

SOIL MECHANICS -- LEVEL I
MODULE 1
UNIFIED SOIL CLASSIFICATION SYSTEM
PART B
USCS USING LABORATORY DATA
STUDY GUIDE

PART B
 UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA
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PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 1 - OBJECTIVES

At the completion of Part B, you will be able to:

1. Identify and describe the use of the flow chart and plasticity chart in classifying soils by the Unified Soil Classification System using laboratory data.
2. Correctly classify all 25 soil classes in the Unified Classification System using the flow chart, plasticity chart, and laboratory data for the soils.

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 2 - PARTICLE SIZE COMPARISONS

The particle size boundaries for the Unified Soil Classification System (USCS) are summarized in the table on the following page. Also shown are particle size boundaries for other classification systems. Notice the differences in particle size definition between the Unified System, and the USDA Textural System, and the American Association of State Highway and Transportation Officials (AASHTO) System.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 3 - FLOW CHART

The flow chart is the basic tool used to classify soils by USCS using laboratory data. You will need to refer to this chart often during this module. You may want to paper clip this page for ease of location. The flow chart is the fold out sheet on the next page.

The flow chart is used by starting at the top of the chart and branching downwards in the chart based on data for the soil you are classifying and the decision blocks shown on the chart. If you follow the chart correctly and evaluate the data correctly, you will arrive at the correct USCS symbol for the soil that you are classifying.

START THE PLAYER WHEN YOU HAVE FINISHED

ABBREVIATIONS

The abbreviation for a soil group in the Unified Soil Classification System consists of two or more letters. Each letter has a particular meaning, which is helpful in the shorthand description of the soil. Each of the letters used in the system and its meaning are summarized below:

- G - Gravel - denotes a soil with less than 50 percent fines containing more gravel than sand
- S - Sand - denotes a soil with less than 50 percent fines containing more sand than gravel
- P - Poorly graded - denotes a sand or gravel with 12% or less fines content that is poorly graded
- W - Well-graded - denotes a sand or gravel with 12% or less fines content that is well-graded
- H - High liquid limit - modifier used for fine-grained soils to denote liquid limit values of 50 or higher
- L - Low liquid limit - modifier used for fine-grained soils to denote liquid limit values of less than 50
- C - Plastic Fines - modifier used to describe plasticity characteristics of fine-grained soils or coarse-grained soils with significant content of fines. Denotes fines with plastic characteristics
- M - Non-plastic to Slightly Plastic - modifier used to describe plasticity characteristics of fine-grained soils or coarse-grained soils with significant content of fines. Denotes fines with non-plastic to slightly plastic characteristics
- O - Organic - modifier used to describe fine-grained soils with organic characteristics
- Pt - Peat - symbol for peat in the Unified Soil Classification System.

By combining these symbols, groups names are derived. For example, a GP soil is a poorly graded gravel. A CH soil is a plastic soil with a high liquid limit. A GC soil is a gravel with plastic fines. There are 30 classifications in the Unified Systems with each classification represented by an abbreviation as shown on the flow chart at the right. Other Activities in this Module give more complete descriptions of terminology.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 4 - ORGANIC SOIL

When organic soils are suspected, a liquid limit test is performed on two samples of the soil. The soil for one test is prepared by air-drying the sample before processing through the No. 40 sieve and performing the test. The other sample is prepared by oven-drying the soil at a temperature of 110 degrees Centigrade + or - 5 degrees, then processing the soil through the No. 40 sieve and performing the liquid limit test.

If the ratio of the liquid limit performed on the oven-dried sample to the liquid limit value of the air-dried sample is less than 0.75, then the soil is an organic silt (OL) or an organic clay (OH). OL soils have air-dried liquid limit values less than 50 percent and OH soils have air-dried liquid limit values equal to or greater than 50 percent.

Classify each of the following soils.

<u>Sample</u>	<u>Percent finer than No. 200 sieve</u>	<u>LL of air-dry sample</u>	<u>LL of oven-dry sample</u>	<u>Ratio of oven-dry to air-dry LL values</u>	<u>Unified class</u>
1	78	45	30		
2	59	35	24		
3	88	58	40		
4	90	62	42		

If you have difficulty completing this activity, or you wish to check your work, please refer to the following page for the solution.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 4

The solution to Activity 4 follows:

<u>Sample</u>	<u>Percent finer than No. 200 sieve</u>	<u>Ratio of oven-dry to air- dry liquid limit values</u>	<u>Unified Class</u>
1	78	0.67	OL
2	59	0.69	OL
3	88	0.69	OH
4	90	0.68	OH

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ACTIVITY 5 - PLASTICITY CHART

The plasticity chart is used for classifying fine-grained soil and for classifying the plasticity characteristics of dirty sand and gravel and dual-classified sand and gravel. The plasticity chart is shown on the next page. You will need to refer to this often in the course, and may want to paper clip the page for ease of location.

Note that the maximum liquid limit shown on this particular chart is 100. However, this is just to keep the chart to a convenient size. If the liquid limits exceed 100, you may extend the "A" line using the same slope.

The plasticity chart has several areas bounded by the lines shown. The vertical line, at a liquid limit of 50, separates soils with "high" liquid limits from those with "low" liquid limits. Soils with liquid limit values of 50 or greater are given the symbol H, while soils with liquid limit values less than 50 are given the symbol L.

The line labeled "A" line separates soils with significant plasticity from those with low plasticity. Soils plotting on or above the "A" line are referred to as plastic and are given the symbol C, while those soils plotting below the "A" line are referred to as slightly plastic or non-plastic and are given the symbol M.

The line labeled "U" line is given to indicate that properly performed Atterberg limit tests will not plot above this line. Note that the "U" line is shown vertically at a liquid limit value of 16. This indicates that it is unlikely that a test could be properly performed on a soil with a liquid limit value less than 16. Such a soil should be labeled non-plastic rather than reporting test values less than 16 for the liquid limit.

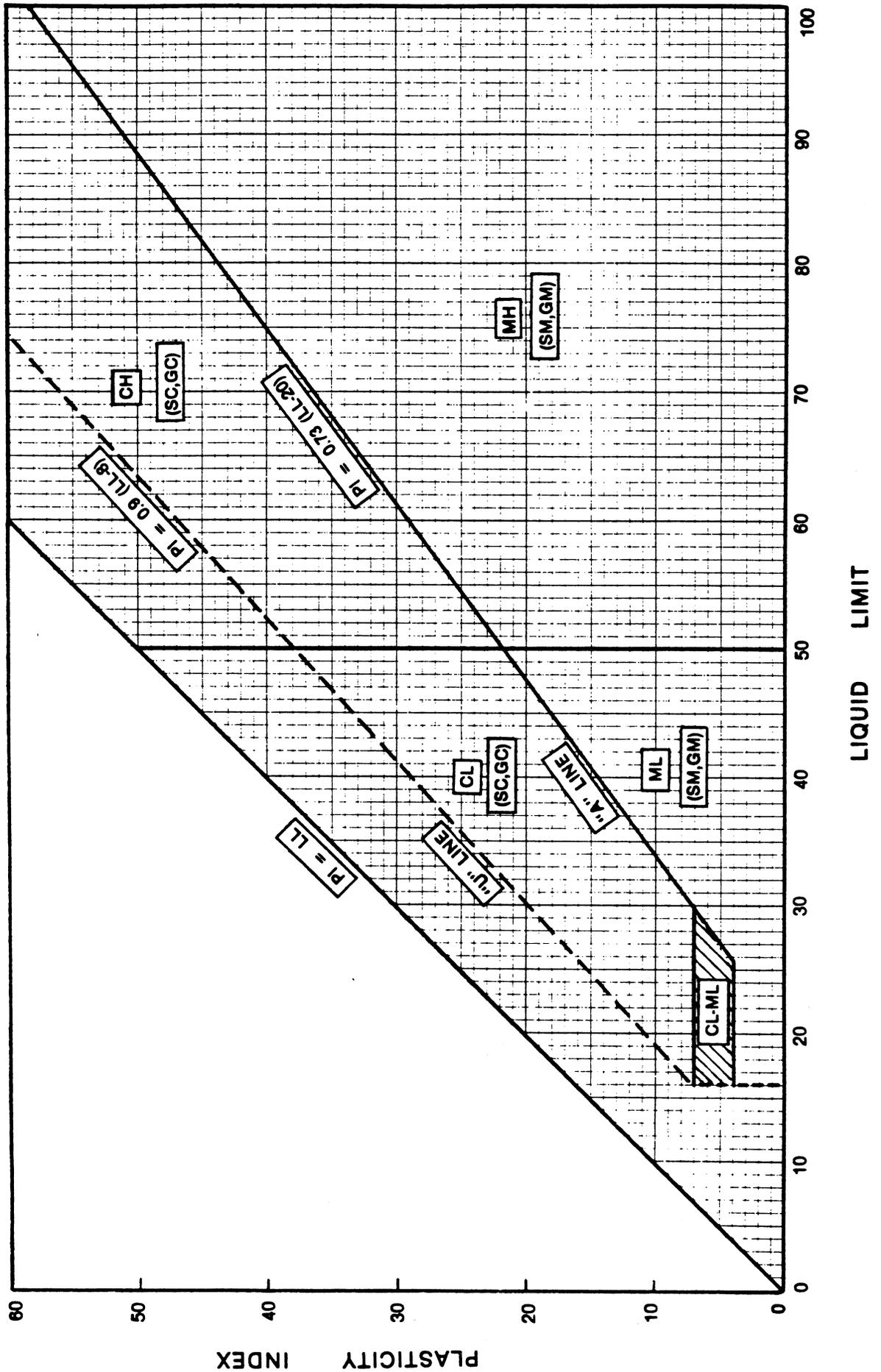
Note that if laboratory test results indicate that a soil is non-plastic, this is equivalent to the soil having a PI equal to 0.

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SOIL MECHANICS
LABORATORY

SOIL CONSERVATION
SERVICE

UNIFIED SOIL CLASSIFICATION SYSTEM PLASTICITY CHART



PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 6 - GROUP NAMES FOR FINE-GRAINED SOILS

Each fine-grained classification in the USCS has a group name as well as a symbol. These group names clarify the amount of sand or gravel or both, that may be a part of the soil. The combinations are:

Primary Descriptive Terms

CL - LEAN CLAY	OL & OH - ORGANIC CLAY - IF PI IS GREATER THAN
CL-ML - SILTY CLAY	OR EQUAL TO 4 AND ATTERBERG LIMITS
ML - SILT	PLOT ON OR ABOVE A-LINE ON PLASTICITY
CH - FAT CLAY	CHART
MH - ELASTIC SILT	OL & OH - ORGANIC SILT - PLOTS BELOW A-LINE ON
	PLASTICITY CHART

Modifiers

86% or more finer than the No.200 sieveno additional modifier terms
71-85% finer than No. 200 sieve, $%S \geq %G$() WITH SAND
71-85% finer than No. 200 sieve, $%S < %G$() WITH GRAVEL
50-70% finer than No. 200 sieve, $%S \geq %G$, $%G < 15%$SANDY ()
50-70% finer than No. 200 sieve, $%S \geq %G$, $%G > 15%$SANDY () WITH GRAVEL
50-70% finer than No. 200 sieve, $%S < %G$, $%S < 15%$GRAVELLY ()
50-70% finer than No. 200 sieve, $%S < %G$, $%S \geq 15%$GRAVELLY () WITH SAND

Examples

Example 1. CL soil with 74% finer than No. 200 sieve, 14% S and 12% G
LEAN CLAY WITH SAND

Example 2. MH soil with 53% finer than No. 200 sieve, 40% G and 7% S
GRAVELLY ELASTIC SILT

Example 3. CH soil with 70% finer than No. 200 sieve, 22% G, 8% S
GRAVELLY FAT CLAY

Example 4. CL-ML soil with 52% finer than No. 200 sieve, 30% S, 18% G
SANDY SILTY CLAY WITH GRAVEL

Example 5. OH soil with 65% finer than No. 200 sieve, 20% S, 15% G, LL and PI
plot below A-Line.
SANDY ORGANIC SILT WITH GRAVEL

Example 6. CL with 88% finer than No. 200 sieve, 10% S, 2% G, LL and PI plot
above A-Line.
LEAN CLAY

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 7 - CLASSIFICATION PROBLEMS

Classify the following soil samples using the data given. Assume the soils are not organic. Include the USCS symbol and group name. Proceed as follows:

1. Go to plasticity chart with LL & PI to determine major USCS symbol.
2. Use gradation data to determine group name by using Activity 6.

<u>Sample</u>	<u>Percent Passing</u>			<u>LL</u>	<u>PI</u>	<u>USCS symbol</u>	<u>Group name</u>
	<u>No.200</u>	<u>No.4</u>	<u>3 inch</u>				
1	58	100	100	58	32		
2	79	95	100	24	7		
3	82	100	100	41	31		
4	69	82	98	70	35		
5	89	100	100	120	77		
6	63	73	100	---	NP		

If you have difficulty completing this activity, or you wish to check your work, the solution to this activity is on the following page.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 8 - PROBLEMS

Determine from data given for each of the following samples: (1) percent sand or gravel, (2) fine-grained or coarse-grained soil, (3) if coarse-grained, clean, dirty, or dual.

<u>Number</u>	<u>Percent Finer</u>			<u>Percent Sand</u>	<u>Percent Gravel</u>	<u>Fine-grained or coarse-grained</u>	<u>Clean, dirty or dual (if coarse-grained)</u>
	<u>No.200</u>	<u>No.4</u>	<u>3 inch</u>				
1	50	78	100				
2	22	98	99				
3	4	27	98				
4	10	100	100				
5	48	82	100				
6	5	42	98				
7	14	74	100				

If you have difficulty completing this activity, or you wish to check your responses, refer to the next page for the solution.

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 8 - SOLUTION

<u>Number</u>	<u>Percent Finer</u>			<u>Percent Sand</u>	<u>Percent Gravel</u>	<u>Fine-grained or coarse-grained</u>	<u>Clean, dirty or dual (if coarse-grained)</u>
	<u>No.200</u>	<u>No.4</u>	<u>3 inch</u>				
1	50	78	100	28	22	fine-grained	NA*
2	22	98	99	76	1	coarse-grained	dirty
3	4	27	98	23	71	coarse-grained	clean
4	10	100	100	90	0	coarse-grained	dual
5	48	82	100	34	18	coarse-grained	dirty
6	5	42	98	37	56	coarse-grained	dual
7	14	74	100	60	26	coarse-grained	dirty

If you have difficulty completing this activity, you should review the flow chart, Activity 3, of your Study Guide before continuing.

* Not applicable for fine-grained soil.

START THE PLAYER WHEN YOU HAVE FINISHED

ACTIVITY 7 - NOTES

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 7 - SOLUTION

<u>Sample</u>	<u>Percent Passing</u>			<u>LL</u>	<u>PI</u>	<u>USCS Symbol</u>	<u>Group name</u>
	<u>No.200</u>	<u>S</u>	<u>G</u>				
1	58	42	0	58	32	CH	SANDY FAT CLAY
2	79	16	5	24	7	CL-ML	SILTY CLAY WITH SAND
3	82	18	0	41	31	Plots above U-Line. Re-check Atterberg results	
4	69	13	16	70	35	MH	GRAVELLY ELASTIC SILT
5	89	11	0	120	77	CH	FAT CLAY
6	63	10	27	---	NP	ML	GRAVELLY SILT

If you had difficulty completing this activity you should review the use of the plasticity chart, Activity 5, and the use of descriptive terms for fine-grained soil, Activity 6, before continuing.

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 9 - DETERMINATION OF D_{10} , D_{30} and D_{60} SIZES AND CALCULATION OF C_u

Discussion of D_{10} , D_{30} , and D_{60} Sizes

The D_{10} size of a soil is the particle size, expressed in millimeters, of which 10 percent of the soil is finer than that size particle. The D_{10} size is determined from a plotted grain-size distribution curve by reading horizontally from the 10 percent finer coordinate to the curve. Then move downward from this point and read the grain size in millimeters on the scale at the bottom of the graph.

The D_{30} size of a soil is the particle size, expressed in millimeters, of which 30 percent of the soil is finer than that size particle.

The D_{60} size of a soil is the particle size, expressed in millimeters, of which 60 percent of the soil is finer than that size particle.

The D_{30} and D_{60} sizes are determined in the same manner as the D_{10} size. These procedures are also illustrated graphically in this activity.

Problem on Calculation of C_u

Using the following laboratory sieve analysis, plot a grain-size distribution curve for the sample. Determine the D_{10} and D_{60} sizes.

Then calculate the coefficient of uniformity, C_u , using the equation:

$$C_u = \frac{D_{60}}{D_{10}}$$

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 9 - Continued

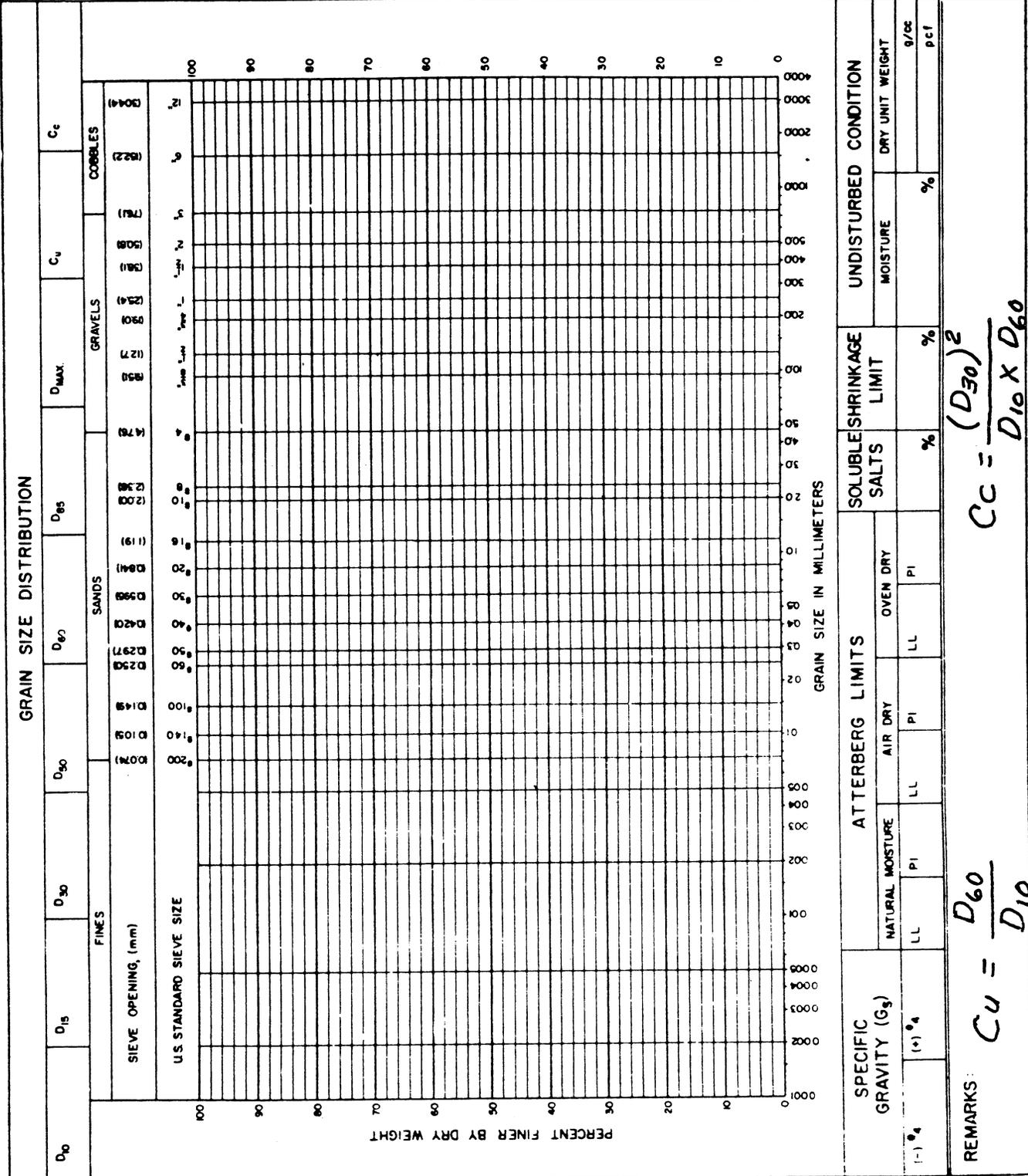
Use the blank SCS-ENG-353 form included in this activity as a worksheet.

If you have difficulty in completing this problem, or wish to check your solution, refer to the solution sheet for Activity 10.

<u>Sieve</u>	<u>Percent Passing</u>
3 inch	100
2 inch	97
1½ inch	93
1 inch	86
¾ inch	82
½ inch	74
¾ inch	68
No. 4	50
No. 10	36
No. 20	26
No. 40	21
No. 60	16
No. 140	8
No. 200	2

START THE PLAYER WHEN YOU HAVE FINISHED

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	SOIL CLASSIFICATION
PROJECT and STATE _____		SAMPLE LOCATION _____
FIELD SAMPLE NO. _____	DEPTH _____	GEOLOGIC ORIGIN _____
TYPE OF SAMPLE _____	TESTED AT _____	APPROVED BY _____
SYMBOL _____		DATE _____
DESCRIPTION _____		



PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

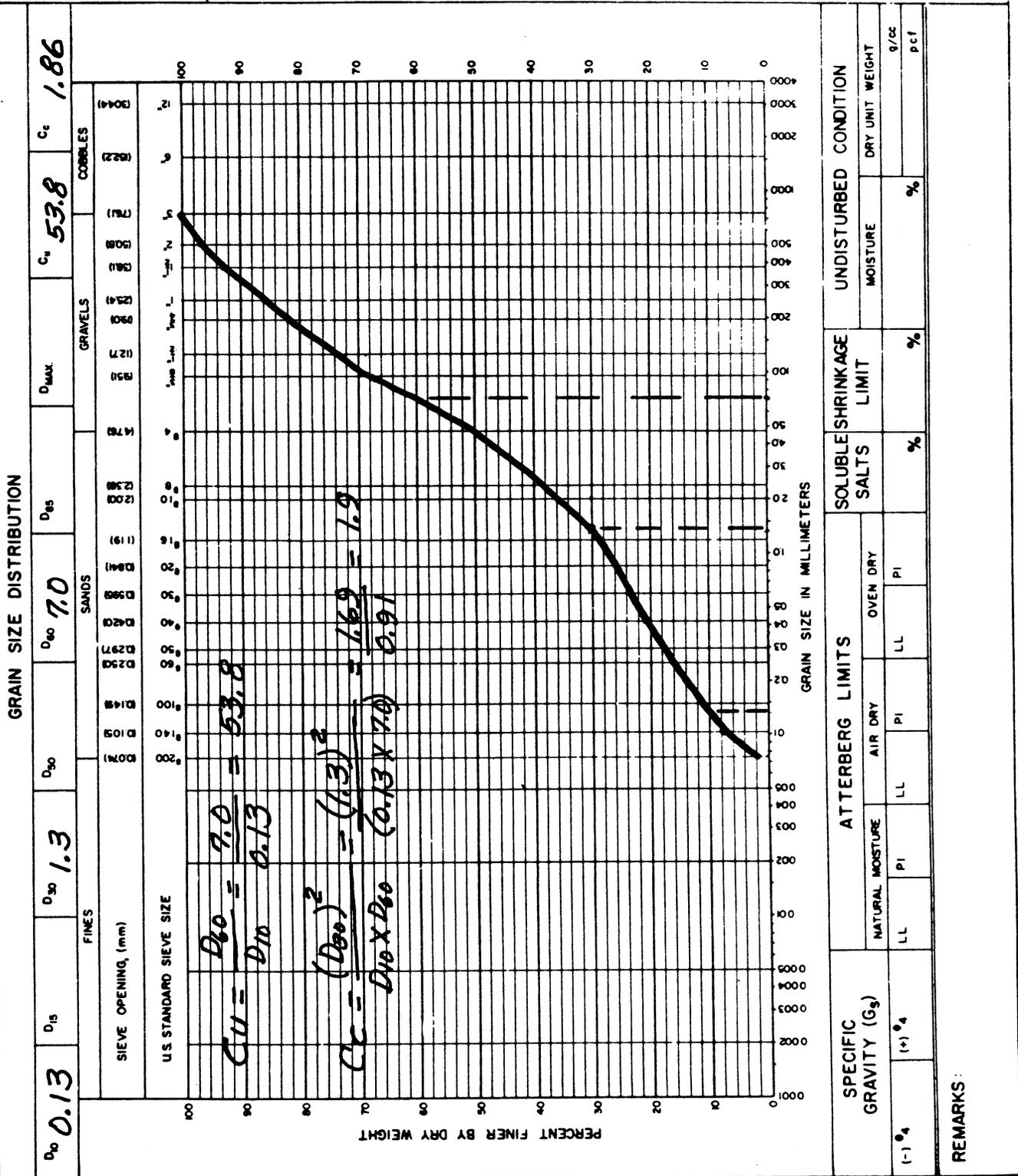
ACTIVITY 10 - PROBLEM

Using the same curve you developed in Activity 9, calculate the coefficient of curvative, using the equation:

$$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

If you have difficulty in completing this activity, or wish to check your solution, please refer to the solution shown on the next page.

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	SOIL CLASSIFICATION
PROJECT and STATE _____		SAMPLE LOCATION _____
FIELD SAMPLE NO. _____	DEPTH _____	GEOLOGIC ORIGIN _____
TYPE OF SAMPLE _____	TESTED AT _____	APPROVED BY _____ DATE _____
SYMBOL _____	DESCRIPTION _____	



PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 11 - CRITERIA FOR CLEAN WELL-GRADED SAND AND GRAVEL AND ILLUSTRATIVE PROBLEMS

Criteria for clean, well- graded gravel

Well-graded gravels must meet all three of the following criteria:

1. Have less than 5 percent finer than the No.200 sieve.
2. Have a C_u value greater than 4, and
3. Have a C_c value between 1 and 3.

If a gravel fails to meet any of these criteria, it is poorly graded.

Criteria for clean, well- graded sand

Well-graded sands must meet all three of the following criteria:

1. Have less than 5 percent finer than the No.200 sieve
2. Have a C_u value greater than 6, and
3. Have a C_c value between 1 and 3.

If a sand fails to meet any of these criteria, it is poorly graded.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 11 - PROBLEMS

Data are given below for 10 example soils. Assume that a gradation curve has been drawn for each soil, and the coefficient of uniformity and coefficient of curvature have been calculated. Use the given information and your flow chart, Activity 3, to classify each soil by the USCS.

If you have difficulty in completing this activity or wish to check your solution, refer to the next page, Activity 11 Solution.

Number	Percent Finer			Percent		Cu	Cc	USCS Class
	No. 200	No. 4	3 inch	Sand	Gravel			
1	4	68	99			16	0.7	
2	3	100	100			5.5	1.2	
3	2	45	100			12	2.2	
4	3	65	100			55	0.9	
5	1	33	97			4.5	1.2	
6	4	72	100			7.6	2.8	
7	3	98	100			5.4	1.1	
8	2	45	100			3.6	3.1	
9	1	29	98			5.2	0.9	
10	3	100	100			7.2	0.8	

ACTIVITY 11 - NOTES

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

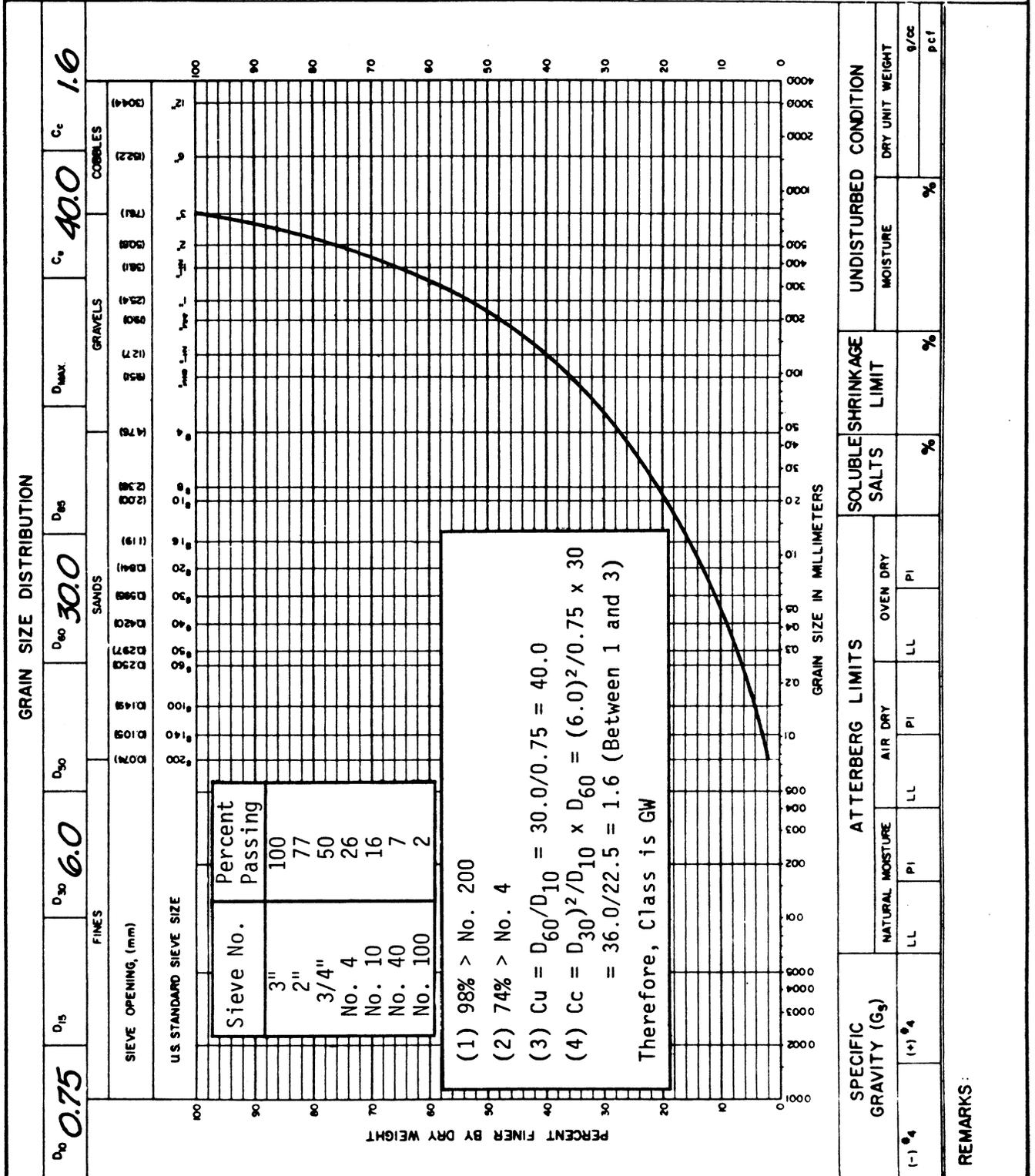
ACTIVITY 11 - SOLUTION

<u>Number</u>	<u>Percent Finer</u>			<u>Percent</u>		<u>Cu</u>	<u>Cc</u>	<u>USCS Class</u>
	<u>No. 200</u>	<u>No. 4</u>	<u>3 inch</u>	<u>Sand</u>	<u>Gravel</u>			
1	4	68	99	64	31	16	0.7	SP
2	3	100	100	97	0	5.5	1.2	SP
3	2	45	100	43	55	12	2.2	GW
4	3	65	100	62	35	55	0.9	SP
5	1	33	97	32	64	4.5	1.2	GW
6	4	72	100	68	28	7.6	2.8	SW
7	3	98	100	95	2	5.4	1.1	SP
8	2	45	100	43	55	3.6	3.1	GP
9	1	29	98	28	69	5.2	0.9	GP
10	3	100	100	97	0	7.2	0.8	SP

If you had difficulty in completing this section or your solutions are not the same as those shown, you should carefully review the flow chart, Activity 3, before continuing.

START THE PLAYER WHEN YOU HAVE FINISHED

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	SOIL CLASSIFICATION
PROJECT and STATE EXAMPLE 1 - GRADATION		SAMPLE LOCATION
FIELD SAMPLE NO.	DEPTH	GEOLOGIC ORIGIN
TYPE OF SAMPLE	TESTED AT	APPROVED BY
DATE		
SYMBOL GW	DESCRIPTION Well Graded Gravel	



PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 13 - PROBLEM

Sieve analysis data are given on the following page. Classify the soil by the USCS using what you have learned at this point.

If you have difficulty in completing this activity, or you wish to check your solution, refer to the page following the problem for the solution.

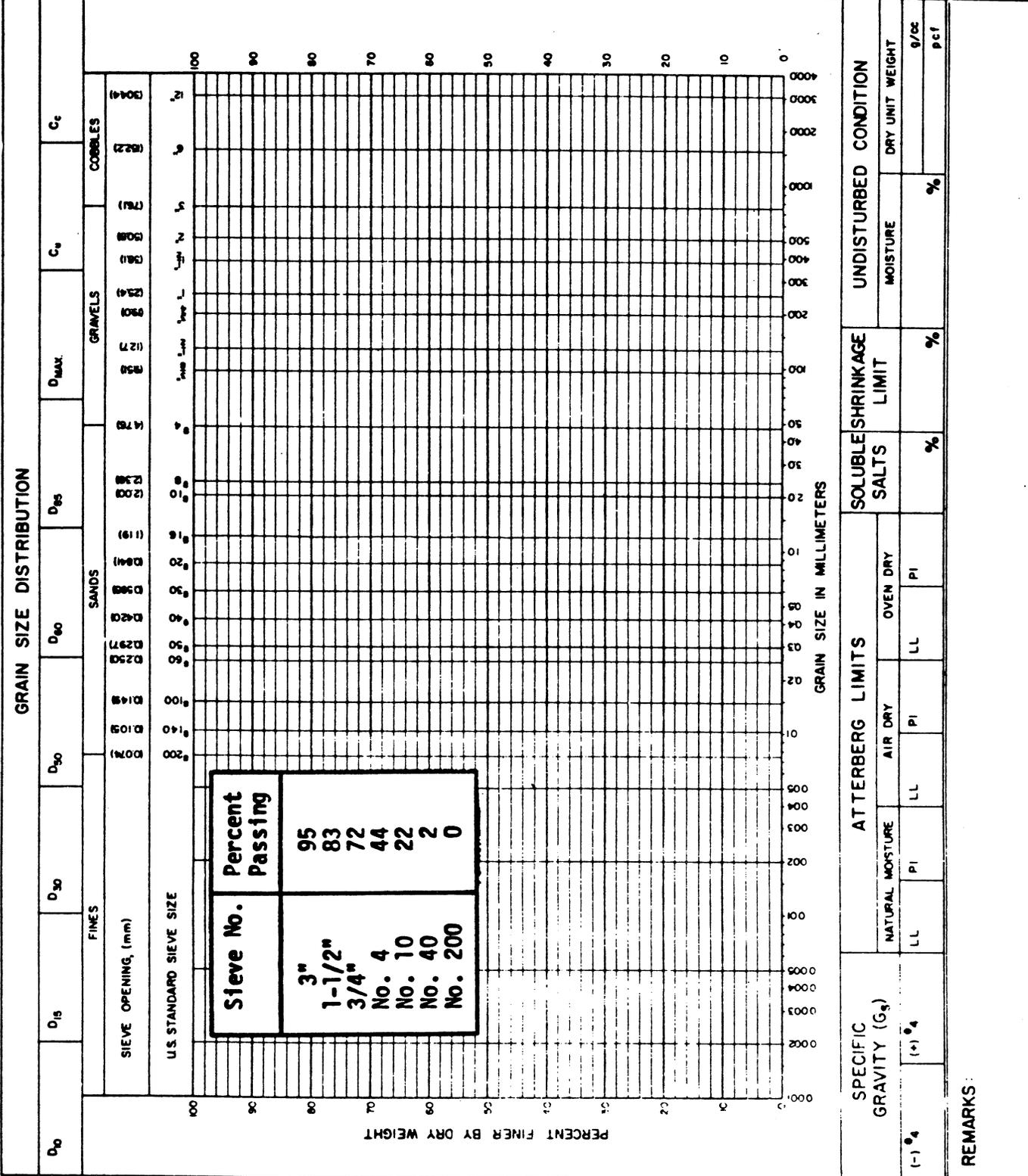
MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	SOIL CLASSIFICATION
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PROJECT and STATE	SAMPLE LOCATION
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FIELD SAMPLE NO.	DEPTH	GEOLOGIC ORIGIN
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TYPE OF SAMPLE	TESTED AT	APPROVED BY	DATE
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SYMBOL	DESCRIPTION
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Activity 13 - NOTES

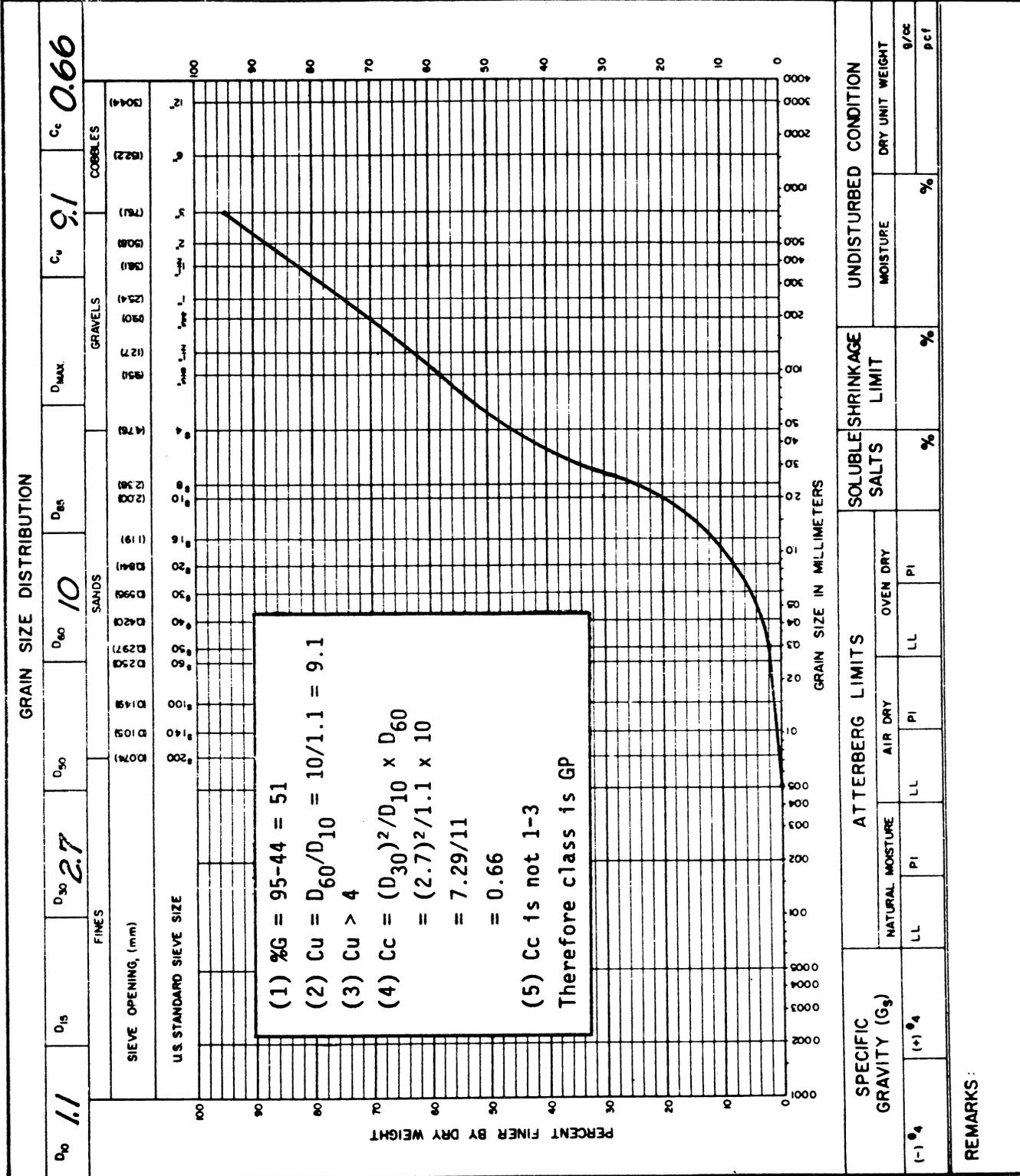
MATERIALS TESTING REPORT U. S. DEPARTMENT of AGRICULTURE **SOIL CLASSIFICATION**
SOIL CONSERVATION SERVICE

PROJECT and STATE: **PROBLEM 1 GRADATION (SOLUTION)** SAMPLE LOCATION: _____

FIELD SAMPLE NO. _____ DEPTH _____ GEOLOGIC ORIGIN _____

TYPE OF SAMPLE _____ TESTED AT _____ APPROVED BY _____ DATE _____

SYMBOL: **GP** DESCRIPTION: **Poorly Graded Gravel**



PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 14 - GROUP NAMES FOR CLEAN COARSE-GRAINED SOILS

The four possible clean coarse-grained soil classifications in the USCS are shown below. In addition to the USCS symbols, you should be familiar with the group names used to describe the classifications. The combinations of descriptive terms and modifiers are:

Primary Descriptive Term

GW - WELL-GRADED GRAVEL

SW - WELL-GRADED SAND

GP - POORLY GRADED GRAVEL

SP - POORLY GRADED SAND

Modifiers

Less than 15 percent of the other coarse-grained constituent - NO MODIFIER

15 percent or more of the other coarse-grained constituent - WITH SAND or
WITH GRAVEL, as
appropriate

Examples

Example 1. GW soil with 34 percent sand - WELL-GRADED GRAVEL WITH SAND

Example 2. SP soil with 14 percent gravel - POORLY GRADED SAND

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 15 - GROUP NAMES FOR DIRTY COARSE-GRAINED SOILS

The six classifications of dirty coarse grained soils in the USCS are summarized below. In addition to giving the USCS symbol, you should be familiar with the group names. The various combinations are:

Primary Descriptive Term

GM - SILTY GRAVEL	SM - SILTY SAND
GC - CLAYEY GRAVEL	SC - CLAYEY SAND
GC-GM - SILTY CLAYEY GRAVEL	SC-SM - SILTY, CLAYEY SAND

Modifiers

Less than 15 percent of the other coarse-grained constituent - NO MODIFIER

15 percent or more of the other coarse-grained constituent - WITH SAND or
WITH GRAVEL, as
appropriate

Examples

Example 1. GC soil with 40 percent sand - CLAYEY GRAVEL WITH SAND

Example 2. SM soil with 10 percent gravel - SILTY SAND

Example 3. GC-GM soil with 16 percent sand - SILTY, CLAYEY GRAVEL WITH SAND

Example 4. SC soil with 15 percent gravel - CLAYEY SAND WITH GRAVEL

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 16 - PROBLEM

Using data below, classify each of the soils by the USCS. Give the symbol and the group name for each soil.

<u>Number</u>	<u>Percent Passing</u>			<u>LL</u>	<u>PI</u>	<u>Symbol and group name</u>
	<u>No. 200</u>	<u>No. 4</u>	<u>3 inch</u>			
1	15	42	100	32	14	
2	39	100	100	--	NP	
3	30	52	100	23	6	
4	18	82	100	40	6	
5	23	47	98	20	5	
6	13	89	100	28	8	
7	40	67	100	42	32	
8	25	40	97	40	20	

If you have difficulty in completing this activity, or you wish to check your solution, refer to the following page for the solution to this activity. If you had difficulty completing this section, you should carefully review the flow chart and plasticity chart before continuing.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 16 - SOLUTION

<u>Number</u>	<u>Percent Passing</u>			<u>LL</u>	<u>PI</u>	<u>Symbol and group name</u>
	<u>No. 200</u>	<u>No. 4</u>	<u>3 inch</u>			
1	15	42	100	32	14	GC - CLAYEY GRAVEL WITH SAND
2	39	100	100	--	NP	SM - SILTY SAND
3	30	52	100	23	6	GC-GM - SILTY, CLAYEY GRAVEL WITH SAND
4	18	82	100	40	6	SM - SILTY SAND WITH GRAVEL
5	23	47	98	20	5	GC-GM - SILTY, CLAYEY GRAVEL WITH SAND
6	13	89	100	28	8	SC - CLAYEY SAND
7	40	67	100	42	32	Plots above "U-Line" - Re-run Atterberg Limit tests.
8	25	40	97	40	20	GC - CLAYEY GRAVEL WITH SAND

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 17 - EXAMPLE OF DUAL COARSE-GRAINED SOIL

The following example illustrates the flow chart process for classifying a dual coarse-grained soil. Use your flow chart and follow the steps in the example.

<u>Sieve</u>	<u>Percent Passing</u>
1/2 inch	100
No. 4	88
No. 10	60
No. 20	33
No. 40	20
No. 60	14
No. 140	7
No. 200	6

Atterberg Limits = Non-Plastic

- Step 1. Sample is coarse-grained because less than 50% is finer than the No. 200 sieve. (6%)
- Step 2. Sample is dual group of coarse-grained soils because between 5% and 12% is finer than No. 200 sieve. (6%)
- Step 3. Sample is a dual group sand, because sample has 12% gravel and 82% sand. (%G= 3"-No. 4) (%S=No. 4-No. 200) (%G=100-88=12, %S=88-6=82)
- Step 4. Plot gradation curve (see next page) and determine D_{10} , D_{30} , and D_{60} . ($D_{10} = 0.15$ mm, $D_{30} = 0.7$ mm, $D_{60} = 2.0$ mm)
- Step 5. Calculate C_u , coefficient of uniformity and C_c , coefficient of curvature. ($C_u = D_{60}/D_{10} = 2.0/0.15 = 13.3$)
 $(C_c = (D_{30})^2/(D_{10} \times D_{60}) = (0.7)^2/(0.15 \times 2.0) = 1.6)$
- Step 6. Determine that both coefficients meet requirements for sand, C_u is greater than 6, and C_c is between 1 and 3.
- Step 7. Plot Atterberg Limits on plasticity chart and determine that plot is below "A-Line". Class is SW-SM.

START THE PLAYER WHEN YOU HAVE FINISHED

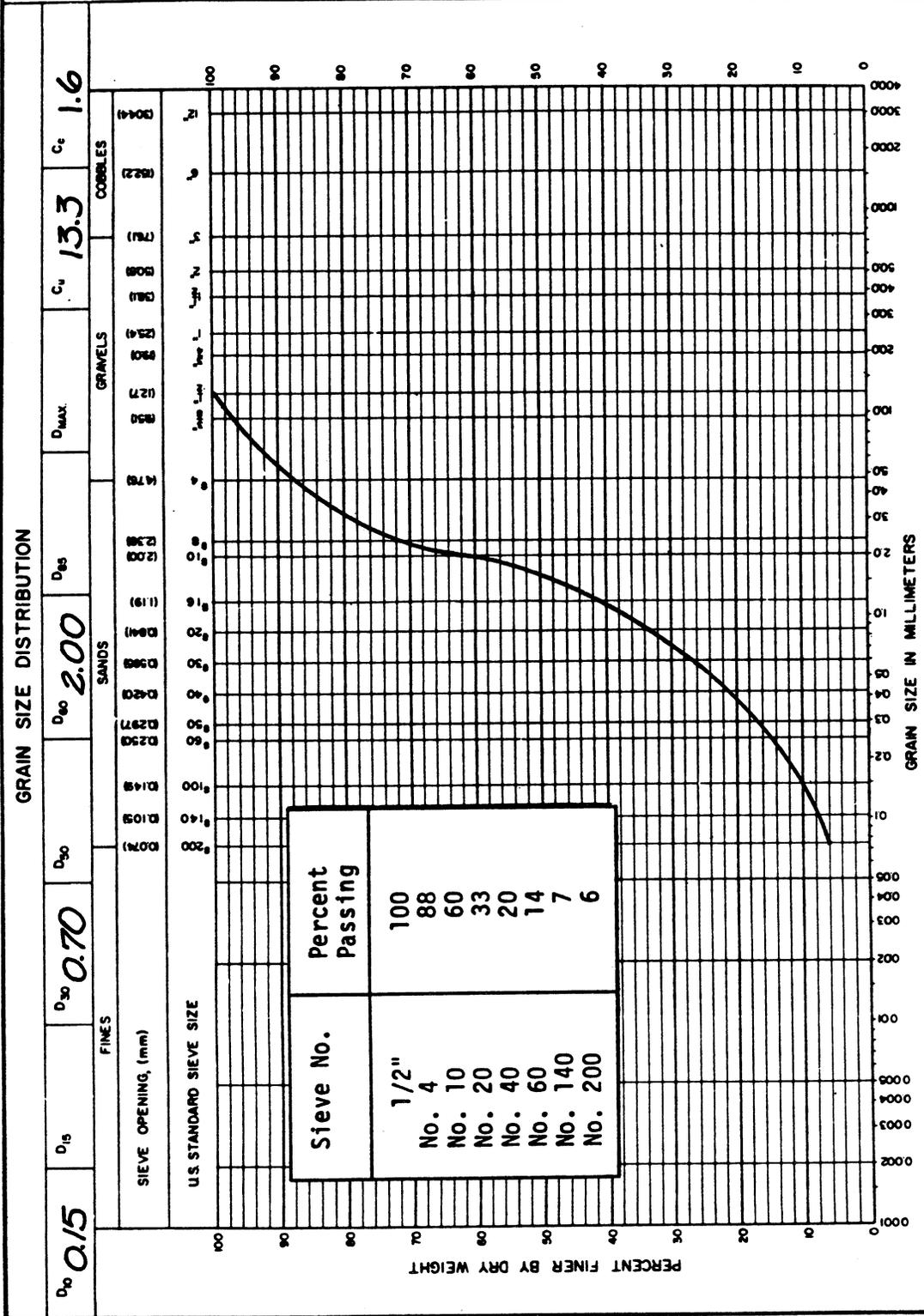
MATERIALS TESTING REPORT U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE **SOIL CLASSIFICATION**

PROJECT and STATE: **PROBLEM 2** SAMPLE LOCATION: _____

FIELD SAMPLE NO. _____ DEPTH _____ GEOLOGIC ORIGIN _____

TYPE OF SAMPLE _____ TESTED AT _____ APPROVED BY _____ DATE _____

SYMBOL _____ DESCRIPTION _____



SPECIFIC GRAVITY (G_s)	ATTERBERG LIMITS				SOLUBLE SHRINKAGE LIMIT		UNDISTURBED CONDITION	
	NATURAL MOISTURE		AIR DRY		SALTS		MOISTURE	
(*) %	LL	PI	LL	PI	%	%	%	g/cc
(*) %	LL	PI	LL	PI	%	%	%	pcf

REMARKS: $C_u = \frac{D_{60}}{D_{10}} = \frac{2.0}{0.15} = 13.3$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(0.7)^2}{(0.15)(2.0)} = 1.6$

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 18 - Problem

Given the following laboratory data, classify the soil with the proper USCS symbol. Use the blank grain-size distribution form on the following page to complete the problem.

<u>Sieve</u>	<u>Percent finer</u>	Atterberg Limits are LL=24 and PI=6
3 inch	100	
2 inch	90	
1 inch	74	
1/2 inch	58	
3/8 inch	53	
No. 4	46	
No. 10	39	
No. 20	30	
No. 40	23	
No. 60	18	
No. 140	12	
No. 200	10	
0.05 millimeters	7	

If you have difficulty in completing this activity, or wish to check your solution, see the completed solution on the second page following. If you had difficulty in completing this activity, you should carefully review the flow chart before continuing.

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

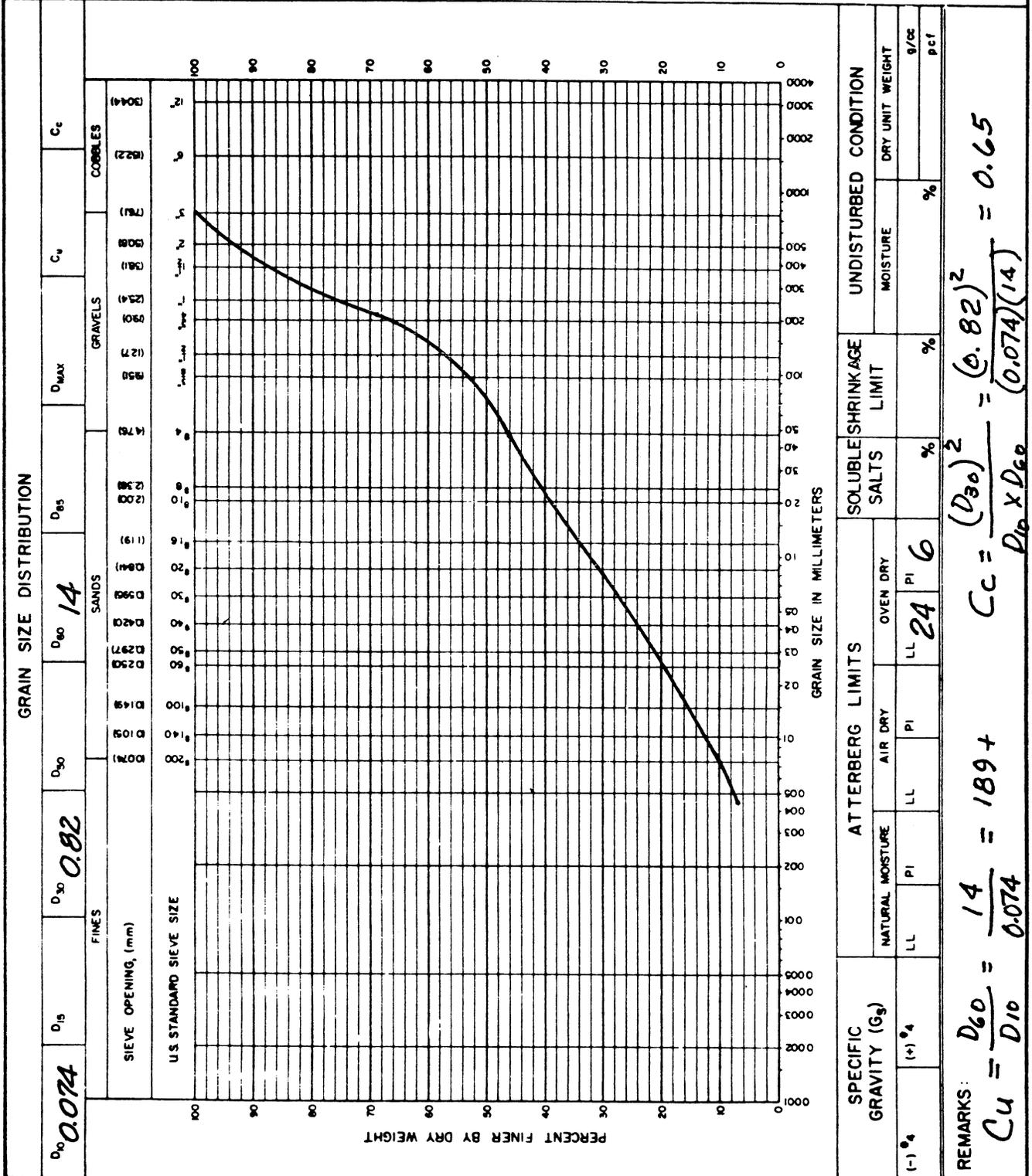
ACTIVITY 18 - SOLUTION

- Step 1. Determine that the sample is coarse-grained because less than 50 percent finer than the No. 200 sieve (10 percent is finer).
- Step 2. Determine that the soil is a dual group coarse-grained sample because between 5 percent and 12 percent is finer than the No. 200 sieve.
- Step 3. Determine which constituent predominates, by calculating the percent of sand and the percent of gravel. The percent S is equal to the percent finer than the No. 4 sieve minus the percent finer than the No. 200 sieve, or 46 percent-10 percent = 36 percent. The percent G is equal to the percent finer than the 3 inch sieve minus the percent finer than the No. 4 sieve, or 100 percent-46 percent = 54 percent. Gravel predominates.
- Step 4. Plot the grain-size distribution curve and determine values for D_{10} , D_{30} , and D_{60} . ($D_{10} = 0.074$ mm, $D_{30} = 0.82$ mm, $D_{60} = 14$ mm.)
- Step 5. Calculate $C_u = D_{60}/D_{10} = 14.0/0.074 = 189$
Calculate $C_c = (D_{30})^2/(D_{10} \times D_{60}) = (0.82)^2/(0.074 \times 14.0) = 0.65$
- Step 6. Determine that coefficient of curvature is not in the range prescribed (between 1 and 3), so the sample is poorly graded.
- Step 7. To complete the classification, plot the Atterberg Limits on the Plasticity chart, and determine that the sample plots in the hatched zone of the chart, and therefore is classified as GP-GC. The correct Group Name is poorly graded gravel with silty clay and sand.

START THE PLAYER WHEN YOU HAVE FINISHED

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	SOIL CLASSIFICATION
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PROJECT and STATE		SAMPLE LOCATION	
FIELD SAMPLE NO.	DEPTH	GEOLOGIC ORIGIN	
TYPE OF SAMPLE	TESTED AT	APPROVED BY	DATE
SYMBOL GP-GC	DESCRIPTION		



PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 19 - GROUP NAMES FOR DUAL COURSE-GRAINED SOILS

The eight dual coarse-grained classifications in the USCS are below. In addition to the USCS symbol for each classification, you should be familiar with the group name for each.

Primary descriptive term

- GW-GM - WELL-GRADED GRAVEL WITH SILT
- GW-GC - WELL-GRADED GRAVEL WITH CLAY (OR SILTY CLAY)
- GP-GM - POORLY GRADED GRAVEL WITH SILT
- GP-GC - POORLY GRADED GRAVEL WITH CLAY (OR SILTY CLAY)
- SW-SM - WELL-GRADED SAND WITH SILT
- SW-SC - WELL-GRADED SAND WITH CLAY (OR SILTY CLAY)
- SP-SM - POORLY GRADED SAND WITH SILT
- SP-SC - POORLY GRADED SAND WITH CLAY (OR SILTY CLAY)

Modifiers

Less than 15 percent of the other coarse grained constituent - NO MODIFIER

15 percent or more of the other coarse grained constituent - and SAND or GRAVEL, as appropriate

Examples

- Example 1. GP-GM soil with 22 percent sand - POORLY GRADED GRAVEL WITH SILT AND SAND
- Example 2. SP-SM soil with 8 percent gravel - POORLY GRADED SAND WITH SILT
- Example 3. SP-SM soil with 28 percent gravel - POORLY GRADED SAND WITH SILT AND GRAVEL

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 20 - REVIEW QUESTIONS

1. Dual coarse-grained soils have between ___ and ___ percent finer than the No.200 sieve.
2. (T/F) An important influence on the classification of a dirty coarse-grained soil is whether it is well-graded or poorly graded.
3. (T/F) The "U-Line" determines whether a soil's fines are plastic or non-plastic.
4. Elastic silt is the group name corresponding to the USCS symbol ___.
5. (T/F) A number 20 sieve has openings that are exactly 1/20 of an inch.
6. The sieve separating sands and gravel-sized particles in the USCS is the ___ sieve.
7. (T/F) If a clean coarse-grained soil meets either of the gradation requirements for the two coefficients, it is well graded.
8. (T/F) A CH soil has a liquid limit value equal to or greater than 50?
9. The hatched zone on the Plasticity chart includes PI values in the range of ___ to ___.

If you have difficulty in completing this activity, or wish to check your solution, refer to the next page for the solutions.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 20 - Review Questions - Solution

1. 5 and 12
2. False. The classification depends on the plasticity of the fines in the sample and whether sand or gravel predominates.
3. False. The "U-Line" is used to determine whether Atterberg test results are reasonable. Data plotting above the "U-Line" is questionable.
4. MH
5. False. A number 20 sieve has 20 openings per inch, but because of the construction of sieves and the space occupied by the sieve wires, the actual opening in the sieve is only 0.033 of an inch.
6. No.4
7. False. To be well-graded, a clean, coarse-grained soil must meet both coefficient requirements. If it fails to meet either one, it is poorly graded.
8. True
9. 4 to 7, inclusive

START THE PLAYER WHEN YOU HAVE FINISHED

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 21 - PROBLEMS

Classify each of the soils on the next page using the laboratory data given for each soil, your flow chart, plasticity chart, and the plotted grain-size distribution curves if applicable. Blank grain-size distribution forms are provided.

Assume that all of the fine-grained soils are not organic.

The 23 soils include one each of the USCS except for the organic classifications. You should also attempt to include the group name for each soil in addition to the USCS symbol.

The data are given on the next sheet. Use the second sheet for computations and answers.

If you have difficulty in completing this part of the Activity, or you wish to check your solution, the answers are included on a following page.

ACTIVITY 21
PROBLEM

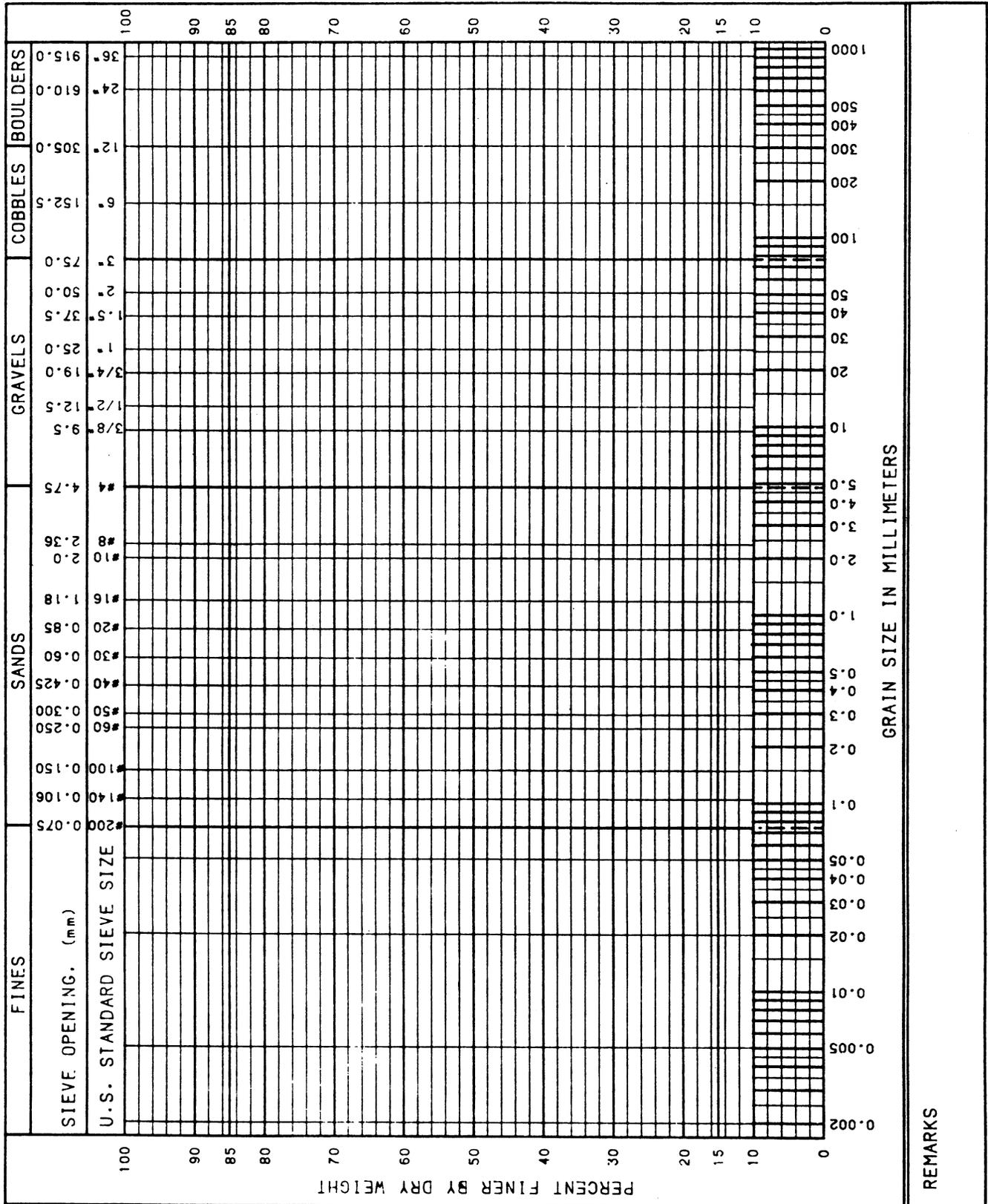
SAMPLE NUMBER	MECHANICAL ANALYSIS GRAIN SIZE DISTRIBUTION EXPRESSED AS PERCENT FINER BY DRY WEIGHT																ATTERBERG LIMITS		UNIFIED CLASSIFICATION		
	FINES				SANDS								GRAVEL				L.L.	P.I.			
	0.002 mm	0.005	0.02	0.05	#200 0.074	#140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1				3" 76.2 mm	
1	10	12	16	22	30	40	65	70	85	90	95	97	98	100				19	2		
2	16	20	28	37	50	52	54	62	64	69	72	76	81	92	100			40	12		
3	2	3	3	4	5	14	50	62	78	83	91	95	100					-	NP		
4	11	12	16	24	32	40	63	71	81	90	100							22	5		
5	58	68	74	81	89					100								72	42		
6	9	10	11	11	12	14	24	28	34	38	48	56	59	67	71	80	100	32	12		
7	6	10	12	14	19	22	31	43	49	52	59	63	72	88	100			20	3		
8	3	5	6	7	8	11	28	39	60	79	94	100						24	3		
9	33	52	63	71	79					100								53	22		
10	27	29	32	36	38	42	46	49	53	56	59	62	67	73	84	92	100	39	16		
11	0	1	2	4	5	6	11	14	17	22	29	53	64	78	87	100		-	NP		
12	26	32	36	43	48	54	69	74	81	89	98	99	100					54	27		
13					3	7	61	78	90	98	100							-	-		
14	32	37	40	49	58	62	64	67	69	72	83	87	90	92	95	100		48	22		
15	0	1	2	3	4	6	11	15	21	30	40	50	58	67	72	82	100	-	NP		
16	7	8	9	10	11	17	72	87	96	100								26	7		
17	10	14	19	23	28	32	35	40	46	50	58	62	70	79	89	99	100	24	4		
18	1	1	2	4	6	7	12	16	22	30	42	54	60	70	75	88	100	-	NP		
19	0	0	1	2	4	9	25	33	37	41	48	62	72	87	94	100		-	-		
20	20	24	34	41	71	79	82	100										22	5		
21	0	0	0	2	3	5	13	19	30	50	76	90	93	98	100			-	-		
22	4	6	8	10	11	12	17	24	33	44	57	76	82	90	94	99	100	24	4		
23	6	7	8	10	12	15	25	32	45	66	83	91	94	97	98	100		22	4		

GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state _____

Designed at _____ By _____ Date _____



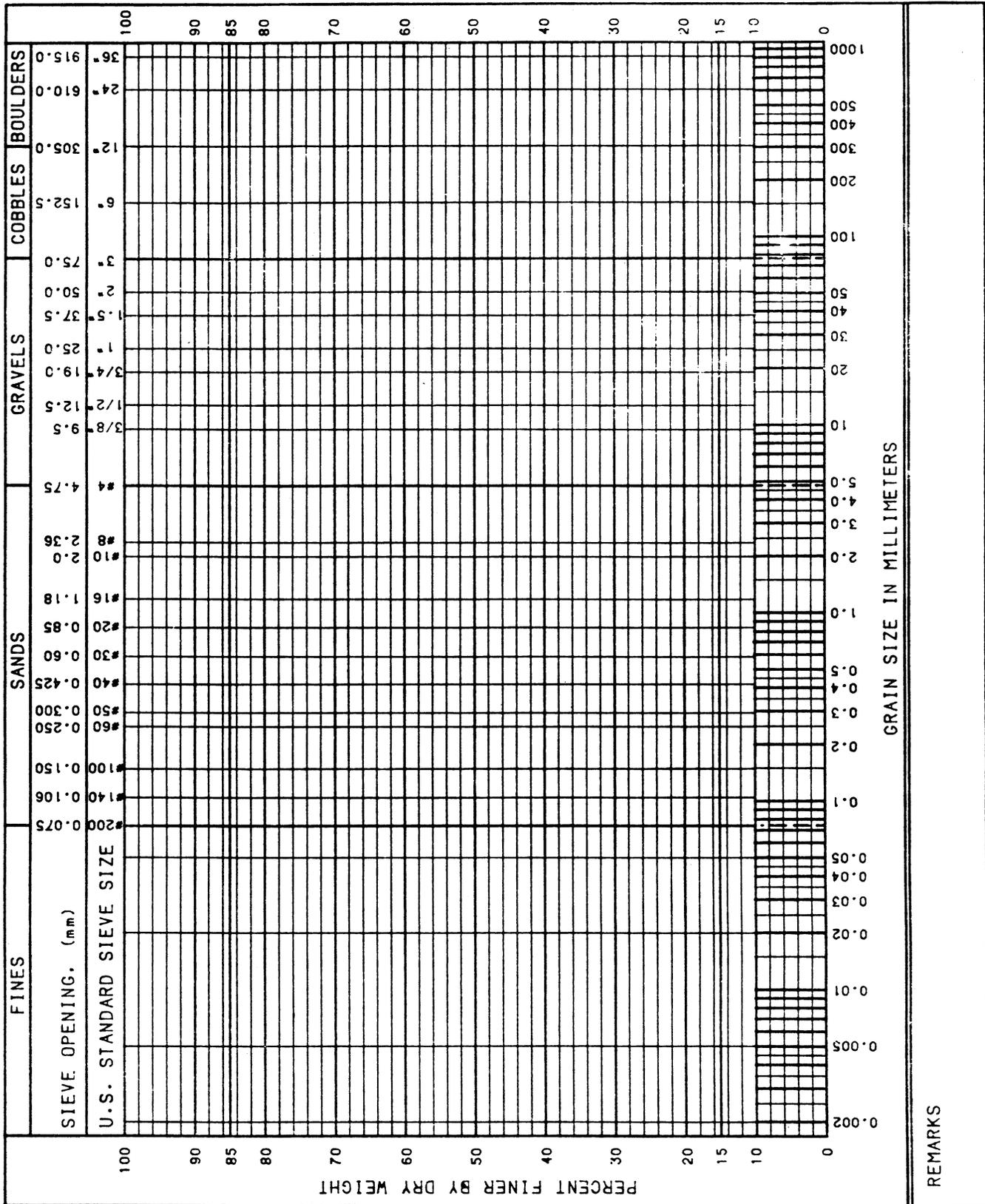
REMARKS

GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state _____

Designed at _____ By _____ Date _____



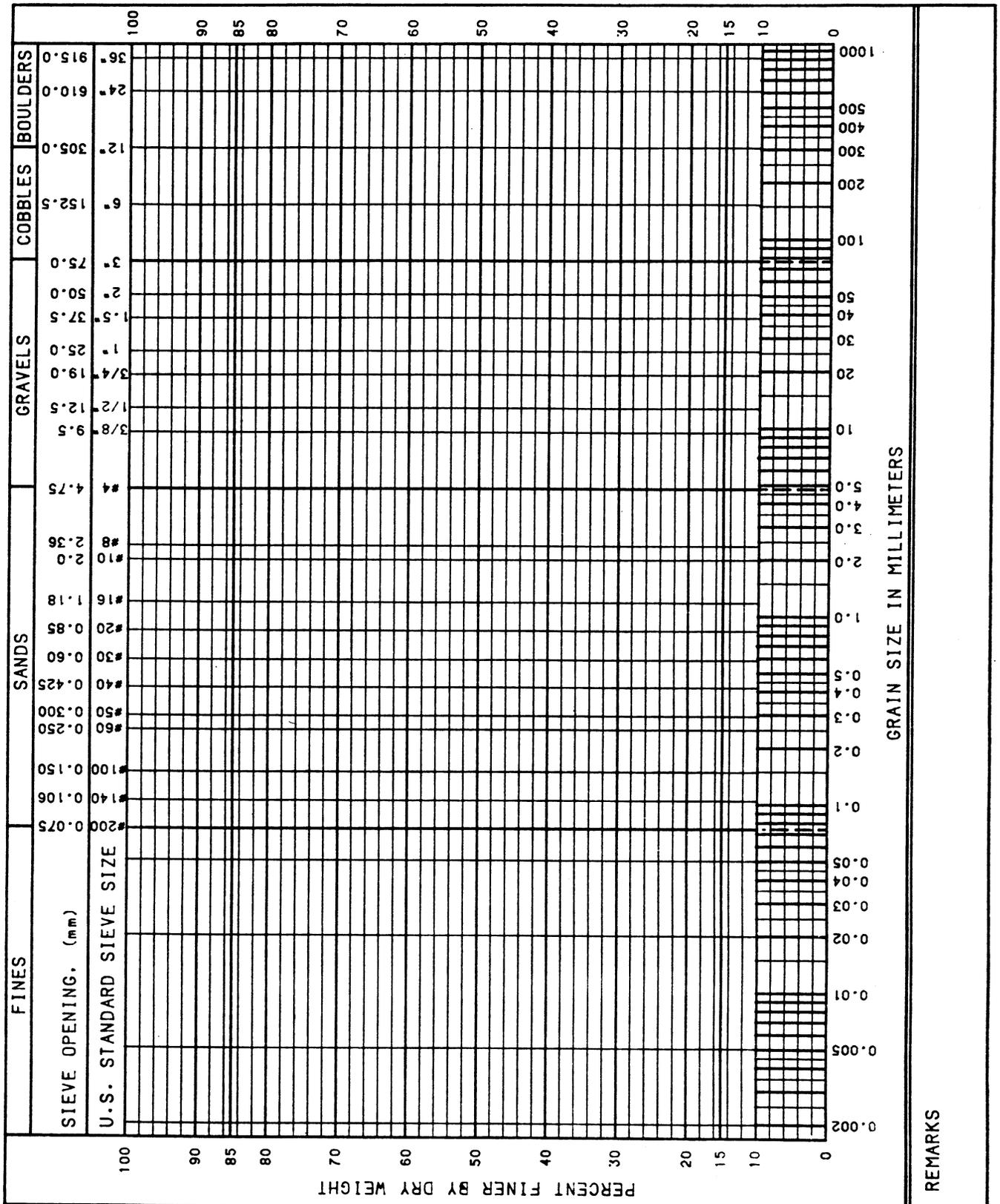
REMARKS

GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state _____

Designed at _____ By _____ Date _____

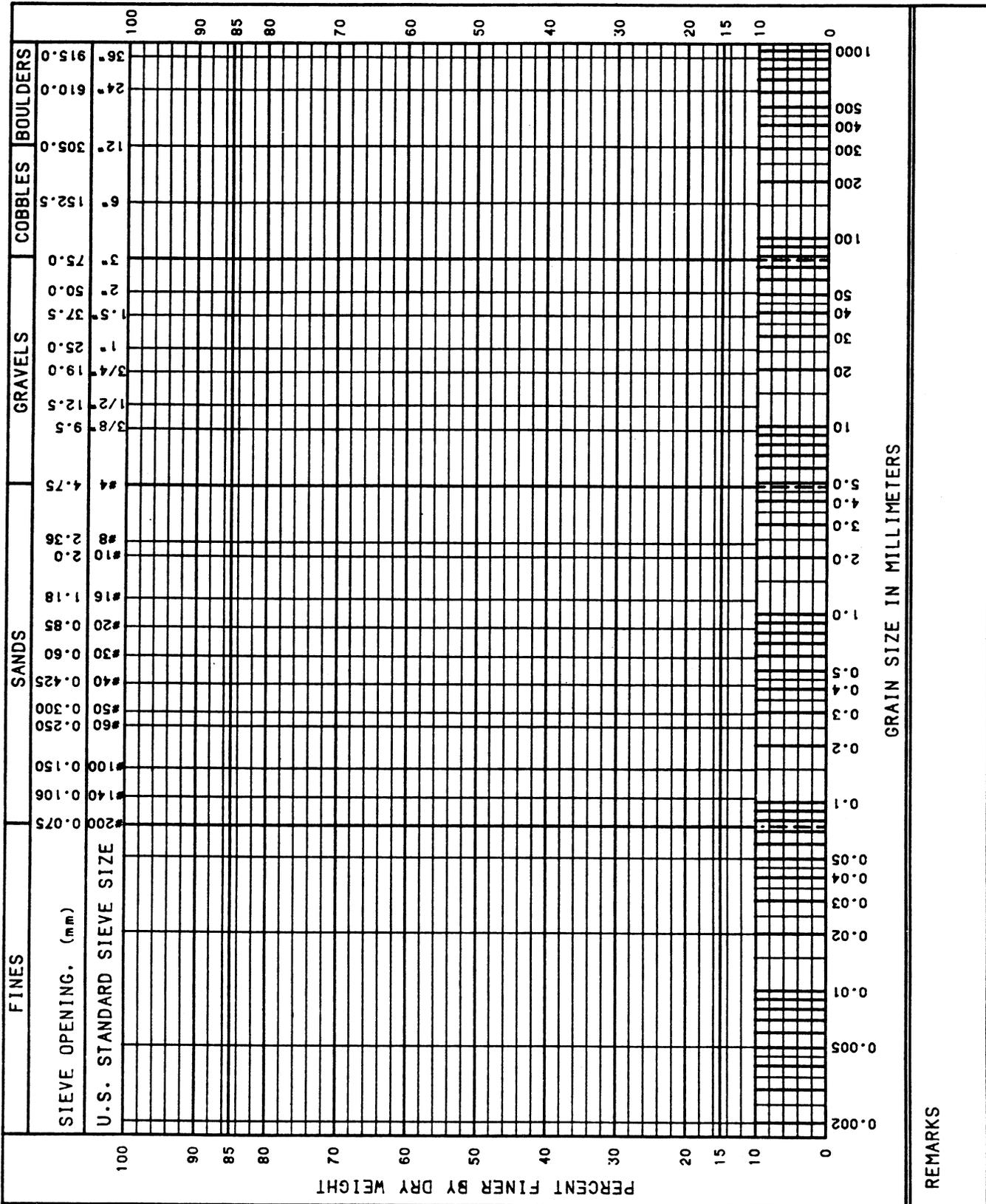


GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state _____

Designed at _____ By _____ Date _____



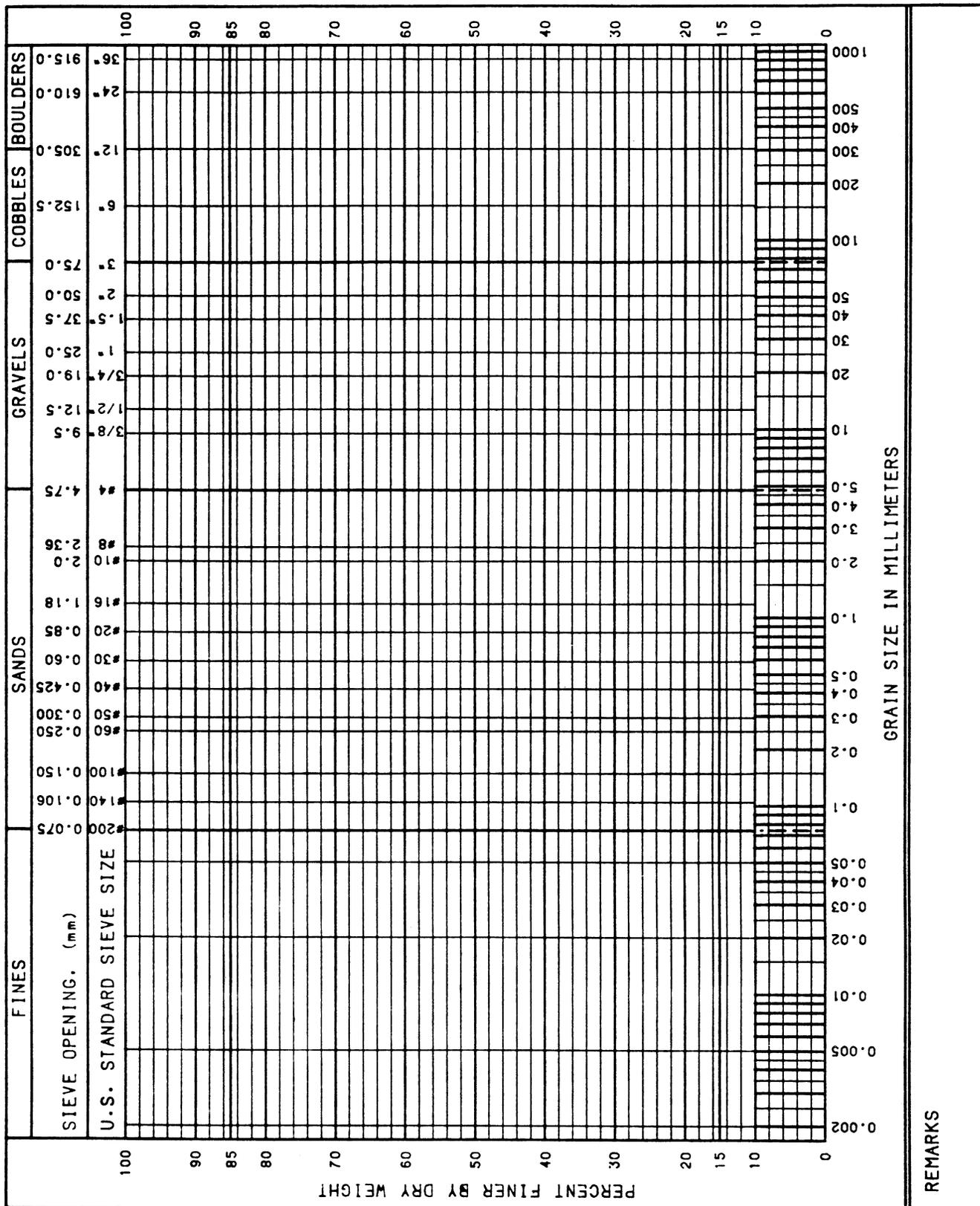
REMARKS

GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state _____

Designed at _____ By _____ Date _____



PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 21 - PROBLEM WORKSHEET

Soil number	Fines	Sand	Gravel	LL	PI	D ₁₀	D ₃₀	D ₆₀	Cu	Cc	USCS Symbol & Group Name
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 21 - SOLUTION

Soil number	Fines	Sand	Gravel	LL	PI	D ₁₀	D ₃₀	D ₆₀	Cu	Cc	USCS symbol and group Name*
1	30	65	5	19	2	-----	---	---	---	---	SM
2	50	22	28	40	12	-----	---	---	---	---	ML
3	5	86	9	--	NP	0.09	0.15	0.36	4.0	0.7	SP-SM
4	32	68	0	22	5	-----	---	---	---	---	SC-SM
5	89	11	0	72	42	-----	---	---	---	---	CH
6	12	36	52	32	12	0.005	0.6	13.0	2600	5.5	GP-GC
7	19	40	41	20	3	-----	---	---	---	---	GM
8	8	86	6	24	4	0.09	0.29	0.82	9.1	1.1	SW-SM
9	79	21	0	53	22	-----	---	---	---	---	MH
10	38	21	41	39	16	-----	---	---	---	---	GC
11	5	24	71	--	NP	0.21	4.9	11.5	55	9.9	GP-GM
12	48	50	2	54	27	-----	---	---	---	---	SC
13	3	97	0	--	--	0.12	0.16	0.23	1.9	0.9	SP
14	58	25	17	48	22	-----	---	---	---	---	CL
15	4	36	60	--	NP	0.21	2.0	13.5	64	1.4	GW
16	11	89	0	26	7	0.05	0.13	0.2	4	1.7	SP-SC
17	28	30	42	24	4	-----	---	---	---	---	GC-GM
18	6	36	58	--	NP	0.15	2.0	12.7	85	2.1	GW-GM
19	4	44	52	--	--	0.11	0.34	9.0	82	0.1	GP
20	71	29	0	22	5	-----	---	---	---	---	CL-ML
21	3	73	24	--	--	0.2	0.84	2.8	14	1.3	SW
22	11	46	43	24	4	0.05	0.65	5.1	102	1.7	SW-SC
23	12	71	17	22	4	0.05	0.39	1.6	32	1.9	SW-SC

*See next page for group name.

PART B - UNIFIED SOIL CLASSIFICATION SYSTEM USING LABORATORY DATA

ACTIVITY 21 - SOLUTION

<u>Soil number</u>	<u>USCS group name and modifiers</u>
1	SM - SILTY SAND
2	ML - GRAVELLY SILT WITH SAND
3	SP-SM - POORLY GRADED SAND WITH SILT
4	SC-SM - SILTY, CLAYEY SAND
5	CH - FAT CLAY
6	GP-GC - POORLY GRADED GRAVEL WITH CLAY AND SAND
7	GM - SILTY GRAVEL WITH SAND
8	SW-SM - WELL-GRADED SAND WITH SILT
9	MH - ELASTIC SILT WITH SAND
10	GC - CLAYEY GRAVEL WITH SAND
11	GP-GM - POORLY GRADED GRAVEL WITH SILT AND SAND
12	SC - CLAYEY SAND
13	SP - POORLY GRADED SAND
14	CL - SANDY LEAN CLAY WITH GRAVEL
15	GW - WELL-GRADED GRAVEL WITH SAND
16	SP-SC - POORLY GRADED SAND WITH SILTY CLAY
17	GC-GM - SILTY, CLAYEY GRAVEL WITH SAND
18	GW-GM - WELL-GRADED GRAVEL WITH SILT AND SAND
19	GP - POORLY GRADED GRAVEL WITH SAND
20	CL-ML - SILTY CLAY WITH SAND
21	SW - WELL-GRADED SAND WITH GRAVEL
22	SW-SC - WELL-GRADED SAND WITH SILTY CLAY AND GRAVEL
23	SW-SC - WELL-GRADED SAND WITH SILTY CLAY AND GRAVEL

START THE PLAYER WHEN YOU HAVE FINISHED