SPECIAL REPORT
EMBANKMENT CRACKING
VINEYARD ROAD DAM
WILLIAMS-CHANDLER WATERSHED

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Background

The Vineyard Road Dam was constructed during the fall of 1967 and the winter, spring and summer of 1968. This 20 ft. high embankment is approximately 29,000 ft. long and is located 4 miles south of Apache Junction on the alluvial fan which spreads southwestward from the Superstitution Mountains. The foundation soils consist of varying gradations of clean sand (SP), silty sand (SM) and sandy silt (ML) overlying siltstone and interbedded gravel (GP) layers. Construction materials primarily consist of silty sands with some sandy silts used as they occurred within the borrow.

During early September 1970, the watershed of this structure received substantial rain (3"±) with runoff resulting in 3 and 4 ft. of water in the reservoir.

During October an inspection of the structure by the MCFCD showed surficial cracks existing along three general reaches of the embankment. Cracks were found along both slopes and the top of the dam. The cracks varied in opening width and depth with no apparent pattern at that time. Since some of the cracking extended transversely across the top of dam with an appearance of considerable depth it was felt necessary to make further investigation to determine the hazard as to the safe function of the dam in case of a high runoff producing storm. In addition, similar cracking has occurred on other structures in Arizona watersheds. Investigation would add to the information as to their hazard and would hopefully provide solutions to the prevention of cracking on similar future projects.

Jack Stevenson, E&WPU Soils Engineer, visited the site during October 1970 and assisted in outlining a program for further investigation. His recommendations were as follows:

(1) Make a surveyed profile of the present top of dam with detailed cross sections at selected spots. These surveys can be limited to the zones of cracking. These surveys should locate the position of all cracks.

(2) Compare the survey data with the profile surveyed immediately after completion of the structure.

(3) Review the construction records to establish the types of materials, the degree of compaction and the moisture content with respect to

optimum in all the zones of cracking. Compare this with the same data for zones where cracking did not occur.

(4) Review the construction records and the pre-construction boring logs and geologic reports and sections to determine the character of the foundations, the amount of stripping and other foundation preparation in the zones of cracking. This should be compared with the same data for selected zones where cracking did not occur.

(5) Fill selected cracks, both transverse and longitudinal, with water to determine their extent. This will require a backhoe to excavate to trace the cracks.

It would be desirable to take samples of materials in the zones of cracking to verify classification.

(6) All the data should be assembled and fully evaluated to determine the cause of the cracking and the likely hazard to the structure.

Making the Investigation

The study was conducted over the period of November 23-25, 1970. Assisting in the study were:

J. J. Turner, State Conservation Engineer
*Ralph M. Arrington, Assistant State Conservation Engineer
*Don Clarke, Geologist, Watershed Planning Staff, Operations & River Basins
*George England, Watershed Project Engineer
Lee Ohsiek, Assistant Chief Engineer, Flood Control District of Maricopa Co. FCDMC
Barry Nauseda FCDMC

*Assisted for the duration of the study.

Arrangements were made with the FCDMC to furnish the equipment and operators to conduct the study. A backhoe and water truck from Maricopa County were on the site to trace out the cracks and make necessary excavations.

The studies were concentrated along three areas of the Vineyard embankment: (1) between stations 315+25 and 316+75; (2) between stations 312+90 and 313+70; and (3) in the vicinity of station 266+00.

The study included sketching cracks which were apparent at the surface, running water into both longitudinal and transverse cracks

and recording time duration before water appeared at the surface, recording locations of water outlet, digging test pits and tracing possible subsurface courses of water, collecting test camples and making field density tests.

Data collected or recorded during the study has been compiled for easy reference and may be found in the Appendix to this report.

Conditions Near Station 316+27

Approximately a 60 ft. long longitudinal surface crack exists along the front edge of the crest of the earth embankment. The alignment of the crack is parallel with the centerline of the dam without deviation. Numerous small transverse cracks of short length extend mainly in the downstream direction. The large crack is receiving surface rain waters, and consequent erosion and small sloughing results increasing the upper width of the crack.

Numerous cracks exist on the upstream slope near this station. The cracks range in width from hairline to 3/4 inch with a predominance of transverse pattern of cracking. (See plan map appendix.)

Water was pumped into the north section of the longitudinal crack at low pressure for approximately 15 min. without any water appearing within the slope cracks. The rate was increased to full pressure for another 45 min. Water appeared approximately 11 ft. down the slope emerging at a slow rate. A cone was built up around the outlet to allow building the hydraulic head, but it was building so slowly that the decision was made to move on to another section. It was assumed the bottom of the long crack and its system was encountered and that the reservoir of the total crack volume was slowly filling. We allowed the wall surfaces to soak ready for excavation by backhoe and later observation.

Test pit No. 1 was excavated across the point where water emerged 11 ft. down the upstream slope of the dam. The excavation showed the depth of crack at approximately 3.0'. The excavation below the 3.0' level was moist at the natural embankment water content. The cracking disappeared (as visible by eye) and no wetting occurred as in the visible cracks above. The upper portion of the crack (1'-0") was dry with a width of 1/8". The lower portion had wetted to a width of approximately 6 inches. The crack alignment and depth were easily followed from the saturated condition.

Moisture samples from pit No. 1 showed a water content of approximately 7.6% in the upper 3.5 ft. excavated.

Test Pit No. 2 was excavated near mid length of the longitudinal crack, being also the point of water intake. Excavation extended to a depth of 8.0 ft. The visible cracks extended to the 6.8 ft. level and closed. The backhoe was unable to continue the excavation beyond 8.0 ft. The crack was ½" to 1/16" wide closing near the 6.8 ft. level. A horizontal deflection in the crack occurred near the 1.3-1.8 ft. level due to a calcareous horizon. No evidence of vertical displacement was observed along the crack. Clean sands deposited within the 3.5-4.0 ft. zone at the crack shows evidence of internal erosion occurring during runoff.

Moisture samples taken show 7% water content at the 2.0 ft. level, 11.0% from 3 ft. to 7 ft. and near 12% at 8.0'. Placement moisture in this vicinity is recorded at 12.6%.

No evidence of transverse cracking appeared in the test pit. The single longitudinal crack along the crest is the only cracking observed.

Conditions Near Station 313+20

Approximately 60 ft. of longitudinal cracking occurs along the crest of the embankment. Transverse cracking occurs in several places extending primarily from the longitudinal cracking in an upstream direction. Some shorter cracks extend transversely downstream.

Water was entered into the mid point of the longitudinal crack and left to run. With time it appeared as though the volume of the crack underground was unlimited. After ninety minutes of time, a gush of water appeared near the downstream toe at the embankment. It continued to run a short time after the water intake was shut off. No surface cracks were located down the slope to indicate the path of water flow. Difficulty of backhoe equipment operating on the 2:1 downstream slope precluded excavation of the flow line.

Test Pit No. 3 was excavated on the embankment crown near the mid point of the longitudinal crack in vicinity of Station 313+20. The pit was excavated to a final depth of 8.0 ft. The profile showed the transverse crack was 1/4" wide at 2.0 ft. then hairline to 4.5 ft. The wetting process had extended from 2.5 ft. to the 4.5 ft. level.

The longitudinal crack was approximately 1/2" wide at 2.0 ft., 1/4" at 5.0 ft. and hairline at 8.0 ft. The crack had wetted from the 2.5 ft. to the 8.0 ft. depth. Sand within the crack to the 6.0 ft. level indicated that erosion from the higher levels was occurring.

A horizontal zone at low density was encountered from 3.0 to 3.3 ft. It was lense shaped with a maximum thickness of 0.3 ft. The horizontal extent was approximately 5.0 ft. at the pit excavation. An open pipe (3" diameter) at the juncture of the soft horizontal zone and the transverse crack was found. Probing inward a length of 3 ft. was possible.

No transverse cracking was found beyond the soft zone level (3.0 ft.) within this pit.

Fine roots were found within the longitudinal cracks to a depth of 2.0 ft. The type of plant to which they belong was not determinable. The adverse effect of the existence of these roots on the cracking problem is unknown but felt to be negligible.

The moisture content within the profile ranged from 5% near the surface to 10.1% near the 8.0 ft. level. The depth of drying appeared to have extended to 2.5 ft. The placement moisture content at the 8 ft. level was 10.7%.

The semblance of a shelf or bench line was identified along the mid-slope on the upstream face. The projection was less than 6" and the length less than 24" in any one location. However, a definite alignment across the slope was distinguishable. No extensive nor decisive cracking pattern near the bench location indicate it resulted from a slump or shear failure condition.

Water placed in other locations of the longitudinal crack resulted in water surfacing on the upstream face. Water was placed in one of the predominant transverse cracks 6.8 ft. downslope at the upstream face. Water showed early at one point downslope but with some shovel diking the blowout was contained and additional water placed in the original intake hole. After considerable time water was spreading to other cracks and surfaced at several locations downslope. Test Pit # 4 was excavated down the slope in an attempt to determine the extent of this crack system. The pit was extended across the front toe of the embankment into the reservoir pool.

Test Pit # 4 was excavated as a trench down the front slope of the embankment beginning approximately 25 ft. downslope of the crest. An attempt was made to follow the alignment of a crack system. Depth at excavation varied from 4.0 ft. to approximately 10 ft. at the toe of the embankment.

As mentioned previously in this report, high water in the reservoir had reached near elevation 1,567 ft. or approximately a 3½ ft. depth against the embankment during the September 5th storm. The duration of the storm was such that the retardation lasted approximately 2½ days. Since this test pit crossed the toe section the pool water wetted zone was very much in evidence although the excavations were made in November.

The water content pattern ranged from 7.5% near slope surface at waterline to 20.5% at 9.5 ft. depth approximately 50 ft. out from the C/L of the embankment. Generally it appeared the wetted bulk extended horizontally into the fill approximately 15 ft., and vertically the depth of the cutoff trench. (Elevation 1,555 ft.)

Placement moisture taken from the test made nearest to this station within the cutoff trench materials was 14.1% at a density of 113.3 pcf.

Density tests within the trench ranged from 85.5 pcf. at 13.8% moisture to 95.3 pcf. at 20.5% moisture. The density in comparison to 118.3 pcf. or 116.3 pcf. from laboratory soil curves results in 73% to 80% compaction. This would indicate a soil loosening had occured since placement was at 95% or greater compaction.

No visible eivdence of shear failure, slippage or displacement could be found within the excavated trench.

Due to the soil-colored blends, moisture contents, and closeness in density values the outline of the earth fill against the foundation soil could not be easily traced. Attempts to do so resulted in only partial correlation with as-built drawings.

Conditions Near Station 266+00.

An approximately 20 ft. longitudinal crack with randon transverse cracks exist at this station. Water was placed in the longitudinal crack at junctions with transverse cracks. Pumping water at three locations produced water surfacing on the downstream slope. Water appeared at two locations only after considerable time had elapsed. After time for wetting had occurred Test Pit # 5 was excavated along the embankment crest and Test Pit # 6 at the downstream toe of the embankment.

No durface cracks were observed along the downstream slope nor along the upstream slope. The water outlets resulted from a wetting surface breaking into a pipe condition at the surface.

Test Pit # 5 was excavated approximately 3.5 ft. deep at the junction of a transverse and longitudinal cracks. The wetting pattern was to a maximum depth of 3.0 ft. The crack closed at that point and only hairline to no cracking existed. A horizontal lense 5 ft. long and 3 inches thick existed at the 1.0 ft. level.

Test Pit # 6 was excavated about 14 ft. down the downstream slope near the toe in an attempt to encounter the flowline from the transverse crack at the crest to where it outletted at the toe. The crack was uncovered, but the equipment was limited in its position of work and was unable to determine the total depth of the crack. Depth of excavation was 3.5 ft.

The crack was found approximately 1.0 ft. below surface level. It was 1/2" wide and dry at approximately the 1.5 ft. depth. Further probing with wire to a depth of 1.5 ft. and 2.5 ft. horizontally into the crack gave no indication of water flow or wetting. The pit walls were dry and brittle the full 3.5 ft. depth.

Embankment Surveys -

Cross section and profile surveys of the reaches containing cracks were made prior to the study period. The data was plotted along with as built data to show possible changes in section. Deviations were minor and within the accuracy of measurements taken. Plottings show no significant changes in section or profile. (See appendix.)

Construction Data -

As the embankment fill was placed compacted density and moisture tests were taken to determine acceptability of fill. The tests were taken at various elevations and distances from centerline. Test results for the various reaches taken in the vicinity of the three reaches of cracking show a range of silty sandy materials placed. Moisture contents vary from 9.4% to 15.4%, the densities range from 104.3 pcf. to 121.8 pcf. and the percent fines varies from 6.5% to 32.5%.

The construction records show the soils within the cracking reaches were placed slightly over optimum moisture content. Of the twelve tests taken near the first reach (sta. 316+00) eight were slightly over optimum. The largest being 2.1% over. Of the ten tests near the second reach (sta. 313+00) five were over optimum. The largest was 1.3% over. Within the last reach (sta. 266+00) only one test of five was over optimum and it was 0.6% over. A total of 41% of all tests taken during construction of the embankment and cutoff were over optimum moisture. A slightly higher percent was found within the reaches of cracking as detailed above.

GEOLOGY

Foundation materials between Sta 313+00 to Sta 320+00 are possibly related with the occurrance of cracking. The foundation consists of seven feet of silty sand (SM) over silt-stone in the southern area of this reach. Silty sand SM (to unknown depth - greater than 12 ft.) occurs in the middle of the reach. Interbedded gravels (GP) and silt-stone comprise the foundation on the northern area of this reach. Of particular interest is the fact that the cut of the trench extended to a depth of 7.0 ft. in this area.

The occurrence of the silty sand to greater depths where the silt-stone or gravels were not encountered occurs only in one other reach of the embankment (Sta 210+00).

The density of these silty sands could provide a potential consolidation layer beneath the embankment if deep penetration and subsequent saturation would occur.

CONCLUSIONS

1. The non plastic properties of the placed soils at the reaches where cracking occurred results in a brittle embankment which upon drying due to convective evaporation and moisture capillary action stresses the soil mass beyond its natural adhesive or cohesive strength and forms an open crack. The cracks are extended in length and depth by the further convective evaporation within the open crack. The crack may or may not extend to the surface layer. These cracks are limited in depth to the embankment surface drying zone now approximately 3.5 feet in depth.

2. The loose surface soils on the embankment face resulting from placement and compacting equipment inability to work to the true line of the designed embankment section delays and/or prevents rapid surface drying due to the moisture barrier created by the break of the capillary action and the still air within the loose material. The addition of gravel or coarse sand surfacing would compliment this condition and further delay the drying process and limit the depth of cracking.

3. The surface cracking patterns primarily oriented perpendicular to center line axis suggest additional stress outside those of desication have been present in their formation. The limitation of cracks to a concentration within three primary reaches also suggests outside causes. On the other hand none of these cracks were observed to extend below the desication zone.

4. No transverse cracks investigated nor observed at the open surfaces extend across the crown of the embankment. Only partial distances were observed. Where longitudinal cracks exist the transverse cracks originate at the longitudinal crack and extend over the nearest embankment edge down the sloping face. No reason is given for the length of individual or group cracks.

5. An extensive underground network of desication cracks within the reaches investigated exists. Although the general pattern of surface cracking suggests downslope orientation, observed interconnected underground cracks allow the possibility of additional networks.

6. Transverse cracks do not extend beyond the freeboard zone (4 ft.) of the embankment. The west elevation of the emergency spillway is 1574.8. Maximum water surface elevation at design flow is 1575.5 ft. The top of dam elevation is 1579.5 ft. plus 8 inch crown. No emergency hazard exists requiring immediate repair of the surface cracks.

7. The wide variety of soil gradations, moisture contents and densities suggests zones of stress being established through the natural maturing of the embankment sufficient to create cracking reaches similar to those investigated, particularly the longitudinal cracks.

8. The unconsolidated condition of the upstream toe slope soils provide the potential for consolidation to occur when wetted to the deeper depths due to horizonal forces exerted by the embankment on to these soils. Minor movements at the toe foundation magnify the resulting embankment movements particularly in the vicinity of the crown and become manifest in open cracks at these locations.

   A slump condition is not suggested but rather a relaxing of internal stresses horizontally toward the toe resulting in fine open cracks throughout the reach near the surfaces.

9. The major embankment movements have occurred with this first deep water penetration and additional movements of toe materials is unlikely with further reservoir fillings. No additional forces will be present upon further wettings unless greater depths of water penetration into unconsolidated materials (unlikely to exist) occurs.

RECOMMENDATIONS

1. Close surface cracks to convective air currents by filling with sand or silty sand (free flowing) materials (10 cy±). Fill materials should be transported to the site. Adjacent embankment soils should not be used since their gradation is not ideal, and their disturbance will effect the present vegetative cover value.

2. Make periodic investigations of the site to observe further aggravation at reaches within this study and the appearance of cracks in other areas along the embankment. Particular emphasis should be given to periods following heavy runoff storms.

3. Future embankment designs on collapsable foundations include extended cutoff trench outside embankment upstream toe of sufficient distance to reduce horizonal stresses at the tow where wetting foundation may allow release of these stresses.

4. Maintain loose fluff of soil materials on the embankment slopes where they cannot be economically replaced with a surface covering of coarse grained materials.

5. Continue thorough geological investigations of consolidating foundations to determine extent of removal or treatment of these materials.

6. Avoid placement of SM and ML embankment materials higher than optimum moisture content to reduce the amount of moisture subject to release in the desiccation processes of surface soils.

7. Avoid where possible a wide variety of material types within an embankment section. Such variations increase construction control problems as well as varying soil properties throughout the section. Design analysis usually considers homogenous conditions to exist.

Flood Control District
of
Maricopa County
3325 WEST DURANGO STREET
PHOENIX, ARIZONA 85009

October 1, 1970

Mr. Marion Strong, State Conservationist
U.S. Soil Conservation Service
Room 6029, Federal Building
230 North First Avenue
Phoenix, Arizona 85025

Dear Mr. Strong:

Following the storm on September 5, 1970, an inspection was made of the three floodwater retarding structures in Pinal County and the Powerline Floodway. The conditions described below have raised concern regarding these structures.

Vineyard Road Retarding Structure:

a. Between approximate stations 305 and 320, there are extensive longitudinal cracks on the crown and at the tops of the slopes. Although rain has washed material into the cracks, some are at least several feet deep and as much as two inches wide at the top.

b. At approximate stations 265 and 255, longitudinal cracks were found, but they extended for only short reaches at each point.

c. Between approximate stations 200 and 215, lateral cracks across the structure were found. At approximate station 108, another short series of lateral cracks were found.

It is requested that you have an engineer, perhaps accompanied by a geologist, inspect these cracks, and make an analysis of the cause. Also, we would like an opinion as to whether the stability of the structure would be affected, particularly in the event a major storm filled the reservoir.

Powerline Floodway:

The concrete lining for the floodway continues to spall at expansion joints. Large spalled areas, some as long as one or two feet, and several inches deep, are appearing. It is requested

that you advise us of procedures that can be followed to prevent this spalling, and also recommended methods of repairing those areas which are severely damaged.

We will be glad to have an engineer accompany your inspection team if you so desire.

Sincerely,

John C. Lowry
Chief Engineer & General Manager

JCL/LEO/dr

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE River Basin-Watershed Planning Staff

Suite 326, Arizona Title Bldg., 111 W. Monroe St., Phoenix, Arizona 85003

Ema
Jack S. report yet to come 5-19-70

SUBJECT: ENG - Trip Report - Vineyard Road FRS, Cracks in Structure

DATE: October 12, 1970

TO: J. J. Turner
State Conservation Engineer

The day of October 6 was spent with George England examining the cracks in Vineyard Road Retarding Structure which were reported by personnel of the Maricopa County Flood Control District. The Flood Control District report indicated the cracks were not fresh at the time of their inspection so presumably they occurred before the storm of September 5. Very little water had been impounded previously to the September 5 storm.

Conclusions: There appears to be no immediate danger to the structure. The cause of the cracking is complicated by many factors but generally the transverse cracks are the result of desiccation of clayey material placed in the fill on the wet side of optimum. The longitudinal cracks are the result of settlement of the toe and heel of the structure perhaps coupled with desiccation.

Doubt if actual cracks ... Ralph please ... Jeff.

Discussion: The transverse cracks are seldom over a few inches wide at the top and although they might extend several feet deep they probably do not go much below spillway crest. As such they should not affect the stability of the structure. The longitudinal cracks extend deeper into the structure but unless they intercept a deep transverse crack they should cause no problem. A maintenance program which causes the cracks to be filled with loose material will inhibit air circulation in the fill and reduce further desiccation.

The transverse cracks appear on the hard packed crest of the structure and disappear on the loose, less well compacted sides. Only one crack was observed which went down the side.

Similar cracks have been observed and are present on the dike above Powerline Retarding Structure. The height of this dike varies from 2 to 4 feet and the cracks are located at the upper end where the height is 2 to 3 feet. George England reports that the section of dike with the cracks had material placed in it on the wet side of optimum. The slightly higher section of dike, which is not cracking, used the same material but it was placed in a drier state. Since the height of this fill rules out settlement as a cause of cracking it seems as if desiccation is the most logical choice. It appears then that transverse cracks can be caused by desiccation of some types of material that are too far

above optimum when placed in the fill. Many of the locations where transverse cracks appear in the Vineyard Retarding Structures were locations where England remembered the fill was on the wet side.

The longitudinal cracks usually occur on the upstream side on or near the top of the structure but a few occur on the downstream side. The crown on the crest of the structure is more prominent than in the uncracked sections. Longitudinal cracking is not present on the low dike mentioned above so it appears that the cause might be different.

These cracks seem to have been caused by the toe and heel of the structure settling and the center section remaining stationary. The cause of the settlement appears to be wetting of the foundation before the September 5th storm. Those areas where cracks appeared on the upstream side are such that impounded water was probably against the dam. Those cracks on the downstream side often have small areas of internal drainage impounded at the heel of the dam or are near outlets through the structure where water from the plunge pool can saturate the collapsible soils under the heel. Once these cracks have opened desiccation might enlarge them.

William F. Mildner
Geologist

cc: Jasper Holland
C. A. Maguire

Arrington

RTSC, E&WP Unit, Portland, Oregon

TRIP REPORT - Arizona, Channel Training Conferance and Embankment Cracking Inspection, Williams-Chandler WPP, Vineyard Road Dam - Oct. 12-16, 1970

October 27, 1970

E. J. Core

Purpose of Trip - The purpose of the trip was to:

1. Assist in conducting an earth channel evaluation workshop.

2. Inspect the cracking problem in the Vineyard Road embankment.

Participating Personnel - A list of the participants at the channel design workshop is attached. Participating in the inspection of the Vineyard Road dam were:

Lee Ohsiek, Maricopa County
Barry Nauseda, Maricopa County
Ralph Arrington, Assistant State Conservation Engineer, SCS, Phoenix
George Watt, Design Engineer, SCS, Phoenix
George England, Project Engineer, SCS, Apache Junction
Don Riddle, Chief Inspector, SCS, Apache Junction

Our observations were discussed with J. J. Turner, State Conservation Engineer, SCS, Phoenix.

Discussions and Observations

Channel Design Workshop and Field Trip - The lectures and discussions at the channel design workshop appeared to be highly productive. Considerable interest was demonstrated by all the participants. Good class participation occurred with the sharing of many experiences in channel work in the area.

Several interesting channel reaches were visited on the field trip. Conditions observed varied from freshly constructed earth floodways with no protection to concrete lined flood channels. Many types of structural treatment were observed.

In general those channels visited looked to be in good shape and appeared to be functioning well. Certainly some erosion will occur on the bare earth channels. They should continue to function if the necessary maintenance is accomplished.

Vineyard Road Dam -

1. General observations - The cracks in the Vineyard Road dam were inspected. About 160 gallons of water were run into one of the cracks. A small amount of water came to the surface downslope.

Form SCS 353
9-64

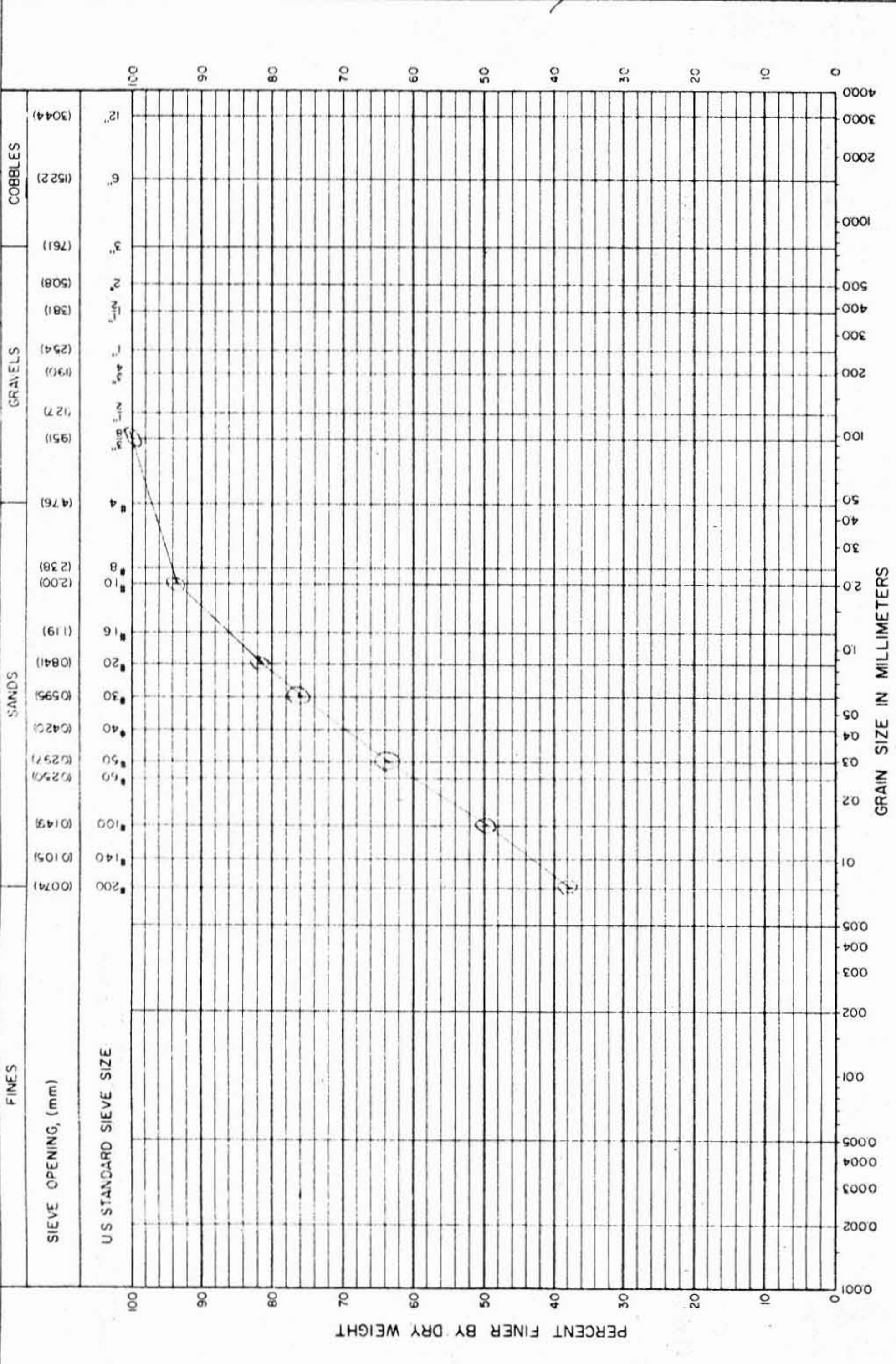
LABORATORY NO. 14

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

PROJECT and STATE: Vineyard Road Dam	SAMPLE LOCATION: 31+20 - 30' upst.
FIELD SAMPLE NO.: 4	DEPTH: El. 21.0
GEOLOGIC ORIGIN:	
TYPE OF SAMPLE: Disturbed	TESTED AT: Apache Jct
APPROVED BY: Ralph M. Arangh	DATE: 30 Nov 70
SYMBOL:	DESCRIPTION: Course Silty Sand

GRAIN SIZE DISTRIBUTION

C_c	C_u	D_{MAX}	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}
		9.51	1.10	.25	0.15			



UNDISTURBED CONDITION	
MOISTURE	15.3 %
DRY UNIT WEIGHT	108.5 pcf

SHRINKAGE LIMIT	SOLUBLE SALTS
%	%

ATTERBERG LIMITS

NATURAL MOISTURE LL	NATURAL MOISTURE PI	AIR DRY LL	AIR DRY PI	OVEN DRY LL	OVEN DRY PI
					N.P.

SPECIFIC GRAVITY (G_s)

(-) #4	(+) #4

REMARKS: Washed 37.86% Passing #200

Ariz

Vineyard Dam Cracking

RA 6-71

Soil Density & Moisture

1

Reach - Sta 315+50 - 316+50

Test	Sta	Loc.	Elev.	Field Moist %	Dry Den. pcf	Opt Moist %	Max Dry pcf	
145	316+60	℄	1578.25	12.8	118.4	12.2	119.5	5 - 119.5 pcf fr Sta 343+00 18% Fines
129	315+60	Rt 2'	1576.75	11.8	115.3	12.2	119.5	2 - 116.3 pcf fr Sta 330 30% Fines
122	316	℄	1574.5	12.3	117.2	12.2	119.5	1 - 118.6 pcf fr Sta
117	315	"	1572.6	14.3	110.9	14.8	116.3	1 - 104.3 pcf Sta 316 15% fines
118	317	"	1571.1	11.7	117.5	12.2	119.5	2 - 121.9 pcf Sta. 365 27% fines
108	316	"	1568.6	13.4	115.7	12.2	119.5	
102	315	"	1567.2	14.2	116.9	12.9	118.6	
97	316	"	1564.6	17	103.1	18.3	104.3	
95	315	Rt 6'	1562.4	13.4	117.2	12.2	119.5	
92	317	℄	1562.4	12.8	118.8	10.7	121.9	
93	315	"	1560.4	11.3	117.9	10.7	121.9	
81	318+00	℄	1559.1	15.3	111.1	14.8	116.3	

Reach Sta 312+90 - 313+70

129	315+60	Rt 2'	1576.75	11.8	115.3	12.2	119.5	
117	315	℄	1578.6	14.3	110.9	14.8	116.3	
119	313	"	1570.8	10.7	116.6	10.7	121.9	
102	315	"	1567.2	14.2	116.9	12.9	118.6	
121	312	"	1566.4	11.8	117.0	12.2	119.5	
112	313	℄	1564.8	15.3	110.8	14.8	116.3	
113	312	Lt 6'	1563.4	9.9	116.9	10.7	121.9	
95	315	Rt 6'	1562.4	13.4	117.2	12.2	119.5	
93	315	℄	1560.4	11.3	117.9	10.7	121.9	
106	312+50	"	1559.4	14.1	113.3	12.8	118.3	

Reach Sta 265+50 - 266+50

237	265	℄	1568.2	10.8	120.3	11.9	122.7
215	267+25	Lt 7'	1566.7	11.5	121.8	11.9	122.7
207	264	℄	1564.75	15.4	116.4	14.8	116.3
195	267+50	Lt 23'	1564.0	9.4	119.8	11.8	122.9
190	264	℄	1559.8	13.9	113.1	14.8	116.3

Ariz
RA

Vineyard Cracking

6-71

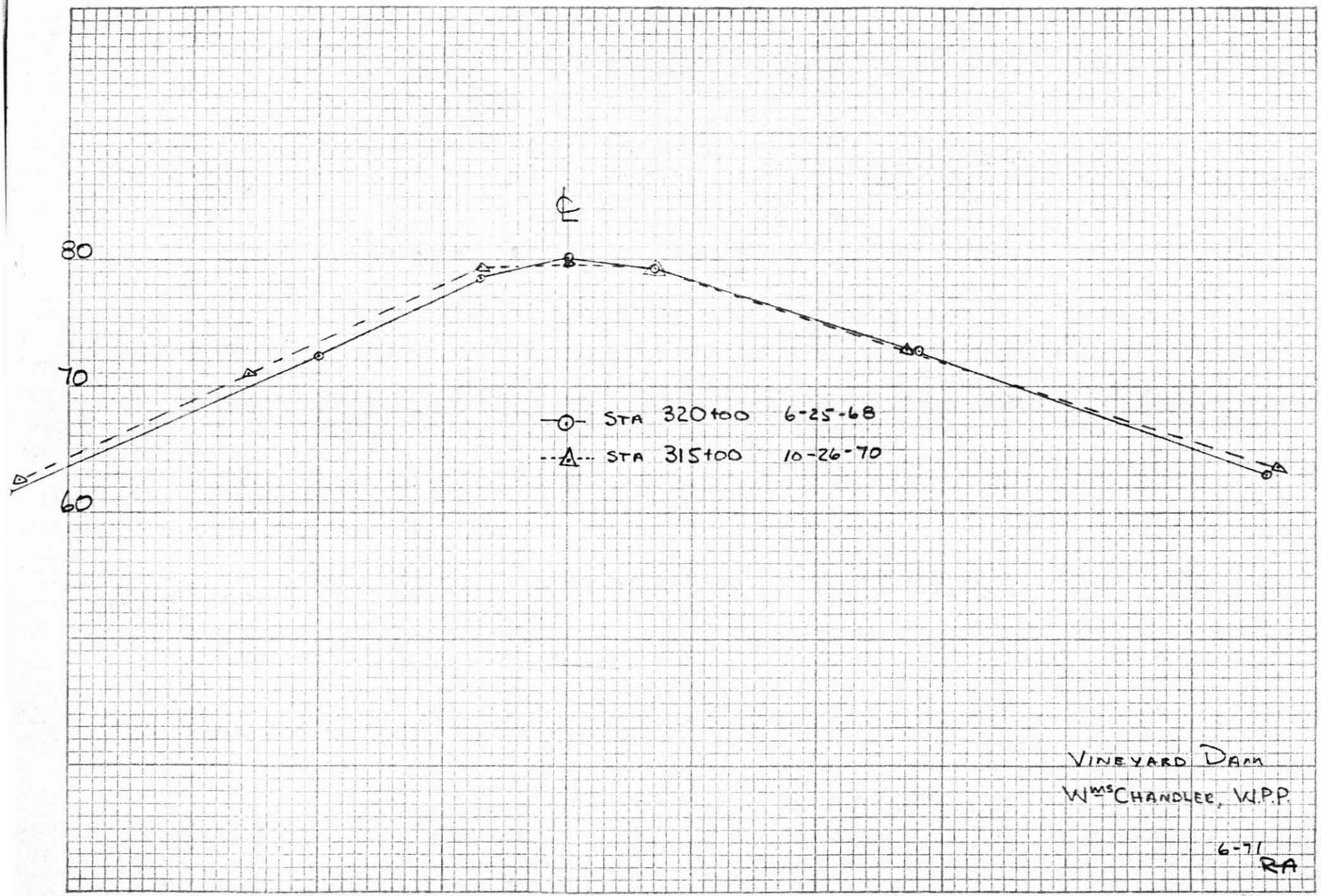
Range of Moisture Contents.

Tests No. 1 to 2 weeks Periods	No. Test Over Opt. Mois	Percent Over Opt.	Working within Cracking Reach
1 - 7	6	86%	
8 - 28	13	65%	Sta 316
62 - 82	9	45%	←
83 - 94	7	64%	← Sta 313
95 - 116	13	62%	← x
117 - 122	2	40%	← x
123 - 143	13	65%	← x
144 - 151	2	28%	←
152 - 173	10		
174 - 182	4		Sta 266
183 - 203	9	45%	o
204 - 224	9	45%	o
225 - 228	2		
229 - 248	10	53%	o
249 - 252	2		
253 - 274	5		
275 - 279	2		
280 - 300	4		
301 - 306	2		
307 - 328	5		
329 - 342	2		
343 - 363	1		
364 - 379	9		
380 - 401	5		
402 - 416	5		
417 - 434	7		
435 - 451	9		
452 - 473	17	81%	
474 - 485	6		
486 - 507	5		
508 - 520	5		
521 - 542	6		
543 - 548	2		
549 - 570	8		
571 - 584	8		
550	224	= 41%	

34 Missing →

Vineyard Road Dam — Apache Junction - Gilbert WPP Arizona

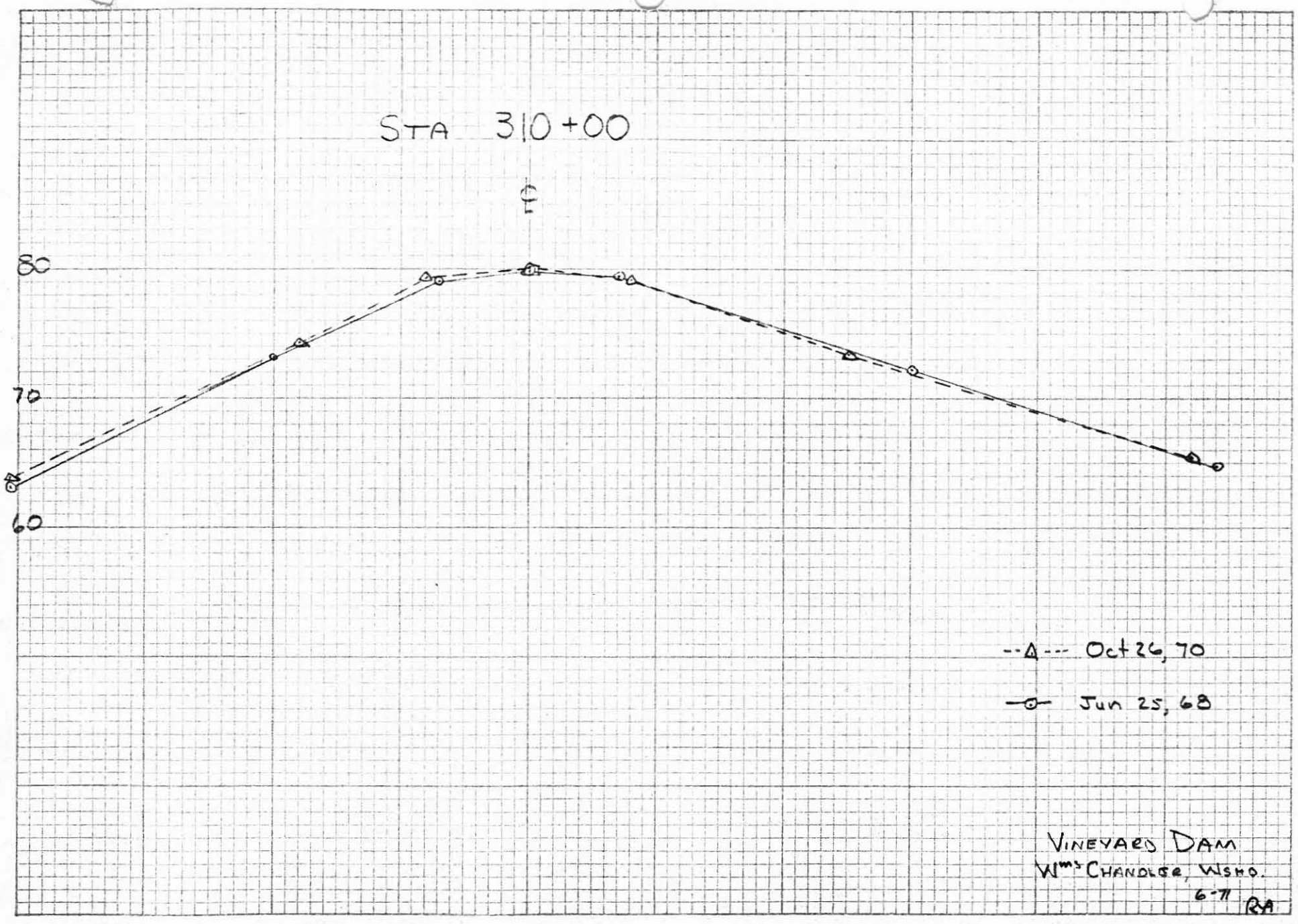
Station	Location	% G	% S	% fines	Gs	% salts	L L	P I	Class Symbol	Opt. Moisture	Max. Density	Remarks
(Design Soil Tests)												
100+00	(2) ℄	0	47	53	2.72	-	35	15	CL	16.5	103.3	Washed
120+00	(4) "	0	47	53	2.71	-	25	9	CL	12.6	112.0	"
150+00	(7) "	0	49	51	2.67	-	26	8	CL	13.2	109.8	"
190+00	(11) "	0	35	65	2.71	-	27	11	CL	5.7	102.3	"
249+50	(17) "	0	41	59	2.71	-	NP	NP	SM	10.7	116.0	"
270+00	(19) "	0	31	69	2.76	-	26	5	CL ML	12.7	110.6	"
300+00	(22) "	0	40	60	2.63	-	29	6	ML	8.28	104.1	"
320+00	(24) "	0	53	47	2.71	-	30	10	SC	11.4	114.2	"
354+25	(301) "	0	39	61	2.68	-	NP	NP	ML	12.4	105.5	"
(Construction Soil Tests)												
355+00±	30' Rt. ℄	0	67.43	32.57					SM	11.7	117.5	Not. Washed
365+00±	30' Rt. ℄	0	73	27					SM	10.7	121.9	" "
17+00±	N. Emerg. Spwy.	0	64	36					SM	10.8	119.8	" "
345+00	℄ dam	0	93.62	6.38					SW	12.8	118.3	" "
343+00	In dam fill	0	82.44	17.56					SM	12.2	119.5	" "
330+00	Borrow Channel	0	70.62	29.38					SM	14.8	116.3	" "
324+00	3' Lt. ℄	0	85.48	14.52					SM	12.8	118.3	" "
316+00	℄	0	85.57	14.43					SM	18.3	104.3	" "
301+00	3' Lt. ℄	0	86.56	13.44					SM	11.8	122.9	" "



VINEYARD DAM

WMS CHANDLER, W.P.P.

6-71 RA


STA 310+00
℄
80
70
60
--Δ--- Oct 26, 70
—o— Jun 25, 68
VINEYARD DAM
Wm^s CHANDLER, WSHO.
6-71 RA

Basically, the cracks are limited to three general areas along the dam. These areas cover several hundred feet of the length of the dam. There appears to be two types of cracks. One, transverse cracks, crossing the top of the embankment and two, longitudinal cracks both upstream and downstream from the center line of the dam.

The transverse cracks do not appear to be deep and they do not appear to go very far down the faces of the structure. No vertical movements appear to be associated with the transverse cracks. Some of these cracks were about two inches wide.

The longitudinal cracks generally paralleled the center line for several tens of feet and appeared to connect with cracks running diagonally down the faces of the dam. Vertical movements of at least an inch were apparent at some of these cracks. Some of these cracks were as wide as four inches at the surface. They appeared to close with depth. Probing indicated some of these cracks were at least three feet deep.

2. Probable causes of cracking

a. Desiccation - According to Mr. England most of the cracks occurred where the wettest embankment was placed.

b. Settlement of the foundation.

c. Differential settlement of the fill because of:

(1) Different types of fill materials.

(2) Variability in moisture content.

d. Loss of shear resistance in the foundation with an associated increase in strain.

e. Strain induced by water load in small desiccation cracks during rain storms.

f. Combination of the above.

The principal cause of the cracking - Certainly the combination of the clayey fill materials, the compaction of parts of the fill above optimum moisture content and the desert environment would cause desiccation cracking. This is undoubtedly one of the principal factors in the problem. The variability in the character of foundation and fill materials and in the moisture content of both the fill and foundation materials would tend to cause differential movements. This quite likely occurred and caused part of the cracks.

The effect of rain water in desiccation and other cracks would increase the shearing stress as well as decrease the shearing resistance. While the magnitude of these changes may never have approached a sliding failure condition, they could have been great enough to have induced strains resulting in further cracking and downward displacement.

3. Hazard to the structure - If the cracks are primarily caused by desiccation and magnified by shearing problems caused by water in the cracks or by settlement near the toes of the dam, no great hazard would be immediately presented.

However, if the transverse cracks are a result of differential movement in the embankment or foundation, they could be deep enough to present a hazard at any time water should be impounded.

4. Recommendations and conclusions - It was concluded by all parties involved in the inspections and discussion that:

a. Because cracking is occurring on several structures in Arizona and because of the unknown hazard presented, full investigation of the magnitude of the cracking in the Vineyard Road dam should be made.

b. The recommended investigations include:

(1) Surveyed profile of the present top of the dam with detailed cross sections at selected spots. These surveys can be limited to the zones of cracking. These surveys should locate the position of all cracks.

(2) Compare the survey data with the profile surveyed immediately after completion of the structure.

(3) Review the construction records to establish the types of materials, the degree of compaction and the moisture content with respect to optimum in all the zones of cracking. Compare this with the same data for zones where cracking did not occur.

(4) Review the construction records and the pre-construction boring logs and geologic reports and sections to determine the character of the foundations, the amount of stripping and other foundation preparation in the zones of cracking. This should be compared with the same data for selected zones where cracking did not occur.

(5) Fill selected cracks, both transverse and longitudinal, with water to determine their extent. This will require a backhoe to excavate to trace the cracks.

It would be desirable to take samples of materials in the zones of cracking to verify classification.

(6) All the data should be assembled and fully evaluated to determine the cause of the cracking and the likely hazard to the structure.

Jack C. Stevenson
Soil Mechanics Engineer

cc:
J. J. Turner, Phoenix
George England, Apache Junction
F. K. Museus

Reviewed and approved
By FKM Date 10-28-70

Attachment

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

LOG OF TEST HOLES

CS-533
REV. 2-64

WATERSHED: Williams - Chandler
SUB-WATERSHED:
SITE NO.: Vineyard Road Dam
LOCATION: Sec 9, 16, 21, 27, 34 T1S, R8E Sec. 2+3 T2S, R8E
OWNER:
STATE: Arizona
LOGGED BY: A.J. Clarke
DATE: 11/23/70
PROJECT: WP-07 ____ WP-08 X FP-03 ____ P.L.-46 ____
DRILLING EQUIPMENT: Backhoe
LOCATION OF HOLES: Embankment (existing)

HOLE NO.	STA. & SURFACE ELEVATION	HOLE DEPTH FROM FT.	HOLE DEPTH TO FT.	DESCRIPTION OF MATERIALS	N	USCS	TYPE BIT USED	SAMPLES NO.	SAMPLES TYPE[1]	SAMPLES FROM FT.	SAMPLES TO FT.	SAMPLES CSE. %	SAMPLES REM.[2] MIN. DIAM.	SAMPLES REC.[3] %
2001 Pit #1	316+27 {0' (slope distance) from upstr. edge of crown on upstr. slope}	0.0	3.0	Sand, V/M - V/C, Calc, Sft. 0.0-1.0, Cpt. 1.0-3.0, reddish brown		SM			D	1.3	1.7			
									D	2.4	2.8			
				Note - Pit dug where water appeared at surface. Transverse crack in upstream face of pit: 1/8" wide and dry 0.0-1.0; 3/4" wide and wet 1.0-3.0										
2002 Pit #2	316+27 on crown 4' west of C/L Dam	0.0	1.3	Sand, V/M - V/C, Calc., Sft, reddish brown		SM								
		1.3	1.8	Sand, M - G, C, V/Calc., Cpt., gray		SM								
		1.8	7.0	Sand, V/M - V/C, G 1.8-3.0, SI/G 3.0-7.0, Calc., Cpt., reddish brown		SM			D	1.8	2.2			
									D	3.3	3.7			
		7.0	8.0	Sand, V/M - V/C, Calc., Cpt., reddish brown		SM			D	4.6	5.0			
									D	5.8	6.2			
									D	7.8	8.0			
				Note - Pit dug at point of water intake. Longitudinal and transverse cracks exposed in pit. No evidence of displacement along cracks. Sand in transverse crack 3.5-4.0 evidence of internal erosion. Longitudinal crack deflected 8" by calcareous horizon (1.3-1.8): 1/2" wide @ 1.5, 1/16" wide @ 3.0, & closed @ 6.8. Wet 3.0-6.8.										

1. DISTURBED-UNDISTURBED-ROCK CORE 2. COARSE MATERIAL REMOVED 3. PERCENT SAMPLE RECOVERY

SHEET 1 OF 5 SHEETS

All fines logged are essentially inactive (little or no plasticity). Wetness in cracks is the result of running water into cracks at other locations.

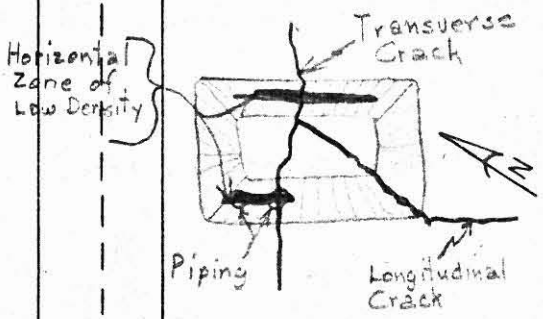
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

LOG OF TEST HOLES

SCS-533
REV. 2-64

WATERSHED: Williams – Chandler	SUB-WATERSHED:	SITE NO.: Vineyard Road Dam
LOCATION: Sec. 9, 16, 21, 27, 34 T1S, R8E Sec. 2+3 T2S, R8E	OWNER:	STATE: Arizona
LOGGED BY: C.D. Clarke	DATE: 11/24/70	PROJECT: WP-07 ____ WP-08 X FP-03 ____ P.L.-46 ____
DRILLING EQUIPMENT: Backhoe	LOCATION OF HOLES: Embankment	

HOLE NO.	STA. & SURFACE ELEVATION	HOLE DEPTH FROM FT.	HOLE DEPTH TO FT.	DESCRIPTION OF MATERIALS	N	USCS	TYPE BIT USED	SAMPLES NO.	SAMPLES TYPE[1]	SAMPLES FROM FT.	SAMPLES TO FT.	SAMPLES CSE. %	SAMPLES REM.[2] MIN. DIAM.	SAMPLES REC.[3] %
2003 Pit #3	313+20 on crown	0.0	3.0	Sand, V/M – V/C, SI/G, Calc., Sft. 0.0-1.0, Cpt. 1.0-3.0, reddish brown		SM				1.1	1.5			
		3.0	3.3	Sand, V/M – V/C, Saturated, Sft, Calc., reddish brown		SM								
		3.3	8.0	Sand, V/M – V/C, SI/G, Moist, Calc., Cpt., reddish brown		SM				5.8 3.1	6.2 3.5			10.1%



Note – Transverse crack: ¼" wide @ 2.0; hairline @ 4.5; wet 2.5 to 4.5.
Longitudinal crack ½" wide @ 2.0; ¼" wide @ 5.0; hairline @ 8.0; wet 2.5-8.0
Sand to 6.0 in longitudinal crack indicative of sediment movement

Horizontal zone of low density 3.0 to 3.3: lense shaped with maximum thickness of 0.3'; 5' horizontal extent; piping (3" diameter) at juncture of soft horizontal zone and transverse crack. Probe extended 3' into pipe.

1. DISTURBED-UNDISTURBED-ROCK CORE
2. COARSE MATERIAL REMOVED
3. PERCENT SAMPLE RECOVERY

All fines logged are essentially inactive (little or no plasticity)
Wetness in cracks is the result of running water into crack at other locations.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

LOG OF TEST HOLES

SCS-533
REV. 2-64

WATERSHED: Williams - Chandler	SUB-WATERSHED	SITE NO.: Vineyard Road Dam
LOCATION	OWNER	STATE: Arizona
LOGGED BY: C.D. Clarke — DATE: 11/25/70	PROJECT: WP-07 ____ WP-08 ____ FP-03 ____ P.L.-46 ____	
DRILLING EQUIPMENT: Backhoe	LOCATION OF HOLES: Embankment	

HOLE NO.	STA. & SURFACE ELEVATION	HOLE DEPTH FROM FT.	HOLE DEPTH TO FT.	DESCRIPTION OF MATERIALS	N	USCS	TYPE BIT USED	SAMPLES NO.	SAMPLES TYPE[1]	SAMPLES FROM FT.	SAMPLES TO FT.	SAMPLES CSE. %	SAMPLES REM.[2] MIN. DIAM.	SAMPLES REC.[3] %
2004 Pit #4	313+40 22' (slope distance) from upstr. edge of crown on upstr. slope	0.0	3.5	Sand, V/M - V/C, Sl/G, Calc., Sft. 0.0-1.0, Cpt 1.0 - 3.5, reddish brown		SM								
		3.5	3.8	Sand, M - G, C, V/Calc., Cpt., gray		SM								
		3.8	5.0	Sand, V/M - V/C, Calc., Cpt., reddish brown		SM								

Note - Transverse crack: ¼" wide @ 2.0 and ⅛" wide @ 3.0; wet 2.7 to 4.0; at 4.0 water movement horizontal and toward surface on upstr. slope.

Longitudinal crack extends to 2.5' depth and joins hairline horizontal crack (both dry).

1. DISTURBED-UNDISTURBED-ROCK CORE 2. COARSE MATERIAL REMOVED 3. PERCENT SAMPLE RECOVERY

SHEET 3 OF 5 SHEETS

All fines logged are essentially inactive (LL or no plasticity)
Wetness in cracks is the result of running water into cracks at other locations.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

LOG OF TEST HOLES

SCS-533
REV. 2-64

WATERSHED: Williams - Chandler	SUB-WATERSHED	SITE NO.: Vineyard Road Dam	
LOCATION	OWNER	STATE: Arizona	
LOGGED BY: C.D. Clarke	DATE: 11/25/70	PROJECT: WP-07 ____ WP-08 X FP-03 ____ P.L.-46 ____	
DRILLING EQUIPMENT: Backhoe		LOCATION OF HOLES: Embankment	

HOLE NO.	STA. & SURFACE ELEVATION	HOLE DEPTH FROM FT.	HOLE DEPTH TO FT.	DESCRIPTION OF MATERIALS	N	USCS	TYPE BIT USED	SAMPLES NO.	SAMPLES 1 TYPE	SAMPLES FROM FT.	SAMPLES TO FT.	SAMPLES CSE. %	SAMPLES 2 REM. MIN. DIAM.	SAMPLES 3 REC. %
2005 Pit #4	313+40 (upstr. toe of dam – 22.8' vert. below top dam)	0.0	3.5	Sand, V/M - V/C, Moist, Cpt. Fill, reddish brown		SM								
		3.5	7.0	Sand, V/M - V/C, Moist, Calc. Con., Sft.-Med., Foundation Soil, reddish brown		SM								

Note: Longitudinal crack at toe is not recognized below 2.5' where it breaks into a network of hairline cracks. Entire profile moist from temporary impoundment of water. Possibility of settlement in upstr. toe area after construction but no clear cut evidence. Apparent potential for additional settlement.

1. DISTURBED-UNDISTURBED-ROCK CORE 2. COARSE MATERIAL REMOVED 3. PERCENT SAMPLE RECOVERY

All fine. logged are essentially inactive (little or n plasticity).

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

LOG OF TEST HOLES

SCS-533
REV. 2-64

WATERSHED: Williams - Chandler		SUB-WATERSHED	SITE NO.: Vineyard Road Dam
LOCATION		OWNER	STATE: Arizona
LOGGED BY: C.D. Clarke	DATE: 11/25/70	PROJECT: WP-07 ____ WP-08 X FP-03 ____ P.L.-46 ____	
DRILLING EQUIPMENT: Backhoe		LOCATION OF HOLES: Embankment	

HOLE NO.	STA. & SURFACE ELEVATION	HOLE DEPTH FROM FT.	HOLE DEPTH TO FT.	DESCRIPTION OF MATERIALS	N	USCS	TYPE BIT USED	SAMPLES NO.	SAMPLES 1 TYPE	SAMPLES FROM FT.	SAMPLES TO FT.	SAMPLES CSE. %	SAMPLES 2 REM. MIN. DIAM.	SAMPLES 3 REC. %
2006 Pit #5	266+10 Crown	0.0	3.5	Sand, V/M - V/C, Calc., Cpt. 1.0-3.5, reddish brown Note - Zone of saturated, low density soil 0.9-1.2 : lense shaped ; 5' horizontal extent ; maximum thickness 3". Transverse and longitudinal cracks both wet to 3.0.		SM				1.0	P 1.2			
2007 Pit #6	266+10 (9.6' vert. below top dam on dnstr. slope)	0.0	3.0	Sand, V/M - V/C, Calc., Cpt 1.0-3.0, reddish brown Note - Transverse crack ; ½" wide and dry at top and bottom of pit. Wire probed 2.5' horizontally from wall of pit and 1.5' vertically from bottom of pit with no indication of water		SM								

1. DISTURBED-UNDISTURBED-ROCK CORE 2. COARSE MATERIAL REMOVED 3. PERCENT SAMPLE RECOVERY

SHEET 5 OF 5 SHEETS

Fines logged are essentially inactive (little or no plasticity).
Wetness in cracks is the result of running water into cracks at other locations.

Form SCS 353
9-64

MATERIALS TESTING REPORT

U. S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE

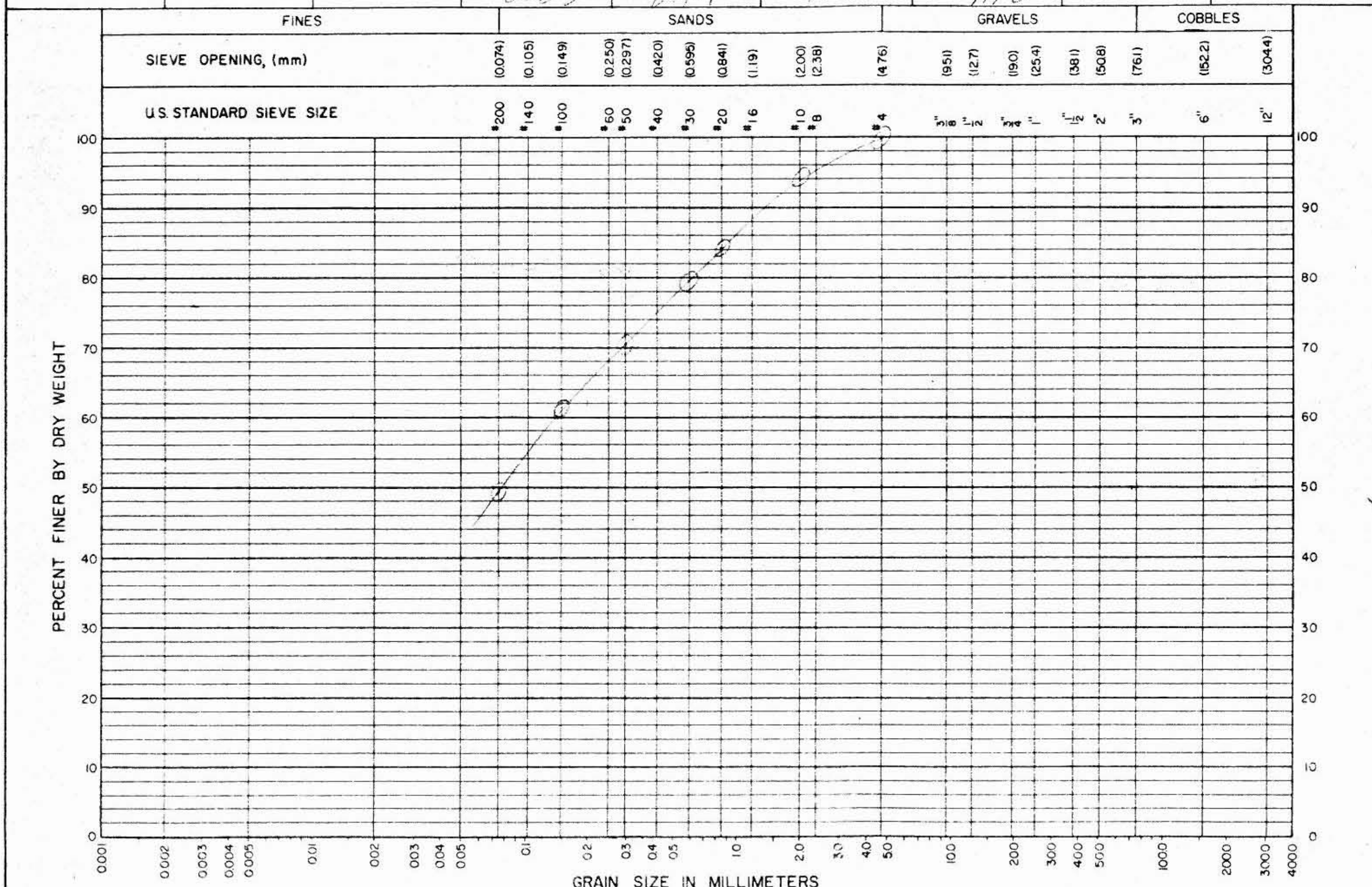
SOIL CLASSIFICATION

LABORATORY NO. 1

PROJECT and STATE	[illegible] Road Dam [illegible]
SAMPLE LOCATION	[illegible] - P.1 #2
FIELD SAMPLE NO.	1
DEPTH	3.0'
GEOLOGIC ORIGIN	
TYPE OF SAMPLE	Disturbed
TESTED AT	[illegible]
APPROVED BY	Ralph M. [illegible]
DATE	2-Dec-70
SYMBOL	SM-2
DESCRIPTION	Fine Silty Sand

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	D_{MAX}	C_u	C_c
			0.08	0.14	1.0	4.76		



FINES
SANDS
GRAVELS
COBBLES
SIEVE OPENING, (mm)
(0.074) (0.105) (0.149) (0.250) (0.297) (0.420) (0.595) (0.841) (1.19) (2.00) (2.38) (4.76) (9.51) (12.7) (19.0) (25.4) (38.1) (50.8) (76.1) (152.2) (304.4)
U.S. STANDARD SIEVE SIZE
#200 #140 #100 #60 #50 #40 #30 #20 #16 #10 #8 #4 3/8" 1/2" 3/4" 1" 1 1/2" 2" 3" 6" 12"
PERCENT FINER BY DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
0.001 0.002 0.003 0.004 0.005 0.01 0.02 0.03 0.04 0.05 0.1 0.2 0.3 0.4 0.5 1.0 2.0 3.0 4.0 5.0 10.0 20.0 30.0 40.0 50.0 100.0 200.0 300.0 400.0 500.0 1000.0 2000.0 3000.0 4000.0
GRAIN SIZE IN MILLIMETERS

SPECIFIC GRAVITY (G_S)		ATTERBERG LIMITS						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI	%	%	11.7 %	g/cc pcf

REMARKS: Washed

49.21 % Passing #200

Form SCS 353
9-64

LABORATORY NO. 1

MATERIALS TESTING REPORT

U. S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION

PROJECT and STATE

SAMPLE LOCATION - Pit #2

FIELD SAMPLE NO. 1

DEPTH

GEOLOGIC ORIGIN

TYPE OF SAMPLE

TESTED AT

APPROVED BY Ralph M Orwig

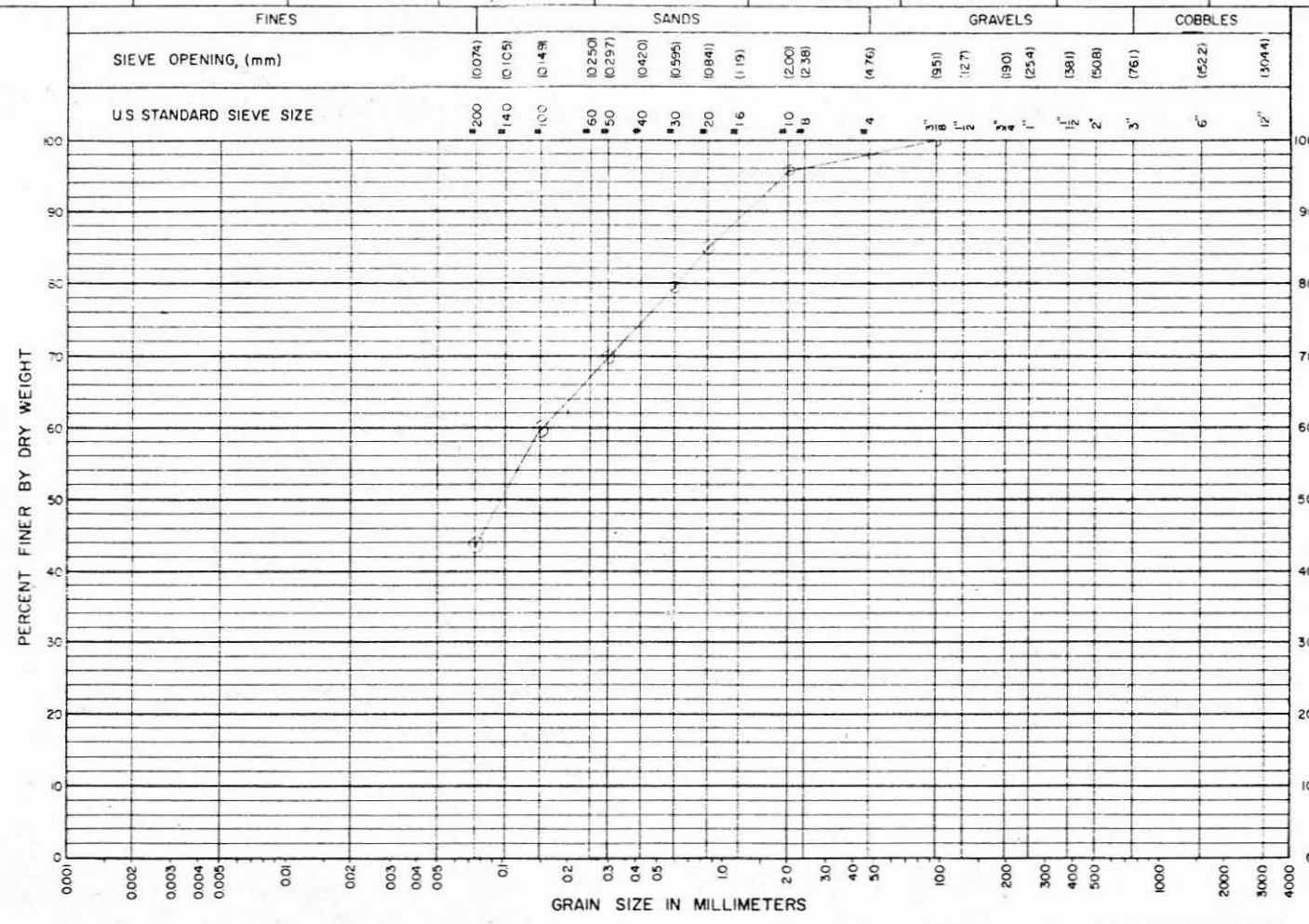
DATE 2-4-[illegible]-70

SYMBOL SC-2

DESCRIPTION Fine silty Sand

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50} 0.10	D_{60} 0.149	D_{85} 0.841	D_{MAX} 9.51	C_u	C_c



SPECIFIC GRAVITY (G_S)		ATTERBERG LIMITS None						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI	%	%	11.0 %	g/cc pcf

REMARKS: washed

43.61 % Passing #200

Form SCS 353
9-64

MATERIALS TESTING REPORT

U. S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION

LABORATORY NO. 2

PROJECT and STATE: [illegible]

SAMPLE LOCATION: 316-327 - P.1 #2

FIELD SAMPLE NO.: 2

DEPTH: 2.0

GEOLOGIC ORIGIN:

TYPE OF SAMPLE: [illegible]

TESTED AT: [illegible]

APPROVED BY: [signature]

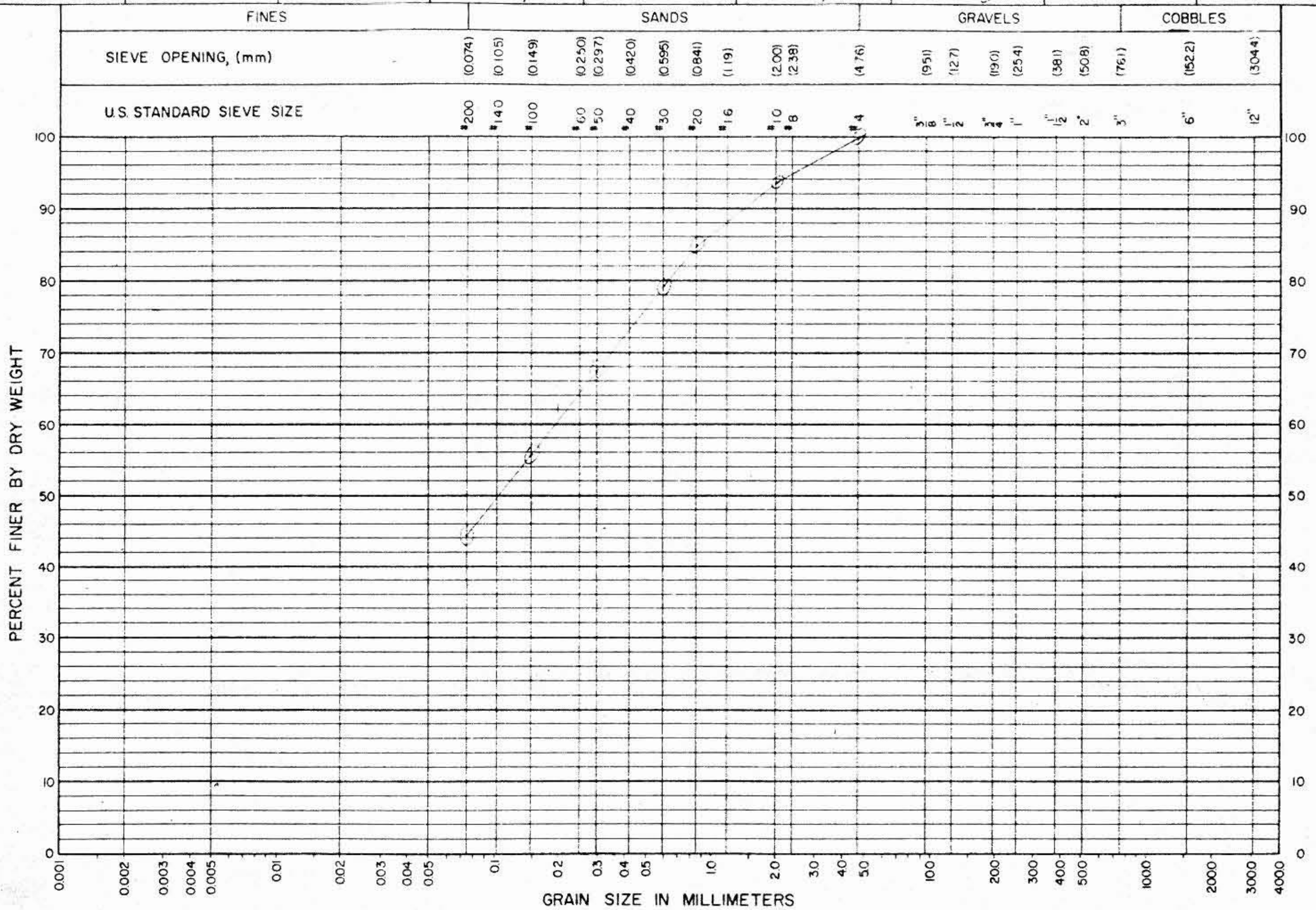
DATE: [illegible]

SYMBOL: SM-2

DESCRIPTION: Fine Silty Sand

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	D_{MAX}	C_u	C_c
			0.10	0.19	0.90	4.76		



FINES
SANDS
GRAVELS
COBBLES
SIEVE OPENING, (mm)
(0.074) (0.105) (0.149) (0.250) (0.297) (0.420) (0.595) (0.841) (1.19) (2.00) (2.38) (4.76) (9.51) (12.7) (19.0) (25.4) (38.1) (50.8) (76.1) (152.2) (304.4)
U.S. STANDARD SIEVE SIZE
#200 #140 #100 #60 #50 #40 #30 #20 #16 #10 #8 #4 3/8" 1/2" 3/4" 1" 1 1/2" 2" 3" 6" 12"
PERCENT FINER BY DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
0.001 0.002 0.003 0.004 0.005 0.01 0.02 0.03 0.04 0.05 0.1 0.2 0.3 0.4 0.5 1.0 2.0 3.0 4.0 5.0 10 20 30 40 50 100 200 300 400 500 1000 2000 3000 4000
GRAIN SIZE IN MILLIMETERS

SPECIFIC GRAVITY (G_S)		ATTERBERG LIMITS None						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI	%	%	2.0 %	g/cc pcf

REMARKS: Washed

44.09 % Passing #200

Form SCS 353
9-64

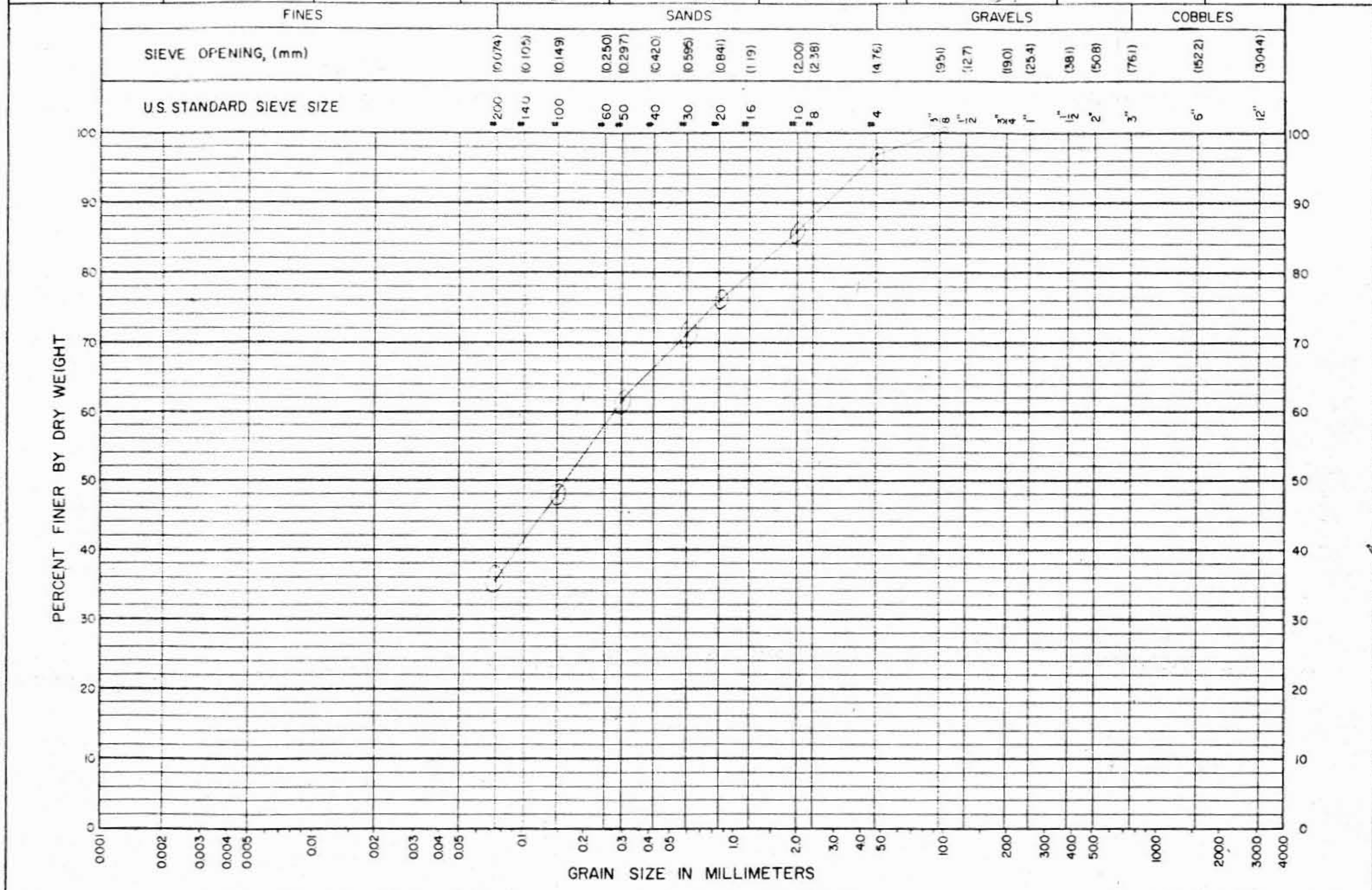
MATERIALS TESTING REPORT
U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE
SOIL CLASSIFICATION

LABORATORY NO. 3

PROJECT and STATE: [illegible]			SAMPLE LOCATION: 3 16+27 - P.I #2
FIELD SAMPLE NO: 3	DEPTH: 2.8'	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE: Disturbed	TESTED AT: [illegible] Ariz.	APPROVED BY: Ralph M. Quinn[illegible]	DATE: [illegible]
SYMBOL: SM-1	DESCRIPTION: Course Silty Sand		

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	$D_{MAX.}$	C_u	C_c
			0.16	0.25	2.20	9.51		



SPECIFIC GRAVITY (G_S)		ATTERBERG LIMITS N.P.						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI	%	%	10.5 %	g/cc pcf

REMARKS: Washed

35.16 % Passing #200

Form SCS-353
9-64

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

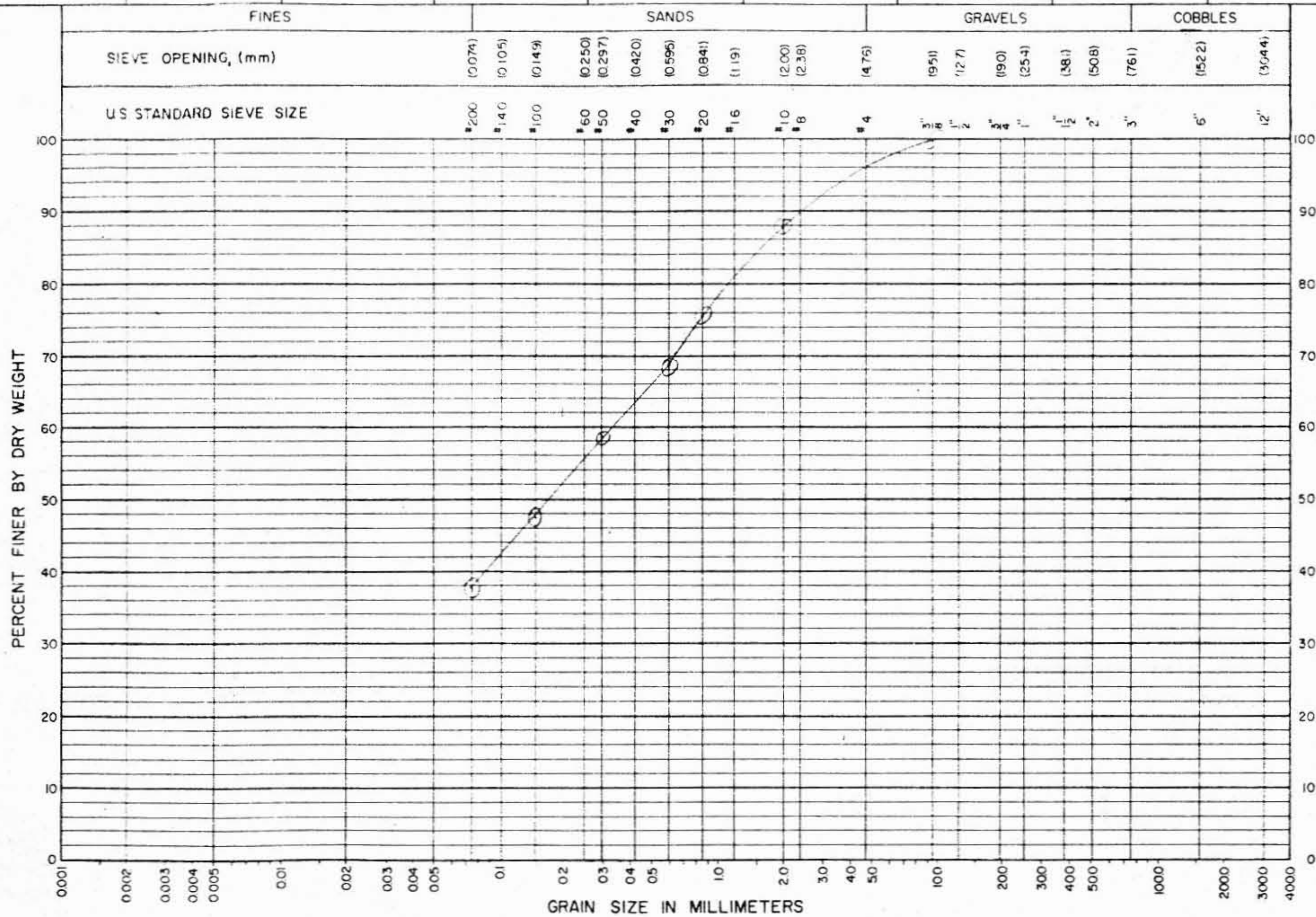
SOIL CLASSIFICATION

LABORATORY NO. 4

PROJECT and STATE: [illegible] Dam, Arizona		SAMPLE LOCATION: 316+27 - P.I. #2
FIELD SAMPLE NO.	DEPTH: 6.0	GEOLOGIC ORIGIN
TYPE OF SAMPLE: Disturbed	TESTED AT: [illegible], Ariz.	APPROVED BY: Ralph M. [illegible]	DATE: 24-Nov-70
SYMBOL: SM-1	DESCRIPTION: Coarse Silty Sand	

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	D_{MAX}	C_u	C_c
						9.51		



SPECIFIC GRAVITY (G_S)		ATTERBERG LIMITS						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI: Non Plastic	LL	PI	%	%	10.8%	g/cc pcf

REMARKS: Washed

37.88 % Passing #200

Form SCS 353
9-64

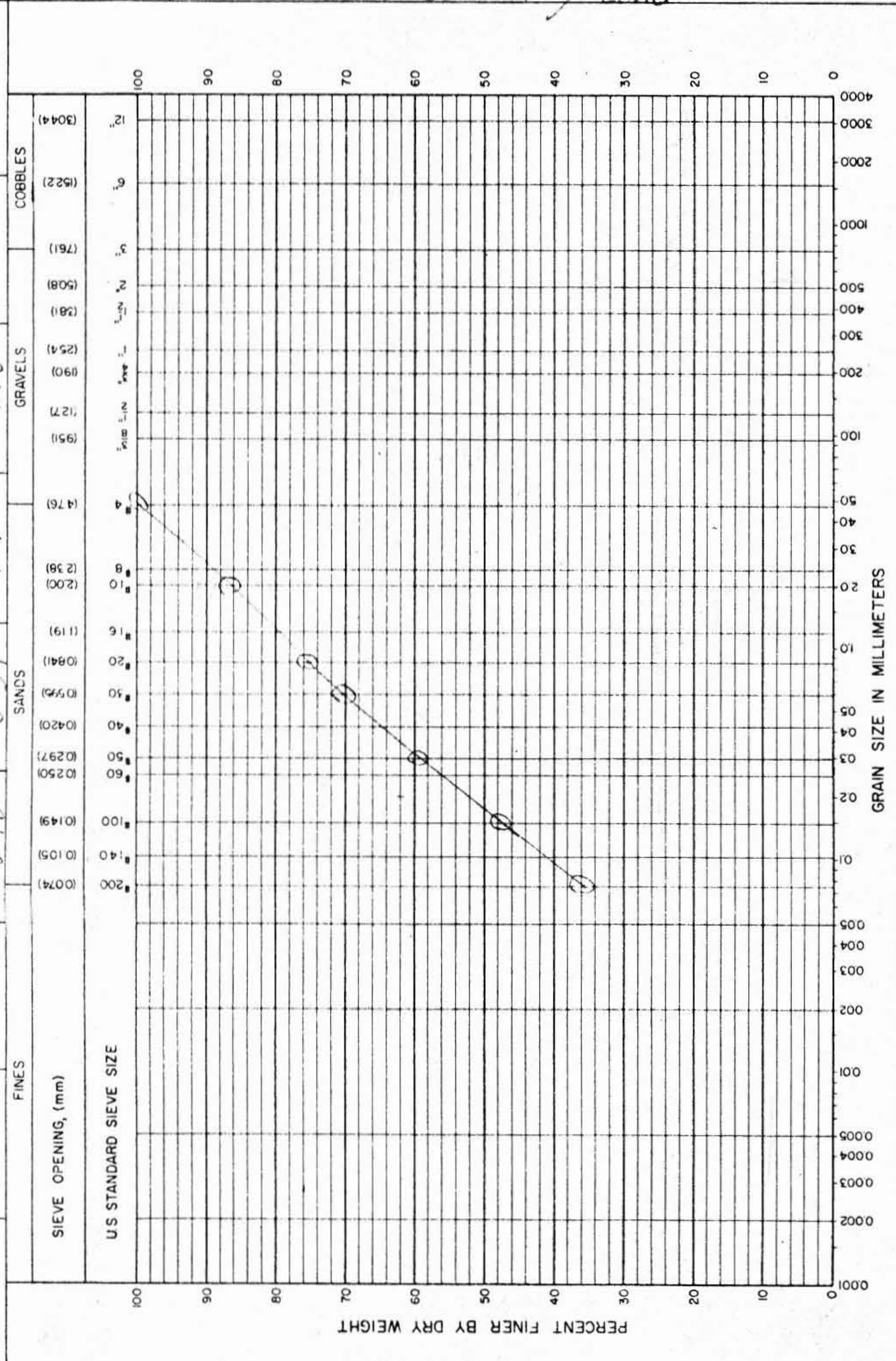
LABORATORY NO. 5

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

PROJECT and STATE: Kingsford Road Dam Arizona		SAMPLE LOCATION: 315+27 (Pit #1)	
FIELD SAMPLE NO. 5	DEPTH 2.8'	GEOLOGIC ORIGIN	
TYPE OF SAMPLE: Disturbed	TESTED AT: Phoenix [illegible] Ariz.	APPROVED BY: Ralph M. Aninyh	DATE: [illegible]
SYMBOL: SM-1	DESCRIPTION: Coarse Silty Sand		

GRAIN SIZE DISTRIBUTION

D_{MAX}	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_u	C_c
4.76	1.9	0.31	0.18					



UNDISTURBED CONDITION: MOISTURE 20 %; DRY UNIT WEIGHT g/cc pcf

SHRINKAGE LIMIT %

SOLUBLE SALTS %

ATTERBERG LIMITS: NATURAL MOISTURE LL PI; AIR DRY LL PI; OVEN DRY LL PI: NP

SPECIFIC GRAVITY (G_s): (+) #4; (-) #4

REMARKS: Washed
35.89 % Passing #200

Form SCS 353
9-64

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

SOIL CLASSIFICATION

LABORATORY NO. 6

PROJECT and STATE

SAMPLE LOCATION P.I #1

FIELD SAMPLE NO. 6

DEPTH 1.5

GEOLOGIC ORIGIN

TYPE OF SAMPLE

TESTED AT

APPROVED BY Kaplan Owings

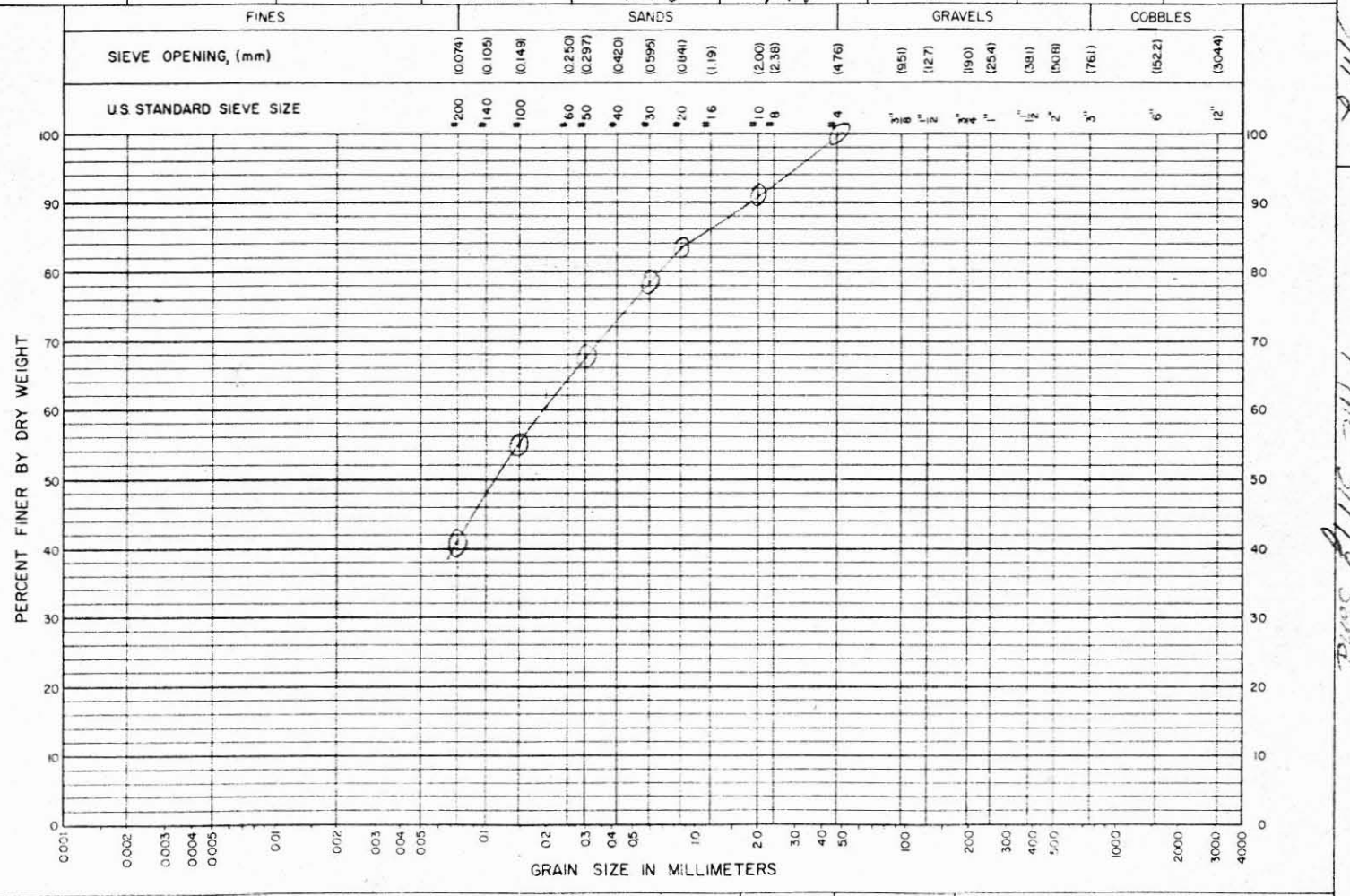
DATE

SYMBOL SM-2

DESCRIPTION Fine Silty Sand

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50} 0.12	D_{60} 0.18	D_{85} 1.10	$D_{MAX.}$ 4.76	C_u	C_c



SPECIFIC GRAVITY (G_s)		ATTERBERG LIMITS						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI	%	%	%	g/cc pcf

REMARKS: washed

40.98 % Passing #200

Form SCS 353
9-64

MATERIALS TESTING REPORT

U. S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION

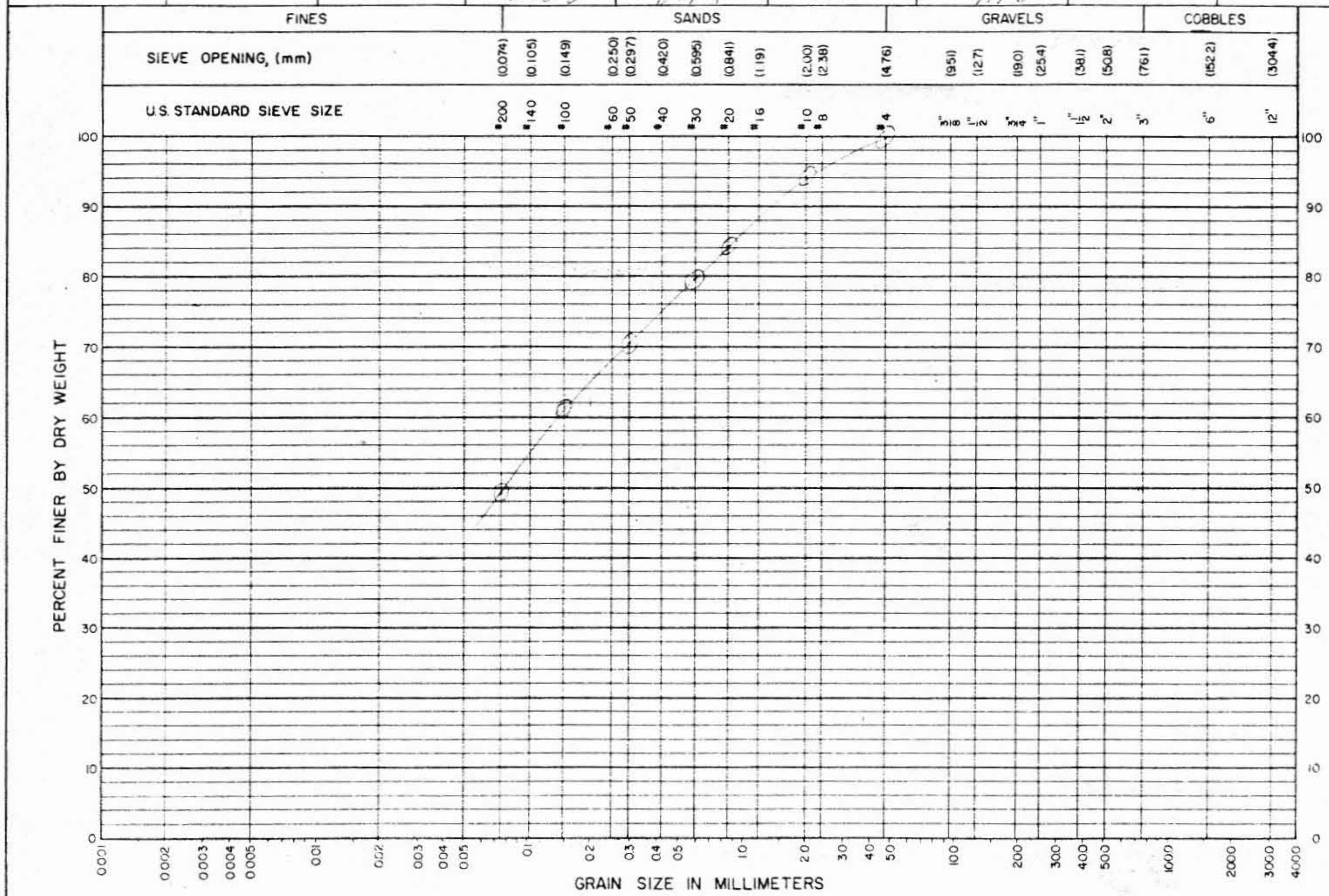
LABORATORY NO. 1

PROJECT and STATE		SAMPLE LOCATION
FIELD SAMPLE NO. 7	DEPTH 8.0'	GEOLOGIC ORIGIN
TYPE OF SAMPLE Disturbed	TESTED AT	APPROVED BY	DATE
SYMBOL SM-2	DESCRIPTION Fine Silty Sand	

Sample location: - P1 #2

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	$D_{MAX.}$	C_u	C_c
			0.08	0.14	1.0	4.76		



FINES
SANDS
GRAVELS
COBBLES
SIEVE OPENING, (mm)
(0.074) (0.105) (0.149) (0.250) (0.297) (0.420) (0.595) (0.841) (1.19) (2.00) (2.38) (4.76) (9.51) (12.7) (19.0) (25.4) (38.1) (50.8) (76.1) (152.2) (304.4)
U.S. STANDARD SIEVE SIZE
#200 #140 #100 #60 #50 #40 #30 #20 #16 #10 #8 #4 3/8" 1/2" 3/4" 1" 1 1/2" 2" 3" 6" 12"
PERCENT FINER BY DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
GRAIN SIZE IN MILLIMETERS
0.001 0.002 0.003 0.004 0.005 0.01 0.02 0.03 0.04 0.05 0.1 0.2 0.3 0.4 0.5 1.0 2.0 3.0 4.0 5.0 10.0 20.0 30.0 40.0 50.0 100.0 200.0 300.0 400.0 500.0 1000 2000 3000 4000

SPECIFIC GRAVITY (G_S)		ATTERBERG LIMITS						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI	%	%	11.7 %	g/cc pcf

REMARKS: Washed

48.21 % Passing #200

Form SCS 353
9-64

LABORATORY NO. 11

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

PROJECT and STATE: Vineyard Road Dam — SAMPLE LOCATION: 313+20 — 45' U.S.

FIELD SAMPLE NO.: 1 — DEPTH: El. 242 — GEOLOGIC ORIGIN:

TYPE OF SAMPLE: Disturbed — TESTED AT: Hopkinton — APPROVED BY: Ralph M Arrington — DATE: 30 Nov 70

SYMBOL: SM-2 — DESCRIPTION: Fine Silty Sand

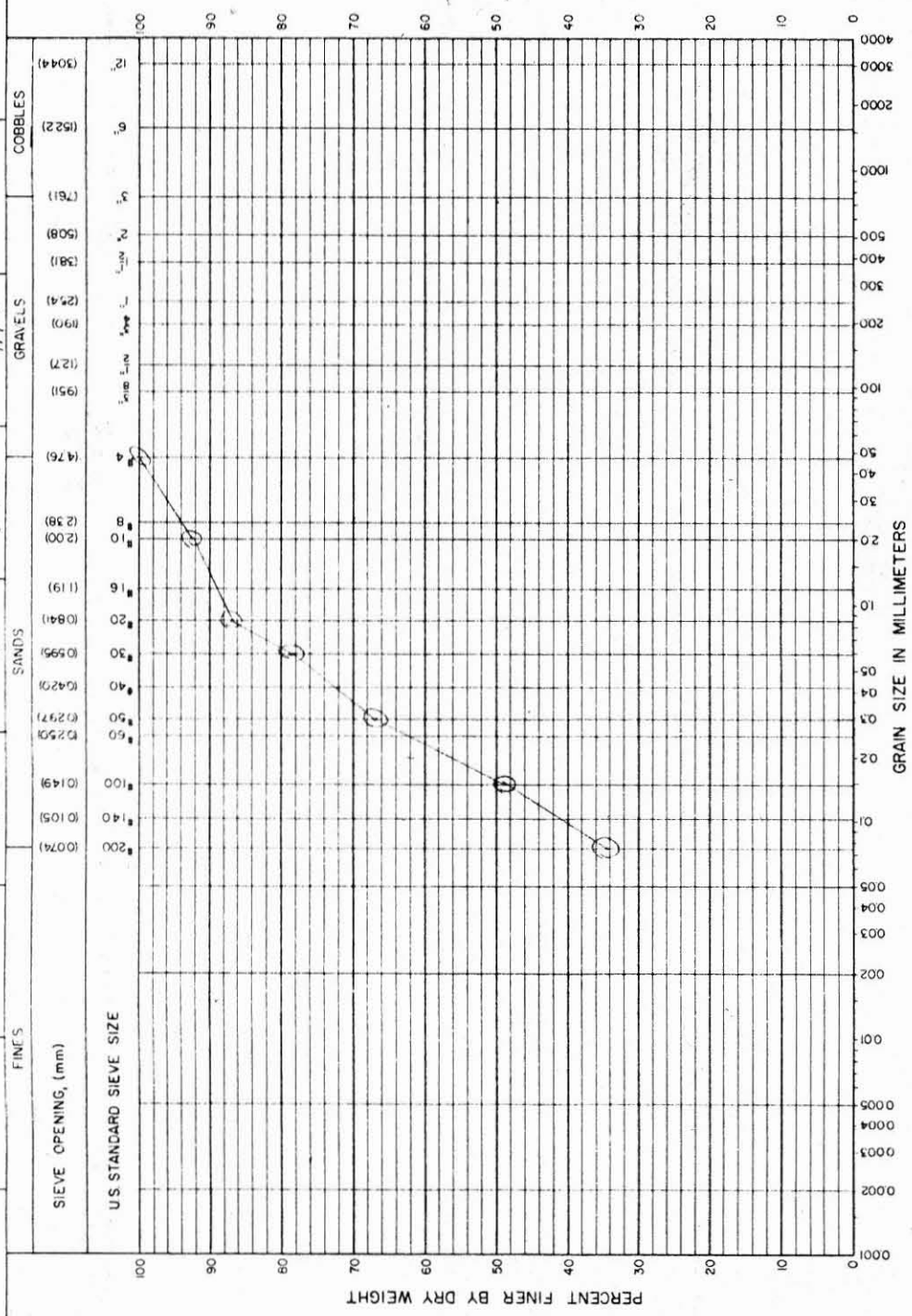
GRAIN SIZE DISTRIBUTION

D_{10} | D_{15} | D_{30} | D_{50} 0.15 | D_{60} 0.32 | D_{85} 0.20 | D_{MAX} 4.76 | C_u | C_c

FINES | SANDS | GRAVELS | COBBLES

SIEVE OPENING, (mm)

U.S. STANDARD SIEVE SIZE



SPECIFIC GRAVITY (G_s)

(-) #4 | (+) #4

ATTERBERG LIMITS

NATURAL MOISTURE: LL, PI

AIR DRY: LL, PI

OVEN DRY: LL, PI

SOLUBLE SALTS: %

SHRINKAGE LIMIT: %

UNDISTURBED CONDITION

MOISTURE: %

DRY UNIT WEIGHT: g/cc, pcf

MOISTURE %	DRY UNIT WEIGHT g/cc	DRY UNIT WEIGHT pcf
20.5		95.3

REMARKS: washed — High lime content

24.1% passing #200

Form SCS 353
9-64

MATERIALS TESTING REPORT

U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE

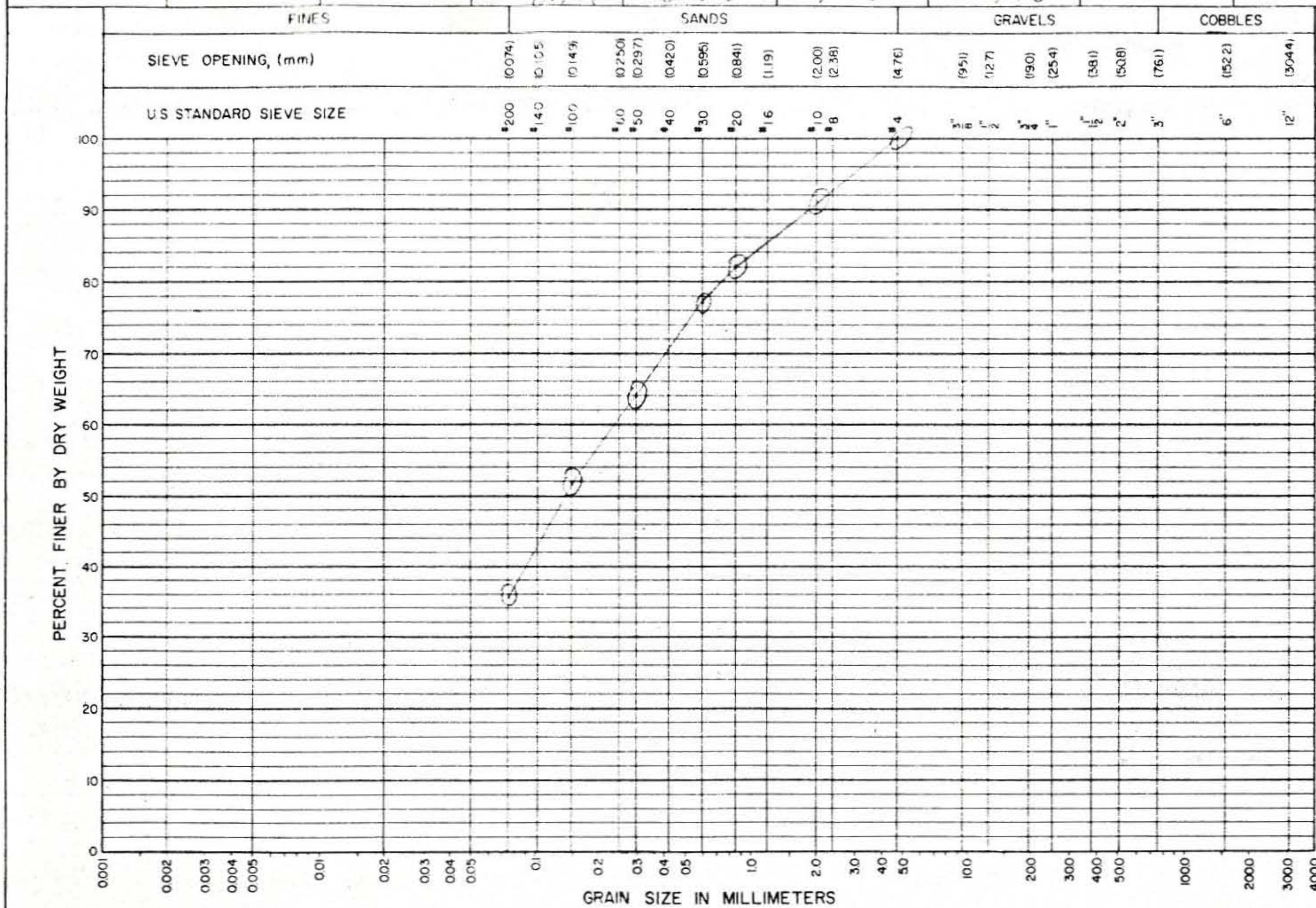
SOIL CLASSIFICATION

LABORATORY NO. 12

PROJECT and STATE: Vineyard Road Dam		SAMPLE LOCATION: 313+20 40' US
FIELD SAMPLE NO.: 2	DEPTH: El. 22.9	GEOLOGIC ORIGIN:
TYPE OF SAMPLE: Disturbed	TESTED AT: Apache Jct	APPROVED BY: Ralph M Armagh	DATE: 30 Nov 70
SYMBOL: SM-2	DESCRIPTION: Fine Silty Sand.	

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	D_{MAX}	C_u	C_c
			0.14	0.23	1.02	4.76		



FINES
SANDS
GRAVELS
COBBLES
SIEVE OPENING, (mm)
(0.074) (0.105) (0.149) (0.250) (0.297) (0.420) (0.595) (0.841) (1.19) (2.00) (2.38) (4.76) (9.51) (12.7) (19.0) (25.4) (38.1) (50.8) (76.1) (152.2) (304.4)
US STANDARD SIEVE SIZE
#200 #140 #100 #60 #50 #40 #30 #20 #16 #10 #8 #4 3/8" 1/2" 3/4" 1" 1 1/2" 2" 3" 6" 12"
PERCENT FINER BY DRY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
GRAIN SIZE IN MILLIMETERS
0.001 0.002 0.003 0.004 0.005 0.01 0.02 0.03 0.04 0.05 0.1 0.2 0.3 0.4 0.5 1.0 2.0 3.0 4.0 5.0 10 20 30 40 50 100 200 300 400 500 1000 2000 3000 4000

SPECIFIC GRAVITY (G_s)		ATTERBERG LIMITS N.P.						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI	%	%	15.4 %	g/cc 86.8 pcf

REMARKS: washed

35.58 % Passing #200

Form SCS 353
9-64

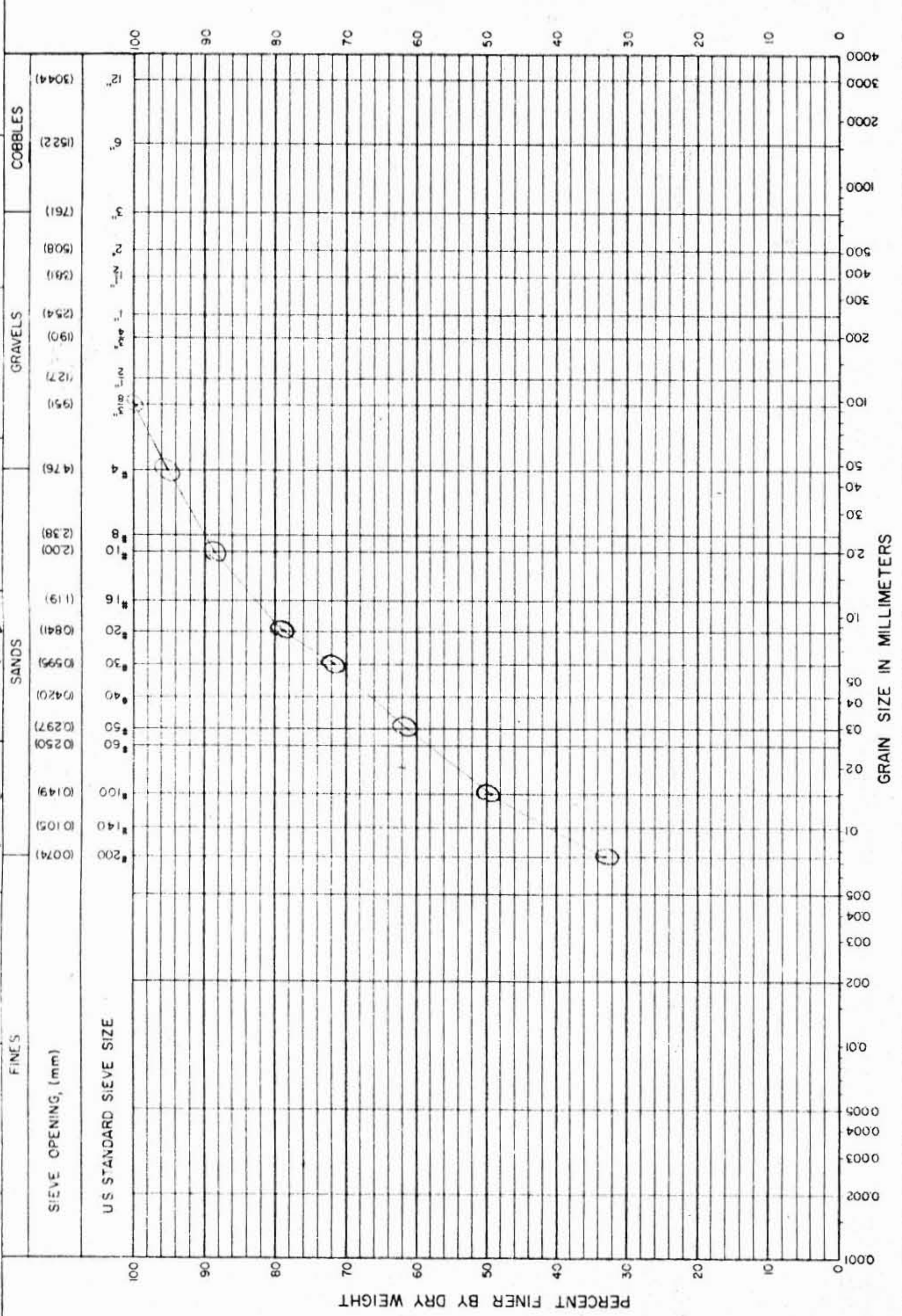
LABORATORY NO. 13

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

PROJECT and STATE: Vineyard Road Dam			SAMPLE LOCATION: 313+20 -55' U.S.
FIELD SAMPLE NO.: 3	DEPTH: 61.23	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE: Disturbed	TESTED AT: Anchorage	APPROVED BY: Ralph M. Amrgh	DATE: 30-Nov-70
SYMBOL: SM-1	DESCRIPTION: Coarse Silty Sand		

GRAIN SIZE DISTRIBUTION

C_c	
C_u	
D_{MAX}	9.51
D_{85}	1.60
D_{60}	0.26
D_{50}	0.15
D_{30}	
D_{15}	
D_{10}	



UNDISTURBED CONDITION	
DRY UNIT WEIGHT (g/cc / pcf)	85.5 pcf
MOISTURE	13.8 %

SHRINKAGE LIMIT	%
SOLUBLE SALTS	%

ATTERBERG LIMITS	N.P.
OVEN DRY	LL / PI
AIR DRY	LL / PI
NATURAL MOISTURE	LL / PI

SPECIFIC GRAVITY (G_s)	
(+) #4	
(-) #4	

REMARKS: washed
32.68% Passing #200

LONGITUDINAL CRACK
Sta 316+27

Looking north along longitudinal crack.
Note hose directing water into crack.

County water truck placing water into
longitudinal crack.

Test Pit # 1

Located 11 ft. upstream of ℄ at Sta 316+27
across a transverse crack - depth 3.5'

County back-hoe begins excavation.

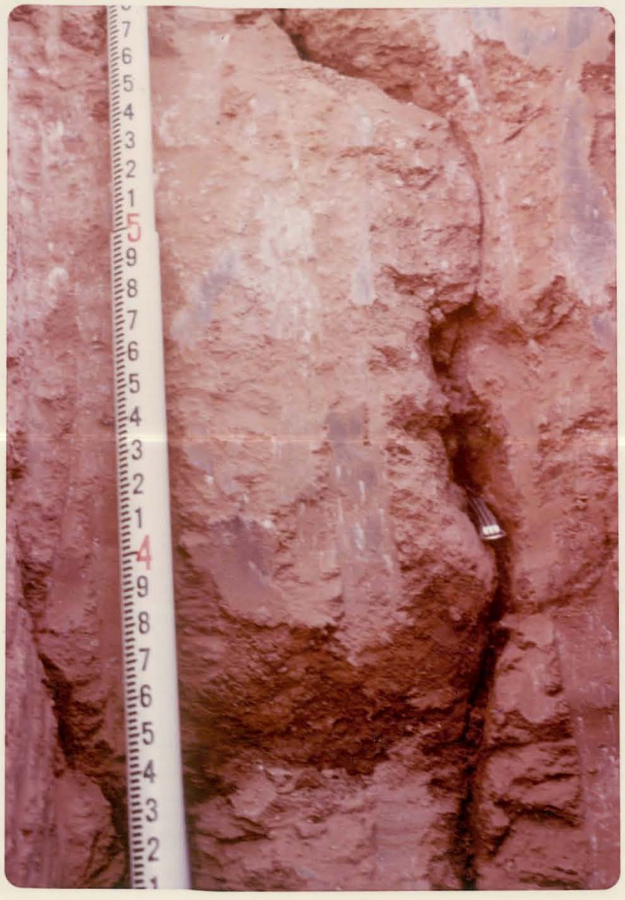
Upper portion of crack is dry and extends to surface.

Wetted portion extends to 3.0 ft.

Test Pit # 2
Located on top of dam and excavated across a longitudinal crack Sta 316+22 depth 8.0 ft.

Irregular alignment due to calcareous zones.

Increasing moisture content with depth.

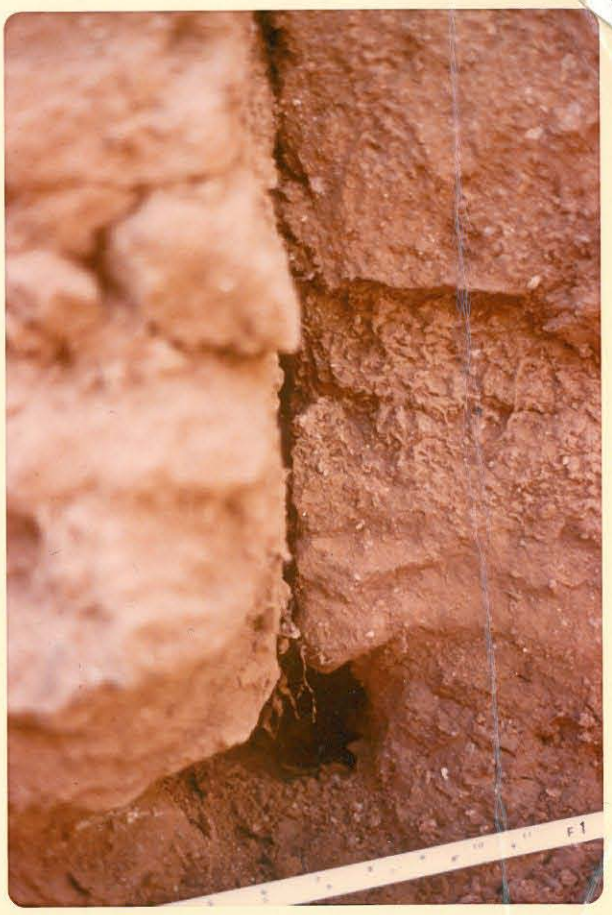


Crack ½" to ¼" open to top.

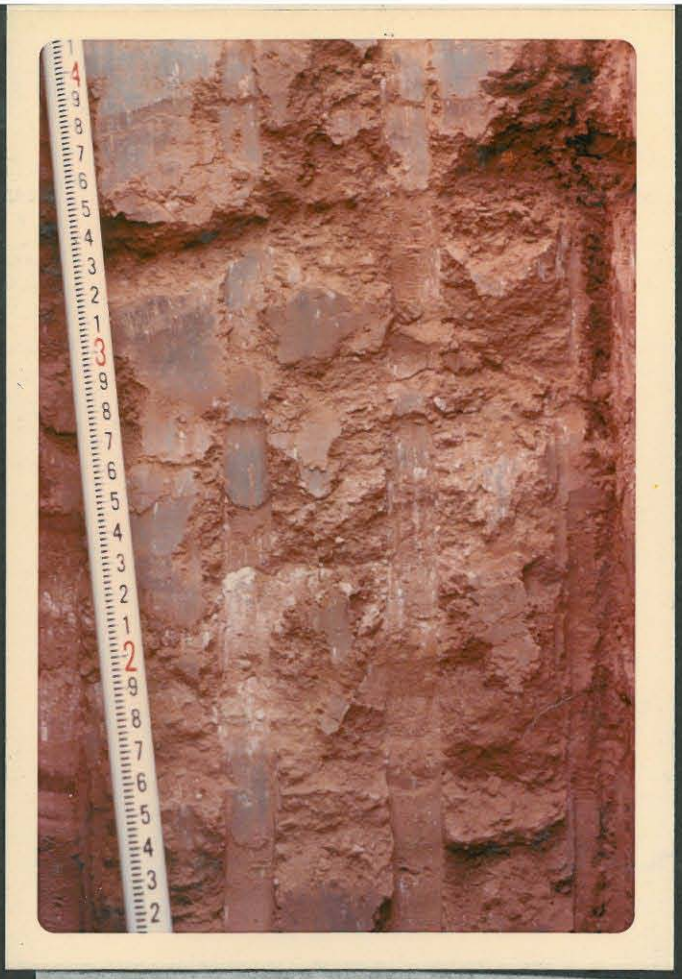
Crack closes at the 6.8' depth.

Test Pit # 3
Located on top of dam and excavated at junction of transverse and longitudinal cracks Sta 313+20.

Looking into transverse crack. Fine roots at 2.0 ft. depth - crack is ½" to 3/4" open.

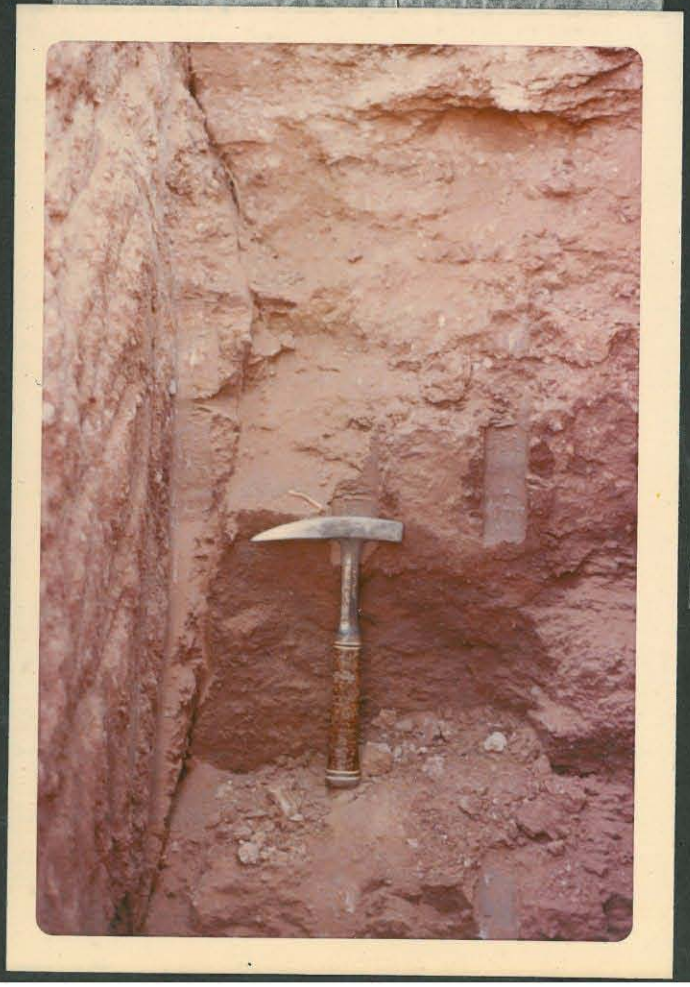


Looking into base of crack at soft horizonal layer 3.3 ft. depth. Hole eroded by piping to a down stream outlet.



Looking into south face of pit horizontal soft layer terminates. Note deepening longitudinal crack at right corner.

Looking into north face of pit near base of pit.



Crack across pit bottom at 6.0 ft. depth. Crack closed at 8.0 ft. depth.

Test Pit # 4
Trench down the upstream slope of Sta 313+20 across transverse crack network. Also includes upstream toe of embankment and cut off trench. Depth 3.0 ft. to 10.0 ft.

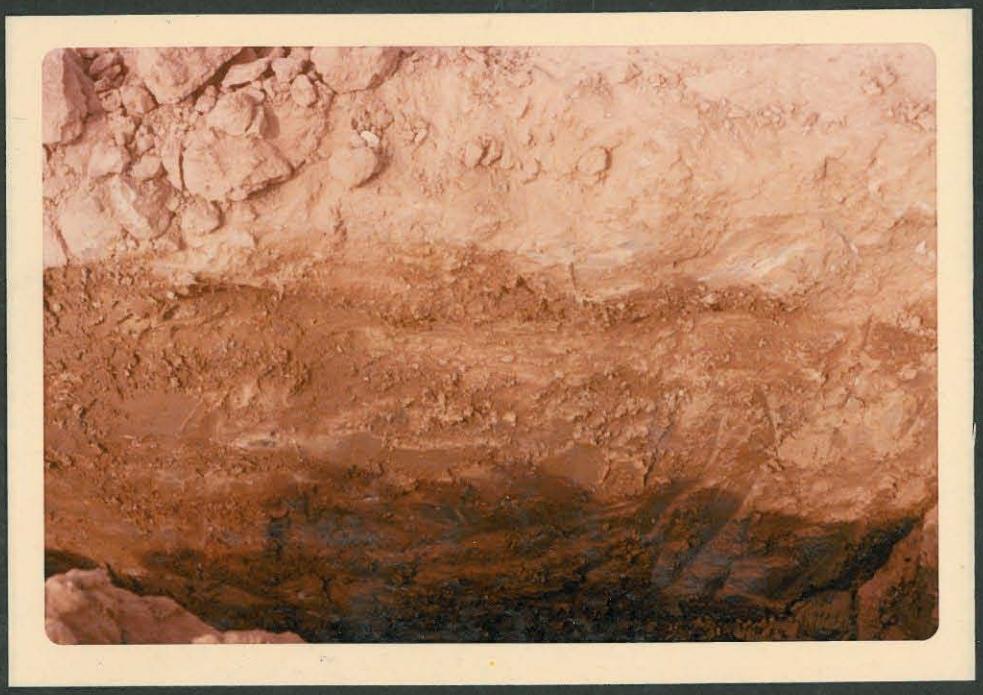
Surface crack - water outlet built up to retain head. Note other downstream outlets.

Lower right approximate foundation contact. Knife indicates moisture penetration zone

Looking east. Density test of foundation toe.

Test Pit # 5

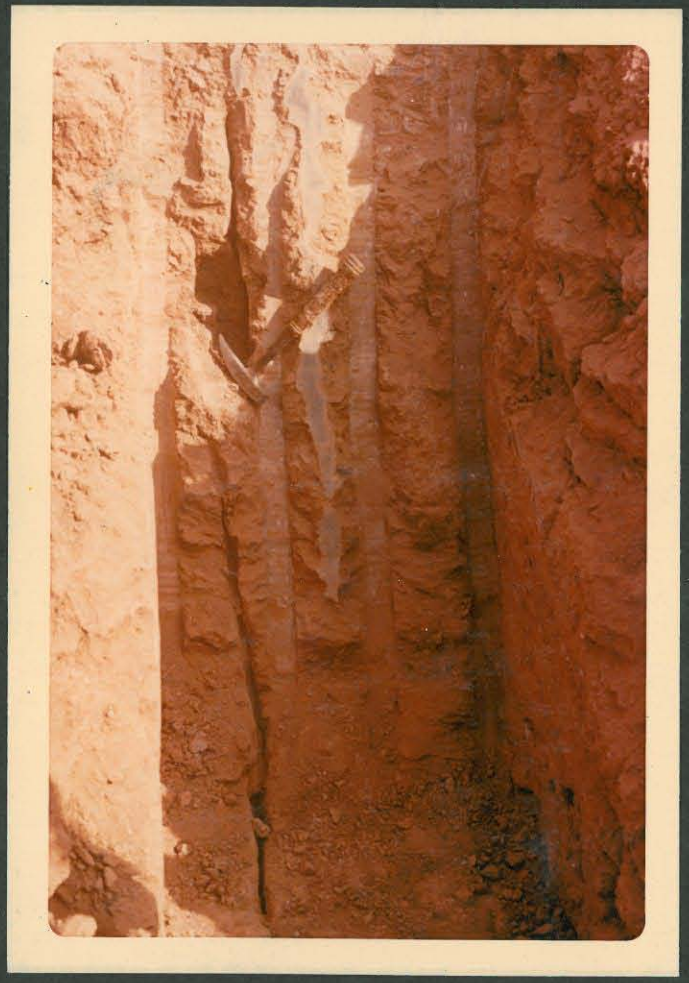
Located at junction of transverse and longitudinal crack on crest of dam Sta. 266+00. Depth 3.0 ft.



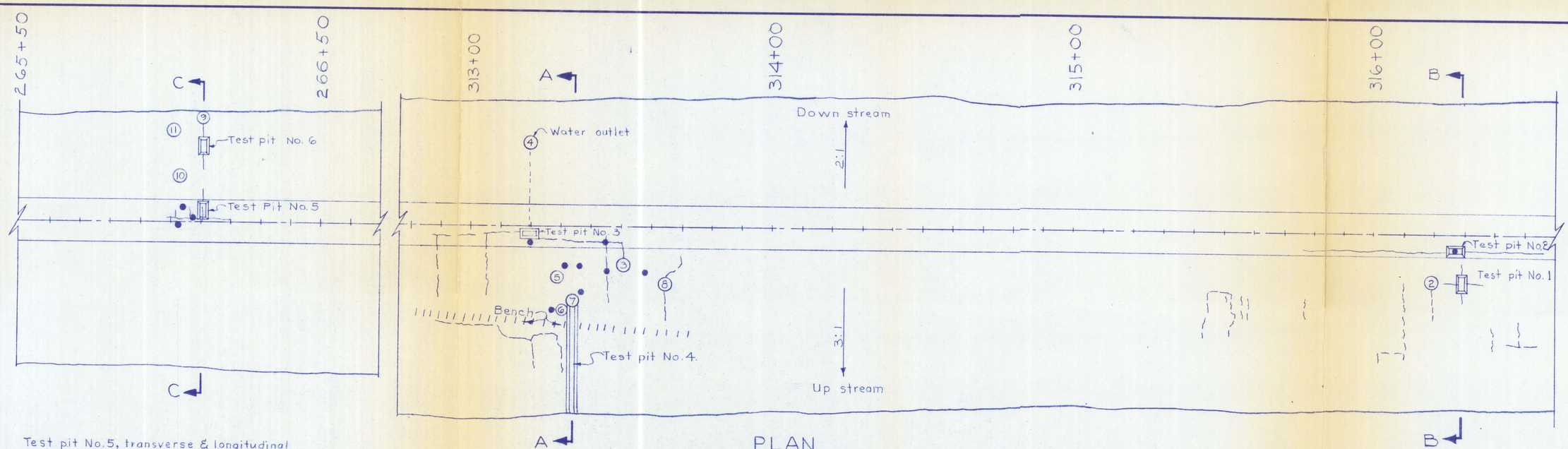
Wetted zone along transverse crack.

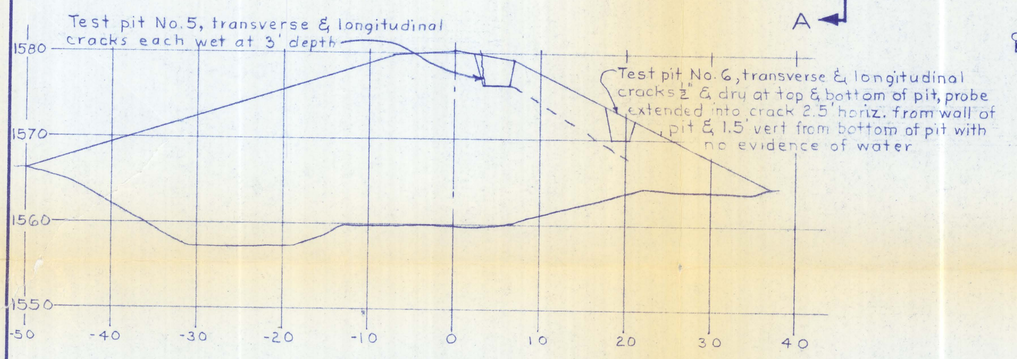
Test Pit # 6

ocated on downstream slope across
ansverse crack Sta. 266+00.

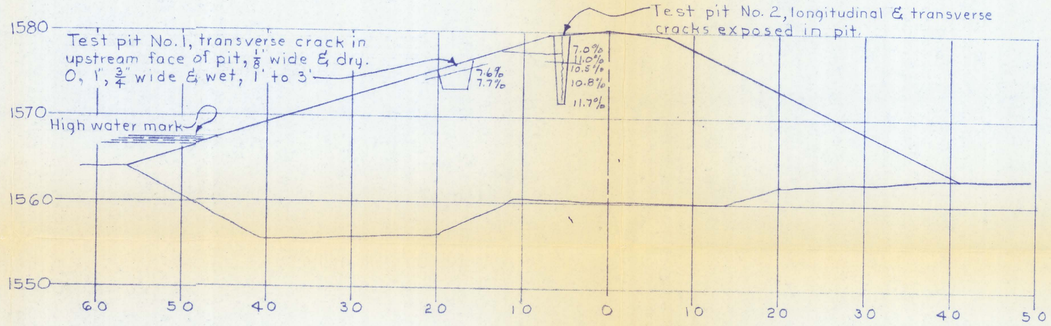


Unexposed crack 3/4" wide along downstream slope.
Note: Discontinuing @ 3.5' depth.

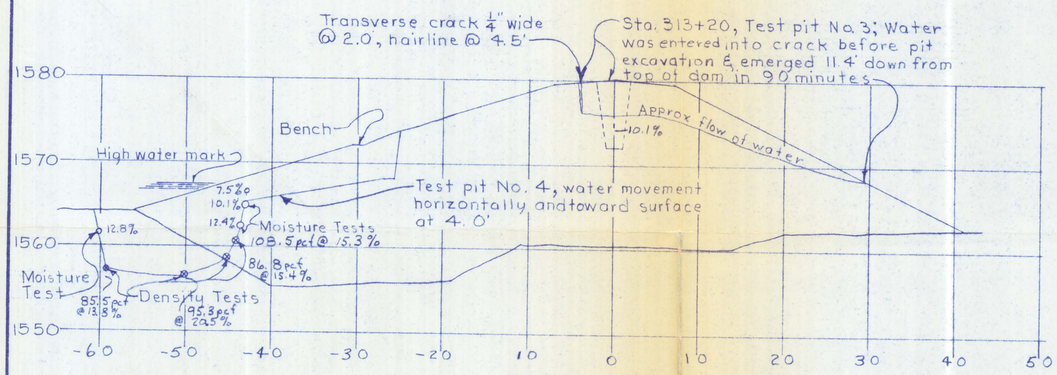




CROSS-SECTION C-C



CROSS-SECTION B-B



CROSS-SECTION A-A

Station	Water Intake Location	Water Outlet No., Location	Elapsed Time Minutes	VERTICAL DISTANCE IN FEET: Water Intake Below top Dam	Water Outlet Below top dam	Water Outlet Above 1/ High Water Mark
265+95	Top of dam	11 down stream	70	0.0'	10.0'	—
266+04	" " "	9 " "	45	0.0'	14.5'	—
266+10	" " "	10 " "	1	0.0'	2.0'	—
313+20	" " "	4 " "	90	0.0'	11.4'	0.0'
313+33	6.8' below top	5 up stream	1	6.8'	7.9'	4.1'
"	" " "	6 " "	45	6.5'	9.4'	2.6'
"	" " "	7 " "	10	6.8'	7.5' 2/	4.5' 2/
"	" " "	8 " "	20	6.8'	9.6'	2.4'
313+40	Top of dam	3 " "	1	0.0'	3.5'	8.5'
316+27	" " "	1 " "	60	0.0	2.0	10.0
"	" " "	2 " "	61	0.0	2.0	10.0

⌇ SURFACE CRACKS
• WATER INTAKE POINTS
① WATER OUTLET POINTS

NOTES:

1/ High water mark is 12 feet below top of dam.

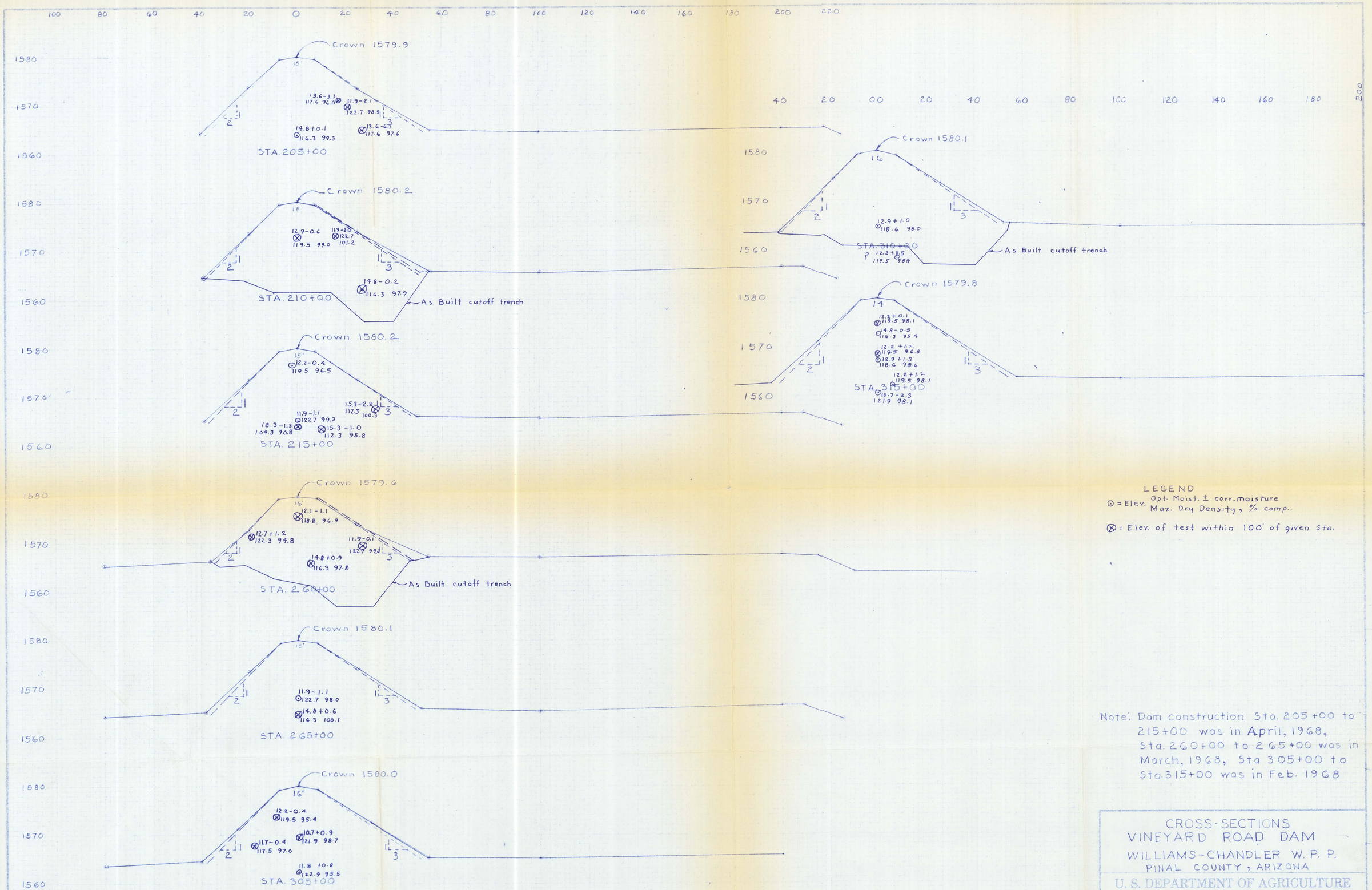
2/ Water appeared at 32 inch depth in pit, not at surface of dam slope

CRACK INVESTIGATION STUDY
VINEYARD ROAD FLOODWATER RETARDING STRUCTURE
WILLIAMS-CHANDLER W. P. P.
PINAL COUNTY, ARIZONA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed		Approved by	Ralph M. Drumheller
Drawn	G. HANLEY 4-29-71	Title	Asst. State Conservation Engr.
Traced		Title	
Checked		Sheet No.	1 of 5
		Drawing No.	72-1001

U.S. GOVERNMENT PRINTING OFFICE : 1966 O—781-124



LEGEND

⊙ = Elev. Opt. Moist. ± corr. moisture
Max. Dry Density, % comp..

⊗ = Elev. of test within 100' of given Sta.

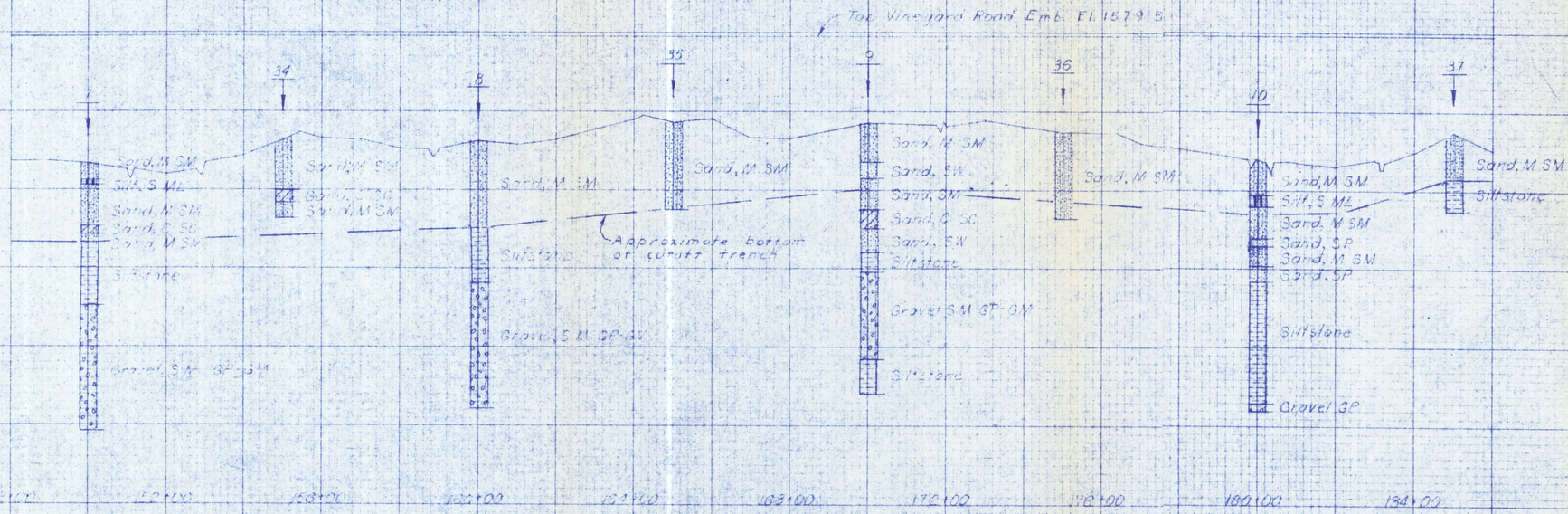
Note: Dam construction Sta. 205+00 to 215+00 was in April, 1968, Sta. 260+00 to 265+00 was in March, 1968, Sta 305+00 to Sta. 315+00 was in Feb. 1968

CROSS-SECTIONS
VINEYARD ROAD DAM
WILLIAMS-CHANDLER W. P. P.
PINAL COUNTY, ARIZONA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed
Drawn G. Hanley 10-28-70
Traced
Checked
Date
Approved by Ralph M. Arrington
Title Asst. State Cons. Engr.
Title
Sheet No. 2 of 5
Drawing No. 72-1001

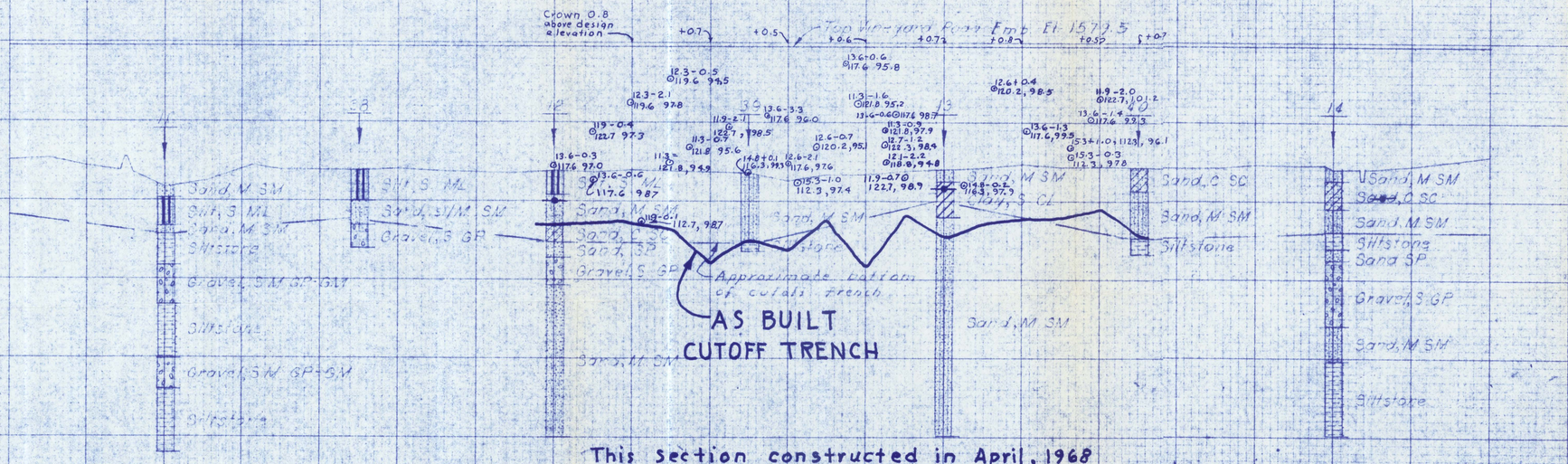
FORM SCS-315 (APRIL 1963)



LEGEND
OF FILL DENSITY & MOISTURE DETERMINATION

Sta. & El. of test → Opt. Moist. ± Corr. Moisture
⊙ Max. Dry Density, % Comp

● Known Elevations of Cut-off trench shelf



This Section constructed in April, 1968
This inspection date, Oct. 26, 1970

LEGEND

SYMBOLS
UNCONSOLIDATED MATERIAL

gravel	sand	silt	clay	cobbles, boulders
gravel, sandy	sand, gravelly	silt, gravelly	clay, gravelly	peat
gravel, silty	sand, silty	silt, sandy	clay, sandy	gypsiferous *
gravel, clayey	sand, clayey	silt, clayey	clay, silty	calcareous *
gravel, sand, silt	sand, silt, clay	organic silt	organic clay	

* to be added to Standard Symbol when significant amounts of dispersed gypsum or calcified zones are present in the section.

CONSOLIDATED MATERIAL
Sedimentary Rocks

shale	sandstone	limestone	chalk	coal
calcareous shale	calcareous sandstone	cherty limestone	marl	gypsum
sandy shale	shaley sandstone	sandy limestone	chert	conglomerate
siltstone	breccia	dolomite		

Metamorphic Rocks: quartzite, slate, gneiss, schist, marble, soapstone talc serpentine
Igneous Rocks: intrusive, extrusive, pyroclastic
Undifferentiated

Other Symbols
- ● hole logged only
- ◉ hole sampled
- dip and strike
- pit or trench

ABBREVIATIONS

aq	aquifer	fri	friable
cav.	cavities	lam	laminated
℄	centerline	mas	massive
con.	concretions	TD	total depth
US	undisturbed samples	v.	very
DS	disturbed samples	w/	with
dip	dipping	wea	weathered
frac	fractured	WL	(date) groundwater level on a specified date

TEST HOLE NUMBERING SYSTEM

Centerline of dam	1 - 99
Borrow area	101 - 199
Emergency spillway	201 - 299
Centerline of outlet structure	301 - 399
Stream channel	401 - 499
Relief wells	501 - 599
	601 - 699
	701 - 799

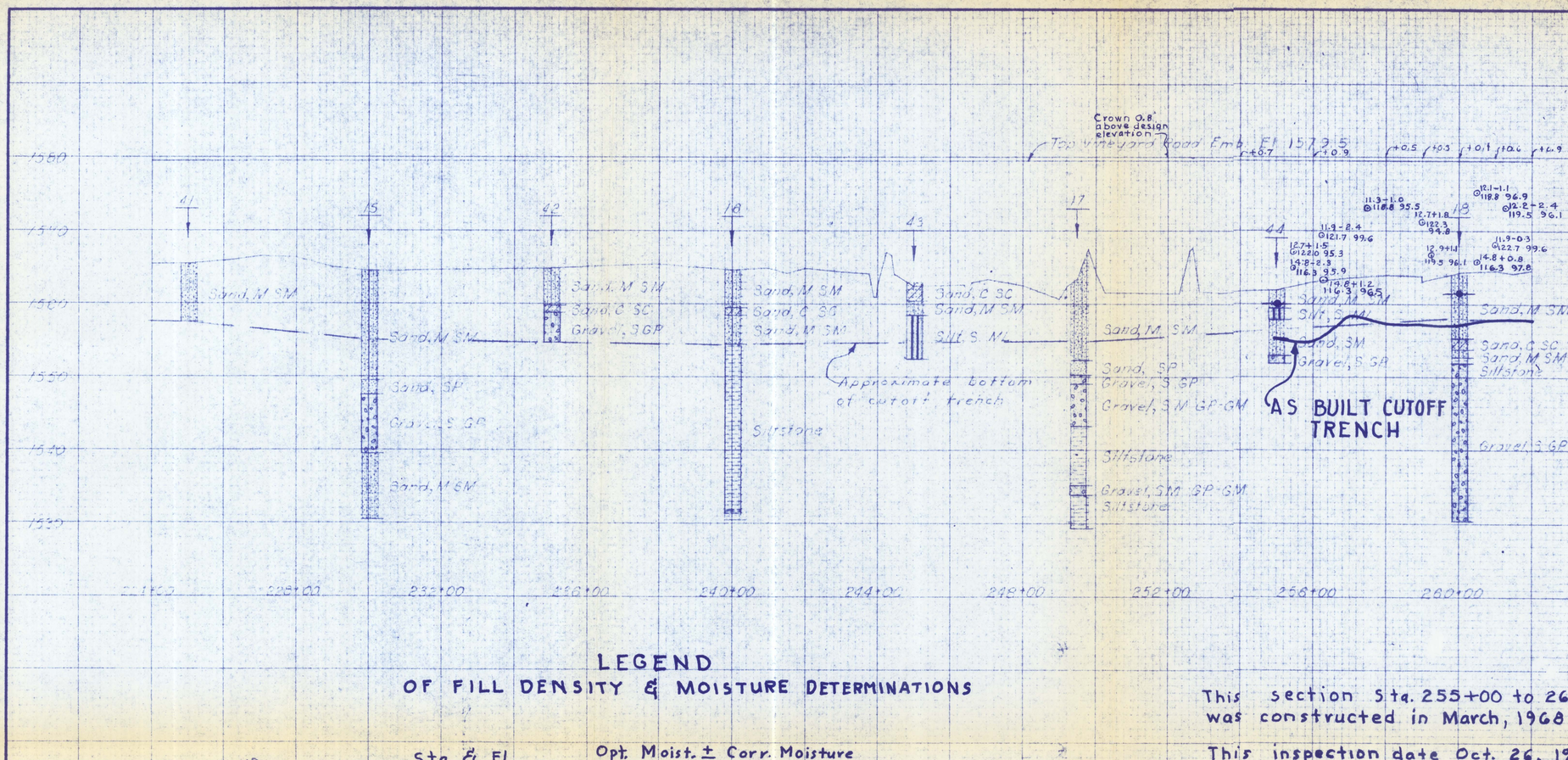
UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOLS

GW	Well graded gravels; gravel-sand mixtures
GP	Poorly graded gravels
GM	Silty gravels; gravel-sand-silt mixtures
GC	Clayey gravels; gravel-sand-clay mixtures
SW	Well graded sands; sand-gravel mixtures
SP	Poorly graded sands
SM	Silty sand
SC	Clayey sands; sand-clay mixtures
ML	Silts; silty, v. fine sands; sandy or clayey silts
CL	Clays of low to medium plasticity; silty, sandy or gravelly clays
CH	Inorganic clays of high plasticity; fat clays
MH	Elastic silts; micaceous or diatomaceous silts
OL	Organic silts and organic silty clays of low plasticity
OH	Organic clays of medium to high plasticity

PLAN AND PROFILES FOR GEOLOGIC INVESTIGATIONS
VINEYARD ROAD FLOODWATER RETARDING STRUCTURE
WILLIAMS-CHANDLER W.P.P.
PINAL COUNTY, ARIZONA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Investigated by	Date	Approved by	
W. F. MILDNER	1-12-65	Title	
Title		Checked by	
Title		Title	
Title		Sheet No. 3 of 5	Drawing No. 72-1001 ~~T-E-18724~~



LEGEND OF FILL DENSITY & MOISTURE DETERMINATIONS

Sta & El. of test → Opt. Moist. ± Corr. Moisture / Max. Dry Density, % Comp.

Known Elevations of Cutoff trench shelf

This section Sta. 255+00 to 265+00 was constructed in March, 1968

This inspection date Oct. 26, 1970

LEGEND

SYMBOLS

UNCONSOLIDATED MATERIAL

gravel; sand; silt; clay; cobbles, boulders
gravel, sandy; sand, gravelly; silt, gravelly; clay, gravelly; peat
gravel, silty; sand, silty; silt, sandy; clay, sandy; gypsiferous *
gravel, clayey; sand, clayey; silt, clayey; clay, silty; calcareous *
gravel, sand, silt; sand, silt, clay; organic silt; organic clay

* to be added to Standard Symbol when significant amounts of dispersed gypsum or calcified zones are present in the section.

CONSOLIDATED MATERIAL

Sedimentary Rocks

shale; sandstone; limestone; chalk; coal
calcareous shale; calcareous sandstone; cherty limestone; marl; gypsum
sandy shale; shaley sandstone; sandy limestone; chert; conglomerate
siltstone; breccia; dolomite

Metamorphic Rocks: quartzite; slate; gneiss; schist; marble; soapstone, talc, serpentine

Igneous Rocks: intrusive; extrusive; pyroclastic

Undifferentiated

Other Symbols

● hole logged only
◉ hole sampled
dip and strike
pit or trench

ABBREVIATIONS

aq aquifer	fri friable
cav. cavities	lam laminated
℄ centerline	mas massive
con. concretions	TD total depth
US undisturbed samples	v. very
DS disturbed samples	w/ with
dip dipping	wea weathered
frac fractured	WL (date) groundwater level on a specified date

TEST HOLE NUMBERING SYSTEM

Centerline of dam	1 - 99
Borrow area	101 - 199
Emergency spillway	201 - 299
Centerline of outlet structure	301 - 399
Stream channel	401 - 499
Relief wells	501 - 599
	601 - 699
	701 - 799

UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOLS

GW	Well graded gravels; gravel-sand mixtures
GP	Poorly graded gravels
GM	Silty gravels; gravel-sand-silt mixtures
GC	Clayey gravels; gravel-sand-clay mixtures
SW	Well graded sands; sand-gravel mixtures
SP	Poorly graded sands
SM	Silty sand
SC	Clayey sands; sand-clay mixtures
ML	Silts; silty, v. fine sands; sandy or clayey silts
CL	Clays of low to medium plasticity; silty, sandy or gravelly clays
CH	Inorganic clays of high plasticity; fat clays
MH	Elastic silts; micaceous or diatomaceous silts
OL	Organic silts and organic silty clays of low plasticity
OH	Organic clays of medium to high plasticity

PLAN AND PROFILES FOR GEOLOGIC INVESTIGATIONS

VINEYARD ROAD - FLOODWATER RETARDING STRUCTURE

WILLIAMS-CHANDLER W. P. P.

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Investigated by W. F. MILONER Date 7-12-65	Approved by
Title	Title
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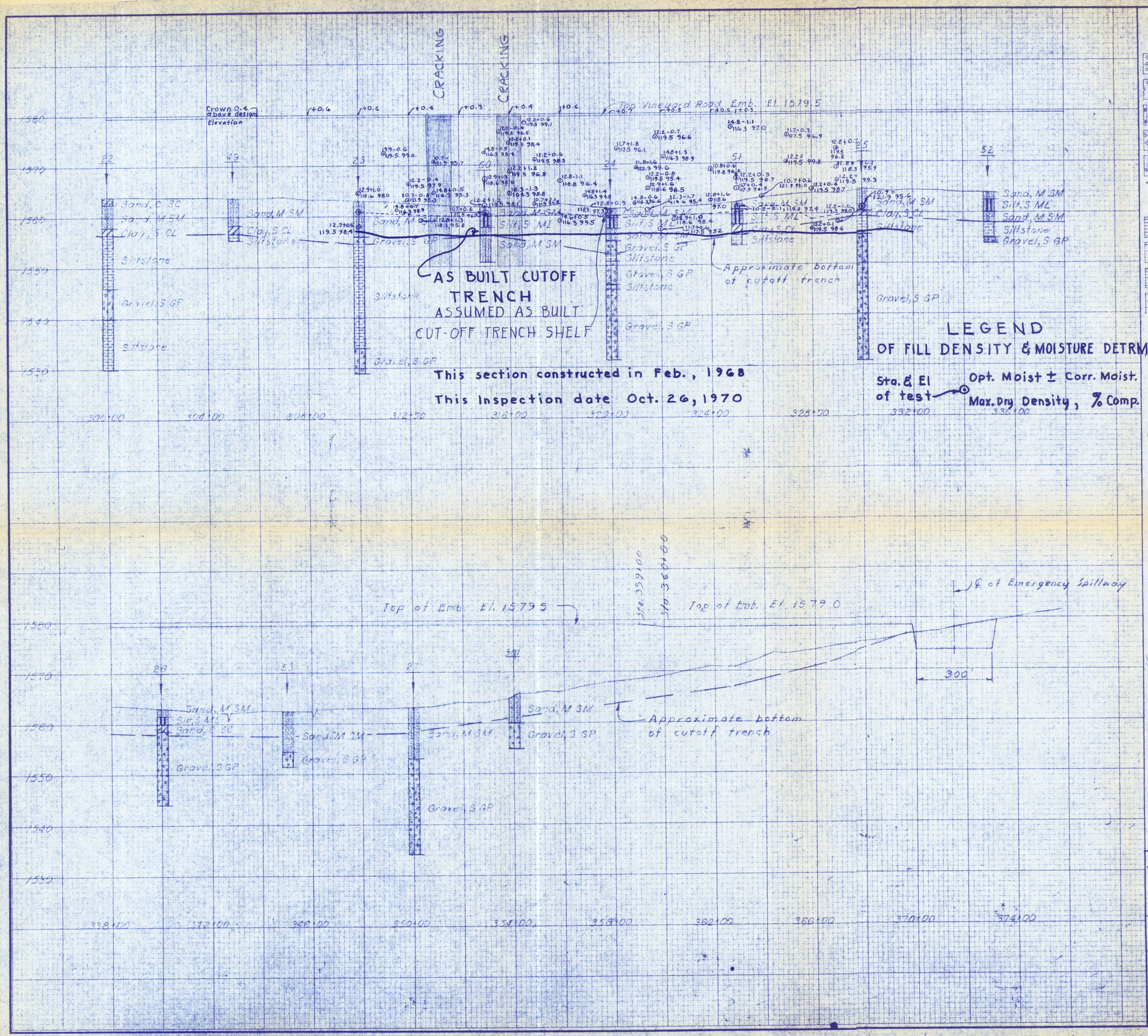
Title	Sheet No. 4 of 5 sheets; Drawing No. 72-1001 (~~7-E-18724~~)

ES 900 Sheet 4 of 4 SCS-350 (6-52)



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LEGEND

SYMBOLS

UNCONSOLIDATED MATERIAL

gravel	sand	silt	clay	cobbles, boulders
gravel, sandy	sand, gravelly	silt, gravelly	clay, gravelly	peat
gravel, silty	sand, silty	silt, sandy	clay, sandy	gypsiferous *
gravel, clayey	sand, clayey	silt, clayey	clay, silty	calcareous *
gravel, sand, silt	sand, silt, clay	organic silt	organic clay	

* to be added to Standard Symbol when significant amounts of dispersed gypsum or calcified zones are present in the section.

CONSOLIDATED MATERIAL

Sedimentary Rocks

shale	sandstone	limestone	chalk	coal
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sandy shale	shaley sandstone	sandy limestone	chert	conglomerate
siltstone	breccia	dolomite		

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Sheet No. 5 of 5
Drawing No. 72-1001 7-E-18724

ES 900 Sheet 4 of 4 SCS-35D (6-59)