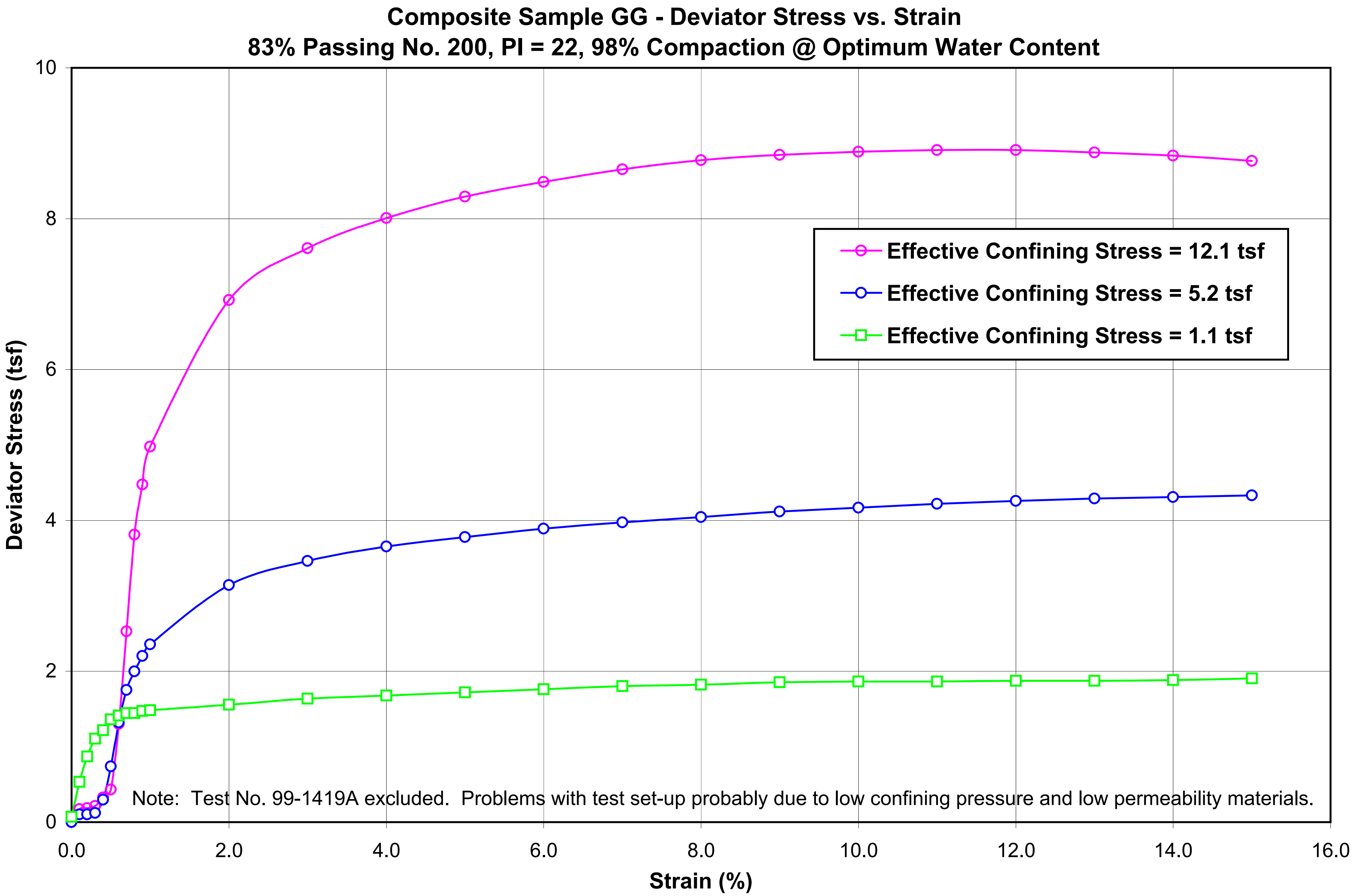
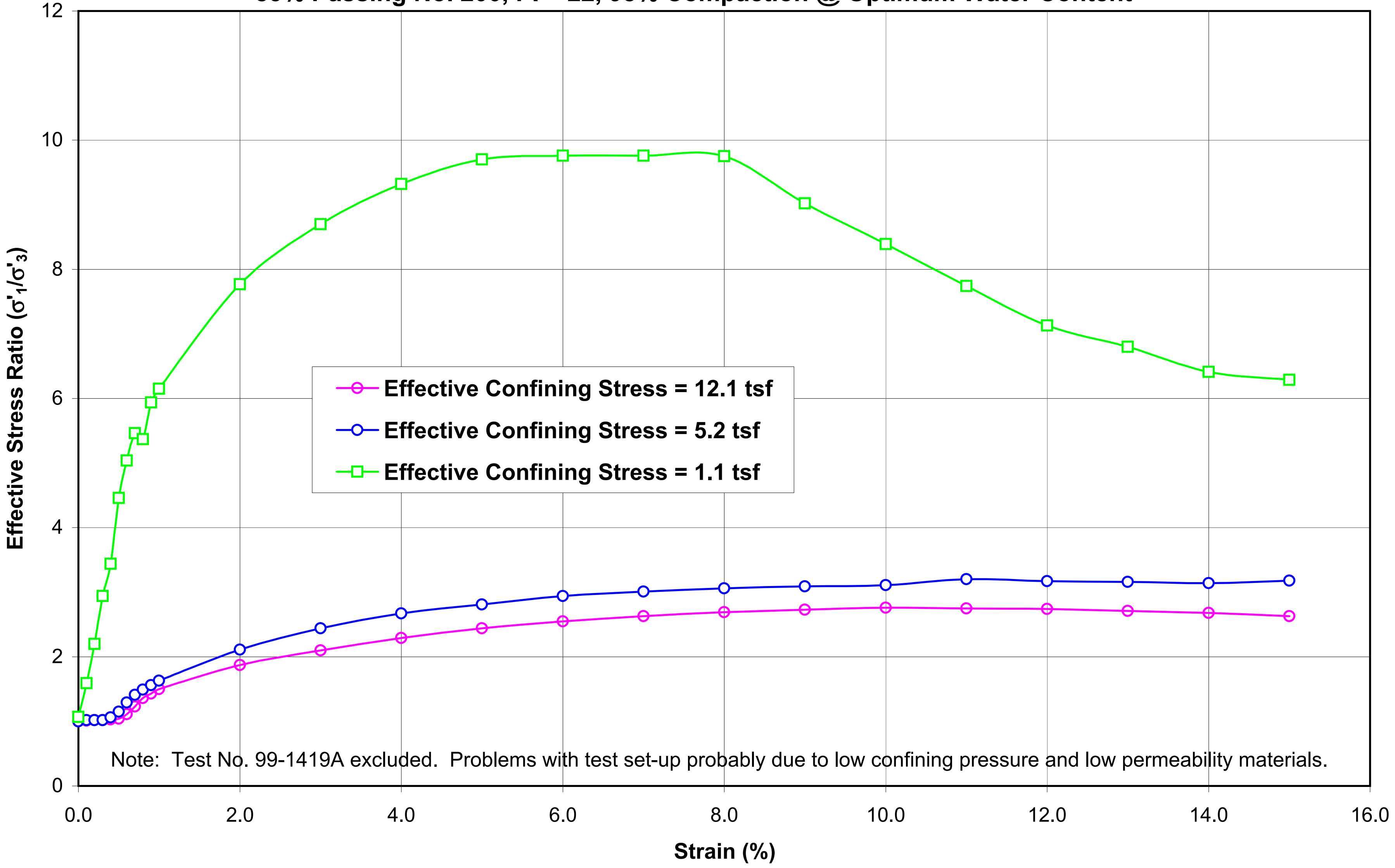


Figure 13

SITES RESERVOIR - MATERIALS INVESTIGATION

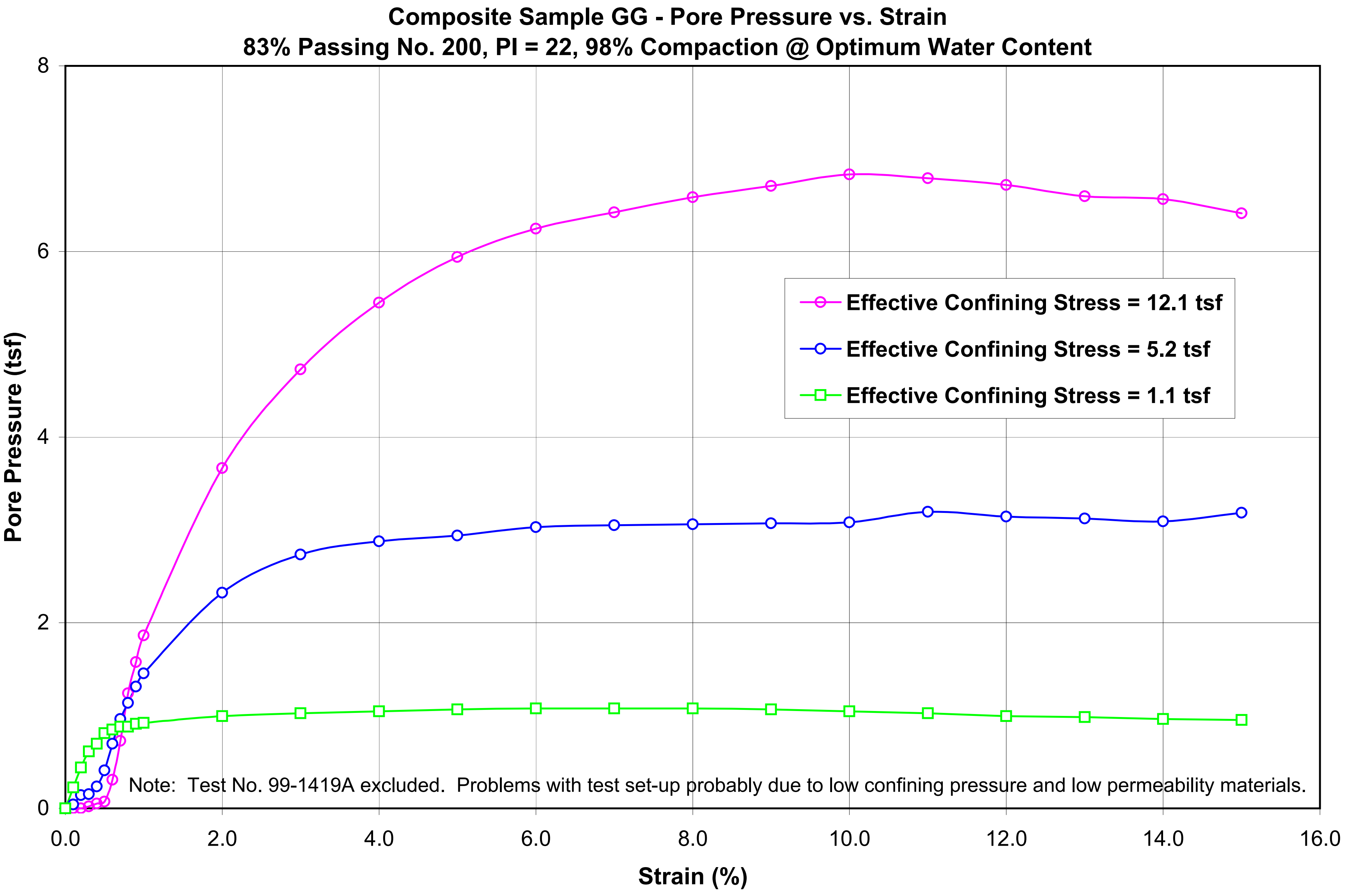
Composite Sample GG - Effective Stress Ratio vs. Strain
83% Passing No. 200, PI = 22, 98% Compaction @ Optimum Water Content



Note: Test No. 99-1419A excluded. Problems with test set-up probably due to low confining pressure and low permeability materials.

Figure 14

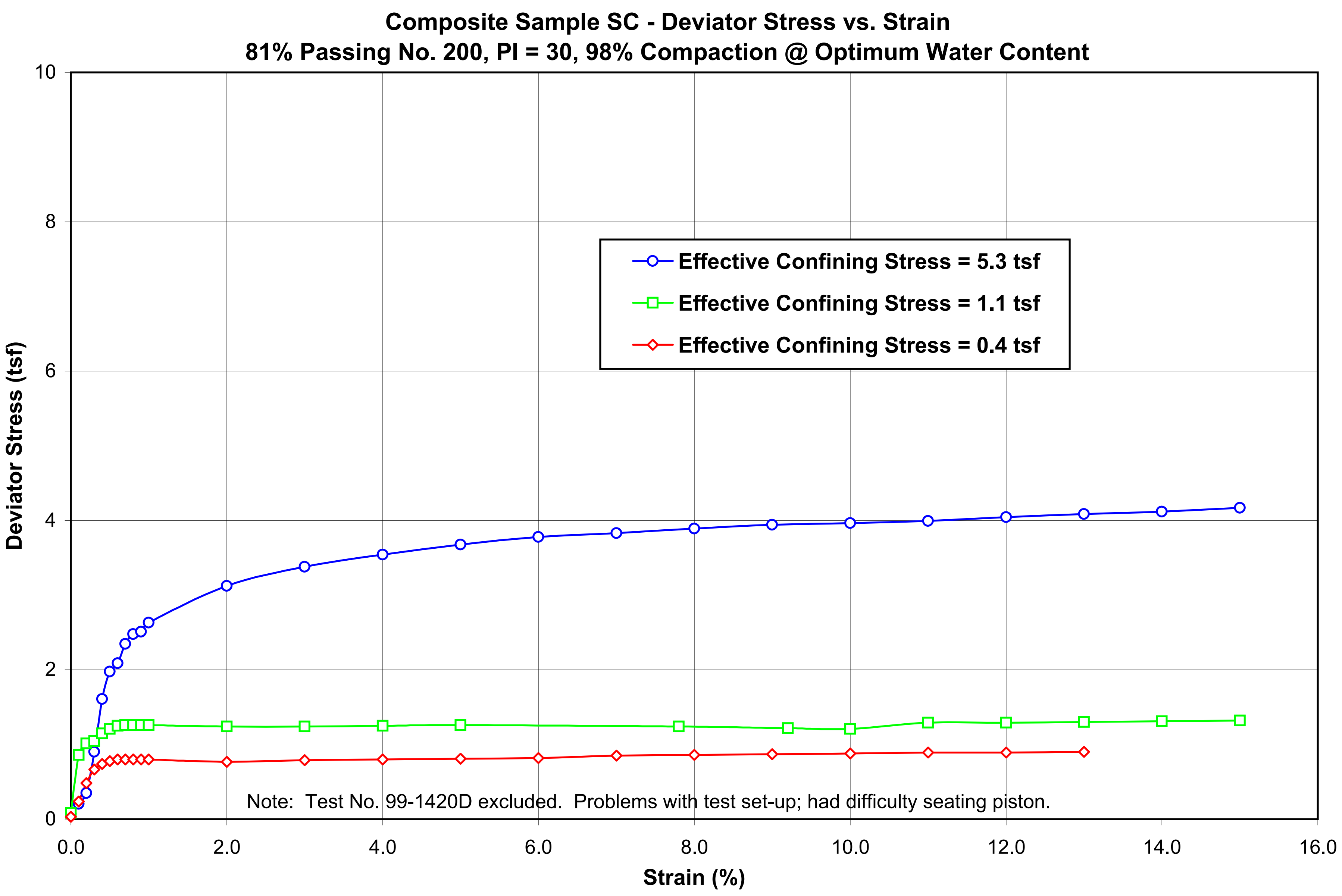
SITES RESERVOIR - MATERIALS INVESTIGATION



Note: Test No. 99-1419A excluded. Problems with test set-up probably due to low confining pressure and low permeability materials.

Figure 15

SITES RESERVOIR - MATERIALS INVESTIGATION

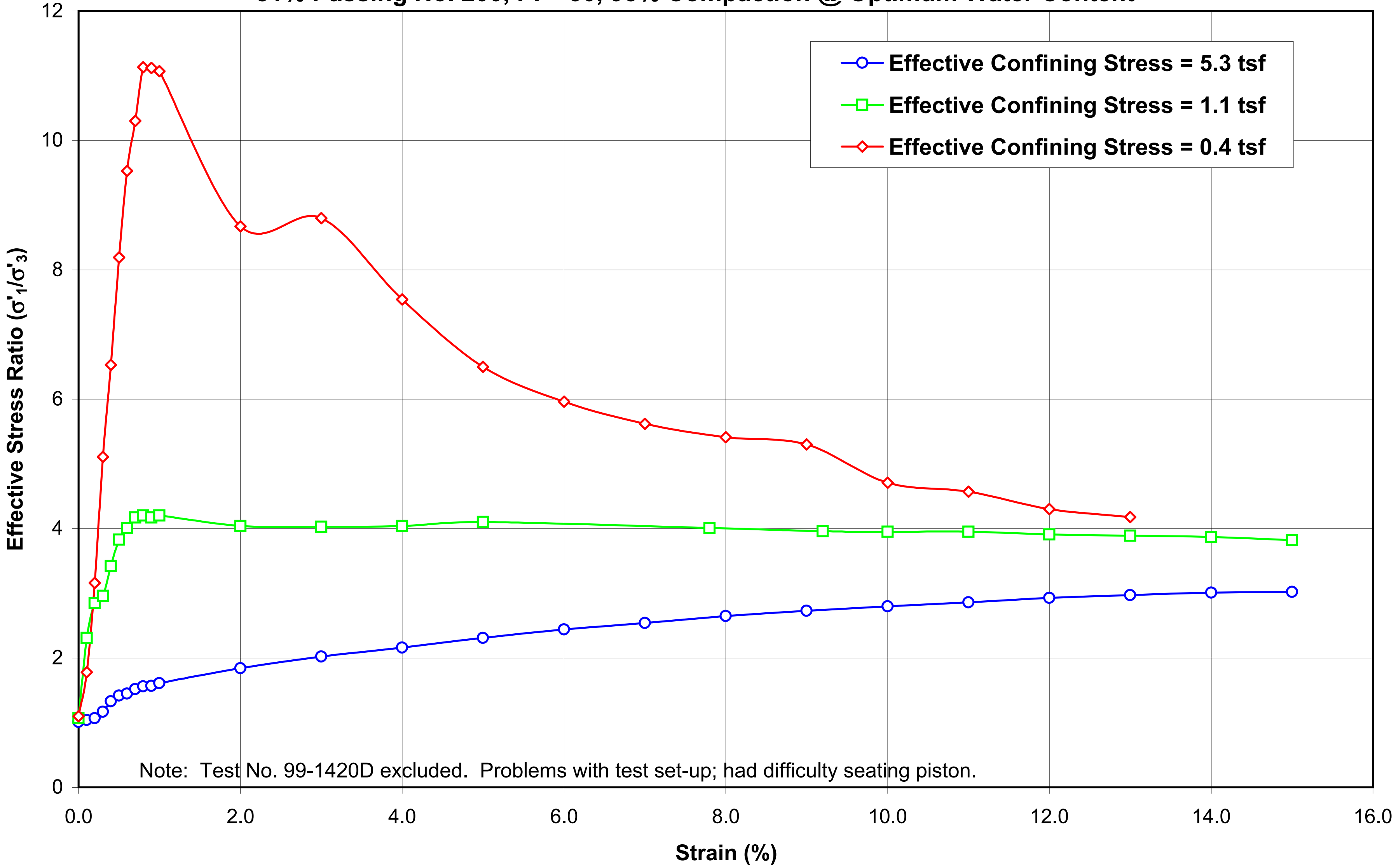


Note: Test No. 99-1420D excluded. Problems with test set-up; had difficulty seating piston.

Figure 16

SITES RESERVOIR - MATERIALS INVESTIGATION

Composite Sample SC - Effective Stress Ratio vs. Strain
81% Passing No. 200, PI = 30, 98% Compaction @ Optimum Water Content

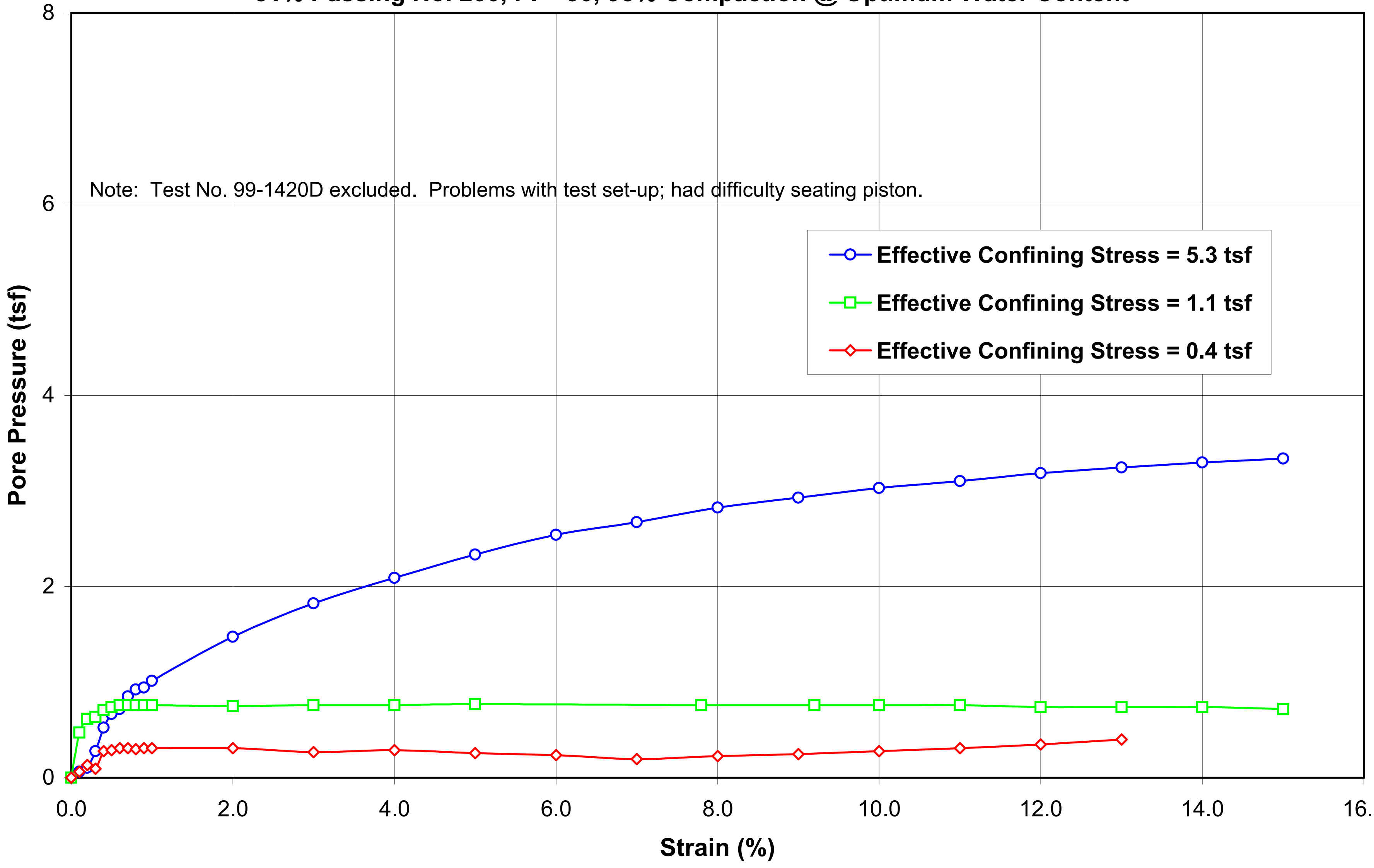


Note: Test No. 99-1420D excluded. Problems with test set-up; had difficulty seating piston.

Figure 17

SITES RESERVOIR - MATERIALS INVESTIGATION

Composite Sample SC - Pore Pressure vs. Strain
81% Passing No. 200, PI = 30, 98% Compaction @ Optimum Water Content



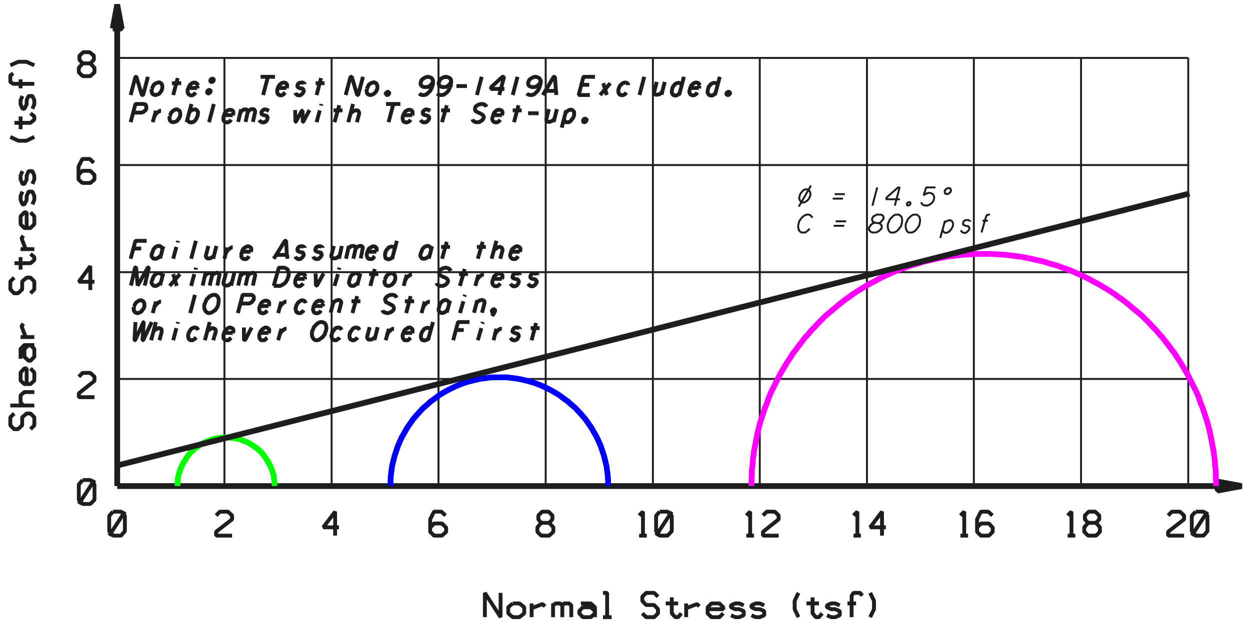
Note: Test No. 99-1420D excluded. Problems with test set-up; had difficulty seating piston.

Figure 18

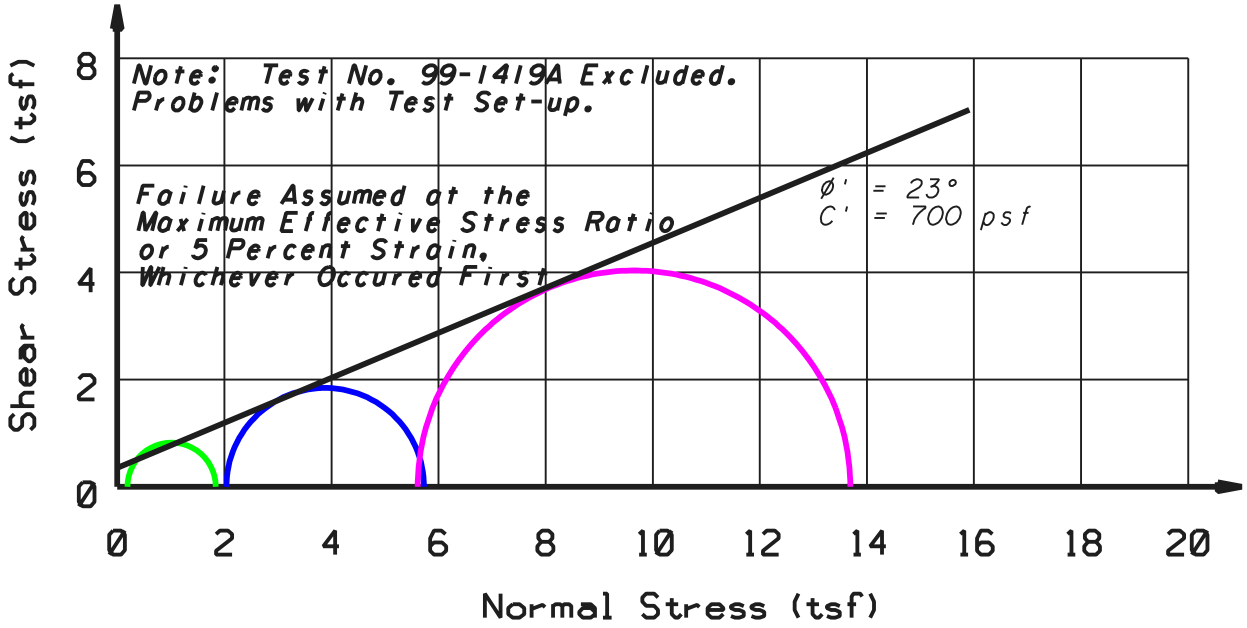
SITES RESERVOIR - MATERIALS INVESTIGATION

Composite Sample GG CUE Test Results
83% Passing No. 200, PI = 22, 98% Compaction @ Optimum Water Content

Total Stress Failure Envelope



Effective Stress Failure Envelope



Initial Effective Confining Stress (tsf)		1.1	5.1	11.8

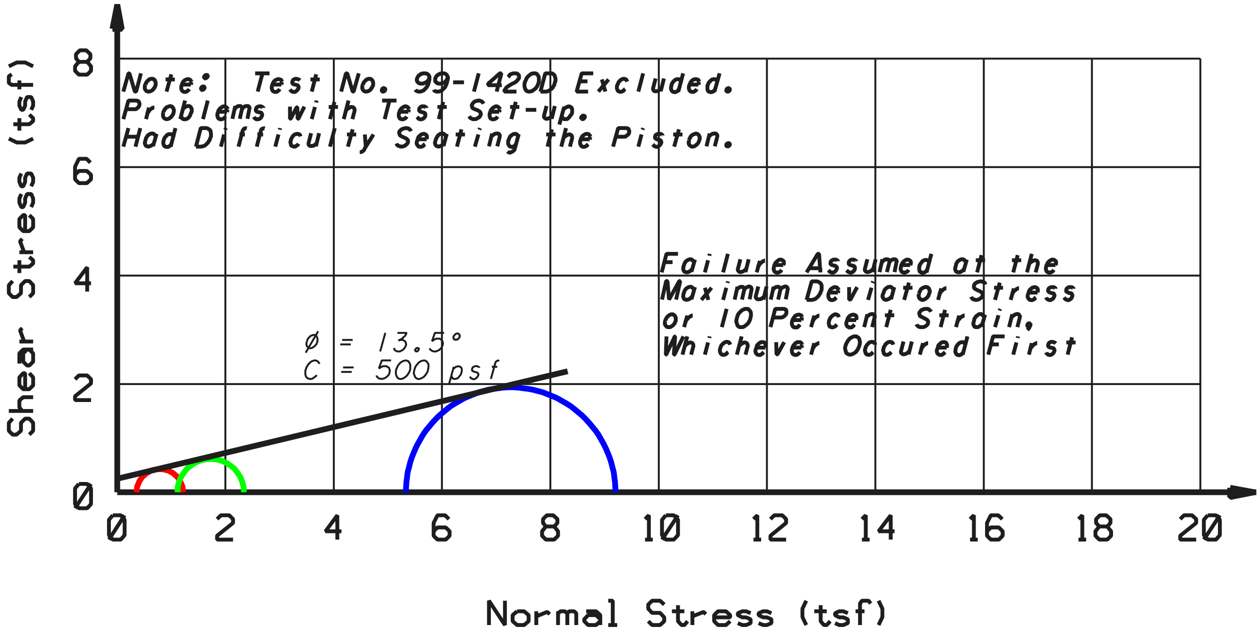
Figure 19

SITES RESERVOIR - MATERIALS INVESTIGATION

Composite Sample SC CUE Test Results

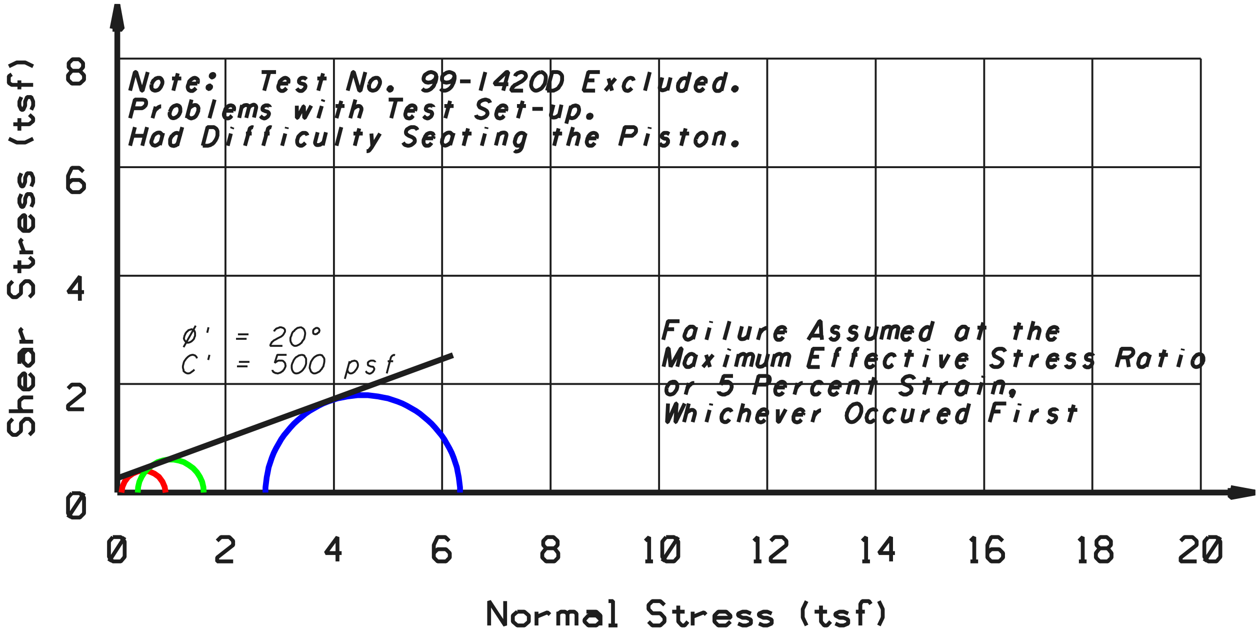
81% Passing No. 200, PI = 30, 98% Compaction @ Optimum Water Conten

Total Stress Failure Envelope


Note: Test No. 99-1420D Excluded.
Problems with Test Set-up.
Had Difficulty Seating the Piston.

Failure Assumed at the
Maximum Deviator Stress
or 10 Percent Strain,
Whichever Occured First

Effective Stress Failure Envelope


Note: Test No. 99-1420D Excluded.
Problems with Test Set-up.
Had Difficulty Seating the Piston.

Failure Assumed at the
Maximum Effective Stress Ratio
or 5 Percent Strain,
Whichever Occured First

Initial Effective Confining Stress (tsf)	0.4	1.1	5.3	

Figure 20

Venado Sandstone at Sites Quarry

Figure 21

Proposed Venado Sandstone Quarry Areas for DWR

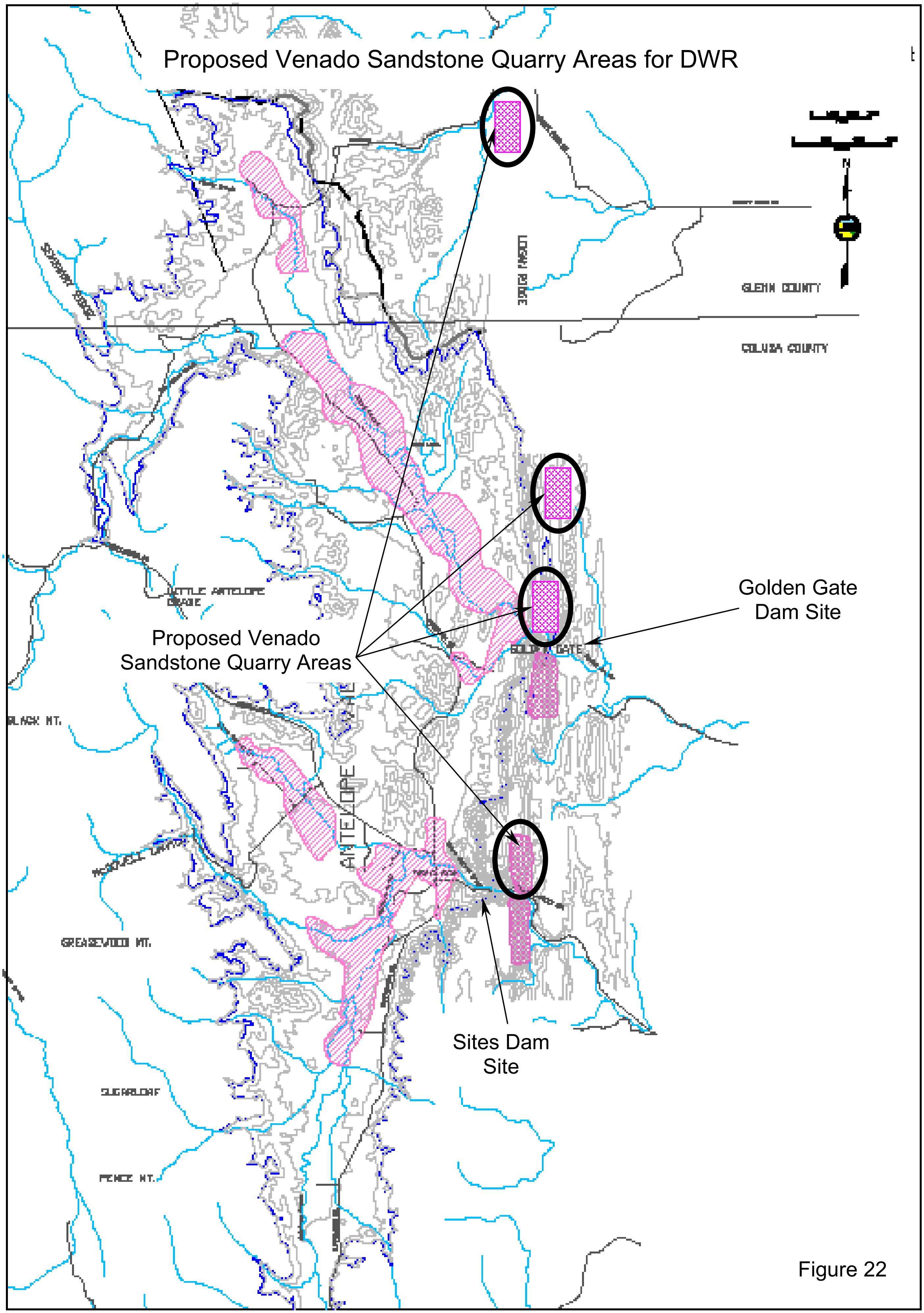
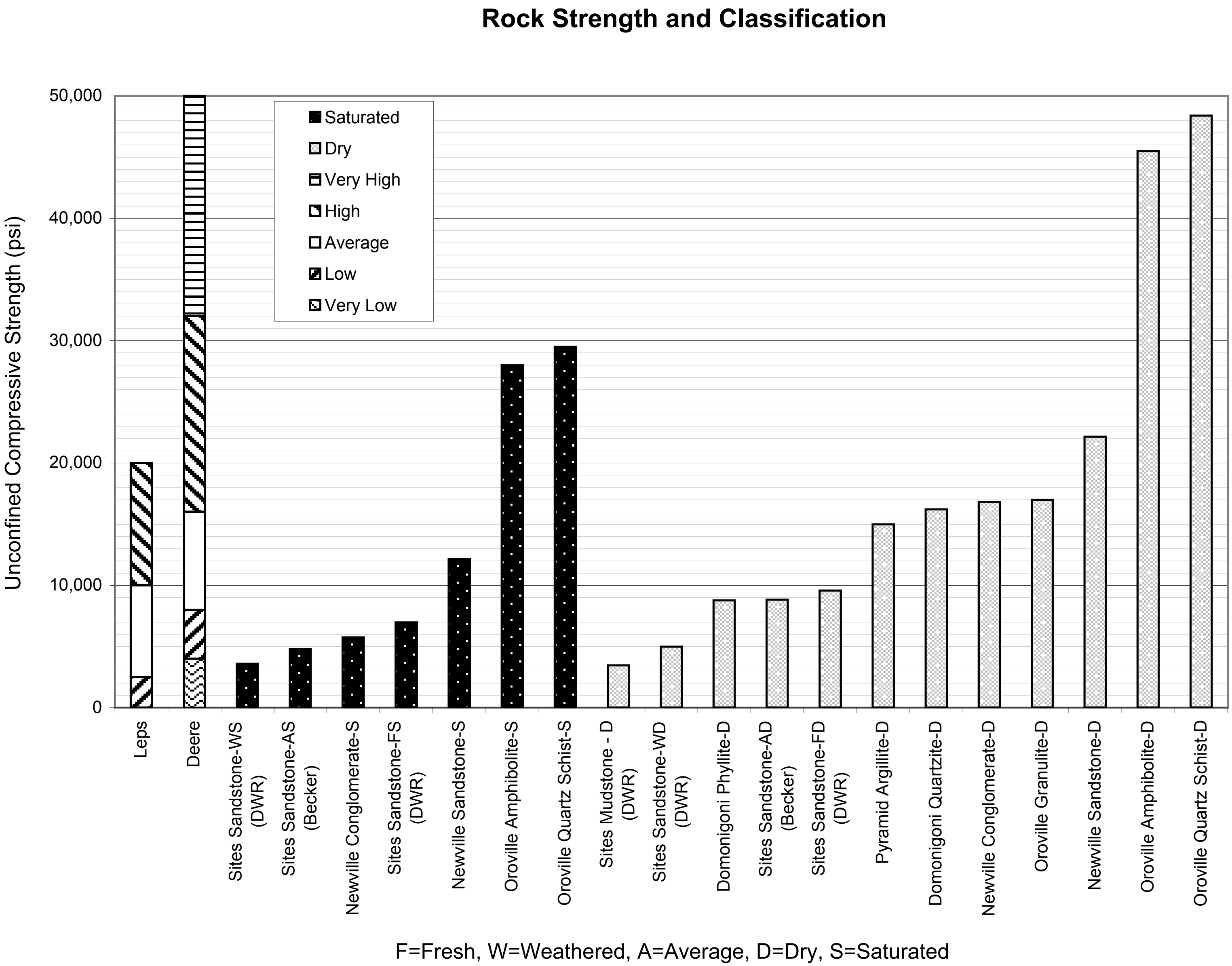
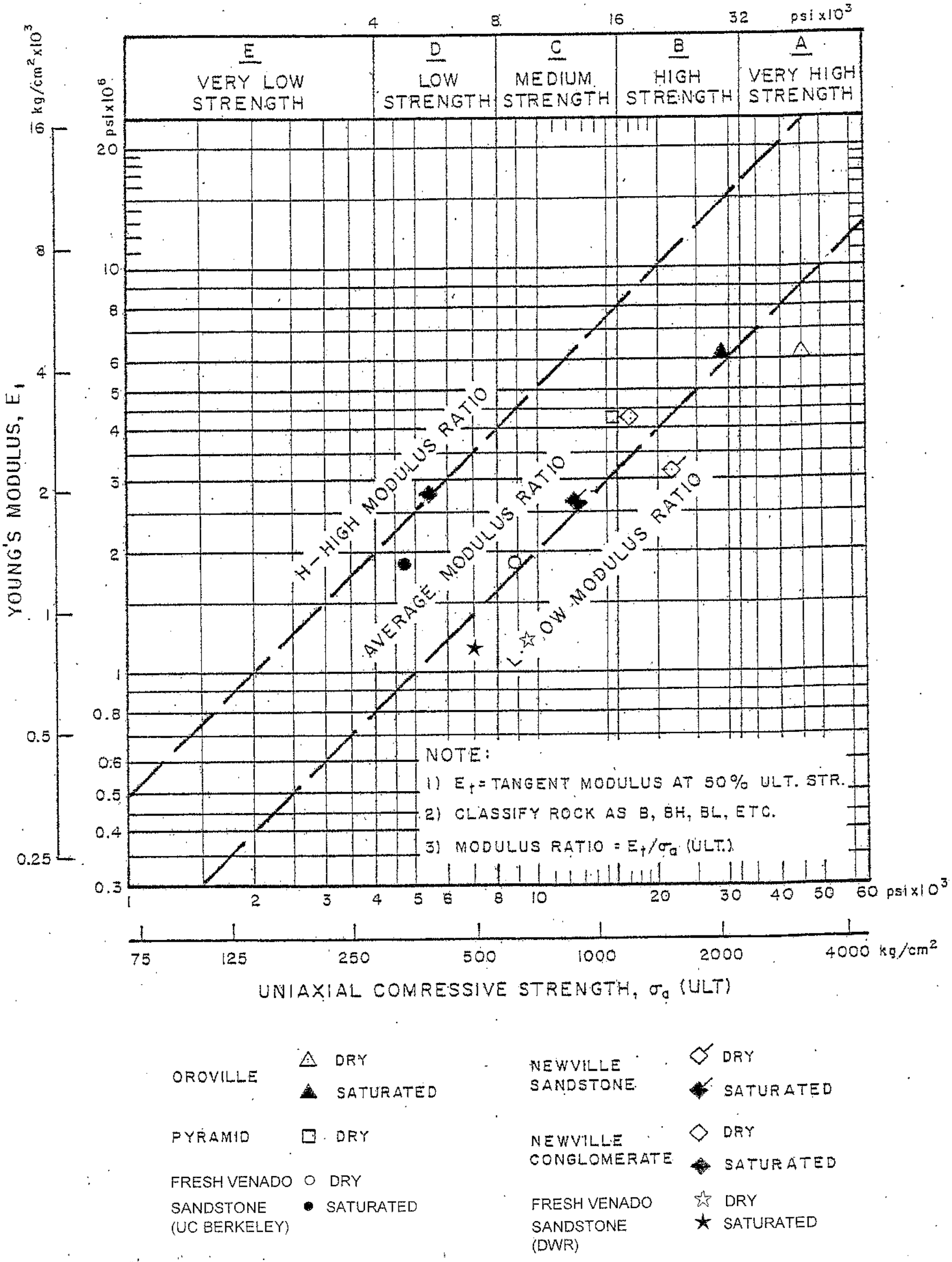


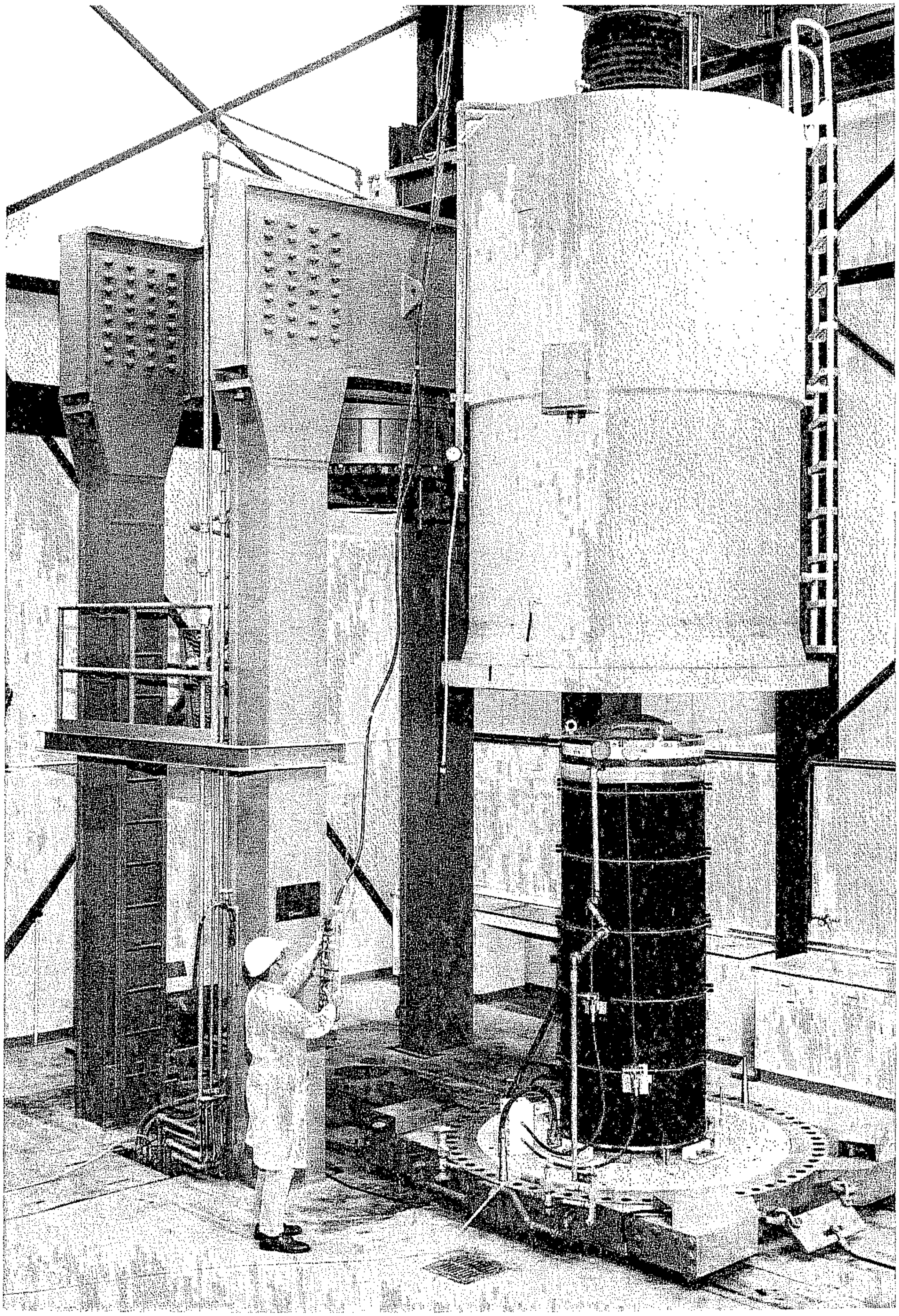
Figure 22


Rock Strength and Classification
Unconfined Compressive Strength (psi)
50,000
40,000
30,000
20,000
10,000
0
Saturated
Dry
Very High
High
Average
Low
Very Low
Leps
Deere
Sites Sandstone-WS (DWR)
Sites Sandstone-AS (Becker)
Newville Conglomerate-S
Sites Sandstone-FS (DWR)
Newville Sandstone-S
Oroville Amphibolite-S
Oroville Quartz Schist-S
Sites Mudstone - D (DWR)
Sites Sandstone-WD (DWR)
Domonigoni Phyllite-D
Sites Sandstone-AD (Becker)
Sites Sandstone-FD (DWR)
Pyramid Argillite-D
Domonigoni Quartzite-D
Newville Conglomerate-D
Oroville Granulite-D
Newville Sandstone-D
Oroville Amphibolite-D
Oroville Quartz Schist-D
F=Fresh, W=Weathered, A=Average, D=Dry, S=Saturated



4
8
16
32
psi x10³
E
VERY LOW STRENGTH
D
LOW STRENGTH
C
MEDIUM STRENGTH
B
HIGH STRENGTH
A
VERY HIGH STRENGTH
kg/cm² x10³
psi x10⁶
YOUNG'S MODULUS, E_t
16
8
4
2
1
0.5
0.25
20
10
8
6
5
4
3
2
1
0.8
0.6
0.5
0.4
0.3
H-HIGH MODULUS RATIO
AVERAGE MODULUS RATIO
L-OW MODULUS RATIO
NOTE:
1) E_t = TANGENT MODULUS AT 50% ULT. STR.
2) CLASSIFY ROCK AS B, BH, BL, ETC.
3) MODULUS RATIO = E_t/σ_a (ULT.)
1
2
3
4
5
6
8
10
20
30
40
50
60
psi x10³
75
125
250
500
1000
2000
4000
kg/cm²
UNIAXIAL COMRESSIVE STRENGTH, σ_a (ULT)
OROVILLE
△ DRY
▲ SATURATED
PYRAMID
□ DRY
FRESH VENADO SANDSTONE (UC BERKELEY)
○ DRY
● SATURATED
NEWVILLE SANDSTONE
◇ DRY
◆ SATURATED
NEWVILLE CONGLOMERATE
◇ DRY
◆ SATURATED
FRESH VENADO SANDSTONE (DWR)
☆ DRY
★ SATURATED

Figure 24



UC Berkeley Large-Scale Triaxial Testing Apparatus

Figure 25

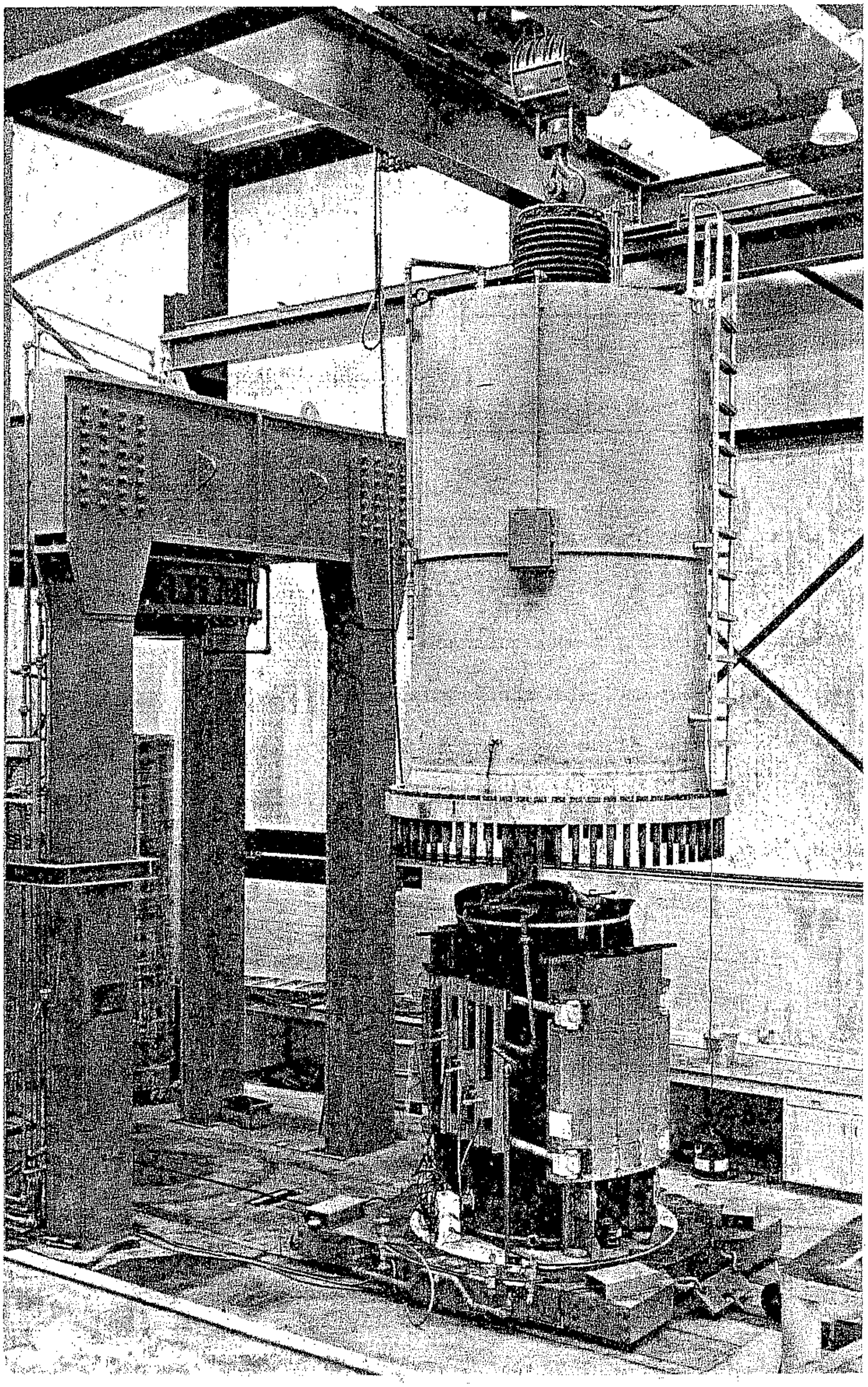
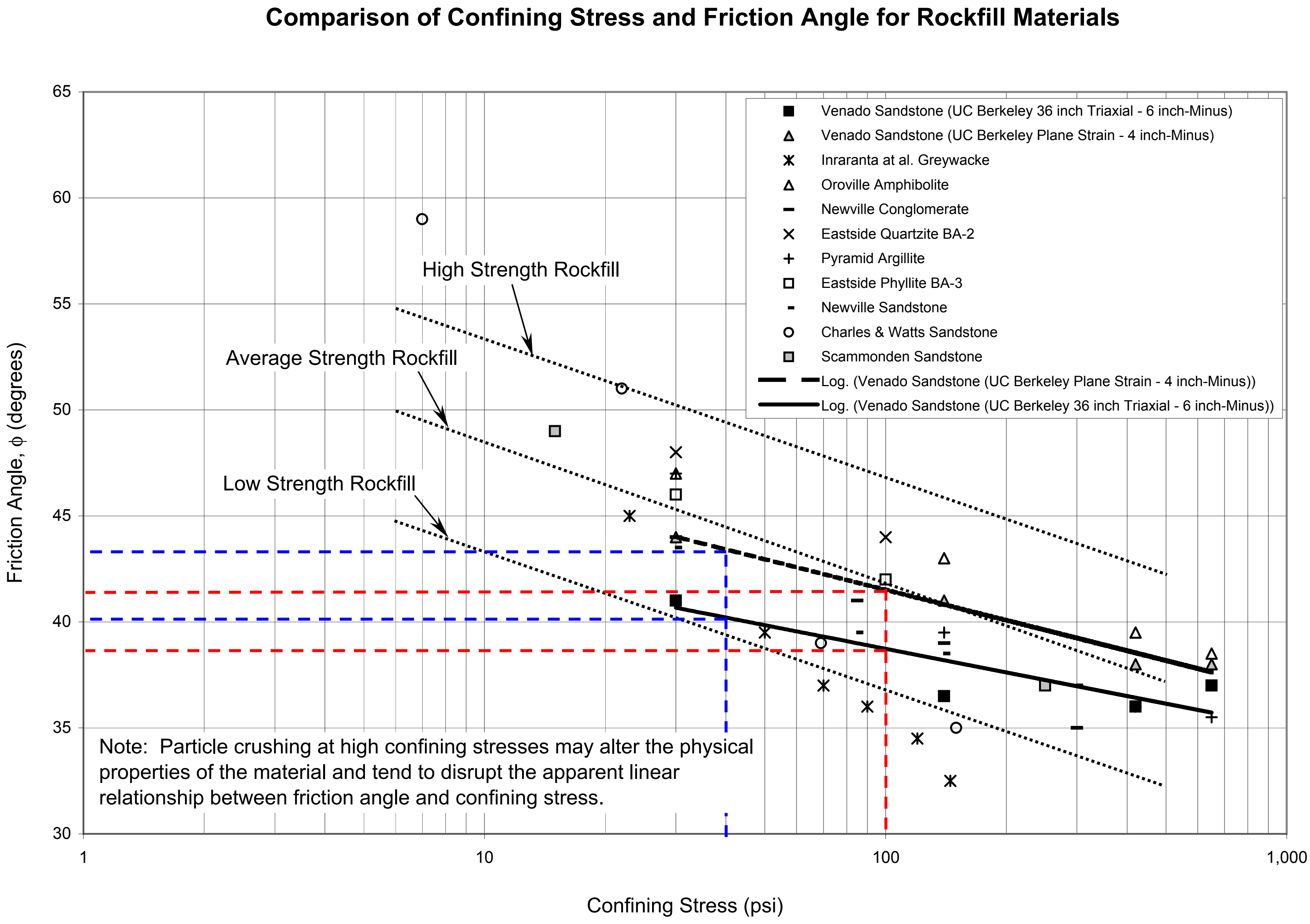


Figure 26

UC Berkeley Large-Scale Plane Strain Testing Apparatus



Comparison of Confining Stress and Friction Angle for Rockfill Materials

Note: Particle crushing at high confining stresses may alter the physical properties of the material and tend to disrupt the apparent linear relationship between friction angle and confining stress.

Figure 27

Comparison of Compressive Strength and Friction Angle of Rockfill Materials
Confining Stress = 40 psi

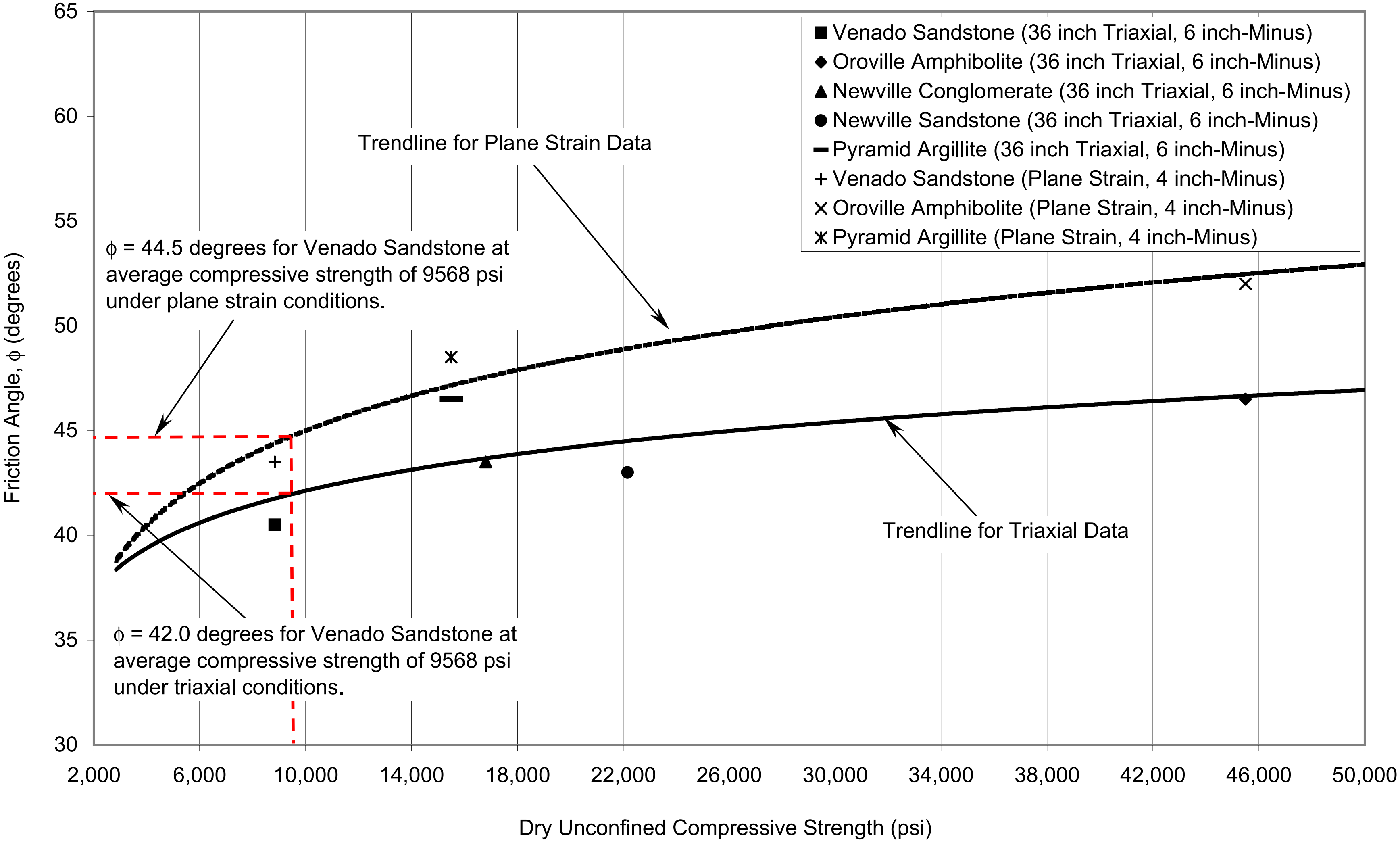


Figure 28

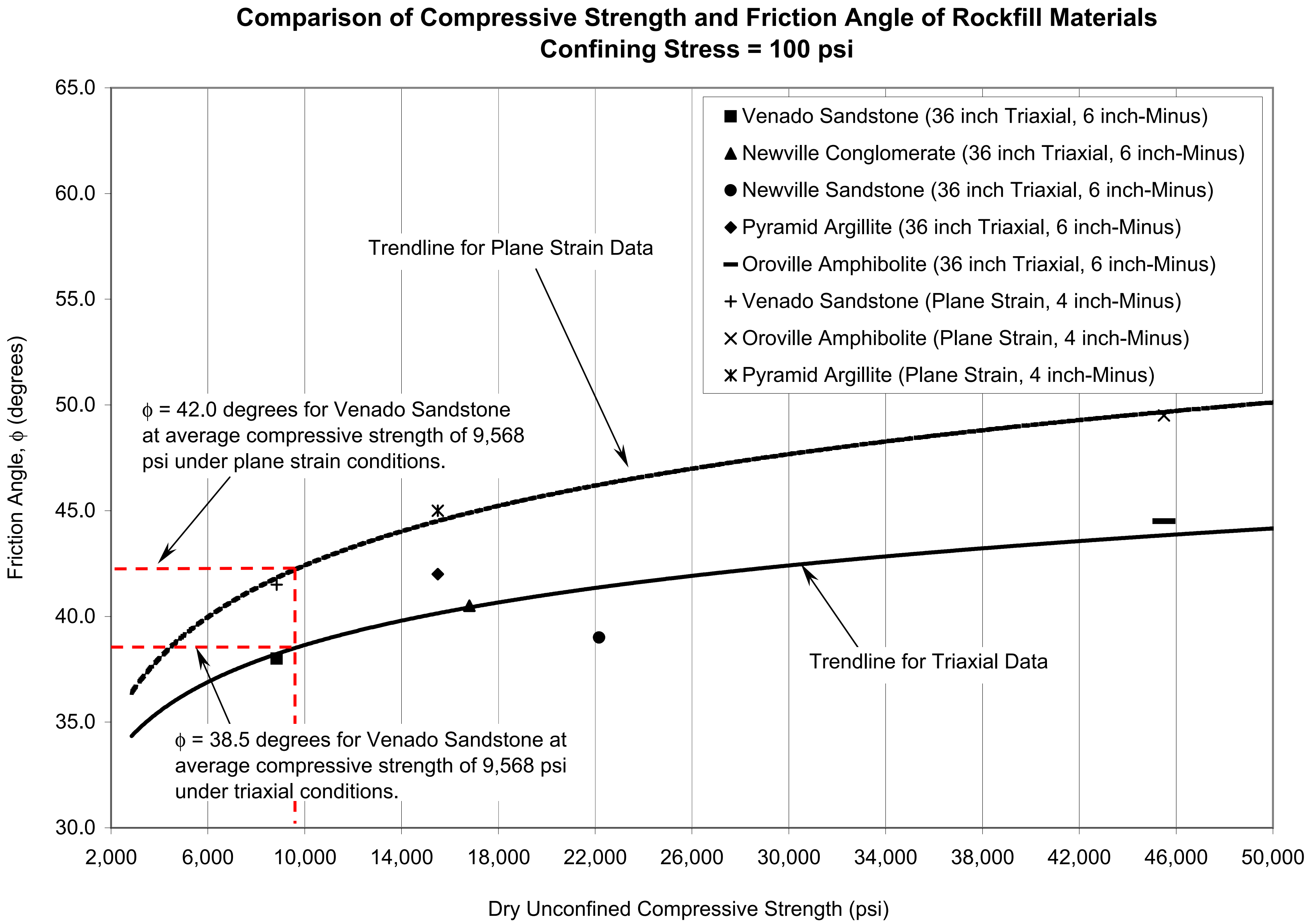

Comparison of Compressive Strength and Friction Angle of Rockfill Materials
Confining Stress = 100 psi
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
Friction Angle, ϕ (degrees)
2,000
6,000
10,000
14,000
18,000
22,000
26,000
30,000
34,000
38,000
42,000
46,000
50,000
Dry Unconfined Compressive Strength (psi)
■ Venado Sandstone (36 inch Triaxial, 6 inch-Minus)
▲ Newville Conglomerate (36 inch Triaxial, 6 inch-Minus)
● Newville Sandstone (36 inch Triaxial, 6 inch-Minus)
◆ Pyramid Argillite (36 inch Triaxial, 6 inch-Minus)
− Oroville Amphibolite (36 inch Triaxial, 6 inch-Minus)
+ Venado Sandstone (Plane Strain, 4 inch-Minus)
× Oroville Amphibolite (Plane Strain, 4 inch-Minus)
⋇ Pyramid Argillite (Plane Strain, 4 inch-Minus)
Trendline for Plane Strain Data
ϕ = 42.0 degrees for Venado Sandstone at average compressive strength of 9,568 psi under plane strain conditions.
Trendline for Triaxial Data
ϕ = 38.5 degrees for Venado Sandstone at average compressive strength of 9,568 psi under triaxial conditions.

Figure 29

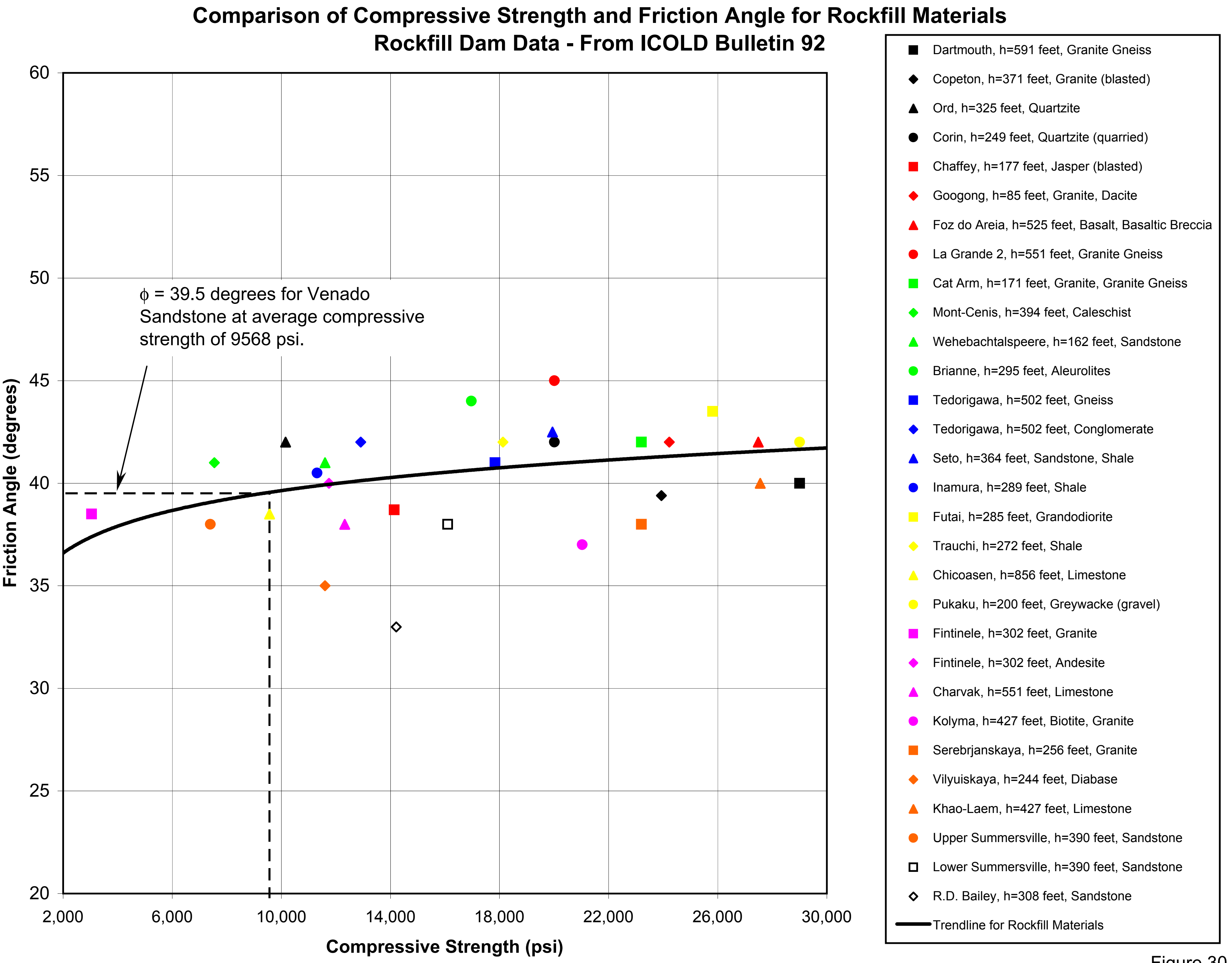
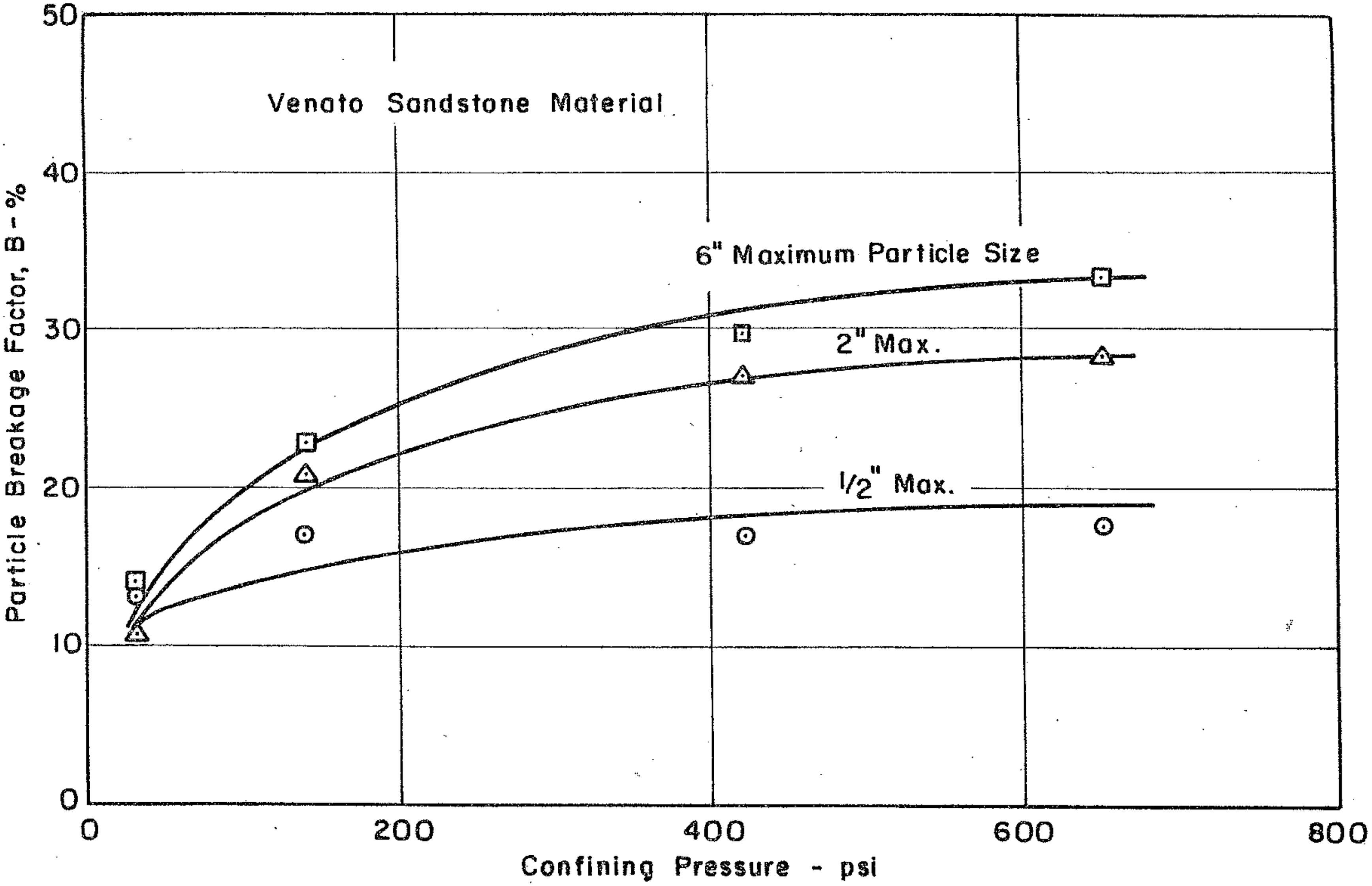

Comparison of Compressive Strength and Friction Angle for Rockfill Materials
Rockfill Dam Data - From ICOLD Bulletin 92
Friction Angle (degrees)
Compressive Strength (psi)
60
55
50
45
40
35
30
25
20
2,000
6,000
10,000
14,000
18,000
22,000
26,000
30,000
ϕ = 39.5 degrees for Venado Sandstone at average compressive strength of 9568 psi.
Dartmouth, h=591 feet, Granite Gneiss
Copeton, h=371 feet, Granite (blasted)
Ord, h=325 feet, Quartzite
Corin, h=249 feet, Quartzite (quarried)
Chaffey, h=177 feet, Jasper (blasted)
Googong, h=85 feet, Granite, Dacite
Foz do Areia, h=525 feet, Basalt, Basaltic Breccia
La Grande 2, h=551 feet, Granite Gneiss
Cat Arm, h=171 feet, Granite, Granite Gneiss
Mont-Cenis, h=394 feet, Caleschist
Wehebachtalspeere, h=162 feet, Sandstone
Brianne, h=295 feet, Aleurolites
Tedorigawa, h=502 feet, Gneiss
Tedorigawa, h=502 feet, Conglomerate
Seto, h=364 feet, Sandstone, Shale
Inamura, h=289 feet, Shale
Futai, h=285 feet, Grandodiorite
Trauchi, h=272 feet, Shale
Chicoasen, h=856 feet, Limestone
Pukaku, h=200 feet, Greywacke (gravel)
Fintinele, h=302 feet, Granite
Fintinele, h=302 feet, Andesite
Charvak, h=551 feet, Limestone
Kolyma, h=427 feet, Biotite, Granite
Serebrjanskaya, h=256 feet, Granite
Vilyuiskaya, h=244 feet, Diabase
Khao-Laem, h=427 feet, Limestone
Upper Summersville, h=390 feet, Sandstone
Lower Summersville, h=390 feet, Sandstone
R.D. Bailey, h=308 feet, Sandstone
Trendline for Rockfill Materials

Figure 30

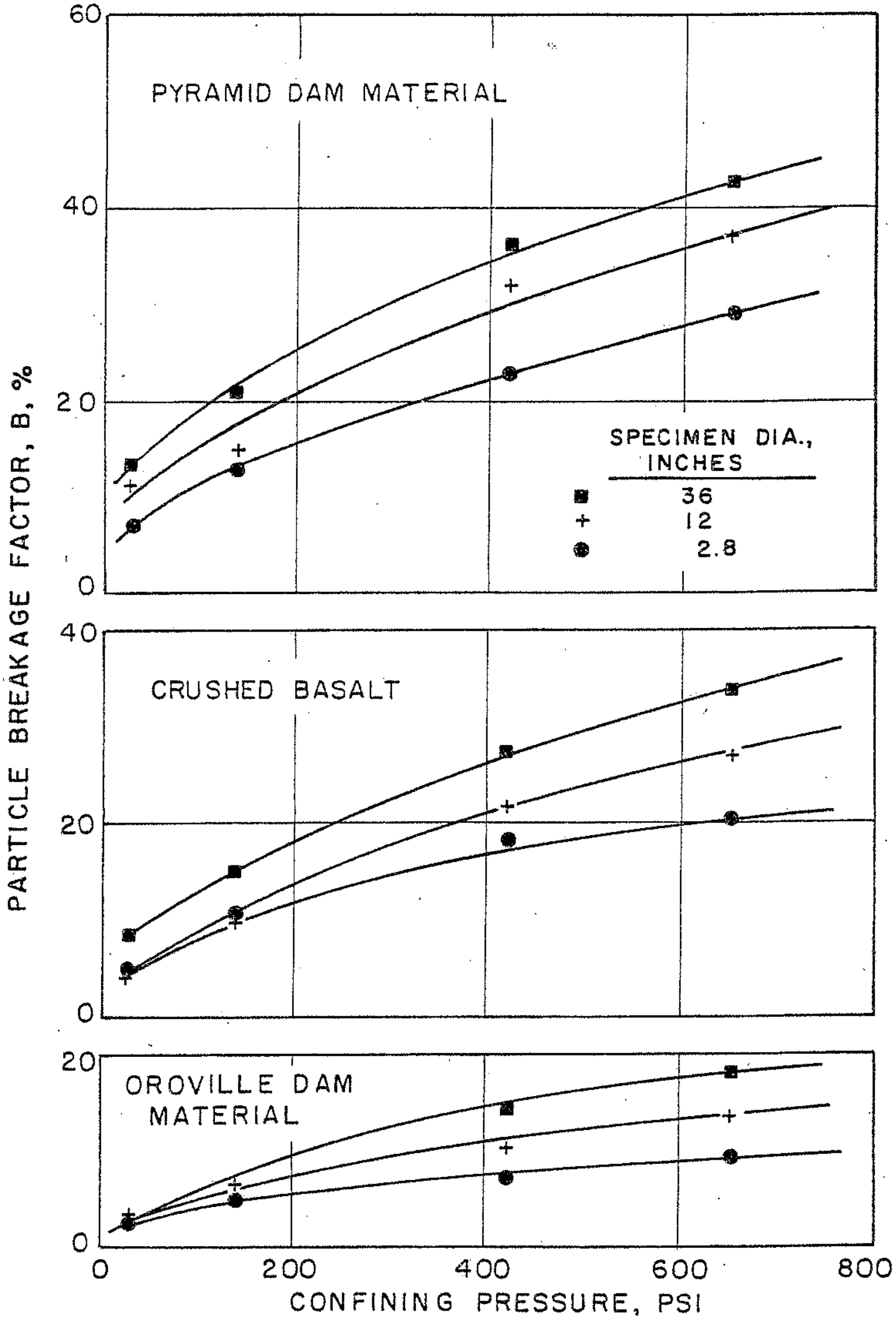


PARTICLE CRUSHING-CONFINING PRESSURE RELATIONSHIP FOR MODELED ROCKFILL MATERIAL UNDER TRIAXIAL CONDITIONS

Figure copied from UC Berkeley report by Becker et. al., 1972.

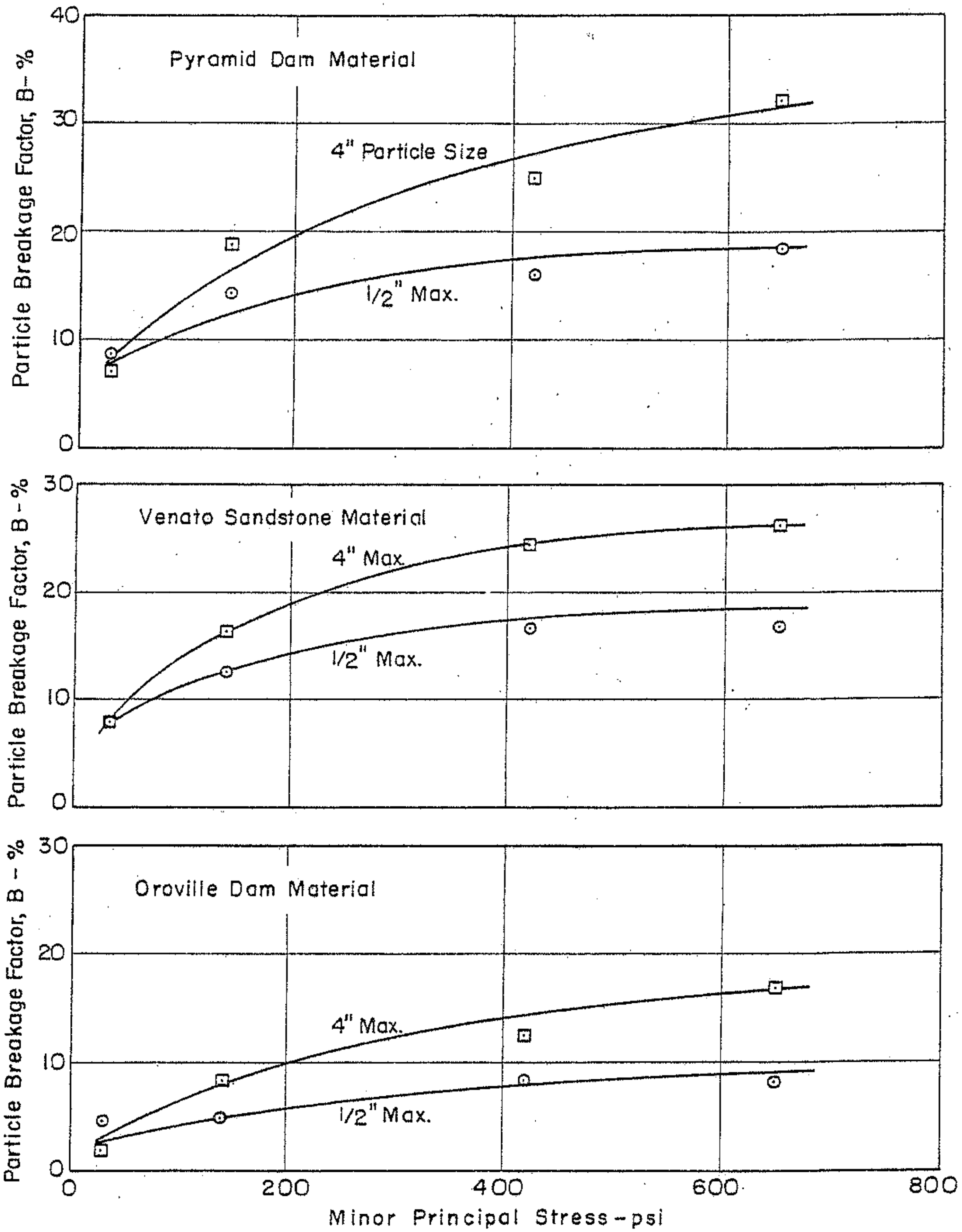
Figure 31

Figure copied from UC Berkeley report by Marachi et. al., 1969.



PARTICLE CRUSHING–CONFINING PRESSURE RELATIONSHIPS FOR MODELED ROCKFILL MATERIALS

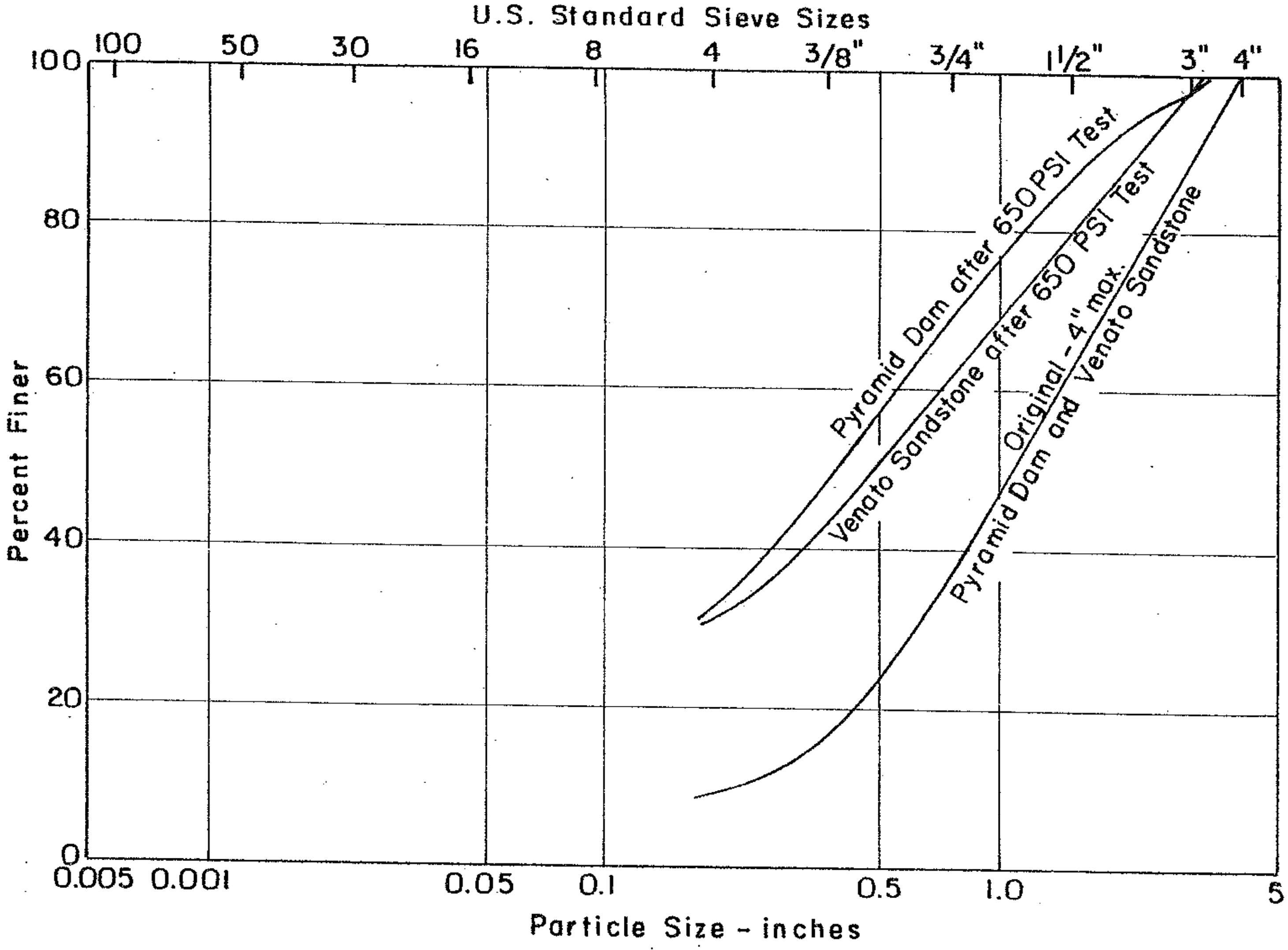
Figure 32



PARTICLE CRUSHING-MINOR PRINCIPAL STRESS RELATIONSHIP FOR MODELED ROCKFILL MATERIALS UNDER PLANE STRAIN CONDITIONS

Figure copied from UC Berkeley report by Becker et. al., 1972.

Figure 33



COMPARISON OF AFTER TEST GRADATION FOR PYRAMID DAM AND VENATO SANDSTONE MATERIALS UNDER PLANE STRAIN CONDITIONS FOR TESTS AT 650 PSI MINOR PRINCIPAL STRESS

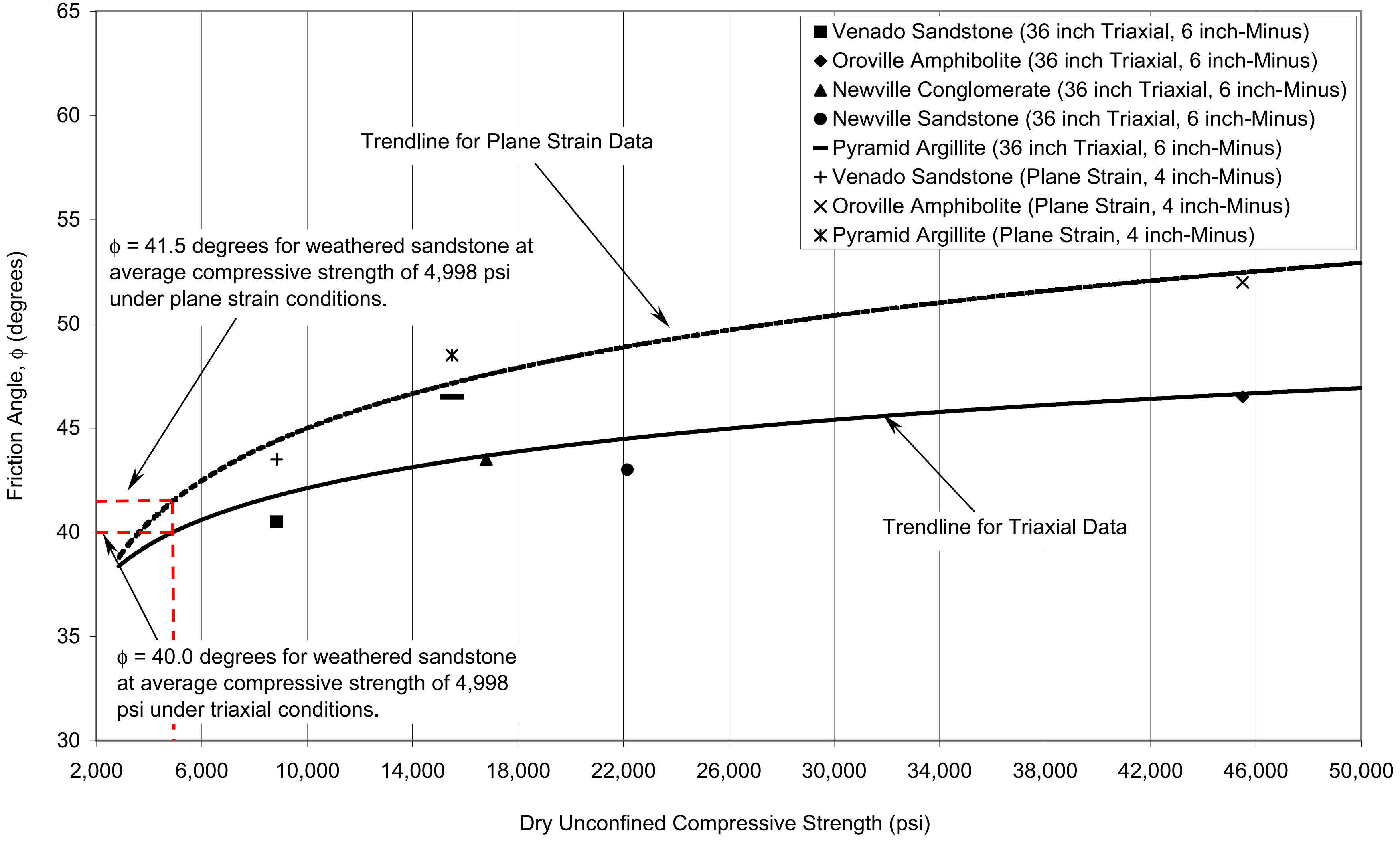
Figure 34

Figure copied from UC Berkeley report by Becker et. al., 1972.

Venado Sandstone Used as Upstream Slope Protection at Funks Reservoir Dam

Figure 35

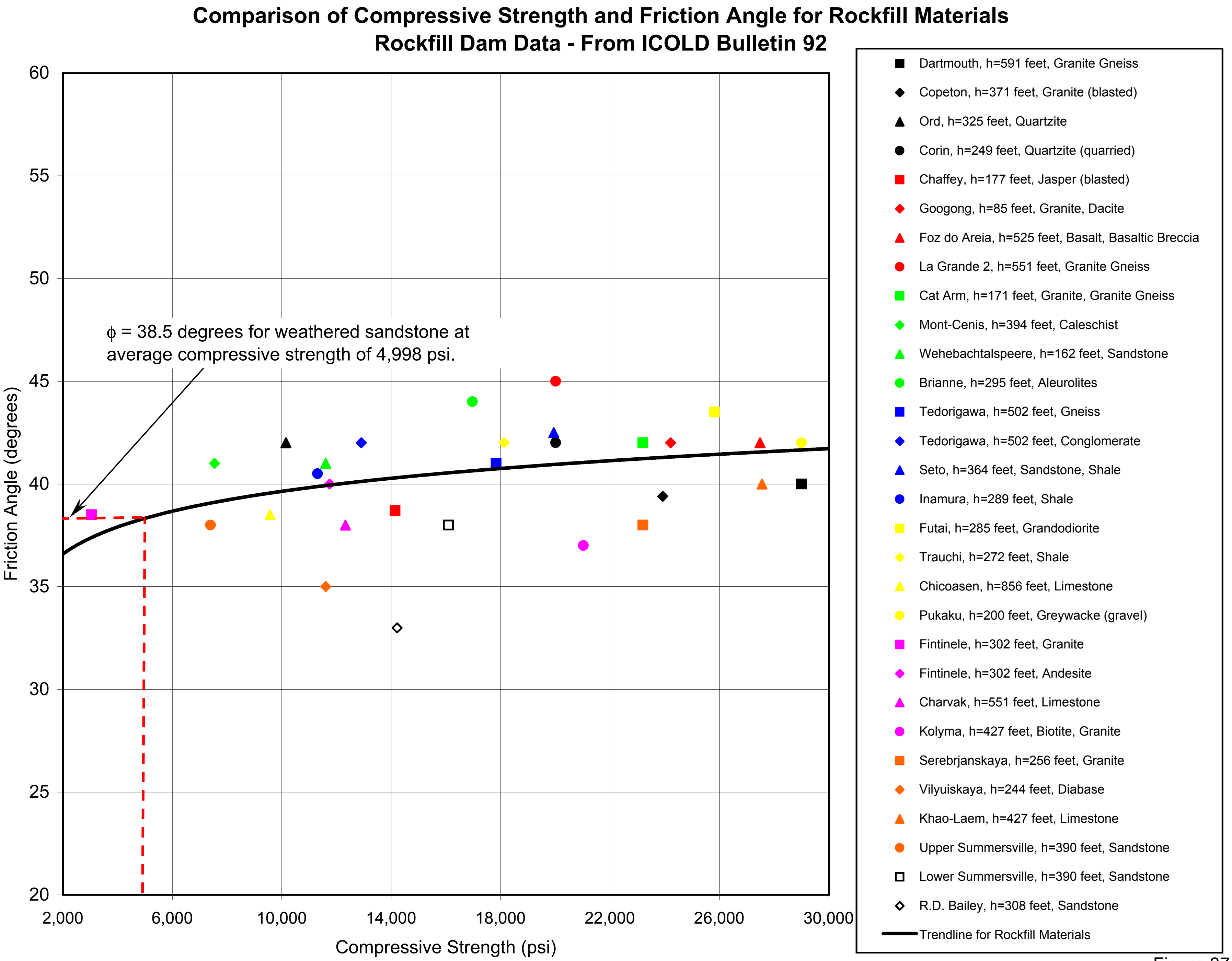
Comparison of Compressive Strength and Friction Angle of Rockfill Materials
Confining Stress = 40 psi



ϕ = 41.5 degrees for weathered sandstone at average compressive strength of 4,998 psi under plane strain conditions.

ϕ = 40.0 degrees for weathered sandstone at average compressive strength of 4,998 psi under triaxial conditions.

Figure 36

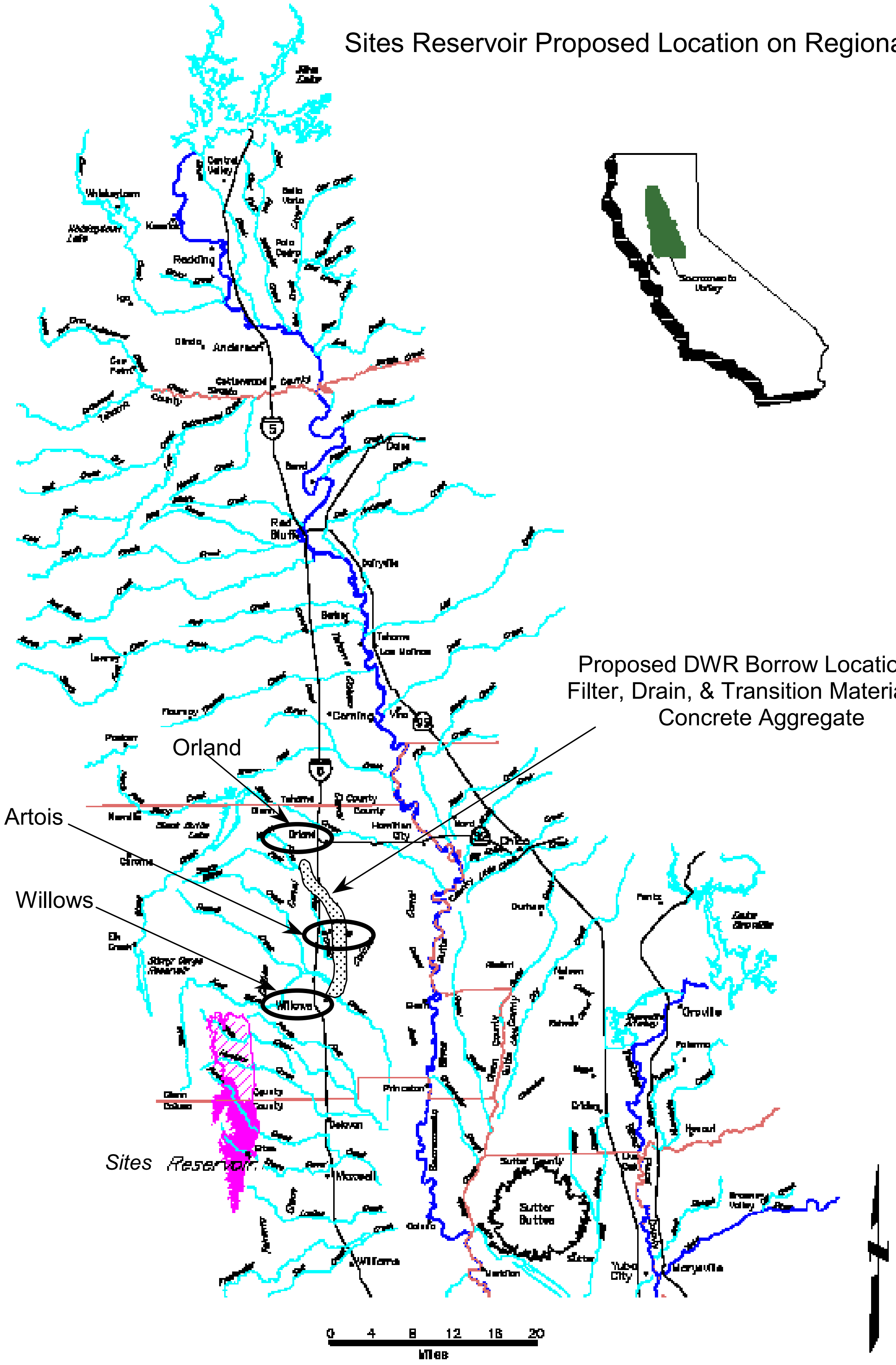


Comparison of Compressive Strength and Friction Angle for Rockfill Materials
Rockfill Dam Data - From ICOLD Bulletin 92

ϕ = 38.5 degrees for weathered sandstone at average compressive strength of 4,998 psi.

Figure 37

Sites Reservoir Proposed Location on Regional Map



Proposed DWR Borrow Location for Filter, Drain, & Transition Material and Concrete Aggregate

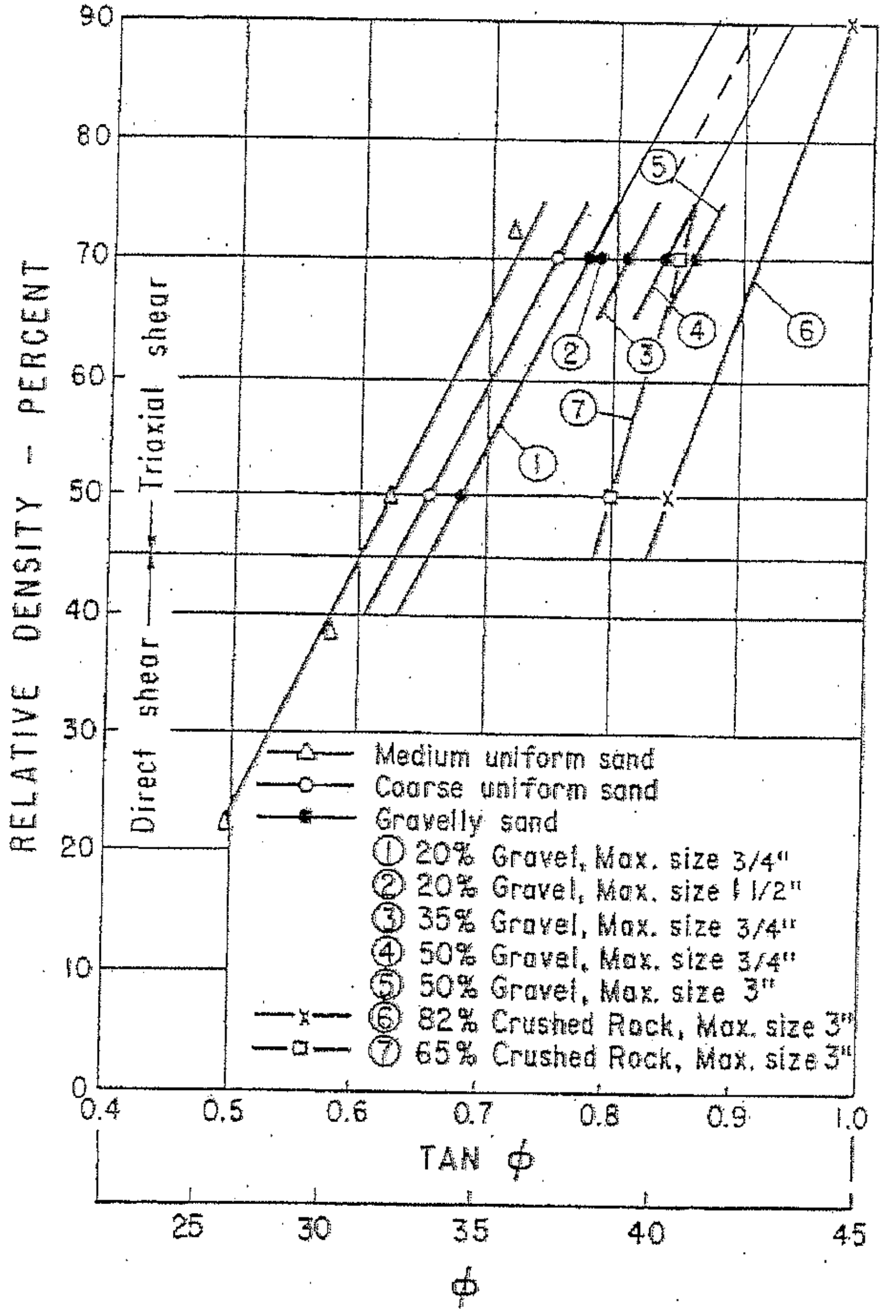
Orland

Artois

Willows

Sites Reservoir

Figure 38



.—Effect of relative density on the coefficient of friction, tan φ, for coarse-grained soils [24, 28].

Figure 39

Figure copied from USBR's Earth Manual, 1998

SITES RESERVOIR

Sites Quarry Aggregates - Fresh

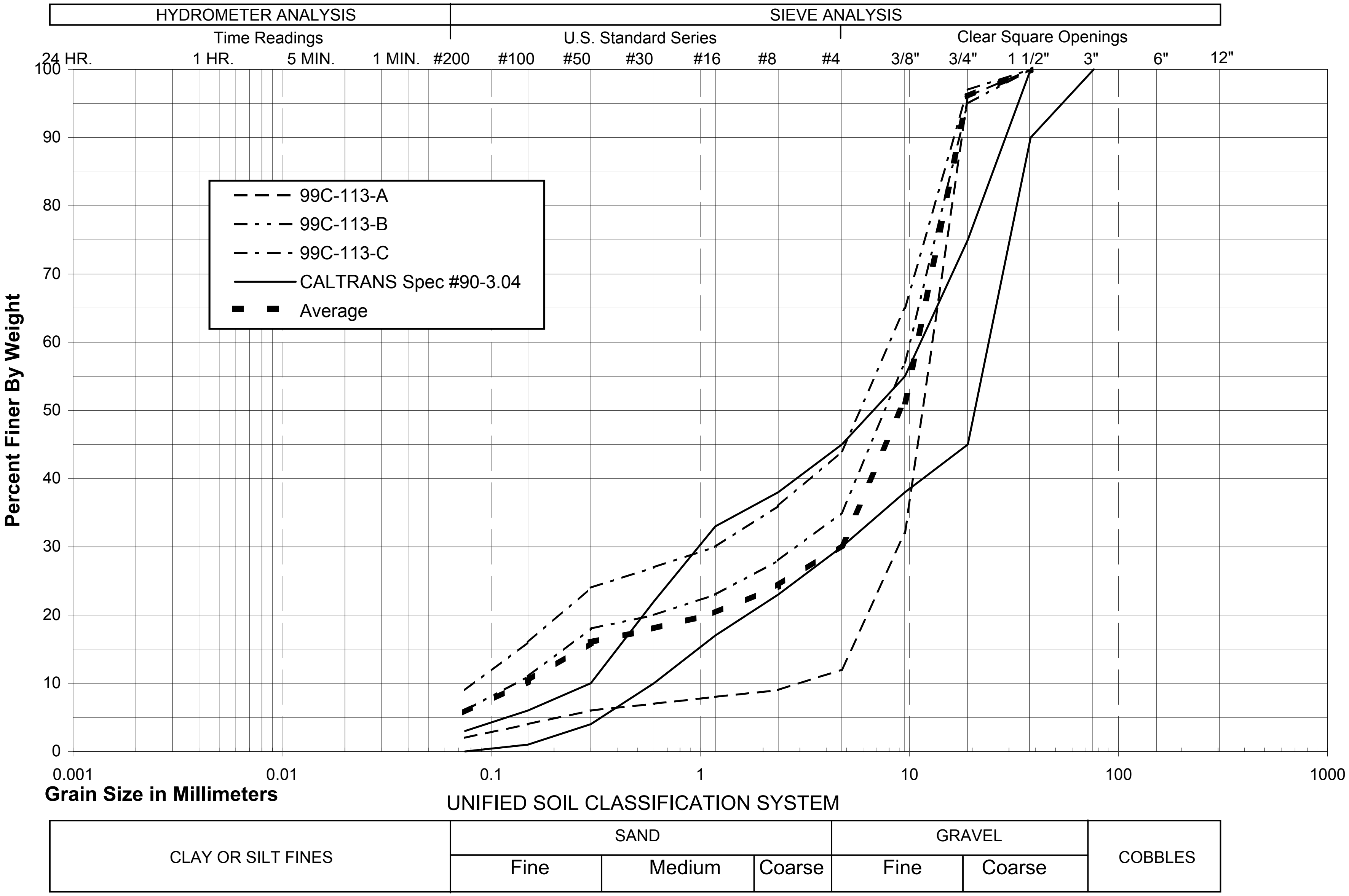


Figure 40

SITES RESERVOIR

Sites Quarry Aggregates - Weathered

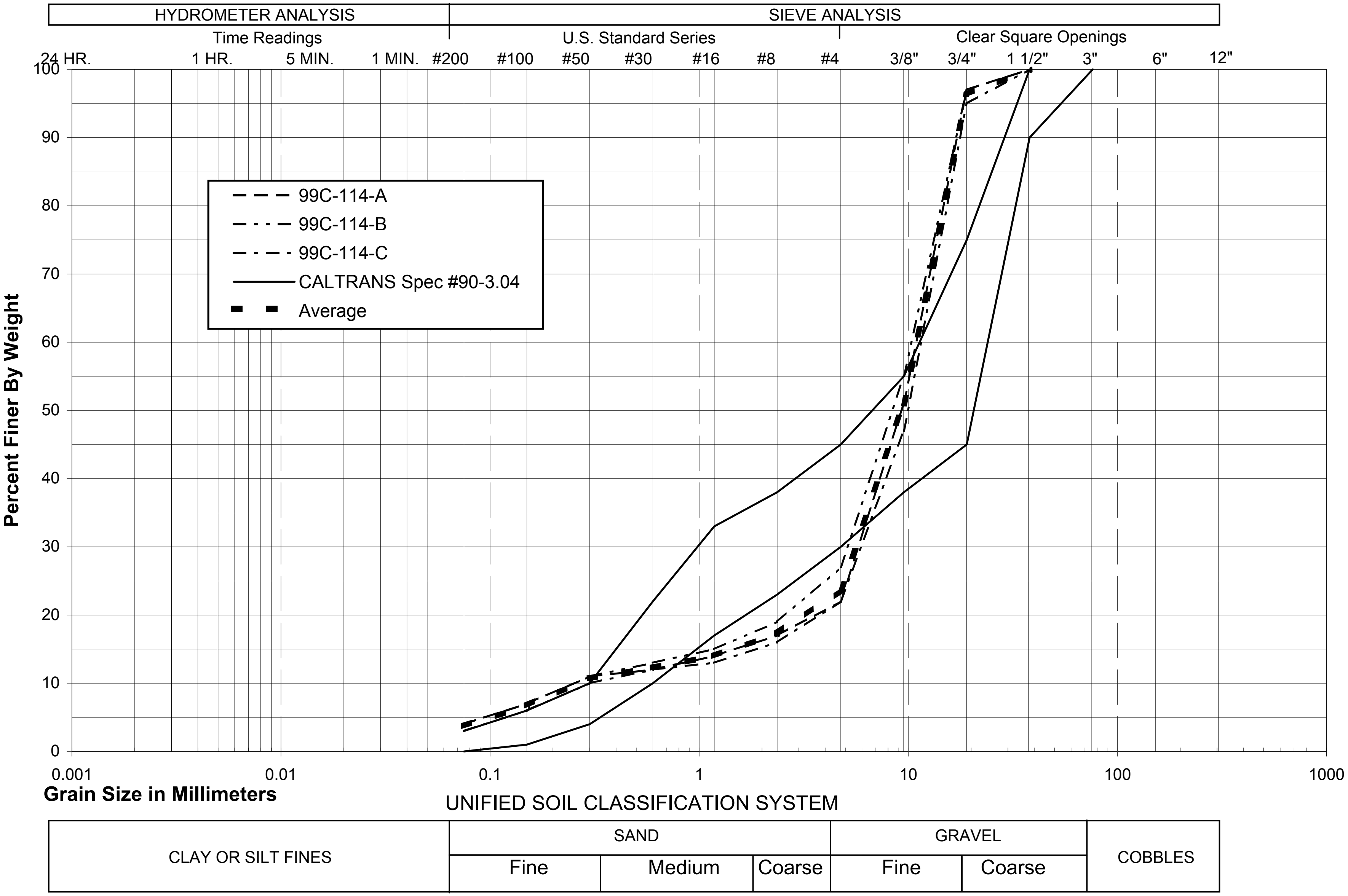


Figure 41

APPENDIX A

IMPERVIOUS MATERIAL
COMPOSITION OF DWR COMPOSITE SAMPLES

Composite Sample SC 99-1420

Composite sample with equal portions of the samples shown in bold (samples not used are: 99-749, 99-750, 99-751, and 99-754).

LAB NO.	HOLE NO.	F.S. NO.	DEPTH (feet)
99-737	**SC-4**	**1**	**5**
99-738		**2**	**10**
99-739		**3**	**15**
99-740	**SC-5**	**1**	**5**
99-741		**2**	**10**
99-742	**SC-6**	**1**	**5**
99-743		**2**	**10**
99-744		**3**	**15**
99-745	**SC-7**	**1**	**5**
99-746		**2**	**10**
99-747	**SC-8**	**1**	**5**
99-748		**2**	**10**
~~99-749~~		~~3~~	~~15~~
~~99-750~~	~~SC-9~~	~~4~~	~~5~~
~~99-751~~		~~2~~	~~10~~
99-752	**SC-10**	**1**	**5**
99-753		**2**	**10**
~~99-754~~		~~3~~	~~15~~

Composite Sample GG 99-1419

Composite sample with equal portions of the samples shown in bold (samples not used are: 99-762, 99-765, 99-767, and 99-768).

LAB NO.	HOLE NO.	F.S. NO.	DEPTH (feet)
99-755	**GG-1**	**1**	**5**
99-756		**2**	**10**
99-757		**3**	**15**
99-758	**GG-2**	**1**	**5**
99-759		**2**	**10**
99-760		**3**	**15**
99-761	**GG-3**	**1**	**5**
~~99-762~~		~~2~~	~~10~~
99-763		**3**	**15**
99-764	**GG-4**	**1**	**4**
~~99-765~~		~~2~~	~~9~~
99-766	**GG-5**	**1**	**5**
~~99-767~~		~~2~~	~~15~~
~~99-768~~	~~GG-6~~	~~4~~	~~3~~
99-769	**GG-7**	**1**	**5**
99-770		**2**	**10**
99-771		**3**	**15**
99-772	**GG-8**	**1**	
99-773		**2**	**8**

APPENDIX B

IMPERVIOUS MATERIAL CLASSIFICATION, GRADATION, ATTERBERG LIMITS, SPECIFIC GRAVITY, AND ORGANIC CONTENT TEST RESULTS FOR DWR SAMPLES

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING BRANCH
DAMS AND CANALS SECTION

PROJECT: Sites Dam

FEATURE: Golden Gate Dam site

				PERCENT FINER																			
				MECHANICAL ANALYSIS											HYDROMETER			ATTERBERG		MOISTURE	PERCENT		
LAB	HOLE	F.S	DEPTH	GRAVEL						SAND					SILT & CLAY			LIMITS		CONTENT	ORGANIC	GROUP	CLASSIFICATION
NO.	NO.	NO.	(feet)	3.0'	1.5"	3/4"	3/8"	4	8	16	30	50	100	200	5m	2m	1m	LL	PI	%		SYMBOL	GROUP NAME
99-755	GG-1	1	5						100	99	99	99	96	87				34	19			CL	Lean clay
99-756		2	10					100	99	98	97	97	96	90				45	28			CL	Lean clay
99-757		3	15					100	97	95	94	93	91	85				41	24			CL	Lean clay with sand
99-758	GG-2	1	5								100	99	96	85				35	19			CL	Lean clay with sand
99-759		2	10							100	99	98	92	77				34	18			CL	Lean clay with sand
99-760		3	15							100	99	98	93	79				33	16			CL	Lean clay with sand
99-761	GG-3	1	5								100	99	95	79				36	19			CL	Lean clay with sand
99-762		2	10					100	94	90	87	81	73	62				32	15			CL	Sandy lean clay
99-763		3	15									100	97	84				33	16			CL	Lean clay with sand
99-764	GG-4	1	4					100	99	98	98	98	96	90				42	25			CL	Lean clay
99-765		2	9									100	99	91				37	22			CL	Lean clay
99-766	GG-5	1	5					100	98	96	95	94	92	89				59	42			CH	Fat clay
99-767		2	15			100	99	99	97	94	89	84	68	55				31	14			CL	Sandy lean clay
99-768	GG-6	1	3					100	99	98	97	97	94	90				52	37			CH	Fat clay
99-769	GG-7	1	5									100	98	86				35	18			CL	Lean clay
99-770		2	10					100	99	99	98	98	96	85				33	16			CL	Lean clay with sand
99-771		3	15					100	99	98	98	98	96	84				30	12			CL	Lean clay with sand
99-772	GG-8	1				100	99	98	96	95	94	93	90	84				54	38			CH	Fat clay with sand
99-773		2	8					100	96	92	91	90	88	87				44	24			CL	Lean clay

93

DATE: 8/17/99
INITIAL:
REQUEST NO.: 99-35

REMARKS:

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING BRANCH
DAMS AND CANALS SECTION

PROJECT: Sites Reservoir

FEATURE: Sites Dam site

			PERCENT FINER																			CLASSIFICATION	
			MECHANICAL ANALYSIS												HYDROMETER			ATTERBERG LIMITS		SPEC. GRAV.	ORG.		
LAB NO.	HOLE NO.	F.S. NO.	GRAVEL					SAND							SILT & CLAY							GROUP SYMBOL	GROUP NAME
			6"	3"	1½"	¾"	⅜"	4	8	16	30	50	100	200	5M	2M	1M	L.L.	P.I.	-#4	%		
98-157	SC-1	1										100	98	93				45	27	2.78	4.7	CL	Lean clay
98-158		2				100	99	99	97	96	95	91	81	70				38	23	2.79	3.6	CL	Sandy lean clay
98-159	SC-2	1								100	99	97	80	61				34	17	--	3.7	CL	Sandy lean clay
98-160		2						100	96	93	92	91	90	87				48	31	--	4.4	CL	Lean clay
98-161	SC-3	1						100	99	97	94	92	90	86				51	35	--	4.9	CH	Fat clay
98-162		2						100	94	89	86	83	81	79				53	34	--	5.0	CH	Fat clay with sand
99-737	SC-4	1	5									100	97	88				35	20			CL	Lean Clay
99-738		2	10					100	99	99	98	98	95	87				39	25			CL	Lean clay
99-739		3	15					100	99	99	98	97	96	94				52	37			CH	Fat clay
99-740	SC-5	1	5						100	99	98	97	96	91				46	31			CL	Lean clay
99-741		2	10					100	99	97	95	94	92	87				57	42			CH	Fat clay
99-742	SC-6	1	5			100	99	99	98	97	96	94	88	80				49	35			CL	Lean clay with sand
99-743		2	10					100	98	97	96	94	89	83				54	38			CH	Fat clay with sand
99-744		3	15			100	98	97	87	82	79	75	68	60				46	30			CL	Sandy lean clay
99-745	SC-7	1	5					100	99	96	94	92	90	88				51	36			CH	Fat clay
99-746		2	10			100	99	99	96	92	87	82	78	73				42	25			CL	Lean clay with sand
99-747	SC-8	1	5		100	99	99	98	96	94	91	87	81	74				43	29			CL	Lean clay with sand
99-748		2	10			100	99	99	96	93	90	85	72	60				40	26			CL	Sandy lean clay
99-749		3	15		100	98	94	91	78	72	68	61	47	38				35	20			SC	Clayey sand
99-750	SC-9	1	5							100	99	99	98	97				72	51			CH	Fat clay
99-751		2	10						100	99	98	98	97	97				66	46			CH	Fat clay
99-752	SC-10	1	5								100	99	95	85				41	24			CL	Lean clay with sand
99-753		2	10					100	99	99	99	99	95	85				41	25			CL	Lean clay with sand
99-754		3	15	100	86	86	80	77	70	67	65	60	53	44				36	21			SC	Clayey sand with gravel

Sheet 1 of 1

DATE: 6/3/98

INITIAL: RGJ

REQUEST NO.: 98-18

REMARKS:

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
DAMS AND CANALS SECTION

PROJECT: Sites Reservoir **FEATURE:** Funks Reservoir Page 1 of 1

				PERCENT FINER																			
				MECHANICAL ANALYSIS											HYDROMETER								
				GRAVEL				SAND							SILT & CLAY							CLASSIFICATION	
LAB. NO.	HOLE NO.	F.S. NO.	DEPTH (feet)	3.0" 75 mm	1.5" 37.5 mm	3/4" 19 mm	3/8" 9.5 mm	4 4.75 mm	8 2.36 mm	16 1.18 mm	30 0.6 mm	50 0.3 mm	100 0.15 mm	200 0.075 mm	5M 0.005 mm	2M 0.002 mm	1M 0.001 mm	ATTERBERG LIMITS L.L.	P.I.	MOISTURE CONTENT %	PERCENT ORGANICS	GROUP SYMBOL	GROUP NAME
2001-44	FR-Aug 7		0-15			100	99	99	97	96	95	93	88	77				41	23			CL	Lean clay with sand
2001-45	FR-Aug 7		15-25		100	98	92	85	73	67	63	56	46	35				29	13			SC	Clayey sand
2001-46	FR-Aug 8		5-20								100	99	96	86				40	23			CL	Lean clay
2001-47	FR-Aug 8		25-35								100	99	95	82				41	25			CL	Lean clay with Sand
2001-48	FR-Aug 9		0-15				100	99	98	98	97	96	91	77				36	19			CL	Lean clay with sand
2001-49	FR-Aug 9		20-30			100	98	97	91	89	87	85	79	68				40	24			CL	Sandy lean clay

DATE: 3/19/01

INITIAL: djn

REQUEST NO.: 2001-08

REMARKS:

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING BRANCH
DAMS AND CANALS SECTION

PROJECT: Sites Reservoir

FEATURE: Composite Samples

Page 1 of 1

				PERCENT FINER																			
				MECHANICAL ANALYSIS											HYDROMETER			ATTERBERG		MOISTURE	PERCENT		
LAB	HOLE	F.S.	DEPTH	GRAVEL				SAND							SILT & CLAY			LIMITS		CONTENT	ORGANICS	GROUP	CLASSIFICATION
NO.	NO.	NO.	(feet)	3.0"	1.5"	3/4"	3/8"	4	8	16	30	50	100	200	5M	2M	1M	L.L.	P.I.	%		SYMBOL	GROUP NAME
99-1419	GG - Samples							100	99	98	97	97	94	83	41	33	27	38	22		3.9	CL	Lean clay w/sand
99-1420	SC - Samples							100	97	96	95	93	89	81	48	38	33	45	30		4.2	CL	Lean clay w/sand

DATE: 9/28/99
INITIAL: dmt
REQUEST NO. 99-51

REMARKS: 99-1419: Specific Gravity - 2.74; Max. Dry Density - 111.8pcf; Opt. Moist. - 17.4%
99-1420: Specific Gravity - 2.74; Max. Dry Density - 110.0pcf; Opt. Moist. - 17.0%

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project ______

Request No. 99-35

Classification ______

Lab No. 99-737

Remarks ______

Date 1/7/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DWT

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				30	22	15	
Container No.		144	V	P15	X	E1	
Wt. Container + Wet Soil, gm	(1)	27.17	29.99	26.67	26.83	26.20	
Wt. Container + Dry Soil, gm	(2)	25.67	28.34	24.62	24.71	24.07	
Wt. Water, Ww, gm (1-2)	(3)	1.50	1.65	2.05	2.12	2.13	
Wt. Container, gm	(4)	15.83	17.57	18.74	18.76	18.28	
Wt. Dry Soil, Ws, gm (2-4)	(5)	9.84	10.77	5.88	5.95	5.79	
Water Content, W, % (3÷5) x 100	(6)	15.2	15.3	34.9	35.6	36.8	

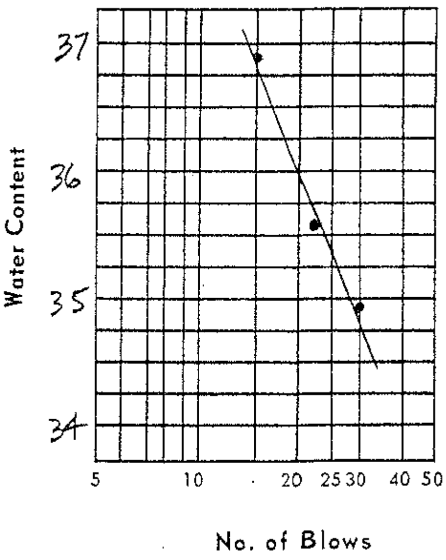
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
15	35	20

Request No. 99-35 Lab No. 99-737

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-738

Remarks

Date 7/9/99

☒ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DWT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			35	26	20	
Container No.	P13	P15	I	146	117	
Wt. Container + Wet Soil, gm (1)	29.68	29.38	24.79	23.93	25.03	
Wt. Container + Dry Soil, gm (2)	28.31	28.07	22.74	21.98	23.03	
Wt. Water, Ww, gm (1-2) (3)	1.37	1.31	2.05	1.95	2.00	
Wt. Container, gm (4)	18.63	18.74	17.31	16.94	18.06	
Wt. Dry Soil, Ws, gm (2-4) (5)	9.68	9.33	5.43	5.04	4.97	
Water Content, W, % (3÷5) x 100 (6)	14.2	14.0	37.8	38.7	40.2	

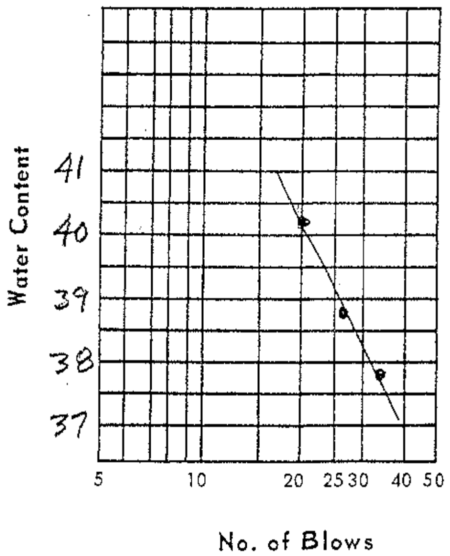
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
14	39	25

Request No. 99-35 Lab No. 99-738

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam
Request No. 99-35
Classification
Lab No. 99-739
Remarks
Date 7/9/99
☑ Air Dried ☐ In Situ ☐ Oven Dried
Tested By DMT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			34	27	23	
Container No.	138	145	S	Y	351	
Wt. Container + Wet Soil, gm (1)	27.50	30.61	25.02	25.80	24.37	
Wt. Container + Dry Soil, gm (2)	26.07	29.30	22.56	23.18	21.91	
Wt. Water, Ww, gm (1-2) (3)	1.43	1.31	2.46	2.62	2.46	
Wt. Container, gm (4)	16.53	20.51	17.62	18.05	17.22	
Wt. Dry Soil, Ws, gm (2-4) (5)	9.54	8.79	4.94	5.13	4.69	
Water Content, W, % (3÷5) x 100 (6)	15.0	14.9	49.8	51.1	52.5	

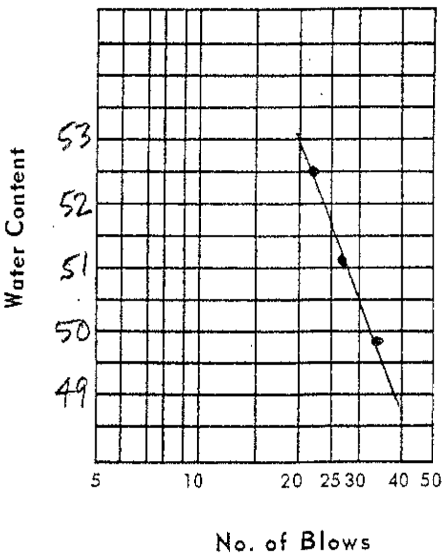
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
15	52	37

Request No. 99-35 Lab No. 99-739

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-740

Remarks

Date 7/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DMT

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				28	20	15	
Container No.		P15	R1	119	138	117	
Wt. Container + Wet Soil, gm	(1)	27.85	28.29	26.86	22.97	25.63	
Wt. Container + Dry Soil, gm	(2)	26.69	27.05	24.38	20.93	23.18	
Wt. Water, Ww, gm (1-2)	(3)	1.16	1.24	2.48	2.04	2.45	
Wt. Container, gm	(4)	18.74	18.66	18.89	16.54	18.06	
Wt. Dry Soil, Ws, gm (2-4)	(5)	7.95	8.39	5.49	4.39	5.12	
Water Content, W, % (3÷5) x 100	(6)	14.6	14.8	45.2	46.5	47.9	

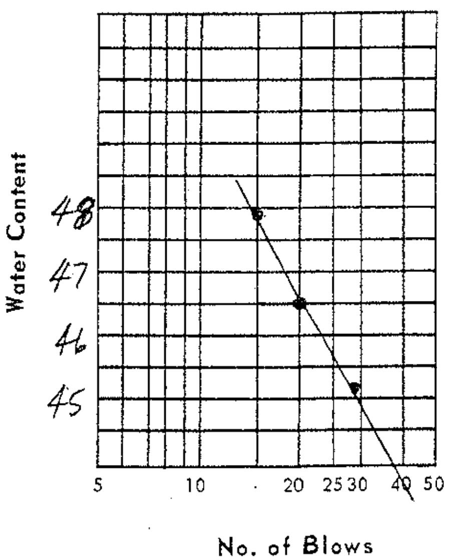
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8)-(9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
15	46	31

Request No. 99-35 Lab No. 99-740

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-741

Remarks

Date 7/12/99

☒ Air Dried ☐ In Situ ☐ Oven Dried

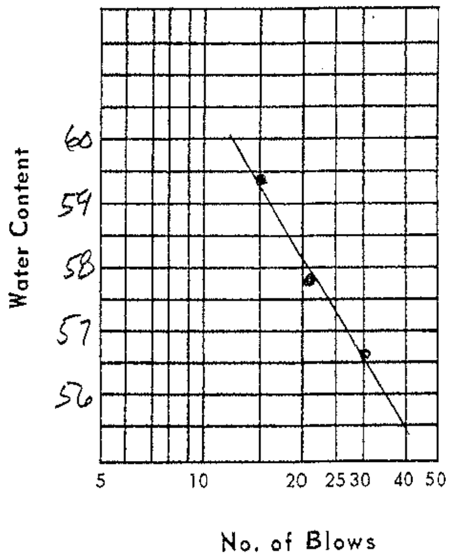
Tested By DMT

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				30	21	15	
Container No.		145	J1	V1	200	I	
Wt. Container + Wet Soil, gm	(1)	30.83	27.39	25.57	24.67	24.58	
Wt. Container + Dry Soil, gm	(2)	29.46	26.18	23.21	21.90	21.87	
Wt. Water, Ww, gm (1-2)	(3)	1.37	1.21	2.36	2.77	2.71	
Wt. Container, gm	(4)	20.52	18.18	19.04	17.11	17.31	
Wt. Dry Soil, Ws, gm (2-4)	(5)	8.94	8.00	4.17	4.79	4.56	
Water Content, W, % (3÷5) x 100	(6)	15.3	15.1	56.6	57.8	59.4	

SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
15	57	42

Request No. 99-35 Lab No. 99-741

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-742

Remarks

Date 7/14/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DWT

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				31	22	18	
Container No.		351	146	142	V	145	
Wt. Container + Wet Soil, gm	(1)	25.51	25.81	27.36	25.49	27.04	
Wt. Container + Dry Soil, gm	(2)	24.51	24.75	25.04	22.86	24.84	
Wt. Water, Ww, gm (1-2)	(3)	1.00	1.06	2.32	2.63	2.20	
Wt. Container, gm	(4)	17.22	16.94	20.17	17.57	20.51	
Wt. Dry Soil, Ws, gm (2-4)	(5)	7.29	7.81	4.87	5.29	4.33	
Water Content, W, % (3÷5) x 100	(6)	13.7	13.6	47.6	49.7	50.8	

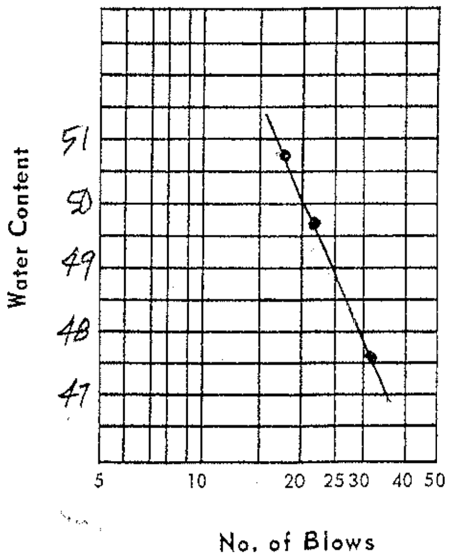
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
14	49	35

Request No. 99-35 Lab No. 99-742

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-743

Remarks

Date 7/15/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DMT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			32	22	15	
Container No.	J1	117	R1	P15	115	
Wt. Container + Wet Soil, gm (1)	26.02	27.49	25.02	26.26	25.54	
Wt. Container + Dry Soil, gm (2)	24.94	26.17	22.83	23.62	23.10	
Wt. Water, Ww, gm (1-2) (3)	1.08	1.32	2.19	2.64	2.44	
Wt. Container, gm (4)	18.19	18.06	18.67	18.74	18.70	
Wt. Dry Soil, Ws, gm (2-4) (5)	6.75	8.11	4.16	4.88	4.40	
Water Content, W, % (3÷5) x 100 (6)	16.0	16.3	52.6	54.1	55.5	

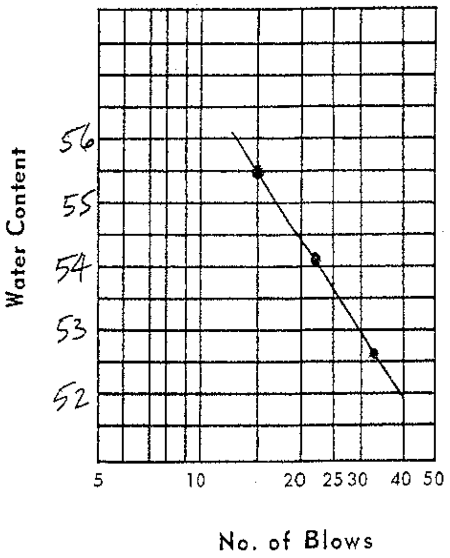
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
16	54	38

Request No. 99-35 Lab No. 99-743

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-744

Remarks

Date 7/15/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

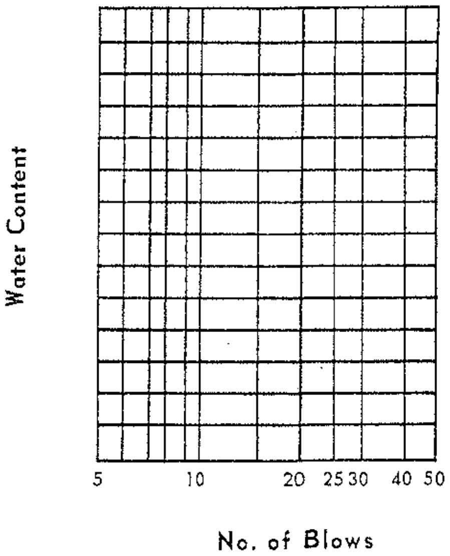
Tested By DMT

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				25			
Container No.		144	S	145	~~143~~	~~E1~~	
Wt. Container + Wet Soil, gm	(1)	24.32	26.09	28.55			
Wt. Container + Dry Soil, gm	(2)	23.15	24.93	26.04			
Wt. Water, Ww, gm (1-2)	(3)	1.17	1.16	2.51			
Wt. Container, gm	(4)	15.84	17.62	20.52	~~14.91~~	~~18.28~~	
Wt. Dry Soil, Ws, gm (2-4)	(5)	7.31	7.31	5.52			
Water Content, W, % (3÷5) x 100	(6)	16.0	15.9	45.5			

SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9x\gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
16	46	30

Request No. 99-35 Lab No. 99-744

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam
Request No. 99-35
Classification
Lab No. 99-745
Remarks
Date 7/15/99
☑ Air Dried ☐ In Situ ☐ Oven Dried
Tested By DMT

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				31	26	21	
Container No.		143	E1	203	146	138	
Wt. Container + Wet Soil, gm	(1)	23.51	25.78	24.96	24.39	24.67	
Wt. Container + Dry Soil, gm	(2)	22.38	24.82	22.35	21.87	21.89	
Wt. Water, Ww, gm (1-2)	(3)	1.13	.96	2.61	2.52	2.78	
Wt. Container, gm	(4)	14.91	18.28	17.12	16.94	16.54	
Wt. Dry Soil, Ws, gm (2-4)	(5)	7.47	6.54	5.23	4.93	5.35	
Water Content, W, % (3÷5) x 100	(6)	15.1	14.7	49.9	51.1	52.0	

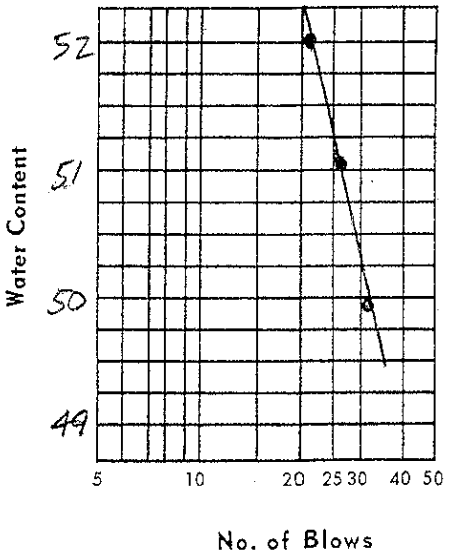
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
15	51	36

Request No. 99-35 Lab No. 99-745

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-746

Remarks

Date 7/23/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DMT

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				25			
Container No.		P13	V1	E1	~~143~~	~~19~~	
Wt. Container + Wet Soil, gm	(1)	27.38	29.08	26.34			
Wt. Container + Dry Soil, gm	(2)	26.14	27.66	23.95			
Wt. Water, Ww, gm (1-2)	(3)	1.24	1.42	2.39			
Wt. Container, gm	(4)	18.63	19.04	18.28	~~14.91~~	~~18.90~~	
Wt. Dry Soil, Ws, gm (2-4)	(5)	7.51	8.62	5.67			
Water Content, W, % (3÷5) x 100	(6)	16.5	16.5	42.2			

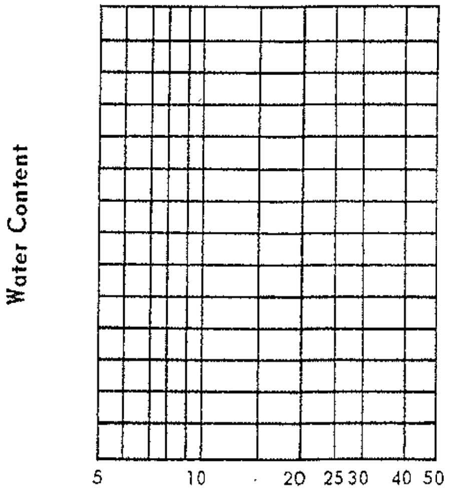
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8)-(9\times\gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



No. of Blows

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	42	25

Request No. 99-35 Lab No. 99-746

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-747

Remarks

Date 7/26/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

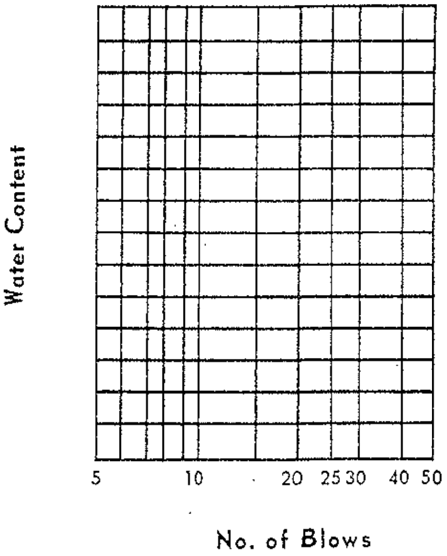
Tested By DWJ

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				25			
Container No.		146	I	P15	~~V~~	~~N5~~	
Wt. Container + Wet Soil, gm	(1)	25.91	25.78	26.53			
Wt. Container + Dry Soil, gm	(2)	24.78	24.72	24.19			
Wt. Water, Ww, gm (1-2)	(3)	1.13	1.06	2.34			
Wt. Container, gm	(4)	16.94	17.31	18.74	~~17.58~~	~~18.70~~	
Wt. Dry Soil, Ws, gm (2-4)	(5)	7.84	7.41	5.45			
Water Content, W, % (3÷5) x 100	(6)	14.4	14.3	42.9			

SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
14	43	29

Request No. 99-35 Lab No. 99-747

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam
Request No. 99-35
Classification
Lab No. 99-748
Remarks
Date 7/23/99
☑ Air Dried ☐ In Situ ☐ Oven Dried
Tested By DWT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			29	24	18	
Container No.	J1	351	141	143	119	
Wt. Container + Wet Soil, gm (1)	27.48	26.08	24.98	24.05	25.60	
Wt. Container + Dry Soil, gm (2)	26.33	25.01	22.78	21.44	23.64	
Wt. Water, Ww, gm (1-2) (3)	1.15	1.07	2.20	2.61	1.96	
Wt. Container, gm (4)	18.18	17.22	17.11	14.91	18.89	
Wt. Dry Soil, Ws, gm (2-4) (5)	8.15	7.79	5.67	6.53	4.75	
Water Content, W, % (3÷5) x 100 (6)	14.1	13.7	38.8	40.0	41.3	

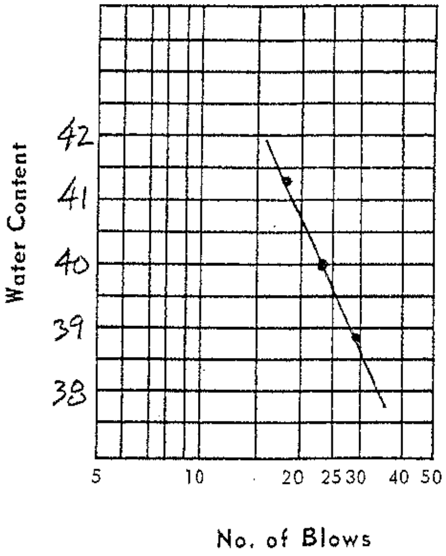
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
14	40	26

Request No. 99-35 Lab No. 99-748

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES
Request No. 99-35
Classification
Lab No. 99-749
Remarks
Date 7-29-99

☐ Air Dried ☐ In Situ ☒ Oven Dried

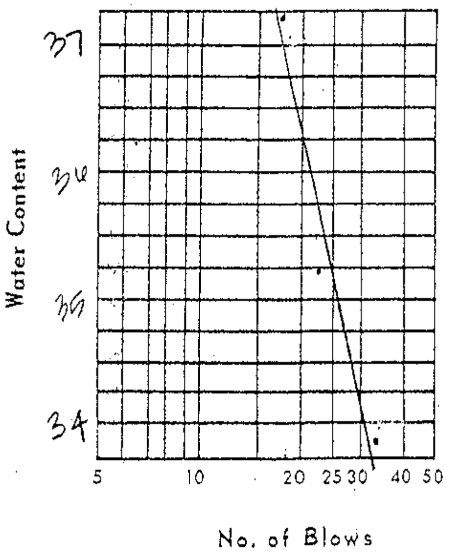
Tested By

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			35	17	23	
Container No.	V	VI	138	141	140	
Wt. Container + Wet Soil, gm (1)	25.37	25.85	26.44	25.76	26.02	
Wt. Container + Dry Soil, gm (2)	24.35	25.00	23.93	23.41	23.61	
Wt. Water, Ww, gm (1-2) (3)	1.02	0.85	2.51	2.35	2.41	
Wt. Container, gm (4)	17.57	19.05	16.53	17.11	16.77	
Wt. Dry Soil, Ws, gm (2-4) (5)	6.78	5.95	7.40	6.30	6.84	
Water Content, W, % (3÷5) x 100 (6)	15.0%	14.3%	33.9	37.3	35.2	

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
15	35	20

Request No. 99-35 Lab No. 99-749

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-750

Remarks

Date 7/29/99

☒ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DM

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			32	29	22	19
Container No.	Z	00	M1	E1	X	S
Wt. Container + Wet Soil, gm (1)	25.41	25.45	25.22	24.98	25.77	25.23
Wt. Container + Dry Soil, gm (2)	24.29	24.57	22.47	22.19	22.81	22.00
Wt. Water, Ww, gm (1-2) (3)	1.12	.88	2.75	2.79	2.96	3.23
Wt. Container, gm (4)	19.04	20.32	18.54	18.28	18.76	17.62
Wt. Dry Soil, Ws, gm (2-4) (5)	5.25	4.25	3.93	3.91	4.05	4.38
Water Content, W, % (3÷5) x 100 (6)	21.3	20.7	70.0	71.3	73.1	73.7

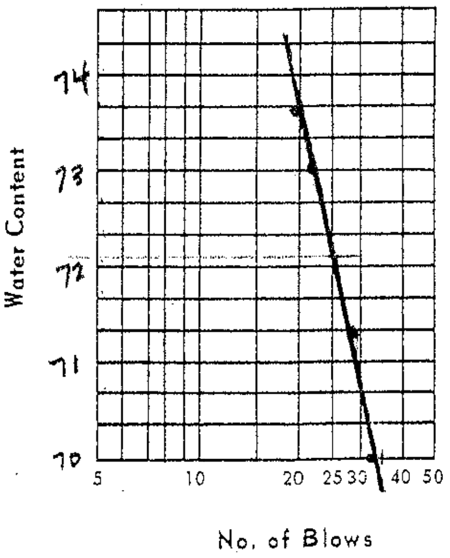
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, W_s, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
$V_2^* = C \div$ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
21	72	51

Request No. 99-35 Lab No. 99-750

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-751

Remarks

Date 8/10/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DMT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows	☒	☒	29	23	15	
Container No.	5	142	200	119	144	
Wt. Container + Wet Soil, gm (1)	26.13	27.48	25.75	27.56	23.61	
Wt. Container + Dry Soil, gm (2)	24.72	26.27	22.37	24.10	20.43	
Wt. Water, Ww, gm (1-2) (3)	1.41	1.21	3.38	3.46	3.18	
Wt. Container, gm (4)	17.62	20.17	17.11	18.89	15.83	
Wt. Dry Soil, Ws, gm (2-4) (5)	7.10	6.1	5.26	5.21	4.60	
Water Content, W, % (3÷5) x 100 (6)	19.9	19.8	64.3	66.4	69.1	

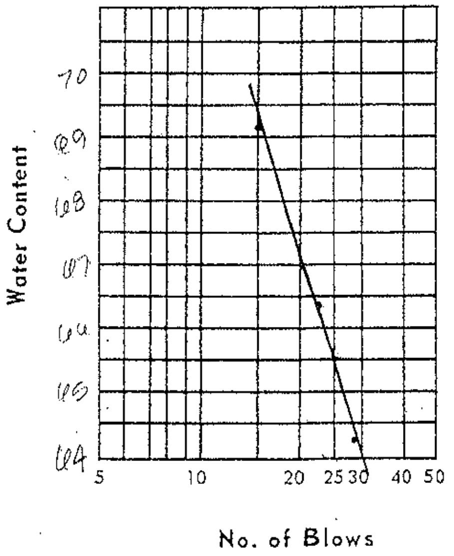
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

(CH)

Plastic Limit	Liquid Limit	Plasticity Index
20	66	46

Request No. 99-35 Lab No. 99-751

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES DAM

Request No. 99-35

Classification

Lab No. 99-752

Remarks

Date 8/10/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows	☒	☒	35	21	16	
Container No.	#140	#48	#138	#351	#143	
Wt. Container + Wet Soil, gm (1)	24.89	28.15	28.71	29.53	25.40	
Wt. Container + Dry Soil, gm (2)	23.71	26.78	25.24	25.91	22.27	
Wt. Water, Ww, gm (1-2) (3)	1.18	1.37	3.47	3.62	3.13	
Wt. Container, gm (4)	16.78	18.81	16.53	17.21	14.91	
Wt. Dry Soil, Ws, gm (2-4) (5)	6.93	7.97	8.71	8.70	7.36	
Water Content, W, % (3÷5) x 100 (6)	17.0	17.2	39.8	41.6	42.5	

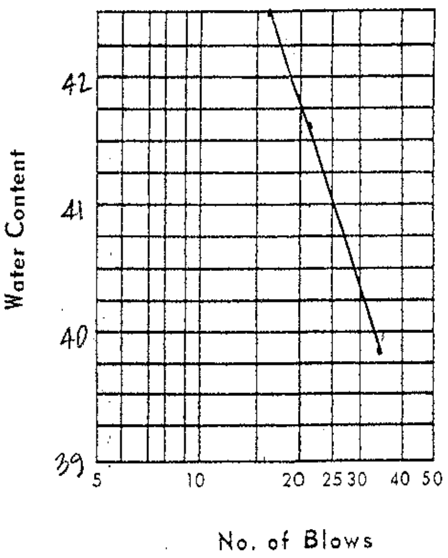
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	41	24

Request No. 99-35 Lab No. 99-752

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES DAM
Request No. 99-35
Classification
Lab No. 99-753
Remarks
Date 8/10/99
Tested By

☒ Air Dried ☐ In Situ ☐ Oven Dried

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			33	20	15	
Container No.	J1	V1	X	P13	E1	
Wt. Container + Wet Soil, gm (1)	23.69	25.24	30.38	30.80	30.87	
Wt. Container + Dry Soil, gm (2)	22.92	24.39	27.06	27.22	27.09	
Wt. Water, Ww, gm (1-2) (3)	0.77	0.85	3.32	3.58	3.78	
Wt. Container, gm (4)	18.19	19.05	18.77	18.64	18.29	
Wt. Dry Soil, Ws, gm (2-4) (5)	4.73	5.34	8.29	8.58	8.80	
Water Content, W, % (3÷5) x 100 (6)	16.3	15.9	40.0	41.7	43.0	

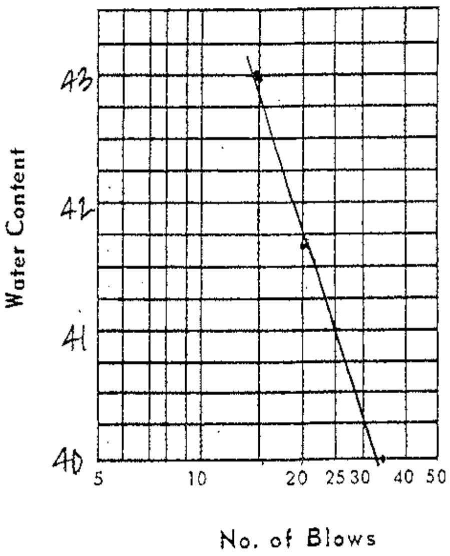
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
16	41	25

Request No. 99-35 Lab No. 99-753

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam
Request No. 99-35

Classification
Lab No. 99-754

Remarks
Date 8/10/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

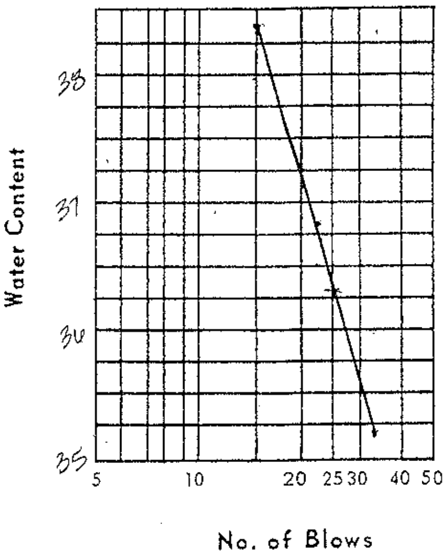
Tested By DMT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows	☒	☒	32	23	15	
Container No.	143-1	59	V	131	115	
Wt. Container + Wet Soil, gm (1)	30.89	29.44	25.86	26.55	27.59	
Wt. Container + Dry Soil, gm (2)	29.59	28.07	23.70	24.05	25.13	
Wt. Water, Ww, gm (1-2) (3)	1.30	1.37	2.16	2.5	2.46	
Wt. Container, gm (4)	20.70	18.61	17.57	17.25	18.70	
Wt. Dry Soil, Ws, gm (2-4) (5)	8.89	9.46	6.13	6.80	6.43	
Water Content, W, % (3÷5) x 100 (6)	14.6	14.5	35.2	36.8	38.3	

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, W_s, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (6÷7) (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
15	36	21

Request No. 99-35 Lab No. 99-754

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-755

Remarks

Date 8/10/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

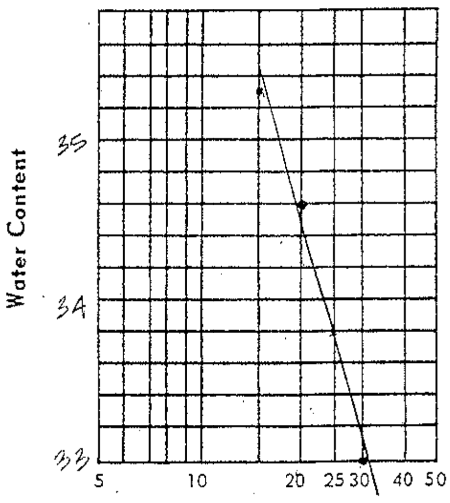
Tested By DMT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows	☒	☒	30	20	15	
Container No.	145	146	203	Y	117	
Wt. Container + Wet Soil, gm (1)	28.95	26.56	25.47	26.49	26.00	
Wt. Container + Dry Soil, gm (2)	27.84	25.29	23.40	24.32	23.93	
Wt. Water, Ww, gm (1-2) (3)	1.11	1.27	2.07	2.17	2.07	
Wt. Container, gm (4)	20.51	16.94	17.12	18.05	18.06	
Wt. Dry Soil, Ws, gm (2-4) (5)	7.33	8.35	6.28	6.27	5.87	
Water Content, W, % (3÷5) x 100 (6)	15.1	15.2	33.0	34.6	35.3	

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



No. of Blows

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

(CL)

Plastic Limit	Liquid Limit	Plasticity Index
15	34	19

Request No. 99-35 Lab No. 99-755

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites DAM
Request No. 99-35
Classification
Lab No. 99-756
Remarks
Date 7-28-99

☐ Air Dried ☐ In Situ ☐ Oven Dried

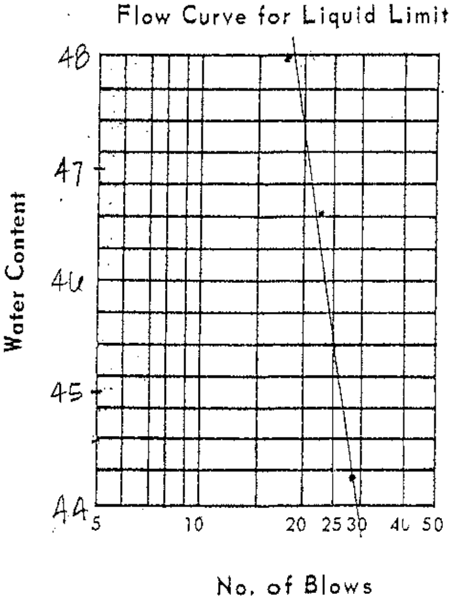
Tested By

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			~~38~~	29	18	24
Container No.			~~142~~	145	117	119
Wt. Container + Wet Soil, gm (1)			~~28.19~~	27.85	26.49	25.34
Wt. Container + Dry Soil, gm (2)				25.60	23.76	23.29
Wt. Water, Ww, gm (1-2) (3)				2.25	2.75	2.05
Wt. Container, gm (4)			~~20.17~~	20.51	18.07	18.89
Wt. Dry Soil, Ws, gm (2-4) (5)				5.09	5.69	4.4
Water Content, W, % (3÷5) x 100 (6)				44.2	48.0	46.6

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	45	28

Request No. 99-35 Lab No. 99-756

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project

Request No. 99-35

Classification

Lab No. 99-756

Remarks

Date 7-26-99

☐ Air Dried ☐ In Situ ☒ Oven Dried

Tested By

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			22	30	16	
Container No.	Y	203	C	D	E	
Wt. Container + Wet Soil, gm (1)	22.95	23.89	26.10	25.51	25.33	
Wt. Container + Dry Soil, gm (2)	22.22	22.90	22.72	22.49	22.22	
Wt. Water, Ww, gm (1-2) (3)	0.73	0.99	3.38	3.02	3.11	
Wt. Container, gm (4)	18.05	17.12	15.55	15.97	15.59	
Wt. Dry Soil, Ws, gm (2-4) (5)	4.17	5.78	7.17	6.52	6.63	
Water Content, W, % (3÷5) x 100 (6)	17.5%	17.1%	47.1%	46.3%	46.9%	

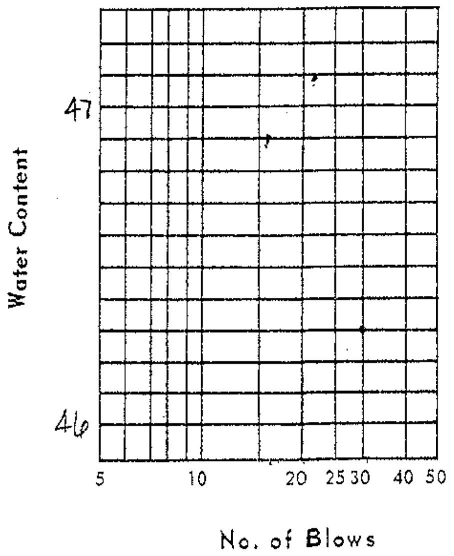
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

Plastic Limit	Liquid Limit	Plasticity Index

Request No. Lab No.

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

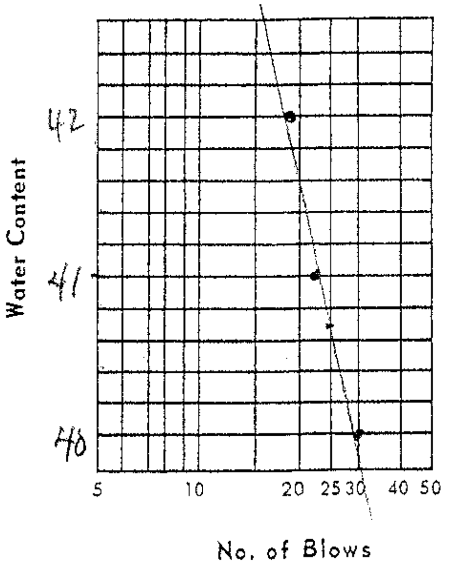
Project SHCS
Request No. 99-35
Classification
Lab No. 99-757
Remarks
Date 8/11/99
☑ Air Dried ☐ In Situ ☐ Oven Dried
Tested By DY

		PLASTIC LIMIT		LIQUID LIMIT ✓			
Determination No.		1	2	1	2	3	4
No. of Blows				30	23	19	
Container No.		140	144	351	200	119	
Wt. Container + Wet Soil, gm	(1)	26.98	25.90	26.95	26.39	28.12	
Wt. Container + Dry Soil, gm	(2)	25.56	24.44	24.17	23.69	25.39	
Wt. Water, Ww, gm (1-2)	(3)						
Wt. Container, gm	(4)	16.77	15.84	17.22	17.11	18.89	
Wt. Dry Soil, Ws, gm (2-4)	(5)						
Water Content, W, % (3÷5) x 100	(6)	16.2	17.0	40	41	42	

SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	41	24

Request No. 99-35 Lab No. 99-757

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES DAM

Request No. 99-35

Classification

Lab No. 99-758

Remarks

Date 8/11/99

☒ Air Dried ☐ In Situ ☐ Oven Dried

Tested By

PLASTIC LIMIT / LIQUID LIMIT ✓

		Plastic Limit 1	Plastic Limit 2	Liquid Limit 1	Liquid Limit 2	Liquid Limit 3	Liquid Limit 4
Determination No.		1	2	1	2	3	4
No. of Blows		╳	╳	27	23	19	
Container No.		Z	V	S	R1	H	
Wt. Container + Wet Soil, gm	(1)	28.93	26.61	27.76	28.72	29.24	
Wt. Container + Dry Soil, gm	(2)	27.54	25.34	25.13	26.06	26.62	
Wt. Water, Ww, gm (1-2)	(3)						
Wt. Container, gm	(4)	19.04	17.57	17.62	18.67	19.50	
Wt. Dry Soil, Ws, gm (2-4)	(5)						
Water Content, W, % (3÷5) x 100	(6)	16.4	16.3	35.0	36.0	36.8	

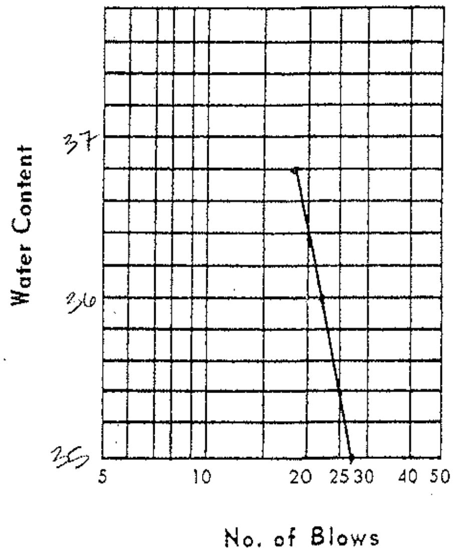
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
16	35	19

Request No. 99-35 Lab No. 99-758

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES DAM

Request No. 99-35

Classification

Lab No. 99-759

Remarks

Date 8/10/99

☒ Air Dried ☐ In Situ ☐ Oven Dried

Tested By

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows	☒	☒	33	24	17	
Container No.	R1	Z	I	U1	H	
Wt. Container + Wet Soil, gm (1)	29.33	28.67	29.33	29.72	30.90	
Wt. Container + Dry Soil, gm (2)	27.85	27.34	26.32	26.86	27.90	
Wt. Water, Ww, gm (1-2) (3)	1.48	1.33	3.01	2.86	3.00	
Wt. Container, gm (4)	18.67	19.03	17.31	18.54	19.51	
Wt. Dry Soil, Ws, gm (2-4) (5)	9.18	8.31	9.01	8.32	8.31	
Water Content, W, % (3÷5) x 100 (6)	16.1	16.0	33.4	34.4	35.8	

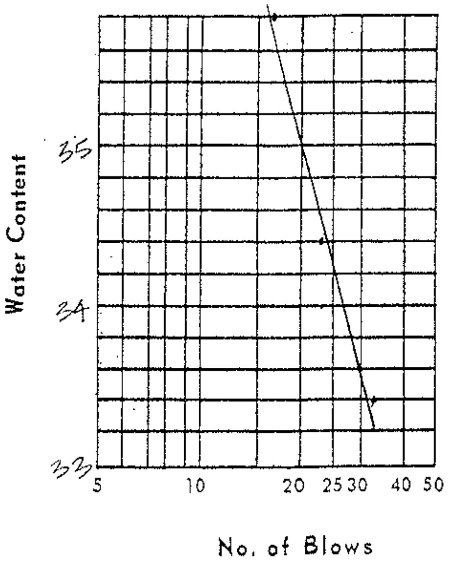
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, W_s, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
16	34	18

Request No. 99-35 Lab No. 99-759

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project S/TB

Request No. 99-35

Classification

Lab No. 99-760

Remarks

Date 8/11/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

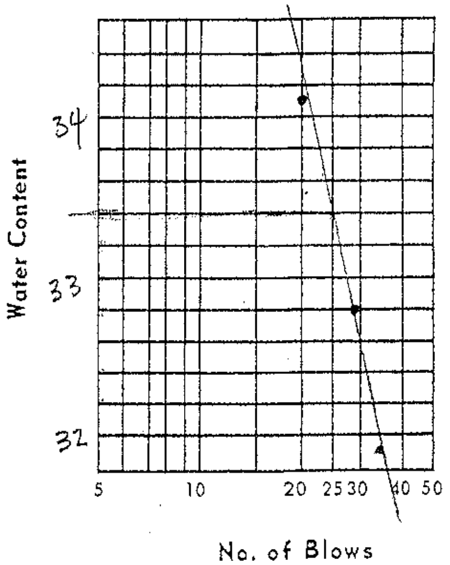
Tested By DY

	PLASTIC LIMIT		LIQUID LIMIT ✓			
Determination No.	1	2	1	2	3	4
No. of Blows	☒	☒	34	29	20	
Container No.	142	203	143-1	115	59	
Wt. Container + Wet Soil, gm (1)	26.96	23.90	30.23	25.70	26.48	
Wt. Container + Dry Soil, gm (2)	25.97	22.96	27.93	23.97	24.48	
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	20.17	17.13	20.71	18.70	18.61	
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	17.1	16.1	31.9	32.8	34.1	

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	33	16

Request No. 99-35 Lab No. 99-760

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES DAM
Request No. 99-35
Classification
Lab No. 99-761
Remarks
Date 8/11/99
Tested By

☒ Air Dried ☐ In Situ ☐ Oven Dried

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				29	24	20	
Container No.		U1	P3	E1	V1	P13	
Wt. Container + Wet Soil, gm	(1)	30.26	33.66	28.03	29.86	27.70	
Wt. Container + Dry Soil, gm	(2)	28.61	31.37	25.51	27.0	25.24	
Wt. Water, Ww, gm (1-2)	(3)						
Wt. Container, gm	(4)	18.55	17.82	18.28	19.04	18.64	
Wt. Dry Soil, Ws, gm (2-4)	(5)						
Water Content, W, % (3÷5) x 100	(6)	16.4	16.9	34.9	35.9	37.3	

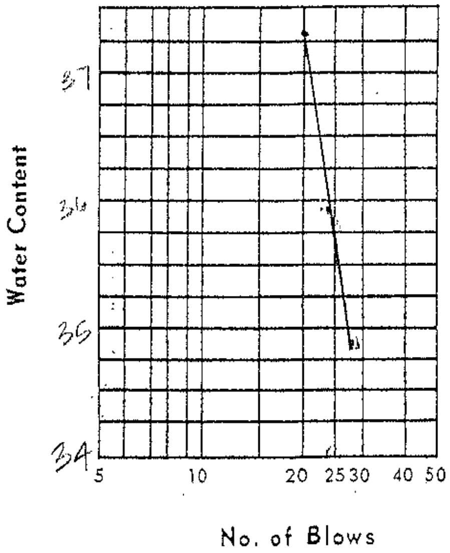
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	36	19

Request No. 99-35 Lab No. 99-761

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam
Request No. 99-35
Classification
Lab No. 99-762
Remarks
Date 8/11/99
Tested By DM

☑ Air Dried ☐ In Situ ☐ Oven Dried

	PLASTIC LIMIT		LIQUID LIMIT ✓			
Determination No.	1	2	1	2	3	4
No. of Blows			34	22	15	
Container No.	117	X	143	145	I	
Wt. Container + Wet Soil, gm (1)	30.33	30.56	24.67	30.73	27.05	
Wt. Container + Dry Soil, gm (2)	28.55	28.88	22.36	28.22	24.58	
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	18.06	18.76	14.91	20.52	17.31	
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	17.0	16.6	31.0	32.6	34.0	

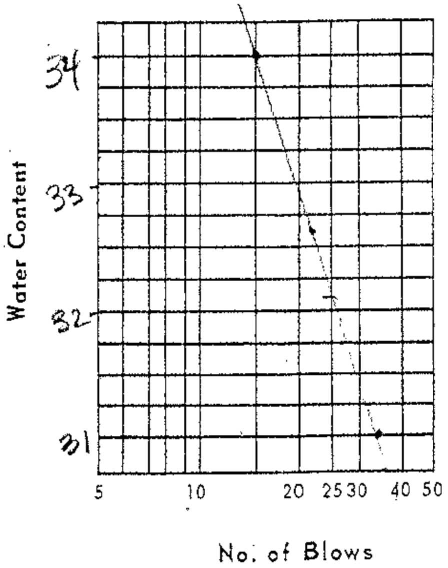
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

ⓐ

Plastic Limit	Liquid Limit	Plasticity Index
17	32	15

Request No. 99-35 Lab No. 99-762

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services O
LABORATORIES BRA
SOILS LABORATOR

ATTERBERG LIMITS

Project Sites

Request No. 99-35

Classification

Lab No. 99-763

Remarks

Date 8/11/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DY

		PLASTIC LIMIT		LIQUID LIMIT ✓		
Determination No.		1	2	1	2	3	4
No. of Blows				33	26	15	
Container No.		J1	Y	131	138	00	
Wt. Container + Wet Soil, gm	(1)	25.14	24.29	26.55	26.54	28.53	
Wt. Container + Dry Soil, gm	(2)	24.15	23.39	24.33	24.08	26.34	
Wt. Water, Ww, gm (1-2)	(3)	.99	.9				
Wt. Container, gm	(4)	18.18	18.05	17.25	16.53	20.33	
Wt. Dry Soil, Ws, gm (2-4)	(5)	5.97	1.30				
Water Content, W, % (3÷5) x 100	(6)	16.6	16.9	31.4	32.6	36.4	

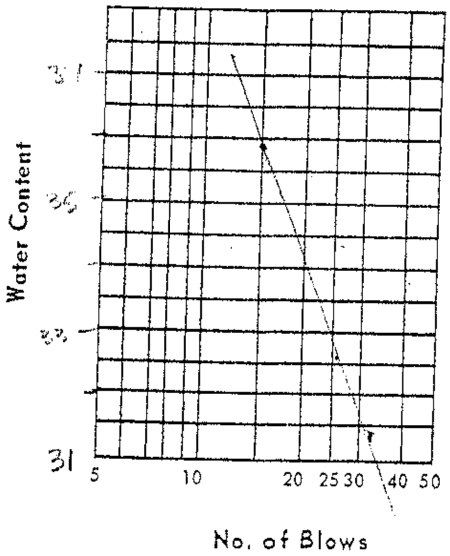
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	33	16

Request No. 99-35 Lab No. 99-763

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES DAN

Request No. 99-35

Classification

Lab No. 99-764

Remarks

Date 8/11/98

☒ Air Dried ☐ In Situ ☐ Oven Dried

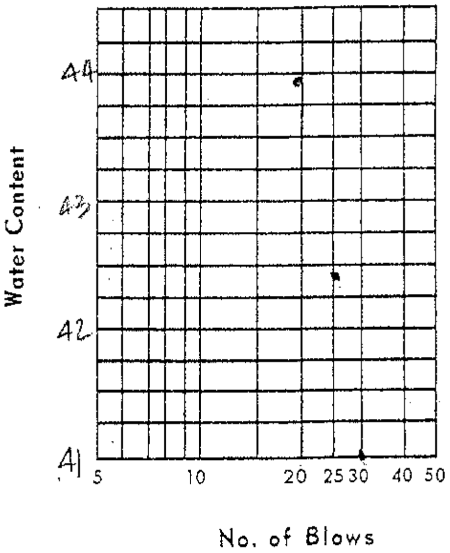
Tested By

	PLASTIC LIMIT		LIQUID LIMIT ✓			
Determination No.	1	2	1	2	3	4
No. of Blows			30	25	19	
Container No.	E	P15	#141	#40	#146	
Wt. Container + Wet Soil, gm (1)	26.02	25.33	26.91	27.28	25.62	
Wt. Container + Dry Soil, gm (2)	24.46	24.36	24.06	24.76	22.97	
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	15.60	18.75	17.11	18.81	16.94	
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	17.6	17.3	41.0	42.4	43.9	

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	42	25

Request No. 99-35 Lab No. 99-764

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-765

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

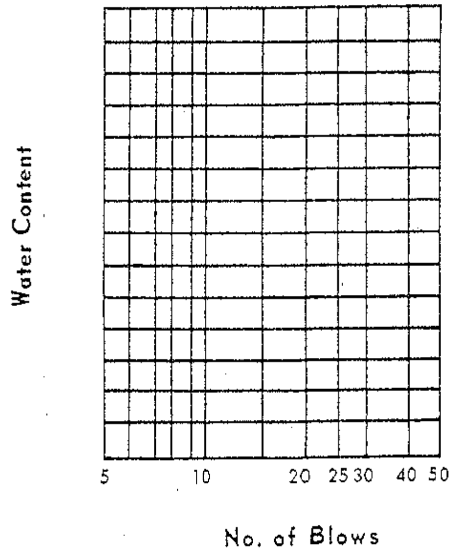
Tested By DMJ

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				25			
Container No.		131	143-1	115	~~J1~~	~~142~~	
Wt. Container + Wet Soil, gm	(1)	27.13	29.86	27.18			
Wt. Container + Dry Soil, gm	(2)	25.81	28.65	24.89			
Wt. Water, Ww, gm (1-2)	(3)	1.32	1.21	2.29			
Wt. Container, gm	(4)	17.25	20.71	18.70	~~18.18~~	~~20.17~~	
Wt. Dry Soil, Ws, gm (2-4)	(5)	8.56	7.94	6.19			
Water Content, W, % (3÷5) x 100	(6)	15.4	15.2	37.0			

SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, Ws, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
15	37	22

Request No. 99-35 Lab No. 99-765

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites

Request No. 99-35

Classification

Lab No. 99-766

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By

		PLASTIC LIMIT		LIQUID LIMIT			
Determination No.		1	2	1	2	3	4
No. of Blows				35	23	19	
Container No.		P13	P15	Z	S	P3	
Wt. Container + Wet Soil, gm	(1)	31.25	27.13	29.56	26.66	27.26	
Wt. Container + Dry Soil, gm	(2)	29.33	25.91	25.76	23.30	23.68	
Wt. Water, Ww, gm (1-2)	(3)						
Wt. Container, gm	(4)	18.63	18.75	19.04	17.62	17.82	
Wt. Dry Soil, Ws, gm (2-4)	(5)						
Water Content, W, % (3÷5) x 100	(6)	17.9	17.0	56.5	59.2	61.1	

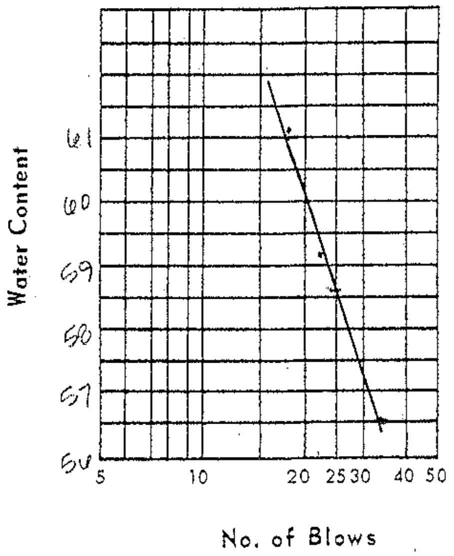
SHRINKAGE LIMIT

Determination No.		1	2
Container No.			
Consistency, No. of Blows			
Wt. Container + Wet Soil, gm	(1)		
Wt. Container + Dry Soil, gm	(2)		
Wt. Container, gm	(3)		
Wt. Wet Soil, W_1, gm (1-3)	(4)		
Wt. Dry Soil, W_s, gm (2-3)	(5)		
Vol. Wet Soil, V_1, cc	(6)		
Vol. Dry Soil, V_2* cc	(7)		
$W_1 - W_s$ (4-5)	(8)		
$V_1 - V_2$ (6-7)	(9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =			
Shrinkage Ratio – (5÷7)			

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm	(A)		
Wt. of Container, gm	(B)		
Wt. of Mercury, Hg, gm (A-B)	(C)		
V_2* = C ÷ Hg gm/cc	(D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
17	59	42

Request No. 99-35 Lab No. 99-766

DWR 714 (Rev. 12/66)

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DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites

Request No. 99-35

Classification

Lab No. 99-767

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DM

	PLASTIC LIMIT		LIQUID LIMIT ✓			
Determination No.	1	2	1	2	3	4
No. of Blows	☒	☒	35	20	15	
Container No.	B	E	VI	E1	146	
Wt. Container + Wet Soil, gm (1)	21.32	20.98	27.24	27.99	26.20	
Wt. Container + Dry Soil, gm (2)	20.56	20.18	25.34	25.64	23.90	
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	16.11	15.59	19.04	18.28	16.94	
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	17.1	17.4	30.2	31.9	33	

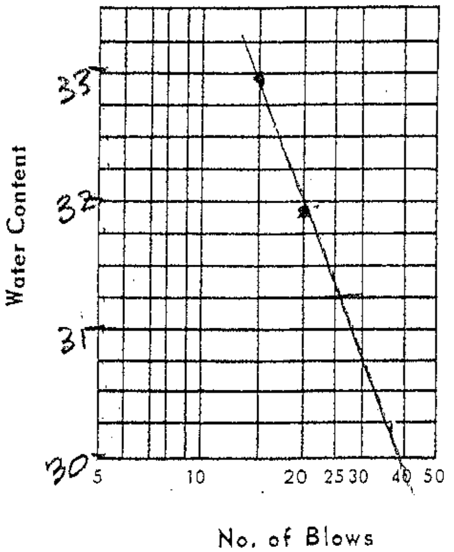
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, W_s, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
17	31	14

Request No. 99-35 Lab No. 99-767

DWR 714 (Rev. 12/66)

14.87 18.74

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Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites Dam

Request No. 99-35

Classification

Lab No. 99-768

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DMT

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			33	23	15	
Container No.	143	117	200	X	Y	
Wt. Container + Wet Soil, gm (1)	23.32	26.38	25.89	27.32	26.68	
Wt. Container + Dry Soil, gm (2)	22.22	25.30	22.94	24.36	23.61	
Wt. Water, Ww, gm (1-2) (3)	1.10	1.08	2.95	2.96	3.07	
Wt. Container, gm (4)	14.91	18.06	17.11	18.76	18.05	
Wt. Dry Soil, Ws, gm (2-4) (5)	7.31	7.24	5.83	5.60	5.56	
Water Content, W, % (3÷5) x 100 (6)	15.0	14.9	50.6	52.9	55.2	

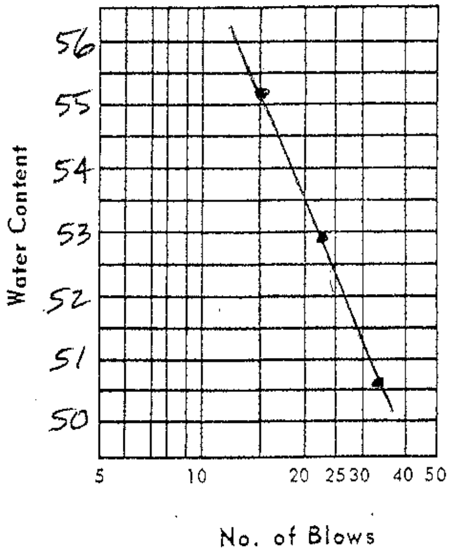
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)} 100 =$		
Shrinkage Ratio - (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
15	52	37

Request No. 99-35 Lab No. 99-768

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites

Request No. 99-35

Classification

Lab No. 99-769

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

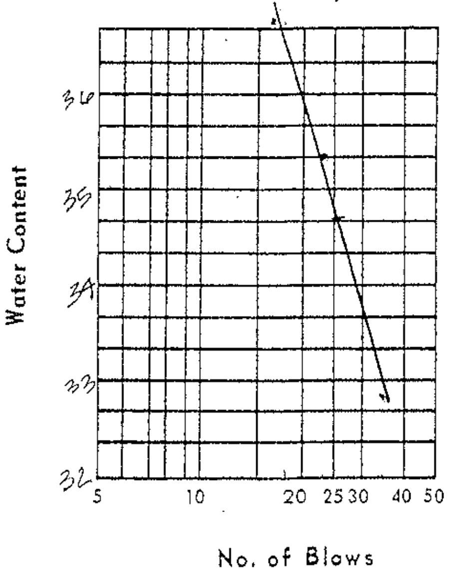
Tested By

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			35	23	17	
Container No.	V	I	U1	H	R1	
Wt. Container + Wet Soil, gm (1)	30.12	33.09	27.78	29.33	27.79	
Wt. Container + Dry Soil, gm (2)	28.30	30.72	25.50	26.77	25.34	
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	17.57	17.31	18.54	19.52	18.67	
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	17.0	17.7	32.0	35.3	36.7	

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

OL

Plastic Limit	Liquid Limit	Plasticity Index
17	35	18

Request No. 99-35 Lab No. 99-769

DWR 714 (Rev. 12/66)

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DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites

Request No. 99-35

Classification

Lab No. 99-770

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DM

	PLASTIC LIMIT		LIQUID LIMIT ✓			
Determination No.	1	2	1	2	3	4
No. of Blows			25			
Container No.	145	144	138			
Wt. Container + Wet Soil, gm (1)	27.57	22.26	28.89			
Wt. Container + Dry Soil, gm (2)	26.51	21.33	25.81			
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	20.52	15.84	16.53			
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	17.7	16.9	33.2			

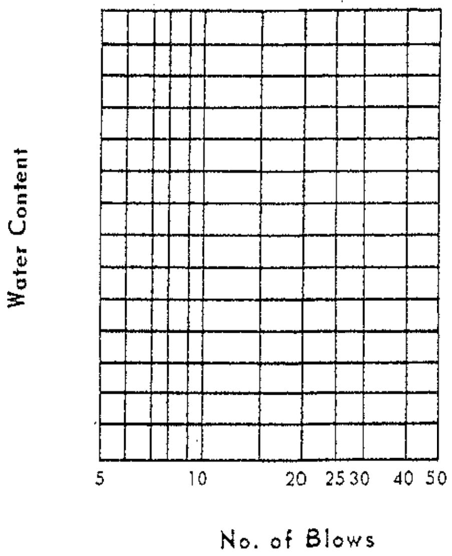
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio = (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

(CL)

Plastic Limit	Liquid Limit	Plasticity Index
17	33	16

Request No. 99-35 Lab No. 99-770

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites

Request No. 99-35

Classification

Lab No. 99-771

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By DY

	PLASTIC LIMIT		LIQUID LIMIT ✓			
Determination No.	1	2	1	2	3	4
No. of Blows			35	25		
Container No.	119	140	351	141		
Wt. Container + Wet Soil, gm (1)	26.31	24.03	29.78	30.15		
Wt. Container + Dry Soil, gm (2)	25.18	22.9	26.99	27.16		
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	18.89	16.78	17.22	17.11		
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	18.0	18.5	28.6	29.8		

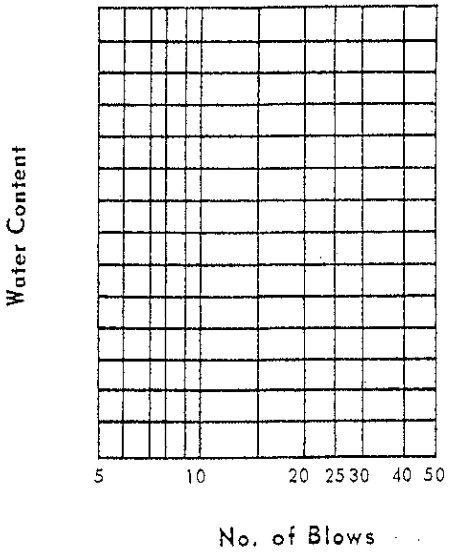
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CL

Plastic Limit	Liquid Limit	Plasticity Index
18	30	12

Request No. 99-35 Lab No. 99-771

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project Sites

Request No. 99-35

Classification

Lab No. 99-772

Remarks

Date 8/12/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

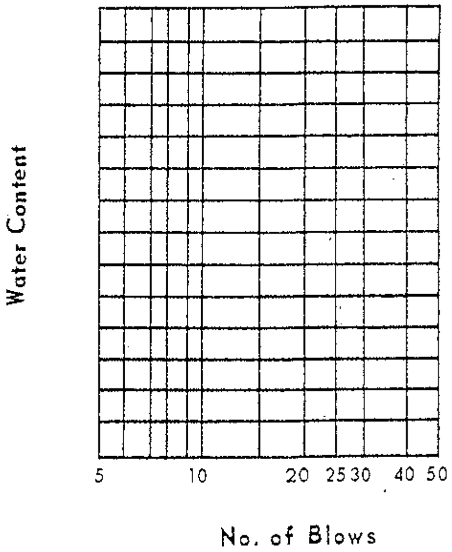
Tested By DM

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			25			
Container No.	203	00	59			
Wt. Container + Wet Soil, gm (1)	23.80	26.51	28.90			
Wt. Container + Dry Soil, gm (2)	22.89	25.65	25.28			
Wt. Water, Ww, gm (1-2) (3)						
Wt. Container, gm (4)	17.13	20.33	18.61			
Wt. Dry Soil, Ws, gm (2-4) (5)						
Water Content, W, % (3÷5) x 100 (6)	15.8	16.2	54.3			

SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

Flow Curve for Liquid Limit



*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

CH

Plastic Limit	Liquid Limit	Plasticity Index
16	54	38

Request No. 99-35 Lab No. 99-772

DWR 714 (Rev. 12/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

ATTERBERG LIMITS

Project SITES DAM
Request No. 99-35

Classification
Lab No. 99-773

Remarks
Date 8/16/99

☑ Air Dried ☐ In Situ ☐ Oven Dried

Tested By

	PLASTIC LIMIT		LIQUID LIMIT			
Determination No.	1	2	1	2	3	4
No. of Blows			33	27	23	
Container No.	#145	#48	#119	#138	#144	
Wt. Container + Wet Soil, gm (1)	29.61	33.40	28.79	26.07	24.69	
Wt. Container + Dry Soil, gm (2)	28.09	31.02	25.85	23.20	21.99	
Wt. Water, Ww, gm (1-2) (3)	1.52	2.38	2.94	2.87	2.70	
Wt. Container, gm (4)	20.52	18.81	18.90	16.55	15.84	
Wt. Dry Soil, Ws, gm (2-4) (5)	7.57	12.21	6.95	6.65	6.15	
Water Content, W, % (3÷5) x 100 (6)	20.0	19.5	42.3	43.2	43.9	

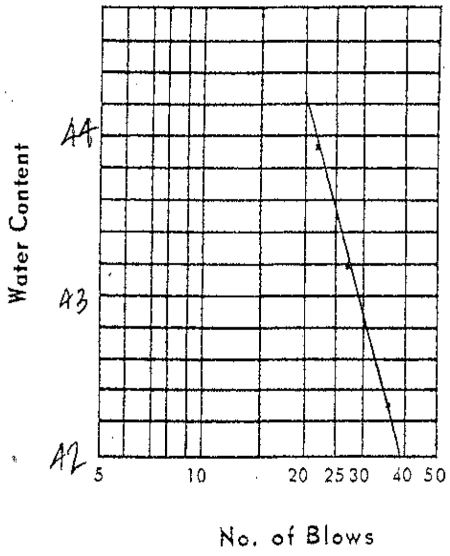
SHRINKAGE LIMIT

Determination No.	1	2
Container No.		
Consistency, No. of Blows		
Wt. Container + Wet Soil, gm (1)		
Wt. Container + Dry Soil, gm (2)		
Wt. Container, gm (3)		
Wt. Wet Soil, W_1, gm (1-3) (4)		
Wt. Dry Soil, Ws, gm (2-3) (5)		
Vol. Wet Soil, V_1, cc (6)		
Vol. Dry Soil, V_2* cc (7)		
$W_1 - W_s$ (4-5) (8)		
$V_1 - V_2$ (6-7) (9)		
W% at Shrinkage Limit $\frac{(8) - (9 \times \gamma w)}{(5)}$ 100 =		
Shrinkage Ratio – (5÷7)		

*Determination V_2 by Weighing

Wt. of Container + Displaced, Hg, gm (A)		
Wt. of Container, gm (B)		
Wt. of Mercury, Hg, gm (A-B) (C)		
V_2* = C ÷ Hg gm/cc (D)		

Flow Curve for Liquid Limit



Mercury, Hg gm/cc =
62° F–68° F = 13.55 gm/cc
69° F–72° F = 13.54 gm/cc
73° F–82° F = 13.53 gm/cc

Shrinkage Limit	Shrinkage Ratio	Shrinkage Index

ⓐ

Plastic Limit	Liquid Limit	Plasticity Index
20	44	24

Request No. 99-35 Lab No. 99-773

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

SPECIFIC GRAVITY TEST FOR SOILS

Request No. 98-18

Project ______ Lab No. 98-167

Classification ______ Date 5/20/98

Tested By DMT

Flask No.	15			
Temp. °C	28			
Wt. Tare + Dry Soil	272.51			
Wt. Tare	170.46			
Wt. Dry Soil (W_s)	102.05			
Wt. Flask + Water (W_2)	667.94			
$W_s + W_2$	769.99			
Wt. Flask + Water + Dry Soil (W_1)	733.28			
$W_s+W_2-W_1$	36.71			
Specific Gravity $= \frac{W_s}{W_s+W_2-W_1} = (G_s)$	2.780			

G_s

% COMBUSTIBLE ORGANIC

Remarks:

Date ______ Tested By ______

Trial	1		2		3	
	IN	OUT	IN	OUT	IN	OUT
Time						
Temp.						
Wt. Container + Oven Dry Soil (1)						
Wt. Container + Burned Soil (2)						
Organic Loss (1-2) (3)						
Wt. Container (4)						
Wt. of Oven Dry Soil (1-4) (5)						
% Organic (3÷5) x 100						

Request No. 98-18 Lab No. 98-167

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

SPECIFIC GRAVITY TEST FOR SOILS

Request No. 98-18

Project____ Lab No. 98-168

Classification____ Date 5/20/98

Tested By DMT

Flask No.	18				
Temp. °C	28				
Wt. Tare + Dry Soil	279.81				
Wt. Tare	179.45				
Wt. Dry Soil (W_s)	100.36				
Wt. Flask + Water (W_2)	676.80				
$W_s + W_2$	777.16				
Wt. Flask + Water + Dry Soil (W_1)	741.27				
$W_s + W_2 - W_1$	35.89				G_S
Specific Gravity $= \frac{W_s}{W_s+W_2-W_1} = (G_S)$	2.796				

% COMBUSTIBLE ORGANIC

Remarks:

Date____ Tested By____

Trial	1		2		3	
	IN	OUT	IN	OUT	IN	OUT
Time						
Temp.						
Wt. Container + Oven Dry Soil (1)						
Wt. Container + Burned Soil (2)						
Organic Loss (1-2) (3)						
Wt. Container (4)						
Wt. of Oven Dry Soil (1-4) (5)						
% Organic (3÷5) x 100						

Request No. 98-18 Lab No. 98-168

DWR 713 (Rev. 4/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

SPECIFIC GRAVITY TEST FOR SOILS

Request No. 98-18

Project

Lab No. 98-157

Classification

Date 5/20/98

Tested By DMT

Flask No.	7				
Temp. °C	28				
Wt. Tare + Dry Soil	271.96				
Wt. Tare	172.47				
Wt. Dry Soil (W_s)	99.49				
Wt. Flask + Water (W_2)	669.81				
$W_s + W_2$	769.30				
Wt. Flask + Water + Dry Soil (W_1)	733.56				
$W_s+W_2-W_1$	35.74				G_s
Specific Gravity $= \frac{W_s}{W_s+W_2-W_1} = (G_s)$	2.784				

% COMBUSTIBLE ORGANIC

Remarks:

Date

Tested By

Trial	1		2		3	
	IN	OUT	IN	OUT	IN	OUT
Time						
Temp.						
Wt. Container + Oven Dry Soil (1)						
Wt. Container + Burned Soil (2)						
Organic Loss (1-2) (3)						
Wt. Container (4)						
Wt. of Oven Dry Soil (1-4) (5)						
% Organic (3÷5) x 100						

Request No. 98-18 Lab No. 98-157

DWR 713 (Rev. 4/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

SPECIFIC GRAVITY TEST FOR SOILS

Request No. 98-18

Project

Lab No. 98-158

Classification

Date 5/20/98

Tested By DWJ

Flask No.	9				
Temp. °C	28.5				
Wt. Tare + Dry Soil	272.09				
Wt. Tare	172.86				
Wt. Dry Soil (W_s)	99.23				
Wt. Flask + Water (W_2)	670.40				
$W_s + W_2$	769.63				
Wt. Flask + Water + Dry Soil (W_1)	734.10				
$W_s+W_2-W_1$	35.53				G_S
Specific Gravity $= \frac{W_S}{W_s+W_2-W_1} = (G_S)$	2.793				

% COMBUSTIBLE ORGANIC

Remarks:

Date

Tested By

Trial	1		2		3	
	IN	OUT	IN	OUT	IN	OUT
Time						
Temp.						
Wt. Container + Oven Dry Soil (1)						
Wt. Container + Burned Soil (2)						
Organic Loss (1-2) (3)						
Wt. Container (4)						
Wt. of Oven Dry Soil (1-4) (5)						
% Organic (3÷5) x 100						

Request No.

Lab No. 98-158

DWR 713 (Rev. 4/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

SPECIFIC GRAVITY TEST FOR SOILS

Request No. 99-51

Project Sites

Lab No. 99-1419

Classification

Date 9/14/99

Tested By DMT

Flask No.	7			
Temp. °C	26			
Wt. Tare + Dry Soil	272.48			
Wt. Tare	172.48			
Wt. Dry Soil (W_s)	100.00			
Wt. Flask + Water (W_2)	670.08			
$W_s + W_2$	770.08			
Wt. Flask + Water + Dry Soil (W_1)	733.64			
$W_s + W_2 - W_1$	36.44			
Specific Gravity = $\frac{W_s}{W_s+W_2-W_1}$ = (G_s)	2.74			

G_s

% COMBUSTIBLE ORGANIC

Remarks:

Date 9/15/99

Tested By DMT

Trial 22	1		2		3	
	IN	OUT	IN	OUT	IN	OUT
Time						
Temp.						
Wt. Container + Oven Dry Soil (1)	47.85					
Wt. Container + Burned Soil (2)	47.10					
Organic Loss (1-2) (3)	.75					
Wt. Container (4)	28.89					
Wt. of Oven Dry Soil (1-4) (5)	19.05					
% Organic (3÷5) x 100	3.9					

Request No. 99-51 Lab No. 99-1419

DWR 713 (Rev. 4/66)

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

Technical Services Office
LABORATORIES BRANCH
SOILS LABORATORY

SPECIFIC GRAVITY TEST FOR SOILS

Request No. 99-51

Project Sites

Lab No. 99-1420

Classification

Date 9/14/99

Tested By DMT

Flask No.	8				
Temp. °C	27.5				
Wt. Tare + Dry Soil	271.95				
Wt. Tare	179.04				
Wt. Dry Soil (W_S)	92.91				
Wt. Flask + Water (W_2)	676.56				
$W_s + W_2$	769.47				
Wt. Flask + Water + Dry Soil (W_1)	735.51				
$W_s+W_2-W_1$	33.96				G_S
Specific Gravity $= \frac{W_S}{W_s+W_2-W_1} = (G_S)$	2.74				

% COMBUSTIBLE ORGANIC

Remarks:

Date 9/15/99

Tested By DMT

Trial 33	1		2		3	
	IN	OUT	IN	OUT	IN	OUT
Time						
Temp.						
Wt. Container + Oven Dry Soil (1)	44.49					
Wt. Container + Burned Soil (2)	43.78					
Organic Loss (1-2) (3)	.71					
Wt. Container (4)	27.39					
Wt. of Oven Dry Soil (1-4) (5)	17.10					
% Organic (3÷5) x 100	4.2					

Request No. 99-51 Lab No. 99-1420

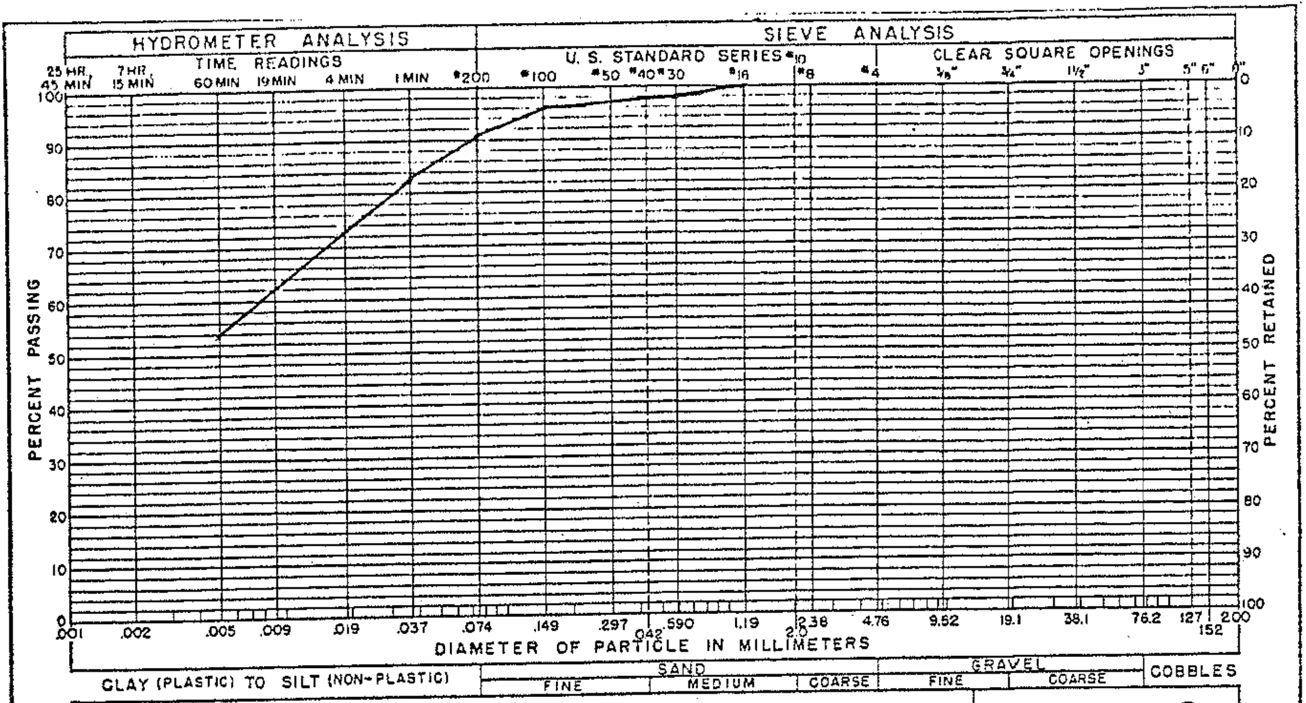
DWR 713 (Rev. 4/66)

APPENDIX C

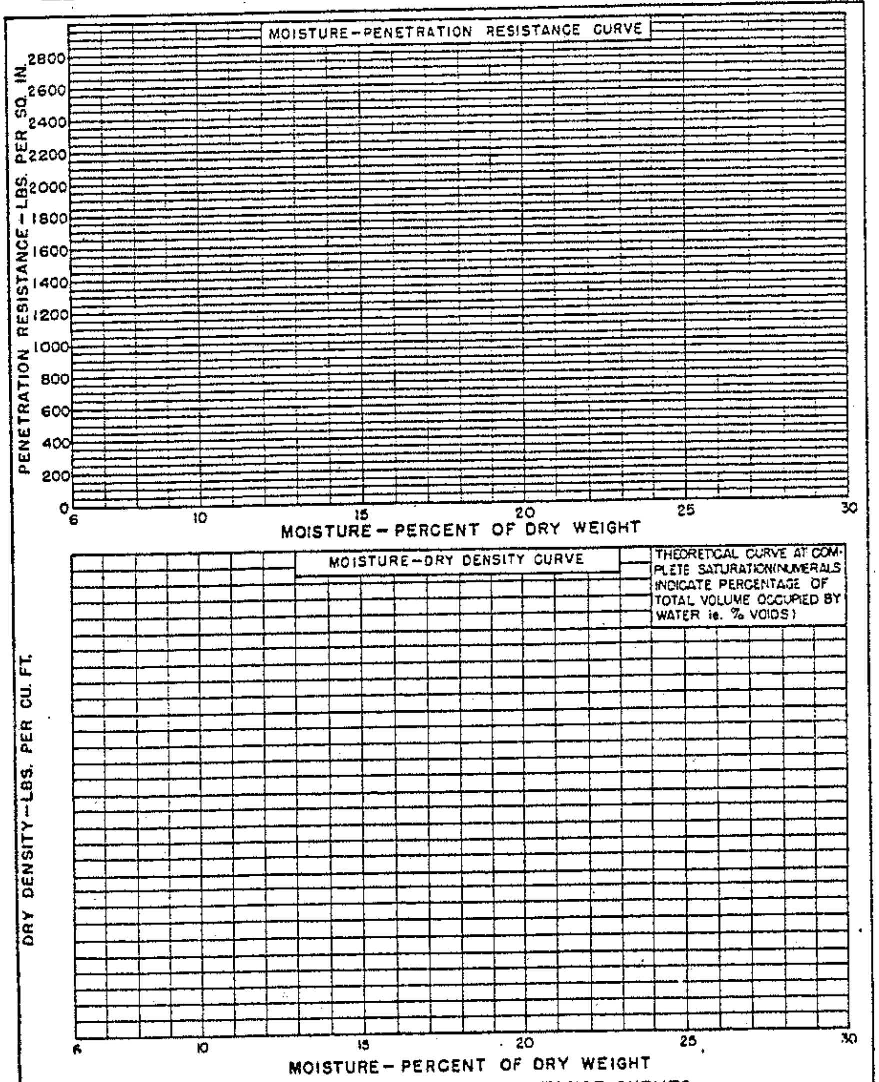
IMPERVIOUS MATERIAL CLASSIFICATION, GRADATION, ATTERBERG LIMITS, SPECIFIC GRAVITY, AND COMPACTION TEST RESULTS FOR USBR SAMPLES

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL.............. *0* %
SAND.................. *9* %
SILT TO CLAY...... *91* %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL *CL*

SPECIFIC GRAVITY *2.67*

ATTERBERG LIMITS

LIQUID LIMIT *41.8*

PLASTICITY INDEX *20.4*

SHRINKAGE LIMIT *9.0*

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT./YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

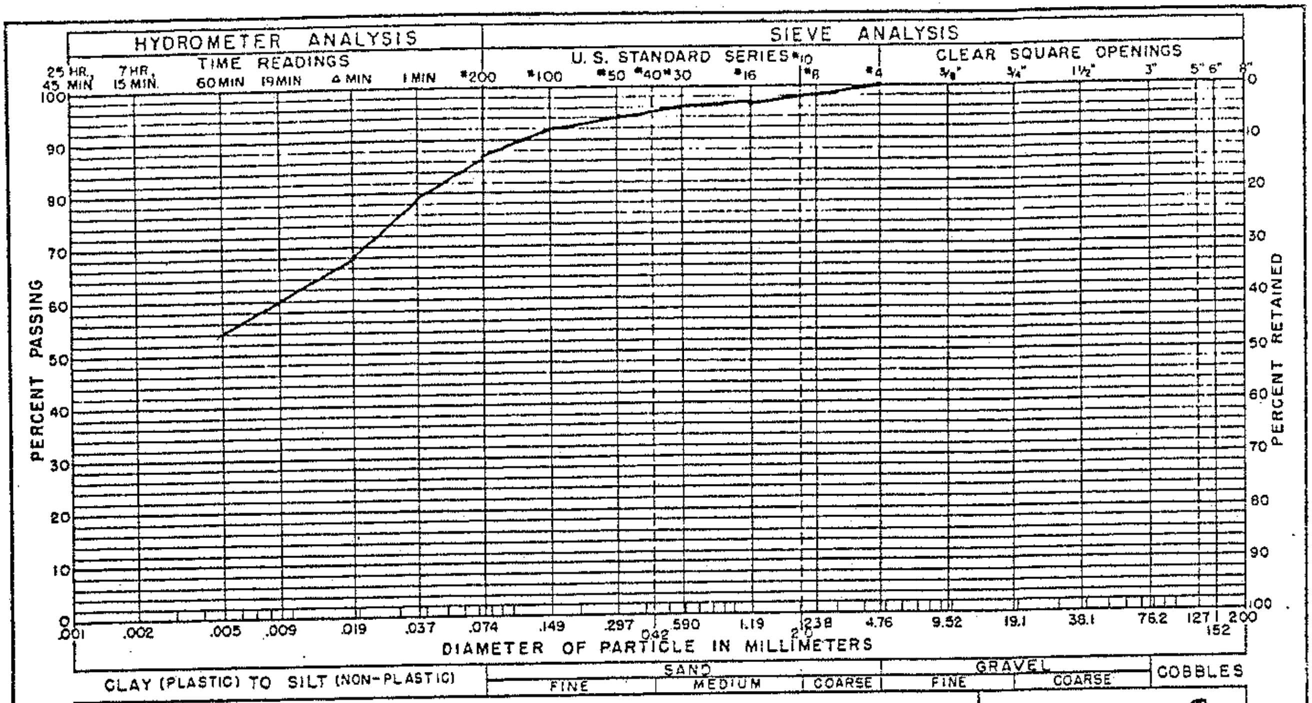
NOTES: ______

LABORATORY SAMPLE No. *AP-2* FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH *0.5-10.0* FT.

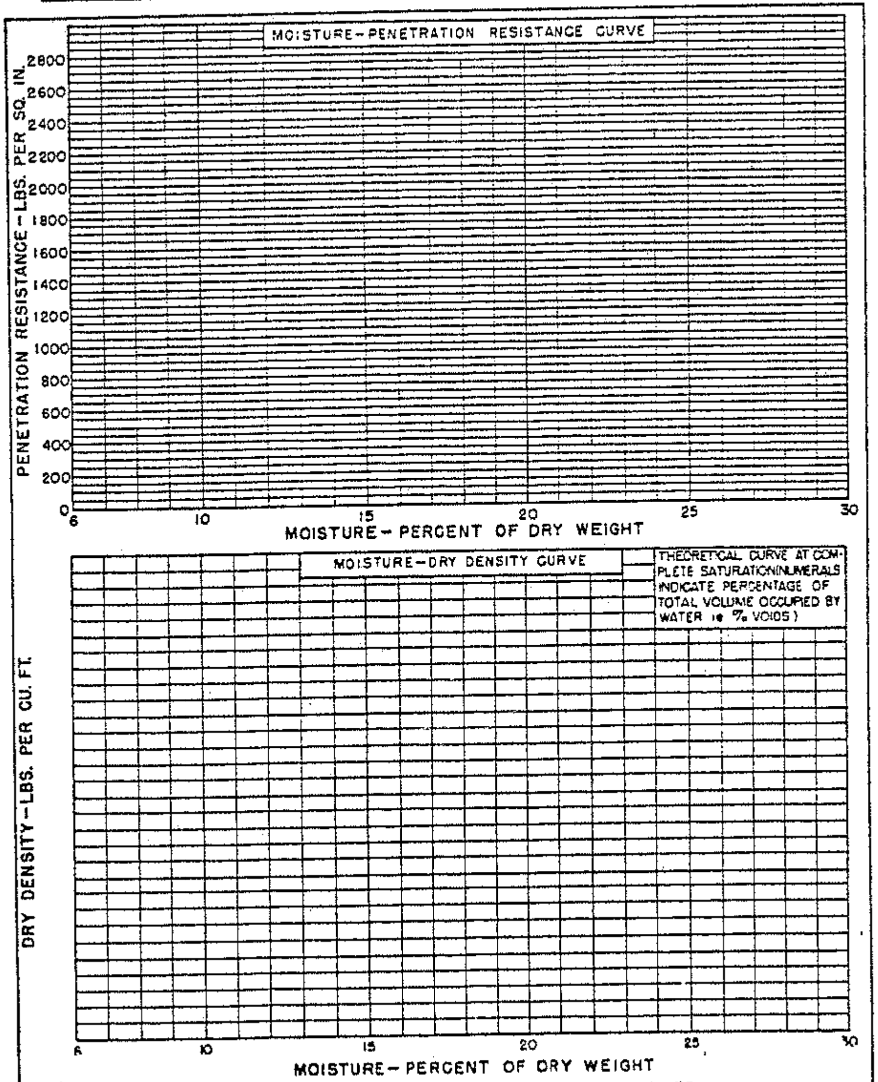
GPO 856928 FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ *0* %
SAND............. *13* %
SILT TO CLAY...... *87* %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL *CH*

SPECIFIC GRAVITY *2.70*

ATTERBERG LIMITS

LIQUID LIMIT *51.4*

PLASTICITY INDEX *28.9*

SHRINKAGE LIMIT *6.4*

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT./YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES: ______

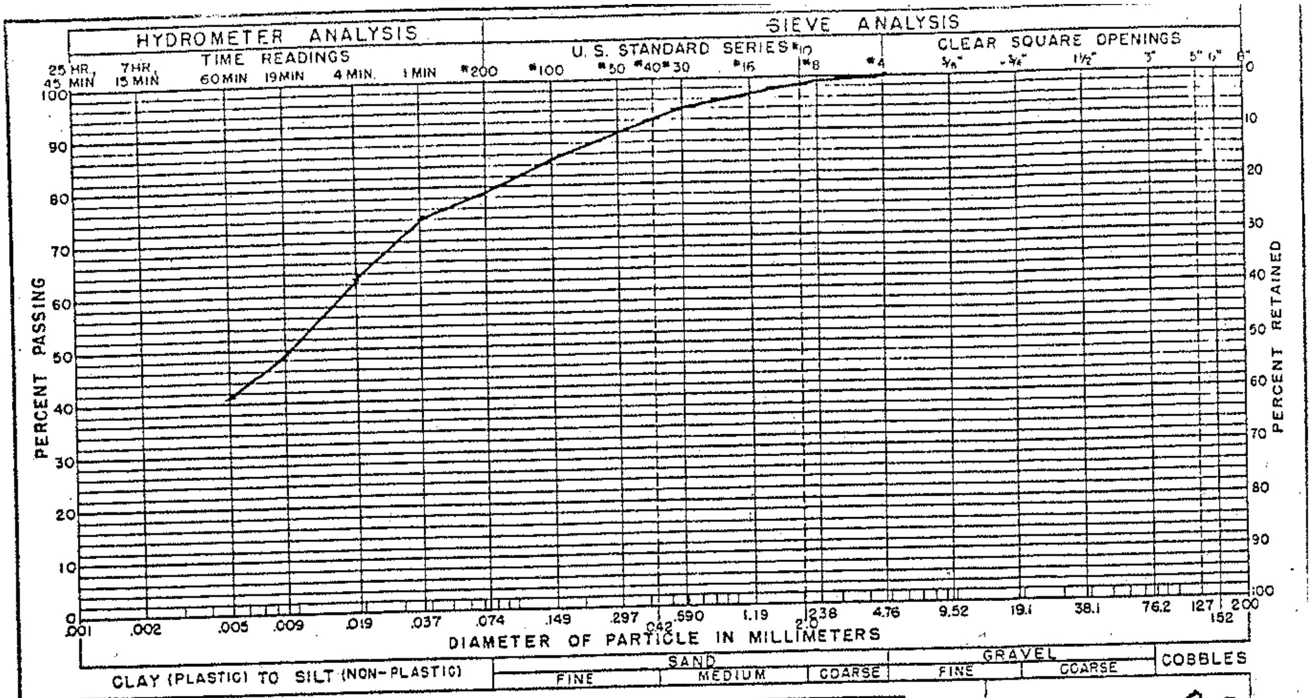
LABORATORY SAMPLE No. *AP-2* FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH *10.0-14.5* FT.

GPO 856928

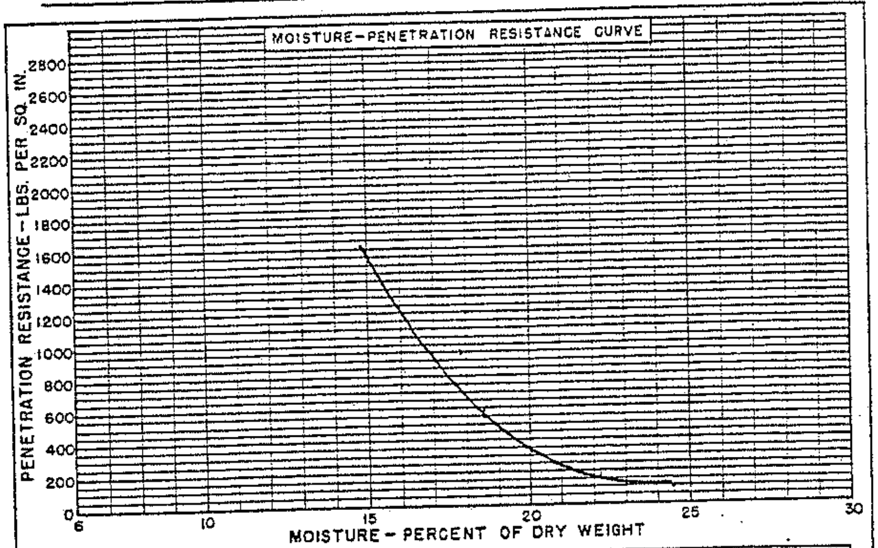
FIGURE NO.

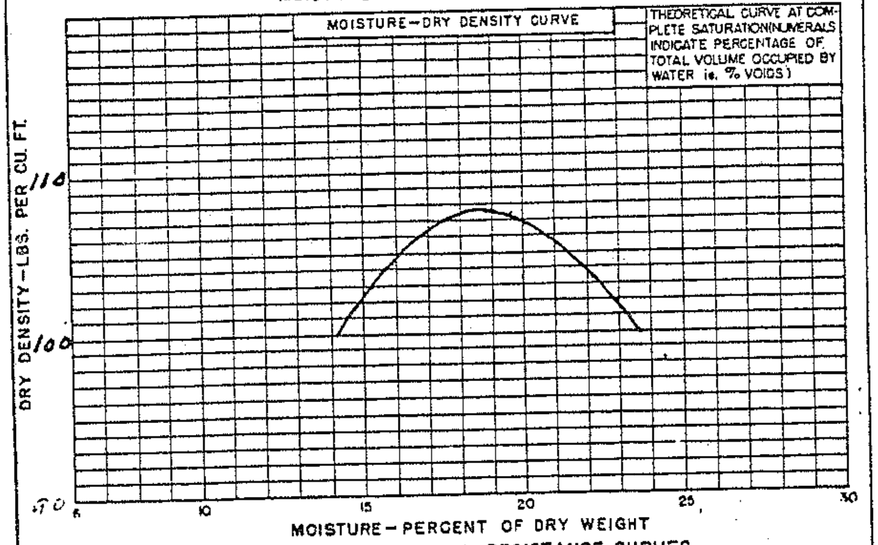
FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL........ 0 %
SAND........ 21 %
SILT TO CLAY...... 79 %





COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL

SPECIFIC GRAVITY 2.65

ATTERBERG LIMITS

LIQUID LIMIT 35.8

PLASTICITY INDEX 17.1

SHRINKAGE LIMIT 12.2

COMPACTION

% LARGER THAN TESTED 0

MAX. DRY DENSITY (P.C.F.) 107.8

OPTIMUM MOIST. CONT. (%) 18.5

PENETRATION RESIST. (P.S.I.) 560

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT./YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES: ______

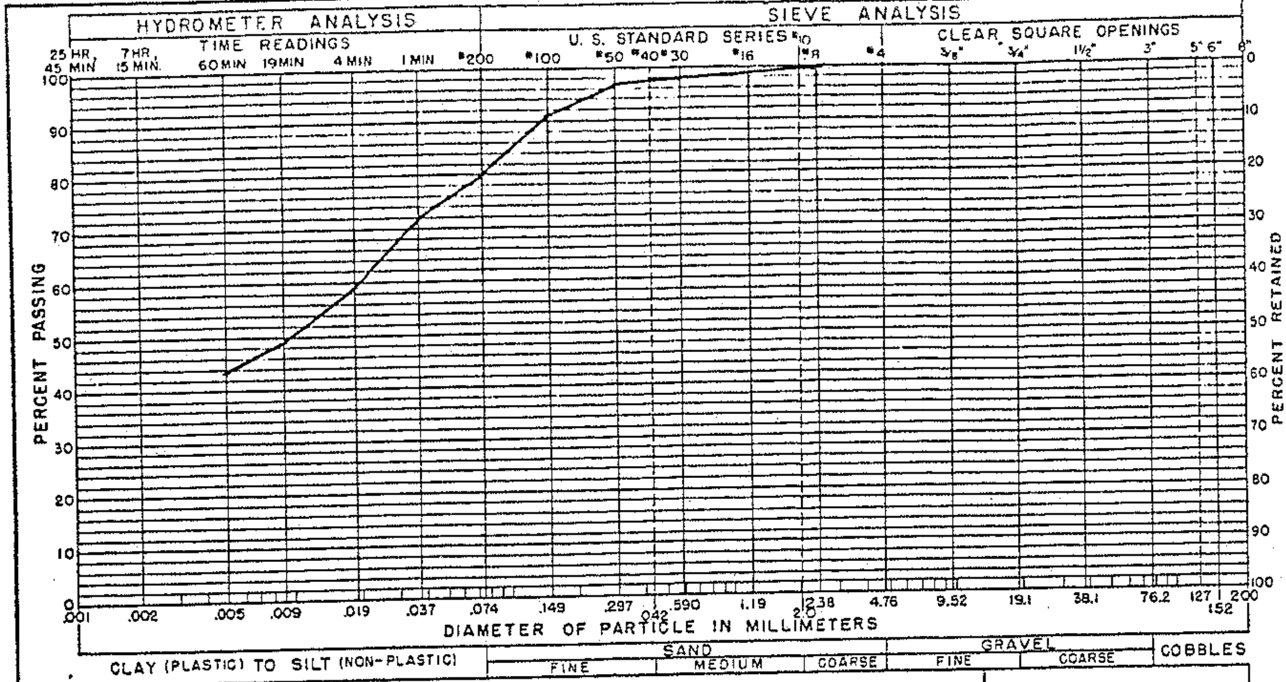
LABORATORY SAMPLE No. AP-10 FIELD DESIGNATION______ EXCAVATION No.______ DEPTH 0-11.0 FT.

GPO 856928

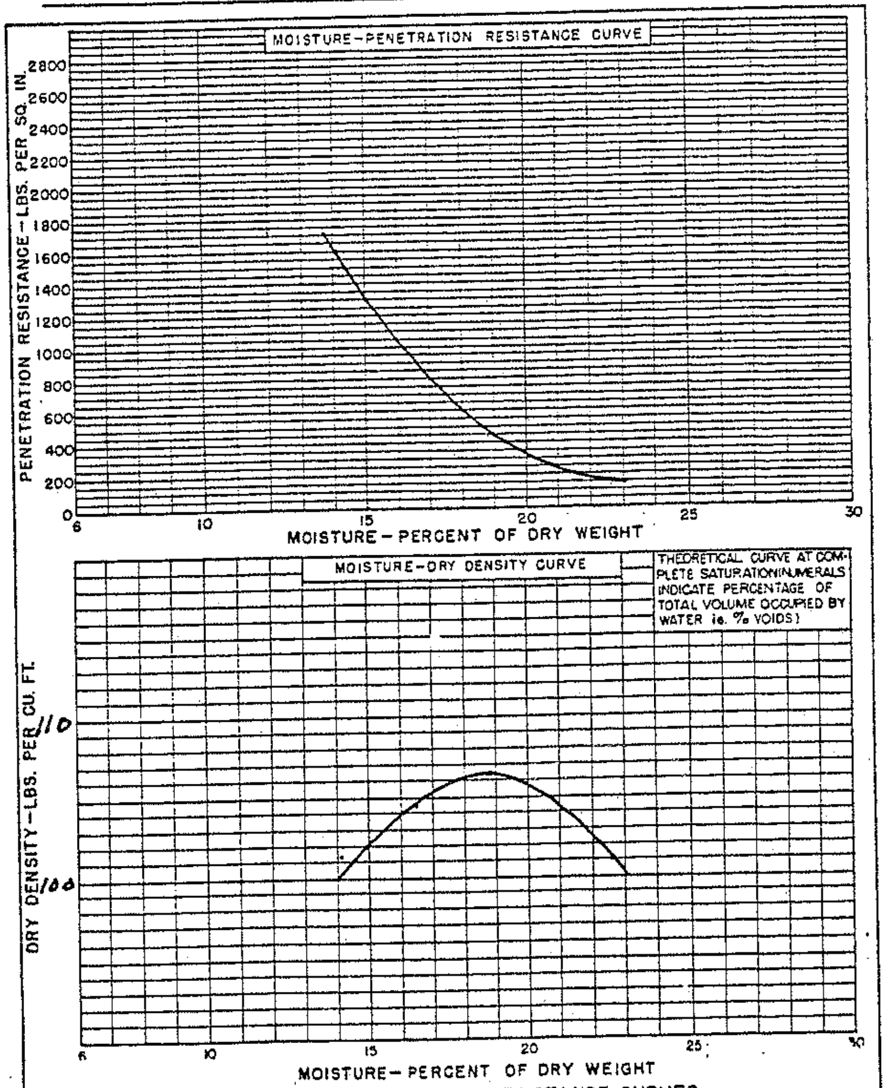
FIGURE NO.

FORM 7-1565
(5-62)
UREAU OF
ECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL .... *0* %
SAND .... *20* %
SILT TO CLAY ...... *80* %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL *CL*
SPECIFIC GRAVITY *2.60*
ATTERBERG LIMITS
LIQUID LIMIT *35.9*
PLASTICITY INDEX *16.4*
SHRINKAGE LIMIT *12.5*
COMPACTION
% LARGER THAN TESTED *0*
MAX. DRY DENSITY (P.C.F.) *106.4*
OPTIMUM MOIST. CONT. (%) *18.9*
PENETRATION RESIST. (P.S.I.) *450*
PERCOLATION SETTLEMENT
PLACEMENT CONDITION ______
PERMEABILITY (FT./YR.) ______
SETTLEMENT (%) UNDER
______ P.S.I. LOAD ______

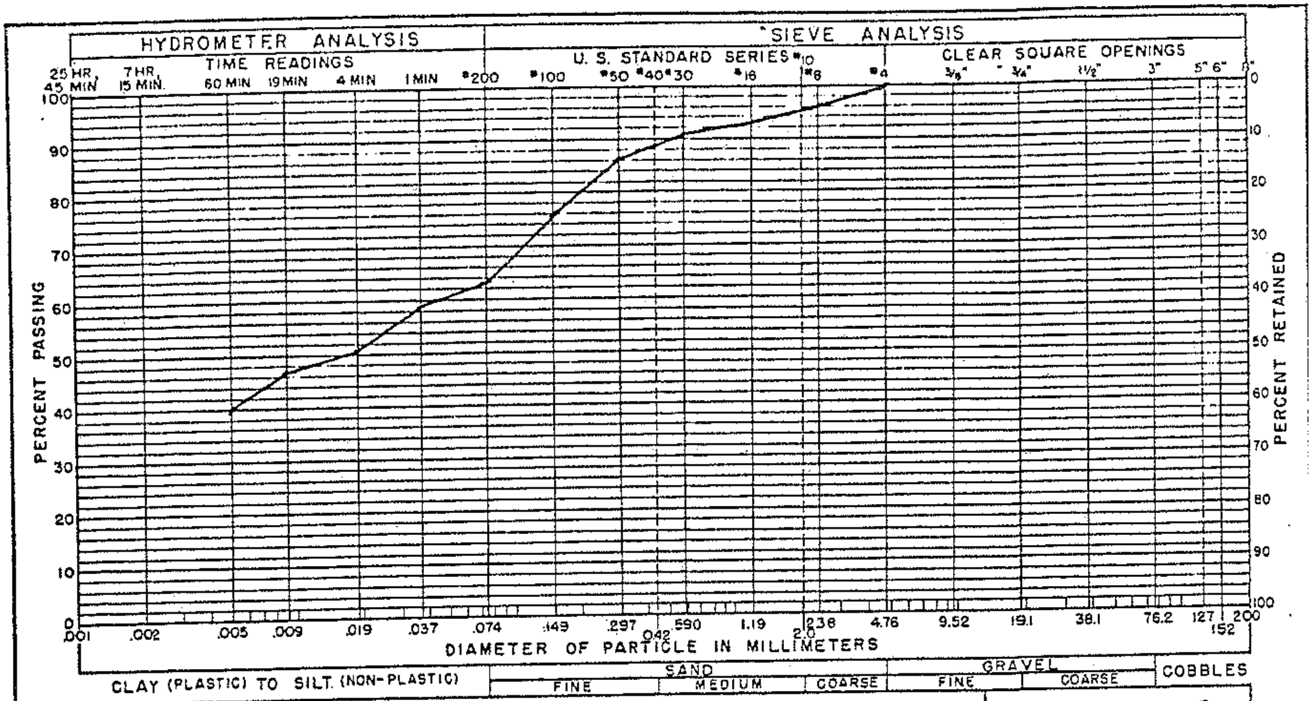
NOTES: ______

LABORATORY SAMPLE No. *AP-12* FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH *1.0-10.0* FT.

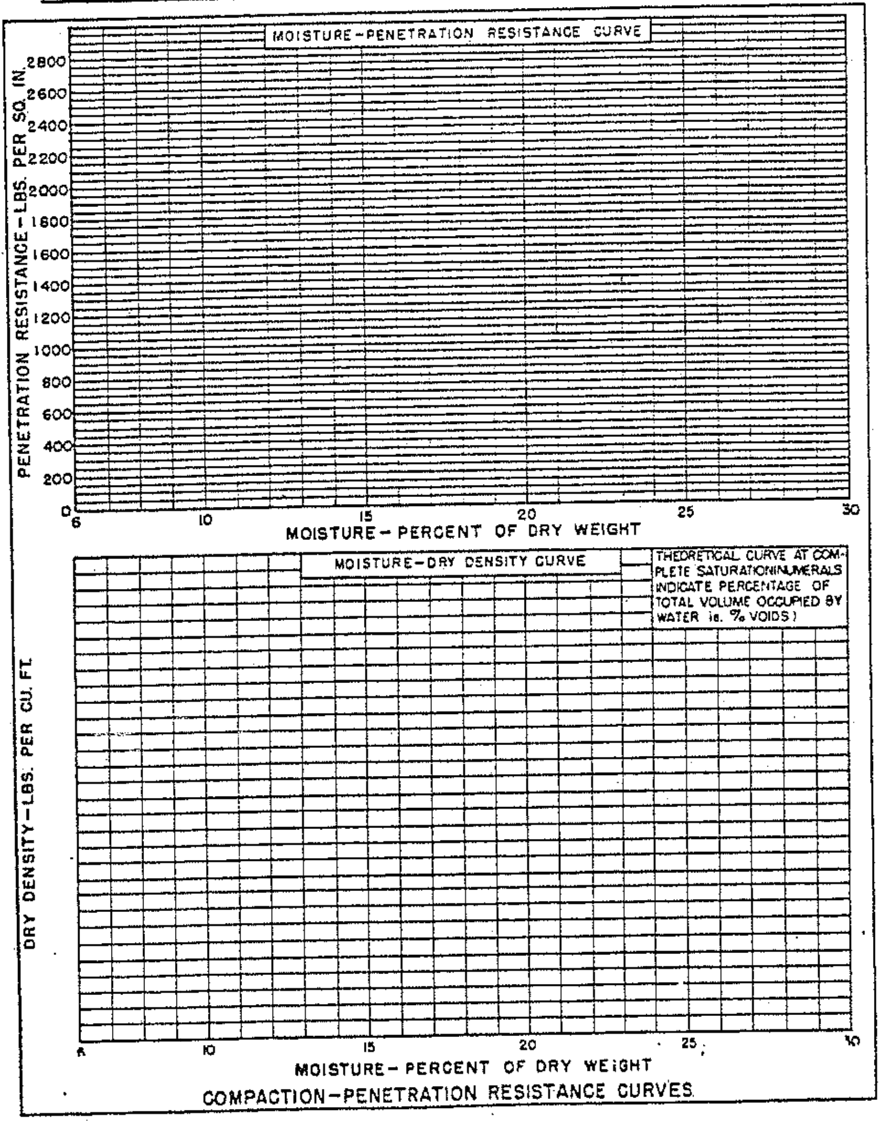
GPO 856928 FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ 0 %
SAND............... 37 %
SILT TO CLAY...... 63 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL

SPECIFIC GRAVITY ______

ATTERBERG LIMITS

LIQUID LIMIT 36.3

PLASTICITY INDEX 17.5

SHRINKAGE LIMIT 9.9

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT/YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

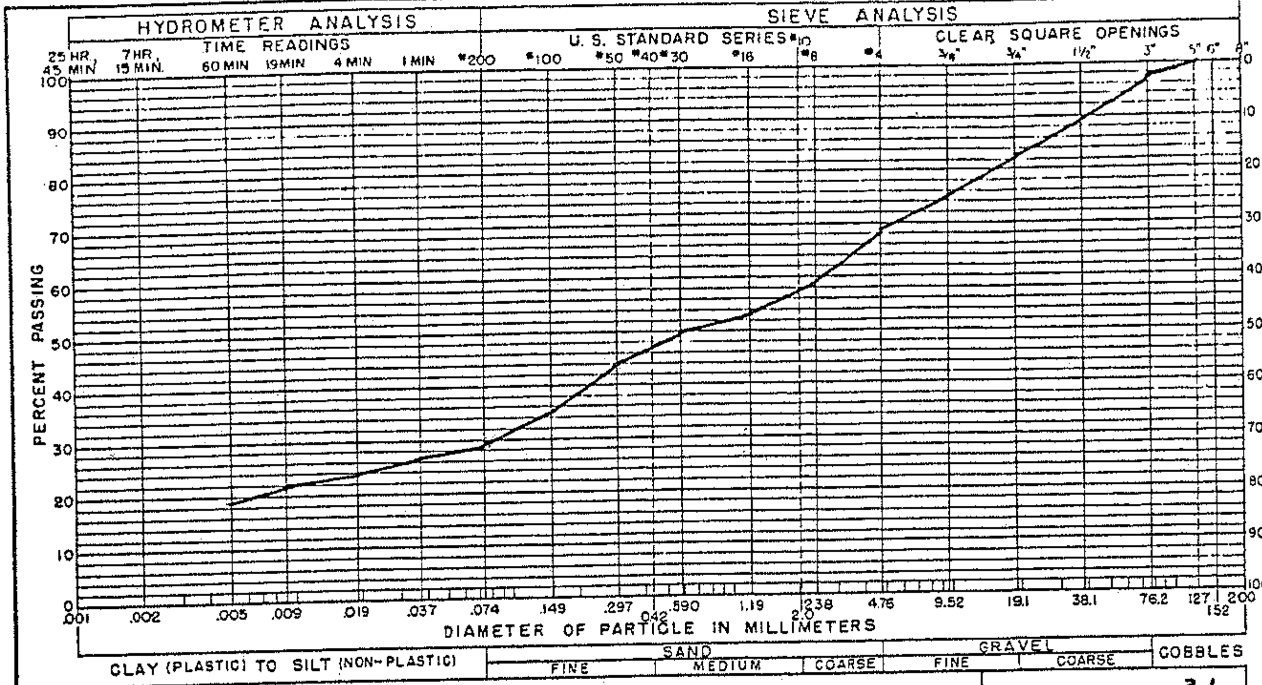
NOTES: ______

LABORATORY SAMPLE No. AP-16 FIELD DESIGNATION ______ EXCAVATION No ______ DEPTH 0.5-5.0 FT.

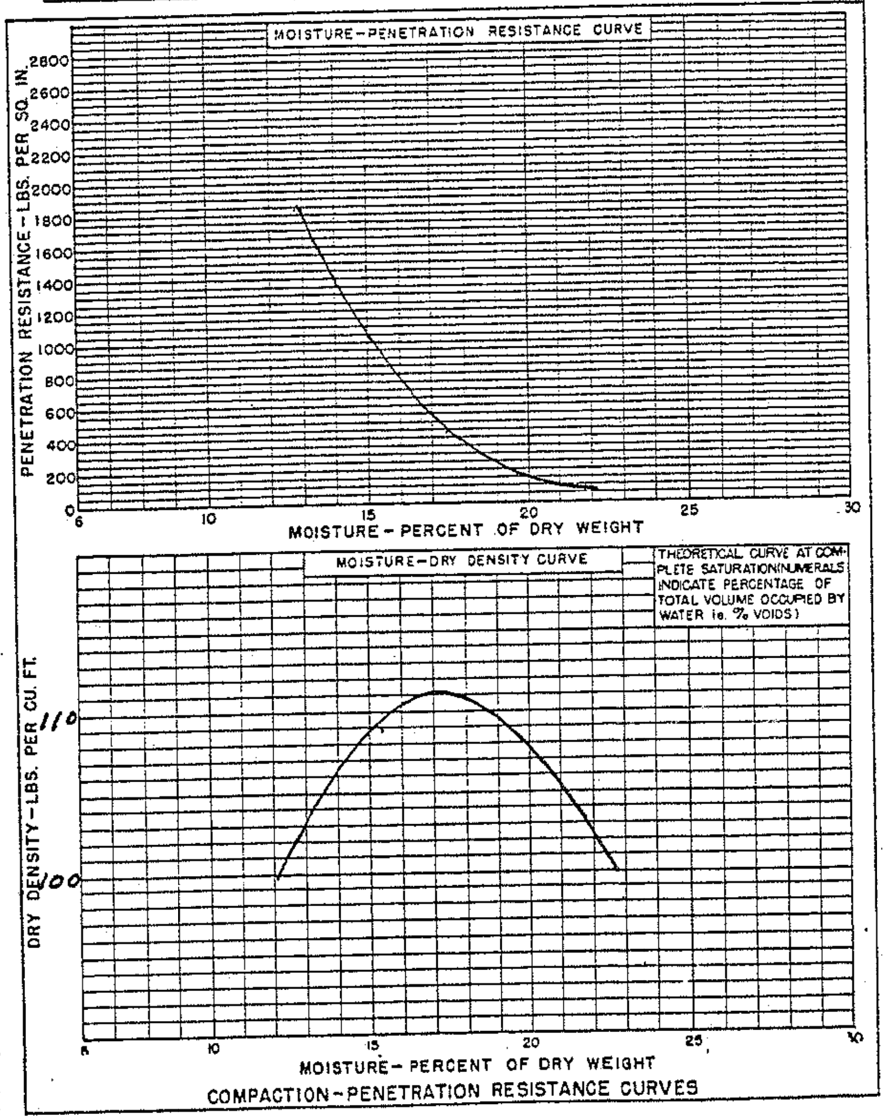
GPO 856128 FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ 31 %
SAND............. 40 %
SILT TO CLAY...... 29 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL SC
SPECIFIC GRAVITY ______
ATTERBERG LIMITS
  LIQUID LIMIT 38.7
  PLASTICITY INDEX 18.6
  SHRINKAGE LIMIT 13.4
COMPACTION
  % LARGER THAN TESTED 0
  MAX. DRY DENSITY (P.C.F.) 111.2
  OPTIMUM MOIST. CONT. (%) 17.1
  PENETRATION RESIST. (P.S.I.) 520
PERCOLATION SETTLEMENT
  PLACEMENT CONDITION ______
  PERMEABILITY (FT./YR.) ______
  SETTLEMENT (%) UNDER
  ______ P.S.I. LOAD ______

NOTES: ______

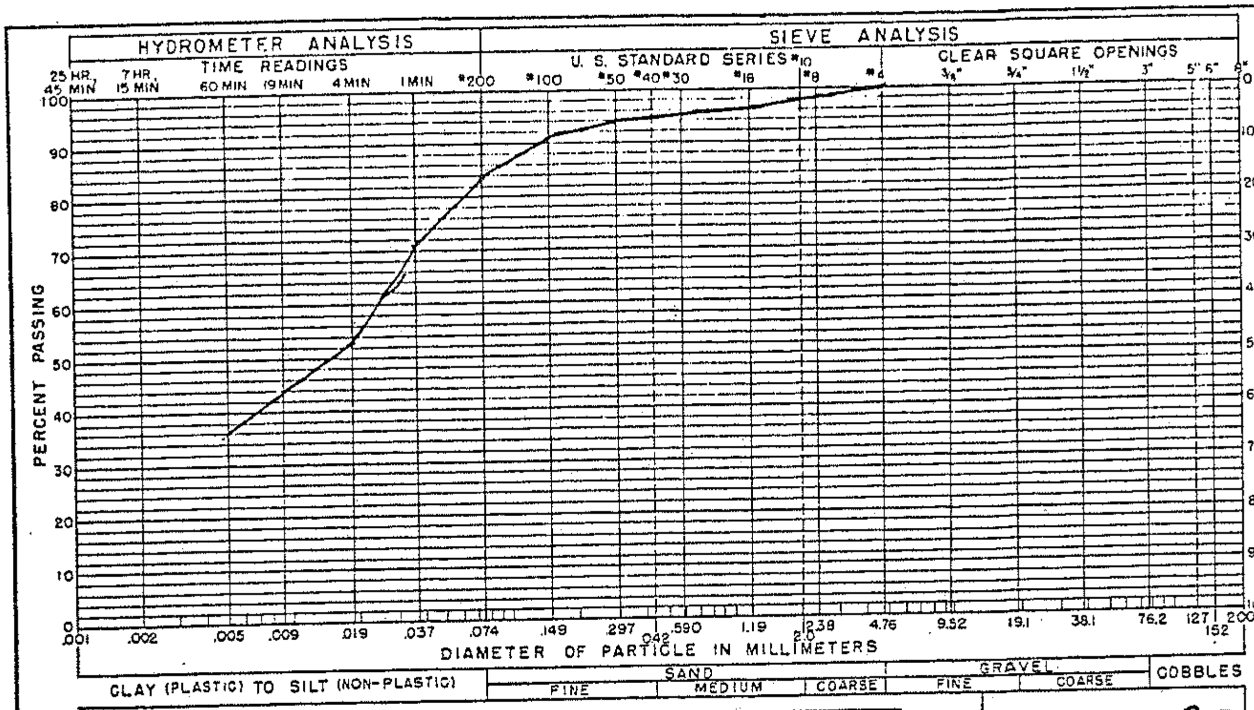
LABORATORY SAMPLE No. AP-16 FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH 5.0-9.5 FT.

GPO 856928

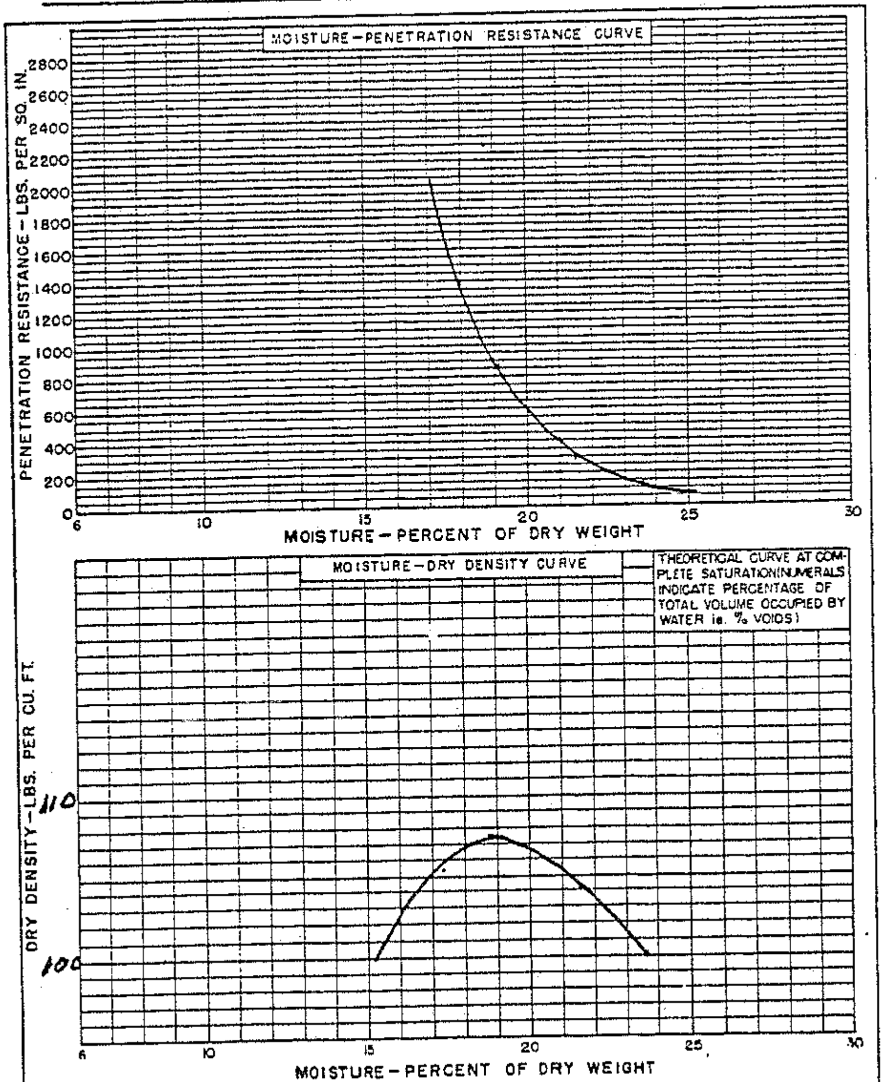
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL........ 0 %
SAND........ 16 %
SILT TO CLAY...... 84 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL

SPECIFIC GRAVITY 2.67

ATTERBERG LIMITS

LIQUID LIMIT 37.1

PLASTICITY INDEX 14.7

SHRINKAGE LIMIT 15.8

COMPACTION

% LARGER THAN TESTED 0

MAX. DRY DENSITY (P.C.F.) 107.4

OPTIMUM MOIST. CONT.(%) 19.0

PENETRATION RESIST.(P.S.I.) 860

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ____

PERMEABILITY (FT/YR.) ____

SETTLEMENT (%) UNDER

____ P.S.I. LOAD ____

NOTES: ____

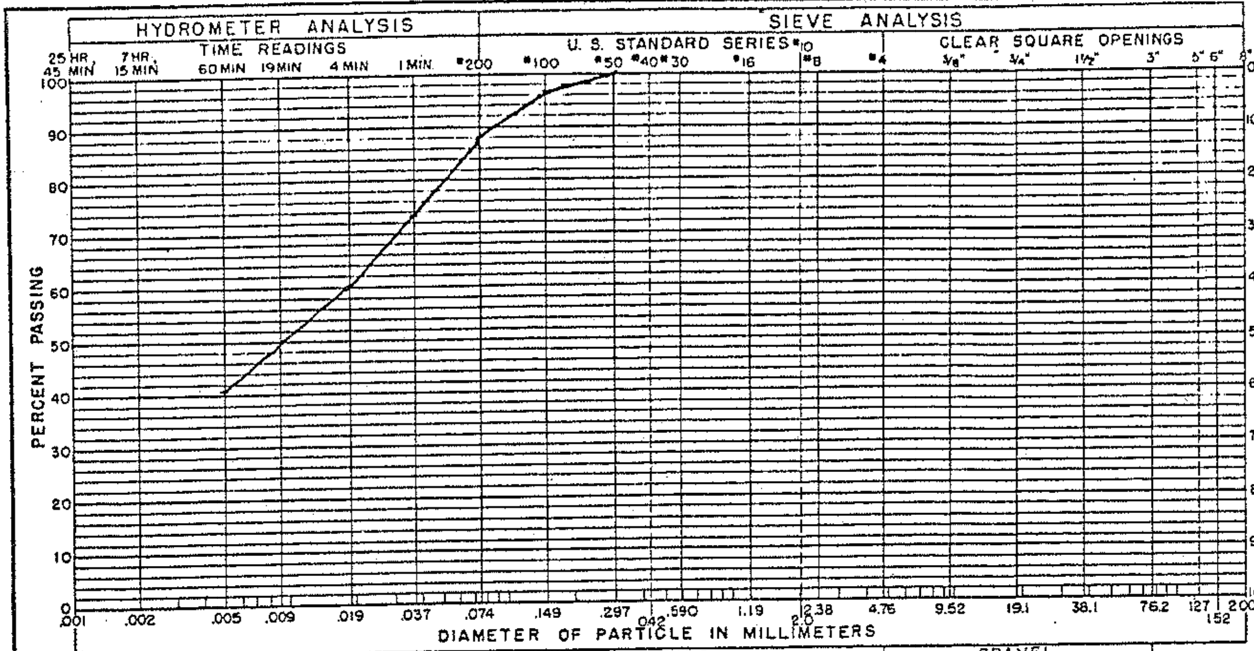
LABORATORY SAMPLE No. AP-16 FIELD DESIGNATION ____ EXCAVATION No ____ DEPTH 9.5-14.0 FT.

GPO 856928

FIGURE NO.

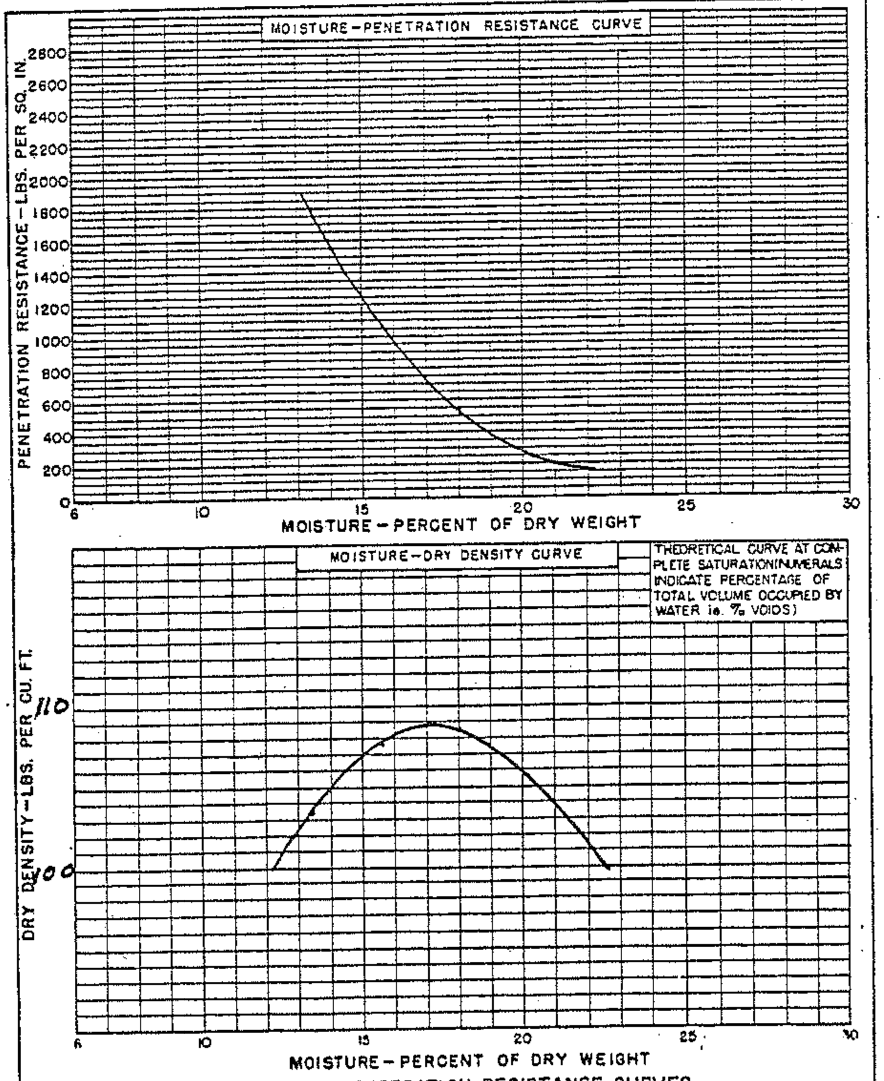
FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

GRAVEL............ 0 %
SAND............ 12 %
SILT TO CLAY...... 88 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL
SPECIFIC GRAVITY 2.70
ATTERBERG LIMITS
  LIQUID LIMIT 34.9
  PLASTICITY INDEX 16.2
  SHRINKAGE LIMIT 10.9
COMPACTION
  % LARGER THAN TESTED 0
  MAX. DRY DENSITY (P.C.F.) 108.9
  OPTIMUM MOIST. CONT.(%) 17.0
  PENETRATION RESIST. (P.S.I.) 720
PERCOLATION SETTLEMENT
  PLACEMENT CONDITION ________
  PERMEABILITY (FT/YR.) ________
  SETTLEMENT (%) UNDER
  ______ P.S.I. LOAD ________

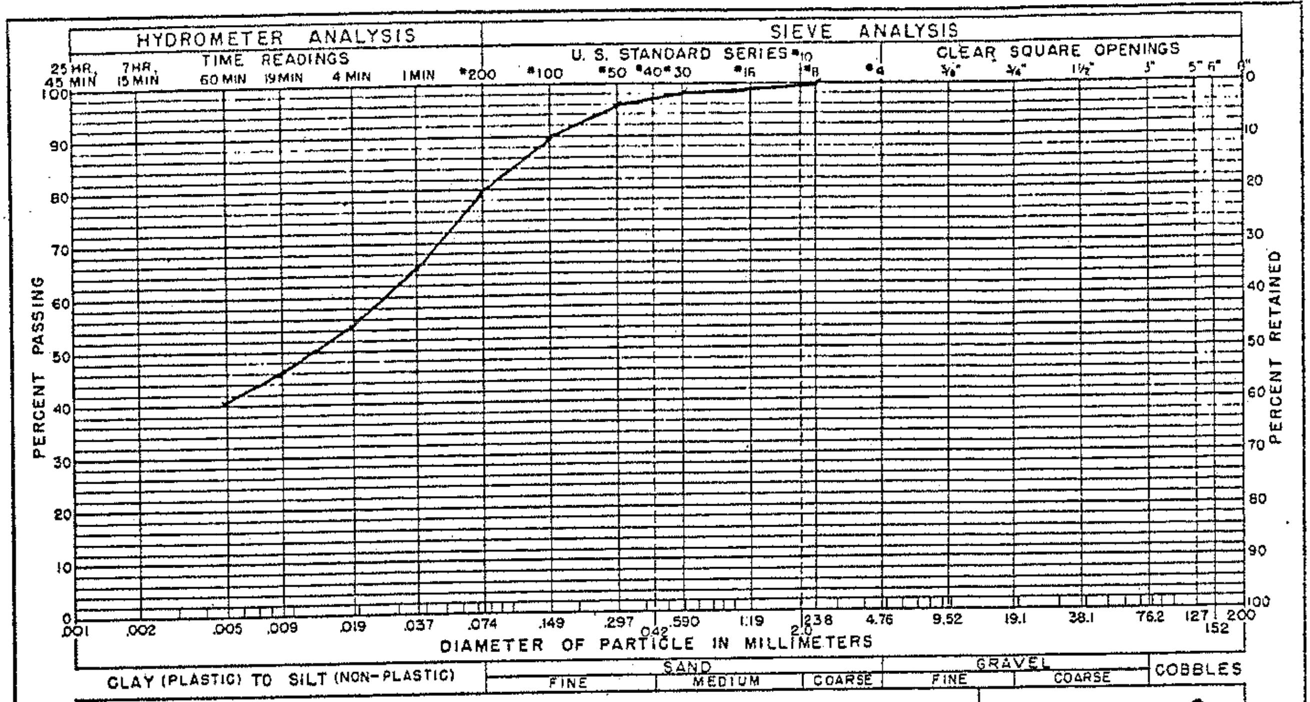
NOTES: ________

LABORATORY SAMPLE No. AP-21 FIELD DESIGNATION ________ EXCAVATION No. ________ DEPTH 1.0-10.0 FT.

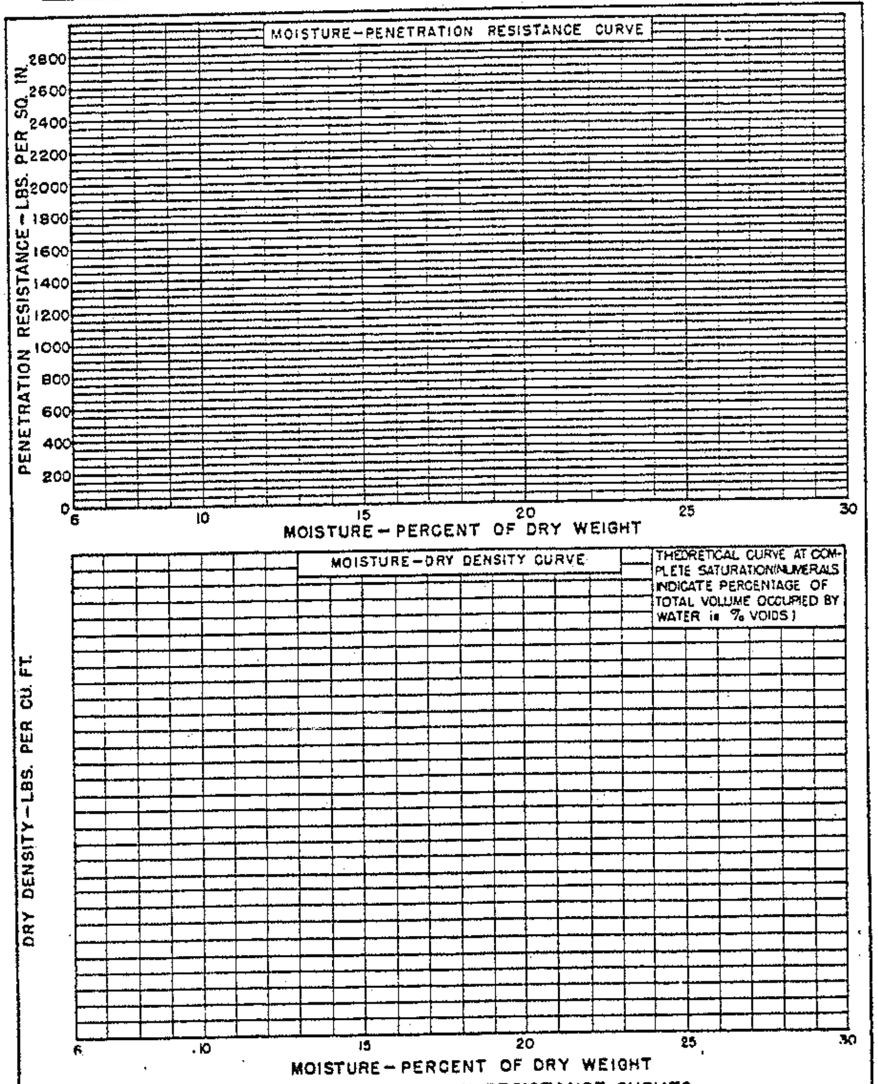
GPO 856928 FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ *0* %
SAND.............. *20* %
SILT TO CLAY...... *80* %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL *CL*
SPECIFIC GRAVITY *2.65*
ATTERBERG LIMITS
LIQUID LIMIT *34.3*
PLASTICITY INDEX *14.2*
SHRINKAGE LIMIT *10.0*
COMPACTION
% LARGER THAN TESTED ______
MAX. DRY DENSITY (P.C.F.) ______
OPTIMUM MOIST. CONT. (%) ______
PENETRATION RESIST. (P.S.I.) ______
PERCOLATION SETTLEMENT
PLACEMENT CONDITION ______
PERMEABILITY (FT/YR.) ______
SETTLEMENT (%) UNDER
______ P.S.I. LOAD ______

NOTES: ______

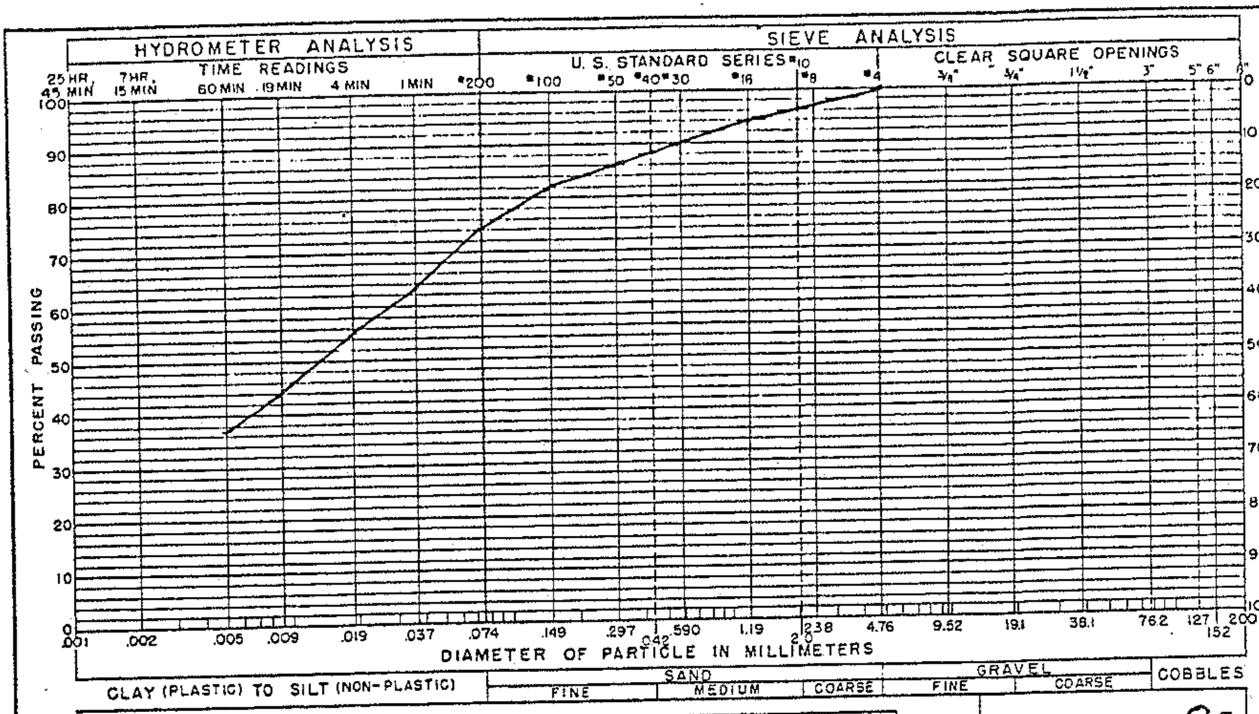
LABORATORY SAMPLE No. *AP-22* FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH *0.5-5.5* FT.

GPO 858128

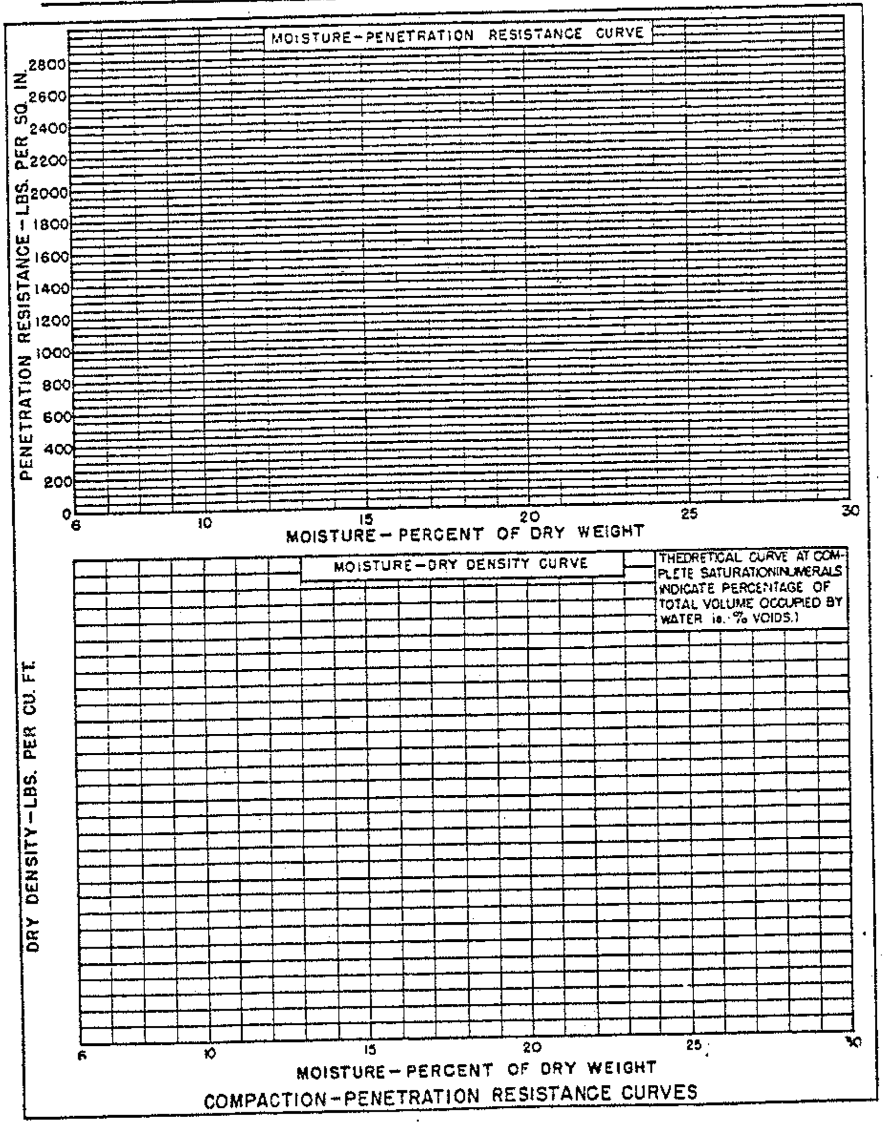
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ 0 %
SAND............ 26 %
SILT TO CLAY...... 74 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL

SPECIFIC GRAVITY 2.65

ATTERBERG LIMITS

LIQUID LIMIT 32.6

PLASTICITY INDEX 13.1

SHRINKAGE LIMIT 11.4

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT/YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES: ______

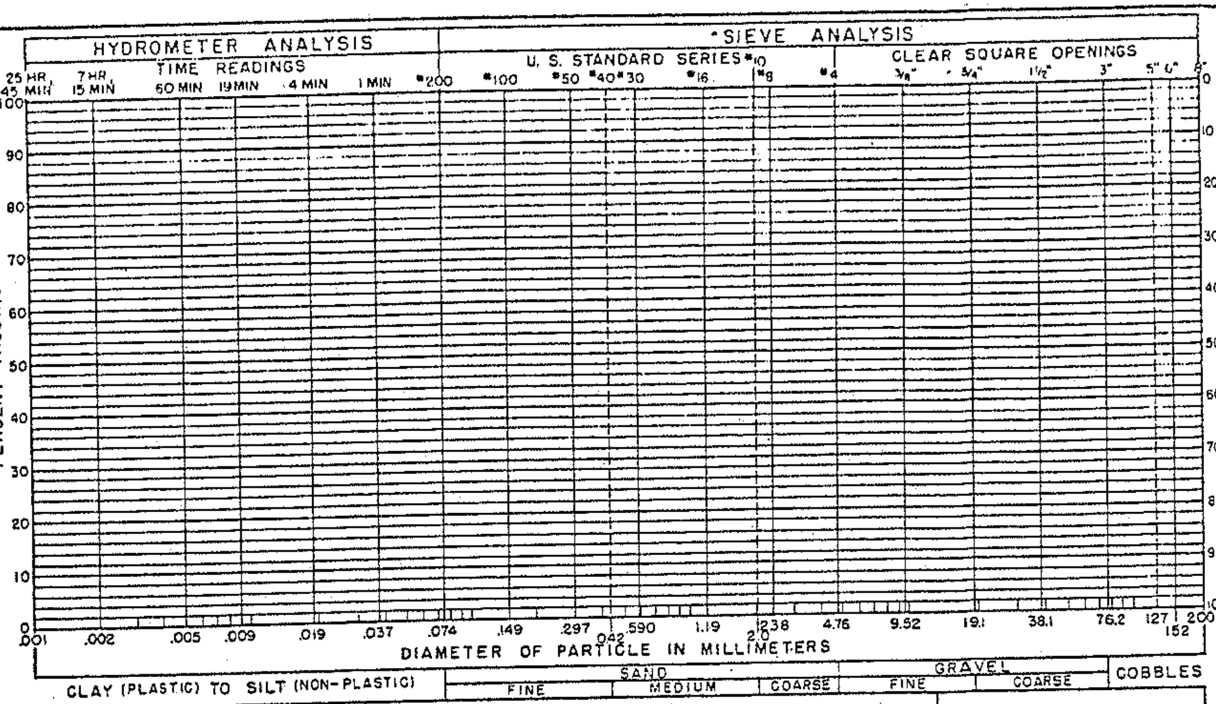
LABORATORY SAMPLE No. AP-22 FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH 5.5-11.0 FT.

GPO 856928

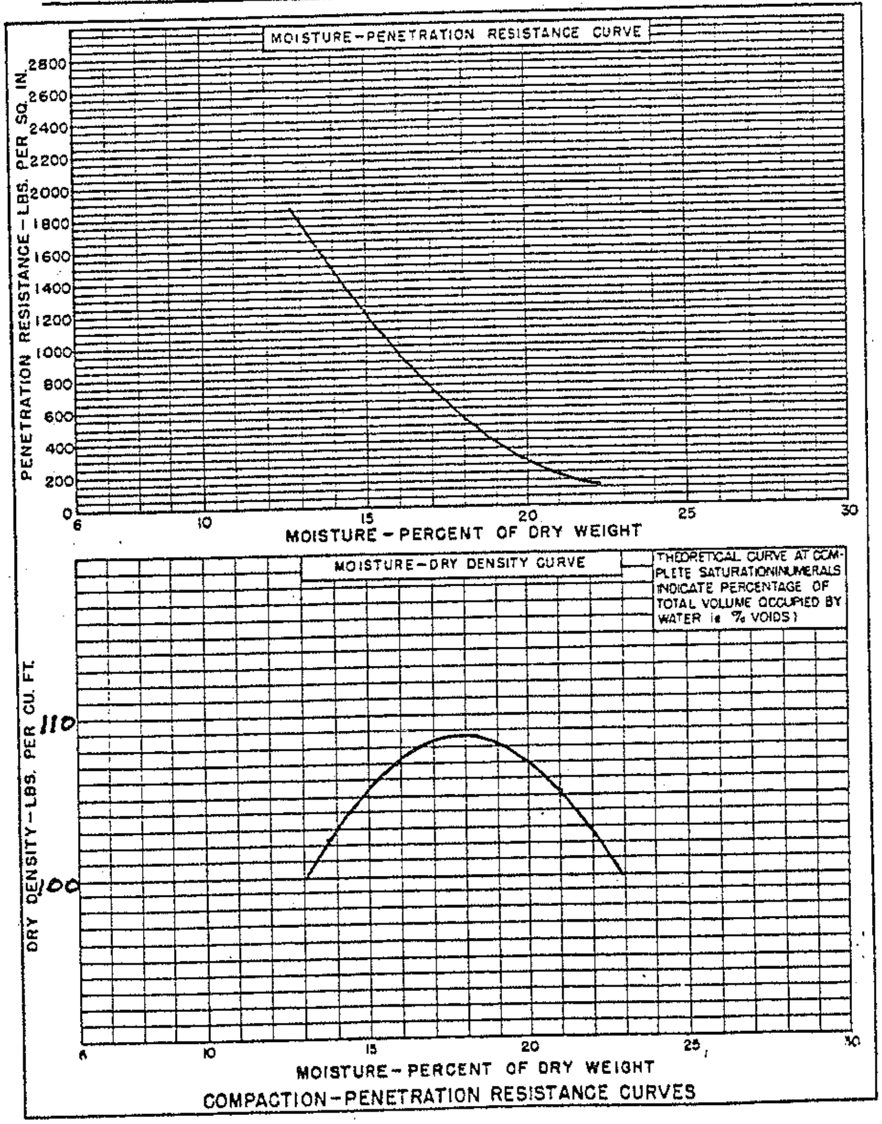
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL.............. %
SAND.............. %
SILT TO CLAY...... %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL ________

SPECIFIC GRAVITY ________

ATTERBERG LIMITS

LIQUID LIMIT ________

PLASTICITY INDEX ________

SHRINKAGE LIMIT ________

COMPACTION

% LARGER THAN TESTED 0

MAX. DRY DENSITY (P.C.F.) 108.8

OPTIMUM MOIST. CONT.(%) 18.0

PENETRATION RESIST.(P.S.I.) 540

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ________

PERMEABILITY (FT/YR.) ________

SETTLEMENT (%) UNDER

_____ P.S.I. LOAD ________

NOTES:

Composite

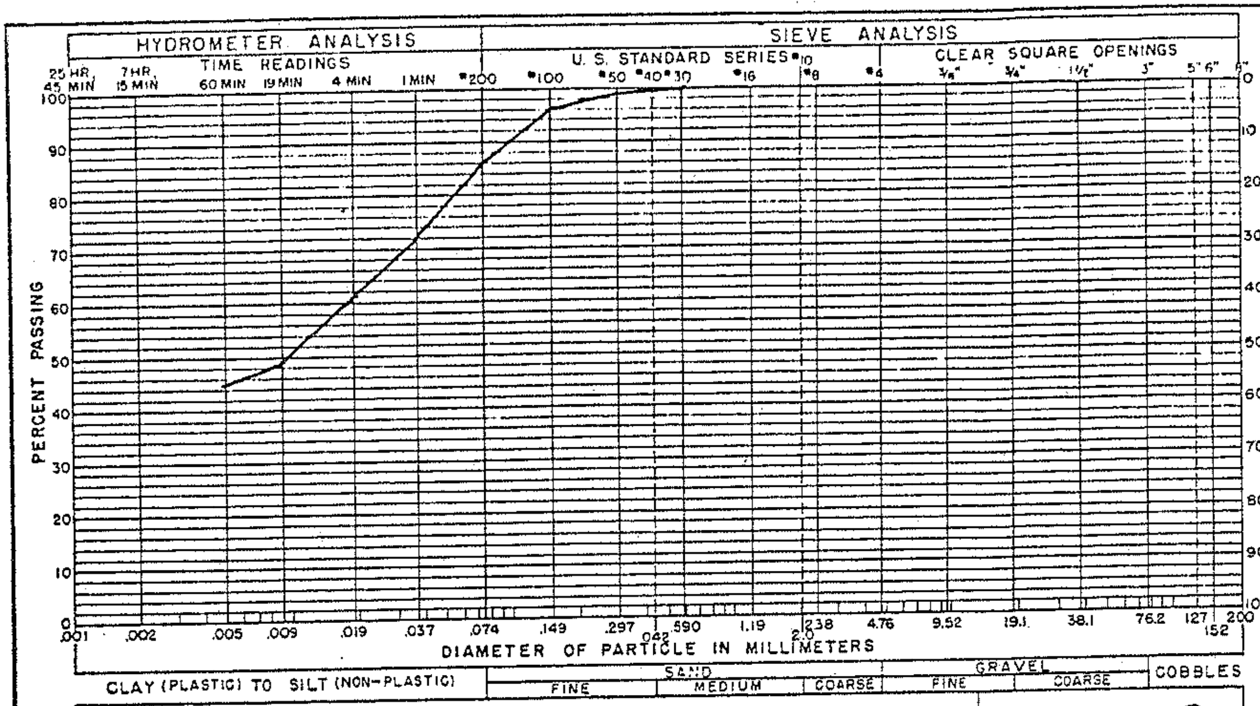
LABORATORY SAMPLE No. AP-22 FIELD DESIGNATION ________ EXCAVATION No. ________ DEPTH 0.5-11.0 FT

GPO 856028

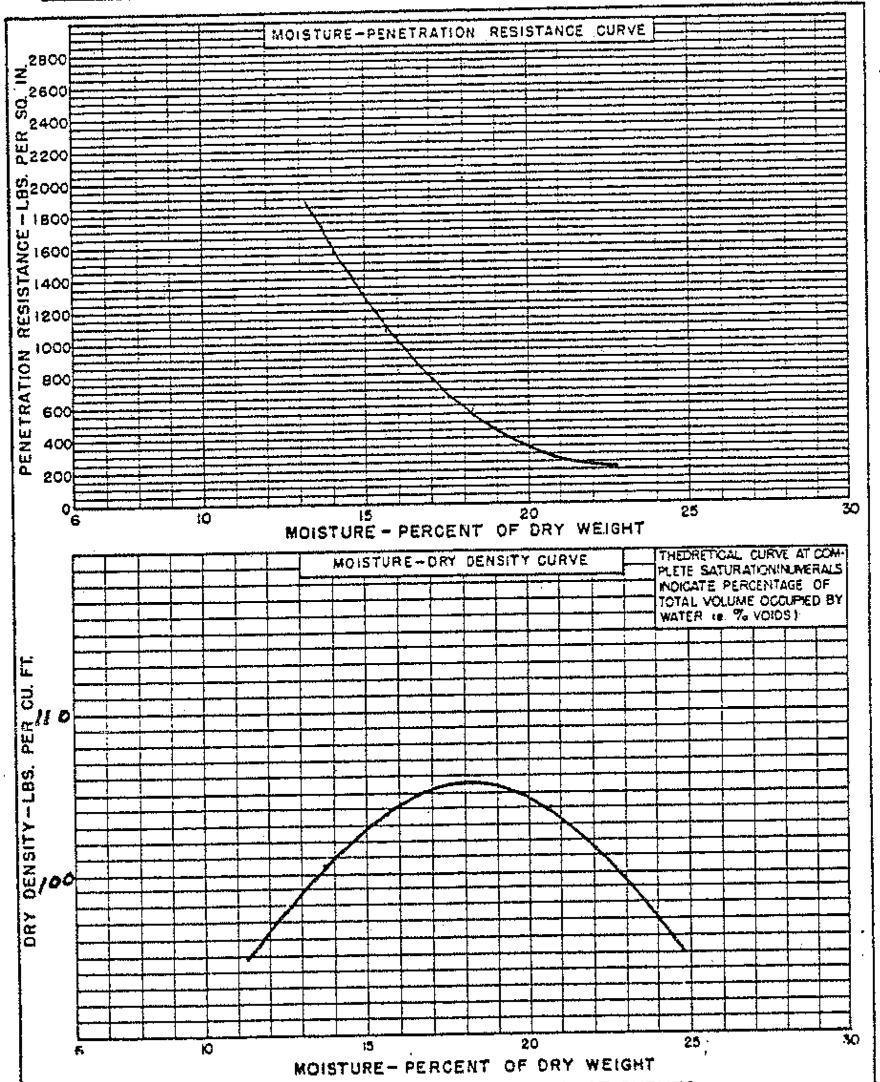
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ 0 %
SAND............ 14 %
SILT TO CLAY...... 86 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL
SPECIFIC GRAVITY 2.67
ATTERBERG LIMITS
LIQUID LIMIT 31.2
PLASTICITY INDEX 12.3
SHRINKAGE LIMIT 12.2
COMPACTION
% LARGER THAN TESTED 0
MAX. DRY DENSITY (P.C.F.) 105.7
OPTIMUM MOIST. CONT. (%) 18.2
PENETRATION RESIST. (P.S.I.) 550
PERCOLATION SETTLEMENT
PLACEMENT CONDITION ______
PERMEABILITY (FT/YR.) ______
SETTLEMENT (%) UNDER
______ P.S.I. LOAD ______

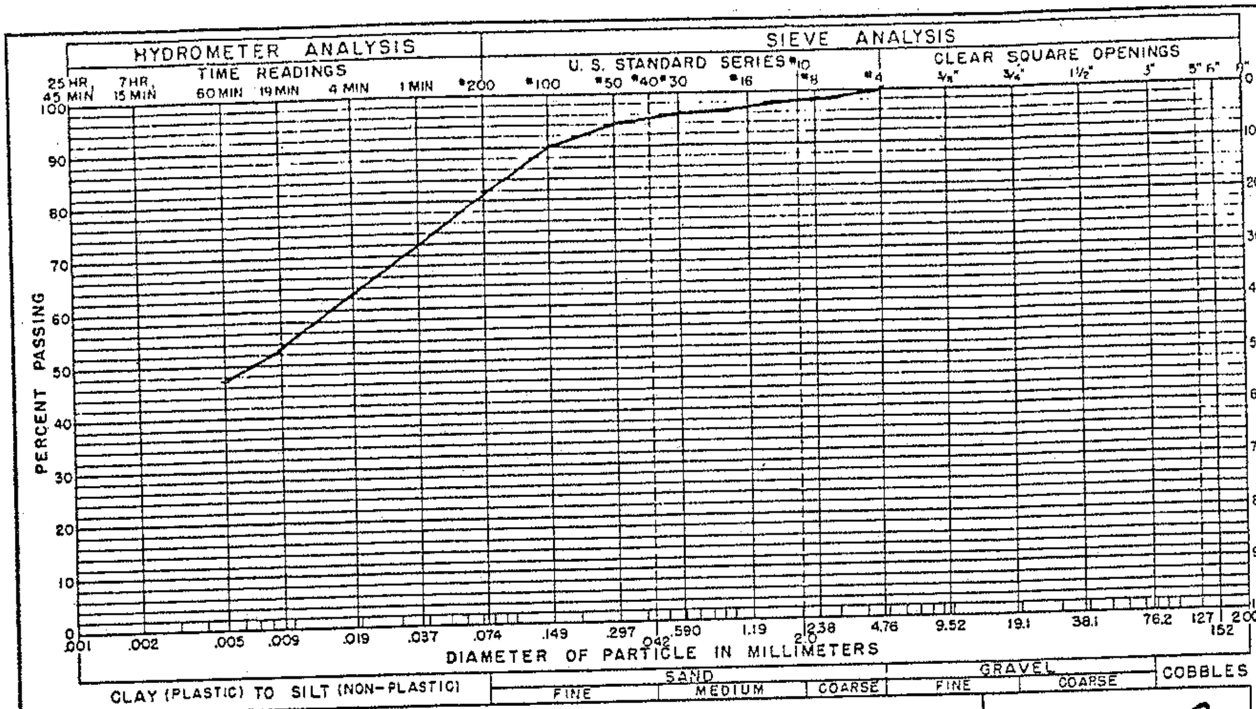
NOTES: ______

LABORATORY SAMPLE No. AP-28 FIELD DESIGNATION ______ EXCAVATION No ______ DEPTH 0.5 - 7.0 FT.

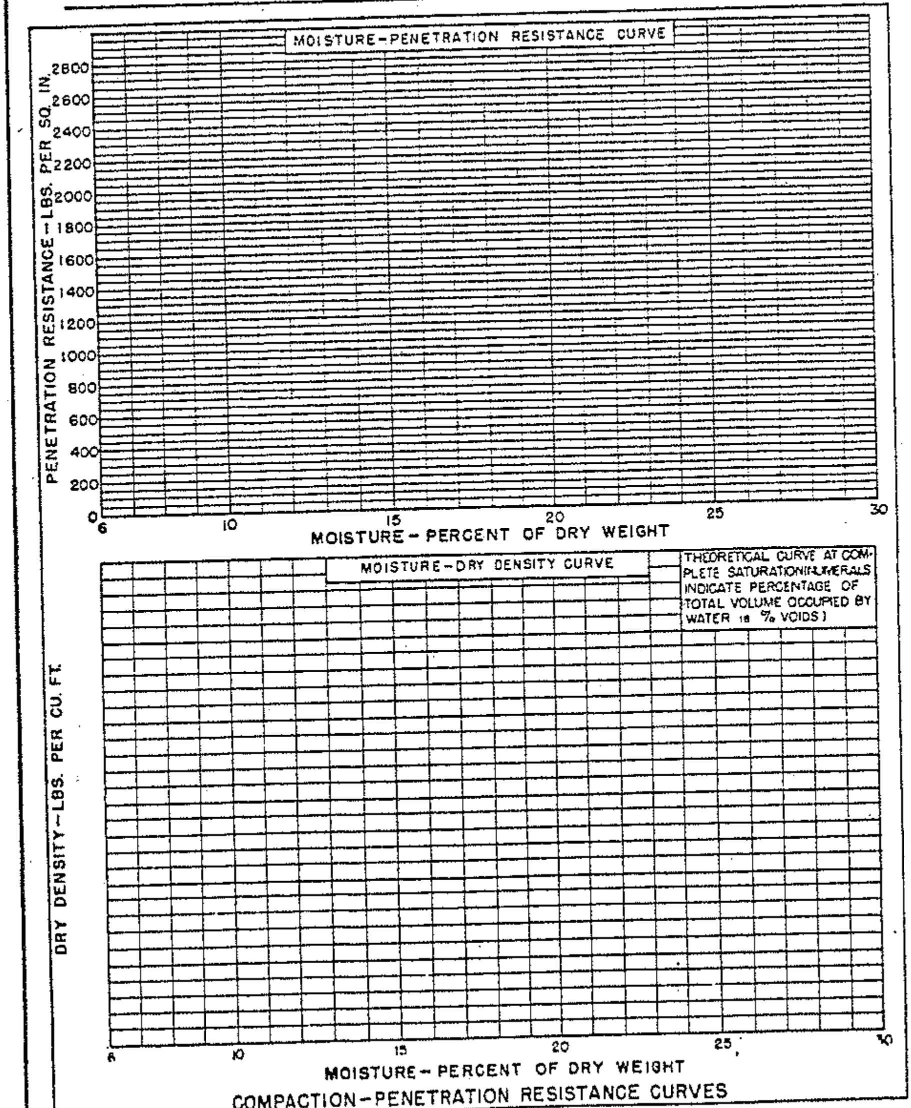
GPO 856728 FIGURE NO.

FORM 7-1565
(5-62)
REAU OF
CLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ 0 %
SAND............ 18 %
SILT TO CLAY...... 82 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL

SPECIFIC GRAVITY 2.73

ATTERBERG LIMITS

LIQUID LIMIT 40.7

PLASTICITY INDEX 21.6

SHRINKAGE LIMIT 9.1

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT/YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

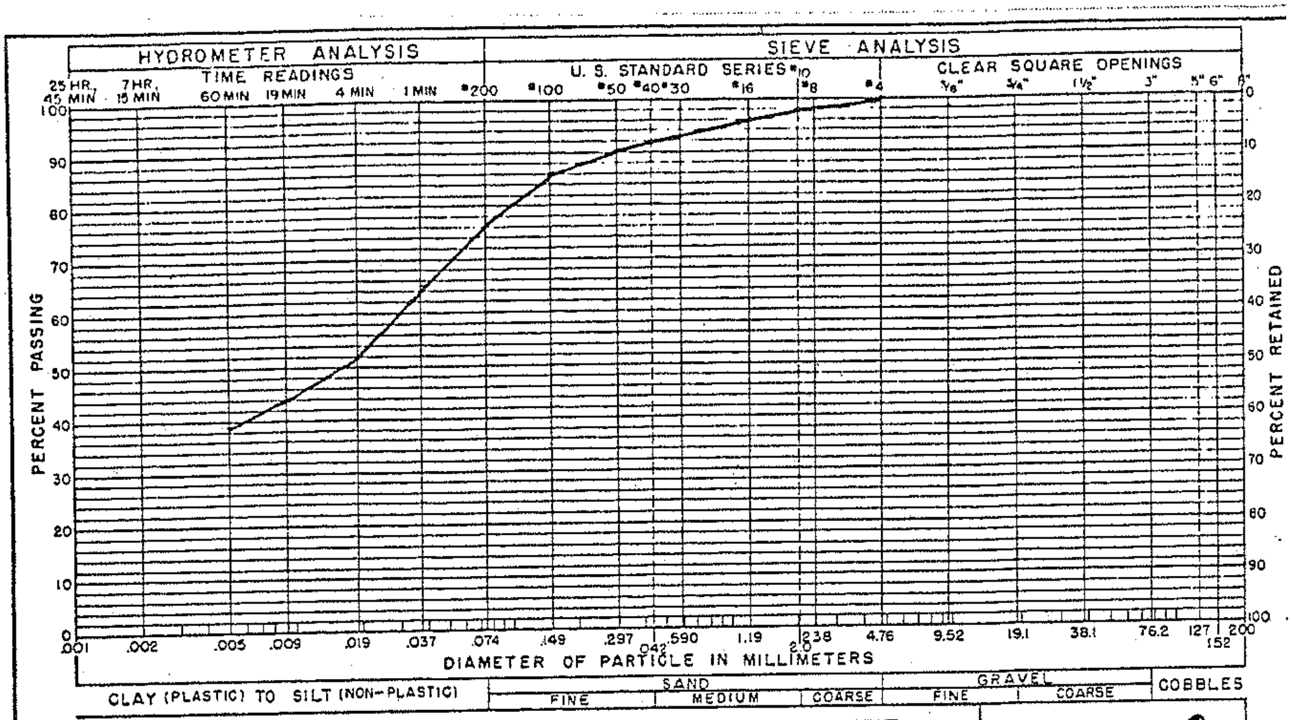
NOTES: ______

LABORATORY SAMPLE No. AP-31 FIELD DESIGNATION ______ EXCAVATION No ______ DEPTH 0.5-6.0 FT.

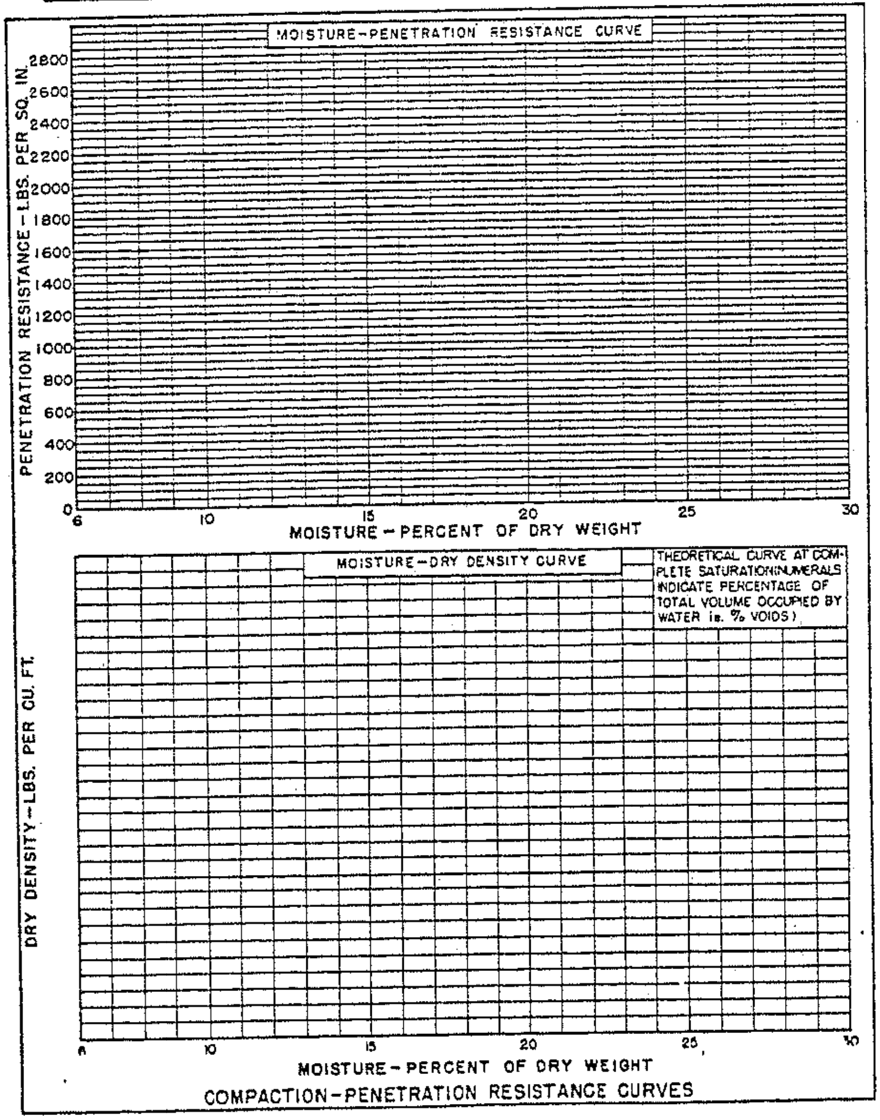
GPO 856028 FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL........ 0 %
SAND........ 24 %
SILT TO CLAY...... 76 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL
SPECIFIC GRAVITY 2.74
ATTERBERG LIMITS
LIQUID LIMIT 35.5
PLASTICITY INDEX 15.7
SHRINKAGE LIMIT 11.2
COMPACTION
% LARGER THAN TESTED ______
MAX. DRY DENSITY (P.C.F.) ______
OPTIMUM MOIST. CONT. (%) ______
PENETRATION RESIST. (P.S.I.) ______
PERCOLATION SETTLEMENT
PLACEMENT CONDITION ______
PERMEABILITY (FT./YR.) ______
SETTLEMENT (%) UNDER
______ P.S.I. LOAD ______

NOTES: ______

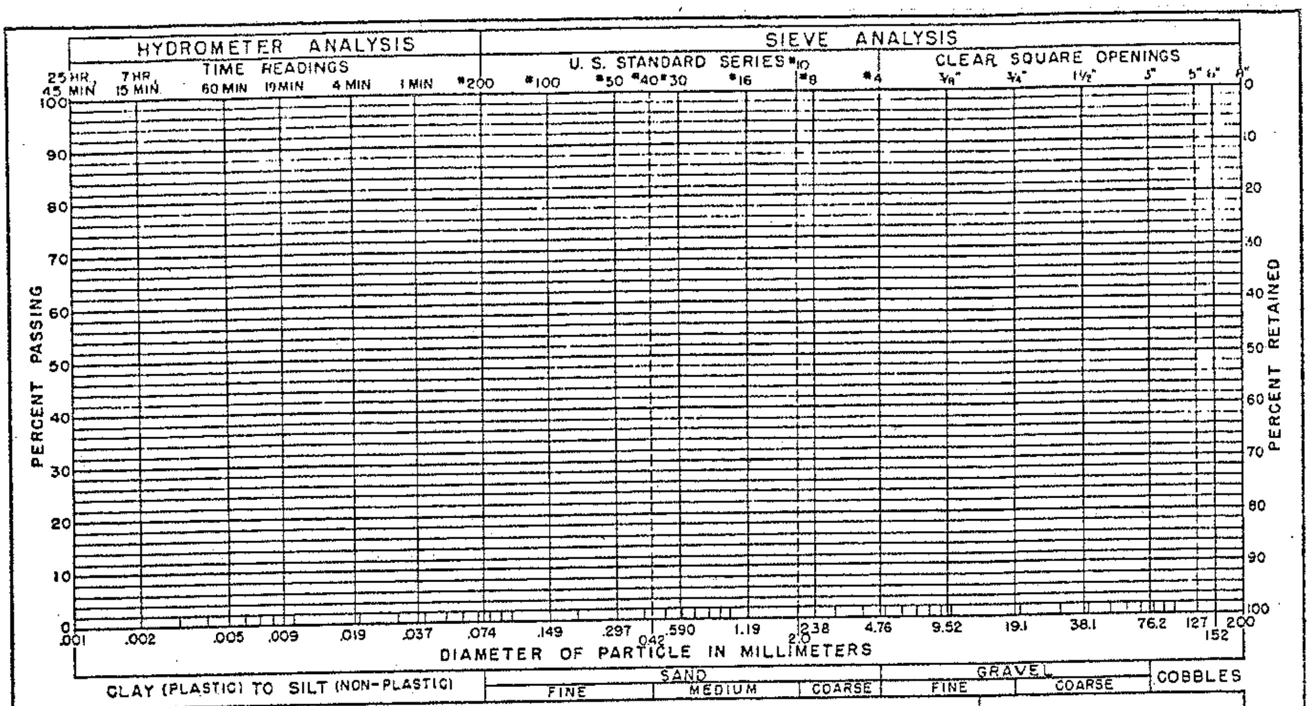
LABORATORY SAMPLE No. AP-31 FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH 6.0-9.0 FT

GPO 856028

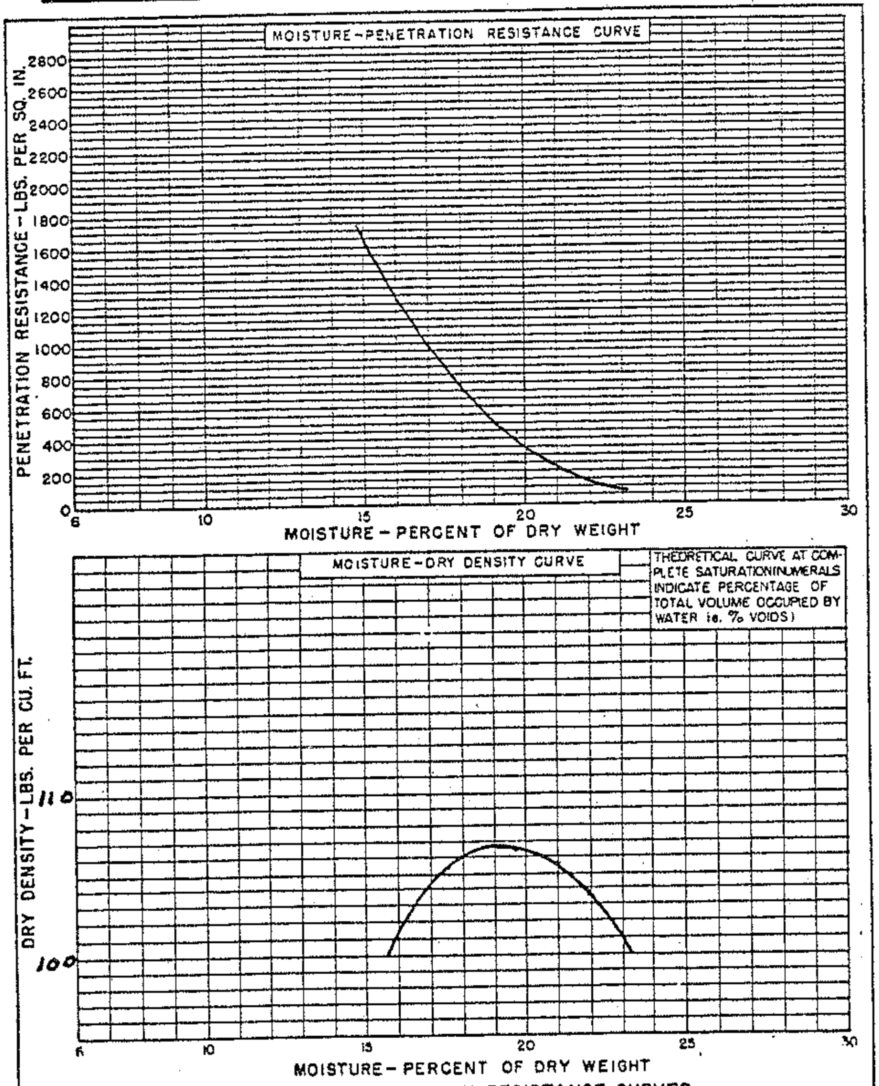
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ %
SAND............ %
SILT TO CLAY...... %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL ______
SPECIFIC GRAVITY ______
ATTERBERG LIMITS
LIQUID LIMIT ______
PLASTICITY INDEX ______
SHRINKAGE LIMIT ______
COMPACTION
% LARGER THAN TESTED 0
MAX. DRY DENSITY (P.C.F.) 106.8
OPTIMUM MOIST. CONT. (%) 19.0
PENETRATION RESIST. (P.S.I.) 500
PERCOLATION SETTLEMENT
PLACEMENT CONDITION ______
PERMEABILITY (FT./YR.) ______
SETTLEMENT (%) UNDER
______ P.S.I. LOAD ______

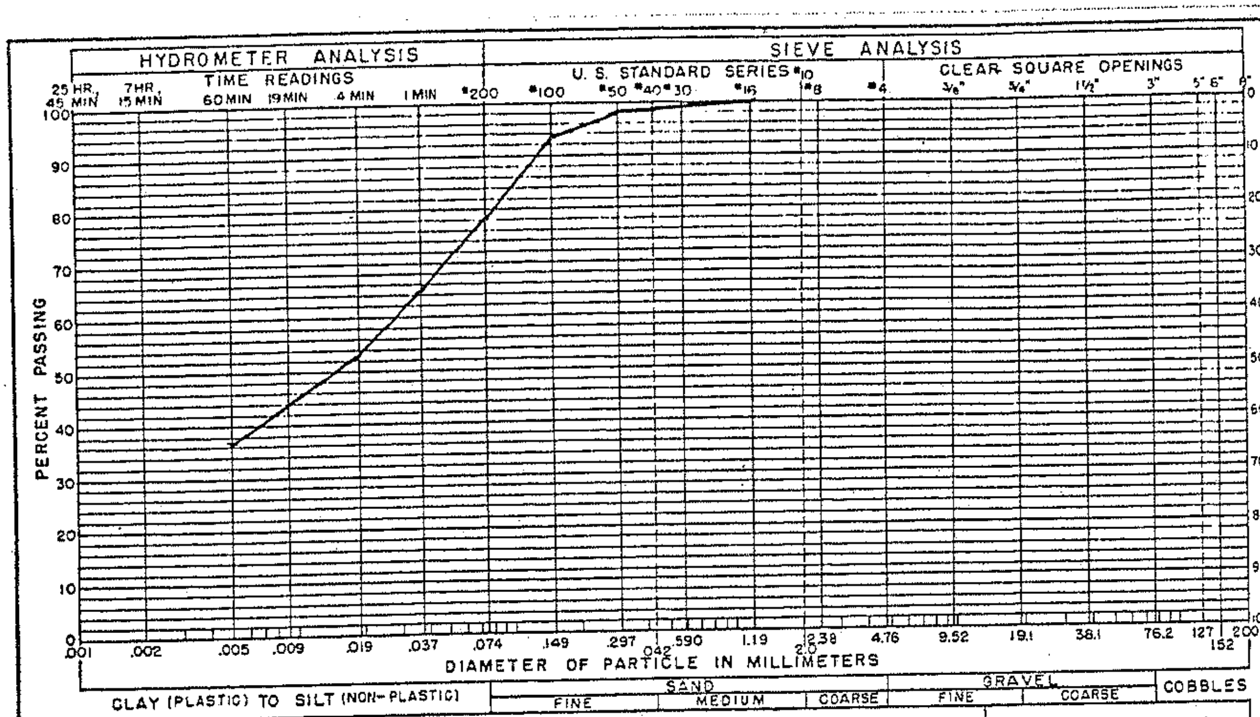
NOTES:
Composite

LABORATORY SAMPLE No. AP-31 FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH 0.5 - 9.0 FT.

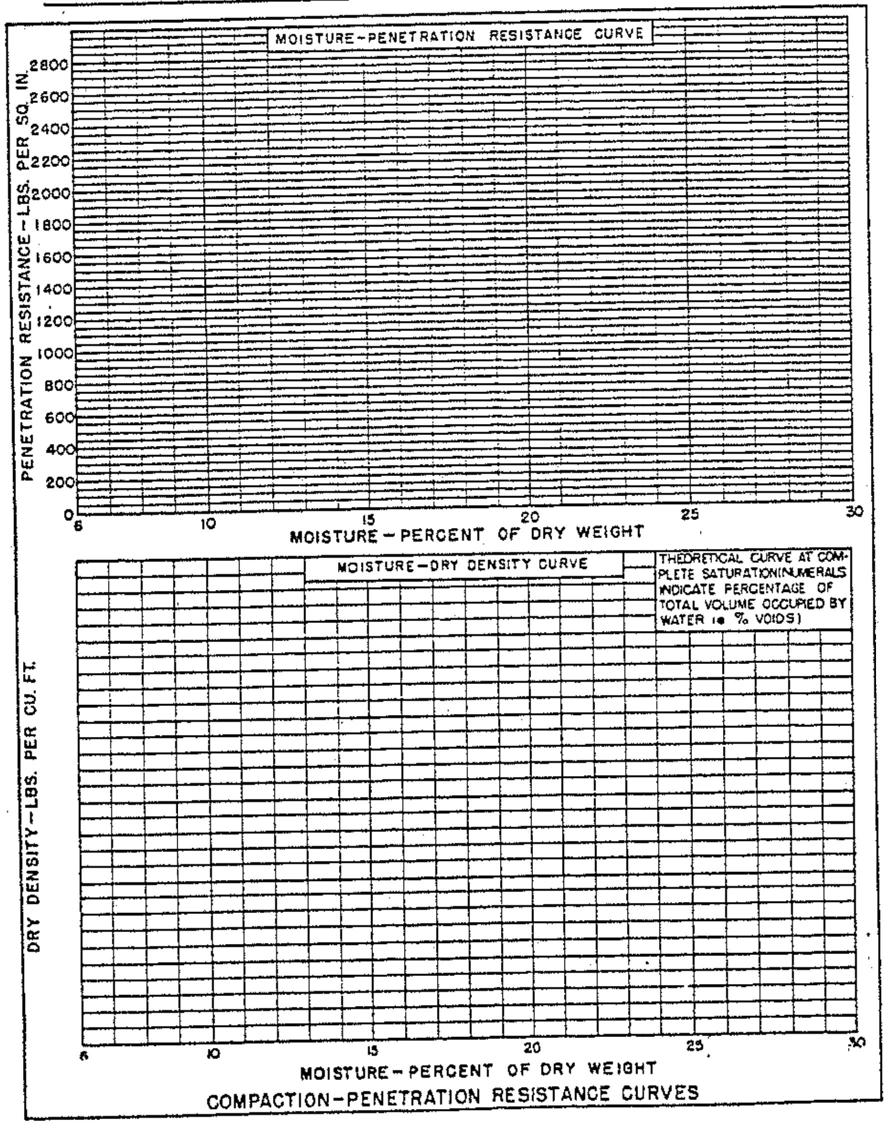
GPO 858128 FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ *0* %
SAND.............. *22* %
SILT TO CLAY...... *78* %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL *CL*

SPECIFIC GRAVITY *2.56*

ATTERBERG LIMITS

LIQUID LIMIT *30.6*

PLASTICITY INDEX *15.2*

SHRINKAGE LIMIT *11.2*

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT/YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES: ______

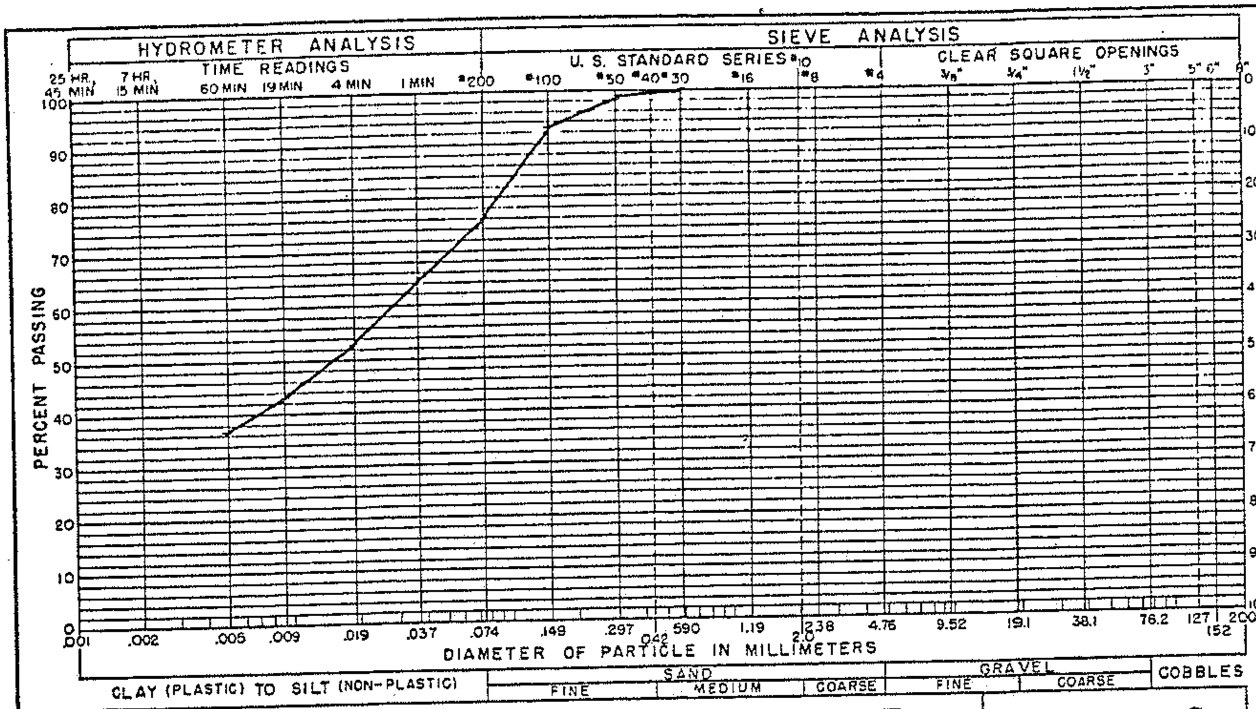
LABORATORY SAMPLE No. *TP-1* FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH *0 - 7.0* FT.

GPO 856928

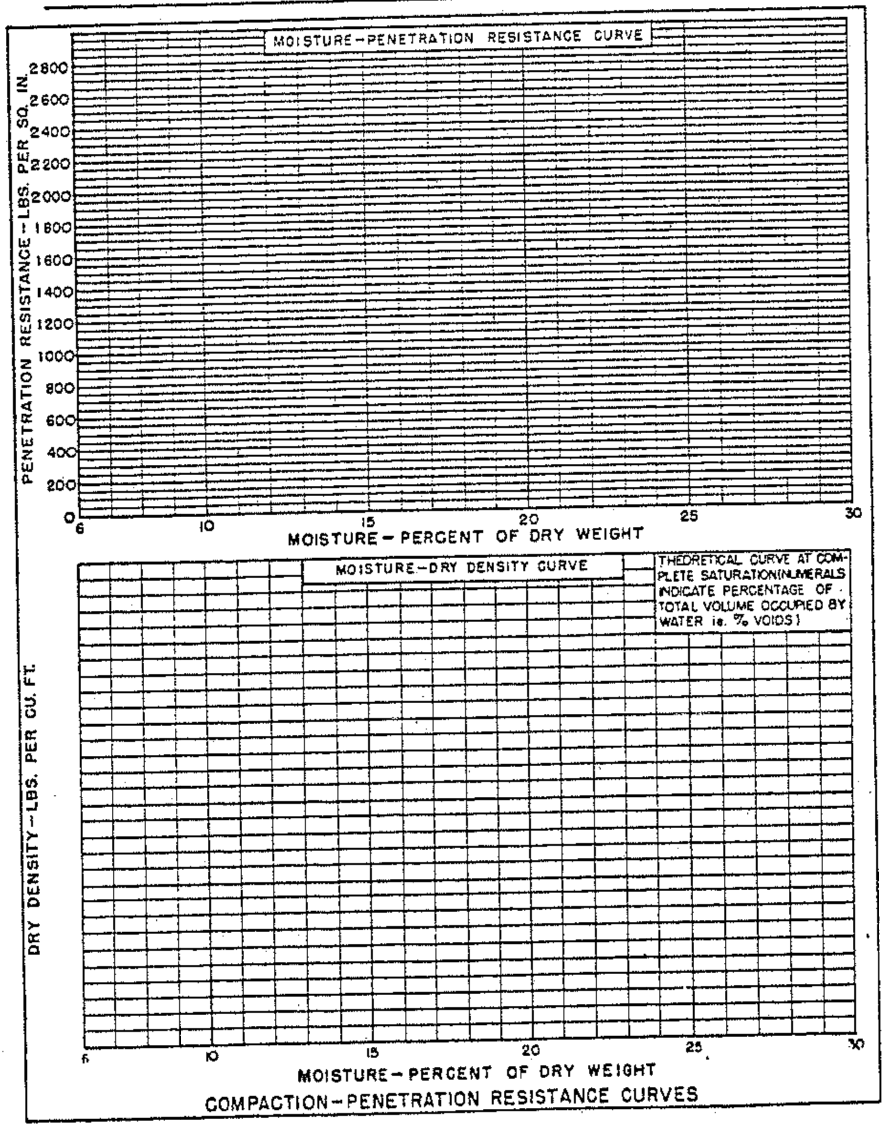
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL.............. 0 %
SAND................ 24 %
SILT TO CLAY...... 76 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL
SPECIFIC GRAVITY 2.61
ATTERBERG LIMITS
- LIQUID LIMIT 30.2
- PLASTICITY INDEX 10.9
- SHRINKAGE LIMIT 19.6

COMPACTION
- % LARGER THAN TESTED ______
- MAX. DRY DENSITY (P.C.F.) ______
- OPTIMUM MOIST. CONT. (%) ______
- PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT
- PLACEMENT CONDITION ______
- PERMEABILITY (FT/YR.) ______
- SETTLEMENT (%) UNDER
- ______ P.S.I. LOAD ______

NOTES: ______

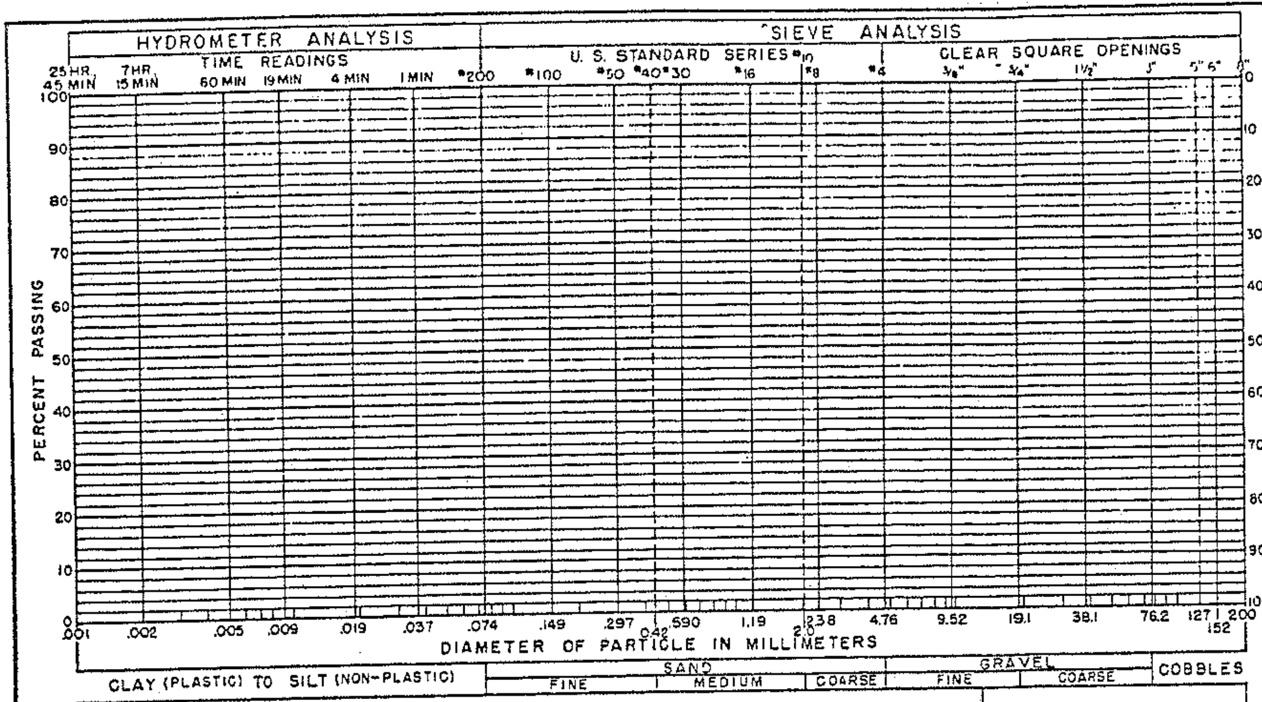
LABORATORY SAMPLE No. TP-1 FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH 7.0-12.0 FT.

GPO 858928

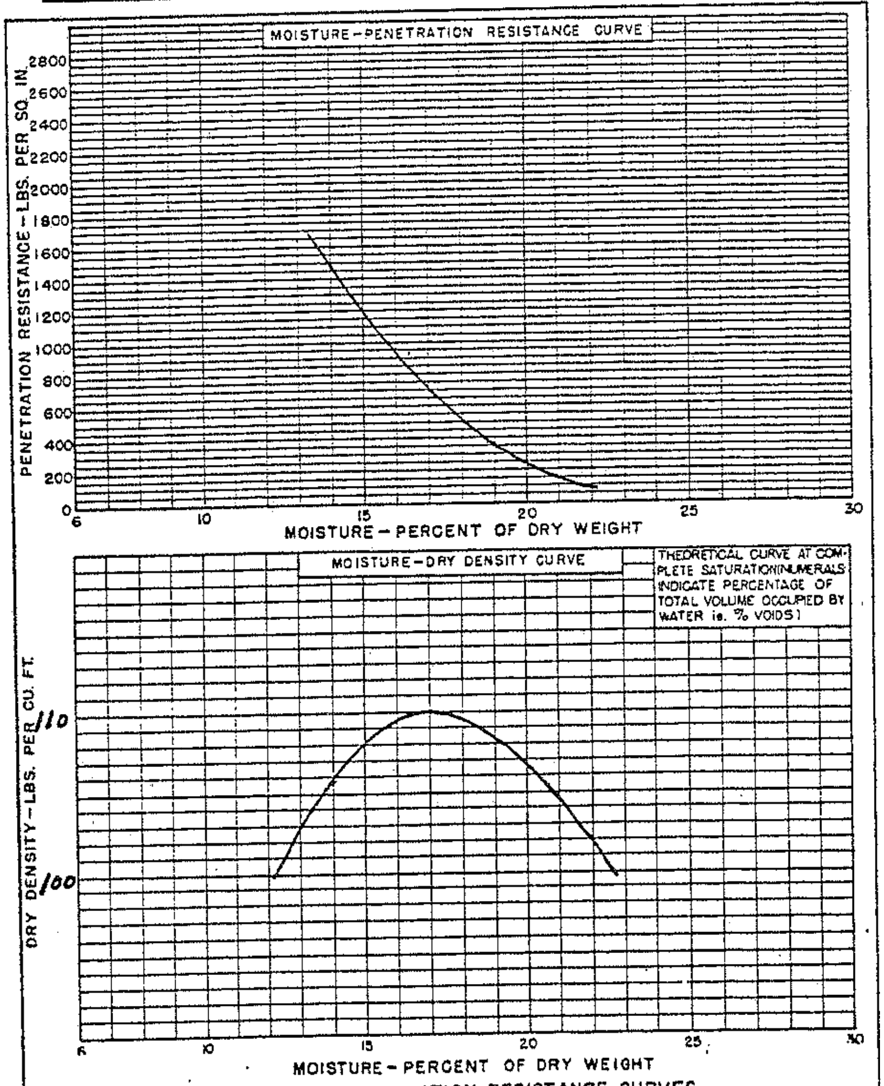
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ %
SAND.............. %
SILT TO CLAY...... %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL ______

SPECIFIC GRAVITY ______

ATTERBERG LIMITS

LIQUID LIMIT ______

PLASTICITY INDEX ______

SHRINKAGE LIMIT ______

COMPACTION

% LARGER THAN TESTED 0

MAX. DRY DENSITY (P.C.F.) 110

OPTIMUM MOIST. CONT. (%) 17.0

PENETRATION RESIST. (P.S.I.) 700

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT/YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES:

Composite

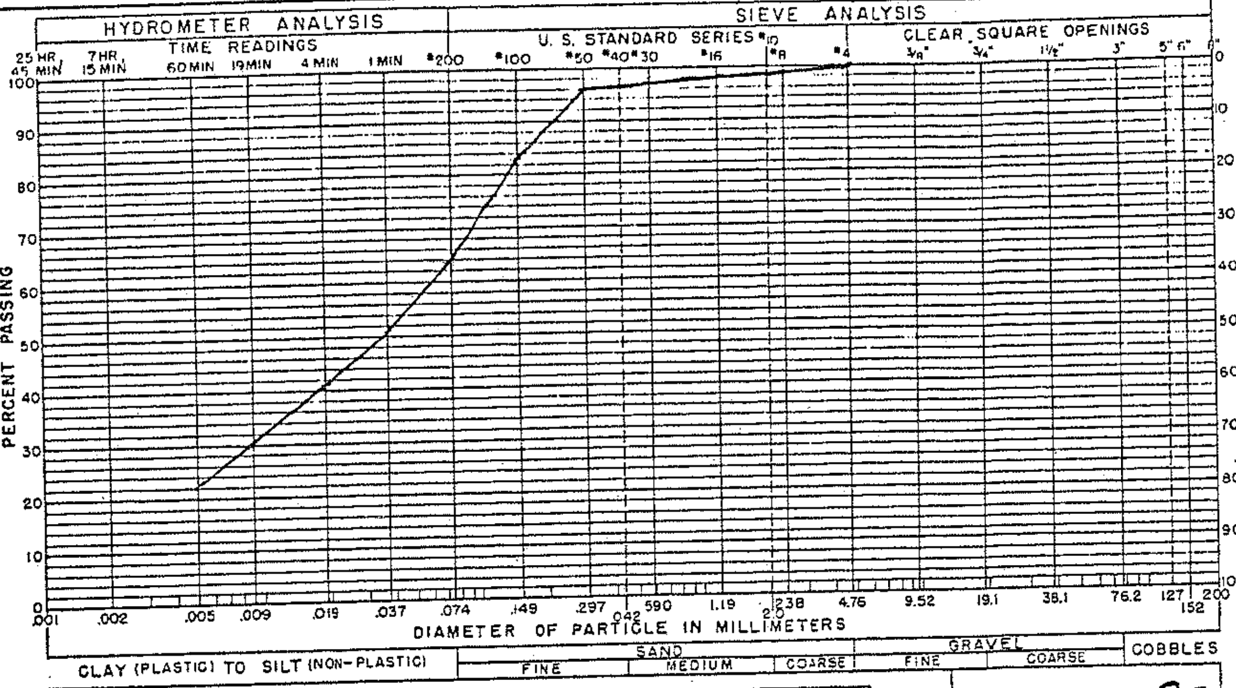
LABORATORY SAMPLE No. TP-1 FIELD DESIGNATION ______ EXCAVATION No ______ DEPTH 0-12.0 FT.

GPO 856128

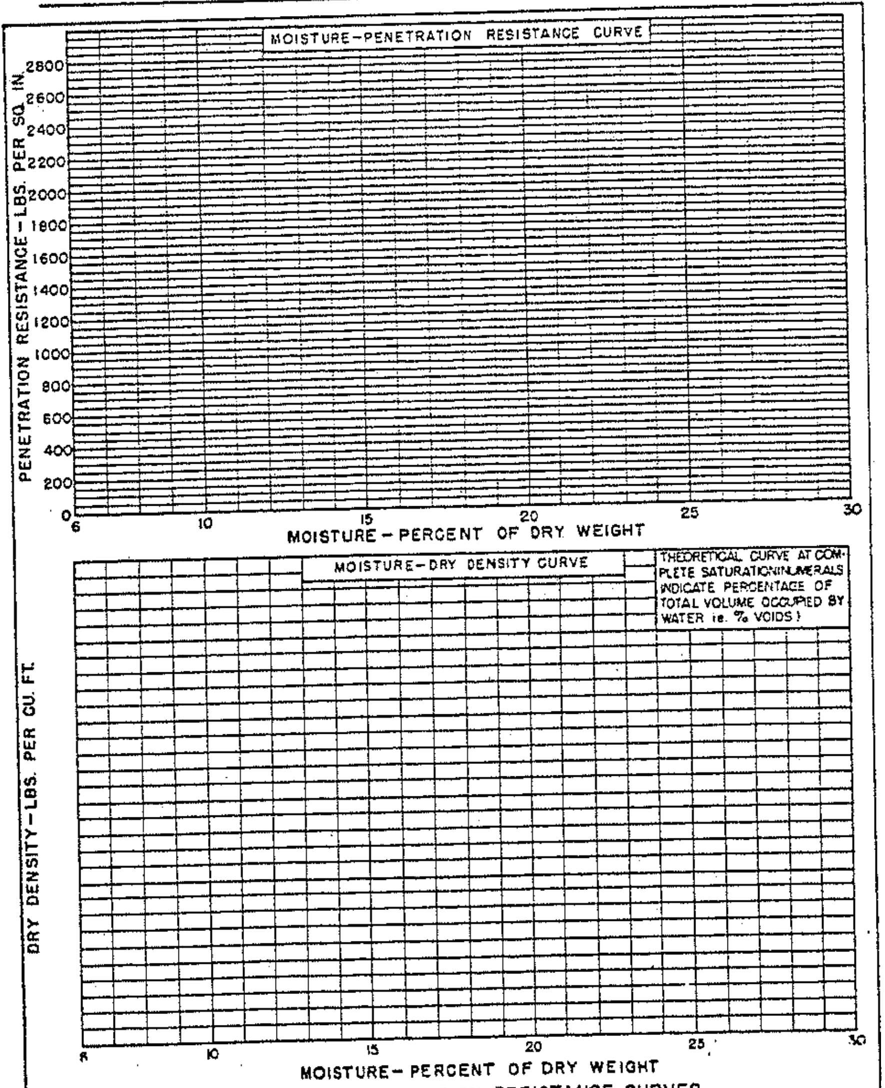
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............ 0 %
SAND.............. 36 %
SILT TO CLAY...... 64 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL-ML

SPECIFIC GRAVITY 2.70

ATTERBERG LIMITS

LIQUID LIMIT 25.6

PLASTICITY INDEX 5.9

SHRINKAGE LIMIT 17.0

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT./YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES:______

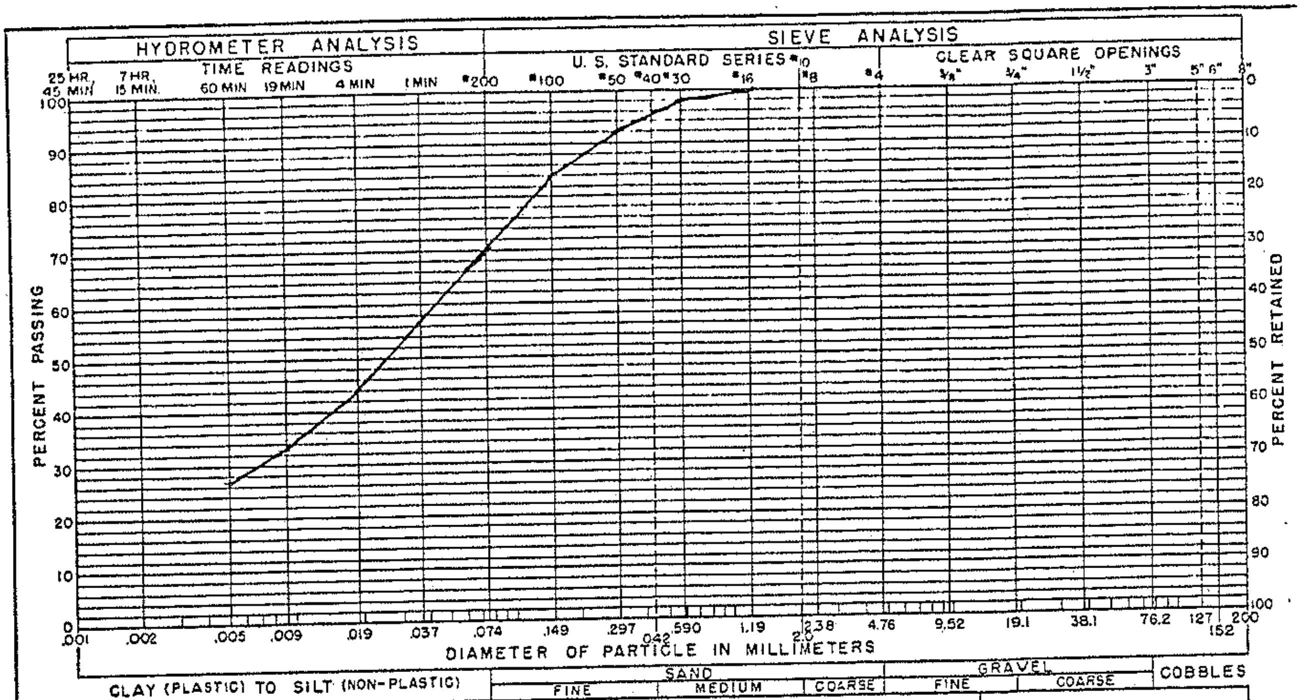
LABORATORY SAMPLE No. TP-2 FIELD DESIGNATION ______ EXCAVATION No. ______ DEPTH 0-10.0 FT.

GPO 856928

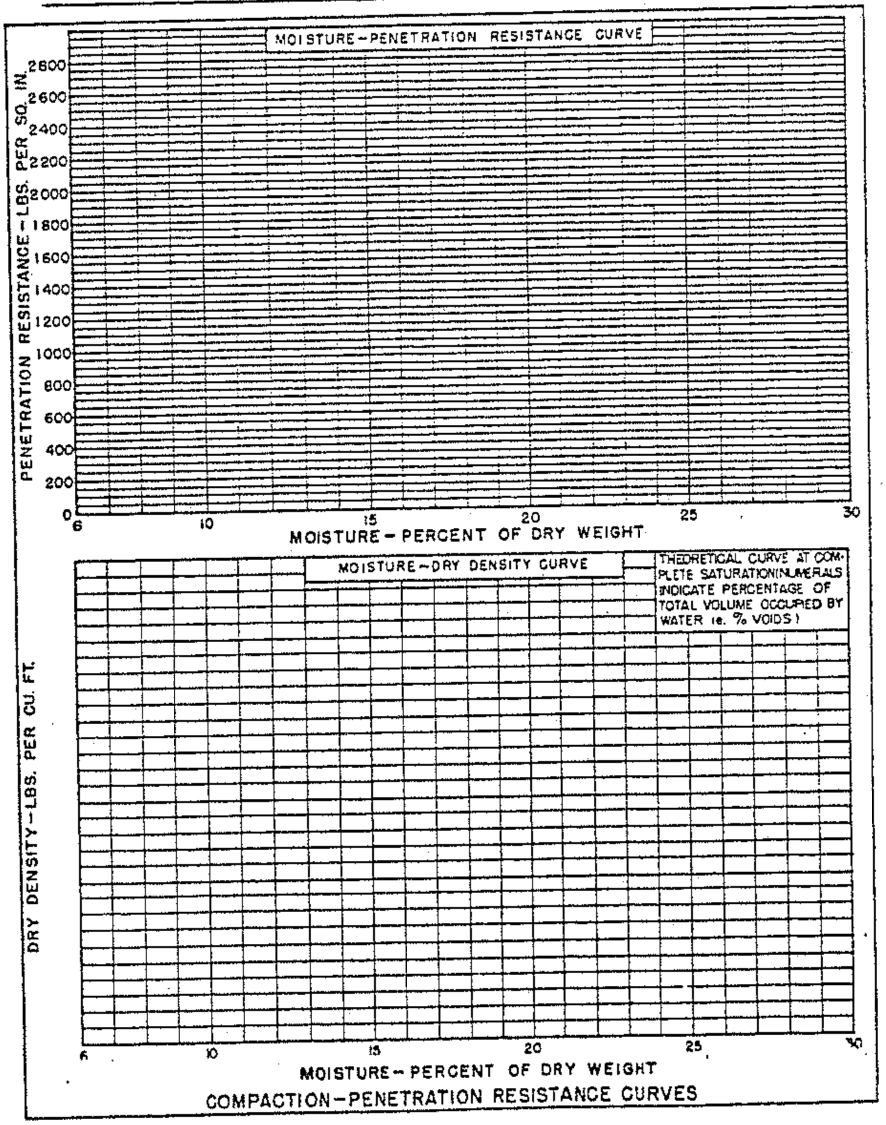
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL............0 %
SAND.............30 %
SILT TO CLAY......70 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL CL-ML

SPECIFIC GRAVITY 2.73

ATTERBERG LIMITS

LIQUID LIMIT 27.8

PLASTICITY INDEX 6.3

SHRINKAGE LIMIT 17.0

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT. (%) ______

PENETRATION RESIST. (P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT./YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES: ______

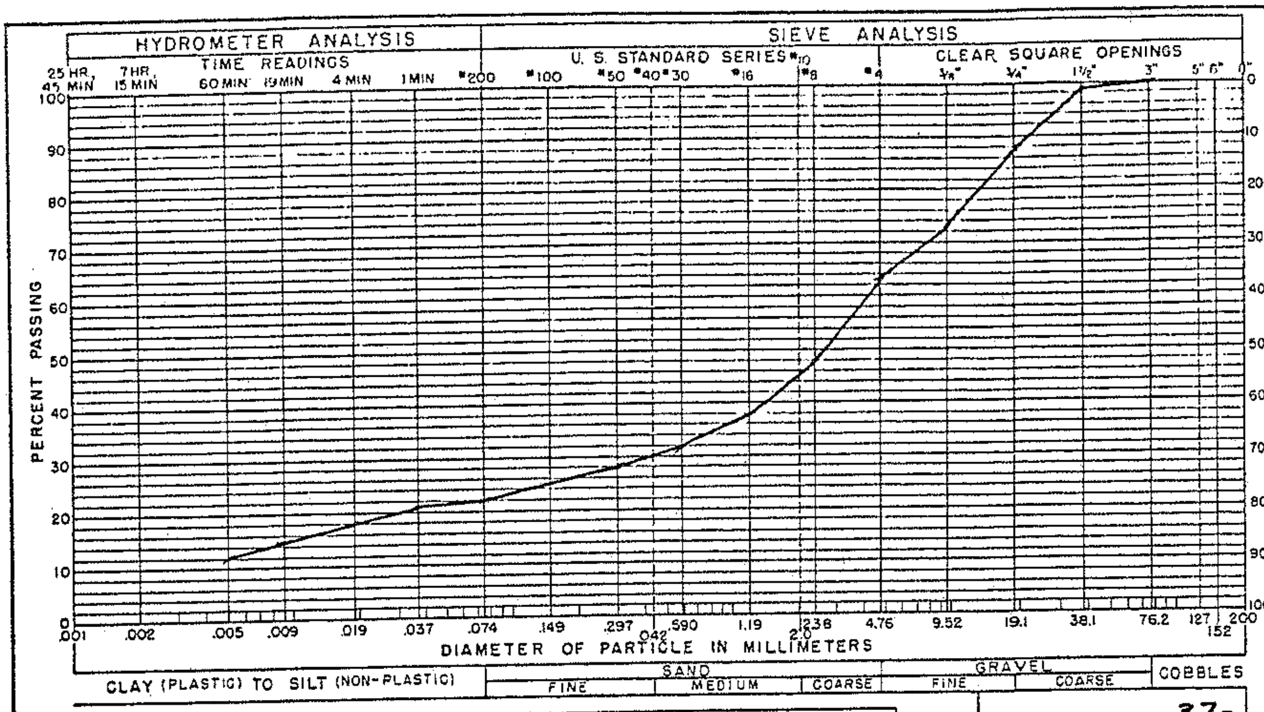
LABORATORY SAMPLE No. TP-2 FIELD DESIGNATION ______ EXCAVATION No ______ DEPTH 10.0-25.0 FT.

GPO 856928

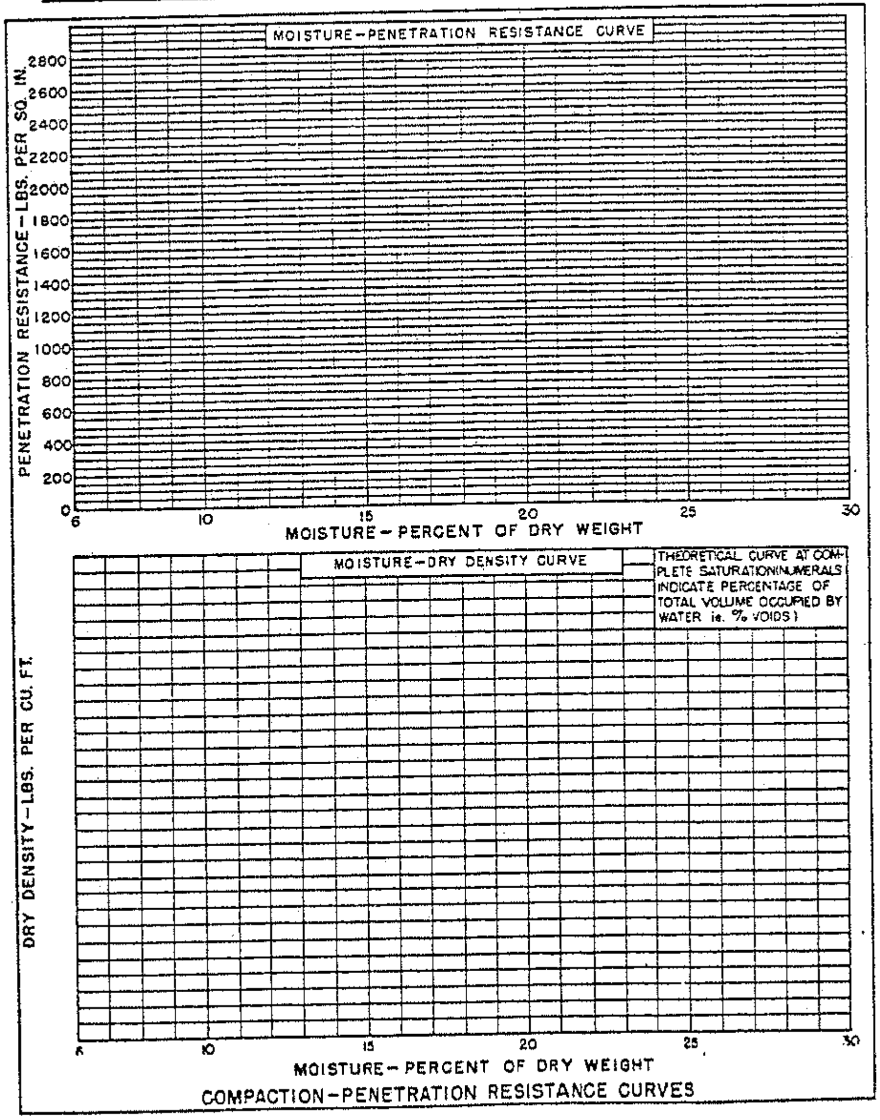
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL.............. 37 %
SAND.................. 41 %
SILT TO CLAY...... 22 %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL SM-GM

SPECIFIC GRAVITY 2.75

ATTERBERG LIMITS

LIQUID LIMIT 22.8

PLASTICITY INDEX 1.0

SHRINKAGE LIMIT 18.3

COMPACTION

% LARGER THAN TESTED ______

MAX. DRY DENSITY (P.C.F.) ______

OPTIMUM MOIST. CONT.(%) ______

PENETRATION RESIST.(P.S.I.) ______

PERCOLATION SETTLEMENT

PLACEMENT CONDITION ______

PERMEABILITY (FT./YR.) ______

SETTLEMENT (%) UNDER

______ P.S.I. LOAD ______

NOTES: ______

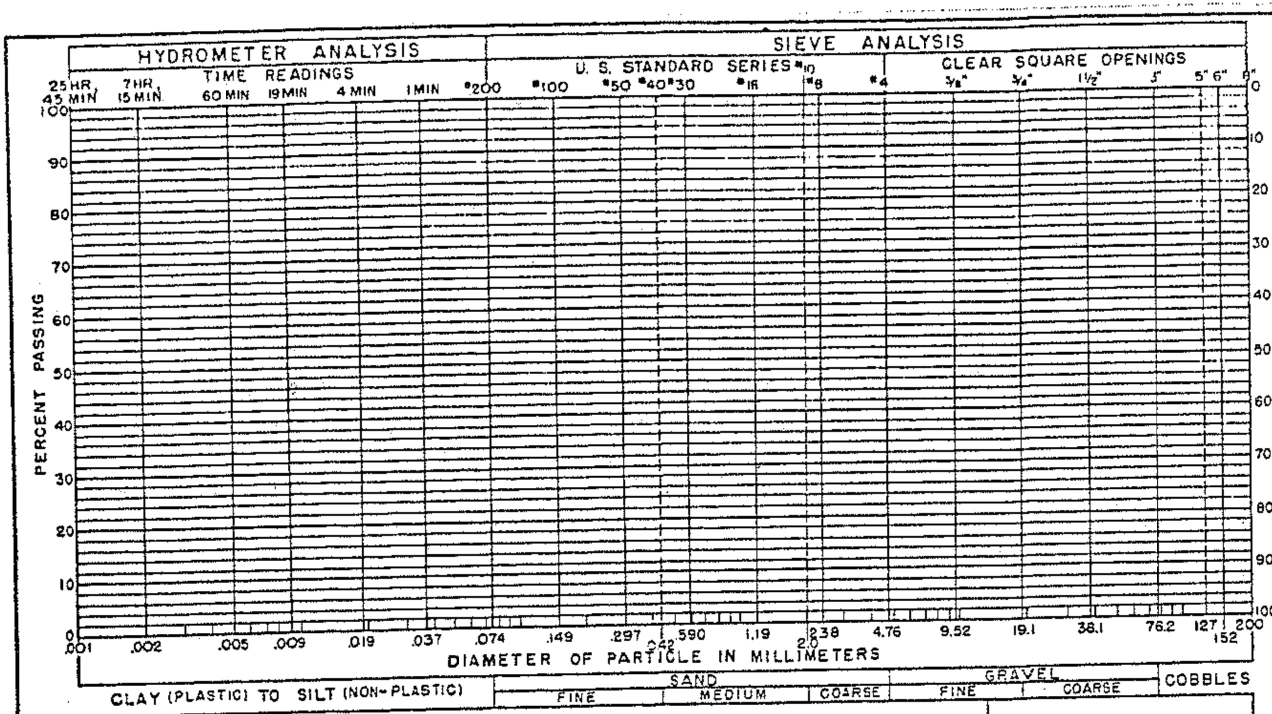
LABORATORY SAMPLE No. TP-2 FIELD DESIGNATION ______ EXCAVATION No ______ DEPTH 25.0 - 28.0 FT.

GPO 856928

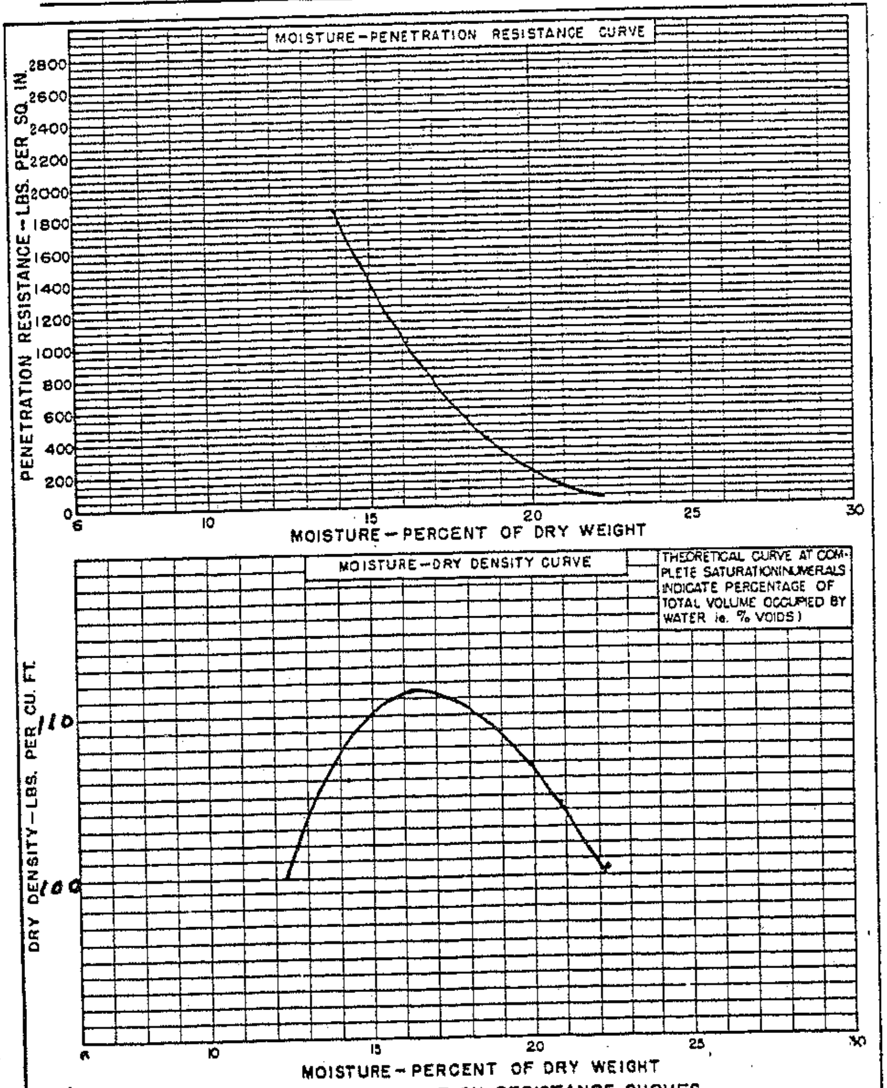
FIGURE NO.

FORM 7-1565
(5-62)
BUREAU OF
RECLAMATION

STANDARD PROPERTIES SUMMARY



GRAVEL.............. %
SAND.................. %
SILT TO CLAY...... %



COMPACTION-PENETRATION RESISTANCE CURVES

STANDARD PROPERTIES SUMMARY

CLASSIFICATION SYMBOL ______

SPECIFIC GRAVITY ______

ATTERBERG LIMITS

- LIQUID LIMIT ______
- PLASTICITY INDEX ______
- SHRINKAGE LIMIT ______

COMPACTION

- % LARGER THAN TESTED 0
- MAX. DRY DENSITY (P.C.F.) 111.5
- OPTIMUM MOIST. CONT. (%) 16.3
- PENETRATION RESIST. (P.S.I.) 940

PERCOLATION SETTLEMENT

- PLACEMENT CONDITION ______
- PERMEABILITY (FT./YR.) ______
- SETTLEMENT (%) UNDER ______ P.S.I. LOAD ______

NOTES:
Composite

LABORATORY SAMPLE No. TP-2 FIELD DESIGNATION ______ EXCAVATION No ______ DEPTH 0 - 28.0 FT.

GPO 856928 FIGURE NO.

APPENDIX D

IMPERVIOUS MATERIAL
PERMEABILITY TEST RESULTS FOR DWR SAMPLES

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF DESIGN AND CONSTRUCTION
CIVIL DESIGN BRANCH
BRYTE SOILS AND CONCRETE LAB

ASTM D5084-90: PERMEABILITY
"Falling Head Test - (Method C)"

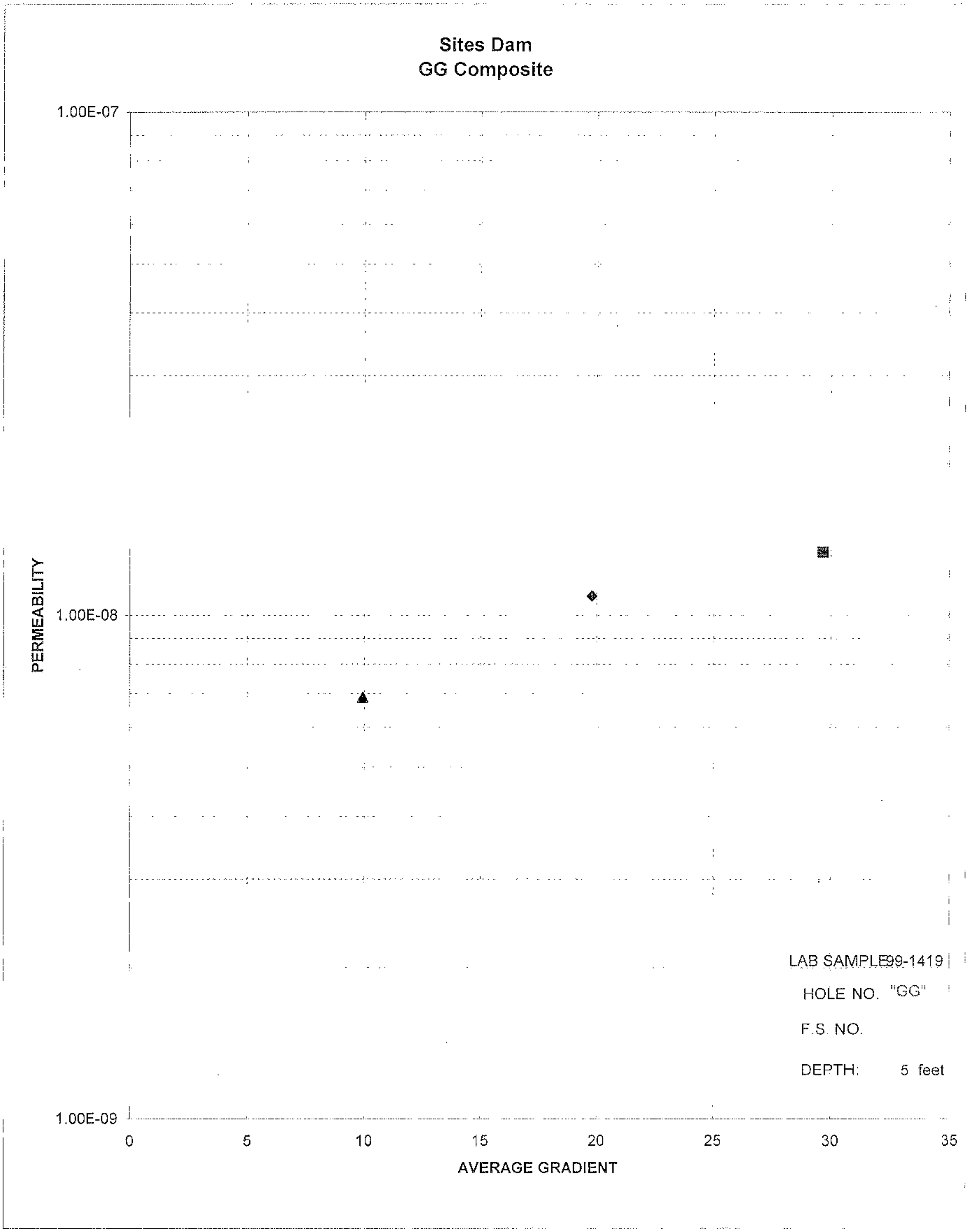
PROJECT: Sites Dam
REQUEST NO. 99-51
LAB SAMPLE 99-1419
HOLE NO. "GG" composite
F.S. NO.
DEPTH: 5 feet
VIS. DESCRIPTION: Lean clay

	BEFORE CONS.	AFTER CONS.	AFTER TEST
SAMPLE LENGTH, L (cm)	15.25	15.30	15.27
SAMPLE DIAMETER, D (cm)	7.14	7.14	7.14
SAMPLE AREA, cm^2	40.04	40.04	40.04
SAMPLE VOL., cm^3	610.60	612.52	611.31
ΔL,cm		0.05	0.02
ΔD,cm		0.00	
TEMPERATURE, °C	22.0		
TEMP. CORRECTION	0.956		
CONSOLIDATION STRESS (ksc)		0.50	

TIME (sec)	Burette Reading "IN"	Burette Reading "OUT"	Added Pressure "IN"	Inflow to Outflow Rate Ratio	h_1	h_2	$\log_n$ (h_1/h_2)	Elapsed Time t (sec)	h_2/h_1 init.	AVERAGE GRADIENT (h1+h2)/2L	PERM RATE K_{20}=cm/sec
0	49.1	0.6	105					0			
506040	48.7	3.1	105	0.16	153.5	150.6	0.0191	506040	0.98	9.94	6.9E-09
				Average	153.5	150.6	0.0191	506040	0.98	9.94	6.9E-09

TIME (sec)	Burette Reading "IN"	Burette Reading "OUT"	Added Pressure "IN"	Inflow to Outflow Rate Ratio	h_1	h_2	ln (h_1/h_2)	Elapsed Time t (sec)	h_2/h_1 init.	AVERAGE GRADIENT (h1+h2)/2L	PERM RATE K_{20}=cm/sec
0	48.7	3.1	260					0			
342360	46.2	6.8	260	0.68	305.6	299.4	0.0205	342360	0.98	19.77	1.1E-08
				Average	305.6	299.4	0.0205	342360	0.98	19.77	1.1E-08

TIME (sec)	Burette Reading "IN"	Burette Reading "OUT"	Added Pressure "IN"	Inflow to Outflow Rate Ratio	h_1	h_2	ln (h_1/h_2)	Elapsed Time t (sec)	h_2/h_1 init.	AVERAGE GRADIENT (h1+h2)/2L	PERM RATE K_{20}=cm/sec
0	46.2	6.8	420					0			
345960	40.7	12.8	420	0.92	459.4	447.9	0.0254	345960	0.97	29.65	1.3E-08
				Average	459.4	447.9	0.0254	345960	0.97	29.65	1.3E-08


Sites Dam
GG Composite
1.00E-07
1.00E-08
1.00E-09
PERMEABILITY
0
5
10
15
20
25
30
35
AVERAGE GRADIENT
LAB SAMPLE99-1419
HOLE NO. "GG"
F.S. NO.
DEPTH: 5 feet

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF DESIGN AND CONSTRUCTION
CIVIL DESIGN BRANCH
BRYTE SOILS AND CONCRETE LAB

ASTM D5084-90: PERMEABILITY
"Falling Head Test - (Method C)"

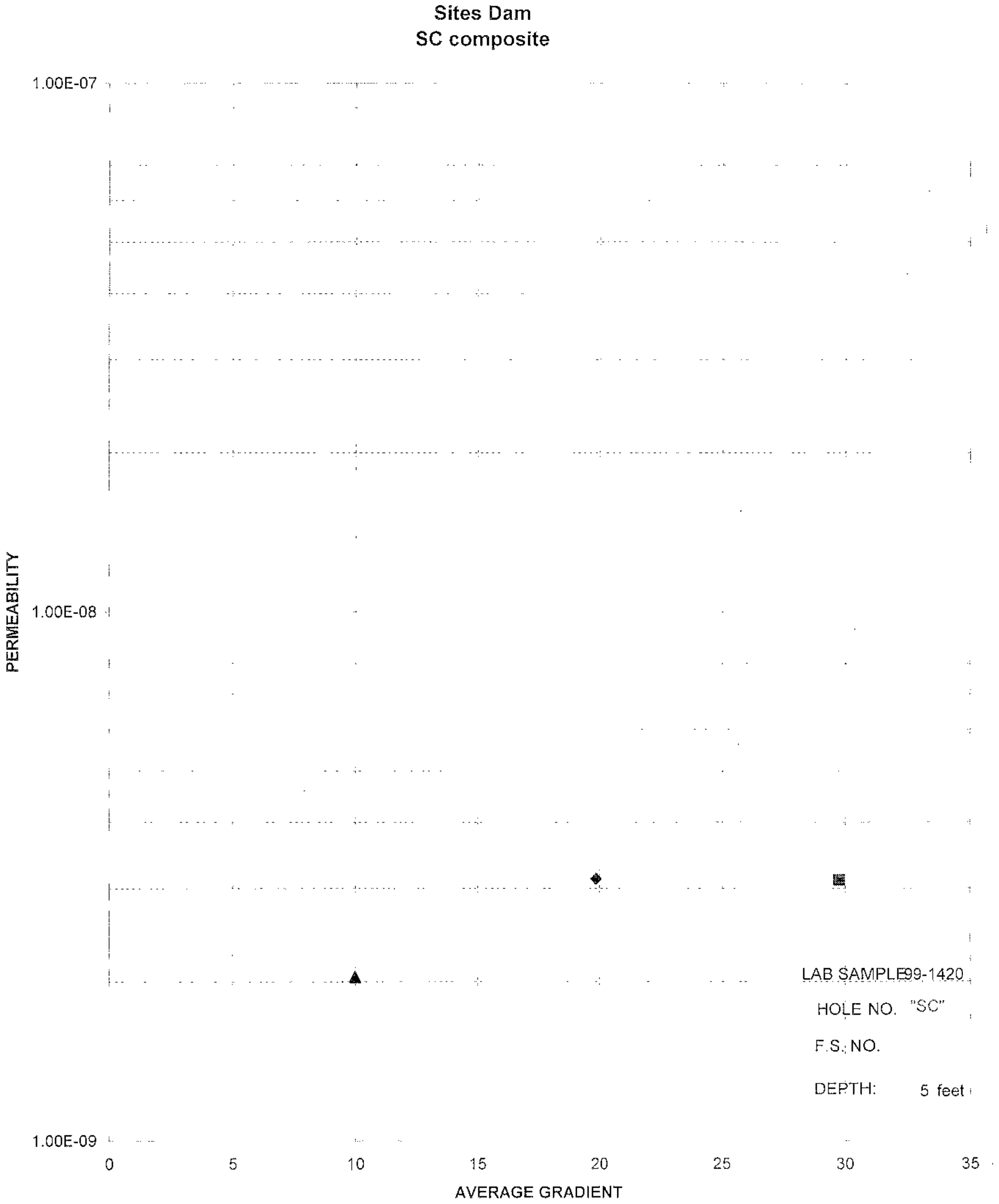
PROJECT: Sites Dam
REQUEST NO. 99-51
LAB SAMPLE 99-1420
HOLE NO. "SC" composite
F.S. NO.
DEPTH: 5 feet
VIS. DESCRIPTION: Lean clay

	BEFORE CONS.	AFTER CONS.	AFTER TEST
SAMPLE LENGTH, L (cm)	14.24	14.27	14.02
SAMPLE DIAMETER, D (cm)	7.13	7.13	7.13
SAMPLE AREA, cm^2	39.93	39.93	39.93
SAMPLE VOL., cm^3	568.56	569.56	559.62
ΔL,cm		0.03	0.22
ΔD,cm		0.00	
TEMPERATURE, °C	22.8		
TEMP. CORRECTION	0.936		
CONSOLIDATION STRESS (ksc)		0.50	

TIME (sec)	Burette Reading "IN"	Burette Reading "OUT"	Added Pressure "IN"	Inflow to Outflow Rate Ratio	h_1	h_2	$\log_n (h_1/h_2)$	Elapsed Time t (sec)	h_2/h_1 init.	AVERAGE GRADIENT (h1+h2)/2L	PERM RATE k_{20}=cm/sec
0	43.2	0.5	100					0			
344940	42.4	0.3	100	-4.00	142.7	142.1	0.0042	344940	1.00	9.98	2.0E-09
				Average	142.7	142.1	0.0042	344940	1.00	9.98	2.0E-09

TIME (sec)	Burette Reading "IN"	Burette Reading "OUT"	Added Pressure "IN"	Inflow to Outflow Rate Ratio	h_1	h_2	$\ln (h_1/h_2)$	Elapsed Time t (sec)	h_2/h_1 init.	AVERAGE GRADIENT (h1+h2)/2L	PERM RATE k_{20}=cm/sec
0	42.4	1.5	244.5					0			
867720	39.5	3.2	244.5	1.71	285.4	280.8	0.0162	867720	0.98	19.85	3.1E-09
				Average	285.4	280.8	0.0162	867720	0.98	19.85	3.1E-09

TIME (sec)	Burette Reading "IN"	Burette Reading "OUT"	Added Pressure "IN"	Inflow to Outflow Rate Ratio	h_1	h_2	$\ln (h_1/h_2)$	Elapsed Time t (sec)	h_2/h_1 init.	AVERAGE GRADIENT (h1+h2)/2L	PERM RATE k_{20}=cm/sec
86400	48.0	3.9	382.8					0			
693240	45.2	5.9	382.8	1.40	426.9	422.1	0.0113	606840	0.99	29.76	3.1E-09
				Average	426.9	422.1	0.0113	606840	0.99	29.76	3.1E-09


Sites Dam
SC composite
PERMEABILITY
1.00E-07
1.00E-08
1.00E-09
0
5
10
15
20
25
30
35
AVERAGE GRADIENT
LAB SAMPLE 99-1420
HOLE NO. "SC"
F.S. NO.
DEPTH: 5 feet

APPENDIX E

IMPERVIOUS MATERIAL
CUE TRIAXIAL TEST RESULTS FOR DWR SAMPLES

HE RESOURCES AGENC
DEPARTMENT OF WATER RESOURCES

SOILS LABORATORY

TRIAXIAL COMPRESSION TEST

TYPE OF TEST CUE

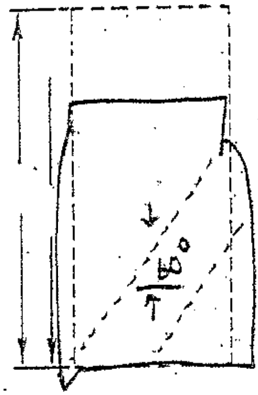
DIAM. OF SPECIMEN 2.809" = 7135 cm.
LENGTH OF SPECIMEN 6.000" = 15.24 cm.
AREA OF SAMPLE 39.98 cm.^{2}
VOLUME OF SAMPLE 609.35 cm.^{3}
WT. + TARE
TARE
WT. OF SAMPLE 1250.5 1298.5
MAX. SIZE 1066.1
184.40

DATE 5-2-00
TESTED BY AW CHECKED BY
SPECIFIC GRAVITY 2.74
WET DENSITY 128.06 pcf
DRY DENSITY 109.17 pcf
WATER CONTENT 17.3 %
WATER CONTENT FOR SAT. 20.7 %
% SAT. 83.6 %
VOID RATIO, e 0.566

DATE	TIME	σ_3 Kg/cm²	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
		0	.100		
5/18		.5	.094		
5/30			.097		
5/31		[illegible]60	.079		

Δ L = ±.02" = .053 cm.
Δ D = .025 cm.

15.240 7.135
.053 .025
15.293 7.160



AFTER CONSOLIDATION
LENGTH 15.29 cm
AREA 40.26 cm^2
VOLUME 615.64 cm^3
DRY DENSITY 108.06 pcf
WATER CONTENT 21.8%
WT. CONT. FOR SAT. 21.2%
% SAT. 102.8%
VOID RATIO, e 0.582
Δ VOL., % 1.0%

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		AG
WT. CONT. + WET SOIL		1179.4
WT. CONT. + DRY SOIL		993.9
WT. OF WATER		185.5
WT. OF CONTAINER		14.3
WT. DRY SOIL		852.6
WATER CONTENT %		21.8

SAMPLE DESCRIPTION:
VIS. CLASS COLOR
STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ STRAT ☐ LAMIN ☐ LENSES ☐
CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐
CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐
REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A ☐ GS ☐ PI ☐

TYPE OF SAMPLE Remolded

FEATURE Sites Dam
HOLE NO. F.S. N O.
DEPTH

DWR 720 (REV. 3/66) REQUEST NO. 99-51 98 CHAMBER NO. A LAB. NO. 99-1419A

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF DESIGN AND CONSTRUCTIO
CIVIL DESIGN BRANCH
BRYTE SOILS AND CONCRETE LAB

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 5/31/00 TIME: 8:00am

SPECIMEN:			MEMBRANE and FILTER STRIPS:			EQUIPMENT:		
New Length *:	15.293	(cm)	Thickness (mem):	0.024	(cm)	Frame No.	87900	
New Diameter *:	7.160	(cm)	E Modulus (mem):	14.0	(kg/cm2)	Load Cell #:	A96356	
New Area, A_o *:	40.26	(cm^2)	K_{fp} (fs)	0.196	(kg/cm)	Initial σ_3' (ksc)	0.09	
B-Value:	95.0		P_{fp} (fs) @:	10.0	(cm)	Axial Strain Rate:	0.0033	(% / min)
(* After consolidation)			(@ Perimeter length of filter strips)					

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1-\sigma_3)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1-\sigma_3)$ (ksc)
0.000	0.0	0.09	6.02	5.97	5.89	40.26	0.00	0.00	0.09	1.02	0.00
0.015	0.1	13.65	6.03	6.05	5.96	40.30	0.00	0.07	0.02	14.76	0.34
0.030	0.2	19.60	6.03	6.05	5.97	40.34	0.00	0.08	0.01	35.52	0.49
0.046	0.3	24.00	6.03	6.06	5.98	40.39	0.00	0.09	0.01	85.43	0.59
0.061	0.4	27.12	6.03	6.06	5.98	40.42	0.00	0.09	0.01	96.34	0.67
0.076	0.5	29.94	6.03	6.06	5.98	40.46	0.00	0.09	0.01	106.10	0.74
0.091	0.6	32.11	6.03	6.06	5.97	40.51	0.00	0.09	0.01	76.07	0.79
0.107	0.7	33.38	6.03	6.05	5.96	40.54	0.00	0.08	0.02	47.77	0.82
0.124	0.8	34.34	6.03	6.05	5.95	40.59	0.00	0.08	0.03	31.03	0.84
0.137	0.9	35.02	6.03	6.03	5.94	40.63	0.00	0.06	0.04	21.39	0.86
0.152	1.0	35.74	6.02	6.02	5.93	40.67	0.00	0.05	0.05	20.19	0.88
0.307	2.0	39.42	6.03	5.93	5.84	41.08	0.00	-0.04	0.15	7.32	0.96
0.460	3.0	40.96	6.03	5.87	5.78	41.51	-0.01	-0.10	0.20	5.90	0.98
0.612	4.0	42.59	6.03	5.83	5.74	41.94	-0.01	-0.14	0.24	5.16	1.01
0.765	5.0	43.73	6.02	5.80	5.71	42.38	-0.01	-0.17	0.26	4.88	1.02
0.917	6.0	44.77	6.02	5.78	5.68	42.83	-0.01	-0.19	0.29	4.59	1.03
1.072	7.0	45.90	6.02	5.77	5.67	43.29	-0.01	-0.20	0.30	4.55	1.05
1.224	8.0	47.04	6.02	5.75	5.65	43.77	-0.01	-0.22	0.32	4.35	1.06
1.379	9.0	47.99	6.02	5.74	5.64	44.25	-0.02	-0.23	0.33	4.23	1.07
1.529	10.0	49.08	6.02	5.72	5.62	44.73	-0.02	-0.25	0.35	4.10	1.08
1.681	11.0	50.17	6.03	5.72	5.61	45.24	-0.02	-0.25	0.36	4.01	1.09
1.836	12.0	50.94	6.02	5.70	5.60	45.75	-0.02	-0.27	0.37	3.96	1.09
1.989	13.0	51.80	6.02	5.68	5.59	46.28	-0.02	-0.29	0.38	3.86	1.10
2.141	14.0	52.80	6.02	5.67	5.58	46.82	-0.02	-0.30	0.39	3.80	1.10
2.296	15.0	53.71	6.01	5.66	5.56	47.37	-0.03	-0.31	0.40	3.76	1.11

Remarks: Composite Sample, GG, remolded @ 98.0% of the maximum dry density

Confining Pressure Requested - 0.05 tsf (0.05 ksc)

This test excluded. Problems with test set-up probably due to low confining pressure and low permeability materials.

Request #: 99-51

Lab #: 99-1419A

DEPARTMENT OF WATER RESOURCES SOILS LABORATORY

TRIAXIAL COMPRESSION TEST

TYPE OF TEST CUE

DIAM. OF SPECIMEN 2.508" = 6.370 cm.

LENGTH OF SPECIMEN 6.017" = 15.283 cm.

AREA OF SAMPLE 31.87 cm.^{2}

VOLUME OF SAMPLE 486.07 cm^3

WT. + TARE

TARE

WT. OF SAMPLE 1005.5g. 1043.4g

MAX. SIZE 860.9
144.6

DATE 4/4/01

TESTED BY AN CHECKED BY

SPECIFIC GRAVITY 2.74

WET DENSITY 129.08 pcf

DRY DENSITY 110.51 pcf

WATER CONTENT 16.8%

WATER CONTENT FOR SAT. 20.0%

% SAT. 84.0%

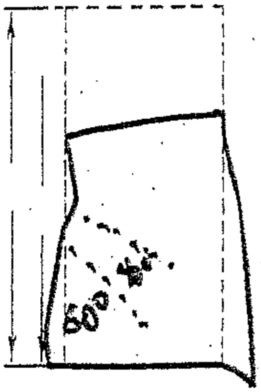
VOID RATIO, e 0.547

DATE	TIME	σ_3 Kg/cm²	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
4/4		0	.100		
		4.0	.089		
			.097		
6/13		47	.103		

ΔL = .003" = .008 cm.

ΔD = = .003 cm.

$$\begin{array}{r} 6.017 \\ .003 \\ \hline 6.014 \end{array} \quad \begin{array}{r} 15.283 \\ .008 \\ \hline 15.275 \end{array} \quad \begin{array}{r} 6.370 \\ .003 \\ \hline 6.367 \end{array}$$



AFTER CONSOLIDATION

LENGTH 15.275 cm.

AREA 31.84 cm.^{2}

VOLUME 486.36 cm.^{3}

DRY DENSITY 110.45 pcf

WATER CONTENT 21.2%

WT. CONT. FOR SAT. 20.0%

% SAT. 106.0%

VOID RATIO, e 0.548

Δ VOL., % .04%

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		
WT. CONT. + WET SOIL		1183.4
WT. CONT. + DRY SOIL		1001.1
WT. OF WATER		182.3
WT. OF CONTAINER		141.7
WT. DRY SOIL		859.4
WATER CONTENT %		21.2

SAMPLE DESCRIPTION:

VIS. CLASS COLOR

STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ S-TRAT ☐ LAMIN ☐ LENSES ☐

CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐

CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐

REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A. ☐ GS ☐ PI ☐

TYPE OF SAMPLE Remolded

FEATURE Sites Dam

HOLE NO. F.S. NO.

DEPTH

DWR 720 (REV. 3/66) REQUEST NO. 99-51 100 CHAMBER NO. LAB. NO. 99-1419B1

THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CIVIL DESIGN BRANCH
BRYTE SOILS AND CONCRETE LAB

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 6/13/01 TIME: 8:42am

SPECIMEN:			MEMBRANE and FILTER STRIPS:			EQUIPMENT:		
New Length *:	15.275	(cm)	Thickness (mem):	0.024	(cm)	Frame No.	87899	
New Diameter *:	6.367	(cm)	E Modulus (mem):	14.0	(kg/cm2)	Load Cell #:	A96370	
New Area, A_o *:	31.87	(cm^2)	K_{fp} (fs)	0.196	(kg/cm)	Initial σ_3' (ksc)	1.12	
B-Value:	96.0		P_{fp} (fs) @:	10.0	(cm)	Axial Strain Rate:	0.0030	(in. / min)
(* After consolidation)			(@ Perimeter length of filter strips)					

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1-\sigma_3)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1-\sigma_3)$ (ksc)
0.000	0.0	2.36	4.70	3.56	3.60	31.87	0.00	0.00	1.12	1.07	0.07
0.015	0.1	16.69	4.70	3.79	3.82	31.90	0.00	0.22	0.89	1.59	0.52
0.030	0.2	27.26	4.70	3.99	3.99	31.93	0.00	0.43	0.71	2.20	0.85
0.046	0.3	34.61	4.70	4.16	4.12	31.97	0.00	0.60	0.56	2.94	1.08
0.064	0.4	38.15	4.70	4.24	4.19	32.00	0.00	0.68	0.49	3.44	1.19
0.079	0.5	42.55	4.70	4.35	4.27	32.04	0.00	0.79	0.38	4.46	1.33
0.099	0.6	44.27	4.70	4.39	4.32	32.08	0.00	0.83	0.34	5.04	1.38
0.109	0.7	45.36	4.70	4.42	4.34	32.10	0.00	0.86	0.32	5.46	1.41
0.127	0.8	45.45	4.70	4.42	4.34	32.13	0.00	0.86	0.32	5.37	1.41
0.137	0.9	46.40	4.70	4.45	4.36	32.16	0.00	0.89	0.29	5.94	1.44
0.152	1.0	46.67	4.70	4.46	4.37	32.19	0.00	0.90	0.28	6.15	1.45
0.310	2.0	49.67	4.70	4.53	4.42	32.53	0.00	0.97	0.22	7.77	1.52
0.460	3.0	52.66	4.70	4.56	4.42	32.86	-0.01	1.00	0.21	8.70	1.60
0.612	4.0	54.66	4.70	4.58	4.43	33.20	-0.01	1.02	0.20	9.32	1.64
0.765	5.0	56.74	4.70	4.60	4.42	33.55	-0.01	1.04	0.19	9.70	1.68
0.917	6.0	58.88	4.70	4.61	4.41	33.91	-0.01	1.05	0.20	9.76	1.72
1.072	7.0	60.65	4.70	4.61	4.39	34.28	-0.01	1.05	0.20	9.76	1.76
1.222	8.0	62.37	4.70	4.61	4.38	34.64	-0.02	1.05	0.20	9.75	1.78
1.377	9.0	63.87	4.70	4.60	4.36	35.03	-0.02	1.04	0.22	9.02	1.81
1.534	10.0	65.14	4.70	4.58	4.33	35.43	-0.02	1.02	0.25	8.39	1.82
1.681	11.0	66.09	4.70	4.56	4.30	35.81	-0.02	1.00	0.27	7.74	1.82
1.834	12.0	67.22	4.70	4.53	4.27	36.22	-0.02	0.97	0.30	7.13	1.83
1.989	13.0	68.13	4.70	4.52	4.25	36.64	-0.03	0.96	0.32	6.80	1.83
2.144	14.0	69.35	4.70	4.50	4.23	37.08	-0.03	0.94	0.34	6.41	1.84
2.301	15.1	70.90	4.70	4.49	4.20	37.53	-0.03	0.93	0.35	6.29	1.86

Remarks: Composite Sample, GG, remolded @ 98.0 % of the maximum dry density
Confining Pressure Requested - 1.2 tsf (1.17 ksc), Retest

Request #: 99-51
Lab #: 1419B1

THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

[illegible]
SOILS LABORATORY

TRIAXIAL COMPRESSION TEST

TYPE OF TEST CUE

DIAM. OF SPECIMEN 2.810" = 7.137 cm
LENGTH OF SPECIMEN 6.000" = 15.240 cm.
AREA OF SAMPLE 40.01 cm^2
VOLUME OF SAMPLE 609.69 cm^3
WT. + TARE
TARE
WT. OF SAMPLE 1254.3 g. 1271.7 g.
MAX. SIZE 1069.6
184.7

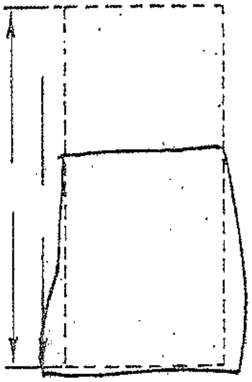
DATE 6-6-00
TESTED BY BN CHECKED BY
SPECIFIC GRAVITY 2.74
WET DENSITY 128.37 pcf
DRY DENSITY 109.44 pcf
WATER CONTENT 17.3%
WATER CONTENT FOR SAT. 20.5%
% SAT. 84.4%
VOID RATIO, e 0.562

DATE	TIME	σ_3 Kg/cm²	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
6/6		0	.100		
		.5	.092		
7/25		9.00	.133		
7/26		9.0	.174		

Δ L = .074" = .188 cm.
Δ D = = .088

15.240
.188
15.052

7.137
.088
7.049



AFTER CONSOLIDATION
LENGTH 15.05 cm.
AREA 39.03 cm.
VOLUME 587.33 cm^3
DRY DENSITY 113.63 pcf
WATER CONTENT 18.9%
WT. CONT. FOR SAT. 18.4%
% SAT. 102.7%
VOID RATIO, e 0.505
Δ VOL., % 3.7%

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		92
WT. CONT. + WET SOIL		1008.3
WT. CONT. + DRY SOIL		869.8
WT. OF WATER		138.5
WT. OF CONTAINER		135.7
WT. DRY SOIL		734.1
WATER CONTENT %		18.9

SAMPLE DESCRIPTION:
VIS. CLASS COLOR
STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ STRAT ☐ LAMIN ☐ LENSES ☐
CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐
CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐
REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A ☐ GS ☐ PI ☐

TYPE OF SAMPLE Remolded

FEATURE Sites Dam
HOLE NO. F.S. NO.
DEPTH

DWR 720 (REV. 3/66) REQUEST NO. 99-51 102 CHAMBER NO. E LAB. NO. 99-1419c

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 7/26/00 TIME: 8:15am

SPECIMEN:		MEMBRANE and FILTER STRIPS:		EQUIPMENT:	
New Length *:	15.052 (cm)	Thickness (mem):	0.024 (cm)	Frame No.	87900
New Diameter *:	7.049 (cm)	E Modulus (mem):	14.0 (kg/cm2)	Load Cell #:	A96356
New Area, A_o *:	39.03 (cm^2)	K_{fp} (fs)	0.196 (kg/cm)	Initial σ_3' (ksc)	8.96
B-Value:	95.0	P_{fp} (fs) @:	10.0 (cm)	Axial Strain Rate:	0.0028 (% / min)
(* After consolidation)		(@ Perimeter length of filter strips)			

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1-\sigma_3)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1-\sigma_3)$ (ksc)
0.000	0.0	2.31	8.97	3.83	3.91	39.03	0.00	0.00	5.10	1.00	0.00
0.015	0.1	3.81	8.96	3.96	3.85	39.07	0.00	0.04	5.06	1.02	0.10
0.030	0.2	4.08	8.96	3.97	3.86	39.11	0.00	0.14	5.05	1.02	0.10
0.046	0.3	4.72	8.96	3.98	3.88	39.15	0.00	0.15	5.03	1.02	0.12
0.061	0.4	11.57	8.96	4.06	3.99	39.19	0.00	0.23	4.94	1.06	0.29
0.076	0.5	28.26	8.96	4.23	4.25	39.23	0.00	0.40	4.72	1.15	0.72
0.091	0.6	50.71	8.96	4.51	4.58	39.27	0.00	0.68	4.42	1.29	1.29
0.107	0.7	67.40	8.96	4.77	4.84	39.31	0.00	0.94	4.16	1.41	1.71
0.122	0.8	76.61	8.96	4.94	5.00	39.35	0.00	1.11	3.99	1.49	1.95
0.137	0.9	84.69	8.96	5.11	5.17	39.38	0.00	1.28	3.82	1.56	2.15
0.150	1.0	90.95	8.96	5.25	5.33	39.42	0.00	1.42	3.67	1.63	2.30
0.302	2.0	122.56	8.96	6.10	6.29	39.83	0.00	2.27	2.77	2.11	3.07
0.452	3.0	136.35	8.96	6.50	6.74	40.24	-0.01	2.67	2.34	2.44	3.38
0.602	4.0	145.38	8.96	6.64	7.01	40.66	-0.01	2.81	2.14	2.67	3.57
0.752	5.0	152.09	8.96	6.70	7.15	41.08	-0.01	2.87	2.04	2.81	3.69
0.904	6.0	158.17	8.96	6.79	7.23	41.53	-0.01	2.96	1.95	2.94	3.80
1.054	7.0	163.47	8.96	6.81	7.26	41.97	-0.01	2.98	1.93	3.01	3.88
1.204	8.0	168.33	8.96	6.82	7.26	42.43	-0.01	2.99	1.92	3.06	3.95
1.354	9.0	172.91	8.96	6.83	7.26	42.89	-0.02	3.00	1.92	3.09	4.02
1.506	10.0	177.40	8.96	6.84	7.23	43.37	-0.02	3.01	1.93	3.11	4.07
1.656	11.0	181.66	8.96	6.95	7.22	43.86	-0.02	3.12	1.88	3.20	4.12
1.808	12.0	185.52	8.96	6.90	7.20	44.36	-0.02	3.07	1.92	3.17	4.16
1.958	13.0	188.97	8.96	6.88	7.17	44.87	-0.02	3.05	1.94	3.16	4.19
2.108	14.0	192.37	8.96	6.85	7.14	45.39	-0.02	3.02	1.97	3.14	4.21
2.258	15.0	195.45	8.96	6.94	7.11	45.92	-0.03	3.11	1.94	3.18	4.23

Remarks: Composite Sample, GG, remolded sample @ 98.0% of the maximum dry density

Confining Pressure Requested - 5.6 tsf (5.47 ksc)

Request #: 99-51

Lab #: 99-1419C

THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SOILS LABORATORY

TRIAXIAL COMPRESSION TEST

TYPE OF TEST CUE

DIAM. OF SPECIMEN 2.807" = 7.130 cm.

LENGTH OF SPECIMEN 6.002" = 15.245 cm.

AREA OF SAMPLE 39.93 cm.^{2}

VOLUME OF SAMPLE 608.69 cm^3

WT. + TARE

TARE

WT. OF SAMPLE 1252.5 1241.7

MAX. SIZE 1065.8
186.7

DATE 7-18-00

TESTED BY AN ; RJ CHECKED BY

SPECIFIC GRAVITY 2.74

WET DENSITY 128.40 pcf

DRY DENSITY 109.26

WATER CONTENT 17.5%

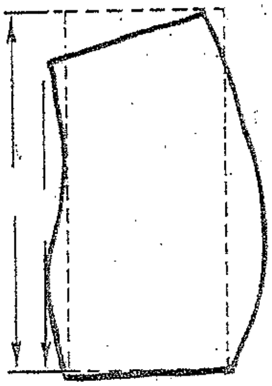
WATER CONTENT FOR SAT. 20.6%

% SAT. 85.0%

VOID RATIO, e 0.565

DATE	TIME	σ_3 Kg/cm²	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
7/18		0	.100		
8/3		.5	.103		
8/10		~~[illegible]~~	.300		
		15.5			

ΔL= .200" = .508 cm.
ΔD= = .238 cm.



AFTER CONSOLIDATION

LENGTH 14.737 cm.

AREA 37.31 cm.^{2}

VOLUME 549.78 cm.^{3}

DRY DENSITY 120.97 pcf.

WATER CONTENT 16.5%

WT. CONT. FOR SAT. 15.1%

% SAT. 109.3%

VOID RATIO, e 0.413

Δ VOL., % 9.7

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		Cu
WT. CONT. + WET SOIL		1379.5
WT. CONT. + DRY SOIL		1204.2
WT. OF WATER		175.3
WT. OF CONTAINER		141.5
WT. DRY SOIL		1062.7
WATER CONTENT %		16.5

SAMPLE DESCRIPTION:

VIS. CLASS COLOR

STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ STRAT ☐ LAMIN ☐ LENSES ☐

CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐

CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐

REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A ☐ GS ☐ PI ☐

TYPE OF SAMPLE Remolded

FEATURE Sites Dam

HOLE NO. F.S. NO.

DEPTH

104

DWR 720 (REV. 3/66) REQUEST NO. 99-51 CHAMBER NO. LAB. NO. 99-1419D

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 8/10/00 TIME: 9:30am

SPECIMEN:		MEMBRANE and FILTER STRIPS:		EQUIPMENT:		
New Length *:	14.737 (cm)	Thickness (mem):	0.024 (cm)	Frame No.	87900	
New Diameter *:	6.892 (cm)	E Modulus (mem):	14.0 (kg/cm2)	Load Cell #:	A96356	
New Area, A_o *:	37.31 (cm^2)	K_{fp} (fs)	0.196 (kg/cm)	Initial σ_3' (ksc)	11.84	
B-Value:	97.0	P_{fp} (fs) @:	10.0 (cm)	Axial Strain Rate:	0.0024	(% / min)
(* After consolidation)		(@ Perimeter length of filter strips)				

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1 - \sigma_3)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1 - \sigma_3)$ (ksc)
0.000	0.0	5.81	15.48	3.66	3.63	37.31	0.00	0.00	11.84	1.00	0.00
0.015	0.1	6.30	15.49	3.66	3.63	37.35	0.00	0.00	11.84	1.01	0.17
0.030	0.2	6.80	15.49	3.66	3.63	37.38	0.00	0.00	11.84	1.02	0.18
0.046	0.3	8.03	15.49	3.68	3.65	37.42	0.00	0.02	11.83	1.02	0.21
0.061	0.4	12.02	15.49	3.71	3.70	37.46	0.00	0.05	11.79	1.03	0.32
0.076	0.5	15.88	15.49	3.73	3.74	37.50	0.00	0.07	11.75	1.04	0.42
0.089	0.6	47.67	15.48	3.96	4.15	37.54	0.00	0.30	11.43	1.11	1.27
0.104	0.7	93.03	15.48	4.37	4.70	37.57	0.00	0.71	10.95	1.23	2.47
0.117	0.8	139.89	15.48	4.87	5.30	37.61	0.00	1.21	10.39	1.36	3.72
0.132	0.9	164.52	15.48	5.20	5.67	37.65	0.00	1.54	10.04	1.43	4.37
0.147	1.0	183.30	15.47	5.48	6.00	37.69	0.00	1.82	9.73	1.50	4.86
0.295	2.0	257.50	15.48	7.24	8.18	38.08	0.00	3.58	7.77	1.87	6.76
0.445	3.0	285.94	15.56	8.28	9.36	38.47	-0.01	4.62	6.74	2.10	7.43
0.589	4.0	304.22	15.55	8.98	10.01	38.87	-0.01	5.32	6.06	2.29	7.82
0.737	5.0	318.33	15.54	9.46	10.42	39.27	-0.01	5.80	5.61	2.44	8.10
0.884	6.0	329.67	15.56	9.76	10.66	39.69	-0.01	6.10	5.35	2.55	8.29
1.031	7.0	339.51	15.56	9.93	10.79	40.12	-0.01	6.27	5.20	2.63	8.45
1.179	8.0	348.09	15.55	10.09	10.86	40.55	-0.01	6.43	5.08	2.69	8.57
1.326	9.0	354.94	15.54	10.21	10.90	41.00	-0.02	6.55	4.99	2.73	8.64
1.476	10.0	360.56	15.56	10.33	10.92	41.46	-0.02	6.67	4.94	2.76	8.68
1.623	11.0	365.69	15.56	10.29	10.91	41.93	-0.02	6.63	4.96	2.75	8.70
1.768	12.0	369.77	15.56	10.22	10.88	42.40	-0.02	6.56	5.01	2.74	8.70
1.918	13.0	373.08	15.55	10.10	10.83	42.89	-0.02	6.44	5.08	2.71	8.67
2.062	14.0	375.57	15.56	10.07	10.76	43.38	-0.03	6.41	5.14	2.68	8.63
2.212	15.0	376.98	15.56	9.92	10.69	43.89	-0.03	6.26	5.25	2.63	8.56

Remarks: Composite Sample. GG, remolded @ 98.0% of the maximum dry density
Confining Pressure Requested - 14.0 tsf (13.67 ksc)

Request #: 99-51
Lab #: 99-1419D

TRIAXIAL COMPRESSION TEST

TYPE OF TEST CUE

DIAM. OF SPECIMEN 2.510" = 6.375 cm.

LENGTH OF SPECIMEN 6.028" = 15.311 cm.

AREA OF SAMPLE 31.92 cm^2.

VOLUME OF SAMPLE 488.70 cm^3

WT. + TARE

TARE

WT. OF SAMPLE 988.1 g 1038.1

MAX. SIZE 844.0

144.1

DATE 2-16-01

TESTED BY AN CHECKED BY

SPECIFIC GRAVITY 2.74

WET DENSITY 126.17 pcf

DRY DENSITY 107.75 pcf

WATER CONTENT 17.1 %

WATER CONTENT FOR SAT. 21.4 %

% SAT. 79.9 %

VOID RATIO, e 0.587

DATE	TIME	σ_3 Kg/cm^2	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
4/16		0	.100		
23		.5	.053		
26		.5	.054		
27		6.3	.051		

ΔL= +.049" = .124 cm.

ΔD= = .052 cm.

6.028
.049
6.077

6.375
.052
6.427

AFTER CONSOLIDATION

LENGTH 15.434

AREA 32.44

VOLUME 500.68

DRY DENSITY 105.19

WATER CONTENT 23.0

WT. CONT. FOR SAT. 22.8

% SAT. 100.9

VOID RATIO, e 0.625

Δ VOL., % 2.5

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		LX
WT. CONT. + WET SOIL		1176.2
WT. CONT. + DRY SOIL		982.7
WT. OF WATER		193.5
WT. OF CONTAINER		142.2
WT. DRY SOIL		840.5
WATER CONTENT %		23.0

SAMPLE DESCRIPTION:

VIS. CLASS COLOR

STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ ST RAT ☐ LAMIN ☐ LENSES ☐

CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐

CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐

REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A ☐ GS ☐ PI ☐

TYPE OF SAMPLE Remolded

FEATURE Sites Dam

HOLE NO. F.S. NO.

DEPTH

DWR 720 (REV. 3/66) REQUEST NO. 99-51 106 CHAMBER NO. A LAB. NO. 1420A1

THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CIVIL DESIGN BRANCH
BRYTE SOILS AND CONCRETE LAB

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 2/27/01 TIME: 8:30am

SPECIMEN:			MEMBRANE and FILTER STRIPS:			EQUIPMENT:		
New Length *:	15.434	(cm)	Thickness (mem):	0.024	(cm)	Frame No.	87899	
New Diameter *:	6.427	(cm)	E Modulus (mem):	14.0	(kg/cm2)	Load Cell #:	A96370	
New Area, A_o *:	32.44	(cm^2)	K_{fp} (fs)	0.196	(kg/cm)	Initial σ_3' (ksc)	0.36	
B-Value:	94.60		P_{fp} (fs) @:	10.0	(cm)	Axial Strain Rate:	0.0016	(% / min)
(* After consolidation)			(@ Perimeter length of filter strips)					

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1-\sigma_3)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1-\sigma_3)$ (ksc)
0.000	0.0	1.13	6.32	6.01	5.91	32.44	0.00	0.00	0.36	1.10	0.03
0.015	0.1	7.53	6.31	6.07	5.97	32.47	0.00	0.06	0.30	1.78	0.23
0.033	0.2	15.29	6.31	6.14	6.04	32.51	0.00	0.13	0.22	3.16	0.47
0.046	0.3	21.18	6.20	6.10	5.99	32.54	0.00	0.09	0.16	5.11	0.65
0.064	0.4	23.45	6.36	6.28	6.19	32.57	0.00	0.27	0.13	6.53	0.72
0.079	0.5	24.77	6.35	6.29	6.19	32.60	0.00	0.28	0.11	8.19	0.76
0.094	0.6	25.49	6.35	6.31	6.21	32.64	0.00	0.30	0.09	9.53	0.78
0.109	0.7	25.67	6.34	6.31	6.21	32.67	0.00	0.30	0.08	10.30	0.78
0.124	0.8	25.67	6.33	6.30	6.20	32.70	0.00	0.29	0.08	11.13	0.78
0.140	0.9	25.67	6.33	6.31	6.21	32.73	0.00	0.30	0.08	11.12	0.78
0.155	1.0	25.58	6.33	6.31	6.21	32.77	0.00	0.30	0.08	11.07	0.78
0.310	2.0	25.13	6.36	6.31	6.22	33.11	0.00	0.30	0.10	8.67	0.75
0.465	3.0	25.90	6.32	6.27	6.17	33.45	-0.01	0.26	0.10	8.80	0.77
0.617	4.0	26.67	6.36	6.29	6.19	33.79	-0.01	0.28	0.12	7.54	0.78
0.775	5.0	27.44	6.36	6.26	6.17	34.15	-0.01	0.25	0.14	6.50	0.79
0.927	6.0	28.12	6.35	6.24	6.14	34.51	-0.01	0.23	0.16	5.96	0.80
1.080	7.0	29.39	6.33	6.20	6.11	34.88	-0.01	0.19	0.18	5.62	0.83
1.237	8.0	30.07	6.37	6.23	6.13	35.27	-0.02	0.22	0.19	5.41	0.84
1.392	9.0	30.84	6.40	6.25	6.17	35.65	-0.02	0.24	0.20	5.30	0.85
1.547	10.0	31.75	6.47	6.28	6.19	36.05	-0.02	0.27	0.23	4.71	0.86
1.699	11.0	32.39	6.51	6.31	6.22	36.45	-0.02	0.30	0.24	4.57	0.87
1.854	12.0	32.93	6.57	6.35	6.26	36.87	-0.02	0.34	0.26	4.30	0.87
2.009	13.0	33.88	6.64	6.40	6.32	37.30	-0.03	0.39	0.28	4.18	0.88

Remarks: Composite Sample, SC, remolded @ 98.0 % of the maximum dry density.
Confining Pressure Requested - 0.05 tsf (0.05 ksc), Retest

Request #: 99-51
Lab #: 1420A1

DEPARTMENT OF WATER RESOURCES — SOILS LABORATORY

TRIAXIAL COMPRESSION TEST

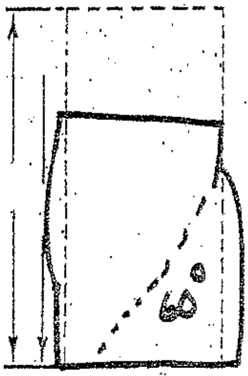
TYPE OF TEST CUE

DIAM. OF SPECIMEN 2.808" = 7.132 cm.
LENGTH OF SPECIMEN 6.011" = 15.268 cm.
AREA OF SAMPLE 39.95 cm.²
VOLUME OF SAMPLE 609.95 cm³
WT. + TARE
TARE
WT. OF SAMPLE 1236.4 1300.6
MAX. SIZE 1056.6
179.8

DATE 7-26-00
TESTED BY AN; RJ CHECKED BY
SPECIFIC GRAVITY 2.74
WET DENSITY 126.49 pcf
DRY DENSITY 108.11 pcf
WATER CONTENT 17.0 %
WATER CONTENT FOR SAT. 21.2 %
% SAT. 80.2 %
VOID RATIO, e 0.582

DATE	TIME	σ_3 Kg/cm²	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
		0	.100		
		.5	.043		
		5.6	.054		

Δ L = +.046" = .117 cm.
Δ D = = .055 cm.



AFTER CONSOLIDATION
LENGTH 15.385 cm.
AREA 40.57 cm²
VOLUME 624.14 cm³
DRY DENSITY 105.63 pcf
WATER CONTENT 23.1%
WT. CONT. FOR SAT. 22.6%
% SAT. 102.2%
VOID RATIO, e 0.619
Δ VOL., % 2.3%

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		V-5
WT. CONT. + WET SOIL		926.8
WT. CONT. + DRY SOIL		779.9
WT. OF WATER		146.9
WT. OF CONTAINER		143.9
WT. DRY SOIL		636.0
WATER CONTENT %		23.1

SAMPLE DESCRIPTION:
VIS. CLASS COLOR
STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ STRAT ☐ LAMIN ☐ LENSES ☐
CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐
CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐
REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A ☐ GS ☐ PI ☐

FEATURE Sites Dam
HOLE NO. F.S. NO.
TYPE OF SAMPLE Remolded
DEPTH

108

DWR 720 (REV. 3/66) REQUEST NO. 99-51 CHAMBER NO. LAB. NO. 99-1420B

THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CIVIL DESIGN BRANCH
BRYTE SOILS AND CONCRETE LAB

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 9/21/00
TIME: 8:00am

SPECIMEN:
New Length *: 15.385 (cm)
New Diameter *: 7.187 (cm)
New Area, A_o *: 40.57 (cm^2)
B-Value: 95.20%
(* After consolidation)

MEMBRANE and FILTER STRIPS:
Thickness (mem): 0.024 (cm)
E Modulus (mem): 14.0 (kg/cm2)
K_{fp} (fs) 0.196 (kg/cm)
P_{fp} (fs) @: 10.0 (cm)
(@ Perimeter length of filter strips)

EQUIPMENT:
Frame No. 87900
Load Cell #: A96356
Initial σ_3' (ksc) 1.11
Axial Strain Rate: 0.0033 (% / min)

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1-\sigma_2)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1-\sigma_3)$ (ksc)
0.000	0.0	3.27	5.65	4.62	4.46	40.57	0.00	0.00	1.11	1.07	0.08
0.015	0.1	34.29	5.65	5.12	4.89	40.61	0.00	0.46	0.64	2.31	0.84
0.046	0.3	40.51	5.64	5.22	4.98	40.69	0.00	0.60	0.54	2.85	0.99
0.046	0.3	41.59	5.64	5.24	4.99	40.69	0.00	0.62	0.52	2.96	1.02
0.064	0.4	45.81	5.65	5.31	5.06	40.74	0.00	0.69	0.46	3.42	1.12
0.079	0.5	48.26	5.64	5.34	5.10	40.77	0.00	0.72	0.42	3.83	1.18
0.094	0.6	49.67	5.65	5.36	5.13	40.82	0.00	0.74	0.40	4.01	1.22
0.109	0.7	50.12	5.64	5.36	5.14	40.86	0.00	0.74	0.39	4.17	1.23
0.124	0.8	50.17	5.64	5.36	5.15	40.90	0.00	0.74	0.38	4.20	1.23
0.140	0.9	50.26	5.64	5.36	5.15	40.94	0.00	0.74	0.39	4.17	1.23
0.155	1.0	50.35	5.65	5.36	5.16	40.98	0.00	0.74	0.38	4.20	1.23
0.307	2.0	50.21	5.65	5.35	5.15	41.40	0.00	0.73	0.40	4.04	1.21
0.462	3.0	51.03	5.65	5.36	5.15	41.82	-0.01	0.74	0.40	4.03	1.21
0.615	4.0	51.85	5.65	5.36	5.13	42.26	-0.01	0.74	0.40	4.04	1.22
0.770	5.0	52.98	5.65	5.37	5.14	42.71	-0.01	0.75	0.40	4.10	1.23
1.199	7.8	53.75	5.65	5.36	5.13	44.00	-0.01	0.74	0.40	4.01	1.21
1.410	9.2	53.80	5.65	5.36	5.13	44.67	-0.02	0.74	0.40	3.96	1.19
1.539	10.0	54.16	5.64	5.36	5.12	45.08	-0.02	0.74	0.40	3.95	1.18
1.694	11.0	58.15	5.65	5.36	5.08	45.59	-0.02	0.74	0.43	3.95	1.26
1.847	12.0	58.92	5.64	5.34	5.07	46.10	-0.02	0.72	0.43	3.91	1.26
2.002	13.0	60.24	5.64	5.34	5.06	46.63	-0.02	0.72	0.44	3.89	1.27
2.154	14.0	61.60	5.65	5.34	5.06	47.18	-0.02	0.72	0.45	3.87	1.28
2.309	15.0	62.78	5.65	5.32	5.06	47.73	-0.03	0.70	0.46	3.82	1.29

Remarks: Composite Sample, SC, remolded @ 98.0% of the maximum dry density
Confining Pressure Requested - 1.2 tsf (1.17 ksc)

Request #: 99-51
Lab #: 99-1420B

TRIAXIAL COMPRESSION TEST

TYPE OF TEST CUE

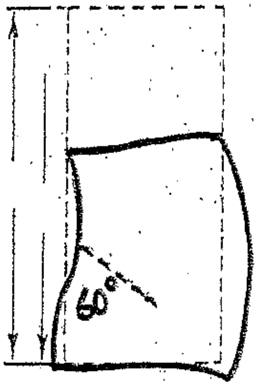
DIAM. OF SPECIMEN 2.510" = 6.375 cm.
LENGTH OF SPECIMEN 6.008" = 15.260 cm.
AREA OF SAMPLE 31.92 cm^2
VOLUME OF SAMPLE 487.10 cm^3
WT. + TARE
TARE
WT. OF SAMPLE 979.6 g 1004.9
MAX. SIZE 838.1
141.5

DATE 2-20-01
TESTED BY AN CHECKED BY
SPECIFIC GRAVITY 2.74
WET DENSITY 125.49 pcf
DRY DENSITY 107.35 pcf
WATER CONTENT 16.9%
WATER CONTENT FOR SAT. 21.6%
% SAT. 78.2%
VOID RATIO, e 0.593

DATE	TIME	σ_3 Kg/cm²	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
2/20		0	.100		
20		.5	.045		
3/13		3.5	.051		
14		8.41	.135		
20			.207		

ΔL = .107" = .272 cm.
ΔD = = .114

$\begin{array}{r} 15.260 \\ .272 \\ \hline 15.532 \end{array}$ $\begin{array}{r} 6.375 \\ .114 \\ \hline 6.261 \end{array}$



AFTER CONSOLIDATION
LENGTH 15.532
AREA 30.79
VOLUME 478.23
DRY DENSITY 109.36
WATER CONTENT 19.9
WT. CONT. FOR SAT. 20.6
% SAT. 96.6
VOID RATIO, e 0.563
Δ VOL., % 1.8

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		KT
WT. CONT. + WET SOIL		1143.7
WT. CONT. + DRY SOIL		977.1
WT. OF WATER		166.6
WT. OF CONTAINER		142.0
WT. DRY SOIL		835.1
WATER CONTENT %		19.9

SAMPLE DESCRIPTION:
VIS. CLASS COLOR
STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ STRAT ☐ LAMIN ☐ LENSES ☐
CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐
CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐
REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A ☐ GS ☐ PI ☐

TYPE OF SAMPLE Remolded

FEATURE Sites Dam
HOLE NO. F.S. NO.
DEPTH

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DWR 720 (REV. 3/66) REQUEST NO. 99-51 CHAMBER NO. LAB. NO. 1420C1

DEPARTMENT OF WATER RESOURCES

CIVIL DESIGN BRANCH
BRYTE SOILS AND CONCRETE LAB

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 2/20/01 TIME: 9:00am

SPECIMEN:
New Length *: 14.945 (cm)
New Diameter *: 6.978 (cm)
New Area, A_o*: 38.24 (cm^2)
B-Value: 96.0
(* After consolidation)

MEMBRANE and FILTER STRIPS:
Thickness (mem): 0.024 (cm)
E Modulus (mem): 14.0 (kg/cm2)
K_{fp} (fs) 0.196 (kg/cm)
P_{fp} (fs) @: 10.0 (cm)
(@ Perimeter length of filter strips)

EQUIPMENT:
Frame No. 87899
Load Cell #: A96370
Initial σ_3' (ksc) 5.30
Axial Strain Rate: 0.0041 (% / min)

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1 - \sigma_3)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1 - \sigma_3)$ (ksc)
0.000	0.0	0.14	9.95	4.65	4.66	38.24	0.00	0.00	5.30	1.00	0.00
0.015	0.1	0.18	9.96	4.68	4.70	38.28	0.00	0.03	5.27	1.00	0.00
0.033	0.2	0.27	9.96	4.68	4.70	38.32	0.00	0.03	5.26	1.00	0.01
0.046	0.3	0.50	9.96	4.70	4.71	38.36	0.00	0.05	5.25	1.00	0.01
0.061	0.4	0.23	9.96	4.71	4.72	38.40	0.00	0.06	5.24	1.00	0.01
0.076	0.5	0.36	9.95	4.72	4.73	38.43	0.00	0.07	5.22	1.00	0.01
0.089	0.6	1.50	9.95	4.75	4.75	38.47	0.00	0.10	5.20	1.01	0.04
0.104	0.7	3.13	9.96	4.77	4.78	38.51	0.00	0.12	5.18	1.02	0.08
0.119	0.8	3.76	9.95	4.79	4.79	38.55	0.00	0.14	5.16	1.02	0.10
0.135	0.9	5.17	9.95	4.81	4.82	38.59	0.00	0.16	5.14	1.03	0.13
0.150	1.0	5.99	9.95	4.82	4.82	38.63	0.00	0.17	5.13	1.03	0.15
0.300	2.0	103.51	9.95	6.03	6.29	39.02	0.00	1.38	3.79	1.70	2.65
0.450	3.0	131.77	9.95	6.73	7.10	39.42	-0.01	2.08	3.03	2.10	3.34
0.597	4.0	142.97	9.94	7.09	7.49	39.83	-0.01	2.44	2.65	2.35	3.58
0.749	5.0	150.00	9.95	7.33	7.73	40.26	-0.01	2.68	2.42	2.54	3.72
0.899	6.0	155.76	9.95	7.51	7.90	40.69	-0.01	2.86	2.25	2.70	3.82
1.049	7.0	160.34	9.96	7.64	8.01	41.12	-0.01	2.99	2.13	2.82	3.89
1.196	8.0	164.52	9.95	7.74	8.11	41.57	-0.01	3.09	2.02	2.95	3.94
1.346	9.0	167.78	9.94	7.83	8.19	42.02	-0.02	3.18	1.93	3.06	3.98
1.496	10.0	170.91	9.94	7.91	8.25	42.49	-0.02	3.26	1.86	3.15	4.00
1.654	11.1	173.59	9.95	7.97	8.31	43.00	-0.02	3.32	1.81	3.22	4.02
1.793	12.0	176.04	9.95	8.01	8.35	43.46	-0.02	3.36	1.77	3.28	4.03
1.943	13.0	178.31	9.96	8.04	8.35	43.96	-0.02	3.39	1.76	3.29	4.03
2.096	14.0	180.39	9.96	8.11	8.36	44.47	-0.03	3.46	1.72	3.34	4.03
2.243	15.0	181.85	9.94	8.16	8.37	44.99	-0.03	3.51	1.68	3.39	4.02

Remarks: Composite Sample, SC, remolded @ 98.0 % of the maximum dry density
Confining Pressure Requested - 5.6 tsf (5.47 ksc)

Request #: 99-51
Lab #: 99-1420C

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DEPARTMENT OF WATER RESOURCES SOILS LABORATORY

TRIAXIAL COMPRESSION TEST

TYPE OF TEST CUE

DIAM. OF SPECIMEN 2.509" = 6.373 cm.
LENGTH OF SPECIMEN 6.016" = 15.281 cm.
AREA OF SAMPLE 31.90 cm^2
VOLUME OF SAMPLE 487.43 cm^3
WT. + TARE
TARE
WT. OF SAMPLE 981.8 g 990.5
MAX. SIZE 843.0
138.8

DATE 2/21/01
TESTED BY AN CHECKED BY
SPECIFIC GRAVITY 2.74
WET DENSITY 125.69 pcf
DRY DENSITY 107.9 pcf
WATER CONTENT 16.5 %
WATER CONTENT FOR SAT. 21.3 %
% SAT. 77.5 %
VOID RATIO, e .585

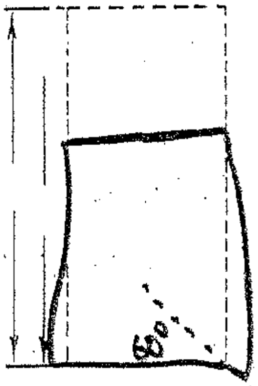
DATE	TIME	σ_3 Kg/cm²	DIAL READING	PIPETTE c.c.	Δ VOL. c.c.
		0	.100		
2/21		.5	.030		
4/6		6.5	.042		
		18.7	.252		
		19.7	.310		

ΔL = .210" = .533 cm.
ΔD = = .222 cm.

6.016
.210
5.806

15.281
.533
14.748

6.373
.222



AFTER CONSOLIDATION
LENGTH 14.748 cm
AREA 29.715 cm^2
VOLUME 438.24 cm^3
DRY DENSITY 120.03 pcf
WATER CONTENT 17.5 %
WT. CONT. FOR SAT. 15.5%
% SAT. 112.9 %
VOID RATIO, e 0.424
Δ VOL., % 10.1 %

WATER CONTENT:	BEFORE	AFTER
CONTAINER NO.		1B
WT. CONT. + WET SOIL		1031.3
WT. CONT. + DRY SOIL		899.0
WT. OF WATER		132.3
WT. OF CONTAINER		141.7
WT. DRY SOIL		757.3
WATER CONTENT %		17.5

SAMPLE DESCRIPTION:
VIS. CLASS COLOR
STRUCTURE HOMO ☐ HETERO ☐ BAND ☐ STRAT ☐ LAMIN ☐ LENSES ☐
CEMENT ☐ FISS ☐ CALC ☐ MOTT ☐ ROOTS ☐ VOIDS ☐ OTHER ☐
CONSISTENCY V. SOFT ☐ SOFT ☐ FIRM ☐ HARD ☐ ROCK ☐
REMARKS

CLASSIFICATION TESTS HYD. ☐ M.A ☐ GS ☐ PI ☐

TYPE OF SAMPLE Remolded

FEATURE Sites Dam
HOLE NO. F.S. NO.
DEPTH

112

DWR 720 (REV. 3/66) REQUEST NO. 99-51 CHAMBER NO. LAB. NO. 99-1420D

TRIAXIAL COMPRESSION

ASTM 4767 : Consolidated-Undrained Triaxial Compression Test on Cohesive Soils

DATE: 5/10/01 TIME: 8:30am

SPECIMEN:		MEMBRANE and FILTER STRIPS:		EQUIPMENT:	
New Length *:	14.748 (cm)	Thickness (mem):	0.024 (cm)	Frame No.	87900
New Diameter *:	6.151 (cm)	E Modulus (mem):	14.0 (kg/cm2)	Load Cell #:	A96356
New Area, A_o*:	29.72 (cm^2)	K_{fp} (fs)	0.196 (kg/cm)	Initial σ_3' (ksc)	13.31
B-Value:	100.0	P_{fp} (fs) @:	10.0 (cm)	Axial Strain Rate:	0.0036 (in. / min)
(* After consolidation)		(@ Perimeter length of filter strips)			

Displacement ΔH (cm)	Axial Strain ε (%)	Axial Load P (kg-f)	Chamber Pressure σ_{3T} (ksc)	Top Pore Pressure u_T (ksc)	Bottom Pore Pressure u_B (ksc)	Corrected Area $A_o/(1-e)$ (cm^2)	Membrane Correction $\Delta(\sigma_1 - \sigma_3)$ (ksc)	Pore Pressure Δu (ksc)	Effective Confining Stress σ_3' (ksc)	Stress Ratio σ_1'/σ_3'	Deviator Stress $(\sigma_1 - \sigma_3)$ (ksc)
0.000	0.0	0.00	19.33	6.00	6.05	29.72	0.00	0.00	13.31	1.00	0.00
0.018	0.1	-0.64	19.27	5.99	6.03	29.76	0.00	-0.01	13.26	1.00	-0.02
0.030	0.2	-1.04	19.21	5.96	5.99	29.78	0.00	-0.04	13.24	1.00	-0.04
0.046	0.3	-0.82	19.14	5.93	5.96	29.81	0.00	-0.07	13.20	1.00	-0.03
0.061	0.4	-0.95	19.05	5.88	5.90	29.84	0.00	-0.12	13.16	1.00	-0.03
0.074	0.5	-0.73	18.98	5.84	5.86	29.87	0.00	-0.16	13.12	1.00	-0.03
0.091	0.6	1.59	18.87	5.80	5.82	29.90	0.00	-0.20	13.06	1.00	0.05
0.104	0.7	2.27	18.77	5.76	5.76	29.93	0.00	-0.24	13.01	1.01	0.07
0.119	0.8	2.95	18.68	5.72	5.70	29.96	0.00	-0.28	12.97	1.01	0.10
0.135	0.9	3.22	18.65	5.69	5.67	29.99	0.00	-0.31	12.97	1.01	0.11
0.147	1.0	3.04	18.58	5.66	5.61	30.02	0.00	-0.34	12.94	1.01	0.10
0.307	2.1	188.01	19.65	7.64	9.78	30.35	0.00	1.64	10.94	1.57	6.19
0.442	3.0	220.22	19.52	8.45	11.05	30.64	-0.01	2.45	9.78	1.73	7.18
0.589	4.0	234.78	18.86	8.66	11.23	30.96	-0.01	2.66	8.91	1.85	7.58
0.742	5.0	247.80	19.78	9.71	12.61	31.29	-0.01	3.71	8.62	1.92	7.91
0.884	6.0	256.73	19.67	10.19	13.03	31.62	-0.01	4.19	8.06	2.01	8.11
1.034	7.0	263.13	19.61	10.60	13.31	31.96	-0.01	4.60	7.65	2.07	8.22
1.181	8.0	266.53	18.79	10.53	12.94	32.31	-0.02	4.53	7.05	2.17	8.23
1.328	9.0	272.75	19.78	11.31	13.79	32.66	-0.02	5.31	7.22	2.15	8.33
1.476	10.0	279.87	19.67	11.60	13.84	33.02	-0.02	5.60	6.95	2.22	8.45
1.623	11.0	284.27	19.61	11.79	13.81	33.40	-0.02	5.79	6.81	2.25	8.49
1.770	12.0	292.02	19.76	12.18	13.85	33.77	-0.02	6.18	6.74	2.28	8.62
1.918	13.0	296.88	18.84	12.04	13.09	34.16	-0.03	6.04	6.27	2.38	8.66
2.068	14.0	301.14	19.79	12.53	13.28	34.57	-0.03	6.53	6.89	2.26	8.68

Remarks: Composite Sample, SC, remolded @ 98.0 % of the maximum dry density

Confining Pressure Requested - 14.0 tsf (13.67 ksc)

(had difficulty seating the piston - maybe due to the high chamber pressure pushing on the piston)

(Air compressor was unstable, chamber pressure fluctuated)

Request #: 99-51

Lab #: 99-1420D

113

APPENDIX F

VENADO SANDSTONE
QUALITY TEST RESULTS FOR DWR SAMPLES

3-Inch Cube Samples from Sites Quarry

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SANDSTONE TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE Sandstone Quality for Rip-Rap and RCC Aggregate

LAB. NO.	HOLE NO.	F.S. NO.	PERCENT FINER											3-inch CUBE SAMPLES			CLASSIFICATION	
			MECHANICAL ANALYSIS											compressive strength	specific gravity	percent absorption		
			GRAVEL					SAND										
			3"	1½"	¾"	⅜"	4	8	16	30	50	100	200	(psi)	(ssd)	%	GROUP SYMBOL	GROUP NAME
98-174	SSQ-1	A												11130	2.50	2.6		
"	"	B												9960	2.48	2.6		
"	"	C												10830	2.48	2.8		
98-175	SSQ-2	A												11840	2.50	2.5		
"	"	B												11690	2.50	2.5		
"	"	C												12370	2.49	2.6		
98-176	SSQ-3	A												*	*	*		
"	"	B												*	*	*		
"	"	C												*	*	*		
98-177	SSQ-4	A												11830	2.50	2.4		
"	"	B												11630	2.50	2.5		
"	"	C												**	**	**		
98-178	SSQ-5	A												10160	2.46	3		
"	"	B												10200	2.45	2.8		
"	"	C												10820	2.45	2.8		
98-179	SSQ-6	A												9940	2.45	2.8		
"	"	B												9910	2.45	2.9		
"	"	C												10990	2.45	2.9		
98-180	SSQ-7	A												11220	2.52	2.5		
"	"	B												10320	2.51	2.3		
"	"	C												10740	2.50	2.7		
98-181	SSQ-8	A												12690	2.48	2.3		
"	"	B												12130	2.49	2.5		
"	"	C												12060	2.49	2.4		

Sheet 1 of 2

DATE: 5/25/1998
INITIAL: RGJ
REQUEST NO.: 98-18

REMARKS: * Unable to obtain cube sample. One side of slab is fractured and uneven.
** can only secure two cube specimens from slab.

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SANDSTONE TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE Sandstone Quality for Rip-Rap and RCC Aggregate

LAB. NO.	HOLE NO.	F.S. NO.	PERCENT FINER											3-inch CUBE SAMPLES			CLASSIFICATION	
			MECHANICAL ANALYSIS															
			GRAVEL					SAND						compressive strength	specific gravity	percent absorption		
			3"	1½"	¾"	⅜"	4	8	16	30	50	100	200	(psi)	(ssd)	%	GROUP SYMBOL	GROUP NAME
98-182	SSQ-9	A												11250	2.49	2.8		
"	"	B												11040	2.49	2.6		
"	"	C												11360	2.48	2.6		
98-183	SSQ-10	A												11240	2.45	2.8		
"	"	B												10970	2.46	2.7		
"	"	C												11490	2.46	2.7		

RESULTS OF QUALITY TESTS ON CRUSHED SANDSTONE

1. ASTM C-131 Los Angeles Rattler Test (Grading A = 1½ x 3/8 size fraction) :

100 revolutions = 11.4 percent loss
500 revolutions = 43.4 percent loss

Specific Gravity and Absorption tests before performing LART

Spec. Grav. = 2.48
Absorption = 4.2 percent

2. ASTM C--- Durabilitly Index (3/4 x #4 size fration)

Durability Index, Dc = 42

Specific Gravity and Absorption tests before performing Coarse Durability Index

Spec. Grav. = 2.50
Absorption = 4.1 percent

Sheet 2 of 2

DATE: 5/25/1998
INITIAL: RGJ
REQUEST NO.: 98-18

REMARKS: In determining the absorption, the strength samples (cubes) were oven dried at 160 °F. The crushed samples were oven dried at 230 °F. All samples were soaked for 24 hours.

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

Project: Sites and Golden Gate Damsites
Feature: Sandstone quality for aggregate (Rip-rap and RCC use)
Request No: 98-18

Hole number	SSQ-1			SSQ-2			SSQ-3			SSQ-4			SSQ-5		
laboratory number	98-174			98-175			98-176			98-177			98-178		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Wt. Saturated surface dry sample	1201	1206	1157	833	818	832				1111	1108		1115	1101	1108
Wt. Oven Dry sample	1170	1175	1126	813	798	811				1085	1081		1082	1071	1078
Wt. water absorbed	31	31	31	20	20	21	0	0	0	26	27	0	33	30	30
% water absorbed	2.6	2.6	2.8	2.5	2.5	2.6	#DIV/0!	#DIV/0!	#DIV/0!	2.4	2.5	#DIV/0!	3.0	2.8	2.8
Wt. S.S.D. sample suspended in water	720	719	691	500	491	498				666	664		662	652	656
Wt. Water Displaced by S.S.D. sample	481	487	466	333	327	334	0	0	0	445	444	0	453	449	452
Wt. Water Displaced by Solid sample	450	456	435	313	307	313	0	0	0	419	417	0	420	419	422
Bulk Specific Gravity (Dry Basis)	2.43	2.41	2.42	2.44	2.44	2.43	#DIV/0!	#DIV/0!	#DIV/0!	2.44	2.43	#DIV/0!	2.39	2.39	2.38
Bulk Specific Gravity (S.S.D. Basis)	2.50	2.48	2.48	2.50	2.50	2.49	#DIV/0!	#DIV/0!	#DIV/0!	2.50	2.50	#DIV/0!	2.46	2.45	2.45
Apparent Specific Gravity	2.60	2.58	2.59	2.60	2.60	2.59	#DIV/0!	#DIV/0!	#DIV/0!	2.59	2.59	#DIV/0!	2.58	2.56	2.55
Total load to failure (pounds)	107000	96000	101000	88000	86500	92500				107500	105000		93000	93000	99000
Calc. area of bearing surface (in2)	9.61	9.64	9.33	7.43	7.4	7.48				9.09	9.03		9.15	9.12	9.15
Comp. strength (psi	11134	9959	10825	11844	11689	12366	#DIV/0!	#DIV/0!	#DIV/0!	11826	11628	#DIV/0!	10164	10197	10820

identification number	SSQ-6			SSQ-7			SSQ-8			SSQ-9			SSQ-10		
laboratory number	98-179			98-180			98-181			98-182			98-184		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Wt. Saturated surface dry sample	1114	1115	1128	1085	1070	1079	1115	1126	1131	963	976	977	1094	1103	1102
Wt. Oven Dry sample	1084	1084	1096	1059	1046	1054	1090	1098	1105	941	953	955	1065	1074	1073
Wt. water absorbed	30	31	32	26	24	25	25	28	26	22	23	22	29	29	29
% water absorbed	2.8	2.9	2.9	2.5	2.3	2.4	2.3	2.6	2.4	2.3	2.4	2.3	2.7	2.7	2.7
Wt. S.S.D. sample suspended in water	660	660	668	654	643	648	666	671	676	577	584	583	648	655	654
Wt. Water Displaced by S.S.D. sample	454	455	460	431	427	431	449	455	455	386	392	394	446	448	448
Wt. Water Displaced by Solid sample	424	424	428	405	403	406	424	427	429	364	369	372	417	419	419
Bulk Specific Gravity (Dry Basis)	2.39	2.38	2.38	2.46	2.45	2.45	2.43	2.41	2.43	2.44	2.43	2.42	2.39	2.40	2.40
Bulk Specific Gravity (S.S.D. Basis)	2.45	2.45	2.45	2.52	2.51	2.50	2.48	2.47	2.49	2.49	2.49	2.48	2.45	2.46	2.46
Apparent Specific Gravity	2.56	2.56	2.56	2.61	2.60	2.60	2.57	2.57	2.58	2.59	2.58	2.57	2.55	2.56	2.56
Total load to failure (pounds)	91000	91000	101500	102000	93500	97000	11500	111000	111500	93000	92500	94500	102500	101000	105500
Calc. area of bearing surface (in2)	9.15	9.18	9.24	9.09	9.06	9.03	9.06	9.15	9.24	8.27	8.38	8.32	9.12	9.21	9.18
Comp. strength (psi	9945	9913	10985	11221	10320	10742	1269	12131	12067	11245	11038	11358	11239	10966	11492

		Wt in Air (SSD) (grams)	Wt. under water (grams)	Wt Water displaced by SS.S sample	spg ssd	Oven dry wt. @ 60°C 24H
SQ-1	A	1201	720	481	2.50	1170
	B	1206	719	487	2.48	1175
	C	1157	691	466	2.48	1126
SQ-2	A	833	500			813
	B	818	491			798
	C	832	498			811
SQ-4	A	1111	666			1085
	B	1108	664			1081
SQ-5	A	1115	662			1082
	B	1101	652			1071
	C	1108	656			1078
SQ-6	A	1114	660			1084
	B	1115	660			1084
	C	1128	668			1096
SQ-7	A	1085	654			1059
	B	1070	64~~4~~3			1046
	C	1079	648			1054
SQ-8	A	1115	666			1090
	B	1126	671			1098
	C	1131	676			1105
SQ-9	A	963	577			941
	B	976	584			953
	C	977	583			955
SQ-10	A	1094	648			1065
	B	1103	655			1074
	C	1102	654			1073

		Ht	Width	Depth	Weight (lbs) air dry over weekend after saw-cutting Friday (lbs)	AVERAGE Dimensions (inches) H	W	D	U.W pcf	spg
SSQ-1	A	3.076 3.089 3.086 3.095	3.118 3.151 3.143 3.121	3.075 3.073 3.074 3.073	2.580	3.09	3.13	3.07	150.2	2.41
	B	3.104 3111 3.079 3082	3069 3069 3070 3078	3127 3123 3159 3154	2.590	3.10	3.07	3.14	149.8	2.40
	C	3.084 3081 3087 3071	3.118 3122 3145 3145	2955 3.000 2946 3.008	2.478	3.08	3.13	2.98	149.1	2.39
SSQ-2	A	2743 2737 2744 2735	2719 2721 2712 2709	2743 2746 2738 2736	1.786	2.74	2.71	2.74	151.7	2.43
	B	2718 2732 2722 2728	2704 2703 2705 2708	2737 2735 2726 2729	1.754	2.72	2.71	2.73	150.6	2.41
	C	2759 2755 2750 2749	2750 2725 2753 2714	2730 2732 2730 2722	1.782	2.75	2.74	2.73	149.7	2.40
SSQ-4	B	3007 3023 3017 3031	3001 2997 3001 3003	3015 3013 3000 2994	23~~88~~78	3.02	3.00	3.01	150.7	2.42
	A	3014 3021 3023 3013	3011 3006 3008 3003	3017 3014 3009 3000	2.388	3.02	3.01	3.02	150.3	2.41
SSQ-5	A	3039 3038 3035 3042	3036 3036 3032 3034	3037 3022 3023 3012	2.384	3.04	3.03	3.02	148.1	2.37
	B	3026 3039 3032 3032	3014 3010 3020 3026	3021 3013 3017 3008	2.358	3.03	3.02	3.02	147.4	2.36
	C	3037 3038 3030 3041	3028 3023 3017 3014	3019 3032 3025 3027	2.376	3.04	3.02	3.03	147.6	2.37
SSQ-6	A	3046 3043 3063 3050	3001 2998 3030 3026	3056 3052 3035 3030	2.390	3.05	3.01	3.04	148.0	2.37
	B	3046 3054 3059 3064	3012 3012 3014 3005	3051 3045 3063 3058	2.390	3.06	3.01	3.05	147.0	2.36
	C	3068 3065 3066 3059	3076 3064 3051 3038	3017 3019 3024 3012	2.416	3.06	3.06	3.02	147.6	2.37
SSQ-7	A	2924 2924 2930 2927	3031 3032 3028 3021	2995 2998 2996 2990	2.330	2.93	3.03	3.00	151.2	2.42
	B	2892 2913 2904 2916	2985 2987 2991 2993	3023 3028 3032 3025	2.302	2.91	2.99	3.03	150.9	2.42
	C	2920 2924 2925 2928	2995 2985 2991 2989	3022 3025 3017 3026	2.318	2.92	2.99	3.02	151.9	2.44
SSQ-8	A	3052 3054 3048 3049	2983 2980 3016 3021	3003 3007 3026 3027	2.402	3.05	3.00	3.02	150.2	2.41
	B	3046 3047 3043 3043	3026 3018 3021 3029	3039 3039 3030 3030	2.422	3.04	3.02	3.03	150.5	2.41
	C	3053 3050 3049 3048	3030 3029 3028 3025	3043 3032 3038 3029	2.436	3.05	3.03	3.04	149.8	2.40
SSQ-9	A	2864 2858 2859 2848	2894 2898 2891 2891	2870 2857 2875 2856	2.066	2.86	2.89	2.86	151.0	2.42
	B	2872 2867 2875 2864	2894 2899 2903 2891	2895 2887 2887 2887	2.096	2.87	2.90	2.89	150.6	2.41
	C	2900 2888 2829 2875	2867 2866 2878 2879	2905 2913 2898 2896	2.098	2.89	2.87	2.90	150.7	2.42
SSQ 10	A	3007 3004 3005 3002	3028 3025 3024 3022	3015 3019 3018 3015	2.346 ~~2.368~~	3.00	3.02	3.02	148.2	2.37
	B	3005 3002 3003 3002	3039 3035 3032 3035	3023 3036 3025 3023	2.368	3.00	3.04	3.03	148.0	2.37
	C	2994 2994 2999 2996	3042 3030 3025 3030	3032 3028 3029 3027	2.366	3.00	3.03	3.03	148.4	2.38

Crushed Sandstone from Drill Cores

Project: Sites and Golden Gate Damsites
Feature: Sandstone quality for aggregate (Rip-rap and RCC use)
Request No: 98-18

Hole number	1.5 c 3/8 fraction graded for			3/4 x #4 fraction graded for		
laboratory number	L.A. Rattler			Coarse Durability Index		
			A			A
Wt. Saturated surface dry sample.			5249			2556
Wt. Oven Dry sample			5037			2455
Wt. water absorbed			212			101
% water absorbed			4.2			4.1
Wt. S.S.D. sample suspended in water			3136			1532
Wt. Water Displaced by S.S.D. sample			2113			1024
Wt. Water Displaced by Solid sample			1901			923
Bulk Specific Gravity (Dry Basis)			2.38			2.40
Bulk Specific Gravity (S.S.D. Basis)			2.48			2.50
Apparent Specific Gravity			2.65			2.66

L.A. Rattler Test Results ASTM C-131 grading A

No. of Revolutions	Original Wt. (grams)	Final WT. (grams)	Loss (grams)	Percent of Wear
100	5009	4440	569	11.4
500	5009	2833	2176	43.4

TECHNICAL SERVICES OFFICE
CONCRETE SECTION

TEST FOR "ABRASION OF COARSE AGGREGATE"
ASTMC-131-76
-535-76

PROJECT ____ LABORATORY NO. ____
FEATURE Sandstone for Rip Rap & RCC FIELD SAMPLE NO. ____
SOURCE OF MATERIAL ____
SIZE FRACTION TESTED 1½ x ½" leftovers from sandstone slabs were crushed (trimings from
WORK ORDER NO. cutting cubes for Comp. Str.) compressive str specimens were also crushed
VISUAL DESCRIPTION & SIEVE

TABLE I – GRADING OF TEST SAMPLES

SIEVE SIZE		Weight & Grading of Test Samples – g						
PASSING	RETAINED	A	B	C	D	I	II	III
3 IN.	2½ IN.					2500*		
2½ IN.	2 IN.					2500*		
2 IN.	1½ IN.					5000*	5000*	
1½ IN.	1 IN. ±25	1250					5000*	5000*
1 IN.	¾ IN. ±25	1250						5000*
¾ IN.	½ IN. ±10	1250	2500					
½ IN.	3/8 IN. ±10	1250	2500					
3/8 IN.	NO. 3			2500				
NO. 3	NO. 4			2500				
NO. 4	NO. 8				5000			

* Tolerance of ± 2% permitted 5000±10

ABRASIVE CHARGE

Grading	No. of Spheres	Weight of Charge – g
[✓ A]	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15
E	12	5000 ± 25
F	12	5000 ± 25
G	12	5000 ± 25

TEST RESULTS

NO. OF REV.	ORIGINAL WT–g	FINAL WT. g	LOSS OF WT. g	PERCENT OF WEAR
100	5009	4440	569	11.4
500	5009	2833	2176	43.4

TESTED BY Roland
DATE TESTED 5/20/98
COMPUTED BY ____
CHECKED BY ____

1½ - 1	1252
1 - ¾	1257
¾ - ½	1249
½ - 3/8	1251
	5009

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

TEST METHOD: ASTM C 127–

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
TECHNICAL SERVICES OFFICE
CONCRETE LABORATORY

Project ______ Laboratory No. Soil REQ 98-18

Feature ______ Field Sample No. ______

Hole No. ______ Elev. Top of Hole ______ Depth of Sample ______

Visual Description ______

DETERMINATION NO.									
DATE TESTED									
TESTED BY									
COMPUTED BY			LART		COARSE Dc				
CHECKED BY			Specimen						
SIZE FRACTION			1½ x 3/8		3/4 x #4				
PROCESSING									
A	WT. SATURATED SURFACE DRY SAMPLE		5249		2556				
B	WT. OVEN DRY SAMPLE		5037		2455.				
C	WT. WATER ABSORBED	A–B	212		101				
D	% WATER ABSORBED	C/B ~~$\frac{C}{A}$~~ x 100	4.2		4.1				
E	WT. S.S.D. SAMPLE SUSPENDED IN WATER		3136		1532				
F	WT. WATER DISPLACED BY S.S.D. SAMPLE	A–E	2113		1024				
G	WT. WATER DISPLACED BY SOLID SAMPLE	F–C	1901		923				
H	BULK SPECIFIC GRAVITY (DRY BASIS)	$\frac{B}{F}$	2.38		2.40				
I	BULK SPECIFIC GRAVITY (S.S.D. BASIS)	$\frac{A}{F}$	2.48		2.50				
J	APPARENT SPECIFIC GRAVITY	$\frac{B}{G}$	2.65		2.66				

REMARKS:

CL 2 (3/57)
DWR 822 (REV.5/66)

CDI

#3 #2

~~20~~

10 min
= 2.7

20 min
S.H. = 5.5"
D_c = 40

20 min
S.H. = 5.6"
D_c = 42

1½ x ¾	¾ x ⅜	Dur Index
2624 ssd	2625	2556
1567 in water	1569	1532
2520 od	2517	2455
1057	1056	1024
2.48 ssd	2.49	2.50
104		
4.1%	4.3%	4.1%

① Petrographic provide info –

indicate –

L.A Rattler

5005 — I blew it. 100 REV DID NOT PROPERLY SET – TIMER DIRTY

3193 ~~did not set to 100 rev~~ NEED TO REDO

1812

	72
1½ - 1	1292
1 - ¾	1258
¾ - ½	1249
½ - ⅜	1251
	5000

5009

4440 = 100 REV = 11.4%

2833 = 500 REV = 43.4%

1½-Inch Minus Crushed Sandstone from Sites Quarry

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SANDSTONE TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE: Venado Sandstone Quality for Rip-Rap and RCC Aggregate

			PERCENT FINER											ASTM	ASTM C-40		ASTM C-127 & 128						ASTM C-131		ASTM C-142		
			MECHANICAL ANALYSIS											C-29		washed	3/4" x 3/8"		3/8" x #4		#4 x #200		100	500	3/4x 3/8	3/8x #4	#4x#8
LAB.	HOLE	F.S.	GRAVEL				SAND							D.R.U.W.	as	fines	spg	% abs	spg	%	spg	%	rev.	rev.	% clay lumps and		
NO.	NO.	NO.	3"	1½"	¾"	⅜"	4	8	16	30	50	100	200	(pcf)	rec'd	removed	(ssd)	abs	(ssd)	abs	(ssd)	abs	% loss	% loss	friable particles		
99C-113		A		100	96	32	12	9	8	7	6	4	2	88.3	clear	clear	2.48	4.9	2.48	6.3	2.57	2.40	11.4	50.8	1.0	2.1	6.5
"		B		100	95	57	35	28	23	20	18	11	6	88.7	clear	clear	2.49	5.0	2.48	6.3	2.58	2.30	7.3	36.9	0.2	0.1	1.7
"		C		100	97	65	44	36	30	27	24	16	9	88.6	clear	clear	2.48	5.4	2.48	6.2	2.58	2.50	11.5	49.5	0.2	0.1	1.3
99C-114		A		100	97	51	22	17	14	12	11	7	4	86.2	2	clear	2.45	6.2	2.47	6.6	2.56	2.70	13.7	56.0	1.7	3.3	8.6
"		B		100	97	55	27	19	15	13	11	7	4	86.4	3	clear	2.46	6.0	2.47	6.6	2.57	2.70	9.2	43.5	0.2	0.4	3
"		C		100	95	47	22	16	13	12	10	6	3	87.5	3	clear	2.46	6.0	2.46	6.6	2.57	2.70	12.5	54.5	0.4	0.9	3.7
			100 PERCENT COARSE AGGREGATE																								
			3"	1½"	¾"	⅜"	4	8	16	30	50	100	200														
99C-113		A		100	95	22	0																				
"		B		100	92	34	0																				
"		C		100	95	38	0																				
99C-114		A		100	96	37	0																				
"		B		100	96	39	0																				
"		C		100	93	33	0																				
			100 PERCENT FINE AGGREGATE																								
			3"	1½"	¾"	⅜"	4	8	16	30	50	100	200														
99C-113		A					100	73	61	56	50	32	18														
"		B					100	78	65	58	51	32	16														
"		C					100	81	68	61	54	36	21														
99C-114		A					100	76	62	54	47	30	16														
"		B					100	68	55	47	40	27	16														
"		C					100	74	60	53	45	29	16														

Sheet 1 of 1

DATE: 6/15/1999

INITIAL: RGJ

REQUEST NO.: 99-19

REMARKS: 99c-113 = fresh crushed sandstone.
99c-114 = weathered crushed sandstone.

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

	1½	3/4	3/8	#4	#8	#16	#30	#50	#100	#200	C-40 AS REC'D	WASHED	ASTM C-127 SPG 3/4 x 3/8	%abs	3/8 x 4		128 SPG SAND*	%abs	ASTM C-131 B-grading 100	500		C-142 3/4 x 3/8	3/8 x #4	#4 - #8 Sand
99C-113A	100	96	32	12	9	8	7	6	4	2	CLEAR	CLEAR	2.48	4.9	2.48	6.3	2.57	2.4	11.4	50.8	.23	1.0	2.1	6.5
-113B	100	95	57	35	28	23	20	18	11	6	CLEAR	CLEAR	2.49	5.0	2.48	6.3	2.58	2.3	7.3	36.7	.20	0.2	0.1	1.7
-113C	100	97	65	44	36	30	27	24	16	9	CLEAR	CLEAR	2.48	5.4	2.48	6.2	2.58	2.5	11.5	49.5	.23	0.2	0.1	1.3
99C-114A	100	97	51	22	17	14	12	11	7	4	2	CLEAR	2.45	6.2	2.47	6.6	2.56	2.7	13.7	56.0	.25	1.7	3.3	8.6
114B	100	97	55	27	19	15	13	11	7	4	3	CLEAR	2.46	6.0	2.47	6.6	2.57	2.7	9.2	43.5	.21	0.2	0.4	3.0
114C	100	95	47	22	16	13	12	10	6	3	3	CLEAR	2.46	6.0	2.46	6.6	2.57	2.7	12.5	54.5	.23	0.4	0.9	3.7

	1½	3/4	3/8	#4	1½	3/4	3/8	#4	D.R.U.W (pcf)
99C-113A	100	95	22	0	0	5	73	22	88.3
B	100	92	34	0	0	8	58	34	88.7
C	100	95	38	0	0	5	57	38	88.6

SAND ONLY	% PASSING #4	#8	#16	#30	#50	#100	#200	% EACH #4	#8	#16	#30	#50	#100	#200	PAN	F.M.
99C-113A	100	73	61	56	50	32	18	0	27	12	5	6	18	14	18	2.28
113B	100	78	65	58	51	32	16	0	22	13	7	7	19	16	16	2.16
113C	100	81	68	61	54	36	21	0	19	13	7	7	18	15	21	2.00
114 A	100	76	62	54	47	30	16	0	24	14	8	7	17	14	16	2.31
114 B	100	68	55	47	40	27	16	0	32	13	8	7	13	11	16	2.63
114 C	100	74	60	53	45	29	16	0	26	14	7	8	16	13	16	2.39

	1½	3/4	3/8	#4	1½	3/4	3/8	#4	
99C-114A	100	96	37	0	0	4	59	37	86.2
B	100	96	39	0	0	4	57	39	86.4
C	100	93	33	0	0	7	60	33	87.5

C-131 GRADING B

2500 ± 10 3/4 x 1/2 charge
2500 ± 10 1/2 x 3/8 11 spheres

	99C-113				99C-114		
	A	B	C		A	B	C
3/4 x 1/2	2503	2502	2501	2502	2507	2502	2500
total wt	5001	5003	5002	5006	5003	5006	5002
after 100 rev	4433	4636	4644	4432	4317	4545	4376
after 500 rev	2460	3174	2789*	2527	2202	2831	2277
loss 100 rev	11.4	7.3	7.2	11.5	13.7	9.2	12.5
loss 500 rev	50.8	36.7		49.5	56.0	43.5	54.5
100/500 loss ratio	.23	.20		.23	.25	.21	.23
		198				.212	

↑ REDO

* 595 REV - total 695 REVS

C-29 Unit wt & Voids of agg
Rodding Procedure sect 10

	99C-113			99C-114		
wt of Rodded agg + Measure (lbs)	60.40	60.60	60.55	59.35	59.45	60.00
wt of Measure (lbs)	16.35			16.35		
wt of Rodded Agg	44.05			43.0	43.1	
Vol of Measure cu.ft	.499					
D.R.U.W. (pcf)	88.3	88.27	88.6	86.2	86.4	87.5

2.5-Inch x 5-Inch x 5-Inch Cubes from Sites Quarry

	Avg Thick (inch)	Avg Width (in)	Avg Depth (in)	5/4/99 AIR DRY Wt. (lbs)	Vol (cu ft)	Unit wt (Air dry) (pcf)	Unit wt (ssd)	calculated from Air dry wt est % absorption	O.D @ 230°F % absorp
99C-79 A	2.736	5.017	5.007	5.844	.03977	146.9	151.8	3.2	4.7
B	2.572	5.016	5.001	5.472	.03734	146.6	151.0	3.0	4.7
C	2.582	5.037	5.010	5.530	.03771	146.7	151.6	3.3	4.7
99C-80 A	2.548	5.026	5.010	5.622	.03713	151.4	156.0	3.0	3.2
B	2.565	5.024	5.021	5.666	.03744	151.3	155.4	2.7	3.3
C	2.569	5.006	5.017	5.650	.03734	151.3	155.4	2.7	3.3

SOAKED 5/4/99

653-4407

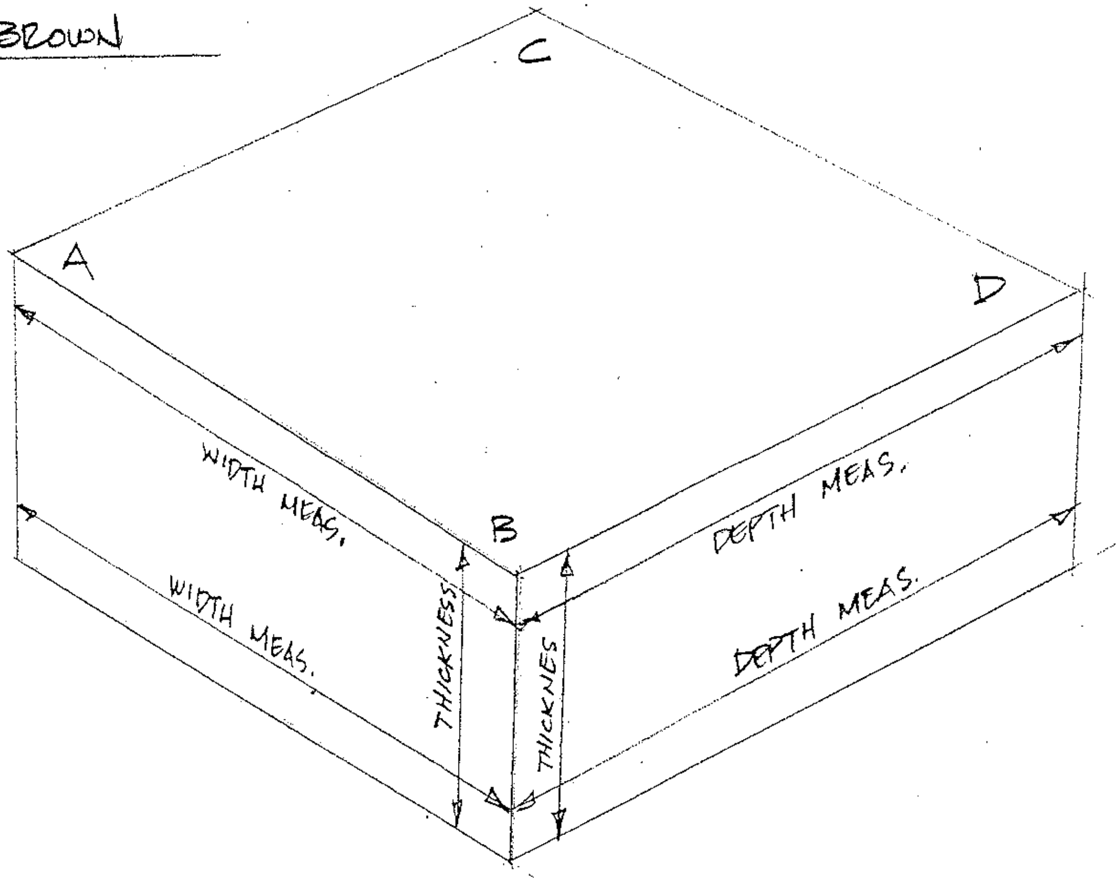
LAB #	79A	79B	79C	80A	80B	80C
ssd wt. (gms)	2738	2564	2591	2613	2634	2627
dry wt. (gms)	2616	2449	2474	2532	2551	2544
absorb water	122	115	117	81	83	83
% absorption	4.7	4.7	4.7	3.2	3.3	3.3
ssd wt in water	1609	1506	1523	1566	1577	1572
water displaced by ssd	1129	1058	1068	1047	1057	1055
" " " solid						
SPG (dry basis)						
SPG (s.s.d.)	2.43	2.42	2.43	2.50	2.49	2.49
SPG (apparent)						
OD after cycle	2600	2434	2461	2519	2538	2531
wt loss	16	15	13	13	13	13
% loss	0.6	0.6	0.5	0.5	0.5	0.5

MCR-3 5350
4 5680

ASTM D 5313 Wet-Dry Durability of RIP-RAP

LAB # 99C-79A

ROCK TYPE BROWN



THICKNESS:

A		B		C		D		
~~2.724~~ 2.762	~~2.722~~ 2.759	~~2.691~~ 2.776	~~2.697~~ 2.778	2.687	2.687	2.720	2.718	avg = 2.736

WIDTH:

AB		CD		
5.013	5.020	5.015	5.019	avg = 5.017

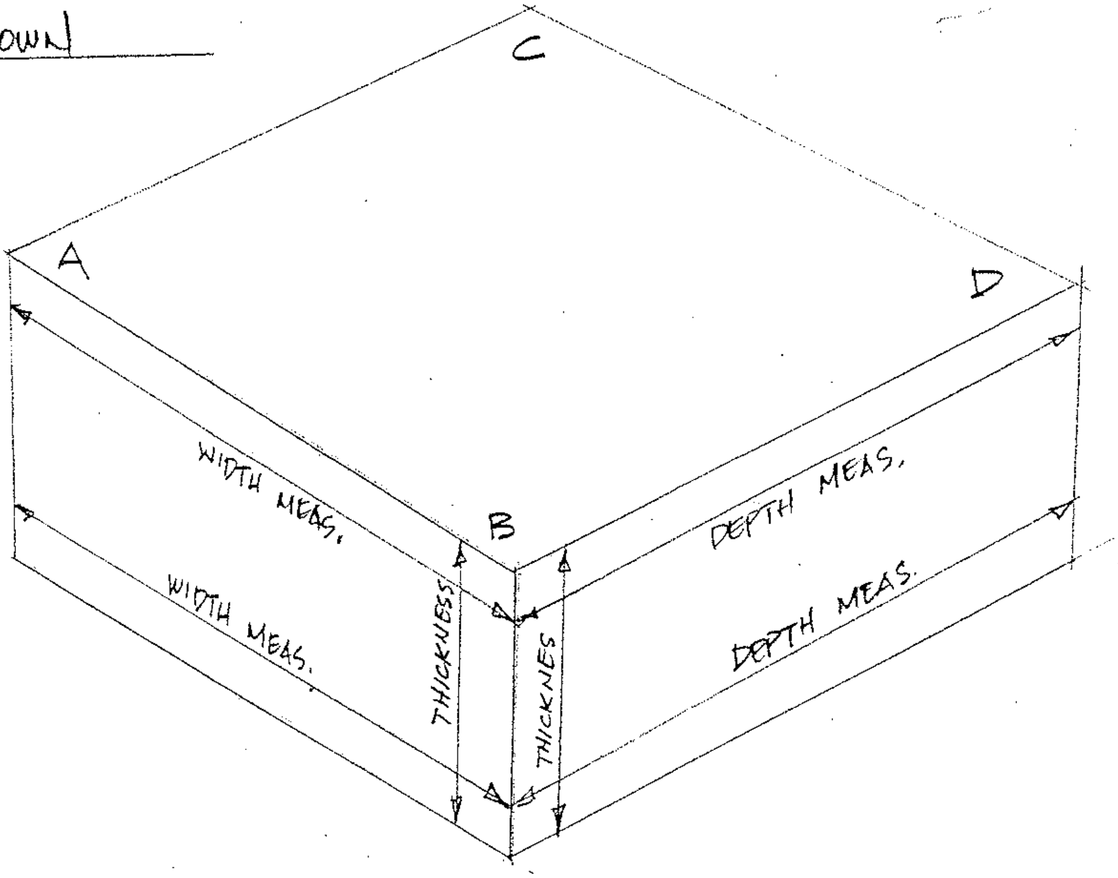
DEPTH

AC		BD		
5.010	5.013	5.000	5.005	avg = 5.007

ASTM D5313 Wet-Dry Durability of RIP-RAP

LAB # 99C-79B

ROCK TYPE BROWN



THICKNESS:

A		B		C		D		
2,573	2,561	2,548	2,553	2,601	2,601	2,565	2,575	avg = 2,572

WIDTH:

AB		CD		
5,014	5,013	5,019	5,017	avg = 5,016

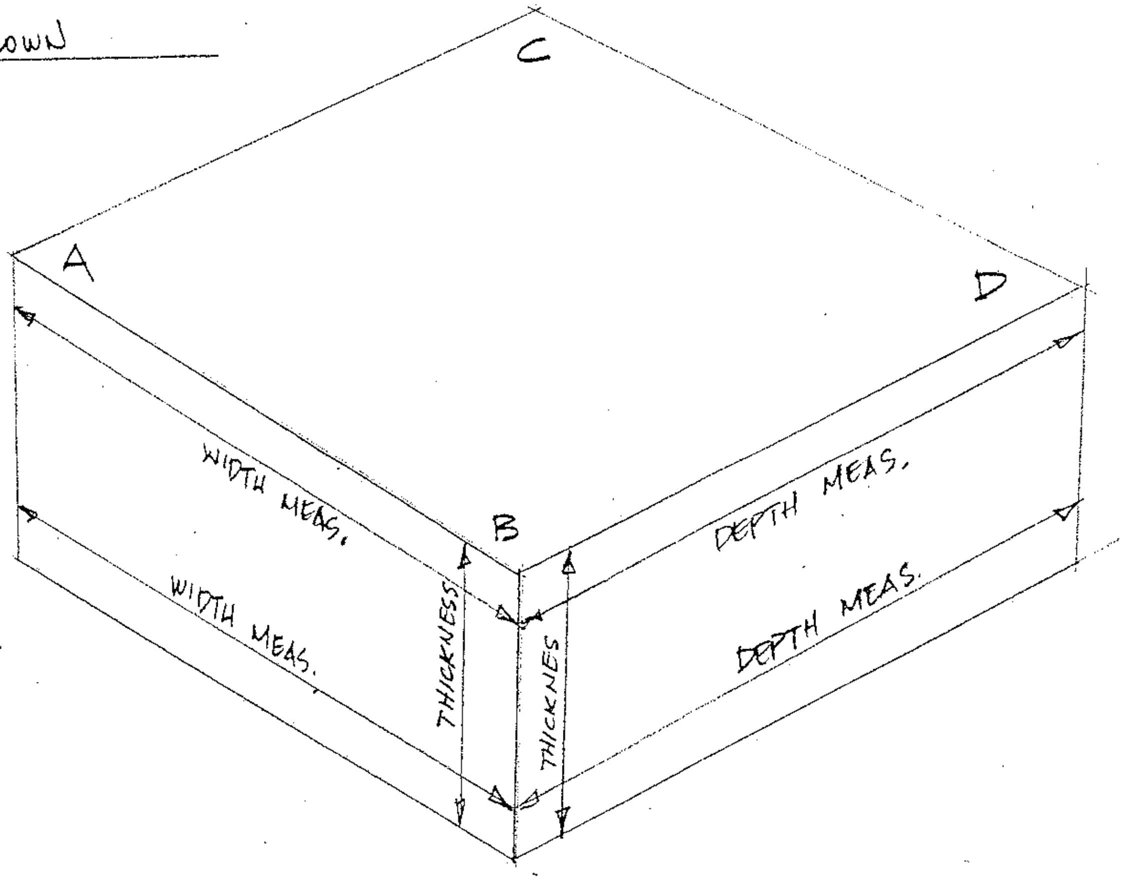
DEPTH

AC		BD		
5,001	5,003	5,001	4,997	avg = 5,001

ASTM D5313 Wet-Dry Durability of Rip-Rap

LAB # 99C-79C

ROCK TYPE BROWN



THICKNESS:

A		B		C		D		
2.529	2.519	2.557	2.561	2.607	2.602	2.641	2.638	avg = 2.582

WIDTH:

AB		CD		
5.019	5.046	5.031	5.053	avg = 5.037

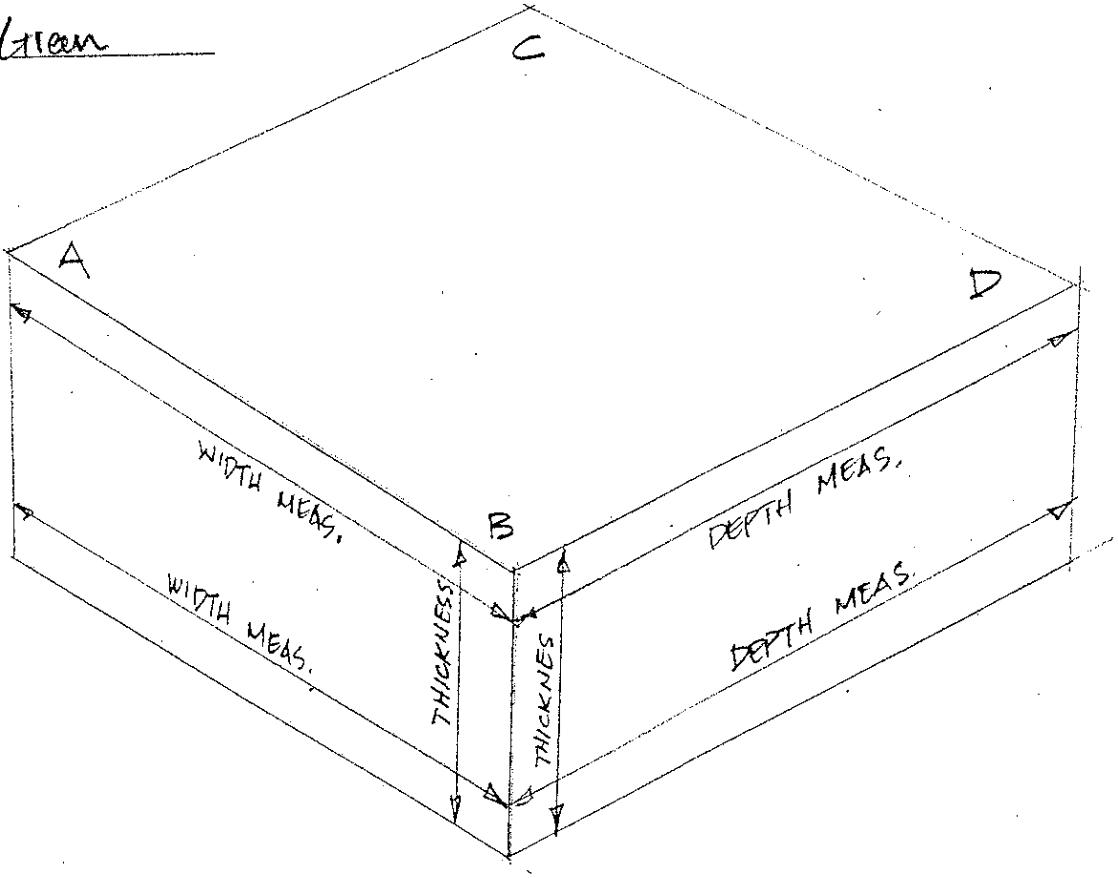
DEPTH

AC		BD		
5.016	5.009	5.008	5.006	avg = 5.010

ASTM D5313 Wet-Dry Durability of RIP-RAP

LAB # 99C-80A

ROCK TYPE Green



THICKNESS:

A		B		C		D		
2,531	2,534	2,519	2,521	2,575	2,574	2,563	2,567	avg 2,548

WIDTH:

AB		CD		
5.024	5,022	5.028	5,029	avg 5.026

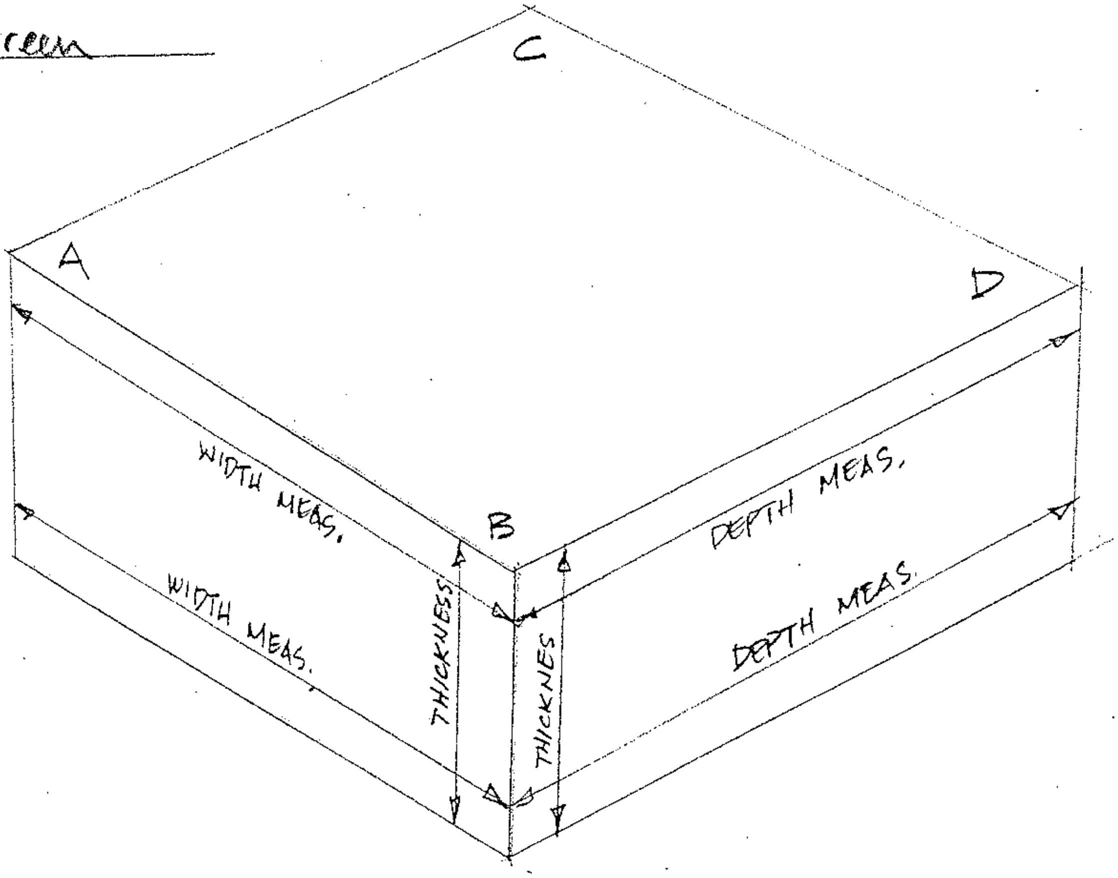
DEPTH

AC		BD		
5006	5.008	5012	5013	avg = 5,010

ASTM D 5313 Wet-Dry Durability of RIP-RAP

LAB # 99C-80B

ROCK TYPE Green



THICKNESS:

A		B		C		D		
2,555	2,555	2,542	2,546	2,588	2,584	2,578	2,575	avg 2,565

WIDTH:

AB		CD		
5,022	5,021	5,024	5,028	avg 5,024

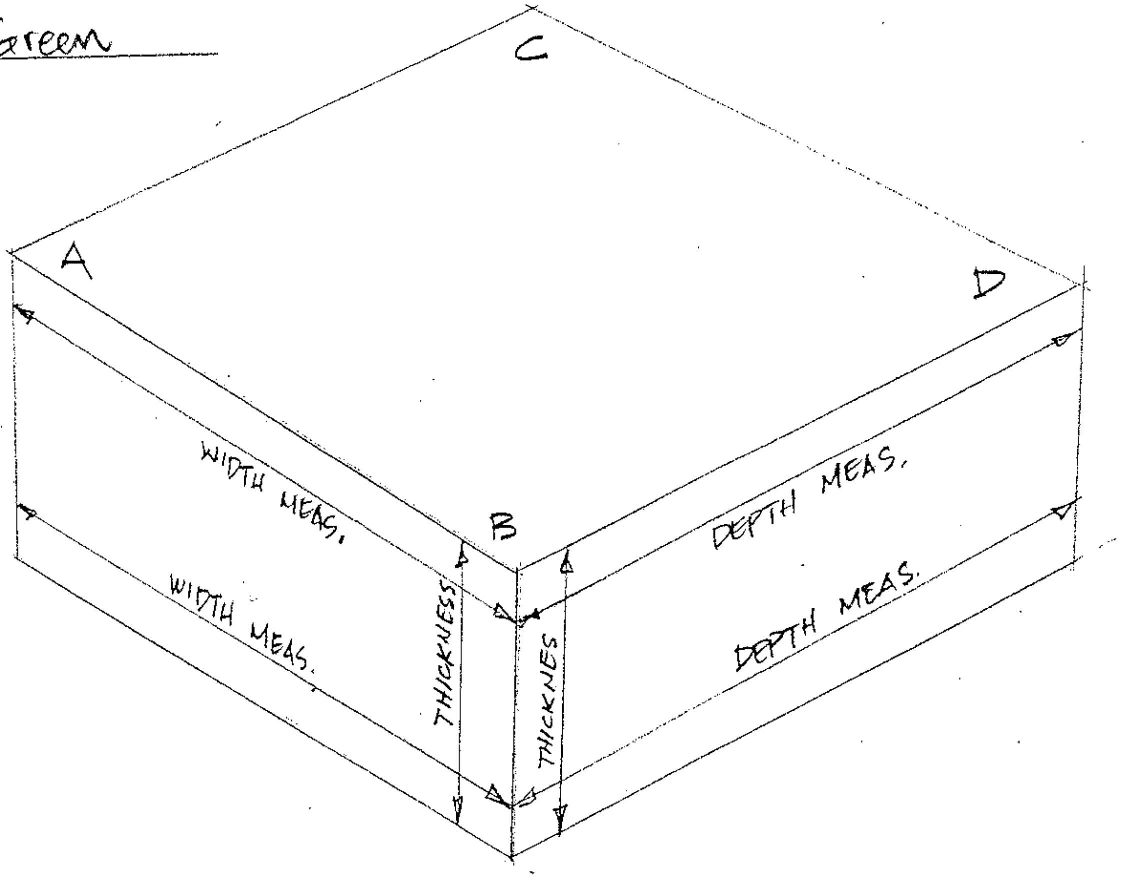
DEPTH

AC		BD		
5,017	5,019	5,024	5,022	avg 5.021

ASTM D 5313 Wet-Dry Durability of RIP-RAP

LAB # 99C-80C

ROCK TYPE Green



THICKNESS:

A		B		C		D		
2585	2581	2580	2580	2,553	2,554	2,560	2,560	avg = 2,569

WIDTH:

AB		CD		
5016	4994	5024	4991	avg = 5,006

DEPTH

AC		BD		
5020	5006	5028	5014	avg = 5,017

2.5-Inch Diameter Drill Cores from Geologic Exploration

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

												ASTM D-2938		ASTM C-97	
LAB NO.	SITE	HOLE NO.	F. S. NO.	DEPTH (feet)	ROCK TYPE	NOTES	LENGTH (inch)	DIAM (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	REMARKS	SPG (ssd)	% ABS
99C-110	Sites	LC-2		51.3-52.0	Ss	Fresh, 45° per-bed, representative of sandstone	4.733	2.365	2.0	78,700	Wet	17,910	Good Test	2.74	0.2
99C-91	GG	RA-1		51.0-52.3	Ss	Fresh	5.010	2.392	2.1	58,800	Dry	13,080	Good Test	2.47	3.7
99C-92	GG	RA-1	A	53.4-54.2	Ss	Fresh	4.521	2.392	1.9	32,500	Wet	7,230	Good Test	2.50	3.5
			B				5.009	2.392	2.1	59,000	Dry	13,120	Good Test	2.50	3.4
99C-88	GG	LC-1		35.6-36.3	Ss	Slightly weathered, representative of pitting	5.018	2.390	2.1	75,600	Dry	16,850	Good Test	2.66	1.5
99C-84	GG	LA-1	A	27.8-28.4	Ss	Slightly weathered	4.010	2.377	1.7	21,200	Wet	4,620	Good Test	2.52	3.7
			B				4.510	2.380	1.9	50,150	Dry	11,270	Good Test	2.50	3.8
99C-90	GG	RA-1		16.2-17.2	Ss	Moderately weathered	5.013	2.385	2.1	32,550	Dry	7,290	Good Test	2.41	5.4
99C-89	GG	LC-1		199.5-200.3	Ms	Fresh	5.038	2.390	2.1	24,200	Dry	5,390	Good Test		
99C-87	GG	LC-1		23.2-23.8	Ms	Moderately weathered	4.555	2.385	1.9	5,250	Dry	1,180	Good Test		

DATE:
INITIAL: RGJ/TEC
REQUEST NO.: 99-19

REMARKS: Rock Types - Ms=Mudstone, Ss=Sandstone, I = Interbedded Mudstone/Siltstone

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO.	HOLE NO.	F.S. NO.	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS.
2001-28	GGC-LA1	A	75.8-77.3	Ss	4.884	2.392	2.04							2.56	2.9
		B		Ss	4.883	2.393	2.04	25650	WET	5703				2.56	2.9
		C		Ss	4.861	2.392	2.03	45500	DRY	10125				2.57	2.8
2001-29	GGC-LA1		163.3-164.4	Ms	1.866	2.387	0.78							2.51^A	4.6
2001-30	GGC-RC1	A	56.0-57.0	Ss	5.007	2.487	2.01	22800	WET	4693				2.49	2.9
		B		Ss	5.020	2.488	2.02	47600	DRY	9791				2.50	2.8
2001-31	GGC-RC1	A	146.7-147.7	Ms	5.047	2.492	2.03							2.56^A	3.6
		B		Ms	1.556	2.493	0.62								
2001-32	GGC-RC2	A	140.1-141.3	Ms	4.919	2.488	1.98	19350	DRY	3980				2.53^A	4.6
		B		Ms	4.990	2.487	2.01								
		C		Ms	3.535	2.487	1.42								
2001-33	GGC-RC2	A	70.8-71.9	Ss	5.024	2.494	2.01							2.53	2.8
		B		Ss	5.027	2.493	2.02							2.52	3.1
		C		Ss	1.545	2.493	0.62							2.55	3.0

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR **FEATURE:** 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB. NO.	HOLE NO.	F. S. NO.	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS.
2001-34	GGC-RA1	A	59.9-61.0	Ss	1.495	2.394	0.62							2.53	2.6
		B		Ss	5.019	2.394	2.10	21650	WET	4810				2.55	2.6
		C		Ss	5.019	2.394	2.10	45000	DRY	9997				2.56	2.6
		D		Ss	1.398	2.394	0.58							2.56	2.8
2001-35	GGC-RA1	A	146.3-147.5	Ms	4.996	2.390	2.09	9800	DRY	2184				2.52^A	3.9
2001-36	GO-DHS-3	A	45.0-46.0	Ss	5.024	2.491	2.02							2.48	2.3
		B		Ss	5.018	2.491	2.01							2.48	2.2
2001-37	SSD3-4		140.1-140.0	Ms										2.40^A	8.4
2001-38	SSD5-3	A	97.1-99.0	*	1.480	2.478	0.60								
		B		*	3.588	2.480	1.45								
		C		*	1.258	2.488	0.51							2.28	8.3
		D		Ss	1.505	2.488	0.60							2.39	6.7
2001-39	SSD8-5		63.0-64.0	Ms										2.41^A	6.8
2001-40	SSD9-1	A	120.4-121.4	Ms	1.283	2.493	0.51								
		B		Ms	1.347	2.493	0.54								
		C		Ms	4.193	2.493	1.68	26150	DRY	5238					
		D		Ms	1.238	2.493	0.50								

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SHEET 2 of 5

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR **FEATURE:** 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F.S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-41	GO-DHT3	A	71.0-72.2	Ss	1.641	2.491	0.66	3630	WET		1776			2.48	4.2
		B		Ss	5.033	2.490	2.02	25450	WET	5226				2.43	3.3
		C		Ss	1.448	2.490	0.58							2.42	3.3
2001-42	GO-DHT3	A	206.5-207.6	Ms	3.762	2.490	1.51							2.57^A	3.9
		B		Ms	4.980	2.491	2.00							2.57^A	3.9
2001-43	GO-DHT3	A	272.0-273.0	Ss	5.020	2.492	2.01							2.45	3.7
		B		Ss	5.021	2.492	2.01							2.44	3.9
		C		Ss	1.520	2.492	0.61							2.44	3.5
		D		Ss	1.398	2.492	0.56							2.43	3.9
2001-51	GGO-DHS3		45.0-46.0	Ss	(did not receive sample)										
2001-52	GGO-DHS4	B	56.0-57.0	Ss	1.593	2.486	0.64	4910	DRY		2480				
		C			4.593	2.490	1.84	33750	WET	6861				2.66	0.8
2001-53	GGO-DHS4		57.0-57.7	Ms	(can not obtain test specimen- see sketch)										
2001-54	GGO-DHS4		26.5-27.0	Ms	1.523	2.491	0.61								

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A - broken and/or end pieces used for specific gravity and absorption

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SUMMARY SHEET

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F.S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS.
2001-55	GGO-DHT1	A	155.7-156.7	Ms	4.980	2.487	2.00	15400	DRY	3170					
		B		Ms	1.414	2.485	0.57	1140	DRY		649				
2001-56	GGO-DHT1	A	176.0-177.2	Ss	4.860	2.497	1.95	0	WET	0	(mudstone separated-water damaged)			2.58	1.5
		B		Ss	4.518	2.502	1.81	59700	DRY	11988				2.66	0.5
2001-57	GGO-DHT3	A	316.3-317.7	Ss	1.345	2.491	0.54							2.33	4.4
		B		Ss	4.999	2.491	2.01							2.42	3.4
		C		Ss	4.993	2.491	2.00							2.43	3.4
		D		Ss	1.499	2.492	0.60	2740	WET		1467			2.44	3.6
		E		Ss	1.499	2.493	0.60	5220	DRY		2795			2.46	3.7
2001-58	GGO-DHT3	A	327.7-329.0	Ss	5.081	2.493	2.04	22200	WET	4548				2.49	2.0
		B		Ss	4.948	2.490	1.99	22400	DRY	4600					
2001-59	GGO-DHT4	A	115.5-116.7	Ms	1.552	2.487	0.62	1780	DRY		922				
		B		Ms	1.521	2.487	0.61								
		C		Ms	1.551	2.491	0.62								
		D		Ms	5.029	2.489	2.02	13700	DRY	2816					
2001-60	GGO-DHT4	A	124.5-125.5	Ss	5.023	2.491	2.02	45150	DRY	9264				2.50	2.7
		B			5.017	2.492	2.01	37750	WET	7740				2.59	1.5

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PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

LAB NO	HOLE NO	F. S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	ASTM D-2938 COMPRESSIVE STRENGTH (psi)	ASTM D-3967 SPLITTING TENSILE (psi)			ASTM C-97 SPG (ssd)	% ABS.
2001-61	GGO-DHT5	A	430.5-432.0	Ss	1.512	2.491	0.61	3200	WET		1700			2.49	3.3
		B			5.028	2.491	2.02	28000	WET	5745				2.53	2.5
		C			5.016	2.491	2.01	42900	DRY	8803				2.54	2.9
		D			5.023	2.491	2.02							2.52	2.1
2001-62	GGO-DHT6	A	535.4-536.4	Ms	4.786	2.495	1.92								
2001-63	GGO-DHT6	A	556.3-557.3	Ms	4.788	2.492	1.92	18900	DRY	3856					
		C			1.555	2.493	0.62	2700	DRY		1393				

DATE:
INITIAL rgj
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Bryte Code	Project	Site	Drill Hole	Start Depth	End Depth	Rock Type (MS = mudstone SS = sandstone)	Rock Description	Condition 1 = decomposed 2 = intensely weathered 3 = moderately weathered 4 = slightly	Sample Comments	Sample Comments 2	Sample Length	Sample Diameter	Sample LD Ratio	Sample Air Weight	Sample Dry Weight	Sample Weight	Sample Area	Load	Load Test Type	Moisture	C-3148	C-2938	Test Comments	Compressive	Compressive Corrected	Tensile	SPG	Absorption
2001-28A	Sites Reservoir	Golden Gate Curved	GGC-LA1	75.8	77.3	Ss		5			4.88	2.39	2.04														2.56	2.93
2001-28B	Sites Reservoir	Golden Gate Curved	GGC-LA1	75.8	77.3	Ss		5			4.88	2.39	2.04					25,650		WET				5,703			2.56	2.92
2001-28C	Sites Reservoir	Golden Gate Curved	GGC-LA1	75.8	77.3	Ss		5			4.86	2.39	2.03					45,600		DRY				10,125			2.57	2.82
2001-29A	Sites Reservoir	Golden Gate Curved	GGC-LA1	163.3	164.4	Ms		5	Broken and/or end pieces used for SPG and absorption		1.87	2.39	0.78														2.51	4.63
2001-30A	Sites Reservoir	Golden Gate Curved	GGC-RC1	56	57	Ss		5			5.01	2.49	2.01					22,600		WET				4,693			2.49	2.91
2001-30B	Sites Reservoir	Golden Gate Curved	GGC-RC1	56	57	Ss		5			5.02	2.49	2.02					47,600		DRY				9,791			2.50	2.79
2001-31A	Sites Reservoir	Golden Gate Curved	GGC-RC1	146.7	147.7	Ms		5	Broken and/or end pieces used for SPG and absorption		5.05	2.49	2.03														2.56	3.56
2001-31B	Sites Reservoir	Golden Gate Curved	GGC-RC1	146.7	147.7	Ms		5			1.56	2.49	0.62															
2001-32A	Sites Reservoir	Golden Gate Curved	GGC-RC2	140.1	141.3	Ms		5	Broken and/or end pieces used for SPG and absorption		4.92	2.49	1.98					19,350		DRY				3,980			2.53	4.63
2001-32B	Sites Reservoir	Golden Gate Curved	GGC-RC2	140.1	141.3	Ms		5			4.99	2.49	2.01															
2001-32C	Sites Reservoir	Golden Gate Curved	GGC-RC2	140.1	141.3	Ms		5			3.54	2.49	1.42															
2001-33A	Sites Reservoir	Golden Gate Curved	GGC-RC2	70.8	71.9	Ss		5			5.02	2.49	2.01														2.53	2.75
2001-33B	Sites Reservoir	Golden Gate Curved	GGC-RC2	70.8	71.9	Ss		5			5.03	2.49	2.02														2.52	3.08
2001-33C	Sites Reservoir	Golden Gate Curved	GGC-RC2	70.8	71.9	Ss		5			1.55	2.49	0.62														2.55	3.00
2001-34A	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			1.50	2.39	0.62														2.53	2.58
2001-34B	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			5.02	2.39	2.10					21,650		WET				4,810			2.55	2.62
2001-34C	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			5.02	2.39	2.10					45,000		DRY				9,997			2.56	2.61
2001-34D	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			1.40	2.39	0.58														2.56	2.76
2001-35A	Sites Reservoir	Golden Gate Curved	GGC-RA1	146.3	147.5	Ms		5	Broken and/or end pieces used for SPG and absorption		5.00	2.39	2.09					9,800		DRY				2,184			2.52	3.87
2001-36A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHS-3	45	46	Ss		5			5.02	2.49	2.02														2.46	2.28
2001-36B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHS-3	45	46	Ss		5			5.02	2.49	2.01														2.46	2.18
2001-37A	Sites Reservoir	Northern Saddle Dams	SSD3-4	140.1	141	Ms		5	Broken and/or end pieces used for SPG and absorption																		2.40	8.39
2001-38A	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			1.48	2.48	0.60															
2001-38B	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			3.59	2.48	1.45															
2001-38C	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			1.26	2.49	0.51														2.28	8.25
2001-38D	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			1.51	2.49	0.60														2.39	6.69
2001-39A	Sites Reservoir	Northern Saddle Dams	SSD8-5	63	64	Ms		5	Broken and/or end pieces used for SPG and absorption																		2.41	6.75
2001-40A	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			1.28	2.49	0.51															
2001-40B	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			1.35	2.49	0.54															
2001-40C	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			4.19	2.49	1.68					26,150		DRY				5,238				
2001-40D	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			1.24	2.49	0.50															
2001-41A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	71	72.2	Ss		5			1.64	2.49	0.66					3,630		WET						1,776	2.48	4.23
2001-41B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	71	72.2	Ss		5			5.03	2.49	2.02					25,450		WET				5,226			2.43	3.30
2001-41C	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	71	72.2	Ss		5			1.45	2.49	0.58														2.42	3.33
2001-42A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	206.5	207.6	Ms		5	Broken and/or end pieces used for SPG and absorption		3.76	2.49	1.51														2.57	3.86
2001-42B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	206.5	207.6	Ms		5	Broken and/or end pieces used for SPG and absorption		4.98	2.49	2.00														2.57	3.86
2001-43A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			5.02	2.49	2.01														2.45	3.72
2001-43B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			5.02	2.49	2.01														2.44	3.94
2001-43C	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			1.52	2.49	0.61														2.44	3.53
2001-43D	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			1.40	2.49	0.56														2.43	3.85
2001-51A	Sites Reservoir	Golden Gate Inlet Outle	GGO DHS3	45	46	Ss		5	(did not receive sample)																			
2001-52B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	56	57	Ss		5			1.59	2.49	0.64					4,910		DRY						2,480		
2001-52C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	56	57	Ss		5			4.59	2.49	1.84					33,750		WET				6,861			2.66	0.76
2001-53A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	57	57	Ms		5	(can not obtain test specimen- see sketch)																			
2001-54A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	26.5	27	Ms		5			1.52	2.49	0.61															
2001-55A	Sites Reservoir	Golden Gate Inlet Outle	GGO DHT1	155.7	156.7	Ms		5			4.98	2.49	2.00					15,400		DRY				3,170				
2001-55B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT1	155.7	156.7	Ms		5			1.41	2.49	0.57					1,140		DRY						649		
2001-56A	Sites Reservoir	Golden Gate Inlet Outle	GGO DHT1	176	177.2	Ss		5	(mudstone separated-water damaged)		4.86	2.50	1.95					0		WET							2.58	1.47
2001-56B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT1	176	177.2	Ss		5			4.52	2.50	1.81					59,700		DRY				11,988			2.66	0.47
2001-57A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			1.34	2.49	0.54														2.33	4.42
2001-57B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			5.00	2.49	2.01														2.42	3.42
2001-57C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			4.99	2.49	2.00														2.43	3.36
2001-57D	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			1.50	2.49	0.60					2,740		WET						1,467	2.44	3.55
2001-57E	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		1			1.50	2.49	0.60					5,220		DRY						2,795	2.46	3.74
2001-58A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	327.7	329	Ss		5			5.08	2.49	2.04					22,200		WET				4,548			2.49	2.03
2001-58B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	327.7	329	Ss		5			4.95	2.49	1.99					22,400		DRY				4,600				
2001-59A	Sites Reservoir	Golden Gate Inlet Outle	GGO DHT4	115.5	116.7	Ms		5			1.55	2.49	0.62					1,780		DRY						922		
2001-59B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	115.5	116.7	Ms		5			1.52	2.49	0.61															

Bryte Code	Project	Site	Drill Hole	Start Depth	End Depth	Rock Type (MS = mudstone SS = sandstone)	Rock Description	Condition 1 = decomposed 2 = intensely weathered 3 = moderately weathered 4 = slightly	Sample Comments	Sample Comments 2	Sample Length	Sample Diameter	Sample LD Ratio	Sample Air Weight	Sample Dry Weight	Sample Weight	Sample Area	Load	Load Test Type	Moisture	C-3148	C-2938	Test Comments	Compressive	Compressive Corrected	Tensile	SPG	Absorption
2001-59C	Sites Reservoir	Golden Gate Inlet Outle	GGO DHT4	115.5	116.7	Ms		5			1.55	2.49	0.62															
2001-59D	Sites Reservoir	Golden Gate Inlet Outle	GGO DHT4	115.5	116.7	Ms		5			5.03	2.49	2.02					13,700		DRY				2,816				
2001-60A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	124.5	125.5	Ss		5			5.02	2.49	2.02					45,150		DRY				9,264			2.50	2.68
2001-60B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	124.5	125.5	Ss		5			5.02	2.49	2.01					37,750		WET				7,740			2.59	1.53
2001-61A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			1.61	2.49	0.61					3,200		WET						1,700	2.49	3.26
2001-61B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			5.03	2.49	2.02					28,000		WET				5,745			2.53	2.45
2001-61C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			5.02	2.49	2.01					42,900		DRY				8,803			2.54	2.92
2001-61D	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			5.02	2.49	2.02														2.52	2.09
2001-62A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT6	535.4	536.4	Ms		5			4.79	2.50	1.92															
2001-63A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT6	556.3	557.3	Ms		5			4.79	2.49	1.92					18,900		DRY				3,856				
2001-63C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT6	556.3	557.3	Ms		5			1.56	2.49	0.62					2,700		DRY						1,393		
1999C-82	Sites Reservoir	Golden Gate Straight	GGLA-1	6.1	6.4	Ss/Ms	intensely weathered sand/silt stone	2	Can't secure test sample	2" available	0.30											Dry						
1999C-83	Sites Reservoir	Golden Gate Straight	GGLA-2	6.7	7	Ss/Ms	intensely weathered sand/silt stone	2	Can't secure test sample	1.7" available	0.30											Wet						
1999C-84A	Sites Reservoir	Golden Gate Straight	GGLA-1	27.8	28.4	Ss	Sandstone.	4	4" & 4.5" test		0.60			732	706	441	4.438	21,200	Tinius Olsen	WET		Dry	Good Test	4,725	4,620		2.52	3.70
1999C-84B	Sites Reservoir	Golden Gate Straight	GGLA-1	27.9	28.4	Ss	Sandstone.	4	4" & 4.5" test		0.60		1.90	823	793	494	4.449	50,150	Wiedeman Baldwin	DRY		Dry	Good Test	11,270			2.50	3.80
1999C-85	Sites Reservoir	Golden Gate Straight	GGLC-1	60.7	61.2	Ms	Shale (mudstone?)	5	can't get good sample	4.5" avail	0.50											Dry						
1999C-86	Sites Reservoir	Golden Gate Straight	GGLA-1	188.2	188.9	Ms	Shale with silt interbeds and shear.	5	can't get good sample	6"	0.70											Dry						
1999C-87	Sites Reservoir	Golden Gate Straight	GGLC-1	23.2	23.8	Ms	Weathered shale	4	4.6"	4.5 (fractured) fair	0.60		1.90				4.468	5,250	Wiedeman Baldwin	DRY		Dry		1,180				
1999C-88	Sites Reservoir	Golden Gate Straight	GGLC-1	35.6	36.3	Ss	Representative of pitting.	4	5" good sample	8"	0.70		2.10	978	964	610	4.486	75,600	Tinius Olsen	DRY		Dry	Good Test	16,850			2.66	1.50
1999C-89	Sites Reservoir	Golden Gate Straight	GGLC-1	199.5	200.3	Ms	Fresh shale.	5	5" fair to good sample	7" soak ends	0.80		2.10				4.486	24,200	Wiedeman Baldwin	DRY		Wet	Good Test	5,390				
1999C-90	Sites Reservoir	Golden Gate Straight	GGRA-1	16.2	17.2	Ss	Weathered sandstone	3	Cut into 2 samples	1 only, 5" good	1.00		2.10	584	839	517	4.468	32,550	Wiedeman Baldwin	DRY		Dry/Wet	Good Test	7,290			2.41	5.40
1999C-91	Sites Reservoir	Golden Gate Straight	GGRA-1	51	52.3	Ss	Unweathered Sandstone.	5	Cut into 2 samples	5" good sample	1.30		2.10	901	869	536	4.494	58,800	Tinius Olsen	DRY	Dry	Wet	Good Test	13,080			2.47	3.70
1999C-92A	Sites Reservoir	Golden Gate Straight	GGRA-1	53.4	54.2	Ss	Unweathered Sandstone.	5	2 samples 4.5" & 5"		0.60		1.90	821	793	493	4.498	32,500	Tinius Olsen	WET		Dry	Good Test	7,230			2.50	3.50
1999C-92B	Sites Reservoir	Golden Gate Straight	GGRA-1	53.4	54.2	Ss	Unweathered Sandstone.	5	2 samples 4.5" & 5"		0.80		2.10	914	884	549	4.498	59,000	Tinius Olsen	DRY		Dry	Good Test	13,120			2.50	3.40
1999C-93	Sites Reservoir	Golden Gate Straight	GGRC-1	96.5	97	Ms	45o per-bed. Shale in shear zone.	5	Can't secure sample-friable	7.8"	0.50											Dry						
1999C-94	Colusa Reservoir	Owens	HOLA-1	19.7	20.5	Ss/Ms	Weathered interbedded sandstone and shale	3	can't secure sample-fracturing	4" avail	0.80											Dry						
1999C-95	Colusa Reservoir	Owens	HOLA-1	20.7	21.6	Ss/Ms	Weathered interbedded sandstone and shale	3	cut into two samples can't secure	7.7" avail	1.10										Dry (no)	Wet						
1999C-96	Colusa Reservoir	Owens	HOLA-1	51.5	52.4	Ss/Ms	Slightly weathered interbedded sandstone and shale	4	cut into 2 samples 5" good	6.9"	0.90		2.10				4.498	3,100	Wiedeman Baldwin	DRY	Dry(no)	Dry	Good Test	690				
1999C-97	Colusa Reservoir	Owens	HOLA-1	55.8	56.8	Ss/Ms	Slightly weathered interbedded sandstone and shale	4	Sheared between SS & Sh	7.9"	1.00			621	590	369	4.494	2,950	Wiedeman Baldwin	WET		Wet		656	630*		2.46	5.30
1999C-98A	Colusa Reservoir	Owens	HOLA-1	172.7	173.8	Ss	Sandstone. Thickly bedded (approx 50o)	5	Cut into 2 samples (yes)	10+"	1.10		2.10	985	965	609	4.513	28,000	Tinius Olsen	WET		Dry/Wet	Failed at bedding	6,200			2.62	2.10
1999C-98B	Colusa Reservoir	Owens	HOLA-1	172.7	173.8	Ss	Sandstone. Thickly bedded (approx 50o)	5	Cut into 2 samples (yes)	10+"	1.10		2.10	931	901	564	4.524	59,100	Tinius Olsen	DRY		Dry/Wet	Good Test	13,060			2.54	3.30
1999C-99	Colusa Reservoir	Owens	HOLA-1	199.2	199.8	Ms	Fractured shale.	5	Can't secure sample	3.6"	0.60											Dry						
1999C-100	Colusa Reservoir	Owens	HOLA-1	208	208.6	Ms	Fractured shale	5	Can't secure sample	4.1"	0.60											Wet						
1999C-101A	Colusa Reservoir	Owens	HOLC-1	29.6	30.6	Ms	Fresh shale. Thinly bedded (approx 60o), some fossils.	4	3.7" & 5" sample	soak ends	1.00						4.475	4,850	Wiedeman Baldwin	WET		Wet	Good Test	1,084	1050*			
1999C-101B	Colusa Reservoir	Owens	HOLC-1	29.6	30.6	Ms	Fresh shale. Thinly bedded (approx 60o), some fossils.	4	3.7" & 5" sample	soak ends	1.00		2.10				4.464	23,200	Wiedeman Baldwin	DRY		Wet	Good Test	5,200				
1999C-102	Colusa Reservoir	Owens	HOLC-1	82.1	82.9	Ms	Fresh shale. Thinly bedded (approx 50o), some soft interbeds	5	5" fair to good sample	6.9" soak ends	0.80		2.00				4.498	21,850	Wiedeman Baldwin	DRY		Wet	Good Test	4,860				
1999C-103A	Colusa Reservoir	Owens	HOLC-1	115.1	116.2	Ms	Fresh shale.	5	Cut into 2 samples yes	2 5" samples	1.10		2.10	944	914	571	4.505	6,200	Wiedeman Baldwin	WET	Dry	Dry	Shale Bedding gave up first	1,380			2.53	3.20
1999C-103B	Colusa Reservoir	Owens	HOLC-1	115.1	116.2	Ms	Fresh shale.	5	Cut into 2 samples yes	2 5" samples	1.10		2.10	954	939	591	4.513	54,100	Wiedeman Baldwin	DRY	Dry	Dry	Good Test	11,990			2.63	1.60
1999C-104	Colusa Reservoir	Owens	HORA-1	13.5	14.3	Ss	Sandstone.	4	5" good sample		0.80		2.10	892	848	525	4.505	14,750	Wiedeman Baldwin	WET		Wet	Good Test	3,270			2.43	5.20
1999C-105	Colusa Reservoir	Owens	HORA-1	33.4	33.8	Ss	Fossiliferous Sandstone.	4	Can't secure test sample	4"	0.40											Dry						
1999C-106	Colusa Reservoir	Owens	HORA-1	34.3	35	Ss	Fossiliferous sandstone. Thinly bedded (approx. 50o).	4	5" fair to good sample	6.5"	0.70		2.10				4.453	7,600	Wiedeman Baldwin	DRY		Dry		1,710				
1999C-107	Colusa Reservoir	Owens	HORA-1	69.1	69.6	Ss/Ms	Soft-sediment features	5	5" good sample	5.5"	0.50		2.10	908	859	537	4.490	40,650	Wiedeman Baldwin	DRY		Dry	Good Test	9,050			2.45	5.70
1999C-108	Colusa Reservoir	Owens	HORC-1	37.3	38.1	Ms	45o perp-bed. Weathered shale	4		6"	0.80											Wet						
1999C-109	Colusa Reservoir	Owens	HORC-1	38.1	39.1	Ms	45o perp-bed. Weathered shale	4	4.5" not too good	8.9"	1.00		1.90				4.490	39,700	Wiedeman Baldwin	DRY		Dry	?	8,840				

Bryte Code	Project	Site	Drill Hole	Start Depth	End Depth	Rock Type (MS = mudstone SS = sandstone)	Rock Description	Condition 1 = decomposed 2 = extremely weathered 3 = moderately weathered 4 = slightly	Sample Comments	Sample Comments 2	Sample Length	Sample Diameter	Sample LD Ratio	Sample Air Weight	Sample Dry Weight	Sample Weight	Sample Area	Load	Load Test Type	Moisture	C-3148	C-2938	Test Comments	Compressive	Compressive Corrected	Tensile	SPG	Absorption
1999C-110	Sites Reservoir	Sites	LC-2	51.3	52	Ss	45o per-bed. Representative of sandstone.	5	4.7" good sample	7.8"	0.70		2.00	928	926	589	4.393	78,700	Tinius Olsen	WET		Wet	Good Test	17,910			2.74	0.20
1999C-111	Colusa Reservoir	Owens	HOLC-1	53.5	54.5	Ss	45o per-bed. Representative of sandstone.	5	5" good sample	8.5"	1.00		2.10	895	856	527	4.501	73,400	Tinius Olsen	DRY	Dry/Wet		Good Test	16,310			2.43	4.70
1999C-112	Colusa Reservoir	Owens	HOLC-2	61.2	62	Ss	45o per-bed. Representative of sandstone.	5	5" good sample	7.5"	0.80		2.10	936	921	569	4.494	80,300	Tinius Olsen	DRY		Dry	Good Test	17,870			2.55	1.60

APPENDIX G

VENADO SANDSTONE
PETROGRAPHIC AND QUALITY TEST RESULTS
USACE SAMPLES

U. S. ARMY ENGINEER DIVISION LABORATORY
SOUTH PACIFIC
CORPS OF ENGINEERS
SAUSALITO, CALIFORNIA

PETROGRAPHIC REPORT
OLD SITES QUARRY
SACRAMENTO RIVER PROJECT

March 1962

1. Sample. A sample of quarry rock, consisting of cobble size particles weighing approximately one hundred pounds was received from the Sacramento District on 8 February 1962, for petrographic analysis, specific gravity and absorption, abrasion, wetting and drying, soundness and x-ray diffraction analysis. The sample represents rock material being considered for possible use as riprap for slope protection on Sacramento River Projects.

2. Summary. Petrographic analysis, x-ray diffraction, wetting and drying test, specific gravity, soundness and abrasion have been completed on the Old Sites Quarry rock sample. The rock sample is considered to be a relatively soft dark grayish-green arkosic graywacke. The component minerals are quartz, feldspar, biotite, chlorite and beidellite, a clay mineral which is the cementing agent. The wetting and drying test caused a noticeable loosening of surface grains but did not result in a complete disintegration of the rock. The Los Angeles rattler abrasion test on the laboratory crushed rock showed a loss of 45%, indicating a relatively soft rock. Preliminary results of magnesium sulphate soundness tests on the laboratory crushed quarry rock show high loss in the coarse and fine sieve sizes.

DETAILED PETROGRAPHY

1. Test Procedure. Selected specimens of the sample were prepared into thin sections for petrographic examination. Other selected specimens were sawed and used for the wetting and drying test, in fresh and salt water. Material for x-ray diffraction was prepared by grinding whole rock and passed through the No. 325 sieve. X-ray diffraction patterns were made on whole rock powder and on fine material of the whole rock powder suspended in distilled water to eliminate minerals other than clay types. Specific gravity and absorption determinations were made on selected specimens weighing approximately one kilogram each. The test for abrasion was run according to standard test method CRD-141-56 on crushed material. The sulphate soundness test was run according to standard test method CRD-155-55.

2. Composition.

a. Megascopic Characteristics. The rock has a dark grayish-green color, and has a fine to medium grained structure. Occasional dark rounded spots approximately one centimeter in diameter occur scattered throughout the rock mass. These spots appear to be composed of dark yellowish-green micaceous minerals. A few lens shaped fractures appear filled with a soft clay type mineral. These lenses were found in several specimens of the sample. The rock material is easily scratched with a steel needle. A slight friability of the rock is noticeable when fresh surfaces are rubbed with the fingers.

b. Microscopic Characteristics. In thin sections the rock is composed of angular to subangular grains of quartz, plagioclase feldspar, crumpled and weathered biotite, green chlorite and a yellowish-green clay mineral. The quartz grains appear clear, with a few showing microfractures. The feldspar grains show some cloudiness and have extinction angles of albite, oligoclase and andesine. The biotite grains show distortion from curved to shredded. Green chlorite is present, closely associated with the biotite especially where the biotite is shredded and streaked around quartz and feldspar grains. The cementing agent is an argillaceous and chloritic mixture and is seen as dark isotrophic material around the quartz and feldspar grains. A rough estimate of the percentage of the component minerals made with the microscope shows approximately 60% quartz, 39% feldspar and 1% of biotite, chlorite and clay. The clay mineral has been shown to be beidellite by x-ray diffraction. The rock is considered to be arkosic graywacke.

3. Results of X-ray Diffraction Analysis. X-ray diffraction patterns show prominent reflections of beidellite, quartz, plagioclase, trace quantitise of orthoclase, chlorites and biotite. Diffraction patterns on glycerine saturated samples showed no swelling type clay minerals.

U. S. ARMY ENGINEER DIVISION LABORATORY
SOUTH PACIFIC
CORPS OF ENGINEERS
SAUSALITO, CALIFORNIA

TABLE 1

RESULTS OF PHYSICAL TESTS

Wetting and Drying Test. After 15 cycles of wetting and drying in both salt and fresh water a noticeable softening and loosening of surface grains is evident.

Specific Gravity and Absorption.

Bulk Specific Gravity	2.36
Bulk Specific Gravity S.S.D.	2.44
Apparent Specific Gravity	2.57
Water Absorption, %	3.4

Abrasion Test CRD-141-56. The result of the abrasion test showed a loss of 45% on the laboratory crushed quarry rock.

Sulphate Soundness Test CRD-115-55. Preliminary results indicate a relatively high loss in coarse and fine sieve sizes.

PETROGRAPHIC REPORT

SITES QUARRY
UNIT 22
SACRAMENTO RIVER PROJECT
COLUSA AND SUTTER COUNTIES, CALIFORNIA
Contract No. DACW05-72-C-0057

April 1972

AUTHORIZATION

1. Results of tests reported herein were requested by DA Form 2544, Work Order VRO-72-3 (72-C-0057-1), 15 March 1972, from the Sacramento District.

PURPOSE

2. Purpose of this study was to determine the quality of the material purposed for use as protection stone on both banks of the Sacramento River at various locations between mile 110.8 and 143.8 in Colusa and Sutter Counties.

SAMPLE

3. A shipment of approximately 200 pounds of rock was received on 15 March 1972. The sample was from Sites Quarry located approximately 1 mile east of Sites, California.

TESTS

4. Tests were performed as follows:

a. Petrographic analysis (including x-ray diffraction) CRD-C 127

b. Abrasion (L.A. Rattler) gradation 1, CRD-C 145

c. Specific gravity and absorption, CRD-C 107

d. Magnesium sulfate soundness test, CRD-C 137

e. Simple wetting and drying test run as follows: Chunks and one-inch thick slabs were subjected to 15 cycles of wetting and drying, one series in fresh water, the other in salt water. Each cycle consisted of soaking the sample overnight at room temperature and then drying it in an oven for eight hours at 140°F. Samples were weighed and photographed before and after the test. Salt water was prepared under ASTM Specification D1141-52, Substitute Ocean Water.

PETROGRAPHY

5. Summary. The sample was an argillaceous, arkosic graywacke. It was primarily composed of angular to subangular grains of feldspar, quartz and different rock types in a chlorite-clay matrix. The clay was expansive montmorillonite. The sample was relatively soft and broke easily when struck with a hammer. Average apparent specific gravity was 2.54 with an absorption of 2.2 percent. Loss due to abrasion was 27 percent. The loss in the magnesium sulfate soundness test was an extremely high 39 percent with all 50 particles flaking due to the breakdown of their matrix. During the wetting and drying test, one of the specimens broke in 3 large and numerous small pieces. The other specimens showed only minor flaking.

6. Megascopic Characteristics. The rock was tannish-greenish-gray and slightly weathered. It was generally fine grained with some larger shale fragments up to 0.5 centimeters in length. The rock was relatively soft and could be scratched with the hardness tester. All particles had a clay coating on at least one side and many particles had open and clay filled fractures.

7. Microscopic Characteristics. The rock contained grains of quartz, feldspar, biotite and chlorite and fragments of rocks in a fine-grained matrix. The feldspar occurred as oligoclase and orthoclase and was generally cloudy and partially altered to sericite. Biotite grains were generally stretched with some bent around other grains. This could have been caused by low grade metamorphism. The rock fragments were principally chert with some shale, metavolcanic and claystone. Some of the metavolcanic rock fragments contained secondary epidote. The matrix was composed of clay, chlorite and sericite and comprised from 5 to 20 percent of the sample. The sample was an argillaceous, arkosic graywacke.

8. Composition by X-Ray Diffraction. Minerals identified were quartz, feldspar, biotite, chlorite and montmorillonite type clay.

RESULTS OF PHYSICAL TESTS

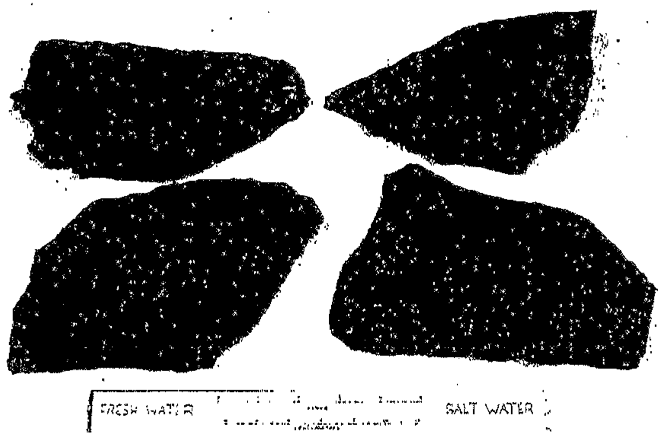
9. Specific Gravity

	Sample Number			
	1	2	3	4
a. Bulk Specific Gravity	2.41	2.41	2.40	2.40
b. Bulk SSD Specific Gravity	2.47	2.46	2.45	2.45
c. Apparent Specific Gravity	2.55	2.54	2.52	2.54
d. Absorption, percent	2.3	2.1	1.9	2.4

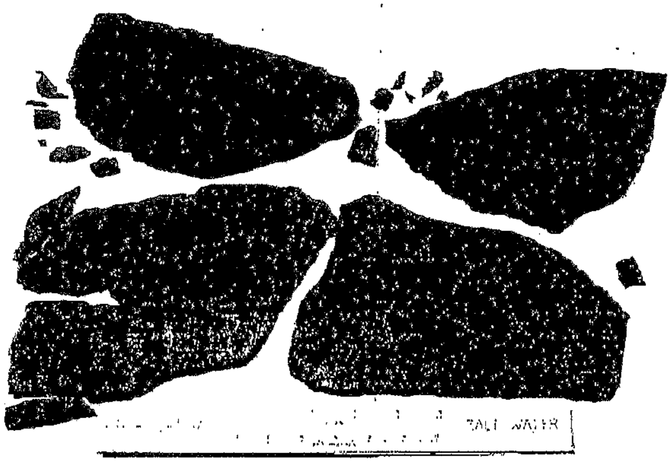
10. Los Angeles Abrasion (Gradation 1)
Loss, percent 27

11. Magnesium Sulfate Soundness
Loss, percent 39

12. _Simple Wetting and Drying Test_. The freshwater slab broke into 3 large fragments during the fifth to seventh cycles, additional flaking occurred for the duration of the test. The other specimens showed only minor flaking during the test. Before and after photographs of the test specimen follow.



Before Test



After Test

Sites Quarry
Unit 22
Sacramento River Project

WETTING AND DRYING TEST

FIGURE 1

PETROGRAPHIC REPORT

SITES QUARRY
UNIT 22
SACRAMENTO RIVER PROJECT
COLUSA AND SUTTER COUNTIES, CALIFORNIA
Contract No. DACW05-72-C-0057

July 1972

AUTHORIZATION

1. Results of tests reported herein were requested by DA Form 2544, Work Order RO-72-4 (72-C-0057-2), 6 June 1972 and Change 1, 14 June 1972, from the Sacramento District.

PURPOSE

2. Purpose of this study was to determine the quality of the material purposed for use as protection stone on both banks of the Sacramento River at various locations between mile 110.8 and 143.8 in Colusa and Sutter Counties.

SAMPLE

3. A shipment of approximately 500 pounds of rock was received on 7 June 1972. The sample was from Sites Quarry located approximately 1 mile east of Sites, California. It was divided into three catagories: "Blue", "Better of The Brown" and "Poorer of The Brown".

TESTS

4. Tests were performed as follows:

a. Petrographic analysis (including x-ray diffraction) CRD-C 127

b. Abrasion (L.A. Rattler) gradation 1, CRD-C 145

c. Specific gravity and absorption, CRD-C 107

d. Magnesium sulfate soundness test, CRD-C 137

e. Simple wetting and drying test run as follows: Chunks and one-inch thick slabs were subjected to [illegible] cycles of wetting and drying, one series in fresh water, the other in salt water. Each cycle consisted of soaking the sample overnight at room temperature and then drying it in an oven for eight hours at 14[illegible]°F. Samples were weighed and photographed before and after the test. Salt water was prepared under ASTM Specification D1141-52, Substitute Ocean Water.

PETROGRAPHY

5. Summary. The sample was divided into three catagories based on the degree of weathering. The "blue" rock was fresh, the "Better of The Brown" was moderately weathered and the "Poorer of The Brown" was deeply weathered. The poorer material fell apart while soaking for the determination of absorption and specific gravity so no further testing was done to this material. The rock in all three catagories was an argillaceous arkosic graywacke composed of angular to subangular grains of quartz, mica, feldspar and rock fragments in a chlorite-clay matrix. Expansive montmorillonite was the principal clay mineral present. The fresh material was generally sound. Some particles had joints, most of which were tight and a few contained minor quantities of secondary calcite. The weathered material was relatively soft and broke easily when struck with a hammer. Average apparent specific gravity was; for the "Blue" material 2.59, for "Better of The Brown" 2.60, and for the "Poorer of The Brown" 2.64. Respective absorptions were; 3.4 percent, 4.4 percent and 6.5 percent. Losses due to abrasion were 26 percent for the "Blue" and 39 percent for the "Better of The Brown". The magnesium sulfate soundness test is still in progress but the loss in the "Blue" material appears to be relatively low while the "Better of The Brown" material already has a comparitively high loss. During the wetting and drying test the fresh material flaked slightly with both slabs parting along joints in the twelfth cycle. The moderately weathered material flaked throughout the test.

6. Megascopic Characteristics. The fresh material was greenish-blue and the moderately weathered material was from greenish-redish-yellow to redish yellow. Both types were fine grained except for medium sized mica grains and shale fragments. All types could be scratched by the harness tester. Most particles had a clay coating.

7. Microscopic Characteristics. Both types were composed of grains of quartz, mica, feldspar and chlorite and rock fragments in a fine grained matrix. Feldspar was present as both the plagioclase and potassium varities. Biotite was the principal mica. In the weathered portion of the sample most of the feldspar has been partially altered to sericite and the iron has been leached out of most of the biotite. The iron was deposited into the surrounding matrix in the form of iron oxide, this was the reason the weathered material had a redish color. Rock fragments were predominately chert and shale with some metavolcanic rock and claystone also present. The matrix was composed of montmorillonite type clay, chlorite and sericite. It comprises from 5 to 30 percent of the individual particles with the weathered material generally containing a higher percentage of matrix than the fresh. The sample was an argillaceous, arkosic graywacke.

8. <u>Composition by X-Ray Diffraction</u>. Minerals identified were quartz, feldspar, biotite, chlorite and montmorillonite type clay.

RESULTS OF PHYSICAL TESTS

9. **Specific Gravity**

Rock Type	Bulk Specific Gravity	Bulk SSD Specific Gravity	Apparent Specific Gravity	Absorption, Percent
"Poorer (1)	2.28	2.42	2.64	6.1
of The (2)	2.21	2.37	2.62	7.0
Brown" (3)	2.27	2.41	2.65	6.3
"Better (1)	2.33	2.44	2.62	4.8
of The (2)	2.33	2.44	2.63	4.8
Brown" (3)	2.32	2.41	2.56	4.1
"Blue" (1)	2.33	2.43	2.58	4.1
(2)	2.42	2.50	2.62	2.9
(3)	2.38	2.45	2.56	3.1

10. <u>Los Angeles Abrasion (Gradation 1), percent loss</u>

a. "Better of The Brown" - 39
b. "Blue" - 26

11. <u>Simple Wetting and Drying Test</u>. Both the fresh water and salt water slab test specimens of the "Blue" rock parted along joints during the twelfth cycle. Minor flaking occurred to all "Blue" specimens throughout the test. The "Better of The Brown" specimens flaked during the entire test. Before and after photographs of all test specimens follow.

Table 1.--Test Data, Rock from Old Sites Quarry

Tests	Sample #1 [a] (Weathered sandstone)	Sample #2 [a] (Fresh sandstone) [c]	Sample #3 [b] (Fresh sandstone) [c]
Specific Gravity (S.S.D.)	2.44	2.58	2.504%
Absorption	3.4%	3.3%	3.5%
Abrasion (L.A. Rattler)	45% loss	39.1%	34.1% loss
Soundness ($Mg\ SO_4$)	"Relatively high loss"	92.5%	15% loss
Wetting and Drying	"after 15 cycles in fresh & salt water a noticeable softening and loosening of surface grains is evident"	"Slight surface sloughing"	Not Reported

---

[a] Test by U.S.C.E. laboratory, Sausalito, California.

[b] Test by Hales Testing Laboratory, Sacramento, California

[c] Probably lightly weathered rock in U.S.B.R. classification.

IMPORTANT NOTICE

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FIGURE 2

EL-251 (6-71)
Bureau of Reclamation

CONCRETE AND STRUCTURAL BRANCH
DIVISION OF GENERAL RESEARCH
ENGINEERING AND RESEARCH CENTER
DENVER, COLORADO 80225

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SHEET NO. 2 OF 3

BRANCH FILE NO. C- 1127 I
COMPILED BY
CHECKED BY
REVIEWED BY
SUBMITTED BY

DATE Dec. 1974

~~XXXXXXXXX~~ RIPRAP QUALITY EVALUATION

STATE California	REG. MP	SOURCE NO.	LAT. 39° N
SAMPLE NO. M-6547*	MATERIAL Quarry rock		LONG. 122° W
DEPOSIT NAME Sites Quarry South			DATE REC'D. 5-2-74
OWNERSHIP Welch Properties			OVERBURDEN Not furnished
LOCATION East slope of Logan Ridge (right bank of Stone Corral Creek) NE 1/4 SEC. 29	T 17 N	R 4 W	VOLUME 1,000,000 yd³
FEATURE Tehama-Colusa Canal, reach 5			MERIDIAN Mount Diablo
PROJECT Central Valley			
REMARKS *Sample from lower layer in quarry. Source previously tested (Sample No. M-6399, Report No. C-1127 F).			DATE LTR. TRANS. Undated

GRADING (DES. 4,5,6) CUM. % RETAINED

SIEVE	PIT RUN	3"-1½"	1½"-¾"	¾"-#4	FINE AGG.	WASHED FINE AGG.
6 IN.						
3½ IN.	Rock crushed in Denver					
3 IN	laboratory					
2½ IN						
1¾ IN.						
1½ IN						
1¼ IN						
⅞ IN						
¾ IN						
⅝ IN.						
⅜ IN.						
5/16 IN.						
NO. 4						
NO. 5						
NO. 8						
NO 16						
NO 30						
NO 50						
NO. 100						
PAN						
F.M						
% SAND						

TEST RESULTS

	6"-3"	3"-1½"	1½"-¾"	¾"-⅜"	⅜"-#4	FINE AGG.	WASHED FINE AGG.
SP. GR., S.S.D. (DES. 9,10)			2.47	2.47	2.45		
ABSORPTION, % (DES. 9,10)			4.4	5.1	6.4		
ORGANIC IMPURITIES, (DES. 14)	——	——	——	——	——		
PERCENT SILT (DES. 16)							
% LIGHTER - SP. GR. (DES. 17,18,42)							
CLAY LUMPS, % (DES. 13)							
SAND EQUIVALENT	——	——	——	——	——		
NA₂SO₄ LOSS, 5 CYC. WGT'D. % LOSS (DES. 19)			28.3			——	

L.A. ABRASION (DES. 21) GRADING	"A"	"B"	"C"	"D"
% LOSS, 100 REV.	18.9			
% LOSS, 500 REV.	52.6			

FREEZING AND THAWING DATA

CONCRETE							1/ RIRRAP	
W/C RATIO	SLUMP INCHES	% AIR METER	H₂O LBS./YD³	28-DAY STRENGTH 3"x 6" CYL'S	WEIGHT LOSS, %	CYCLES	WEIGHT LOSS, % 3 INCH CUBE	CYCLES
							1.3	250

ALKALI - AGGREGATE REACTIVITY DATA

MATERIALS	SAND				GRAVEL			
CEMENT NO.								
SODA EQUIVALENT								
TEST AGG. %	100	100	50	25	100	100	50	25
EXP % - 6 MO.								
EXP % - 12 MO.								

PETROGRAPHIC DESCRIPTION: MEMORANDUM NO. 74-22 DATE: 9-19-74 BY: L. D. Klein,
C. A. Bechtold

The examined arkosic sandstone consists of angular rock fragments that appear fresh and contain some tight, well-healed fractures. The rocks are fine-grained, homogeneous, moderately to highly porous and absorptive, somewhat friable, and are composed of mostly angular and subangular to rounded grains of quartz, chert, plagioclase and orthoclase feldspar, biotite, muscovite, magnetite, hornblende, calcite, iron oxide, clay, and a few scattered rock fragments. The fragment size appears to be generally controlled by jointing.

Conclusions: Rock comparable to Sample No. M-6547 is of poor quality for use as riprap.

1/ Average for two cubes.

IMPORTANT NOTICE

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FIGURE 3

SHEET NO. 3 OF 3

EL-851 (8-71)
Bureau of Reclamation

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

CONCRETE AND STRUCTURAL BRANCH
DIVISION OF GENERAL RESEARCH
ENGINEERING AND RESEARCH CENTER
DENVER, COLORADO 80225
DATE Dec 1974

~~XXXXXXXXX~~
RIPRAP
QUALITY EVALUATION

BRANCH FILE NO. C- 1127 I
COMPILED BY
CHECKED BY
REVIEWED BY
SUBMITTED BY

STATE California	REG. MP	SOURCE NO.	LAT. 39° N		LONG. 122° W
SAMPLE NO. M-6548	MATERIAL Quarry rock				DATE REC'D. 5-2-74
DEPOSIT NAME Sites Quarry North				OVERBURDEN Not furnished	
OWNERSHIP Henry Kron				VOLUME Plus 1,000,000 yd^3	
LOCATION East slope of Logan Ridge (left bank of Stone Corral Creek)					
SW 1/4 SEC. 21	T 17 N	R 4 W		MERIDIAN Mount Diablo	
FEATURE Tehama-Colusa Canal, reach 5					
PROJECT Central Valley					
REMARKS					
				DATE LTR. TRANS. Undated	

GRADING (DES. 4,5,6) CUM. % RETAINED						
SIEVE	PIT RUN	3"-1½"	1½"-¾"	¾"-#4	FINE AGG.	WASHED FINE AGG.
6 IN.						
3½ IN.	Rock crushed in Denver					
3 IN.	laboratory.					
2½ IN						
1¾ IN						
1½ IN						
1¼ IN.						
⅞ IN.						
¾ IN.						
⅝ IN.						
⅜ IN.						
5/16 IN.						
NO. 4						
NO. 5						
NO. 8						
NO 16						
NO 30						
NO 50						
NO 100						
PAN						
F.M		——				
% SAND		——				

TEST RESULTS	6"-3"	3"-1½"	1½"-¾"	¾"-⅜"	⅜"-#4	FINE AGG.	WASHED FINE AGG
SP. GR., S.S.D. (DES. 9,10)			2.48	2.47	2.46		
ABSORPTION, % (DES. 9,10)			4.4	5.1	6.5		
ORGANIC IMPURITIES, (DES. 14)	——	——	——	——	——		
PERCENT SILT (DES. 16)							
% LIGHTER - SP. GR. (DES. 17,18,42)							
CLAY LUMPS, % (DES. 13)							
SAND EQUIVALENT	——	——	——	——	——		
NA$_2$SO$_4$ LOSS, 5 CYC. WGT'D. % LOSS (DES. 19)			25.7			——	

L.A. ABRASION (DES. 21) GRADING	"A"	"B"	"C"	"D"
% LOSS, 100 REV.	12.8			
%. LOSS, 500 REV.	50.2			

FREEZING AND THAWING DATA

CONCRETE							1/ RIRRAP	
W/C RATIO	SLUMP INCHES	% AIR METER	H$_2$O LBS./YD.^{3}	28-DAY STRENGTH 3"x 6" CYL'S	WEIGHT LOSS, %	CYCLES	WEIGHT LOSS, % 3 INCH CUBE	CYCLES
							2.2	250

ALKALI - AGGREGATE REACTIVITY DATA

MATERIALS	SAND				GRAVEL			
CEMENT NO.								
SODA EQUIVALENT								
TEST AGG. %	100	100	50	25	100	100	50	25
EXP % - 6 MO.								
EXP % - 12 MO.								

PETROGRAPHIC DESCRIPTION: MEMORANDUM NO. 74-22 DATE: 9-19-74 BY: L. D. Klein,
C. A. Bechtold

The examined arkosic sandstone consists of angular and slabby rock fragments that appear fresh and contain some tight, well-healed fractures. The rocks are fine-grained, homogeneous, moderately to highly porous and absorptive, somewhat friable and are composed of mostly angular and subangular to rounded grains of quartz, chert, plagioclase and orthoclase feldspar, biotite, muscovite, magnetite, hornblende, calcite, iron oxide, clay, and a few scattered rock fragments. The fragment size appears to be genarally controlled by jointing.

Conclusions: Rock comparable to Sample No. M-6548 is of poor quality for use as riprap.

1/ Average for two cubes.

SITES QUARRY (Cron)

Lessee: James L. Ferry & Son
Sacramento, California

Location: One mile east of Sites, California, Colusa County, T 17 N, R 4 W, Sec 20 and 21, Sites 7.5' Quad.

Rock Type: Sandstone (Graywacke)

Laboratory Reports: SPD Lab, March 1962 and June 1962
Hales Testing Lab, Sacramento, February 1962

Summary of Test Results:	Mar 62	Feb 62	Jun 62
Specific Gravity	2.44	2.50	2.46
LA Abrasion Test Loss	45%	34.5%	"A" 39.1%
Magnesium Sulfate Test Loss	Rel. high	15.0%	92.5%
Wetting and Drying Test Fresh Water Salt Water	Loosening of surface grains		Slight surface sloughing
Absorption	3.4%	3.5%	3.3%

Use: Rejected

Geology: The rock is a grayish-green graywacke sandstone, fine to medium-grained in texture. The rock has been used for many years in construction of buildings in San Francisco, such as the Ferry Building and the U.S. Post Office. It has also been used in Colusa and Glenn Counties for construction of various drainage structures. Results of the petrographic examination are given in the SPD Lab reports.

(R 7/86)

SITES (WELCH)

LESSEE: Teichert Construction Company
8811 Kiefer Boulevard
Sacramento, California
NO EQUIPMENT OR SIGNS OF OPERATION FOR SOME TIME.

LOCATION: One mile east of Sites, California, Colusa County, T17N, R4W, Sections 28 & 29, Sites 7.5' Quadrangle.
LAT 122° 19' LONG 39° 18'

Rock Type: Sandstone (Graywache)

Laboratory Reports: SPD Lab, April 1972 & July 1972

Summary of Test Results:	April 1972	July 1972 Blue Rock
Specific Gravity (Bulk SSD)	2.45-2.47	2.43-2.50
L.A. Abrasion Test Loss	"1" 27%	"1" 26%
Magnesium Sulfate Test Loss	39%	
Wetting & Drying Test		
Fresh Water	Fractured 5th Cycle	Fractured 12th Cycle
Salt Water	Minor Flaking	" " "
Absorption	1.9-2.4%	2.9-4.1%
Petrographic Analysis		Chlorite and Montmorillonite present

USE: Levee protection Upper Sacramento River. Rejected for contracts awarded after 1 October 1972.

GEOLOGY: In October 1972, a quarry face about 75 feet high and 200 feet long was exposed. It is a bedding plane face that slopes to the east at about 45 degrees. The top half of the face is weathered and discolored tan to brown sandstone which is unsuitable for riprap. The bottom half is fresh bluish gray sandstone. Layers of shale are interbedded with the sandstone. The shale is fissile, soft, and unsuitable for use as riprap. Results of the petrographic examination are given in the SPD Lab reports.

APPENDIX H

VENADO SANDSTONE
PHYSICAL PROPERTIES AND ROCK STRENGTH
(DWR SAMPLES)

2.5-Inch Diameter Drill Cores from Geologic Exploration

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

												ASTM D-2938		ASTM C-97	
LAB NO.	SITE	HOLE NO.	F. S. NO.	DEPTH (feet)	ROCK TYPE	NOTES	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	REMARKS	SPG (ssd)	% ABS
99C-110	Sites	LC-2		51.3-52.0	Ss	Fresh, 45° per-bed, representative of sandstone	4.733	2.365	2.0	78,700	Wet	17,910	Good Test	2.74	0.2
99C-91	GG	RA-1		51.0-52.3	Ss	Fresh	5.010	2.392	2.1	58,800	Dry	13,080	Good Test	2.47	3.7
99C-92	GG	RA-1	A	53.4-54.2	Ss	Fresh	4.521	2.392	1.9	32,500	Wet	7,230	Good Test	2.50	3.5
			B				5.009	2.392	2.1	59,000	Dry	13,120	Good Test	2.50	3.4
99C-88	GG	LC-1		35.6-36.3	Ss	Slightly weathered, representative of pitting	5.018	2.390	2.1	75,600	Dry	16,850	Good Test	2.66	1.5
99C-84	GG	LA-1	A	27.8-28.4	Ss	Slightly weathered	4.010	2.377	1.7	21,200	Wet	4,620	Good Test	2.52	3.7
			B				4.510	2.380	1.9	50,150	Dry	11,270	Good Test	2.50	3.8
99C-90	GG	RA-1		16.2-17.2	Ss	Moderately weathered	5.013	2.385	2.1	32,550	Dry	7,290	Good Test	2.41	5.4
99C-89	GG	LC-1		199.5-200.3	Ms	Fresh	5.038	2.390	2.1	24,200	Dry	5,390	Good Test		
99C-87	GG	LC-1		23.2-23.8	Ms	Moderately weathered	4.555	2.385	1.9	5,250	Dry	1,180	Good Test		

DATE:
INITIAL: RGJ/TEC
REQUEST NO.: 99-19

REMARKS: Rock Types - Ms=Mudstone, Ss=Sandstone, I = Interbedded Mudstone/Siltstone

SUMMARY SHEET

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CIVIL ENGINEERING
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PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F.S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-28	GGC-LA1	A	75.8-77.3	Ss	4.884	2.392	2.04							2.56	2.9
		B		Ss	4.883	2.393	2.04	25650	WET	5703				2.56	2.9
		C		Ss	4.861	2.392	2.03	45500	DRY	10125				2.57	2.8
2001-29	GGC-LA1		163.3-164.4	Ms	1.866	2.387	0.78							2.51^A	4.6
2001-30	GGC-RC1	A	56.0-57.0	Ss	5.007	2.487	2.01	22800	WET	4693				2.49	2.9
		B		Ss	5.020	2.488	2.02	47600	DRY	9791				2.50	2.8
2001-31	GGC-RC1	A	146.7-147.7	Ms	5.047	2.492	2.03							2.56^A	3.6
		B		Ms	1.556	2.493	0.62								
2001-32	GGC-RC2	A	140.1-141.3	Ms	4.919	2.488	1.98	19350	DRY	3980				2.53^A	4.6
		B		Ms	4.990	2.487	2.01								
		C		Ms	3.535	2.487	1.42								
2001-33	GGC-RC2	A	70.8-71.9	Ss	5.024	2.494	2.01							2.53	2.8
		B		Ss	5.027	2.493	2.02							2.52	3.1
		C		Ss	1.545	2.493	0.62							2.55	3.0

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SUMMARY SHEET

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DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR **FEATURE:** 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F. S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-34	GGC-RA1	A	59.9-61.0	Ss	1.495	2.394	0.62							2.53	2.6
		B		Ss	5.019	2.394	2.10	21650	WET	4810				2.55	2.6
		C		Ss	5.019	2.394	2.10	45000	DRY	9997				2.56	2.6
		D		Ss	1.398	2.394	0.58							2.56	2.8
2001-35	GGC-RA1	A	146.3-147.5	Ms	4.996	2.390	2.09	9800	DRY	2184				2.52^A	3.9
2001-36	GO-DHS-3	A	45.0-46.0	Ss	5.024	2.491	2.02							2.48	2.3
		B		Ss	5.018	2.491	2.01							2.48	2.2
2001-37	SSD3-4		140.1-140.0	Ms										2.40^A	8.4
2001-38	SSD5-3	A	97.1-99.0	*	1.480	2.478	0.60								
		B		*	3.588	2.480	1.45								
		C		*	1.258	2.488	0.51							2.28	8.3
		D		Ss	1.505	2.488	0.60							2.39	6.7
2001-39	SSD8-5		63.0-64.0	Ms										2.41^A	6.8
2001-40	SSD9-1	A	120.4-121.4	Ms	1.283	2.493	0.51								
		B		Ms	1.347	2.493	0.54								
		C		Ms	4.193	2.493	1.68	26150	DRY	5238					
		D		Ms	1.238	2.493	0.50								

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PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F. S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-41	GO-DHT3	A	71.0-72.2	Ss	1.641	2.491	0.66	3630	WET		1776			2.48	4.2
		B		Ss	5.033	2.490	2.02	25450	WET	5226				2.43	3.3
		C		Ss	1.448	2.490	0.58							2.42	3.3
2001-42	GO-DHT3	A	206.5-207.6	Ms	3.762	2.490	1.51							2.57^A	3.9
		B		Ms	4.980	2.491	2.00							2.57^A	3.9
2001-43	GO-DHT3	A	272.0-273.0	Ss	5.020	2.492	2.01							2.45	3.7
		B		Ss	5.021	2.492	2.01							2.44	3.9
		C		Ss	1.520	2.492	0.61							2.44	3.5
		D		Ss	1.398	2.492	0.56							2.43	3.9
2001-51	GGO-DHS3		45.0-46.0	Ss	(did not receive sample)										
2001-52	GGO-DHS4	B	56.0-57.0	Ss	1.593	2.486	0.64	4910	DRY		2480				
		C			4.593	2.490	1.84	33750	WET	6861				2.66	0.8
2001-53	GGO-DHS4		57.0-57.7	Ms	(can not obtain test specimen- see sketch)										
2001-54	GGO-DHS4		26.5-27.0	Ms	1.523	2.491	0.61								

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FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F.S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-55	GGO-DHT1	A	155.7-156.7	Ms	4.980	2.487	2.00	15400	DRY	3170					
		B		Ms	1.414	2.485	0.57	1140	DRY		649				
2001-56	GGO-DHT1	A	176.0-177.2	Ss	4.860	2.497	1.95	0	WET	0	(mudstone separated-water damaged)			2.58	1.5
		B		Ss	4.518	2.502	1.81	59700	DRY	11988				2.66	0.5
2001-57	GGO-DHT3	A	316.3-317.7	Ss	1.345	2.491	0.54							2.33	4.4
		B		Ss	4.999	2.491	2.01							2.42	3.4
		C		Ss	4.993	2.491	2.00							2.43	3.4
		D		Ss	1.499	2.492	0.60	2740	WET		1467			2.44	3.6
		E		Ss	1.499	2.493	0.60	5220	DRY		2795			2.46	3.7
2001-58	GGO-DHT3	A	327.7-329.0	Ss	5.081	2.493	2.04	22200	WET	4548				2.49	2.0
		B		Ss	4.948	2.490	1.99	22400	DRY	4600					
2001-59	GGO-DHT4	A	115.5-116.7	Ms	1.552	2.487	0.62	1780	DRY		922				
		B		Ms	1.521	2.487	0.61								
		C		Ms	1.551	2.491	0.62								
		D		Ms	5.029	2.489	2.02	13700	DRY	2816					
2001-60	GGO-DHT4	A	124.5-125.5	Ss	5.023	2.491	2.02	45150	DRY	9264				2.50	2.7
		B			5.017	2.492	2.01	37750	WET	7740				2.59	1.5

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SHEET 4 of 5

STATE OF CALIFORNIA
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SUMMARY SHEET

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO.	HOLE NO.	F.S. NO.	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS.
2001-61	GGO-DHT5	A	430.5-432.0	Ss	1.512	2.491	0.61	3200	WET		1700			2.49	3.3
		B			5.028	2.491	2.02	28000	WET	5745				2.53	2.5
		C			5.016	2.491	2.01	42900	DRY	8803				2.54	2.9
		D			5.023	2.491	2.02							2.52	2.1
2001-62	GGO-DHT6	A	535.4-536.4	Ms	4.786	2.495	1.92								
2001-63	GGO-DHT6	A	556.3-557.3	Ms	4.788	2.492	1.92	18900	DRY	3856					
		C			1.555	2.493	0.62	2700	DRY		1393				

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
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Bryte Code	Project	Site	Drill Hole	Start Depth	End Depth	Rock Type (MS = mudstone SS = sandstone)	Rock Description	Condition 1 = decomposed 2 = intensely weathered 3 = moderately weathered 4 = slightly	Sample Comments	Sample Comments 2	Sample Length	Sample Diameter	Sample LD Ratio	Sample Air Weight	Sample Dry Weight	Sample Weight	Sample Area	Load	Load Test Type	Moisture	C-3148	C-2938	Test Comments	Compressive	Compressive Corrected	Tensile	SPG	Absorption
2001-28A	Sites Reservoir	Golden Gate Curved	GGC-LA1	75.8	77.3	Ss		5			4.88	2.39	2.04														2.56	2.93
2001-28B	Sites Reservoir	Golden Gate Curved	GGC-LA1	75.8	77.3	Ss		5			4.88	2.39	2.04					25,650		WET				5,703			2.56	2.92
2001-28C	Sites Reservoir	Golden Gate Curved	GGC-LA1	75.8	77.3	Ss		5			4.86	2.39	2.03					45,500		DRY				10.125			2.57	2.82
2001-29A	Sites Reservoir	Golden Gate Curved	GGC-LA1	163.3	164.4	Ms		5	Broken and/or end pieces used for SPG and absorption		1.87	2.39	0.78														2.51	4.63
2001-30A	Sites Reservoir	Golden Gate Curved	GGC-RC1	56	57	Ss		5			5.01	2.49	2.01					22,800		WET				4,693			2.49	2.91
2001-30B	Sites Reservoir	Golden Gate Curved	GGC-RC1	56	57	Ss		5			5.02	2.49	2.02					47,600		DRY				9,791			2.50	2.79
2001-31A	Sites Reservoir	Golden Gate Curved	GGC-RC1	146.7	147.7	Ms		5	Broken and/or end pieces used for SPG and absorption		5.05	2.49	2.03														2.56	3.56
2001-31B	Sites Reservoir	Golden Gate Curved	GGC-RC1	146.7	147.7	Ms		5			1.56	2.49	0.62															
2001-32A	Sites Reservoir	Golden Gate Curved	GGC-RC2	140.1	141.3	Ms		5	Broken and/or end pieces used for SPG and absorption		4.92	2.49	1.98					19,350		DRY				3,980			2.53	4.63
2001-32B	Sites Reservoir	Golden Gate Curved	GGC-RC2	140.1	141.3	Ms		5			4.99	2.49	2.01															
2001-32C	Sites Reservoir	Golden Gate Curved	GGC-RC2	140.1	141.3	Ms		5			3.54	2.49	1.42															
2001-33A	Sites Reservoir	Golden Gate Curved	GGC-RC2	70.8	71.9	Ss		5			5.02	2.49	2.01														2.53	2.75
2001-33B	Sites Reservoir	Golden Gate Curved	GGC-RC2	70.8	71.9	Ss		5			5.03	2.49	2.02														2.52	3.08
2001-33C	Sites Reservoir	Golden Gate Curved	GGC-RC2	70.8	71.9	Ss		5			1.55	2.49	0.62														2.55	3.00
2001-34A	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			1.50	2.39	0.62														2.53	2.58
2001-34B	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			5.02	2.39	2.10					21,650		WET				4,810			2.55	2.62
2001-34C	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			5.02	2.39	2.10					45,000		DRY				9,997			2.56	2.61
2001-34D	Sites Reservoir	Golden Gate Curved	GGC-RA1	59.9	61	Ss		5			1.40	2.39	0.58														2.56	2.76
2001-35A	Sites Reservoir	Golden Gate Curved	GGC-RA1	146.3	147.5	Ms		5	Broken and/or end pieces used for SPG and absorption		5.00	2.39	2.09					9,800		DRY				2,184			2.52	3.87
2001-36A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHS-3	45	46	Ss		5			5.02	2.49	2.02														2.46	2.28
2001-36B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHS-3	45	46	Ss		5			5.02	2.49	2.01														2.48	2.18
2001-37A	Sites Reservoir	Northern Saddle Dams	SSD3-4	140.1	141	Ms		5	Broken and/or end pieces used for SPG and absorption																		2.40	6.39
2001-38A	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			1.48	2.48	0.60															
2001-38B	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			3.59	2.48	1.45															
2001-38C	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			1.26	2.49	0.51														2.28	8.25
2001-38D	Sites Reservoir	Northern Saddle Dams	SSD5-3	97.1	99	Ss		5			1.51	2.49	0.60														2.39	6.69
2001-39A	Sites Reservoir	Northern Saddle Dams	SSD8-5	63	64	Ms		5	Broken and/or end pieces used for SPG and absorption		-																2.41	6.75
2001-40A	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			1.28	2.49	0.51															
2001-40B	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			1.35	2.49	0.54															
2001-40C	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			4.19	2.49	1.68					26,150		DRY				5,238				
2001-40D	Sites Reservoir	Northern Saddle Dams	SSD9-1	120.4	121.4	Ms		5			1.24	2.49	0.50															
2001-41A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	71	72.2	Ss		5			1.64	2.49	0.66					3,630		WET						1,776	2.48	4.23
2001-41B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	71	72.2	Ss		5			5.03	2.49	2.02					25,450		WET				5,226			2.43	3.30
2001-41C	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	71	72.2	Ss		5			1.45	2.49	0.58														2.42	3.33
2001-42A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	206.5	207.6	Ms		5	Broken and/or end pieces used for SPG and absorption		3.76	2.49	1.51														2.57	3.86
2001-42B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	206.5	207.6	Ms		5	Broken and/or end pieces used for SPG and absorption		4.98	2.49	2.00														2.57	3.86
2001-43A	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			5.02	2.49	2.01														2.45	3.72
2001-43B	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			5.02	2.49	2.01														2.44	3.94
2001-43C	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			1.52	2.49	0.61														2.44	3.53
2001-43D	Sites Reservoir	Golden Gate Inlet Outle	GO-DHT3	272	273	Ss		5			1.40	2.49	0.56														2.43	3.85
2001-51A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS3	45	46	Ss		5	(did not receive sample)																			
2001-52B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	56	57	Ss		5			1.59	2.49	0.64					4,910		DRY						2,480		
2001-52C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	56	57	Ss		5			4.59	2.49	1.84					33,750		WET				6,861			2.66	0.76
2001-53A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	57	57	Ms		5	(can not obtain test specimen- see sketch)																			
2001-54A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHS4	26.5	27	Ms		5			1.52	2.49	0.61															
2001-55A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT1	155.7	156.7	Ms		5			4.98	2.49	2.00					15,400		DRY				3,170				
2001-55B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT1	155.7	156.7	Ms		5			1.41	2.49	0.57					1,140		DRY						649		
2001-56A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT1	176	177.2	Ss		5	(mudstone separated-water damaged)		4.86	2.50	1.95					0		WET							2.58	1.47
2001-56B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT1	176	177.2	Ss		5			4.52	2.50	1.81					59,700		DRY				11,988			2.66	0.47
2001-57A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			1.34	2.49	0.54														2.33	4.42
2001-57B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			5.00	2.49	2.01														2.42	3.42
2001-57C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			4.99	2.49	2.00														2.43	3.36
2001-57D	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		5			1.50	2.49	0.60					2,740		WET						1,467	2.44	3.55
2001-57E	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	316.3	317.7	Ss		1			1.50	2.49	0.60					5,220		DRY						2,795	2.46	3.74
2001-58A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	327.7	329	Ss		5			5.08	2.49	2.04					22,200		WET				4,548			2.49	2.03
2001-58B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT3	327.7	329	Ss		5			4.95	2.49	1.99					22,400		DRY				4,600				
2001-59A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	115.5	116.7	Ms		5			1.55	2.49	0.62					1,780		DRY						922		
2001-59B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	115.5	116.7	Ms		5			1.52	2.49	0.61															

Bryte Code	Project	Site	Drill Hole	Start Depth	End Depth	Rock Type (MS = mudstone SS = sandstone)	Rock Description	Condition 1 = decomposed, 2 = intensely weathered 3 = moderately weathered 4 = slightly	Sample Comments	Sample Comments 2	Sample Length	Sample Diameter	Sample LD Ratio	Sample Air Weight	Sample Dry Weight	Sample Weight	Sample Area	Load	Load Test Type	Moisture	C-3148	C-2938	Test Comments	Compressive	Compressive Corrected	Tensile	SPG	Absorption
2001-59C	Sites Reservoir	Golden Gate Inlet Outlet	GGO-DHT4	115.5	116.7	Ms		5			1.55	2.49	0.62															
2001-59D	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	115.5	116.7	Ms		5			5.03	2.49	2.02					13,700		DRY				2,816				
2001-60A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	124.5	125.5	Ss		5			5.02	2.49	2.02					45,150		DRY				9,264			2.50	2.68
2001-60B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT4	124.5	125.5	Ss		5			5.02	2.49	2.01					37,750		WET				7,740			2.59	1.53
2001-61A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			1.51	2.49	0.61					3,200		WET						1,700	2.49	3.26
2001-61B	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			5.03	2.49	2.02					28,000		WET				5,745			2.53	2.45
2001-61C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			5.02	2.49	2.01					42,900		DRY				8,803			2.54	2.92
2001-61D	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT5	430.5	432	Ss		5			5.02	2.49	2.02														2.52	2.09
2001-62A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT6	535.4	536.4	Ms		5			4.79	2.50	1.92															
2001-63A	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT6	556.3	557.3	Ms		5			4.79	2.49	1.92					18,900		DRY				3,856				
2001-63C	Sites Reservoir	Golden Gate Inlet Outle	GGO-DHT6	556.3	557.3	Ms		5			1.56	2.49	0.62					2,700		DRY						1,393		
1999C-82	Sites Reservoir	Golden Gate Straight	GGLA-1	6.1	6.4	Ss/Ms	intensely weathered sand/silt stone	2	Can't secure test sample	2" available	0.30											Dry						
1999C-83	Sites Reservoir	Golden Gate Straight	GGLA-2	6.7	7	Ss/Ms	intensely weathered sand/silt stone	2	Can't secure test sample	1.7" available	0.30											Wet						
1999C-84A	Sites Reservoir	Golden Gate Straight	GGLA-1	27.8	28.4	Ss	Sandstone.	4	4" & 4.5" test		0.60		—	732	706	441	4.438	21,200	Tinius Olsen	WET		Dry	Good Test	4,725	4,620		2.52	3.70
1999C-84B	Sites Reservoir	Golden Gate Straight	GGLA-1	27.8	28.4	Ss	Sandstone.	4	4" & 4.5" test		0.60		1.90	823	793	494	4.449	50,150	Wiedeman Baldwin	DRY		Dry	Good Test	11,270			2.50	3.80
1999C-85	Sites Reservoir	Golden Gate Straight	GGLC-1	60.7	61.2	Ms	Shale (mudstone?)	5	can't get good sample	4.5" avail	0.50											Dry						
1999C-86	Sites Reservoir	Golden Gate Straight	GGLA-1	188.2	188.9	Ms	Shale with silt interbeds and shear.	5	can't get good sample	6"	0.70											Dry						
1999C-87	Sites Reservoir	Golden Gate Straight	GGLC-1	23.2	23.8	Ms	Weathered shale	4	4.6"	4.5 (fractured) fair	0.60		1.90				4.468	5,250	Wiedeman Baldwin	DRY		Dry		1,180				
1999C-88	Sites Reservoir	Golden Gate Straight	GGLC-1	35.6	36.3	Ss	Representative of pitting.	4	5" good sample	8"	0.70		2.10	978	964	610	4.486	75,600	Tinius Olsen	DRY		Dry	Good Test	16,850			2.66	1.50
1999C-89	Sites Reservoir	Golden Gate Straight	GGLC-1	199.5	200.3	Ms	Fresh shale.	5	5" fair to good sample	7" soak ends	0.60		2.10				4.486	24,200	Wiedeman Baldwin	DRY		Wet	Good Test	5,390				
1999C-90	Sites Reservoir	Golden Gate Straight	GGRA-1	16.2	17.2	Ss	Weathered sandstone	3	Cut into 2 samples	1 only, 5" good	1.00		2.10	684	839	517	4.468	32,550	Wiedeman Baldwin	DRY		Dry/Wet	Good Test	7,290			2.41	5.40
1999C-91	Sites Reservoir	Golden Gate Straight	GGRA-1	51	52.3	Ss	Unweathered Sandstone.	5	Cut into 2 samples	5" good sample	1.30		2.10	901	869	536	4.494	58,800	Tinius Olsen	DRY	Dry	Wet	Good Test	13,080			2.47	3.70
1999C-92A	Sites Reservoir	Golden Gate Straight	GGRA-1	53.4	54.2	Ss	Unweathered Sandstone.	5	2 samples 4.5" & 5"		0.80		1.90	821	793	493	4.498	32,500	Tinius Olsen	WET		Dry	Good Test	7,230			2.50	3.50
1999C-92B	Sites Reservoir	Golden Gate Straight	GGRA-1	53.4	54.2	Ss	Unweathered Sandstone.	5	2 samples 4.5" & 5"		0.80		2.10	914	884	549	4.498	59,000	Tinius Olsen	DRY		Dry	Good Test	13,120			2.50	3.40
1999C-93	Sites Reservoir	Golden Gate Straight	GGRC-1	96.5	97	Ms	45o par-bed. Shale in shear zone.	5	Can't secure sample-friable	7.8"	0.50											Dry						
1999C-94	Colusa Reservoir	Owens	HOLA-1	19.7	20.5	Ss/Ms	Weathered interbedded sandstone and shale	3	can't secure sample-fracturing	4" avail	0.80											Dry						
1999C-95	Colusa Reservoir	Owens	HOLA-1	20.7	21.8	Ss/Ms	Weathered interbedded sandstone and shale	3	cut into two samples can't secure	7.7" avail	1.10										Dry (no)	Wet						
1999C-96	Colusa Reservoir	Owens	HOLA-1	51.5	52.4	Ss/Ms	Slightly weathered interbedded sandstone and shale	4	cut into 2 samples 5" good	6.9"	0.90		2.10				4.498	3,100	Wiedeman Baldwin	DRY	Dry(no)	Dry	Good Test	690				
1999C-97	Colusa Reservoir	Owens	HOLA-1	55.8	56.8	Ss/Ms	Slightly weathered interbedded sandstone and shale	4	Sheared between SS & Sh	7.9"	1.00			621	590	369	4.494	2,950	Wiedeman Baldwin	WET		Wet		656	630*		2.46	5.30
1999C-98A	Colusa Reservoir	Owens	HOLA-1	172.7	173.8	Ss	Sandstone. Thickly bedded (approx 50o).	5	Cut into 2 samples (yes)	10+"	1.10		2.10	985	965	609	4.513	28,000	Tinius Olsen	WET		Dry/Wet	Failed at bedding	6,200			2.62	2.10
1999C-98B	Colusa Reservoir	Owens	HOLA-1	172.7	173.8	Ss	Sandstone. Thickly bedded (approx 50o)	5	Cut into 2 samples (yes)	10+"	1.10		2.10	931	901	564	4.524	59,100	Tinius Olsen	DRY		Dry/Wet	Good Test	13,060			2.54	3.30
1999C-99	Colusa Reservoir	Owens	HOLA-1	199.2	199.8	Ms	Fractured shale.	5	Can't secure sample	3.6"	0.60											Dry						
1999C-100	Colusa Reservoir	Owens	HOLA-1	208	208.6	Ms	Fractured shale.	5	Can't secure sample	4.1"	0.60											Wet						
1999C-101A	Colusa Reservoir	Owens	HOLC-1	29.6	30.6	Ms	Fresh shale. Thinly bedded (approx. 60o), some fossils.	4	3.7" & 5" sample	soak ends	1.00						4.475	4,850	Wiedeman Baldwin	WET		Wet	Good Test	1,084	1050*			
1999C-101B	Colusa Reservoir	Owens	HOLC-1	29.6	30.6	Ms	Fresh shale. Thinly bedded (approx. 60o), some fossils	4	3.7" & 5" sample	soak ends	1.00		2.10				4.464	23,200	Wiedeman Baldwin	DRY		Wet	Good Test	5,200				
1999C-102	Colusa Reservoir	Owens	HOLC-1	62.1	82.9	Ms	Fresh shale. Thinly bedded (approx. 50o), some soft interbeds	5	5" fair to good sample	6.9" soak ends	0.80		2.00				4.498	21,850	Wiedeman Baldwin	DRY		Wet	Good Test	4,860				
1999C-103A	Colusa Reservoir	Owens	HOLC-1	115.1	116.2	Ms	Fresh shale.	5	Cut into 2 samples yes	2 5" samples	1.10		2.10	944	914	571	4.505	6,200	Wiedeman Baldwin	WET	Dry	Dry	Shale Bedding gave up first	1,380			2.53	3.20
1999C-103B	Colusa Reservoir	Owens	HOLC-1	115.1	116.2	Ms	Fresh shale.	5	Cut into 2 samples yes	2 5" samples	1.10		2.10	954	939	591	4.513	54,100	Wiedeman Baldwin	DRY	Dry	Dry	Good Test	11,990			2.63	1.60
1999C-104	Colusa Reservoir	Owens	HORA-1	13.5	14.3	Ss	Sandstone.	4	5" good sample		0.80		2.10	892	848	525	4.505	14,750	Wiedeman Baldwin	WET		Wet	Good Test	3,270			2.43	5.20
1999C-105	Colusa Reservoir	Owens	HORA-1	33.4	33.8	Ss	Fossiliferous Sandstone	4	Can't secure test sample	4"	0.40											Dry						
1999C-106	Colusa Reservoir	Owens	HORA-1	34.3	35	Ss	Fossiliferous sandstone. Thinly bedded (approx. 50o).	4	5" fair to good sample	6.5"	0.70		2.10				4.453	7,600	Wiedeman Baldwin	DRY		Dry		1,710				
1999C-107	Colusa Reservoir	Owens	HORA-1	69.1	69.6	Ss/Ms	Soft-sediment features	5	5" good sample	5.5"	0.50		2.10	908	859	537	4.490	40,650	Wiedeman Baldwin	DRY		Dry	Good Test	9,050			2.45	5.70
1999C-108	Colusa Reservoir	Owens	HORC-1	37.3	38.1	Ms	45o perp-bed Weathered shale	4		6"	0.80											Wet						
1999C-109	Colusa Reservoir	Owens	HORC-1	38.1	39.1	Ms	45o perp-bed Weathered shale	4	4.5" not too good	8.9"	1.00		1.90				4.490	39,700	Wiedeman Baldwin	DRY		Dry	?	8,840				

Bryte Code	Project	Site	Drill Hole	Start Depth	End Depth	Rock Type (MS = mudstone SS = sandstone)	Rock Description	Condition 1 = decomposed 2 = intensely weathered 3 = moderately weathered 4 = slightly	Sample Comments	Sample Comments 2	Sample Length	Sample Diameter	Sample LD Ratio	Sample Air Weight	Sample Dry Weight	Sample Weight	Sample Area	Load	Load Test Type	Moisture	C-3148	C-2938	Test Comments	Compressive	Compressive Corrected	Tensile	SPG	Absorption
1999C-110	Sites Reservoir	Sites	LC-2	51.3	52	Ss	45o per-bed. Representative of sandstone.	5	4.7" good sample	7.8"	0.70		2.00	928	926	589	4.393	78,700	Tinius Olsen	WET		Wet	Good Test	17,910			2.74	0.20
1999C-111	Colusa Reservoir	Owens	HOLC-1	53.5	54.5	Ss	45o per-bed. Representative of sandstone.	5	5" good sample	8.5"	1.00		2.10	895	856	527	4.501	73,400	Tinius Olsen	DRY	Dry/Wet		Good Test	16,310			2.43	4.70
1999C-112	Colusa Reservoir	Owens	HOLC-2	61.2	62	Ss	45o per-bed Representative of sandstone.	5	5" good sample	7.5"	0.80		2.10	936	921	569	4.494	80,300	Tinius Olsen	DRY		Dry	Good Test	17,870			2.55	1.60

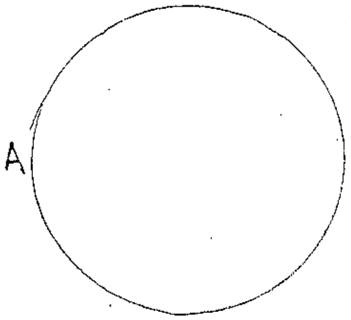
LAB # 99C - 82

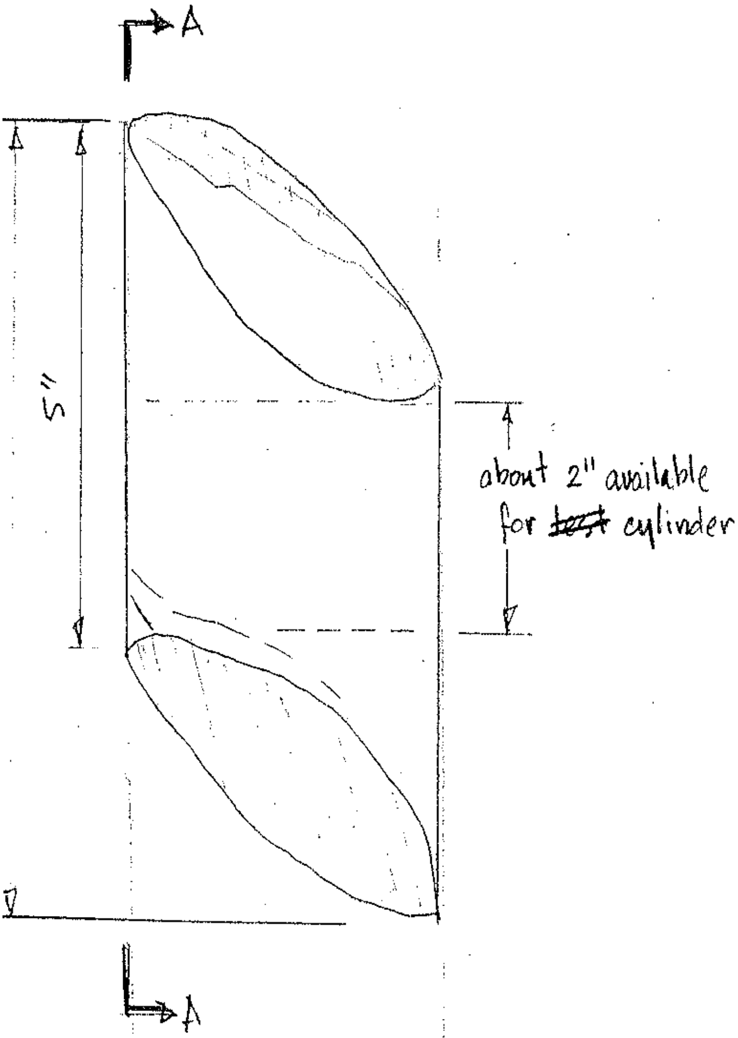
ROCK DESCRIPTION : intensely weathered sand/SILT STONE (brown)

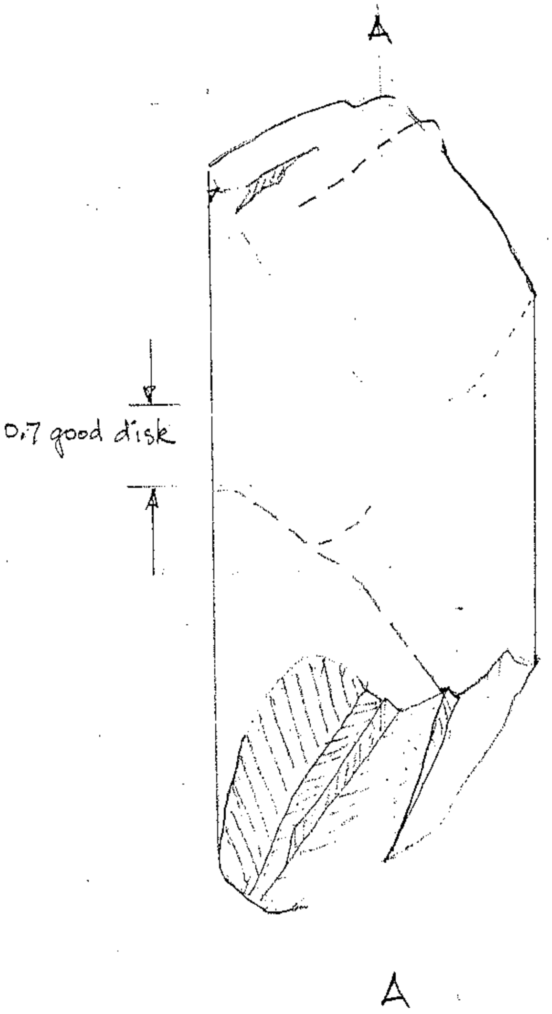
HOLE : LA-1

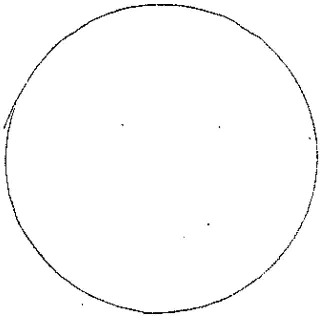
DEPTH : 6.1 ~ 6.4

GOLDEN Gates









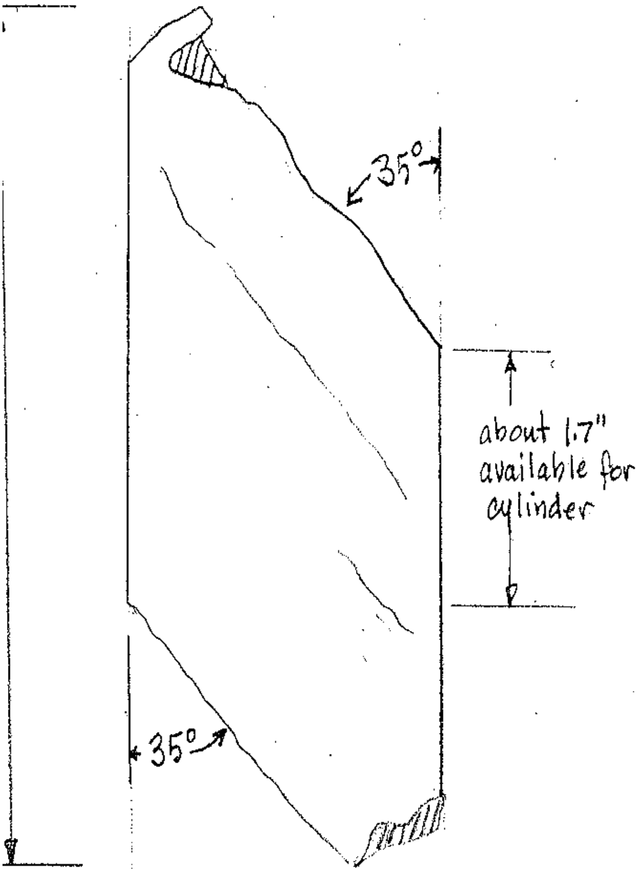
LAB # 99C-83

ROCK DESCRIPTION: intensely weathered sand/silt stone (brown)

HOLE: LA-1

Depth: 6.7~7.0

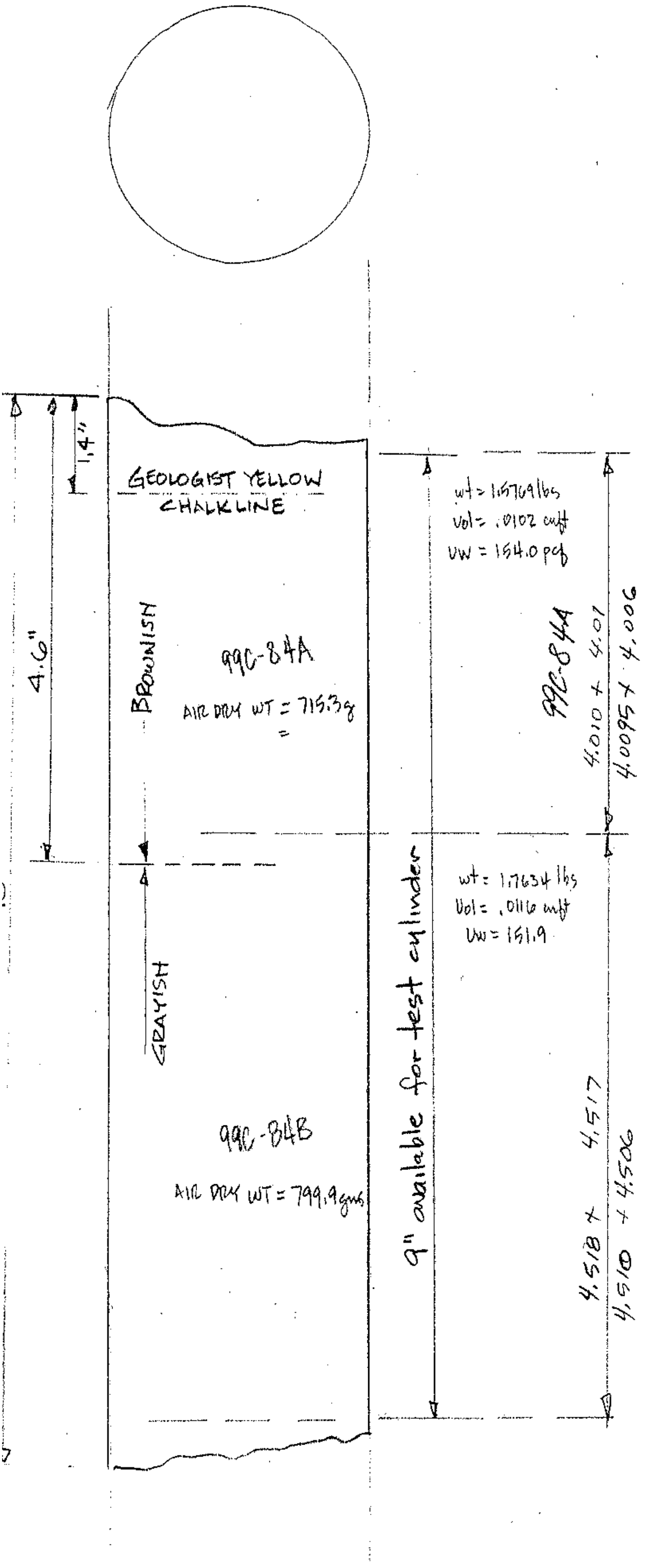
Golden Gate



LAB # 99C - 84
ROCK DESCRIPTION: Sanstone

Hole: LA-1
Depth: 27.8 ~ 28.4

Golden Gate



Dia
top 2.376
mid 2.377
bot 2.379

L = 4.01
D = 2.377
Area = 4.4376
L/D = 1.69 *

21,200 lbs

L_{avg} = 4.51
D_{avg} = 2.380
Area = 4.449
L/D = 1.90
Load = 50150 lbs
Comp Str =

Dia
top 2.399
mid 2.378
bott 2.382

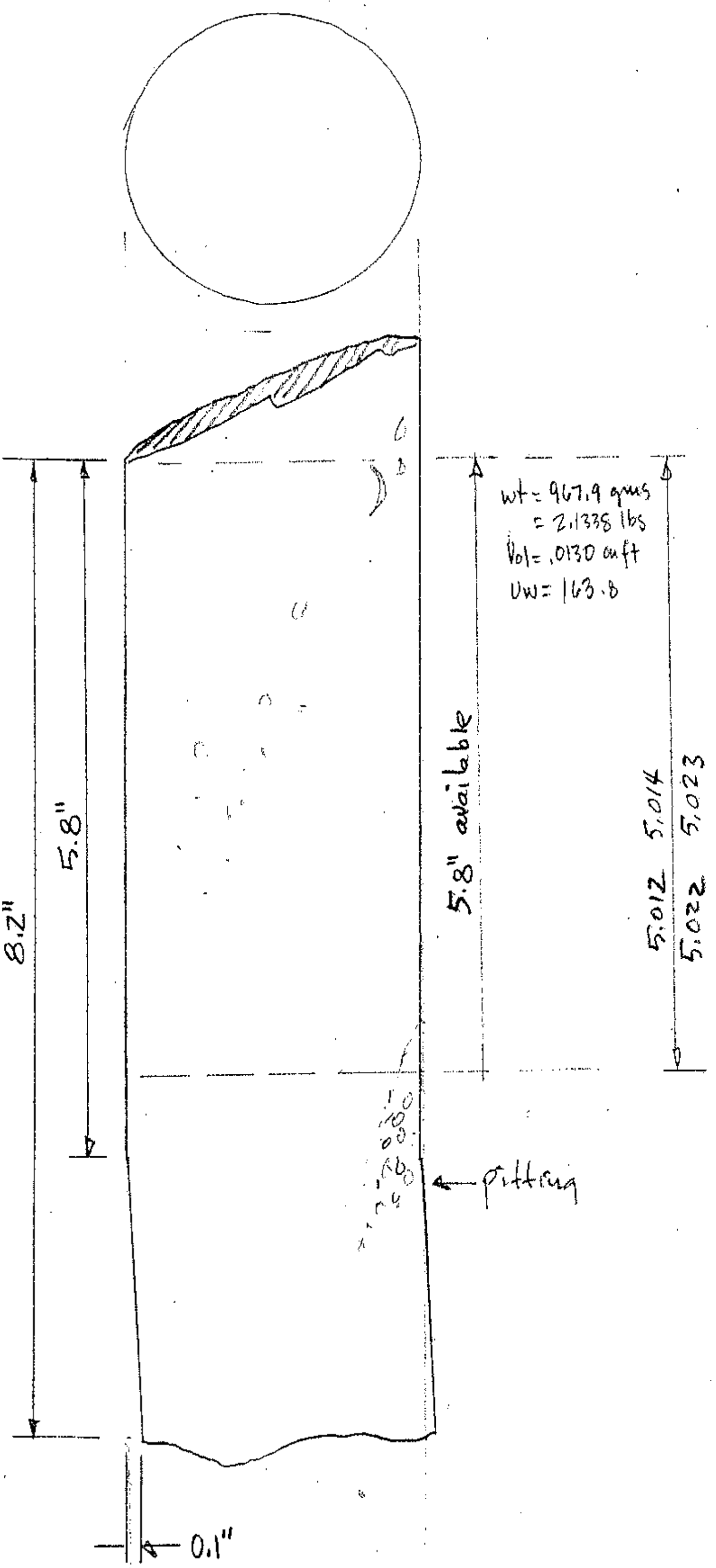
LAB # 99C-88

ROCK DESCRIPTION: Sandstone (representative of pitting)

Hole: LC-1

Depth: 35.6 ~ 36.3

Golden Gate



wt = 967.9 gms
= 2.1338 lbs
Vol = .0130 cuft
UW = 163.8

L = 5.018
D = 2.390
Area = 4.486
Load 75600

L/D = 2.10

Dia
top 2.392
mid 2.390
bott 2.389

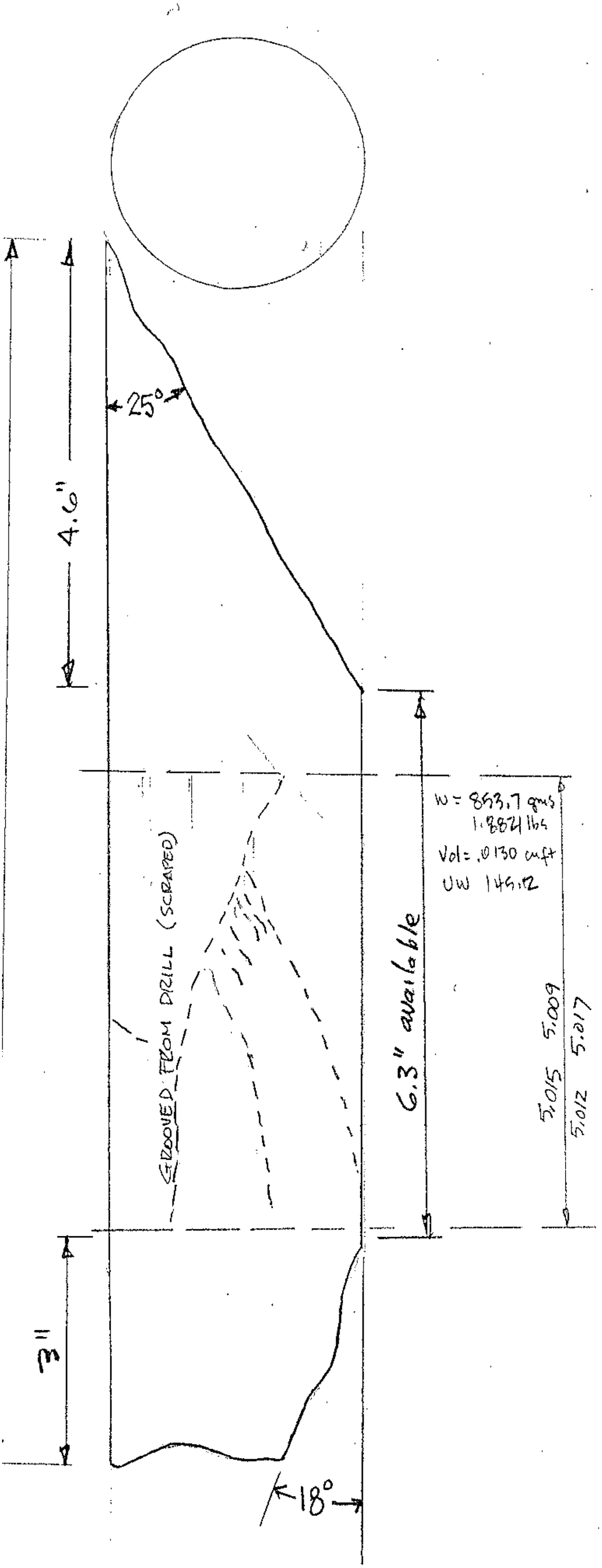
LAB # 99C - 90

ROCK DESCRIPTION: Weathered Sandstone (brown)

Hole: RA - 1

Depth: 16.2 ~ 17.2

Golden Gate



W = 853.7 gms
1.8824 lbs

Vol = .0130 cuft

UW 145.12

Dia

top 2.384

mid 2.383

bott 2.387

avg L = 5.013

avg D = 2.385

Area = 4.468

L/D = 2.10

32550 lbs

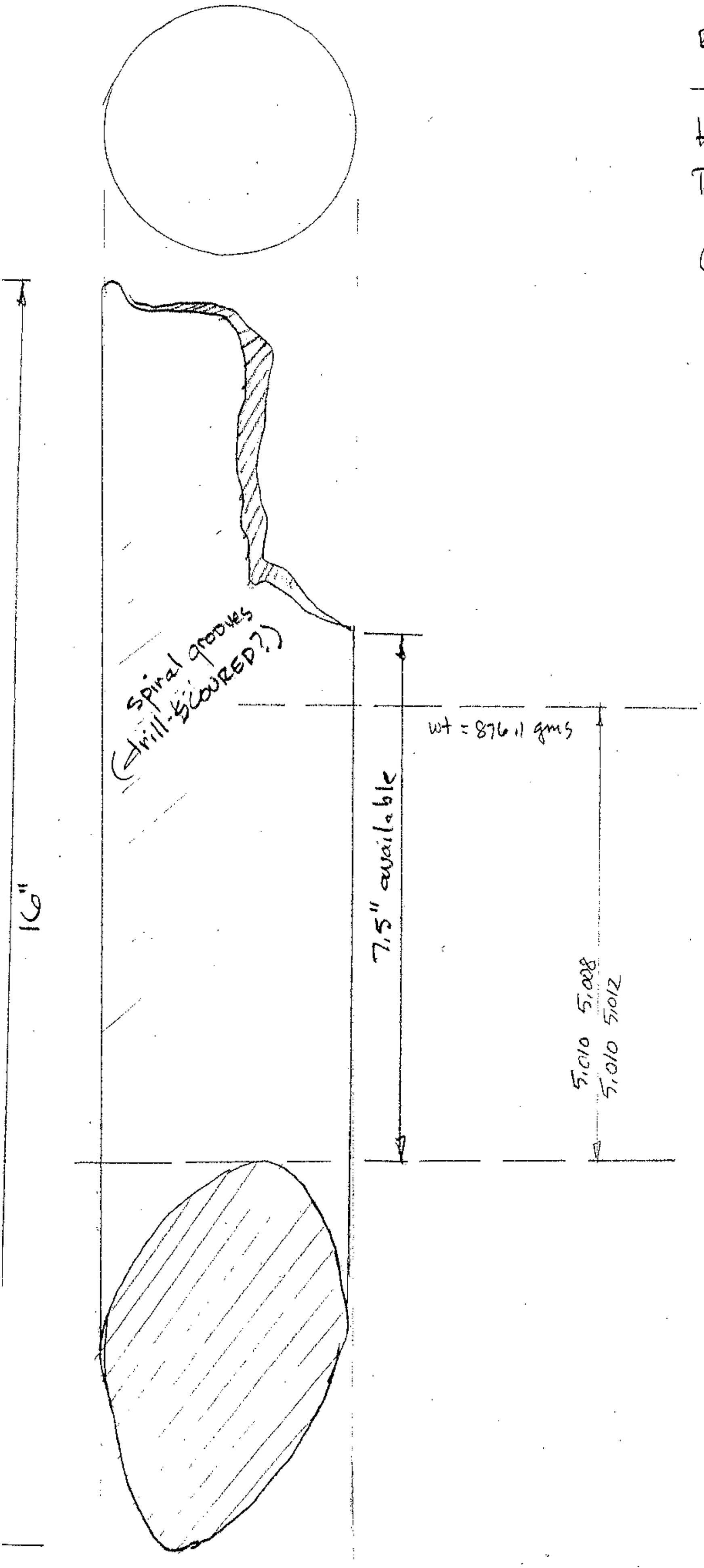
LAB # 99C - 91

ROCK DESCRIPTION: Sandstone
(light gray)

Hole: RA-1

Depth: 51,0 ~ 52,3

Golden Gate



Dia	
top	2,393
mid	2,390
bott	2,392

avg L = 5,010

avg D = 2,392

Area = 4,494#

L/D = 2,09

58800

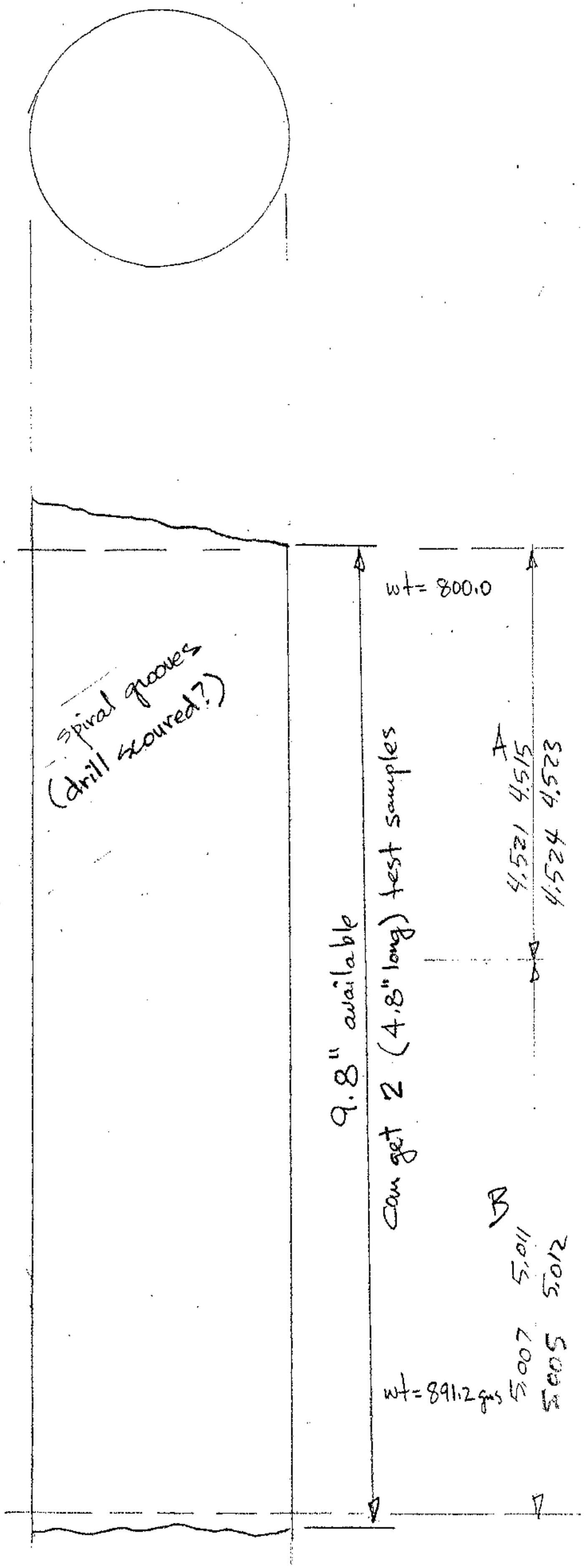
LAB # 99C - 92

ROCK DESCRIPTION: Sandstone (Light gray)

Hole : RA-1

Depth: 53.4 ~ 54.2

Golden Gate



Dia
top 2.395
mid 2.388
bott 2.393

avg L = 4.521
avg D = 2.392
Area = 4.498
L/D = 1.9
32500

Dia
Top 2.390
Mid 2.392
Bott 2.395

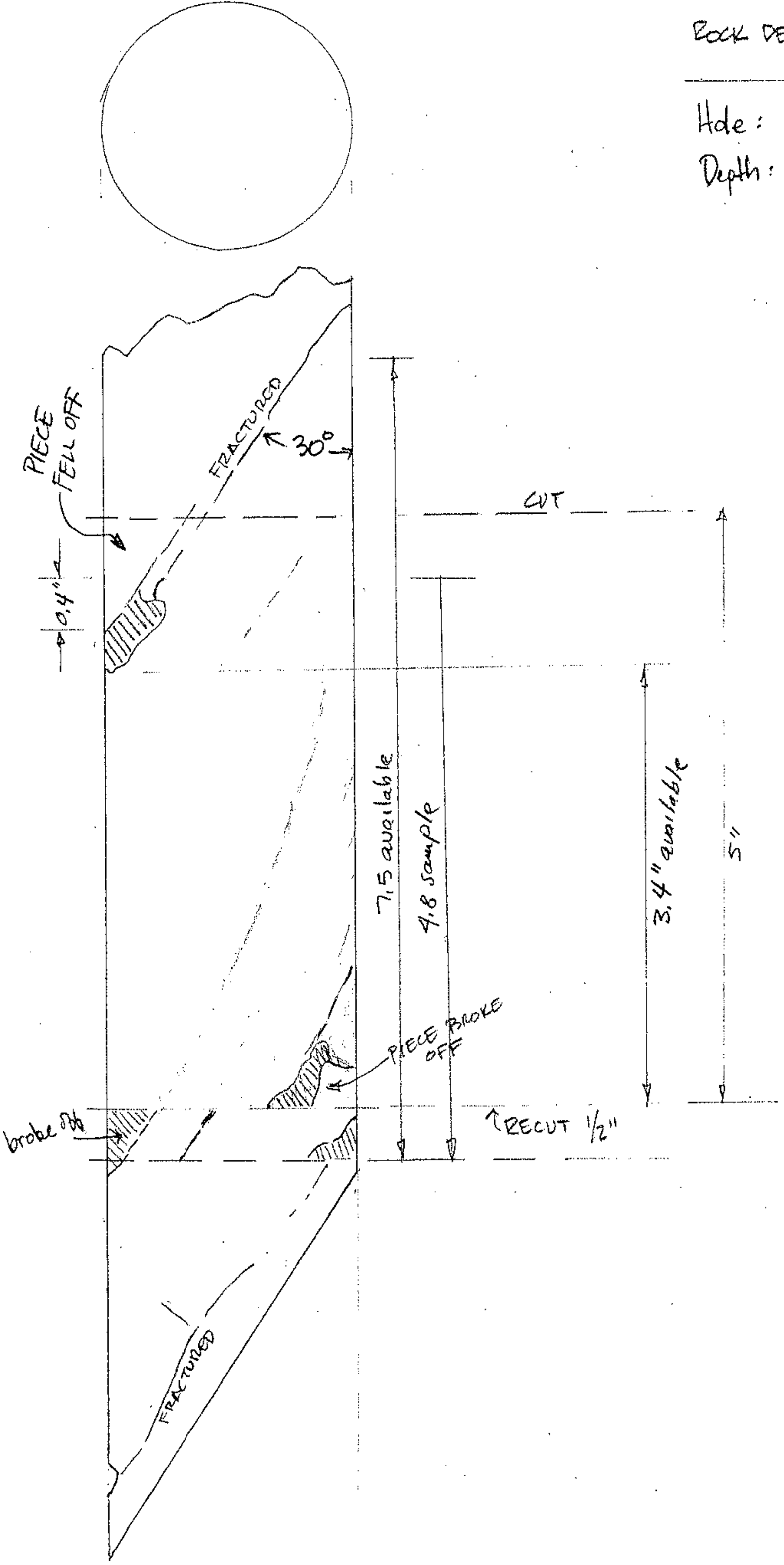
avg L = 5.009
avg D = 2.392
Area = 4.498
L/D = 2.09
59000

LAB # 99C-94

ROCK DESCRIPTION: ______________________

Hole: LA-1

Depth: 19.7 ~ 20.5

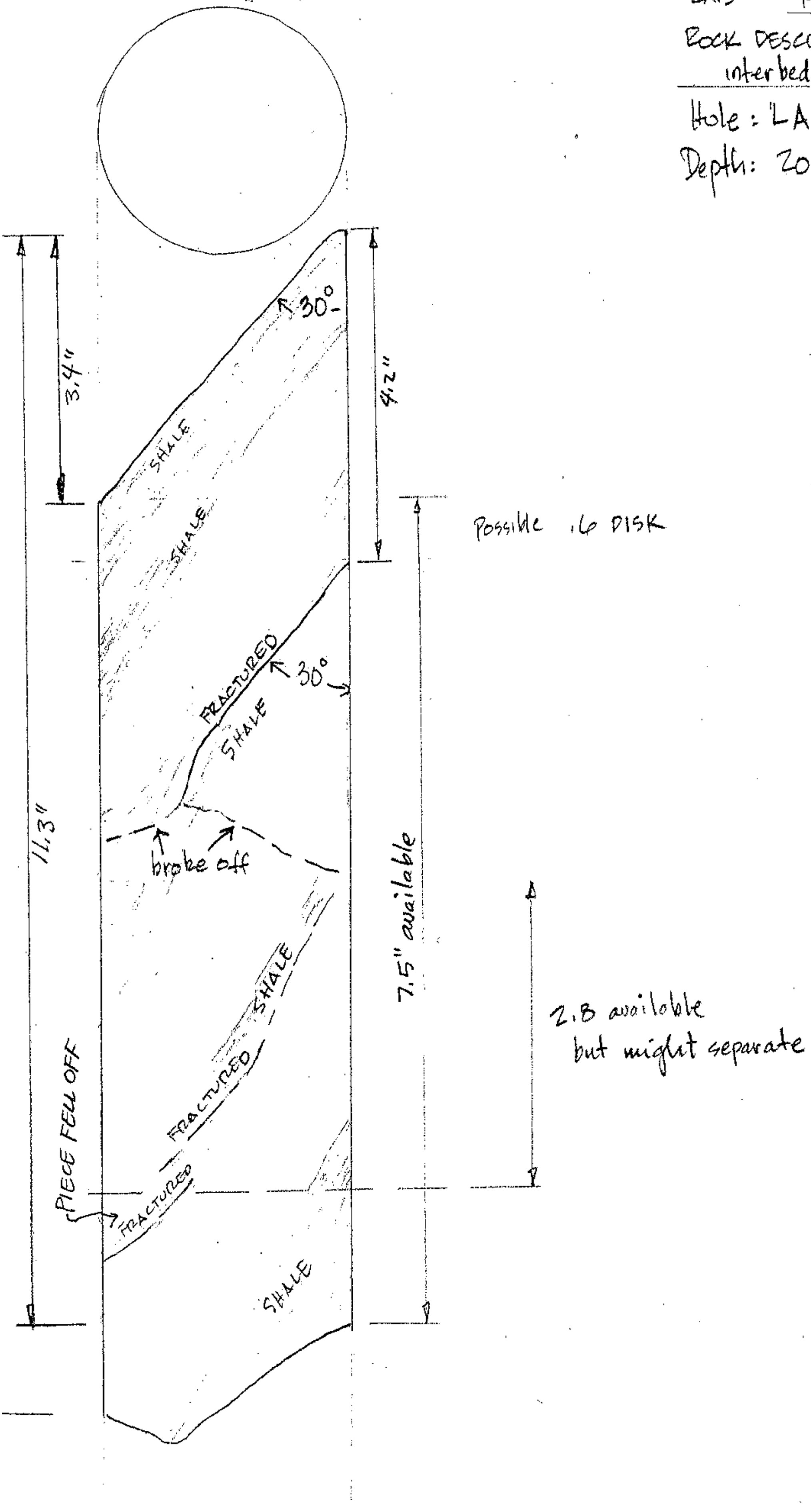


LAB # 99C-95

ROCK DESCRIPTION: weathered interbedded ss & sh

Hole: LA-1

Depth: 20.7 ~ 21.8

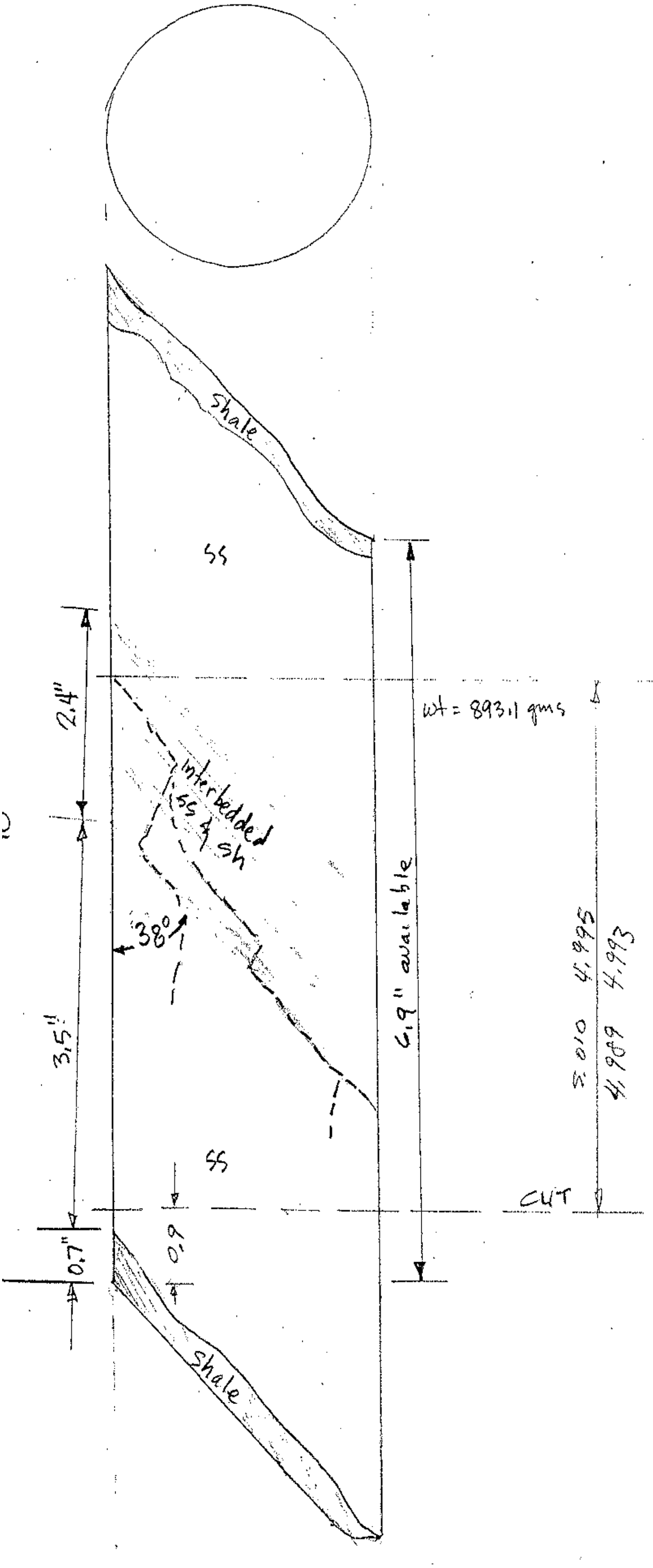


LAB # 99C-96

ROCK DESCRIPTION: ______________

HOLE: LA-1

Depth: 51.5 ~ 52.4



3100 lbs

avg L = 4.997"
avg D = 2.393"
Area = 4.498#
L/D = 2.09

Dia

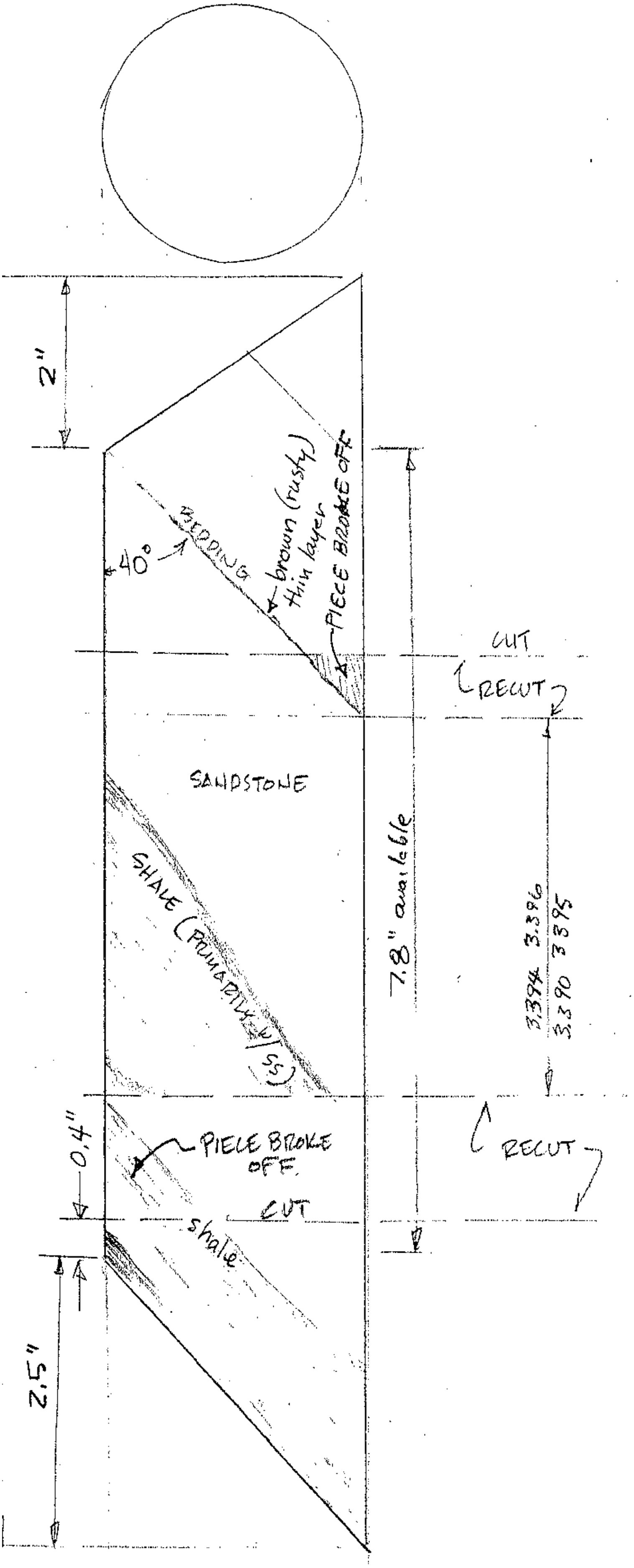
top	2.395
mid	2.389
bott	2.394

LAB # 99C - 97

ROCK DESCRIPTION: ______________________

Hole: LA-1

Depth: 55.8 ~ 56.8



avg L = 3.394

avg D = 2.392

L/D = 1.42

Area = 4.4938

2.950

Dia

top 2.395

mid 2.392

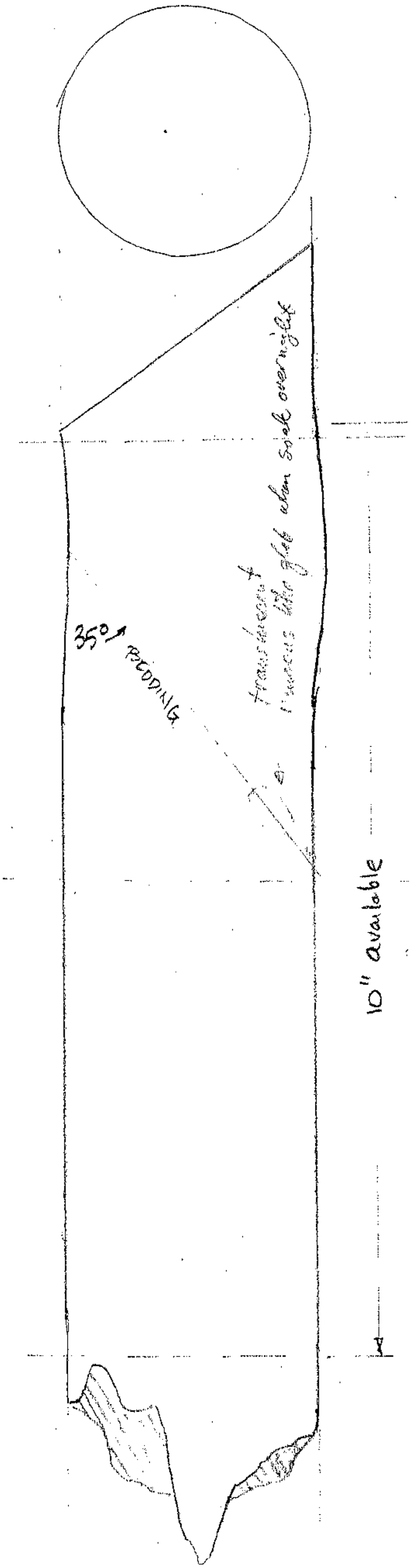
bott 2.389

LAB # 99C - 98

ROCK DESCRIPTION : Sandstone

hole : LA-1

depth : 172.7 ~ 173.8



99C-98A

5.125 5.074
5.056 5.143

Dia
Top 2.394
Mid 2.398
bott 2.399

avg L = 5.100"
avg D = 2.397"
Area = 4.513 #
L/D = 2.13

28,000
sheared @ bedding

99C-98B

4.992 4.974
4.984 4.973

Dia
Top 2.400
Mid 2.400
bott 2.400

avg L = 4.981"
avg D = 2.400"
Area = 4.524 #
L/D = 2.08

54550

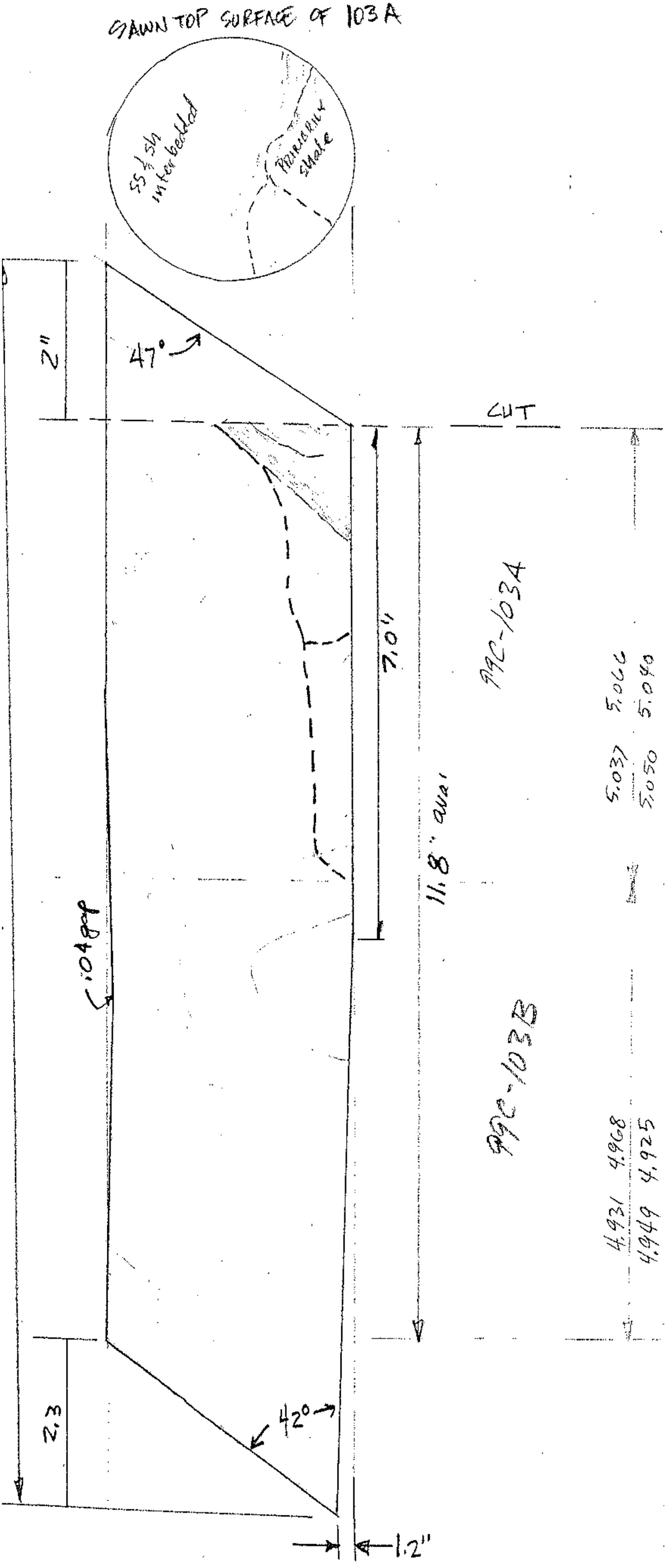
59100

LAB # 99C - 103

ROCK DESCRIPTION: ______________________

HOLE: LC-1

DEPTH: 115.1 ~ 116.2



Dia
Top 2.394
Mid 2.396
bott 2.396

avg L = 5.048"
avg D = 2.395
Area = 4.505 #
L/D = 2.11

6200

Avg L = 4.943"
avg D = 2.397"
Area = 4.513 #
L/D - 2.06

Dia
Top 2.398
Mid 2.397
bott 2.396

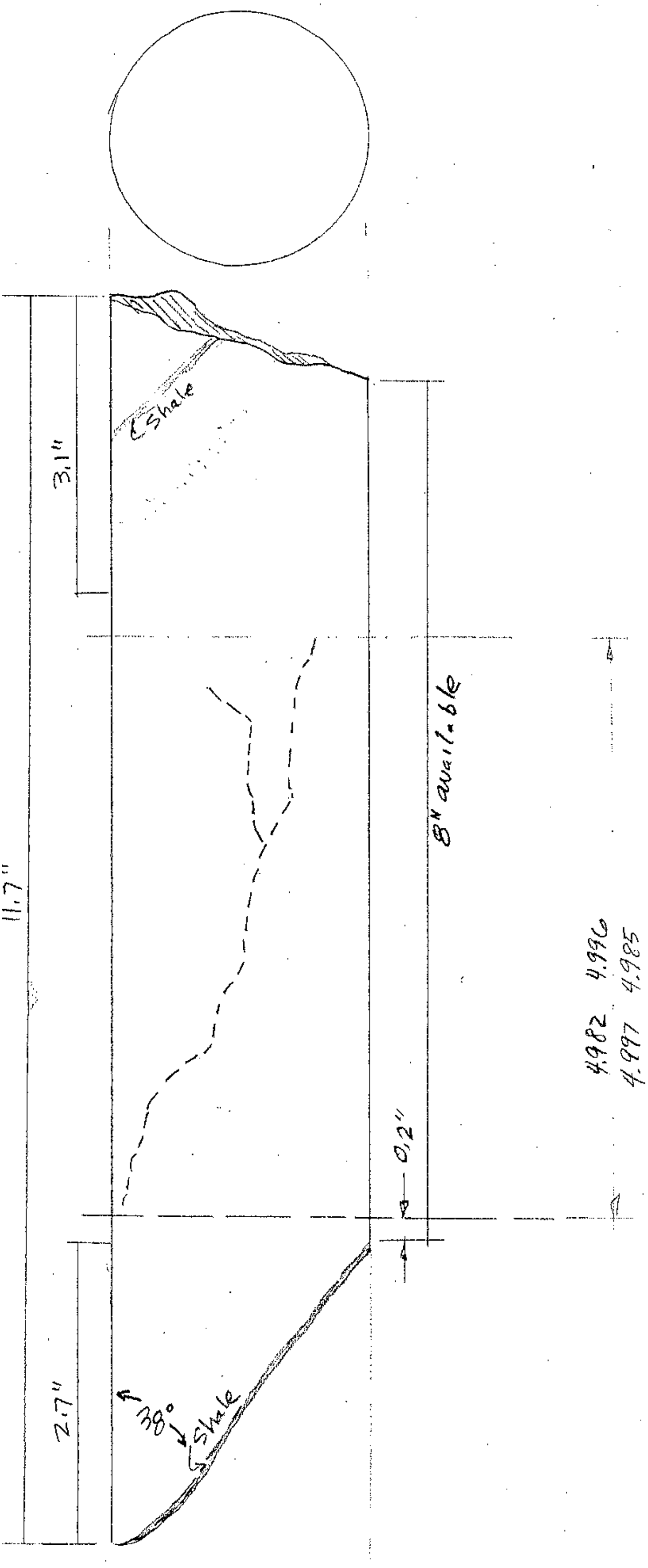
54100

LAB # 99C-104

ROCK DESCRIPTION: Sandstone (brown)

HOLE: RA-1

DEPTH: 13.5~14.3



Dia

Top 2.394

mid 2.399

bott 2.392

avg L = 4.990

avg D = 2.395

Area = 4.505 #

L/D = 2.08

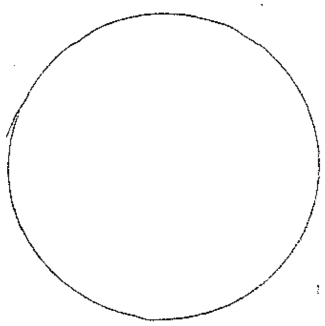
14750

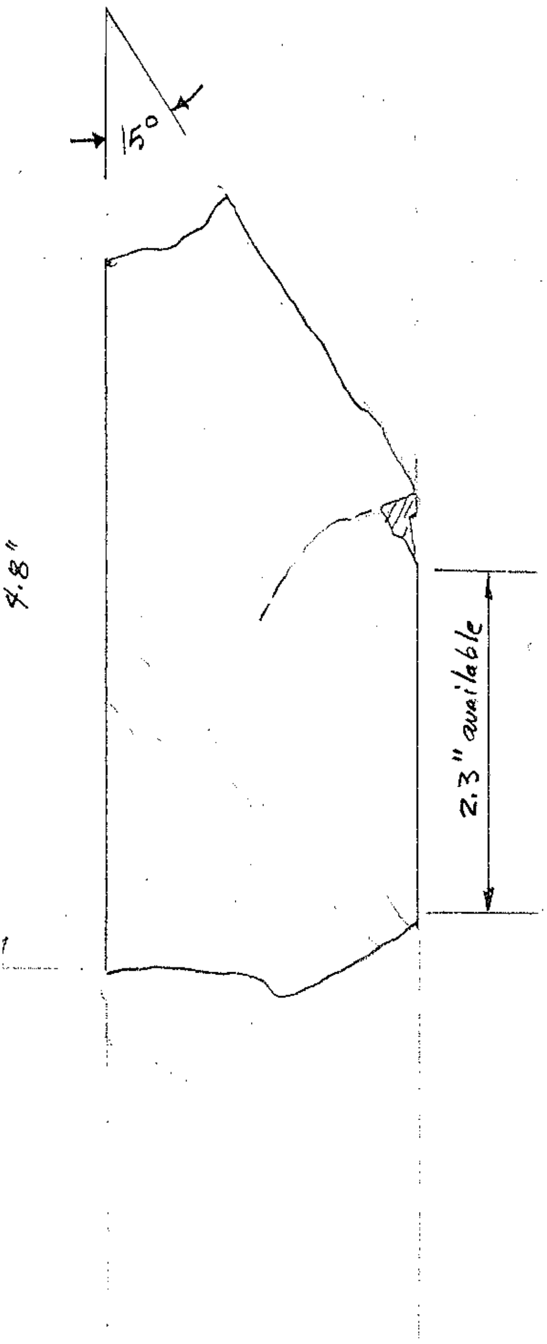
LAB # 99C - 105.

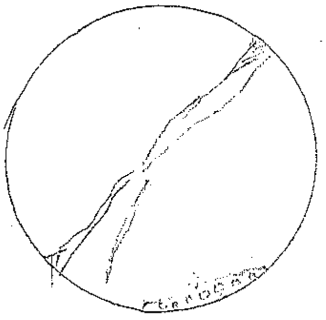
ROCK DESCRIPTION: Fossiliferous SS

HOLE: RA-1

DEPTH: 33.4 ~ 33.8





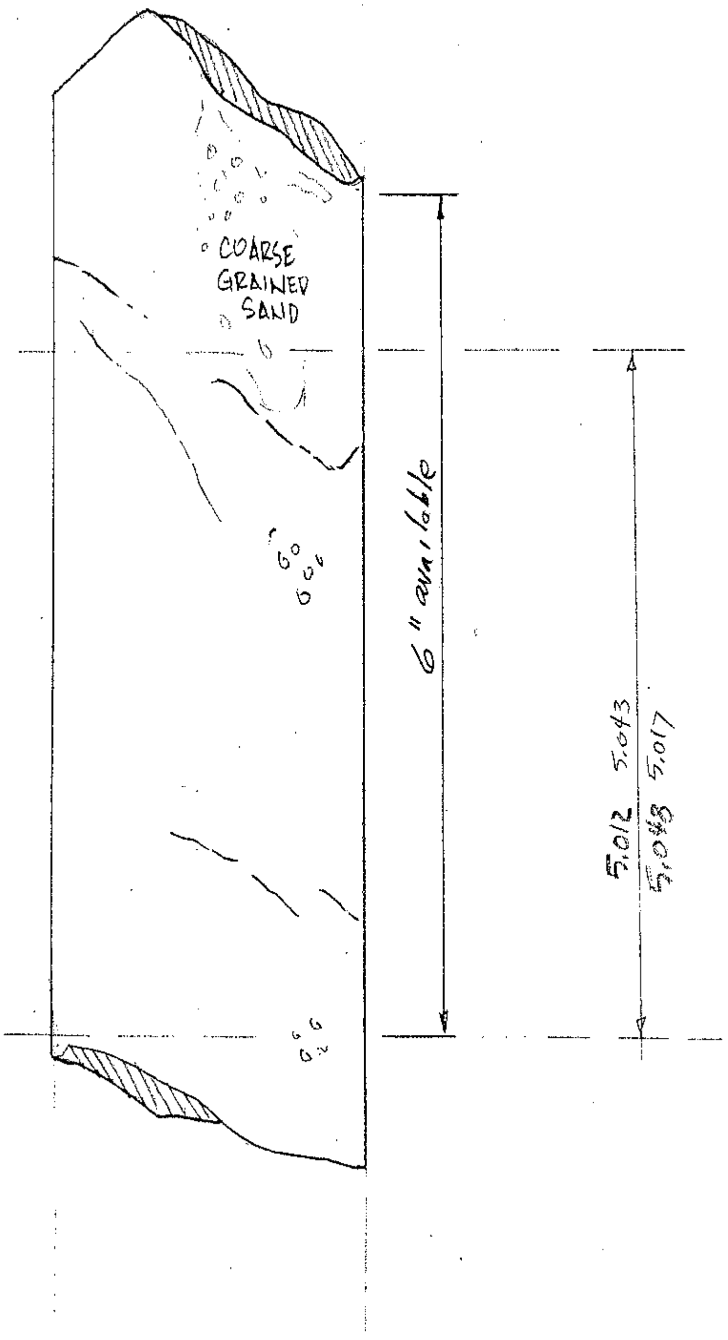


LAB # 99C-106

ROCK DESCRIPTION: Fossiliferous SS

HOLE: RA-1

DEPTH: 34.3~35.0



7600 lbs

avg L = 5,030
avg D = 2,381
Area = 4,453 #
L/D = 2,11

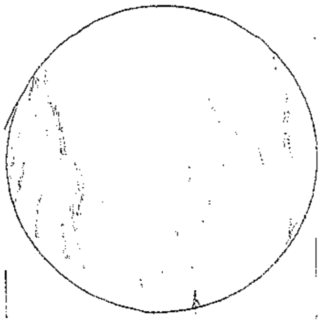
Dia
Top 2,381
Mid 2,384
bott 2,379

LAB # 99C - 107

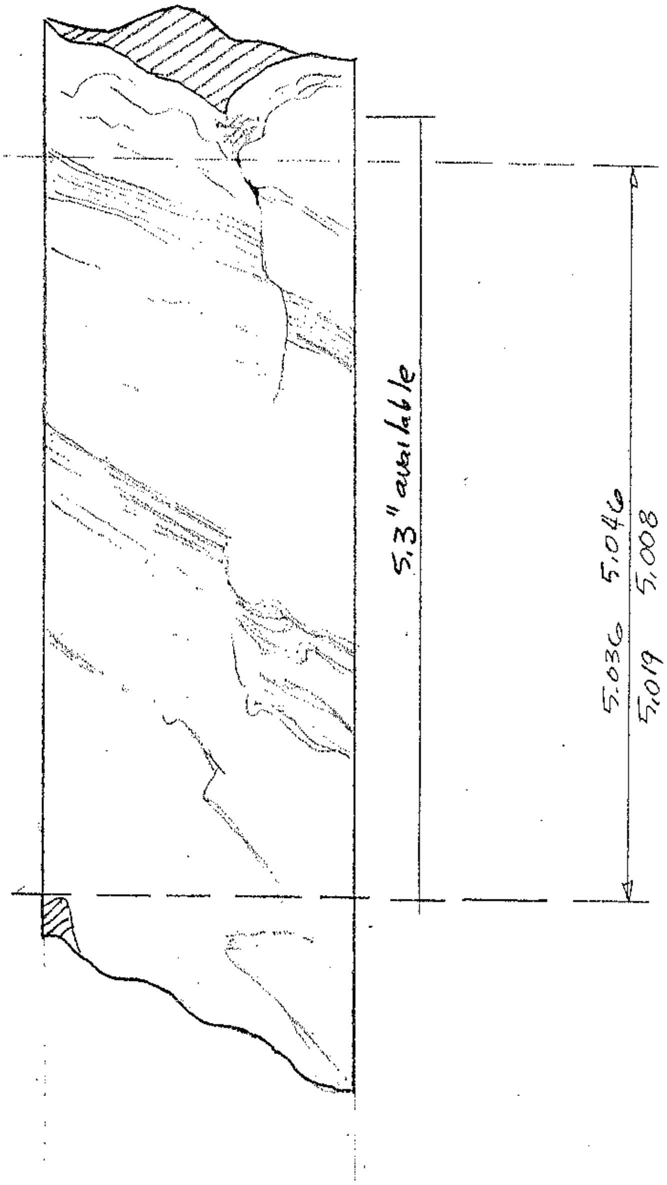
ROCK DESCRIPTION: ______________

HOLE: RA-1

DEPTH: 69,1 ~ 69,6



SAWN TOP SURFACE

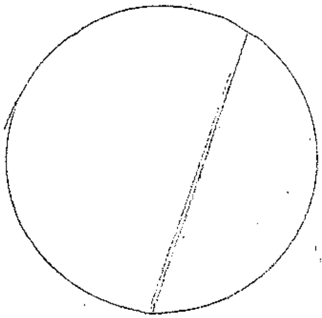


avg L = 5,027
avg D = 2,391
Area = 4,490
L/D = 2,10

Dia

Top	2,390
mid	2,391
bott	2,392

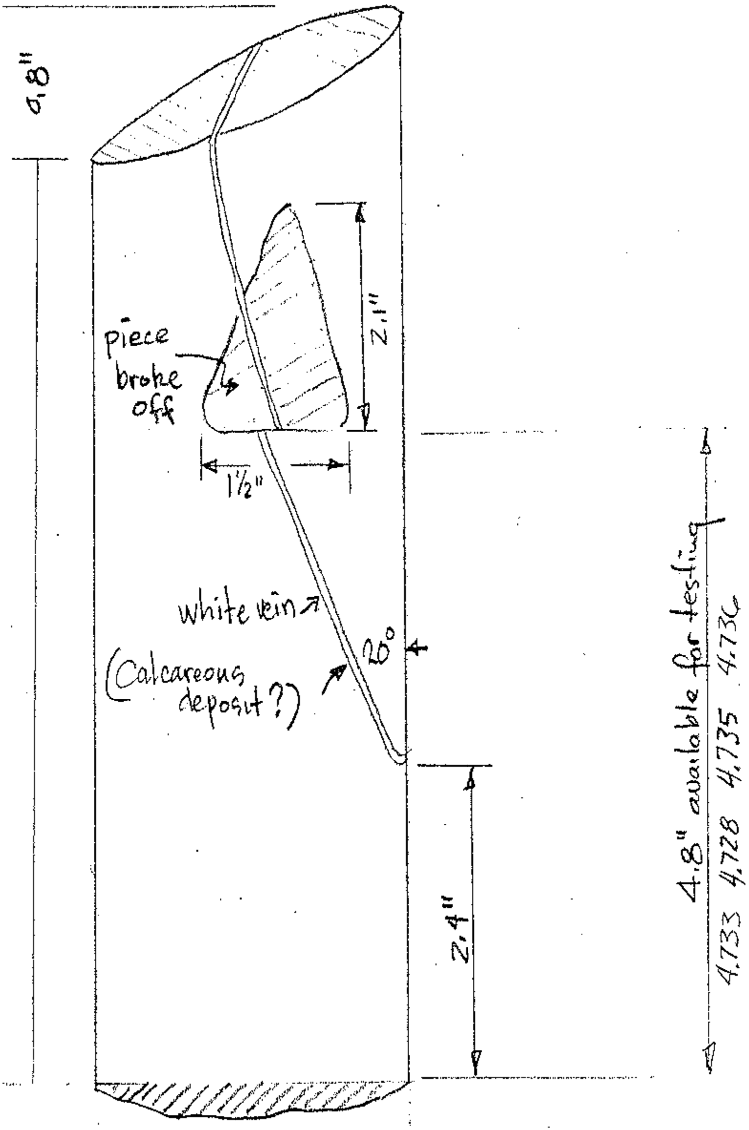
40650lbs



LAB # 99C-110
ROCK DESCRIPTION: Sandstone

HOLE: LC-2
Depth: 51.3 ~ 52.0

Sites



Dia

Top	2.373
mid	2.362
bott	2.361

avg L = 4.733"
avg D = 2.365"
Area = 4.393#
L/D = 2.00

78700

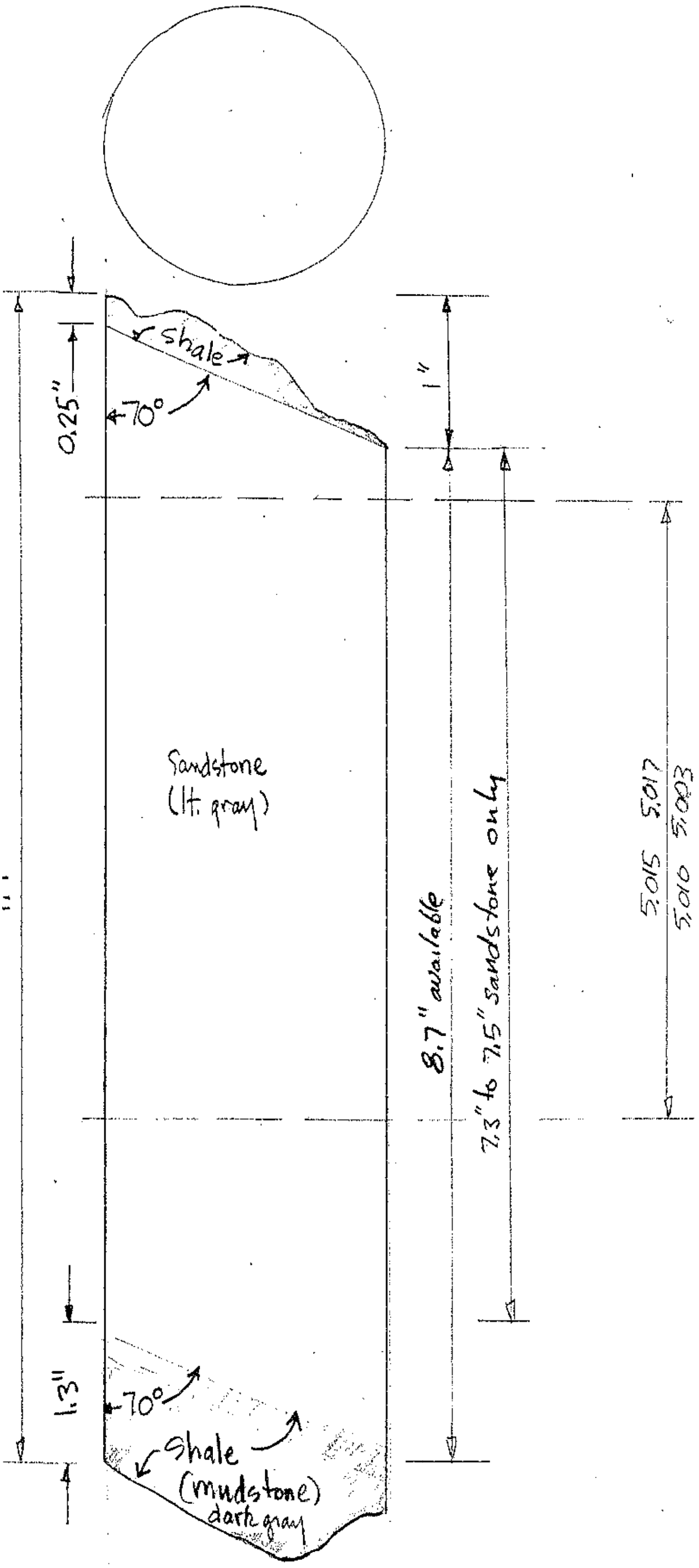
LAB # 99c - 111

ROCK DESCRIPTION: ____________________

Hole: LC-2

Depth: 53.5 ~ 54.5

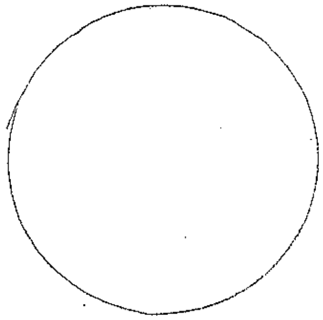
Sites



avg L = 5.011"
avg D = 2.394"
Area = 4.501⧄
L/D = 2.09

73,400 lbs

Dia
Top 2.395
mid 2.393
bottom 2.395



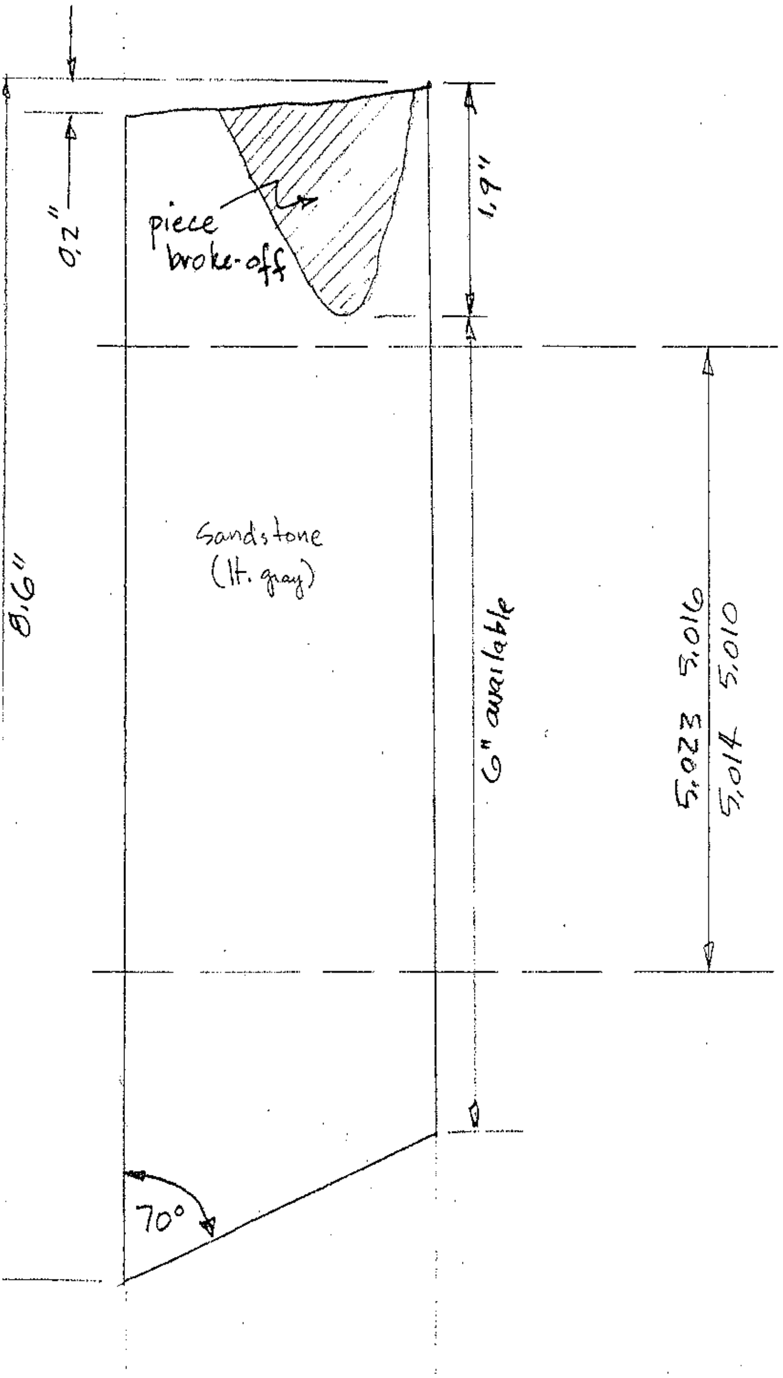
LAB # 99C-112

ROCK DESCRIPTION: Sandstone

Hole: LC-2

Depth: 61.2~62.0

Sites



Dia
Top 2,393
mid 2,391
bott 2,391

avg L = 5.016"
avg D = 2,392
Area = 4.494 #
L/D = 2,10

80300

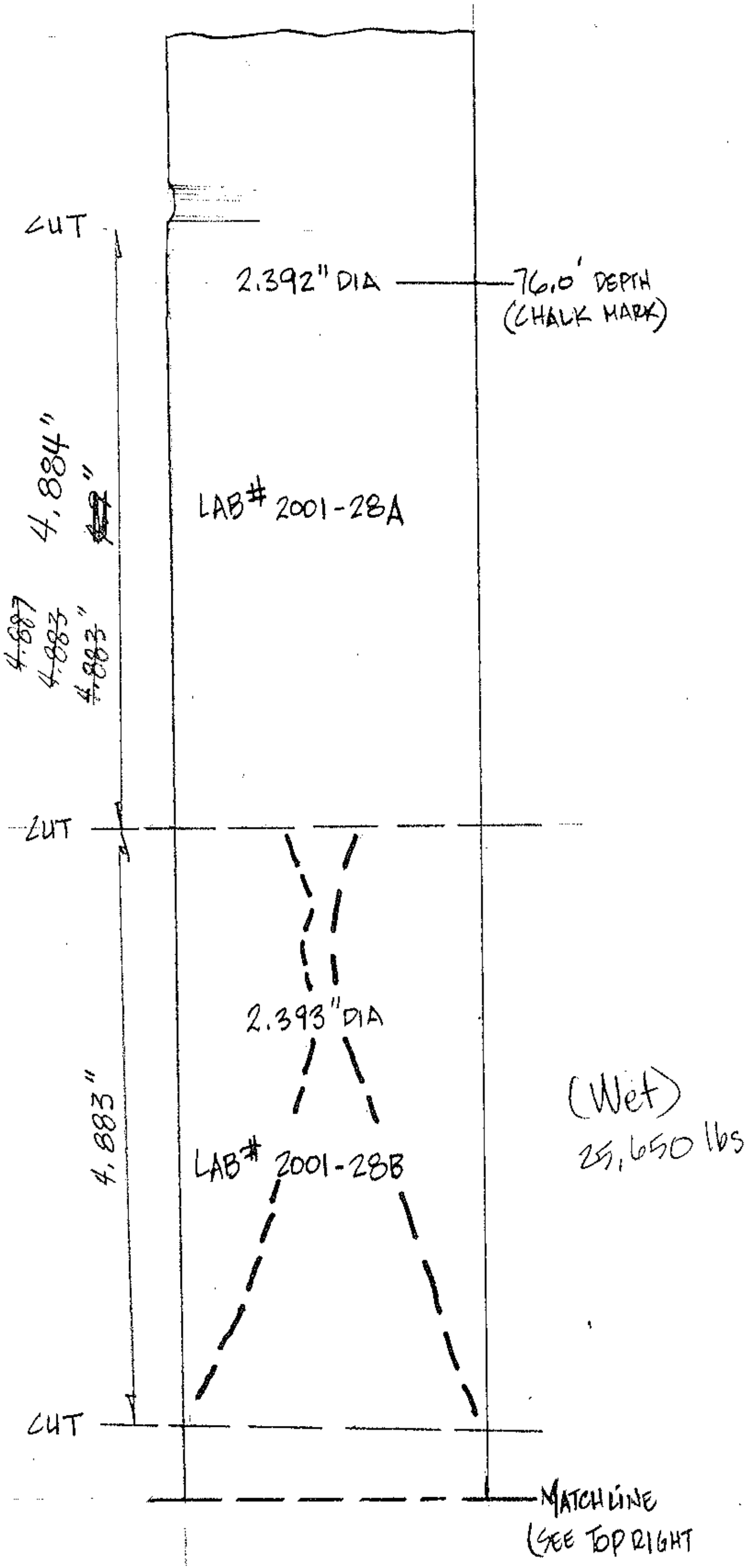
ASTM D 2938 Unconfined Compressive Strength

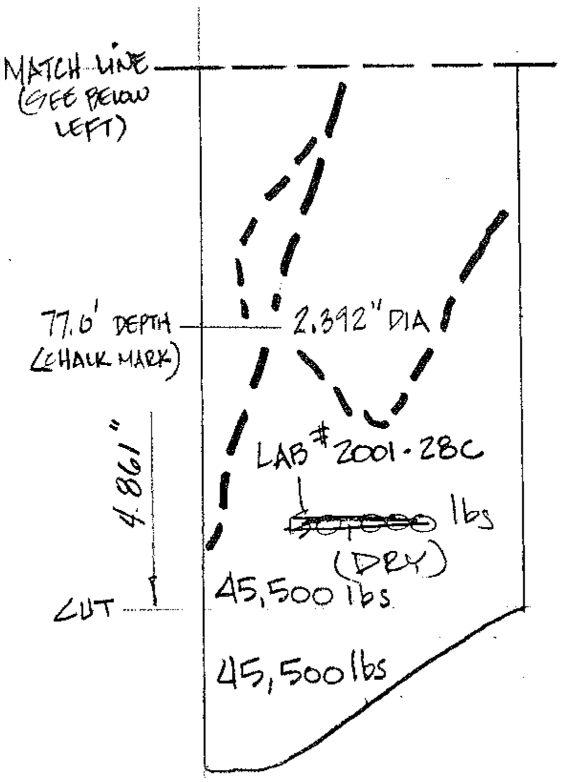
	Wt in Air (ssd condition) (gms)	OVEN DRY Wt. (gms) 230°F	wt in water (gms)	SPG (ssd cond.)	% abs	REMARKS	Moisture condition	L/D RATIO	LOAD (lbs)	AREA #	COMP. STR. (PSI)
C-111	895	856	527	2.43	4.7	GOOD TEST	DRY	2.1	73400^A	4.501	16310
-112	936	921	569	2.55	1.6	GOOD TEST	DRY	2.1	80300^A	4.494	17870
-110	928	926	589	2.74	0.2	GOOD TEST	Wet	2.0	78700^A	4.393	17910
-98A**	985	965	409	2.62	2.1	FAILED @ bedding	Wet	2.1	28000^A	4.513	6200
-98B**	931	901	564	2.54	3.3	GOOD TEST	DRY	2.1	59100^A	4.524	13060
-91	901	869	536	2.47	3.7	GOOD TEST	DRY	2.1	58800^A	4.494	13080
-92A	821	793	493	2.50	3.5	GOOD TEST	Wet	1.9	32500^A	4.498	7230
-92B	914	884	549	2.50	3.4	GOOD TEST	Dry	2.1	59000^A	4.498	13120
-106	---	---	---	---	---		Dry	2.1	7600	4.453	1710
-88	978	964	610	2.66	1.5	GOOD TEST	Dry	2.1	75600^A	4.486	16850
-84A	732	706	441	2.52	3.7	GOOD TEST	Wet	1.7*	21200^A	4.438	4725/4620*
-84B	823	793	494	2.50	3.8	GOOD TEST	Dry	1.9	50150	4.449	11270.
-104	892	848	525	2.43	5.2	GOOD TEST	Wet	2.1	14750	4.505	3270
-90	884	839	517	2.41	5.4	GOOD TEST	Dry	2.1	32550	4.468	7290
-107	908	859	537	2.45	5.7	GOOD TEST	Dry	2.1	40650	4.490	9050
89	---	---	---	---	---	GOOD TEST	Dry	2.1	24200	4.486	5390
-103A	944	914	571	2.53	3.2	shale bedding gave up first	Wet	2.1	6200	4.505	1380
-103B	954	939	591	2.63	1.6	GOOD TEST	Dry	2.1	54100	4.513	11990
-102	---	---	---	---	---	GOOD TEST	Dry	2.0	21850	4.498	4860
-109	---	---	---	---	---	?	Dry	1.9	39700	4.490	8840
-101A	---	---	---	---	---	GOOD TEST	Wet	1.6*	4850	4.475	1084/1050*
-101B	---	---	---	---	---	GOOD TEST	Dry	2.1	23200	4.464	5200
-87	---	---	---	---	---	GOOD TEST	Dry	1.9	5250	4.468	1180
-96	---	---	---	---	---	GOOD TEST	Dry	2.1	3100	4.498	690
-97	621	590	369	2.46	5.3	sheared between ss & sh	wet	1.4*	2950	4.494	656/630*

* corrected for L/D < 2, see formula, section 7.1.9 $C = C_a / (0.88 + (0.24 b/h))$

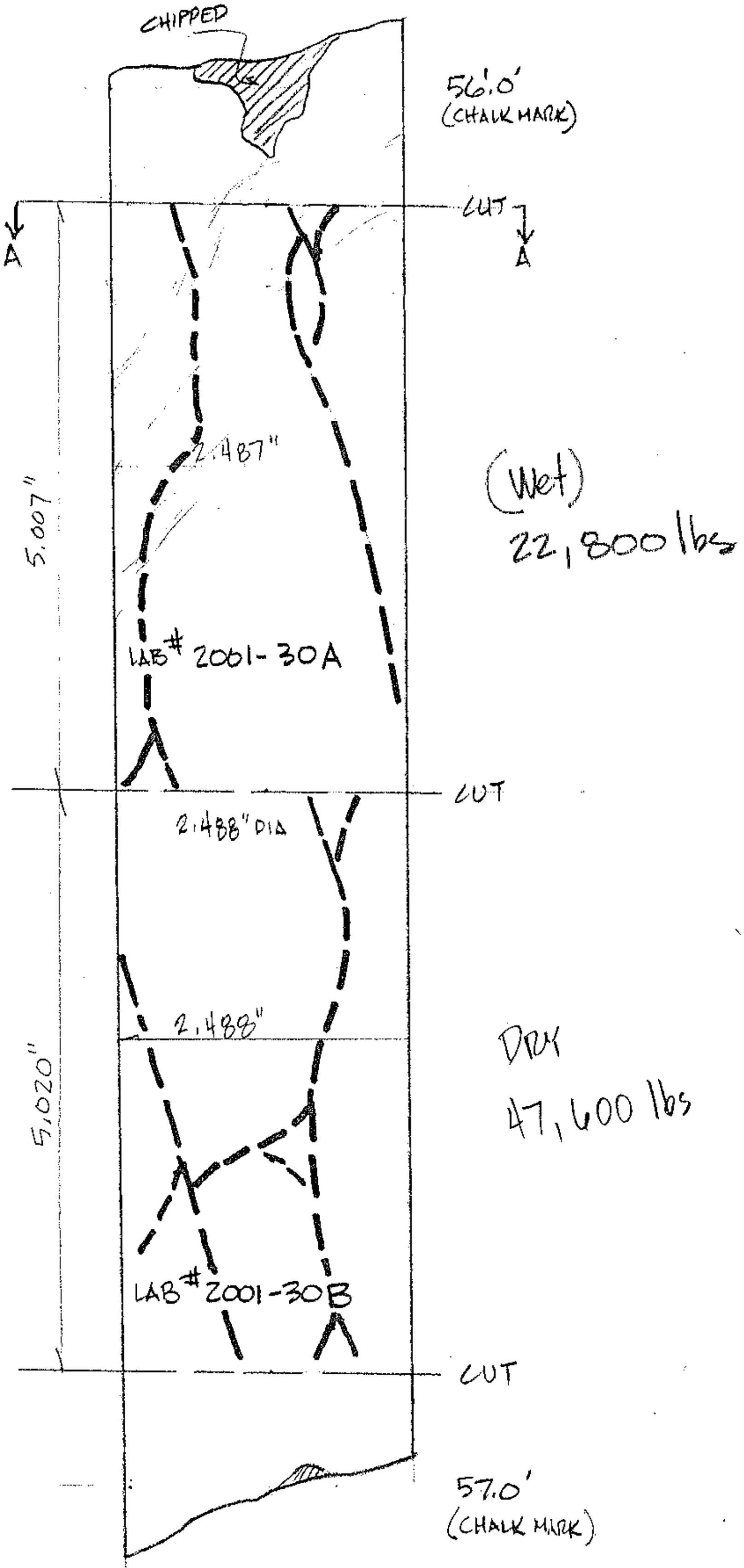
** translucent glob of gel observed (after soaking) leached from bedding

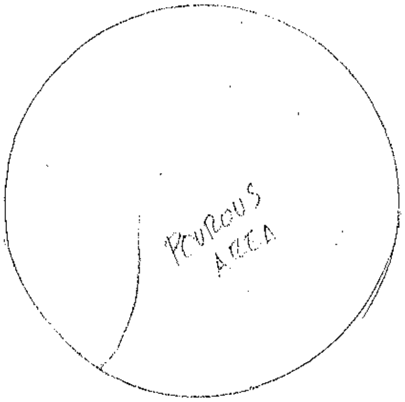
A: tested in Tinius Olsen test machine using medium range - all others were tested WIEDEMAN Baldwin





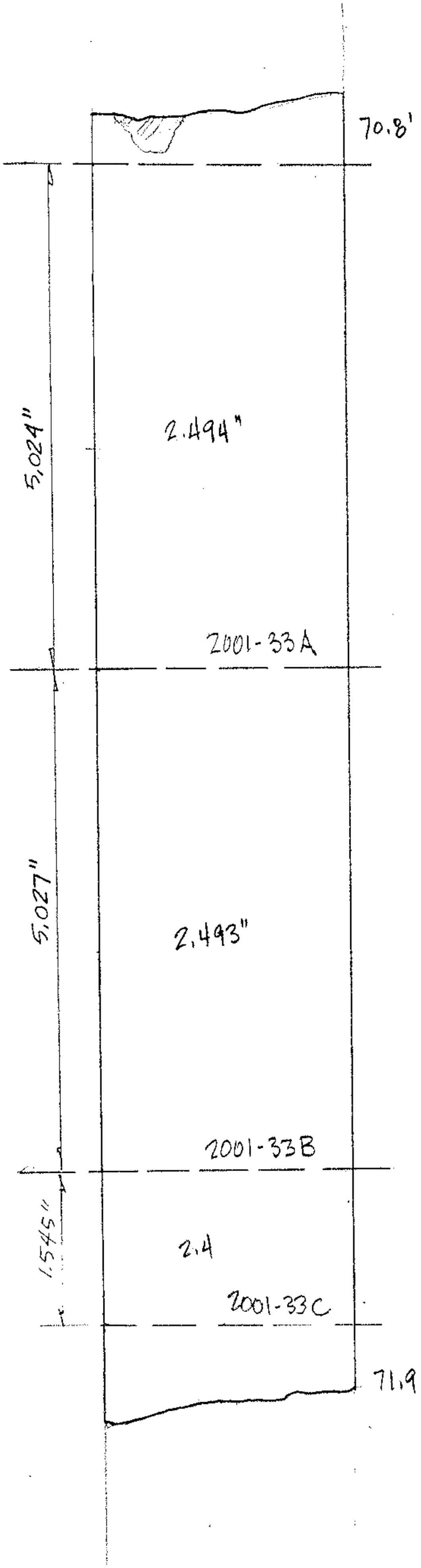
PROJECT: SITES RESERVOIR
HOLE #: GGC-LA1
DEPTH (ft): 75.8 - 77.3
SOILS LAB #: 2001-28



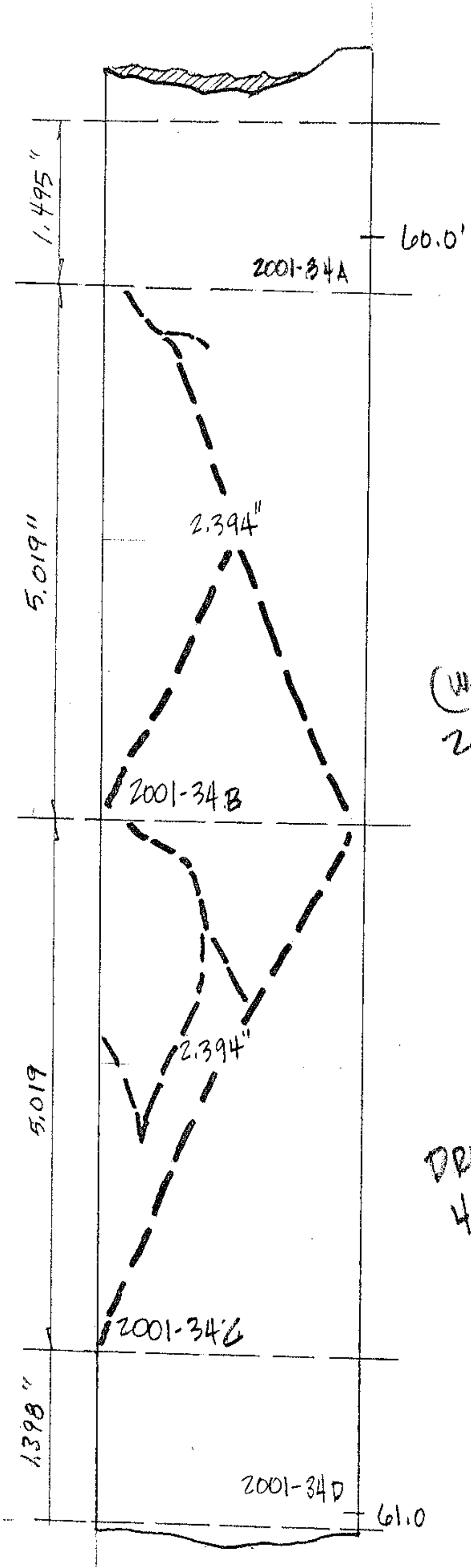


SECTION A-A

PROJECT: SITES
HOLE #: GGC-RC1
DEPTH (ft): 56.0 - 57.0
SOILS LAB #: 2001-30



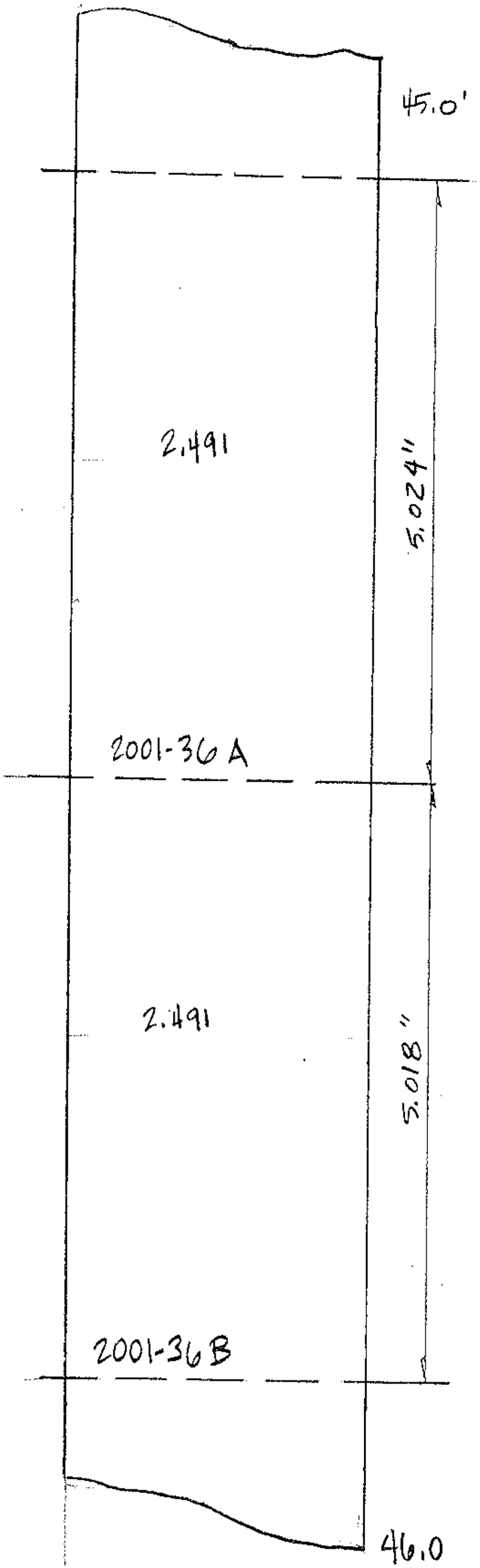
PROJECT: SITES
HOLE #: GGC-RC2
DEPTH (ft): 70.8 - 71.9
SOILS LAB #: 2001-33



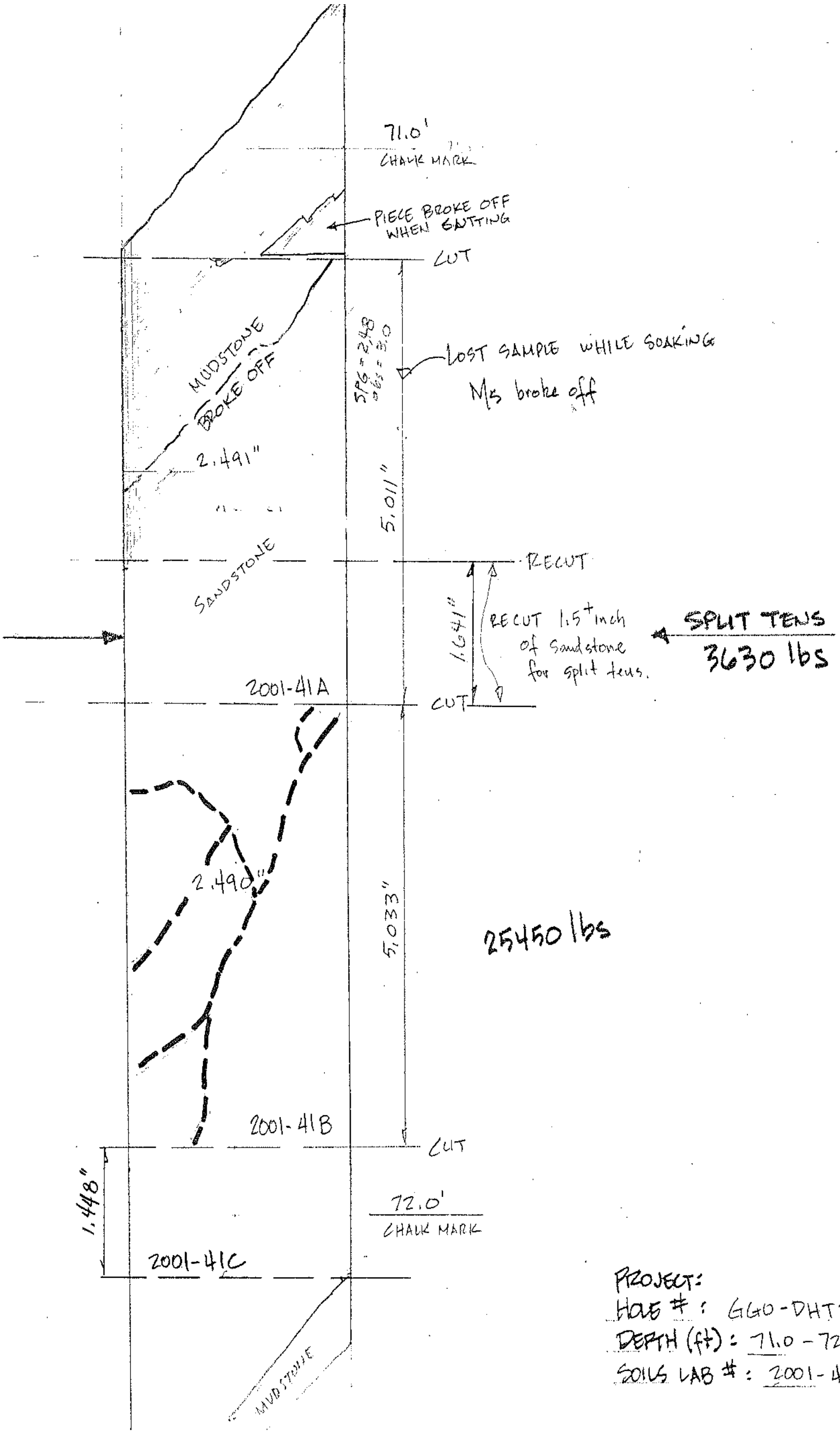
(wet)
21,650 lbs

DRY
45,000

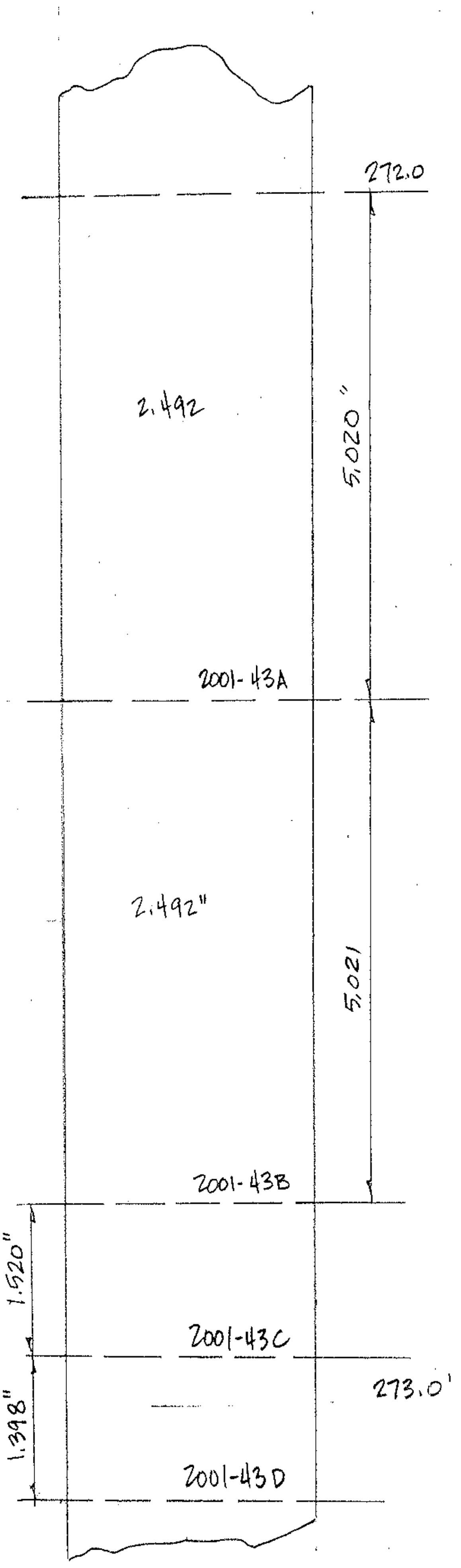
PROJECT:
HOLE # : GGC-RA1
DEPTH (ft) : 59.9 - 61.0
SOILS LAB # : 2001-34



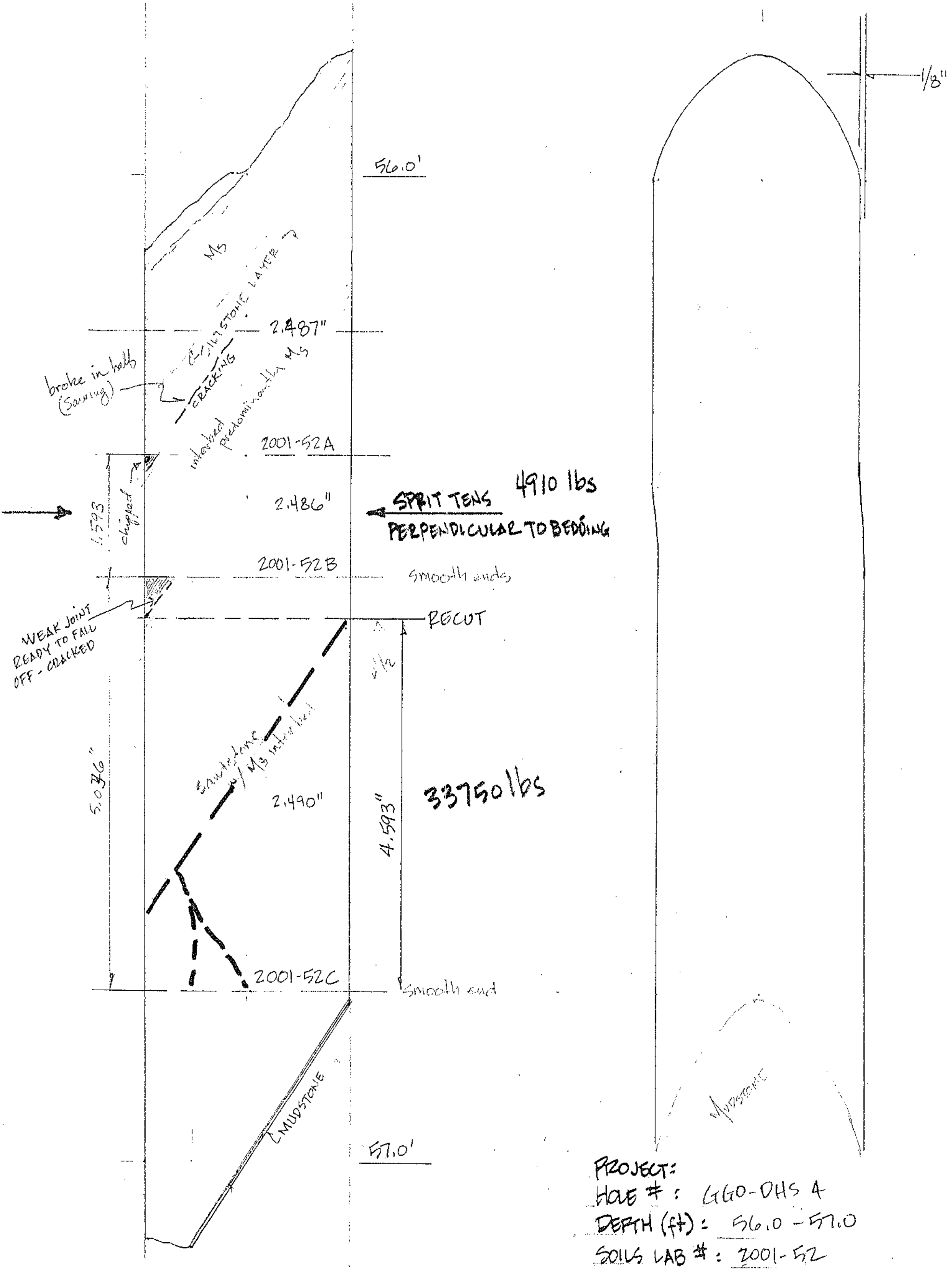
PROJECT:
HOLE # : GGO-DHS-3
DEPTH (ft) : 45.0 - 46.0
SOILS LAB # : 2001-36



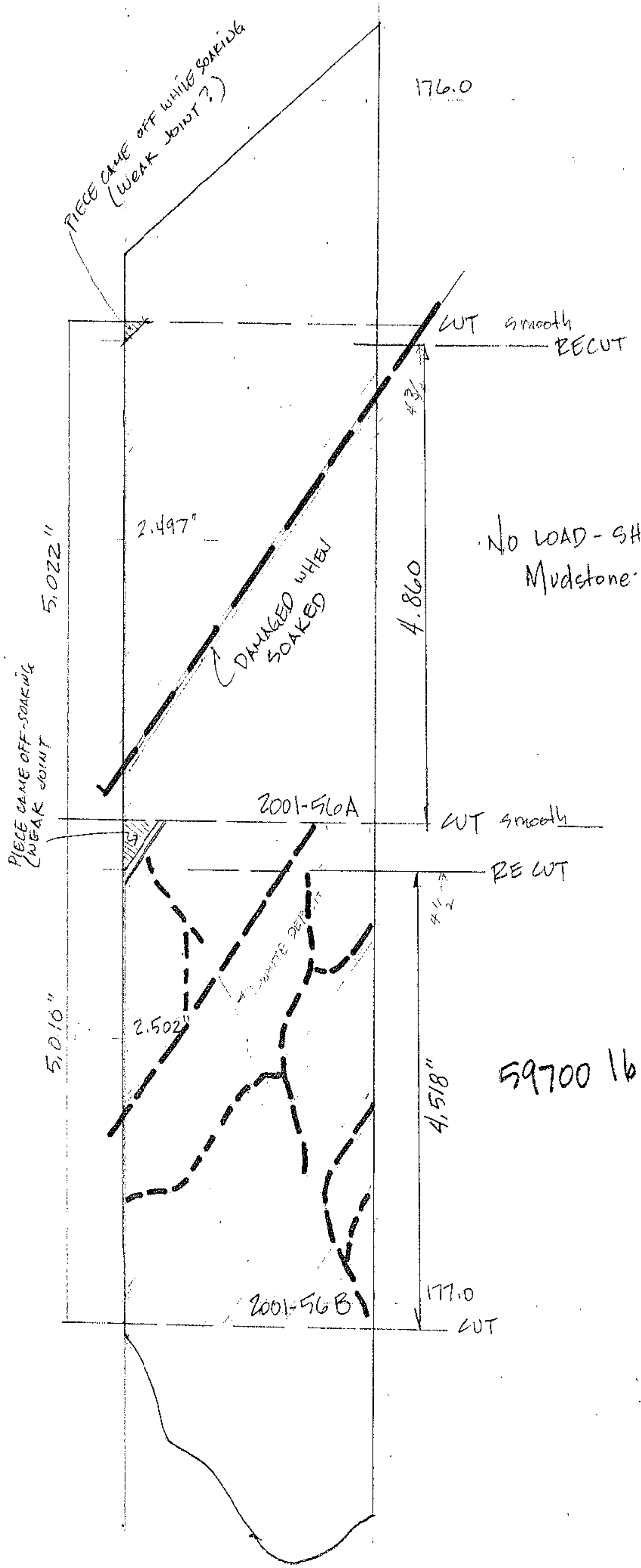
PROJECT:
HOLE # : GGO-DHT3
DEPTH (ft) : 71.0 - 72.2
SOILS LAB # : 2001-41



PROJECT:
HOLE #: GGO DHT 3
DEPTH (ft): 272.0 - 273.0'
SOILS LAB #: 2001-43



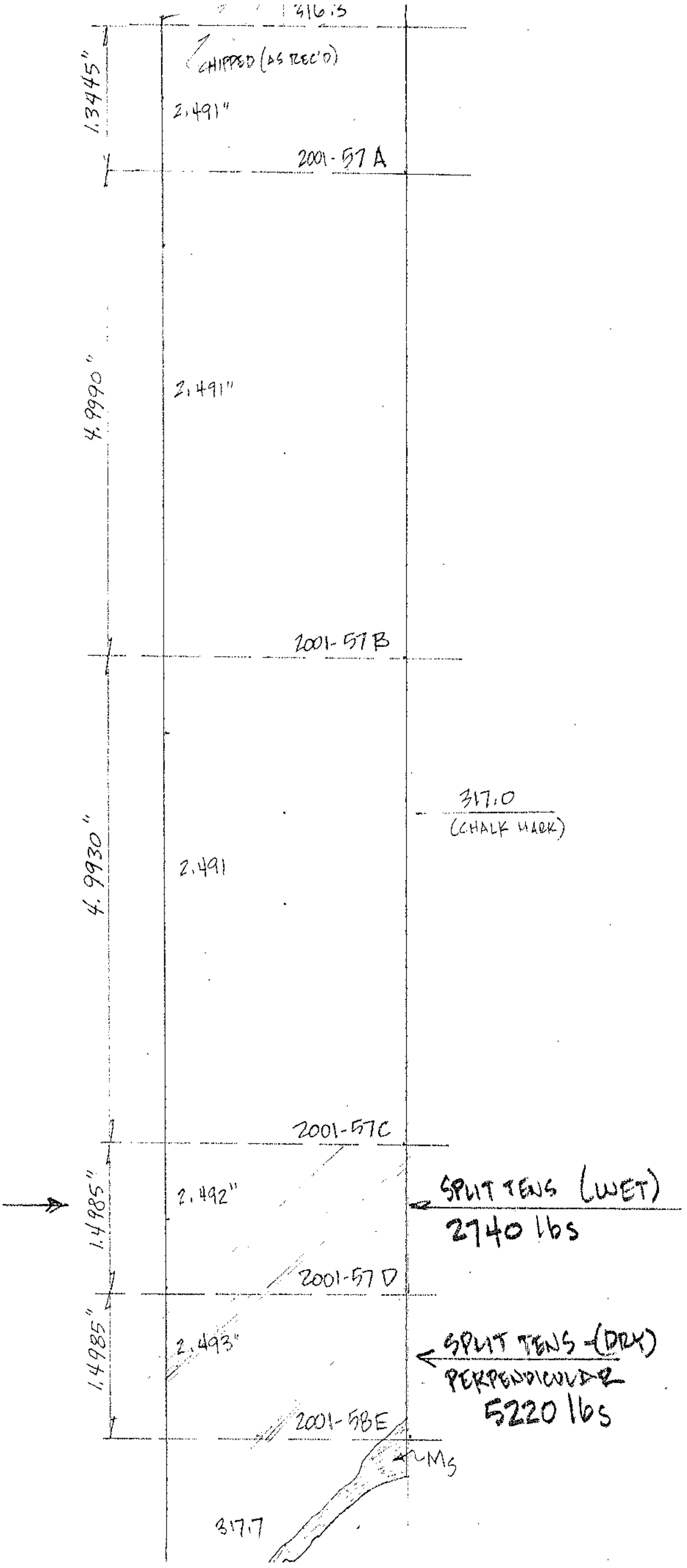
PROJECT:
HOLE #: GGO-DHS 4
DEPTH (ft): 56.0 - 57.0
SOILS LAB #: 2001-52



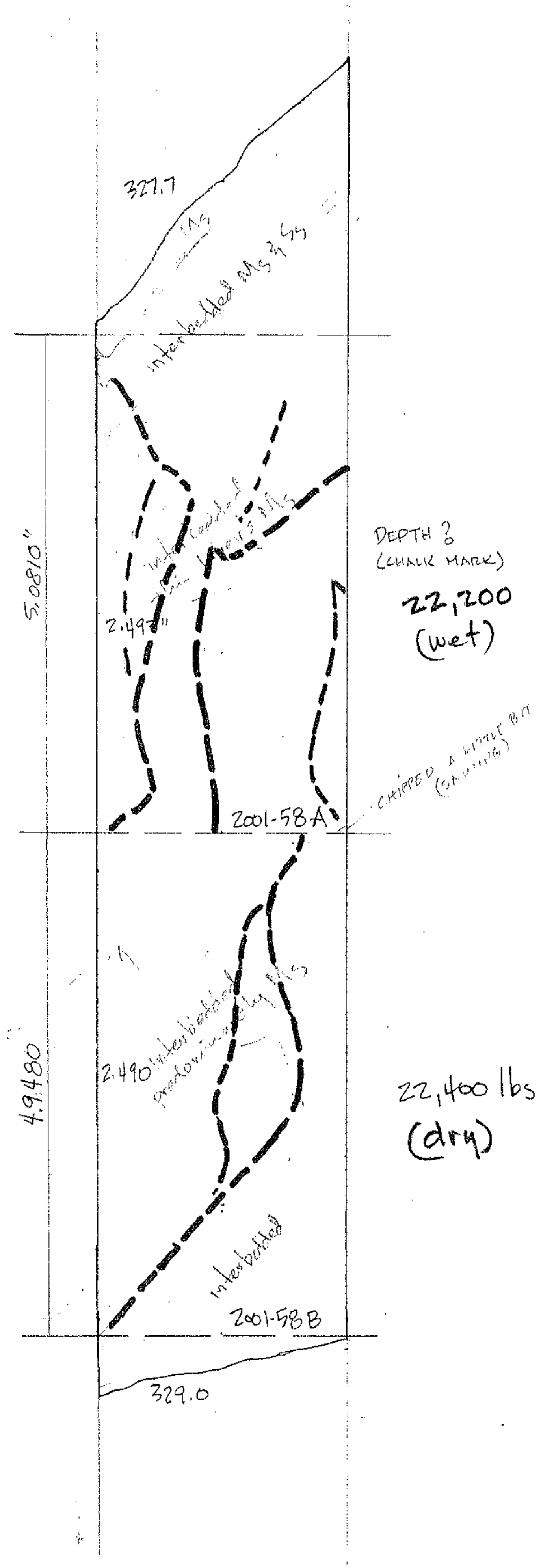
NO LOAD - SHEARED
Mudstone damaged by soak water

59700 lbs

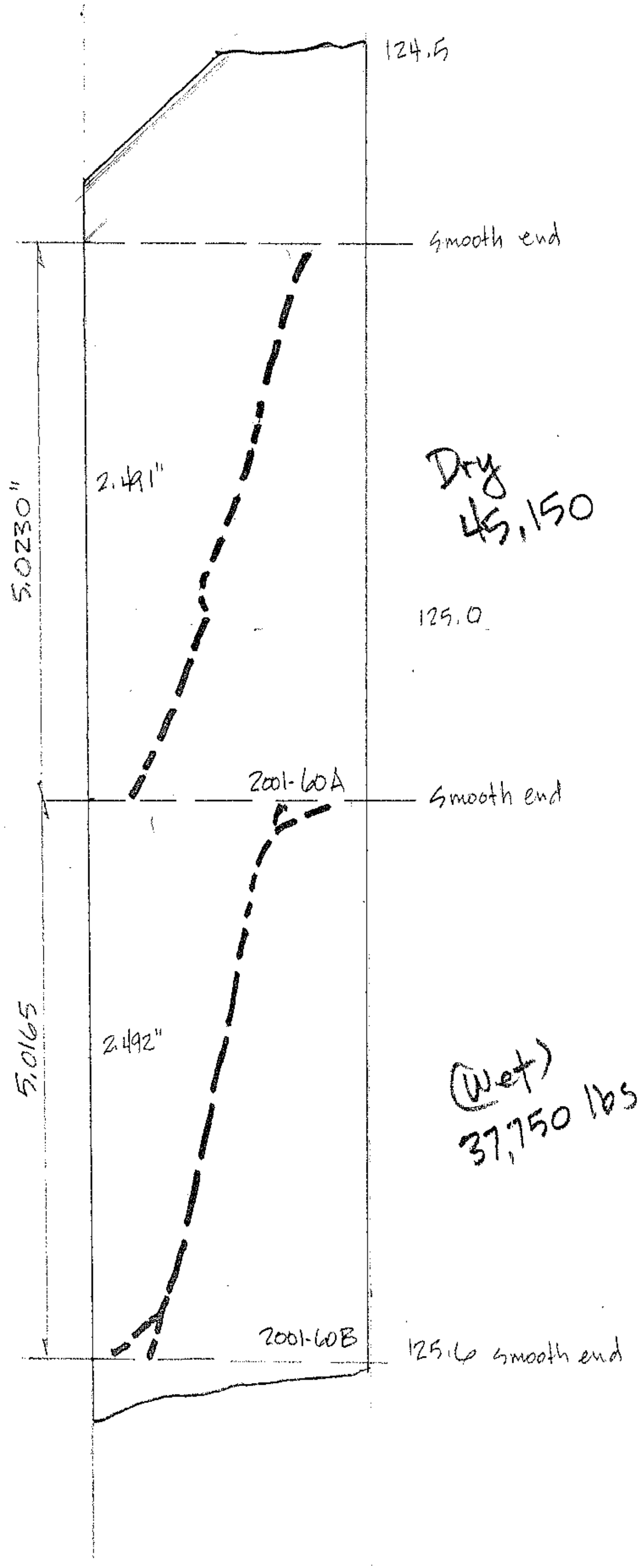
PROJECT:
HOLE # : GGO - DHT-1
DEPTH (ft) : 176.0 - 177.2
SOILS LAB # : 2001-56



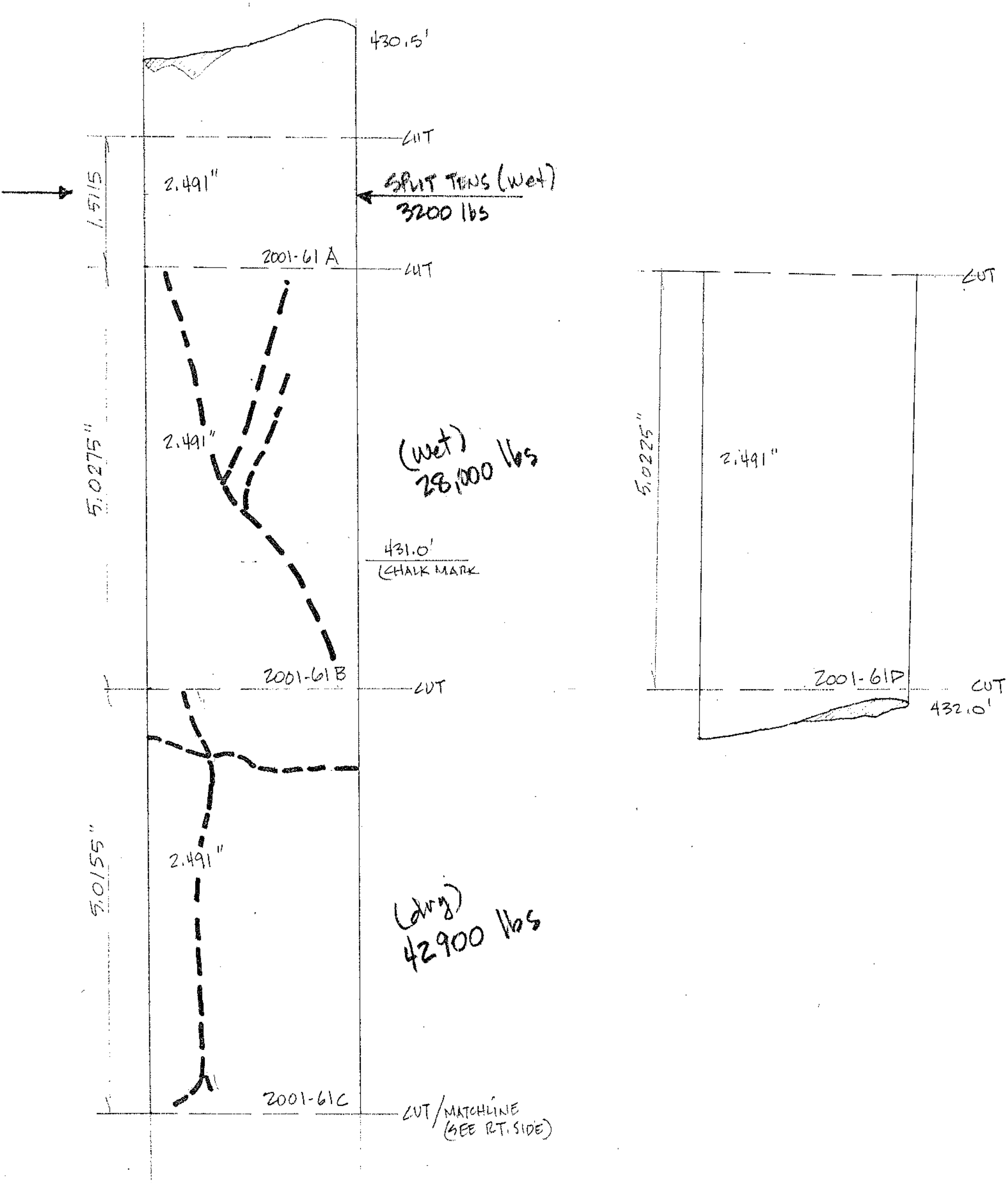
PROJECT:
HOLE # : DHT-3
DEPTH (ft) : 316.3 - 317.7
SOILS LAB # : 2001-57



PROJECT:
HOLE # : GGO-DHT3
DEPTH (ft) : 327.7 - 329.0
SOILS LAB # : 2001-58



PROJECT:
HOLE # : GGO-DHT-4
DEPTH (ft) : 124.5 - 125.5
SOILS LAB # : 2001-60



PROJECT:
HOLE # : DGGO-DHT5
DEPTH (ft): 430.5 - 432.0
SOILS LAB # : 2001-61

6-Inch Diameter x 12-Inch Long Cores from Sites Quarry

Physical Properties of 6-Inch Diameter Sandstone Rock Cores from Sites Quarry

Lab No.	Weathering	Unconfined Compressive Strength (psi)		Young's Modulus ($\times 10^6$ psi)		Poisson's Ratio		Brazilian Tensile Strength (psi)		Orientation to Bedding
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	
99C-62	Mod. Weathered	5,511		0.945		0.06				
99C-55	Mod. Weathered	4,842		0.896		0.16				
99C-59	Mod. Weathered	4,640		0.906		0.10				
99C-53	Mod. Weathered		3,790		0.663		0.10			
99C-59	Mod. Weathered		3,516		0.730		0.11			
99C-61	Mod. Weathered		3,461		0.813		0.15			
99C-66	Fresh	8,994		1.303		0.22				
99C-69	Fresh	9,983		1.262		0.15				
99C-73	Fresh	9,727		1.209		0.14				
99C-70	Fresh		6,904		1.157		0.22			
99C-72	Fresh		6,818		1.188		0.14			
99C-74	Fresh		7,227		1.196		0.13			
99C-54-3A	Mod. Weathered								182	parallel
99C-54-3B	Mod. Weathered								272	perpendicular
99C-54-3C	Mod. Weathered							247		parallel
99C-54-3D	Mod. Weathered							450		perpendicular
99C-56-5A	Mod. Weathered								172	parallel
99C-56-5B	Mod. Weathered								278	perpendicular
99C-56-5C	Mod. Weathered							235		parallel
99C-56-5D	Mod. Weathered							415		perpendicular
99C-58-7A	Mod. Weathered								174	parallel
99C-58-7B	Mod. Weathered								282	perpendicular
99C-58-7C	Mod. Weathered							279		parallel
99C-58-7D	Mod. Weathered							461		perpendicular
99C-60-9A	Mod. Weathered								145	parallel
99C-60-9B	Mod. Weathered								301	perpendicular
99C-60-9C	Mod. Weathered							304		parallel
99C-60-9D	Mod. Weathered							470		perpendicular
99C-67-2A	Fresh								394	parallel
99C-67-2B	Fresh								577	perpendicular
99C-67-2C	Fresh							617		parallel
99C-67-2D	Fresh							763		perpendicular
99C-71-6A	Fresh								433	parallel
99C-71-6B	Fresh								612	perpendicular
99C-71-6C	Fresh							561		parallel
99C-71-6D	Fresh							798		perpendicular
99C-75-10A	Fresh								342	parallel
99C-75-10B	Fresh								367	perpendicular
99C-75-10C	Fresh							626		parallel
99C-75-10D	Fresh							629		perpendicular
99C-78-13A	Fresh								318	parallel
99C-78-13B	Fresh								508	perpendicular
99C-78-13C	Fresh							539		parallel
99C-78-13D	Fresh							754		perpendicular
	Average for Fresh =	9,568	6,983	1.258	1.180	0.170	0.164	661	444	
	Average for Mod. Weathered =	4,998	3,589	0.916	0.735	0.107	0.120	358	226	

		(inches) AVG LENGTH	(inches) AVG DIAMETER	(sq. in) Area	(cu ft.) Volume	AIR DRY WT. (lbs)	Unit Wt (pcf) by AIR DRY dimension	Unit wt (pcf) SSD		Modulus ELASTICITY		L/D RATIO
1-52	1											
-53	2	12.01	5.934	27.67	.1923	28.468	148.0	151.9	3800 psi	5/3	wet	2.02
-54	3	SPLIT TENSILE. 4 TEST SPECIMEN CUT TO 3" LENGTH										
-55	4	11.96	5.934	27.66	.1914	28.514	149.0	.....	4840 psi	5/3	dry	2.02
-56	5	SPLIT TENSILE										
-57	6	11.99	5.935	27.67	.1920	28.396	147.9	152.1	3520 psi	5/3	wet	
-58	7	SPLIT TENSILE										
-59	8	11.99	5.938	27.69	.1922	28.424	147.9	.....	4640 psi	5/3	dry	2.02
-60	9	SPLIT TENSILE										
-61	10	11.98	5.937	27.68	.1919	28.426	148.1	152.0	3470 psi	5/3	wet	2.02
-62	11	12.04	5.938	27.69	.1930	28.752	149.0	.....	5490 psi	5/3	dry	2.03
-63	⑫	Petrographic Analysis										
-64	13	11.98	5.939	compression test only - to determine ultimate strength before performing modulus of elasticity					4240 psi	5/3	wet	2.02
-65	14											
-66	1	11.67	5.937	27.68	.1870	28.220	150.9	---	9020		Dry	1.97
-67	2	SPLIT TENSILE										
-68	3	11.85	5.945	comp. str to determine ult strength					6910 psi	5/3	Wet	1.99
-69	4	12.08	5.933	27.65	.1933	28.962	149.9	----	9980		Dry	2.04
-70	5	12.07	5.935	27.67	.1932	29.070	150.4	154.1	6900	5/11	Wet	2.03
-71	6	SPLIT TENSILE										
-72	7	11.71	5.933	27.65	.1873	28.366	151.4	154.8	6820	5/11	Wet	1.97
-73	8	11.93	5.934	27.66	.1909	28.876	151.2	----	9730		Dry	2.01
-74	9	12.00	5.936	27.66	.1922	29.052	151.2	154.8	7230	5/11	Wet	2.02
-75	10	SPLIT TENSILE										
-76	11											
-77	⑫	Petrographic Analysis										
-78	13	SPLIT TENSILE										

SOILS LAB REQ 99-19

LAB # "CONCRETE" 99C-53

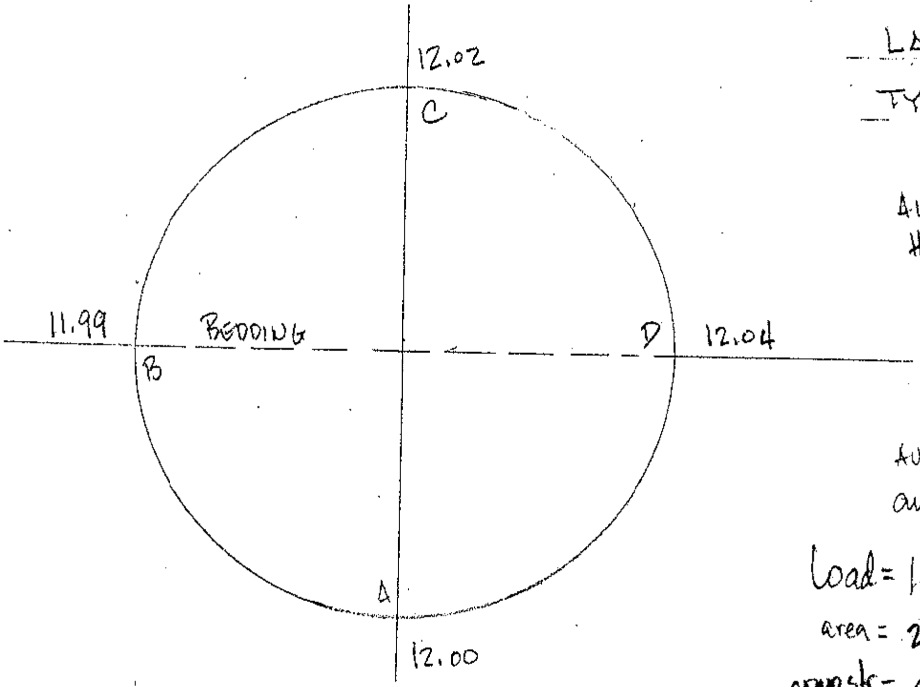
TYPE OF ROCK BROWN

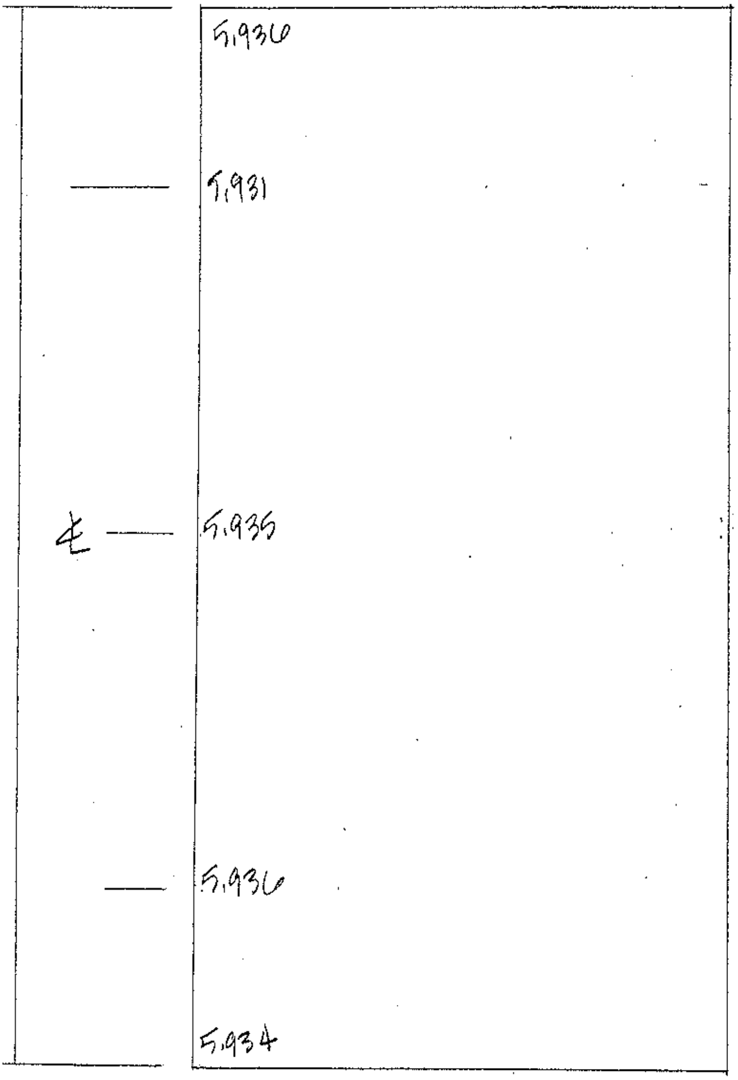
AIR 13228
H_2O 7793

(WET)

Avg ht = 12.01
avg dia = 5.934 ( )

Load = 105,000 lbs
area = 27.66
comp str = 3800 psi

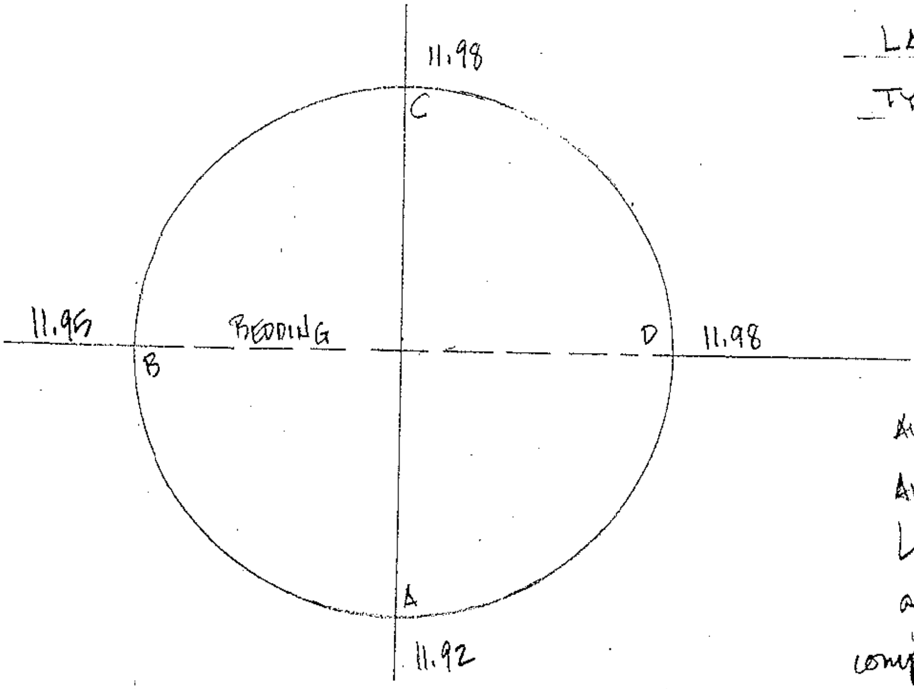




SOILS LAB REQ 99-19 T 4

LAB # "CONCRETE" 99C-55

TYPE OF ROCK BROWN



(DRY)

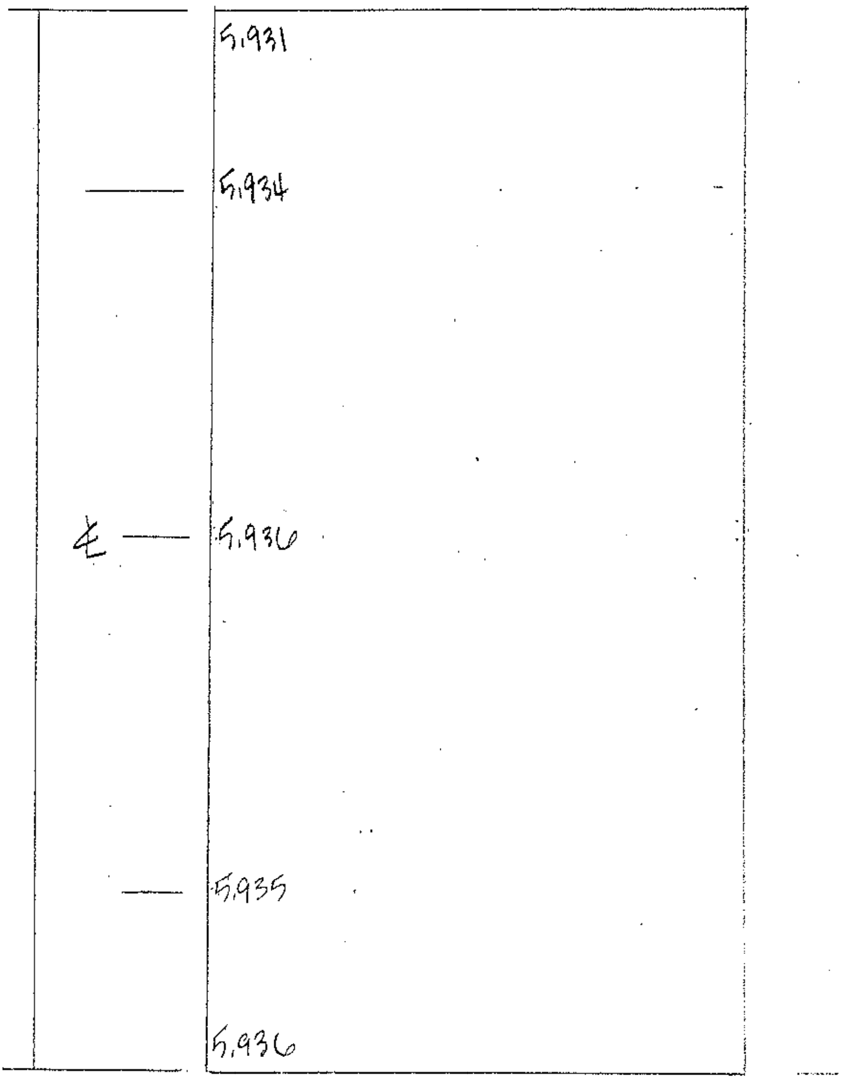
Avg ht = 11.96

Avg dia = 5.934 (5.936)

Load = 134,000 lbs

area = 27.67 #

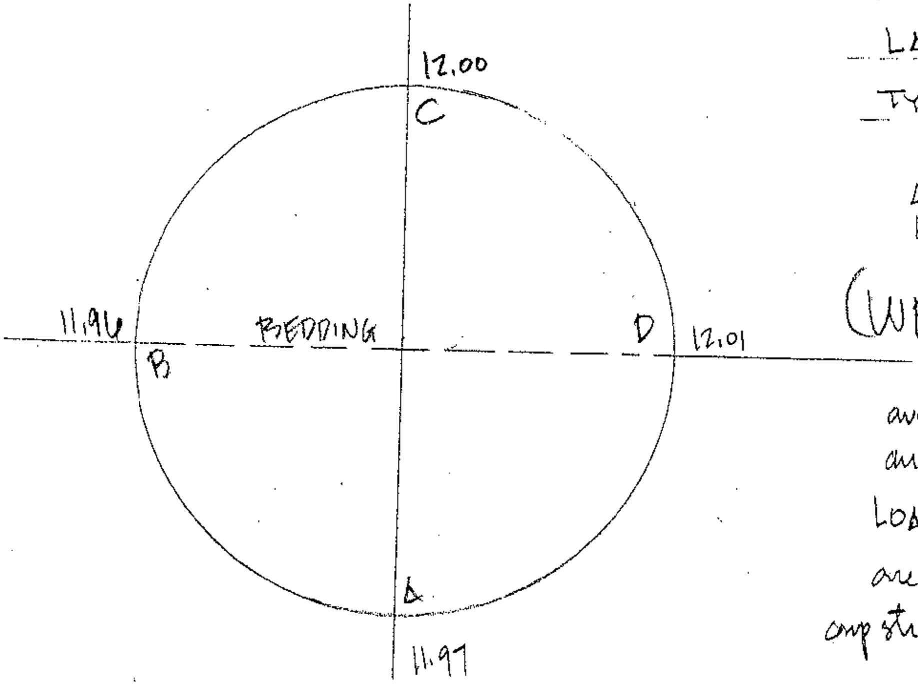
comp. str = 4840 psi



SOILS LAB REQ 99-19

LAB # "CONCRETE" 99C-57

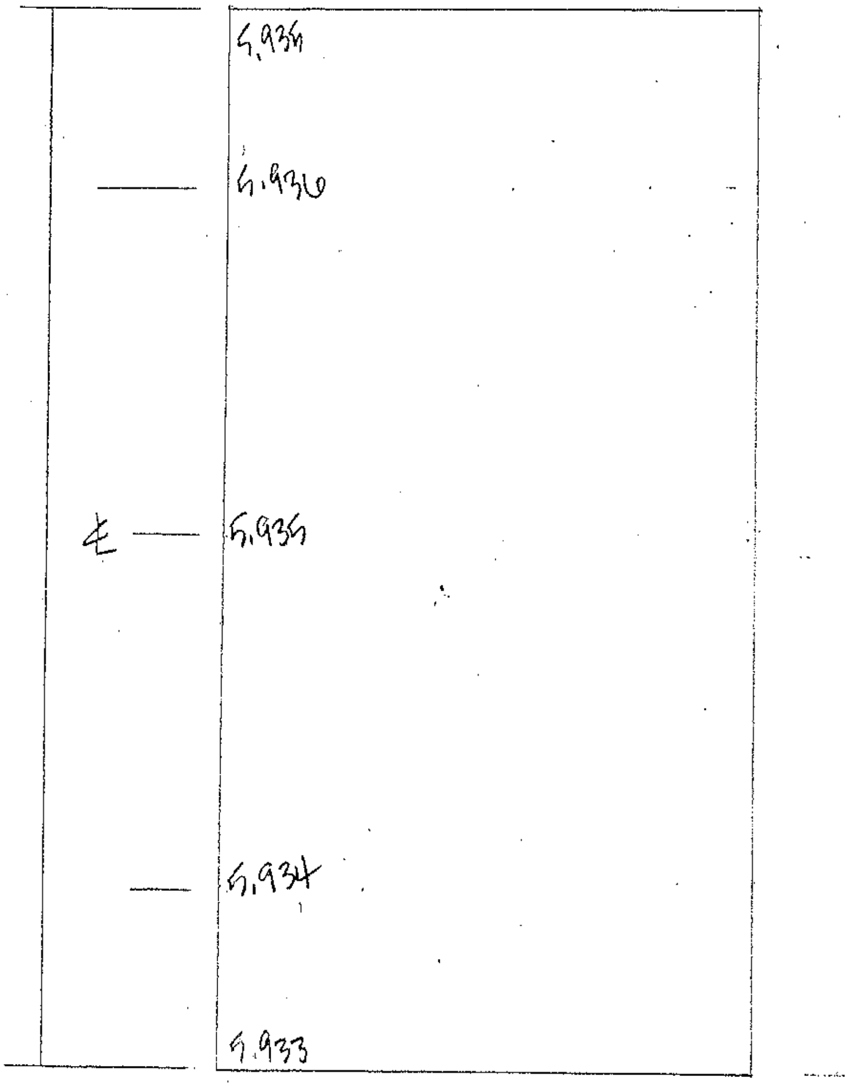
TYPE OF ROCK BROWN



AIR 13198
H_2O 7785

(WET)

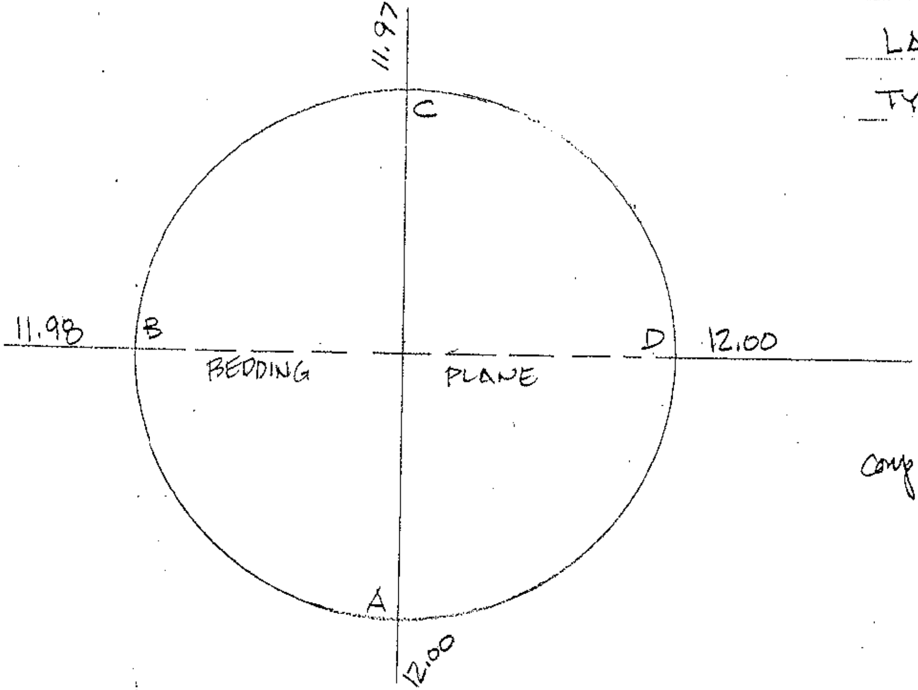
avg ht = 11.99
avg dia = 5.935 (5.942)
LOAD = 97,500 lbs
area = 27.73 #
cmp str = 3520 psi



SOILS LAB REQ 99-19 #8

LAB # "CONCRETE" 99C-59

TYPE OF ROCK BROWN



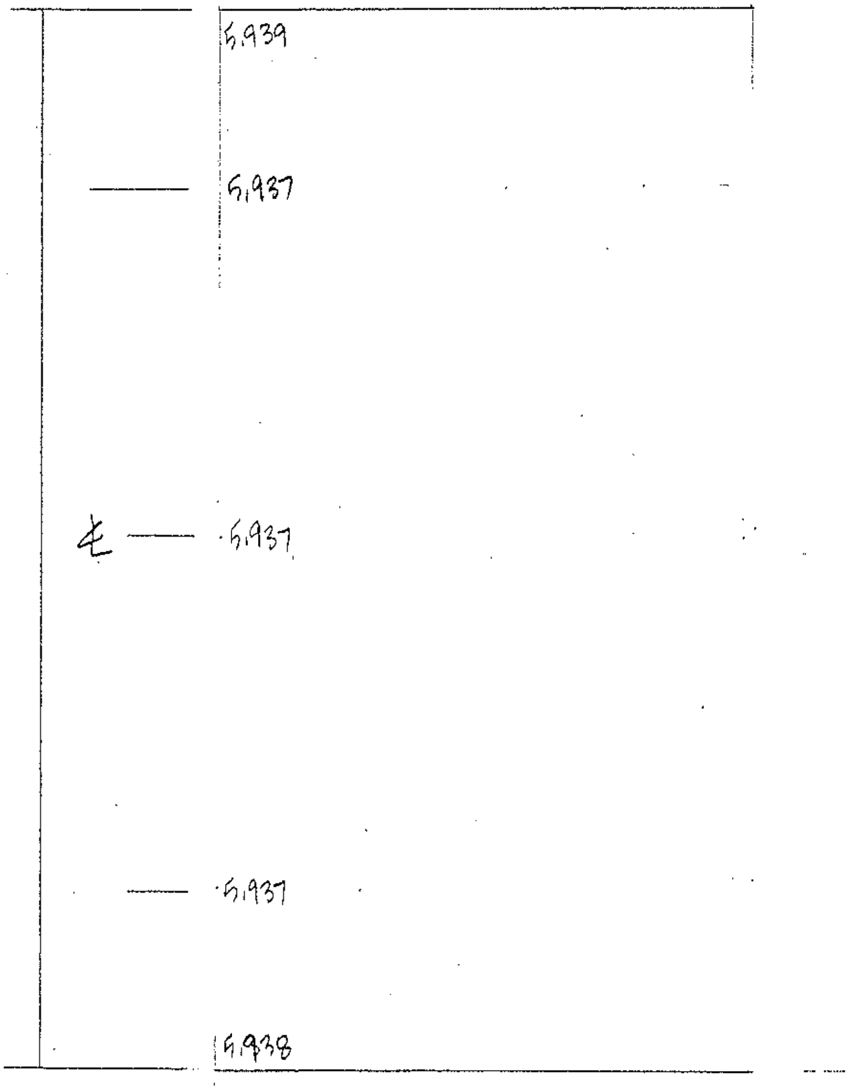
Avg ht = 11.99

Avg Dia = 5.938 (5.938)

Load = 128,500 lbs

area = 27.69

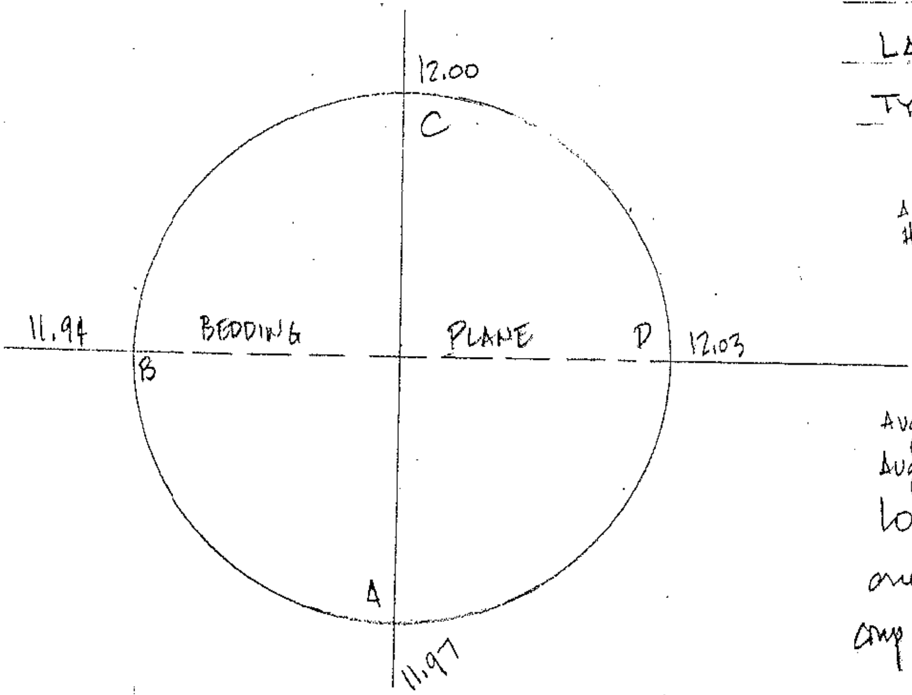
comp str = 4640 psi



SOILS LAB REQ 99-19

LAB # "CONCRETE" 99C-61

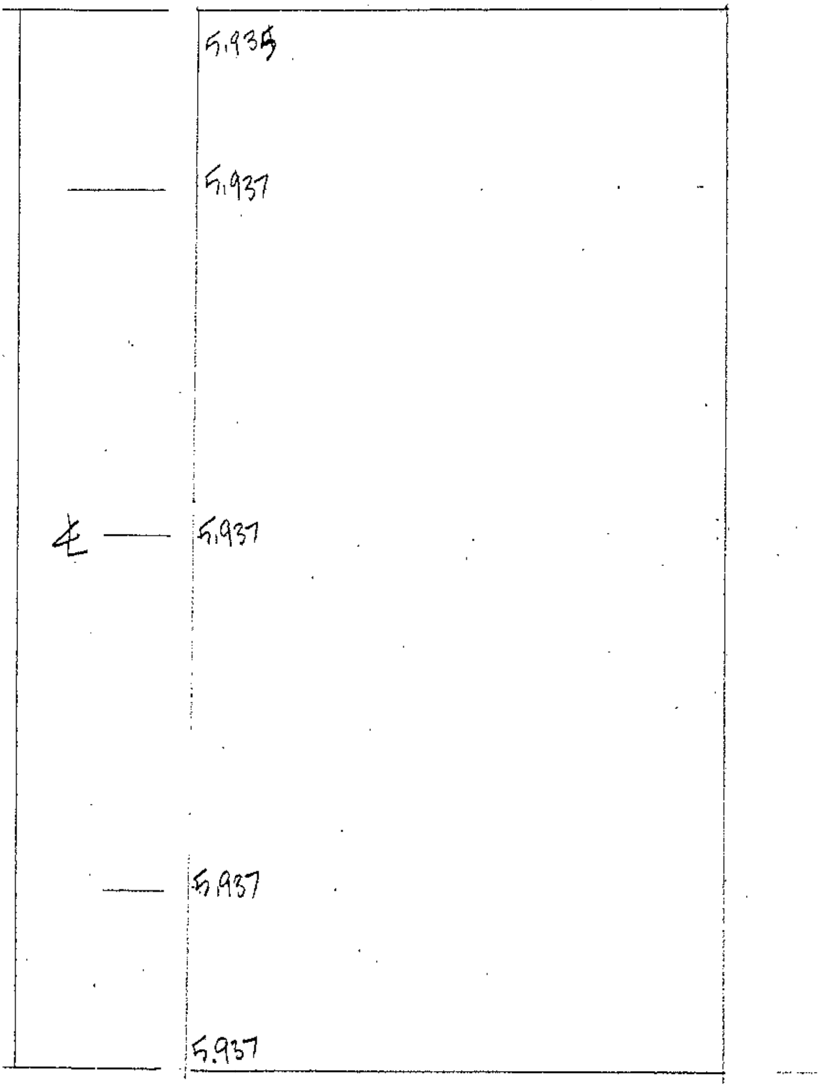
TYPE OF ROCK BROWN



AIR 13200
H_2O 7782

(WET)

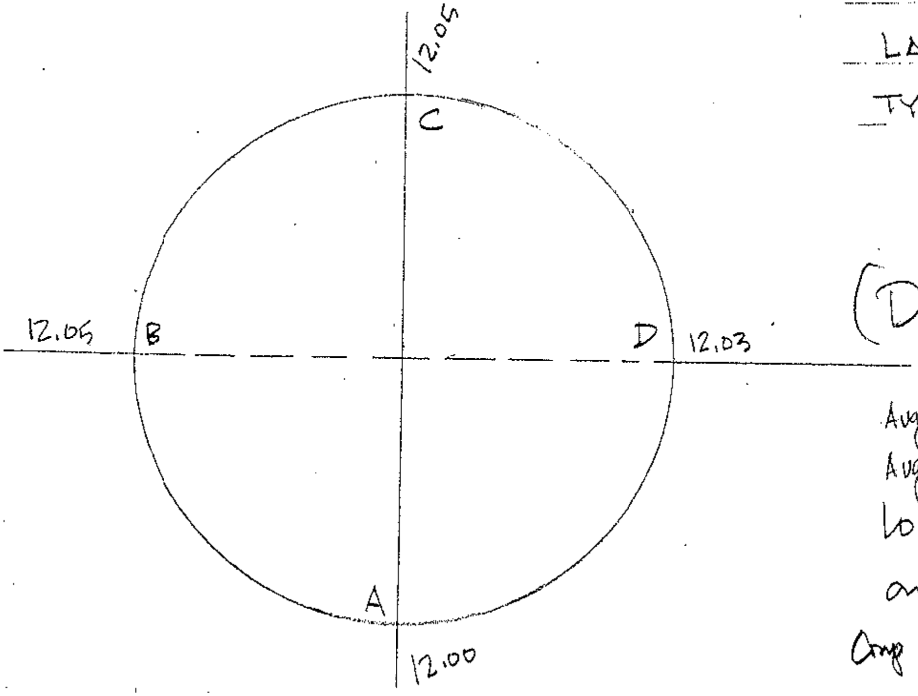
Avg ht = 11.98
Avg dia = 5.937 (~~5.943~~)
load = 96,000 lbs
area = 27.68 #
comp str = 3470 psi



SOILS LAB REQ 99-19 #11

LAB # "CONCRETE" 99C-62

TYPE OF ROCK BROWN



(DRY)

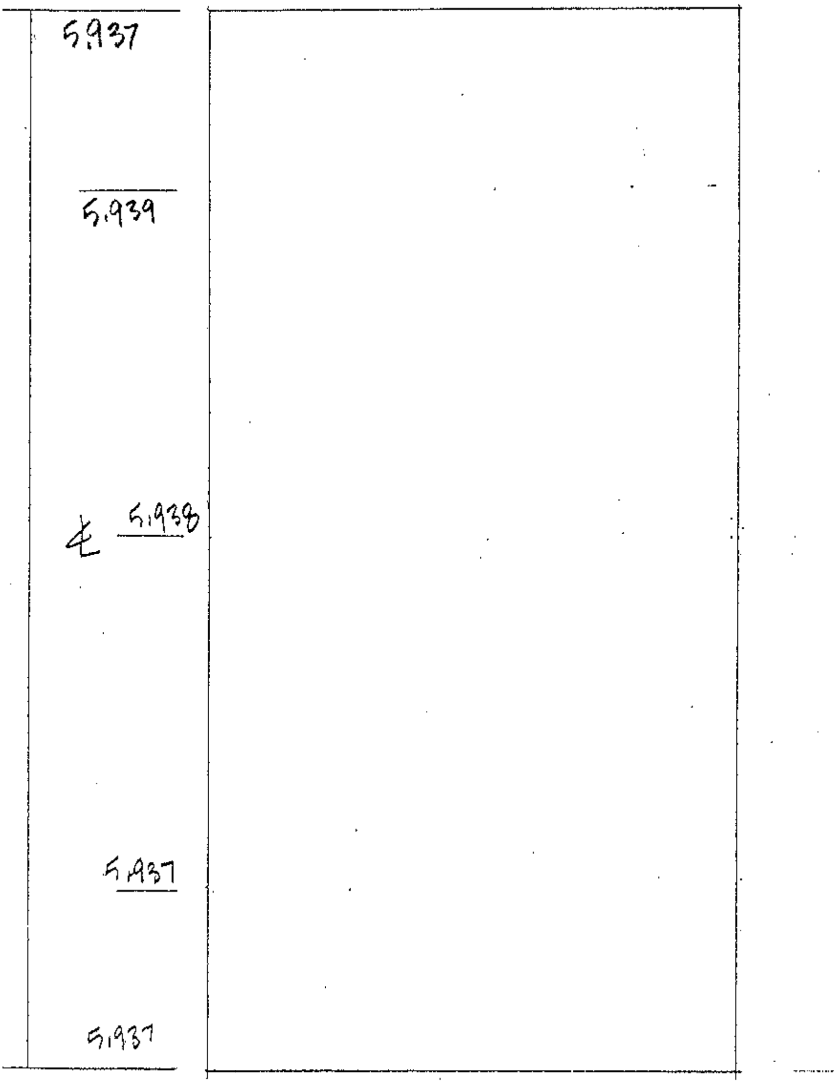
Avg ht = 12.04

Avg dia = 5.938 (~~5.936~~)

load = 152,500 lbs

area = 27.69 #

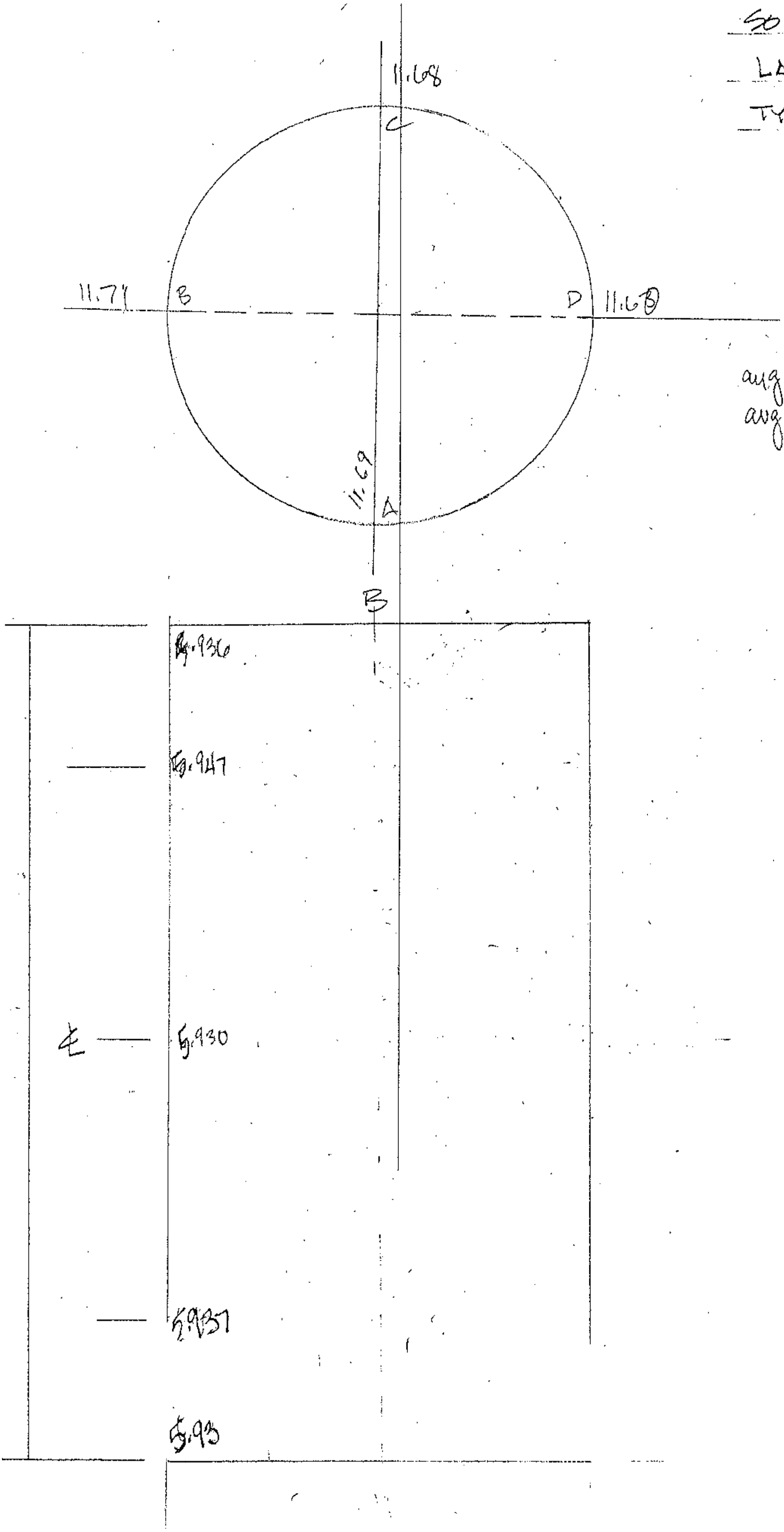
Comp str = 5490



SOILS LAB REQ 99-19

LAB # "CONCRETE" 99C-666

TYPE OF ROCK Green



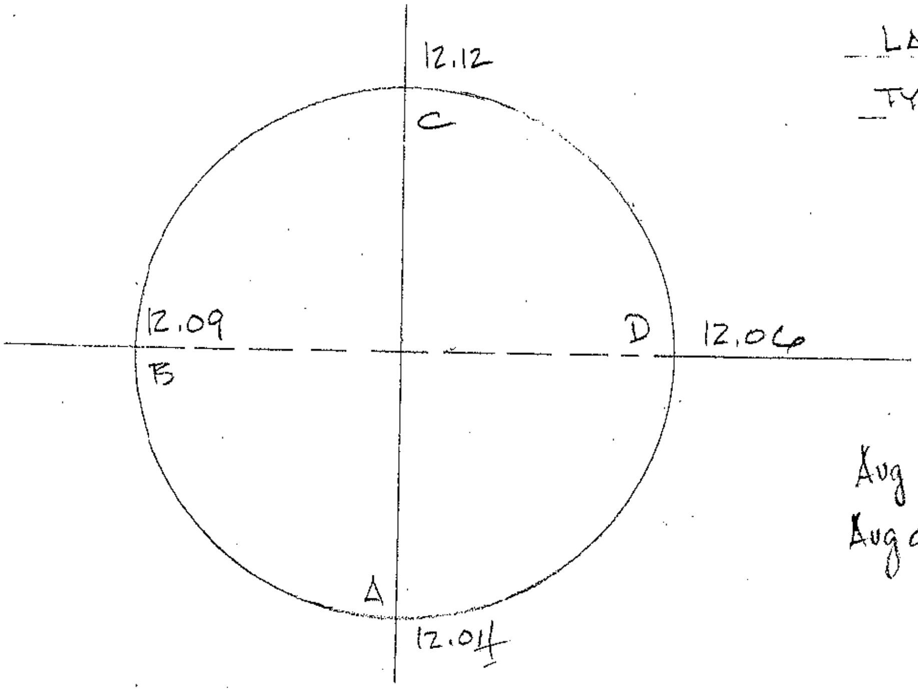
avg ht = 11.67

avg dia = 5.937

SOILS LAB REQ 99-19

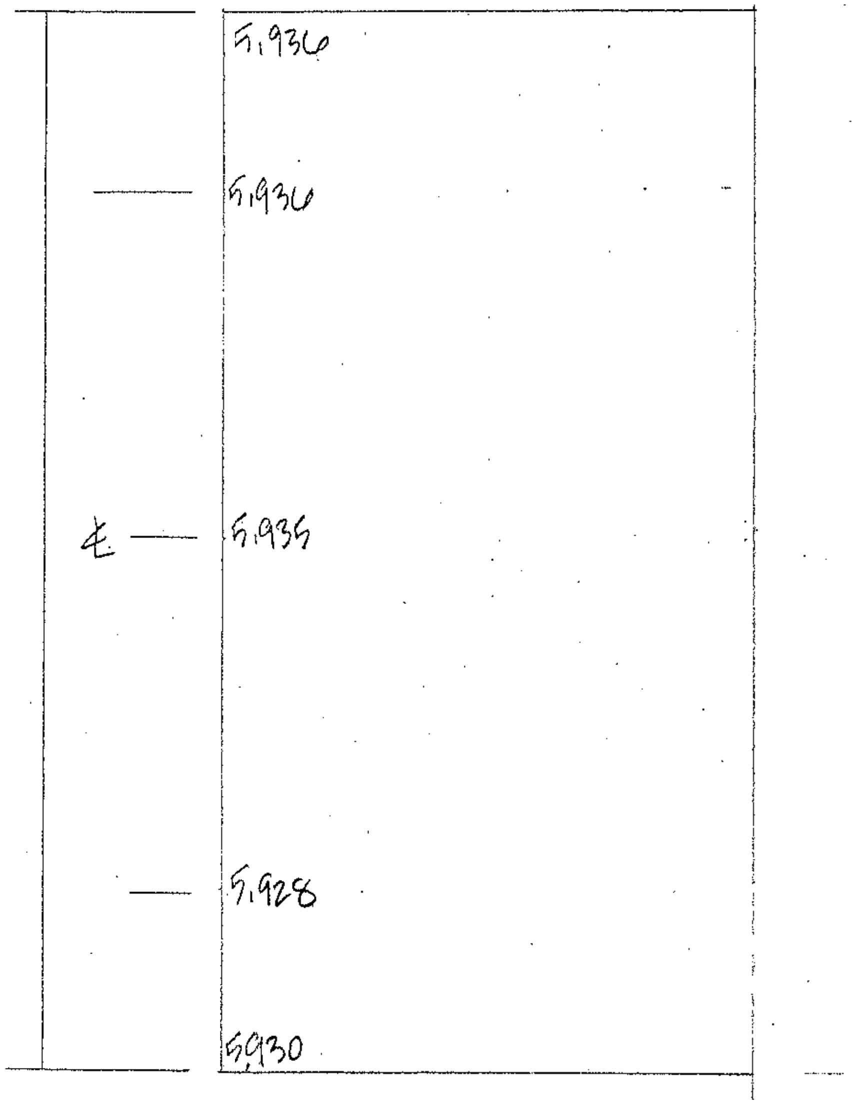
LAB # "CONCRETE" 99C-69

TYPE OF ROCK GREEN



Avg ht = 12.08

Avg dia = 5.933



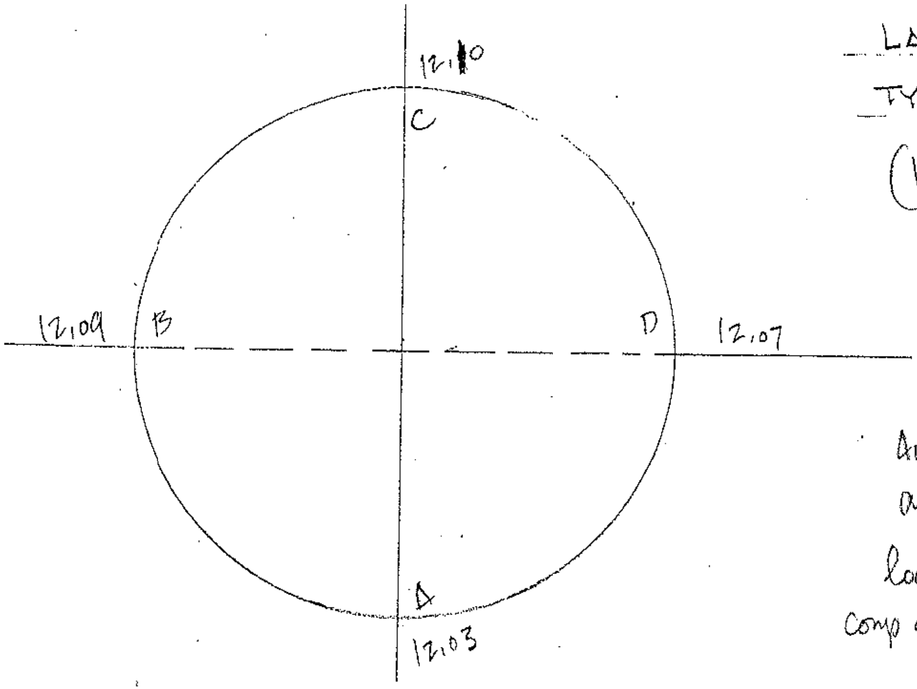
SOILS LAB REQ 99-19

LAB # "CONCRETE" 99C-70

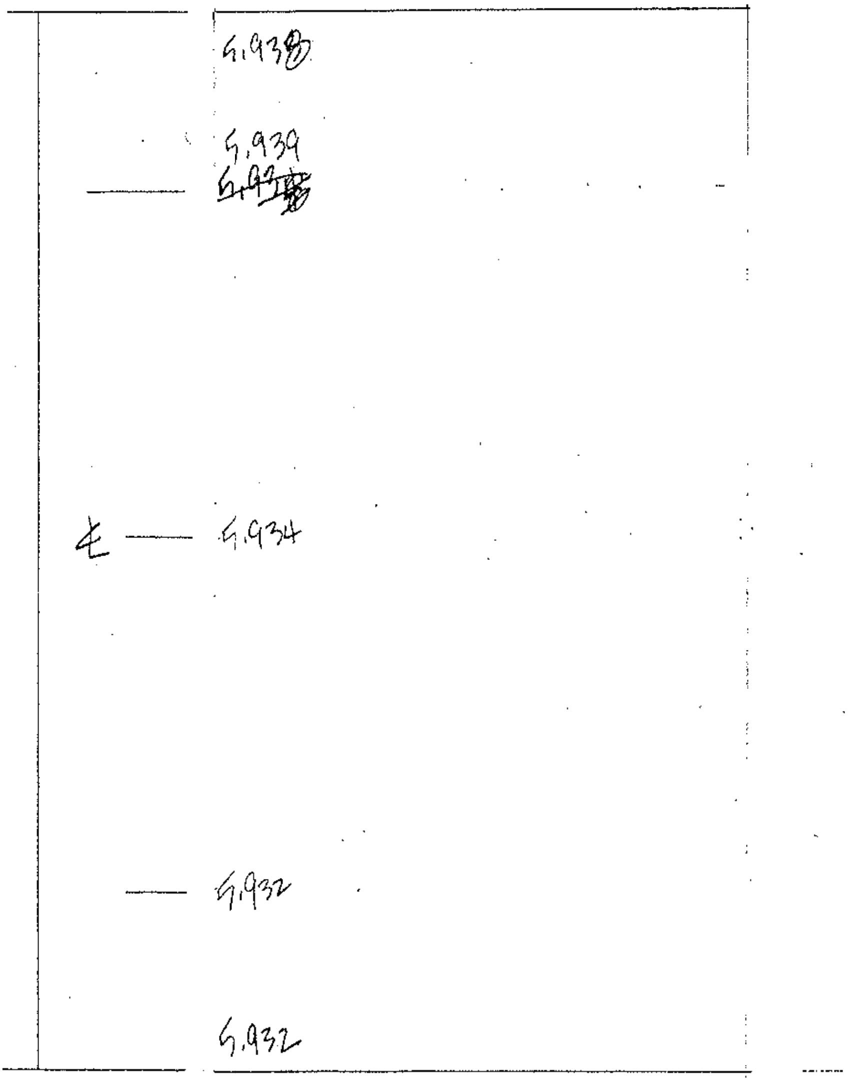
TYPE OF ROCK Green

(Wet)

air = 13486 gms
water = 8023
ssd spg = 2.47



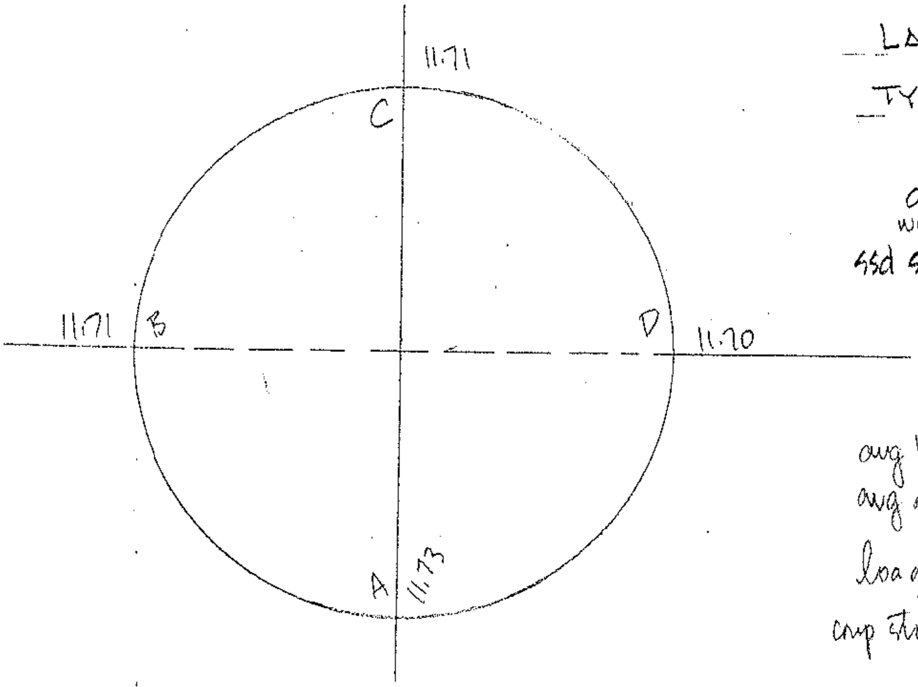
Avg ht 12.07
avg dia 5.935
load = 191,000 lbs
Comp str = 6900 psi



SOILS LAB REQ 99-19

LAB # "CONCRETE" 99C-72

TYPE OF ROCK GREEN



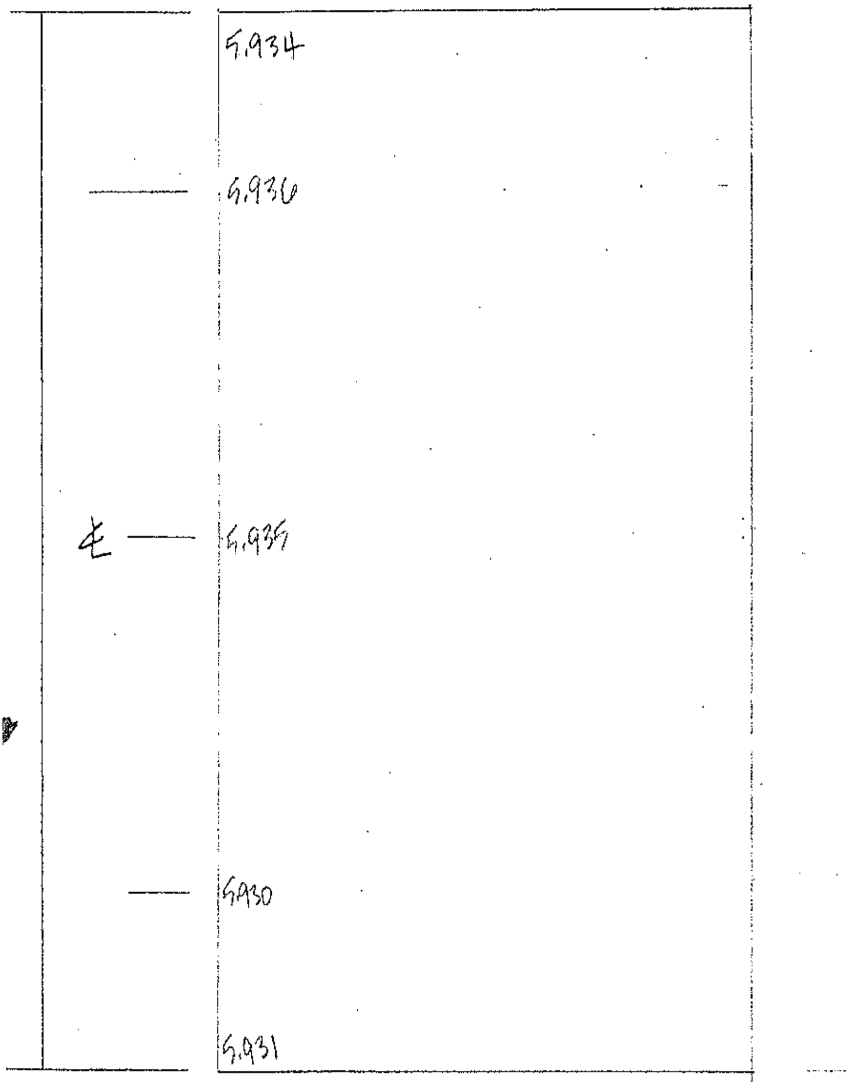
air : 13154
water : 7857
ssd spg : 2.48

(Wet)

avg ht = 11.71
avg dia = 5.933

load = 188500

cmp stn = 6820



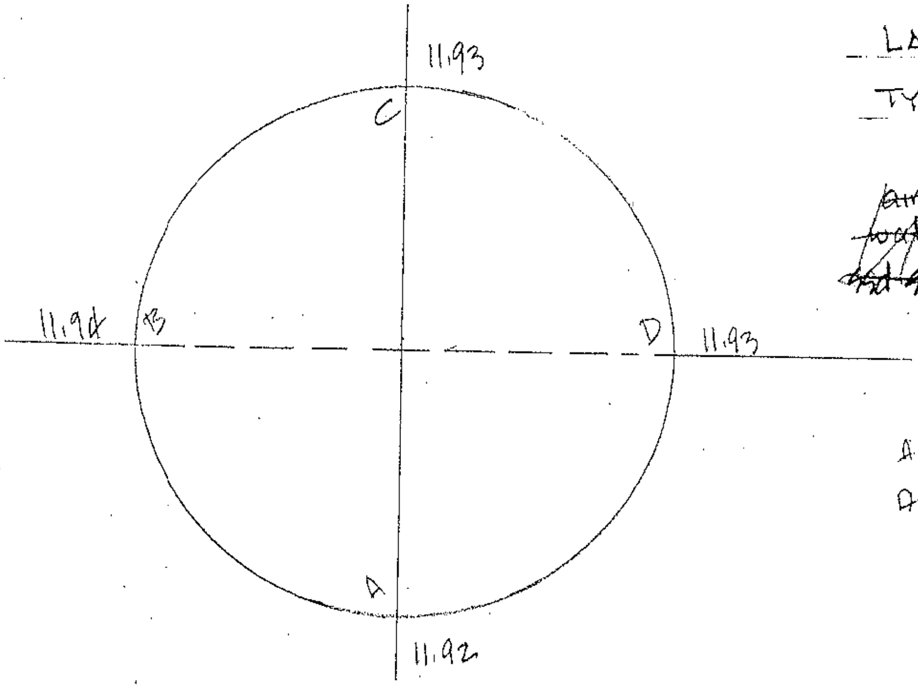
SOILS LAB REQ 99-19

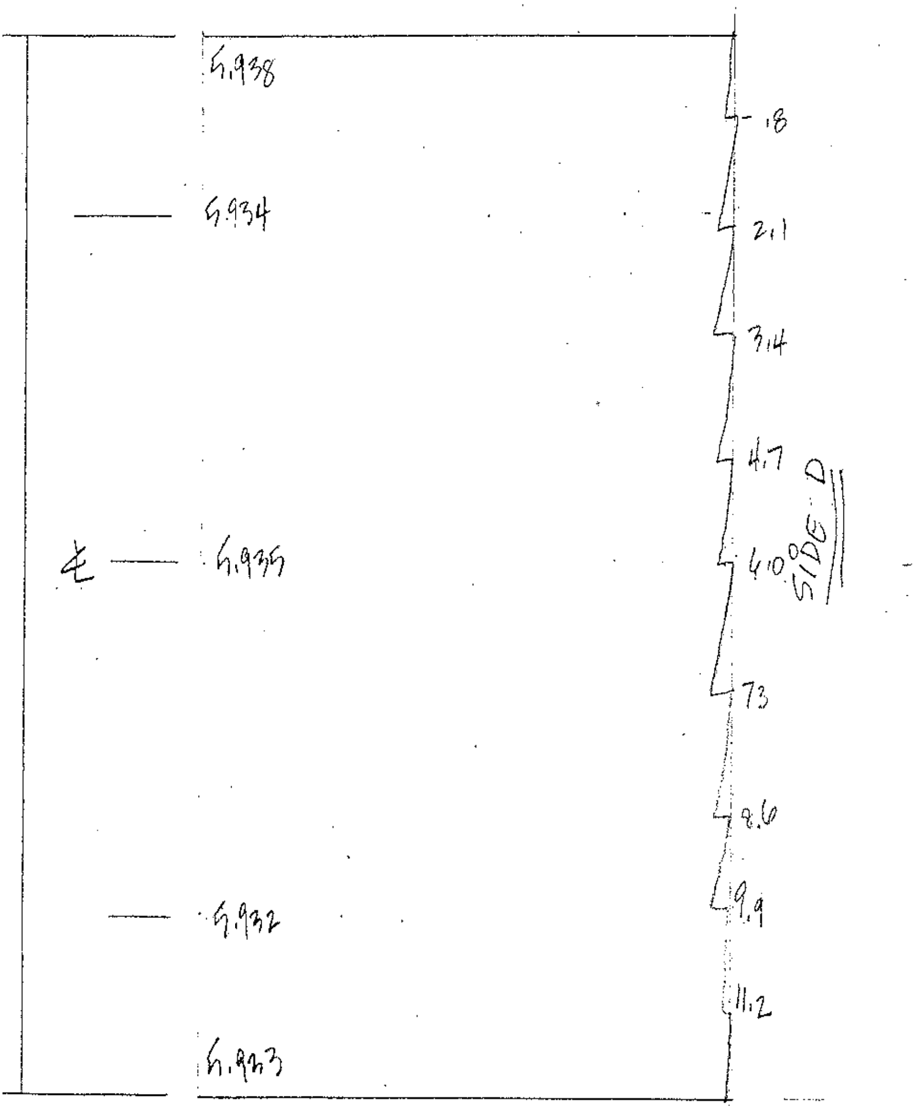
LAB # "CONCRETE" 99C-73

TYPE OF ROCK Green

~~air = 1346g~~
~~water = 8039~~
~~ssd spg = 2.48~~

Avg ht = 11.93
Avg dia = 5.934

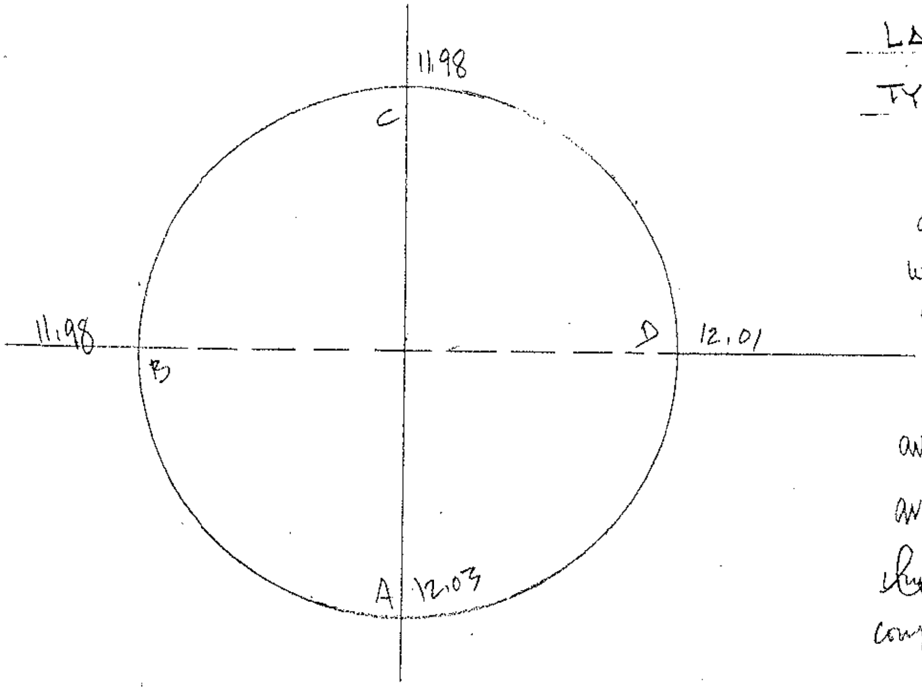




SOILS LAB REQ 99-19

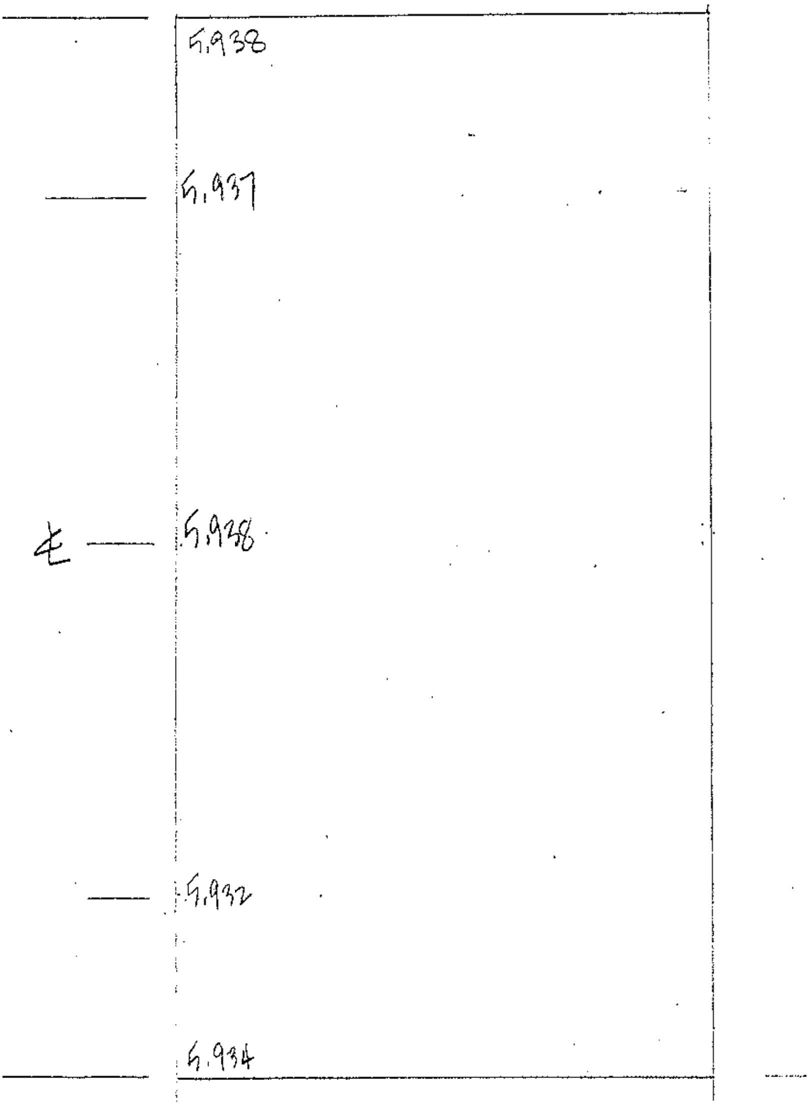
LAB # "CONCRETE" 99C-74

TYPE OF ROCK GREEN



air = 13468
water = 8039
spg = 2.48

avg ht = 12.00
avg dia = 5.936
load = 200,000
comp str = 7230



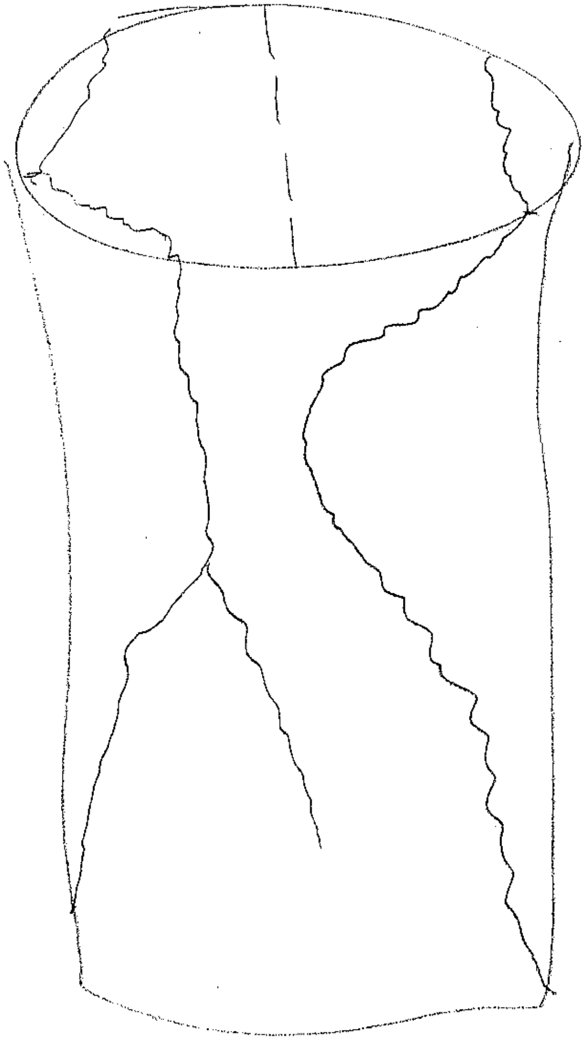
#2 99C-SS
Brown - wet

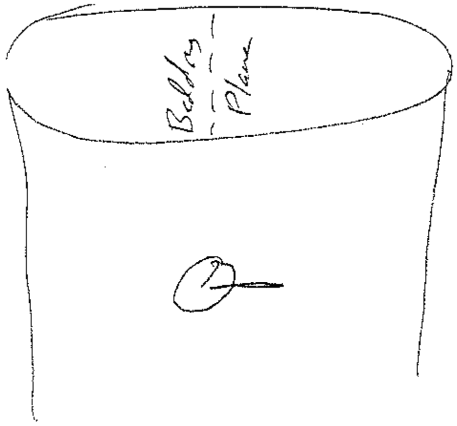
5-3-99

$\phi = 5.939$ $P_u = 105{,}000^{lb}$

	trial 1	trial 2	trial 3
	0	99	0.2
	0	99	0.2
	0	99	0.2
	0	99	0
	99.2	97.8	98.2
5	97.8	95.6	96
	95.6	93	93
5	92.4	90	90
0	90	87.6	87.4
5	86.6	84.8	84.6
0	82.4	81.2	80.8
15	82.6	81.8	81.2
40	84	83.2	83
35	85.8	85	85
30	87.6	87	86.8
5	89.4	89	89
0	91.4	91.4	91.4
5	94.2	94.2	94.6
0	96.6	97	97.8
5	98.2	99	99.8
	99	0.2	1

Lateral Gage





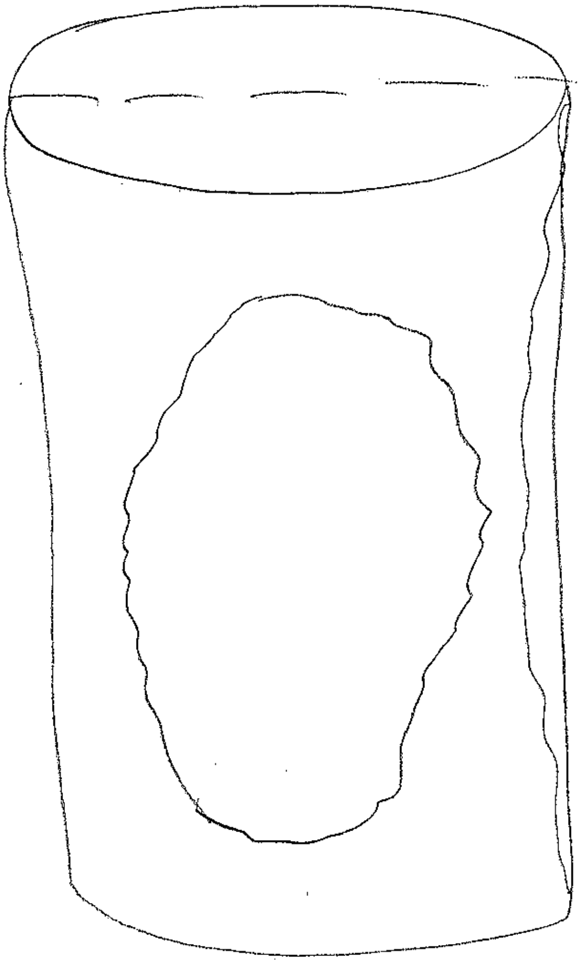
99C-53
#2

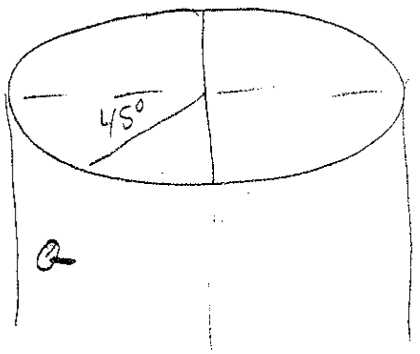
	1		2		3	
0	0	.0016	.0016	.0020	.0020	.0022
5,000	.0039	.0082	.0059	.0088	.0063	.0091
10	074	124	095	130	102	134
15	102	154	126	160	133	164
20	128	178	154	185	162	189
25	.0151	.0199	.0180	.0207	.0187	.0212
30	176	219	203	226	211	231
35	201	235	225	243	232	248
40	224	250	244	258	251	263
45	249	.0263	263	.0271	270	.0276
50,000	.0275		.0284		.0289	

#4
99-C-55 Brown - Dry

$P_u = 134,000$ lbs

	Trial #1	Trial #2	Trial #3
0	6	98	99.2
5	99.4	97.6	99
10	98	96.6	97.4
15	96.6	94.8	95.8
20	95.6	93.2	94
25	94.8	92.2	92.6
30	93.8	91.4	91.5
35	91.6	89.8	90
40	88.6	87.8	87.6
45	85.6	85	84.8
50	81.8	81.5	81.6
55	77.6	78	78
60	73	74	74.4
55	74	74.6	75.2
50	76	76.4	77
45	78	78.2	78.6
40	79.8	80	80.6
35	81.6	82.2	82.6
30	83.6	84.2	85
25	85.8	87	87.4
20	88	89	89.6
15	90.2	91.2	91.8
10	92.6	93.8	94.4
5	95.4	96.2	97
0	98	99.2	0





99C-55

#4

5/3/99

	1		2		3	
0	0	.0019	.0019	.0019	.0019	.0018
5	.0014	049	033	048	033	046
10	031	073	050	072	051	071
15	048	093	069	092	070	091
20	062	110	087	110	089	108
25	076	125	102	125	104	124
30	.0093	.0139	.0112	.0139	.0120	.0139
35	111	152	132	152	135	153
40	130	164	147	166	149	165
45	149	175	162	177	164	176
50	168	187	177	188	178	187
55	186	.0197	192	.0198	193	.0198
60,000	.0206		.0207		.0207	

#6 Brown - Wet

99C-59

$\phi = 5.942$

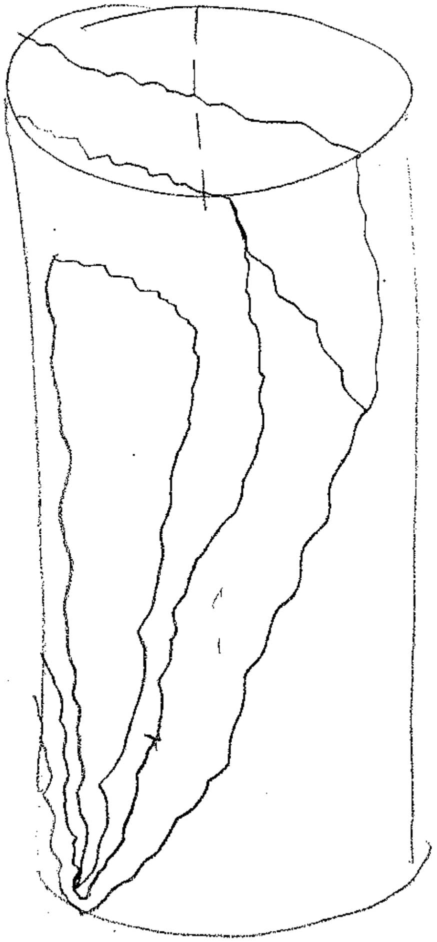
7/9/99

$P_u = 97,500$

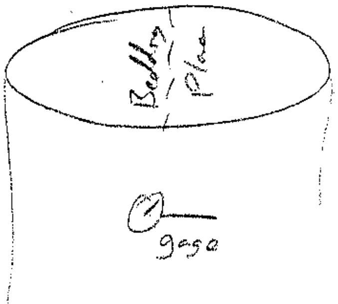
Sealed by running to 25K lbs

Trial 1	Trial 2	Trial 3
0	1.5	5
0.5	1.8	5
1.0	1.8	5.2
1.2	1.8	5
1.2	2.0	5
0	1.6	4.4
97	99.2	1.2
93.5	96	98
90.2	92.6	94.6
86	89.6	91.2
81.8	85.2	87.2
82.5	85.8	88
84.5	87.6	89.6
86	89.2	91.2
87.4	91.8	92.8
89.8	92.8	95
92	95.6	97.2
94.8	97.8	0.4
96.8	1	3.2
99.4	3.2	5.2
1	5	6.6

Lateral Gage



Lateral Gage set perpendicular to Bedding Plane



992-59

Vertical Gage

#6	#1		#2		#3	
0	0	.0009	.0009	.0009	.0009	.0010
5000	.0030	.0064	.0040	.0063	043	064
10	58	097	071	098	075	100
15	79	123	096	124	100	126
20	.0100	.0144	.0119	.0146	.0124	.0149
25	120	163	141	165	147	168
30	142	179	161	182	166	184
35	164	194	180	197	185	200
40	185	.0208	198	212	203	215
45	.0208	.0221	.0217	.0225	221	.0228
50,000	.0232		.0236		.0239	

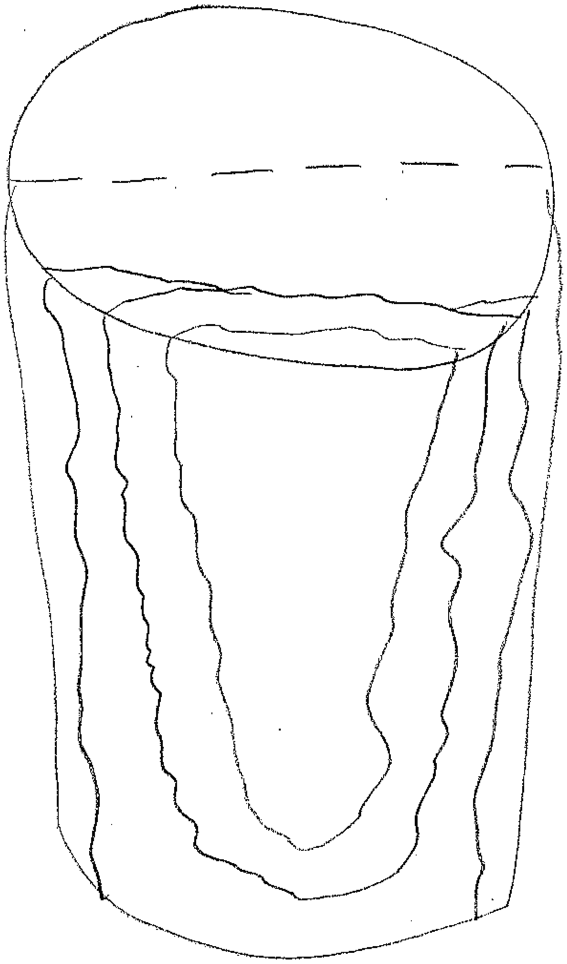
#8
99C-59
Brown - Dry

$\phi = 5.938$

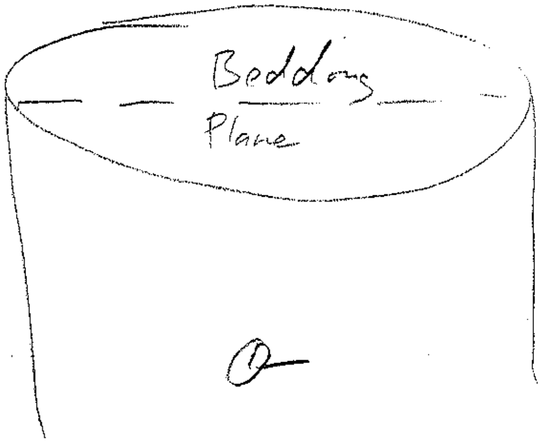
$P_u = 128{,}500$ lbs

Lateral Gage

Load	Trial #1	Trial #2	Trial #3
0	0.2	99	99.6
5	0.2	99	99.4
10	99.6	99	99.4
15	98.6	98.2	98.6
20	97.6	97	97.2
25	96.2	95.6	96.8
30	95	94	94
35	93	92.4	92.4
40	91.8	90.6	90.2
45	90	89	88.8
50	87.8	87.2	87
55	84.8	84.8	84.8
60	82	82.6	82.8
55	82.6	83	83
50	84.2	84.6	84.5
45	85.6	85.8	86
40	87	87.2	87
35	88	88.2	88.2
30	89.2	89.2	89.4
25	90.6	91	91
20	92.4	92.6	92.8
15	94.2	94.4	94.6
10	95.8	96.2	96.4
5	97.4	97.8	98.2
6	99	99.4	0



Fractured into lots of longitudinal pieces



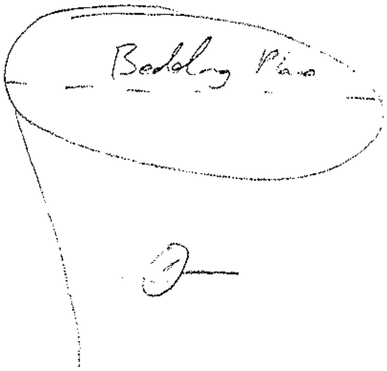
99C-59

#8

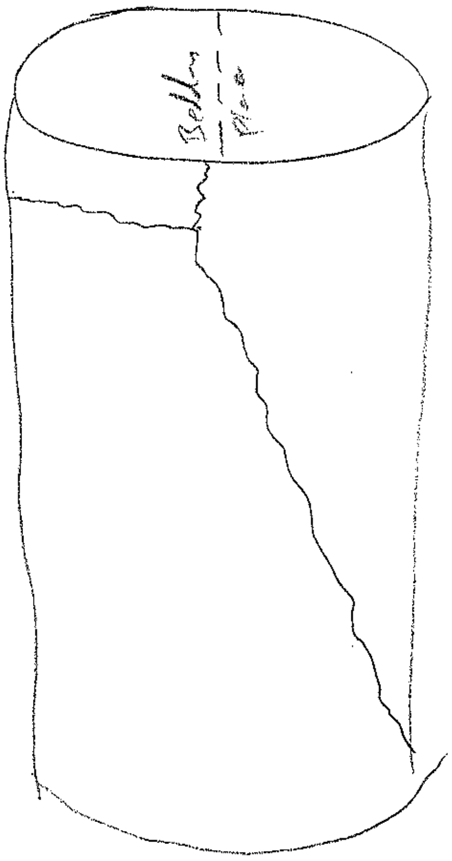
	1		2		3	
0	0	.0018	.0018	.0017	.0017	.0017
5	.0015	049	032	048	033	047
10	033	074	052	073	052	073
15	052	095	070	094	070	095
20	070	115	089	114	090	114
25	089	133	108	132	109	133
30	.0109	.0149	.0127	.0149	.0128	.0150
35	132	163	145	164	147	165
40	149	176	162	177	165	178
45	167	187	177	188	179	189
50	184	198	191	200	193	201
55	202	.0209	206	.0211	207	.0213
60,000	.0221		.0222		.0223	

Wet Sample 17C-61 Lateral Dial Reading
#16 $\phi = 5.943$ H=11.98

	Seating	Trial #1	Trial #2	Trial #3
0	0	0	97.5	96
5	0.1	0	97.7	96.4
10	0.2	99.5	97.	95.5
15	0	98	95.5	94
20	99	95	92.5	90
25	97	92.5		87
30	95	90	87	83
35	93	87	83	80.2
40	91	84.9	80	72.5
45	88	82.5	77.4	74.5
50	84.8	80	74.5	71.5
55	81	76.5	71.5	68
60	75.5	73	67.5	64
65	69	68.5	63	59.8
70	55	59.5	55.5	53
65	53.5	59.8	56	53
60	54.8	60.4	56.5	54
55	56	61.5	58	55
50	58	63.5	59.5	57
45	60.3	66	61.7	59.5
40	63	69	65	63
35	65.5	71.5	68.5	66.5
30	68	74.2	71	69.5
25	71	77.5	74.4	73
20	74	80.8	78.2	77
15	77	84.5	82.5	81.5
10	81	88.8	87	86
5	84	93	91.3	91
0	95.5	97.5	[illegible]	95.5



P_u = 96000 lbs



Brown - Wet

#10
99C-61

#10 99C-61

(1000#)	Seating	Trial
0	0	
5	.0035	.0090
10	.0064	.0130
15	.0089	.0161
20	.0121	.0185
25	.0140	210
30	.0163	231
35	.0183	250
40	.0202	.0266
45	.0221	281
50	.0244	294
55	.0268	310
60	.0290	320
65	.0313	.0328
70	.0340	
75		
80		
85		
90		
95		
100		

	#10 ~~#1~~		#2		#3	
0	~~0~~	.0007	.0006		.0018	
5	.0040	.0070	.0048	.0078	.0055	.0078
10	.0073	.0112	.0085	.0121	93	123
15	.0066	.0153	.0114	150	123	167
20 ~~15~~	.0134	.0172	144	180	154	183
25	0160	196	170	.0203	.0178	209
30 ~~25~~	184	218	195	223	.0203	.0230
35	205	235	217	243	224	248
40 ~~35~~	221	252	237	260	242	266
45 ~~40~~	238	.0268	251	277	258	282
50 ~~45~~	255	281	.0268	.0291	276	297
55	274	295	.0286	304	294	311
60	291	307	.0303	317	.0312	321
65 ~~60~~	308	.0320	.319	.0328	328	.0334
70 ~~65~~	.0331		.0340		.0346	
~~70~~						

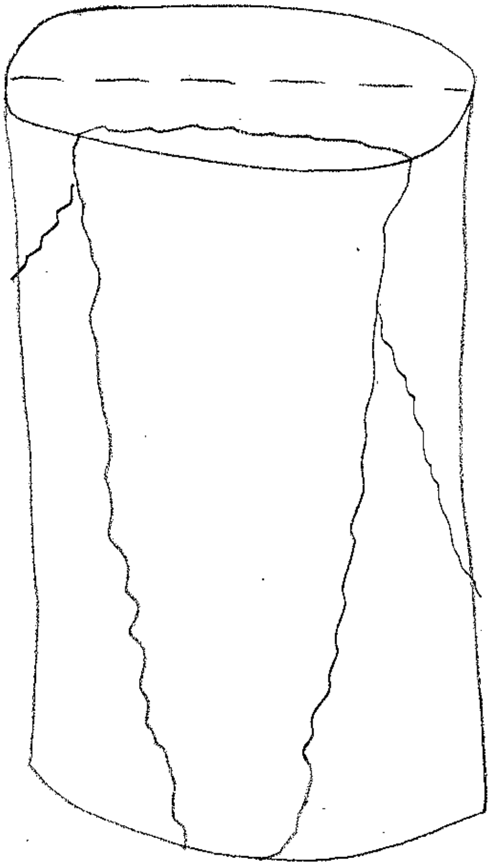
#11 ϕ = 5.936

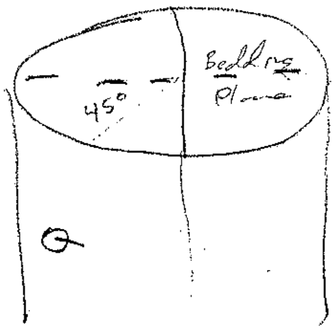
99C-62 Brown-Dry

P_u = 152,500 lbs

Dial gage (lateral) did not seem to be working correct based on data.

	Trial #1	Trial #2	Trial #3
0	0.4	10	11.8
5	0.4	10	11.8
10	0.4	10	11.8
15	0	10	11.8
20	0	9.2	11
25	99.8	8.2	9.6
30	99.8	7.8	9
35	99.8	7.4	8.6
40	0	6.6	8
45	0.2	5.8	7
50	0.2	4.8	6
55	0.2	3.6	4.8
60	0	2.2	3.2
55	0	2.2	3.2
50	0.8	3	4
45	1.8	3.8	5
40	2.4	4.8	5.8
35	3.6	5.5	6.8
30	4.4	6.4	7.6
25	5.2	7.2	8.2
20	6.2	8	9
15	8.6	9.4	10.2
10	9.2	10.4	11.6
5	9.8	11.4	12.4
0	10	11.8	12.4





99C62
#11

5/3/99

	1		2		3	
0	~~0~~	.0024	.0024	.0024	.0024	.0026
5	.0014	051	037	052	039	053
10	031	071	055	073	057	075
15	047	089	072	092	074	093
20	062	107	089	110	092	111
25	075	122	105	125	108	127
30	.0092	.0137	.0120	.0139	.0123	.0141
35	110	150	135	152	138	155
40	127	162	150	165	153	167
45	146	173	164	176	167	178
50	164	184	178	187	181	190
55	183	.0195	192	.0197	194	.0200
60	.0201		.0207		.0208	

/1499

99C-66 #1

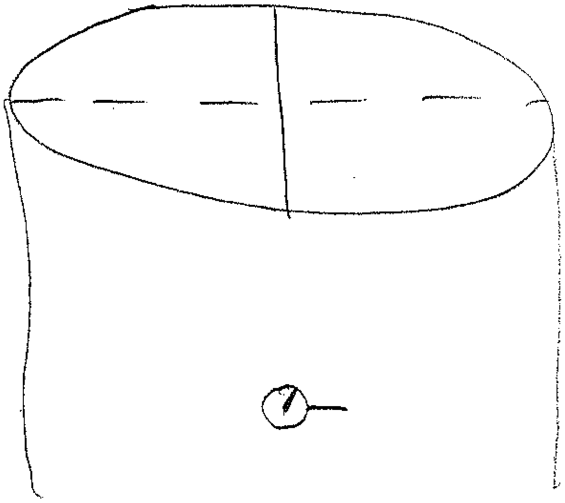
Sandstone Fresh Dry

$\phi = 5.937$
$L = 11.67$

$P_{ult} = 249,000$ lb

Preload to set gages to 75 kips

Load	Trial #1		Trial #2		Trial #3	
0	17.8	18	18.6	18.6	19	18.4
10	16.4	11.8	18	11.6	18	11.4
20	15	7.6	15.8	6.8	15.4	6.2
30	14.6	3	12.6	1.6	12.4	1.2
40	13.4	97.6	9.4	96.8	8.6	96
50	11	93	6	91.8	5.2	91.2
60	3	89	2.6	88.4	1.6	87.4
70	98	85	99.2	84	98	83
80	93	81	95.6	80.4	94	79.4
90	88.8	77	93.2	76	91.4	74.6
100	85	71.6	90.6	70.4	88.6	69
110	80.6	66	88	63.4	86	62
120	76.4		82	59	82	58
130	73	60	73.6	57.2	73.6	56.2
140	68.4	58.6	66	55.8	65	55
150	64	57.4	60	54.4	58	53.4
160	58		54.8		53	



99C-66 DRY

5/12/99

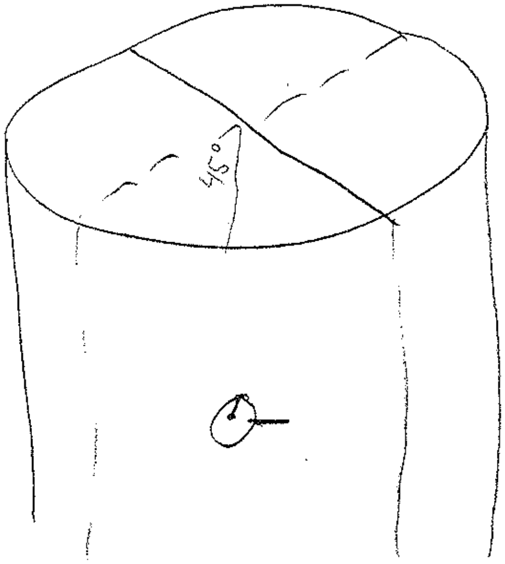
	1		2		3	
0	0	.0029	.0029	.0034	.0034	.0036
10	.0035	97	65	.0102	73	.0102
20	68	.0140	.0100	146	.0110	147
30	96	173	133	180	140	183
40	.0122	207	165	213	173	216
50	146	237	193	243	201	244
60	172	261	223	267	231	270
70	194	283	248	290	256	292
80	219	303	273	311	281	313
90	246	322	295	330	303	332
100	273	341	315	348	324	351
110	300	359	337	367	344	369
120	327		358	383	364	385
130	353	390	378	398	384	400
140	379	403	398	413	404	415
150	403	.0418	417	.0428	424	.0429
160	.0427		.0439		.0444	
170						
180						

5/12/99
99C-69 #4
Sandstone Fresh Dry

ϕ = 5.933
L = 12.08

P_{ult} = 276,000 lb

Load	Trial #1		Trial #2		Trial #3	
0	0	86.6	87	84.4	84.8	83
10	97.6	80.4	85.6	78	83	77
20	95	74.4	82.6	72.4	80	71
30	92.8	70	79.6	67	77	66
40	90	65.4	76.4	62.8	74	62
50	87.4	62	73	58.4	70	57.8
60	84.4	57.6	69.4	54.6	66.4	53.2
70	81.6	54	66	51.2	63	49.8
80	78.2	51	62	47.4	59	46
90	74.2	47.6	58.4	44	55.4	42.8
100	69.4	44.4	54.6	41.4	51.4	40
110	64	42	50.6	38.4	47.8	36.6
120	59	39.2	46.8	35.6	44	34
130	53	36.8	42.6	33	39.6	31.6
140	47.4	34.4	38	31	35	29
150	40.8	32.8	34	29	31	27
160	336		29		26	



99C-69 DRY

5/12/99

	1		2		3	
0	~~0~~	.0030	.0030	.0032	.0032	.0034
10	.0032	93	62	96	67	94
20	64	.0137	94	.0137	98	138
30	94	169	.0124	171	127	171
40	.0123	197	155	202	158	202
50	152	224	183	229	186	227
60	177	250	208	250	213	253
70	199	272	231	275	237	276
80	224	294	256	298	261	298
90	249	314	279	317	284	318
100	275	334	303	337	307	337
110	302	353	325	355	329	356
120	327	369	348	372	352	372
130	354	386	370	388	373	389
140	378	401	391	404	394	405
150	403	.0415	411	.0418	414	.0419
160	.0427		.0431		.0435	

5/12/99

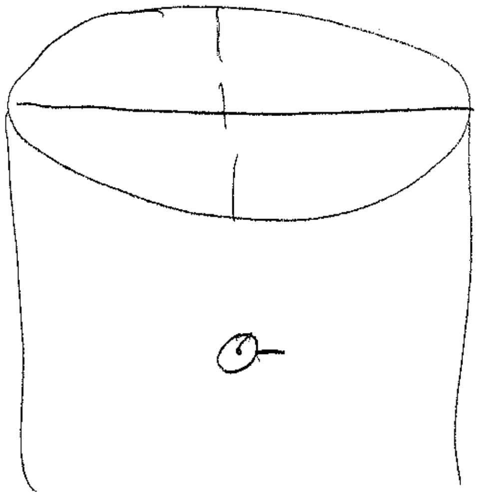
99C-73 #8

ϕ = 5.934
L = 11,93

P_{ult} = 269,000 #

Sandstone Fresh Dry

Load	Trial #1		Trial #2		Trial #3	
0	0	86	86	84	84,2	83
10	99	80.6	96	78.6	84	77
20	97	75,4	84	73	81.6	72
30	94,8	70,8	81	68	78.6	66
40	92	65.4	78	62.8	75,2	61
50	89.4	61	74.8	58	71,8	56.2
60	86.6	57	71.4	54	68,4	52,8
70	83.8	53.8	68	50.4	64.8	49
80	80,2	50,4	63.8	46.8	60,6	46
90	76	47,2	60	43.6	56.4	42,2
100	71,2	44.6	55.6	40.8	52,4	39,2
110	66	42	51.4	38	48,4	36.2
120	60	39.2	47,4	35,2	44	33.8
130	54	37	43	33	39.8	31.4
140	48	34.8	38.6	30.6	35.2	29
150	40.6	33	33.8	28.8	30.8	27
160	33.6		28		26	



990-73 DRY

5/12/99

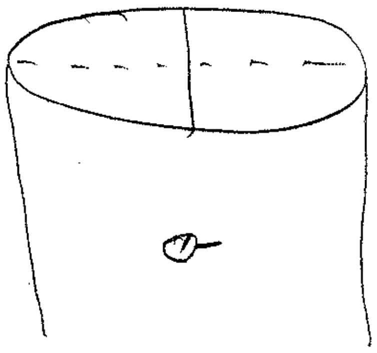
	1		2		3	
0	0	.0035	.0035	.0040	.0040	.0042
10	.0037	.0108	74	.0110	79	.0110
20	74	154	.0110	157	116	157
30	.0107	191	143	196	150	197
40	141	227	175	231	183	233
50	167	258	205	261	211	262
60	196	284	233	287	240	288
70	221	308	260	311	265	311
80	249	331	287	335	293	336
90	278	353	313	356	319	357
00	307	372	338	375	344	376
10	337	391	363	394	368	395
20	364	409	386	411	390	413
30	391	425	407	427	413	428
40	418	441	429	444	434	445
50	445	.0456	452	.0459	456	.0458
60	.0467		.0473		.0475	

99C-74 #9 $\phi = 5.936$ $P_{ult} = 200,000$ lbs

$L = 12.00$

Sandstone Fresh Wet Load to 75 kips to seat

Load (kips)	Trial #1	Trial #2	Trial #3
0	30.4	21.4	19.2
10	30.2	21.4	19.2
20	28.6	20	17.4
30	28.4	17	14
40	27.8	13.4	10
50	26	9.8	6
60	25	6	2
70	22.4	4	99
80	18	1.4	97
90	13	98	94
100	6.6	95.2	90.4
110	0.6	91	87
120	93.8	86.4	82
130	85.6	80	77
120	85.4	80	77.2
110	87	81.4	79
100	89	84	81.4
90	91.4	81.2	84
80	94	89	87
70	96.2	91.2	89
60	99	94	91.2
50	1.2	97	94.6
40	5.4	1	99.4
30	9.4	6	4
20	13	10	8.4
10	17.6	14.4	13
0	21.4	19	18



99C-74 WET

5/12/99

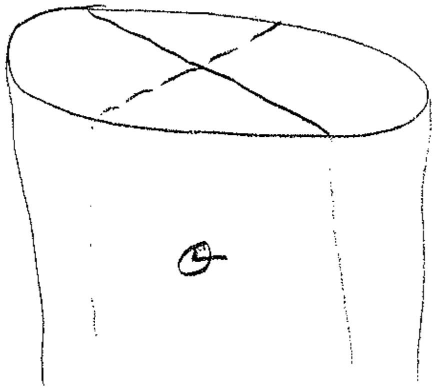
	1		2		3	
0	0		.0013	.0017	.0017	.0019
10	.0062	.0106	80	.0113	84	.0113
20	.0110	162	.0132	165	.0134	170
30	145	202	169	208	178	212
40	175	238	207	246	216	246
50	204	270	239	275	248	278
60	229	292	270	301	277	304
70	253	315	293	323	302	327
80	279	336	317	344	326	348
90	307	355	342	365	349	368
100	335	372	363	381	371	385
110	364	389	385	398	392	402
120	392	.0405	406	.0414	413	.0418
130	.0419		.0430		.0435	

99C-72 #7

Fresh Sandstone Wet $\phi = 5.933$ $P_{ULT} = 188,500^{lb}$ $H = 11.71$

Lateral Gage Reading Load to 75k to seat gages

Load (kips)	Trial #1	Trial #2	Trial #3
0	25	32	31
10	25	32	31.4
20	24	31.6	28.6
30	21	26.2	24
40	19.6	20.4	18
50	18	15	11.6
60	15.6	9	5.4
70	13	3	99
80	10	98	93.6
90	7	94	89
100	2	89	84.6
110	95	84	79
120	87	78	73
130	77	69	65.6
120	75	70	65.6
110	77	72	68
100	79.6	75	71
90	82.4	78.2	73.6
80	85.4	81.2	77
70	88	84	80.4
60	92	88	85
50	98	93.2	90
40	3	0	97
30	10	12	4
20	17	14	11
10	24	22	21
0	32	31	30



Vertical Gage

99C-72 WET

5/12/99

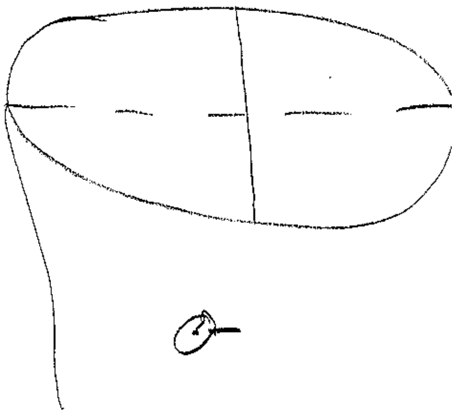
	1		2		3	
0	~~0~~	.0017	.0017	.0020	.0020	.0021
10	.0045	98	66	.0103	70	.0102
20	86	.0147	.0110	152	.0117	156
30	.0122	182	148	190	155	192
40	150	216	184	222	190	225
50	175	243	213	251	221	255
60	200	269	241	275	249	280
70	222	292	268	299	276	303
80	248	311	292	318	300	324
90	276	330	315	338	323	344
100	304	347	337	356	344	361
110	333	363	359	372	366	378
120	363	.0380	380	.0389	387	.0394
130	.0389		.0403		.0409	

99C-70 #5 $\phi = 5.935$ $H = 12.07$

Fresh Sandstone Wet $P_{ULT} = 191,000$ lbs

Lateral Gage Reading Load to 50 kips to seat gages

Load (kips)	Trial #1	Trial #2	Trial #3
0	99.6	88.6	86
10	98.8	88.6	86
20	96.8	86	83.4
30	94	83	79.8
40	92.2	80	76.4
50	89.8	77	73
60	86.8	73	68.8
70	80.6	66	61.6
80	73	59	54.2
90	63.6	50.4	46
100	55.2	42.8	37.6
110	46.4	35.4	30
120	36	28	23
130	25	19	15
120	—	19.6	15.2
110	27	21.4	17
100	30.4	24	20
90	33	26.8	23.4
80	38	33	29.6
70	45.4	40	37
60	53.6	47.4	45
50	60	54.8	52
40	65.4	61.6	59
30	70.6	67	65
20	75.4	72	70
10	81.6	78.6	77
0	88	86	85



99C-70 Wet Vertical Gage 5/12/99

	1		2		3	
0	0	.0020	.0020	.0026	.0026	.0029
10,000	.0048	.0102	72	.0110	79	.0110
20	93	155	.0118	164	.0126	167
30	.0130	193	158	200	167	204
40	163	225	192	232	202	238
50	190	253	.0220	262	231	268
60	217	277	248	287	258	292
70	242	300	273	309	282	313
80	268	320	298	331	308	336
90	295	341	323	351	333	356
100	322	358	347	370	356	377
110	350	.0377	370	387	379	394
120	378		393	.0403	402	.0409
130	.0407		.0418		.0426	

ASTM D 3967 - SPLITTING TENSILE STRENGTH - σ_t

BROWN

3 #	FIELD SAMPLE #	THICKNESS (inches)				AVERAGE	DIAMETER (inches) TOP	MID	BOTT	AVERAGE	Moisture Condition during test	LOAD ORIENTATION	L/D RATIO	LOAD (Lbs)	σ_t (psi)
-54	3A	3.077	3.068	3.065	3.077	3.072	5.934	5.936	5.934	5.935	Wet	along bedding	.52	5200	570✓
	B	3.040	3.041	3.036	3.037	3.039	5.933	5.935	5.929	5.932	Wet	Perpendicular to bedding	.51	7700	850✓
	C	3.031	3.041	3.059	3.042	3.043	5.935	5.934	5.933	5.934	Dry	along bedding	.51	8400	930✓
	D	3.090	3.077	3.111	3.120	3.100	5.932	5.936	5.932	5.933	Dry	Perpendicular	.52	13000	1410✓
-56	5A	3.007	2.999	2.971	2.983	2.990	5.932	5.935	5.937	5.935	Wet	along bedding	.50	4800	540✓
	B	3.094	3.075	3.077	3.090	3.084	5.935	5.935	5.936	5.935	Wet	Perpendicular to bedding	.52	8000	870✓
	C	2.998	3.000	3.025	3.020	3.011	5.937	5.935	5.935	5.936	Dry	along bedding	.51	6600	740✓
	D	3.079	3.093	3.069	3.056	3.074	5.933	5.934	5.933	5.933	Dry	Perpendicular to bedding	.52	11900	1300✓
-58	7A	3.0~~84~~77	3.070	3.075	3.081	3.076	5.934	5.936	5.936	5.935	Wet	along bedding	.52	5000	550
	B	3.091	3.049	3.032	3.032	3.041	5.933	5.936	5.936	5935	Wet	Perpendicular to bedding	.51	8000	890
	C	3.047	3.035	3.021	3.031	3.034	5.934	5.935	5.934	5.935	Dry	along bedding	.51	7900	880
	D	3.134	3.126	3.103	3.103	3.117	5.934	5.929	5.934	5.932	Dry	Perpendicular	.53	13400	1450
-60	9A	2.867	2.880	2.898	2.868	2.878	5.936	5.937	5.937	5.937	Wet	along bedding	.48	3900	460
	B	2.817	2.826	2.813	2.808	2.816	5.934	5.932	5.935	5.934	Wet	Perpendicular to bedding	.47	7900	950
	C	3.020	3.026	3.030	3.023	2.825	5.934	5.936	5.936	5.935	Dry	along bedding	.48	8000	950
	D	3.046	3.055	3.025	3.019	3.036	5.932	5.934	5.936	5.934	Dry	Perpendicular	.51	13300	1480

used: Tinius Olsen test machine - replaced top platen w/ 3"

used Medium Load - 100 lbs graduation (LOW RANGE goes up to only 8000 lbs)

each cored cylinders were saw-cut to 3"± designated as A, B, C & D

ASTM D 3967 - SPLITTING TENSILE STRENGTH - σ_t

GREEN

		THICKNESS (inches)				AVERAGE	DIA. (inches) TOP	MID	BOTT.	AVERAGE	MOISTURE CONDITION during test	LOAD ORIENTATION	L/D RATIO	LOAD (lbs)	σ_t (psi)
-67	2 A	2.817	2.8~~08~~31	2.843	2.816	2.827	5.937	5.939	5.934	5.937	Wet	along bedding	.48	10,400	1240
	B	2.910	2.910	2.907	2.901	2.807	5.934	5.930	5.932	5.932	Wet	perpendicular to bedding	.47	15,100	1810
	C	2.749	2.815	2.820	2.752	2.784	5.931	5.932	5.927	5.930	Dry	along bedding	.47	16,000	1940
	D	2.864	2.868	2.943	2.917	2.898	5.931	5.932	5.928	5.930	Dry	perpendicular to bedding	.49	20,600	2400
71	6 A	2.841	2.810	2.~~774~~816	2.826	2.823	5.938	5.940	5.937	5.938	Wet	along bedding	.48	11,400	1360
	B	2.796	2.783	2.780	2.792	2.788	5.932	5.934	5.933	5.933	Wet	perpendicular to bedding	.47	15,900	1920
	C	2.925	2.906	2.895	2.913	2.910	5.937	5.928	5.928	5.931	Dry	along bedding	.49	15,200	1760
	D	2.899	2.909	2.924	2.895	2.907	5.930	5.930	5.933	5.931	Dry	perpendicular to bedding	.49	21,600	2510
75	10 A	3.012	3.008	3.005	3.017	3.011	5.936	5.939	5.935	5.937	Wet	along bedding	.51	9,600	1070
	B	3.025	3.012	3.007	3.016	3.015	5.928	5.931	5.932	5.930	Wet	perpendicular to bedding	.51	10,300	1150
	C	3.086	3.043	3.048	3.094	3.068	5.932	5.935	5.928	5.932	Dry	along bedding	.52	17,900	1970
	D	3.001	3.037	3.040	3.006	3.021	5.924	5.927	5.930	5.927	Dry	perpendicular to bedding	.51	17,700	1980
78	13A	3.046	3.060	3.089	3.075	3.068	5.935	5.932	5.925	5.931	Wet	along bedding	.52	9,100	1000
	B	3.118	3.134	3.109	3.091	3.113	5.923	5.924	5.920	5.922	Wet	perpendicular to bedding	.53	14,700	1590
	C	3.058	3.012	2.996	3.045	3.028	5.930	5.930	5.926	5.929	Dry	along bedding	.51	15,200	1690
	D	2.732	2.733	2.840	2.803	2.777	5.930	5.925	5.922	5.926	Dry	perpendicular to bedding	.47	19,500	2370

APPENDIX I

ROCKFILL MATERIALS
PHYSICAL PROPERTIES AND ROCK STRENGTH
(PUBLISHED DATA)

UC Berkeley Report by Becker, et. al., 1972

TABLE 2-4 COMPARISON OF AVERAGE MECHANICAL PROPERTIES OF OROVILLE, PYRAMID AND SANDSTONE ROCK CORES

Test	Moisture	Oroville*	Pyramid**	Sandstone
Unconfined Compressive Strength Average	Dry.	45,500 psi	15,500 psi	8,845 psi
	Sat.	28,000 psi		4,797 psi
Young's Modulus Compression	Dry and Sat.	$6.2\text{x}10^6$ psi	$4.2\text{x}10^6$ psi	$1.8\text{x}10^6$ psi
Brazilian Tension	Dry	1,870 psi	1,896 psi	1,133 psi

*Amphibolite only

**Not reported if dry or saturated

Deere and Miller (1966) proposed an engineering classification based on strength and deformation. They tested a large variety of rock cores in unconfined compression and plotted the average values of the uniaxial compressive strength versus the modulus of elasticity (tangent modulus at 50% ultimate strength) as an arithmetic plot. The plot indicated that the data could be fitted approximately by a straight line with the equation:

$$E_t = 300\ \sigma_a\ (\text{ult})$$

where E_t is the tangent modulus at 50% of ultimate strength and σ_a is the ultimate uniaxial compressive stress. The ratio E_t/σ_a (ult) was called the modulus ratio and its average value was about 300. They proposed a classification chart as shown on Figure 2-4. The average results of unconfined compressive strength and Young's modulus in compression for the Pyramid Dam, Oroville Dam and Venato Sandstone materials have been plotted on this figure. According to this classification the saturated Venato

DWR Report on Rockfill Materials for Newville Dam, 1980

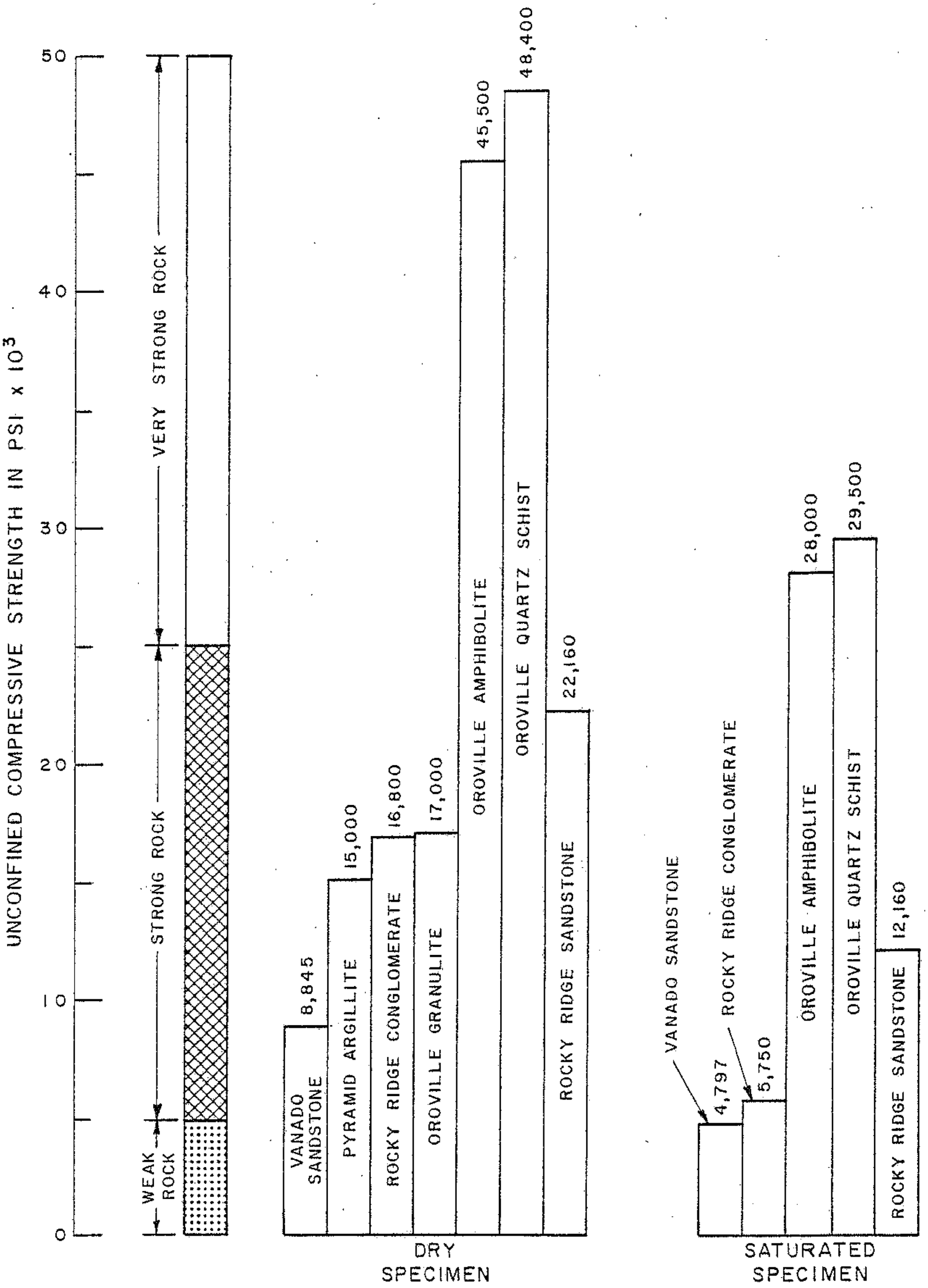


FIGURE 3-1 COMPARISON OF AVERAGE UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORES

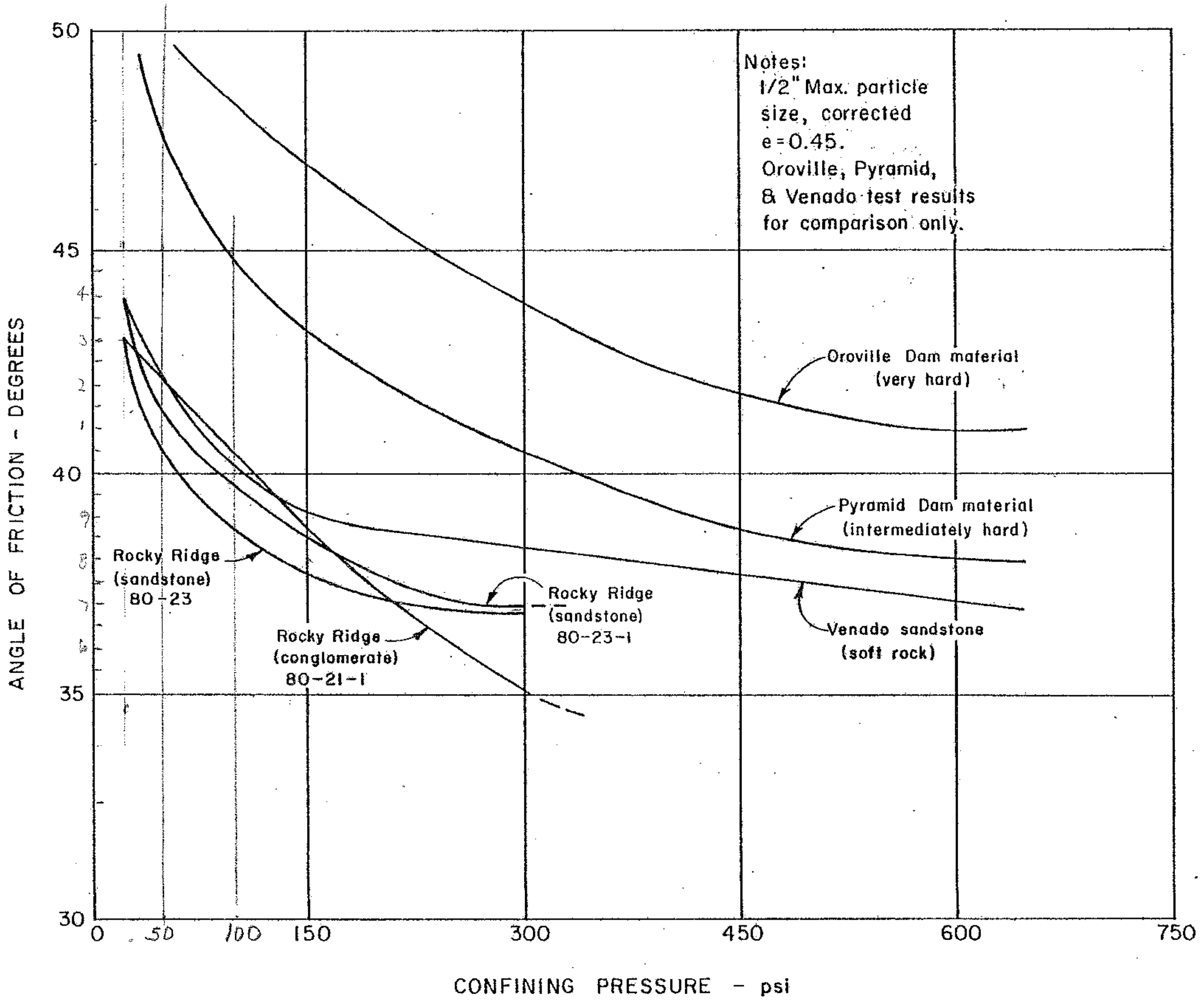


FIGURE 3-7 TEST RESULTS OF ROCKY RIDGE MATERIAL

APPENDIX J

ROCKFILL MATERIALS
SHEAR STRENGTH
(PUBLISHED DATA)

"Review of Shearing Strength of Rockfill," Leps 1970

Figure 11

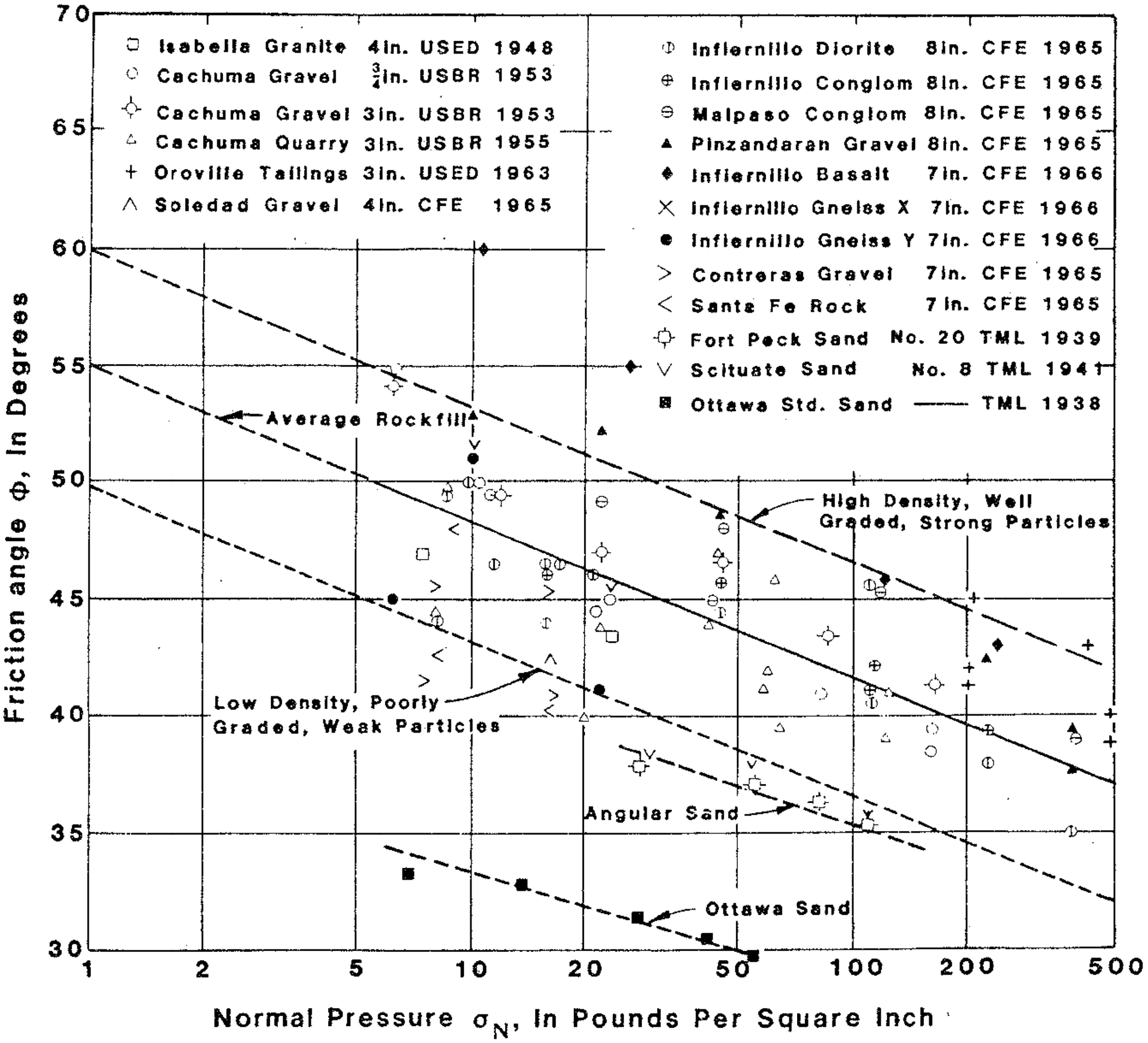


Figure 11. - Shearing resistance of rockfill from large triaxial tests [19].

USBR's Earth Manual, 1998

Table 1-3.—Average engineering properties of compacted soils from the 17 Western United States. Data from reports published between June 1960 and December 1985. Data from 2005 tests on 1110 samples. Table compiled January 1988

				Compaction				Shear Strength								
		Specific gravity		Laboratory		Index density		Consolidated-drained and consolidated-undrained triaxial shear tests				Unconsolidated-undrained triaxial shear tests				
								Av. placement conditions		Effective stress		Av. placement conditions		Effective stress		
USCS soil type	Total No. of samples tested	No. 4 minus	No. 4 plus	Max. dry density kg/m³	Optimum moisture content %	Max. kg/m³	Min. kg/m³	Dry density kg/m³	Moisture content %	Friction angle degrees	Cohesion kPa	Dry density kg/m³	Moisture content %	Friction angle degrees	Cohesion kPa	Values listed
GW	22	2.69	2.58	1989	11.4	2167	1746									Average
		0.03	0.08	51	1.2	139	128									Std. dev.
		2.63	2.39	1907	9.9	1810	1417									Minimum
		2.75	2.67	2042	13.3	2332	1896									Maximum
		17	10	5		20										# of tests
GP	62	2.68	2.52	1907	12.2	2212	1808	1933	7.5	42.2	8.1					Average
		0.04	0.21	153	4.3	113	124	238	4.1	2.1	16.3					Std. dev.
		2.54	1.76	1436	9.1	1826	1375	1489	3.3	38.0	0.0					Minimum
		2.77	2.65	2045	26.5	2383	1986	2144	15.1	43.8	40.7					Maximum
		37	15	16		50		5								# of tests
GM	37	2.73	2.43	1819	15.7											Average
		0.07	0.18	189	5.9											Std. dev.
		2.65	2.19	1393	5.8											Minimum
		2.92	2.92	2130	29.5											Maximum
		35	17	35												# of tests
GC	32	2.73	2.50	1854	14.2											Average
		0.09	0.15	126	3.9											Std. dev.
		2.67	2.38	1537	6.0											Minimum
		3.11	2.78	2066	23.6											Maximum
		30	5	32												# of tests
SW	20	2.67	2.57	2019	9.1	1987	1576									Average
		0.03	0.03	96	1.7	128	142									Std. dev.
		2.64	2.54	1896	7.4	1683	1278									Minimum
		2.72	2.59	2162	11.2	2207	1758									Maximum
		13	2	4		13										# of tests
SP	81	2.66	2.62	1827	10.5	1890	1542									Average
		0.04	0.08	160	2.1	120	144									Std. dev.
		2.60	2.52	1649	7.8	1621	1252									Minimum
		2.86	2.75	2159	13.4	2199	1960									Maximum
		50	5	8		43										# of tests
SM	174	2.68	2.50	1877	12.3	1803	1379	1760	13.2	34.0	20.7	1821	12.6	33.5	59.3	Average
		0.06	0.12	140	3.3	147	136	145	5.2	4.9	25.5	201	5.5	6.1	42.1	Std. dev.
		2.51	2.24	1488	6.8	1417	1034	1459	4.6	23.7	0.0	1488	7.6	23.3	0.0	Minimum
		3.11	2.69	2114	25.5	1968	1555	2019	23.0	40.7	90.3	2122	25.0	45.0	146.2	Maximum
		162	10	133		20		10				8				# of tests
SC	112	2.69	2.47	1906	12.4			1773	15.4	32.7	19.3	1967	11.1	35.1	53.8	Average
		0.04	0.18	99	2.4			225	5.2	3.8	14.5	88	2.1	0.7	4.1	Std. dev.
		2.56	2.17	1547	6.7			1459	7.5	25.5	0.0	1843	9.7	34.2	49.0	Minimum
		2.84	2.59	2109	22.1			2111	22.7	38.3	42.1	2035	14.0	35.8	58.6	Maximum
		110	4	90				11				3				# of tests
ML	63	2.70		1645	20.1			1528	25.2	35.2	4.8	1678	17.4	31.8	61.4	Average
		0.09		168	5.7			179	9.5	2.5	3.4	161	5.7	4.3	24.1	Std. dev.
		2.52		1355	10.6			1292	13.5	31.4	0.0	1512	11.1	25.2	21.4	Minimum
		3.10		2018	34.6			1778	40.3	38.3	10.3	1909	25.8	37.2	82.0	Maximum
		60		36				11				4				# of tests
MH	11	2.79		1372	33.1											Average
		0.27		35	1.5											Std. dev.
		2.47		1327	31.5											Minimum
		3.50		1425	35.5											Maximum
		9		4												# of tests
CL	395	2.70	2.48	1768	16.4			1665	18.3	28.1	15.2	1760	15.3	24.4	91.0	Average
		0.05	0.13	97	3.1			174	5.7	5.0	18.6	86	2.4	7.0	49.0	Std. dev.
		2.56	2.34	1398	10.7			1297	10.2	10.8	0.0	1622	11.6	8.0	0.0	Minimum
		2.87	2.75	2002	30.9			1922	35.0	36.8	104.1	1986	20.2	33.8	164.1	Maximum
		361	8	286				31				24				# of tests
CH	101	2.73		1531	24.8			1406	30.6	20.5	32.4	1574	22.7	15.1	124.1	Average
		0.06		102	5.2			107	5.7	6.3	31.0	92	4.6	6.7	25.5	Std. dev.
		2.51		1318	16.6			1249	22.4	10.8	0.0	1438	17.9	5.1	85.5	Minimum
		2.89		1720	41.8			1555	42.0	30.9	108.2	1680	29.1	26.1	148.2	Maximum
		93		36				11				5				# of tests

Conversion factors: 1 kg/m³ = 0.06243 lb/ft³; 1 kPa = 0.145 lb/in²

UC Berkeley Report by Marachi et. al., 1969

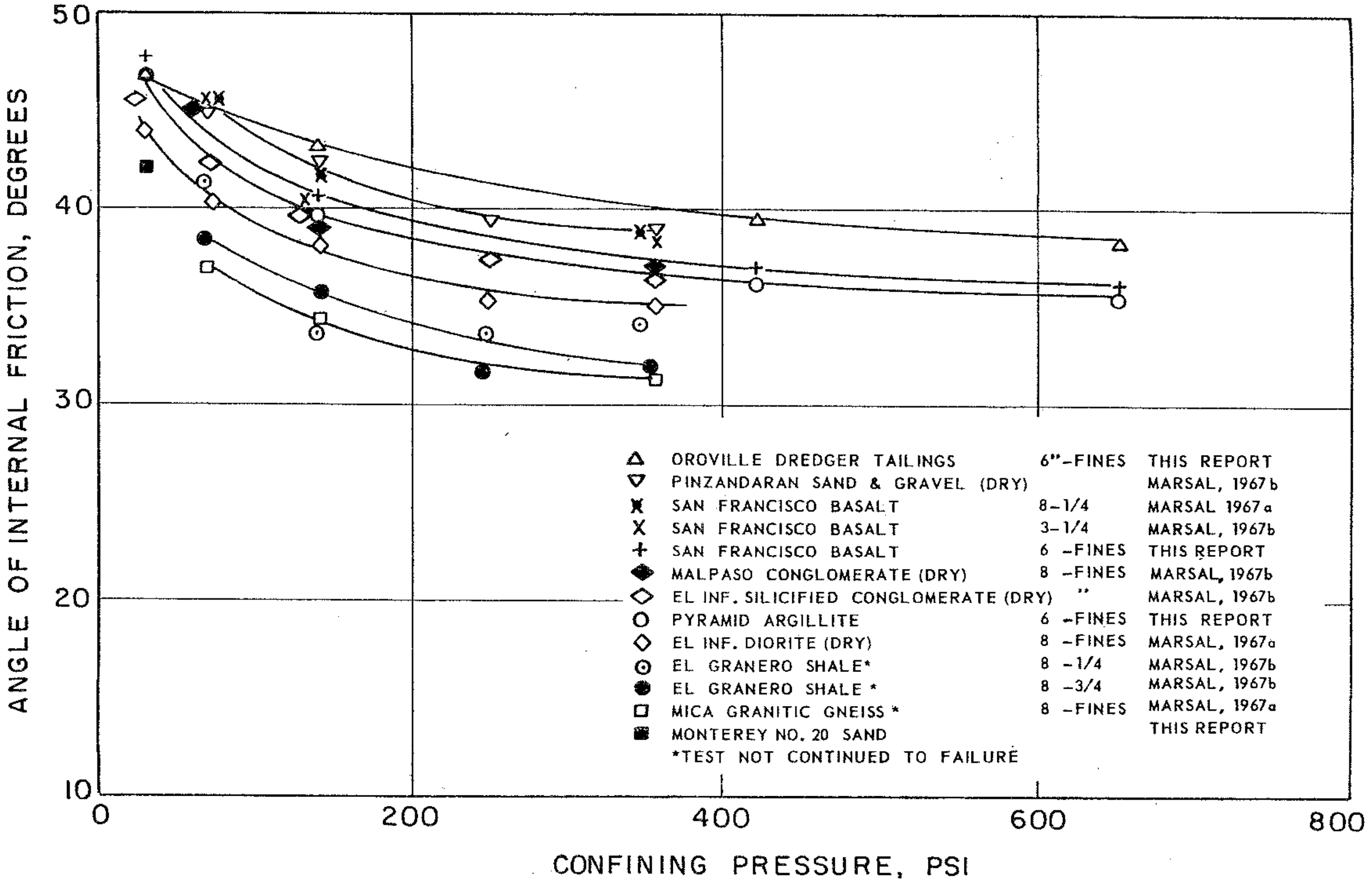


FIG. 51 ANGLES OF INTERNAL FRICTION FOR LARGE SIZE ROCKFILL SPECIMENS

UC Berkeley Report by Becker et. al., 1972

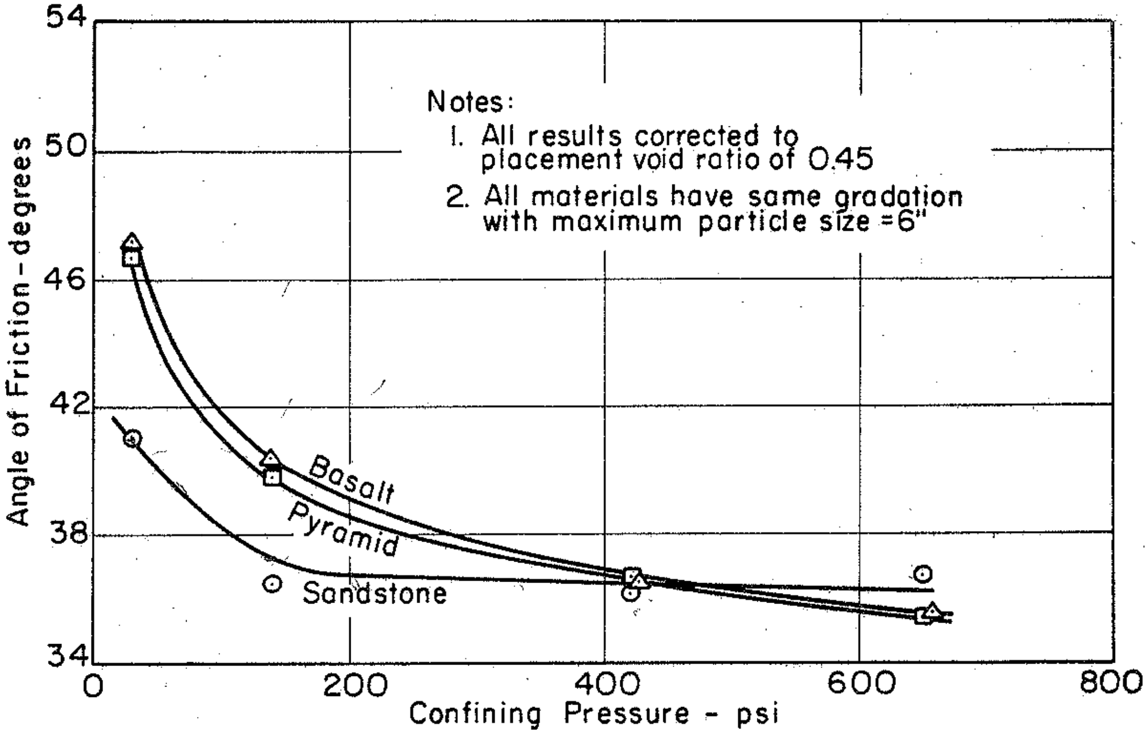


FIG. 3-9 IC-D TEST RESULTS FOR 36" DIA. SPECIMENS OF MODELED ROCKFILL MATERIALS

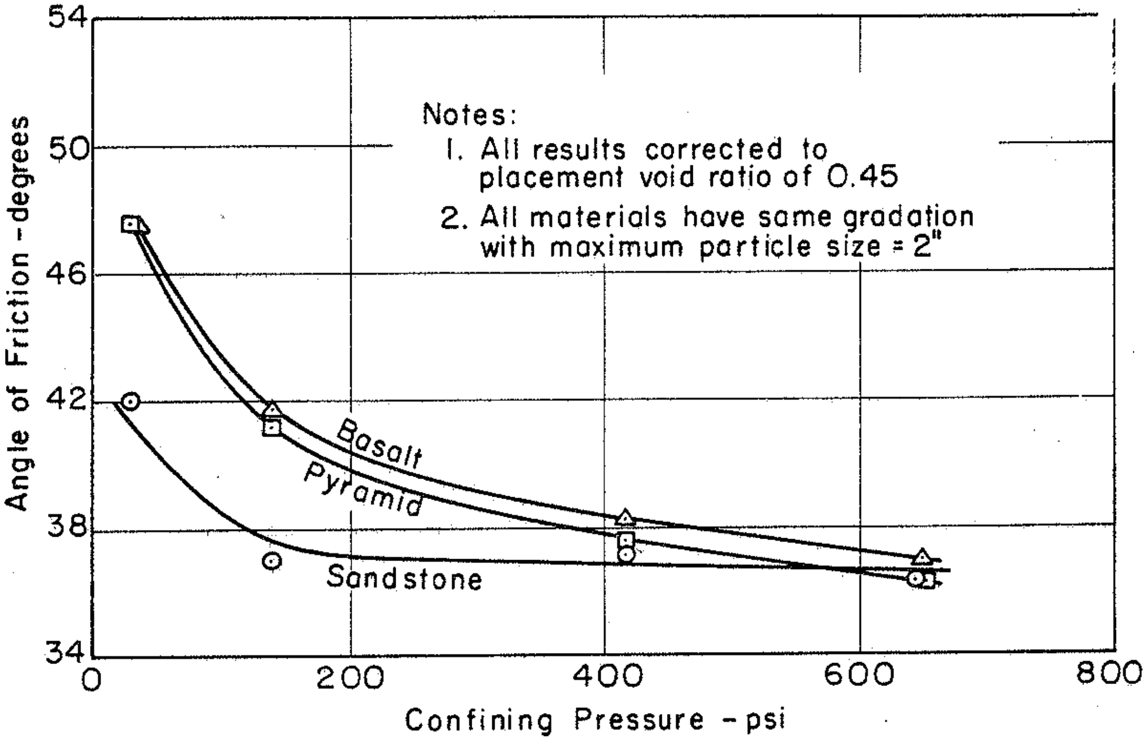


FIG. 3-10 IC-D TEST RESULTS FOR 12" DIA. SPECIMENS OF MODELED ROCKFILL MATERIALS

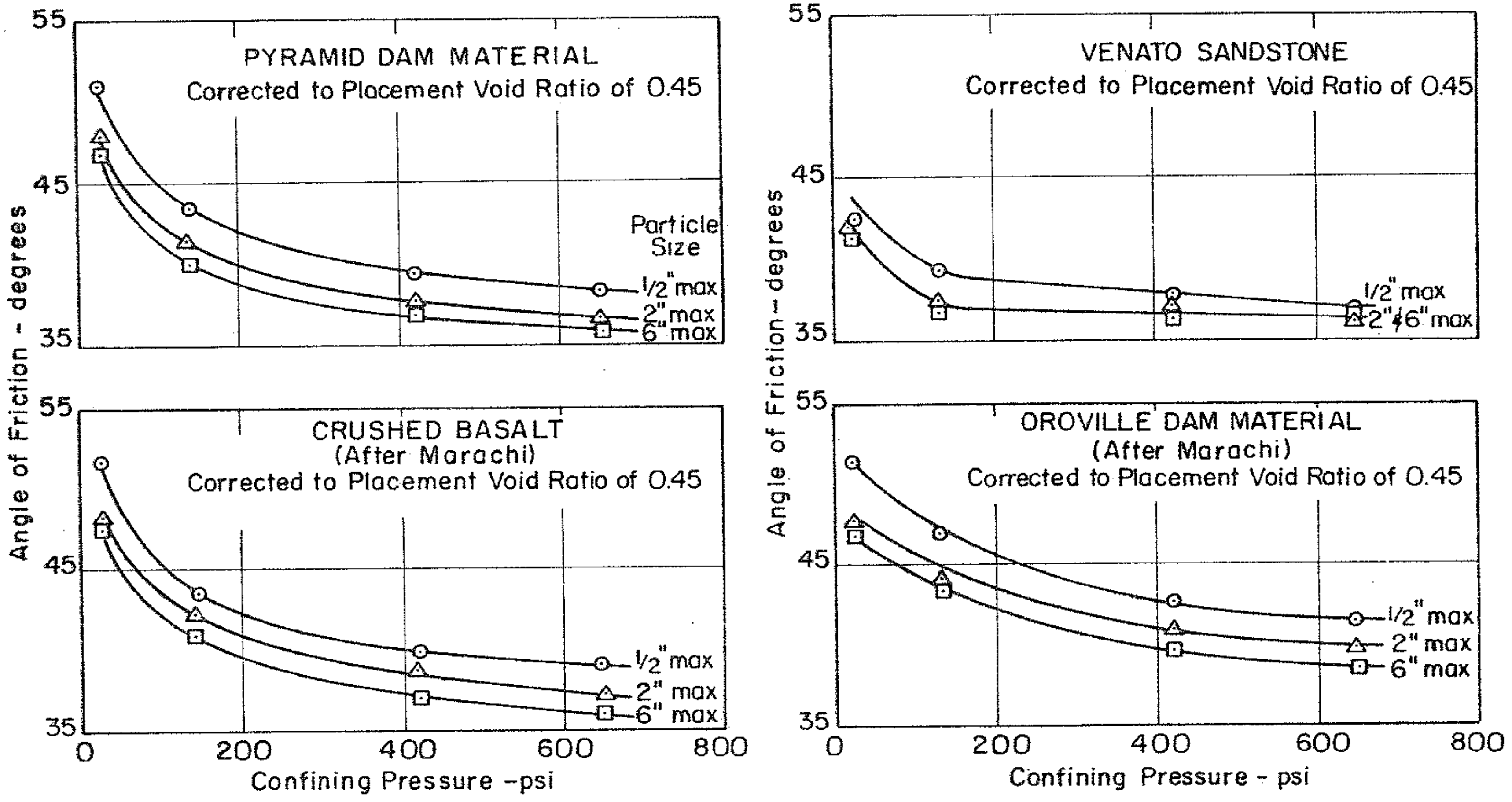


FIG. 3-8 IC-D TEST RESULTS FOR MODELED ROCKFILL MATERIALS

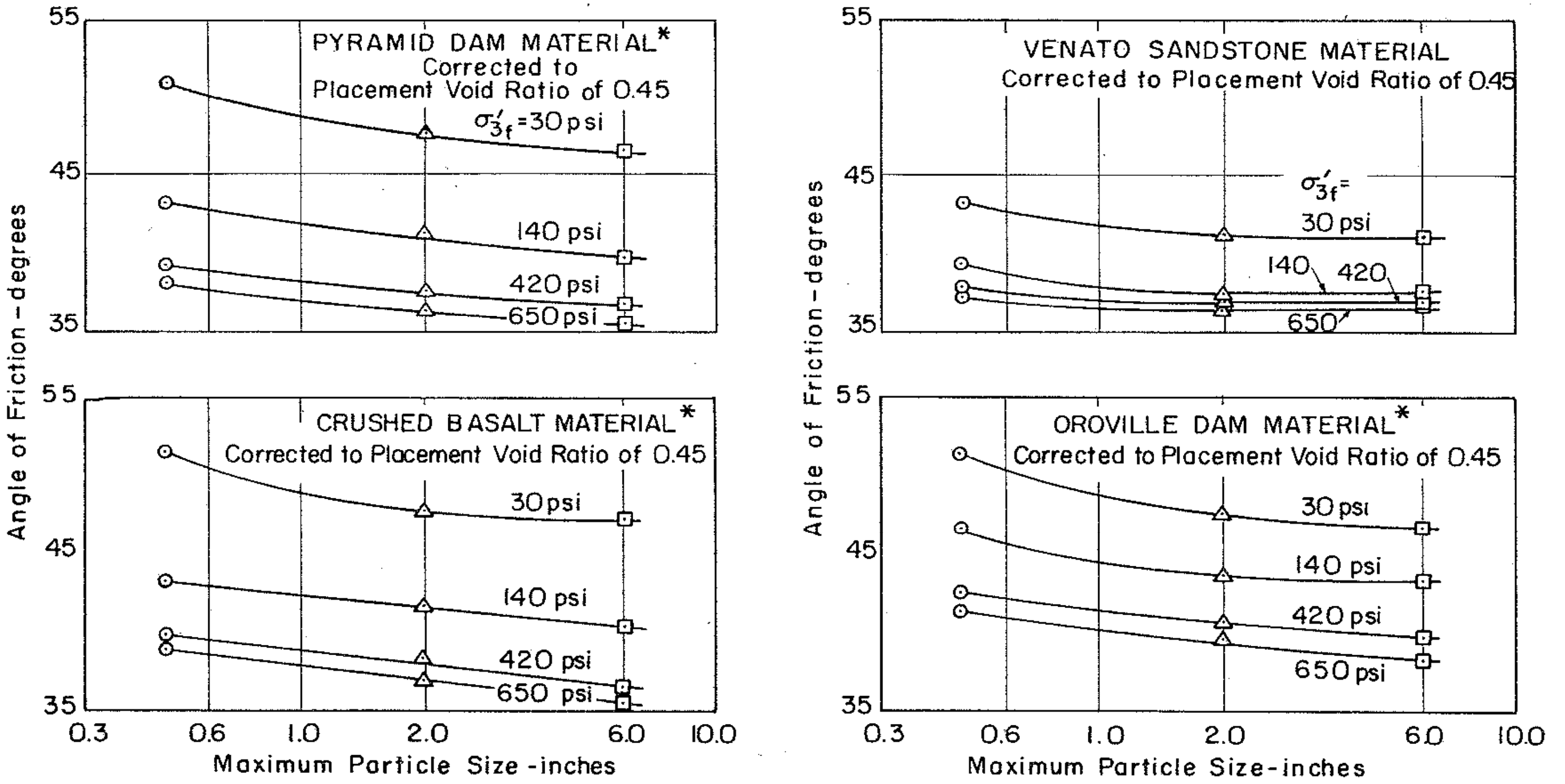


FIG. 3-11 EFFECT OF MAXIMUM PARTICLE SIZE ON THE ANGLE OF FRICTION FOR MODELED ROCKFILL MATERIALS

*Data after Marachi (1969)

“The Quality and Suitability of Rockfill Used in Dam Construction,”
by Penman and Charles, 1976

high at confining pressures up to 2.5 MN/m². The loading frame was designed with a capacity of 15 MN. Drained triaxial tests on rockfill from Infiernillo showed Φ' decreasing from 46° to 36° as the confining pressure was raised from 0.1 MN/m² to 2.5 MN/m². Marsal *et al.* describe the rockfill as a mixture of sound fragments of silicified conglomerate and diorite and add that this may be considered among the best materials possible for rockfill.

A triaxial machine built at Imperial College to test samples of rockfill 0.3 m in diameter has been described by Tombs (1969). Tests on heavily compacted samples of Carboniferous sandstone rockfill from Scammonden dam showed a $\Phi' = 49°$ at a confining pressure of 0.1 MN/m² decreasing to $\Phi' = 37°$ at a confining pressure of 1.7 MN/m² (Charles, 1973), i.e. comparable with the strength parameters found for the Infiernillo fill.

If the Scammonden rockfill is regarded as an average quality rockfill, then the material used at Balderhead must stand on the borderline of what can be usefully described as rockfill. Consolidated undrained tests on the Balderhead shale (Kennard *et al.*, 1967) show Φ' reducing from 39° at an effective confining pressure of 0.08 MN/m² to 35° at an effective confining pressure of 0.17 MN/m².

In making comparisons between these results several factors must be considered. Firstly, the tests were made on rockfill samples with different maximum particle sizes. In the large-scale rockfill testing equipment built at the University of California samples 0.91 m diameter × 2.3 m high can be tested and drained triaxial tests on rockfills with parallel grading but different maximum particle size have that gradings with a maximum particle size of 150 mm have an angle of shearing resistance about 4° smaller than samples of the same material with a maximum particle size of 12 mm (Marachi *et al.*, 1969). This may account for the Scammonden sandstone, tested with a maximum particle size of 76 mm giving slightly greater angles of shearing resistance than the Infiernillo conglomerate rockfill with a maximum particle size of 200 mm.

Marsal has carried out tests on a granitic gneiss rockfill from the site of Mica dam and also used different gradings of the rockfill (Marsal, 1973). When results were compared at the same confining pressure, a well graded sample showed an angle of shearing resistance typically about 4° greater than a uniformly graded sample.

The shear strength of rockfill measured in triaxial compression also depends on the initial porosity of the sample. Small-scale triaxial tests on the Scammonden rockfill indicated that the angle of shearing resistance reduced by about 1° per 1 % increase in porosity at low confining pressures. With increase in confining pressure the dependence on initial porosity was less marked.

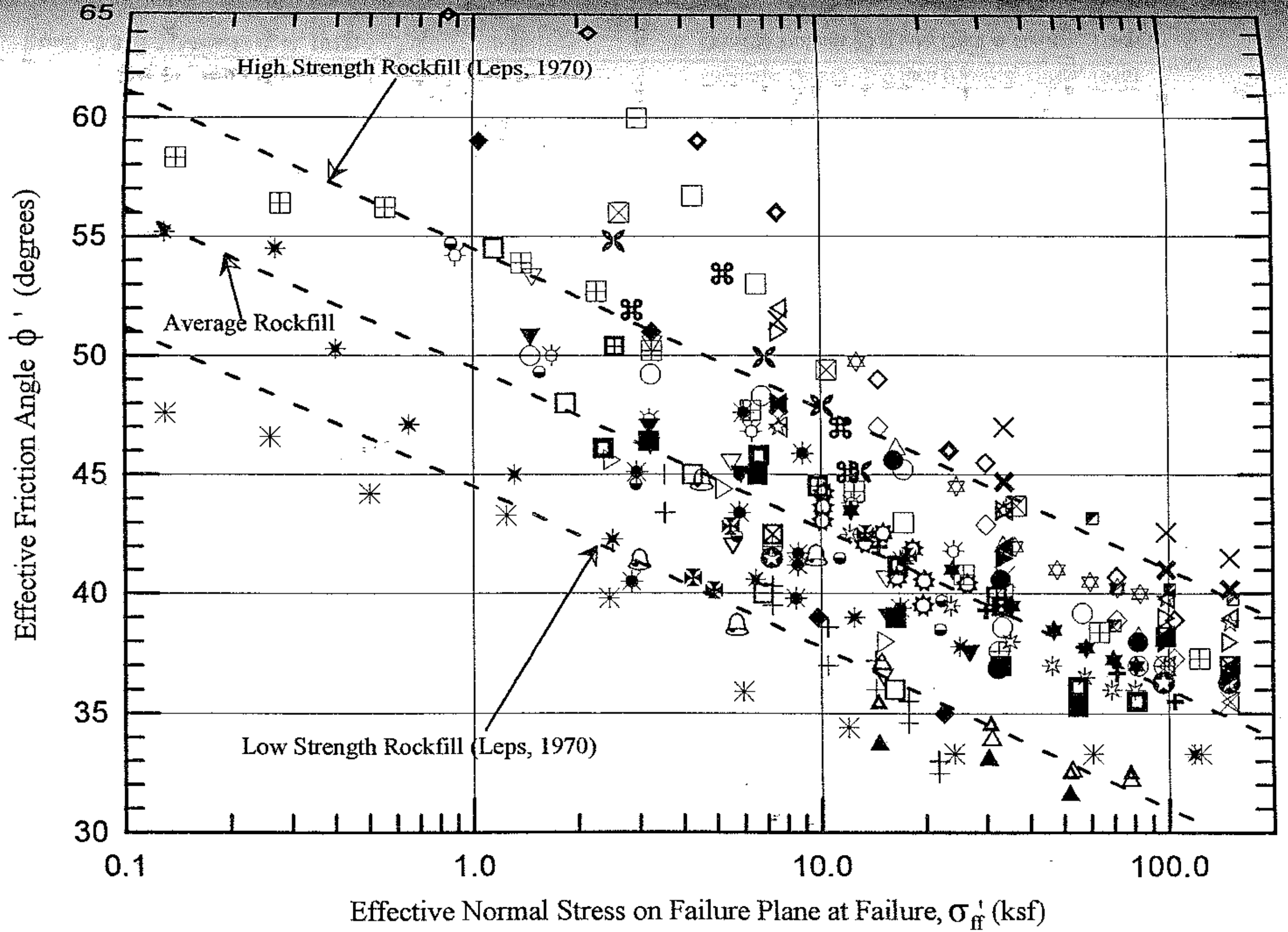
The angle of shearing resistance measured in the triaxial tests on these three widely different types of rockfill do illustrate the relatively small

Domenigoni Valley Reservoir Project, 1994

Note: 1) α is defined as the ratio of the initial static driving shear stress on a horizontal plane to the initial effective overburden stress.

After Seed and Harder, 1990

RELATIONSHIP BETWEEN K_α AND α



Note: See Figure E-48B for rock type, maximum particle size and reference

VARIATION OF EFFECTIVE FRICTION ANGLE WITH EFFECTIVE NORMAL STRESS FOR VARIOUS ROCKFILL MATERIALS

	Date: June 1994	Project: DOMENIGONI VALLEY RESERVOIR PROJECT	Fig. E-48A

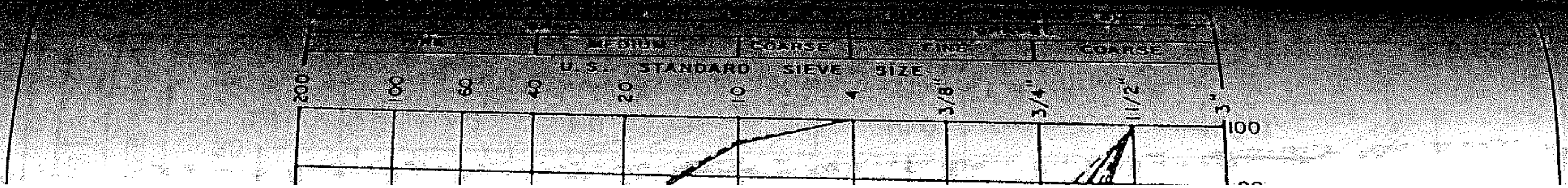
c:-stength-summry2b.grf

Domenigoni Valley Reservoir Project

Ebasco / Black & Veatch

+	Greywacke - 1.5 inch (Indraratna et. al, 1993)	◀	Basalt - 12 inch (Marachi et. al, 1972)
+	Greywacke - 1.0 inch (Indraratna et. al, 1993)	✕	Basalt - 36 inch (Marachi et. al, 1972)
✚	Basalt - 0.25 inch (Al-Hussaini, 1983)	✕	Amphibolite (Oroville Dam) - 2.8 inch (Marachi et. al, 1972)
◇	Basalt - 1.0 inch (Al-Hussaini, 1983)	✖	Amphibolite (Oroville Dam) - 12 inch (Marachi et. al, 1972)
◇	Basalt - 3.0 inch (Al-Hussaini, 1983)	☆	Amphibolite (Oroville Dam) 36 inch (Marachi et. al, 1972)
◈	Basalt (Charles & Watts, 1980)	⊠	Venato Sandstone - 2.8 inch (Becker et al. 1972)
◆	Sandstone (Charles & Watts, 1980)	⊕	Venato Sandstone - 12 inches (Becker et al. 1972)
□	High Grade Slate (Chrles & Watts, 1980)	⊙	Venato Sandstone - 36 inches (Becker et al. 1972)
□	Low Grade Slate (Charles & Watts, 1980)	⌘	Quartzite, Test Fill No. 1 (U.S. Army Corps of Engineers, 1976)
▣	Silicified Conglomerate - El Infiernillo Dam (Marsal, 1973)	✖	Argillite and Phyllite, Test Fill No. 2 (U.S. Army Corps of Engineers, 1976)
■	Diorite - El Infiernillo Dam (Marsal, 1973)	☼	Quartzite, Argillite and Phyllite, Test Fill No. 5 (U.S. Army Corps of Engineers , 1976)
○	Conglomerate - Malposa (Marsal, 1973)	❁	Gneiss - Scalped Gradation (U.S. Army Corps of Engineers, 1992)
●	Basalt - 3.0 inch (Marsal, 1973)	🔔	Gneiss - Parallel Gradation (U.S. Army Corps of Engineers, 1992)
△	Basalt - 8.0 inch (Marsal, 1973)	✶	Quartzite and Quartz - 1.5 inch (Skermer & Hillis, 1970)
△	Granitic Gneiss - 8.0 inch (Marsal, 1973)	✡	Quartzite and Quartz - 1.5 inch (Skermer & Hillis, 1970)
▲	Granitic Gneiss - 8.0 inch (Marsal, 1973)	✺	Quartzite and Quartz - 0.2 inch (Skermer & Hillis, 1970)
△	Granitic Gneiss plus 30% Schist (Marsal, 1973)	✱	Granulated Chalk (Billam, 1971)
▽	Slate - 8.0 inch dense (Marsal, 1973)	✳	Crushed Anthracite (Billam, 1971)
▽	Slate - 8.0 inch loose (Marsal, 1973)	⊞	Limestone Sand (Billam, 1971)
▼	Slate - 8.0 inch dense (Marsal, 1973)	⊞	Silurian Mudstone (Tombs, 1969)
▷	Slate - 8.0 inch loose (Marsal, 1973)	⊠	Granitic Gneiss (Tombs, 1969)
▷	Argillite (Pyramid Dam) - 2.8 inch (Marachi et. al, 1972)	•	Cachuma Gravel - 0.75 inch (Holtz & Gibbs, 1956)
▶	Argillite (Pyramid Dam) - 12 inch (Marachi et. al, 1972)	☼	Cachuma Gravel - 3.0 inch (Holtz & Gibbs, 1956)
◁	Argillite (Pyramid Dam) - 36 inch (Marachi et. al, 1972)	✹	Cachuma Quarry - 3.0 inch (Holtz & Gibbs, 1956)
◁	Basalt - 2.8 inch (Marachi et. al, 1972)	▪	Oroville Tailings - 3.0 inch (Hall & Gordon, 1963)

VARIATION OF EFFECTIVE FRICTION ANGLE WITH EFFECTIVE NORMAL STRESS FOR VARIOUS ROCKFILL MATERIALS - LEGEND



APPENDIX K

ROCKFILL MATERIALS
DENSITY
(PUBLISHED DATA)

UC Berkeley Report by Becker et. al., 1972

Pyramid gradation. The change in relative density of specimens having the same void ratio, but different maximum particle size for the modeled gradations can readily be seen in Table 4-2. The Venato Sandstone material has the least variation in relative density for change in maximum particle size of the modeled gradation, which corresponds to the nearly flat curves for this material on Figure 4-3.

TABLE 4-1 MAXIMUM-MINIMUM DRY DENSITIES AND VOID RATIOS FOR MODELED ROCKFILL MATERIALS

MATERIAL	MAXIMUM PARTICLE SIZE (IN)	SPECIFIC GRAVITY	MAXIMUM DRY DENSITY (PCF)	MINIMUM VOID RATIO	MINIMUM DRY DENSITY (PCF)	MAXIMUM VOID RATIO
Pyramid Dam at Pyramid Gradation	6 2 $\frac{1}{2}$	2.62 2.62 2.62	120.2 118.6 116.5	.360 .378 .403	95.5 94.2 92.5	.712 .735 .767
Crushed Basalt at Pyramid Gradation	6 2 $\frac{1}{2}$	2.87 2.87 2.87	136.0 131.2 125.0	.317 .365 .433	108.2 103.3 96.7	.655 .733 .852
Venato Sandstone at Pyramid Gradation	6 2 $\frac{1}{2}$	2.74 2.74 2.74	119.7 119.1 118.3	.428 .435 .445	91.0 91.0 91.0	.879 .879 .879
Oroville Dam at Oroville Gradation	6 2 $\frac{1}{2}$	2.93 2.91 2.88	157.0 153.5 146.1	.165 .187 .230	128.5 124.2 115.9	.423 .467 .550
Oroville Dam at Pyramid Gradation	2	2.93	139.0	.314	117.3	.557

Angle of Friction and Relative Density

In order to determine the effect of maximum particle size on the angle of friction for tests performed at constant placement relative density, it was necessary to prepare curves showing the relationship of the angle of friction at different placement relative densities. These relationships, for samples with $\frac{1}{2}$" maximum particle size are shown in Figures 4-5 through 4-7.

APPENDIX L

USACE INSPECTION REPORTS OF SITES QUARRY AND SITES QUARRY (SOUTH) FOR SANDSTONE USED AS RIVERBANK SLOPE PROTECTION

RJA/sjf
14Mar72
Revised 21 Mar 72

SPKED-F

MEMO FOR RECORD

SUBJECT: Inspection of the Welch and Cron Quarries near Sites, California

1. The subject quarries were inspected on 13 March and 20 March 1972, by the following District personnel:

Edward M. Hashimoto	C-O Division
Chester R. Ziebarth	Valley Resident Ofc
Ervin L. Olen	Msvl Project Office
Reed J. Anderson	Engineering Division

Mr. Olen was not present on the 20 March inspection.

The two quarries are located about 0.3 miles apart in the lower foothills of the Coast Range. They are 8.7 to 9.0 miles northwest of Maxwell (freeway exit) and about 0.8 mile to 1.1 miles east of Sites in Colusa County (see attached location map). Both quarries are in T17N, R4W. The Welch Quarry is in Section 29 and the Cron Quarry is almost due north in Sections 20 and 21. They are accessible from Interstate 5 via the Sites-[illegible] Road, a paved two-lane highway. The area is shown on the Sites Quadrangle, USGS 7.5 minute series.

2. The purpose of the inspection was to make a preliminary evaluation of the Welch Quarry and to obtain a rock sample for testing by the Division Laboratory. Teichert Construction Company intends to use the rock, if acceptable, for bank protection on the Sacramento River for a Corps of Engineers contract (72C-0057, Unit 22, Sacramento River Bank Protection, Colusa and Sutter Counties). The Cron Quarry was visited and will be described briefly to eliminate some confusion that has existed between the two quarries. Previous reports refer to both quarries as the Sites Quarry. The inspection of the Welch Quarry was made with Mr. Wayne Russell of Teichert Construction.

3. The history of the quarries is not available in detail. Samples from the Welch Quarry were tested by the SPD Laboratory in March and June of 1962 and by a private laboratory in February 1962. In July 1962 the quarry was approved by the Sacramento District as a source of rock for bank protection providing only the fresh, dark grayish green graywacke (sandstone) is used. As far as is known the rock had not been used on a

Sacramento River job until about one year ago, when it was used on a Sacramento River job near Princeton by H. Earl Parker. Rock from the Cron Quarry has not been tested by the Sacramento District and has not been used on any District job. Rock from one or both quarries is reported to have been used for building construction in San Francisco and in the old Post Office Building at 7th and K Streets in Sacramento. The south face of the Cron Quarry has been line drilled on 2 to 2.5 foot centers, probably for the purpose of taking out building stone. Present owners of the quarries are Harry Cron, Williams, and Eleanor Welch, Colusa. The Cron Quarry is leased by James L. Ferry and Son, Sacramento, and the Welch Quarry is presently leased by Teichert Construction, Sacramento.

4. Except for slight color variations, rock from the two quarries is similar. It is a grayish green to bluish gray graywacke (sandstone) containing a few thin beds of shale. It probably belongs to the Cretaceous Chico or Shasta Formation. It is distinctly bedded, strikes about north-south and dips to the east at 40 to 45 degrees. Thickness of the sandstone beds ranges from a few inches up to about 5 feet. Beds appear to be getting thicker with depth. Where thin bedded, the rock tends to be weathered, at least near the surface. Breakage will be controlled partly by bedding, especially in the thinner bedded sequences. At the Welch Quarry the present face is a bedding plane surface at least 100 feet high and about 150 feet wide. The rock in the face is massive appearing and has no apparent structural weaknesses except for scattered joints. Where broken by previous blasting operations, the rock has some tendency to break into irregular slabby pieces that are not related to bedding plane weaknesses. The Cron Quarry has been opened at the south end of a north-south ridge, and the face developed is about perpendicular to the strike of the bedding. A thick section of east dipping graywacke beds is exposed. The rock is essentially the same as at the Welch Quarry.

5. In detail the rock is a fairly uniform fine-grained graywacke that is moderately hard and very slightly friable (a few grains can be broken off by hard rubbing). It appears to be heavy enough to meet minimum specific gravity requirements, although some of the samples tested by SPD in 1962 were just under the minimum required. The fresh rock is fairly tough and appears able to withstand such treatment as blasting, loading, dumping, and spreading without excessive breakdown. A definite statement regarding durability cannot be made prior to laboratory testing, however, as the rock is not extremely well cemented.

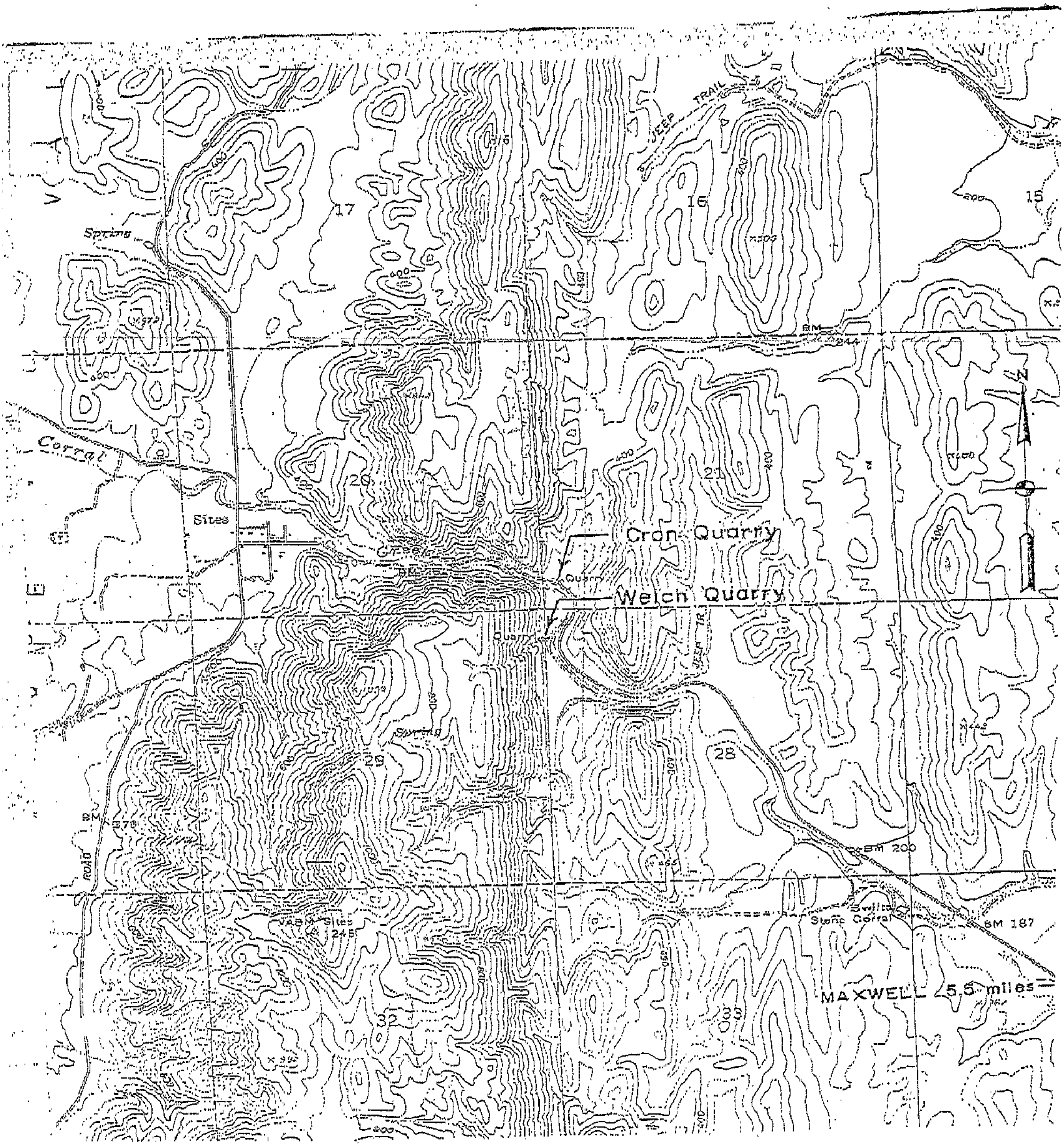
6. In the rock exposed in the Welch Quarry, weathering is not a problem except in the upper 5 to 10 feet, in the thin, highly fissile shale beds and on the extreme left side of the quarry where there is a sharp break between good quality fresh rock and rotten rock. Mr. Russell said that the Contractor does not intend to work the left side where the weathered rock occurs.

7. Conclusions.- Welch Quarry. Although the rock appears to be of acceptable quality, the specific gravity and durability characteristics have to be considered questionable until proven adequate by laboratory tests. The rock in the main part of the quarry appears to be uniform in quality, and if the sample submitted to the SPD Laboratory proves to be acceptable there should be little need for extensive inspection or control at the quarry site. The contractor should understand, however, that the rotten rock near the surface and on the left (south) side of the quarry face will have to be avoided or wasted.

Reed J. Anderson
REED J. ANDERSON
Geologist

1 Incl
as

cc: Engr Div (2)
C-O Div
Valley Res Ofc
F&M Branch
Emb Des Sec ✓
Geol & Conc Sec


JEEP TRAIL
Spring
17
16
15
Corral
Sites
20
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N
Cron Quarry
Quarry
Welch Quarry
Quarry
JEEP TR.
Spring
29
28
BM 370
ROAD
BM 200
Stone Corral
BM 187
VABM Sites
1245
MAXWELL 5.5 miles
32
33

RJA/sjf
5July72

29 June 1972

SPKED-F

MEMO FOR RECORD

SUBJECT: Inspection of Quarrying Operation at Welch (Sites) Quarry

1. References:

a. Memo for Record by R. J. Anderson, 21 March 1972, "Inspection of the Welch and Cron Quarries near Sites, California."

b. Memo for Record by P. J. Guthrie, 21 April 1972, "Inspection of Rock from Welch (Sites) Quarry."

2. The subject quarry was visited on 29 June 1972, by E. M. Hashimoto, C-O Division. R. J. Anderson, Foundations and Materials Branch and D. L. Mauck, Valley Resident Office. Purpose of the trip was to observe the shooting of an area of the main quarry face and to inspect the rock produced by the blast. The Contractor (Teichert Construction) had reported that the main face would be shot at 2:00 p.m. on 29 June. The area is of particular interest because, on the surface, it appears to contain better rock than any produced from the quarry thus far.

3. On arrival at the site the drilling and blasting methods being used were discussed with B. Lundgren of Mid State Contractors, Sonora, California, who has subcontracted with Teichert to operate the quarry. Methods being used seem appropriate for the rock type and condition of the quarry. According to Mr. Lundgren an average 8-foot hole spacing is being used, but the holes might be in an 8 x 8 foot square or staggered pattern or in a 7 x 9 foot staggered pattern depending on the size and shape of the area being drilled out. Maximum hole depth in production areas was said to be 20 feet. Ammonium nitrate (fertilizer) with fuel oil is used with 55 percent gel primers. Milisecond delay caps are used for each succeeding row of holes. Powder factors are reported to be between 0.6 and 0.8 pound per yard.

4. The area which was drilled out and loaded at the time of the visit was not the area of the main face as anticipated. It was a small area (perhaps 25 by 40 feet) to the left (south) of the main face where the rock is highly jointed, weathered and seamy. The area could not be inspected closely before the blast because the shot was already wired. The blast lifted the area only enough to open up joints and loosen the rock sufficiently so it could be pushed down the slope with dozers. It did not open up a face on the back or side that could be inspected for rock quality. The rock in the shot that could be seen was brown, blockily jointed, weathered and it seemed to contain a lot of soil.

5. Three rows of holes in the upper central part of the main face had been drilled but they were not loaded. According to the foreman from Mid State Contractors, drilling will be finished in this area about 6 July and the blast will probably be made at 5:00 p.m. on that date.

6. The overall condition of the quarry did not seem to be improved over its condition on the last visit of the undersigned (6 June). On the south side at about the elevation of the crusher and above the material exposed contains more soil than rock. It was being excavated and wasted with front end loaders. The crusher was not operating, and there was no material in sight that appeared to be suitable for processing. Stripping at the top of the main face and above has produced two benches about 20-30 feet wide. Rock exposures are spotty in the areas being stripped.

Reed J. Anderson
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C-O Div
John Crowe
Valley Res Ofc
Design Branch
F&M Branch (Orig)
Geol & Conc Sec
Emb Des Sec ✓

jcs

RJA/sjf
17Jul72

SPKED-F

14 July 1972

MEMO FOR RECORD

SUBJECT: Inspection of Rock at Welch (Sites) Quarry

1. References:

a. Memo for Record by T. R. Smith, 13 July 1972, "Meeting with A. Teichert Personnel to Discuss Sites Quarry, Contract 72-C-0057, Unit 22, Sacramento River Bank Protection Project."

b. Memo for Record by R. J. Anderson, 29 June 1972, "Inspection of Quarrying Operation at Welch (Sites) Quarry" and references a and b.

2. The subject quarry was visited on 14 July 1972, by E. M. Hashimoto, C-O Division and R. J. Anderson, Foundations and Materials Branch. The trip was made specifically to inspect the 5,000 ton stockpile of good quality rock that personnel of Teichert Construction had said was at the quarry site (ref. a.) and incidentally to observe the overall quarry operation and the quality of rock exposed.

3. There is no separate stockpile of better quality rock at the quarry. The rock being produced at the quarry at the present time is being dumped on the west side and around the south end of the existing stockpile. The dumping has been done in such a way that it is impossible to separate the more recently processed rock from the older rock. Thus, there is no distinction between the newer, "better quality" rock and the older rock which has been inspected, sampled and tested previously.

4. The rock that was being hauled from the crusher during the inspection of the stockpile was better than most of the rock seen at the quarry before. It contained an estimated 10 to 15 percent brown rock of which a large portion was the softer brown. However, inspection of the stockpile where (according to an equipment operator) recently processed rock had been dumped indicated that overall it is similar to that produced previously. Some is better quality, most appeared to be about average for the quarry, some is considerably worse than average. One area contained more than 50 percent brown rock. It appears that the contractor is deliberately mixing poor quality brown rock at the crusher with the better quality rock. During the visit the equipment operators were observed taking 4 or 5 buckets of recently shot rock to the crusher followed by 1 or 2 buckets from an area near the crusher which consists of soil and soft brown rock.

5. The quarry itself has not improved much in appearance since the visit of 29 June. One area in the upper central part has fresh blue rock exposed in the back face. A bench in front of this face contains relatively fresh shale which is too soft and platy to be acceptable. An area on the upper right side is being drilled out, but rock exposed downslope from the work area is of poor quality. Therefore, it appears that the overall quality of rock produced from the quarry will not improve in the immediate future. The contractor is not concentrating his efforts in the part of the quarry that contains the better quality rock.

R. J. Anderson
R. J. ANDERSON
Geologist

cc: Engr Div (2)
C-O Div
John Crowe
Valley Res Ofc
Design Branch
F&M Branch (Orig)
Geol & Conc Sec
Emb Des Sec ✓

TEICHERT CONSTRUCTION

September 28, 1972

Department of the Army
Corps of Engineers
Sacramento District
650 Capitol Mall
Sacramento, California 95814

Attention: James C. Donovan
Colonel, CE
Contracting Officer

Subject: Quarry Stone at Sites Quarry

Gentlemen:

At this time we wish to inquire what the Corps of Engineers' position will be on suitability of quarry stone produced at the Sites Quarry for slope protection rock on future contracts.

As you are aware, this quarry has been on the Corps of Engineers approved list for some time. We are currently using it on our Unit 22 contract and it has been used on other past contracts in recent years.

At the present time, we have developed the quarry to the extent that we are producing almost entirely a hard, durable graywacke sandstone, dark gray or gray-green in color. The quantity of rock of this quality is extensive. The specific gravity is over 2.5 and the absorption is less than four percent according to tests you have run.

There is some question as to the rock meeting the specification requirements that have appeared in your most recent bid invitations. The most critical test for this rock appears to be the sodium sulfate requirement (ASTM-C 88) that has appeared in recent specifications. Although we have not received any test results from you on sodium sulfate, we have some tentative results on magnesium sulfate soundness (CRD-C 137) that would require further clarification.

As you are aware, economical sources of rock are scarce in the upper Sacramento River area (Knights Landing North). It appeared to us that the Sites location would fulfill the needs for future contracts in this area because of its proximity to the river and the suitability of the rock.

On this basis, we entered into a long term lease with Mrs. Welch, the owner of the quarry, and have made considerable investment in plant equipment and pit development, not only to fulfill the requirements of our Unit 22 contract, but in order to supply rock for future work.

At this time we are negotiating the extension of our lease with the owner and, as a result, the future of this pit needs to be determined at this time, both by ourselves and for the owner.

We will appreciate an early reply to this inquiry. If you have any questions in this regard, please contact us.

Very truly yours,

TEICHERT CONSTRUCTION

Carl F. B

Carl F. Bauer
Manager Heavy Engineering

CFB:dw

RJA/sjf
13Oct72

12 October 1972

SPKED-F

MEMO FOR RECORD

SUBJECT: Inspection of Welch (Sites) Quarry

1. The subject quarry was visited on 11 October 1972, by J. Crowe, C-O Division, W. L. Goecker and R. J. Anderson, Foundations and Materials Branch. The trip was made to observe the condition of the quarry, the quality of rock being produced and the potential of the quarry in terms of rock quality and quantity.

2. Description of quarry. At the present time a face about 200 feet long and 75 feet high is exposed in the central part of the quarry. It is a bedding plane face that slopes to the east at about 45 degrees and is 50 to 60 feet farther into the hill than the original face that had been developed. A small plug of rock between these two faces remains to be blasted, and the south side of this section exposes the type of rock that has been excavated recently. It consists of about equal amounts of bluish gray to dark gray mostly fresh sandstone (graywacke) and interbedded shale. The quality of the sandstone appears to be as good as the quarry is capable of producing, which is to say that it is borderline for use as bank protection (ref. SPD Laboratory report dated July 1972, "Petrographic Report, Sites Quarry, Unit 22, Sacramento River Project, Colusa and Sutter Counties, California"). The shale, which is fissile and soft is completely unsuitable for riprap, and it must be separated from the harder and more durable sandstone in order to produce rock that comes close to meeting Sacramento District specifications. Sandstone exposed in the main face is bluish gray and fresh from the bottom upward about 30 to 40 feet and is discolored tan to brown by weathering in the upper 30 to 40 feet. The uppermost 5 to 10 feet is highly weathered rock and soil.

3. Upslope from the quarry face is a series of sandstone faces that are separated by relatively flat benches. The sandstone outcrops are dip faces; the benches are interpreted to be shale layers, and it appears that the percentages of sandstone and shale are roughly equal.

4. A muck pile in the quarry consists of fresh to slightly weathered sandstone with a large percentage of dark gray fines that are apparently produced from shale layers breaking down from blasting and equipment operation. Much of the sandstone is in blocks that are too large to be run through the crusher. They will require plugging and shooting or will have to be wasted. The need to separate fines and redrill and shoot boulders would seem to create a very inefficient operation.

5. At both ends of the quarry in front of the present face are large banks of moderately to highly weathered sandstone and shale with large amounts of brown clay. This material should have been stripped before quarrying operations were begun. In the past much of this type of material has been processed through the plant. and some of it ends up in the stockpiles mixed with the better rock.

6. Evaluation of quarry. Considering the overall quarry it is estimated that only 25 to 40 percent of the material available will be usable, and the best of it is only considered to be marginal under the specification currently in use. Any upgrading of the specifications would probably eliminate all of the rock from consideration. The low yield of usable rock cuts production, increases the time factor considerably and causes delays, and it appears that this situation is not going to change in the forseeable future. The problem will continue as it has throughout the operation of the quarry of separating the poor to medium quality rock from the acceptable rock. In the central part of the quarry where excavation is underway at the present time, the soft platy shale must be separated from sandstone. This is being accomplished with a grizzly, and the operation is generally successful, but a few large flat blocks of shale are getting through the grizzly and into the stockpile. On the levee slope they would break down rapidly and leave a void in the rock facing. When a new face is started in back of the present one, there will be two problems; separating shale from sandstone and separating softer, weathered sandstone from harder fresh sandstone. In the upper part of the quarry (from ground surface to a depth of 30 to 40 feet), an estimated 50 percent shale and 25 percent weathered sandstone will cut the volume of acceptable (marginal) rock to about 25 percent of the total production. Below the weathered zone the ratio of good rock to waste will increase to about 40 to 50 percent. Past experience has shown that it is not possible to separate weathered sandstone from fresh sandstone, and the resulting product is a mixture in varying proportions of suitable and unsuitable rock.

SPKED-F 13 October 1972
SUBJECT: Inspection of Welch (Sites) Quarry

7. Conclusions. The inspection trip and the past record of the quarry lead to the following conclusions.

a. The best rock available from the quarry is still marginal under present specifications.

b. Any rock furnished from the quarry will contain a certain amount of soft shale and weathered sandstone mixed with the bluish gray sandstone.

c. Because of the large amount of waste, the quarrying operation is inefficient and it is doubtful that large amounts of riprap can be furnished in a timely manner.

d. There is no data such as core samples available to indicate the type of material behind the present face; however, surface evidence indicates that it will be similar to that produced in the past. Therefore, there is no reason to expect improvement in the rock quality or operating conditions.

e. The quarry should be considered as a source of riprap only for emergency situations.

Reed J. Anderson
REED J. ANDERSON
Geologist

cc: Engr Div (2)
C-O Div
John Crowe
Valley Res Ofc
Design Branch
F&M Branch (Orig)
Geol & Conc Sec
Emb Des Sec

APPENDIX M

MUDSTONE
COMPRESSIVE STRENGTH AND BRAZILIAN TENSILE STRENGTH TEST RESULTS
(2.5-INCH DIAMETER DRILL CORES FROM GEOLOGIC EXPLORATION)

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

												ASTM D-2938		ASTM C-97	
LAB NO.	SITE	HOLE NO.	F. S. NO.	DEPTH (feet)	ROCK TYPE	NOTES	LENGTH (inch)	DIAM (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	REMARKS	SPG (ssd)	% ABS
99C-110	Sites	LC-2		51.3-52.0	Ss	Fresh, 45° per-bed, representative of sandstone	4.733	2.365	2.0	78,700	Wet	17,910	Good Test	2.74	0.2
99C-91	GG	RA-1		51.0-52.3	Ss	Fresh	5.010	2.392	2.1	58,800	Dry	13,080	Good Test	2.47	3.7
99C-92	GG	RA-1	A	53.4-54.2	Ss	Fresh	4.521	2.392	1.9	32,500	Wet	7,230	Good Test	2.50	3.5
			B				5.009	2.392	2.1	59,000	Dry	13,120	Good Test	2.50	3.4
99C-88	GG	LC-1		35.6-36.3	Ss	Slightly weathered, representative of pitting	5.018	2.390	2.1	75,600	Dry	16,850	Good Test	2.66	1.5
99C-84	GG	LA-1	A	27.8-28.4	Ss	Slightly weathered	4.010	2.377	1.7	21,200	Wet	4,620	Good Test	2.52	3.7
			B				4.510	2.380	1.9	50,150	Dry	11,270	Good Test	2.50	3.8
99C-90	GG	RA-1		16.2-17.2	Ss	Moderately weathered	5.013	2.385	2.1	32,550	Dry	7,290	Good Test	2.41	5.4
99C-89	GG	LC-1		199.5-200.3	Ms	Fresh	5.038	2.390	2.1	24,200	Dry	5,390	Good Test		
99C-87	GG	LC-1		23.2-23.8	Ms	Moderately weathered	4.555	2.385	1.9	5,250	Dry	1,180	Good Test		

DATE:
INITIAL: RGJ/TEC
REQUEST NO.: 99-19

REMARKS: Rock Types - Ms=Mudstone, Ss=Sandstone, I = Interbedded Mudstone/Siltstone

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F. S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-28	GGC-LA1	A	75.8-77.3	Ss	4.884	2.392	2.04							2.56	2.9
		B		Ss	4.883	2.393	2.04	25650	WET	5703				2.56	2.9
		C		Ss	4.861	2.392	2.03	45500	DRY	10125				2.57	2.8
2001-29	GGC-LA1		163.3-164.4	Ms	1.866	2.387	0.78							2.51^A	4.6
2001-30	GGC-RC1	A	56.0-57.0	Ss	5.007	2.487	2.01	22800	WET	4693				2.49	2.9
		B		Ss	5.020	2.488	2.02	47600	DRY	9791				2.50	2.8
2001-31	GGC-RC1	A	146.7-147.7	Ms	5.047	2.492	2.03							2.56^A	3.6
		B		Ms	1.556	2.493	0.62								
2001-32	GGC-RC2	A	140.1-141.3	Ms	4.919	2.488	1.98	19350	DRY	3980				2.53^A	4.6
		B		Ms	4.990	2.487	2.01								
		C		Ms	3.535	2.487	1.42								
2001-33	GGC-RC2	A	70.8-71.9	Ss	5.024	2.494	2.01							2.53	2.8
		B		Ss	5.027	2.493	2.02							2.52	3.1
		C		Ss	1.545	2.493	0.62							2.55	3.0

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2936	ASTM D-3967			ASTM C-97	
LAB NO.	HOLE NO.	F. S. NO.	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-34	GGC-RA1	A	59.9-61.0	Ss	1.495	2.394	0.62							2.53	2.6
		B		Ss	5.019	2.394	2.10	21650	WET	4810				2.55	2.6
		C		Ss	5.019	2.394	2.10	45000	DRY	9997				2.56	2.6
		D		Ss	1.398	2.394	0.58							2.56	2.8
2001-35	GGC-RA1	A	146.3-147.5	Ms	4.996	2.390	2.09	9800	DRY	2184				2.52^A	3.9
2001-36	GO-DHS-3	A	45.0-46.0	Ss	5.024	2.491	2.02							2.48	2.3
		B		Ss	5.018	2.491	2.01							2.48	2.2
2001-37	SSD3-4		140.1-140.0	Ms										2.40^A	8.4
2001-38	SSD5-3	A	97.1-99.0	*	1.480	2.478	0.60								
		B		*	3.588	2.480	1.45								
		C		*	1.258	2.488	0.51							2.28	8.3
		D		Ss	1.505	2.488	0.60							2.39	6.7
2001-39	SSD8-5		63.0-64.0	Ms										2.41^A	6.8
2001-40	SSD9-1	A	120.4-121.4	Ms	1.283	2.493	0.51								
		B		Ms	1.347	2.493	0.54								
		C		Ms	4.193	2.493	1.68	26150	DRY	5238					
		D		Ms	1.238	2.493	0.50								

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR **FEATURE:** 2.5" DIAMETER ROCK CORES

LAB NO	HOLE NO	F.S NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	ASTM D-2938	ASTM D-3967			ASTM C-97	
										COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-41	GO-DHT3	A	71.0-72.2	Ss	1.641	2.491	0.66	3630	WET		1776			2.48	4.2
		B		Ss	5.033	2.490	2.02	25450	WET	5226				2.43	3.3
		C		Ss	1.448	2.490	0.58							2.42	3.3
2001-42	GO-DHT3	A	206.5-207.6	Ms	3.762	2.490	1.51							2.57^A	3.9
		B		Ms	4.980	2.491	2.00							2.57^A	3.9
2001-43	GO-DHT3	A	272.0-273.0	Ss	5.020	2.492	2.01							2.45	3.7
		B		Ss	5.021	2.492	2.01							2.44	3.9
		C		Ss	1.520	2.492	0.61							2.44	3.5
		D		Ss	1.398	2.492	0.56							2.43	3.9
2001-51	GGO-DHS3		45.0-46.0	Ss	(did not receive sample)										
2001-52	GGO-DHS4	B	56.0-57.0	Ss	1.593	2.486	0.64	4910	DRY		2480				
		C			4.593	2.490	1.84	33750	WET	6861				2.66	0.8
2001-53	GGO-DHS4		57.0-57.7	Ms	(can not obtain test specimen- see sketch)										
2001-54	GGO-DHS4		26.5-27.0	Ms	1.523	2.491	0.61								

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SUMMARY SHEET

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DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F. S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2001-55	GGO-DHT1	A	155.7-156.7	Ms	4.980	2.487	2.00	15400	DRY	3170					
		B		Ms	1.414	2.485	0.57	1140	DRY		649				
2001-56	GGO-DHT1	A	176.0-177.2	Ss	4.860	2.497	1.95	0	WET	0	(mudstone separated-water damaged)			2.58	1.5
		B		Ss	4.518	2.502	1.81	59700	DRY	11988				2.66	0.5
2001-57	GGO-DHT3	A	316.3-317.7	Ss	1.345	2.491	0.54							2.33	4.4
		B		Ss	4.999	2.491	2.01							2.42	3.4
		C		Ss	4.993	2.491	2.00							2.43	3.4
		D		Ss	1.499	2.492	0.60	2740	WET		1467			2.44	3.6
		E		Ss	1.499	2.493	0.60	5220	DRY		2795			2.46	3.7
2001-58	GGO-DHT3	A	327.7-329.0	Ss	5.081	2.493	2.04	22200	WET	4548				2.49	2.0
		B		Ss	4.948	2.490	1.99	22400	DRY	4600					
2001-59	GGO-DHT4	A	115.5-116.7	Ms	1.552	2.487	0.62	1780	DRY		922				
		B		Ms	1.521	2.487	0.61								
		C		Ms	1.551	2.491	0.62								
		D		Ms	5.029	2.489	2.02	13700	DRY	2816					
2001-60	GGO-DHT4	A	124.5-125.5	Ss	5.023	2.491	2.02	45150	DRY	9264				2.50	2.7
		B			5.017	2.492	2.01	37750	WET	7740				2.59	1.5

DATE:
INITIAL: rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB. NO	HOLE NO	F. S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM. (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS.
2001-61	GGO-DHT5	A	430.5-432.0	Ss	1.512	2.491	0.61	3200	WET		1700			2.49	3.3
		B			5.028	2.491	2.02	28000	WET	5745				2.53	2.5
		C			5.016	2.491	2.01	42900	DRY	8803				2.54	2.9
		D			5.023	2.491	2.02							2.52	2.1
2001-62	GGO-DHT6	A	535.4-536.4	Ms	4.786	2.495	1.92								
2001-63	GGO-DHT6	A	556.3-557.3	Ms	4.788	2.492	1.92	18900	DRY	3856					
		C			1.555	2.493	0.62	2700	DRY		1393				

DATE:
INITIAL. rgj
REQUEST NO. 2001-08

REMARKS: Rock Types Ms=Mudstone Ss=Sandstone I = Interbedded Mudstone/Siltstone
A - broken and/or end pieces used for specific gravity and absorption

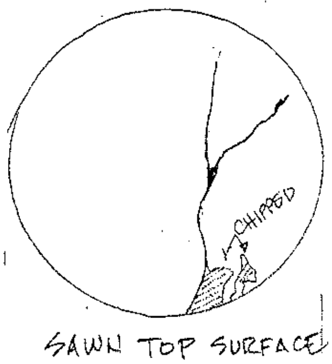
LAB # 99C-87

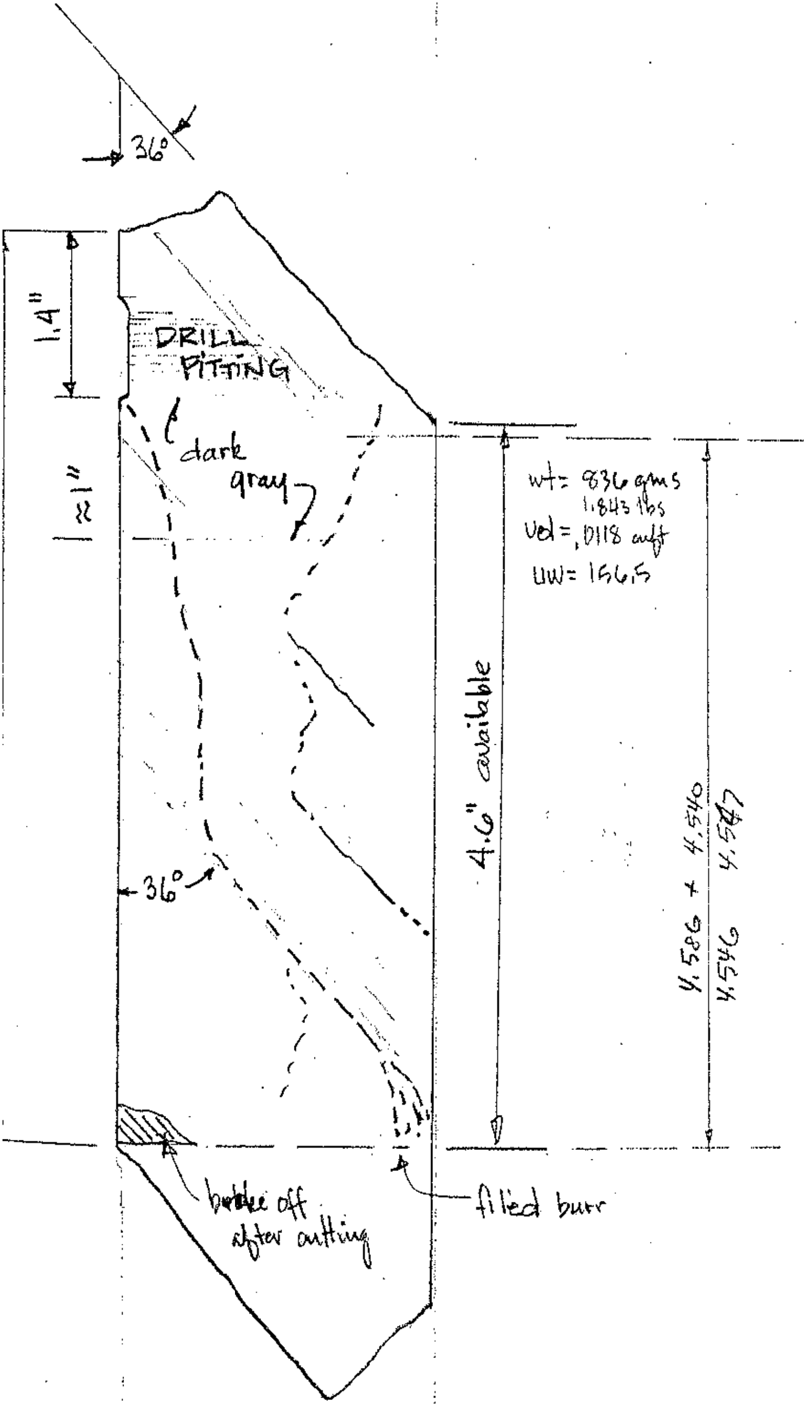
ROCK DESCRIPTION: Weathered shale (mudstone)

Hole: LC-1

Depth: 23.2 ~ 23.8

Golden Gate





wt= 836 gms
1.843 lbs
Vol= .0118 cuft
UW= 156.5

5250 lbs

avg L = 4.555"
avg D = 2.385"
Area = 4.468 #
L/D = 1.91

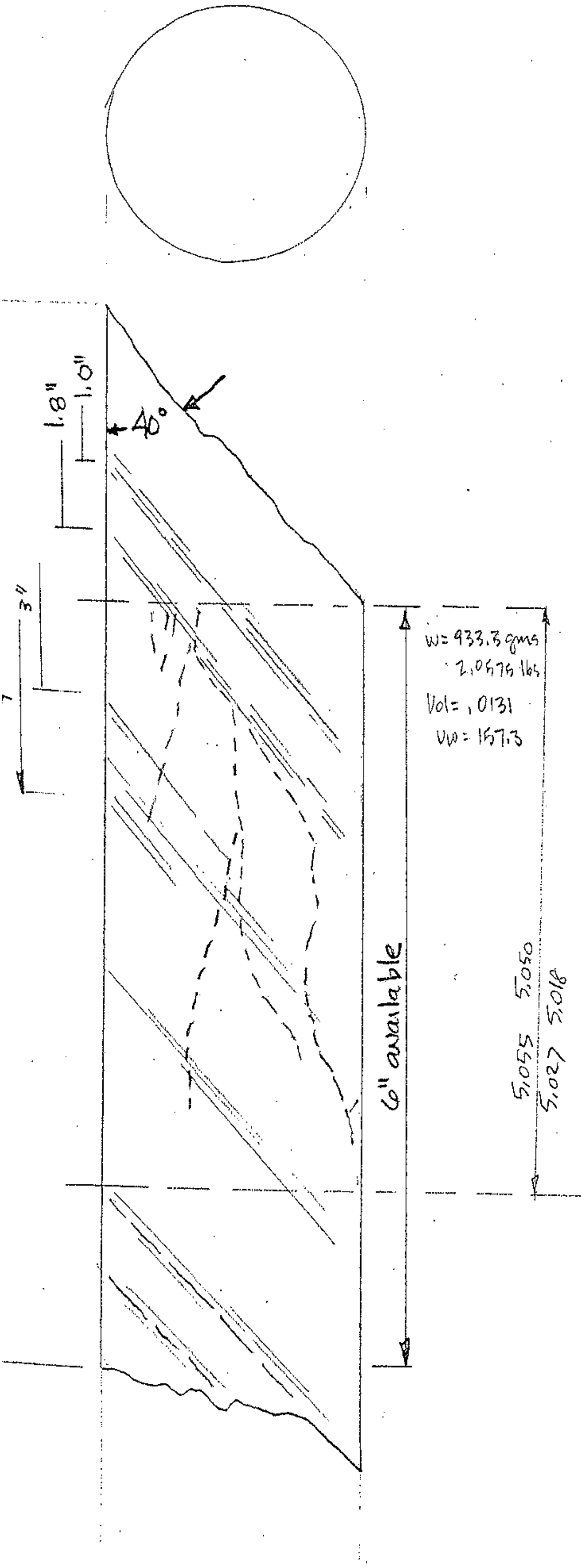
Dia
top 2.385
mid 2.386
bott 2.383

(CANNOT SOAK)

LAB # 99C - 89
ROCK DESCRIPTION: Shale (mudstone)

Hole: LC-1
Depth: 199,5 ~ 200,3

Golden Gate

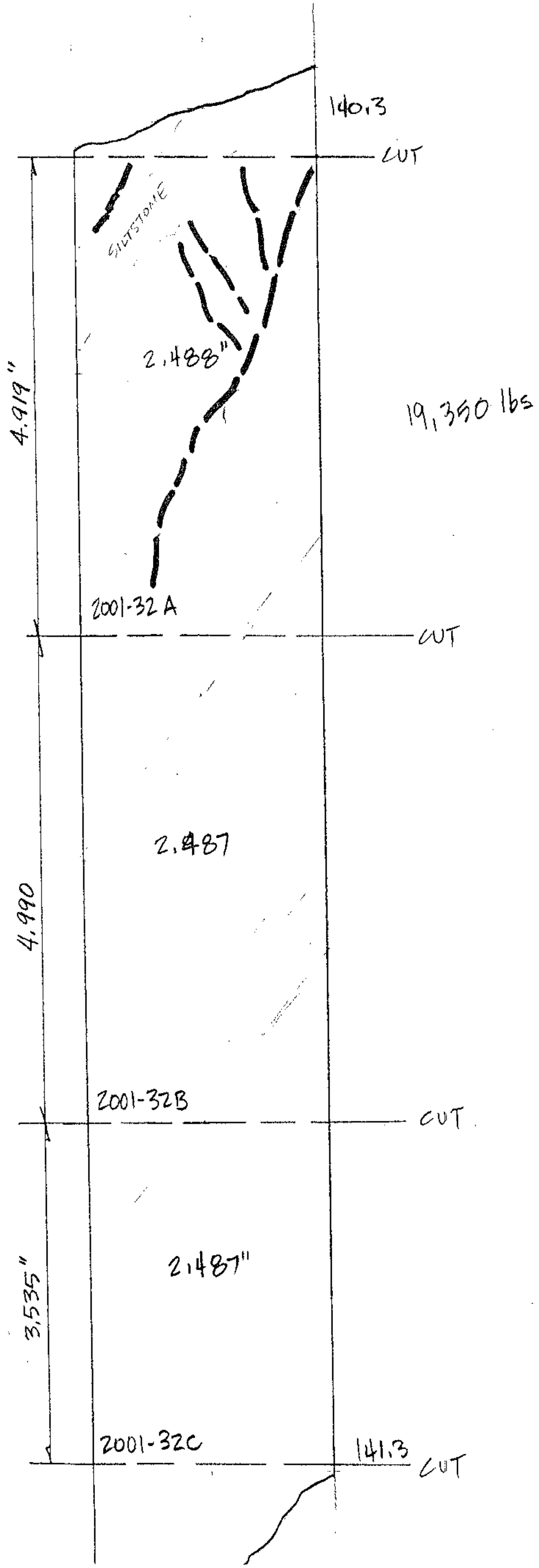


24200 lbs

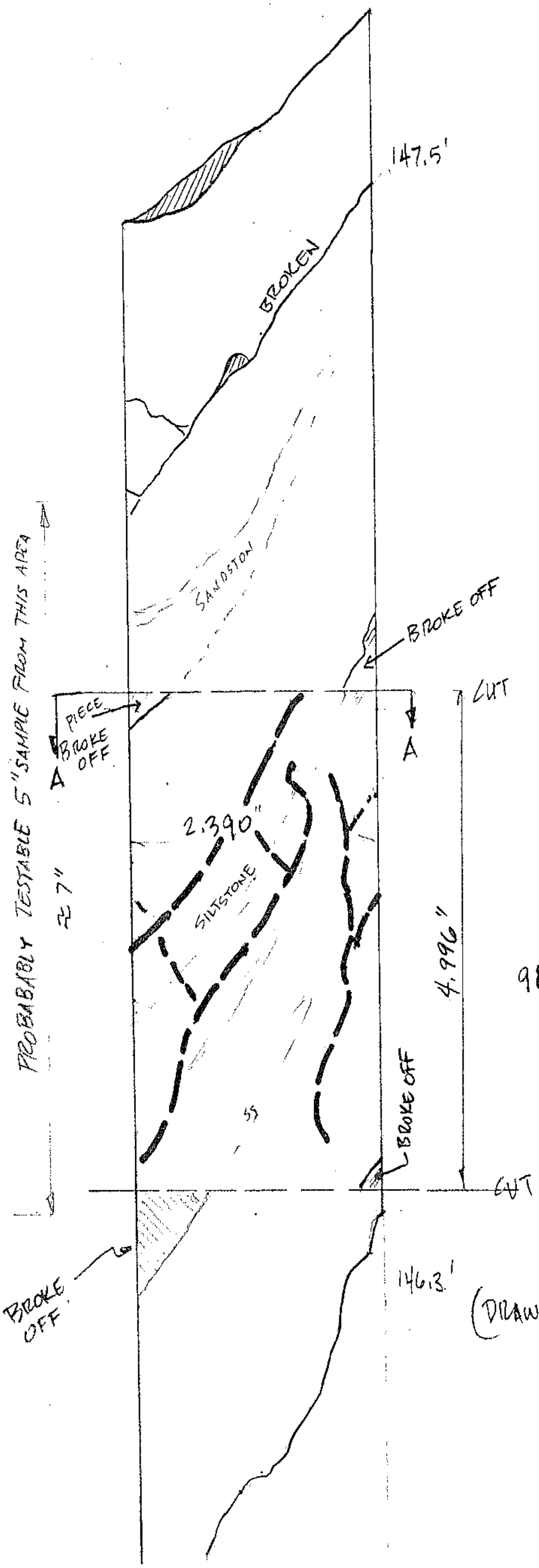
Dia
top 2,390
mid 2,389
bott 2,392

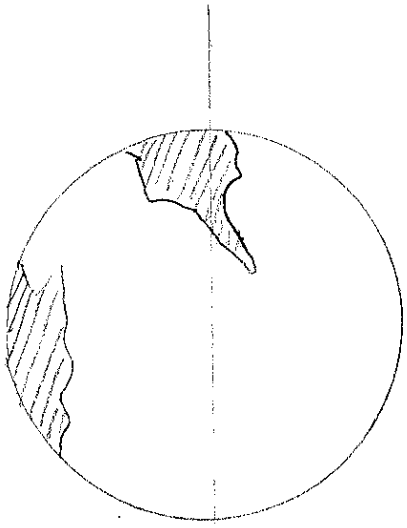
avg L = 5,038
avg D = 2,390
Area = 4,486
L/D = 2,11

(CANNOT SOAK)



PROJECT: SITE
HOLE #: GGC-RC2
DEPTH (ft): 140.1 - 141.3
SOILS LAB #: 2001-32



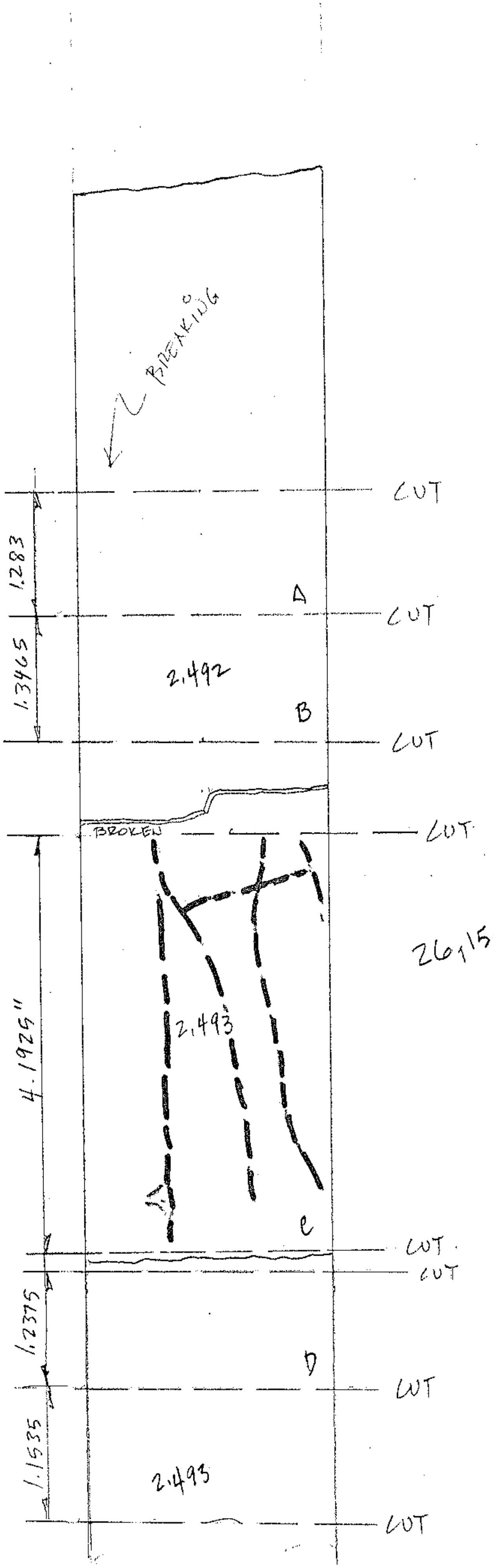


SECTION A-A

9800 lbs

(DRAWN UPSIDE DOWN)

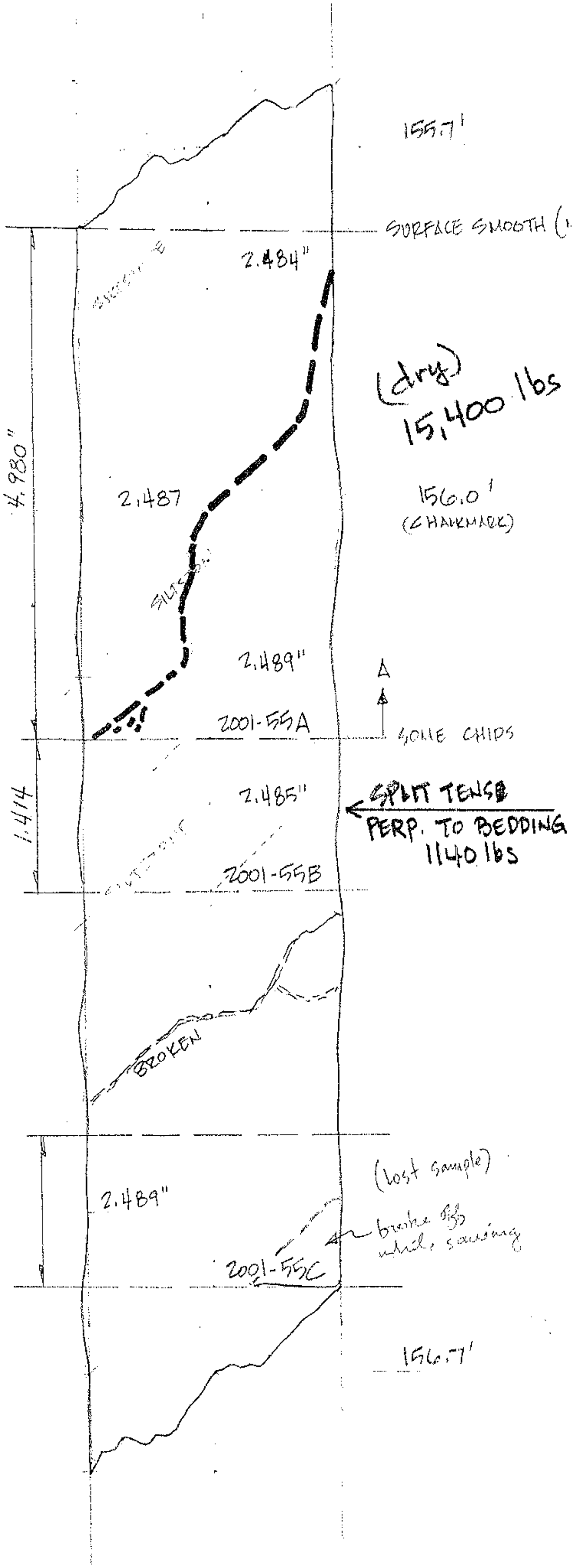
PROJECT: SITES
HOLE # : GGC-RA1
DEPTH (ft) : 146.3 - 147.5
SOILS LAB # : 2001-36

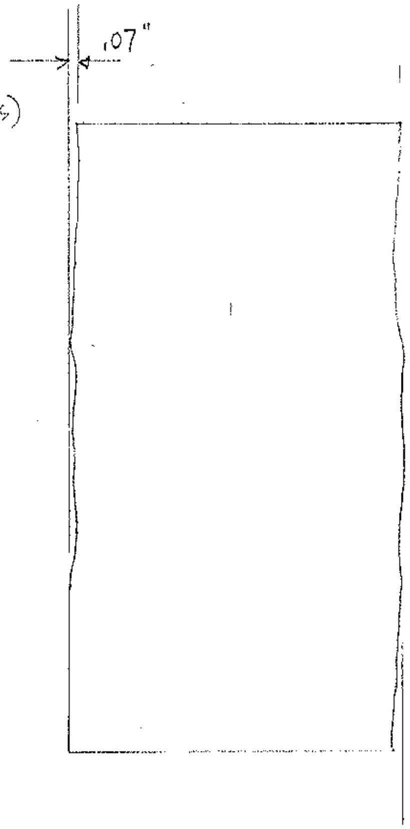


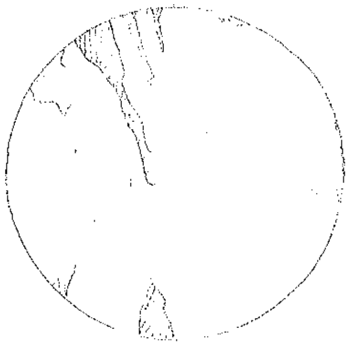
26,150 lbs

"Sample dry cut"
did not use water
blade wobbling - getting hot

PROJECT:
HOLE #: SSD9-1
DEPTH (ft): 120.4' - 121.4
SOILS LAB #: 2001-40

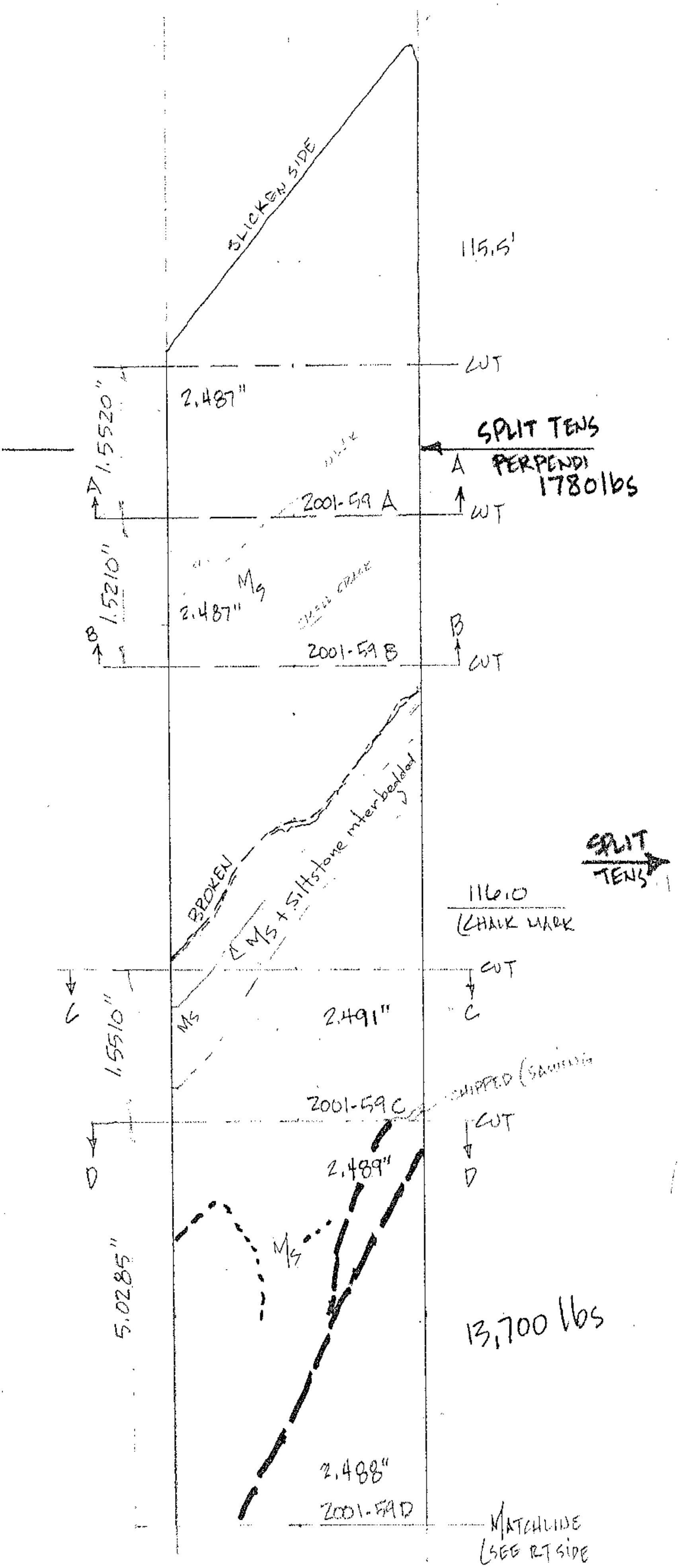


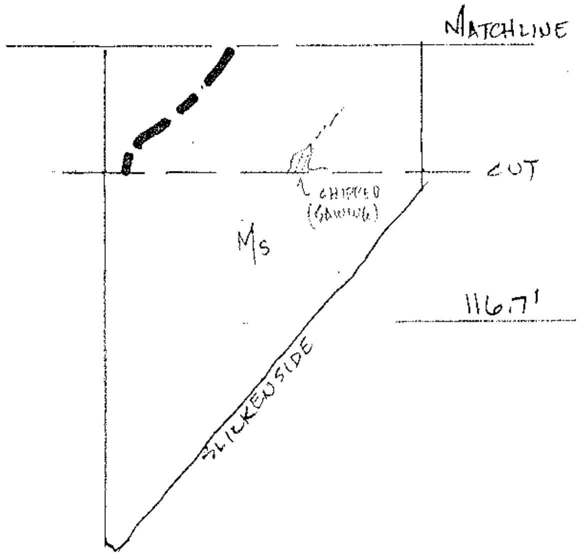


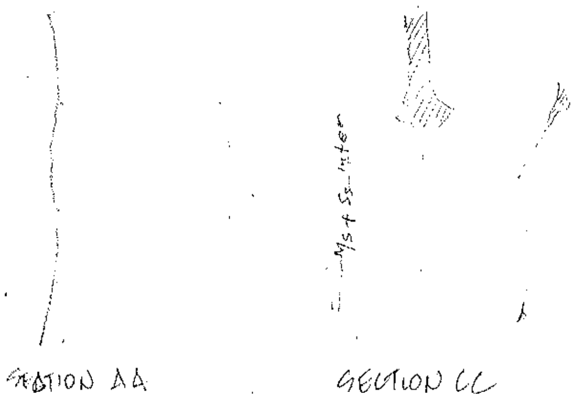


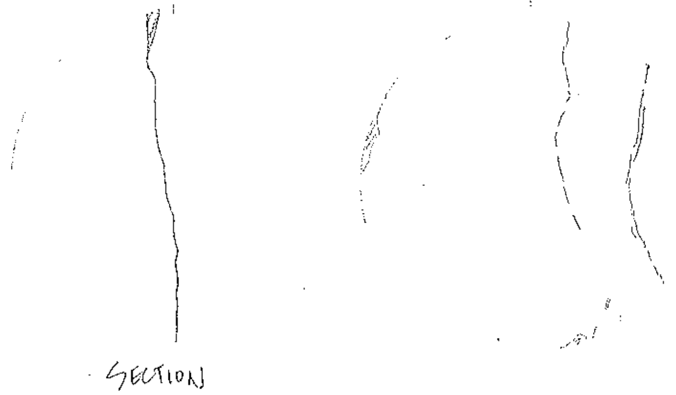
"A" looking up from bottom

PROJECT:
HOLE #: GGO-DHT1
DEPTH (ft): 155.7-156.7
SOILS LAB #: 2001-~~56~~ 55

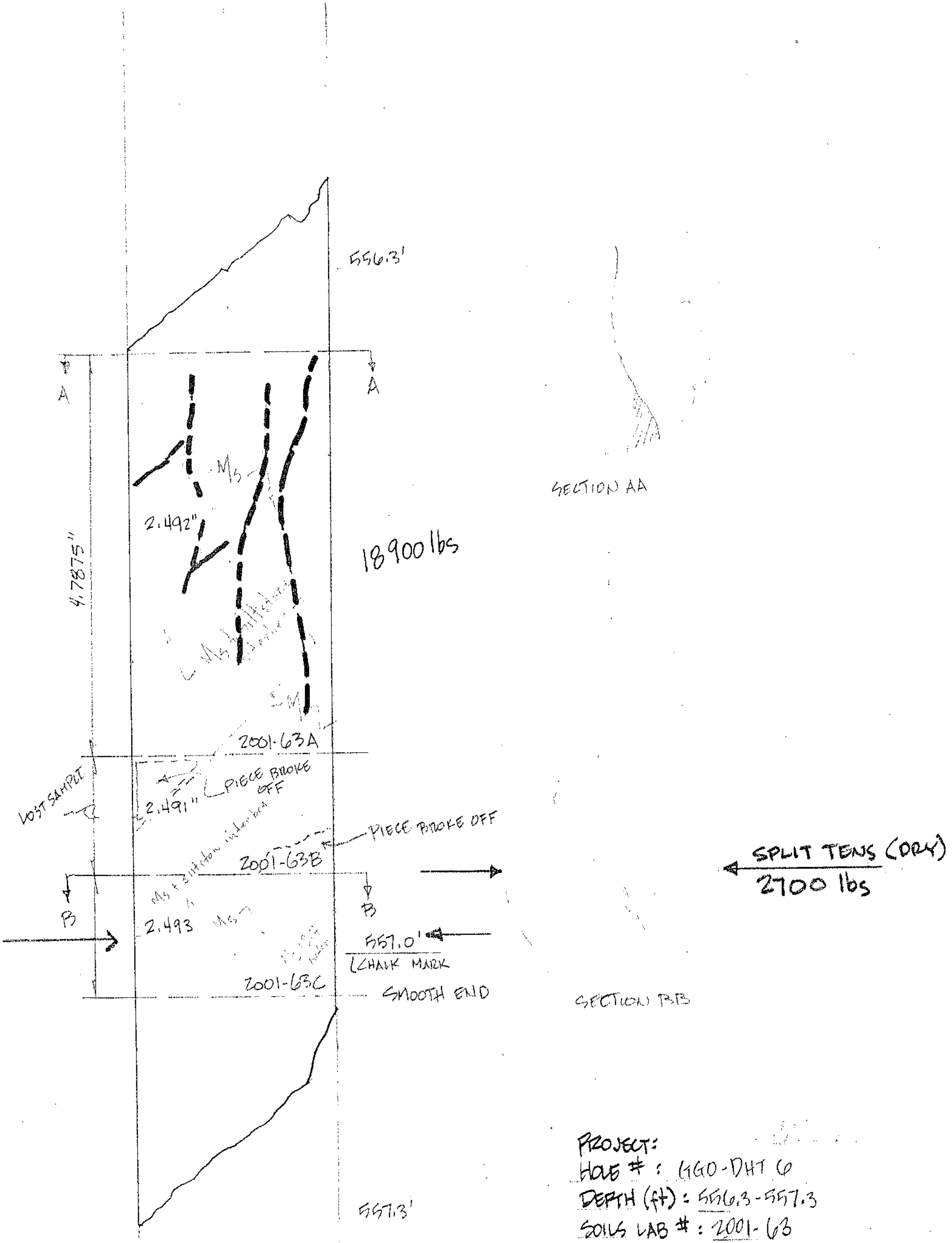








PROJECT:
HOLE #: GGO-DHT 4
DEPTH (ft): 115.5-116.7
SOILS LAB #: 2001-59



PROJECT:
HOLE # : GGO-DHT 6
DEPTH (ft) : 556.3 - 557.3
SOILS LAB # : 2001-63

APPENDIX N

MUDSTONE
SHEAR STRENGTH
(DWR PUBLISHED DATA)

SHEAR STRENGTH CORRELATION STUDY

1- 1-1976

SOIL TEST DATA -- TABLE 2

NAME	DEFINITION	
OR	SOIL ORIGIN V-VOLCANIC I-INTRUSIVE M-METAMORPHIC S-SEDIMENTARY A-ALLUVIAL	
PS	PARTICLE SHAPE(SAND-GRAVEL) A-ANGULAR SA-SUBANGULAR SR-SUBROUNDED R-ROUNDED WR-WELL ROUNDED P-PLATEY	
EN	COMPACTION ENERGY	FT-KIPS PER CU FT
MDN	MAXIMUM DRY DENSITY	LB PER CU FT
IDN	INITIAL DRY DENSITY	LB PER CU FT
TDN	DRY DENSITY AFTER CONSOLIDATION	LB PER CU FT
COMP	PER CENT COMPACTION	PER CENT
WC	INITIAL WATER CONTENT	PER CENT
SAT	SATURATION	PER CENT
B	PORE PRESSURE PARAMETER B	
NOR	FOR TRIAX-AVERAGE PRINCIPAL STRESS AT FAILURE	KGMS PER SQ CM
NOR	FOR DIRECT SHEAR-NORMAL STRESS	KGMS PER SQ CM
SHR	FOR TRIAX-HALF THE DEVIATOR STRESS AT FAILURE	KGMS PER SQ CM
SHR	FOR DIRECT SHEAR-SHEAR STRESS AT FAILURE	KGMS PER SQ CM
PWP	PORE WATER PRESSURE AT FAILURE	KGMS PER SQ CM
EPHI	ANGLE OF STRENGTH ENVELOPE-EFFECTIVE STRESSES	DEGREES
EC	INTERCEPT OF STRENGTH ENVELOPE-EFFECTIVE STRESSES	KGMS PER SQ CM
TPHI	ANGLE OF STRENGTH ENVELOPE-TOTAL STRESSES	DEGREES
TC	INTERCEPT OF STRENGTH ENVELOPE-TOTAL STRESSES	KGMS PER SQ CM
STY	SAMPLE TYPE U-UNDISTURBED R-REMOLDED	
STRAIN RATE		IN PER MIN

DEFINITION OF FAILURE

(MAX DEVIATOR STRESS-TOTAL STRESS
-------------- (MAX EFF PRIN STRESS RATIO-EFF STRESS
-------------- MAX SHEAR STRESS

TYPE OF TEST

CUE (TRIAX-CONS UNDRAINED-MEASURE PWP)

TYPE OF SOIL(UNIFIED CLASSFICATION SYSTEM)

SM

I.D.	OR	PS	LL	PI	-4	-30	-200	-5M	SP.G.	EN	MDN	IDN	TDN	COMP	W/C	SAT	B-VALUE	EPHI	EC	TPHI	TC	STY
68162 3818			NP	NP	100	71	13	0	2.71	20	118	112	113	94.9	11.1	0	.94	34	.1	22	1.7	R
68162 3818			NP	NP	100	71	13	0	2.71	20	118	112	113	94.9	11.0	0	.89	34	.1	22	1.7	R
68162 3818			NP	NP	100	71	13	0	2.71	20	118	112	113	94.9	11.1	0	.88	34	.1	22	1.7	R
69156 530			NP	NP	100	78	13	0	2.72	20	125	119	119	95.2	10.3	0	.91	0	0	0	0	R
63048 3585			NP	NP	100	61	23	11	2.73	20	128	121	121	94.5	9.9	100	0	39	0	0	0	R
63048 3585			NP	NP	100	61	23	11	2.73	20	128	121	122	94.5	10.0	97	0	39	0	0	0	R
63048 3585			NP	NP	100	61	23	11	2.73	20	128	121	123	94.5	9.9	99	0	39	0	0	0	R
66062 438			NP	NP	100	65	25	10	2.69	20	125	119	121	95.2	10.4	0	.90	39	0	21	1.3	R
66062 438			NP	NP	100	65	25	10	2.69	20	125	119	122	95.2	10.9	0	.60	39	0	21	1.3	R
66062 438			NP	NP	100	65	25	10	2.69	20	125	119	122	95.2	10.9	0	.50	39	0	21	1.3	R
66062 438			NP	NP	100	65	25	10	2.69	20	125	119	120	95.2	11.2	0	1.00	37	0	20	1.5	R
66062 438			NP	NP	100	65	25	10	2.69	20	125	119	121	95.2	11.1	0	1.00	37	0	20	1.5	R

I.D.	OK	PS	LL	PI	-4	-30	-200	-5M	SP.G.	EN	MDN	IDN	TDN	COMP	W/C	SAT	B-VALUE	EPHI	EC	TPHI	TC	STY
66062 438			NP	NP	100	65	25	10	2.69	20	125	119	123	95.2	10.7	0	.80	37	0	20	1.5	R
66062 438			NP	NP	100	65	25	10	2.69	20	125	119	122	95.2	11.0	0	.40	37	0	20	1.5	R
65053 7258			NP	NP	100	72	27	11	2.68	20	124	118	119	95.2	12.1	0	1.00	37	0	22	1.4	R
65063 7258			NP	NP	100	72	27	11	2.68	20	124	118	120	95.2	12.1	0	.88	37	0	22	1.4	R
65063 7258			NP	NP	100	72	27	11	2.68	20	124	118	123	95.2	11.8	0	1.00	37	0	22	1.4	R
69071 1402			NP	NP	100	72	29	14	2.65	20	126	119	119	94.4	10.0	0	.93	35	0	20	1.5	R
69071 1402			NP	NP	100	72	29	14	2.65	20	126	119	121	94.4	10.0	0	.92	35	0	20	1.5	R
69071 1402			NP	NP	100	72	29	14	2.65	20	126	119	121	94.4	9.9	0	.91	35	0	20	1.5	R
69071 1402			NP	NP	100	72	29	14	2.65	20	126	120	121	95.2	9.5	0	.95	35	0	20	1.5	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	117	118	94.4	11.4	0	1.00	35	0	17	.8	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	118	120	95.2	11.2	0	.90	35	0	17	.8	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	118	120	95.2	10.7	0	.80	35	0	17	.8	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	118	122	95.2	10.8	0	.80	35	0	17	.8	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	118	119	95.2	10.7	0	1.00	36	0	17	1.2	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	118	120	95.2	10.6	0	1.00	36	0	17	1.2	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	118	122	95.2	10.7	0	1.00	36	0	17	1.2	R
66062 437			NP	NP	100	73	31	14	2.70	20	124	117	123	94.4	11.3	0	.70	36	0	17	1.2	R
6622011697			NP	NP	100	76	37	12	2.65	20	115	108	108	93.9	14.8	0	1.00	38	0	27	1.1	R
6622011697			NP	NP	100	76	37	12	2.65	20	115	109	109	94.8	14.3	0	1.00	38	0	27	1.1	R
6622011697			NP	NP	100	76	37	12	2.65	20	115	109	110	94.8	14.5	0	.90	38	0	27	1.1	R
66062 439			NP	NP	100	78	38	15	2.70	20	122	116	118	95.1	12.1	0	1.00	35	0	19	.8	R
66062 439			NP	NP	100	78	38	15	2.70	20	122	116	117	95.1	12.3	0	1.00	35	0	19	.8	R
66062 439			NP	NP	100	78	38	15	2.70	20	122	116	119	95.1	11.7	0	.40	35	0	19	.8	R
66062 439			NP	NP	100	78	38	15	2.70	20	122	116	123	95.1	12.2	0	.80	35	0	19	.8	R
69071 1419			NP	NP	100	84	38	17	2.65	20	121	114	116	94.2	12.6	0	.92	32	0	16	.3	R
69071 1419			NP	NP	100	84	38	17	2.65	20	121	115	117	95.0	11.9	0	.95	32	0	16	.3	R
66114 4199			NP	NP	100	74	40	12	2.76	20	131	125	126	95.4	8.9	0	.92	37	0	0	0	R

I.D.	OR	PS	LL	PI	-4	-30	-200	-5M	SP.G.	EN	MDN	IDN	TON	COMP	W/C	SAT	B-VALUE	EPHI	EC	TPHI	TC	STY
66134 4199			NP	NP	100	74	40	12	2.76	20	131	124	127	94.7	9.0	0	.78	37	0	0	0	R
66134 4199			NP	NP	100	74	40	12	2.76	20	131	125	128	95.4	8.9	0	.52	37	0	0	0	R
68048 5872			NP	NP	100	92	41	18	2.71	20	125	119	119	95.2	10.2	0	.83	36	.1	33	1.3	R
68048 5872			NP	NP	100	92	41	18	2.71	20	125	119	120	95.2	9.9	0	.60	36	.1	33	1.3	R
68048 5872			NP	NP	100	92	41	18	2.71	20	125	119	120	95.2	9.7	0	.65	36	.1	33	1.3	R
66134 4197			29	5	100	77	42	17	2.76	20	128	122	124	95.3	10.3	0	.90	33	.1	12	.9	R
66134 4197			29	5	100	77	42	17	2.76	20	128	122	125	95.3	10.4	0	.80	33	.1	12	.9	R
66134 4197			29	5	100	77	42	17	2.76	20	128	122	126	95.3	10.4	0	.63	33	.1	12	.9	R
65063 7247			NP	NP	100	90	43	14	2.70	20	118	112	113	94.9	11.8	0	1.00	30	.5	15	1.0	R
65063 7247			NP	NP	100	90	43	14	2.70	20	118	112	115	94.9	11.5	0	1.00	30	.5	15	1.0	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	116	117	95.1	12.8	0	1.00	33	.2	16	1.0	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	116	118	95.1	12.9	0	1.00	33	.2	16	1.0	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	116	121	95.1	12.7	0	.70	33	.2	16	1.0	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	116	125	95.1	12.5	0	.90	33	.2	16	1.0	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	117	118	95.9	12.1	100	0	30	.3	19	.9	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	116	116	95.1	12.3	94	0	30	.3	19	.9	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	116	121	95.1	12.3	99	0	30	.3	19	.9	R
66062 436			NP	NP	100	86	43	14	2.72	20	122	116	134	95.1	12.9	100	0	30	.3	19	.9	R
66134 4186			NP	NP	100	89	50	17	2.76	20	121	115	117	95.0	13.0	0	.91	35	0	0	0	R
66134 4186			NP	NP	100	89	50	17	2.76	20	121	115	118	95.0	13.0	0	.90	35	0	0	0	R
66134 4186			NP	NP	100	89	50	17	2.76	20	121	115	120	95.0	13.0	0	.73	35	0	0	0	R

SHEAR STRENGTH CORRELATION STUDY
SOIL TEST DATA -- TABLE 2

1- 1-1976

NAME	DEFINITION	
OR	SOIL ORIGIN V-VOLCANIC I-INTRUSIVE M-METAMORPHIC S-SEDIMENTARY A-ALLUVIAL	
PS	PARTICLE SHAPE(SAND-GRAVEL) A-ANGULAR SA-SUBANGULAR SR-SUBROUNDED R-ROUNDED WR-WELL ROUNDED P-PLATEY	
EN	COMPACTION ENERGY	FT-KIPS PER CU FT
MDN	MAXIMUM DRY DENSITY	LB PER CU FT
IDN	INITIAL DRY DENSITY	LB PER CU FT
TDN	DRY DENSITY AFTER CONSOLIDATION	LB PER CU FT
COMP	PER CENT COMPACTION	PER CENT
WC	INITIAL WATER CONTENT	PER CENT
SAT	SATURATION	PER CENT
B	PORE PRESSURE PARAMETER B	
NOR	FOR TRIAX-AVERAGE PRINCIPAL STRESS AT FAILURE	KGMS PER SQ CM
NOR	FOR DIRECT SHEAR-NORMAL STRESS	KGMS PER SQ CM
SHR	FOR TRIAX-HALF THE DEVIATOR STRESS AT FAILURE	KGMS PER SQ CM
SHR	FOR DIRECT SHEAR-SHEAR STRESS AT FAILURE	KGMS PER SQ CM
PWP	PORE WATER PRESSURE AT FAILURE	KGMS PER SQ CM
EPHI	ANGLE OF STRENGTH ENVELOPE-EFFECTIVE STRESSES	DEGREES
EC	INTERCEPT OF STRENGTH ENVELOPE-EFFCTIVE STRESSES	KGMS PER SQ CM
TPHI	ANGLE OF STRENGTH ENVELOPE-TOTAL STRESSES	DEGREES
TC	INTERCEPT OF STRENGTH ENVELOPE-TOTAL STRESSES	KGMS PER SQ CM
STY	SAMPLE TYPE U-UNDISTURBED R-REMOLDED	
STRAIN RATE		IN PER MIN

DEFINITION OF FAILURE

(MAX DEVIATOR STRESS-TOTAL STRESS
-------------- (MAX EFF PRIN STRESS RATIO-EFF STRESS
-------------- MAX SHEAR STRESS

TYPE OF TEST

CUE (TRIAX-CONS UNDRAINED-MEASURE PWP)

TYPE OF SOIL(UNIFIED CLASSFICATION SYSTEM)

SC

I.D.	OR	PS	LL	PI	-4	-30	-200	-5M	SP.G.	EN	MDN	IDN	TDN	COMP	W/C	SAT	B-VALUE	EPHI	EC	TPHI	TC	STY
59371 1401			20	3	100	74	31	13	2.66	20	127	122	122	96.1	9.6	0	.92	38	0	21	2.0	R
69071 1401			20	3	100	74	31	13	2.66	20	127	120	123	94.5	9.7	0	.91	38	0	21	2.0	R
59071 1401			20	3	100	74	31	13	2.66	20	127	121	125	95.3	9.6	0	.93	38	0	21	2.0	R
67148 16870			41	20	100	75	39	0	2.69	20	105	99	101	94.3	19.5	0	.83	36	0	13	.5	R
57148 16870			41	20	100	75	39	0	2.69	20	105	101	105	96.2	17.2	0	.87	36	0	13	.5	R
67148 16870			41	20	100	75	39	0	2.69	20	105	100	103	95.2	19.0	0	.80	36	0	13	.5	R
63056 3759			33	13	100	70	40	20	2.65	20	120	113	114	94.2	13.1	100	0	30	0	15	.2	R
53056 3759			33	13	100	70	40	20	2.65	20	120	114	115	95.0	13.1	100	0	30	0	15	.2	R
53056 3759			33	13	100	70	40	20	2.65	20	120	114	116	95.0	13.0	100	0	30	0	15	.2	R
57136 8981			26	8	100	81	40	17	2.73	20	130	124	127	95.4	8.9	0	.87	38	0	14	1.0	R
67136 8981			26	8	100	81	40	17	2.73	20	130	124	129	95.4	8.9	0	.87	38	0	14	1.0	R
67136 8981			26	8	100	81	40	17	2.73	20	130	124	131	95.4	8.7	0	.87	38	0	14	1.0	R

I.D.	OR	PS	LL	PI	-4	-30	-200	-5M	SP.G.	EN	HDN	IDN	TDN	COMP	W/C	SAT	B-VALUE	EPHI	EC	TPHI	TC	STY
6714816830			45	25	100	80	42	0	2.67	20	105	100	103	95.2	19.3	0	.90	~~36~~	~~0~~	~~13~~	~~.4~~	R
6714816830			45	25	100	80	42	0	2.67	20	105	100	105	95.2	19.4	0	.92	36	0	13	.4	R
6714816830			45	25	100	80	42	0	2.67	20	105	100	106	95.2	19.3	0	.83	~~36~~	~~0~~	~~13~~	~~.4~~	~~R~~
68048 5859			37	22	100	77	45	29	2.70	20	114	108	106	94.7	14.0	0	.94	~~34~~	~~.1~~	~~15~~	~~.3~~	~~R~~
68048 5859			37	22	100	77	45	29	2.70	20	114	108	108	94.7	14.1	0	.91	34	.1	15	.3	R
68048 5859			37	22	100	77	45	29	2.70	20	114	108	109	94.7	14.2	0	.84	~~34~~	~~.1~~	~~15~~	~~.3~~	~~R~~
6714816834			41	18	100	76	47	0	2.73	20	106	101	103	95.3	20.1	0	.92	35	0	12	.5	R
6714816834			41	18	100	76	47	0	2.73	20	106	101	105	95.3	20.0	0	.84	35	0	12	.5	R
6714816834			41	18	100	76	47	0	2.73	20	106	101	107	95.3	19.8	0	.85	35	0	12	.5	R
67136 8969			27	9	100	85	48	20	2.77	20	126	119	123	94.4	11.3	0	.91	33	0	14	.4	R
67135 8969			27	9	100	85	48	20	2.77	20	126	120	124	95.2	10.7	0	.82	33	0	14	.4	R
67136 8969			27	9	100	85	48	20	2.77	20	126	119	125	94.4	10.9	0	.61	33	0	14	.4	R

APPENDIX O

VENADO SANDSTONE (CRUSHED)
CONCRETE AGGREGATE
QUALITY TEST RESULTS

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SANDSTONE TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE: Sandstone Quality for Rip-Rap and RCC Aggregate

			PERCENT FINER											3-inch CUBE SAMPLES			CLASSIFICATION	
			MECHANICAL ANALYSIS											compressive	specific	percent		
LAB	HOLE	F.S.	GRAVEL				SAND							strength	gravity	absorption	GROUP	
NO.	NO.	NO.	3"	1½"	¾"	⅜"	4	8	16	30	50	100	200	(psi)	(ssd)	%	SYMBOL	GROUP NAME
98-182	SSQ-9	A												11250	2.49	2.8		
"	"	B												11040	2.49	2.6		
"	"	C												11360	2.48	2.6		
98-183	SSQ-10	A												11240	2.45	2.8		
"	"	B												10970	2.46	2.7		
"	"	C												11490	2.46	2.7		

RESULTS OF QUALITY TESTS ON CRUSHED SANDSTONE

1. ASTM C-131 Los Angeles Rattler Test (Grading A = $1^1/_2$ x 3/8 size fraction) :
   100 revolutions = 11.4 percent loss
   500 revolutions = 43.4 percent loss

   Specific Gravity and Absorption tests before performing LART
   Spec. Grav. = 2.48
   Absorption = 4.2 percent

2. ASTM C---- Durabilitly Index (3/4 x #4 size fration)
   Durability Index, Dc = 42

   Specific Gravity and Absorption tests before performing Coarse Durability Index
   Spec. Grav. = 2.50
   Absorption = 4.1 percent

Sheet 2 of 2

DATE: 5/25/1998
INITIAL: RGJ
REQUEST NO.: 99-19

REMARKS: In determining the absorption, the strength samples (cubes) were oven dried at 160 °F. The crushed samples were oven dried at 230 °F. All samples were soaked for 24 hours.

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

SANDSTONE TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: Sites and Golden Gate Dams

FEATURE: Venado Sandstone Quality for Rip-Rap and RCC Aggregate

			PERCENT FINER											ASTM	ASTM C-40		ASTM C-127 & 128						ASTM C-131		ASTM C-142		
			MECHANICAL ANALYSIS											C-29		washed	3/4" x 3/8"		3/8" x #4		#4 x #200		100	500	3/4x 3/8	3/8x #4	#4x#8
LAB.	HOLE	F.S.	GRAVEL				SAND							D.R.U.W.	as	fines	spg	% abs	spg	%	spg	%	rev.	rev.	% clay lumps and		
NO.	NO.	NO.	3"	1½"	¾"	⅜"	4	8	16	30	50	100	200	(pcf)	rec'd	removed	(ssd)	abs.	(ssd)	abs	(ssd)	abs	% loss	% loss	friable particles		
99C-113		A		100	96	32	12	9	8	7	6	4	2	88.3	clear	clear	2.48	4.9	2.48	6.3	2.57	2.40	11.4	50.8	1.0	2.1	6.5
"		B		100	95	57	35	28	23	20	18	11	6	88.7	clear	clear	2.49	5.0	2.48	6.3	2.58	2.30	7.3	36.9	0.2	0.1	1.7
"		C		100	97	65	44	36	30	27	24	16	9	88.6	clear	clear	2.48	5.4	2.48	6.2	2.58	2.50	11.5	49.5	0.2	0.1	1.3
99C-114		A		100	97	51	22	17	14	12	11	7	4	86.2	2	clear	2.45	6.2	2.47	6.6	2.56	2.70	13.7	56.0	1.7	3.3	8.6
"		B		100	97	55	27	19	15	13	11	7	4	86.4	3	clear	2.46	6.0	2.47	6.6	2.57	2.70	9.2	43.5	0.2	0.4	3
"		C		100	95	47	22	16	13	12	10	6	3	87.5	3	clear	2.46	6.0	2.46	6.6	2.57	2.70	12.5	54.5	0.4	0.9	3.7
			100 PERCENT COARSE AGGREGATE																								
			3"	1½"	¾"	⅜"	4	8	16	30	50	100	200														
99C-113		A		100	95	22	0																				
"		B		100	92	34	0																				
"		C		100	95	38	0																				
99C-114		A		100	96	37	0																				
"		B		100	96	39	0																				
"		C		100	93	33	0																				
			100 PERCENT FINE AGGREGATE																								
			3"	1½"	¾"	⅜"	4	8	16	30	50	100	200														
99C-113		A					100	73	61	56	50	32	18														
"		B					100	78	65	58	51	32	16														
"		C					100	81	68	61	54	36	21														
99C-114		A					100	76	62	54	47	30	16														
"		B					100	68	55	47	40	27	16														
"		C					100	74	60	53	45	29	16														

Sheet 1 of 1

DATE: 6/15/1999

INITIAL: RGJ

REQUEST NO.: 99-19

REMARKS: 99c-113 = fresh crushed sandstone.
99c-114 = weathered crushed sandstone.

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD

Project: Sites and Golden Gate Damsites
Feature: Sandstone quality for aggregate (Rip-rap and RCC use)
Request No: 98-18

Hole number	1.5 c 3/8 fraction graded for			3/4 x #4 fraction graded for		
laboratory number	L.A. Rattler			Coarse Durability Index		
			A			A
Wt. Saturated surface dry sample			5249			2556
Wt. Oven Dry sample			5037			2455
Wt. water absorbed			212			101
% water absorbed			4.2			4.1
Wt. S.S.D. sample suspended in water			3136			1532
Wt. Water Displaced by S.S.D. sample			2113			1024
Wt. Water Displaced by Solid sample			1901			923
Bulk Specific Gravity (Dry Basis)			2.38			2.40
Bulk Specific Gravity (S.S.D. Basis)			2.48			2.50
Apparent Specific Gravity			2.65			2.66

L.A. Rattler Test Results ASTM C-131 grading A

No. of Revolutions	Original Wt. (grams)	Final WT. (grams)	Loss (grams)	Percent of Wear
100	5009	4440	569	11.4
500	5009	2833	2176	43.4

TECHNICAL SERVICES OFFICE
CONCRETE SECTION

TEST FOR "ABRASION OF COARSE AGGREGATE"
ASTMC-131-76
-535-76

PROJECT ______ LABORATORY NO. ______
FEATURE Sandstone for Rip Rap & RCC FIELD SAMPLE NO. ______
SOURCE OF MATERIAL ______
SIZE FRACTION TESTED 1½ x ½" leftovers from sandstone slabs were crushed (trimmings from
WORK ORDER NO. cutting cubes for Comp. Str.) compressive str specimens were also crushed
VISUAL DESCRIPTION & SIEVE

TABLE I – GRADING OF TEST SAMPLES

SIEVE SIZE		Weight & Grading of Test Samples ~ g						
PASSING	RETAINED	A	B	C	D	I	II	III
3 IN.	2½ IN.					2500*		
2½ IN.	2 IN.					2500*		
2 IN.	1½ IN.					5000*	5000*	
1½ IN.	1 IN. ±25	1250					5000*	5000*
1 IN.	¾ IN. ±25	1250						5000*
¾ IN.	½ IN. ±10	1250	2500					
½ IN.	3/8 IN. ±10	1250	2500					
3/8 IN.	NO. 3			2500				
NO. 3	NO. 4			2500				
NO. 4	NO. 8				5000			

* Tolerance of ± 2% permitted 5000 ± 10

ABRASIVE CHARGE

Grading	No. of Spheres	Weight of Charge ~ g
[✓ A]	12	5000 ± 25
B	11	4584 ± 25
C	8	3330 ± 20
D	6	2500 ± 15
E	12	5000 ± 25
F	12	5000 ± 25
G	12	5000 ± 25

TEST RESULTS

NO. OF REV.	ORIGINAL WT-g	FINAL WT. g	LOSS OF WT. g	PERCENT OF WEAR
100	5009	4440	569	11.4
500	5009	2833	2176	43.4

TESTED BY Roland
DATE TESTED 5/20/98
COMPUTED BY ______
CHECKED BY ______

1½ - 1	1252
1 - ¾	1257
¾ - ½	1249
½ - 3/8	1251
	5009

DWR 956

State of California
The Resources Agency
Department of Water Resources
Division of Design & Construction

Durability Index Test --------------- California Test Method 229

PROJECT

LABORATORY NO. Soil Req 98-18

FEATURE

S.I.C. or FIELD NO.

VISUAL DESCRIPTION Crushed Sandstone

TRIAL NO.	#2	#3		
DATE TESTED	5/19	5/19		
TESTED BY	Roland	Roland		
COMPUTED BY				
CHECKED BY				
SIZE FRACTION	3/4 x #4			
PROCESSING				
A TIME STARTED SOAKING				
B TIME STARTED SHAKING				
C TIME STARTED SETTLING	0:00	02:30		
D TIME READINGS TAKEN	20:00	22:30		
E LEVEL AT TOP OF SEDIMENT	5.1"	5.5"		
F DURABILITY FACTOR D_c	42	40		
G AVERAGE				
H REPORTED VALUE				

REMARKS

		prepared (cum. wt)	
3/4 x 1/2	1070 ± 10	1080	+10
1/2 x 3/8	570 ± 10	1660	+20
3/8 x #4	910 ± 5	2574	
	2550	2490 after initial prep & o.d.	

State of California
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
TECHNICAL SERVICES OFFICE
CONCRETE LABORATORY

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

TEST METHOD: ASTM C 127-

Project ______ Laboratory No. Soil REQ 98-18

Feature ______ Field Sample No. ______

Hole No. ______ Elev. Top of Hole ______ Depth of Sample ______

Visual Description ______

DETERMINATION NO.									
DATE TESTED									
TESTED BY									
COMPUTED BY			LART		COARSE Dc				
CHECKED BY			Specimen						
SIZE FRACTION			1½x3/8		3/4 x #4				
PROCESSING									
A	WT. SATURATED SURFACE DRY SAMPLE		5249		2556				
B	WT. OVEN DRY SAMPLE		5037		2455				
C	WT. WATER ABSORBED	A-B	212		101				
D	% WATER ABSORBED	C/B ~~C/A~~ × 100	4.2		4.1				
E	WT. S.S.D. SAMPLE SUSPENDED IN WATER		3136		1532				
F	WT. WATER DISPLACED BY S.S.D. SAMPLE	A-E	2113		~~[illegible]~~ 1024				
G	WT. WATER DISPLACED BY SOLID SAMPLE	F-C	1901		923				
H	BULK SPECIFIC GRAVITY (DRY BASIS)	$\frac{B}{F}$	2.38		2.40				
I	BULK SPECIFIC GRAVITY (S.S.D. BASIS)	$\frac{A}{F}$	2.48		2.50				
J	APPARENT SPECIFIC GRAVITY	$\frac{B}{G}$	2.65		2.66				

REMARKS:

CL 2 (3/57)
DWR 822 (REV.5/66)

CDI

#3 #2

~~20~~

10 min
= 7.7

20 min 26 min

S.H. = 5.5" S.H. = 5.6"

D_c = 40 D_c = 42

1½ x ¾	¾ x ⅜	Dur Index
2624 ssd	2625	2556
1567 in water	1569	1532
2520 od	2517	2455
1057	1056	1024
2.48 ssd	2.49	2.50
104		
4.1%	4.3%	4.1%

① Petrographic provide info –
indicate –

L.A Rattler

5005 — I blew it. 100 REV DID NOT PROPERLY SET – TIMER DIRTY
3193 ~~did not set to 100 rev~~ NEED TO REDO
1812

1½ - 1	72 1252
1 - ¾	1258
¾ - ½	1249
½ - ⅜	1251
	5600

5009
4440 = 100 REV = 11.4%
2833 = 500 REV = 43.4%

											C-40		ASTMC-127				128		ASIC-131 B-grading			C-142		
	1½	3/4	3/8	#4	#8	#16	#30	#30	#100	#200	ASREC'D	WASHED	SPG 3/4 x 3/8	%abs	3/8 x 4		SPG SAND*	%abs	100	500		3/4 x 3/8	3/8 x #4	#4 - #8 Sand
9C-113A	100	96	32	12	9	8	7	6	4	2	CLEAR	CLEAR	2.48	4.9	2.48	6.3	2.57	2.4	11.4	50.8	.23	1.0	2.1	6.5
-113B	100	95	57	35	28	23	20	18	11	6	CLEAR	CLEAR	2.49	5.0	2.48	6.3	2.58	2.3	7.3	36.2	.20	0.2	0.1	1.7
-113C	100	97	65	44	36	30	27	24	16	9	CLEAR	CLEAR	2.48	5.4	2.48	6.2	2.58	2.5	11.5	49.5	.23	0.2	0.1	1.3
9C-114A	100	97	51	22	17	14	12	11	7	4	2	CLEAR	2.45	6.2	2.47	6.6	2.56	2.7	13.7	56.0	.25	1.7	3.3	8.6
114B	100	97	55	27	19	15	13	11	7	4	3	CLEAR	2.46	6.0	2.47	6.6	2.57	2.7	9.2	43.5	.21	0.2	0.4	3.0
114C	100	95	47	22	16	13	12	10	6	3	3	CLEAR	2.46	6.0	2.46	6.6	2.57	2.7	12.5	54.5	.23	0.4	0.9	3.7

[illegible]	1½	3/4	3/8	#4	1½	3/4	3/8	#4	D.R.U.W(pcf)
99C-113A	100	95	22	0	0	5	73	22	88.3
B	100	92	34	0	0	8	58	34	88.7
C	100	95	38	0	0	5	57	38	88.6

	% PASSING							% EACH								
SAND ONLY	#4	#8	#16	#30	#50	#100	#200	#4	#8	#16	#30	#50	#100	#200	PAN	F.M.
99C-113A	100	73	61	56	50	32	18	0	27	12	5	6	18	14	18	2.28
113B	100	78	65	58	51	32	16	0	22	13	7	7	19	16	16	2.16
113C	100	81	68	61	54	36	21	0	19	13	7	7	18	15	21	2.00
114 A	100	76	62	54	47	30	16	0	24	14	8	7	17	14	16	2.31
114 B	100	68	55	47	40	27	16	0	32	13	8	7	13	11	16	2.63
114 C	100	74	60	53	45	29	16	0	26	14	7	8	16	13	16	2.39

	1½	3/4	3/8	#4	1½	3/4	3/8	#4	
99C-114A	100	96	37	0	0	4	59	37	86.2
B	100	96	39	0	0	4	57	39	86.4
C	100	93	33	0	0	7	60	33	87.5

99C-113

	A		B		C	
Dry wt	3608		2838			
	Wt gms	% Pass	Wt	% Pass	Wt	% Pass
1½	0	100	0	100	0	100
¾	163	95.5	150	94.7	96	97.1
⅜	2472	31.5	1215	57.2	1146	65.4
#4	3168	12.2	1835	35.3	1852	44.0
#8	116.9 3285	9.0	221.4 2056	27.6	280.6 2133	35.5
#16	53.7 3339	7.5	128.4 2185	23.0	186.3 2319	29.9
#30	25.0 3364	6.8	74.4 2259	20.4	103.5 2422	26.8
#50	25.4 3389	6.1	70.1 2329	17.9	98.9 2521	23.8
#100	78.0 3467	3.9	185.9 2515	11.4	269.1 2790	15.7
#200	64.2 3531	2.1	165.6 2680	5.6	3002	9.3
Pan	3608		2838		3309	

FINE AGG

#4	0	100	0	100	0	100
#8	117	73.4	221	78.0	281	80.7
#16	171	61.1	350	65.1	467	68.0
#30	196	55.5	424	57.7	570	60.9
#50	221	49.8	494	50.8	649	54.1
#100	299	32.1	680	32.2	938	35.6
#200	363	17.5	845	15.8	1150	21.1
Pan	440		1003		1457	

COARSE AGG ONLY

				Avg	% EACH
1½	100	100	100	100	0
¾	94.9	91.8	94.8	93.8	4
⅜	22.0	33.8	38.1	31.3	63
#4	0.0	0.0	0.0	0	31

44C-114

	A		B		C	
1½	0	100	0	100	0	100
3/4	105	97.2	101	97.2	173	94.7
3/8	1822	51.2	1617	55.3	1708	47.4
#4	2898	22.4	2635	27.1	2537	21.8
#8	204 3102	16.9	311.0 2946	18.5	185.7 2723	16.1
#16	110. 3212	14.0	130.4 3076	14.9	97.0 2820	13.1
#30	69.2 3281	12.1	77.6 3154	12.7	54.5 2874	11.5
#50	62.1 3343	10.5	65.2 3219	10.9	50.3 2925	9.9
#100	138.4 3482	6.7	128.7 3348	7.4	119.2 3044	6.2
#200	99.5 21.9 3604	3.5	97.4 16.5 3460	4.3	81.5 11.4 3136	3.4
Pan	3733		3614		3246	

Fine Agg

#4	0	100		0	100	0	100
#8	200 204	75.6		311 311	68.2	185.7 186	73.8
#16	110 314	62.4		130.4 441	55.0	97 283	60.1
#30	69 383	54.1		77.6 519	47.0	54.5 337	52.5
#50	62 445	46.7		65.2 584	40.4	50.3 388	45.3
#100	139 584	30.1		128.7 713	27.2	119.2 507	28.5
#200	122 705	15.6	825	97.4 16.5 825	15.7	5.19 81.5 11.4 599	15.5
Pan	129 835			154 979		110 709	

Coarse Agg

					AVG	% EACH
1½	0	100	100	100	100	0
3/4		96.4	96.2	93.2	95.3	5
3/8		37.1	38.7	32.7	36.2	59
#4	0	0	0	0	0	36

	99C-113A		B		C				99C-114A		B		C	
	IND	CUM	IND	CUM										
# 4	0	0	0	0	0	0			0	0	0	0	0	0
# 8	27	27	22	22	19	19	15	15	24	24	32	32	26	26
# 16	12	39	13	35	13	32	15	30	14	38	13	45	14	40
# 32	5	44	7	42	7	39	25	55	8	46	8	53	7	47
# 50	6	50	7	49	7	46	25	80	7	53	7	60	8	55
# 100	18	68	19	68	18	64	10	10	17	70	13	73	16	71
# 200	14		16		15		7		14		11		13	
PAN	18	2.28	16	2.16	21	2.00	3		16	2.31	16	2.63	16	2.39

	99C-113						99C-114					
	A		B		C		A		B		C	
moist mple Wt (gms)	3657		2909		3410		3814		3723		3329	
ven Dry Wt (gms)	3608	1.4	2838	2.5	3309	3.1	3733	2.2	3614	3.0	3246	2.6
D. after washing	3531	2.1	2680	5.6	3002	9.3	3604		3460		3136	
							129 = 3.5%		154 = 4.3		110 = 3.4	
	Ind	cum										
1½	0	0										
3/4	163	163	150	150	96	96	105	105	101	101	173	173
3/8	2309	2472	1065	1215	1050	1146	1717	1822	1516	1617	1535	1708
#4	696	3168	620	1835	706	1852	1076	2898	1018	2635	829	2537
−4	363	3531	845	2680	1150	3002	706	3604	825	3460	599	3136
	305											
#8	422.5	32.2	430.0	26.2	424.1	24.4	451.0	28.9	492.9	37.7	459.0	31.0
#16	476.5	14.8	502.6	15.2	503.3	16.2	529.9	15.6	571.5	15.8	539.3	16.2
#30	501.5	6.9	544.6	8.8	547.0	9.0	579.4	9.8	618.2	9.4	584.6	9.1
#50	527.0	7.0	584.1	8.3	589.0	8.6	623.9	8.8	657.4	7.9	626.4	8.4
#100	609.6	21.5	689.0	22.0	703.0	23.4	723.0	19.6	735.0	15.6	725.5	19.9
#200	662.0	15.4	762.2	15.4	778.5	15.5	794.0	14.1	794.0	11.8	793.0	13.6
	670.2	2.3	782.0	4.2	792.8	2.9	809.6	3.1	804.0	2.0	802.3	1.9
	365.2	100.1	477	100.1	487.8	100		99.9		100.2		100.1

C40 WASHED	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR
AS REC'D	CLEAR	CLEAR	CLEAR	2	3	3
1½	100	100	100	100	100	100
3/4	95.5	94.7	97	97.2	97.2	94.7
3/8	31.5	57.2	65.4	51.2	55.3	47.4
# 4	12.2	35.3	44.0	22.4	27.1	21.8
# 8						
# 16						
# 30						
# 50						
#100						
#200						

C-142

	#4	#8	#20

99C-113A

	3/4x3/8	3/8 x #4	Minus 4
O.D. (gms)	2332	1566	170
O.D wt after Processing gms	2310	1533	159
wt. loss	22	33	11
% loss	1.0.	2.1	6.5

99C 114A

3/4 x 3/8	3/8x #4	Minus 4
2200	1632	128
2162	1578	117
38	54	11
1.7	3.3	8.6

99C-113 B

O.D	2600	1488	172
O.D after	2596	1487	169
wt loss	4	1	3
% loss	.2	0.1	1.7

99C-114B

2528	1139	169
2524	1135	164
4	4	5
.2	.4	3.0

99C-113C

O.D	2381	1305	298
O.D. after	2376	1304	294
wt loss	5	1	4
% loss	0.2	0.1	1.3

99C-114C

2709	1392	274
2697	1379	264
12	13	10
0.4	0.9	3.7

SPG & ABS

	99-113						99-114					
	A	A	B	B	C	C	A 27 1.6	A 41 3.9	B 16 1.1	B 32 3.1	C 15 1.0	C ~~45~~ 23 2.8
	3/4x3/8	3/8x#4	3/4x3/8	3/8-#4	3/4x3/8	3/8x#4	3/4x3/8	3/8x#4	3/4x3/8	3/8x#4	3/4x3/8	3/8x#4
Wt in Air SSD	2382	713	1087	625	1174	705	1744	1068	1510	1055	1583	853
Wt in Air O.D	2270	671	1035	588	1114	664	1642	1002	1424	990	1494	800
Wt of H_2O absor	112	42	52	37	60	41	102	66	86	65	89	53
% absorption	4.9	6.3	5.0	6.3	5.4	6.2	6.2	6.6	6.0	6.6	6.0	6.6
Wt ssd in water	1423	426	650	373	701	421	1033	635	895	627	940	506
Wt H2O Displaced by SSD sample	959	287	437	252	473	284	711	433	615	428	643	347
Wt H2O Displaced by solid sample	847	245	385	215	413	243						
BULK SPG (DRY BASIS)	2.37	2.34	2.37	2.33	2.36	2.34	2.45	2.47	2.46	2.47	2.46	2.46
BULK SPG (SSD BASIS	2.48	2.48	2.49	2.48	2.48	2.48						
APPARENT SPG												

	A	MC deter	B	MC deter	C	MC deter	A	MC determi	B		C	
Wt Sat Surf dry sample	500.6	536.8	501.6	630.6	500.4	570.4	506.1	583.7	500.7	560.4	500.6	577.2
Wt oven dry sample	488.9	523.4 524.3	490.3	616.7	488.2	556.6	492.8	567.6 568.2	487.5	545.5	487.4	562.3
wt water absorbed	11.7	12.5	11.3	13.9	12.2	13.8	13.3	15.5	13.2	14.9	13.2	14.9.
% water absorbed	2.4	2.4	2.3	2.3	2.5	2.5	2.7	2.65 2.7	2.7	2.7	2.7	2.7
00 ml Vol flask #	D	677.0 176.4	F	692.8 191.2	G	666.2 165.8	F	697.2 191.1	G	666.5 165.8	F	691.8 191.2
Wt filled w/ H2O ___ °C	73° 675.25		78° 689.6		77° 664.0		74.5 689.9	693.0 103.4 689.1 673.6	77° 664.0		77° 689.7	
Wt SSD + wt flask w/ water	1175.85	715.5 703.0 178.7	1191.2	803.2 789.3	1164.4	676.0 662.2	1196.0		1164.7	721.0 706.1	1190.3	740.2 725.3 163.0
Wt flask after Vacuum	980.9		997.1	172.6 #4	970.7	105.6 #33	998.5		969.9	160.6 #98	995.5	
wt displaced by SSD	194.95		194.1		193.7		197.5		194.8		194.8	
wt displaced by solid	183.25		182.8		181.5		184.2		181.6		181.6	
BULK SPG (DRY BASIS)	2.51		2.53		2.52		2.50		2.50		2.50	
BULK SPG (SSD BASIS	2.57		2.58		2.58		2.56		2.57		2.57	
APPARENT SPG	2.67		2.68		2.69		2.68		2.68		2.68	

C-131 GRADING B

2500 ± 10 3/4 x 1/2
2500 ± 10 1/2 x 3/8

charge
11 spheres

	99C-113				99C-114		
	A	B	C		A	B	C
3/4 x 1/2	2503	2502	2501	2502	2507	2502	2500
total wt	5001	5003	5002	5006	5003	5006	5002
after 100 rev	4433	4636	4644	4432	4317	4545	4376
after 500 rev	2460	3174	2789*	2527	2202	2831	2277
loss 100 rev	11.4	7.3	7.2	11.5	13.7	9.2	12.5
loss 500 rev	50.8	36.7		49.5	56.0	43.5	54.5
100/500 loss ratio	.23	.20 198		.23	.25	.21 .212	.23

↑ REDO

* 595 REV - total of 695 REVS

C-29 Unit Wt & Voids of agg
Rodding Procedure Sect 10

	99C-113			99C-114		
Wt of Rodded agg + Measure (lbs)	60.40	60.60	60.55	59.35	59.45	60.00
wt of Measure (lbs)	16.35			16.35		
wt of Rodded Agg	44.05			43.0	43.1	
Vol of Measure cu.ft	.499					
D.R.U.W. (pcf)	88.3	88.27	88.6	86.2	86.4	87.5

APPENDIX P

CONGLOMERATE
Compressive Strength Test
Results for DWR Samples

SUMMARY SHEET

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

DIVISION OF ENGINEERING
CIVIL ENGINEERING
CANALS AND LEVEES SECTION

PROJECT: SITES RESERVOIR

FEATURE: 2.5" DIAMETER ROCK CORES

										ASTM D-2938	ASTM D-3967			ASTM C-97	
LAB NO	HOLE NO	F. S. NO	DEPTH (feet)	ROCK TYPE	LENGTH (inch)	DIAM (inch)	L/D RATIO	LOAD (applied to failure) (lbs.)	MOISTURE CONDITION	COMPRESSIVE STRENGTH (psi)	SPLITTING TENSILE (psi)			SPG (ssd)	% ABS
2002-114	SSD 6-1	A	30.8 - 31.2	Ss	5.295	2.493	2.12	17200	WET	3524				2.37	3.8*
		B	31.6 - 32.0	Ss	5.274	2.500	2.11	31500	DRY	6417				2.35	3.8
2002-115	SSD 6-1	A	71.6 - 72.0	Cng	5.132	2.499	2.05	17800	DRY	3629				2.60	1.4
		B	72.0 - 72.4	Cng	5.128	2.497	2.05	12300	WET	2512				2.60	1.4*
		C	72.4 - 72.9	Cng	5.146	2.498	2.06	17800	DRY	3632				2.59	1.2
		D	72.9 -73.3	Cng	5.225	2.495	2.09	13000	WET	2659				2.59	1.2*
		E	73.3 - 73.7	Cng	5.185	2.497	2.08	14000	DRY	2859				2.57	1.4
2001-31	SSD 6-1	A	111.8 - 112.2	Cng	5.264	2.501	2.10	27600	DRY	5618				2.62	1.0
		B	112.2 - 112.7	Cng	5.266	2.503	2.10	29900	WET	6077				2.63	0.9*
		C	112.7 - 113.2	Cng	5.257	2.503	2.10	27500	DRY	5589				2.65	0.6

DATE: 4/16/02
INITIAL: rgj
REQUEST NO. 2002-09

REMARKS: Rock Types Ss=Sandstone Cng = Conglomerate (3/4 inch nominal max. size aggregate)
* Did not oven dry - values were estimated
Test Machine = Tinius Olsen set at middle range (80,000 lbs. capacity, 100 lbs. division)

SHEET 1 of 1

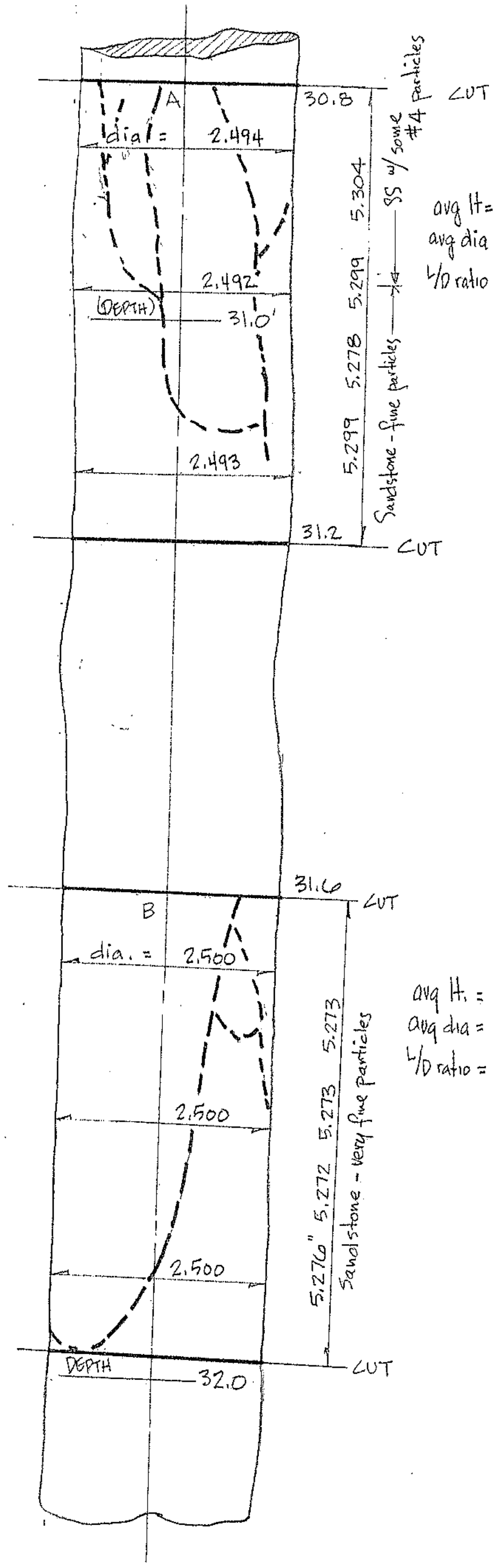
SITES RESERVOIR

LAB. NO.	HOLE NO.	DEPTH	
02-114	SSD 6-1	31.0-32.0	Sandstone - 2.5 x 16.5 inches
02-115	SSD 6-1	72.0-73.0	Conglomerate - 2.5 inch x 26.5 inches
02-116	SSD 6-1	112.0-113.0	Conglomerate - 2.5 inch x 16.0 inches

SPECIFIC GRAVITY AND ABSORPTION

LAB. NO.			02-114A	02-114B			02-115A	02-115B	02-115C	02-115D	02-115E
LENGTH (inches)			5.295	5.274			5.132	5.128	5.146	5.225	5.185
DIAMETER (inches)			2.493	2.500			2.499	2.497	2.498	2.495	2.497
moisture condition for unconfined compressive strength			WET	DRY			DRY	WET	DRY	WET	DRY
A	WT.SATURATED SURFACE DRY SAMPLE		999.9	992.5			1068.4	1063.9	1062.3	1079.8	1064.8
B	WT.OVEN DRY SAMPLE		962.9	956.2			1053.4	1048.9	1049.4	1066.9	1049.6
C	WT. WATER ABSORBED	A-B	37	36.3			15.0	15.0	12.9	12.9	15.2
D	% WATER ABSORBED	C/B x 100	3.8	3.8			1.4	1.4	1.2	1.2	1.4
E	WT. S.S.D. SAMPLE SUSPENDED IN WATER		578.6	570.5			657.8	654.6	651.4	662.9	650.3
F	WT. WATER DISPLACED BY S.S.D. SAMPLE	A-E	421.3	422			410.6	409.3	410.9	416.9	414.5
G	WT. WATER DISPLACED BY SOLID SAMPLE	F-C	384.3	385.7			395.6	394.3	398	404	399.3
H	BULK SPECIFIC GRAVITY (DRY BASIS)	B/F	2.29	2.27			2.57	2.56	2.55	2.56	2.53
I	BULK SPECIFIC GRAVITY (S.S.D. BASIS)	A/F	2.37	2.35			2.60	2.60	2.59	2.59	2.57
J	APPARENT SPECIFIC GRAVITY	B/G	2.51	2.48			2.66	2.66	2.64	2.64	2.63

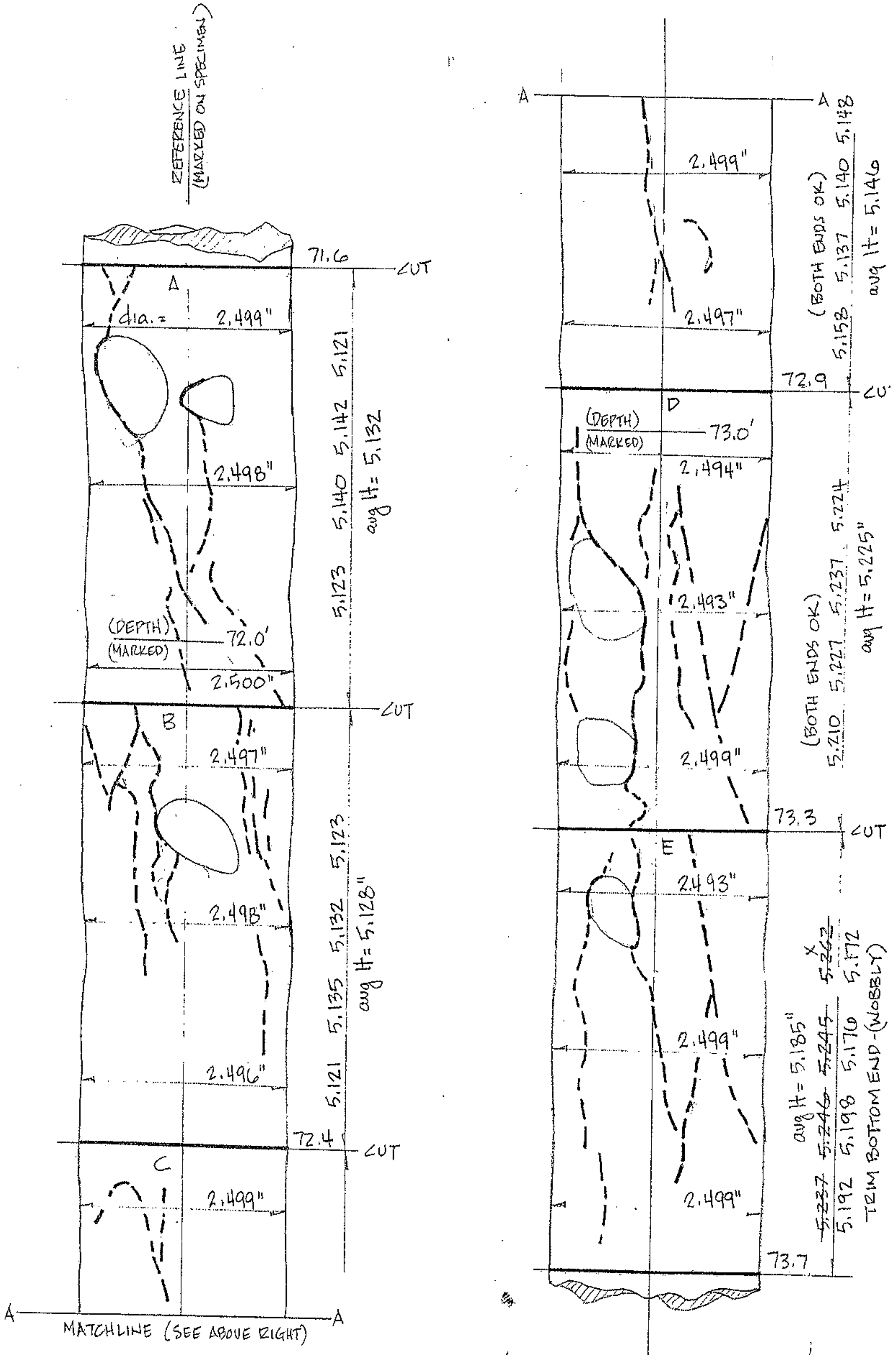
LAB. NO.			02-116A	02-116B	02-116C			-114	-114	-116	
LENGTH (inches)			5.264	5.266	5.257			mid	bottom	top &	
DIAMETER (inches)			2.501	2.503	2.503			section	section	bottom	
moisture condition for unconfined compressive strength			DRY	WET	DRY					section	
A	WT.SATURATED SURFACE DRY SAMPLE		1105.1	1112.9	1117.5			708.9	320.9	611.7	
B	WT.OVEN DRY SAMPLE		1094.7	1102.5	1111.2			678.9	307.1	603.8	
C	WT. WATER ABSORBED	A-B	10.4	10.4	6.3			30	13.8	7.9	
D	% WATER ABSORBED	C/B x 100	1.0	0.9	0.6			4.4	4.5	1.3	
E	WT. S.S.D. SAMPLE SUSPENDED IN WATER		683.3	690.5	696.2			409.4	185.7	377	
F	WT. WATER DISPLACED BY S.S.D. SAMPLE	A-E	421.8	422.4	421.3			299.5	135.2	234.7	
G	WT. WATER DISPLACED BY SOLID SAMPLE	F-C	411.4	412	415			269.5	121.4	226.8	
H	BULK SPECIFIC GRAVITY (DRY BASIS)	B/F	2.60	2.61	2.64			2.27	2.27	2.57	
I	BULK SPECIFIC GRAVITY (S.S.D. BASIS)	A/F	2.62	2.63	2.65			2.37	2.37	2.61	
J	APPARENT SPECIFIC GRAVITY	B/G	2.66	2.68	2.68			2.52	2.53	2.66	



avg Ht = 5.295"
avg dia = 2.493"
L/D ratio = 2.12

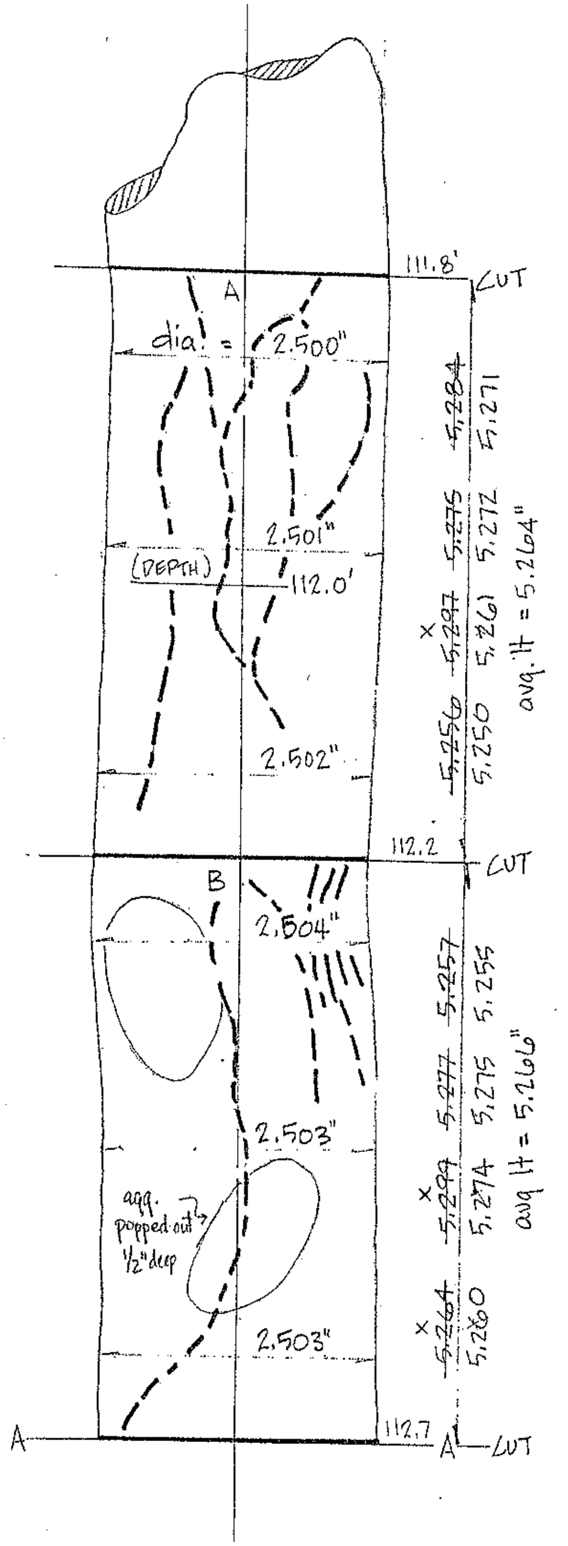
avg Ht. = 5.274"
avg dia = 2.500"
L/D ratio = 2.11

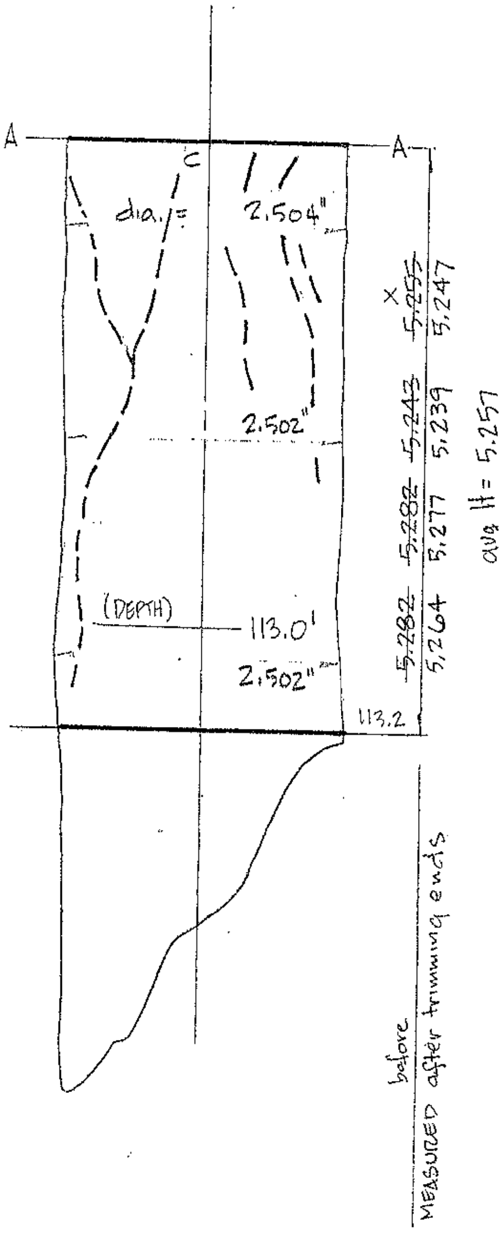
Sandstone
Hole : SSD 6-1
DEPTH: 31.0' ~ 32.0'
LAB # 02-114



CONGLOMERATE

HOLE: SSD6-1
DEPTH: 72.0'~73.0'
LAB #: 02-115





CONGLOMERATE

Hole: SSD6-1

DEPTH: 112.0'~113.0'

LAB #: 02-116

APPENDIX Q

MUDSTONE
After Compaction Classification Test Results for DWR Samples

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

CLASSIFICATION TEST SUMMARY

DIVISION OF ENGINEERING
CIVIL ENGINEERING
DAMS AND CANALS SECTION

PROJECT: Sites Dam

FEATURE: Mudstone from Drill Holes SSD 5-3 (16.0' to 16.9'), SSD 8-1 (7.3' to 8.5' & 10.2' to 11.0'), & SSD 8-3 (9.0' to 11.0')

Page 1 of 1

LAB. NO.	HOLE NO.	F.S. NO.	DEPTH (feet)	PERCENT FINER																			
				MECHANICAL ANALYSIS											HYDROMETER								
				GRAVEL				SAND							SILT & CLAY								CLASSIFICATION
				3.0"	1.5"	3/4"	3/8"	4	8	16	30	50	100	200	5M	2M	1M	ATTERBERG LIMITS		MOISTURE CONTENT %	PERCENT ORGANICS	GROUP SYMBOL	GROUP NAME
				75 mm	37.5 mm	19 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	0.6 mm	0.3 mm	0.15 mm	0.075 mm	0.005 mm	0.002 mm	0.001 mm	L.L.	P.I.				
02-109				100	91	48	23	11	10	9	9	9	9	8				42	17				
02-110					100	90	65	43	40	38	37	36	36	35									
02-111					100	99	70	54	52	50	50	49	49	48				43	19			SC	Clayey sand with gravel

DATE: 3/27/2002
INITIAL: djn
REQUEST NO.: 2002-09

REMARKS: 02-109, sample insitu
02-110, sample 2X through compaction machine
02-111, sample hydrated @ 10%, 1X through compaction machine

IM - INSUFFICIENT MATERIAL
NP - NON-PLASTIC
NG - NO GOOD