LAW/CRANDALL

A DIVISION OF LAW ENGINEERING
AND ENVIRONMENTAL SERVICES, INC.

REPORT OF GEOTECHNICAL INVESTIGATION

Law/Crandall Project 702.41-50354.07

SOSSAMAN CHANNEL MESA, ARIZONA ASSIGNMENT NO. 8 CONTRACT FCD 95-40

Prepared for:

FLOOD CONTROL DISTRICT
MARICOPA COUNTY, ARIZONA

NOVEMBER 27, 1996

LAW/CRANDALL
A DIVISION OF LAW ENGINEERING
AND ENVIRONMENTAL SERVICES, INC.

November 27, 1996

Mr. Warren Rosebraugh
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Subject: **Report of Geotechnical Investigation**
Sossaman Channel; Mesa, Arizona
Assignment No. 8
Contract FCD 95-40
Law/Crandall Project No. 702.41-50354.07

Dear Mr. Rosebraugh:

Law/Crandall (LAW) is pleased to present this report of our geotechnical investigation for Sossaman Channel located south of the Superstition Freeway and north of Baseline Road in Mesa, Arizona. Our services were provided in general accordance with our *Scope of Services and Cost Estimate for Geotechnical Investigation* dated September 25, 1996. Our services were authorized under Flood Control District of Maricopa County (FCDMC) Contract FCD 95-40 for *On-Call Geotechnical and Testing Services*.

Our report presents a review of the project information provided to us, a description of the surface and subsurface conditions, and a summary of our excavation and earthwork recommendations for the soils encountered along the channel. The attachments to the report include a vicinity map, boring location plans, soil boring logs, and the results of our laboratory testing.

We appreciate this opportunity to provide our services, and we look forward to serving as your geotechnical consultant throughout this project. Please contact us if you have any questions or require additional information.

Sincerely,

LAW/CRANDALL
A Division of Law Engineering and Environmental Services, Inc.

Bruce A. Wolle, P.E.
Project Engineer

Marshall Lew, Ph.D., P.E.
Principal Engineer
Vice President

Registered Professional Engineer (Civil)
CERTIFICATE NO.
19979
MARSHALL LEW
Date Signed 11-27-96
ARIZONA, U.S.A.

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REPORT OF
GEOTECHNICAL INVESTIGATION

SOSSAMAN CHANNEL
MESA, ARIZONA
ASSIGNMENT NO. 8
CONTRACT FCD 95-40

PREPARED FOR:

FLOOD CONTROL DISTRICT
MARICOPA COUNTY, ARIZONA

PREPARED BY:

LAW/CRANDALL
PROJECT NO. 702.41-50354.07

NOVEMBER 27, 1996

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1.0 EXECUTIVE SUMMARY

LAW completed a subsurface investigation for a reach of the Sossaman Channel extending from the Superstition Freeway (US 60) to Baseline Road in eastern Mesa, Arizona. The purpose of our investigation was to obtain general subsurface soil information, observe surface erosion conditions, provide the results of the laboratory testing, and provide recommendations for earthwork and foundation construction.

The topography of the existing ground surface on both sides of the channel is relatively flat. The channel area is bordered by housing developments on both the east and west sides. Based on our subsurface explorations, the channel reach encounters primarily native soils. Our borings encountered brown silty sand to a depth of about 20 feet with an intermittent sandy clay layer at a depth of about 5 feet below the ground surface. Firm to hard subsurface conditions with cemented layers were encountered and moderate excavation difficulties should be anticipated. Ground water and deleterious fills were not encountered during our field subsurface exploration.

2.0 PROJECT INFORMATION

We received project information during telephone conversations with Mr. Warren Rosebraugh on August 26 and September 24, 1996. Further information was obtained from site plans received on August 27, 1996. Based on these conversations, we understand that features are being considered for flow and erosion control on the Sossaman Channel reach between the Superstition Freeway (US 60) and Baseline Road. The features should include reinforced concrete drop structures, shaping, and rock lining along the channel reach. We understand that proposed construction of the features will consist of excavation and modification of the existing channel.

We were not provided with plans for the construction details of the channel features. We were advised that the features will be placed based on energy reduction needs, water flow conditions, and protection of the channel from soil erosion. We have assumed the structures will be sized for a net dead plus live load bearing pressure of 2,000 pounds per square foot (psf). When final plans are prepared they should be forwarded to us for review and allow us to make any necessary modifications to our recommendations.

3.0 PURPOSE AND SCOPE

The purpose of this investigation was to evaluate the subsurface conditions and provide recommendations for construction of structures along the channel reach located in eastern Mesa, Arizona. The following information is provided in our report:

- A summary of the information provided to us;
- A brief summary of our test procedures and the results of the testing conducted;
- A summary of surface and subsurface soil and ground water conditions encountered in the borings;
- A general evaluation of the site based on assumed construction and the subsurface conditions encountered;
- Recommendations for excavation, earthwork, and compaction; and,
- Estimated allowable bearing pressures, friction, and passive values for resistance of lateral loads.

The assessment of geologic hazards, site environmental conditions or the presence of pollutants in the soil, rock, and ground water of the site was beyond the scope of this investigation.

4.0 FIELD EXPLORATIONS AND LABORATORY TESTING

4.1 FIELD EXPLORATIONS

The soil conditions beneath the site were explored on October 10, 1996 by drilling four borings in the vicinity of the channel reach. The approximate locations of the borings are shown on Figure 2. The depths of the borings were dependent on both surface and subsurface conditions encountered during the drilling process. The four borings were completed to the planned termination depth of about 20 feet. Details of the explorations and logs of the soil borings are presented in the attached Appendix.

4.2 LABORATORY TESTING

Laboratory tests were performed on selected samples obtained from the borings to aid in the classification of the soils and to determine the pertinent engineering properties of the channel soils. The following tests were performed:

- Atterberg Limits
- Consolidation Collapse/Swell
- In-Situ Moisture Content and Dry Density Determination
- Moisture-Density Relationship
- Sieve Analysis

The testing was performed in general accordance with applicable ASTM specifications. Details of the laboratory testing program and test results are presented in the Appendix.

5.0 SURFACE AND SUBSURFACE CONDITIONS

5.1 SURFACE CONDITIONS

According to USGS topographic maps of the area and plans provided to us, the elevation of the vicinity adjacent to the channel is approximately 1,400 feet above mean sea level. The existing topography near the channel is relatively flat and bordered by housing developments on both the east and west sides. The direction of the channel is generally south with a curve toward the southwest direction about midway along the reach with general access from Baseline Road.

Surface conditions were observed during our field exploration on October 10, 1996. At the time of our field exploration, the condition of the channel flow area from the Superstition Freeway south to Baseline Road appeared relatively unobstructed. The channel bottom near the Superstition Freeway (US 60) ranges from approximately 5 feet deep to approximately 15 feet deep near Baseline Road. The northern reach of the channel has gently sloped banks covered in grass with a limited quantity of rock and debris. As the channel extends southward, the grass coverage reduces to rock and cobble along the bottom with steep sides and some construction debris at the midway curve. The channel reach south of the curve is steeply sloped with rock and cobbles along the bottom. Near Baseline Road, the channel encounters a culvert for conveyance under the roadway. Access roads border the channel along the east and west banks with gravel coverage existing on the east bank. Surface soil conditions of the access roads consisted of gravel and exposed silty clayey sand free of vegetation growth.

5.2 SUBSURFACE CONDITIONS

The subsurface soils encountered during our exploration are described on the Test Boring Records in the Appendix. These Test Boring Records represent our interpretation of the subsurface conditions based on the field logs, visual examination of the field samples by an engineer, and tests of the collected field samples. The lines designating the interface between various strata on the Test Boring Records represent the approximate interface location; the actual transition between strata may be gradual. The following section summarizes our findings.

Subsurface conditions along the channel reach were explored on October 10, 1996 by advancing four borings. The soils encountered in Borings B-1, B-2, B-3, and B-4 consisted primarily of a very firm to hard, brown, silty clayey sand with low to moderate plasticity (USCS classification of SC). At the four boring locations, a weak to moderately cemented sandy clay layer of low to moderate plasticity (USCS classification of CL) at a depth of approximately 5 feet was encountered. The sandy clay layer extended to a depth of about 10 feet (approximately 5 feet thick). Below a depth of approximately 10 feet, silty clayey sand was encountered extending to the auger termination depth of about 20 feet below the ground surface.

The soils encountered were generally low in moisture content. Ground water and deleterious fill were not encountered in the soil borings at the time of drilling.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 FOUNDATIONS

6.1.1 General

Based upon our field explorations and laboratory results, the existing native soils encountered along the channel reach between the Superstition Freeway (US 60) and Baseline Road consist of firm to hard silty clayey sand with fines. Layers of weak to moderately cemented sandy clay were encountered at a depth of approximately 5 feet which may require moderate excavation efforts. We recommend the contractor be prepared for the possibility of moderate to difficult excavation conditions with the availability of heavy equipment and ripping tools for excavation through the cemented sandy clay layers.

6.1.2 Bearing Value

Spread footings and slabs-on-grade established in properly compacted fill may be designed to impose a net dead plus live load pressure of 2,000 pounds per square foot. A one-third increase in the bearing value may be used for wind or seismic loads.

While the actual bearing value of the compacted fill will depend on material used and the compaction methods employed, the quoted value will be applicable if acceptable soils are used and are compacted as recommended. The bearing value of the fill should be confirmed after completion of the grading.

6.1.3 Settlement

If our design recommendations are incorporated, we estimate total settlement of spread footings and slabs-on-grade to be less than about 1/2 inch. We anticipate the structural loading from the concrete flow control structures, drop structures, and erosion preventive measures to be minimal.

6.1.4 Lateral Loads

Lateral loads may be resisted by soil friction on the footings and by the passive resistance of the soils. A coefficient of friction of 0.35 may be used between the footings and the supporting soils. The passive resistance of properly compacted fill soils against footings may be assumed to be 250 pounds per square foot. A one-third increase in the passive value may be combined with the frictional resistance without reduction in determining the total lateral resistance.

6.1.5 Footing Observation

The footing excavations should be observed by personnel of our firm to verify that the spread footings and slabs-on-grade are founded in satisfactory soils. All required backfill should be mechanically compacted and flooding should not be permitted.

6.2 GRADING

With the exception of channel liners, to provide support for spread footings and slabs-on-grade, the natural soils should be excavated and recompacted to allow the placement of at least 2 feet of properly compacted fill beneath footings and slabs. All required additional fill should be properly compacted.

After excavating the site as required, the exposed soils should be carefully inspected to verify the removal of all unsuitable deposits. Next, the exposed soils should be scarified to a depth of 6 inches, brought to within 2 percent of optimum moisture content, and compacted to at least 95 percent of the maximum dry density obtainable by the ASTM Designation D698-78, Method A, Standard method of compaction.

After compacting the exposed soils, all required fill should be placed in loose lifts not more than 8 inches in thickness and compacted to at least 95 percent. The moisture content of the on-site clayey soils should be brought to between optimum and two percent above optimum moisture content during compaction.

The on-site soils, less any debris or organic matter within the existing fill, may be used in compacted fills. Any required imported fill should consist of relatively non-expansive soils with a Plasticity Index less than 15. The material should contain sufficient fines (binder material) so as to be relatively impermeable when compacted and result in a stable subgrade. The moisture content of imported fill, and non-clayey on-site soils should be brought to within two percent of optimum moisture content during compaction.

Imported fill soils are recommended to be free of deleterious material, expansive clays, and organic material. Import fill soil should not contain material larger than 3 inches in largest dimension and should have less than 50 percent passing the #200 sieve. To disclose soft or "pumping" areas, the properly compacted subgrade should be proofrolled with heavy construction equipment, such as a heavily loaded dump truck. The proofrolling should include four passes, with the last two being perpendicular to the first two. The proofrolling procedures should be performed in the presence of a geotechnical engineer or his representative. If soft or "pumping" areas are observed, the area should be excavated beyond the limits of the soft pocket, and recompacted with engineered fill according to the recommendations presented in this section.

The fill surface must be maintained during construction in order to achieve the recommended compaction. We recommend that the fill surface be sloped to provide drainage and to prevent water from ponding on the fill. If precipitation is expected, fill construction should be temporarily halted and the surface should be rolled with a steel drum or rubber-tire roller to improve surface runoff. If the surface soils become excessively wet, fill operations should be halted and the geotechnical engineer should be consulted prior to initiating fill operations.

7.0 CONSTRUCTION QUALITY CONTROL MEASURES

The following are based upon the field and laboratory testing, our site observations and our experience:

1. Prior to compaction and backfill procedures, samples of native and imported fill material should be collected. These samples should be tested to determine location specific dry density and optimum moisture contents. Classification (Atterberg limits and grain size) and swell potential testing should be performed on proposed imported fill materials to evaluate their suitability for use as engineered fill.

2. For fill soils placed on the site, we recommend that a minimum of one in-place field density test be conducted per 1 foot of fill thickness and per 5,000 square feet of compacted soil area to determine that specified compaction is achieved.

3. We recommend that a representative from our firm be present during the earthwork and foundation construction phases of this project.

8.0 BASIS FOR RECOMMENDATIONS

The recommendations provided in this report are based on our understanding the project described and on our interpretation of the data collected during the subsurface exploration. We have made our recommendations based on experience with similar subsurface conditions under similar building conditions. These recommendations apply to the specific project discussed in this report; therefore, any changes in load conditions or site grades should be provided to us so that we may review our conclusions and recommendations and make any necessary modifications.

Regardless of the thoroughness of the geotechnical exploration, there is always a possibility that conditions between the borings will be different than those encountered in the test borings, or that soil conditions may have changed since our investigation. Therefore, a representative from our firm should monitor the earthwork and foundation construction to confirm that anticipated soil conditions exist.

9.0 CONSTRUCTION PLANS AND SPECIFICATION REVIEW

We recommend LAW be retained to perform a review of the foundation and earthwork plans and specifications prepared from the recommendations presented in this report to determine if the plans and specifications are in compliance with the intent of our recommendations. Our report has been written in a guideline recommendation format and is not appropriate for use as a specification without being reworded into a specification-type format.

APPENDIX

SUMMARY OF FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

Subsurface Investigation

To explore the subsurface conditions in the area of the channel reach, four test borings (designated B-1 through B-4) were drilled at the site. The approximate locations of the borings are shown on Figure 2.

The locations of the soil test borings were planned by FCDMC and LAW personnel and established in the field by LAW personnel. The boring locations should be considered accurate only to the degree implied by the method used. Ground surface elevations at the boring locations were established by LAW personnel.

Relatively undisturbed and bulk samples were obtained from the borings. The samples were used for classification and in laboratory testing to determine various properties of soil. Our drilling and sampling was performed in general accordance with applicable ASTM standards.

The soil borings were advanced using a truck-mounted, hollow stem auger drilling equipment. Soil samples were obtained using a 2 inch outside diameter, 1-3/8 inch inside diameter split spoon (standard SPT sampler), or a 3 inch outside diameter, 2.42 inch inside diameter California ring sampler. Soil samples were collected at intervals ranging from 2 to 10 feet, commencing at a depth of approximately 2 feet below the ground surface. Our field engineer monitored the drilling operations, logged the borings, recorded the penetration resistances of the samplers, and obtained relatively undisturbed and bulk samples for the laboratory testing.

After drilling, the boreholes were backfilled with the soil drill cuttings. At the completion of the drilling operations, the soil samples were transported to our laboratory where they were reviewed by a geotechnical engineer and samples were selected for laboratory testing.

The soils were visually classified in the field by our engineer in accordance with the Unified Soil Classification System (USCS). The logs of the borings are presented in the attached Test Boring Records. The USCS is also presented. These records present our interpretations of the subsurface conditions based on our field observations, a visual examination of samples by our engineer, and the indicated laboratory tests performed on selected samples. The lines designating the interface between various strata on the test boring records represent the approximate positions of the interface. The transition between strata may be gradual. Ground water conditions indicated in our report represent conditions only at the time of our exploration.

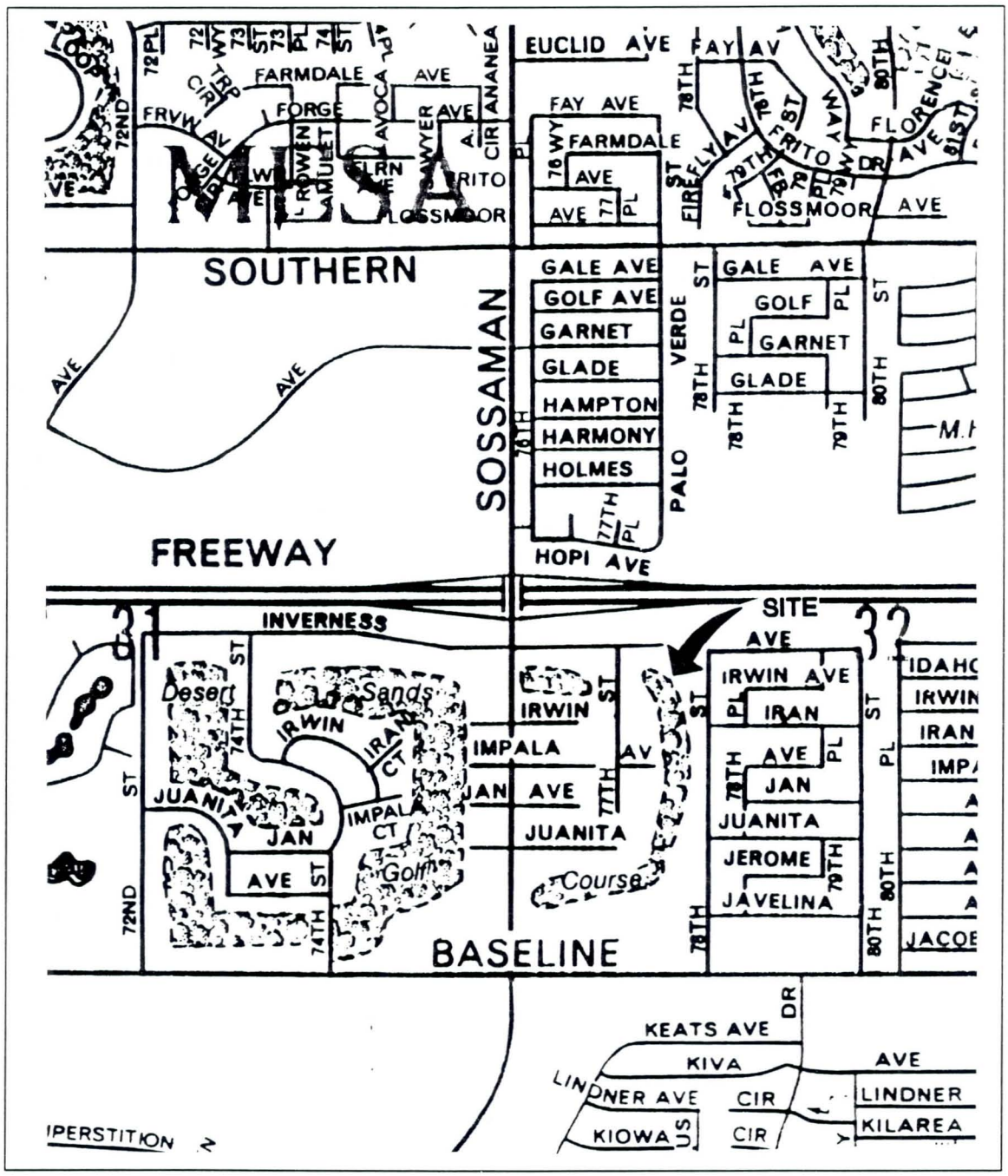
LABORATORY TESTING

Laboratory tests were performed on selected soil samples to aid in classification and to evaluate the physical and engineering characteristics of the soil. Laboratory testing included Atterberg limits testing, consolidation collapse/swell testing, in-situ moisture and density determinations, moisture-density relationship, and sieve analyses to establish grain size distribution. The testing was performed in general accordance with applicable ASTM standards. We will store the collected samples for a period of 60 days, after which time they will be discarded, unless we are otherwise notified. The results of the laboratory tests are discussed in this section.

The field moisture content and dry density of the soils encountered were determined by performing tests on the relatively undisturbed samples. Dry densities and moisture contents obtained from relatively undisturbed ring samples indicated a range of about 100.7 to 112.4 pounds per cubic foot, and 2.5 percent to 6.8 percent, respectively. The results of the testing is presented on Table I - Summary of Laboratory Testing.

Consolidation testing was performed on a total of two relatively undisturbed soil samples to assist in evaluating the collapse/swell and settlement potential of the on-site soils. Water was added to the relatively undisturbed samples after applying a load of 2,000 pounds per square foot to illustrate the effect of moisture on the sample. The results of the tests are presented on the attached Consolidation Test Data figures and on Table I - Summary of Laboratory Testing.

To determine the particle size distribution of the soils and to aid in classifying the soils, mechanical analyses were performed. Three sieve analyses and Atterberg limits tests were performed on selected soil samples collected from about 2 feet, 5 feet, and 10 feet below the ground surface. Percentages of gravel sized particles ranged from 2.0 percent to 6.0 percent, percentages of sand sized particles ranged from about 36.4 percent to 55.9 percent, and percentages of fines ranged from about 38.1 percent to 61.6 percent. To aid in the classification of the soils, Atterberg limits tests were also performed on selected samples. Liquid limits ranged from 26 to 33 with plasticity indices ranging from 9 to 13. The results of the testing are presented on the attached Consolidation Test Report, Moisture-Density Relationship Test Reports, Particle Size Distribution Test Reports, and on Table I - Summary of Laboratory Testing.



SOURCE: WIDE WORLD OF MAPS, DATED 1994.

SCALE

0 1200 2400 FEET

N

VICINITY MAP	FIGURE 1

LAW PROJECT NAME: SOSSAMAN CHANNEL
LAW PROJECT NO: 70241-50354.07
DRAWN BY: RAA
DATE: 11/96

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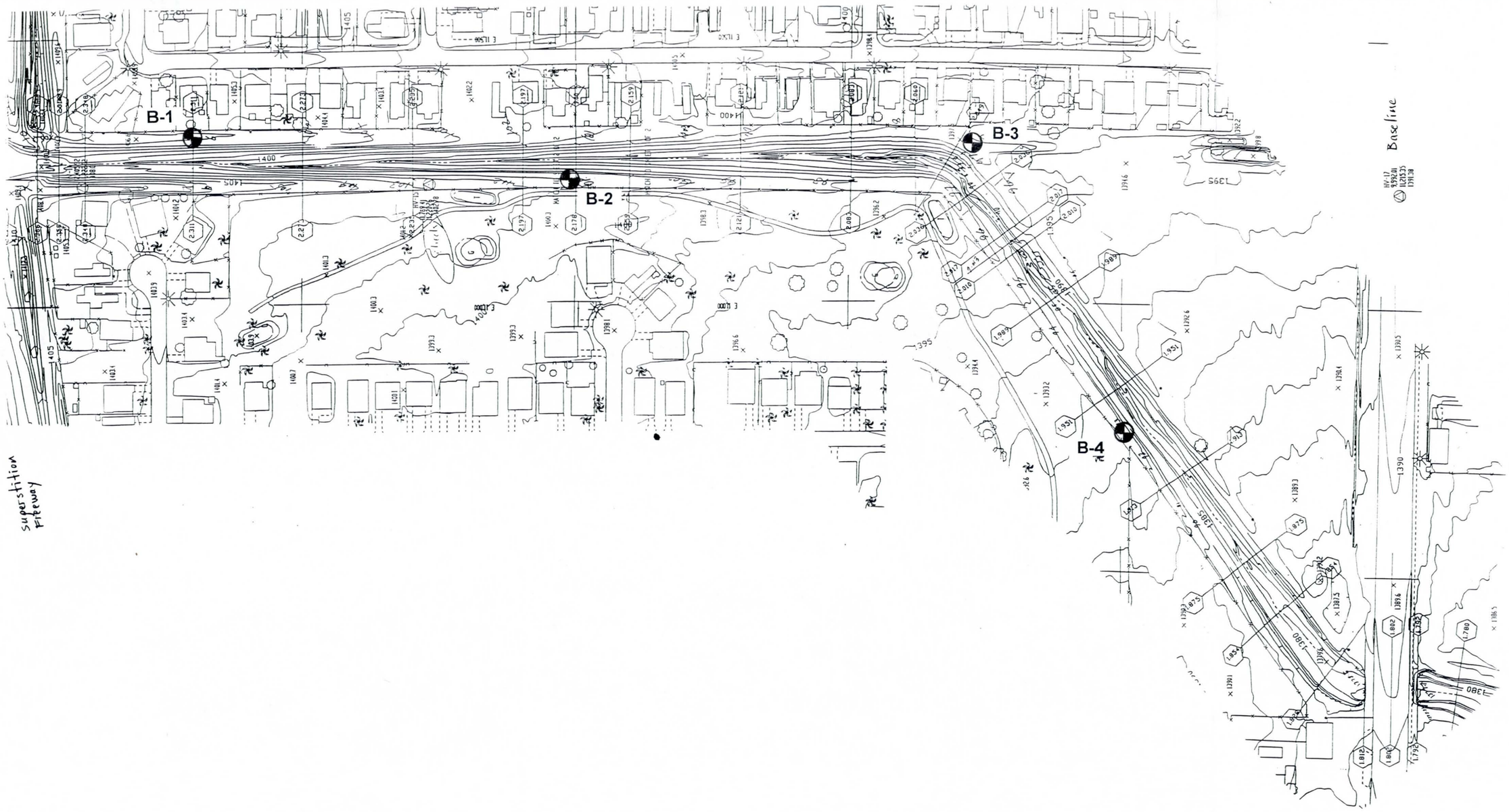
ENGINEERING AND ENVIRONMENTAL SERVICES

CHECKED: PM, PRINCIPAL

CHECKED: P.M. BW, PRINCIPAL _____



APPROX. SCALE 1" = 186 FEET

0 186 372

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ENGINEERING AND ENVIRONMENTAL SERVICES

REFERENCE	BORING LOCATION PLAN	FIGURE 2

ENTITLED: SOSSAMAN CHANNEL US 60 TO BASELINE ROAD

PREPARED BY: FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

LAW PROJECT NAME: SOSSAMAN CHANNEL

LAW PROJECT NO: 70241-503540T

DRAWN BY: RAA

DATE: 11/96

SAMPLE NO.	BLOWS/FOOT	SYMBOL	TYPE N R B	DRY DENSITY (PCF)	MOISTURE CONTENT %	UNIFIED CLASSIFICATION	SYMBOL	DEPTH IN FEET	DESCRIPTION	REMARKS
						SC			Brown silty SAND with fines, low moisture, low to moderate plasticity.	Approximate Boring Location: East bank of channel 400 feet south of US 60.
	15		R	112.4	6.4					
								5		
	20		R	108.7	5.6	CL			Brown sandy CLAY with moderate cementation, low moisture, low to moderate plasticity.	
								10		
	47		R			SC			Brown silty SAND with fines and trace gravel, low moisture, low to moderate plasticity.	
								15		
								20		
	50		R							
									Gravel overlay at ground surface approximately 3 inches thick. Approximate ground surface elevation = 1,400 feet. Total depth = 21 feet below ground surface. No groundwater encountered.	

NOTES: SPT = Standard Penetration Test; N = SPT value (140 lb hammer free-falling 30 inches); R = ring sample; 8 inch diameter borehole

TEST BORING RECORD

BORING NUMBER	B-1
DATE DRILLED	October 10, 1996
PROJECT NUMBER	702.41-50354.07
PROJECT	Sossaman Channel (South of US 60).
PAGE 1 OF 1	

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SAMPLE NO.	BLOWS/FOOT	SYMBOL	TYPE N R B	DRY DENSITY (PCF)	MOISTURE CONTENT %	UNIFIED CLASSIFICATION	SYMBOL	DEPTH IN FEET	DESCRIPTION	REMARKS
						SC			Brown silty SAND with fines, low moisture, low to moderate plasticity.	Approximate Boring Location: West bank of channel 1,100 feet south of US 60.
	9		R	111.0	2.6					
								5		
	12		R	106.9	5.6	CL			Brown sandy CLAY with moderate cementation, low moisture, low to moderate plasticity.	
								10		
	50		R			SC			Brown silty SAND with fines and trace gravel, low moisture, low to moderate plasticity.	
								15		
								20		
	50		R							
									Approximate ground surface elevation = 1,400 feet. Total depth = 21 feet below ground surface. No groundwater encountered.	

NOTES: SPT = Standard Penetration Test; N = SPT value (140 lb hammer free-falling 30 inches); R = ring sample; 8 inch diameter borehole

TEST BORING RECORD

BORING NUMBER	B-2
DATE DRILLED	October 10, 1996
PROJECT NUMBER	702.41-50354.07
PROJECT	Sossaman Channel (South of US 60).
PAGE 1 OF 1	

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SAMPLE NO.	BLOWS/FOOT	SYMBOL	TYPE N R B	DRY DENSITY (PCF)	MOISTURE CONTENT %	UNIFIED CLASSIFICATION	SYMBOL	DEPTH IN FEET	DESCRIPTION	REMARKS
	8		R	110.1	6.8	SC			Brown silty SAND with fines, low moisture, low to moderate plasticity.	Approximate Boring Location: East bank of channel 1,800 feet south of US 60.
	9		N			CL		5	Brown sandy CLAY with moderate cementation, low moisture, low to moderate plasticity.	
	40		N	105.7	4.8	SC		10	Brown silty SAND with fines and gravel, low moisture, low to moderate plasticity.	
								15		
	50		R					20		
									Gravel overlay at ground surface approximately 3 inches thick. Approximate ground surface elevation = 1,400 feet. Total depth = 21 feet below ground surface. No groundwater encountered.	

NOTES: SPT = Standard Penetration Test; N = SPT value (140 lb hammer free-falling 30 inches); R = ring sample; 8 inch diameter borehole

TEST BORING RECORD

BORING NUMBER	B-3
DATE DRILLED	October 10, 1996
PROJECT NUMBER	702.41-50354.07
PROJECT	Sossaman Channel (South of US 60).
PAGE 1 OF 1	

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SAMPLE NO.	BLOWS/FOOT	SYMBOL	TYPE N R B	DRY DENSITY (PCF)	MOISTURE CONTENT %	UNIFIED CLASSIFICATION	SYMBOL	DEPTH IN FEET	DESCRIPTION	REMARKS
	8		R	100.7	5.2	SC			Brown silty SAND with fines, low moisture, low to moderate plasticity.	Approximate Boring Location: West bank of channel 600 feet southwest of curve in channel.
	22		R			CL		5	Brown sandy CLAY with moderate cementation, low moisture, low to moderate plasticity.	
	40		R			SC		10	Brown silty SAND with fines and trace gravel, low moisture, low to moderate plasticity.	
								15		
	47		R	110.6	5.0			20		
									Approximate ground surface elevation = 1,400 feet. Total depth = 21 feet below ground surface. No groundwater encountered.	

NOTES: SPT = Standard Penetration Test; N = SPT value (140 lb hammer free-falling 30 inches); R = ring sample; 8 inch diameter borehole

TEST BORING RECORD

BORING NUMBER	B-4
DATE DRILLED	October 10, 1996
PROJECT NUMBER	702.41-50354.07
PROJECT	Sossaman Channel (South of US 60).
PAGE 1 OF 1	

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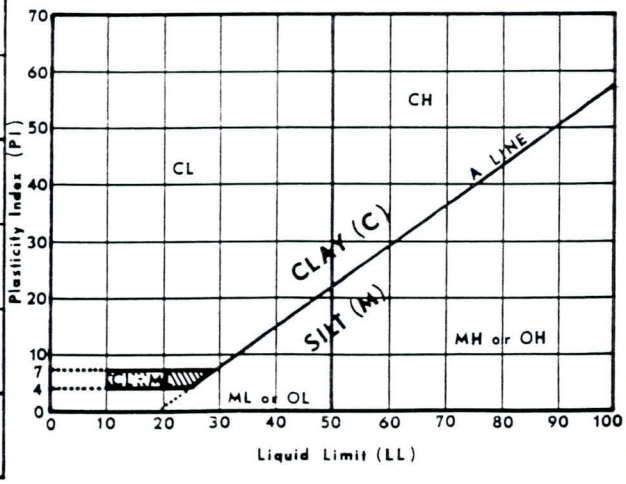
Unified Soil Classification System

Major divisions			Group Symbol	Typical names	Laboratory classification criteria	
COARSE GRAINED SOILS (More than half of material is larger than No. 200 sieve)	Gravels (More than half of coarse fraction is larger than No 4 sieve)	Clean gravels	GW	Well graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}} > 4$; $1 < C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} < 3$	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW	
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve)	Clean sands	SW	Well graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}} > 6$; $1 < C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} < 3$	
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW	
		Sands with fines	SM	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring the use of dual symbols
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
FINE GRAINED SOILS (More than half of material is smaller than No. 200 sieve)	Silts and clays (LL less than 50)		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and clays (LL greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
	Highly Organic Soils		Pt	Peat and other highly organic soils		

Determine percentages of sand and gravel from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse grained soils are classified as follows:

Less than 5% ..... GW, GP, SW, SP
More than 12% ..... GM, GC, SM, SC
5 to 12% ..... Borderline cases requiring dual symbols

1. Plot intersection of PI and LL as determined from Atterberg Limits tests.
2. Points plotted above A line indicate clay soils, those below the A line indicate silt.



Plasticity Chart

UNIFIED SOIL CLASSIFICATION

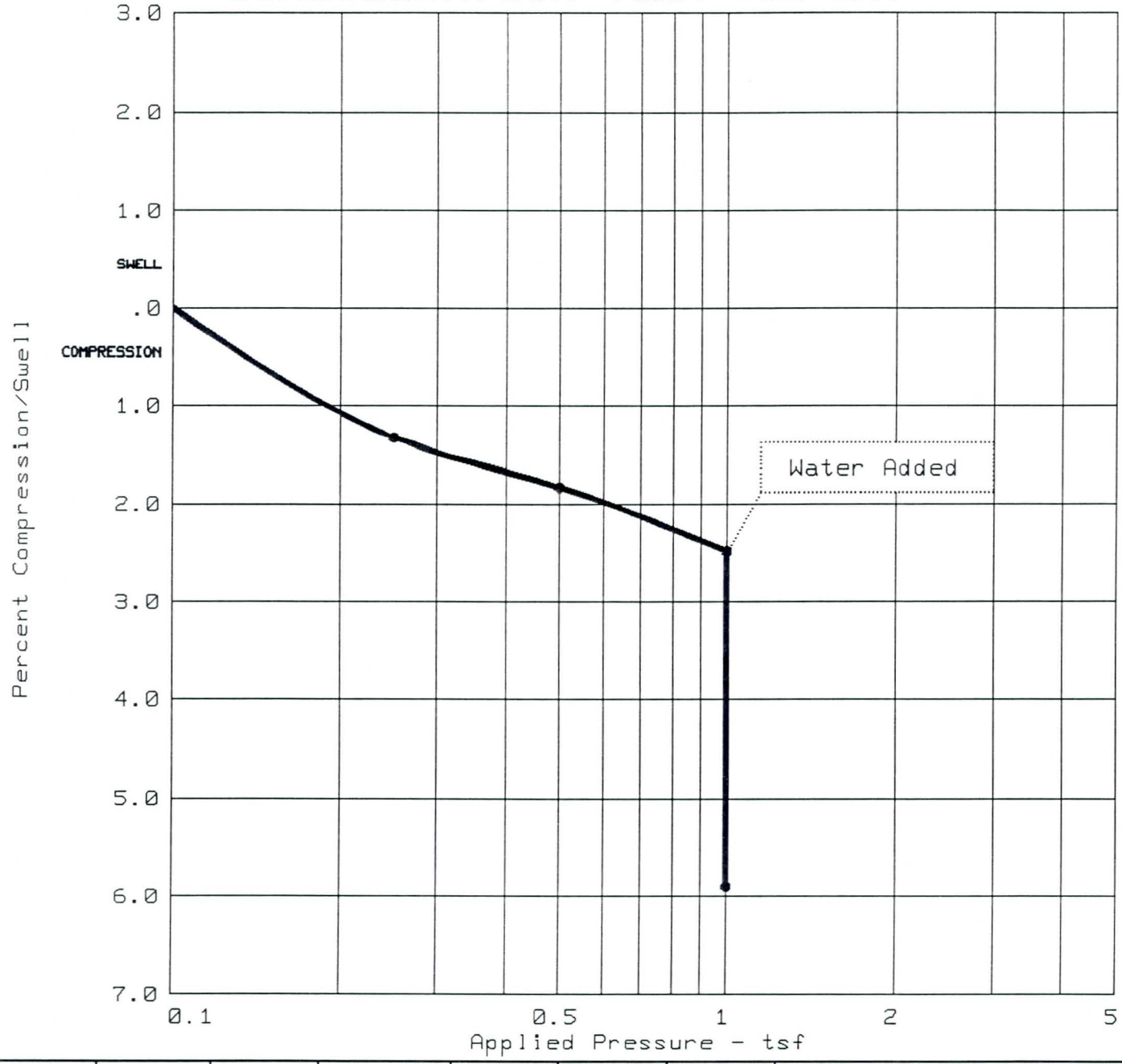
LAW/CRANDALL
Engineering and Environmental Services

TABLE I
Summary of Laboratory Testing
Sossaman Channel
Superstition Freeway (US 60) to Baseline Road
Mesa, Arizona
Law/Crandall Project No. 702.41-50354.07

Sample Location Boring/Depth	Sieve Analysis			In-Situ Moisture Content (%)	In-Situ Dry Density (pcf)	Consol. Swell / Collapse ±, (%)	Atterberg Limits, %		Moisture-Density Relationship ASTM D 698-78, Meth A, Std		USCS[1]
	Gravel (%)	Sand (%)	Fines (%)				Liquid Limit	Plasticity Index	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	
B-1 / (2' - 3')	2.0	49.1	48.9	6.4	112.4	NT	26	9	NT	NT	SC
B-1 / (5' - 6')	NT	NT	NT	5.6	108.7	NT	NT	NT	NT	NT	CL
B-2 / (2' - 3')	NT	NT	NT	2.5	111.0	NT	NT	NT	NT	NT	SC
B-2 / (5' - 6')	2.0	36.4	61.6	5.6	106.9	NT	26	9	NT	NT	CL
B-3 / (2' - 3')	NT	NT	NT	6.8	110.1	3.4	NT	NT	NT	NT	SC
B-3 / (10' - 11')	6.0	55.9	38.1	4.8	105.7	NT	33	10	NT	NT	SC
B-4 / (0' - 5')[2]	2.0	44.3	53.7	NT	NT	NT	30	13	117.6	12.7	CL
B-4 / (2' - 3')	NT	NT	NT	5.2	100.7	NT	NT	NT	NT	NT	SC
B-4 / (5' - 6')	NT	NT	NT	5.0	109.1	0.7	NT	NT	NT	NT	CL
B-4 / (20' - 21')	NT	NT	NT	5.0	110.6	NT	NT	NT	NT	NT	SC

NT = Not Tested
[1]USCS = Unified Soil Classification System
[2]Bulk Sample of Near Surface Auger Cuttings

CONSOLIDATION TEST REPORT



Clpse. %	Nat. Sat.	Nat. Moist.	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
3.4	23.0 %	4.0	113.7			2.65	0.4551

TEST RESULTS	MATERIAL DESCRIPTION
	Native Soil B3 (2'-3')

Project No.: 702.41-50354.07
Project: Sossaman Channel (Assignment No. 8)
Location: US 60 to Baseline Road

Date: 11-20-96

Remarks:

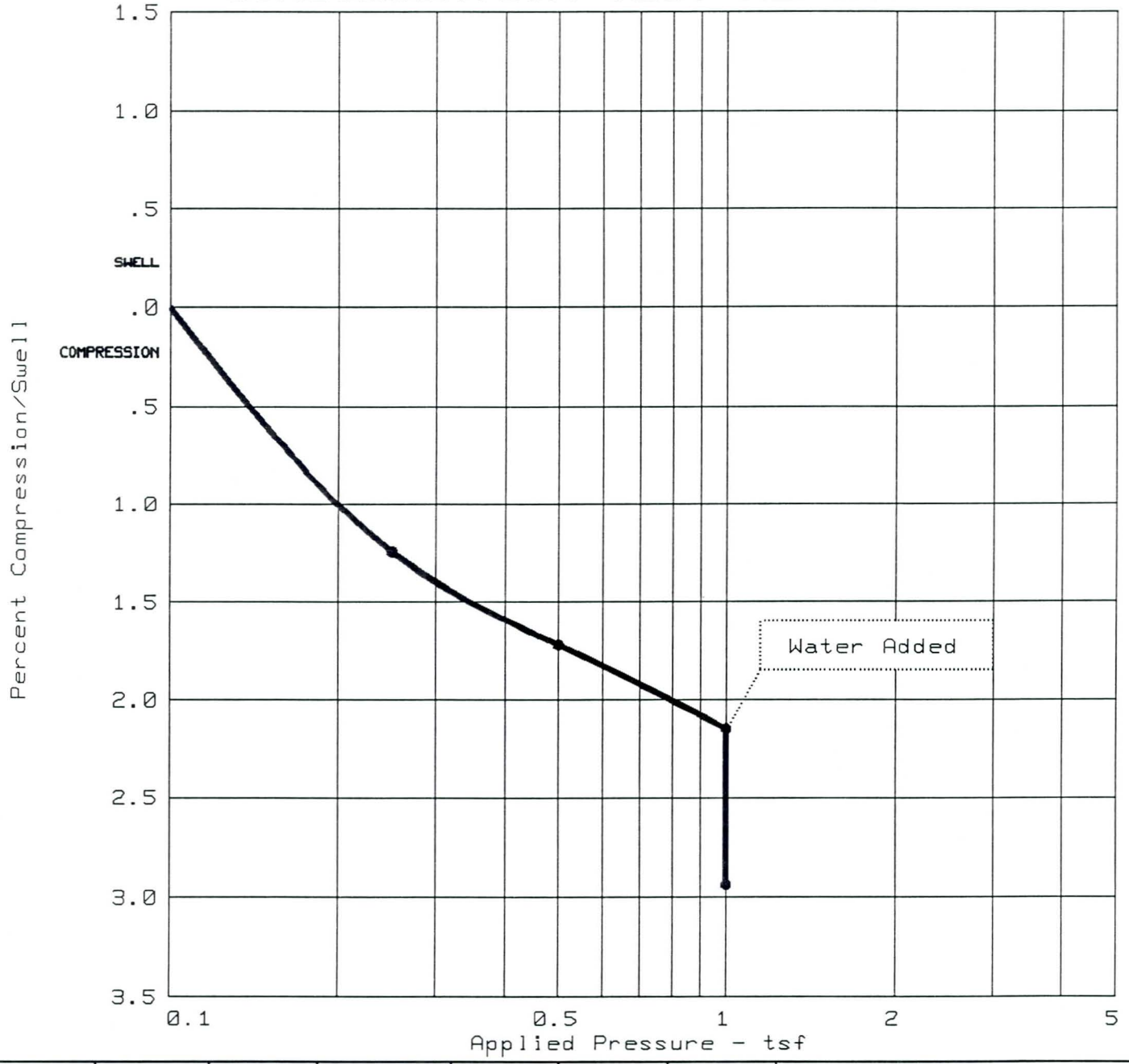
Law Lab No. 61541

CONSOLIDATION TEST REPORT

LAW/CRANDALL, INC.

Fig. No._____

CONSOLIDATION TEST REPORT



Clpse. %	Nat. Sat.	Nat. Moist.	Dry Density	LL	PI	Sp.Gr.	Initial void ratio
0.7	25.8 %	5.0	109.1			2.65	0.5170

TEST RESULTS	MATERIAL DESCRIPTION
	Native Soil B4 (5'-6')

Project No.: 702.41-50354.07
Project: Sossaman Channel (Assignment No. 8)
Location: US 60 to Baseline Road

Date: 11-25-96

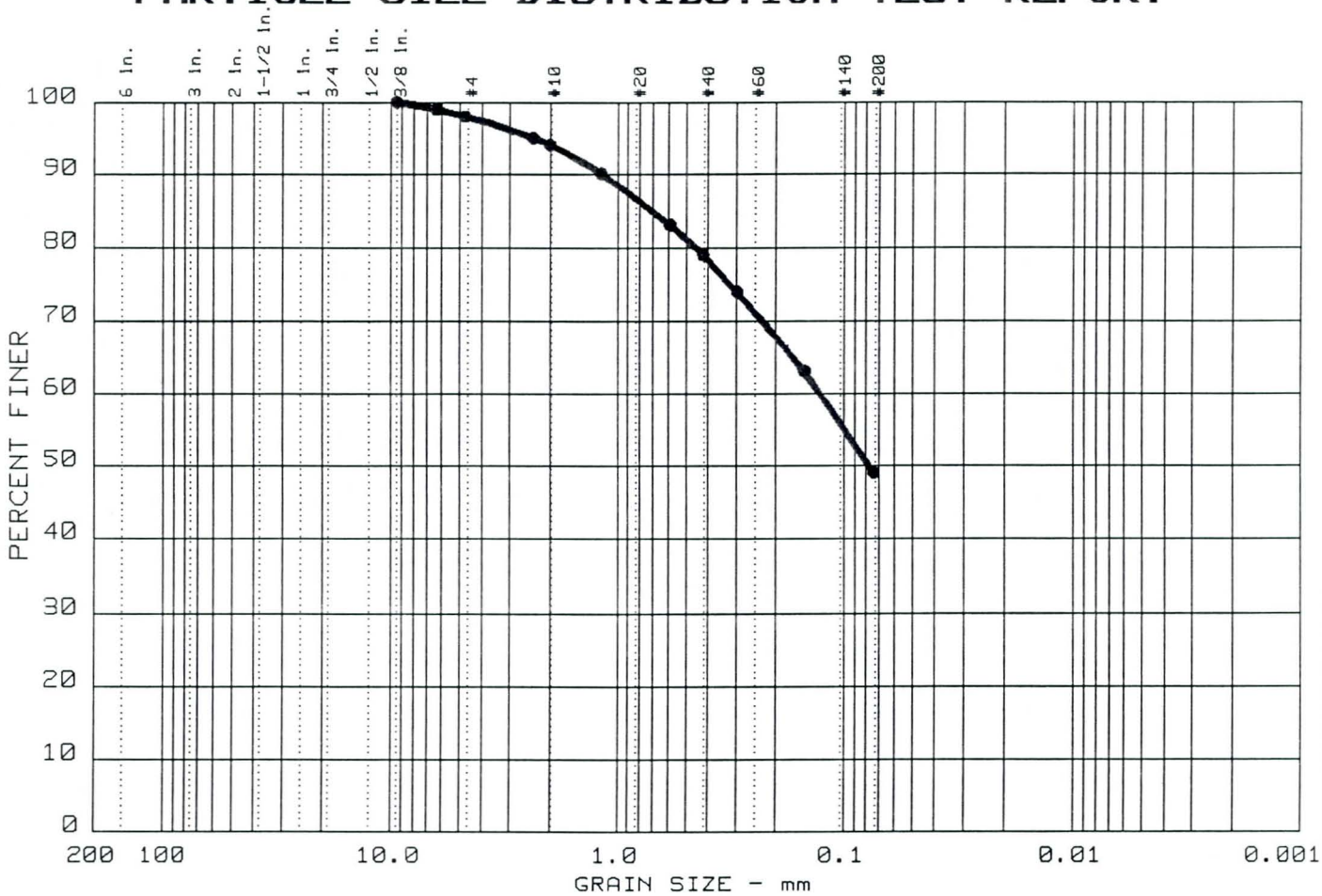
Remarks:
Law Lab No. 61637

CONSOLIDATION TEST REPORT

LAW/CRANDALL, INC.

Fig. No._____

PARTICLE SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	2.0	49.1	48.9		SC	26	9

SIEVE inches size	PERCENT FINER ●		
0.375	100.0		
0.25	99.0		
	GRAIN SIZE		
D_{60}	0.13		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	98.0		
8	95.0		
10	94.0		
16	90.0		
30	83.0		
40	79.0		
50	74.0		
100	63.0		
200	48.9		

Sample information:

● US 60 to Baseline Road
B1(2'-3')
Clayey Sand

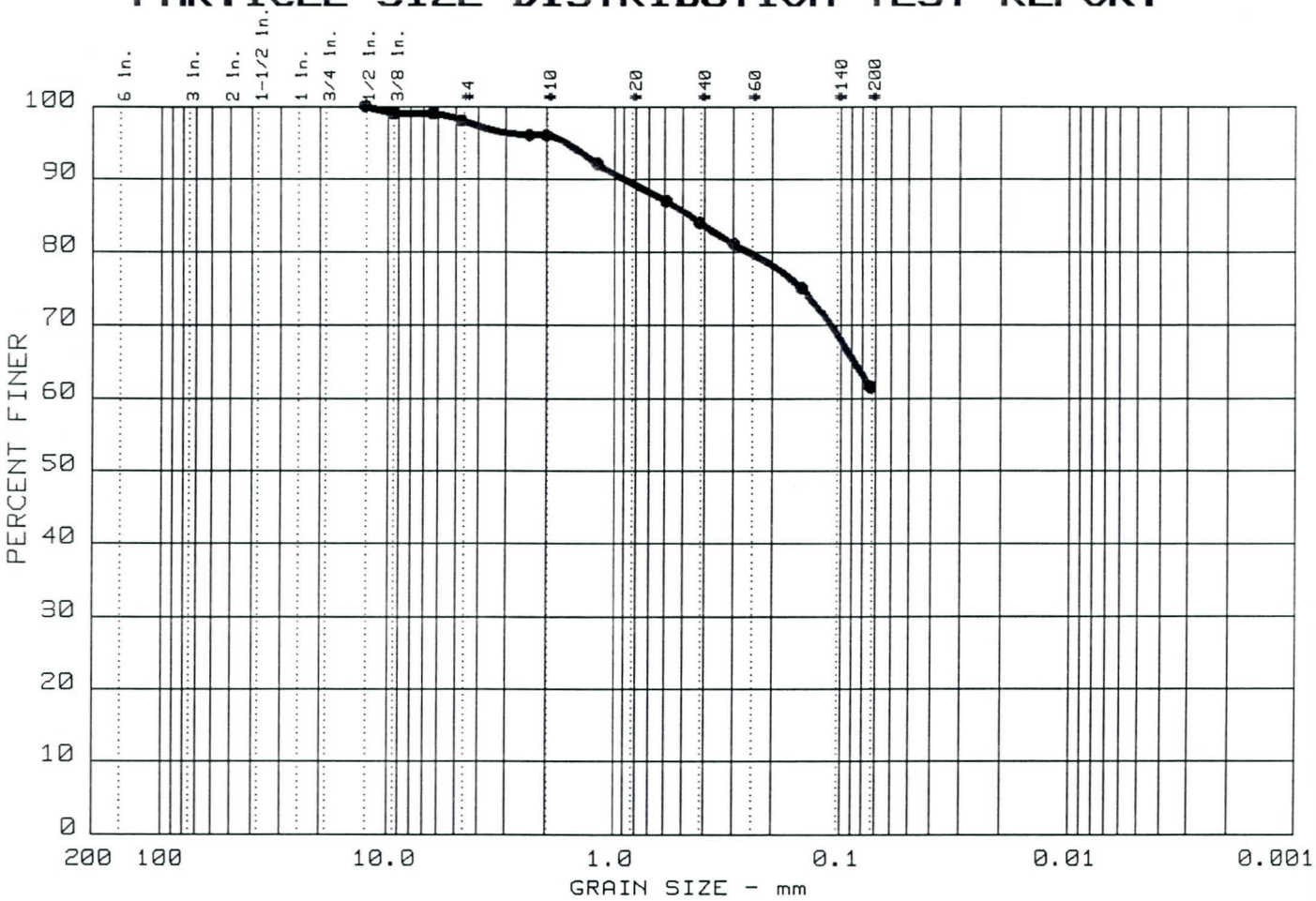
Remarks:
Law Lab No. 61533

LAW/CRANDALL, INC.

Project No.: 702.41-50354.07
Project: Sossaman Channel (Assignment No. 8)

Date: 11-12-96 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	2.0	36.4	61.6		CL	26	9

SIEVE inches size	PERCENT FINER ●		
0.5	100.0		
0.375	99.0		
0.25	99.0		
	GRAIN SIZE		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	98.0		
8	96.0		
10	96.0		
16	92.0		
30	87.0		
40	84.0		
50	81.0		
100	75.0		
200	61.6		

Sample information:

● US 60 to Baseline Road
B2(5'-6')
Sandy Lean Clay

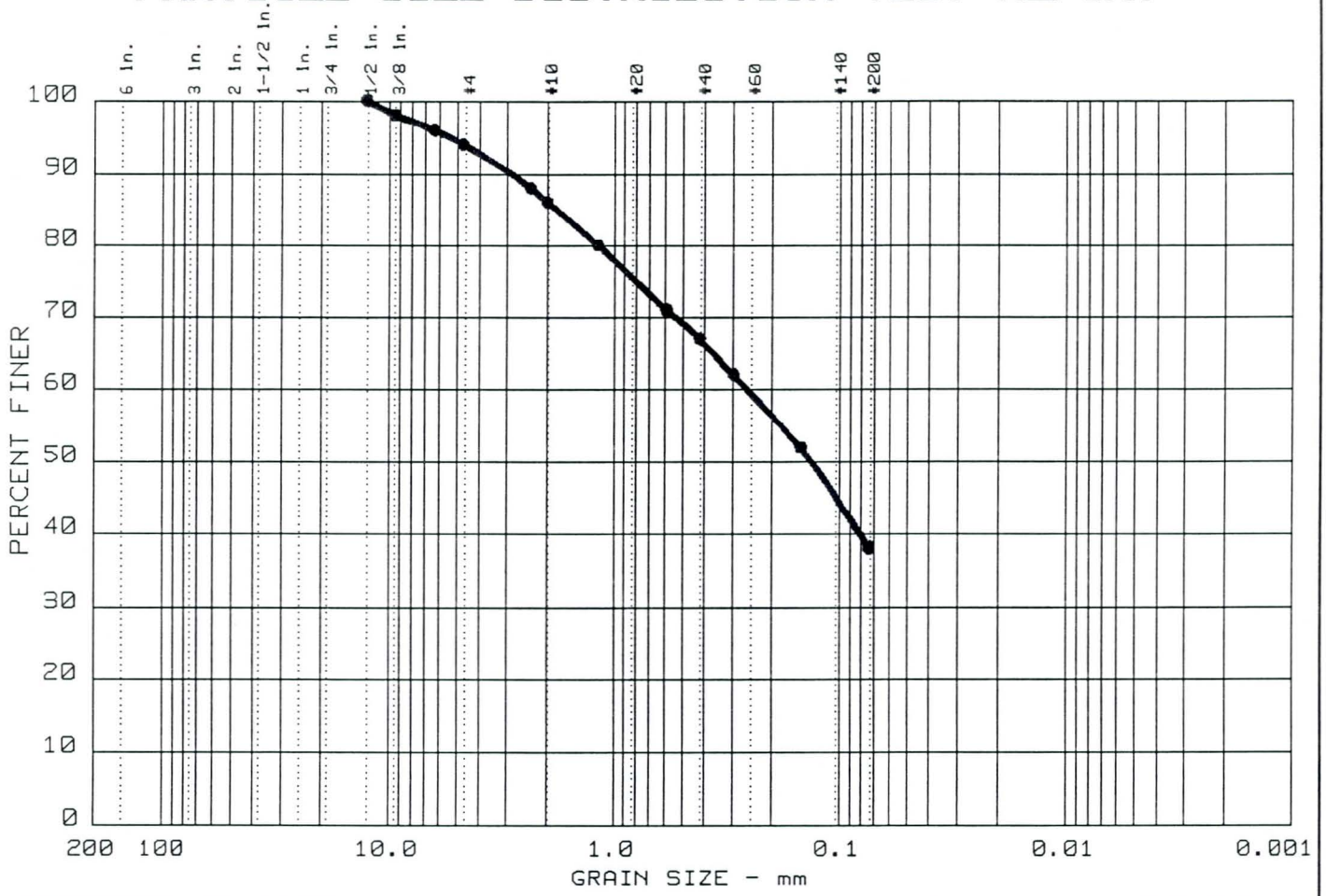
Remarks:
Law Lab No. 61534

LAW/CRANDALL, INC.

Project No.: 702.41-50354.07
Project: Sossaman Channel (Assignment No. 8)

Date: 11-12-96 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	6.0	55.9	38.1		SC	33	10

SIEVE inches size	PERCENT FINER ●		
0.5	100.0		
0.375	98.0		
0.25	96.0		
	GRAIN SIZE		
D_{60}	0.26		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	94.0		
8	88.0		
10	86.0		
16	80.0		
30	71.0		
40	67.0		
50	62.0		
100	52.0		
200	38.1		

Sample information:

● US 60 to Baseline Road
B3(10'-11')
Clayey Sand

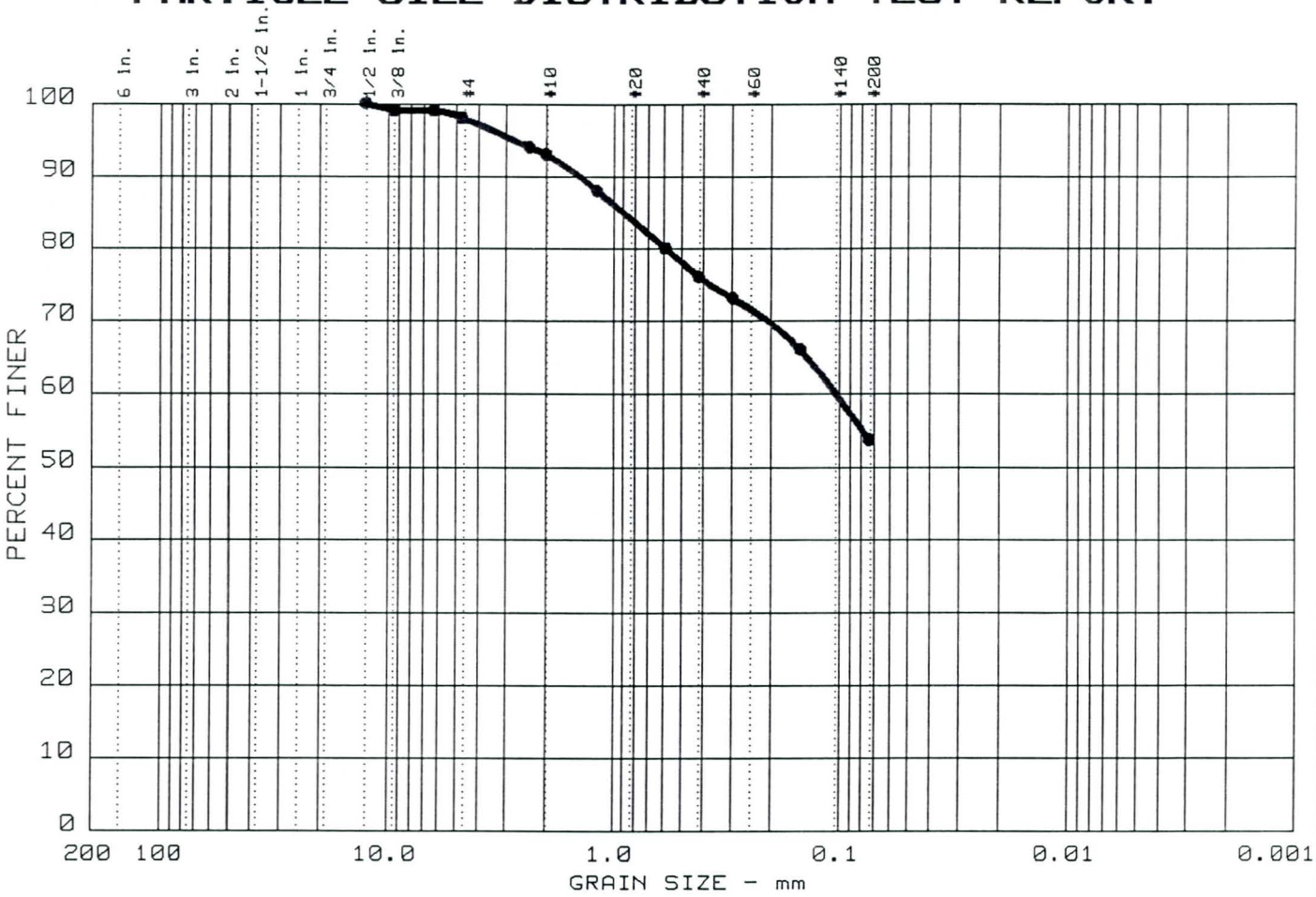
Remarks:
Law Lab No. 61535

LAW/CRANDALL, INC.

Project No.: 702.41-50354.07
Project: Sossaman Channel (Assignment No. 8)

Date: 11-12-96 Data Sheet No. ——

PARTICLE SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PI
●	0.0	2.0	44.3	53.7		CL	30	13

SIEVE inches size	PERCENT FINER ●		
0.5	100.0		
0.375	99.0		
0.25	99.0		
	GRAIN SIZE		
D_{60}	0.10		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ●		
4	98.0		
8	94.0		
10	93.0		
16	88.0		
30	80.0		
40	76.0		
50	73.0		
100	66.0		
200	53.7		

Sample information:

● US 60 to Baseline Road
B4(0'-5')
Sandy Lean Clay

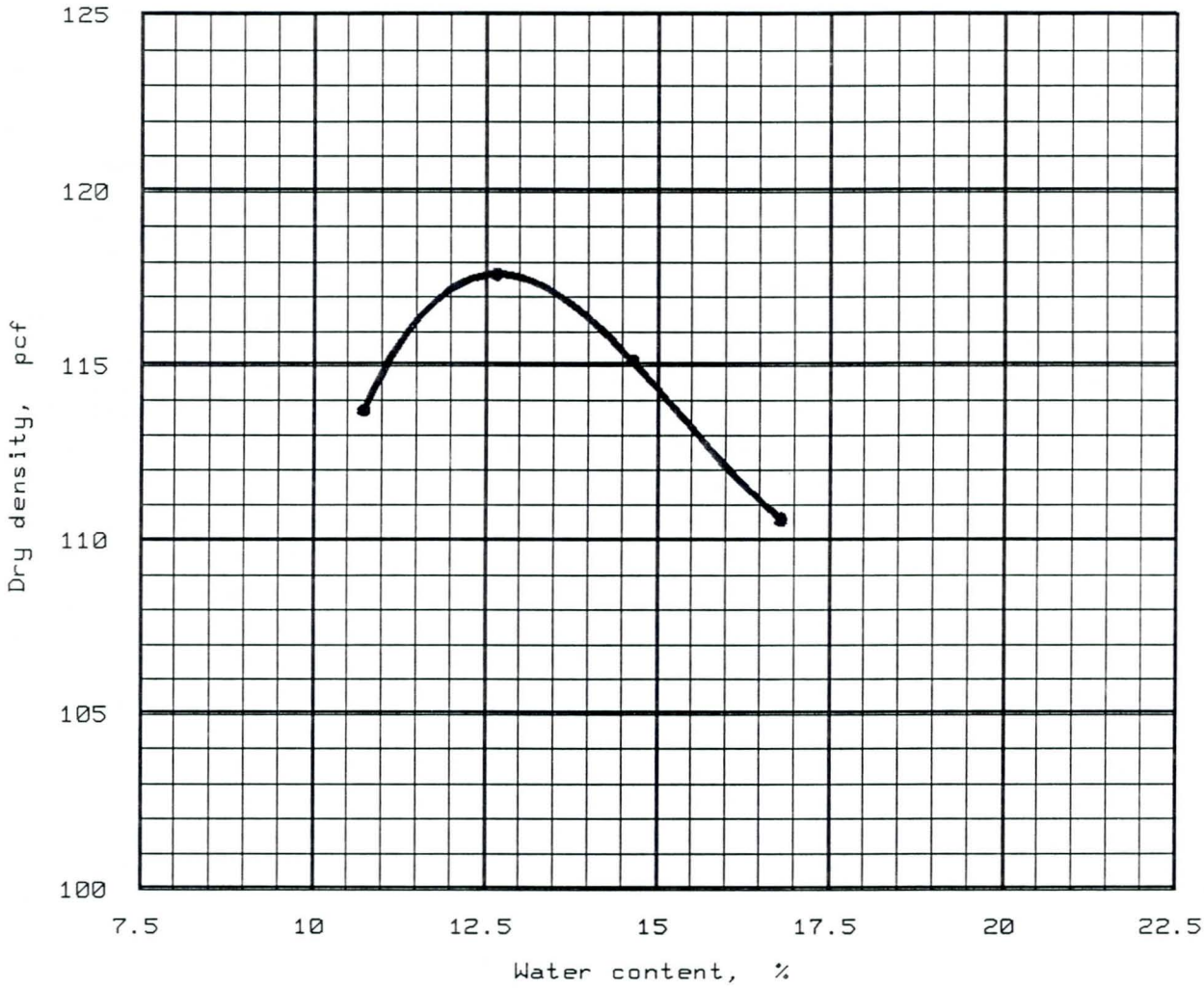
Remarks:
Law Lab No. 61536

LAW/CRANDALL, INC.

Project No.: 702.41-50354.07
Project: Sossaman Channel (Assignment No. 8)

Date: 11-12-96 Data Sheet No. ——

MOISTURE-DENSITY RELATIONSHIP TEST



Test specification: ASTM D 698-78 Method A, Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	CL				30	13	2 %	53.7 %

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 117.6 pcf Optimum moisture = 12.7 %	Sandy Lean Clay B4(0'-5')

Project No.: 702.41-50354.07

Project: Sossaman Channel (Assignment No. 8)

Location: US 60 to Baseline Road

Date: 11-12-96

Remarks:

Law Lab No. 61536

MOISTURE-DENSITY RELATIONSHIP TEST

LAW/CRANDALL, INC.

Fig. No. _____