East Maricopa Floodway Phase I Reach 1 & 2 Re

United States Department of Agriculture

Soil Conservation Service

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

Subject: ENG - Review of Permeability Tests - Harquahala Flood Retarding Structure

Date: June 17, 1986

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

File Code:

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 E Wallin

DONALD E. WALLIN
Head, Engineering Staff, WNTC

Attachments

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

HARQUAHALA FRS - ARIZONA -- REGRADED CURVES

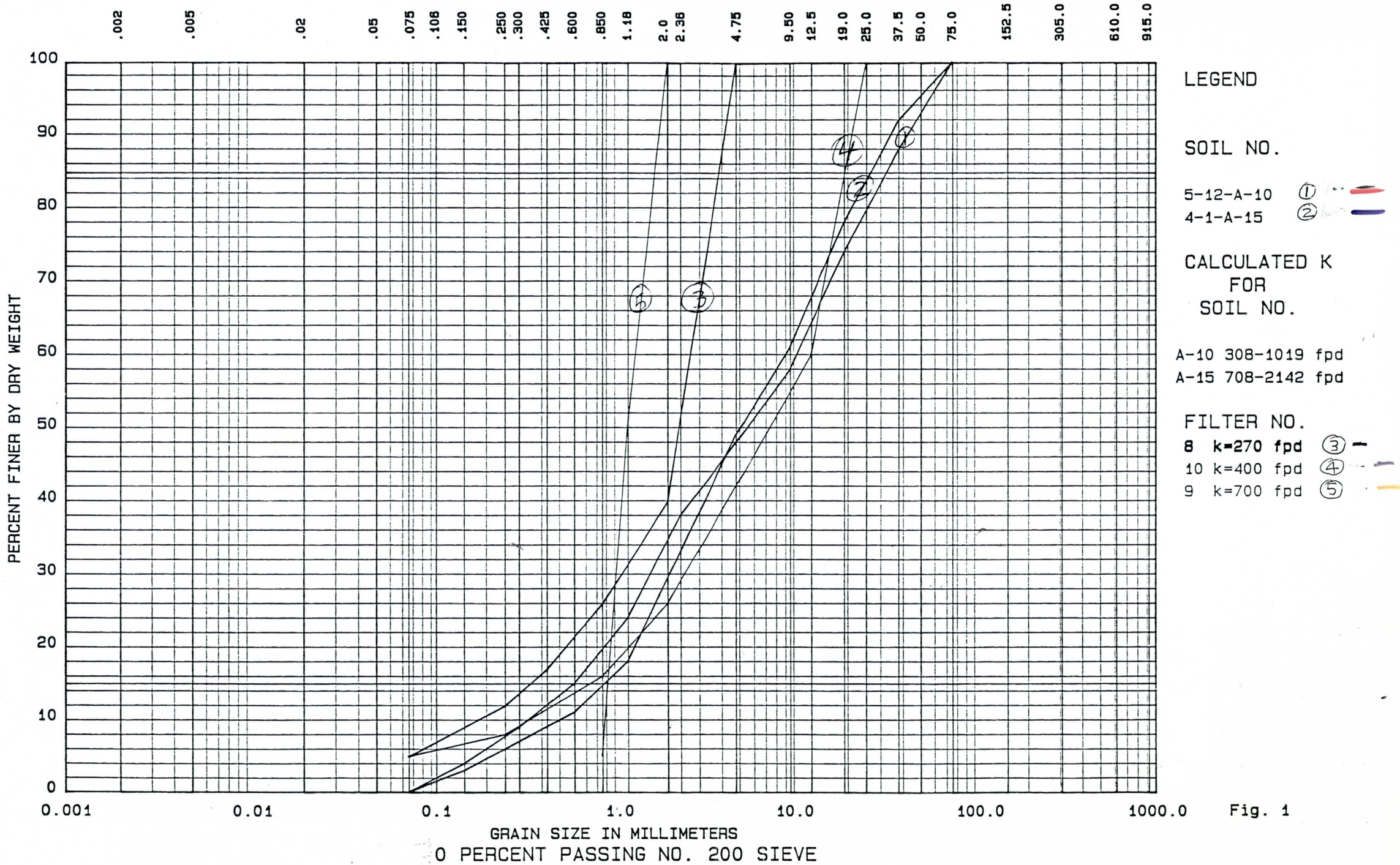


Fig. 1

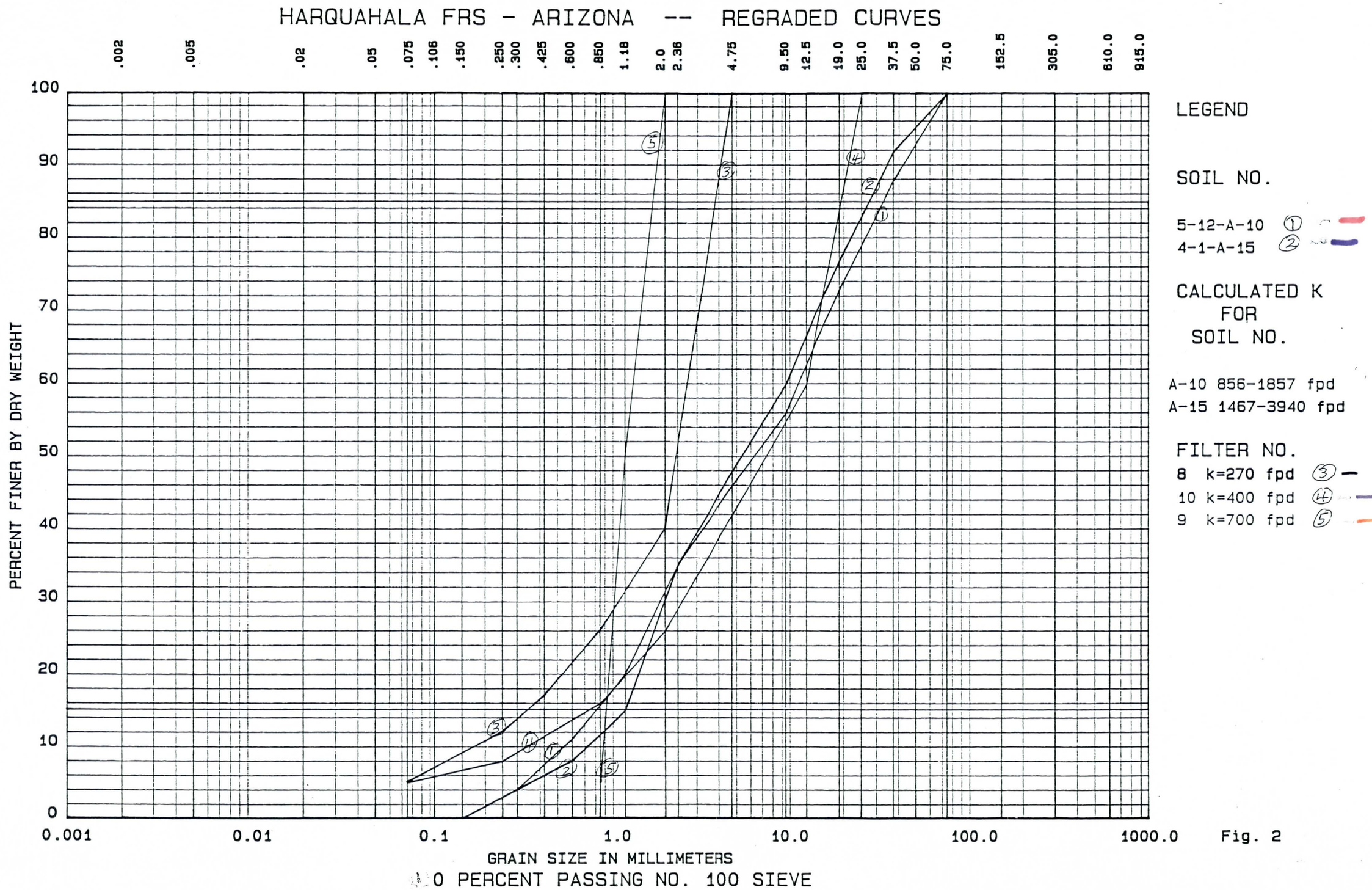
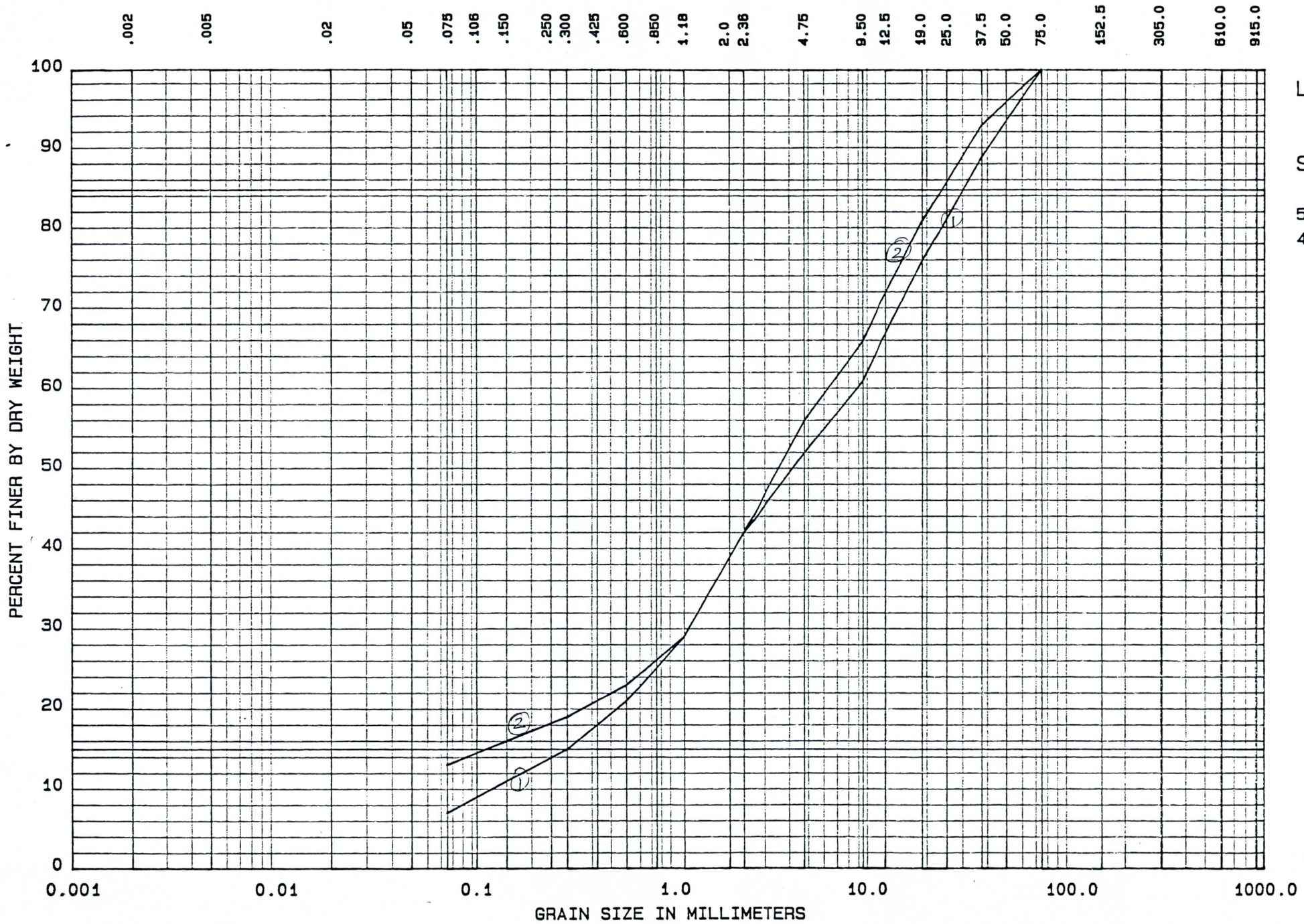

HARQUAHALA FRS - ARIZONA -- REGRADED CURVES
.002
.005
.02
.05
.075
.106
.150
.250
.300
.425
.600
.850
1.18
2.0
2.36
4.75
9.50
12.5
19.0
25.0
37.5
50.0
75.0
152.5
305.0
610.0
915.0
100
90
80
70
60
50
40
30
20
10
0
PERCENT FINER BY DRY WEIGHT
0.001
0.01
0.1
1.0
10.0
100.0
1000.0
GRAIN SIZE IN MILLIMETERS
0 PERCENT PASSING NO. 100 SIEVE
LEGEND
SOIL NO.
5-12-A-10 1
4-1-A-15 2
CALCULATED K
FOR
SOIL NO.
A-10 856-1857 fpd
A-15 1467-3940 fpd
FILTER NO.
8 k=270 fpd 3
10 k=400 fpd 4
9 k=700 fpd 5

Fig. 2

HARQUAHALA FRS - ARIZONA -- SAMPLE CURVES



LEGEND

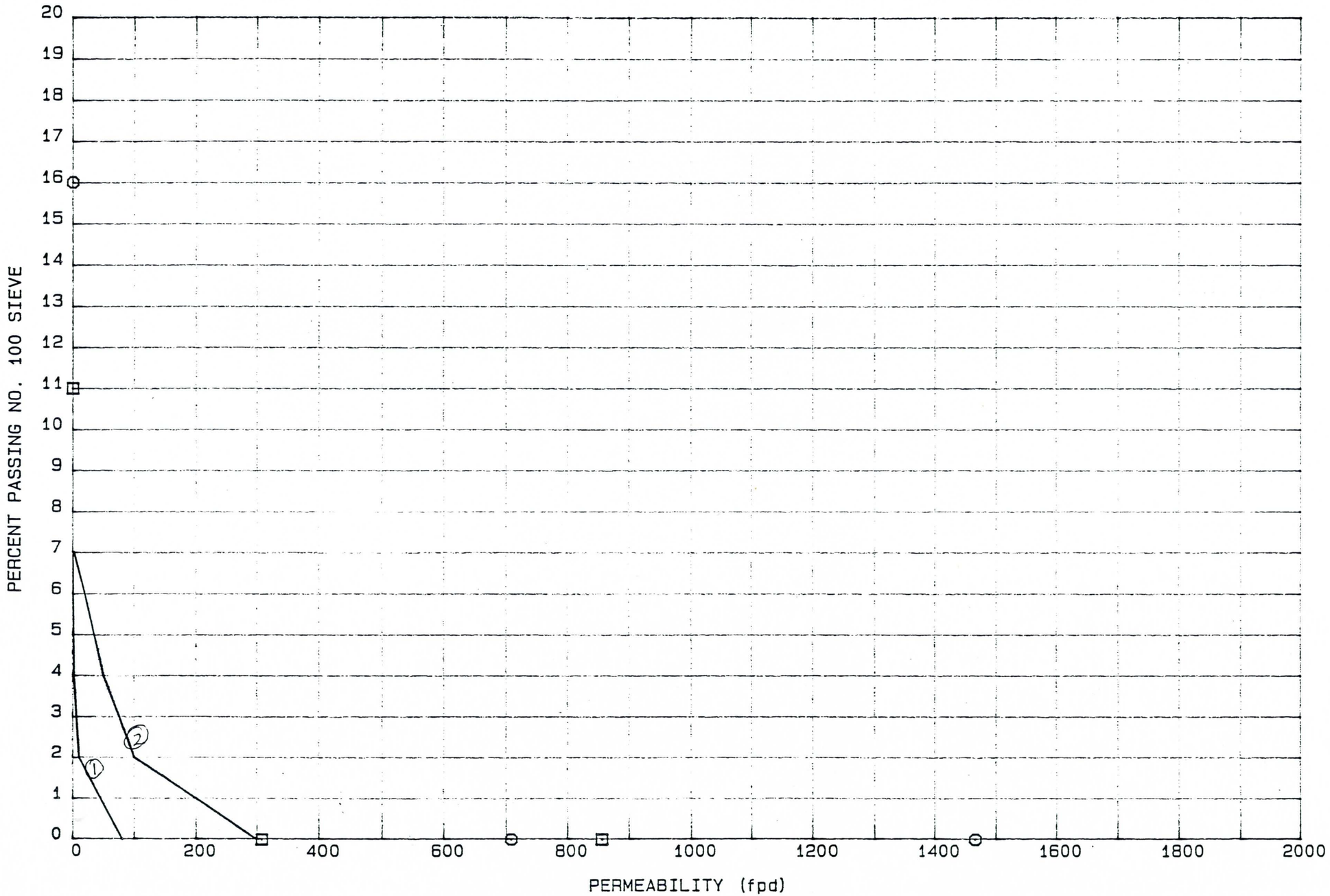
SOIL NO.

5-12-A-10 ①

4-1-A-15 ②

Fig. 3

HARQUAHALA FRS - ARIZONA



LEGEND

FILTER NO.

LOW SIDE ①
HIGH SIDE ②

SOIL NO.

5-12-A-10
4-1-A-15

PERMEABILITY VS PERCENT PASSING NO. 100

Fig. 4

HARQUAHALA FRS - ARIZONA

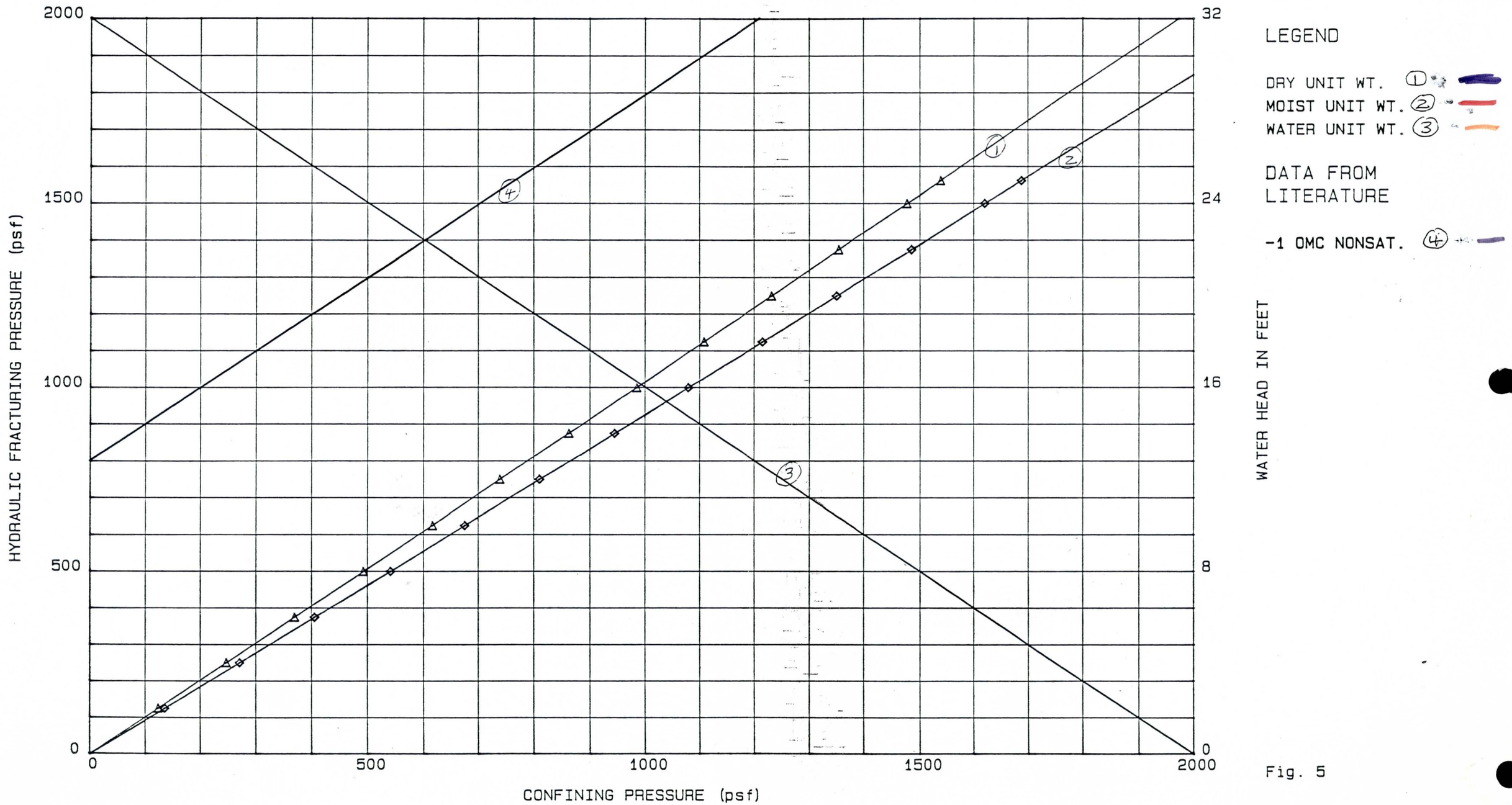


Fig. 5

NPK

United States Department of Agriculture

Soil Conservation Service

201 E. Indianola Suite 200
Phoenix, Arizona 85012

JUN 21 '90

SUBJ: ENG-EMF Reach 6
Soil Cement-Side Inlets
FCD Report-Jan. 12, 1990

DATE: May 29, 1990

TO: Ralph M. Arrington
State Conservation Engineer

FILE: 210

The FCD report concerning the soil cement placed during the EMF Reach 6 project last year is in agreement with SCS findings that the soil cement within the main floodway is acceptable in accordance with the intent of the design. However, the FCD report concludes that the side inlets have inadequate thickness and should be reconstructed. The FCD used the SCS Engineering Design Standards, Far West States Figure 1.7, "Minimum Section Thickness" for concrete channels as the basis for the soil cement thickness determination in their memorandum dated January 12, 1990.

The FCD adjusted the concrete section thickness vs. water velocity relationship shown on Figure 1.7 with the assumption that the lining thickness is directly related to the compressive strength of the material used to line the channel. This resulted in a section thickness 5 times greater than that shown in Figure 1.7 by comparing the lowest in-place compressive strength of the soil cement (500 psi) to an assumed concrete strength of 2,500 psi.

We contacted the WNTC about Figure 1.7 and found that the figure was based on data from the Corp of Engineers, relating velocity head of water to the weight (ie., thickness) of the concrete slab. We do not know what minimum strength of concrete was used to develop Figure 1.7. Though the relatively high strength of concrete as compared to soil materials is obvious, the unit strength of concrete does not appear to be directly related to Figure 1.7.

The original design for the soil cement side inlets for this project applied the "industry standard" of 750 psi laboratory design strength which has been widely used by various agencies for channel work in Arizona. Subsequent to the construction of the EMF Reach 6 project, the SCS state design section applied a tractive power analysis using the tested field strengths of the soil cement to evaluate its resistance to erosion. The result of the tractive power analysis is that in general, the in-place soil cement has a durable wearing surface with a substantial factor of safety to resist the erosive attack from flowing water.

The overall stability of the side inlets is dependent upon the effectiveness of the gravel drains to relieve uplift pressure and the effectiveness of maintenance to prevent infiltration of water into the shrinkage cracks inherent in soil cement. The O&M plan written by Greiner Engineering during the design of the project requires routine inspection of the side inlets for evidence of uplift and other damage. Some degree of maintenance, i.e., sealing of the cracks, was anticipated in the O&M plan.

It would be premature to reconstruct the side inlets at this time. The side inlets should be monitored regularly for performance and possible deterioration. Should the side inlets require excessive maintenance, an engineering report can then be prepared and alternative measures recommended.

John M. Harrington
State Design Engineer

United States
Department of
Agriculture

Soil
Conservation
Service

201 E. Indianola
Suite 200
Phoenix, AZ 85012

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1	DEP		HYDRO
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2	ENGR		

REMARKS Copy to HSC

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

N. Karan

United States Department of Agriculture

Soil Conservation Service

201 E. Indianola Avenue
Suite 200
Phoenix, Arizona 85012

FLOOD CONTROL DIST. RECEIVED JUN 21 '90 GM ENG DEI ADMIN FINANCE C & O ENGR REMARKS

Subject: ENG - East Maricopa Floodway, Reach 1 Repair

Date: June 19, 1990

To: Meeting Attendees

File Code: 210

A meeting of Maricopa County Flood Control District (MCFCD) and Soil Conservation Service (SCS) representatives was held, with John Harrington presiding, on June 6, 1990, at 9:00 a.m., at the Soil Conservation Service. The purpose was to discuss proposed methods of improving approximately 24,000 linear feet of earth lined channel at the downstream end of the East Maricopa Floodway (EMF). The limits of the project are from the spillway of the Saint Anthony Falls in Reach 2 to the spillway at the Gila River in Reach 1.

The original design of the channel was based on the TR-25 tractive power method of analysis. The subsequent engineering report dated November 1985 questioned the validity of the tractive power method of TR-25 in general. Also after completion of the project, soils containing dispersive clays were discovered at the site. The result is a potential for severe erosion. The subject project is to control the threat of damage to the channel and reduce maintenance problems which would be expected.

Several potential solutions were discussed:

1. Riprap the banks; construct soil cement sills at the downstream end of each riprap section and at intermediate points where justified or required.

2. Riprap the entire cross-section.

3. Construct an embankment along the center of the channel, creating two channels. The new main channel would be deeper and completely lined with soil cement between riprap sections. The secondary channel would be used as a borrow area and groundwater recharge basin.

Solution No. 1 was agreed to be the most economical and practical solution, and was selected for proceeding with preliminary design. Among advantages are flexibility in resistance to erosion, and ease of maintenance. Riprap will extend up the slope to the 100-year design water level. Riprap is to be designed with a minimum factor of safety of 1.5 in tractive stress analysis.

Solution No. 2 was found to be too costly to construct, and difficult to maintain. Also, large rock could cause an increase in n-value resulting a decreased channel capacity.

Solution No. 3 was considered too costly and too hydraulically complex. The aesthetics of the proposal were also questioned. Doubts on adequacy of 12" thickness were expressed by the Flood Control District.

Other general features of Solution No. 1 includes an aggregate base course for tops of slope and the maintenance roads, a filter layer under the riprap, and access ramps for maintenance. Minor design details are to be worked out with the preliminary design. The basic concepts are to be included in the preliminary design shown on the attached sketches EMF-1 and EMF-2.

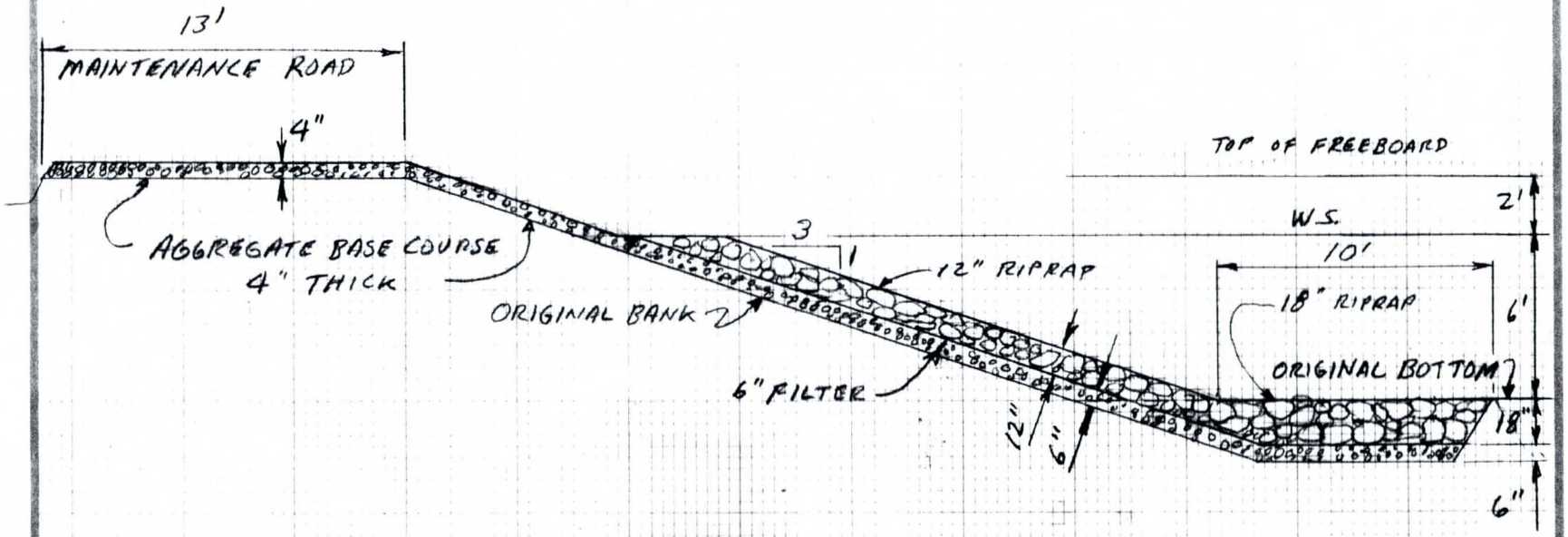
Those who attended:

Maricopa County Flood Control District	Soil Conservation Service
Nick Karan	Ralph Arrington
Jon Hughes	John Harrington
Scott Clement	Leland Seale
Bill McFerrin	John Sullivan
	Aubrey Sanders
	Tom Jayo

If there are any questions, please direct them to Bill McFerrin or John Harrington at the Soil Conservation Service, (602) 640-5152.

William A. McFerrin

WILLIAM MCFERRIN
Civil Engineer



TYPICAL
CROSS SECTION

SCALE 1" = 4'

EMF REACH 1 & 2 REPAIR,
RIPRAP W/ FILTER (BANKS)
ABC FOR MAINTENANCE ROAD

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed WAM 6/8/01

Drawn

Traced

Checked

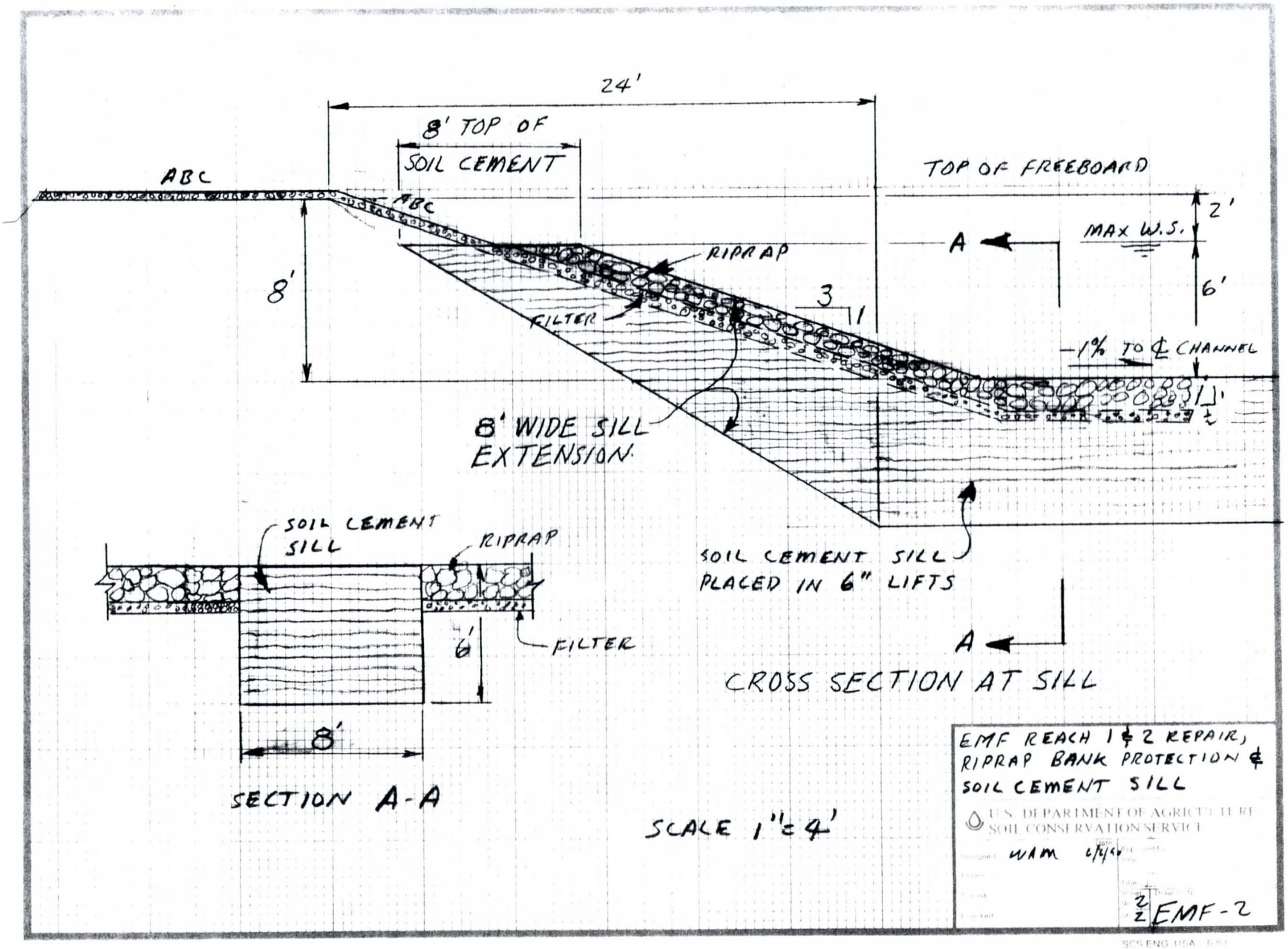
Approved by

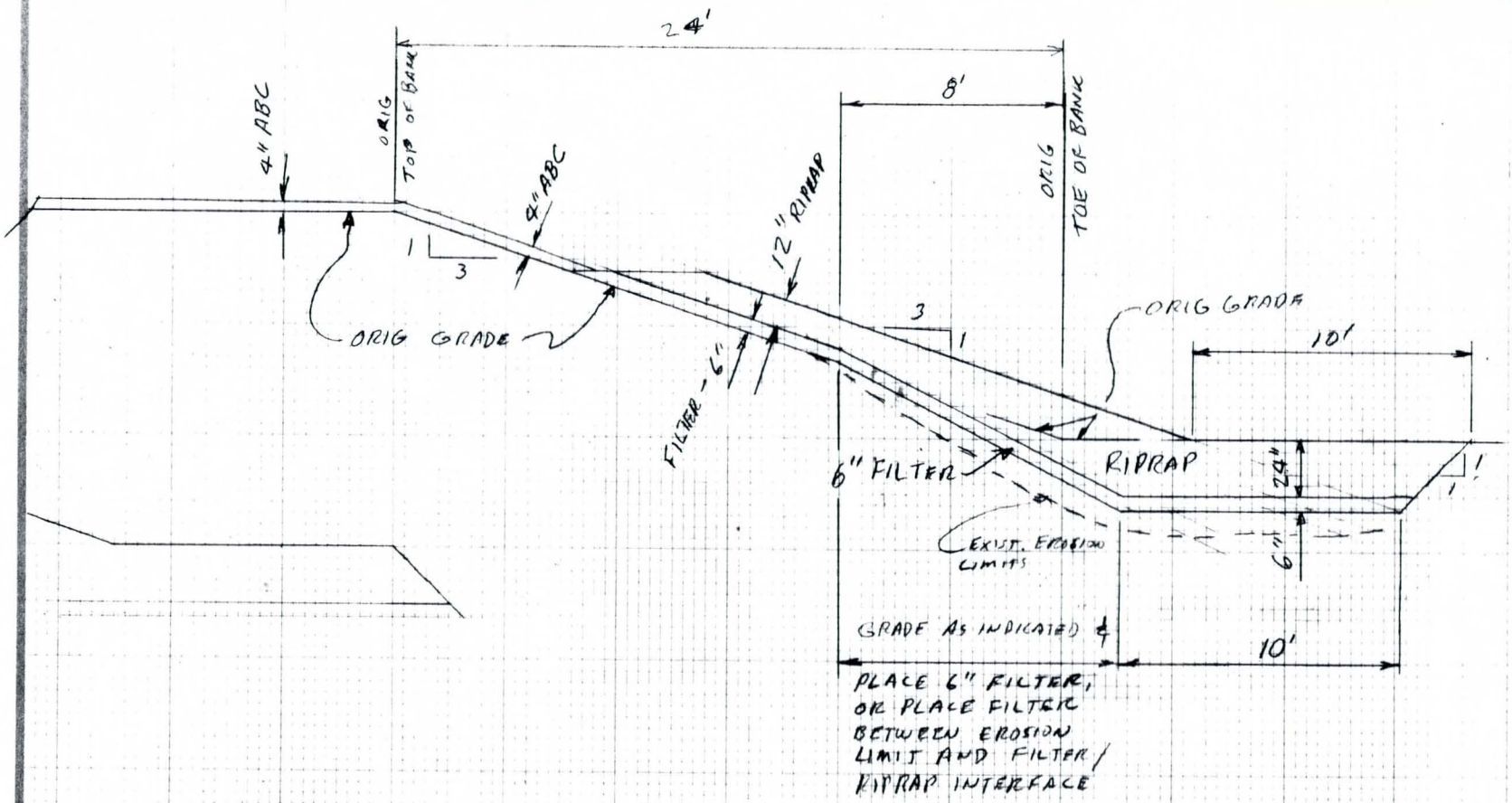
Title

Sheet No. 1 of 2

Drawing No. EMF-1

SCS-ENG-315A 6-81


24'
8' TOP OF SOIL CEMENT
ABC
ABC
TOP OF FREEBOARD
2'
MAX W.S.
A
RIPRAP
6'
8'
3
1
FILTER
1% TO ℄ CHANNEL
1½'
8' WIDE SILL EXTENSION
SOIL CEMENT SILL
RIPRAP
SOIL CEMENT SILL PLACED IN 6" LIFTS
FILTER
6'
A
CROSS SECTION AT SILL
8'
SECTION A-A
SCALE 1" = 4'
EMF REACH 1 & 2 REPAIR, RIPRAP BANK PROTECTION & SOIL CEMENT SILL
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WAM 6/1/64
2/2 EMF-2



NOTE: THIS SECTION HAS EXTRA-THICK RIPRAP (24") AND IS TO BE PLACED WITHIN THE FIRST 100' DOWNSTREAM OF EACH SOIL CEMENT SILL

RIPRAP DESIGN DOWNSTREAM OF SOIL CEMENT SILLS - ATTACH TO EMF 1 & 2

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed: WAM Date: 6/15/80
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Checked:
Approved by:
Title:
Sheet No. of
Drawing No.

SCS-ENG-315A (6-81)

United States
Department of
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Soil
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West National Technical Center
511 NW Broadway, Room 547
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	DET ADMIN		HYDRO
	FINANCE		LMGT
	C & O		FILE
	ENGR		

REMARKS

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

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

ICC:nn

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 spillway 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 the 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 the other cell remained as it is left after installation of the central graded filter section.

The 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 lt 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 was 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 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.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

INTEROFFICE MEMORANDUM

Subject: East Maricopa Floodway **File:**

To: Scott Clement **From:** Cyrous Vahidnia **Date:** Oct. 23, 1990.
Via: Ed Raleigh

The referenced subject was reviewed. Assuming the submitted data is reflecting the correct information, the following item needs to be addressed:

Scour analysis should be provided to support the adequacy of the proposed thickness of soil cement and the 7 foot extension of riprap on the bed for the purpose of bank protection.

Cyrous Vah

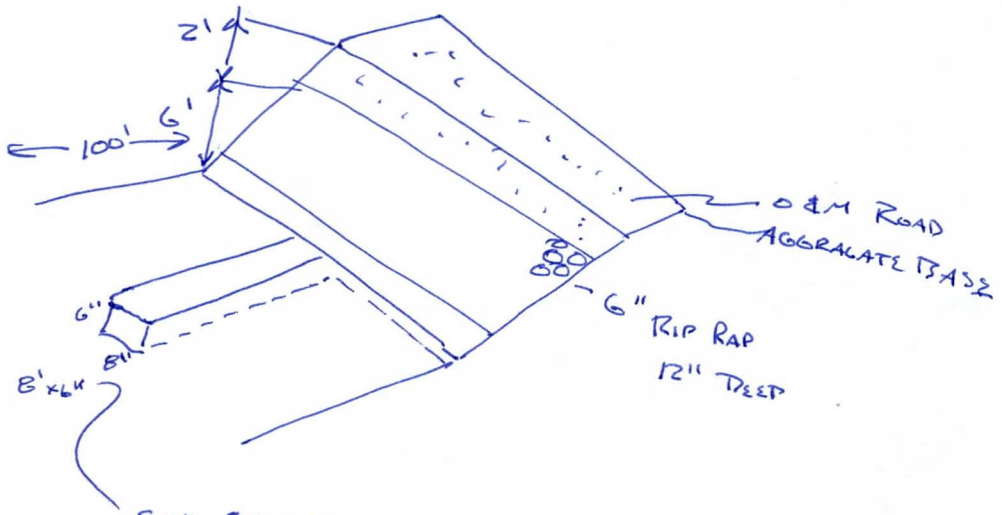
Cyrous Vahidnia

CONCEPT 1 - SOIL CEMENT, LINE ENTIRE CHANNEL 12" THICK
V → 12 FPS $6.0 MILL

2) - ROCK RIP-RAP D-50 = 3"-4", WITH FILTER
6-8" MINUS
$4.0 MILL

- WOULD USE 1/2 OF EXISTING FREEBOARD
n = .033-.034

3)



SOIL CEMENT SILLS EVERY 1000'
SC 20,000 Y @ 30 = 8'x6' $600 K
ABC 30,000 Y @ 15 = 450 K
ROCK 65,000 Y @ 25 = 1.625 K
$ 2,675 K

100 YR DESIGN NPK WANTS 1.5 SAFETY FACTOR

* AESTHETICS - GILA INDIAN RESERVATION MTG, COUNTY PARKS
@ CONCEPT COMPLETION

TO DO

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY	DATE	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET ____ OF ____

DESIGN MEETING -
Date 6-6-90

Name	Organization	Phone
Tom Jayo	SCS	640-5151
John Sullivan	SCS	640-5149
SCOTT CLEMENT	FCD	262-1501
AUBREY SANDERS	SCS	640-5146
Leland Saele	SCS (Portland)	
RALPH ARRINGTON	SCS	640-5148
John Harrington	SCS	
Nick Karan	FCD	262-1501
JON HUGHES	"	269-4725
Bill McFerrin	"	642-5150

S. Clement

United States Department of Agriculture

Soil Conservation Service

201 E. Indianola Avenue
Suite 200
Phoenix, Arizona 85012

FLOOD CONTROL DISTRICT
RECEIVED
JUN 21 '90
ENG
P & PM
HYDRO
ADMIN
LMG1
FINANCE
FILE
O & O
ENGR
REMARKS

Subject: ENG - East Maricopa Floodway, Reach 1 Repair

Date: June 19, 1990

To: Meeting Attendees

File Code: 210

SCS ESTIMATES STONE COSTS.

A meeting of Maricopa County Flood Control District (MCFCD) and Soil Conservation Service (SCS) representatives was held, with John Harrington presiding, on June 6, 1990, at 9:00 a.m., at the Soil Conservation Service. The purpose was to discuss proposed methods of improving approximately 24,000 linear feet of earth lined channel at the downstream end of the East Maricopa Floodway (EMF). The limits of the project are from the spillway of the Saint Anthony Falls in Reach 2 to the spillway at the Gila River in Reach 1.

The original design of the channel was based on the TR-25 tractive power method of analysis. The subsequent engineering report dated November 1985 questioned the validity of the tractive power method of TR-25 in general. Also after completion of the project, soils containing dispersive clays were discovered at the site. The result is a potential for severe erosion. The subject project is to control the threat of damage to the channel and reduce maintenance problems which would be expected.

I-10 CASABLANCA EXIST TO SACATON 1ST STOP SIGN STR HOG LEFT 1ST ROAD H2O TANK

Several potential solutions were discussed:

1. Riprap the banks; construct soil cement sills at the downstream end of each riprap section and at intermediate points where justified or required.

2. Riprap the entire cross-section.

3. Construct an embankment along the center of the channel, creating two channels. The new main channel would be deeper and completely lined with soil cement between riprap sections. The secondary channel would be used as a borrow area and groundwater recharge basin.

Solution No. 1 was agreed to be the most economical and practical solution, and was selected for proceeding with preliminary design. Among advantages are flexibility in resistance to erosion, and ease of maintenance. Riprap will extend up the slope to the 100-year design water level. Riprap is to be designed with a minimum factor of safety of 1.5 in tractive stress analysis.

Solution No. 2 was found to be too costly to construct, and difficult to maintain. Also, large rock could cause an increase in n-value resulting a decreased channel capacity.

Solution No. 3 was considered too costly and too hydraulically complex. The aesthetics of the proposal were also questioned. Doubts on adequacy of 12" thickness were expressed by the Flood Control District.

Other general features of Solution No. 1 includes an aggregate base course for tops of slope and the maintenance roads, a filter layer under the riprap, and access ramps for maintenance. Minor design details are to be worked out with the preliminary design. The basic concepts are to be included in the preliminary design shown on the attached sketches EMF-1 and EMF-2.

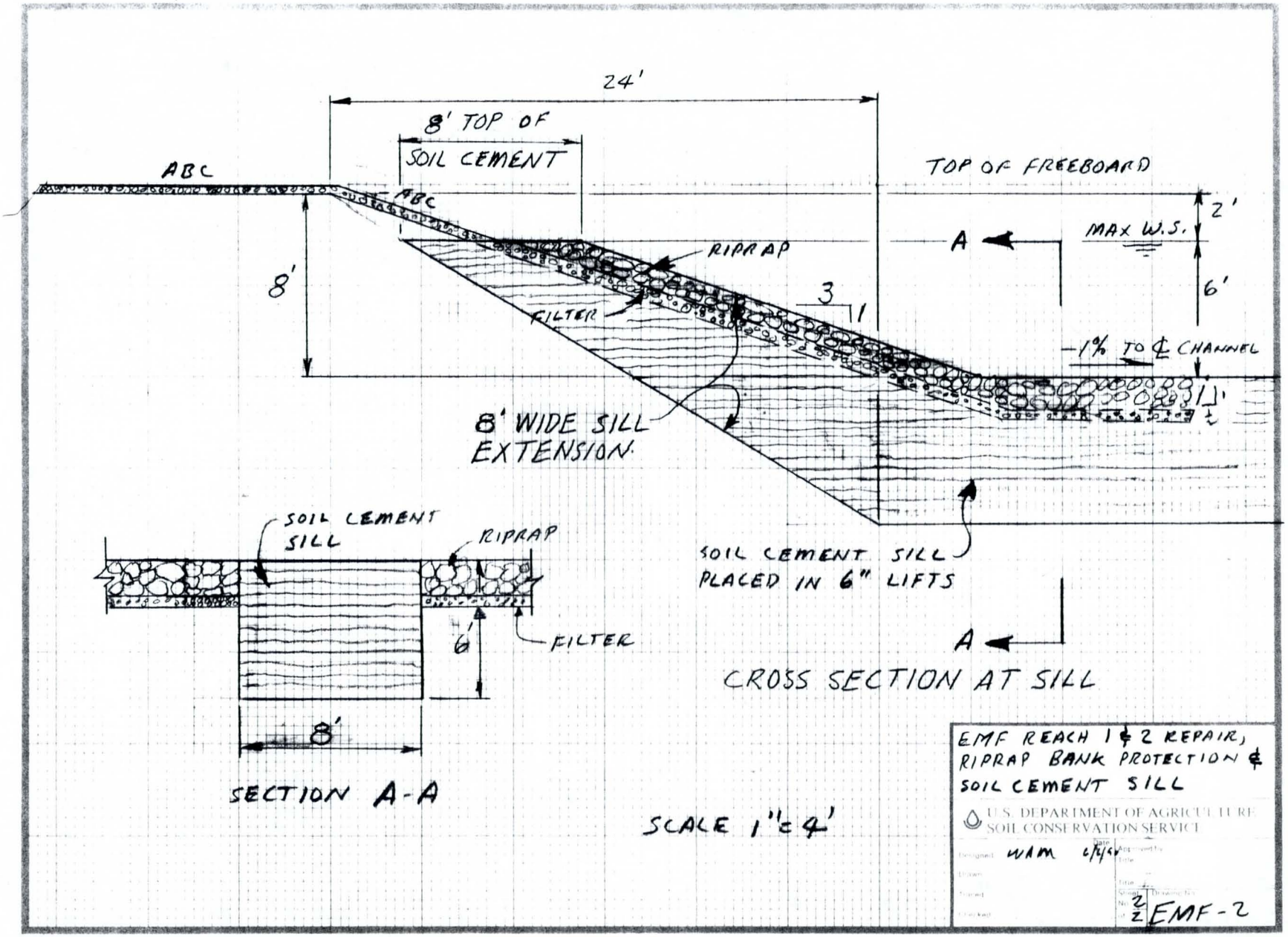
Those who attended:

Maricopa County Flood Control District	Soil Conservation Service
Nick Karan	Ralph Arrington
Jon Hughes	John Harrington
Scott Clement	Leland Seale
Bill McFerrin	John Sullivan
	Aubrey Sanders
	Tom Jayo

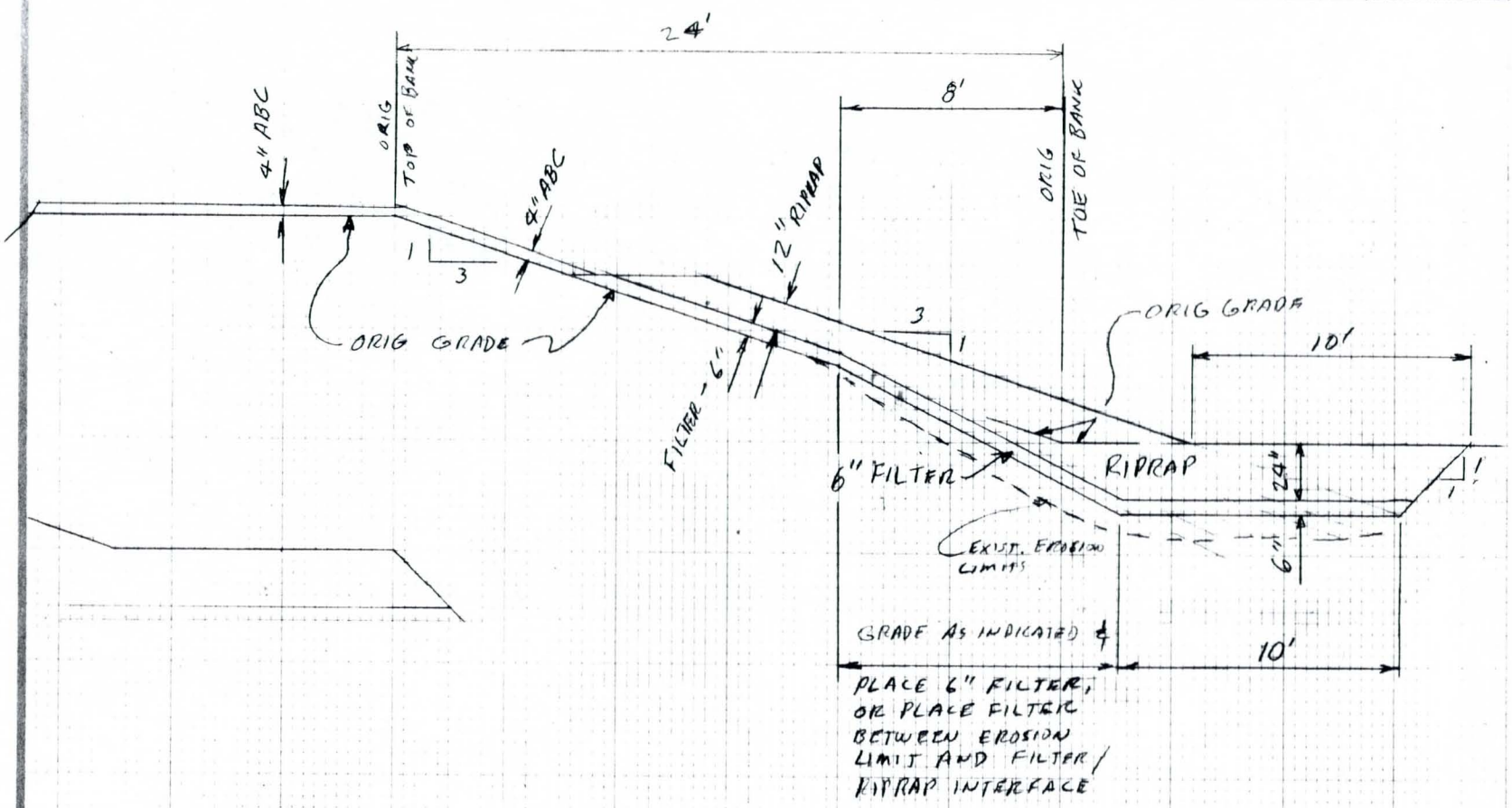
If there are any questions, please direct them to Bill McFerrin or John Harrington at the Soil Conservation Service, (602) 640-5152.

William A. McFerrin

WILLIAM MCFERRIN
Civil Engineer


24'
8' TOP OF SOIL CEMENT
ABC
ABC
TOP OF FREEBOARD
2'
MAX W.S.
A
RIPRAP
8'
3
1
FILTER
6'
-1% TO ℄ CHANNEL
1'
8' WIDE SILL EXTENSION
SOIL CEMENT SILL
RIPRAP
SOIL CEMENT SILL PLACED IN 6" LIFTS
FILTER
6'
A
CROSS SECTION AT SILL
8'
SECTION A-A
SCALE 1"=4'
EMF REACH 1 & 2 REPAIR, RIPRAP BANK PROTECTION & SOIL CEMENT SILL
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WAM
2/2
EMF-2

SCS ENG 315A



NOTE: THIS SECTION HAS EXTRA-THICK RIPRAP (24") AND IS TO BE PLACED WITHIN THE FIRST 100' DOWNSTREAM OF EACH SOIL CEMENT SILL

RIPRAP DESIGN DOWNSTREAM OF SOIL CEMENT SILLS - ATTACH TO EMF 1 & 2

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed WAM Date 4/15/80
Drawn
Traced
Checked
Approved
Title
Sheet No.
Drawing No.

SCS-ENG-415A (6-8)

1

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
PHOENIX, ARIZONA
SEPTEMBER 1990

PRELIMINARY DESIGN REPORT

JOB: Phase I, East Maricopa Floodway, Reaches 1 & 2 Repair

PROJECT: East Maricopa Floodway

LOCATION: Pinal County, Arizona

AUTHORITY: Public Law 566

PHASE: Preliminary Design

SUMMARY

An engineering report dated November 8, 1985 was prepared by an investigation committee for Reach 1 of the East Maricopa Floodway (formerly RWCD Floodway). The following problems were identified:

1. Excessive toe erosion of the channel banks in the soil lined portions of the floodway,

2. Local scour downstream from most of the rock lined sections,

3. Rilling and gully development on most of the channel banks, and

4. Jug hole development on the crest and banks of the dikes along Reach 1.

The committee concluded that the problem was related to dispersive, plastic soils in the earth lining of the channel; and to the use of the tractive power design procedure in TR-25. It recommended that, when maximum velocity and maximum tractive stress greatly exceed the allowable velocity and allowable tractive stress, there should be concern with use of the tractive power procedure.

Project review started in March 1990, followed by comparative designs and estimates to develop an array of alternative solutions to the erosion problems. A meeting was held on July 6, 1990 among SCS and MCFCD representatives to discuss those alternatives which appeared most feasible. Agreement was reached on a solution which called for 1) riprap of the channel slopes; and 2) construction of soil-cement sills across the channel to provide grade control.

who?

The project was divided into Phases 1 and 2 for funding purposes. Phase 1, the upstream approximate half, is to be constructed first.

DESCRIPTION OF THE JOB

The project includes repair/protection of all earthen channel segments between the downstream end of the SAF Basin in Reach 2 (Station 1160+32.10) and the discharge of Reach 1 (Station 1450+50) into the Gila River. Phase 1 extends from Station 1160+32.10 to Station 1316+60. Design parameters of the existing channel are as follows for a 100 year storm event:

Q = 8700 cfs
d = 6 feet
v = 6.7 fps
b = 200 feet
z = 3
n = 0.027

The major feature of the work is riprap protection of the earthen slopes. The riprap will be placed on filter fabric which will overlay a 2-inch minimum bed of aggregate base course (ABC).

Soil-cement sills will be constructed at the downstream end of each existing channel riprap section, and at selected intermediate points for grade stabilization. The sills will be 8 feet wide and approximately 6 feet deep. The finished grade of each sill will be from as-built channel grade at new toe of slope to 1 foot below grade at centerline of channel, forming a shallow "V" shaped channel bottom.

Another feature of the work will be placement of ABC on maintenance roads and on the freeboard portion of channel slopes.

DESIGN OBJECTIVE

The objective of the proposed work is to protect the channel from excessive erosion. It is accepted that erosion will occur in the unprotected portion of the channel bottom until it tends to stabilize through an aging process controlled by the soil cement sills and channel riprap. Scour holes will develop immediately after the sills. Deposition will tend to maintain normal grade upstream of riprap sections and intermediate sills. The "V" shaped soil cement sills are intended to keep the more frequent flows at the center of the channel, away from the banks.

ABC on the maintenance roads and freeboard area of channel slopes is intended to prevent rills and jugging in those areas, and to allow maintenance access during periods of wet conditions.

The plans call for a minimum of 3 inches of loose soil obtained from required excavations to be placed over the riprap. The intended purpose is

to help lock the riprap in place as the soil is worked into the riprap by rainfall or channel flow. This will also act as the spoil area for the excavation. Minor amounts of borrow, if required to complete the loose soil cover, will be taken from the center of the channel to enhance formation of a low-flow channel.

BASIS FOR DESIGN

1. Far West States (FWS), "Criteria for Riprap Rock size", pg. 6-13a to 6-13d.

2. Advisory PO-18 (HRP 108 Adoption) "Rock Riprap Design Procedure", May 1, 1974.

3. Corps of Engineers EM 1110-2-1601, July 1970, pg. 43.

4. Engineering Field Manual, Chapter 16, Streambank Protection

5. National Crushed Stone Association

6. TR-59, Hydraulic Design of Riprap Gradient Control Structures

7. "Soil-Cement Slope Protection for Embankments: Planning and Design", PCA, 1975, Reprint 1984.

8. "Short Cut Soil-Cement Testing Procedures for Sandy Soils", PCA, 1958.

9. Chapter 6, Stability Design, TR-25, SCS, October 1977.

GENERAL BASIC DATA

In 1985, nine soil samples were taken in the earth lining of Reach 1. The fines content (passing #200 sieve) averaged 77 percent. Two design problems were encountered because of the fine grain soils:

1. A single aggregate filter could not be readily designed to satisfy the requirements for preventing migration of the fines and also preventing migration of the filter through the overlaying riprap. A secondary filter was desirable between the primary filter and the riprap.

   A filter fabric placed over 2 inch minimum ABC bedding was selected in favor of an aggregate filter. The ABC bedding is to fill the irregularities of the existing slopes and provide intimate contact between the subgrade and filter fabric. This was estimated to be the more economical solution and allowed for more flexibility in design of a stable riprap surface.

2. The high fines content makes the soil unsuitable for soil-cement, the design of which usually calls for 5-35 percent fines. The project specifications require soil-cement materials meet a specific gradation.

A satisfactory mix could be produced using some local material. However, considering the moderate quantity of soil-cement (approximately 3,200 cu. yd.) to be produced, it likely will not be produced on site and the extra hauling for local material would probably not be economical.

The channel has a maintenance road on each side. Each is to be surfaced with 4 inches of ABC to prevent jugging and rilling that is degrading the O&M roads.

The condition of the maintenance roads at present is that they have some rills, jug holes and other rough features. Heavily loaded trucks carrying construction materials could damage the roads at these bumps. It is therefore being specified that the ABC material be placed on the road before it is used as a haul road for other materials, and that the Contractor maintain all in good condition during the construction period.

LOCATION AND LAYOUT

A topographic survey of the channel bottom was conducted in April 1990 to more precisely describe the scope of work. The most severe erosion was observed at the downstream end of each hard spot (riprap section). Scour holes were created sporadically across the channel as a result of turbulence from flow over and around large riprap rocks. Some of the rock was washed downstream as a result of the scour holes below the riprapped areas.

Soil-cement sills are to be placed at the downstream end of each riprap section to hold the rock in place and reduce the severity of the downstream erosion. The improved erosion conditions are expected because of sheet flow over the flat-topped soil cement-sills.

Intermediate soil-cement sills were located by establishing a maximum distance between grade control structures. That distance was set at 1,500 feet to 2,000 feet, and was based on an assumption of conditions when the channel is moderately aged. Those conditions are for a level channel bottom between grade control structures, resulting in erosion of 2.25 feet to 3 feet on the downstream sides of soil-cement sills.

One other feature was added to minimize the effects of erosion on the downstream side of the sills. The portion of riprap bank protection located in the channel bottom was increased in thickness by 33 percent (6 inches) for 100 feet downstream of each sill to provide extra protection of toe of slope where it is most vulnerable.

HYDROLOGY

No hydrologic parameters were involved in this repair project as they were already considered in the original design of the floodway.

5

HYDRAULIC DESIGN

Hydraulic Slope The hydraulic slope of the floodway was determined by its original design and no changes were made in the channel based solely on hydraulic considerations. Rather, the elements of this project are intended to provide a satisfactory degree of protection to the earth lining in the channel under the conditions of flow in the original design (Q = 8,700 cfs).

The hydraulic design is affected in one way: the existing channel banks will be covered with approximately 14 inches of riprap and bedding material. This bank cover encroaches on the original design cross section, which was 200 feet wide at the bottom, and 6 feet deep. Was that taken in consideration the change Hydraulic data? CV

The encroachment was considered not to be significant for the following reasons:

1. The n-value assumed in the original design was 0.027. The real n-value may be lower in the straight channel segments because of the fineness of the soil materials, and could be as low as 0.022. The true overall n-value of the channel should be little affected by the increased roughness of the riprapped banks. ?

2. Aging of the channel will come with erosion of the earth lining in the channel bottom, resulting in increased channel cross sectional area between hard spots. Velocities will be reduced and the affect of the riprap encroachment will tend to be abated. Decrease

3. Excavation along the banks for installation of the riprap would have required considerable additional improvements. It would have included redesign of the top of bank, narrowing of the maintenance road, or acquisition of additional right of way together with extensive grading and drainage work. These alternatives would have required excessive difficulties and expenditures.

Channel Stability Stability of the channel was checked in accordance with the tractive stress procedure in TR-25. It was clearly demonstrated that the channel lining is not stable if the fine grained materials in the lining are not sufficiently cohesive.

Sediment Transport Analysis of sediment transport was not a major part of the original design because the lining material was considered to be stable with cohesive soils and no consideration was given to import of soils from upstream reaches. Under the design for channel protection no attempt was made to quantify sediment transport, but rather to limit the erosive effects on the noncohesive soils. It is expected that sediment transport will be minimal after aging of the channel.

FOUNDATION AND/OR EMBANKMENT DESIGNS

Native Soil Material No special consideration for use of native soil material was made except that in areas of severe erosion of the embankment it shall be compacted to at least 90 percent of maximum density. Generally, this material is used as embankment material only to fill eroded channel areas to support new riprap being installed. The effort necessary to achieve a higher compaction level is not considered justified because the dispersive nature of the compacted material will cause it to soften after long term exposure to saturation, regardless of degree of compaction.

Aggregate Base Course (ABC) An ABC material was selected to serve as bedding for filter fabric and as gravel cover for maintenance roads and freeboard on channel slopes. The design selected was based on economics and ease of placement/grading to a thin layer down to 2 inches on the slopes (4" on the O&M roads). Compaction beyond placement operations is not required of ABC materials.

Loose Rock Riprap Riprap design was based on review of several analyses made in conformance with design methods listed under "BASIS FOR DESIGN". The minimum factor of safety was 1.5 in accordance with a request by the Flood Control District.

Using Lanes' Method of the tractive stress approach, a D75 of 2.11 inches would provide a minimum riprap design with 1.5 factor of safety.

Calculations based on SCS Advisory PO-18 resulted in D50 = 2.5 inches, without additional consideration for factor of safety. Other methods suggested larger rock was necessary. A more conservative design gradation was selected with D50 > 4 inches.

The use of filter fabric limits the drop of riprap during placement to 3 feet. The advantage the filter fabric offers in this project is that the riprap need not serve as a secondary filter for a primary aggregate filter. The riprap can therefore be designed with economy and stability as the main considerations.

STRUCTURAL DESIGN

No structural designs were necessary for this project.

ENVIRONMENTAL CONSIDERATIONS

The construction of ABC and riprap surface over the existing soil surface will have a positive impact on the visual aspects of the channel. The severe erosion and rilling that is occurring on the channel banks will be eliminated. The gravelled O&M roads will reduce dust produced by maintenance vehicles travelling on them.

No impact on the conservation of biological or water resources is predicted. Water will be used to abate potential dust generated by construction activities.

CONSTRUCTION DRAWINGS

Original construction drawings for Reach 1 and Reach 2 were used to provide basic drafting information for the required drawings. The CADD system was used to produce and store the drawings using Versacad Software, Version 5.4.

SPECIFICATIONS

The technical specifications were prepared using the appropriate sections from NEH-20, and no special written specifications were required. A supplementary requirement under 202, Gravel Cover, is that ABC be placed on maintenance roads prior to their being used for haul roads. Furthermore, these surfaces are to be maintained in a smooth condition to prevent roadway damage.

BID SCHEDULE

Water is considered a subsidiary item in this project because its main use is for dust abatement. The need for dust abatement is mostly a function of how the contractor conducts his work, and is less directly related to the materials being installed. Water will be necessary for earthfill and soil cement, but the quantity will be relatively small.

COST ESTIMATE

The Engineer's Estimate for Phase 1 is $1,566,250. Most of the work involves the use of aggregate materials. ABC and materials for soil cement could be available within about 4 miles near the Gila River. Riprap for previous riprap work in the floodway came from the Salt River, approximately 25 miles away; however, the somewhat smaller grained riprap being specified for this project might be available locally.

The materials for construction are relatively simple, so little special preparation should be required to construct them. The project is of reasonable size so that little economy of scale is likely to result from doubling the scope of work. No seasonal variation is expected.

Cost for mobilization will occur with each phase of the work constructed separately. Some savings might be realized by timing the start-up of Phase 2 with the completion of Phase 1.

CONSTRUCTION SCHEDULE

The construction period was based on an assumed production rate of 216 cubic yards (16 truck loads) per day of riprap placement, requiring 8 months for completion. Another month was added for mobilization and initial construction, making a total contract period of 9 months.

OPERATION AND MAINTENANCE

In general, the new improvements are expected to minimize maintenance requirements in the channel. However, some work might be necessary to repair maintenance ramps after high flows. The ramps are to be covered with 12 inches of ABC only, which might be subject to erosion with high flow. Riprap was not used on the ramps because it would be more difficult to maintain an ABC layer on top of it.

CONSTRUCTION REVIEW

Each proposed location of soil cement sill should be reviewed before proceeding with construction in order to verify there is no reason to adjust the stationing of the sill.

Damage to existing structures or other channel features should be noted along the channel in advance of the contractor's activities in the area of the damage. The objective is to prepare for extra items of work at a time when they can be least costly to the Contractor and SCS. A typical repair project would be replacement of riprap not already covered in the bid items.

AUTHORITY

Submitted by: _____ (Design Engineer) _____ Date

Approved by: _____ (State Design Engineer) _____ Date

Approved by: _____ (State Conservation Engineer) _____ Date

ADDENDUM #1 - REACH 1
ADDENDUM #2 - REACH 2

OPERATION AND MAINTENANCE PLAN

EAST MARICOPA FLOODWAY, REACHES 1 & 2
(Formerly RWCD Floodway)

The operation and maintenance plans for Reaches 1 and 2 of the East Maricopa Floodway are hereby amended by adding the following maintenance items resulting from the repair contract to construct riprapped banks, soil-cement sills and related works. The limits of the work are from Station 1160+32.10 in Reach 2 to Station 1316+60 in Reach 1.

MAINTENANCE

Riprap

Check periodically and after major flows to appraise riprap damage. Replace rock in those areas where damage has occurred.

Riprap placed in the bottom of the channel at the toe of slope is extra thick to allow for moderate erosion in the channel. The rock will fall and continue to armor the toe of slope when the soil beneath is scoured away. However, if excessive scouring causes the rock to separate and expose the underlying filter fabric, the rock should be replaced.

Filter Fabric

A filter fabric is between the riprap and a bedding layer of aggregate base course (ABC). The fabric is not to be exposed to sunlight.

Check periodically and after major flows to verify that no filter fabric is exposed. If it is exposed, cover the exposed area with riprap at least 12 inches thick. If the exposed fabric is damaged, cover the damaged area with other filter fabric having at least two feet overlap all around the damaged area, and restore the appropriate riprap cover.

Aggregate Base Course (ABC)

ABC covers the maintenance roads and the freeboard portion of the top of slope. The ABC should be checked periodically and after heavy rain to determine if there has been rain damage. Holes, ruts and other rough areas should be filled with ABC and graded.

Soil-Cement Sills

No maintenance requirements are anticipated for the soil-cement sills.

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE AZ		PROJECT EMF REACHES 1 & 2, PHASE 1		
BY WAM	DATE 8/13/90	CHECKED BY	DATE	JOB NO.
SUBJECT CONSTRUCTION SCHEDULE				SHEET 1 OF 1

Critical Item = Riprap.

Quantity required = 35,000 Cu Yd

Assume 30 min between loads,

16 loads per day

Truck Capacity $\cong$ 23 tons $\rightarrow \frac{23}{1.7} =$

$13.5 \frac{\text{Cu Yd}}{\text{Truck}}$

$13.5 \text{ Cu Yd/Truck} \times 16 \text{ Trucks} = 216 \frac{yd^3}{day}$

$$\frac{35{,}000 \ yd^3}{216 \ yd^3/day} = 162 \text{ days (working days)}$$

$$\frac{162 \text{ days}}{20 \text{ days/mo}} = 8 \text{ months}$$

Add 30 days for mobilization and initial construction

Total Constr Time = <u>9 months</u>

BID SCHEDULE
EAST MARICOPA FLOODWAY
REACHES 1 & 2 REPAIR
PHASE 1

ENGINEER'S ESTIMATE

Item	Work or Material	Spec. No.	Quantity	Unit	Unit Price	Amount
1	Mobilization	8	1	L.S.	$ xxx	~~$ 20,000~~ 30,000
2	Excavation, Common	21	20,900	Cu.Yd	$ 3.00	$ 62,700
3	Earthfill	23	2,000	Cu. Yd.	$ 7.00	$ 14,000
4	Loose Rock Riprap	61	35,000	Cu Yd	$ 24.00	$ 840,000
5	Gravel Cover (ABC)	202	~~11,000~~ 26,430	~~Cu. Yd.~~ Ton	$ ~~20.00~~ 12.00	~~$ 220,000~~ 317,160
6	Geotextiles	203	90,300	Sq. Yd.	$ 1.30	$ 117,390
7	Soil Cement	206	3,100	Cu. Yd.	$ 50.00	$ 155,00
8	Surveys	7	1	L.S.	$ XXX	$ ~~10,00~~ 15,00
9	Contractor Inspection	94	1	L.S.	$ xxx	$ 15,00
				Total		~~$1,454,090~~ ~~$1,551,250~~ $1,566,250

1.7 I ABC

COMPUTATION SHEET

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

A2
WAM 8/7/90
COST ESTIMATE

EMF REACH 1 & 2 REPAIR, PHASE 1

Item No	Work or Material	Spec. No.	Quantity	Unit	Unit Price	Amount
1	Mobilization	8	1	L.S.	XXX	$ 20,000
2	Excavation, Common	21	20,900	Cu. Yd.	$ 3.00	62,700
3	Earthfill	23	2,000	Cu. Yd.	7.00	14,000
4	Loose Rock Riprap	61	35,000	Cu. Yd.	24.00	840,000
5	Gravel Cover (ABC)	202	10,640	Cu. Yd.	20.00	212,800
6	Geotextiles	203	87,330	Sq. Yd	1.30	113,529
7	Soil Cement	206	3,100	Cu. Yd	50.00	155,000
8	Surveys	7	1	L.S.	XXX	10,000
9	Contractor Inspection	94	1	L.S.	XXX	15,000

Total $1,443,029

Gerard

EMF REACH 1 & 2 REPAIR, PHASE 1

WAM 6/22/90
COST ESTIMATE

	ITEM	QUANTITY (CUBIC YARDS)	UNIT PRICE	AMOUNT
X	~~1) FILTER~~	~~15,400~~	~~22.00~~	~~338,800~~
	2) SOIL CEMENT	3,103	50.00	155,150
XX	~~3) STRUCTURAL EX.~~	~~3,103~~	~~10.00~~	~~31,030~~
XXX	4) GENERAL EX	~~22,000~~ ~~17,000~~ 20,900	3.00	~~66,000~~
	5) COMPACTED FILL	2,000	7.00	14,000
	6) AGGREGATE BASE	~~7,565~~ 10,643	~~15.00~~ 20.00	~~113,475~~ 212,860
	7) RIPRAP	35,000	24.00	840,000
			SUB TOTAL	~~$1,558,445~~ ~~$1,319,040~~
	Filter Fabric	87,333 sq yd	1.30	113,500
			Total	~~$1,432,540~~

X Filter was replaced by 2" ABC because of use of filter fabric

XX This is not structural excavation because it is excavated to limits of sill by excavator, over-excavation filled with soil cement. Therefore, add to General Ex.

XXX General Ex. reduced because 2" ABC replaces 6" filter. Increased by excavation for sills.

EAST MARICOPA FLOODWAY, REACH 1 & 2 REPAIR

WAM 7/23/90

COST ESTIMATE USING FILTER FABRIC

This estimate was prepared at the request of John Harrington following a discussion he held with Lee Saale regarding filter and riprap grading for filtering properties. It had been assumed prior to this that the riprap would be designed to serve as a filter for the filter blanket, which might otherwise be washed through the riprap.

The following are assumed:

1. Thin aggregate filter blanket (2-3") over base
   Cost = $22.00 / cu yd.

2. Filter cloth, material cost = $0.65/sq yd
   installation cost = 0.65/sq yd
   Total $1.30/sq yd
   (Based on Star Valley Estimate)

3. 12" riprap over filter cloth, cost = $24/cu yd

Sieve Size	% Passing
3 1/2"	100
6"	60 - 100
3"	0 - 30
1"	0 - 5

Total length of filter/riprap = 13,322' along channel ℄
Total cross-sectional length of filter aggregate & cloth = 62'
Total area = 13,322 x 62 x 1/9 = 91,774 sq yd

Cost of 3" thick aggregate filter = 91,774 x $\frac{1}{12}$ x $22 = $168,250

Cost of filter fabric = 91,774 x 1.30 = $119,300

Cost of riprap (see estimate) = 840,000

$1,127,550

GEOPRODUCTS –
ARMORFLEX
PH.D. JIM FISH

7/5/90

per Ralph A, representative Fish indicated approximate cost in place, complete is $2.85 / sq ft

2.85 x 9 = $25.65 / sq yd

Approx channel line cost = 2 x 32 x $2.85 x 13,222

= $2,400,000

Estimated cost of filter + riprap ≅ $1,180,000

∴ ArmorFlex twice as costly

EMF REACHES 1 & 2 REPAIR

WAM 9/6/90
SURVEY/COMPUTER DATA

Computer Reference	Sections	Stationing
Job #1	1 thru 63	1450+50 to 1368+35
Job #2	1 thru 94	1367+34 to 1249+90
Job #3	1 thru 39	1234+85 to 1160+50
Job #4 (Same as #3)	"	"
Job #5 (Same as #1)	1 thru 63	1450+50 to 1368+35

WAM 6/19/90
PROJECT STATIONING

SEGMENT 1

Upstream end of Phase 1	1160 + 32.10
Downstream end of Segment 1	1208 + 04.42
Total length Segment 1	4,772.32'
Length of 2-intermediate sills	16.00
Segment 1 length of filter & riprap	4,756.32'

Segment 2

Upstream end of Segment 2	1215 + 00
Downstream end " "	1234 + 89
Length of filter & riprap	1989.00'
—Sill @ 1215 + 10, 8' wide	1981.00

Segment 3

Upstream end of Segment 3	1249 + 80
Downstream end of Segment 3	1314 + 97
Total Length Segment 3	6517.00'
Length of 4 sills	32.00
Length of filter & riprap	6485.00
TOTAL SEGMENTS 1, 2 & 3	13,222'

Segment 4

Upstream end of Segment 4	1315 + 46
Upstream sill ℄	1315 + 56
Downstream end Phase 1	~~1315 + 60~~ 1316 + 6[illegible]

WAM 6/29/90

SILL STATIONING

(see Soil Cement Design)

SILL NO.	℄ SILL STATION
1	1176 + 00
2	1192 + 00
3	1215 + 10
4	1249 + 90
5	1269 + 50
6	1287 + 00
7	1301 + 00
8	1315 + 56

EMF REPAIR

WBM 7/6/90

STATIONS FOR PLAN CROSS-SECTIONS

SHT NO	STATION OF CROSS-SECTION
3	1165
4	1185
5	~~1200~~ 1201
6	1225
7	NO CROSS-SECTION
8	1260
9	1280
10	1300
11	1316

LAYOUT DATA

Monuments - Brass Caps In Concrete

HORIZONTAL CONTROL	VERTICAL CONTROL	Distance From Centerline	
STATION	ELEVATION	Lt.	Rt.
1170+04	1248.88		159.4'
1185+04	1242.73		151.5'
1200+04	1241.82		163.7'
1215+00	1238.54	160'	
1220+00	1238.44	160'	
1225+00	1238.70	160'	
1230+00	1236.24	160'	
1242+26.30	1234.66	160'	
1249+12.57	1233.38	160'	
1255+00	1233.35	160	
1260+00	1232.73	160'	
1265+00	1230.40	160'	
1270+00	1229.13	160'	
1275+00	1229.06	160'	
1280+00	1227.31	160'	
1290+00	1226.97	160'	
1295+00	1227.69	160'	
1300+00	1226.30	160'	
1305+00	1225.56	160'	
1310+00	1222.94	160'	
1317+00	1222.74		163'
1320+00	1219.98	160'	

Bench Marks for Phase 1

9/7/90

EMF REACHES 1 & 2 REPAIR

WAM 8/23/90

RIPRAP DESIGN

The following calculations were based on the assumption that an aggregate filter would be placed between the existing soil channel surfaces and new protective riprap. The fineness of the existing soil made it difficult to design a riprap with small enough material to act as a secondary filter to contain the primary filter while providing sufficient resistance against erosion. On 6/27/90, following a discussion between John Harrington and Lee Saele, a decision was made to use a filter fabric with bedding instead of aggregate filter. The gradation of of the riprap was then designed to assure it would be large enough to prevent erosion but small enough for ease of placement and increased availability.

Riprap Gradation:

Sieve Size	% Passing
8"	100
6"	60 – 100
3"	< 30
1"	< 5

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		EMF- REACH 1 REPAIR		
BY JMH	DATE 7-17-90	CHECKED BY	DATE	JOB NO.
SUBJECT Rock Riprap — Size Rock Using Various method				SHEET 1 OF

$\tau = \frac{62.4 \times 5.5 \times .0015}{1.02 \times .004}$

$d_{50} = 2''$

GIVEN:

$Q = 8,700$ cfs

$V = 6.7$ Fps (Vel. Full)

$d = 6.0$ Ft (flow depth)

$WP = 238$ Ft (wetted per.)

$A = 1308$ Ft^2 (x-sect area)

$S = 0.0015$ Ft/Ft (channel grade)

$Z = 3:1$ (side slope)

$n = 0.02$? — See page. (Mannings "n")

$R = 5.49$

REQUIRED:

Size rock riprap using following methods:

1. Eng. Field Manual
2. Far West States
3. SCS Advisory PD-17 (HRP-108 adaptation)
4. National Crush Stone Assoc.
5. TR-59
6. Corp of Eng. Stone Stability Charts

ASSUMPTIONS:

- $\gamma_{stone} =$ ~~165 lb/ft³~~
- Do not extrapolate charts
-

ie $\gamma = 165$.
$G = 2.65$.
Not 2.5.

COMPUTATION SHEET
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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY	DATE	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 2 OF

SOLUTIONS:

1. EFM

EFM Ex. 16-1 p 16-20

$V = 6.7 \Rightarrow D_{100} \approx 7$ inches

Use 8 inches

8 inch stone weighs $4/3 \pi R^3 (165) = 25$ lbs

Range 5 to 25 lbs OR 4" to 8"

2. FWS

p 6-13b
p 6-13c

$K = 0.87$
$C = 1.0$ straight ch.

Fig 6-13d

Because nomograph was not extrapolated, smallest D_{75} is 5"

No guidance is given for gradation

Say 2" to 8" for practical limits.

COMPUTATION SHEET
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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY	DATE	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 3 OF

3. SCS Advisory PO-18

$$D_{50} = \left[\frac{118\, Q\, (s)^{13/6}\, R}{\rho} \right]^{0.4} K$$

$$K = K_{SG} K_A K_S$$

$$K_{SG} = \frac{1.706}{[SG-1]^{16/15}} = \frac{1.706}{[2.65-1]^{16/15}} = 1$$

$K_A = 1$ straight channel

$$K_S = \frac{0.816}{\sqrt{1-\left(\frac{\sin\theta}{.643}\right)^2}} = 0.94$$

$$K = 1(1)(.94)$$

$$D_{50} = \left[\frac{118\,(8700)(.0015)^{\frac{13}{6}}\,(5.49)}{238} \right]^{0.4} (0.94)$$

$D_{50} = 0.19$ feet

$\approx$ 2.5 inches

COMPUTATION SHEET

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SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY	DATE	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 4 OF

NSCA Table

4. Nat. Crushed Stone

V = 6.7 fps

D_{100} = 6"+ D_{min} = 2" D_{Avg} = 3"

5. TR-59

See pages 5 & 6

$\tau_s - \tau_w$ d50

(100÷2) d50

τ_s = .014

τ_w = .0015

τ_s = 62.4 x 6 x .0015

(3)

6. Corp charts.

Low Turbulence

D_{50} = 0.5 ≈ 6"

(High Turb - stilling basin N/A)

SAY 3" to 9"

.5d

4.1 d50

.9

COMPUTATION SHEET
SCS–ENG–523 Rev. 8–69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		EMF R-1		
BY JMH	DATE 7-18-90	CHECKED BY	DATE	JOB NO.
SUBJECT RIPRAP SIZING				SHEET 5 OF

$C_{\tau_s} = 1.13$

TR-59 $C_{\tau_b} = 1.30$

pg 16 max. stress $\tau_{sm} = C_{\tau s} \gamma r S$

$$\tau_{sm} = 1.13(62.4) \cdot \frac{1308}{238} (0.0015) = 0.58 \text{ psf}$$

allowable $\tau_{sa} = \dfrac{K C_{50} D_{50}}{FS}$

$FS = 1.5$

$C_{50} = 4$

$$K = \sqrt{1 - \frac{\sin^2(\tan^{-1} z)}{\sin^2 \theta}} \qquad z = 3, \quad \theta = 30^\circ$$

$K \approx 1$

$$\tau_{sa} = \frac{4 D_{50}}{1.5} = 0.58$$

$D_{50} = 0.218$ ft

$D_{50} = 2.6$ inches

Say 3 inches

COMPUTATION SHEET

SCS-ENG-525 Rev. 3-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		EMF R-1		
BY JMH	DATE 7-18-90	CHECKED BY	DATE	JOB NO.
SUBJECT RIPRAP SIZING				SHEET 6 OF

TR-59

Gradation

$$\left[\frac{D_{85}}{D_{50}} + \frac{D_{50}}{D_{15}}\right] \leq 5.5$$

$D_{50} = 3$ inches

Try: $D_{85} = 6''$, $D_{15} = 1.5$ inches

$$\left[\frac{6}{3} + \frac{3}{1.5}\right] = 4 < 5.5 \quad \underline{ok}$$

Try $D_{85} = 6''$ $D_{15} = 1$ inch

$$\left[\frac{6}{3} + \frac{3}{1}\right] = 5 < 5.5 \quad \underline{ok}$$

COMPUTATION SHEET
SCS-ENG-523 Rev. 8-69

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		EMF REACH - 1 REPAIR		
BY JMH	DATE 7-18-90	CHECKED BY	DATE	JOB NO.
SUBJECT Riprap Sizing.				SHEET 7 OF

Summary of Riprap Size based on various methods

	ENG. FIELD MANL.	FAR WEST STATES	SCS ADVISORY PO-18	NATL CRUSHED STONE	CORP ENG. CHARTS	TP-59 (BASIC) PO-18?
D_{100}	7"			6"		
D_{95}						6"
D_{75}		5"				
D_{50}			2.5"	3"	6"	2.6"
D_{30}						
D_{15}						1"

Based on above results, use the small side of the gradation envelope with above numbers. All results are comparable except Corp of ENG. Charts being larger. In our application, only one or two flows per year, and design flow every 100 years so the most conservative solution given by the COE Charts can be tossed.

SIZE	% PASSING
8"	100
6"	50 - 85
3"	25 - 50
1"	0 - 15

COMPUTATION SHEET
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SOIL CONSERVATION SERVICE

STATE		PROJECT		
ARIZONA		EMF R-1		
BY JMH	DATE 7-18-90	CHECKED BY	DATE	JOB NO.
SUBJECT RIPRAP				SHEET 8 OF

Thickness of Lining

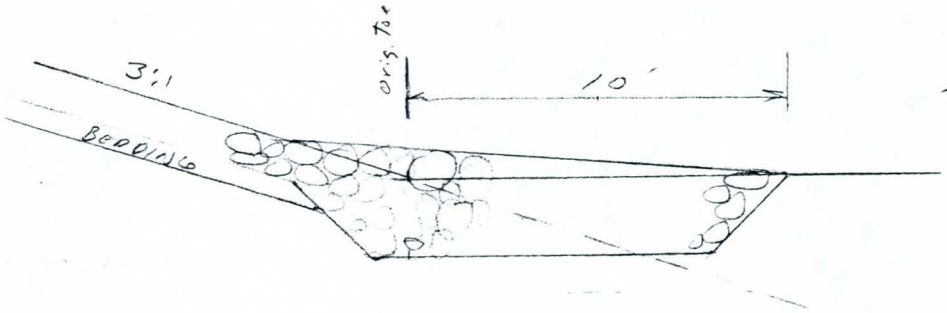
TR-59
pg 17

1) No Filter $3 \times D_{50} = 3 \times (3'' \text{ to } 4'') \approx 12$ inches

2) Filter $2 \times D_{50}$ & $1.5\, D_{50}$
$\downarrow$ 8" $\downarrow$ 12"

Suggest 12-inch thickness on banks

2 to 3' thick toe



1.9
+ 2.0
3.9 cy per ft

ABC BEDDING

QUICK CHECK

$$\frac{D_{15}\ R.R.}{D_{85}\ Base} < 5 < \frac{D_{15}\ RR.}{D_{15}\ BASE} < 40$$

D_{15} RR = 38 mm
D_{50} RR = 110 mm

D_{15} B = 0.3 mm
D_{50} B = 1.4 mm
D_{85} B = 7 mm

$$5.4 \not< 5 < 126 \not< 40$$

$$\frac{D_{50}\ RR}{D_{50}\ B} < 40$$

$$68 \not< 40$$

skip Filter, add thickness to Riprap, ie, 16-inches

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Soil Conservation Service

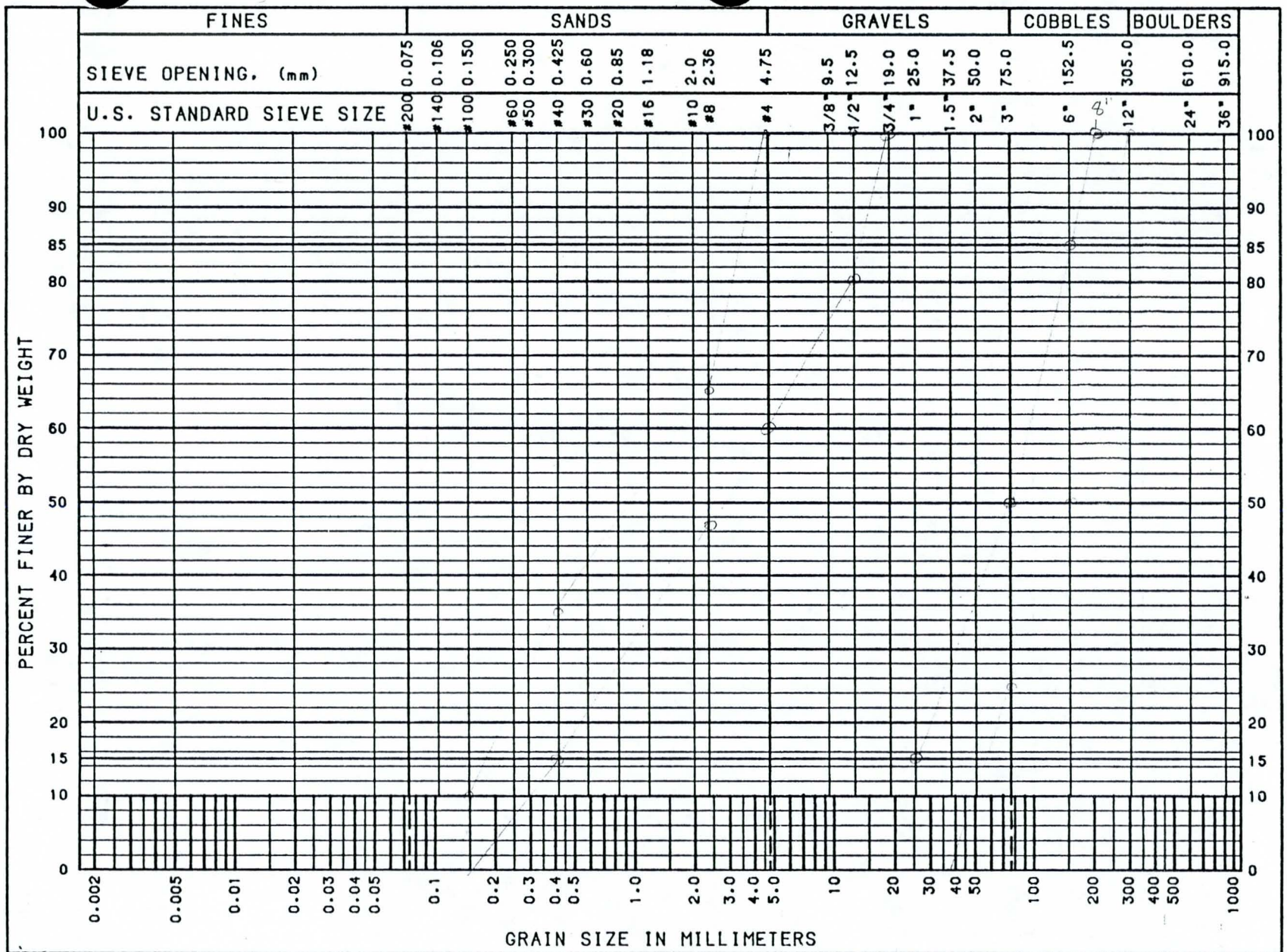
SCS-ENG-130
2-65

GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state

Designed at _____ By _____ Date _____



REMARKS

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR		
BY WAM	DATE 6/14/90	CHECKED BY	DATE	JOB NO.
SUBJECT FILTER & RIPRAP DESIGN				SHEET 1 OF 2

SUMMARY.

FILTER DESIGN

Sieve	% Passing
3/4"	100
1/2"	80 - 100
#4	60 - 100
#8	47 - 65
#40	15 - 35
#100	0 - 10
#200	0 - 5

RIPRAP/FILTER DESIGN

USE

Sieve	% Passing	
9	100	100
6	90 - 100	60-90
5	70 - 100	
3	55 - 70	<30
1½	30 - 45	
1/2	15 - 25	
#4	0 - 10	<5

NOTE: This riprap design was suggested by John Harrington on 6/27/90 subsequent to a telephone conversation with Lee Saele WAM

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Soil Conservation Service

SCS-ENG-130
2-85

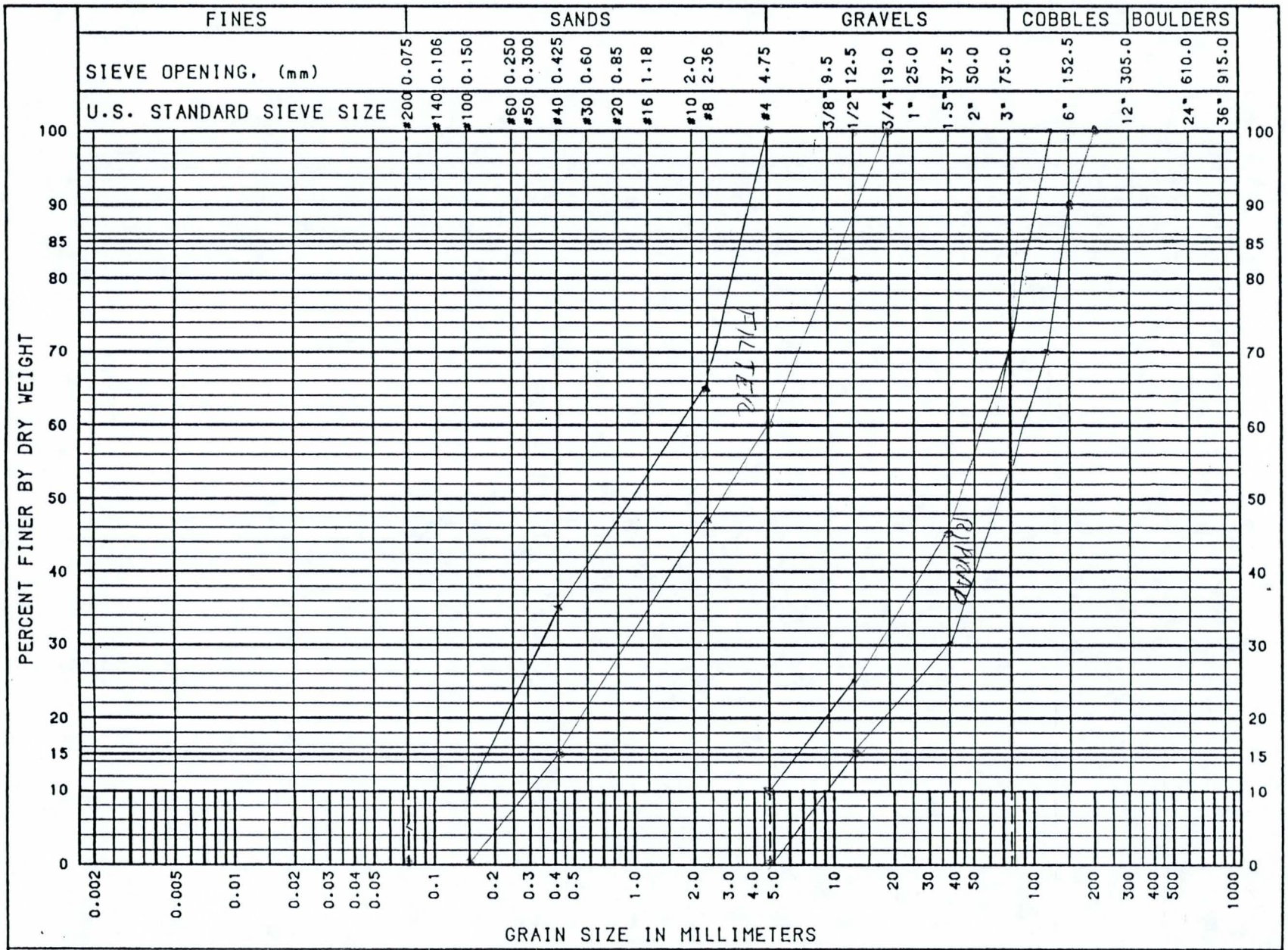
GRAIN SIZE ANALYSIS FOR

FILTER & FILTER/RIPRAP
(Specify)

Project and state RWCD REPAIR

Designed at RHD ENG. By WAM Date 6/14/90

SHT 2 of 2



REMARKS

U.S. Department of Agriculture
Soil Conservation Service

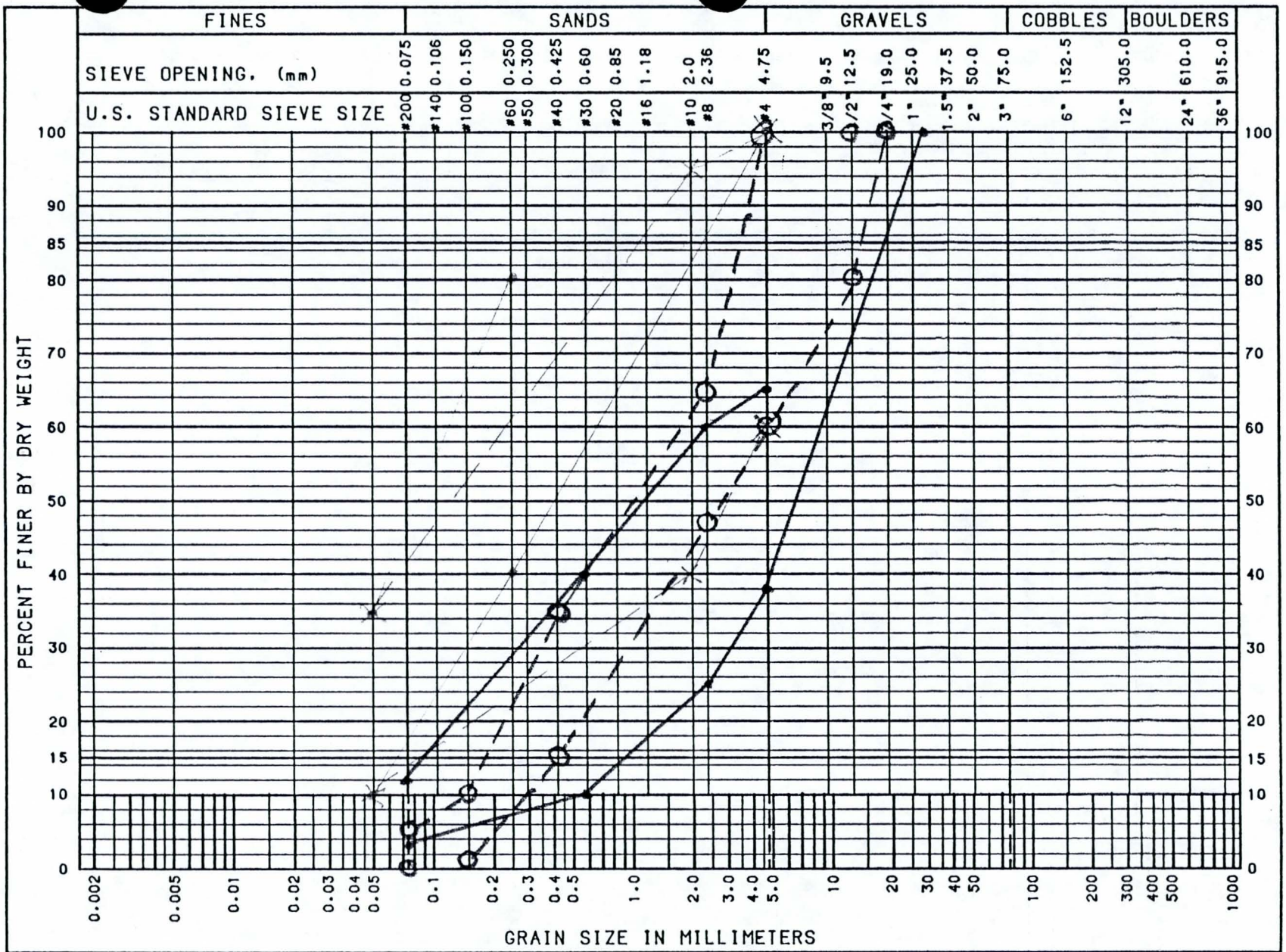
GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state

Designed at _____ By _____ Date _____

SCS-ENG-130
2-95



REMARKS
—●— AGG BASE
—○— FILTER
—●— METHOD A SOIL CEMENT DESIGN
—○— METHOD B " " "

COMPUTATION SHEET
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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR		
BY WAM	DATE 6/7/90	CHECKED BY	DATE	JOB NO.
SUBJECT RIPRAP/FILTER DESIGN				SHEET 1 OF

REFERENCES

RIPRAP

1. TSJ calculations dated 4/90

2. Far West States (FWS) "Criteria for Riprap Rock Size", P-16a to 13d
3. Advisory PO-18 (HRP 108- Adaption) "Rock Riprap Design Procedure, May 1, 1974

4. Corps of Engineers EM 1110-2-1601, July 1970 p. 43

FILTER

1. SCS Soil Mechanics Note 1

COMPUTATION SHEET

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U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR		
BY WAM	DATE 6/12/90	CHECKED BY	DATE	JOB NO.
SUBJECT DETERMINE MINIMUM RIPRAP SIZE				SHEET 1 OF

The purpose of these calcs is to determine what size of riprap rock will give a 1.5 safety factor based on tractive stress

GIVEN: $d = 6'$

$b = 200'$

$Z = 3:1$

$S_e = 0.0015$

$n = 0.029$ (assumed for aged channel)

Factor of safety $= 1.5$ (Req'd by FCD)

$n_t = \frac{(2.11)^{1/6}}{39}$ →

? when whole channel is not $D_{75} = 2.11$? Very questionable

Assume: $D_{75} = 2.11''$ ∴ Lanes Method

Actual Tractive stress (τ_s & τ_b)

$$S_t = \left(\frac{n_t}{n}\right)^2 S_e = (1)^2 S_e = 0.0015 \qquad \left(\frac{.029}{.102}\right)^2$$

$$\text{Actual } \tau_\infty = \gamma_w d S_t$$

$$= 62.4\ (6)\ 0.0015 \qquad .022$$

$$= 0.562 \text{ psf} \qquad 1.12$$

$b/d = 200 \div 6 = 33.3$

$\tau_b/\tau_\infty = 1.0$ (Fig 6-3, TR-25)

$\tau_s/\tau_\infty = 0.8$ (Fig 6-4, TR-25)

Actual $\tau_b = 1.0 \times 0.562 = 0.562$ psf 1.12

Actual $\tau_s = 0.8 \times 0.562 = 0.450$ psf 0.90

COMPUTATION SHEET
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SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WDM	DATE 6/12/90	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 2 OF

Allowable Tractive Stress

$\tau_{Lb} = 0.4\, D_{75}$

$= 0.4 \times 2.11 = 0.844$ psf

$\frac{\text{Allowable}}{\text{Actual}} = \frac{\tau_{Lb}}{\tau_b} = \frac{0.844}{0.562} = 1.50$ = FACTOR OF SAFETY

$\tau_{Ls} = 0.4\, K\, D_{75}$

$= 0.4(0.86)(2.11)$

$= 0.726$ psf

See Fig 6-7, TR-25
Assume slightly rounded
$D_{75} = 2.11$, $z = 3$
$\phi_R = 38°$, cot =

$K = \sqrt{\frac{z^2 - \cot^2 \phi_R}{1 + z^2}}$

$= \sqrt{\frac{9 - 1.64}{1 + 9}}$

$= 0.86$

$\frac{\text{Allowable}}{\text{Actual}} = \frac{\tau_{Ls}}{\tau_s} = \frac{0.726}{0.450} = 1.61$ = Factor of Safety

∴ Min D_{75} for stability, based on the tractive stress method, = 2.11"

COMPUTATION SHEET
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SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR		
BY WAM	DATE 6/12/90	CHECKED BY	DATE	JOB NO.
SUBJECT FILTER DESIGN				SHEET 3 OF

Determine filter limits based on Category 1 and Category 2 per Table 1 of Soil Mechanics Note No. 1.

FOR CATAGORY 1		FOR CATAGORY 2
Sieve	% pass	
#10	100	100
200	94	77
0.05	83	69
0.02	69	56
0.005	55	44
0.002	13	26

Note:

- Category 1 is from sample test #5 in 1985 testing program. See sht 6A

- Category 2 is the average of all 9 samples from the 1985 tests (see sht 6A)

COMPUTATION SHEET
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SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WAM	DATE 6/12/90	CHECKED BY	DATE	JOB NO.
SUBJECT FILTER DESIGN				SHEET 4 OF

1. ASSUME Category 1, finer than 200 sieve > 85%

Step 1 - See sht #3

Step 2 - No gravel, skip Step 3

Step 4 - Category 1

Step 5 - $D_{15}^{MAX} \leq 9 \times d_{85} = 9 \times 0.051 = 0.46$ mm
(see Curve 1, sht 6

Step 6 - min $D_{15} \geq 4 \times d_{15} = 4 \times 0.002 = 0.008$

Use Min $D_{15} = 0.1$ mm

Step 7 - Max size = 3"
max passing #200 = 5% (passing #40 has PI = 0)

Step 8. min $d_{10} < 0.5$
Max $D_{90} = 20$

GRADATION

SIEVE SIZE	% PASSING	REGRADE 100 ÷ 80 = 1.25
1 1/2"	100	
3/4"	88-100	
3/8"	75-95	
#4	60-80	100
10	45-60	75
20	25-45	56
40	15-30	38
200	0-5	6

COMPUTATION SHEET
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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WAM	DATE 6/12/90	CHECKED BY	DATE	JOB NO.
SUBJECT FILTER DESIGN				SHEET 5 OF

2. Assume Category 2, Fines 40-85% pass #200

Use average of 9 analyses

Step 1 - See sht #3

Step 2 - No gravel, skip Step 3

Step 4 - Category 2

Step 5 - Max $D_{15} \leq 0.7$ mm

Step 6. - Min $D_{15} \geq 4 \times d_{15}$, $d_{15} \cong 0$

∴ Min $D_{15} = 0.1$

Step 7 - Max size = 3"

- Limit 5% pass #200

Step 8 - Min $D_{10} = 0.085$ (< 0.5)

Max $D_{90} = 20$ mm

GRADATION

Sieve Size	% Passing
1 1/2"	100
3/4	88-100
3/8	75-95
#4	60-80
10	40-60
20	20-45
40	15-30
200	0-5

COMPUTATION SHEET
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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WAM	DATE 6/13/90	CHECKED BY	DATE	JOB NO.
SUBJECT RIPRAP SIZE ANALYSIS				SHEET ____ OF ____

REFERENCE: FAR WEST STATES ENGINEERING DESIGN STANDARDS, pp 6-13a to 6-13d, "CRITERIA FOR RIPRAP ROCK SIZE"

Paper states that where only the banks are riprapped the contrasting roughness of the bank and bed cause a higher shear on the bank. A conservative estimate is that τ_s is 1.4 time τ_b.

$$\tau_b = wDS$$

w = specific weight of H_2O
D = depth of flow
S = channel slope

for $w = 62.4$, $D = 6$, $S = 0.0015$

$$\tau_b = 0.562 \text{ psf}$$

$$\tau_s = 1.4 \times 0.562 = 0.787$$

$$K = \tau_s / \tau_b = 0.87 \quad \text{for } Z = 3$$

$$\tau_{bL} = 0.4 D_s$$

$$\tau_{sL} = 0.4 K D_s$$

$$D_s = \frac{3.5}{K} wDS = \frac{3.5}{0.87}(0.562) = 2.26''$$

- same as determined by Tom Jago

Add factor of safety of 1.5.

$$\tau_s = 1.5 \times 0.787 = 1.18 \text{ psf}$$

$$\tau_{sL} = 0.4 K D_s = 1.18$$

$$D_s = \frac{1.18}{0.4K} = \frac{1.18}{0.4(.87)} = 3.39$$

{ TOO CONSERVATIVE, USE $D_{75} \geq 3''$ for rock gradation

EMF REACH 1&2 REPAIR, PHASE 1

WDM 7/10/90

RIPRAP/FILTER DESIGN

Reference: "Design of Stable Channels with Flexible Linings," U.S. Dept. of Transportation Hydraulic Engineering Circular No. 15, Oct 1977

p 53 - Dumped Rock Riprap

- Design of Filter Blanket

FOR BASE

$$\frac{D_{15}\ \text{Filter}}{D_{85}\ \text{Base}} < 5 < \frac{D_{15}\ \text{Filter}}{D_{15}\ \text{Base}} < 40$$

$$\frac{D_{50}\ \text{Filter}}{D_{50}\ \text{Base}} < 40$$

FOR RIPRAP

$$\frac{D_{15}\ \text{Riprap}}{D_{85}\ \text{Filter}} < 5 < \frac{D_{15}\ \text{Riprap}}{D_{15}\ \text{Filter}} < 40$$

$$\frac{D_{50}\ \text{Riprap}}{D_{50}\ \text{Filter}} < 40$$

NOTE: THIS DESIGN METHOD WILL NOT ALLOW ONE FILTER GRADATION TO SATISFY REQUIREMENTS FOR GIVEN BASE & RIPRAP GRADATIONS

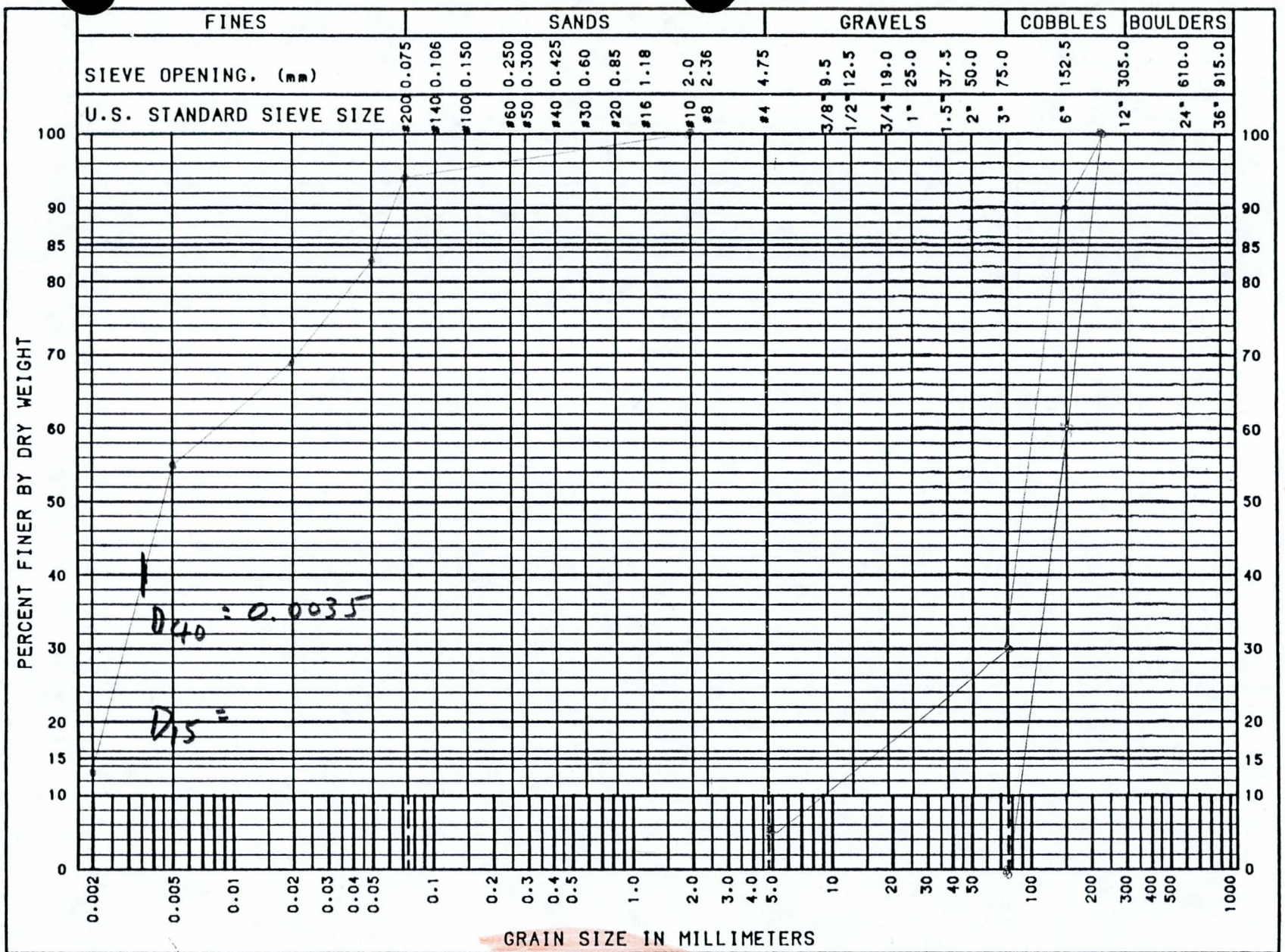
U.S. Department of Agriculture
Soil Conservation Service

GRAIN SIZE ANALYSIS FOR

SCS-ENG-130
2-05

Project and state _____ (Specify)

Designed at _____ By _____ Date _____



REMARKS D_{15} = 0.002 ~~D_{40}~~ D_{50} = 0.0044 D_{85} = 0.055

Sample #5 from 1985 Testing

location

P1A

U.S. Department of Agriculture
Soil Conservation Service

SCS-ENG-130
2-85

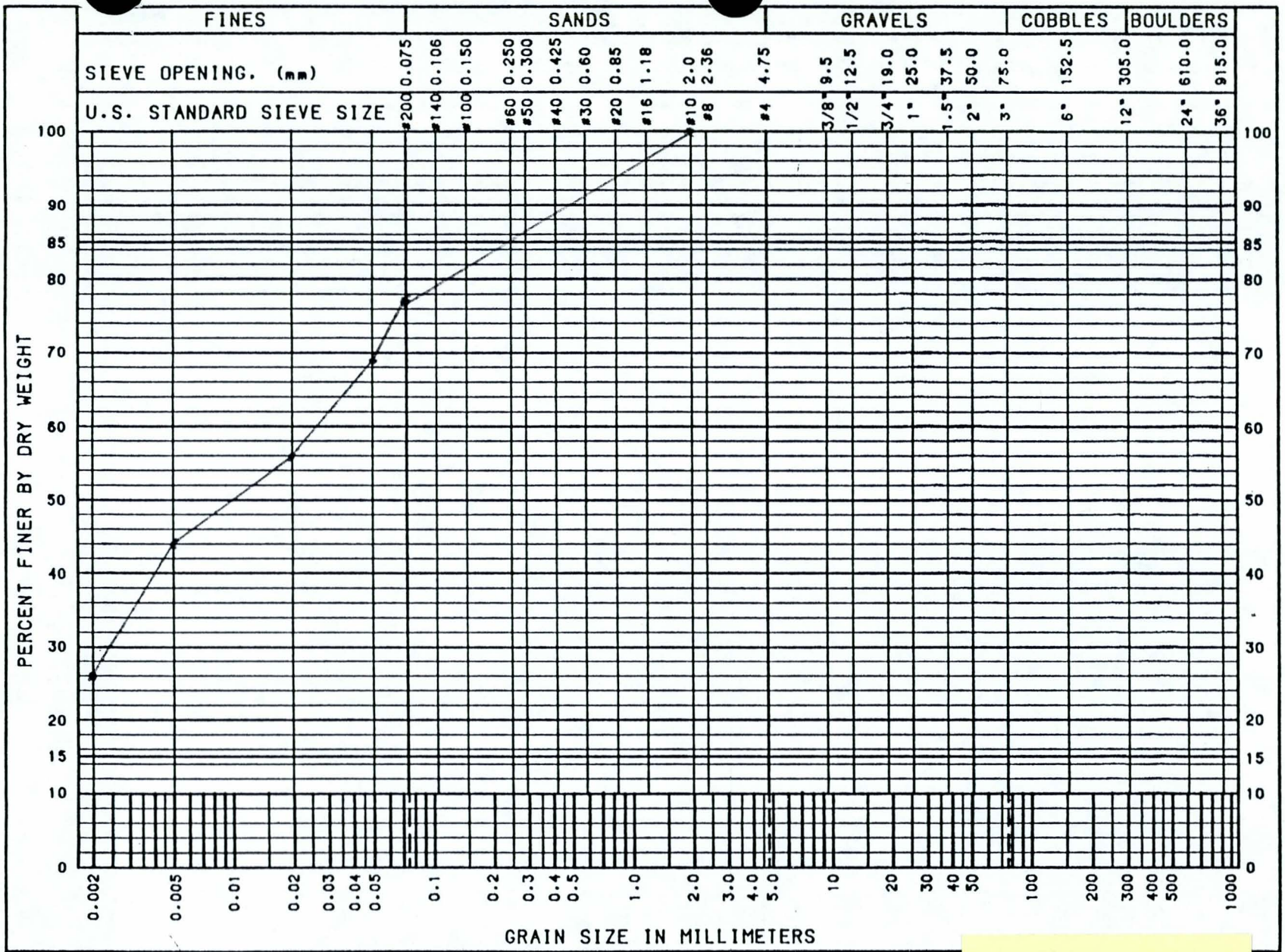
GRAIN SIZE ANALYSIS FOR

AVERAGE OF 1985 SOIL TESTS

(Specify)

Project and state

Designed at _____ By _____ Date _____



REMARKS $D_{15} > 0.002$, $D_{50} \approx 0.01$, $D_{85} = 0.25$

Assume $D_{15} = 0.002$

See notebook

P/B

WAM 7/10/90
RIPRAP/FILTER DESIGN (DOT CIRC 15) 2

FOR BASE/FILTER Calculations

Base $D_{50} = 0.0044$ mm
$D_{85} = 0.055$ "
$D_{15} = 0.002$ "

Riprap $D_{50} = 140$ mm
$D_{85} = 200$ mm
$D_{15} = 95$ mm
} per John Harrington design

FILTER/BASE CALCULATIONS

$$\frac{D_{15}(F)}{D_{85}(B)} = \langle 5 \rangle \frac{D_{15}(F)}{0.055}, \quad D_{15}(F) < 0.275 \text{ mm}$$

$$\frac{D_{15}(F)}{D_{15}(B)} < 40 \rangle \frac{D_{15}(F)}{0.002}, \quad D_{15}(F) < 0.080 \text{ mm}$$

$$\frac{D_{15}(F)}{D_{15}(B)} \rangle 5 \langle \frac{D_{15}(F)}{0.002}, \quad D_{15}(F) \rangle 0.010 \text{ mm}$$

$$\frac{D_{50}(F)}{D_{50}(B)} < 40 \rangle \frac{D_{50}(F)}{0.0044}, \quad D_{50}(F) < 0.176$$

FILTER MUST BE: $D_{50}(F) < 0.176$
$0.010 < D_{15}(F) < 0.080$

WAm 7/10/90
RIPRAP / FILTER DESIGN (DOT CIRC 15)

RIPRAP / FILTER CALCULATIONS

$$\frac{D_{15}(R)}{D_{85}(F)} \langle 5 \rangle \frac{95}{D_{85}(F)}, \quad D_{85}(F) \rangle \frac{95}{5} = 19$$

$$\frac{D_{15}(R)}{D_{15}(F)} \langle 40 \rangle \frac{95}{D_{15}(F)}, \quad D_{15}(F) \rangle \frac{95}{40} = 2.375$$

$$\frac{D_{15}(R)}{D_{15}(F)} \rangle 5 \langle \frac{95}{D_{15}(F)}, \quad D_{15}(F) \langle \frac{95}{5} = 19$$

$$\frac{D_{50}(R)}{D_{50}(F)} \langle 40 \rangle \frac{140}{D_{50}(F)}, \quad D_{50}(F) \rangle \frac{140}{40} = 3.5$$

FILTER MUST BE:

$$D_{50}(F) \rangle 3.5$$

$$2.375 \langle D_{15}(F) \langle 19 \text{ mm}$$

$$D_{85}(F) \rangle 19$$

FILTER MATERIALS CANNOT BE DESIGNED FOR THIS BASE/RIPRAP COMBINATION

LAM 7/10/90

RIPRAP / FILTER DESIGN

4

TRY THE FOLLOWING RIPRAP:

$D_{50} = 65$ mm, $D_{85} = 200$ mm, $D_{15} = 13$ mm

$$D_{85}(F) > \frac{13}{5} = 2.6$$

$$D_{15}(F) > \frac{13}{40} = 0.325$$

$$D_{15}(F) < \frac{13}{5} = 2.6$$

$$D_{50}(F) > \frac{65}{40} = 1.625$$

FILTER MUST BE:

$$D_{50} > 1.625$$

$$0.325 < D_{15} < 2.6$$

$$D_{85} > 2.6$$

RIPRAP IS TOO BIG

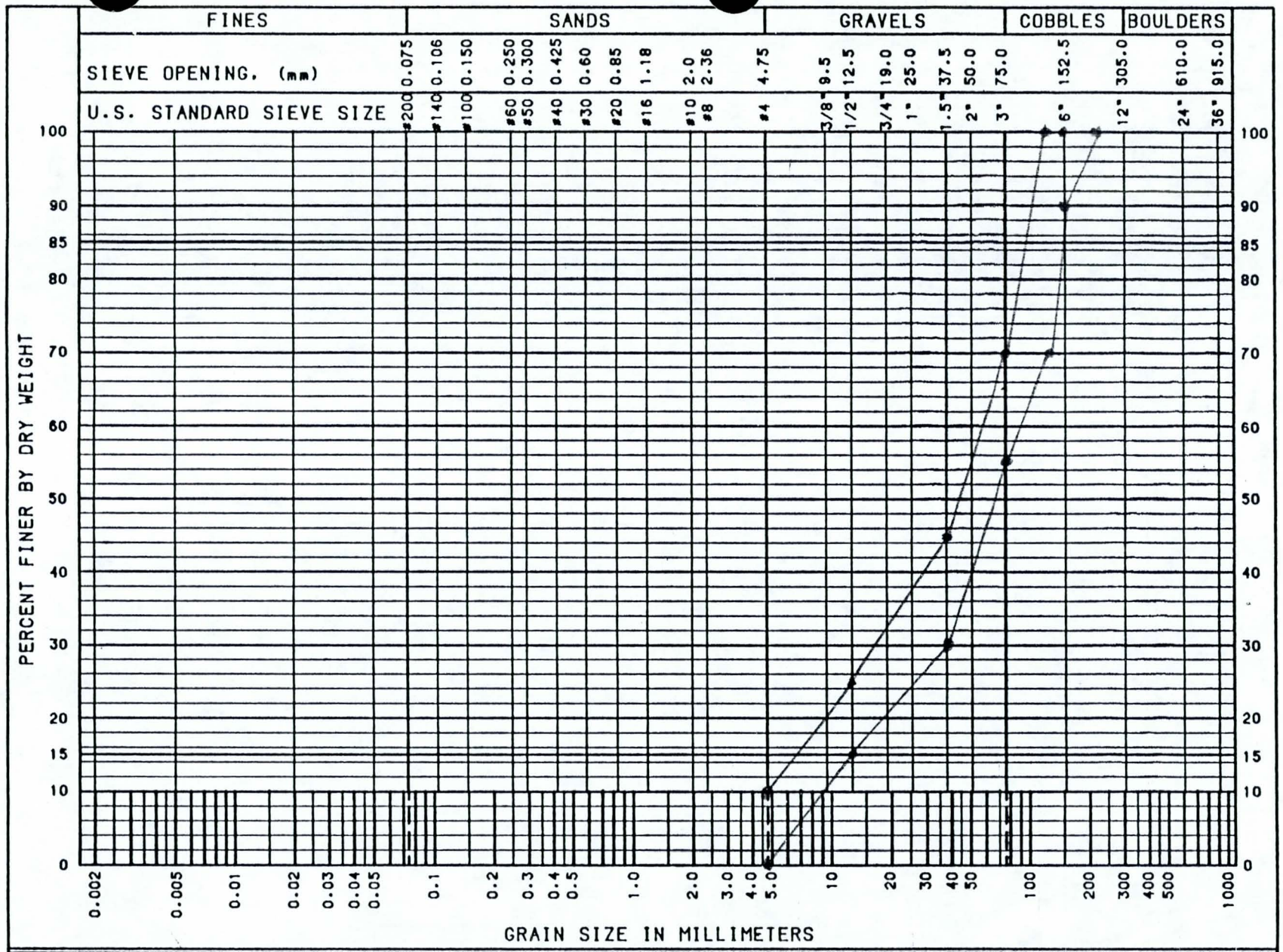
U.S. Department of Agriculture
Soil Conservation Service

SCS-ENG-130
2-85

GRAIN SIZE ANALYSIS FOR

(Specify)

Project and state _____ Designed at _____ By _____ Date _____



REMARKS D_{85} = 200 mm D_{50} = 65 mm D_{15} = 13 mm

Figure 2

P 4A

WAM 7/10/90

5

Analyze the FILTER / BASE relationship using the average gradation from the 1985 testing

$$\frac{D_{15}(F)}{D_{85}(B)} \langle 5 \rangle \frac{D_{15}(F)}{0.25}, \quad D_{15}(F) < 1.25 \text{ mm}$$

$$\frac{D_{15}(F)}{D_{15}(B)} \langle 40 \rangle \frac{D_{15}(F)}{0.002}, \quad D_{15}(F) < 0.080$$

TOO FINE

Assume Base Material (see p.6A):

$D_{50} = 0.075$

$D_{85} = 0.70$

$D_{15} = 0.0045$

NOTE: This is assuming all material smaller than 0.002 would be allowed to move thru filter

$$\frac{D_{15}(F)}{D_{85}(B)} < 5 > \frac{D_{15}(F)}{0.70}, \quad D_{15}(F) < 5 \times 0.70 = 3.5 \text{ mm}$$

$$\frac{D_{15}(F)}{D_{15}(B)} < 40 > \frac{D_{15}(F)}{0.0045}, \quad D_{15}(F) < 0.18 \text{ mm}$$

$$\frac{D_{15}(F)}{D_{15}(B)} > 5 < \frac{D_{15}(F)}{0.0045}, \quad D_{15}(F) > 5 \times 0.0045 = 0.0225 \text{ mm}$$

$$\frac{D_{50}(F)}{D_{50}(B)} < 40 > \frac{D_{50}(F)}{0.075}, \quad D_{50}(F) < 0.075 \times 40 = 3.00 \text{ mm}$$

$$D_{50}(F) < 3.00 \text{ mm}$$

$$0.18 > D_{15}(F) > 0.0225$$

$D_{15}(F)$ is still too small to design filter which will be accomodated by specified riprap

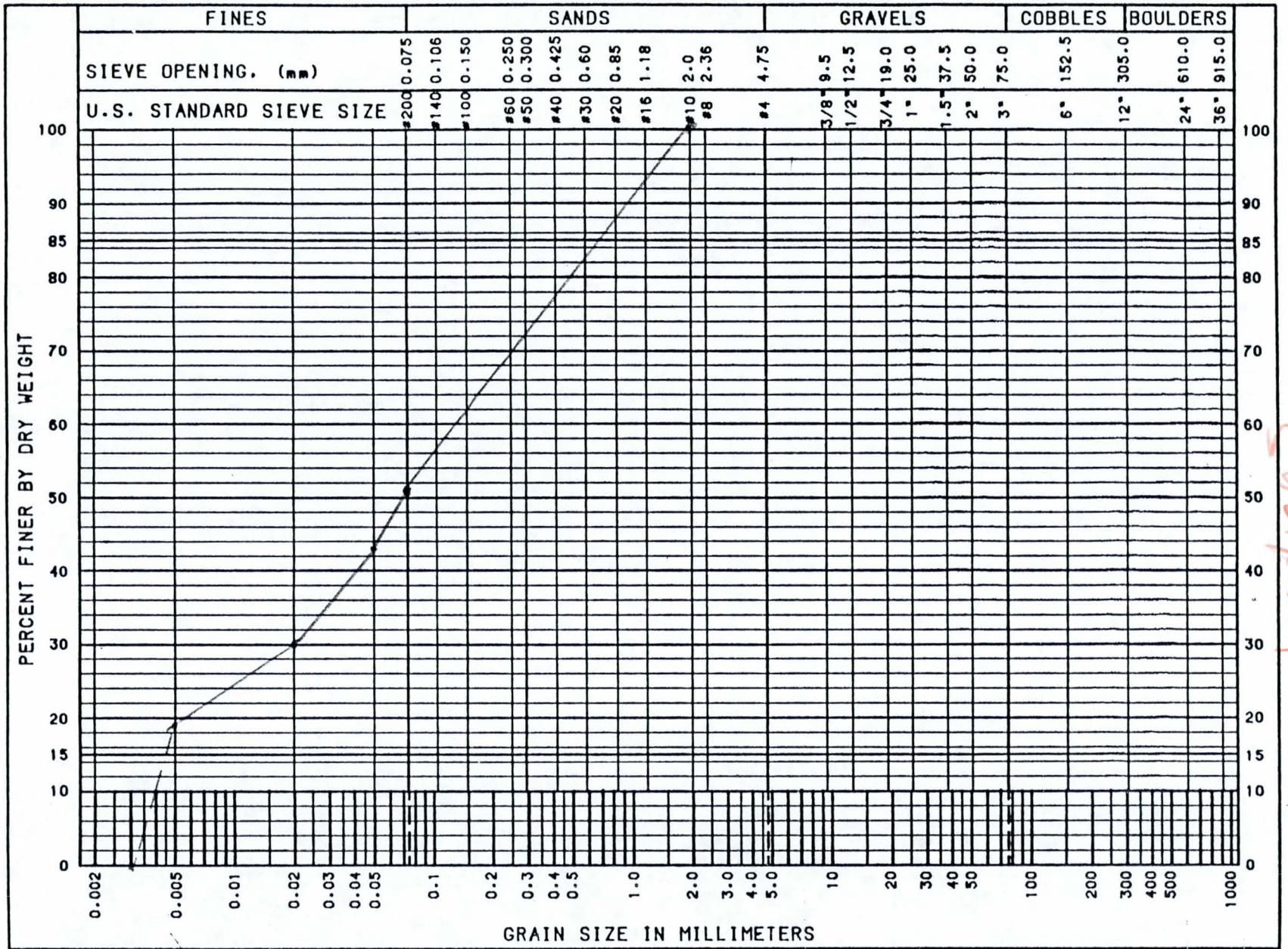
U.S. Department of Agriculture
Soil Conservation Service

SCS-ENG-130
2-85

GRAIN SIZE ANALYSIS FOR

Project and state (Specify) [illegible]

Designed at _____ By _____ Date _____



REMARKS $D_{85} = 0.70$, $D_{50} = 0.075$, $D_{15} = 0.0045$

SKT 6A

COMPUTATION SHEET
SCS–ENG–522 REV. 3–69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE	PROJECT		
Arizona	East Maricopa Floodway Reach 1 & 2 Repair		
BY TSJ / DATE 4-2-90	CHECKED BY	DATE	JOB NO.
SUBJECT Cr on Slope Stability			SHEET 1 OF

Basic Design Data - Given

slope - 0.0015

Q - 8700 cfs (100 yr)

n - 0.027

d - 6.0 ft

V = 6.67 ft/sec

D_{75} = 0.00185"

D_{65} = 0.00118" (for tractive stress calcs, fine soil use D_{65} = 0.1mm = 0.003328')

P.6-27, TR-25

TR-25 - P6-26

Allowable tractive force in Fine-Grained material, D_{50} < 0.1mm (0.0039 in)

Clear water - 0.025 psf

Low fine transport - 0.050 psf

High fine transport - 0.075 psf

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE AZ		PROJECT East Maricopa Floodway Reach 1 & 2 Repair		
BY TJJ	DATE 4-3-90	CHECKED BY	DATE	JOB NO.
SUBJECT CK on Slope Stability				SHEET 2 OF

Coarse-Grained Discrete -
Using Bill McFarvin Analysis

$D_{75} = 1.36$ in, $n = .027$

$S_t = \left(\frac{n_t}{n}\right)^2 S_e = S_e = 0.0150$

$\tau_\infty = w d S_t = 62.4(6)(0.0015) = 0.562$ psf

$b/d = \frac{200}{6} = 33.33$

$\tau_b = \frac{\tau_b}{\tau_\infty} \times \tau_\infty = 1(\tau_\infty) = 0.562$

$\tau_s = \frac{\tau_s}{\tau_\infty} \times \tau_\infty = 0.78(0.562) = 0.438$

Allowable tractive stress

1. $\tau_{L_b} = 0.4 D_{75} = 0.4(1.36) = 0.544$

2. $\tau_{L_s} = K \tau_{L_b} = K(0.4 D_{75}) = K(0.544)$

K from fig 6-8 TR 25 & $\phi_R = 38.5°$ for moderately angular rock
$K = 0.87$

$\tau_{L_s} = 0.87(0.544) = 0.473$ on sides of channel

Agrees with Bill conclusions -
that $D_{75} > 1.36$
$S < 0.0015$
$d > 6.0$

COMPUTATION SHEET

SCS–ENG–522 REV. 3–69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		East Maricopa Floodway Reach 1 & 2 Repair		
BY Tom Jayo	DATE 9-4-90	CHECKED BY	DATE	JOB NO.
SUBJECT Rock Size Determination				SHEET 3 OF

GIVEN.

1. Average stream channel slope = 0.0015 FT/FT
2. Depth = 6 ft.
3. Side Slopes = 3:1
4. Area at bank full = 1309 FT^2
5. Wetted Perimeter = 206.33 FT
6. Hydraulic Radius = R = 6.34
7. Velocity = 6.65 FT/sec
8. Design Discharge = 8700 CFS
9. Mannings n = 0.027
10. Straight Alignment
11. Length of treatment = Reach 1

REQUIRED

Rock size for the following methods:
1. Far West States (FWS)
2. Advisory PO-18 (HRP 108 - adaptation)

SOLUTION

1. FWS

Ref: "Criteria for Riprap Rock size", p-16a to 13d

channel slope = 0.0015
Depth = 6.0 ft
Side slope = 3:1
Straight Alignment

K = 0.87
C = 1.0

$$D_{75} = \frac{3.5}{CK} w DS = \frac{3.5\,(62.4)(6)(0.0015)}{1(0.87)} = \underline{\underline{2.26 \text{ in.}}}$$

Ck - using chart Fig 6-13d

$DS = D_{75} = 2\frac{1}{4}$ in $\pm$ OK

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		East Maricopa Floodway Reach 1&2 Repair		
BY Tom Jayo	DATE 4-4-90	CHECKED BY	DATE	JOB NO.
SUBJECT Rock Size Determination (Solution cont):				SHEET 4 OF

2. Advisory PD-18 (Adaptation to HRP-103)

Ref: "Rock Riprap Design Procedure", May 1, 1974

Design Discharge, $Q = 8700$ CFS
channel slope, $S_c = 0.0015$ FT/FT
Hydraulic Radius, $R = 6.34$ FT
Wetted Perimeter, $P = 206.33$ FT

Correction Factor, K

K_{SG} - Specific gravity of rock
K_A - Channel alignment
K_S - Side slope

$$K = (K_{SG})(K_A)(K_S)$$

Assume 2.65

$$K_{SG} = \frac{1.706}{[S.G.-1]^{\frac{16}{15}}} = \frac{1.706}{[2.65-1]^{\frac{16}{15}}} = \frac{1.706}{1.706} = 1$$

$$K_A = \frac{(\tau_0/\bar{\tau}_0)_{max}}{1.5} = 1.0 \text{ (straight channel Alignment)}$$

θ = angle of repose for the rock - assume 40°
ϕ = slope angle; for $Z = 3$ $\phi = 18.435°$

$$K_{3.0} = \sqrt{1 - \frac{\sin^2\phi}{\sin^2\theta}} = \sqrt{1 - \left(\frac{0.316}{0.643}\right)^2} = 0.871$$

From Fig 25 $\theta = 40°$ determine Z recommended $= 2.5$

$$K_{recommended} = \sqrt{1 - \left(\frac{\sin 21°48'}{\sin 40°}\right)^2} = 0.816$$

$$K_S = \frac{K_{2.5}}{K_{3.0}} = \frac{0.816}{0.871} = 0.937$$

$$K = (K_{SG})(K_A)(K_S) = 1(1)(0.937) = 0.937$$

$$D_{50} = \left[\frac{118Q(S_c)^{13/6}R}{P}\right]^{0.4} K = \left[\frac{118(8700)(0.0015)^{13/6}(6.34)}{206.33}\right]^{0.4}(0.937) =$$

$= 0.211$ FT $= 2.53$ inches — use $2\frac{1}{2}$ in for D_{50} per this procedure.

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
Az		East Maricopa Floodway Reach 1 & 2 Repair		
BY Tom Joyd	DATE 4-5-90	CHECKED BY	DATE	JOB NO.
SUBJECT Riprap Criteria -				SHEET 4 OF

1. Riprap Layer thickness ~ t:

1. Corp of Engineers EM 1110-2-1601 July 1970
Page 43 -

D_s = spherical diameter

recommends -

(a) $t \geq D_s$ of $W_{100\,upper}$ or $t \leq 1.5\ D_s$ of $W_{50\,upper}$ } which ever results in greater t

(b) It should not be less than 12 inches

2. Stone size and weight - from Corp of Eng EM 1110-2-1601 above

$$D_s = \left(\frac{6W}{\pi \gamma_s}\right)^{1/3}$$

where D_s = equiv-volume spherical stone diameter, ft.

W = stone weight, lb

γ_s = Saturated surface dry (SSD) specific weight of stone, pcf.

for $\gamma_s = 165\ lb/ft^3$

$$D_s = (0.01157\,W)^{1/3}$$

$$W = \frac{(D_s)^3}{0.001157}$$

COMPUTATION SHEET

SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		East Maricopa Floodway Reach 1&2 Repair		
BY	DATE	CHECKED BY	DATE	JOB NO.
Tom Joyce	4-5-96			
SUBJECT				SHEET 5 OF
Riprap Gradation				

Ref – Rock Riprap - Size, Distribution & Gradation Limits Per HRP-103

$D_{50_{lower}}$ Reference Size = 2.5" $D = D_{50}(k)$

% Passing	Lower Limit (in)	Upper Limit (in)
10	0.625	2.0
30	1.5	3.12
50	2.5	4.25
75	3.75	5.8
100	5.0	7.5

thickness > 7.5" or 1.5 (4.25) = 6.375" (see sheet 4) part 1 ($D_{50\,upper}$)

→ Per Corp of ENG See sheet 4

$t = 1.3 \text{ to } 2.0 \left(\frac{D_{50L} + D_{50U}}{2}\right) = 1.3 \text{ to } 2 \left(\frac{2.5 + 4.25}{2}\right) = 4.4'' \text{ to } 6.75''$ (Per HRP-108)

use t = 8 inches

Gradation – from Plot SCS ENG 353

Sieve Size	Percent Passing (By Weight)
8 inch	100
4 inch	35 – 75
2 inch	5 – 25
# 200	0 – 5

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

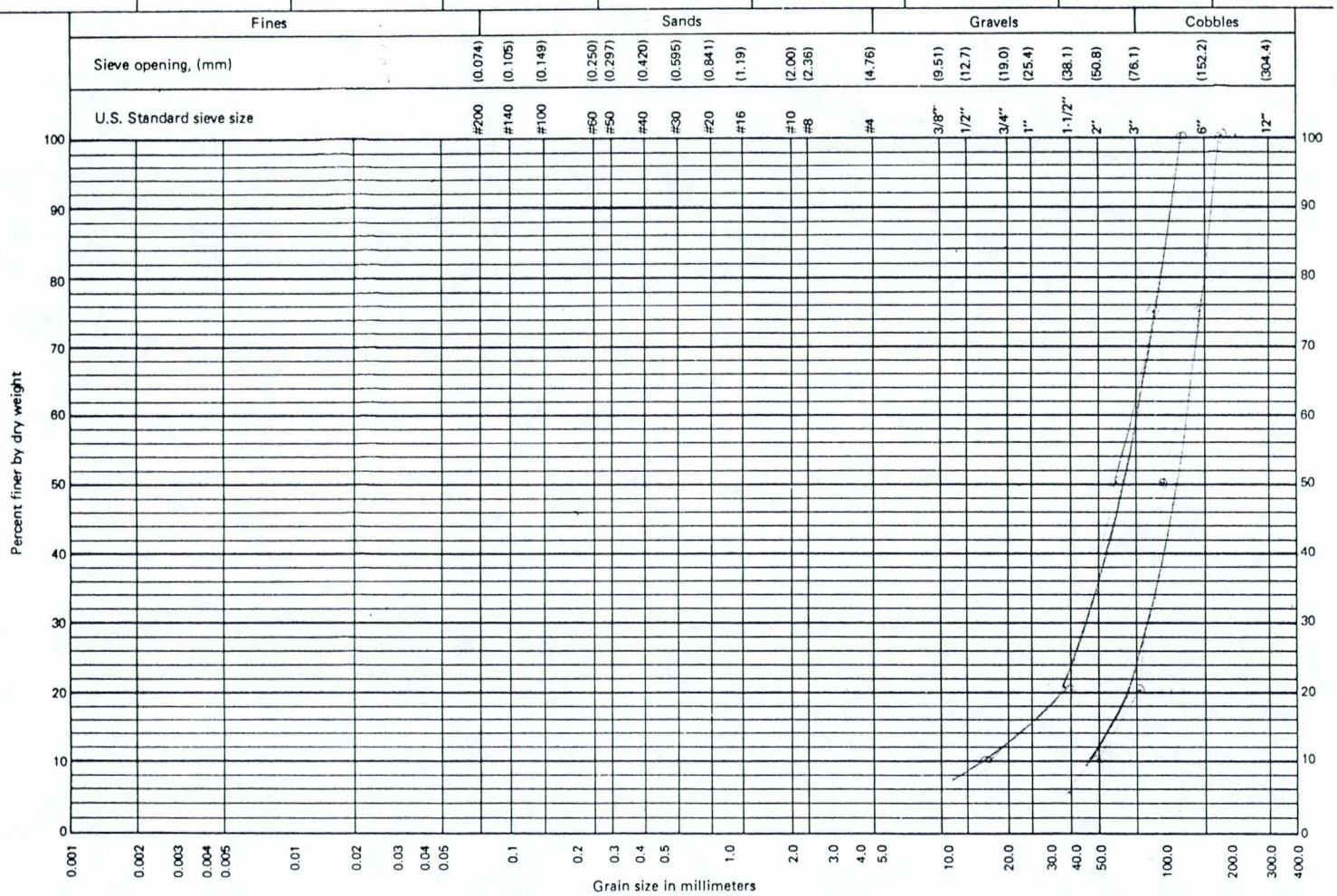
SCS-ENG-353
2-80

MATERIALS TESTING REPORT: SOIL CLASSIFICATION

Project and state: AZ
Sample location: _____
Laboratory No. _____
Field sample No. _____
Depth _____
Geologic origin _____
Type of sample _____
Tested at: East Mesa Proving Ground
Approved by: Roy Bennett
Date: 2-5-80
Symbol _____
Description: Poor Graded Sand (SP)

Grain Size Distribution

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	$D_{Maximum}$	C_u	C_c



Specific gravity (G_s)		Atterberg limits						Soluble salts	Shrinkage limit	Undisturbed condition	
		Natural moisture		Air dry		Ovendry				Moisture	Dry-unit weight
– No. 4	+ No. 4	LL	PI	LL	PI	LL	PI	%	%	%	g/cm³ / lb/ft³

Remarks:

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		East Maricopa Floodway Reach 1 & 2 Repair		
BY	DATE	CHECKED BY	DATE	JOB NO.
Tom Jayo	4-5-90			

SUBJECT
Filter Requirement Analysis

SHEET 7 OF

Soil Testing from investigating Committee in 1985
soils contain 63 to 94% fines and classify as CL and CH's. with PIs > 15 & with four have PI > 20
soils highly dispersed -

dispersive clays are present & were used in the construction of the liner. - act as discrete particles - & are very highly erosive -

60% of samples had PI > 15
40% " " " PI > 20
} For all samples 1973 to 1985

Note
Untreated dispersed clays used in the liner can erode in practically still water. -

4291 ft of rock-lined sections that safely remove 6.4 feet of drop -

44.9 ft total drop in 30,378 ft of channel

Armoring needed sta 1160+22 to sta 1464+00 excluding any rock riprap section.

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
Az		East Maricopa Floodway Reach 1 & 2 Repair		
BY Tom Jayo	DATE 4-5-90	CHECKED BY	DATE	JOB NO.
SUBJECT Filter Requirement Analysis				SHEET 8 OF

Step 1 - Design filter for base soil that requires the smallest D_{15} size -

Step 2 - No gravel therefore proceed to Step 4

Step 4 - Percent finer then No 200 = 63 to 94%

Use catagory 1 for % finer then 200 > 85

Step 5 - Use Table 2

$D_{15} \leq 9 \times d_{85}$
$\leq 9(0.01) \leq 0.09mm < 0.2mm$ use 0.2 mm for max D_{15} size

Step 6 - min $D_{15} \geq 4 \times d_{15}$ but $\geq 0.1mm$

min $D_{15} \geq 4 \times 0.001 = 0.004mm$
therefore min $D_{15} = 0.1mm$

Step 7 max size $\leq$ 3 inches 100% passing
max passing #200 = 5%

PI of Portion passing #40 = 0

Step 8 - Design Filter limits within max & min values in steps 5, 6 & 7 above.

max D_{90} for $D_{10} < 0.01$ = 20mm

Base soil is very fine and it therefore requires a very fine filter -

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		EAST MARICOPA FLOODWAY REACH 1&2 Repair		
BY Tom Jays	DATE 4-5-90	CHECKED BY	DATE	JOB NO.
SUBJECT Filter Reqt. Analysis (Cond)				SHEET 9 OF

Suggested specification Limits
same as Soils NOTE 1 Example 1 — "fine base soil"

Sieve Size	% passing
3/8	100
NO 4	90-100
NO 10	70-100
NO 20	50-85
NO 50	25-50
NO 100	8-30
NO 140	0-15
NO 200	0-5

Dr. Fred Theurer Soil Conservationist who did the stability and Erosion Analysis of the RWCD Floodway Reaches 1 & 2 raised the question about how expensive it would be to use a rock liner in Reach 1 and he indicated in this question that a bedding should be used. In letter to Ralph Arrington dated May 23 1985.

Bedding - Thickness — use 6" for estimate

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		East Maricopa Floodway Reach 1 & 2		
BY Tom Jayo	DATE 4-18-90	CHECKED BY	DATE	JOB NO.

SUBJECT: Check on Rock Rip Gradation For Filter Using Soil Mechanics Note 1

SHEET 10 OF

Base soil = filter material.

Step 1 - Design rock rip for base soil that requires the smallest D_{15} size.

Step 2 - Filter contains material > #4 sieve so go to Step 3

Step 3 - Prepare adjusted gradation curve for filter or base soil

(a) Correction factor $= \frac{100}{95\%} = 1.05$

(b)

Sieve size	% passing base soil	% passing Regraded base soil
		100 %
#10	85 x1.05	89.3
#20	67.5 x1.05	70.9
#50	37.5 x1.05	39.4
#100	19.0 x1.05	20.0
#140	7.5 x1.05	7.9
#200	2.5 x1.05	2.6

Step 4 - Regraded base soil shows 2.6% passing #200 sieve; therefore base soil is in category 4 per table 1.

Step 5 Determine Max D_{15} Size per table 2

Max $D_{15} \leq 4 \times d_{85} = 4(1.7) = \underline{6.8\ mm}$

Step 6 - $D_{15}^{min} \geq 4 \times d_{15}$ but no less than 0.1mm

$D_{15} > 4(0.14) = 0.56\ mm$

Step 7 - max particle size = 3 in

& max passing #200 = 5%

Step 8 Design filter limits using max & min limits in steps 5 & 7

<u>Conclusion</u> - Rock Riprap specd out on sheet 5 is too large for filter material that was specd out for EMF channel material.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-ENG-353
2-80

MATERIALS TESTING REPORT: SOIL CLASSIFICATION

Project and state _____ Sample location _____ Laboratory No. _____

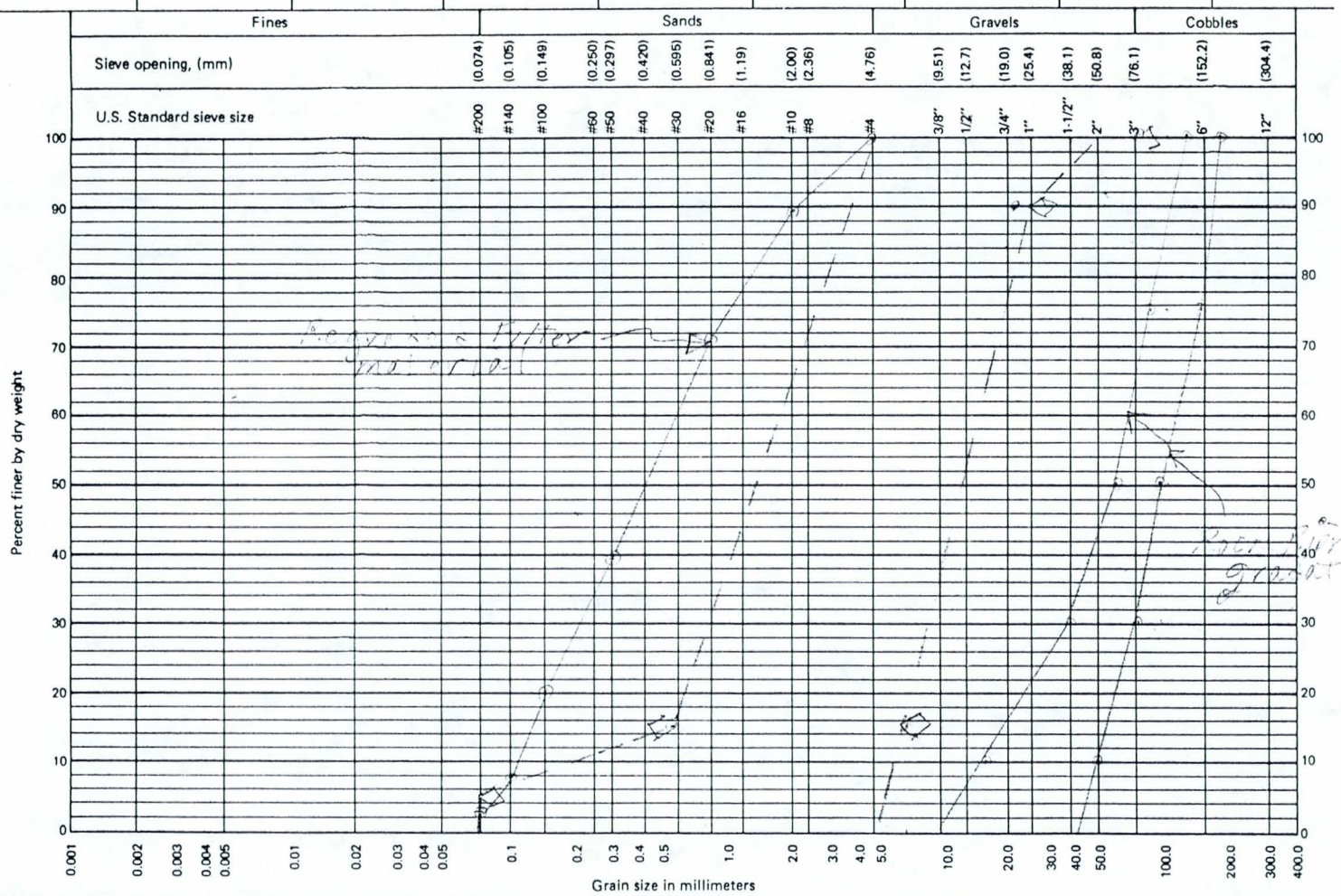
Field sample No. _____ Depth _____ Geologic origin _____

Type of sample _____ Tested at _____ Approved by _____ Date _____

Symbol _____ Description _____

Grain Size Distribution

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	$D_{Maximum}$	C_u	C_c



Specific gravity (G_s)		Atterberg limits						Soluble salts	Shrinkage limit	Undisturbed condition	
		Natural moisture		Air dry		Ovendry				Moisture	Dry-unit weight
– No. 4	+ No. 4	LL	PI	LL	PI	LL	PI	%	%	%	g/cm³
											lb/ft³

Remarks:

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCS-ENG-353
2-80

MATERIALS TESTING REPORT: SOIL CLASSIFICATION

ct and state _____ Sample location _____ Laboratory No. _____

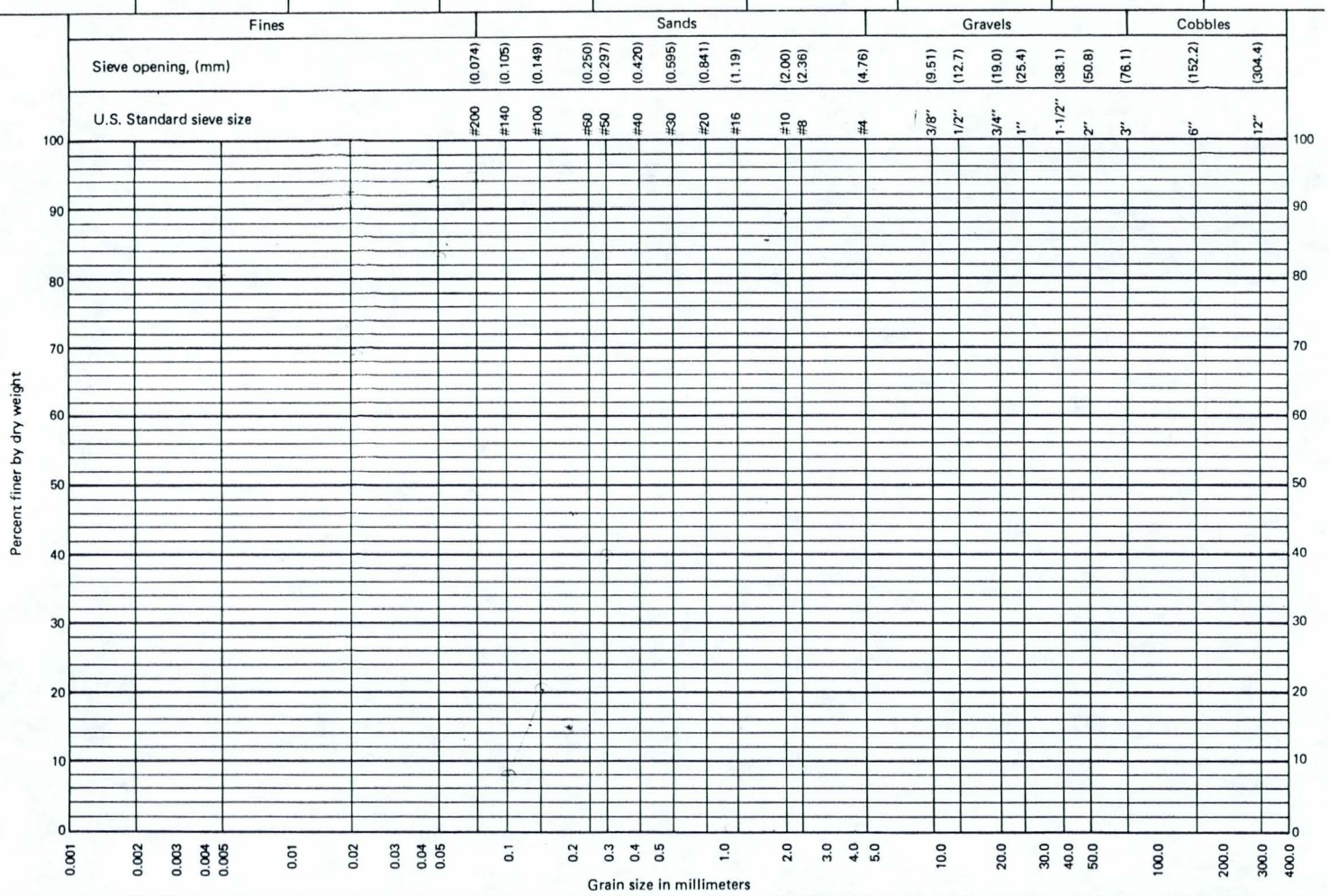
Field sample No. _____ Depth _____ Geologic origin _____

Type of sample _____ Tested at _____ Approved by _____ Date _____

Symbol _____ Description _____

Grain Size Distribution

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	$D_{Maximum}$	C_u	C_c



Specific gravity (G_s)		Atterberg limits						Soluble salts	Shrinkage limit	Undisturbed condition	
		Natural moisture		Air dry		Ovendry				Moisture	Dry-unit weight
– No. 4	+ No. 4	LL	PI	LL	PI	LL	PI	%	%	%	g/cm^3 / lb/ft^3

Remarks:

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		EMF REACH I & REACH II REPAIR		
BY	DATE	CHECKED BY	DATE	JOB NO.
Tom Joyo	4-16-90			

SUBJECT: Length Determination For Protection-

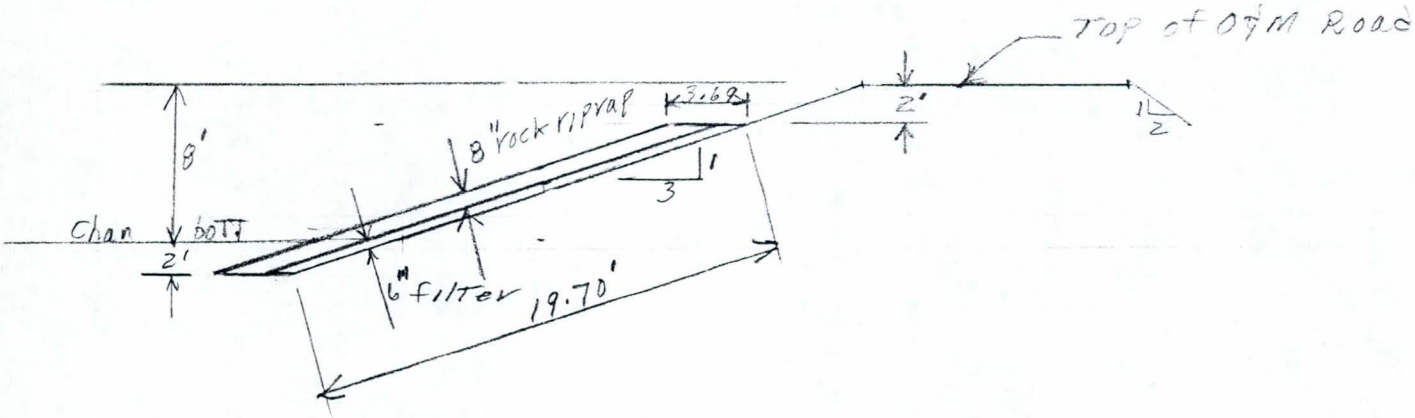
SHEET 12 OF

STATION	DESCRIPTION	LENGTH (to be protected) (FT)
1215+75	Begin const- Reach I	
		1914.0
1234+89	Begin loose rock for Sor Tar Church Road- & R/C slope protection on slopes	
1235+89	Begin loose rock bottom & sides	
1249+80	End loose rock riprap type 1 bottom & sides	
		6517.0
1314+97	start of asphalt concrete Dip crossing-	
1315+46	End loose rock riprap @ Dip crossing-	
		5194.0
1367+40	Begin loose rock riprap (type 1) H.W. 93-	
1368+40	End loose rock riprap (type 1) H.W. 93 -	
		1262.0
1381+02	Begin loose rock riprap (type 1) @ start of curve	
1395+45	End loose rock riprap (type 1) @ end of curve	
		600.0
1401+40.	Begin loose rock riprap (type 1) @ start of curve	
1414+95	End loose rock riprap (type 1) @ end of curve	
		1568.0
1430+63	Start of asphalt concrete Dip Crossing-	
1431+12	End loose rock riprap @ Dip Crossing-	
		1938.0
1450+50	End compacted channel lining begin loose rock riprap (type 1)	
Reach II		
1160+32.1	end rock riprap-begin compacted lining	
		4771.9
1203+04	- Begin rock riprap - For HW 87	
	TOTAL =	23,765 FT

COMPUTATION SHEET
SCS–ENG–522 REV. 3–69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		EMF REACH 1 & 2 REPAIR		
BY Tom Joyo	DATE 9-16-90	CHECKED BY	DATE	JOB NO.
SUBJECT SIDE SLOPE LENGTH FOR PROTECTION-				SHEET 13 OF



Filter Area = 19.70 (0.5) = 9.85 Ft^2 (one side)

Rock Riprap Area = 19.70 (0.667) = 13.14 Ft^2 (one side)

Bottom filter Area = $d[B.W.+3d] = 0.5[192.62+3(0.5)] = 97.06\ Ft^2$

Bottom Rock Riprap Area = $d[BW+3d] - 97.06 = 1.167[192.62+3(1.167)] - 97.06 = 131.81\ Ft^2$

TOTAL Filter Area = 9.85(2) + 97.06 = 116.76 Ft^2

TOTAL Rock Riprap Area = 13.14(2) + 131.81 = 158.09 Ft^2

Reduction in Cross Section Area due to Filter & Rock

TOTAL X-Sec Area without filter & rock = $6[200+36] = \underline{1308\ Ft^2}$

TOTAL X-Sec Area with filter & rock = $4.83[192.62+3(4.83)] = \underline{1000.34\ Ft^2}$

% Reduction = $\frac{307.66}{1308} \times 100 = 23.52\%$ - Too high -

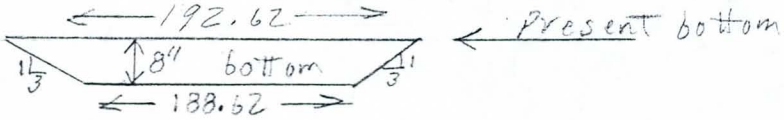
Place rock riprap & filter 1.167' below present grade on bottom of floodway only

COMPUTATION SHEET
SCS–ENG–522 REV. 3–69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

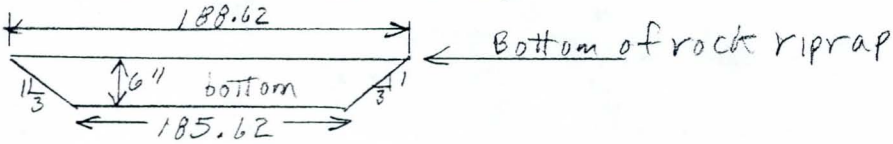
STATE AZ		PROJECT EMF REACH 1 & 2 REPAIR		
BY Tom Jays	DATE 4-16-90	CHECKED BY	DATE	JOB NO.
SUBJECT Rock Riprap & Filter- X-Sec Area				SHEET 14 OF

1. Rock Riprap Area - assuming rock & filter placed ontop of existing slopes only.



Area = $0.667[188.62 + 3(0.667)] = 127.14\ Ft^2$

2. Filter Area - same assumption as 1.0 above



Area = $0.5[185.62 + 3(0.5)] = 93.56\ Ft^2$

TOTAL Filter Area = $9.85(2) + 93.56 = \underline{\underline{113.26}}\ Ft^2$

TOTAL Rock Riprap Area = $13.14(2) + 127.14 = \underline{\underline{153.42}}\ Ft^2$

TOTAL X-sec Area with filter & rock = $6[192.62 + 3(6)] = 1263.7^2$

% reduction = $\frac{44.28}{1308} \times 100 = \underline{\underline{3.39\%}}$ ok - can probably justify this reduction

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
AZ		EMF REACH 1 & 2 REPAIR		
BY Tom Jayo	DATE 4-17-90	CHECKED BY	DATE	JOB NO.
SUBJECT Riprap & Filter Quantities -				SHEET 15 OF

1. Filter Quantity

length = 23,765 FT - See sht 10
X-Sec Area = 113.26 FT^2 - See sht 12

Vol = 23,765 (113.26)($\frac{1}{27}$) = 99,689.8 cu yd.

2. Rock Riprap Quantity

length = 23,765 ft

X-sec Area = 127.14 FT^2 - See sht 12

Vol = 23,765 (127.14)($\frac{1}{27}$) = 111,906.7 cu yd.

3. Cost Estimate. (For Filter & Rock placement)

Assume \$15.00/cu yd for both filter & Rock Riprap

Cost = \$15.00 (99,689.8 + 111,906.7) = \$3,173,947.50

Earth excavation - For filter & rock riprap - (bottom of channel) & cutoff sctoe

Area = d (200+3d) = 1.17 (200+3(1.17)) = 238.11 FT^2

Vol = 23,765 (238.11)($\frac{1}{27}$) = 209,580.9 cu yd.

Cutoff vol - along Toes -

Vol = 2.04 (1.17)(2)(23,765)($\frac{1}{27}$) = 4201.65 cu yd

TOTAL = 213,782.6 cu yd -

Cost @ 2.00/c.y. = 2.00 (213,782.6) = \$427,565.20

TOTAL COST \$3,601,513.00

U.S. DEPARTMENT OF AGRICULTURE
SCS-ENG-522 REV. 3-69 SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR - Phase 1		
BY WAM	DATE 6/14/90	CHECKED BY	DATE	JOB NO.
SUBJECT SOIL CEMENT SILLS				SHEET 1 OF

- See sketches EMF -1 to 3 for preliminary design of sills.
- Phase 1 repair is to cover approximately one-half the entire project. This first phase is to cover the upstream segment because it has not been replenished after eroded material was transported from upstream to downstream.
- Soil Cement sills are to be placed at the downstream end of each section of riprap and at any other points where grade protection is required. Others may be placed at intermediate points to provide additional grade control.

1. Determine the preferred distance between sills placed at intermediate points to control grade.

COMPUTATION SHEET

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U.S. DEPARTMENT OF AGRICULTURE

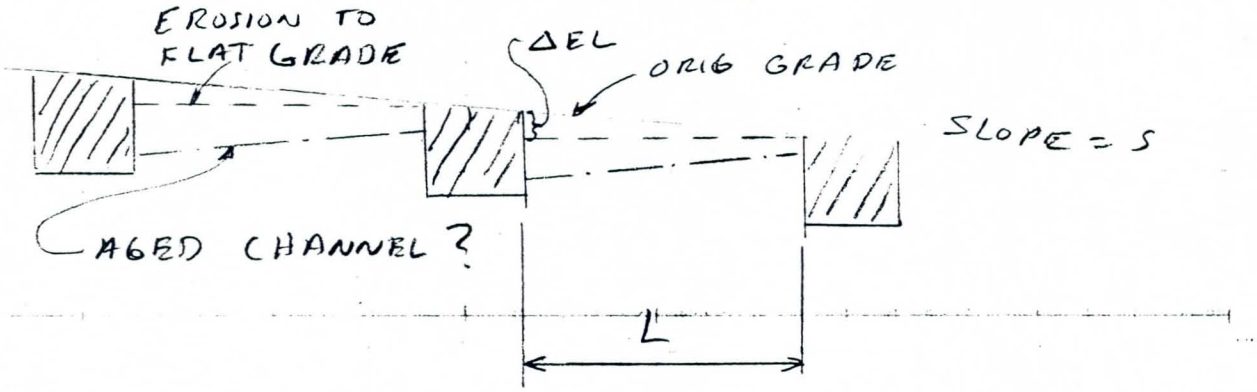
SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR - Phase 1		
BY WDM	DATE 6/14/90	CHECKED BY	DATE	JOB NO.
SUBJECT SOIL CEMENT SILLS				SHEET 2 OF

- Channel slope = 0.0015

- sills will have tops at original grade at the toe of slope, one foot below original grade at ℄.

- If erosion creates straight grade between sills,



$\Delta EL = S \times L = 0.0015\,L$

L	ΔEL
1000'	1.5'
1500	2.25
2000	3.00
2500	3.75
3000	4.5

The upstream segment of channel to be repaired is from the Saint Anthony Falls to the railroad bridge. The distance is approx 4800 feet. The ΔEL for this segment with one intermediate sill would be 0.0015 x 2400 feet = 3.6 ft. The ΔEL for two sills @ 1600 feet = 2.4 ft. In the interest of long-term channel stability, and potential decrease in erosion, the lesser spacing appears to be justified. Each segment will be considered separately, with sills placed at [illegible] 1500 - 2000 feet [illegible]

COMPUTATION SHEET
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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WDM	DATE 6/14/90	CHECKED BY	DATE	JOB NO.
SUBJECT SOIL CEMENT SILLS				SHEET 3 OF

Select Locations for sills. Determine the station of the centerline of 10' sill.

Sill No	Station	Description
1	1176+00	Intermediate Location
2	1192+00	" "
3	1215+10	Downstream end of riprap station = 1215+00
4	1249+90	Downstream end of riprap station = 1249+80
5	1268+50	Intermediate Location
6	1287+00	Grade control for siphon at sta 1285+00
7	1301+00	Intermediate Location
8	1315+56	Grade control for downstream end of riprap sta 1315+46

— END OF PHASE 1 —

NOTE: The centerline of each sill placed at the downstream end of riprap is located approx 10' from the station of that downstream end. This will accomodate construction of the sill by reducing the excavation of rock. See Sht 4

COMPUTATION SHEET
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U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR - PHASE 1		
BY WAM	DATE 6/15/90	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 4 OF

SOIL CEMENT DESIGN

The native soils in the channel are not satisfactory for a good soil cement mix. However there is an aggregate plant (Tanner - aggregate, PCC batch, AC batch) approximately 3 miles from the center of the project.

Determine from the literature what would be a good mix and verify the availability & cost a reliable soil cement mix

1. "Soil-Cement Slope Protection for Embankments: Planning and Design", PCA, 1975, reprint 1984

Sieve	% Passing
2"	100
#4	55 — 100
#200	5 - 35

2. "Short-Cut Soil-Cement Testing Procedures for Sandy Soils", PCA, 1958

There are two methods used to design soil cement mixes where the soil contains less than 50% silt & clay (smaller than 0.05) and less than 20% clay (smaller than 0.005).

COMPUTATION SHEET

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U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WAM	DATE 6/15/90	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 5 OF

METHOD A, 100 % passing # 4 sieve

In reviewing this procedure, the following gradation appears to be satisfactory for an 8% by weight cement content

Sieve	% Passing
#4	100
#60	40 - 80
0.05	10 - 35

METHOD B, retention on #4 sieve

Sieve	% Passing	
2"		100
#4	~~60 - 100~~	60 - 100
#10	~~40 - 95~~	50 - 80
0.05	~~10 - 35~~	5 - 25

Note: The soil cement density increases rapidly with increase in % retained on #10 sieve (between #4 & #10). It might be the best material for blending with the native soil.

ESTIMATING PRICE

Received from Don Green, Tanner Co., 220-5633, for 8% cement content, mixed using ABC gradation estimated price of $42.50/yd delivered to site.

COMPUTATION SHEET

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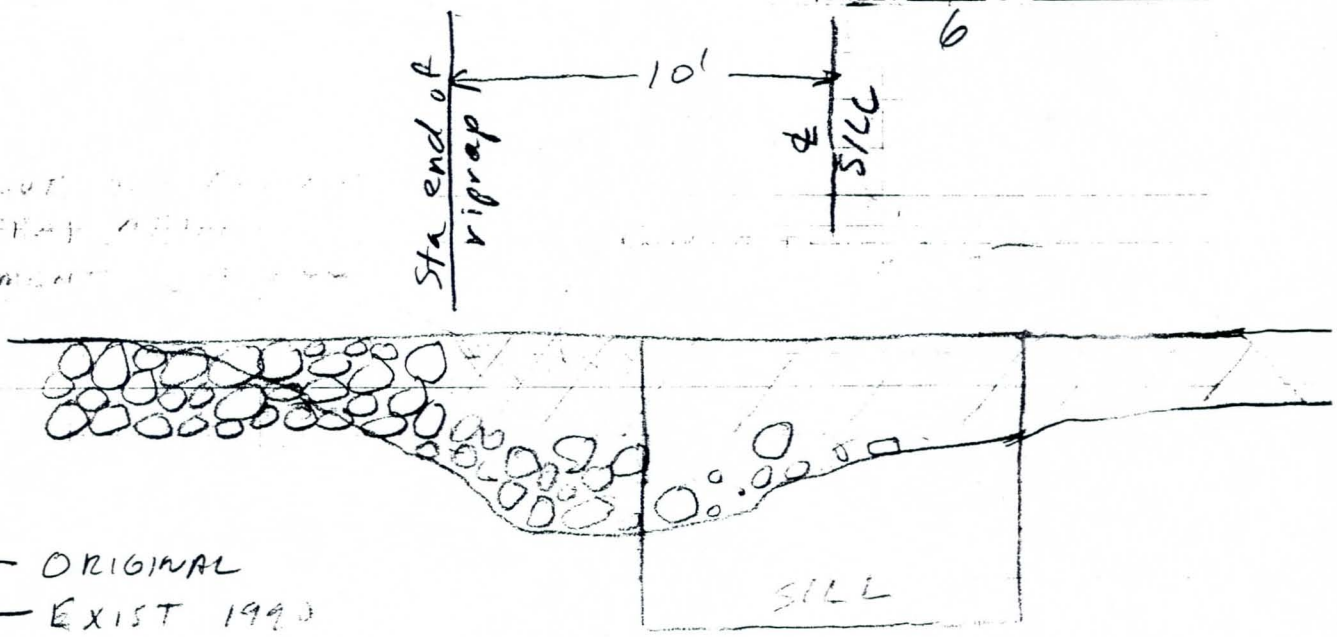
U.S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WAM	DATE 6/15/90	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 4 OF 6



— ORIGINAL

— EXIST 1990

— TO BE CONSTRUCTED

STEPS

1. Place compacted soil to grade

2. Excavate for sill

3. place sill

4. Excavate upstream side of sill and place riprap

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT RWCD REPAIR		
BY WAM	DATE 6/18/90	CHECKED BY	DATE	JOB NO.
SUBJECT SOIL CEMENT SILLS				SHEET ____ OF ____

Determine the difference in cost of soil cement for 8-foot wide vs 10-foot wide sills. There is some doubt that savings would be realized by going with the smaller sill because of the difficulty of excavation. It is felt that a scraper would likely be used for excavation and would be much wider than 8 feet. The specifications should require that the entire excavation be filled with soil cement.

However, if backhoes and/or front-end loaders are used to excavate, the width could be readily dug to whatever size is considered to be satisfactory.

The extra volume to construct 2' wider is approx
$2' \times 6' \times 220 \times 8 \times \frac{1}{27} = 782$ yd

≈ 100 yd/sill

100 yd $\times \$50 = \$5{,}000$

1 backhoe can dig 400 yd^3 in 4 hours

SOIL CEMENT INFORMATION
PORTLAND CEMENT ASSOCIATION
PAVING BUREAU

SHORT-CUT SOIL-CEMENT TESTING PROCEDURES FOR SANDY SOILS

ASTM AND AASHO methods for testing soil-cement mixtures have been used successfully to establish controls for cement content, moisture content and density on projects comprising many millions of square yards of soil-cement. The performance of these installations attests the dependability of these procedures. These tests are:

1. Method of Test for Moisture-Density Relations of Soil-Cement Mixtures, ASTM Designation: D 558; AASHO Designation: T 134.[1]
2. Method of Wetting-and-Drying Test of Compacted Soil-Cement Mixtures, ASTM Designation: D 559; AASHO Designation: T 135.[1]
3. Method of Freezing-and-Thawing Test of Compacted Soil-Cement Mixtures, ASTM Designation: D 560; AASHO Designation: T 136.[1]

Completion of these tests requires about six weeks and 100 lb. of soil. In an attempt to establish procedures that would require less time and work, a study was made of data obtained by ASTM-AASHO tests on 2,229 sandy soil-cement mixtures. Development of the short-cut test procedures for sandy soils given in this information sheet was based on this study.[2]

No new tests or additional equipment is required for these short-cut procedures. The charts and figures eliminate some tests and greatly reduce the amount of work previously required. A grain-size analysis, a moisture-density test and a compressive-strength test are the only laboratory tests required, and soil samples may be relatively small. Except for the 7-day compressive-strength test, all tests can be completed in one day. Two procedures are used: Method A for soils containing no material retained on the No. 4 sieve, and Method B for soils containing material retained on the No. 4 sieve.

The procedures may be applied only to soils containing less than 50 per cent silt and clay smaller than 0.05 mm. and less than 20 per cent clay smaller than 0.005 mm. The short-cut procedures should not be used for dark grey to black soils containing appreciable amounts of organic impurities, or for miscellaneous granular materials such as cinders, caliche, chat, chert, marl, red dog, scoria, shale, slag, etc. In addition, the short-cut test should not be used for granular soils containing material retained on the No. 4 sieve that has a bulk specific gravity of less than 2.45. Until information on these materials is sufficient to permit the use of short-cut testing procedures, they should be tested by the complete ASTM-AASHO procedures.

The cement factor indicated by the short-cut test procedures will be adequate, but it will not necessarily be the minimum that may be used. Therefore, the procedures and, more particularly, the charts presented here are not to be considered final or irrevocable. Local climatic and soil conditions may suggest modifications to improve and augment the short-cut procedures.

OTHER TESTS AND METHODS OF ESTABLISHING CEMENT FACTORS

Control factors for soil-cement construction have been established in some areas by procedures other than those following ASTM-AASHO test methods. These locally developed methods are proving satisfactory for specific soils and climatic conditions.

Furthermore, soil-cement testing can be sharply reduced or eliminated for large areas. This can be accomplished if portland cement requirements are established by horizon for specific soil series as classified in most areas by the U.S. Department of Agriculture.[3] This soil classification system has proved helpful in soil-cement work, because studies have shown that the cement requirement of a specific soil series and horizon remains the

[1] The ASTM-AASHO test procedures are also covered in *Soil-Cement Laboratory Handbook*, Chapter 3, published by the Portland Cement Association, available free only in the United States and Canada.

[2] Results of the original study are contained in "Soil-Cement Test Data Correlation Affords Methods of Quickly Determining Cement Factors for Sandy Soils," Highway Research Board Bulletin 61, 1952, pages 29-46. More recent information is given in a second paper, "Expanded Short-Cut Test Methods for Determining Cement Factors for Sandy Soils," which was presented at the thirty-seventh annual meeting of the Highway Research Board, January 1958. Copies of this paper are available free on request to the Portland Cement Association in the United States and Canada.

[3] The U.S. Department of Agriculture Classification System is discussed in *PCA Soil Primer* (pages 31-35), published by the Portland Cement Association, available free only in the United States and Canada.

PORTLAND CEMENT ASSOCIATION • 33 West Grand Avenue • Chicago 10, Illinois

The activities of the Portland Cement Association, a national organization, are limited to scientific research, the development of new or improved products and methods, technical service, promotion and educational effort (including safety work), and are primarily designed to improve and extend the uses of portland cement and concrete. The manifold program of the Association and its varied services to cement users are made possible by the financial support of over 75 member companies in the United States and Canada, engaged in the manufacture and sale of a very large proportion of all portland cement used in these two countries. A current list of member companies will be furnished on request.

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same, regardless of where the soil is encountered. It is obvious, then, that once the cement requirement of a soil has been determined by laboratory tests, no further tests will be needed when the soil is to be used on another project. An increasing number of engineers are using this system to reduce their soil-cement testing work.[4]

On the other hand, roadways and streets frequently contain soil and soil mixtures that cannot be identified as to soil series, and often it is impossible to determine the original location of the material. Existing undisturbed soil materials are also sometimes difficult to identify, and in some instances the soils have not even been mapped. Furthermore, samples are occasionally sent to laboratories without a notation of soil series or horizon identification. In each of these situations, the cement requirements must be determined by complete laboratory tests or, if the materials are sandy soils, by the short-cut testing procedures outlined herein.

STEP-BY-STEP PROCEDURES

The short-cut testing procedures involve

- — determining the gradation of the soil;
- — performing a moisture-density test;
- — determining the indicated portland cement requirements by the use of charts; and
- — verifying the indicated cement requirement by compressive-strength tests.

add 2% for stone work after test requirements made —

Preliminary Steps

1. Make a grain-size analysis of the soil. If the soil contains less than 50 per cent silt and clay (smaller than 0.05 mm.) and less than 20 per cent clay (smaller than 0.005 mm.), the short-cut procedures may be used.[5]
2. Determine the absorption and bulk specific gravity of the material retained on the No. 4 sieve, if any.
3. Use Method A if the soil has no material retained on the No. 4 sieve; otherwise, use Method B.

Method A

Step 1: Determine by test the maximum density and optimum moisture content for a mixture of the soil and portland cement.[6] The cement content by weight to be used in the test can be read from Fig. 2 by using an estimated maximum density and the percentage of material smaller than 0.05 mm. An estimated maximum density to use with Fig. 2 can be determined from Fig. 1.

Step 2: Using the maximum density obtained by test in Step 1, determine from Fig. 2 the indicated cement requirement.

Step 3: Using the indicated cement factor obtained in Step 2, mold compressive-strength specimens[7] in triplicate at maximum density and optimum moisture.

Step 4: Determine the average compressive strength of the specimens after 7 days' moist-room curing.

Step 5: On Fig. 3, plot the average compressive strength value obtained in Step 4. If this value plots above the curve, the indicated cement factor by weight, determined in Step 2, is adequate. Then, by using Fig. 7, convert this cement content by weight to a volume basis for field construction.

Note 1: If the average compressive-strength value plots below the curve of Fig. 3, the indicated cement factor obtained in Step 2 is probably too low, and additional testing is needed to establish the cement requirement for the soil. These additional tests generally involve molding two 4-in. diameter by 4.6-in. height test specimens, one at the indicated cement factor obtained in Step 2 and one at a cement content two percentage points higher. The specimens are then tested by ASTM-AASHO freeze-thaw test procedures.

Method B

Step 1: Determine by test the maximum density and optimum moisture content for a mixture of the soil and portland cement.[8] The cement content by weight to be used in the test can be read from Fig. 5 by using the percentage of material smaller than 0.05 mm., the percentage of material retained on the No. 4 sieve, and an estimated maximum density. The estimated maximum density may be determined from Fig. 4. The soil sample for the test shall contain the same percentage of material retained on the No. 4 sieve as the original soil sample. However, ¾-in. material is the maximum size used in the test. If there is material larger than ¾ in. in the original soil sample, it is replaced in the test sample with an equivalent weight of material passing the ¾-in. sieve and retained on the No. 4 sieve.

Step 2: Using the maximum density obtained by test in Step 1, determine from Fig. 5 the indicated cement requirement.

Step 3: Mold compressive-strength specimens[9] in triplicate at maximum density and optimum moisture content,

[4] L. D. Hicks, "The Use of Agricultural Soil Maps in Making Soil Surveys," *Engineering Use of Agricultural Soil Maps*, Highway Research Board Bulletin No. 33, October 1949, page 108.

[5] The short-cut tests do not apply to dark grey or black organic soils; to miscellaneous granular materials such as cinders, caliche, chat, chert, marl, red dog, scoria, shale and slag; or to soils containing material retained on the No. 4 sieve that have a bulk specific gravity less than 2.45. These soils should be tested by the complete ASTM-AASHO procedures.

[6] "Method of Moisture-Density Relations of Soil-Cement Mixtures," ASTM Designation D 558; AASHO Designation T 134. The procedures and calculations are discussed in *Soil-Cement Laboratory Handbook*, Chapter 3.

[7] Specimens of 2-in. diameter by 2-in. height or 4-in. diameter by 4.6-in. height may be molded. The 2-in. specimens shall be submerged in water for 1 hour before testing and the 4-in. specimens for 4 hours. The 4-in. specimens shall be capped before testing. Procedures for molding and testing these specimens and the required calculations are explained in *Soil-Cement Laboratory Handbook*, Chapter 4.

[8] See footnote 6.

[9] Specimens of 4-in. diameter by 4.6-in. height shall be molded. They shall be submerged in water for 4 hours and shall be capped before testing. Procedures for molding and testing these specimens and the calculations required are explained in *Soil-Cement Laboratory Handbook*, Chapters 3 and 4.

using total material as described in Step 1 and the indicated cement factor obtained in Step 2.

Step 4: Determine the average compressive strength of the specimens after 7 days' moist-room curing.

Step 5: From Fig. 6, determine the minimum allowable compressive strength for the soil-cement mixture. If the average compressive strength obtained by test in Step 4 equals or exceeds the minimum allowable strength, the indicated cement factor by weight determined in Step 2 is adequate. For field construction, use Fig. 7 to convert this cement content by weight to a volume basis.

Note 2: If the average compressive-strength value is lower than the minimum allowable strength, the indicated cement factor obtained in Step 2 is probably too low. Additional testing, as described in Note 1, is needed to establish the cement requirement for the soil.

EXAMPLE OF USE OF SHORT-CUT TEST PROCEDURES

Preliminary tests determine the gradation of the soil and the absorption and bulk specific gravity of the material retained on the No. 4 sieve. These data are tabulated below. In this example, Method B should be used since the soil contains material retained on the No. 4 sieve.

Gradation:

passing:

No. 4 sieve	82 per cent
No. 10 sieve	77 per cent
No. 60 sieve	58 per cent
No. 200 sieve	37 per cent

smaller than:

0.05 mm. (silt and clay combined)	32 per cent
0.005 mm. (clay)	13 per cent

Color: brown

Bulk specific gravity of material retained on No. 4 sieve: 2.50

Absorption of material retained on No. 4 sieve: 2.1 per cent

Step 1: Fig. 4 indicates that the estimated maximum density of the soil-cement mixture is 122 lb. per cu.ft. since the soil contains 32 per cent material smaller than 0.05 mm. and 23 per cent material retained on the No. 10 sieve.

Fig. 5 may be used to determine the cement content by weight to use in the moisture-density test. Since the soil contains 32 per cent material smaller than 0.05 mm. and 18 per cent material retained on the No. 4 sieve, and since the estimated maximum density is 122 lb. per cu.ft., 6 per cent cement by weight is indicated.

Perform the moisture-density test using 6 per cent cement by weight.

For this example, assume the maximum density obtained by test to be 123.2 lb. per cu.ft. at 10.2 per cent moisture.

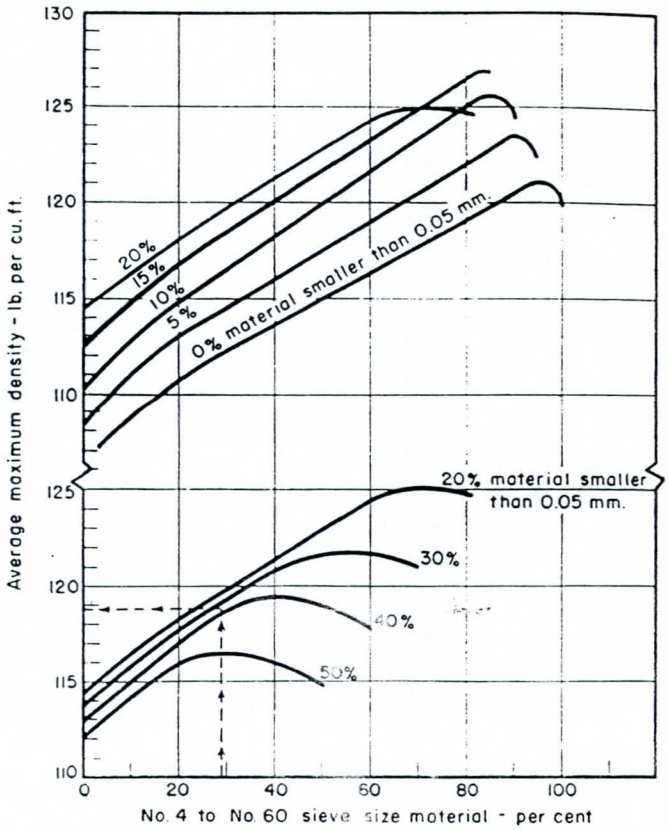


Fig. 1. Average maximum densities of soil-cement mixtures having no material retained on the No. 4 sieve.

Step 2: With the actual maximum density of 123.2 lb. per cu.ft. determined by test, Fig. 5 indicates a cement factor of 6 per cent.

Step 3: Using total material and 6 per cent cement by weight, mold compressive-strength specimens in triplicate at maximum density (123.2 lb. per cu.ft.) and optimum moisture (10.2 per cent).

Step 4: Determine the average 7-day compressive strength.

For this example, assume the average compressive strength to be 345 psi.

Step 5: Since the soil contains 32 per cent material smaller than 0.05 mm. and 18 per cent material retained on the No. 4 sieve, Fig. 6 shows the minimum allowable compressive strength for this soil-cement mixture to be

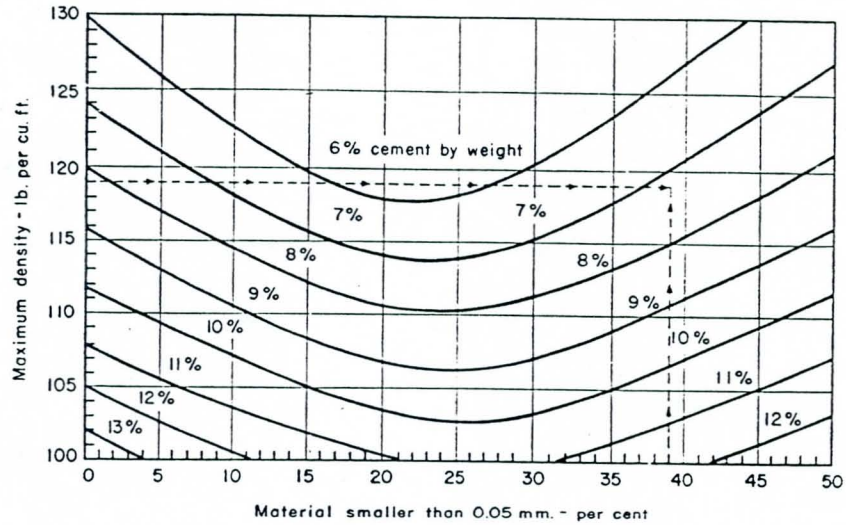


Fig. 2. Indicated cement content of soil-cement mixtures having no material retained on the No. 4 sieve.

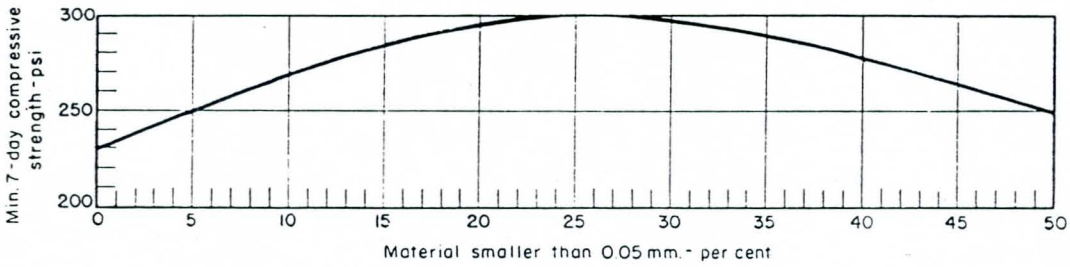


Fig. 3. Minimum 7-day compressive strengths required for soil-cement mixtures having no material retained on the No. 4 sieve.

280 psi. The average compressive strength of the mixture obtained in Step 4 (345 psi) is higher than the minimum allowable strength. Therefore, the indicated cement content of 6 per cent by weight is adequate.

For field construction, Fig. 7 indicates that 6 per cent cement by weight is equivalent to 7.4 per cent cement by volume.

If the average compressive strength obtained in Step 4 had been less than the minimum allowable strength, say 245 psi, 6 per cent cement by weight probably would not have been adequate. Additional testing would have then been required to establish the cement requirement for the soil. These tests would have involved molding and testing freeze-thaw specimens according to ASTM procedures.[10] Freeze-thaw specimens containing 6 and 8 per cent cement by weight would have probably been adequate in this instance.

[10] See footnote 1, page 1.

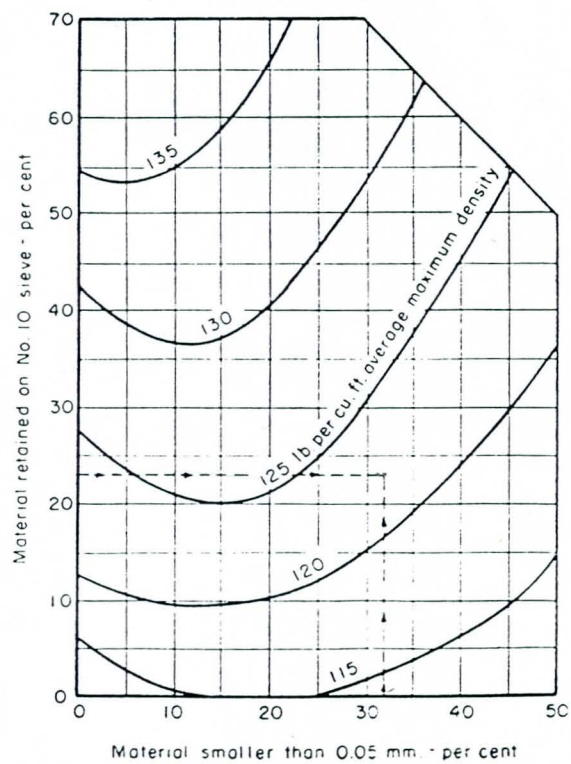


Fig. 4. Average maximum densities of soil-cement mixtures having material retained on the No. 4 sieve.

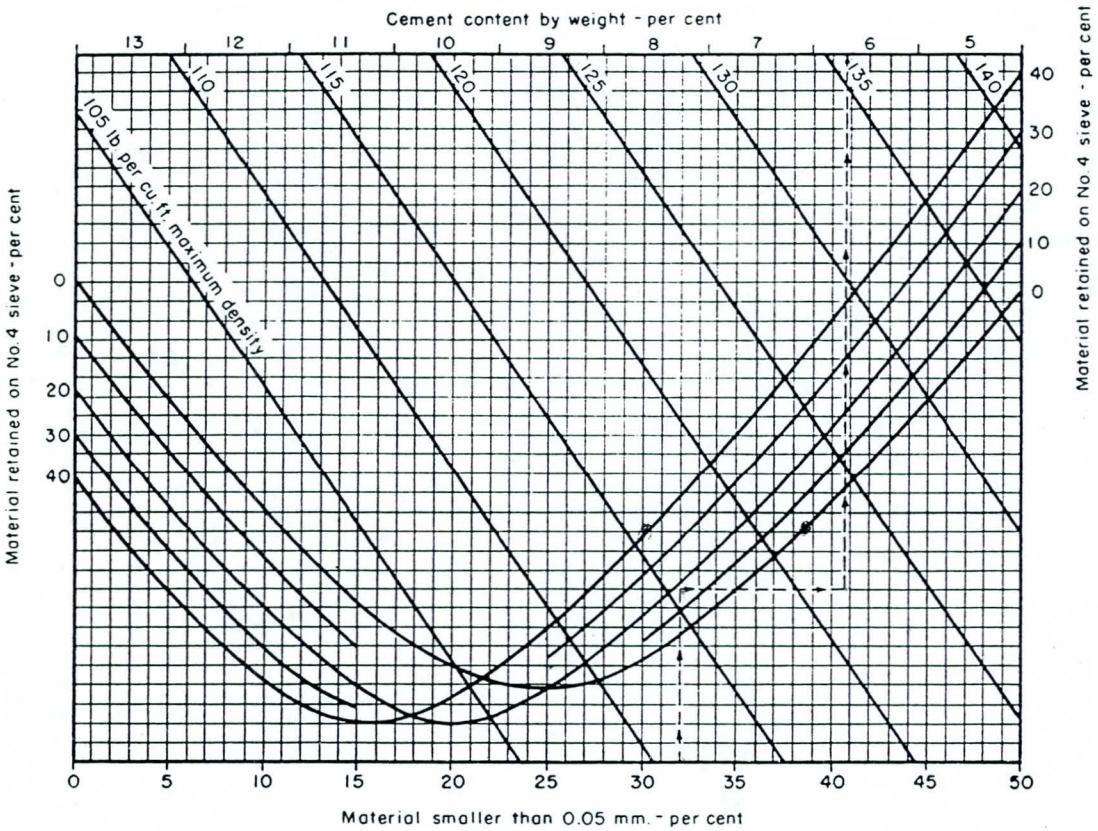
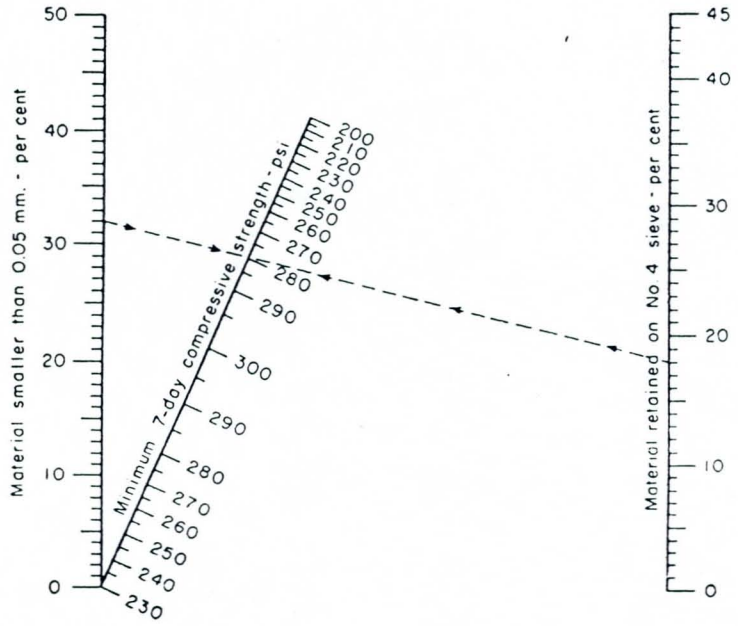


Fig. 5. Indicated cement content of soil-cement mixtures having material retained on the No. 4 sieve.

Fig. 6. Minimum 7-day compressive strength required for soil-cement mixtures having material retained on the No. 4 sieve.



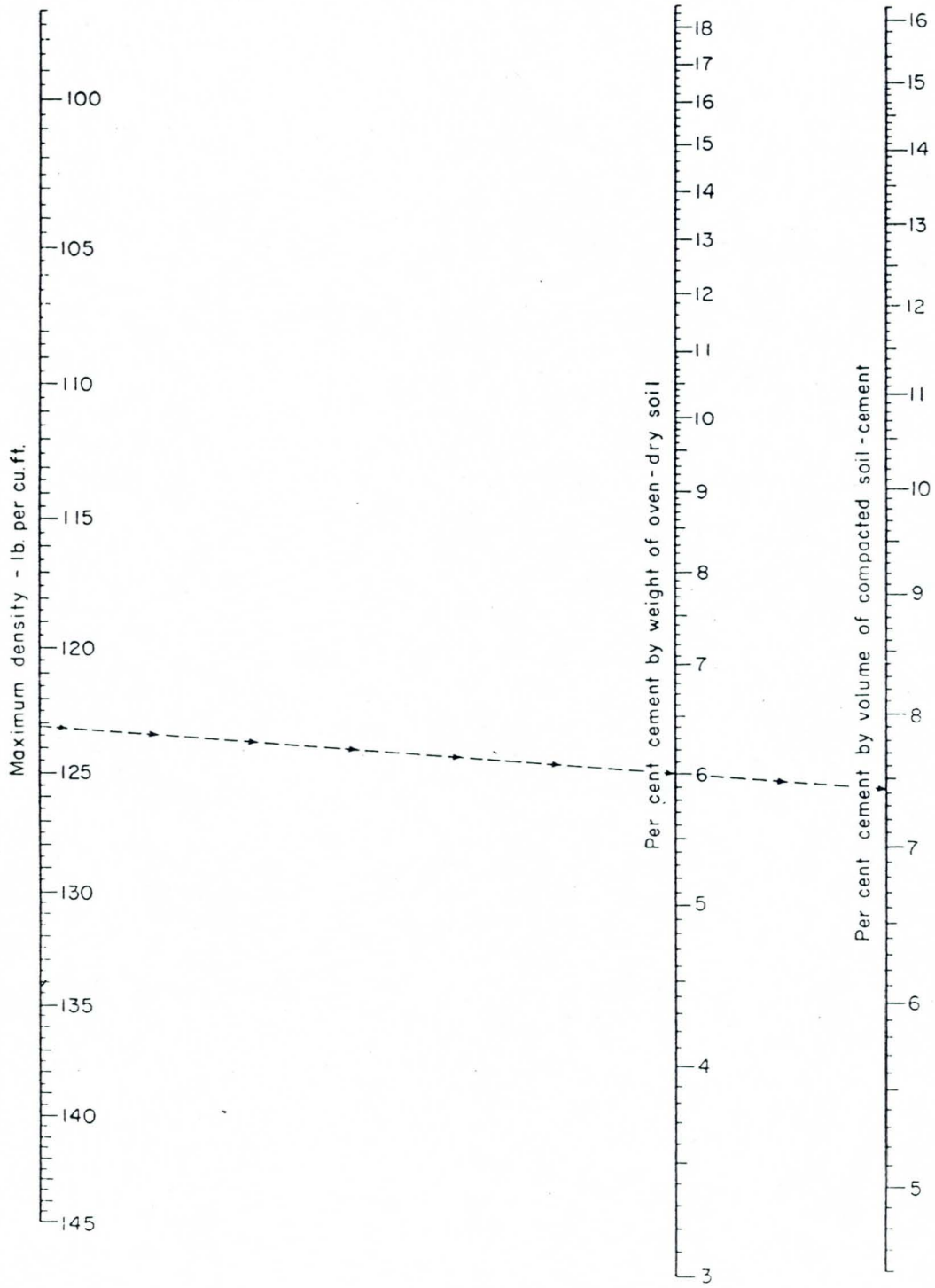


Fig. 7. Relation of cement content by weight of oven-dry soil to cement content by volume of compacted soil-cement mixture.

It is essential that the soil-cement extend below the minimum water level and above the maximum water level. The latter elevation should have a freeboard allowance of at least 1.2 times the anticipated maximum wave height, or about 5 ft., whichever is greater. The edges of the completed soil-cement layers should not be trimmed as the rounded stair-step effect is beneficial in retarding wave runup.

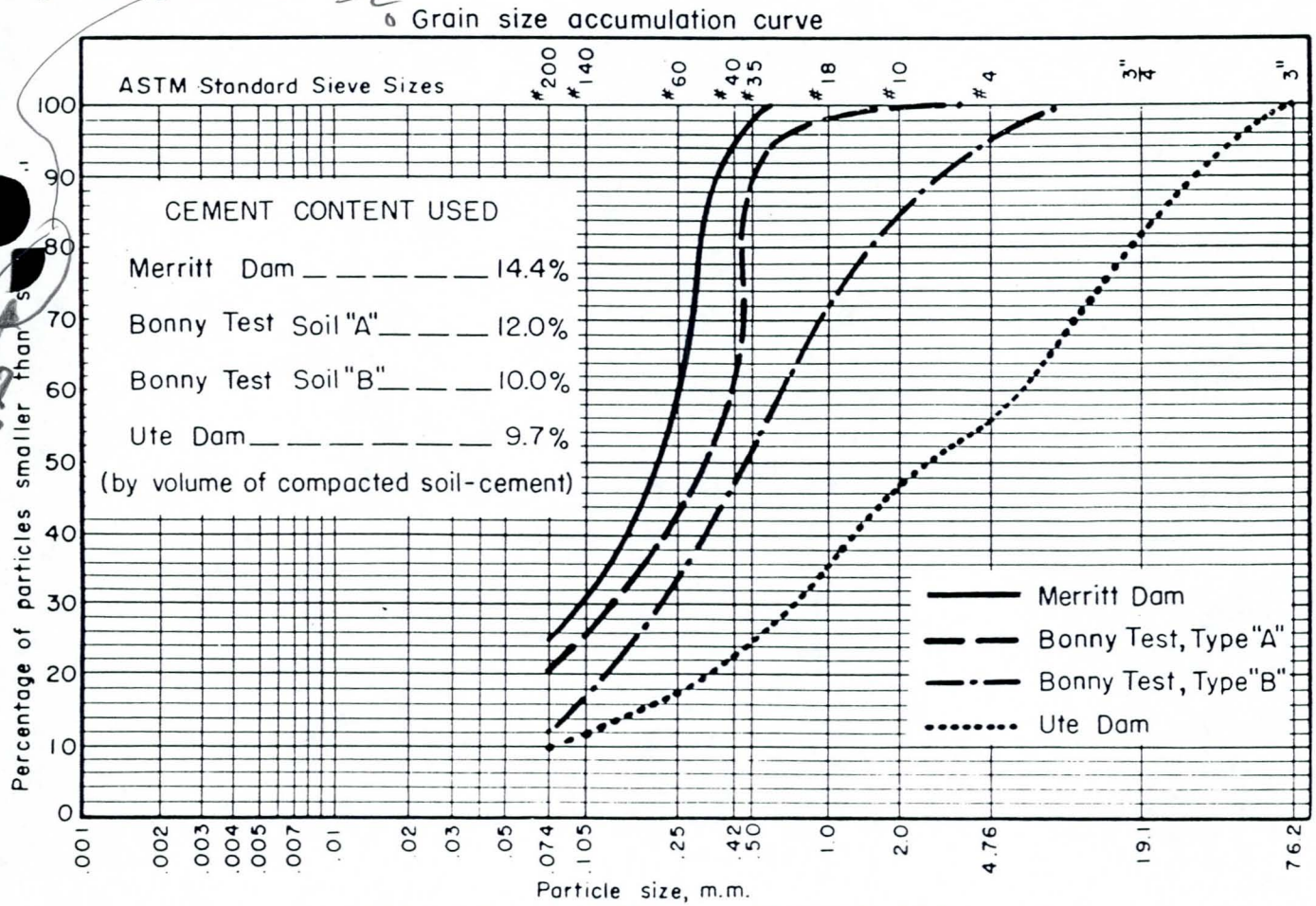
The construction of a soil-cement patrol road along the top of the dam will provide additional protection against erosion of the crest.

SOILS

Soil-cement can be built with a wide variety of soils. The principal criterion for determining soil type is gradation (Fig. 6). Coarse sandy or gravelly soils containing about 10 to 25 percent material passing the No. 200 sieve are ideal (American Society for Testing and Materials Standard Sieve Series). If the amount of material smaller than the No. 200 sieve exceeds 35 percent, some effort to find a coarser material may be justified from a processing cost standpoint. Soils containing 50 percent or more material passing the No. 200 sieve are not recommended for use in their natural state; but they can be utilized in combination with a more granular material that may be hauled in from another source.

Soils that are bright in overall coloration (white, yellow, red-brown) generally are excellent soil-cement aggregates; those that are dark (gray, dark brown, black) are more apt to contain excessive fines and organic matter. Potentially suitable soils near the project site can usually be selected by visual observation and samples taken for design tests in the laboratory.

Fig. 6. Soil gradations.



U.S. DEPT. OF AGRICULTURE SOIL SEPARATE SIZE LIMITS

Clay	Silt	Sand					Gravel
		Very Fine	Fine	Medium	Coarse	Very Coarse	
-.002	.002 – .05	.05-.1	.1 - .25	.25-.5	.5-1.0	1.0-2.0	2.0 – 76.2

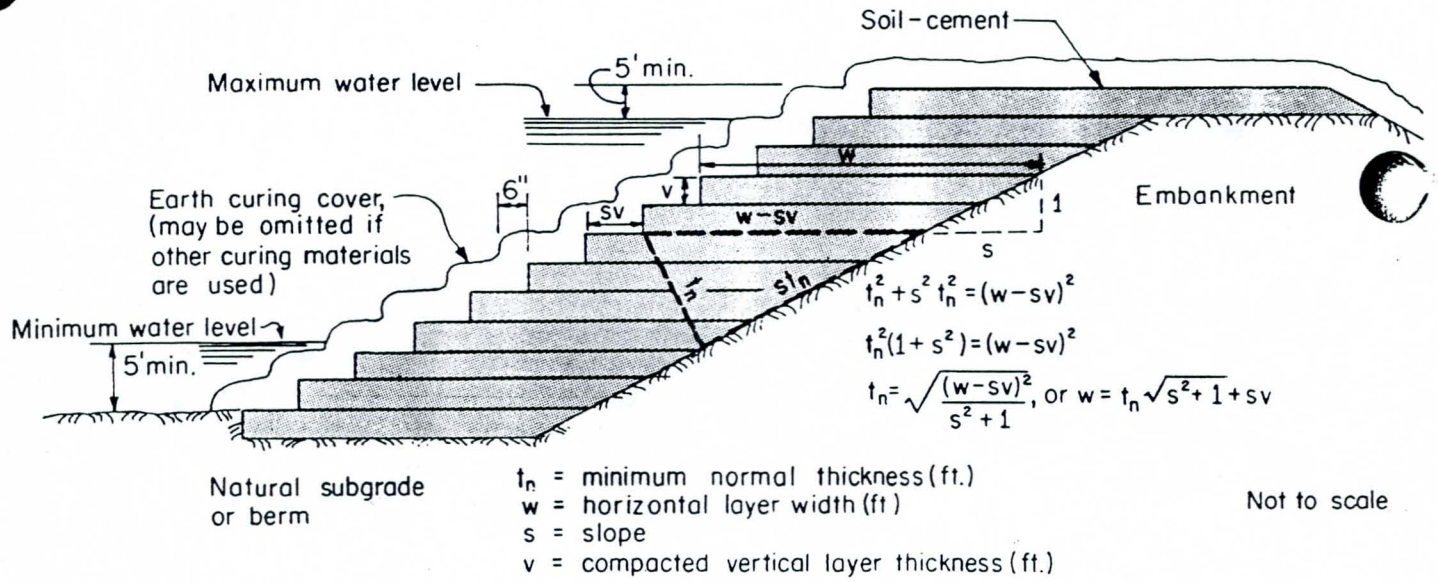


Fig. 4. Typical soil-cement slope protection.

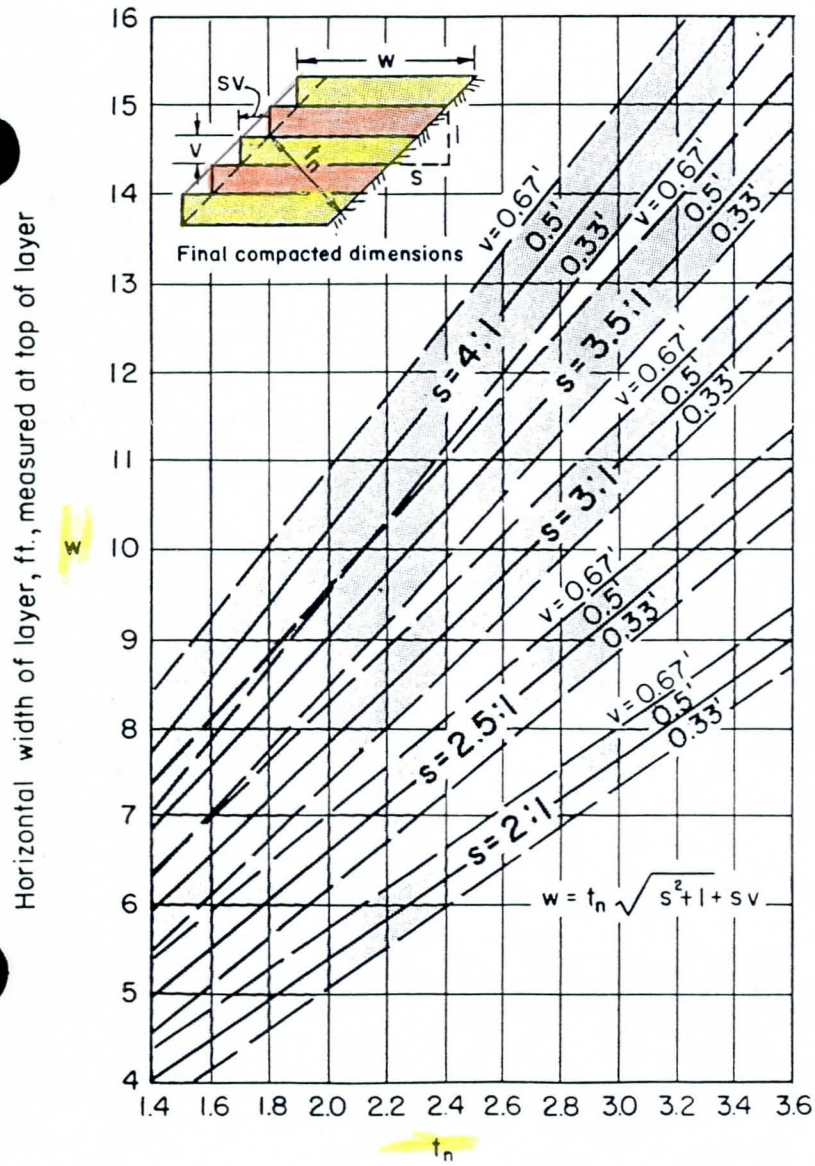


Fig. 5. Nomograph of soil-cement slope protection dimensions.

CEMENT

Any type of portland cement meeting the requirements of the latest American Society for Testing and Materials (ASTM), American Association of State Highway Officials (AASHO), or federal specifications may be used (ASTM C 150, C 175, or C 205; AASHO M 85, M 134, or M 151; or Federal SS-C-192 or SS-C-197).

Type I, or normal portland cement, is most commonly used, as the special properties of other types of portland cement are not usually required for soil-cement construction. Where sulfate soils or waters are encountered, however, the use of Type II or Type V portland cement may be desirable. Type I or Type IS cement may be used in sulfate soil or water environments if the amount of tricalcium aluminate (C_3A) in the cement is low enough to meet the requirements for sulfate resistance.

WATER

Water from most sources, whether raw or treated, and even sea water, is suitable for mixing with soil and cement. The only requirement is that it be free from excessive amounts of alkalies, acids, or organic matter that might inhibit its reaction with the soil and cement. Laboratory analyses should be made of any proposed water source of dubious quality, unless the proposed water is used for making preconstruction test cylinders.

LABORATORY DESIGN TESTS

Standard laboratory tests (ASTM D 558, D 559, and D 560) are necessary to verify the acceptability of the soil and to determine proper cement content, optimum moisture, and maximum density of the soil-cement. If on-site soils contain excessive fines, mixtures of these soils with nearby granular materials can be tested for required cement contents to determine the most economical combination. All design tests should be made by a qualified soils laboratory.

After the soil has been classified as one of the standard AASHO soil groups by sieve analyses and other tests, the required cement content may be estimated. Moisture-density curves are plotted from test mixtures using the estimated cement content and at least 4 moisture contents in order to accurately determine optimum moisture and maximum density of the mixture.

A number of test cylinders are prepared using the estimated cement content and also cement contents 2 percentage points above and below the estimated content. The results of wet-dry and freeze-thaw tests and the Portland Cement Association's weight-loss criteria will determine the cement content required for stabilization of the soil in accordance with accepted highway design standards. This cement content is then increased by 2 percentage points for erosion resistance. If it is necessary to use a soil containing more than 50 percent fines, the cement content increase required for erosion resistance is 4 percentage points. For most soils, a total required cement content of 10 to 12 percent by compacted volume of soil-cement can be considered typical.

Compressive strength tests for soil-cement (Fig. 7) are considered supplementary to the standard soil-cement tests. Soil-cement mixtures with a compressive strength of about 450 psi or more at 7 days will generally pass the wet-dry and freeze-thaw tests. Using cement contents of about 10 percent, 7-day compressive strengths of 500 to 1,000 psi are common with a wide range of soils. In some cases, coarse, well-graded, sandy soils used in conjunction with even lower cement contents have devel-

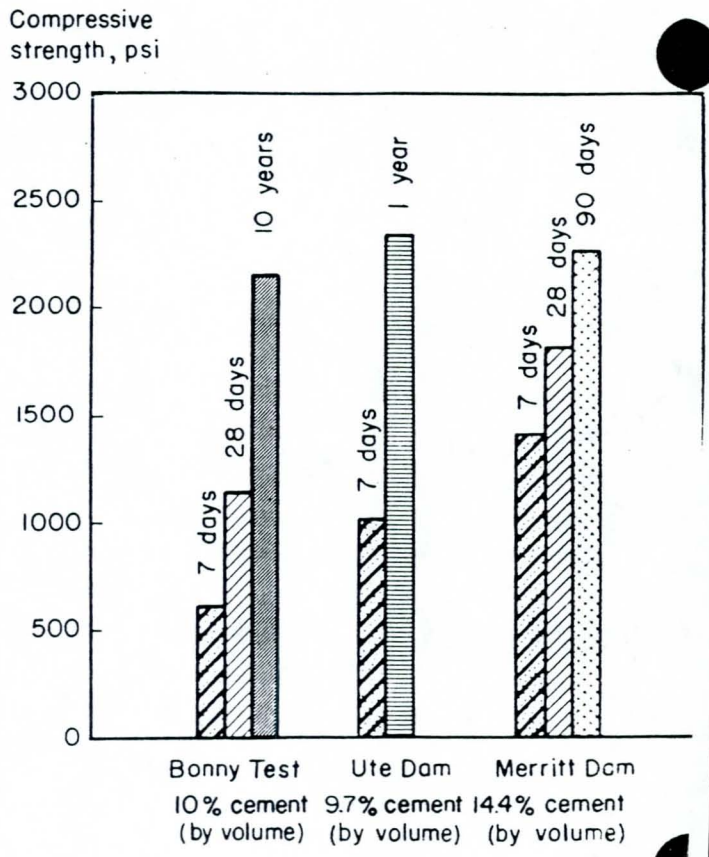


Fig. 7. Strength of soil-cement.

oped 7-day compressive strengths in excess of 500 psi. The strength gain between 7 and 28 ys is usually less than 50 percent, but the 28-day strength may be doubled in 10 years, as in the case of the Bonny Reservoir test section.

Other tests, such as the Portland Cement Association's short-cut procedures for sandy soils, are available for special situations. The short-cut procedure takes only about two weeks, instead of approximately six weeks for the standard procedures described. The short-cut method will determine a safe cement content. The more accurate results given by the standard procedure are preferable except for emergency, preliminary, or small project tests.

Construction

GENERAL

Suitable equipment maintained in good operating condition is the key to rapid, high-quality production in building soil-cement slope protection.

With adequate lighting, night operations can also be efficient and uniform, with the advantage of a lesser variation in moisture loss of the mixed material on the slope.

Moisture control is important in minimizing rinkage cracking. Shrinkage cracking is normal evidence of satisfactory hardening in all soil-cement construction. The amount of cracking varies directly with original moisture content and rate of moisture loss. These factors are of primary importance in field control. Shrinkage cracking will be held to the minimum by placing the mixture at optimum moisture content and preventing rapid loss of the moisture by proper curing. On the Bonny Reservoir test section, the pattern of narrow transverse shrinkage cracks, spaced about 10 to 20 ft. apart, developed during the first year and did not change significantly thereafter.

WEATHER CONDITIONS

Soil-cement should not be placed in freezing weather and should be protected from freezing for 7 days after placement. Earth, straw, or other suitable materials may be used for cold-weather protection. Easily removable materials, such as heavy paper or blankets, should be provided for bonding surfaces. Frozen soil should not be used in construction.

Rain is not usually a problem; the mixing ater required is generally equivalent to more han an inch of rain. The only critical time for rainfall is the brief period on mixed-in-place projects between the spreading and mixing of the cement. This period can be made as brief as weather conditions dictate.

On central-plant projects, trucks hauling the mixed soil-cement to the placing area should be provided with protective covers. Uncompacted soil-cement to which the mixing water has already been added can be protected from sudden heavy showers by rapid rolling with all available equipment to seal the surface. Once the soil-cement has been compacted and finished, it will not be damaged by rainfall.

MIXING

Soil-cement slope protection has been successfully constructed with both central-plant (Fig. 8) and mixed-in-place (Fig. 3) procedures. The central-plant method provides more accurate control, ensuring uniform mixing and resulting in a generally faster, smoother-running sequence of operations.

For small projects, the mixed-in-place method may be more economical. When mixed-in-place procedures are used, close and constant attention must be given to verify accurate depth control of the traveling mixer. The mixer blades

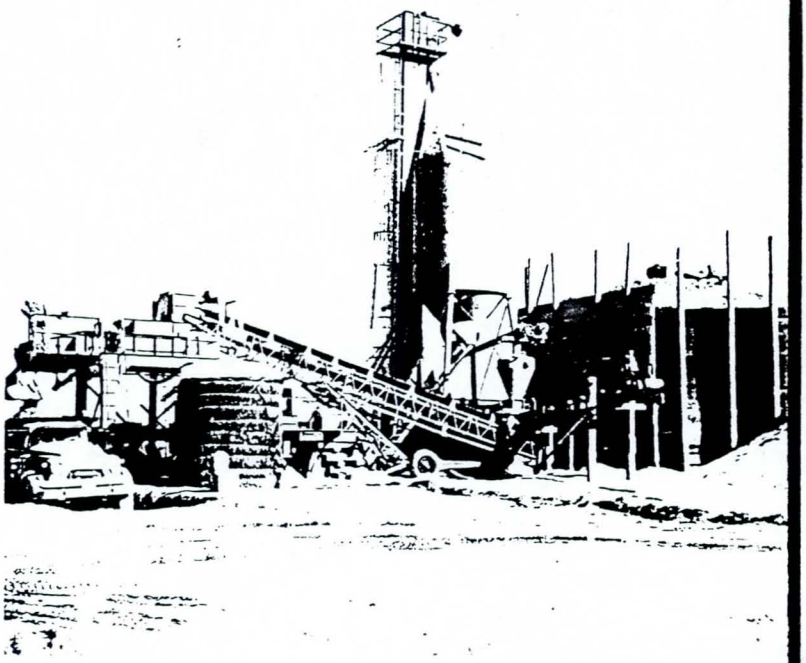


Fig. 8. Central plant at Merritt Dam near Valentine in north central Nebraska. Bulldozer at head of stockpile feeds soil hopper. A second bulldozer was used simultaneously to move material to the one visible at the upper right. Small conveyor belt at right calibrated cement feeder.

should continuously skim the completed surface below the layer being processed.

Suitable central-mix plants with capacities of 200 to 600 tons per hour are produced by several manufacturers. The plant should be of the twin-shaft pug-mill type with either continuous flow or batch operation. Specifications for the plant should provide that all materials will be proportioned within less than 3 percent by weight of the design mix quantities.

Accurate calibration of the central plant before the start of construction is essential. The soil feed rate will vary in accordance with the size, gradation, and moisture content of the stockpile. Surge hoppers and compressed air agitation are important in obtaining a uniform cement feed rate. Uniform soil feed is simplified by keeping a reasonably constant head of soil above the hopper, sometimes by using two bulldozers or other machines simultaneously on the stockpile. Shuttling or reciprocating plates in the raw soil hopper are also helpful in maintaining a steady flow of material.

The quantities of soil, cement, and water produced at various control settings should be collected separately and weighed for several periods of operation. Any necessary adjustments to the plant and stockpile operations may be made then in order to bring all feed rates to the required accuracy before starting soil-cement production. The plant calibration should be rechecked periodically and whenever a change is noted in the soil-cement mixture or the stockpile. Close observation of the stockpile moisture content is necessary for continuous proportioning accuracy.

The mixing time necessary to achieve an intimate uniform combination of the soil, cement, and water will vary with the soil gradation and the mixing plant being used. Usually the time is about 30 seconds.

TRANSPORTING

The mixture should be hauled from the plant to the placing area in trucks with smooth, clean, tight beds. Protective covers should be available

Fig. 9. Complete soil-cement processing train at Ute Dam. Empty truck returns to plant as loaded truck backs up to mechanical spreader and another truck stands by. Dual windrow spreader and pneumatic-tire compactor follow closely behind placing operation.

as a precaution against sudden showers or other weather extremes.

On sizable projects, a smooth traffic flow for the hauling trucks is essential for efficiency and uniformity of construction (Fig. 9). This can be achieved by the use of a multilevel road system with intermediate earth ramps compacted to a thickness of about 2 ft. The hauling time, from completion of moist-mixing to placement for compaction, should be limited to 30 minutes.

PLACING

It is important that the surface on which the fresh soil-cement is to be placed be firm, clean, and surface-moist in order to secure uniform layers that are well bonded together.

The soil-cement should be placed through a mechanical spreader. If the width of the spreader is not equal to the desired width of the soil-cement layer, a windrow spreader should be used to obtain full layer width of the loose material. The loose thickness required for a 6-in. compacted layer is usually 8 to 9 in. The spread layer should not remain undisturbed for more than 30 minutes.

COMPACTION

Most soils can be effectively compacted with a sheepsfoot roller (Fig. 10) to the 96 or 98 percent maximum density required for soil-cement slope protection. Pneumatic-tire or steel-wheel rolling equipment can then be used for final compaction of the upper portion of the layer.

Some of the more granular soils may be satisfactorily compacted with pneumatic-tire (Fig. 11) or steel-wheel rolling only. When sheepsfoot rollers are used, the length of the feet should be less than the loose layer thickness and approximately the same as the compacted layer thickness. This will avoid damage to the completed layer below while still attaining full depth compaction in the fresh layer.

The outer edge of the layer may be compacted on the first pass of the pneumatic-tire roller, allowing about half the width of the outside tires to extend beyond the outer edge of the layer, in order to avoid shoving fresh material down the slope.

No portion of the freshly placed soil-cement layer should be left undisturbed for more than 30 minutes during compaction operations. Compaction of any portion of a layer to the required density should be completed within 1½ hours after the material has been spread (Fig. 12) to its required width and loose thickness.

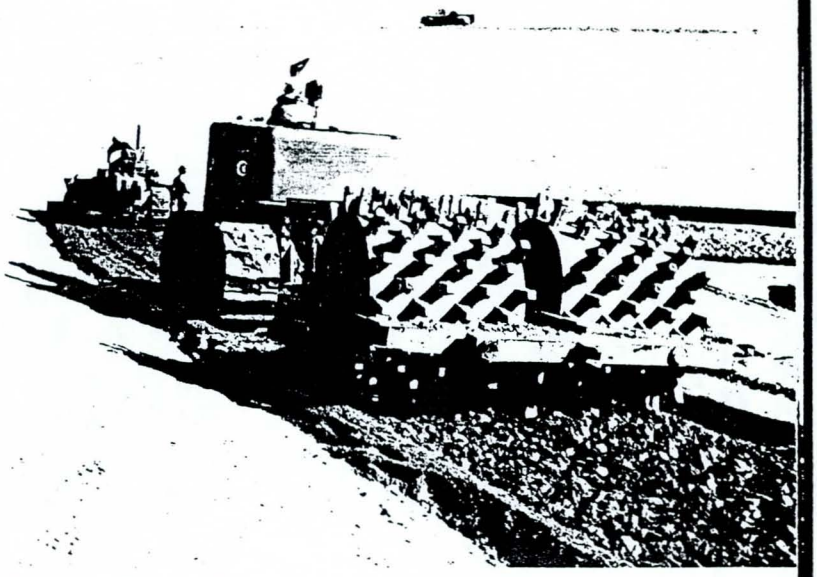


Fig. 10. Sheepsfoot roller compacts fresh soil-cement solidly against impervious zone of embankment and previously placed soil-cement layer.

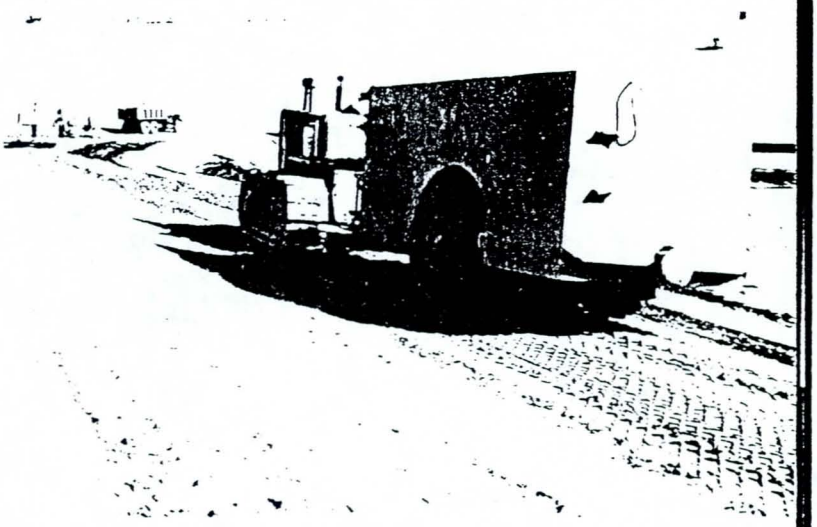


Fig. 11. Pneumatic-tire roller compacts upper portion of soil-cement layer to required density.

FINISHING

It is not necessary to trim and roll the completed layer to exact line and grade, although excessive step-backs reducing the normal thickness and feathering out of the compacted vertical thickness to less than 4 in. should be avoided. Any surface "fluff" should be rolled down, but irregularities left by pneumatic tire treads on a well-compacted surface (Fig. 11) need not be removed. The entire surface of a completed layer or section should be kept continuously moist by fine-spraying or fog-spraying with water for 7 days, or until covered by additional soil-cement or curing material.

BONDING

In order to secure good bond between the layers of the slope protection, it is essential that the lower bonding surface be clean and moist and the upper bonding surface uniformly mixed and solidly compacted. While the best bond is achieved when the lower surface is still fresh, it is not necessary to keep an exposed bonding surface continuously moist for more than 7 days. When construction of the next layer is necessarily delayed beyond this time, adequate bond can be obtained by cleaning and moistening the hardened soil-cement surface just before the new layer is placed.

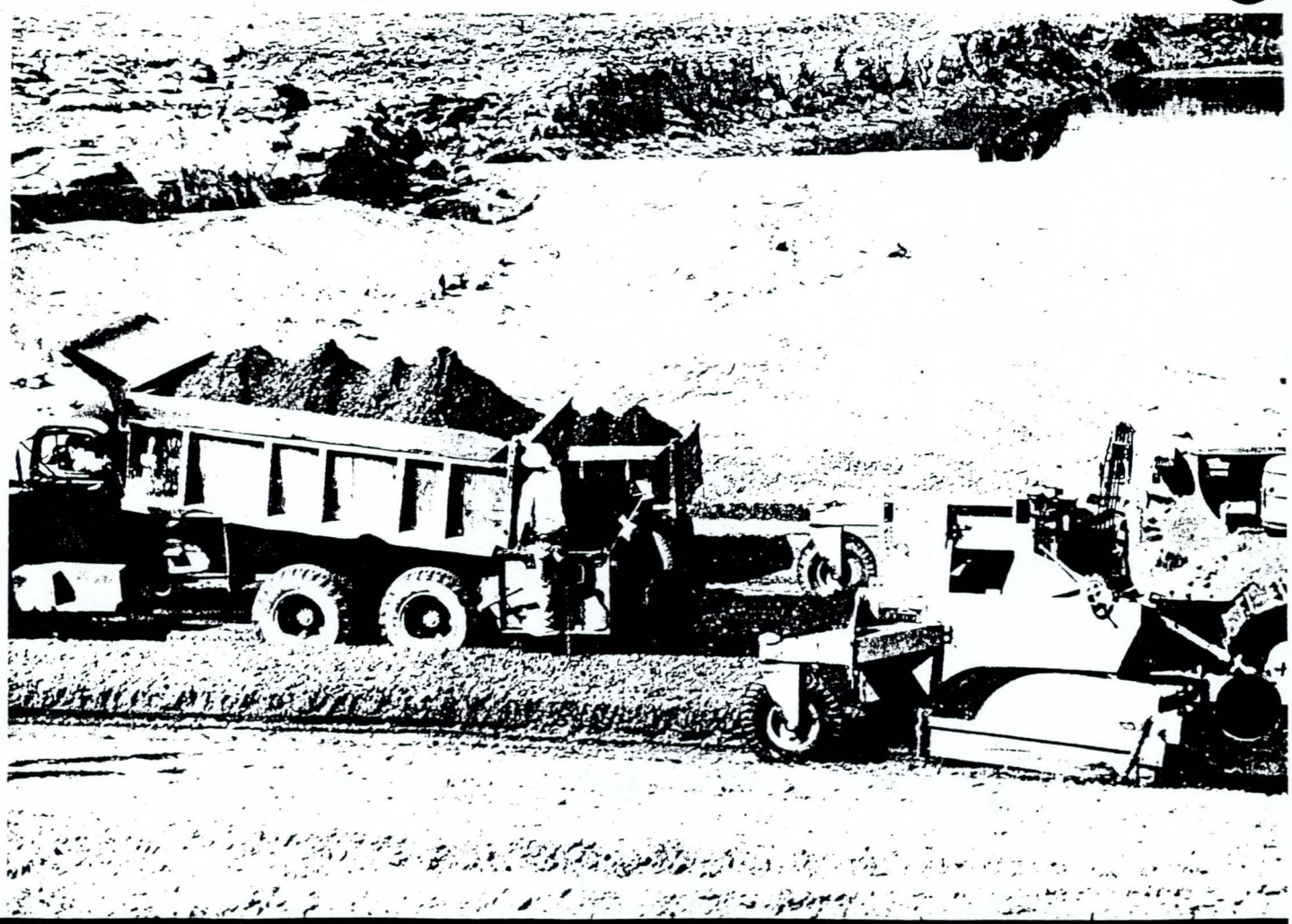
CURING

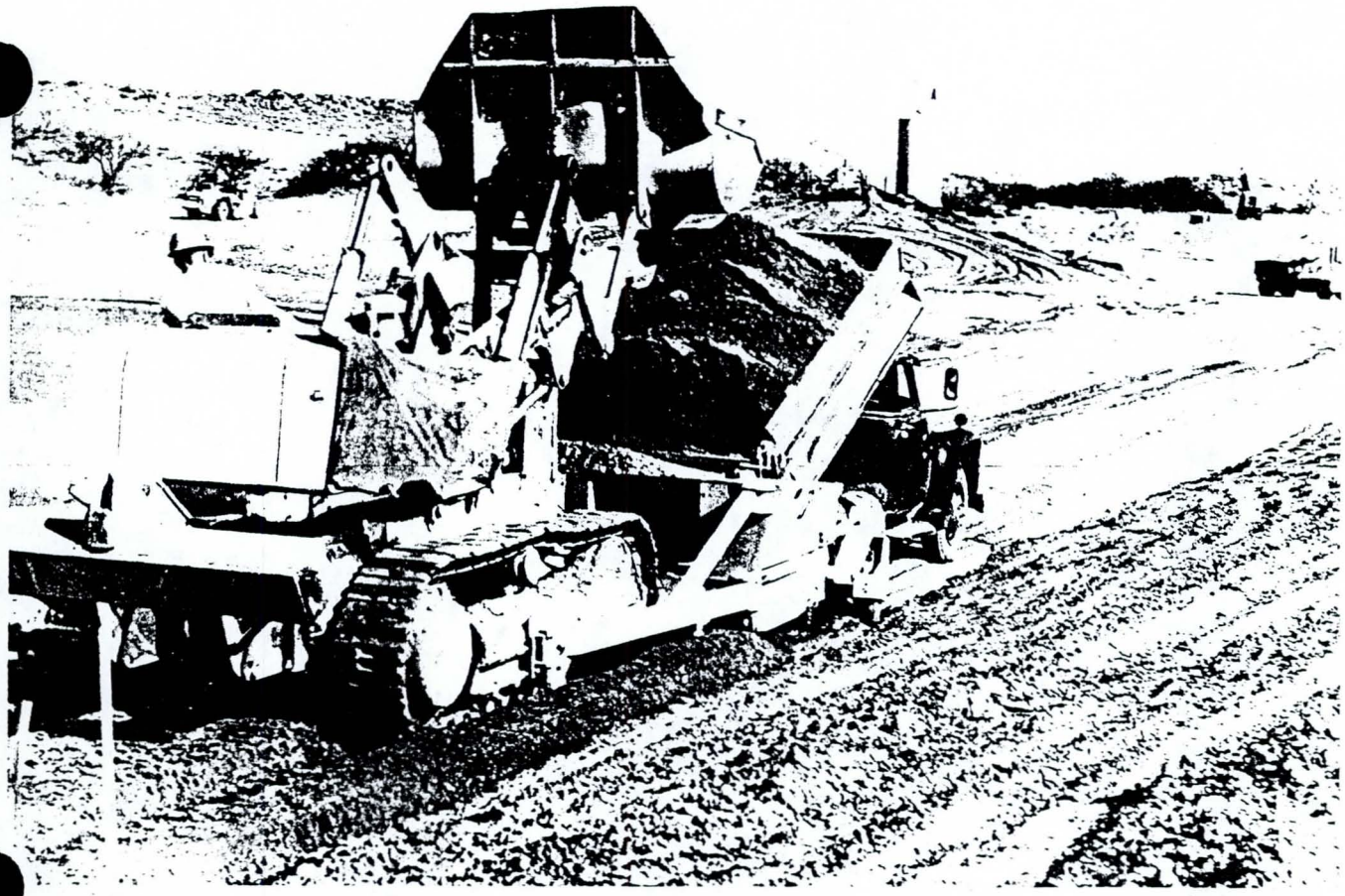
All permanently exposed surfaces should be cured for a period of 7 days. The curing material, which should be applied within 24 hours, may be a 6-in. covering of earth, a spray-applied compound, or any other material within the limits of economical practice that will prevent loss of moisture from the soil-cement.

Heavy curing papers and insulating blankets are desirable from the standpoint of speed in application and removal. If earth or liquid curing materials are used, a surface-moist condition of the soil-cement layer at the time of application is particularly essential to prevent penetration of the curing materials into surface voids. Where earth, straw, or burlap curing covers are used, they should be kept continuously moist for the 7-day period. If a bituminous curing membrane is used, it should be applied at the rate of about 0.25 gal. per square yard and maintained intact for 7 days.

Proprietary curing compounds and products

Fig. 12. Central plant mixed soil-cement (center strip) is leveled simultaneously with pervious zone material by a dual windrow spreader at Ute Dam.





ıg. 13. Soil-cement construction gets under way at Site No. 3, Cobb Creek Watershed near Weatherford in western Oklahoma. This small dam is typical of many such projects built every year by the U. S. Soil Conservation Service.

should be applied in accordance with the manufacturer's recommendations. Care should be taken to ensure that no loose or liquid curing material other than water is applied to bonding surfaces.

INSPECTION AND CONTROL

The key checkpoints for controlling field operations may be summarized as follows.

1. Subgrade condition
2. Cement content
3. Moisture content
4. Mixing
5. Compaction
6. Bonding
7. Curing

The subgrade condition can usually be controlled by visual inspection since generally the subgrade consists of a completed layer of soil-cement, which should be clean and surface-moist. The special case where soil-cement is being placed on an embankment surface also requires the presence of surface moisture plus verification that the embankment is supporting the equipment without yielding.

An adequate cement content is perhaps the control factor deserving the most attention in the field. If the mixed-in-place procedure is used, the cement spread should be spot-checked at frequent intervals.

One method of spot-checking is to place a square-yard canvas ahead of the cement spreader. After the spreader has passed, the canvas and the deposited cement are weighed. The net weight of deposited cement is then compared with the required cement weight per square yard. In addition, each truckload of cement should be checked by the total area over which it is spread.

The cement content being supplied at a central plant can be checked by collecting the cement output of the feeder over a convenient unit of time and comparing it with a counterpart soil-feed determination.

Cement content is commonly expressed as a percentage, by weight, to be added to the dry soil; it can also be expressed as a percentage of the compacted volume of the soil-cement mixture. In all calculations involving cement content, a 94-lb. bag of cement is considered to have a volume of 1 cu.ft. One barrel of cement is considered to weigh 376 lb. in the United States and 350 lb. in Canada. The volume percentage of cement is most convenient to use in field-spreading operations, but the percentage by weight of the dry soil is necessary for accuracy in central plant proportioning control.

Conscientious application of these key control factors for soil-cement construction will ensure a sound and durable slope protection at minimum cost.

Technical Reference List

All references listed are available free from the Portland Cement Association in the United States and Canada.

1. *Essentials of Soil-Cement*
2. *PCA Soil Primer*
3. *Soil-Cement Laboratory Handbook*
4. *Soil-Cement Construction Handbook*
5. *Soil-Cement Inspector's Manual*
6. *Short-Cut Soil-Cement Testing Procedures for Sandy Soils*
7. *Suggested Specifications: Soil-Cement Slope Protection for Earth Dams*

Fig. 14. Soil-cement construction approaches south abutment of Ute Dam.

how thick is soil-cement built?

Most soil-cement is built 6 in. thick. The thickness may be reduced if the subgrade is very stable. For very light traffic, even 4 in. may be enough. On the other hand, high volumes of traffic may call for thicknesses of 8 in. or more. An 8-in. thickness may be built in one lift, but greater thicknesses must be built in two or more layers.

Soil-cement has a substantially greater bearing value than the best granular bases. Some highway design methods take into account the quality and strength of various base-course materials. When this is done, soil-cement may be built thinner than other materials for the same traffic and subgrade conditions. Clearly, this can result in a considerable saving in construction costs.

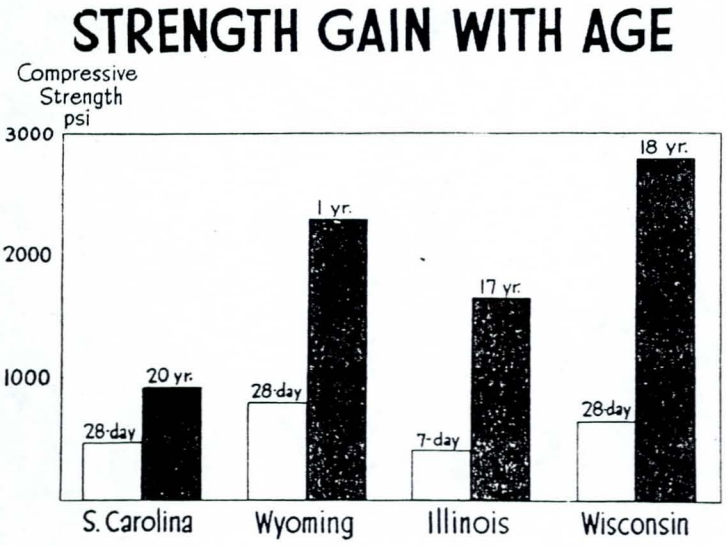
what are some of soil-cement's engineering properties?

Soil-cement is compacted to high density. As the cement hydrates, the mixture hardens in that state. It does not consolidate further under traffic, nor does it rut or "shove" during spring thaws.

Hard soil-cement can bridge over local weak subgrades. It does not soften when exposed to extreme wetting and drying or freezing and thawing.

Because soil-cement is a hardened, slab-like material, it has great load-carrying capacity. Bearing tests show that soil-cement can support over twice as heavy a load as other low-cost materials of the same thickness.

The cement in soil-cement continues to hydrate for a long time. Cores taken from roads after 15 or 20 years of use show appreciably greater strength than samples tested when the road was built. This means that soil-cement has a "reserve" of strength to accommodate higher volumes and weights of traffic.



Soil-cement grows stronger as it grows older, providing a "reserve" of strength for the future. This chart shows gains in strength of projects in four states.

what materials are needed for soil-cement?

Only three materials are needed for soil-cement: soil, portland cement, and water. The use of cheap local materials brings down the cost. The soil, which comprises about 90 per cent of the material for soil-cement, may be that in place or obtained nearby. Water is usually hauled only short distances.

soil

The word "soil" as used in soil-cement means almost any combination of gravel, sand, silt and clay. It includes such materials as cinders, caliche, shale and chat, and many waste materials.

Nearly all soils can be hardened with portland cement. They do not need to be well-graded "aggregates" because the stability of a soil-cement mixture results mainly from cement hydration and not from cohesion and internal friction of the materials.

Gradation: On the basis of gradation, soils for soil-cement construction may be divided into three groups:

1. *Sandy and gravelly soils* with about 10-35 per cent silt and clay combined are best. Generally, they require the least amount of cement. Almost all granular materials work well if they contain at least 55 per cent material passing the No. 4 sieve. Included are glacial and wind-deposited sands and gravels, crusher-run limestone, caliche and limerock. Well-graded materials may contain up to 65 per cent gravel retained on the No. 4 sieve and still have enough fines for proper binding.

2. *Sandy soils deficient in fines* may require slightly more cement than the soils in Group 1. This is true of certain beach, glacial and wind-blown sands. They make excellent soil-cement.

3. *Silty and clayey soils* make good soil-cement, but those with much clay are harder to pulverize. In general, the more clay a soil contains, the more cement it will need. If a soil can be pulverized, it is not too heavy-textured for soil-cement.

Profile: A soil profile is a vertical cross-section of the earth's surface. A soil's position in the profile can be an indication of its suitability for soil-cement construction.

Each soil layer, or horizon, is usually of a different gradation, structure or color. Color shows the soil's chemical make-up, which is sometimes more important than its gradation. For example, a red soil probably contains iron. It would react very well with cement. On the other hand, a black farmland soil may react poorly because it contains a large amount of organic material.

Soils formed from similar parent material and under the same climatic conditions, topography, drainage and vegetation are similar. They have the same soil profile wherever they are found. These soils have been identified as soil series by the U.S. Department of Agriculture. Studies have shown that a definite soil series and horizon will always require the same amount of cement.

Old Road Material: Materials in old gravel or stone base roadways make excellent soil-cement. They usually are easily pulverized and mixed, and they require a minimum of cement. If there is an old bituminous surface, it can usually be pulverized and used in the soil-cement.

Borrow Soils: Sometimes it is easier or cheaper to [illegible] borrow soil instead of the material in place. Soils [illegible]ntered in place may contain much clay, which is [illegible]er to pulverize and will require relatively high cement factors. In many cases granular or friable borrow soils are easily located nearby. The borrow may be used to blanket the clayey in-place soil or it may be combined with the in-place soil to reduce the cement factor and to make construction simpler.

portland cement

Any type of portland cement may be used if it complies with the latest ASTM specifications, C150, C175 or C205. Types I and IA, normal and air-entraining portland cements, are most common. Laboratory tests determine how much cement and water should be added and what the compacted density of the mixture should be.

water

The water used in soil-cement should be relatively clean and free of harmful amounts of alkalies, acids, or organic matter. Water fit to drink is satisfactory. Seawater may be used when fresh water is not available.

The water serves two purposes: It helps to obtain maximum compaction by lubricating the soil grains, and it is necessary for cement hydration, which hardens and binds the soil into a solid mass. Properly built soil-cement contains enough water for both purposes.

Material from worn-out stone or gravel base roads makes excellent soil-cement. Here a motor grader rips up the old base to prepare it for soil-cement processing.

What control factors are used for soil-cement construction?

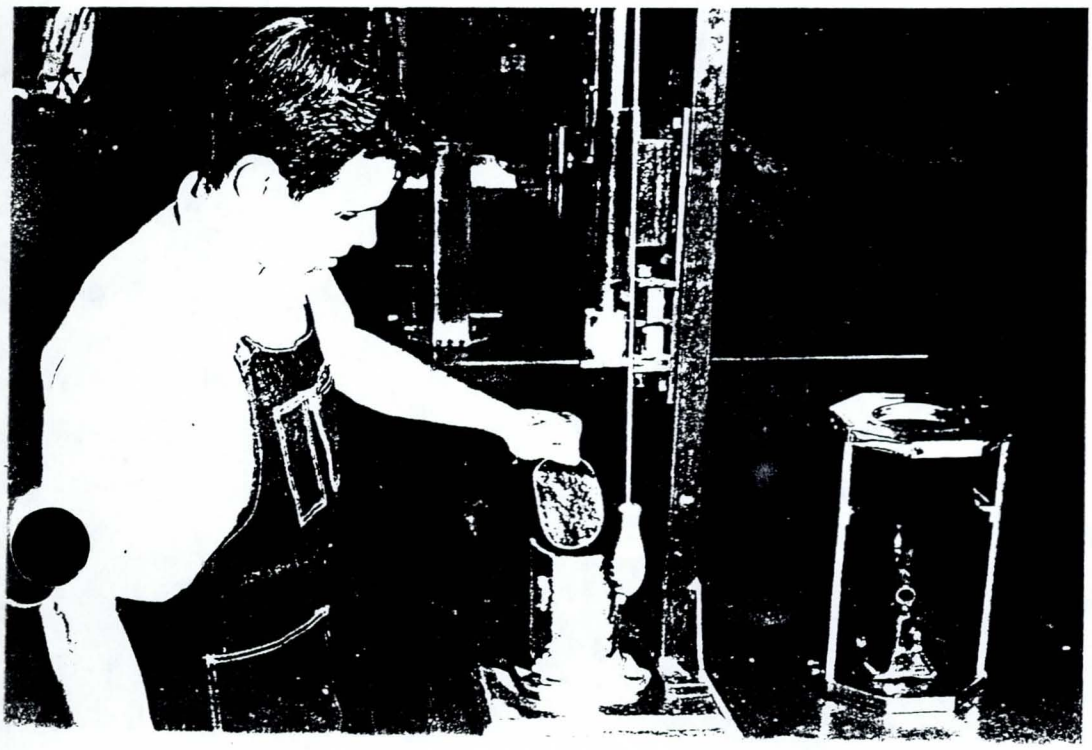
Three major controls are used in building soil-cement. They are (1) proper cement content, (2) proper moisture content and (3) adequate compaction. Simple laboratory and field tests establish these controls.

Cement Content: To find how much cement is needed, the following steps are necessary:

1. The engineer should identify and sample the soil or soils to be used for soil-cement. Laboratory tests determine the required cement content for each soil.

2. The laboratory tests to determine the cement factor ordinarily involve two series: the ASTM wetting-and-drying test: D559, and the ASTM freezing-and-thawing test: D560. (These tests are designated by AASHO as T135 and T136.)

These two series of tests use companion specimens containing different amounts of cement. The specimens undergo alternate wetting and drying and freezing and



Control factors for building soil-cement are established in the laboratory before construction begins. Soils are tested to determine the portland cement content, optimum moisture and maximum density.

thawing. The laboratory observes the behavior of the two sets of specimens for 12 cycles; results are recorded.

The cement requirement of the soil is based on how much loss the specimens undergo during the tests. A loss of up to 14 per cent is allowed for AASHO soil groups A-1, A-2-4, A-2-5, and A-3. A-2-6, A-2-7, A-4 and A-5 soils are permitted a 10 per cent loss; A-6 and A-7 groups, 7 per cent.

Sandy soils may be tested by short-cut methods. These methods are based on correlations of data from ASTM tests of thousands of sandy soils. The short-cut method for sandy soils greatly reduces the time and effort needed to find an adequate cement factor.

In some areas, other test methods have been developed. These methods are quite satisfactory, especially for local climatic and soil conditions. Table 1 gives the normal range of cement contents for the various AASHO soil groups. Generally, the more clay a soil contains, the more cement it will need.

Moisture Content and Density: The moisture content and density of compacted soil-cement should be close to the optimum moisture content and maximum density determined in the laboratory.

The moisture-density test has two important functions: It gives the optimum moisture content and maximum density for molding test specimens, and it shows how much water is needed for proper compaction and what the density should be.

The optimum moisture content is the one that produces the greatest density, referred to as the "maximum density." Soil-cement at optimum moisture is neither mushy nor dry, but it does contain enough water to make a firm cast when the mixture is squeezed in the hand. With practice, one can judge the correct amount of water by how the mixture feels. A little too much is better than not enough.

Sandy soil-cement mixtures need about 5 gal. of water per square yard for a 6-in. compacted thickness. Silty and clayey mixtures require about 7 gal. per square yard. Losses by evaporation may call for an additional 2 gal. per square yard, or more.

From a practical standpoint, the engineer should maintain the highest moisture content that will permit packing and finishing without surface checking, "shoving," rutting, or displacement.

Table 1. normal range of cement requirements for B and C horizon soils[a]

AASHO soil group	Per cent by volume	Per cent by weight
A-1-a	5-7	3-5
A-1-b	7-9	5-8
A-2-4, A-2-5, A-2-6, A-2-7	7-10	5-9
A-3	8-12	7-11
A-4	8-12	7-12
A-5	8-12	8-13
A-6	10-14	9-15
A-7	10-14	10-16

(a) "A" horizon soils may contain organic or other material detrimental to cement reaction and may require higher cement factors. For dark grey to grey A horizon soils, increase the above cement contents four percentage points; for black A horizon soils, six percentage points.

how is soil-cement built?

In soil-cement construction, the object is to mix pulverized soil with the correct amount of portland cement and enough water to permit maximum compaction. Construction is simple. It follows a set procedure.

preparation

1. *Before processing begins, any required fine grading is completed.* During grading, all debris should be removed and all soft subgrade areas corrected. Soft areas can be detected by observing the stability of an area as the motor grader passes over it. Soft subgrade areas can often be corrected by mixing in a small amount of cement

A soil-cement mixture at optimum moisture content should make a firm cast when squeezed in the hand. It may be broken into two pieces without crumbling.

WAM 6/25/90

ESTIMATE FOR RIPRAP 1 5

1) NORMAL CHANNEL SECTION (NOT INCLUDING D/S OF SILLS)

RIPRAP FOR BANKS = ~~28.44~~ 18.96 ft^2/bank

RIPRAP FOR BOTTOM = 15.22 ft^2/bank

34.18 ft^2/bank

= 68.36 ft^2 of channel

TOTAL LENGTH OF CHANNEL TO HAVE RIPRAP CONSTRUCTED:

SEGMENT	1	4756.32
"	2	1981.00
"	3	6485.00
		13,222 feet

DEDUCT DOWNSTREAM 100' SECTIONS AFTER SEVEN SILLS = 700 ft (to be estimated separately)

REMAINING LENGTH TO BE RIPRAPED

= 12,522 ft

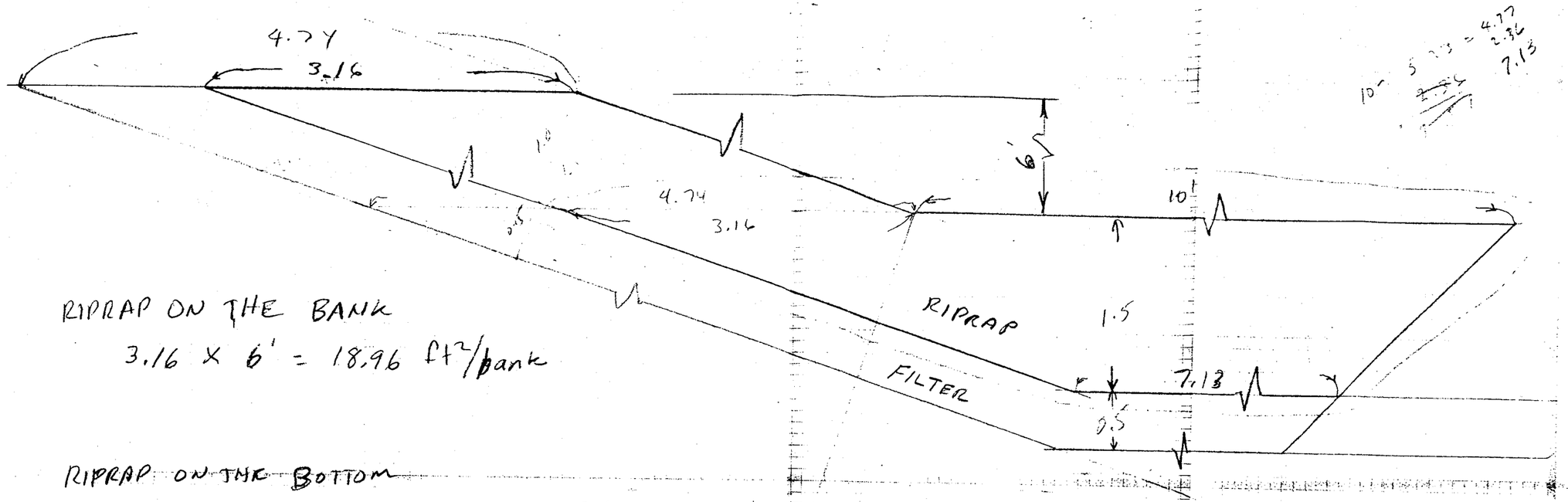
68.36 ft^2 × 12,522 feet = 856,004 ft^3

= 31,704 yd^3

→ ≐ 31,700 yd^3

SUMMARY

NORMAL SECTION	31,700
AFTER SILLS	2,900
BETWEEN RIPRAP & SILLS (3 SILLS)	400
TOTAL RIPRAP	35,000 yd^3



RIPRAP ON THE BANK

$3.16 \times 6' = 18.96$ ft²/bank

RIPRAP ON THE BOTTOM

$\frac{7.13 + 13.16}{2} \times 1.5 = 15.22$ ft²/bank

Total 43.66 /bank

= 87.32 /~~linear ft~~ of Channel

1" = 1'-0"

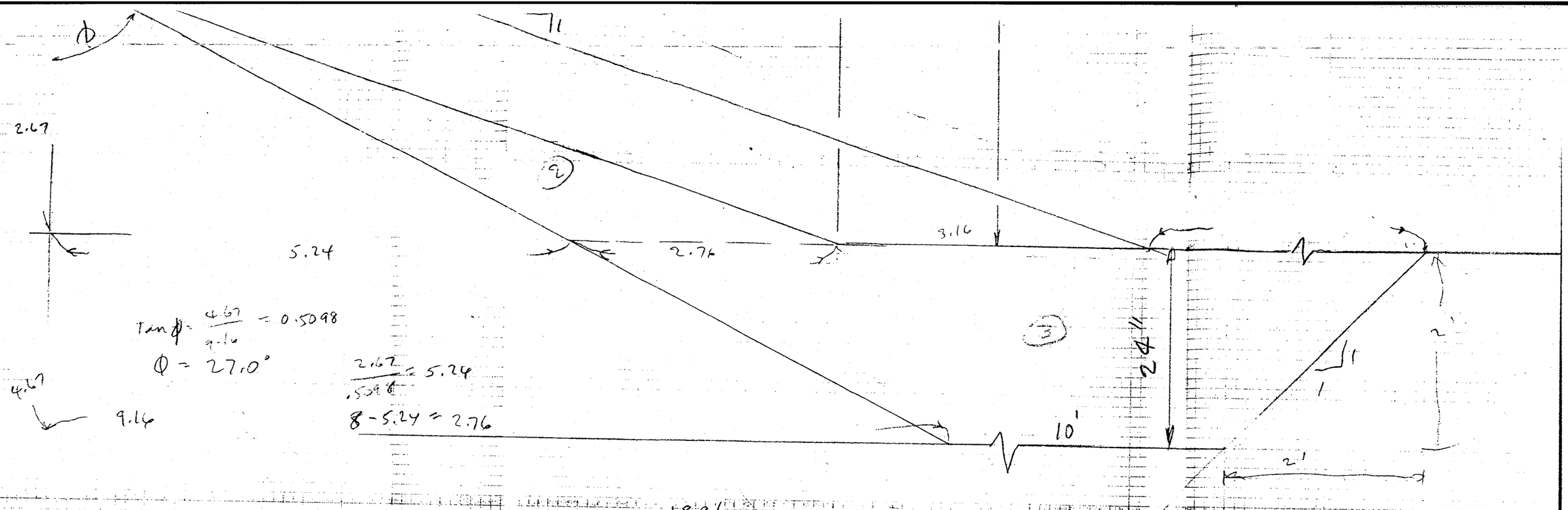
CROSS-SECTION FOR ESTIMATING RIPRAP - NORMAL SECTION

WAM 6/26/90

RIPRAP ESTIMATE 3 5

2) A 2-foot thick riprap section at toe of slope is to be placed over 100' of length downstream of each sill to protect against erosion of the channel at those points of high turbulence.

per sketches and calculations on page 4 (attached) the total riprap required for this purpose is 2,900 cubic yards.



$\tan\phi = \frac{4.67}{9.16} = 0.5098$

$\phi = 27.0°$

$\frac{2.67}{.5098} = 5.24$

$8 - 5.24 = 2.76$

Area ① $= 3.16 \times 6 =$ $= 18.96$

Area ② $= 2.67 \times 2.76 \times \frac{1}{2} =$ $= 3.68$

Area ③ $= \frac{2.76 + 3.16 + 10 + 10}{2} \times 2$ $= 25.92$

$= 48.56$ ft²/bank

$= 97.12$ ft²/channel

CONSTRUCT DOWNSTREAM OF EACH SILL, 8 REQ'D

TOTAL VOLUME $= 97.12$ ft² $\times$ 100 ft $\times$ 8 SILLS

$= 77{,}696$ ft²

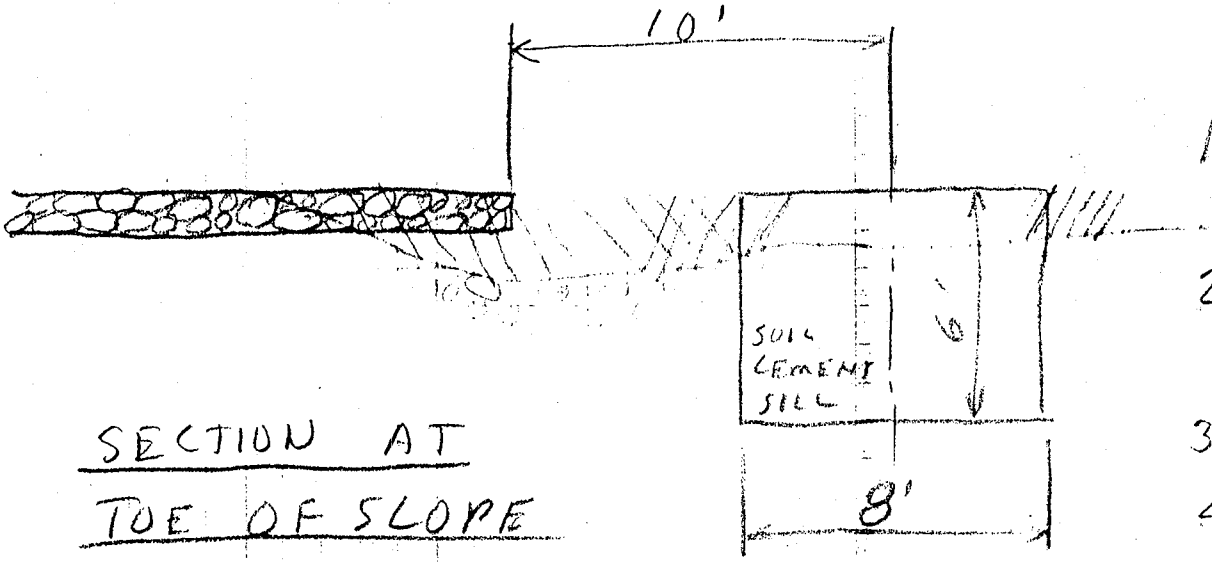
$= 2{,}878$ yd³

$\rightarrow = 2{,}900$ yd³

WAM 6/26/90

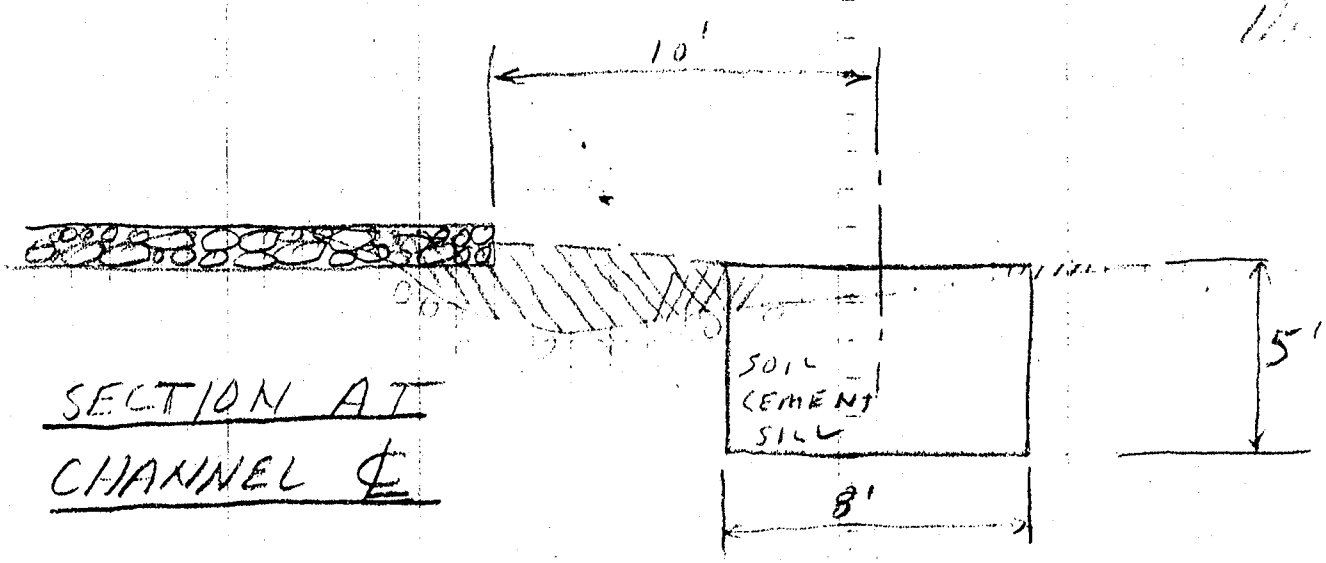
SOIL CEMENT SILLS -

EMF



SECTION AT TOE OF SLOPE

1. FILL ////
2. EXCAVATE FOR SOIL CEMENT SILL
3. INSTALL S.C.
4. EXCAVATE
5. INSTALL RIPRAP



SECTION AT CHANNEL ℄

NOTE: THIS DESIGN IS FOR SOIL CEMENT SILLS LOCATED DOWNSTREAM OF RIPRAP SECTIONS, 3-REQ'D

5 5

APPROX. AREA OF RIPRAP FILL = 15 ft³/LINEAR FOOT OF SILL

$15\,ft^2 \times 236' \times 3 \text{ SILLS} \times \frac{1}{27}\frac{yd^3}{ft^3} \approx 400\ yd^3$ RIPRAP

WAM 8/22/90

ESTIMATE FOR ABC

Recalculate ABC quantity assuming the cover on the slope for freeboard and riprap will average 3" thick because of rilling. Assume the roadway cover will average 4 1/2" thick because of jugging and rilling.

1. Extra ABC for 1' wider maintenance road in Reach 2

$1' \times 4\tfrac{1}{2}'' \times 4756'$ length $\times$ 2 banks $\times \frac{1'}{12''} = 3562\ ft^3 = \underline{\underline{132\ yd^3}}$

2. Road cover along new riprap work,

$13'$ wide $\times \frac{4\tfrac{1}{2}''}{12''/1} \times 13{,}322$ long $\times$ 2 banks $= 129{,}900\ ft^3 = \underline{\underline{4810\ yd^3}}$

3. 2" min (3" ave) cover on freeboard and bedding

$\frac{3''}{12''/1} \times 38'$ section width $\times 13{,}322' \times 2$ banks $= 253{,}120\ ft^3 = \underline{\underline{9375\ yd^3}}$

4. Reach 2 extra 1.58' width of freeboard each bank, 3" ave cover

$\frac{3''}{12''/1} \times 1.58' \times 4756' \times 2$ banks $= 3757\ ft^3 = \underline{\underline{139\ yd^3}}$

5. ABC for maintenance ramps = $\underline{\underline{300\ yd^3}}$ (see other calcs)

6. ABC road surface along existing riprap, length = 2187'

$\frac{4\tfrac{1}{2}''}{12''/1} \times 13'$ wide road $\times$ 2 banks $\times$ 2187' long $= 21{,}323\ ft^3 = \underline{\underline{790\ yd^3}}$

TOTAL EST VOLUME = $15{,}546\ yd^3$

Assume density = 1.7 Tons/yd^3

tonnage = $15{,}546 \times 1.7 = 26{,}430$ Tons

EMF REPAIR, PHASE I

WAM 6/29/30

ABC ESTIMATE - MAINTENANCE RAMPS

Estimate the ABC necessary to cover each maintenance ramp ~~and and~~ the connecting riprap base with 12" ABC cover (see attached plan of ramp).

Ramp ABC = $1' \times 13' \times 49' = 637\ ft^3$

Bottom ABC = $1 \times \frac{11.33 \times 26.51}{2}$

$+ 14.74 \times 26.51 = 150 + 391 = 541$

Total for each ramp = $1178\ ft^3$

$= 43.6\ yd^3/ramp$

For 7 ramps, $7 \times 43.6 = 305\ yd^3$

EMF

WAM 6/25/90

AGGREGATE BASE COURSE (ABC)

This is the estimate for ABC to be used as a surface course for the maintenance roads and top 2 feet of freeboard. It is to be placed 4" thick. All access roads shall also be surfaced.

Total cross-sectional area per bank

$0.33' \times 20'$ length $= 6.67\ ft^2$ / bank

$= 13.33\ ft^2$ total

Total length of channel for maintenance road surfacing

Segment	1	4,772.32
"	2	1,989
"	3	6,517
		13,278.32 (Top + freeboard, 13.33 ft^2)

Exist riprap between 1208+04.42 & 1215+00 — 696

Exist riprap between 1234+89 & 1249+80 — 1491

2187 (Top only, 4" x 13' x 2 banks = 8.67 ft^2)

Total ABC $= 13,278 \times 13.33 + 2187 \times 8.67$

$= 177,030 + 18,950$

$= 195,986\ ft^3$

$= 7260.\ yd^3$

SUPERSEDED

ADD 305 yd^3 FOR RAMPS

TOTAL ABC $= 7260 + 305 = \underline{7565\ yd^3}$

EMF REACH 1 & 2 REPAIR, PHASE 1

WAM 7/26/90

ESTIMATE FOR ABC 1 2

SEGMENT 1 LENGTH = 4,756.32'

Extra ABC for segment 1 is for extra one foot (1') of cover for 14' wide maintenance road. Total extra over normal section = 1' x 4" x 4756' x 2 banks x $\frac{1'}{12''}$

= 3170 ft^3 ≈ 117 yards

Other ABC

1. Roadways = 13' wide x $\frac{1}{3}$' thick ABC x 13,322' long x 2 banks = 115,457 ft^3 = 4,276 yd^3

(REACH 1) 2. Riprap bedding, 2" thick x 38' long section per bank

Volume = 38' wide x 2" thick x $\frac{1'}{12''}$ x 13,322' long x 2 banks = 168,745 ft^3 = 6250 yd^3

(REACH 2) 3. Additional 1.58' per bank because of 0.5' extra freeboard

1.58' wide x 2" thick x $\frac{1'}{12''}$ x 2 banks x $\frac{13,322}{4,756}$ = $\frac{7016}{2,505}$ ft^3 = $\frac{260}{93}$ yd^3

TOTAL ABC = 117 + 4,276 + 6,250 + $\frac{260}{93}$

= 10,903 yd^3

Deduct 1' wide section per bank where filter fabric is embedded in bank.

$\frac{1'}{1.58'}$ x 260 yd^3 = 165

Net TOTAL ABC = 10,903 − 165

= 10,738 yd^3

WAW 8/7/90

ESTIMATE FOR ABC

Additional ABC for maintenance ramps (7 each)

area of 1' thick ABC

$13 \times 49' = 637$

$26.5 \times 13.7 = 363$

$\frac{26.5 \times 11.3}{2} = 150$

$1150\ ft^2$

$1150\ ft^2 \times 1\ ft \times \frac{1\ yd^3}{27\ ft^3} = 42.6\ yd^3/ramp$

42.6×7 ramps $= 298 \rightarrow$ **300 yd^3 Total for all ramps**

Total ABC =

$117 + 4276 + 6250 + 93 + 300 + 700$

~~$= 11{,}036\ yd^3$~~ 11,700

8/10/90

ADD ROAD SURFACE ALONG EXIST RIPRAP

1. EXIST RIPRAP STA 1208+04.42 to 1215+00 → 696'
2. " " " 1234+89 to 1249+80 → 1491'

2187'

$2187' \times 13' \times 2 \times 4'' \times \frac{1\ ft}{12\ in} = 18{,}954\ ft^3$

$= 702\ yd^3$

Each rock of the 5 sizes shall be dropped 3 times on the group of the other 4, in an enclosure, from successive heights of 10, 15, and 18 feet. The enclosure shall have a flexible medium weight galvanized iron floor or equivalent, set on a solid foundation. Order of dropping shall be Nos. 3, 2, 4, 1, 5. All rock passing a 3 inch square mesh screen after test shall be weighed and recorded as a percentage of the total initial weight of the 5 rocks.

(2) Los Angeles abrasion machine, per ASTM C-131, Grading B.

(C) Wetting and drying. The stone shall be crushed, screened, and 1000 or 1500 grams of the ¾ inch to ⅜ inch fraction taken for the test.

The crushed and graded stone shall be submerged in water for 18 hours at room temperature, after which the sample shall be drained and oven-dried at 140°F. When dry, the sample shall be cooled to room temperature. This would complete one cycle.

The percent loss shall be determined by screening the tested sample on a No. 4 sieve and shall be computed as follows:

$$\frac{100 \times \text{Weight of Material Passing No. 4 Sieve}}{\text{Total Weight of Sample}} = \%\ \text{Loss}$$

(D) Accelerated water breakdown and solubility test. Air-dry samples of representative stone weighing approximately 1 lb. each shall be immersed for 8 hours at 140°F., in distilled water, local tap water, or 3.5 percent sodium chloride solution.

SECTION 702

BASE MATERIALS

702.1 GENERAL:

Materials for use as aggregate base shall be classified in the order of preference as follows:

(A) Crushed Aggregate.

(B) Processed Natural Material.

(C) Decomposed Granite.

When base material without further qualification is specified, the Contractor may supply any of these materials. When a particular classification of base material is specified, the Contractor may substitute any higher classification of base material for the specified classification.

Except where materials are being obtained from a previously approved source, the Contractor shall give the Engineer 10 days advance notice, in writing, of the source of the base material he intends to use in order to allow sufficient time to perform the necessary tests.

702.2 CRUSHED AGGREGATE:

Crushed aggregate shall consist of crushed rock or crushed gravel or a combination thereof as defined in Section 701.

702.2.1 Soundness: The percentage of wear of crushed aggregate to be used as base will be determined as in Section 701, except that Grading B of ASTM C-131 shall be used. The percentage of wear of the material shall not exceed 40 after 500 revolutions.

702.2.2 Grading: The aggregate shall be well graded when tested in accordance with ASTM C-136 and C-117. The percentage composition by weight shall be within the following limits.

TABLE 702			
Sieve Sizes (Square Openings)	Percentage by Weight Passing Sieve		
	Select Material		Aggregate Base
	Type A	Type B	
3″	100		
1½″		100	
1⅛″			100
No. 4	30-75	30-70	38-65
No. 8	20-60	20-60	25-60
No. 30	10-40	10-40	10-40
No. 200	0-12	0-12	*3-12
P.I. MAX.	5	5	*5

*Except as required in Section 312.5 for inverted section.

702.3 PROCESSED NATURAL MATERIAL:

702.3.1 General: Processed natural material shall consist of hard, durable fragments of stone or gravel and a filler of sand or other finely divided mineral matter. It shall be free from an excess of soft or disintegrated pieces, alkali, adobe, vegetable matter, loam, or other deleterious substances.

702.3.2 Physical Requirements: When sampled and tested in accordance with standard test methods, the aggregate shall meet the following requirements:

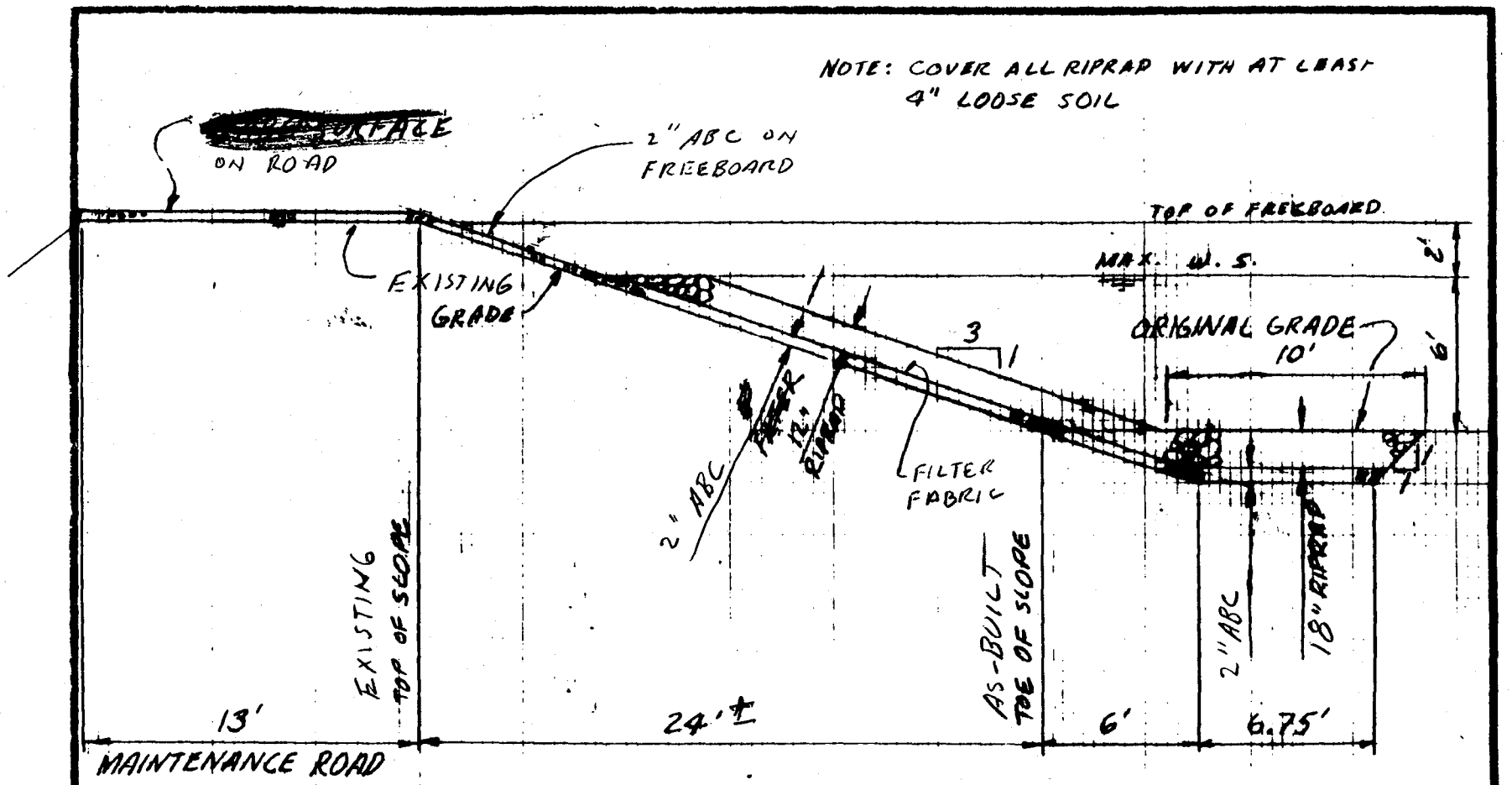
(A) Percentage of Wear: When tested in accordance with ASTM C-131, the percentage of wear shall not exceed 40 percent after 500 revolutions.

(B) Plasticity Index: When tested in accordance with AASHTO T-90, the plasticity index shall not be more than 5.

(C) Liquid Limit: When tested in accordance with AASHTO T-89, the liquid limit shall not be more than 25 percent.

702.3.3 Crushed Material: Crushed material is not required, but may be incorporated in the finished product.

702.3.4 Grading: The aggregate shall conform to the sieve analysis in this specification except that the least dimension of the maximum particle size shall not exceed ⅔ of the compacted thickness of the specified lift being placed.

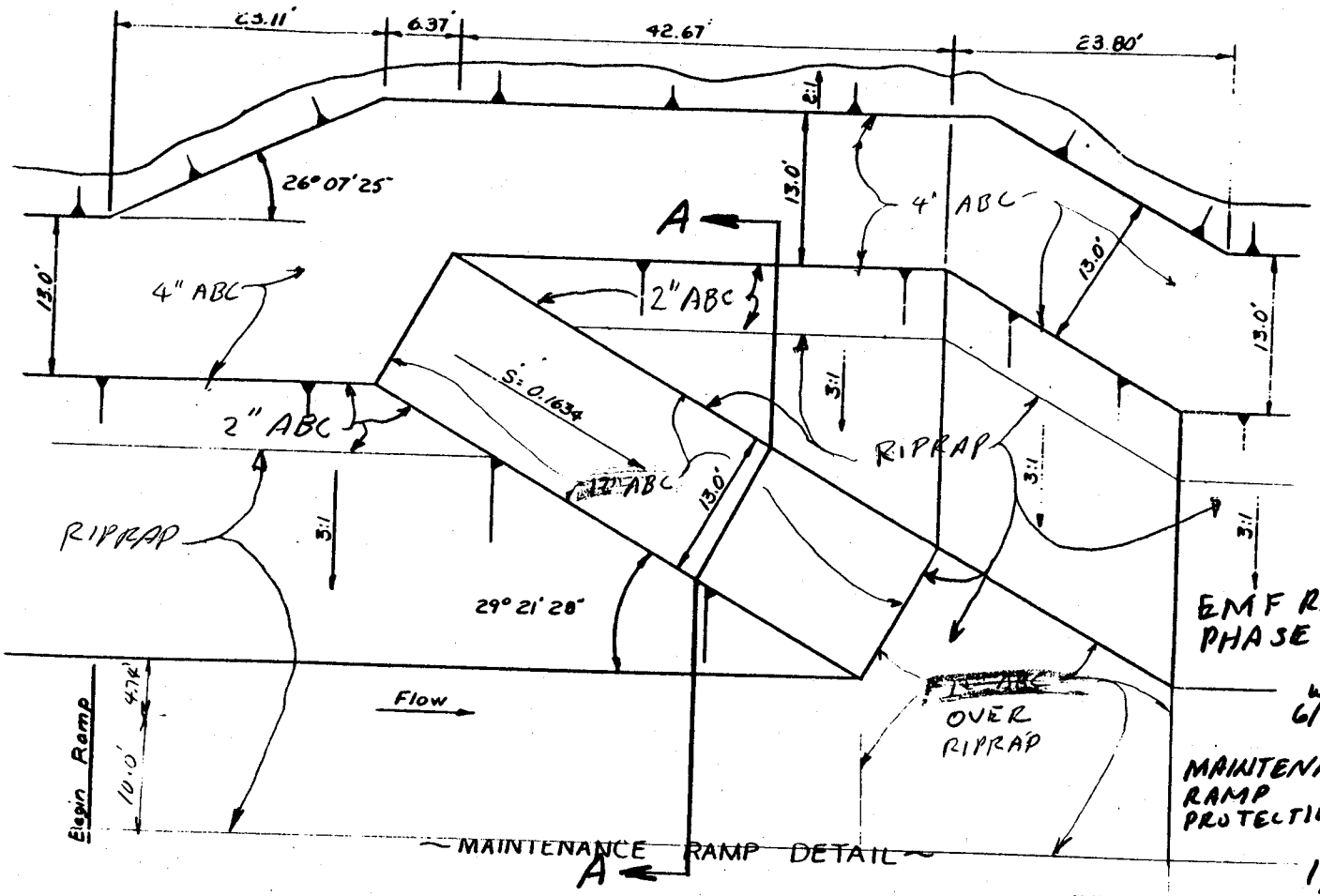


TYPICAL CROSS SECTION
OF
EARTH CHANNEL + PROPOSED IMPROVEMENTS

SCALE: 1" = 4' (ORIG DWG)

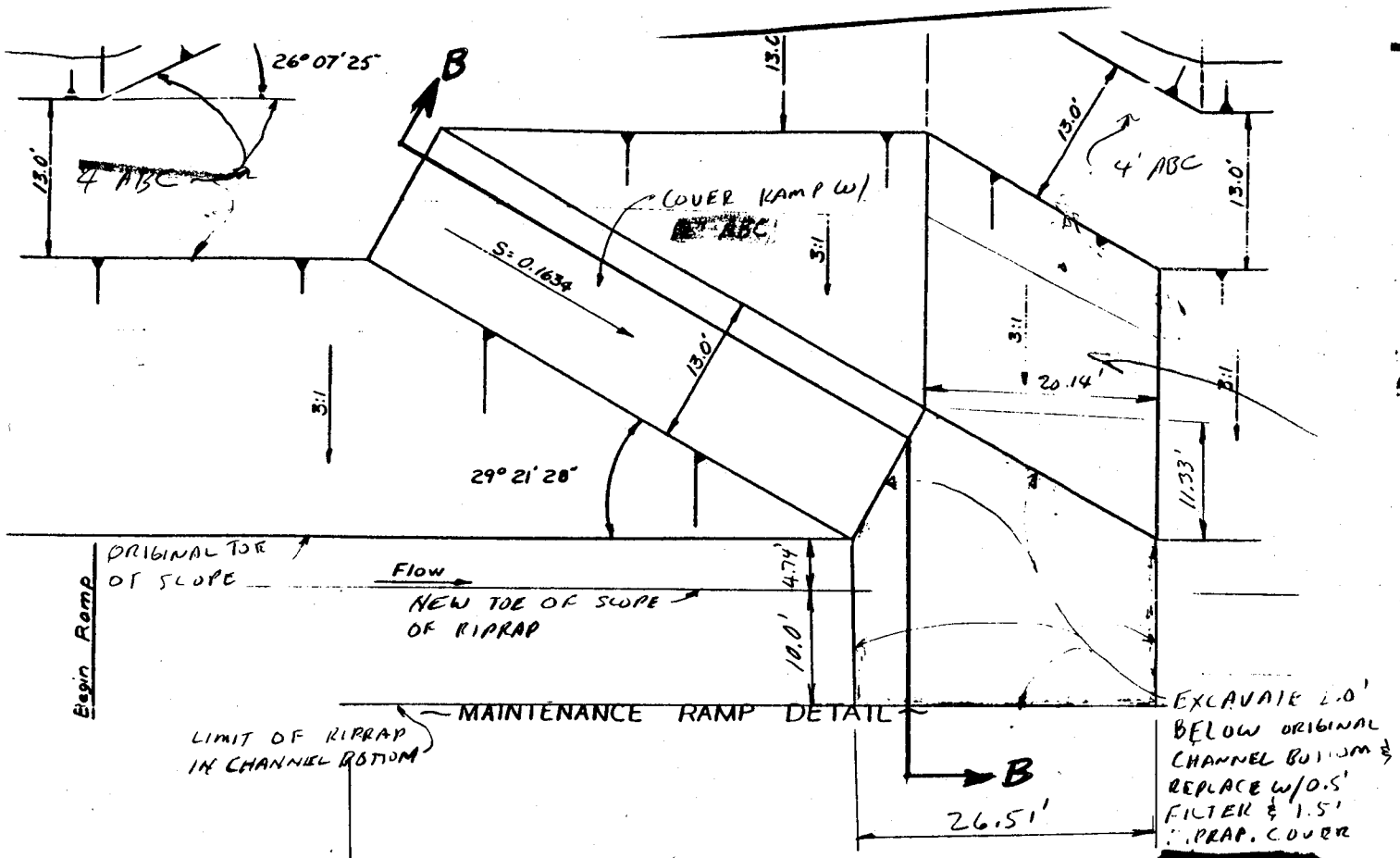
EAST MARICOPA FLOODWAY
REACH 1 & 2 REPAIR
PHASE 1

WAM 4/4/90



PROTECTION
EMF REPAIR PHASE I

WAM 6/27



EMF REPAIR
PHASE 1 WAM 6/27/90

MAINTENANCE
RAMP PROTECTION
2/4

EMF REPAIR PHASE I
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WAM 6/27

3/4

PROJECT FMF REACHES 1 & 2 REPAIR

WAM 7/26/90

FILTER FABRIC ESTIMATE

FILTER FABRIC

Membrane width per bank = 30.5'

Total length of banks = 13,322'

Total area of membrane =

30.5' x 13,322' x 2 banks = 812,642 ft²

= 90,294 yd²

→ 90,300 yd²

Estimated fabric material cost = $0.65/yd²

Estimated installation cost = $0.65/yd²

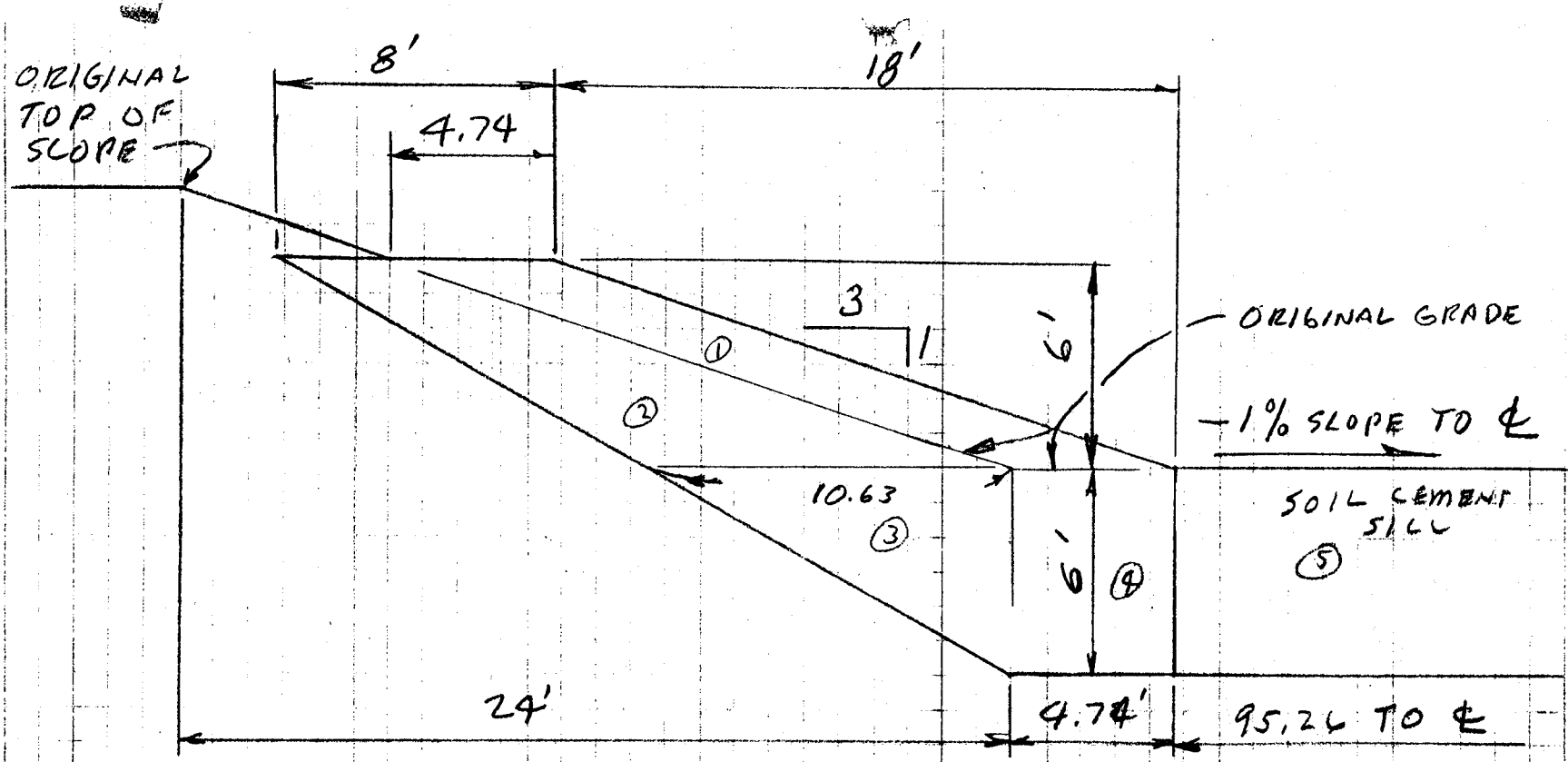
Total filter fabric unit cost = $1.30/yd²

Total Cost = 90,300 x $1.30 = $117,390

EMF REACH 1 REPAIR PHASE 1

ESTIMATE FOR SOIL CEMENT

WMM 6/28/90



$A_1 = 4.74 \times 6 = 28.56$

$A_2 = (3.26 + 10.63)\ 6 \times \frac{1}{2} = 41.67$

$A_3 = 10.63 \times 6 \times \frac{1}{2} = 31.89$

$A_4 = 6 \times 4.74 = 28.44$

$A_5 = 95.26\ (6+5)\ \frac{1}{2} = 523.93$

654.49 per bank, x2 = 1309.0

$1309.0\ ft^2 \times 8'$ wide $\times \frac{1}{27} \frac{yd^3}{ft^3} = 388\ yd^3$/sill $\times$ 8 sills = **3103 yd^3 TOTAL SOIL CEMENT**

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WAM	DATE 9/12/90	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET 1 OF 1

Station limits for fill at toe of slope before excavation and placement of riprap

Station	to	Station	Bank - Left/Right
1249+80		1250+50	L
1254+00		1258+50	R
1263+33 (pipe inlet)		1265+50	R
1274+00		1279+00	R
1291+50		1293+00	R
1294+00		1303+00	R
1305+00		1307+50	R
1213+00		1214+00	L
1315+46		1316+60	L

Note: Based on field survey conducted 9/11/90 WAM

EMF REACHES 1 & 2 REPAIR

WAM 9/6/90

SURVEY/COMPUTER DATA

Computer Reference	Sections	Stationing
Job #1	1 thru 63	1450+50 to 1368+35
Job #2	1 thru 94	1367+34 to 1249+90
Job #3	1 thru 39	1234+85 to 1160+50
Job #4 (same as #3)	"	"
Job #5 (Same as #1)	1 thru 63	1450+50 to 1368+35

WAM 7/27/90

EXCAVATION ESTIMATE

1) NOTE: Excavation was originally estimated based on a 6" aggregate filter being placed under the riprap. However, this week the decision was made to use a filter fabric under the riprap and a 2" layer of ABC bedding under the filter fabric. This will result in 4" less excavation in the toe of slope and channel bottom portions of the construction.

Total Volume of reduction, assuming both banks are affected over the entire length of construction:

Scaled width per bank = 12.8'

$$12.8' \text{ wide} \times 13{,}322' \text{ long} \times 2 \text{ banks} \times 4'' \text{ thick} \times \frac{1 \text{ ft}}{12 \text{ in.}}$$

$$= 113{,}681 \text{ ft}^3 = 4{,}210 \text{ yd}^3$$

Former estimate for general excavation

$$= 22{,}000 \text{ yd}^3$$

$$22{,}000 - 4{,}200 = 17{,}800 \text{ yd}^3$$

Add 3100 yd³ for excavation for sills,

Ex = 17,800 + 3100 = 20,900 yd³

2) note:

Most of the calculations for fill are for material necessary to fill beyond the riprap in the channel and is not affected by change in material under the riprap. ∴ Fill Volume will not change.

EMF REACH 1 & 2 REPAIR, PHASE I

WAM 7/2/90

LOW-FLOW-CHANNEL GRADING

	SECTION NO	STATION	FILL	END AREA	LENGTH	Vol yd^3
LEFT	19	1343	0	0		
	20	1344	0.5x20	10	100	500
	21	3	1.0x20	20	100	1500
	22	2	1.0x20	20	100	2000
	23	1	1.0x20	20	100	2000
	24	1340	1.0x20	20	100	2000
	25	1339	0	0	100	1000
						9,000
	42	1320	0	0		
	43	1319	1.0x20	20	100	1000
	44	1318	2.0x20	40	100	3000
	45	1317	2.0x20	40	100	4000
	46	1316	1.5x20	30	100	3500
	47	1315+50	2.0x20	40	50	1750
	48	1315+19	0	0	31	620
						13,870
RIGHT	67	1285	0	0		
	68	1283	1.5x20	30	200	3000
	69	1281	2.0x20	40	200	7000
	70	1280	2.0x20	40	100	4000
	71	1279	2.0x20	40	100	4000
	72	1278	2.0x20	40	100	4000
	73	1277	2.0x20	40	100	4000
	74	1276	2.0x20	40	100	4000
	75	1275	1.5x20	30	100	3500
	76	1274+25	1.0x20	20	25	625
	77	1274	2.0x20	40	25	750
	78	1273	1.2x20	24	100	3200
	79	1272	0	0	100	1200
						39,275
	82	1266	0	0		
	83	1264	1.5x20	30	200	3000
	84	1262	1.5x20	30	200	6000
	85	1260	1.7x20	34	200	~~3200~~
	86	1258	2.0x20	40	200	3700
	87	1256	2.0x20	40	200	8000
	88	1254	2.0x20	40	200	8000
	89	1253	1.5x20	30	100	3500
	90	1252	0	0	100	1500
						36,900

total = 99,045 ft^3 = 3,668 yd^3

ATION SHEET

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TE PROJECT

WAM 6/25/90
SUBJ EARTHWORK CALCULATIONS

SUMMARY

TOTAL GENERAL EXCAVATION AT TOE OF SLOPE	22,000 yd^3
TOTAL FILL ALONG TOE OF SLOPE	2,000 yd^3

8/27/90

NOTE The estimate for fill above (2000 yd^3) was based on fill at the end of riprap being 5' wide. The width was later changed to 2' wide which would have resulted in about 50% reduction of fill. However, in mid-August there was flow in the channel which caused some erosion, and likely increased the need for fill. In lieu of having a new survey, the amount of fill was left at 2000 yd^3

WAM

EMF REPAIR

WAM 6/20/90

EARTHWORK CALCULATIONS

-For filled channel conditions

-MATERIAL FOR RIPRAP COVER = 8.1 ft^2 -

ELEVATION WITH RESPECT TO ORIGINAL GRADE * (1)	(2) ΔEX	QUANTITIES IN FT^2 EX (3)	EX FACTOR (4)	EXCESS EX (5)
0	-	21.5 →	22	13.4
0.1	1.5	23.0	23	14.9
0.2	1.5	24.5	25	16.4
0.3	1.6	26.1	26	18.0
0.4	1.6	27.7	28	19.6
0.5	1.6	29.3	29	21.2
0.6	1.7	31.0	31	22.9
0.7	1.7	32.7	33	24.6
0.8	1.7	34.4	34	26.3
0.9	1.7	36.1	36	28.0
1.0	1.7	37.8	38	29.7
1.1	1.8	39.6	40	31.5
1.2	1.8	41.4	41	33.3
1.3	1.8	43.2	43	35.1
1.4	1.9	45.1	45	37.0
1.5	1.9	47.0	47	38.9
1.6	1.9	48.9	49	40.8
1.7	2.0	50.9	51	42.8
1.8	2.0	52.9	53	44.8
1.9	2.0	54.9	55	46.8
2.0	2.1	57.0	57	48.9
2.1	2.1	59.1	59	51.0
2.2	2.1	61.2	61	53.1

* This table is for elevations above original grade (original grade = elev 0)

(1) Assumed elev in feet above original grade
(2) Change in sq ft area of excavation of channel bottom, 1 bank
(3) Total excavation reqd to place riprap + 6" filter, in ft^2 per bank
(4) Item (3) rounded off

(5) Excess excavated material after deducting 8.1 ft^2 for riprap cover

WAM 6/21/90

EARTHWORK CALCULATIONS

Note:- Material needed for riprap cover = 8.1 ft^2

- All figures in ft^2 - for eroded channel conditions

ELEVATION WITH RESPECT TO * ORIGINAL GRADE	QUANTITIES IN FT^2						
	Δ EX	EX FACTOR		Δ FILL	FILL FACTOR		EXCESS EX
1	2	3					
0	—	21.5	22	—	0		13.4
-0.1	-1.4	20.1	20	0.5	0.5	1	11.5
-0.2	-1.4	18.7	19	0.6	1.1	1	9.5
-0.3	-1.4	17.3	17	0.6	1.7	2	7.5
-0.4	-1.3	16.0	16	0.7	2.4	2	5.5
-0.5	-1.3	14.7	15	0.8	3.2	3	3.4
-0.6	-1.3	13.4	13	0.8	4.0	4	1.3
-0.7	-1.2	12.2	12	0.9	4.9	5	-0.8
-0.8	-1.2	11.0	11	0.9	5.8	6	-2.9
-0.9	-1.1	9.9	10	1.0	6.8	7	-5.0
-1.0	-1.1	8.8	9	1.0	7.8	8	-7.1
-1.1	-1.0	7.8	8	1.0	8.8	9	-9.1
-1.2	-1.0	6.8	7	1.1	9.9	10	-11.2
-1.3	-0.9	5.9	6	1.2	11.1	11	-13.3
-1.4	-0.9	4.8	5	1.2	12.3	12	-15.6
-1.5	-0.9	3.9	4	1.3	13.6	14	-17.8
-1.6	-0.8	3.1	3	1.3	14.9	15	-19.9
-2.0	-3.1	0		5.6	20.5	21	-28.6
-3.0				22.0	42.5	42	-50.6
-5.0				47.4	89.9	90	-98.0
-6.0				25.0	114.9	115	-123.0

BORROW NEEDED

* This table is for elevations below original grade (Original grade = 0)

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY WAM	DATE 6/18/90	CHECKED BY	DATE	JOB NO.

SUBJECT: EXIST. CONDITIONS - APPROX FILL / APPROX EROSION

SHEET ____ OF ____

	STA	APPROX FILL L	APPROX FILL R	APPROX EROSION L	APPROX EROSION R
1	1450+50	1.2	1.2		
2	1449+50	2.0	1.5		
3	1448+50	1.2	2.0		
4	1448	1.4	2.0		
5	1447	1.5	1.5		
6	1446	1.5	1.5		
7	1445	1.2	1.0		
8	1444	0.6	0.6		
9	144[illegible]	0.6	0.6		
10	144[illegible]	1.2	0.8		
11	1441	1.2	1.0		
12	1440	1.2	1.0		
13	1439	1.1	1.0		
14	1438	1.2	2.0		
15	1437	0.8	0.6		
16	1436	0.4	0.5		
17	1435	0.6	0.6		
18	1434	0.8	0.4		
19	1433	0.7	0.7		
20	1432	0.8	1.2		
21	1431+50	0.7	1.3		
22	1431+25	0.8	1.0		
23	1430+97	0.7	0.6		
24	1430+70	1.1	1.1		
25	1430	1.0	1.0		
26	1429	1.1	1.0		
27	1428	1.1	1.0		
28	1427	1.7	1.0		
29	1426	1.2	1.0		
30	1425	0.8	0.9		
31	1424	0.9	0.8		
32	1423	0.6	0.7		
33	1422	0.6	0.7		

COMPUTATION SHEET
CS-ENG-522 REV. 3-69

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY	DATE 6/18	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET ____ OF ____

34	1421	0.4	0.6		
35	1420	0.4	0.5		
36	1419	0.2	0.7		
37	1418	0.2	0.4		
38	1417	0	0.6		
39	1416		0.6	0.2	
40	1415 150	0.2	0.4		
41	1415			-1.0	-1.0
42	1401+41	0.8	0.8		
43	1401	0.8	0.8		
44	1400	1.0	0.9		
45	1399	1.1	0.5		
46	1398	1.0	0.9		
47	1397	0.4	1.0		
48	1396	0.6	1.1		
49	1395+40	0.7	0.3		
50	1381	2.0	1.6		
51	1380	1.2	1.4		
52	1379	1.2	2.0		
53	1378	2.0	2.0		
54	1377	2.0	1.8		
55	1376	2.0	1.8		
56	1375	2.0	2.0		
57	1374	1.8	2.0		
58	1373	2.0	2.5		
59	1372	2.0	2.5		
60	1371	2.2	2.2		
61	1370	1.2	1.2		
62	1369	1.2	1.2		
63	1368+35	1.4	1.2		

WPM 6/18
#2

	STA	Approx Fill L	Approx Fill R	Approx Erosion L	Approx Erosion R
1	1367+34	1.3	1.5		
2	1366	0.5	0.2		
3	1365	1.0	0.4		
4	1364	1.0	0.1		
5	1363	0.8	0.2		
6	1362	0.9	0.7		
7	1361	0.8	1.3		
8	1360	0.7	0.8		
9	1358	1.4	0.6		
10	1356	0.7	0.7		
11	1355	0.6	1.1		
12	1353	0.7	0.8		
13	1351	0.7	0.7		
14	1350	0.8	1.0		
	1349	0.7	0.6		
	1348	0.6	0.7		
	1347	0.8	1.4		
18	1346	0.6	0.4		
19	1345	0.5	0.7		
20	1344	0.6	0.8		
21	1343		0.9	0.5	
22	1342		0.8	0.5	
23	1341		0.1	1.2	
24	1340			0.7	0.5
25	1339	0			0.2
26	1338	0.1	0		0
27	1337	0	0		
28	1336	0.1	0		
29	1335	0.1	0		
30	1334	0	0		
31	1333	0	0.7		
32	1332	0.2	0.2		
33					

WAM 6/18/20

	Sta	Approx Fill L	Approx Fill R		Approx Erosion L	Approx Erosion R
33	1331	0.1	0.1			
34	1330	0.1	0.1			
35	1329	0	0.1			
36	1327				0.3	0.3
37	1325				0.2	0.2
38	1324				0.2	0.2
39	1323		0		0.3	
40	1322		0		0.4	
41	1321		0	(bank eroded) (needs fill)	0.3	
42	1320				0.3	0.1
43	1319				1.1	0.6
44	1318 (V end bank)		0.1		1.0	
45	1317			(no fill)	0.7	0.1
46	1316		0.1		0.4	
47	1315+50				1.0	1.0
48	1315+19 (roadway)	0.5	0.6			
49	1314		1.2		0.4	
50	1313		0.4		0.4	
51	1312	0.3	0.4			
52	1310	0.8	0.2			
53	1308	0.3				0.2
54	1306	0.5				0.6
55	1304	0.2				0.3
56	1302 ← 1301 SILLRD	0.4				0.1
57	1300	0.4				0.6
58	1298	0.3				0.6
59	1296	0				0.6
60	1294	0			0.1	0.2
61	1292	0.1	0.1			
62	1290	0	0.2			
63	1289		0.2		0.2	

1314+97 Begin Dip crossing

1315+44 end riprap downstream of dip crossing

1315+54 ℄ 8' wide sill

WPM 6/18/80

	STA	L	R		L	R
SILC #6	64 1288		0.2		0.4	
	65 1287		0.2		0.1	
	66 1286		0.3		0.5	
	67 1285		0.2		0.1	
	68 1283		~~0.4~~		0.4	0.4
	69 1281		~~1.0~~		0.4	1.0
	70 1280		~~2.0~~		0.4	2.0
	71 1279			bank fill	0.5	2.0
	72 1278			under	1.2	2.0
	73 1277 (Vert			"	0.5	1.2
	74 1276 Slope)			"	0.2	1.2
	75 1275			"	0	1.2
	76 1274+25			"	0	1.0
	77 1274			"	0	1.5
	78 1273	0.1				0.8
	79 1272	0.1				0.6
	80 1270				0	0.2
	81 1268 ← SILC #5 1268+50	0.3				0.7
	82 1266	0.1				0.9
	83 1264	0.1				1.2
	84 1262	0.1				1.4
	85 1260	0.1				1.4
	86 1258	0.1				2.0
	87 1256	0				1.6
	88 1254	0.1				1.6
	89 1253	0				1.0
	90 1252	~~0.2~~			0.2	0.4
	91 1251	~~0.4~~			0.4	0.4
	92 1250+40	~~1.5~~			3.0 ~~1.5~~ 5.0	0.4
	93 1250+20			Bank full	5.0 ~~2.5~~	0.4
	94 1249+90			"	6.0	2.0
	1249+80 = end survey					

1249+90 - SILC #4

COMPUTATION SHEET
SCS–ENG–522 REV. 3–69

#4

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY [illegible]	DATE 6/18/90	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET ____ OF ____

#3 & #4 are same?

	STA	Approx Fill L	Approx Fill R	Approx Erosion L	Approx Erosion R
1	1234+85	0.4	0.3	~~0.2~~	~~0.2~~
2	1234			0.2	0.2
3	1232			0.2	0
4	1230			0.2	0
5	1228			0	0.2
6	1226			0.6	0.6
7	1225			0	0
8	1224			0.3	0.3
9	1222			0.6	0.6
10	1220			0.3	0.4
11	1218			0.4	0.3
12	1216			0.5	0.8
13	1215			0.8	0.8
	1208	0.7	1.0		
15	1207	0.3	1.0		
16	1205	1.5	1.3		
17	1203	1.0	1.0		
18	1201	0.2	0.3		
19	1199	0.2	1.0		
20	1197	0.5	0.3		
21	1195	0.2	0.5		
22	1193	0.3	0.1		
23	1191	0.3	0.3		
24	1189	0.2	0.7		
25	1187	0.0	0.3		
26	1185	0.2	0.3		
27	1183	0.4	0.3		
28	1181	0.1	1.0		
29	1179		0.2	0.1	
	1177	0			0.2

COMPUTATION SHEET
SCS-ENG-522 REV. 3-69

#4

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STATE		PROJECT		
BY [illegible]	DATE 6/18/90	CHECKED BY	DATE	JOB NO.
SUBJECT				SHEET ____ OF ____

#3 & #4 are same?

	STA	Approx Fill L	Approx Fill R	Approx Erosion L	Approx Erosion R
1	1234+85	0.4	0.3	~~0.2~~	~~0.2~~
2	1234			0.2	0.2
3	1232			0.2	0
4	1230			0.2	0
5	1228			0	0.2
6	1226			0.6	0.6
7	1225			0	0
8	1224			0.3	0.3
9	1222			0.6	0.6
10	1220			0.3	0.4
11	1218			0.4	0.3
12	1216			0.5	0.8
13	1215			0.8	0.8
14	1208	0.7	1.0		
15	1207	0.5	1.0		
16	1205	1.5	1.3		
17	1203	1.0	1.0		
18	1201	0.2	0.5		
19	1199	0.2	1.0		
20	1197	0.5	0.3		
21	1195	0.2	0.5		
22	1193	0.3	0.1		
23	1191	0.3	0.3		
24	1189	0.2	0.7		
25	1187	0.0	0.3		
26	1185	0.2	0.3		
27	1183	0.4	0.3		
28	1181	0.1	1.0		
29	1179		0.2	0.1	
30	1177	0			0.2

PHASE 1

1301 SILL #7

1287 LOCATION OF SILL #6

1	2	3	4	5	6	7	8	9	10	11	12	13	14
SECT NO	STA	DIST	LEFT BANK ELEV	EX FACTOR	3 x 5 = EX ft³	FILL FACTOR	3 x 7 = FILL ft³	RIGHT BANK ELEV	EX FACTOR	3 x 10 = EX ft³	FILL FACTOR	3 x 12 = FILL ft³	
	1314+97	DIP CROSSING		END OF PHASE 1									
49	1314	147	-.4	16	2352	2	294	1.2	41	6027			
50	1313	100	-.4	16	1600	2	200	0.4	28	2800			
51	1312	150	0.3	26	3900			0.4	28	4200			
52	1310	200	0.8	34	6800			0.2	25	5000			
53	1308	200	0.3	26	5200			-.2	19	3800	1	200	
54	1306	200	0.5	29	5800			-.6	13	2600	4	800	
55	1304	200	0.2	25	5000			-.3	17	3400	2	400	
					30,652		494			27,827		1400	
56	1302	200	0.4	28	5600			-.1	20	4000	1	200	
57	1300	200	0.4	28	5600			-.6	13	2600	4	800	
58	1298	200	0.3	26	5200			-.6	13	2600	4	800	
59	1296	200	0	22	4400			-.6	13	2600	4	800	
60	1294	200	-0.1	20	4000	1	200	-.2	19	3800	1	200	
					24,800		200			15,600		2800	
61	1292	200	0.1	23	4600			0.1	23	4600			
62	1290	150	0	22	3300			0.2	25	3750			
63	1289	100	-.2	19	1900	1	100	0.2	25	2500			
64	1288	100	-.4	16	1600	2	200	0.2	25	2500			
65	1287	100	-.1	20	2000	1	100	0.2	25	2500			
66	1286	100	-.5	15	1500	3	300	0.8	34	3400			
67	1285	150	-.1	20	3000	1	150	0.2	25	3750			
68	1283	200	-.4	16	3200	2	400	0.4	28	5600			
69	1281	200	-.4	16	3200	2	400	1.0	38	7600			
70	1280	200	-.4	16	3200	2	400	2.0	57	11,400			
					27,500		2050			47,600		—	
SUBTOTALS FOR PAGE					82,952		2744			91,027		4200	

TOTAL EX THIS PAGE = 173,979 ft³ = 6,444 yd³

TOTAL FILL THIS PAGE 6944 ft³ = 257 yd³

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGNED BY	APPROVED BY
CHECKED BY	DRAWING NO.
DATE:	SHEET OF

Form SCS-316A (March 1957)

U. S. GOVERNMENT PRINTING OFFICE: 1957 O - 425111

1 SECT NO	2 STA	3 DIST	4 LEFT BANK ELEV	5 EX FACTOR	6 col 3 x col 5 = EX ft³	7 FILL FACTOR	8 3x7 = FILL ft³	9 RIGHT BANK ELEV	10 EX FACTOR	11 3x10 = EX ft³	12 FILL FACTOR	13 3x12 = FILL ft³	14
71	1279	100	-.5	15	1500	3.2	320	-2.0	0	0	21	2100	
72	1278	100	-1.2	7	700	9.9	990	-2.0	0	0	21	2100	
73	7	100	-.3	17	1700	1.7	170	-1.2	7	700	10	1000	
74	6	100	-.2	19	1900	1.1	110	-1.2	7	700	10	1000	
75	5	87	0	22	1914			-1.2	7	609	10	870	
76	1274+25	50	0	22	1100			-1.0	9	450	8	400	
77	1274	63	0	22	1386			-1.5	4	252	14	882	
78	1273	100	0.1	23	2300			-.8	11	1100	6	600	
79	1272	150	0.1	23	3450			-.6	13	1950	4	600	
80	1270	200	0	22	4400			-.2	19	3800	1	200	
					20,350		2,211			9561		9,752	
81	1268	200	0.3	26	5200			-.7	12	2400	5	1000	
82	1266	200	0.1	23	4600			-.9	10	2000	7	1400	
83	1264	200	0.1	23	4600			-1.2	7	1400	10	2000	
84	1262	200	0.1	23	4600			-1.4	5	1000	12	2400	
85	1260	200	0.1	23	4600			-1.4	5	1000	12	2400	
86	1258	200	0.1	23	4600			-2.0	0	0	21	4200	
87	1256	200	0	22	4400			-1.6	3	600	15	3000	
88	1254	150	0.1	23	3450			-1.6	3	450	15	2250	
89	1253	100	0	22	2200			-1.0	9	900	8	800	
90	1252	100	-.2	19	1900	1.1	110	-0.4	16	1600	2	200	
					40,150		110			11,350		17,250	
91	1251	80	-.4	16	1600	2.4	192	-0.4	16	1280	2	160	
92	1250+40	30	-3.0	0	0	42.5	1,275	-0.4	16	480	2	60	
93	1250+20	25	-5.0	0	0	89.9	2,247	-0.4	16	400	2	50	
94	1249+90	20	-6.0	0	0	114.9	2,298	-0.4	16	320	2	40	
—	1249+80	5	-6.0	0	0	114.9	575	-2.0	0	0	21	105	
					1600		6,697			3,480		415	
				Total	62,100		9,018			23,391		27,417	

Total Ex this page = 85,492 ft³ = 3,166 yd³

Total Fill this page = 36,435 ft³ = 1,349 yd³

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGNED BY	APPROVED BY
CHECKED BY	DRAWING NO.
DATE.	SHEET OF

1	2	3	4	5	6	7	8	9	10	11	12	13	14
SECT NO	STA	DIST	LEFT BANK ELEV	EX FACTOR	3 x 5 = EX ft³	FILL FACTOR	3 x 7 = FILL ft³	RIGHT BANK ELEV	EX FACTOR	3 x 10 = EX ft³	FILL FACTOR	3 x 12 = FILL ft³	
1	1234+85	45	0.4	28	1260	0	0	0.3	26	1170	0	0	
2	1234	145	-.2	19	2755	1	145	-.2	19	2755	1	145	
3	1232	200	-.1	20	4000	1	200	0	22	4400	0	0	
4	1230	200	-.2	19	3800	1	200	0	22	4400	0	0	
5	1228	200	0	22	4400	0	0	-.2	19	3800	1	200	
6	1226	150	-.6	13	1950	4	600	-.6	13	1,950	4	600	
7	1225	100	0	22	2200	0	0	0	22	2200	0	0	
8	1224	150	-.3	17	2550	2	300	-.3	17	2550	2	300	
9	1222	200	-.6	13	2600	4	800	-.6	13	2600	4	800	
10	1220	200	-.3	17	3400	2	400	-.4	16	3200	2	400	
11	1218	200	-.4	16	3200	2	400	-.3	17	3400	2	400	
12	1216	150	-.5	15	2250	3	450	-.8	11	1650	6	900	
13	1215	50-8=42	-.8	11	462	6	252	-.8	11	462	6	252	
					34,827		3,747			34,537		3,997	
14	1208	50	0.7	33	1650			1.0	38	1900			
15	1207	150	0.3	26	3900			1.0	38	5700			
16	1205	200	1.5	47	9400			1.3	43	8600			
17	1203	200	1.0	38	7600			1.0	38	7600			
18	1201	200	0.2	25	5000			0.3	26	5200			
19	1199	200	0.2	25	5000			1.0	38	7600			
20	1197	200	0.5	29	5800			0.3	26	5200			
21	1195	200	0.2	25	5000			0.5	29	5800			
22	1193	196	0.3	26	5096			0.1	23	4508			
8' SILL @ 1192													
23	1191	196	0.3	26	5096			0.3	26	5096			
					53,542					57,204			
					88,369		3,747			91,741		3,997	

1215+10 - Sc. SILL

TOTAL EX = 180,110 ft³ = 6670 yd³

TOTAL FILL = 7,744 ft³ = 290 yd³

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGNED BY	APPROVED BY
CHECKED BY	DRAWING NO.
DATE	SHEET OF

1	2	3	4	5	6	7	8	9	10	11	12	13	14
SECT NO	STA	DIST	LEFT BANK ELEV	EX FACTOR	3 x 5 = EX ft³	FILL FACTOR	3 x 7 = FILL ft³	RIGHT BANK ELEV	EX FACTOR	3 x 10 = EX ft³	FILL FACTOR	3 x 12 = FILL ft³	
24	1189	200	0.2	25	5000			0.7	33	6600			
25	1187	200	0	22	4400			0.3	24	5200			
26	1185	200	0.2	25	5000			0.3	26	5200			
27	1183	200	0.4	28	5600			0.3	26	5200			
28	1181	200	0.1	23	4600			1.0	38	7600			
29	1179	200	-.1	20	4000	1	200	0.2	25	5000			
30	1177	196	0	22	4312			-.2	19	3724	1	196	
SC SILL - 1176													
31	1175	196	0.4	28	5488			0.6	31	6076			
32	1173	200	0.5	29	5800			0.3	26	5200			
33	1171	200	0.3	26	5200			0.2	25	5000			
34	1169	200	0.3	26	5200			0.4	28	5600			
35	1167	200	0.2	25	5000			0.4	28	5600			
36	1165	200	0.4	28	5600			0.5	29	5800			
37	1163	192	0	22	4224			0.3	26	4992			
38	1161+15	118	0	22	2596			0.4	28	3304			
39	1160+50	57	0.3	26	1482			-.4	16	912	2	114	
	1160+32				73,502		200			81,008		310	

End Exist Riffle, BEGINNING PHASE 1

TOTAL EX = 154,510 ft³ = 5720 yd³

TOTAL FILL = 510 ft³ = 20 yd³

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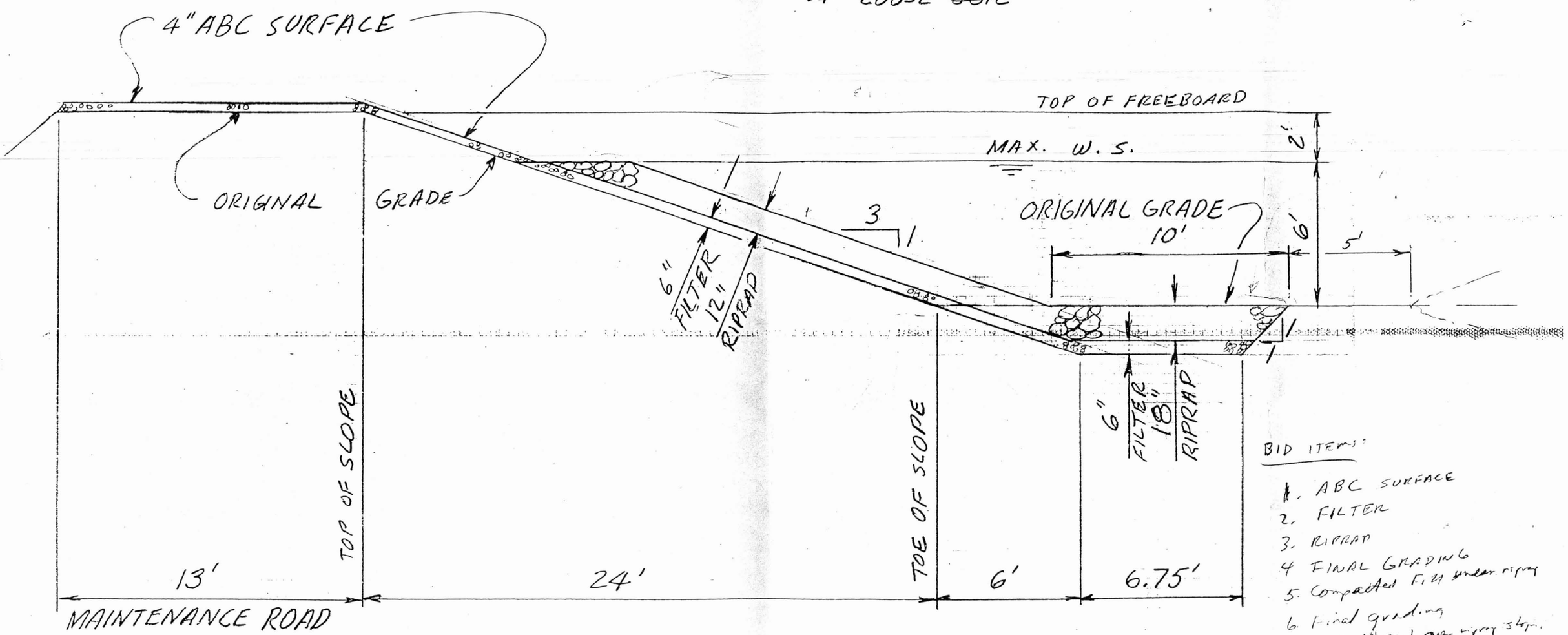
CHECKED BY	DRAWING NO.
DATE	SHEET OF

NOTE: ~~COVER ALL RIPRAP WITH AT LEAST 4" LOOSE SOIL~~



BID ITEMS:

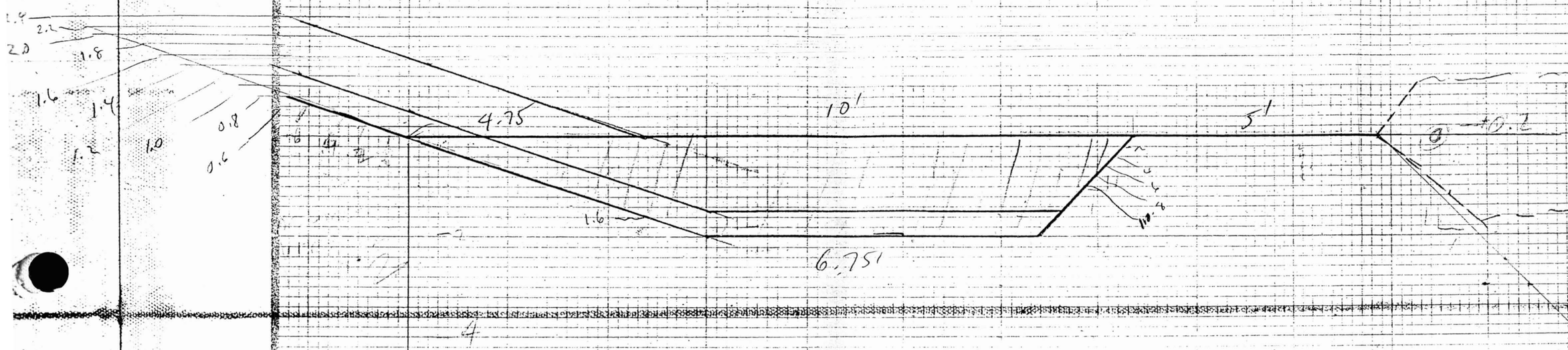
1. ABC SURFACE
2. FILTER
3. RIPRAP
4. FINAL GRADING
5. Compacted Fill under riprap
6. Final grading
   (a) 1" soil over riprap slope
   [illegible] over riprap bottom
   [illegible] to 3 from riprap
   (b) existing [illegible]

TYPICAL CROSS SECTION
OF
ORIGINAL EARTH CHANNEL & PROPOSED IMPROVEMENTS

SCALE: 1" = 4' (ORIG DWG)

EAST MARICOPA FLOODWAY
REACH 1 & 2 REPAIR
PHASE 1

WAM 6/20/90



DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed _____ Date _____ Approved by _____ Title _____

FP-LOM

SCS-ENG-3154 8-81

EMF REPAIR

WAM 6/20/90

Discussion re need for new soil tests

MEMO TO DESIGN FILE.

6/19/90 - Discussed project with Aubrey Sanders to resolve whether or not to order soil analyses.

(1) FILTER DESIGN - need to check 1985 soil tests to see if preliminary filter design is satisfactory for those analyses. Also check 1973-78 tests.

(2) EMBANKMENT BACKFILL - Minor backfill replacement will be necessary at the toe of slope at a few locations before placing filter and riprap. It was agreed no testing was necessary for that purpose since (a) it will be retained by the filter and (b) exposed earth channel will be allowed to erode within reasonable limits.

(3) TESTS AT SOIL CEMENT SILLS - The only reason to test the soils to be excavated from sill locations would be to determine the feasibility for using the soil as part of the soil cement mix. However, since the total soil cement to be processed is only about 3200 cubic yards, it is not likely that a pugmill would be set up at the site, and it does not seem logical that channel material would be hauled from the site to a pugmill plant for mixing, because the plant can surely process its own material more readily. Furthermore, the filter design would make excellent soil cement and would probably be used.

8/27/90 The above is partially superseded because a fabric filter will be used instead of aggregate filter. However, there is still no need for additional soil tests for design purposes.

Sht 2A

TABLE 1. CHEMICAL DISPERSION ANALYSIS

Sample No.	Sta	Na Meq /L	Na,Cl,Mg K, Meq /L	Na %
1	1343+00	56.11	124.045	45.23
2	1365+00	51.20	116.553	43.93
3	1338+00	58.63	87.989	66.63
4	1271+00	24.84	37.735	65.83
5	1277+00	27.58	77.342	35.66
6	66+00	21.01	22.079	95.16
7	1242+00	30.36	37.020	82.01
8	1261+00	24.97	30.230	82.60
9	1252+00	34.10	40.145	84.94
10	1250+40	43.67	53.397	81.78
11	1250+50	31.10	43.274	71.87
12	1375+00	36.45	63.920	57.02
13	1401+00	43.54	85.959	50.65
14	1435+00	27.23	28.414	95.83
		510.79	848.102	60.23

It is reasonable to assume that general bed erosion has occurred. It will be checked by determining the difference between existing and as-built sections. The existing section have been stressed nearly 50% greater than the maximum allowable. That fact that this has occurred for a discharge less than 30% of the design discharge, suggests that general bed degradation at design discharges would be massive, endangering the integrity of the levees.

The distance between the downstream end of the concrete chute and (sta 1160+22) and upstream end of the rock chute (sta 1464+00) is 30,378 feet with a drop of 44.9 feet. The compacted earth-lining can safely withstand only 10.8 feet of that fall. There are 4291 feet of rock-lined sections that safely removed 6.4 feet of the drop. The remaining 27.7 feet of fall must be safely withstood or that much accumulative bed degradation can be eventually expected with subsequent downstream deposition that will encroach on the design capacity.

SCS-MQT-7
REV. 1-71

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Sht 28

Tabula

RWCD - Reach I claim

SCS Sample #	UofA Sample #	USDA Class.	Unif. Class. 60°C 110°C	Gypsum %	$CaCO_3$ % (equiv.)	% clay .002 mm	% silt .002-.05mm	% sand .05-2mm	0.05-0.1mm	S 0.1-0.25mm	A 0.25-0.5mm	N 0.5-1mm	D 1.0-2.0mm	pH	Sol. Salts (1:5) %	PI 60°C 110°C	LL 60°C 110°C
1	2977	clay	CL	10.3	7.46	44.3	33.2	22.5	2.93	3.70	4.14	5.37	6.35	7.9	0.8024	22	42
			CL					77.5							0.8024	25	46
2	2979	clayloam	CL	9.7	4.80	37.3	38.0	24.6	2.46	4.44	5.22	6.83	5.65	7.8	0.7466	23	41
								75.4									
3	2985	clayloam	CL	6.0	8.78	39.7	34.0	26.4	2.51	4.56	4.94	6.94	7.44	8.15	0.5944	18	38
								73.6									
4	2976	loam	CL	5.2	7.11	27.0	29.5	43.5	4.14	10.16	12.62	10.16	6.42	8.25	0.2487	19	35
								56.5									
5	2973	clayloam	CL	8.5	8.20	32.0	42.6	25.4	2.84	5.18	5.23	6.71	5.43	7.8	0.4896	22	37
								74.6									
6	2983	clay	CH	2.7	8.34	51.3	34.7	14.0	1.45	1.95	2.58	3.99	4.02	9.0	0.1372	37	58
			CH					86								40	61
7	2981	loam	CL	4.0	7.70	25.8	33.6	40.5	5.34	11.60	10.58	8.49	4.42	8.6	0.2235	12	26
								59.5									
8	2982	clayloam	CL	4.2	9.63	32.7	30.7	36.6	7.13	8.87	7.88	7.19	5.53	8.6	0.1842	17	32
								63.4									
9	2978	clayloam	CL	4.2	10.47	36.4	32.0	31.6	3.82	6.65	8.50	7.38	5.26	8.5	0.2794	18	34
								68.4									
10	2986	clayloam	CL	4.0	14.59	39.7	35.7	24.6	2.80	4.88	5.88	5.97	4.70	8.35	0.3531	27	45
								75.4									
11	2980	clayloam	CL	4.2	11.08	34.2	32.0	33.7	3.61	7.74	9.01	8.18	5.16	8.2	0.2925	24	40
								66.3									
12	2984	clayloam	CL	6.4	12.31	30.4	45.8	23.8	3.59	4.46	4.07	5.71	5.73	8.3	0.4511	15	31
								76.2									
13	2974	si.c.loam	CL	7.5	9.44	33.5	50.2	16.3	3.08	3.06	3.03	3.85	3.27	8.0	0.5494	17	35
								83.7									
14	2975	clay	CH	2.7	9.46	49.0	37.0	14.0	1.26	2.05	2.89	4.17	3.63	8.95	0.1784	31	55
			CH					86.0								34	57
								Ave									
								73.0									

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 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 done 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 to 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 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 or reduce pollution.

(2) This specification shall apply to all construction activities within the Floodway Right-of-Way.

(3) The Contractor is required to adhere to all applicable local, State and Federal laws and regulations pertaining to the control of pollution as may result from construction of this project. These laws and regulations include but are not limited to:

(a) The "Policy on Construction and Related Activities in Water" adopted April 13, 1977, by the Water Quality Control Council of Arizona.

(b) The Clean Air Act (42 U.S.C. 1857 et seq. as amended by Pub. L. 91-604) Section 114, and Section 308 of the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq., as amended by Pub. L. 92-500) relating to inspection, monitoring, entry, reports, and information as well as the other requirements of these sections.

(4) 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, and staging earthwork activities to prevent contamination of air and water, to minimize destruction of existing vegetation, and to minimize erosion.

(b) Operating mechanized equipment at the job site in a manner that will avoid destruction or removal of trees and shrubs other than as necessary for construction of the measure.

(5) Under Section 2, Materials, there are no material specifications required.

(6) Under Section 3, Seeding, no seeding is required.

(7) No separate payment will be made for this item. Compensation for this work will be included in the payment for Bid Item 2, Excavation, Common, and Bid Item 4, Loose Rock Riprap.

CONSTRUCTION SPECIFICATION

7. CONSTRUCTION SURVEYS FOR LAYOUT, CONTROL AND MEASUREMENT

1. SCOPE

The work shall consist of performing: (1) all specified surveys for layout of work and construction controls, and (2) quantity surveys and computations for progress payment estimates. It includes furnishing all necessary equipment, personnel and material to perform the surveys required by the methods specified.

2. EQUIPMENT AND MATERIALS

Equipment for construction surveys shall be of a quality and condition to provide the specified accuracy. The equipment shall be maintained in good working order and in proper adjustment at all times. Records of calibration tests, accuracy checks and adjustments shall be maintained and be available for inspection by the Contracting Officer.

Materials include all the necessary field notebooks, stakes, templates, platforms, equipment, spikes, steel pins, tools, and all other items necessary to perform the work specified.

3. QUALITY OF WORK

All work shall follow recognized professional practice and the standards of the industry unless otherwise specified in Section 9. The work shall be performed to the accuracy and detail appropriate for the type of job. Notes, sketches, and other data shall be complete, recorded neatly, legible, reproducible and organized in a manner that will allow reproduction of copies for job documentation.

All computations shall be mathematically correct. Computations shall include information to identify the bid item, date, and who performed, checked and approved the computations. Computations shall be legible, complete and clearly document the source of all information used including assumptions and measurements made.

If a computer program is used to perform the computations, a copy of the program, with user information, shall be submitted with the first set of computations. Computer generated computations shall show the input data used including the source of all information used and software assumptions.

The elevations of permanent and temporary bench marks shall be determined and recorded to the nearest 0.01 foot. Differential leveling and transit traverses shall be of such precision that the error of vertical closure in feet shall not exceed plus or minus 0.1 times the square root of the traverse distance in miles. Linear

measurements shall be accurate to within 1.0 foot in 5000 feet, unless otherwise specified in Section 9. The angular error of closure for transit traverses shall not exceed 1.0 minute times the square root of the number of angles turned.

Slope stakes shall be placed, as a minimum; at 100 foot stations, breaks in the original ground surface and at any other intermediate stations necessary to insure accurate location for construction layout and measurement. Slope stakes and cross sections shall be perpendicular to the centerline. Significant breaks in grade shall be determined for cross sections. Distances shall be measured horizontally and recorded to the nearest 0.1 foot. Side shots for interim construction stakes may be taken with a hand level.

Unless otherwise specified in Section 9, measurement for stationing and establishing the location of structures shall be made to the nearest 0.1 of a foot.

Elevations for concrete work, pipes and mechanical equipment shall be determined and recorded to the nearest 0.01 foot. Elevations for earth work shall be determined and recorded to the nearest 0.1 foot.

4. PRIMARY CONTROL

The baselines and bench marks for primary control, necessary to establish lines and grades needed for construction, are shown on the drawings and have been located on the job site.

These baselines and bench marks shall be used as the origin of all surveys, layouts and measurements to establish construction lines and grades. The Contractor shall take all necessary precautions to prevent the loss or damage of primary control points.

5. CONSTRUCTION SURVEYS

Prior to commencement of work requiring contractor performed surveys, the Contractor shall submit in writing to the Contracting Officer for approval the name, qualifications and experience of the individuals to be assigned to the job.

Contractor performed surveys shall consist of the work necessary for: (1) establishing line and grade for all work, (2) setting slope stakes for all work, (3) checking and any supplemental or interim staking, (4) establishing final grade stakes, (5) performing quantity surveys, measurements and computations for progress payment and (6) other surveys as described in Section 9.

6. STAKING

Prior to the commencement of work on any item the construction staking required for that item shall be completed. Construction staking shall be completed as follows, or as otherwise specified in Section 9:

a. Clearing and grubbing - the boundary of the clearing and grubbing areas shall be staked or flagged at 200 foot intervals, or closer if needed, to clearly mark the limits of work.

b. Excavation and fill - slope stakes shall be placed at the intersection of the specified slopes and ground line. Slope stakes or the reference stakes for slopes shall be marked with the stationing, required cut, slope ratio and horizontal distance. Offset reference stakes and hubs shall be placed, as a minimum, at 100 foot stations, and shall be placed on at least one side of specified excavations and on both sides of specified fills.

c. Structures - centerline and offset reference line stakes for location, alignment and elevation shall be placed for all structures.

7. RECORDS

All survey data shall be recorded in fully identified, standard hard-bound engineering survey field notebooks with consecutively numbered pages. All field notes and printed data shall include the purpose or description of the work, the date the work was performed, weather data, sketches and the personnel who performed and checked the work. Electronically generated survey data and computations shall be bound, page numbered and cross referenced in a bound field notebook containing the index for all survey data.

The construction survey records shall be available at all times during the progress of the work for examination and use by the Contracting Officer and copies shall be made available to the Contracting Officer upon request. The original field notebooks and other records shall be turned over to and become the property of the Contracting Officer prior to final acceptance of the work.

Complete documentation of computations and supporting data for progress payments shall be submitted to the Contracting Officer with each invoice for payment as specified in Section 9.

8. MEASUREMENT AND PAYMENT

Work performed in accordance with this specification, for which a specified lump sum price has been established in the contract, will not be measured. Payment will be made as the work proceeds, after receipt of invoices from the Contractor. Reimbursement for the cost of materials and equipment having a residual value will not be

considered for inclusion in the progress payments. If the total of progress payments is less than the contract lump sum for this bid item, the balance will be included in the final contract payment. Total payment will be the contract lump sum price for this bid item, regardless of actual cost to the Contractor.

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 complete 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 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 8, Surveys

(1) This item shall consist of furnishing personnel, equipment, materials and performing surveys required for:

(a) Construction layout
(b) Computation of quantities (for progress payments)
(c) "As-Built" construction drawings

(2) The Contractor shall provide the Government Representative a statement of qualifications, including specific experience of each of the survey personnel assigned to the job.

(3) The Contractor shall provide the Government Representative a schedule of surveys to be performed each month.

(4) In Section 1, Scope, the last sentence does not apply.

(5) Base lines and bench marks for primary control are located on the sides of the right of way approximately at 500 foot stations, PC's and PT's.

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 at 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 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 1, Mobilization

1. This item shall consist of mobilization of the Contractor's equipment and forces for construction of the Floodway repair, ~~including riprap~~ lining and soil-cement sills, and all appurtenant and related work.

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

For water items for which specific unit prices are established in the contract, the volume of water furnished and used in accordance with the specifications will be measured to the nearest 1000 gallons.

Except as otherwise specified, the measurement for payment will include all water needed at the construction site, except as noted in Section 5, to perform the work required under the contract in accordance with the specifications but will not include water wasted or used in excess of the amount needed. It will not include water used in concrete which is mixed elsewhere and transported to the site.

Payment for water will be made at the contract unit price. Such payment will constitute full compensation for all labor, materials, equipment, and all other items necessary and incidental to furnishing, transporting, and using the water.

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 and applying all water necessary for performance of the work described in this contract.

2. Payment for water used to mix soil-cement will be included in the bid for Bid Item 8, Soil-Cement.

3. Payment for water used for compacted earthfill will be included in the price bid for Bid Item 3, Earthfill.

4. Payment for water for installation or grading of ABC will be included in the price bid for Bid Item 5, Gravel Cover (ABC).

5. Payment for water used for dust abatement will be included in the prices bid for various items to be delivered to the site.

Filing

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 drainageway 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 surface and ground water from the construction area shown on the drawings.

2. The diversion or dewatering plans submitted to the Contracting Officer for approval shall be specific to each construction site or section of work. Any diversions or dikes proposed in the existing floodway shall incorporate "fuse" or breakaway sections or otherwise be capable of rapid removal in the event of unusual surface water flows during construction.

3. No separate payment will be made for the Removal of Water. Compensation for this work will be included in the payment for Bid Item 2, Excavation, Common.

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 onto 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

Method 1 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 suitability of materials for specific purposes will be determined by the Engineer. The Contractor shall not waste or otherwise dispose of suitable excavated materials.

Method 2 Suitable materials from the specified excavations may be used in the construction of required earthfill or rockfill. The suitability of materials for specific purposes will be determined by the Engineer.

6. DISPOSAL OF WASTE MATERIALS

All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at the locations 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 workmen, 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 4-1/2 sacks of cement per cubic yard. The concrete shall be placed and cured as specified by the Engineer.

Excavation in earth beyond the specified lines and grades shall be corrected by filling the resulting voids with approved compacted 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.

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 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 2, Excavation Common

This item shall consist of all excavation required to construct:

1. The toe of slope including all riprap, ABC and filter items indicated on the plans.

2. Soil cement sills at the following station locations:

   1176+00
   1192+00
   1215+00
   1249+90
   1268+50
   1287+00
   1301+00
   1315+56

3. Measurement and payment shall be in accordance with Section 11 of this specification and will include compensation for subsidiary items: Pollution Control, Water for Construction, and Removal of Water.

4. Excess excavated materials from the toes of slope shall be stockpiled adjacent to the excavation for later placement over the completed riprap, as provided in Bid Item 7, Riprap.

5. Soil material excavated for soil cement sills shall be stockpiled near by and shall be used for loose soil cover for riprap, earthfill along the sides, or loose fill along the sides to direct low flow toward the channel center.

6. Over excavation beyond the lines and grades indicated on the plans for the placement of riprap, filter and ABC materials, shall be corrected in accordance with Section 10 of this specification, and no extra payment will be made therefore.

7. Over excavation beyond the lines and grades indicated on the plans for soil cement sills shall be corrected by filling the over excavation with compacted soil cement, and no extra payment will be made therefore.

b. Subsidiary Item, Grading for Soil Cement Sill Excavation

1. This item shall consist of grading the site of each soil cement sill to a level of five feet (5') above bottom grade of sill as indicated on the plans.

2. Payment for this item of work will be included in Bid Item 8, Soil Cement Sills.

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 as specified for subsequent layers 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 exceed 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 structures 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 powertampers, 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 determining 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

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 composition for comparison. 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 or 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 overexcavation 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.

Payment for compaction of earthfill will be made at the contract unit price for earthfill. Such payment will constitute full compensation for all labor, materials, equipment and all other items necessary and incidental to the performance of the work, including furnishing, transporting, and applying water to the foundation and fill materials.

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 3, Earthfill

1. This item shall consist of placing and compacting all earthfill required to construct the floodway repairs as shown on the drawings:

   a. Earthfill shall be placed at the lower slope and channel bottom limits of ABC bedding as indicated when necessary to bring the grade up to the subgrade level of the ABC bedding. Approximate Station limits of the fill are shown on the plans.

   b. Earthfill shall be placed at the locations of soil cement sills, as indicated on the plans, before excavating for placement of soil cement.

2. Material included in the fill shall consist of material obtained from the required excavation.

3. In Section 6, Compaction, Class A shall apply. The fill matrix shall be compacted to at least 90 percent of the maximum density obtained in compaction tests of the fill materials performed by ASTM D 698, Method A (Standard Proctor Test or Rapid Compaction Test (Test No. S-6) SCS National Engineering Handbook, Section 19.

4. The maximum size of rock fragments incorporated in the fill shall be six (6) inches.

5. The maximum thickness of a layer before compaction shall be nine (9) inches.

6. In Section 8, Testing, densities of fill will be determined in accordance with ASTM 1556. The moisture content of the material incorporated in the fill shall be maintained within the range of the optimum moisture content to three (3) percentage points below the optimum moisture content as determined by ASTM D 2216.

7. Finished top of earthfill shall be to the neat line and grade indicated on the plans.

b. Subsidiary Item, Grading for Soil Cement Sills

1. This item shall consist of grading the site of each soil cement sill to a level of five feet above bottom grade of sill and as indicated on the plans, all following placement of earthfill as required.

2. Payment for this item of work will be included in Bid Item 8, Soil Cement Sills.

c. Subsidiary Item, Fill at Channel Limit of Riprap

1. This item shall consist of fill placed in the channel, as indicated on the plans, to provide support for the channel limit of riprap located 86 feet and 4 inches from the centerline of the channel. This fill shall have Class C compaction, and shall be placed after completion of adjacent earthfill required for ABC subgrade.

2. Payment for this item of work will be included in Bid Item 3, Loose Rock Riprap.

CONSTRUCTION SPECIFICATION

61. LOOSE ROCK RIPRAP

1. SCOPE

The work shall consist of the construction of loose rock riprap revetments and blankets, including filter layers or bedding where specified.

2. MATERIALS

Rock for loose rock riprap shall conform to the requirements of Material Specification 523 or, if so specified shall be obtained from designated sources. It shall be free from dirt, clay, sand, rock fines and other materials not meeting the required gradation limits.

At least 30 days prior to delivery of rock from other than designated sources, the Contractor shall designate in writing the source from which he intends to obtain the rock and information satisfactory to the Contracting Officer that the material meets the requirements of the contract. The Contractor shall provide the Engineer free access to the source for the purpose of obtaining samples for testing. The size and grading of the rock shall be as specified in Section 9 of this specification.

Rock from designated sources shall be excavated, selected and processed as necessary to meet the quality and grading requirements in Section 9 of this specification. The rock shall conform to the specified grading limits when installed in the riprap.

Filter or bedding materials when required, shall, unless otherwise specified, conform to the requirements of Material Specification 521.

3. SUBGRADE PREPARATION

The subgrade surfaces on which the ABC bedding course is to be placed shall be cut or filled and graded to the neat lines and grades shown on the drawings. Except when repair of bank erosion is specified, existing slopes shall not be graded prior to placement of ABC. The ABC surface shall be graded to the neat lines indicated on the plans prior to placement of filter fabric.

Filter fabric shall not be placed until the foundation preparation is completed and the bedding surfaces have been inspected and approved by the Engineer.

4. EQUIPMENT-PLACED ROCK RIPRAP

The rock shall be placed by equipment on the surfaces and to the depths specified. The riprap shall be constructed to the full course

thickness in one operation and in such a manner as to avoid serious displacement of the underlying materials. The rock shall be delivered and placed in a manner that will insure that the riprap in place shall be reasonably homogeneous with the larger rocks uniformly distributed and firmly in contact one to another with the smaller rocks and spalls filling the voids between the larger rocks.

Riprap shall be placed in a manner to prevent damage to filter fabric or bedding. Hand placing will be required to the extent necessary to prevent damage to the permanent works. The maximum allowable drop of rock onto filter fabric is three feet.

5. HAND-PLACED RIPRAP

The rock shall be placed by hand on the surfaces and to the depths specified. Rock shall not be dropped more than three feet onto the filter fabric. It shall be securely bedded with the larger rocks firmly in contact one to another. Spaces between the larger rocks shall be filled with smaller rocks and spalls. Smaller rocks shall not be grouped as a substitute for larger rock. Flat slab rock shall be laid on edge.

6. FILTER LAYERS OR BEDDING

When the drawings specify a filter layer and bedding beneath riprap, the filter and bedding material shall be spread uniformly on the subgrade surfaces to the depth specified. Compaction of bedding will not be required, but the surface shall be finished reasonably free of mounds, dips or windrows.

7. TESTING

The Engineer will perform such tests as are required to verify that the riprap, filter, and bedding materials and the completed work meet the requirements of the specifications. 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 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 riprap will be measured within the specified limits and computed to the nearest cubic yard by the method of average cross-sectional end areas. Payment for riprap will be made at the contract unit price for riprap. Payment for filter or bedding will be made at the contract unit prices for filter or bedding. Such payment will be considered full compensation for all labor, materials,

equipment and all other items necessary and incidental to the completion of the riprap, filter layer and bedding.

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 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 4, Loose Rock Riprap

1. This item shall consist of furnishing and placing all riprap between Station 1160+32.10 and Station 1208+04.42, between Station 1215+00 and Station 1234+89, between Station 1249+80 and Station 1314+97, between station 1315+46 and Station 1316+60, except at the locations of eight (8) 8' wide soil cement-sills.

2. The rock shall be graded as follows:

Particle Size (Inch)	Percent Passing (by Dry Weight)
8	100
6	60 - 100
3	0 - 30
1	0 - 5

3. Rock shall be either hand or equipment placed. It shall not be dropped more than three (3) feet onto the filter fabric and shall not be pushed or rolled around on the filter fabric.

4. Measurement and Payment will be in accordance with the requirements of Section 8, except that only that area of riprap installed and completed with a loose soil cover, as required herein, shall be considered for payment.

b. Subsidiary Item, Three Inch Loose Soil Cover Over Riprap

The Contractor shall place a three inch minimum layer of loose soil over all riprap surfaces. The soil layer shall be placed on any section of riprap only after the Engineer has approved that section as complete. The loose soil to be installed shall be from material excavated for construction along the toe of slope, or from the center 50' of channel bottom.

CONSTRUCTION SPECIFICATION 94

CONTRACTOR INSPECTION

1. SCOPE

The work shall consist of providing all equipment, materials, labor and services necessary to ensure that the specified quality is maintained on all work performed. The Contractor shall be responsible for the day-to-day quality control.

2. EQUIPMENT AND MATERIALS

Equipment for materials testing shall be of the quality and condition required to meet the test specifications cited in the contract references. Equipment shall be in good condition and properly adjusted. Calibration of equipment shall be done at the frequency specified in Section 8. Records of equipment calibration tests shall be available to the government at all times. Nuclear devices shall be operated and maintained by qualified operators and as prescribed by applicable state and federal regulations.

Materials include but shall not be limited to: sand for density tests, bound field books and forms for record-keeping, concrete specimen molds, and all other equipment and materials prescribed by the test procedures referenced in the contract.

The quality of materials used in quality control testing and the equipment employed shall: meet the appropriate standards specified and the standards specified and the standards of the industry, be appropriate for its intended use, and provide the accuracy specified by the contract requirements unless otherwise specified in Section 8 of this specification.

3. INSPECTION PERSONNEL

Inspections and materials testing shall be accomplished by qualified personnel: a licensed engineering firm, testing laboratory, certified inspection technicians, or licensed and experienced personnel from the Contractor`s organization. The Contractor's written inspection plan shall identify the names and qualifications, training, and experience of all quality control personnel who will actually be performing the inspection and quality control work.

4. INSPECTION SYSTEM

The Contractor shall develop and conduct an inspection system adequate to maintain quality control of all work performed and materials and equipment used. The inspection system established shall be based upon a plan and implemented by the necessary mobilization of personnel, equipment and materials. Inspection shall include the initial work needed to verify adequacy of completed work and provide controls for

Needs updated spec 3-90

any corrective work. The inspection system and records to substantiate daily conduct of the system shall be kept by the Contractor and are subject to review by the Contracting Officer at any time.

The Contractor's inspection system shall cover all aspects of quality control and shall specifically address any testing and inspection requirements detailed in Section 8 of this specification. The planned inspection system shall also identify the Contractor's primary quality control manager and provide an organizational listing of the individual quality control personnel and their specific duties, experience and qualifications.

If the government's quality assurance inspections indicate that the Contractor's inspection system is not adequate or is not producing the desired results, corrective actions shall be taken by the Contractor in both the inspection system, its plan and the work. The Contracting Officer may direct that changes be made in the inspection system including, but not limited to, the removal of unsatisfactory quality control personnel.

5. PRE-CONSTRUCTION CONFERENCE

After the contract is awarded and before construction operations are started the Contractor shall meet with the Contracting Officer and discuss the Contractor's inspection plan. The meeting shall develop a mutual understanding regarding inspection details including the form of documentation to be used for recording the quality control operations, inspections, management procedures and the interrelationship of Contractor and government inspection efforts. The finalized plan will be approved by the Contracting Officer and it shall become a part of the contract.

6. RECORDS

The inspection records shall be kept daily and shall document both acceptable and deficient features of the work. They shall include complete records of required material tests, submittal and approval of shop drawings, manufacturer's recommendation and certifications, and a complete record of materials delivery, quality examination, certification and storage. Tests performed by the Contractor (including subcontractors) shall be part of the record. All records shall be on forms acceptable to the Contracting Officer and and shall be legible, properly dated and identified as to the responsible tester, the material or item tested, and its location of placement in the structure. In addition, these records shall include factual evidence that required activities or tests have been performed, including but not limited to the following:

1. Type and number of control activities and test involved and the location (elevation, station and offset) of the work tested.

2. Result of control activities or tests.

3. Method of testing used (e.g. citation of reference specification).

4. Nature of defects, cause for rejection, etc.

5. Proposed remedial action.

6. Corrective actions taken and quality control testing.

7. MEASUREMENT AND PAYMENT

For items of work for which lump sum prices are established in the contract, payment for contractor inspection will be made at the contract lump sum price. Such payment shall constitute full compensation for all labor, materials, equipment, transportation and all other items necessary and incidental to completion of the work. Progress estimates for payment of this bid item will be based on the percent completion of all contract items (dollar value) used in preparing the regular progress payments.

Payment will not be made under this item for the purchase cost of materials and equipment having a residual value.

Payment of the lump sum contract price for contractor inspection will constitute full compensation for all labor, materials, equipment, transportation, 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 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. Bid Item 9, Contractor Inspection

1. This item shall consist of furnishing the personnel, equipment and material required by the Contractor to perform the testing and inspection that is necessary to implement an inspection system that will insure the specified quality is being maintained for:

   a. All Excavation
   b. Earthfill
   c. Loose Rock Riprap
   d. Gravel Cover (ABC)
   e. Geotextiles
   f. Soil Cement

2. The moisture density determinations required for the quality control of earthfill be performed in accordance with Method A, ASTM D 698 (Standard Proctor Test) or test No. S-6 (Rapid Compaction Control Method) as described in Section 19 of the SCS National Engineering Handbook. Testing for densities of fill shall be determined in accordance with ASTM Method D-1556 and the moisture content by ASTM D-2216.

3. Prior to establishing fill production operations, it shall be demonstrated and verified by test results that the proposed equipment fleet is capable of producing fill of the quality specified.

4. For production operations the initial moisture density test frequency shall be 1 test per 500 cubic yards of compacted earthfill. When approved by the Contracting Officer, the testing frequency may be modified as the job progresses, provided the quality of the fill is consistent or when the testing frequency is not compatible with the daily production.

5. The gradation of ABC shall be determined in accordance with ASTM C 136 and C117. The inspection plan shall include those tests and inspections required during the processing or importation operation to verify that the processed material is within the specified limits. During placement

operations one sieve analysis of the in-place ABC will be performed for each 1,000 tons placed. Sieve analysis will be performed at more frequent intervals whenever the tested in-place material does not meet the gradation requirements, or visual inspection indicate the need to increase the frequency.

6. The moisture density determinations required for the quality control of soil cement shall be performed in accordance with Method B, ASTM D558 or Test No S-6 (Rapid Compaction Control Method) as described in Section 19 of the SCS National Engineering Handbook. Testing for densities of the soil cement shall be determined in accordance with ASTM D1556 (sand cone) or ASTM D2922 and D3017 (nuclear) methods. The moisture content shall be determined by ASTM D2216 with an oven dry temperature of 50 ± degrees C.

   For production operations the initial moisture density tests shall be used to determine adequate compaction procedures. Test frequency thereafter shall be one test per 100 cubic yards of compacted soil cement.

7. Testing equipment shall be calibrated after it is delivered to the site and whenever erratic or unreasonable test results are being obtained.

   The sand used for testing fill densities shall be claibrated whenever there is a change in the humidity or lot of sand.

8. The Contractor shall designate an experienced quality control manager and inspection staff whose primary responsibility will be implementing the inspection system. The manager shall be on site during major construction activities and will not be involved in directing production oriented activities unless it pertains to achieving the specified quality for the work being performed. The quality control manager shall be employed by and answerable to the Contractor. The manager's duties cannot be delegated to a subcontractor or others.

9. The names and qualifications of proposed quality control personnel shall be submitted to the Contracting Officer for review and approval prior to the pre construction conference. Any changes in quality control personnel will require the approval of the Contracting Officer.

10. Copies of all test results and inspection reports (including visual inspections of earthwork, and placement of ABC,

filter fabric, riprap and soil cement), required by the approved inspection plan shall be submitted to the Contracting Officer within 24 hours of when the test or inspection report is completed and certified.

11. Measurement and payment will be in accordance with Section 7, Measurement and Payment.

CONSTRUCTION SPECIFICATION 202

GRAVEL COVER

1. SCOPE

The work shall consist of the construction of cover over slopes or on other areas that are subject to erosion.

2. MATERIALS

Gravel shall meet the requirements of Section 8 of this specification 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 where excavation and earthfill are shown or indicated on the drawings or the existing surfaces of slopes and maintenance roads.

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 course 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 extend 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. Bid Item 5, Gravel Cover (ABC)

1. This item shall consist of furnishing and placing ABC bedding (for riprap) and gravel cover on the floodway slopes, channel bottom, maintenance roads, and maintenance ramps, all to the limits and thicknesses indicated on the plans.

2. The bedding and gravel cover material (ABC) shall meet the requirements of Section 702, Base Materials, in the MAG specifications. The material shall be either crushed aggregate or processed natural material meeting the following limits of gradation:

Sieve Size	Percent Passing
1 1/8"	100
#4	38 - 65
#8	25 - 60
#30	10 - 40
#200	3 - 12

3. Measurement and payment for items of work for which specific unit prices are established in the contract, the quantity of work within the specified limits will be measured to the nearest ton by actual weight. For each load of ABC placed as specified the Contractor shall furnish to the Engineer a statement of delivery ticket showing the weight to the nearest 0.1 ton, of ABC delivered.

b. Subsidiary Item, Maintenance of Maintenance Road

1. The Contractor shall install a 4 inch ABC cover on any maintenance road before using that road as a haul road for project purposes. The road shall be maintained in good, level condition during project use and shall be left to the thickness and neat line and grade indicated on the plans. Compensation for this item will be included in payment for Bid Item 5, Gravel Cover (ABC).

CONSTRUCTION SPECIFICATION

203 GEOTEXTILES

1. SCOPE

This work shall consist of furnishing all materials, equipment, and labor necessary for the installation of geotextiles.

2. MATERIALS

Geotextile materials shall conform to the requirements of Material Specification 303 and Section 7 of this specification.

3. STORAGE

Prior to use, the geotextile shall be stored in a clean dry place, out of direct sunlight, not subject to extremes of either hot or cold, and with the manufacturer's protective cover in place.

4. SURFACE PREPARATION

The surface on which the geotextile is to be placed shall be graded to the neat lines and grades as shown on the drawings. The surface shall be reasonably smooth, free of holes, depressions, and projections. Excessively wet, muddy conditions shall be dewatered where geotextiles are to be placed against an excavation or prepared slope. The surface preparation will be inspected and approved by the Engineer prior to placing the geotextile.

5. PLACEMENT

A. General

The geotextile shall be placed in intimate contact with the approved prepared surface at the locations and in accordance with the details shown on the drawings and specified in Section 7. The geotextile shall be unrolled along the placement area and loosely laid (not stretched) in such a manner that it will conform to the surface irregularities when the stone or other material is placed on or against it. No cuts or punctures will be permitted in the geotextile unless otherwise specified. The geotextile may be folded and overlapped to permit proper placement in the designated area.

When specified in Section 7, the geotextile shall be provided in panels. Seams of the geotextile shall be machine sewn with thread of a material meeting the chemical requirements specified by the manufacturer. The panels shall be manufactured at the factory for the size specified.

The orientation of the width and length of the geotextile panels shall be as shown on the drawings. (NOTE: Alternate panel sizes may be submitted for approval.) The length shall be placed parallel to the direction of water flow unless otherwise indicated on the drawings. The end roll details shall be as shown on the drawings or as specified in Section 7. The minimum overlap shall be 18 inches unless otherwise specified. Field sewing can be used in lieu of overlap seams. If field sewing is used, two rows of stitching, located at least three inches from the edge shall be provided. Thread shall meet the chemical requirements specified by the manufacturer.

Securing pins, provided by the geotextile manufacturer, shall be placed along the edge of the geotextile to adequately secure it during placement. Pins shall be steel or fiberglass formed as a "U", "L", or "T" shape or contain "ears" to prevent total penetration. Washers shall be provided on all but the "U" shaped pins. At vertical laps, securing pins shall be inserted through both layers along a line through the approximate midpoint of the overlap. At horizontal laps and laps across slopes, securing pins shall be inserted through the bottom layer only. Securing pins shall be placed along a line approximately 2 inches in from the edge of the outer limits of the placed geotextile at intervals not greater than 12 feet unless otherwise specified. Additional pins shall be installed as necessary to prevent any slippage of the geotextile, regardless of locations. The use of securing pins shall be held to the minimum necessary. Pins shall be left in place unless otherwise specified. The geotextile may be secured with other methods when specified.

Unless otherwise specified in Section 7, material shall not be dropped on uncovered geotextile from a height greater than three feet.

B. Slope Protection

The geotextile shall not be placed until it can be anchored and protected with the intended covering within 48 hours. If this is not practical, temporary cover, for protection from ultraviolet light, may be used as approved by the Engineer.

C. Subsurface Drains

The geotextile shall not be placed until drainfill or other material can be used to cover it within the same working day. Drainfill material shall be placed in a manner that prevents damage to the geotextile.

D. Road Stabilization

The geotextile shall be unrolled parallel to the roadway centerline, and loosely laid (not stretched) in a manner that it will conform to the surface irregularities when the gravel or other fill material is placed on it. Unless otherwise specified, the minimum overlap of geotextile shall be 24 inches for unsewn laps. Securing pins, provided by the geotextile manufacturer, may be used when necessary, to insure temporary anchoring of the geotextile during the installation process. The pins shall be removed prior to permanent backfilling.

The gravel or select backfill shall be dumped and spread in a uniform thickness generally not to exceed 9 inches after compaction. The first 2 or 3 lifts may be used to cover the geotextile and receive only light compaction. Overstressing the soil and sever rutting shall be avoided by utilizing equipment in spreading and dumping that exerts only moderate pressures on the soil. Backfill depths may have to be increased and equipment loads reduced to control soil stress. Ruts developed during spreading and compacting shall be filled with additional backfill material so that backfill thickness can be maintained.

6. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the quantity of geotextile placed within the specified limits will be determined to the nearest unit area by computing the area covered. Payment for the geotextile will be made at the contract unit price. Such payment will be considered full compensation for all labor, materials, equipment, (including specified overlaps and anchorages, as shown on he drawings), and other incidental items necessary for the completion of the work.

For items of work for which specific lump sum prices are established in the contract, payment for geotextiles will be made at the contract lump sum price. Such payment will constitute full compensation for furnishing, transporting, and installing the geotextile including furnishing all labor, equipment, tools, materials, and other incidental items necessary for 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 construction details are:

a. Bid Item 6, Geotextiles

1. This item shall consist of providing and installing Class I nonwoven geotextile filter fabric between the gravel cover and the riprap, all in accordance with this specification, Material Specification 303, and the detail drawings.

2. Measurement and payment will be in accordance with Section 6 of this specification.

CONSTRUCTION SPECIFICATION

206 SOIL-CEMENT

1. SCOPE

The work shall consist of the furnishing, placing, compacting, and curing a mixture of soil material, Portland cement and water. The mixture shall be uniformly mixed, blended, compacted, finished and cured as specified. It shall conform to the lines, grades, thicknesses, and cross section(s) shown on the plans.

2. MATERIALS

Soil materials shall be obtained from the required excavations or designated borrow locations and shall meet the requirements stated below.

Deleterious materials such as sod, brush, or roots shall be separated from soil materials during the selection, blending, and routing operations. Maximum size of rock particles shall be 2 inches. Soil materials, cement content, and moisture content other than those specified in Section 15 may be used as approved by the Engineer. Proposed alternatives must meet one of the following requirements to be considered:

a. If the soil material to be used has similar gradation and Atterberg limits as the soils specified, the same cement content and water content shall be used. The Contractor shall provide gradation and Atterberg test data from a reputable commercial soil testing laboratory verifying gradation and Atterberg limits.

b. If the soil materials do not have the same gradation and Atterberg limits as the soils specified, the Contractor shall provide soil-cement durability tests, moisture density relations data, Atterberg limits and gradation tests from a reputable commercial soil testing laboratory. The soil-cement mix ratio and water content shall also be provided by the lab. As a minimum, the following durability tests shall be provided: ASTM D 559 and ASTM D 560. The moisture density relations are to be in accordance with ASTM D 558. The tests must indicate a soil-cement of a quality equal to or exceeding the quality specified.

Portland cement shall conform to the requirements of Material Specification 531 for the specified type. Mixing of different brands or types of cement will not be allowed.

Portland cement shall be furnished in sacks, barrels, or bulk. Sacked cement that is stored at the job site shall be used in the same order as the deliveries to the site. Each shipment of sacked cement shall

be stored so that it may be readily distinguished from other shipments. Emptied cement sacks shall be burned or buried in accordance with Construction Specification 5 unless otherwise specified.

Water used in mixing or curing soil-cement shall be clean and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substances and shall meet the requirements for water as specified in ASTM C 94.

Pozzolanic Materials, if used, shall comply with requirements of ASTM C 618 Class F, Specifications for Fly Ash, and Raw or Calcined Natural Pozzolan, except the loss of ignition shall not exceed 3.0 percent.

Curing compounds shall conform to the requirements of Material Specification 534 for the type of curing compound specified. A liquid petroleum asphalt curing material may be used as specified in Section 15. Application of the curing compound shall be in accordance with Section 12 of this specification and the manufacturer's recommendations.

3. OPERATIONS OF PITS OR STOCKPILES OF SOIL MATERIALS

All work involved in the opening and/or operation of borrow pits or stockpiles shall be performed by the Contractor. The pits or stockpiles shall be opened in such a manner as to expose a near vertical face of the soil material for a suitable working depth. The face should not exceed five feet in height without benching back if it poses a threat to workers.

Material shall be excavated in successive vertical cuts extending across the pit or stockpile. When approved by the Engineer, successive horizontal cuts on a horizontal oriented working face may be permitted in homogeneous soils. All pockets or strata of unsuitable materials not meeting the quality requirements specified in Section 2 shall be wasted. The method of operating the pit or stockpile and the blending of materials shall be changed when such action is necessary to obtain material conforming to the specifications. Upon completion of the work, the pits shall be graded and dressed to minimize erosion and drain freely.

4. FOUNDATION PREPARATION

Before soil-cement processing begins, the subgrade placement area shall be graded, shaped, and compacted in conformance with the lines and grades shown on the plans. The subgrade shall firmly support the construction equipment. Immediately prior to the placement of the soil-cement, the subgrade surface shall be moistened to approximately the same moisture content as specified for the soil-cement, and shall be kept moist until the soil cement is placed.

5. DESIGN OF SOIL-CEMENT MIXTURE

General - The materials and proportion of the soil-cement mixture shall constitute the "job mix". After a job mix has been approved, neither the source, character or grading of the soil nor the type, brand, or quantity of cement or pozzolanic material shall be changed without prior approval of the Engineer. A change in materials or proportions requires the establishment of a new job mix supported by evidence, as required for the initial job mix, that the proposed new materials and mix proportions will produce soil-cement of the strength specified.

The use of calcium chloride or other accelerators or antifreeze compounds will not be allowed unless approved by the Engineer.

The percent of cement to be used in the mix will be determined by dividing the weight of cement by the oven dry weight of the soil material.

6. MIXING

The mixing plant shall be capable of producing a uniform mixture of soil, cement, and water. The plant shall be equipped with measurement devices that will proportion the mix in the specified quantities. Prior to use, all measurement devices shall be calibrated and certified by a technician approved by the Engineer. The actual quantities of the mix shall not vary more than 2 percent from the specified quantities, unless otherwise specified. The water content shall be percentage of moisture in the mixture at the time of compaction.

The Engineer shall have free access to the mixing plant at all times for inspection of the plant's operation and for sampling the soil-cement mixture and its components.

Method 1 Mixing of the soil, cement, and water shall be accomplished in a stationary mixing plant. The plant may be either a batch type of a continuous flow type design. The plant may use either weight or volume proportioning. The scale or metering devices shall be sensitive to one percent of the maximum load that may be required or imposed. The mixer shall be a pugmill, revolving blade or rotary drum system.

Facilities for efficiently storing, handling and proportioning unmixed materials shall be provided at the plant.

Method 2 Mixing of the soil, cement, and water shall be accomplished in a truck mixer. The mixer shall meet the requirements for truck mixers contained in ASTM C 94.

The following provisions apply to all methods of mixing. The mixing time shall be controlled so that all ingredients shall be mixed for at least 30 seconds or longer as may be necessary to insure a thorough, uniform and homogeneous mixture of soil, cement, pozzolanic materials (if used) and water. Mixing time may be adjusted based on tests and field determinations. The mixing time shall be considered as the interval between the time and cement contacts the soil and water and the time the mixture leaves the mixing unit or when the mixer speed is reduced to the agitating speed. The soil and cement shall be mixed sufficiently to prevent cement balls from forming before the water is added. The water may be applied throughout the mixing machine or separately by approved pressure distributing equipment.

Soils containing plastic silt or clay lumps larger than 1 inch shall be pulverized or screened out of the raw soil prior to mixing.

7. TRANSPORTING

The soil-cement mixture shall be transported from the mixing plant to the site of placement in vehicles having tight, clean and smooth beds or mixer trucks. Haul time shall not exceed 30 minutes. Haul time shall be the elapsed time form when the water and cement are mixed together and the mixture is spread onto the foundation or soil cement surface.

The Contractor shall protect the soil-cement mixture if transported during unfavorable weather. Any material excessively wet by precipitation will be subject to rejection.

Equipment shall not be operated on a finished and compacted layer of the soil-cement, except where specifically permitted. Any damage resulting from the finished surfaces of the soil-cement from such operation shall be repaired by the Contractor at no cost to the Government.

Earth ramps crossing over completed soil-cement must have a minimum compacted thickness of 2 feet. Where ramps are constructed over soil-cement that is not to finished grade, all foreign materials and the uppermost 1 inch of the top layer of soil-cement must be removed prior to the continuation of the soil-cement construction.

8. PLACEMENT

Soil-cement shall not be placed until the required excavations and preparation of the foundation are completed and the foundation has been inspected and approved by the Engineer.

Equipment for spreading the soil-cement mixture shall be suitable for the purpose and shall be operated in such a manner as to produce a reasonably smooth, uniform surface. The equipment shall be controllable so as to produce uniform layers not more than the specified maximum thickness. The layer of soil- cement, or each successive lift when layering is required, shall be spread and compacted as soon as possible after the preceding layer is completed and approved. Soil-cement shall be placed in horizontal layers or layers conforming to the plane of the subgrade.

If the time elapsed between completion of compaction on a layer and start of placement of the next layer is greater than 2 hours, the Contractor shall scarify the surface to a depth of 1 inch. The Contractor shall clean off the scarified surface thoroughly by power brooming or other approved methods prior to proceeding. The broomed surface shall then be thoroughly moistened over its entire surface before the next layer of soil-cement is placed.

Soil-cement shall not be mixed or placed when the air temperature is below 45 degrees F. Soil-cement shall not be placed on a frozen foundation, or if the soil to be processed is frozen, or if weather conditions are such that the material being processed cannot be completely compacted and protected before the onset of damaging weather (such as overnight lows below 40 degrees F, cold fronts, rainstorms, etc.) . The use of accelerators or antifreeze compounds will not be allowed, unless otherwise specified. The temperature of fresh soil-cement shall not be allowed to drop below 32 degrees F for a period of 7 days. If temperatures are expected to be below 45 degrees F, the Contractor's method for protection shall be approved by the Engineer prior to placement of any soil-cement.

9. COMPACTION

a. Equipment- The Contractor may use any type of compaction equipment to obtain the specified density of the soil cement mixture, provided such equipment does not have any projections or tamping feet which penetrate to previously compacted layers. Wheel rolling with only the hauling equipment shall not be an acceptable method of compaction.

b. Compaction Requirements - Soil- cement shall be uniformly compacted to a density not less than the minimum density specified. Optimum moisture and maximum density shall be determined by ASTM D 558. Soil Conservation Service Test No. S-6 (USBR Test E-25), Rapid Compaction Control Method, as referenced in NEH-19, may be used as equivalent to ASTM D 588. The compaction shall begin on all areas within 30 minutes after the addition of water to the soil-cement mixture. The compaction

shall proceed in such a manner that the length of time between spreading of the soil-cement mixture and completion of compaction shall not exceed 1 hour for each layer.

c. Other Requirements - If the surface of a layer of soil-cement has been rutted or compacted unduly by hauling or other equipment, the Contractor shall scarify and recompact such surfaces. When required to maintain uniformity of the layer surface, blading in connection with compaction operations shall be employed. If blading is required, raw unmixed soil shall not be bladed onto the mixed soil cement.

10. CONSTRUCTION JOINTS

At the end of each workday, or when the adjacent placing operation is shut down for a period longer than 2 hours, a vertical construction joint shall be made along all unfinished edges of the thoroughly compacted soil-cement. Just before placing operations are resumed, the construction joint shall be shaved to remove all dry soil-cement and all curing compound from the face of the joint.

11. REMOVAL AND REPLACEMENT

Rejected or defective soil-cement shall be removed and replaced in accordance with these specifications, when:

a. Compaction operations are interrupted for any reason prior to the completion of compaction and the soil-cement mixture is left undisturbed for more than 30 minutes.

b. The soil-cement mixture, prior to completion of compaction, becomes excessively wet so that the moisture content exceeds the specified limits.

c. The compacted soil-cement does not meet the density and moisture requirements; except that when the moisture is lower than required, the soil cement mixture may be reworked, thoroughly mixed and compacted within the 1 hour time limit as stated in Section 9. (b)., Compaction Requirements.

d. The finished surface is rough or below grade such that a thin "scab" section would be required to smooth the surface or bring the surface to grade.

12. PROTECTING AND CURING

a. Moistening Bonding Surfaces - Compacted surfaces of soil-cement that are to receive an overlying layer of soil-cement or concrete shall be kept moist, until placement of the overlying or adjacent layer of soil-cement or concrete. The Contractor will not be required to keep such surfaces moistened for longer than 7 days.

b. Curing Finished Exposed Surfaces - Concrete curing compound conforming the ASTM C 309 of the type specified shall be applied at a rate of not less than 1 gallon per 150 square feet of surface using constantly agitating, pressure spray equipment. It shall form a uniform, continuous, adherent film that shallnot check, crack, or peel.

Any curing membrane that is removed from the surface or damaged within 7 days after application shall be repaired immediately. The surfaces of each section of soil-cement to be treated with curing compound shall be moistened with a light spray or water immediately after the section has been compacted. As soon as the surface film of moisture disappears, but while the surface still has a damp appearance, the curing compound shall be applied. Special care shall be taken to insure ample coverage with the compound at edges, corners and around rough spots. After application of the curing compound has been completed and the coating is dry to the touch, any required repair of the soil cement surfaces shall performed. Each repair, after being finished, shall be moistened and coated with curing compound in accordance with foregoing requirements. The Contractor shall have all equipment and materials required for curing at the site ready for use before placement of soil-cement begins.

13. INSPECTION AND TESTING

The Engineer shall make such inspections and tests as necessary to verify that the soil-cement materials and soil-cement in place meet the specified requirements.

All testing of soil-cement or its individual components, unless otherwise specified, will be in accordance with the latest applicable ASTM Specifications. These tests are not intended to provide the Contractor with information he needs to assure that the material and workmanship meets the requirements of the specifications and their performance will not relieve the Contractor of the responsibility of performing tests for that purpose.

Tests for density and moisture will be performed at any location chosen by the Engineer. If the soil cement-does not pass the minimum moisture and density requirements specified, it shall be reworked or removed at the Contractor's expense. The Contractor shall not place any additional soil-cement until the rejected material has been removed, or reworked, and meets the density requirements specified.

14. MEASUREMENT AND PAYMENT

For items of work for which specific unit prices are established in the contract, the quantity of soil-cement will be measured within the specified limits and computed to the nearest cubic yard by the method of average cross sectional end areas. The quantity of soil-cement required to fill voids resulting from overexcavation outside the neat

lines or pay limits will be included in the measurement for payment where such overexcavation is directed by the Engineer to remove unsuitable foundation material, but only to the extent that the unsuitable condition is not a result of the Contractor's improper construction operations, as determined by the Engineer.

Payment for soil-cement will be made at the contract unit price per cubic yard. The payment will constitute full compensation for all labor, materials, equipment, transportation, tools and all other items necessary and incidental to completion of the work, but not including furnishing and handling cement or other items listed for payment elsewhere in the contract.

Compensation for any item of work described in the contract but not listed in the bid schedule will be included in the payment for items ofwork to which it is made subsidiary. Such payment and the items to which they are made subsidiary are identified in Section 15 of this specification.

15. 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 7, Soil-Cement

1. This item shall consist of the placement of soil-cement required for installation of 8 soil-cement sills at the following locations:

Sill Number	Station
1	1176+00
2	1192+00
3	1215+10
4	1249+90
5	1268+50
6	1287+00
7	1301+00
8	1315+56

2. The subgrade area shall be cut from existing compacted fill or native soil. Overexcavation shall be filled with soil-cement at the Contractor's expense.

3. The soil-cement mix shall be designed for a minimum compressive strength of 750 psi at the end of 7 days as determined from ASTM D-1632 and ASTM D-1633. The soil-cement mix ratio and optimum water content shall be determined as specified in Section 2, Materials, except that the minimum cement content shall be not less than 8 percent. The cement content shall be monitored throughout construction of the project with modifications as required to meet field conditions.

4. Soils to be used for soil-cement shall meet the following gradation:

Sieve Size	Percent Passing (Dry Weight)
2"	100
#4	60 - 100
#10	40 - 70
#200	5 - 25

The Plasticity Index shall not exceed 5. Materials shall be obtained from off-site sources as the Contractor chooses.

5. Portland cement shall be Type II, IIA or IP(MS).

6. If Type IP(MS) is used, pozzolan shall not exceed 20 percent based on absolute volume and the R factor ($R = CaO_5/Fe_2O_3$) shall be less than 1.5.

7. At the time of compaction, the moisture content shall not be below optimum and shall not be more than 2 percentage points above optimum when the mean air temperature during construction hours does not exceed 90 degrees F. Testing shall be in accordance with ASTM D-2216 at an oven temperature of 60±5 C.

8. The compacted layers of soil-cement shall not exceed 8 inches in thickness, nor be less than 4 inches in thickness.

9. Section 9, Compaction, soil-cement shall be uniformly compacted to a minimum of 98 percent of maximum density as determined by ASTM D-558. Method B or Test No. S-6 (Rapid Compaction Control Method) as described in Section 19 of the SCS National Engineering Handbook. Testing for density shall be determined in accordance with ASTM D-1556 or ASTM D-2922 and ASTM D-3017.

10. Section 12, Protecting and Curing, the curing compound shall be Type I-D, Class B.

b. Subsidiary Item, Cement

1. This item shall consist of all Portland cement necessary to construct the sills from the soil-cement mixture determined in accordance with these specifications.

2. Payment for this item of work will be included in Bid Item 7, Soil-Cement.

c. Subsidiary Item, Grading for Soil-Cement Sills

1. This item shall consist of grading the site of each soil-cement sill to a level of 5 feet above the bottom grade of sill and as indicated on the plans.

2. Payment for this item of work will be included in Bid Item 7, Soil-Cement.

d. Subsidiary Item, Water for Soil Cement

1. This item includes the water necessary to produce the soil-cement mix.

2. Payment for this item of work will be included in Bid Item 7, Soil-Cement.

MATERIAL SPECIFICATION

523. ROCK FOR RIPRAP

1. SCOPE

This specification covers the quality of rock to be used in the construction of rock riprap.

2. QUALITY

Individual rock fragments shall be dense, sound and free from cracks, seams and other defects conducive to accelerated weathering. The rock fragments shall be angular to subrounded in shape. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment.

Except as provided below, the rock shall have the following properties:

a. Bulk specific gravity (saturated surface-dry basis) not less than 2.5.

b. Absorption not more than 2 percent.

c. Soundness: Weight loss in 5 cycles not more than 10 percent when sodium sulfate is used or 15 percent when magnesium sulfate is used.

The bulk specific gravity and absorption shall be determined by ASTM Method C 127. The test for soundness shall be performed by ASTM Method C 88 for coarse aggregate modified as follows:

The test sample shall not be separated into fractions. It shall consist of 5000 ± 300 grams of rock fragments, reasonably uniform in size and shape and weighing approximately 100 grams each, obtained by breaking the rock and selecting fragments of the required size.

After the sample has been dried, following completion of the final test cycle and washing to remove the sodium sulfate or magnesium sulfate, the loss of weight shall be determined by subtracting from the original weight of the sample the final weight of all fragments which have not broken into three or more pieces.

The report shall show the percentage loss of weight and the results of the qualitative examination.

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Rock that fails to meet the requirements stated in a, b, and c above, may be accepted only if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this specification.

3. GRADING

The rock shall conform to the specified grading limits after it has been placed in the riprap.

MATERIAL SPECIFICATION

303 GEOTEXTILES, WOVEN AND NONWOVEN

1. SCOPE

This specification is applicable to the quality control of both woven and nonwoven geotextiles.

2. QUALITY

Geotextiles shall be manufactured from synthetic long chain or polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride. The geotextile shall be formed into a stable network of filaments or yarn that retain their relative position to each other, are inert to commonly encountered chemicals, and are resistant to ultraviolet light, heat, hydrocarbons, mildew, rodents, and insects. The geotextile shall be free of any chemical treatment or coating that might significantly reduce its permeability and shall have no flaws or defects that significantly alter its physical properties. The geotextile shall not be exposed to ultraviolet radiation (sunlight) for more than 15 days total in the period of time following manufacture until the geotextile is covered with soil, rock, concrete, etc. Unless otherwise specified, the requirements for materials are a follows:

a. Woven Geotextile

Woven geotextile shall conform to the physical properties listed in Table 1. The woven geotextile shall be manufactured from monofilament yarn that is woven into a uniform pattern with distinct and measurable openings. The geotextile shall be manufactured so that the yarns will retain their relative position with regard to each other. Yarn composition shall be at least 85 percent by weight of propylene, ethylene, or vinylidene-chloride, and shall contain stabilizers and/or inhibitors to enhance its resistance to ultraviolet or heat exposure. The edges of the material shall be selvaged or otherwise finished to prevent the outer yarn form unraveling.

b. Nonwoven Geotextile

Nonwoven geotextile shall conform to the physical properties listed in Table 2. Nonwoven geotextile shall be manufactured from randomly oriented fibers bonded together by the needle-punched process. In addition, one side may be slightly heat bonded.

(NOTE: Non-needle punch, heat bonded nonwoven geotextile may be used for Class IV in Table 2.)

c. Shipping, Product Identification, Certification, and Test Data

The geotextile shall be shipped in rolls wrapped with a protective covering to keep out mud, dirt, dust, debris and direct sunlight. Each roll of geotextile shall be clearly marked to identify the brand, type and the individual production run. (See ASTM D 4873, Standard Guide for Identification, Storage, and Handling of Geotextiles.)

The geotextile shall meet the specified requirements (Table 1 or 2) for the product style or type shown on the label. Product properties as listed in the "Specifiers Guide" (latest issue), Geotechnical Fabrics Report, Industrial Fabrics Association International, 345 Cedar Bldg., Suite 450, St. Paul, MN, 55105, and test data that represent minimum average roll values, will be acceptable documentation that the product style or type meets these specified requirements.

For products that do not appear in the above guide, or do not have minimum average roll values listed, typical test data from the identified production run of the geotextile will be required for each of the specified tests, Table 1 or 2, as appropriate.

All geotextile materials will be subject to sampling and testing by qualified testing laboratories at any time.

TABLE 1. REQUIREMENTS FOR WOVEN GEOTEXTILES

Property	Test Method	Slope Protection Unprotected Class I	Slope Protection Protected and Subsurface Drainage Class II & III	Road Stabilization Class IV
Tensile Strength lbs 1/	ASTM D 4632 Grab Test Method	200 min. in any principal direction	120 min. in any principal direction	150 min. in any principal direction
Bursting Strength psi 1/	ASTM D 3786 Diaphragm Tester	450 min	300 min.	250 min.
Elongation - % 1/ Failure	ASTM D 4632	35 max.	35 max.	35 max.
Puncture - lbs. 1/	ASTM D 4833	100	55	60
Ultraviolet Light Resistance	ASTM D 4355 500 hrs. exposure	70% min. tensile strength retained	70% min. tensile strength retained	70% min. tensile strength retained
Apparent Opening Size (AOS)	ASTM D 4751	As specified	As specified	As specified
Percent Open Area	CW-02215	As specified	As specified	As specified
Permeability 2/	ASTM D 4491	As specified	As specified	As specified

1/ Average roll minimum value (weakest principal direction).

2/ Permeability = Permittivity x geotextile thickness.

TABLE 2. REQUIREMENTS FOR [illegible]OVEN GEOTEXTILES

Property	Test Method	Slope Protection Unprotected Class I	Slope Protection Protected Class II	Subsurface Drainage Class III	Road Stabilization Class IV 3/
Tensile Strength lbs 1/	ASTM D 4632 Grab Test Method	180 min.	120 min.	90 min.	120 min.
Bursting Strength psi 1/	ASTM D 3786 Diaphragm Tester	320 min.	210 min.	180 min.	210 min.
Elongation - % 1/ Failure	ASTM D 4632	100 max.	100 max.	100 max.	100 max.
Puncture - lbs. 1/	ASTM D 4833	80	40	35	50
Ultraviolet Light Resistance	ASTM D 4355 500 hrs.	70% tensile strength retained	70% tensile strength retained	70% tensile strength retained	70% tensile strength retained
Apparent Opening Size (AOS)	ASTM D 4751	Size ≤ #40 max. 2/	Size ≤ #40 max. 2/	Size ≤ #40 max. 2/	Size ≤ #40 max. 2/

1/ Average roll minimum value (weakest principal direction).

2/ U.S. standard sieve size.

3/ A heat-bonded (non-needle punched) nonwoven geotextile may be used for this class.

MATERIAL SPECIFICATION

523. ROCK FOR RIPRAP

1. SCOPE

This specification covers the quality of rock to be used in the construction of rock riprap.

2. QUALITY

Individual rock fragments shall be dense, sound and free from cracks, seams and other defects conducive to accelerated weathering. The rock fragments shall be angular to subrounded in shape. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment.

Except as provided below, the rock shall have the following properties:

a. Bulk specific gravity (saturated surface-dry basis) not less than 2.5.

b. Absorption not more than 2 percent.

c. Soundness: Weight loss in 5 cycles not more than 10 percent when sodium sulfate is used or 15 percent when magnesium sulfate is used.

The bulk specific gravity and absorption shall be determined by ASTM Method C 127. The test for soundness shall be performed by ASTM Method C 88 for coarse aggregate modified as follows:

The test sample shall not be separated into fractions. It shall consist of 5000 ± 300 grams of rock fragments, reasonably uniform in size and shape and weighing approximately 100 grams each, obtained by breaking the rock and selecting fragments of the required size.

After the sample has been dried, following completion of the final test cycle and washing to remove the sodium sulfate or magnesium sulfate, the loss of weight shall be determined by subtracting from the original weight of the sample the final weight of all fragments which have not broken into three or more pieces.

The report shall show the percentage loss of weight and the results of the qualitative examination.

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Rock that fails to meet the requirements stated in a, b, and c above, may be accepted only if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed under this specification.

3. GRADING

The rock shall conform to the specified grading limits after it has been placed in the riprap.

MATERIAL SPECIFICATION

531. PORTLAND CEMENT

1. SCOPE

This specification covers the quality of portland cements.

2. QUALITY

Portland cement shall conform to the requirements of ASTM Specification C 150 for the specified types of cement, except that, when Type I portland cement is specified, Type IS portland blast-furnace slag cement or Type IP portland-pozzolan cement conforming to the requirements of ASTM Specification C 595 may be used unless prohibited in the specifications.

If air-entraining cement is to be used, the Contractor shall furnish the manufacturer's written statement giving the source, amount and brand name of the air-entraining addition.

3. STORAGE AT THE CONSTRUCTION SITE

Cement shall be stored in such a manner as to be protected from weather, dampness or other destructive agencies. Cement that is partially hydrated or otherwise damaged will be rejected.

MATERIAL SPECIFICATION

534. CURING COMPOUND (FOR CONCRETE)

1. SCOPE

This specification covers the quality of liquid membrane-forming compounds suitable for spraying on concrete surfaces to retard the loss of water during the curing process.

2. QUALITY

The curing compound shall meet the requirements of ASTM Specification C 309.

Unless otherwise specified the compound shall be Type 2.

3. DELIVERY AND STORAGE

All curing compound shall be delivered to the site of the work in the original container bearing the name of the manufacturer and the brand name. The compound shall be stored in a manner to prevent damage to the containers and to protect water-emulsion types from freezing.

GOVERNMENT CONSTRUCTION AND QUALITY MANAGEMENT PLAN
for
EAST MARICOPA FLOODWAY REACHES 1 & 2, REPAIR PHASE 1

General

The repair work is within the East Maricopa Floodway in Pinal County, Arizona, approximately seven (7) miles south of Chandler Municipal Airport. The work will be constructed under a government contract that is scheduled to be awarded in January 1991.

Major items of work requiring inspection during construction are:

1.	Common Excavation	20,900 cy
2.	Earthfill	2,000 cy
3.	Loose Rock Riprap	35,000 cy
4.	Gravel Cover (ABC)	26,430 cy
5.	Geotextiles	90,300 sy
6.	Soil Cement	3,100 cy
7.	Surveys	L.S.

Items of work to be inspected:

Periodic Inspection	Continuous Inspection
Survey	Common Excavation
Mobilization	Earthfill
Pollution Control	Loose Rock Riprap
Removal of Water	Gravel Cover
Water	Geotextiles
Grading	Soil Cement

A. Excavation, Common

No specific material Testing is required. An inspector will be required to assure the correct geometrical foundation shape has been achieved in the channel bottom at toe of slope before placing ABC bedding.

B. Earthfill

1. All earthfill will be tested for compaction and moisture. An inspector and materials testing technician will be required to document quality assurance.

2. The test frequency for compaction and moisture will be 400± cubic yards. This will require at least five (5) compaction and moisture tests for quality assurance.

C. Loose Rock Riprap

1. Rock for riprap will be tested for gradation, bulk specific gravity, absorption and soundness. An inspector and material testing technician will be required to document quality insurance.

2. Initial testing will be performed on the material to demonstrate that it conforms with requirements of the specifications before being delivered to the site. Thereafter, gradation shall be tested once for each 1,000 cy and the other tests shall be performed for each 2,000 cy. If confidence in the Contractor's quality control is developed, frequency of testing may be decreased to a gradation test for each 2,000 cy and the other tests for each 6,000 cy.

D. Gravel Cover

1. Crushed aggregate will be tested for gradation and soundness. Processed material will be tested for gradation, percentage of wear, plasticity index and liquid limit. An inspector and materials testing technician will be required to document quality assurance.

2. The initial test frequency for all applicable tests will be one test for each 300 cy of material or approximately one per day. As confidence in the Contractor's quality control is developed, the Engineer may approve reduced test frequency to one gradation test for each 750 cy or one test per week, and to one of each of the other applicable tests for each 1,500 cy or every other week.

E. Geotextiles

1. Geotextiles will be tested for tensile strength, bursting strength, elongation, puncture, ultraviolet light resistance and apparent opening size (AOS). An inspector and materials testing technician will be required to document quality assurance.

2. Approval for use of the geotextile (filter fabric) will be based on the manufacturer's literature having test results demonstrating the material equals or exceeds the applicable specifications. Material delivered to the site shall be thoroughly tested at a frequency of approximately once per 2,500 sq yd installed (once per week) initially. As confidence in the quality control of the material is developed, the Engineer may reduce the testing frequency to as low as one set of tests per 10,000 sq yd of material installed (approximately once per month).

F. Soil Cement

1. All materials proposed for use in mixing soil cement will be tested, and "job mix" designed in accordance with the specifications. Compaction testing will be used to confirm that soil cement has been properly placed. An inspector and material testing technician will be required to document quality assurance.

2. Testing shall be performed on all soil cement to the extent necessary to demonstrate satisfactory mixture, placement and curing.

G. 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 the slope and reference stakes, and as-built sections are within tolerance.

Timing of Inspections

It is anticipated that the notice to proceed will be issued in January, and the performance time has been calculated to be 270 calendar days. Once construction starts, work accomplished per day should be uniform with little variation. The construction sequence and performance time is based on the work being performed by an average small business contractor.

SKILLS NEEDED FOR CONTRACT ADMINISTRATION AND INSPECTION

Project Engineer

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 inspection 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.

b. Have completed the Unified Soil Classification (SM-1) course offered through SCS.

c. Have completed the Management Level II Course.

CHIEF INSPECTOR

Skills Needed:

a. Must be able to communicate effectively with the Contractor's field supervisory personnel.

b. Must understand basic staking and construction layout.

c. Must know the principles of earthwork inspection.

d. The ability to perform quantity computations.

e. The ability to maintain construction records.

f. The ability to 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, aggregate and riprap testing procedures.

SURVEY PARTY CHIEF, GS-6/7

Skills Needed:

a. Have 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 experience.

SURVEY RODMAN, GS-5/6

Skills Needed:

a. Must be capable of performing the duties required of a rodman or chainman 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. 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	1,060 hours
Chief Inspector	1,780 hours
Material Testing Technician	1,060 hours
Survey Party Chief	710 hours

Not included in the above hours is the estimated overtime. If more hours of inspection are required, project personnel will be rotated to cover inspection duties.

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 the construction.

NAMES AND QUALIFICATIONS OF ASSIGNED PERSONNEL

Noller Herbert, Project Engineer/Government Representative GS-11

Experience:

Worked for SCS three 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 and 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 Reach 4 and Signal Butte Floodway Joint Sealant Repair, EMF Reach 6 Floodway Joint Sealant Repair, EMF Reach 6 Floodway construction ($2.0 million), Vineyard Road FRS Repair ($400,000), and Saddleback Diversion Repair ($560,000).

Training:

Engineering NPEG	Ft. Worth, TX 3/87
Engineering NPEG Continuation	Ft. Worth, TX 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

Reaches 1, 2, and 3, Vanar Diversion Repair, Signal Butte FRS/Pass Mountain Diversion, Apache FRS/Bulldog Floodway, and EMF Reach 6 Floodway, and Vineyard Road FRS Repair.

Soil Mechanics	Portland, OR 1969
Soil Mechanics II	Salt Lake UT 1978
Construction Inspection	Ft. worth, TX 1968
Construction Inspection	Ft. Worth, TX 1988
Concrete	Ft. Worth, TX 1980
Claim Avoidance, FAR's	Phoenix, AZ 1985
Troxler Nuclear Density Gauge	Phoenix, AZ 1981
ACI Grade I Certification	Phoenix, AZ 1987
Soil Compaction Techniques	Phoenix, AZ 1988
Contract Administration	Columbus, OH 1989

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, six years.

He has worked on the survey crew monitoring contractor surveys for EMF Floodway, Reaches 2, 3, 5, and 6. Signal Butte Floodway, Vanar Diversion Repair, Signal Butte FRS and Pass Mountain Diversion, Apache Junction FRS and Bulldog Floodway, and Vineyard Road FRS Repair.

Training:

Survey Records Investigation (BLM)	Phoenix, AZ 1984
Troxler Nuclear Gage	Phoenix, AZ 1980
Management Level II	Phoenix, AZ 1980

Gary Mason, Materials Testing Technician, GS-7

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 Diversion Repair, EMF Reaches 3, 5, and 6, Signal Butte/Pass Mountain, and Apache/Bulldog and Vineyard Road FRS from 1984 to present.

Training:

Soils Testing	Lincoln, NE 1985
Concrete	Ft. Worth, TX 1985
Construction Inspection	Ft. Worth, TX 1983
Troxler Nuclear Gage	Las Vegas, NV 1984
ACI Grade I Certification	Phoenix, AZ 1987
Hydraulics for Technicians	Phoenix, AZ 1987
Management Level II	Phoenix, AZ 1989

Survey Rodman, GS-5

No one assigned, as surveying needs arise the position will be filled by available inspectors 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: _____
State Conservation Engineer Date

By: _____
Project Engineer Date

APPROVAL OF CO-DETERMINERS/

_____
State Conservation Engineer Date

_____
Contracting Officer Date