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DESIGN REPORT

UNITED STATES DEPARTIMENT OF AGRICULATURE
SOIL CONSERVATION SERVICE

ARIZONA STATE OFFICE
DESIGN STAFF
PHOENIX, ARIZONA

December 1988

FINAL DESIGN REPORT

Job: Vineyard Road FRS Embankment and Drainfill Repair

Project: Williams-Chandler Water Protection and Flood Prevention

Location: Pinal County, Arizona

Authority: Public Law 566

Phase: Final Design

Summary

Original construction for the repair of Vineyard Road FRS embankment cracking was contracted and completed in 1982/1983.

During this time the contract was modified to construct four test cells for a study to determine the behavior of the cracked embankment under fully hydrostatic conditions. A final report of the study is being completed by the WNTC.

This design is being completed as a result of activities carried out during the above study. Work includes: 1) repair of the FRS embankment, 2) removal of test cell dikes at the test cell locations, and 3) installation of the vertical transition zone at the contaminated test cell locations and those areas where the original construction either did not fully encompass the vegetative outlet pipes, did not extend to the necesssary depth, or was not installed.

Description of Job

The project consists of repairing the FRS embankment due to the construction and investigation activities carried out during the contract for the 1983 crack study. Work includes: (1) reconstructing the embankment where a number of test pits and trenches were excavated to investigate the extent of seepage through existing cracks; (2) removal of piezometers, steel pipe casings, wires, etc., installed to monitor seepage; (3) removal of test cell dikes and wasting the material between the upstream toe of the FRS and the low flow channel; (4) removal of contaminated transition zone material and replacement with specified transition zone material; (5) extend the transition zone below all pipe outlets; and (6) install transition zone material in those reaches that were deleted in the original repair contract.

Design Objective

The design objective is to restore the structure embankment to the design lines and grades and complete the installation of the vertical transition zone as a measure against dam failure due to embankment cracking.

Basis for Design

1. Soil Mechanics Note No. 1.

2. As-Built Plans and Specifications for Construction of Vineyard Road FRS.

3 "Cracking of Dams in Arizona" 1978 Report.

4. Plans and Specifications for Repair of the Vineyard Road Floodwater - Retarding Structure, 1982.

5. Soil Mechanics Test Results - March 29, 1985, April 26, 1985, June 12, 1985.

6. Letter to Jack Stevenson, head, Engineering Staff, WNTC, from Ralph Arrington, SCS, Arizona, Dated July 2, 1985.

7. Letter to Ralph Arrington, SCS, Arizona, from Jack Stevenson, Head Engineering Staff, WTNC, dated July 15, 1985.

8. Trip Report, September 27-30, 1988 by Leland M. Saele, WNTC.

9. Minutes to Preliminary Design Presentation meeting, October 4, 1988.

10. Letter to Ralph Arrington, SCS, Arizona, from W. R. Evans, Head, Engineering Staff, WTNC, dated January 17, 1989.

Embankment Design

The test trench and gully, at test cells No. 1 and No. 3 respectively, will be spot repaired by removing the disturbed material and replacing it with compacted earthfill. The side slopes of the excavated area will be no steeper than 1:1 to ensure proper bonding between the surfaces of embankment in place and the earthfill to be placed.

The test trench at test cell No. 3 which was cut transverse through the dam will be spot repaired by removing the disturbed material and replacing it with compacted earthfill. The side slopes of the transverse excavated area will be no steeper than 3:1 (horz. to vert.) to ensure proper bonding between the surfaces of embankment in place and the earthfill to be placed.

Multiple test pits and trenches at test cells No. 2 and No. 5 will be repaired by breaching the FRS to a specified depth with 3:1 abutment slopes and replacing with compacted earthfill.

Defaced upstream slopes of the FRS embankment at test cell locations No. 2 and No. 5 will be repaired by reconstructing an approximate three (3) foot layer of earthfill to original lines and grades.

Earthfill will be obtained from required excavations.

Construction details for compaction and moisture of earthfill and drainfill will be the same as used in the original contract. Approximately 85% of the transition zone was completed under the original repair contract.

The extent and location of embankment cracks along the trench faces will be mapped prior to installing the drainfill.

Environmental Considerations

The earthen dikes used to impound water at the test cell locations will be removed and wasted between the low flow channel and the upstream toe of the FRS. The sponsors stated that future O&M costs outweighed the benefits of keeping them in place.

Specifications

Excavation: Review and discussion for repair procedures on breached sections of the dam took place with the FCD and ADWR on 10/4/88. It was recommended that we specify once the contractor breaches a section of the dam that his scheduled work continue at this site until the embankment repair has been completed.

Earthfill: The sponsors have been in agreement with the SCS that O&M would not be performed within the test cell locations until after final repair. As a result, Subsidiary Item, Gravel Cover, has been included to repair the FRS embankment slopes from the rill erosion which has occured since the time of the crack study.

Contractor Inspection: Because of the type of work and small quantity of material involved, contractor inspection will not be used.

Water for Construction: Due to the small quantity of water that will be needed to perform the items of work water has been included as a subsidiary item to the bid item which it will be used, namely earthfill, structure backfill, and drainfill.

Construction Schedule

The contractors construction schedule should be flexible to avoid breaching the dam during unusual or threatening weather conditions.

An emergency action plan should be prepared by the sponsors in case of an emergency condition.

Construction Review

A SCS Geologist will examin and map embankment cracks along the trench side walls of the FRS. Timely notification of the construction activities will need to be given to the geologist such that the contractors delay will be minimized.

A shield will be used for the mapping of the embankment cracks within the trench. It is anticipated that the shield unit will be moved by winches or towed with cables by construction equipment. Keep a safe distance from taut cables.

Persons working above the shield should be aware of those working in the trench. Scrape your feet before walking onto the platform and avoid kicking dirt and rocks into the trench.

ADWR will inspect the trench excavation and foundation before backfill operations. Coordination for timely inspections will be needed.

Recommended: Donald E. Paulus 2/23/89
Donald E. Paulus, State Design Engineer — Date

Approved: Ralph M. Arrington 2-23-89
Ralph M. Arrington, State Conservation Engineer — Date

DESIGN/CORRESPONDENCE

2/27/89
by DP

NEYARD RD FRS

Distribution of Final Design:

WNTC:	Design Folder	2 copies
	Construction Drawings	4 sets
	Extra - Specs	1 copy
FCD:	Design Folder	2 copies
	Construction Drawings	5 sets
	Extra Specs	2 copies
WR	Design Folder	1 copy
	Construction Drawings	3 sets
	Extra Specs	1 copy
*NRCD	Construction Drawings	2 sets
	Specs	2 copies
	Design Report	2 copies
AZ S.O.	Construction Drawings	1 set

TOTALS	- Design Folder (3-ring binder, tab sections)	5 copies
	- Construction Drawings	15 sets
	- Extra Specs	6 copies
	- Extra Design Report	2 copies

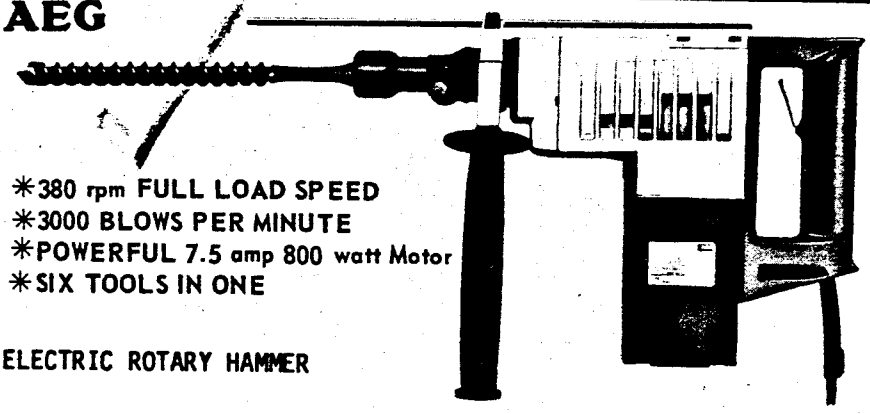
EQUIPMENT NEEDS FOR VINEYARD REPAIR.

see attached descriptions

Total Cost = $2252.33

A Sanders
2/15/89

AEG



- ✳380 rpm FULL LOAD SPEED
- ✳3000 BLOWS PER MINUTE
- ✳POWERFUL 7.5 amp 800 watt Motor
- ✳SIX TOOLS IN ONE

ELECTRIC ROTARY HAMMER

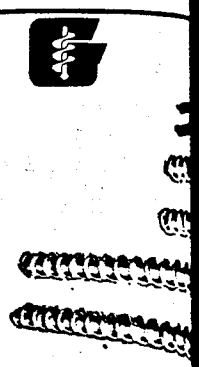
An easy to use rotary hammer that is six tools in one. It is designed for drilling, rotary hammering, hammering, chipping, chiseling, and scaling. Vibrations and recoils are absorbed by the specially designed percussion body. A safety clutch protects the operator should the bit jam. Size: 16" x 10" x 3-1/4". Weighs 13-1/2 lbs. Complete with metal carrying case, fully adjustable side handle and depth gauge. Shipping weight 29 lbs.
K 2060 $ 749.65

READY-TO-SAMPLE KIT

This kit includes: one Miners K2060 electric rotary hammer; one 1500 watt portable generator; one 1" x 16" carbide drill bit; one bull point; one 1" wide cold chisel; one 2" wide sealing chisel; and 250 feet of 12 gauge 3 wire electric cord. Shpg wt 180 lbs.
K 2059 $ 1872.00

ACCESSORIES FOR ELECTRIC ROTARY HAMMER

ITEM	STOCK NUMBER	SHIPPING WEIGHT	PRICE EACH
Carbide drill bit, 1" x 16"	K 2062	2 lbs.	$ 49.60
Bull point	K 2063	2 lbs.	$ 18.10
Cold chisel, 1" wide	K 2064	2 lbs.	$ 18.10
Scaling chisel, 2" wide	K 2065	3 lbs.	$ 29.10
Cord, electric, 3-wire, 12-gauge, 50 feet, each	K 2061	6 lbs.	$ 61.40
Cord, electric, 3-wire, 12-gauge, 250 feet, each	K 2066	65 lbs.	$ 283.45



A.) AUGER POWE

A lightweight, capacity and ve unit features a positive control 2 cycle, air co 22-11/16 x 12-1 lbs. (Use with th
DO 500

B.) 12 FOOT DR

Use with the DO50 depth of 12 fee auger with carb augers; an auge inserts. Shipping
DO 501

MICROSPLITTER

A precision riff granular material exacting quantit Top hopper and c wide chutes to s of stainless steel with 2 pans. Size: weight 5 lbs.

K 2022

ROCK PICKS TO MEET VARIOUS SAMPLE COLLECTING NEEDS!

ROCK PICKS

Estwing

ESTWING LONG HANDLE PICK

The 16" long handle and 22 oz. pick head aid in providing extra leverage and prying power. Forged one piece head and handle. Blue nylon-vinyl cushion grip. Shipping weight 3 lbs.

AO 640 $ 27.56
WITH SWING HOLSTER (D1679)
AO 641 $ 45.35

LEATHER GRIP ROCK PICK

Pointed tip rock pick, 22 ounce head. Polished head and shank. Brown laminated leather grip. Shipping weight 3 lbs.
PICK ONLY
AO 633 $ 24.30
PICK WITH SWING HOLSTER (D1679)
AO 635 $ 41.68

Estwing delivery time during 1988 has extended from an average of 155 days to in excess of 198 days, resulting in unanticipated "stock out" on the popular Hoe Pick and Long Handled Rock Pick. Estwing reports they are making production facility adjustments to improve the situation and assure a more prompt availability of these items.

POINTED TIP ROCK PICK

22 ounce head. Polished head and shank. Blue nylon-vinyl grip. Shipping weight 3 lbs.
PICK ONLY
AO 662 $ 24.84
PICK WITH SWING HOLSTER (D1679)
AO 663 $ 42.54

14 ounce head. Polished head and shank. Blue nylon-vinyl grip. Shipping weight 2 lbs.
PICK ONLY
AO 661 $ 24.00
PICK WITH SWING HOLSTER (D1679)
AO 672 $ 41.43

CHISEL EDGE ROCK PICK

20 ounce head. Polished head and shank. Blue nylon-vinyl grip. Shipping weight 3 lbs.
PICK ONLY
AO 660 $ 25.28
PICK WITH SWING HOLSTER (D1679)
AO 671 $ 42.93

12 ounce head. Polished head and shank. Blue nylon-vinyl grip. Shipping weight 2 lbs.
PICK ONLY
AO 664 $ 24.20
PICK WITH SWING HOLSTER (D1679)
AO 673 $ 41.61

(SWING HOLSTER DESCRIBED ON PAGE 42.)

WOODEN HANDLE GEOLOGIST'S PICK

A finely crafted pick with the l and feel of quality. The pick h is 7-1/4" from hammer to pick poi with a 3/4" hammer surface. The p head is of chrome-plated steel. hard-wood handle measuring 13" length provides a slightly contour grip for easier rock chipping a breaking. Weighs 22 oz. Shippi weight 3 lbs. Made in Spain.
AO 545 $ 22.

MINING PICK

This Pick/Mattock is designed for use in breaking and trenching operat The pick head measures 18" from ma to pick point, with a 2" wide ma blade. The hardwood handle is 36" and specially designed to match the head. Weighs 5 lb 3 oz. Shipping we 7 lbs. Pick head made in Spain.
AO 695 $ 1

HOE PICK

Lightweight, all steel, easy to carry 4 lb. tool can be used as pick, hoe, wedge, and prybar. Forged steel head. Blue nylon-vinyl grip. Length 26". Estwing temper. Shipping weight 7 lbs.
AO 670 $ 35.80

FIBERGLASS HANDLE GEOLOGIST'S PICK

A well constructed rock pick featuring a fiberglass handle, a comfortable contoured grip, and a 25 ounce weight. The pick head is 7¼" from hammer to pick point, with a 3/4" hammer surface. Fiberglass handle with cushioned grip is 10¾" long. Shipping weight 3 lbs. Made in West Germany.
AO 548 $ 35.30

SUBJECT: VINEYARD FRS REPAIR
IN-HOUSE REVIEW
Final Design

2/10/89

TO: Dave Lambson
Ralph Arrington
John Sullivan
John Harrington

Please review the enclosed information by Feb. 17, 1989. Also schedule yourself to attend a review meeting for Feb 17th at 8AM to discuss the project and review comments. If you are unable to attend the meeting please let me know the closest date & time you will be available.

Don Paulus

Enclosed:
- Final Design Report
- Bid Schedule
- Specifications
- Cost Estimate & performance rates
- Inspection Plan
- Construction Schedule
- Construction Drawings

United States Department of Agriculture

Soil Conservation Service

West National Technical Center
511 NW Broadway, Room 248
Portland, Oregon 97209-3489

Subject: ENG - Vineyard Road Dam Repair, Drain Outlet Design Criteria

Date: January 24, 1989

To: Ralph Arrington, State Conservation Engineer, SCS, Phoenix, Arizona

File code: 210-13D

In response to your request for further documentation of why it is technically possible to change the original design requirements for outlets from the central transition, we offer the following discussion. This discussion supplements previous reasons listed in your letter of July 2, 1985, and our agreement with those reasons in a letter dated July 15, 1985.

Many reports, by numerous investigators, show the cracking at this site to be dynamic. Most of these reports indicate desiccation is presumed to be a major cracking mechanism. This is supported not only by the various reports but by the crack pattern observed at Vineyard Road.

Desiccation cracks usually have an orthogonal polygon pattern. This pattern was observed at Cell No. 2 and recorded by video tape. Consequently, some of the cracking at Vineyard Road is of a type that is caused by volume change behavior and will be very susceptible to moisture change effects.

Soil volume change behavior can be expressed as a function of stress state variables and material properties. Two constitutive relationships exist that represent this behavior. One relationship is based on the soil structure while the other is based on the water phase. The first of these relationships is referred to as elastic equilibrium while the second represents plastic equilibrium.

A study of these two relationships indicates the mode of failure of a desiccated soil is better represented by elastic equilibrium than by plastic equilibrium. Results of experimental work by Fredlund and Jacky Tak Kwai Lau, at the University of Saskatchewan, has shown this to be the case. Consequently, the process does not result in shearing stresses at the particle contacts but rather particle separation due to the pulling force of the matric suction pressure.

Since desiccation cracking is the result of soil volume reduction, elastic equilibrium analysis should represent the physical behavior of cracking at Vineyard Road FRS. Consequently, a reversible process prevails and results in a direct relationship between an increase in water volume and a reduction in crack width. Therefore, any introduction of water will cause expansion of the soil with a corresponding reduction in crack widths. With the closing of the cracks, water movement from the surface of the dam to any point in the

interior of the embankment will be reduced to a hydraulic conductivity with a conductivity value near that of the compacted soil at saturation. The time necessary for the swelling to occur, based on field trial observations, is nearly immediate. This is further supported by the high matric suction associated with soils comprising Vineyard Road. The higher matric suction value will result in a faster movement of the water into the soil. Most desiccation cracks are initiated at a matric suction of less than 10 kPa (1.45 psi) for most soils. Due to the silty nature of these soils at Vineyard Road FRS, the suction value would be greater.

Once the crack has closed and the soil is saturated, the rate of water movement is less than the reservoir drawdown time. As the field trial has shown, a saturation time in excess of 20 days resulted in a water penetration of less than 30 cm (12 inches). This means that water in any appreciable amount, even at the maximum possible depth, never reached the upstream edge of the central transition zone.

To theoretically illustrate the effect of cracking due to desiccation, actual crack depths were compared with critical depths calculated using the following equation:

$$dc = \frac{(Dw)\ (Fw)\ (\tau w)\ (E/H)}{(\mu)\ (\tau)}$$

Where: dc = theoretical crack depth
Dw = depth of water table
Fw = matric suction profile factor
τ = total unit weight of soils
τw = total unit weight of water
μ = Poisson's ratio
E = elastic modulus with respect to total stress $(\sigma - u_a)$
H = elastic modulus with respect to matric suction $(u_a - u_w)$
u_a = pore air pressure
u_w = pore water pressure
σ = total stress

The results of these comparisons show that the depth of cracks measured agree very well with those calculated. For example, a maximum crack length of 21.5 feet was measured. Using the elastic equilibrium equation and the follwoing values to represent an average soil condition at the imposed stress level, a crack length of approximately 20.5 feet was computed.

$F_w = 1.0$ $\tau = 17.99$ kN/m^3 (114.5 pcf) $D_w = 112.78$ m (370')
$\mu = 0.3$ $\tau_w = 9.08$ kN/m3 (62.4 pcf) $D/B_m = 0.133$

Where: $E/H = D(1+\mu)\ (1-2\mu)/3B_m(1-\mu)$
D = constrained modulus with respect to the net total stress $(\sigma - \mu_a)$
B_m = bulk modulus

$$dc = \frac{(112.78)\ (1)\ (9.08)\ (0.133)\ (1 + .3)\ (1 - 2(.3))}{(0.3)\ (17.99)\ (3)\ (1 - 0.3)} = 6.25\ m\ (20.5\ ft)$$

Other soil conditions and stress levels can result in depths of cracks similar to those measured. The D/B_m values are based on data from the literature and not actual data. However, the value used is representative for soils found at Vineyard Road.

A further indication of desiccation is the results of COLE and other shrinkage tests which show the majority of the soils have a high potential for shrink-swell.

Sample Type	USCS	LL	PI	SHRINKAGE LIMITS - Range				
				COLE (5)	SL (%)	SR (g/cc)	VC (5)	LINEAR (%)
Embankment	CL	29	13	7.98	13.7	1.88	25.9	7.4
	CL	27	11	8.24	13.3	1.90	22.8	6.6
Foundation	CL	26	8	4.69	12.5	1.73	14.75	4.5
	SC	38	13	9.55	13.1	1.75	31.52	8.7

Where:

USCS = the Unified Soil Classification System
LL = the liquid limit of the soil
PI = plastic index of the soil
COLE = the Coefficient of Linear Extensibility
SL = shrinkage limit
SR - shrinkage ratio
VC = volumetric shrinkage; $(100([COLE + 1]^3 - 1))$.
LINEAR = Linear shrinkage computed from the following equation $[1 - (100/V_s + 100)^{1/3}]100$

Where:

V_s = volumetric shrinkage; $(100([\%w - SL])SR)$.
%w = percent moisture of SL test

The results of clay mineralogy tests indicate all soils analyzed had moderate amounts of clay mica and smectite and small amounts of kaolinite. Since this represents a mixed mineraology, how the soils will shrink-swell is governed mostly by the smectite. Consequently, shrink-swell may be higher than anticipated. Other index tests, like AI (Activity Index), indicate some intermediate value for shrink-swell potential for these soils.

All of the previous discussion shows that these soils will experience crack closure. Unless the crack is maintained open by hydraulic fracturing, closure will occur each time there is an increase in moisture content. Closure will occur even if the crack is the result of differential settlement or collapse. In those cases it may not close completely due to swelling but as the plastic equilibrium equation shows the crack walls will collapse due to loss of

stability upon saturation. This collapsing compliments the effects of the swelling. The plastic equilibrium equation, in addition to having some of the same parameters as the elastic equilibrium equation, contains a cohesion intercept and unconfined compressive strength parameter. Consequently, changes in water content will have a very large impact on cracking widths by reducing the critical depth.

It is very unlikely that hydraulic fracturing is possible with the maximum water depths that can occur at this site, the stresses that develop as the result of the soil swelling and the time over which the maximum water depths in the reservoir will develop. Please refer to a letter from Donald E. Wallin, dated June 17, 1986, discussing the head of water at which hydraulic fracturing may occur.

As noted in your letter dated July 2, 1985, a second line of defense against the need for outlets originally planned does develop. That defense is the effect of the "Filter Cake" which develops at the interface of the transition zone material and the embankment soils wherever a crack exists. This cake will act to reduce the permeability of the transition materials to a hydraulic conductivity value near that of the compacted soil at saturation. Therefore, the high seepage volumes that are normally expected through a crack will not develop. The amounts are very small due to the low permeability and the small area transmitting the flow. This is true until total saturation of the embankment occurs. At that time, steady seepage conditions will dictate the need for outlets. However, as previously discussed, steady seepage conditions will not occur during the allowed drawdown time.

Based on the previous discussion, the need for outlets originally designed for the central transition zone does not appear to be necessary. We do not object to using the existing vegetative outlets to provide outlets for the transition zone but we believe they will not provide the anticipated safety factor. This is because of the long flow paths needed to reach the outlets. The water heads between the outlets necessary to push the water over these long flow paths would result in most of the water flowing out the existing cracks rather that flowing to the vegetative outlets. Consequently, the increased safety factor obtained will only be for the immediate area of the vegetative outlet.

If you need further help with this problem, please contact Clifton Deal.

Donald E Wallin Acting
W. R. EVANS
Head, Engineering Staff

cc:
Charles R. Adams, State Conservationist, SCS, Phoenix, Arizona
Stanley N. Hobson, Director, SCS, WNTC
James R. Talbot, National Soil Engineer, SCS, Washington, D. C.
Clifton E. Deal, Soil Mechanics Engineer, SCS, WNTC

FACSIMILE TRANSMITTAL SHEET

NUMBER OF PAGES	TRANSMITTAL SHEET + 5	DATE: 1/20/89
TO:	Ralph M. Arrington, SCE	
	Phoenix Arizona	
	TELEPHONE #:	
	FAX TELEPHONE #:	
FROM:	Clifton E. Deal, SME	
	WNTC	
	Portland, OR	

COMMENTS: Attached is the second draft for the letter you requested for Vineyard Road FRS

TRANSMISSION COMPLETED BY: [signature] DATE: 1/20/89 TIME: 12:10 PM

West National Technical Center
511 NW Broadway, Room 248
Portland, Oregon 97209-3489

ENG - Vineyard Road Dam Repair - Drain Outlet Design Criteria. January 17, 1989

Ralph M. Arrington, State Conservation Engineer, SCS, Phoenix, Arizona 210-22

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To theoretically illustrate the effect of cracking due to desiccation, actual crack depths were compared with critical depths calculated using the following equation:

$$dc = \frac{(Dw)(Fw)(\tau_w)(E/H)}{(\mu)(\tau)}$$

Where:
- dc = theoretical crack depth.
- Dw = depth to water table.
- Fw = matric suction profile factor.
- τ = total unit weight of soils.
- τ_w = total unit weight of water.
- μ = Poisson's ratio.
- E = elastic modulus with respect to total stress $(\sigma - u_a)$.
- H = elastic modulus with respect to matric suction $(u_a - u_w)$.
- u_a = Pore air pressure.
- u_w = Pore water pressure.
- σ = Total stress.

The results of these comparisons show that the depth of cracks measured agree very well with those calculated. For example, a maximum crack length of 21.5 feet was measured. Using the elastic equilibrium equation and the following values to represent an average soil condition at the imposed stress level, a crack length of approximately 20.5 feet was computed.

$Fw = 1.0$ $\tau = 17.99\ kN/m^3$ (114.5 pcf) $D_m = 112.78\ m$ (370')
$\mu = 0.3$ $\tau_w = 9.08\ kN/m^3$ (62.4 pcf) $D/B_m = 0.133$

Where: $E/H = D(1+\mu)(1-2\mu)/3B_m(1-\mu)$
D = Constrained modulus with respect to the net total stress ($\sigma - \mu_m$).
B_m = Bulk modulus.

$$dc = \frac{(112.78)(1)(9.08)(0.133)(1 + .3)(1 - 2(.3))}{(0.3)(17.99)(3)(1 - 0.3)} = 6.25\ m\ (20.5\ ft)$$

Other soil conditions and stress levels can result in depths of cracks similar to those measured. The D/B_m values are based on data from the literature and not actual data. However, the value used is representative for soils found at Vineyard Road.

A further indication of desiccation is the results of COLE and other shrinkage tests which show the majority of the soils have a high potential for shrink-swell.

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	SC	38	13	9.55	13.1	1.75	31.52	8.7

Where:

USCS = The Unified Soil Classification System.
LL = The liquid limit of the soil.
PI = Plastic Index of the soil.
COLE = The Coefficient of Linear Extensibility.
SL = Shrinkage Limit.
SR = Shrinkage Ratio.
VC = Volumetric Shrinkage; $(100([COLE + 1]^3 - 1))$.
LINEAR = Linear Shrinkage computed from the following equation:

$$[1-(100/V_m+100)^{1/3}]100$$

Where:
V_m = Volumetric shrinkage; $(100([\%w - SL])SR)$.
$\%w$ = Percent moisture of SL test.

The results of clay mineralogy tests indicates all soils analyzed had moderate amounts of clay mica and smectite and small amounts of kaolinite. Since this represents a mixed mineralogy, how the soils will shrink-swell is governed mostly by the smectite. Consequently, shrink-swell may be higher than anticipated. Other index tests, like AI (Activity Index), indicates some intermediate value for shrink-swell potential for these soils.

All of the previous discussion shows that these soils will experience crack closure. Unless the crack is maintained opened by hydraulic fracturing, closure will occur each time there is an increase in moisture content. Closure will occur even if the crack is the result of differential settlement or collapse. In those cases it may not close completely due to swelling but as the plastic equilibrium equation shows the crack walls will collapse due to loss of stability upon saturation. This collapsing complements the effects of the swelling. The plastic equilibrium equation, in addition to having some of the same parameters as the elastic equilibrium equation, contains a cohesion intercept and unconfined compressive strength parameter. Consequently, changes in water content will have a very large impact on cracking widths by reducing the critical depth.

It is very unlikely that hydraulic fracturing is possible with the maximum water depths that can occur at this site, the stresses that develop as the result of the soil swelling and the time over which the maximum water depths in the reservoir will develop. Please refer to a letter from Donald E. Wallin dated June 17, 1986 discussing the head of water at which hydraulic fracturing may occur.

As noted in your letter dated July 2, 1985, a second line of defense against the need for outlets originally planned does develop. That defense is the effect of the "Filter Cake" which develops at the interface of the transition zone material and the embankment soils wherever a crack exists. This cake will act to reduce the permeability of the transition materials to a hydraulic conductivity value near that of the compacted soil at saturation. Therefore, the high seepage volumes that are normally expected through a crack will not develop. The amounts are very small due to the low permeability and the small area transmitting the flow. This is true until total saturation of the embankment occurs. At that time steady seepage conditions will dictate the need for outlets. However, as previously discussed steady seepage conditions will not occur during the allowed drawdown time.

Based on the previous discussion, the need for outlets originally designed for the central transition zone does not appear to be necessary. We do not object to using the existing vegetative outlets to provide outlets for the transition zone but we believe they will not provide the anticipated safety factor. This is because of the long flow paths needed to reach the outlets. The water heads between the outlets necessary to push the water over these long flow paths would result in most of the water flowing out the existing cracks rather than flowing to the vegetative outlets. Consequently, the increased safety factor obtained will only be for the immediate area of the vegetative outlet.

If you need further help with this problem, please contact Clifton Deal.

W. R. EVANS
Head, Engineering Staff

cc:
Charles R. Adams, State Conservationist, SCS, Phoenix, Arizona
Stanley N. Hobson, Director, WNTC, SCS, Portland, Oregon
James R. Talbot, National Soil Engineer, SCS, Washington, D. C.
Clifton E. Deal, Soil Mechanics Engineer, WNTC, SCS, Portland, Oregon

1-20-89
by DKP

Vineyard FRS Repair

Use of Vegetative Outlet Pipes as drains as safety factor:

1. Very localized area of protection — (immediate pipe area vs 5 miles of dam) water in transition would tend to move down in foundation before moving laterally

A. DRILL HOLES
- holes should be bigger than the thickness of the walls to do much good. In addition to drill enough holes would jeopardize the strength of the pipe and also increase the potential for corrosion. Other disadvantage would be the location of the Bell & spicot and anti-seep collars fall at the location of the trench.

B. Cut 2-foot section of pipe:
- provide a stainless steel screen on front face of cut pipe.
- provide a mortar block on U.S. end of pipe
- provide an epoxy finish to the cut surfaces.

FAILURE OF THE MORTARED ENTRANCE AND CUT SECTION OF THE PIPE to hold water COULD CAUSE a greater amount of damage to the dam.

Rme

Don P.
Looks ok. RM

FACSIMILE TRANSMITTAL SHEET

NUMBER OF PAGES	TRANSMITTAL SHEET + 3	DATE: 1/12/89
TO:	Ralph M. Arrington, SCE	
	Phoenix, AZ	
	TELEPHONE #:	
	FAX TELEPHONE #:	
FROM:	Clifton E. Deal, SME	
	WNTC	
	Portland, OR	

COMMENTS:

Attached is a first draft of a letter in response to your request concerning Drain Outlet Design Critera on Vineyard Road FRS.

TRANSMISSION COMPLETED BY: [signature] DATE: 1/12/89 TIME: 12:30PM

West National Technical Center
511 NW Broadway, Room 248
Portland, Oregon 97209-3489

ENG - Vineyard Road Dam Repair - Drain Outlet 210-22
Design Critera.

Ralph M. Arrington, State Conservation Engineer,
SCS, Phoenix, Arizona

In response to your request for further documentation of our letter of July 15, 1985 and your letter of July 2, 1985, we offer the following:

1. Due to the many reports showing that the cracking at this site is dynamic, desiccation is persumed to be a major cracking mechanism. This is supported not only by the various reports but by the crack pattern observed and recorded by video tape at test Cell No. 2.

2. Soil volume change behavior can be expressed as a function of stress state variables and material properties. Two consitutive relationships exist that represent this behavior. One relationship is based on the soil structure while the other is based on the water phase. The first of these relationships is refered to as elastic equilibrium while the second represents plastic equilibrium. A study of these two relationships indicates the mode of failure of a desiccated soil is better represented by elastic equilibrium than by plastic equilibrium. Results of experimental work by Fredlund and Jacky Tak Kwai Lau at the University of Saskatchewan has shown this to be the case. Consequently, the process does not result in shearing stresses at the particle contacts but rather paricle separation due to the pulling force of the matric suction pressure.

   Since desiccation cracking is the result of soil volume reduction, elastic equilibrium analysis should represent the physical behavior of cracking. Consequently, a reversible process prevails and results in a direct relationship between an increase in water volume and a reduction in crack width. Therefore, any introduction of water will cause expansion of the soil with a corresponding reduction in crack widths. With

the closing of the cracks water movement from the surface of the dam to any point in the interior of the embankment will be reduced to a hydraulic conductivity near that of the compacted soil at saturation. The time necessary for the swelling to occur, based on field trial observations, is nearly immediate. This is futher supported by the high matric suction associated with soils comprising Vineyard Road. The higher matric suction value will result in a faster movement of the water into the soil. Most desiccation cracks are initiated at a matric suction of less than 10 kPa (1.45 psi) for most soils. Due to the silty nature of these soils the suction value would be greater.

3. To theoretically illustrate that desiccation is a major cracking mechanism, acutal crack depths were compared with critical depths calculated using the following equation:

A. $$dc = \frac{Dw}{\dfrac{\mu\ \tau}{Fw\ \tau_w\ \ (E/H)}}$$

Where: dc = theoretical crack depth.
Dw = depth to water table.
Fw = matric suction profile factor.
τ = total unit weight of soils.
τ_w = total unit weight of water.
μ = Poisson's ratio.
E = elastic modulus with respect to total stress $(\sigma - u_a)$.
H = elastic modulus with respect to matric suction $(u_a - u_w)$.

B. The results of these comparisons show that the depth of cracks measured agree very well with those calculated. For example, a maximum crack length of 21.5 feet was measured. Using the following values to represent an average soil condition at the imposed stress level, a crack length of approximately 20.5 feet was computed.

$Fw = 1.0$ $\tau = 17.99$ kN/m³ (114.5 pcf) $D_w = 112.78$ m (370')
$\mu = 0.3$ $\tau_w = 9.08$ kN/m³ (62.4 pcf) $D/B_m = 0.133$

Where: $E/H = D(1+\mu)(1-2\mu)/3B_m(1-\mu)$

Other soil conditions and stress levels will result in depths of cracks similar to those measured, The D/B_m values are based on data from the literature and not on actual data. However, the value used is representative for soils found at Vineyard Road.

C. A further indication of desiccation is the results of COLE and other shrinkage tests which show the majority of the soils have a high potential for shrink-swell.

Sample Type	USCS	LL	PI	COLE (%)	SHRINKAGE LIMITS - Range SL (%)	SR (g/cc)	VC (%)	LINEAR (%)
Embankment	CL	29	13	7.98	13.7	1.88	25.83	7.4
	CL	27	11	8.24	13.3	1.90	22.80	6.6
Foundation	CL	26	8	4.69	12.5	1.73	14.75	4.5
	SC	38	13	9.55	13.1	1.75	31.52	8.7

Where:

USCS = The Unified Soil Classification System.
LL = The liquid limit of the soil.
PI = Plastic Index of the soil.
COLE = The Coefficient of Linear Extensibility.
SL = Shrinkage Limit.
SR = Shrinkage Ratio.
VC = Volumetric Shrinkage.
LINEAR = Linear Shrinkage computed from the following equation:

$$[1-(100/V_m+100)^{1/3}]100$$

D. The results of clay mineralogy tests indicates all soils analyzed had moderate amounts of clay mica and smectite and small amounts of kaolinite. Since this represents a mixed mineralogy, how the soils will shrink-swell is governed mostly by the smectite. Consequently, shrink-swell may be higher than anticipated. Other index tests, like AI (Activity Index), indicates some intermediate value for shrink-swell potential for these soils.

All of the previous discussion shows that these soils experience crack closure for a varity of reasons. Unless the crack is maintained opened by hyradulic fracturing, closure will occur each time there is an increase in moisture content. It is very unlikely that hyradulic fracturing is possible with the maximum water depths that can occur at this site. Consequently, the need for outlets to the central transition zone does not appear to be necessary. Using the existing vegetative outlets is an excellent means to provide a factor of safety and a visible means of monitoring any discharge of water from the transition zone.

not applicable

NO

- Spacing is too great. (Spigots)
- corrosion
- strength of pipe w/ drilled holes.
- use of geotextile fabric

ACTION REQUIRED BY JAN. 20, 89

VINEYARD Submittal - Prel. In-House REVIEW

TO: RALPH ARRINGTON
JOHN SULLIVAN
AUBREY SANDERS
JOHN HARRINGTON
Dave Lambson

Please review the following items and submit your comments to Don Paulus no later than Jan. 20, 1989. It is important that we maintain our schedules for design to ensure the time needed for contracting.

ITEMS:

1) Design Report
2) Bid Schedule
3) Specifications
4) Inspection Plan
5) Construction Drawings

Donald Paulus

11/8/88
by DP

Vineyard FRS Repair

Conversation with Ralph Arrington concerning the depth we should require for ripping to re-shape the FRS embankment slopes:

Agreed that we should return these cell sections back to the FCD at the same quality as originally built. Therefore, we will rip to a depth of 2 inches below the sill inverts to assure proper bonding of in-place material and the added fill in ripped area during compaction.

United States Department of Agriculture

Soil Conservation Service

West National Technical Center
511 NW Broadway, Room 248
Portland, Oregon 97209-3489

Kuk

Don Parks

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Vineyard Road FRS

Date: October 31, 1988

To: Lorn P. Dunnigan, Head, Soil Mechanics Laboratory, SCS, Lincoln, Nebraska

File code: 210-22

Enclosed is a request for supplemental testing for the Vineyard Road Site. The samples are already in the laboratory. If you cannot find all of the samples listed, please perform the tests on those samples you still have.

During the Free Swell testing, please record the time involved from introduction of the water to completion of swelling.

CLIFTON E. DEAL
Soil Mechanics Engineer

Enclosure

cc: (w/o enclosure)
Ralph Arrington, State Conservation Engineer, SCS, Phoenix, Arizona
W. R. Evans, Head, Engineering Staff, SCS, WNTC

DATE 10/25/88 ARIZONA CRACKED DAM FIELD TRIAL - SOIL TESTS PAGE 1

Lab. No.	Field No.	Atterberg Limits	Sieve Analysis	Hydrometer Analysis	Shrinkage Limit	COLE	Unit Weight	Moisture Content	Free Swell	Permeability
84w667					X	X		X		
85w1027		X	X	X	X	X		X		
85w1028						X		X		
85w1029		X	X	X	X					
85w1030		X	X	X	X					
85w1097		X	X	X	X		X	X		
85w1098A		X	X	X	X		X	X		X
85w1098B		X	X	X	X		X	X		
85w1099		X	X	X	X	X	X	X	X	
85w1100A		X	X	X	X	X	X	X	X	X
85w1101		X	X	X	X		X	X		X

10/24/88
JP

Memo from Cliff Deal w/ Conclusions of crack study ~~a~~ report, to ADWR FCD by Jan 1, 89

Ralph coordinating...

w/ Ralph & John L.

Decision is made not to include Contractor Inspection on this job because of ~~the~~ its size. Testing by SCS for quality assurance will be approx. the same as what would be needed for quality control.

VINEYARD REVIEW

10/17

Ide:

Would like to review current status of Vineyard

- Specs
- All design, design Folder
- Design Report
- Cost Est / Perf time
- Previous contract mod's
- O&M plan? - no O&M on dikes if left in - how to fix cracks..
- Inspection plan?

} Would like all information for my file.

} comments

✓

10/17

K

- Review notes attached and apply to current drawings
- Prepare a set of drawings for me to red-line by 10/21
- After red-lines:
  - Make drawing corrections
  - Prepare final quantities
  - Develope Performance time for small business (< 17,000,000/yr company) use libr. references etc. for production rates. Also research initial contract for drain fill operations.
  - O&M plan addendum?
  - Inspection plan?

10/17
by DP

VINEYARD Review

1. Need all design info from Ilde. / Prel. specs.
2. Follow-up to letter sent to ADWR & FCD (find copies of letters & attachmts)
   Options a. Even Cut/Fill ✓
   b. Ramps
   c. Leave as is.
3. Review of Field trip (Don, Aubrey, Jack)
   a. Dress-up slopes of Earth Emb. within the reach we do repair work. ✓
   b. An extra 12 feet should be removed each side of the cells to remove "Plugs" ✓
   c. Cell #3, sta 253+75 to be repaired (3:1 slopes) ✓
   , sta 252+53 Rill " " (≈4' deep, 5' wide) ✓
   d. Do NOT use continuous cut between cells 2 & 5 ✓
   e. No repair @ 297+80 (switch to 253+75) ✓
4. Contract Mod's (Ilde)? NONE REPORTED
5. Design:
   a. Gradation (C-33? ✓ (6)), Keep within 1 foot of top dam.
   b. Construction tech. / Re-use of ✓ material or borrow
6. Breach of dam
   a. Limit time
   b. Constr. Sequence Plan ?
7. Cost Est — SBA
8. Drawings
   a. Show Prin. Spw Pipe, location plan/profile, & sht 7 table ✓
   b. No emb. drain in Cell #3, sec. D, sht 6 ✓
   c. ≈7' below veg. pipes, sht. 7, sec A. ✓
   d. Even ≈3.5' cut on face of defaced dam. ✓

United States Department of Agriculture

Soil Conservation Service

West National Technical Center
511 N. W. Broadway, Room 248
Portland, Oregon 97209-3489

Subject: MGT - Trip Report, Arizona
September 27-30, 1988

Date: October 12, 1988

To: W. R. Evans, Head, Engineering Staff, WNTC

File code: 330-

Purpose: The primary purpose of this trip was to provide assistance in the evaluation of joint preparation for the repair of joints on Reach 4, of the East Maricopa Floodway.

Participants: Don Paulus, State Design Engineer, SCS, Arizona
Elde Chevaz, Design Engineer, SCS, Arizona (part-time)
Noller Herbert, Project Engineer, SCS, Arizona (part-time)
Larry Moliter, Inspector, SCS, Arizona
Leland Saele, Design Engineer, SCS, WNTC

Background: A portion of Reach 4, of the East Maricopa Floodway (RWCD R4), consists of a concrete lined, trapezodial shaped channel, approximately 6700 feet long with expansion-contraction joints at 100 foot intervals. The sealant used to seal the joints failed shortly after installation. An investigation report attributed the failure to joint design. A construction contract has been awarded for repair of the joints. This will include an initial phase for testing and evaluation of three different joint widths. The contractor began preparing the test joints on September 26, with an estimated completion time of three days.

During the week we also visited Vineyard Road Dam, the nearly completed Apache Junction Dam and Bulldog Wash Floodway projects, and made a general inspection of RWCD Reach 4 and the recently completed Reach 5 for rilling of the side slopes or other potential problems. The final design for the repair of Vineyard Road Dam will be prepared by the state design staff and forwarded to the WNTC for approval by the end of the year.

Findings/Recommendations:

RWCD R4, Joint Repair: Several visits were made to the site throughout the week to observe the contractor's operations and to discuss progress with the SCS inspector and project engineer. The concrete temperature sensors had been installed and were functioning well. The measured temperature of the concrete ranged from 72°F to 105°F between 7 a.m. and 4 p.m. The daily high ambient air temperature was near 100°F. Saw cutting of the test joints to the specified width was completed by Thursday afternoon and cleaning of the joint face was underway. The saw cutting and joint cleaning operation was progressing at a considerably slower pace than indicated by the contractors schedule.

Three joint widths, existing, 2-inch and 3-inch, are specified for the test section. The contractor is using a high pressure wash and is experiencing difficulty in removing all of the existing sealant from the "existing" and "2-inch" joint widths. Old sealant remains in pockets where stones apparently were dislodged during the original joint, saw cutting and sealant installation operation. A visual examination of the "2-inch" joints indicated approximately 5 to 10 percent of the effective joint surface for adhesion was still covered with old sealant. Considerably more sealant was evident on the "existing" joint faces. The contractor will have to put forth more effort to properly prepare these joints.

done

Existing sealant between the bridge piers and the channel lining is in excellent condition whth no sign of distress. Because of the difficulty involved in saw cutting at this location and the condition of existing sealant, it is recommended that joints around the bridge piers not be disturbed.

Larry (SCS inspector) is well versed on the contract requirements for this project and is doing an excellent job of inspection and documentation of the contractors work.

Reach 4 and 5: Although the general appearance of Reach 5 is excellent, there is some evidence of side slope rilling in its early stages. The 2-inch minus, pit-run, gravel lining placed downstream of the Power Road Bridge shows no sign of rilling whereas the earth slope just downstream of this section has several rills forming. The gravel, with a small percentage of fines, appears to offer excellent resistance to rilling. Similar conditions were observed on Reach 4, downstream of Station 530+00, where gravel cover (3-inch minus) was placed on the upper right bank.

Nearly all of the 3-inch diameter drain outlets in the concrete lined channel on Reach 4 are plugged with sediment. Inspection at two locations found sediment completely filling the transverse drain outlet pipe to the "T" connection and possibly some extending into the longitudinal perforated drain pipe. Since the outlet pipe is 36+ inches long, it is speculated that there may be reverse flow carrying sediment laden flow into the drain pipe. We expect the situation to improve with the completion of Reach 6 and sediment due to construction minimized. It is recommended that the drains be cleaned to provide free outlets. Locating the drain outlets 12 inches or more above the invert would have helped prevent this problem.

Piping of foundation material and rilling along the side was noted at three grouted rock side inlets at the following locations:

left bank, just upstream of Sta. 570+00
left bank, Sta. 595+75
left bank, Sta. 625+00

Inspection of the exposed grouted rock section indicates that less than full grout penetration may have been a problem during construction. Expedient O&M is recommended to control the piping and prevent further damage. Damage should be treated by pumping or placing grout to fill voids under the structure and placement of 3-inch minus, well graded, pit-run, sand/gravel along the sides of the structures to control surface erosion. If, during repair, it becomes apparent that numerous voids exist under the grouted rock, the upstream cutoff should be exposed and treated to form a positive cut off acoss the inlet.

Future designs using grouted rock inlets need to consider a more open rock gradation, similar to what was used on Reach 5 for better grout penetration and a more positive cut off.

Occasional areas of light rilling and some isolated deeper rills exist randomly throughout Reach 4. Also, downstream of Sta. 605+00, in the vicinity of the gas pipeline relocation, erosion and settlement of the left bank has occured along a 3-foot wide strip, diagonally up the slope, to the approximate original ground line. This is apparently due to insufficient compaction of material replaced after relocation of the pipeline but prior to the construction of Reach 4. This damaged area, as well as any significant rilling that has developed in Reach 4 or Reach 5, should be repaired by filling with 3-inch minus, well-graded, pit-run, sand/gravel mixture.

Vineyard Road Dam: The design being prepared for this structure is to repair damage done by excavation into the embankment during the study and evaluation of flow through cracks that was conducted at this site several years ago. The repair also includes installing a transition filter along the centerline of the embankment where it was left out for testing. The test cells constructed for the test do not appear to interfere with the function of the dam and do not need to be removed from a design standpoint. Their easthetic value is less certain and may justify removal.

Serious erosion was noted in at least one location on the downstream slope. This was apparently due to localized concentration of runoff from the top of the dam. The eroded area should be filled with compacted material (per original specifications) and concentration of drainage alleviated to prevent further damage. A 12-inch thick section of sand/gravel, in areas of concentrated drainage, graded as noted above for the RWCD Floodway, may work well here, too.

Action Items:
State Responsibility

1. Notify the sponsors of need for maintainance to repair rilling on channel side slopes and side inlets on Reach 4 and 5 and to clean out drain outlets on Reach 4.

done 2. Notify the sponsors of need for maintenance to repair rills on the downstream slope of Vineyard Road Dam.

WNTC Responsibility

1. Assist state design staff by preparation of designs for control of rilling for evaluation by field trial.

I appreciated this opportunity to work with the Arizona design and construction personnel and to evaluate structural performance.

Leland M. Saele

LELAND M. SAELE
Design Engineer

cc:
Charles R. Adams, State Conservationist, SCS, Phoenix, Arizona
Stanley N. Hobson, Director, SCS, WNTC
Donald Basinger, Director, Engineering Division, SCS, Washington, D. C.
Ralph Arrington, State Conservation Engineer, SCS, Phoenix, Arizona

201 E. Indianola
Suite 200
Phoenix, AZ 85012

October 6, 1988

Dan Sagramoso, P.E.
Chief Engineer and General Manager
Flood Control District of Maricopa County
3335 West Durango Street
Phoenix, Arizona 85009

RE: Vineyard Rd FRS Repair

Dear Dan:

As requested during the SCS presentation meeting, October 4, 1988, for recommended repair methods, we are forwarding copies of the letter of concurrence and supporting documentation recommending the elimination of all drain outlets from the embankment crack repair of the subject project. The copies are being forwarded to both Scott Clement of your staff and Bill Jenkins of ADWR.

Please review the documents and return your comments or approval to SCS by October 17, 1988.

At this time we would also appreciate your decision on whether or not the test cell dikes should remain in place or be removed as discussed at the presentation meeting.

Sincerely,

Charles Adams
State Conservationist

cc: Scott Clement/MCFCD
Bill Jenkins/ADWR

Enclosures

J.YL

10/4/88

Vineyard ERS REPAIR.

- Will submit 'total' design report/folder to FCD & ADWR
- Use veg. outlets as drain pipe? NO - justify not using...
- Breach -
  * Limit time of construction
  * Plans for construction sequence.
  * Timing of Contract (Seasonal)

Aug '82 original repair plans
- Cost information & As-builts.

Get information for FCD & ADWR. info. on outlets:

Saddleback Div. Repair

- Present O&M repair in Prel. Report.
- "Leave Veg. Outlets out of Contract" & enter into agreement for other alternatives.

AGENDA FOR
Vineyard Road Drainfill Repair
Prel. design presentation ~~Design Staff~~ Meeting
October 4, 1988 @ 9:00 a.m.

OBJECTIVES

1. Complete installation of the Drainfill, and
2. Repair of all disturbed embankment by SCS forces.

DECISIONS MADE TO DATE

1. No crack eradicator drain outlets will be required.
   * ADWR & FCD expressed the need for documentation. FCD suggested perforating the existing veg. outlet
2. Remove all foreign materials (piezometers, HDPE, etc...),
3. Return dam to original design cross-section,
4. Map all cracks in the center-line trench, and
5. Use the same drainfill gradation. (compare w/ new SMN-1)

RECOMMENDED REPAIR METHOD

Drainfill Completion

1. Place drainfill uniformly across all discontinuities (Vegetative and Principle R/C Pipes Outlets, and un-trenched areas).

Station 102+00 to 111+40 (Test Cells #2 and #5)

1. Remove and recompact the embankment continuously between test cell #2 and #5 down to the lowest point of known disturbance (approximate elevation 1568.50).
2. Leave existing piezometers within the embankment below elevation 1568.50.
3. Side abutments would be on 3:1 slopes.

can not do, earth bulk head on each side of drainfill. Remove to full depth.

4. Test cells would be removed and excess material placed between the toe of the dam and the edge of the convayence channel as a banquette. ✓

<u>Station 120+00 to 124+00 (Test Cell #1) and</u>
<u>Station 252+00 to 256+00 (Test Cell #3)</u>

1. Spot repair embankment,

2. Each spot repair will be sloped back on a 1:1 slope and transverse cuts to the embankment will be sloped back on a 3:1, and ✓

3. Test cells would be removed and excess material placed between the toe of the dam and the edge of the convayence channel as a banquette. ✓

<u>DISCUSSION</u>

A. Leaving the test cells in place

1. The WNTC has expressed that they would give their concurrence for leaving the test cells in place.

2. We feel the following are benifits for leaving the test cells in place:

   a. Cost,

   b. Offers a turn-around area on top of the embankment,

   c. Ramp access down into the dam, and

   d. Asthetics (Brakes up horizontal line, wildlife, etc...)

met w/FCO O&M rep on last field trip. Indicated that dikes would be O&M problem or nuisance DR 1/88

B. Rilling erosion on the down stream slope of the dam.
⇒ Bob will take care of this item.

OTHER TOPICS (O&M)

a. EMF Reach-4, Side Inlets.

b. EMF Reach-5, Inlet station 450+00 - Need gravel at bank.

OCTOBER 4, 1988

	NAME	AGENCY	PHONE
1.	Bob Payette	FCD	262-1501
2.	H. S. CLEMENT	FCD	262-1501
3.	Bill Jenkins	ADWR	255-1541
4.	Aubrey Sanders	SCS	241-5146
5.	DON PAULUS	SCS	241-5143
6.	K. M. Hussain	ADWR	255-1541
7.	JOE CHAVEZ	SCS	241-5144
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			

MEMO: Notes to the file (Includes comments received by September 29,1988.)

RE: These are minutes of a meeting held in the Phoenix State Office on September 26, 1988 for completion of Vineyard Road FRS Drainfill Repair.

Attending the meeting were, Ralph Arrington, Carol Harris, John Sullivan, Don Paulus, Aubrey Sanders, and Ilde Chavez.

The meeting was held to discuss two possible methods of repair for above stated project.

The first alternative is to breach the dam by removing the embankment down to the lowest point of known disturbance (Approx. 11'-0"). The embankment would then be brought up to original design elevation along with the drainfill. The advantage of this alternative is knowing the precise limits of embankment removal and thereby requiring no variation in quantities.

The second alternative is to spot repair known places of disturbance. Repair of areas which traverse the crest of the dam will need to be repaired on a 3:1 slope, and repairs which are on either side of the crest of the dam will be repaired on a 1:1 slope. The disadvantage of this alternative is possibly not designating for removal, the full extent of disturbance within the dam. The engineer in the field would then direct further excavation and possibly exceed the 15 percent variation clause.

It was agreed by those in attendance, that the embankment behind test cells #2 and #5 would be repaired by alternative number one, respectfully, since a large part of the embankment had been disturbed. Embankment behind test cell #1 and embankment at station 297+80 would be repaired by the second alternative, respectfully, since probing at these sites was held to a minimum. Expanded limits of excavation will be defined to insure positive repair of all the disturbed area.

It was also agreed that:

a. All pipe (PVC or Steel) used in the testing would be left in-place by cutting the pipe to the lowest point of repair excavation,

b. Ramps would be graded out from the existing test cells embankment (At no additional cost if agreed by MCFCD and ADWR that there is a benefit to leave the ramps in place), and

c. The excess material from the test cells removal would be distributed between the toe of the dam and the low flow channel at a 1'-0" depth (ie. Banquette).

Filling-in of the test cells was discounted since questions regarding consolidation would remain unanswered without extensive prior testing.

Also mentioned at the meeting was that the repair work included placing drainfill around the vegetative and Principle Spillway Outlet pipes to the elevations on either side of the pipes. The only discussion over this item was the mention that extensive hand excavation would be required. No further discussion.

Aubrey Sanders expressed the need to log cracks within the center-line trench. It was agreed that the only trench that would be made available for inspection would be test cell #3 (Station 248+80 to 257+75) which has not been trenched along the center-line to date.

Ralph suggested to Aubrey that he rent a backhoe and operator to probe the embankment for mapping cracks in the other three test cells prior to the repair work commencing if he so desired.

The meeting started at approximately 7:20AM and concluded at approximately 8:15AM.

Ilde Chavez

Ilde Chavez

DP 9/27/88

MEMO: Note to the files

RE: These are minutes of ~~a~~ 26 meeting held in the Phoenix State Office on September ~~9~~, 1988 for completion of Vineyard Road FRS Drainfill Repair.

Attending the meeting were, Ralph Arrington, Carol Harris, John Sullivan, Don Paulus, Aubrey Sanders, and Ilde Chavez.

The meeting was held to discuss two possible methods of repair for above stated project.

The first alternative is to breach the dam by removing the embankment down to the lowest point of known disturbance (Approx. 11'-0"). The embankment would then be brought up to original design elevation along with the drainfill. The advantage of this alternative is knowing the precise limits of embankment removal and thereby requiring no variation in quantities.

The second alternative is to spot repair known places of disturbance. Repair of areas which traverse the crest of the dam will need to be repaired on a 3:1 slope, and repairs which are on either side of the crest of the dam will be repaired on a 1:1 slope. The disadvantage of this alternative is possibly not designating for removal, the full extent of disturbance within the dam. The engineer in the field would then direct further excavation and possibly exceed the 15 percent variation clause.

It was agreed by those in attendance, that the embankment behind test cells #2 and #5 would be repaired by alternative number one, respectfully, since a large part of the embankment had been disturbed. Embankment behind test cell #1 and embankment at station 297+80 would be repaired by the second alternative, respectfully, since probing at these sites was held to a minimum. However, Expanded limits of excavation will be ~~used~~ defined to insure positive repair of all the disturbed area.
It was also agreed that:

a. All pipe (PVC or Steel) used in the testing would be left in-place by cutting the pipe to the lowest point of repair excavation,

b. Ramps ~~(Banketes)~~ would be graded out from the existing test cells embankment (At no additional cost), and
   (it agreed by FCD & ADWR that there is a benefit to leave a RAMP in place.

c. The excess material from the test cells removal and the low flow channel would be distributed ~~along~~ between the toe of the dam at a ? 1'-0" depth (i.e. banquette)

Filling-in of the test cells was discounted since questions regarding consolidation would remain unanswered without extensive prior testing.

Also mentioned at the meeting was that the repair work included placing drainfill around the vegetative and Principle Spillway Outlet pipes to the elevations on either side of the pipes. The only discussion over this item was the mention that extensive hand excavation would be required. No further discussion.

Aubrey Sanders expressed the need to log cracks within the center-line trench. It was agreed that the only trench that would be made available for inspection would be test cell #3 (Station 248+80 to 257+75) which has not been trenched along the center-line to date.

Ralph suggested to Aubrey that he rent a backhoe and operator to probe the embankment for mapping cracks in the other three test cells prior to the repair work commencing if he so desired.

The meeting started at approximately 7:20AM and concluded at approximately 8:15AM.

Ilde Chavez

RE: MEMO to the files

On September 20, 1988, there was a meeting held by the design staff to discuss alternative methods of repair for the Vineyard Road FRS Drainfill Repair by the following people; Don Paulus, Jack Burgin, Ilde Chavez, and John Harrington.

Among the things discussed at the meeting were:

a. Defining the objectives for repair,
b. Listing decisions made to date (History), finally
c. Alternative methods of repair.

The consensus was between two methods of repair.

One method of repair is to excavate the embankment to the lowest point of known disturbance on a 3:1 abutment slope. The embankment would then be recompacted to the original grade.

The second method is to spot repair known placed of disturbance. These areas would be excavated on a 1:1 slope and recompacted to original grade.

Since both methods meet the stated objectives, cost and ease of contracting will be used to determining the method of repair.

It was recommended that a meeting be scheduled between the Contracting Officer, State Conservation Engineer, State Design Engineer, and State Construction Engineer to discuss and decide which of the two methods of repair would be used.

Attached are the results of the meeting:

Ilde Chavez
Civil Engineer

Vineyard Road Drainfill Repair
Design Staff Meeting
(September 1988)

OBJECTIVES

1. Complete installation of the Drainfill - Including around the vegetative and principle spillway R/C pipe outlets, and

2. Repair of all disturbed embankment.

DECISIONS MADE TO DATE (History)

1. No crack eradicator drain outlets will be required,

2. Remove all foreign materials (piezometers, HDPE, etc...),

3. Return dam to original design cross-section,

4. Map all cracks in the center-line trench,

5. Continue subsidence surveys,

6. Review original repair contract to incorporate pertinent modifications into the present contract,

7. Drainfill gradation,

8. Competitive Bid for small business,

9. Complete design by February 1989, and

10. Cost should be less than $350,000.00.

ALTERNATIVES

1. Fill-in the test cells,

2. Remove and replace the embankment at the cells,

3. Re-work disturbed areas - Spot repair,

5. Leave existing drainfill in both test cells (including piezometers and HDPE liner),

6. Have SCS monitor subsidence surveys,

7. Use part of cells as ramps,

8. Use cell material as borrow source,

9. No spot repair will be needed if the test cells are filled-in,

10. No embankment repair (leave alone),

11. Use top of dam as haul road,

12. Doze test cell material against dam,

13. Breach existing dam and replace embankment only to the disturbed level,

14. Equipment rental - MCFCD, and

RE: MEMO

Don Paulus has requested that we meet on for Tuesday September 20, 1988 at 1:00PM to discuss the Vineyard Road FRS Repair. The following people are requested to attend:

Don Paulus
Jack Burgin
Ilde Chavez
John Harrington

This meeting has been scheduled to produce and combine ideas for determining the best and most efficient way of completing the repair work.

Discussed at the meeting will be:

1. Place drainfill in those areas that were neglected along the centerline of dam.

2. What to do with the dikes used in the test cell study.

3. Is it necessary to place drainfill completely around the vegetative outlet pipes (18 & 24-inch diameter)?

4. How should the work be contracted (i.e. Lump Sum, Item Quantities, Open Bid, Blanket Purchase Order, etc...)?

Come with lots of *ideas*!

Ilde Chavez

Ilde Chavez

Alternatives for completing work on
Vineyard Road FRS
September 1988

Alternative #1
(One Contract)

This alternative would consist of removing the embankment behind the test cells and backfill against the remaining embankment which would have been left on a 1:1 slope.

After the FRS embankment has been repaired, the test cells would be removed.

Advantages:
a. All of the required repair work could be performed behind the test cell which would act as a coffer dam while the work was in progress.
b. We would be confident that all disturbed areas would be removed and replaced with sound material.

Disadvantages:
a. An NTC and Washington wavier would be required for backfilling against a 1:1 slope.

Alternative #2
(One Contract)

This alternative would consist of removing the embankment and then backfill against the remaining embankment which would have been left on a 3:1 slope.

Advantages:
a. We would be confident that all disturbed areas would be removed and replaced with sound material.

Disadvantages:
a. The required work would extend beyond the protection of the coffer dam (test cells).

Alternative #3
(Two Contracts)

This alternative would consist of spot repairing the embankment in the areas in question.

The first contract would consist of an investigation for locating possible material disturbance, and repairing the site as confirmation of site disturbance progresses (This contract would be done by an hourly rate Blank Purchase Order.).

The second contract would consist of removing the vegetative outlets, test cells embankment, and trenching the FRS for installation of the Crack Eradicator material (This contract would would be done by the normal bid process.).

Advantages:
a. We would be confident that all disturbed areas would be removed and replaced with sound material.

Disadvantages:
a. May be difficult to locate all disturbed areas.

Alternative #4
(One Contract)

This alternative would consist of doing nothing in so far as removing or repairing the embankment. Since the test cells and FRS embankment have proven to be sound in so far as holding water for 30 days, we would leave both embankments in their present state and fill-in the volume between both embankments. This area could be used to turn or pass when parking on the FRS is required.

Advantages:
a. There would be no need to make the costly expense of removing and repairing the embankment.
b. The work could be finished in a short period of time.

Disadvantages:
a. We are relying on field trial test data to support our conclusion that both the test cells and FRS embankment will not fail within the designed maximum water retention time of 10days.

Neal

West National Technical Center
511 N. W. Broadway, Room 547
Portland, Oregon 97209-3489

ENG - Review of Permeability Tests - Harquahala Flood Retarding Structure

June 17, 1986

Ralph Arrington, State Conservation Engineer
SCS, Phoenix, Arizona

Attached are five figures that represent a pictorial of an analysis made to further explain the effect fines have on the permeability of the soils of this embankment. One figure presents an analysis of potential hydraulic fracturing during inplace permeability testing.

Figure 1 shows the changes expected when the two soils (5-12-A-10 and 4-1-A-15) are regraded with zero percent passing the No. 200 sieve. The permeability that can be calculated using the D15 and D10 sizes ranges from 308 to 1019 fpd for soil No. 5-12-A-10 and 708 to 2142 fpd for soil No. 4-1-A-15. Figure 2 provides the permeability ranges calculated for soil No. 5-12-A-10 and 4-1-A-15 when regraded with a zero percent passing the No. 100. They are 856 to 1857 fpd and 1467-3940 fpd respectively. These results indicate with a 4 percent change in the percent passing the No. 100 sieve the permeability reduces approximately 45-64 percent for soil No. 5-12-A-10 while for soil No. 4-1-A-15 the permeability reduces approximately 46-52 percent for a 3 percent change in the percent passing the No. 100 sieve. These data correlate very well with that presented on Figure 4.

The red and purple curves on Figure 4 illustrate the numerical effects the percent passing the No. 100 sieve have on permeability. These represent actual test data. Plotted on this same figure is the calculated permeabilities and the USBR permeability results for the same soils as a "square" for soil No. 5-12-A-10 and a "circle" for soil No. 4-1-A-15. The USBR results are plotted on the vertical axis while the calculated results are plotted on the horizontal axis. Using the red and purple curves as indicators it is readily apparent that the plotted permeabilities are reasonable for the amount passing the No. 100 sieve (11 and 16). Consequently, the time calculations using a permeability like 2.38 fpd is certainly conservative for this site.

Determining the head of water at which hydraulic fracturing may occur is very difficult to estimate even with the best of data. To estimate it for this embankment is made more difficult because of the low percentage passing the No. 200 sieve and the absence of laboratory data for soils of the southwest.

Based on the evaluation of the Vineyard Road FRS data a low percentage of minus No. 200 fines do not preclude significant volume changes and the consequent reduction in either the intermediate or minor principal stresses or both. If either of these stresses is zero, hydraulic fracturing will occur as noted by J. L. Sherard in his paper, Hydraulic Fracturing in Low Dams of Dispersive Clay, in the 1972 Specialty Conference on Performance of Earth and Earth-Supported Structures.

Recent laboratory work done by A. W. Hassani, B. Singh, S. S. Saini, and M. C. Goel of the University of Roorkee, Roorkee, India and published in the Proceedings of the Eleventh International Conference on Soil Mechanics and Foundation Engineering indicates a linear relationship between hydraulic fracturing pressure and confining pressure. Their work was done on a low plastic CL with liquid and plastic limits of 32.5% and 22% respectively. These values are not too far from those of the soils of this embankment, further indicating the activity of the fines of these soils and the possibility of sufficient volume changes to promote stress reduction or cracking of the embankment. Consequently, the confining pressures may be lower than can be calculated using either dry or moist unit weights.

Utilizing the linear relationship concluded by A. W. Hassani and the assumptions listed, a plot represented by Figure 5 shows that hydraulic fracturing may occur with water depths of approximately 15 feet. This is providing the confining pressures are equal to or less than approximately 1000 psf and the water head equals or exceeds 15 feet. The assumptions used to develop Figure 5 are: (1) moist unit weight is 135 pcf, (2) dry unit weight is 123 pcf, (3) lateral stress ratio is 0.5, (4) very minor cracking has occurred in the interior of the embankment as the result of drying during construction, and (5) the data found in the literature can be used to provide for a factor of safety of 1.5 for the estimated water depth.

Based on the preceding data, we still do not believe much will be gained from performing additional permeability tests on the soils of this embankment. In fact indications are that significant damage may be done if inplace tests are not carefully controlled.

If you have any questions, please contact Clifton Deal, Soil Mechanics Engineer, Engineering Staff, FTS: 423-2854.

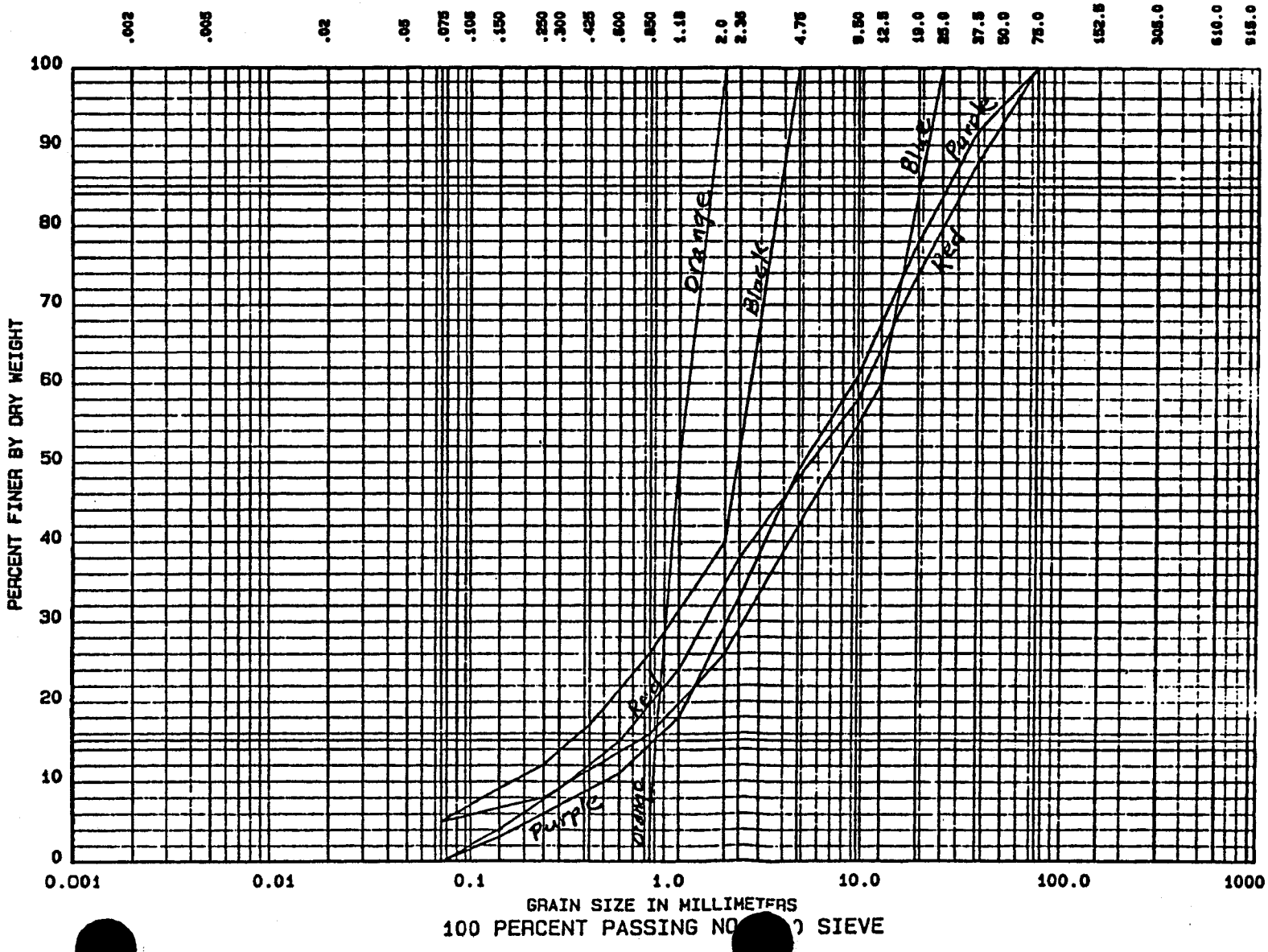
Donald Wallin

DONALD E. WALLIN,
Head, Engineering Staff, WNTC

Attachments

cc:
Clifton E. Deal, Soil Mechanics Engineer,
WNTC, Portland, OR

HARQUAHALA FRS - ARIZONA -- REGRADED CURVES



LEGEND

SOIL NO.

5-12-A-10 (Red)
4-1-A-15 (Purple)

CALCULATED K
FOR
SOIL NO.

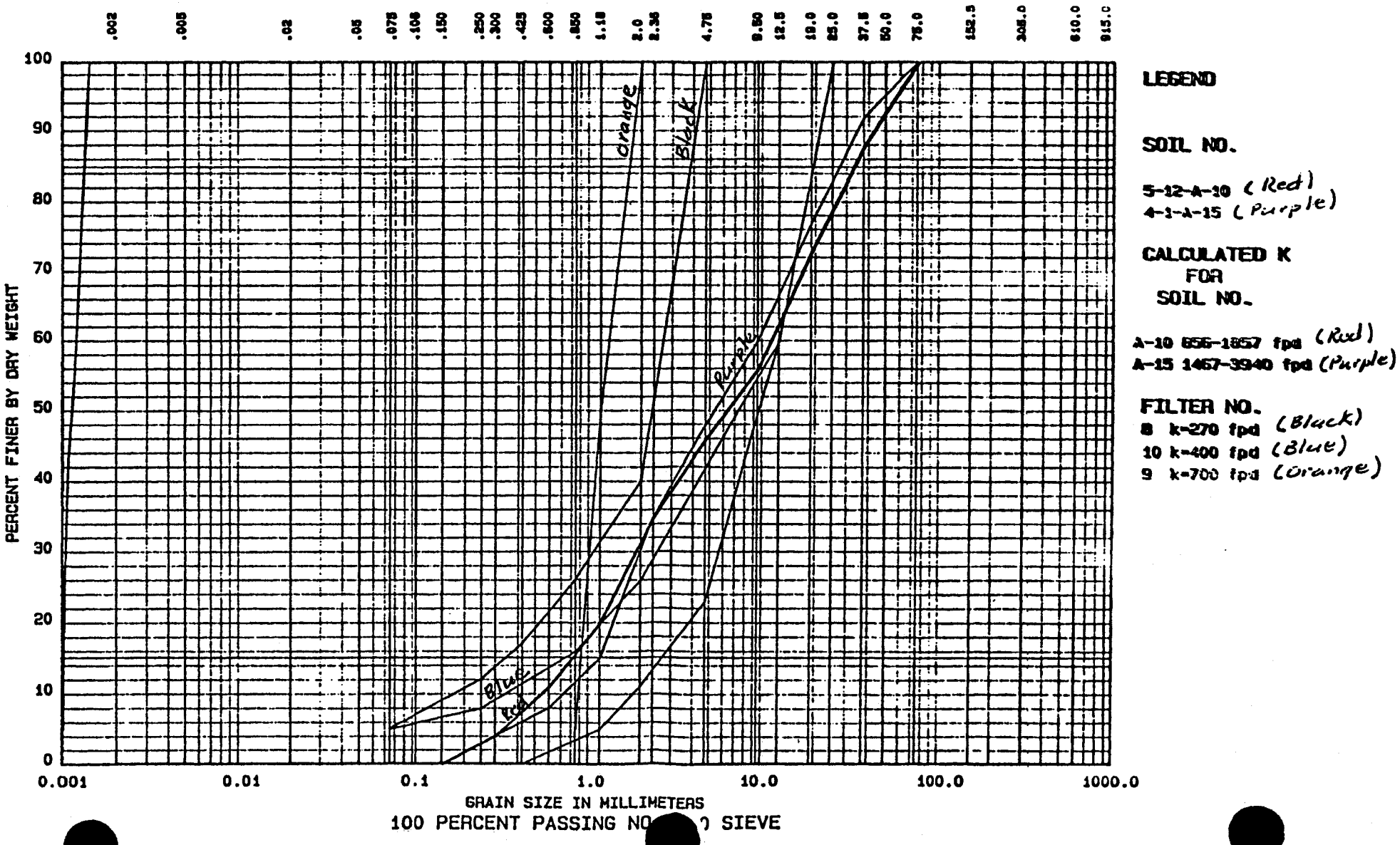
A-10 308-1019 fpd (Red)
A-15 708-2142 fpd (Purple)

FILTER NO.
8 k=270 fpd (Black)
10 k=400 fpd (Blue)
9 k=700 fpd (Orange)

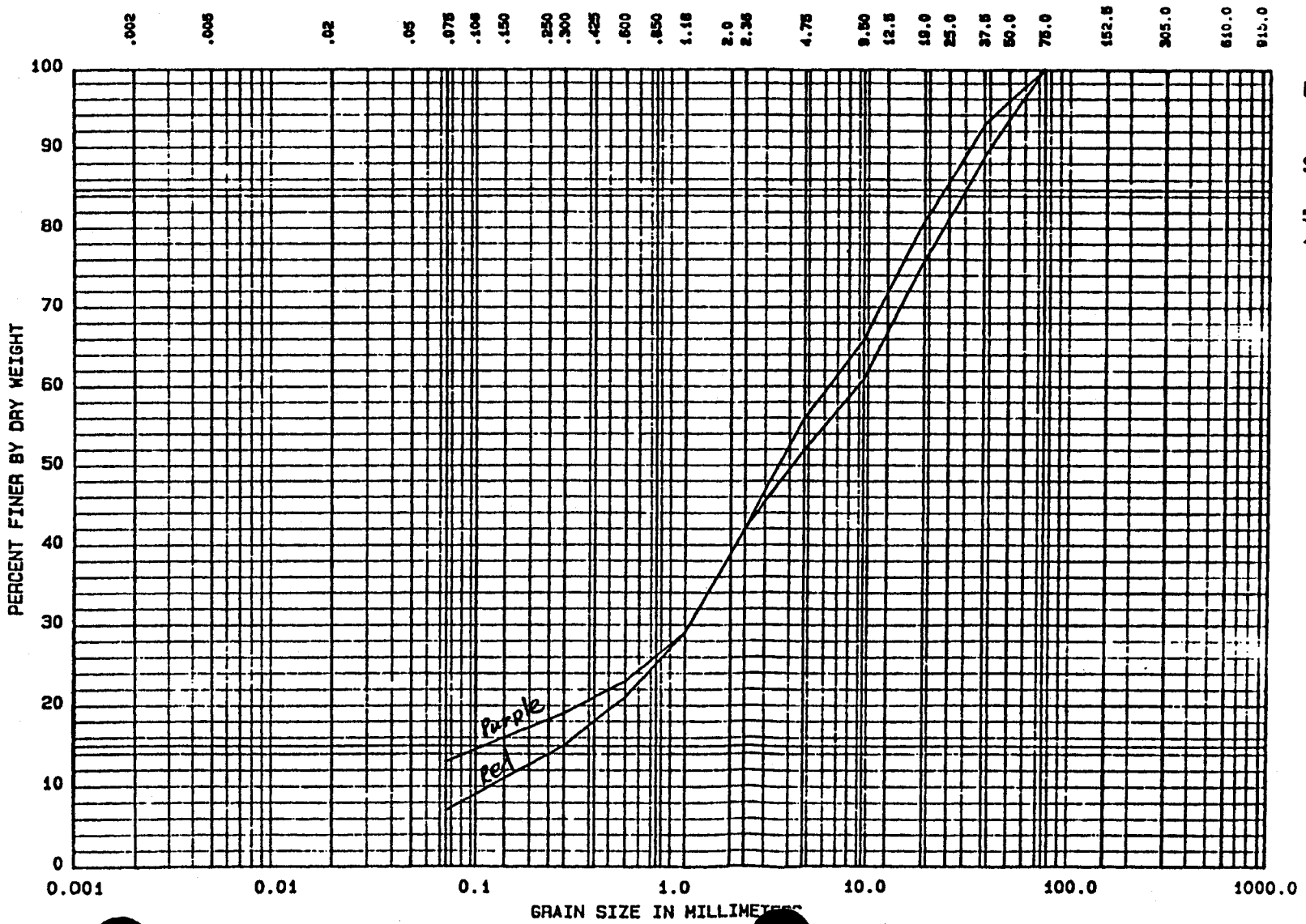
100 PERCENT PASSING NO. [illegible] SIEVE

Fig. 1

HARQUAHALA FRS - ARIZONA — REGRADED CURVES



HARQUAHALA FRS - ARIZONA -- SAMPLE CURVES



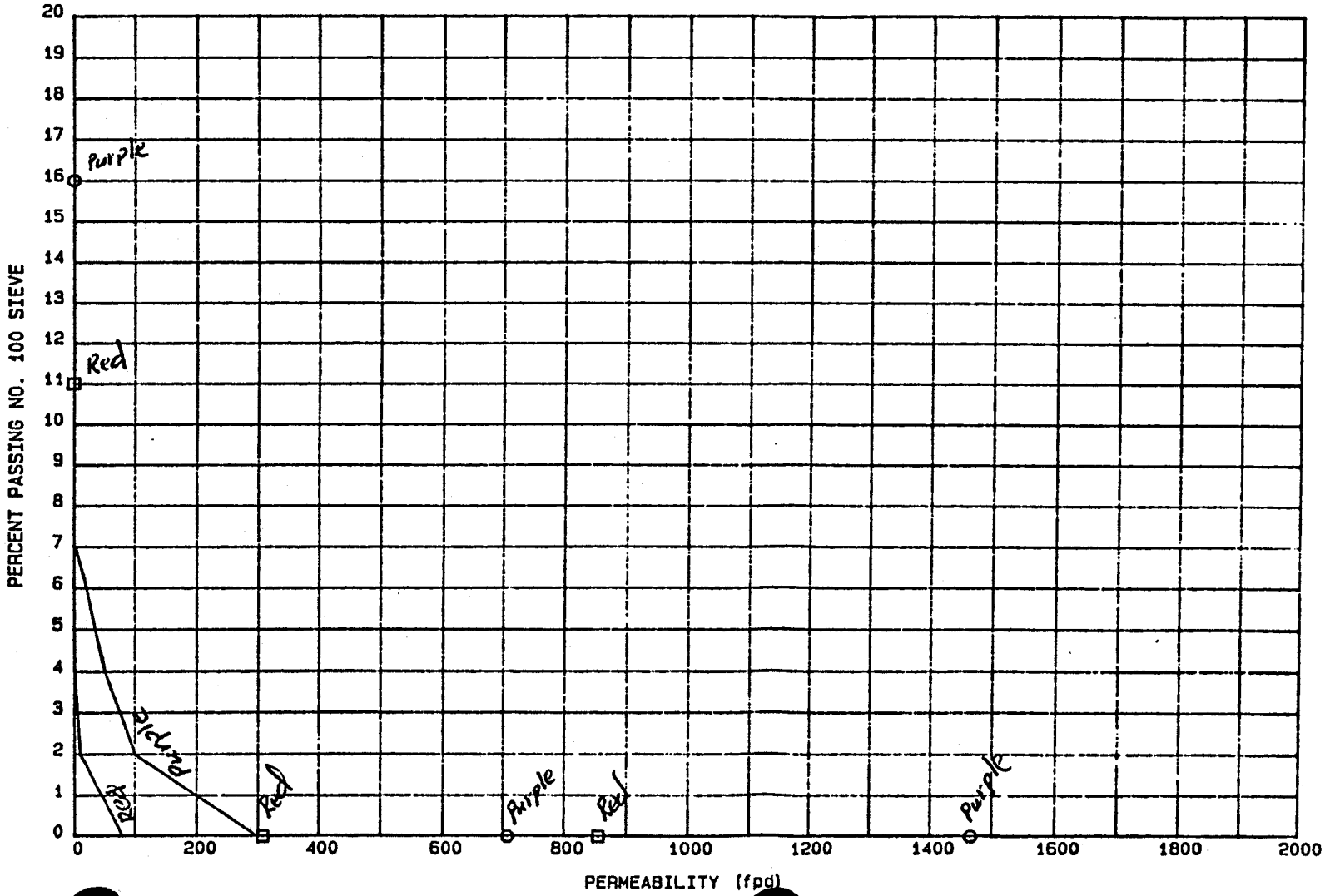
LEGEND

SOIL NO.

5-12-A-10 (Red)
4-1-A-15 (Purple)

Fig. 3

HARQUAHALA FRS - ARIZONA



LEGEND

FILTER NO.

LOW SIDE (Red)
HIGH SIDE (Purple)

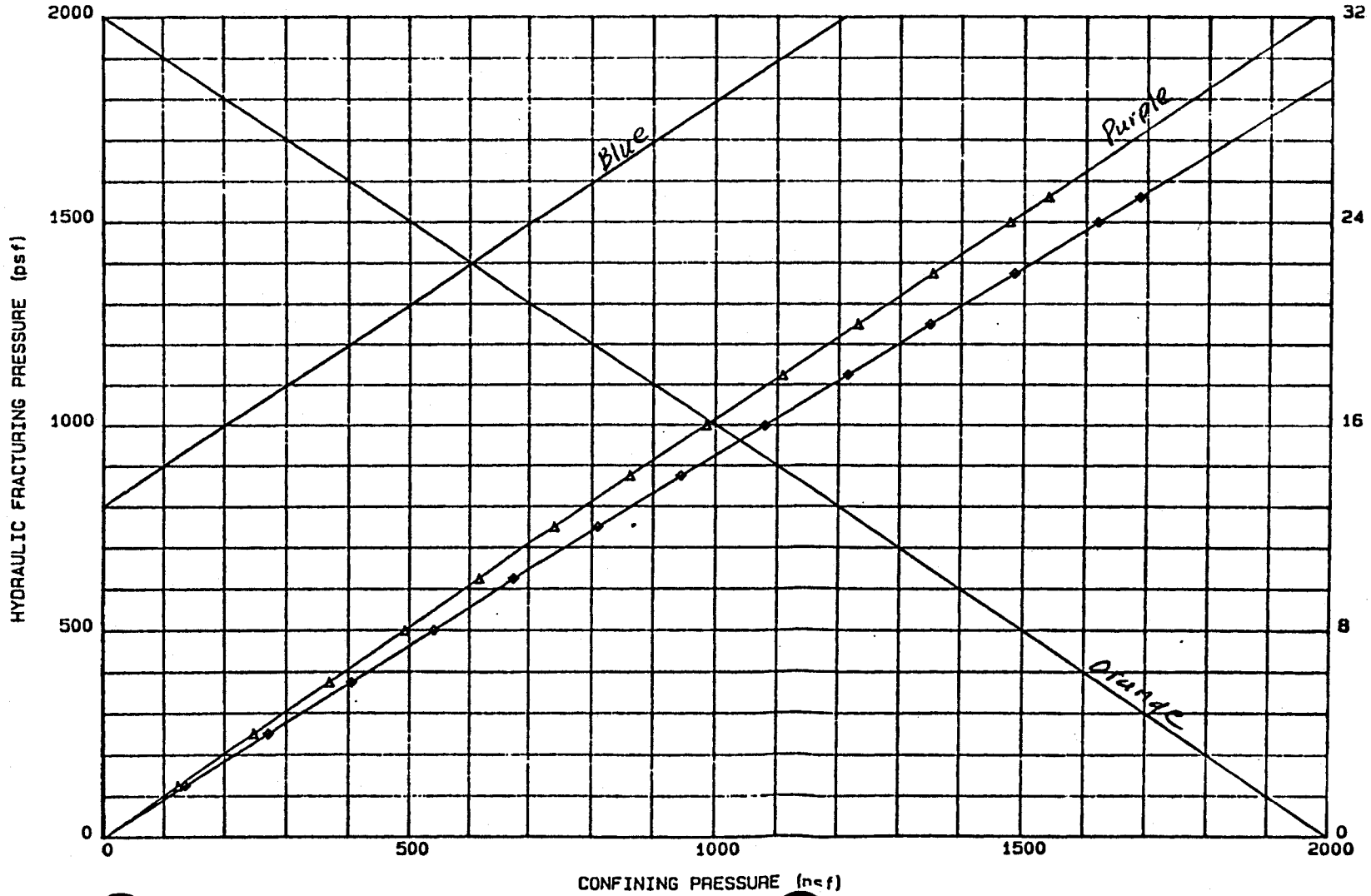
SOIL NO.

5-12-A-10 □ (Red)
4-1-A-15 ○ (Purple)

Fig. 4

PERMEABILITY VS PERCENT [illegible]NG NO. 100

HARQUAHALA FRS - ARIZONA



LEGEND

DRY UNIT WT. (Purple
MOIST UNIT WT.
WATER UNIT WT. (orange

LITERATURE RESULTS

-1 OMC NONSAT. (Blue)

Fig. 5

Vineyard 12-18-85

John L
Aubrey
Ralph
Don P.

1.) Isolated area between HDPE liner + drain fill.
2.) 1' scraped off of front face.
3.) Survey extent of damage @ cells. (Spot repair alt.)
4.) Aubrey + Ilde to visit site + recall past occurences. Make recommendations. (Fri, Mon, / (or) week of 6th)
5.) Backhoe out liner

United States
Department of
Agriculture

Soil
Conservation
Service

West National Technical Center
511 NW Broadway, Room 547
Portland, Oregon 97209-3489

Subject: ENG - Vineyard Road Dam Repair

Date: July 15, 1985

To: Ralph M. Arrington, State Conservation Engineer,
SCS, Phoenix, Arizona

File Code:

We concur in your recommendation to eliminate all drain outlets designed using criteria based on a width or depth of crack.

We agree that the vegetative outlets should be interrupted to ensure continuity of the transition trench at those locations. "Crack eradicator" type outlets will accomplish the need for this continuity.

Clifton P. Deal Acting For

JACK C. STEVENSON
Head, Engineering Staff

cc:
George C. Bluhm, Director, WNTC
Verne M. Bathurst, State Conservationist, SCS, Phoenix, Arizona
Clifton Deal, Soil Mechanics Engineer, Engineering Staff, WNTC
Donald E. Wallin, Head, Design Unit, Engineering Staff, WNTC

201 E. Indianola
Suite 200
Phoenix, Arizona 85012

ENG-Vineyard Road Dam Repair July 2, 1985

Jack Stevenson, Head Engineering Staff, WNTC 210

We are recommending eliminating all drain outlets designated to a crack width size (See WNTC letter dated October 4, 1984). Our recommendations are based on the following evidences.

1. Water ponded against the Vineyard Road FRS embankment as long as 68 days (August 5 through October 11, 1983) was not able to penetrate through the structure.

2. During the same 68 day time period, the formation of a phreatic line (6 inches deep) occurred parallel to the upstream slope and not through the embankment.

3. The drainfill material installed in the center of the dam will interupt any flow from vertical cracks or porous layers (horizontal).

4. Seepage that reaches the centerline trench will form a "Filter Cake" (layer of fines plugging the surface of the coarse material).

We recommend drain outlets at the five vegetative outlets as a factor of safety against any seepage that may escape the concrete plugged vegetative outlets.

The approximate stations are 129+70, 152+40, 251+00, 276+80 and 321+50.

Your concurrence would be greatly appreciated.

Acting

Ralph M. Arrington
State Conservation Engineer

Cliff Deal, Soil Mechanics Engineer, WNTC
Aubrey C Sanders, Jr. State Geologist
Bill Payne, State Design Engineer

ICC:nn

ENGINEERING REPORTS

United States Department of Agriculture

Soil Conservation Service

West National Technical Center
511 NW Broadway, Room 248
Portland, Oregon 97209-3489

Jc
KM
~~John Sullivan~~
File

Subject: ENG - Engineering Report on Signal Butte FRS, Buckhorn Mesa Watershed, AZ

Date: July 10, 1987

To: Mervin Ice, National Construction Engineer, NHQ, SCS, Washington D.C.

File code:

The attached sheets represent the first draft of the sections of the Engineering Report I have agreed to work on. Please review these and delete any superfluous materials or add items you feel are more appropriate. I have attached copies of a document that you may not have in the materials you received in Arizona. It tends to shed more light on the reasons for the method selected for installation of the membrane.

Clifton E. Deal

CLIFTON E. Deal
Soil Mechanics Engineer

Attachments

cc: (w/attach)
W. Evans, Head, Engineering Staff, WNTC
~~R. Arrington, State Conservation Engineer, SCS, Phoenix, AZ~~
J. Harrington, Project Engineer, SCS, Mesa, AZ
J. Sullivan, Construction Engineer, SCS, Phoeniz, AZ

INTRODUCTION

Many unique and state of the art designs have been developed by SCS in recent years. This information deserves a wider distribution within SCS and the engineering profession. Signal Butte Floodwater Retarding Structure (FRS), near the Phoenix, Arizona area, is one of those unique designs.

In order to evaluate this uniqueness and prepare a "Lessons Learned" report, an engineering team was formed by Verne Bathurst, Arizona State Conservationist. The committee consisted of the following:

Chairman: Mervin Ice, National Construction Engineer, NHQ
Member: Clifton Deal, Soil Mechanics Engineer, WNTC
Member: John Sullivan, State Construction Engineer, Az.
Member: David Lambson, State Administrative Officer, Az.
Member: John Harrington, GR & Project Engineer, Az.

most earth dams built in the Phoenix area cracking was a concern ing the development of the design. Many alternatives were considered and the defense that was selected consists of an impervious central geomembrane curtain made of 100mil. High Density Polyethylene (HDPE).

Signal Butte FRS is a 7000 feet long, 38.5 feet maximum height flood retarding structure located northwest of Apach Junction, Arizona in the Buckhorn - Mesa Watershed. The structure is part of a complex system intended to divert floodwaters from Apache Junction and the Phoenix area, and controls a drainage area of 10.6 sq. miles plus 5.8 sq. miles of diverted area.

The top of dam elevation, after settlement, is 1721 MSL while the crest elevation of the 140 feet wide reinforced concrete baffled apron chute emergency spillway with a Fujimoto entrance is 1712.4 MSL. The crest elevation of the standard covered top principal spillway is 1701 MSL. The principal spillway conduit is a 36" reinforced concrete pipe with a standard impact basin.

This is a class "c" high hazard dam as defined by TR 60. The freeboard storm discharge through the emergency spillway is 11,126.5 cfs while the emergency spillway design storm discharge is 2284 cfs. The emergency lway crest has a 1% chance of use.

DESIGN ALTERNATIVES STUDIED

In order to understand the development of alternatives a general review of the cracking problem that exists with "dry" floodwater retarding earth dams in Arizona should be discussed first.

In 1977 the Soil Conservation Service in the western region investigated six cracked earth dams near Phoenix, Arizona. The results of this investigation provided the basis for understanding the magnitude of the problem and establishing the techniques for repairing existing earth dams and design of future earth dams. Many techniques were reviewed and appear in the report, "Cracking of Dams in Arizona", April 1978. The major solution to the problem reported by the SCS regional investigation team consists of the use of graded sand and gravel sections.

Since the investigation in 1977 two field trials have been made to prove the use of graded sand and gravel sections will indeed provide the appropriate defense against cracking. One study was made in Arizona while other was in Nebraska.

The results of these two studies are somewhat conflicting as to proving that a graded sand and gravel section will provide the necessary defense against failure due to flow through cracks and the resulting erosion. The Nebraska study revealed what can be expected should the top of the graded sand and gravel section not remain above the maximum water surface. During the test water broke out of the downstream slope indicating the water was able to flow through the cracks without any appearant restriction by the graded sand and gravel section. Later excavation of the test site showed the water had over topped the filter section with erosion of the sand. This report concluded that the section as constructed served as an effective filter because the crack upstream of the sand and gravel section was filled with mud below the depth of erosion of the filter. This conclusion was further supported by the fact that the interface between the mud and the sand was abrupt with no fines in the filter sand.

On the other hand the Arizona study was performed with four test cells using three different methods of crack control. Those methods were: (1) a three feet wide central section composed of a graded filter, (2) an impervious central section composed of High Density Polyethylene (HDPE), and (3) no repair of any kind. Two test cells contained the graded filter but one cell had the upstream face cleaned of all loose material and all crack openings cleared of any obstructions while the upstream surface of other cell remained as it is left after installation of the central ed filter section.

Results of this test showed that after 20 days with the water at the top of the earth dam no water had reached the upstream face of the filter or the HDPE. After 30 days with water in the unrepaired cell an increase in the moisture content of the dam was noticed from the upstream surface to the centerline of the dam. However, the soil was not yet saturated at the centerline but water was noted following discontinunities created by roots or soil zones that had not been throughly mixed. No water was ever noted flowing in the cracks because none of the cracks remained open after water was introduced in the cells.

The conclusion of this test is that cracks in the materials of the test fill will close as water contacts the soil. In fact the depth of penetration and saturation is not over four feet in the crack and not over 12 inches in the area between each crack. To support this observation the water was lowered in one of the cells to allow the excavation of an eight feet deep trench within four feet of the filter sand. The cell was refilled and after 12 days there was no indication of the water reaching the filter. The closing mechanism is a combination of swelling and sloughing.

Both of these tests indicate many aspects of the site and the soils must be considered before deciding on the most appropriate crack protection. In case of dams built in the arid southwest cracking is not only the fit of dessication but of differential settlement, type of soil salts and clay chemistry and the potential for fissure cracking intersecting the dam.

In the case of Signal Butte FRS these various modes of cracking were considered along with the type of soils used in construction of the earth dam. Several items that made it more appropriate to consider an impervious type of crack protection were: (1) the foundation is caliche which has been shown to be considerably less compressible than other foundation materials on which dams have been built in the area, (2) the borrow materials contain varying quantities of calcium carbonate and other associated salts, (3) the embankment materials have a low percentage of fines with those fines predominately non-plastic, (4) the site is located high on the alluvial fan where there isn't a watertable to decline and cause deep subsidence, (5) with the presence of calcium carbonate and other salts in the embankment materials the potential for secondary cementation in the filter materials is a possibility and (6) cracking is still a possibility over the life of the structure due to the movement of moisture and salts and the effect these movements will have on the brittle nature of the embankment materials.

Once it was decided to use the impervious approach to crack protection it necessary to evaluate the various means of securing that objective. of the materials discussed in "The Cracking of Dams in Arizona", April 1978 report involved materials that were inflexible and subject to cracking or tearing themselves (soil-cement core, compacted earth core, and 12 mil plastic). However, a literature search showed recent useage of High

ity Polyethylene (HDPE) by other Federal agencies to accomplish similar objectives.

The Army Corps of Engineers installed a HDPE geomembrane in a slurry trench to repair Mohicanville Dike No. 2. They used a 100 mil HDPE liner, 34 feet deep in the foundation, as a defense against differential settlement cracks. The 100 mil material was used by the Army because of their lack of experience with the material and the difficult installation conditions requiring material that could tolerate rough handling.

HDPE is an inert material developed from a polymer without plasticizers. Carbon black is added to the mixture to provide ultraviolet light protection. The tensile stress at yield is over 2800 psi while elongation at yield is more than 15%. At break the tensile strength is 4500 psi while elongation at break is 800%. Consequently, this material is very strong and has the capability to tolerate significant elongation before breaking. No other materials reviewed has both strength and elongation capabilities as the HDPE does. Therefore, it was selected to provide the impervious membrane.

Before any design is complete a comparison between the alternatives must indicate cost comparability or the more costly alternative must have technical superiority. In this case it was determined the impervious membrane is more appropriate for the conditions at this site. A cost comparison with the conventional installation of a graded filter central section was made using the following installation alternatives for the HDPE: (1) the membrane is placed near the center of the dam in a "zig-zag" pattern as the fill is placed in six feet lifts adjacent to the membrane, (2) the downstream half of the embankment will be constructed to the top elevation planned for the HDPE membrane with the upstream face on a 1:1 slope. The membrane will be placed on this slope from the anchor block to the top elevation and the remaining fill will be placed on the HDPE membrane to the top of the dam, and (3) construct the HDPE membrane vertically, using pipes to hold the membrane upright until the fill can be placed on either side. Of these three alternatives the first alternative was selected as having the lest problems. The second alternative is objectionable because of the potential instability of the 1:1 slope during periods of rainfall causing extra work needed for repair of the slope by the contractor. The unknown costs associated with this repair made the alternative undesirable. The third alternative was discarded because of the unknown factor of wind when the geomembrane was only supported by the pipes. Another concern was the problem of routing of the scrapers over or around the membrane to place fill on either side of the supported geomembrane.

On the basis of these comparisons and the objectionable items it was shown that the first HDPE alternative was even cost comparable with the conventional graded sand and gravel filter system. The attached documents show the results of the comparison analyses.

United States Department of Agriculture

Soil Conservation Service

Room 3008 Federal Building
230 North First Avenue
Phoenix, Arizona 85025

RWM
File

November 21, 1983

Dick Raymond
Bureau of Reclamation
Suite 1880, Valley Center
210 N. Central Ave.
Phoenix, Arizona 85073

Dear Dick:

You have asked about the study the Soil Conservation Service (SCS) is doing at Vineyard Road Flood Retarding Structure (dam). The study is not complete, but I will be happy to provide you with a description of what has been done and what remains to be done. This information is necessarily informal to meet your deadline for review of proposed Bureau of Reclamation tests.

Introduction

The SCS does not do research. This study was initiated as a result of the unanticipated depth and number of cracks encountered during construction of Vineyard Road FRS Repair.

The repair design called for a trench in the center of the dam, three feet deeper than the existing cracks, backfilled with clean granular material. Every crack wider or deeper than specified dimensions would be eliminated on the downstream side by trenching and backfilling with granular material. The downstream trenches were modified out of the repair contract for the time being. The study was to determine behavior of the dam during a hypothetical flood event without elimination of the cracks downstream from the (already constructed) centerline granular material. (See the enclosed plans and specifications).

Cells

Four reservoirs, called cells, were constructed against the existing dam at sites where cracks were known to exist. One side of each cell was the existing dam, 100 to 200 feet long (see enclosed drawings). The cells were numbered during discussion sessions and the numbers never changed, therefore they are not in geographic order along the dam and there is no Cell 4.

Cell 3 was a control section of the dam left unrepaired and undisturbed by the repair contract. It is located between Stations 253+00 and 255+00.

Cell 1 was a repaired section, otherwise undisturbed. It is located

between Stations 121+00 and 123+00.

Cell 2 was a repaired section of the dam that was re-excavated for the purpose of placing monitors on specific cracks and then backfilled with materials meeting the original repair contract specifications. Then a 100-foot section of the upstream face of the dam was scraped off (approximately one foot deep). This cell is located between Stations 103+50 and 105+00.

Cell 5 was a repaired section that was re-excavated for monitoring and installation of an impermeable barrier of 100-mil thick high-density polyethylene (HDPE). For the purposes of this test, the HDPE was installed against the downstream vertical wall of the trench. The granular material in the bottom one foot of the trench was not removed. new granular backfill was placed to approximately two feet up from the bottom of the HDPE. (The purpose of the granular backfill at the upstream bottom of the HDPE was to (a) provide a discontinuity at any crack that might form at the edge of the HDPE and (b) cause formation of a "filter cake".) The rest of the trench was backfilled with soil borrowed at the site. No compaction was attempted since this is not a permanent installation and the only purpose was to hold the HDPE in place. This is a proposed barrier against cracks in a future design. Cell 5 is located between Stations 109+00 and 110+00 (approximately). A 100-foot section of the face of the dam in this cell was scraped off, too. Our geologist, Aubrey Sanders, used an air compressor to expose and clean the cracks at the scraped off sections of Cells 2 and 5 to encourage water penetration.

Water

As you know, Vineyard Road FRS is immediately adjacent to Reach 2, Salt Gila Aqueduct, Central Arizona Project. Reach 2 was under construction during the repair contract and the study contracts. One of our greatest difficulties was locating a source of water at a high enough discharge rate to approximate a flood event. Most of the possible sources were already in use for construction prewet on the aqueduct.

We were trying to fill each cell within six hours. We finally settled for a minimum discharge rate of 500 gallons per minute. The final arrangement consisted of an irrigation well that discharged into an existing concrete lined ditch which conveyed the water to a sump. A portable pump at the sump pumped water through portable irrigation pipe to each cell. There were two flow meters in the line, one adjacent to Cell 2 and one adjacent to Cell 3. Cells 2, 5 and 1 are fairly close together. Cell 3 is 2.5 miles from Cell 1. The sump was several miles from the dam.

Cell 3, the largest, was filled in 44.5 hours. This was the first cell to be filled and there were a few problems with the pump, materials in the pipe jamming the flow meters and lack of communications between the cell and the pump sites. The smallest cell (2) was filled in just less than 22 hours. Considerably more water was required to fill Cell 3 than the actual storage volume.

All four cells were filled by August 5, 1983 and maintained full until at least September 1, 1983. Depth in each cell was about fourteen feet.

Depth was maintained within a range of one foot measured on a staff gauge in each cell. Cell 5 was maintained full until October 11, 1983 and has not been drawn down.

The original idea was just to keep the cells full about fifteen days to simulate a worst-case condition. The flood control dam is designed to drain in a maximum of ten days. Since none of the monitors gave any indication of water movement through the structure after fifteen days, the test time was increased.

One of the questions we hoped to resolve was: Does a filter cake form at the contact between a crack in a dam and the granular zone when water flows through the crack? Laboratory tests indicate the rapid formation of a positive seal, filter cake, when water is introduced to a crack in soil adjacent to granular material with a minimum D_{15} between 0.4 and 0.7 mm (varies with specific soil). The concern revolves around the low height of dams in this location and the part pressure and velocity may play in formation of that seal.

Unfortunately, we do not have any samples of runoff water from a typical storm to compare with the water used in the study. Three samples of water used in the study were tested for cations, anions and pH. (See enclosed test results.)

Excavation

Water in Cell 2 was drawn down five feet to permit excavation at the crack sites from the upstream face of the dam. Three of these cracks were investigated August 25, 1983. Trenches were approximately eight feet deep and ended four feet from the upstream side of the filled centerline trench. The cracks were visible on the slope prior to excavation with the backhoe. The trenches were left open and the cell refilled as a further attempt to get water through the cracks to the repair work. During this excavation, one of the electric crack monitors indicated water. It was later discovered that the activities on the dam caused that monitor wire to be damaged.

Cells 2 and 1 were evacuated and Cell 3 was drawn down the first week in September. A team of geologists and engineers supervised and participated in investigative excavations on these cells the week of September 6 - 9, 1983. They ran out of time and did not participate in excavations on Cell 5. Phil Jones (NM State Soil Mechanics Engineer) and I investigated Cell 5 for flow in cracks and through the embankment September 12, and I supervised the investigation October 11, 1983. The investigation proceeded with a full reservoir to make location of cracks and seepage simpler and unquestionable.

Monitors

No monitor other than a staff guage was used at Cell 3. The dam at that site was totally undisturbed.

Cell 1 had a staff gauge and several PVC piezometers driven into the granualar material at known crack locations. The piezometers were

protected by a steel pipe sleeve, for the top three feet, with a threaded cap. The pipe extended one foot above grade. The caps were to keep rain and dirt out, but if left on all the time moisture condensed in the pipe and caused the electric sensor to show water. No water apparently reached the centerline of this part of the dam.

Cells 2 and 5 were monitored the same way. Piezometers were installed in the same relative locations as in Cell 1. Pairs of piezometers were located at selected cracks. One six inches from the upstream trench wall and one six inches from the downstream trench wall (or at the wall behind the HDPE in Cell). Two additional piezometers were installed in the center of the trench approximately 25 feet away from the north and south crack monitors, respectively, in each cell. The trench was twenty feet deep and the piezometers were set into the bottom of the trench about six inches to maintain their location during backfilling operations. Water entered through slots in the pipe.

A minimum of three cracks were monitored at each cell (2 and 5). Electric sensors were stapled into the cracks with plumbers tape at the apparent bottom of the crack and at the widest part if the crack on the upstream wall of the trench. Two more sensors were set below the cracks on the upstream and downstream bottom of the trench, respectively. Wires from these monitors were run to a construction trailer between the two cells. Clocks and buzzers were attached to alert us of any water that came through and the exact time and location. None of the electric monitors ever actually registered water. The damaged wire on Cell 2 produced a false indication.

There was an attempt to keep evaporation and rainfall data. These are questionable, but may show some trends.

Staff gauges were read often. They indicated relatively slow loss of water due to seepage.

Photography

Much of the study is on video tape and/or slides. These have not been edited and spliced, so they are very time-consuming to watch. In fact, I have not had an opportunity to look at the last film (October 11).

Some locations and results were hard to photograph due to darkness in the trenches and similarity of color and texture between wet soils and dry soils.

Soils

Ten soil samples from Cell 2 are at the Soil Mechanics Lab at this time. Nine are CL's and one is SC. These were taken adjacent to cracks.

More samples of embankment materials are planned along the length of the dam to aid in projecting the results of the study throughout this structure and, potentially, to other structures.

Dams constructed with different soils may behave in an altogether

different manner than this study would indicate.

Observations

The fully saturated "phreatic line", after more than 30 days of storage, appeared to parallel the upstream slope of the dam roughly six inches deep. The surface material under water appeared to behave in a structureless single-grained manner except at the scraped off sections.

The overall moisture content of the embankment materials appeared to increase with time and proximity to the upstream face of the reservoir. A memo in the files concerning the first excavation (August 25) at Cell 2 says that "The water seemed to be following...seams of horizontal layers..." (Ralph Arrington, SCE). In Cell 5 both September 12 and October 11 this was very evident. The source of all of the moisture in the middle of the dam at Cell 5 appeared to be a horizontal layer of saturated material at approximately eight vertical feet from the top of the dam and another layer about three feet below that.

No water passed all the way through the dam at any of the four sites. Seepage reached the center of the dam at Cell 5 and the downstream side of the center of the dam at Cell 3.

Excavation of the dam from the downstream side while water was still in the reservoir made location of flow paths positive. Cracks were otherwise difficult to locate when the embankment soils became uniformly more moist. The appearance (color) of saturated soils did not vary appreciably from the appearance of merely moist soils.

Conclusions

No conclusions can be made before final data have been collected and analyzed. In the meantime, you are welcome to look at the data we have. It is not reduced and organized at this time. As mentioned before, the results are only applicable to the sites tested until soil correlations are made. Also, we only looked at relatively short-term storage.

Susanne Leckband

Susanne Leckband, P.E.
State Soil Mechanics Engineer

Enclosures

cc: Ralph Arrington
Clifton Deal
Jim Talbot
Aubrey Sanders
Verne M. Bathurst

ABSTRACT

Cracks have been observed in the flood control dams constructed in the arid southwest since the mid-60's. (Magma, July 30, 1965).

This report gives a brief history of the Arizona dams where cracks have been noted and information about their foundations and embankment soils. Most cracking can be attributed to foundation movement of one kind or another.

Protection from these cracks has been a major concern, since failure of one of these structures during a flood would, as a minimum, cause local damage and expensive emergency repair. A test was conducted at Vineyard Road FRS to evaluate performance of the prevalent repair method. Results of that test are reported and discussed.

Suggestions are made for possible alternate designs. Sources are suggested for research results that might apply to flood control dam design.

VINEYARD ROAD FRS STUDY

The 1978 report on cracked dams in Arizona was necessarily brief and, apparently, was intended to officially recognize the problem and suggest protection methods. One of those recommended protection methods was a transition zone of coarse grained material within the dam to break the path of any crack and prevent piping of upstream soils. Since such a design was already in progress during the week of the study, it was endorsed and installed in the existing Rittenhouse FRS. This "repaired" that cracked dam. Installation experience, apparent acceptance by all reviewers and the need to address the problem of cracks in a number of structures led to replication of this basic method in all Arizona dams repaired since 1978.

Since SCS knows of no former use of a crack protection zone in dry (flood control) dams, design details have been based on judgment and opinion as much as on extrapolated research data.

Lack of solid information about the performance of this zone led to considerable effort on the part of Bob Nelson, WNTC Soil Mechanics Engineer, and others to predict behavior and set design criteria.

Questions to be resolved were not limited to:

1. Optimum gradation of transition material.

2. Effect of crack width on flow behavior.

3. Behavior of three-dimensional flow along a wetting front.

(Flow nets and computer programs are generally based on two dimensions and steady-state seepage, a condition that does not exist until the material is saturated. In other words, if the whole transition zone is filled with water and a sufficient volume of water is still entering the zone from the cracks, then--if you have properly described the outlet--the results of the formulas and flownets are probably valid)

4. Soil parameters to be used in design formulae. A crack is a void. What soil will be between the void and the transition zone?

5. The number of "Outlets" needed from the transition zone.

There was a program available at the University of Arizona that would analyze flow through different soils three dimensionally. November 16, 1981, a number of SCS people met in Arizona to review the problem of embankment cracking and evaluate construction progress. Jim Talbot, Bob Nelson and Susanne Leckband met at the U of A with Dr. C. Desai about the SEEP3D computer program. Dr. Desai explained the formulae the program is based on. They are essentially the same as the calculations Bob was working with. (Further use of the program revealed that it was 1) too small and cumbersome and 2) assumed saturated steady flow, so really didn't answer the questions.)

It was agreed during that trip that we should construct a cofferdam on a section of dam that had been repaired with a transition zone and also on a section of dam that is cracked, but not repaired. The cofferdam would be filled with water and performance checked by subsequent excavations into the cracked areas of the dam. (Jim Talbot to Buell Ferguson for November 16-20, 1981 trip.) No action followed until repair of Vineyard Road FRS

In 1982-83, Vineyard Road FRS was being repaired with the transition zone installation. A number of outlets were included in the design (84) based on the width and severity of cracks. Many more cracks were located during construction than were anticipated. The number of outlets required by design criteria were estimated at approximately 400.

At first (January 12, 1983), the criteria was modified to permit a greater crack width than design (1/4") in the first 1800 feet. Outlets would be installed where cracks exceeded 1/2 inch in width. In an area with a number of serious cracks, outlets would be placed no more than 100 feet apart with the outlet on the largest crack. Outlets would not be placed closer than 25 feet apart. (Serious cracks were as close as 3 feet apart.) Then in early February, the decision to study behavior of the embankment without outlets to determine whether they really are necessary to protect the dam from failure. The construtiion of the outlets for the repair contract was to be delayed until the results of this test were known. The test was to include a cracked section of dam where no repairs

have been made, a section of dam repaired with a vertical transition zone

and, possibly, a section of dam repaired with a geomembrane (2-9-83 letter to Verne Bathurst from Chuck Lemon).

Bob Middlecamp, WNTC Construction Engineer, recorded in his report from March 21-23, 1983:

The tentative test sections would be:

#1 Sta. 121+00 - 123+00

#2 Sta. 103+50 - 105+00

#3 Sta. 253+00 - 255+00

#4 Sta. 262+00 - 264+00

These locations would be verified by field conditions. "Observation of these areas scheduled to test crack repair techniques indicates that crack locations during wet weather are hard to identify due to the swelling nature of the soil materials." It was recommended that the tests be performed during dryer weather. Since the Arizona desert's most intense storms usually occur July through September, summer would be a reasonable time.

Bob Middlecamp continued, "The need for a state office technical staff

person to act as test coordinator for the Vineyard Road test effort was discussed and it was agreed that one would be designated. Many of the questions that must be answered during the test effort can be more quickly resolved among the NTC, State Office, and Project Office through a single state office liaison person."

In April, Clifton Deal, WNTC Soil Mechanics Engineer (Bob Nelson retired) worked with Ralph Arrington, Susan Leckband, Aubrey Sanders and Tom Jayo to design and install the insturmentation in the test sections. Requested coordination of monitor efforts with construction people (Bob Middlecamp and John Sullivan) was denied by the SCE.

It was decided that five test sections, called "cells", would be constructed and they would be maintained full for 15 days apiece. SCS personnel constructed monitors and a central control box.

Clif recorded, "The most critical time for failure of this structure is when the cracks are open to the surface of the fill, the embankment is dry. And a freeboard storm occurs on the upper watershed without rainfall on the dam. Due to these recent rains, cracks are not visible on the surface of the dam and recent trenching shows significant infiltration of water into the embankment. The presence of the water in the cracks with corresponding closing or filling certainly will not enhance the success of this field trial."

"Because of the importance of this field trial, very close control by a

member or members of the state staff familiar with monitoring, instrumentation and cracking mechanism can't be overstressed. This type the type of job that cannot be handled as a routine job and, therefore, should receive special consideration by state specialists." (Clifton Deal to Verne Bathurst 4-5-83).

The importance of the coordinator was most apparent by two major losses. Soil samples were taken throughout the trench to monitor soil moisture. The structure with soils at the individual test cells. The project soils laboratory was unaware of this intention and, therefore, dumped all of those samples when the laboratory was moved. This made a separate soil collection program mandotory. The second major difficulty has been timely consolidation and reporting of the study results. Part of this is related to the geotechnical work above, but there has been no individual responsible/accountable for this study, therefore, there has been no champion for its priority in the total program.

The prime purpose of this test, as documented by Jack Stevenson 3-16-83, was to evaluate the effectiveness of the repair method in use for protection of badly cracked dams.

This evaluation would:

1. Determine behavior of a unrepaired (control) section of the dam.

2. Determine if a filter cake develops on the upstream surface of the transition zone.

3. Determine how quickly a filter cake develops.

4. Determine the amount and distribution of water that reaches the transition zone.

5. Determine that amount of water that reaches the crack downstream from the transition zone.

6. Determine the type and amount of erosion into the downstream cracks.

The monitoring system was to include a combination of piezometers, visual

HISTORY

White Tanks

One of the first PL-566 (Flood Control) projects in the United States was White Tanks, northwest of the Phoenix metropolitan area (see maps). White Tanks #3 and White Tanks #4 were completed in May of 1954. McMicken Dam, in cooperation with the Corps of Engineers, was completed in July of 1956).

Almost no geologic information is available to us for these structures. According to the "White Tanks Repair As-Built Geologic Report", there was little or no foundation excavation prior to embankment construction. Natural soil under the dam was approximately 0.5 feet deeper than the adjacent natural ground elevation.

These dams were repaired in spring of 1982 by excavation of a trench through the embankments on the centerline and backfilling with a coarse grained soil material for protection against cracks. The cracks were mapped as part of the repair procedure. The majority went to the foundation. The geologist (Ronnie Rappmund) observed a correlation between the pre-dam natural channels and the "degree of cracking".

Graveyard Wash

The geologic strata which are present at the Graveyard Wash damsite consist of a thick sequence of alluvial deposits which extend to a depth of several thousand feet. The lowest unit identified is a widely distributed stratum of pre-consolidated silt or clay commonly referred to as "lakebed clays". The top of this unit lies at depths ranging from about 20 feet to more than 35 feet below the present land surface. The lakebed clays are overlain by old stream gravels with an average thickness of about 12 to 15 feet. The gravels are overlain by playa deposits consisting of clayey silt, silty sand and sandy silt which are locally as much as 10 feet thick. Overlying the playa deposits are sandy gravels deposited on the surface. This unit ranges in thickness up to 10 feet or more.

Subsequent to the deposition of the above described sequence the present drainage system of Graveyard Wash developed concurrent with down cutting in the Gila River Valley.

The steep walled valley cut down to the surface of the lakebed clays and the channel was deeply incised into the lakebed clays as a steep sided channel. Subsequently the channel was filled with alluvium consisting of random deposits of sandy and clayey silt and sand. Sediment deposition in the valley continued until as much as 30 feet of sands, gravelly sands, sandy gravel, silts and cobbles were deposited over the lakebed clays. The incised channel lies between approximate stations 12+00 and 25+00.

The investigators (Dames and Moore) recognized the potential for differential settlement in the vicinity of stations 3+00 and 26+00 due to the steep contact between the younger valley fill alluvium and the older alluvium into which the valley was cut. It was later recognized by SCS Geologists that another area of potentially severe differential settlement existed in the vicinity of stations 12+00 to 14+00. It was at station 13+50 that severe cracking of the embankment occurred.

Prior to the development of embankment cracking, water had been allowed to pond in a borrow area upstream of the dam in the general vicinity shown on Exhibit A4. The dam was designed as a floodwater retarding structure with a maximum detention period of 72 hours, so the foundation would not become saturated. It has been determined that saturation of the foundation materials did occur at a depth of 12 feet near station 13+00. Thus is it hypothesized that the ponding of water facilitated differential settlement in the foundation, thereby causing the major crack that was recognized and repaired in 1981.

FREDONIA

Fredonia dam is located in Coconino County, Arizona, approximately one mile east of the town of Fredonia, Arizona. Construction was completed in July, 1973.

The embankment foundation consists of extensive deposits of Quaternary alluvium, most of which was deposited by sheet flow on low gradient alluvial fans under unsaturated conditions. The alluvium consists of a variety of soil types, ranging from clayey silt (ML) to fine to medium grained clean sands (SP). Much of the material was described as having a high consolidation potential. Most soils contained gypsum sand; with gypsum contents as high as 51% identified. The water table was encountered at depths of about 29 to 40 feet beneath the land surface in 1971.

The alluvium overlies a very irregular surface of gypsiferous shale and claystone of the Moenkopi Formation. Depth to bedrock below the land surface ranged from less than ten feet to undetermined depths exceeding fifty feet.

The supplemental geologic report (Don Clark 1971) presented the following numbered conclusions:

6. "A very irregular subsurface contact between the Moenkopi Formation and the . . .alluvium is indicated. . .the possibility of nearly vertical slopes does exist. . .differential settlement problems due to this condition would be more likely to occur in the vicinities of stations 110+00, 140+00, and 165+00."

7. "The possibility of consolidation caused by soluble salts in the materials of the dam and foundation going into solution makes rapid drawdown of the detention pool advisable."

9. "Because of the thickness and nature of foundation materials, it is expected that consolidation will occur regardless of treatment. This consolidation may cause cracking in the embankment which could necessitate major repairs during the life of the structure."

The development of cracks associated with the Fredonia structure was first reported in 1976. A number of depressions on "sinks" developed in the alluvium in the reservoir area. Concentric cracks developed around the depressed areas. Minor cracking of the lower portion of the upstream slope of the dam occurred between stations 132+50 and 134+00. These cracks were primarily of the longitudinal type. The investigators, Ralph Arrington and Don Clark (State Conservation Engineer and Geologist; respectively), concluded that these sinks and cracks were associated with consolidation of "in-place" soils.

In 1980, Paul Monville (Design Engineer) and Jack Stevenson (WTSC Engineer) investigated a number of cracks in the dam. They concluded that the more severe cracks, at stations 107+75± and 111+75 were the result of differential settlement due to the presence of an old buried channel beneath the dam. They further stated that "other cracks appear to be caused by dessication." They reported a "2 to 4 inch diagonal crack at station 111+75± which extended beyond the limits (10') of an excavated backhoe pit.

Further investigation of embankment cracking was done by Aubrey Sanders and Ronnie Rappmund (SCS Geologists) in 1981. They excavated several pits and described the cracks at various locations. They noted the presence of sub-parallel transverse cracks ranging from 1 to 6 inches apart, with voids ranging from 1/4 to 3/4 inches wide. At one location they reported that air could be felt moving through a crack in the dam at a depth of 13 feet below the top of the dam. They also excavated a narrow, shallow trench on the top of the embankment, extending the entire length of the dam. This trench was filled with water in order to locate cracks in the embankment. Numerous cracks were identified and mapped using this procedure. During this study this study, additional drilling was undertaken in order to further evaluate foundation conditions and to better define the rock line. This study revealed that the water table was about sixteen feet higher then it was when the 1971 investigation was done. It also showed that the dip of the rock surface was steeperr in some areas than had been determined by earlier investigations.

At the time of the 1981 study it was determined that longitudinal cracks in the upstream slope of the embankment had developed into area not identified by earlier studies. These cracks also had extended in length and number the area previously identified.

The dam was repaired during the summer of 1982 by excavation of a trench in the embankment between stations 99+80 and 153+00 and backfilling with a coarse-grained material for protection against cracks. Similar measures were installed at the downstream toe of the dam between stations 103+00 to 117+35 and from station 136+00 to 151+00, with an average depth of approximately 20 feet.

The most severe cracking observed during the repairs include the section between stations 104+100 to 115+00 and the section between stations 143+00 to 146+00. This is entirely consistent with Don Clark's 1971 supplemental geology report prediction.

Preprint

INVESTIGATION OF CRACKED FLOODWATER RETARDING EARTH FILL DAMS

by

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FUGRO

INVESTIGATION OF CRACKED FLOODWATER RETARDING EARTH FILL DAMS

by

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INTRODUCTION

Earth fill dams have been constructed in the vicinity of Phoenix Arizona since the early 1950's under federal watershed programs. These structures are classified as dry dams because they retain water only for short periods following rainfall. They are also designated as Flood Retarding Structures (FRS).

Cracking had been reported a short time following construction. Inspection of these dams by the Soil Conservation Service (SCS) in 1977 revealed the existence of extensive transverse and longitudinal cracks which could pose a hazard to the integrity of the structures (SCS, 1978). Subsequent to the SCS studies, Fugro investigated five of the most severely affected structures to document the locations and characterize the depth and extent of cracking that may affect stability of the embankments. Services were also contracted for construction inspection of an embankment drain in a previously investigated FRS to provide protection against possible failure caused by piping through the structure.

The primary purpose of the crack location investigation was to provide sufficient data for engineering design of remedial measures, not to specifically determine the cause(s) of cracking. The data obtained should assist, however, in evaluating and identifying cracking processes. Degree of cracking maps were developed to assist in prioritization of corrective action at each of the five structures. Several possible mechanisms for cracking include desiccation and differential settlement induced by hydrocompaction, subsidence and/or consolidation.

The crack location investigation encompassed a total of 109,349 linear feet of structures in Maricopa and Pinal Counties, Arizona (figure 1). This

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included Magma FRS (28,750 feet); Vineyard FRS (28,400 feet); Buckeye FRS (37,400 feet); White Tanks No. 3 FRS (7,920 feet); and White Tanks No. 4 FRS (6,389 feet). Remedial actions were applied to Rittenhouse FRS which required 13,500 feet of trench excavation and backfilling with engineered drain fill.

The work performed during the crack location investigations and construction inspection included:

- Review and analysis of studies previously conducted by the SCS and other related maps and reports concerning the site area.
- Detailed mapping of features along the crest of the 109,349 feet of structures.
- Excavation and flooding of 402 shallow trenches totalling 26,635 linear feet.
- Excavation and detailed logging of 71 backhoe trenches.
- Collection and classification of soil samples obtained from exploratory trenches.
- Photographic documentation of field activities and selected features identified during the detailed mapping and subsurface exploration.
- Detailed logging of the centerline remedial drain trench excavated at the Rittenhouse FRS.
- Analysis of the collected data to prepare appropriate plans, profiles, and a final report for each structure.

GEOLOGIC SETTING

The study area is situated in the northcentral part of the Sonoran Desert subprovince of the Basin and Range Physiographic Province (figure 2).

Stratigraphically the generalized sequence includes (1) the basement complex consisting of Precambrian, Laramide and granite, gneiss, volcanic and minor sedimentary rock, and (2) Tertiary through Quaternary valley fill consisting of a volcano-sedimentary unit, a thick (10,000 ± ft.) essentially fine-grained deposit and thin heterogeneous unconsolidated alluvium.

Groundwater extraction induced subsidence and associated earth fissuring is occurring within and at the margins of the deep basin deposits.

CLIMATE

The area has essentially a dry climate with most precipitation resulting from summer thunderstorms or winter Pacific storms. Annual precipitation averages

from 7 to 10 inches whereas average evaporation rates range from 68 to 73 inches per year. The temperature range is also extreme with summer highs exceeding 100°F and winter highs averaging 50°F. Diurnal temperature changes exceeding 40° are not uncommon.

EMBANKMENT CHARACTERISTICS

All of the embankment structures investigated are similar in profile with 2:1 or 3:1 (horizontal to vertical) upstream slope inclinations, and 2:1 downstream slope (figure 3). As-built construction plans indicate over excavation of foundation soils was performed to varying depths depending on soil conditions. The structures vary in height from grade to about 43 feet. All are homogeneous earth fill dams with no internal drainage systems. Drainage from the structures is controlled primarily via vegetation gates of low discharge capacity. During periods of high volume runoff, discharge is provided by an emergency spillway. The structures are constructed on or downstream from the lower slopes of alluvial fans in nearly flat but rolling terrain.

CRACK LOCATION FIELD PROCEDURES

Detailed Surficial Mapping

The detailed mapping emphasized features occurring along and near the crest of the structure where they were not obscured by slopewash and vegetation. Cracks, pipes, anomalous depressions and animal burrows were described and mapped at a scale of one inch to 20 feet along the entire length of each structure (figure 4). Many features occurring on the slopes of the structures were also mapped. During the field mapping, flexible wire probes were used to ascertain the apparent depth and continuity of the features as well as shallow hand-dug pits.

Shallow Trenching and Flooding

Following completion and analysis of the detailed mapping, shallow trenches, one-half foot wide by two feet deep were excavated with a Ditch Witch-type trencher along the crest centerline in representative cracked and uncracked segments of the structure ranging from 25 feet to 100 feet in length (figure 5). A total of 26,635 linear feet or 24 % of the structure was trenched in this manner. These trenches were flooded to determine the relative extent of cracking by noting the volume of water required to fill the trenches. Records of trench dimensions, water used, time required to fill each trench segment,

and water loss (due to trench leakage) were used to calculate a rough index number, called the flooding ratio, to rank the apparent internal extent of cracking. Flooding ratio (F.R.) is defined as:

$$F.R. = \frac{\text{volume of water required to fill trench}}{\text{volume of trench}}$$

The flooding ratio is a useful indicator of cracked areas because as the flooding ratio increases it signifies an increasing amount of leakage into cracked areas. Ratios between 1.0 and 1.2 indicate no water loss into the embankment.

A total of 402 trenches were tested in this manner. Of these, 195 had no detectable leakage and 81 had leakage so severe that the trenches could not be filled at the maximum pumping rate of about 240 gal/min. It would appear that the trenches intercepted a major conduit connected to a complex network of transverse and/or longitudinal cracks. Leakage from down slope conduit outlets induced by artificial flooding was observed in only a few of the flooded areas which would indicate that most of the water losses were internal.

Deep Trenching and Subsurface Investigation

Portions of each structure were excavated with a backhoe to allow for subsurface inspection of crack features (figure 6). Seventy-one backhoe trenches, 1.5 feet wide and ranging in depth from 3.3 to 17 feet were excavated. Detailed trench logs of each excavation were drawn at a scale of one inch equals two feet.

The embankment soil types of the structures range from clay to gravelly sand (USCS nomenclature) and are commonly dry to moist. The dominant soil types encountered were silty clay and clayey sand. The cracks most commonly encountered in the trenches were of the transverse type because of the orientation of the trench and narrowness of the crest; however, longitudinal cracks and cracks oblique to the centerline of the structures were also trenched.

CHARACTER OF CRACKING

Cracking patterns observed in this study (similar to those described by Sherard, (1973)), include transverse - normal to the embankment axis, longitudinal - parallel to the axis, and oblique - intermediate to the transverse and longitudinal (figure 7). Cracks are well developed along and across the crest of the structures yet many may be found on both upstream and downstream slopes. There appears to be no preferred clustering or dominance of crack type.

Transverse, longitudinal, and oblique cracks are easily identified at the surface by the alignment of the vertical to near-vertical conduits or pipe-shaped circular features (figure 8). The conduits range in size from one to three inches in diameter and a few inches to two feet in depth. Conduits up to 12 inches in diameter were observed where localized erosion or collapse had occurred. These pipe-like features were also observed on the upstream and downstream slope as much as 20 feet below crest grade. The features appear to be identical in character to vertical erosion tunnels described by Sherard (1977) that affected the Wister Dam in southeastern Oklahoma. It is suspected that the tunnels developed from rainfall or slope wash entering desiccation cracks. Where open cracks were observed, they were at least 1/16 inch to three inches wide. Incipient cracks less than 1/16 inch wide occur both transversely and longitudinally to the centerline. Surficial "healing" or infilling has occurred in some cracks. This sediment filling was much more loose and coarse-grained than the adjacent undisturbed fill of the structure.

The maximum depth of cracking ranged from 8.6 feet below the crest grade at the White Tanks No. 4 structure to 21.9 feet at White Tanks No. 3. Most were vertical or slightly inclined from vertical. The average opening of the cracks were about one-half inch and terminated at depth as a hairline crack (figure 9). Where the cracks were open, the crack face was usually irregular and rough but smooth portions were observed locally. Some cracks were characterized by sediment-filled intervals containing loose, poorly graded sand. These filled intervals, where they occurred, were discontinuous along the lengths of the cracks. Commonly, horizontal pipe-like structures were also located along the cracks. Their origin is unclear but they appear to represent conduits through which water escaped during induced flooding.

DEGREE OF CRACKING

A map depicting the apparent degree of cracking affecting each structure was developed from the field data (figure 10). The highest degree, moderate to severe, was defined where significant cracks or related features were identified. Distances between features were less than 60 feet and the features were primarily open cracks, large conduits and clusters of small conduits. Crack or conduit outlets were identified from the induced flooding and the flooding ratio exceeded 1.3. The next degree was defined as low where some cracks were identified (primarily short incipient cracks and small conduits).

The distance between features was generally less than 100 linear feet or where a particular reach of the structure was bounded by moderate to severe areas. The flooding ratio was also less than 1.2. No cracking was defined where no cracks or related features were identified on a reach of the structure for at least 150 linear feet or 50 feet where the crest height was less than five feet. Also, the flooding ratio for the reach was less than 1.2.

REMEDIAL MEASURES

As a result of this investigation Fugro has suggested several remedial measures. These measures do not represent a permanent cure to the cracking problems but represent interim corrective action to minimize existing hazards. The use of these measures is dependent on problems that may be unique to the particular structure; upstream and downstream developments; design capacity; geologic, hydrologic and soil parameters; ease of construction and economics.

The proposed alternative remedial measures include:

1. Excavation of a centerline trench and backfill with an engineered drain fill aggregate.
2. Placement of an engineered earth fill buttress on the upstream slope.
3. Installation of a downstream toe drain and graded filter blanket.
4. Channelize runoff to reduce impoundment.
5. Modify retention capacity of structure.
6. Breach the structure to eliminate dam breakage hazard.
7. Raze and reconstruct structure using current state-of-the-arts designs.
8. Utilize combination of measures for the most effective mitigation of potential problems.

Remedial action similar to alternative 1 was applied to the Rittenhouse FRS upon the recommendations of the SCS studies (Stevenson, J. C., et al, 1978). The action involved the excavation of a centerline trench with outlets to the downstream toe. The main trench was approximately 13,000 linear feet in length. The nominal width of the trench was about 2.6 feet with depths ranging from about 13 feet to about 15.8 feet. A total of 40 outlet drain trenches were excavated at the locations specified on construction drawings and as required by the Resident Engineer. These drains were excavated to a

depth sufficient to maintain trench drainage. The drain fill was placed in 2 to 3 feet lifts. No water was used during placement and no compactive effort was applied. Trenches were excavated with a Parsons 250 bucket trencher and an American 35 backhoe. Equipment used in placing the fill consisted of a Link Belt LS 118 track-mounted crane with a bottom dump bucket and tremmie (figure 11).

Continuous geologic inspection of the upstream face of the trench was performed by Fugro during construction to provide assurances that all cracks were adequately intercepted by the drain trench. Cracking intensity was about 7 to 8 cracks per 100 linear feet of embankment. Ninety percent of the cracks observed were transverse to the centerline of the dam. The remaining 10% are longitudinal or oblique. These percentages are probably biased because of the orientation of the interceptor and outlet trenches. The deepest observed crack was about 16 feet below the top of embankment. The maximum width and probed length of the cracks was 0.4 feet and 2.8 feet, respectively. They were generally hair-line and vertical or near-vertical. Crack surfaces were irregular but planar surfaces were observed locally. Loose infilling with coarser soil was common.

CONCLUSIONS

Cracking of earth fill embankment dams has been recognized and reported as affecting many structures, particularly after dam failures have occurred. Few detailed investigations have been performed on smaller dry dams because the potential hazards are not readily apparent. This false sense of security could be devastating. More work is required on small structures of this type to determine the severity of the problems and expand the data base whereby the cause(s) can be determined and existing designs modified to eliminate or minimize the problems.

ACKNOWLEDGEMENTS

The authors wish to thank Robert Lynn, J. Carl Stepp, J. C. Stevenson, R. Smith, C. E. Sterns, Harold Gill and Steven Haire for their review of the paper and for providing constructive criticism and comments. The illustrations were prepared by Nick Patz and Jim Nenneman.

REFERENCES

Sherard, James L., 1977, Embankment Dam Cracking, Embankment-Dam Engineering, Casagrande Volume, John Wiley & Sons, New York, 122 p.

Stevenson, J. C., Smith, R., and Stearns, C. E., U. S. Soil Conservation Service, 1978, Cracking of Earth Dams in Arizona; Report of Crack Study Team, 31 p.

U. S. Bureau of Reclamation, 1976, Geology and Groundwater Resources Report, Maricopa and Pinal Counties, Arizona, Vol. 1.

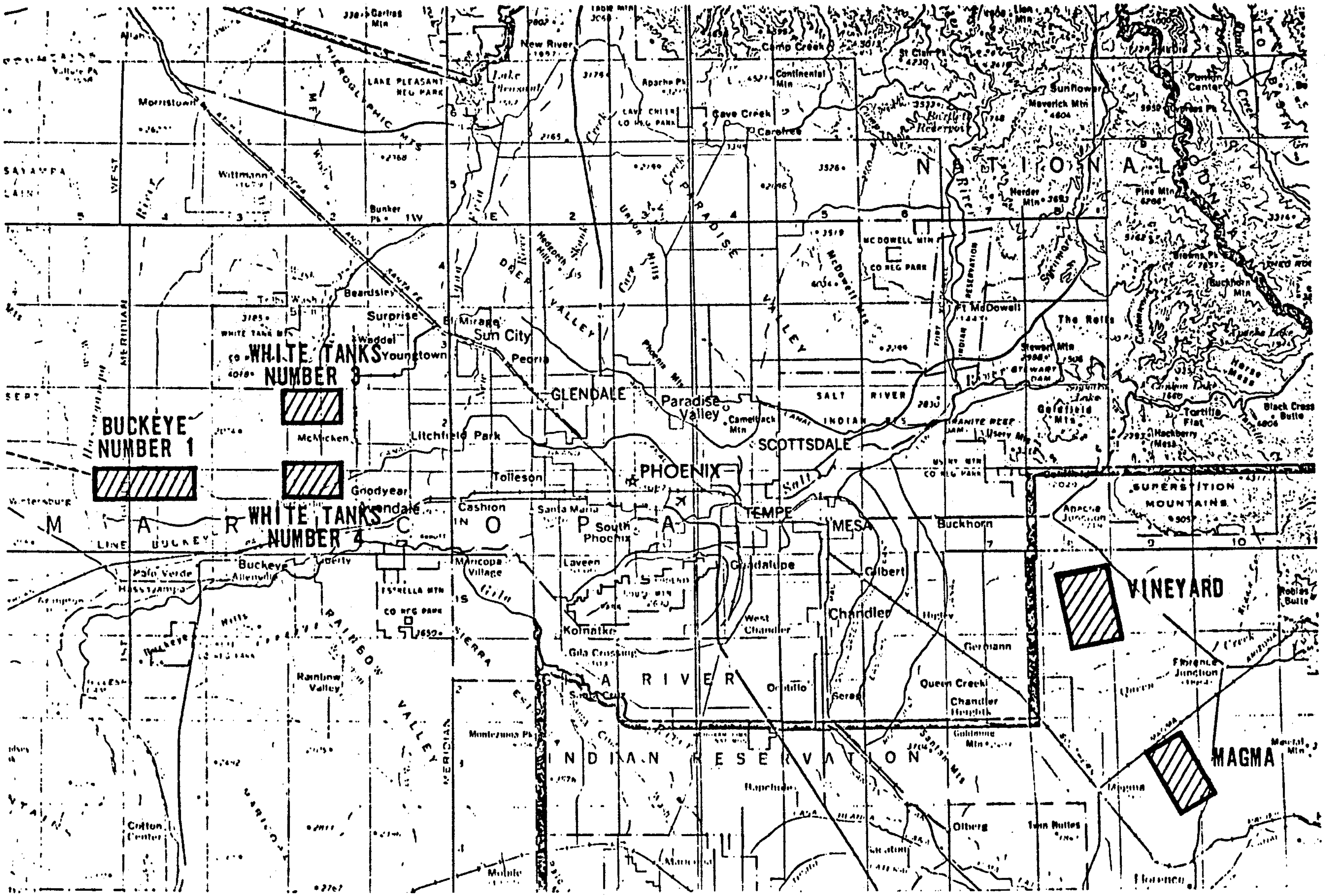


FIGURE 1 Location map

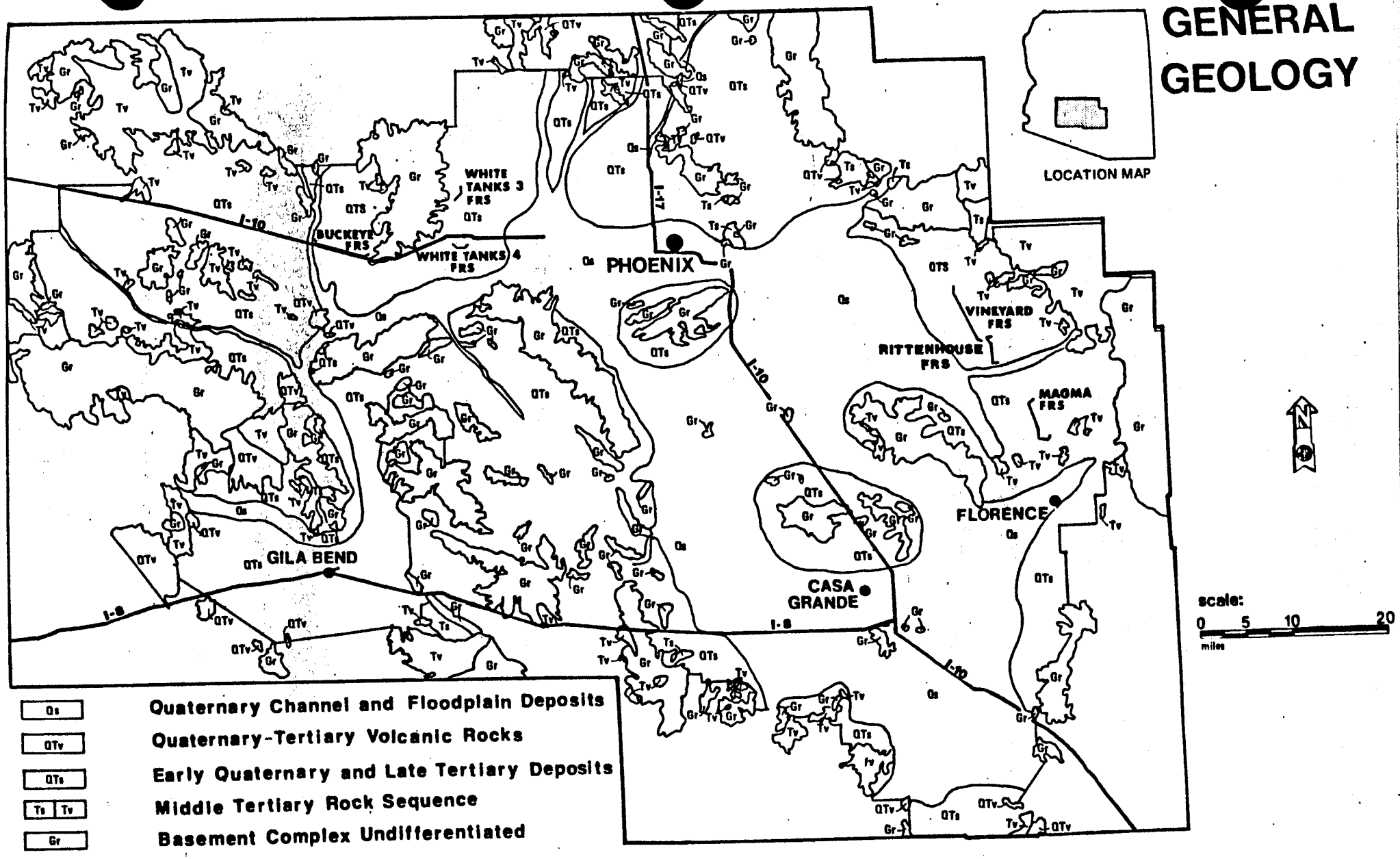


FIGURE 2 General geologic map of south-central Arizona

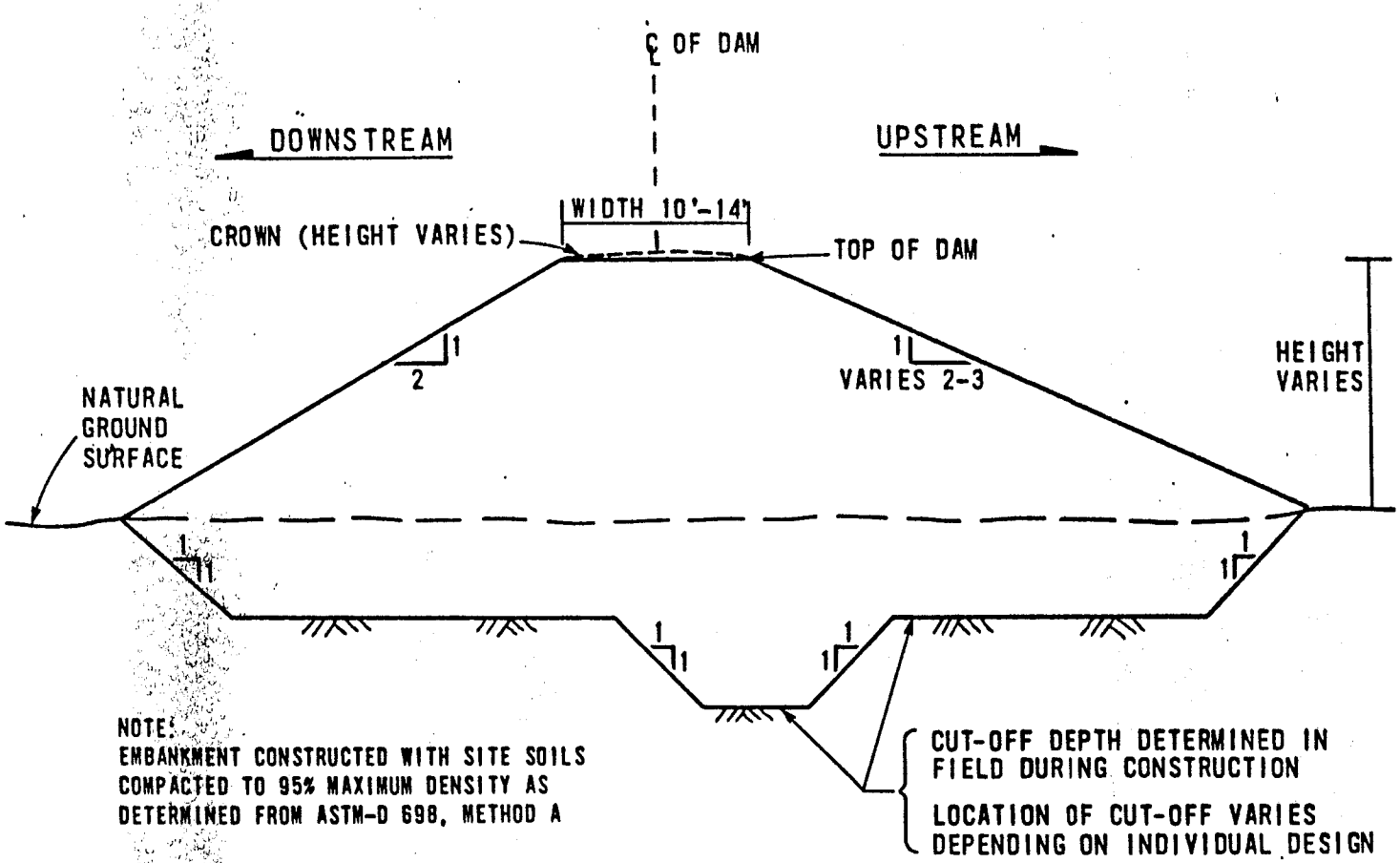


FIGURE 3 Typical embankment cross-section

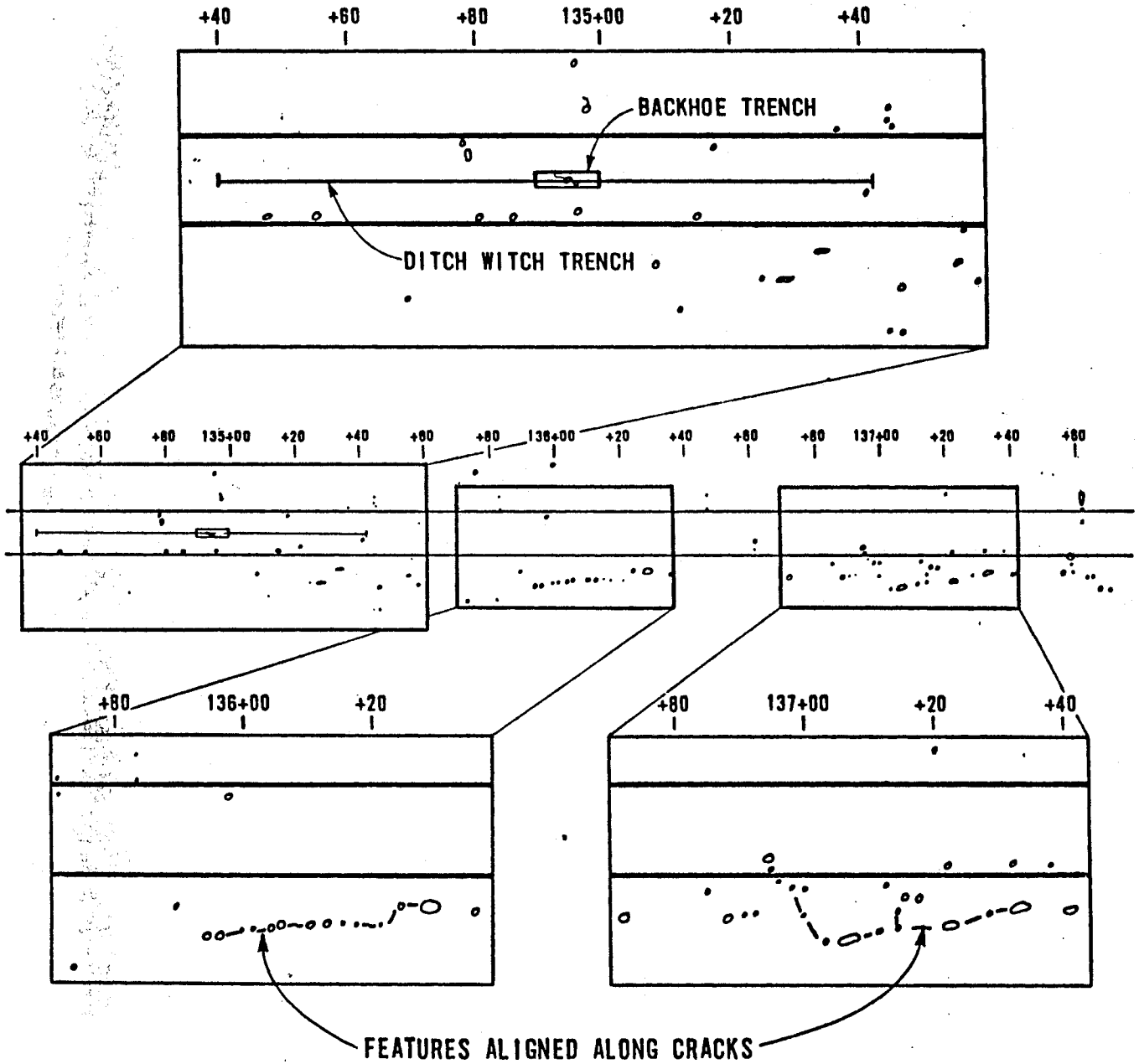


FIGURE 4 Segment of surficial map of structure

FIGURE 5 Shallow trenching/flooding operation

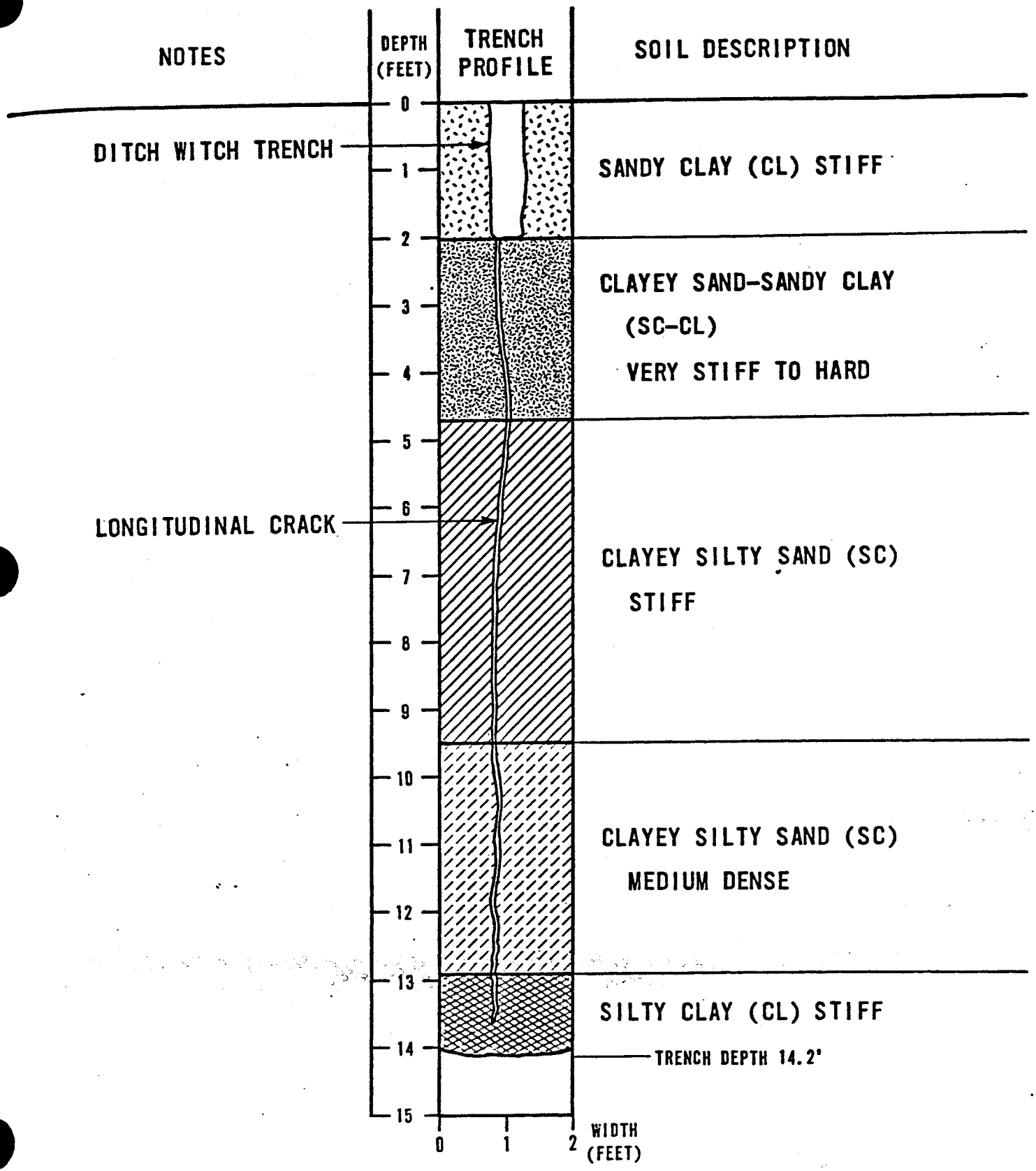
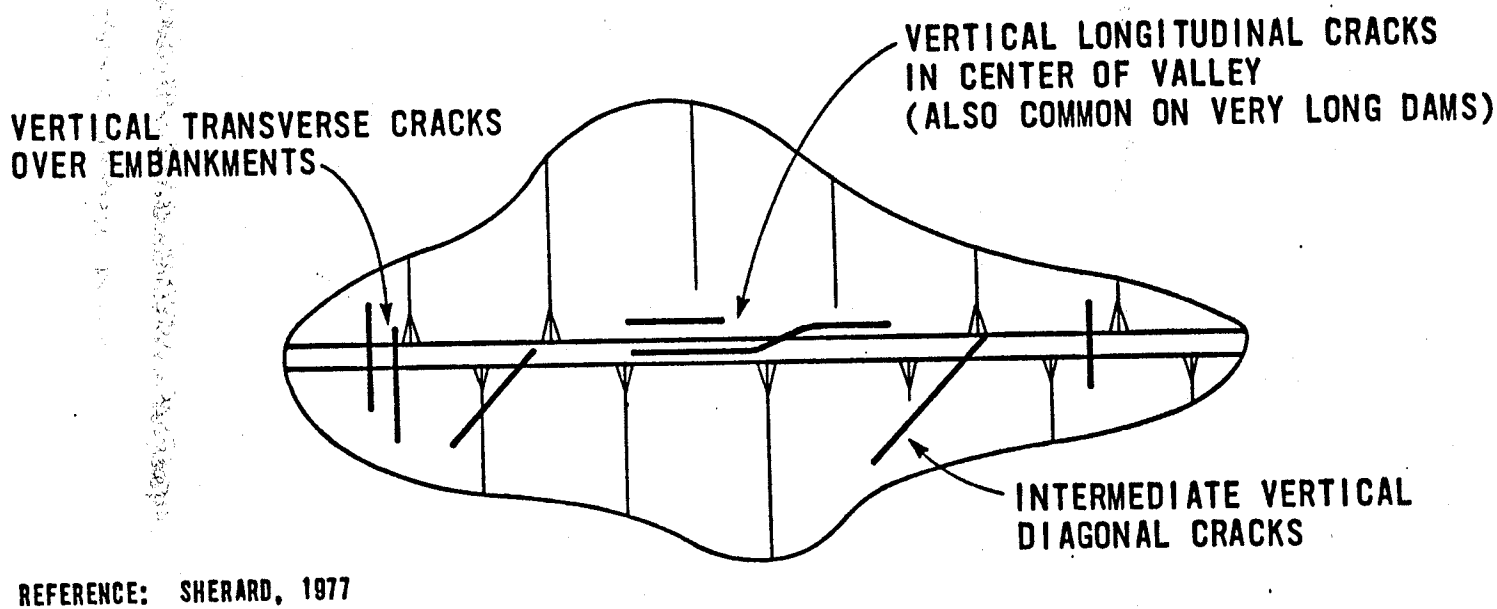


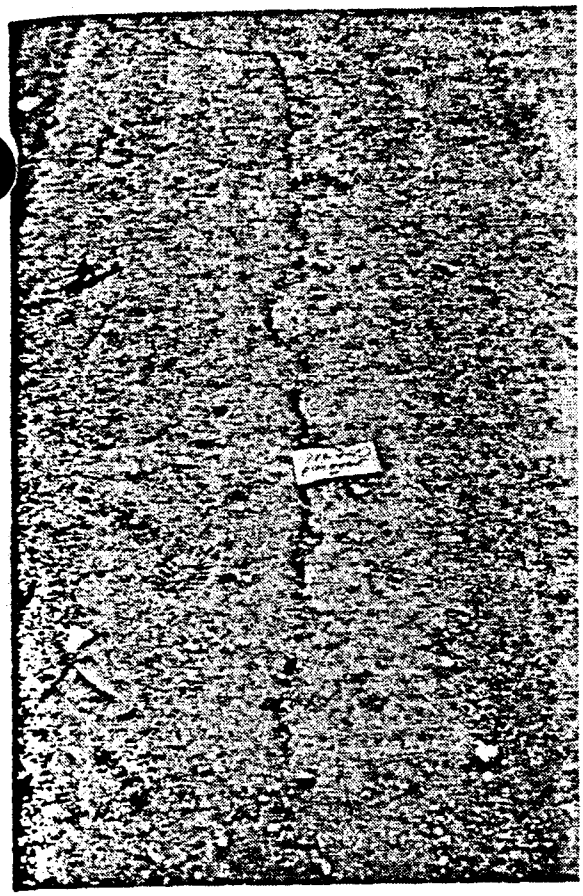
FIGURE 6 Log depicting crack characteristics within the embankment



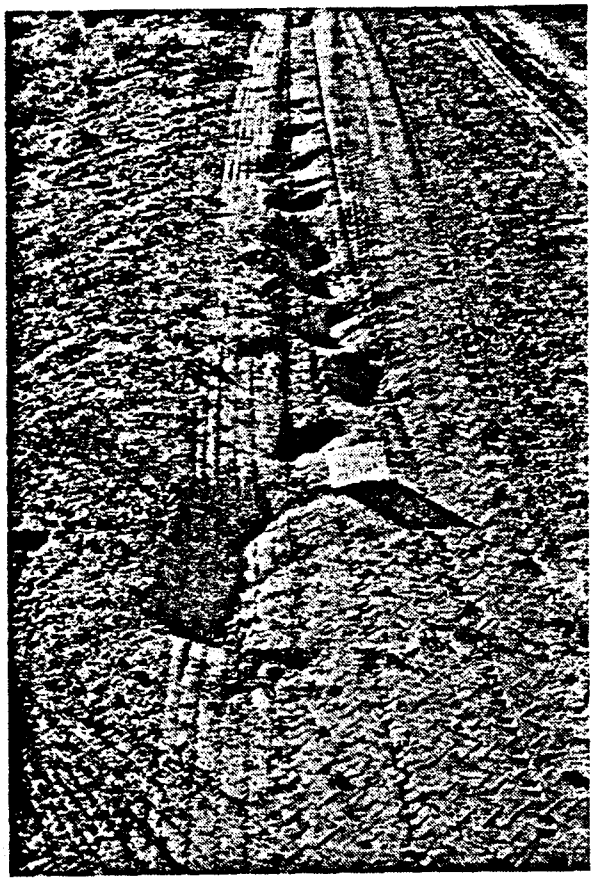
REFERENCE: SHERARD, 1977

COMMON CRACK PATTERNS IN SMALL DAMS

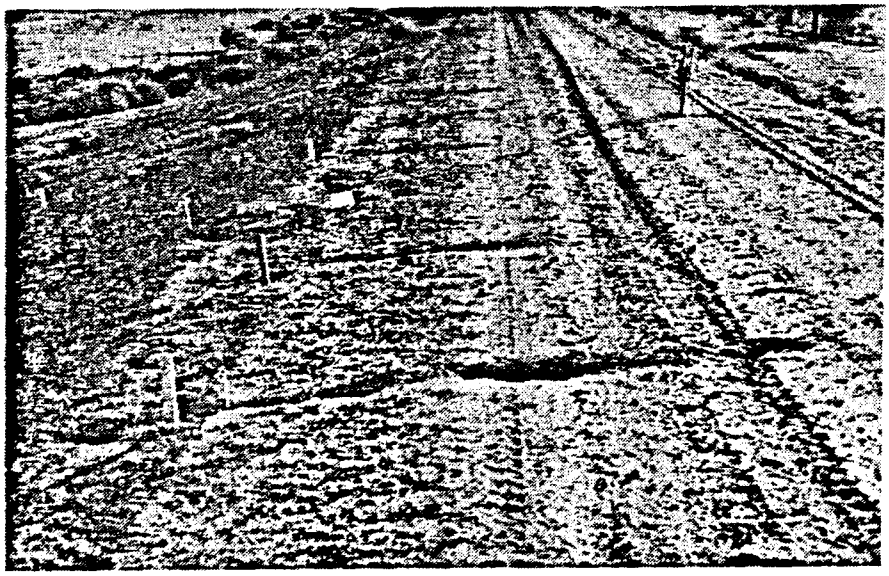
FIGURE 7 Generic types of cracking



(A) Longitudinal crack in young stage of development

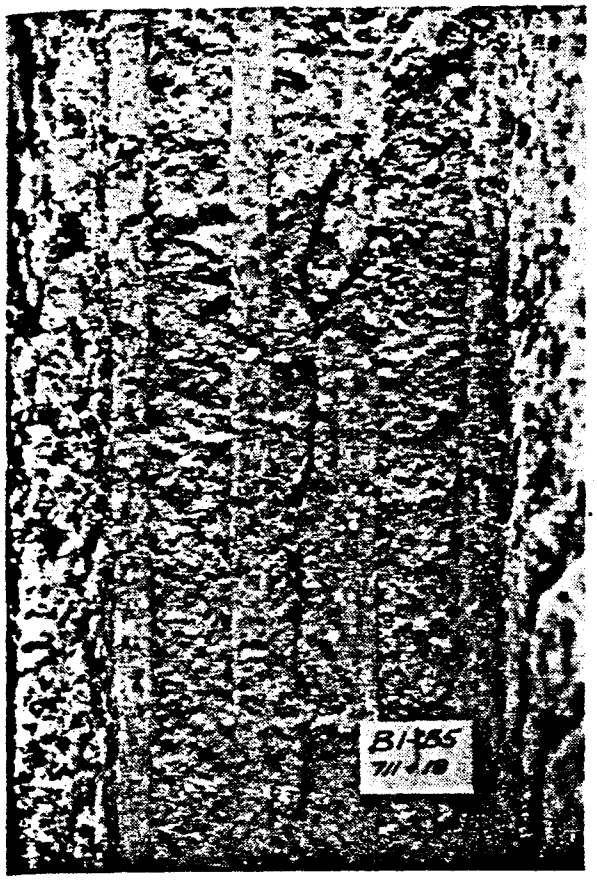


(B) Conduits aligned along mature longitudinal crack

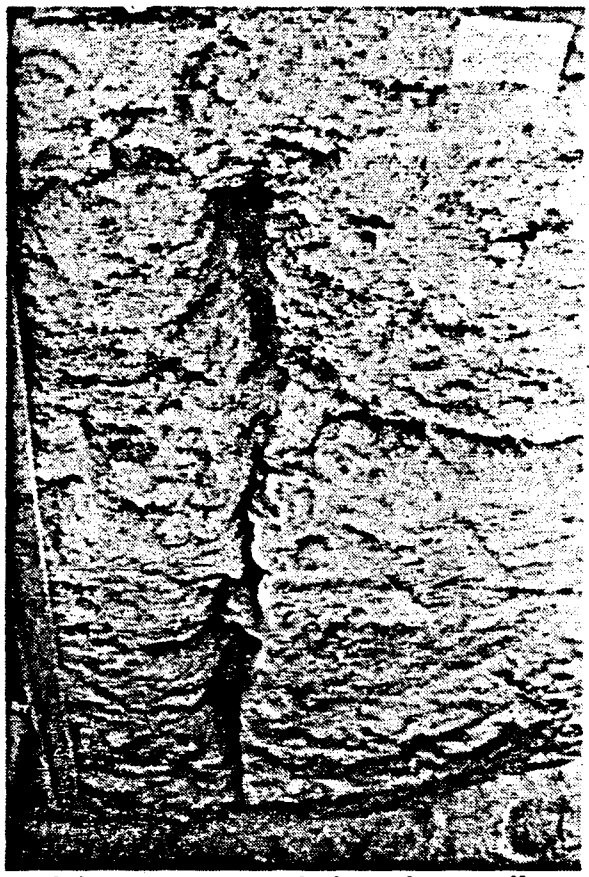


(C) Eroded transverse cracks and aligned conduits

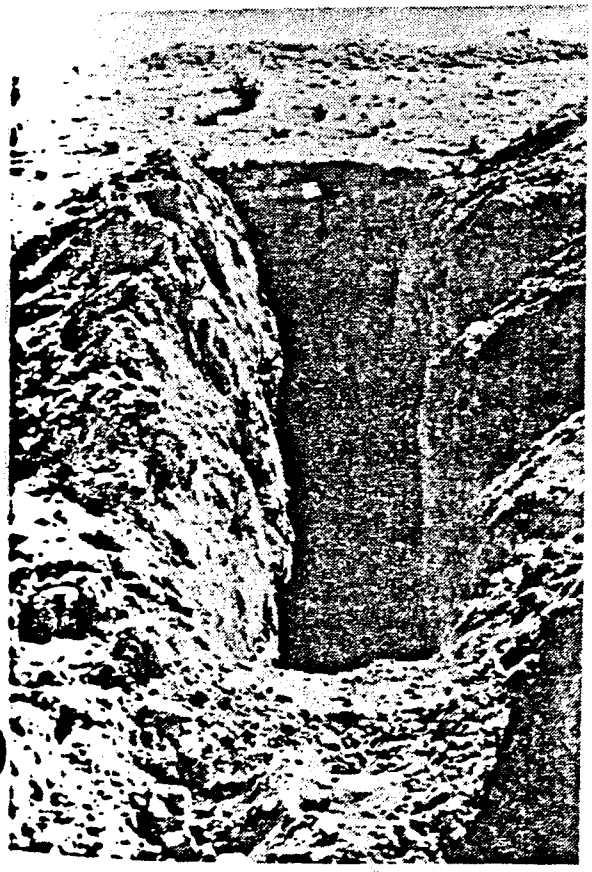
FIGURE 8 Typical cracks exposed along crest of embankment



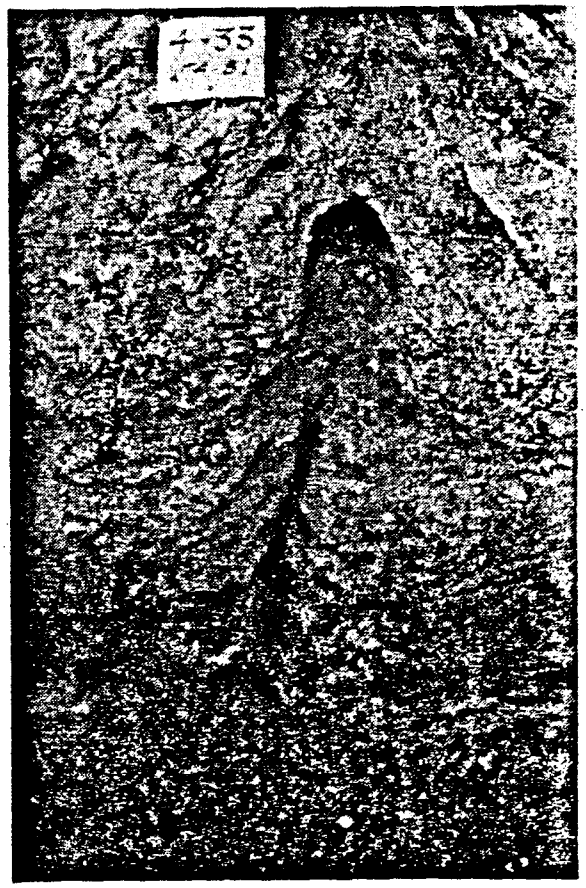
(A) Longitudinal crack along centerline of structure



(B) Transverse crack through centerline



(C) Transverse crack continuing downslope from crest.



(D) Transverse crack through centerline

FIGURE 9 Cracks exposed in backhoe trench excavations

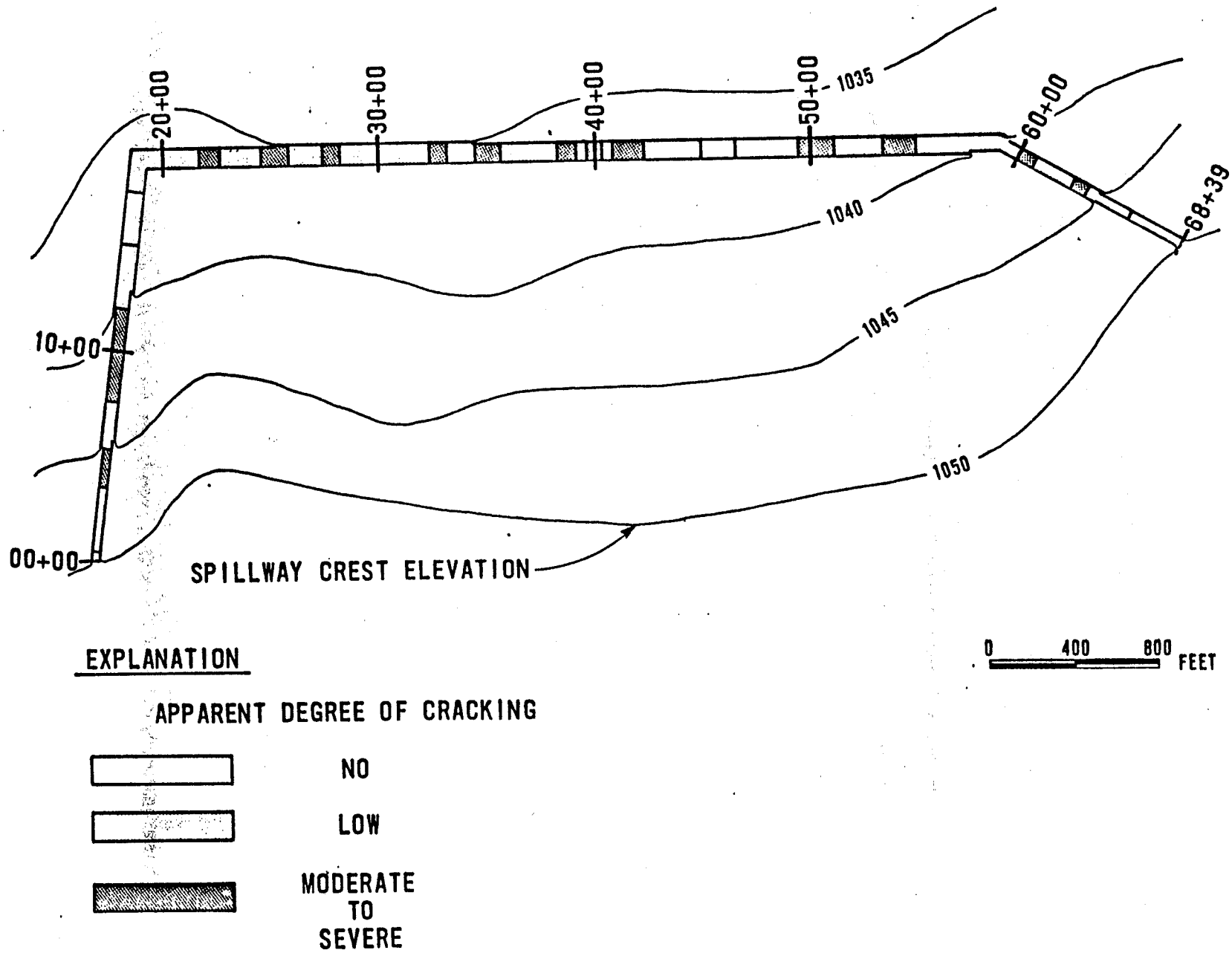
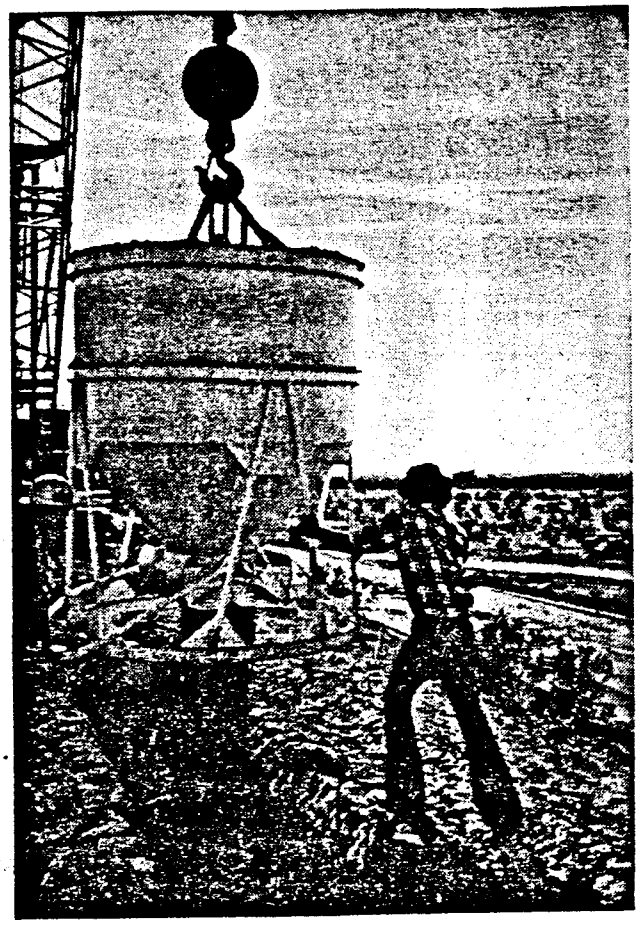


FIGURE 10 Degree of cracking map

(A) Centerline drain trench excavated with Parsons 250 trencher; shoring in for ground installed for geologic inspection



(B) Placement of drain fill with bottom dump bucket hoisted with Link Belt LS-118 track mounted crain.

FIGURE 11

CRACKING OF DAMS

IN

ARIZONA

Report of the Crack Study Team

April 27, 1978

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Cracking of Earth Dams in Arizona

Report of SCS Study Team, April 1978

I. Authority and Charges

A team was appointed to investigate reported cracking of earth dams in the vicinity of Phoenix, Arizona. The distressed dams have been constructed since the early 1950's under the Pilot Watershed Program and the PL-566 watershed protection program.

The team members are:

C. E. Stearns, State Geologist, SCS, Davis, California
R. J. Smith, State Design Engineer, SCS, Bozeman, Montana
J. C. Stevenson, Construction Engineer, SCS, WTSC, Portland, Oregon

The team was specifically charged to conduct sufficient studies to determine the magnitude of the cracking problem, its probable effect on existing structures, repair needs and methods, and changes in procedures and criteria needed to eliminate or control the problem in future SCS work in the area.

This report completes the assignment of the study team. Contained in the report is an analysis of the cause of the problem, the likely consequences of the cracking and proposals for repair. The team also proposed changes for investigation, planning, design, and construction of new dams in the area.

II. Introduction

The history of SCS earth dam design and construction in Arizona is included in this study team's interim report, dated July 21, 1977. Also,

in that report and in the Engineering Testing Laboratories, Inc., report, dated July 1, 1977, are descriptions and photographs documenting the cracking. Subsequent to these reports, much excavating, sampling, testing, and field surveys have been made.

III. Summary of Conclusions and Recommendations

The Dam Cracking Team has concluded that the transverse cracks pose the greatest hazard to the dams. The transverse cracking problem is of a greater magnitude than originally recognized and poses a real hazard to the integrity of the structures.

The principal cause of transverse cracking is tension release associated with embankment drying. Secondary causes could have aggravated the cracking but cannot be verified.

A dust mulch does not prevent cracking. Natural self-healing of the cracks has not occurred and cannot be depended upon unless a filtered discharge face is provided.

It is recommended that all structures distressed by cracking be expeditiously identified and repaired. Repair by installing a graded sand and gravel filter in a trench parallel to the structure centerline is recommended.

It is recommended that all future designs of dams in hot arid areas incorporate features to eliminate or control transverse drying cracks.

IV. Effects of Regional Subsidence

A. General

In the Phoenix area (Salt River Valley), excessive groundwater use has caused widespread land subsidence. Groundwater, not unlike any other mineral, is being actively mined in this valley. More water is taken out of the basin each year than is being replaced by recharge. The net effect of this overdraft has been subsidence in the heavily overdrafted areas. The subsiding areas are well known locally and are listed below:

1. Between the White Tank Mountains and Sun City
2. Mesa-Queen Creek area to the Santan Mountains
3. Eloy-Picacho area
4. Miracopa-Stanfield area

Our dams are on the edge of the first two areas. The Buckeye dams and White Tanks 3 and 4 are on the south edge of area 1. Spook Hill (under construction), Queen Creek (in planning), Powerline, Vineyard, Rittenhouse, and Magma are on the east side of area 2.

What was said about subsidence in our Interim Report, dated July 21, 1977, is still valid. Since that time, more data has become available and more is rapidly being developed. A real effort is being made now to understand the mechanics of regional subsidence, the mechanics of the formation of earth fissures and, perhaps of more importance to the Service, where the fissures will next occur. The following brief discussion summarizes in more detail the current thinking on the subsidence problem, and in later sections, this committee's feelings on

the effect it will have on Service dams.

Overpumping in this groundwater basin has long been recognized as a problem, but initially the problems caused by the resulting subsidence affected only isolated areas. As the population grew, more people and projects were affected. As the population build-up continues, it's certain that more people and property will be affected in the future. One very large project that will be affected by subsidence problems is the Bureau's Central Arizona Project (CAP). This project seems to have brought all those working individually on the subsidence problem together.1/ Consequently, the most detailed information on subsidence is being developed along the Bureau's CAP canal alignment on the east side of the valley. The CAP centerline is immediately downstream of our east side dams, Powerline, Vineyard, Rittenhouse,Magma, and Spook Hill. The information and techniques developed should be applicable to other areas in the state as well. The information being developed is vitally important to the Service and will have to be used in planning future projects. Service people are keeping current on this developing information and, in fact, are sharing data with the four principal agencies listed in the footnote.

B. Earth Fissures

Earth fissures in basins like the Salt River are vertical cracks in the alluvium. Though not wide, they can be miles in length. Those

1/ Data is being generated principally by four groups: Bureau of Reclamation (USBR), Geological Survey (USGS), Arizona Transportation Department, Highways Division, Photogrammetry and Mapping Services (ATD) and Arizona State University, Dept. Geology (ASU).

that have been trenched are 1 inch or less in width and are partially filled with loose sediment washed in from above. They have not been seen deeper than can be easily trenched with a backhoe, so our observation is limited to 12-14 feet below the ground, at least at this time. The cracks have been described in various publications since they were first seen near Picacho in 1927. It is thought they propagate upward from depth, and may extend hundreds or perhaps thousands of feet into the alluvium. They first appear as hairline cracks on the surface. Subsequent erosion of the sides enlarges them into gullies as much as 20-feet-wide and 25-feet-deep. One crack has been probed to 60 feet.

Erosion of a fissure occurs either from sheet flow (runoff) or from irrigation. Since the fissures are parallel to the basin margins, they intercept sheet flow on the fans and shortly develop into gullies. The resulting gulley has been logically called a fissure gulley. Though commonly parallel to the basin margins, some fissures have other orientations. One on the north side of the Santan Mountains is normal to the basin. It has captured the nearby drainage and has been greatly enlarged by the stream flowing into it.

Differential movement is reported across some fissures. The down side typically is on the basin side of the crack. A famous fissure near Picacho has dropped Interstate Highway 10 about 1.5 feet. The section of highway is constantly being repaired as a result.

In summary, an earth fissure is the surface expression of tension cracks that form on the margins of subsiding basins. Some fissures have shown offset, but most do not. They form on the margins of the subsiding basins and are roughly parallel to the basins. The spectacular gullies frequently seen are the result of erosion. They are called fissure gullies.

C. Effect of Fissures on Dams

To date, no earth fissures are known to intersect any of the dams the team studied in the valley. The lineament seen in the Magma reservoir has not been verified as to its origin. This will be done shortly by USBR and USGS people. The team believes there is always a possibility a fissure could break the surface near or through one of the dams. The reasoning is that the fissures occur on the margins of the valley where the dams are located. Should this happen, the respective section of the dam will be unserviceable. The dam will automatically then have to be divided into two segments and the area of the fissure abandoned. The runoff from the affected watershed can be controlled by making wing dikes on either side of the breach. The above solution is relatively simple when the fissure is about at right angles to the dam.

A more serious case is one where a fissure occurs parallel to one of the dams. Should the fissure occur within about 500 feet up or downstream, the dam would be unserviceable. The reason is that the fissures and their resulting gullies are commonly in zones 100-200-feet-

wide with intersecting cracks and gullies criss-crossing the zone in an en-echalon pattern.

Therefore, the assumption is that the dam should be reasonably safe if the fissure zone is about 500 feet away from the dam. Should a parallel fissure zone develop near enough to jeopardize a dam, and a decision be made to destroy the dam because of it, a much greater reach of the dam would need to be breached. Although it is believed the likelihood of a parallel fissure occurring under the dams is low, the possibility exists. The consequences should be considered along with an appropriate course of action should the situation occur.

D. Subsidence

Subsidence can be most simply called a sinking or lowering of the land surface. As fluids are pumped out and the sediments permanently dewatered, the overlying column of soil is supported more and more by the soil grains rather than the buoyant effect of water. Settlement occurs as the individual grains adjust and re-orient themselves to the increased weight they now carry. The effect is cumulative over several hundred feet. The result is expressed on the surface as a lowering of the land surface. As much as 12 feet of lowering has occurred at Picacho. Since 1971, up to 1.2 feet of subsidence has occurred in the area of the Powerline Dam and about 0.5 feet near Rittenhouse. The attached profile shows the lowering of the ground surface, the lowering of the water table and the proximity of the east county dams to the subsidence area on the same plot. Data is from measurements on USBR benchmarks along the CAP centerline.

E. Effect of Subsidence on Dams

Dams constructed with SCS assistance in the Salt River Valley are on the margins of major subsidence areas. Consequently, they are away from centers of maximum settlement. Nevertheless, the areas are subsiding as the plotted USBR and later SCS survey data document. Nothing can be done to control or stop the subsidence short of stopping groundwater pumping in the areas, which is not practical at this time.

What can be done is to systematically and periodically monitor and document the subsidence. This aspect of data gathering is very important. Should a dam settle lower than the emergency spillway, for example, it would be overtopped in a design storm. This is a serious problem. Another possibility is that capacity of the reservoir may change as the reservoir tilts and have less capacity than designed. Either way, the subsidence must be monitored so corrective measures can be taken as needed. The monitoring should be done so that the elevation of the emergency spillway relative to the dam is always known. The only corrective measure considered is to raise the dams should they subside to the danger point.

V. Investigations Needed for Planning and Design in Subsidence Areas

Two major problems may be encountered at a dam built in areas undergoing regional subsidence:

A. An earth fissure can breach the dam

B. Differential movement due to subsidence can cause loss of storage capacity.

Because of the danger of breaching, dams should not be built across earth fissures. Known areas of earth fissures can be avoided. They are usually known locally and are documented in reports and maps. Even if not previously mapped, they can be found because they are exposed. Newly developing fissures are a different problem. In the past, fissures were ignored until found. In the future, it may be possible to predict the location of new fissures. Should this happen as is anticipated, such areas can be avoided at damsites. Costly repairs and potential disasters can thus be avoided.

In future investigations for dams, the committee recommends that a serious effort be made to locate existing earth fissures. The following suggestions are methods that could be used, state staff people probably have knowledge of others:

A. Research published maps and reports

B. Study existing aerial photos

C. Take special aerial photos for a given site using various means that will emphasize surface features. Low-sun angle photos are good for these purposes.

D. Fly over the area in a lightplane or helicopter to check data gathered in the previous studies and to make a final check for features that may have been missed.

Different studies need to be made in order to predict locations of new earth fissures. Such technology is rapidly being developed mostly through the impetus of the Bureau's CAP. Work now in progress shows that reasonably valid predictions can be made. To do this, the following data needs

to be gathered and analyzed:

A. Depth and form of bedrock beneath the alluvium

B. Depth to water table and average rate of lowering

C. Historic rate of land subsidence

D. Nature of alluvium in the area of interest such as:

1. Location, extent, and depth of gravel beds

2. Location of major facies change from gravel to sand and clay

The above information is important because current studies have documented that fissures occur on the margins of subsiding basins, on the margins of bedrock islands or hills, over buried bedrock ridges, knobs, or breaks in slope of the rock, and through changes in facies from gravel to sand and clay.

In the planning phase of Service work, the information can be obtained from gravity surveys, water well data, and land subsidence data. The USBR and USGS have recently had success using seismic refraction surveys in finding facies changes and predicting the nature of the underlying alluvium. Some deep borings may be necessary to verify assumptions.

The committee strongly believes that the studies outlined above are essential when planning dams in subsiding basins. The studies should be made a routine part of geologic investigations in such areas.

VI. Cracking Problems, Observations, and Testing

In 1970 similar investigations of cracking in the Vineyard Road dam were conducted by Arizona SCS personnel. There is considerable parallelism

in the condition found and documented in that study and the findings of the current effort. In fact, there is strong evidence that the cracking situation may not be significantly worse now than it was in 1970 in this dam.

At the time of 1977 Interim Report, it was thought that self-healing of some cracks was occurring by the formation of natural filter faces. It was also thought surface dragging at White Tanks No. 4 had either prevented cracking or had effectively sealed them. Those two conclusions were based on evidence observed on the surface of the dams. The Study Team recommended these two items be checked with test pits. These later investigations showed that both processes were too erratic to be reliable. The test pits showed that some cracks were sealed, some tightly and some loosely, or not at all. Therefore, the two processes are not dependable and must be disregarded in the repair of the dams. It is recommended that any dams having cracked zones have the entire zone repaired as recommended below.

Under the direction of the State Conservation Engineer, Ralph Arrington, the nature and extent of the apparent cracks in the Florence and Magma dams were investigated. This work was done in October 1977. Several cracks apparent on the surface of the dams were excavated and studied with somewhat erratic results. Some cracks were fairly well healed by washing in of materials and creation of natural filter faces. Some of the natural crack filling was dense and continuous. Other cracks were

erratically filled with loose to dense material, with some voids remaining. In at least one instance, an open 2" crack abruptly terminated in a very short distance. This crack could not be seen in a pit only 3 or 4 feet from its widest expression.

The results of this study certainly raise serious questions about the reality and predictability of natural self-healing processes in earth cracks.

In January 1978, county crews excavated pits to study cracks in the Buckeye No. 1 dam. At this time, they used a small trenching machine to explore the condition of the White Tanks No. 4 dam. Several open cracks were discovered in both dams. Open cracks were found and traced to depths of 11+ feet. At White Tanks No. 4, several cracks were traced that were well filled with dense material. Such fillings may have resulted from the dragging of the surface that was regularly done for many years. However, open cracks were traced that certainly compromise the safety of the dam.

In April 1978, additional excavations were made under direction of the study team at Buckeye No. 1, White Tank No. 3, Rittenhouse, and Vineyard Road dams. At Buckeye No. 1, pits were excavated near the upstream and downstream toes in the areas of severest embankment cracking. No cracks were found in the foundation. The pits verified cemented caliche

at shallow depths except near Palo Verde Road, where no cemented material was found to a depth of 10+ feet.

At White Tanks No. 3, pits were excavated in the embankment in two areas of suspected cracking. No cracks were located.

At Vineyard Road, pits were excavated in the dam to try to locate and observe cracks that were repaired in 1970. Two well filled cracks were located. It could not be determined whether these were a result of activities to fill cracks in 1970, or a result of natural filling. At Rittenhouse, several pits were excavated in the south part of the dam that is covered with a gravel facing. The gravel facing is about 8' thick. In all cases the lower part of the gravel was moist. The earth core was moist, though probably slightly drier than optimum, and looked very good. This verifies the effectiveness of a gravel surfacing to maintain moisture in an embankment even under hot, arid conditions. What is unknown, is the minimum effective thickness of gravel facing needed to break up capillarity and insulate against the hot conditions.

Trenches were excavated at the upstream and downstream toes at Sta. 130+12, very near to the deepest crack found by the consultant in 1977. Two cracks were discovered in a layer about 2' deep in the downstream pit. These cracks did not go to the surface nor penetrate into underlying material deeper than 3½ to 4'. These cracks would be cut off by the core trench. The backhoe operator told us such cracks were very common in the area. He regularly encounters them in excavating trenches and foundations. No cracks were found in the upstream pit. A 4-foot-deep pit was excavated

across a crack in the top of the dam at this station. The crack was open about 1/2 to 3/4 inches wide in both sides and in the bottom of the pit. The pit was near the downstream shoulder of the dam. The crack in the downstream face and the pit bottom was cleaned out. A probe wire would penetrate about 3' plus toward the downstream face. Water was pumped into the pit and it drained rapidly. After several minutes, water emerged on the upstream face about 10.5 feet below the top of the dam. An attempt was made to plug the crack in the bottom and upstream side of the pit, to see if water would follow an open crack to the downstream face of the dam. Water was again pumped in. After a few minutes the plug failed and water again emerged on the upstream face of the dam, about 3 feet higher than the previous time. No evidence of water moving toward the downstream face could be determined.

A pit was excavated across a longitudinal crack zone near Stations 201+46 on the north wing of the dam. This crack was 3 or 4 inches wide near the surface and penetrated to 11'+. The crack zone appeared to be about 150-200 feet long. The crack was cleaned and water was pumped into the crack a few feet east from the pit. Water followed the crack into the pit and after several minutes of pumping did not erode deeper. Part of the water followed the crack away from the pit. Water was pumped into a crack a few feet west of the pit. No water flowed into the pit. No water surfaced anyplace after several minutes of pumping at a rate estimated to exceed 25 gpm.

A feature resembling a subsidence fissure was seen in the reservoir of Magma Dam. The feature was a shallow crack in one spot, but its principal feature was an alignment of small sinkholes 12 inches or less in diameter. The total length of string of sinkholes was about 200 feet. It is parallel to the dam and about 50 feet upstream. The feature has the appearance of a subsidence crack. Another similar feature was reported by county flood control inspectors on Vineyard Road on December 8, 1977. We looked for it and couldn't find it, so the sinkholes may have been covered up with sediment by runoff from the 1978 storms. If this happened, it is unlikely the Vineyard feature was a subsidence fissure.

VII. Causes of Cracking

Analysis of observations made and data collected indicates the majority of the transverse cracking is a result of tension zones because of drying of embankment materials. No direct evidence of dessication cracking of high shrink potential soils was observed. At the worst, some of the soils in the embankment might have moderate shrinkage potential. Most of the soils have low shrinkage potential. The mode of cracking suggests that relatively minor volume changes occur as the material slowly dries, the dams untimately become essentially large adobe bricks. During the baking-drying process, cracks form when shrinkage stresses exceed the tensile strength of the soil. These cracks are then aggravated by volume changes due to temperature changes. The evidence collected and studied certainly supports the above mode of cracking, particularly for the transverse cracks in the White Tanks No. 4, Rittenhouse, Vineyard Road, and Magma dams. It is the opinion of the Study Team that most of the trans-

verse cracks occur because the tensile strength of the soil is exceeded by the capillary stresses of drying.

Certainly, the movement associated with subsidence as a result of groundwater removal may well have aggravated the cracking in some areas. No evidence has been collected to indicate that subsidence cracks occur in any of the dams' foundations.

Equally certain is the fact that shallow foundation compression can cause cracking by differential settlement. This potential cause has not been verified for any transverse cracks. This mode of cracking is quite likely the cause of many of the longitudinal cracks observed.

The Team recognizes that tremors or shocks from earthquakes would likely contribute to the cracking of these dried, brittle embankments; no evidence to verify this as a primary cause has been documented.

The Team's studies have not verified that any of the cracks are a direct result of different materials being placed adjacently, or because of different degrees of compaction or moisture in the fills. It is believed, however, that such conditions may well have added to the magnitude of the problem. The Team's studies pretty much verify that the magnitude of the cracking is greater where materials have been placed at moisture contents greater than optimum.

VIII. Summary of Findings

A. The principal cause of the transverse cracking is tension release because of shrinkage as the embankments dry from placement moisture content

in the severely hot, arid climatic conditions in the area.

B. Secondary causes of cracking are:

1. Tension zones resulting from differential settlement because of shallow foundation compression. This is the primary cause of the longitudinal cracks investigated.

2. Tension zones resulting from stress differences caused by regional subsidence associated with groundwater withdrawal.

3. Tension zones caused by stress differences resulting from variations in type of material, degree of compaction or moisture content in fill materials as placed.

4. Stresses induced by tremors and earthquakes.

C. As a result of recent storms, Rittenhouse and Magma had up to 11.5 feet of water in their flood pools. The foundationsdidn't leak, so it is believed this has verified that cracking does not completely traverse the lower portions of these embankments or disrupt their foundations.

D. Cracking is sufficiently severe in the upper zones of essentially all the embankments studied to require repairs.

E. Studies have not located any cracks penetrating through the foundation. No cracks have been identified in any of the dam foundations that are clearly associated with the embankment cracking.

F. The studies made have verified that natural self-healing processes cannot be depended upon, unless a filtered discharge face is present.

G. The safety of all the dams studied can be assured with properly applied repairs.

H. Gravel (shells) or thick facings on embankments effectively control cracking caused by drying in this hot, arid area.

I. Although the design and construction of the dams was commensurate with the state of the art at the time, methods of analysis, investigation, and construction procedures used by the industry in the past have been proven to be inadequate to assure safe dams with reasonable maintenance requirements.

Consequently, a change in the philosophy of earth dam design and construction is necessary to assure safe and proper functioning of earth embankments to be constructed in the future in this area.

J. Significant regional subsidence has occurred at the east county dams.

IX. Monumenting and Monitoring Future Structures

In a subsiding basin continued monitoring of all earth embankment structures is necessary to insure long-term safe operation. It is essential to install a system of measuring points so that movements of each structure relative to its elements as well as absolute movements with respect to a fixed datum can be determined and evaluated. The measuring point system should be spaced and referenced to provide sufficient detail to determine regional as well as highly localized movements. Generally, of principal concern are vertical movements; however, longitudinal shortening or lengthening along the centerline of the dam, as well as movements at the embankment toes with respect to the centerline are also needed.

Significant examining of the structure should be done at regular intervals and after significant storm events or other natural happenings that indicate

the need, i.e., newly developed earth fissures in the general area, seismic disturbances, etc. Overall conditions, any apparent movements, cracking, erosion, etc., should be recorded and measuring points established as necessary to monitor further action. A well planned and executed photo documentation of events and observations would be very valuable.

While the 500 feet apart monuments established on several of the dams are producing good results indicating the magnitude of general subsidence, they are inadequate to permit evaluation of differential movements that may occur in short distances.

It is recommended that settlement and ℄ of dam horizontal monitoring monuments be installed at intervals of 100 feet along the top of all newly constructed embankments. Also, measuring points to establish cross-section movements should be established at each shoulder of the dam and each toe at approximate 1,000-foot intervals.

These points should be measured at least annually until pattern of movement or lack of movement has been established. The measuring period can then be extended commensurate with conditions as they develop.

X. Recommendations for Repair

A. Possible Methods of Repair

Several methods of repair have been considered by the Study Team; several have been suggested by other parties. All methods have been considered, studied and discussed in detail by the Team.

The alternative methods of repair are:

1. A graded sand and gravel filter installed in a trench parallel to the centerline.

2. A narrow reworked compacted earth core installed parallel to the centerline.

3. A narrow soil cement core parallel to the centerline.

4. A program of periodic repair by water cleaning and mud grouting all cracks.

5. A granular filter in a filter cloth envelope installed in the lower portion of a narrow trench parallel to the centerline. The upper portion of the trench backfilled with excavated material compacted at a moisture content dry of optimum. ?

6. A filter cloth filter installed along the upstream face of a narrow trench parallel to the centerline. The trench to be backfilled with excavated material compacted to a moisture content dry of optimum.

7. Lower the emergency spillways and decrease detention capacity to an elevation at or below that of the average maximum depth of cracking.

8. Lower the spillways as in No. 7 above and construct floodgates in the spillways. Should leakage or piping start,the floodgates could be opened to increase the rate of drawdown and decrease the extent of damage to the dam.

9. Segment the detention storage within the reservoir by installing dikes perpendicular to the dams to limit the volume released by failure of a cracked section.

10. Install a graded sand and gravel filter on the existing downstream face of the dams and cover with additional embankment section from material excavated for the Central Arizona Project (CAP) canal. This would be a method limited to structures adjacent to the CAP canal alignment.

B. Discussion of Methods of Repair

1. General. Since subsequent investigations have revealed cracking in areas not previously located, a detailed inspection will be required to identify all areas needing treatment. On dams with known cracking problems, all reaches not already identified as having cracks should be investigated. Investigation by means of flooding a 6-inch-wide by 2-foot-deep, "Ditch Witch," trench has proven to be a good method to locate areas of cracking. Backhoe pits are then required to investigate and determine the depth of cracking.

On dams with no known or visual evidence of cracking, a random selection of areas should be investigated by the Ditch Witch method to check for cracks.

2. Method No. 1. Sand and Gravel filter.

The committee recommends repair by this method, as discussed and also recommended in our interim report of July 1977 (see interim report). The sand and gravel filter should be installed to a depth of 12+ feet, adjusted to deeper depths where inspection indicates the existence of cracks deeper than 9 feet. Careful inspection during repair will be required to determine the full depth of cracking.

Initial investigations indicated many cracks were partially filled with loose material and some were partially filled with dense material. Later investigations have shown many areas where the loose materials are actually packed into the crack during the excavation process and was only surficial filling adjacent to the pit walls. Some locations were found where the excavation process packed material into the crack so tightly that all evidence of the crack was obliterated. In such instances, careful inspection and probing is required to continue tracing the crack.

Probing with a thin wire cannot determine the total extent of cracking. Although probing proves the existence of an open crack, resistance to probing can be caused by irregularities in crack alignment. Cracks thinner than the probe wire cannot be successfully probed.

A two-step inspection process is recommended to verify a trench depth 3 feet deeper than any existing cracks. The first step is an in-trench inspection and probing at selected locations of extensive cracking. In-trench inspection and probing with an ice pick or similar tool and a probe wire to determine the maximum depth of the larger and generally deeper cracks. Shoring or portable shielding will be required to protect personnel during in-trench inspections. The second step should be washing (hosing) down the trench sidewalls to identify all cracks. Any crack appearing to be deeper than those found by the in-trench probing should be further inspected.

Any locations where the trench does not exceed the maximum crack depth in that area by 3 feet will require additional trench excavation to deepen the trench. The trench bottom should be graded to drain to an outlet.

This method will control seepage quantities by flow resistance so that water quantities will not create a piping problem in cracks downstream from the filter. It will also provide limited protection to piping of undetected cracks that may not be intercepted by the filter.

A graded filter of concrete aggregate will have a satisfactory gradation and is readily available. A mixture of 45% fine aggregate and 55% size (1½" minus) in accordance with ASTM-C33 appears to be adequate for most of the needed repairs.

3. Method No. 2. A narrow reworked compact earth core.
This method was described in the interim report. It is not considered a viable alternative because of the rapid development of drying cracks.

4. Method No. 3. A narrow soil cement core.
This method was also described in the interim report. It is not recommended as a viable alternative because of its rigid brittle nature and associated problems noted in the interim report.

5. Method No. 4. A continuing program of cleaning and mud grouting cracks. This is not considered a viable solution for the following reasons: First, it provides no protection against failure through newly developed cracks; second, to be successful, every individual crack needs to be located, cleaned, and grouted - logistically impossible; third, unconfined cracks cannot be completely filled; fourth, mud grout will shrink and recrack as it dries. A variation of this method where mud grouting should be done along with installing a vertical filter was discussed. The same basic uncertainties are common to this possibility.

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6. Methods 5 and 6. Using cloth filter.

These alternatives were identified by ETL (consultant engineer) in the crack evaluation report for FCDMC. The committee cannot recommend these alternatives because of the nearly total reliance on an unproven material (filter cloth). We question any filter cloth's ability to resist tearing if subjected to crack development of the magnitudes encountered in the dams investigated. If the filter cloth did not tear, the stretching across a crack could significantly alter its filtering ability.

Although Alternate No. 5, the cloth enveloped granular filter, could be designed to function satisfactorily should the cloth tear, it would have no advantage over Alternate No. 1, and would be more difficult and expensive to install. The filter cloth would partially prevent filter material from filling voids that may develop under the filter.

7. Methods 7 and 8. Lowering emergency spillways and installing floodgates. These are also alternatives identified by ETL in their report to FCDMC. The committee does not consider these as viable repair alternatives because they change the scope of the original project.

8. Method No. 9. Segmenting the detention area with dikes.

This method was suggested by ETL and others as a means of decreasing the extent of damages caused by a failure. Although it is not a repair measure, it does have merit when considered in conjunction with other repair methods.

The detention basin could be divided into several basins by constructing dikes (embankments) perpendicular to the main dam. The smaller basins would need to be interconnected by conduits through the dividing dikes.

9. Method No. 10. Combining repair with construction of the CAP. This is not considered a viable alternative because:

a. It would delay needed emergency repairs for an unknown period.

b. It has not been determined at this time when the CAP will be completed.

C. Conclusions and Recommendations for Repair

The Team has concluded the cracking problem is of greater magnitude than originally recognized. Investigations subsequent to our interim report of July 1977, have revealed areas of cracking not previously identified in dams, with little or no surface evidence of cracking. Cracks have been found to extend to greater depths than previously encountered. Any one of these deep cracks could endander the structure if it extends through or nearly through the embankment.

The Team has concluded the cracks pose a real hazard to the integrity of the structures. We recommend that steps be taken to identify all dams with cracking problems, to identify the extent of the cracking in each dam, to repair the cracked dams and to incorporate design methods to eliminate or control drying cracks in future structures.

Priority of repair should be based on a combination of factors. These include the hazard and damage potential from failure, the severity and depth of cracking and a hydrologic evaluation of the probability of significant runoff producing events. All structures distressed by cracking should be repaired expeditiously. Structures should be repaired by installing a sand and gravel filter in a trench parallel to the ℄ (Method No. 1).

XI. Design Concepts to Control Cracking

A. Alternate Methods

Several alternatives are available to design for control of cracking problems. Some are intended to prevent cracking, others to control the effects of cracking. These alternatives are:

1. A granular filter zone within the embankment. This design feature is similar to the recommended method of treatment proposed for the existing cracked structure. In new construction, the filter zone could be either sloped or vertical. It would also extend down to or into the embankment foundation.

1a. Placing and compacting the embankment dry of optimum combined with a granular filter zone. The compaction of fill materials dry of optimum is supplemental to Alternative No. 1.

2. Granular embankment shells. A gravel shell can be used to prevent cracking of the core zone of embankments provided it has adequate thickness.

3. Install a sand wick and drip irrigation system in the top of the dam. This alternative would prevent crack development by replacing moisture lost from the fill.

4. Install a vapor barrier over and around a core section of the embankment. This is a new concept and is intended to prevent moisture loss by using a vapor barrier of plastic or rubber sheeting or other similar material.

B. Discussion of Alternatives

1. Granular filter zone within the embankment.

This method will not prevent the formation of drying cracks within the embankment. A filter will control the problems associated with cracking and prevent breaching of the embankment by internal erosion and piping. It provides a filter face to stop migration of fines and promotes self healing of the crack. A filter zone will also provide protection to the embankment from cracking caused by differential movements. The single-grained granular material will readily readjust without rupturing.

In dry dams, the filter zone can be relatively thin since hydraulic conductivity is not of paramount importance. The rapid development of a filter face within a crack will quickly restrict water movement into the filter zone. For downstream toe stability, the embankment should be designed to be structurally stable with the filter zone fully saturated.

This will require the filter zone to be placed near the center of the embankment. For upstream toe stability and full drawdown, the filter zone can be considered as drained.

1a. Compacting the embankment dry of optimum combined with a granular filter zone. This alternative is a modification of Alternative No. 1. By compacting the embankment dry of optimum, shrinkage from drying will be decreased. Cracking will still occur, but the width of each crack should be smaller than for the same material compacted at or above

optimum moisture content. The embankment will be more brittle and susceptible to cracking from differential movements. However, the filter zone will adequately control problems associated with cracking. At the filter face, the narrower cracks will heal faster than wider cracks.

2. Granular embankment shells.

Where large quantities of granular materials are readily available, drying cracking can be prevented by gravel shells. Adequate thickness is required for insulation as well as breaking capillary rise. The thickness of gravel shell that prevented drying cracks is 8 feet. It is believed that a thickness of 5 feet may be adequate. However, verification is needed.

A gravel shell helps prevent surface rilling. However, vegetation on the embankment will need to be controlled.

3. Sand wick and irrigation system.

This method relies on supplemental moisture, supplied by a drip irrigation system, to replace soil moisture lost by drying. It would consist of a shallow 2-foot-deep trapezoidal sand wick with drip irrigation installed in the top of the dam. The sand would be a small reservoir and would provide uniform distribution of water. The object is to keep the core of the embankment at or above field capacity and prevent the buildup of high capillary stresses. Instrumentation could be used to determine the need for the timing of irrigation.

This alternative requires continued operation and maintenance. It will have a relatively high first cost and annual operating cost. However, it

may be viable alternative where granular filter materials are limited and expensive. Some vegetation control would be required.

4. Install a vapor barrier over and around a core section of the embankment. This is a new concept in embankment design to prevent crack formation with drying. It is intended to prevent moisture loss during hot periods. The Team believes it holds promise as a possible design solution in specific instances. This alternative would require stage construction. The first stage would be to construct and trim a narrow core section with steep side slopes. Something like a 5-foot-top with 1/2:1 side slopes. The core would then be covered with a continuous vapor barrier of 12 mill, or thicker plastic, rubber sheeting, or other long-life watertight material. Remaining sections of the embankment would then be constructed around the core. Care would be required to prevent puncturing the vapor barrier.

Each of the outer sections of the embankment would be designed as independently stable structures.

Unless properly installed, the vapor barrier could be subject to tearing as the outer portions of the embankment crack. A thin sand section next to the barrier would provide protection from tearing.

Poorly graded sand unsuitable for use in a filter would be adequate to protect the vapor barrier.

Unless the vapor barrier is of a tough durable material, it could be punctured by plant roots. Some vegetation control may be required.

Although the vapor barrier will also function as a diaphram in the embankment, that is not its principal purpose.

C. Design Conclusions and Recommendations

Deep cracking in dry dams in hot, arid areas presents a greater problem than previously considered. Dust mulch covers, which break the capillary rise do not effectively prevent drying cracks. It is also our opinion that thin granular blankets are also inadequate. To be effective, the gravel blanket should be thick enough to be called a shell, or gravel zone. To be effective, the shell must be thick enough to provide insulation from heat buildup within the embankment and to break up the capillary rise.

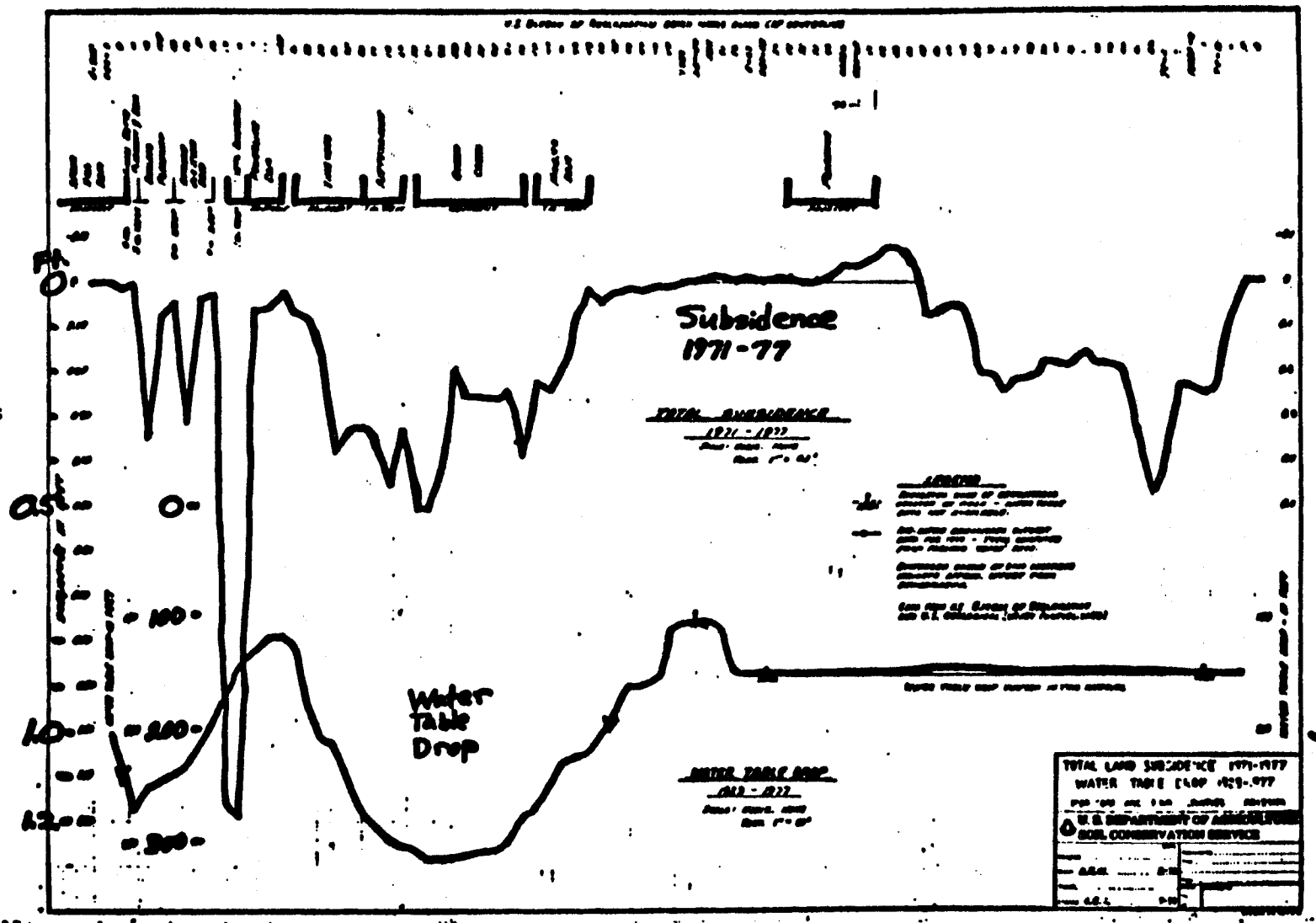
The design of future dams, in hot, arid areas where past experience has indicated cracking problems, should include features to effectively eliminate or control cracking problems.

The Arizona Engineering staff and Design Unit have already adopted improved design procedure in their current design. They are providing filter drains as an integral part of structure designs.

Jack Stevenson (Team Leader)

Ray Smith

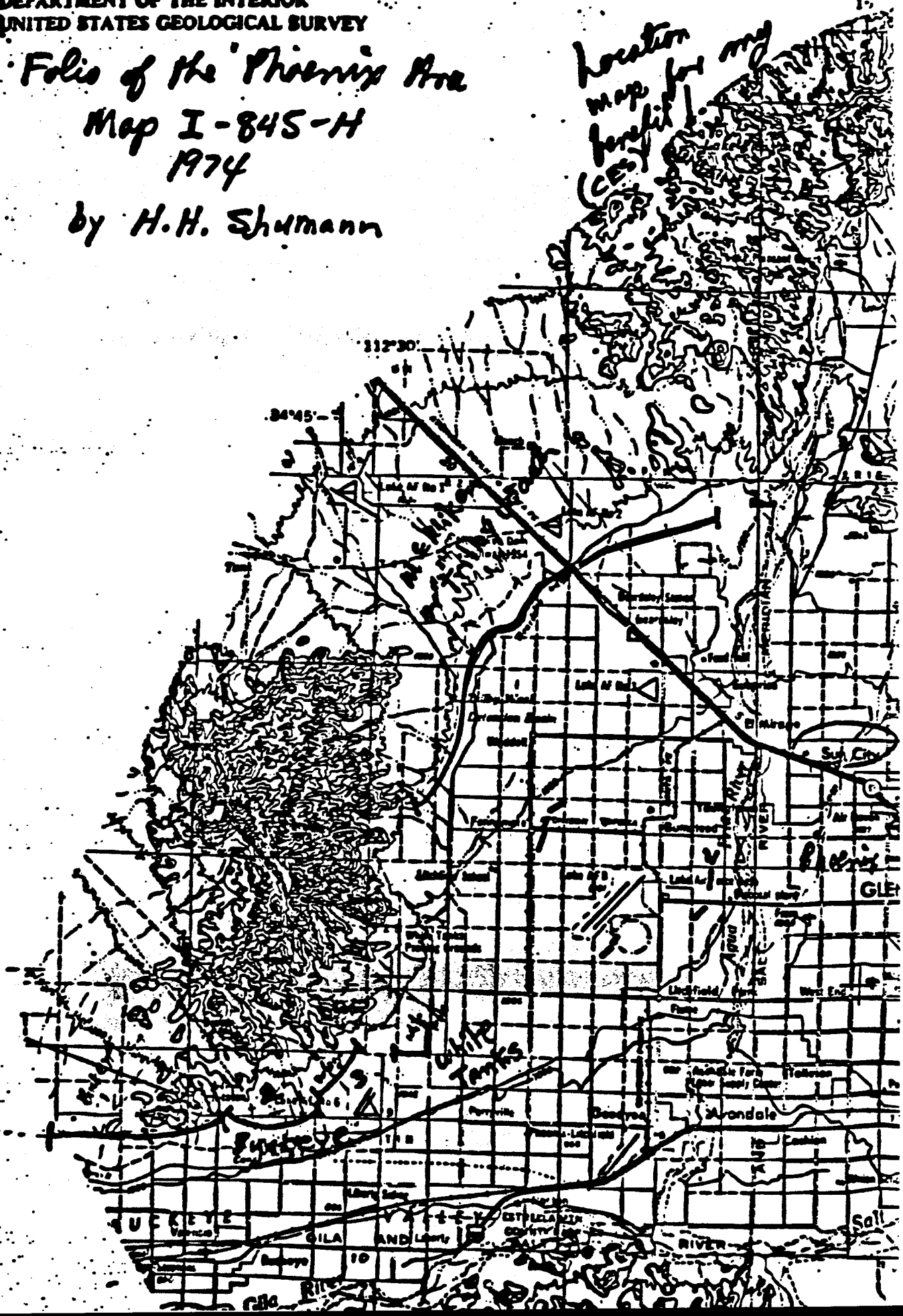
Ed Stearns

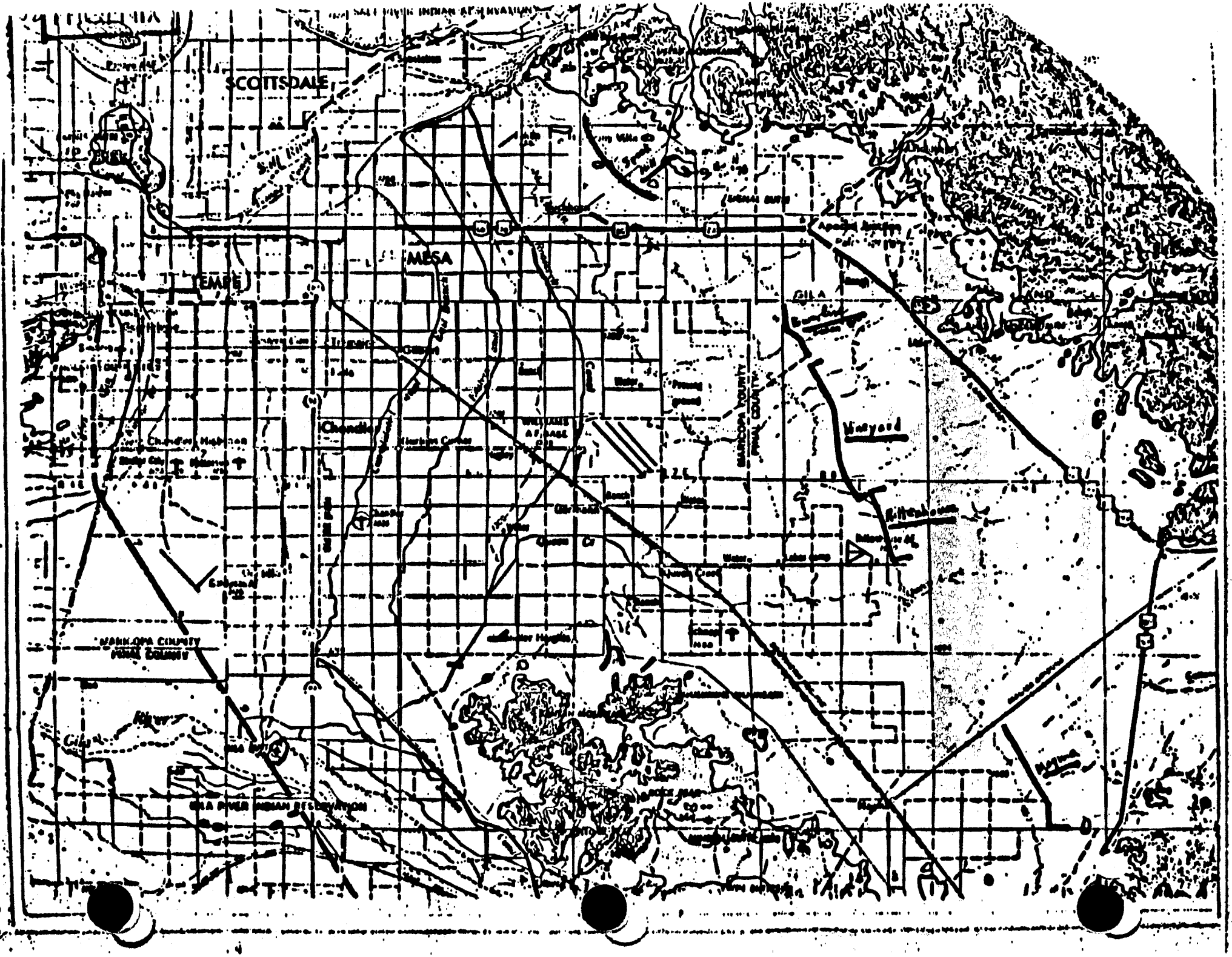

Subsidence
1971-77
Water
Table
Drop
TOTAL LAND SUBSIDENCE 1971-1977
WATER TABLE DROP
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Folio of the Phoenix Area
Map I-845-H
1974
by H.H. Shumann

Location map for my benefit (CE)

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Queen Creek
Gilbert
Chandler
Tempe
Mesa
Scottsdale
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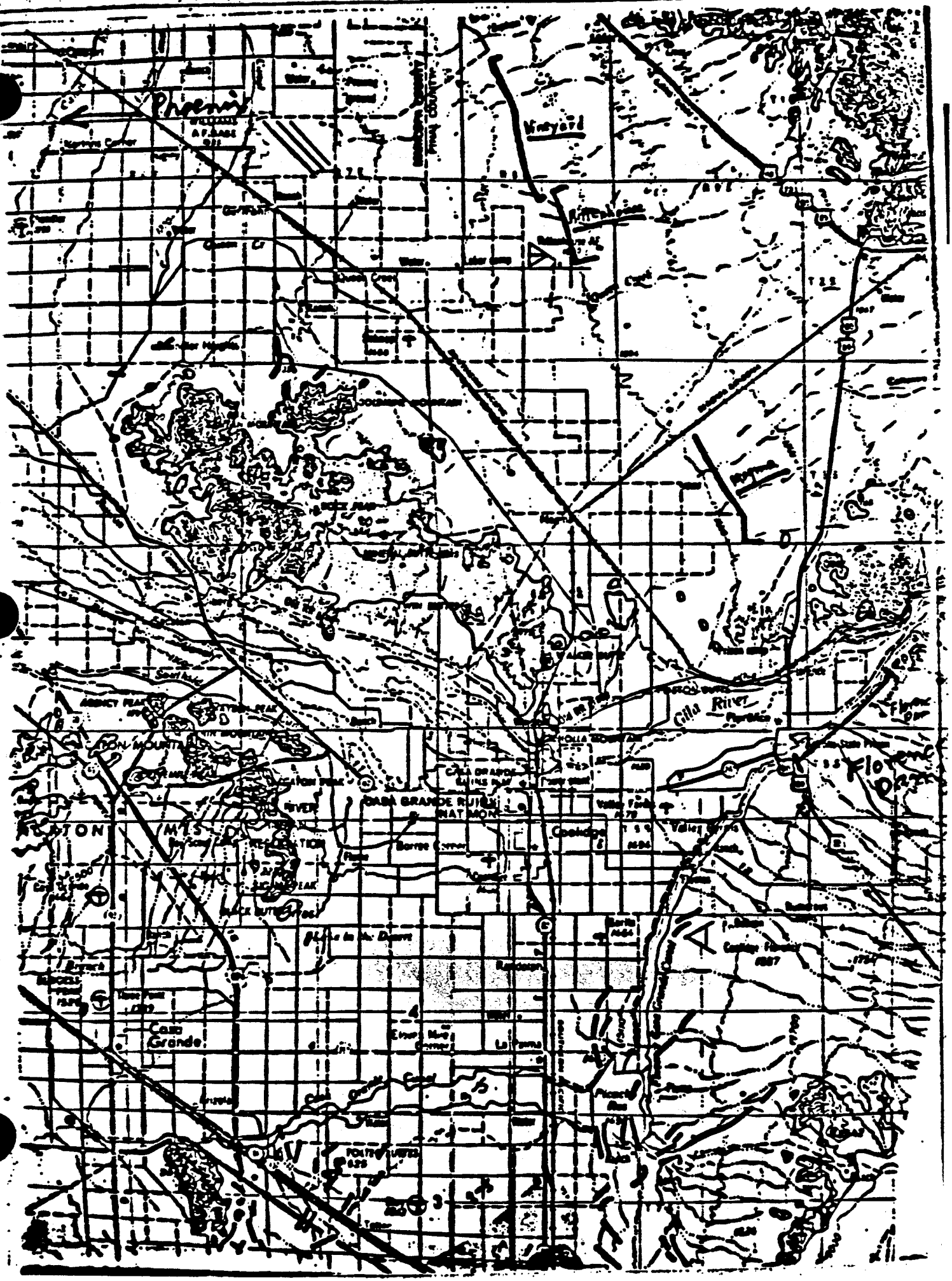
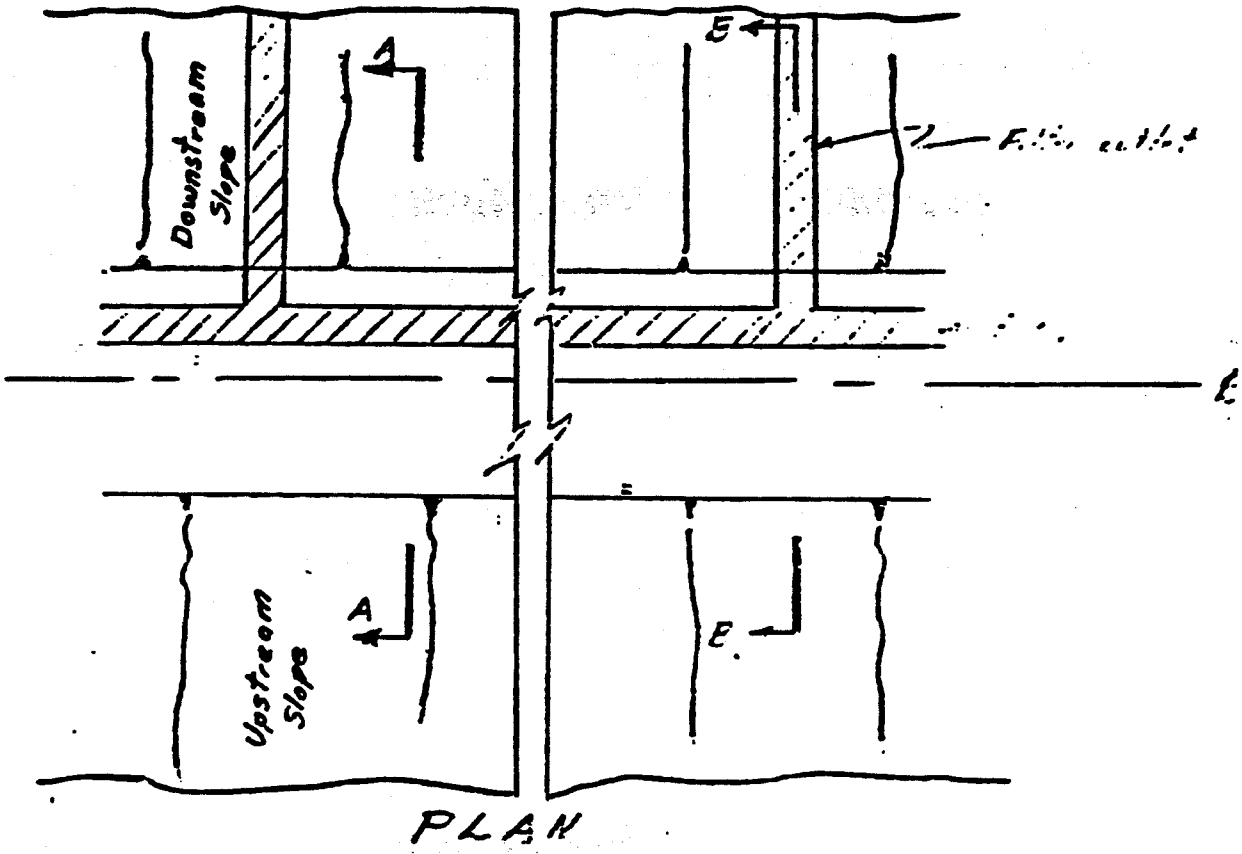
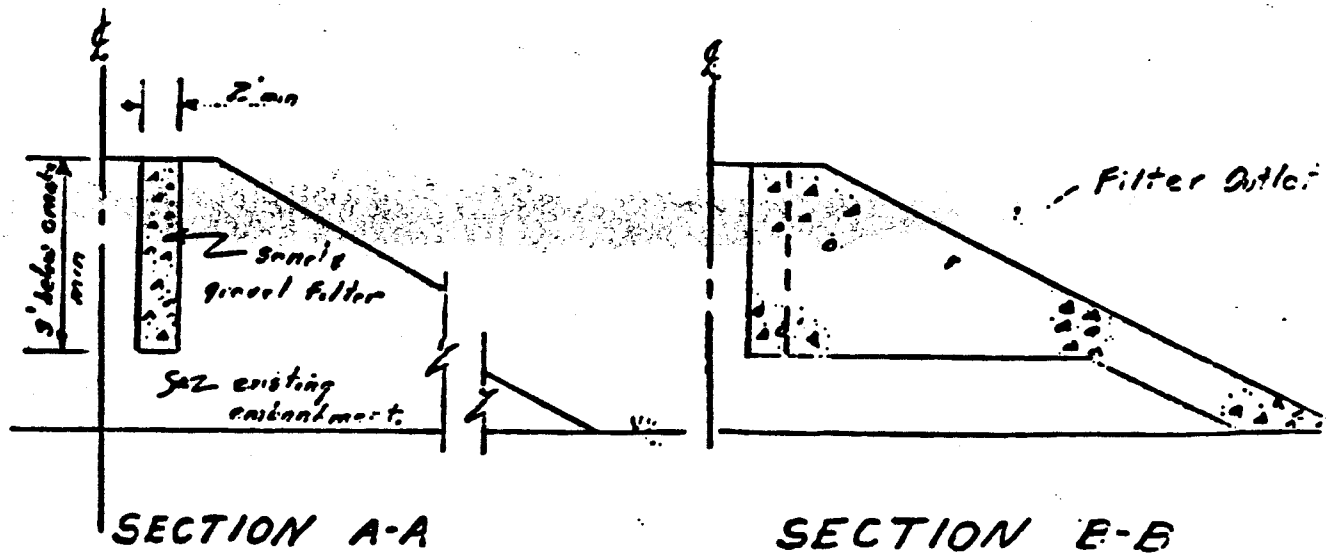

Phoenix
Gila River
Casa Grande
Coolidge
Florence

Attachment A





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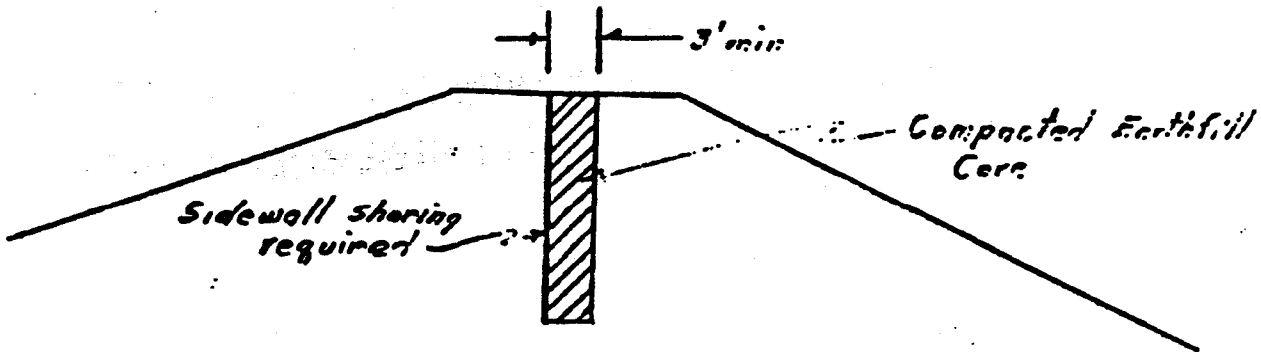

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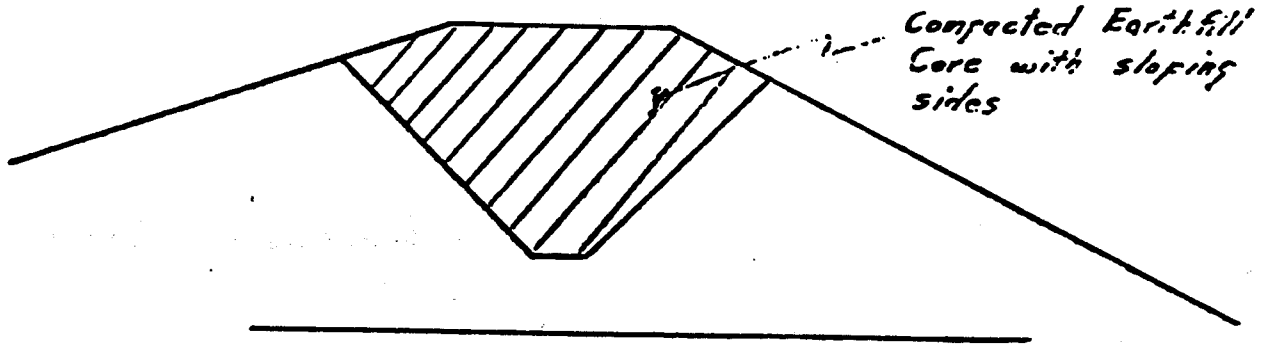

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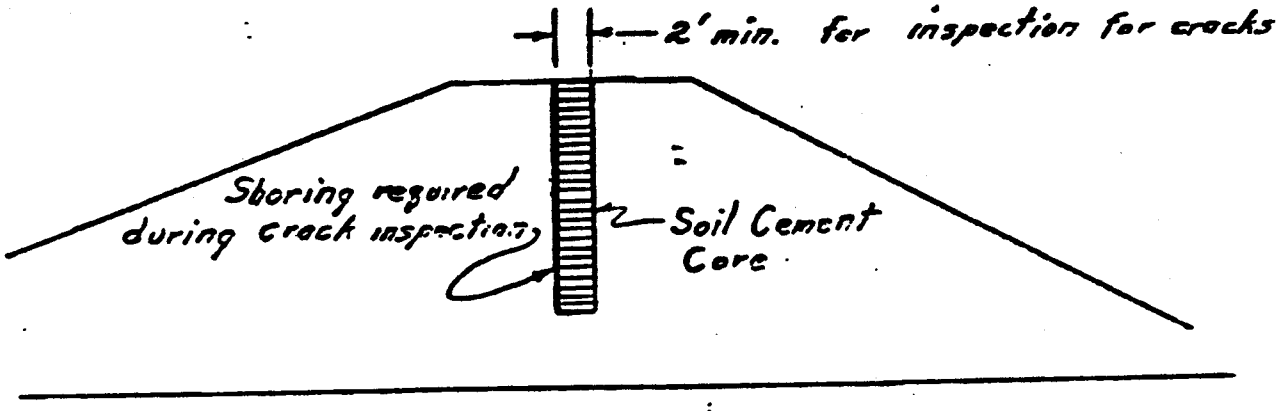

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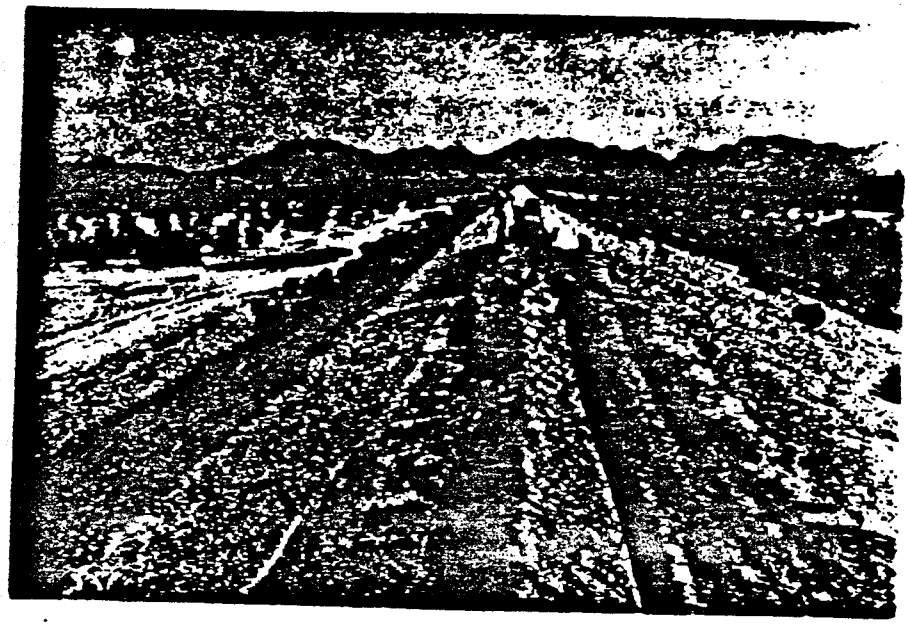
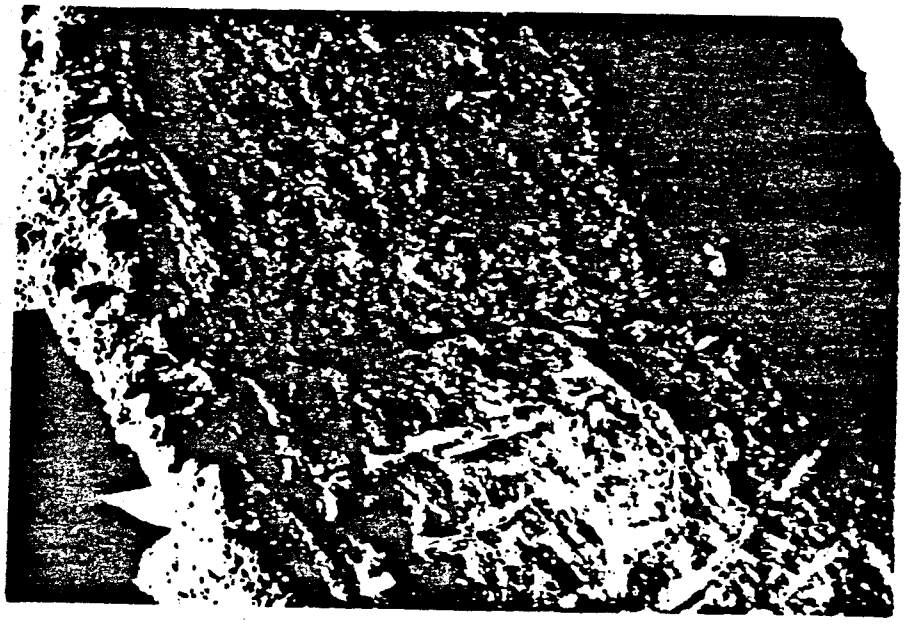


1. Trenching Operation - Vineyard Road dam near Station 200+00. 36" depth, 6" width, date 6/6/77.

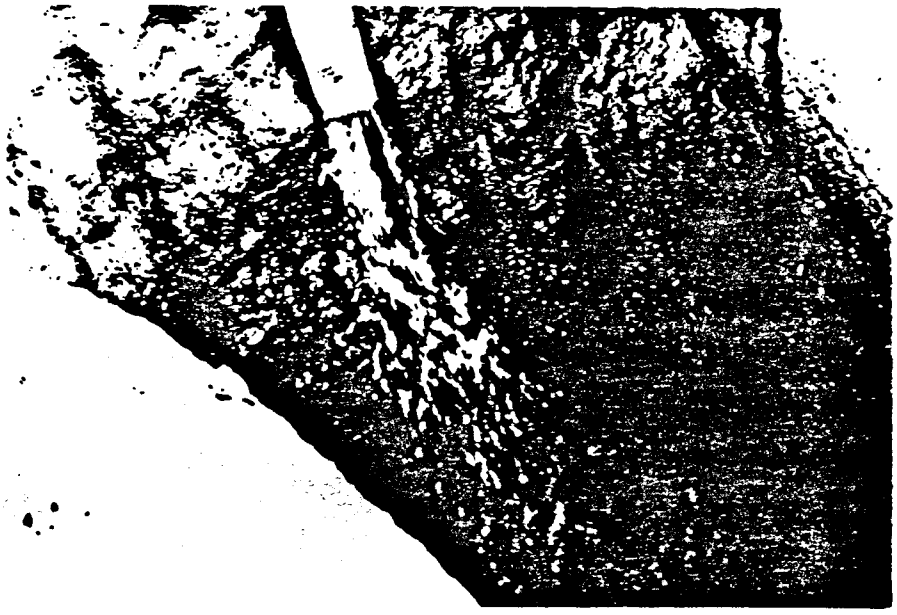
2. Backhoe Pit (V-3-A) - Vineyard Road dam Station 111+08 - Cracked dry layer over firm moist soil.



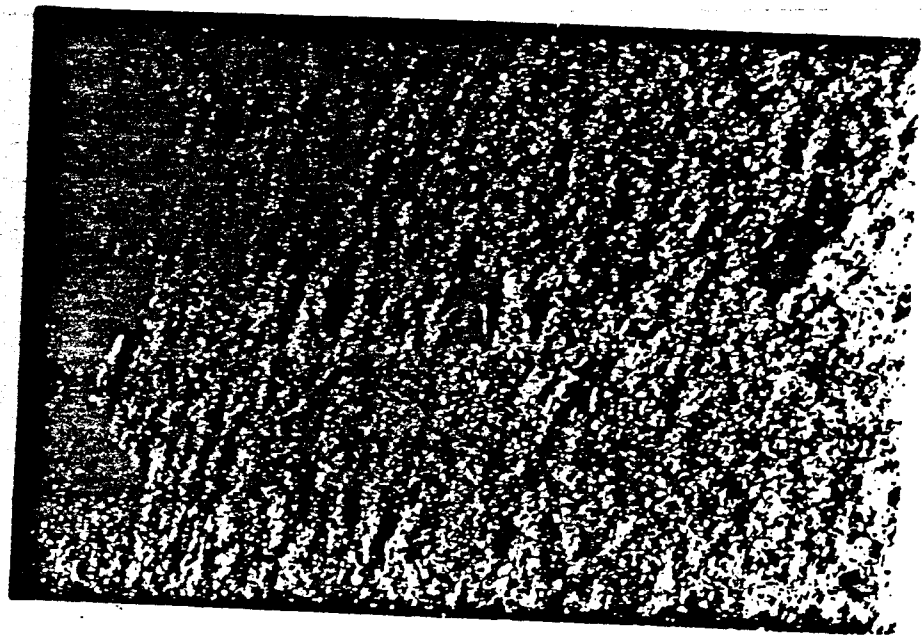
3. Backhoe Pit - Rittenhouse dam-Station 183+82 (R-D-2)
Transverse Crack 6' ±

4. Backhoe Pit - Rittenhouse dam Station 129+82 - (R-I-D)
Transverse Crack opened to 4 1/2 feet.

5. Rittenhouse dam Station 129+82 (R-I-D) - Transverse Crack opened to 5' and 400 gallon of water poured into crack. Evidence of deeper crack. Later excavated to 10' depth.

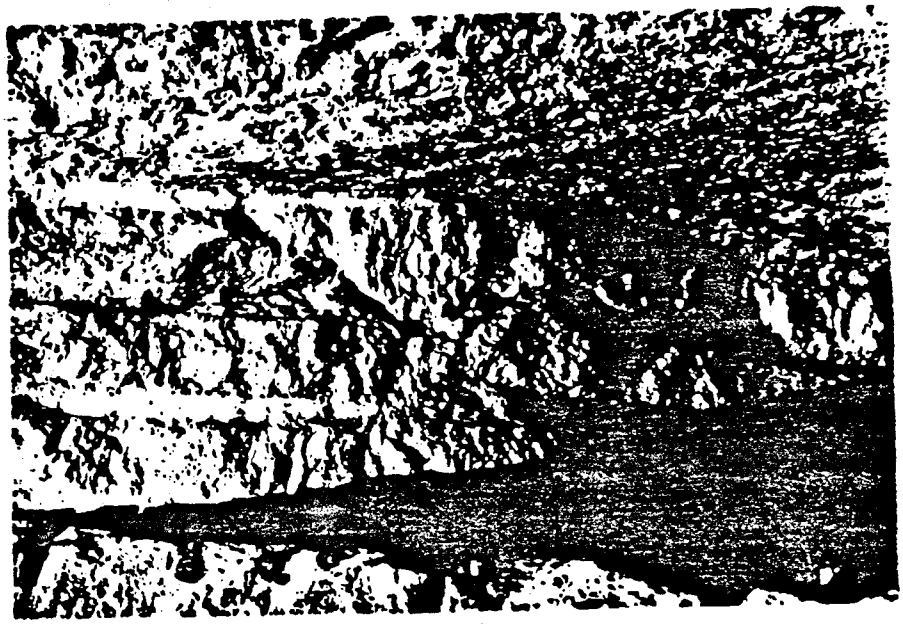


6. Rittenhouse dam Station 129+82 (R-I-D) - Transverse Crack opened to 10 feet level - Water entered into crack. Evidence of 6" diameter x 30" long cavity. Crack is not continuous thru embankment at depth - D.S. 7' U.S. 3'



7. Longitudinal Crack - Station 133+56 to Station 135+07 Vineyard Road dam upstream slope (near Schrapnel area).

8. Longitudinal Crack Vineyard dam Station 111+45 - (V-3-B) ℄ crest at dam.



9. Rittenhouse dam - Longitudinal Crack Station 158+04 depth 6'0" - (R-3-B)

10. Rittenhouse dam Station 185+82 (R-2-B) - Wide longitudinal crack - 7"0" depth.

SOIL MECHANICS REPORTS

Don Paulu

United States Department of Agriculture

Soil Conservation Service

Midwest National Technical Center
Soil Mechanics Laboratory
512 South 7th Street
Lincoln, NE 68508-2919

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Vineyard Road FRS Study

Date: December 8, 1988

To: Ralph M. Arrington
State Conservation Engineer
SCS, Phoenix, AZ

File code: 210-22

The soil mechanics tests requested for the subject site have been completed except for those which could not be run due to the condition of the sample. The free-swell test on samples 85W1099 and 85W1100A and the permeability test on sample 85W1100A could not be run. These samples were dried out and contained material greater than the 3/4 inch size.

The COLE values can be calculated from the shrinkage factors as follows:

$$COLE = \left(\sqrt[3]{\frac{V_{moist}}{V_{dry}}} - 1 \right) x100$$

Sample No.	V_m	V_d	COLE, %
85W1027	14.0	11.1	8.04
1029	14.1	11.2	7.98
1030	14.0	11.4	8.24
1097	14.2	11.8	6.37
1098A	14.0	12.2	4.69
1098B	14.1	10.9	8.96
1100A	14.0	11.4	7.09
1101	14.2	10.8	9.55

Edgar L Steele, Acting
LORN P. DUNNIGAN
Head, Soil Mechanics Laboratory

Enclosures:
Form SCS-ENG-354, Soil Mechanics Laboratory Data, 3 sheets
Form SCS-ENG-127, Soil Permeability, 2 sheets
Shrinkage Factor Worksheet, 2 sheets
Photograph (1), to SCE only

cc: w/encls.
Ralph M. Arrington (Original + 3 copies)
W. R. Evans, Head, Engineering Staff, West NTC, SCS, Portland, OR (ltr only)
Clifton E. Deal, Soil Mechanics Engineer, Engineering Staff, West NTC, SCS, Portland, OR

SCS-ENG-354
Rev. 3-70
File Code ENG-13-18

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 1 of 2

4/8/85

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.06	#200 0.074	Sand: #140 0.105	#80 0.177	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd g/cc	Opt. %	%	Special Tests: Failure Heads Atm. & Sat.	Shrinkage Limit %	Shrinkage Ratio	Volumetric Shrinkage %	Linear Shrinkage %
85W		Vineyard Road FRS Study																																					
1097	TP.1	300+00 D/S	Undist	4.0-5.0		16	16	22	41	59	67	80	86	91	95	99	100						26	8							1.55	4.8			11.10	1.81	20.34	6.0
1098A	TP.1	" "	Undist	7.5-8.5		12	12	17	35	52	60	75	84	93	100								20	2							1.60	1.4	2.70	4.0 @ C_0	12.48	1.73	14.75	4.5
1098B	TP.1	" "	Undist	10.5-11.5		26	28	37	56	72	78	87	91	96	100								42	20							1.57	3.6			17.37	1.69	29.35	8.2
1099	TP.3	253+75 D/S	Undist	9.0-10.0		4	4	4	7	9	11	20	31	48	71	90	96	97	99	99	100		Non-Plastic								1.67	1.2						
1100A	TP.3	" "	Undist	12.0-13.0		10	11	14	19	24	26	30	33	37	48	63	72	77	85	87	100		38	13							1.76	2.9			22.33	1.59	22.80	6.6
1100B	TP.3	" "	Undist	12.0-13.0																																			
1101	TP.4	107+60 D/S	Undist	6.0-7.5		19	20	26	41	56	62	70	74	79	88	94	98	99	100				33	15							1.57	2.4	2.65	2.0 @ C_0	13.13	1.75	31.52	8.7
1102	44.A.5	210+00 U/S Toe	Undist	13.5-15.5																																			

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
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4/8/85

ARIZONA

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests				
85W		Vineyard Road FRS Study																																				
1103	44.A.6	210+00 Toe Undist	16.0-18.0																																			
1104	44.A.8	" " Undist	20.5-21.7																																			
1105	55.A.1	" " Undist	3.8-5.9																																			

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 2 of 6

3/25/85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.01	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γd pcf	Opt. wc %	Undisturbed Sample Data: γd pcf	wc %	Gs	Special Tests: Shrink. Limit %	Shrink. Ratio	Vol. Shrink. %	Lin. Shrink %
85W		Vineyard Watershed																																			
1024	63.13	100' U/S from Toe @ 300+00 S. Bag	43.0-44.0		5	5	7	8	9	10	12	14	18	27	41	53	62	78	83	94	100										4.55					
1025	63.14	" " " " " " S. Bag	44.0-45.0		20	34	45	63	77	81	87	90	95	100																	0.96					
1026	64.1	5' U/S 300+00, ℄ Dam S. Bag	1.5-2.0		18	19	29	42	55	62	74	81	87	95	98	99	99	100				27	10	CL							2.60					
1027	64.2	" " " " " S. Bag	4.5-5.5		18	18	28	38	49	54	65	73	82	92	97	98	99	100				26	11	SC							7.54	10.03	1.86	26.15	7.5	
1028	64.3	" " " " " S. Bag	8.0-9.0		25	27	37	52	67	73	81	85	89	96	99	100						33	15	CL							12.23					
1029	64.5	" " " " " S. Bag	10.5-11.5		21	24	34	50	64	71	81	85	91	96	99	100						29	13	CL							11.72	19.70	1.88	25.83	7.4	
1030	64.6	" " " " " S. Bag	14.0-15.0		19	19	28	41	53	58	68	73	79	89	95	98	99	100				27	11	CL							8.67	18.93	1.90	21.80	6.6	
1031	64.7	" " " " " S. Bag	15.5-16.0		18	19	29	44	59	66	77	83	89	95	98	99	99	100				25	8	CL							12.44					
1032	64.8	" " " " " S. Bag	17.0-18.0		18	21	30	45	58	65	75	81	88	95	99	100						24	8	CL							11.42					
1033	64.9	" " " " " S. Bag	20.5-21.5		18	18	29	45	59	68	83	88	94	97	99	100															10.29					
1034	64.10	" " " " " S. Bag	23.0-24.0		26	28	37	55	74	80	88	92	96	100																	12.85					
1035	64.11	" " " " " S. Bag	28.0-29.0		23	26	40	56	69	74	81	84	91	97	99	100						38	16	CL							12.64					
1036	64.12	" " " " " S. Bag	31.0-32.0		11	13	18	26	33	38	45	50	55	66	82	90	93	95	95	100											7.23					
1037	64.13	" " " " " S. Bag	34.0-34.5		4	4	7	9	11	13	21	28	41	67	90	96	98	93	95	100											4.43					
1038	64.14	" " " " " S. Bag	36.0-38.0		16	17	25	43	62	71	83	89	95	100																	9.83					

4/15/86

SCS-ENG-127
REV. 1-72

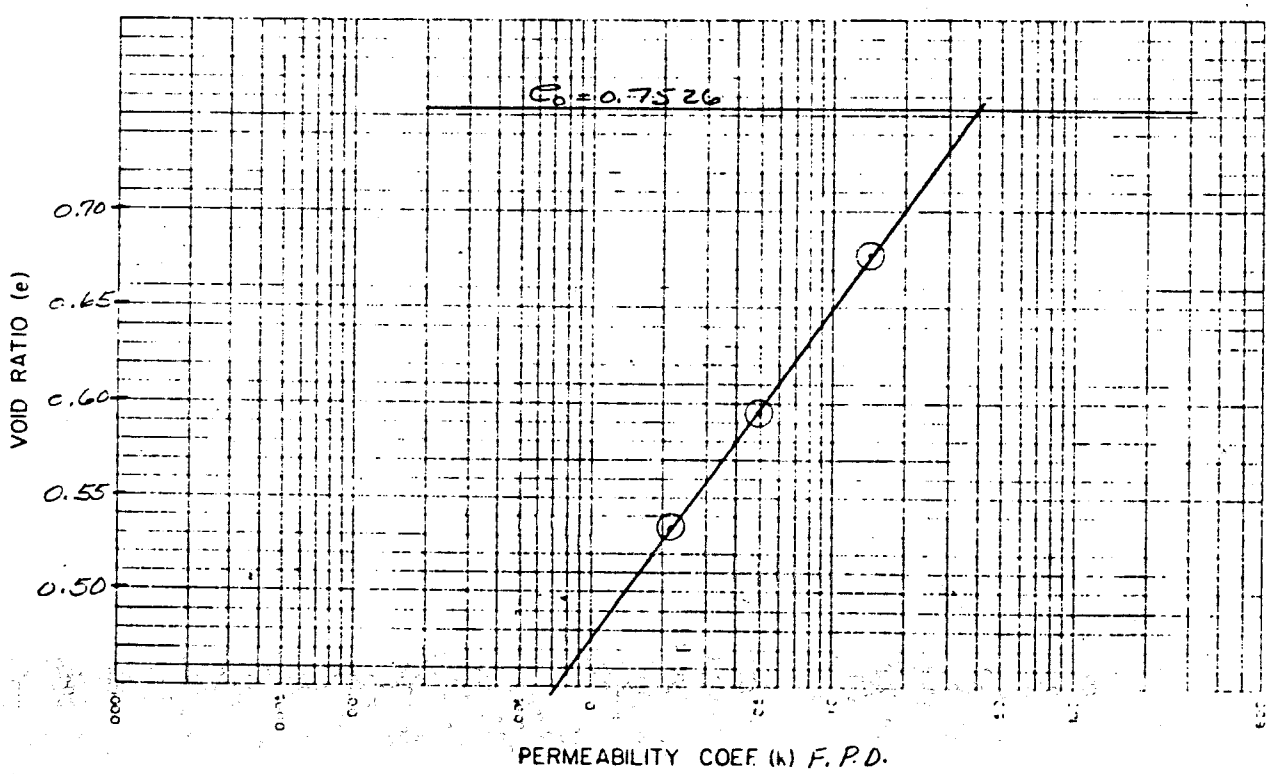
85W 1098A

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

PROJECT and STATE: Vineyard Road FRS, ARIZONA			SAMPLE LOCATION: 300+00, D/5
FIELD SAMPLE NO: TP. 1	DEPTH: 7.5 - 8.5	GEOLOGIC ORIGIN	
TYPE OF SAMPLE: undisturbed	TESTED AT: SML, Lincoln	APPROVED BY	DATE

CLASSIFICATION LL ___ PI ___

TEST NO.	2000	4000	8000	4	SPECIFIC GRAVITY	
INITIAL MOISTURE %					G_s (-)#4	2.71
DRY DENSITY ☐ g/cc ☐ pcf	1.62	1.70	1.77		G_s (+)#4	
VOID RATIO	.6772	.5941	.5335		G_m(Bulk)(+) #4	
PERMEABILITY COEF. F.P.D.	1.5840	.5032	.21245		TEST SPECIFICATIONS: Falling Head Perm.	
PERCOLATION COEF						
H/L DURING TEST						



REMARKS

k ≈ 4.0 FPD @ e_o

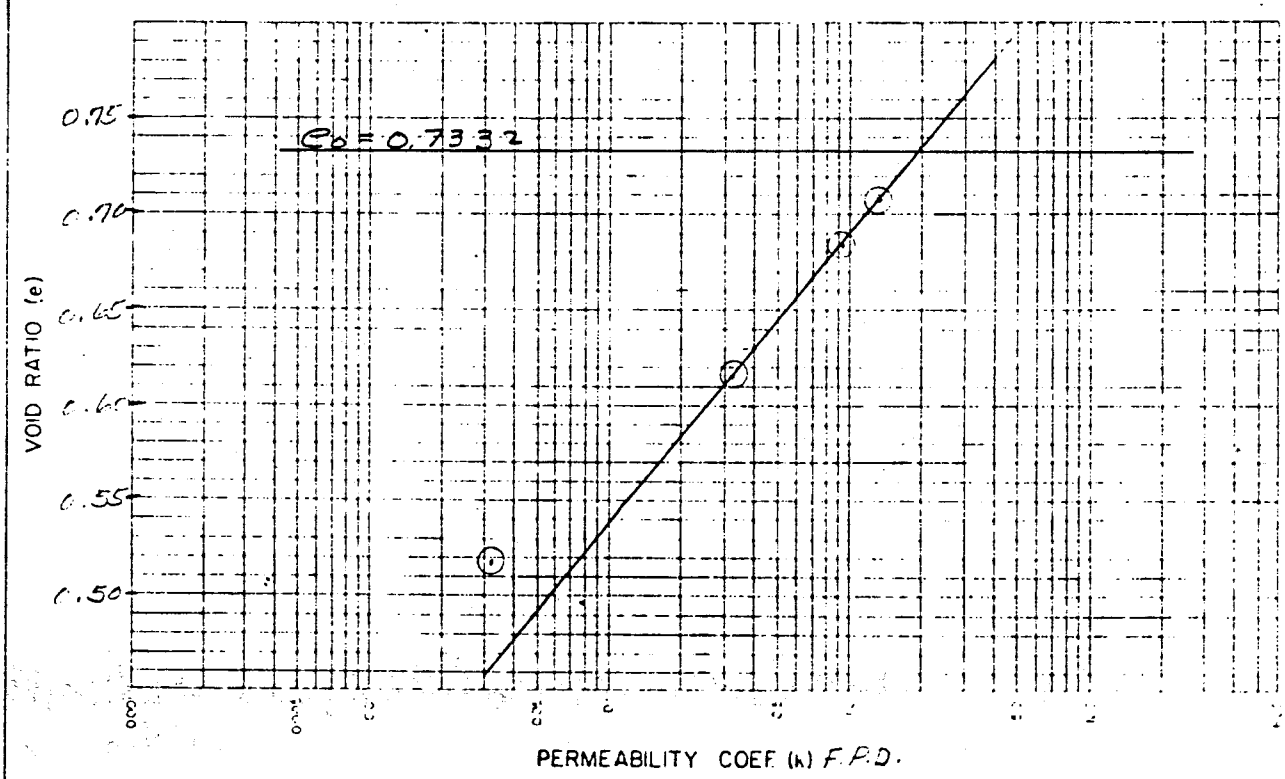
SCS-ENG-127
REV. 1-72

85W1101

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

PROJECT and STATE: Vineyard Road FRS, ARIZONA			SAMPLE LOCATION: 107+60 D/S.
FIELD SAMPLE NO: TP. 4	DEPTH: 6.0-7.5	GEOLOGIC ORIGIN	
TYPE OF SAMPLE: undisturbed	TESTED AT: SML, Lincoln	APPROVED BY	DATE

CLASSIFICATION LL ___ PI ___					SPECIFIC GRAVITY	
TEST NO	1000	2000	4000	8000	G_s (-)#4	2.63
INITIAL MOISTURE %					G_s (+)#4	
DRY DENSITY ☐ g/cc ☐ pcf	1.54	1.56	1.63	1.73	G_m(Bulk)(+) #4	
VOID RATIO	.7088	.6836	.6157	.5181	TEST SPECIFICATIONS Falling Head Form	
PERMEABILITY COEF F.P.D.	1.4044	.9405	.3165	.03175		
PERCOLATION COEF						
H/L DURING TEST						



REMARKS $k \approx 2.0$ @ e_o

SHRINKAGE FACTORS

SAMPLE NO.			85-W-1027	85-W-1028	85-W-1030	85 W 1097
1. DISH + WET SOIL	GM		46.30	46.52	49.19	47.34
2. DISH + DRY SOIL	GM		41.33	40.73	43.70	42.57
3. WATER ①-②	GM	W_w	4.97	5.79	5.49	~~4.8~~ 4.77
4. SHRINKAGE DISH	GM		20.70	19.63	22.03	21.22
5. DRY SOIL ②-④	GM	W_s	20.63	21.10	21.67	21.35
6. PER CENT MOISTURE ③/⑤ X100	%		24.09	27.44	25.33	~~20.70~~ 22.34
7. VOLUME OF SHRINKAGE DISH	CC	V	14.0	14.1	14.0	14.2
8. VOLUME OF DRY SOIL	CC	V_1	11.1	11.2	11.4	11.8
9. V-V_1 ⑦-⑧	CC		2.9	2.9	2.6	2.4
10. (V-V_1) ÷ W_s X100 ⑨/⑤	CC/GM		14.06	~~14.06~~ 13.94	12.00	11.24
11. SHRINKAGE LIMIT ⑥-⑩	%	S_L	10.03	~~[illegible]~~ 13.20	13.33	~~11.20~~ 10.10
12. SHRINKAGE RATIO ⑤/⑧	%	R	1.86	1.88	1.90	1.81
13. VOLUMETRIC SHRINKAGE ⑫ x ⑩	%	V_s	26.135	~~25.88~~ 25.83	22.80	20.~~26~~34
14. (100) ÷ (⑬ + 100)			.793	~~.74~~ .795	.814	.83~~2~~1
15. $\sqrt[3]{⑭}$			.9265	.9256	.934	.940
16. LINEAR SHRINKAGE (1-⑮) X100	%	L_s	7.45	7.54	6.6	~~5.9~~ 6.0

SHRINKAGE LIMIT = PERCENT MOISTURE − $\left(\frac{\text{VOLUME OF DISH} - \text{VOLUME OF DRY SOIL}}{\text{WT. OF DRY SOIL}} \times 100\right)$

SHRINKAGE RATIO = $\frac{\text{WT. OF DRY SOIL}}{\text{VOLUME OF DRY SOIL}}$

VOLUMETRIC SHRINKAGE = (PER CENT MOISTURE* − SHRINKAGE LIMIT) X SHRINKAGE RATIO

LINEAR SHRINKAGE = $\left(1 - \sqrt[3]{\frac{100}{V_s + 100}}\right) \times 100$

COMPLETED BY - PSP

CHECKED BY - Rich 11-21-88

* THIS MOISTURE CONTENT MAY BE VARIED. UNLESS OTHERWISE SPECIFIED, USE PER CENT MOISTURE OF SL TEST.

SHRINKAGE FACTORS

SAMPLE NO.			85W 1098A	85W 1098B	85W 1100A	85W 1101
1. DISH + WET SOIL	GM		46.29	44.45	46.81	45.95
2. DISH + DRY SOIL	GM		41.85	38.05	40.16	40.07
3. WATER ①-②	GM	W_w	4.44 ✓	6.40 ✓	6.65 ✓	5.88 ✓
4. SHRINKAGE DISH	GM		20.70 1	19.62 2	22.02 3	21.19 4
5. DRY SOIL ②-④	GM	W_s	21.15 ✓	18.43 ✓	18.14 ✓	18.88 ✓
6. PER CENT MOISTURE ③/⑤ X100	%		20.99 ✓	34.73 ✓	36.66	31.14 ✓
7. VOLUME OF SHRINKAGE DISH	CC	V	14.0	14.1	14.0	14.2
8. VOLUME OF DRY SOIL	CC	V_1	12.2	10.9	11.4	10.8
9. $V-V_1$ ⑦-⑧	CC		1.8 ✓	3.2 ✓	2.6 ✓	3.4 ✓
10. $(V-V_1) \div W_s$ X100 ⑨/⑤	CC/GM		8.51 ✓	17.36 ✓	14.33 ✓	18.01 ✓
11. SHRINKAGE LIMIT ⑥-⑩	%	S_L	12.48 ✓	17.37 ✓	22.33	13.13 ✓
12. SHRINKAGE RATIO ⑤/⑧	%	R	1.73 ✓	1.69 ✓	1.59 ✓	1.75 ✓
13. VOLUMETRIC SHRINKAGE ⑫ x ⑩	%	V_s	14.75 ✓	29.35 ✓	22.80 ✓	21.52 ✓
14. (100) ÷ (⑬ + 100)			.871 ✓	.773 ✓	.814 ✓	.760 ✓
15. $\sqrt[3]{⑭}$			.955 ✓	.918 ✓	.934 ✓	.9[illegible] ✓
16. LINEAR SHRINKAGE (1-⑮) X100	%	L_s	4.5 ✓	8.2 ✓	6.6 ✓	[illegible] ✓

SHRINKAGE LIMIT = PERCENT MOISTURE − $\left(\frac{\text{VOLUME OF DISH} - \text{VOLUME OF DRY SOIL}}{\text{WT. OF DRY SOIL}} \times 100\right)$

SHRINKAGE RATIO = $\frac{\text{WT. OF DRY SOIL}}{\text{VOLUME OF DRY SOIL}}$

VOLUMETRIC SHRINKAGE = (PER CENT MOISTURE* − SHRINKAGE LIMIT) X SHRINKAGE RATIO

LINEAR SHRINKAGE = $\left(1 - \sqrt[3]{\frac{100}{V_s + 100}}\right) \times 100$

COMPLETED BY - PSH

CHECKED BY - Rich 11-23-88

* THIS MOISTURE CONTENT MAY BE VARIED. UNLESS OTHERWISE SPECIFIED, USE PER CENT MOISTURE OF SL TEST.

United States Department of Agriculture

Soil Conservation Service

Midwest National Technical Center
Soil Mechanics Laboratory
512 South 7th Street
Lincoln, NE 68508-2919

File

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Vineyard Road FRS Study

Date: June 12, 1985

To: Ralph M. Arrington
State Conservation Engineer
SCS, Phoenix, AZ

File Code: 210-22

Atterberg limit tests were made on 98 of the samples submitted to SML on March 12 and March 25, 1985. The test data are recorded on the attached forms SCS-ENG-354. If additional tests are needed, let us know.

Lorn P. Dunnigan

LORN P. DUNNIGAN
Head, Soil Mechanics Laboratory

Attachments:
Form SCS-ENG-354, Soil Mechanics Laboratory Data, 27 sheets

cc:
Ralph M. Arrington (Original + 3 copies)
Jack C. Stevenson, Head, Engineering Staff, WNTC, SCS, Portland, OR (ltr only)
Clifton E. Deal, Soil Mechanics Engineer, Engineering Staff, WNTC, SCS, Portland, OR

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File Code ENG-13-18

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 1 of 6

3/25/85

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Fines 0.005 mm	Fines 0.005	Fines 0.02	Fines 0.05	Fines #200 0.074	Sand #140 0.105	Sand #60 0.250	Sand #40 0.42	Sand #20 0.84	Sand #10 2.0	Sand #4 4.76	Gravel 3/8" 9.525	Gravel 1/2" 12.7	Gravel 3/4" 19.05	Gravel 1" 25.4	Gravel 1 1/2" 38.1	Gravel 3" 76.2 mm	Atterberg Limits LL	Atterberg Limits PL	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships Standard Max. γd pcf	Moisture-Density Relationships Standard Opt. wc %	Moisture-Density Relationships Modified Max. γd pcf	Moisture-Density Relationships Modified Opt. wc %	Undisturbed Sample Data γd g/cm³	Undisturbed Sample Data wc %	Gs	Special Tests
85W		Vineyard Watershed																																	
1009	62.7	300+00, P/S Toe Dam	S. Bag	33.0-34.0		18	23	38	63	76	83	92	96	99	100								38	10	ML								10.01		
1010	62.8	" " " "	S. Bag	38.0-39.0		5	5	7	11	13	15	20	24	30	37	52	67	76	88	97	100												2.79		
1011	62.9	" " " "	S. Bag	43.0-44.0		2	2	3	3	4	5	6	7	14	31	45	57	64	75	85	95	100											2.65		
1012	63.1	100' U/S from Toe @ 300+00	S. Bag	2.0-3.0		12	12	16	28	40	47	60	68	78	88	94	96	97	99	100			NON PLASTIC		ML								5.55		
1013	63.2	" " " " " "	S. Bag	7.0-8.0		18	18	23	33	50	56	68	74	81	90	95	98	99	100				NON PLASTIC		ML								7.08		
1014	63.3	" " " " " "	S. Bag	14.0-15.0		23	30	42	58	70	74	81	84	88	93	98	99	100					39	18	CL								8.34		
1015	63.4	" " " " " "	S. Bag	19.0-20.0		20	25	35	53	64	70	79	84	88	93	97	100						42	15	ML								7.04		
1016	63.5	" " " " " "	S. Bag	21.5-22.5		17	17	19	31	40	45	60	73	84	92	98	100																5.91		
1017	63.6	" " " " " "	S. Bag	22.5-23.5		3	3	4	6	6	6	10	17	30	55	79	91	96	100														2.43		
1018	63.7	" " " " " "	S. Bag	24.5-25.5		22	24	30	46	65	74	88	92	96	99	100																	7.11		
1019	63.8	" " " " " "	S. Bag	27.0-28.0		13	16	20	27	33	36	43	48	55	68	83	91	95	98	100													8.71		
1020	63.9	" " " " " "	S. Bag	28.0-29.0		17	19	23	37	51	58	71	78	87	93	97	99	99	100														7.02		
1021	63.10	" " " " " "	S. Bag	34.0-35.0		23	29	39	54	68	73	80	84	88	95	99	100																11.86		
1022	63.11	" " " " " "	S. Bag	37.0-38.0		14	22	37	61	77	81	86	90	94	96	98	99	100															7.32		
1023	63.12	" " " " " "	S. Bag	41.0-43.0		9	11	16	22	27	28	31	37	44	47	58	68	72	79	90	100												3.73		

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Rev. 3-70
File Code ENG-13-18

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 2 of 6

3/25/85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γd pcf	Opt. w %	Undisturbed Sample Data: γd pcf	w %	Gs	Special Tests
85W		Vineyard Watershed																															
1024	63.13	100' U/S from Toe @ 300+00	43.0-44.0		5	5	7	8	9	10	12	14	18	27	41	53	62	78	83	94	100										4.55		
		S. Bag																															
1025	63.14	" " " " " "	44.0-45.0		29	34	45	63	77	81	87	90	95	100																	10.96		
		S. Bag																															
1026	64.1	5' U/S 300+00, ℄ Dam S. Bag	1.5-2.0		18	19	29	42	55	62	74	81	87	95	98	99	99	100				27	10	CL							9.60		
1027	64.2	" " " " " S. Bag	4.5-5.5		18	18	28	38	49	54	65	73	82	92	97	98	99	100													7.54		
1028	64.3	" " " " " S. Bag	8.0-9.0		25	27	37	52	67	73	81	85	89	96	99	100						33	15	CL							12.23		
1029	64.5	" " " " " S. Bag	10.5-11.5		21	24	34	50	64	71	81	85	91	96	99	100															11.72		
1030	64.6	" " " " " S. Bag	14.0-15.0		19	19	28	41	53	58	68	73	79	89	95	98	99	100													8.67		
1031	64.7	" " " " " S. Bag	15.5-16.0		18	19	29	44	59	66	77	83	89	95	98	99	99	100													14.44		
1032	64.8	" " " " " S. Bag	17.0-18.0		18	21	30	45	58	65	75	81	88	95	99	100															11.42		
1033	64.9	" " " " " S. Bag	20.5-21.5		18	18	29	45	59	68	83	88	94	97	99	100															10.29		
1034	64.10	" " " " " S. Bag	23.0-24.0		26	28	37	55	74	80	88	92	96	100																	13.85		
1035	64.11	" " " " " S. Bag	28.0-29.0		23	26	40	56	69	74	81	84	91	97	99	100						38	16	CL							12.68		
1036	64.12	" " " " " S. Bag	31.0-32.0		11	13	18	26	33	38	45	50	55	66	82	90	93	95	95	100											7.23		
1037	64.13	" " " " " S. Bag	34.0-34.5		4	4	7	9	11	13	21	28	41	67	80	86	88	93	95	100											4.43		
1038	64.14	" " " " " S. Bag	36.0-38.0		16	17	25	43	62	71	83	89	95	100																	9.83		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074	#325 0.044	0.02	0.05	0.005	Sand: #100 0.149	#80 0.177	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 1/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
1039	64.15	5' U/S 300+00, ℄ Dam	S. Bag	38.0-39.0		8	8	13	16	19	21	26	33	48	66	82	89	92	98	100													4.90		
1040	64.16	" " " " "	S. Bag	39.0-40.5		24	32	48	67	79	83	90	94	98	100																		15.69		
1041	64.17	" " " " "	S. Bag	42.0-44.0		20	24	34	51	65	70	81	86	90	95	98	99	100															12.11		
1042	64.18	" " " " "	S. Bag	44.0-45.5		21	25	36	58	72	77	84	87	91	96	100																	12.87		
1043	64.19	" " " " "	S. Bag	48.0-49.0		25	30	42	58	73	78	85	88	92	96	98	99	100						38	13	ML							12.09		
1044	65.1	U/S of Dam @ 253+57	S. Bag	0.0-2.5		17	18	26	41	59	65	76	82	88	96	100								24	8	CL							11.74		
1045	65.2	" " " " "	S. Bag	4.5-5.5		14	14	20	41	58	76	91	95	98	100									22	3	ML							11.34		
1046	65.3	" " " " "	S. Bag	7.0-8.0		11	12	16	31	46	53	68	75	81	89	94	96	97	99	100													18.20		
1047	65.4	" " " " "	S. Bag	10.5-14.0		6	7	9	11	12	13	19	27	40	53	72	81	85	92	95	100												5.42		
1048	65.5	" " " " "	S. Bag	14.0-15.5		18	23	28	41	53	59	67	71	77	90	98	100							37	14	CL							18.49		
1049	65.6	" " " " "	S. Bag	16.0-18.0		14	17	23	34	42	47	55	61	68	77	88	97	99	100														12.97		
1050	65.7	" " " " "	S. Bag	18.0-20.5		18	25	37	54	67	72	81	86	90	95	98	99	99	100														21.46		
1051	65.8	" " " " "	S. Bag	23.0-25.0		18	24	36	54	64	70	81	85	91	96	99	99	100															20.47		
1052	65.9	" " " " "	S. Bag	26.0-28.0		24	27	34	48	60	64	71	75	78	87	99	100							41	19	CL							12.43		
1053	65.10	" " " " "	S. Bag	28.5-30.5		11	13	25	50	66	76	92	96	99	100																		21.99		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (☐ Standard ☐ Modified): Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																												
1054	65.11	U/S of Dam @ 253+57	S. Bag	31.5-33.0		6	6	8	10	11	13	20	28	38	47	69	82	89	97	100									5.61		
1055	65.12	" " " " "	S. Bag	34.0-35.5		17	19	25	44	59	65	77	84	90	96	100													18.09		
1056	65.13	" " " " "	S. Bag	36.0-37.0		13	14	17	27	33	36	45	54	66	78	91	95	96	99	100									12.05		
1057	65.14	" " " " "	S. Bag	38.5-39.5		4	4	5	7	8	8	12	16	26	51	86	93	95	96	98	100								4.33		
1058	65.15	" " " " "	S. Bag	39.5-40.5		20	21	28	42	55	60	67	71	78	89	96	99	99	100										16.11		
1059	65.16	" " " " "	S. Bag	42.0-43.0		7	7	19	15	17	18	23	29	44	73	92	97	98	100										11.44		
1060	65.17	" " " " "	S. Bag	44.0-45.0		17	24	36	58	73	78	85	89	93	96	97	98	99	99	100									16.18		
1061	65.18	" " " " "	S. Bag	48.0-50.0		7	10	25	49	66	73	86	92	98	100														20.73		
1062	65.19	" " " " "	S. Bag	51.0-53.0		5	6	17	46	67	78	94	98	99	100														23.18		
1063	65.20	" " " " "	S. Bag	53.0-55.5		3	3	5	10	15	17	26	39	54	73	85	92	96	99	100									7.35		
1064	29.1	℄ Dam, 220+00	L. Bag	2.0-4.0		19	21	27	40	56	62	73	78	85	93	98	99	100				28	13	CL					9.70		
1065	29.3	" " "	L. Bag	7.0-10.0		22	22	27	40	53	58	67	73	82	91	97	99	100											9.23		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines 0.005 mm	Fines 0.005	Fines 0.02	Fines 0.05	Fines #200 0.074	Sand #100 0.149	Sand #60 0.250	Sand #40 0.42	Sand #20 0.84	Sand #10 2.0	Sand #4 4.76	Gravel 3/8" 9.525	Gravel 1/2" 12.7	Gravel 3/4" 19.05	Gravel 1" 25.4	Gravel 1 1/2" 38.1	Gravel 3" 76.2 mm	Atterberg Limits LL	Atterberg Limits PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Optimum %	Max γ_d pcf	w_o %	Undisturbed Sample Data γ_d g/cc	w_o %	G_s	Special Tests				
85W		Vineyard Watershed																																				
1066	41.2	145+00	L. Bag	7.0-10.0		20	22	31	47	62	69	78	83	88	96	99	100						27	12	CL							9.03					
1067	42.2	150+00	L. Bag	7.0-10.0		21	24	30	45	60	66	75	81	88	95	99	100						29	14	CL							9.26					
1068	43.1	210+00	L. Bag	0.0-5.0		20	23	27	43	60	68	79	85	93	100								26	11	CL							8.71					
1069	43.4	"	L. Bag	7.0-10.0		19	20	25	39	52	58	69	75	83	91	98	99	99	100				27	12	CL							9.04					
1070	43.6	"	L. Bag	15.0-18.0		21	22	29	43	61	68	77	82	87	93	98	100						29	14	CL							10.13					
1071	64.4	5' U/S 300+00, ℄ Dam	L. Bag	8.0-12.0		19	19	26	40	53	58	68	73	81	88	95	98	99	100				28	11	CL							9.44					

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.062 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests				
85W		Vineyard Watershed																																				
1072	55.14	107+80 U/S Undist	21.0-23.0		18	18	23	40	56	62	71	76	82	91	97	99	99	99	100			32	10	CL						1.45	22.0							
1073	55.15	" " Undist	42.5-43.8		14	24	44	68	83	87	93	96	99	100								27	6	CL-ML						1.55	22.2							
1074	60.18	107+60 D/S Undist	0.5-1.5		13	14	17	30	43	51	66	74	83	93	97	98	99	100				20	4	SC-SM						1.91	7.43							

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines					Sand						Gravel						Atterberg Limits		Unified Classification	Soluble Salts %	Dispersion %	Moisture - Density Relationships ☐ Standard ☐ Modified			Undisturbed Sample Data		G_s	Special Tests				
						2.000 mm	0.005	0.02	0.05	#200 0.074	#140 0.105	#100 0.150	#60 0.25	#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	2" 50.8	LL	PI				Optimum %	Max. γ_d pcf	%	γ_d g/cc	%						
85W		Vineyard Watershed																																				
1089	TP.1	300+00 D/S	L. Bag	7.5		7	8	10	18	26	30	41	50	59	69	78	83	85	88	91	96	100	20	1	SM							2.27						
1090	TP.1	300+00 U/S	S. Bag	7.0-9.5		7	7	9	18	26	30	40	48	59	73	90	96	98	99	100			20	1	SM							0.95						
1091	TP.1	300+00 D/S	S. Bag	9.5-10.5		3	3	5	6	11	12	21	36	62	78	89	94	96	99	100			NON PLASTIC		SW-SM							0.71						
1092	TP.2	300+00 U/S	M. Bag	4.0-6.5		4	4	5	7	10	12	18	25	35	46	64	78	85	92	95	98	100	22	3	SW-SM							0.74						
1093	TP.2	300+00 U/S	S. Bag	7.0-8.0		13	14	16	25	34	39	52	60	70	82	91	95	97	97	98	100		32	10	SC							1.60						
1094	TP.2	300+00 U/S	M. Bag	8.0-9.0		14	15	21	32	44	49	58	65	72	79	87	90	91	92	92	94	100	29	10	SC							2.16						
1095	TP.3	253+75 D/S	L. Bag	6.5-9.0		4	4	4	6	11	12	18	26	40	51	68	80	85	92	95	98	100	20	2	SW-SM							0.91						
1096	TP.3	253+75 D/S	L. Bag	12.0-13.0		9	9	12	16	20	22	26	29	35	48	69	82	88	93	97	99	100	34	13	SC							4.54						

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.01	0.05	#200 0.074	Sand: #100 0.149	#50 0.297	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γd p.c.f.	Opt. %	Undisturbed Sample Data: γd g/cc	Opt. %	Gs	Special Tests				
85W		Vineyard Watershed																																				
726	1.1	365+00	S. Bag	1.5'-2.0'		13	13	23	43	47	54	68	75	94	93	97	100						21	2	SM							7.57					
727	1.2	"	S. Bag	4.5'-6.0'		24	26	40	67	75	79	87	91	95	98	99	100						27	9	CL							10.32					
728	1.3	"	S. Bag	10.5'-15.5'		6	6	7	12	12	13	17	21	30	40	57	67	73	84	88	100											4.32					
729	2.1	360+00	S. Bag	5.0'-6.0'		13	13	21	43	55	62	75	82	87	93	96	98	100														6.75					
730	2.2	"	S. Bag	10.0'-10.5'		16	16	22	41	48	54	68	75	84	92	96	98	99	100				23	6	SC-SM							7.95					
731	3.1	355+00	S. Bag	5.5'-6.0'		14	14	21	39	48	55	68	76	85	93	98	100															7.24					
732	3.2	"	S. Bag	10.0'-10.5'		14	14	20	38	50	57	73	81	88	96	98	99	99	100													8.99					
733	3.3	"	S. Bag	12.0'-14.0'		8	8	10	19	21	25	35	46	59	69	80	86	90	92	100												6.08					
734	3.4	"	S. Bag	14.0'-15.0'		14	14	20	35	49	56	70	77	86	93	97	99	100														9.37					
735	4.1	350+00	S. Bag	6.0'-7.0'		12	12	17	32	44	51	64	71	78	87	92	96	98	100													6.90					
736	4.2	"	S. Bag	9.0'-10.0'		22	24	35	55	73	79	88	92	96	100								27	9	CL							12.77					
737	4.3	"	S. Bag	10.5'-15.5'		28	32	49	69	84	89	95	97	99	100								33	15	CL							16.96					
738	5.1	345+00	S. Bag	6.0'-7.0'		18	18	26	42	55	61	72	77	85	92	96	98	99	100				26	9	CL							8.07					
739	5.2	"	S. Bag	9.5'-10.5'		20	22	31	47	61	67	76	82	88	95	98	100						28	12	CL							9.04					
740	5.3	"	S. Bag	10.5'-13.0'		17	17	24	38	50	57	68	74	83	93	97	99	100														8.72					

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines					Sand						Gravel						Atterberg Limits		Unified Classification	Soluble Salts %	Org. Perm. %	Moisture-Density Relationships ☐ Standard ☐ Modified			Undisturbed Sample Data		Gs	Special Tests				
85W		Vineyard Watershed																																				
741	6.1	340+00	S. Bag	5.5'-6.5'		14	14	19	36	47	54	68	76	85	92	97	99	100					22	5	SC-SM								6.34					
742	6.2	"	S. Bag	10.5'-11.5'		22	24	31	45	57	64	75	81	87	95	98	98	100					30	14	CL								10.53					
743	6.3	"	S. Bag	18.0'-20.0'		22	24	31	45	59	65	77	84	90	96	99	100																10.21					
744	7.1	335+00	S. Bag	5.5'-6.5'		20	21	29	41	53	59	69	76	82	89	93	96	99	100				27	10	CL								9.68					
745	7.2	"	S. Bag	10.0'-10.5'		25	25	31	43	54	60	70	76	84	93	97	99	99	100														10.61					
746	7.3	"	S. Bag	15.0'-15.5'		18	18	24	36	46	52	64	71	79	87	92	95	97	99	100			27	11	SC								13.01					
747	8.1	330+00	S. Bag	5.5'-6.5'		16	18	22	38	49	57	70	78	86	95	98	100						24	7	SC-SM								6.69					
748	8.2	"	S. Bag	11.0'-12.0'		17	17	22	32	44	50	60	66	74	80	87	91	93	94	96	100												8.59					
749	9.1	325+00	S. Bag	5.5'-6.5'		17	17	23	34	46	52	61	66	74	83	90	92	94	95	96	100												8.33					
750	9.2	"	S. Bag	10.5'-11.5'		16	16	19	33	44	50	63	70	78	88	94	98	99	100														8.75					
751	10.1	320+00	S. Bag	5.5'-6.5'		20	20	26	39	51	56	68	74	83	94	99	100						28	12	CL								9.16					
752	10.2	"	S. Bag	10.5'-11.5'		22	22	28	40	55	60	71	78	86	94	99	100																10.94					
753	10.3	"	S. Bag	13.0'-14.0'		21	21	27	38	50	56	66	73	81	93	98	99	99	100														10.51					
754	11.1	315+00	S. Bag	5.5'-6.5'		19	19	25	37	50	56	67	73	82	94	99	100						26	10	CL								7.39					
755	11.2	"	S. Bag	7.5'-8.5'		20	21	29	42	53	60	71	78	86	92	96	97	97	100														8.85					

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.06	#200 0.074	Sand: #100 0.149	#80 0.177	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Optimum %	Max. γ_d pcf	%	Undisturbed Sample Data: γ_d g/cc	%	Gs	Special Tests					
85W		Vineyard Watershed																																					
756	11.3	315+00	S. Bag	14.5'-15.5'		21	21	29	41	53	59	69	74	83	93	97	99	99	100													9.84						
757	13.1	310+00	S. Bag	5.5'-7.5'		21	21	26	38	53	59	69	74	82	93	98	100						26	10	CL							7.86						
758	13.2	"	S. Bag	10.5'-12.5'		22	22	27	40	54	61	73	80	87	95	99	100															10.73						
759	13.3	"	S. Bag	15.5'-17.5'		19	19	26	38	53	59	69	75	82	91	97	100															11.17						
760	14.1	305+00	S. Bag	5.5'-6.5'		21	21	27	39	52	58	69	75	84	92	97	98	99	100				28	11	CL							8.38						
761	14.2	"	S. Bag	10.5'-12.5'		21	21	28	42	56	63	74	81	87	94	98	100															9.81						
762	15.1	295+00	S. Bag	5.5'-7.5'		18	18	22	33	45	50	61	68	77	88	95	97	98	98	100			29	11	SC							10.59						
763	15.2	"	S. Bag	10.5'-11.5'		30	30	35	49	62	68	76	81	86	93	98	100						40	20	CL							13.48						
764	15.3	"	S. Bag	14.5'-15.5'		14	15	19	33	47	53	65	71	79	90	97	99	99	100													9.45						
765	16.1	290+00	S. Bag	5.5'-6.5'		18	18	25	37	51	56	66	73	80	92	98	99	99	99	100			25	8	CL							8.71						
766	16.2	"	S. Bag	10.5'-11.5'		23	23	37	60	70	75	83	87	92	97	99	100															11.72						
767	17.1	285+00	S. Bag	5.5'-6.5'		10	10	12	23	31	34	43	50	59	71	78	82	84	86	90	100		22	4	SC-SM							6.89						
768	17.2	"	S. Bag	10.5'-11.5'		10	10	13	26	35	39	49	56	66	79	88	90	91	93	93	100											6.36						
769	18.1	280+00	S. Bag	5.5'-6.5'		18	18	23	38	54	61	73	78	86	93	98	100															9.78						
770	18.2	"	S. Bag	7.0'-8.0'		17	17	22	37	50	56	67	75	80	88	94	97	99	100													7.98						

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γd pcf	Wopt %	Undisturbed Sample Data: γd g/cm³	Wn %	Gs	Special Tests
85W		Vineyard Watershed																															
771	18.3	280+00 S. Bag	10.5'-11.5'		19	19	25	42	55	62	73	79	86	94	99	100																8.70	
772	19.1	275+00 S. Bag	5.5'-6.5'		19	19	27	45	54	61	72	78	86	95	99	100																9.57	
773	19.2	" S. Bag	10.5'-11.5'		19	19	26	43	60	67	78	84	90	96	99	100																11.46	
774	20.1	270+00 S. Bag	5.5'-6.5'		18	18	25	40	52	58	69	75	82	92	97	99	99	100														9.22	
775	20.2	" S. Bag	10.5'-11.5'		19	19	26	45	58	63	72	77	85	93	97	98	98	100														10.41	
776	21.1	255+00 S. Bag	5.5'-6.5'		19	19	27	44	58	65	76	82	87	95	99	100						25	8	CL								11.36	
777	21.2	" S. Bag	10.5'-11.5'		19	19	23	38	47	52	61	69	79	93	98	99	100															10.78	
778	22.1	253+57.5 S. Bag	6.5'-7.0'		22	26	36	52	68	74	81	84	87	96	99	100						26	9	CL								13.28	
779	22.2	" S. Bag	10.0'-10.5'		20	20	26	41	53	59	68	74	83	93	99	100																11.26	
780	22.3	" S. Bag	11.4'-11.6'		14	14	22	32	41	45	53	59	71	90	98	100																12.59	
781	22.4	" S. Bag	15.0'-15.5'		21	22	30	46	60	67	76	82	87	94	99	100																12.02	
782	22.5	" S. Bag	17.6'-18.0'		23	24	30	43	52	57	66	71	78	89	96	99	100															14.15	
783	22.6	" S. Bag	19.5'-22.5'		16	18	24	35	46	52	61	68	77	91	97	98	99	100														10.00	
784	22.7	" S. Bag	24.5'-25.7'		9	9	12	18	22	24	32	39	52	68	83	90	93	98	100													5.18	
785	22.8	" S. Bag	29.5'-30.5'		19	25	37	53	69	76	83	86	91	97	100							39	12	ML								13.19	

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#80 0.177	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γd pcf	Wo %	Undisturbed Sample Data: γd g/cc	Wo %	Gs	Special Tests				
85W		Vineyard Watershed																																					
786	22.9	253+57.5	S. Bag	34.5'-35.5'		14	18	28	45	57	63	73	78	85	89	93	96	98	98	100													9.81						
787	22.11	"	S. Bag	41.0'-42.0'		12	13	16	23	29	32	39	45	55	71	91	97	99	100														6.42						
788	22.12	"	S. Bag	43.0'-44.0'		5	17	24	41	54	59	68	74	82	91	97	99	100															8.45						
789	22.13	"	S. Bag	45.5'-46.5'		10	10	13	21	27	31	39	45	52	68	89	96	98	100														6.28						
790	22.14	"	S. Bag	49.5'-50.5'		15	18	24	35	46	51	61	69	80	91	97	99	100															9.04						
791	24.1	250+00	S. Bag	5.5'-6.5'		27	29	37	50	63	67	75	80	86	95	99	100						32	16	CL								9.27						
792	24.2	"	S. Bag	7.0'-7.5'		17	19	26	39	49	54	64	71	79	87	94	97	97	100														7.49						
793	24.3	"	S. Bag	10.5'-11.5'		22	23	25	38	52	59	68	74	81	90	95	97	98	100														11.71						
794	25.1	240+00	S. Bag	5.5'-6.5'		14	14	17	29	39	44	54	61	71	86	95	98	99	100				23	6	SC-SM								6.29						
795	25.2	"	S. Bag	10.5'-11.5'		13	13	17	26	36	41	52	60	71	86	96	99	100															6.71						
796	26.1	235+00	S. Bag	5.5'-6.5'		15	16	20	30	42	48	59	65	73	85	93	95	96	97	100			24	9	SC								6.07						
797	26.2	"	S. Bag	10.5'-11.5'		15	17	20	34	46	52	61	68	76	89	96	98	98	99	100													7.22						
798	27.1	230+00	S. Bag	5.5'-6.5'		19	19	24	39	54	60	71	75	83	94	99	100						24	7	CL-ML								9.18						
799	27.2	"	S. Bag	7.0'-7.5'		16	17	23	34	46	51	61	66	72	78	85	90	92	94	94	100												8.64						
800	27.3	"	S. Bag	10.5'-11.5'		19	19	24	38	52	59	70	75	83	94	99	100																9.45						

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85W Vineyard Watershed

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.007	0.015	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
801	28.1	225+00	S. Bag	5.5'-6.5'		19	19	24	39	54	60	71	76	83	94	98	99	100															8.62		
802	28.2	"	S. Bag	10.5'-11.5'		20	21	26	41	56	63	74	80	86	94	98	98	98	100														10.99		
803	29.2	220+00	S. Bag	5.5'-6.5'		20	20	24	38	54	60	72	77	85	93	98	99	100					28	12	CL								9.10		
804	29.4	"	S. Bag	10.5'-11.5'		20	20	24	39	54	61	72	78	86	94	99	100																10.48		
805	30.1	215+00	S. Bag	5.5'-6.5'		20	20	24	36	49	56	67	73	82	93	98	99	100															8.83		
806	30.2	"	S. Bag	10.5'-11.5'		20	20	29	47	51	56	66	72	80	91	97	98	99	100														10.18		
807	31.1	205+00	S. Bag	5.5'-6.5'		17	18	25	40	49	56	67	74	81	92	97	98	98	100				24	9	SC								8.32		
808	31.2	"	S. Bag	10.5'-11.5'		23	25	34	51	61	68	79	83	90	97	100																	11.42		
809	32.1	200+00	S. Bag	5.5'-6.5'		23	25	35	50	62	67	77	82	87	95	99	100						26	11	CL								10.33		
810	32.2	"	S. Bag	10.5'-11.5'		21	24	32	46	60	65	76	82	88	96	99	99	100															11.51		
811	33.1	195+00	S. Bag	5.5'-6.5'		24	26	37	52	69	76	86	91	96	100																		11.31		
812	33.2	"	S. Bag	10.5'-11.5'		28	32	45	64	79	84	91	94	97	100								30	13	CL								13.88		
813	34.1	190+00	S. Bag	5.5'-6.5'		15	16	22	37	46	51	58	64	71	82	92	96	97	99	100													6.68		
814	34.2	"	S. Bag	10.5'-11.5'		19	20	29	45	59	63	71	75	81	92	97	98	98	100														9.72		
815	35.1	185+00	S. Bag	5.5'-6.5'		11	11	20	30	41	45	52	58	66	80	90	94	95	97	100			22	5	SC-SM								5.46		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines					Sand						Gravel						Atterberg Limits		Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified			Undisturbed Sample Data		G_s	Special Tests				
85W		Vineyard Watershed				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	LL	PI				Compactive Effort	Max. γ_d pcf	w_o %	γ_d g/cc	w_o %						
816	35.2	185+00	S. Bag	10.5'-11.5'		14	14	21	33	45	50	59	64	71	85	93	96	98	100														5.00					
817	36.1	180+00	S. Bag	5.5'-6.5'		9	9	17	26	38	44	55	61	70	83	94	98	99	100				20	2	SM								5.19					
818	36.2	"	S. Bag	10.5'-11.5'		16	16	23	37	51	57	68	74	82	91	97	98	98	99	100													7.15					
819	37.1	125+00	S. Bag	5.5'-6.5'		27	28	37	48	63	68	78	83	88	95	98	99	100					32	15	CL								11.63					
820	37.2	"	S. Bag	10.5'-11.5'		22	23	29	41	52	57	70	76	84	94	98	99	100															10.58					
821	38.1	130+00	S. Bag	5.5'-6.5'		25	27	37	51	63	70	80	84	89	96	99	100						29	12	CL								10.25					
822	38.2	"	S. Bag	10.5'-11.5'		25	27	37	51	64	70	80	84	90	96	98	99	100															12.05					
823	38.3	"	S. Bag	14.5'-15.5'		26	29	41	56	71	77	86	90	95	100																		12.83					
824	39.1	135+00	S. Bag	5.6'-6.5'		25	28	43	61	76	82	90	93	97	100																		10.71					
825	39.2	"	S. Bag	10.5'-11.5'		22	25	33	49	64	70	80	84	90	96	99	100																11.20					
826	40.1	140+00	S. Bag	5.5'-6.5'		18	19	26	44	59	65	72	76	81	94	98	99	99	99	100			26	8	CL								11.01					
827	40.2	"	S. Bag	10.5'-11.5'		21	24	33	52	65	79	88	92	96	100																		10.82					
828	41.1	145+00	S. Bag	5.5'-6.5		15	18	23	39	54	60	71	77	84	94	98	99	99	100				23	5	CL-ML								7.64					
829	41.2	"	S. Bag	10.5'-11.5'		19	20	30	45	63	70	82	87	92	96	98	100																9.63					
830	42.1	150+00	S. Bag	5.5'-6.5'		21	22	31	46	61	67	78	83	90	97	99	99	99	100														9.54					

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.005 mm	0.005	0.02	0.05	0.074 mm	Sand: 0.149 mm	0.250	0.42	0.59	0.84	1.19	2.38	Gravel: 3/8"	1/2"	3/4"	1"	1 1/2"	2"	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Compaction	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd g/cm³	%	Gs	Special Tests				
85W		Vineyard Watershed																																					
831	43.2	210+00 ℄	S. Bag	5.5'-6.5'		20	21	27	41	56	65	77	83	89	96	99	100							26	8	CL								9.55					
832	43.3	210+00 U/S	S. Bag	8.0'-10.0'		21	21	27	39	55	61	72	78	85	96	99	100																	12.20					
833	43.5	210+00 ℄	S. Bag	12.0'-13.5'		19	19	24	38	51	60	71	77	85	93	96	97	97	98	100														9.84					
834	43.7	"	S. Bag	15.5'-16.5'		23	24	30	43	60	65	74	79	85	96	99	100																	12.70					
835	43.8	"	S. Bag	18.0'-19.0'		21	22	29	44	60	67	76	81	86	95	99	100																	12.22					
836	43.9	"	S. Bag	19.5'-20.5'		14	14	19	31	47	54	66	72	79	93	98	99	100																9.14					
837	43.10	"	S. Bag	21.0'-22.5'		17	18	20	33	50	58	70	76	85	93	98	100																	7.93					
838	43.11	"	S. Bag	24.5'-25.5'		16	17	18	31	43	49	62	69	78	88	97	100																	7.46					
839	43.12	"	S. Bag	25.5'-26.5'		14	15	18	26	34	38	47	53	61	73	87	95	98	100					32	9	SC								9.15					
840	43.13	"	S. Bag	26.5'-29.0'		6	6	10	10	11	11	15	23	41	70	91	95	97	98	100														3.69					
841	43.14	"	S. Bag	29.0'-30.5'		22	22	26	32	42	45	50	52	56	66	80	88	91	96	96	100													13.75					
842	43.15	"	S. Bag	31.0'-32.0'		20	25	34	51	66	72	80	84	88	93	97	100																	10.71					
843	43.16	"	S. Bag	34'-35'		18	25	36	52	67	74	83	86	89	92	96	99	100																12.84					
844	43.17	"	S. Bag	35.5'-38'		19	26	39	61	79	87	95	97	99	100									42	11	ML								12.75					
845	43.18	"	S. Bag	38.0'-40.0'		18	20	25	39	51	64	78	85	90	94	97	99	100																6.69					

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																															
846	43.19	210+00 ℄ S. Bag	40.5'-42.5'		19	21	29	42	54	60	73	79	86	94	99	100																7.35	
847	43.20	" S. Bag	42.5'-45.0'		18	23	27	36	44	49	63	70	77	88	98	100																5.45	
848	43.21	" S. Bag	45.5'-47.0'		24	28	40	63	74	80	90	94	98	100																		9.65	
849	43.22	" S. Bag	51.0'-53.0'		15	15	18	25	28	31	38	45	54	66	85	93	96	98	100													5.07	
850	43.23	" S. Bag	55.0'-55.5'		20	26	37	60	72	76	83	87	93	100																		6.58	
851	44.1	210+00 U/S S. Bag	1.0'-4.0'		22	24	29	42	54	59	70	77	86	94	98	99	99	100				27	13	CL								13.32	
852	44.2	" S. Bag	4.5'-5.5'		18	20	25	42	63	74	90	95	98	100																		14.23	
853	44A.3	" S. Bag	5.5'-8.0'		24	27	33	50	67	73	82	87	93	100																		12.93	
854	44.3	" S. Bag	5.5'-10.5'		20	24	29	46	59	66	78	84	88	93	97	99	99	100														19.21	
855	44.4	" S. Bag	10.5'-12.5'		13	15	21	34	47	55	69	77	86	93	98	99	100															18.69	
856	44.5	" S. Bag	12.5'-15.5'		13	14	16	19	22	25	35	41	53	69	87	94	96	99	100													8.93	
857	44.7	" S. Bag	15.5'-18.0'		8	8	9	14	15	18	29	41	56	67	82	89	93	96	98	100												5.66	
858	44.8	" S. Bag	18.0'-20.5'		22	27	37	57	75	81	89	92	96	100								39	17	CL								18.01	
859	44.9	" S. Bag	20.5'-23.0'		17	22	33	55	71	79	89	93	97	100																		21.65	
860	44.10	" S. Bag	23.0'-24.0'		11	13	18	24	29	32	40	44	50	60	75	87	91	96	98	100												10.66	

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #100 0.149 mm	#200 0.074 mm	0.005 mm	0.002 mm	0.001 mm	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d p.c.f.	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																
861	44.11	210+00 U/S	S. Bag	24.0'-25.5'		26	31	42	60	76	83	91	94	97	100																			19.6
862	44.12	"	S. Bag	25.5'-28.0'		19	25	33	42	51	55	65	70	77	89	96	99	100																12.97
863	44.13	"	S. Bag	28.0'-30.5'		15	19	23	30	36	39	48	55	62	73	86	91	92	94	95	100													12.71
864	44.14	"	S. Bag	30.5'-31.5'		37	43	56	73	81	85	91	94	98	100																			22.56
865	44.15	"	S. Bag	32.0'-35.5'		17	22	36	58	74	81	90	94	97	100																			21.85
866	44.16	"	S. Bag	38.0'-40.5'		18	23	35	57	71	77	86	91	96	100																			17.78
867	45.1	210+00	S. Bag	0-1.5'		17	19	24	36	48	56	67	73	83	94	98	99	99	100															9.30
868	45.2	"	S. Bag	1.5'-5.0'		28	32	38	54	73	79	87	91	97	100								32	17	CL									9.0
869	45.3	"	S. Bag	5.5'-7.5'		9	11	12	26	40	50	64	74	94	92	98	99	99	100				20	2	SM									3.13
870	45.4	"	S. Bag	10.5'-12.5'		8	10	10	14	18	19	24	28	37	51	65	72	76	85	89	89	100												3.49
871	45.5	"	S. Bag	12.5'-14.5'		11	12	12	19	24	26	33	40	48	62	77	85	87	91	94	100													3.39
872	45.6	"	S. Bag	15.5'-17.5'		17	19	23	35	52	59	73	78	85	92	97	99	99	100															6.52
873	45.7	"	S. Bag	20.5'-22.5'		17	22	28	42	57	64	74	77	82	91	98	99	100					36	12	CL									8.34
874	45.8	"	S. Bag	25.5'-27.5'		7	8	8	12	15	16	21	26	33	44	56	67	77	95	96	100													2.47
875	45.9	"	S. Bag	28.5'-30.5'		38	47	56	70	78	82	90	94	98	100								58	29										15.79

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#50 0.297	#40 0.42	#30 0.59	#16 1.19	#8 2.38	#4 4.76	Gravel: 3/8" 9.52	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd pcf	Wn %	Gs	Special Tests				
85W		Vineyard Watershed																																					
876	45.10	210+00	S. Bag	35.5'-38.0'		9	11	12	16	18	20	24	27	34	47	63	73	77	83	88	100												4.21					
877	45.11	"	S. Bag	38.5'-40.5'		12	14	18	27	37	40	44	49	55	66	78	84	94	94	94	100												7.65					
878	46.1	175+00 ℄	S. Bag	5.5'-8.0'		14	18	21	36	54	61	73	80	87	94	98	99	99	100					22	5	CL-ML							5.62					
879	46.2	"	S. Bag	10.5'-12.0'		9	11	12	25	35	41	51	57	65	77	87	91	93	97	97	100												4.53					
880	47.1	170+00 ℄	S. Bag	5.5'-7.0'		18	20	26	42	58	65	76	82	87	94	98	99	99	100														11.92					
881	47.2	"	S. Bag	11.5'-13.0'		10	13	16	28	41	46	57	63	71	86	94	96	98	100														6.87					
882	48.1	165+00 ℄	S. Bag	5.5'-7.0'		14	18	24	43	63	70	82	86	91	96	99	100																9.21					
883	48.2	"	S. Bag	10.5'-12.0'		11	13	17	31	45	53	65	72	80	89	95	98	99	99	100													5.68					
884	49.1	160+00	S. Bag	5.5'-7.0'		13	14	18	34	47	55	68	75	82	92	97	99	99	99	100													5.43					
885	49.2	"	S. Bag	11.0'-12.0'		17	20	25	45	62	70	81	86	90	94	98	100																10.31					
886	50.1	155+00	S. Bag	5.5'-7.0'		19	20	33	55	71	78	88	92	97	100									26	9	CL							10.60					
887	50.2	"	S. Bag	11.0'-12.0'		13	14	30	41	54	61	74	81	87	94	98	99	100															7.85					
888	51.1	120+00	S. Bag	6.0'-7.5'		21	22	29	42	53	60	71	78	86	95	99	100							29	14	CL							10.21					
889	51.2	"	S. Bag	11.0'-12.5'		23	24	33	45	59	66	77	83	88	95	99	100																8.30					
890	52.1	115+00 ℄	S. Bag	6.0'-7.5'		22	25	31	46	57	64	78	86	94	100									28	13	CL							9.30					

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 1/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
891	52.2	115+00 ℄	S. Bag	11.0'-12.0'		26	28	37	49	64	72	85	91	96	100																		13.23		
892	53.1	109+70 ℄	S. Bag	2.5'-3.5'		22	25	33	49	63	71	84	90	96	100								28	12	CL								12.43		
893	53.2	"	S. Bag	4.5'-5.0'		18	19	29	45	60	67	80	86	90	95	98	99	99	100														10.47		
894	53.3	"	S. Bag	9.0'-10.5'		15	15	20	32	44	51	66	74	83	91	97	99	99	100														15.0		
895	53.4	"	S. Bag	6.0'-7.0'		22	23	30	43	59	66	79	85	90	96	99	100																18.97		
896	53.5	"	S. Bag	14.5'-15.5'		24	25	32	47	58	65	78	84	92	100																		12.22		
897	53.6	"	S. Bag	11.0'-12.0'		22	24	33	47	63	72	84	90	96	100																		13.51		
898	53.7	"	S. Bag	18.0'-19.0'		24	26	32	46	60	67	78	84	89	95	98	100																14.76		
899	53.8	"	S. Bag	19.0'-20.0'		21	22	29	44	62	70	81	86	90	94	96	98	99	100														12.75		
900	53.9	"	S. Bag	21.0'-22.5'		22	23	31	47	64	72	87	92	97	100																		13.86		
901	53.10	109+70 ℄	S. Bag	23.0'-24.0'		25	31	44	58	70	81	89	93	97	100								39	17	CL								18.35		
902	54.1	107+60 ℄	S. Bag	4.0'-5.0'		25	26	33	46	61	68	82	88	95	100								30	14	CL								9.40		
903	54.2	"	S. Bag	6.0		21	25	33	51	65	77	87	91	96	100																		10.06		
904	54.3	"	S. Bag	16.0'-16.5'		19	20	28	45	61	68	81	87	94	100																		10.74		
905	54.4	"	S. Bag	19.5'-20.0'		19	20	27	39	53	60	73	80	87	96	99	99	99	100				28	11	CL								12.41		

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 1/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																															
906	54.5	107+60 ℄ S. Bag	24.0'-24.5'		21	29	40	53	64	68	77	80	86	90	94	96	97	98	100													13.49	
907	54.6	" S. Bag	25.5'-28.0'		6	7	9	14	17	20	27	34	42	50	60	68	74	78	86	88	100											4.73	
908	54.7	" S. Bag	28.0'-30.5'		6	6	7	10	10	11	16	23	36	49	63	73	78	88	93	96	100											5.83	
909	54.8	" S. Bag	30.5'-31.5'		13	14	15	20	29	33	44	53	62	73	85	90	94	96	100													6.38	
910	54.9	" S. Bag	33.0'-35.5'		6	7	9	12	14	15	19	24	33	51	75	86	91	96	98	100												5.36	
911	54.10	" S. Bag	35.5'-36.5'		9	9	10	14	16	18	22	27	37	55	74	83	88	94	97	100												6.34	
912	54.11	" S. Bag	36.5'-37.0'		22	23	29	50	65	79	90	93	97	100																		15.51	
913	54.12	" S. Bag	38.0'-39.0'		19	23	29	44	60	67	76	81	86	93	97	99	99	100														17.38	
914	54.13	" S. Bag	42.5'-43.5'		15	15	16	21	24	26	35	45	61	74	87	91	93	95	100													8.06	
915	54.14	" S. Bag	46.0'-47.0'		7	7	8	12	14	16	21	25	35	54	76	87	91	98	100													7.04	
916	54.15	" S. Bag	51.0'-52.0'		5	5	6	7	9	10	16	23	34	49	72	85	90	97	100													4.43	
917	54.16	" S. Bag	54.5'-55.5'		9	9	12	18	26	30	39	46	53	62	70	76	79	86	88	100												9.73	
918	55.1	107+80 U/S S. Bag	0.5'-1.5'		13	14	19	31	45	54	73	82	92	100								19	2	SM								14.67	
919	55.2	" S. Bag	4.0'-5.0'		34	35	41	57	70	82	89	93	97	100								37	18	CL								16.16	
920	55.3	" S. Bag	9.0'-9.5'		11	11	13	19	24	27	34	42	54	67	83	90	94	98	100													18.16	

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Class-ification	Mechanical Analysis: Coarse Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2	Atterberg Limits: L.L.	P.I.	Unified Class-ification	Soluble Salts %	Des-Moisture %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd g/cc	Wn %	Gs	Special Tests
85W		Vineyard Watershed																																	
921	55.4	107+80 U/S	S. Bag	14.0'-15.5'		5	6	7	10	12	13	19	25	32	39	50	58	64	70	80	100													7.44	
922	55.5	"	S. Bag	19.0'-20.0'		23	23	26	39	51	57	70	77	87	98	98	99	100																18.75	
923	55.6	"	S. Bag	23.0'-24.0'		16	18	26	41	61	68	77	81	86	91	94	96	96	96	96	100													21.97	
924	55.8	"	S. Bag	28.5'-29.5'		23	24	31	43	52	54	61	69	79	89	97	99	100																20.21	
925	55.9	"	S. Bag	31.0'-32.0'		5	6	7	10	11	12	16	22	32	54	77	88	92	95	100														7.38	
926	55.10	"	S. Bag	36.0'-37.0'		14	15	25	44	57	64	80	87	93	100																			19.25	
927	55.11	"	S. Bag	39.0'-40.0'		4	4	6	11	11	13	22	32	45	62	81	88	90	96	100														5.57	
928	55.12	"	S. Bag	44.0'-45.0'		12	14	26	54	71	77	86	91	96	100																			21.86	
929	55.13	"	S. Bag	48.0'-50.0'		4	4	5	9	9	10	17	27	42	52	71	87	92	99	100														6.67	
930	56.1	82+00 ℄	S. Bag	0.5'-1.5'		29	30	36	49	61	68	81	87	94	100							33	15	CL										11.47	
931	56.2	"	S. Bag	4.0'-5.0'		21	21	27	38	52	60	73	79	87	93	97	98	99	100			29	12	CL										11.99	
932	57.1	90+00 ℄	S. Bag	1.0'-1.5'		19	19	23	35	47	54	68	75	85	93	98	100																	10.79	
933	57.2	"	S. Bag	4.5'-5.0'		21	21	24	37	50	57	71	78	87	94	98	99	99	100															7.99	
934	57.3	"	S. Bag	6.5'-7.0'		20	20	24	35	47	52	63	70	79	88	95	97	98	100															9.04	
935	57.4	"	S. Bag	9.5'-10.0'		18	19	24	35	48	56	71	78	86	96	99	100																	10.48	

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074	#325 0.044	Sand: #10 2.0	#4 4.76	Gravel: 3/8" 9.52	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd g/cc	%	Gs	Special Tests
85W		Vineyard																									
936	57.5	90+00 ℄	S. Bag	11.0'-12.0'		19	19	24	37	50	57	72	79	87	96	99	100										10.58
937	57.6	"	S. Bag	14.5'-15.5'		18	19	24	36	48	56	71	80	88	96	98	99	99	100		32	12	SC				10.24
938	57.7	"	S. Bag	16.0'-17.0'		6	7	9	15	20	23	31	37	43	49	59	68	73	81	87	100						5.10
939	58.1	95+00 ℄	S. Bag	3.5'-4.5'		23	23	29	42	58	65	78	84	91	96	98	99	100									8.47
940	58.2	"	S. Bag	9.5'-10.5'		17	18	21	33	48	54	69	76	86	92	96	98	99	100								7.55
941	59.1	100+00	S. Bag	4.5'-5.5'		23	24	30	42	55	63	77	83	91	97	99	100				31	15	CL				12.99
942	59.2	"	S. Bag	9.5'-10.5'		23	24	29	40	55	62	76	83	90	96	99	100										14.03
943	60.1	107+60 D/S	S. Bag	3.0'-4.0'		23	25	29	41	52	59	74	83	92	97	100					29	14	CL				10.36
944	60.3	"	S. Bag	5.5'-7.0'		14	16	21	28	35	38	45	50	56	61	68	73	75	80	86	94	100	38	16	SC		5.46
945	60.4	"	S. Bag	10.5'-11.5'		5	5	5	9	12	13	20	26	34	42	57	69	76	83	90	100						3.42
946	60.5	"	S. Bag	14.0'-15.0'		6	6	8	12	16	17	21	24	27	31	39	46	52	62	67	82	100					3.26
947	60.6	"	S. Bag	15.5'-16.0'		12	12	13	17	22	23	29	36	50	70	82	88	91	92	92	100						5.62
948	60.7	"	S. Bag	20.0'-20.5'		25	26	31	48	72	81	90	93	97	100												9.07
949	60.9	"	S. Bag	26.0'-27.0'		13	15	20	31	43	49	58	64	69	73	76	78	80	84	84	84	100					6.86
950	60.10	"	S. Bag	28.0'-30.5'		12	15	17	22	30	33	39	45	53	68	88	94	97	99	100							4.59

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SOIL MECHANICS LABORATORY DATA
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03-12-85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γd pcf	% %	Undisturbed Sample Data: γd g/cm³	% %	Gs	Special Tests				
85W		Vineyard Watershed																																				
951	60.11	107+60 D/S S. Bag	35.0'-36.0'		10	10	11	13	16	17	23	30	45	56	66	73	77	81	83	100												3.85						
952	60.12	" S. Bag	37.0'-37.5'		26	28	33	46	60	64	76	84	92	100																		11.59						
953	60.13	" S. Bag	37.5'-38.0'		7	7	9	12	16	18	23	26	30	35	43	51	58	67	70	73	100											4.16						
954	60.14	" S. Bag	38.0'-39.0'		5	5	6	11	14	16	22	29	35	42	52	61	67	73	76	90	100											3.59						
955	60.15	" S. Bag	48.5'-50.0'		11	11	11	15	19	20	23	28	40	60	80	88	92	95	98	100												5.49						
956	60.16	" S. Bag	52.5'-53.0'		16	20	31	56	73	85	91	94	97	100																		6.81						
957	60.17	" S. Bag	41.0'-42.0'		12	18	30	52	72	79	90	95	98	100																		6.81						
958	61.1	253+75 D/S S. Bag	0.0-1.0'		23	26	37	58	74	82	89	92	96	100								31	13	CL								11.69						
959	61.2	" S. Bag	3.0'-4.0'		18	19	24	36	51	58	69	77	86	96	99	100						24	8	CL								5.20						
960	61.3	" S. Bag	6.0'-8.0'		10	11	12	22	33	37	47	55	67	81	90	93	94	95	98	100		21	3	SM								3.51						
961	61.4	" S. Bag	14.0'-15.0'		9	10	12	16	23	25	30	34	42	53	68	78	82	91	96	100												4.45						
962	61.6	" S. Bag	23.0'-24.0'		17	21	30	48	64	71	82	86	92	96	99	100																8.78						
963	61.8	" S. Bag	26.0'-27.0'		6	6	6	11	13	15	22	30	40	50	69	82	88	96	98	100												3.31						
964	61.9	" S. Bag	29.0'-30.0'		15	17	20	26	35	38	48	56	66	79	92	96	97	99	99	100												5.37						
965	61.10	" S. Bag	31.0'-32.0'		4	4	4	7	9	11	16	25	39	50	67	75	79	86	91	91	100											3.00						

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SOIL MECHANICS LABORATORY DATA
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03-12-85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#50 0.297	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests: Wn %				
85W		Vineyard Watershed																																					
966	61.13	253+75 D/S	S. Bag	35.5'-36.5'		9	9	13	23	24	27	39	49	62	76	88	92	94	100																3.76				
967	61.14	"	S. Bag	37.0'-38.0'		5	5	7	10	13	15	25	34	45	55	71	78	80	84	89	100														3.03				
968	61.15	"	S. Bag	39.0'-40.0'		9	9	11	14	15	18	35	59	87	100																				4.15				
969	61.18	"	S. Bag	50.0'-50.5'		9	18	44	75	93	97	99	100																						9.42				
970	62.1	300+00 D/S	S. Bag	4.0'-5.0'		20	21	23	38	49	56	68	74	84	93	98	100						26	10	SC										5.50				
971	62.2	"	S. Bag	5.5'-6.5'		5	5	7	14	20	23	32	39	46	55	67	74	77	82	85	88	100													2.88				
972	62.4	"	S. Bag	17.5'-18.5'		19	21	31	58	77	84	91	94	97	100								34	15	CL										8.25				
973	62.5	"	S. Bag	23.5'-24.5'		14	18	26	53	70	86	96	98	99	100																				7.13				
974	62.6	"	S. Bag	28.0'-29.0'		15	16	21	40	55	63	75	82	87	92	95	97	98	100																8.41				
975	54	107+60 ℄	Undist	0.5'-1.0'		20	22	24	38	55	61	74	81	88	96	99	100						27	10	CL							1.93	10.7						
976	54	"	Undist	1.0'-1.5'		22	23	28	41	55	62	79	86	93	100																	1.92	8.37						
977	54	"	Undist	3.5'-4.0'		31	33	40	55	76	83	92	96	99	100								33	15	CL							1.83	9.91						

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SOIL MECHANICS LABORATORY DATA
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03-12-85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	Fines: 0.005	Fines: 0.02	Fines: 0.05	Fines: #200 0.074	Sand: #100 0.149	Sand: #80 0.177	Sand: #60 0.250	Sand: #40 0.42	Sand: #20 0.84	Sand: #10 2.0	Sand: #4 4.76	Gravel: 3/8" 9.525	Gravel: 1/2" 12.7	Gravel: 3/4" 19.05	Gravel: 1" 25.4	Gravel: 1 1/2" 38.1	Gravel: 3" 76.2	Atterberg Limits: L.L.	Atterberg Limits: P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd g/cm³	Wn %	Gs	Special Tests				
85W		Vineyard Watershed																																					
978	54	107+60 ℄	Undist	8.5'-10.5'		25	25	30	42	58	65	79	85	90	96	98		99	99	100				30	14	CL						1.91	9.67						
979A	54	"	Undist	11.5'-13.0'		18	19	24	38	54	61	75	82	89	96	98		99	99	100												1.70	9.15						
979B	54	"	Undist	11.5'-13.0'		20	21	25	40	57	65	80	87	95	100																	1.72	13.8						
980	54	"	Undist	23.0'-23.5'		22	26	33	48	64	70	78	83	87	92	95		96	96	96	100											1.54	12.1						
981	54	"	Undist	24.5'-25.0'		24	34	44	56	69	74	80	83	87	91	94		97	97	100												1.83	14.7						
982	54	"	Undist	32.0'-33.0'		10	10	10	13	19	21	30	44	59	74	87		93	95	97	100											1.65	8.05						
983	54	"	Undist	37.0'-38.0'		24	25	31	49	65	79	90	94	98	100									36	17	CL						1.64	16.5						
984	54	"	Undist	39.0'-40.0'		20	24	29	44	63	70	80	85	89	94	98		99	99	100												1.52	15.4						

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SOIL MECHANICS LABORATORY DATA
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03-12-85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074 mm	#100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Sand: #40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Compact. Wt.	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd g/cc	%	Gs	Special Tests				
85W		Vineyard Watershed																																					
985	54	107+60 ℄	Undist	52.0'-52.8'		24	25	30	42	56	59	69	76	84	91	95	98	99	100													1.69	13.8						
986	54	"	Undist	52.8'-53.3'		10	10	11	17	21	24	31	36	41	50	59	67	73	89	90	100											1.86	10.8						
987	60	107+60 D/S	Undist	4.0'-5.5'		32	33	41	59	81	87	94	96	99	100								37	20	CL							1.53	11.3						
988A	60	"	Undist	22.0'-23.0'		19	23	30	44	57	67	74	78	84	90	95	98	100														1.56	7.07						
988B	60	"	Undist	22.0'-23.0'		17	17	18	34	53	60	70	74	82	93	98	100															1.64	4.76						
989	60	"	Undist	27.0'-27.5'		22	28	34	45	59	63	72	78	86	90	95	98	99	100				43	13	ML							1.51	21.5						
990	60	"	Undist	39.5'-40.5'		18	18	22	37	53	58	71	78	87	94	98	99	100														1.55	7.56						
991	61.5	253+75 D/S	Undist	18.0'-20.0'		20	27	43	65	83	87	93	96	99	100																	1.54	12.1						

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SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
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03-12-85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines 0.005 mm	Fines 0.005	Fines 0.02	Fines 0.05	Fines #200 0.074	Sand #140 0.105	Sand #60 0.250	Sand #40 0.42	Sand #20 0.84	Sand #10 2.0	Sand #4 4.76	Gravel 3/8" 9.525	Gravel 1/2" 12.7	Gravel 3/4" 19.05	Gravel 1" 25.4	Gravel 1 1/2" 38.1	Gravel 3" 76.2	Atterberg Limits LL	Atterberg Limits PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (☐ Standard ☐ Modified) Curve No.	Max γ_d pcf	w_o %	Undisturbed Sample Data γ_d g/cc	Undisturbed Sample Data w_o %	G_s	Special Tests
85W		Vineyard Watershed																																
992	61.7	253+75 D/S	Undist	22.0'-23.0'		18	23	29	46	62	69	79	84	89	94	98	99	100														1.58	8.61	
993	61.11	"	Undist	33.0'-34.0'		17	18	22	33	45	49	60	69	79	88	95	97	98	98	100			32	12	SC							1.75	6.93	
994	61.16	"	Undist	42.0'-42.5'		14	16	19	26	36	39	46	52	59	69	84	92	92	94	96	100											1.92	5.66	
995	61.17	"	Undist	44.5'-45.0'		8	8	8	12	14	16	21	27	36	50	75	88	91	97	100												1.93	4.32	
996	61.19	"	Undist	49.0'-50		16	25	43	71	90	94	97	98	99	100																	1.51	10.9	
997	62.3	300+00 D/S	Undist	12.0'-13.0'		20	27	34	49	66	72	82	86	91	95	98	100															1.69	8.42	

Payne

United States Department of Agriculture

Soil Conservation Service

Midwest National Technical Center
Soil Mechanics Laboratory
512 South 7th Street
Lincoln, NE 68508-2919

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Vineyard Road FRS Study
Re: March 29, 1985, SML Report on 274 Samples
Received from the Subject Site on 3/12/85

Date: April 26, 1985

To: Ralph M. Arrington
State Conservation Engineer
SCS, Phoenix, AZ

File Code: 210-22

The gradation data and moisture content data for 66 samples received on March 25, 1985, and for 8 samples received April 8, 1985, from the subject site are recorded on the attached forms SCS-ENG-354.

Lorn P. Dunnigan

LORN P. DUNNIGAN
Head, Soil Mechanics Laboratory

Attachments:
Form SCS-ENG-354, Soil Mechanics Laboratory Data, 7 sheets

cc:
Ralph M. Arrington (Original + 3 copies)
Jack C. Stevenson, Head, Engineering Staff, WNTC, SCS, Portland, OR (ltr only)
Clifton E. Deal, Soil Mechanics Engineer, Engineering Staff, WNTC, SCS, Portland, OR

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SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 1 of 6

3/25/85

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.005 mm	0.005	0.01	0.05	#200 0.074	Sand: #100 0.149	#80 0.177	#60 0.25	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	2" 50.8	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dis-persion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
1009	62.7	300+00, P/S Toe Dam S. Bag	33.0-34.0		18	23	38	63	76	83	92	96	99	100																		10.01			
1010	62.8	" " " " S. Bag	38.0-39.0		5	5	7	11	13	15	20	24	30	37	52	67	76	88	97	100												2.79			
1011	62.9	" " " " S. Bag	43.0-44.0		2	2	3	3	4	5	6	7	14	31	45	57	64	75	85	95	100											7.65			
1012	63.1	100' U/S from Toe @ 300+00 S. Bag	2.0-3.0		12	12	16	28	40	47	60	68	78	88	94	96	97	99	100													5.55			
1013	63.2	" " " " " " S. Bag	7.0-8.0		18	18	23	33	50	56	68	74	81	90	95	98	99	100														7.08			
1014	63.3	" " " " " " S. Bag	14.0-15.0		23	30	42	58	70	74	81	84	88	93	98	99	100															8.34			
1015	63.4	" " " " " " S. Bag	19.0-20.0		20	25	35	53	64	70	79	84	88	93	97	100																7.04			
1016	63.5	" " " " " " S. Bag	21.5-22.5		17	17	19	31	40	45	60	73	84	92	98	100																5.91			
1017	63.6	" " " " " " S. Bag	22.5-23.5		3	3	4	6	6	6	10	17	30	55	79	91	96	100														7.43			
1018	63.7	" " " " " " S. Bag	24.5-25.5		22	24	30	46	65	74	88	92	96	99	100																	7.11			
1019	63.8	" " " " " " S. Bag	27.0-28.0		13	16	20	27	33	36	43	48	55	68	83	91	95	98	100													8.71			
1020	63.9	" " " " " " S. Bag	28.0-29.0		17	19	23	37	51	58	71	78	87	93	97	99	99	100														7.02			
1021	63.10	" " " " " " S. Bag	34.0-35.0		23	29	39	54	68	73	80	84	88	95	99	100																11.86			
1022	63.11	" " " " " " S. Bag	37.0-38.0		14	22	37	61	77	81	86	90	94	96	98	99	100															7.32			
1023	63.12	" " " " " " S. Bag	41.0-43.0		9	11	16	22	27	28	31	37	44	47	58	68	72	79	90	100												3.73			

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
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3/25/85

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074	#140 0.105	#80 0.177	#60 0.250	#40 0.42	#30 0.59	#20 0.84	#16 1.19	#8 2.38	#4 4.76	Sand: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	2" 50.8	Gravel: 3" 76.2	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d pcf	w_o %	G_s	Special Tests
85W		Vineyard Watershed																															
1024	63.13	100' U/S from Toe @ 300+00 S. Bag	43.0-44.0		5	5	7	8	9	10	12	14	18	27	41	53	62	78	83	94	100										4.55		
1025	63.14	" " " " " " S. Bag	44.0-45.0		29	34	45	63	77	81	87	90	95	100																	10.96		
1026	64.1	5' U/S 300+00, ℄ Dam S. Bag	1.5-2.0		18	19	29	42	55	62	74	81	87	95	98	99	99	100													9.60		
1027	64.2	" " " " " S. Bag	4.5-5.5		18	18	28	38	49	54	65	73	82	92	97	98	99	100													7.54		
1028	64.3	" " " " " S. Bag	8.0-9.0		25	27	37	52	67	73	81	85	89	96	99	100															12.23		
1029	64.5	" " " " " S. Bag	10.5-11.5		21	24	34	50	64	71	81	85	91	96	99	100															11.72		
1030	64.6	" " " " " S. Bag	14.0-15.0		19	19	28	41	53	58	68	73	79	89	95	98	99	100													8.67		
1031	64.7	" " " " " S. Bag	15.5-16.0		18	19	29	44	59	66	77	83	89	95	98	99	99	100													14.44		
1032	64.8	" " " " " S. Bag	17.0-18.0		18	21	30	45	58	65	75	81	88	95	99	100															11.42		
1033	64.9	" " " " " S. Bag	20.5-21.5		18	18	29	45	59	68	83	88	94	97	99	100															10.29		
1034	64.10	" " " " " S. Bag	23.0-24.0		26	28	37	55	74	80	88	92	96	100																	13.85		
1035	64.11	" " " " " S. Bag	28.0-29.0		23	26	40	56	69	74	81	84	91	97	99	100															12.68		
1036	64.12	" " " " " S. Bag	31.0-32.0		11	13	18	26	33	38	45	50	55	66	82	90	93	95	95	100											7.23		
1037	64.13	" " " " " S. Bag	34.0-34.5		4	4	7	9	11	13	21	28	41	67	80	86	88	93	95	100											4.43		
1038	64.14	" " " " " S. Bag	36.0-38.0		16	17	25	43	62	71	83	89	95	100																	9.83		

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SOIL MECHANICS LABORATORY DATA
Sheet 1 of 1

3/25/85

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.005 mm	0.005	0.02	0.05	0.200 0.074	Sand: 0.100 0.149	0.250 0.590	0.500 0.42	0.710 0.84	0.42 20	0.4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dis-persion %	Relative - Density Relationships: Standard / Modified: Density	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cm	w_o %	G_s	Special Tests				
		ARIZONA																																				
85W	.	Vineyard Watershed																																				
1039	64.15	5' U/S 300+00, ℄ Dam	S. Bag	38.0-39.0		8	8	13	16	19	21	26	33	48	66	82	89	92	98	100												4.90						
1040	64.16	" " " " "	S. Bag	39.0-40.5		24	32	48	67	79	83	90	94	98	100																	15.69						
1041	64.17	" " " " "	S. Bag	42.0-44.0		20	24	34	51	65	70	81	86	90	95	98	99	100														12.11						
1042	64.18	" " " " "	S. Bag	44.0-45.5		21	25	36	58	72	77	84	87	91	96	100																12.87						
1043	64.19	" " " " "	S. Bag	48.0-49.0		25	30	42	58	73	78	85	88	92	96	98	99	100														12.09						
1044	65.1	U/S of Dam @ 253+57	S. Bag	0.0-2.5		17	18	26	41	59	65	76	82	88	96	100																11.74						
1045	65.2	" " " " "	S. Bag	4.5-5.5		14	14	20	41	58	76	91	95	98	100																	11.34						
1046	65.3	" " " " "	S. Bag	7.0-8.0		11	12	16	31	46	53	68	75	81	89	94	96	97	99	100												10.20						
1047	65.4	" " " " "	S. Bag	10.5-14.0		6	7	9	11	12	13	19	27	40	53	72	81	85	92	95	100											5.42						
1048	65.5	" " " " "	S. Bag	14.0-15.5		18	23	28	41	53	59	67	71	77	90	98	100															18.49						
1049	65.6	" " " " "	S. Bag	16.0-18.0		14	17	23	34	42	47	55	61	68	77	88	97	99	100													12.97						
1050	65.7	" " " " "	S. Bag	18.0-20.5		18	25	37	54	67	72	81	86	90	95	98	99	99	100													21.16						
1051	65.8	" " " " "	S. Bag	23.0-25.0		18	24	36	54	64	70	81	85	91	96	99	99	100														20.47						
1052	65.9	" " " " "	S. Bag	26.0-28.0		24	27	34	48	60	64	71	75	78	87	99	100															12.43						
1053	65.10	" " " " "	S. Bag	28.5-30.5		11	13	25	50	66	76	92	96	99	100																	21.99						

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SOIL MECHANICS LABORATORY DATA
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3/25/85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.06	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Compact. No.	Max. γd pcf	Opt. %	Undisturbed Sample Data: γd g/cm³	Wn %	Gs	Special Tests				
85W	.	Vineyard Watershed																																				
1054	65.11	U/S of Dam @ 253+57	S. Bag	31.5-33.0		6	6	8	10	11	13	20	28	38	47	69	82	89	97	100													5.61					
1055	65.12	" " " " "	S. Bag	34.0-35.5		17	19	25	44	59	65	77	84	90	96	100																	18.09					
1056	65.13	" " " " "	S. Bag	36.0-37.0		13	14	17	27	33	36	45	54	66	78	91	95	96	99	100													12.05					
1057	65.14	" " " " "	S. Bag	38.5-39.5		4	4	5	7	8	8	12	16	26	51	86	93	95	96	98	100												4.33					
1058	65.15	" " " " "	S. Bag	39.5-40.5		20	21	28	42	55	60	67	71	78	89	96	99	99	100														16.11					
1059	65.16	" " " " "	S. Bag	42.0-43.0		7	7	19	15	17	18	23	29	44	73	92	97	98	100														11.44					
1060	65.17	" " " " "	S. Bag	44.0-45.0		17	24	36	58	73	78	85	89	93	96	97	98	99	99	100													16.18					
1061	65.18	" " " " "	S. Bag	48.0-50.0		7	10	25	49	66	73	86	92	98	100																		20.73					
1062	65.19	" " " " "	S. Bag	51.0-53.0		5	6	17	46	67	78	94	98	99	100																		23.18					
1063	65.20	" " " " "	S. Bag	53.0-55.5		3	3	5	10	15	17	26	39	54	73	85	92	96	99	100													7.35					
1064	29.1	℄ Dam, 220+00	L. Bag	2.0-4.0		19	21	27	40	56	62	73	78	85	93	98	99	100															9.70					
1065	29.3	" " "	L. Bag	7.0-10.0		22	22	27	40	53	58	67	73	82	91	97	99	100															9.23					

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SOIL MECHANICS LABORATORY DATA
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3/25/85

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.01	0.05	#200 0.074	Sand: #140 0.105	#80 0.177	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	2" 50.8	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture - Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d p.c.f.	w_o %	Specific Gravity γ_s g/cc	w_o %	S_r	Special Tests				
85W	.	Vineyard Watershed																																				
1066	41.2	145+00	L. Bag	7.0-10.0		20	22	31	47	62	69	78	83	88	96	99	100																9.03					
1067	42.2	150+00	L. Bag	7.0-10.0		21	24	30	45	60	66	75	81	88	95	99	100																9.26					
1068	43.1	210+00	L. Bag	0.0-5.0		20	23	27	43	60	68	79	85	93	100																		8.71					
1069	43.4	"	L. Bag	7.0-10.0		19	20	25	39	52	58	69	75	83	91	98	99	99	100														9.04					
1070	43.6	"	L. Bag	15.0-18.0		21	22	29	43	61	68	77	82	87	93	98	100																10.13					
1071	64.4	5' U/S 300+00, ℄ Dam	L. Bag	8.0-12.0		19	19	26	40	53	58	68	73	81	88	95	98	99	100														9.44					

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SOIL MECHANICS LABORATORY DATA
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3/25/85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis Grain Size Distribution Expressed as Percent Finer by Dry Weight: Fines 2.000 mm	Fines 0.095	Fines 0.07	Fines 0.05	Fines #200 0.074	Sand #100 0.149	Sand #80 0.177	Sand #60 0.250	Sand #40 0.42	Sand #20 0.84	Sand #10 2.0	Sand #4 4.76	Gravel 3/8" 9.525	Gravel 1/2" 12.7	Gravel 3/4" 19.05	Gravel 1" 25.4	Gravel 1 1/2" 38.1	Gravel 3" 76.2 mm	Atterberg Limits LL	Atterberg Limits PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships Standard Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data γ_d g/cc	Undisturbed Sample Data w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
1072	55.14	107+80 U/S Undist	21.0-23.0		18	18	23	40	56	62	71	76	82	91	97		99	99	99	100												1.45	22.0		
1073	55.15	" " Undist	42.5-43.8		14	24	44	68	83	87	93	96	99	100																		1.55	22.2		
1074	60.18	107+60 D/S Undist	0.5-1.5		13	14	17	30	43	51	66	74	83	93	97		98	99	100													1.91	7.43		

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA

4/8/85

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines					Sand						Gravel						Atterberg Limits LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (☐ Standard ☐ Modified) Optimum	Max. γd pcf	Moisture %	Undisturbed Sample Data γd g/cm³	Moisture %	Gs	Special Tests
85W		ARIZONA Vineyard Watershed																															
1089	TP.1	300+00 D/S L. Bag	7.5		7	8	10	18	26	30	41	50	51	69	78	83	85	88	91	96	100	20	1	SM							2.77		
1090	TP.1	300+00 U/S S. Bag	7.0-9.5		7	7	9	18	26	30	40	48	58	73	90	96	98	99	100			20	1	SM							0.95		
1091	TP.1	300+00 D/S S. Bag	9.5-10.5		3	3	5	6	11	12	21	36	62	78	89	94	96	99	100			NON PLASTIC		SW-SM							0.71		
1092	TP.2	300+00 U/S M. Bag	4.0-6.5		4	4	5	7	10	12	18	25	35	46	64	78	85	92	95	98	100	22	3	SW-SM							0.74		
1093	TP.2	300+00 U/S S. Bag	7.0-8.0		13	14	16	25	34	39	52	60	70	82	91	95	97	97	98	100		32	10	SC							1.60		
1094	TP.2	300+00 U/S M. Bag	8.0-9.0		14	15	21	32	44	49	58	65	72	79	87	90	91	92	92	94	100	29	10	SC							2.16		
1095	TP.3	253+75 D/S L. Bag	6.5-9.0		4	4	4	6	11	12	18	26	40	51	68	80	85	92	95	98	100	20	2	SW-SM							0.91		
1096	TP.3	253+75 D/S L. Bag	12.0-13.0		9	9	12	16	20	22	26	29	35	48	69	82	88	93	97	99	100	34	13	SC							4.54		

United States Department of Agriculture

Soil Conservation Service

Midwest National Technical Center
Soil Mechanics Laboratory
512 South 7th Street
Lincoln, NE 68508-2919

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Vineyard Road FRS Study

Date: March 29, 1985

To: Ralph M. Arrington
State Conservation Engineer
SCS, Phoenix, AZ

File Code: 210-22

On March 12, 1985, we received 249 small bag samples and 25 core samples from the subject site. On March 25 we received some additional samples from this site.

The test data that we have to date for samples from the initial shipment are recorded on the attached SCS-ENG-354. These data include water content as received for all samples, complete gradation for 212 samples, and gravel sieve data for 46 of the remaining 62 samples. Unit weight data is provided for the core samples.

The small bag samples were submitted in plastic bags to prevent moisture loss and the cores were waxed or wrapped to prevent moisture loss. A few of the core samples were broken, but the rest of the samples arrived in very good shape.

This data is transmitted at this time so that you will have it in hand by April 8. The rest of the gradation tests on these samples will be completed shortly, but it will be several weeks before we can complete Atterberg limit tests on these samples and do the testing on the samples submitted on March 25. We plan to make Atterberg limit tests on selected samples rather than on all samples from this site. We would appreciate your suggestions on this.

Lorn P. Dunnigan

LORN P. DUNNIGAN
Head, Soil Mechanics Laboratory

Attachment:
Form SCS-ENG-354, Soil Mechanics Laboratory Data, 20 sheets

cc:
Ralph M. Arrington (Original + 3 copies)
Jack C. Stevenson, Head, Engineering Staff, WNTC, SCS, Portland, OR (ltr only)
Clifton E. Deal, Soil Mechanics Engineer, Engineering Staff, WNTC, SCS, Portland, OR

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SOIL MECHANICS LABORATORY DATA
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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.01	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
726	1.1	365+00	S. Bag	1.5'-2.0'		13	13	23	43	47	54	68	75	84	93	97	100																7.57		
727	1.2	"	S. Bag	4.5'-6.0'		24	26	40	67	75	79	87	91	95	98	99	100																10.32		
728	1.3	"	S. Bag	10.5'-15.5'		6	6	7	12	12	13	17	21	30	40	57	67	73	84	88	100												4.32		
729	2.1	360+00	S. Bag	5.0'-6.0'		13	13	21	43	55	62	75	82	87	93	96	98	100															6.75		
730	2.2	" ℄	S. Bag	10.0'-10.5'		16	16	22	41	48	54	68	75	84	92	96	98	99	100														7.95		
731	3.1	355+00	S. Bag	5.5'-6.0'		14	14	21	39	48	55	68	76	85	93	98	100																7.24		
732	3.2	"	S. Bag	10.0'-10.5'		14	14	20	38	50	57	73	81	88	96	98	99	99	100														8.99		
733	3.3	"	S. Bag	12.0'-14.0'		8	8	10	19	21	25	35	46	59	69	80	86	90	92	100													6.08		
734	3.4	"	S. Bag	14.0'-15.0'		14	14	20	35	49	56	70	77	86	93	97	99	100															9.37		
735	4.1	350+00	S. Bag	6.0'-7.0'		12	12	17	32	44	51	64	71	78	87	92	96	98	100														6.90		
736	4.2	"	S. Bag	9.0'-10.0'		22	24	35	55	73	79	88	92	96	100																		12.77		
737	4.3	"	S. Bag	10.5'-15.5'		28	32	49	69	84	89	95	97	99	100																		16.96		
738	5.1	345+00	S. Bag	6.0'-7.0'		18	18	26	42	55	61	72	77	85	92	96	98	99	100														8.07		
739	5.2	"	S. Bag	9.5'-10.5'		20	22	31	47	61	67	76	82	88	95	98	100																9.04		
740	5.3	"	S. Bag	10.5'-13.0'		17	17	24	38	50	57	68	74	83	93	97	99	100															8.72		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#80 0.177	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests				
85W		Vineyard Watershed																																					
741	6.1	340+00	S. Bag	5.5'-6.5'		14	14	19	36	47	54	68	76	85	92	97	99	100				1											6.24						
742	6.2	"	S. Bag	10.5'-11.5'		22	24	31	45	57	64	75	81	87	95	98	98	100															10.53						
743	6.3	"	S. Bag	18.0'-20.0'		22	24	31	45	59	65	77	84	90	96	99	100																10.21						
744	7.1	335+00	S. Bag	5.5'-6.5'		20	21	29	41	53	59	69	76	82	89	93	96	99	100														9.68						
745	7.2	"	S. Bag	10.0'-10.5'		25	25	31	43	54	60	70	76	84	93	97	99	99	100														10.61						
746	7.3	"	S. Bag	15.0'-15.5'		18	18	24	36	46	52	64	71	79	87	92	95	97	99	100													13.01						
747	8.1	330+00	S. Bag	5.5'-6.5'		16	18	22	38	49	57	70	78	86	95	98	100																6.69						
748	8.2	"	S. Bag	11.0'-12.0'		17	17	22	32	44	50	60	66	74	80	87	91	93	94	96	100												8.59						
749	9.1	325+00	S. Bag	5.5'-6.5'		17	17	23	34	46	52	61	66	74	83	90	92	94	95	96	100												8.33						
750	9.2	"	S. Bag	10.5'-11.5'		16	16	19	33	44	50	63	70	78	88	94	98	99	100														8.75						
751	10.1	320+00	S. Bag	5.5'-6.5'		20	20	26	39	51	56	68	74	83	94	99	100																9.16						
752	10.2	"	S. Bag	10.5'-11.5'		22	22	28	40	55	60	71	78	86	94	99	100																10.94						
753	10.3	"	S. Bag	13.0'-14.0'		21	21	27	38	50	56	66	73	81	93	98	99	99	100														10.51						
754	11.1	315+00	S. Bag	5.5'-6.5'		19	19	25	37	50	56	67	73	82	94	99	100																7.39						
755	11.2	"	S. Bag	7.5'-8.5'		20	21	29	42	53	60	71	78	86	92	96	97	97	100														8.85						

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SOIL MECHANICS LABORATORY DATA
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03-12-85 ARIZONA

Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Fines #200 0.074 mm	Fines 0.005 mm	Fines 0.002 mm	Sand #140 0.105 mm	Sand #60 0.250 mm	Sand #40 0.42 mm	Sand #20 0.84 mm	Sand #10 2.0 mm	Sand #4 4.76 mm	Gravel 3/8" 9.525 mm	Gravel 1/2" 12.7 mm	Gravel 3/4" 19.05 mm	Gravel 1" 25.4 mm	Gravel 1 1/2" 38.1 mm	Gravel 3" 76.2 mm	Atterberg Limits LL	Atterberg Limits PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (☐ Standard ☐ Modified) Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data γ_d g/cm³	w_o %	G_s	Special Tests
85W		Vineyard Watershed																														
756	11.3	315+00	S. Bag	14.5'-15.5'		21	21	29	41	53	59	69	74	83	93	97	99	99	100											9.84		
757	13.1	310+00	S. Bag	5.5'-7.5'		21	21	26	38	53	59	69	74	82	93	98	100													7.86		
758	13.2	"	S. Bag	10.5'-12.5'		22	22	27	40	54	61	73	80	87	95	99	100													10.79		
759	13.3	"	S. Bag	15.5'-17.5'		19	19	26	38	53	59	69	75	82	91	97	100													11.17		
760	14.1	305+00	S. Bag	5.5'-6.5'		21	21	27	39	52	58	69	75	84	92	97	98	99	100											8.38		
761	14.2	"	S. Bag	10.5'-12.5'		21	21	28	42	56	63	74	81	87	94	98	100													9.81		
762	15.1	295+00	S. Bag	5.5'-7.5'		18	18	22	33	45	50	61	68	77	88	95	97	98	98	100										10.59		
763	15.2	"	S. Bag	10.5'-11.5'		30	30	35	49	62	68	76	81	86	93	98	100													13.48		
764	15.3	"	S. Bag	14.5'-15.5'		14	15	19	33	47	53	65	71	79	90	97	99	99	100											9.45		
765	16.1	290+00	S. Bag	5.5'-6.5'		18	18	25	37	51	56	66	73	80	92	98	99	99	99	100										8.71		
766	16.2	"	S. Bag	10.5'-11.5'		23	23	37	60	70	75	83	87	92	97	99	100													11.72		
767	17.1	285+00	S. Bag	5.5'-6.5'		10	10	12	23	31	34	43	50	59	71	78	82	84	86	90	100									6.89		
768	17.2	"	S. Bag	10.5'-11.5'		10	10	13	26	35	39	49	56	66	79	88	90	91	93	93	100									6.36		
X 769	18.1	280+00	S. Bag	5.5'-6.5'		18	18	23	38	54	61	73	78	86	93	98	100													9.78		
770	18.2	"	S. Bag	7.0'-8.0'		17	17	22	37	50	56	67	75	80	88	94	97	99	100											7.98		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Fines					Sand						Gravel						Atterberg Limits LL	Atterberg Limits PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (Standard / Modified) Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data γ_d g/cc	Undisturbed Sample Data w_o %	G_s	Special Tests				
85W		Vineyard Watershed				0.002 mm	0.005	0.02	0.06	#200 0.074	#100 0.149	#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																
* 771	18.3	280+00	S. Bag	10.5'-11.5'		19	19	25	42	55	62	73	79	86	94	99	100															8.76					
* 772	19.1	275+00	S. Bag	5.5'-6.5'		19	19	27	45	54	61	72	78	86	95	99	100															9.57					
* 773	19.2	"	S. Bag	10.5'-11.5'		19	19	26	43	60	67	78	84	90	96	99	100															11.46					
774	20.1	270+00	S. Bag	5.5'-6.5'		18	18	25	40	52	58	69	75	82	92	97	99	99	100													9.22					
775	20.2	"	S. Bag	10.5'-11.5'		19	19	26	45	58	63	72	77	85	93	97	98	98	100													10.41					
* 776	21.1	255+00	S. Bag	5.5'-6.5'		19	19	27	44	58	65	76	82	87	95	99	100															11.36					
777	21.2	"	S. Bag	10.5'-11.5'		19	19	23	38	47	52	61	69	79	93	98	99	100														10.78					
778	22.1	253+57.5	S. Bag	6.5'-7.0'		22	26	36	52	68	74	81	84	87	96	99	100															13.28					
779	22.2	"	S. Bag	10.0'-10.5'		20	20	26	41	53	59	68	74	83	93	99	100															11.26					
780	22.3	"	S. Bag	11.4'-11.6'		14	14	22	32	41	45	53	59	71	90	98	100															12.59					
781	22.4	"	S. Bag	15.0'-15.5'		21	22	30	46	60	67	76	82	87	94	99	100															12.02					
782	22.5	"	S. Bag	17.6'-18.0'		23	24	30	43	52	57	66	71	78	93	96	99	100														14.15					
783	22.6	"	S. Bag	19.5'-22.5'		16	18	24	35	46	52	61	68	77	91	97	98	99	100													10.00					
784	22.7	"	S. Bag	24.5'-25.7'		9	9	12	18	22	24	32	39	52	68	83	90	93	98	100												5.10					
* 785	22.8	"	S. Bag	29.5'-30.5'		19	25	37	53	69	76	83	86	91	97	100																13.19					

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SOIL MECHANICS LABORATORY DATA
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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074 mm	Fines: #140 0.105 mm	Fines: #100 0.149 mm	Fines: #60 0.250 mm	Sand: #40 0.42 mm	Sand: #20 0.84 mm	Sand: #10 2.0 mm	Sand: #4 4.76 mm	Gravel: 3/8" 9.525	Gravel: 1/2" 12.7	Gravel: 3/4" 19.05	Gravel: 1" 25.4	Gravel: 1 1/2" 38.1	Gravel: 3" 76.2 mm	Atterberg Limits: L.L.	Atterberg Limits: P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																													
786	22.9	253+57.5 S. Bag	34.5'-35.5'		14	18	28	45	57	63	73	78	85	89	93	96	98	98	100	1										9.81	
787	22.11	" S. Bag	41.0'-42.0'		12	13	16	23	29	32	39	45	55	71	91	97	99	100												6.42	
788	22.12	" S. Bag	43.0'-44.0'		5	17	24	41	54	59	68	74	82	91	97	99	100													8.45	
789	22.13	" S. Bag	45.5'-46.5'		10	10	13	21	27	31	39	45	52	68	89	96	98	100												6.28	
790	22.14	" S. Bag	49.5'-50.5'		15	18	24	35	46	51	61	69	80	91	97	99	100													9.04	
* 791	24.1	250+00 S. Bag	5.5'-6.5'		27	29	37	50	63	67	75	80	86	95	99	100														9.27	
792	24.2	" S. Bag	7.0'-7.5'		17	19	26	39	49	54	64	71	79	87	94	97	97	100												7.49	
793	24.3	" S. Bag	10.5'-11.5'		22	23	25	38	52	59	68	74	81	90	95	97	98	100												11.71	
794	25.1	240+00 S. Bag	5.5'-6.5'		14	14	17	29	39	44	54	61	71	86	95	98	99	100												6.29	
795	25.2	" S. Bag	10.5'-11.5'		13	13	17	26	36	41	52	60	71	86	96	99	100													6.71	
796	26.1	235+00 S. Bag	5.5'-6.5'		15	16	20	30	42	48	59	65	73	85	93	95	96	97	100											6.07	
797	26.2	" S. Bag	10.5'-11.5'		15	17	20	34	46	52	61	68	76	89	96	98	98	99	100											7.22	
798	27.1	230+00 S. Bag	5.5'-6.5'		19	19	24	39	54	60	71	75	83	94	99	100														9.18	
799	27.2	" S. Bag	7.0'-7.5'		16	17	23	34	46	51	61	66	72	78	85	90	92	94	94	100										8.64	
800	27.3	" S. Bag	10.5'-11.5'		19	19	24	38	52	59	70	75	83	94	99	100														9.45	

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.01	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests				
85W		Vineyard Watershed																																				
801	28.1	225+00	S. Bag	5.5'-6.5'		19	19	24	39	54	60	71	76	83	94	98	99	100														8.62					
802	28.2	"	S. Bag	10.5'-11.5'		20	21	26	41	56	63	74	80	86	94	98	98	98	100													10.99					
803	29.2	220+00	S. Bag	5.5'-6.5'		20	20	24	38	54	60	72	77	85	93	98	99	100														9.10					
804	29.4	"	S. Bag	10.5'-11.5'		20	20	24	39	54	61	72	78	86	94	99	100															10.48					
805	30.1	215+00	S. Bag	5.5'-6.5'		20	20	24	36	49	56	67	73	82	93	98	99	100														8.83					
806	30.2	"	S. Bag	10.5'-11.5'		20	20	29	47	51	56	66	72	80	91	97	98	99	100													10.18					
807	31.1	205+00	S. Bag	5.5'-6.5'		17	18	25	40	49	56	67	74	81	92	97	98	98	100													8.32					
808	31.2	"	S. Bag	10.5'-11.5'		23	25	34	51	61	68	79	83	90	97	100																11.42					
809	32.1	200+00	S. Bag	5.5'-6.5'		23	25	35	50	62	67	77	82	87	95	99	100															10.33					
810	32.2	"	S. Bag	10.5'-11.5'		21	24	32	46	60	65	76	82	88	96	99	99	100														11.51					
811	33.1	195+00	S. Bag	5.5'-6.5'		24	26	37	52	69	76	86	91	96	100																	11.31					
812	33.2	"	S. Bag	10.5'-11.5'		28	32	45	64	79	84	91	94	97	100																	13.88					
813	34.1	190+00	S. Bag	5.5'-6.5'		15	16	22	37	46	51	58	64	71	82	92	96	97	99	100												6.68					
814	34.2	"	S. Bag	10.5'-11.5'		19	20	29	45	59	63	71	75	81	92	97	98	98	100													9.72					
815	35.1	185+00	S. Bag	5.5'-6.5'		11	11	20	30	41	45	52	58	66	80	90	94	95	97	100												5.46					

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#80 0.177	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_n %	G_s	Special Tests
85W		Vineyard Watershed																																
816	35.2	185+00	S. Bag	10.5'-11.5'		14	14	21	33	45	50	59	64	71	85	93	96	98	100			1										5.00		
817	36.1	180+00	S. Bag	5.5'-6.5'		9	9	17	26	38	44	55	61	70	83	94	98	99	100													5.19		
818	36.2	"	S. Bag	10.5'-11.5'		16	16	23	37	51	57	68	74	82	91	97	98	98	99	100												7.75		
819	37.1	125+00	S. Bag	5.5'-6.5'		27	28	37	48	63	68	78	83	88	95	98	99	100														11.63		
820	37.2	"	S. Bag	10.5'-11.5'		22	23	29	41	52	57	70	76	84	94	98	99	100														10.58		
821	38.1	130+00	S. Bag	5.5'-6.5'		25	27	37	51	63	70	80	84	89	96	99	100															10.25		
822	38.2	"	S. Bag	10.5'-11.5'		25	27	37	51	64	70	80	84	90	96	98	99	100														12.05		
823	38.3	"	S. Bag	14.5'-15.5'		26	29	41	56	71	77	86	90	95	100																	12.83		
824	39.1	135+00	S. Bag	5.6'-6.5'		25	28	43	61	76	82	90	93	97	100																	10.71		
825	39.2	"	S. Bag	10.5'-11.5'		22	25	33	49	64	70	80	84	90	96	99	100															11.20		
826	40.1	140+00	S. Bag	5.5'-6.5'		18	19	26	44	59	65	72	76	81	94	98	99	99	99	100												11.01		
827	40.2	"	S. Bag	10.5'-11.5'		21	24	33	52	65	79	88	92	96	100																	10.82		
828	41.1	145+00	S. Bag	5.5'-6.5'		15	18	23	39	54	60	71	77	84	94	98	99	99	100													7.64		
829	41.2	"	S. Bag	10.5'-11.5'		19	20	30	45	63	70	82	87	92	96	98	100															9.63		
830	42.1	150+00	S. Bag	5.5'-6.5'		21	22	31	46	61	67	78	83	90	97	99	99	99	100													9.54		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																
831	43.2	210+00 ℄	S. Bag	5.5'-6.5'		20	21	27	41	54	65	77	83	89	96	99	100				1											9.55		
832	43.3	210+00 U/S	S. Bag	8.0'-10.0'		21	21	27	39	55	61	72	78	85	96	99	100															12.20		
833	43.5	210+00 ℄	S. Bag	12.0'-13.5'		19	19	24	38	51	60	71	77	85	93	96	97	97	98	100												9.84		
834	43.7	"	S. Bag	15.5'-16.5'		23	24	30	43	60	65	74	79	85	96	99	100															12.70		
835	43.8	"	S. Bag	18.0'-19.0'		21	22	29	44	60	67	76	81	86	95	99	100															12.22		
836	43.9	"	S. Bag	19.5'-20.5'		14	14	19	31	47	54	66	72	79	93	98	99	100														9.14		
837	43.10	"	S. Bag	21.0'-22.5'		17	18	20	33	50	58	70	76	85	93	98	100															7.93		
838	43.11	"	S. Bag	24.5'-25.5'		16	17	18	31	43	49	62	69	78	88	97	100															7.46		
839	43.12	"	S. Bag	25.5'-26.5'		14	15	18	26	34	38	47	53	61	73	87	95	98	100													9.15		
840	43.13	"	S. Bag	26.5'-29.0'		6	6	10	10	11	11	15	23	41	70	91	95	97	98	100												3.69		
841	43.14	"	S. Bag	29.0'-30.5'		22	22	26	32	42	45	50	52	56	66	80	88	91	96	96	100											13.75		
842	43.15	"	S. Bag	31.0'-32.0'		20	25	34	51	66	72	80	84	88	93	97	100															10.71		
843	43.16	"	S. Bag	34'-35'		18	25	36	52	67	74	83	86	89	92	96	99	100														12.84		
844	43.17	"	S. Bag	35.5'-38'		19	26	39	61	79	87	95	97	99	100																	12.75		
845	43.18	"	S. Bag	38.0'-40.0'		18	20	25	39	51	64	78	85	90	94	97	99	100														6.69		

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LABORATORY SAMPLE NUMBER	FIELD NUMBER	LOCATION AND DESCRIPTION		DEPTH	FIELD CLASSIFICATION	MECHANICAL ANALYSIS GRAIN SIZE DISTRIBUTION EXPRESSED AS PERCENT FINER BY DRY WEIGHT: FINES 0.002 mm	0.005	0.02	0.05	#200 0.074	SAND #140 0.105	#80 0.177	#40 0.42	#20 0.84	#10 2.0	#4 4.76	GRAVEL 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	ATTERBERG LIMITS LL	PL	UNIFIED CLASSIFICATION	SOLUBLE SALTS %	ORG-PERSHOR %	MOISTURE - DENSITY RELATIONSHIPS ☐ STANDARD ☐ MODIFIED CURVE NO.	MAX. γ_d pcf	w_o %	UNDISTURBED SAMPLE DATA γ_d g/cc	w_o %	G_s	SPECIAL TESTS
85W		Vineyard Watershed																																	
846	43.19	210+00 ℄	S. Bag	40.5'-42.5'		19	21	29	42	54	60	73	79	86	94	99	100																7.35		
847	43.20	"	S. Bag	42.5'-45.0'		18	23	27	36	44	49	63	70	77	88	98	100																5.45		
848	43.21	"	S. Bag	45.5'-47.0'		24	28	40	63	74	80	90	94	98	100																		9.65		
849	43.22	"	S. Bag	51.0'-53.0'		15	15	18	25	28	31	38	45	54	66	85	93	96	98	100													5.07		
850	43.23	"	S. Bag	55.0'-55.5'		20	26	37	60	72	76	83	87	93	100																		6.58		
851	44.1	210+00 U/S	S. Bag	1.0'-4.0'		22	24	29	42	54	59	70	77	86	94	98	99	99	100														13.32		
852	44.2	"	S. Bag	4.5'-5.5'		18	20	25	42	63	74	90	95	98	100																		14.23		
853	44A.3	"	S. Bag	5.5'-8.0'		24	27	33	50	67	73	82	87	93	100																		12.93		
854	44.3	"	S. Bag	5.5'-10.5'		20	24	29	46	59	66	78	84	88	93	97	99	99	100														19.21		
855	44.4	"	S. Bag	10.5'-12.5'		13	15	21	34	47	55	69	77	86	93	98	99	100															18.69		
856	44.5	"	S. Bag	12.5'-15.5'		13	14	14	19	22	25	35	41	53	69	87	94	96	99	100													8.93		
857	44.7	"	S. Bag	15.5'-18.0'		8	8	9	14	15	18	29	41	56	67	82	89	93	96	98	100												5.66		
858	44.8	"	S. Bag	18.0'-20.5'		22	27	37	57	75	81	89	92	96	100																		18.01		
859	44.9	"	S. Bag	20.5'-23.0'		17	22	33	55	71	79	89	93	97	100																		21.65		
860	44.10	"	S. Bag	23.0'-24.0'		11	13	18	24	29	32	40	44	50	60	75	87	91	96	98	100												16.44		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074 mm	#140 0.105 mm	#60 0.250 mm	#40 0.42 mm	#20 0.84 mm	#10 2.0 mm	#4 4.76 mm	Sand: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Gravel	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture - Density Relationships: Curve No.	Max. γ_d p.c.f.	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																													
861	44.11	210+00 U/S	S. Bag	24.0'-25.5'		26	31	42	60	76	83	91	94	97	100																19.6
862	44.12	"	S. Bag	25.5'-28.0'		19	25	33	42	51	55	65	70	77	89	96	99	100													17.97
863	44.13	"	S. Bag	28.0'-30.5'		15	19	23	30	36	39	48	55	62	73	86	91	92	94	95	100										12.71
864	44.14	"	S. Bag	30.5'-31.5'		37	43	56	73	81	85	91	94	98	100																22.56
865	44.15	"	S. Bag	32.0'-35.5'		17	22	36	58	74	81	90	94	97	100																21.85
866	44.16	"	S. Bag	38.0'-40.5'		18	23	35	57	71	77	86	91	96	100																12.78
867	45.1	210+00	S. Bag	0-1.5'		17	19	24	36	48	56	67	73	83	94	98	99	99	100												9.30
868	45.2	"	S. Bag	1.5'-5.0'		28	32	38	54	73	79	87	91	97	100																9.0
869	45.3	"	S. Bag	5.5'-7.5'		9	11	12	26	40	50	64	74	84	92	98	99	99	100												3.13
870	45.4	"	S. Bag	10.5'-12.5'		8	10	10	14	18	19	24	28	37	51	65	72	76	85	89	89	100									3.49
871	45.5	"	S. Bag	12.5'-14.5'		11	12	12	19	24	26	33	40	48	62	77	85	87	91	94	100										3.39
872	45.6	"	S. Bag	15.5'-17.5'		17	19	23	35	52	59	73	78	85	92	97	99	99	100												6.52
873	45.7	"	S. Bag	20.5'-22.5'		17	22	28	42	57	64	74	77	82	91	98	99	100													8.34
874	45.8	"	S. Bag	25.5'-27.5'		7	8	8	12	15	16	21	26	33	44	56	67	77	95	96	100										2.47
875	45.9	"	S. Bag	28.5'-30.5'		38	47	56	70	78	82	90	94	98	100																15.79

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Fines 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand #140 0.105	#80 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																
876	45.10	210+00	S. Bag	35.5'-38.0'		9	11	12	16	18	20	24	27	34	47	63	73	77	83	88	100											4.21		
877	45.11	"	S. Bag	38.5'-40.5'		12	14	18	27	37	40	44	49	55	66	78	84	84	84	84	100											7.65		
878	46.1	175+00 ℄	S. Bag	5.5'-8.0'		14	18	21	36	54	61	73	80	87	94	98	99	99	100													5.62		
879	46.2	"	S. Bag	10.5'-12.0'		9	11	12	25	35	41	51	57	65	77	87	91	93	97	97	100											4.53		
880	47.1	170+00 ℄	S. Bag	5.5'-7.0'		18	20	26	42	58	65	76	82	87	94	98	99	99	100													11.92		
881	47.2	"	S. Bag	11.5'-13.0'		10	13	16	28	41	46	57	63	71	86	94	96	98	100													6.87		
882	48.1	165+00 ℄	S. Bag	5.5'-7.0'		14	18	24	43	63	70	82	86	91	96	99	100															9.21		
883	48.2	"	S. Bag	10.5'-12.0'		11	13	17	31	45	53	65	72	80	89	95	98	99	99	100												5.68		
884	49.1	160+00	S. Bag	5.5'-7.0'		13	14	18	34	47	55	68	75	82	92	97	99	99	99	100												5.43		
885	49.2	"	S. Bag	11.0'-12.0'		17	20	25	45	62	70	81	86	90	94	98	100															10.31		
886	50.1	155+00	S. Bag	5.5'-7.0'		19	20	33	55	71	78	88	92	97	100																	10.68		
887	50.2	"	S. Bag	11.0'-12.0'		13	14	20	41	54	61	74	81	87	94	98	99	100														7.45		
888	51.1	120+00	S. Bag	6.0'-7.5'		21	22	29	42	53	60	71	78	86	95	99	100															10.21		
889	51.2	"	S. Bag	11.0'-12.5'		23	24	33	45	59	66	77	83	88	95	99	100															8.30		
890	52.1	115+00 ℄	S. Bag	6.0'-7.5'		22	25	31	46	57	64	78	86	94	100																	9.38		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Clays 0.002 mm	Silts 0.005	0.02	0.05	Fine Sand #200 0.074	#140 0.105	#80 0.177	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Coarse Sand 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (☐ Standard ☐ Modified): Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests				
85W		Vineyard Watershed																																					
891	52.2	115+00 ℄	S. Bag	11.0'-12.0'		26	28	37	49	64	72	85	91	96	100							1											13.23						
892	53.1	109+70 ℄	S. Bag	2.5'-3.5'		22	25	33	49	63	71	84	90	96	100																		12.43						
893	53.2	"	S. Bag	4.5'-5.0'		18	19	29	45	60	67	80	86	90	95	98	99	99	100														10.47						
894	53.3	"	S. Bag	9.0'-10.5'		15	15	20	32	44	51	66	74	83	91	97	99	99	100														15.0						
895	53.4	"	S. Bag	6.0'-7.0'		22	23	30	43	59	66	79	85	90	96	99	100																10.97						
896	53.5	"	S. Bag	14.5'-15.5'		24	25	32	47	58	65	78	84	92	100																		13.22						
897	53.6	"	S. Bag	11.0'-12.0'		22	24	33	47	63	72	84	90	96	100																		13.51						
898	53.7	"	S. Bag	18.0'-19.0'		24	26	32	46	60	67	78	84	89	95	98	100																14.76						
899	53.8	"	S. Bag	19.0'-20.0'		21	22	29	44	62	70	81	86	90	94	96	98	99	100														12.75						
900	53.9	"	S. Bag	21.0'-22.5'		22	23	31	47	64	72	87	92	97	100																		13.86						
901	53.10	109+70 ℄	S. Bag	23.0'-24.0'		25	31	44	58	70	81	89	93	97	100																		18.35						
902	54.1	107+60 ℄	S. Bag	4.0'-5.0'		25	26	33	46	61	68	82	88	95	100																		9.40						
903	54.2	"	S. Bag	6.0		21	25	33	51	65	77	87	91	96	100																		10.06						
904	54.3	"	S. Bag	16.0'-16.5'		19	20	28	45	61	68	81	87	94	100																		10.74						
905	54.4	"	S. Bag	19.5'-20.0'		19	20	27	39	53	60	73	80	87	96	99	99	99	100														12.41						

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#80 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d p.c.f.	w_o %	Undisturbed Sample Data: γ_d p/cu	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
906	54.5	107+60 ℄	S. Bag	24.0'-24.5'		21	29	40	53	64	68	77	80	86	90	94	96	97	98	100													13.49		
907	54.6	"	S. Bag	25.5'-28.0'		6	7	9	14	17	20	27	34	42	50	60	68	74	78	86	88	100											4.73		
908	54.7	"	S. Bag	28.0'-30.5'		6	6	7	10	10	11	16	23	36	49	63	73	78	88	93	96	100											5.83		
909	54.8	"	S. Bag	30.5'-31.5'		13	14	15	20	29	33	44	53	62	73	85	90	94	96	100													6.38		
910	54.9	"	S. Bag	33.0'-35.5'		6	7	9	12	14	15	19	24	33	51	75	86	91	96	98	100												5.36		
911	54.10	"	S. Bag	35.5'-36.5'		9	9	10	14	16	18	22	27	37	55	74	83	88	94	97	100												6.34		
912	54.11	"	S. Bag	36.5'-37.0'		22	23	29	50	65	79	90	93	97	100																		15.51		
913	54.12	"	S. Bag	38.0'-39.0'		19	23	29	44	60	67	76	81	86	93	97	99	99	100														17.38		
914	54.13	"	S. Bag	42.5'-43.5'		15	15	16	21	24	26	35	45	61	74	87	91	93	95	100													8.06		
915	54.14	"	S. Bag	46.0'-47.0'		7	7	8	12	14	16	21	25	35	54	76	87	91	98	100													7.04		
916	54.15	"	S. Bag	51.0'-52.0'		5	5	6	7	9	10	16	23	34	49	72	85	90	97	100													4.43		
917	54.16	"	S. Bag	54.5'-55.5'		9	9	12	18	26	30	39	46	53	62	70	76	79	86	88	100												9.73		
918	55.1	107+80 U/S	S. Bag	0.5'-1.5'		13	14	19	31	45	54	73	82	92	100																		10.67		
919	55.2	"	S. Bag	4.0'-5.0'		34	35	41	57	70	82	89	93	97	100																		16.14		
920	55.3	"	S. Bag	9.0'-9.5'		11	11	13	19	24	27	34	42	54	67	83	90	94	98	100													18.16		

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines 0.002 mm	Fines 0.005	Fines 0.02	Fines 0.06	Fines #200 0.074	Sand #140 0.105	Sand #60 0.250	Sand #40 0.42	Sand #20 0.84	Sand #10 2.0	Sand #4 4.76	Gravel 3/8" 9.525	Gravel 1/2" 12.7	Gravel 3/4" 19.05	Gravel 1" 25.4	Gravel 1 1/2" 38.1	Gravel 3" 76.2 mm	Atterberg Limits LL	Atterberg Limits PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
921	55.4	107+80 U/S	S. Bag	14.0'-15.5'		5	6	7	10	12	13	19	25	32	39	50	58	64	70	80	100											7.44			
922	55.5	"	S. Bag	19.0'-20.0'		23	23	26	39	51	57	70	77	87	94	98	99	100														18.75			
923	55.6	"	S. Bag	23.0'-24.0'		16	18	26	41	61	68	77	81	86	91	94	96	96	96	96	100											21.97			
924	55.8	"	S. Bag	28.5'-29.5'		23	24	31	43	52	54	61	69	79	89	97	99	100														29.21			
925	55.9	"	S. Bag	31.0'-32.0'		5	6	7	10	11	12	16	22	32	54	77	88	92	95	100												7.38			
926	55.10	"	S. Bag	36.0'-37.0'		14	15	25	44	57	64	80	87	93	100																	19.25			
927	55.11	"	S. Bag	39.0'-40.0'		4	4	6	11	11	13	22	32	45	62	81	88	90	96	100												5.57			
928	55.12	"	S. Bag	44.0'-45.0'		12	14	26	54	71	77	86	91	96	100																	21.86			
929	55.13	"	S. Bag	48.0'-50.0'		4	4	5	9	9	10	17	27	42	52	71	87	92	99	100												6.67			
930	56.1	82+00 ℄	S. Bag	0.5'-1.5'		29	30	36	49	61	68	81	87	94	100																	11.47			
931	56.2	"	S. Bag	4.0'-5.0'		21	21	27	30	52	60	73	79	87	93	97	98	99	100													11.99			
932	57.1	90+00 ℄	S. Bag	1.0'-1.5'		19	19	23	35	47	54	68	75	85	93	98	100															10.79			
933	57.2	"	S. Bag	4.5'-5.0'		21	21	24	37	50	57	71	78	87	94	98	99	99	100													7.99			
934	57.3	"	S. Bag	6.5'-7.0'		20	20	24	35	47	52	63	70	79	88	95	97	98	100													9.04			
935	57.4	"	S. Bag	9.5'-10.0'		18	19	24	35	48	56	71	78	86	96	99	100															10.48			

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#80 0.177	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cm³	w_n %	G_s	Special Tests
85W		Vineyard																															
936	57.5	90+00 ℄ S. Bag	11.0'-12.0'		19	19	24	37	50	57	72	79	87	96	99	100															10.58		
937	57.6	" S. Bag	14.5'-15.5'		18	19	24	36	48	56	71	80	88	96	98	99	99	100													10.26		
938	57.7	" S. Bag	16.0'-17.0'											49	59	68	73	81	87	100											5.10		
939	58.1	95+00 ℄ S. Bag	3.5'-4.5'											96	98	99	100														8.47		
940	58.2	" S. Bag	9.5'-10.5'											92	96	98	99	100													7.55		
941	59.1	100+00 S. Bag	4.5'-5.5'											97	99	100															12.49		
942	59.2	" S. Bag	9.5'-10.5'											96	99	100															14.03		
943	60.1	107+60 D/S S. Bag	3.0'-4.0'											97	100																10.36		
944	60.3	" S. Bag	5.5'-7.0'											61	68	73	75	80	86	94	100										5.46		
945	60.4	" S. Bag	10.5'-11.5'											42	57	69	76	83	90	100											3.42		
946	60.5	" S. Bag	14.0'-15.0'											31	39	46	52	62	67	82	100										3.26		
947	60.6	" S. Bag	15.5'-16.0'											70	82	88	91	92	92	100											5.62		
948	60.7	" S. Bag	20.0'-20.5'																												9.07		
949	60.9	" S. Bag	26.0'-27.0'											73	76	78	80	84	84	84	100										6.86		
950	60.10	" S. Bag	28.0'-30.5'											68	88	94	97	99	100												4.59		

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Gravel 3"	Gravel 1 1/2"	Gravel 3/4"	Gravel 3/8"	Gravel #4	Sand #10	Sand #20	Sand #40	Sand #60	Sand #100	Sand #140	Sand #200	Fines 0.005 mm	Fines 0.002	Fines 0.001	Fines 0.0005 mm	Atterberg Limits L.L.	Atterberg Limits P.I.	United Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (☐ Standard ☐ Modified): Curve No.	Max. γ_d p.c.f.	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																														
951	60.11	107+60 D/S S. Bag	35.0'-36.0'											56	66	73	77	81	83	100										3.85		
952	60.12	" S. Bag	37.0'-37.5'																											11.59		
953	60.13	" S. Bag	37.5'-38.0'											35	43	51	58	67	70	73	100									4.16		
954	60.14	" S. Bag	38.0'-39.0'											42	52	61	67	73	76	90	100									3.59		
955	60.15	" S. Bag	48.5'-50.0'											60	80	88	92	95	98	100										5.49		
956	60.16	" S. Bag	52.5'-53.0'																											6.81		
957	60.17	" S. Bag	41.0'-42.0'																											6.81		
958	61.1	253+75 D/S S. Bag	0.0-1.0'																											11.69		
959	61.2	" S. Bag	3.0'-4.0'											96	99	100														5.20		
960	61.3	" S. Bag	6.0'-8.0'											81	90	93	94	95	98	100										3.51		
961	61.4	" S. Bag	14.0'-15.0'											53	68	78	82	91	96	100										4.45		
962	61.6	" S. Bag	23.0'-24.0'											96	99	100														8.78		
963	61.8	" S. Bag	26.0'-27.0'											50	69	82	88	96	98	100										3.31		
964	61.9	" S. Bag	29.0'-30.0'											79	92	96	97	99	99	100										5.37		
965	61.10	" S. Bag	31.0'-32.0'											50	67	75	79	86	91	91	100									3.00		

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: #200 0.074	Sand: #140 0.105	#100 0.149	#80 0.177	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships (☐ Standard ☐ Modified): Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests: Wn %
85W		Vineyard Watershed																													
966	61.13	253+75 D/S S. Bag	35.5'-36.5'									76	88	92	94	100															3.76
967	61.14	" S. Bag	37.0'-38.0'									55	71	78	80	84	99	100													3.03
968	61.15	" S. Bag	39.0'-40.0'																												4.15
969	61.18	" S. Bag	50.0'-50.5'																												9.42
970	62.1	300+00 D/S S. Bag	4.0'-5.0'									93	98	100																	5.50
971	62.2	" S. Bag	5.5'-6.5'									55	67	74	77	82	85	88	100												2.88
972	62.4	" S. Bag	17.5'-18.5'																												8.25
973	62.5	" S. Bag	23.5'-24.5'																												7.13
974	62.6	" S. Bag	28.0'-29.0'									92	95	97	98	100															8.41
975	54	107+60 ℄ Undist	0.5'-1.0'									96	99	100														1.93	10.7		
976	54	" Undist	1.0'-1.5'																									1.92	8.37		
977	54	" Undist	3.5'-4.0'																									1.83	9.91		

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Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.06	#200 0.074	Sand: #140 0.105	#100 0.150	#60 0.25	#40 0.42	#20 0.84	Gravel: #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	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests				
85W		Vineyard Watershed																																					
978	54	107+60 ℄ Undist	8.5'-10.5'												96	98	99	99	100												1.91	9.67							
979A	54	" Undist	11.5'-13.0'												96	98	99	99	100												1.70	9.15							
979B	54	" Undist	11.5'-13.0'																												1.72	13.8							
980	54	" Undist	23.0'-23.5'												92	95	96	96	96	100											1.54	12.1							
981	54	" Undist	24.5'-25.0'												91	94	97	97	100												1.83	14.7							
982	54	" Undist	32.0'-33.0'												74	87	93	95	97	100											1.65	8.05							
983	54	" Undist	37.0'-38.0'																												1.64	16.5							
984	54	" Undist	39.0'-40.0'												94	98	99	99	100												1.52	15.4							

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Laboratory Sample Number	Field Number	Location and Description		Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.I.	Unified Classification	Soluble Salts %	Dispersion %	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max. γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests
85W		Vineyard Watershed																																	
985	54	107+60 ℄	Undist	52.0'-52.8'											91	95	98	99	100		1										1.69	13.8			
986	54	"	Undist	52.8'-53.3'											50	59	67	73	89	90	100										1.86	10.8			
987	60	107+60 D/S	Undist	4.0'-5.5'																											1.53	11.3			
988A	60	"	Undist	22.0'-23.0'											90	95	98	100													1.56	7.07			
988B	60	"	Undist	22.0'-23.0'											93	98	100														1.64	4.76			
989	60	"	Undist	27.0'-27.5'											90	95	98	99	100												1.51	21.5			
990	60	"	Undist	39.5'-40.5'											94	98	99	100													1.55	7.56			
991	61.5	253+75 D/S	Undist	18.0'-20.0'																											1.54	12.1			

SCS-ENG-354
REV. 3-70
FILE CODE ENG-13-18

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
No. 20 of 20

03-12-85

LABORATORY SAMPLE NUMBER	FIELD NUMBER	LOCATION AND DESCRIPTION		DEPTH	FIELD CLASSIFICATION	MECHANICAL ANALYSIS GRAIN SIZE DISTRIBUTION EXPRESSED AS PERCENT FINER BY DRY WEIGHT: FINES 0.002 mm	0.005	0.02	0.05	#200 0.074	SAND #140 0.105	#80 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	GRAVEL 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	ATTERBERG LIMITS LL	PI	UNIFIED CLASSIFICATION	SOLUBLE SALTS %	DISPERSION %	MOISTURE - DENSITY RELATIONSHIPS ☐ STANDARD ☐ MODIFIED CURVE NO.	MAX. γ_d pcf	w_o %	UNDISTURBED SAMPLE DATA γ_d g/cc	w_o %	G_s	SPECIAL TESTS
85W		Vineyard Watershed																																
992	61.7	253+75 D/S	Undist	22.0'-23.0'											94	98	99	100													1.58	8.61		
993	61.11	"	Undist	33.0'-34.0'											88	95	97	98	98	100											1.75	6.93		
994	61.16	"	Undist	42.0'-42.5'											69	84	92	92	94	96	100										1.92	5.64		
995	61.17	"	Undist	44.5'-45.0'											50	75	88	91	97	100											1.93	4.32		
996	61.19	"	Undist	49.0'-50																											1.51	10.9		
997	62.3	300+00 D/S	Undist	12.0'-13.0'											95	98	100														1.69	8.42		

United States Department of Agriculture

Soil Conservation Service

Midwest National Technical Center
Soil Mechanics Laboratory
512 South 7th Street
Lincoln, NE 68508

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Vineyard Rd. Study No. 2

Date: March 22, 1984

To: Ralph M. Arrington
State Conservation Engineer
SCS, Phoenix, AZ

File Code: 210-22

The identification tests requested for the samples from this site have been completed and the test results are summarized on the attached reporting forms.

Lorn P. Dunnigan

LORN P. DUNNIGAN
Head, Soil Mechanics Laboratory

Attachments:
Form SCS-ENG-354, Soil Mechanics Laboratory Data, 3 sheets
Form SCS-ENG-352, Compaction and Penetration Resistance, 3 sheets
Form SCS-ENG-353, Soil Classification, 3 sheets

cc:
Ralph M. Arrington (Original + 3 copies)
Jack C. Stevenson, Head, Engineering Staff, WNTC, SCS, Portland, OR (ltr. only)
Clifton E. Deal, Soil Mechanics Engineer, Engineering Staff, WNTC, SCS, Portland, OR

SCS-ENG-354
Rev. 3-70
File Code ENG-13-10

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 1 of 1

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion % Finer Soil	Moisture-Density Relationships (Standard / Modified): Curve No.	Max γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	G_s	Special Tests: C_s 60°C					Chemical Test
1/4/84		ARIZONA																																					
84W		Vineyard Rd. Study #2																																					
2361	1	104+34, 2' U.S. ℄ of filter	4.0-5.0		24	25	32	45	61	67	78	83	88	94	98	99	100					32	16	CL	0.21	Tr.						2.67						1
		trench L. Bag																						DRY DENSITY < NO. 4			①	113.5	14.5									
2362	2	104+98, 5' U.S. ℄ of filter	5.0-6.0		24	25	29	43	59	66	77	83	88	94	98	99	99	100				29	13	CL	0.29	4						2.67						1
		trench L. Bag																						DRY DENSITY < NO. 4			②	115.5	13.5									
2363	3	123+02, U.S. side of filter	6.0-7.0		18	20	24	35	49	56	69	76	84	91	97	98	99	100				26	11	SC	0.26	Tr.						2.67	2.64					1
		trench, cell #1 L. Bag																						DRY DENSITY < NO. 4			③	119.5	12.0									
2364	4	104+31.5, U/S edge drain S. Bag	4.6		20	21	26	39	55	61	73	79	86	93	96	98	98	98	100			29	12	CL	0.22	Tr.						2.69						1
2365	5	104+31.5, D/S interface fill/drain S. Bag	4.6		23	24	29	44	60	67	78	84	89	95	97	98	98	98	100			30	14	CL	0.19	Tr.						2.68	2.66					1
2366	6	104+34, U/S side drain/emb interface S. Bag	3.2-6.2		23	25	29	43	60	66	77	84	90	96	98	99	100					30	13	CL	0.24							2.67						
2367	7	104+34, Immed. adj. to crack U/S side drain S. Bag	4.2-4.5		22	23	27	40	56	62	75	81	87	96	98	100						29	11	CL	0.23	Tr.						2.68						1

SCS-ENG-354
Rev. 3-70
File Code ENG-13-18

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 2 of 2

1/4/84 Laboratory Sample Number 84W	Field Number	Location and Description: ARIZONA Vineyard Rd. Study #2	Depth	Field Classification	Mechanical Analysis, Grain Size Distribution Expressed as Percent Finer by Dry Weight: Fines 0.002 mm	Fines 0.005	Fines 0.02	Fines 0.05	Fines #200 0.074	Sand #100 0.149	Sand #60 0.250	Sand #40 0.42	Sand #20 0.84	Sand #10 2.0	Sand #4 4.76	Gravel 3/8" 9.525	Gravel 1/2" 12.7	Gravel 3/4" 19.05	Gravel 1" 25.4	Gravel 1 1/2" 38.1	Gravel 3" 76.2 mm	Atterberg Limits: LL	Atterberg Limits: PI	Unified Classification	Soluble Salts %	Dispersion % Moist Soil	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	e_o	Special Tests: G_s 60°C				Chemical Test
2368	8	104+34, U/S interface drain fill	4.2		21	23	30	48	69	76	86	91	96	100								27	10	CL	0.26	Tr.						2.66					1
		(showing crack surface) S. Bag																																			
2369	9	121+74, Drain fill, D/S side of	6.0-7.0		5	5	7	7	10	12	22	32	46	60	72	84	89	99	100			NON PLASTIC		SP-SM	0.38							2.73					
		filter trench S. Bag																																			
2370	10	104+35, Filter material S. Bag	8.0		2	2	2	3	5	7	20	36	48	55	61	69	73	91	100			NON PLASTIC		SP-SM	0.17							2.72					
2371	11	105+01 S. Bag	18.5-18.7		1	1	1	3	5	7	32	51	66	72	80	89	93	98	100			NON PLASTIC		SP-SM	0.18							2.71					
2372	12	105+01, 20' Depth below filter			22	23	29	42	58	65	76	83	89	95	99	100						31	14	CL	0.22							2.66					
		S. Bag																																			
2373	13	109+75, DS Behind hope line, 12'			20	21	29	40	55	62	74	81	87	95	97	98	98	98	100			26	11	CL	0.22							2.67	2.66				
		deep, original trench wall S. Bag																																			
2374	14	123+02, On downstream side of	3.5-4.0		20	21	25	36	52	59	72	79	86	93	96	98	98	98	98	100		28	13	CL	0.22	Tr.						2.67					1
		filter trench S. Bag																																			
2375	15	123+02, On downstream side of	6.0-6.5		19	21	26	37	55	64	82	89	94	100								25	10	CL	0.21	Tr.						2.70					1
		filter trench S. Bag																																			

SCS-ENG-354
REV. 3-70
FILE CODE ENG-13-18

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 3 of 3

1/4/84 — ARIZONA

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #140 0.105	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: LL	PI	Unified Classification	Soluble Salts %	Dispersion % (Hydr. Soil)	Moisture-Density Relationships ☐ Standard ☐ Modified: Curve No.	Max γ_d pcf	w_o %	Undisturbed Sample Data: γ_d g/cc	w_o %	e_o	Special Tests: G_s 60°C				Curve No. Test
84W		Vineyard Rd. Study #2																																			
2376	16	123+02, On downstream side of filter face S. Bag	9.0-9.5		28	30	35	48	62	72	83	89	95	100								33	16	CL	0.22	Tr.						2.70	2.65				1
2377	17	123+02, On upstream side of filter trench S. Bag	3.5-4.0		21	22	29	37	51	57	72	79	86	94	98	100						27	12	CL	0.22	Tr.						2.67					1
2378	18	123+02, U/S side of filter trench, cell #1 S. Bag	9.0-9.5		26	28	35	47	61	67	78	85	92	100								30	15	CL	0.23	4						2.66					2
2379	19	Tag completely obliterated S. Bag			20	22	29	45	62	67	75	79	85	92	96	98	99	100				27	11	CL	0.19	Tr.						2.70	2.67				1

SCS-ENG-352 (REV. 3-70)
FILE CODE ENG-22

LABORATORY NO 84W2361

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	COMPACTION AND PENETRATION RESISTANCE

PROJECT and STATE: VINEYARD RD. STUDY #2, ARIZONA

FIELD SAMPLE NO.	LOCATION	DEPTH
1	104+34, 2' U.S. ℄ OF FILTER TRENCH	4.0'-5.0'

GEOLOGIC ORIGIN	TESTED AT	APPROVED BY	DATE
	SML-LINCOLN	EFS	3/22/84

CLASSIFICATION CL LL 32 PI 16 CURVE NO. 1 OF 3

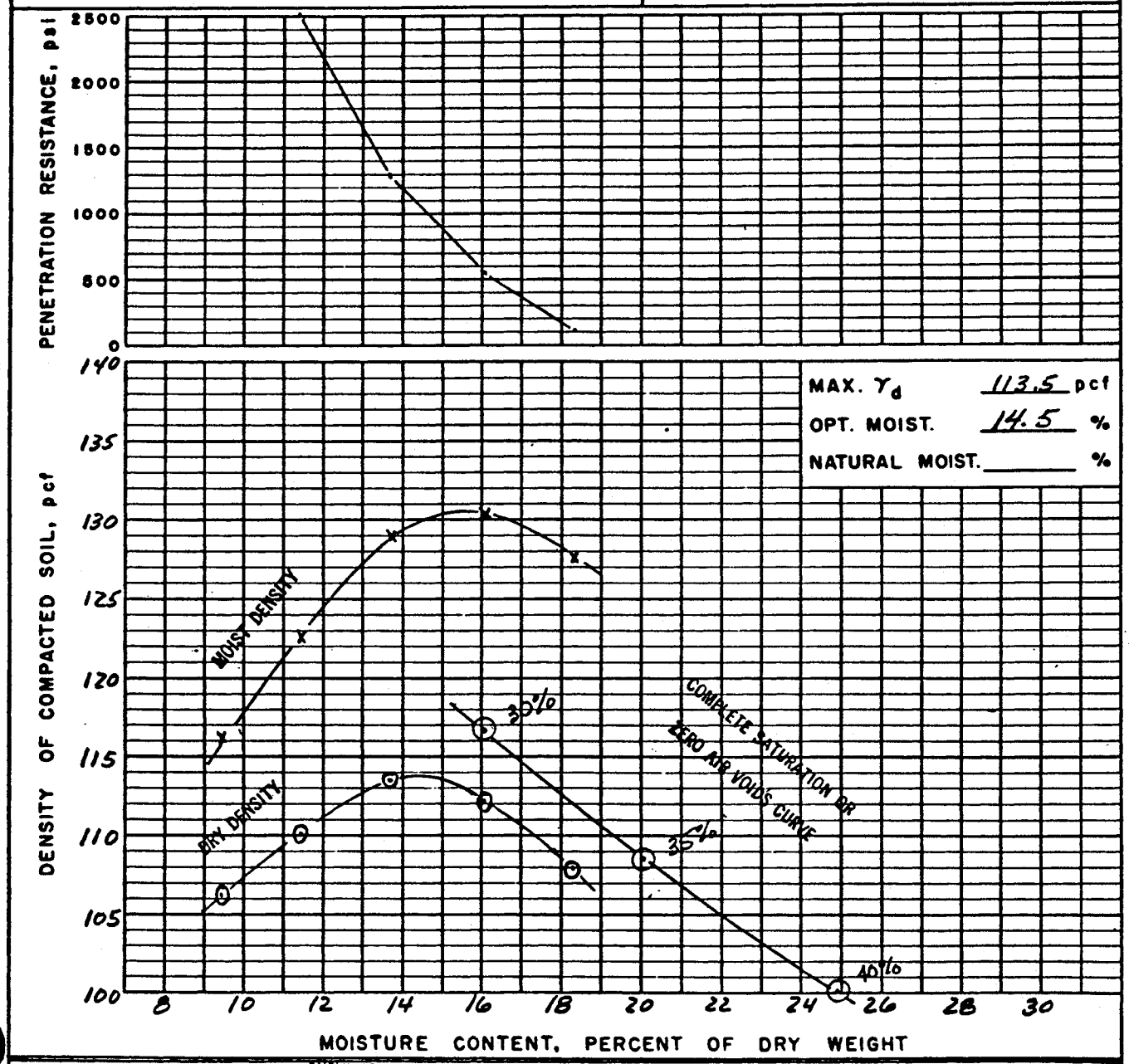
MAX. PARTICLE SIZE INCLUDED IN TEST < #4 "

SPECIFIC GRAVITY (G_s) { MINUS NO. 4 2.67 / PLUS NO. 4 ____

STD. (ASTM D-698) ☒; METHOD A

MOD. (ASTM D-1557) ☐; METHOD ____

OTHER TEST ☐ (SEE REMARKS)



MAX. γ_d 113.5 pcf

OPT. MOIST. 14.5 %

NATURAL MOIST. ____ %

REMARKS

CURVE IS FOR THE MINUS NO. 4 FRACTION

GRADUATION OF TOTAL SAMPLE

< NO. 200 61 %; < NO. 4 98 %; < 1/2 IN. 100 %

USDA SCS-HYATTSVILLE MD 1966

SCS-ENG-352 (REV. 3-70)
FILE CODE ENG-22

LABORATORY NO 84W2362

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	COMPACTION AND PENETRATION RESISTANCE

PROJECT and STATE: VINEYARD RD. STUDY #2, ARIZONA

FIELD SAMPLE NO.	LOCATION	DEPTH
2	104+98, 5' U.S. ℄ OF FILTER TRENCH	5.0'-6.0'

GEOLOGIC ORIGIN	TESTED AT	APPROVED BY	DATE
	SML-LINCOLN	EFS	3/22/84

CLASSIFICATION CL LL 29 PI 13

CURVE NO. 2 OF 3

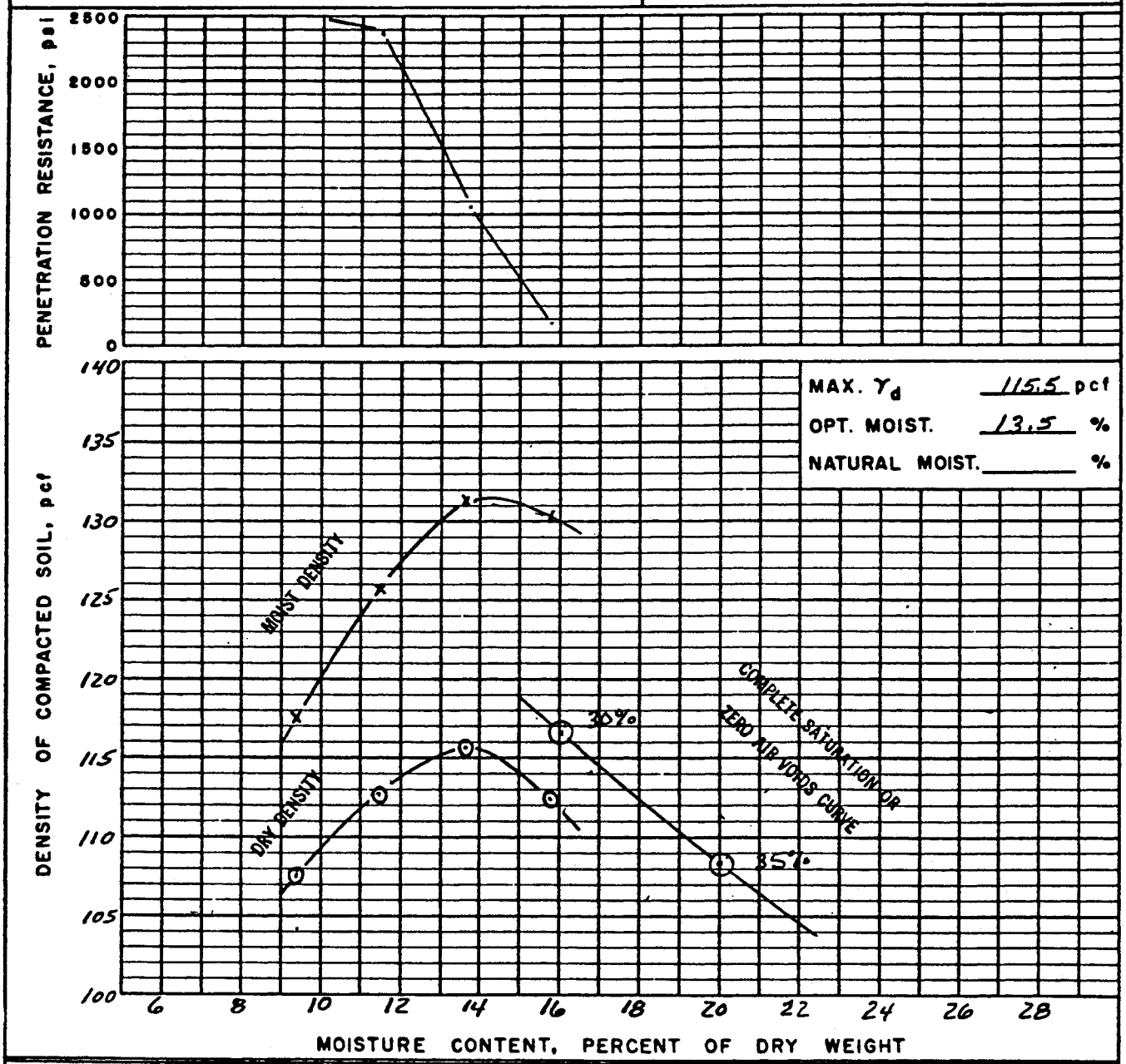
MAX. PARTICLE SIZE INCLUDED IN TEST <#4 "

SPECIFIC GRAVITY (G_s) { MINUS NO. 4 2.67 ; PLUS NO. 4 ____

STD. (ASTM D-698) ☒; METHOD A

MOD. (ASTM D-1557) ☐; METHOD ____

OTHER TEST ☐ (SEE REMARKS)



MAX. γ_d 115.5 pcf

OPT. MOIST. 13.5 %

NATURAL MOIST. ____ %

REMARKS

CURVE IS FOR THE MINUS NO. 4 FRACTION

GRADUATION OF TOTAL SAMPLE

< NO. 200 59 %; < NO. 4 98 %; < 3/4 IN. 100 %

USDA SCS-HYATTSVILLE MD. 1966

SCS-ENG-352 (REV. 3-70)
FILE CODE ENG-22

LABORATORY NO 84W2363

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	COMPACTION AND PENETRATION RESISTANCE

PROJECT and STATE: VINEYARD RD. STUDY #2, ARIZONA

FIELD SAMPLE NO.	LOCATION	DEPTH
3	123+02, U.S. SIDE OF FILTER TRENCH, CELL #2	6.0'-7.0'

GEOLOGIC ORIGIN	TESTED AT	APPROVED BY	DATE
	SML	EJB	3/22/84

CLASSIFICATION SC LL 26 PI 11

MAX. PARTICLE SIZE INCLUDED IN TEST < #4 "

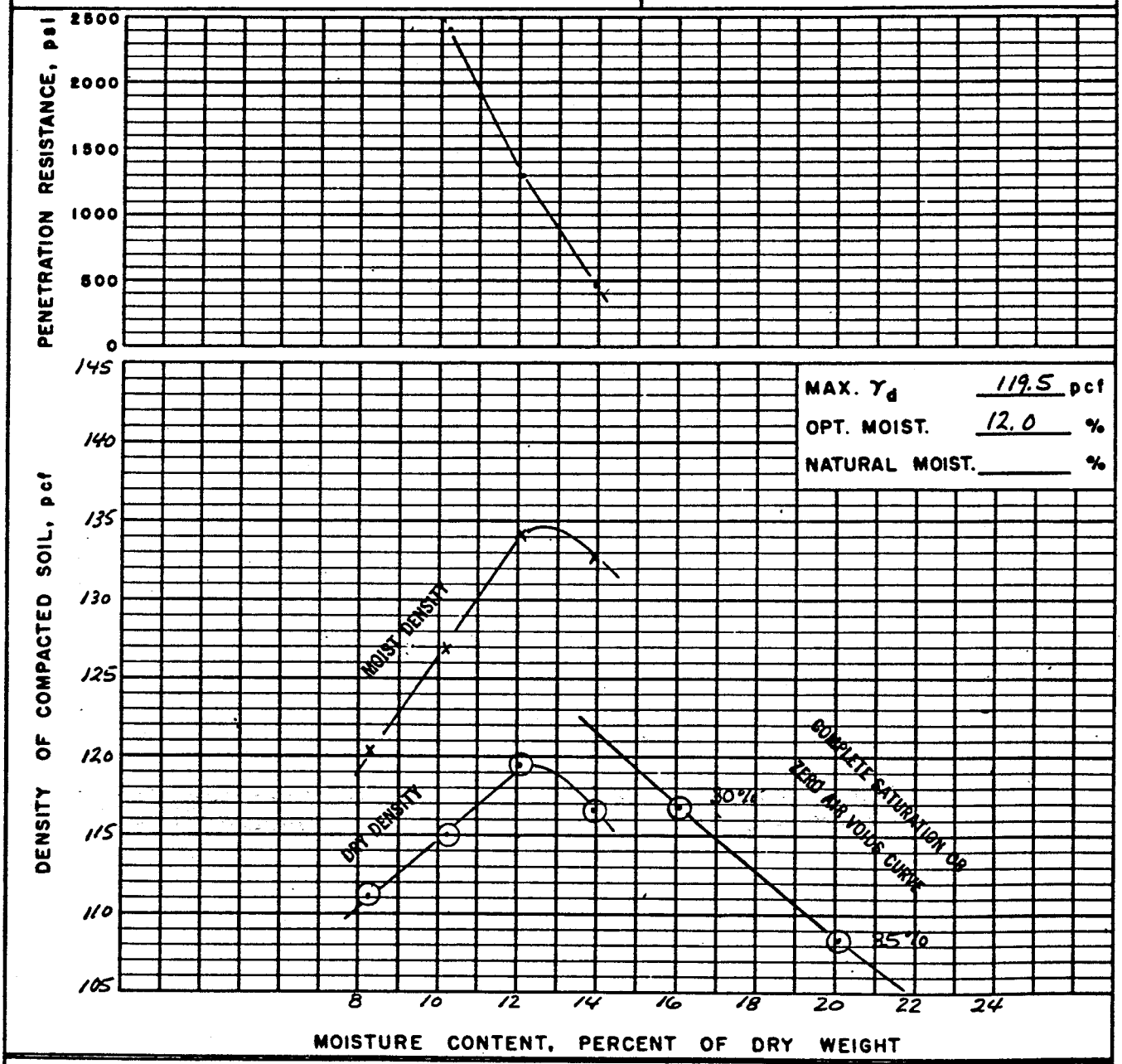
SPECIFIC GRAVITY (G_s) { MINUS NO. 4 2.67 ; PLUS NO. 4 ____

CURVE NO. 3 OF 3

STD. (ASTM D-698) ☒; METHOD A

MOD. (ASTM D-1557) ☐; METHOD ____

OTHER TEST ☐ (SEE REMARKS)



REMARKS

CURVE IS FOR THE MINUS NO. 4 FRACTION
GRADUATION OF TOTAL SAMPLE

< NO. 200 49 %; < NO. 4 97 %; < 3/4 IN. 100 %

USDA-SCS-HYATTSVILLE MD. 1968

SCS-ENG-353 (REV. 3-70)
FILE CODE ENG-22

LABORATORY NO 84W2369

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

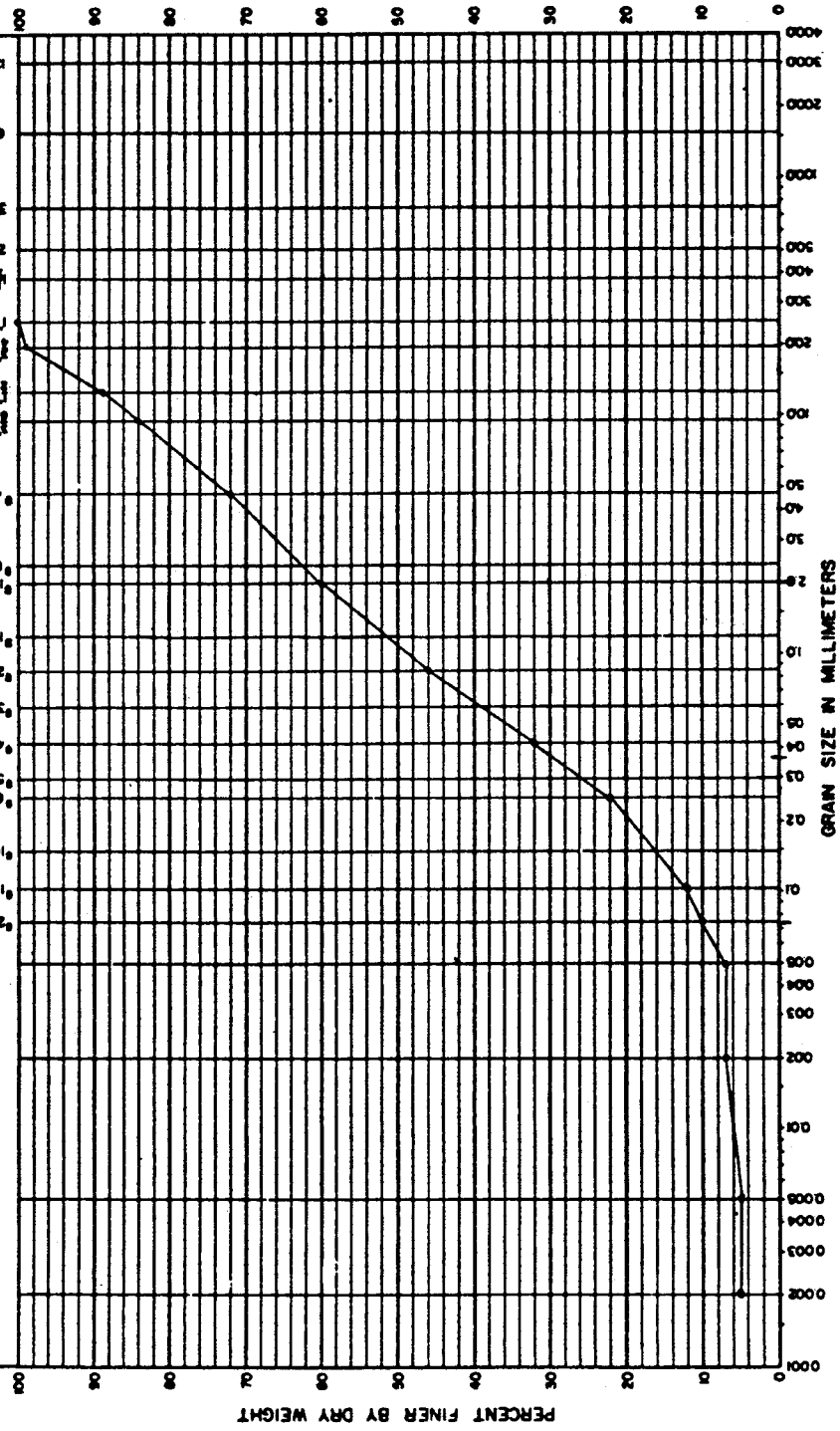
PROJECT and STATE: Vineyard Rd. Study #2		SAMPLE LOCATION: 121+74	
FIELD SAMPLE NO.: 9	DEPTH: 6-7	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE:	TESTED AT: SML	APPROVED BY: E.F.S.	DATE: 3/22/84
SYMBOL: SP-SM	DESCRIPTION: Poorly graded silty sand		

GRAIN SIZE DISTRIBUTION

C_u 0.86
C_c 26.7
$D_{MAX.}$
D_{85}
D_{60} 2.0
D_{50}
D_{30} .36
D_{15}
D_{10} .015

COBBLES | GRAVELS | SANDS | FINES

SIEVE OPENING (mm) | U.S. STANDARD SIEVE SIZE



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

SOLUBLE SALTS %

SHRINKAGE LIMIT %

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

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

REMARKS:

SCS-ENG-353 (REV. 3-70)
FILE CODE ENG-22

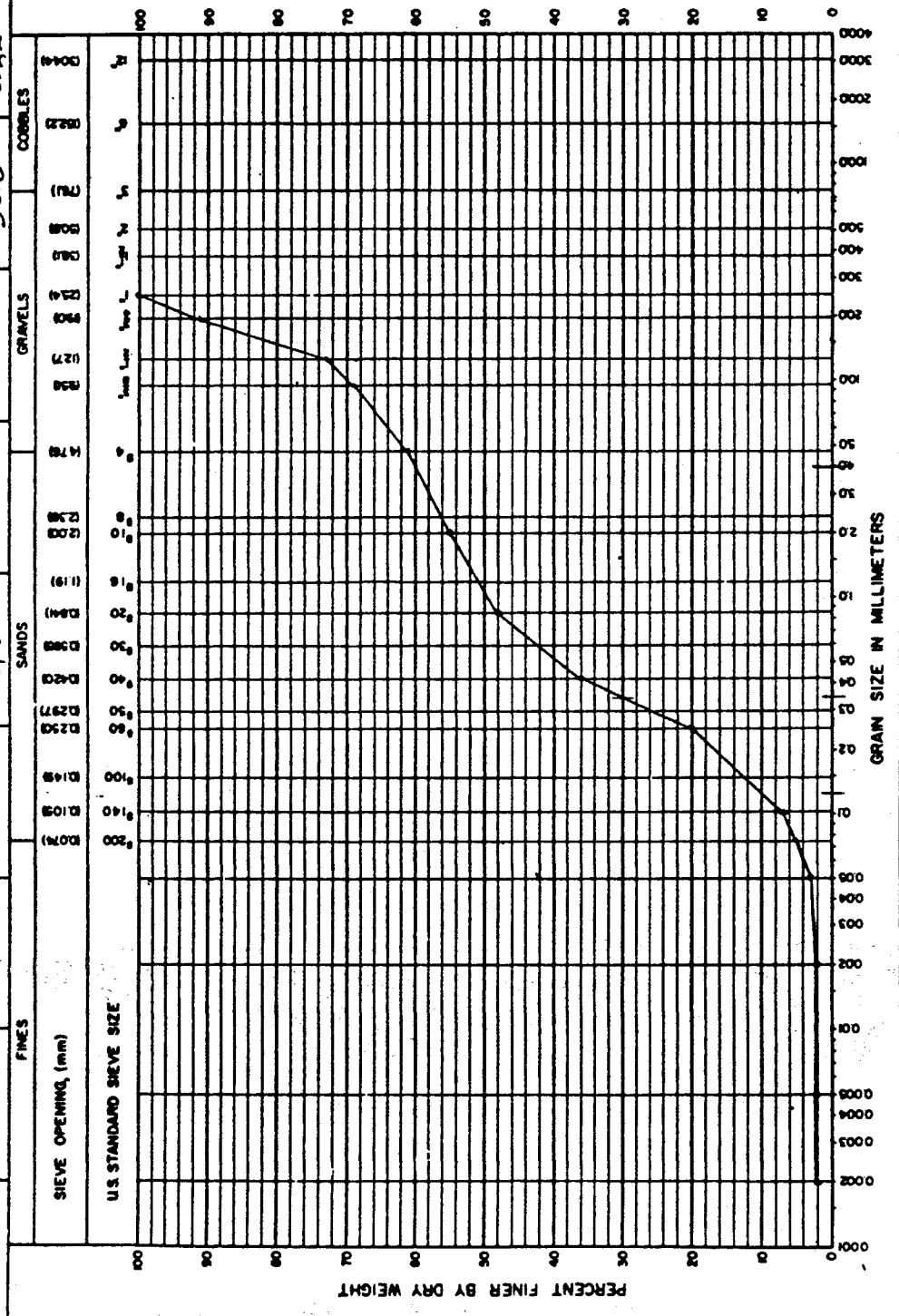
LABORATORY NO 84W2370

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

PROJECT and STATE: Vineyard Rd Study #2			SAMPLE LOCATION: 104+35
FIELD SAMPLE NO.: 1D	DEPTH: 8	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE:	TESTED AT: SML	APPROVED BY: EFS	DATE: 3/22/84
SYMBOL: SP-SM	DESCRIPTION: Poorly graded silty sand		

GRAIN SIZE DISTRIBUTION

D_{10} .13 | D_{15} | D_{30} .34 | D_{50} | D_{60} 4.0 | D_{85} | D_{MAX} | C_u 30.8 | C_c 0.22



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

SHRINKAGE LIMIT %

SOLUBLE SALTS %

ATTERBERG LIMITS: NATURAL MOISTURE, AIR DRY, OVEN DRY — LL, PI

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

REMARKS:

SCS-ENG-353 (REV. 3-70)
FILE CODE ENG-22

LABORATORY NO 84W 2371

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

PROJECT and STATE: Vineyard Rd. Study #2			SAMPLE LOCATION: 105+01
FIELD SAMPLE NO.: 11	DEPTH: 18.5-18.7	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE:	TESTED AT: SML	APPROVED BY: EFS	DATE:
SYMBOL: SPSM	DESCRIPTION: Poorly graded silty sand		

GRAIN SIZE DISTRIBUTION

C_c 1

C_u 5.42

D_{MAX}

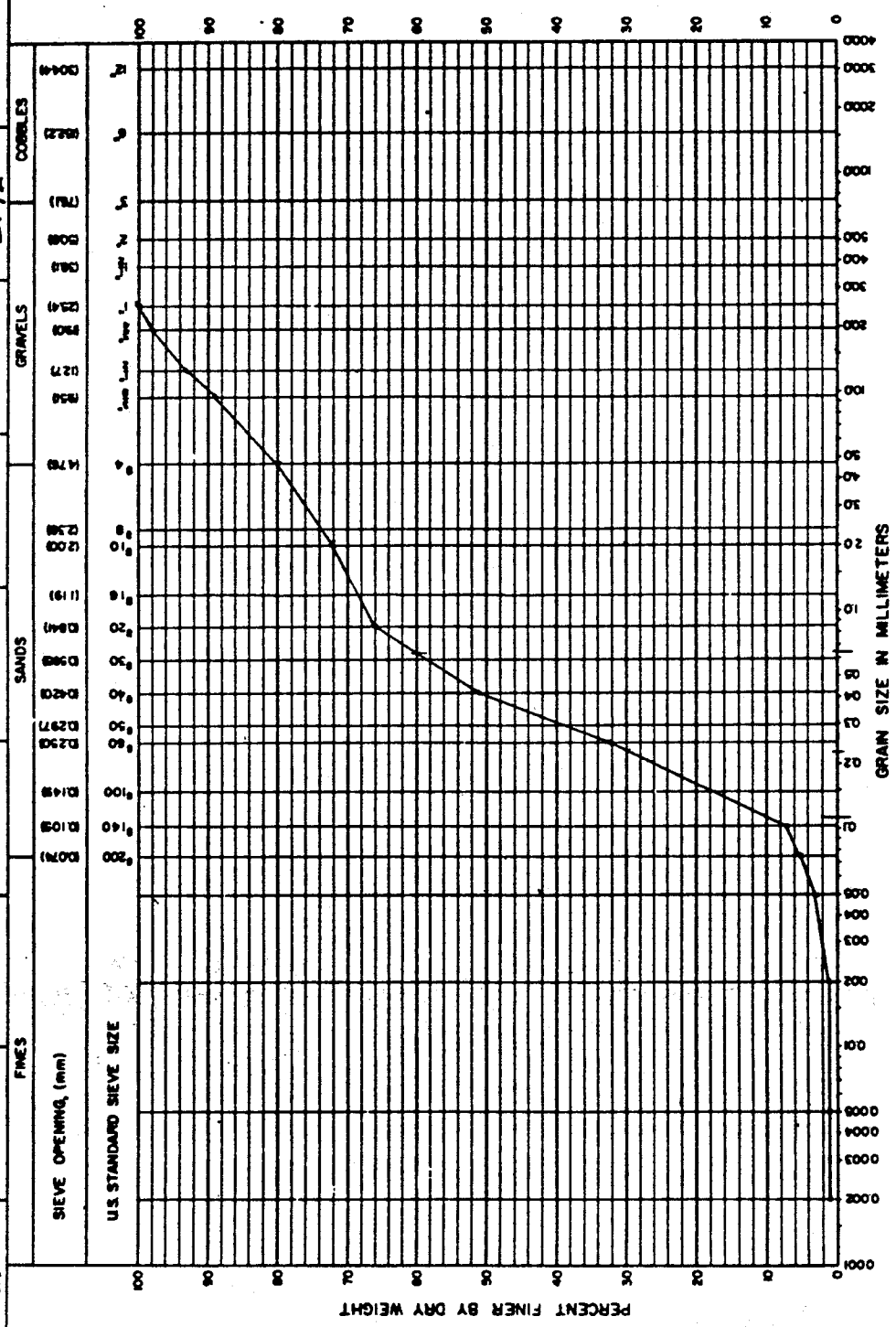
D_{60} .65

D_{50}

D_{30} .22

D_{10}

D_{10} .12



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

SHRINKAGE LIMIT %

SOLUBLE SALTS %

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

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

REMARKS:

608

United States Department of Agriculture

Soil Conservation Service

Midwest National Technical Center
Soil Mechanics Laboratory
512 South 7th Street
Lincoln, NE 68508

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Williams-Chandler
Site: Vineyard Road

Date: February 14, 1984

To: Ralph M. Arrington
State Conservation Engineer
SCS, Phoenix, AZ

File Code: 210-22

Test data requested from the National Soil Survey Laboratory for the subject project are attached.

Lorn P. Dunnigan

LORN P. DUNNIGAN
Head, Soil Mechanics Laboratory

Attachment

cc:
Ralph M. Arrington (Original + 3 copies)
Jack C. Stevenson, Head, Engineering Staff, WNTC, SCS, Portland, OR (ltr only)
Clifton E. Deal, Soil Mechanics Engineer, Engineering Staff, WNTC, SCS, Portland, OR

United States
Department of
Agriculture

Soil
Conservation
Service

Midwest National Technical Center
Federal Building, Room 345
100 Centennial Mall North
Lincoln, NE 68508

FTS 541-5363; Commercial 402-471-5363

Subject: SOILS - Soil Mechanics, 1984: Lincoln (Williams-Chandler-Vineyard Rd., Arizona) RT84-SM017

Date: February 9, 1984

To: Lorn P. Dunnigan, Head
Soil Mechanics Laboratory
Soil Conservation Service
512 South Seventh Street
Lincoln, NE 68508

File Code: 430-13-5

We have completed the analyses for the project. Five copies of the printout are attached.

Wiley D. Nettleton

WILEY D. NETTLETON
Liaison to the West
National Soil Survey Laboratory

Attachments

cc:
S. M. Leckband, Design Engineer, AZ State Office, SCS, Phoenix, AZ
C. S. Holzhey, Head, NSSL, MNTC, SCS, Lincoln, NE

USDA - SOIL CONSERVATION SERVICE
NATIONAL SOIL SURVEY LABORATORY
LINCOLN, NEBRASKA

PROJECT : RT84-SM017 FEB 2, 1984

NSSL NUMBER	SML NUMBER	X-RAY DIFFRACTION (7A2B)	DTA (7A3) %KK	DTA (7A3) %GI	TOTAL ANALYSIS (6Q3A) %K2O	TOTAL ANALYSIS (6C7A) %FE
		- - - - CLAY MINERALOGY - - - - -				
84Q0069	84-W-658	MI3 MT3 KK2	6	-	2.4	4.8
84Q0070	84-W-659	MI4 MT3 KK2 QZ1	9	-	3.3	5.8
84Q0071	84-W-660	MI3 MT3 KK2	9	-	2.8	5.2
84Q0072	84-W-661	MI3 MT3 KK2 CL1	8	-	2.5	5.0
84Q0073	84-W-662	MI3 MT3 KK2	7	-	2.5	5.0
84Q0074	84-W-663	MI3 MT3 KK2 QZ1	6	-	2.6	5.0
84Q0075	84-W-664	MI3 MT3 KK2	7	-	2.2	4.5
84Q0076	84-W-665	MI3 MT3 KK2	5	-	2.5	4.5
84Q0077	84-W-666	MI3 MT3 KK2 VR1	7	-	2.6	4.9
84Q0078	84-W-667	MI3 MT3 KK2 VR1	4	-	2.8	4.5

MINERAL CODE:

MI - MICA/ILLITE
MT - MONTMORILLONITE
KK - KAOLINITE
VR - VERMICULITE
CL - CHLORITE
QZ - QUARTZ

RELATIVE AMOUNTS (X-RAY):

1 - TRACE
2 - SMALL
3 - MODERATE
4 - ABUNDANT
5 - DOMINANT
6 - INDETERMINATE

file

United States Department of Agriculture

Soil Conservation Service

Midwest National Technical Center
Soil Mechanics Laboratory
512 South 7th Street
Lincoln, NE 68508

Subject: ENG - Soil Mechanics - Arizona (WF-08)
Williams-Chandler
Site: Vineyard Road

Date: December 7, 1983

To: Ralph M. Arrington
State Conservation Engineer
SCS, Phoenix, AZ

File Code: 210-22

Test data requested are recorded on the attached form SCS-ENG-354 for ten samples submitted from the subject site. The National Soil Survey Laboratory is determining clay mineralogy and we will forward this data when we receive it.

Lorn P Dunnigan

LORN P. DUNNIGAN
Head, Soil Mechanics Laboratory

Attachment:
Form SCS-ENG-354, Soil Mechanics Laboratory Data, 2 sheets

cc:
Ralph M. Arrington (Original + 3 copies)
Jack C. Stevenson, Head, Engineering Staff, WNTC, SCS, Portland, OR (ltr. only)
Clifton E. Deal, Soil Mechanics Engineer, Engineering Staff, WNTC, SCS, Portland, OR

SCS-ENG-354
Rev. 3-70
FILE CODE ENG-13-10

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 1 of 2

9/1/83

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	0.005	0.02	0.05	#200 0.074	Sand: #100 0.149	#60 0.250	#40 0.42	#20 0.84	#10 2.0	#4 4.76	Gravel: 3/8" 9.525	1/2" 12.7	3/4" 19.05	1" 25.4	1 1/2" 38.1	3" 76.2 mm	Atterberg Limits: L.L.	P.L.	Unified Classification	Soluble Salts %	Dispersion % Moist Soil	Moisture-Density Relationships: Standard / Modified: Curve No.	Max. γd p.c.f.	%	Undisturbed Sample Data: γd g/cc	%	Gs	Special Tests: Clay Test		%w 60°C	%w 60°C to 105°C	%w Total
84W		ARIZONA Williams-Chandler Site: Vineyard Road																																				
658	1	Dam, 4.5' Right of ℄ 104+11 S. Bag	3.0-3.5		23	24	33	46	60	67	77	85	90	94	96	97	97	100				31	15	CL		Tr						2.69	1		11.25	0.60	11.85
659	2	Dam, 4.5' Right of ℄ 104+11 S. Bag	5.0-5.5		25	27	34	48	61	67	78	84	91	97	99	100						33	17	CL		4							2		17.99	0.65	18.64
660	3	Dam, 4.5' Right of ℄ 104+11 S. Bag	7.0-7.5		24	26	31	48	61	68	79	85	90	94	96	97	97	97	100			30	15	CL		4							1		15.72	0.72	16.44
661	4	Dam, 4.5' Right of ℄ 104+65 S. Bag	2-3		21	22	26	34	45	51	62	70	78	88	93	97	98	100				31	16	SC		Tr						2.70	1		12.57	0.60	13.17
662	5	Dam, 4.5' Right of ℄ 104+65 S. Bag	5.0-5.5		23	24	30	49	63	70	81	87	93	97	98	99	99	100				29	13	CL		Tr							2		14.17	0.56	14.73
663	6	Dam, 4.5' Right of ℄ 104+65 S. Bag	7-8		25	27	35	51	66	72	82	87	92	96	99	100						33	17	CL		Tr							4		14.31	0.80	15.11
664	7	Dam, 7' Right of ℄ 105+01 S. Bag	3.0-3.5		23	24	30	42	56	61	75	82	89	96	98	99	100					26	11	CL		4						2.70	2		15.03	0.52	15.55
665	8	Dam, 7' Right of ℄ 105+01 S. Bag	5.0-5.5		24	25	30	46	62	69	80	87	93	98	99	100						29	13	CL		Tr							4		13.35	0.59	13.94

SCS-ENG-354
Rev. 3-70
File Code ENG-13-10

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL MECHANICS LABORATORY DATA
Sheet 2 of 2

9/1/83

Laboratory Sample Number	Field Number	Location and Description	Depth	Field Classification	Mechanical Analysis: Grain Size Distribution Expressed as Percent Finer by Dry Weight — Fines: 0.002 mm	Fines: 0.005	Fines: 0.02	Fines: 0.05	Fines: #200 0.074	Sand: #140 0.105	Sand: #60 0.250	Sand: #40 0.42	Sand: #20 0.84	Sand: #10 2.0	Sand: #4 4.76	Gravel: 3/8" 9.525	Gravel: 1/2" 12.7	Gravel: 3/4" 19.05	Gravel: 1" 25.4	Gravel: 1 1/2" 38.1	Gravel: 3" 76.2 mm	Atterberg Limits: L.L.	Atterberg Limits: P.I.	Unified Classification	Soluble Salts %	Dispersion % Finer Soil	Moisture-Density Relationships: Standard / Modified: Dry Den.	Moisture-Density Relationships: Max. γd p.c.f.	Moisture-Density Relationships: Opt. %	Undisturbed Sample Data: γd p.c.f.	Undisturbed Sample Data: %	G_s	Special Tests: Clang Test		%w 60°C	%w 60°C to 105°C	%w Total
84W																																						
666	9	Dam, 7' Right of ℄ 105+01 S. Bag	7-8		21	21	27	33	53	59	75	82	90	97	99	100						25	10	CL		5							2		13.24	0.66	13.90
667	10	Dam, 7' Right of ℄ 105+01 S. Bag	9.5-10.0		23	24	29	45	57	64	76	83	89	95	98	99	99	100				28	12	CL		4							2		11.63	0.67	1230

DESIGN

1-12-89
by DB

SUBJECT:
Use of Earthfill Spec. for Drainfill:

After review of the material covered in the drainfill spec my recommendation would be to use it as is. If the soundness testing is a concern then it can be deleted in the items of work.

11AM — call to Cliff Deal WATC

Cliff agrees with the current use of the drainfill spec and not deleting the soundness testing. However, Cliff brought up the following points regarding compaction.

1. Drainfill being placed concurrently with earthfill should be compacted > 70% (min density w/o bulking) relative density or equivalent 95% of a modified compaction. (Nuclear testing may be used to verify)

2. Where drainfill is going into a trench and compaction can not be obtained as in the earthfill process then the moisture should be specified the same as that, that would give you min. density for drainfill without bulking. Most likely 10 to 12% moisture.

NOTE: 85% of this job has been completed with no control of moisture and no compaction. Recommend completion in same manner. (Dam is only as good as the rest of it

Az. Vineyard Road FRS Drain Repair

D.E. Paulus 11/10/88

Gradation design. / |

The attached SCS-ENG-353's show the gradation of the base soil, within the remaining reaches of drainfill repair, which represents the highest amount of fines and the average amount of fines.

Design gradation limits of the drainfill material using SMN-#1 compute to be the same for both base materials. The limits are shown for sample #54.

C-33 fine aggregate meets the gradation design according to SMN-1, (plotted)

The specified limits of the previous Vineyard drain repair (also plotted) contract falls slightly outside the upper level of the D_{15} material, according to SMN-1. Also the C-33 material does not fall within the old Vineyard gradation.

To prevent segregation due to broadness of the filter gradation design, SMN-1 suggests for a Min. $D_{10} < 0.5$ mm the max. D_{90} should be 20mm.

D_{90} (OLD DESIGN) ≈ 23 mm

D_{90} (C-33) ≈ 4 mm

∴ I recommend using C-33 material to minimize segregation during placement of the material.

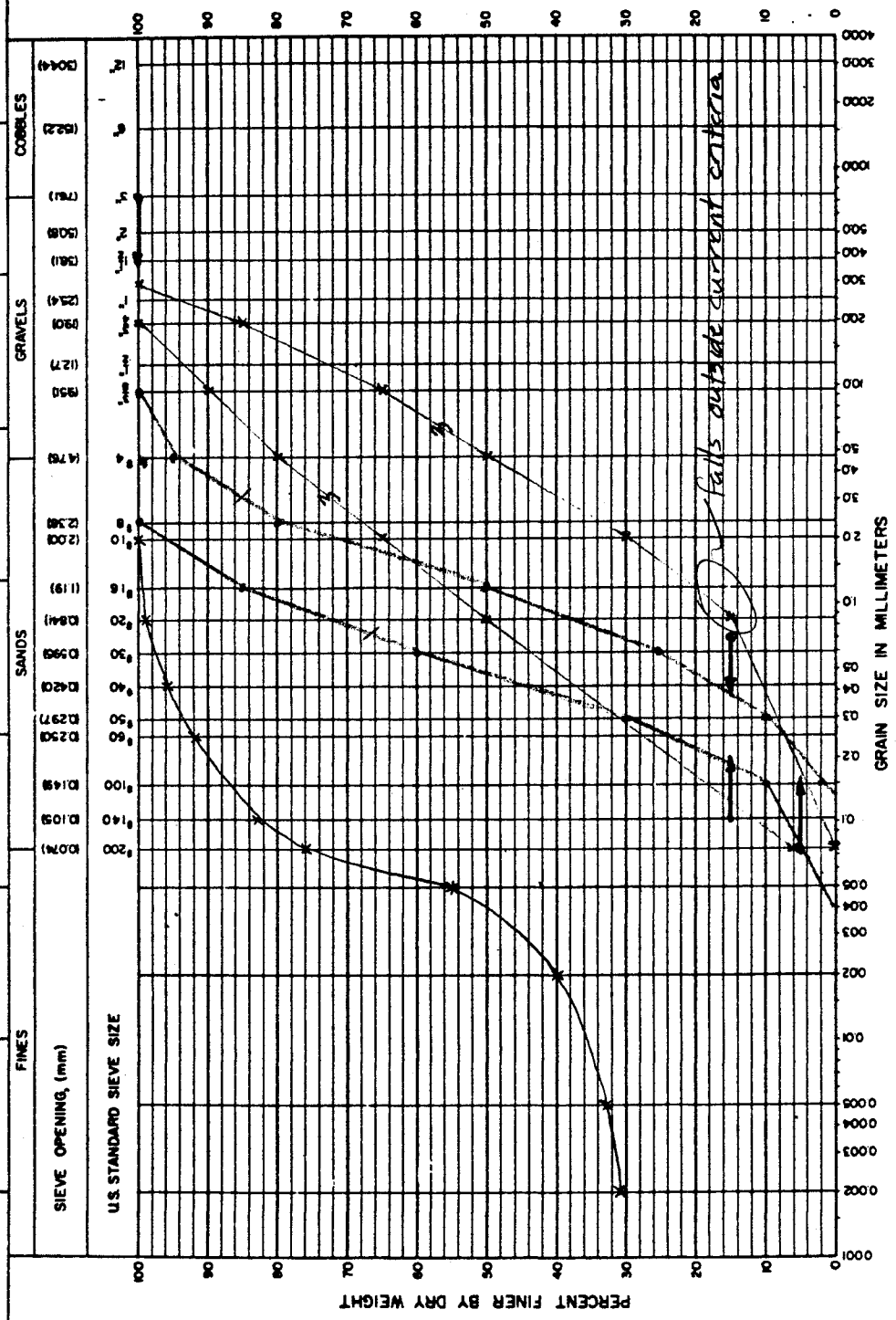
REF: Soil Mechanics test results from Lincoln Lab. dated March 29, 1985
April 26, 1985
June 12, 1985

SCS-ENG-353 (REV. 3-70)
FILE CODE ENG-22

LABORATORY NO. 977

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

PROJECT and STATE: Vineyard Road FRS Repair, Az.			SAMPLE LOCATION: 107+60 ℄
FIELD SAMPLE NO.: 54	DEPTH: 3.5 to 4.0	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE: Undist.	TESTED AT: Lincoln	~~APPROVED BY~~ Design: D.E. Paulus	DATE: 11/8/88
SYMBOL: CL	DESCRIPTION:		



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

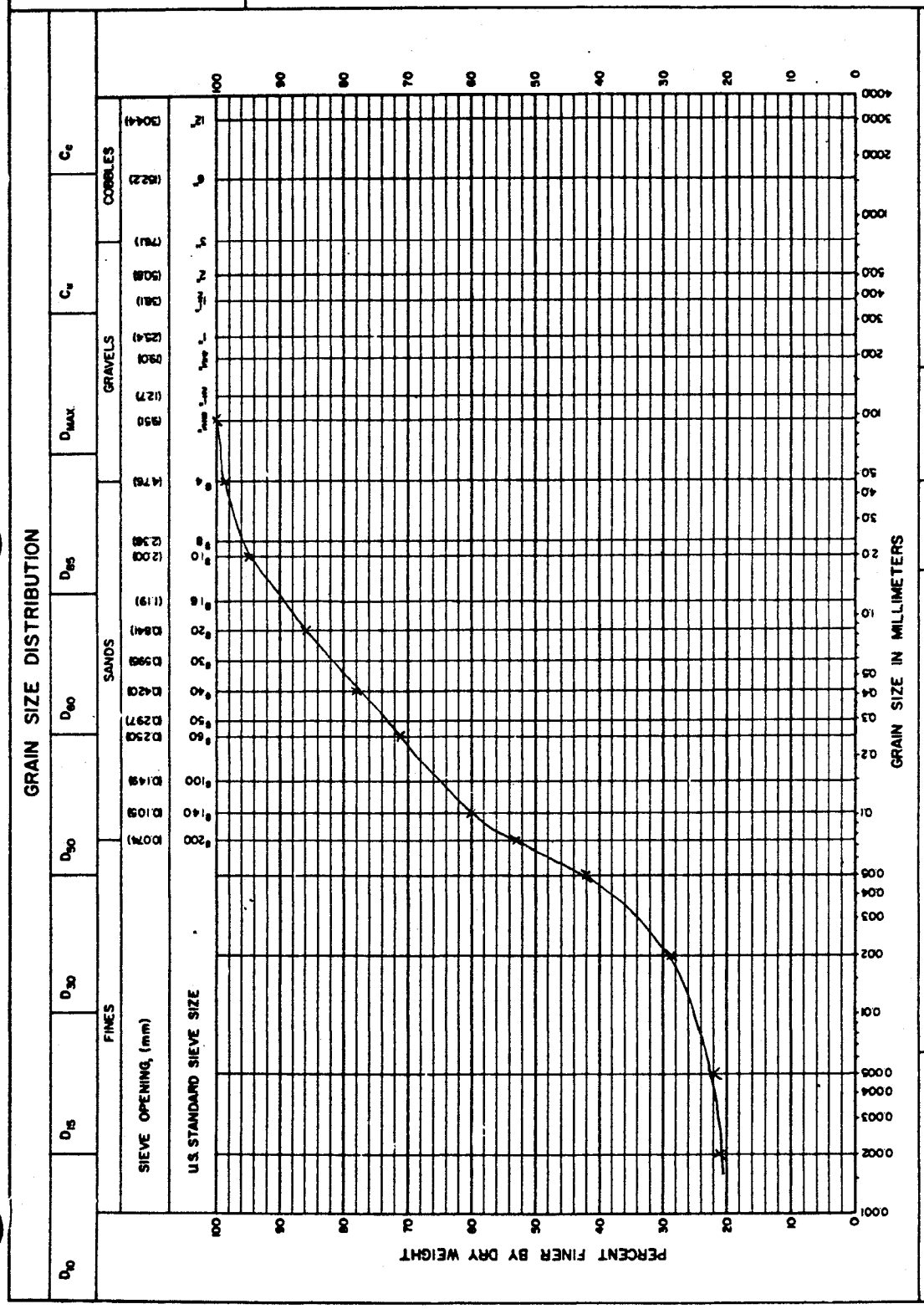
REMARKS: *This sample represents the highest amounts of fines within the repair reaches
SMU #1 Design – Base material is cat. #2
P.I. = 0 for material < #40 sieve. ASTM-D-4318
+ ≡ C-33 material limits
✱ ≡ SMU-1 Limits
✱ ≡ OLD Dmin design limits

SCS-ENG-353 (REV. 3-70)
FILE CODE ENG-22

LABORATORY NO. 888

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

PROJECT and STATE: Vineyard Road FRS Repair, Az.			SAMPLE LOCATION: 120+00 ℄
FIELD SAMPLE NO.: 51.1	DEPTH: 6.0-7.5	GEOLOGIC ORIGIN:	
TYPE OF SAMPLE: S. Bag	TESTED AT: LINCOLN	~~APPROVED BY~~: Designed D.E. Paulus	DATE: 11/8/88
SYMBOL	DESCRIPTION		



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

REMARKS: This sample represents approx. average gradation within the repair reaches. SMU #1 design — same as that for soil sample #54

Az Vineyard FRS Drain Repair

DEPaulus 11/10/88

Breach of the FRS for embankment repairs

Discussion took place on 10/4/88 at the preliminary design presentation meeting with the FCD & ADWR. Possible alternatives to handle the breach during construction were: 1) Limit the time for that phase of construction; 2) Specify a construction sequence, 3) Let the contract such that the construction would take place during the non-rain periods, 4) Do nothing - the actual time for the contractor to finish this phase of work would be minimal. In addition, there will be +5.5' elevation difference between the principal spw. crest and the invert of the breached section allowing for a substancial amount of storage (including sect. storage area still avail.) - See attach. detailed elevation/storage information.

Recommendation is not to take any further precautionary measures except to make the contractor aware, and specify that once the contractor opens a section of the dam he shall continually work at this site until <u>all</u> earthfill has been placed according to the plans & specifications.

RE: Breach of FRS at cells 2 & 5

FACTS ABOUT VINEYARD RD. FRS

1. Principle Spillway Elev. - 1563.00
2. Top of Dam Elev. - 1579.50
3. Breached Dam Repair Elev. "1568.50"
4. Length of Dam 5.45 miles
5. Flood Pool Elev. - 1578.20
6. Flood Pool Capacity - 4325 AcFt.
7. Crest of Emer. Spw. - 1574.80

P

Arizona Vineyard Rd Dam
Watt 6-20-65
Floodrouting Results

Principal Spillway Crest	1566 ±
Emergency Spillway Crest	1574 ±
Sediment Volume	185 AcFt
Water Surface 10 day drawdown	1573.5
Max W.S. Emg Sp Hydrograph	1575.5
" " Freeboard Hyd.	1578.2
Top Dam 1' Settlement + 3.0' F.B. above 75 ±	1579.5
Floodwater Retarding Volume	4325 AcFt
Vel Emg Sp Design Hyd	1.5 ft/sec
" " " Freeboard Hyd	6.2 ft/sec

3' FB above routed E.S. Design Flow + Sediment
Unrouted flow: 0.7
= 1574.8 + 3.7 = 1578.5

Add 1' Settlement 1579.5'

Arizona Vineyard Road Dam

JMM 12-10-64

Floodrouting results & elevations

		1% Drawdown Time 10 Day	30 Day
Principal Spillway crest	elevation	1565.6	1565.6
Emergency Spillway crest	elevation	1574.9	~~1574.4~~ 1574
Sediment Volume	AF	185	185
Water Surface after 10 day drawdown		1564.6	1573.5 ~~1574.0~~
Available Storage to crest of em. Sp.		3814	996
Max. W.S. after routing Em. Sp. Hydrograph		1571.8	1575.45 ~~1576.4~~
Max W.S. after routing Fbd. Hydrograph		1577.4	1578.2 ~~1579.2~~
Floodwater retarding Volume	AF	3814	4325 ~~4127~~
Pr. Sp. Release Max	cfs	709	327
Maximum Em. Sp. Velocity	ft/sec		N. 6.15, S 6.0

5.25

75.5
74.8
0.7

1577.4
1575.4
~~1.6~~
3.8

COMPUTATION SHEET
SCS-523A REV 5-58

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE Arizona PROJECT Vineyard Road Dam
BY GDH DATE 6-15-65 CHECKED BY DATE JOB NO.
SUBJECT Storage Vs. Cfs-hrs. SHEET OF

From Runoff volume-duration Curves = 1.1

D. A. = [redacted] $\frac{640}{12} = 53.33$

Silt Pool El. = 1566.2

Emerg Spwy (@ 30 day drawdown) = El. 1574.8

Storage = (1.1 X 53.9 X 53.33) + 178 = [redacted] = El. 1573.5

Table (1)

El.	Storage Ac. ft.	Storage above El. 1573.5	Storage X 12.1 = cfs-hrs	Total Disc. cfs. (see table 2)
1573.5	3,311	0		305
1574.0	3,675	364	4,404	313
1574.8	4,325	1,014	12,270	326
1575.0	4,500	1,189	14,387	
1576.0	5,400	2,089	25,277	1,899
1577.0	6,380	3,069	37,135	3,708
1578.0	7,500	4,189	50,687	6,346
1579.0	8,630	5,319	64,660	10,534
1580.0	9,820	6,509	78,759	17,547

Table (2) Principal & Emerg. Spwy. discharge

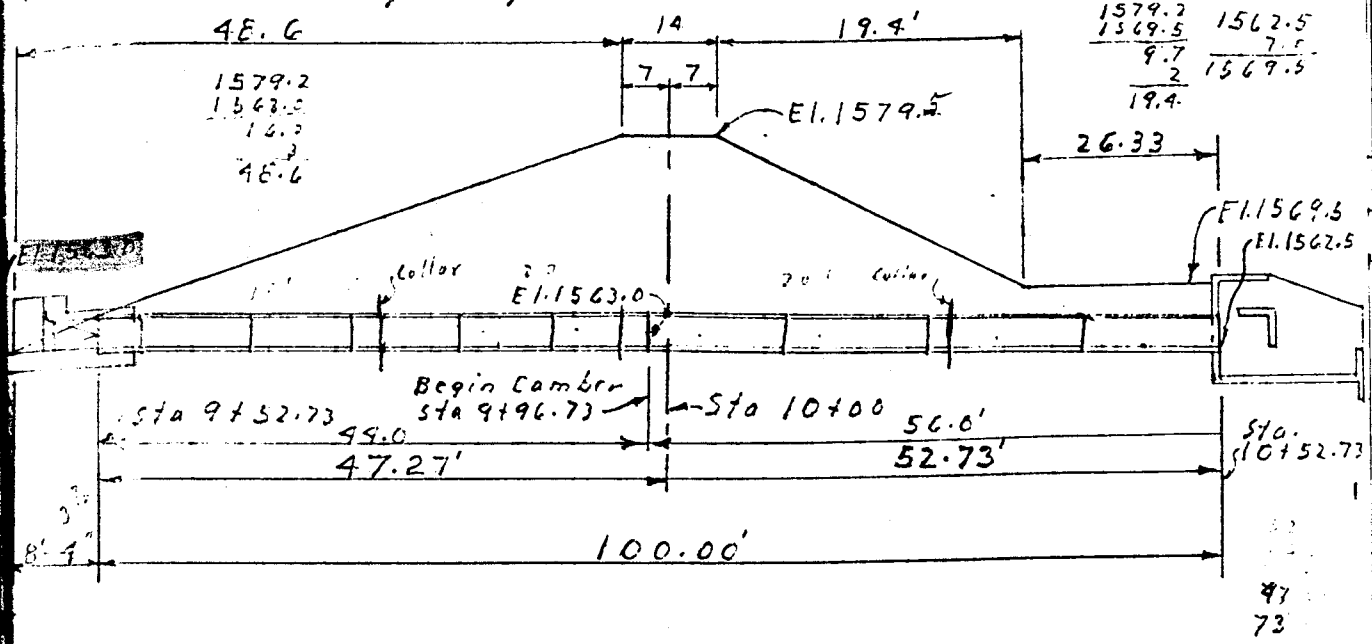
El.	Pr. Spwy cfs.	(S) Em. Spwy cfs	(N) Em. Spwy. cfs.	Total Discharge
1573.5	305			305
1574.0	313			313
1574.8	326	0	0	326
1576.0	344	750	800	1,899
1577.0	358	1660	1,750	3,708
1578.0	371	2900	3,075	6,346
1579.0	384	5150	5,000	10,534
1580.0	397	9,550	7,600	17,547

DAM Alignment

Arizona — Vineyard Road Dam

GDH 9-3-65

Principal Spillway Layout



1	2	3	4	5	6	7	8
Sta.	L	x	x/L	$(x/L)^2$	e	y Col. 5 x 6	El.
9+52.73	0	0	0	0	0	0	1563.0
9+96.73	44	44	1	1	0	0	1563.0
[illegible]	56	16	0.28571	0.081630	.50	0.04	1562.96
[illegible]	56	32	0.57142	0.32652	.50	0.16	1562.84
[illegible]	56	48	0.85714	0.73469	.50	0.37	1562.63
[illegible]	56	56	1.0	1.0	.50	0.50	1562.50

Number of cutoff collars $l = 47.27 + 26.40 = 73.67$ say 74'

$V = 2.0'$

$$n = \frac{0.075 l}{V} = \frac{0.075 \times 74}{2} = 2.78 \text{ use 3 collars @ 20' c-c}$$

QUANTITIES

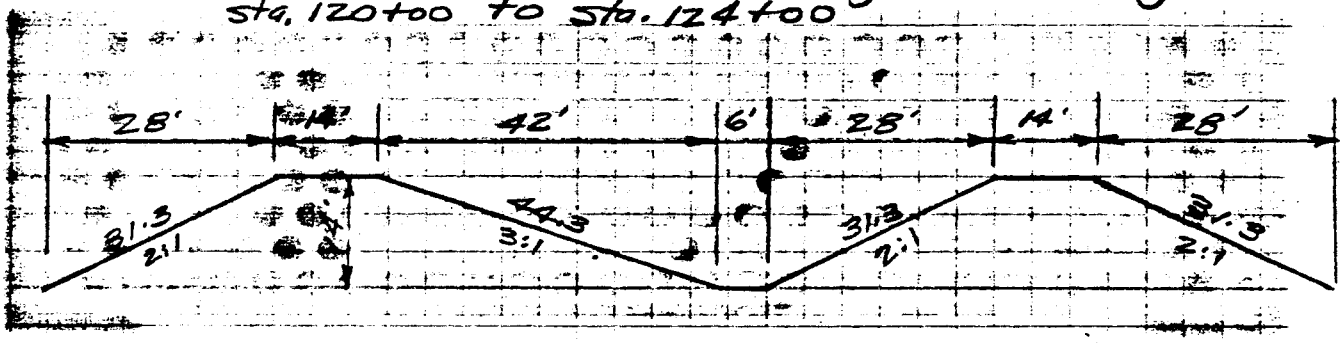
CLEARING & GRUBBING

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE ARIZONA		PROJECT VINEYARD ROAD FRS EMBANKMENT & DRAINFILL REPAIR		
BY J.E.B.	DATE FEB. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT CLEARING & GRUBBING CELL 1				SHEET ____ OF ____

Test Cell No. 1 Clearing & Grubbing
sta. 120+00 to sta. 124+00



Length of 2:1 slope $\sqrt{14^2+28^2}$ = 31.3 ft.

Length of 3:1 slope $\sqrt{14^2+42^2}$ = 44.3 ft

TOTAL width = 31.3 + 14 + 44.3 + 6 + 31.3 + 14 + 31.3

CALL 172 ft. wide (slope surfaces)

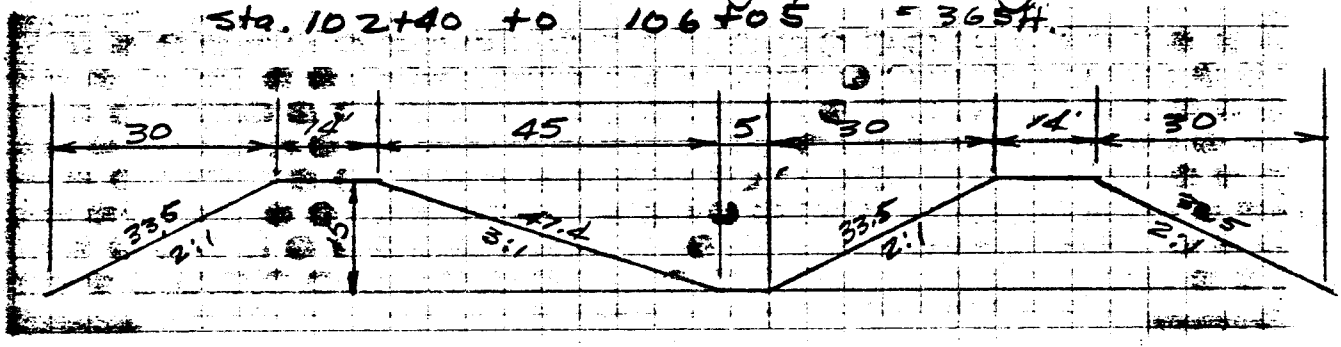
$$\frac{(172')(400')}{43560} = 1.58 \text{ Acres}$$

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	VINEYARD ROAD FRS EMBANKMENT & DRAIN FILL REPAIR		
BY JEB / DATE FEB 1989	CHECKED BY	DATE	JOB NO.
SUBJECT CLEARING & GRUBBING CELL 2			SHEET ____ OF ____

Test Cell No. 2 Clearing & Grubbing
Sta. 102+40 to 106+05 = 365'.



Length of 2:1 slopes = $\sqrt{15^2 + 30^2}$ = 33.5'

Length of 3:1 slopes = $\sqrt{15^2 + 45^2}$ = 47.4

TOTAL WIDTH = 33.5 + 14.0 + 47.4 + 5.0 + 33.5 + 14.0 + 33.5 = 180.9

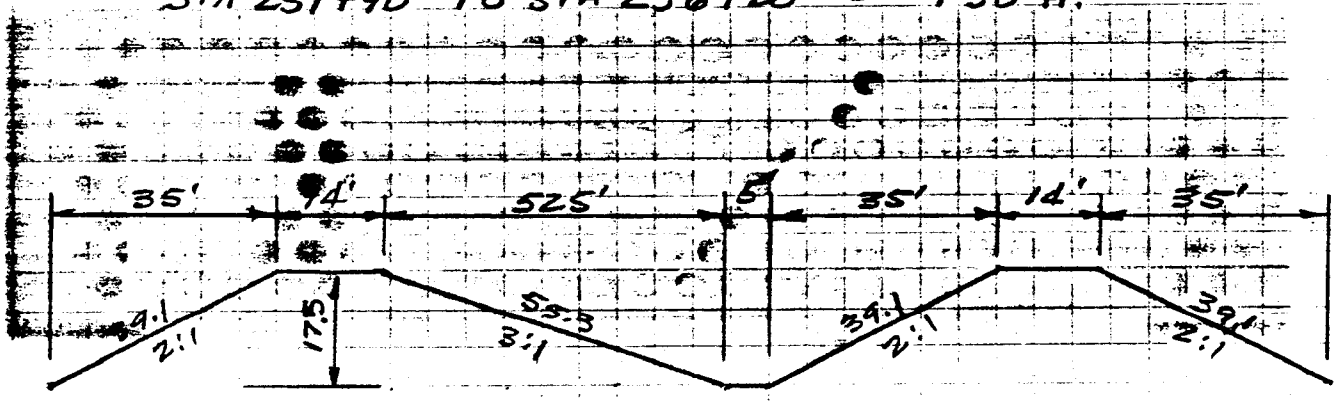
$$\frac{(181')(365')}{43560} = 1.52 \text{ Acres}$$

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE ARIZONA		PROJECT VINEYARD ROAD FRS EMBANKMENT & DRAINFILL REPAIR	
BY JEB	DATE FEB 1989	CHECKED BY	DATE	JOB NO.
SUBJECT CLEARING & GRUBBING CELL NO.3			SHEET ____ OF ____

TEST CELL NO.3 CLEARING AND GRUBBING
STA 251+90 to STA 256+20 = 430 ft.



Length of 2:1 slope = $\sqrt{17.5^2 + 35^2}$ = 39.1

Length of 3:1 slope = $\sqrt{17.5^2 + 52.5^2}$ = 55.3

TOTAL WIDTH 39.1 + 14 + 55.3 + 5' + 39.1 + 14 + 39.1

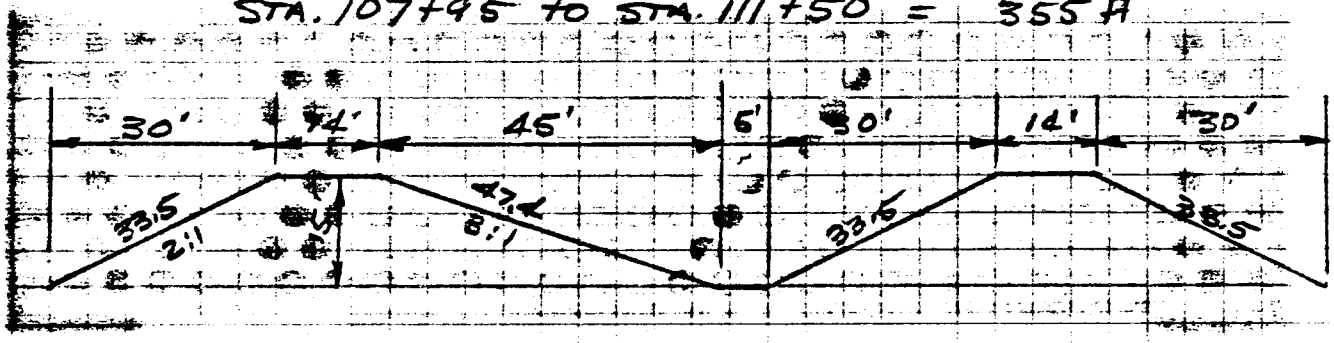
$$\frac{(200.6')(430')}{43560} = 1.98 \text{ ACRES}$$

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		VINEYARD ROAD FRS EMBANKMENT & DRAINFILL REPAIR		
BY JEB	DATE FEB. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT CLEARING & GRUBBING CELL No. 5				SHEET ____ OF ____

TEST CELL NO. 5 CLEARING & GRUBBING
STA. 107+95 to STA. 111+50 = 355 ft



Length of 2:1 slope $\sqrt{15^2+30^2}$ = 33.5 ft.

Length of 3:1 slope $\sqrt{15^2+45^2}$ = 47.4 ft.

TOTAL WIDTH 33.5 + 14 + 47.4 + 5 + 33.5 + 14 + 33.5

$$\frac{(181')(355')}{43560} = 1.48 \text{ Acres}$$

TRENCH EXCAVATION & DRAINFILL

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT			
ARIZONA	Vineyard Road F.R.S. Embankment & Drainfill Repair			
BY J.E.B.	DATE Feb. 1989	CHECKED BY	DATE	JOB NO. Summary of Drainfill
SUBJECT TRENCH EXCAVATION & DRAINFILL QUANTITIES				SHEET 1 OF 3

LIST DRAIN FILL REPAIRS BY STATIONING

	BEGIN STA.	END STA.	TRENCH EXCAVATION	DRAIN FILL PAY LIMIT AREA	DRAIN FILL TO PURCHASE
cell 2	102+00	106+50	711 cy	911 cy	1204 cyd
cell 5	107+60	111+80	470 cy	850 cy	1140 cyd
	129+00	130+90	333 cy	333 cy	433 cyd
	151+11	153+80	574 cy	514 cy	668 cyd
cell 3	248+59	258+00	2211 cy	2264 cy	2950 cyd
	275+59	278+21	518 cy	518 cy	675 cyd
	320+29	322+91	521 cy	521 cy	677 cyd
	352+12	353+92	311 cy	311 cy	404 cyd.
PROJECT TOTALS			5589 cyd	6222 cyd	8151 cyd

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	VINEYARD ROAD FRS, EMBANKMENT & DRAINFILL REPAIR		
BY JEB / DATE Feb. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT Trench Excavation & Drainfill Quantities			SHEET 2 OF 3

	STATION	END AREA	DOUBLE END A.	DISTANCE	DOUBLE VOLUME
	129+00	0			
			60	40	2400
C20.0	129+40	60			
			120	110	13200
C20.0	130+50	60			
			60	40	2400
	130+90	0			
					18000

$\frac{18000}{54}$ = 333 cuyds cut & Fill (to pay line limits)

333 X 30% handling loss = 99.9 cuyds
333
Drainfill C33 material to buy = 432.9 cuyds

	151+11	0			
			60	40	2400.0
Cut 20'	151+51	60			
			121.5	188	22842.0
Cut 20.5'	153+39	61.5			
			61.5	41	2521.5
	153+80	0			
					27763.5

$\frac{27763.5}{54}$ = 514 cu. yds. cut & Fill (to payline limits)
(514)(30% loss) = 154 + 514 = 668
Drainfill C33 material to buy 668 cuyds

	275+59	0			
			64.5	43	2773.5
C21.5	276+82	64.5			
			127.5	177	22567.5
C21.0	277+79	63.0			
			63.0	42	2646.0
	278+21	0			
					27987.0

$\frac{27987}{54}$ = 518.3 cuyds cut & Fill (to pay limit lines)

518.3 X 30% loss of material = 155.5 cuyds
518.3
DRAIN FILL (C33) material to buy = 673.8 call 675 cuyds

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT			
ARIZONA	VINEYARD ROAD FRS EMBANKMENT & DRAINFILL REPAIR			
BY JEB	DATE FEB. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT TRENCH EXCAVATION & DRAINFILL QUANTITIES				SHEET 3 OF 3

	STATION	END AREA	DOUBLE END AREA	DISTANCE	DOUBLE VOLUME
	320+29	0			
			63.0	42	2646.0
C21.0	320+71	63.0			
			127.5	178	22695.0
C21.5	322+49	64.5			
			64.5	43	2773.5
	322+91	0			
					28114.5

$\frac{2811.5}{54}$ = 520.6 call 521 cuyd cut & Fill (pay limit lines)

521 X 30% loss of material = 156 cuyd

521

Drain fill (C33) material to pay 677 cuyds

	352+12	0			
			57.0	38	2166.0
C19.0	352+50	57.0			
			120.0	100	12000.0
C21.0	353+50	63.0			
			63.0	42	2646.0
	353+92	0			
					16,812.0

$\frac{16812}{54}$ = 311.3 cuyds cut & Fill (pay limits lines)

311 X 30% loss of material = 93 cuyd

311

DRAINFILL (C33) Material to pay = 404 cuyds

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT			
ARIZONA	VINEYARD ROAD FRS. EMBANKMENT & DRAINFILL REPAIR			
BY JEB	DATE FEB-89	CHECKED BY	DATE	JOB NO. TEST CELL NO 2
SUBJECT TRENCH EXCAVATION & DRAINFILL QUANTITIES, CELL 2				SHEET ____ OF ____

TRENCH EXCAVATION AT TEST CELL NO. 2.
TYPICAL TRENCH 3' WIDE X DEPTH = END AREA

STATION	CUT DEPTH	END AREA	DOUBLE E AREA	DISTANCE	DOUBLE VOLUME
102+00	0.0	0			
			60	40	2,400.0
102+40	20.0	60			
			120	112	13440.0
103+52	20.0	60			
			87	33	2,871.0
103+85	9.0	27			
			54	131	7,074.0
105+16	9.0	27			
			87	33	2,871.0
105+49	20.0	60			
			120	61	7320.0
106+10	20.0	60			
			60	40	2400.0
106+50	0.0	0			
					38376.0

$\frac{38376}{54}$ = 711 cuyds Trench excavation

Fill 711 cuyds + 200 = 911 cuyds TOTAL FOR CELL 2

For materials estimate assume 30% loss = 213 cuyds

711 + 213 = 924 cuyds to purchase

AS A ZONE FILL TO a 3' wide X 11' height
SEE SHEET 2 of Common Excavation & Earth fill for Cell No. 2 -
FIND 200 cuyds Drainfill

For cost estimate assume 40% loss = 80 cuyds

200 + 80 = 280 cuyds to purchase
924
1204 cuyds @ Cell 2

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT			
ARIZONA	VINEYARD ROAD F.R.S. - EMBANKMENT & DRAINFILL REPAIR			
BY JEB	DATE FEB. - 1989	CHECKED BY	DATE	JOB NO. TEST CELL NO. 3
SUBJECT TRENCH EXCAVATION & DRAINFILL QUANTITIES AT TEST CELL 3				SHEET ____ OF ____

TRENCH EXCAVATION AT TEST CELL NO. 3 VICINITY
TYPICAL CROSSSECTION OF TRENCH 3' wide X Depth

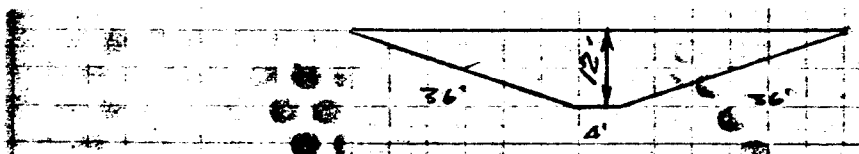
	STATION	DEPTH OF CUT	END AREA	DOUBLE END AREA	DISTANCE	DOUBLE VOLUME
	248+59	0	0			
				63.0	42.0	2,646.0
	249+01	21	63.0			
				131.4	436.0	57,290.4
	253+37	22.8	68.4			
				101.4	36.0	3,650.4
23.0	253+73	11.0	33.0			
				66.0	4.0	264.0
23.0	253+77	11.0	33.0			
				102.3	36.0	3682.8
	254+13	23.1	69.3			
				142.8	338.0	48266.4
	257+51	24.5	73.5			
				73.5	49.0	3601.5
	258+00	0	0			

Double Vol = 119,401.5

$\frac{119,401.5}{54}$ = 2211 cuyds TRENCH CUT

FOR MATERIAL NEEDED ASSUME 30% loss = 663
2211
DRAIN FILL (C-33) MATERIAL to Buy 2874 cuyd

IN THE STRUCTURE BACKFILL AREA



3' wide X 12" X 40' long
1440 sq. ft.
27

NEATLINES DRAIN FILL = 53.33 cuyds

53.33 X 40% loss = 21.33
53.33
DRAINFILL (C33) MATERIAL TO Buy 74.66 call 75 cuyds

2874 + 75 = 2949 - Call 2950 cuyds C33

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	VINEYARD ROAD FRS EMBANKMENT & DRAINFILL REPAIR		
BY JEB / DATE Feb. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT TRENCH EXCAVATION & DRAINFILL QUANTITIES, CELL 5			SHEET ___ OF ___

TRENCH EXCAVATION AT TEST CELL NO. 5
TYPICAL TRENCH 3' wide X Depth = END AREA

STATION	CUT DEPTH	END AREA	DOUBLE END AREA	DISTANCE	DOUBLE VOL.
107+60	0	0.0			
			60.0	40.0	2400.0
108+00	20.0	60.0			
			120.0	7.0	840.0
108+07	20.0	60.0			
			87.0	33.0	2871.0
108+40	9.0	27.0			
			54.0	280.0	15120.0
111+20	9.0	27.0			
			74.1	20.0	1482.0
111+40	15.7	47.1			
			87.6	13.0	1138.8
111+53	13.5	40.5			
			40.5	27.0	1093.5
111+80	0	0.0			
				TOTAL =	24,945.3

TRENCH = $\frac{24,945.3}{54}$ = 462 cuyds - call 470 for cost est.

For purchase of drainfill estimate assume a 30% fare

462 X .30 = 139 cuyds fare
462 cuyds pay lines

PAYLIMITS DRAINFILL
462
383
845 cuyds call 850

601 cuyds drainfill (C33) to buy for trench

As a zone fill to a 3' wide X 11' height (see SHEET 2 of Common Excavation & Earthfill for Cell No. 5)
Find 383 cuyds to Neat Lines - add 40% fare
453 cuyds.

536 cuyds, drainfill (C-33) in zone
601 cuyds trench

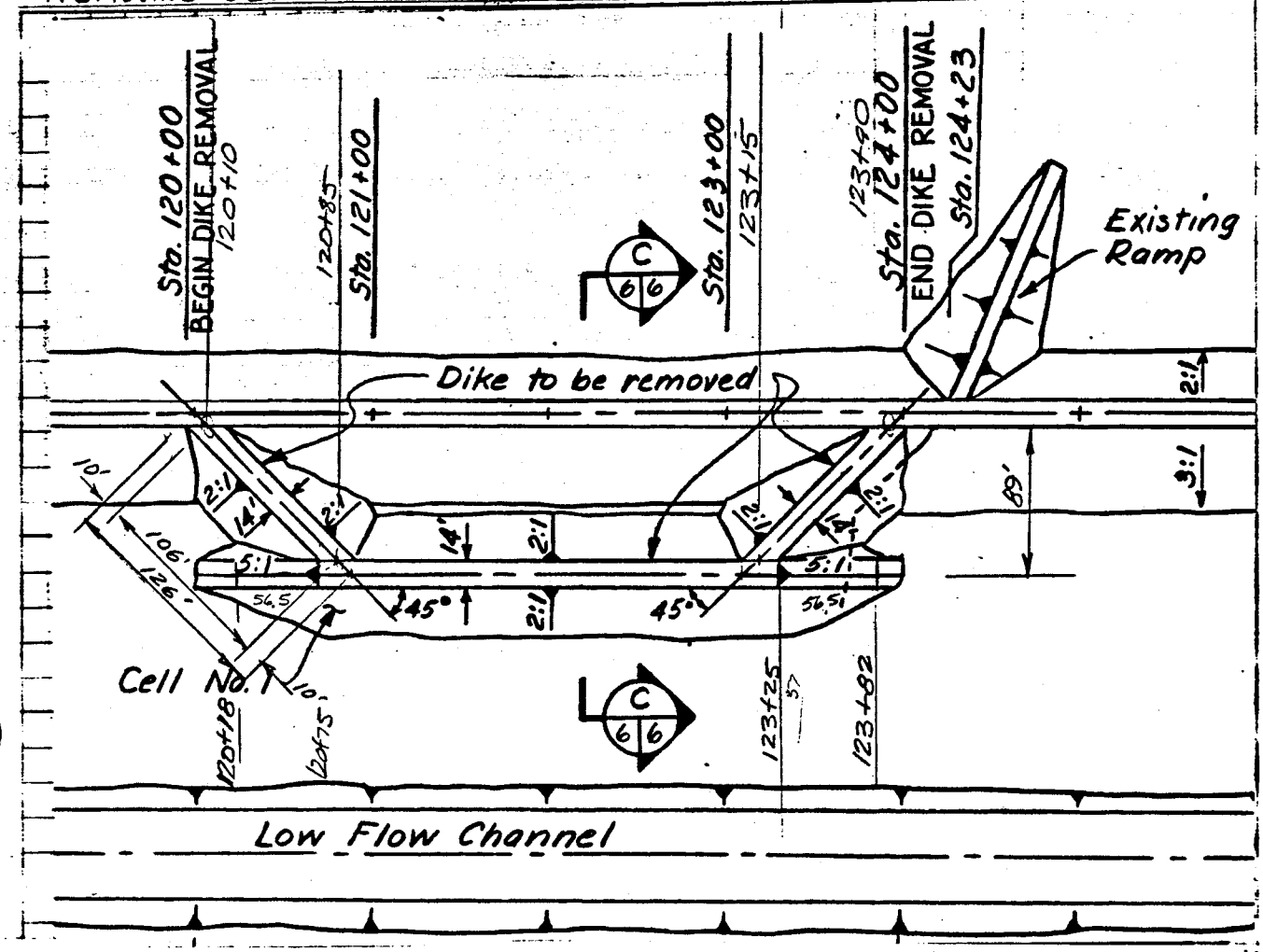
1137 cuyds call 1140 cuyds to purchase

EXCAVATION & EARTHWORK

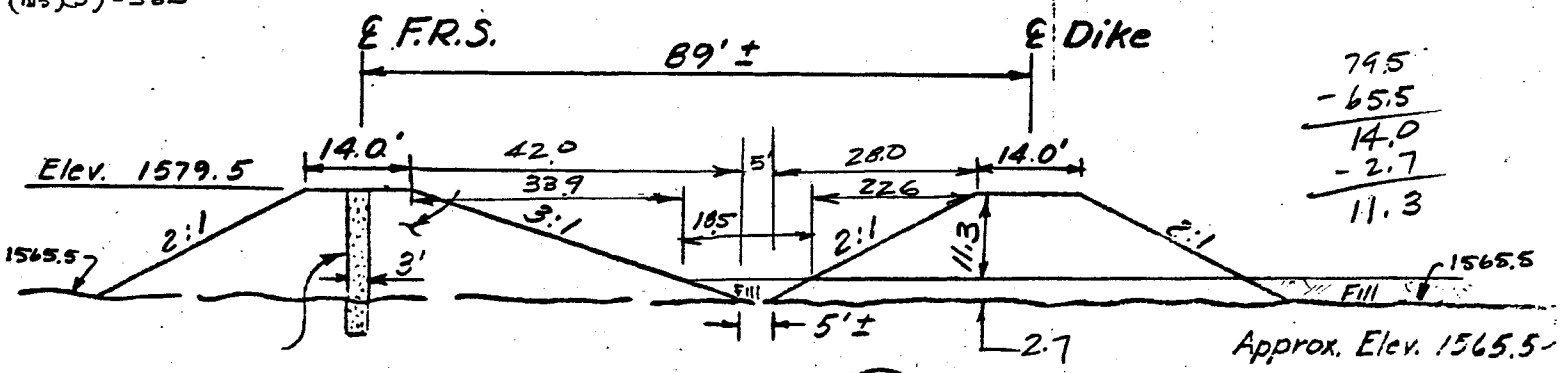
SCS-ENG-523A Rev 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR
BY: J.E.B. DATE: DEC. 1988
CHECKED BY: DATE: JOB NO:
SUBJECT: REMOVING CELL NO. 1 EXCAVATION QUANTITIES
SHEET 1 OF 3



(11.3)(5) = 56.5



79.5
− 65.5
14.0
− 2.7
11.3

SECTION C

$E.A. = (11.3)\left(\frac{14 + 22.6 + 14 + 22.6}{2}\right)$

413.6 sq ft

$\sqrt{28^2 + 28^2} = 39.6$
− 32.0
7.6

COMPUTATION SHEET

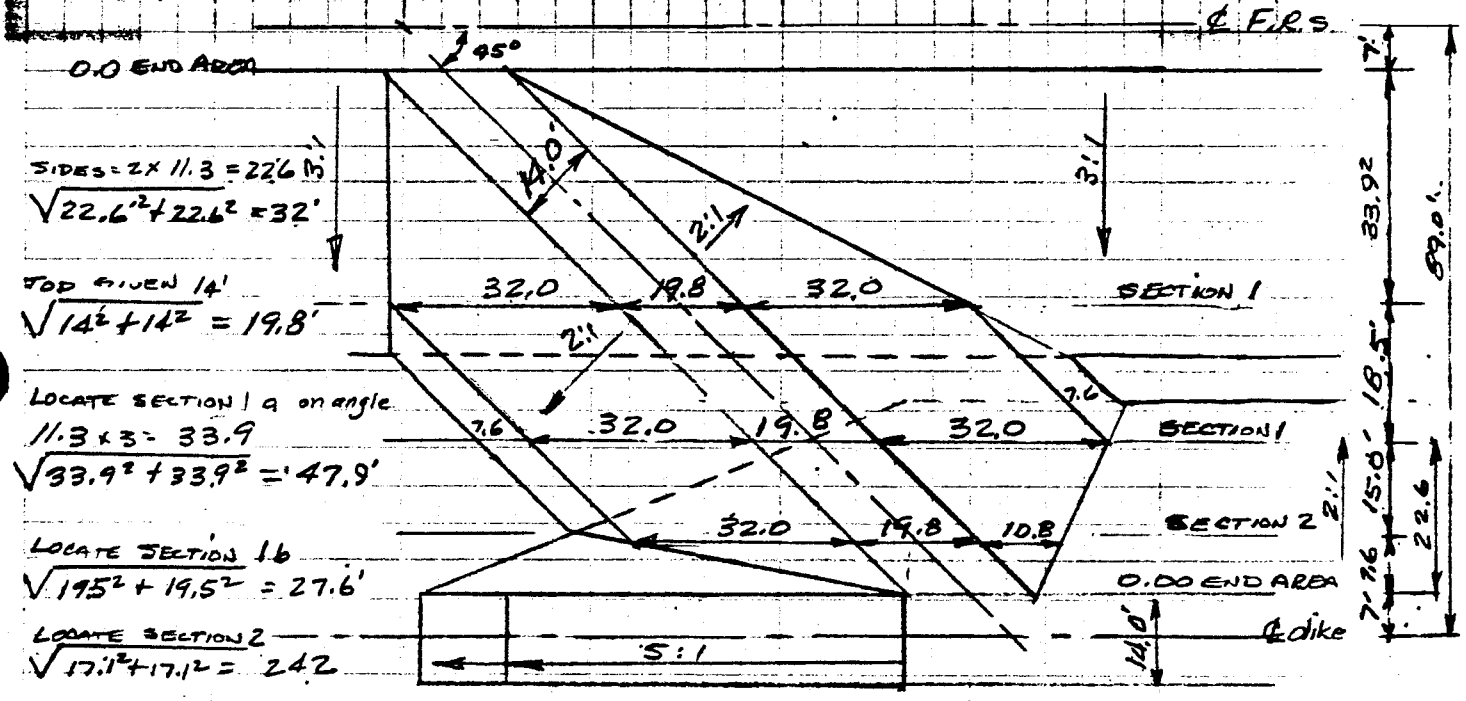
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. REMOVE TEST CELLS
BY: J.E.B. DATE: DEC. 1988
CHECKED BY: DATE: JOB NO:
SUBJECT: EXCAVATION QUANTITIES CELL NO. 1
SHEET 2 OF 3

Assume there is a dike parallel to F.R.S and this dike has 5:1 end slopes.

Then Assume there are end plugs @ 45° angle connecting the F.R.S. and test cell dike.

Compute one end plug cross sections to be used with all test cells.



SIDES = 2 × 11.3 = 22.6

$\sqrt{22.6^2 + 22.6^2} = 32'$

TOP GIVEN 14'

$\sqrt{14^2 + 14^2} = 19.8'$

LOCATE SECTION 1 a on angle

11.3 × 3 = 33.9

$\sqrt{33.9^2 + 33.9^2} = 47.9'$

LOCATE SECTION 1b

$\sqrt{19.5^2 + 19.5^2} = 27.6'$

LOCATE SECTION 2

$\sqrt{17.1^2 + 17.1^2} = 24.2$

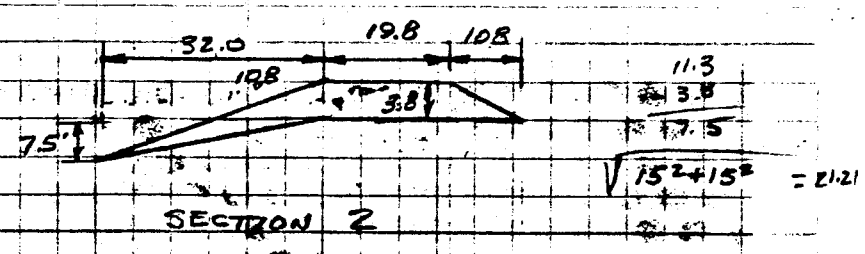
SECTION 1 (a and b)

Trapezoid

TOP + BOTTOM

$\left(\frac{19.8 + 83.8}{2}\right)(11.3)$

585 sq.ft.



$\sqrt{15^2 + 15^2} = 21.21$

SECTION 2

Triangle $\frac{(7.5)(10.8)}{2}$ = 40.50 sq.ft.

SECTION 2

Trape $\left(\frac{19.8 + 41.4}{2}\right)(3.8) = 116.28$ sq.ft.

156.78 sq.ft.

COMPUTATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR
BY: J.E.B. DATE: DEC. 1988
CHECKED BY: DATE: JOB NO.:

EXCAVATION QUANTITIES CELL No. 1 SHEET 3 OF 3

COMPUTE THE EXCAVATION FROM DIKE THAT IS PARALLEL TO F.R.S. ℄

	STA.	END AREA	DOUBLE E.A.	DIST.	DOUBLE VOLUME
	120+48	0.0			
			413.6	57	23575.2
	120+75	413.6			
			827.2	250	206800.0
	123+25	413.6			
			413.6	57	23575.2
	123+82	0.0			
					253950.4

FROM SHEET 2 FIND END AREAS

	0+00	0.0			
			585.0	33.9	19,831.5
Sec. 1a	0+33.9	585.0			
			1170.0	18.5	21,645.0
Sec. 1b	0+52.4	585.0			
			741.8	15.0	11,127.0
	0+67.4	156.8			
			156.8	7.6	1191.7
	0+75.0	0.0			
					53795.2

END PLUG + PARALLEL DIKE + END PLUG

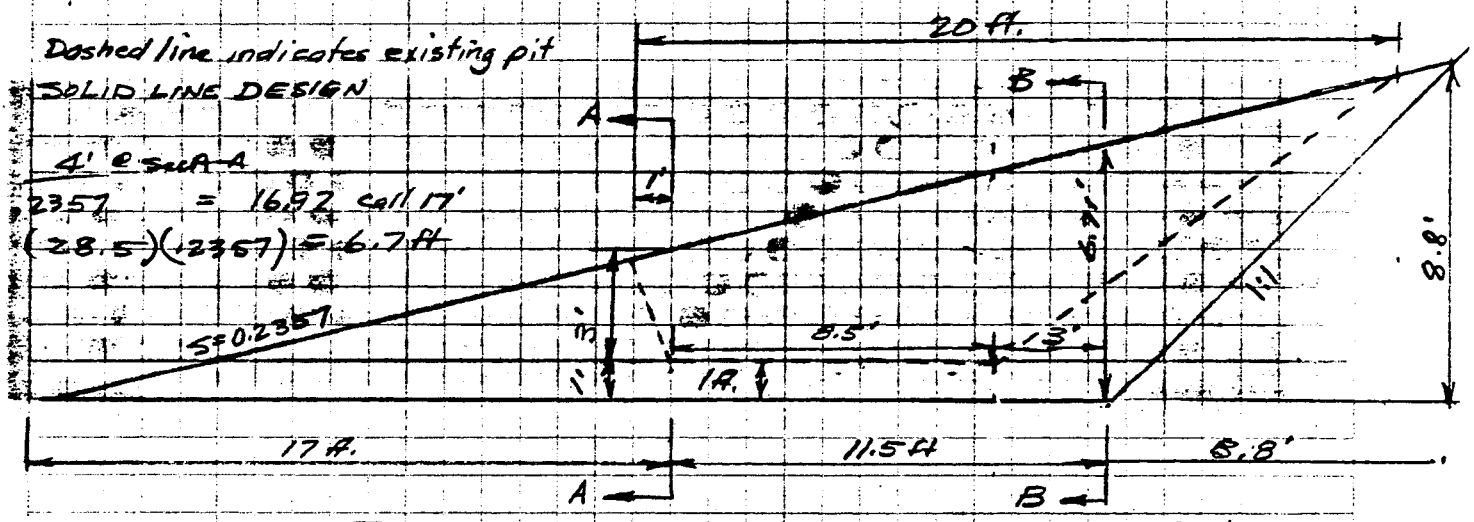
53795.2 + 253,950.4 + 53795.2 =

361,540.8 / 54 = 6695.2 cu yds

COMPUTATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR
BY: J.E.B. DATE: DEC. 1988
CHECKED BY: DATE: JOB NO.:
SUBJECT: Cut & Fill Quantities at test pit at cell No 1 (STA 121+72) SHEET OF



4' @ Sec A-A

2357 = 16.92 call 17'

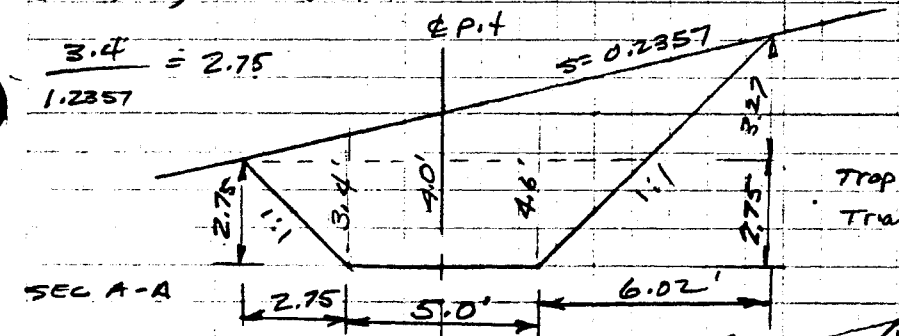
(28.5)(.2357) = 6.7 ft

PROFILE & TEST PIT @ CELL NO. 1

$\frac{6.71}{(1-0.2357)} = 8.78$

1/2 bottom

(.2357)(2.5) = .589 (call 0.6



$\frac{3.4}{1.2357} = 2.75$

$\frac{4.6}{(1-0.2357)} = \frac{4.6}{0.7643} = 6.01$ ft

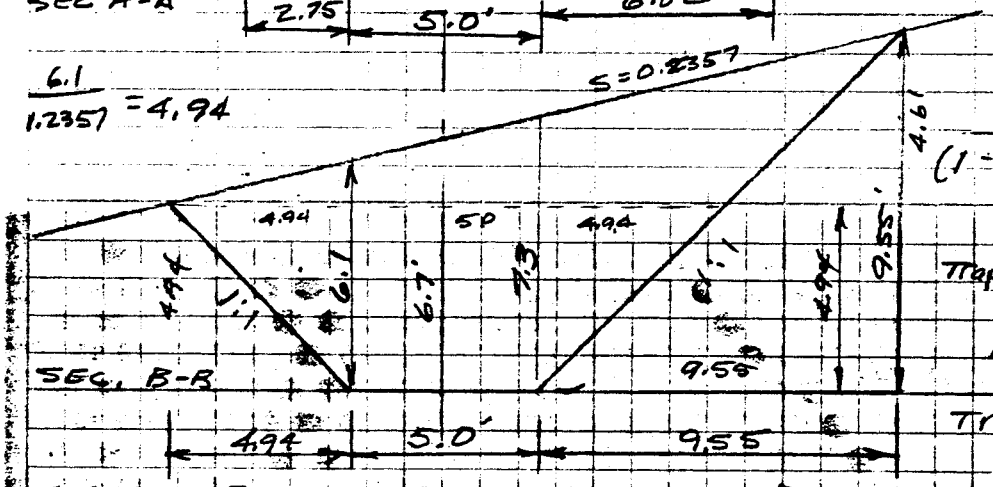
END AREA

Trap = $\left(\frac{5.0+2.75+5.0+2.75}{2}\right)(2.75) = 21.31$

Triangle $\frac{(10.5)(3.27)}{2} = 17.17$

SEC A-A

END AREA 38.48 sq



$\frac{6.1}{1.2357} = 4.94$

$\frac{7.3}{(1-0.2357)} = 9.55$ ft

END AREA

Trap = $\frac{(5.0+4.94+5.0+4.94)(4.94)}{2}$

E.A. = 49.1

Triangle $\frac{(14.88)(4.61)}{2} = 34.3$

83.4

SEC. B-B

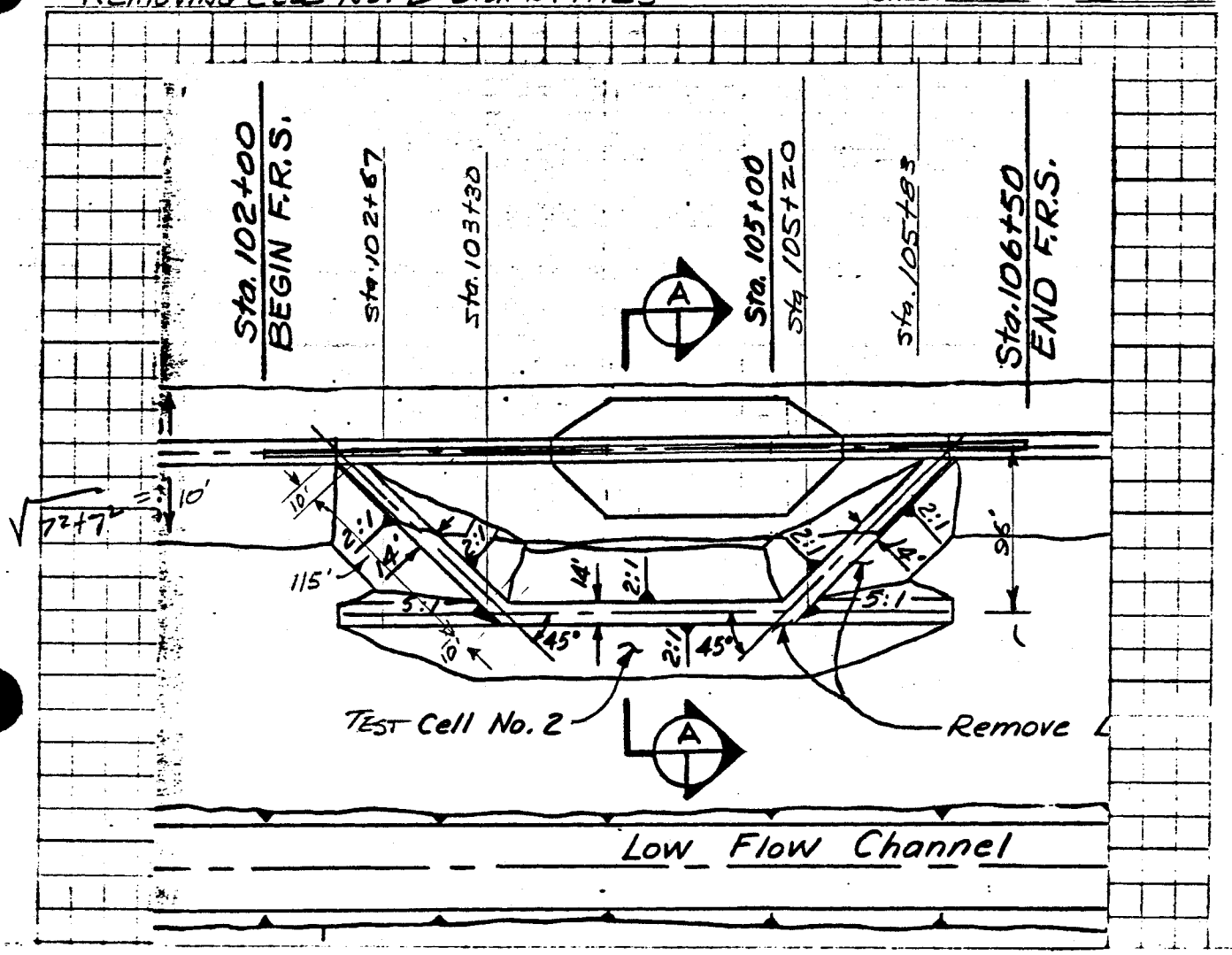
STA	END AREA	DOUBLE EA	DIST	Double Volume
0	0 P			
		38.5	17.0	654.5
17.0	38.5			
		121.9	11.5	1401.9
28.5	83.4			
		83.4	9.6	800.6
37.3	0.0			
				2857.0

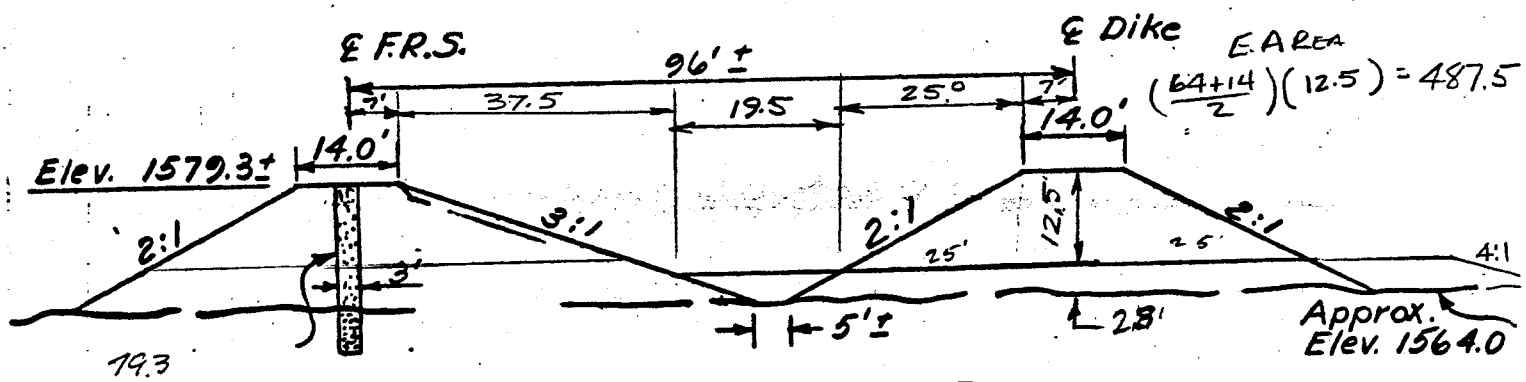
$\frac{2857}{54} = 52.9$ cu yds

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR		
BY J.E.B. / DATE DEC. 1988	CHECKED BY	DATE	JOB NO.
SUBJECT REMOVING CELL NO. 2 QUANTITIES			SHEET 1 OF 3





AREA $\left(\frac{64+14}{2}\right)(12.5) = 487.5$

79.3
− 64.0
15.3
− 12.5
2.8 OK

SECTIONS A & B

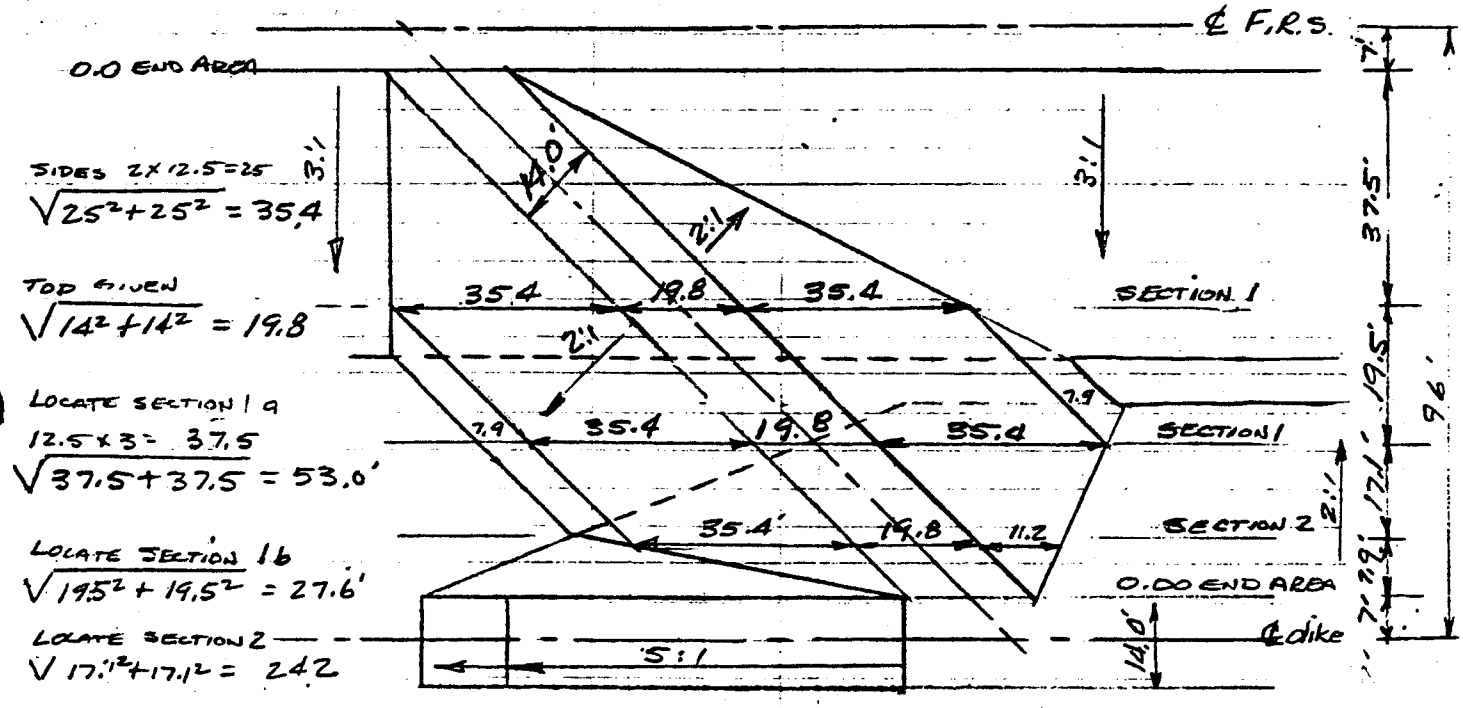
STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. REMOVE TEST CELLS
DATE: DEC. 1988
CHECKED BY: J.E.B.
DATE
SHEET 2 OF 3

EXCAVATION QUANTITIES CELL NO. 2

Assume there is a dike parallel to F.R.S. and this dike has 5:1 end slopes.

Then Assume there are end plugs @ 45° angle connecting the F.R.S. and test cell dike.

Compute one end plug cross sections to be used with all test cells.



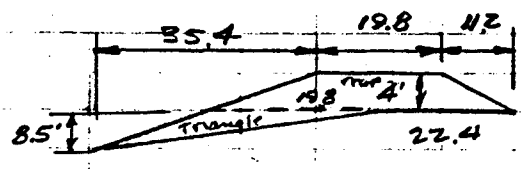
SECTION 1

Trapezoid

Top + Bottom

$\left(\frac{19.8 + 90.6}{2}\right)(12.5)$

690 sq.ft.



SECTION 2

Triangle $\frac{(8.5')(19.8)}{2}$ = 84.15 sq.ft.

Trape. $\left(\frac{19.8 + 42.2}{2}\right)(4)$ = 124.00 sq ft

208.15 sq ft.

BEGIN FILL at STA 101+60

END RAMP STA 102+67

END RAMP STA 105+83

COMPUTATION SHEET

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. REMOVE TEST CELL 2
BY: J.E.B. DATE: DEC. 1988
CHECKED BY: DATE: JOB NO.:
SUBJECT: EXCAVATION QUANTITY CELL 2
SHEET 3 OF 3

COMPUTE THE EXCAVATION FROM DIKE THAT IS PARALLEL TO F.R.S. ℄

STA	END AREA	DOUBLE E.A.	DIST	DOUBLE VOLUME
102+67	0.0			
		487.5	63.0	30712.5
103+30	487.5			
		975.0	190.0	185250.0
105+20	487.5			
		487.5	63.0	30712.5
105+83	0.0			
				246675.0

FROM SHEET 2 FIND END AREAS FOR PLUGS

0+00	0.0			
		690.0	37.5	25875.0
0+37.5	690.0			
		1380.0	19.5	26910.0
0+57.0	690.0			
		898.2	17.1	15359.2
1+74.1	208.2			
		208.2	7.9	1644.8
1+82	0.0			
				69789.0

END PLUG + DIKE + END PLUG

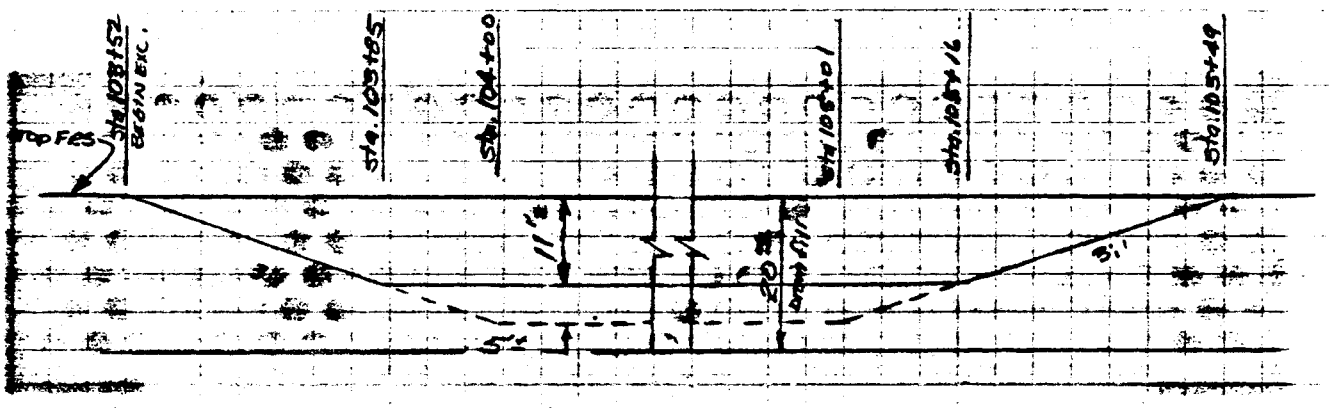
69789 + 246675.0 + 69789

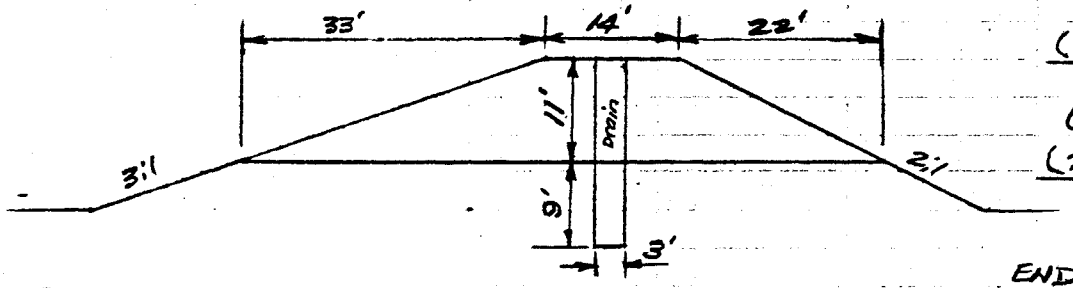
54 = 7153 cu.yd.

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		VINEYARD ROAD FRS EMBANKMENT & DRAIN FILL REPAIR		
BY JEB	DATE Feb. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT Common Excavation at disturbed Area Cell No. 2				SHEET 1 OF 2





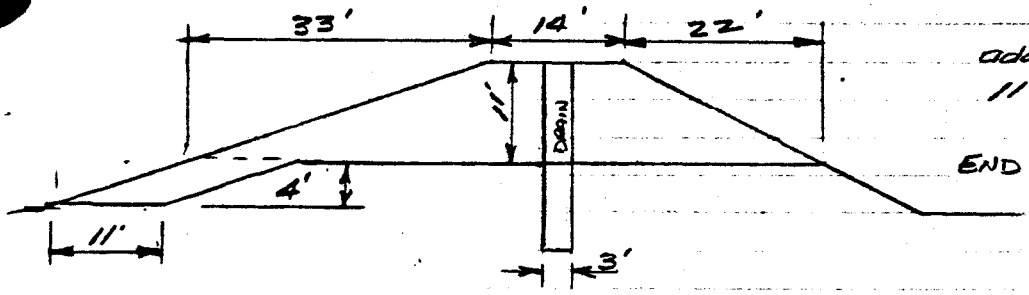
$\frac{(33)(11)}{2} = 181.50$

$(14)(11) = 154.00$

$\frac{(22)(11)}{2} = 121.00$

END AREA 456.5 sq ft

SECTION FOR STA 103+85 & 105+16

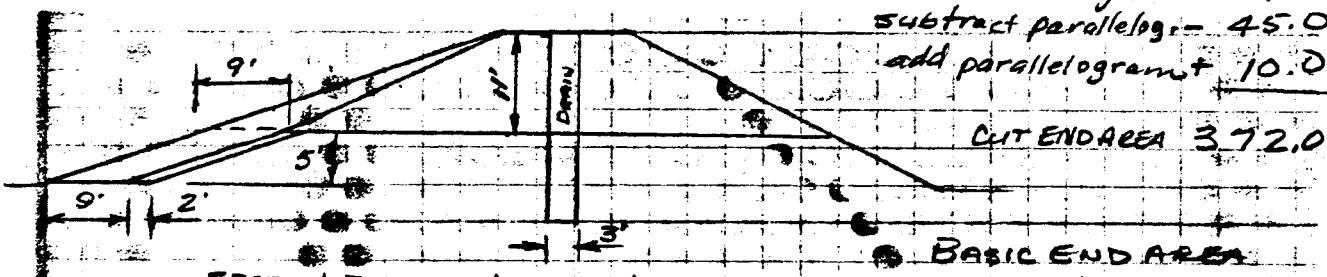


add a parallelogram
11' X 4 = 44.0
456.5
END AREA 500.5 sq ft

SECTION FOR STA. 103+97 & 105+04

BASIC END AREA 456.5 sq ft
subtract triangle − 49.5
subtract parallelog. − 45.0
add parallelogram + 10.0

CUT END AREA 372.0 sq ft



SECTION FOR STA. 104+00 & 105+01

BASIC END AREA 456.5
+ 55.0

FILL END AREA 511.5 sq ft

$-\frac{(9)(11)}{2} = 49.5$ sq ft

$-(9)(5) = 45$

$+(2)(5) = 10$

$+(11)(5) = 55$

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	VINEYARD ROAD FRS EMBANKMENT & DRAINFILL REPAIR		
BY J.E.B. / DATE FEB. 1989	CHECKED BY	DATE	JOB NO.

SUBJECT Cut & Fill Quantities to remove & replace disturbed FRS. @ Cell 2 — SHEET 2 OF 2

Compute cut quantities, then the fill quantities

Station	End Area	Double End Area	Distance	Double Volume
103+52	0.0			
		456.5	33	15,064.5
103+85	456.5			
		957.0	12	11,484.0
103+97	500.5			
		872.5	3	2,617.5
104+00	372.0			
		744.0	101	75,144.0
105+01	372.0			
		872.5	3	2,617.5
105+04	500.5			
		957.0	12	11,484.0
105+16	456.5			
		456.5	33	15,0645
105+49	0.0			
				133,476.0

Common excavation = 2472 cuyd = $\frac{133,476.0}{54}$

103+52	0.0			
		456.5	33	15,064.5
103+85	456.5			
		968.0	15	14,520.0
104+00	511.5			
		1023.0	101	103,323.0
105+01	511.5			
		968.0	15	14,520.0
105+16	456.5			
		456.5	33	15,064.5
105+49	0.0			
				162,492.0

EARTH FILL (INCLUDES DRAIN) 3010 Cuyds. $\frac{162,492.0}{54}$

3010 − 200 = 2810 cuyds Earth fill

	103+52	0.0			
			33.0	33	1089.0
3'x11'	103+85	33.0			
			66.0	131	8646.0
3'x11'	105+16	33.0			
			33.0	33	1089.0
	105+49	0.0			
					10,824.0

3' wide Drain fill zone = 200.44 cuyds = $\frac{10,824.0}{54}$

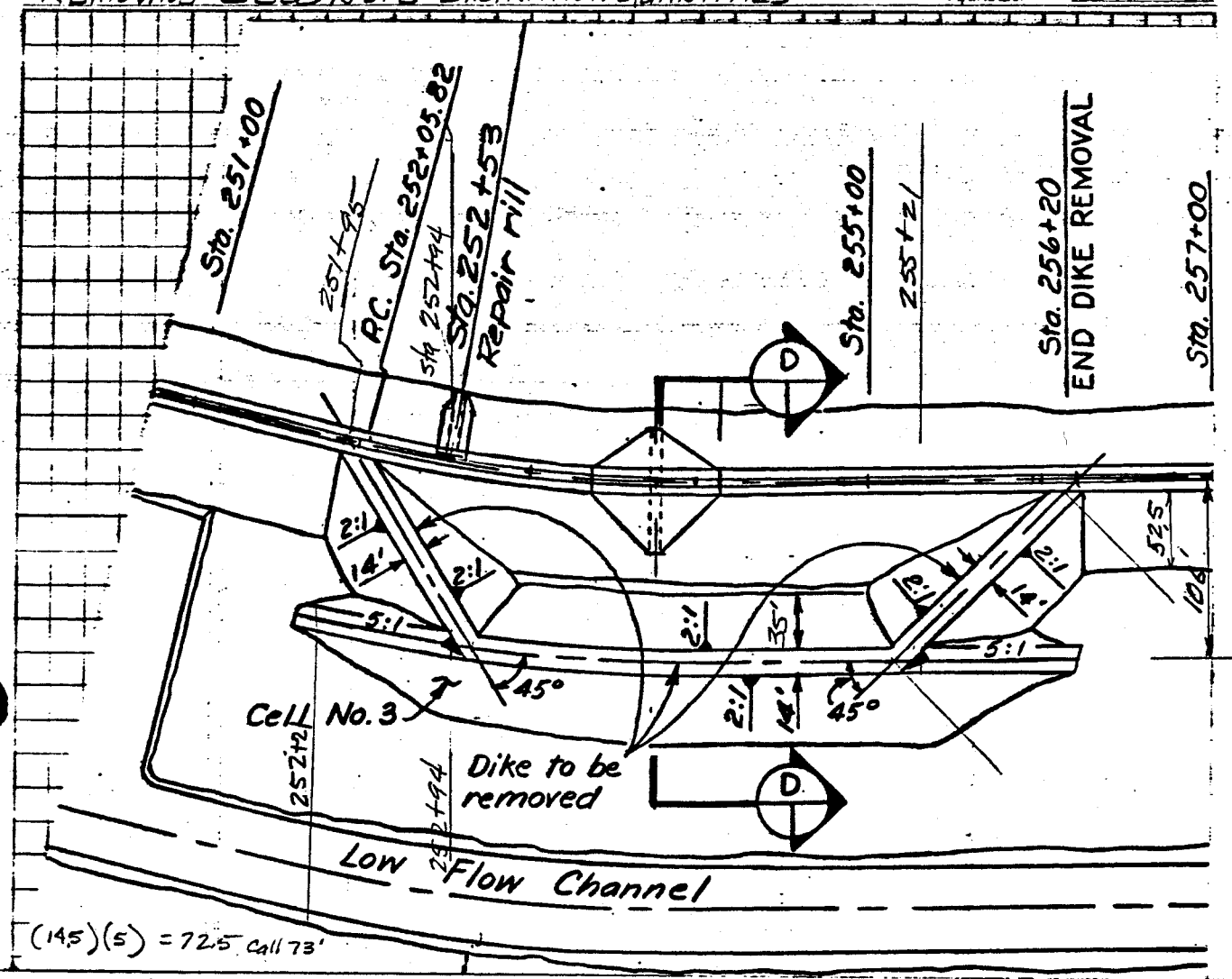
COMPUTATION SHEET

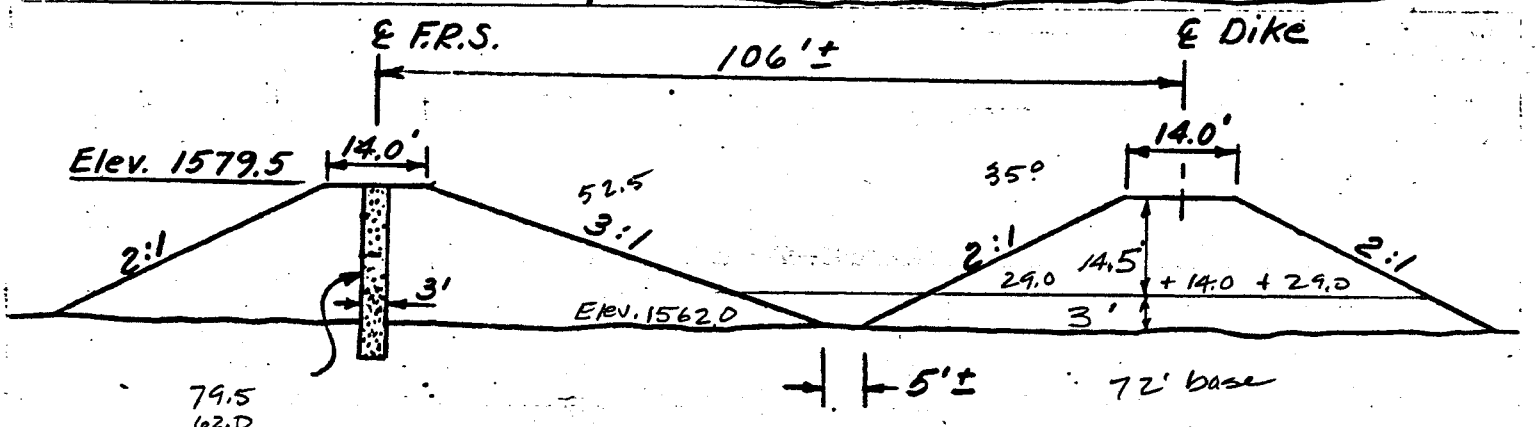
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR		
BY J.E.B.	DATE DEC. 1988	CHECKED BY	DATE	JOB NO.

SUBJECT REMOVING CELL NO. 3 EXCAVATION QUANTITIES SHEET 1 OF 3





79.5
62.0
17.5

SECTION D

Trapezoid Area

$\left(\frac{14.0 + 72^{\circ}}{2}\right)(14.5) = 623.5$

STATE: ARIZONA PROJECT: VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR

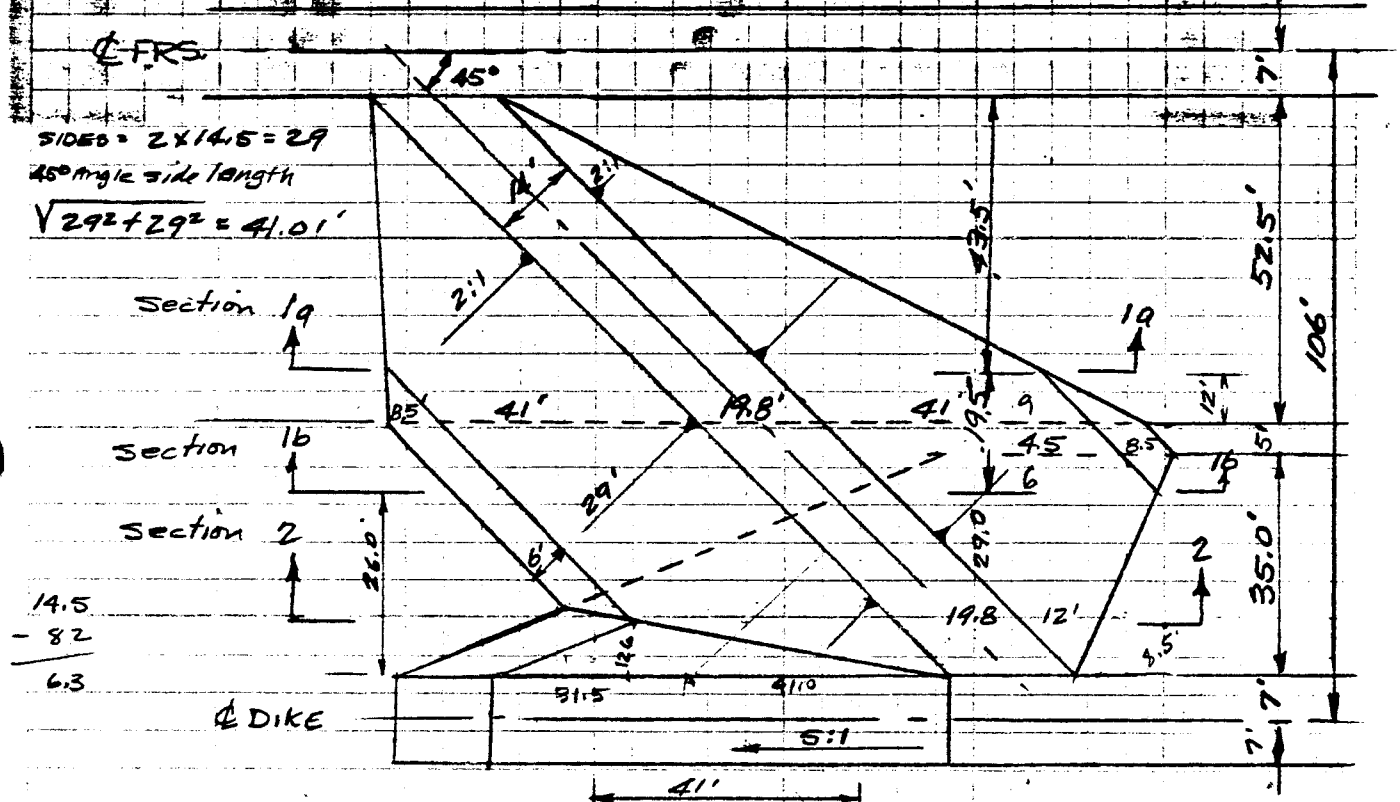
J.E.B. DEC. 1988

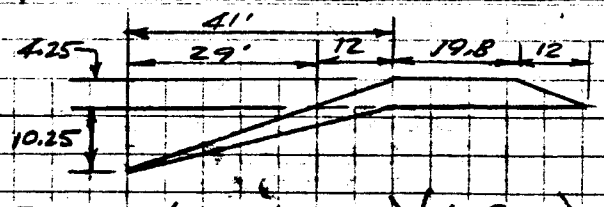
REMOVING CELL NO. 3 EXCAVATION QUANTITIES SHEET 2 OF 3

Assume there is a dike parallel to the F.R.S. ℄ and this dike has 5:1 slopes at each end

Then Assume there are end plugs at 45° angle from ℄ F.R.S. connecting the F.R.S. embankment and the parallel dike to make the test cell.

Compute one end plug to be used at both ends





SECTION 2 Trape = $\left(\frac{19.8 + 43.8}{2}\right)(4.25)$ = 135.15 sq ft

Triangle $\frac{(10.25)(12)}{2}$ = 61.50

196.65 sq. ft.

SECTION 1a & b Trape $\left(\frac{19.8 + 101.8}{2}\right)(14.5)$ = 881.60 sq ft.

ARIZONA — PROJECT: VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR

J.E.B. — DEC 1988

REMOVING CELL NO. 3 EXCAVATION QUANTITIES — PAGE 3 3

COMPUTE THE EXCAVATION FROM DIKE THAT IS PARALLEL TO THE F.R.S. ℄

STATION	END AREA	DOUBLE E.A.	DISTANCE	DOUBLE VOLUME
252+21	0			
		623.5	73	45515.5
252+94	623.5			
		1247.0	227	283069.0
255+21	623.5			
73		623.5	73	45515.5
255+94	0			
				374100.0

FROM SHEET 2 FIND END AREAS FOR PLUG

0+00	0			
		881.6	43.5	38349.6
0+43.5	881.6			
19.5		1763.2	19.5	34382.4
0+63.0	881.6			
20.5		1078.3	20.5	22105.2
0+83.5	196.7			
8.5		196.7	8.5	1671.9
0+92.0	0			
				96509.1

PLUG + DIKE + PLUG

96509.1 + 374100.0 + 96509.1

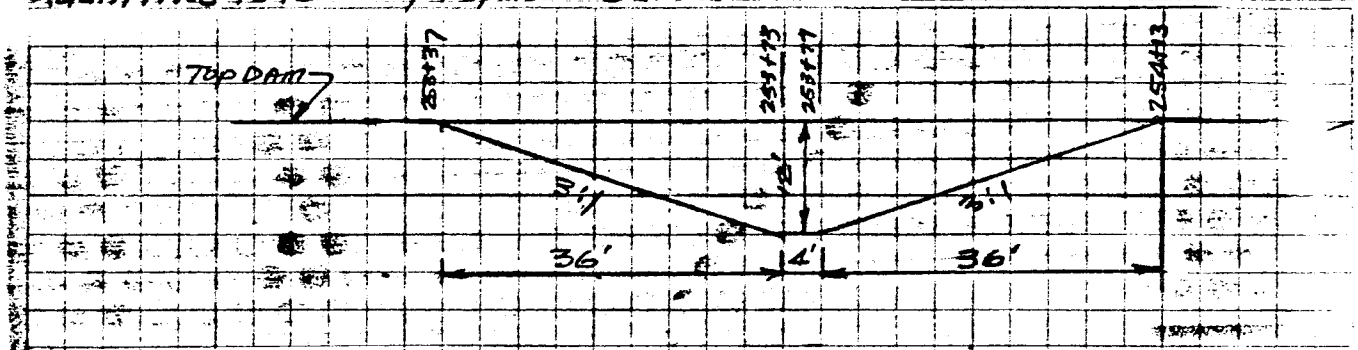
54

10,502.2 cuyds.

COMPUTATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD FRS EMBANKMENT DRAIN REPAIR
BY: J.E.B. DATE: DEC. 1988
CHECKED BY: DATE: JOB NO:
SUBJECT: Quantities to remove & replace disturbed area at Cell 3 SHEET 1 OF 1

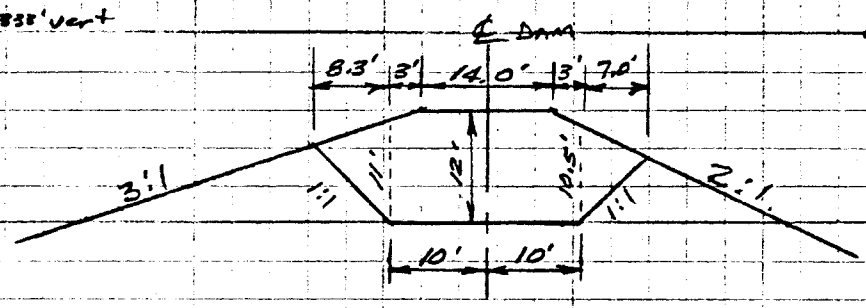


1' horiz = 1.833' vert

$\frac{11}{1.33} = 8.27$

1' horiz = 1.5' vert

$\frac{10.5}{1.5} = 7.0'$



Section @ sta 253+73 & 253+77

END AREA triangle + trapezoid + rectangle + trapezoid + triangle

$$\frac{(8.3)(11.0)}{2} + \left(\frac{11.0+12.0}{2}\right)(3) + (14.0)(12.0) + \left(\frac{11.0+12.0}{2}\right)(3) + \left(\frac{(10.5)(7.0)}{2}\right)$$

$$45.65 + 34.5 + 168.0 + 34.5 + 36.75 = 319.4 \text{ sq ft.}$$

STATION	END AREA	DOUBLE END AREA	DISTANCE	DOUBLE VOLUME
253+37	0			
		319.4	36.0	11,498.4
253+73	319.4			
		638.8	4.0	2555.2
253+77	319.4			
		319.4	36.0	11,498.4
254+13	0			
				25552.0

$$\frac{25552}{54} = 473.2 \text{ cuyds}$$

Cut = 473 cuyds.

Fill = 420 cuyds.

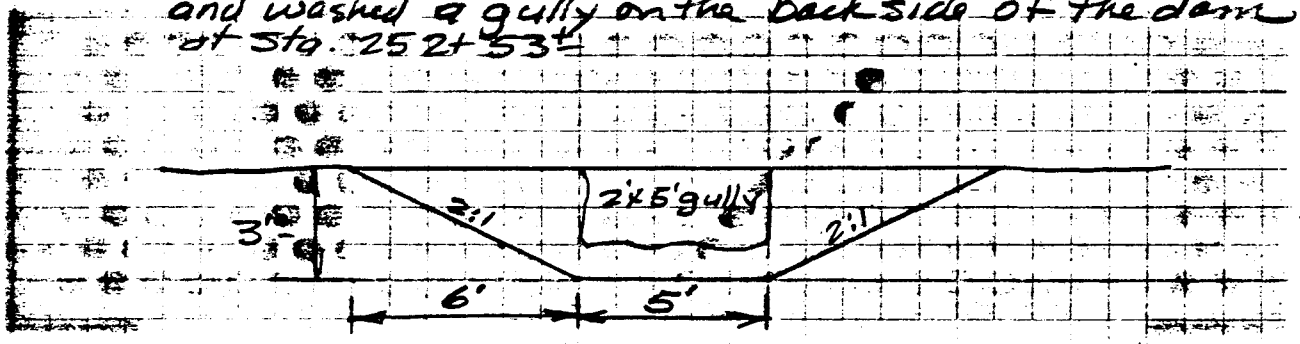
Drain fill = 53 cuyds

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

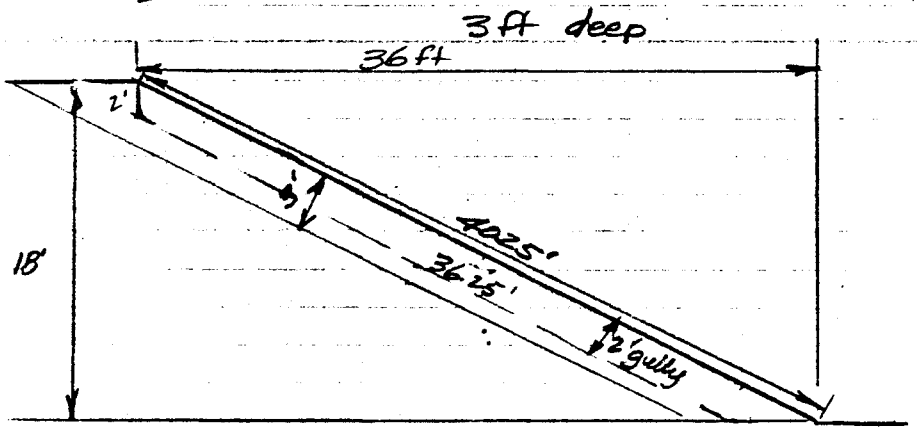
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	Williams - Chandler W.P.P. - Vineyard Road FRS. Repair		
BY JEB / DATE FEB. 89	CHECKED BY	DATE	JOB NO.
SUBJECT Test cell 3 Rill Quantities			SHEET 1 OF 1

The F.R.S. overtopped when a pump was left on to long and washed a gully on the back side of the dam at Sta. 252+53±



Top $\frac{17.0' + \text{bottom } 5.0'}{2}$ = 11 ft. ave. width



$\frac{11' \times 3' \times 40.25'}{27}$ = 49.2 call 50 cu yds Fill

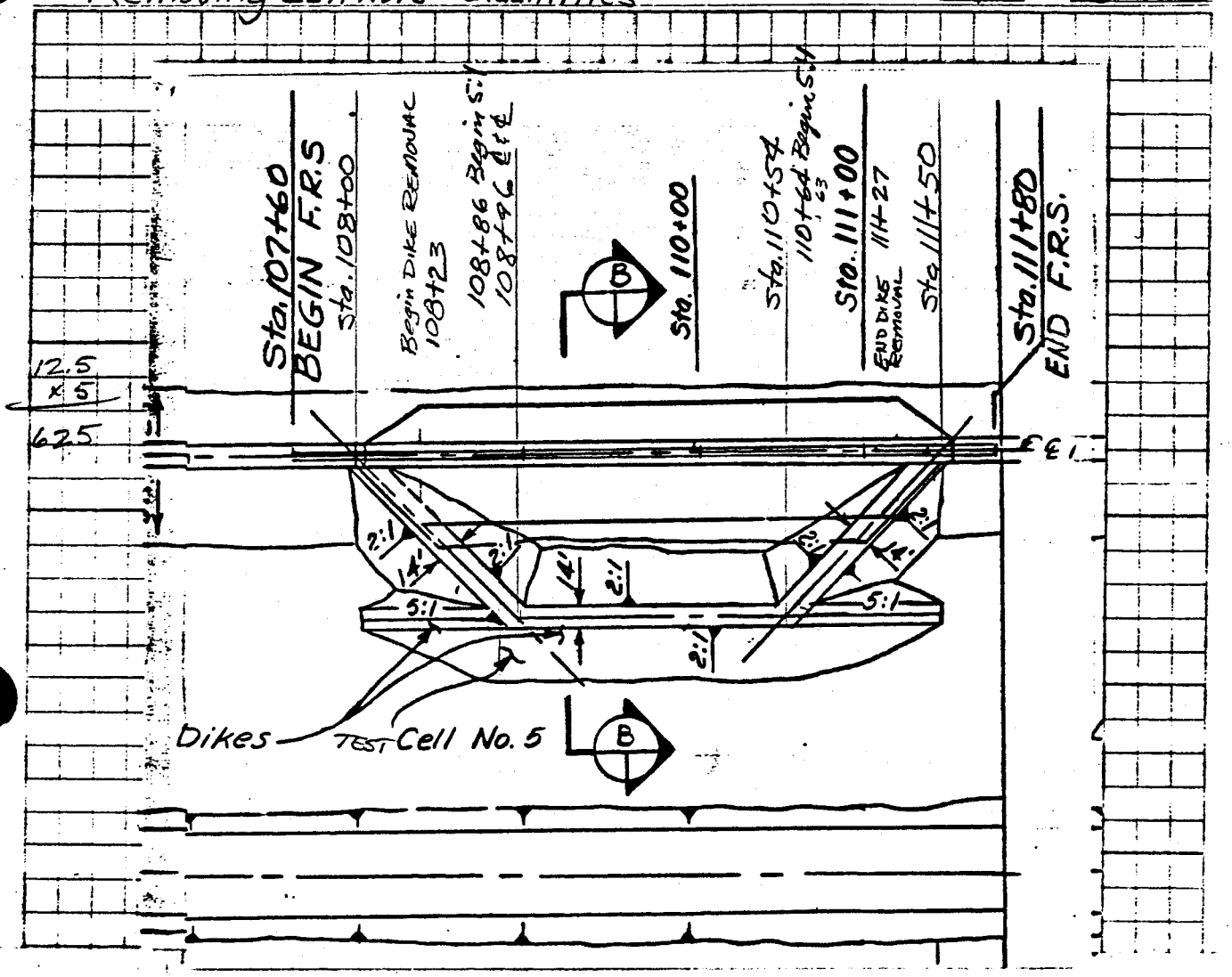
- Existing Gully $\frac{2' \times 5' \times \left(\frac{40.25 + 36.25}{2}\right)}{27}$ = 14 cu yds

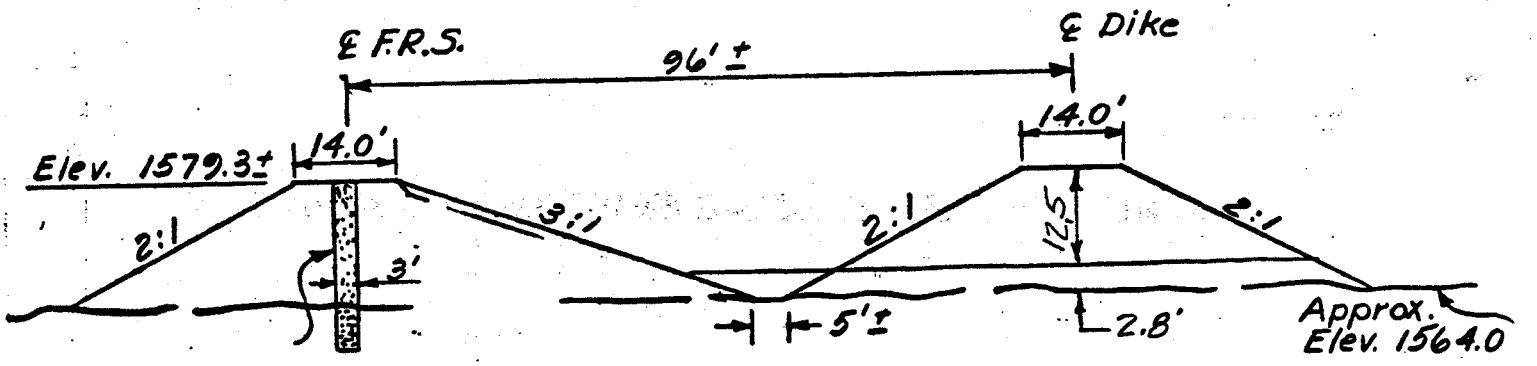
50 - 14 = 36 cu yds excavation to shape gully

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT			
ARIZONA	VINEYARD ROAD F.R.S.			
BY J.E.B.	DATE DEC. 88	CHECKED BY	DATE	JOB NO.
SUBJECT Removing Cell No. 5 Quantities				SHEET 1 OF 3





SECTIONS A & B

COMPUTATION SHEET

SCS-ENG-5234 Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

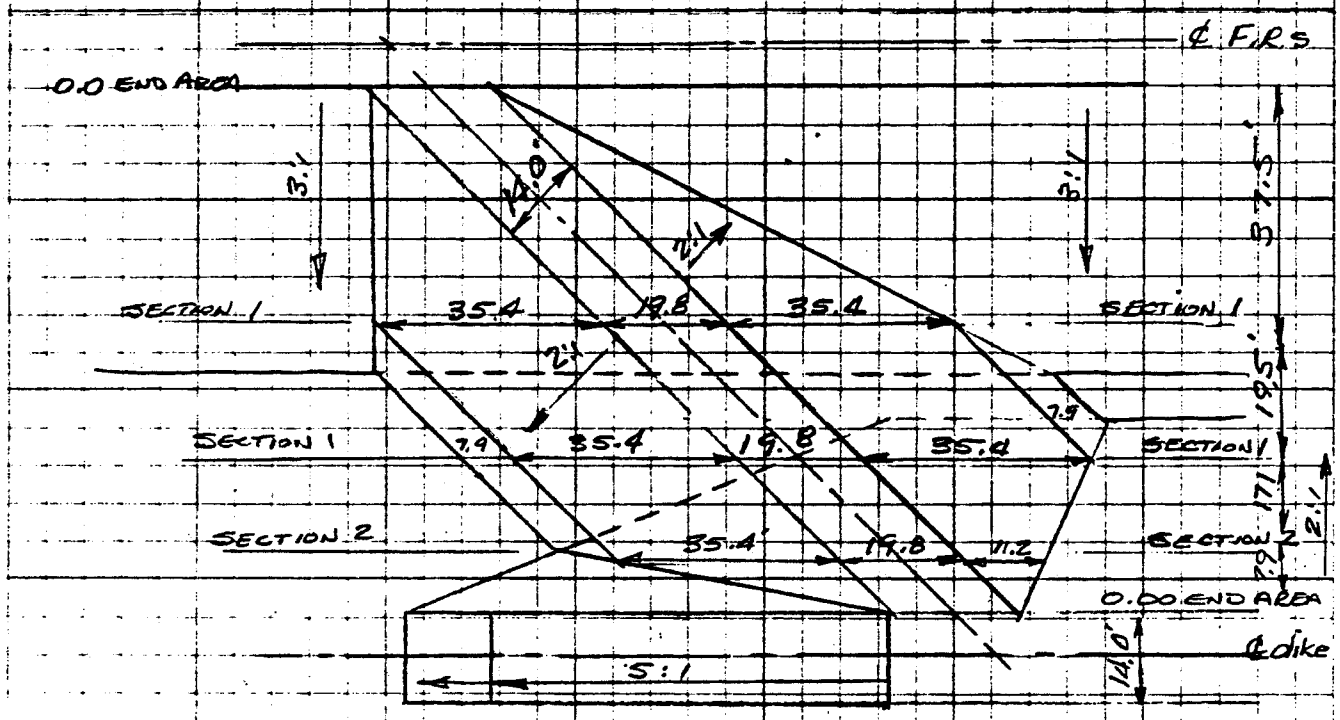
STATE	PROJECT		
ARIZONA	VINEYARD ROAD F.R.S. REMOVE TEST CELLS		
BY J.E.B.	DATE DEC. 1988	CHECKED BY	DATE	JOB NO.

SUBJECT EXCAVATION QUANTITIES CELL NO. 5 SHEET 2 OF 3

Assume there is a dike parallel to F.R.S and this dike has 5:1 end slopes.

Then Assume there are end plugs @ 45° angle connecting the F.R.S. and test cell dike.

Compute one end plug cross sections to be used with all test cells.



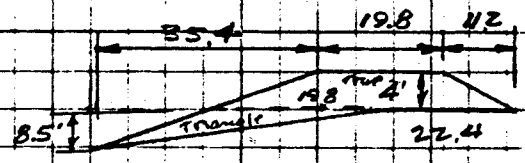
SECTION 1

Trapezoid

Top + Bottom

$\left(\frac{19.8 + 90.6}{2}\right)(12.5)$

690 sq.ft.



SECTION 2

Triangle $\frac{(8.5')(19.8)}{2}$ = 84.15 sq.ft.

Trape. $\left(\frac{19.8 + 42.2}{2}\right)(4)$ = 124.00 sq ft

208.15 sq.ft.

COMPUTATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. REMOVE TEST CELLS
BY: JEB
DATE: DEC. 88
CHECKED BY
DATE
JOB NO.

EXCAVATION QUANTITIES CELL 5

SHEET 3 OF 3

COMPUTE THE EXCAVATION FROM DIKE THAT IS PARALLEL TO F.R.S. ℄

STA	END AREA	DOUBLE E.A.	DIST.	DOUBLE VOLUME
108+23	0.0			
		487.5	63.0	30,712.5
108+86	487.5			
		975.0	178.0	173,550.0
110+64	487.5			
		487.5	63.0	30,712.5
111+27	0.0			
				234,975.0

FROM SHEET 2 FIND END AREAS

STA	END AREA	DOUBLE E.A.	DISTANCE	DOUBLE VOLUME
0+00	0.0			
		690.0	37.5	25875.0
0+37.5	690.0			
		1380.0	19.5	26910.0
0+57	690.0			
		898.2	17.1	15359.2
1+74.1	208.2			
		208.2	7.9	1644.8
1+82	0.0			
				69789.0

END PLUG + PARALLEL DIKE + END PLUG

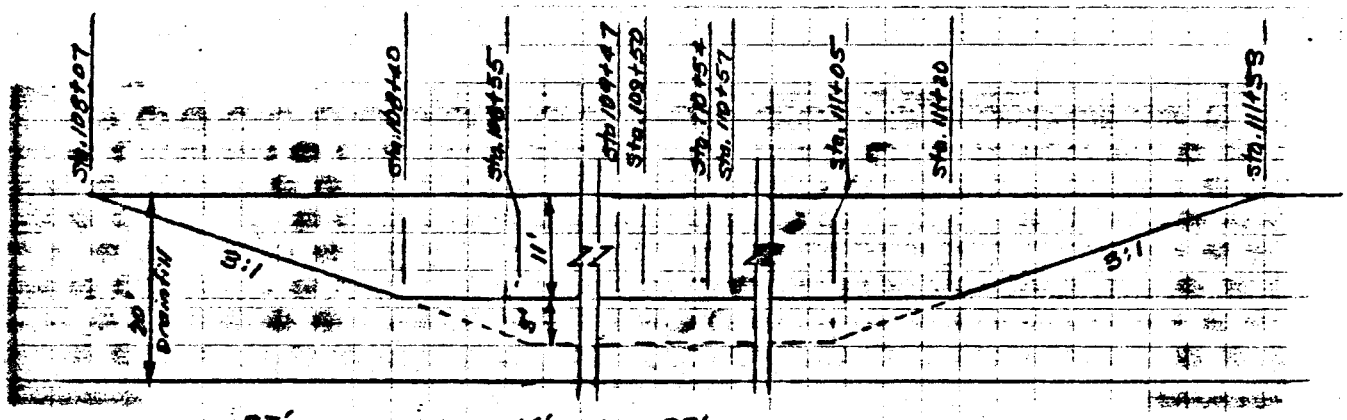
$$\frac{69789 + 234975.0 + 69789}{54} = 6936.2 \text{ cu yd}$$

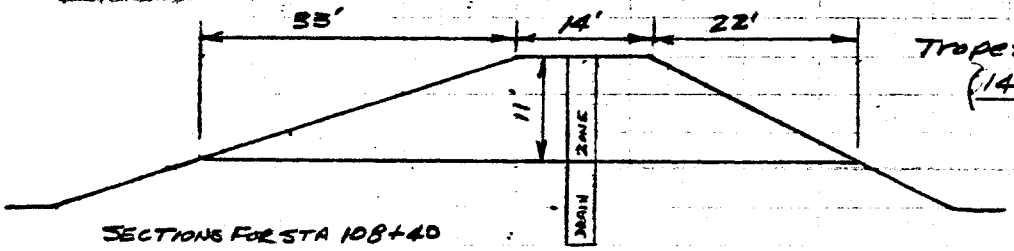
CALL 6940 cu yds

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

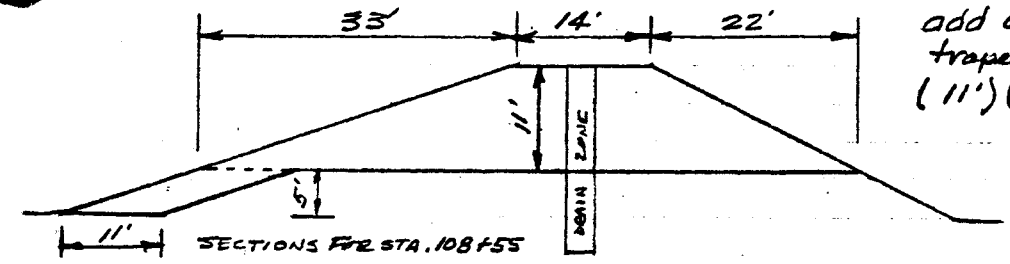
STATE		PROJECT		
ARIZONA		VINEYARD ROAD FRS EMBANKMENT & DRAIN FILL REPAIR		
BY JEB	DATE FEB. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT COMMON EXCAVATION & EARTHFILL AT DISTURBED AREA OF CELL 5				SHEET 1 OF 2





SECTIONS FOR STA 108+40
STA 111+20

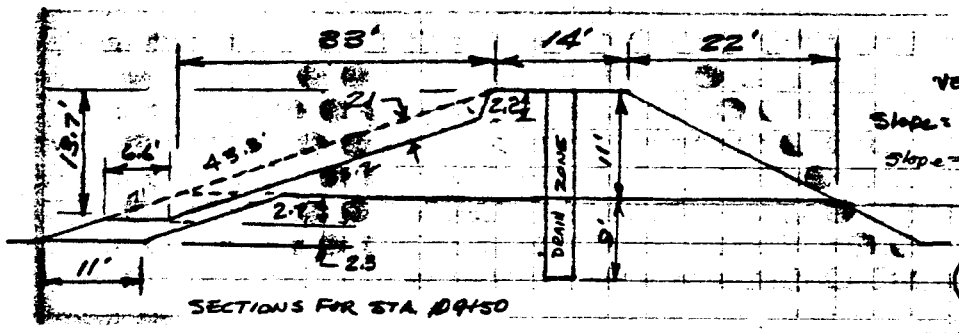
Trapezoid
$\left(\frac{14+69}{2}\right)(11) = 456.5$ sq.ft.



SECTIONS FOR STA. 108+55
STA 109+47
STA 110+57
STA 111+05

add a parallelogram to the trapezoid 456.5
(11')(5') + 55.0

511.5 sq.ft.



SECTIONS FOR STA 109+50
STA 110+54

SUBTRACT THE EXCAVATION ON THE FACE OF THE DAM

Vert 13.7' X 3 = 41.1' Horiz

Slope = $\sqrt{13.7^2 + 41.1^2}$ = 43.3' slope surface

Slope = $\sqrt{2.2^2 + 6.6^2}$ = - 7'

$\sqrt{2.2^2 + 2.2^2}$ = - 3.1'

33.2' cut surface

$\left(\frac{43.3 + 33.2}{2}\right)(2.1) = 80.33$

511.5 - 80.33 = 431.2 sq ft.

DRAIN FILL IN FILL AREA 3' wide X 313' long X 11' deep = 10329 cu ft. / 27

TO NEAT LINES 383 cu yds Drain fill

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT			
ARIZONA	VINEYARD ROAD FRS EMBANKMENT & DRAINFILL REPAIR			
BY JEB	DATE FEB. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT COMMON EXCAVATION & EARTHFILL AT DISTURBED AREA OF CELL 5				SHEET 2 OF 2

Compute cut quantities, then the fill quantities

STATION	END AREA	DOUBLE E. AREA	DISTANCE	DOUBLE VOLUME
108+07	0.			
		456.5	33	15,064.5
108+40	456.5			
		968.0	15	14,520.0
108+55	511.5			
		1023.0	92	94,116.0
109+47	511.5			
		942.7	3	2,828.1
109+50	431.2			
		862.4	104	89,689.6
110+54	431.2			
		942.7	3	2,828.1
110+57	511.5			
		1023.0	48	49,104.0
111+05	511.5			
		968.0	15	14,520.0
111+20	456.5			
		456.5	33	15064.5
111+53	0	EXCAV. = 5513.6 cyd =		297,734.8 / 54

108+07	0.			
		456.5	33	15,064.5
108+40	456.5			
		968.0	15	14,520.0
108+55	511.5			
		1023.0	250	255,750.0
111+05	511.5			
		968.0	15	14,520.0
111+20	456.5			
		456.5	33	15,064.5
111+53	0.			
		EARTHFILL = 5832 cuyd		314,919.0 / 54
	-	DRAINFILL 383		

CALL EARTHFILL 5450 cuyds

CONTINUATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR
BY: J.E.B. DATE: DEC. 1988
CHECKED BY: DATE: JOB NO.:
SUBJECT: EXTENT OF EARTH FILL @ CELL NO. 1
SHEET 1 OF

TEST CELL NO. 1

BEGIN FILL @ STA. 119+00

160' wide X 118' long X 2.7' deep / 27 = 1888 cuyd

at cell no 1.

80' wide X 365' long X 2.7' deep / 27 = 2920 cuyds

END FILL @ STA 125+00

160' wide X 117' long X 2.7' deep / 27 = 1872 cuyds

Fill 6680 cuyd

Cut = 6695 cuyds,

Fill = 6680 cuyds.

COMPUTATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA PROJECT: VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR

BY: J.E.B. DATE: DEC. 1988 CHECKED BY: DATE: JOB NO:

EXTENT OF EARTH FILL @ CELLS 2 & 5 SHEET 1 OF

TEST CELLS 2 & 5 FILL VOLUME

DEPTH OF FILL 2.7 ft ave.

BEGIN FILL @ sta 101+00

$\frac{160' \text{ wide} \times 167' \text{ long} \times 2.7' \text{ deep}}{27}$ = 2670 cuyds

at cell no. 2

$\frac{80' \text{ wide} \times 316' \text{ long} \times 2.7' \text{ deep}}{27}$ = 2530 cuyds

Between cell no. 2 & cell no. 5

$\frac{160' \text{ wide} \times 240' \text{ long} \times 2.7' \text{ deep}}{27}$ = 3840 cuyds

at Cell no. 5

$\frac{80' \text{ wide} \times 304' \text{ long} \times 2.7' \text{ deep}}{27}$ = 2432 cuyds

END FILL @ sta 112+95

$\frac{160' \text{ wide} \times 165' \text{ long} \times 2.7' \text{ deep}}{27}$ = 2688 cuyds

Fill 14,160 cuyd

Available cut 6940 Cut 14093

7153

14093

COMPUTATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE ARIZONA PROJECT VINEYARD ROAD F.R.S. EMBANKMENT DRAIN REPAIR

BY J.E.B. DATE DEC. 1988 CHECKED BY DATE JOB NO

SUBJECT EXTENT OF EARTH FILL @ CELL NO. 3 SHEET OF

TEST CELL NO. 3

Fill Volumes

251+20 BEGIN FILL @ STA 251+20

252+20 $\frac{160' \text{ wide} \times 100' \text{ long} \times 3' \text{ deep}}{27}$ = 1778 cuyds

at test cell no. 3

252+20

255+95 $\frac{60' \text{ wide} \times 375' \text{ long} \times 3' \text{ deep}}{27}$ = 2500 cuyds

NORTH OF CELL NO. 3

255+95

259+45 $\frac{160' \text{ wide} \times 350' \text{ long} \times 3' \text{ deep}}{27}$ = 6222 cuyds

TOTAL FILL 10,500 cuyds.

TOTAL CUT 10,502 cuyds.

COST ESTIMATE

COST ESTIMATE

VINEYARD ROAD FRS
EMBANKMENT AND DRAIN REPAIR

Bid Item	Work or Material	Spec. No.	Quantity	Unit	Unit Price	Amount
1.	Clearing & Grubbing	2	6.6	Ac.	$850	$ 5,610
2.	Structure Removal	3	1	L.S.	XXX	7,670
3.	Survey	7	1	L.S.	XXX	8,000
4.	Mobilization	8	1	L.S.	XXX	10,400
5.	Common Excavation	21	7,990	C.Y.	3.50	27,965
6.	Trench Excavation	21	5,590	C.Y.	11.10	62,049
7.	Dike Excavation	21	31,300	C.Y.	2.25	70,425
8.	Structure Excavation	21	560	C.Y.	5.00	2,800
9.	Earthfill	23	8,260	C.Y.	4.30	35,518
10.	Structure Backfill	23	523	C.Y.	11.20	5,858
11.	Drainfill	24	6,225	C.Y.	26.25	163,405
					TOTAL	$ 399,701

Az. Vineyard FRS Emb. & Drainfill Repair

DE Paulus 12/30/88

Performance Time & Cost Estimate 1 5

Procedure:

1.) Review & summarize original repair cost estimate, and construction contract.

2.) Calc. Perf. time & Cost Est.

1.) REVIEW

A. Cost Estimate 6/82 — Low bid (negot.)

- Trench Excavation (41500 c.y.)	$4.00	$7.50	
- Drainfill (41500 c.y.)	$15.00	$24.00	Labor, Hoe, Conveyor, crawler, shoring, super., water trk, material pick up, Loader
- Water (mod. #6) (3900 MG.)	$16.00		includes bigger pump (500 gpm) & removal of water from test cells.

- Pump & Water meters (rental)
- Road crossing over line
- Mobilization (pipe)
- Installation of pump & pipe.

B. Employee rates 1983 interviews vs Davis/Bacon

- trencher oper.	$16.71	$16.63
- oiler	$13.00	$13.53
- trench labor	$12.30	$12.67
- waterpull oper.	$15.85	$15.84
- Dozer oper/loader	$13.30	$15.84
- Conveyor oper		$13.99

C. GRL Constr. Co. 4223 S Highway 666, P.O. Box 1350, 602-428-6540 Safford, Az 85548

From claim submittal

- Pump rental (Marlow)	$20.00/day	+ Insurance + Tax
- Morgan Conveyor	$83.33/day	+ Insurance + Tax
- 950 loader	$100.00/day	+ Insurance + Tax

Az. Vineyard FB Emb. & Drainfill Repair

DE Paulus 12/30/88

Performance Time & Cost Est. 2 5

D. Equipment Rates for Mod #8 & Mod #7 cost est.

mod #8 Case 850B Crawler	$17.51/hr.
Cat 950 Loader	$28.82/hr
Generator for Conveyor	$8.71/hr.
Case W24C Loader	$32.08/hr.
John Deere JD 690B Hydr. Excavator	$34.55/hr.
Conveyor (self propelled 2'x94')	$11.31/hr.
mod #7 D-8 Cat	$63.82/hr
988 Loader	$66.74/hr.
Cat 225 backhoe	$40.94/hr
John Deer Grader AE401	$23.22/hr.
Pickup	$1.94/hr.
Shoring	$2.10/hr.
Trencher	$82.30/hr.
Waterpull	$33.35/hr.

E. Equipment Speed for moving to different sites.

Grader	77'/min
225 backhoe	128'/min
Trencher	77'/min.
Dozer	366'/min.

F. Handwork - digging trench over Prin. Spw Mod #6

- Excavator
- Shoring
- Forman & Pickup
- 2 to 3 labors.

G. Clean Outs for Geologist investigation.

≈ 1.2 hours per time (handwork)

+ Downtime of equipment

Az Vineyard FRS Emb. & Drainfill Repair

DE Paulus 12/30/88

Performance time & cost estimate 3 5

H. Production Rates:

- trencher (new or old) 419'/day @ 18.5'
  ≈ 1000 c.y. / day
- D8 Cat Push 1000c.y./day down 3:1

2.) PERFORMANCE & COST

A. Mobilization – Contractor is req'd to commence work 20 days after the notice to proceed.

∴ USE 20 days

Costs – 1. Mob. & De-Mob. OF EQUIPMENT
(Ref. EMF R-2 Side Inlet Repair Invoices)

GENERAL –

Compactor/Scraper		$1200.00 x 2 = $2400
Backhoe		1000.00
Waterpull		900.00
Blade		200.00
Crane		1000.00
Loader		200.00
Dozer	est.	800.00

2. Bond (Ref. R-2 inlets)
≈ 1% of total Bid
Est bid @ 350,000 (0.01) $3500

3. Fence $300
4. Permits (assume) $50

$10,350 ≈ 3%

Az. Vineyard FRS Emb. & Drainfill Repair

DE Paulus 1/4/89

Perf. time & Cost Est. 4 5

B. SURVEY

seems high for this job.

- Costs based on past bids (% of total) ≈ 4%
  Est. 350,000 x 0.04 = $14,000

- Estimate of actual time:

REF. EST prepared for EMF R-2 Inlet REPAIR

1. Construction Layout – (Includes travel time)
   a) Common Exc. & Str. Exc. 10hrs/cell x 4 cells = 40 hrs
   40 hr. @ 65.00 = $2600.00
   3 man-crew
   b) Trench Exc. 3 hr./trench x 9 trenches = 27 hrs.
   27 hr. @ 60.00 = $1620.00
   2 man-crew
   c) Dike Exc. 0.5 hr./dike x 4 dikes = 2 hrs
   2.0 hr. @ 60.00 = $120.00
   2 man-crew
   d) Earthfill, Str. backfill, & drainfill – NO TIME; (replacing exc.)
   e) Final slope checks on Embankment – 8 hrs.
   8 hrs @ $65.00 = $520.00
   crew

2. Quantity Surveys (includes as-builts)
   1 set per month @ 3 months = 3

   - Estimate 5 items to survey/month @ 1 day
   8 hrs x $65.00 = $520.00 x 3 = $1560.00
   crew

3. Office Time
   a. est. 2 hrs x 12 Bid Items x $35.00 = $840.00
   Bid Item hr

Az. VINEYARD FRS Emb & Drainfill Repair

DE Paulus 1/11/89

Perf. time & Cost Est. 5 5

6.8 hrs (Records) x $35.00/hr = $280.00

4. SUMMARY

1	a.	2600
	b.	1620
	c.	120
	d.	—
	e.	520
2		1560
3	a.	840
	b.	280
TOTAL		7540

USE $8000

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		Williams-Chandler W.P.P. - VINEYARD ROAD FRS. REPAIR		
BY JEB	DATE 2MAR 1989	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET ____ OF ____

DRAIN FILL SUMMARY

LOCATION	CU YDS	COST	MATERIAL	COST	WATER	COST
cell 2&5	1181	$10512	1570	$15700	47M	$235
cell 2&5	583	6816	816	8160	24.5M	123
sta 130+-t	333	3504	433	4330	13M	65
sta 152±	514	5694	668	6680	20M	100
cell 3	2211	21024	2874	28740	86.2M	430
cell 3	53	1363	70	700	2M	10
sta 276±	518	5840	675	6750	20.3	102
sta. 323±	521	5840	675	6750	20.3	102
sta 353±	311	4752	404	4040	12.1	61
	6225	$65,345	8185	$81850	245.4	$1228

65345
81850
1228

$148,423
profit Add 10% 14842

TOTAL $163,265-

$163265 / 6225 cu yds = $26.22

call 26.25 per cu yd

COMPUTATION SHEET
SCS–ENG–523 Rev. 8–69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		WILLIAMS - CHANDLER W.P.P. - VINEYARD ROAD FRS REPAIR		
BY JEB	DATE MAR 1, 89	CHECKED BY	DATE	JOB NO.
SUBJECT STRUCTURE BACKFILL SUMMARY				SHEET ____ OF ____

structure backfill at cell 3

Gully	50 cuyds	$ 712
F.R.S. Repair	420 cuyds	$3 446
	470 cuyds	$4 158

$$470 \text{ cuyds} \times \frac{60 \text{ gal}}{1 \text{ cuyd}} = 28{,}200 \text{ gal. water}$$

$$28.2 \text{ M} \times \frac{\$5^{00}}{1 \text{ M}} = \$141$$

INSTALLATION COST	$4158
water	141
	4299
add 10% profit	430
TOTAL COST	$4729

cell 3	$ 4729	470
cell 1	1128	53
TOTAL	$ 5,857	523 cuyds

$$\frac{\$5857}{523} = \$11.20 \text{ per cuyd}$$

COMPUTATION SHEET
SCS-ENG-523A Rev 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
GPO 1969 O-364-109

STATE: ARIZONA
PROJECT: WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD F.R.S. REPAIR
BY: JEB & DEP
DATE: JAN. 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: COST ESTIMATE
SHEET 1 OF 21

ITEM	OPERATING COST (HOURS)(UNIT COST)	+ STANDBY COST (HOURS)(UNIT RENT)	=	TOTAL COST
FOREMAN & pickup	(320)(28)	+ 0	=	8,960
D8 DOZER	(271)($108)	+ 0	=	29,268
12G GRADER	(160)($64)	+ (111)($30)	=	13,570
615 SCRAPER	(408)($92)	+ (67)($46)	=	40,618
3000gal WATER TRUCK	(202)($43)	+ (29)($10)	=	8976
950 WHEEL LOADER	(149)($58)	+ (82)($23)	=	10,528
235 BACKHOE	(95)($113)	+ (136)($63)	=	19,303
50 ton CRANE	(93)($113)	+ (138)($63)	=	19,203
2½ton Flat bed Truck	(135)($32)	+ (96)($430)	=	4733
GRADE CHECKER	(174)($19)	— —	=	3306
815 Compactor	(48)($79)	(72)($40)	=	6672
TRACTOR & DISK	(48)($70)	(72)($36)	=	5952
HAND CONTROL COMPACT	(48)($23)	(75)($6)	=	1554
2 WHACKER COMPACTOR		(128)($2)	=	256
WATER PUMP	(202)($2)		=	404
LABORERS	(420)($16)		=	6880
				$180,183
	add 20% overhead			36,037
	TOTAL CONSTRUCTION COST			$216,220
	ADD MOBILIZATION			10,400
	SURVEYS			8,000
	C33 Drain fill (add 33% for waste) @$10.00			91,000
	845M Water @$5.00			4,225
				$329,845
	10% profit			32,985
				$362,830

COMPUTATION SHEET

SCS-ENG-523A Rev 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O - 364-104

STATE: ARIZONA

PROJECT: WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD F.R.S. REPAIR

BY: JEB & DEP | DATE: JAN, 1989 | CHECKED BY | DATE | JOB NO.

SUBJECT: Operating time Summary

SHEET 2 OF 21

	D-8 DOZER	12G GRADER	615 SCRAPER	950 WHEEL LOAD	WATER TRUCK	235 BACKHOE	50 TON CRANE	815 COMPACTOR	TRACTOR - DISK	FLAT BED TRUCK	FOREMAN/PICKUP	GRADE CHECKER	LABORERS
Clear & Grub		18	26		16						18		
Common ex. @ 2&5	40		80		40						40	40	
STRUCTURE REMOVE 2&5										56			56
Trench EX & Drain fill 2&5	16	16	16	16	16	16	16				16	16	32
STRUCTURE EXC. Cell 1						1						1	2
STRUCTURE FILL Cell 1				8	8					2			24
EARTH & DRAIN FILL 2&5		40	80	40	40			40	40		40	40	
12x10 Trench EX. & Drain fill	6	6		6	3	6	6				6	6	24
									str remov	15			15
15x10 Trench EX. & Drain fill	9	9		9	9	9	9				9	9	36
DIKE EX. Cells 2&5	60		120								18		
STRUCTURE EXC. Cell 3	6	1	6			1							
Trench EX & DRAIN FILL @3	32	32		32	32	32	32			32	32	32	128
STRUCT. BACKFILL Cell 3		8	8	8	8			8	8		8		8
DIKE EXC. Test cell 1	28		28								7		
DIKE EXC. Test cell 3	44		44								11		
Trench EXC & Drain Fill	11	11		11	11	11	11			11	11	11	44
Trench EXC & Drain Fill	11	11		11	11	11	11			11	11	11	44
Trench EXC & Drain Fill	8	8		8	8	8	8			8	8	8	32
	271	160	408	149	202	95	93	48	48	135	235	174	430

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO : 1969 O—364-109

STATE: ARIZONA

PROJECT: Williams-Chandler W.P.P. – Vineyard Road F.R.S. Repair

BY: JEB & DEP | DATE: Jan. 1989 | CHECKED BY | DATE | JOB NO.

SUBJECT: Cost Estimate FOR EQUIPMENT (173 hr/mo.)

SHEET 3 OF 21

	EQUIPMENT	COST MO.*	COST/hr.	operation COST	operator**	TOTAL
–	D-8 DOZER	10850	63	29	28.25	*120
–	12G GRADER	5515	32	13	28.97	74
–	615 Scraper	8450	49	26	28.25	103
–	3000 gal. Water Truck	1715	10	14.35	26.61	51
	page 6 815 Compactor	7285	42	19.30	27.59	89
–	235 Backhoe	11,620	67	30	28.25	125
–	950 Wheel loader	4245	25	15	28.25	68
–	50 ton Crane	11,620	67	30	28.97	126
	Tractor/disk	–	36	15	26.60	78
–	2½ ton Flat Bed	785	4.54	8.20	26.60	39
–	Foreman & pickup	520	3.01	3.00	30.37	36
	Laborers				22.19	22
	page 6 Hand Control Compactor	1095	6.33	1.45	22.19	30
–	page 6 43 Whacker	325	1.88	0.90	22.19	25
	Grade Checker				26.46	27
–	Pump (10M)	190	1.10	0.70		2
	16' Trench Shore	115	0.66			1

* Blue Book (88)

** Davis-Bacon Rates X 1.4 labor burden = operator cost

COMPUTATION SHEET
SCS-ENG-523A Rev. 6-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
GPO 1969 O—364-109

STATE: ARIZONA
PROJECT: Williams-Chandler W.P.P. - Vineyard Road F.R.S. Repair
BY: JEB & DEP
DATE: JAN. 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: A PLAN OF OPERATION
SHEET 4 OF 21

1. Mobilization
2. Clear & grub 6.6 acres @ $850/ac = $5610
3. Common excavation Cells 2 & 5 7990 cuyds. $ 25,459
4. Trench for drain fill Cells 2 & 5 } structure removal 1181 cuyd. $ 13,104
5. Drain fill in trench cells 2 & 5 1181 cu.yd $ 29,100
6. Structure excavation cell 3 473 cuyds
7. Earth Fill cells 2 & 5 8260 cuyds.
8. Drain fill zone cells 2 & 5 583 cuyds.
9. structure excavation cell 1 53 cuyds
10. Structure backfill Cell 1 53 cuyds
11. Trenching & drain fill @ pipe sta. 129+70 333 cuyds
12. Trenching & drain fill @ pipe @ sta 152+40 514 cu yds
13. Remove dikes @ Test Cells 2 & 5 14,093 cuyds
cell No.3 14. Trenching & drain fill @ pipe @ sta. 251+00 2211 trench
15. structure excavation rill @ cell 3 36 cuyd
16. structure backfill rill @ cell 3 50 cuyd
17. Trenching & drain fill @ cell 3 each = 2211 cuyds
18. structure backfill cell 3 420 cuyd
19. Drain fill zone in str. backfill cell 3 53 cuyd
20. Remove dike @ Test cells 1 & 3 6700 + 10,500 cuyd
21. Trench and drain fill @ pipe @ sta. 276+80 each 518 cu.yd.
22. Trench and drain fill @ pipe @ sta. 321+50 each 521 cu.yd.
23. Trench and drain fill @ prop. spillway @ sta. 352+00

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

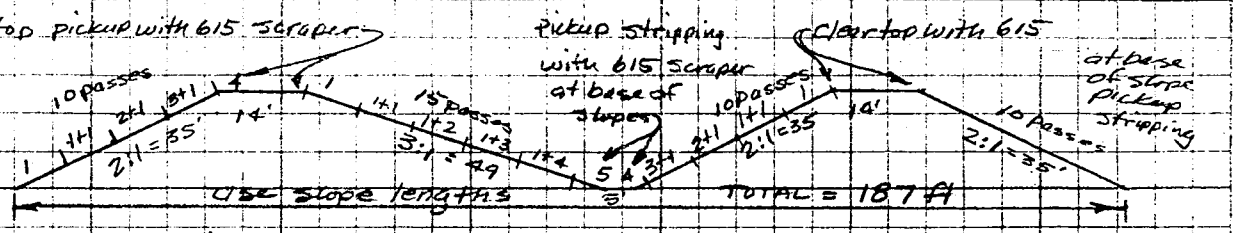
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O-364-409

STATE	PROJECT			
ARIZONA	VINEYARD ROAD F.R.S. REPAIR			
BY J.E.B.	DATE JAN. 1989	CHECKED BY	DATE	JOB NO. COST ESTIMATE

SUBJECT CLEARING & GRUBBING

SHEET 5 OF 21



Do side slopes with 12G grader (12 ft blade) I assume we will make a clearing cut of 8" + - Note: previous cuts must be moved before a new cut can be made

Total passes with grader 10 + 15 + 10 + 10 = 45 passes
length of cut 365' & operation speed 0.88 mph
(45)(365') / 5280 ft/mi = 16,425 ft = 3.11 miles

3.11 miles / .88 mph = 3.53 hrs. with 12G blade
call 4 hours

width x length x depth cut / 27 = cu.yds. to be hauled to Refuse Area

(187')(365')(0.5') / 27 = 1264 cu.yds To be hauled

Assume each trip to be 365' + 300' + 365' + 300' = 1330 Ft
Load time 1 minute for 365' haul 300' in 1/2 min
unload time 1 minute for 365' return to cut area 1/2 min
Call cycle 3 minutes and 20 trips per hour
Use 50 min hour. 20 x .83 = 16 trips per hour
15 cuyds in scraper x 16 trips = 240 cuyds per hr

1264 cuyds / 240 cuyds/hr = 5.27 hours with 615 scraper
CALL 6 hours

Summary

Machine	Cost Per Hour from table	Hours	= Cost
12G Grader	$74	x 4	= $296
615 Scraper	103	x 6	= $618
Foreman & pick-up	36	x 4	= $144
			$1058
20% overhead			212
		TOTAL	$1270

$1270 / 1.5 acres = $846.4 per acre call $850

6.6 acres @ $850 Est. Cost $5610.00

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
GPO 1969 O-364-109

STATE: ARIZONA
PROJECT: WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD F.R.S. REPAIR
BY: J.E.B. & DEP
DATE:
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: COMMON EXCAVATION COST ESTIMATE
SHEET 6 OF 21

Considering ripping and watering operations in the limited area of Excavation at Test cells 285 I will assume each 615 scraper can get 7-12 cuyd loads per hour or 84 cuyds per hour per machine

Common excavation 7990 cuyds / 84 cuyds/hr = 95 hrs. Call time 96 hrs

Base other machine time on 1/2 the scraper time

Machine	rent + maint. + operator = cost/Hr.	X Hours	= Cost Est.
(2) 615 scraper	(From table) = 103	X 96	= 9888
D-8 dozer	= 120	X 48	= 5760
Water truck	= 51	X 48	= 2448
Grade checker	= 27	X 48	= 1296
Foreman-pickup	= 36	X 48	= 1728
Pump	= 2	X 48	= 96
			$21216
$15,360 X 20% overhead			4243
$25 459 X 10% profit			$25459
$28 005			2546
7990 cuyds = $3.50 per yd.			$28,005

STRUCTURE REMOVAL AT THIS SITE

FLAT BED TRUCK & driver (From table)	= $39	X 48	$1872
(1) Laborer	= 22	X 48	1056
			$2928
$1920 X 20% overhead			586
SUBTOTAL STRUCTURE REMOVAL			$3514

Water 8000 cuyd X 30 gal/cuyd = 240 m / 55 = $12.00

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: WILLIAMS - CHANDLER W.P.P. - VINEYARD ROAD F.R.S. REPAIR
BY: JEB & DEP. DATE: Jan. 1989
CHECKED BY: DATE: JOB NO.:
SUBJECT: TEST CELLS 2 & 5 TRENCH EXCAVATION COST EST. SHEET 7 OF 21

I assumed the common excavation has been completed. The next portion of the job is trench excavation. As a safety consideration the trench will not be left open so excavation and drain fill will be done at the same time. Also we will do structure removal of HDPE and other foreign materials from the trench excavation.

TEST CELL NO. 2 TRENCH EXCAVATION = 711 cu.yds.
TEST CELL NO. 5 TRENCH EXCAVATION = 470
1181 cu.yds.

The 50 ton crane with a 1 cu.yd concrete bucket will be the critical machine.
Time for 1 cycle = 50 seconds or 1.2 cu.yd. per min
use 50 minute hour and we have 60 cu.yds. per hr.
Drain fill total $\frac{1181 \text{ cu.yds}}{60 \text{ cu.yds/hr}}$ = 19.68 hours
Call 20 hours
The 235 backhoe bucket is 2.2 cu.yds. and the cycle time would be similar to the crane. Setting shoring and crack inspection 4 hrs. JOB TOTAL 24 hours

Trench Excavation

MACHINE	RENT/HR + MAINT./HR + OPERATOR	X HRS	= COST EST.
235 BACKHOE	(FROM TABLE) $125	X 24	= $3000
D8 DOZER	120	X 24	= 2880
615 Scraper	103	X 24	= 2472
Foreman/pickup	36	X 24	= 864
Grade checker	27	X 24	= 648
Laborers (2) ($22)	44	X 24	= 1056
			$10,920
+ $10,920 X 20% overhead			2,184
COST ESTIMATE			$13,104
add 10% profit			1310
			$14,414

$\frac{14,414}{1181 \text{ cu.yd}}$ = $12.20 per cu.yd.

STRUCTURE REMOVAL

Flat bed truck with operator	$39	X 24	936
1 Laborer	22	X 24	528
			$1464
add 20% overhead 1464 X 20%			292
			$1756

$1756 STRUCTURE REMOVAL

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O-364-199

STATE	PROJECT			
ARIZONA	WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD F.R.S. REPAIR			
BY JEB & DEP	DATE JAN. 1989	CHECKED BY	DATE	JOB NO.

SUBJECT
TEST CELLS 2 & 5 DRAIN FILL

SHEET 8 OF 21

Continued from sheet 7

MACHINE	RENT/HOUR + MAINT/HR + OPERATOR/HR		
50 ton crane	FROM TABLE $126	X 24 =	$3024
950 wheel loader	68	X 24 =	1632
12G Grader	74	X 24 =	1776
WATER TRUCK	51	X 24 =	1224
2 Laborers (2) ($22)	44	X 24 =	1056
Pump	2	X 24 =	48
			$8760
add 20% overhead			
$8760 X 20%			1752
			$10,512

$10,512 / 1181 cuyd = $8.90 per cuyd (pay lines)

1181 cuyd + (33% waste) 390 = 1570 cuyds to buy @ $10 = 15,700

1570 X 30 gal = 47 m water @ $5 = $235

COST OF MATERIAL DELIVERED TO STOCKPILE OR COULD be in concrete mix truck delivered to crane bucket -

1181
33% loss 389
1570 cuyds to buy

Material = 1570 cuyd X $10.00 = $15,700

Water @ 30 gal per cuyd X 1570 = 47,000 gal

Cost of water $5.00 X 47M = $235

EQUIPMENT	$10,512
C33 Material	$15,700
Water	235
	$26,447
add 10% profit	2645
	$29,092 call $29,100

$29,100 / 1181 = $24.65 per cuyd.

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O—364-109

STATE	PROJECT		
ARIZONA	WILLIAMS-CHANDLER WPA - VINEYARD ROAD FRS REPAIR		
BY JEB & DEP.	DATE Jan. 1989	CHECKED BY	DATE	JOB NO.

SUBJECT TEST CELL 1 STRUCTURE EXCAVATION

SHEET 9 OF 21

TEST CELL 1 OBSERVATION PIT AT STA. 121+72
STRUCTURE EXCAVATION 53 cu.yds.
Use 235 Backhoe to excavate - stock pile excavation to be used for structure Backfill - Need to have water available. Distance to travel 121+72
-111+80
9 92 call 1000 ft.

1000 ft move
100 ft per min speed = 10 min move time
54 cu yds EXC
2 cu yd bucket = 27 buckets of material = 20 min
try 1/2 hour excavation time add 1/2 travel time

Machine	Rent/Hr. + Maint/HR + Operator Hour = TOTAL	
235 Backhoe	(FROM TABLE)	$125
Grade checker		27
2 laborers	(2)($22)	44
		$196
$196 X 20% over head =		39.20
CALL TIME 1 HOUR =		$235
10% profit		24
		$259 TOTAL

$\frac{\$259}{53}$ = $4.89 per yard

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O-268-109

STATE	PROJECT		
ARIZONA	WILLIAMS-CHANDLER W.P.P. -VINEYARD ROAD FRS REPAIR		
BY JEB & DEP	DATE Jan. 1989	CHECKED BY	DATE	JOB NO.
SUBJECT TEST CELL 1 STRUCTURE BACK FILL			SHEET 10 OF 21

53 cu.yds. BACKFILL TEST PIT AT TEST CELL NO.1
HAND COMPACTION TIME CONTROLS SCHEDULE
say we have 17 lifts placed in 5 hours

	MACHINE	Rent/Hr. + MAINT/HR + OPERATOR/HR. = COST/HR	X Hr.	TOTAL
	950 Wheel loader	$ 68	X 5 =	$ 340
	HAND CONTROL COMP.	30	X 5	150
	Whackers (2) ($25)	50	X 5	250
HALFTIME	WATER TRUCK call 2hrs	51	X 2	102
				$842
	add 20% overhead			168
				$1010

water = 53 cuy X 50 gal per yd = 2650 gal
say 3M X $5.00 = $15.00 water cost

INSTALL	COST	$1010
	WATER	15
		$1025
	10% profit	103
		$1128

$\frac{\$1128}{53}$ = $21.28 call $21.30

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O—364-109

STATE	PROJECT			
ARIZONA	WILLIAMS-CHANDLER WRP - VINEYARD ROAD FRS. REPAIR			
BY JEB & DEP	DATE Jan-89	CHECKED BY	DATE	JOB NO.

SUBJECT EARTH FILL @ TEST CELLS 2 & 5 ALSO DRAIN FILL

SHEET 11 OF 21

Use 2 - 615 scrapers to bring fill material to the fill area - TOTAL FILL 8260 cuyds. ÷ 84 = 98hrs 615 scraper time
Water truck and 12 G blade will premix fill material at the borrow - may also add water on the fill. From page 6 each 615 scraper hauls 84 cuyd/hr.

MACHINE	RENT/HR + MAINT./HR + OPERATOR/HR	COST/hr	Time
1 615 Scraper	FROM TABLE COST/HR	$103	X 50 = $5150
Tractor/disk		78	X 50 = 3900
815 Compactor		89	X 50 = 4450
Water truck	(12)($51)	102	X 50 = 5100
Grade Checker		27	X 50 = 1350
Foreman/pickup		36	X 50 = 1800
Pump		2	X 50 = 100
1 615 scraper		103	X 50 = 5150

$27000
add 20% overhead 5400
$32400
add 10% profit 3240
TOTAL $35640

$35640 / 8260 cuyds = $4.30

Install drain fill as a zone fill

12 G. Grader	$ 74	X 40 = 2960
950 Wheel loader	68	X 40 = 2720
		$5680
add 20% overhead		1136
TOTAL COST		$6816

$6816 / 583 cuyds = $11.69 per cu.yd.

583 cuyd x 30 gal = 17490 call 18000
8260 cuyds earth x 60 gal/yd = 496 000 gal
514 M gal water

514 M x $5 = $2570 water

Drain fill (ZONE) 583 X 1.40 = 816 cuyd C33

816 X $10.00 $8162.00

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

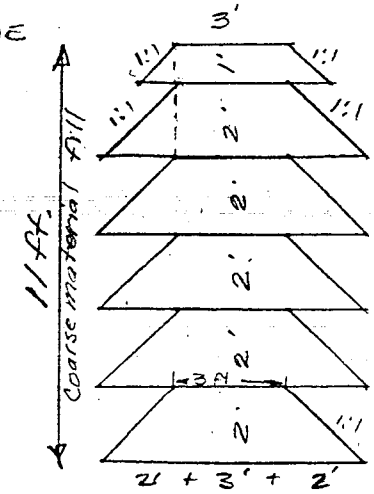
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZ		VINEYARD ROAD FRS REPAIR		
BY JEB	DATE JAN 89	CHECKED BY	DATE	JOB NO.
SUBJECT DRAIN FILL QUANTITIES IN EARTH FILL				SHEET 11A OF 21

TEST CELL 2
DRAIN FILL ZONE
IN EARTH FILL

DESIGN Trench

$\frac{3' \times 1'}{27} = \frac{1.22 \text{ cuyd}}{1 \text{ ft}}$



4 sq ft
10 sq. ft
10 sq. ft
10 sq ft
10 sq ft
10 sq ft.

$\frac{54 \text{ sq ft}}{27} = 2 \text{ cuyd/ft}$

STA 105+08 - 103+67 = 141 ft ave length
141 ft x $\frac{2 \text{ cuyd}}{1 \text{ ft}}$ = 282 cuyds

TEST CELL 5
DRAIN FILL ZONE WITHIN EARTH FILL

STA 111+20 - 108+07 = 313 ft ave length
313 ft $\frac{2 \text{ cu.yd}}{1 \text{ ft}}$ = 626 cuyds

TOTAL 282 + 626 = 908 cuyds.
Add 10% waste = 92
1000 cuyds. C33 material

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD F.R.S. REpair		
BY JEB & DEP	DATE Jan. 1989	CHECKED BY	DATE	JOB NO.

SUBJECT Trenching & drainfill @ R/C pipe sta 129+70 SHEET 12 OF 21

Trench excavation from sta 129+00 to 130+90
333 cu.yds. excavation & drainfill
The 1 cu.yd. concrete bucket on crane is the control factor: 50 sec cycle = 6 cu.yds in 5 minutes
50 minute hour = 60 cu.yd per hour
Call construction time 6 hours
add time for inspection 2 hours

$\frac{333}{60}$ = 5.6 hrs

Call 6 hours

TOTAL TIME 8 hours

EXCAVATION COST

MACHINE	TOTAL COST/HR		Time	
235 BACKHOE	FROM TABLE	$125	X 8 hr	= $1000
D8 DOZER		120	X 8	= 960
FOREMAN/pickup		36	X 8	= 288
Grade Checker		27	X 8	= 216
(2) Laborers	(2)(22)	44	X 8	= 352
				$2816
	add 20% overhead			564
				$3380
	10% profit			338
				$3718

$\frac{\$3718}{333 \text{ cu yds}}$ = $11.17 per cu.yd. excavation

DRAIN FILL COST

MACHINE		TOTAL COST	X TIME	
50 ton crane	(FROM TABLE)	$126	X 8 hr	= $1008
950 wheel loader		68	X 8 hr	= 544
12G Grader		74	X 8 hr	= 592
Watertruck		51	X 8 hr	= 408
(2) Laborers	(2)(22)	44	X 8 hr	= 352
Pump		2	X 8 hr	= 16
				$2920
	add 20% overhead			584
				$3504

$\frac{\$3504}{333}$ = $10.52 per cu.yd installation

pay line material	333
add 30% waste	100
Buy drainfill	433 cu yds

Water 433 cu yd X 30 gal/yd = 12990 = 13 M @ $5 = $65.00

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: WILLIAMS - CHANDLER W.P.P. - VINEYARD ROAD FRS
BY: JEB - DEP
DATE: Jan. 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: Trenching & drainfill @ R/c pipe @ Sta. 152+40
SHEET 13 OF 21

Trench excavation from Sta 151+11 to 153+80
514 cu.yds. excavation & drainfill
The 1 cu.yd. concrete bucket on the crane is the control factor, 50 second cycle = 6 cu.yds. in 5 minutes
50 minute hour = 60 cu.yds per hour
call construction time 9 hours
add time for crack inspection 4 hours

514/60 = 8.6
call 9 hrs

TOTAL 13 hours

EXCAVATION COST

MACHINE	TOTAL COST/HOUR (FROM TABLE)
235 BACKHOE	$ 125
D8 DOZER	120
FOREMAN/pickup	36
Grade Checker	27
(2) Laborers (2)(22)	44

$352 X 13 hrs = $4576
20% overhead 915
$5491
10% profit 549
$6040

$6040 / 514 cu.yds = $11.75 per cu.yd.

DRAIN FILL COST

MACHINE	TOTAL COST/HOUR (FROM TABLE
50 ton crane	$ 126
950 Wheel loader	68
12G Grader	74
Water Truck	51
(2) Laborers (2)(22)	44
Pump	2

365 X 13 hrs = $4745
20% overhead 949
$5694

$5694 / 514 cu.yds = $11.08

514 + (30% waste) 154 = 668 cu.yds drainfill to buy
668 X $10 = $6680

Water 668 X 30 gal/yd = 20M @ $5.00 = $100.00

COMPUTATION SHEET

SCS-ENG-523A Rev 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O-342-[illegible]

STATE: ARIZONA
PROJECT: WILLIAMS-CHANDLER W.P.P.-VINEYARD ROAD F.R.S. Repair
BY: JEB & DEP
DATE: Jan. 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: DIKE EXCAVATION TEST CELLS 2 & 5
SHEET 14 OF 21

REMOVE EARTH DIKES FOR TEST CELLS 2 & 5
EACH 615 scraper can get 8 - 12 cu.yd. loads per hour, or 96 cu.yds per hour.

Cell 2 7160 cu.yds dike excavation
Cell 5 6940 cu.yds
14,100 cu.yds. dike excavation

$\frac{14,100 \text{ cu.yds}}{96 \text{ cu.yds/hr}}$ = 146.9 hours / 2 machines = 73 hours 615 scraper time

MACHINE	TOTAL COST/HOUR
615 scraper	$103
615 scraper	$103
D-8 Dozer	$120
	$326

$326 X 73 hrs = $23800
+ 20% overhead 4760
$28560
profit add 10% 2856
$31,416

$\frac{\$31,416}{14,100 \text{ cu.yd.}}$ = $2.23 per cu.yd $31,416

COMPUTATION SHEET

SCS-ENG-523A Rev 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
ARIZONA	WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD FRS. REPAIR		
BY JEB & DEP	DATE Jan. 1989	CHECKED BY	DATE	JOB NO.

SUBJECT STRUCTURE EXCAVATION AT TEST CELL No. 3 SHEET 15 OF 21

Use a 615 scraper and D-8 Dozer to excavate at the test pit. Assume 7-12 cuyd loads per hour = 84

STRUCTURE EXCAVATION $\frac{373 \text{ cuyds}}{84 \text{ cuyd/hr}}$ = 4.44 hours
call 5 hours
moving add 1 hour
Job time 6 hours

Road time: sta. 253+75
sta. 110+00

$\frac{14375 \text{ ft}}{5280}$ = 2.72 miles

allow 1 hr. to move from cells 2 & 5 Area

Machine	TOTAL COST HOUR
615 scraper	$103
D-8 Dozer	$120

$223 X 6 hours = $1338
add 20% for overhead = 268
TOTAL $1606
add 10% profit 161
$1767

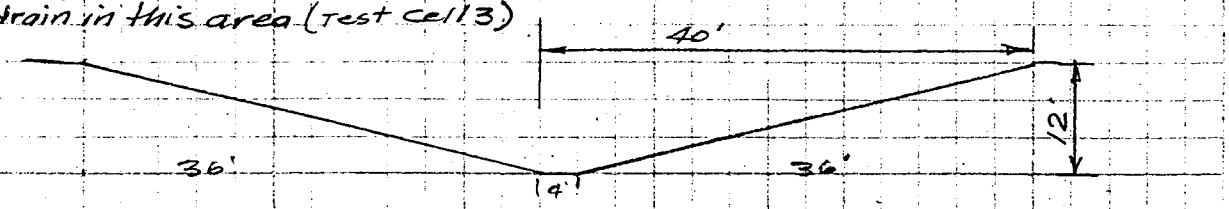
$\frac{\$1767}{373 \text{ cuyd}}$ = $4.74 per cu.yd.

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: WILLIAMS - CHANDLER W.P.P. - VINEYARD ROAD FRS REPAIR
BY: JEB & DEP
DATE: Jan. 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: Trenching & drainfill Sta. 248+59 to Sta. 258+00
SHEET 16 OF 21

No drain in this area (Test cell 3)



Volume of trench removed by structure excavation

$\frac{(40')(12')(3')}{27}$ = 53.33 cuyds. trench excavation

Total trench volume 2264.3
− 53.3
2,211 cuyds. trenching

The 50 ton crane with a 1 cu.yd. concrete bucket will be the critical machine. (I assume for safety we will trench and backfill as one operation)
Time for 1 cycle is 50 seconds or 6 cu.yds. in 5 min.
Use a 50 minute hour so we will place 60 cuyds. per hour

$\frac{2211 \text{ cuyd}}{60 \text{ cuyd/hr}}$ = 37 hours
Shoring & crack inspection 7
Time to move & setup operation 4 hours
48 hours

MACHINE	TOTAL COST-HOUR
235 Backhoe	$125
D8 Dozer	120
Foreman/pickup	36
Grade Checker	27
(2) Laborers (2)(22)	44

$352.00 per hour

(48 hours)($352) = $16,896
20% overhead = 3379
$20,275
10% profit 2028
TOTAL $22,303

$\frac{\$22303}{2211}$ $10.09 per cuyd

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: WILLIAMS-CHANDLER W.P.P.-VINEYARD ROAD FRS REPAIR
BY: JEB & DEP
DATE: Jan. 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: Trenching & drainfill Sta. 248+59 to Sta. 258+00
SHEET 17 OF 21

CONTINUED FROM SHEET 14
DRAIN FILL 2211 cuyds.

MACHINE	TOTAL COST/HOUR
50 ton Crane	$126
950 Wheelloader	68
12G Grader	74
Water truck	51
Pump	2
(2) Laborers (2)(22)	44
	$365 per hour

(48 hrs)($365) = $17,520
20% over head 3504
$21024

$21024 / 2211 cuyd = $9.51 per cuyd

2211 cuyds Pay lines
663 30% handling loss
2874 cuyds Drain fill to buy

2874 x $10 = $28740

2874 cuy x 30 gal water / yd x $5/1000 = $430

STRUCTURE REMOVAL

FLAT BED TRUCK	$39
1 Laborer	22
	$61

(28 hours)($61) = $1708

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O—364-109

STATE ARIZONA | PROJECT WILLIAMS-CHANDLER W.P.P.-VINEYARD ROAD FRS REPAIR

BY JEB & DEP | DATE JAN. 1989 | CHECKED BY | DATE | JOB NO.

SUBJECT STRUCTURE EXCAVATION & STRUCTURE BACKFILL CELL 3 gully

Assume the 235 backhoe can excavate this gully while it is doing the Drain fill trench operation - ALLOW 1 hour for 36 cuyds

MACHINE	TOTAL RATE/HR.
235 BACKHOE	$125
126 GRADER	$ 74
laborer (2)(22	$ 44
TOTAL COST	$243
20% OVERHEAD	49
	$292

$292 = $8.11
EAC. 36 cuyd

STRUCTURE BACK FILL OF GULLY 50 cuyds earth

MACHINE	
950 wheel loader	$ 68
Laborer/whacker	$ 25
Laborer/whacker	$ 25
Laborer/Hand directed	$ 30
	$148
20% Overhead	30
	$178

$178 x 4 hrs. = $712

$712 / 50 cuyds = $14.24 per cuyd.

STRUCTURE BACK FILL FRS DIKE 420 cuyds

MACHINE	TOTAL Cost per hr.
615 scraper	$103
Tractor disk	78
815 Compactor	89
Water truck	51
water pump	2
Foreman/pickup	36
TOTAL	$359

per hour X 8 hours = $2872
20% overhead 574
TOTAL $3446

$3446 / 420 cuyd = $8.20 per cuyd

INSTALL DRAIN FILL AS A ZONE FILL

126 Grader	$ 74
950 wheel loader	$ 68
TOTAL	$142.00 per hour

$142.00 per hour X 8 hours = $1136
20% overhead = 227
$1363

$1363.00 / 53 cuyds = $25.72 per yard

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O-364-

STATE	PROJECT		
ARIZONA	WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD FRS REPAIR		
BY JEB & DEP	DATE Jan. 1989	CHECKED BY	DATE	JOB NO.

SUBJECT Dike Excavation Test Cell 1 & Test Cell 3 SHEET 19 OF 21

Remove Earth dike at test cell No. 1
Excavation quantity = 6700 cuyds
Each 615 scraper can get 8 - 12 cuyd loads per hour = 96 cy
(2) 615 scrapers 96 cuyds = 192 cuyds per hour

$\frac{6700 \text{ cuyds}}{192 \text{ cuyd/hr}}$ = 35 hours

MACHINE	TOTAL COST/HOUR
615 Scraper	$ 103
615 Scraper	103
D-8 Dozer	120
	$ 326

$ 326 x 35 hours = $ 11,410
20% overhead = 2,282
$ 13,692
add 10% profit 1369
$ 15061

$15061
6700 = $2.25 per cuyd.

Remove Earth dike at test cell No. 3
Excavation quantity = 10500 cuyds

$\frac{10,500 \text{ cuyds}}{192 \text{ cuyds/hr}}$ = 55 hours

MACHINE	TOTAL COST/HOUR
615 Scraper	$ 103
615 Scraper	103
D-8 Dozer	120
	$ 326

$ 326 x 55 hours = $17,930
20% overhead = 3,586
$ 21,516
add 10% profit 2152
TOTAL $ 23,668

$23,668
10500 cuyd = $2.25 per cuyd.

COMPUTATION SHEET
SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: WILLIAMS-CHANDLER W.P.P.-VINEYARD ROAD F.R.S. REPAIR
BY: JEB & DEP
DATE: Jan. 1989
CHECKED BY
DATE
JOB NO.
SUBJECT: TRENCH EXCAVATION & DRAIN FILL STA 275+59 to 278+21
SHEET 20 OF 21

REPEAT FOR STA 320+29 to 322+91
520 cuyds. cut & Fill
50 ton crane is the critical equipment. (Assume the cut & fill will done together, to avoid an open trench)
Rate of fill 6 cuyds. in 5 minutes, 50 min hour
= 60 cuyds per hour $\frac{520}{60}$ = 8.7 - call 9 hours

4 hours moving time, shoring & inspection
9 hours fill time
1 hour time diff between cut & fill operation

14 hours performance time

EXCAVATION

Machine	TOTAL Cost/Hour
235 Backhoe	$125
D-8 Dozer	$120
Grade Checker	$27
(2) Laborers (2)($22)	$44
	$316

X 14 hrs. = $4424.00
20% overhead = 885.00
$5309.00
add 10% profit 531.00
$5840.00

$5840 / 520 cuyd = $11.23 per yd

DRAIN FILL

MACHINE	TOTAL COST / HOUR
50 TON CRANE	$126
950 wheel loader	68
12G Grader	74
water truck	51
pump	2
(2) Laborers (2)($22)	44
Foreman	36
Flat bed truck	39

$440 X 14 hrs = $6160
20% overhead 1232
$7392

$7392 / 520 cuyds = $14.22 per yd

REPEAT FOR STA 320+29 TO STA 322+91

COMPUTATION SHEET

SCS-ENG-523A Rev. 9-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

GPO 1969 O—364-109

STATE: ARIZONA
PROJECT: WILLIAMS-CHANDLER W.P.P.-VINEYARD ROAD F.R.S. REPAIR
BY: JEB & DEP
DATE: Jan. 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: TRENCH EXCAVATION & DRAIN FILL STA. 352+12 to 353+92
SHEET 21 OF 21

311 cuyds cut & Fill

50 ton crane with 1 cuyd conc. bucket is the critical equipment (For safety I assume the cut & fill will be done together to avoid an open trench - Rate of fill with crane 6 cuyds each 5 minutes, 50 minute hour = 60 cuyds per hour $\frac{311}{60}$ = 5.18 call 5 hours

3 hours moving-shoring & inspection
5 hours fill time
1 hour difference between cut & fill operation

9 hours performance time

EXCAVATION

MACHINE	TOTAL COST / HOUR
235 Backhoe	$125
D-8 Dozer	120
Grade checker	27
(2) Laborers (2)($22)	44
	$316.00

$316.00 x 9 hrs. = $2844.00
20% overhead 569.00
$3413.00
10% profit 341.00
$3754

$ 3754
311 cuyd = $12.07 per yard

DRAIN FILL

MACHINE	TOTAL COST / HOUR
50 ton Crane	$126
950 Wheel loader	68
12 G Grader	74
water truck	51
water pump	2
(2) Laborers (2)($22)	44
Foreman / pickup	36
FLAT BED TRUCK	39

$440.00 x 9 hr = $3960
20% overhead = 792
$4752

$ 4752
311 cuyd = $15.28 per yard

311
311 x 30% = 93
c 33 material 404 cuyds

CONSTRUCTION SCHEDULE

Short Form Project Summary

Project Information

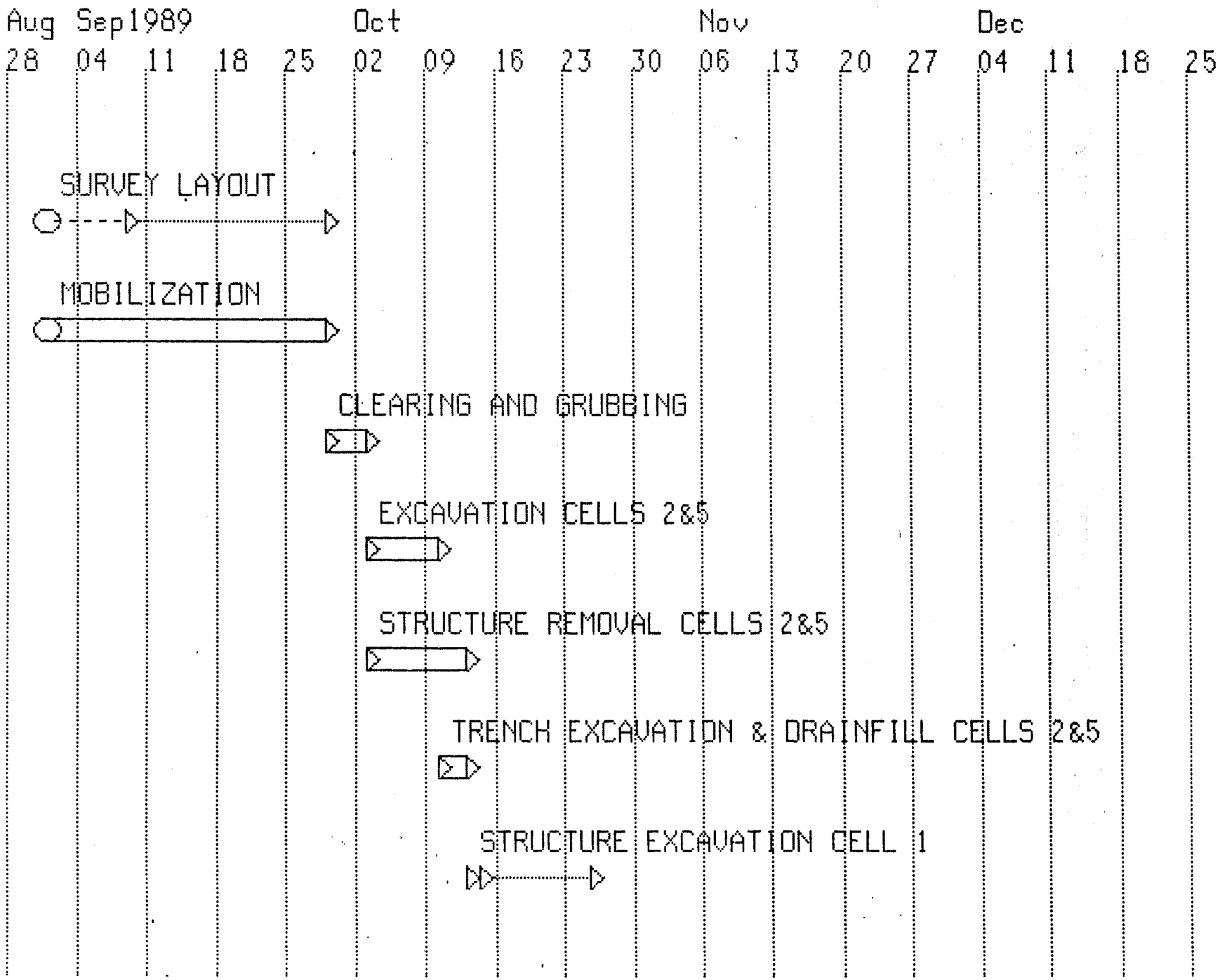
Project Title: VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE
Project Manager: D Paulus

Projected Start Date: Sep 01, 1989
Projected End Date: Dec 23, 1989
Number of Activities: 22
Hours Per Day: 8.0
Days Per Week: 5.0
Min. Project Duration: 113.4 (days)
Exp. Project Duration: 113.4 (days), Exp. Project Work Days: 81.0
Max. Project Duration: 113.4 (days)

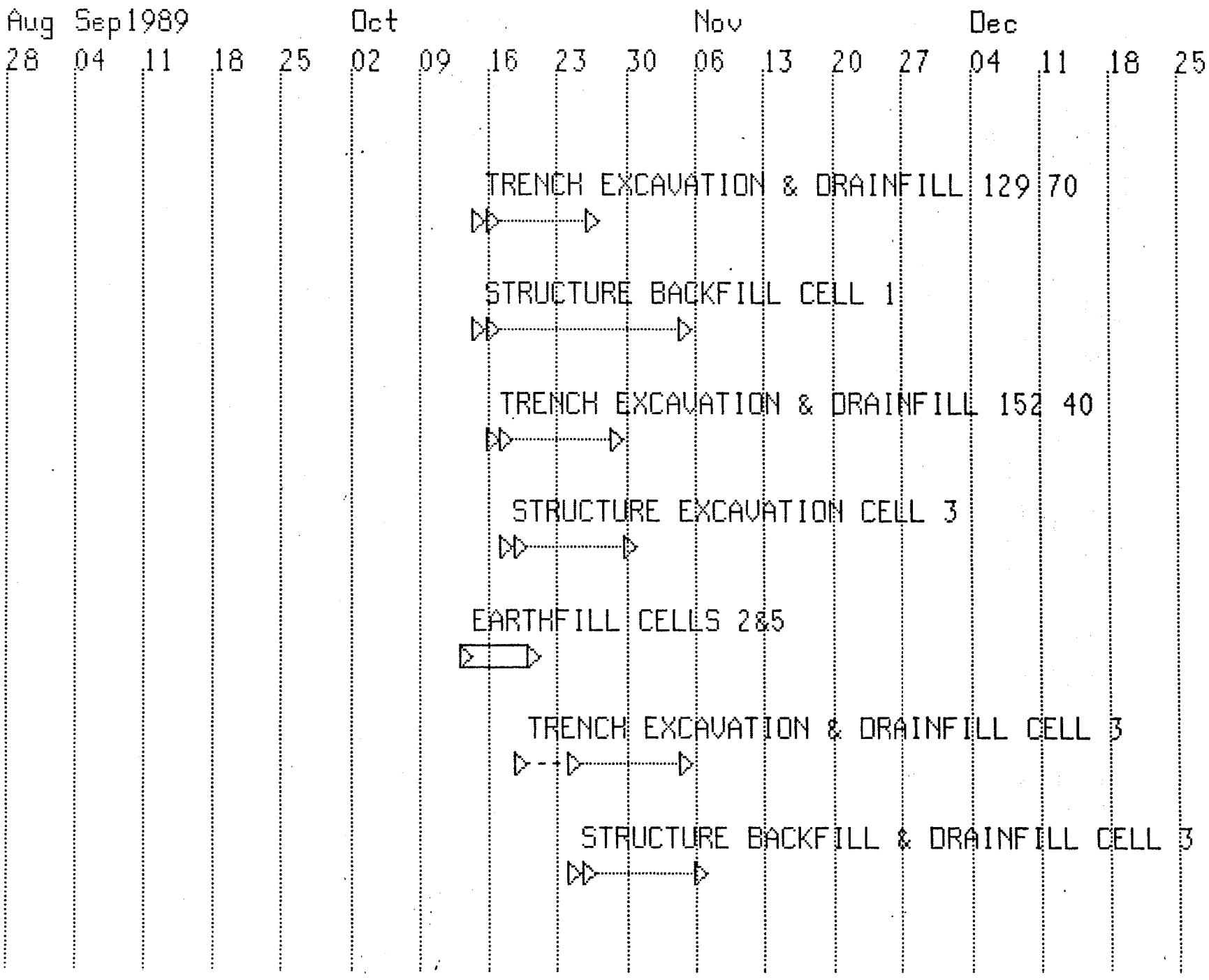
Budget Information

Minimum Labor Cost:	$	0.00	Labor Cost per Day:	$	0.00
Expected Labor Cost:	$	0.00	Project Capital:	$	0.00
Maximum Labor Cost:	$	0.00	Budgeted Capital:	$	0.00

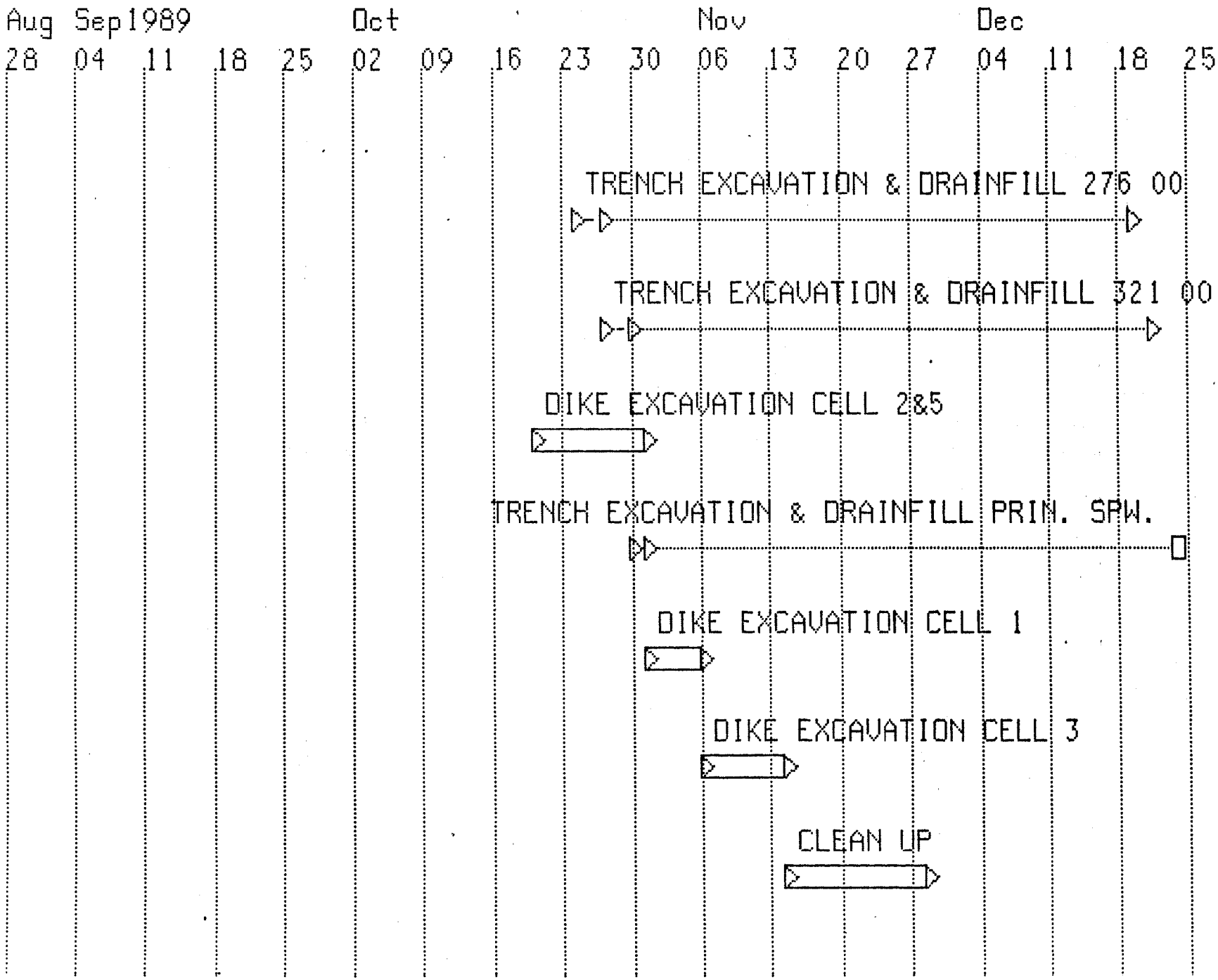
VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart



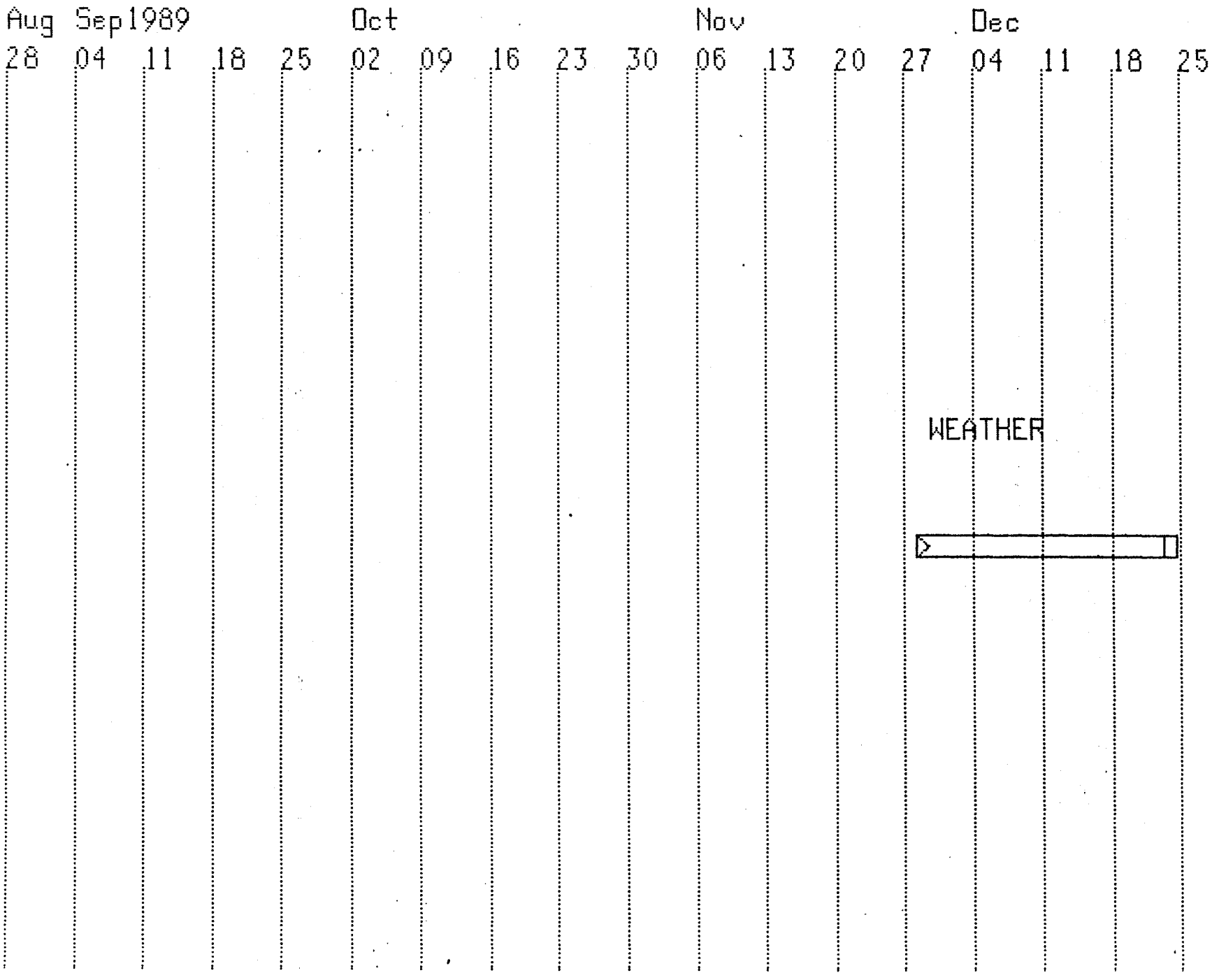
VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart



VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart



VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart



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Activity: SL
Description: SURVEY LAYOUT
Prerequisites:
Class: Responsibility:

Early Start Date: Sep 01, 1989 Early Stop Date: Sep 08, 1989
Late Start Date: Sep 21, 1989 Late Stop Date: Sep 29, 1989
Duration (in days): (Min.) 7.0 (Exp.) 7.9 (Max.) 8.9
Duration Variance: 0 Slack Time: 20.1

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

==========

Activity: M Critical
Description: MOBILIZATION
Prerequisites:
Class: Responsibility:

Early Start Date: Sep 01, 1989 Early Stop Date: Sep 29, 1989
Late Start Date: Sep 01, 1989 Late Stop Date: Sep 29, 1989
Duration (in days): (Min.) 28.0 (Exp.) 28.0 (Max.) 28.0
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

==========

Activity: C Critical
Description: CLEARING AND GRUBBING
Prerequisites: M,SL
Class: Responsibility:

Early Start Date: Sep 29, 1989 Early Stop Date: Oct 03, 1989
Late Start Date: Sep 29, 1989 Late Stop Date: Oct 03, 1989
Duration (in days): (Min.) 4.2 (Exp.) 4.2 (Max.) 4.2
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

==========

Activity: E1 Critical
Description: EXCAVATION CELLS 2&5
Prerequisites: C
Class: Responsibility:

Early Start Date: Oct 03, 1989 Early Stop Date: Oct 10, 1989
Late Start Date: Oct 03, 1989 Late Stop Date: Oct 10, 1989
Duration (in days): (Min.) 7.0 (Exp.) 7.0 (Max.) 7.0
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: S1 Critical
Description: STRUCTURE REMOVAL CELLS 2&5
Prerequisites: C
Class: Responsibility:

Early Start Date: Oct 03, 1989 Early Stop Date: Oct 13, 1989
Late Start Date: Oct 03, 1989 Late Stop Date: Oct 13, 1989
Duration (in days): (Min.) 9.8 (Exp.) 9.8 (Max.) 9.8
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: TD1 Critical
Description: TRENCH EXCAVATION & DRAINFILL CELLS 2&5
Prerequisites: E1
Class: Responsibility:

Early Start Date: Oct 10, 1989 Early Stop Date: Oct 13, 1989
Late Start Date: Oct 10, 1989 Late Stop Date: Oct 13, 1989
Duration (in days): (Min.) 2.8 (Exp.) 2.8 (Max.) 2.8
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: E2
Description: STRUCTURE EXCAVATION CELL 1
Prerequisites: TD1
Class: Responsibility:

Early Start Date: Oct 13, 1989 Early Stop Date: Oct 14, 1989
Late Start Date: Oct 24, 1989 Late Stop Date: Oct 25, 1989
Duration (in days): (Min.) 1.4 (Exp.) 1.4 (Max.) 1.4
Duration Variance: 0 Slack Time: 11.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: TD2
Description: TRENCH EXCAVATION & DRAINFILL 129 70
Prerequisites: E2
Class: Responsibility:

Early Start Date: Oct 14, 1989 Early Stop Date: Oct 15, 1989
Late Start Date: Oct 25, 1989 Late Stop Date: Oct 26, 1989
Duration (in days): (Min.) 1.4 (Exp.) 1.4 (Max.) 1.4
Duration Variance: 0 Slack Time: 10.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: F1
Description: STRUCTURE BACKFILL CELL 1
Prerequisites: E2
Class: Responsibility:

Early Start Date: Oct 14, 1989 Early Stop Date: Oct 15, 1989
Late Start Date: Nov 02, 1989 Late Stop Date: Nov 04, 1989
Duration (in days): (Min.) 1.4 (Exp.) 1.4 (Max.) 1.4
Duration Variance: 0 Slack Time: 19.6

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: TD3
Description: TRENCH EXCAVATION & DRAINFILL 152 40
Prerequisites: TD2
Class: Responsibility:

Early Start Date: Oct 15, 1989 Early Stop Date: Oct 17, 1989
Late Start Date: Oct 26, 1989 Late Stop Date: Oct 28, 1989
Duration (in days): (Min.) 1.4 (Exp.) 1.4 (Max.) 1.4
Duration Variance: 0 Slack Time: 11.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: E3
Description: STRUCTURE EXCAVATION CELL 3
Prerequisites: TD3
Class: Responsibility:

Early Start Date: Oct 17, 1989 Early Stop Date: Oct 18, 1989
Late Start Date: Oct 28, 1989 Late Stop Date: Oct 29, 1989
Duration (in days): (Min.) 1.4 (Exp.) 1.4 (Max.) 1.4
Duration Variance: 0 Slack Time: 11.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: F2 Critical
Description: EARTHFILL CELLS 2&5
Prerequisites: TD1,S1
Class: Responsibility:

Early Start Date: Oct 13, 1989 Early Stop Date: Oct 20, 1989
Late Start Date: Oct 13, 1989 Late Stop Date: Oct 20, 1989
Duration (in days): (Min.) 7.0 (Exp.) 7.0 (Max.) 7.0
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: TD4
Description: TRENCH EXCAVATION & DRAINFILL CELL 3
Prerequisites: E3
Class: Responsibility:

Early Start Date: Oct 18, 1989 Early Stop Date: Oct 24, 1989
Late Start Date: Oct 29, 1989 Late Stop Date: Nov 04, 1989
Duration (in days): (Min.) 5.6 (Exp.) 5.6 (Max.) 5.6
Duration Variance: 0 Slack Time: 11.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: F3
Description: STRUCTURE BACKFILL & DRAINFILL CELL 3
Prerequisites: TD4,F1
Class: Responsibility:

Early Start Date: Oct 24, 1989 Early Stop Date: Oct 25, 1989
Late Start Date: Nov 04, 1989 Late Stop Date: Nov 05, 1989
Duration (in days): (Min.) 1.4 (Exp.) 1.4 (Max.) 1.4
Duration Variance: 0 Slack Time: 11.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: TD5
Description: TRENCH EXCAVATION & DRAINFILL 276 00
Prerequisites: TD4
Class: Responsibility:

Early Start Date: Oct 24, 1989 Early Stop Date: Oct 27, 1989
Late Start Date: Dec 16, 1989 Late Stop Date: Dec 19, 1989
Duration (in days): (Min.) 2.8 (Exp.) 2.8 (Max.) 2.8
Duration Variance: 0 Slack Time: 53.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: TD6
Description: TRENCH EXCAVATION & DRAINFILL 321 00
Prerequisites: TD5
Class: Responsibility:

Early Start Date: Oct 27, 1989 Early Stop Date: Oct 29, 1989
Late Start Date: Dec 19, 1989 Late Stop Date: Dec 21, 1989
Duration (in days): (Min.) 2.8 (Exp.) 2.8 (Max.) 2.8
Duration Variance: 0 Slack Time: 52.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: E4 Critical
Description: DIKE EXCAVATION CELL 2&5
Prerequisites: F2
Class: Responsibility:

Early Start Date: Oct 20, 1989 Early Stop Date: Oct 31, 1989
Late Start Date: Oct 20, 1989 Late Stop Date: Oct 31, 1989
Duration (in days): (Min.) 11.2 (Exp.) 11.2 (Max.) 11.2
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: TD7
Description: TRENCH EXCAVATION & DRAINFILL PRIN. SPW.
Prerequisites: TD6
Class: Responsibility:

Early Start Date: Oct 29, 1989 Early Stop Date: Oct 31, 1989
Late Start Date: Dec 21, 1989 Late Stop Date: Dec 23, 1989
Duration (in days): (Min.) 1.4 (Exp.) 1.4 (Max.) 1.4
Duration Variance: 0 Slack Time: 53.2

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: E5 Critical
Description: DIKE EXCAVATION CELL 1
Prerequisites: E4
Class: Responsibility:

Early Start Date: Oct 31, 1989 Early Stop Date: Nov 05, 1989
Late Start Date: Oct 31, 1989 Late Stop Date: Nov 05, 1989
Duration (in days): (Min.) 5.6 (Exp.) 5.6 (Max.) 5.6
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: E6 Critical
Description: DIKE EXCAVATION CELL 3
Prerequisites: E5,F3
Class: Responsibility:

Early Start Date: Nov 05, 1989 Early Stop Date: Nov 14, 1989
Late Start Date: Nov 05, 1989 Late Stop Date: Nov 14, 1989
Duration (in days): (Min.) 8.4 (Exp.) 8.4 (Max.) 8.4
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: CU Critical
Description: CLEAN UP
Prerequisites: E6
Class: Responsibility:

Early Start Date: Nov 14, 1989 Early Stop Date: Nov 28, 1989
Late Start Date: Nov 14, 1989 Late Stop Date: Nov 28, 1989
Duration (in days): (Min.) 14.0 (Exp.) 14.0 (Max.) 14.0
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

Activity: W Critical
Description: WEATHER
Prerequisites: CU
Class: Responsibility:

Early Start Date: Nov 28, 1989 Early Stop Date: Dec 23, 1989
Late Start Date: Nov 28, 1989 Late Stop Date: Dec 23, 1989
Duration (in days): (Min.) 25.2 (Exp.) 25.2 (Max.) 25.2
Duration Variance: 0.0 Slack Time: 0

Percentage of Work Completed: Manpower: 1.0
Estimated Capital Expenditures to Date This Activity: 0

	Early Path	Expected Path	Late Path
Capital	0.00	0.00	0.00
Labor	0.00	0.00	0.00
Total	0.00	0.00	0.00

COMPUTATION SHEET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE: ARIZONA
PROJECT: WILLIAMS-CHANDLER W.P.P. - VINEYARD ROAD F.R.S. REPAIR
BY: JEB & DEP
DATE: JAN 1989
CHECKED BY:
DATE:
JOB NO.:
SUBJECT: DAYS LOST DUE TO WEATHER
SHEET 1 OF 1

FROM MARICOPA COUNTY WEATHER RECORDS
1979 THROUGH 1985

SEPT. 3 days
OCT. 1 day
NOV. 2 days

6 Rain days

Assume 3 drying days after a rain

6 Rain days
18 Drying days

24 Weatherdays

$$\frac{\text{5 day work week}}{\text{7 day week}} = 0.71$$

70% of the 24 weather days should be work days

(24 weatherdays)(70%) = 17 days

SPECIFICATIONS

BID SCHEDULE

VINEYARD ROAD FRS
EMBANKMENT AND DRAIN REPAIR

Bid Item	Work or Material	Spec. No.	Quantity	Unit	Unit Price	Amount
1.	Clearing & Grubbing	2	6.6	Ac.		
2.	Structure Removal	3	1	L.S.	XXX	
3.	Survey	7	1	L.S.	XXX	
4.	Mobilization	8	1	L.S.	XXX	
5.	Common Excavation	21	7,600	C.Y.		
6.	Trench Excavation	21	6,190	C.Y.		
7.	Dike Excavation	21	31,300	C.Y.		
8.	Structure Excavation	21	560	C.Y.		
9.	Earthfill	23	7,700	C.Y.		
10.	Structure Backfill	23	510	C.Y.		
11.	Drainfill	24	6,735	C.Y.		

CONSTRUCTION SPECIFICATION

2. CLEARING AND GRUBBING

1. SCOPE

The work shall consist of the clearing and grubbing of designated areas by removal and disposal of trees, snags, logs, stumps, shrubs and rubbish.

2. MARKING

The limits of the areas to be cleared and grubbed will be marked by means of stakes, flags, tree markings or other suitable methods. Trees to be left standing and uninjured will be designated by special markings placed on the trunks at a height of about six feet above the ground surface.

3. REMOVAL

All trees not marked for preservation and all snags, logs, brush, stumps, shrubs and rubbish shall be removed from within the limits of the marked areas. Unless otherwise specified, all stumps, roots and root clusters having a diameter of one inch or larger shall be grubbed out to a depth of at least two feet below subgrade elevation for concrete structures and one foot below the ground surface at embankment sites and other designated areas.

4. DISPOSAL

All materials removed from the cleared and grubbed areas shall be burned or buried at locations shown on the drawings or as specified in Section 6 of this specification.

5. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the cleared and grubbed area will be measured to the nearest 0.1 acre. Payment for clearing and grubbing will be made for the total area within the designated limits at the contract unit price. Such payment will constitute full compensation for all labor, equipment, tools and all other items necessary and incidental to the completion of the work.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 7 of this specification.

6. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 1, Clearing and Grubbing

(1) This item shall consist of clearing and grubbing all areas as shown on the drawings and staked in the field.

(2) Materials resulting from the clearing and grubbing operations that are to be burned shall be carried out in accordance with state, county, and local regulations. Burning shall take place within the refuse areas shown on the drawings.

(3) If materials resulting from the clearing and grubbing operations are disposed of by burying, they shall be buried a minimum of 24 inches below the existing ground surface in the refuse areas shown on the drawings. When disposal is complete, the refuse areas shall be smoothed and graded to blend with the surrounding terrain.

(4) Section 5, Measurement and Payment, payment shall include compensation for Subsidiary Item, Gravel Cover.

CONSTRUCTION SPECIFICATION

3. STRUCTURE REMOVAL

1. SCOPE

The work shall consist of the removal, salvage and disposal of structures (including fences) from the designated areas.

2. MARKING

The limits of the areas from which structures must be removed will be marked by means of stakes, flags or other suitable methods. Structures to be preserved in place or salvaged will be designated by special markings.

3. REMOVAL

Within the areas so marked all visible structures and attachments and all buried structures located and identified by survey stakes shall be removed to the specified extent and depth.

4. SALVAGE

Structures that are designated to be salvaged shall be carefully removed and neatly placed in the specified storage areas. Salvaged structures that are capable of being disassembled shall be dismantled into individual members or sections. Such structures shall be neatly match marked with paint prior to disassembly. All pins, nuts, bolts, washers, plates and other loose parts shall be marked or tagged to indicate their proper locations in the structure and shall be fastened to the appropriate structural member or packed in suitable containers. Materials from fences designated to be salvaged shall be placed outside the work area on the property from which they were removed. Wire shall be rolled into uniform rolls of convenient size. Posts and rails shall be neatly piled.

5. DISPOSAL OF REFUSE MATERIALS

Refuse materials resulting from structure removal shall be burned or buried at location shown on the drawings or as specified in Section 7 of this specification.

6. MEASUREMENT AND PAYMENT

For items of work for which specific lump sum prices are established in the contract, payment for structure removal will be made at the contract lump sum price.

Such payment will constitute full compensation for all labor, equipment, tools, and all other items necessary and incidental to the completion of the work.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 7 of this specification.

7. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 2, Structure Removal

(1) This item shall consist of the removal and disposal of all non-fill materials within the trench excavation limits of the test cells including: plastic liner (100 mil HDPE), piezometers, wires, steel and plastic pipe, and wood.

(2) Materials resulting from structure removal shall be buried a minimum of 24 inches below the existing ground surface in the refuse areas shown on the drawings. When disposal is complete, the refuse areas shall be smoothed and graded to blend with the surrounding terrain.

CONSTRUCTION SPECIFICATION

5. POLLUTION CONTROL

1. SCOPE

The work shall consist of installing measures or performing work to control erosion and minimize the production of sediment, dust and other pollutants to water and air during construction operations in accordance with these specifications.

2. MATERIALS

All materials furnished shall meet the requirements of the Material Specifications listed in Section 8 of this specification.

3. EROSION AND SEDIMENT CONTROL MEASURES AND WORKS

The work and measures shall include but not be limited to the following, as shown on the drawings or as specified in Section 8 of this specification.

Staging of Earthwork Activities - The excavation and moving of soil materials shall be scheduled so that the smallest possible areas will be unprotected from erosion for the shortest time feasible.

Seeding - Seedings to protect disturbed areas shall be as specified on the drawings or in Section 8 of this specification.

Mulching - Mulching shall be used to provide temporary protection to soil surfaces from erosion.

Diversions - Diversions shall be used to divert water away from work areas and/or to collect runoff from work areas for treatment and safe disposition.

Stream Crossings - Culverts or bridges shall be used where equipment must cross streams.

Sediment Basins - Sediment basins shall be used to settle and filter out sediment from eroding areas to protect properties and streams below the construction site.

Straw Bale Filters - Straw bale filters shall be used to trap sediment from areas of limited runoff. Bales are temporary and shall be removed when permanent measures are installed.

Waterways - Waterways shall be used for the safe disposal of runoff from fields, diversions and other structures or measures.

4. CHEMICAL POLLUTION

The Contractor shall provide watertight tanks or barrels or construct a sump sealed with plastic sheets to be used to dispose of chemical pollutants (such as drained lubricating or transmission oils, greases, soaps, asphalt, etc.) produced as a by-product of the project's work. At the completion of the construction work, sumps shall be voided without causing pollution as specified in Section 8 of this specification.

Sanitary facilities such as pit toilets, chemical toilets, or septic tanks shall not be placed adjacent to live streams, wells, or springs. They shall be located at a distance sufficient to prevent contamination of any water sources. At the completion of construction work, facilities shall be disposed of without causing pollution as specified in Section 8 of this specification.

5. AIR POLLUTION

Local and state regulations concerning the burning of brush or slash or disposal of other materials shall be adhered to.

Fire prevention measures shall be taken to prevent the start or the spreading of fires which result from project work. Fire breaks or guards shall be constructed at locations shown on the drawings.

All public access or haul roads used by the contractor during construction of the project shall be sprinkled or otherwise treated fully suppress dust.

6. MAINTENANCE, REMOVAL ,AND RESTORATION

All pollution control measures and works shall be adequately maintained in a functional condition as long as needed during the construction operation. All temporary measures shall be removed and the site restored to as nearly to original conditions as practicable.

7. MEASUREMENT AND PAYMENT

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items, and the items to which they are made subsidiary, are identified in Section 8 of this specification.

8. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Subsidiary Item, Pollution Control

(1) This item shall consist of all work and materials required to control pollution.

(2). The Contractor is responsible for maintaining air, water, and vegetative quality within the work area.

Methods include:

(a) Establishing turn areas, haul roads, work site access roads, temporary building sites, equipment yards, etc., in approved locations best suited to prevent contamination of air and water and minimize erosion and destruction of existing vegetation.

(b) Staging earthwork activities.

(3) Section 7, Measurement and Payment, no separate payment will be made for pollution control. Compensation for this work will be included in the payment for Bid Item 9, Earthfill, Bid Item 10 Structure Backfill, and Bid Item 11 Drainfill.

CONSTRUCTION SPECIFICATION

7. ENGINEERING CONSTRUCTION SURVEYS

1. SCOPE

The work consists of performing all surveys required for (1) layout of the work, (2) construction control, and (3) quantity surveys for progress payment estimates from baselines and bench marks established by the Government. It includes furnishing all the necessary equipment, labor, and materials. Not included is work required for making the original and final surveys for computing quantities.

2. EQUIPMENT AND MATERIALS

Equipment used for all construction surveys shall be of a quality and condition that provides the specified accuracy. The equipment shall be maintained in good working order and good adjustment. Records of calibration tests and adjustments shall be maintained and be available for inspection by the Government

Materials include all the necessary field notebooks, stakes, templates, platforms, equipment, spikes, steel pins, tools, and other accessories required for layout and construction control of all of the work.

3. QUALITY OF WORK

Surveys shall be certified by a Land Surveyor or Engineer licensed by the State. The work shall be performed to the accuracy and detail appropriate for the location and type of job. Daily quantities of earthwork may be estimated from load count or equivalent measurement (within 25 percent ±); measurement for progress payments should be accurate within 10 percent ±/

Notes, sketches, and other data shall be complete, recorded neatly, and organized in a manner that will allow reproduction of copies for job documentation.

Differential leveling shall be third order with such precision that the error of closure (in feet) shall not exceed plus or minus 0.1 times the square root of the distance (in miles). The elevations of bench marks and temporary bench marks shall be determined and recorded to the nearest 0.01 foot.

Transit traverses shall be third order with such precision that; (1) the linear error of closure shall not exceed one foot in 3,000 feet, and (2) the angular error of closure shall not exceed 1.0 minute times the square root of the number of angles turned.

Surveys will be reviewed periodically and randomly checked by the Government to assure that the specified quality is being maintained.

4. PRIMARY CONTROL

The base lines and bench marks for primary control, which are necessary to establish the lines and grades needed for construction, will be established by the Government. They will be shown on the drawings and located on the ground before construction.

The base lines and benchmarks shall be used as the origin of all surveys needed to establish lines and grades for construction.

5. CONSTRUCTION SURVEY AND MEASUREMENT RECORDS

All survey data will be recorded in fully identified, bound field notebooks, Pages shall be numbered consecutively. The required books shall be turned over to and become the property of the Government, prior to acceptance of the work or any part of this work. All entries shall be legible, reproducible, and follow the format in Soil Conservation Service TR-62, "Engineering Layout, Notes, Staking and Calculations." The bound field note books shall be available at all times during the progress of the work for examination and use by the Government. Copies of field book notes shall be made available to the Contracting Officer upon request. Electronically generated survey data and computations shall be bound, paginated, and referenced in the bound field notebook containing the survey control in a manner that will make all of the information intelligible and permanent. All field notes and printed data shall include the purpose or description of the work, the date the work was performed, the weather (if field work), the individual or individuals who performed and checked the work and sketches and other information pertinent to the work.

6. STAKING

The location and marking of all stakes shall be as shown in Soil Conservation Service TR-62 as supplemented below.

a. Clearing and grubbing - The boundary of the clearing and grubbing areas shall be staked or flagged at 200-foot intervals or less if needed to clearly mark the limits of work.

b. Excavation - Cut stakes shall be placed on the centerline at the intersection of the planned side slopes and natural ground line. All slope stakes shall be marked with the required cut, horizontal distance, and slope ratio. Offset reference stakes and hubs shall be placed at full stations, on at least one side of the proposed excavation.

c. Earth Fill - Fill stakes shall be placed on the centerline and at the toes of the planned slopes and shall be marked with the fill, horizontal distance, constucted slope ratio, and stationing. Offset reference stakes and hubs shall be provided as a minimum on both sides of the fill at full stations.

Earthwork slope stakes shall be placed as a minimum at full stations, break in the original ground surface, and at other intermediate stations as necessary to insure accurate location of construction. Slope stakes and cross sections shall be at right angles to the centerline. Distances shall be measured horizontally; rod readings shall be taken vertically and recorded to the nearest 0.1 foot.

7. MEASUREMENT AND PAYMENT

Payment will be made as the work proceeds, after receipt of invoices from the contractor showing (contractor or subcontractor) surveying costs and cost of supplies. If the total of incremental payments is less than the contract lump sum for surveys, the balance will be included in the final contract payment. Total payment will be the contract lump sum price for surveys, regardless of actual cost to the contractor.

Payment will not be made under this item for the purchase cost of materials and equipment having a residual value.

Payment of the contract lump sum price for surveys will constitute full compensation for all labor, materials, equipment, and all other items necessary and incidental to completion of the work.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the item to which they are made subsidiary are identified in Section 8 of this specification.

8. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 3, Survey

(1) This item shall consist of furnishing personnel, equipment, materials and performing surveys required for:

(a) Construction Layout
(b) Computation of Quantities for monthly and final payments.
(c) "As-Built" Construction Drawings

(2) Section 1, Scope, the last sentence does not apply.

(3) The Contractor shall provide the Contracting Officer a statement of qualifications, including specific experience of each of the survey personnel assigned to the job.

(4) The Contractor shall provide the Contracting Officer with a schedule of surveys to be performed each week.

(5) Monuments damaged by the contactor which are outside of the work limits will be replaced by the government at the contractors expense. The actual cost to the government of replacing subsidence monuments will be deducted from the payment due to the contractor.

CONSTRUCTION SPECIFICATION

8. MOBILIZATION

1. SCOPE

The work shall consist of the mobilization of the Contractor's forces and equipment necessary for performing the work required under the contract. Mobilization will not be considered as work in fulfilling the contract requirement for commencement of work.

Mobilization shall include the cost for transportation of personnel, equipment, and operating supplies to the site; establishment of offices, buildings, and other necessary facilities as the site not covered in specific bid items, and other preparatory work at the site. The cost of the entire amount of premiums paid for performance and payment bonds, including coinsurance and reinsurance agreements as applicable shall be paid upon request when evidence of full payment to the surety has been provided to the Contracting Officer.

Work done under this specification shall not include mobilization for any specific item of work for which payment for mobilization is provided elsewhere in the contract.

The specification covers mobilization for work required by the contract at the time of award. If additional mobilization costs are incurred during performance of the contract as a result of changed or added items of work for which the Contractor is entitled to an adjustment in contract price, compensation for such costs will be included in the price adjustment for the item or items of work changed or added.

2. PAYMENT

Payment will be made as the work proceeds, after presentation of invoices by the Contractor showing his own mobilization costs and evidence of the charges of suppliers, subcontractors, and others for mobilization work performed by them. If the total of such payments is less than the contract lump sum for mobilization, the unpaid balance will be included in the price final contract payment. Total payment will be the lump sum contract price for mobilization, regardless of actual cost to the Contractor.

Payment will not be made under this item for the purchase costs of materials having a residual value, the purchase costs of materials to be incorporated in the project, or the purchase costs of operating supplies.

Payment of the lump sum contract price for mobilization will constitute full compensation for all labor, materials, equipment, and all other items necessary and incidental to completion of the work.

3. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 4, Mobilization

(1) This item shall consist of the mobilization of the Contractor's equipment and forces to perform the work required under this contract.

CONSTRUCTION SPECIFICATION

10. WATER FOR CONSTRUCTION

1. SCOPE

The work shall consist of furnishing, transporting, and using water for construction purposes in accord with the applicable specifications.

2. FACILITIES AND EQUIPMENT

The Contractor shall build and maintain such access and haul roads as are needed, and shall furnish, operate, and maintain all pumps, piping, tanks, and other facilities needed to load, transport, and use the water as specified.

These facilities shall be equipped with meters, tanks, or other devices by which the volume of water supplied can be measured.

3. DUST ABATEMENT AND HAUL ROAD MAINTENANCE

Water for dust abatement and haul road maintenance shall be applied to haul roads and other dust-producing areas as needed to prevent excessive dust and to maintain the roads in good condition for efficient operation while they are in use.

4. EARTHFILL, DRAINFILL, ROCKFILL

Water for earthfill, drainfill, or rockfill shall be used in the fill materials as specified in the applicable construction specifications.

5. CONCRETE, MORTAR, GROUT

Water used in mixing or curing concrete, pneumatically applied mortar, or other portland cement mortar or grout shall meet the requirements of the applicable construction specifications and shall be used in conformance with those specifications. Payment for water used in these items is covered by the applicable concrete, mortar or grout specification.

6. MEASUREMENT AND PAYMENT

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 7 of this specification.

7. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Subsidiary Item, Water

(1) This item shall consist of furnishing, transporting, and applying all water necessary for performance of the work described in this contract.

(2) In Section 6, Measurement and Payment, no separate payment will be made for this item. Compensation for this work will be included in the payment for Bid Item 9, Earthfill; Bid Item 10, Structure Backfill and Bid Item 11, Drainfill.

CONSTRUCTION SPECIFICATION

11. REMOVAL OF WATER

1. SCOPE

The work shall consist of the removal of surface water and ground water as needed to perform the required construction in accordance with the specifications. It shall include (1) building and maintaining all necessary temporary impounding works, channels, and diversions, (2) furnishing, installing and operating all necessary pumps, piping and other facilities and equipment, and (3) removing all such temporary works and equipment after they have served their purposes.

2. DIVERTING SURFACE WATER

The Contractor shall build, maintain and operate all cofferdams, channels, flumes, sumps, and other temporary diversion and protective works needed to divert streamflow and other surface water through or around the construction site and away from the construction work while construction is in progress. Unless otherwise specified, a diversion must discharge into the same natural drainage way in which its headworks are located.

Unless otherwise specified, the Contractor shall furnish to the Contracting Officer, in writing, his plan for diverting surface water before beginning the construction work for which the diversion is required. Acceptance of this plan will not relieve the Contractor of responsibility for completing the work as specified.

3. DEWATERING THE CONSTRUCTION SITE

Foundations, cutoff trenches and other parts of the construction site shall be dewatered and kept free of standing water or excessively muddy conditions as needed for proper execution of the construction work. The Contractor shall furnish, install, operate and maintain all drains, sumps, pumps, casings, wellpoints, and other equipment needed to perform the dewatering as specified. Dewatering methods that cause a loss of fines from foundation areas will not be permitted.

Unless otherwise specified, the Contractor shall furnish to the Contracting Officer in writing, his plan for dewatering before beginning the construction work for which the dewatering is required. Acceptance of this plan will not relieve the Contractor of responsibility for completing the work as specified.

4. DEWATERING BORROW AREAS

Unless otherwise specified in Section 8, the Contractor shall maintain the borrow areas in drainable condition or otherwise provide for timely and effective removal of surface and ground waters that accumulate within the borrow areas from any source. Borrow material shall be processed as necessary to achieve proper and uniform moisture content for placement.

If pumping to dewater borrow areas is included as an item of work in the bid schedule, each pump used for this purpose shall be equipped with a water meter in the discharge line. Accuracy of the meters shall be such that the measured quantity of water is within 3 percent, plus or minus, of the true quantity. Means shall be provided by the Contractor to check the accuracy of the water meters when requested by the Contracting Officer.

5. EROSION AND POLLUTION CONTROL

Removal of water from the construction site, including the borrow areas shall be accomplished in such a manner that erosion and the transmission of sediment and other pollutants are minimized.

6. REMOVAL OF TEMPORARY WORKS

After the temporary works have served their purposes, the Contractor shall remove them or level and grade them to the extent required to present a sightly appearance and to prevent any obstruction of the flow of water or any other interference with the operation of or access to the permanent works.

Except as otherwise specified, pipes and casings shall be removed from temporary wells and the wells shall be filled to ground level with gravel or other material approved by the Contracting Officer.

7. MEASUREMENT AND PAYMENT

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 8 of this specification.

8. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Subsidiary Item, Removal of Water

(1) This item shall consist of the removal or diversion of storm water from the construction area as needed to perform the required work.

(2) In the case of storm runoff filling the reservoir during the work period, the contractor should expect the drawdown time to the principal spillway inlet elevation to be ten (10) days.

(3). Section 7, Measurement and Payment, no separate payment will be made for this item. Compensation for this work will be included in the payment for Excavation Bid Items 5, 6, 7, and 8.

CONSTRUCTION SPECIFICATION

21. EXCAVATION

1. SCOPE

The work shall consist of the excavation required by the drawings and specifications and disposal of the excavated materials.

2. CLASSIFICATION

Excavation will be classified as common excavation or rock excavation in accordance with the following definitions or will be designated as unclassified.

Common excavation shall be defined as the excavation of all materials that can be excavated, transported, and unloaded by the use of heavy ripping equipment and wheel tractor-scrapers with pusher tractors or that can be excavated and dumped into place or loaded on to hauling equipment by means of excavators having a rated capacity of one cubic yard and equipped with attachments (such as shovel, bucket, backhoe, dragline or clam shell) appropriate to the character of the materials and the site conditions.

Rock excavation shall be defined as the excavation of all hard, compacted or cemented materials the accomplishment of which requires blasting or the use of excavators larger than defined for common excavation. The excavation and removal of isolated boulders or rock fragments larger than one cubic yard in volume encountered in materials otherwise conforming to the definition of common excavation shall be classified as rock excavation.

Excavation will be classified according to the above definitions by the Engineer, based on his judgment of the character of the materials and the site conditions.

The presence of isolated boulders or rock fragments larger than one cubic yard in size will not in itself be sufficient cause to change the classification of the surrounding material.

For the purpose of this classification, the following definitions shall apply:

Heavy ripping equipment shall be defined as a rear-mounted, heavy duty, single-tooth, ripping attachment mounted on a tractor having a power rating of 200-300 net horsepower (at the flywheel).

Wheel tractor-scraper shall be defined as a self-loading (not elevating) and unloading scraper having a struck bowl capacity of 12-20 yards.

Pusher tractor shall be defined as a track type tractor having a power rating of 200-300 net horsepower (at the flywheel) equipped with appropriate attachments.

3. UNCLASSIFIED EXCAVATION

Items designated as "Unclassified Excavation" shall include all materials encountered regardless of their nature or the manner in which they are removed. When excavation is unclassified, none of the definitions or classifications stated in Section 2 of this specification shall apply.

4. BLASTING

The transportation, handling, storage, and use of dynamite and other explosives shall be directed and supervised by a person of proven experience and ability in blasting operations.

Blasting shall be done in such a way as to prevent damage to the work or unnecessary fracturing of the foundation and shall conform to any special requirements in Section 12 of this specification.

5. USE OF EXCAVATED MATERIALS

To the extent they are needed, all suitable materials from the specified excavations shall be used in the construction of required permanent earthfill or rockfill. The suitablity of materials for specific purposes will be determined by the Engineer. The Contractor shall not waste or otherwise dispose of suitable excavated materials.

6. DISPOSAL OF WASTE MATERIALS

All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at the location shown on the drawings.

7. BRACING AND SHORING

Excavated surfaces too steep to be safe and stable if unsupported shall be supported as necessary to safeguard the work and workers, to prevent sliding or settling of the adjacent ground, and to avoid damaging existing improvements. The width of the excavation shall be increased if necessary to provide space for sheeting, bracing, shoring, and other supporting installations. The Contractor shall furnish, place and subsequently remove such supporting installations.

8. STRUCTURE AND TRENCH EXCAVATION

Structure or trench excavation shall be completed to the specified elevations and to sufficient length and width to include allowance for forms, bracing and supports, as necessary, before any concrete or earthfill is placed or any piles are driven within the limits of the excavation.

9. BORROW EXCAVATION

When the quantities of suitable materials obtained from specified excavations are insufficient to construct the specified fills, additional materials shall be obtained from the designated borrow areas. The extent and depth of borrow pits within the limits of the designated borrow areas shall be as directed by the Engineer.

Borrow pits shall be excavated and finally dressed in a manner to eliminate steep or unstable side slopes or other hazardous or unsightly conditions.

10. OVEREXCAVATION

Excavation in rock beyond the specified lines and grades shall be corrected by filling the resulting voids with portland cement concrete made of materials and mix proportions approved by the Engineer. Concrete that will be exposed to the atmosphere when construction is completed shall contain not less than 6 sacks of cement per cubic yard of concrete. Concrete that will be permanently covered shall contain not less than 4.5 sacks of cement per cubic yard. The concrete shall be placed and cured as specified by the Contracting Officer.

Excavation in earth beyond the specified lines and grades shall be corrected by filling the resulting voids with approved compacated earthfill, except that, if the earth is to become the subgrade for riprap, rockfill, sand or gravel bedding or drainfill, the voids may be filled with material conforming to the specifications for the riprap, rockfill, bedding or drainfill.

11. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the volume of each type and class of excavation within the specified pay limits will be measured and computed to the nearest cubic yard by the method of average cross-sectional end areas. Regardless of quantities excavated, the measurement for payment will be made to the specified pay limits, except that excavation outside the specified lines and grades directed by the Engineer to remove unsuitable material will be included. Excavation required because unsuitable conditions result from the Contractor's improper construction operations, as determined by the Contracting Officer will not be included for measurement and payment.

The pay limits shall be defined as follows:

a. The upper limit shall be the original ground surface as it existed prior to the start of construction operations except that where excavation is performed within areas designated for previous excavation or fill the upper limit shall be the modified ground surface resulting from the specified previous excavation or fill.

b. The lower and lateral limits shall be the neat lines and grades shown on the drawings.

Payment for each type and class of excavation will be made at the contract unit price for that type and class of excavation. Such payment will constitute full compensation for all labor, materials, equipment, and all equipment, and all other items necessary and incidental to the performance of the work, except that extra payment for backfilling overexcavation will be made in accordance with the following provisions:

Payment for backfilling overexcavation, as specified in Section 10 of this specification, will be made only if the excavation outside specified lines and grades is directed by the Engineer to remove unsuitable material and if the unsuitable condition is not a result of the Contractor's improper construction operations as determined by the Contracting Officer.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 12 of this specification.

12. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 5, Common Excavation

(1) This item shall consist of all excavation required for the embankment repair at test cells No. 2 and 5 as shown on the drawings.

(2) All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at the waste area shown on the drawings.

(3) The existing test trenches and pits shown on the drawings are filled with uncompacted earth. Dimensions shown on the drawings are approximate.

(4) Ten (10) days prior to commencing the work for this bid item the contractor shall submit to the Contracting Officer for approval a plan showing a continous sequence of excavation, drainfill and earthfill which will minimize the breach time for the repair work at test cell sites No. 2 and No. 5.

(5) Section 11, Measurement and Payment, payment shall include compensation for Subsidiary Items, Waste Disposal and Removal of Water.

b. Bid Item 6, Trench Excavation

(1) This item shall consist of excavation required for installation of the drainfill material within the embankment as shown on the drawings.

(2) All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at the waste areas shown on the drawings.

(3) Section 7, Bracing and Shoring, shall require furnishing, placing and removing portable shields for the inspection and construction operations. The support works shall be designed and used in a manner to prevent failure of the vertical trench walls and permit inspection of the upstream and downstream faces of the trench. The design shall include the following:

(a) Each unit shall be eight (8) foot high and twelve (12) feet long with the lower unit mounted with skids for towing.

(b) A permanently installed steel ladder mounted to the steel side wall.

(c) Safety chains for the upper deck of the shield and guard rails for all other decks.

(d) Design shall be incompliance with all OSHA and AISC standards.

(e) The front and back three (3) feet of the shield shall be left open to allow for inspection of the trench side walls.

(f) The shield shall be painted a bright white to provide maximum light enhancement.

(g) Open non-skid grading shall be used for platforms on each 8' level except the ground level and to shield the face of the units exposed to the towing cables.

(h) The top platform shall be layed out such that it can be used by personnel to cross over the open trench.

A sample layout of a shield meeting the above requirements is available for review.

The Contractor shall furnish to the Engineer, in writing, his plan and design for support of the trench. The design shall be prepared and sealed by a licensed professional engineer. This plan will have to be approved by the Contracting Officer prior to any trench excavation being performed. Approval of this plan will not relieve the Contractor of safety responsibilities.

(4) No heavy equipment shall be operating within 100' of the shield with persons in it.

(5) Time for foundation inspection by the Arizona Department of Water Resources and SCS geologic examination and mapping of embankment cracks along the trench side walls could hinder production and should be anticipated.

(6) In Section 11, Measurement and Payment, payment shall include compensation for Subsidiary Items, Removal of Water, and Waste Disposal.

c. <u>Bid Item 7, Dike Excavation</u>

(1) This item shall consist of all excavation required to remove the earth dike at test cells No. 1, 2, 3, and 5 as shown on the drawings.

(2) All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at the waste areas shown on the drawings.

(3) Section 11, Measurement and Payment, payment shall include compensation for Subsidiary Items, Waste Disposal and Removal of Water.

d. Bid Item 8, Structure Excavation

(1) This item shall consist of all excavation required for the embankment repair at test cells No. 1 and 3.

(2) All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at the locations shown for waste on the drawings.

(3) The existing test trenches and pits shown on the drawings are filled with uncompacted earth. Dimensions shown on the drawings are approximate.

(4) Ten (10) days prior to commencing the work for this bid item the Contractor shall submit to the Contracting Officer for approval a plan showing a continuous sequence of excavation, drainfill, and structure backfill which will minimize the breach time for the repair of the test trench at test cell No. 3

(5) Section 11, Measurement and Payment, payment shall include compensation for Subsidiary Items, Waste Disposal and Removal of Water.

CONSTRUCTION SPECIFICATION

23. EARTHFILL

1. SCOPE

The work shall consist of the construction of earth embankments and other earthfills required by the drawings and specifications.

2. MATERIALS

All fill materials shall be obtained from required excavations and designated borrow areas. The selection, blending, routing and disposition of materials in the various fills shall be subject to approval by the Engineer.

Fill materials shall contain no sod, brush, roots or other perishable materials. Rock particles larger than the maximum size specified for each type of fill shall be removed prior to compaction of the fill.

The types of materials used in the various fills shall be as listed and described in the specifications and drawings.

3. FOUNDATION PREPARATION

Foundations for earthfill shall be stripped to remove vegetation and other unsuitable materials or shall be excavated as specified.

Except as otherwise specified, earth foundation surfaces shall be graded to remove surface irregularities and shall be scarified parallel to the axis of the fill or otherwise acceptably scored and loosened to a minimum depth of 2 inches. The moisture content of the loosened material shall be controlled as specified for the earthfill, and the surface materials of the foundation shall be compacted and bonded with the first layer of earthfill.

Earth abutment surfaces shall be free of loose, uncompacted earth in excess of two inches in depth normal to the slope and shall be at such a moisture content that the earthfill can be compacted against them to effect a good bond between the fill and the abutments.

Rock foundation and abutment surfaces shall be cleared of all loose materials by hand or other effective means and shall be free of standing water when fill is placed upon them. Occasional rock outcrops in earth foundations for earthfill, except in dams and other structures designed to restrain the movement of water, shall not require special treatment if they do not interfere with compaction of the foundation and initial layers of the fill or the bond between the foundation and the fill.

Foundation and abutment surfaces shall be not steeper than 1 horizontal to 1 vertical unless otherwise specified. Test pits or other cavities shall be filled with compacted earthfill conforming to the specifications for the earthfill to be placed upon the foundation.

4. PLACEMENT

Fill shall not be placed until the required excavation and foundation preparation have been completed and the foundation has been inspected and approved by the Engineer. Fill shall not be placed upon a frozen surface, nor shall snow, ice, or frozen material be incorporated in the fill.

Fill shall be placed in approximately horizontal layers. The thickness of each layer before compaction shall not exeed the maximum thickness specified. Materials placed by dumping in piles or windrows shall be spread uniformly to not more than the specified thickness before being compacted. Hand compacted fill, including fill compacted by manually directed power tampers, shall be placed in layers whose thickness before compaction does not exceed the maximum thickness specified for layers of fill compacted by manually directed power tampers.

Adjacent to structures, fill shall be placed in a manner which will prevent damage to the structures and will allow the structures to assume the loads from the fill gradually and uniformly. The height of the fill adjacent to a structure shall be increased at approximately the same rate on all sides of the structure.

Earthfill in dams, levees and other structures designed to restrain the movement of water shall be placed so as to meet the following additional requirements:

a. The distribution of materials throughout each zone shall be essentially uniform, and the fill shall be free from lenses, pockets, streaks or layers of material differing substantially in texture, moisture content, or gradation from the surrounding material.

b. If the surface of any layer becomes too hard and smooth for proper bond with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than 2 inches before the next layer is placed.

c. The top surfaces of embankments shall be maintained approximately level during construction, except that a crown or cross-slope of approximately 2 percent shall be maintained to insure effective drainage, and except as otherwise specified, for drainfill or sectional zones.

d. Dam embankments shall be constructed in continuous layers from abutment to abutment except where openings to facilitate construction or to allow the passage of stream flow during construction are specifically authorized in the contract.

e. Embankments built at different levels as described under (c) or (d) above shall be constructed so that the slope of the bonding surfaces between embankment in place and embankment to be placed is not steeper than 3 feet horizontal to 1 foot vertical. The bonding surface of the embankment in place shall be stripped of all material not meeting the requirements of this specification, and shall be scarified, moistened and recompacted when the new fill is placed against it as needed to insure a good bond with the new fill and to obtain the specified moisture content and density at the contact of the in place and new fills.

5. CONTROL OF MOISTURE CONTENT

During placement and compaction of fill, the moisture content of the Materials being placed shall be maintained within the specified range.

The application of water to the fill materials shall be accomplished at the borrow areas insofar as practicable. Water may be applied by sprinkling the materials after placement on the fill, if necessary. Uniform moisture distribution shall be obtained by disking.

Material that is too wet when deposited on the fill shall either be removed or be dried to the specified moisture content prior to compaction.

If the top surface of the preceding layer of compacted fill or a foundation or abutment surface in the zone of contact with the fill becomes too dry to permit suitable bond it shall either be removed or scarified and moistened by sprinkling to an acceptable moisture content prior to placement of the next layer of fill.

6. COMPACTION

Earthfill shall be compacted according to the following requirements for the class of compaction specified:

Class A compaction. Each layer of fill shall be compacted as necessary to make the density of the fill matrix not less than the minimum density specified. The fill matrix is defined as the portion of the fill material finer than the maximum particle size used in the compaction test method specified.

Class B compaction. Each layer of fill shall be compacted to a mass density not less than the minimum density specified.

Class C compaction. Each layer of fill shall be compacted by the specified number of passes of the type and weight of roller or other equipment specified, or by an approved equivalent method. Each pass shall consist of at least one passage of the roller wheel or drum over the entire surface of the layer.

Fill adjacent to strutures shall be compacted to a density equivalent to that of the surrounding fill by means of hand tamping, or manually directed power tampers or plate vibrators. Unless otherwise specified, heavy equipment including backhoe mounted power tampers, or vibrating compactors and manually directed vibrating rollers, shall not be operated within 2 feet of any structure. Towed or self-propelled vibrating rollers shall not be operated within 5 feet of any structure. Compaction by means of drop weights operating from a crane or hoist will not be permitted.

The passage of heavy equipment will not be allowed: (1) over cast-in-place conduits prior to 14 days after placement of the concrete; (2) over cradled or bedded precast conduits prior to 7 days after placement of the concrete cradle or bedding; or (3) over any type of conduit until the backfill has been placed above the top surface of the structure to a height equal to one-half the clear span width of the structure or pipe or 2 feet, whichever is greater.

Compacting of fill adjacent to structures shall not be started until the concrete has attained the strength specified in Section 10 for this purpose. The strength will be determined by compression testing of test cylinders cast by the Engineer for this purpose and cured at the work site in the manner specified in ASTM Method C 31 for determing when a structure may be put into service.

When the required strength of the concrete is not specified as described above, compaction of fill adjacent to structures shall not be started until the following time intervals have elapsed after placement of the concrete.

Structure	Time Interval
Retaining walls and counterforts (impact basins)	14 days
Walls backfilled on both sides simultaneously	7 days
Conduits and spillway risers, cast-in-place (with inside forms in place)	7 days
Conduits and spillway risers, cast-in-place (inside forms removed)	14 days
Conduits, precast, cradled	2 days
Conduits, precast, bedded	1 day
Cantilever outlet bents (backfilled both sides simultaneously)	3 days

7. REWORKING OR REMOVAL AND REPLACEMENT OF DEFECTIVE FILL

Fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content or otherwise not conforming to the requirements of the specifications shall be reworked to meet the requirements or removed and replaced by acceptable fill. The replacement fill and the foundation, abutment and fill surfaces upon which it is placed shall conform to all requirements of this specification for foundation preparation, approval, placement, moisture control and compaction.

8. TESTING

During the course of the work, the Engineer will perform such tests as are required to identify materials, to determine compaction characteristics, to determine moisture content, and to determine density of fill in place. These tests performed by the Engineer will be used to verify that the fills conform to the requirements of the specifications. Such tests are not intended to provide the Contractor with the information required by him for the proper execution of the work and their performance shall not relieve the Contractor of the necessity to perform tests for that purpose.

Densities of fill requiring Class A compaction will be determined by the Engineer in accordance with ASTM Method D 1556, D 2167, D 2922 or D 2937 except that the volume and moist weight of included rock particles larger than those used in the compaction test method specified for the type of fill will be determined and deducted from the volume and moist weight of the total sample prior to computation of density or if using the nuclear gauge, added to the specified density to bring it to the measure of equivalent compostion for comparision. The density so computed will be used to determine the percent compaction of the fill matrix. Unless otherwise specified, moisture content will be determined by one of the following methods: ASTM Method D-2216, D-3017.

9. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the volume of each type and compaction class of earthfill within the specified zone boundaries and pay limits will be measured and computed to the nearest cubic yard by the method of average cross-sectional end areas. Unless otherwise specified, no deduction in volume will be made for embedded conduits and appurtenances.

The pay limits shall be as defined below, with the further provision that earthfill required to fill voids resulting from over excavation of the foundation, outside the specified lines and grades, will be included in the measurement for payment only where such overexcavation is directed by the Engineer to remove unsuitable material and where the unsuitable condition is not a result of the Contractor's improper construction operations as determined by the Contracting Officer.

The pay limits shall be as designated on the drawings.

Payment for each type and compaction class of earthfill will be made at the contract unit price for that type and compaction class of fill. Such payment will constitute full compensation for all labor, materials, equipment and all other items necessary and incidental to the performance of the work, except furnishing, transporting, and applying water to the foundation and fill materials. Water applied to the foundation and fill materials will be measured and payment will be made as specified in Construction Specification 10.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 10 of this specification.

10. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 9, Earthfill

(1) This item shall consist of placing and compacting all earthfill required to construct the embankment repair at test cells No. 2 and 5 as shown on the drawings.

(2) All earthfill material shall be obtained from the required excavations.

(3) The maximum thickness of a layer prior to compaction shall be nine (9) inches.

(4) The maximum size of rock fragement incorporated in the fill shall be six (6) inches.

(5) Section 6, Compaction, Class A shall apply. The fill matrix shall be compacted to at least 95 percent of the maximum density obtained from compaction tests performed by ASTM D 698, Method A or the rapid compaction test (Test No. S-6, SCS Reference NEH Section 19.)

(6) Section 8, Testing, the fill densities will be determined in accordance with ASTM 1556. The moisture content of the fill material at the time of compaction shall not be less than two (2) percent below nor more than two (2) percent above optimum moisture content, as determined by ASTM D 2216.

(7) Section 9, Measurement and Payment, payment shall include compensation for subsidiary items, Water and Pollution Control.

b. Bid Item 10, Structure Backfill

(1) This item shall consist of placing and compacting backfill for the embankment repair at test cells No. 1 and 3 as shown on the drawings.

(2) All structure backfill material shall be obtained from required excavations.

(3) The maximum thickness of a layer prior to compaction shall be six (6) inches.

(4) The maximum size of rock fragement incorporated in the fill shall be four (4) inches.

(5) Section 6, Compaction, Class A shall apply. The fill matrix shall be compacted to at least 95 percent of the maximum density obtained from compaction tests performed by ASTM D 698, Method A or the rapid compaction test (Test No. S-6, SCS Reference NEH Section 19).

(6) Section 8, Testing, the fill densities will be determined in accordance with ASTM 1556. The moisture content of the fill material at the time of compaction shall not be less than two (2) percent below nor more than two (2) percent above optimum moisture content, as determined by ASTM D 2216.

(7) Section 9, Measurement and Payment, payment shall include compensation for subsidiary items Water and Pollution Control.

c. Subsidiary Item, Waste Disposal

(1) This item shall consist of stockpiling, transporting, placing and smoothing all waste in the waste areas shown on the drawings.

(2) Waste material shall consist of all surplus or unsuitable material resulting from the required excavations.

(3) Section 6, Compaction, does not apply to this item.

(4) Waste material shall be placed uniformly over the entire waste area to a depth not to exceed three (3) feet. The finished surface shall not vary more than one half (0.5) foot, plus or minus, from the average grade and shall be graded to drain away from the FRS.

(5) Fill slopes resulting from the deposition of waste shall not be steeper than 4:1.

(6) No special moisture content of waste material is required.

(7) Section 9, Measurement and Payment, no separate payment will be made for this item. Compensation for this work will be included in the payment for excavation Bid Items 5, 6, 7, and 8.

CONSTRUCTION SPECIFICATION

24. DRAINFILL

1. SCOPE

The work shall consist of furnishing, placing and compacting drainfill required in the construction of structure drainage systems.

2. MATERIALS

Drainfill materials shall conform to the requirements of Material Specification 521. At least 30 days prior to the delivery of the materials to the site the Contractor shall inform the Contracting Officer in writing of the source from which he intends to obtain them. The Contractor shall provide the Engineer free access to the source for the purpose of obtaining samples for testing.

3. BASE PREPARATION

Foundation surfaces and trenches shall be clean and free of organic matter, loose soil, foreign substance, and standing water when the drainfill is placed. Earth surfaces upon or against which drainfill will be placed shall not be scarified.

4. PLACEMENT

Drainfill shall not be placed until the subgrade has been inspected and approved by the Engineer. Drainfill shall shall not be placed over or around pipe or drain tile until the installation of the pipe or tile has been inspected and approved.

Drainfill shall be placed uniformly in layers not more than 12 inches deep before compaction. When compaction is accomplished by manually controlled equipment, the layers shall be not more than 8 inches deep. The material shall be placed in a manner to avoid segregation of particle sizes and to insure the continuity and integrity of all zones. No foreign materials shall be allowed to become intermixed with or otherwise contaminate the drainfill.

Traffic shall not be allowed to cross over drains at random. Equipment crossovers shall be maintained, and the number and location of such crossovers shall be established and approved prior to the beginning of drainfill placement. Each crossover shall be cleaned of all contaminating materials and shall be inspected and approved by the Engineer before additional drainfill is placed.

Any damage to the foundation surface or the sides or bottoms of trenches occurring during placement of drainfill shall be repaired before drainfill placement is continued.

The upper surface of drainfill constructed concurrently with adjacent zones of earthfill shall be maintained at an elevation at least one foot above the upper surface of the adjacent fill.

Drainfill over or around pipe or drain tile shall be placed in a manner to avoid any displacement in line or grade of the pipe or tile.

Drainfill shall not be placed adjacent to structures until the concrete has attained the strength specified in Section 9 of this specification. The strength shall be determined by compression testing of test cylinders cast by the Engineer for this purpose and cured at the work site in the manner specified in ASTM Method C 31 for determining when a structure may be put in service.

When the required strength of the concrete is not specified as described above, placement of drainfill adjacent to structures shall not be started until the following item intervals have elapsed after placement of the concrete.

Structure	Time Interval
Retaining walls and counterforts (impact basins)	14 days
Walls backfilled on both sides simultaneously	7 days
Conduits and galleries, cast-in-place (with inside forms in place)	7 days
Conduits and galleries, cast-in-place (inside forms removed)	14 days
Conduits, precast, cradled	2 days
Conduits, precast, bedded	1 day
Cantilever outlet bents backfilled on both sides simultaneously	3 days

5. CONTROL OF MOISTURE

The moisture content of drainfill materials shall be controlled as specified in Section 9. When the addition of water is required, it shall be applied in such a way as to avoid excessive wetting to adjacent earth fill. Except as specified in Section 9, control of moisture content will not be required.

6. COMPACTION

Drainfill shall be compacted according to the following requirements for the class of compaction specified:

Class A Compaction. Each layer of drainfill shall be compacted to a relative density of not less than 70 percent as determined by ASTM Method D 4254.

Class I Compaction. Each layer of drainfill shall be compacted by at least 2 passes, over the entire surface, of a steel-drum vibrating roller weighing not less than 5 tons and exerting a vertical vibrating force of not less than 20,000 pounds at least 1200 times per minute, or by an approved equivalent method.

Class II Compaction. Each layer of drainfill shall be compacted by one of the following methods or by an approved equivalent method:

a. At least 2 passes, over the entire surface,of a pneumatic-tired roller exerting a pressure of not less than 75 pounds per square inch. A pass is defined as at least one complete coverage of the roller wheel, tire or drum over the entire surface of the layer.

b. At least 4 passes, over the entire surface, of the track of a crawler-type tractor weighing not less than 20 tons.

c. Controlled movement of the hauling equipment so that the entire surface is traversed by not less than one tread track of the loaded equipment.

Class III compaction. No compaction will be required beyond that resulting from the placing and spreading operations.

When compaction other than Class III compaction is specified materials placed in trenches or other locations inaccessible to heavy equipment shall be compacted by means of manually controlled pneumatic or vibrating tampers or by approved equivalent methods.

Heavy equipment shall not be operated within 2 feet of any structure. Vibrating rollers shall not be operated within 5 feet of any structure. Compaction by means of drop weights operating from cranes or hoists will not be permitted.

7. TESTING

The Engineer will perform such tests as are required to verify that the drainfill materials and the drainfill in place meet the requirements of the specifications. These tests are not intented to provide the Contractor with information he needs to assure that the materials and workmanship meet the requirements of the specifications, and their performance will not relieve the Contractor of the responsibility of performing his own tests for that purpose.

8. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the volume of drainfill within the neat lines shown on the drawings will be measured and computed to the nearest cubic yard. Where the Engineer directs placement of drainfill outside the neat lines to replace unsuitable foundation material, the volume of such drainfill will be included, but only to the extent that the unsuitable condition is not a result of the Contractor's improper construction operations as determined by the Contracting Officer.

Payment for drainfill will be made at the contract unit price for each type of drainfill, complete in place. Except as otherwise specified in Section 9, such payment will consititute full compensation for all labor, materials, equipment and all other items necessary and incidental to the performance of the work.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subisdiary are identified in Section 9 of this specification.

9. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Bid Item 11, Drainfill

(1) This item shall consist of furnishing and placing all the drainfill material required for the drainfill repairs as shown on the drawings.

(2) The drainfill material shall meet the grading requirments for fine aggregate as defined in ASTM C-33.

(3) Drainfill shall be placed in horizontal layers not to exceed 18 inches. Drainfill shall be conveyed using special equipment to prevent segregation and the free vertical drop shall not exceed 30 inches.

(4) In Section 6, Compaction, Class III shall apply.

(5) The moisture content shall be maintained in a range, as determined by the Engineer, that will minimize aggregate segregation.

(6) The material passing the #40 sieve shall be non plastic when tested in accordance with ASTM D 4318.

(7) Prior to placement of drainfill the existing drainfill surfaces shall be cleaned of all contaminating materials and shall be inspected and approved by the engineer.

(8) Section 8, Measurement and Payment, payment shall include compensaion for subsidiary items Water and Pollution Control.

CONSTRUCTION SPECIFICATION 202
GRAVEL COVER

1. SCOPE

The work shall consist of the construction of gravel cover over slopes or on other areas that are subject to erosion.

2. MATERIALS

Gravel shall meet the requirements of Section 8 of this specifiction or be obtained from designated sources as shown on the drawings. Gravel from designated sources shall be excavated, selected, handled, and processed as necessary to meet the quality and grading requirements specified.

3. SUBGRADE PREPARATION

The subgrade surfaces shall be the neat lines and grades shown on the drawings.

Gravel cover shall not be placed until the subgrade surfaces have been inspected and approved by the Engineer.

4. PLACEMENT

The gravel cover shall be placed by equipment on the surfaces and to the depths specified in Section 8 of this specification. The cover shall be constructed to the full coarse thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The gravel shall be delivered and placed in a manner that will ensure that the cover in-place shall be reasonably homogeneous and the fractions well distributed.

Hand placing of gravel cover shall be required to the extent necessary to prevent damage to the permanent works.

The gravel cover may be placed in sequence with the placement of earth fill zones of the embankment or after completion of the embankment. If sequential placement is used, it is emphasized that the Contractor shall complete the earthwork to the required cross-sectional line and grade prior to gravel cover placement. Contamination of earth fill zones by gravel cover placement operations will not be allowed. Surfaces of the completed gravel cover shall be finished reasonably free of mounds, dips or windrows to the lines and grades specified.

5. COMPACTION AND MOISTURE REQUIREMENTS

No compaction will be required beyond that resulting from the placing and spreading operations unless otherwise specified in Section 8 of this specification. Moisture control shall be that necessary to control dust during borrow and placing operations.

6. TESTING AND MEASUREMENTS

The Engineer will perform such tests and measurements as are required to verify that the gravel material and work meet the requirements of this specification. These tests are not intended to provide the Contractor with the information he needs to assure that the materials and workmanship meet the requirements of this specification, and their performance will not relieve the Contractor of the responsibility of performing his own tests for the purpose.

7. MEASUREMENT AND PAYMENT

Compensation for any items of work described in the contract but not listed in the Bid Schedule will be included in the payment for the item of work to which it is made subsidiary. Such items and the items to which they are made subsidiary are identified in Section 8 of this specification.

8. ITEMS OF WORK AND CONSTRUCTION DETAILS

Items of work to be performed in conformance with this specification and the construction details are:

a. Subsidiary Item, Gravel Cover

(1) This item shall consist of furnishing and installing gravel cover to shape the upstream and downstream FRS embankment slopes to the finished grade lines as shown on the drawings.

(2) The gravel cover shall be a well graded pit run with maximum size of three (3) inches.

(3) Section 3, Subgrade Preparation, the subgrade shall be the existing slope surfaces of the FRS.

(4) Gravel cover does not apply to those areas designated for embankment repair.

(5) Section 7, Measurement and Payments, no separate payment will be made for this item. Compensation for this work will be included in the payment for Bid Item 1, Clearing and Grubbing.

MATERIAL SPECIFICATION

521. AGGREGATES FOR DRAINFILL AND FILTERS

1. SCOPE

This specification covers the quality of mineral aggregates for the construction of drainfill and filters.

2. QUALITY

Drainfill and filter aggregates shall be sand, gravel or crushed stone or mixtures thereof. They shall be composed of clean, hard, durable mineral particles free from organic matter, clay balls, soft particles or other substances that would interfere with their free-draining properties.

Aggregates of crushed limestone shall be thoroughly washed and screened. Course aggregate containing crushed limestone shall have not more than 3 percent by weight of particles finer than the No. 4 sieve. Crushed limestone shall not be used for fine aggregates except in combination with other materials such that not more than 5 percent of the portion finer than the No. 4 sieve shall be crushed limestone.

Aggregates shall be tested for soundness according to ASTM Method C 88, and shall have a weighted average loss in five cycles of not more than 12 percent when sodium sulfate is used or 18 percent when magnesium sulfate is used.

3. GRADING

Drainfill and filter aggregates shall conform to the specified grading limits after being placed in the work, and after being compacted if compaction is specified. Grading shall be determined by ASTM Method C 136. The percentage of material finer than the No. 200 sieve shall be determined by the method in ASTM Designation C 117.

4. STORING AND HANDLING

Drainfill and filter aggregates shall be stored and handled by methods that prevent segregation of particle sizes or contamination by mixing with other materials.

bcc - Ralph Arrington, SCE, Phoenix, Ariz

Should become the property of Gov't upon completion. Need special tools for investigation — show we purchase or spec for contractor to supply?

United States Department of Agriculture
Soil Conservation Service
517 Gold Ave., SW, Room 3301
Albuquerque, New Mexico 87102

Subject: ENG-Design, Trench Inspection Shield

Date: January 27, 1989

To: W. R. Evans, Head, Engineering Staff, WNTC, Portland, OR

File Code: 210-13-21

This is in response to Phil Jones' January 20, 1989, telephone request. He and Cliff Deal were interested in a trench shield, designed and used by New Mexico in 1983, for crack inspection and repair of the Hackberry, Site 1 dam. They felt that Arizona and other states may benefit from the design.

A copy of all of our documentation and drawings are included in the attached booklet. The following discussion will be helpful in reviewing the contents of the booklet and in pursuing other designs:

The initial input requirements from the site conditions and our geologists were:

1. The trench in the existing dam was to be dug to a depth of approximately 25 feet and 5 feet wide along the centerline of the dam from abutment to abutment.

2. Portability/mountability was a concern, therefore it was determined that it should be constructed of 3, 8 foot high units that bolted together readily and easily; the lower one of which was skid mounted for towing. bolted

3. Personal protection was a concern, therefore the following special features were included:

on side wall

A. A permanently installed steel ladder within the shield for safe escape.

on sides to protect from cable breakage

B. Non-skid grating platforms on each 8' level, designed for a ~~100~~psf live load.

specific locations

C. Guard rails and safety chains for the upper deck of the shield and safety chains for the lower and middle decks.

D. Minimum design lateral loads of 100psf and compliance with all OSHA and AISC standards.

? E. Restrictions of no equipment within 5 feet of the edges of the trench and no heavy equipment "operating" within 100 feet of the shield with persons in it.

4. Usability for crack mapping was a concern therefore the following special features were included:

dimension ? A. The front and back extensions of the shield were left open for close visual inspection and cleaning of cracks on the trench walls (central portions of the shield sidewalls were solid steel plated).

YES ? B. The shield was painted a bright white and open grating was used for the platforms to provide maximum light enhancement within the trench. Electrical connections on or within the shield frame were not considered because of potential safety problems; a portable generator and drop lights were available on-site but were not needed.

A complete detailed shield design was prepared by the NMSO Design Staff in June 1988. Copies of the supporting design documentation, computations and drawings are in the booklet. The design drawings are numbered 9A, 9B and 9C.

During the review process, the WNTC felt that SCS should not prepare and provide the detailed design because of the implied responsibility and liability; it was felt that this should be borne by the contractor. Consequently, sheets 9B and 9C, (structural details), were voided and removed from the contract drawings. Sheet 9A, (conceptual and overall proportioning), was left in the contract drawings. The specifications were revised to include the design requirements mentioned above and to require design preparation and sealing by a licensed professional engineer hired by the contractor. Submittal of sealed design drawings for the Contracting Officers' review and approval was also required in the specifications. Copies of excerpts from the Design Engineers Report explaining this, and the final specifications and conceptual drawing, (9A), are also included in the booklet.

The contractor for the project was Monaco Contractors, Inc., P. O. Box 8585, Scottsdale, Arizona, 85252. After award of the contract, and before the trenching was begun, the contractor submitted design drawings for CO review and approval. They were prepared by Telesis Engineering, of Carlsbad, New Mexico (no longer in business). The NMSO Design Staff reviewed these and provided comments to the CO on June 26, 1984; the CO transmitted these comments to the contractor on the same date. On July 25, 1984, Telesis Engineering responded with satisfactory resolutions of the comments and the SCE accepted and concurred in the design on July 27, 1984. Copies of these comments and resolutions, and the contractors sealed drawings, are also included in the booklet. We do not have copies of the "as-built" drawings of the shield in our files.

The shield worked very well without any safety or use problems. It was constructed by a local sub-contractor, Mr. Larry Lunsford, (505) 887-6749, in Carlsbad, New Mexico. Since the shield was "contractor owned", its present location or existence is unknown; it may have been dismantled.

pre dur design presentation meeting. Example drawings on file.

Our state geologist, Doyle Meadows, offers the following additional comments:

1. He felt well protected from cave-ins while working in the trench. Up to 3 or 4 persons worked in the trench at the same time. Portions of the trench walls failed while the trench was open but the persons in the trench were never placed in any danger at any time.

2. The white color of the shield and the 5 foot width of the trench provided sufficient light for the work. A light plant was available, but it was not necessary to use it.

3. There was adequate room for two persons plus their equipment on each platform. He felt that the size of the unit was "good".

4. The unit (when all three sections were stacked) was sometimes difficult for the contractor to move in the trench. Tractors with winches and cranes were used; the most satisfactory method was lifting and moving it with a large crane. Units of one or two sections could be skidded with tractor mounted winches. Rollers on the lower section rather than skids may have allowed easier moving within the trench.

5. Safety precautions while in the trench shield should still be observed. Namely:

A. Always stay in the shield while in the trench.

B. Leave the shield while it is being moved and keep a safe distance from taut cables.

C. Persons working on upper levels of the shield should scrape their feet before walking on the platform grating (falling rocks, etc. on persons below were no problem, but dirt and dust was).

D. Hard hats are a must.

We trust the above and the attached booklet will be helpful. Please feel free to call if we can offer more assistance.

J. Gordon Odell
State Conservation Engineer

Attachment

cc w/o att:

Cliff Deal, Soil Mechanics Engineer, WNTC, Portland, OR

bcc w/o att:

Ralph M. Arrington, State Conservation Engineer, Pheonix, AZ

USDA/SCS/GMCUNNINGHAM/1/27/89

1/23/89
by DEP

PROJECT : Vineyard Road FRS Repair

SUBJECT: Water Specification

In our preliminary In-house review meeting held 1/20/89 John Sullivan & John Harrington asked the question whether we should use water as a subsidiary item vs. a bid item.

They mentioned that the quantity that will be needed to perform the work is very low and that there is a very good chance that the quantity variation could be exceeded due to over use on access or haul roads, leakage from pipelines if using water from farmers well & piping to site, etc.. Also cited is the fact of exceeding the quantity variation for water on our last 2 jobs EMF R-5 & Apache/Bulldog, that water quantity is hard to figure within 15%.

It is also anticipated, from experience of negotiating past modifications, that the unit price for water could increase as much as 4 times once the Contractor has his chance to show his costs after the fact.

With this in mind I asked Dave Jamison what he recommended and what he recalls for the purpose of using water as a bid item on all jobs. First Dave indicated that the reason for using water as a bid item is so that the Contractor does not absorb a big cost of a water

over-run that was required for the installation of major bid items on a project. Second, given our situation total water for major items will be very low ≈ 1000MG. Therefore, if we are willing to battle the contractor for use of water ~~#~~ for pollution control he would recommend using water a a SUBSIDIARY ITEM.

Called Lee Saale WMTC and asked if there would be a problem with changing the NEH-20 specification so that we are able to use water as a subsidiary item, given the above information. He said he did not see any problem with just going ahead and doing it, but he would check with others.

INSPECTION PLAN

GOVERNMENT
INSPECTION PLAN
for
VINEYARD ROAD FRS EMBANKMENT AND DRAIN REPAIR

GENERAL

The repair work is located in the Williams-Chandler Watershed, approximately six (6) miles southeast of Apache Junction, Pinal County, Arizona. The work will be constructed under a government contract that is scheduled to be awarded in August 1989.

Major items of work requiring inspection during construction are:

1.	Common excavation	-	8300	cubic yards
2.	Trench excavation	-	6735	cubic yards
3.	Dike excavation	-	31,300	cubic yards
4.	Structure excavation	-	560	cubic yards
5.	Earthfill	-	8950	cubic yards
6.	Structure backfill	-	560	cubic yards
7.	Drainfill	-	6735	cubic yards

ITEMS OF WORK TO BE INSPECTED

It is anticipated that the degree of inspection (periodic or continuous) per NEM, Part 512, subpart D will be provided for the following work to be performed under the construction contract.

Periodic Inspection	Continuous Inspection
Clearing and grubbing	Trench Excavation
Structure removal	Earthfill
Survey	Structure Backfill
Mobilization	Drainfill
Pollution control	
Removal of Water	
Water	
Dike Excavation	
Shaping	
Waste Disposal	
Common Excavation	
Structure Excavation	

A. Excavation; Common, Trench, and Structure

1. No specific material testing is required. An inspector will be required to evaluate the soils encountered for their suitability for earthfill and to ensure removal and waste of all unsuitable material. A Geologist will be required for the examination and mapping of embankment cracks along the trench side walls.

B. Earthfill and Structure Backfill

1. All fill will be tested for compaction and moisture, and classified according to the unified classification system. An inspector and materials testing technician will be required to document Quality Assurance.

2. The test frequency for compaction and moisture will be 2000 ± cubic yards for earthfill and one test per site of structure backfill. This will require at least 8 compaction and moisture tests for Quality Assurance. One (1) material classification will be done for both test cell locations No. 2 and No. 5.

C. Drainfill

1. Drainfill will be tested for gradation and plasticity index. An inspector and materials testing technician will be required to document Quality Assurance.

2. The test frequency for gradation and plasticity index will be one test for each 500 C.Y. of material and not less than one per site of drainfill placement. This will require at least 9 tests for Quality Assurance.

D. Survey

The SCS survey party chief will observe the contractor's survey crew performance during the initial survey work and then at random intervals as the surveys progress to verify their ability, and for assurance that the staking is compatible with SCS standards. Random survey spot checks by SCS survey personnel will be made to determine if both the slope and reference stakes, and as-built sections are within the tolerances.

TIMING OF INSPECTIONS

It is anticipated that the notice to proceed will be issued in September, and the performance time has been calculated to be 114 calendar days. The construction sequence as shown in Exhibit A is based on the work being performed by an average small business Contractor. The schedule will be adjusted after the successful bidder submits his construction schedule.

SKILLS NEEDED FOR CONTRACT ADMINISTRATION AND INSPECTION

PROJECT ENGINEER GS-9/11

Skills Needed:

a. Must be able to manage and schedule project staff effectively.

b. Must be familiar with and understand the philosophy and critical elements of the design.

c. Must be knowledgeable of quality assurance testing and inspections required for the works of improvement.

d. Must be knowledgeable of OSHA safety requirements, and the SCS Supplement.

Training/Experience Required:

a. Have two years or more of construction inspection and contract administration. Have completed the contract Administration for Construction Contracts training course, or will receive equivalent on the job training by the Contracting Officer.

b. Have completed the Unified Soil Classification (SM-1) course offered through SCS.

c. Have completed the Management Level II course.

CHIEF INSPECTOR, GS-7/9

Skills Needed:

a. Must be able to communicate effectively with the Contractor's field supervisory personnel.

b. Understand basic staking and construction layout.

c. Know the principles of earthwork inspection.

d. Perform quantity computations.

e. Ability to maintain records.

f. Supervise technicians assigned to the project.

g. Knowledge of OSHA safety requirements and the SCS Supplement.

Training/Experience Required:

a. A minimum of two construction contracts as lead inspector of a critical element of the work being constructed.

b. Have a minimum of four years construction inspection and testing experience.

c. Worked on one or more contracts as an earth inspector. Completed the SCS Construction Inspection training course.

d. Know earthfill and drainfill testing procedures.

GEOLOGIST GS-11/12

Skills Needed:

a. Ability to determine equipment needs and devise appropriate procedures for mapping cracks in excavated trench faces.

b. Knowledge of geologic mapping of discrete features exposed in excavated trench.

c. Skill in observation and investigation of often indistinct evidence of cracks present in the embankment.

d. Knowledgeable of OSHA Safety requirements, and the SCS Supplement.

e. Skilled in identifying soils using the unified soil classification system.

f. Physically fit to perform the rigorous duties attendant to mapping in a deep trench with vertical sidewalls.

Training/Experiences Required:

a. Minimum of one year experience in performing geologic mapping.

b. Completion of training in unified Soil Classification System.

SURVEY PARTY CHIEF, GS-6/7

Skills Needed:

a. Have the ability to determine survey controls required for the construction of various elements of a project.

b. Must be capable of communicating with contractor's survey crew and evaluate their abilities and effectiveness.

c. Coordinate SCS surveys with the contractor's survey to verify compliance.

d. Must be capable of checking field notes for accuracy and completeness.

Training/Experience Required:

a. Have worked as an instrument man for two years.

b. Completed the SCS Construction Inspection Training course or received comparable OJT.

c. Must have the ability to interpret plans and specifications.

d. Have received formal math training through trigonometry or equivalent experienced.

SURVEY RODMAN, GS-5/6

Skills Needed:

a. Must be capable of performing the duties required of a rodman or chairman and other routine survey duties as directed by the survey party chief.

b. Must be able to determine distances, grades, etc., and interpret construction drawings.

Training/Experience Required:

a. Have sufficient mathematics training to perform simple calculations needed for construction layout.

MATERIALS TESTING TECHNICIAN, GS-5/6/7

Skills Needed:

a. Must have the knowledge required to perform earthwork testing such as compaction, moisture determination, sieve analysis, unified soil classification system, etc., in accordance with the appropriate ASTM's.

b. Knowledgeable of the OSHA safety requirements and the SCS Supplement.

c. Understand the principles of placing and compacting earthfills and the placement of drainfills.

Training/Experience Required:

a. Worked a minimum of one year as the primary lab technician on one or more construction projects.

b. Have the ability to perform the computations necessary to complete test results and reports.

c. Knowledgeable of the allowable tolerances for testing equipment.

d. Knowledgeable of the procedures for testing earthwork and drainfills.

e. Have completed the SCS Construction Inspection training course or received comparable OJT.

ESTIMATED STAFF HOURS REQUIRED TO COMPLETE THE CONTRACT

	Regular Time
Project Engineer	400 hours
Chief Inspector	688 hours
Geologist	160 hours
Material Testing Technician	648 hours
Survey Party Chief	256 hours

Not included in the above hours is the estimated overtime. Overtime will be authorized as required to adequately inspect the construction activities. The overtime on past projects in Arizona has been in the range of 5 to 10 percent of the regular time.

PROJECT TESTING EQUIPMENT, FACILITIES AND PERSONNEL

The Mesa Construction Office will provide the necessary office space and a testing lab trailer, which is fully equipped to perform the required soil testing. All testing equipment is according to ASTM standards and will be serviced and calibrated prior to the start of construction.

NAMES AND QUALIFICATIONS OF ASSIGNED PERSONNEL

Noller Herbert, Project Engineer/Government Representative-GS-11

Experience:

Worked for SCS 3 years in the student cooperative program in the Area I office, state design office, on several EWP construction contracts, and Assistant Project Engineer for one-half years during construction of Signal Butte FRS, Pass Mountain Diversion, Apache Junction FRS and Floodway ($3.3 million), and Bulldog Floodway ($4.7 million). Worked as Project Engineer for EMF R-4 and Signal Butte Floodways joint sealant repair, and EMF R-6 Floodway construction ($2.0 million).

Training:

Engineering NPEG	Ft. Worth, 3-87
Engineering NPEG Continuation	Ft. Worth, 5-88
EIT Certificate	Phoenix, AZ 5-87
Soil Compaction Techniques	Phoenix, AZ 2-88
Contract Administration	Columbus, OH 2-89
Management Level II	Phoenix, AZ 2-89

Albert Rutledge, Chief Inspector - GS-9.

Experience:

Has been assigned to construction inspection duties in Arizona for 19 years.
Has served as Chief Inspector during the construction of RWCD Reach 1, 2, and 3, Vanar Diversion Repair, Signal Butte FRS/Pass Mountain Diversion, Apache FRS/Bulldog Floodway, and EMF R-6 from 1978 to present.

Training:

Soil Mechanics	Portland, Oregon	1969
Soil Mechanics II	Salt Lake, Utah	1978
Construction Inspection	Ft. Worth, Texas	1968
Construction Inspection	Ft. Worth, Texas	1988
Concrete	Ft. Worth, Texas	1980
Claim Advoidance, FAR's	Phoenix, Arizona	1985
Troxler Nuclear Density Gage	Phoenix, Arizona	1981
ACI Grade I Certification	Phoenix, Arizona	1987
Soil Compaction Techniques	Phoenix, Arizona	1988
Contract Asministration	Columbus, OH	1989

Aubrey Sanders, Geologist, GS-12

Experience:

Twenty-seven years experience in all phases of engineering and sedimentation geology. Mapped embankment cracks on Fredonia and Vineyard Road Dams during repairs and investigated cracking in numerous other dams.

Training:

Soil Mechanics SM-1
Soil Mechanics SM-20
Contract Administration

Tod Rodenbaugh, Earth Inspector-GS-5

Experience:

Approximately four years of construction experience, of which over three years has been with SCS. During this time he has worked with the survey crew, as batch plant inspector, earthfill inspector and has worked with the lab personnel to become knowledgeable of testing procedures.

Training:

ACI Grade Certification	Phoenix, Arizona 4-87
Management Level II	Phoenix, Arizona 2-89

David Clough, Survey Party Chief - GS-7

Experience:

Has worked for the SCS since 1979 in the following positions:

Materials Testing Lab Technician - one year.
Instrument Man - four years.
Survey Party Chief - five years.

He has worked on the survey crew monitoring contractor surveys for EMF Floodway, Reach 2, 3, 5, and 6. Signal Butte Floodway, Vanar Diversion Repair, Signal Butte FRS and Pass Mountain Diversion, Apache Junction FRS and Bulldog Floodway.

Training:

Survey Records Investigation (BLM)	Phoenix, Arizona	1984
Troxler Nuclear Gage	Phoenix, Arizona	1980
Management Level II	Phoenix, Arizona	1980

Gary Mason, Materials Testing Technician - GS-6

Experience:

Employed by SCS in Arizona for nine years in construction inspection. Served as an assistant laboratory testing technician for two years during construction of EMF Reach 1 and 2.

Assigned as the materials testing technician for the construction of Vanar Division Repair, EMF Reach 3, 5, and 6, Signal Butte/Pass Mountain, and Apache/Bulldog from 1984 to present.

Training:

Soils Testing	Lincoln, Nebraska	1985
Concrete	Ft. Worth, Texas	1985
Construction Inspection	Ft. Worth, Texas	1983
Troxler Nuclear Gage	Las Vegas, Nevada	1984
ACI Grade I Certification	Phoenix, Arizona	1987
Hydraulics for Technicians	Phoenix, Arizona	1987
Management Level II	Phoenix, Arizona	1989

Larry Molitor, Chief Inspector - GS-8

Experience:

Total time with SCS 12 years, total construction 8 years. Inspected excavation and placement of drainfill on Vineyard FRS. Worked as concrete inspector for 3 years during the construction of Signal Butte Floodway (9000 CY of concrete), RWCD Reach 3 (1100 CY concrete), Signal Butte FRS (787 CY of concrete) and Apache/Bulldog (18,100 CY concrete). Chief inspector for the joint sealant repair on EMF R-4 and Signal Butte Floodway, and construction of EMF R-5. Served as alternate Chief Inspector on EMF R-6.

Training:

Mgmt Level II	Phoenix, AZ	1978
Soil Mechanics Level I	Phoenix, AZ	1-82
Construction Inspection	Ft. Worth, TX	5-83
Concrete	Ft. Worth, TX	5-83
Troxler Nuclear Density Gage	Tempe, AZ	4-85
Hydraulics for Technicians	Phoenix, AZ	2-87
ACI Grade I Certification	Phoenix, AZ	4-87

Materials Testing Technician, Blake Covey, GS-802 5

Experience:

Has a B.S. in Geology and been employed by SCS in Arizona for 2 years performing material testing duties for the Apache junction FRS, Bulldog Floodway, and EMF R-2 side inlet repair.

Survey Rodman, GS-5

No one assigned, will be filled by available inspector on the job sites.

STATEMENT OF AVAILABILITY

The above mentioned staff and equipment will be available for this project and will be assigned according to the inspection and testing needs.

By: _____ (Supervisor)

Title: State Conservation Engineer

Date: _____

By: _____ (Supervisor)

Title: Project Engineer

Date: _____

APPROVAL OF CO-DETERMINERS

_____

State Conservation Engineer — Date

_____

Contracting Officer — Date

EXHIBIT A

Short Form Project Summary

Project Information

Project Title: VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE
Project Manager: D Paulus

Projected Start Date: Sep 01, 1989
Projected End Date: Dec 23, 1989
Number of Activities: 22
Hours Per Day: 8.0
Days Per Week: 5.0
Min. Project Duration: 113.4 (days)
Exp. Project Duration: 113.4 (days), Exp. Project Work Days: 81.0
Max. Project Duration: 113.4 (days)

Budget Information

Minimum Labor Cost:	$	0.00	Labor Cost per Day:	$	0.00
Expected Labor Cost:	$	0.00	Project Capital:	$	0.00
Maximum Labor Cost:	$	0.00	Budgeted Capital:	$	0.00

EXHIBIT A

VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart

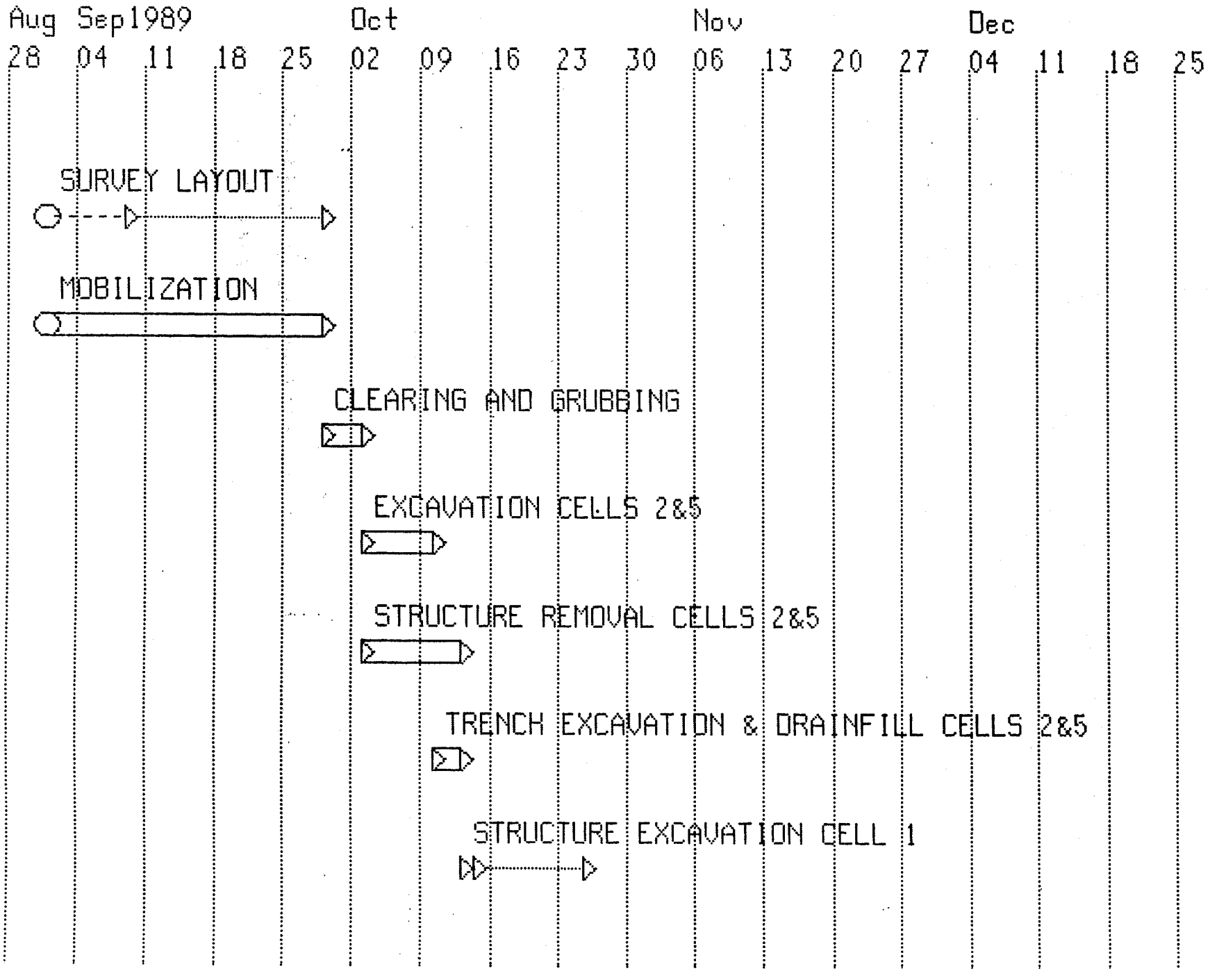
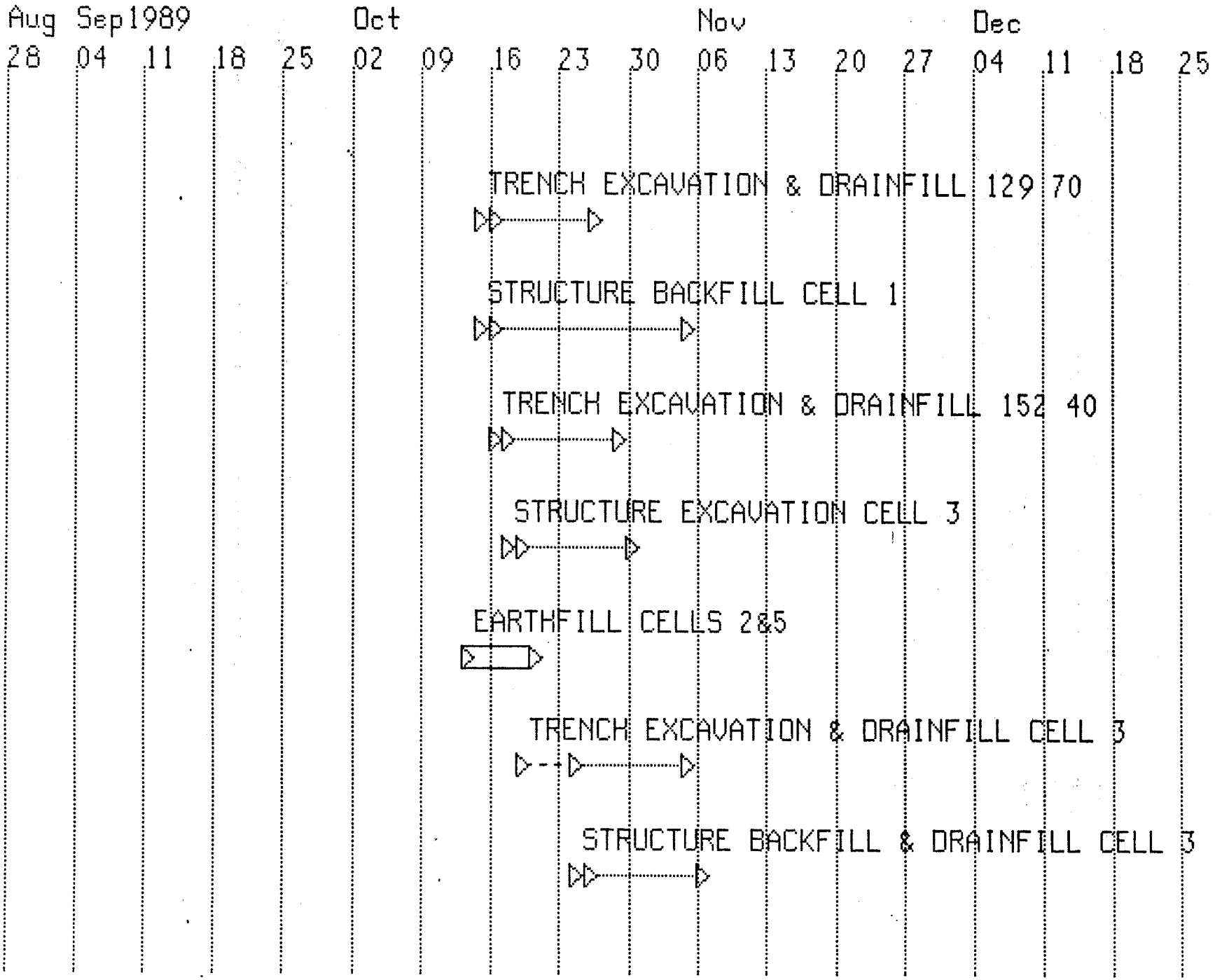


EXHIBIT A

VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart



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VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart

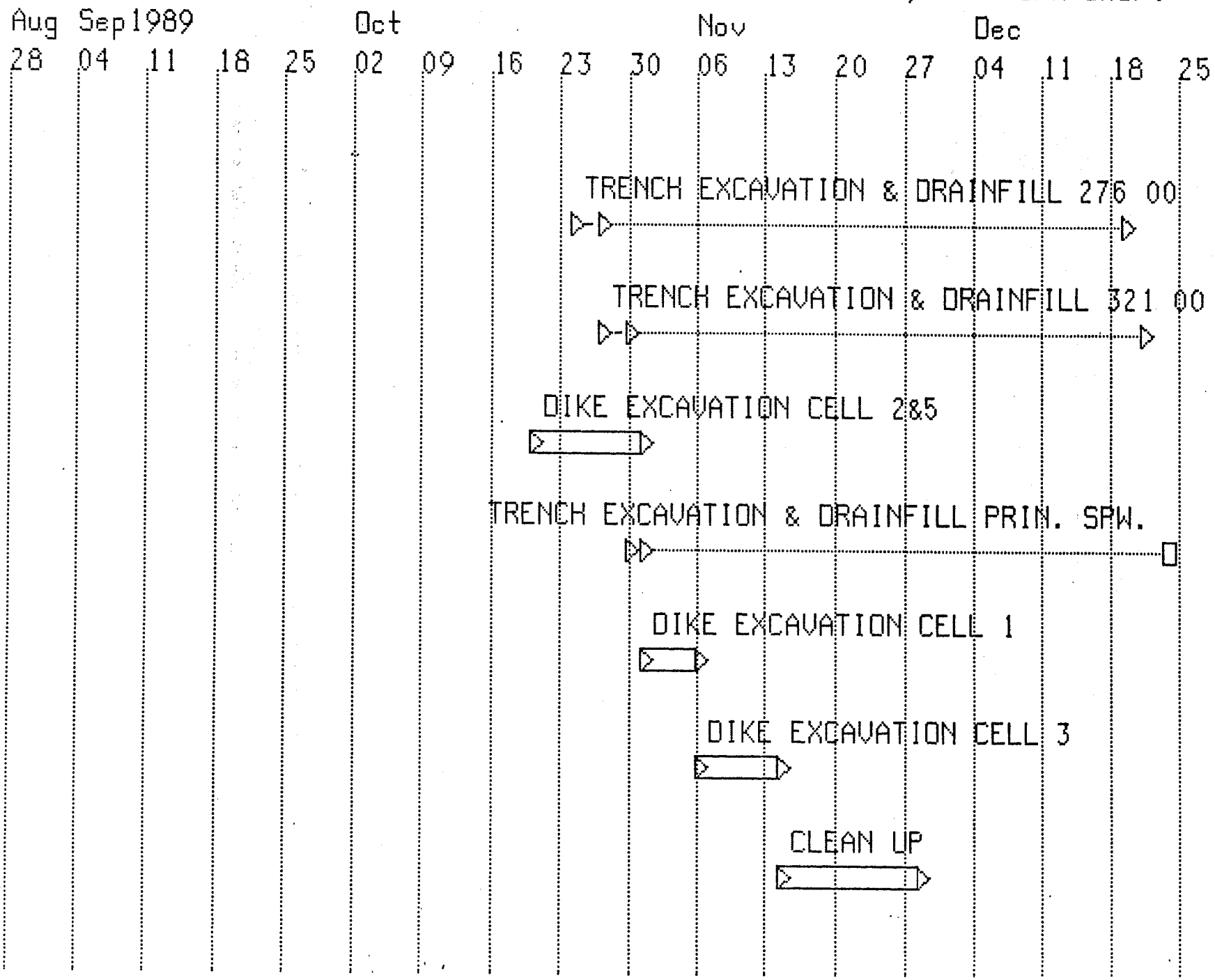
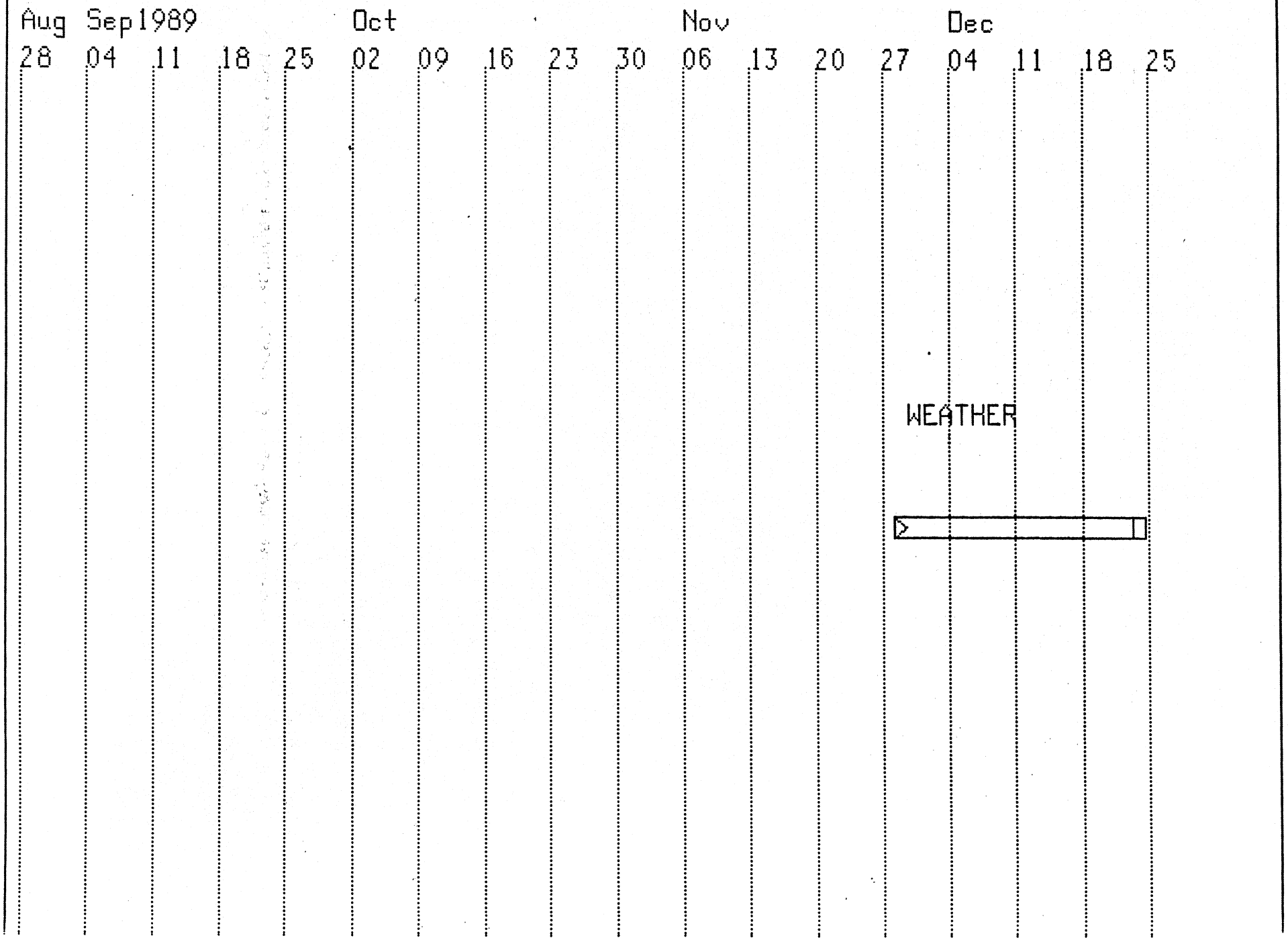
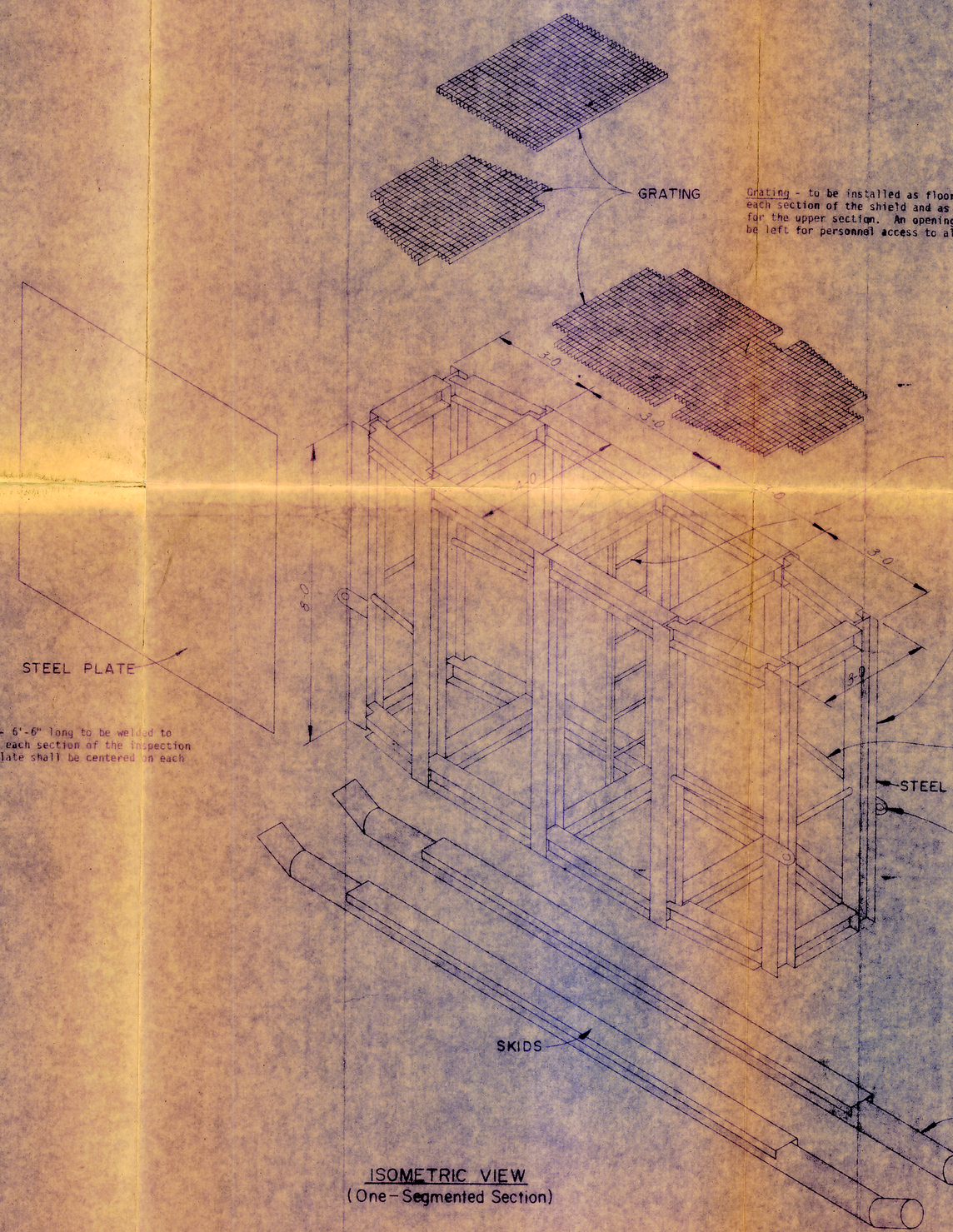


EXHIBIT A

VINEYARD ROAD FRS REPAIR CONSTRUCTION SCHEDULE, PERT/CPM Chart



DRAWINGS



Grating - to be installed as flooring for each section of the shield and as a top for the upper section. An opening is to be left for personnel access to all levels.

Ladder - vertical welded steel ladder shall be included in each section such that the ladder becomes continuous when the sections are assembled.

One of the three required sections, 8 feet high each. Each section to be welded frame and plate. Section connections are to be bolted for field assembly or disassembly. Total maximum operating depth is 24 feet.

Personnel protection bar spaced 4' from grate.

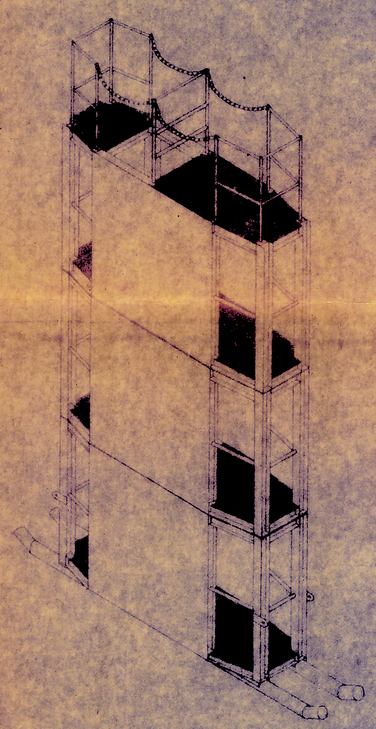
Towing connection for cable or chain for towing by heavy equipment without jamming or tipping of shield when fully assembled (all 3 sections) or partially assembled (1 or 2 sections). Towing connections will be provided at each end of the cage.

Steel Plate - 6'-6" long to be welded to the sides of each section of the inspection cage. The plate shall be centered on each side.

ISOMETRIC VIEW
(One-Segmented Section)

Note: The top section is to be provided with a system of guard rails and chains to control access to the top of the cage and ladder. Guard rails will be used except where access to the ladder or trench crossing is required. Access will be controlled by safety chains with one end having a safety latch.

The guard rail shall be such that it can be reinstalled on top of whatever section is upper most in the trench at the time of use.



ISOMETRIC VIEW
(All 3 Sections fully assembled)

TRENCH INSPECTION SHIELD
SITE I REPAIR
HACKBERRY DRAW WATERSHED

Eddy Co. New Mexico

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	W. Trujillo, J. Nesbitt	6-83	Approved by J. Gordon Dodds
Drawn	R. Armijo, L. Gallegos	6-83	Title State Conservation Engineer
Traced	R. Armijo, L. Gallegos	6-83	Title
Checked	J. Harris, M. Butler	6-83	Sheet No. 9A of 25 — Drawing No. NM-E-0730