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A DAMES & MOORE GROUP COMPANY

REPORT
INTERIM DAM SAFETY
60 PERCENT SUBMITTAL
WHITE TANKS FRS #3

60%

Prepared for:
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Prepared by
Dames & Moore

D&M Job No. 15448-007-058
February 10, 2000

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7500 North Dreamy Draw Drive
Suite 145
Phoenix, Arizona 85020
602 371 1110 Tel
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February 10, 2000

Mr. Tom Renckly, P.E.
Project Manager
Maricopa County Flood Control District
2801 West Durango
Phoenix, AZ 85009

Re: White Tanks FRS #3 Dam
Interim Dam Safety
60 Percent Design Report
and Design Drawings
D&M Job No. 15448-007-058

Mr. Renckly:

This letter transmits our 60 percent design report and drawings, in accordance with our engineering contract with the District, Change Order No. 5, Task 1- Interim Dam Safety. This submittal follows our 30 percent level report, submitted in January, 2000. As you requested, we are also sending these documents to ADWR and NRCS.

This 60 percent submittal incorporates comments that we received on the 30 percent submittal from the District and ADWR (reference ADWR letter of January 19, 2000). A response to the ADWR comment letter is provided in Appendix C of this report, and identifies the sections where the comments are addressed. ADWR's comment 1, concerning the filter investigation, was not addressed as this investigation is still underway.

Sincerely,

DAMES & MOORE

Scott G. Newhouse, P.E.
Project Engineer

Todd E. Ringsmuth, P.E.
Assistant Project Manager

SGN/TER/tc

cc: Warren Rosebraugh - FCDMC
Mike Greenslade - ADWR
Noller Herbert – NRCS
Sandy Gourlay – D&M

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1.0 INTRODUCTION

This report was prepared to document the background and design basis for interim dam safety improvements to the White Tanks FRS #3, owned and maintained by the Flood Control District of Maricopa County (the District). The purpose and scope for this engineering work are described in contract FCD 98-11, Change Order No. 5. Measures are required for renovation of the dam for safety purposes. The required measures dictated in the Arizona Department of Water Resource (ADWR) memo dated July 1999 and letter dated August 9, 1999 are as follows:

- Provide minimum 4 feet freeboard
- Outlets require trash racks
- Outlets require diaphragm filters
- Develop operational plan
- Ensure dam's safety against erosion in cracks
- Verify adequate filter protection between Station 57+00 and Station 59+00

This is a 60 percent level design submittal prepared for review by the District, ADWR, and the National Resources Conservation Service (NRCS). ADWR comments on the previous submittals (10 and 30 percent level design) and responses to the comments are presented in Appendix C.

1.1 OBJECTIVES

The design objectives of the interim dam safety improvements are to increase the confidence of ADWR and the District in the integrity of the embankment and viable operation of outlet works during an impoundment event, and to implement several freeboard and erosion-related improvements in the vicinity of the south abutment spillway.

A series of dam safety inspections and engineering studies (Dames & Moore, 1999) have characterized the elements of the dam that require renovation or modification. Previously identified features requiring modification consist of trash racks on outlet works, diaphragm filters around conduits and associated extension of outlet pipes, riprap armor at the right dam abutment, and emergency spillway modifications.

The final design report will include design drawings, a construction cost estimate, construction specifications, and a construction quality assurance and quality control (QA/QC) plan. An operations plan will be submitted separately by the District.

2.0 PROJECT OVERVIEW

2.1 DAM HISTORY

2.1.1 Initial Design and Construction

White Tanks FRS #3 was built as a flood control structure in 1954. It was initially a homogenous earth embankment dam constructed by the NRCS (then the Soil Conservation Service). In later renovations filter/drainage works were added, as described Section 2.1.2.

The dam is currently owned and operated by the District. The embankment is approximately 7,500 feet long and was constructed using material borrowed from the reservoir of the dam. The embankment is approximately 30 feet high. The crest width varies between 10 and 11 feet. The upstream and downstream faces are sloped at 2.5:1 (horizontal to vertical) and 2:1, respectively. Three gated corrugated metal pipes (CMPs) through the embankment serve as the principal outlets from the reservoir. Two outlets are of 48-inch diameter while the third is of 24-inch diameter. The northernmost outlet is connected to the Beardsley Canal via a concrete-lined channel, while the other two outlets discharge into desert washes. The emergency spillway for the facility is cut into natural ground at the south abutment of the dam. The spillway crest elevation is approximately 1,210 feet. To the knowledge of the District, the reservoir has never been full and the dam has yet to experience a first filling event.

2.1.2 Past Observed Problems

Cracks

Transverse and, to a lesser extent, longitudinal cracks have been observed through the embankment. In 1982, the NRCS implemented a remedial action program to address the issue of transverse cracking. A section of the embankment between Station 56+10 and Station 59+90 was breached and re-constructed. A central chimney drain also was installed along the entire length of the embankment. Finger drains, which daylight at the downstream toe, were provided at the location of the identifiable transverse cracks to convey water intercepted by the chimney drain.

A new transverse crack in the reconstructed zone was encountered during an inspection in November 1999. The crack was located at approximately Station 59+00. A work plan to investigate this crack is currently under review.

Subsidence

Since its construction in 1954, the crest of the dam has settled approximately 3.6 feet at the northern end of the alignment. This settlement is a result of regional land subsidence associated with groundwater withdrawal in the area. The amount of settlement appears to decrease steadily along the alignment until virtually no settlement is observed at the southern end of the embankment.

Potential Voids Around Outlet Pipes

The outlet pipes were inspected by Speedie and Associates in October 1999. The inspection revealed that the pipes are in relatively good condition in that they did not identify areas of significant corrosion and/or deformation. However, the sound generated when the pipe was tapped lightly with the hammer suggested that the soils around the haunches of the pipe may have been inadequately compacted during construction and voids may be present around the outlet pipes.

3.0 FILTER INVESTIGATION

3.1 FIELD INVESTIGATION

The District and ADWR agreed that additional efforts should be made to verify the presence of a seepage control filter between Station 57+00 and Station 59+00. Finger drains at the toe are not visible through this portion of the dam, and construction records are inconclusive. Therefore, we conducted a field investigation to confirm the presence of a filter. Our field investigation consisted of drilling three exploratory borings on the dam.

Filter material was found in all three borings. The filter extended to depths equal to the base of the embankment. The borings were drilled on the crest of the dam on November 1, 1999. ATL, Inc. completed the work under the supervision of a Dames & Moore field engineer using a CME 75 with a 3 ¾-inch hollow stem auger. The borings were located at Stations 57+30, 58+00, and 59+00 and were drilled to depths of 30 feet.

3.2 LABORATORY TESTING

Mechanical sieve tests were performed on samples from each of the three borings to obtain a grain-size distribution. Results of these tests are included in Appendix A.

3.3 ADDITIONAL INVESTIGATION

Plans currently are being developed for additional investigation of the reconstructed zone of the dam. A work plan currently is being reviewed by the District and ADWR.

The dam inspection conducted in November 1999 identified a transverse crack approximately located at Station 59+00. In order to investigate this crack, we plan to excavate an exploratory trench at this location. We will determine the depth of the crack and use the opportunity to further investigate the construction of the existing filter at this location. Results of our evaluation will be presented in a future report.

4.0 DESIGN

4.1 DIAPHRAGM FILTERS AND OUTLET PIPE EXTENSIONS

White Tanks FRS #3 originally was designed as a homogeneous embankment. Consequently, filters were not included around conduits that pass through the dam. Current practice in dam engineering is to include diaphragm filters around conduits to prevent internal erosion of soil in a seepage path along the conduit. Previous investigations (Speedie & Associates, 1999) have identified potential voids around the outlet pipes within the embankment which increases the need for the diaphragm filter to prevent such erosion.

The filter material is designed to retain the soil within the embankment while passing seepage. Design criteria require the filter to have an opening size specifically to retain soil particles. At the same time, the opening size must be sufficient to provide a high coefficient of permeability, with little resistance to seepage. NRCS has established filter criteria that will be the basis of design. Their criteria also include dimensions of filter zone. The filter must reach above and below the conduit a sufficient distance to intercept seepage paths. Similarly, lateral dimensions of the filter are required to intercept likely seepage paths.

4.1.1 Conventional Graded Sand Filter

A conventional graded sand filter will be installed around each of the three outlets at the existing toe of the dam. The filter was designed according to NRCS guidelines presented in Technical Release No. 60C (TR-60C) (NRCS, 1985). According to TR-60C, minimum diaphragm filter thickness is 3 feet; however, for ease of construction, the filter thickness was increased to 4 feet. The filter will extend twice the diameter of the pipe on each side as well as above the pipe. The filter will extend one and a half times the diameter below the pipe. The filter will be composed of ASTM C33 sand. The calculation supporting this is present in Appendix B, Diaphragm Filter Gradation.

The embankment cover was calculated according to the methods in TR-60C. This calculation resulted in 6-7 feet of cover at the top of the filter and 10.5-12.5 feet of cover at the bottom of the filter. This calculation is presented in Appendix B, Diaphragm Filter and Fill Cover Sizing. The top of the embankment will be at least 10 feet wide and the berm will have a 2:1 (horizontal: vertical) or flatter slope. The existing headwall will be demolished and the outlet pipe will be cut off at the diaphragm filter. Cross-sections of the filters on each outlet are shown on Drawings D2, D3 and D4.

4.1.2 Outlet Pipe Extension

In order to install the diaphragm filter, a section of the existing CMP must be demolished and extended beyond the toe of the new soil berm. The extension will use galvanized, polymer-coated CMP to extend the outlet pipe. The use of CMP is appropriate because it will be protected by the new filter, the relatively small load on the new section of pipe, and the ease of connection to the existing CMP. Riprap will be placed around the outlet pipe instead of constructing a new headwall.

The potential negative aspects associated with the use of CMP are poor compaction around the pipe, or deformation of the pipe allowing erosion or piping of embankment fill. This mechanism should not be a concern in this case since the CMP is being installed downstream of the new filter, which will provide protection against piping.

The existing headwall will be demolished and the cut slope resulting from the demolition will be the upstream face of the new filter. The existing CMP will be demolished to the position of the filter. A conventional banded connection at the filter location will join the existing CMP to the extension (see Drawing D5 for detail).

The existing CMP has an asbestos coating. Therefore, special precautions may be needed for the demolition of this pipe. The construction specifications will identify these requirements.

4.2 TRASH RACKS

Trash racks are required to prevent outlets from clogging with debris during flood events. Two designs will be used for the trash racks. The design for the central outlet trash rack is illustrated on Drawing D5. This trash rack was designed according to *Design of Small Dams* (Bureau of Reclamation, 1987) and TR-60C. The main criteria that we met was the flow velocity through the trash rack be 2.5 feet per second (ft/sec). The trash rack is designed to cover the outlet pipe allowing for operation of the slide gate within the rack. Accordingly the trash rack will be 9.5 feet long, 5 feet wide, and 2.5 feet high. The trash rack will be constructed of flat bars with a 6-inch bar spacing in both directions. The supporting calculation is presented in Appendix B, Trash Racks.

The north and south pipes will have smaller trash racks. These racks will differ from the central trash rack mainly in that they will not completely enclose the outlet and slide gate. The design for these trash racks is illustrated on Drawing D5.

4.3 RIPRAP AT THE RIGHT DAM ABUTMENT

Armor protection of the right dam abutment, within the emergency spillway, and along a portion of the downstream toe of the dam, is needed in order to prevent erosion of the embankment during flood events when the emergency spillway is passing flow.

Riprap sizing was conducted using a computer program called Riprap Design System, Version 2.0 developed by West Consultants, Inc. A flow rate of 525 cubic feet per second (cfs) was used in the design as this is the maximum expected flow over the spillway as specified in "Maximum Water Surface Elevation for Inflow Design Flood (IDF) at White Tank Flood Retarding Structure No. 3 under Current Conditions" (District, 1998). The riprap will have a D_{50} of 6 inches with a minimum stone size of 2 inches and a maximum stone size of 12 inches. The details of this calculation are presented in Appendix B, Riprap.

The riprap will extend approximately 155 feet along the downstream toe of the dam and approximately 50 feet along the upstream toe, as shown on Drawing C1. The depth of the water through the spillway was used to estimate riprap height and location. The riprap will extend 2.5 feet vertically from the toe of the dam as illustrated on Drawing D1.

4.4 EMERGENCY SPILLWAY MODIFICATIONS

The dam has been shown to have insufficient freeboard during passage of the inflow design flood (half-PMF) due to the subsidence of the northern end of the embankment. In order to improve freeboard and decrease the potential for overtopping the dam, modifications will be made to the spillway. The form and extent of these modifications have been negotiated between the District and ADWR.

The concept for emergency spillway modifications consists of lowering a portion of the existing spillway through the construction of a channel, or "notch." The notch will be cut such that its base elevation is 4 feet below the lowest elevation on the crest of the dam per an ADWR letter dated August 19, 1999. Since the north end of the dam is subsiding as discussed in Section 2.1.2, the spillway notch base elevation also will account for future subsidence. Ten years of subsidence were accounted for in the elevation calculation, which is presented in Appendix B, Spillway Notch Elevation. The subsidence rate was calculated by comparing elevations for subsidence marker A-1, located at Station 10+00 on the crest of the dam, taken during subsidence surveys dated July 1990 and July 1997. This resulted in a subsidence rate of 0.0266 feet per year (ft/yr) and a 10-year subsidence allowance of 0.266 feet.

The lowest point on the dam as determined during a survey conducted on December 8 and 9, 1999 is located approximately at Station 8+70. The elevation at this point is 1211.385 feet. Therefore, the notch base elevation was calculated to be 1207.119 feet (which was rounded down to 1207 feet for clarity during construction). The notch will vary in depth, be 10 feet wide, and approximately 470 feet long. The alignment of the notch was determined by the topography, required channel dimensions, and property line considerations. These factors require the channel alignment to be toward the dam. Although the channel directs flow toward the dam toe, the design flow, based on notch capacity, is low and will not inundate the toe. A plan of the spillway modifications is shown on Drawing C1. Sections of the spillway modifications are shown on Drawing D1.

4.5 DAM BREAK ANALYSIS

Since the spillway modifications are minor, these modifications should have no effect on previous dam break analyses. Therefore, previous dam break analyses (AGK Engineers, 1991) are sufficient.

4.6 INTERIM OPERATION PLAN

The District will develop an interim operation plan and submit it to ADWR as a separate document. This document will address how the District will operate the outlet gates during periods when water may be present behind the dam.

5.0 CONSTRUCTION SUPPORT DOCUMENTATION

5.1 DESIGN DRAWINGS

Design drawings reflect 60 percent completion of engineering and design for each of the elements described above. This 60 percent design submittal consists of twelve drawings containing all major components of the project. Details or technical notes may have been added, however changes or more detail may be reflected in the drawings pending further engineering and technical review. In addition, we intend to submit full-size drawings for the 90 percent submittal. The drawing package will be revised for the 90 percent submittal to incorporate refinement of the design, the District's review comments, and ADWR's review comments.

5.2 CONSTRUCTION COST ESTIMATE

The construction cost estimates presented in Tables 1 and 2 are based on the 60 percent design drawings and specifications and carries with it a ±30 percent level of accuracy, given that the engineering and design are still in progress. The estimate is comprised of a list describing the basis-for-estimate, list of assumptions presented in Appendix D, and cost estimate spreadsheet presented in Table 1. The cost estimate outlines the quantities, unit prices and total capital costs associated with the construction activities for performing modifications to FRS #3.

Quantities in the cost estimate are based on the lines and grades shown on the design drawings, based on the assumption that the District will construct work elements on a lump sum basis or unit price basis measured in-place. Volumes of soil are calculated from the drawings based on "in-place" dimensions. Factors such as swell, shrink, or contingency have not been assigned to these volumes based on our recommendation for measurement and payment based on in-place volumes. Unit costs have been developed from a combination of sources, including vendor and contractor quotes, Dames & Moore's historical project cost database, and RS Means Site Work Cost Guide (1997) correlated to year 1999 dollar value.

The estimate is generally structured to follow the Maricopa Association of Governments (MAG) number system and includes general requirements such as mobilization, temporary controls, permits, insurance, construction testing, etc. A 30 percent cost contingency has been assigned to the estimate for this 60 percent submittal, which is typical for the industry. The percentage of contingency will be lowered as more engineering and design detail is available in subsequent submittals.

The 90 percent cost estimate submittal will reflect revisions to line items, quantities, and unit costs as more analysis is performed on the estimate and overall design. The next submittal also will incorporate additional review comments from the District.

5.3 CONSTRUCTION SPECIFICATIONS

The construction specifications will provide technical instructions and guidance for the contractor performing the installation of the Interim Dam Safety project components. The construction specifications rely upon Uniform Standard Specifications and Details for Public Works Construction sponsored by MAG, and supplemented by language borrowed from Dames & Moore's historical project database of technical specifications. Dames & Moore's supplemental specifications will modify the MAG specifications to incorporate the requirements of this site-specific project. This specification approach is consistent with the specification example and general guidance we obtained from the District.

It is our understanding that the District will develop the "upfront" documents describing the Bidding and Contract Requirements for this project, separately from the technical oriented construction specifications. The specification package contained in Appendix E includes all applicable sections to the design; however, further engineering and design may change or enhance the detailed site-specific technical instructions and requirements. The MAG format has been followed throughout and supplemental specifications have been modified accordingly.

5.4 CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL PLAN

The construction QA/QC Plan will provide guidance for the District or its designated Construction Quality Assurance (CQA) Consultant conducting inspection, construction oversight, and materials testing for the installation of the Interim Dam Safety components. The QA/QC Plan, a stand-alone document, is presented in Appendix F. The plan is written as a separate guide for the oversight on behalf of the District. The plan can be used by a third-party CQA Consultant engaged in oversight or by the District directly. The plan summarizes the project components, project and QA/QC team, responsibilities, lists of observations and testing requirements, documentation requirements and forms, and a table showing suggested materials testing methods and frequencies. Similar to the construction specifications, this plan will be revised each time for successive design submittals, incorporating new design information and the District comments.

TABLES

White Tanks FRS #3
Interim Dam Safety
Cost Estimate
(60% Submittal)

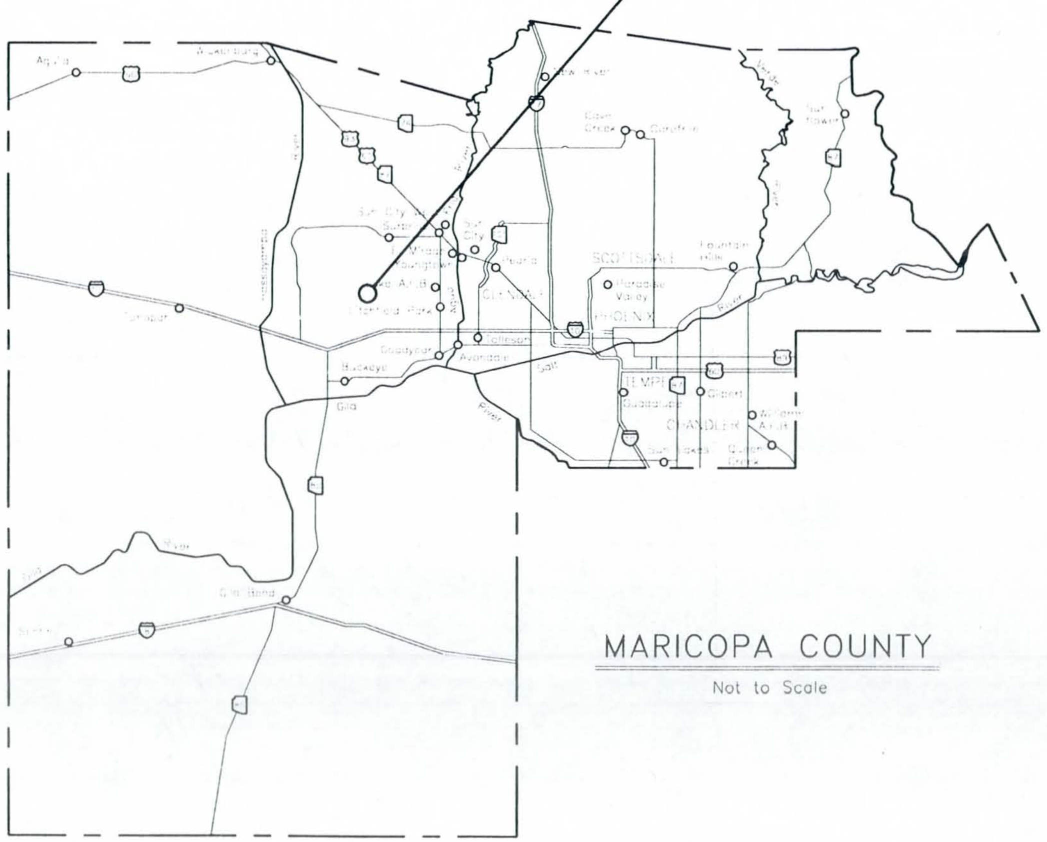
MAG ID	DESCRIPTION	Unit	Quantity	Unit Price	Total Cost
107	Constr. SWPPP (Temp Hay Bales, Silt Fence, Riprap Sed. Basin)	LS	1	$2,347	$2,347
201	Clearing/Grubbing/Stripping	SY	1350	$0.45	$609
201	Clearing/Grubbing/Stripping	SY	1,500	$0.45	$677
202	Mobilization (includes gen cond. and temp facilities)	LS	1	$4,695	$4,695
206	Import, Place, Grade, Compact Filter Sand	CY	250	$28.21	$7,051
210	Excavation of Dam Face and Toe	CY	2,000	$2.54	$5,077
211-1	Embankment Fill (Using Excavated Spillway Material as Borrow)	CY	2,800	$3.38	$9,477
211-2	Grade Slopes	SY	1,700	$4.51	$7,672
215	Channel Excavation	CY	1,000	$3.95	$3,949
215	Install Soil Berms	CY	450	$2.26	$1,015
220-2	Import, Place Riprap Around Pipe, Up Slope, for South, Central Channel	CY	175	$39.49	$6,910
220-2	Import, Place Riprap On Dam Embankment Slope	CY	280	$39.49	$11,056
220-2	Import, Place 1-inch stone at road crossing riprap	CY	15	$39.49	$592
225	Watering for dust control and moisture conditioning	LS	1	$846	$846
230-1	Install Geotextile Beneath Riprap	SF	150	$0.45	$68
230-2	Install Geotextile Beneath Riprap	SF	2,400	$0.45	$1,083
350-1	Demolition of Existing Concrete Headwall & Removal of Pipe & Shotcrete	EA	3	$2,031	$6,092
401	Traffic Control	LS	1	$2,600	$2,600
405	Monuments/survey as-built	LS	1	$1,579	$1,579
420	Perimeter Fencing (includes removal and replace of existing barbed fence)	LS	1	$1,354	$1,354
430	Revegetate	AC	0.5	$2,256	$1,128
430	Revegetate	AC	0.5	$2,256	$1,128
515-1	Trash Rack Central Outlet Pipe (48-inch pipe)	EA	1	$6,318	$6,318
515-2	Trash Rack North Outlet Pipe (48-inch pipe)	EA	1	$4,287	$4,287
515-3	Trash Rack South Outlet Pipe (24-inch pipe)	EA	1	$3,159	$3,159
525	Pnuematically placed mortar (shotcrete) north channel only	SF	800	$7.33	$5,867
530	Painting trash racks	LS	1	$1,974	$1,974
621	Install 48-inch Diameter CMP Outlet Pipe Extension	LF	82	$45.13	$3,700
621	Install 24-inch Diameter CMP Outlet Pipe Extension	LF	35	$34.97	$1,224

Subtotal	$103,537
Contigency 30%	$31,061
Total Project Cost	$134,597

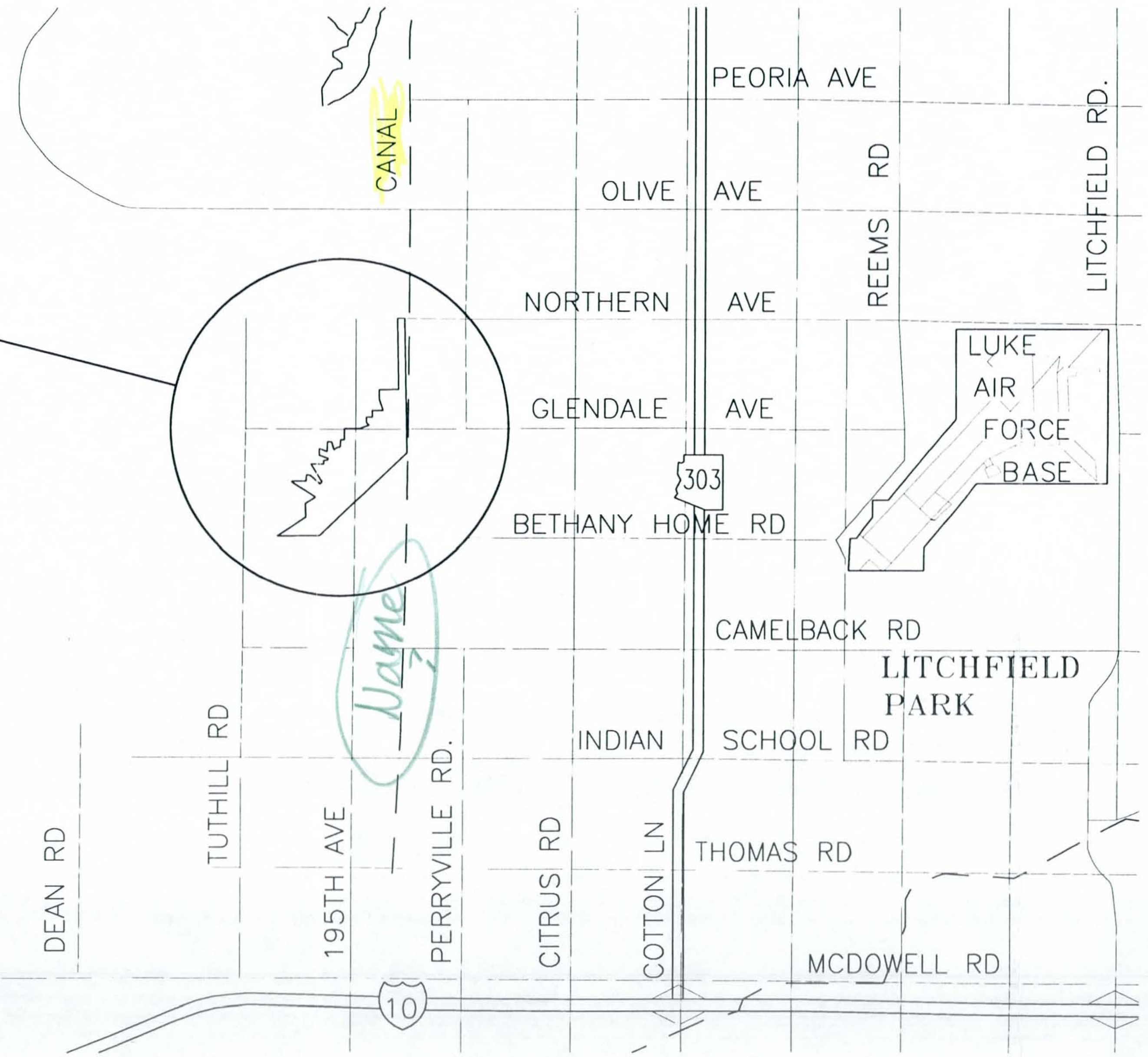
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

PLANS FOR THE WHITE TANKS FRS#3
INTERIM DAM SAFETY IMPROVEMENTS
PCN.
FCD CONTRACT NO.

PROJECT LOCATION



MARICOPA COUNTY
Not to Scale



VICINITY MAP
Not to Scale

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

ISSUED FOR PUBLIC BIDDING BY:

CHIEF ENGINEER AND
GENERAL MANAGER

BOARD OF DIRECTORS OF
THE FLOOD CONTROL DISTRICT

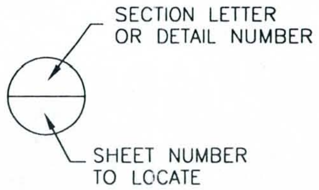
- CHAIRMAN

DISTRICT 1
DISTRICT 2
DISTRICT 3
DISTRICT 4
DISTRICT 5

LEGEND

STRUCTURAL NOTES

GENERAL NOTES



ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

ABBREVIATIONS

INDEX OF SHEETS

DRAWING NO.	TITLE	SHEET NO.
G1	COVER SHEET AND VICINITY MAP	1
G2	DRAWING INDEX, LEGEND AND GENERAL NOTES	2
G3	SITE MAP	3
C1	PLAN AND ALIGNMENT OF EMERGENCY SPILLWAY MODIFICATIONS AND ARMOR	4
C2	NORTH OUTLET PLAN	5
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D4	SOUTH OUTLET SECTION, ELEVATION AND DETAIL	11
D5	OUTLET PIPES AND TRASH RACK SECTION AND DETAILS	12

PROJECT BENCHMARK

NO.	REVISION	BY	DATE
C	60% SUBMITTAL	TER	02/00
B	30% SUBMITTAL	TER	01/00
A	10% SUBMITTAL	TER	11/99

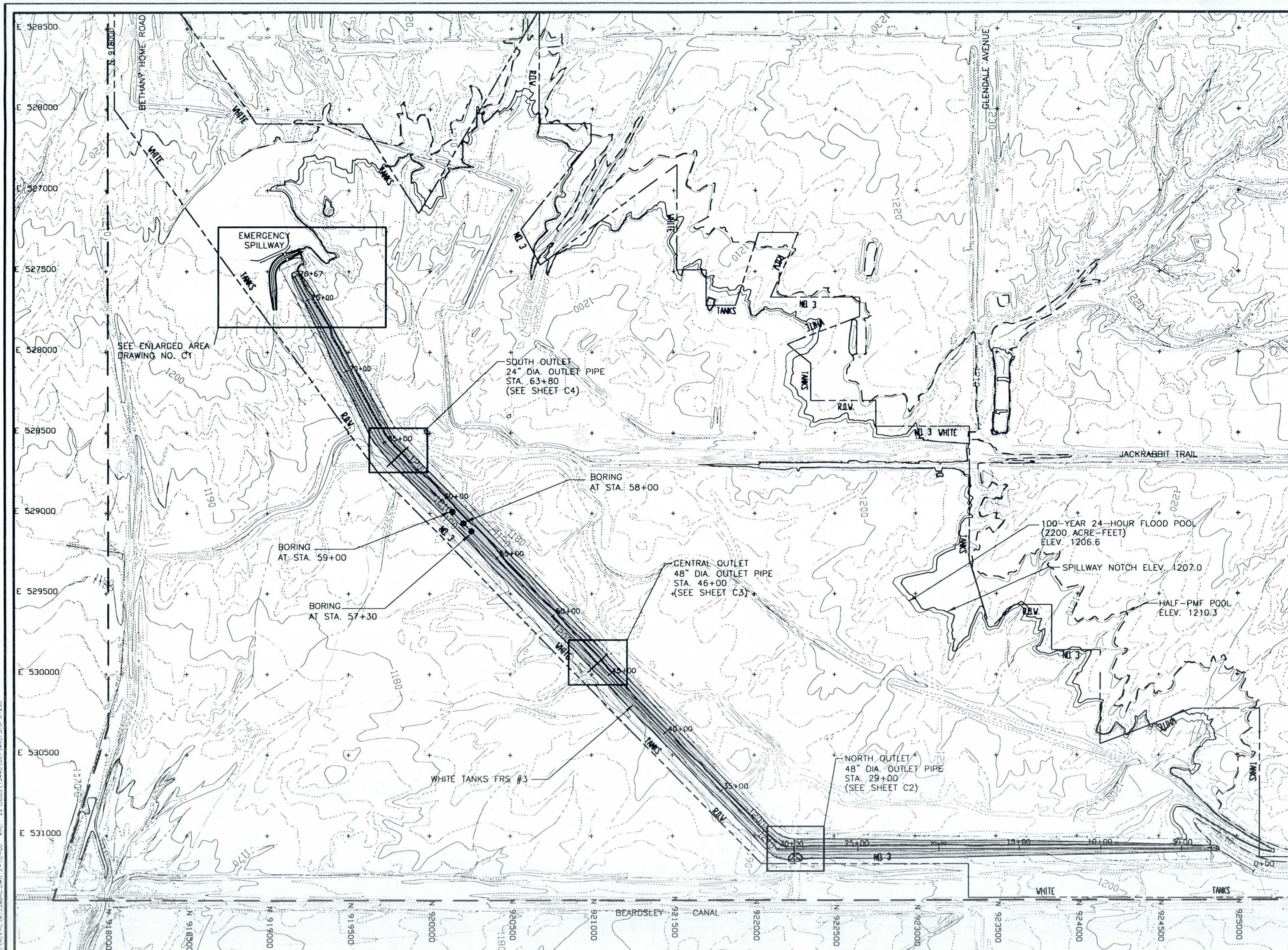
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	M. HANCHETT	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.	TITLE	SHEET	OF
G2	DRAWING INDEX, LEGEND AND GENERAL NOTES	2	12



SOURCE:
BASE MAP OF WHITE TANKS/AGUA FRIA A.D.M.S. TOPOGRAPHIC MAPS, FLOWN 12/22/89 BY COOPER AERIAL OF PHOENIX, INC. FOR THE WLB GROUP INC., AREA DRAINAGE MASTER STUDY.
BASIS OF BEARING: COVERTED FROM NAD 27 TO ARIZONA ZONE 12 CENTRAL NAD 83

N

0 300 600
SCALE IN FEET
2 FOOT CONTOUR INTERVAL

LEGEND:

1200	EXISTING CONTOUR 5' INTERVAL
	EXISTING CONTOUR 1' INTERVAL
	FCDMC PROPERTY LINE
	APPROXIMATE PROJECT BOUNDARY
	EXISTING DIRT ROAD

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
3	60% SUBMITTAL	TER	02/00
2	30% SUBMITTAL	TER	01/00
1	10% SUBMITTAL	TER	11/99

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS #3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

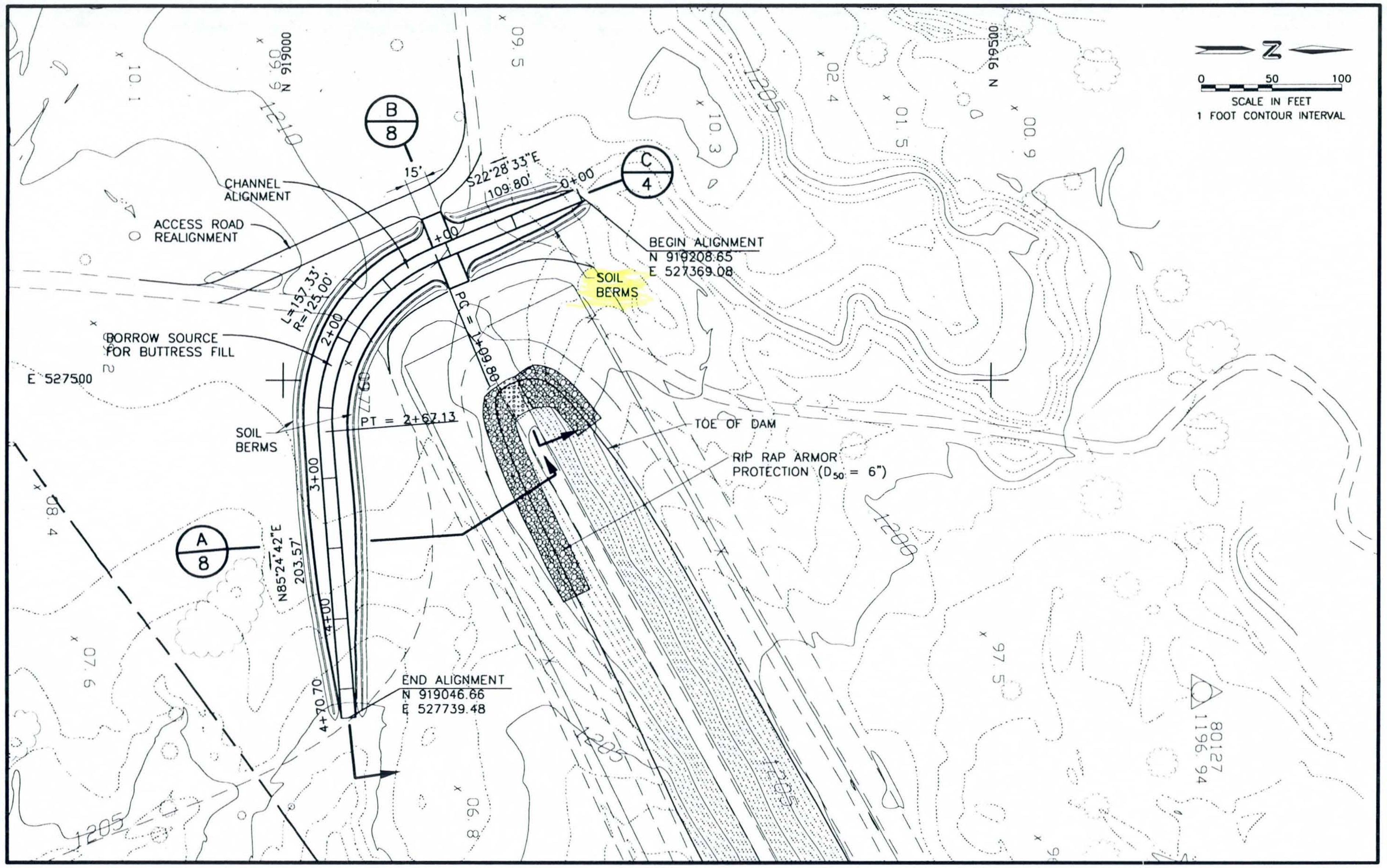
	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
G3	SITE MAP	3 12

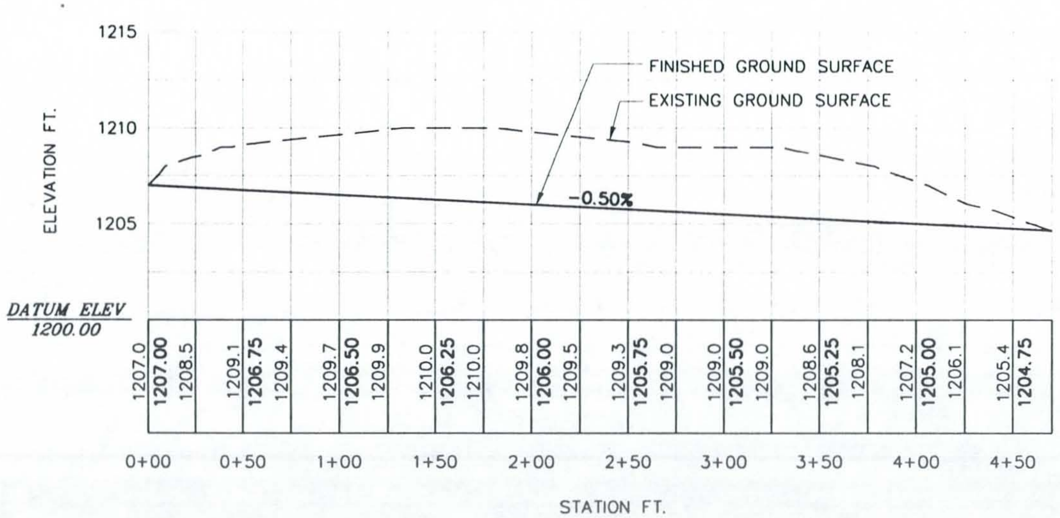
LEGEND:

1200 (solid line)	EXISTING CONTOUR 5' INTERVAL
(dotted line)	EXISTING CONTOUR 1' INTERVAL
(long-dash line)	PROPERTY LINE (WHITE TANKS FRS #3)
(double-dashed line)	EXISTING DIRT ROAD



SOURCE:
BASE MAP OF WHITE TANKS/AGUA FRIA A.D.M.S. TOPOGRAPHIC MAPS, PROVIDED BY FCDMC 12/98.
BASIS OF BEARING: ARIZONA ZONE 12 CENTRAL NAD 83

A/4 SPILLWAY PLAN



C/4 CHANNEL PROFILE

LEGEND:

1209.1 EXISTING GROUND SURFACE ELEVATION
1206.75 FINISHED GROUND SURFACE ELEVATION

HORIZONTAL SCALE: 0 50 100 SCALE IN FEET

VERTICAL SCALE: 0 5 10 SCALE IN FEET

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C			
B	30% SUBMITTAL	TER	01/00
A	10% SUBMITTAL	TER	11/99

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

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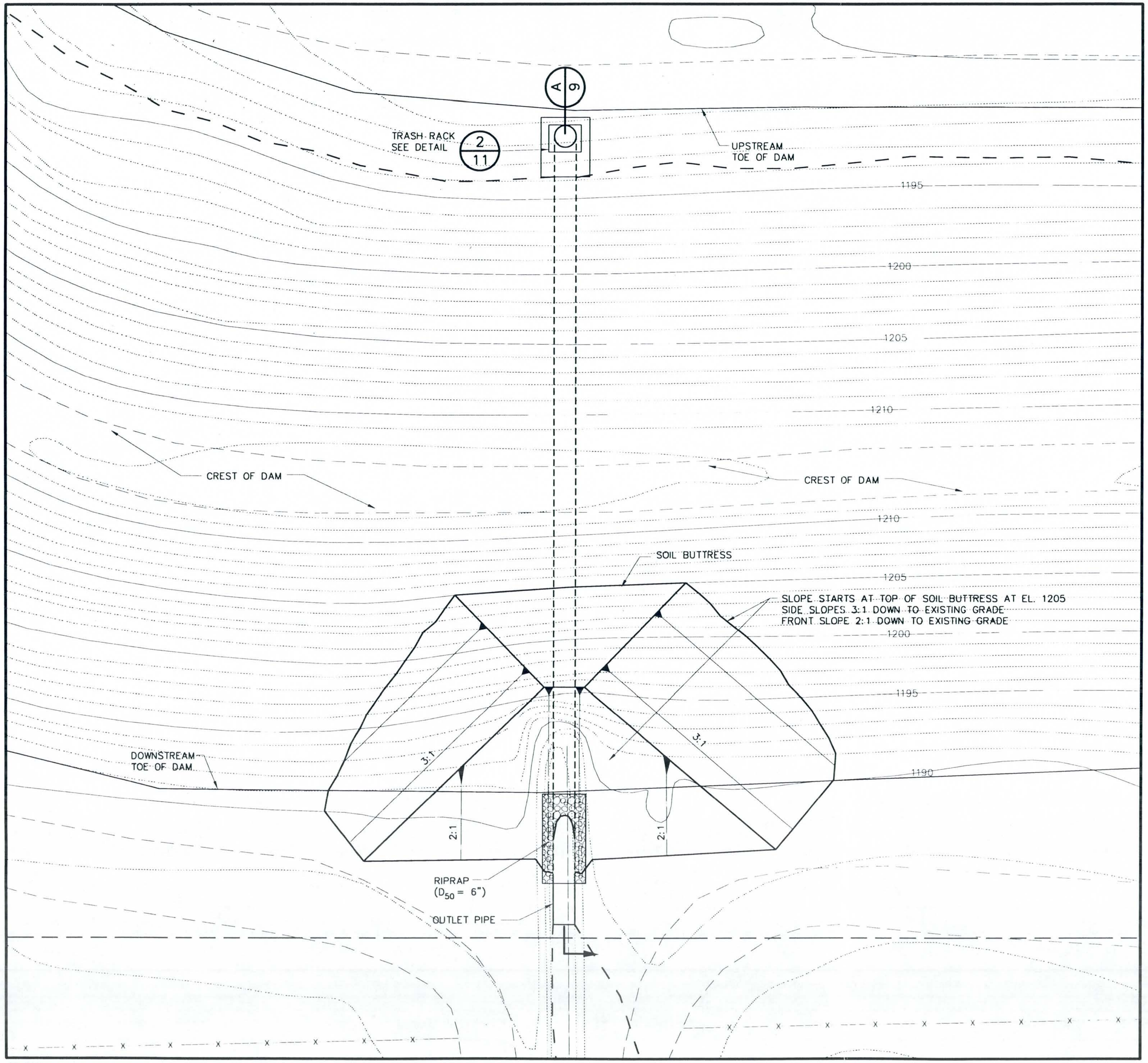
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
C1	PLAN AND ALIGNMENT OF EMERGENCY SPILLWAY MODIFICATIONS AND ARMOR	4 12



SOURCE:
BASE MAP OF WHITE TANKS/AGUA FRIA A.D.M.S. TOPOGRAPHIC MAPS, PROVIDED BY FCDMC 12/98
BASIS OF BEARING: ARIZONA ZONE 12 CENTRAL NAD 83

N

0 10 20
SCALE IN FEET
1 FOOT CONTOUR INTERVAL

NORTH OUTLET PLAN

LEGEND:
- 1200 — EXISTING CONTOUR 5' INTERVAL
- EXISTING CONTOUR 1' INTERVAL
- FCDMC PROPERTY LINE
- EXISTING DIRT ROAD
- x — x EXISTING FENCE
- WATERS OF US

NOTE: LIMITS OF CONSTRUCTION 20 FT PAST PROPERTY LINE FOR WORK ON OUTLET.

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	60% SUBMITTAL	TER	02/00
B	30% SUBMITTAL	TER	01/00
A	10% SUBMITTAL	TER	11/99

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
C2	NORTH OUTLET PLAN	5 12

SOURCE:
BASE MAP OF WHITE TANKS/AGUA FRIA A.D.M.S. TOPOGRAPHIC MAPS, PROVIDED BY FCDMC 12/98.
BASIS OF BEARING: ARIZONA ZONE 12 CENTRAL NAD 83

N

0 10 20
SCALE IN FEET
1 FOOT CONTOUR INTERVAL

CENTRAL OUTLET PLAN

LEGEND:

- 1200 — EXISTING CONTOUR 5' INTERVAL
- EXISTING CONTOUR 1' INTERVAL
- FCDMC PROPERTY LINE
- EXISTING DIRT ROAD
- x — x EXISTING FENCE
- WATERS OF US

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	NEW SHEET 60% SUBMITTAL	TER	02/00

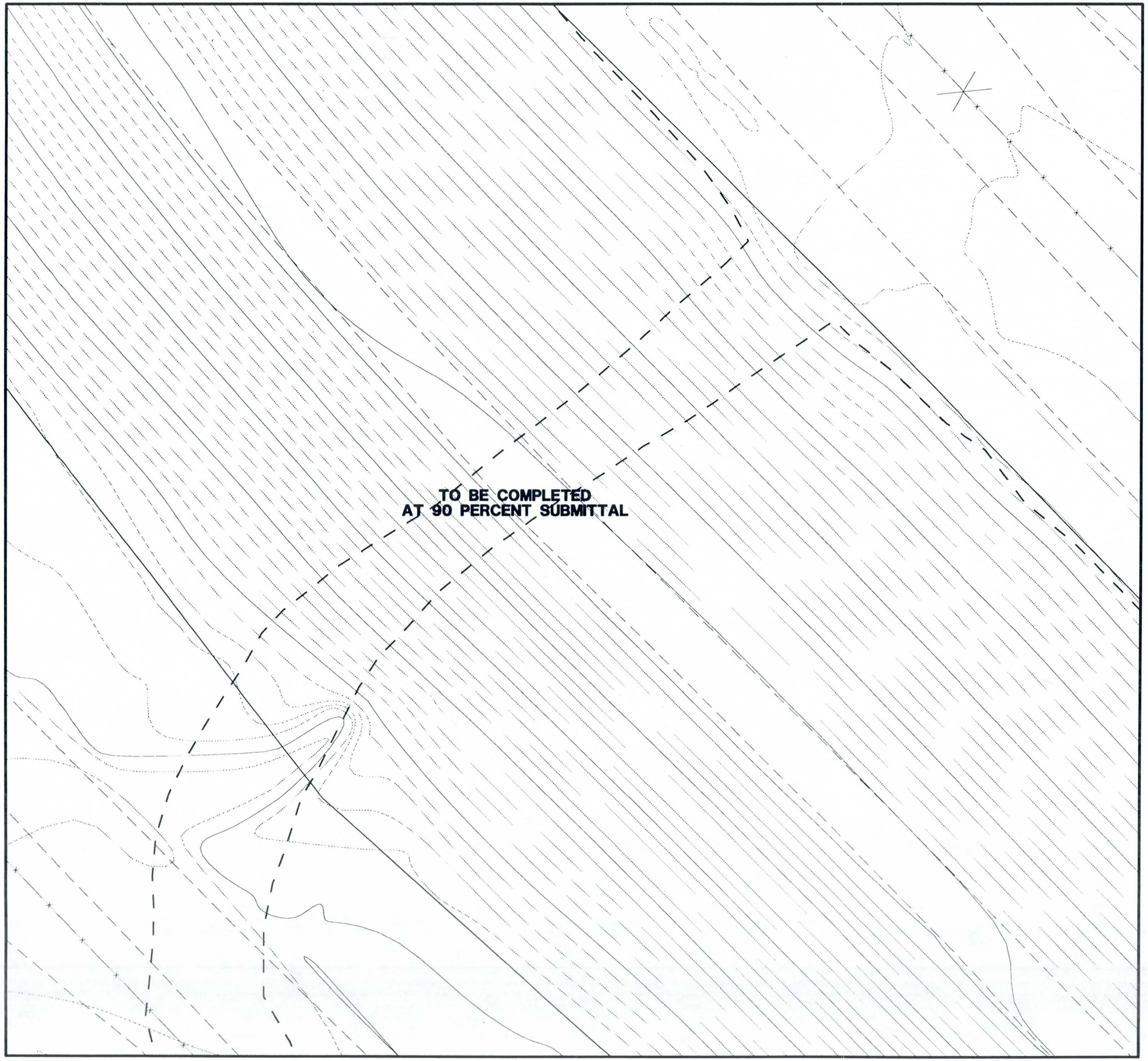
FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
C3	CENTRAL OUTLET PLAN	6 12



SOURCE:
BASE MAP OF WHITE TANKS/AGUA FRIA A.D.M.S. TOPOGRAPHIC MAPS, PROVIDED BY FCDMC 12/98.
BASIS OF BEARING: ARIZONA ZONE 12 CENTRAL NAD 83

N

0 10 20
SCALE IN FEET
1 FOOT CONTOUR INTERVAL

SOUTH OUTLET PLAN

LEGEND:

1200	EXISTING CONTOUR 5' INTERVAL
	EXISTING CONTOUR 1' INTERVAL
	FCDMC PROPERTY LINE
	EXISTING DIRT ROAD
x x	EXISTING FENCE
	WATERS OF US

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	NEW SHEET 60% SUBMITTAL	TER	02/00

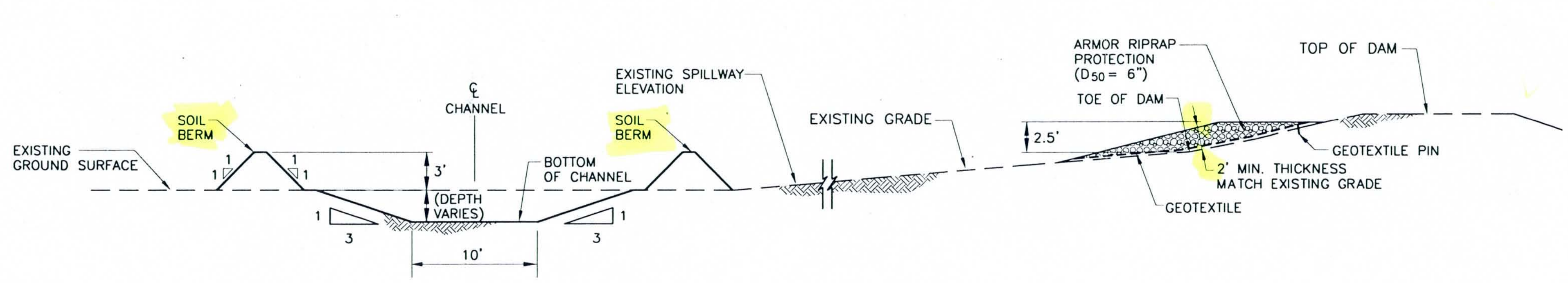
FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

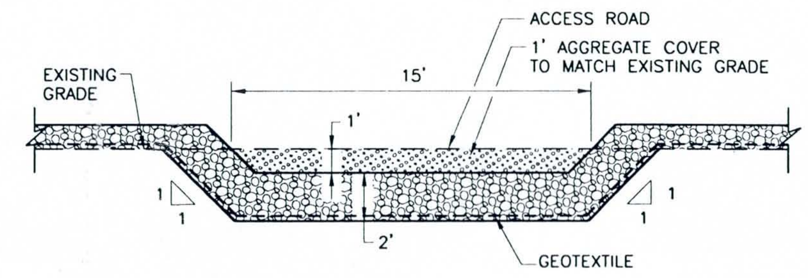
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
C4	SOUTH OUTLET PLAN	7 12



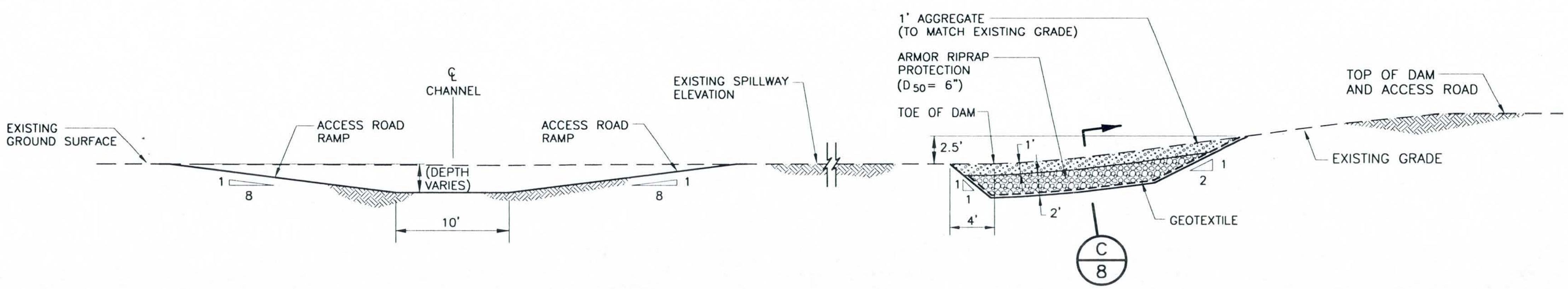
A/8 CHANNEL SECTION

0 6 12
SCALE IN FEET



C/8 ACCESS ROAD RIPRAP SECTION

0 4 8
SCALE IN FEET



B/8 ACCESS ROAD SECTION

0 6 12
SCALE IN FEET

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	NEW SHEET 60% SUBMITTAL	TER	2/00

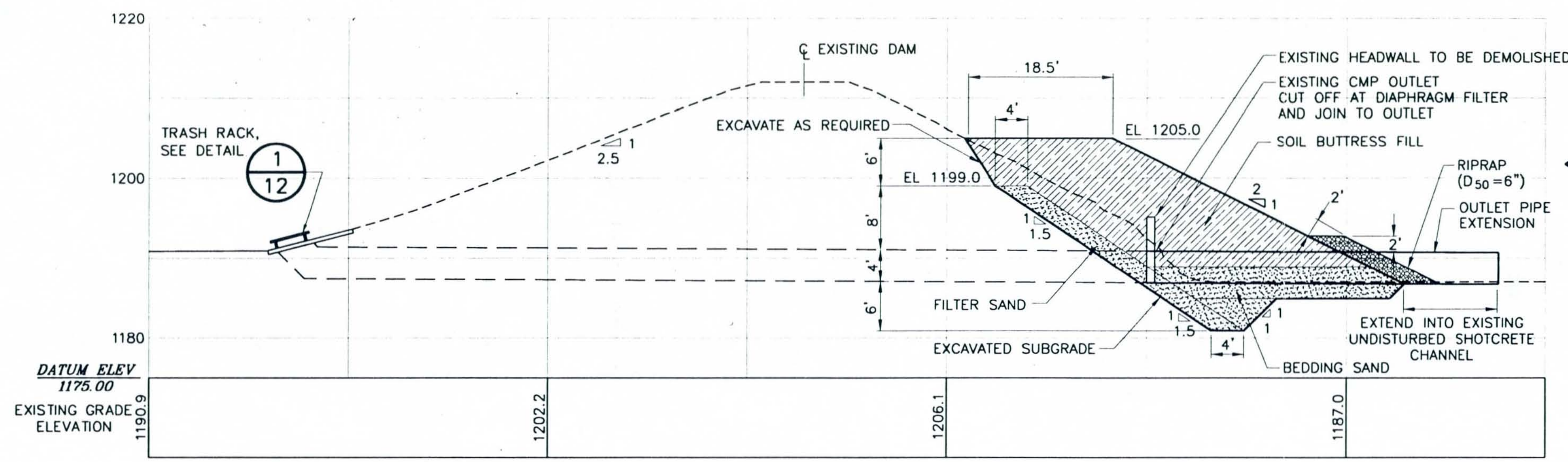
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

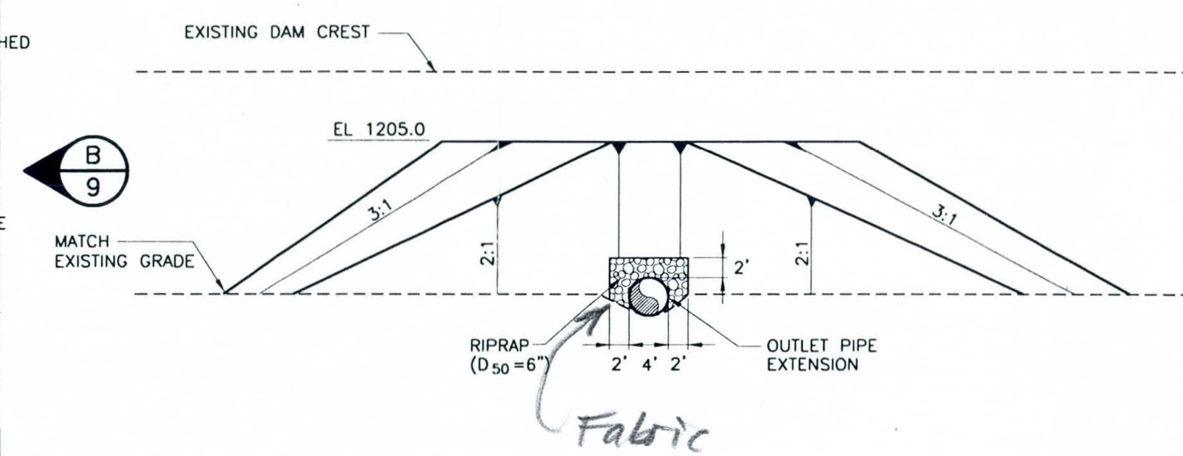
DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
D1	EMERGENCY SPILLWAY SECTIONS	8 12



1 / 9 NORTH OUTLET SECTION

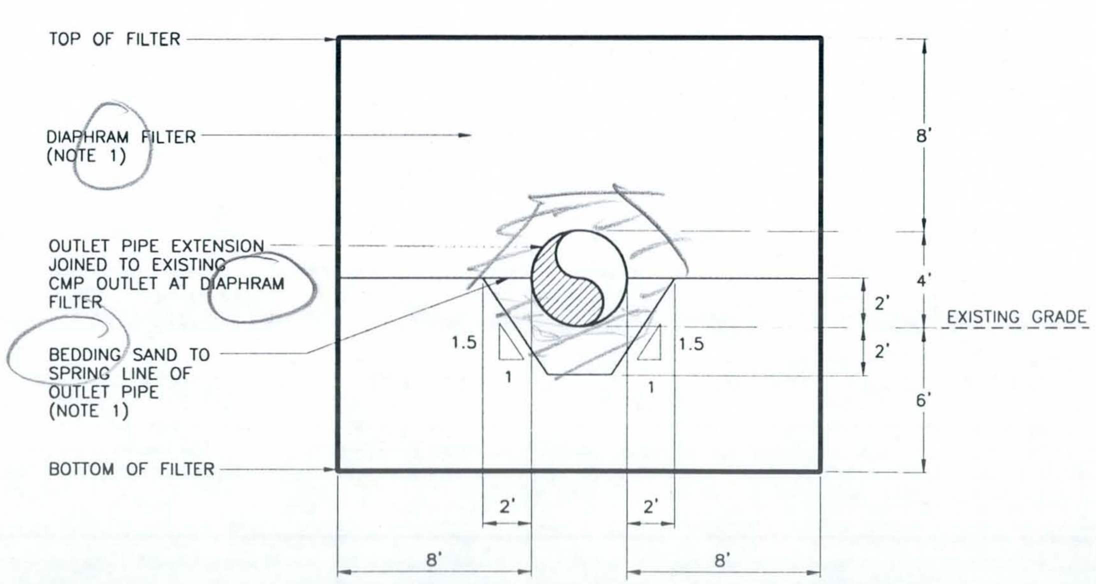
0 10 20
SCALE IN FEET



B / 9 NORTH OUTLET ELEVATION

0 10 20
SCALE IN FEET

ADWR APPROVAL



1 / 9 DIAPHRAGM FILTER DETAIL

0 4 8
SCALE IN FEET

NOTE 1: WASHED SAND CONFORMING TO ASTM C33 GRADATION (AS SPECIFIED)

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	60% SUBMITTAL	TER	02/00
B	30% SUBMITTAL	TER	01/00
A	10% SUBMITTAL	TER	11/99

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
D2	NORTH OUTLET SECTION, ELEVATION AND DETAIL	9 12

TO BE COMPLETED
AT 90 PERCENT SUBMITTAL

1/10 CENTRAL OUTLET SECTION

0 10 20
SCALE IN FEET

TO BE COMPLETED
AT 90 PERCENT SUBMITTAL

B/10 CENTRAL OUTLET ELEVATION

0 10 20
SCALE IN FEET

TO BE COMPLETED
AT 90 PERCENT SUBMITTAL

1/10 DIAPHRAGM FILTER DETAIL

0 4 8
SCALE IN FEET

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	NEW SHEET 60% SUBMITTAL	TER	02/00

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO.		SHEET OF
D3	CENTRAL OUTLET SECTION, ELEVATION AND DETAIL	10 12

TO BE COMPLETED
AT 90 PERCENT SUBMITTAL

1/11 SOUTH OUTLET SECTION

0 10 20
SCALE IN FEET

TO BE COMPLETED
AT 90 PERCENT SUBMITTAL

B/11 SOUTH OUTLET ELEVATION

0 10 20
SCALE IN FEET

TO BE COMPLETED
AT 90 PERCENT SUBMITTAL

1/11 DIAPHRAGM FILTER DETAIL

0 4 8
SCALE IN FEET

ADWR APPROVAL

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	NEW SHEET 60% SUBMITTAL	TER	02/00

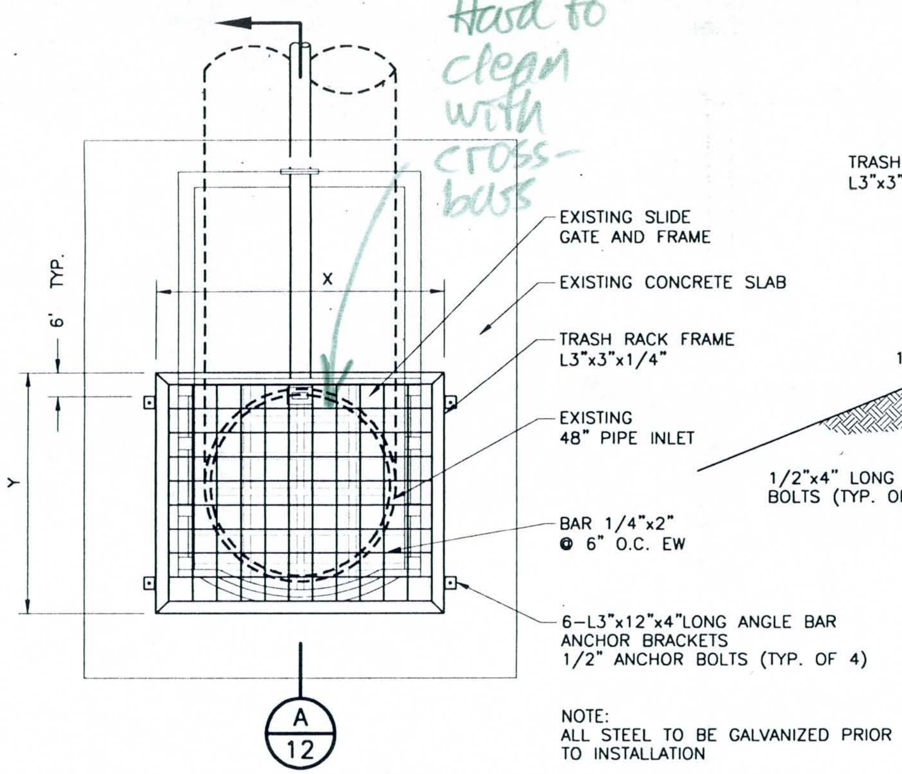
FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

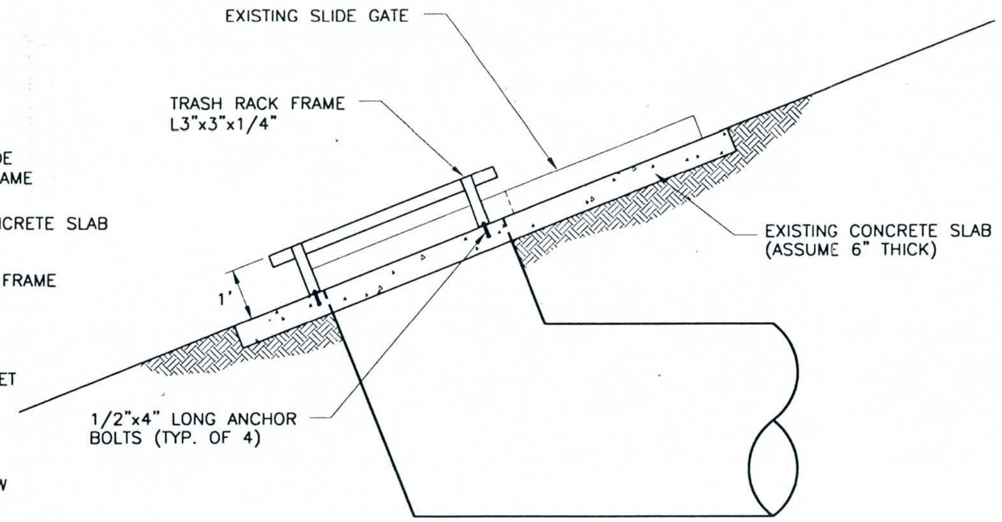
DRAWING NO.		SHEET	OF
D4	SOUTH OUTLET SECTION, ELEVATION AND DETAIL	11	12



NOTE:
ALL STEEL TO BE GALVANIZED PRIOR TO INSTALLATION

1/12 SOUTH AND NORTH TRASH RACK PLAN

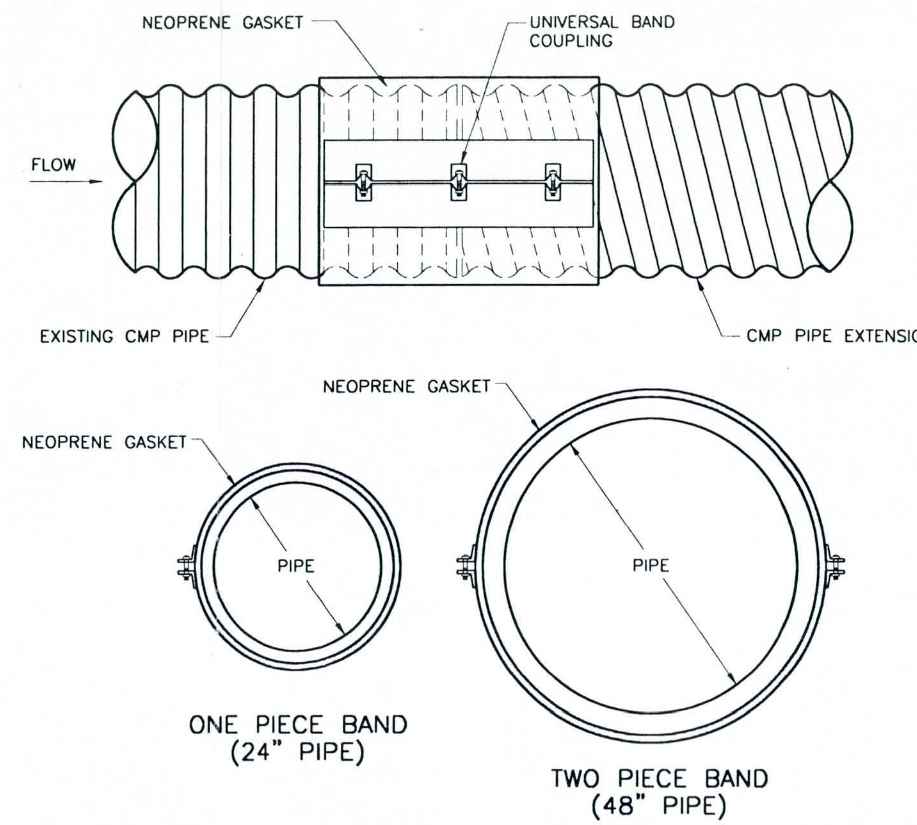
0 2 4
SCALE IN FEET



A/12 SOUTH AND NORTH TRASH RACK SECTION

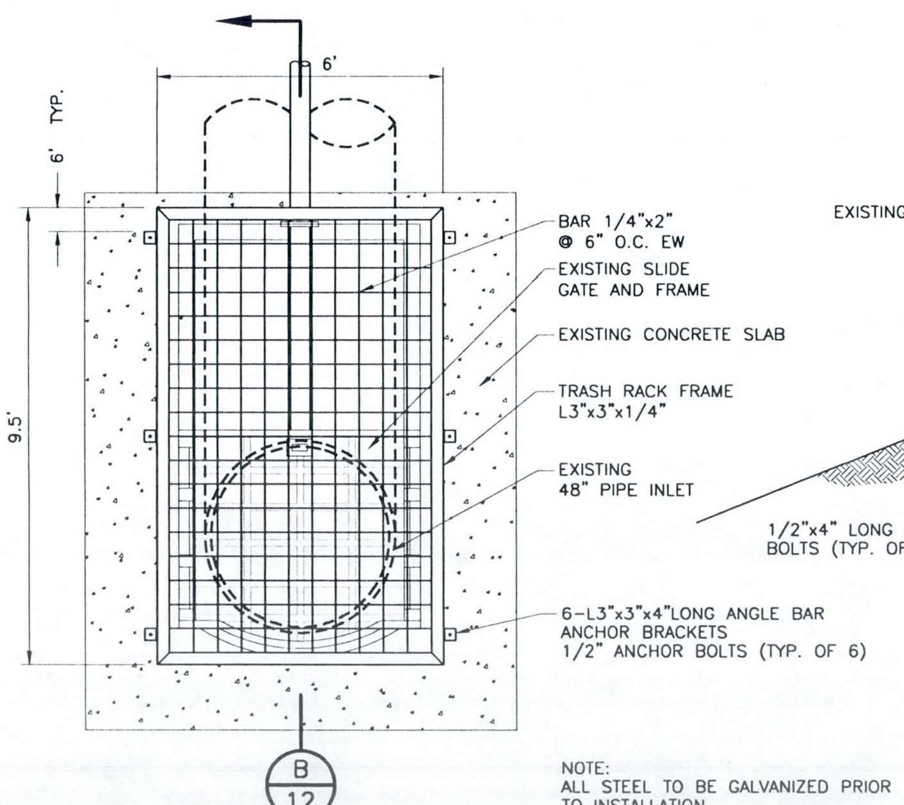
0 2 4
SCALE IN FEET

TYPE BASED ON PIPE SIZE							
LOCATION	PIPE SIZE (INCHES)	NO. OF BARS		LENGTH OF BARS (INCHES)		DIMENSIONS (INCHES)	
		X	Y	X	Y	X	Y
SOUTH	24	4	5	35.5	27.5	36	28
NORTH	48	6	10	71.5	59.5	72	60



3/12 OUTLET PIPE COUPLING DETAIL
NTS

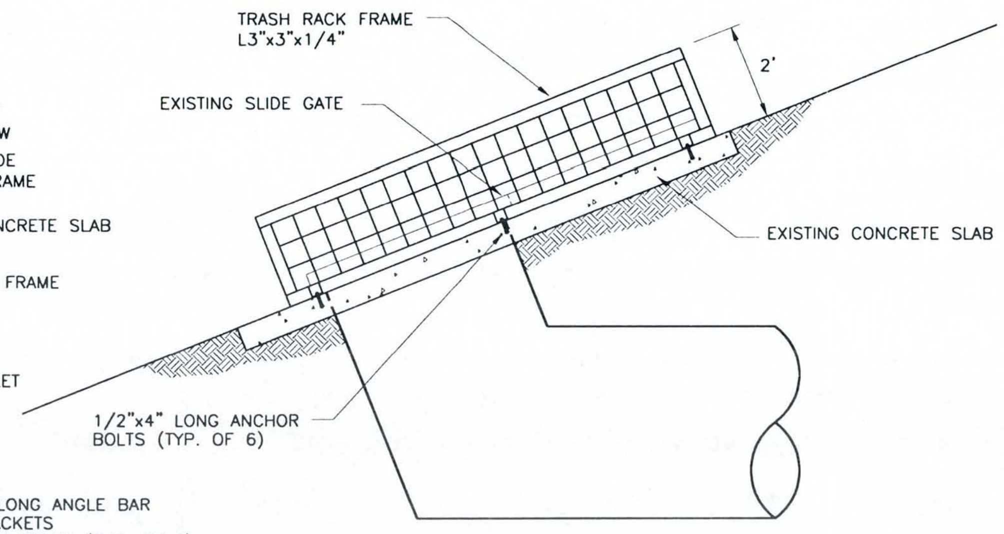
ADWR APPROVAL



NOTE:
ALL STEEL TO BE GALVANIZED PRIOR TO INSTALLATION

2/12 CENTRAL TRASH RACK PLAN

0 2 4
SCALE IN FEET



B/12 CENTRAL RASH RACK SECTION

0 2 4
SCALE IN FEET

60% SUBMITTAL
NOT FOR CONSTRUCTION

NO.	REVISION	BY	DATE
C	60% SUBMITTAL	TER	02/00
B	30% SUBMITTAL	TER	01/00
A	10% SUBMITTAL	TER	11/99

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

WHITE TANKS FRS#3
INTERIM DAM SAFETY
F.C.D. CONTRACT NO.

	BY	DATE
DESIGNED	S. NEWHOUSE	11-15-99
DRAWN	K. PALMISANO	11-15-99
CHECKED	T. RINGSMUTH	11-15-99

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

DRAWING NO. D5
OUTLET PIPES AND TRASH RACK SECTION AND DETAILS
SHEET 12 OF 12

APPENDIX A

BORING LOGS AND LABORATORY TESTS

BORING LOG

LOCATION OF BORING:	JOB NO.	CLIENT	LOCATION
STA. 57+30 WHITE TANKS DAM	15448-007-058	FCDMC	BUCKEYE, AZ

DRILLING METHOD:	INTERVAL:	DRILLER:	BORING NO.
CME 75 WITH 3 3/4-INCH HOLLOW STEM AUGER	0'-31.5'	ATL	57+30

SAMPLING METHOD:	INTERVAL:	SHEET
STANDARD PENETRATION TEST WITH SPLIT SPOON (SPT)	5-FOOT INTERVALS	1 OF 1

LOGGED BY: BKW

CHECKED BY: SGN

DATUM: APPROX. ELEVATION: feet

WATER LEVEL	NA	
TIME		
DATE		
CASING DEPTH		

DRILLING	START	FINISH
TIME		
DATE	11/1/99	11/1/99

SURFACE CONDITIONS:

DEPTH IN FEET	SAMPLER TYPE	SAMPLE NO.	SAMPLE DEPTH (ft)	LABORATORY TESTS: % PASSING #200 SIEVE	LIQUID LIMIT %	PLASTICITY INDEX %	WATER CONTENT %	DRY DENS. (pcf)	BLOWS/ft	GRAPHIC LOG	USCS	DESCRIPTION
											GP	SANDY GRAVEL: Big round particles
5	SPT	1	5.0						9			2 bag sample from 5 to 10 feet
10	SPT	2	10.0						7			1 bag sample from 10 to 15 feet
15	SPT	3	15.0						9			Less sand, more cobbles and rock at depth (from bag samples)
												1 bag sample from 15 to 20 feet
20	SPT	4	20.0						13			Nothing but cobbles in cuttings
												1 bag sample from 20 to 25 feet
25	SPT	5	25.0						15			1 bag sample from 25 to 30 feet
30	SPT	6	30.0						18		ML	Through dam fill into native ground silt, brown, dry
												Boring terminated at 31.5' below ground surface.
35												

BORING LOG

LOCATION OF BORING:	JOB NO.	CLIENT	LOCATION
STA. 58+00 WHITE TANKS DAM	15448-007-058	FCDMC	BUCKEYE, AZ

DRILLING METHOD:	INTERVAL:	DRILLER:	BORING NO.
CME 75 WITH 3 3/4-INCH HOLLOW STEM AUGER	0'-31.5'	ATL	58+00

SAMPLING METHOD:	INTERVAL:	SHEET
STANDARD PENETRATIN TEST WITH SPLIT SPOON (SPT)	5-FOOT INTERVALS	1 OF 1

LOGGED BY: BKW

CHECKED BY: SGN

DATUM: **APPROX. ELEVATION:** feet

WATER LEVEL	NA	
TIME		
DATE		
CASING DEPTH		

DRILLING	
START	FINISH
TIME	TIME
DATE	DATE
11/1/99	11/1/99

SURFACE CONDITIONS:

DEPTH IN FEET	SAMPLER TYPE	SAMPLE NO.	SAMPLE DEPTH (ft)	LABORATORY TESTS: % PASSING #200 SIEVE	LIQUID LIMIT %	PLASTICITY INDEX %	WATER CONTENT %	DRY DENS. (pcf)	BLOWS/ft	GRAPHIC LOG	USCS	DESCRIPTION
											GP	SANDY GRAVEL: 4" max round 1 bag sample 0-5 feet
5	SPT	1	5.0						6			No recovery 1 bag sample 5-10 feet
10	SPT	2	10.0						10			No recovery
15	SPT	3	15.0						17			No recovery
20	SPT	4	20.0						12			No recovery
25	SPT	5	25.0						19			No recovery
30	SPT	6	30.0						50/6"			No recovery
												Boring terminated at 31.5' below ground surface.
35												

BORING LOG

LOCATION OF BORING:	JOB NO.	CLIENT	LOCATION
STA. 59+00 WHITE TANKS DAM	15448-007-058	FCDMC	BUCKEYE, AZ

DRILLING METHOD:	INTERVAL:	DRILLER:	BORING NO.
CME 75 WITH 3 3/4-INCH HOLLOW STEM AUGER	0'-31.5'	ATL	59+00

SAMPLING METHOD:	INTERVAL:	SHEET
STANDARD PENETRATIN TEST WITH SPLIT SPOON (SPT)	5-FOOT INTERVALS	1 OF 1

LOGGED BY: BKW

CHECKED BY: SGN

DATUM: APPROX. ELEVATION: feet

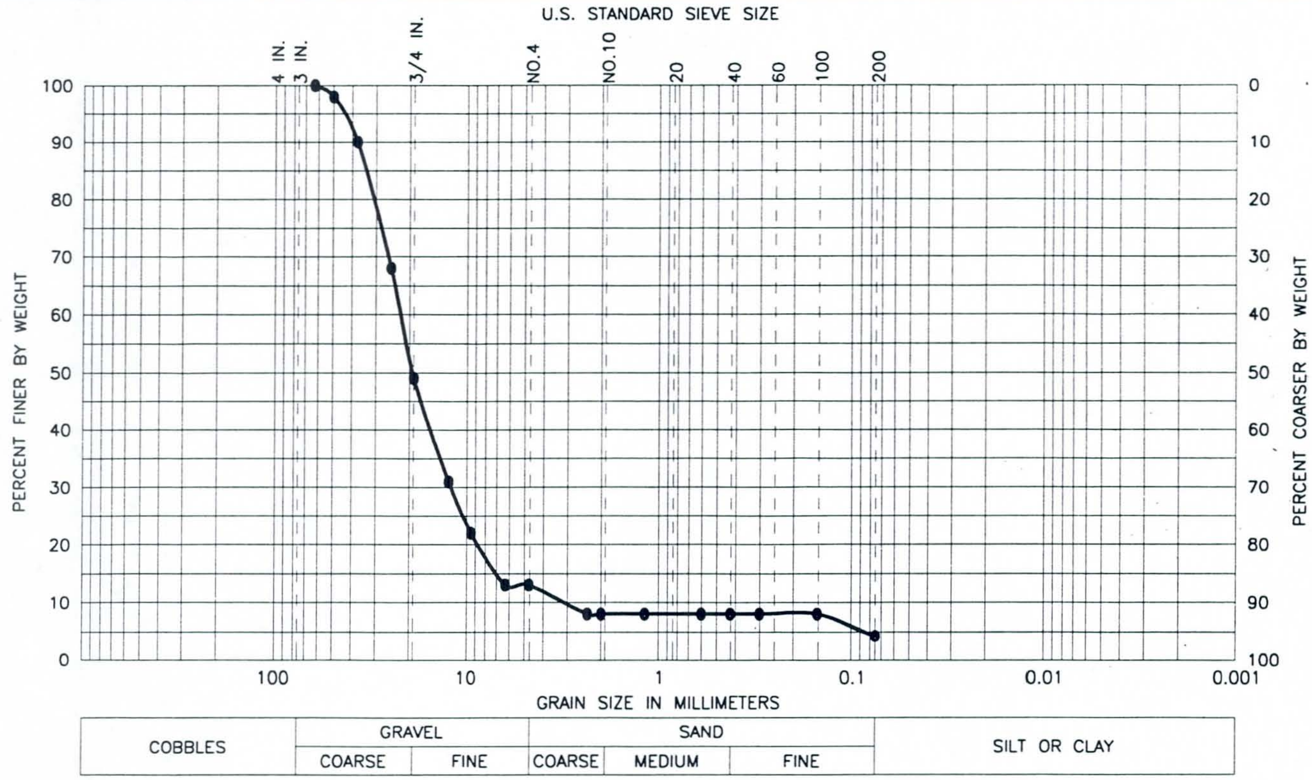
WATER LEVEL	NA	
TIME		
DATE		
CASING DEPTH		

DRILLING	
START	FINISH
TIME	TIME
DATE	DATE
11/1/99	11/1/99

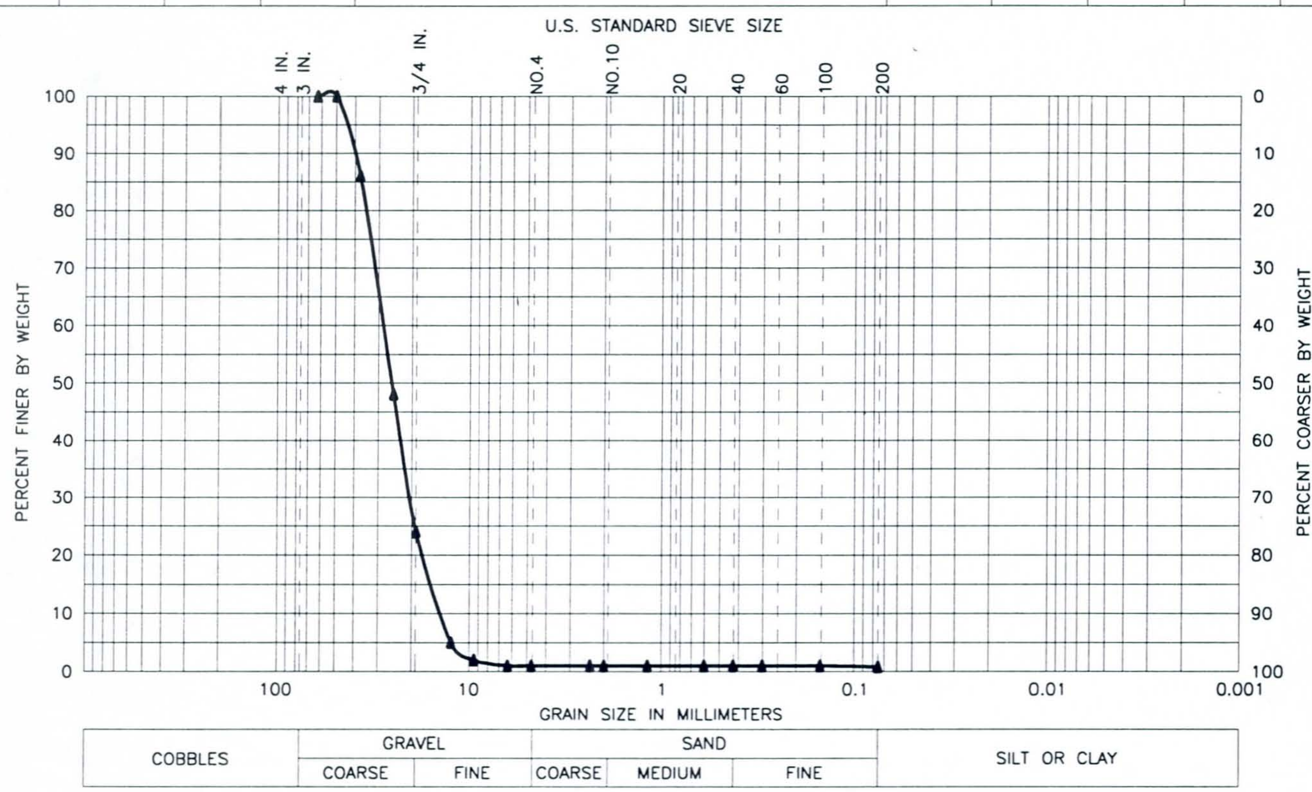
SURFACE CONDITIONS:

DEPTH IN FEET	SAMPLER TYPE	SAMPLE NO.	SAMPLE DEPTH (ft)	LABORATORY TESTS: % PASSING #200 SIEVE	LIQUID LIMIT %	PLASTICITY INDEX %	WATER CONTENT %	DRY DENS. (pcf)	BLOWS/ft	GRAPHIC LOG	USCS	DESCRIPTION
											GP	SANDY GRAVEL: 3" max rounded 1 bag sample 0-5 feet
5	SPT	1	5.0						5			No recovery
10	SPT	2	10.0						5			No recovery
15	SPT	3	15.0						11			No recovery
20	SPT	4	20.0						15			No recovery 1 bag sample 20-25 feet
25	SPT	5	25.0						12			No recovery
30	SPT	6	30.0						50/6"			No recovery
												Boring terminated at 31.5' below ground surface.
35												

DAMES & MOORE



BORING	SMPL NO.	DEPTH	CLASSIFICATION		MOIST %	DD pcf	LL	PL	PI
57+30		5-10	GP	POORLY GRADED GRAVEL					



BORING	SMPL NO.	DEPTH	CLASSIFICATION		MOIST %	DD pcf	LL	PL	PI
57+30		20-25	GP	POORLY GRADED GRAVEL					

LEGEND:

MOIST %	Moisture Content (rounded to the nearest 0.5%)
DD pcf	Dry Density (rounded to the nearest 1 pcf)
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NV	No Value
NP	Non Plastic

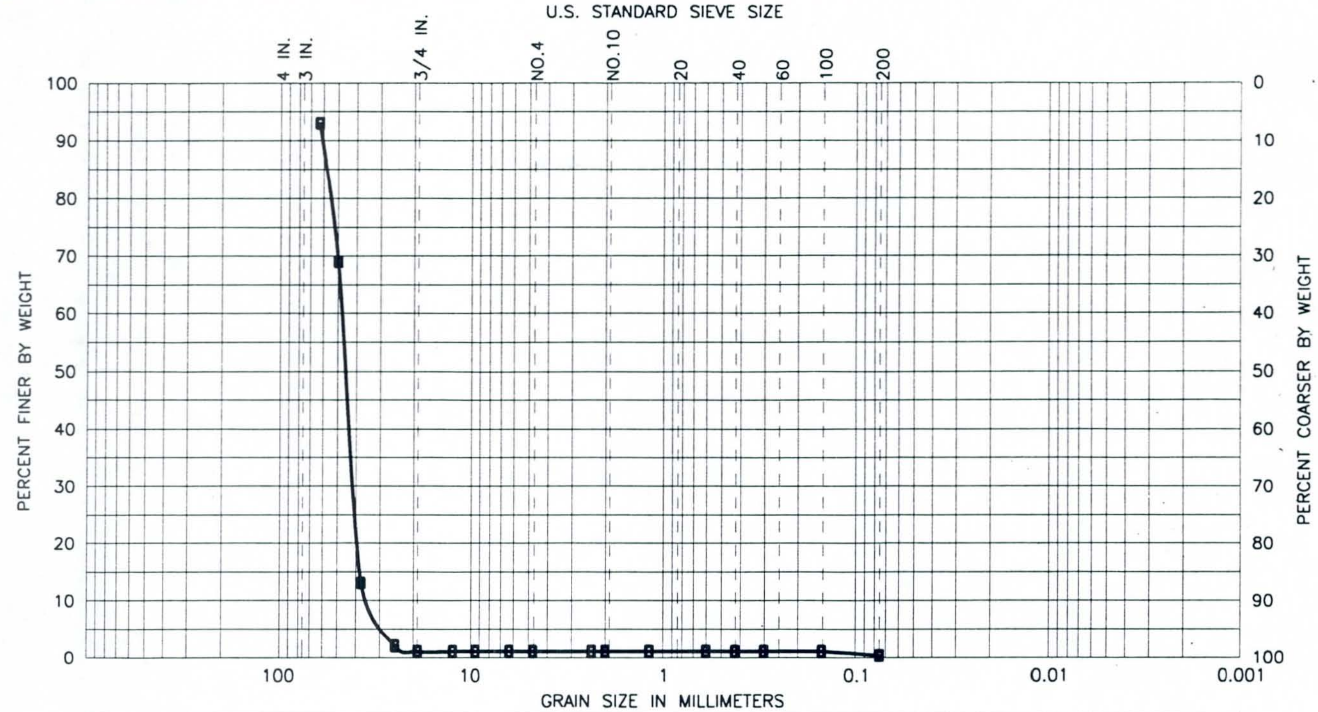
WHITE TANKS FRS #3

SIEVE ANALYSIS

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
15448-007-058

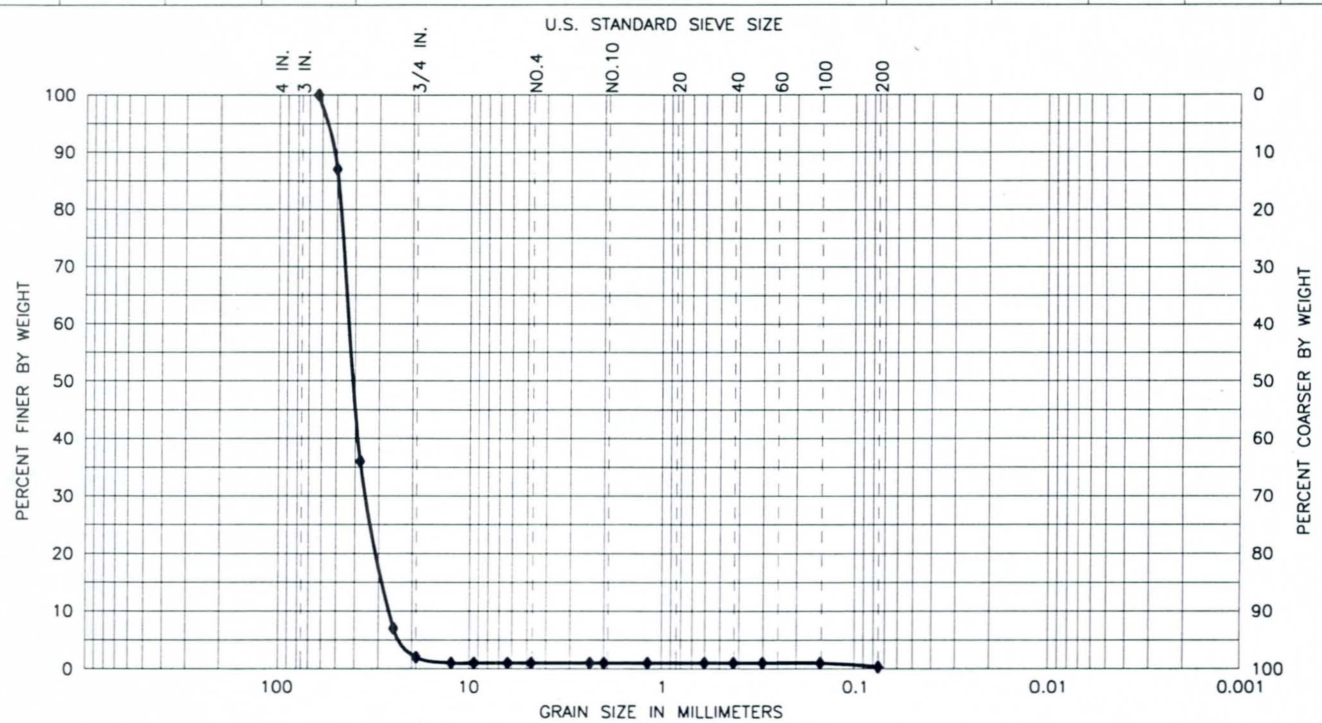
Figure ??

A13654.DWG 1-28-00



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

BORING	SMPL NO.	DEPTH	CLASSIFICATION		MOIST %	DD pcf	LL	PL	PI
58+00		5-10	GP	POORLY GRADED GRAVEL					



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

BORING	SMPL NO.	DEPTH	CLASSIFICATION		MOIST %	DD pcf	LL	PL	PI
59+00		15-20	GP	POORLY GRADED GRAVEL					

LEGEND:

MOIST %	Moisture Content (rounded to the nearest 0.5%)
DD pcf	Dry Density (rounded to the nearest 1 pcf)
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
NV	No Value
NP	Non Plastic

WHITE TANKS FRS #3

SIEVE ANALYSIS

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY
15448-007-058

Figure ??

A13655.DWG 1-28-00

White Tanks FRS #3
15448-007-058
Dam Filter Investigation
Sieve Analysis

		% Passing					
Sieve	Particle Size (mm)	59+00, 15-20 ft	58+00, 5-10 ft	57+30, 20-25 ft	57+30, 5-10 ft	Revised Drain Fill Requirements	Coarse Aggregate Requirements
3"						100	100
2.5"	63	100	93	100	100		90-100
2"	50	87	69	100	98		35-70
1.5"	37.5	36	13	86	90		0-15
1"	25	7	2	48	68		
3/4"	19	2	1	24	49	52-100	0-5
1/2"	12.5	1	1	5	31		
3/8"	9.5	1	1	2	22		
1/4"	6.3	1	1	1	13		
#4	4.75	1	1	1	13	31-57	
#8	2.36	1	1	1	8	23-46	
#10	2	1	1	1	8		
#16	1.18	1	1	1	8		
#30	0.6	1	1	1	8		
#40	0.425	1	1	1	8		
#50	0.3	1	1	1	8		
#60						0-18	
#100	0.15	1	1	1	8		
#200	0.075	0.3	0.3	0.8	4.2	0-6.5	

1. According to Repair As-Built documents Drain Fill was placed in the embankment between Stations 56+10 and 59+90. Coarse Aggregate was placed at Station 58+00.
2. Drain Fill requirements were changed during repair construction as per ADWR letter dated November 25, 1981.
3. Coarse Aggregate requirements were specified in White Tanks No. 3 Repair Bid Schedule.

APPENDIX B

CALCULATION PACKAGES

Calculation Packages

1. Spillway Notch Elevation
2. Central Trash Rack Sizing
3. Diaphragm Filter and Fill Cover Sizing
4. Diaphragm Filter Gradation
5. Riprap Sizing at the Southern Side of White Tanks FRS #3 and at the Northern Outlet

DAMES & MOORE

CALCULATIONS COVER SHEET

PROJECT NO. 15448-007-058

SUBJECT: ______

SHEET 1 OF 3

White Tanks Spillway Notch Elevation

TITLE OF CALCULATIONS/DOCUMENT

CALCULATIONS/DOCUMENT BY: Bonnie Whitley (PRINT NAME)

Bonnie Whitley (SIGNATURE) — 1-25-00 (DATE)

ASSUMPTIONS CHECKED BY CONSULTANT/SENIOR PERSONNEL: Todd Ringsmuth (PRINT NAME)

[signature] (SIGNATURE) — 1-28-00 (DATE)

CALCULATIONS/DOCUMENT CHECKED BY: CHRIS WIGGINTON (PRINT NAME)

[signature] (SIGNATURE) — 1-28-00 (DATE)

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT, OR PM) Todd Ringsmuth (PRINT NAME)

[signature] (SIGNATURE) — 1-28-00 (DATE)

Approval Notice: If Calculations/Document are only spot checked, do not require checking, or are assumed to be correct by experience of engineering judgement, it should be noted here.

Revision Number	Date	By	Checked By	Approval
1				
2				
3				
4				

INITIALS

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Sheet No. 2 of 3
Calc. No.
Rev. No.
By BKW Date 1-25-[illegible]
Chk'd. CNW Date 1-28-00

Job No. 15482-007-058 Job
Client Subject

White Tanks Spillway Notch Elev

Notch Elev = Lowest Point On Dam − Subsidence Allowance − 4 ft Freeboard

Lowest Point On Dam = 1211.385 ft (Sta 8+70, survey 12/99)

Subsidence Allowance account for 10 yrs
subsidence @ A-1 (Sta 10+00) = 0.0266 ft/yr
(subsidence survey, 7/90 + 7/97)

Subsidence Allowance = (0.0266 ft/yr)(10 yrs)
= 0.266 ft

Notch Elev = 1211.385 ft − 0.266 ft − 4 ft =
= 1207.[illegible] ft use 1207 ft

F-132(7/91)

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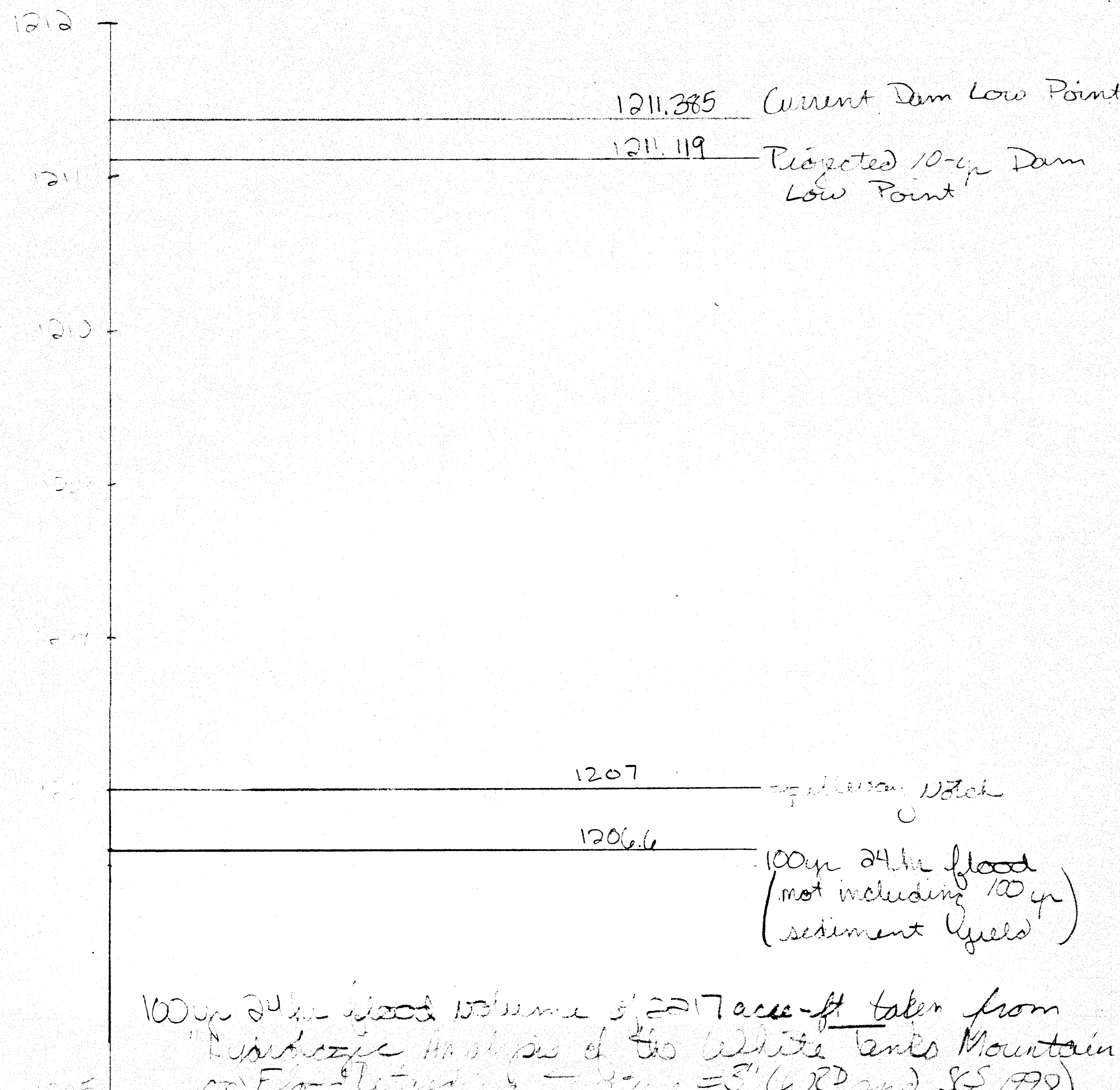
Job No. 15488-007-059	Job
Client	Subject

Sheet No.	3 OF 3
Calc. No.	
Rev. No.	
By	Date -25-00
Chk'd. CDW	Date 1-28-00



100yr 24hr flood volume of 2217 acre-ft taken from "Hydrologic Analysis of the White Tanks Mountain Flood Retarding Structure #3" (WRD and SGS, 1998)

F-132(7/91)

GILBERTSON ASSOCIATES inc.

WHITE TANKS F.R.S. NO. 3
SUBSIDENCE SURVEYS

Sta.	Monument	7-97 Elev.
10+00	Brass Cap A-1 Brass Cap B-1	1211.464 1201.417
19+95	Brass Cap A-2 Brass Cap B-2	1211.764 1192.919
30+00	Brass Cap A-3 Brass Cap B-3	1212.019 1190.514
40+00	Brass Cap A-4 Brass Cap B-4	1212.736 1192.624
49+88	Brass Cap A-5 Brass Cap B-5	1214.206 1191.187
60+08	Brass Cap A-6 Brass Cap B-6	1214.524 1190.149
70+07	Brass Cap A-7 Brass Cap B-7	1215.106 1195.949

Prime Benchmark USGS Domed Brass Cap – Stamped N-475, located 1,320' South of the northeast corner of Section 1, along the East line of Section 1, T2N, R3W of the Gila and Salt River Base and Meridian. Elevation = 1474.154

Certification

This Survey was done under my direction during the Month of July, 1997.

Richard D. Tabor, R.L.S. #19857

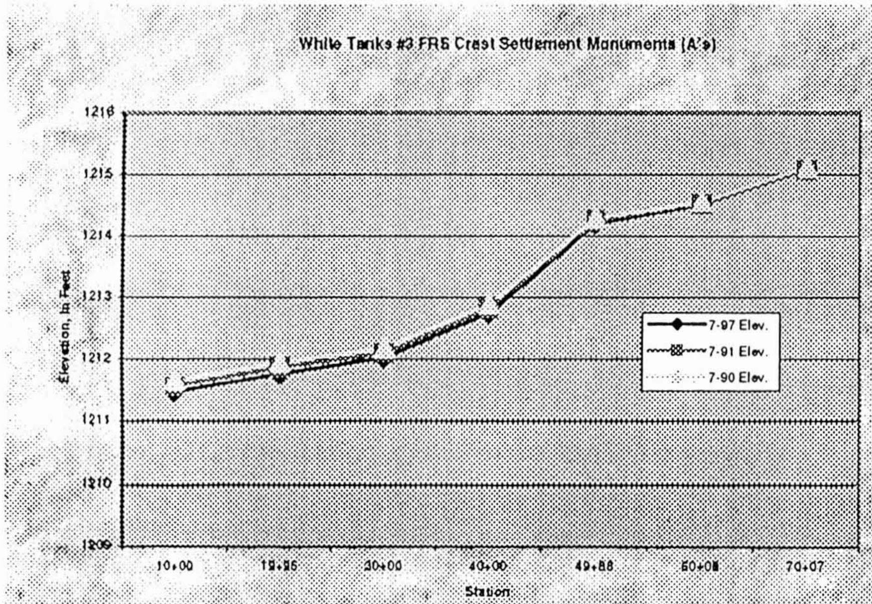
consulting civil engineers & land surveyors

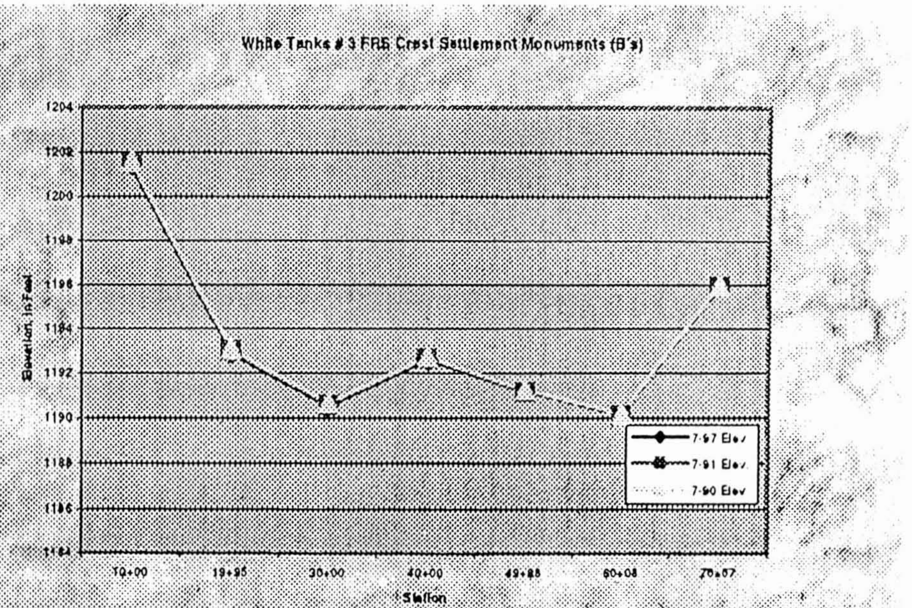
15974 North 77th Street. Scottsdale, Arizona 85260-1761
Telephone:\602\607\2244 Facsimile:\602\607\2299

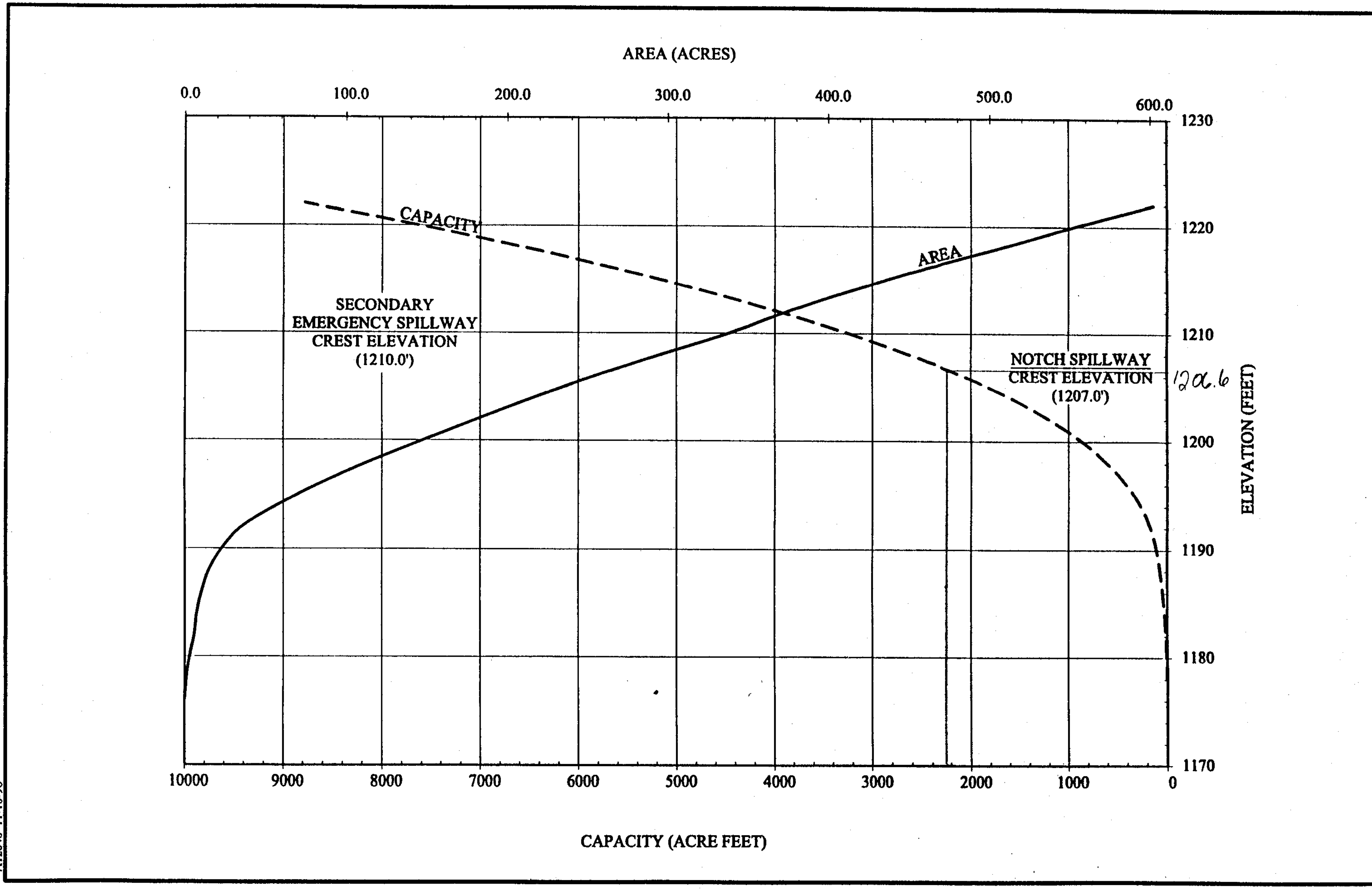
August 26, 1997

Sta.	Monument	7-97 Elev.	7-91 Elev.	7-90 Elev.
10+00	A-1	1211.464	1211.561	1211.65
	B-1	1201.417	1201.491	1201.586
19+95	A-2	1211.764	1211.866	1211.946
	B-2	1192.919	1192.979	1193.071
30+00	A-3	1212.019	1212.099	1212.183
	B-3	1190.514	1190.562	1190.65
40+00	A-4	1212.736	1212.812	1212.883
	B-4	1192.624	1192.664	1192.728
49+88	A-5	1214.206	1214.255	1214.297
	B-5	1191.187	1191.19	1191.242
60+08	A-6	1214.524	1214.531	1214.559
	B-6	1190.149	1190.129	1190.175
70+07	A-7	1215.106	1215.091	1215.124
	B-7	1195.949	1195.931	1195.973

Prime benchmark USGS Domed Brass Cap - Stamped N-475, Located 1,320' South of the northeast corner of Section 1, along the East line of Section 1, T2N, R3W of the Gila and Salt River Base and Meridian. Elevation = 1474.154







— — CAPACITY

—— AREA

Area Capacity Curves

White Tanks Dam - FRS #3

Figure 4-1

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15448-005-022

DAMES & MOORE

CALCULATIONS COVER SHEET

PROJECT NO. 15448-007-058

SUBJECT: ______________________

SHEET 1 OF 9

Central TRASHRACK SIZING

TITLE OF CALCULATIONS/DOCUMENT

WHITE TANKS FRS #3

CALCULATIONS/DOCUMENT BY: CHRIS WIGGINTON
PRINT NAME

[signature] SIGNATURE — 1-28-00 DATE

ASSUMPTIONS CHECKED BY CONSULTANT/SENIOR PERSONNEL: SCOTT NEWHOUSE
PRINT NAME

[signature] SIGNATURE — 2-01-00 DATE

CALCULATIONS/DOCUMENT CHECKED BY: Bonnie Whitley
PRINT NAME

Bonnie Whitley SIGNATURE — 1-31-00 DATE

APPROVED BY:
(PRINCIPAL INVESTIGATOR, CONSULTANT, OR PM) Todd Ringsmuth
PRINT NAME

[signature] SIGNATURE — 2-1-00 DATE

Approval Notice: If Calculations/Document are only spot checked, do not require checking, or are assumed to be correct by experience of engineering judgement, it should be noted here.

Revision Number	Date	By	Checked By	Approval
1				
2				
3				
4				

INITIALS

DAMES & MOORE
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Job No.	Job
Client	Subject

Calc. No.
Rev. No.
By ODW Date 1-28-0[illegible]
Chk'd. BKW Date 1-31-0[illegible]

Central TRASHRACK SIZING CALC.

FROM THE DESIGN CRITERA TAKEN FROM "DESIGN OF SMALL DAMS", SECTION 10.9, PGS. 451 & 452, THE TRASHRACK SHALL "CONSIST OF THIN, FLAT STEEL BARS THAT ARE PLACED ON EDGE FROM 3 TO 6 INCHES APART AND ASSEMBLED IN A GRID PATTERN." ALSO, "WHERE AN OUTLET INVOLVES A LARGE CONDUIT WITH LARGE SLIDE GATE CONTROLS, THE RACKS CAN BE MORE WIDELY SPACED."

FROM THESE STATEMENTS IT WAS ASSUMED THAT THE TRASH RACK WOULD BE CONSTRUCTED USING THIN, FLAT STEEL BARS PLACED ON EDGE, 6" APART IN A GRID PATTERN.

FROM THE SAME DOCUMENT IT READS "WHERE THE TRASHRACKS ARE INACCESSIBLE FOR CLEANING, THE VELOCITY THROUGH THE RACKS ORDINARILY SHOULD NOT EXCEED 2 FT/SEC. A VELOCITY OF UP TO APPROXIMATELY 5 FT/SEC MAY BE TOLERATED FOR RACK THAT ARE ACCESSIBLE FOR CLEANING.

FROM THIS TEXT, AND FROM THE ASSUMPTION THAT INACCESSIBILITY IS SYNONOMOUS WITH SUBMERGED, THE DESIGN FLOW RATE THAT APPLIES TO OUR CONDITION IS 5 FT/SEC.

HOWEVER, FROM THE SOIL CONSERVATION SERVICE TECHNICAL RELEASE NOTICE 60C, 210V, IT STATES, "THE AVERAGE VELOCITY OF FLOW THROUGH A CLEAN TRASH RACK

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Sheet No. 3 of 9
Calc. No.
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By CDW Date 1-28-0
Chk'd. PKW Date 1-31-0

Job No. | Job
Client | Subject

IS NOT TO EXCEED 2.5 FEET PER SECOND UNDER THE FULL RANGE OF STAGE AND DISCHARGE."

FROM THIS DOCUMENT WE DECIDED TO USE A MAXIMUM DESIGN FLOW RATE OF 2.5 FEET/SEC. FOR THIS CALC.

WE ASSUMED THAT THE TRASHRACK MUST EXTEND BEYOND THE LIMITS OF THE SLIDE GATE FRAME IN ORDER TO PREVENT DEBRIS FROM INTERRUPTING THE OPERATION OF THE SLIDE GATE.

DISCHARGE OF 207 cfs WAS TAKEN FROM THE "DRAFT - PROPOSED NEW OPERATIONAL PLAN for WHITE TANKFLOOD RETARDING STRUCTURE NO. 3 OUTLET PIPES" DATED JAN. 12 2000. PUBLISHED BY FCMCD.

F-132(7/91)

BY: CDW, 1-28-00
CKD - BKW 1-31-00

TRASHRACK SIZING SPREADSHEET
WHITE TANKS FRS #3

Bar Diameter or Bar Edge Width (in) 0.25
Edge Angle Width (in) 3
Bar Spacing (in) 6

Discharge (cfs) 207

Target Flow Velocity < 2.5 ft/sec

Height (ft)	Length (ft)	Width (ft)	Adjusted Height (ft)	Adjusted Length (ft)	Adjusted Width (ft)	Gross Area (sf)	Net Area (sf)	Flow Velocity (ft/sec)
1.5	9.5	6	0.98	8.65	5.29	103.5	73.05	2.83
2	9.5	6	1.46	8.65	5.29	119	86.40	2.40
2.5	9.5	6	1.94	8.65	5.29	134.5	99.76	2.08

This spreadsheet calculates the flow velocity through a cage trashrack. The variables used to calculate this flow velocity are as follows:

Bar Diameter:	This spreadsheet calculation assumes the use of round bars. If thin, flat bars are desired, the width of the bar can be inserted into this cell.
Edge Angle Width:	This spreadsheet calculation assumes that the trashrack cage will have angle iron supports on all of the edges of each of the 5 sides.
Bar Spacing:	The bar spacing is a center to center dimension that is consistent for horizontal and vertical spacing
Discharge:	This number is the calculated maximum discharge through the outlet pipe in question. This maximum discharge is used to calculate the flow velocity through the trashrack.
Target Flow Velocity:	This requirment was taken from the SCS Technical Release Notice 60C, 210-V. It states, "The average velocity of flow through a clean trash rack is not to exceed 2.5 feet per second under the full range of stage and discharge. Velocity is to be computed on the basis of the net area of opening through the rack."
Height:	Actual height of the trash rack (see attached drawing)
Length:	Actual length of the trash rack (see attached drawing)
Width:	Actual width of the trash rack (see attached drawing)
Adj. Height:	Actual height of the trash rack minus the area of the edge angles and bar thicknesses.
Adj. Length:	Actual length of the trash rack minus the area of the edge angles and bar thicknesses.
Adj. Width:	Actual width of the trash rack minus the area of the edge angles and bar thicknesses.
Gross Area:	Height x Length x Width
Net Area:	Adj. Height x Adj. Length x Adj. Width
Flow Velocity:	Discharge / Net Area, from the equation Q=VA

	A	B	C	D	E
2	Bar Diameter or Bar Edge Width (in)		0.25		Target Flow Velocity <
3	Edge A		3		
4	Bar Sp:		6		
5					
6	Discharge		207		
7					
8					
9	Height (ft)	Length (ft)	Width (ft)	**Adjusted Height (ft)**	**Adjusted Length (ft)**
10	1.5	9.5	6	=((A11*12)-(((ROUND((A11/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12	=((B11*12)-(((ROUND((B11/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12
11	2	9.5	6	=((A12*12)-(((ROUND((A12/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12	=((B12*12)-(((ROUND((B12/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12
12	2.5	9.5	6	=((A13*12)-(((ROUND((A13/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12	=((B13*12)-(((ROUND((B13/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12

No. of bars

FORMULAS

BY: CWJ 1-28-00
CKD: BJ 1-31-00

	F	G	H	I
1				
2		2.5 ft/sec		
3				
4				
5				
6				
7				
8				
9	**Adjusted Width (ft)**	**Gross Area (sf)**	**Net Area (sf)**	**Flow Velocity (ft/sec)**
10	=((C11*12)-(((ROUND((C11/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12	=(B11*C11)+(2*B11*A11)+(2*C11*A11)	=(E11*F11)+(2*E11*D11)+(2*F11*D11)	=$C$6/H11
11	=((C12*12)-(((ROUND((C12/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12	=(B12*C12)+(2*B12*A12)+(2*C12*A12)	=(E12*F12)+(2*E12*D12)+(2*F12*D12)	=$C$6/H12
12	=((C13*12)-(((ROUND((C13/($C$4/12)),0))-2)*$C$2)-($C$3*2))/12	=(B13*C13)+(2*B13*A13)+(2*C13*A13)	=(E13*F13)+(2*E13*D13)+(2*F13*D13)	=$C$6/H13

$Q = vA$

$v = \frac{Q}{A}$

6 OF 9
By: CDW 2002
Ck'D: BKW 1-31-00

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Job No.	Job	Sheet No. 7 OF 9
Client	Subject	Calc. No.
		Rev. No.
		By CDW Date 1-28-?
		Chk'd. BKW Date 1-31-0

CONCLUSION

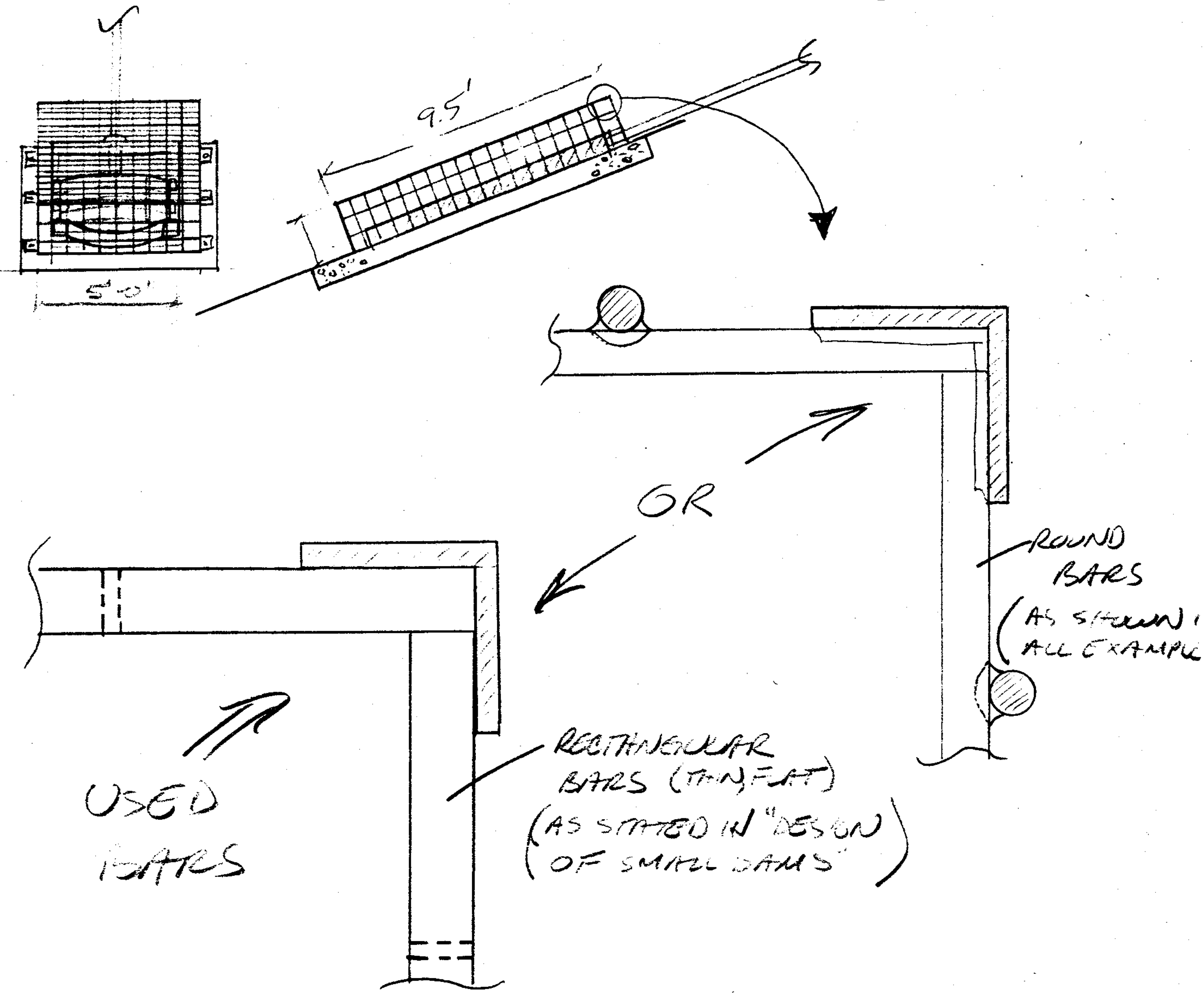
BASED ON THESE CALCULATIONS, WE INTEND TO USE A TRASH RACK THAT IS

9.5' LONG × 6' WIDE × 2' HIGH

IT WILL BE CONSTRUCTED USING 3"×3"×1/4" ANGLE ~~ST~~ ALONG ALL EDGES, WITH 2"×1/4" BAR STOCK USED FOR THE GRATE. ALSO IT WILL BE FASTENED USING 6 - 1/2"ϕ ANCHOR BOLTS, 3 ON EACH SIDE.

FILE BY: CDW, 1-28-00
SUBJECT CKD: BLW 1-31-00

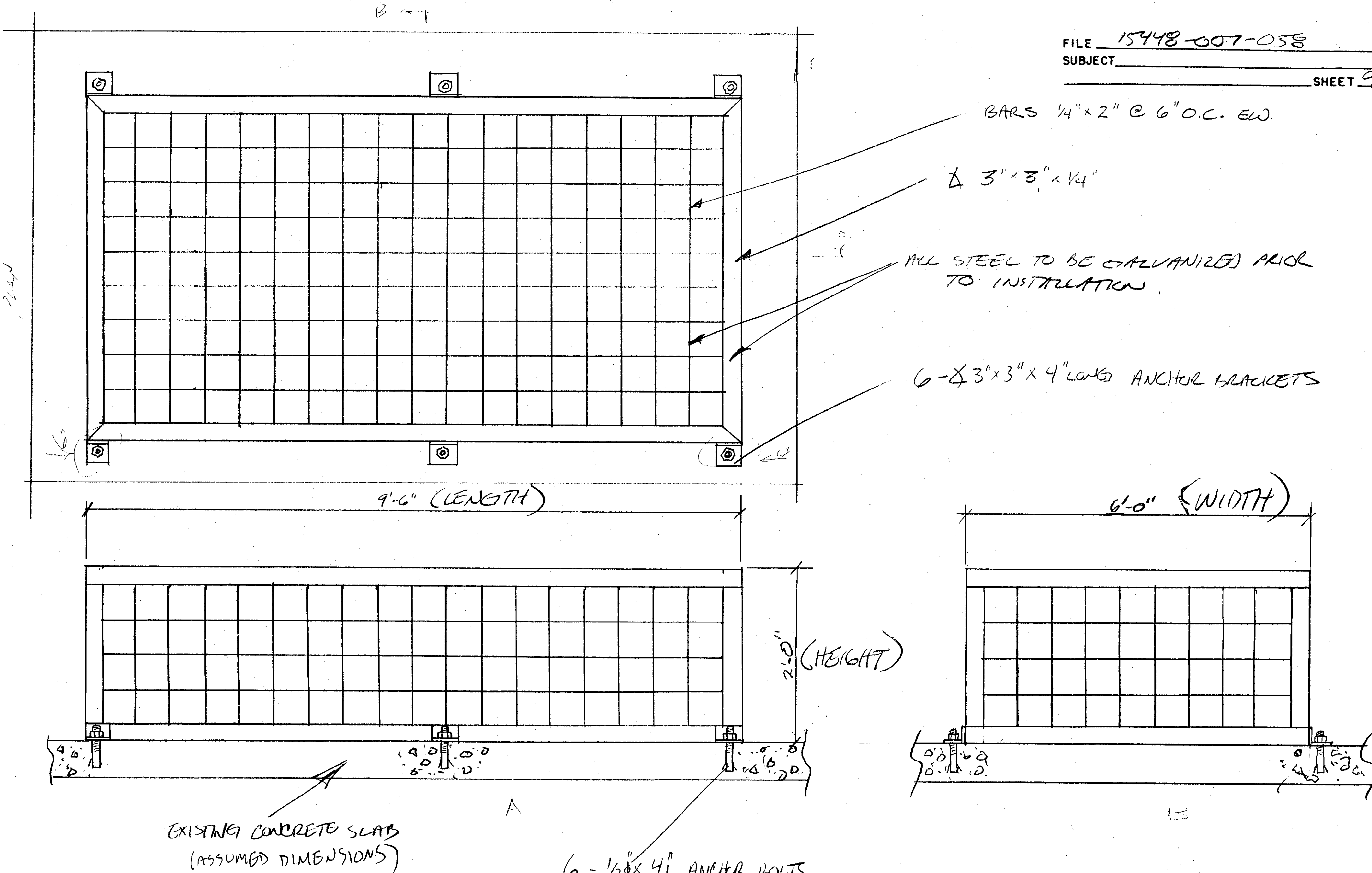
REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____



BY ____ DATE ____
CHECKED BY ____
COPY TO EO ____

FILE 15448-007-058
SUBJECT
SHEET 9 OF 9

REVISIONS
BY ____ DATE ____ TO EO ____
BY ____ DATE ____ TO EO ____



BY CDW DATE 2/1/80
CHECKED BY BKW 2/1/80
COPY TO EO

SCALE = 3/4" = 1'

CENTRAL OUTLET TRASH RACK

DAMES & MOORE

946 8 (10-67)

structed through the dam embankment. The structural design must consider the possibility of settlement and of lateral displacement caused by the movement of the embankment. Where a wet-well shaft is used, care must be taken in the design to prevent cracking and the opening of joints, which would permit leakage from the interior of the shaft into the surrounding embankment. The walls of the wet-well shaft must be designed to resist the internal hydrostatic pressure from full reservoir head and the external embankment loading. If a shaft extends through the embankment and projects into the reservoir, external hydrostatic loads and, where applicable, earthquake loads must also be considered. The protruding portion of the shaft is a tower, which is subject to the ice loads discussed in section 10.9.

(d) *Control Houses.*—A housing is sometimes provided around the outlet controls where operating equipment would otherwise be exposed or where adverse weather conditions will prevail during operating periods. A house is sometimes provided to enclose the top of an access shaft, although the controls may be located elsewhere. Such houses are usually made large enough to accommodate auxiliary equipment, such as ventilating fans, heaters, flow-measuring and recording meters, air pumps, small power-generator sets, and equipment needed for maintenance.

10.9. *Intake Structures.*—In addition to forming the entrance to the outlet works, an intake structure may accommodate control devices. It also supports necessary auxiliary appurtenances (such as trashracks, fishscreens, and bypass devices), and it may include temporary diversion openings and provisions for installation of bulkhead or stoplog closure devices.

Intake structures may appear in many forms. The type of intake structure selected should be based on several factors: the functions it must serve, the range in reservoir head under which it must operate, the discharge it must handle, the frequency of reservoir drawdown, the trash conditions in the reservoir (which will determine the need for or the frequency of cleaning of the trashracks), reservoir ice conditions or wave action that could affect the stability, and other similar considerations. Depending on its function, an intake structure may be either submerged or extended in the form of a tower above the maximum reservoir water surface. A tower must be provided if the controls are placed at the intake, or if an operating platform is needed for trash removal, maintaining and cleaning fishscreens, or installing stoplogs. Where the structure serves only as an entrance to the outlet conduit and where trash cleaning is ordinarily not required, a submerged structure may be adopted.

The conduit entrance may be placed vertically, inclined, or horizontally, depending on intake requirements. Where a sill level higher than the conduit level is desired, the intake can be a drop inlet similar to the entrance of a drop inlet spillway. A vertical entrance is usually provided for inlets at the conduit level. In certain instances, an inclined intake structure may be placed along the upstream slope of the dam or along the reservoir bank upstream of the dam. Such an arrangement is typified by the Ortega Reservoir outlet shown on figure 10-7. In most cases, conduit entrances should be rounded or bellmouthed to reduce hydraulic entrance losses.

The necessity for trashracks on an outlet works depends on the size of the sluice or conduit, the type of control device used, the nature of the trash burden in the reservoir, the use of the water, the need for excluding small trash from the outflow, and other factors. These factors determine the type of trashracks and the size of the openings. Where an outlet consists of a small conduit with valve controls, closely spaced trash bars are needed to exclude small trash. Where an outlet involves a large conduit with large slide-gate controls, the racks can be more widely spaced. If there is no danger of clogging or damage from small trash, a trashrack may consist simply of struts and beams placed to exclude only larger trees and similarly sized floating debris. The rack arrangement should also be based on the accessibility for removing accumulated trash. Thus, a submerged rack that seldom will be unwatered must be more substantial than one at or near the surface. Similarly, an outlet with controls at the entrance, where the gates can be jammed by trash protruding through the rack bars, must have a more substantial rack arrangement than one whose controls are not at the entrance.

Trash bars usually consist of thin, flat steel bars that are placed on edge from 3 to 6 inches apart and assembled in a grid pattern. The area of the trashrack required is fixed by a limiting velocity through the rack which, in turn, depends on the nature of the trash to be excluded. Where the trashracks are inaccessible for cleaning, the velocity through the racks ordinarily should not exceed 2 ft/s. A velocity of up to approximately 5 ft/s may be tolerated for racks that are accessible for cleaning.

Trashrack structures may have varied shapes, depending on how they are mounted or arranged on the intake structure. Trashracks for a drop inlet intake are generally formed as a cage atop the entrance. They may be arranged as an open box placed in front of a vertical entrance, or they may be positioned along the front side of a tower structure. Figures 10-1 through 10-7 show various arrangements of trashracks at entrances to outlet works.

At some reservoir sites, it may be desirable or required to screen the inlet entrance to prevent fish from being carried through the outlet works. Two such installations are illustrated on figure 10-2. Because small openings must be used to exclude fish, the screens can easily become clogged with debris. Provisions must therefore be made for periodically removing the fish screens and cleaning them by brooming or water jetting.

Where the control is placed at an intermediate point along a conduit, some means of unwatering the upstream pressure section of the conduit and the intake is desirable to make inspections and needed repairs. Stoplog or bulkhead slots are generally provided for this purpose in the intake or immediately downstream from the intake. In intake towers containing control devices, the stoplog slots are placed upstream from the controls. A circular, flat bulkhead that can drop down over the entrance is generally provided for a drop inlet structure. This type of bulkhead is normally lowered into place from a barge and positioned on a seat embedded in the intake sill concrete by divers. It can, however, be put in place in the dry condition and used for initial filling or refilling of the outlet works pipe.

For an intake structure with an inlet sill above the invert of the conduit, it may be desirable for various reasons to draw the reservoir down below the level of the sill. In such an instance, a bypass may be provided near the base of the structure to connect the reservoir to the conduit downstream. In other instances where flow must be maintained while installing or maintaining the control gates and outlet pipes or while repairing or maintaining the free flow conduit concrete, it may be desirable to carry a separate pipe under or alongside the conduit to bypass it entirely. In either case, the bypass inlet may be placed in the intake structure where it usually can be controlled by a gate or butterfly valve mounted on or in the structure and operated from some higher level.

Where winter reservoir storage is maintained and the surface ices over, the effect of such conditions on the intake structure must be considered. When the reservoir surface freezes around an intake structure, there is danger to the structure not only from the ice pressures acting laterally, but also from the uplift forces if a filling reservoir lifts the ice mass vertically. These effects must be considered when the advantages or disadvantages of a tower are compared with those of a submerged intake.

If a tower is constructed where icing conditions present a hazard, ice may be prevented from forming around the structure by the subsurface release of compressed air. The released air causes the slightly warmer water at lower depths to rise and mix with the cooler surface water, thus preventing freezing. However, if not enough warm water is available, as when the approach channel to the tower is shallow or the reservoir storage is small, the release of air may actually enhance freezing around the structure.

10.10. ***Terminal Structures and Dissipating Devices.***—The discharge from an outlet, whether it be a gate valve, or free flow conduit, will emerge at a high velocity, usually in a nearly horizontal direction. If erosion-resistant bedrock exists at shallow depths, the flow may be discharged directly into the river. Otherwise, it should be directed away from the toe of the dam by a deflector. Where erosion is to be minimized, a plunge basin may be excavated and lined with riprap or concrete. The design of such a basin is discussed in section 9.24.

When more energy dissipation is required for free flow conduits, the terminal structures described for spillways (part E, ch. 9) may be used. The hydraulic-jump basin is most often used for energy dissipation of outlet works discharges. However, flow that emerges from the outlet in the form of a free jet, as is the case for valve-controlled outlets of pressure conduits, must be directed onto the transition floor approaching the basin so it will become uniformly distributed before entering the basin. Otherwise, proper energy dissipation will not be obtained.

Two types of dissipating devices used more commonly with outlet works than with spillways are the impact-type stilling basin and the stilling well. An impact-type stilling basin dissipates energy by impeding the flow with a stationary concrete baffle.

usually require the use of footings, keywalls and counterforts and drainage is properly located immediately downstream of these features. This drainage when properly designed can control piping and provide significant economies due to the effect on soil loads, uplift pressures, overturning forces and sliding stability.

Outlets

The choice of outlet is to be based on a careful consideration of all site and flow conditions that may affect operation and energy dissipation.

1. Cantilever outlet and plunge pools may be installed where their use:

   a. Does not create a piping hazard in the foundation of the structure.

   b. Is compatible with other conditions at the site.

   Plunge pools are to be designed to dissipate the energy and be stable. Unless the pool is to be in bedrock or very erosion resistant materials, riprap will be necessary to insure stability. Design Note 6, entitled, "Armored Scour Hole for Cantilever Outlet", is to be used for design.

   Cantilever outlets are to be supported on bents or piers and are to extend a minimum of 8 feet beyond the bents or piers. The bents are to be located downstream from the intersection of the downstream slope of the earth embankment with the grade line of the channel below the dam. They are to extend below the lowest elevation anticipated in the plunge pool. The invert of the cantilever outlet is to be at least 1 foot about the tailwater elevation at maximum discharge.

2. SAF basins may be used when there is adequate control of tailwater. Use TR-54 for structural design and NEH-14 for hydraulic design.

3. Impact basins may be used when positive measures are taken to prevent large debris from entering the conduit. TR-49 is to be used for hydraulic design.

Trash Racks

Trash racks are to be designed to provide positive protection against clogging of the spillway under any operating level. The average velocity of flow through a clean trash rack is not to exceed 2.5 feet per second under the full range of stage and discharge. Velocity is to be computed on the basis of the net area of opening through the rack.

If a reservoir outlet with a trash rack or a ported concrete riser is used to keep the sediment pool drained the trash rack or riser is to extend above the anticipated sediment elevation at the riser to provide

* additional criteria for trash racks from SCS Tech. Release.

for full design flow through the outlet during the design life of the dam. The velocity through the net area of the trash rack above the maximum sediment elevation must not exceed 2 feet per second when the water surface in the reservoir is 5 feet above the top of the trash rack or riser inlet.

Antivortex Device

All closed conduit spillways designed for pressure flow are to have adequate antivortex devices.

High Sulfate Areas

Under certain conditions concrete is susceptible to deterioration from sulfate ions, especially those derived from sodium and magnesium sulfates. In areas where experience or soil tests indicate the potential for problems, the following table will be used for design purposes:

Sulfate Concentration [1/] (parts per million)	Hazard	Corrective Measures
0 - 150	Low	None
150 - 1,000	Moderate	Use Type II Cement. (ASTM C-150). Adjust mix to protect against sulfate action.
1,000 - 2,000	High	Use Type V Cement (ASTM C-150). Adjust mix to protect against sulfate action. Use soils in contact with concrete surfaces that are low in sulfates.
2,000 - up		Do not use concrete materials unless measures are taken to protect concrete surfaces from sulfates. Product manufacturers should be consulted.

[1/] Sulfate concentration is for soil water at the concrete surface.

DAMES & MOORE

CALCULATIONS COVER SHEET

PROJECT NO. 15448-007-058

SUBJECT. ______

SHEET 1 OF 10

DIAPHRAM FILTER & FILL COVER SIZING

TITLE OF CALCULATIONS/DOCUMENT

WHITE TANKS FRS #3

CALCULATIONS/DOCUMENT BY: CHRIS WIGGINTON

PRINT NAME

[signature]

SIGNATURE

1/27/00

DATE

ASSUMPTIONS CHECKED BY CONSULTANT/SENIOR PERSONNEL: SCOTT NEINHOUSE

PRINT NAME

[signature]

SIGNATURE

2-01-00

DATE

CALCULATIONS/DOCUMENT CHECKED BY: Bonnie Whitley

PRINT NAME

Bonnie Whitley

SIGNATURE

1/27/00

DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT, OR PM) Todd Ringsmuth

PRINT NAME

[signature]

SIGNATURE

2-1-00

DATE

Approval Notice: If Calculations/Document are only spot checked, do not require checking, or are assumed to be correct by experience of engineering judgement, it should be noted here.

Revision Number	Date	By	Checked By	Approval
1				
2				
3				
4				

INITIALS

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Sheet No. 2 OF 10
Calc. No.
Rev. No.

Job No. 15448-007 Job WHITE TANKS FRS #3 By CDW Date 1/27/00
Client Subject Chk'd. [illegible] Date 1/27/00

* DETERMINE THE DIMENSIONS OF THE FILTER SAND FOR EACH OF THE THREE OUTLET PIPES FOR THE WHITE TANK FRS #3.

* FROM THE SOIL CONSERVATION SERVICE TECHNICAL RELEASE NOTICE 60C, 210-V, PGS. 6-7 & 6-8. (SEE ATTACHED REFERENCE)

* ASSUME SETTLEMENT RATIO OF THE CONDUIT IS LESS THAN 0.7. THEREFORE, FILTER SAND EXTENDS 1.5 TIMES THE CONDUIT DIAMETER BELOW THE OUTLET PIPE. MAXIMUM REQUIREMENT.

* THE LIMITS OF THE DIAPHRAGM FILTER MUST EXTEND 2 TIMES THE DIAMETER OF THE PIPE ON EACH SIDE AS WELL AS ABOVE THE PIPE.

* ACCORDING TO THE SCS TECHNICAL RELEASE NOTICE 60C, 210-V PGS. 6-8, MINIMUM DIAPHRAGM THICKNESS IS [illegible] FEET. IN ORDER TO ACCOMMODATE CONSTRUCTION METHODS WE INCREASED THIS THICKNESS TO 4 FEET FOR ALL THREE OUTLETS.

* ACCORDING TO THE SCS TECHNICAL RELEASE NOTICE 60C, 210-V, PG. 6-8, THE EMBANKMENT COVER WILL BE AT LEAST HALF OF THE DIFFERENCE IN ELEVATION BETWEEN THE DIAPHRAGM AND THE MAX. POTENTIAL RESERVOIR WATER LEVEL

* MAX. POTENTIAL RESERVOIR WATER LEVEL IS ELEVATION 1210'.

F-132(7/91)

DAMES & MOORE

GROUP

A DAMES & MOORE GROUP COMPANY

Sheet No. 3 OF 10

Calc. No.

Rev. No.

Job No. 15448-007 Job WHITE TANKS FRS #3

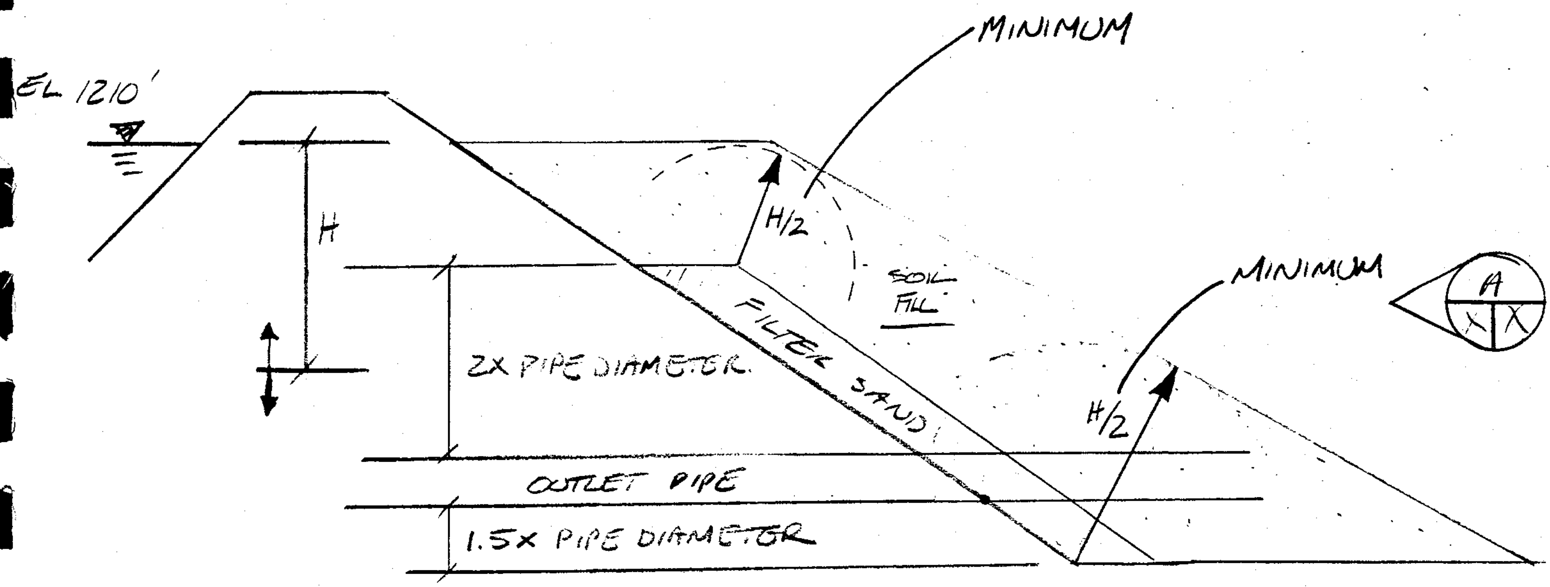
By CDW Date 1/27/00

Client Subject

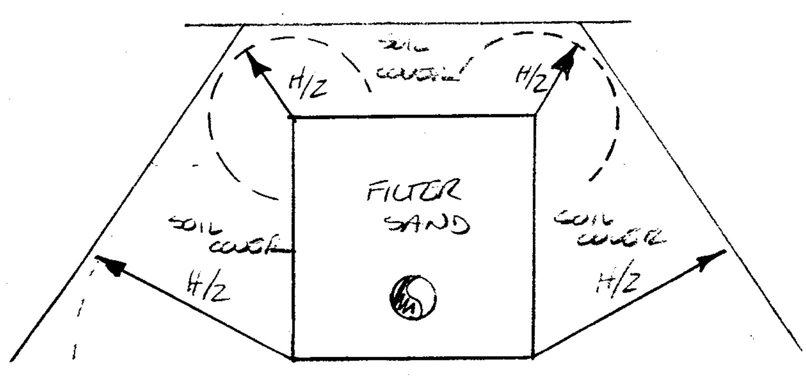
Chk'd. [illegible] Date 1/27/00

* PIPE INVERT ELEVATIONS WERE TAKEN FROM THE WHITE TANKS FRS #3, DECEMBER 1999 SURVEY.

F-132(7/91)



* DIAGRAM TO ACCOMPANY ALL CALCULATIONS FOR EACH OUTLET PIPE



ELEVATION A X|Y

NORTH OUTLET PIPE STA. 29+00

ELEVATION OF INVERT OF PIPE = 1186.891'

DIAMETER OF PIPE = 4'

2 TIMES THE PIPE DIAMETER = 8'

∴ ELEVATION OF TOP OF FILTER:

1186.891' + 4' + 8' = 1198.891' = 1199'

FILTER DIMENSIONS:

8' ABOVE THE PIPE TO ELEVATION = 1199'
8' TO THE LEFT & RIGHT OF THE PIPE
6' BELOW THE PIPE.

DETERMINATION OF FILL COVER THICKNESS:

H = DIFFERENCE IN ELEVATION BETWEEN THE MAX. POTENTIAL RESERVOIR WATER LEVEL & THE DIAPHRAM FILTER ELEVATIONS.

(SEE PG. 4 OF 6 FOR DRAWING)

H/2 = MINIMUM FILL COVER

(SEE PG. 4 OF 6 FOR DRAWING)

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Sheet No. 6 OF 10
Calc. No.
Rev. No.
By CDW Date 1/27/00
Chk'd. Date

Job No. 15448-007 Job WHITE TANKS FRS #3
Client Subject

$H_{(TOP\ OF\ FILTER)} = 1210 - 1199 = 11'$

$H/2_{(TOP\ OF\ FILTER)} = 5.5'$ OF FILL MINIMUM

* USE MIN 6' OF FILL OVER FILTER IN ALL DIRECTIONS AT FILTER ELEVATION 1199'

$H_{(INVERT\ OF\ PIPE)} = 1210 - 1186.891' = 23.109'$

$H/2_{(INVERT\ OF\ PIPE)} = 11.6'$ OF FILL MINIMUM

* USE MIN 12' OF FILL OVER FILTER IN ALL DIRECTIONS AT FILTER ELEVATION 1186.891'

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Sheet No. 7 OF 10	Calc. No.
Rev. No.	
Job No. 15448-007	Job WHITE TANKS FRS #3
By CDW	Date 1/27/00
Client	Subject
Chk'd. [illegible]	Date [illegible]

CENTRAL OUTLET PIPE STA. 46+00

ELEVATION OF INVERT OF PIPE = 1185.918'

DIAMETER OF PIPE = 4'

2 TIMES THE PIPE DIAMETER = 8'

∴ ELEVATION OF TOP OF FILTER:

1185.918 + 4' + 8' = 1197.918 = 1198'

FILTER DIMENSIONS:

8' ABOVE THE PIPE TO ELEVATION = 1198'
8' TO THE LEFT & RIGHT OF THE PIPE
6' BELOW THE PIPE.

DETERMINATION OF FILL COVER THICKNESS:

H = DIFFERENCE IN ELEVATION BETWEEN THE MAX POTENTIAL RESERVOIR WATER LEVEL & THE DIAPHRAGM FILTER TOP ELEVATION.

(SEE DWG ON SHEET 4 OF 6)

H/2 = MINIMUM FILL COVER

(SEE DWG ON SHEET 4 OF 6)

DAMES & MOORE

A DAMES & MOORE GROUP COMPANY

Sheet No. 8 OF 10

Calc. No.

Rev. No.

Job No. 15448-007 Job WHITE TANKS FRS #3

By CDW Date 1/27/

Client Subject

Chk'd. Date

$H_{(TOP\ OF\ FILTER)} = 1210 - 1198 = 12'$

$H/2_{(TOP\ OF\ FILTER)} =$ 6' OF FILL

* USE MIN. OF 6' OF FILL OVER FILTER IN ALL DIRECTIONS AT FILTER ELEVATION 1198'

$H_{(INVERT\ OF\ PIPE)} = 1210 - 1185.918' = 24.082$

$H/2_{(INVERT\ OF\ PIPE)} = 12.041$

* USE MIN. OF 12.5' OF FILL OVER FILTER IN ALL DIRECTIONS AT FILTER ELEVATION 1185.918'

F-132(7/91)

Sheet No. 9 OF 10	
Calc. No.	
Rev. No.	
By CDW	Date 1/27/0
Chk'd.	Date

Job No. 15448-007 Job WHITE TANKS FRS #3

Client Subject

SOUTH OUTLET PIPE STA. 63+80

ELEVATION OF INVERT OF PIPE = 1189.261'

DIAMETER OF PIPE = 2'

2 TIMES THE PIPE DIAMETER = 4'

∴ ELEVATION OF THE TOP OF FILTER:

1189.261 + 2' + 4' = 1195.261 => 1196'

FILTER DIMENSIONS:

4' ABOVE THE PIPE TO ELEVATION = 1196'
4' TO THE LEFT & RIGHT OF THE PIPE
3' BELOW THE PIPE.

DETERMINATION OF FILL COVER THICKNESS:

H: DIFFERENCE IN ELEVATION BETWEEN THE MAX. POTENTIAL RESERVIOR WATER LEVEL & THE DIAPHRAM FILTER TOP ELEVATION

(SEE DWG ON SHEET 4 OF 6)

H/2 = MINIMUM FILL COVER

(SEE DWG ON SHEET 4 OF 6)

DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

Calc. No.
Rev. No.

Job No. 15448-007 Job WHITE TANKS FRS #3 By CDW Date 1/27/00
Client Subject Chk'd. Date

H (TOP OF FILTER) = 1210 - 1196 = 14'

H/2 (TOP OF FILTER) = 7'

* USE MIN. OF 7' OF FILL OVER FILTER IN ALL DIRECTIONS AT FILTER ELEVATION 1196.

H (INVERT OF PIPE) = 1210 - 1189.261 = 20.759'

H/2 (INVERT OF PIPE) = 10.4'

* USE MIN. OF 10.5' OF FILL OVER FILTER IN ALL DIRECTIONS AT FILTER ELEVATION 1189.261

F-132(7/91)

White Tanks FRS #3
December 1999 Survey

North Pipe Cross-Section

1018	13574.124	22355.272	1190.62	TOE ST -	U/S Natural Ground
1019	13573.808	22360.669	1191.034	SH -	U/S Intake
1020	13573.942	22362.03	1187.226	PIPE ST -	U/S Invert
1021	13573.843	22370.081	1194.232	SH -	U/S Top of Headwall
1022	13573.291	22385.567	1199.456	SH	U/S Slope
1023	13574.075	22404.383	1207.091	SH	U/S Slope
1024	13573.641	22419.868	1212.454	TOP ST -	U/S Crest
1025	13574.176	22425.279	1212.387	TOP -	Dam Centerline
1026	13574.222	22431.898	1212.247	TOP -	D/S Crest
1027	13574.799	22442.973	1205.949	SH	D/S Slope
1028	13575.5	22453.915	1199.511	SH	D/S Slope
1029	13575.828	22462.859	1195.146	SH	D/S Top of Headwall
1033	13575.908	22470.919	1186.891	PIPE	D/S Invert

Central Pipe Cross-Section

1072	12407.457	21228.715	1189.466	TOE ST -	U/S Natural Ground
1074	12404.703	21231.35	1190.107	SH -	U/S Intake
1073	12403.793	21232.446	1186.573	PIPE ST -	U/S Invert
1075	12396.054	21239.247	1195.145	SH -	U/S Top of Headwall
1076	12384.806	21249.742	1201.66	SH	U/S Slope
1077	12374.279	21260.125	1207.659	SH	U/S Slope
1078	12362.774	21269.967	1213.387	TOP ST -	U/S Crest
1079	12358.944	21273.353	1213.543	TOP -	Dam Centerline
1080	12355.332	21276.73	1213.479	TOP -	D/S Crest
1082	12346.212	21286.876	1206.698	SH	D/S Slope
1083	12332.749	21300.026	1197.692	SH	D/S Slope
1084	12324.438	21308.224	1193.137	SH	D/S Top of Headwall
1086	12318.716	21314.403	1185.918	PIPE	D/S Invert

South Pipe Cross-Section

Point	Northing	Easting	Elevation		
1132	11170.173	19949.391	1191.396	TOE ST -	U/S Natural Ground
1133	11167.113	19952.224	1192.004	SH -	U/S Intake
1134	11166.494	19952.9	1189.577	PIPE ST -	U/S Invert
1135	11162.819	19955.806	1194.074	SH -	U/S Top of Headwall
1136	11148.05	19968.91	1201.865	SH	U/S Slope
1137	11134.27	19980.946	1209.264	SH	U/S Slope
1138	11121.962	19991.784	1215.183	TOP ST -	U/S Crest
1139	11118.351	19994.606	1215.245	TOP -	Dam Centerline
1140	11114.419	19998.526	1215.216	TOP -	D/S Crest
1141	11102.9	20008.983	1207.417	SH	D/S Slope
1142	11092.832	20021.093	1199.727	SH	D/S Slope
1143	11082.839	20031.959	1192.285	SH -	D/S Top of Headwall
1144	11082.635	20032.969	1189.261	PIPE	D/S Invert

United States Department of Agriculture

Soil Conservation Service

P.O. Box 2890
Washington, D.C.
20013

April 6, 1984

TECHNICAL RELEASE NOTICE 60C
210-V

SUBJECT: ENG-CONTROL OF SEEPAGE AND PIPING ALONG SPILLWAYS THROUGH DAMS

Purpose. To change the requirement for seepage control from antiseep collars to using drains with filters.

Effective Date. This amendment is effective upon receipt.

This amendment requires the use of a filter and drain collar to be used for controlling seepage along principal spillway structures in place of using antiseep collars. The use of drains with properly designed filters to control seepage and associated piping is consistent with the scientific evidence.

Filing Instructions. Remove pages 6-7 through 6-9 and replace with enclosed pages.

Distribution. The amendment should be made available to all offices having a copy of TR-60. Additional copies are available from Central Supply under stock number TR-60C.

Gerald D. Seinwill

GERALD D. SEINWILL
Associate Deputy Chief
for Technology

DIST: TR 60

Only joints incorporating a round rubber gasket set in a positive groove which will prevent its displacement from either internal or external pressure under the required joint extensibility are to be used on precast concrete pipe conduits. Concrete pipe must have steel joint rings providing rubber to steel contact in the joint.

Articulation of the conduit (freedom for required rotation) is to be provided at each joint in the conduit, at the junction of the conduit with the riser and any outlet structure. Concrete bedding for pipe conduits need not be articulated. Cradles are to be articulated if on yielding foundations. Welded steel pipe conduits need not be articulated if the pipe and bedding rest directly on firm bedrock.

Piping and Seepage Control - Use a filter and drainage diaphragm around any structure that extends through the embankment to the downstream slope. Design the diaphragm with single or multizones to meet the requirements of Soil Mechanics Note No. 1 except that the maximum D_{15} shall be 0.35 mm for filters to protect base soils with PI greater than 15.

Locate the diaphragm aligned approximately parallel to the centerline of the dam or approximately perpendicular to the direction of seepage flow. Extend the diaphragm horizontally and vertically into the adjacent embankment and foundation to intercept potential cracks, poorly compacted soil zones or other discontinuities associated with the structure or its installation.

Design the diaphragms to extend the following minimum distances from the surface of rigid conduits:

1. Horizontally and vertically upward 3 times the outside diameter of circular conduits or the vertical dimension of rectangular box conduits except that:

    a. the vertical extension need be no higher than the maximum potential reservoir water level and,

    b. the horizontal extension need be no further than 5 feet beyond the sides and slopes of any excavation made to install the conduit.

2. Vertically downward:

    a. for conduit settlement ratios (δ) of 0.7 and greater (reference SCS Technical Release No. 5), the greater of (1) 2 feet or (2) 1 foot beyond the bottom of the trench excavation made to install the conduit. Terminate the diaphragm at the surface of bedrock when it occurs within this distance. Additional control of general seepage through an upper zone of weathered bedrock may be needed.

b. 1.5 times the outside diameter of circular conduits or the outside vertical dimension of box conduits for conduit settlement ratios (δ) less than 0.7.

Design the diaphragms to extend in all directions a minimum of 2 times the outside diameter from the surface of flexible conduits, except that the diaphragm need not extend beyond the limits in 1a and 1b above nor beyond a bedrock surface beneath the conduit.

Provide minimum diaphragm thickness of 3 feet and a minimum thickness of 1 foot for any zone of a multizone system. Use larger thickness when needed for (1) capacity, (2) tieing into embankment or foundation drainage systems, (3) accommodating construction methods, or (4) other reasons.

For homogeneous dams, locate the diaphragm in the downstream section of the dam such that it is:

1. Downstream of the cutoff trench,

2. Downstream of the centerline of the dam when no cutoff trench is used, and

3. Upstream of a point where the embankment cover (upstream face of the diaphragm to the downstream face of the dam) is at least one-half of the difference in elevation between the top of the diaphragm and the maximum potential reservoir water level.

For zoned embankments, locate the diaphragm downstream of the core zone and/or cutoff trench, maintaining the minimum cover as indicated for homogeneous dams. When the downstream shell is more pervious than the diaphragm material, locate the diaphragm at the downstream face of the core zone.

It is good practice to tie these diaphragms into the other drainage systems in the embankment or foundation. Foundation trench drains and/or embankment chimney drains that meet the minimum size and location limits are sufficient and no separate diaphragm is needed.

Design the minimum capacity of outlets for diaphragms not connected to other drains by assuming the coefficient of permeability (k) in the zone upstream of the diaphragm is 100 times the coefficient of permeability in the compacted embankment material. Assume this zone has a cross-sectional area equal to the diaphragm area and the seepage path distance equal to that from the embankment upstream toe to the diaphragm. This higher permeability simulates a sealed filter face at the diaphragm with partially filled cracks and openings in the upstream zone.

For channels, chutes or other open structures, seepage and piping control can be accomplished in conjunction with drainage for reduction of uplift and water loads. The drainage, properly designed to filter the base soils, is to intercept areas of potential cracking caused by shrinkage, differential settlement or heave and frost action. These structures usually require the use of footings, keywalls and counterforts and drainage is properly located immediately downstream of these features. This drainage when properly designed can control piping and provide significant economies due to the effect on soil loads, uplift pressures, overturning forces and sliding stability.

Outlets

The choice of outlet is to be based on a careful consideration of all site and flow conditions that may affect operation and energy dissipation.

1. Cantilever outlet and plunge pools may be installed where their use:

    a. Does not create a piping hazard in the foundation of the structure.

    b. Is compatible with other conditions at the site.

    Plunge pools are to be designed to dissipate the energy and be stable. Unless the pool is to be in bedrock or very erosion resistant materials, riprap will be necessary to insure stability. Design Note 6, entitled, "Armored Scour Hole for Cantilever Outlet", is to be used for design.

    Cantilever outlets are to be supported on bents or piers and are to extend a minimum of 8 feet beyond the bents or piers. The bents are to be located downstream from the intersection of the downstream slope of the earth embankment with the grade line of the channel below the dam. They are to extend below the lowest elevation anticipated in the plunge pool. The invert of the cantilever outlet is to be at least 1 foot about the tailwater elevation at maximum discharge.

2. SAF basins may be used when there is adequate control of tailwater. Use TR-54 for structural design and NEH-14 for hydraulic design.

3. Impact basins may be used when positive measures are taken to prevent large debris from entering the conduit. TR-49 is to be used for hydraulic design.

Trash Racks

Trash racks are to be designed to provide positive protection against clogging of the spillway under any operating level. The average velocity of flow through a clean trash rack is not to exceed 2.5 feet per second under the full range of stage and discharge. Velocity is to be computed on the basis of the net area of opening through the rack.

If a reservoir outlet with a trash rack or a ported concrete riser is used to keep the sediment pool drained the trash rack or riser is to extend above the anticipated sediment elevation at the riser to provide for full design flow through the outlet during the design life of the dam. The velocity through the net area of the trash rack above the maximum sediment elevation must not exceed 2 feet per second when the water surface in the reservoir is 5 feet above the top of the trash rack or riser inlet.

Antivortex Device

All closed conduit spillways designed for pressure flow are to have adequate antivortex devices.

High Sulfate Areas

Under certain conditions concrete is susceptible to deterioration from sulfate ions, especially those derived from sodium and magnesium sulfates. In areas where experience or soil tests indicate the potential for problems, the following table will be used for design purposes:

Sulfate Concentration 1/ (parts per million)	Hazard	Corrective Measures
0 - 150	Low	None
150 - 1,000	Moderate	Use Type II Cement. (ASTM C-150). Adjust mix to protect against sulfate action.
1,000 - 2,000	High	Use Type V Cement (ASTM C-150). Adjust mix to protect against sulfate action. Use soils in contact with concrete surfaces that are low in sulfates.
2,000 - up		Do not use concrete materials unless measures are taken to protect concrete surfaces from sulfates. Product manufacturers should be consulted.

1/ Sulfate concentration is for soil water at the concrete surface.

United States Department of Agriculture

Soil Conservation Service

South Technical Service Center
P.O. Box 6567
Fort Worth, Texas 76115

November 22, 1989

ENG - TECHNICAL NOTE NO. 709, SUPPLEMENT
210-A

SUBJECT: ENG - FILTER-DRAINAGE DIAPHRAGM OUTLET

Purpose. To transmit the above named supplement.

Effective Date. When received.

Attached is a supplement to Technical Note 709, titled Filter-Drainage Diaphragm Outlet. Please file with Technical Note 709, Dimensioning of Filter-Drainage Diaphragm for Conduits According to TR-60, dated April 2, 1985.

PAUL F. LARSON
Director

Dist:
S-S
T
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TECHNICAL NOTE SUPPLEMENT

Subject: **ENGINEERING**

Series No.: **709**

Reference: **FILTER-DRAINAGE DIAPHRAGM OUTLET**

PURPOSE

This technical note supplement presents two examples of how to arrive at the design capacity and minimum size of the outlet for the diaphragm filter around the principal spillway of dams.

SCOPE

This technical note supplement will consider diaphragms not connected to other drains. Where foundation trench drains, abutment drains, or blanket drains are connected to the diaphragm, additional design procedures are required.

REFERENCES

Technical Release No. 60	Earth Dams and Reservoirs
Practice Standard 378	Pond
Soil Mechanics Note No. 1	Guide for Determining the Gradation of Sand and Gravel Filters
Soil Mechanics Note No. 3	Soil Mechanics Considerations for Embankment Drains
Soil Mechanics Note No. 9	Permeability of Selected Clean Sands and Gravels
SNTC Technical Note 709	Dimensioning of Filter-Drainage Diaphragms for Conduits According to TR-60

FUNCTION OF THE FILTER DIAPHRAGM

A recent change in design criteria replaces the structural walls or anti-seep collars around spillway conduits with a filter diaphragm. The filter diaphragm is used to intercept seepage through the pores of the soil and through internal cracks in the earthfill to prevent internal erosion of the backfill materials along the pipe. The seepage or internal erosion through cracks along the pipe can be caused, or contributed to, by improper compaction methods around the pipe, backfilling with unsuitable material, differential settlement of the embankment, and hydraulic fracturing of the embankment soils. These mechanisms can cause cracking along the pipe which can lead to concentrated seepage, internal erosion of the backfill material, and eventual failure of the embankment. As a defense against internal erosion of the embankment material, a properly designed filter (Soil Mechanics Note 1) can prevent soil particles from moving through and allow any cracks upstream of the filter to eventually close.

DESIGN

The design criteria for the filter diaphragm is contained in TR-60 and Practice Standard 378 Pond. In order to simulate a sealed filter face at the diaphragm with cracks or openings upstream, the coefficient of permeability (k) of the soil in the zone upstream of the filter is increased 100 times. The seepage zone is taken as the upstream cross-sectional area of the filter diaphragm (viewed in elevation), and the seepage path distance is the distance from the upstream toe of the embankment to the filter diaphragm.

As stated in Practice Standard 378 Pond, *The drain shall be outletted at the embankment downstream toe, preferably using a drain backfill envelope continuously along the pipe to where it exits the embankment.* TR-60 contains no such specific requirements due to the variety of outlet structures used on these larger dams.

It is required that the outlet for the filter diaphragm be sized to safely discharge the design flow. Where a drain backfill envelope is used as the outlet, it is recommended that it be designed so the hydraulic head does not exceed the depth of the drain outlet. The exposed area of the drain outlet must also be protected from external attack such as surface erosion and slope instability due to horizontal seepage pressures. A weighted toe cover such as riprap can be effective if protected with a properly designed filter between the sand drain material and the riprap cover.

If pipe drain outlets are used, consideration must be given to the structural design of the conduit in resisting external loading and the design life of the pipe must be consistent with the design life of the dam and physical conditions of the site. Also, the pipe must be designed for capacity and size of perforations as outlined in Soil Mechanics Notes 1 and 3. If the pipe corrodes, is crushed by exterior loading, or is otherwise damaged, the outlet of the filter diaphragm is lost and a piping failure may occur.

The design quantity (Q) used to size the outlet can be calculated by Darcy's Law, Q = kiA where:

k = permeability of the embankment or drain outlet material (ft/day)

i = hydraulic gradient where i = h/l

h = head differential (ft)

l = seepage path (ft)

A = area of flow (diaphragm or outlet) (ft^2)

The two presented examples considers the embankment material as isotropic where $k_h = k_v$. However, in most cases the permeability of the embankment is significantly higher in the horizontal direction than the vertical direction due to the construction methods used and because of the non-uniformity of the borrow material. Additional methods of design and examples are presented in Soil Mechanics Notes No. 3, No. 5 and No. 7 that consider anisotrophic conditions.

Example 1 provides a solution which strictly adheres to the requirements of TR-60 for calculating the design outlet quantity. This method also uses the outlet depth of flow for proportioning the thickness of the drainfill needed for the outlet (not specifically required in TR-60).

Example 2 is a less conservative design that takes advantage of one of several accepted SCS methods of estimating seepage through embankments. This method uses the average depth of flow in the outlet for establishing the required thickness of the outlet. Example 2 is presented to illustrate a more rational approach to the design problem.

ILLUSTRATIVE

SOLUTIONS

STATE SNTC		PROJECT Example 1		
BY W.A.Hughey	DATE 11-7-89	CHECKED BY W.H.L.	DATE 11-14-89	JOB NO.
SUBJECT Filter Diaphragm Outlet				SHEET 1 OF 4

Soil Mech. Report

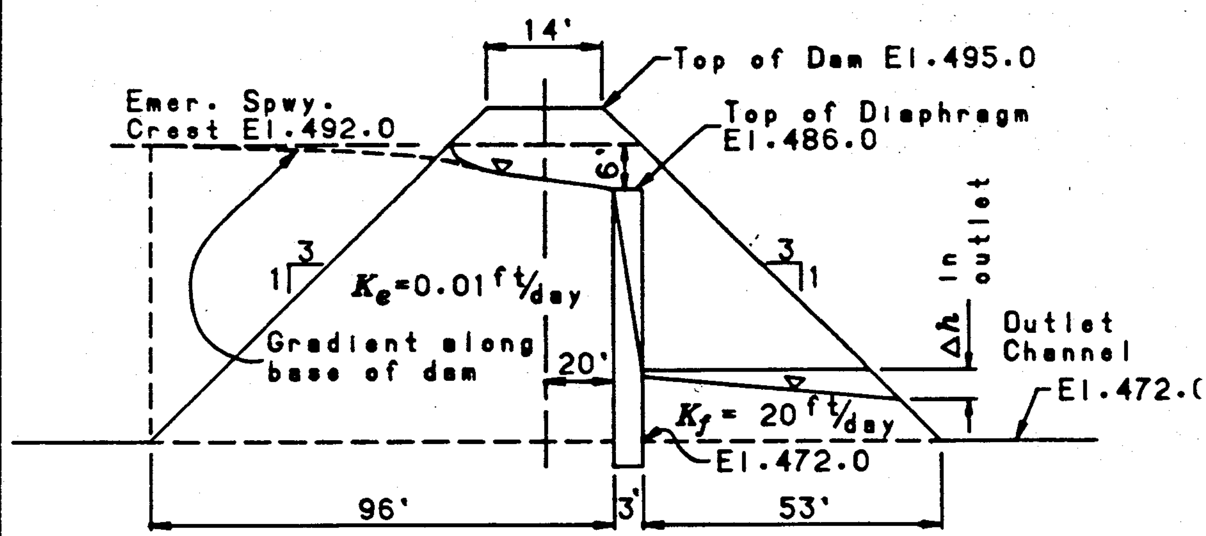
SM Note 9

GIVEN: Earth Embankment as shown

D_o = 38 in for 30 in pipe

K_e = 0.01 ft/day embankment

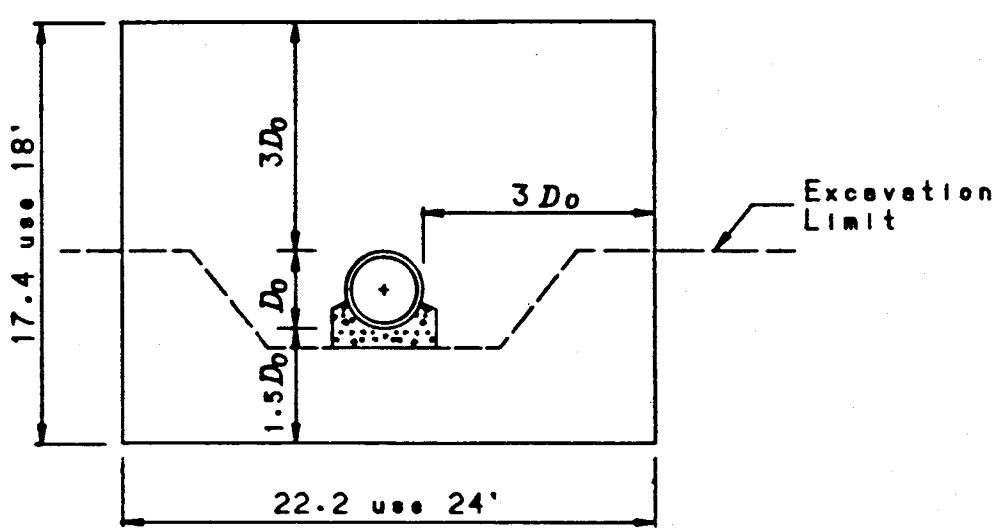
K_f = 20 ft/day filter



STRUCTURE LAYOUT

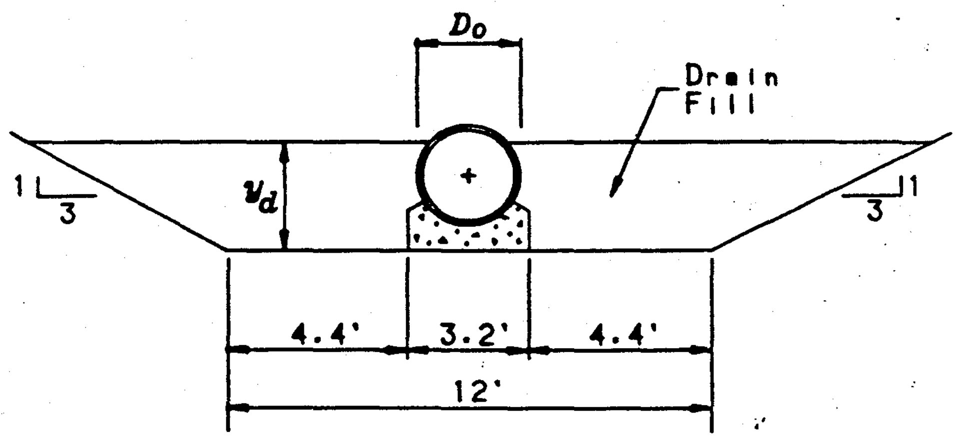
(NTS)

SNTC Tech Note No. 709



FILTER DIAPHRAGM

STATE SNTC		PROJECT Example 1		
BY W.A.Hughey	DATE 11-7-89	CHECKED BY W.H.L.	DATE 11-14-89	JOB NO.
SUBJECT Filter Diaphragm Outlet				SHEET 2 OF 4



OUTLET FOR DIAPHRAGM

FIND: Area of drain outlet

1. Seepage Zone equals area of filter diaphragm.

   Sheet 1 of 4 Filter Diaphragm

   A_{fd} = 18 x 24 = 432 ft^2

2. Hydraulic Gradient, $i = h/l$

   h = reservoir elevation minus top of filter diaphragm elevation

   h = 492 - 486 = 6 ft

   l = seepage path which is the distance from the upstream toe of the embankment to the face of the diaphragm

   l = 96 ft

   $i = h/l = 6\text{ft}/96\text{ft} = 0.063$

3. Permeability coefficient K

   TR-60 p.6-8

   $K = 100\,K_e = 100(0.01) = 1.0$ ft/day

4. Design Q

   Darcy's Law $Q = KiA$

   $Q = 1.0$ ft/day X 0.063 X 432 ft^2

   $Q = 27.2$ ft^3/day

STATE SNTC		PROJECT Example 1		
BY W.A.Hughey	DATE 11-7-89	CHECKED BY W.H.L.	DATE 11-14-89	JOB NO.
SUBJECT Filter Diaphragm Outlet				SHEET 3 OF 4

SM Note 9
C33 Fine Agg. average of fine limit of rounded and angular

5. Find the area of the drain outlet using several Δh to find the minimum outlet area.

Given:

$K_f = 20$ ft/day , $A = \frac{Q}{K_f i}$, $Q = 27.2$ ft³/day

$i = \frac{\Delta h}{53}$ in drain $\therefore$ $A = \frac{27.2}{20 i}$ = flow area

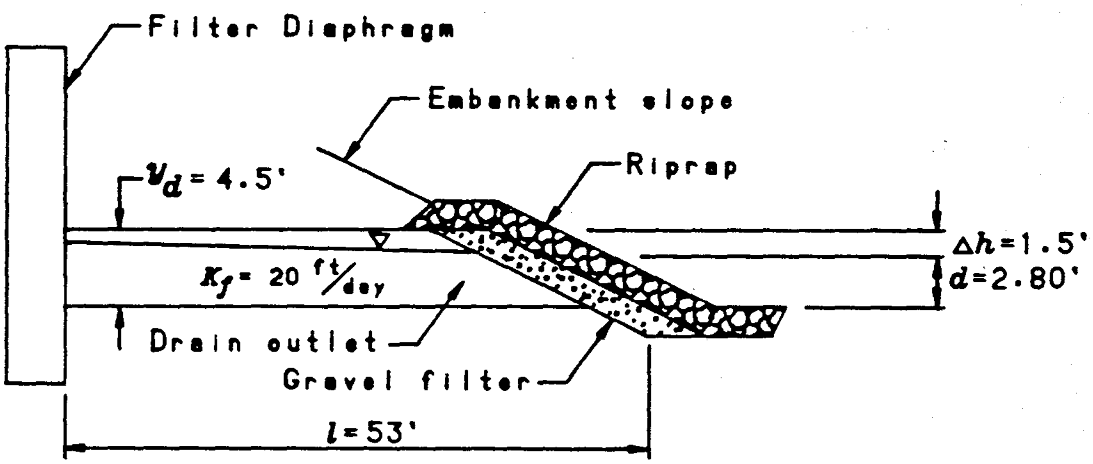
quadratic equation

$3d^2 + 8.8d = A$, $\mathcal{V}_d = d + \Delta h$

Δh ft	i	A ft²	d ft	$\mathcal{V}_d$ ft
1.0	0.0186	73.12	3.68	4.68
1.5	0.0283	48.05	2.80	4.30
2.0	0.0377	36.04	2.30	4.30
2.5	0.0472	28.83	1.96	4.46

Therefore: The drainfill depth must be 4.30 ft.
Use 4.50 ft.

Note: The drainfill will need protection from slope failure and erosion. An adequately filtered riprap blanket over the drain outlet will provide the required protection.



PROFILE OF DRAIN

Area of drain outlet with depth of 4.5 ft is:

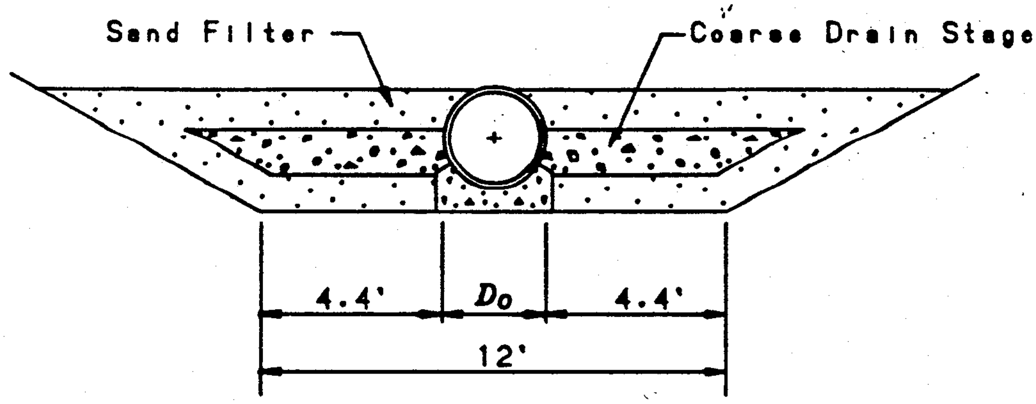
$$3(4.5^2) + 8.8(4.5) = 100.35 \text{ ft}^2$$

Designer may want to consider using a drain material with a greater permeability or include a two stage drain. A properly designed pipe outlet could also be considered. If a 2-stage outlet is used, the same type of analysis is used.

STATE SNTC		PROJECT Example 1		
BY W.A.Hughey	DATE 11-7-89	CHECKED BY W.H.L.	DATE 11-14-89	JOB NO.
SUBJECT Filter Diaphragm Outlet				SHEET 4 OF 4

A simplified assumption can be made that considers that all discharge occurs within the coarse drain stage.

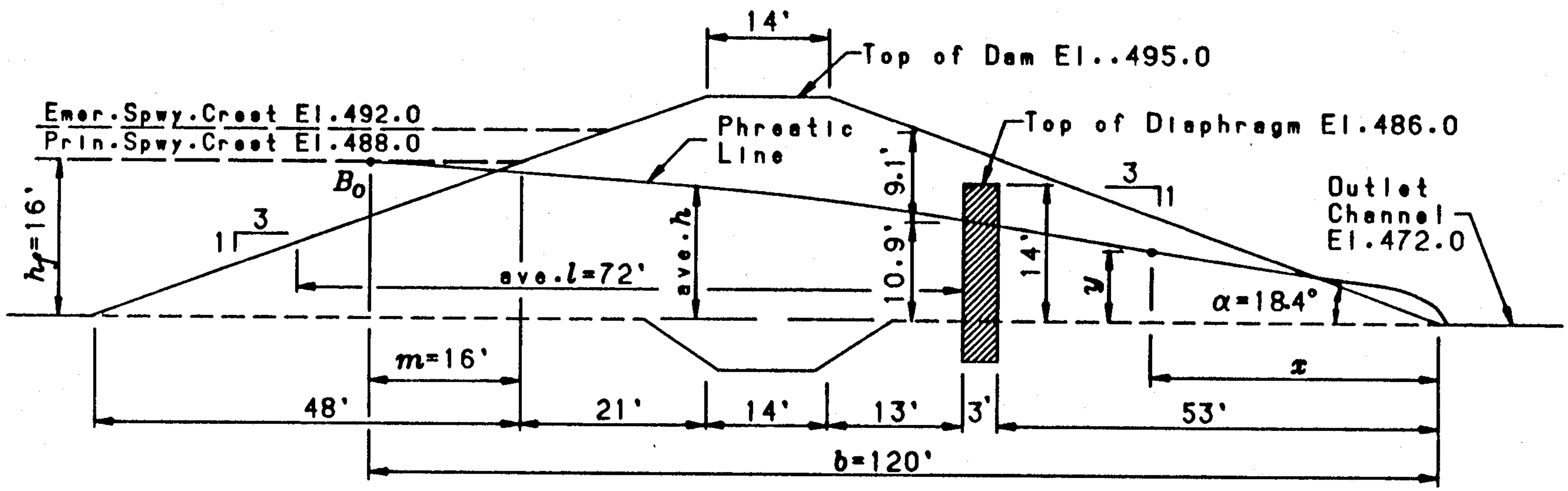
Example section of a two stage drain:



TWO STAGE DRAIN

FDO-03

STATE	SNTC
PROJECT	Example 2
BY	W.A.Hughey
DATE	11-7-89
CHECKED BY	W.H.L.
DATE	11-14-89
JOB NO.	
SUBJECT	Filter Diaphragm & Outlet Design
SHEET	1 OF 5



STRUCTURE LAYOUT

ASSUMPTIONS:

1. Homogeneous, isotropic cross-section.
2. Relatively impervious base.
3. Phreatic Line is developed from Principal Spillway Crest without influence of any drain.
4. Head for seepage calculation is from Emergency Spillway Crest.
5. Area of seepage zone is calculated from average depth under phreatic line.
6. Length of flow path is average of distance from diaphragm to toe of dam and Crest of Principal Spillway.

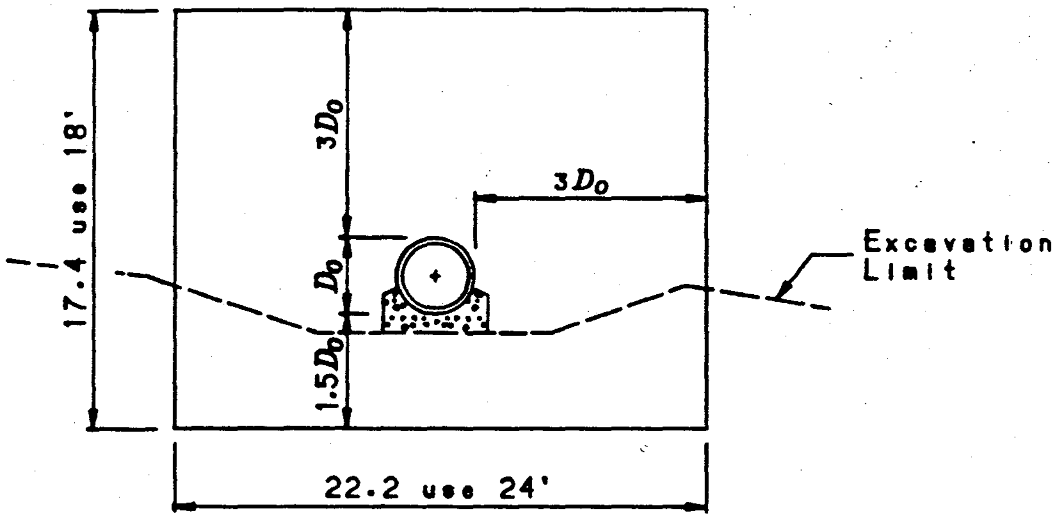
STATE SNTC	PROJECT Example 2		
BY W.A.Hughey / DATE 11-7-89	CHECKED BY W.H.L. / DATE 11-14-89	JOB NO.	
SUBJECT Filter Diaphragm & Outlet Design		SHEET 2 OF 5	

GIVEN: Earth Embankment as shown on sheet 1

D_o = 38 in. for 30 in. pipe

K_e = 0.01 ft/day - Embankment

K_f = 20 ft/day - Filter & Outlet



FILTER DIAPHRAGM

FIND: Area of Drain Outlet

Soil Mechanics Note 7 p.7

Construct Phreatic Line by Casagrande method

1. $m = \frac{1}{3}(488-472)3 = 16$ ft.
2. $b = 16 + 3(495-488) + 14 + 3(495-472) = 120$ ft.
3. $h_f = 488.0 - 472.0 = 16.0$ ft.
4. $Y_o = \sqrt{h_f^2 + b^2} - b$

   $Y_o = \sqrt{16^2 + 120^2} - 120$

   $Y_o = 1.06$ ft.
5. Calculate values of y corresponding to various values of x.

   $y = \sqrt{2Y_o x + Y_o^2}$

   $y = \sqrt{2(1.06)x + 1.06^2}$

x	y
10	4.7
20	6.6
40	9.3
56	10.9
70	12.2
100	14.6
120	16.0

6. Using the above x and y coordinates plot basic parabola as the phreatic line on the structure layout. (See Sheet 1)

Calculate Design Q for Filter Diaphragm.

Use Darcy's Law $Q=KiA$

1. Seepage Zone equals average height under phreatic line times width of diaphragm

$$A = (16+10.9)/2 \times 24 = 322.80 \text{ ft}^2$$

2. Hydraulic gradient, $i=\frac{h}{l}$

h = difference between emergency spillway and the height where the phreatic line hits the upstream face of the diaphragm.

$$h = 492 - (472+10.9) = 9.1 \text{ ft.}$$

l = average seepage flow path from midpoint between the upstream toe of the embankment to the principal spillway crest, horizontally to the face of the diaphragm.

$$l = 16(3)/2 + 21 + 14 + 13 = 72 \text{ ft.}$$

$$i = h/l = 9.1/72 = 0.126$$

TR-60 page 6-8

3. Permeability Coefficient K

$$K = 100K_e = 100(0.01) = 1.0 \text{ ft/day}$$

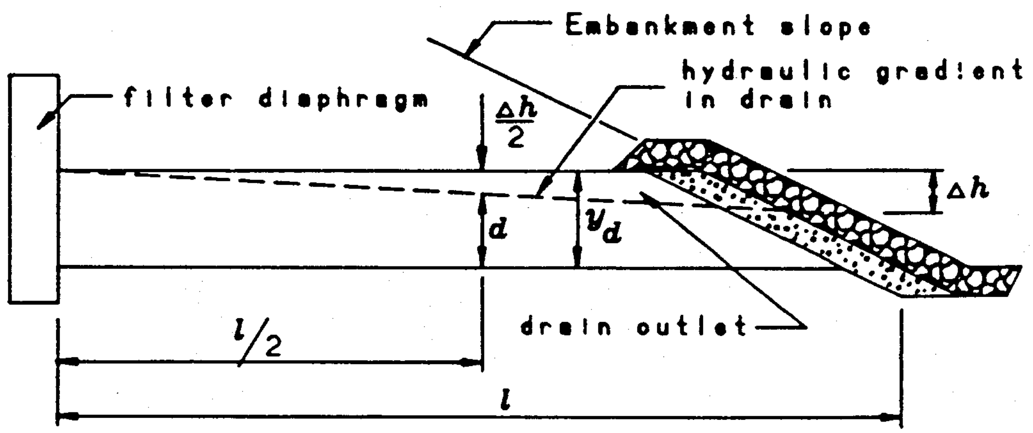
4. Design Q using Darcy's Law

$$Q = 1.0 \text{ ft/day} \times 0.126 \times 322.80 \text{ ft}^2$$

$$Q = 40.7 \text{ ft}^3\text{/day}$$

Calculate area of outlet for Filter Diaphragm

1. Consider the height of the drain as the height corresponding to the area calculated by Darcy's Law plus half of the hydraulic gradient in the drain.



STATE SNTC		PROJECT Example 2		
BY W.A.Hughey	DATE 11-7-89	CHECKED BY W.H.L.	DATE 11-14-89	JOB NO.
SUBJECT Filter Diaphragm & Outlet Design				SHEET 4 OF 5

Sheet 4
SM Note 9
Sheet 1

2. Calculate the average flow area of the drain outlet by Darcy's law.

GIVEN: $Q = 40.7\ ft^3/day$

K_f for drain outlet $= 20\ ft/day$

$i = \Delta h / l = \Delta h / 53$

$Q = KiA \longrightarrow A = \frac{Q}{K_f i} = \frac{40.7}{20i}$

$y_d = d + \frac{\Delta h}{2}$

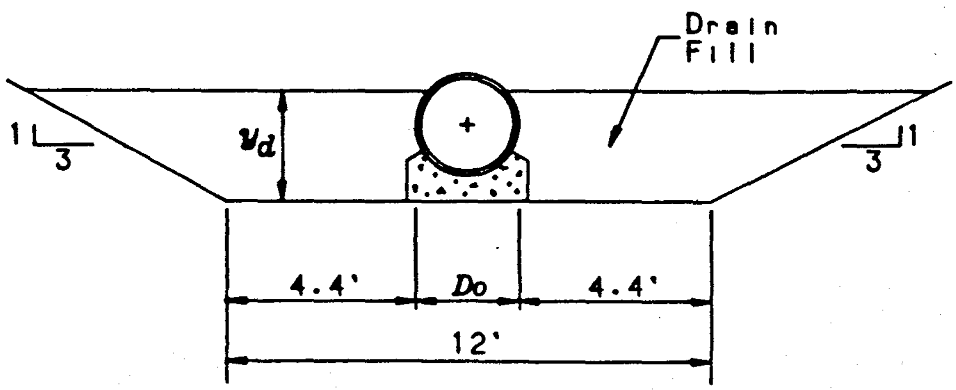
$3d^2 + 8.8d = A$

By trial find minimum y_d

Δh	i	A	d	y_d
1.0	0.0189	107.86	4.71	5.21
1.5	0.0283	71.90	3.64	4.39
2.0	0.0377	53.93	3.02	4.02
2.5	0.0472	43.14	2.60	3.85
3.0	0.0566	35.95	2.29	3.79
3.5	0.0660	30.82	2.06	3.81
4.0	0.0755	26.96	1.87	3.87

Therefore, drain depth must be a minimum of 3.79 ft

Use y_d = 4.0 ft.



OUTLET FOR DIAPHRAGM

3. Area of drain outlet

$$A = 3y_d^2 + 8.8y_d$$
$$= 3(4^2) + 8.8(4)$$
$$A = 83.2 \text{ ft}^2$$

The designer may want to consider:

(1) A drain outlet of material with a greater rate of permeability to reduce the area of the outlet, or,

See Soil Mechanics Note No.9

(2) A two-stage drain outlet using a gravel drain material surrounded by a compatible sand filter for greater outlet capacity. Gravel drain materials typically will have a K value of about 2500 fpd. (Refer to SM Note 9 for specific values.)

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CALCULATIONS COVER SHEET

SUBJECT: ______________________

PROJECT NO. 15448-007-058

SHEET 1 OF 15

Diaphragm Filter Gradation

TITLE OF CALCULATIONS/DOCUMENT

CALCULATIONS/DOCUMENT BY: Bonnie Whitley

PRINT NAME

Bonnie Whitley

SIGNATURE

2-1-00

DATE

ASSUMPTIONS CHECKED BY CONSULTANT/SENIOR PERSONNEL: SCOTT NEWHOUSE

PRINT NAME

Scott Newhouse

SIGNATURE

2-2-00

DATE

CALCULATIONS/DOCUMENT CHECKED BY: CHRIS WIGGINTON

PRINT NAME

SIGNATURE

2-2-00

DATE

APPROVED BY:
(PRINCIPAL INVESTIGATOR, CONSULTANT, OR PM) Todd Ringsmuth

PRINT NAME

SIGNATURE

2-2-00

DATE

Approval Notice: If Calculations/Document are only spot checked, do not require checking, or are assumed to be correct by experience of engineering judgement, it should be noted here.

Revision Number	Date	By	Checked By	Approval
1				
2				
3				
4				

INITIALS

Calculated according to National Engineering Handbook, Chapter 26 Gradation Design of Sand and Gravel Filters (SCS, 1994) p26-1 to 26-6

Base soil gradations of five samples taken from the dam are shown on sheets 9 to 13. D_{15} for each is 0.075mm

Determine base soil category according to Table 26-1 (see sheet 6)

Base Soil Category = 2

Determine maximum allowable D_{15} based on Table 26-2 (see sheet 6)

$$\text{Max } D_{15} \leq 0.7\text{mm}$$

Determine minimum allowable D_{15} based on Table 26-3 (see sheet 6)

$$\text{Min } D_{15} \geq 4 \times D_{15} \text{ of base soil}$$
$$\geq 4(0.075\text{mm})$$
$$\geq 0.3\text{mm}$$

Adjust Max D_{15} and Min D_{15} so that ratio is 5 or less at any given percentage passing of 60 or less

$$\frac{\text{Max } D_{15}}{\text{Min } D_{15}} = \frac{0.7\text{mm}}{0.3\text{mm}} = 2.33$$ no adjustment needed

Label Max D_{15} as Control Point 1 (see sheet 5)

Label Min D_{15} as Control Point 2

Adjust limits of design filter band so that the coarse and fine sides have a coefficient of uniformity of 6 or less.

$$CU = \frac{D_{60}}{D_{10}} \leq 6$$

$$\text{Max } D_{10} = \frac{\text{Max } D_{15}}{1.2} = \frac{0.7\text{mm}}{1.2} = 0.583\text{mm}$$

$$\text{Max } D_{60} = 6 \times D_{60} = 6 \times 0.583\text{mm} = 3.5$$

Label Max D_{60} Control Point 3

$$\text{Min } D_{60} = \frac{\text{Max } D_{60}}{5}$$ (ratio is 5 or less at any percentage passing of 60 or less)

$$= \frac{3.5\text{mm}}{5} = 0.7\text{mm}$$

Label Min D_{60} Control Point 4

Determine minimum D_5 and maximum D_{100} according to Table 26-5 (see sheet 7)

$$\text{Min } D_5 = 0.075 \text{ mm}$$

Label as Control Point 5

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Calc. No.
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Job No. 15449-007-058 Job
By [illegible] Date 2-1-[illegible]
Client
Subject
Chk'd. CDW Date 2-2-0[illegible]

Max $D_{100} \leq 75mm$

Label as Control Point 6

Determine maximum D_{90} according to Table 26-6, first calculating a minimum D_{10}

$$\text{Min } D_{10} = \frac{\text{Min } D_5}{1.2}$$

$$= \frac{0.3mm}{1.2}$$

$$= 0.25mm$$

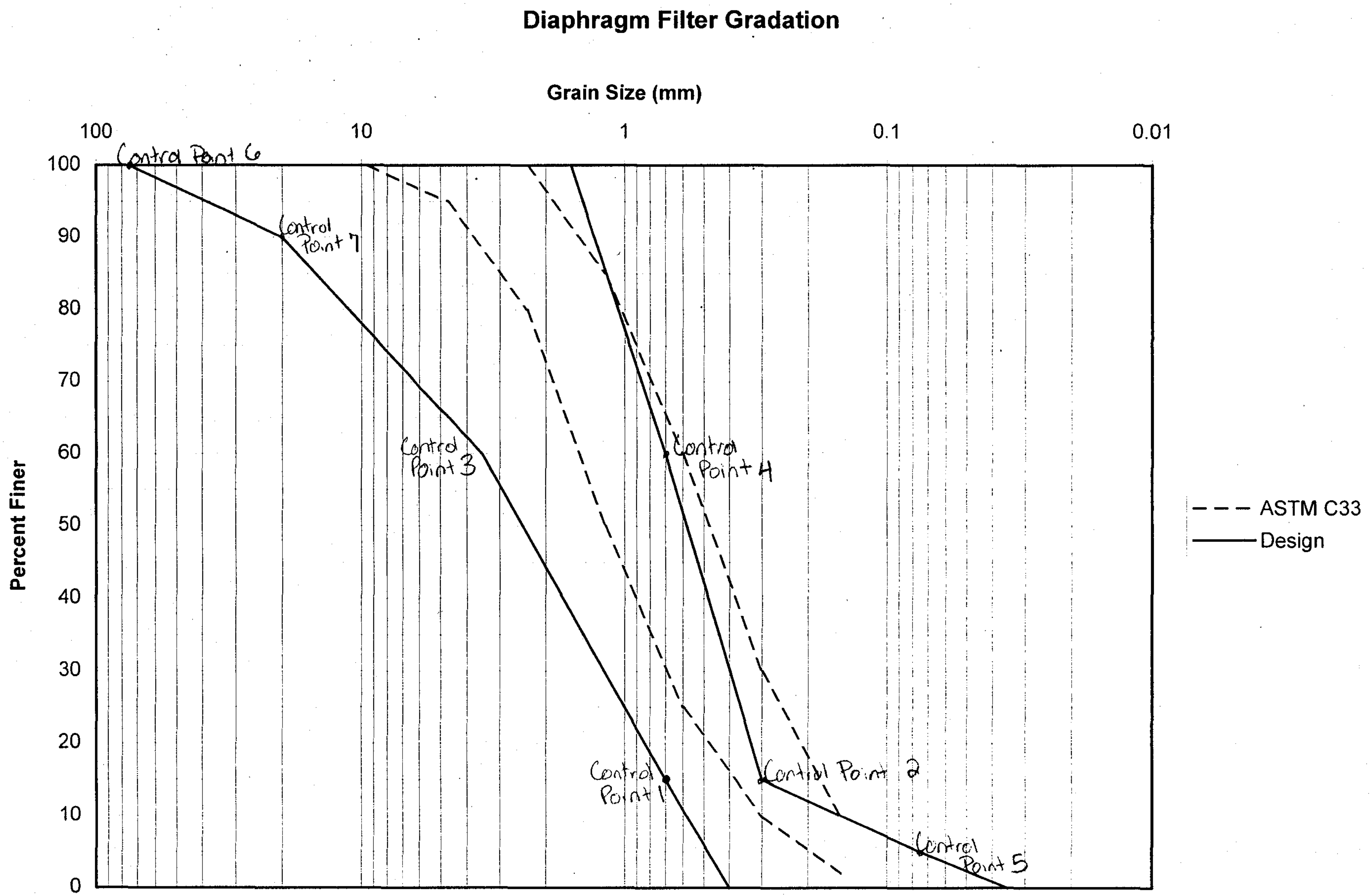
Max D_{90} = 20mm according to Table 26-6 (see sheet

Label as Control Point 7

Connect Control Points 4, 2, and 5 to form a partial design of the fine side.

Connect Control Points 6, 7, 3 and 1 to form a design for the coarse side.

Conclusion: ASTM C33 Sand falls within the design band and is an acceptable material for the diaphragm filter


Diaphragm Filter Gradation
Grain Size (mm)
100
10
1
0.1
0.01
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
Control Point 6
Control Point 7
Control Point 3
Control Point 4
Control Point 1
Control Point 2
Control Point 5
ASTM C33
Design

Chapter 26 Gradation Design of Sand and Gravel Filters

633.2600 Purpose

Chapter 26 presents criteria for determining the grain-size distribution (gradation) of sand and gravel filters needed to prevent internal erosion or piping of soil in embankments or foundations of hydraulic structures.

These criteria are based on results of an extensive laboratory filter study carried out by the Soil Conservation Service at the Soil Mechanics Laboratory in Lincoln, Nebraska, from 1980 to 1985. (See Section 633.2605, References, for published reports.)

Refer to section 633.2604 for definitions used in this chapter.

633.2601 Basic purpose o filters and drains

Filters are placed in embankment zones, foundation: or other areas of hydraulic structures for two purposes:

- To intercept water flowing through cracks or openings in a base soil and block the movement of eroding soil particles into the filter. Soil particles are caught at the filter face, reducing the flow of water through cracks or openings and preventing further erosion and enlargement of the cracks or openings.
- To intercept water flowing through the pores of the base soil, allowing passage of the water while preventing movement of base soil particles. Without filters, piping of susceptible base soils can occur when seepage gradients or pressures are high enough to produce erosive discharge velocities in the base soil. The filter zone is generally placed upstream of the discharge point where sufficient confinement prevents uplift or blow-out of the filter.

Drains consist of sand, gravel, or a sand and gravel mixture placed in embankments, foundations, and backfill of hydraulic structures, or in other locations t reduce seepage pressure. A drain's most important design feature is its capacity to collect and carry wate to a safe outlet at a low gradient or without pressure build-up. Drains are often used downstream of or in addition to a filter to provide outlet capacity.

Combined filters and drains are commonly used. The filter is designed to function as a filter and as a drain.

633.2602 Permeability and capacity

The laboratory filter study clearly demonstrated that graded filters designed in accordance with these criteria will seal a crack. The sealing begins when water flows through a crack or opening and carries soil particles eroded from the sides of the openings. Eroding soil particles collect on the face of the filter and seal the crack at the interface. Any subsequent flow is through the pores of the soil. If filters are designed to intercept cracks, the permeability required in the filter zone should be based on the steady state seepage flow through the pores of the base soil alone. The hydraulic capacity of any cracks need not be considered in designing the filter because the cracks have been shown to seal.

Where saturated steady-state seepage flow will not develop, for instance in dry dams for flood control having a normal drawdown time of 10 days or less, filter capacity need only be nominal. Filters designed either to protect against steady state seepage or internal erosion through cracks are to be thick enough to compensate for potential segregation and contamination of the filter zones during construction. They must also be thick enough that cracks cannot extend through the filter zone during any possible differential movements.

A zone of coarser materials immediately downstream or below the filter, or both, provides additional capacity to collect and convey seepage to a controlled outlet. In some cases a strip drain is used, and in others a perforated collector pipe is employed to outlet the collected seepage. To prevent movement of the filter materials into the coarse drain materials, the coarse drain materials must be designed for the proper gradation using procedures in this subchapter. Perforations in collector pipes must also be sized properly to prevent movement of the coarse drain materials into the perforations.

633.2603 Determining filter gradation limits

Determine filter gradation limits using the following steps:

Step 1: Plot the gradation curve (grain-size distribution) of the base soil material. Use enough samples to define the range of grain sizes for the base soil or soils. Design the filter using the base soil that requires the smallest D_{15} size for filtering purposes. Base the design for drainage purposes on the base soil that has the largest D_{15} size.

Step 2: Proceed to step 4 if the base soil contains no gravel (material larger than No. 4 sieve).

Step 3: Prepare adjusted gradation curves for base soils that have particles larger than the No. 4 (4.75 mm) sieve.

- Obtain a correction factor by dividing 100 by the percent passing the No. 4 (4.75 mm) sieve.
- Multiply the percentage passing each sieve size of the base soil smaller than No. 4 (4.75 mm) sieve by the correction factor determined above.
- Plot these adjusted percentages to obtain a new gradation curve.
- Use the adjusted curve to determine the percentage passing the No. 200 (0.075 mm) sieve in step 4.

Step 4: Place the base soil in a category determined by the percent passing the No. 200 (0.075 mm) sieve from the regraded gradation curve data according to table 26–1.

Step 5: To satisfy filtration requirements, determine the maximum allowable D_{15} size for the filter in accordance with the table 26–2.

If desired, the maximum D_{15} may be adjusted for certain noncritical uses of filters where significant hydraulic gradients are not predicted, such as bedding beneath riprap and concrete slabs. For fine clay base soil that has d_{85} sizes between 0.03 and 0.1 mm, a maximum D_{15} of $\leq$ 0.5 mm is still conservative. For fine-grained silt that has low sand content, plotting below the "A" line, a maximum D_{15} of 0.3 mm may be used.

Sheet 7 of 12

Step 6: If permeability is a requirement (see section 633.2602), **determine the minimum allowable D_{15} in accordance with table 26–3.** Note: The permeability requirement is determined from the d_{15} size of the base soil gradation before regrading.

Step 7: The width of the allowable filter design band must be kept relatively narrow to prevent the use of possibly gap-graded filters. Adjust the maximum and minimum D_{15} sizes for the filter band determined in steps 5 and 6 so that the ratio is 5 or less at any given percentage passing of 60 or less. Criteria are summarized in table 26–4.

Table 26–1 Regraded gradation curve data

Base soil category	% finer than No. 200 sieve (0.075 mm) (after regrading, where applicable)	Base soil description
1	> 85	Fine silt and clays
2	40 – 85	Sands, silts, clays, and silty & clayey sands
3	15 – 39	Silty & clayey sands and gravel
4	< 15	Sands and gravel

Table 26–2 Filtering criteria — Maximum D_{15}

Base soil category	Filtering criteria
1	$\le 9 \times d_{85}$ but not less than 0.2 mm
2	≤ 0.7 mm
3	$\le \left(\frac{40-A}{40-15}\right)\left[\left(4\times d_{85}\right)-0.7\text{mm}\right]+0.7\text{mm}$
	A = % passing #200 sieve after regrading (If $4 \times d_{85}$ is less than 0.7 mm, use 0.7 mm)
4	$\le 4 \times d_{85}$ of base soil after regrading

This step is required to avoid the use of gap-graded filters. The use of a broad range of particle sizes to specify a filter gradation could result in allowing the use of gap-graded (skip-graded) materials. These materials have a grain size distribution curve with sharp breaks or other undesirable characteristics. Materials that have a broad range of particle sizes may also be susceptible to segregation during placement. The requirements of step 9 should prevent segregation, but other steps are needed to eliminate the use of any gap-graded filters.

Gap-graded materials generally can be recognized by simply looking at their grain size distribution curve. However, for specification purposes, more precise controls are needed. In designing an acceptable filter band using the preliminary control points obtained in steps 1 through 6, the following additional requirements should be followed to decrease the probability of using a gap-graded filter.

Table 26–3 Permeability criteria

Base soil category	Minimum D_{15}
All categories	$\ge 4 \times d_{15}$ of the base soil before regrading, but not less than 0.1 mm

Table 26–4 Other filter design criteria

Design element	Criteria
To prevent gap-graded filters	The width of the designed filter band should be such that the ratio of the maximum diameter to the minimum diameter at any given percent passing value ≤ 60% is ≤ 5.
Filter band limits	Coarse and fine limits of a filter band should each have a coefficient of uniformity of 6 or less.

First, calculate the ratio of the maximum D_{15} to the minimum D_{15} sizes determined in steps 5 and 6. If this ratio is greater than 5, adjust the values of these control points so that the ratio of the maximum D_{15} to the minimum D_{15} is no greater than 5. If the ratio is 5 or less, no adjustments are necessary. Label the maximum D_{15} size as Control point 1 and the minimum D_{15} size as Control point 2. Proceed to step 8.

The decision on where to locate the final D_{15} sizes within the range established with previous criteria should be based on one of the following considerations:

1. Locate the design filter band at the maximum D_{15} side of the range if the filter will be required to transmit large quantities of water (serve as a drain as well as a filter). With the maximum D_{15} size as the control point, establish a new minimum D_{15} size by dividing the maximum D_{15} size by 5, and locate a new minimum D_{15} size. Label the maximum D_{15} size Control point 1 and the minimum D_{15} size Control point 2.

2. Locate the band at the minimum D_{15} side of the range if it is probable there are finer base materials than those sampled and filtering is the most important function of the zone. With the minimum D_{15} size as the control point, establish a new maximum D_{15} size by multiplying the minimum D_{15} size by 5, and locate a new maximum D_{15} size. Label the maximum D_{15} size Control point 1 and the minimum D_{15} size Control point 2.

3. The most important consideration may be to locate the maximum and minimum D_{15} sizes, within the acceptable range of sizes determined in steps 5 and 6, so that a standard gradation available from a commercial source or other gradations from a natural source near the site would fall within the limits. Locate a new maximum D_{15} and minimum D_{15} within the permissible range to coincide with the readily available material. Ensure that the ratio of these sizes is 5 or less. Label the maximum D_{15} size Control point 1 and the minimum D_{15} size Control point 2.

Step 8: The designed filter band must not have an extremely broad range of particle sizes to prevent the use of possibly gap-graded filters. Adjust the limits of the design filter band so that the coarse and fine sides have a coefficient of uniformity of 6 or less. The width of the filter band should be such that the ratio of maximum to minimum diameters is less than or equal to 5 for all percent passing values of 60 or less.

Other filter design criteria in step 8

To prevent gap-graded filters—Both sides of the design filter band will have a coefficient of uniformity, defined as:

$$CU = \frac{D_{60}}{D_{10}} \leq 6$$

Initial design filter bands by this step will have CU values of 6. For final design, filter bands may be adjusted to a steeper configuration, with CU values less than 6, if needed. This is acceptable so long as other filter and permeability criteria are satisfied.

Calculate a maximum D_{10} value equal to the maximum D_{15} size divided by 1.2. (This factor of 1.2 is based on the assumption that the slope of the line connecting D_{15} and D_{10} should be on a coefficient of uniformity of about 6.) Calculate the maximum permissible D_{60} size by multiplying the maximum D_{10} value by 6. Label this Control point 3.

Determine the minimum allowable D_{60} size for the fine side of the band by dividing the determined maximum D_{60} size by 5. Label this Control point 4.

Step 9: Determine the minimum D_5 and maximum D_{100} sizes of the filter according to table 26–5. Label as Control points 5 and 6, respectively.

Table 26–5 Maximum and minimum particle size criteria*

Base soil category	Maximum D_{100}	Minimum D_5, mm
All categories	≤ 3 inches (75 mm)	0.075 mm (No. 200 sieve)

* The minus No. 40 (.425 mm) material for all filters must be nonplastic as determined in accordance with ASTM D4318.

Step 10: To minimize segregation during construction, the relationship between the maximum D_{90} and the minimum D_{10} of the filter is important. Calculate a preliminary minimum D_{10} size by dividing the minimum D_{15} size by 1.2. (This factor of 1.2 is based on the assumption that the slope of the line connecting D_{15} and D_{10} should be on a coefficient of uniformity of about 6.) Determine the maximum D_{90} using table 26–6. Label this as Control point 7.

Sand filters that have a D_{90} less than about 20 mm generally do not require special adjustments for the broadness of the filter band. For coarser filters and gravel zones that serve both as filters and drains, the ratio of D_{90}/D_{10} should decrease rapidly with increasing D_{10} sizes.

Step 11: Connect Control points 4, 2, and 5 to form a partial design for the fine side of the filter band. Connect Control points 6, 7, 3, and 1 to form a design for the coarse side of the filter band. This results in a preliminary design for a filter band. Complete the design by extrapolating the coarse and fine curves to the 100 percent finer value. For purposes of writing specifications, select appropriate sieves and corresponding percent finer values that best reconstruct the design band and tabulate the values.

Step 12: Design filters adjacent to perforated pipe to have a D_{85} size no smaller than shown in table 26–7. For critical structure drains where rapid gradient reversal (surging) is probable, it is recommended that the D_{15} size of the material surrounding the pipe be no smaller than the perforation size.

Additional design considerations: Note that these steps provide a filter band design that is as well graded as possible and still meets criteria. This generally provides the most desirable filter characteristics. However, in some cases a more poorly graded filter band may be preferable; for example, if more readily available standard gradations are needed or where onsite filters are used for economy.

The design filter band obtained in steps 1 through 12 may be adjusted to a steeper configuration in such cases. The width of the filter band should be maintained so that the ratio of the maximum diameters to the minimum diameters at a given percent finer is no greater than 5 below the 60 percent finer value.

Only the portion of the design filter band above the previously established minimum and maximum D_{15} sizes should be adjusted. The design band may be adjusted so that the coefficients of uniformity of both the coarse and fine sides of the design band are less than 6, but not less than 2, to prevent use of very poorly graded filters.

Table 26–6 Segregation criteria

Base soil category	If D_{10} is :	Then maximum D_{90} is:
	(mm)	(mm)
All categories	< 0.5	20
	0.5 – 1.0	25
	1.0 – 2.0	30
	2.0 – 5.0	40
	5.0 – 10	50
	> 10	60

Table 26–7 Criteria for filters used adjacent to perforated collector pipe

Noncritical drains where surging or gradient reversal is not anticipated	The filter D_{85} must be greater than or equal to the perforation size
Critical drains where surging or gradient reversal is anticipated	The filter D_{15} must be greater than or equal to the perforation size.

PARTICLE SIZE ANALYSIS

DAMES & MOORE GROUP

Project: White Tanks FRS #3 | Project No.: 15448-005-022 | Date: December 21, 1998

Client: Maricopa County Flood Control District

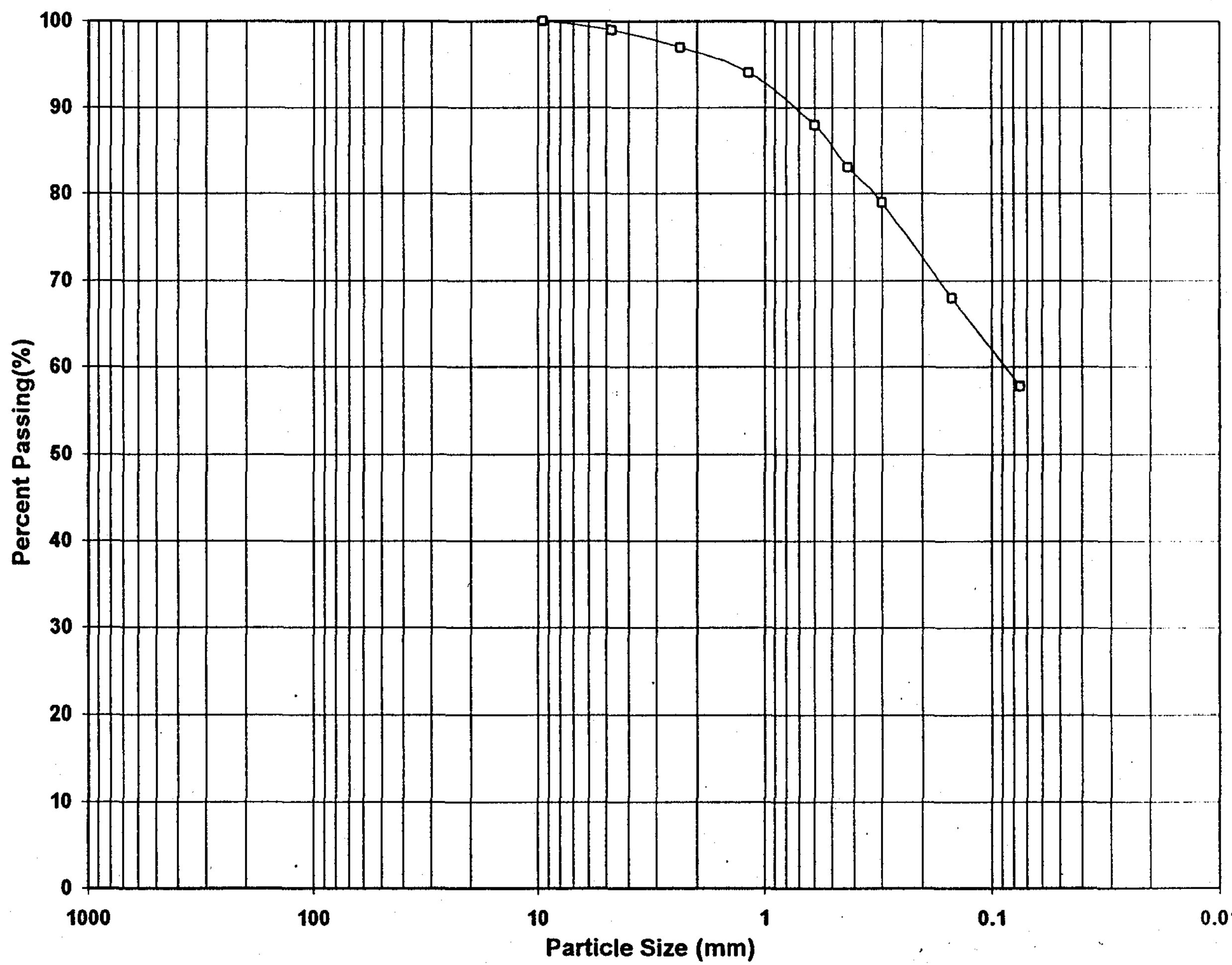
Stockpile/Windrow Sample
Location:

Drilled Sample:
Boring DMB-4 Sample # 1 Depth 5'-5.5'

Sieve US Std	Sieve Metric(mm)	Percent Passing	Specification
3"	75.0		
2.5"	62.5		
2"	50.0		
1.5"	37.5		
1.25"	31.3		
1"	25.0		
3/4"	19.0		
1/2"	12.5		
3/8"	9.5	100	
#4	4.75	99	
#8	2.36	97	
#10	2.0		
#16	1.18	94	
#30	0.6	88	
#40	0.43	83	
#50	0.3	79	
#100	0.15	68	
#200	0.075	57.8	

Plasticity Index 7

USCS Classification: CL-ML



Sheet 11 of 13

PARTICLE SIZE ANALYSIS

DAMES & MOORE GROUP

Project: **White Tanks FRS #3** Project No.: **15448-005-022** Date: **December 21, 1998**

Client: **Maricopa County Flood Control District**

Stockpile/Windrow Sample

Location:

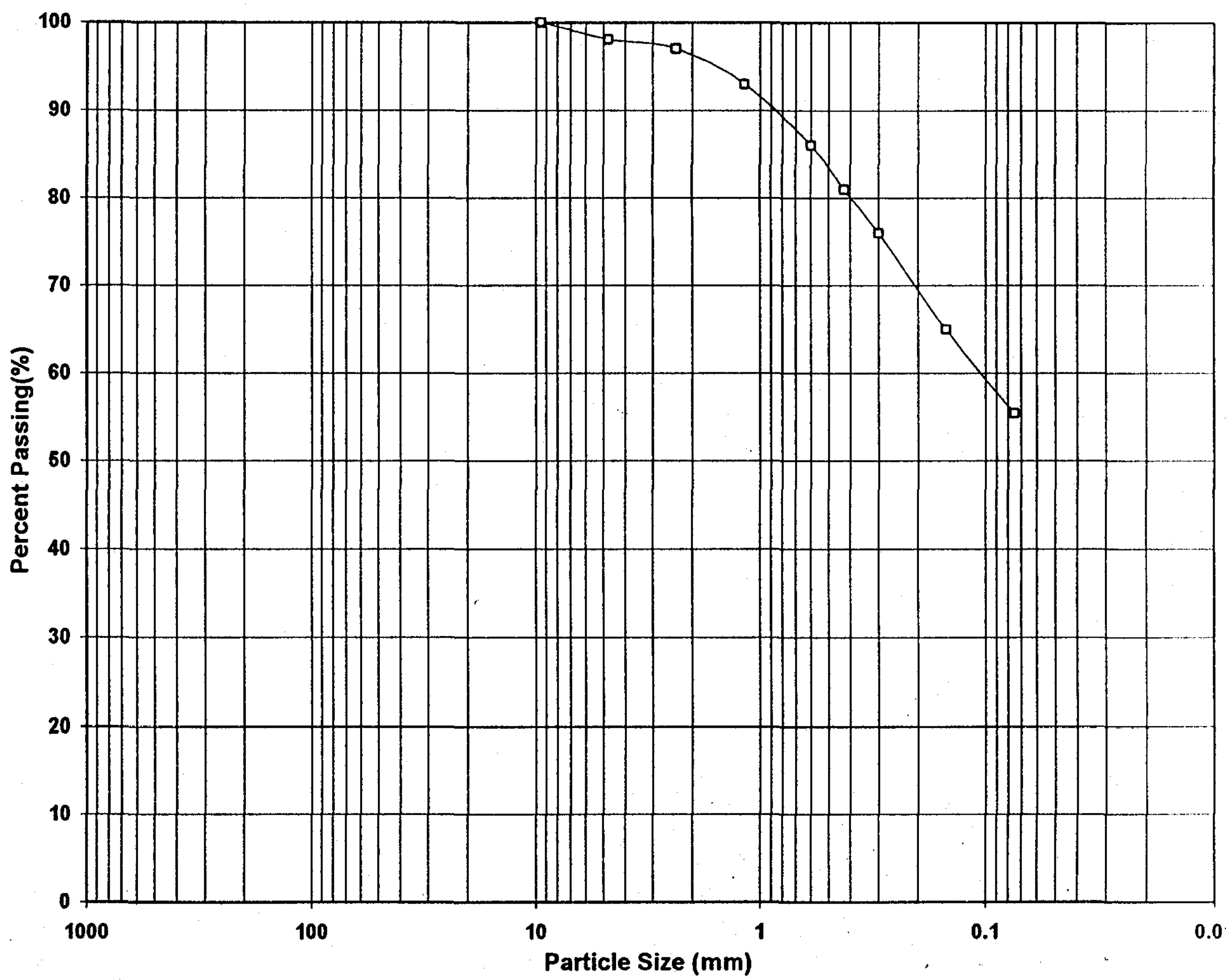
Drilled Sample:

Boring **DMB-4** Sample # **4** Depth **20'**

Sieve US Std	Sieve Metric(mm)	Percent Passing	Specification
3"	75.0		
2.5"	62.5		
2"	50.0		
1.5"	37.5		
1.25"	31.3		
1"	25.0		
3/4"	19.0		
1/2"	12.5		
3/8"	9.5	100	
#4	4.75	98	
#8	2.36	97	
#10	2.0		
#16	1.18	93	
#30	0.6	86	
#40	0.43	81	
#50	0.3	76	
#100	0.15	65	
#200	0.075	55.4	

Plasticity Index **8**

USCS Classification: **CL**



Sheet 10 of 12

PARTICLE SIZE ANALYSIS

DAMES & MOORE GROUP

Project: White Tanks FRS #3 — Project No.: 15448-005-022 — Date: December 21, 1998

Client: Maricopa County Flood Control District

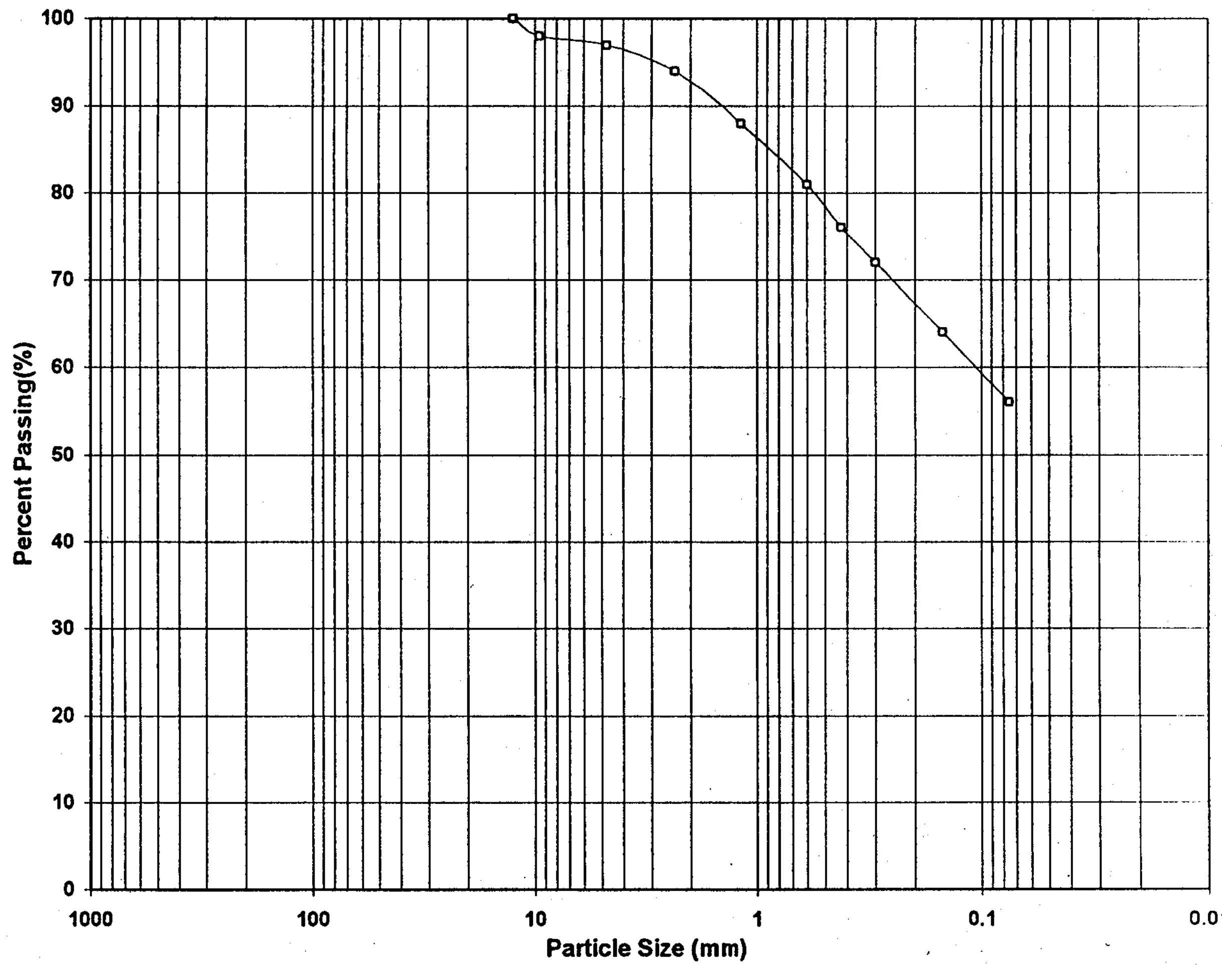
Stockpile/Windrow Sample
Location:

Drilled Sample:
Boring DMB-7 Sample # 1 Depth 5'-6'

Sieve		Percent Passing	Specification
US Std	Metric(mm)		
3"	75.0		
2.5"	62.5		
2"	50.0		
1.5"	37.5		
1.25"	31.3		
1"	25.0		
3/4"	19.0		
1/2"	12.5	100	
3/8"	9.5	98	
#4	4.75	97	
#8	2.36	94	
#10	2.0		
#16	1.18	88	
#30	0.6	81	
#40	0.43	76	
#50	0.3	72	
#100	0.15	64	
#200	0.075	56	

Plasticity Index 17

USCS Classification: CL



Sheet 13 of 15

PARTICLE SIZE ANALYSIS

DAMES & MOORE GROUP

Project: **White Tanks FRS #3** Project No.: **15448-005-022** Date: **December 21, 1998**

Client: **Maricopa County Flood Control District**

Stockpile/Windrow Sample

Location:

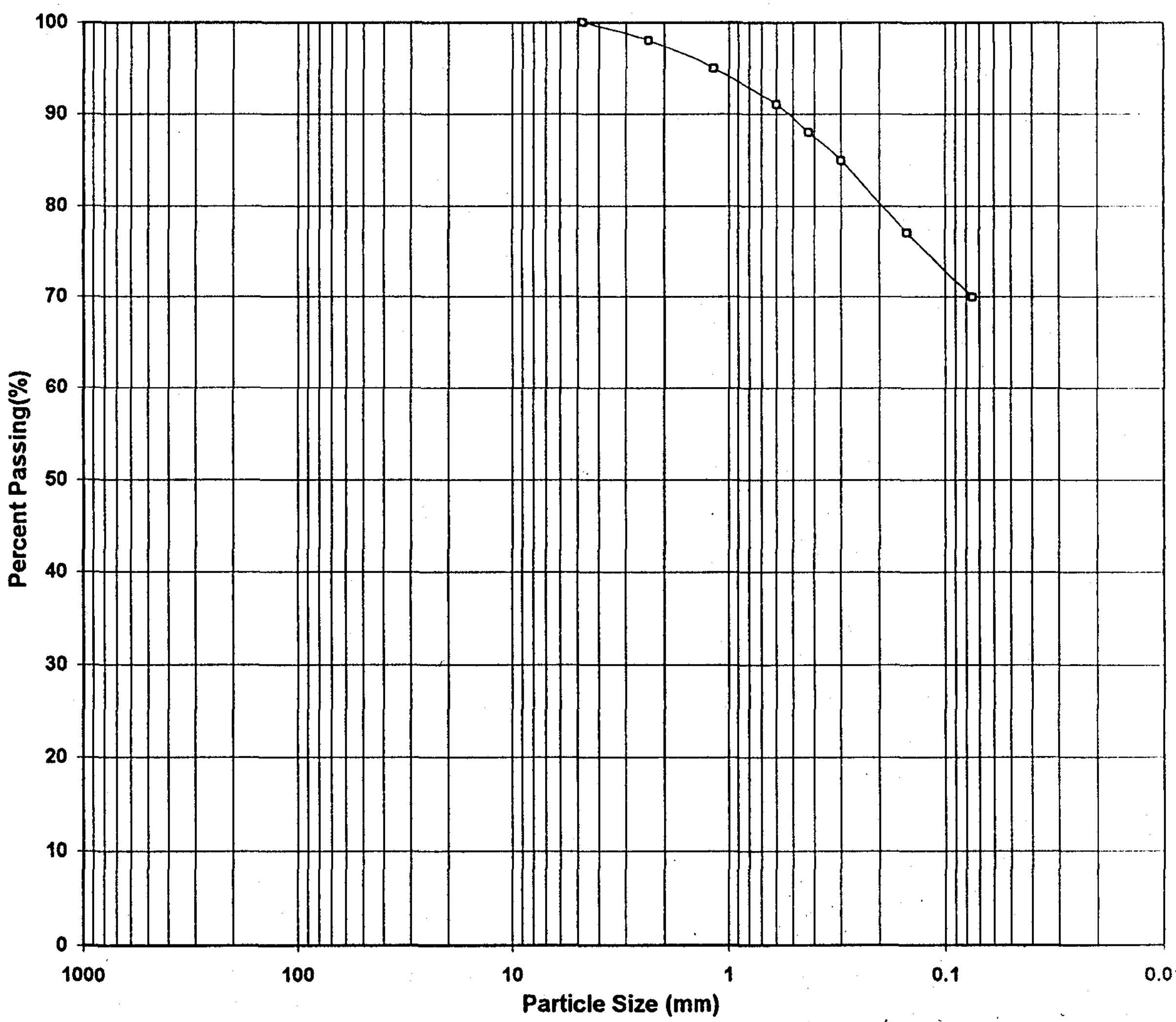
Drilled Sample:

Boring **DMB-6** Sample # **6** Depth **30'**

Sieve		Percent Passing	Specification
US Std	Metric(mm)		
3"	75.0		
2.5"	62.5		
2"	50.0		
1.5"	37.5		
1.25"	31.3		
1"	25.0		
3/4"	19.0		
1/2"	12.5		
3/8"	9.5		
#4	4.75	100	
#8	2.36	98	
#10	2.0		
#16	1.18	95	
#30	0.6	91	
#40	0.43	88	
#50	0.3	85	
#100	0.15	77	
#200	0.075	69.9	

Plasticity Index **13**

USCS Classification: **CL**



Sheet 14 of 15

PARTICLE SIZE ANALYSIS

DAMES & MOORE GROUP

Project: White Tanks FRS #3 Project No.: 15448-005-022 Date: December 21, 1998

Client: Maricopa County Flood Control District

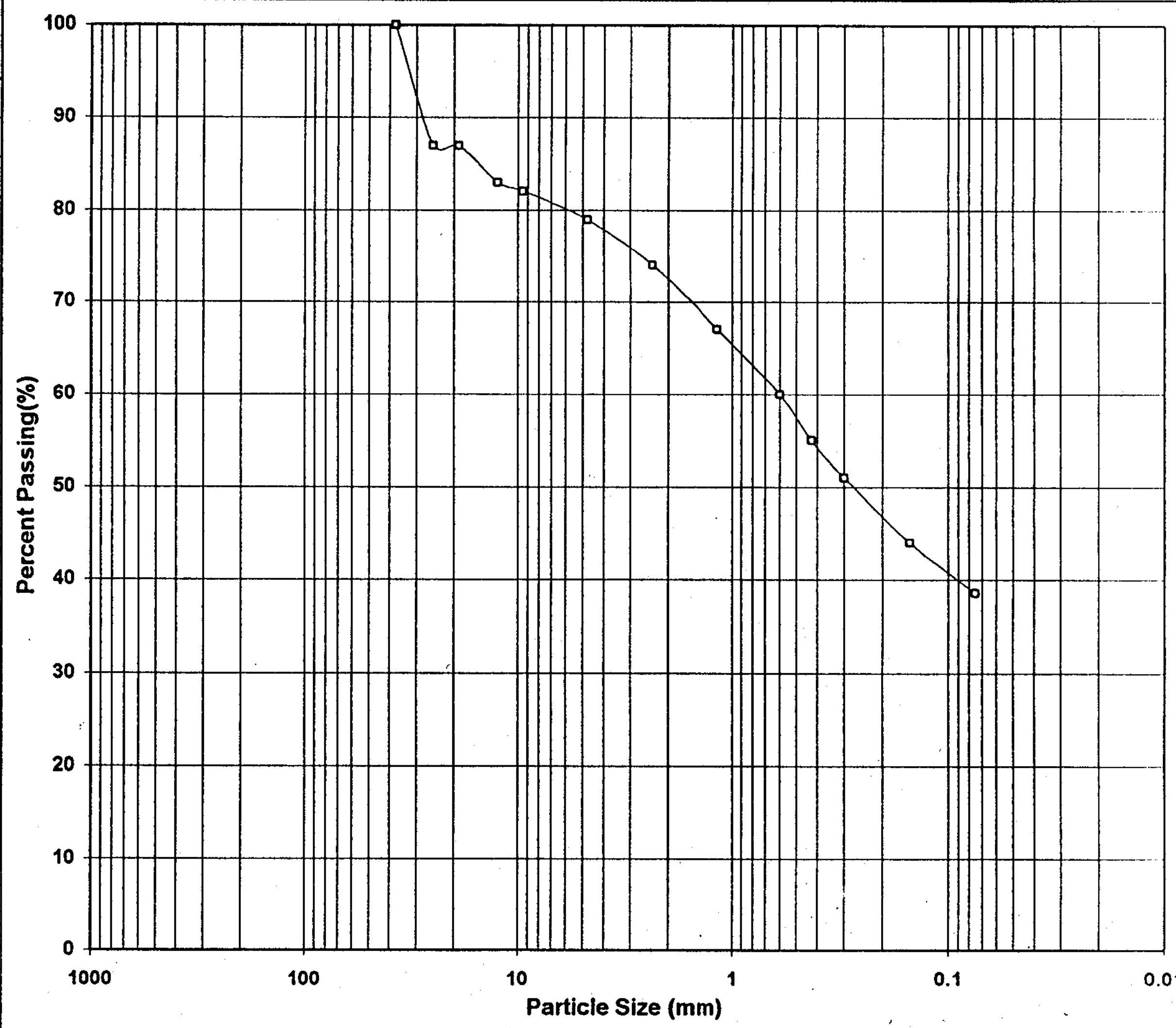
Stockpile/Windrow Sample
Location:

Drilled Sample:
Boring DMB-6 Sample # 1 Depth 5'

Sieve US Std	Sieve Metric(mm)	Percent Passing	Specification
3"	75.0		
2.5"	62.5		
2"	50.0		
1.5"	37.5	100	
1.25"	31.3		
1"	25.0	87	
3/4"	19.0	87	
1/2"	12.5	83	
3/8"	9.5	82	
#4	4.75	79	
#8	2.36	74	
#10	2.0		
#16	1.18	67	
#30	0.6	60	
#40	0.43	55	
#50	0.3	51	
#100	0.15	44	
#200	0.075	38.6	

Plasticity Index 9

USCS Classification: SC



Sheet 15 of 15

DAMES & MOORE

CALCULATIONS COVER SHEET

PROJECT NO. 15448-007-5555

SUBJECT: WT FRS Interim Dam Safety

SHEET 1 OF 40

Riprap sizing at the southern side of White Tanks FRS 3 and at the northern outlet

TITLE OF CALCULATIONS/DOCUMENT

CALCULATIONS/DOCUMENT BY: Mike K. Radaideh
PRINT NAME

M K Radaideh
SIGNATURE

2-2-2000
DATE

ASSUMPTIONS CHECKED BY CONSULTANT/SENIOR PERSONNEL: Todd Ringsmuth
PRINT NAME

[signature]
SIGNATURE

2-7-00
DATE

CALCULATIONS/DOCUMENT CHECKED BY: Bonnie Whitley
PRINT NAME

Bonnie Whitley
SIGNATURE

2-7-00
DATE

APPROVED BY: (PRINCIPAL INVESTIGATOR, CONSULTANT, OR PM) Todd Ringsmuth
PRINT NAME

[signature]
SIGNATURE

2-7-00
DATE

Approval Notice: If Calculations/Document are only spot checked, do not require checking, or are assumed to be correct by experience of engineering judgement, it should be noted here.

Revision Number	Date	By	Checked By	Approval
1				
2				
3				
4				

INITIALS

Objective:

-To assess the extent of contact between water flowing over the White Tanks FRS #3 and the downstream side of the dam.
-Size of riprap needed to provide the necessary protection for the dam from flows over the spillway.
- Size of riprap needed to provide the necessary protection at the exit of the North Outlet.

Flow:

-The flow rate of 525 cfs used in this design is the maximum expected flow over the spillway as specified in the FCDMC "Maximum Water Surface Elevation for Inflow Design Flood (IDF) at White Tank Flood Retarding Structure No.3 under Current Conditions" report dated September 1, 1998.
-Flow rate of 208 cfs used for riprap sizing at the northern outlet was from the FCDMC report titled "Proposed New Operational Plan for White Tank Flood Retarding Structure No. 3 Outlet Pipes, January 12, 2000".

Calculation details and assumptions:

The following calculation and design methods were used:
-Hydraulic calculations were conducted using Manning's equation. A spreadsheet was developed and used to carry out these calculations. A spreadsheet showing the calculations equations is included.
-Similar Manning's coefficients (n) were used as those calculated in the JE Fuller/ Hydrology and Geomorphology White Tanks FRS #3 Reconnaissance Report, January 1999.
-Riprap design was conducted using a computer software known as "Riprap Design System, Version 2.0", developed by West Consultants, Inc. The following riprap design methods were used:

-USCOE Method (recommended by the ADWR)
-ASCE Method
-USBR Method (recommended by the ADWR)
-USGS Method
-Isbash Method
-Cal B&SP Method

The parameters used in these calculations were:
-Velocity type (local or average): average velocity was used.
-Channel type (natural or trapezoidal): natural channel type was used because it relates more to this case and would be more conservative.
-Average channel velocity (calculated by Manning's equation)

-Unit weight of Stone: natural stone generally varies from 150 to 175 lb/ft^3 according to the Riprap Design System, Version 2.0 (User Guide). A value of 165 lb/ft^3 was used in these calculations.
-Local flow depth: is 80% of the total flow depth (also in the User Guide).
-A factor of safety of 1.5 was used.

Results:

Resulting riprap sizes at the dam were very small due to the low velocity used in the design. The calculated D_{50}, minimum D_{30} and minimum D_{90} are shown for each of the cases in the Program Output sheets attached. We recommend the use of a D_{50} of 6 inches with a minimum stone size of 2 inches and a maximum stone size of 12 inches. Riprap will be needed up to the location of cross section #2 but extended to a distance similar to that of the spillway channel as an added element of safety (see Figure 2). Riprap is not as critical on the upstream side of the dam and would only cover a distance of about 50 feet to an elevation higher than the water level as shown on Figure 2.

The high velocity at the North Outlet resulted in a stone size greater than the largest USCOE stone gradation in most cases. In this case, a better surface protection is recommended; like shotcrete or a combination of shotcrete and riprap. However, the outlet pipe may be extended through the disturbed portions of the channel into existing portions. No shotcrete or riprap in the channel would be required for this scenario.

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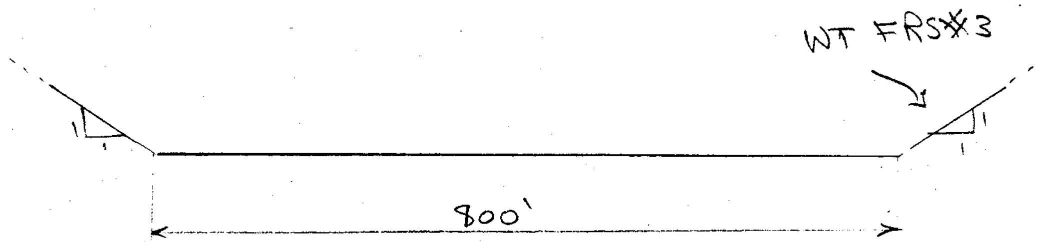
(I) Cross Sections at and downstream of spillway

(a) Cross Section 1 at top of spillway (see attac[hed] Figure)

$Q = 525$ cfs
$n = 0.05$ (JE Fuller Field Reconnaissance
$S = 0.01$ Report, Jan 1999)



Using Excel Spreadsheet Attached:

$Y_n = 1.72'$

$Y_c = 0.24'$ ⇒ Flow is subcritical

Flow Velocity = 0.38 ft/sec. (to be use[d] for riprap desi[gn])

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White Tanks FRS#3 Spillway
X-Section 1 at Spillway

Normal Depth

Cross Section #	Normal depth	Bottom width	Ditch left side slope	Ditch right side slope	Manning's n	Flow area	Wetted Perimeter	Hydraulic Radius	Slope	Flow velocity	Flow, Q*	peak flow
	(ft)	(ft)	(z:1)	(z:1)		(ft^2)	(ft)	(ft)	(percent)	(ft/s)	(cfs)	(cfs)
1	**1.72**	800.00	1.00	1.00	0.05	1379.20	804.87	1.71	0.01	0.38	**525.00**	525

Critical Depth

Cross Section #	critical depth	Bottom width	Left side slope	Right side slope	Channel top width, T	Flow Area	Flow, Q	Q^2/g	A^3/T*
	(ft)	(ft)	(z:1)	(z:1)	(ft)	(sq ft)	(cfs)		
1	**0.24**	800.00	1.00	1.00	800.47	189.93	525.00	8559.78	**8559.78**

*Goal Seek in Microsoft Excel's Tools was used to fix "Flow, Q" and "A3/T" values to values related to the 525 cfs flow. These values were fixed by changing the normal depth and critical depth values.

Old Pkg 27-a

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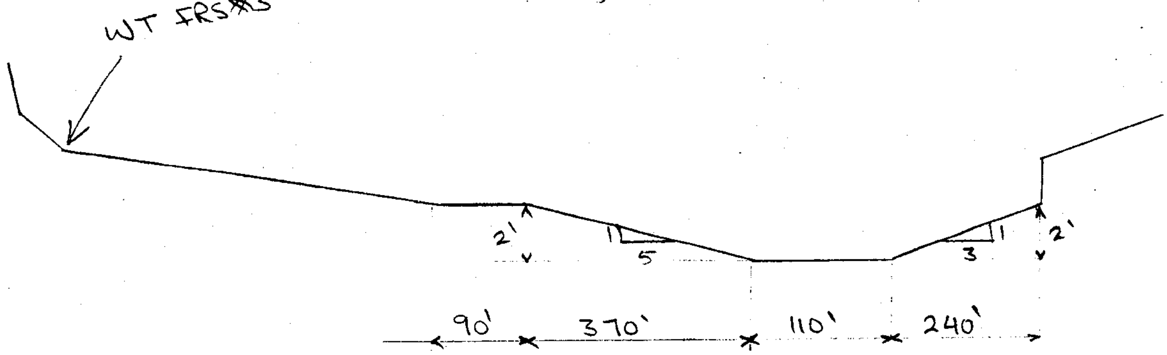
(b) at Cross Section 2 (shown on Figure 1 attach
(Looking away from spillway)



$n = 0.05$ (from JE Fuller's Field Reconnaissance Report, Jan. 1999)

$Q = 525$ cfs

slope = 0.039

Using Excell spreadsheet attached

$Y_n = 0.98' < 2'$ ✓ ⇒ Water would stay within the steep portion of the cross section away from the dam

$Y_c = 0.88'$ (subcritical flow) ✓

∴ Stop riprap here (as a measure of assurance, riprap can be extended as shown on drawing)

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White Tanks FRS#3 Spillway
X-Section 2

Normal Depth

Cross Section #	Normal depth	Bottom width	Ditch left side slope	Ditch right side slope	Manning's n	Flow area	Wetted Perimeter	Hydraulic Radius	Slope	Flow velocity	Flow, Q*	peak flow
	(ft)	(ft)	(z:1)	(z:1)		(ft^2)	(ft)	(ft)	(percent)	(ft/s)	(cfs)	(cfs)
2	**0.98**	110.00	5.00	3.00	0.06	111.52	118.09	0.94	3.90	4.71	**525.00**	525

Critical Depth

Cross Section #	critical depth	Bottom width	Left side slope	Right side slope	Channel top width, T	Flow Area	Flow, Q	Q^2/g	A^3/T*
	(ft)	(ft)	(z:1)	(z:1)	(ft)	(sq ft)	(cfs)		
2	**0.88**	110.00	5.00	3.00	117.05	100.06	525.00	8559.78	**8559.78**

*Goal Seek in Microsoft Excel's Tools was used to fix "Flow, Q" and "A3/T" values to values related to the 525 cfs flow.
These values were fixed by changing the normal depth and critical depth values.

p:/15448/007/dam safety/spillwayx-section 6502/3/00x-sec 2

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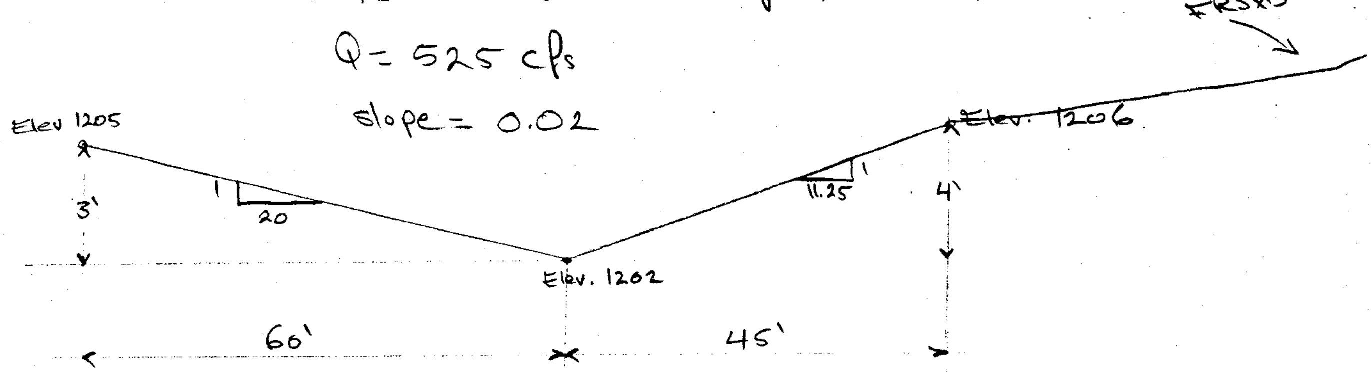
* Flow in cross sections when notch is at spillway (Looking towards spillway)

(C) Cross Section # 3 (immediately downstream of end of notch)

$n = 0.06$ (JE Fuller Report, Jan 1999)

$Q = 525$ cfs

slope = 0.02



$Y_n = 2.78' < 3'$ ✓ ⇒ Flow will be contained within V-cross section away from FRS #3

$Y_c = 2.34'$ (subcritical) ✓

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White Tanks FRS#3 Spillway
X-Section 3

Normal Depth

Cross Section #	Normal depth	Bottom width	Ditch left side slope	Ditch right side slope	Manning's n	Flow area	Wetted Perimeter	Hydraulic Radius	Slope	Flow velocity	Flow, Q*	peak flow
	(ft)	(ft)	(z:1)	(z:1)		(ft^2)	(ft)	(ft)	(percent)	(ft/s)	(cfs)	(cfs)
3	**2.78**	0.00	20.00	11.25	0.06	120.58	87.01	1.39	2.00	4.35	**525.00**	525

Critical Depth

Cross Section #	critical depth	Bottom width	Left side slope	Right side slope	Channel top width, T	Flow Area	Flow, Q	Q^2/g	A^3/T*
	(ft)	(ft)	(z:1)	(z:1)	(ft)	(sq ft)	(cfs)		
3	**2.34**	0.00	20.00	11.25	73.12	85.54	525.00	8559.78	**8559.78**

*Goal Seek in Microsoft Excel's Tools was used to fix "Flow, Q" and "A3/T" values to values related to the 525 cfs flow.
These values were fixed by changing the normal depth and critical depth values.

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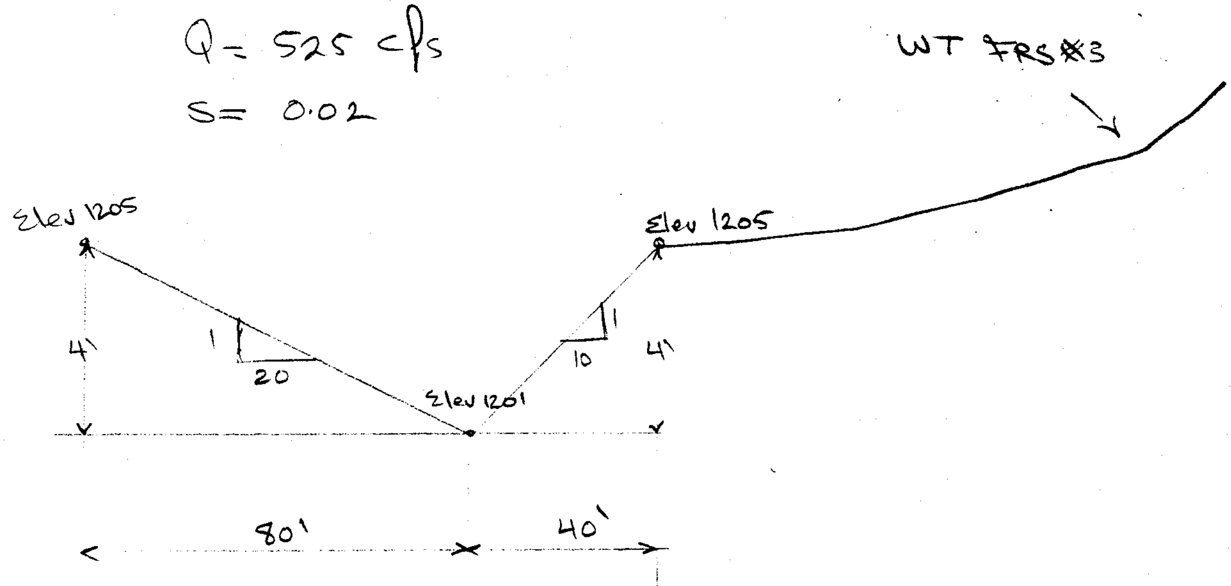
(d) Cross Section #4 (Looking towards the spillway)

n = 0.06 (JE Fuller Report, Jan 1999)
Q = 525 cfs
S = 0.02



$Y_n = 2.82' < 4'$ ✓ ⇒ Flow will be contained within V-shaped cross section

$Y_c = 2.38'$ (subcritical flow) ✓

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White Tanks FRS#3 Spillway

X-Section 4

Normal Depth

Cross Section #	Normal depth	Bottom width	Ditch left side slope	Ditch right side slope	Manning's n	Flow area	Wetted Perimeter	Hydraulic Radius	Slope	Flow velocity	Flow, Q*	peak flow
	(ft)	(ft)	(z:1)	(z:1)		(ft^2)	(ft)	(ft)	(percent)	(ft/s)	(cfs)	(cfs)
4	**2.82**	0.00	20.00	10.00	0.06	119.37	84.84	1.41	2.00	4.40	**525.00**	525

Critical Depth

Cross Section #	critical depth	Bottom width	Left side slope	Right side slope	Channel top width, T	Flow Area	Flow, Q	Q^2/g	A^3/T*
	(ft)	(ft)	(z:1)	(z:1)	(ft)	(sq ft)	(cfs)		
4	**2.38**	0.00	20.00	10.00	71.35	84.84	525.00	8559.78	**8559.78**

*Goal Seek in Microsoft Excel's Tools was used to fix "Flow, Q" and "A3/T" values to values related to the 525 cfs flow.
These values were fixed by changing the normal depth and critical depth values.

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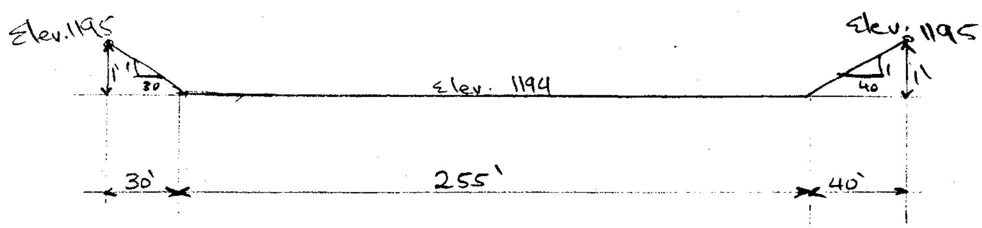
e) Cross section # 5 (Looking toward spillway)

n = 0.06 (JE Fuller Report, Jan 1999)
Q = 525 cfs
S = 0.02



$Y_n = 0.71' < 1'$ ✓ ⇒ flow is still contained within cross section

$Y_c = 0.50$ (subcritical flow) ✓

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White Tanks FRS#3 Spillway
X-Section 5

Normal Depth

Cross Section #	Normal depth	Bottom width	Ditch left side slope	Ditch right side slope	Manning's n	Flow area	Wetted Perimeter	Hydraulic Radius	Slope	Flow velocity	Flow, Q*	peak flow
	(ft)	(ft)	(z:1)	(z:1)		(ft^2)	(ft)	(ft)	(percent)	(ft/s)	(cfs)	(cfs)
5	**0.71**	255.00	30.00	40.00	0.06	199.10	304.82	0.65	2.00	2.64	**525.00**	525

Critical Depth

Cross Section #	critical depth	Bottom width	Left side slope	Right side slope	Channel top width, T	Flow Area	Flow, Q	Q^2/g	A^3/T*
	(ft)	(ft)	(z:1)	(z:1)	(ft)	(sq ft)	(cfs)		
5	**0.50**	255.00	30.00	40.00	289.79	135.37	525.00	8559.78	**8559.78**

*Goal Seek in Microsoft Excel's Tools was used to fix "Flow, Q" and "A3/T" values to values related to the 525 cfs flow. These values were fixed by changing the normal depth and critical depth values.

From X-sections shown on attached topo map

White Tanks FRS#3 Spillway
EQUATIONS

Normal Depth

A	B	C	D	E	F	G	H	I	J	K	L	M
Cross Section #	Normal depth[1]	Bottom width[2]	Ditch left side slope[2]	Ditch right side slope[2]	Manning's n[2]	Flow area[3]	Wetted Perimeter[3]	Hydraulic Radius	Slope[2]	Flow velocity	Flow, Q*	peak flow
	(ft)	(ft)				(ft^2)	(ft)	(ft)		(ft/s)	(cfs)	(cfs)
8 #	Yn	B	(z:1)	(z:1)	n	=C8*B8+0.5*B8*B8*D8+0.5*B8*B8*E8	=(C8+((B8^2)+((D8*B8)^2))^0.5)+(((B8^2)+((E8*B8)^2))^0.5)	=G8/H8	%slope	=L8/G8	=(1.486/F8)*(G8)*(I8^(2/3))*(J8)^0.5	Q

From JE Fuller Field Reconnaissance Report, Jan. 1999

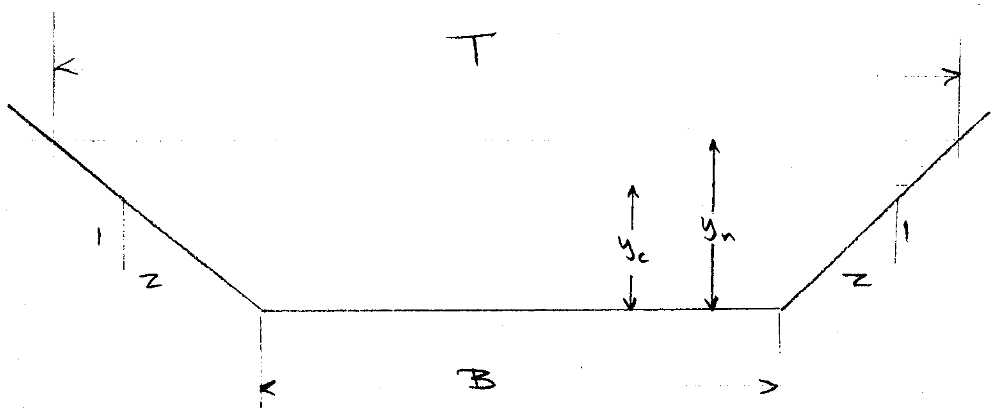
From the District Hydrologic report

Critical Depth

Cross Section #	critical depth[4]	Bottom width	Left side slope	Right side slope	Channel top width, T	Flow Area	Flow, Q	Q^2/g	A^3/T^*
	(ft)	(ft)			(ft)	(sq ft)	(cfs)		
15 =A8	Yc	B	(z:1)	(z:1)	=C15+B15*D15+B15*E15	=C15*B15+0.5*B15*B15*D15+0.5*B15*B15*E15	Q	=(H15^2)/32.2	=(G15^3)/F15

$$\frac{Q^2}{g} = \frac{A^3}{T}$$ to calculate y_c

(from Water Resources Engineering, Linsley et al 1992)



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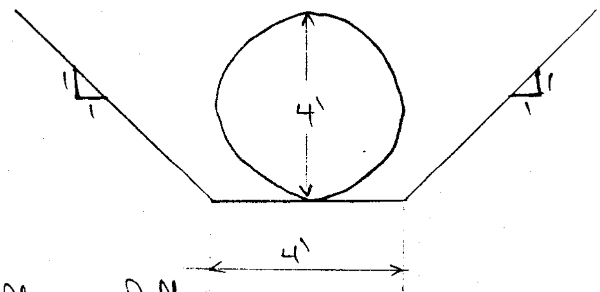
* Northern Outlet

$Q = 208$ cfs



4' pipe flowing full

$Q = VA$

$208 \text{ cfs} = V * (\pi * 4)$

$V = 16.6$ fps ✓

Riprap design for outlet channel will be based on the 16.6 fps velocity.

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(II) Riprap Design

— Two designs were conducted

a) Riprap size and gradation based on velocity from X-section 1

b) Riprap size and gradation at North Outlet structure

The following methods are used:

* a) USCOE Method (recommended by DWR)

b) ASCE Method

* c) USBR Method (recommended by DWR)

d) USGS Method

e) Isbash Method

f) Cal B&SP Method

Riprap at the dam min D_{30} = 0.37', min D_{90} = 0.53 (All meth

Use D_{50} = 0.5' min of 2" & max of 12"

Riprap at northern outlet is greater than the largest USCOE stone gradation.

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WHITE TANKS FRS #3 MODIFICATION DESIGN
Contract FCD 98-11
Dames & Moore Job No. 15448-0005-022

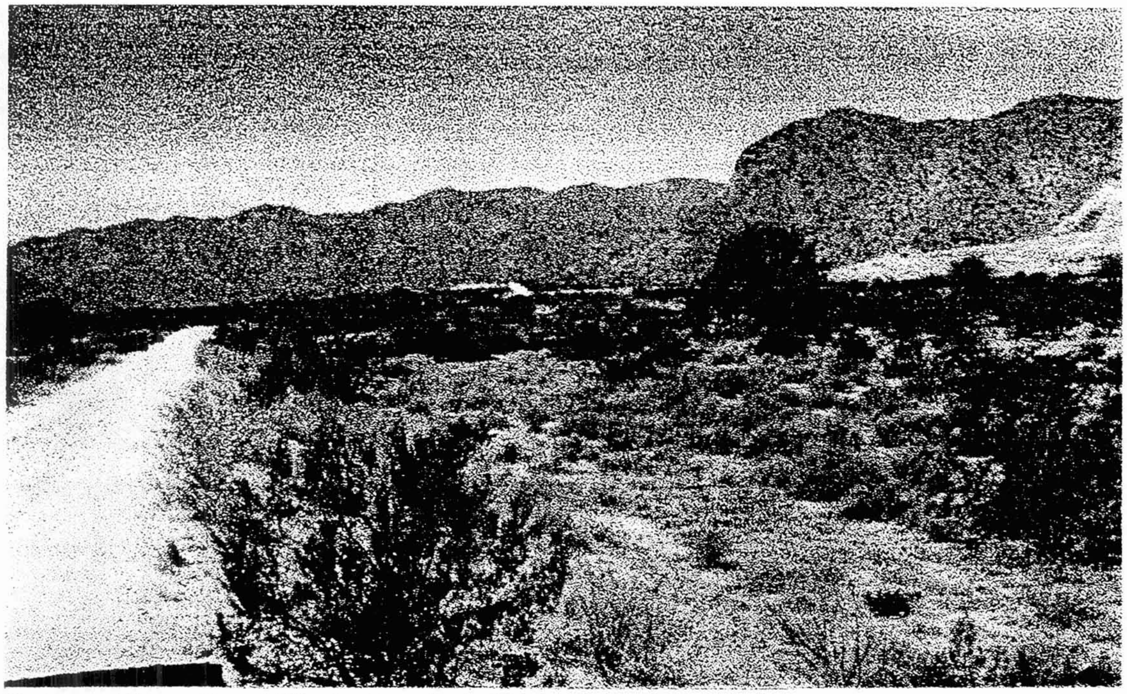
TASK 3.24.3 FIELD RECONNAISSANCE REPORT
DRAFT
January 1999

JE Fuller Hydrology and Geomorphology, Inc., (JEF) conducted its original field reconnaissance of the project area on September 14, 1998. Subsequent field reconnaissance was undertaken on November 18 and 27 and December 28, 1998. The purpose of the field reconnaissance was to document channel and overbank Manning's "n" values, floodplain conditions affecting the floodplain delineation, and major hydraulic structures. The project area, channel alignments (where applicable) ground photo locations, and Manning's "n" values are shown on Figure 1.

Manning's "n" Values

Manning's "n" values were determined using the methodology in the USGS report, "Estimating Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona". On the following pages, photographs showing typical conditions at various locations are followed by the worksheet used to determine the Manning's "n" values for the location depicted in the photographs.

The project area consists of a broad shallow inundation area composed primarily of active and former agricultural fields. As such, in most locations the inundation area is not a typical riverine configuration composed of a channel and associated overbanks. Roughness coefficients were developed and assigned based on distinctions in land use, vegetation, effects of infrastructure such as roads and canals and, where applicable, channel characteristics. Manning's roughness coefficients for the agricultural areas were developed assuming worst case conditions (i.e., mature crops present). These agricultural areas (for which typical photos are shown on the following page) represent overbank conditions for all channels except where noted. Where defined channels or flow paths exist, names for these conveyances have been taken from the White Tanks ADMS (where applicable) for the sake of familiarity and consistency.



Bethany Home Road Wash, Reach A, Photo 2.08:
Looking upstream toward existing White Tanks FRS #3 spillway.

DETERMINATION OF MANNING'S ROUGHNESS COEFFICIENTS BY FCDMC METHOD

Project: White Tanks FRS #3 Modification Design, FCD98-11
Stream: Bethany Home Road Wash
Location: Reach A
Photo No: 2.08

Channel Conditions		Manning's n Adjustment		Left Overbank (Undisturbed Desert)	Channel (Firm Soil)	Right Overbank (Undisturbed Desert)
Channel Material	Concrete	n_b	.012 - .018			
	Firm Soil		.025 - .032	.030	.030	.030
	Coarse Sand		.026 - .035			
	Gravel		.028 - .035			
	Cobble		.030 - .050			
	Boulder		.040 - .070			
Degree of Irregularity	Smooth	n_1	0	0	0	0
	Minor		.001 - .005			
	Moderate		.006 - .010			
	Severe		.011 - .020			
Effects of Obstruction	Negligible	n_2	.000 - .004	0		0
	Minor		.005 - .015		.005	
	Appreciable		.020 - .030			
	Severe		.040 - .060			
Vegetation	Small	n_3	.002 - .010			
	Medium		.010 - .025		.015	
	Large		.025 - .050	.030		.030
	Very Large		.050 - .100			
Variations in Channel Cross section	Gradual	n_4	0	0	0	0
	Occ. Alt.		.001 - .005			
	Freq. Alt.		.010 - .015			
				0.060	0.050	0.060
Degree of Meandering	Minor	m	1	1	1	1
	Appreciable		1.15			
	Severe		1.3			
$n = (n_b+n_1+n_2+n_3+n_4)m$				**0.060**	**0.050**	**0.060**

C:\PROJECTS\Dames & Moore\White Tanks FRS#3\draft field recon report\Mannings Tables\Bethany Home Road Wash - Reach A.WPD

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Dames & Moore/Phoenix
Riprap Design

PROGRAM OUTPUT

USCOE Method

Input Parameters:

Run Name: WT FRS3   Description: X-Section 1 at Spillway

Velocity	Average
Channel Type	Natural
Straight Channel	Yes
Bend Angle, °	N/A
Average Channel Velocity, ft/sec	0.38
Bottom Width, ft	N/A
Minimum Centerline Bend Radius, ft	N/A
Water Surface Width, ft	N/A
Unit Weight of Stone, lbs/cu ft	165.00
Riprap Layer Thickness	1.00
Local Flow Depth, ft	1.40
Cotangent of Sideslope	1.50
Safety Factor	1.50

Output Results:

Computed Local Depth Average Velocity, ft/sec	0.38
Local Velocity / Avg. Channel Velocity	1.00
Correction for Layer Thickness	1.00
Side Slope Correction Factor	1.52
Correction for Secondary Currents	1.00

*** Using Gradation from COE ETL 1110-2-120 ***

Computed D30, ft	0.00
Specific Weight, pcf	165.00
Layer Thickness, ft	0.75
Selected Minimum D30, ft	0.37
Selected Minimum D90, ft	0.53

Percent Lighter by Weight	Stone Weight, lbs Minimum	Maximum
W100	15	36
W50	7	11
W15	2	5

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PROGRAM OUTPUT

ASCE Method

Input Parameters:

Run Name: WT FRS3 Description: X-Section 1 at Spillway

Local Depth Averaged Velocity, ft/sec	4.20
Unit Weight of Stone, lbs/cu ft	165.00
Cotangent of Sideslope	1.50

Output Results:

Computed D50, ft	0.14

*** Using Gradation from COE ETL 1110-2-120 ***

Computed D30, ft	0.11
Specific Weight, pcf	165.00
Layer Thickness, ft	0.75
Selected Minimum D30, ft	0.37
Selected Minimum D90, ft	0.53

Percent Lighter by Weight	Stone Weight, lbs Minimum	Maximum
W100	15	36
W50	7	11
W15	2	5

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PROGRAM OUTPUT

USBR Method

Input Parameters:

Run Name: WT FRS3 Description: X-Section 1 at Spillway

Average Channel Velocity, ft/sec 0.38

Output Results:

Computed D50, ft 0.00

*** Using Gradation from COE ETL 1110-2-120 ***

Computed D30, ft	0.00
Specific Weight, pcf	165.00
Layer Thickness, ft	0.75
Selected Minimum D30, ft	0.37
Selected Minimum D90, ft	0.53

Percent Lighter by Weight	Stone Weight, lbs Minimum	Maximum
W100	15	36
W50	7	11
W15	2	5

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PROGRAM OUTPUT

USGS Method

Input Parameters:

Run Name: WT FRS3   Description: X-Section 1 at Spillway

Average Channel Velocity, ft/sec   0.38

Output Results:

Computed D50, ft   0.00

*** Using Gradation from COE ETL 1110-2-120 ***

Computed D30, ft	0.00
Specific Weight, pcf	165.00
Layer Thickness, ft	0.75
Selected Minimum D30, ft	0.37
Selected Minimum D90, ft	0.53

Percent Lighter by Weight	Stone Weight, lbs Minimum	Maximum
W100	15	36
W50	7	11
W15	2	5

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PROGRAM OUTPUT

Isbash Method

Input Parameters:

Run Name: WT FRS3   Description: X-Section 1 at Spillway

Average Channel Velocity, ft/sec	0.38
Unit Weight of Stone, lbs/cu ft	165.00
Turbulence Level	Low

Output Results:

Computed D50, ft	0.00

*** Using Gradation from COE ETL 1110-2-120 ***

Computed D30, ft	0.00
Specific Weight, pcf	165.00
Layer Thickness, ft	0.75
Selected Minimum D30, ft	0.37
Selected Minimum D90, ft	0.53

Percent Lighter by Weight	Stone Weight, lbs Minimum	Maximum
W100	15	36
W50	7	11
W15	2	5

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PROGRAM OUTPUT

Cal B&SP Method

Input Parameters:

Run Name: WT FRS3 Description: X-Section 1 at Spillway

Local Depth Averaged Velocity, ft/sec	4.20
Unit Weight of Stone, lbs/cu ft	165.00
Cotangent of Sideslope	1.50

Output Results:

Computed W33, lb 0.31

*** Using CalTrans Gradation - Placement Method A ***

Gradation Class	1/2 ton
Layer Thickness, ft	3.34

Percent Larger Than	Rock Size
0-5	1 Ton
50-100	1/2 Ton
95-100	1/4 Ton

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PROGRAM OUTPUT

USCOE Method

Input Parameters:

Run Name: WT~FRS#3 Description: North Outlet

Velocity	Average
Channel Type	Trapezoidal
Straight Channel	Yes
Bend Angle, °	N/A
Average Channel Velocity, ft/sec	16.60
Bottom Width, ft	N/A
Minimum Centerline Bend Radius, ft	N/A
Water Surface Width, ft	N/A
Unit Weight of Stone, lbs/cu ft	165.00
Riprap Layer Thickness	1.00
Local Flow Depth, ft	4.00
Cotangent of Sideslope	1.50
Safety Factor	1.50

Output Results:

Computed Local Depth Average Velocity, ft/sec	16.60
Local Velocity / Avg. Channel Velocity	1.00
Correction for Layer Thickness	1.00
Side Slope Correction Factor	1.52
Correction for Secondary Currents	1.00

Computed D30, ft 3.82

* * * * * * * * **WARNING** * * * * * * * *
THE REQUIRED STONE SIZE IS GREATER THAN THE LARGEST USCOE STONE GRADATION

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PROGRAM OUTPUT

ASCE Method

Input Parameters:

Run Name: WT~FRS#3 Description: North Outlet

Local Depth Averaged Velocity, ft/sec	4.20
Unit Weight of Stone, lbs/cu ft	165.00
Cotangent of Sideslope	1.50

Output Results:

Computed D50, ft	0.14

*** Using Gradation from COE ETL 1110-2-120 ***

Computed D30, ft	0.11
Specific Weight, pcf	165.00
Layer Thickness, ft	0.75
Selected Minimum D30, ft	0.37
Selected Minimum D90, ft	0.53

Percent Lighter by Weight	Stone Weight, lbs Minimum	Maximum
W100	15	36
W50	7	11
W15	2	5

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PROGRAM OUTPUT

USBR Method

Input Parameters:

Run Name: WT~FRS#3 Description: North Outlet

Average Channel Velocity, ft/sec 16.60

Output Results:

Computed D50, ft 3.98

Computed D30, ft 3.26

* * * * * * * **WARNING** * * * * * * *

THE REQUIRED STONE SIZE IS GREATER THAN THE LARGEST USCOE STONE GRADATION

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PROGRAM OUTPUT

USGS Method

Input Parameters:

Run Name: WT~FRS#3 Description: North Outlet

Average Channel Velocity, ft/sec 16.60

Output Results:

Computed D50, ft 9.49

Computed D30, ft 7.77

* * * * * * * * **WARNING** * * * * * * * *
THE REQUIRED STONE SIZE IS GREATER THAN THE LARGEST USCOE STONE GRADATION

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PROGRAM OUTPUT

Isbash Method

Input Parameters:

Run Name: WT~FRS#3 Description: North Outlet

Average Channel Velocity, ft/sec	16.60
Unit Weight of Stone, lbs/cu ft	165.00
Turbulence Level	Low

Output Results:

Computed D50, ft	1.81

*** Using Gradation from COE ETL 1110-2-120 ***

Computed D30, ft	1.48
Specific Weight, pcf	165.00
Layer Thickness, ft	3.50
Selected Minimum D30, ft	1.70
Selected Minimum D90, ft	2.47

Percent Lighter by Weight	Stone Weight, lbs Minimum	Stone Weight, lbs Maximum
W100	1,482	3,704
W50	741	1,096
W15	232	548

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PROGRAM OUTPUT

Cal B&SP Method

Input Parameters:

Run Name: WT~FRS#3 Description: North Outlet

Local Depth Averaged Velocity, ft/sec	4.20
Unit Weight of Stone, lbs/cu ft	165.00
Cotangent of Sideslope	1.50

Output Results:

Computed W33, lb 0.31

*** Using CalTrans Gradation - Placement Method B ***

Gradation Class	Facing
Layer Thickness, ft	1.41

Percent Larger Than	Rock Size
0-5	200 Lb.
50-100	75 Lb.
90-100	25 Lb.

RIPRAP DESIGN SYSTEM

Version 2.0

USER'S GUIDE

WEST Consultants, Inc.

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2.3.1 USCOE Method

The U.S. Army Corps of Engineers method (USCOE, 1994) of riprap placement was developed for flow in man-made or natural channels having low turbulence and slopes less than two percent. The channel section to be protected should not be immediately downstream of stilling basins or other highly turbulent areas. The following equation is used with the USCOE method.

$$D_{30} = S_f C_s C_v C_t d \left(\left(\frac{\gamma_w}{\gamma_s - \gamma_w} \right)^{0.5} \frac{V}{\sqrt{K_1 g d}} \right)^{2.5}$$

Where:

D_{30} = stone size, feet

S_f = safety Factor (see description later in this section)
= 1.25, downstream of concrete channels, end of dikes, flow impingement

C_s = stability coefficient for incipient failure
= 0.30 for angular rock
(for rounded rock, increase safety factor)

C_v = vertical velocity distribution coefficient
= 1.0 for straight channels, inside of bends
= 1.283-0.2log(R/W), outside of bends (1 for R/W >26)
(see Figure 2.5 for a description of R/W)

C_t = thickness coefficient
= 1.0 for thickness = $1 * D_{100}$(max) or $1.5 * D_{50}$(max) whichever is greater

d = local depth of flow at same location as V, feet

γ_s = unit weight of stone, lbs/ft^3

γ_w = unit weight of water, lbs/ft^3

V = local depth averaged velocity, V_{ss} for side slope riprap, ft/s

g = gravitational constant, ft/sec^2

K_1 = side slope correction factor
= 1 for bottom riprap

$$= \left(1 - \frac{\sin^2 \theta}{\sin^2 \phi} \right)^{0.5}$$

$$\theta = \arctan \left(\frac{1}{\text{cotangent of sideslope}} \right)$$

ϕ = riprap angle of repose = 40 degrees turbulence). A minimum safety factor of 1.5 should be used when cobbles (rounded stone) are used. A minimum safety factor of 1.25 should be used at abrupt changes in roughness (e.g., riprap to natural channel or concrete).

2.3.2 ASCE Method

The American Society of Civil Engineers (Vanoni, 1977) design method uses the Isbash equation (Isbash, 1936) with a modification to account for channel bank slope. The median rock size (D_{50}) is based upon the channel flow velocity, unit weight of stone and the channel sideslope.

$$D_{50} = \left(\frac{6\,W}{\pi\,\gamma_s} \right)^{1/3}$$

Where:

$$W = \frac{0.000041\,G_s V^6}{(G_s - 1)^3 \cos^3(\theta)} \qquad \theta = \arctan\left(\frac{1}{\text{cotangent of sideslope}} \right)$$

- D_{50} = stone size, feet
- W = weight of stone, lbs.
- V = local depth averaged velocity, ft/s
- γ_s = unit weight of stone, lb/ft^3
- γ_w = unit weight of water, lb/ft^3
- G_s = specific gravity of stone, (γ_s / γ_w)

Note: RIPRAP layer thickness for ASCE method is $1 * D_{100}$.

The following describes the required input parameters shown in Figure 2.6.

<u>Local Depth Averaged Velocity:</u> The local depth averaged velocity is the average water velocity above a certain point in a channel cross-section,

2.3.3 USBR Method

The U.S. Bureau of Reclamation method (USBR EM-25, Peterka, 1958) was developed for estimating the riprap size to be used downstream of a stilling basin. The procedure was developed using eleven prototype installations with velocities varying from about one foot per second to about eighteen feet per second. This method calculates the median size of stable rock with the following equation.

$$D_{50} = 0.0122\, V_a^{2.06}$$

Where:

D_{50} = stone size, feet
V_a = average channel velocity, ft/s

The following describes the required input parameters shown in Figure 2.7.

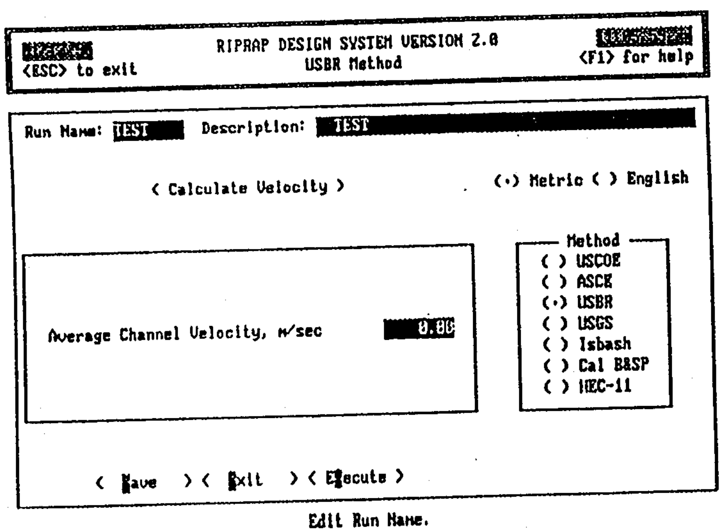


Figure 2.7 USBR Method Input Screen

Average Channel Velocity: The average channel velocity is defined as the total discharge (ft^3/s or m^3/s) divided by the flow area (ft^2 or m^2). Valid values are greater than zero in either ft/s or m/s.

> Note: When using USCOE gradations (See Sec. 2.5), a default value of 165 lb/ft^3 (2,645 kg/m^3) for unit weight of stone is assumed. This can be changed by entering the desired value in the Unit Weight of Stone input field of the USCOE Method.

2.3.4 USGS Method

The U.S. Geological Survey riprap design equation resulted from the analysis of field data taken from Washington, Oregon, California, Nevada, and Arizona (Blodgett, 1981). A survey was taken that related the site hydraulic conditions to the performance of the riprap protection. The surveys included 39 events of which 22 resulted in no riprap damage. The remaining 17 events were analyzed and 14 failures were found to be caused by particle erosion. The field data from the 39 events, as well as the velocity/D_{50} relationship from HEC-11 (FHWA, 1989), were then plotted. Using the plot with recognition of those sites with riprap failure, the USGS riprap design equation was developed.

$$D_{50} = 0.01\, V_a^{2.44}$$

Where:

D_{50} = stone size, feet
V_a = average velocity in cross section, ft/s

The following describes the required input parameters shown in Figure 2.8.

Average Channel Velocity: The average channel velocity is defined as the total discharge (ft^3/s or m^3/s) divided by the flow area (ft^2 or m^2). Valid values are greater than zero in either ft/s or m/s.

2.3.5 Isbash Method

The Isbash formula (Isbash, 1936) as used by the U.S. Army Corps of Engineers (USCOE, 1971), was developed for the construction of dams by depositing rock into running water. The median stone size of stable rock is computed by;

$$D_{50} = \frac{V_a^2}{2gC^2 (G_s - 1)}$$

Where:

D_{50} = stone size, feet
V_a = average Channel Velocity, ft/s
G_s = specific gravity of stone (γ_s/γ_w)
g = gravitational constant, feet/sec^2
C = 0.86 for high turbulence zones
= 1.20 for low turbulence zones

The following describes the required input parameters shown in Figure 2.9.

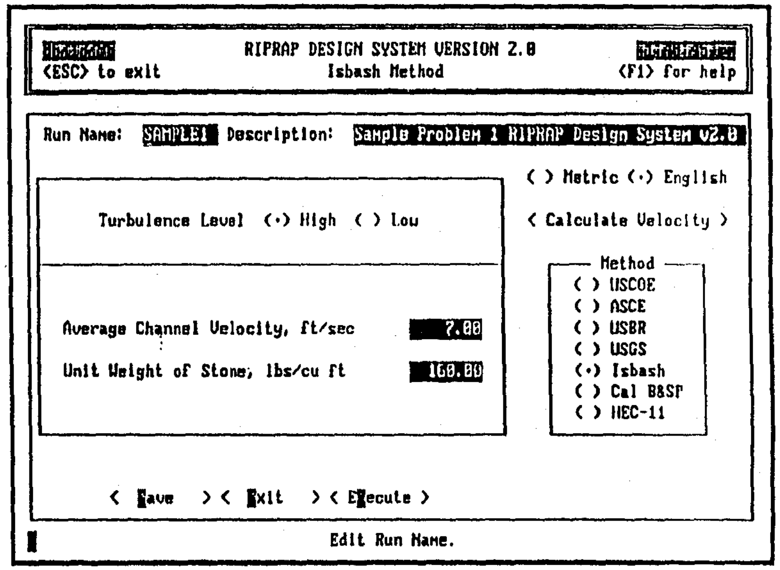


Figure 2.9 ISBASH Method Input Screen

Turbulence Level: The value of the variable "C" in the Isbash equation varies for high turbulence (C=0.86) or low turbulence (C=1.20) flows. The Isbash coefficients are from tests with essentially no boundary layer development and average flow velocities representative of the velocity against stone. When the stone movement resulted by sliding, a coefficient

2.3.6 *Cal B & SP Method*

The California Department of Transportation developed the California Bank and Shore Protection riprap design method to protect highway embankments (CDPW, 1970). The method accounts for large impinging flow forces by modifying the average channel velocity. The multiplication factor for impinging flows is 4/3 and for tangential flows is 2/3. This modification converts the average channel velocity into the local depth averaged velocity. The following equation is used to size rock:

$$W_{33} = \left(\frac{0.00002\, V^6 G_s}{(G_s - 1)^3 \sin^3(\rho - \theta)} \right)$$

Where:

W_{33} = minimum weight of outside stone for no damage, lbs
V = stream velocity to which bank is exposed, ft/s
= $4/3V_a$ for impinging flow

= $2/3V_a$ for tangential flow
V_a = average channel velocity, ft/s
ρ = 70° for randomly placed rubble
θ = bank angle, degrees
G_s = specific gravity of stone, (γ_s/γ_w)

The following describes the required input parameters shown in Figure 2.10.

Local Depth Averaged Velocity: The local depth averaged velocity is the average water velocity located at a certain point in a channel cross-section, irrespective of the shape of the channel. This velocity is often determined beforehand by physical or numerical models or from field measurements.

> **Note:** For this method the local depth averaged velocity may be the average channel velocity multiplied by 4/3 for impinging flows, or by 2/3 for tangential flows.

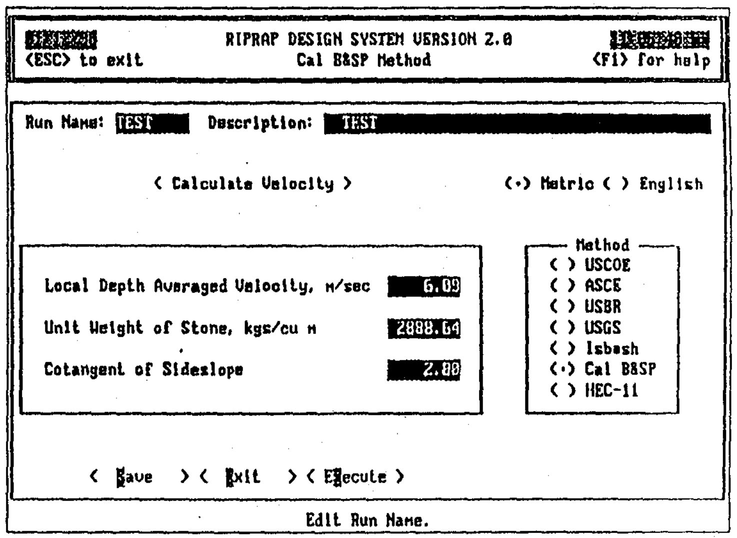


Figure 2.10 Cal B & SP Method Input Screen

Unit Weight of Stone: This is the weight of one solid cubic foot or meter of the stone that will be used and varies by the type of rock. Valid values are

2.3.7 HEC-11 Method

The HEC-11 Riprap design method (FHWA, 1989) was developed for use in rivers or streams with typical non-uniform flow conditions and discharges normally greater than fifty cubic feet per second. The application of the HEC-11 equation is limited to uniform or gradually varying flow conditions in straight or mildly curving channel reaches with relatively uniform cross sections. Modifications to the method have been developed to allow its use in non-uniform rapidly varying flow conditions as well as allowances for steep slopes, large channel bends, bridge piers and abutments (FHWA, 1989). The stable median rock size is calculated by;

$$D_{50} = D_{50}' \, C_f \, C_s$$

Where:

$$D_{50}' = \frac{0.001 V_a^3}{\sqrt{d}\, K_1^{1.5}}$$

$$K_1 = \left(1 - \frac{\sin^2\theta}{\sin^2\phi}\right)^{0.5}$$

$$\theta = \arctan\left(\frac{1}{\text{cotangent of sideslope}}\right)$$

$$C_f = \left(\frac{\text{safety factor}}{1.2}\right)^{1.5}$$

$$C_s = \frac{2.12}{(G_s - 1)^{1.5}}$$

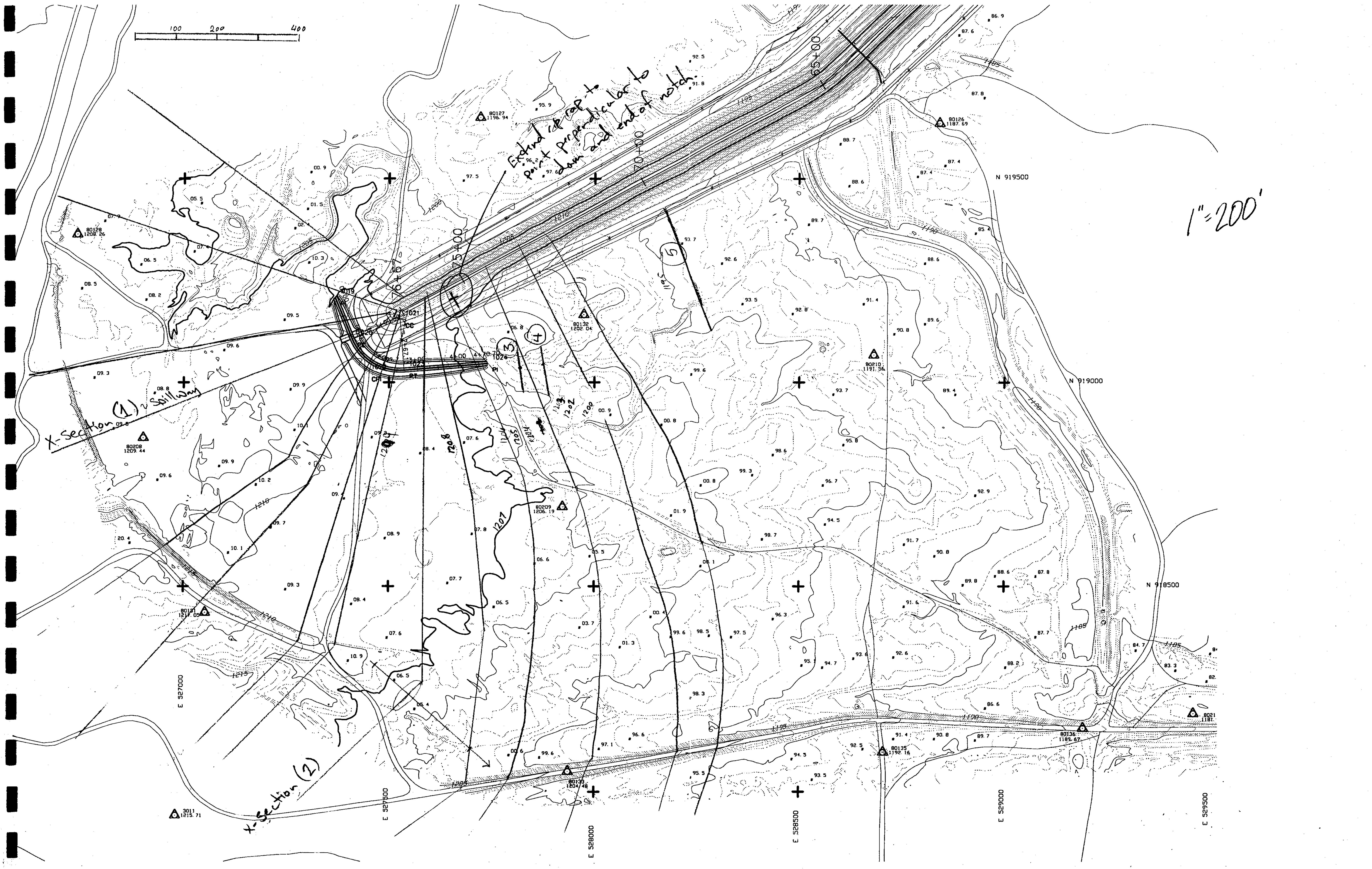
D_{50} = stone size, feet
V_a = average channel velocity, ft/s
ϕ = material angle of repose, degrees
G_s = specific gravity of stone, (γ_s/γ_w)
d = average flow depth, feet

The following describes the required input parameters shown in Figure 2.11.

<u>Average Channel Velocity:</u> The average channel velocity is defined as the total discharge (ft^3/s or m^3/s) divided by the flow area (ft^2 or m^2). Valid values are greater than zero in either ft/s or m/s.

<u>Average Flow Depth:</u> This is found by measuring the distance from the channel bottom to the free surface at various points along a given channel section and averaging the results. The average flow depth is reported in feet or meters.

<u>Unit Weight of Stone:</u> This is the weight of one solid cubic foot or meter of the stone that will be used and varies by the type of rock. Valid values are 130lbs/ft^3 to 200 lbs/ft^3 in English units and 2085 kg/m^3 to 3206 kg/m^3 in


100 200 400
1"=200'
Extend rip rap to point perpendicular to dam and end of notch.
X-Section (1) Spillway
X-Section (2)
65+00
70+00
75+00
N 919500
N 919000
N 918500
E 527000
E 527500
E 528000
E 528500
E 529000
E 529500

APPENDIX C

ADWR REVIEW COMMENTS

DISPOSITION OF COMMENTS ON 30 PERCENT LEVEL SUBMITTAL

ADWR Comments – Reference ADWR letter dated January 19, 2000. This letter is included in this appendix.

1. Section 3.0 (Filter Investigation)…

Filter investigation is still underway.

2. Section 4.1.1.1 (Conventional Graded Sand Filter)…

Design calculations mentioned are included in Appendix B.

3. Section 4.2 (Trash Racks)…

Trash racks have been redesigned, see Section 4.2.

4. Section 4.3 (Riprap at the Right Dam Abutment)…

Riprap has been designed, see Section 4.3.

5. Section 4.4 (Emergency Spill Modifications)…

A copy of the December 8 and 9, 1999 survey will be included in 90 percent report. The spillway notch elevation has been re-calculated to account for 10 years of future subsidence.

6. Section 4.6 (Interim Operation Plan)…

No action required by Dames & Moore. The District will supply the Interim Operation Plan.

7. Appendix A …

Dam filter sieve analyses have been modified accordingly.

8. Appendix E…

Specifications for the filter material including compaction requirements have been provided. Calculations supporting the D_{50} sizing of the riprap have also been provided, see Appendix B.

9. Drawing G3…

Additional labeling has been added.

10. Drawing C1...

Comments have been integrated into revised drawing.

11. Drawing C2...

Additional cross-section requested has been provided.

12. Drawing D1...

Cross-sections for each outlet have been provided. Other comments have been added.

13. Drawing D2...

Stilling basins have been removed. Trash racks have been redesigned.

ARIZONA DEPARTMENT OF WATER RESOURCES
Dam Safety Section
500 North Third Street, Phoenix, Arizona 85004
Telephone (602) 417-2445
Fax (602) 417-2423

January 19, 2000

JANE DEE HULL
Governor

RITA P. PEARSON
Director

Mr. Tom Renckly, P.E.
Flood Control district of Maricopa County
2801 West Durango
Phoenix, Arizona 85009

Subject: **White Tanks FRS #3 Dam (07.28)**
Interim Dam Safety Measures (30% Submittal)

Dear Mr. Renckly:

The Arizona Department of Water Resources (Department) has evaluated and provides comments regarding the Flood Control District of Maricopa County's (FCDMC) proposed interim dam safety measures as detailed in the Dames & Moore report titled "Report, Interim Dam Safety, 30% Submittal, White Tanks FRS #3" dated January 10, 2000.

1. Section 3.0 (Filter Investigation) – In addition to documenting the gradation of the filter material found, the report should evaluate the material for conformance with the design, and provide an engineering assessment as to the suitability of the in-place filter. Plotting the gradations of the material found in the borings on the SCS Soil Mechanics Note #1 design gradations contained in the SCS design report (attached) indicates an inadequate filter.
2. Section 4.1.1.1 (Conventional Graded Sand Filter) – Design calculations need to be provided supporting the diaphragm design dimensions and filter material gradations. It is recommended that the SCS design calculations be reviewed for conformance with current standards. In addition, calculations should demonstrate that buttress fill placed adjacent to the filter material is also filter matched. Due to the temporary nature of the structure, a filter fabric may be considered to protect against loss of filter material due to piping.
3. Section 4.2 (Trash Racks) – The design should provide sufficient spacing away from the slide gate to ensure that debris, wedged in the trashrack, does not interfere with the operation of the slide gate. It is recommended thattrash rack designs conform to the requirements in Section 10.9 of the Bureau of Reclamation's "Design of Small Dams" (1987) which reads as follows:

   "Trash bars usually consist of thin, flat steel bars that are placed on edge from 3 to 6 inches apart and assembled in a grid pattern. The area of the trashrack required is fixed by the limiting velocity through the rack which, in turn, depends on the nature of the trash to be excluded. Where the trashracks are inaccessible

for cleaning, the velocity through the racks ordinarily should not exceed 2 ft/s. A velocity of up to approximately 5 ft/s may be tolerated for trashracks that are accessible for cleaning."

4. Section 4.3 (Riprap at the Right Dam Abutment) – For design of the riprap, the Department recommends the Bureau of Reclamation's "Design Standards No. 13: Embankment Dams. Chapter 7 Riprap Slope Protection" dated July 1992, and the Corp of Engineer's "Earth and Rock-Fill Dams – General Design and Construction Considerations" (EM 1110-2-2300) dated July 31, 1994.
5. Section 4.4 (Emergency Spillway Modifications) – This section references a December 8 & 9 settlement survey, and indicates that based on this survey the emergency spillway will be lowered to elevation 1207.5 feet. Please provide the Department a copy of this survey. Also, does this proposed elevation account for potential future settlement?
6. Section 4.6 (Interim Operation Plan) – Comments on the interim operation plan will be provided seperately.
7. Appendix A – Additional detail should be provided for the Dam Filter Investigation Sieve Analysis. Standard sieve sizes should be included. Are the results percent passing or percent retained? According to the original project specifications, two types of filter material (Drain Fill and Course Aggregate) were used to construct the embankment drain. It is recommended that two additional columns be added to this table showing the gradation limits for these two drain materials (example attached). It appears that the samples obtained from Sta. 59+00 and 58+00 meet or are close to the Course aggregate specification while the samples from Sta. 57+30 do not meet either specification.
8. Appendix E – The specification for the filter material needs to be included. The specifications should also include compaction requirements for the filter material. It is anticipated that relative density determinations utilizing ASTM methods 4253 and 4254 will be required. Calculations need to be provided supporting the specification for the D_{50} sizing of the riprap.
9. Drawing G3 – It is recommended that stationing be added to the outlet identifiers, and Beardsley Canal and the emergency spillway be labeled. It is also recommended that the 100-year and maximum pool contours be identified.
10. Drawing C1 – It is recommend that the note "Primary Borrow Source for Soil Berms" in the plan view be relabeled to read "Borrow Source for Buttress Fill" for consistency with the detail notes on Drawing D1. A bedding layer for the riprap is needed. For an interim repair, a geotextile should be sufficient. The top of riprap elevations shown (1195 feet) on the sections are incorrect considering that the top of the low flow channel is set at elevation 1206.68 feet. The height of riprap, 2.5 feet, shown would appear to vary if the top elevation of the riprap is set. It is recommended that the channel profile include riprap elevations. Embankment slopes should be revised to show existing slopes. The width of the access road should be specified. The one-foot of soil cover specified on the access road should be changed to an aggregate material to ensure all weather access.
11. Drawing C2 – On this drawing, it is recommended that an additional cross section be cut perpendicular to the outlet pipe through the berm.
12. Drawing D1 – Dimension "B" in the table should be in terms of feet. The diaphragm filter dimensions are not consistent with SCS Technical Note W-21. For flexible conduits, the diaphragm limits should be 2 times the pipe diameter in all directions, or 5

feet beyond the excavation. Cross sections for each outlet should be provided. The location of the cross section in the upper right hand corner should be shown on the outlet sections, and the bedding sand design should be clarified as discussed during our January 13, 2000 meeting. Filter material may not be required full depth downstream of the diaphragm.

13. Drawing D2 - As discussed during the January 13, 2000 meeting, stilling basins may not be required. Since the only means of drawdown will be the 48-inch outlet located at Sta. 46+00, an additional extension of the pipe may be adequate. The vertical bar spacing of the trash rack, 12-inches, is marginal for the 48-inch inlets, and excessive for the 24-inch inlet. Horizontal bars need to be included to reduce the spacing in the horizontal direction.

If you have any question concerning this letter please contact Michael Greenslade of the Dam Safety Section at (602) 417-2400 extension 7188.

Sincerely,

Jon M. Benoist, P.E.
Supervisor
Dam Safety Section

JMB:mdg

White Tanks FRS #3
15448-007-058
Dam Filter Investigation
Sieve Analysis

Sieve Size

% Passing ??

% Passing

Sieve Size	Particle Size (mm)	59+00, 15-20 ft	58+00, 5-10 ft.	57+30, 20-25 ft	57+30, 5-10 ft	Specs for Coarse Drain Rock	Specs for Fine Drain Rock
2.5"	63	100	93	100	100	90-100	
2"	50	87	69	100	98	35-70	
1½"	37.5	36	13	86	90	0-15	100
1"	25	7	2	48	68		80-100
3/4"	19	2	1	24	49	0-5	70-95
½"	12.5	1	1	5	31		
3/8	9.5	1	1	2	22		49-65
1/4	6.3	1	1	1	13		
#4	4.75	1	1	1	13		35-50
#8	2.36	1	1	1	8		25-40
#10	2	1	1	1	8		
#16	1.18	1	1	1	8		
#30	0.6	1	1	1	8		10-25
#40	0.425	1	1	1	8		
#50	0.3	1	1	1	8		
#100	0.15	1	1	1	8		
#200	0.075	0.3	0.3	0.8	4.2		2-8

Close to Coarse

Mostly Coarse

Narrower

Narrower

SCS-ENG-353A
Rev. 11-71

MATERIALS TESTING REPORT

U.S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE

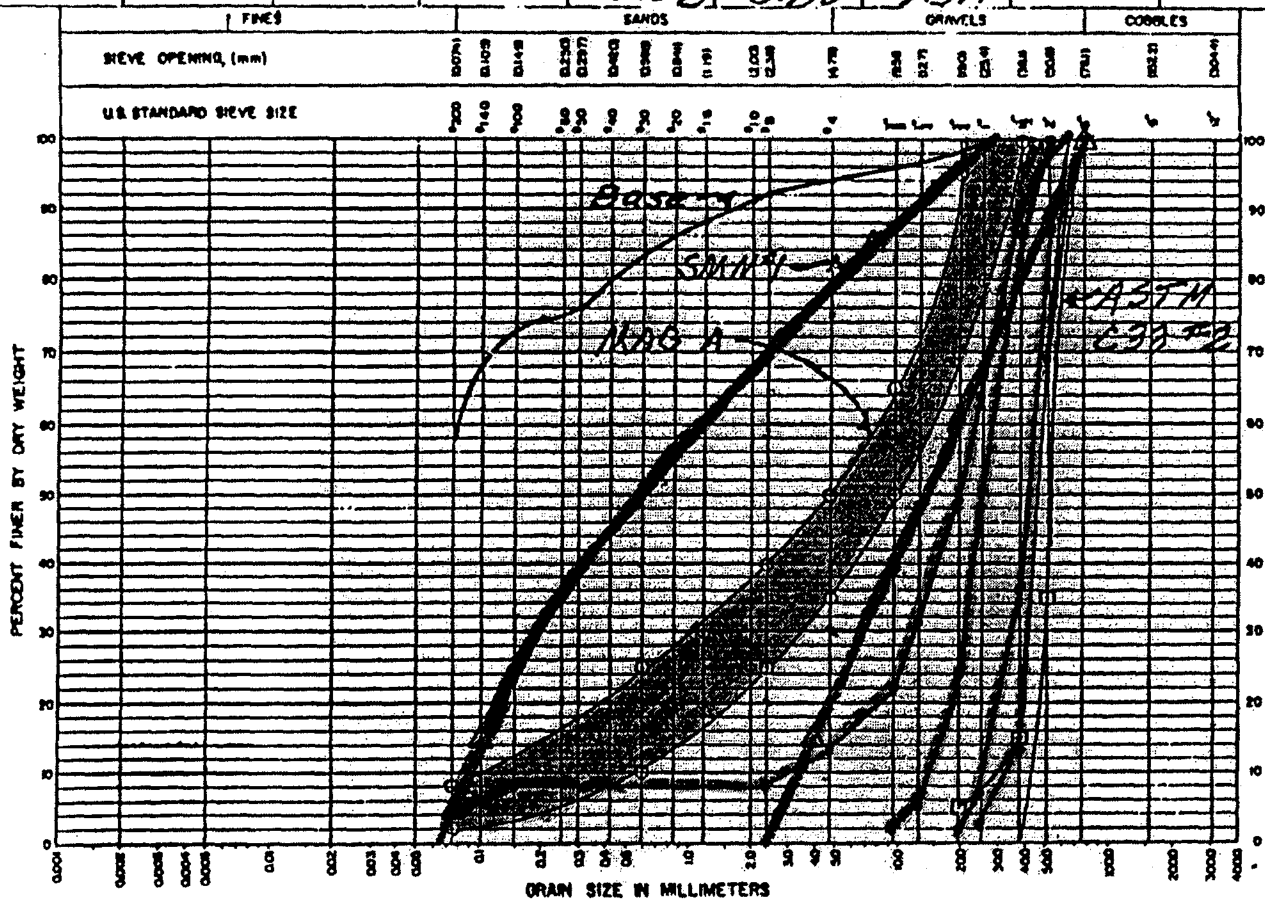
SOIL CLASSIFICATION

LABORATORY NO. 2181

PROJECT and STATE	White Tanks #3 Arizona
FIELD SAMPLE NO.	21-
DEPTH	5.5'
SAMPLE LOCATION	Sta 40+00 @ Dam
TYPE OF SAMPLE	Disturbed
TESTED AT	ATL
GEOLOGIC ORIGIN	
APPROVED BY	
DATE	3-10-81
SYMBOL	CL
DESCRIPTION	

GRAIN SIZE DISTRIBUTION

D_{10}	D_{16}	D_{30}	D_{50}	D_{60}	D_{85}	D_{MAX}	C_u	C_c
				0.08	0.80	75.4		



SPECIFIC GRAVITY (G_s)		ATTERBERG LIMITS						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI				
2.667						38	8	%	%	%	g/cc pcf

REMARKS:

GPO: 1971 O-430-349

SCS-ENG-353A
Rev. 11-73

SOIL CLASSIFICATION

MATERIALS TESTING REPORT

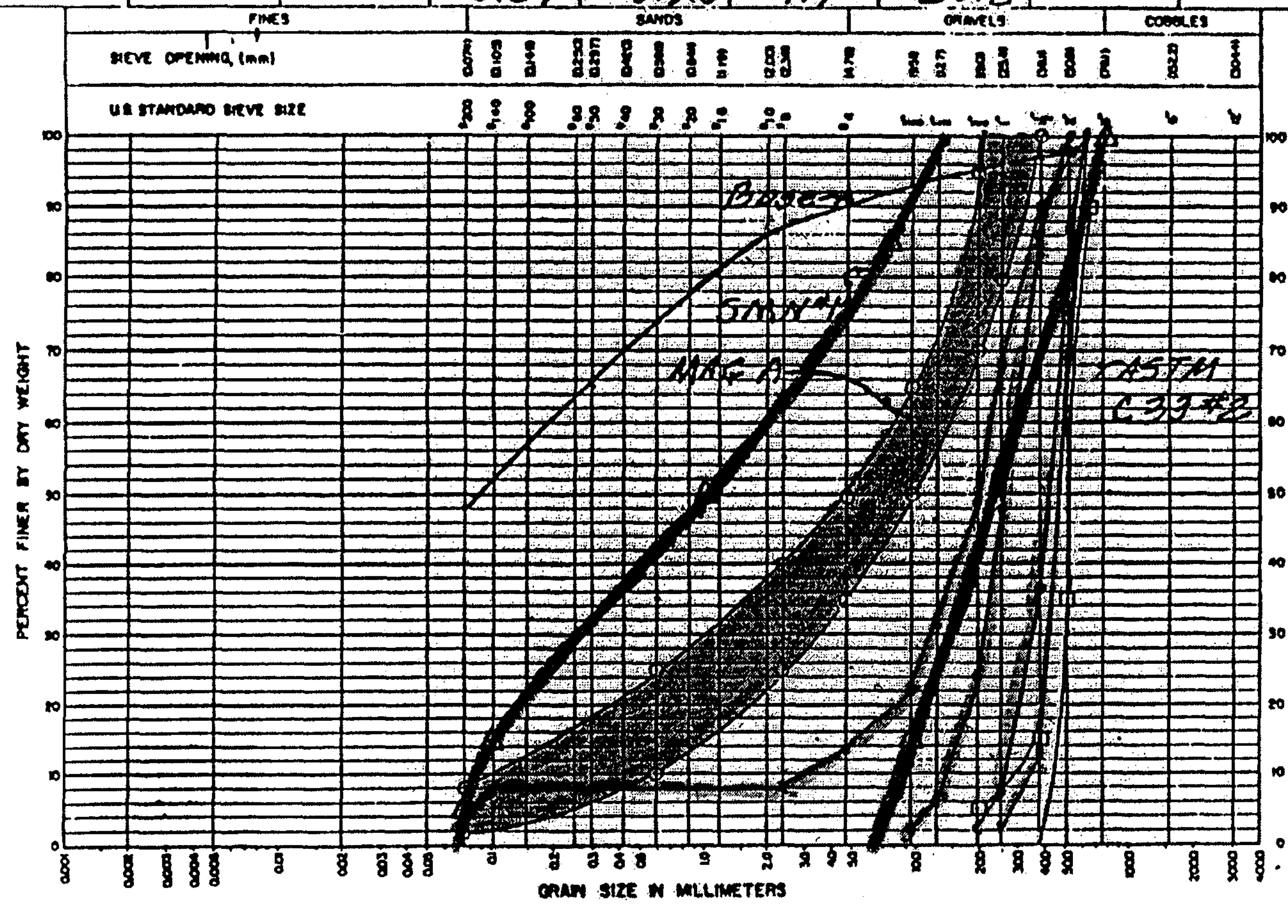
U.S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE

LABORATORY NO 2160

PROJECT and STATE	White Tanks #3 Arizona
SAMPLE LOCATION	Sta. 35+00 d Dam
FIELD SAMPLE NO	3.1
DEPTH	6.0'
GEOLOGIC ORIGIN	
TYPE OF SAMPLE	Disturbed
TESTED AT	ATL
APPROVED BY	
DATE	3-11-81
SYMBOL	SC
DESCRIPTION	

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	D_{MAX}	C_u	C_c
			0.09	0.20	1.9	50.8		



SPECIFIC GRAVITY (G_s)		ATTERBERG LIMITS						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI				
2.681						30	8	%	%	4.3 %	g/cc pcf

REMARKS:

GPO 1971 O-450-349

SCS-ENG-353A
Rev. 11-71

MATERIALS TESTING REPORT

U.S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION

LABORATORY NO. 3179

PROJECT and STATE	SAMPLE LOCATION
White Tanks #3 Arizona	Sta. 70+00 & Cen

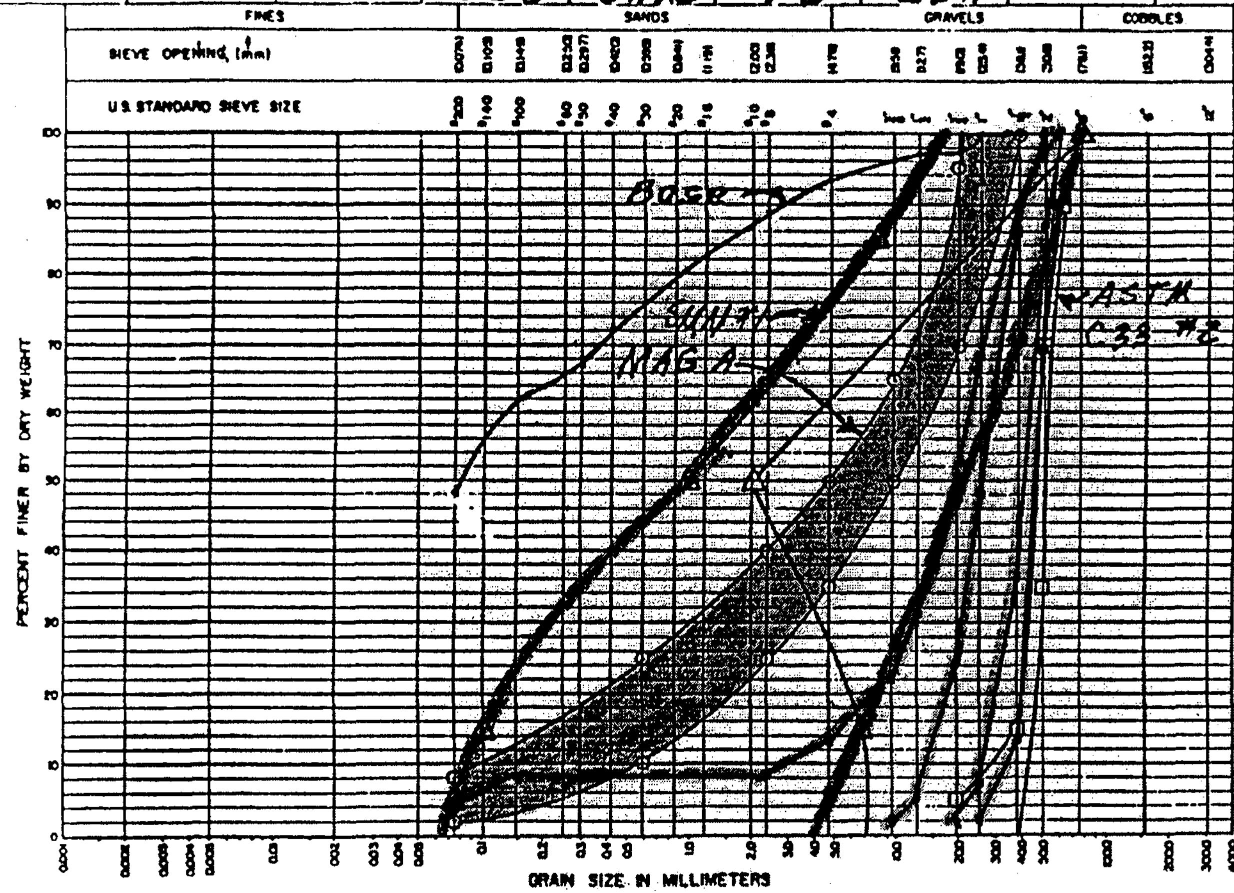
FIELD SAMPLE NO.	DEPTH	GEOLOGIC ORIGIN
11	5.0'	

TYPE OF SAMPLE	TESTED AT	APPROVED BY	DATE
Disturbed	ATL		3-10-81

SYMBOL	DESCRIPTION
SM	

GRAIN SIZE DISTRIBUTION

D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	D_{MAX}	C_u	C_c
			0.08	0.125	1.6	58.1		



SPECIFIC GRAVITY (G_s)		ATTERBERG LIMITS						SOLUBLE SALTS	SHRINKAGE LIMIT	UNDISTURBED CONDITION	
		NATURAL MOISTURE		AIR DRY		OVEN DRY				MOISTURE	DRY UNIT WEIGHT
(-) #4	(+) #4	LL	PI	LL	PI	LL	PI				
2.674						21	3	%	%	4.6 %	g/cc pcf

REMARKS:

GPO : 1971 O - 450-346

DISPOSITION OF COMMENTS ON 10 PERCENT LEVEL SUBMITTAL

ADWR Comments – Reference ADWR letter dated December 16, 1999. This letter is included in this appendix.

1. Section 3.0 (Filter Investigation)…

   This comment will be addressed when more data are acquired from additional field investigation. Additional exploration is planned related to crack investigation that will include trenches to explore the dam's filter zone.

2. Section 4.0 (Design)…

   In disposition similar to comment 1, above, we will address this comment after further field exploration.

3. Section 4.0 (Design)…

   The report text addresses the interim operation plan. This plan will be prepared by the District.

4. Section 4.1 (Diaphragm Filters and Outlet Pipe Extensions)…

   The report text now includes a sub-section on pipe addressing the information called for.

5. Section 4.1 (Diaphragm Filters and Outlet Pipe Extensions)…

   The alternative discussed in Section 4.1.1.1 is one that complies with NRCS design criteria. The second alternative proposes use of a geo-synthetic (fabric) filter.

6. Section 4.2 (Trash Racks)…

   The revised report text gives the MAG designation requested.

7. Section 4.3 (Riprap at the Right Dam Abutment)…

   Riprap design is in-progress engineering work. At the appropriate level we will select and report the design basis. We will consult the references indicated.

8. Appendix A (Boring Logs)…

   Boring logs are now included in the appendix.

9. Drawing C1…

This drawing has been revised. The flow from the low flow channel, or notch, is relatively low and does not wet the dam's toe. The riprap on the toe is not for armor protection against flow from the spillway notch. Rather, it is necessary for the design inflow event, when spillway discharge is at a maximum.

The alignment of the notch is based upon topography and property lines. It was selected in order to provide the required channel dimensions (determined by freeboard requirements), to discharge to a wash close by and down-slope, and to avoid a property line close to the downstream toe of the dam. Alignment that routes flow in another direction would require extensive earthwork that does not appear justified.

Section A has been modified. We now show two cross sections, at the District's request, to show typical channel dimensions, and non-typical dimensions for a roadway crossing. To comply with ADWR's comment we now show the armor in the section.

10. Drawing C2…

This drawing has been revised. Its intention should now be clear.

11. Drawing D1…

This drawing has been revised. The sections have been re-worked extensively to show detail. The space on the trash-rack has been dimensioned.

ARIZONA DEPARTMENT OF WATER RESOURCES
Dam Safety Section
500 North Third Street, Phoenix, Arizona 85004
Telephone (602) 417-2445
Fax (602) 417-2423

December 16, 1999

JANE DEE HULL
Governor

RITA P. PEARSON
Director

Mr. Tom Renckly, P.E.
Flood Control district of Maricopa County
2801 West Durango
Phoenix, Arizona 85009

Subject: **White Tanks FRS #3 Dam (07.28)**
Interim Dam Safety Measures (10% Submittal)

Dear Mr. Renckly:

The Arizona Department of Water Resources (Department) has evaluated and provides comments regarding the Flood Control District of Maricopa County's (FCDMC) proposed interim dam safety measures as detailed in the Dames & Moore report titled "Report, Interim Dam Safety, 10% Submittal, White Tanks FRS #3" dated November 22, 1999.

1. Section 3.0 (Filter Investigation) – This section only states that filter material was found in all three borings drilled at Stations 57+30, 58+00, and 59+00. The report should document the gradation of the filter material found, confirm if the material found is consistent with the as-built drawings, and provide an engineering assessment as to the suitability of the in-place filter. During an inspection on November 4, 1999 the Department was informed that 2-inch drain rock was found in these three borings and that a suitable filter material was not in-place. The presence of 2-inch drain rock would appear to provide for an inadequate filter unless multiple zones of material were utilized.
2. Section 4.0 (Design) – This section should include a discussion about the partial central filter/drain installed and an assessment about the adequacy of the filter/drain in protecting the dam from the historic cracking. The Department has identified historic cracking and the presence of an inadequate filter/drain as a safety deficiency. Justification for not requiring interim safety measures for this safety deficiency needs to be documented in this report.
3. Section 4.0 (Design) – This section should include a discussion about an interim operation plan previously requested by the Department. If the operation plan is not within the scope of this report, the report should clarify who is responsible for the operation plan development.
4. Section 4.1 (Diaphragm Filters and Outlet Pipe Extensions) – Although the title of this section references the outlet pipe extensions, the report does not include a discussion about the outlet pipe extensions (i.e., type of pipe, coating, presence of asbestos in the coating of the existing pipe, connections, headwalls, etc).

5. Section 4.1 (Diaphragm Filters and Outlet Pipe Extensions) – This section states that NCRS criteria will be the basis of design of the diaphragm filters. It appears that only one of the three alternatives presented could meet NCRS design criteria. Deviation from the NCRS design criteria will need to be justified.
6. Section 4.2 (Trash Racks) – This section indicates that the design was taken from MAG details. Please include the specific MAG detail reference.
7. Section 4.3 (Riprap at the Right Dam Abutment – This section indicates that "several accepted" design methods, including the NCRS method, will be utilized in the design of the riprap. The Department recommends the Bureau of Reclamation's "Design Standards No. 13: Embankment Dams. Chapter 7 Riprap Slope Protection" dated July 1992, and the Corp of Engineer's "Earth and Rock-Fill Dams – General Design and Construction Considerations" (EM 1110-2-2300) dated July 31, 1994.
8. Appendix A (Boring Logs) – The one page provided states that the boring logs are to be completed in the 60% design report. Boring logs and laboratory test results typically provide basic design information, and should have been included with this 10% report. Consequently, without this information the Department may have comments on the 60% design report that may have been more appropriate at the 10% design level.
9. Drawing C1 – This drawing indicates that the proposed low flow channel alignment will direct flows to the toe of the dam. Consequently, approximately 1,500 feet of the toe is proposed to be armored with riprap. Directing flows to the downstream toe of the dam will promote wetting of the foundation of the dam and may result in adverse settlements. Directing flows away from the dam would appear to be more appropriate and significantly reduce the amount of riprap needed. Also, Section A on this drawing should show the right abutment of the dam and the proposed riprap protection.
10. Drawing C2 – It is unclear what this drawing is trying to show. The section references are confusing.
11. Drawing D1 – In the two Section A's, identify the various materials. On Section C, does the open space between the trashrack and slope exceed the trash rack bar spacing?

If you have any question concerning this letter please contact Michael Greenslade of the Dam Safety Section at (602) 417-2400 extension 7188.

Sincerely,

Jon M. Benoist, P.E.
Supervisor
Dam Safety Section

JMB:mdg

APPENDIX D

COST ESTIMATE ASSUMPTIONS

COST ESTIMATE ASSUMPTIONS

OUTLET WORKS

Construction Stormwater Pollution Prevention Plan (SWPPP) – Cost generated is based on 2.5 percent of project line item totals. At this level of estimate, it is assumed that the project will require a construction SWPPP. This percentage includes costs for air quality permitting, generating the construction SWPPP, and implementation.

Mobilization/Demobilization – This percentage was calculated from the sum of the percentages for mobilization/demobilization, general condition, and temporary facilities. These percentages total 5 percent of the project line item totals.

Clear/Grub/Strip – A unit cost of $.40 per square yard (sy) was used for this small scale. This quantity is based on the footprint area of the berm on the dam face.

Demolition of Headwall – This lump sum includes removal of concrete, stone, pipe, and shotcrete, and haul to landfill.

Mass Excavation (Outlet Pipes) – An excavation cost of $2.25 per cubic yards (cy) was used from the previous estimate. This excavation will be conducted by a trackhoe to excavate and stockpile soil adjacent to excavation. Excavation consists of cutting the existing slope to 1.5H:1V.

Import, Place, Grade, Compact Filter Sand - The unit cost converted to cubic yards is $15.00/cy delivered, assuming $10.00/cy to place, grade, and compact. Therefore $25.00/cy is the unit cost. This cost is based on using C33 construction sand. It is assumed that the compaction effort will be minimal. If a major compaction effort is required for this sand, then the unit cost could be increased as much as 20 pecent.

Install 48-inch Diameter Outlet Pipe Extensions – The cost presented is a vendor-quoted unit cost for delivered and installed CMP. This price includes a standard coupling in order to attach the CMP extension to the existing CMP. Therefore, this unit cost does not include any welding or concrete encasement around the pipe. It was assumed that each extension would be 25 feet in length.

Install 24-inch Diameter Outlet Pipe Extensions – The cost presented is a vendor-quoted unit cost for delivered and installed CMP. This price includes a standard coupling in order to attach the CMP extension to the existing CMP. Therefore, this unit cost does not include any welding or concrete encasement around the pipe. It was assumed that each extension would be 25 feet in length.

Embankment Fill – After quantity take off, we concluded that the material excavated from the dam face would be a sufficient quantity to fill the berm with a large quantity left over. Also we assumed that the left over material could be left on-site (spread flat). This estimate was made using a unit cost of $3.00/cy. We assumed that the material excavated from the dam would not have to be screened. Also, we assumed that the amount of large rocks would be minimal and could be hand-picked prior to placement.

Grade Slopes – This estimate was made assuming the area of all slopes would need to be graded. We used a unit price of $4.00/sy based on previous estimates for the replacement of outlet pipes.

Import, Place Bedding Rock (plunge pool) – We used an escalated unit cost for 3- to 6-inch river rock from a vendor quotation. The delivered material will be approximately 17.00/cy. We assumed that the placement would cost 13.00/cy, and therefore used a unit cost of 30.00/cy.

Import, Place, Riprap – This estimate was made assuming delivered material would be approximately 27.30/cy. A unit cost of 35.00/cy was used for estimate of placed riprap.

48-inch Trash Rack – Plug number cost. The unit cost is inclusive of all components of the trash rack. We assumed that these trash racks would be shop-fabricate, and field installation would consist of installing anchor bolts in the existing concrete slab and bolting the trash rack down. We assumed that these trash racks would not be hinged due to the fact that they will be extremely heavy. We also assumed that the trash racks would be shop primed and painted. The material used would be steel, but not galvanized steel.

24-inch Trash Rack – Plug number cost. The unit cost is inclusive of all components of the trash rack. We assumed that these trash racks would be shop-fabricated, field installation would consist of installing anchor bolts in the existing concrete slab and bolting the trash rack down. We assumed that these trash racks would not be hinged due to the fact that they will be extremely heavy. We also assumed that the trash racks would be shop primed and painted. The material used would be steel, but not galvanized steel.

Revegetate – It was assumed that all excavated and or fill areas would need to be seeded with desert vegetation. We assumed a total of 1 acre.

Install Perimeter Fencing – This estimate was made using a lump sum of 1,200.00. The existing fence consists of 4-strands of barbed wire attached to 3-foot posts driven into the ground. Fence Removal is rolled into this cost as well.

Geotextile –

SPILLWAY MODIFICATIONS

Clear/Grub/Strip – A unit cost of $.40/sy was used for this small scale. This quantity is based on the footprint area of the channel cut.

Excavation – Typically, scrapers would be used for a channel excavation given that the spoil material could be stockpiled within close proximity. However, scrapers would not be feasible for this small of a scale. We assumed the excavation would be completed using a combination of dozer, loader, and trucks. The material excavated from the spillway will be waste soil and therefore stockpiled within close proximity. A $3.50/cy price was used because excavation is relatively small.

Riprap – This line item is for armor along the face of the dam. Material should be dumped in place with minor grade control. Delivered, the riprap will cost $27.30, with an escalated cost of $35.00/cy for place and grade.

GENERAL

All unit costs listed in the assumptions and contained in this cost estimate have been escalated a calculated percentage in order to include costs for permits, insurance, performance bonds, QC testing, taxes, surveying and grade control, dust control, and haul roads. The calculated escalation percentage is 12.82 percent.

APPENDIX E

CONSTRUCTION SPECIFICATIONS

SPECIAL PROVISIONS TO TECHNICAL SPECIFICATIONS

FOR

INTERIM DAM SAFETY PROJECT
WHITE TANKS FRS#3

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONSTRUCTION CONTRACT NO. FCD 98-11
PCN 4700430

SPECIAL PROVISIONS FOR TECHNICAL SPECIFICATIONS
(60 PERCENT SUBMITTAL)

FOR

INTERIM DAM SAFETY PROJECT
WHITE TANKS FRS#3

Prepared for:
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Prepared by:
Dames & Moore

DISTRICT DESIGN CONTRACT NO.:	**FCD98-11**
DISTRICT PCN:	**4700430**
D&M JOB NO:	**15448-007-058**

February 10, 2000

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SECTION **PAGE**

SPECIAL PROVISIONS TO TECHNICAL SPECIFICATIONS
(60 PERCENT SUBMITTAL)
FOR
INTERIM DAM SAFETY
WHITE TANKS FRS #3

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONTRACT NO. FCD98-11
PCN 4700430

SECTION 201 - CLEARING AND GRUBBING

Clearing and grubbing shall conform to Section 201 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 201.1 – Description

Add the following:

Clearing and grubbing shall be performed within the limits of work only, including borrow areas, excavation limits, foundation footprint, and fill zone. Do not clear excessive areas. Large trees should not be encountered, and should not be affected by the Contractor's activities.

Subsection 201.2 – Preservation of Property

No changes.

Subsection 201.3 – Methods

Add the following:

Vegetative and deleterious material shall be carefully removed and discarded from fill material. Hand removal of small roots may be required.

Dispose of material generated from clear and grubbing activities shall be disposed of at an approved landfill or greenwaste recycling facility.

Subsection 201.4 – Removal and Disposal of Salvageable Items

No changes.

Subsection 201.5 - Payment

No payment will be made for clearing and grubbing as such; the cost thereof shall be included in the bid price for the construction or installation of the items to which said clearing and grubbing are incidental or appurtenant.

Subsection 201.6 – Measurement, Removal, and Disposal of Trees

Add the following:

The scope of the project does not include removal of trees, and unless otherwise approved by the Engineer and the District, the Contractor is prohibited from damaging or removing trees.

Delete the following:

Reference to tree size and measurement of trees to be removed is not applicable to this project.

Subsection 201.7 – Payment, Removal and Disposal of Trees

Add the following:

No payment will be made for removal of trees. The Contractor will be responsible for avoiding and protecting trees on the site from damage or being destroyed. Equivalent replacement of damaged or destroyed trees of like kind will be at the cost of the Contractor.

Delete the following:

Reference to payment on a unit price is not applicable to this project.

NO BID ITEM 201 - in cost est.

--End of section--------------------------------------

SECTION 202 - MOBILIZATION

Mobilization section has been developed by the Engineer to identify an important activity not currently listed in the MAG Uniform Standard Specifications.

Subsection 202.1 - Description

The work under this section shall consist of preparatory work and operations, including but not limited to, the movement of personnel, equipment, supplies and incidentals to the project site; the establishment of all offices, buildings and other facilities necessary for work on the project, permits and licenses, and for all other work and operations that must be performed, and costs incurred prior to beginning work on various items on the project site.

Subsection 202.2 - Field Offices

Field offices are not required unless otherwise specified.

Subsection 202.3 – Methods

Contractor shall receive Notice-to-proceed prior to mobilizing to the site and make necessary arrangements for site access, staging, and equipment parking areas.

Subsection 202.4 - Payment

Payment shall be made on the basis of the lump sum price bid and shall be full compensation for supplying and furnishing all materials, facilities, and services and performing all work involved as specified herein. The lump sum price bid shall not exceed three (3%) percent of the total project bid amount exclusive of mobilization and permits and licenses. No additional payment will be made for occupancy and services during periods of contract extension of time due to engineering changes or shutdowns.

BID ITEM 202 - MOBILIZATION

--End of section--------------------------------------

SECTION 206 - STRUCTURE EXCAVATION AND BACKFILL

Structure excavation and backfill shall conform to Section 206 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 206.1 - Description

Add the following:

Work specified in this item includes excavation and sand backfill required to construct the diaphragm filter structure at each of the three outlet pipes as shown on the plans. The earthwork described in this section shall be coordinated with the requirements specific to the culvert pipe, fill construction, and associated subsections.

Subsection 206.2 - Foundation Material Treatment

Add the following:

All foundation excavations shall be inspected and approved by the Engineer prior to placing the filter sand and/or culvert pipe and all trench excavations shall be inspected prior to placing engineered material. Any loose or disturbed zones should be removed and replaced with compacted fill as directed by the Engineer.

Below outlet pipe extensions, the moisture content of existing site soils (subgrade) shall be maintained between optimum and optimum plus 3 percent moisture, as determined by Standard Proctor ASTM D 698, during and subsequent to compaction and final grading.

At these moist conditions, some pumping may be experienced under dynamic loading if the compaction is done by very heavy equipment (i.e., loaded scrapers, water-pulls, etc.) Some pumping is not considered detrimental in areas below the culvert/pipeline bottom (i.e., static loading conditions) provided specified field densities are obtained. Lighter compaction equipment and/or drying of wet soils may be used to reduce pumping if this condition becomes severe.

Delete the following:

Reference to concrete and/or piles is not applicable to this project.

Subsection 206.3 – Inspection

Add the following:

Inspection of the excavation limits is required to verify lines and grades and subgrade compaction. Materials testing for density of in-place subgrade is required prior to backfill operations.

Delete the following:

Reference to concrete or masonry is not applicable to this project.

Subsection 206.4 - Structure Backfill

Add the following:

The backfill material for the diaphragm shall be engineered sand. Imported commercially manufactured sand (typically used in concrete mix as described in subsection 701.3.2), uniformly washed, used for outlet pipe culvert bedding and diaphragm filter shall conform to the following requirements:

Concrete Sand complying with ASTM C 33

* Certificates of compliance or recent test results signed and stamped by a representative of the commercial supplier that ensures the sand delivered to the site meets the requirements of ASTM C 33.

The minimum strength requirement for backfill against and over top of the concrete collar where the culvert pipe extension is joined shall apply.

Field Compaction

Delete the following:

Reference to backfill in streets is not applicable to this project.

Subsection 206.5 - Payment

No payment will be made for structure excavation or backfill as such; the cost thereof shall be included in the bid price for the construction or installation of the outlet pipe extension items for which said excavation is incidental or appurtenant.

NO BID ITEM see cost est

---End of section---------------------------------------

<u>SECTION 210 – BORROW EXCAVATION</u>

Fill construction shall conform to Section 210 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 210.1 - Description

Add the following:

Borrow material for cover over each of the three outlet pipe extensions shall be excavated from the notch channel proposed at the spillway location. Should additional borrow be needed for access ramps or to replace unsuitable material, then the notch can be uniformly widened in the field with prior approval and direction from the Engineer and the District.

Subsection 210.2 – Imported Borrow

Add the following:

Borrow sites other than the one identified for the construction of the spillway notch channel require prior approval by the Engineer and the District and are subject to materials testing.

Subsection 210.3 – Placing and Compacting

No changes.

Subsection 210.4 – Measurement

Add the following:

Measurement and quantity verification only apply to the determination of fill required to meet the configuration of soil cover over each of the three outlet pipes. No measurement will be made for purposes of payment.

Delete the following:

Reference to roadway excavation, Section 205, is not applicable to this project.

Subsection 210.5 – Payment

Add the following:

No payment compensation shall be made for this scope of work. Compensation shall be included in the fill construction of the soil cover.

Delete the following:

Reference to pay quantities and payment on a unit price or alternate method is not applicable to this project.

NO BID ITEM

--End of section--

SECTION 211 - FILL CONSTRUCTION

Fill construction shall conform to Section 211 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 211.1 - Description

Add the following:

The work under this section shall consist of fill to provide soil cover over the top of the diaphragm filter and culvert pipe extensions at each of the three locations. The minimum limits of fill are delineated on the plans by a fill line.

The Contractor's approach may include, but is not required to, constructing access ramps on one or both sides.

The Contractor's approach may include, but is not required to, temporarily filling the shotcrete-lined outlet channel for a segment downstream of the work zone to maintain access to both sides.

Subsection 211.2 - Placing

Add the following:

Highly plastic soils, PI >25, removed from the excavation shall not be used in any required fills or structural backfills.

Fill material placed beyond the minimum soil cover configuration over top of the pipes and diaphragm shall be meet the same material, moisture conditioning, placement, and compaction requirements as the fill, incorporating the ramp into the soil cover.

Fill temporarily placed in the outlet channel for access purposes shall be removed upon completion of work on the outlet structures. Shotcrete debris shall be disposed of offsite at an approved construction debris landfill. Excess soil may be stockpiled or spread out at a location onsite approved by the Engineer and the District. Riprap shall replace portions of the outlet channel previously lined with pneumatically placed mortar in general accordance with Section 220.

Subsection 211.3 - Compacting

Add the following:

Compaction of exposed site soil, backfill, fill, and base course materials shall be accomplished to the following density criteria:

Material	Minimum Percent Compaction (ASTM D698)	Moisture Range (ASTM D698
Subgrade Soil:		
Below structural elements	95	At optimum to plus 3%
Backfill:		
Below outlet pipe	95	At optimum to plus 3%
Fill Construction of Soil Cover	95	Plus 3% to minus 3%

On site undisturbed soils or compacted soils subsequently disturbed or removed by construction operations should be replaced by materials compacted as specified above.

Compaction operations shall be accomplished by mechanical methods. Water settling or jetting shall not be permitted. Compaction of soil adjacent to culverts or concrete collar within 3 feet shall be accomplished using manual or walk-behind compaction equipment only.

Backfill cover material shall consist of soils, free of vegetation, debris, organic contaminants, using on-site soils.

Maximum Particle size:	3-inches (nominal)
Plasticity Index:	<10
Soil Type:	CL, ML, or SM (per Unified Soil Classification System)

* Investigative soils data indicates gradation and plasticity index and classification of existing soil from the spillway notch excavation would be appropriate borrow for fill at each of the culvert extensions. A copy of the soils report can be made available from the Engineer upon request.

Subsection 211.4 – Tests

Delete the following:

Reference to AASHTO T-99 test is not applicable for this project.

Subsection 211.5 – Measurement

No change.

Subsection 211.6 - Payment

No changes.

BID ITEM 211-1 FILL CONSTRUCTION

---End of section-------------------------------------

SECTION 215 - EARTHWORK FOR OPEN CHANNEL

Earthwork for open channel excavation to notch the spillway shall conform to Section 215 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 215.1 - Description

Add the following:

The work in this section consists of excavation, over-excavation, fill, grading, and disposal of excavated and removed material for the modification of the spillway by constructing a notch at the desired elevations and dimensions.

The cut material resulting from the channel excavation shall be used as fill at each of the three outlet pipe locations.

Coordinate channel construction with placement of Riprap as described in Section 220.

Subsection 215.2 – Stripping

Add the following:

If field observations during construction identify the soil proposed for fill construction is unsuitable due to the presence of vegetative matter or does not meet the gradation requirements, then the Contractor is responsible for minor stripping of the upper 12 inches to remove and discard. Stripping would be required to gain access to more suitable borrow material for the fill construction portion of the project.

Subsection 215.3 – Excavation

Add the following:

Excavation to the lines and grades shown on the plans is required and deviations to the plans for purpose of borrow ease or quantities shall be prior approved by the Engineer and the District. Consideration shall be given to the access road which will cross the channel at the location perpendicular to the road along the crest of the dam.

Delete the following:

Reference to concrete lining is not applicable to this project.

Subsection 215.4 – Fill and Backfill

Delete the following:

Reference to possible permission of concrete and bituminous type pavement as described in Section 211 is not applicable to this project. Fill materials containing such concrete and asphalt debris will be rejected.

Subsection 215.5 – Grading

Add the following:

The contractor will maintain a 0.5 % grade along the length of the channel as shown on the drawings. The grade is of the utmost importance. Abrupt crowns or depression shall be eliminated to the practical extent possible by fine grading.

Delete the following:

Reference to levee construction is not applicable to this project.

Subsection 215.6 – Tests

Add the following:

The channel bottom shall be proof rolled using rubber tire equipment with a gross vehicle weight of no less than 30,000 pounds. Proof rolling shall be conducted with no less than two passes with overlapping tire path and shall be witnessed by the Engineer.

Delete the following:

Reference to density testing in accordance with Section 211 is not applicable to this project.

Subsection 215.7 - Measurement

Add the following:

Measurement for excavation will be made according to the quantity of material excavated from natural ground to the finished sub-grades shown on the plans. The Engineer will verify the quantities of excavation by a method, which in his opinion is best suited to obtain an accurate determination. What about berms ?

Subsection 215.8 - Payment

Payment for excavation shall be made on the basis of the price bid per cubic yard, and shall include stockpiling of excess material at an approved location on site.

BID ITEM 215-1 – EARTHWORK FOR OPEN CHANNEL

215-2 ?

---End of section---

SECTION 220 - RIPRAP CONSTRUCTION

Riprap construction shall conform to Section 220 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 220.1 - Description

Add the following:

The construction of plain riprap at the outlet pipes of the FRS#3 Dam and outlet channel shall consist of furnishing and placing stone to the dimensions as shown on the plans.

Riprap shall replace removed or damaged shotcrete lining in the outlet channels.

Riprap shall be placed along one side of the spillway notch channel to armor the dam embankment from erosion.

Riprap construction shall be coordinated with the placement of geotextile filter fabric beneath stone per drawing sections and details.

Delete the following:

Reference to grouting and sacked concrete riprap alternatives is not applicable to this project.

Subsection 220.2 - Materials:

Add the following:

In order to maintain slope stability where plain riprap is constructed, stones shall be angular in shape and conform to the requirements set forth in the Table below.

A geotextile fabric underlay shall be furnished in accordance with Section 230.

Gradation requirements for the two riprap classifications are provided below:

Location	Right Dam Abutment	North Outlet Channel
D_{50} (inches)	6	12
Minimum Stone Size (inches)	2	6
Maximum Stone Size (inches)	12	18

Subsection 220.3 – Preparation of Ground Surfaces

Add the following:

The bed (or subgrade) shall be proof rolled along the slope and bottom to establish a firm surface.

Place the geotextile filter fabric to the same dimensions that are to receive riprap in accordance with Section 230.

Protect the position and integrity of the geotextile during placement of the riprap.

Delete the following:

Reference to a footing trench for riprap is not applicable to the project.

Subsection 220.4 – Plain Riprap

Add the following:

Riprap may initially be placed by dumping from loader-type equipment in a careful, methodical manner. However, hand placement to the outer dimensions and hand repositioning shall be conducted to the Engineer's satisfaction in the field.

Place the riprap in the outlet channel to the limits and thickness shown on the plans.

Place the riprap along one side of the spillway notch channel to the limits, elevation, and thickness shown on the plans. Elevation measurements shall be staked prior to placement of riprap and to be inspected and verified in the field by the Engineer.

Delete the following:

Reference to a toe trench is not applicable to this project.

Subsection 220.5 – Grouted Riprap

Delete the following:

This subsection is not applicable to the project.

Subsection 220.6 – Sacked Concrete Riprap

Delete the following:

This subsection is not applicable to the project.

Subsection 220.7 - Measurement

No change.

Subsection 220.8 - Payment

Payment for riprap construction shall be made at the price bid per cubic yard to the neat lines shown on the plans, and shall include full compensation for furnishing all labor, materials, tools, and equipment, and doing all the work involved in constructing the riprap structures complete in place as specified on the plans, and in the special provisions. This includes, but is not limited to, preparation of ground surfaces, excavation and backfill, geotextile fabric, riprap, and cleanup.

BID ITEM 220-1 - PLAIN RIPRAP (6-INCH D_{50})
BID ITEM 220-2 - PLAIN RIPRAP (12-INCH D_{50})

--End of section--

SECTION 225 - WATERING

Watering shall conform to Section 225 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 225.1 - Description

Add the following:

The moisture content of soil shall be kept at a content sufficient to insure that dust will be kept at a minimum for the excavation, hauling, and disposal or placement of soil.

All fill materials shall be moisture condition with uniform water application prior to spreading or placement to desired location, blend soil with water to ensure uniform moisture content. Moisture content shall be adjusted to within the required range as specified in Section 206 and Section 211.

Subsection 225.2 - Water Supply

Add the following:

Water used for construction purposes such as moisture conditioning, excavation, dust control, etc. may be obtained from the Beardsley Irrigation Canal. Permits must be obtained from Maricopa Water District for the use of this water. The Contractor should contact Christine Kvistad. The permit paperwork can be obtained at the Maricopa Water District offices located at 19420 North Grand Avenue, Surprise, AZ.

Subsection 225.3 – Construction Equipment

No changes.

Subsection 225.4 – Measurement

No changes.

Subsection 225.5 - Payment

No changes.

NO BID ITEM

--End of section--

SECTION 230 – GEOTEXTILE FILTER FABRIC

Geotextile filter fabric shall conform to the following:

The MAG Uniform Standard Specifications does not include a section for geotextile filter fabric.

Subsection 230.1 - Description

Add the following:

Geotextile filter fabric shall be placed to the same limits and dimensions as the riprap construction, as indicated on the plans.

Subsection 230.2 – Materials

Add the following:

Geotextile filter fabric shall be a non-woven material manufactured for erosion control that meet or exceed the following requirements:

Property	Test Method	Value
Unit Weight	ASTM	Range: 6 oz/sy to 12 oz/sy
Apparent Opening Size (AOS)	U.S. Standard Sieve	70 (minimum)
Burst Strength	ASTM D 3786	410 psi (minimum)

Manufactured roll length and width shall be standard for the industry. Used or scrap pieces will not be accepted.

Subsection 230.3 – Installation

Add the following:

The subgrade shall be verified it is ready to receive geotextile filter fabric by the Engineer prior to deployment. The subgrade shall be trimmed and firm density.

The fabric shall be placed evenly with significant wrinkles or excessive stretching. Securing the fabric on the slope using sandbags, stakes, or pins may be required until all of the riprap is placed to prevent the wind from displacing the fabric and the riprap from dragging the fabric down the slope.

A minimum of 12 inches of overlap shall be placed when splicing two pieces of fabric either side by side or end to end. No sewing, stitching, or heat bonding is required at the seam.

Torn or otherwise damaged areas of the fabric shall be repaired with a patch of like material that is 24 inches larger than the damaged area in all directions.

Coordination of fabric installation and riprap construction is required to maintain the integrity of the fabric from possible damage that may emanate from riprap placement. The method of riprap construction may need to consider the use of particular equipment, sequence of activities, and employment of hand labor to protect the fabric.

Subsection 230.4 – Measurement

Add the following:

Measurement for pay quantities is not required. The Contractor is required to procure and install the required quantity of fabric as per plans.

Subsection 230.5 – Payment

Add the following:

No payment will be made for geotextile filter fabric as such; the cost thereof shall be included in the bid price for the riprap construction items for which said fabric is incidental or appurtenant.

NO BID ITEM

---End of section---

SECTION 240 – REVEGETATION

Revegetation shall conform to the following:

The MAG Uniform Standard Specifications does not include a section for revegetation.

Subsection 240.1 - Description

Add the following:

Revegeation shall be applied to areas disturbed by construction to the like plant-type and like density as adjacent land or structure.

The Contractor is responsible for application and temporary watering associated with revegetation.

Subsection 240.2 – Materials

Add the following:

The hydroseeding mix design shall consist of native plants, grasses and other ground cover specific to the area. The mix design shall be submitted to the Engineer for review and approval.

Mulching and/or tackifiers are applied with seeding at the Contractor's discretion to ensure sustainability of growth for a minimum of 6 months. The type and technical data on mulching or tackifier products shall be submitted to the Engineer for review and approval.

Subsection 240.3 – Application

Add the following:

Revegetation using hydroseeding methods shall commence upon prior approval of construction components obtained from the Engineer and the District.

Subsection 240.4 – Measurement

Add the following:

Measurement for revegetation shall be performed in the field based on the site conditions of the disturbed areas as a result of construction, except for areas within stormwater drainage channels where no vegetation is desired.

Establish the general limits requiring revegetation by conducting a site walk with the Engineer and the District and mutually agreeing on the boundaries to be staked and surveyed.

From the staked boundaries, conduct a land survey to calculate the total area from the sum of aggregate subareas. The units of measurement and calculation shall be in square yards.

Payment shall be made based on the agreed upon area and total square yards. It is anticipated this quantity will be more than 2,000 square yards and no greater than 9,000.

Subsection 240.5 – Payment

Add the following:

Payment for revegetation shall be based on the agreed upon limits of application as measured and verified in the field on a square yard basis (given that the total area is relatively small). Payment on a square yard basis shall include all materials, supplies, equipment and labor for initial and any subsequent applications or temporary watering activities necessary to sustain vegetation on the applied areas for a minimum of 6 months from the date of which it is initially applied.

BID ITEM 240-1 REVEGETATION

---End of section---

SECTION 350 - REMOVAL OF EXISTING IMPROVEMENTS

Removal of existing improvements shall conform to Section 350 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 350.1 - Description

Add the following:

The work includes the removal and disposal of existing outlet headwall structures.

The work also includes the temporary removal and reconstruction of the existing fence along the District right-of-way as shown on the plans. The fence shall be removed for extension of the outlet pipes. The fencing shall be reinstalled at the same location after construction of these pipe extensions.

The disposal of all construction debris waste material removed under this item shall be the responsibility of the Contractor. The disposal site shall be approved by the Engineer.

Delete the following:

Reference to concrete and pavement structures is not applicable to this project.

Subsection 350.2 – Methods

Add the following:

All construction debris and waste materials shall be disposed of at an approved landfill. If a Maricopa County landfill is selected for disposition of waste materials and/or debris, a Maricopa County Landfill Use Permit will be required. Application for permit can be made at the Maricopa County Landfill Office, located at 2801 West Durango Street, Phoenix, Arizona 85009 (telephone (602) 269-2661). Charges will be levied on a volume basis for each load delivered to the landfill in accordance with the current fee schedule.

The project construction limits shall be cleared of all trash and construction debris. Such material as collected shall be disposed of at an approved landfill site and shall be subject to landfill fees so assessed, which will be included in the unit price bid for this item.

Weigh tickets from all landfill disposal must be furnished to the Engineer.

The Contractor may have to temporarily remove part of an existing barbed wire fence along the property line to maintain access to the work zone. It is the Contractor's responsibility to minimize the amount of impacted fence and to restore the fence to at least its original condition. As observed at the time of a pre-bid site walk, the barbed wire fence is a standard 4-strand with diagonal reinforcing posts at intersections to alignment or grade. New replacement barbed wire and/or tee posts will be the responsibility of the Contractor and no additional compensation will be made for materials or labor.

Delete the following:

Reference to concrete and pavement structures is not applicable to this project.

Subsection 350.3 – Miscellaneous Removal and Other Work

Delete the following:

Reference to work items B through H are not applicable for this project.

Subsection 350.4 - Payment

Payment for the removal and reinstallation of the existing fencing along the District property line shall be made on the basis of the lump sum price bid.

Payment for all miscellaneous removals (construction debris) required for construction of the project shall be made on the basis of the lump sum price bid, and including but not limited to, removal and disposal of headwalls, shotcrete, vegetative matter, unsuitable riprap, and pipe remnants abandoned within the area of construction, and other items as required.

BID ITEM 350-1 – REMOVE AND REPLACE FENCING
BID ITEM 350-2 - MISCELLANEOUS REMOVALS

---End of section--

SECTION 401 - TRAFFIC CONTROL

Traffic control shall conform to Section 401 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 401.1 - Description

Add the following:

Traffic control necessary for delivery of bulk stone materials or oversize pipe materials shall conform to Section 701 of the Arizona Department of Transportation (ADOT) Stored Specifications. References made to approval authority shall be understood to be Flood Control District of Maricopa County acting on behalf of ADOT.

All traffic control shall conform to the Construction Specifications for this project, including Part VI of the "Manual On Uniform Traffic Control Devices For Streets And Highways" (U.S. Department of Transportation, Federal Highway Division) and the associated ADOT supplement.

It shall be Contractor's responsibility to provide, erect and maintain and remove after completion of the work all necessary signs, barricades, barriers, berms, lights, high level warning devices, delineators, and any other required devices, uniformed officers, and flagman, necessary to properly mark and control the construction area for the safe and efficient movement of traffic. Temporary traffic control devices shall be installed prior to the start of work necessitating traffic safety. It shall be Contractor's responsibility to construct the required detour lanes in order to make the road available to traffic.

Approval of the Contractor's traffic control method by The District, or Federal guidelines shall not relieve Contractor of its responsibility to protect the work, the Contractor's personnel, or the general public.

Subsection 401.2 – Traffic Control Devices

Add the following:

Devices and equipment may include barricades, signage, high-visibility cones.

Delete the following:

Reference to devices other than listed above is not applicable to this project.

Subsection 401.3 – Flagmen or Pilot Cars

No changes.

Subsection 401.4 – Traffic Control Measures

No changes.

Subsection 401.5 - General Traffic regulations

Add the following:

All temporary traffic control devices and equipment shall be ballasted with sandbags or other approved ballast.

The "SPEED LIMIT 25" sign shall be used where traffic is maintained on unpaved shoulders, on temporary detour roads, on road sections where the existing pavement has been removed, or on traffic lanes that are severely restricted.

Access to all adjacent properties shall be maintained at all times. When access cannot be maintained, Contractor shall notify the adjacent residents at least 48 hours in advance of the access closure.

Contractor shall maintain or relocate all existing signal indications, warning signs, STOP, YIELD, and street name signs erect, clean and in full view of the intended traffic at all times. Portable signs should be used to supplement blocked or removed signs. Contractor shall reset all disturbed signs to permanent locations when construction is completed. The Contractor shall cover all existing signs that are in conflict with the traffic control signing. Contractor is responsible for the cost of replacing lost or damaged traffic signs.

Delete the following:

Reference to item 'A' regarding Bond Issue and Budget Projects are not applicable to this project.

Reference to item 'B' regarding Improvement District Projects are not applicable to this project.

Subsection 401.5.1 - Special Traffic Regulations

Add the following:

The public will be adequately notified of construction operations using methods including distribution of construction alert publications.

Prior to construction activities, the Engineer shall be notified regarding any road closures or temporary impedance of traffic.

Construction shall not commence or proceed without an approved Traffic Control Plan. The Traffic Control Plans shall address all construction staging and special provisions requirements.

At the time of the Pre-Construction conference, the Contractor shall designate an employee, other than the Project Superintendent, who is well qualified and experienced in construction traffic control and safety, to be available on the project site during all periods of construction to set up, maintain and coordinate safe barricading whenever construction restricts traffic. This individual shall be authorized to receive and fulfill instructions from the Engineer and shall supervise and direct the work. Instructions and information given by the Engineer to this individual shall be considered as having been given to the Contractor.

Subsection 401.6 – Measurement

No changes.

Subsection 401.7 - Payment

Add the following:

Payment for traffic control shall be made on the basis of the lump sum price bid and shall be full compensation for all work, including mobilization, placing, storing, removal and maintenance of all traffic control devices, signing and striping, flag persons, and other activities incidental to the implementation of the approved traffic control plan.

BID ITEM 401-1 – TRAFFIC CONTROL

---End of section---

SECTION 405 - MONUMENTS

Monuments shall conform to Section 405 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 405.1 – Description

Add the following:

The primary scope of work is the utilization and protection of existing survey monuments. Construction of survey monuments is only required in the event an existing one was inadvertently damaged or altered. Should the replacement of a survey monument be necessary, the Contractor would bear the associated

The Contractor is required to utilize benchmark SCS BM 8-90 located approximately 1 mile west of the dam to tie-in construction layout for work and as-built survey data. In addition, construction activity involving heavy earthmoving equipment shall be conducted using delineated work zones and planned haul routes that avoid existing monuments (including project survey control stakes). The Contractor has the responsibility of protecting the survey monuments from damage and inadvertent altering from its own earthmoving equipment and construction activity, including its subcontractors.

Delete the following:

Reference to right-of-way monuments is not applicable to this project.

Subsection 405.2 – Materials

Add the following:

Construction materials for a new monument will only be required if the Contractor inadvertently damaged an existing monument and therefore is responsible for its replacement.

Materials required for the protection of existing monuments includes, but is not limited to, painted lath or staking, flagging, barricades, orange safety fence, etc.

Subsection 405.3 – Construction

No changes.

Subsection 405.4 – Installation

Delete the following:

Reference to this subsection is not applicable to the project.

Subsection 405.5 – Payment

Add the following:

No payment shall be made for protection or possible replacement of a survey monument. Should the replacement of a survey monument be necessary, the Contractor would bear the associated costs for construction and independent detailed survey and seal by a registered land surveyor.

NO BID ITEM

---End of section---

SECTION 515 – TRASH RACK

Trash rack shall conform to the following:

The MAG Uniform Standard Specifications does not include a section for trash racks, however, MAG Standard Detail 502 has been incorporated and modified as shown on the plans.

Subsection 515.1 - Description

Add the following:

A shop-fabricated trash rack shall be provided and installed for each of the three outlet structures. The trash rack shall be installed on the upstream side of the outlet pipe structure and anchored to the existing concrete pad. A trash rack shall be installed at the following locations:

North Outlet Structure	48-inch pipe
Central Outlet Structure	48-inch pipe
South Outlet Structure	24-inch pipe

The trash racks shall be fabricated to the dimensions and specified materials shown on the plans. All surfaces shall be shop primed.

Subsection 515.2 – Materials

Add the following:

Subsection 515.3 – Coupling Bands

Subsection 515.4 – Fabrication

Subsection 515.5 – Installation

Subsection 515.6 – Measurement

Subsection 515.7 – Payment

BID ITEM 515-1 TRASH RACK

Subsection 515.4 – Permissible Variations in Dimension

NO BID ITEM

---End of section-------------------------------------

SECTION 525 – PNUEMATICALLY PLACED MORTAR

The pneumatically placed mortar shall conform to Section 525 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 525.1 - Description

Add the following:

Pneumatically placed mortar shall be applied to the sides and bottom of the north outlet channel to the extent existing concrete lining is damaged as a result of construction.

Delete the following:

Reference to the dry mix process is not applicable to this project.

Subsection 525.2 – Dry Mix Process

Reference in this section is not applicable to this project.

Subsection 525.3 – Wet Process

Add the following:

The required gradation as shown in Table 525-1 shall be Gradation No. 1.

The minimum thickness shall be 3 inches.

Subsection 525.4 – Reinforcing Steel

Add the following:

Welded wire fabric shall be used. Overlap of 12 inches shall be maintained for splicing fabric pieces, wired together.

Delete the following:

Reference to steel bars is not applicable to this project.

Subsection 525.5 – Equipment

Add the following:

The Contractor or Subcontractor shall provide sufficient documentation of previous projects similar in nature that are directly relevant to the company and the foreman proposed to oversee the work in the field. If documentation is sufficient and approved by the Engineer and District, then a procedure for field demonstration and testing is not required.

Subsection 525.6 – Surface Preparation

No changes.

Subsection 525.7 – Forms and Ground Wires

Subsection 525.8 – Joints

No changes.

Subsection 525.9 – Finishing

No changes.

Subsection 525.10 – Curing

No changes.

Subsection 525.11 – Testing

No changes.

Subsection 525.12 –Subsection 525.5 – Payment

No changes.

BID ITEM 525-1 PNUEMATICALLY PLACED MORTAR

--End of section--

SECTION 530 – PAINTING

Painting shall conform to Section 530 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 530.1 - Description

Add the following:

Painting shall be applied to the metal trash racks installed as part of this project at each of the three outlet structures.

Subsection 530.2 – Materials

Add the following:

Paint materials shall consist of weather-resistant, UV resistant, acrylic paint manufactured for metal surfaces. The paint shall be compatible with shop primers used in the fabrication of the trash racks.

Paint material shall meet or exceed the following requirements:

Color		industrial gray
Type		acrylic
System		two coat
Solids Content	0.5 %	
Thickness per coat		3 mils

Subsection 530.3 – Installation

Add the following:

The trash racks will be shop fabricated and primed to the dimensions and details shown on the plans. Upon completion of installation of each trash rack and approval by the Engineer, the trash racks shall be painted. The trash rack may also be painted prior to installation and touched up after upon the Engineer's approval of timing and sequence.

Treat the shop primer as necessary to prepare for paint. Clean the surface of any residue, dirt, grease, and lightly brush with steel wool to remove oxidized contact surface. Touch up primer where scratches or marring has occurred during shipment or installation of the trash rack.

Paint the trash rack completely on all exposed surfaces with two coats, allowing time for drying per the manufacturer's recommendations. The paint may either be applied by spray or brush methods.

Do not paint during inclement weather and protect a freshly painted trash rack from rain for at least 24 hours.

Subsection 530.4 – Measurement

Add the following:

The measurement of painting will be made on a per trash rack basis. There are three trash racks.

Subsection 530.5 – Payment

Payment will be made for each trash rack painted to the Engineer's satisfaction. Payment shall be for inclusive materials, labor, equipment, and supervision.

BID ITEM 530-1 PAINTING

---End of section---

SECTION 621 – CORRUGATED METAL PIPE AND ARCHES

Outlet construction/extension shall conform to Section 621 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 621.1 - Description

Add the following:

The outlet pipe extension shall consist of cylindrical, polymer coated, corrugated metal pipe as specified in Section 760 and at each of three locations as shown on the plans.

Delete the following:

Reference to arched or elliptical metal pipe or culvert is not applicable to this project.

Subsection 621.2 - Materials

Add the following:

Corrugated metal pipe, couplings, and coating shall be according to Section 760.

Subsection 621.3 – Installation

Add the following:

A universal band coupling with gasket shall be used to join the existing pipe and new pipe. The universal coupling is required because the existing pipe has standard corrugations and the new pipe required is helical wound corrugated pipe. A typical detail is shown on the plans for both the 24-inch diameter and 48-inch diameter pipe.

Marring or damage to the polymer coated pipe shall be repaired in the field using like polymer system as recommended by manufacturer of primary coating system. Any damage or marring shall be brought to the attention of the Engineer and repairs shall be witnessed by the Engineer.

Delete the following:

Reference to Section 601 is not applicable to this project.

Reference to Standard MAG detail for corrugated metal pipe is not applicable to the project.

Reference to bituminous coating on the pipe is not applicable to the project.

Reference to repair of damaged shop-applied coating using bituminous coating is not applicable to this project.

Subsection 621.4 – Test Specimens

Add the following:

Manufacturer certification and/or test data indicating the polymer coating has been properly applied to the pipe and at the required thickness.

Delete the following:

Reference to bituminous material testing is not applicable to this project.

Subsection 621.5 - Measurement

Add the following:

All pipe installation shall be measured on a per linear foot basis.

Subsection 621.6 - Payment

Payment for the installation of outlet pipe extensions shall be made on the basis of the price bid per linear foot, and shall be full compensation for furnishing and installing the pipe, coatings, and couplings, and all incidental work not specifically covered in other pay items.

BID ITEM 621-1 – CORRUGATED METAL PIPE

--End of section--

SECTION 760 – COATING, CORRUGATED METAL PIPE AND ARCHES

The coatings and corrugated metal pipe for the outlet extension shall conform to Section 760 of the MAG Uniform Standard Specifications except as modified herein.

Subsection 760.1 - Description

Add the following:

Corrugated metal pipe shall be used to extend the outlets at each of the three locations to the dimensions shown on the plans.

Polymer coating shall be shop-applied and touched up in the field.

Standard universal coupling shall be used to join the existing pipe with the new pipe.

Subsection 760.2 – Materials

Add the following:

Corrugated metal pipe shall be 24-inches diameter for the South outlet extension.
Corrugated metal pipe shall be 48-inches diameter for the Central outlet extension.
Corrugated metal pipe shall be 48-inches diameter for the North outlet extension.

Wall thickness of pipe at all three locations shall be .079 inches (14 gauge).

Coupling shall be universal type, bolted with gasket.

Coating shall be polymer system applied at a minimum 10 mils thickness per ASTM A742.

Gasket material shall be a standard neoprene, manufactured fit for the respective pipe diameter and coupling type.

Subsection 760.3 – Metal, Spelter and Fabrication

Incidental to

---End of section---

APPENDIX A

EXCERPTS FROM
UNIFORM STANDARD SPECIFICATIONS AND DETAILS
FOR
PUBLIC WORKS CONSTRUCTION

MARICOPA ASSOCIATION OF GOVERNMENTS

(TO BE SUBMITTED WITH THE FINAL REPORT)

APPENDIX F

CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL PLAN

CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL PLAN
(DESIGN 60 PERCENT SUBMITTAL)

FOR THE

INTERIM DAM SAFETY PROJECT
WHITE TANKS FRS #3

FOR

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

February 10, 2000

CQA PLAN
TABLE OF CONTENTS
(60 PERCENT SUBMITTAL)

LIST OF TABLES

1.0 INTRODUCTION

This Construction Quality Assurance Plan (CQA Plan) applies to the provision of Construction Quality Assurance services for the procurement and construction of components of the Interim Dam Safety Project for the FRS #3.

1.1 PLAN PURPOSE

The purpose of this plan is to provide a project-specific technical guide to the Owner and its representatives to ensure a quality project, defensible documentation, and conformance with the drawings and specifications. This plan has been prepared on behalf of the Flood Control District of Maricopa County (the District), the owner and operator of the FRS #3 located in west Phoenix, near the White Tanks mountains. This CQA Plan has been prepared by Dames & Moore as part of the Interim Dam Safety Project; White Tanks FRS #3, Contract No. FCD98-11.

1.2 SCOPE OF THIS DOCUMENT

This plan address the quality control and assurance of the construction work associated with this project. Assurance in the quality expected on this project and conformance with approved drawings and specifications relies upon the execution of this plan, specifically the field monitoring and documentation of the activities. This CQA Plan therefore outlines in detail the CQA procedures that are provided and shall be considered in conjunction with the project contract, drawings, and specifications. The construction activities requiring CQA procedures in this document include:

- Meetings
- Measurement and Payment Verification
- Site Visits and Observations
- Earthwork
- Piping
- Survey Control

Any conflict between the requirements of this document and the approved drawings and specifications shall be reported to the Engineer, for clarification or adjudication, as required. In general, however, the requirements of the specifications shall prevail.

1.3 DEFINITION OF QUALITY CONTROL VERSUS QUALITY ASSURANCE

There is often considerable confusion between the definition of quality control and quality assurance. This document refers to the provision of quality control and quality assurance for various components of the project:

- **Quality Control** refers to those actions taken by all parties involved in the construction, including the Contractor, those parties charged with procurement and installation of manufactured materials, and the placement and compaction of the soil materials, which provide a means to determine and sometimes quantify the characteristics of the product. The results of a quality control program are compared to the specifications or other contractual or regulatory requirements. During each aspect of the handling of these materials, quality control is provided by the manufacturer, fabricator, or installer of materials, or the supplier and earthworks contractor for the soils, to ensure that the materials and workmanship conform to the plans and specifications. Quality control responsibility is retained by the Contractor, suppliers, and manufacturers because these entities have the most direct control over qualifications of personnel, specialized experience or expertise, choice in type and quantity of equipment, scheduling, sequencing, and workmanship that all factor in to the quality of the finished project.

- **Quality Assurance** is a planned and systematic pattern of all means and actions intended to provide adequate confidence that the materials and procedures conform to the plans and specifications, and any applicable regulatory requirements. Quality assurance can either be provided by the Owner, or their designated representative, which is often an independent consulting, engineering, or construction management firm. Although quality assurance is as important during all phases of the project, construction quality assurance is often in association with those actions taken in relation to the installation of the geosynthetics materials, installation of structural concrete, and the placement and compaction of the soils materials. CQA is a critical component of a project because field conditions are the most variable and the most difficult to control and documentation is being recognized as invaluable to Owners and regulatory agencies.

2.0 PARTIES TO THE WORK AND RESPONSIBILITIES

The successful completion of the production and installation of the liner and capping systems is dependent on the interaction and cooperation of many parties. The following parties are represented in the project.

Engineer. The Engineer for this project is Dames & Moore of Phoenix, Arizona.

General/Earthwork Contractor. The General/Earthwork Contractor is responsible for the mass earthworks, development of final slopes, placement of diaphragm filter sand, placement at riprap, placement of geotextile, placement and compaction of structural fill. The General/Earthwork Contractor, or its approved subcontractor, is responsible for pipe installation.

Subcontractors. The Subcontractor is retained directly by the General/Earthwork Contractor and is likely responsible for specialty work such as surveying, fencing, commercial sand and rock suppliers, etc.

Geosynthetics Manufacturer. The Manufacturer(s) of the geotextile filter fabric.

CQA Consultant. The CQA Consultant is responsible for the monitoring and documentation of the activities of the General/Earthworks Contractor. The CQA Consultant for this work is the Engineer, Dames & Moore.

CQA Director. The CQA Director, a designated person or department of the District, is responsible for overseeing the CQA Consultant and participates in the monitoring and documentation of the activities of the General/Earthworks Contractor.

Soils Laboratory. The Soils Laboratory is a party, independent of the General/Earthwork Contractor, that is responsible for the laboratory testing and reporting to verify the soil materials' conformance to the Specifications. In addition, quality control testing may be conducted to determine the as-compacted conditions of the soil materials for conformance with the Specifications. The CQA Consultant is responsible for the selection of samples from the site, and shipping them to the Soils Laboratory. The Soils Laboratory testing can be retained by the District or the Engineer.

Owner. The Owner is the Flood Control District of Maricopa County (the District).

Responsible Regulatory Agencies. The regulatory agency for the design and construction of the Interim Dam Safety Project: FRS #3 is Arizona Department of Water Resources (ADWR).

2.1 CQA TEAM

The CQA Director assigned by the District will be the Owner's representative during the construction phase of the project.

- **CQA Director.** The CQA Director shall be a registered professional engineer (P.E.) in the state of Arizona and is responsible for all of the activities of the CQA Consultant. The CQA Project Director will be kept appraised of field progress and decisions and will visit the site to review the operations and progress by the CQA Consultant.

The CQA Consultant is responsible for the provision of construction quality assurance services for the installation of the lining system. The personnel of the CQA Consultant include:

- **CQA Consultant Manager.** The CQA Consultant Manager shall be a registered professional engineer (P.E.) in the state of Arizona and is responsible for all of the activities of the CQA Consultant. Duties include final reviewing all on-site activities, laboratory test results, and directly addressing any deficiencies that are encountered. In addition, the CQA Consultant Manager will be kept appraised of field progress and decisions and will visit the site to review the operations and progress by the CQA Consultant team members.

- **CQA Construction Manager**. The CQA Construction Manager, demonstrating experience in construction and field oversight, will be involved in design and construction issues and provide liaison activities which bridge the two phases of the project, and provide construction management insight and guidance as needed to the CQA Representatives in the field on a daily basis, and assist with quantity verification and scheduling.

- **CQA Project Engineer**. The Project Engineer, who is intimately knowledgeable with the design calculations and design intent, will interface in the field to provide technical guidance.

- **CQA Field Representative.** The on-site representative of the CQA Consultant, the CQA Field Representative, liaisons directly with the CQA Director, the General/Earthworks Contractor, and will coordinate with CQA Technicians on site.

- **CQA Field Technicians.** The CQA Field Technicians, either employed by the CQA Consultant or by an independent construction materials testing company, performs soil materials testing, primarily compaction density testing. CQA Field Technicians may be used on an on-call, as-needed basis.

The specific functions and responsibilities of these personnel are presented in the following sections.

2.1.1 CQA Director

The CQA Director is the Owner's representative administers the contract and technical direction for the CQA Consultant. In particular, the CQA Director:

- Reviews the design, Plans, and Specifications for the project.
- Co-administers the CQA program with the CQA Consultant.
- Receives and reviews weekly reports, and provides final reviews laboratory and field test data submitted by the CQA Consultant.
- Participated in progress meetings.
- Periodically visits the site to review progress of the CQA program.
- Participates in any proposals for changes to the design, Plans, or Specifications that may be necessitated by field conditions.
- Receives and reviews the draft and final CQA report.

2.1.2 CQA Consultant Manager

The CQA Consultant Manager is the professional engineer (P.E.) in direct charge of the CQA program and certifies the work for submittal to the *regulatory agency*. In particular, the CQA Consultant Manager:

- Reviews the design, Plans, and Specifications for the project.
- Co-administers the CQA program with the District, including the supervision of the CQA Construction Manager, CQA Project Engineer, and CQA Field Representative.
- Review progress with the CQA Construction Manager and CQA Field Representative, review of all daily and weekly reports, review and interpretation of all

laboratory test data, and engineering review of any aspects of the liner system during installation.

- Periodically visits the site to review progress of the CQA program.
- Participate in any proposals for changes to the design, Plans, or Specifications that may be necessitated by field conditions.
- Prepares, with the CQA Construction Manager and CQA Field Representative, the draft and final CQA report.

2.1.3 CQA Construction Manager

The CQA Construction Manager is involved in the office and fieldwork and will conduct the following:

- Attend Pre-Bid and Pre-Construction conferences.
- Attend periodic progress meetings and conduct site visit.
- Scheduling of CQA team
- Supervises and reviews daily field reports from CQA Field Representative and Technicians.
- Review the schedule and progress to-date and provide recommendations for corrective actions, if any.
- Observe construction procedures and, with the CQA Project Engineer, assess that the intent of design is being met.
- Assist in resolving potential issues that may come up, including, but not limited to, schedules, non-conformance to drawings and specifications, methods, equipment, payment, and sequencing.
- Prepare a weekly summary report for the designated District representative that outlines progress, problems, and resolutions.
- Assist with punch list development and final inspections.
- Assist with preparing draft and final CQA Report.

2.1.4 CQA Project Engineer

The CQA Project Engineer will be an integral part of the team both in the office and field, by conducting the following:

- Budget management
- Review of Contractor submittals
- Review of CQA/QC results
- Review of daily field notes

- Assist with final acceptance of construction and report
- Attend progress meetings (as necessary)
- Conduct routine site visits
- Provide design clarification in general
- Provide technical direction on critical start-up activities
- Review material gradations and selection submittals

2.1.5 CQA Field Representative

The CQA Field Manager is the full-time on-site representative of the CQA Consultant. The CQA Field Representative:

- Serves as the on-site representative of the CQA Consultant and supervises all other CQA Field Technicians.
- Reviews the CQA Plan, project Plans, and Specifications for the site, and ensures that all CQA Field Technicians are fully informed of the requirements of the work.
- Assigns the daily responsibilities of all CQA Field Technicians, to ensure that all relevant activities of the General/Earthworks Contractor are monitored and documented.
- The CQA Field Representative shall prepare daily field reports (notes) documenting the activities of the General/Earthworks Contractor for each day worked.
- Attends all progress meetings as required plus any activity-specific meetings necessary to review the installation of a critical component and/or CQA activities.
- Collects, collates, and reviews the documentation provided by the General/Earthwork Contractor and their suppliers of the materials to be used on the project.
- Observing and verifying by review of data made available by the contractor that construction is performed to the depths, lines, and grades as indicated on the drawings.
- Selects sample locations for conformance testing of all soils in accordance with the frequencies and test requirements specified, forwards these samples to the Soils Laboratory, and reviews all results for conformance and acceptability.
- When necessary, designates another of the on-site CQA personnel to act on his behalf whenever he is absent from the site, to ensure continuity during operations.
- Prepares, with the CQA team, the final completion report.

In addition, the CQA Field Representative regularly reports on both a verbal basis, and through periodic submittal of the daily CQA reports, to the designated District Representative to ensure that any problems are identified and communicated to all parties of the project on a timely basis.

2.1.6 CQA Field Technicians

One or more CQA Field Technicians will be assigned to the project on an on-call basis to ensure that the activities of the Earthworks Contractor are adequately tested for quality control and documented. The activities to be monitored, and duties to be carried out within the scope of the overall CQA program include:

- Schedule, observe, perform, and/or report construction materials testing.
- Examination of all soils delivered to the site and collection of samples for laboratory testing for conformance to the specifications. Testing type and frequency is estimated in Table 1, however the actual test selection and frequency of testing will be a the discretion of the CQA team and the District based on field conditions and construction sequence.
- Testing, monitoring, and documenting the placement, backfilling, and compaction of all earthwork components and material types. Testing will include field moisture determinations, field compaction density by nuclear methods and by sand cone methods.

3.0 MEETINGS

Meetings of all parties are required at various times during the project based on the following objectives:

- Establish work schedules
- Resolve problems
- Generally maintain good lines of communication.

3.1 PRECONSTRUCTION MEETING

The Pre-construction Meeting is held in advance of the start of construction, to introduce all parties, and resolve any particular issues prior to the commencement of work, and to establish the requirements for construction quality assurance.

The following is a typical agenda for a pre-construction meeting:

- Use of site by contractor and owner.
- Owner's contract or site requirements.
- Construction facilities and temporary controls provided by Contractor.
- Survey layout.
- Security protocols.

- Housekeeping procedures.
- Public relations and confidentiality protocols.
- Inspections required.
- Quality control of major or critical activities in the project and a methodology.
- Proposed schedules and sequence of activities.
- Identification of the responsibilities project team.
- The timing and distribution of project correspondence.
- Establish the lines of authority and communication.
- Health and safety.

The Pre-construction Meeting, may also be concluded with a site walk-around to determine the status of activities, and re-discuss items during the meeting (if necessary).

This meeting shall be documented by the CQA Consultant and minutes prepared and circulated to all present, plus any other interested parties.

3.2 PROGRESS MEETINGS

Periodic progress meetings shall be held on a schedule to be determined by the CQA Consultant and the District in order to review the status of the schedule, problems, and measures for resolution of problems. These meetings shall be documented, as required, and the decisions reached promulgated to all affected parties.

Areas of concern and potential future problems shall also be outlined, and addressed at the next planned Progress Meeting, unless of sufficient importance or urgency as to warrant an *ad hoc* meeting.

The following is a typical agenda for a pre-construction meeting:

- Review minutes of previous meetings.
- Review work progress.
- Field observations, problems, and decisions.
- Identification of problem which impede planned progress.
- Review submittals schedule and status of submittals.
- Review health and safety concerns and issues.
- Revisions to progress schedule.
- Corrective measures to regain projected schedules.
- Planned progress during succeeding work period.

- Coordination of projected progress.
- Effect of proposed changes on progress schedule and coordination.
- Potential change conditions or review of change order submittals.

4.0 MEASUREMENT AND PAYMENT VERIFICATION

Based on the final contract documents and bid schedule, the quantities are verified in the field using total count of items or survey of in-place volumes. Measurement calculation shall be initiated in the field by the CQA Representative and supported by independent registered land surveyor. The calculations are reviewed or checked by a second method to assess reasonableness. Report estimated pay measurements and explain any discrepancies.

4.1 PAYMENT REVIEW AND APPROVAL

Upon request of the District, review Contractor pay requests to render an independent opinion of progress and equitable request amount. The review is to include a written analysis discussing the major pay items and any discrepancy or suggested revision. Finally, the CQA Representative is to provide conclusions and recommendations for approval or rejection.

5.0 SITE VISITS AND GENERAL OBSERVATIONS

The CQA Project Director, CQA Project Engineer, or CQA Construction Manager shall conduct site visits, to ensure that all outstanding issues are resolved on a timely basis, and to review personally the progress and methodology of the Installer. The schedule of these site visits will be determined by project demands. In addition, the CQA Project Director, CQA Project Engineer, or CQA Construction Manager will have to make site visits when a problem arises which cannot be easily resolved or which impacts the design of the facility. In that regard, the CQA Project Director should make periodic site visits in order to review the progress and any aspects of the project that are particularly critical to the performance of the system.

6.0 EARTHWORK CQA

The soils components of the liner system, and engineered fills associated with the channel regrading will consist of a variety of materials. The construction quality assurance of these soil materials is presented in the following subsections.

6.1 STRUCTURAL FILL

The CQA Representative shall conduct the following prior to and during structural fill placement:

- Structural fill materials to be used for engineered fills shall consist of inorganic soils free of debris and gradation.
- Verify clearing, grubbing, or stripping necessary to eliminate organic matter.
- The soil should be within the required moisture content in the range for which the specified compaction is attainable.
- Coordinate field density testing and review results immediately (same day).
- Removal of oversize rocks beyond the required gradation may be accomplished by screen, handpicking, or scarification and windowing.
- The CQA Field Manager shall monitor material selection and placement.

6.2 SOILS TESTING

6.2.1 Laboratory Soils Testing

Laboratory testing of the soils materials to be used at the site shall be carried out for the purpose of materials selection prior to construction and for materials quality control and evaluation during construction operations.

6.2.2 Laboratory Conformance and Quality Control Testing

Conformance testing associated with the selection of suitable materials for use in the project will be carried out by the Soils Laboratory and evaluated by the Engineer, the District, and the CQA Consultant in advance of the commencement of construction.

Tests are to be carried out to provide quality control and ensure that the source of the materials does not vary significantly or adversely from one area of the source to another and that the properties that are required in the Specifications are met. The frequency and need for a given test is shown in Table 2.

6.2.3 Laboratory Testing Frequency

The frequency of testing required during the selection process for soil materials is a function of the quantity of each soil type required, in addition to the existing documentation of the source. In general, however, testing shall be conducted in accordance with the requirements of the project Specifications, and, at a minimum frequency as shown in Table 2 for material for each test procedure.

It should be noted that in all cases, at least one test shall be carried out, regardless of the quantity of materials placed and compacted, where relevant. The CQA Consultant shall review all laboratory test results and forward an summary of all testing to the designated District Representative and the Earthworks Contractor.

The CQA Representative shall coordinate the following laboratory testing:

- Nuclear moisture-density relation testing in accordance with ASTM D698.
- Sieve analysis in accordance with ASTM 422.
- Mortar compressive strength in accordance with ASTM _________.

6.2.4 Field Soils Testing

The CQA Consultant shall be responsible for providing field *in situ* testing of the soils after placement and compaction, to determine their as-compacted properties and confirm conformance with the Specifications. Field quality control testing is carried out as a component of the construction quality assurance program by the CQA Consultant. The principal *in situ* testing carried out is the field determination of density and moisture content.

The CQA Representative shall conduct the following activities regarding contractor's materials submittals:

- Nuclear moisture-density relation testing using a gauge in accordance with ASTM D2922 and D3017.
- Moisture-density relationship testing using the sand cone method in accordance with ASTM 1556.
- Relative density determinations in accordance with ASTM Methods D4253 and D4254.
- Mortar coring and cube preparation in accordance with ASTM C _______.

6.3 CONTRACTOR'S MATERIAL SUBMITTALS

The CQA Representative shall conduct the following activities regarding contractor's materials submittals:

- Log the receipt of contractor's submittals and correspondence.
- Review submittals for schedules.
- Review submittals for geotextile filter fabric materials.
- Review submittals for import riprap materials.
- Review submittals for import filter sand materials.
- Review submittals for pneumatically placed mortar materials.
- Review submittals for landfill and disposal documentation.
- Review submittals for measurement and pay requests.
- Review submittals for as-built data.

6.4 OBSERVATIONS

The CQA Representative shall conduct the following observations:

- General/earthwork contractor's daily activities.
- Subcontractor's daily activities.
- Surveyor's activities.
- Removal of outlet headwall structure.
- Pipe placement.
- Filter sand placement.
- Fill placement.
- Geotextile filter fabric placement.
- Trash rack installation.
- As-built survey data collection.
- Construction materials testing.

6.5 EXCAVATIONS

The CQA Representative shall conduct the following prior to and during excavation:

- Verify the excavation limits are established and agreed upon.
- Verify clearing, grubbing, and stripping has been conducted as necessary.
- Verify the excavation is conducted to the limits and thickness required as shown on

the drawings.

- Observe and verify unsuitable material (i.e. concrete, shotcrete, oversize rock) does not get commingled with structural fill that may be reused.

6.6 DIAPHRAGM FILTER SAND

The CQA Representative shall conduct the following prior to and during placement of filter sand:

- Verify the subgrade is prepared and ready to receive sand.
- Observe the placement per project specifications.
- Observe the compaction by method, equipment, and number of passes that may be necessary to achieve the desired results in the project specifications.
- Observe and verify the field density based on relative determinations.
- Verify the sand is placed to the limits and thickness required as shown on the drawings.
- Observe sand placement is not adversely affected or is damaged during placement of structural fill.

6.7 GEOTEXTILE FILTER FABRIC

The CQA Representative shall conduct the following prior to and during placement of geotextile filter fabric:

- Verify the subgrade is prepared and ready to receive fabric.
- Observe the deployment per manufacturer's recommendations and project specifications.
- Verify the fabric is placed to the limits required as shown on the drawings.
- Verify overlap dimensions are achieved.
- Observe fabric is anchored properly to resist uplifting due to wind and sliding during rock placement.
- Observe rock placement and verify that fabric does not move or is damaged.

6.8 RIPRAP

The CQA Representative shall conduct the following prior to and during placement of riprap:

- Verify the subgrade is prepared and ready to receive riprap.
- Verify the riprap meets the gradation requirements.
- Observe the placement per project specifications.
- Verify the riprap is placed to the limits and thickness required as shown on the drawings.
- Observe hand placement of riprap to achieve desired results and intent of project requirements.

7.0 PIPING CQA

The CQA Representative shall ensure the manufacturer submits the appropriate certification of pipe and fitting materials for the application of this project.

7.1 SHIPPING, HANDLING, AND STORAGE

The CQA Representative shall be on-site at the time of receipt of material and observe off-loading procedures. The following verifications shall be made:

- Pipe and fitting material complies with specification requirements.
- Pipe and fitting material to be off-loaded is not damaged before or during off-loading operations.
- The pipe materials are placed out of the traffic so that damage does not occur.
- Inappropriate equipment and procedures such as fork lifts used with separation 2 by 4 boards.
- The pipe ends are kept clean and free of soil and debris during handling and storage.
- The pipe is inspected for possible damage within one hour of installation.

7.2 PIPE INSTALLATION

The CQA Representative shall monitor the installation of pipe at all times to the greatest extent possible. The CQA Representative shall ensure that in his absence the Owner's Representative or Contractor's superintendent is present during pipe placement, joining, and backfilling.

The CQA Representative shall observe several activities that may be occurring simultaneously, including, but not limited to, the following:

- Verify the area to receive pipe is marked and the alignment and grade is correct.
- Upon observation and complete inspection of the installed pipe, the placement of backfill materials shall be monitored to prevent any dumping of bulk material directly onto the top of the pipe. Also observe the careful placement of the required uniform

6 inch loose lift on either side of the pipe and observe that proper haunching is being conducted.

- Observe that successive lifts of select material are properly placed without displacing the pipe and that the pipe is held firmly in place by the compacted fill.
- Document all verifications and observations made, including the number of passes with compaction equipment.

8.0 FIELD DOCUMENTATION

8.1 DAILY FIELD REPORTS

The CQA Representative shall document in his/her daily field reports following:

- Name
- Company name
- Date
- Start time and ending time
- Weather
- Job reference number
- Contractor or subcontractor onsite
- Major equipment onsite and/or used (or list)
- Page number
- Visitors to the site
- Activities performed that consumed the day
- Activities performed started or restarted that day
- Activities performed started or completed critical to the project
- Reference attached test results, sketches, etc

8.2 LOG FORMS

The CQA Representative shall use and maintain the following log forms:

- Soil sample collection and laboratory chain-of-custody
- Soil density results
- Concrete/mortar test results
- Contractor submittals

- Photographs
- Daily field reports
- Record of conversation

8.3 PHOTOGRAPHS

The CQA Representative shall document the following project activities using photographs:

- Existing conditions
- Progress of key activities at the various steps or phases of implementation
- Areas or items that are planned to be buried and not expected to be seen
- Completed components of work as project progress
- Completed project from various views (taken in last few days of work)

Photos are developed in duplicate to provide the District a full set of photo documentation.

9.0 CQA FINAL REPORT

Upon completion of the project, the CQA Consultant will prepare the CQA Final Report. This report will be the final record of the Construction Quality Assurance information for the site. In general, the report shall include all submittal items discussed in this CQA Plan. This shall include, at a minimum:

- The pipe manufacturer's certification and warranty documents.
- Field notes from the installation procedure, including such information as weather and unusual circumstances.
- Summary tables of results for soils.
- The geotextile filter fabric manufacturer's data.
- Compilation of copies of photo documentation.
- Field notes during construction and installation.
- The results of all soils testing, including both *in situ* field testing and laboratory testing in an appendix.

The report shall also provide a narrative description, in general, of the site's construction, noting all unusual occurrences encountered (i.e., failed seams, extreme weather, etc.). This report shall be provided to the District shortly after the completion of work.

TABLES

TABLE 1

MINIMUM CQA/QC EARTHWORK TESTING REQUIRED

Test Methods		Frequency of Tests			
Reference	Description	Foundation/ Subgrade	Structural Fill	Coarse Rock	Diaphragm Filter Sand
ASTM D422	Particle size	500 l.f.		0	1/500 cy/matl
ASTM D698	Laboratory compaction-standard			0	
ASTM D1557	Laboratory compaction-modified	500 l.f.			1/500 cy/matl
ASTM D1556	In-place density by sand cone method	0	0	0	1/10 nuclear test
ASTM D2216/D4643	Laboratory Moisture content (oven-dry)	0	0	0	1/10 nuclear test
ASTM D2922	In-place density by nuclear methods	200 l.f.	200 l.f.	0	100 l.f.
ASTM D3017	Field moisture content	1/500 cy	1/500 cy	0	1/500 cy
ASTM D4318	Atterberg limits	0	0	0	0
The frequency of testing presented in this table is based on the minimum testing required. Final quantities will be at the discretion of the CQA Engineer.					

APPENDIX G

DECEMBER 1999 SURVEY

TO BE PROVIDED IN 90 PERCENT REPORT