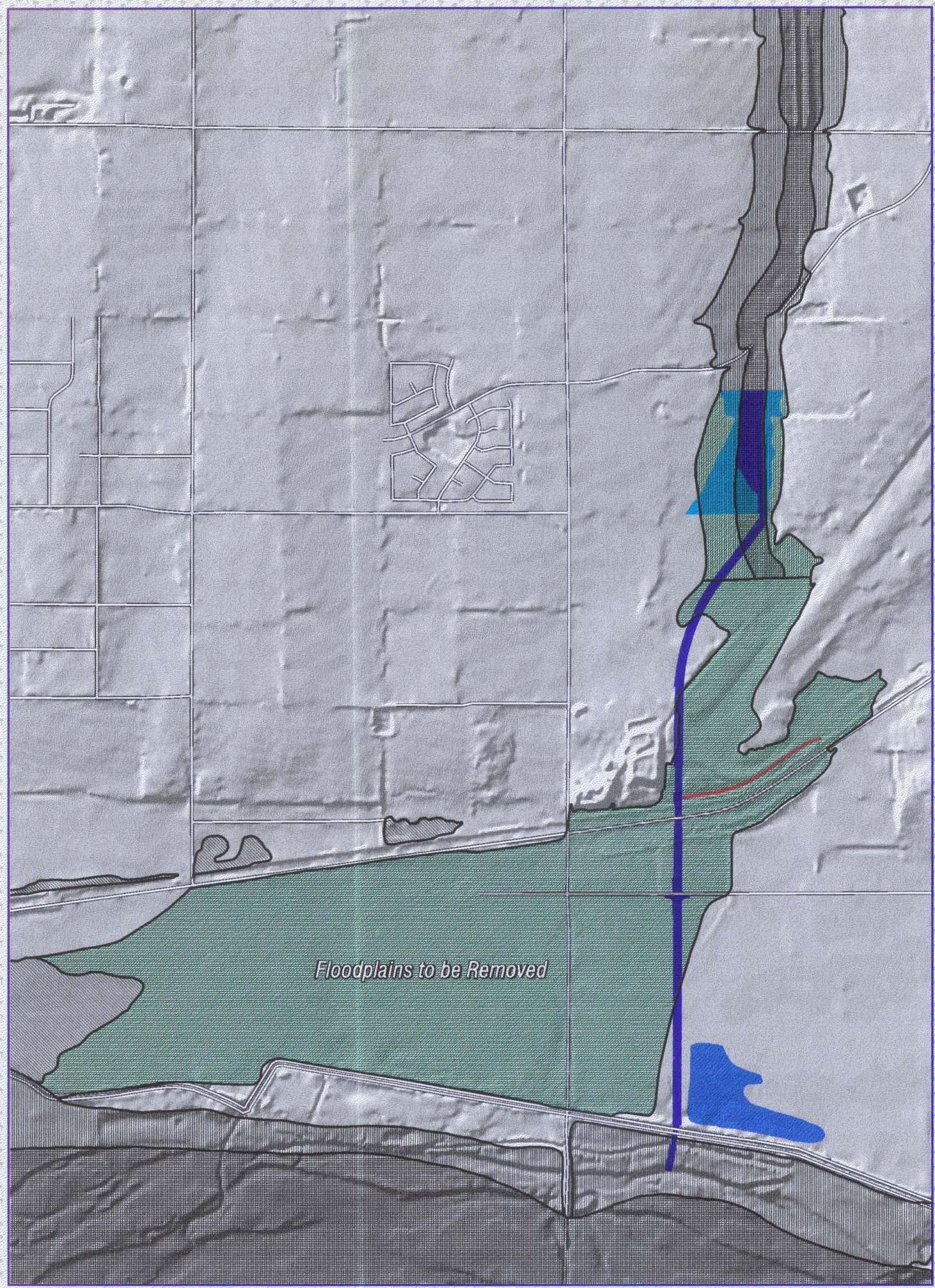
Bullard Wash Channel Improvements

City of Goodyear, Maricopa County, Arizona

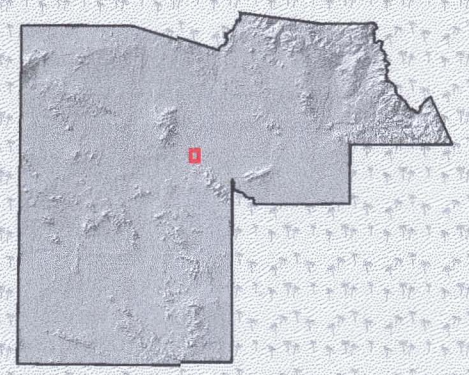
TECHNICAL DATA NOTEBOOK

VOLUME 2 OF 2

FCD #95-39



Location within Maricopa County



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FLOOD CONTROL DISTRICT of MARICOPA COUNTY

CITY OF GOODYEAR ARIZONA

BULLARD WASH CHANNEL IMPROVEMENTS

City of Goodyear, Maricopa County, Arizona

TECHNICAL DATA NOTEBOOK

VOLUME TWO

FCD #95-39

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Prepared for:

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Suite 101
Tempe, AZ 85281
(602) 303-9799

And

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
2801 West Durango
Phoenix, AZ 85009
(602) 506-1501

Prepared by:

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1550 East Missouri Avenue, Suite 203
Phoenix, AZ 85014
(602) 234-1344

Registered Professional Engineer (Civil)
CERTIFICATE NO. 22208
JACK K. MOODY
Date Signed 11/4/98
ARIZONA, U.S.A.

Registered Professional Engineer (Civil)
CERTIFICATE NO. 32842
DAVID T. PHELPS
Date Signed 4 Nov 98
ARIZONA U.S.A.

November 4, 1998
WP #96464

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(Following Appendices)

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Exhibit B	Proposed Construction Plans (submitted under separate cover)
Exhibit C	Proposed Floodway Work Maps

Registered Professional Engineer (Civil) CERTIFICATE NO. 22208 JACK K. MOODY Date Signed 11/4/97 ARIZONA, U.S.A.

Registered Professional Engineer (Civil) CERTIFICATE NO. 32842 DAVID T. PHELPS Date Signed 4 Nov 98 ARIZONA U.S.A.

1.0 INTRODUCTION

1.1 Background

The Flood Control District of Maricopa County (FCDMC) has contracted (FCD #95-39) with Sverdrup Civil, Inc. (Sverdrup) to complete final design plans and construction documents for the channelization of Bullard Wash between the Gila River and Lower Buckeye Road. Wood, Patel & Associates, Inc., as a sub-consultant, has been assisting Sverdrup on several tasks, more specifically, hydraulics, sediment transport, and scour analysis for the proposed design.

The flooding potential of the area has been previously studied in the *White Tanks/Agua Fria Area Drainage Master Study (ADMS)* prepared by the WLB Group and submitted to the FCDMC in October, 1992. In addition, the *Bullard Wash Outfall Feasibility Study, Final Design Concept Report for Recommended Alternative* was prepared for the District by Stanley Consultants, Inc. (Stanley) and submitted in September 1995. That Report documented a recommended alternative for the Bullard Wash Outfall Channel. Subsequent to the Stanley Report, the FCDMC has selected a horizontal alignment of the channel and type of channel lining, including typical cross-sections, with input from the City of Goodyear, Maricopa County Department of Transportation (MCDOT), and Sverdrup.

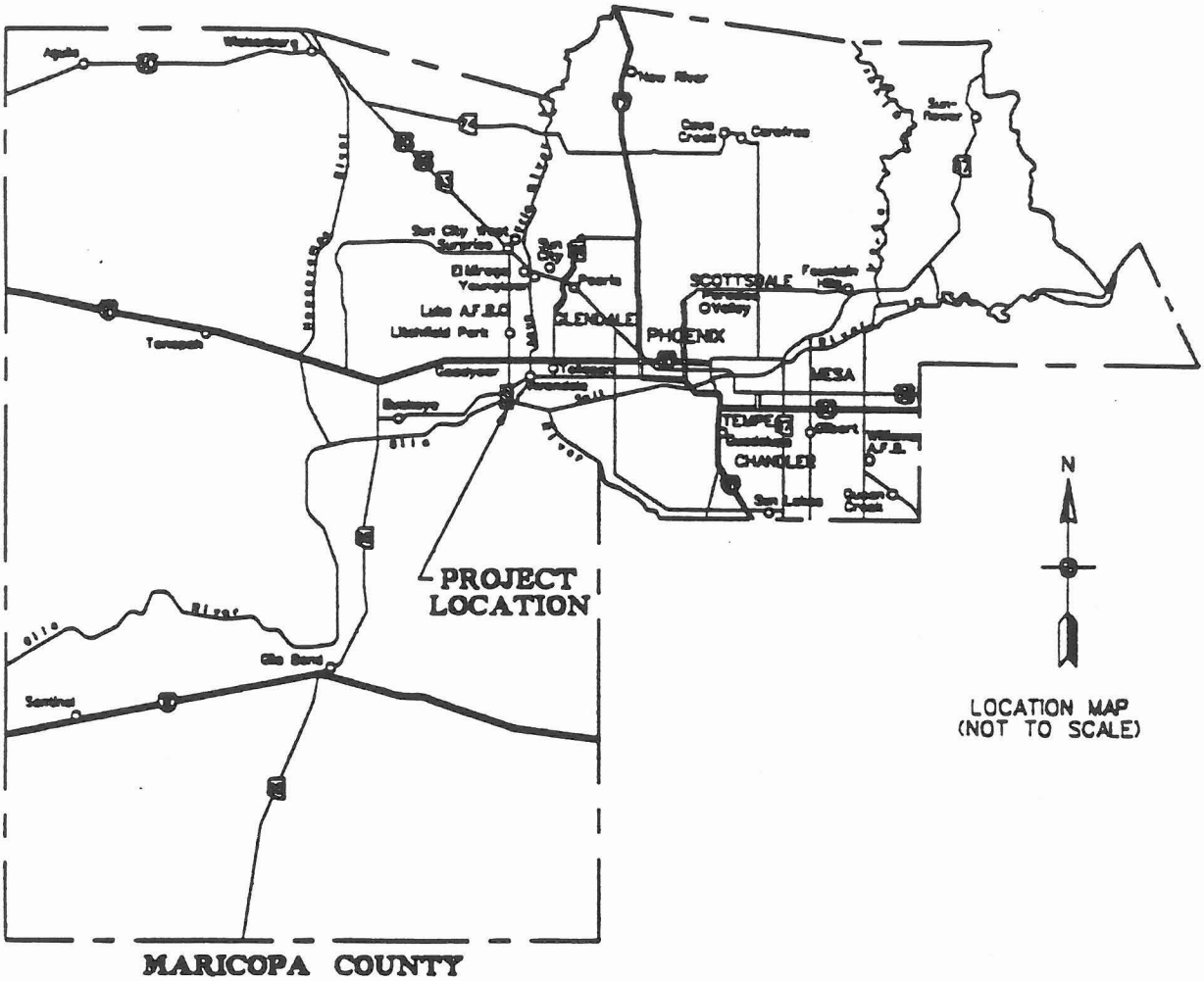
Bullard Wash is approximately eight miles long, and originates just south of Luke Air Force Base near Bethany Home Road. The wash continues south between Estrella Parkway (formerly Reems Road) and Bullard Avenue. The outfall of Bullard Wash has been encroached upon, and in some locations almost completely obliterated due to farming activities over the years. The Bullard Wash Channel ends near the Maricopa County Highway Route 85 (MC 85) - Estrella Parkway intersection, with only a minor roadside ditch and 42" cmp outfall pipe to convey low flows to the Gila River. Due to various encroachments and the elimination of a positive outfall, the area is subject to substantial flooding, as documented in the White Tanks/Agua Fria ADMS.

The project area lies entirely within the incorporated limits of the City of Goodyear between Sarival Road on the west, Bullard Avenue on the east, Yuma Road on the north, and the Gila River on the south. The Bullard Wash Floodplain upstream from Yuma Road is relatively free from encroachment, diversions, and obstruction and was, therefore, not included in this project. This submittal documents Phases 1 and 2 of the Bullard Wash Outfall Channel from the Gila River to Lower Buckeye Road.

There are major transportation facilities located within the study area involving the jurisdictions of MCDOT (MC 85), the City of Phoenix (Phoenix - Goodyear Municipal Airport), the Union Pacific Railroad (UPRR, formerly Southern Pacific Railroad), as well as the local roadways within the City of Goodyear right-of-way. The study area also includes jurisdictions of the Buckeye Irrigation District (BID) and the Roosevelt Irrigation District (RID). There are also numerous major utilities within the study area. Figures 1 and 2 indicate the location and vicinity of this project.

The results of this project are documented in two separate technical data notebook volumes with this report being Volume Two. The sister report to this is titled *Bullard Wash Channel Improvements, Technical Data Notebook, Volume One*, November, 1998. For ease of discussion, that report will be herein referred to as TDN Volume One.

BULLARD WASH OUTFALL FEASIBILITY STUDY
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
(FCD 94-06)

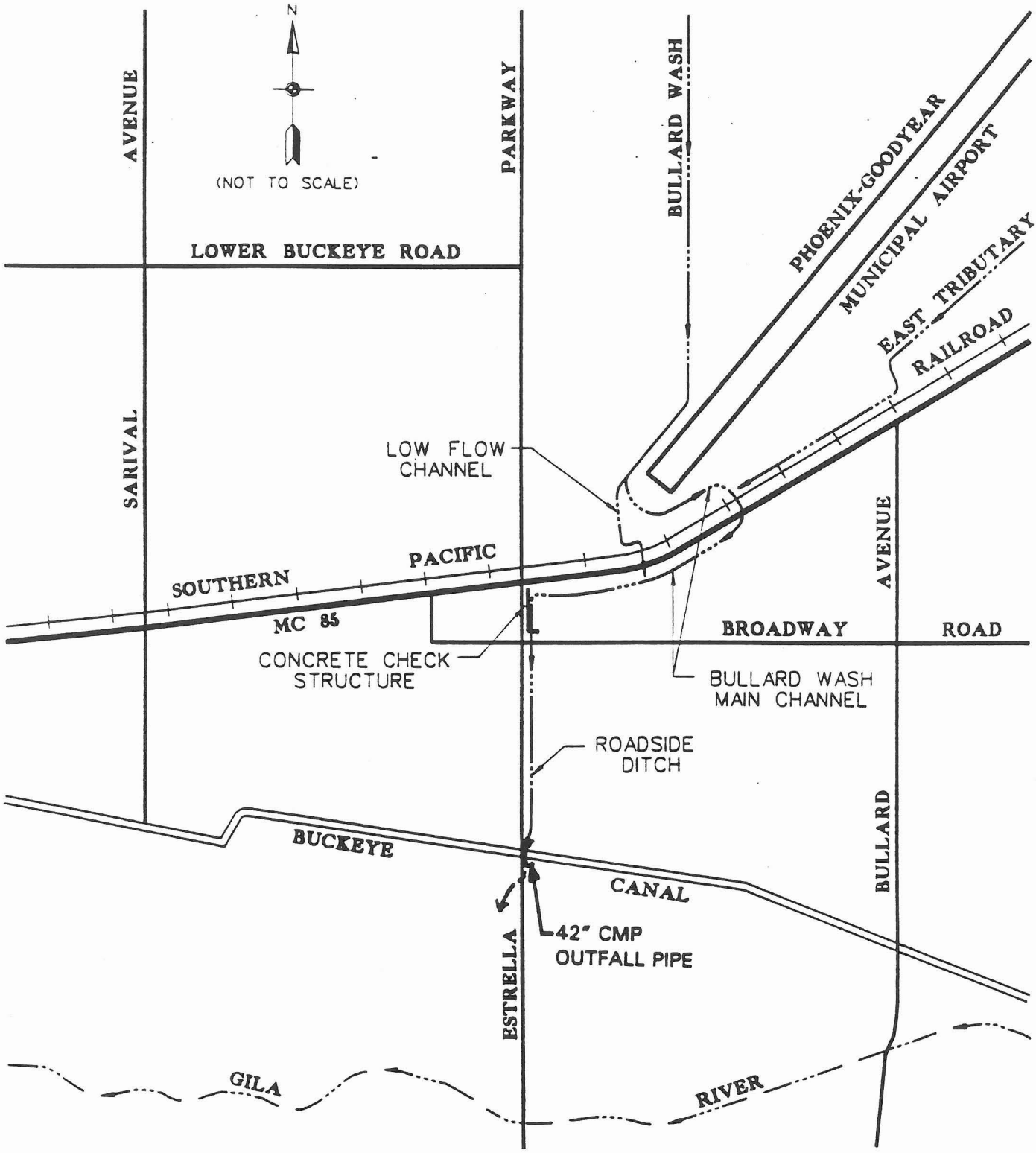


MARICOPA COUNTY
LOCATION MAP

FIGURE 1

Source: Bullard Wash Outfall Feasibility Study

BULLARD WASH OUTFALL FEASIBILITY STUDY
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
(FCD 94-06)



VICINITY MAP

FIGURE 2

Source: Bullard Wash Outfall Feasibility Study

1.2 Purpose and Scope

During the initial design phase of this project, Sverdrup, together with the FCDMC, the City of Goodyear, and MCDOT, agreed upon a revised channelization concept. The concept addressed the City's requirements on the aesthetics, recreational, and equestrian needs, as well as maintenance issues. As a result, a workable channel cross-section, style of bank protection, and drop structure scheme have been mutually agreed upon for this channelization project.

The purpose of this Report is to document the channel design, including key channel features such as typical bank protection and type of drops used. In addition, it documents design constraints, such as highway, railroad, canal, irrigation, and utility conflicts as well as environmental constraints, floodplain issues, and recreational facilities. This Report is intended to follow the Arizona Department of Water Resources (ADWR) State Standard SS-97 Technical Data Notebook (TDN) format.

The Scope of this Report along with TDN Volume One is to provide a TDN package documenting the proposed Bullard Wash Channelization sufficient to obtain a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA).

1.3 Methods of Analysis

The following methods of analysis are used for this project:

- Hydrology - methods as documented in the *FCDMC Drainage Design Manual, Volume I, Hydrology,* revised January 1995. The 100-year, 24-hour peak design discharge is 3,200 cfs for Bullard Wash, as modeled by the US Army Corps of Engineers (COE) HEC-1 Version 4.0.1e microcomputer software.

- Hydraulics - methods as documented in the *FCDMC Drainage Design Manual, Volume II, - Hydraulics,* January 1996. The proposed channel is modeled utilizing the COE HEC-RAS Version 2.1 hydraulic modeling software.

- Erosion and Sedimentation Transport - methods of erosion and sediment transport analysis as documented in ADWR, *Design Manual for Engineering Analysis of Fluvial Systems,* 1985.

2.0 ADWR/FEMA FORMS

2.1 Study Documentation Abstract for FEMA Submittals

Study Documentation Abstract for FEMA Submittals		Initial Study		Restudy		CLOMR	X	LOMR		Other	
2.1.1	Date Study Accepted										
2.1.2	Study Contractor Contract(s) Address Phone Internal Reference Number	Sverdrup Civil, Inc. Brad Olbert, P.E. 637 South 48th Street, Suite 101 Tempe, AZ 85281 (602) 303-9799 Fax (602) 303-9899									
2.1.3	FEMA Technical Review Contractor Contact(s) Address Phone Internal Reference Number										
2.1.4	FEMA Regional Reviewer Phone										
2.1.5	State Technical Reviewer Phone										
2.1.6	Local Technical Reviewer Phone	Flood Control District of Maricopa County (602) 506-1501									
2.1.7	Reach Description	Bullard Wash Outfall Channel from Lower Buckeye Road to Gila River									
2.1.8	USGS Quad Sheet(s) with original photo date & Latest photo revision date	7.5 Minute Perryville, AZ Quad Map, 1957, photo revised 1982									
2.1.9	Unique Conditions and Problems	None									
2.1.10	Coordination of Q's Discharges (Agency, Date, Comments)	100-year, 24-hour peak discharge = 3,200 cfs per FCDMC									

2.2 FEMA Forms

The appropriate FEMA forms from the current FEMA MT-2 packet (May 1996) follow:

Form 1	Revision Requestor and Community Official Form - Please refer to TDN Volume One
Form 2	Certification by Registered Professional Engineer and/or Land Surveyor Forms
Form 3	Hydrologic Analysis Form - Please refer to TDN Volume One
Form 4	Riverine Hydraulic Analysis Form - Please refer to TDN Volume One
Form 5	Riverine Costal Mapping Form - Please refer to TDN Volume One
Form 6	Channelization Form
Form 7	Bridge/Culvert Forms
Form 8	Levee/Floodwall System Analysis Form

FEDERAL EMERGENCY MANAGEMENT AGENCY
CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR FORM

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You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in Hydrology, Hydraulics and Sediment Transport
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have 20 years experience in the expertise listed above.
4. I have ☐ prepared ☒ reviewed the attached supporting data and analyses related to my expertise.
5. I ☒ have ☐ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:
   Hydraulics, Erosion and Sedimentation analysis of Bullard Wash (Lower Buckeye Rd to Gila River)
7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☐ Other *(Specify)* _____
8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Ashok C. Patel
(please print or type)

Title: President
(please print or type)

Registration No. 10512 Expiration Date: N/A

State Arizona

Type of License Civil

Ashok C. Patel
Signature

11/5/98
Date

Registered Professional Engineer (Civil) CERTIFICATE NO. 10512 ASHOK C. PATEL Date Signed 11/5/98 ARIZONA, U.S.A.

Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

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1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in Hydrology & Hydraulics
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have 15 years experience in the expertise listed above.
4. I have ☐ prepared ☒ reviewed the attached supporting data and analyses related to my expertise.
5. I ☒ have ☐ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:
   Interrior Drainage Hydrology, Hydraulics of Bullard Wash (Lower Buckeye Rd to Gila River
7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☐ Other *(Specify)* _____
8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Jack K. Moody
(please print or type)

Title: Senior Project Engineer
(please print or type)

Registration No. 22208 Expiration Date: N/A

State Arizona

Type of License Civil

Jack K. Moody
Signature

11-4-98
Date

Registered Professional Engineer (Civil)
CERTIFICATE NO. 22208
JACK K. MOODY
Date Signed
ARIZONA, U.S.A.

Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

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1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in Hydrology and Hydraulics
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have 6 years experience in the expertise listed above.
4. I have ☒ prepared ☒ reviewed the attached supporting data and analyses related to my expertise.
5. I ☒ have ☐ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:
   Interrior Drainage Hydrology, Hydraulics of Bullard Wash (Lower Buckey Rd to Gila River)
7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☐ Other *(Specify)* _____
8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: DAVID T. PHELPS
(please print or type)

Title: Project Engineer
(please print or type)

Registration No. 32842 Expiration Date: 30 Sept 2001

State ARIZONA

Type of License Civil

Signature

4 Nov 98
Date

Registered Professional Engineer (Civil) CERTIFICATE NO. 32842 DAVID T. PHELPS Date Signed ARIZONA U.S.A.

Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

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1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in Drainage Design
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have 20 years experience in the expertise listed above.
4. I have ☒ prepared ☐ reviewed the attached supporting data and analyses related to my expertise.
5. I ☒ have ☐ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:

   Construction Documents for the Bullard Wash Channel Design

7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☐ Other *(Specify)* _____

8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Bradford D. Olbert
(please print or type)

Title: Project Manager
(please print or type)

Registration No. 13955 Expiration Date: 12/31/2000

State Arizona

Type of License Registered Professional Engineer

Bradford D. Olbert
Signature

9/18/98
Date

Registered Professional Engineer (Sanitary)
CERTIFICATE NO. 13955
BRADFORD D. OLBERT
Date Signed 9/18/98
ARIZONA, U.S.A.

Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

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1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in Structural
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have 31 years experience in the expertise listed above.
4. I have ☒ prepared ☐ reviewed the attached supporting data and analyses related to my expertise.
5. I ☐ have ☒ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:
   Construction documents for the Bullard Wash Channel structural design.
7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☐ Other *(Specify)* _____
8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: John F. Fischer
(please print or type)

Title: Structural Manager
(please print or type)

Registration No. 13769 Expiration Date: 12-31-99

State Arizona

Type of License Professional Engineer

John F. Fischer
Signature

9-18-98
Date

Registered Professional Engineer (Civil)
CERTIFICATE NO. 13769
JOHN F. FISCHER
Date Signed 9-18-98
ARIZONA, U.S.A.

Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

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You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in Geotechnical Engineering
   [example: water resources (*hydrology, hydraulics, sediment transport, interior drainage*)* structural, geotechnical, land surveying.]
3. I have 31 years experience in the expertise listed above.
4. I have ☒ prepared ☐ reviewed the attached supporting data and analyses related to my expertise.
5. I ☒ have ☐ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:
   Levee Stability
7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications. N/A

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☐ Other (*Specify*) _____
8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: David P. Hayes
(please print or type)

Title: Executive Vice President
(please print or type)

Registration No. 22719 Expiration Date: 3/31/2000

State Arizona

Type of License Civil

David P. Hayes
Signature

July 8, 1998
Date

Registered Professional Engineer (Civil)
CERTIFICATE NO.
22719
David Preston
Hayes
Date Signed
ARIZONA, U.S.A.

Seal
(*Optional*)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

FEDERAL EMERGENCY MANAGEMENT AGENCY

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR FORM

FEMA USE ONLY

O.M.B. No. 3067-0148
Expires July 31, 1997

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average . 23 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472.

You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in LAND SURVEYING
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have 20 years experience in the expertise listed above.
4. I have ☒ prepared ☐ reviewed the attached supporting data and analyses related to my expertise.
5. I ☒ have ☐ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:

   FIELD TOPO. FIELD NOTES

7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☐ Other *(Specify)* _____

8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: ALLEN C. AERNI
(please print or type)

Title: SURVEY MANAGER
(please print or type)

Registration No. 24513 Expiration Date: 03-31-99

State ARIZONA

Type of License LAND SURVEYOR

Signature

Date

REGISTERED LAND SURVEYOR
CERTIFICATE NO.
24513
ALLEN C.
AERNI
Date Signed 7-3-98
ARIZONA, U.S.A.

Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

FEDERAL EMERGENCY MANAGEMENT AGENCY **CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR FORM**	FEMA USE ONLY	O.M.B. No. 3067-0148 Expires July 31, 1997

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1. This certification is in accordance with 44 CFR Ch. I, Section 65.2
2. I am licensed with expertise in SURVEY & ENGINEERING
   [example: water resources *(hydrology, hydraulics, sediment transport, interior drainage)** structural, geotechnical, land surveying.]
3. I have 40 & 58 years experience in the expertise listed above.
4. I have ☐ prepared ☒ reviewed the attached supporting data and analyses related to my expertise.
5. I ☐ have ☒ have not visited and physically viewed the project.
6. In my opinion, the following analyses and /or designs, is/are being certified:

   Aerial Mapping Data

7. Based on the following review, the modifications in place have been constructed in general accordance with plans and specifications.

   Basis for above statement: (check all that apply)
   - a. ☐ Viewed all phases of actual construction.
   - b. ☐ Compared plans and specifications with as-built survey information.
   - c. ☐ Examined plans and specifications and compared with completed projects.
   - d. ☒ Other *(Specify)* reviewed aerial photography & mapping data

8. All information submitted in support of this request is correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Paul Clouse
(please print or type)

Title: VICE PRESIDENT
(please print or type)

Registration No. 4135 Expiration Date: _____

State AZ

Type of License CIVIL ENGINEERING

Paul E Clouse
Signature

_____
Date

_____
Seal
(Optional)

*Specify Subdiscipline

Note: Insert not applicable (N/A) if statement does not apply.

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

FEDERAL EMERGENCY MANAGEMENT AGENCY **CHANNELIZATION FORM**	FEMA USE ONLY	O.M.B. No. 3067-0148 Expires July 31, 1997

PUBLIC BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1.75 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472.

You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

Community Name: City of Goodyear, Arizona

Flooding Source: Bullard Wash

Project Name/Identifier: Bullard Wash Outfall Channel

1. EXTENT OF CHANNELIZATION

Downstream limit: Gila River

Upstream limit: Lower Buckeye Road

2. CHANNEL DESCRIPTION

1. Describe the inlet to the channel Step Gabion Basket drop inlet structure Refer to Exhibit B for plan/profile information.

2. Briefly describe the shape of the channel *(both cross sectional and planimetric configuration)* and its lining *(channel bottom and sides)* Trapezoidal channel with earthen bottom, step gabion sides. Trapezoidal channel with concrete bottom + sides. Grouted rip rap and gabion basket drop structures. Channel traverses from north to south, generally.

3. Describe the outlet from the channel Earthen trapezoidal channel graded in the Gila River Floodplain.

4. The channelization includes:

- [x] Levees *(Attach Levee/Floodwall system analysis Form)*
- [x] Drop structures
- [ ] Superelevated sections
- [x] Transitions in cross sectional geometry
- [ ] Debris basin/detention basin
- [ ] Energy dissipater
- [ ] Other

5. Attach the following: (Please Refer to Exhibit B)

a. Certified engineering drawings showing channel alignment and locations of inlet, outlet, and items checked in item 4

b. Typical cross sections and profiles of channel banks and invert

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

3. HYDRAULIC CONSIDERATIONS

1. What is the 100-year flood discharge? ..... 3,200 cfs
2. Do the cross sections in the hydraulic model match the typical cross sections in the plans? ☒ Yes ☐ No
3. Are the channel banks higher than the 100- year flood elevations everywhere? ..... ☒ Yes ☐ No
4. Are the channel banks higher than the 100-year flood energy grade lines everywhere? .. ☒ Yes ☐ No
5. Is the land on both sides of the channel above the adjacent 100-year flood elevation at all points along the channel? ..... ☐ Yes ☒ No
6. What is the range of freeboard? ..... 1.5 – 3.5+ feet
7. What is the range of the 100-year flood velocities? ..... 3 – 26 ft/sec
8. What is the lining type (both bottom and sides)? Sides are step gabion baskets & concrete, bottom: vegetated earth, conc. or grouted rip

   Explain how the channel lining prevents erosion and maintains channel stability *(attach documentation)*

   Grade control structures are gabion basket, grouted rip rap or concrete

   Refer to section 6.0 for more details on errosion control measures.

9. What is the design elevation in the channel based on?

   ☒ Subcritical flow
   ☐ Critical flow
   ☒ Supercritical flow (for sloping drop structures)
   ☐ Energy grade line

   Is the 100-year flood profile based on the above type of flow? ..... ☒ Yes ☐ No

   If no, explain: _____

10. Is there the potential for a hydraulic jump at the following locations:

    Inlet to channel? ..... ☒ Yes ☐ No
    Outlet of channel? ..... ☐ Yes ☒ No
    At Drop Structures? ..... ☒ Yes ☐ No
    At Transitions? ..... ☒ Yes ☐ No
    Other locations.? Explain: _____

    If the answer to any of the above is yes, please explain how the hydraulic jump is controlled and the effects of the hydraulic jump on the stability of the channel.

    Explain: These Channel Segments are lined with concrete.

    Refer to section 5.5.1 for further details

4. SEDIMENT TRANSPORT CONSIDERATIONS

1. a. Is there any indication from historical records that sediment transport (including scour and deposition) can affect the 100-year water surface elevations and/or the capacity of the channel? ..... ☐ Yes ☒ No

   b. Based on the conditions of the watershed and stream bed, is there a potential for sediment transport (including scour and deposition) to affect the 100-year water surface elevations and /or the capacity of the channel? ..... ☐ Yes ☒ No

2. If the answer to either 1A or 1B is yes:

   a. What is the estimated sediment (bed) load?
   _____cfs (attach gradation curve)

   Explain method used to estimate load_____

   _____

   _____

   _____

   _____

   b. Is the 100-year flood velocity anywhere within the channel less than the 100-year flood velocity of the inlet? ☐ Yes ☐ No

   c. Will sediment accumulate anywhere within the channel? ☐ Yes ☐ No

   d. Will deposition or scour occur at or near the inlet? ☐ Yes ☐ No

   e. Will deposition or scour occur at or near the outlet? ☐ Yes ☐ No

Attach documentation showing affects on the hydrologic and hydraulic analyses

FEDERAL EMERGENCY MANAGEMENT AGENCY **BRIDGE/CULVERT FORM**	FEMA USE ONLY	O.M.B. No. 3067-0148 Expires July 31, 1997

PUBLIC BURDEN DISCLOSURE NOTICE

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You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

Community Name: City of Goodyear, Arizona

Flooding Source: Bullard Wash

Project Name/Identifier: Bullard Wash Outfall Channel

1. IDENTIFIER

1. Name of structure (roadway, railroad, etc.): BID Bypass Road Culvert
2. Location of bridge/culvert along flooding source (in terms of stream distance or cross-section identifier): Station 29+01.4
3. This revision reflects (*check one of the following*):

   ☒ New bridge/culvert not modeled in the FIS

   ☐ Modified bridge/culvert previously modeled in the FIS

   ☐ New analysis of bridge/culvert previously modeled in the FIS

   (*Explain why new analysis was performed*) _____

2. BACKGROUND

Provide the following information about the structure:

1 Dimension, material, and shape of structure (e.g. two 10 x 5 feet reinforced concrete box culvert; three 30-foot span bridge with 2 rows of two 3- foot diameter circular piers; 40-foot wide ogee shape spillway) Four 12 ft x 10 ft Concrete box culvert

2. Entrance geometry of culvert/type of bridge opening (e.g. 30° - 75° wing walls with square top edge, sloping embankments and vertical abutments) 30 - 75° Wing walls

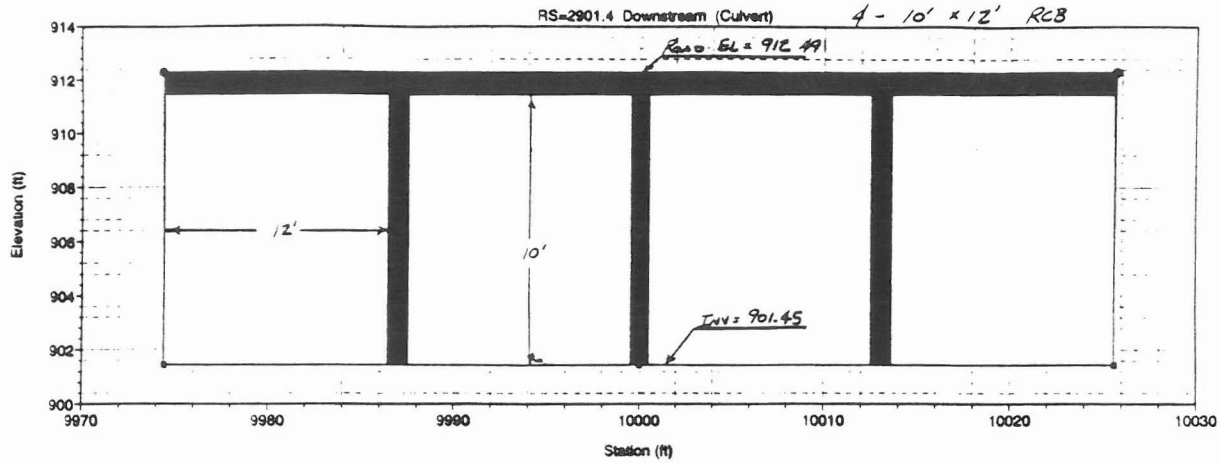
3. Hydraulic model used to analyze the structure (*e.g., HEC-2 with special bridge routine, WSPRO, HY8*) HEC-RAS v 2.1

If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structure(s). (*Attach justification*)

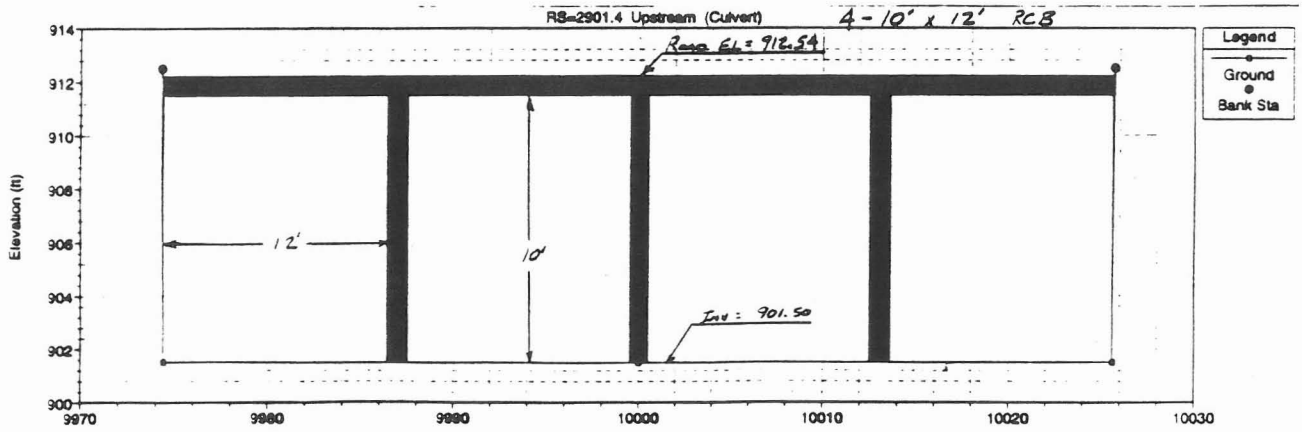
Note: If any items do not apply to submitted hydraulic analysis, indicate with " N/A"
• One form per new/revised bridge/culvert

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

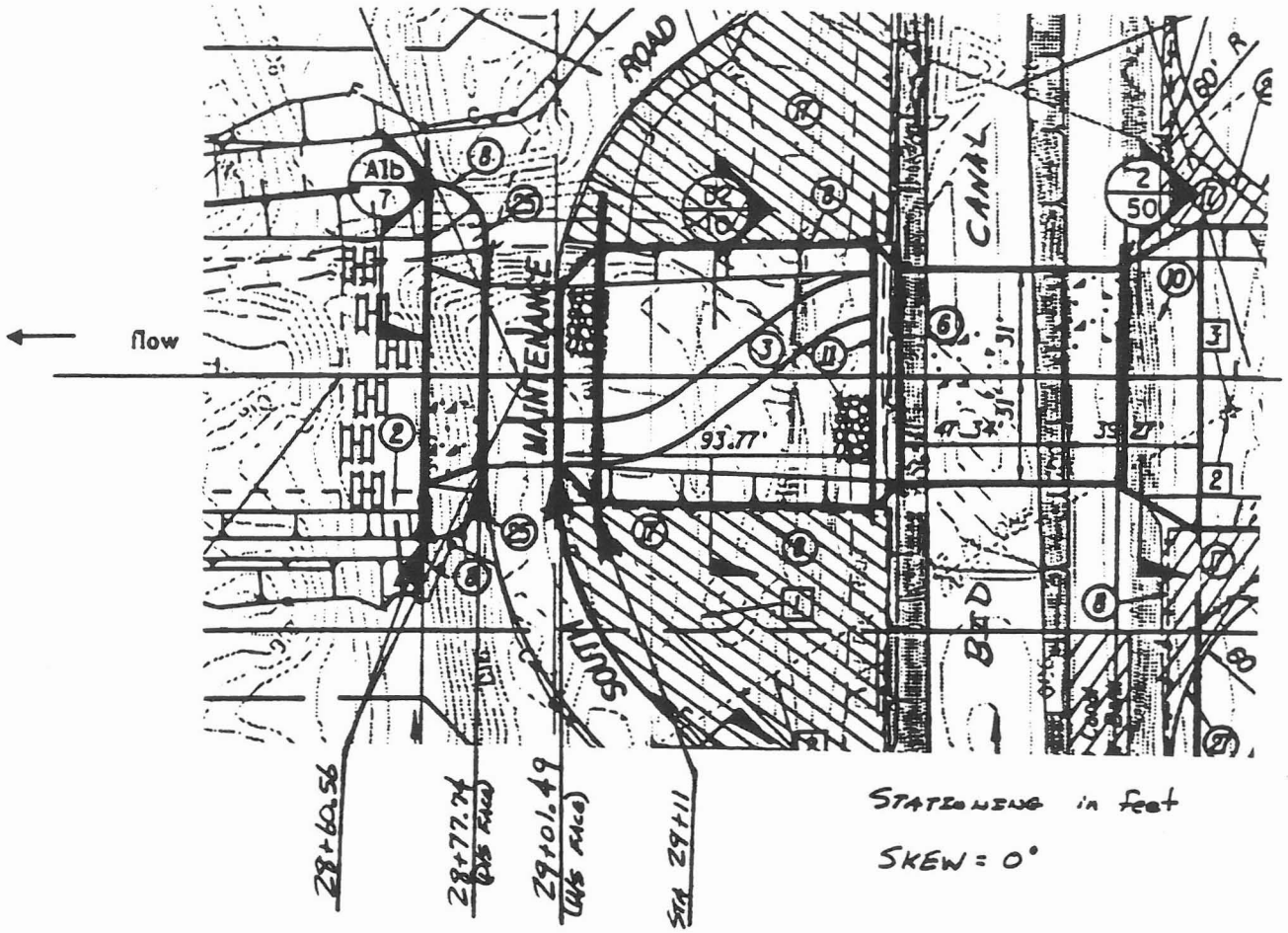
Sketch the downstream face of the structure together with the road profile. Show, at a minimum, the maximum low chord elevation, invert elevation, minimum top of road elevation, and ineffective flow widths.



Sketch the upstream face of the structure together with the road profile. Show, at a minimum, the maximum low chord elevation, invert elevation, and minimum top of road elevation.



Sketch the plan view of the structure(s) Show, at a minimum, the skew angle, cross-section locations, distances between cross sections, and length of structure (s).



Attach plans of the structure (s) certified by a registered professional engineer.

Culvert length or bridge width (ft)	23 ft
Calculated culvert/bridge area (ft²) by the hydraulic model, if applicable	407.7 sf @ U/S
Total culvert/bridge area (ft²)	480 sf

Elevations Above Which Flow is Effective for Overbanks

	Left Overbank	Right Overbank
Upstream face	N/A	N/A
Downstream face	N/A	N/A

Minimum Top of Road Elevation

	Left Overbank	Right Overbank
Upstream face	912.54	912.54
Downstream face	912.49	912.49

100-Year flood elevations	Water Surface Elevations	Energy Gradient Elevations
Upstream face	909.45	910.41
Downstream face	906.45	908.87

Discharge	Low Flow	Pressure Flow	Weir Flow	Total Flow
Amount of flow through/over the structure (s) (cfs)	3200	—	—	3200

The maximum depth of flow over the roadway/railroad (ft.) ..... N/A

Weir length (ft.) ..... N/A

Top Widths	Total Floodplain Width	Total Effective Flow Width	Floodway Width
Upstream face	51.34	51.34	52
Downstream face	51.29	51.29	52

Loss Coefficients

Entrance loss coefficient	0.5
Manning's "n" value assigned to the structure(s)	0.015
Friction loss coefficient through structure (s)	N/A
Other loss coefficients (e.g., bend manhole, etc.)	N/A
Total loss coefficient	1.5
Weir coefficient	2.6
Pier coefficient	N/A
Contraction loss coefficient	0.3
Expansion loss coefficient	0.5

4. SEDIMENT TRANSPORT CONSIDERATIONS

1. a. Is there any indication from historical records that sediment transport (*including scour and deposition*) can affect the 100-year water surface elevations? ..... ☐ Yes ☒ No

   b Based on the conditions (*such as geomorphology, vegetative cover and development of the watershed and stream bed, and bank conditions*), is there a potential for debris and sediment transport (*including scour and deposition*) to affect the 100-year water surface elevations and/or conveyance capacity through the bridge/culvert? ..... ☐ Yes ☒ No

2. If the answer to either 1a or 1b is yes:

   a. What is the estimated sediment (*bed material*) load?
   _____cfs (*attach gradation curve*)

   Explain method used to estimate the sediment transport and the depth of scour and/or deposition_____

   b. Will sediment accumulate anywhere through the bridge/culvert? ☐ Yes ☒ No

   If yes, explain the impact on the conveyance capacity through the bridge/culvert?_____

5. FLOODWAY ANALYSIS

Explain method of bridge encroachment (floodway run)

None – Ingized channel, therefore floodway is designated from left bank to right bank (entire channel)

Comments (*explain any unusual situations*):

Hydraulic jump upstream of Box culvert due to sloping drop upstream.
Refer to Appendix E for hydraulic jump analysis.

Attach analysis.

Refer to Appendix E for HEC-RAS output

FEDERAL EMERGENCY MANAGEMENT AGENCY **BRIDGE/CULVERT FORM**	FEMA USE ONLY	O.M.B. No. 3067-0148 Expires July 31, 1997

PUBLIC BURDEN DISCLOSURE NOTICE

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You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

Community Name: City of Goodyear, Arizona

Flooding Source: Bullard Wash

Project Name/Identifier: Bullard Wash Outfall Channel

1. IDENTIFIER

1. Name of structure (roadway, railroad, etc.): MC 85 Bridge
2. Location of bridge/culvert along flooding source (in terms of stream distance or cross-section identifier): Station 73+57
3. This revision reflects *(check one of the following)*:
   - [x] New bridge/culvert not modeled in the FIS
   - [ ] Modified bridge/culvert previously modeled in the FIS
   - [ ] New analysis of bridge/culvert previously modeled in the FIS

   (Explain why new analysis was performed)

2. BACKGROUND

Provide the following information about the structure:

1 Dimension, material, and shape of structure (e.g. two 10 x 5 feet reinforced concrete box culvert; three 30-foot span bridge with 2 rows of two 3- foot diameter circular piers; 40-foot wide ogee shape spillway) 105 ft 3 Span Bridge (2 spans @ 31 Ft, middle span @ 39 Ft), two rows of two 2 Ft dia circular piers.

2. Entrance geometry of culvert/type of bridge opening (e.g. 30° - 75° wing walls with square top edge, sloping embankments and vertical abutments) Sloping embankments and vertical abutments

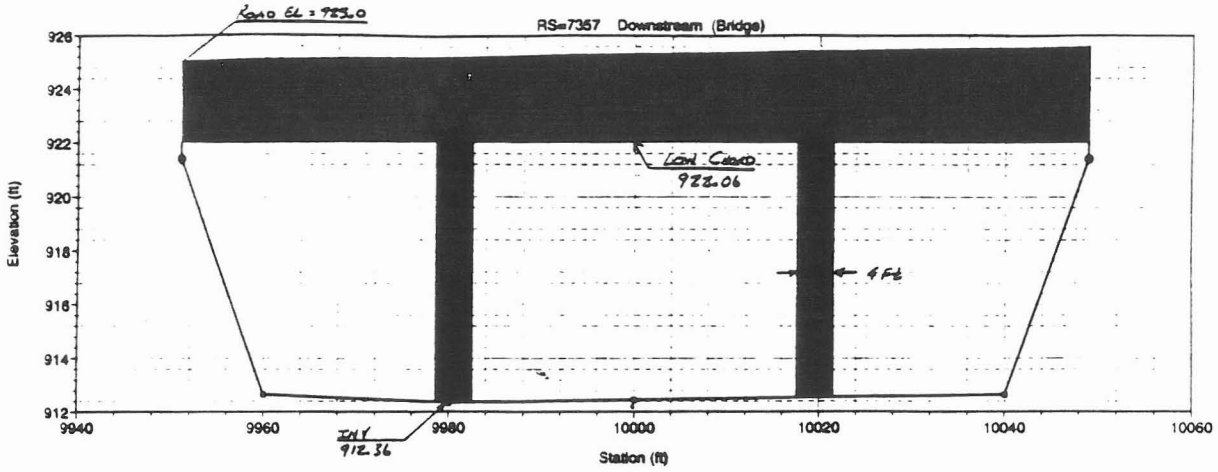
3. Hydraulic model used to analyze the structure (*e.g., HEC-2 with special bridge routine, WSPRO, HY8*) HEC-RAS v 2.1

If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structure(s). *(Attach justification)*

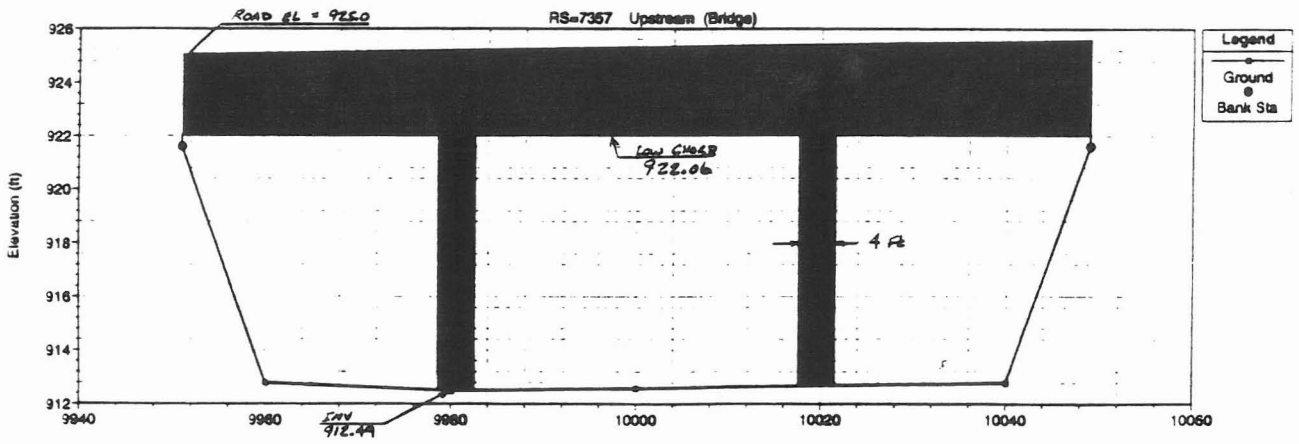
Note: If any items do not apply to submitted hydraulic analysis, indicate with " N/A"
• One form per new/revised bridge/culvert

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

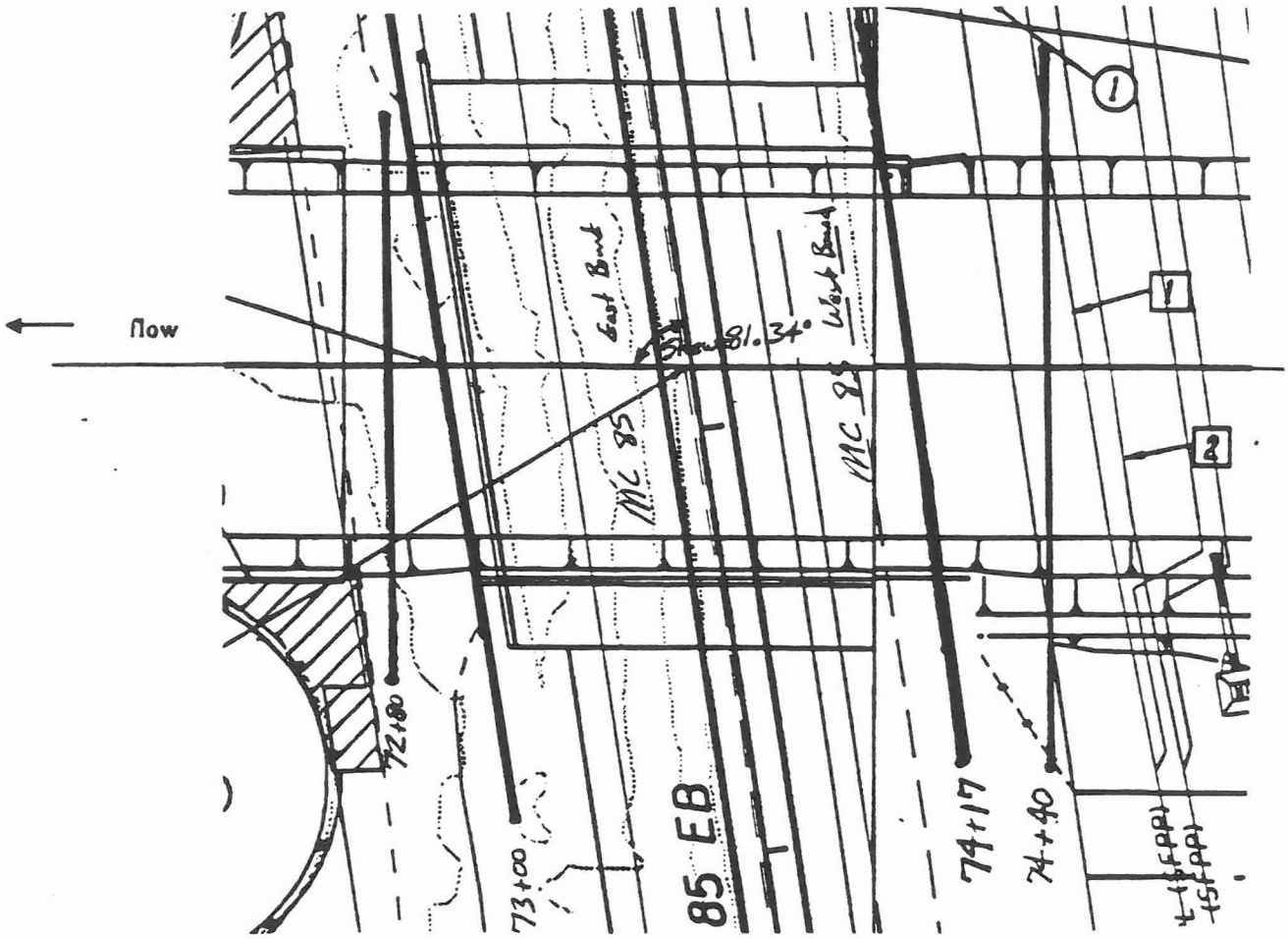
Sketch the downstream face of the structure together with the road profile. Show, at a minimum, the maximum low chord elevation, invert elevation, minimum top of road elevation, and ineffective flow widths.



Sketch the upstream face of the structure together with the road profile. Show, at a minimum, the maximum low chord elevation, invert elevation, and minimum top of road elevation.



Sketch the plan view of the structure(s) Show, at a minimum, the skew angle, cross-section locations, distances between cross sections, and length of structure (s). Note: Stationing in feet. Skew = 81.34°



Attach plans of the structure (s) certified by a registered professional engineer.

Culvert length or bridge width (ft)	117 ft
Calculated culvert/bridge area (ft²) by the hydraulic model, if applicable	765.4 sf
Total culvert/bridge area (ft²)	approx. 800 sf

Elevations Above Which Flow is Effective for Overbanks

	Left Overbank	Right Overbank
Upstream face	N/A	N/A
Downstream face	N/A	N/A

Minimum Top of Road Elevation

	Left Overbank	Right Overbank
Upstream face	924.99	925.64
Downstream face	924.99	925.64

100-Year flood elevations	Water Surface Elevations	Energy Gradient Elevations
Upstream face	919.26	916.26
Downstream face	918.91	916.13

Discharge	Low Flow	Pressure Flow	Weir Flow	Total Flow
Amount of flow through/over the structure (s) (cfs)	3200	N/A	N/A	3,200

The maximum depth of flow over the roadway/railroad (ft.) ..... N/A

Weir length (ft.) ..... N/A

Top Widths	Total Floodplain Width	Total Effective Flow Width	Floodway Width
Upstream face	84.78	84.78	110 ft
Downstream face	84.58	84.58	110 ft

Loss Coefficients

Entrance loss coefficient	N/A
Manning's "n" value assigned to the structure(s)	Concrete: Sides = 0.015, Raked Bottom = 0.019
Friction loss coefficient through structure (s)	N/A
Other loss coefficients (e.g., bend manhole, etc.)	N/A
Total loss coefficient	N/A
Weir coefficient	2.6
Pier coefficient	1.33
Contraction loss coefficient	0.3
Expansion loss coefficient	0.5

4. SEDIMENT TRANSPORT CONSIDERATIONS

1. a. Is there any indication from historical records that sediment transport (*including scour and deposition*) can affect the 100-year water surface elevations? ..... ☐ Yes ☒ No

   b Based on the conditions (*such as geomorphology, vegetative cover and development of the watershed and stream bed, and bank conditions*), is there a potential for debris and sediment transport (*including scour and deposition*) to affect the 100-year water surface elevations and/or conveyance capacity through the bridge/culvert? ..... ☐ Yes ☒ No

2. If the answer to either 1a or 1b is yes:

   a. What is the estimated sediment (*bed material*) load?
   _____cfs (*attach gradation curve*)

   Explain method used to estimate the sediment transport and the depth of scour and/or deposition _____

   b. Will sediment accumulate anywhere through the bridge/culvert? ☐ Yes ☐ No

   If yes, explain the impact on the conveyance capacity through the bridge/culvert? _____

5. FLOODWAY ANALYSIS

Explain method of bridge encroachment (floodway run)

None - Insized channel therefore floodway is designated from left bank to right bank (entire channel).

Comments (*explain any unusual situations*):

Attach analysis.

Refer to Appendix E for HEC-RAS output.

FEDERAL EMERGENCY MANAGEMENT AGENCY
BRIDGE/CULVERT FORM

FEMA USE ONLY

O.M.B. No. 3067-0148
Expires July 31, 1997

PUBLIC BURDEN DISCLOSURE NOTICE

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You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

Community Name: City of Goodyear, Arizona

Flooding Source: Bullard Wash

Project Name/Identifier: Bullard Wash Outfall Channel

1. IDENTIFIER

1. Name of structure (roadway, railroad, etc.): UPRR Bridge
2. Location of bridge/culvert along flooding source (in terms of stream distance or cross-section identifier): Station 75+33
3. This revision reflects (*check one of the following*):
   - ☒ New bridge/culvert not modeled in the FIS
   - ☐ Modified bridge/culvert previously modeled in the FIS
   - ☐ New analysis of bridge/culvert previously modeled in the FIS

   (*Explain why new analysis was performed*) _____

2. BACKGROUND

Provide the following information about the structure:

1 Dimension, material, and shape of structure (e.g. two 10 x 5 feet reinforced concrete box culvert; three 30-foot span bridge with 2 rows of two 3- foot diameter circular piers; 40-foot wide ogee shape spillway) Three 34 Ft Nominal girder span bridge with 2 rows of 20 inch dia. circular piers

2. Entrance geometry of culvert/type of bridge opening (e.g. 30° - 75° wing walls with square top edge, sloping embankments and vertical abutments) Sloping embankments and vertical abutments

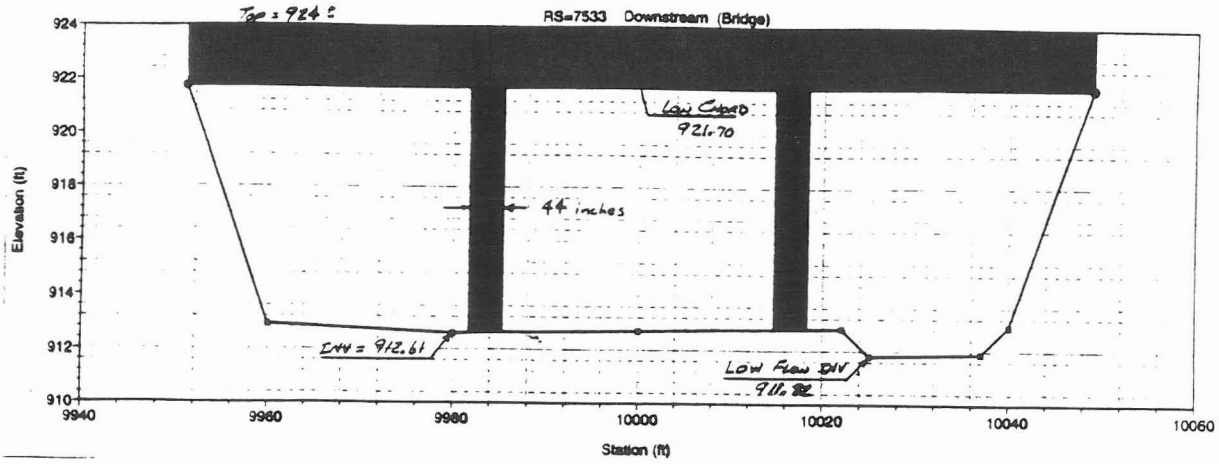
3. Hydraulic model used to analyze the structure (*e.g., HEC-2 with special bridge routine, WSPRO, HY8*) HEC-RAS v 2.1

If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structure(s). (*Attach justification*)

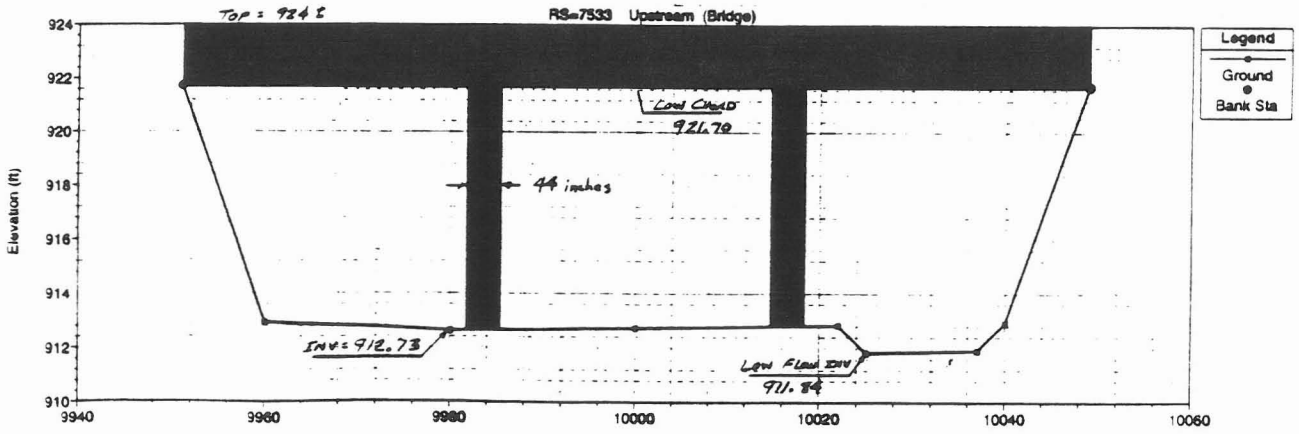
Note: If any items do not apply to submitted hydraulic analysis, indicate with " N/A"
*** One form per new/revised bridge/culvert**

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

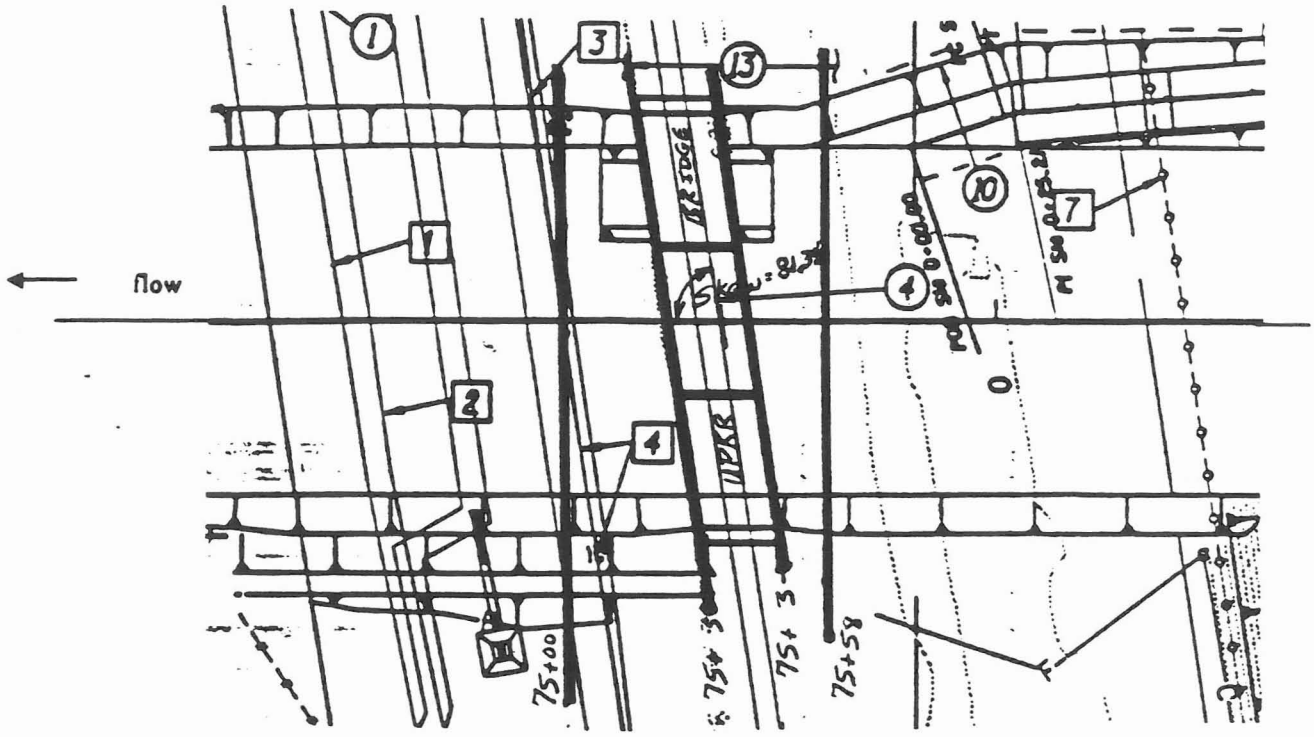
Sketch the downstream face of the structure together with the road profile. Show, at a minimum, the maximum low chord elevation, invert elevation, minimum top of road elevation, and ineffective flow widths.



Sketch the upstream face of the structure together with the road profile. Show, at a minimum, the maximum low chord elevation, invert elevation, and minimum top of road elevation.



Sketch the plan view of the structure(s) Show, at a minimum, the skew angle, cross-section locations, distances between cross sections, and length of structure (s).



Note: Stationing is in feet. Skew = 81.34°

Attach plans of the structure (s) certified by a registered professional engineer.

Culvert length or bridge width (ft)	20 ft
Calculated culvert/bridge area (ft²) by the hydraulic model, if applicable	740.9 sf
Total culvert/bridge area (ft²)	approx. 800 sf

Elevations Above Which Flow is Effective for Overbanks

	Left Overbank	Right Overbank
Upstream face	N/A	N/A
Downstream face	N/A	N/A

Minimum Top of Road Elevation (TOP OF RAIL)

	Left Overbank	Right Overbank
Upstream face	925.7	925.7
Downstream face	925.7	925.7

100-Year flood elevations	Water Surface Elevations	Energy Gradient Elevations
Upstream face	919.43	919.89
Downstream face	919.34	919.80

Discharge	Low Flow	Pressure Flow	Weir Flow	Total Flow
Amount of flow through/over the structure (s) (cfs)	3,200	N/A	N/A	3,200

The maximum depth of flow over the roadway/railroad (ft.) .....

Weir length (ft.) .....

Top Widths	Total Floodplain Width	Total Effective Flow Width	Floodway Width
Upstream face	85.54	85.54	110 FT
Downstream face	85.50	85.50	110 FT

Loss Coefficients

Entrance loss coefficient	N/A
Manning's "n" value assigned to the structure(s)	Concrete: Sides = 0.015, Ribbed Bottom = 0.019
Friction loss coefficient through structure (s)	N/A
Other loss coefficients (e.g., bend manhole, etc.)	N/A
Total loss coefficient	N/A
Weir coefficient	2.6
Pier coefficient	1.33
Contraction loss coefficient	0.3
Expansion loss coefficient	0.5

4. SEDIMENT TRANSPORT CONSIDERATIONS

1. a. Is there any indication from historical records that sediment transport (*including scour and deposition*) can affect the 100-year water surface elevations? ..... ☐ Yes ☒ No

   b Based on the conditions (*such as geomorphology, vegetative cover and development of the watershed and stream bed, and bank conditions*), is there a potential for debris and sediment transport (*including scour and deposition*) to affect the 100-year water surface elevations and/or conveyance capacity through the bridge/culvert? ..... ☐ Yes ☒ No

2. If the answer to either 1a or 1b is yes:

   a. What is the estimated sediment (*bed material*) load?
   _____cfs (*attach gradation curve*)

   Explain method used to estimate the sediment transport and the depth of scour and/or deposition_____

   b. Will sediment accumulate anywhere through the bridge/culvert? ☐ Yes ☐ No

   If yes, explain the impact on the conveyance capacity through the bridge/culvert?_____

5. FLOODWAY ANALYSIS

Explain method of bridge encroachment (floodway run)

None - Insized Channel, therefore Floodway is designated from left bank to right bank (entire channel).

Comments (*explain any unusual situations*):

Hydraulic jump upstream of UPRR bridge due to sloping drop upstream.
Refer to Appendix E for hydraulic jump analysis

Attach analysis.

Refer to appendix E for HEC-RAS output

FEDERAL EMERGENCY MANAGEMENT AGENCY
LEVEE/FLOODWALL SYSTEM ANALYSES FORM

FEMA USE ONLY

O.M.B. No. 3067-[illegible]
Expires July 31, 1997

PUBLIC BURDEN DISCLOSURE NOTICE

[illegible]blic reporting burden for this form is estimated to average 3.0. hours per response. The burden estimate includes the [illegible]e for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and [illegible]mpleting and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden, to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington, DC 20472.

You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

Community Name: City of Goodyear, Arizona

Flooding Source: Bullard Wash

Project Name/Identifier: Bullard Wash Outfall Channel

1. REACH TO BE REVISED

Downstream limit: Gila River

Upstream limit: Lower Buckeye Road

This Levee/Floodwall analysis is based on:

- ☐ upgrading of an existing levee/floodwall system
- ☒ a newly constructed levee/floodwall system
- ☐ reanalysis of an existing levee/floodwall system

2. LEVEE/FLOODWALL SYSTEM ELEMENTS

1. Levee elements and locations:

- ☒ earthen embankment, dike, berm etc. — Station 30+33 to 58+50
- ☐ structural floodwall — Station _____ to _____
- ☐ other (describe) _____ — Station _____ to _____

2. Structural Type:

- ☐ monolithic cast-in place reinforced concrete
- ☐ reinforced concrete masonry block
- ☐ sheet piling
- ☐ other (describe) _____

3. Has this levee/floodwall system been certified by a Federal agency to provide protection against the 100-year flood event?

☐ Yes ☒ No

If yes, by which agency? _____

If yes, complete only the interior drainage section on pages 7 and 8 of this form and the operation and maintenance section of Revision Requestor and Community Official Form.

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

3. Attach certified drawings containing the following information (indicate drawing sheet numbers):
See Exhibit B

a. Plan of the levee embankment and floodwall structures. Sheet Numbers 15 - 18

b. A profile of the levee/floodwall system showing the 100-year water surface elevations, levee and/or wall crest and foundation, and closure locations for the total levee system. Sheet Numbers 15 - 18

c. A profile of the 100-year water surface elevation, closure opening outlet and inlet invert elevations, type and size of opening, and kind of closure device. Sheet Numbers N/A

d. A layout detail for the embankment protection measures. Sheet Numbers 7

e. Location, layout, and size and shape of the levee embankment features, foundation treatment, floodwall structure, closure structures, and pump stations. Sheet Numbers NA

3. FREEBOARD

1. The minimum freeboard provided above the 100-year water surface elevation is:

Riverine

3.0 feet or more at the downstream end and throughout ☒ Yes ☐ No
3.5 feet or more at the upstream end ☒ Yes ☐ No
4.0 feet immediately upstream and downstream of all structures and constrictions ☒ Yes ☐ No
NOTE: Within the levee reach, there are NO STRUCTURES or CONSTRICTIONS.

Coastal

1.0 foot above the height of the one percent wave for the 100-year stillwater surge elevation or maximum wave runup (whichever is greater). ☐ Yes ☐ No

2.0 feet above 100-year stillwater surge elevation ☐ Yes ☐ No

Please note, occasionally exceptions are made to the minimum freeboard requirement. If an exception is requested, attach documentation addressing Part 65.10 (b) (1) (ii) of the National Flood Insurance Program regulations.

If no is answered to any of the above, please explain where and why: _____

2. Is there an indication from historical records that ice-jamming can effect the 100-year water surface elevation?
☐ Yes ☒ No If yes, provide ice-jam analysis profile and evidence that the minimum freeboard discussed above still exists.

3. Tabulate the elevations at critical locations (tabulate values at each levee crest grade change)

Station	Location	100-Year Water Surface Elevation	Levee Crest	Freeboard (ft.)
58+50	Upper end	917.10	920.67	3.57
30+33	Lower end	913.25	917.00	3.75

(Extend table on an added sheet as needed and reference) See Table E5.6 for more details.

5. SEDIMENT TRANSPORT CONSIDERATIONS

1. a. Is there any indication from historical records that sediment transport (including scour and deposition) can affect the 100-year water surface elevations?

☐ Yes ☒ No

b. Based on the conditions (such as geomorphology, vegetative cover and development of the watershed and stream bed, and bank conditions), is there a potential for debris and sediment transport (including scour and deposition) to affect the 100-year water surface elevations and/or the freeboard for the levee/floodwall?

☐ Yes ☒ No

2. If the answer to either 1a or 1b is yes:

A. What is the estimated sediment (bed material) load?

_____cfs (attach gradation curve)

Explain method used to estimate the sediment transport and the depth of scour and/or deposition

_____

_____

_____

_____

_____

B. Will sediment accumulate anywhere along the levee/floodwall (such as along any bends in the channel)?

☐ Yes ☒ No

If yes, what is the minimum freeboard at these locations?_____feet.

6. CLOSURES

1. Openings through the levee system:

☐ exist ☒ do not exist

If openings exist, list all closures:

Channel Station	Left or Right Bank	Opening Type	Highest Elevation for Opening Invert	Type of Closure Device

(Extend table on an added sheet as neded and reference)

Geotechnical and geologic data:

In addition to the required detail analysis reports, data obtained during field and laboratory investigations and used in the design analysis must be submitted in a tabulated summary form for the following levee system features. (Reference U S. Army Corps of Engineers EM-1110-2-1906 Form 2086).

4. EMBANKMENT PROTECTION

1. Maximum levee slope landside: 2:1

2. Maximum levee slope floodside: 1:1

3. Range of 100-year riverine flood velocities along the levee: 5.5 fps (min.) to 7.1 fps (max.)

4. Embankment material is protected by (describe the kind): 9-inch thick Gabion Mattress (rock encased within wire baskets) and 8-inch thick Concrete Lining.

5. Riprap Design Parameters: (Include references) ☐ Velocity; ☐ Tractive stress

	Reach	Sideslope	Flow depth	Velocity	Curve or Straight	Stone Riprap D_{100}	D_{50}	Thickness	Depth of Toedown
Sta_____ to_____									
Sta_____ to_____									
Sta_____ to_____									

(Extend table on an added sheet as needed and reference)

6. Has a bedding/filter analysis and design been included ☐ Yes ☐ No

7. Describe the analysis for other kinds of protection used (include copies of the design analysis):

Gabion mattresses were utilized as bank protection for most of the levee. Shear stress was analyzed to determine the thickness of the gabion mattresses and size of rock to use in the baskets. Design analysis also checked for filter fabric requirement. Engineering analysis has been attached. Refer to Appendix F.

Attach engineering analysis to support construction plans.

1. Identify locations and describe the basis for selection of critical locations for analyses: This "levee" is an extension of the side slopes. All sections are similar

☒ Overall height: Sta 63+33 to 72+90 height 40 ft.

☐ Limiting foundation soil strength:

Sta _____ depth _____ to _____

strength Ø = 38 degrees, c = 400 psf

☒ slope: SS = 1 (h) to 1 (v)

(Repeat as needed on an added sheet for additional slopes and locations)

2. Specify the embankment stability analyses methodology used (e.g. circular arc, sliding block, infinite slope, etc.): Not required since height is less than 6 feet

3. Summary of stability analysis results:

Case	Loading Conditions	Critical Safety Factor	Criteria (Min.)
I	End of construction		1.3
II	Sudden drawdown	N/A	1.0
III	Critical flood stage		1.4
IV	Steady seepage at flood stage		1.4
VI	Earthquake (Case I)		1.0

(Reference: U.S. Army Corps of Engineers EM-1110-2-1913 Table 6-1)

4. Was a seepage analysis for the embankment performed? ☐ Yes ☒ No

Describe methodology used: _____

5. Was a seepage analysis for the foundation performed? ☐ Yes ☒ No

Were uplift pressures at the embankment landside toe checked? ☐ Yes ☒ No

Were seepage exit gradients checked for piping potential? ☐ Yes ☒ No

6. Duration of 100-year flood hydrograph against the embankment : _____ Hrs.

Note: Attach engineering analysis to support construction plans.

1. Describe analysis submittal based on Code:

☐ UBC (1988) or ☐ Other (specify) _____

2. Stability analysis submitted provides for:
☐ Overturning; ☑ Sliding; If not, explain _____

3. Loading included in the analyses were:

☑ Lateral earth @ P_A = 29 psf; P_p = 500 psf
☑ Surcharge–Slope @ N/A , ☑ surface , 121 psf
☑ Wind @ P_w = 0 psf
☑ Seepage (Uplift) 0 ☑ Earthquake @ P_{eq} = _____ %g
☑ 100-year significant wave height 0 ft.
☑ 100-year significant wave period 0 sec.

4. Summary of Stability Analysis Results: Factors of Safety. Itemize for each range in site layout dimension and loading condition limitation for each respective reach. N/A

Loading Condition	Criteria (Min) Overturn	Criteria (Min) Sliding	Sta Overturn	To Sliding	Sta Overturn	To Sliding
Dead & Wind	1.5	1.5				
Dead & Soil	1.5	1.5				
1, Soil, Flood & Impact	1.5	1.5				
Dead, Soil & Seismic	1.3	1.3				

(Ref: FEMA 114 Sept 1986; COE EM 1110-2-2502)

(Note: Extend table on an added sheet as needed and reference)

5. Foundation bearing strength for each soil type: CL

Bearing Pressure	Sustained Load	Short Term Load
Computed design maximum	3400 psf	4200 psf
Maximum allowable	16,500 psf	16,500 psf

6. Foundation scour protection ☐ is, ☑ is not provided, (describe)

_____

Note: Attach engineering analysis to support construction plans.

9. SETTLEMENT

1. Has anticipated potential settlement been determined and incorporated into the specified construction elevations to maintain the established freeboard margin?

☒ Yes ☐ No

Computed range of settlement: 0.1 ft. to 0.2 ft.

3. Settlement of the levee crest is determined to be primarily from:

☐ Foundation consolidation
☒ Embankment compression
☐ Other (describe) _____

4. Differential settlement of floodwalls N/A

☐ has ☒ has not been accommodated in the structural design and construction.

Note: Attach engineering analysis to support construction plans.

10. INTERIOR DRAINAGE

1. Specify size of each interior watershed

Draining to pressure conduit: 0.9 sq. mi

Draining to ponding area: N/A

2. Relationships Established

Ponding elevation vs. storage	☐ Yes	☒ No
Ponding elevation vs. gravity flow	☒ Yes	☐ No
Differential head vs. gravity flow	☐ Yes	☒ No

3. The river flow duration curve is enclosed ☐ Yes ☒ No

4. Specify the discharge capacity of the head pressure conduit: 60 cfs in pipes + ≈ 105 cfs in spillway

5. Which Flooding Conditions Were Analyzed?

• Gravity flow (Interior Watershed)	☒ Yes	☐ No
• Common storm (River Watershed)	☐ Yes	☒ No
• Historical ponding probability	☐ Yes	☒ No N/A
• Coastal wave overtopping	☐ Yes	☒ No N/A

If no, explain why: The interior drainage outlet structure outfalls to the BID canal not Bullard Wash.

6. Interior drainage has been analyzed based on joint probability of interior and exterior flooding and the capacities of pumping and outlet facilities to provide the established level of flood protection.

☒ Yes ☐ No

If no, explain why: _____

The rate of seepage through the levee system for the 100-year flood is N/A cfs

8. The length of levee system used to drive the seepage rate in item 7: N/A ft.

9. Will a pumping plant(s) be used for interior drainage? ☐ Yes ☒ No

If yes, include the number of pumping plants: _____

For each pumping plant, list:

	Plant #1	Plant #2
The number of pumps		
The ponding storage capacity		
The maximum pumping rate		
The maximum pumping head		
The pumping starting elevation		
The pumping stopping elevation		
Is the discharge facility protected?		
Is there a flood warning plan?		
How much time is available between warning and flooding?		

Will the operations be automatic? ☐ Yes ☐ No

If the pumps are electric, are there backup power sources? ☐ Yes ☐ No

(Reference: U.S. Army Corps of Engineers EM-1110-2-3101, 3102, 3103, 3104, and 3105)

Note: Include a copy of supporting documentation of data and analysis. Provide a map showing the flooded area and maximum ponding elevations for all interior watersheds that result in flooding.

11. OTHER DESIGN CRITERIA

1. The following items have been addressed as stated:

Liquifaction ☐ is ☒ is not a problem.

Hydrocompaction ☐ is ☒ is not a problem

Heave differential movement due to soils of high shrink/swell ☐ is ☒ is not a problem.

2. For each of these problems, state the basic facts and corrective action taken.

N/A

3. If the levee/floodwall is new or enlarged, will the structure adversely impact flood levels and/or flow velocities floodside of the structure? ☐ Yes ☒ No

Attach supporting documentation

Are the planned/installed works in full compliance with NFIP regulations, Section 44 CFR Ch. 1. 65.10?

☒ Yes ☐ No

1. Does the operation plan incorporate all the provisions for closure devices as required in Section 65.10 (c) (1), of the NFIP regulations?

   ☒ Yes ☐ No

2. Does the operation plan incorporate all the provisions for interior drainage as required in Section 65.10 (c) (2), of the NFIP regulations?

   ☒ Yes ☐ No

If the answer is no to either of the above, please explain below.

3.0 SURVEY AND MAPPING INFORMATION

3.1 Field Survey Information

Field survey information is provided in TDN Volume One under separate cover.

3.2 Mapping

Please refer to Exhibit B for detail of mapping used for this study.

4.0 HYDROLOGY

4.1 Method Description

The hydrology for this study is broken into two parts. The first part includes the entire drainage area contributing to Bullard Wash. Refer to TDN Volume One, Section 4.0 for documentation of this hydrology.

A second hydrologic analysis was prepared by Wood, Patel & Associates, Inc. in order to estimate the amount of surface runoff contributing to the interior drainage sediment basin and surface water inlet to the Buckeye Irrigation District Canal located at the northwest corner of the intersection of the Bullard Wash alignment and the Buckeye Irrigation District Canal. It is estimated that the 100-year 24-hour runoff collecting at this location is 355 cfs. Refer to Table 4.1 below for modeling details of the interior drainage. The HEC-1 model is included on diskette and the filename is SURFACE. The file date is April 4, 1998. Refer the readme file included on the diskette for further details.

4.2 Parameter Estimation

The hydrologic parameters listed in Table 4.1 are used for both hydrology models.

TABLE 4.1
Summary of Hydrologic Parameters

Parameter	FCDMC Methods	Result
Rainfall Depth	NOAA Atlas 2	4.03 inches
Design Storm Frequency/Duration	100-Year , 24-hour[1]	per White Tanks ADMS
Design Storm Distribution	SCS Type II[2]- (represents regions in which high rates of runoff are generated by large winter storm cells).	per FCDMC
Rainfall Losses	Green and Ampt	per White Tanks ADMS
Unit Hydrograph	S-Graph	Agricultural per FCDMC
Lag	$Lag = C(L\ L_{ca}/S^{P})^{m}$	per MCUHP2
Channel Routing	Normal depth	per FCDMC

Table Notes:

1. FCDMC criteria is the greater of either the 100-year, 6-hour, or the 100-year 24-hour. For this Study, the 100-year, 24-hour storm controls.
2. For the 100-year 24-hour storm, the SCS type II distribution is utilized.

4.2.1 Drainage Area Boundaries

- Bullard Wash Outfall Channel:
  Refer to TDN, Volume One
- Interior Drainage:
  The Bullard Wash Outfall Feasibility Study reveals that there are two sub basins contributing to the interior drainage location, sub basins 364 and 365. The Bullard Wash alignment traverses sub basin 364 as shown on Exhibit A. Thus, the sub basin area was revised and the unit hydrograph recomputed utilizing the FCDMC microcomputer program MCUHP2. This information was then input to the U.S. Army Corps of Engineers HEC-1 microcomputer program v 4.0.1e. The following FCDMC criteria was utilized. Refer to Exhibit A for the drainage area map. The HEC-1 output file is provided in Appendix D.

4.2.2 Watershed Work Maps

Exhibit A contains a 11" x 17" print out of the interior drainage map. Also included in this submittal is a 24" x 36" copy of the WLB White Tanks/Agua Fria ADMS watershed map.

4.2.3 Gage Data

There are no gage data available to calibrate precipitation, watershed runoff, or statistical parameters.

4.2.4 Statistical Parameters

There are no statistical parameters available for this study area.

4.2.5 Precipitation

Refer to Table 4.1 for the precipitation data used for this study area.

4.2.6 Physical Parameters

Refer to Table 4.1 for the physical parameters used for this study area.

4.3 Problems Encountered During the Study

There are no unique problems or conditions for this study.

4.4 Calibration

No calibration of the watershed physical parameters was attempted.

4.5 Final Results

The hydrologic results for this study area are summarized below in Table 4.2

TABLE 4.2
Summary of Peak Discharges

Parameter	Interior Drainage
HEC-1 Model Filename	SURFACE
Concentration Point Identifier	C@364
Peak Discharge, in cfs	355
Time to Peak, in hours	13.25
Volume of Runoff, in ac-ft	59
Comments	n/a

5.0 HYDRAULICS

5.1 Method Description

The proposed Bullard Wash Outfall Channel will improve the flooding south of Lower Buckeye Road by intercepting the surface runoff north of Lower Buckeye Road and conveying it to the Gila River. The COE HEC-RAS v 2.1 microcomputer program is utilized to model the hydraulic characteristics of Bullard Wash for this study. Cross section geometry is based on the proposed construction drawings as documented on Exhibit B.

The HEC-RAS analysis is based on the following boundary conditions:

- The downstream 100-year starting water surface elevation is 906.58 ft for Bullard Wash as computed by HEC-RAS using the slope area method with a slope of 0.002 ft/ft. The 10-year water surface in the Gila River is 906.3 ft per the FEMA study of record by Dames & Moore.

- The upstream 100-year starting water surface elevation (supercritical run) is computed by HEC-RAS using the slope area method with a slope of 0.0046 ft/ft.

HEC-RAS output for the mixed flow analysis of the Bullard Wash Outfall Channel and supporting hydraulic calculations are provided in Appendix E.

5.2 Work Study Map

There is only one reach for this project. The proposed channelization reach of the Bullard Wash Outfall is from Lower Buckeye Road to the Gila River. The proposed outfall channel will contain the full 3,200 cfs with adequate freeboard. Wood, Patel & Associates, Inc. recommends that the entire proposed channel, left bank to right bank, be designated as the floodway. This proposed floodway is shown on Exhibit C.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

Tables E1.1 and E1.2 provide a summary of the Manning's n-values used for this study and are located in Appendix E.

5.3.2 Expansion and Contraction Coefficients

Table E3, located in Appendix E, provides a summary of the expansion and contraction coefficients used for this study.

5.4 Cross Section Description

The study reach of the Bullard Wash Outfall Channel, as shown on Exhibit B, is modeled using 64 hard coded cross sections with 28 interpolated sections by HEC-RAS, for a total of 92 cross sections. The distance between sections is not greater than 200 feet for the proposed Bullard Wash Outfall Channel. The three most northern sections are taken from the WLB study. Cross section numbering corresponds to the construction plan stationing, and is the distance in feet above the confluence with the Gila River.

Cross section plots are provided in Appendix E. The selected locations of the channel banks and assigned Manning's n-values are shown on the plots. The cross sections were selected based on the following criteria.

- Representative of the local channel reach.
- Oriented perpendicular to the direction of flow with the perspective of looking downstream.
- Do not include ineffective flow areas.
- Large enough to contain the 100-year peak discharge.

5.5 Modeling Considerations

5.5.1 Hydraulic Jump and Drop Analysis

The proposed Bullard Wash Outfall Channel contains three sloping drop structures. Each of which force a hydraulic jump. These structures are designed to prevent erosion as documented in section 6. Appendix E contains the analysis of each hydraulic jump. The floodplain limits are not adjusted for the hydraulic jump areas as the entire channel is proposed as the floodway (Section 5.6).

5.5.2 Bridges and Culverts

There are three proposed structures to be built within this study reach, two bridges and one box culvert. Each crossing is modeled utilizing HEC-RAS. Table 5.1 provides a summary of each proposed crossing. Refer to Exhibit B for the design details of each structure. Appendix E contains the HEC-RAS output tables for each structure.

TABLE 5.1
Summary of Bridge and Culvert Crossings

Crossing Name	Station	Description	Method of Analysis
UPRR Bridge	75+43	3 span concrete bridge	HEC-RAS bridge routine
SR 85 Bridge	73+57	3 span concrete bridge	HEC-RAS bridge routine
BID Bypass Culvert	28+90.42	4 barrel 12'x10' CBC	HEC-RAS culvert routine

5.5.3 Levees and Dikes

There is a gabion lined mattress levee from station 33+30 to station 58+50 for this study reach. Sufficient freeboard is maintained along this reach as shown in Table E5.6 of Appendix E. The construction drawings for the proposed levee are provided on Exhibit B.

5.5.4 Islands and Flow Splits

There are no flow splits or islands within this study reach.

5.5.5 Ineffective Flow Areas

In general, there are no ineffective flow areas of concern for this study reach. However, there are 7 maintenance ramp locations. Cross sections are placed at the upstream and downstream limits of the maintenance ramps, thus they are treated as ineffective flow areas where possible.

There is a 1 foot deep low flow channel from station 82+10 to station 119+43 and an maintenance underpass dip section at the UPRR Bridge. The geometry of these low flow channels are coded in the HEC-RAS model. It is the opinion of Wood, Patel & Associates, Inc. that the maintenance ramps and low flow channel are hydraulically insignificant.

5.5.6 Supercritical Flow

The mixed flow option available in HEC-RAS is utilized to analyze the flow regime of Bullard Wash. Supercritical reaches within this study area are limited to the sloping drop structures.

5.6 Floodway Modeling

Wood, Patel and Associates, Inc. proposes that the entire limits of the proposed Bullard Wash Outfall Channel be designated as a floodway. Henceforth, a Method 4 floodway encroachment analysis is performed with zero rise for the proposed Bullard Wash Outfall Channel. Method 1 encroachment is utilized for station 137+00 to station 122+00. This study matches the FEMA regulated floodplain and floodway data at station 137+00 (rivermile 2.883) as shown in Table E5.2 of Appendix E. Table 7.2 provides a draft summary of floodway data in FEMA format.

5.7 Problems Encountered During the Study

5.7.1 Special Problems and Solutions

As described in the Bullard Wash Feasibility Study, the FCDMC has constructed the Dysart Drain in the northern portion of the White Tanks/Agua Fria ADMS watershed. This flood control structure intercepts and diverts the 100-year surface runoff to the Agua Fria River north of Glendale Avenue. Thus, the 100-year flowrate for station 137+00 (RM 2.883 of WLB Study) is 3,200 cfs. However, FEMA requires this study to match existing floodplain limits of record, thus, stations 137+00 and 131+20 are modeled using the FEMA regulated discharge of 4,906 cfs. The 100-year water surface at station 137+00 is 952.8 feet. The floodway elevation is 953.8. Refer to Table 5.2 of Appendix E for verification of these results.

The drop inlet area north of Lower Buckeye Road is designed to allow the FEMA designated flooding zones A and AE to weir flow into the proposed channel. An uneven weir analysis is performed for each side of the drop inlet structure. These water surface elevations are used to establish the floodplain limits along the drop structure. Refer to Appendix E for weir flow calculations.

5.7.2 Modeling Warning and Error Messages

The HEC-RAS model contains several non critical error messages and notes. The majority of notes occur for the reaches that contain the concrete lined low flow channel or sides and bottoms of differing roughness, thus HEC-RAS computes a composite Manning's n-value for the channel. The second majority of warnings are related to the conveyance ratio and velocity head differences between cross sections exceeding the standard HEC-RAS values. These warnings are deemed insignificant due to a maximum cross section spacing of 200 feet. As expected, the sloping drop structures produce critical depth warnings and hydraulic jump warnings.

There are four cross sections that HEC-RAS reports the end points had to be extended to contain the flow. However, sections 124+45, 123+45, 122+00, and 121+98 are located at the channel inlet area, which is upstream of the drop inlet structure. This area is modeled with levees to simulate a 1:1 contraction of the effective flow area upstream of the drop inlet structure. HEC-RAS links these levee sections to the vertical extention of end points warning, thus the warning is not significant. A print out of the HEC-RAS warnings and notes is also provided in Appendix E.

5.8 Calibration

No calibration of hydraulic parameters were performed for this study reach.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

The COE HEC-RAS microcomputer model is used to simulate the riverine characteristics of the proposed Bullard Wash Outfall Channel. The 100-year design discharge for this reach is 3,200 cfs. Adequate freeboard is maintained throughout: 1 ft minimum plus super elevation component where appropriate, for subcritical flow; 2 ft minimum plus super elevation component where appropriate, for supercritical flow. For bridges the minimum freeboard is 2 ft, and for levees (hydraulic grade line above natural ground) the minimum freeboard is 3 ft. HEC-RAS output and freeboard considerations are provided in Appendix E.

5.9.2 Verification of Results

The HEC-RAS output provided in Appendix E appears to be reasonable. Bullard Wash Outfall Channel is a proposed man made channel designed to convey 3,200 cfs with adequate freeboard and erosion protection where necessary.

6.0 EROSION AND SEDIMENT TRANSPORT

Erosion and sediment transport analysis for this study area is performed under separate cover and is included with this submittal. Please refer to *Sediment Transport & Scour Analysis, Bullard Wash Outfall Channel Improvements,* FCD 95-39 by Wood, Patel & Associates, Inc., dated April 10, 1998 for this information. Subsequent to the aforementioned report, two local scour locations were analyzed, downstream of the Ford crossing at Broadway Road, and downstream of the BID Bypass Road. Calculations for these two locations as well as riprap sizing for the grouted riprap reaches and gabion mattress design for the levee reach are included in Appendix F.

7.0 DRAFT FIS REPORT DATA

7.1 Summary of Discharges

Table 7.1 provides a summary of discharges in FEMA format for the study area.

TABLE 7.1
Summary of Discharges in FEMA Format

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs)			
		10-year	50-year	100-year	500-year
Bullard Wash					
At Confluence with Gila River	47.09	--1	--1	3,200	--1
At Confluence with East Tributary (@UPRR)	46.57	--1	--1	3,200	--1
At Lower Buckeye Road	91.66	--1	--1	4,906	--1
East Tributary to Bullard Wash	4.59	--1	--1	850	--1

--1 Not Computed

7.2 Floodway Data

Table 7.2 provides a summary of floodway data results in FEMA format for this study area.

TABLE 7.2
Flooday Data in FEMA Format for Bullard Wash Outfall Channel

FLOODING SOURCE				FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
	Cross Section ID			Width	Section Area	Mean Velocity	Regulatory	Without	With	Increase
Reach	Sta, in feet	Sta, in miles (1)	FEMA ID	(ft)	(sq. ft.)	(fps)		Floodway	Floodway	(ft)
Bullard Wash	2500.00	0.473	A	96	506	6.3	906.58	906.58	906.58	0
Bullard Wash	2660.00	0.504	B	96	505	6.3	906.90	906.90	906.90	0
Bullard Wash	2860.56	0.542	C	96	505	6.3	907.30	907.30	907.30	0
Bullard Wash	2877.74	0.545	D	51.4	256	12.5	906.45	906.45	906.45	0
Bullard Wash	2901.40	0.550	Culvert	--	--	--	--	--	--	--
Bullard Wash	2901.49	0.550	E	51.4	408	7.9	909.45	909.45	909.45	0
Bullard Wash	2911.00	0.551	F	84.8	517	6.2	909.93	909.93	909.93	0
Bullard Wash	2995.26	0.567	G	81.4	229	14.0	909.69	909.69	909.68	0
Bullard Wash	3002.33	0.569	H	62.2	270	11.9	910.82	910.82	910.82	0
Bullard Wash	3049.67	0.578	I	62.2	312	10.3	911.59	911.59	911.59	0
Bullard Wash	3064.67	0.580	J	62.2	315	10.2	911.65	911.65	911.65	0
Bullard Wash	3088.94	0.585	K	88	465	6.9	912.81	912.81	912.81	0
Bullard Wash	3141.00	0.595	L	88	459	7.0	912.84	912.84	912.84	0
Bullard Wash	3266.00	0.619	M	88	449	7.1	912.92	912.92	912.92	0
Bullard Wash	3330.00	0.631	N	110	548	5.8	913.25	913.25	913.25	0
Bullard Wash	3372.00	0.639	O	120	583	5.5	913.35	913.35	913.35	0
Bullard Wash	3562.61 *	0.675	P	120	582	5.5	913.62	913.62	913.62	0
Bullard Wash	3753.23 *	0.711	Q	120	582	5.5	913.90	913.90	913.90	0
Bullard Wash	3943.84 *	0.747	R	120	582	5.5	914.17	914.17	914.17	0
Bullard Wash	4134.46 *	0.783	S	120	581	5.5	914.45	914.45	914.45	0
Bullard Wash	4325.07 *	0.819	T	120	581	5.5	914.72	914.72	914.72	0
Bullard Wash	4515.69 *	0.855	U	120	580	5.5	915.00	915.00	915.00	0
Bullard Wash	4706.30 *	0.891	V	120	581	5.5	915.28	915.28	915.28	0
Bullard Wash	4896.92 *	0.927	W	120	581	5.5	915.55	915.55	915.55	0
Bullard Wash	5087.53 *	0.964	X	120	580	5.5	915.83	915.83	915.83	0
Bullard Wash	5278.15 *	1.000	Y	120	580	5.5	916.11	916.11	916.11	0
Bullard Wash	5468.76 *	1.036	Z	120	580	5.5	916.38	916.38	916.38	0
Bullard Wash	5659.38 *	1.072	AA	120	580	5.5	916.66	916.66	916.66	0
Bullard Wash	5850.00	1.108	AB	120	580	5.5	916.94	916.94	916.94	0
Bullard Wash	5900.00	1.117	AC	116	580	5.5	917.01	917.01	917.01	0
Bullard Wash	6020.00	1.140	AD	116	579	5.5	917.18	917.18	917.18	0
Bullard Wash	6220.00	1.178	AE	116	580	5.5	917.47	917.47	917.47	0
Bullard Wash	6322.00	1.197	AF	116	579	5.5	917.62	917.62	917.62	0
Bullard Wash	6400.00	1.212	AG	116	583	5.5	917.74	917.74	917.74	0
Bullard Wash	6510.00 *	1.233	AH	116	586	5.5	917.90	917.90	917.90	0

TABLE 7.2
Flooday Data in FEMA Format for Bullard Wash Outfall Channel

FLOODING SOURCE				FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
	Cross Section ID			Width	Section Area	Mean Velocity	Regulatory	Without	With	Increase
Reach	Sta, in feet	Sta, in miles (1)	FEMA ID	(ft)	(sq. ft.)	(fps)		Floodway	Floodway	(ft)
Bullard Wash	6620.00	1.254	AI	116	590	5.4	918.07	918.07	918.07	0
Bullard Wash	6776.75 *	1.283	AJ	116	595	5.4	918.29	918.29	918.29	0
Bullard Wash	6933.50 *	1.313	AK	116	600	5.3	918.50	918.50	918.50	0
Bullard Wash	7090.25 *	1.343	AL	116	603	5.3	918.71	918.71	918.71	0
Bullard Wash	7247.00	1.373	AM	116	606	5.3	918.92	918.92	918.92	0
Bullard Wash	7280.00	1.379	AN	98	553	5.8	918.90	918.90	918.90	0
Bullard Wash	7300.00	1.383	AO	98	552	5.8	918.91	918.91	918.91	0
Bullard Wash	7357 BR D	1.393	--	--	489	6.6	918.77	918.77	918.77	0
Bullard Wash	7357 BR U	1.393	--	--	501	6.4	919.04	919.04	919.04	0
Bullard Wash	7417.00	1.405	AP	98	573	5.6	919.26	919.26	919.26	0
Bullard Wash	7440.00	1.409	AQ	98	572	5.6	919.27	919.27	919.27	0
Bullard Wash	7500.00	1.420	AR	98	567	5.6	919.30	919.30	919.30	0
Bullard Wash	7523.00	1.425	AS	98	583	5.5	919.34	919.34	919.34	0
Bullard Wash	7533 BR U	1.427	--	--	524	6.1	919.22	919.22	919.22	0
Bullard Wash	7533 BR D	1.427	--	--	526	6.1	919.25	919.25	919.25	0
Bullard Wash	7543.00	1.429	AT	98	591	5.4	919.43	919.43	919.43	0
Bullard Wash	7558.00	1.431	AU	98	572	5.6	919.42	919.42	919.42	0
Bullard Wash	7605.00	1.440	AV	98	572	5.6	919.44	919.44	919.44	0
Bullard Wash	7700.00	1.458	AW	112	566	5.7	919.47	919.47	919.47	0
Bullard Wash	7744.00	1.467	AX	112	222	14.4	917.48	917.48	917.48	0
Bullard Wash	7771.64	1.472	AY	98	228	14.1	918.71	918.71	918.71	0
Bullard Wash	7925.82 *	1.501	AZ	98	200	16.0	925.06	925.06	925.06	0
Bullard Wash	8080.00	1.530	BA	98	260	12.3	932.41	932.41	932.41	0
Bullard Wash	8100.00	1.534	BB	125	314	10.2	933.73	933.73	933.73	0
Bullard Wash	8210.00	1.555	BC	125	465	6.9	935.30	935.30	935.30	0
Bullard Wash	8348.00 *	1.581	BD	125	494	6.5	935.74	935.74	935.74	0
Bullard Wash	8486.00 *	1.607	BE	125	515	6.2	936.10	936.10	936.10	0
Bullard Wash	8624.00 *	1.633	BF	125	530	6.0	936.41	936.41	936.41	0
Bullard Wash	8762.00 *	1.659	BG	125	543	5.9	936.69	936.69	936.69	0
Bullard Wash	8900.00	1.686	BH	125	552	5.8	936.94	936.94	936.94	0
Bullard Wash	9000.00	1.705	BI	116	537	6.0	937.09	937.09	937.09	0
Bullard Wash	9080.00	1.720	BJ	116	543	5.9	937.24	937.24	937.24	0
Bullard Wash	9200.00	1.742	BK	116	547	5.9	937.44	937.44	937.44	0
Bullard Wash	9372.00	1.775	BL	125	579	5.5	937.77	937.77	937.77	0
Bullard Wash	9529.00 *	1.805	BM	125	584	5.5	938.00	938.00	938.00	0

TABLE 7.2
Flooday Data in FEMA Format for Bullard Wash Outfall Channel

FLOODING SOURCE					FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
	Cross Section ID										
Reach	Sta, in feet		Sta, in miles (1)	FEMA ID	Width (ft)	Section Area (sq. ft.)	Mean Velocity (fps)	Regulatory	Without Floodway	With Floodway	Increase (ft)
Bullard Wash	9686.00	*	1.834	BN	125	587	5.5	938.22	938.22	938.22	0
Bullard Wash	9843.00	*	1.864	BO	125	591	5.4	938.44	938.44	938.44	0
Bullard Wash	10000.00		1.894	BP	125	594	5.4	938.66	938.66	938.66	0
Bullard Wash	10100.00		1.913	BQ	116	574	5.6	938.77	938.77	938.77	0
Bullard Wash	10200.00		1.932	BR	116	576	5.6	938.92	938.92	938.92	0
Bullard Wash	10300.00		1.951	BS	125	602	5.3	939.09	939.09	939.09	0
Bullard Wash	10430.00	*	1.975	BT	125	602	5.3	939.26	939.26	939.26	0
Bullard Wash	10560.00	*	2.000	BU	125	604	5.3	939.43	939.43	939.43	0
Bullard Wash	10690.00	*	2.025	BV	125	605	5.3	939.59	939.59	939.59	0
Bullard Wash	10820.00		2.049	BW	125	605	5.3	939.76	939.76	939.76	0
Bullard Wash	11000.00		2.083	BX	125	606	5.3	939.98	939.98	939.98	0
Bullard Wash	11100.00		2.102	BY	116	585	5.5	940.09	940.09	940.09	0
Bullard Wash	11200.00		2.121	BZ	116	586	5.5	940.22	940.22	940.22	0
Bullard Wash	11300.00		2.140	CA	125	611	5.2	940.39	940.39	940.39	0
Bullard Wash	11425.00	*	2.164	CB	125	612	5.2	940.54	940.54	940.54	0
Bullard Wash	11550.00		2.188	CC	125	612	5.2	940.70	940.70	940.70	0
Bullard Wash	11735.00		2.223	CD	116	590	5.4	940.90	940.90	940.90	0
Bullard Wash	11883.00		2.251	CE	116	592	5.4	941.10	941.10	941.10	0
Bullard Wash	11932.00		2.260	CF	116	591	5.4	941.16	941.16	941.16	0
Bullard Wash	11943.00		2.262	CG	98	544	5.9	941.13	941.13	941.13	0
Bullard Wash	12195.00		2.310	CH	98	145	22.1	936.92	936.92	936.92	0.00
Bullard Wash	12198.00		2.310	CI	1450	640	5.0	945.82	945.82	945.82	0.00
Bullard Wash	12200.00		2.311	CJ	130	481	6.7	946.90	946.90	947.50	0.60
Bullard Wash	12345.00		2.338	CK	225	783	4.1	946.92	946.92	947.87	0.95
Bullard Wash	12445.00		2.357	CL	300	885	3.6	947.51	947.51	948.30	0.79
Bullard Wash	12640.00	2	2.394	CM	415	1,378	2.3	947.85	947.85	948.67	0.82
Bullard Wash	13120.00	2	2.485	CN	365	725	6.8	948.89	948.89	949.04	0.15
Bullard Wash	13700.00	2	2.595	CO	350	1,430	3.4	952.80	952.80	953.80	1.00

Notes: * Denotes HEC-RAS Interpolated Cross Section
1) Miles above confluance with Gila River
2) Stations 126+40, 131+20 & 137+00 are RM 2.690, 2.771, & 2.883 of previos study, respectively. Channelication of Bullard Wash reduces the distance from the confuance with the Gila River by approximately 0.29 miles

7.3 Annotated Flood Insurance Rate Map

Figure 7.1 contains the proposed Bullard Wash Outfall Channel CLOMR information as documented within this report. Refer to Exhibit C for floodway work maps.

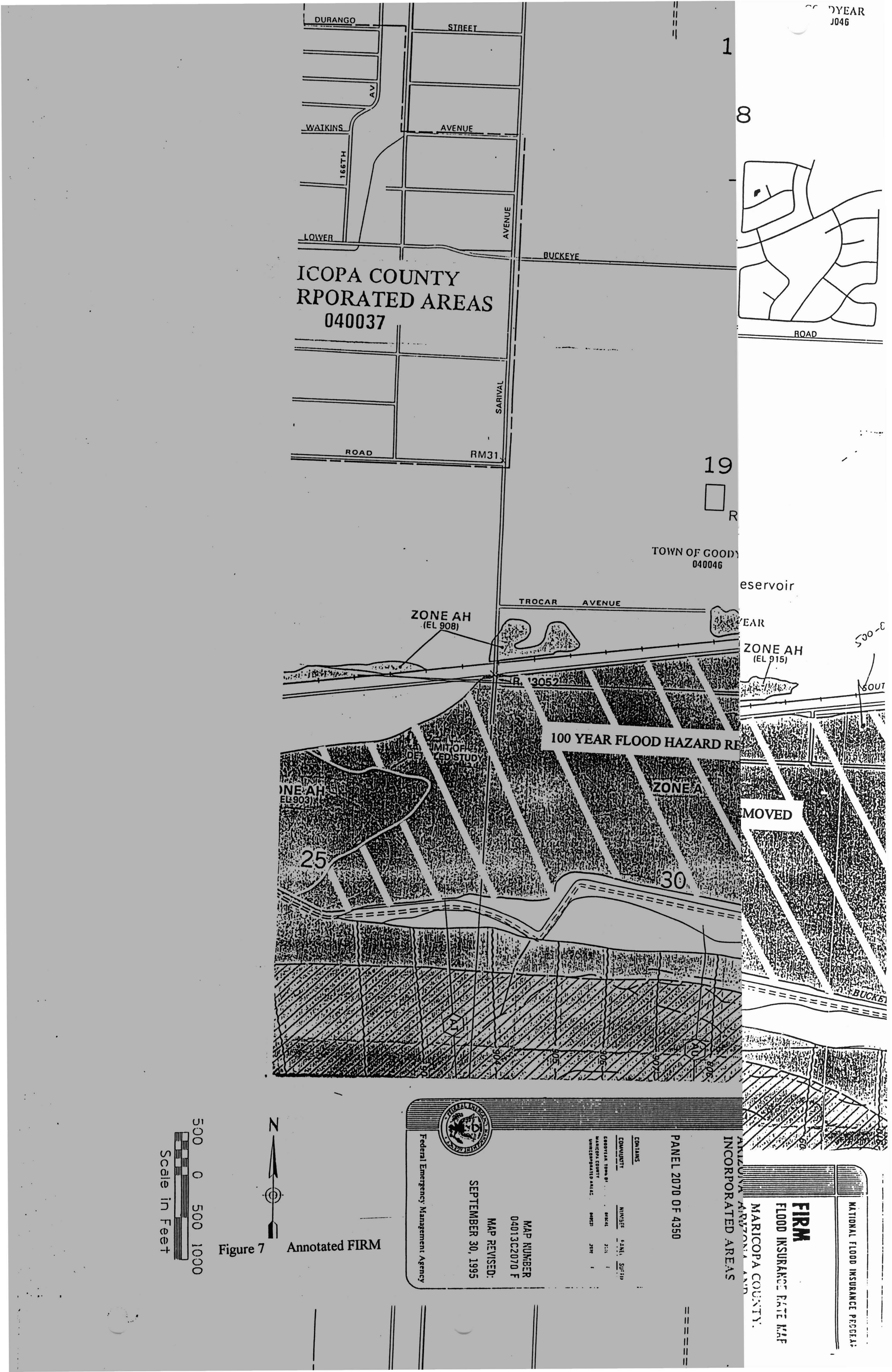
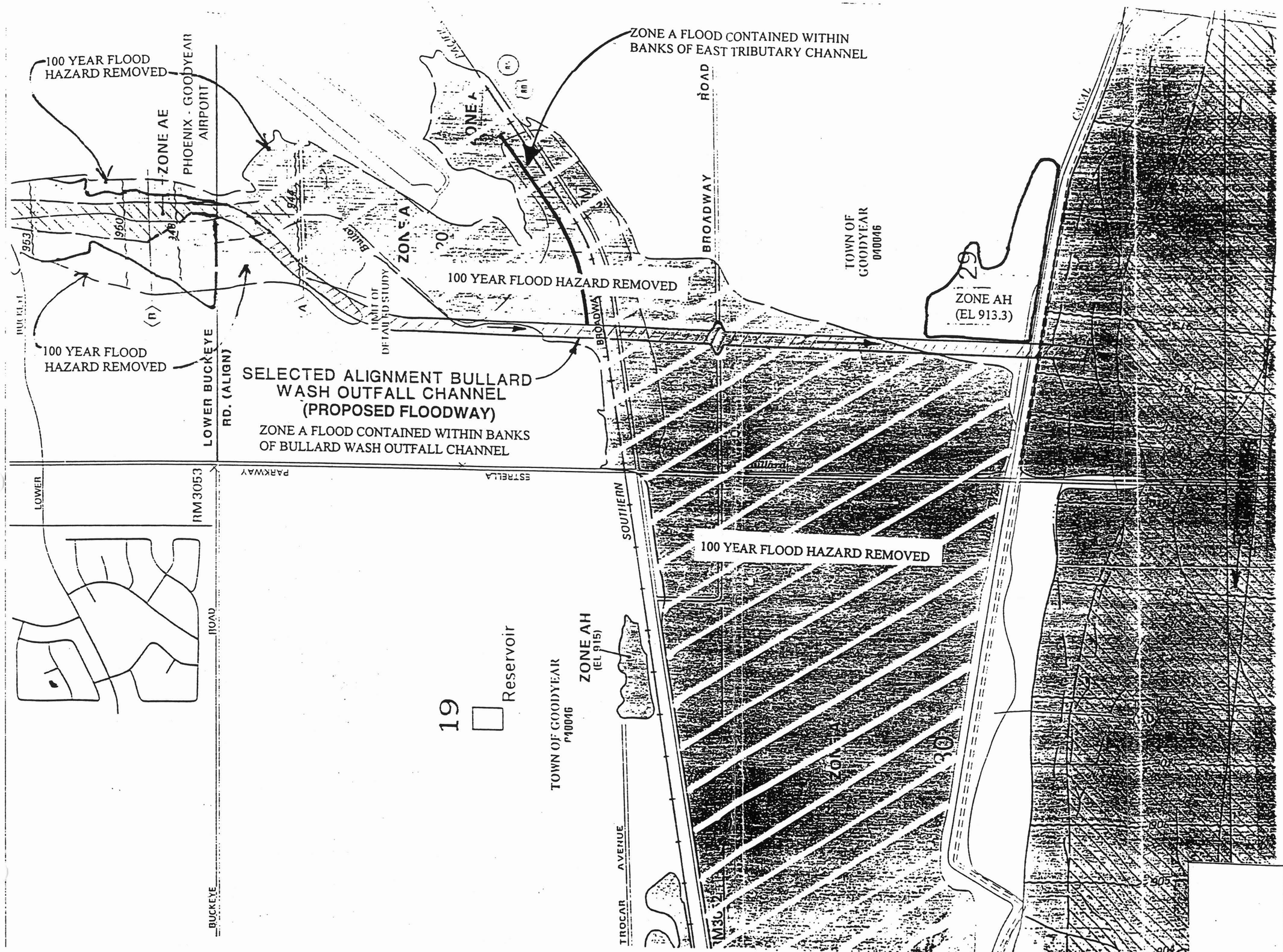


Figure 7 Annotated FIRM



NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 2070 OF 4350

CONTAINS

COMMUNITY	NUMBER	PANEL	SUFFIX
GOODYEAR, TOWN OF	040046	2070	F
MARICOPA COUNTY UNINCORPORATED AREAS	040037	2070	F

MAP NUMBER
04013C2070 F

MAP REVISED:
SEPTEMBER 30, 1995

Federal Emergency Management Agency

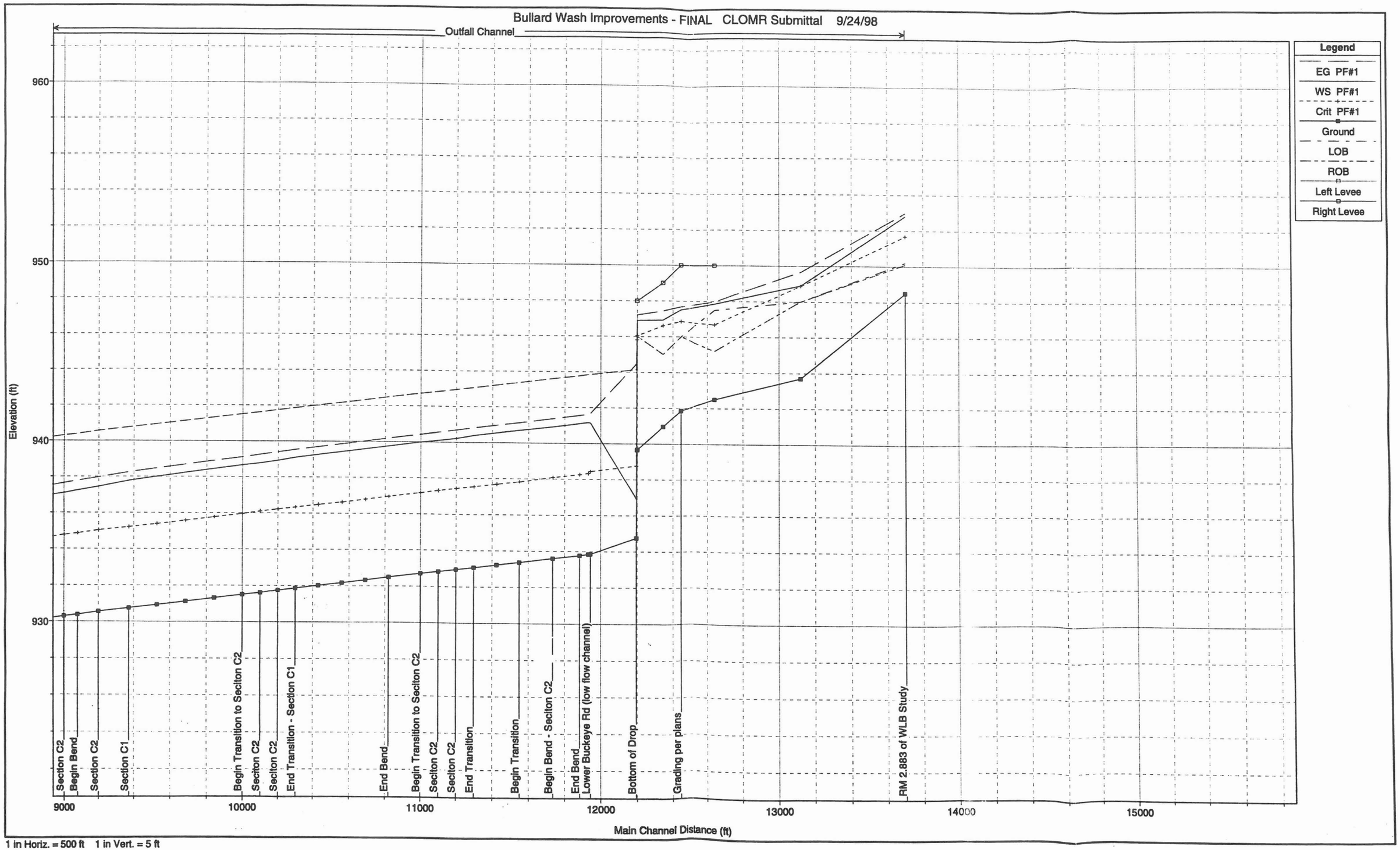
FLOOD INSURANCE RATE MAP
FIGURE 7.1

WOOD/PATEL ASSOCIATES Civil Engineers Hydrologists	SCALE 1" = 1000'	SHEET 1 OF 1
	DATE	JOB NO.

7.4 Flood Profiles

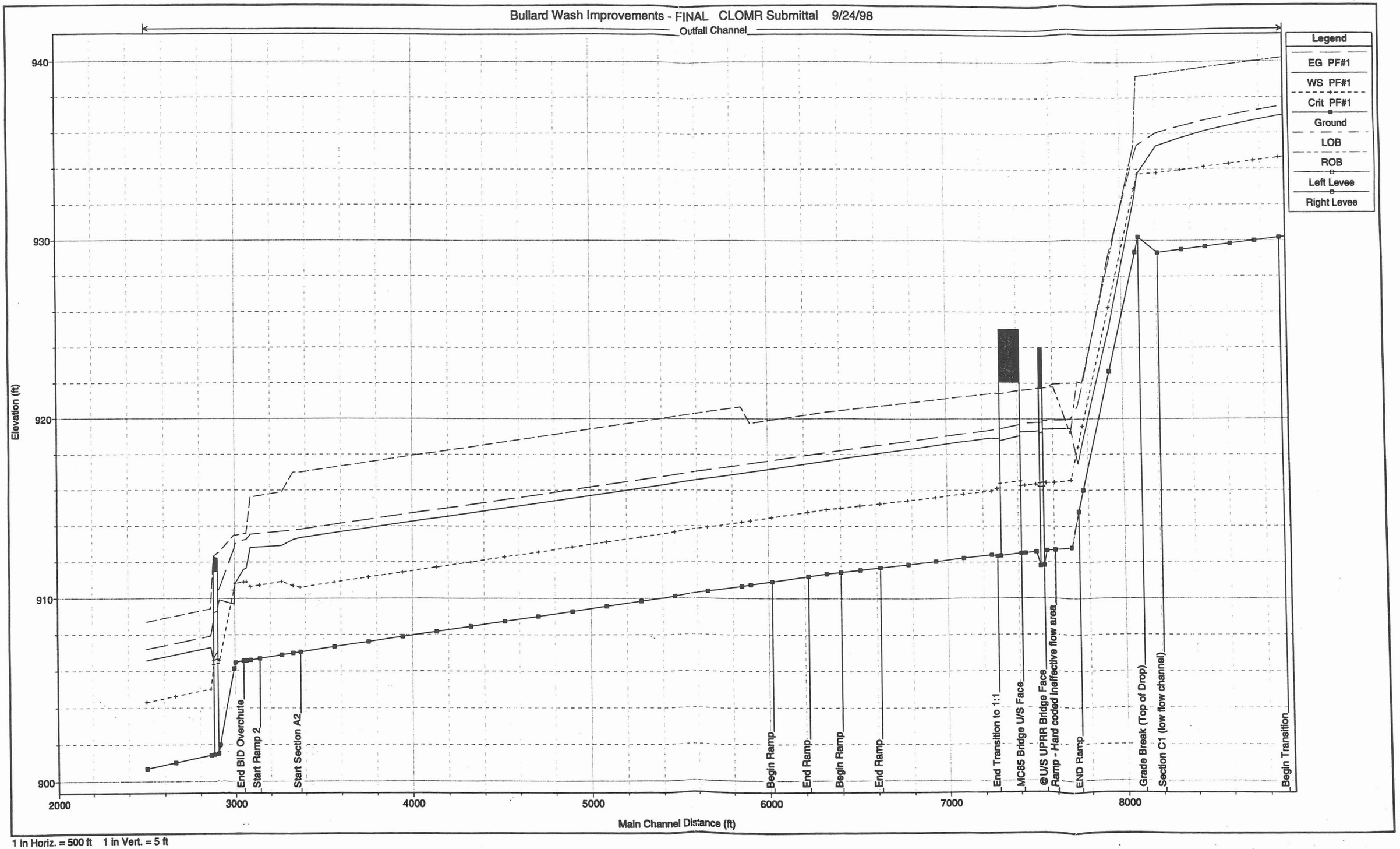
Figure 7.2 contains the proposed Bullard Wash Outfall Channel flood profile for the 100-year storm.

FIGURE 7.2



1 in Horiz. = 500 ft 1 in Vert. = 5 ft

FIGURE 7.2



1 in Horiz. = 500 ft 1 in Vert. = 5 ft

LIST OF APPENDICES
(Following Text)

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Appendix F Erosion and Sedimentation Analysis

LIST OF EXHIBITS
(Following Appendices)

Exhibit A Hydrology Maps
Exhibit B Proposed Construction Plans (submitted under separate cover)
Exhibit C Proposed Floodway Work Maps

Appendix A

References

Appendix A1 Data Collection Summary

Appendix A2 List of References

Appendix A1

Data Collection Summary

The following is a list of data collected for this study area:

- Electronic copies of the White Tanks/Agua Fria ADMS HEC-1 input and output files, electronic copies of HEC-2 input files.

- A 24" x 36" copy of the White Tanks/Agua Fria ADMS Drainage Area Map.

- FEMA FIRM panel 04013C2070F, dated September 30, 1995.

- A 11" x 17" reduced copy of the construction plans for the proposed Bullard Wash Outfall Channel by Sverdrup Civil, Inc., July 1998, included in Exhibit B.

- General details of proposed bridge crossings, more specifically, type of crossing, length and number of spans, pier information, and proposed geometry necessary for hydraulic modeling purposes. General bridge information follows this page. Design data for bridges is attached to the construction plan set as referenced in Exhibit B, and also included in Appendix E4.

Appendix A2

List of References

LIST OF REFERENCES

1) Flood Control District of Maricopa County, *White Tanks/Auga Fria Area Drainage Master Study*, The WLB Group, Inc., October 1992.

2) Flood Control District of Maricopa County, *Aerial Topography for White Tanks/Agua Fria Area Drainage Master Study*, The WLB Group, Inc., flown by Cooper Aerial of Phoenix, Inc., Flight Date: December 22, 1989, Contour Intervals: 2 feet.

3) Flood Control District of Maricopa County, *Gila River Study*, Dames & Moore, revised December 3, 1993.

4) Flood Control District of Maricopa County, *Flood Delineation Study of Salt-Gila Rivers (in progress)*, Michael Baker Jr., Inc.

5) Flood Control District of Maricopa County, *Bullard Wash Outfall Feasibility Study (FCD 94-06), Volume 1 of 2*, Stanley Consultants, Inc. et al, September 1995.

6) Flood Control District of Maricopa County, *Sediment Transport & Scour Analysis, Bullard Wash Outfall Channel Improvements (FCD 95-39)*, Wood, Patel and Associates, Inc., April 10, 1998.

7) Flood Control District of Maricopa County, *Plans for the Construction of : Bullard Wash Channel Improvements Project (FCD 98-15), Final Submittal*, Svderup Corp., September, 1998.

8) Flood Control District of Maricopa County, *Design Data Report, Bullard Wash Channel Improvements Final Design*, Sverdrup Corp., September 1998.

9) Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Arizona; Volume I - Hydrology*, revised January 1995.

10) Flood Control District of Maricopa County, *Drainage Design Manual for Maricopa County, Arizona; Volume II - Hydraulics*, January 1996.

11) HEC-1 Flood Hydrograph Package, Version 4.0.1e, US Army Corps of Engineers, Hydrologic Engineering Center, as implemented by Dodson & Associates, Inc., Houston Texas, May 1991.

12) HEC-RAS River Analysis System, Version 2.1, US Army Corps of Engineers, Hydrologic Engineering Center, Davis California, October 1997.

13) Chow, Ven Te, Ph D., *Open Channel Hydraulics*, McGraw-Hill, 1959.

14) Brater and King, *Handbook of Hydraulics 6th Ed.*, McGraw-Hill, 1976.

Appendix B

General Documentation & Correspondence

Appendix B1	Special Problem Reports
Appendix B2	Contact (Telephone) Reports
Appendix B3	Meeting Minutes and Reports
Appendix B4	General Correspondence
Appendix B5	Contract Documents

Appendix B1

Special Problem Reports

There are no special problem reports for this study area.

Appendix B2

Contact (Telephone) Reports

TELECON

Sverdrup Civil, Inc.

Date: December 17, 1997

TO: Gary Voogd
Union Pacific Railroad

FROM: Bradford D. Olbert, P.E.
Project Manager
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
UPRR Bridge over Proposed Bullard Wash Channel

SUMMARY:

Mr. Olbert contacted Mr. Voogd on December 12th concerning the design of a new railroad bridge over the proposed Bullard Wash Channel in Maricopa County, Arizona. Mr. Voogd had discussed the project earlier in the week with Don Rerick (Flood Control District of Maricopa County (FCDMC)) and received a copy of the schematic of the bridge site.

Mr. Voogd said that the railroad bridge over the proposed Bullard Wash Channel will need to use a special abutment to accommodate a "U" shaped channel section with a retaining wall adjacent to the abutment. The railroad can accommodate the channel shape but not with their standard abutment design. The special abutment would double the cost of the railroad structure because of additional pile bents and concrete.

Mr. Voogd suggested that the railroad bridge standard span be lengthened to 34 feet to maintain an earth berm on the inside of the abutment. A 3-foot earth shelf is needed on the channel side of the pile cap with a 1:1 slope down to the channel bottom provided the channel is lined with concrete to cover the soil berm. Mr. Voogd provided a sketch (by Fax) of the basic dimensions of the bridge abutment utilizing the 34-foot span length with the berm (see attachment). The resultant channel will have a bottom width of 79 feet. The cost per foot for the bridge is approximately $3800/LF.

The proposed at-grade crossing and the tailwater culvert, shown on the bridge site plan, will need to be addressed by Bob Prince. Mr. Voogd will only provide costs for the proposed bridge crossing. Removal of the two existing railroad bridges (tailwater bridge @ MP 887.39 and the bridge over existing Bullard Wash @ MP 887.76) should be a separate issue from the railroad bridge and can

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be done at a later date (because their removal is not required for this project).

Mr. Olbert said that the removal of the existing railroad bridge in the future at MP 887.76 should be coordinated with the Maricopa County Department of Transportation (MCDOT). MCDOT will also need to remove their highway bridge over the existing Bullard Wash. The bridges need to be replaced with a small culvert (possibly a pipe culvert) to carry tailwater from the East Tributary under both the railroad and the highway.

Mr. Olbert confirmed the change in the proposed channel section and longer bridge with Mr. Rerick at the Flood Control District of Maricopa County (FCDMC). A follow-up message was left on Mr. Voogd's voice mail to proceed with the UPRR cost estimate using a ~~112~~-foot long bridge with the earth berm as described above and shown on the attached sketch. 102 (320)

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: Don Rerick - FCDMC
013884-2B

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Fax. (602) 220-9199

UNION PACIFIC RAILROAD

FORM 24003 (Rev. 3-84)

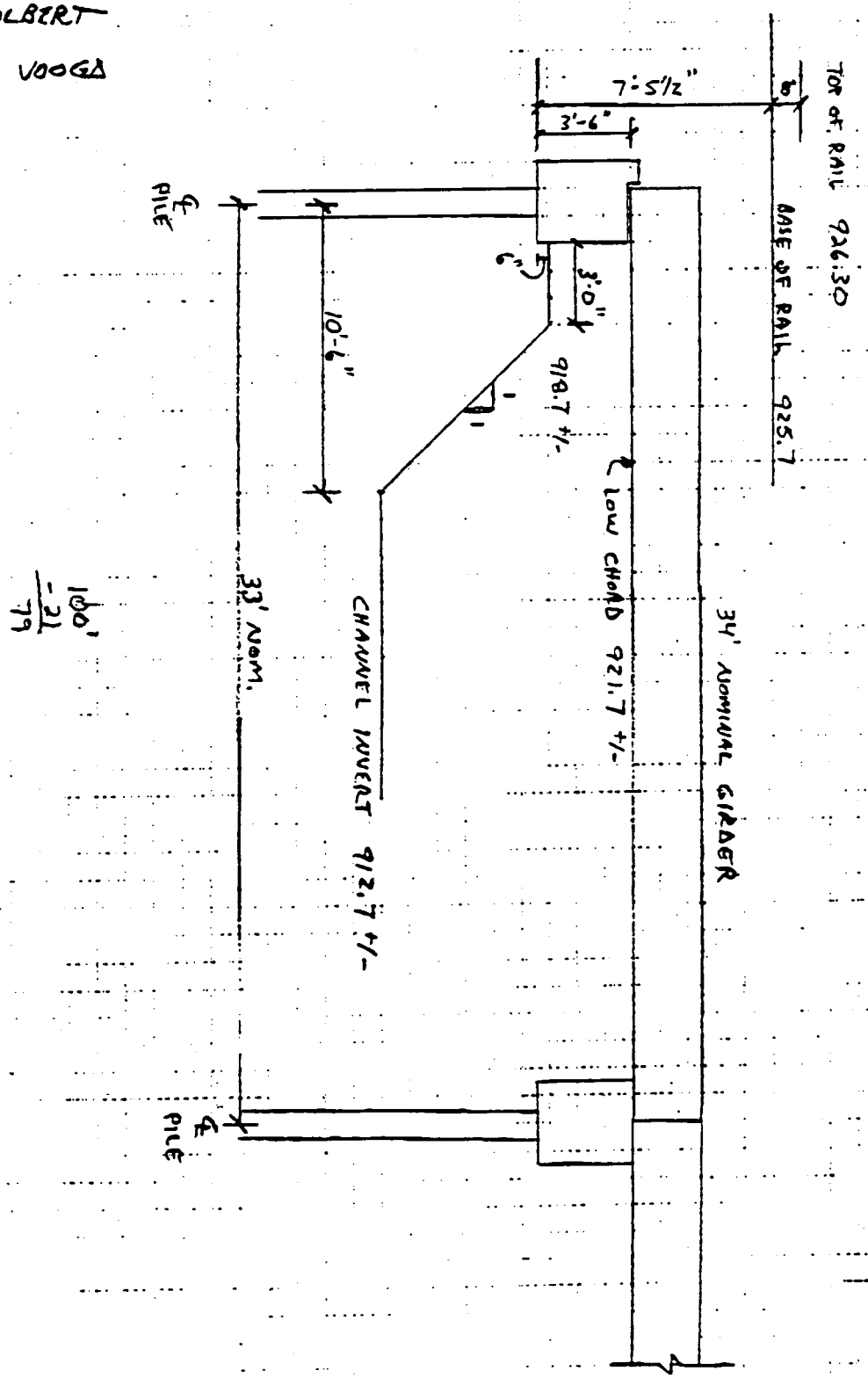
OFFICE OF V.P. ENGINEERING
OMAHA, NEBRASKA

PROJECT: BR. 887.30 PHOENIX LINE
SHEET NUMBER _____ OF _____ W.O. _____
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____
FILE NUMBER _____

NOTES:

TO: BRAD OLBERT

FROM: GARY VOOGD



TELECON

Sverdrup Civil, Inc.

Date: January 12, 1997

TO: Ron Rayner
A-Tumbling-T Ranches

FROM: Bradford D. Olbert, P.E.
Project Manager
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Tailwater Discharge from East Local Tributary

SUMMARY:

Mr. Rayner returned Mr. Olbert's call on January 12th concerning the meeting date for the proposed Bullard Wash Channel. He will be able to attend the meeting in Goodyear on January 20th. Mr. Olbert asked Mr. Rayner if he knew what the tailwater flow rates were from both the East Local Tributary and the Bullard Wash tailwater ditch. Mr. Rayner said the maximum flow rates are in the range of 10 to 15 cfs. If pipe sizes of 30 to 36-inches are provided, it would be adequate for his needs. Mr. Rayner preferred a pipe size that would provide the tailwater flow but would also reduce the amount of storm water flow he receives. The storm water causes considerable damage to his facilities, so a smaller pipe would be better. Mr. Olbert said he would look at the 30 and 36-inch pipe size flow ranges and bring the information to the meeting next week. A pipe size can be selected at the meeting.

Signed: Bradford D. Olbert
Bradford D. Olbert, P.E.

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TELECON

Sverdrup Civil, Inc.

Date: April 6, 1998

TO: **File**

FROM: **Dan Stough, P.E.**
Project Engineer
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
(Western Area Power Association OH Power Line Clearances)

SUMMARY:
Mr. Stough contacted Roy Watson (Western Area Power Association, WAPA). Mr. Stough asked for clarification of the overhead power line clearances stated by Mr. Watson in a letter to John Palmeri.

Mr. Watson stated in the phone conversation that the minimum clearance is twenty-four feet (24') from wires to top of berm (the operation and maintenance road surface). The maximum height VEHICLE is 15' at any time. Extra caution should be used during summer months because of increased sag due to load and heat.

Mr. Watson also added that warning balls must be installed on the wires if the channel is to be inspected using helicopter or winged aircraft. The Operation and Maintenance guidelines will be written to include maximum heights on vehicles (not to exceed 15 feet) and that aircraft shall NOT be used to inspect the channel south of MC 85.

Signed: Daniel E. Stough

Daniel E. Stough, P.E.

Distribution:

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TELECON

Sverdrup Civil, Inc.

Date: June 9, 1998

TO: **Tim Smith**

FROM: **Bradford D. Olbert, P.E.**
Project Engineer
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
60% Construction Plan Review by Tim Smith

SUMMARY:

Mr. Olbert contacted Tim Smith for his comments on the above plan set. The following are his comments:

1. Because of the way the fields drain, additional tailwater pipes will be needed at stations 107+50 and 116+00. The pipes should be 12 inches in diameter.

2. The tailwater pipe located at station 119+80 is shown as a 12-inch pipe. This is too small of a pipe diameter. The existing pipe is larger than 12 inches. The minimum pipe size should be 18 inches. Mr. Olbert said he will check the existing pipe size before resizing the pipe.

3. All other plan items were satisfactory.

Signed: Bradford D. Olbert
Bradford D. Olbert, P.E.

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TELECON

Sverdrup Civil, Inc.

Date: June 22, 1998

TO: **Tim Smith**

FROM: **Bradford D. Olbert, P.E.**
Project Engineer
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
60% Construction Plan Review by Tim Smith

SUMMARY:

Tim Smith contacted Mr. Olbert concerning the deletion of a tailwater pipe requested earlier (6/9/98) by Mr. Smith at station 116+50. Mr. Smith said that the Wood property has a low spot at that location. Mr. Olbert said that the new tailwater ditch would be located approximately 220 ft to the west of its current location. Because the ditch is further to the west the ground can be graded to drain to the north to the location of the proposed tailwater inlet. Mr. Smith said that the ground is higher to the west of the new channel and agreed that a tailwater ditch could be graded to the proposed tailwater inlet.

Signed: Bradford D. Olbert
Bradford D. Olbert, P.E.

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TELECON

Sverdrup Civil, Inc.

Date: June 24, 1998

TO: **Pete Thomas, APS**
Transmission Maintenance Dept.
 # 371-7156

FROM: **Bradford D. Olbert, P.E.**
Project Engineer
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Fence Grounding under Transmission Towers

SUMMARY:

Mr. Olbert contacted Mr. Thomas about the grounding of fences and railings under the high voltage transmission lines. The following was discussed.

- In a situation such as Bullard Wash where there are three transmission lines crossing the channel adjacent to one another, APS would place a grounding rod 75 feet each side of the transmission corridor (not on each side of a transmission line) and possibly one more in the center of the three lines. For a single high voltage transmission line place a grounding rod 75 feet to each side of the line.

- He will send grounding details to Sverdrup that APS uses.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: Don Rerick, FCDMC
013884-2B

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TELECON

Sverdrup Civil, Inc.

Date: June 30, 1998

TO: **Barbara Rust**
Coe & Van Loo Consultants, Inc.

FROM: **Bradford D. Olbert, P.E.**
Project Engineer
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Broadway Road Access through Bullard Wash

SUMMARY:

Mr. Olbert contacted Ms. Rust concerning the Broadway Road access through Bullard Wash. The following was discussed.

- During construction of the channel, there will be periods of time that access through the channel at Broadway Road will be restricted. The specification will be clear that the contractor will need to coordinate with Mr. Rayner to schedule the closures.

- The contractor will be required to maintain the irrigation system through the construction site for the duration of the work.

- Ms. Rust said that everyone always assumed that some closure would be necessary but she will contact Mr. Rayner and inform him of the possible closures and the coordination with the contractor on the timing and duration of the closures.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

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Appendix B3

Meeting Minutes and Reports

Standard Maintenance Procedures
Prepared for the Bullard Wash Channel Project

SUBJECT: Maintenance of Channels, Linings and Structures

PURPOSE: To insure the integrity of the project is preserved and will function as designed.

OWNERSHIP: The City of Goodyear, Arizona shall be responsible for the ownership, operation and maintenance of the completed project. The Interim Public Works Director, Andrew Cooper, will be the responsible person at the City.

LOCATION: Main Bullard Wash Channel, East Tributary Channel, Spillway at the BID Canal east of the Bullard Wash Channel, and the O&M Road and Berm at Lower Buckeye Road

PROCEDURE A: Channel and Inlet Pipes

1. **Vegetation** - Desert brush and grasses can be allowed to grow within the channel bottom. Desert brush must not exceed 2-3 feet in height and vegetation type must be able to break away during storm event (i.e. brittlebush) or be able to bend over and flatten (i.e. Desert Marigold). Vegetation types that must be removed include woody stemmed plants (i.e. Desert Broom, Salt Cedar, etc.). If grasses are established, maintain the height to a maximum of six inches.

2. **Sediment Deposits** – Remove deposits of loose material to obtain designed grades and cross sections. Loose deposited materials shall not be used within the channel unless tested to meet the earthfill criteria in the construction specifications. At a minimum, sediment deposits shall be removed annually, unless quarterly inspections identify a need for more frequent removal.

3. **Erosion** – Make repairs to eroded areas by replacing lost material with compacted earth, or other suitable erosion resistant material, in accordance with the original construction specifications.

4. **Debris/Trash** – During quarterly inspections and after storm events, all trash and organic debris is to be removed from the area as soon as possible. Inspect all drainage pipes that discharge into the channel. Remove all trash and organic debris from pipe inlets as soon as possible.

5. **Gabion Lining** – During quarterly inspections and after storm events, all gabion baskets or mattresses that have been damaged shall be repaired using the manufacturer procedures as soon as possible. The Polyvinyl Chloride (PVC)

coating on the gabion wire also requires inspection. Where the PVC coating has been damaged, the damaged coating shall be removed and the PVC coating reapplied per manufacturer's procedures. Yearly inspections will include excavation of buried gabions and a check of steel anchor stakes to inspect for corrosion. At a minimum, excavation locations will include one site south of the Buckeye Irrigation District (BID) South Maintenance Road, three sites between the BID Canal and the MC 85 Bridge, and three additional sites between the drop structure located north of the Union Pacific Railroad Bridge and Lower Buckeye Road. Each yearly inspection shall also stagger the excavation locations so that a comprehensive inspection is performed year-to-year.

6. **Grouted Riprap Lining** – During quarterly inspections and after storm events, riprap lining that has been damaged shall be repaired. Repairs shall include replacement of riprap material and grout, filter blankets, and the seepage/back drainage system. Inspections shall include a check of all weep holes and removal of any blockages.

7. **Concrete Lining** – During quarterly inspections and after storm events, the concrete lining shall be checked for damage and cracking. Hairline cracks are typically caused by shrinkage of the concrete, which is a normal condition. Cracks that are wide enough for a quarter to be inserted into the crack, should be repaired as soon as possible. Inspection shall include a check of the weep holes.

8. **BID Overchute / BID South Maintenance Road Box Culvert** – During quarterly inspections and after storm events, the concrete surfaces shall be checked for damage and cracking. Inspect the condition of all joints. Items requiring repair should be scheduled as soon as possible. Maintenance vehicle weights should be limited to that which is legal for operation on a highway. The box culvert has a height limitation of 10 feet.

9. **Levee** – Top of berm elevations along the earthen levee, located between the BID Canal and 450 feet south of Broadway Road, shall be surveyed annually for the first five (5) years of operation to check for settlement and/or subsidence, and then bi-annually in the following years. Areas requiring repair shall be scheduled as soon as possible. Caution must be given to overhead power lines. The maximum height of vehicles is 15 feet.

PROCEDURE B: Rodent Control

1. Gophers can damage embankments, berms and levees by burrowing deep holes with more than one outlet. Fresh mounds of soil can identify new gopher outlets.

2. Ground squirrels can also damage structures even with insignificant numbers and must be treated.

3. A licensed pesticide applicator shall apply the appropriate pesticide and the Material Safety Data Sheets shall be with the licensed applicator.

4. After rodent activity has been controlled, holes are to be filled and compacted.

PROCEDURE C: General Vandalism and Graffiti

1. Graffiti needs to be removed as soon as possible to discourage repeated applications.

2. General vandalism to include cut or damaged fencing, damaged signs, illegal ingress, dumped trash, etc. are to be removed/repaired as soon as noted for the safety of the general public and to control other forms of vandalism from occurring.

3. All vandalized signs are to be repaired or replaced to insure public safety and awareness.

INSPECTIONS:

1. Quarterly Operational Inspections:
   a. List any discrepancies.
   b. Review for action required.
   c. Schedule necessary repairs.

2. Annual Maintenance Inspection:
   a. List all needed maintenance and repairs.
   b. Assign work orders for the noted repairs.

3 Formal Annual Inspection:
   a. Inspect project to insure all maintenance and repairs are completed satisfactorily.
   b. Complete annual inspection reports for file.

4. Major Storm Event:
   a. Inspect project during or after every major storm event.
   b. List any problems.
   c. Record flow depths.
   d. Schedule necessary repairs.

5. Citizen Complaints/Inquiries:
   a. Investigate area of complaint.
   b. Respond to citizen within 48 hours.
   c. Take action if in-house/refer to proper agency, if not.

MEMORANDUM

Sverdrup Civil, Inc.

Date: August 5, 1998

TO: **Larry Martinez and Chris Stevens**
City of Goodyear
119 North Litchfield Road
Goodyear, Arizona 85338

Don Rerick
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

FROM: **Bradford D. Olbert, P.E.**
Project Manager
Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Channel Roughness Factors

The proposed Bullard Wash Channel from the Lower Buckeye Road inlet area to the Gila River is composed of several different channel sections and types of lining materials. Below is a discussion of the roughness factors used to calculate the channel hydraulic capacity/water surface profiles, and the limitations of each channel section to keep the channel operating within the design parameters.

To simplify the discussion, Bullard Wash has been divided into segments correlating to the different types of channel section used. Starting from just north of Lower Buckeye Road and proceeding south to the Gila River, the channel segments are identified by the stationing used in the construction plan set.

Station 122+00 to 119+54 (Channel Inlet Area) – Drop inlet area is designed to collect upstream flows. The inlet area will be lined with rock-filled gabion baskets and mattresses to minimize erosion to the channel. The baskets will be stair stepped to provide a cascading effect to the captured overbank flows. The rock-filled baskets have a roughness factor (n) of 0.029 (per manufacturer). For the design, an n value of 0.030 was used. This channel section is temporary and will be removed when the channel is extended to the north.

Station 119+54 to 81+02 (Composite Channel Section) – Composite channel section is designed to convey flows around the west end of the Phoenix Goodyear Airport. The composite section is composed of 2:1 and 3:1 sideslopes lined with rock-filled mattresses (to minimize erosion to the channel banks) and an earthen bottom. In addition, a narrow concrete lined ditch is located within the channel section to convey irrigation tailwater flows. The tailwater exits at the end of this channel reach. The rock-filled mattresses have a roughness factor of 0.027 (per manufacturer). For the design,

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an n value of 0.030 was used. The higher n value was chosen to allow for some vegetative growth (grasses and brush 1 to 2 ft high) along the sideslopes. For the channel bottom an n value of 0.032 was selected for the design. A clean soil bottom will have an n value of 0.025, however, with the City of Goodyear's desire to allow vegetative growth within the channel, for aesthetic reasons, the higher n value was used. The narrow concrete lined ditch will have an n value of 0.015 (heavy broom finish).

The vegetative growth on the channel bottom will need to be limited to grasses and short brush 1 to 3 ft in height. Some examples of brush types to use are common desert plants such as the brittle bush and desert marigold. The brittlebush is particularly good because of its brittle nature it will be easily striped away during a major storm event. One brush type to avoid is the desert broom, which has a deep taproot and can grow to 10+ ft in height. Tree plantings should be avoided within this section.

Station 81+02 to 77+00 (Grouted Riprap Channel Section) – The grouted riprap channel section is designed to provide a roughened (high n value) channel section in lieu of a drop structure at the southwest end of the Phoenix Goodyear Airport. The section is lined with grouted rock that is 22 inches thick. A narrow 15-ft wide concrete maintenance roadway is located within the channel section to provide continuous access along the channel bottom. The pathway surface will have a roughened surface (raked finish) to discourage the use of roller blades or skateboards. In addition, several tree wells using concrete pipe section have been added to enhance aesthetics. The grouted riprap has an n value of 0.042. The narrow 15-ft wide concrete maintenance roadway has an n value of 0.019. A composite n value of 0.038 was used for the design of the channel section.

Station 77+00 to 72+90 (Concrete Lined Channel Section) – The concrete lined channel section is designed to provide a hardened channel section at the end of the grouted riprap section and through the railroad and highway bridges. The section is lined with reinforced concrete that is 6 inches thick. The hardened surface is necessary to control the erosive action downstream of the grouted riprap section and eliminate local scour conditions at the bridges. The railroad bridge has a limited vertical clearance. A 15-ft wide maintenance path that is depressed one-foot under the railroad bridge will provide a 10-ft clearance for maintenance vehicles. The highway bridge provides 10+ ft of clearance. The bottom concrete surface will be roughened (raked finish) to discourage the use of roller blades or skateboards. The concrete bottom surface and the concrete sideslopes (heavy broom finish) have roughness factors of 0.019 and 0.015 respectively.

Station 72+90 to 33+30 (Composite Channel Section) – Composite channel section is designed to convey flows south of the highway to the BID canal. The composite section is composed of sideslopes lined with rock-filled mattresses (to minimize erosion to the channel banks) and an earthen bottom. The rock-filled mattresses have a roughness factor of 0.027 (per manufacturer). For the design, an n value of 0.030 was used. The higher n value was chosen to allow for some vegetative growth (grasses) along the sideslopes. For the channel bottom an n value of 0.032 was selected for the design. See earlier section concerning the City of Goodyear's desire to allow vegetative growth within the channel for aesthetic reasons.

Station 33+30 to 30+02 (Concrete Lined Channel Section) – The concrete lined channel section is designed to provide a hardened transition channel section from the PVNGS 96-inch concrete encasement to the BID overchute structure. The section is lined with reinforced concrete that is 6 inches thick. The hardened surface is necessary to transition from the 80-ft wide composite section to the 62-ft wide overchute structure. The bottom concrete surface will be roughened to discourage

the use of roller blades or skateboards. The concrete bottom surface (raked finish) and the concrete sideslopes (heavy broom finish) have roughness factors of 0.019 and 0.015 respectively.

Station 30+02 to 29+04 (Grouted Riprap Channel Section) – The grouted riprap channel section is designed to provide a roughened (high n value) channel section in lieu of a drop structure at the south end of the BID overchute structure. The section is lined with grouted rock that is 22 inches thick. A narrow 15-ft wide concrete maintenance roadway is located within the channel section to provide continuous access along the channel bottom. The roadway surface will have a roughened surface (raked finish) to discourage the use of roller blades or skateboards. The grouted riprap has a roughness factor of 0.042. A composite n value of 0.038 was used for the design of the channel section.

Station 29+04 to 28+60 (Box Culvert Section) – The box culvert is designed to convey flows under the BID South Maintenance Road. The box culvert has four barrels that are 10-ft high and 12-ft wide. The eastern most barrel will be used to provide continuous maintenance access from the Gila River to the upper sections of the channel. For the design, the bottom surface of the eastern most barrel will be roughened with a raked finish similar to the maintenance roadway (n value of 0.019). The other three barrels will have the bottom surface roughened with a heavy broom finish (n value of 0.015).

Station 28+60 to 25+00 (Composite Channel Section) – Composite channel section is designed to convey flows south of the BID canal maintenance road to the Gila River. The composite section is composed of sideslopes lined with rock-filled gabion baskets (to minimize erosion to the channel banks) and an earthen bottom. An n value of 0.030 was used for the rock-filled gabion baskets and 0.032 was selected for the channel bottom. See earlier composite channel section description concerning the City of Goodyear's desire to allow vegetative growth within the channel for aesthetic reasons. This section is located within the Gila River floodway and may experience damage when the river flows. The flexible gabion system has the highest potential of surviving a major flow on the Gila River in comparison to other lining materials.

Station 25+00 to 18+00 (Earthen Channel Section) – The earthen channel section is designed to convey low flows south of the composite channel section. The earthen channel section is located within the Gila River floodway and provides an excavated low flow pathway to the main Gila River channel. This section may be washed away when the river flows. A roughness factor of 0.032 was used for the channel sideslopes and bottom. See earlier section concerning the City of Goodyear's desire to allow vegetative growth within the channel for aesthetic reasons.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: 013884-2B

MEMORANDUM

Sverdrup Civil, Inc.

Date: July 14, 1998

TO: Tim Edwards and Larry Martinez
City of Goodyear
119 North Litchfield Road
Goodyear, Arizona 85338

Don Rerick
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

FROM: Bradford D. Olbert, P.E.
Project Manager
Sverdrup Civil, Inc.

SUBJECT: Contract FCD 95-39
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Gabion Basket Longevity and Maintenance

The proposed Bullard Wash Channel from the Lower Buckeye Road inlet area to the Gila River utilizes the gabion system (rock filled wire baskets) of lining material for approximately 87 percent of the channel length. Several linings were investigated to preclude meandering of the channel including concrete, soil cement, grouted riprap, riprap and gabions. The City of Goodyear chose the gabion system because it was more aesthetically pleasing than the concrete lining material that was recommended in an earlier study. Other benefits of the gabion system are it provides a bank lining that is flexible (less likely to have a total failure of the lining), it is durable, and it is easier for an individual to exit the drainage channel during a flood event (in comparison to concrete). Three drawbacks of the gabion system include a higher roughness coefficient (in comparison to concrete, 0.030 vs. 0.015), wire damage, and corrosion potential of the wire. The higher roughness coefficient results in a larger channel section, while damage and corrosion of the wire are related to how long the system will last and maintenance concerns. Below is a discussion of the wire damage and corrosion potential of the system and measures taken to reduce that potential.

The gabion system of bank protection has been widely used for many years and many locations. The first gabion system has been in use since 1894 along the Reno River banks in Italy. The gabion system has been used in Arizona for flood protection. One installation located in the City of Glendale on Skunk Creek south of Union Hills Road has been in place since 1987. The Skunk Creek installation used the standard zinc-coated steel gabion mesh. Inspection of the gabion system showed no signs of corrosion or damage to the baskets over that time period. Additional flood protection along Skunk Creek using the gabion system is proposed for the near future. ADOT has used the gabion system principally for local scour conditions at its older bridge locations. ADOT's major concern has been the longevity of the wire mesh against impacts from other rocks being transported downstream during a storm event.

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The Bullard Wash project is located in an area where soil corrosion has been identified as an issue. Corrosion of utilities have been reported by the City of Goodyear of its ductile iron pipes near the wastewater treatment facility, located west of Estrella Parkway and north of the Buckeye Irrigation Canal (BID). APS has performed corrosion repair work to its 96-inch reclaimed water line in several locations just north of the BID Canal. While damage to the gabion basket wires is always a concern, damage to basket wires below the channel bottom caused by large stones will not be an issue for this project because borings along the channel have indicated no large rocks and only traces of gravel. Wire damage should be limited to above ground by floating debris or vandals.

Manufacturers of gabion systems have provided improved corrosion protection coatings to minimize corrosion potential. The traditional zinc coating can be replaced with a zinc-aluminum alloy coating with a non-porous surface that reduces the rate of corrosion. Manufacturer corrosion tests indicated that the zinc-aluminum coating lasts 2-½ times longer than the traditional zinc coatings. In addition, PVC coatings help to further improve long lasting protection against corrosion. The coating completely protects the wire from corrosion. For the Bullard Wash Channel improvements, a higher level of corrosion protection is warranted based upon the corrosion history of the area. Claims of complete protection for the PVC coating may be true where the coating is fully intact for the life of the improvement. However, with time, damage will occur to the PVC coating from debris contact, vandalism, damage during construction, and from contact with maintenance vehicles. The complete protection is only as good as the PVC coverage. Nicks or scratches in the coating will provide locations where corrosion would take place. A combination of the two coatings would maximize the corrosion protection, and this combination will be used for this project.

While the coatings provide a passive protection system against corrosion, annual inspections of the channel lining to check for damage to the lining and corrosion is necessary. Spot inspections will be required on the below ground lining protection as well. Repairs to damaged wires discovered should be scheduled immediately after the inspections have been completed. This maintenance requirement will be addressed in the operation and maintenance manual being prepared for this project.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: 013884-2B

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MEETING MINUTES

Sverdrup Civil, Inc.

Date: March 30, 1998

LOCATION AND DATE: Sky Harbor International Airport, Aviation Department
March 25, 1998; 8:30 am

PARTICIPANTS: Don Rerick, Flood Control District of Maricopa County (FCDMC)
Doug McLaughlin, FCDMC
Jack Shelter, City of Phoenix Aviation Department
Cynthia Parker, City of Phoenix Aviation Department
Shawn Arena, City of Phoenix Aviation Department
Rosemary Ware, City of Phoenix Aviation Department
Bill Siggins, City of Phoenix Real Estate Department
Don Williams, City of Phoenix Law Department
Larry Martinez, City of Goodyear (COG)
Dan Stough, Sverdrup Civil, Inc.
Brad Olbert, Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
30% Plans Review Meeting

SUMMARY:

The above participants met to discuss coordination issues related to the Phoenix Goodyear Airport (PGA) and any comments from PGA regarding the 30% construction plan submittal for the Bullard Wash Channel Improvement project.

Mr. Rerick presented a quick review of the Bullard Wash project.

Mr. Shelter said that Mr. Arena is the new PGA manager. Mr. Arena will be the point man for construction issues concerning the project from now on. Mr. Shelter will deal with issues related to the transfer of property and funds for this project. Mr. Shelter requested that the contractor include the Phoenix Goodyear Airport as an additional insured for the project.

Mr. Shelter said that the City is concerned about the access to the project. The perimeter road is not designed to handle heavy trucks, only pickup truck type loads. Mr. Rerick said that the principal access points near the airport are from Lower Buckeye Parkway and just west of the Bullard Wash Channel at a new at-grade crossing of the railroad. New fencing will be provided to separate the final Bullard Wash Channel from the airport property. The fence will be a standard MAG fence with three-strand barbed wire at the top tilted away from the airport. Along the East Local Tributary the contractor will protect the fence in place. If the contractor needs to remove the fence for construction purposes, he will need to replace it.

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Mr. Arena will develop a bullet list of security, access, contacts, service road use, equipment restrictions, placement of spoil material, and other items the contractor will need to adhere to.

Mr. Shelter was concerned that there will be enough time to receive the required City Council approvals on the property transactions. The City Council will be out July and August. The Council sessions on the first week of July and the last week of August are difficult at best to get on the agenda. Mr. Shelter said that the City should not have to follow a parallel appraisal process on the parcels involved. If the FCD has not selected an appraiser for the land the City of Phoenix and the FCD should compare appraiser lists and select a common appraiser for the project. The airport will need FAA approval for the land swap, but that can come at a later date. The focus will be to receive City Council approval of the land swap arrangements and issuance of a right-of-entry based on settlement of value based on "fair market value". Determination of fair market value and follow up monetary exchanges can take place at a later date. The FCD must provide all required parcel takes and TCE's to the City of Phoenix Real Estate Department by mid April to get Council approval in June.

Ms. Parker would like to add words in the document that addresses the landfill and the possibility of hazardous materials. We would like the FCD to accept full responsibility for the material in the landfill. Mr. Rerick said that the FCD will accept responsibility for the trash and asbestos, but if there are buried drums of chemicals, the FCD will not accept responsibility for the pre-existing condition. The FCD will provide environmental personnel at the site to observe the trash removal process and respond appropriately if a hazmat condition is encountered. Ms. Parker said that we should identify our responsibilities in the right-of-entry document. Also, full disclosure of existing documents is in order. The District has already provided such documents to Ms. Parker, which consists of the Geotechnical Reports on the landfill. Ms. Parker will provide a bibliography and copies of the actual documents that she has on this subject to the District for District use. Ms. Parker said that she will bring in a geotechnical firm to provide additional borings to identify the limits of the landfill area.

Mr. Shelter said that since the FCD will pay for the trash removal then the property appraisal person should ignore potential hazmat conditions in his appraisal. The appraiser will be notified of the existence of the landfill, but it is not certain whether this will have an affect on the appraised value determined by the appraiser. The FCD will need to supply to the City of Phoenix, legal descriptions of all R/W takes and TCE 's.

Mr. Rerick said that as a part of the project, the FCD will fill the ditches that are vacated by the project. The ditches will be cleared, grubbed, and fill material will be compacted to 95% maximum density. A large envelope TCE will be delineated to encompass the ditches that will need to be backfilled.

Mr. Shelter asked about the possibility of having the FCD remove all of the landfill material as a part of the payment for the parcels. Mr. Rerick said the FCD would prefer to swap land and pay fair market value for the difference in the land cost. This provides the cleanest approach while the landfill option has to many variables to try to set a value on. An exchange for waste soil is a possibility if a prior agreement can be made on the cost of the soil. A better situation for the contractor is to allow the contractor to make arrangements with the adjacent property owners to dispose of the soil. This gives the contractor the greatest flexibility to reduce his costs. If he can find a buyer for the soil before the bid then that can help him to possibly win the project with a lower bid. In this arrangement the FCD will provide names and telephone numbers of the property owners desiring soil, including the airport (Mr. Arena). Also any

conditions of the soil disposal can be spelled out in the specifications.

Mr. Shelter said the City of Phoenix will put together a bullet list of conditions for the contractor to follow in order to dispose of soil on the airport property. Ms. Parker said she will send over the environmental language concerning the landfill for the FCD to review.

Mr. Olbert asked if there are any requirements or restrictions on the height of construction equipment that the contractor may want to use on the project. Mr. Shelter said that since the equipment will be less than 40 feet in height, there are a few restrictions; such as tall equipment needs to be flagged and all cranes/booms must be down at night. Mr. Rerick asked that the City develop bullet items for these requirements as well.

Mr. Shelter said that the perimeter fencing can be down during the daytime hours, but the fencing must be up with no breaks at night. Temporary fencing will be adequate during the construction period.

Mr. Shelter said that superfund I.D. information for the airport is available from Ms. Parker. The information will be forwarded to FCD.

Mr. Rerick reviewed the adjustment in the East Local Tributary alignment with the City. The main reason for the adjustment is to avoid relocation of the El Paso Natural Gas Line at the proposed box culvert. The gas line relocation cost was $150,000. Shifting the alignment to the south also provided better interception of the sheet flooding adjacent to the railroad. Several new concrete pipes will be placed under the perimeter roadway to collect the flows on the north side of the perimeter road as well as tailwater flows. A concrete beam will be used to support the security fence where the concrete channel passes under the fence. Breakaway fence sections will be used in the channel. Mr. Rerick stated that the breakaway fence concept has been successfully used at other locations. This concept may not be necessary with further discussions with the City, because of the new fence criteria along the north side of the channel.

Mr. Shelter agreed with the East Local Tributary alignment adjustment and to providing access gates to the facility for routine maintenance. But there must be a security fence on the north side of the channel to separate the channel from the airport. Mr. Rerick agreed to add the fence and to place it at the edge of the R/W. The City of Phoenix and the City of Goodyear will meet and work out access agreements at a later date.

Mr. Shelter was concerned about air quality during construction. Mr. Rerick said this is an item that the FCD is very aware of and one that they are very strict with the contractors.

Mr. Shelter was also concerned about the interface between the landfill and the maintenance road cut slope in the landfill area. Of special concern was erosion control. Mr. Rerick said that the FCD will not have a maintenance road on the airport side of Bullard Wash. The proposed roadway was for the airport perimeter road if required by the airport. Mr. Shelter said they didn't know where they want to locate the perimeter road at this point. Sverdrup will provide a 2 ft bench behind the fence with a 3:1 cut slope where needed. If necessary, a gravel mulch may be used to control the erosion on the backslope. Mr. Shelter said that would be adequate to address their erosion concerns.

Mr. Olbert requested information on airport drainage patterns. Mr. Shelter said that the information is available from Dibble and Associates. Call Kent Dibble to request the CADD file information.

Please review these meeting minutes and call me (231-8999) if you have comments.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

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Meeting Attendees

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MEETING MINUTES

Sverdrup Civil, Inc.

Date: March 23, 1998

LOCATION AND DATE: Flood Control District
March 17, 1998; 9:00 am

PARTICIPANTS: Don Rerick, Flood Control District of Maricopa County (FCDMC)
Olin Sutton, FCDMC
Bruce Ward, Maricopa County Department of Transportation (MCDOT)
Laura Fritschi, MCDOT
Wayne Butch, MCDOT
Jim Neibergall, MCDOT
Larry Martinez, City of Goodyear (COG)
Bob Prince, UPRR
Roger Miles, Sverdrup Civil, Inc.
Dan Stough, Sverdrup Civil, Inc.
Brad Olbert, Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
30% Plans Review Meeting with UPRR

SUMMARY:

The above participants met to discuss coordination issues related to the Union Pacific Railroad (UPRR) and any comments from UPRR regarding the 30% construction plan submittal for the Bullard Wash Channel Improvements and the 40% construction plan submittal for the Estrella Parkway project.

Mr. Rerick presented a quick review of the Bullard Wash and Estrella Parkway project. The roadway at-grade crossing will be discussed first then the channel crossing.

Mr. Prince said he had few comments on the plans, because the railroad design has been fairly standardized according to the MUTCD requirements. The work north of the intersection of MC 85 and Estrella Parkway is divided into two parts, the surface work (placement of concrete panels) and the signal work (electrical work, and installation of gates and flashers). Cost estimates for the surface and signal work will be into the county this month. Cost estimates are good for only one year.

UPRR will want to construct the railroad surface work prior to the roadway construction work starting. It is better for the roadway grading and pavement work to match with the railroad crossing. Results in less roadway damage. UPRR would prefer to coordinate with the contractor after the rough grading is complete to install the signal equipment.

Mr. Prince said that 60 days after the surface agreement has been accepted UPRR could place the surface work. Signals can be installed six months after the signal agreement has been accepted. The six-month lead-time is to order and receive the signal equipment. After the six-month period the contractor can then schedule the installation of the signals with UPRR.

Mr. Ward stated that in order to have the railroad surface and signal work not affect the roadway construction, MCDOT will need to obtain a place holder on the agenda for the Board of Supervisors.

Mr. Prince agreed to prepare an outline of the process needed to obtain railroad approval and construction process that follows. Mr. Rerick said that the information could be worked into the SP's with the lead-time information and persons with the railroad to call.

Mr. Miles asked if they have a record of longitudinal easements within their R/W. Mr. Prince said that UPRR's record department has moved around a lot, so the information will be hard to come by. The Roosevelt Irrigation District (RID) says it has a longitudinal and a crossing easement with the railroad for the ditch and culvert crossing located just west of Estrella Parkway. If they do, the county will need specific instructions on how to transfer the title of the easement. **Mr. Prince will check his maps for the easement agreement number because the information is sometimes listed on his railroad maps.**

Mr. Miles asked for specific information on the setbacks needed for the construction. Mr. Prince gave the following information.

- All curbing needs to be placed 10 ft from the track centerline.
- The railroad concrete surface typically comes in 10-ft long sections that are also 10-ft wide. The concrete surface is set at the top of rail elevation. Pavement design matches concrete section 5 ft from track centerline. The concrete surface is placed a minimum of 3 ft back of curbing.
- The center of the railroad signal will typically be placed 4 ft back of curbing. UPRR prefers that the inside edge of the sidewalk be placed a minimum of 4 ft back from the center of the railroad signal.

Other coordination issues discussed by Mr. Prince are as follows:

- UPRR will take the lead on requesting power service from APS for their signals. A cabinet and meter are currently located in the southwest corner of the crossing.
- MCDOT will need to place a pull box adjacent to the railroad control panel for a signal pre-empt connection.
- UPRR will need to coordinate with the City of Goodyear to allow a 5-day shut down of Estrella Parkway in order for the concrete surface to be installed.
- MCDOT will need to coordinate with the railroad if underground conduit will be placed for future streetlights and to underground overhead railroad communication lines. Mr. Martinez indicated that the City of Goodyear would prefer to underground the overhead railroad communication lines.

- Contact Mary Gross for agreements on utility easements for utilities and the channel. Her phone number is (402) 997-3623 in Omaha, Nebraska. Contact Cheryl Kinkel at (402) 997-3620 for public roadway easement agreements. UPRR typically will not dedicate roadway R/W or easements. UPRR will ask for fair market value for easements.

Mr. Miles said that curb and gutter would be constructed along Estrella Parkway. Will UPRR need access to their R/W? UPRR will not need a curb cut on Estrella Parkway because they will access the R/W from the break in the curb at the track. However, if curb and gutter is constructed along MC 85 then curb cuts will be requested along MC 85.

Mr. Miles asked if the railroad has any drainage requirements at the crossing location. Mr. Prince said no; they will be providing their own system using a French drain with filter fabric to drain the crossing.

Mr. Martinez said the City would want to post, mail and publish advanced notices of the construction. Mr. Ward said that MCDOT's public relation staff could provide to the City information from past projects. MCDOT will also want to publish notices in the paper.

Mr. Olbert suggested that conduit provisions for future street lighting be provided at this time. Mr. Martinez will discuss issue with staff. Mr. Ward said that irrigation conduit should also be considered for the median areas.

BULLARD WASH CHANNEL

Mr. Prince said that the contractor will need a right of entry permit, show proof of insurance ($2M) and be required to purchase $6M of railroad protective insurance. If one contractor bids both the channel and the roadway project then only one permit is needed. Subcontractors need no additional permits. **Mr. Prince will send a copy of the contractors Right of Entry Agreement to Mr. Rerick.**

Mr. Prince will send to Mr. Rerick criteria for the design of jack and bore culvert crossing located just west of the Bullard Wash Channel. Mr. Prince said that this crossing would need to be in the RID's name. The FCDMC will handle all of the fees associated with the crossing.

UPRR will need three sets of plans to expedite the next review. Mr. Prince will distribute the plan sets.

Mr. Prince has the cost estimate for the at-grade crossing. He will forward it on to Omaha on Wednesday. Omaha will then process the cost estimate and forward it along with an agreement to the FCDMC. There will be another fee (Approximately $1,000) for the agreement. The FCDMC should receive the estimate and agreement this month. If there are any questions on the agreement form call him first, then Omaha. There is no charge for the construction permits. There are charges for easement agreements. Two separate easement agreements are needed, one for the channel work and one for the at-grade crossing. Forward a copy of the signed agreements to him.

Mr. Rerick asked Mr. Prince what the process is for the railroad bridgework. Mr. Prince said that when the agreement is signed, he will contact Mr. Tripp and Mr. Tripp will order the bridge materials. Mr. Prince will also contact Mr. Voogd on the design for checking. Mr. Voogd and Mr. Tripp will talk with each other about the bridge design. Mr. Tripp will then set the bridge work schedule. **Mr. Prince will contact Mr. Tripp about the bridge completion date to be prior to Labor Day.** Since the at-grade crossing work and the bridgework are done by different crews they will be scheduled at different times. The roadway at-grade crossing will probably go first, then the bridge, and then the channel at-grade crossing.

Mr. Rerick asked Mr. Prince if UPRR would send a set of the railroad bridge plans to him for cross checking. **Mr. Prince will notify Mr. Voogd of the request. Mr. Olbert will also give Mr. Voogd a call.**

Mr. Rerick asked Mr. Prince if Mr. Voogd had decided on how many cubic yards of soil he would want placed at the existing Bullard Wash Bridge site? No. Mr. Prince said it would be better if the consultant came up with an approximate quantity. Mr. Rerick said we would need additional TCE's to place the material. Mr. Prince said TCE's are not required if the county and the contractor have all the necessary agreements and permits.

Mr. Prince said for the maintenance road at-grade crossing, plan on a 1% slope for 20 ft each side of the track. Mr. Rerick requested at least 20 ft of clearance for the signal lines above the maintenance road for construction safety. Mr. Prince said they would provide the 20-ft of clearance through the entire easement. Normally the railroad would like to relocate the signal lines at the same time as the roadway signal work. For this project the signal lines will need to be relocated prior to the channel construction. Rodney Pipper (520) 629-2237 will coordinate the signal line relocation. Send a copy of plan and profile sheet number 7 to Mr. Prince he will forward a copy to Mr. Pipper.

Mr. Olbert requested 30% review comments from UPRR. **Mr. Prince will contact Mr. Voogd to decide on who will write the comments on the 30% plans.**

A tentative meeting was scheduled for Tuesday, May 12th at 9 am with Mr. Prince. The meeting will cover the 60%/70% construction plans submittal.

Please review these meeting minutes and call me (231-8999) if you have comments.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

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MEETING MINUTES

Sverdrup Civil, Inc.

Date: February 23, 1998

LOCATION AND DATE: Maricopa County Department of Transportation
February 23, 1998: 10:00 am

PARTICIPANTS: Don Rerick, Flood Control District of Maricopa County (FCDMC)
Theresa Hoff, FCDMC
David Haag, ADEQ
Kris Commalon, ADEQ
Cynthia Parker, City of Phoenix
Dick Bartholomew, Bartholomew Engineering, Inc.
Brad Olbert, Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvement Project
Estrella Parkway - Buckeye Canal to Yuma Road
Airport Environmental Coordination Meeting

SUMMARY:

Mr. Rerick presented a brief overview of the Bullard Wash project and answered general questions regarding the details of the construction and construction schedule. Since the airport is interested in obtaining soil from the project to fill low areas around the airport, the contractor will be given the opportunity to spoil the material on the airport. It will be up to the airport to coordinate with and work out the details with the contractor.

Mr. Rerick requested from Ms. Parker information regarding locations of the monitoring and injection wells. The information can be provided in the special provisions of the contract documents or on a plan sheet as a way to alert the contractor of their presence. Mr. Bartholomew can provide coordinates of the wells to Sverdrup via e-mail. Sverdrup can translate coordinates to project data base provided two common points are provided such as section corners. Mr. Bartholomew will provide the common point information to Sverdrup.

Ms. Parker said that since the airport is a super fund site she will provide some written text that should be included in the special provisions. The text will be forwarded to FCDMC and ADEQ for their review.

Mr. Olbert noted that several of the wells are located in the low areas that might be affected by the material spoiling on the airport. Mr. Bartholomew will have the wells flagged in the field ahead of the construction work. All of the wells currently have steel pipes set around them for protection. Mr.

Bartholomew will prepare a spoil plan for the airport. The intent of the plan will be to locate spoil sites and identify the wells to be avoided by the contractor. The information will be provided to the contractor ahead of construction. The information may possibly be placed in the contract package.

Include in the special provisions Ms. Parker's name and phone number as a reference. Also include Mr. Bartholomew's name and phone number with a request to contact him 48 hours ahead of any construction work within the area of the wells.

Ms. Parker was concerned about the construction debris left by the navy at the south end of the runway when they controlled the airport. Mr. Olbert said the borings prepared by ATL identified the debris as being only in the top 5 to 6 feet of the fill area. ATL recently adjusted the borings in the fill area. A copy of the revised borings will be sent to Ms. Parker and Ms. Hoff for review. Mr. Olbert said that ATL recommended only screening of the debris prior to disposal. Ms. Parker said the navy frequently discarded asbestos materials in their construction debris. The FCDMC will have persons available to oversee removal of the debris in this area to watch for possible hazardous materials. Add Ms. Hoff's name and phone number to the special provisions as a reference to contact during excavation of material in this area. Sverdrup to add information to the special provisions on the limits of excavation for the construction debris and possible over excavation of material and backfill required for the channel and maintenance roads.

Sverdrup will send 90% construction plan sets to ADEQ and Mr. Bartholomew to review for environmental issues.

Invite Mr. Bartholomew and Ms. Parker to the pre-construction meeting to present an overview of the superfund site and to identify contact persons.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: 013884-2B
Participants

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MEETING MINUTES

Sverdrup Civil, Inc.

Date: December 4, 1997

LOCATION AND DATE:	Flood Control District of Maricopa County November 24, 1997; 10:00 am
PARTICIPANTS:	Don Rerick, Flood Control District of Maricopa County (FCDMC) Doug McLaughlin, Flood Control District of Maricopa County Jack Schelter, City of Phoenix - Aviation Department Rosemary Ware, City of Phoenix - Aviation Department Brad Olbert, Sverdrup Civil, Inc.
SUBJECT:	**Contract FCD 95-39** **Flood Control District of Maricopa County** **Bullard Wash Channel Improvements - Final Design** **Phoenix - Goodyear Airport Meeting**

SUMMARY:

The above participants met to discuss right-of-way issues for the referenced project. Mr. Rerick reviewed the progress to date on the overall project for both Mr. Schelter and Ms. Ware.

Mr. McLaughlin asked if the City of Phoenix had any use for the airport property located between the channel and the IMSALCO property. Mr. Schelter said the airport has no need for the severed property and would like to include the property in the land exchange plus other compensation. Improvements to the airport property should include items like removal and replacement of fencing, filling and compaction of existing ditches/channels, and removal of construction debris in the landfill area. He requested that the MAG standards for compaction requirements and fencing be used.

Mr. Rerick had previously requested the City's Aviation Department for a list of any security measures that the airport would want to have in place for the project. The FCDMC has not yet received a list from the Aviation Department. The security measures will be included in the special provisions for the project. The list from the Aviation Department will become a part of the project record.

Access to the project was a concern to Mr. Schelter. The access road (security road) along the south fence line was designed for light vehicles. Heavy equipment and haul trucks should use an alternate access point. Mr. Rerick said that access from Lower Buckeye Road is a good possibility as well as a proposed at-grade crossing of the Union Pacific Railroad located just west of the proposed channel. If access to the work area by work crews is acceptable, the airport may want check-in and check-out requirements imposed at the entrance.

Mr. Schelter said that fencing of the project will be necessary to preclude access to the airport runway area by pedestrians. Temporary fencing materials will be adequate until permanent fencing is erected. Mr. Olbert asked if the airport will want their security road located adjacent to the new perimeter fence. Mr. Schelter said that he will have Dick Traill (Planning and Development, 271-3339) make that decision. If the soils are poor along the fence, they may choose to locate it further to the east around the landfill site. If a soils report along the channel is made available to them, they will be able to make the decision quickly. Mr. Olbert will make a copy of the report for Mr. Schelter when it is available.

Mr. Schelter said that the airport is a Superfund site, and suggested this condition should be mentioned in the construction documents. The Superfund site designation was caused by TCE dumped years ago at the north end of the airport. However, the entire airport is included in the designation. The airport has had some problems in the past with the IMSALCO property. The stockpiles of ground up aluminum have collapsed onto airport property after heavy rains. Mr. Olbert will check with Cynthia Parker (Environmental, 273-2730) about any environmental concerns. She is located in Terminal 3 at Sky Harbor. Mr. Rerick will check the FCDMC environmental reviews of the area adjacent to the IMSALCO property and Section 404 permit requirements for the East Tributary.

Ms. Ware requested a copy of the blueline aerials that show the airport property. It will be useful in future discussions concerning the channel. Mr. Olbert will contact Ms. Ware when the bluelines and soils report are available. She will send a runner to pick up the information.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: 013884-2B
Participants

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MEETING MINUTES

Sverdrup Civil, Inc.

Date: November 25, 1997

LOCATION AND DATE: **City of Goodyear**
November 10, 1997

PARTICIPANTS: Steve Cleveland - City of Goodyear
Larry Martinez - City of Goodyear
Douglas Sanders - City of Goodyear
Joe Evans - Yost and Gardener Engineers
Don Rerick - FCDMC
Laura Fritschi - MCDOT
Brad Olbert - Sverdrup Civil Inc.
Dan Stough - Sverdrup Civil Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Channel Aesthetics Coordination Meeting

SUMMARY:

Mr. Martinez opened the meeting with a general overview of the Bullard Wash project. The City of Goodyear will allow certain sections of the Bullard Wash channel to be lined with hard lining (concrete or shotcrete) if the following key features are incorporated into the channel segments:

- The City of Goodyear desires a bicycle / pedestrian path on top of the channel bank. The path would be set back approximately 2 feet from the top line of gabions or bank lining to avoid damage to the lining. Mr. Cleveland stated that the City desires a meandering path that allows the use of both the channel bottom and top of bank. Ramps would be required to join the levels.

- Discussion ensued regarding the City's desired locations for the ramps. It was agreed that the ramps should be placed where cyclists, equestrians, and pedestrians would all derive some benefit, and that the initial ramp locations will be shown on the 30% plan set (for review by City staff).

- Mr. Olbert suggested the design incorporate the ramp standard from the "Skunk Creek Master Drainage Plan"; a target maximum ramp slope of 8 percent (12:1) on the inclines with periodic level landings to provide rest areas (per ADA requirements). The overall slope would be approximately 5 percent (20:1).

Mr. Cleveland stated that wide spots should be provided periodically along the top of bank, to provide rest areas and shade trees. To achieve this effect, the path could meander away from the channel lining, or the lining could be steepened (narrower top width) in those locations. City of Goodyear will be responsible for the rest area development and all landscaping.

Mr. Olbert noted that a pedestrian rail should be used behind the bank lining when the bank protection is steeper than 2 to 1 or stepped gabions are used that are higher than 3 feet. The FCDMC standard handrail will be used which has a top and mid rail made of galvanized pipe stock.

The City planners have specified that the Bullard Wash corridor will be equestrian accessible. Mr. Cleveland stated that the City of Goodyear must strive to provide a continuous equestrian corridor within the Bullard Wash corridor. Although equestrians will be allowed access to the trail at the top of the bank, they will most likely choose to travel in the channel bottom, separated from pedestrian and bicycle traffic.

Mr. Olbert explained the following constraints to equestrian access along the channel corridor:

- the BID canal overchute has a significant grade control structure located south of the BID canal.
- the standard Union Pacific Railroad (UPRR) bridge has a low vertical clearance (approximately 7 feet) that will be passable only by pedestrians. Even dismounted horseback riders will have difficulty getting a horse to pass under the low chord of the bridge.
- UPRR does not allow equestrians within their right-of-way, nor will they allow a designated equestrian at-grade crossing of the tracks.
- three grade control structures located just north of the railroad bridge will be too steep and tall to be negotiated on horseback.

The following equestrian crossing alternatives were discussed by the group:

Design the grade control structure at the BID canal overchute to be usable by equestrians. The drop can possibly be reduced in height by steepening the slope of the overchute and then use a 12 to 1 ramp for the drop.

Mr. Olbert suggested that ramps leading out of the channel, on both sides of the channel, could direct equestrians onto the north bank of the BID canal. From there, they could be routed west to the Estrella Parkway crossing of the canal or to a separate bridge crossing of the BID canal. He also agreed that Sverdrup will check on what is needed to make the BID overchute safe for equestrian use.

To avoid the UPRR bridge, an equestrian path could be developed along the Elwood Street alignment to the west , that would turn south and follow Estrella Parkway. Equestrians would cross over the railroad tracks at the railroad at-grade crossing. Additional right-of-way could be obtained on the east side of Estrella Parkway to provide additional width (10 feet) for a path behind the sidewalk.

The at-grade crossing of the railroad was unacceptable to the City of Goodyear. Mr. Cleveland explained that the City must uphold an "equestrian friendly" requirement for this project. Failure to do so would give future land developers sufficient reason to evade the requirement, as well.

A concrete box culvert (10-foot height) could be constructed parallel to and separate from the Bullard Wash channel. A designated equestrian path would diverge from the Bullard Wash channel leading to the new CBC. A sump pump would keep the depressed CBC free of nuisance water. The CBC would also need lighting and phone equipment.

The City of Goodyear would have to negotiate the separate CBC crossing (at a later date) with UPRR and the affected utilities. The new crossing project would be built independent of the Bullard Wash Final Design project. The City of Goodyear would bear all costs, including construction, relocation of utilities (including UPRR shoo-fly), and O&M of the structure.

Mr. Cleveland suggested that the CBC design of the UPRR crossing (whatever form it may take) should occur during the design of the Bullard Wash channel, for the sake of design consistency. The intergovernmental agreement (IGA) would be renegotiated, such that the City of Goodyear would pay for additional CBC design costs.

Mr. Rerick reviewed the channel lining types that were visited by City of Goodyear officials the previous week. Mr. Rerick also noted that for the channel design to proceed, this meeting must reach a decision pertaining to which channel bank linings are acceptable to the City.

Mr. Cleveland stated that exposed stepped-gabions, soil-covered slope-blanket gabions, shotcrete banks with natural bottom, and full-concrete lining were each appropriate in certain locations. He elaborated that the channel lining types could be varied along the length of the channel. He also stated that mixed bank-lining treatments could be used, if needed. The City recognized the need to use concrete for sideslopes in the bridge and drop structures just north of the UPRR bridge.

Mr. Cleveland specified that the "form liner" style concrete (with a pattern) is desirable in locations where vertical concrete banks are used. He also requested that shotcrete lining be textured and colored to match the predominant soil type in the reach.

Mr. Rerick stated that the FCDMC have the personnel and equipment to hydroseed the banks on any soil-covered gabion segment(s) if they are desired.

Mr. Olbert explained that the channel profile grade line between the BID canal and the railroad is constrained by the APS pipeline crossing, the City of Goodyear sanitary sewer, and the proposed UPRR bridge. Between the BID canal and Broadway Road, the 100-year water surface is above the existing ground using a typical section with gabion bank protection that is covered with soil. The resulting channel banks must be 3 feet above the design 100-year water surface to meet FEMA requirements. The resulting channel/maintenance road footprint results in a 210-foot wide

(minimum) width right-of-way. He stated that the land owner (Sun Chase) was not agreeable with the possible FCDMC acquisition of sixty or more additional feet of property to meet this need. Mr. Olbert suggested a stepped-gabion lining with a 1:1 or 1.5 to 1 sideslope through this area. The slope of the sideslope can be selected based on the right-of-way. Gabion baskets can be used on the backslope of the dike to reduce right-of-way needs.

The meeting attendees reached an agreement on the bank linings to be used in the following locations:

PHASE I LININGS (Gila River to north of the UPRR Bridge)

- Exposed slope-blanket gabions (3:1 sideslope) with a natural stream bed will be allowed in the segment from the Gila River to the BID canal overchute.

- Full-section concrete lining from the BID maintenance road box culvert, through the grade control structure just downstream from the BID canal crossing, north to the APS (Arizona Public Service 96-inch reclaimed water) pipeline. The bank sideslopes will transition from vertical walls at the overchute to 1:1 or 1.5:1 sideslopes just north of the structure. The full-section lining with 1:1 or 1.5:1 sideslopes would continue north and match the top of the proposed APS pipeline encasement.

- Stepped, rock filled gabions (1:1 or 1.5:1 sideslopes) with natural stream bed from the 96-inch pipeline to just south of MC 85.

- Full-section concrete lined channel from just downstream of the MC 85, through the Union Pacific Railroad (UPRR) bridge and grade control structures north of UPRR. The channel sideslopes will transition to vertical walls through the MC 85 bridge, and transition to 1:1 sideslopes between the MC 85 bridge and the UPRR bridge. The channel sideslopes will transition back to vertical walls through the UPRR bridge and then transition to 1:1 sideslopes through the drop structures.

PHASE II LININGS (North of the Drop Structures to Lower Buckeye Road)

- Slope-blanket gabions from the drop structures to the north end of the channel at Lower Buckeye Road. The bank protection on the east side of the channel will be sloped at a 1.5:1 rate and vary between 2:1 and 3:1 on the west side.

- Slope-blanket or stepped gabions will be used in the 200-foot long inlet area to the north of Lower Buckeye Road. Work in this area will be considered temporary until the future channel section is designed and constructed (by others).

BROADWAY ROAD CROSSING

Mr. Olbert stated that farm access will initially be recommended at Broadway Road in the form of an interim "dip" crossing. A hardened ford will be used to prevent undermining of the roadway. The

crossing roadway will have an approach grade of 10:1.

Discussion ensued about locations for access points for channel maintenance. Mr. Martinez agreed to discuss the matter with City of Goodyear Operations and Maintenance personnel. The FCDMC and Sverdrup have had discussions with the BID and local land owners to determine other locations. Current locations include north of the BID canal, north of Broadway Road, north of the UPRR bridge, north of the drop structures, and south of Lower Buckeye Road. The access ramps will double as ramps for equestrian access to the channel bottom. Sverdrup will then identify access locations in the 30-percent plans.

DISCUSSION OF FUTURE PUBLIC MEETING

The group reached a consensus on the date for the public information meeting: ***December 4, 1997***. Mr. Rerick stated that FCDMC will mail meeting notices to land owners (within one half mile of Bullard Wash or Estrella Parkway). He suggested an "open house" format for the upcoming public information meeting. He added that the Estrella Parkway/MC 85 and the Bullard Wash Channel final designs will be on the meeting agenda. Mr. Cleveland and Mr. Martinez agreed to this style of meeting.

Mr. Olbert explained that Sverdrup, FCDMC, and MCDOT personnel will mingle with the public, explaining the key points of the design concept, listen to specific comments, and address questions that arise. Informational handouts will be produced and distributed by FCDMC that include a fact sheet with the key project features, an overall project map with improvements delineated, and a questionnaire.

Mr. Martinez suggested that additional notices be posted along Estrella Parkway and MC-85 and in the local Goodyear newspaper. He also suggested that SunCorp be included on the mailing list (because of their significant role in land development in the area).

Ms. Fritschi agreed to create a County location board for display at the entrance to the meeting. Mr. Martinez agreed to arrange for the City Hall or the Community Center to be used for the meeting place. Mr. Olbert agreed to create the following exhibits by December 1, for use at the public meeting:

- Bullet charts showing the key design features of the channel design (emphasis placed on aesthetics, multi-use access, equestrian access).
- Bullet charts showing the key design features of the roadway design.
- Roadway typical sections.
- Channel typical sections (stepped gabions, slope-blanket gabions, shotcrete, concrete lined).
- Mounted 8" x 10" photos of recommended linings.

- 12-foot long aerial photo with proposed channel right-of-way limits (Gila River to Lower Buckeye Road).

- A 1"=100' scale strip drawing showing the edge of pavement, existing and new rights-of-way, property lines and owner names. The drawings will be displayed flat, rolled out on 8-foot long tables. Use markers to write down public comments at the appropriate locations on the strip maps.

- 1" = 20' scale illustrations of intersections at MC 85, Elwood Street, Lower Buckeye Road, Lower Buckeye Parkway and Yuma Road.

CITY OF GOODYEAR TOWN COUNCIL MEETINGS

Mr. Cleveland agreed to arrange a City of Goodyear Town Council work session (briefing) on ***December 9, 1997***. Mr. Rerick stated that FCDMC will provide flyers for that meeting (and 25 will be given to the council).

A regular Town Council business meeting will follow on ***December 16th***, at which time the council will vote on the recommended action items.

Please contact me at (602) 231-8999 if you have additions to or comments on these meeting minutes.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution:

Attendees
RWM
013884-2B

432 N. 44th Street, Suite 250 Phoenix, Arizona 85008 Tel. (602) 231-8999
Fax. (602) 220-9199

MEETING MINUTES

Sverdrup Civil, Inc.

Date: November 4, 1997

LOCATION AND DATE:	Flood Control District of Maricopa County October 28, 1997, 10:00 am
PARTICIPANTS:	Don Rerick - Flood Control District of Maricopa County Doug McLaughlin, FCDMC R/W Clarence Wood, Wood Family Enterprises Ronald Wood, Wood Family Enterprises Margaret Carl, Wood Family Enterprises Tim Smith, Wood Family Enterprises Larry Martinez, City of Goodyear Joe Evans, Yost and Gardner Engineers Roger Miles, Sverdrup Civil, Inc. Dan Stough, Sverdrup Civil, Inc. Brad Olbert, Sverdrup Civil, Inc.
SUBJECT:	**Contract FCD 95-39** **Flood Control District of Maricopa County** **Bullard Wash Channel Improvements - Final Design** **Property Owner Meeting - Wood Family Enterprises**

SUMMARY:

The above attendees met to discuss the short and long term effects of the proposed channel upon the Wood Family property. Mr. Rerick opened the meeting with each individual introducing themselves.

Mr. Rerick wanted to discuss the need to capture storm flows north of Lower Buckeye Road using berms to direct flows into the proposed Bullard Wash channel. Mr. Rerick asked if removing a portion of the old sump ponds located north of Lower Buckeye Road would cause any problems. Clarence Wood said that the sump ponds are no longer being used and that they are owned by SunChase now. Mr. Rerick said that one possibility in constructing berms to direct the flood water into Bullard Wash is to raise Lower Buckeye Road, and construct a berm with the roadway on top. Tim Smith said that they use the Lower Buckeye Road as a farm road. The existing roadway is nearly at the same elevation as the field to the north. If the roadway is raised to incorporate the berm, he will need a maintenance road on the north side of Lower Buckeye Road. Presently, he uses the roadway to turn his equipment. The width needed for a maintenance road and a tailwater ditch is approximately 20 feet. The tailwater from the field to the north currently discharges into Bullard Wash at the southeast corner of the field. Ms. Carl asked if raising the road will raise the height of the flood water on their property. Mr. Olbert said that extending the channel section north of the Lower Buckeye Road alignment approximately 100 to 200 feet will cause the flood water to begin

to draw down prior to reaching the berm. The berm will be used to stop the spread of the flood water to the south and direct the water into the channel. A computer model will be developed of the improvements to verify that the channel and berm design will not raise the flood waters.

Mr. Olbert asked Mr. Wood if he knew what the area was like prior to the construction of the airfield. Ronald Wood said that Lower Buckeye Road originally extended east through the present airport. When the airfield was constructed, the roadway alignment was severed. In addition, the original alignment of Bullard Wash was filled in with the airfield construction, and the wash was relocated to its present location. At that time, Mr. Wood said the federal government said the wash would not flood his property, however, the property has flooded on numerous occasions.

Mr. Smith said that they were planning to plant a double crop beginning with barley in November and cotton later. The irrigation would stop in August, and cotton harvesting would be done in November. If construction is delayed until after September, there will be no tailwater/delivery water for construction to deal with. If construction begins after November, then he could harvest the cotton and be out the fields. Mr. Rerick advised Mr. Smith to contact the District before planting crops in areas needed for the channel after August 1998. Mr. Smith said that if the area needed by the District can be staked, then he can plant outside that area.

Mr. Olbert said the Goodyear City Council recently said they would not participate in funding a concrete-lined channel, that the channel must be aesthetically pleasing, and that the council preferred an earth-lined channel that could be used for recreational purposes. Mr. Olbert said the existing R/W width is inadequate for an earth-lined channel. A minimum width of 200 feet is needed to accommodate the channel. Additional width may be needed for berming depending upon the depth of the channel. Because of the extremely flat slopes for the channel north of the drop structures, a bottom width of 120 feet may be needed to maintain a water depth of 5 feet, and that would require more right-of-way than was requested earlier. Mr. Wood said that recreational use of the channel will cause them grief from kids getting into their fields. Mr. Rerick said that the channel right-of-way will be gated and fenced with 3- to 4-strand barbed wire to help control access to the fields from the channel.

The tailwater from the east side of the Wood's farm currently discharges into Bullard Wash at several locations and flows southerly into a low flow channel for use by farms south of MC 85. An alternative location for the tailwater ditch was reviewed but discarded since tailwater from farms other than the Wood's farm enters Bullard Wash upstream of the Wood farm. The alternative tailwater ditch would not be able to control that water. It was determined that the best solution will be to continue to discharge tailwater into the channel near the current locations.

At the south end of the farm, the existing delivery ditch that will be cut by the new channel will need to be relocated to the west side of the channel. A new farm road will be needed on the west side of the channel. The farm road needs to be 12' - 14' wide plus a tailwater ditch where appropriate. A TCE will be needed for construction purposes.

Mr. Olbert asked what sources of water are used by the farm. Mr. Smith said that water for the farm comes from two wells owned by the Wood family and also from the Roosevelt Irrigation District (RID). At present, they try to use as much RID water as possible because it is less expensive and a

better quality water than what is delivered by the wells. RID ditches along Yuma Road and Estrella Parkway deliver water to the northern most well site for distribution to the farm. The two existing wells owned by the Wood family are located a ¼-mile south of Yuma Road on the east side of Estrella Parkway and at the Southeast corner of the intersection of Lower Buckeye Road and Estrella Parkway.

Mr. Smith asked if replacement of the delivery ditches would occur prior to channel construction. For any of the future roadway work to be done on Estrella Parkway or channel work for Bullard Wash, all utilities along the projects must be cleared prior to construction, including replacement of the irrigation delivery ditches. At the present time, the two wells on Estrella Parkway are missed by the roadway, but will need to be shielded by guardrail to protect drivers from running into the wells. Mr. Olbert asked if they knew if the well located south of Yuma Road approximately a ¼-mile west of Estrella Parkway was active or not. Mr. Smith said that the well is no longer in use.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: 013884-2B
Laura Fritschi, MCDOT
Participants

MEETING MINUTES

Sverdrup Civil, Inc.

Date: October 31, 1997

LOCATION AND DATE: Flood Control District of Maricopa County
October 28, 1997, 8:00 am

PARTICIPANTS: Don Rerick - Flood Control District of Maricopa County
Doug McLaughlin, FCDMC R/W
Bruce Ward, MCDOT
Todd Belzner, MCDOT R/W
John Christensen, SunChase
Barbara Rust, Coe & Van Loo Consultants, Inc.
Ron Rayner, A-Tumbling-T Ranches
Larry Martinez, City of Goodyear
Joe Evans, Yost and Gardner Engineers
Roger Miles, Sverdrup Civil, Inc.
Dan Stough, Sverdrup Civil, Inc.
Brad Olbert, Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Property Owner Meeting - SunChase (A-Tumbling-T Ranches)

SUMMARY:

The above attendees met to discuss the short and long term effects of the proposed channel upon the SunChase property. Mr. Rerick opened the meeting with each individual introducing themselves.

Mr. Rerick identified several delivery ditches and tailwater ditches that will be cut by the channel construction. Mr. Rayner was asked about the significance of each ditch to his farm operation. Mr. Rayner identified two primary sources of water for his farm; i.e., the tailwater and stormwater from the East Tributary Wash, and the tailwater from the Bullard Wash. Water from the East Tributary flows into a storage pond located south of MC 85 and is then pumped to the northeast end of the farm where the water can flow to any of their fields located east of Estrella Parkway. Overflow from the pond, along with water from Bullard Wash, flows west to irrigate the fields (as well as another farmer's fields) located west of Estrella Parkway. Tailwater from the fields ultimately flows into the Buckeye Irrigation District's canal.

Mr. Rayner identified four fields that will be affected by the channel alignment. The north and south fields have been leveled and thus have no tailwater ditch. The two middle fields are graded with a slope from north to south. The north field receives its water from a delivery ditch located on the east side of the field. The second field to the south receives its water from a delivery ditch located on the north side

of the field. A tailwater ditch for this second field is located on the south side of the field. Tailwater from this field flows into a delivery ditch located on the north side of the third field to the south, which is similar to the second field. The fourth field receives its water from a delivery ditch located on the north side of the field.

Mr. Rayner said that the first and fourth fields will have small areas to the west of the proposed channels that will become uneconomical to farm. The fields have been reseeded with alfalfa, which has a three-year production cycle. After the cycle, another type of crop will planted. There can be no interruption of water flow during or after construction.

A discussion of how to handle the tailwater from the East Tributary and Bullard Wash ensued. Sverdrup will evaluate three scenarios to handle the water.

1) The tailwater from the East Tributary will be discharged into existing Bullard Wash and enter the existing holding pond as it currently does. Storm flows in the East Tributary will flow westward and discharge into the proposed Bullard Wash Channel for discharge into the Gila River. A siphon will be designed to carry excess flow from the holding pond under the Bullard Wash Channel for use on the farms to the west of Estrella Parkway. Mr. Rayner suggested a minimum 24-inch pipe for the siphon. Tailwater from Bullard Wash will be conveyed under the railroad in a new culvert located within the drainage easement immediately west of the proposed Bullard Wash Channel. The flows will discharge into the existing channel that conveys flows to a pipe crossing under Estrella Parkway. The pipe flows will ultimately reach the agricultural fields located west of Estrella Parkway.

2) The tailwater from the East Tributary will be discharged into an existing culvert crossing located just east of the proposed Bullard Wash Channel. (The existing culvert originally conveyed tailwater flows from Bullard Wash but will be isolated by the proposed Bullard Wash Channel.) The existing holding pond will be expanded on the west end to allow tailwater flow to enter from the west. Storm flows in the East Tributary will continue westward in a new channel, discharge into the proposed Bullard Wash Channel, and ultimately discharge into the Gila River. A siphon will be designed to carry excess water from the holding pond under the Bullard Wash Channel for use on the farms to the west of Estrella Parkway. Tailwater from Bullard Wash will be conveyed under the railroad in a new culvert located within the drainage easement immediately west of the proposed Bullard Wash Channel. The flows will discharge into the existing channel that conveys flows to a pipe crossing under Estrella Parkway. The pipe flows will ultimately reach the agricultural fields located west of Estrella Parkway.

3) Mr. Rayner proposed a third alternative. Tailwater from the East Tributary and Bullard Wash will flow into the proposed Bullard Wash Channel. A new pond will be constructed north of the Broadway Road alignment within the proposed Bullard Wash Channel. The existing pump (from the holding pond) or a new pump will be relocated adjacent to the new holding pond to deliver water to the existing A-Tumbling-T irrigation piping system. The channel will need to be widened to provide adequate water and sediment storage capacity.

Mr. Rerick made it clear that the pumps and/or siphons will be operated and maintained by the local farmer, regardless of whichever system is chosen.

Mr. Martinez will check if a holding pond within the proposed Bullard Wash Channel is acceptable to the City of Goodyear relative to the proposed recreational use of the channel and if the City is willing

to accept the liability of the pond. Mr. Stough asked if it was necessary to separate storm water from tailwater for irrigation purposes? Mr. Rayner said that it was not necessary.

Mr. Rayner questioned the FCDMC if the channel will provide an adequate barrier against gophers. The sideslope treatment will need to act as a barrier against gophers. If berms are constructed above the existing ground, then the gophers will tunnel into the sideslopes. Concrete gopher barriers can be constructed within the berm that are 4-inches wide and 4-feet deep. This will contain the gophers activity.

Mr. McLaughlin said that Mr. Rayner should receive a notice from the Flood Control District in November asking him to suspend any further farming in the areas being purchased by the District. Mr. Rayner asked who would control the weeds in these areas and why farming couldn't continue until construction takes place. Mr. Rerick suggested that if construction is not started until the fall of 1998 that a 30-60 day notice could be issued to the farmer to allow time for the fields to dry up in time for construction.

A discussion of how to handle the delivery/tailwater for the fields adjacent to the proposed channel ensued. The basic concepts developed are:

- A siphon is required for the holding pond overflow. The overflow from the holding pond provides water to several farmers west of Estrella Parkway and cannot be shut off.

- A siphon is required at the Broadway Road alignment to deliver water to the fields between the channel and Estrella Parkway.

- Additional siphons may be needed depending upon the channel grade, north/south delivery ditch on the west side of channel, and channel dip crossing locations.

Access to the farm facilities and fields was discussed. Mr. Rayner said that the Broadway Road alignment carries semi truck traffic in both directions. The trucks are mainly hauling fresh cut alfalfa from the fields. The farm road to the south of Broadway Road carries semi truck traffic in an easterly direction and farm equipment. The next farm road to the south handles only farm equipment. Mr. Rayner said he will either need dip crossings at all farm roads, or a crossing at Broadway with a road that parallels the channel on the west side in order to get to his fields. Mr. Rerick said that the farm road parallel to the channel will need to be located west of the channel maintenance road. This will require a temporary construction easement (TCE). Additional delivery ditches and tailwater ditches will also need to be constructed within the TCEs.

Mr. Rerick asked if Mr. Rayner used the BID canal maintenance roadway. Mr. Rayner said not for any of his farming activities.

Mr. Olbert said that in a recent city council meeting, the council said that they would not participate in funding a concrete-lined channel, the channel must be aesthetically pleasing, they preferred an earth-lined channel. Mr. Olbert said that for an earth-lined channel the existing R/W width is inadequate. A minimum width of 200 feet is needed to accommodate the channel. Additional width may be needed for berming and dip crossings depending upon the depth of the channel. Because of the extremely flat slopes for the channel just north of the BID canal, a bottom width of 120 feet will be

needed to maintain a water depth of 5 feet. This is the minimum depth available according to the Feasibility Report. Sverdrup will not be able to determine the exact R/W needs until the mapping becomes available later this week.

Mr. Christensen said that SunChase will not be willing to give up additional land without compensation from the City of Goodyear.

Mr. Christensen said that SunChase anticipates that the property will be developed within a 10-year time frame. However, there is no firm time because no one can anticipate the market cycles.

Mr. Olbert briefly reviewed the MC 85 profile. Discussions with MCDOT have refined the bridge selection to either a three span continuous slab bridge or a box culvert. A single-span AASHTO girder bridge is too expensive and would raise the road profile too much. Neither the continuous slab bridge or the box culvert will raise the profile at the channel crossing. Both structures will be evaluated in the bridge selection report. It is anticipated that the edge of the roadway to the east of the bridge will be raised approximately 2 to 3 feet through the horizontal curve because of a 5.5 percent superelevation cross slope. Because the widening is on the south side of the roadway, more R/W will be required on the south side to provide enough R/W for the ultimate 6-lane facility fill slope, i.e., that 100 feet south of the proposed roadway centerline will be needed.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: 013884-2B
Laura Fritschi, MCDOT
Participants

MEETING MINUTES

Sverdrup Civil, Inc.

Date: October 8, 1997

LOCATION AND DATE: City of Goodyear
October 2, 1997, 10:00 am

PARTICIPANTS: Doug Sanders, City of Goodyear
Larry Martinez, City of Goodyear
Joe Evans, Yost and Gardner Engineers
Don Rerick - Flood Control District of Maricopa County
Dan Stough, Sverdrup Civil, Inc.
Brad Olbert, Sverdrup Civil, Inc.

SUBJECT: **Contract FCD 95-39**
Flood Control District of Maricopa County
Bullard Wash Channel Improvements - Final Design
Coordination Meeting - Channel Design

SUMMARY:

The above participants met to discuss issues pertaining to the Bullard Wash Channel improvements. Mr. Olbert presented information that affected the channel design. Those items are listed below.

The Buckeye Irrigation Canal, the 96-inch water line to the Palo Verde Nuclear Plant, and the 15-inch sewer line under Broadway Road act as constraints to the grade for the channel bottom. The bottom of the railroad bridge acts as a constraint for the channel water surface elevation. These constraints will keep the channel grade very flat regardless of what type of channel is selected. The net result means additional maintenance to remove sediment buildups.

From the MC 85 bridge north to the grade control structures, there is a great deal of turbulence caused by the drop structures, the discharge from the East Tributary side channel, and the bridge piers. For this reason, this area will require concrete or shotcrete to ensure stability of the channel in this area. The use of concrete for the channel would not preclude the use of ramps in the channel area.

North of the drop structure, the channel needs to discharge tailwater flows into a side ditch at the top of the drop structure and be able to intercept overbank flows into the channel at the inlet. Horizontally the channel needs to be located outside the safety zone and not interfere with monitor wells tied into the TCE cleanup system at the airport.

The channel section used will need to have an armored sideslope to prevent horizontal migration of the channel alignment. The soils in the area are mainly fine sands with silt and little or no gravel.

During high flow periods, channel migration can easily occur with soils that are not cohesive and lack adequate vegetative cover. The types of bank armor reviewed in the Skunk Creek Master Plan included soil cement, concrete, shotcrete, earth channel, slope mattress gabions, stair stepped gabions, and grouted riprap. Of these systems, only the earthen channel, slope mattress and colored shotcrete have some aesthetic appeal. In Glendale, the City requested that the gabions be covered with 6-inches of soil. With a soil covering, the gabions were limited to a maximum channel sideslope of 3:1.

In all of the channel sections using a soil bottom or soil covering, vegetative management was a major concern. The design roughness factor for the channel needs to be maintained. Short grasses and plants that will flatten during a major storm event are acceptable to maintain the flood limits within the channel.

Maintenance will also include checking for corrosion with the gabion system. Sacrificial anodes can be used to control the corrosion, however, periodic checks are mandatory. Mr. Evans said that the area is very corrosive.

Maintenance roads can double up as pedestrian trails, bicycle and equestrian routes. The type of surface needs to be reviewed. FCDMC provides a 4-inch ABC surface. Other surfaces include asphalt or crushed granite. Access under the railroad structure may be a problem. In a previous meeting, UPRR indicated very strongly that they will fight against recreational use of the channel under their bridge. Also the FCDMC does not have a separate bridge structure for pedestrians/bicycles/equestrians over the BID canal.

At our next meeting, we need to discuss access to the channel for maintenance purposes. The ramps can also function as ramps for equestrian use of the channel bottom and pedestrian crossings. Sverdrup will develop some ramp locations for the next meeting. Aerials should be available by next week.

The FCDMC only provides minimal landscaping, such as seeding of the sideslopes. A landscaping committee may be desired to anticipate future needs of the channel. It can be used to identify a theme desired by the City to be used along the channel and possibly constructed as part of package provided by developers adjacent to the channel.

Mr. Rerick said that the FCDMC usually fences new R/W. However, the City may choose to do away with the fence and assume the liability of the channel. The access roads near the main roads will require locked gates.

Signed: Bradford D. Olbert

Bradford D. Olbert, P.E.

Distribution: 013884-2B
Don Rerick - FCDMC
Participants

Appendix B4

General Correspondence

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
ARIZONA-NEVADA AREA OFFICE
3636 NORTH CENTRAL AVENUE, SUITE 760
PHOENIX, ARIZONA 85012-1936

REPLY TO
ATTENTION OF:

Office of the Chief
Regulatory Branch

January 20, 1998

JAN 21 1998

/ RBS

Maricopa County Flood Control District
ATTN: Mr. Robert B. Stevens
2801 W. Durango Street
Phoenix, Arizona 85009-6399

File Number: 984-0165-LSF

Dear Mr. Stevens:

Reference is made to your letter of January 13, 1998 in which you inquired as to whether or not a Section 404 permit is required from the U.S. Army Corps of Engineers to construct a drainage channel in the Bullard Wash irrigation ditch to capture sheet flows that threaten the Phoenix-Litchfield Municipal Airport adjacent to, but outside of, the jurisdictional boundary of Gila River at (Section 20, & 29, T1N, R1W), Goodyear, Maricopa County, Arizona.

Based on the information furnished in your letter (referenced above), review of the USGS contour maps and current aerial photographs, and your January 8, 1998 meeting with Mr. Larry Flatau of this office, we have determined that, although your proposed project area does include jurisdictional waters, your proposed project does not discharge dredged or fill material into a water of the United States or an adjacent wetland. Therefore, the project is not subject to our jurisdiction under Section 404 of the Clean Water Act, and no Section 404 permit is required from our office.

The receipt of your letter is appreciated. If you have questions, please contact Larry S. Flatau at (602) 640-5385 x 225.

Sincerely,

Cindy Lester

Cindy Lester
Chief, Arizona Section
Regulatory Branch

cc: Don Reynolds
Tom Johnson
File: Bullard Wash (1.5.7)

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
Telephone (602) 506-1501
Fax (602) 506-4601
TT (602) 506-5859

BOARD OF DIRECTORS
Betsey Bayless
Jan Brewer
Fulton Brock
Don Stapley
Mary Rose Garrido Wilcox

MAY 26 1998
5/26/98

May 20, 1998

Joanne Miller, Compliance Specialist/Archeologist
State Historic Preservation Office
1300 West Washington
Phoenix, Arizona 85007

RE: Bullard Wash Outfall Project
Archeological Inventory
Request for Concurrence

Dear Ms. Miller:

Enclosed, please find one copy of the report "An Archeological Inventory of the Expanded Bullard Wash Outfall Project Area of Southern Goodyear, Arizona" prepared by Scientific Archeological Services (SAS). The Flood Control District of Maricopa County reviewed the SAS report and agrees with the conclusion that the concerned project should have no effect upon any prehistoric or historic cultural resources. Prior archeological work for the proposed project was completed by SAS in January 15, 1997, and April 21, 1995, however, the project area was expanded since then. A signed concurrence letter from your office for the previous work and corresponding reports is enclosed for your review.

The District requests your concurrence that the proposed project will have no effect on any historic property, and the authorization to continue its planned development of the Bullard Wash Outfall Project in Goodyear, Arizona.

'u have any questions or comments, please call Theresa Hoff at 506-8127. Thank you for your time.

Sincerely,

Theresa M. Hoff

Theresa M. Hoff
Environmental Services Planner

Enclosures

CONCUR

for ARIZONA STATE HISTORIC PRESERVATION OFFICER
ARIZONA STATE PARKS BOARD

June 11, 19

Memorandum

To: Don Rerick

CC: Bob Stevens

From: Theresa Hoff

Date: 12/05/97

Re: Bullard Wash Project

Don – Here is a summary of the potential Bullard Wash environmental concerns. Some of the information is similar to the memo sent to you previously, however, it contains additional information as well (e.g., a synopsis of the Phase II investigation).

Conclusions

Based on the Phase II investigation results and the verification that aluminum oxide is not a hazardous material, additional Phase II investigation is not necessary at this time to proceed with the Bullard Wash project.

Several injection wells, monitor wells, and injection pipelines are located on the PGA property, which is part of the groundwater and soil treatment system. Therefore, the channel should be routed to ensure the treatment system is avoided and not impacted.

Phase II Investigation Conducted for the Bullard Wash Project

Growth Environmental drilled twelve soil borings for the Phase II investigation. Eight of the soil borings were located south of highway 85 and the other four were located near the southwest corner and western border of PGA South. Three samples were collected from each soil boring at varying depths (i.e., 14-24", 5-7', and 10-12' bgs). The samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and the eight listed RCRA metals (Test numbers EPA 8260, 8270, & 6010). The sample results indicated no detectable concentrations of VOCs or SVOCs. Twenty-six of the 27 samples analyzed for the eight RCRA metals resulted in detectable concentrations for four of the eight metals, however, the concentrations were below the ADHS health based guidance levels (HBGLs). One of the 27 samples resulted in detectable concentrations of three of the RCRA metals, which were also below the HBGLs. Therefore, based on these results, no further soil sampling is recommended.

Aluminum Oxide

Aluminum oxide is not a listed RCRA hazardous waste. ADEQ does not have soil remediation clean-up levels for aluminum oxide. According to Mr. Tony Debenedetto from ADEQ hazardous waste compliance division, if there are no soil remediation clean-up levels for a substance, the substance is not listed as RCRA hazardous waste, and the substance does not exhibit any of the

RCRA hazardous waste characteristics (i.e., reactivity, ignitablility, corrosivity, or toxicity), then the soil containing the substance is non-hazardous.

Aluminum Oxide Fines on PGA Property

According to a report by Scott Allard, & Bohannan, Inc., (SAB), the soil affected by the aluminum oxide fines on the Phoenix Goodyear Airport (PGA) was removed using hand tools and deposited back onto the IMALSCO property in April, 1993. It appears that the extent of the affected soil was determined by visual inspection. The remaining soil was not sampled to confirm that the aluminum oxide fines were completely removed. However, aluminum oxide is not a RCRA listed or characteristic hazardous waste and is sometimes used in the production of concrete. Furthermore, in May 1993, Ms. Cynthia Parker, Environmental Programs Coordinator, City of Phoenix Aviation Department, stated that the cleanup was acceptable to the City of Phoenix. Since aluminum oxide is not a hazardous material and the affected soil was removed, sampling is not recommended in this area of the PGA.

Aluminum Oxide Fines on the Railroad Property

Soil on the railroad property adjacent to PGA and IMSALCO's southern borders was also affected by the aluminum oxide fines. The SAB report did not explicitly state that the affected soil on the railroad property was cleaned up or removed, although, the site map depicting the corrective action area (assumed to be the area cleaned-up) did include the affected soil on the railroad property. Therefore, some of the soil on the railroad property may still contain aluminum oxide fines because it is not clear whether or not it was removed; however, as discussed previously, aluminum oxide is not a hazardous substance.

Additional items of potential concern of which you may already be aware:

- Groundwater in the area is reported to be approximately 40 feet bgs.

- Several wells and an injection pipeline are located in the in the area of the proposed Bullard Wash project.

- Two groundwater wells are located near the northwest corner of the IMALSCO facility. The construction plans should not compromise the integrity of the wellhead that could provide a means of access for contaminant migration into the low levels of the aquifer. If construction does impact the wells, the wells can be formally abandoned in accordance with ADWR requirements.

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
Telephone (602) 506-1501
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BOARD OF DIRECTORS
Jan Brewer
Fulton Brock
Andrew Kunasek
Don Stapley
Mary Rose Garrido Wilcox

August 3, 1998

Ms. Cynthia Parker, Environmental Coordinator
Aviation Environmental Department
City of Phoenix Aviation
3400 Sky Harbor Boulevard
Phoenix, Arizona 85034

Subject: Bullard Wash Channel Improvements Project – Phoenix Goodyear Airport Debris Dump

Dear Ms. Parker:

As you know the Flood Control District of Maricopa County and the City of Goodyear are working together to design and construct the subject channel improvements project. The alignment of the channel crosses through the southwest corner of the Phoenix Goodyear Airport. Airport staff notified the District of the existence of an old construction debris landfill located in this area of the airport.

We appreciate the information you have provided us about the landfill, including a copy of the characterization report completed for you by SCS Engineers, dated June 4, 1998. The report is comprehensive and includes data on numerous test trenches. In a recent telephone conversation, you stated that you "felt very good about the material in the landfill" and that "you had retrieved all of the waste oil bowsers" attributed to be in the landfill. The characterization done by SCS plus previous historical information you provided indicates that no hazardous or other substances requiring special handling are present within the landfill.

You have also provided to us information regarding the fact that the airport is within a superfund site. The FAX included suggested language to be included in our specifications.

I have coordinated all this information with District Environmental staff and with District General Counsel. We have incorporated this information into our project specifications, and we will address the construction debris landfill as follows:

1. The specifications include the superfund site information language you recommended.

2. The specifications direct the contractor on how to excavate within the limits of the landfill. This includes having either District Environmental staff or one of our on-call environmental consultants on site at all times during such excavation.

3. Any material exposed during excavation which requires special handling will be handled by District staff and our on-call consultant services, which are experienced in removing and disposing of such material. Work by the contractor would cease in the area of the exposed special material until it was mitigated.

4. Where construction debris remains exposed at the face of excavation limits as required for the project, a minimal amount of over-excavation will be done to remove the exposed debris, and the area will then be backfilled and compacted with approximately three feet of clean dirt. This will create a more acceptable finished surface of the dump at such locations.

5. Debris, stained soils and other similar materials will be removed to the limits required for the project, plus any over-excavation as described above. We will not "chase" any debris or stains beyond the required limits of the project beyond the over-excavation limits as described above. Should our contractor cause a substance to leak and stain the soil, the District would remove this soil.

You have been provided with the 90% plans for the project, and we will be happy to provide you with a set of the final plans and specifications when available. You are also welcome to attend the project construction pre-bid meeting, which will be held at District offices sometime in October. The District will notify you of the date and time of the meeting. This will provide you an opportunity to make any comments to the potential contractors bidding on the project.

If you should have any other questions or need additional information from us, or if you have any additional information that would be helpful to us, please do not hesitate to call me at 506-4878. Thank you again for your assistance on this project.

Sincerely,

Donald J. Reriek, P.E.
Project Manager

Copies to: Shawn Arena, Phoenix Goodyear Airport
Jack Shelter, City of Phoenix Aviation Department
Brad Olbert, Sverdrup Civil, Inc.

Appendix B5

Contract Documents

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

BULLARD WASH OUTFALL CHANNEL IMPROVEMENTS
FINAL DESIGN

CONTRACT FCD #95-39

EXHIBIT A

SCOPE OF WORK

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1.0 PROJECT DESCRIPTION

1.1 General Description

1.1.1 Bullard Wash Outfall Channel. The Flood Control District of Maricopa County (DISTRICT) has completed the Bullard Wash Outfall Feasibility Study, September 1995 (Feasibility Study). The feasibility study established the required 100-year capacity channel. Grade control and drop structures are incorporated into the design. Completion of the project will stabilize the channel banks, restore the capacity of the channel to convey the 100-year peak discharge, and reduce the floodplain to the channel limits. The project features include a 2-mile outfall channel with concrete armored banks, bridges at Highway MC-85 and the Southern Pacific Railroad (SPRR), and an over chute structure at the BID canal. The project limits are shown on Figure 1. The Bullard Wash Outfall Channel project is referred to herein as the DISTRICT project.

This project includes completion of final design plans and construction documents, and an Engineer's Estimate for the reach of Bullard Wash Creek between the Gila River and Lower Buckeye Road. The final design will be based upon the results of the *Feasibility Study*. The project will be constructed in two phases, with the first phase extending from the SPRR to the Gila River. The second phase will extend from the SPRR to Lower Buckeye Road. Design and construction documents will be completed for both phases.

1.1.2 Maricopa County Highway 85/ Estrella Intersection Improvements. This project is to upgrade the existing Highway MC-85 and Estrella Parkway intersection from a two-lane roadway to a four-lane arterial roadway with left turn lanes. This project extends along Highway MC-85 from approximately 1,500 feet west of Estrella Parkway to approximately 3,500 feet east of Estrella Parkway. Additionally the Estrella Parkway will be upgraded from a 2 lane roadway to a 4 land roadway with a raised median, from the Buckeye Canal bridge to approximately 1,500 feet north of Lower Buckeye Road and approximately 1,500 feet, east and west, along Lower Buckeye Road. The project limits are shown on Figure 1. The Maricopa County Highway 85/ Estrella Intersection Improvements project is also referred to herein as the MCDOT project.

1.1.3 The City of Goodyear Estrella Parkway Improvements. This project includes the improvements to the Estrella Parkway extending from 1,500 feet north of Lower Buckeye Road to approximately 2,600 feet North of Yuma Road and approximately 1,500 feet, east and west, along Yuma Road. The project limits are shown on Figure 1. The City of Goodyear Estrella Parkway Improvement project is referred to herein as the City of Goodyear project.

1.1.4 Project Funding. This design contract is funded by the DISTRICT who will be reimbursed for portions of the work by MCDOT and the City of Goodyear. The DISTRICT is responsible for costs related to the design of the Bullard Wash Outfall Channel. MCDOT and the DISTRICT are each responsible costs related to the design of portions of the Maricopa County Highway 85/ Estrella Intersection Improvements with the City of Goodyear reimbursing MCDOT for portions of its share. The City of Goodyear is responsible for costs related to the design of the City of Goodyear Estrella Parkway Improvements. Intergovernmental agreements are being negotiated accordingly between the three agencies and authorization of the related work is dependent upon completion of the intergovernmental agreements.

1.1.5 Project Review. The DISTRICT and the City of Goodyear will be responsible for review and approval of the Bullard Wash Outfall Channel. The DISTRICT and MCDOT will be responsible for review and approval of the Bullard Wash Channel bridge at MC85. MCDOT will be responsible for the review and approval of the MC85 roadway designs. The City of Goodyear will be responsible for the review and approval of the Estrella Parkway

Improvements. Design submittals for review and approval are to be transmitted accordingly.

1.1.6 Project Fee Proposal, Notice to Proceed, and Invoices. The work and payment for the MCDOT and City of Goodyear projects are not authorized with execution of this contract and a separate Notice to Proceed may be issued in writing by the District. The CONSULTANT shall submit separate cost estimates in the fee proposal and invoices for each the Bullard Wash Channel Improvement designs, the MC85 bridge designs, the MC85 roadway designs, and the Estrella Parkway improvements design.

1.2 Purpose

The purpose of this project is to improve the capacity of the Bullard Wash channel to contain the 100-year flood flows within a stable channel. The project design will be based upon FEMA guidelines and will provide information needed by the Federal Emergency Management Agency (FEMA) to modify the Flood Insurance Rate Maps reducing the floodplain to the area of the channel. This scope of work describes the tasks to be completed for delivering complete final design and construction bid documents for construction of the channel improvements, as described in the Feasibility Study.

1.3 Location

The project area is bounded by the Gila River and Lower Buckeye Road on the south and north respectively, and by Bullard Avenue and Estrella Parkway on the east and west respectively.

1.4 Agencies

In addition to the DISTRICT, the following representative will be receiving copies of project submittals and will act as a point of contact:

Tomothy Edwards, P.E., City Engineer
City of Goodyear
119 North Litchfield Road
Goodyear, Az. 85338
(602) 932-1637

Paul Sullivan, Project Manager
Maricopa County Department of Transportation
2901 West Durango Street
Phoenix, AZ 85009
(602) 506-8649

2.0 SCHEDULE

2.1 The CONSULTANT will submit a separate project schedule for each the DISTRICT, MCDOT, and the City of Goodyear projects within 14 days of the Notice to Proceed given for each project, showing coordination meetings, dates of all required submittals for each of the tasks in the scope, and significant project milestones. The schedule shall be developed in a computerized format that contains the anticipated beginning and end dates for the tasks identified in section 2.2, the time duration of each task, a bar chart (Gantt Chart) showing the tasks, and the overall duration of the project. The computer program MS PROJECT ver. 3.0 or compatible is preferred. The CONSULTANT shall update this project schedule when appropriate.

The schedule shall provide for completion of the Bullard Wash Outfall Channel project within the contract period of 334 calendar days from the initial Notice to Proceed and the MCDOT project within 180 days from the Notice to Proceed for that work. The schedule for the City of Goodyear project will be negotiated prior to the Notice to Proceed for that work and will be completed within the contract period of 334 calendar days.

2.2 Schedule Content. The schedule shall provide for completion of the work within the contract time unless an extension is accepted by the District. The schedule shall include a minimum of the major project milestones, project meetings, and submittal of deliverables.

2.3 Agency Review. The CONSULTANT shall allow for a three week review period, by the DISTRICT

and other involved parties, for all reports and data submitted for review and comment on the Bullard Wash submittals and four weeks for all reports and data submitted for review and comment on the MCDOT and Town of Goodyear roadway design project, unless otherwise instructed.

3.0 TASKS

3.1 Coordination

3.1.1 Project Management

3.1.1.1 The CONSULTANT shall appoint a Project Manager who has responsible charge of the progress of each phase of the project. The Project Manager shall be the same person listed in the CONSULTANT's Technical Proposal, unless otherwise approved by the DISTRICT.

3.1.1.2 The DISTRICT may request replacement of the Project Manager if it becomes apparent that this would be in the best interest of the project.

3.1.1.3 The Project Manager shall be the point of contact for the DISTRICT.

3.1.1.4 Invoices

a. The CONSULTANT will submit a quarterly estimation of the projected billing within 14 days of Notice to Proceed. Thereafter, this estimation will be updated and submitted to the DISTRICT's project manager at least 10 days prior to the end of each quarter.

b. The CONSULTANT will submit monthly invoices which reflect work accomplished during the invoice period. The invoices shall identify this contract number and shall include: the total contract amount (total and amount for each work task identified in the negotiated fee proposal) times the percent complete, the amounts previously billed, and the amount due for the period.

c. Invoices shall be submitted to Accounts Payable, Flood Control DISTRICT of Maricopa County, 2801 West Durango, Phoenix, Arizona, 85009.

3.1.1.5 The CONSULTANT shall submit monthly progress reports which discuss project activities for the same time period as included in the monthly invoices. The report shall be brief (i.e., no longer than two typed pages). At a minimum, the monthly report shall contain the following:

a. A description of the work accomplished by task during the reporting month.

b. A determination of the percent (%) completed for the month and percent (%) cumulative completed for each task. The tasks shall be the same as the tasks contained in the project cost proposal.

c. A brief description of the work to be accomplished in the following month.

d. A description of any problems encountered and actions to resolve the problems.

3.1.1.6 The Project Manager shall call the DISTRICT's project manager once a week (or less frequently as approved by the project manager) to provide a progress report.

3.1.1.7 The CONSULTANT shall participate in monthly (or other less frequent time increment as approved by the project manager) coordination meetings with the DISTRICT's Project Manager and in milestone coordination meetings in the development of the design and construction contract documents. The CONSULTANT is responsible for the minutes of all meetings. Whenever possible, coordination and milestone/deliverable review meetings should be combined.

3.1.1.8 The Project Manager shall keep the DISTRICT informed of all coordination with outside agencies and other affected parties.

3.1.1.9 The Project Manager shall provide copies of minutes of meetings, telephone conversations, and correspondence to the DISTRICT on a monthly basis.

3.1.2 Meetings

3.1.2.1 The CONSULTANT shall meet with officials from the City of Goodyear. The purpose of the meeting is to identify local flooding problems and obtain information on current and planned public works projects, channel modifications, storm-drainage systems, development, and corporate limit changes.

3.1.2.2 Meetings with other agencies and utilities will be held, as required, and will generally be held at their offices. Additionally, the CONSULTANT will meet with representatives of the A-Tumbeling-T Ranch, which is located between the MC-85 and the Buckeye Canal, to refine the required modifications to the existing irrigation distribution system. The DISTRICT will be kept informed of all such meetings, and shall attend the meetings when needed. The DISTRICT will be provided copies of all meeting minutes.

3.1.2.3 Meetings with the DISTRICT will generally be held at the DISTRICT offices.

3.1.2.4 Project Kickoff Meeting - The CONSULTANT will meet with the DISTRICT to submit dates of all proposed submittals and review meetings, and to discuss the schedule and tasks necessary to complete the project. The CONSULTANT will bring the key project team members, including the project checkers, to the meeting to introduce them to the DISTRICT staff who will be working on the project. The DISTRICT will give the data and information described in section to the CONSULTANT at this time.

3.1.2.5 Draft Design Concept Analysis Report Review Meeting - The CONSULTANT will meet with the District Project Manager and members of the project review team to review the overall project status, and to discuss the Draft Design Concept Analysis Report review comments which will be provided to the CONSULTANT at the meeting. The CONSULTANT should be prepared to discuss the design concept analysis. A consensus on the design concept to be used in final design will be reached at this meeting. Any problems will be identified and resolved at this meeting.

3.1.2.6 30% Submittal Meeting - The CONSULTANT shall meet with the DISTRICT Project Manager and members of the project review team to review the overall project status, and to discuss the 30% review comments which will be provided to the CONSULTANT at the meeting. The CONSULTANT will prepared to explain all assumptions and calculations completed up to this point. Any problems will be identified and corrective actions agreed upon at this meeting. The first Performance Evaluation shall be completed at this time.

3.1.2.7 60% Submittal Meeting - The CONSULTANT will meet with the DISTRICT Project Manager to review the overall project status and to discuss the 60% review comments which will be provided to the CONSULTANT at the meeting. The CONSULTANT should be prepared to discuss alternative flood mitigation solutions and the preliminary cost estimates.

3.1.2.8 90% Submittal Meeting - The CONSULTANT will meet with the DISTRICT Project Manager to review the overall project status and to discuss the 90% review comments which will be provided to the CONSULTANT at the meeting. All calculations, analyses, drawings, and the design data report should be substantially complete at this point. The final submittal requirements will be reviewed.

3.1.2.9 Final (100%) Submittal Meeting - The CONSULTANT will meet with the DISTRICT Project Manager to make the final submittal of the final deliverables which have been modified to incorporate the 90% review comments. A Performance Evaluation will be completed at this time.

3.2 Data Collection

3.2.1 The CONSULTANT will collect and review pertinent data from the DISTRICT and other outside sources. Data to be collected will include material relevant to the project, such as previous flood hazard reports and hydrology for the study area; existing topographic mapping; historical flooding information; as-built plans for existing structures; FEMA Flood Hazard Boundary Maps and any Letters of Map Amendment and/or Revisions, and other pertinent information.

3.2.2 The DISTRICT will provide the data described in section 5.1 at the Kickoff meeting.

3.2.3 The CONSULTANT will provide a list of the data items obtained in the Design Data Report.

3.3 Site Visits

3.3.1 The CONSULTANT will make site visits as necessary to become familiar with existing conditions and to facilitate the design and preparation of construction contract documents.

3.3.2 The CONSULTANT will conduct field review at the following times:

- Prior to completion of the 30 % submittal,
- Prior to completion of the 60 % submittal, and
- Upon completion of the 90 % submittal review.

3.4 Survey

3.4.1 General Description, Requirements, and Documentation

3.4.1.1 Limits of Survey

The field control survey, topographic survey, and aerial control points for the project will be supplied by the DISTRICT. The CONSULTANT will be required to complete any supplemental survey required for design details and survey of potential borrow or waste sites, according to the requirements herein. The CONSULTANT shall complete photogrammetric mapping, with two foot contour intervals, for the project and shall coordinate with the DISTRICT to assure completion of the setting of the aerial targets prior to taking the aerial photographs. Aerial photography may be used to supplement the design process, however, all final design and quantities will be based on the field survey, not the aerial photography.

3.4.1.2 Supervision and Level of Accuracy and Detail.

All survey work shall be supervised by a Registered Land Surveyor. Except for the survey data to be provided by the DISTRICT which is described in section 5.1, the CONSULTANT shall conduct all field surveys and prepare all mapping necessary to complete the project. The surveys shall be completed by the CONSULTANT at a level of accuracy and detail for completion of final design, computation of quantities for payment to the contractor, and for identification of right-of-way requirements.

3.4.1.3 Topographic Survey

The survey shall include, but not be limited to, field survey of ground terrain points sufficient to define all terrain slope break points, identify all ridge lines, and terrain detail with points located at no greater than a 100 foot grid. All points will be three dimensional. Topographic features shall be surveyed to locate existing structures, walls, streets, above ground utilities including pole locations, invert and rim of manholes, edges of sidewalks and street curbs, existing bank protection, existing storm water inlets, and any other features or structures which may impact the proposed construction.

3.4.1.4 Documentation of Survey Data

Survey data will be documented in a project survey report. Copies of all survey notebooks or printout of digital files developed with data collectors will be provided. All survey documentation and reports shall be sealed by a Registered Land Surveyor,

registered in the State of Arizona.

3.4.2 Survey and Ground Control Mapping Standards

3.4.2.1 Accuracy and Procedural Standards

All topographic mapping and survey work shall meet or exceed FEMA minimum criteria as defined in the FEMA Document 37, Flood Insurance Study Guidelines and Specifications for Study Contractors, January 1995.

3.4.2.2 Horizontal and Vertical Control Datum

The DISTRICT will provide a description of the existing horizontal and vertical control points to be used for this project.

3.4.3 Field Survey Control Points

3.4.3.1 Section Control Ties **Not Required**

3.4.3.2 Temporary Bench Marks **Not Required**

3.4.3.3 Temporary Survey Ties **Not Required**

3.4.4 Digital Topographic Mapping

3.4.4.1 Digital Terrain Modeling

The CONSULTANT shall use digital terrain modeling (DTM) and contour generating software to create data files. The DTM shall be completed consistent with the DISTRICT "Digital Terrain Model Mapping Data Collection and Delivery Specifications", release 1.0, May 1994. The CONSULTANT shall provide data files of the DTM data which will allow extrapolation of HEC-II cross-sections. The data files shall contain 3-dimensional survey points and any topographic contours developed for the project which shall have elevations assigned to all contours.

3.4.4.2 Final Submittal (Digital Data)

The final submittal of all digital maps, computer files, and other data shall be prepared and submitted in the manner defined for input by the guidelines in "Data Delivery Specifications: The Hydrologic Information System (HIS)" which is available from the DISTRICT.

3.4.4.3 **not required**

3.5 Hydrology **not required**

3.6 Hydraulics

3.6.1 The CONSULTANT shall perform complete and detailed hydraulic analysis of the project channel and hydraulic structures.

3.6.2 The CONSULTANT shall follow the procedures outlined in the "Drainage Design Manual for Maricopa County, Volume II Hydraulics" for all hydraulics calculations.

3.6.3 The design discharges to be used for this project will be provided by the DISTRICT and will be confirmed by the CONSULTANT.

3.6.4 The DISTRICT has submitted documentation to FEMA in a request for a Conditional Letter of Map Revision, including a HEC-2 model for the proposed conditions. The CONSULTANT will document any design changes from the HEC-2 model, and will make modifications to the model to reflect the final designs completed under this scope of work.

3.7 Floodplain Delineations ** not required**

3.8 Geotechnical Investigation

3.8.1 The CONSULTANT shall conduct or contract for necessary geotechnical investigations to determine the soils engineering properties. The geotechnical investigations shall include borings completed within locations of anticipated project excavations exceeding 3 feet in depth. Borings are to be completed to a depth of 5 feet below the depth of excavation and at intervals

not to exceed 500 feet. The DISTRICT will approve the proposed locations of all soil borings and laboratory testing prior to any field work.

The CONSULTANT shall contact Mr. Bob N. Prince, Southern Pacific Lines, 1200 Corporate Center Drive, Monterey Park, Ca. 91754, (213)980-6956, to acquire an agreement to conduct geotechnical work within the Southern Pacific Lines property.

3.8.2 The CONSULTANT shall provide soil boring logs drafted on 4-mill mylar sheets for incorporation into the plans.

3.8.3 The CONSULTANT shall notify the DISTRICT of any hazardous materials encountered during geotechnical investigations which have not been previously identified be the DISTRICT.

3.8.4 The CONSULTANT shall complete a geotechnical engineering report prepared and sealed by a qualified, registered professional engineer. The report shall include maps showing the sample site locations with survey data for horizontal and vertical control, documentation of laboratory test results, calculations, and narrative summarizing the results and design recommendations. The report shall be prepared and sealed by a qualified, registered Professional Engineer and shall include any necessary calculations to support the recommendations. Seven (7) copies of the geotechnical engineering report, and any revisions, will be submitted prior to the 30% submittal.

3.9 Hazardous Materials

3.9.1 The CONSULTANT will document, in the Design Data Report, if the project design requires the use of any materials either brought onto the site or created on the site that are covered by the State of Arizona Hazard Communication Standard. This identification shall be included on all affected drawings and within the specifications. The CONSULTANT shall provide any required Special Provisions listing of the hazardous materials and a cross-reference to the plans

3.9.2 The CONSULTANT shall provide Material Safety Data Sheets, where appropriate.

3.9.3 The DISTRICT will provide documentation of any studies conducted by the DISTRICT to identify existing hazardous materials on land within the project construction area.

3.10 Rights of Way and Easements

3.10.1 The DISTRICT will acquire rights-of-entry for site investigations including geotechnical investigations. The CONSULTANT shall coordinate the schedule of all field activities with the DISTRICT's Project Manager.

3.10.2 Existing property boundaries, in AutoCAD format, will be provided to the CONSULTANT by the DISTRICT.

3.10.3 ** Not Required**

3.10.4 The CONSULTANT shall review permanent right-of-way and easement requirements established by the DISTRICT necessary for the project features. The CONSULTANT shall confirm the adequacy of the established right-of-way and easement requirements.

3.10.5 The CONSULTANT shall review and confirm any temporary construction easements established by the DISTRICT for this project.

3.10.6 ** Not Required**

3.11 Utilities

3.11.1 The CONSULTANT is responsible for contacting known existing utilities prior to design.

3.11.2 The DISTRICT shall provide available utility maps and identify utilities within the general project limits. The DISTRICT does not guarantee the accuracy of this information. The CONSULTANT shall analyze and verify the available information and, where necessary, obtain additional data from the utility. Utility map information is to be supplemented by a field survey of surface features (i.e., water valves, manhole covers, etc.) and potholing for

design.

3.11.3 Existing utility locations shall be shown on the earliest practical plan submittal. and in no case later than the 60 percent submittal.

3.11.4 The CONSULTANT shall provide design calculations, plans. and specifications for the relocation of all water and sewer lines. The CONSULTANT shall coordinate these relocations with the jurisdiction that owns the facilities. Design for the relocation of municipally or privately owned facilities shall be in accordance with the standards of the owner and shall be subject to approval by the municipality and the DISTRICT.

3.11.5 The CONSULTANT shall be responsible for potholing utilities, and the cost of this work shall be included in the CONSULTANT's proposal.

3.12 Traffic

3.12.1 The CONSULTANT shall identify requirements for public and private access within and across the project limits, review traffic control requirements and provide traffic control plans, and, if necessary, detour plans for the construction phase. The CONSULTANT shall coordinate all aspects of traffic control and detour design, subject to the review and approval of the jurisdictional authority.

3.13 Drainage Master Plan **not required**

3.14 Pre-design **not required**

3.15 Final Design Calculations and Construction Documents

3.15.1 General Design Requirements

3.15.1.1 Channel designs - Channel designs shall be based upon the preliminary designs as documented in the Feasibility Study, and shall be consistent with the DISTRICT's *Channel Design Criteria for Major Water courses* (dated 3 February 1994) and the *Drainage Design Manual for Maricopa County* (dated 1 September 1992). The channel design will require earthwork calculations to excavate/fill the existing channel to the prisms required to convey the 100-year discharge. Earthwork calculations shall include volumes for borrow and waste and construction drawings shall show the volumes, location, grades and limits of borrow/waste sites.

The CONSULTANT will review the existing HEC-2 model of the proposed design. Any revisions made during the final design phase will be incorporated into the model for submittal to FEMA to update DISTRICT's request for a CLOMR. The modified HEC-2 model will be submitted at the 90% submittal. Narrative describing the modifications shall be prepared and submitted with the revised model.

The CONSULTANT will review existing scour analysis for armor toe down depth, conduct bridge scour analysis at bridge and culvert crossings, use existing sediment gradations and supplement as required for local site scour requirements.

3.15.1.2 Bank armor - The majority of the reach is to be armored with reinforced concrete. The reach at the SPRR bridge inlet is to be fully lined with reinforced concrete. The reach from the BID overchute to the Gila River is to have banks armored with gabions.

3.15.1.3 Bridges - The CONSULTANT shall complete designs for the Highway MC-85 road crossing. The the SPRR bridge designs are to be completed by the SPRR.

The CONSULTANT shall coordinate with the SPRR to assure compatibility of the railroad bridge design with the Bullard Wash design. The designs are to be completed using standards and procedures acceptable to the Maricopa County Department of Transportation (MCDOT) for the Highway MC-85 bridge. The CONSULTANT will coordinate with the SPRR and MCDOT throughout the design process. Copies of all correspondence and telephone conversation memos are to be provided to the DISTRICT's Project Manager.

3.15.1.4 BID Canal Overchute -The BID Canal Overchute shall be designed consistent with the preliminary designs summarized in the Feasibility Study. The CONSULTAANT shall complete designs of a maintenance/access bridge crossing the Buckeye Canal overchute for access along the canal maintenance road.

3.15.1.5 Access Ramps - The channel design shall include access ramps for maintenance and access across the channel for continued farming activities.

3.15.1.6 Earthwork Calculations - Earthwork calculations shall be completed using software which computes earthwork from a digital terrain modes. Quantities for each reach shall be shown on the plan/profile sheets. Any required fill areas, borrow/waste sites shall be shown on the plans.

3.15.1.7 Revegetation, vegetation maintenance (trimming and clearing) - Required revegetation and/or seeding shall be shown on the plans and addressed in the specifications.

3.15.1.8 Irrigation Facilities - Existing irrigation facilities convey water to and distribute water throughout the lands located between the Highway MC-85 and the BID Canal. The designs to maintain service during construction and modifications required for construction of the Bullard Wash Outfall Channel shall be coordinated with the representative of the property owner. The CONSULTANT shall coordinate with the owner's representative and shall keep the DISTRICT's Project Manager informed of the design requirements.

3.15.1.9 Aesthetic Treatment and Landscaping - The DISTRICT will form an advisory committee to recommend aesthetic features for the project. The committee will be composed of the DISTRICT's project manager, public involvement coordinator, ecologist; the CONSULTANT; and if available a neighborhood representative, cooperative agency project managers, other DISTRICT staff, and other agency representatives. The DISTRICT will conduct a public involvement meeting to present and discuss the project aesthetic treatment. The landscaping design requirements are limited to inclusion of overseeding and minor plantings and/or salvage and replanting. Design of an irrigation system for landscaping is not included in this scope of work.

3.15.2 Design Concept Analysis - The CONSULTANT shall review existing designs as provided in the Feasibility Study Report. The concept analysis shall include an evaluation of alternative drop structure types, heights, hydraulic characteristics, costs, and aesthetics. Alternative methods to direct and/or convey flows into the channel shall be studied and summarized in the Design Concept Analysis Report. Alternative channel geometry to improve aesthetic and recreational potential shall be studies with at lease three alternative channel concepts studied. Alternatives to allow access for recreational purposes shall be studies. The study results shall be incorporated into the draft design concept analysis report. The report shall include a summary of the review of the Feasibility Study designs and shall include a summary of the methodologies and procedures to be used in completing the final designs.

3.15.3 Designs and Calculations - The CONSULTANT shall use methods and procedures which are normal and customary standards of the industry. All calculations, sketches, computer

printouts, or other written or printed data used in the final design shall be included in the design data report.

3.15.4 Construction Drawings - The CONSULTANT shall prepare separate design plans and construction documents for Phase 1 and Phase 2 including, but not limited to:

- Flood Control District standard cover sheet
- General notes
- Summary Sheets - The plans shall include a summary table of concrete, excavation, and structural backfill quantities for each structure. These quantities shall be shown on an appropriate structures summary sheet; a separate quantity sheet shall not be prepared. The quantities in the table shall add up to the bid item quantities for each bid item, including the appropriate class and strength of concrete (i.e., Class "A", Class "AA"). The CONSULTANT shall itemize the quantities using the appropriate M.A.G. Specification Section numbers.
- Plan and profile sheets Cross sections
- Utility relocations
- Special details
- Separate documents for phase 1 and 2

3.15.5 Construction Special Provisions

3.15.5.1 The CONSULTANT shall prepare Construction Special Provisions as part of this contract. The Construction Special Provisions shall be numbered, named, and sequenced in the same order as MAG Specifications. Each Construction Special Provision item referenced shall state whether it replaces all or part of, or is added to, the corresponding MAG Specification Section numbers.

3.15.5.2 The District shall provide an example of Construction Special Provisions for the CONSULTANT to follow.

3.15.6 Quantities/Engineer's Estimate

3.15.6.1 The CONSULTANT shall prepare a Bidding Schedule and an Engineer's Estimate for all elements of the design including costs for alternative materials. The items in the Engineer's Estimate shall conform exactly to the Bidding Schedule Items. Item numbers in the Bidding Schedule shall follow MAG Specification Section numbers.

3.15.6.2 The CONSULTANT shall include quantity calculations and unit cost backup documentation.

3.15.7 Design Data Report - The CONSULTANT shall maintain a design report throughout the project which contains documentation of the designs, analysis, and calculations. The report shall be organized to include, but not limited to, the following sections as appropriate tothe project:

- A recommendation of lateral design, configuration, alignment, and feature locations. (Include a 1"=100' scale preliminary plan at ½ scale).
- Location of conflicting utility relocations and potholing locations.
- Requirements for public and private access.
- Right-of-way and easement information.
- Identification of hazardous materials.
- Design review and permitting requirements.
- Construction duration and schedule.
- Special project features, including unusual construction techniques, special materials, and/or conditions.
- Maps, sketches, calculations, and other supporting documentation as required.
- Recommendations for additional field surveys and/or soils investigations.

3.16 Construction Management ** Not Required**

3.17 Public Involvement

3.17.1 The DISTRICT will plan and conduct two public meetings in conjunction with this study. The first meeting will be to inform the public of the Design Concept Analysis results. The second meeting will be to inform the public and obtain public comment on the project status and the landscaping and aesthetics proposed for the project, and shall take place at the project 30 percent level of completion. One representative from the CONSULTANT will attend each of the meetings. The CONSULTANT will respond to the public's comments and make revisions to the study if necessary.

3.17.2 CONSULTANT will provide an exhibit (8 1/2 inch X 11 inch) showing the general project features or project impact area suitable for reproduction or publication and a digital file of the exhibit.

3.17.3 The CONSULTANT shall assist the DISTRICT in the preparation of the graphic displays by providing digital and hard copies of drawings and figures which the CONSULTANT has completed for other portions of this scope of work.

3.18 Permits and Approvals

3.18.1 The CONSULTANT shall be responsible for determining if plan approvals, permits, or licenses from other agencies will be required. Other agencies may include, but may not be limited to: municipalities, tribal governments, the CountyHealth Department, the Arizona Department of Environmental Quality, the Arizona Department of Water Resources, the Army Corps of Engineers, railroads, utilities, and water districts.

3.18.2 The CONSULTANT shall be responsible for obtaining required approvals from municipalities.

3.18.3 The DISTRICT will be responsible for coordination with the US Army Corps of Engineers regarding Clean Water Act section 404 permits and with the Arizona Department of Environmental Quality reguarding Clean Water Act section 401 permits.

3.19 Performance Evaluation

3.19.1 The Performance Evaluation Form shall be given to the CONSULTANT at the preliminary meeting to provide the CONSULTANT with the criteria for doing the Performance Evaluations.

3.19.2 Performance Evaluations shall be completed by the CONSULTANT and the DISTRICT at the 30% Submittal Meeting and at the Final Submittal Meeting. The standardevaluation forms shall be provided by the DISTRICT.

3.20 FEMA Submittal for CLOMR

3.20.1 Utilizing data developed for the Skunk Creek Master Plan, the CONSULTANT shall prepare documentation suitable for submittal to FEMA to request a Conditional Letter of Map Revision (CLOMR) based upon the proposed channel improvements. A FEMA CLOMR is to be requested by the DISTRICT. CONSULTANT shall prepare documentation of the recommended project alternative in sufficient detail to document the resulting changes in the floodplain delineation due to the proposed project. Documentation sufficient for submittal for a CLOMR shall be provided by the CONSULTANT and shall include data described in section 4.3. The CONSULTANT will prepare the study documentation using the guidelines established in FEMA documents:

- Flood Insurance Study Guidelines and Specification for Study Contractors, Document 37, January 1995,

- Appeals, Revisions, and Amendments to Flood Insurance Maps, FIA Document 12, January 1990
- Revisions to National Flood Insurance Program Maps, Application/Certification Forms and Instructions.

3.20.2 Consultant shall provide responses to review comments, questions, and requests for additional information by FEMA.

3.21 Maintenance Plan

The CONSULTANT shall prepare a maintenance plan which shall document the required maintenance of the project facilities. The plan shall include descriptions of the required vegetation maintenance, periodic dredge and fill requirements within the channel, materials (paints, lubricants, etc.), any specialized equipment required, maintenance intervals, manufacturers data and specifications, and an estimate of the required manpower and costs required. The maintenance plan shall be submitted in draft form for review and in final form after completing revisions to incorporate review comments.

4.0 DELIVERABLES

4.1 Hydrology ** Not Required**

4.2 Floodplain Delineation **Not Required**

4.3 FEMA Submittal

4.3.1 Preliminary FEMA Submittal

The CONSULTANT will submit documentation of the Skunk Creek Master Plan to the District for review by FEMA and any other appropriate governmental agency. All of the following products are considered deliverables for the Preliminary FEMA submittal:

- Documentation of public involvement,
- Two (2) complete printed sets of plan-profile drawings or topographic base maps with the proposed channel improvements and the floodplain/floodway delineations if the channel will convey a maximum capacity less than the 100-year peak flow. All drawings will be signed and sealed by persons of appropriate professional registration(s). Each registrant will provide a specific statement as to what service they performed.
- Two (2) complete copies of the Technical Data Notebook, including HEC-1 and HEC-2 input/output files on diskettes. HEC-1 and/or hydrology documentation shall be provided by the DISTRICT. The Technical Data Notebook will be prepared in accordance with ADWR State Standards Attachment 1-90 (SSA 1-90).
- Two (2) sets of completed FEMA forms will be submitted in a notebook or binding separate from the Final Report.
- Documentation of the survey data.
- Two (2) copies of the current FIRM panels showing the proposed delineation.

4.3.2 Final FEMA Submittal: The following products are considered deliverables forthe final submittal to the District after FEMA approval is issued:

- One (1) complete sets of mylars and four (4) complete sets of sealed blueline topographic base maps or plan-profile drawings showing the proposed channel improvements and the floodplain/floodway delineations if the channel is designed to convey less than the 100-year peak discharge. Sheets shall be non-erasable mylar, 24" X 36" in size, and numbered to correspond to the delineation maps. Alldrawings will be signed and sealed by persons of appropriate professional registration(s). Each registrant will provide a specific statement as to what service they performed.

- Four (4) complete copies of the Technical Data Notebook including HEC-1 and HEC-2 input/output files on diskettes. The Technical Data Notebook will be prepared in accordance with ADWR State Standards Attachment 1-90 (SSA 1-90). This submittal of the Technical Data Notebook shall include any correspondence and/or meeting minutes with the reviewing agencies and shall reflect any revisions required by those reviewing agencies. Revisions may include, but are not limited to, modifications to the delineation maps, the HEC-1 model, the HEC-2 model, and/or the Final Report.

4.4 Pre-design *Not Required**

4.5 Final Design

4.5.1 Data Collection Report

4.5.2 Concept Submittal or Study

4.5.2.1 Draft Design Concept Report

4.5.2.2 Final Design Concept Report

4.5.3 Survey Report

4.5.4 Geotechnical Report

4.5.5 30% Design Submittal:

Upon approval of the Concept Submittal by the District, the CONSULTANT shall incorporate review comments and perform preliminary investigation and calculations necessary to prepare the 30% Submittal. All submitted items shall be dated and marked "Preliminary, 30% Submittal".

4.5.5.1 Design Data Report - Submit six (6) copies to the District for review.

4.5.5.2 Construction Drawings

Indicate existing topography.

Indicate lateral alignment, plan/profile, cross-section, and traffic control requirements.

Include the approximate size and configuration of project features.

Indicate right-of-way and easements required.

Indicate conflicting utilities that are to be relocated and/or protected.

Details need not be included.

Submit ten (10) full size and two (2) half size sets to the District for review.

Submit copies as required to the municipality for review of water and sewer relocations and to all other utilities.

4.5.5.3 Quantities/Engineer's Cost Estimate. Submit two (2) copies to the District for review.

4.5.5.4 Correspondence. Submit one (1) copy of all correspondence and minutes of conversations/meetings with other affected agencies and utility owners for District records.

4.5.6 **60% Design Submittal:**

Upon approval of the 30% Submittal by the District, the CONSULTANT shall incorporate review comments and perform hydrology, hydraulic, civil, and structural calculations necessary to prepare the 60% Submittal. All Submitted items shall be dated and marked "Preliminary, 60% Submittal".

4.5.6.1 Design Data Report

4.5.6.1.1 Update all of the items contained in the Concept Submittal.

4.5.6.1.2 Submit three (3) copies to the District and one copy to each agency identified in section 1.4.

4.5.6.2 Construction Drawings

Plans shall be complete with the exception that details and schedules may be preliminary in nature. Submit three (3) full size sets to the District and one copy to

each agency identified in Section 1.4. Submit copies, as required, to the municipality for review of water and sewer relocations. The District shall distribute plans to all other utilities.

4.5.6.3 Construction Special Provisions (CSPs)
Include a Bidding Schedule.
Submit three (3) copies to the District and one copy to each agency identified in Section 1.4.

4.5.6.4 Quantities/Engineer's Estimate. Submit one (1) copy to the District and one copy to each agency identified in Section 1.4.

4.5.6.5 Correspondence. Submit one (1) copy of all correspondence and minutes of conversations/meetings with other affected agencies and utility owners, which were not previously submitted, for District records.

4.5.7 **90% Submittal:**

Upon approval of the 60% Submittal by the District, the CONSULTANT shall incorporate review comments and perform hydrology, hydraulic, civil, and structural calculations necessary to prepare the 90% Submittal. All Submitted items shall be dated and marked "Preliminary, 90% Submittal".

4.5.7.1 Design Data Report - Update all of the items contained in the 60% Submittal. Submit ten (10) copies to the District for review.

4.5.7.2 Construction Drawings
Drawings shall be complete and appear ready to bid. Include soil boring logs sheets. Submit five (5) full size and two (2) half size sets to the District for review. Submit copies as required to the municipality for review of water and sewer relocations. The District shall distribute plans to all other utilities.

4.5.7.3 Construction Special Provisions
Include Bidding Schedule.
Submit four (4) copies to the District for review.

4.5.7.4 Quantities/Engineer's Cost Estimate
Submit four (4) copies to the District for review.

4.5.7.5 Submit Revised HEC-2 model and documentation.

4.5.7.6 Correspondence. Submit one (1) copy of all correspondence and minutes of conversations/meetings with other affected agencies and utility owners, which were not previously submitted, for District records.

4.5.8 **Design Final Submittal:**

Upon approval of the 90% Submittal by the District, the CONSULTANT shall incorporate review comments and make required corrections, changes, etc., to the hydrology, hydraulic, civil, and structural calculations, and incorporate comments and make changes and corrections to the design report, plans, CSPs, and cost estimate. All submitted items shall include the construction number and shall be 'sealed' by a registered engineer and ready for advertising and bidding. Upon receipt of the final submittal, the District shall review the plans and special provisions for the accurate incorporation of all final comments. If incomplete and/or incorrect incorporation of those comments is found, the original documents shall be returned to the CONSULTANT for correction and resubmittal.

4.5.8.1 Design Report. Submit twelve (12) copies to the District in final bound format.

4.5.8.2 Construction Drawings. Submit original sealed mylars ready for reproduction and two (2) half size sets. Submit floppy diskettes containing .DGN or .DWG files.

4.5.8.3 Construction Special Provisions. Submit sealed original documents for reproduction Submit floppy diskettes containing files in either Word Perfect or ASCII format.

4.5.8.4 Final Engineer's Construction Cost Estimate. The cost estimate will be delivered to the DISTRICT in a sealed envelope marked with the date, the project name and "Engineer's Estimate". Cost estimate shall be sealed by a registered engineer.

4.5.8.5 Correspondence. Submit one (1) copy of all correspondence and minutes of conversations/meetings with other affected agencies and utility owners, which were not previously submitted, for District records.

4.6 HIS Data

The CONSULTANT shall prepare digital data in conformance with the District's Hydrologic Information System (HIS) FCDMC, Ver. 2.0, June 1995, for the following themes:

NDXPRJ (Project map Index)	LP-40
CORNERS (PLSS Survey Control Points)	LP-210
CTRL (Miscellaneous Survey Points)	LP-215
STRCT (Structures : bridges,culverts, ...)	LP-360
DQ.REL (Data Quality)	LP-410
PRJ.REL (Project Information Table)	LP-430
FPBLN (Floodplain Baseline)	LP-520
FPSRFFCD (Surface Water Elevation)	LP-535
FPXFCD (Cross Sections from HEC2)	LP-540
STRTDTL (Street Detail)	LP-660
UTLTY (Utilities)	LP-670
ELV (Contours and Spot Elev., for new topo)	LP-710
RIVER (Stream flow lines)	LP-960

5.0 DESIGN REFERENCES, SPECIFICATIONS AND STANDARDS

5.1 Project Reference Material

The following data is available and will be provided to the CONSULTANT at the project Kickoff Meeting by the DISTRICT:

- The *Bullard Wash Outfall Feasibility Study* report, Volumes 1 and 2, September 1995
- Digital files of drawings and exhibits contained in the *Bullard Wash Outfall Feasibility Study* report in Microstation format,
- Digital file of the property boundary survey in DXF format,
- Two foot contour interval topographic mapping, in DXF format.
- Survey bench marks, ERM's, and control points
- HEC-2 model for existing and proposed conditions

5.2 Standard Details and Specifications

5.2.1 "*Uniform Standard Details for Public Works Construction*", Maricopa Association of Governments (MAG), 1979;

5.2.2 "*Uniform Standard Specifications for Public Works Construction*", MAG, 1979;

5.2.3 "*Supplement to the MAG Uniform Standards Details and Specifications for Public Works Construction*" by Maricopa County Highway Department (now referred to as MCDOT), together with current revisions shall be utilized as part of the design criteria.

5.2.4 Use standard MAG details on plans unless otherwise requested by FCDMC. ADOT standard details may be used, as approved and when appropriate, then modified to be referenced to MAG specifications.

5.2.5 "Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects", latest revision.

5.3 Design Manuals, Policies, Guides and Procedures

5.3.1 "*Drainage Design Manual for Maricopa County, Arizona, Volume I Hydrology*", latest edition.

5.3.2 "*Drainage Design Manual for Maricopa County Arizona, Volume II Hydraulics*", latest edition.

5.3.3 "*Drainage Design Manual for Maricopa County, Arizona, Volume III Erosion Control*", latest edition.

5.3.4 "*Urban Highways, Channel Lining Design Guidelines*", February 1989, ADOT.

5.3.5 Structural design shall be in accordance with current AASHTO Specifications. Street and maintenance road crossings shall be designed to accommodate HS20-44 loading. Calculations shall be based on service loads and the working stress method.

5.3.6 "Policy on Geometric Design of Highways and Streets", AASHTO, 1990, commonly referred to as the "Green Book", and "Maricopa County Department of Transportation Roadway Design Manual" latest edition and revisions shall be used, unless otherwise requested by FCDMC.

5.3.7 "Roadside Design Guide", 1989, AASHTO, to be used to establish clear distances and other related safety issues.

5.3.8 "Channel Design Criteria for Major Watercourses", MCFCD, latest edition.

5.3.9 "A Levee Policy for the National Flood Insurance Program",National Research Council, 1982.

5.4 Survey and Mapping

5.4.1 Data Format

5.4.1.1 All field collected survey data obtained using conventional survey methods shall be noted in standard 5" x 7" hard-bound survey books

5.4.1.2 All survey data collected electronically shall be submitted on 3.5"or 5.25" diskettes.

5.4.2 Elevation Datum

5.4.2.1 Plans shall be based on the survey control datums as noted in Section 3.4.2.3.

5.4.3 Restoration of lost or obliterated section corners shall be set in accordance with current publications of the following and shall be per MAG Standard Detail 120-1, type C: "Minimum Standards for Arizona Lang Boundary Surveys" by Arizona State Board of Technical Registration and "Restoration of Lost or Obliterated Corners and Subdivision of Sections" by the United States Department of Interior Bureau of Land Management.

5.4.4 Elevation Reference Marks (ERMS) shall be labeled on the plans and described in a manner which allows them to be relocated in the field.

5.5 Drafting Standards for Construction Drawings

5.5.1 FCDMC sample plans may be provided with the intention thatthey shall be used as a guide, and are not a substitute for design criteria, technical assistance, or sound engineering judgement. The CONSULTANT shall use plan symbols shown in the MAG Standard Details and MCDOT Supplement to the MAG Standard Details, unless otherwise requested. FCDMC makes extensive use of reduced plan sets. The CONSULTANT shall submit sample plans for approval prior to commencing work. Plans not capable of producing high quality prints by FCDMC in reduced form shall be considered unacceptable and shall be redrawn by the CONSULTANT at no additional cost to FCDMC.

5.5.2 The DISTRICT uses a "Xerox" process for final reproduction of drawings for bid sets. The CONSULTANT shall not draw on the back side of drawings, or use any form of shading techniques that will not reproduce clearly using this form of reproduction.

5.5.3 Unless otherwise directed, the CONSULTANT shall use the following scales.

5.5.3.1 Plan Scales:

1" = 40' Horizontally and 1" = 4' Vertically in rural areas, unless otherwise approved in writing by FCDMC. Plans for construction in urban areas are usually 1"=20" Horizontally, unless otherwise approved in writing by FCDMC.

The CONSULTANT shall use a larger scale if necessary to obtain good clarity in the plans and reduced prints. The CONSULTANT shall be responsible for using a scale that results in good plan clarity.

5.5.4 Drawings shall be prepared using MicroStation PC, Version 4 or AutoCad, Release 12 per DISTRICT standards.

5.5.5 All lettering on drawings shall be vertical, plain, and legible. 'Architectural' style lettering shall not be accepted. The following lettering sizes apply:

1/8" Lettering and Notes
5/32" Subtitles
7/32" Main Titles

5.5.6 The final (100%) submittal shall be plotted at a minimum of 400 dots per square inch on 4 mil mylar. The final plot shall be plotted or photo reproduced on 4 mil mylar without sticky backs. If plans have been hand drafted, the final (100%) submittal shall be rapidograph-inked drawings on 4 mil mylar. If sticky backs have been used, 4 mil photo reproducible mylars shall be submitted, with original seal and signature on the photo mylars. All seals and signatures shall be in smudge-proof ink.

5.5.7 The DISTRICT shall provide the CONSULTANT with a diskette containing .DWG or .DGN files for the standard cover sheet and working drawing sheets.

5.5.8 The plans shall include a summary table of concrete, excavation and structural backfill quantities for each structure. These quantities shall be shown on an appropriate structures sheet, a separate quantity sheet shall not be prepared. The quantities in the table shall add up to the bid item quantities for each bid item, including the appropriateclass and strength of concrete (i.e., Class "A", Class "AA").

5.6 Calculations Standards

5.6.1 The CONSULTANT shall independently check all design drawings and calculations. Each drawing shall be initialed and dated by both the designer and checker for each and every submittal of design drawings and calculations. The CONSULTANT shall verify the completeness of the check before submitting drawings or calculations to the DISTRICT.

5.6.2 All design calculations submitted to the DISTRICT shall be complete in detail and shall be checked. All engineering assumptions made during the design other than standard engineering judgements shall be documented with appropriate references on the calculation sheets.

5.6.3 The person checking the calculations shall not be the originator, and shall be of equal or better qualifications than the originator.

5.6.4 Calculations can be either hand calculations or computer generated calculations. Computer generated calculations can be used for either the design or the check, but cannot be used for both the design and the check. All hand calculations and computer generated calculations shall be sealed prior to submittal to the DISTRICT. HEC-I and HEC-II modeling are excepted from the hand calculation requirement.

5.6.5 The work of any sub-consultants utilized by CONSULTANT for this contract (i.e., civil design structural design) shall be reviewed by CONSULTANT for compliance with this scope of work and these specifications prior to submittal for review by the DISTRICT. In particular, all calculations sheets shall be initialed and dated by both a designer and a checker.

5.7 Geotechnical

5.7.1 In-situ soils testing, if required, shall be in accordance with NAVFAC DM-7.1, Soil Mechanics Design Manual 7.1, May 1982. Boring and test pit locations must be submitted to the DISTRICT for review and approval. An attempt shall be made to extend all test borings through the significant zone by auger, however, if refusal is met at a lesser depth, each test boring shall extend at least five (5) feet beyond the anticipated depth of the invert, unless

bedrock is hit. If ground water is encountered, then standard penetration tests shall be performed with the water level in the hole at or above the ground water level.

5.7.2 Allowable soil bearing values and lateral load capacities shall be determined in accordance with NAVFAC DM-7.2, Foundations and Earth Structure Design Manual 7.2, May 1982, and in accordance with current AASHTO Specifications as interpreted by the DISTRICT. In case of conflict between AASHTO and NAVFAC specifications, AASHTO specifications shall govern. The effect of future elevated moisture content or saturated condition of the soil due to potential future seepage from the drainage structure should be considered and included in the soils report. The maximum allowable soil bering values recommended in sections 4.2.3 of AASHTO shall not be exceeded without prior consultation with the DISTRICT.

5.7.3 The CONSULTANT shall have soils tests prepared and shall provide the DISTRICT the original and copies of the report and any subsequent revisions as noted in Section 3.5, Geotechnical Investigation. The report shall be prepared by the CONSULTANT or SUBCONSULTANT named in the CONSULTANT's proposal. The report shall provide narrative, sieve analysis, PI, moisture content, optimum moisture, shrinkage and swell factors, expected ground compaction, subsidence potential in the area, "R" values, resistivity values and recommendations to support or reject the use of metal pipes and specific recommendations. The report shall also include foundation requirements and supporting calculations for design loading. The report shall be sealed by a qualified registered engineer.

5.8 GIS/HIS Standards

5.8.1 "*Data Delivery Specifications: The Hydrologic Information System (HIS)*" Flood Control DISTRICT of Maricopa County, latest edition.

5.9 Landscape/Irrigation Standards

5.9.1 The CONSULTANT's design shall be in compliance with the "*Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects*", latest edition.

Appendix C

Survey Field Notes

Please refer to ***Design Data Report, Bullard Wash Channel Improvements, Final Design,*** Sverdrup Corp., September 1998 submitted under separate cover regarding survey information for this study area.

There are no hydrologic survey field notes for this study area. The previous study (WLB) 2 ft CI mapping provided adequate relief for the interior drainage hydrologic model.

Appendix D

Hydrologic Analysis Supporting Documentation for Interior Drainage Analysis

Appendix D1	**Precipitation Data**
Appendix D2	**Physical Parameters**
Appendix D3	**Hydrograph Routing Data**
Appendix D4	**Reservoir Routing Data**
Appendix D5	**Flow Split and Diversion Data**
Appendix D6	**Hydrologic Calculations**

Appendix D1

Precipitation Data

As listed in Table 4.1, the 100-year 24-hour precipitation for this study area is 4.03 inches. A statistical analysis is not deemed necessary for this study.

Appendix D2

Physical Parameters

This appendix contains a summary of the physical parameters used for the interior drainage analysis of this project. Refer to Bullard Wash Outfall Feasibility Study for the physical parameters used for that study.

WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT Bullard Wash

PROJECT No. 96464 SHEET No. 1 OF 1

CALCULATED BY DTP DATE 26 Feb 98 CHECKED BY _____ DATE _____

Interior Drainage

PHYSICAL PARAMETERS

Reference: FCDMC Drainage Design Manual – Volume I, Hydrology, revised Jan 1995
FCDMC Bullard Wash Outfall Feasibility Study, Stanley Consultants, Inc, Sept 1995

Unit Hydrograph Selected: Agricultural S-Graph

S-Graph Parameters

Sub Basin ID	Flowpath Length, L (mi)	L_{CA} (mi)	Elevations (ft) Top	Elevations (ft) Bottom	Slope ft/mile	Lag (min)
365	Refer to the Stanley Study - Sub basin parameters were not revised.					
364rev	1.1	0.6	922	913	8.2	63.8

$$LAG = C\left(\frac{L L_{CA}}{S^{P}}\right)^{m} \quad \text{per FCDMC}$$

LAG and S-Graph UH computed by FCDMC DDMS (MCWSP2) microcomputer software.

Green and Ampt Rainfall Loss Parameters

Sub Basin ID	IA (in)	DTHETA (saturated)	PSIF (in)	$\overline{XKSAT}$ (in/hr)	RTIMP (%)
365	0.50	0	4.11	0.73	0
364rev	0.50	0	4.22	0.43	0

Refer to the Stanley Study - These parameters were not revised.

Note: landuse and soils parameters have not changed since Stanleys analysis in 1995.

Appendix D3

Hydrograph Routing Data

There is only one routing operation for the interior drainage analysis, operation R365. The geometry is taken directly from the Bullard Wash Outfall Feasibility Study. The length, slope, and NSTPS values were revised to account for the selected alignment of Bullard Wash. The results of the routing operation seem reasonable as shown on the following sheet.

WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT Bullard Wash Outfall Channel

PROJECT NO. 96464 SHEET NO. 1 OF 1

CALCULATED BY DTP DATE 5 July 98 CHECKED BY _____ DATE _____

VERIFICATION of NSTPS

NMIN = 5 min.

ITERATION	ROUTE REACH ID	LENGTH (ft)	TRAVEL TIME (hrs)	VELOCITY (fps)	NSTPS in Model	NSTPS Calculated
1	R365	4000	0.75	1.48	5	9

Since the velocity and HEC-1 results seem reasonable, no further adjustment is needed.

Equations: Avg Velocity : $V = \frac{\text{Length}}{\text{travel time}}$

$$NSTPS = \frac{L/V}{NMIN}$$

Reference: HEC-1 Flood Hydrograph Package, Users Manual, US Army Corps of Engineers, Sept

Appendix D4

Reservoir Routing Data

There are no reservoir routing operations for the interior drainage analysis of this study area.

Appendix D5

Flow Split and Diversion Data

There are no flow splits or diversions for the interior drainage analysis of this study area.

Refer to the Bullard Wash Outfall Feasibility Study (FCD 94-06) for details of the Dysart Drain diversion.

Appendix D6

Hydrologic Calculations

This appendix contains the HEC-1 output file for the interior drainage analysis of this project. Refer to the diskette holder for electronic copies of the input and output HEC-1 files. This Appendix also contains hydrologic information documenting the East Tributary Channel peak flowrate to the Bullard Wash Outfall Channel peak flowrate.

Refer to the Bullard Wash Outfall Feasibility Study (FCD 94-06) for HEC-1 output of the Bullard Wash Outfall Channel. An electronic copy of the HEC-1 input and output files for the Bullard Wash Outfall Channel is included in the diskette folder.

```
1*************************************
*                                   *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)*
*            MAY   1991             *
*          VERSION 4.0.1E           *
*    Lahey F77L-EM/32 version 5.01  *
*      Dodson & Associates, Inc.    *
* RUN DATE  04/28/98  TIME  14:59:49 *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
*   HYDROLOGIC ENGINEERING CENTER   *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X        XXXXX X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   BULLARD WASH OUTFALL STUDY
  2           ID   FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, FCD95-39
  3           ID   HEC-1 Modeling for SVERDRUP Inc. by Wood, Patel & Associates Inc.
  4           ID   100-yr 24-hr storm   File = V:\Projects\96464 - Bullard Wash\Surface.ih1
  5           ID                        Date = 27 APR 1998  by David T. Phelps
  6           ID
  7           ID   Base model from White Tanks ADMS as revised by Stanley Consultants Inc
  8           ID    for Bullard Wash Outfall Feasibility Study (FCD 94-06), HEC-1 file 12278H1A
  9           ID
 10           ID   Modeling for Interrior Sediment Basin located at Buckeye Canal & Bullard Wash
 11           ID     - Contributing area for interrior drain is local watershed.
 12           ID     - Bullard Wash intercepts 100% of watershed to north of MC85.
 13           ID
              *
              *DIAGRAM
              *
 14           IT       5                    300
 15           IO       5
 16           IN      15
              *
 17           JD    4.03     .001
 18           PC    .000     .002     .005     .008     .011     .014     .017     .020     .023     .026
 19           PC    .029     .032     .035     .038     .041     .044     .048     .052     .056     .060
 20           PC    .064     .068     .072     .076     .080     .085     .090     .095     .100     .105
 21           PC    .110     .115     .120     .126     .133     .140     .147     .155     .163     .172
 22           PC    .181     .191     .203     .218     .236     .257     .283     .387     .663     .707
 23           PC    .735     .758     .776     .791     .804     .815     .825     .834     .842     .849
 24           PC    .856     .863     .869     .875     .881     .887     .893     .898     .903     .908
 25           PC    .913     .918     .922     .926     .930     .934     .938     .942     .946     .950
 26           PC    .953     .956     .959     .962     .965     .968     .971     .974     .977     .980
 27           PC    .983     .986     .989     .992     .995     .998    1.00    1.000    1.000    1.000
 28           JD    3.99       10
 29           JD    3.83       50
 30           JD    3.76      100
 31           JD    3.70      200
              *

 32           KK     365
 33           KM        RUNOFF HYDROGRAPH FROM SUB-BASIN 365
 34           BA     .38
 35           LG     .50      .00     4.11      .73      .00
 36           UI     22.      22.      37.      78.      98.     114.     128.     145.     167.     200.
 37           UI    261.     272.     222.     192.     172.     148.     130.     111.      96.      71.
 38           UI     47.      38.      36.      29.      22.      22.       9.       7.       7.       7.
 39           UI      7.       7.       7.       7.       0.       0.       0.       0.       0.       0.
 40           UI      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
              *

 41           KK    R365
 42           KM        ROUTE FLOW FROM CP365 TO CP364
 43           RS       5       -1
 44           RC    .035     .035     .075    4000   0.0028
 45           RX    1000     1001     1015    1140     1560     1700     2009     2010
 46           RY     915      915      914   913.5    913.5     914      915      915
              *
```

1 HEC-1 INPUT PAGE 2

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LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

 47           KK  364rev
 48           KM   BASIN 364rev
 49           KM   THE FOLLOWING PARAMETERS WERE PROVIDED FOR THIS BASIN
 50           KM   L=      1.1  Lca=       .6   S=     8.2  Kn= .080  LAG=  63.8
 51           KM   AGRICULTURAL S-GRAPH WAS USED FOR THIS BASIN
 52           BA     .49
 53           LG     .50      .00     4.22      .43      .00
 54           UI     28.      28.      38.      61.     112.     161.     154.     199.     217.     237.
 55           UI    237.     237.     227.     197.     210.     195.     148.     164.     122.     108.
 56           UI     88.      79.      85.      54.      48.      45.      35.      35.      26.      26.
 57           UI     26.      16.      16.      16.      16.      13.       4.       4.       4.       4.
 58           UI      4.       4.       4.       4.       4.       4.       4.       4.       4.       4.
 59           UI      4.       4.       4.       4.       4.       4.       4.       0.       0.       0.
 60           UI      0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
              *
```

```
          61            KK   C0364
          62            KM        ADD HYDROGRAPHS AT CP364
          63            KM        Surface Drain Inlet Location @ Buckeye Canal & Bullard Wash
          64            HC       2
                        *
                        *
          65            ZZ
1
              SCHEMATIC DIAGRAM OF STREAM NETWORK
 INPUT
  LINE      (V) ROUTING          (--->) DIVERSION OR PUMP FLOW

   NO.      (.) CONNECTOR        (<---) RETURN OF DIVERTED OR PUMPED FLOW

   32         365
                V
                V
   41        R365
                .
                .
   47           .       364rev
                .            .
                .            .
   61       C0364............
 (***) RUNOFF ALSO COMPUTED AT THIS LOCATION
1*************************************                    *************************************
*                                   *                    *                                   *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                *   U.S. ARMY CORPS OF ENGINEERS    *
*              MAY   1991           *                    *   HYDROLOGIC ENGINEERING CENTER   *
*           VERSION 4.0.1E          *                    *         609 SECOND STREET         *
*     Lahey F77L-EM/32 version 5.01 *                    *      DAVIS, CALIFORNIA 95616      *
*       Dodson & Associates, Inc.   *                    *         (916) 551-1748            *
*  RUN DATE  04/28/98  TIME  14:59:49 *                  *                                   *
*************************************                    *************************************
```

BULLARD WASH OUTFALL STUDY
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY, FCD95-39
HEC-1 Modeling for SVERDRUP Inc. by Wood, Patel & Associates Inc.
100-yr 24-hr storm File = V:\Projects\96464 - Bullard Wash\Surface.ihl
Date = 27 APR 1998 by David T. Phelps

Base model from White Tanks ADMS as revised by Stanley Consultants Inc
for Bullard Wash Outfall Feasibility Study (FCD 94-06), HEC-1 file 12278H1A

Modeling for Interrior Sediment Basin located at Buckeye Canal & Bullard Wash
- Contributing area for interrior drain is local watershed.
- Bullard Wash intercepts 100% of watershed to north of MC85.

```
  15 IO          OUTPUT CONTROL VARIABLES
                       IPRNT          5  PRINT CONTROL
                       IPLOT          0  PLOT CONTROL
                       QSCAL         0.  HYDROGRAPH PLOT SCALE

     IT          HYDROGRAPH TIME DATA
                        NMIN          5  MINUTES IN COMPUTATION INTERVAL
                       IDATE      1    0  STARTING DATE
                       ITIME       0000  STARTING TIME
                          NQ        300  NUMBER OF HYDROGRAPH ORDINATES
                      NDDATE      2    0  ENDING DATE
                      NDTIME       0055  ENDING TIME
                       ICENT         19  CENTURY MARK

                 COMPUTATION INTERVAL    0.08 HOURS
                      TOTAL TIME BASE   24.92 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
               PRECIPITATION DEPTH    INCHES
               LENGTH, ELEVATION      FEET
               FLOW                   CUBIC FEET PER SECOND
               STORAGE VOLUME         ACRE-FEET
               SURFACE AREA           ACRES
               TEMPERATURE            DEGREES FAHRENHEIT

  17 JD          INDEX STORM NO. 1
                       STRM       4.03  PRECIPITATION DEPTH
                       TRDA       0.00  TRANSPOSITION DRAINAGE AREA

  18 PI            PRECIPITATION PATTERN
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.01      0.00      0.01
                     0.01      0.01      0.01      0.01      0.01      0.01      0.01      0.01      0.03      0.03
                     0.03      0.09      0.09      0.09      0.01      0.01      0.01      0.01      0.01      0.01
                     0.01      0.01      0.01      0.01      0.01      0.01      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
                     0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
```

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

28 JD INDEX STORM NO. 2

STRM 3.99 PRECIPITATION DEPTH
TRDA 10.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03
0.03	0.09	0.09	0.09	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

29 JD INDEX STORM NO. 3

STRM 3.83 PRECIPITATION DEPTH
TRDA 50.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03
0.03	0.09	0.09	0.09	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
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0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

30 JD INDEX STORM NO. 4

STRM 3.76 PRECIPITATION DEPTH
TRDA 100.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03
0.03	0.09	0.09	0.09	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

31 JD INDEX STORM NO. 5

STRM 3.70 PRECIPITATION DEPTH
TRDA 200.00 TRANSPOSITION DRAINAGE AREA

0 PI PRECIPITATION PATTERN

0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03
0.03	0.09	0.09	0.09	0.01	0.01	0.01	0.01	0.01	0.01
0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	365	272.	12.83	47.	12.	11.	0.38		
+	ROUTED TO	R365	189.	13.58	47.	12.	11.	0.38		
+	HYDROGRAPH AT	364rev	315.	12.75	73.	18.	17.	0.49		
+	2 COMBINED AT	C8364	355.	13.25	119.	30.	29.	0.87		

*** NORMAL END OF HEC-1 ***

EAST TRIBUTARY CHANNEL HYDROLOGY

WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT Bullard Wash

PROJECT NO. 96464 SHEET NO. 1 OF 1

CALCULATED BY DTP DATE 2 July 98 CHECKED BY _____ DATE _____

East Tributary Channel HYDROLOGY

Reference: FCDMC, Bullard Wash Outfall Feasibility Study (FCD 94-06), Volume 1 of 2

There are three concentration points for the proposed Bullard Wash given in the Feasibility study; and two concentration points for the East Tributairy.

HEC-1 ID	100-YR 24-hr Q (cfs)	Time to Peak (hrs)	Description
CP335	3168	19.67	Bullard Wash N of airport
2I336	3172	19.75	Bullard Wash @ UPRR (East Trib. Confluence
CP364A	3175	19.92	Bullard Wash @ Outfall to Gila River
1I336	311	13.83	East Tributary ≅ Litchfield & Lower Buckeye R
336	552	13.92	Contributing Subbasin to East Tributary

The Feasibility Study did not revise the original WLB ADMS combination order for the proposed East Tributary Channel. However, it is intuitive that the sum of the East Tributairy hydrographs will be 850 cfs (per Feasibility Study) and the time to peak will be 13.9 hrs. This is 5.8 hrs before the peak flow of 3200 cfs arives in Bullard Wash.

CONCLUSION: The peak flow of 850 cfs in the East Tributary Channel will enter and pass through Bullard Wash 5.8 hours before the peak flow of 3200 cfs arrives, thus the peaks do not coincide, and are not modeled by HEC-RAS.

Appendix E

Hydraulic Analysis and Supporting Calculations

Appendix E1	Roughness Coefficient Estimations
Appendix E2	Cross Section Plots
Appendix E3	Expansion and Contraction Coefficients
Appendix E4	Analysis of Structures
Appendix E5	Hydraulic Calculations for Bullard Wash Outfall Channel
Appendix E6	Hydraulic Calculations for East Tributary Channel
Appendix E7	Hydraulic Calculations for Interior Drainage Outlet Structure

Appendix E1

Roughness Coefficient Estimations

TABLE E1.1
Manning's n-values Used for Each Channel Material

Channel Material	Manning's n-value
Concrete - troweled or float finish	0.015
Concrete - heavy broom or raked finish	0.019
Concrete - form liner finish	0.024
Grouted rip rap	0.038
Vegetated earth	0.032
Gabion basket or mattress	0.030

References: Flood Control District of Maricopa County, Drainage Design Manual - Volume II, Hydraulics, January 1996
Chow, Ven Te, Open-Channel Hydraulics, 1959

TABLE E1.2
Summary of Manning's n-values Used for Bullard Wash

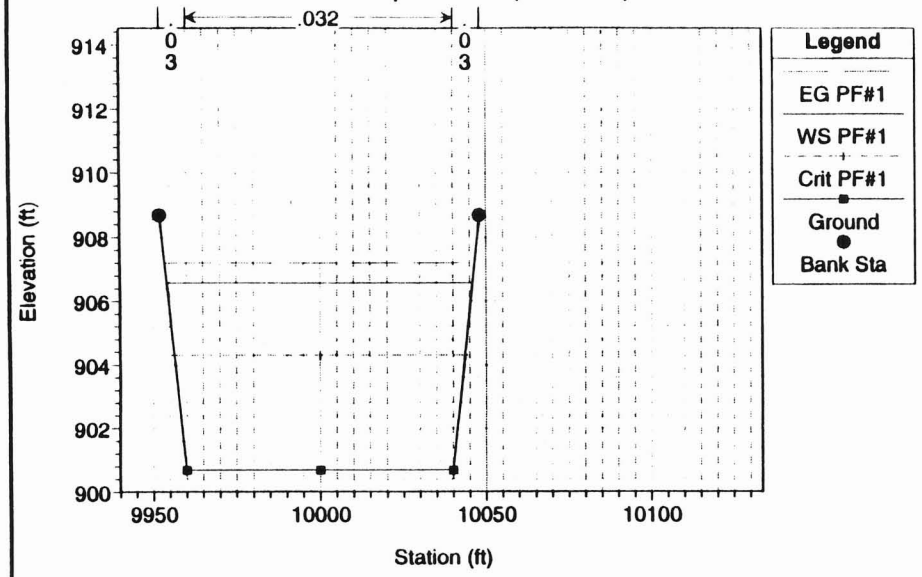
From Station	To Station	Channel Description	Assigned Manning's n-values		
			Left Side	Channel	Right Side
18+00.00	25+00.00	Reach not modeled (earthen section graded into Gila river)	--	--	--
25+00.00	28+60.56	Trap. channel, gabion mattress sides, vegetated earthen bottom.	0.030	0.032	0.030
28+60.56	28+77.74	Box culvert outlet apron, concrete sides (float finish) and bottom (raked).	0.015	0.019	0.015
28+77.74	29+01.49	Box culverts, 4 - 12'x10' CBC (eastern box is raked on bottom).	0.015	0.015	0.015
29+01.49	29+95.26	Trap. channel, grouted rip rap sides and bottom (d50 = 15 inches).	0.038	0.038	0.038
29+95.26	30+02.33	Rect. to trap. channel transition, concrete sides (form liner finish), bottom (raked finish).	0.024	0.019	0.024
30+02.33	30+64.67	Rect. overchute, concrete sides (form liner finish) and bottom (raked).	0.024	0.019	0.024
30+64.67	33+30.00	Trap. channel, concrete Sides (float finish) and bottom (raked finish).	0.015	0.019	0.015
33+30.00	72+47.00	Trap. channel, gabion mattress sides, vegetated earthen bottom.	0.030	0.032	0.030
72+47.00	77+00.00	Trap. channel, concrete Sides (float finish) and bottom (raked finish).	0.015	0.019	0.015
77+00.00	81+00.00	Trap. channel, grouted rip rap sides and bottom (d50 = 15 inches).	0.038	0.038	0.038
81+00.00	119+43.00	Trap. channel, gabion mattress sides, vegetated earthen bottom, concrete trapezoidal low flow channel (n = 0.015).	0.030	0.032	0.030
119+43.00	121+98.00	Channel inlet area, gabion basket sides and bottom apron (n-value in overbanks = 0.045).	0.030	0.030	0.030
121+98.00	122+00.00	Channel inlet area, gabion basket sides, concrete channel @ top of drop (n-value in overbanks = 0.045).	0.030	0.015	0.030
122+00.00	123+45.00	Channel inlet area, vegetated earthen overbanks, concrete channel (n-value in overbanks = 0.045).	0.032	0.015	0.032
123+45.00	124+45.00	Channel inlet area, vegetated earthen channel (n-value in overbanks = 0.045).	0.032	0.032	0.032
124+45.00	131+20.00	Channel inlet area, vegetated earthen channel, undisturbed overbanks per WLB Study.	0.045	0.032	0.070
131+20.00	137+00.00	Bullard Wash, geometry per WLB Study.	0.045	0.032	0.070

Appendix E2

Cross Section Plots

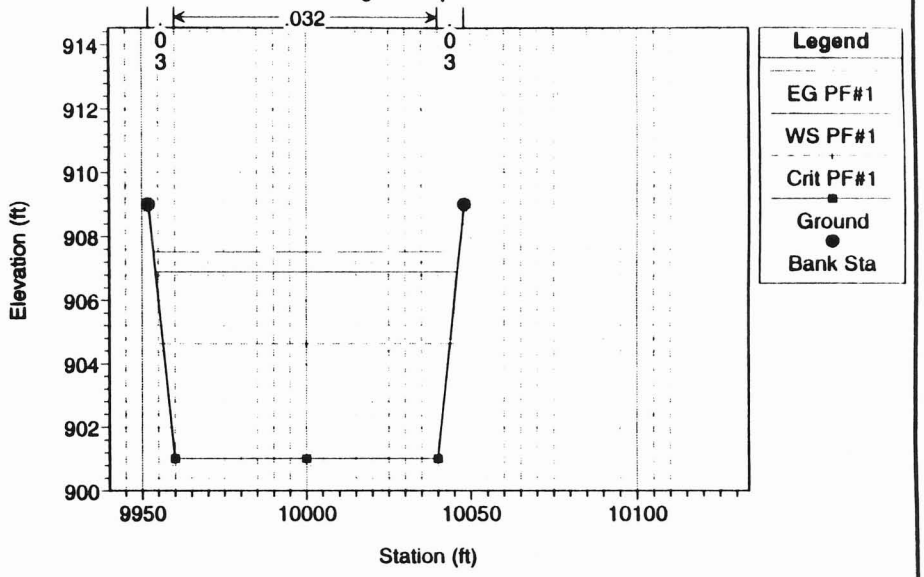
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Start Bullard Wash Improvements (Seciton A1) RS = 2500



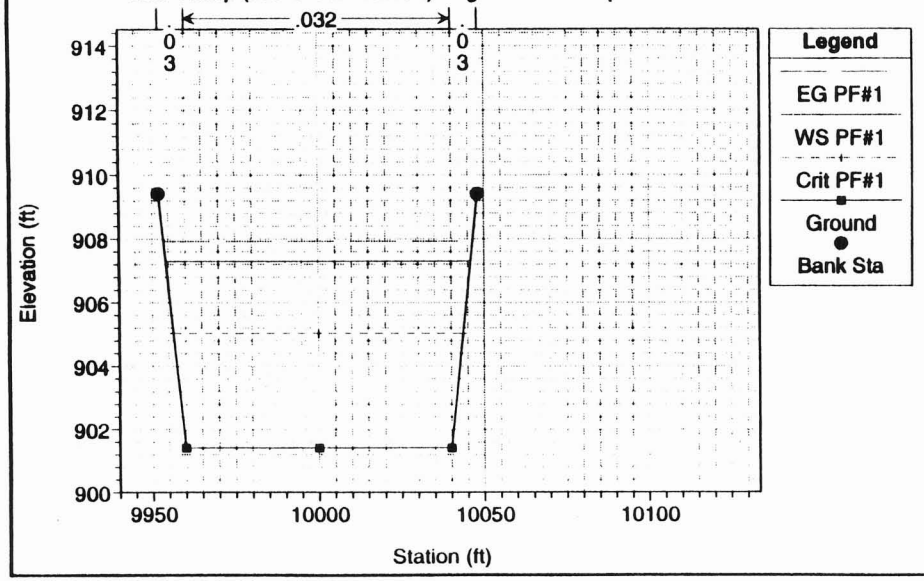
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Ramp RS = 2660



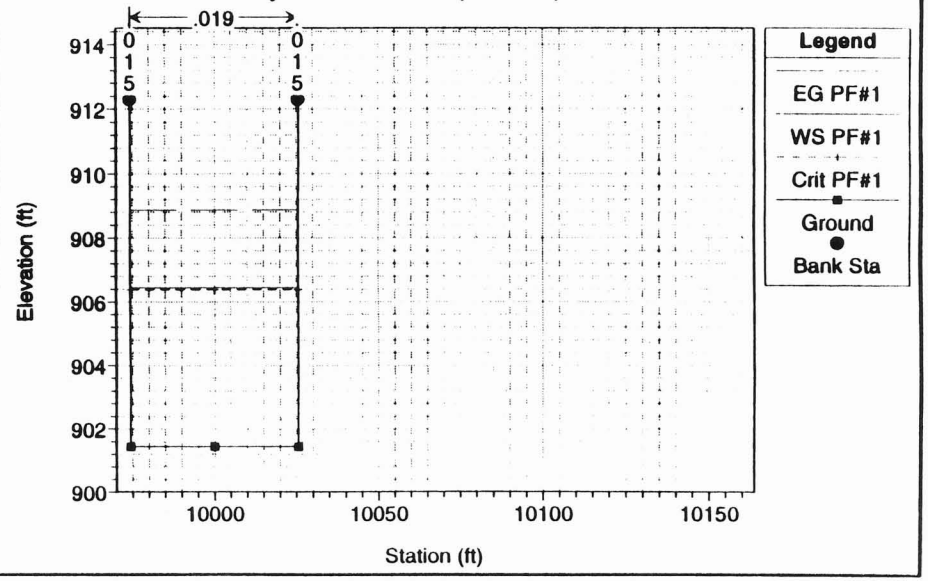
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Ramp (D/S of BID Culvert) Begin Concrete Apron RS = 2860.56



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

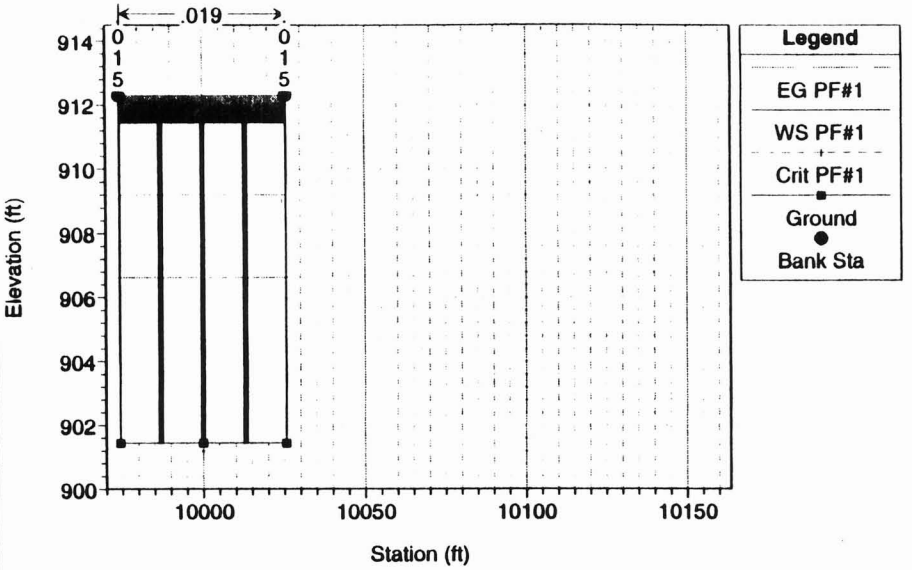
Buckeye Canal Maint. Rd (D/S Face) RS = 2877.74



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

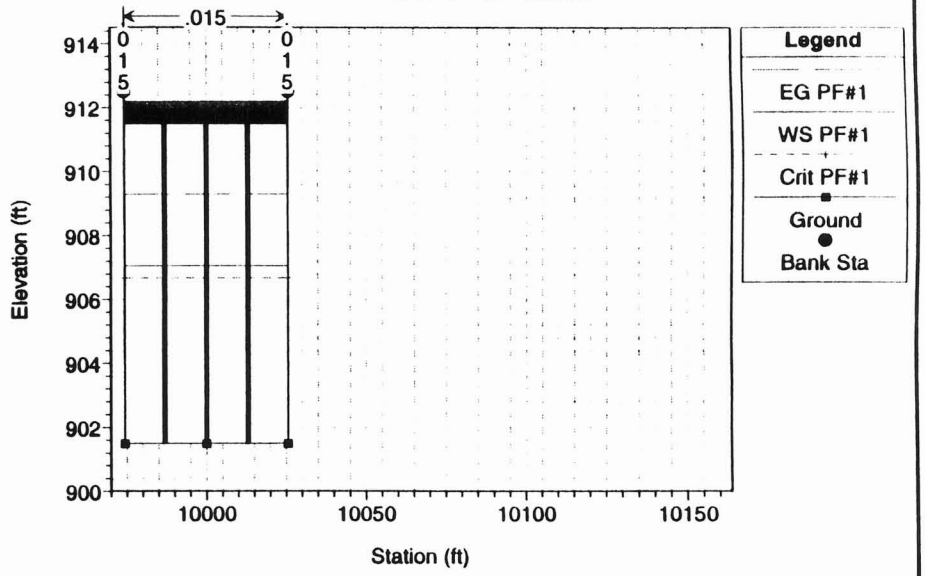
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

4-12x10ft CBC RS = 2901.4



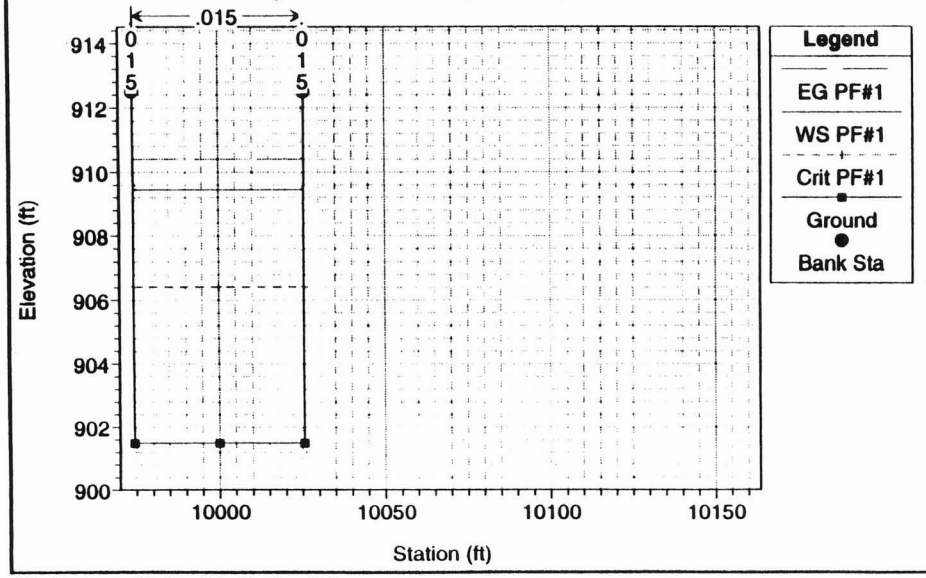
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

4-12x10ft CBC RS = 2901.4



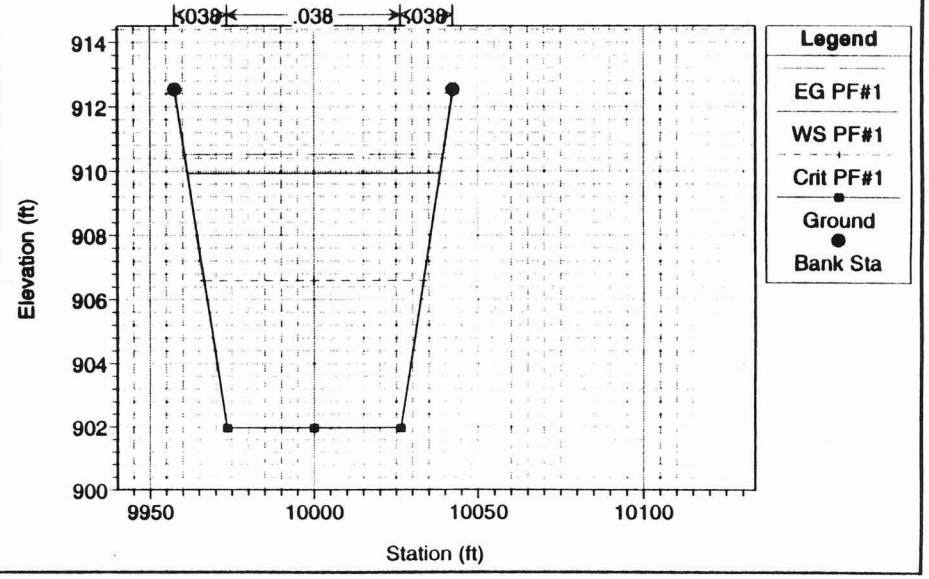
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Buckeye Canal Maint. Rd (U/S Face) RS = 2901.49



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

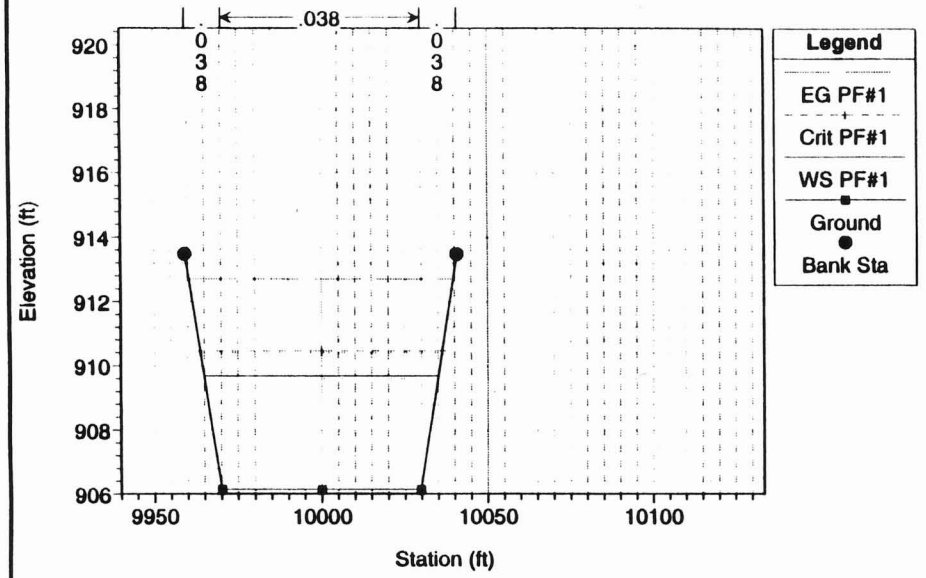
U/S of BID Culvert RS = 2911



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

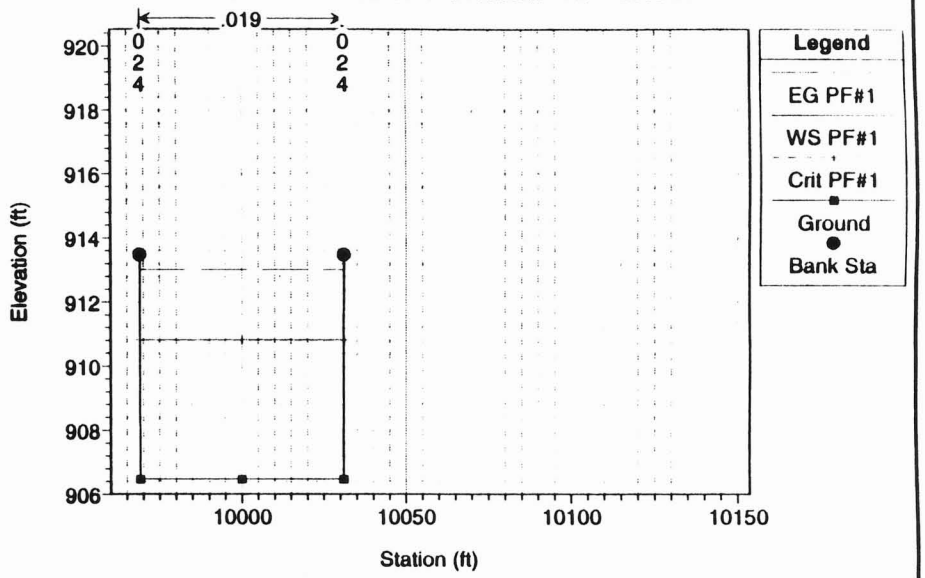
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 2995.26



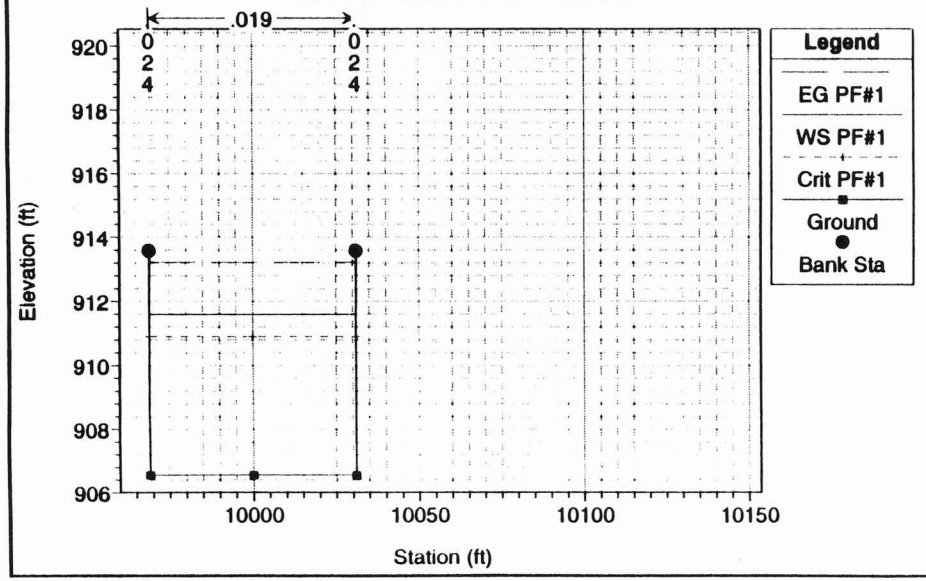
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Grade Break - Start BID Overchute RS = 3002.33



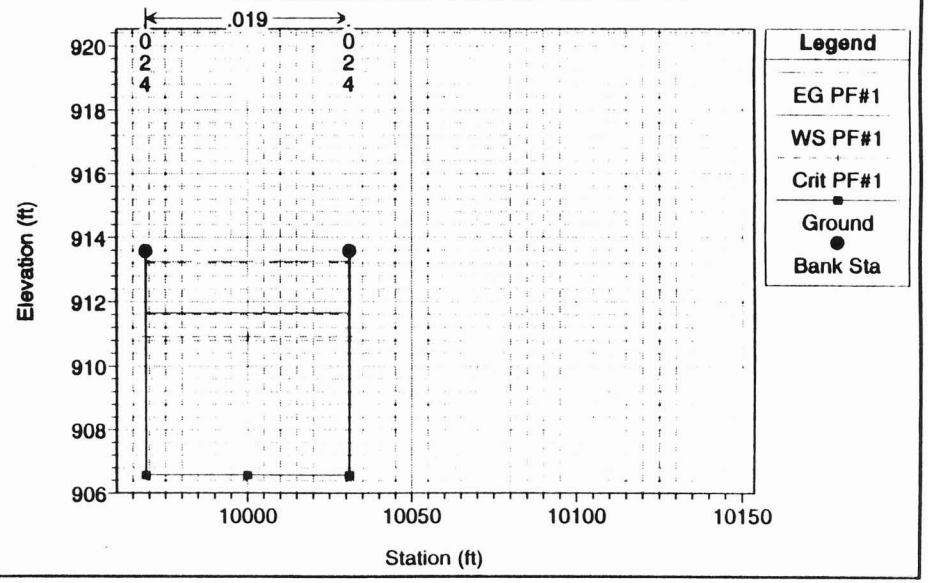
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End BID Overchute RS = 3049.67



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

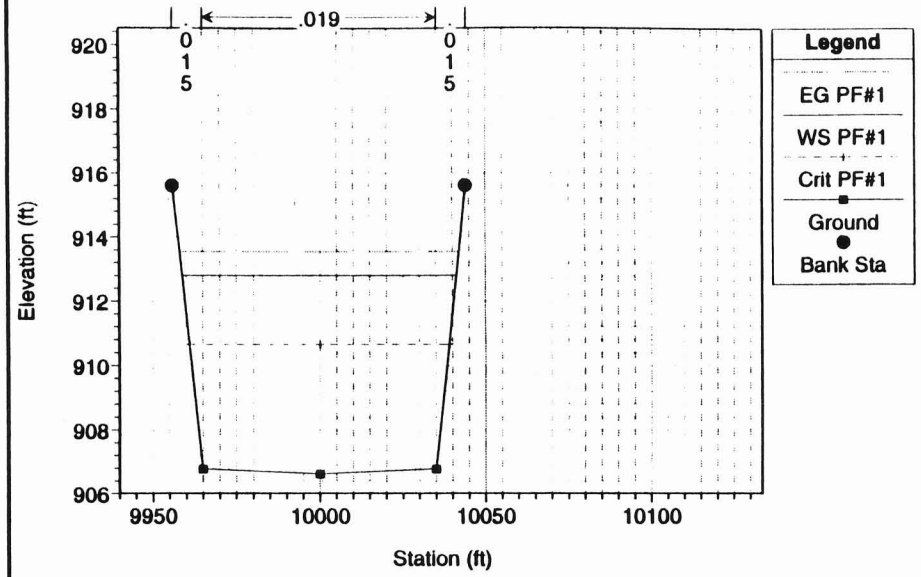
Start Transition to BID Overchute RS = 3064.67



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

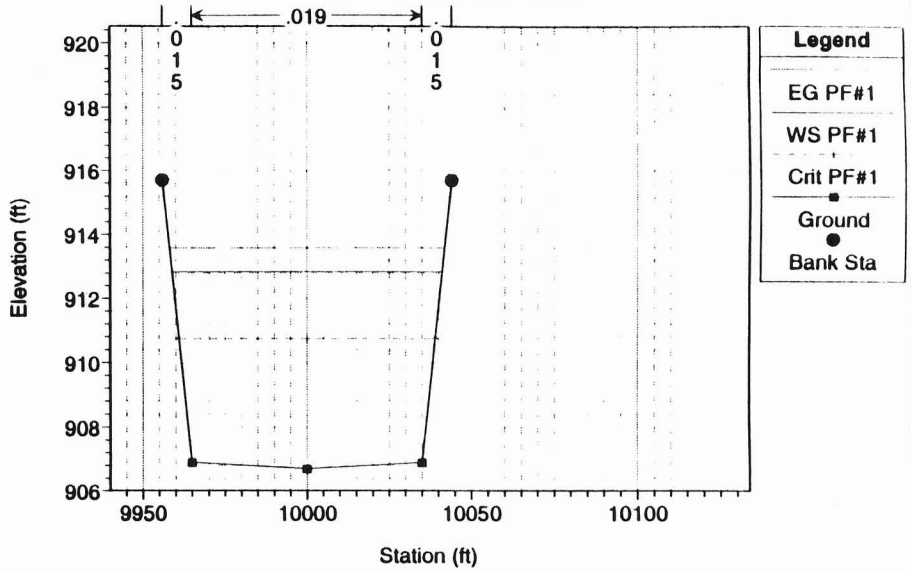
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Transition to BID Overchute RS = 3088.94



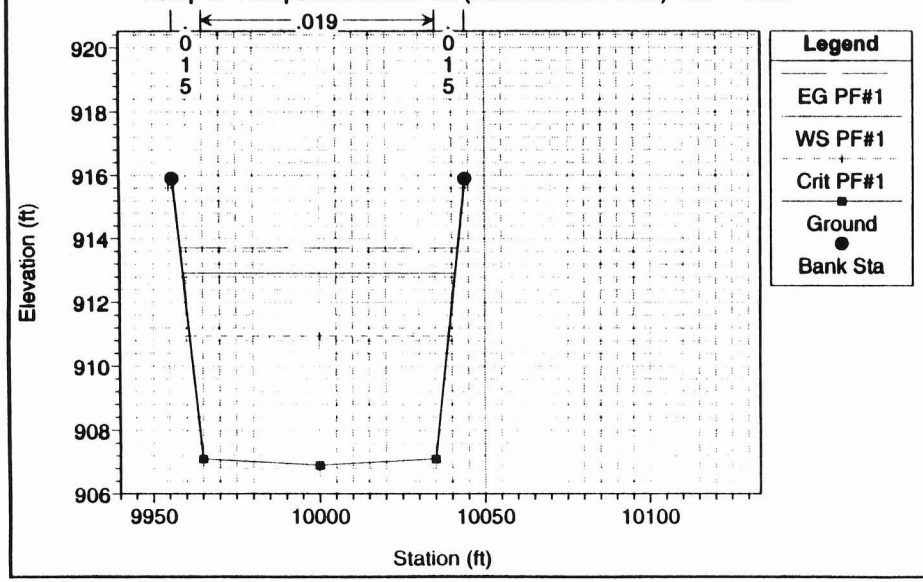
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Start Ramp 2 RS = 3141



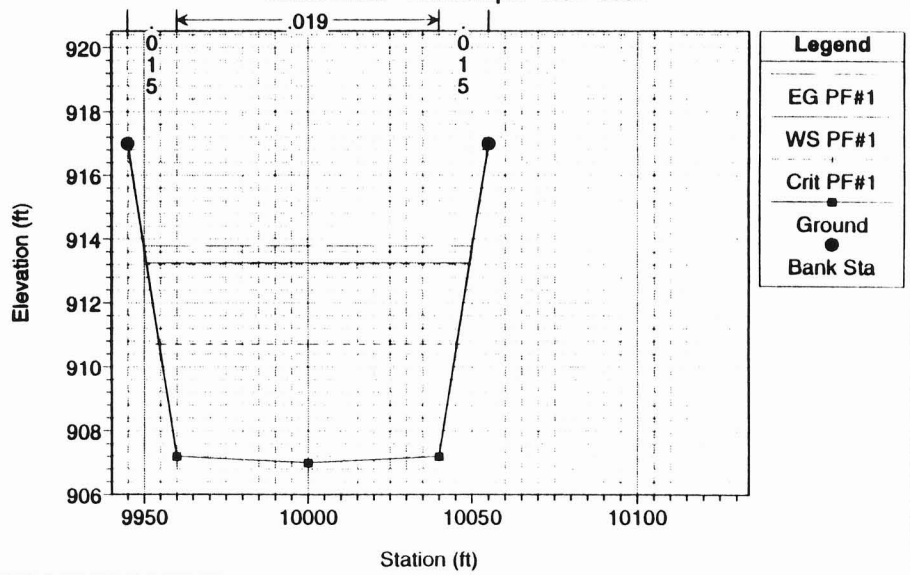
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Ramp 2 - Ramps hard coded out (ineffective flow area) RS = 3266

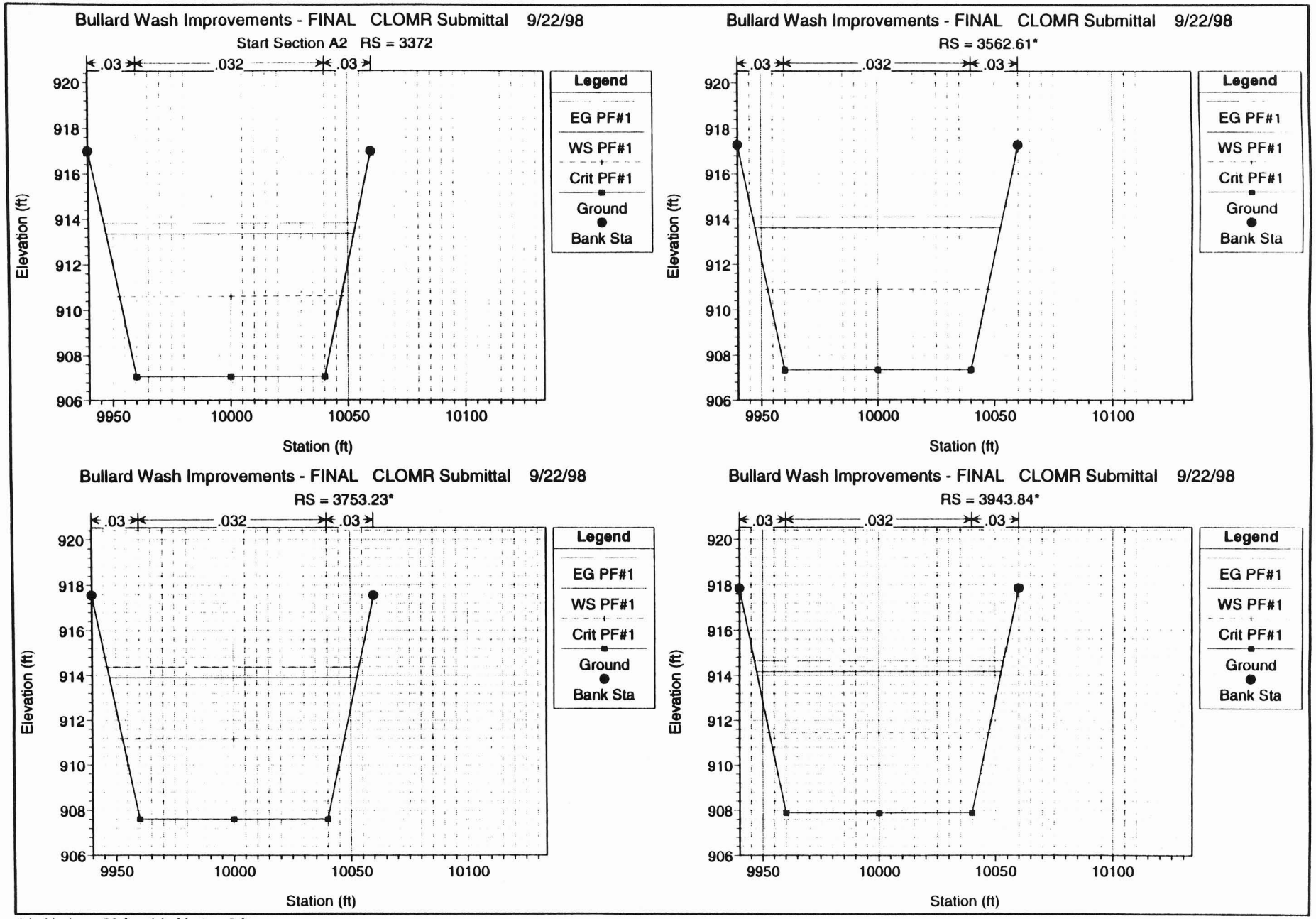


Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

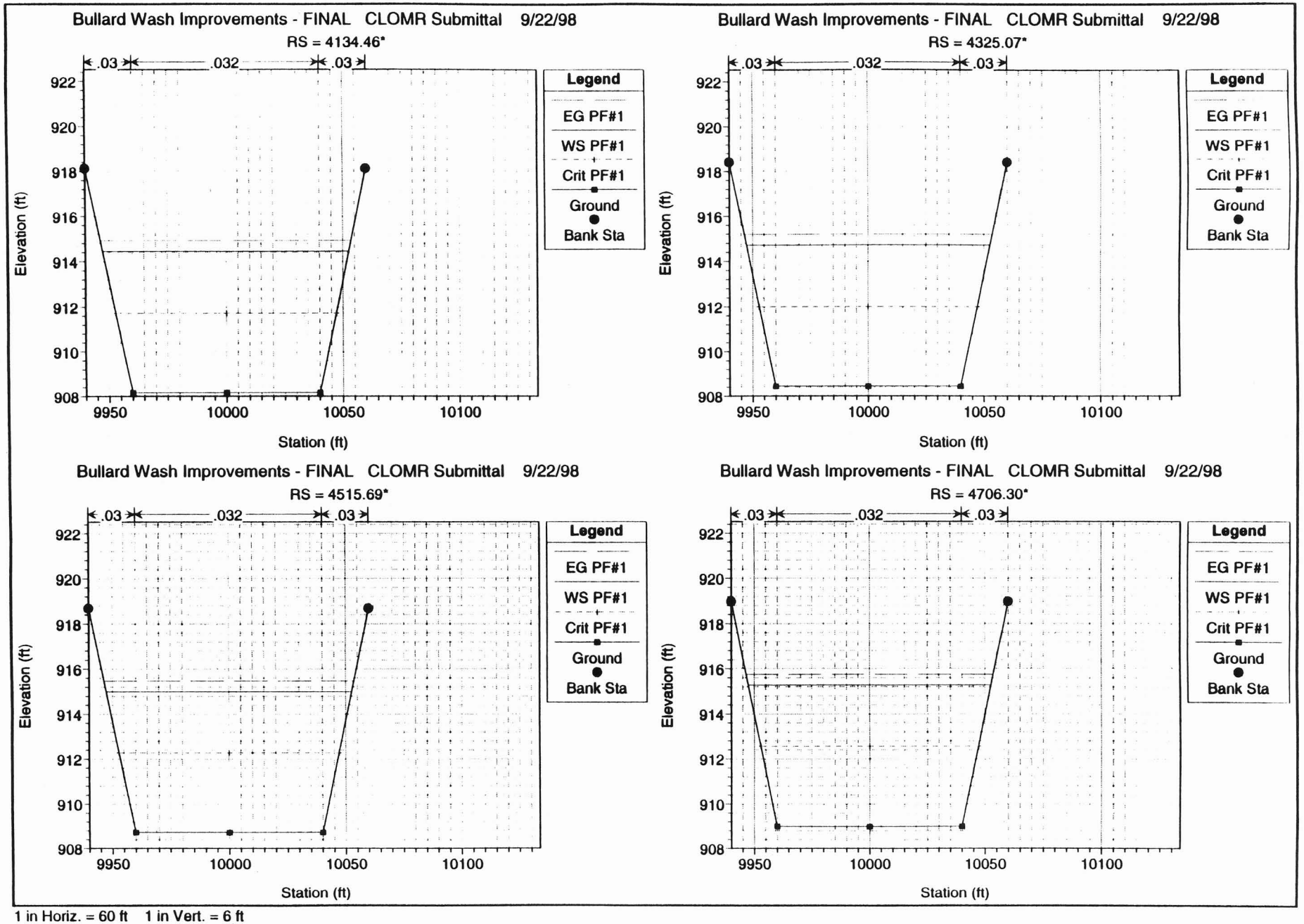
Grade Break - End Ramp 2 RS = 3330



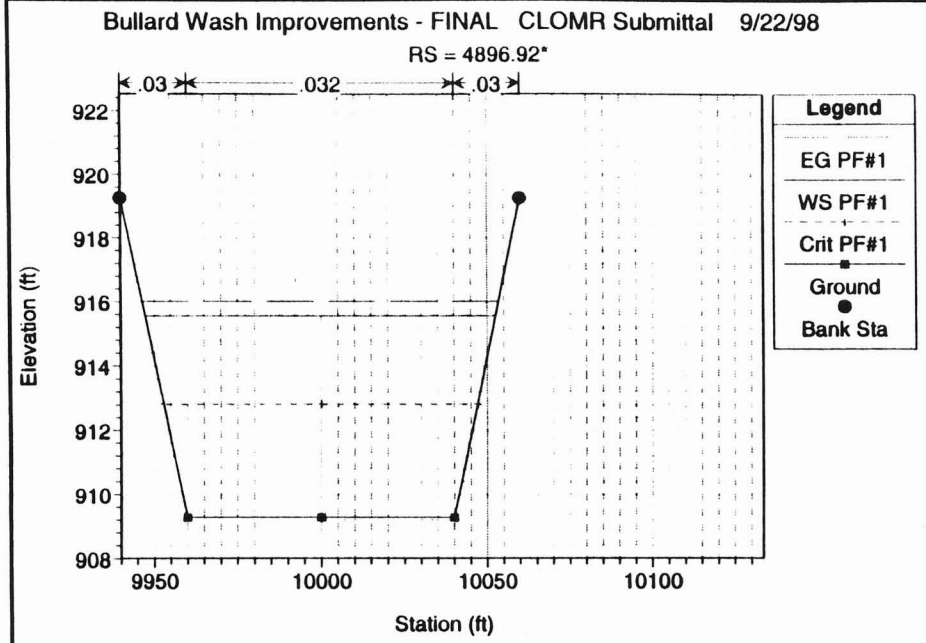
1 in Horiz. = 60 ft 1 in Vert. = 6 ft

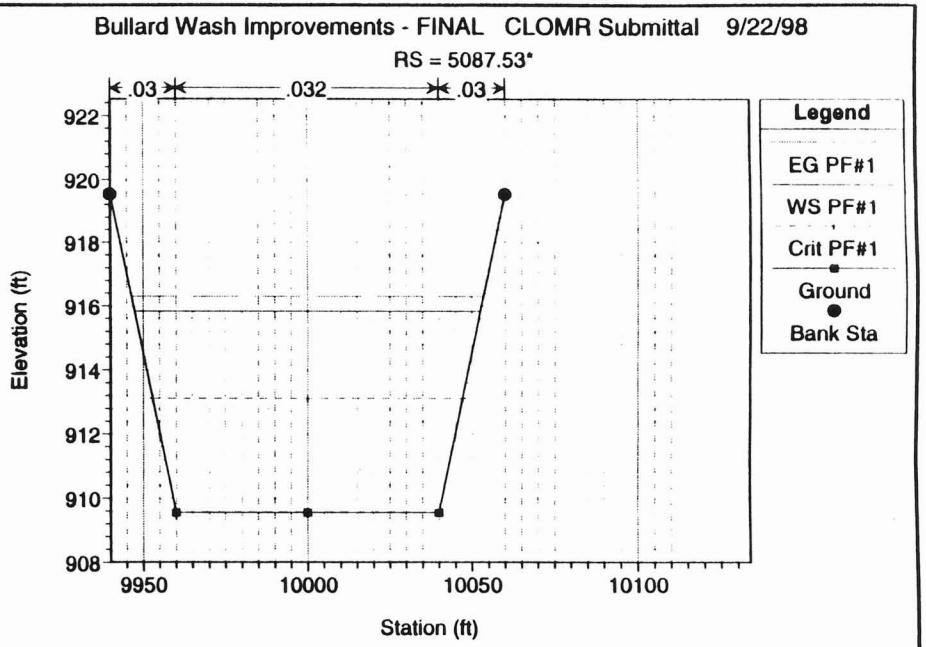


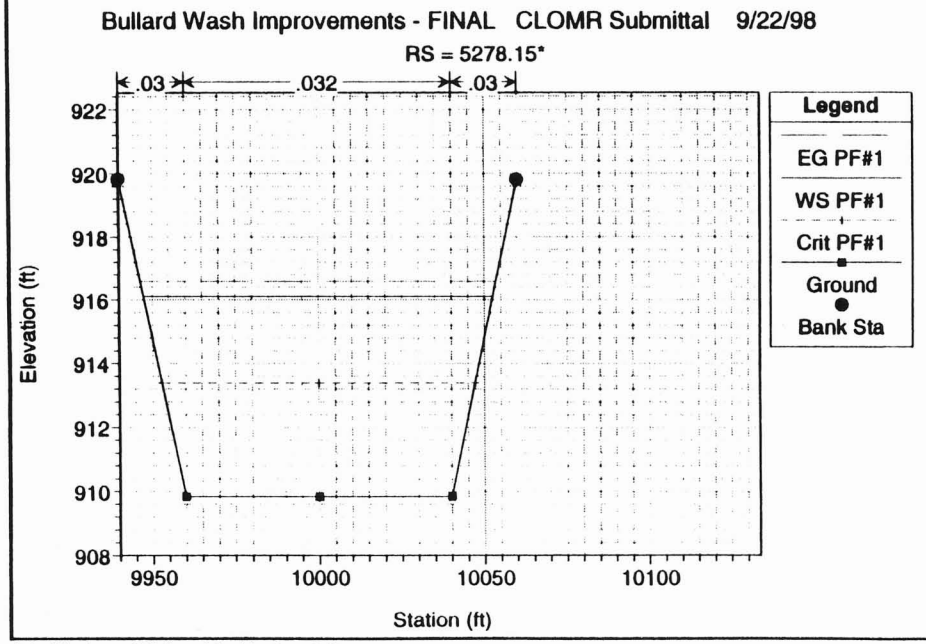
1 in Horiz. = 60 ft 1 in Vert. = 6 ft

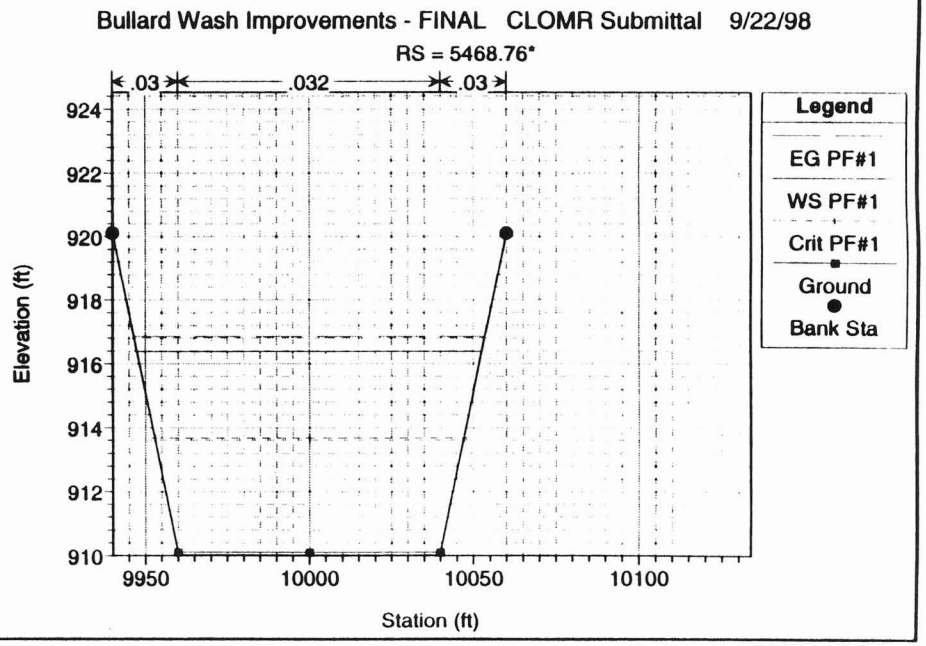


1 in Horiz. = 60 ft 1 in Vert. = 6 ft

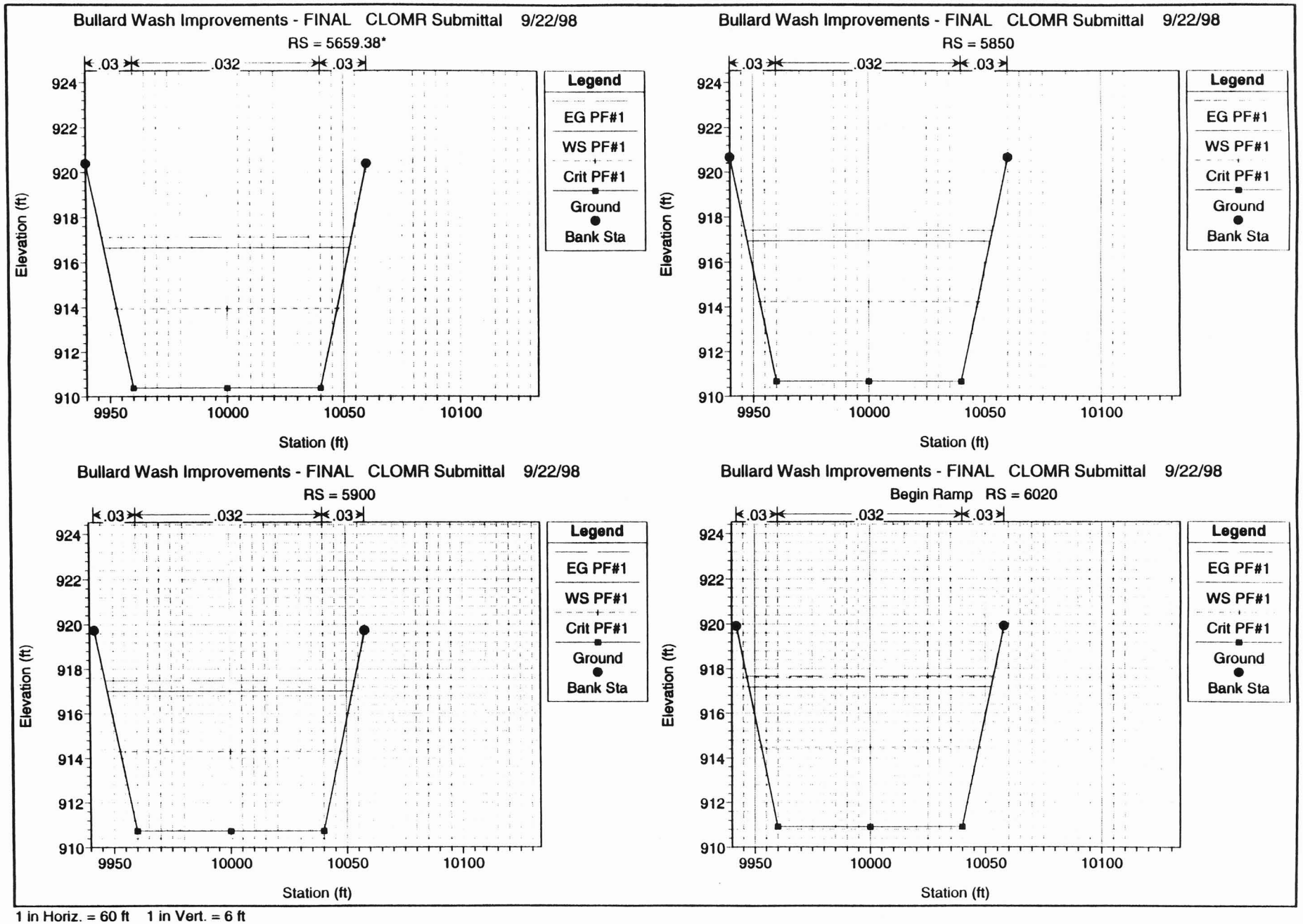








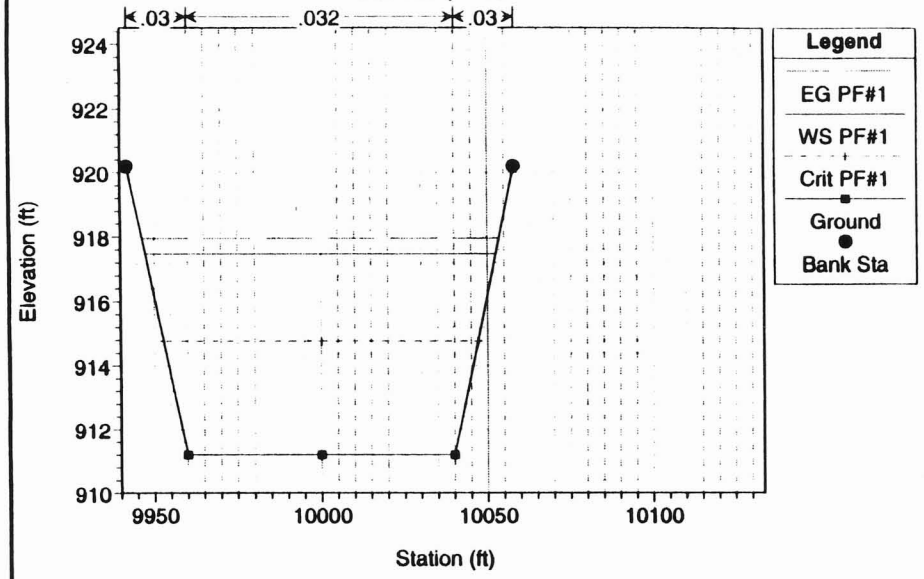
1 in Horiz. = 60 ft 1 in Vert. = 6 ft



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

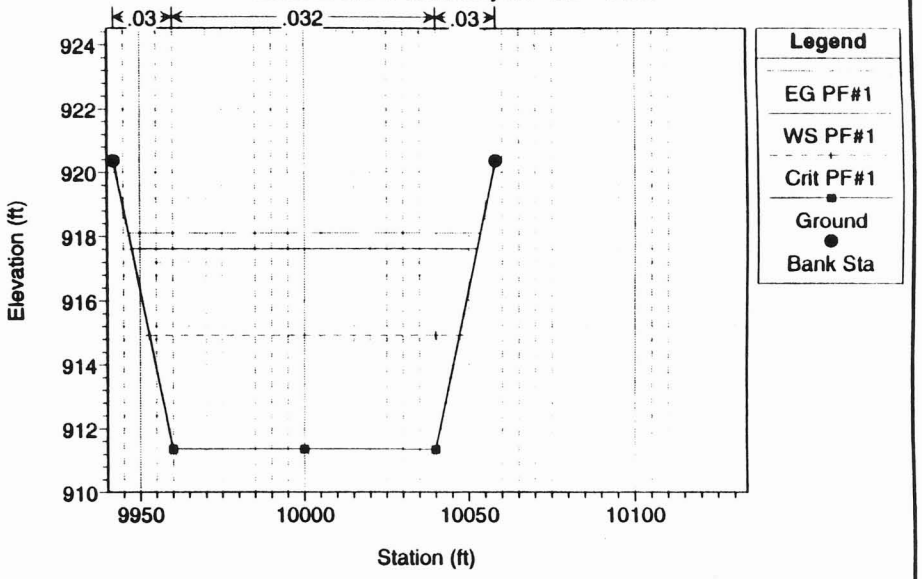
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Ramp RS = 6220



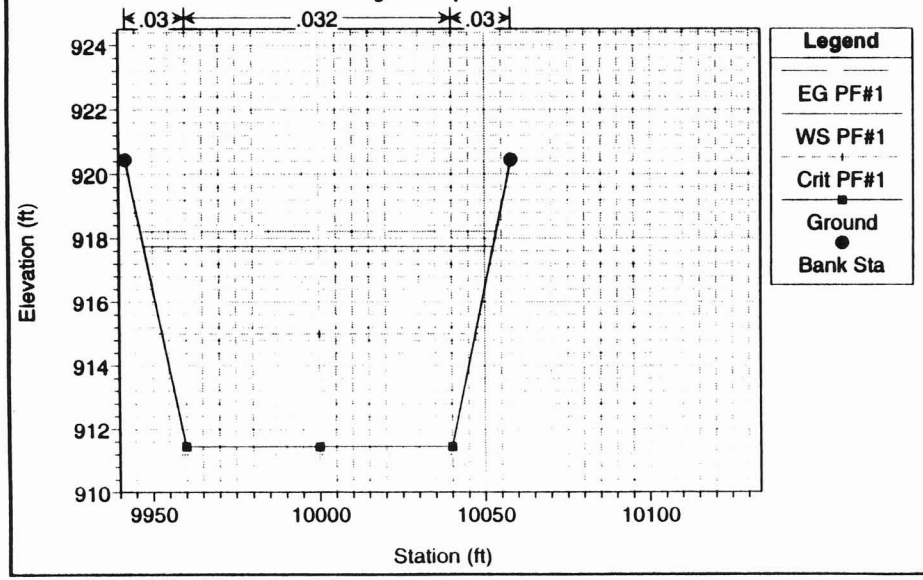
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Grade Break @ Broadway Rd RS = 6322



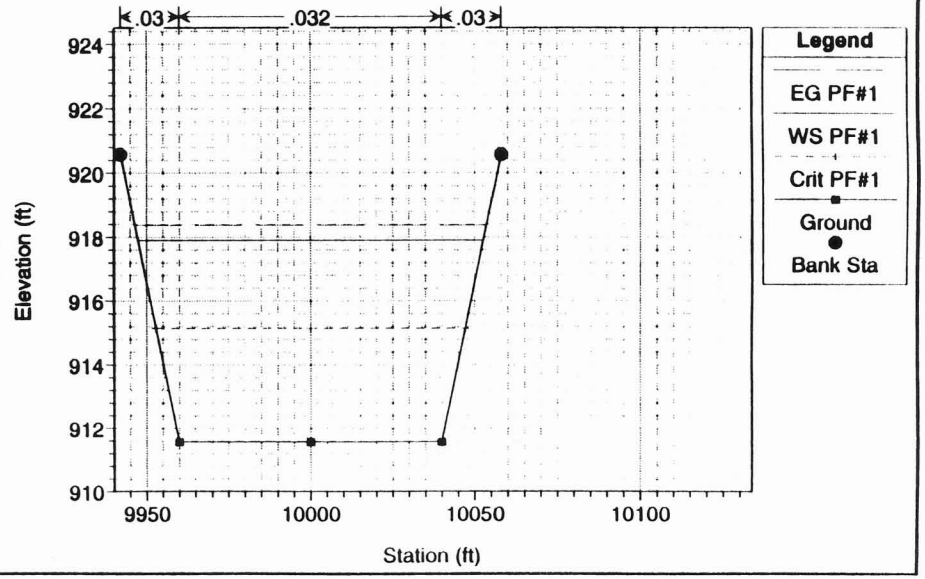
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Ramp RS = 6400



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

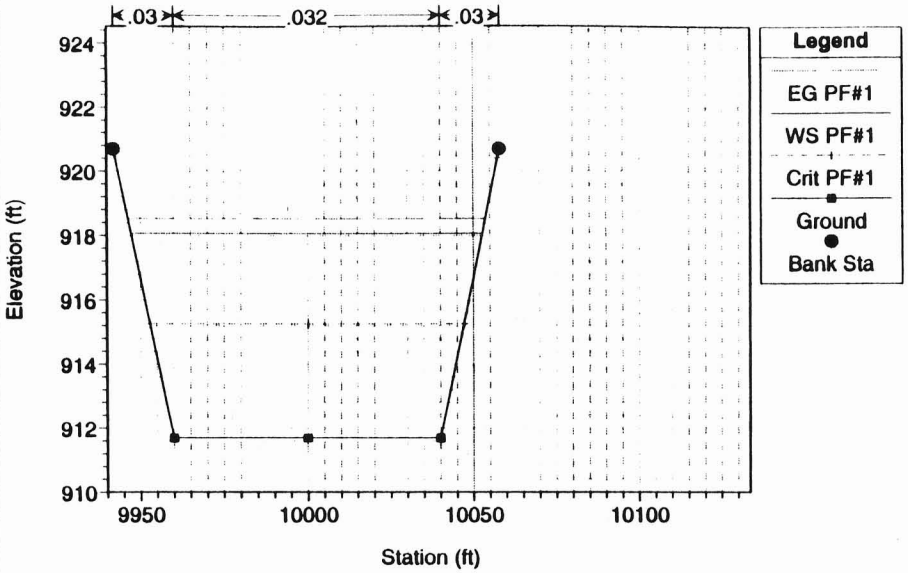
RS = 6510.*



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

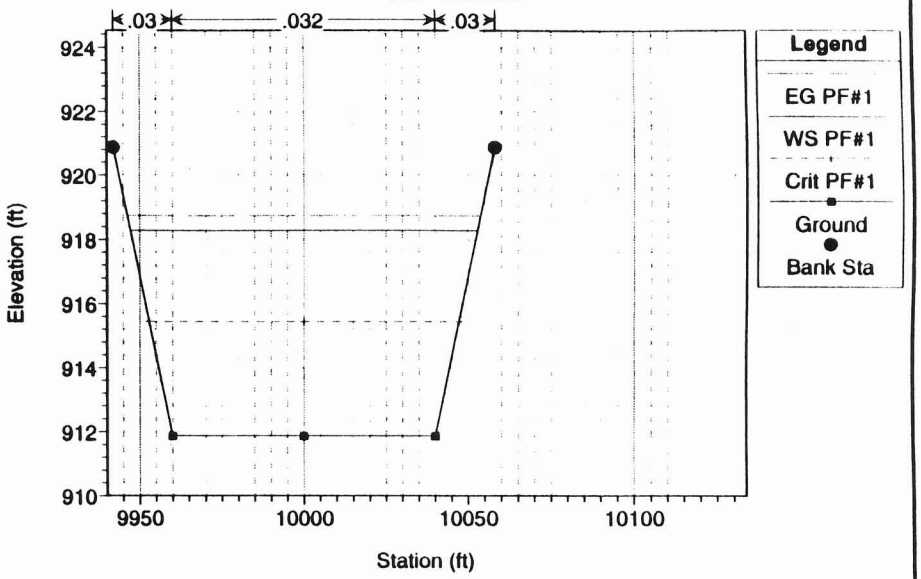
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Ramp RS = 6620



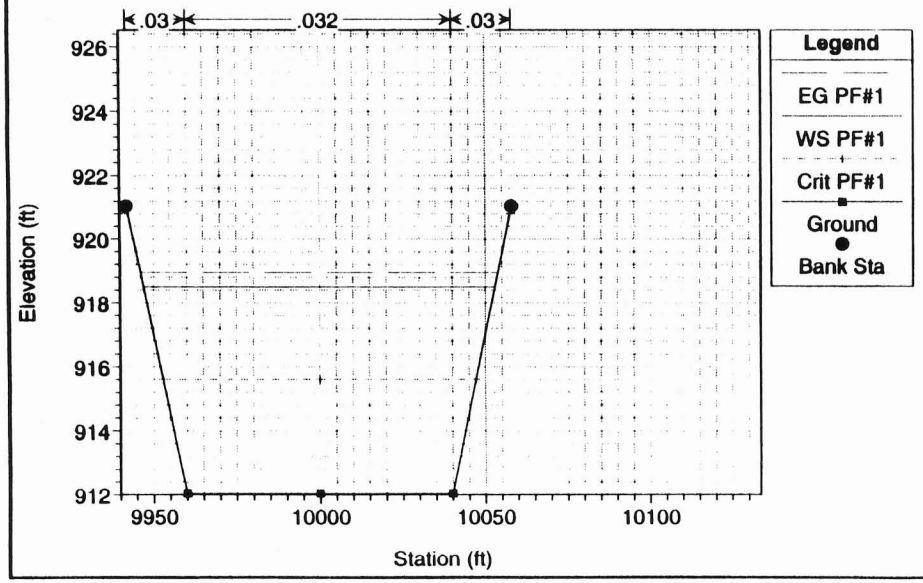
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 6776.75*



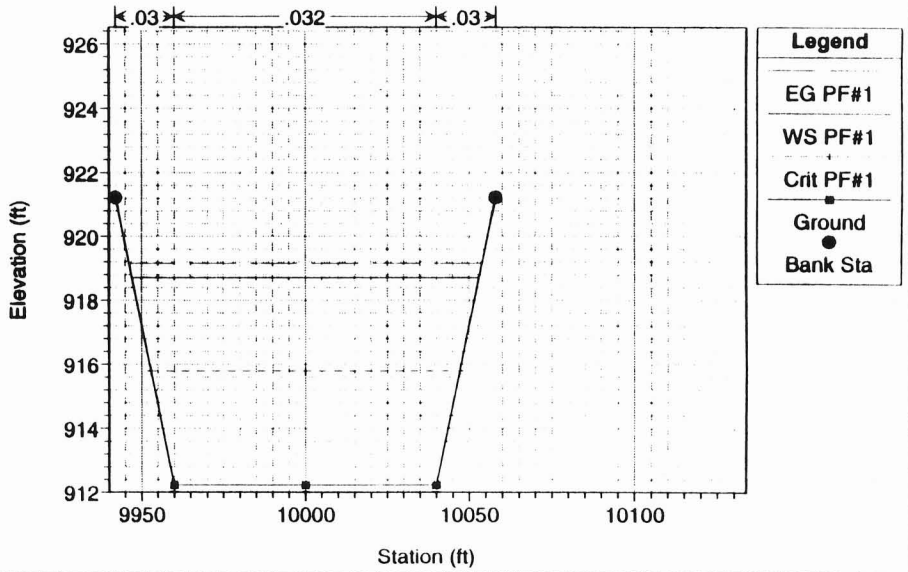
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 6933.5*



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

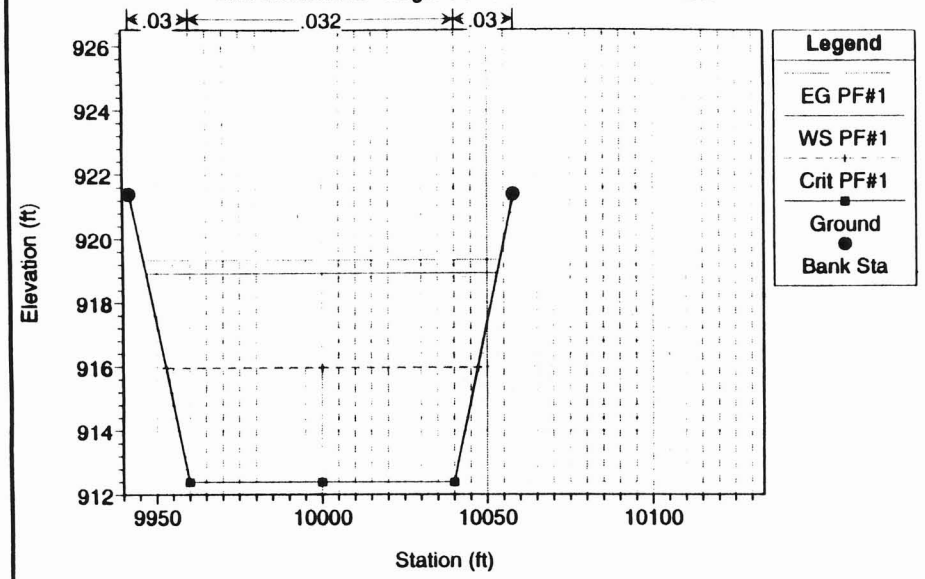
RS = 7090.25*



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

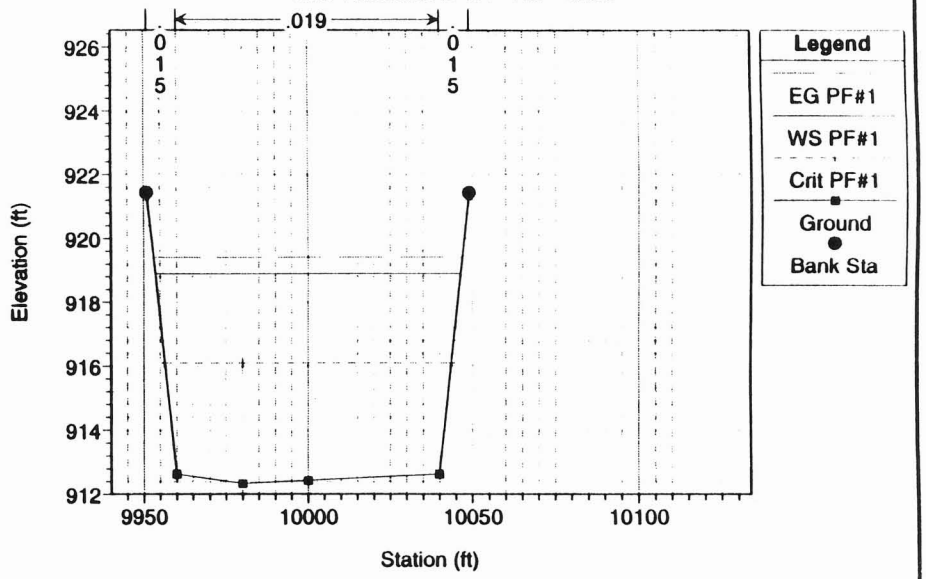
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Section A2 - Begin Transition to 1:1 RS = 7247



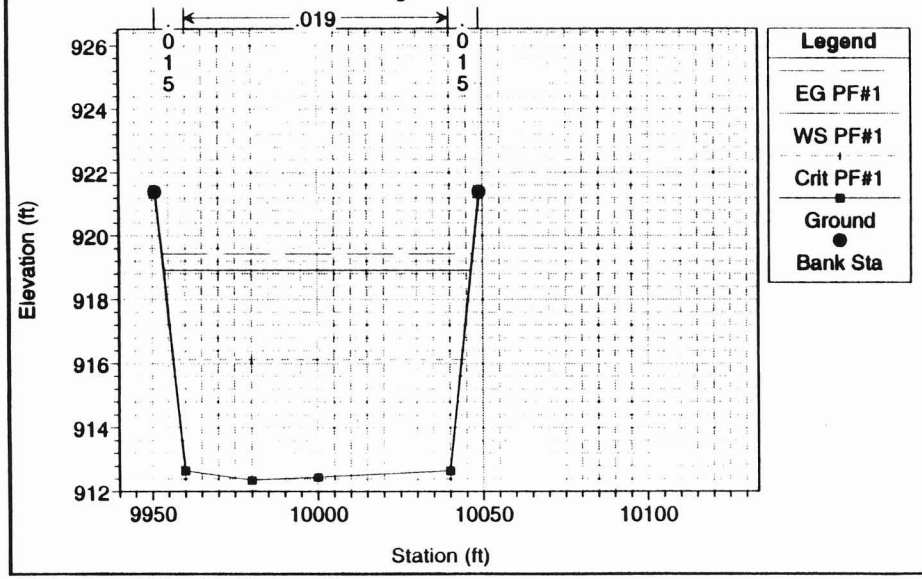
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Transition to 1:1 RS = 7280



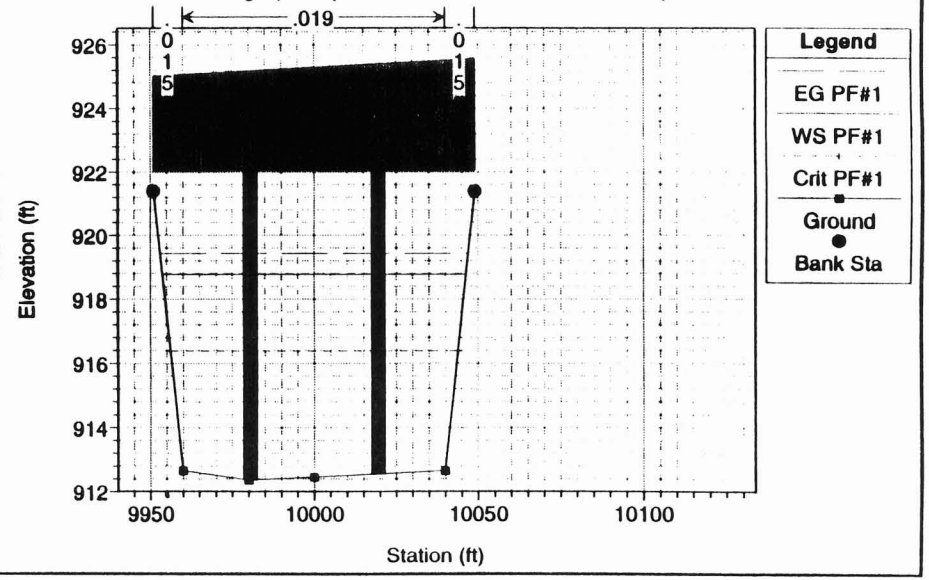
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

MC85 Bridge D/S Face RS = 7300



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

MC 85 Bridge (24 in piers coded at 48 inches for debris) RS = 7357

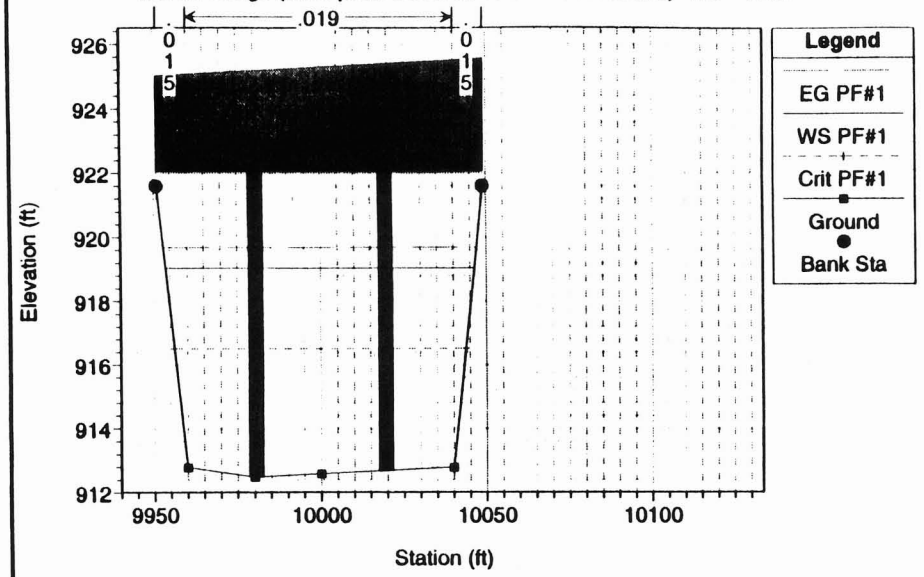


1 in Horiz. = 60 ft 1 in Vert. = 6 ft

//

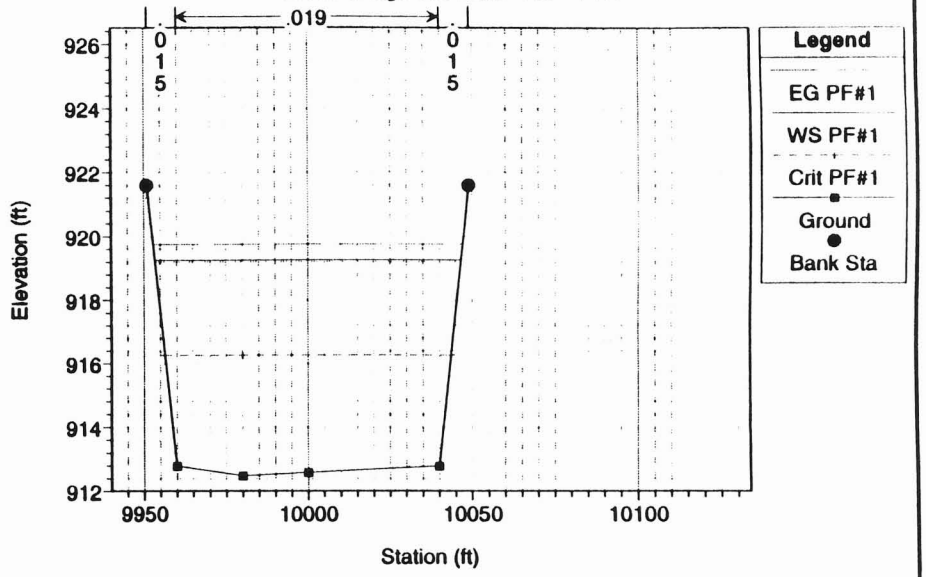
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

MC 85 Bridge (24 in piers coded at 48 inches for debris) RS = 7357



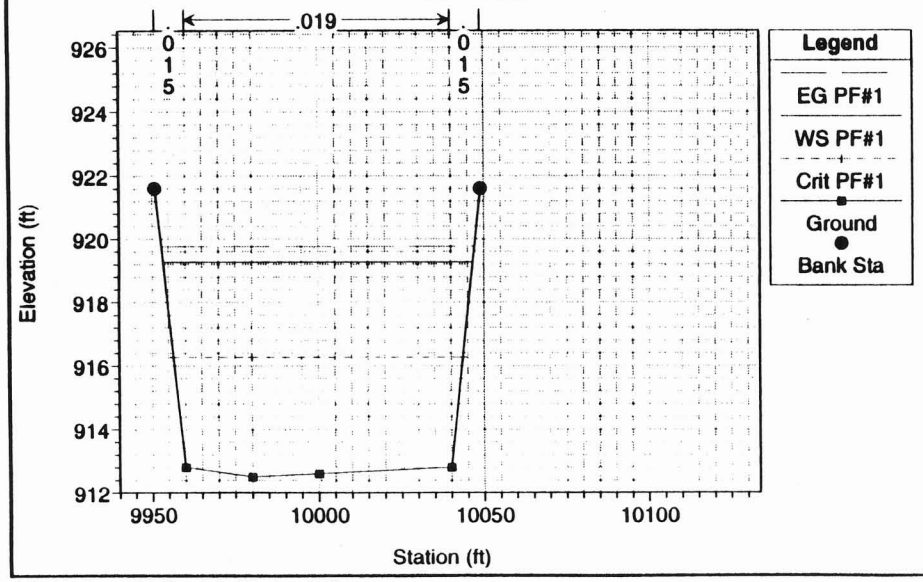
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

MC85 Bridge U/S Face RS = 7417



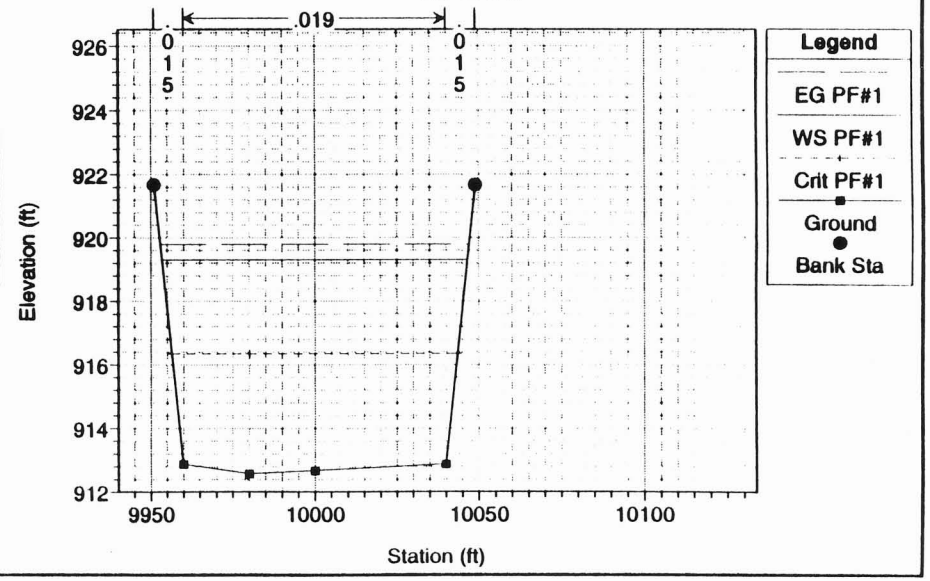
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 7440



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

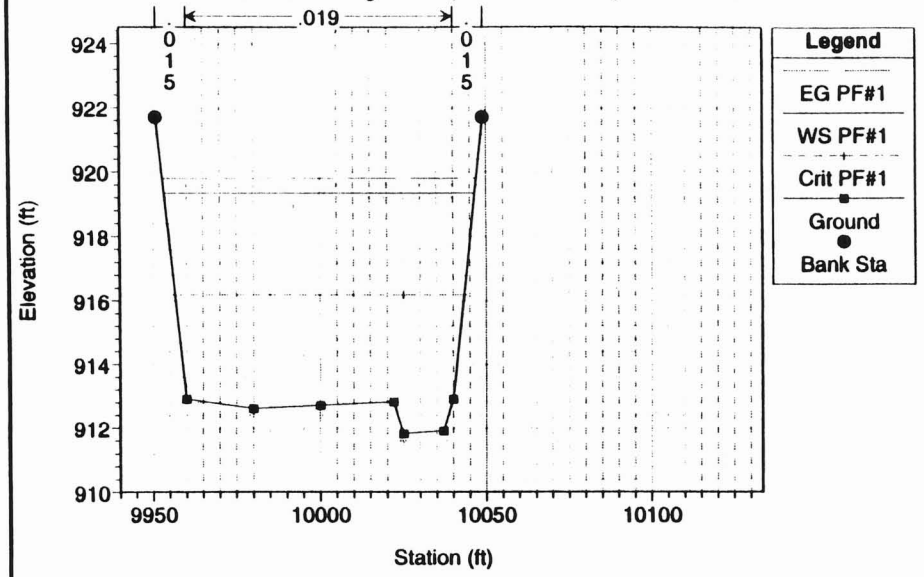
RS = 7500



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

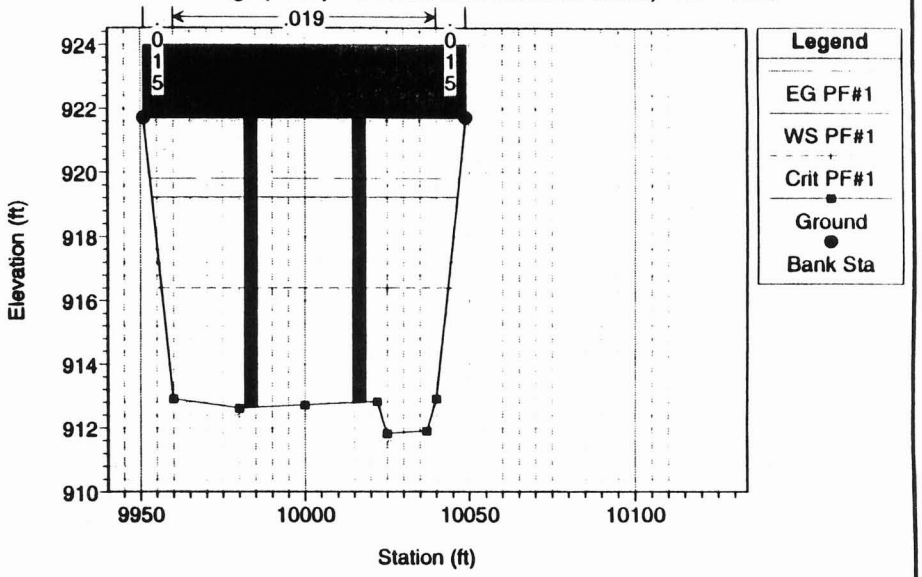
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

@D/S UPRR Bridge Face (low flow channel) RS = 7523



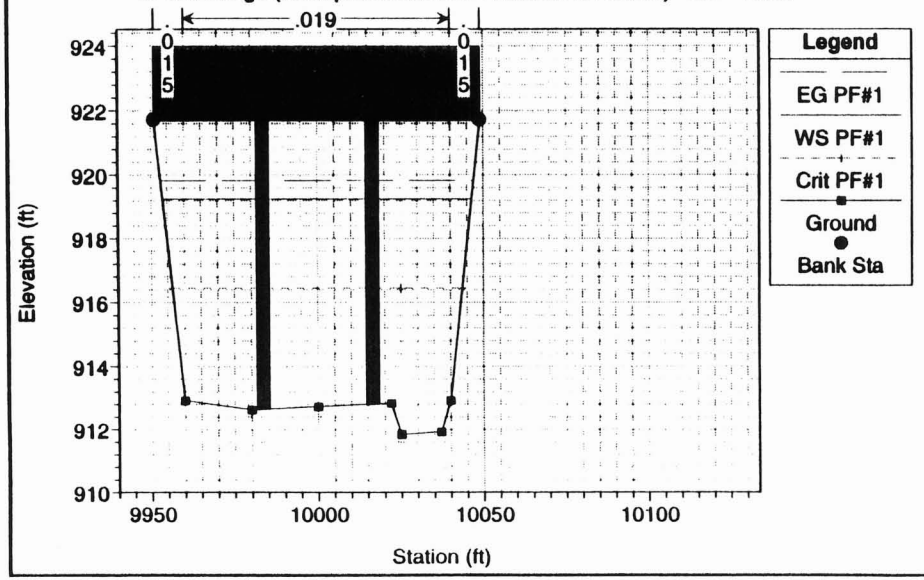
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

UPRR Bridge (20 in piers coded at 44 inches for debris) RS = 7533



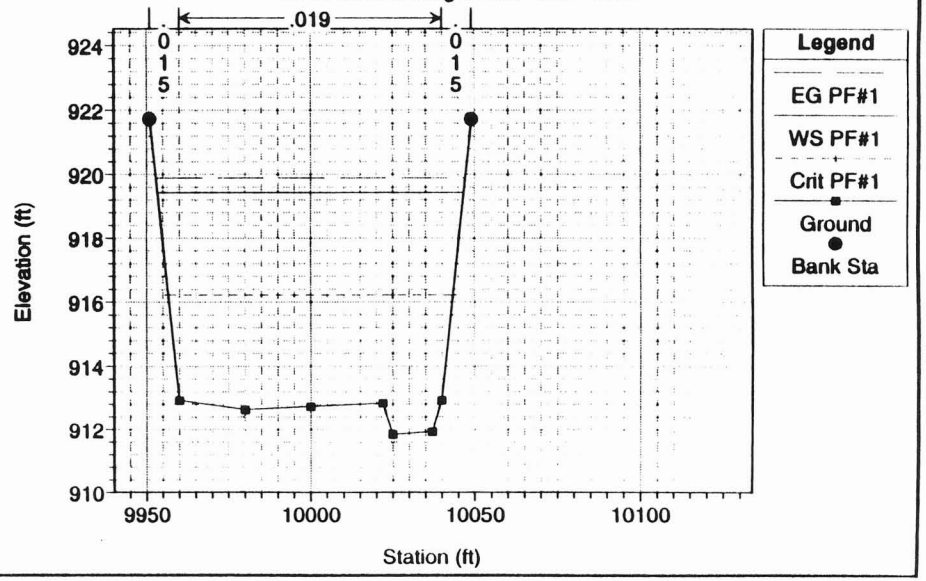
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

UPRR Bridge (20 in piers coded at 44 inches for debris) RS = 7533



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

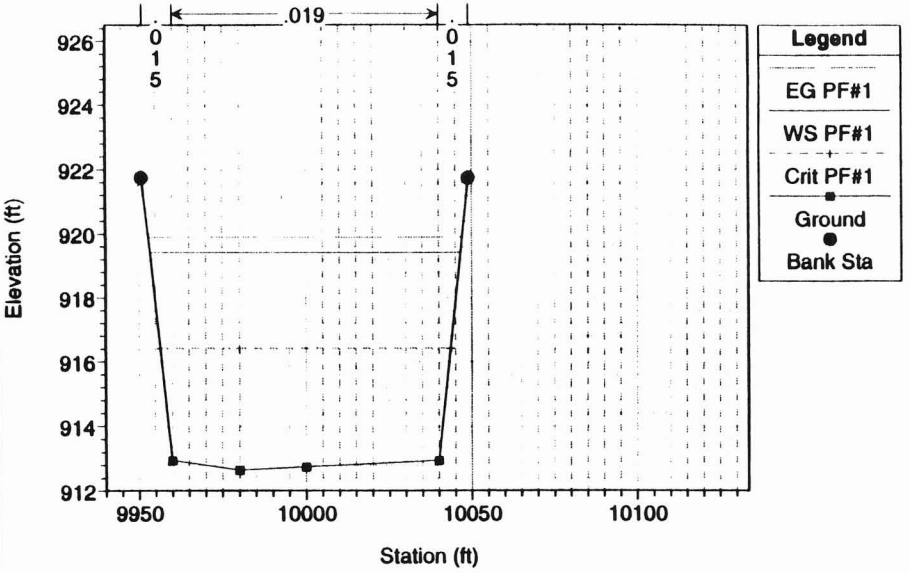
@U/S UPRR Bridge Face RS = 7543



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

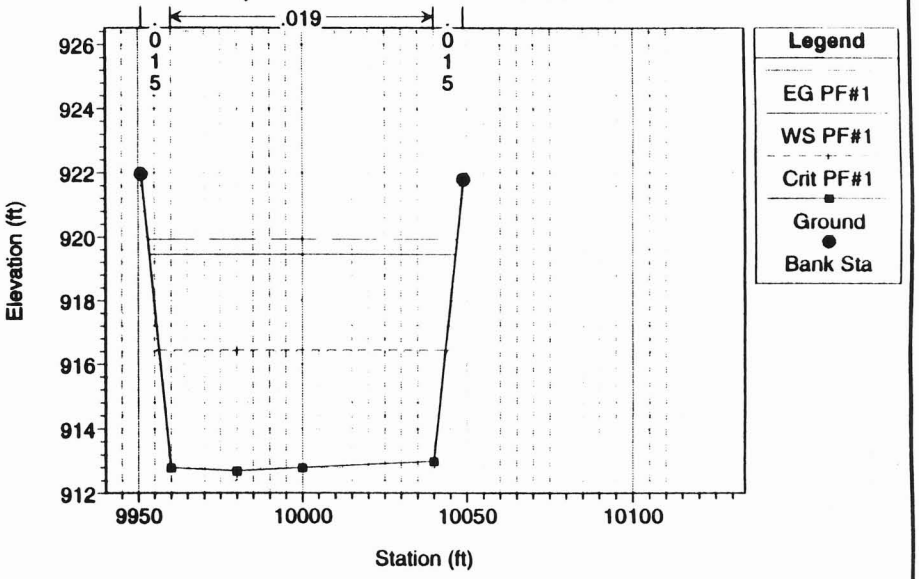
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Ramp RS = 7558



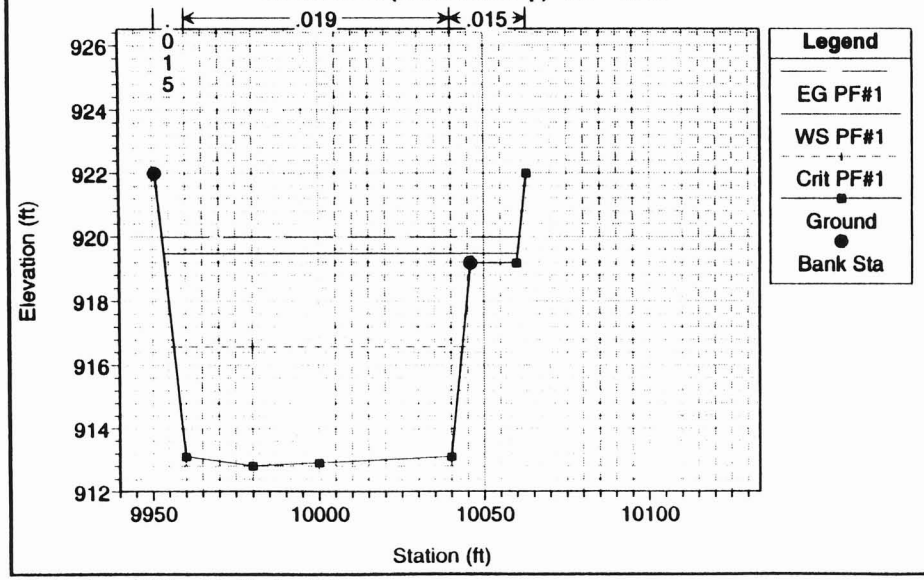
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Ramp - Hard coded ineffective flow area RS = 7605



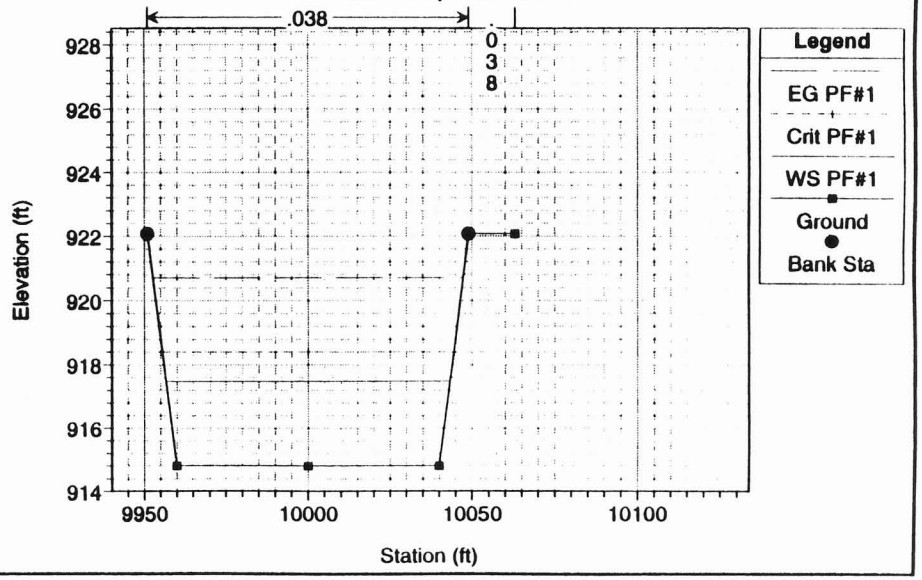
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Grade Break (Bottom of Drop) RS = 7700



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

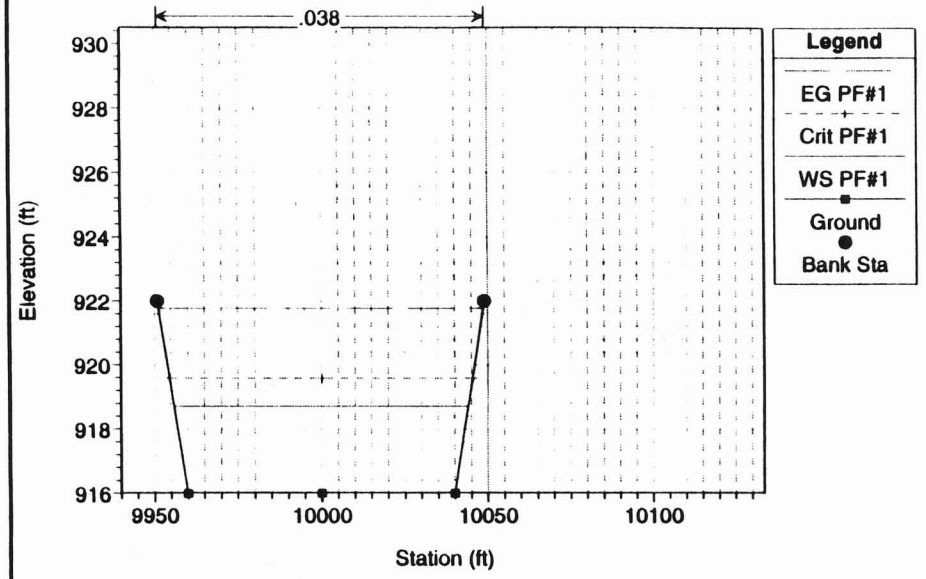
END Ramp RS = 7744



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

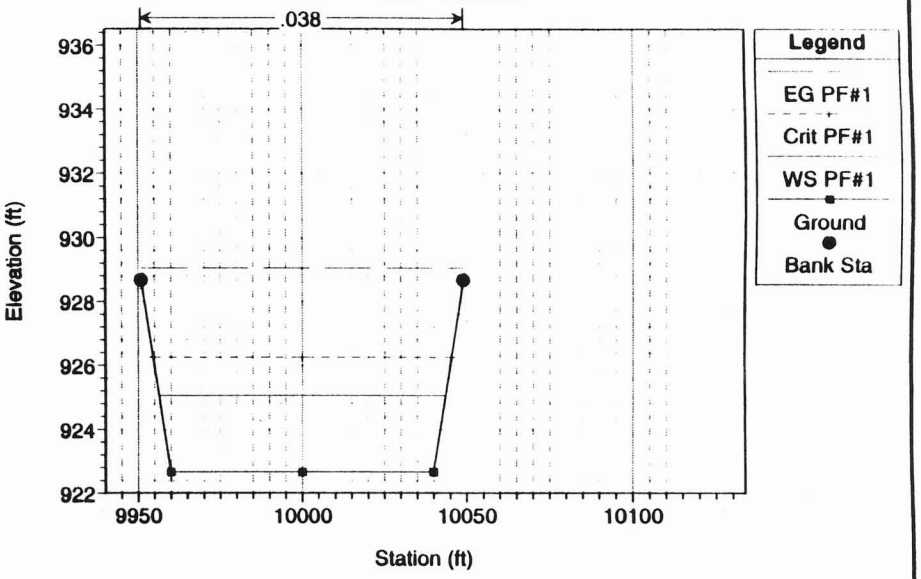
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 7771.64



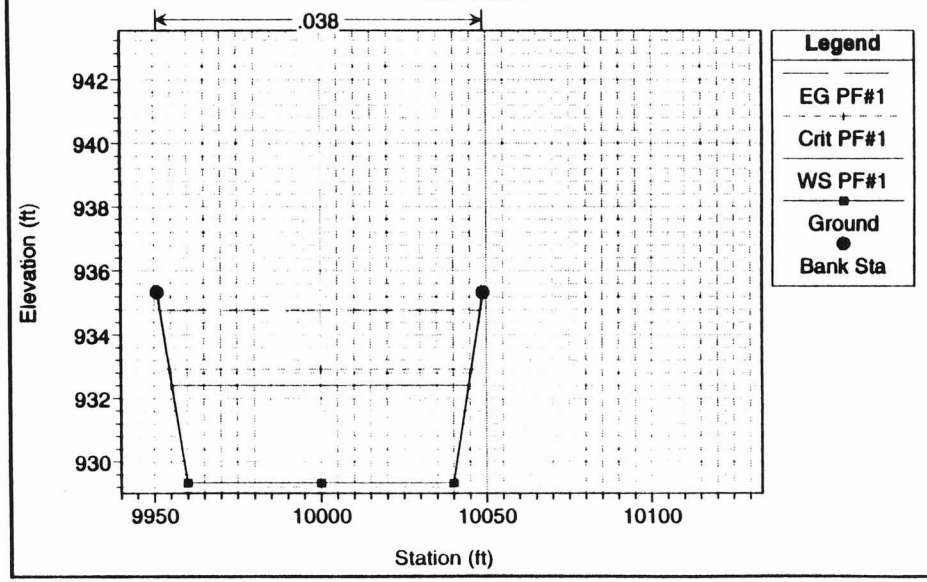
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 7925.82*



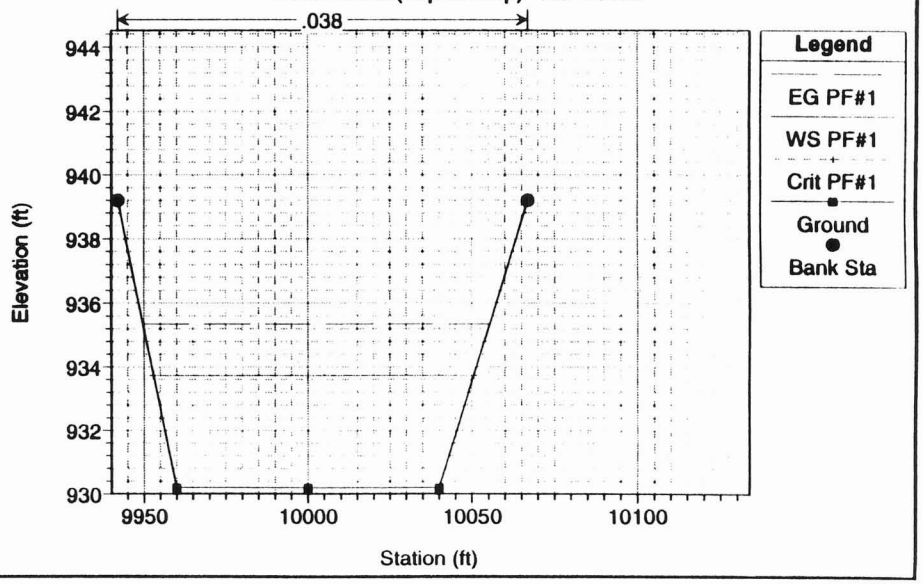
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 8080



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

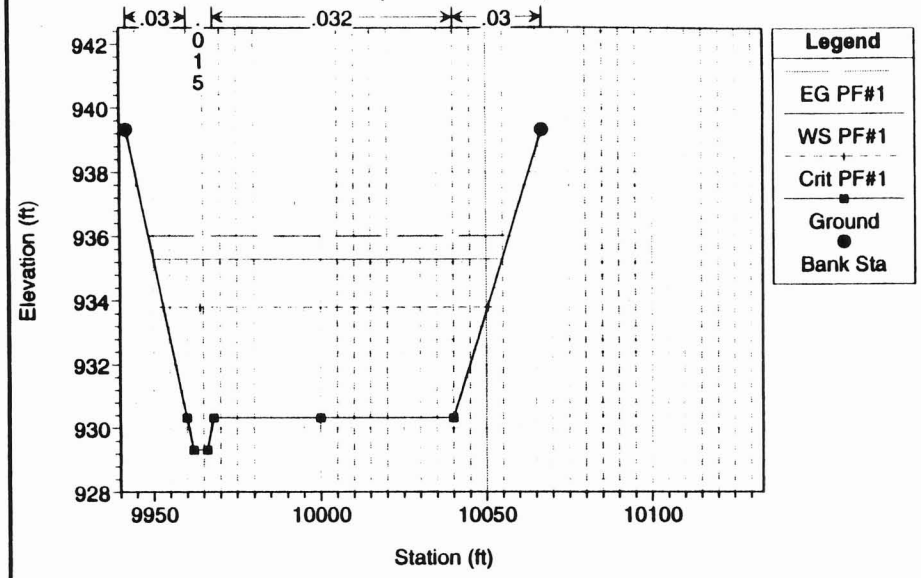
Grade Break (Top of Drop) RS = 8100



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

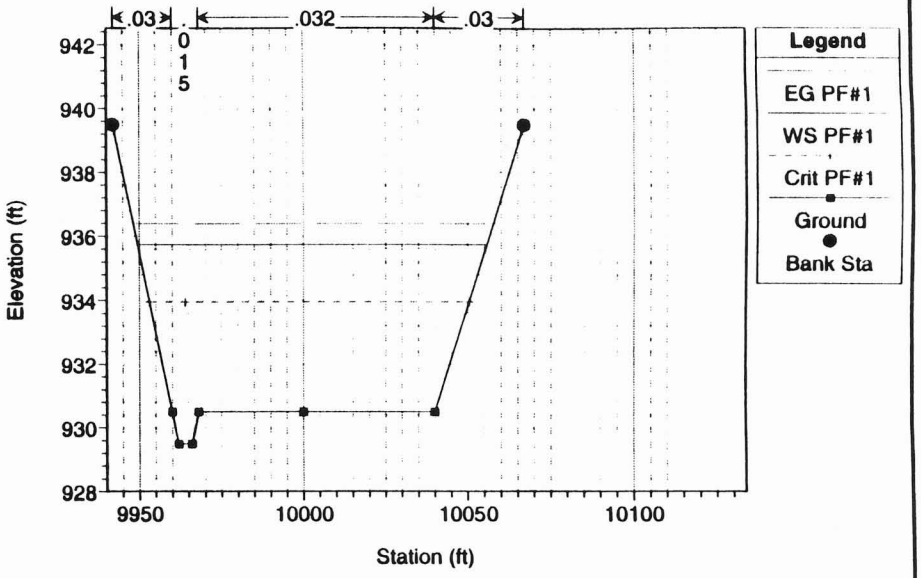
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Section C1 (low flow channel) RS = 8210



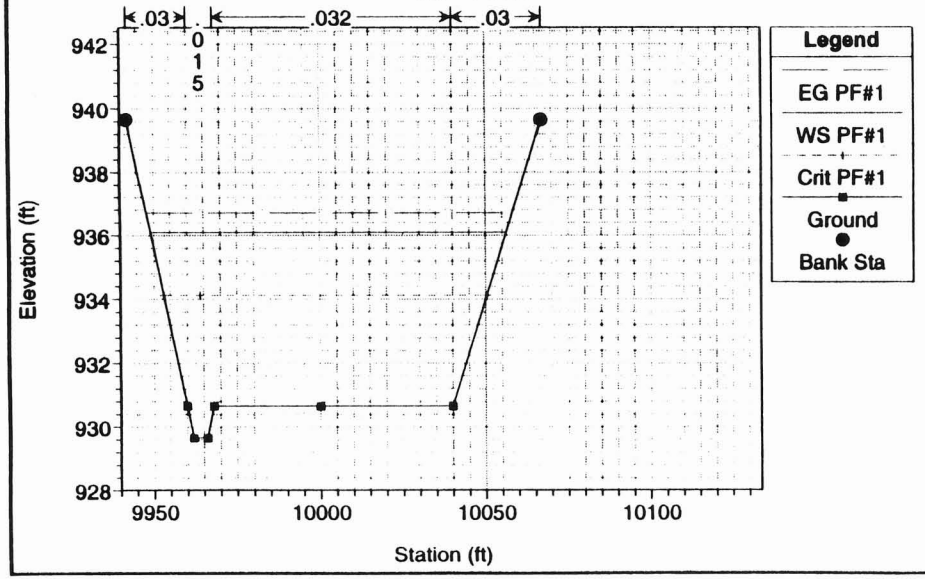
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 8348.*



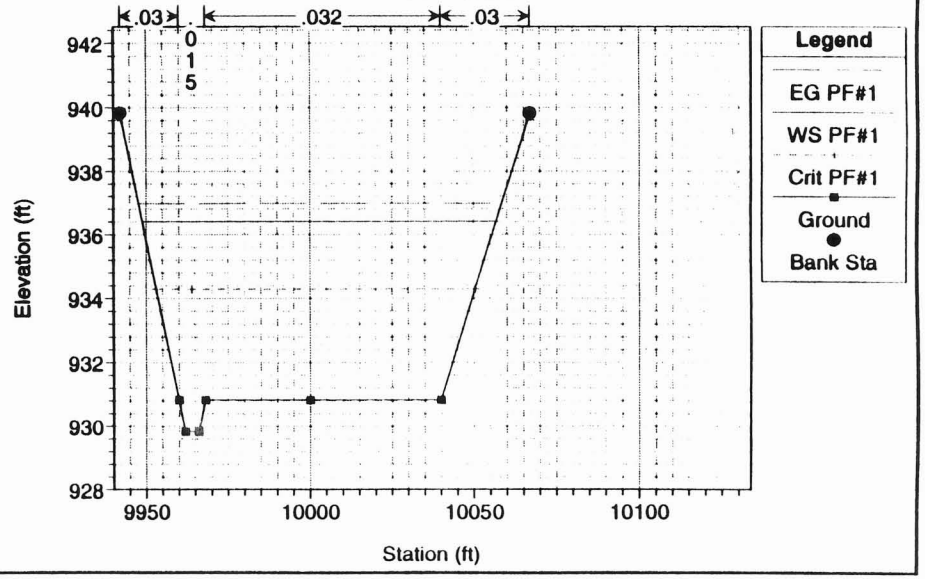
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 8486.*



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

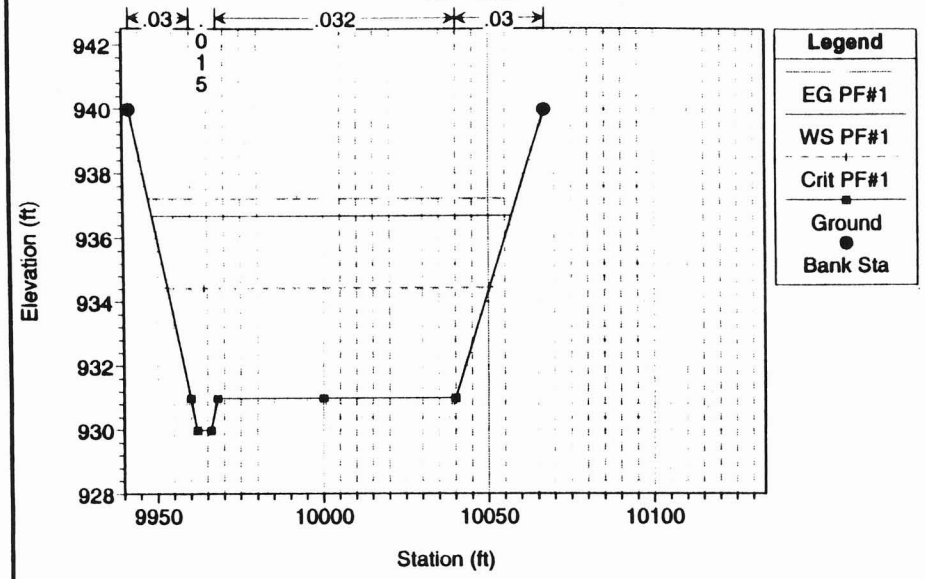
RS = 8624.*



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

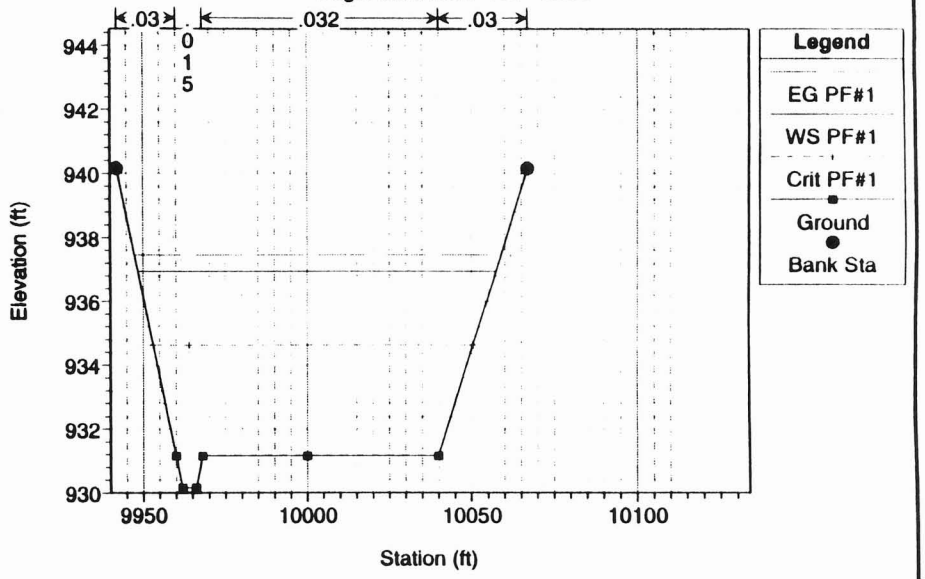
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 8762.*



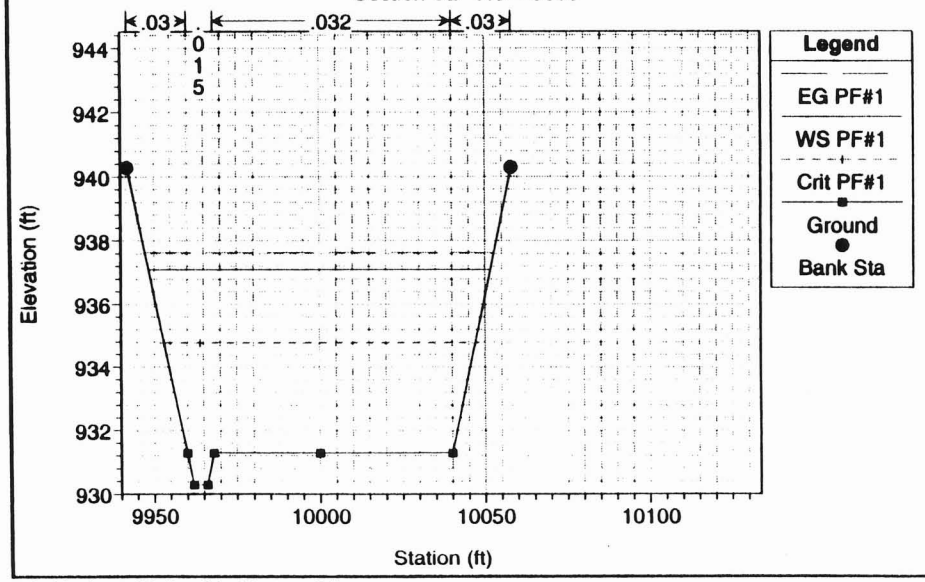
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Transition RS = 8900



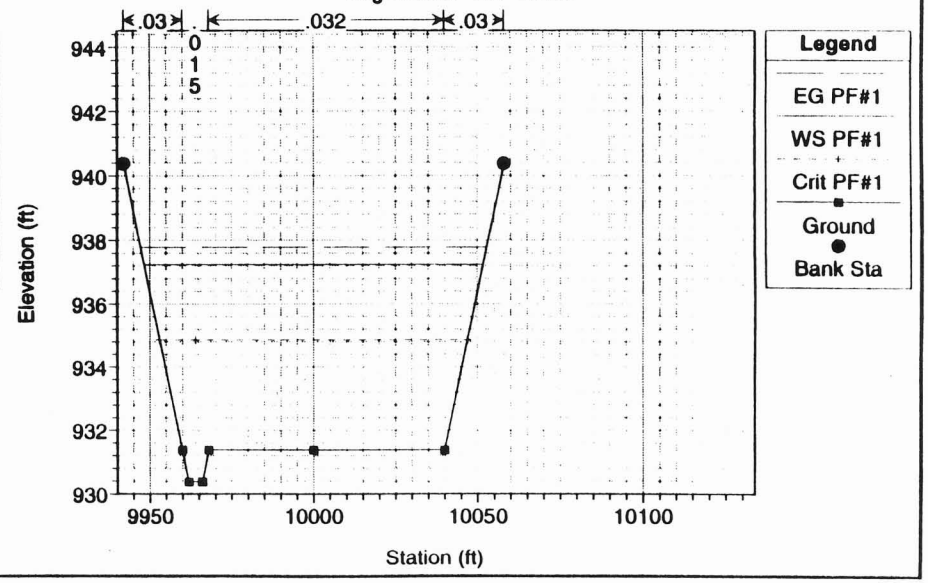
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Section C2 RS = 9000

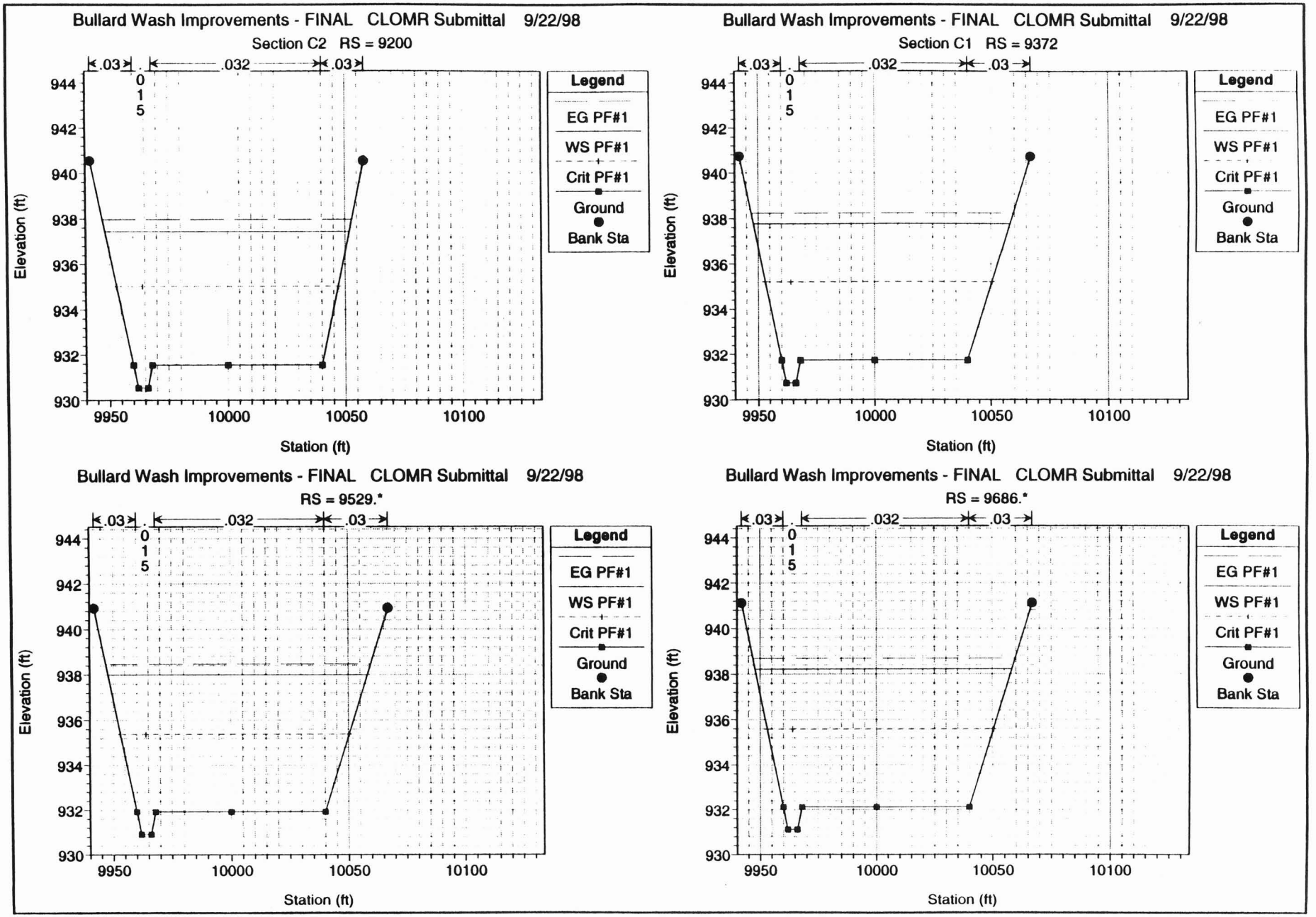


Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Bend RS = 9080



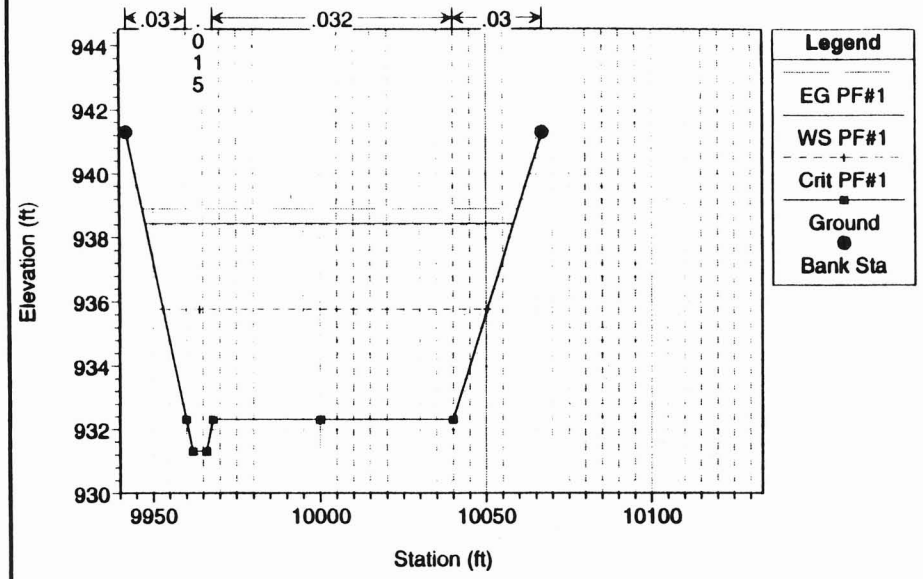
1 in Horiz. = 60 ft 1 in Vert. = 6 ft



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

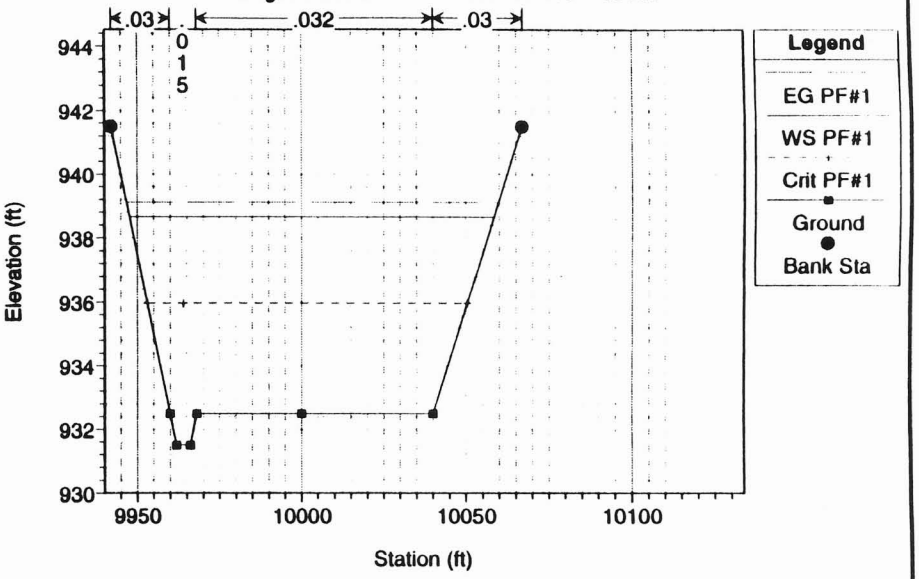
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 9843.*



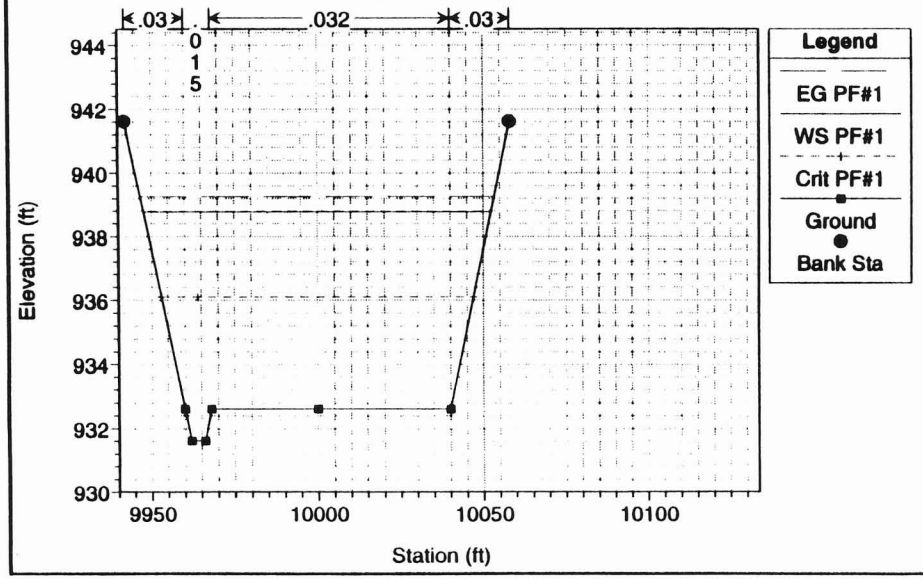
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Transition to Seciton C2 RS = 10000



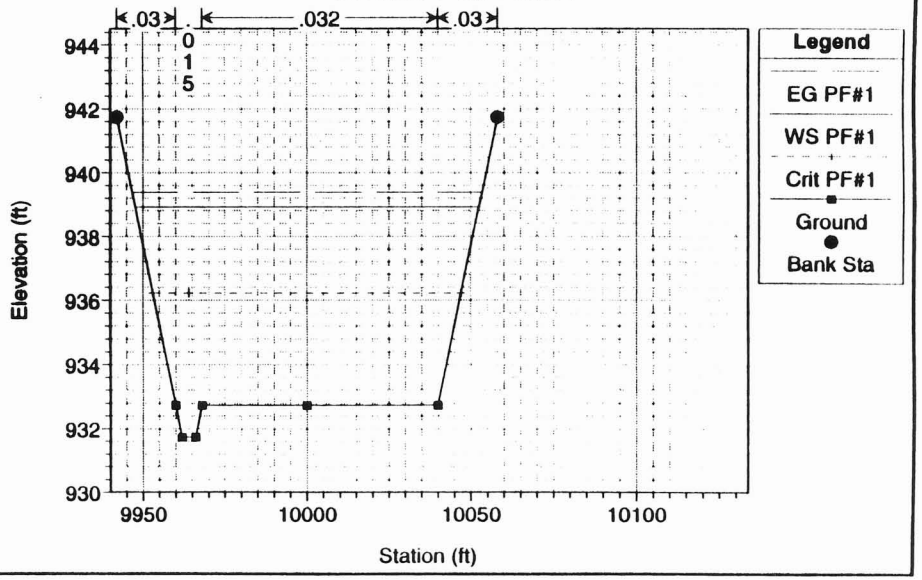
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Seciton C2 RS = 10100



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

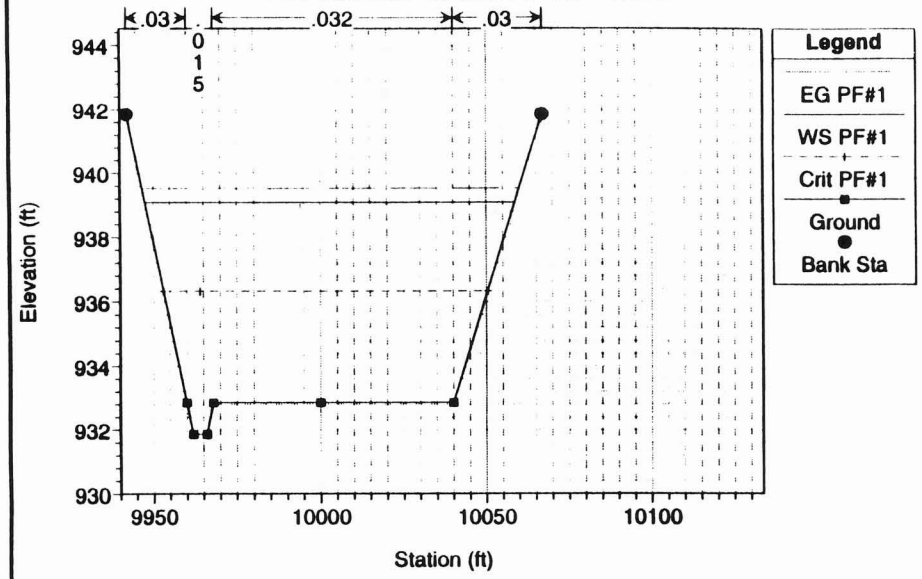
Seciton C2 RS = 10200



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

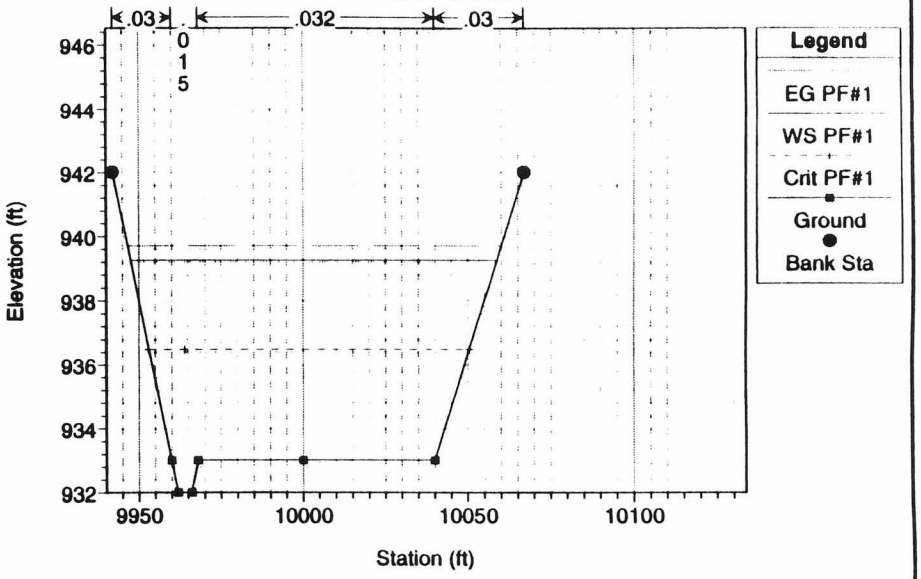
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Transition - Section C1 RS = 10300



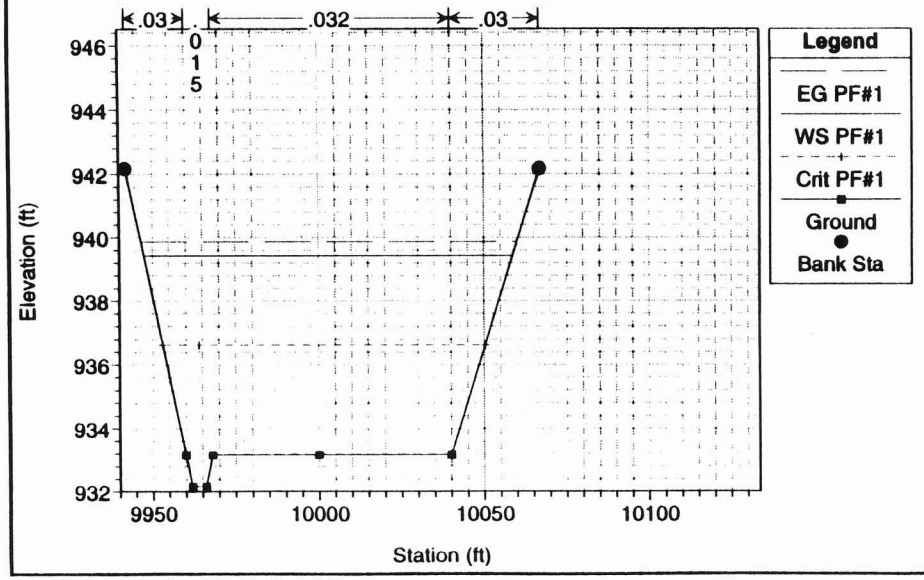
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 10430.*



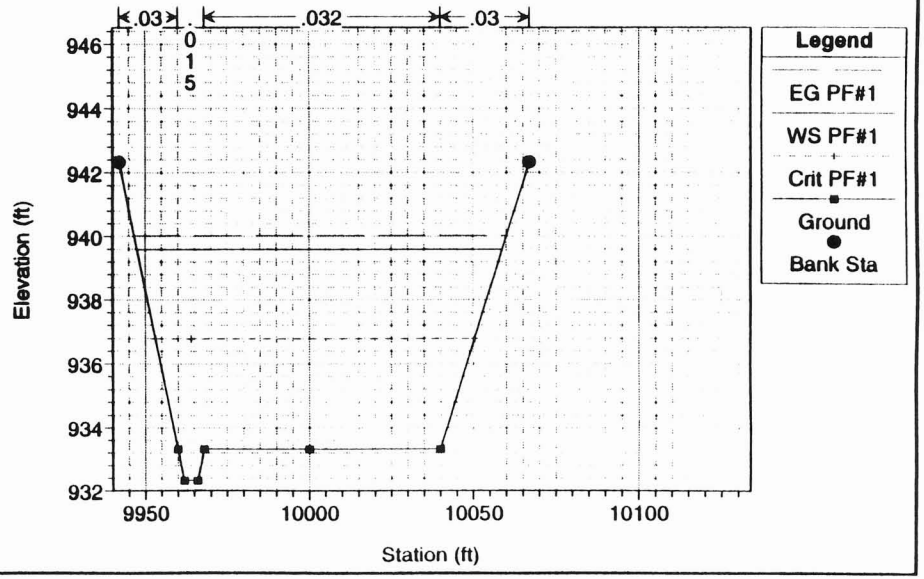
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 10560.*



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

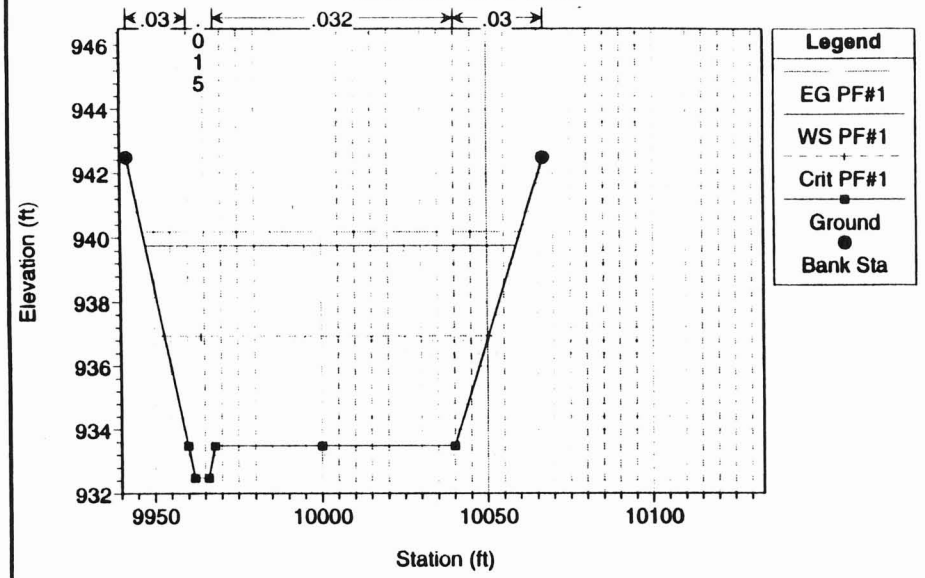
RS = 10690.*



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

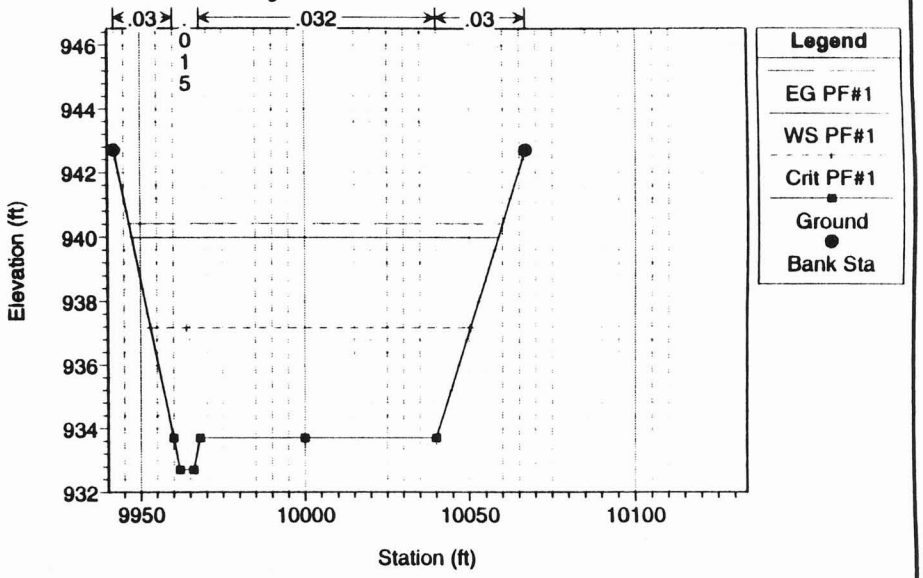
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Bend RS = 10820



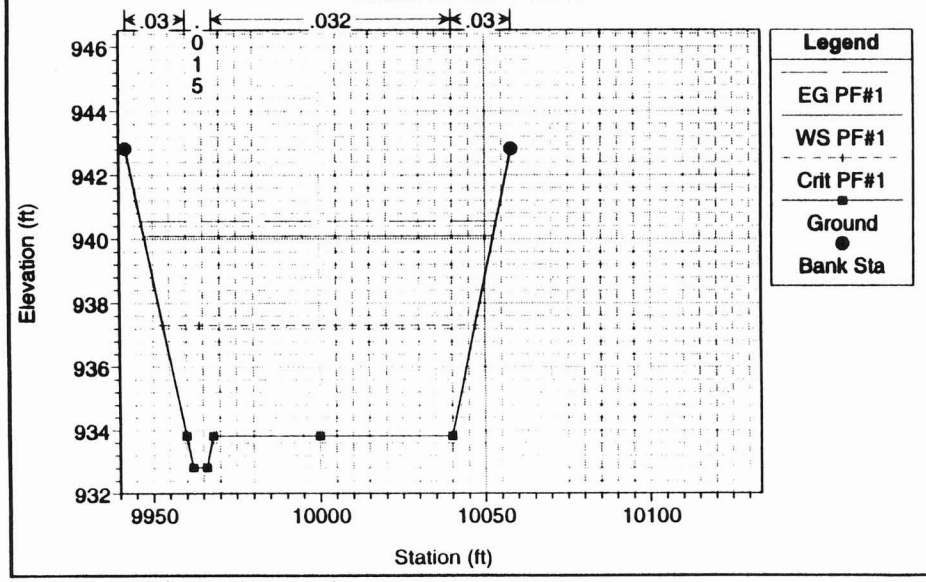
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Transition to Seciton C2 RS = 11000



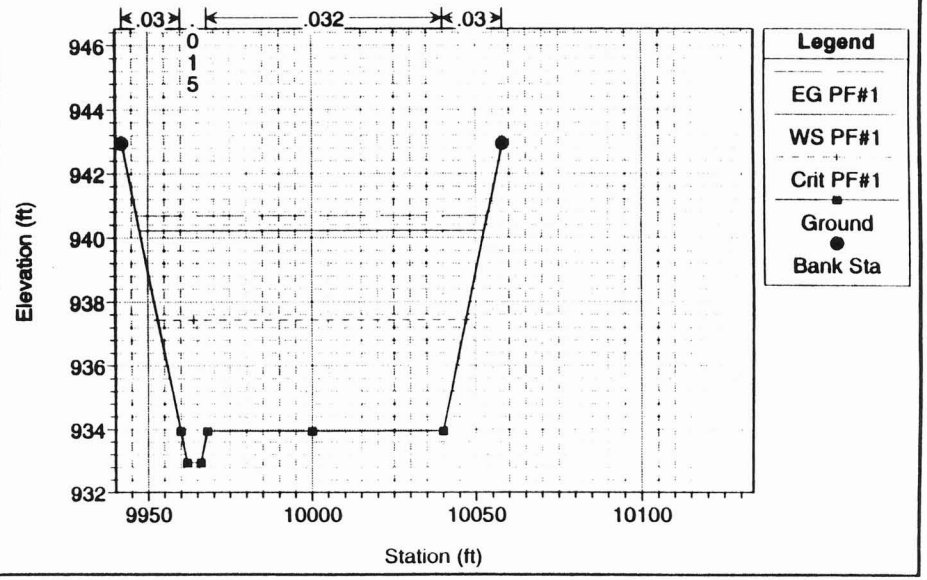
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Seciton C2 RS = 11100



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

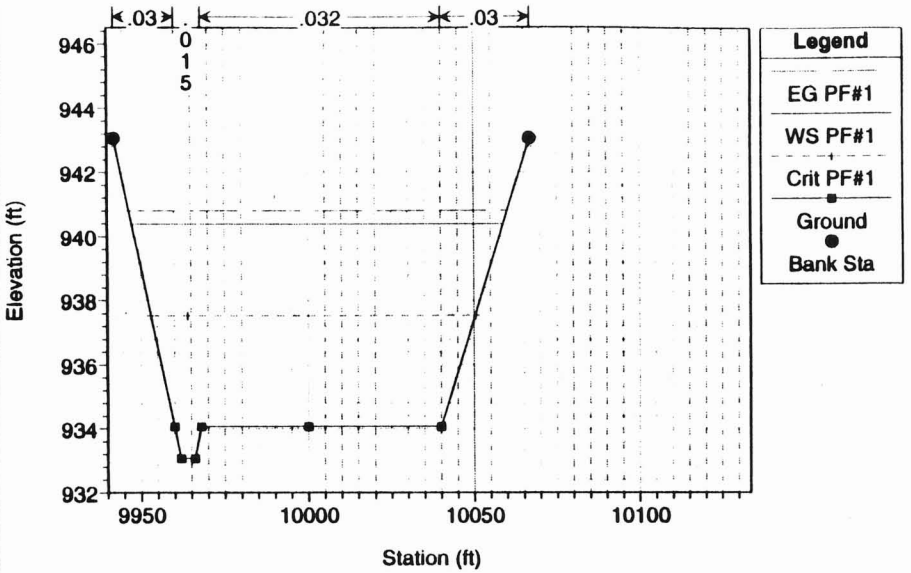
Seciton C2 RS = 11200



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

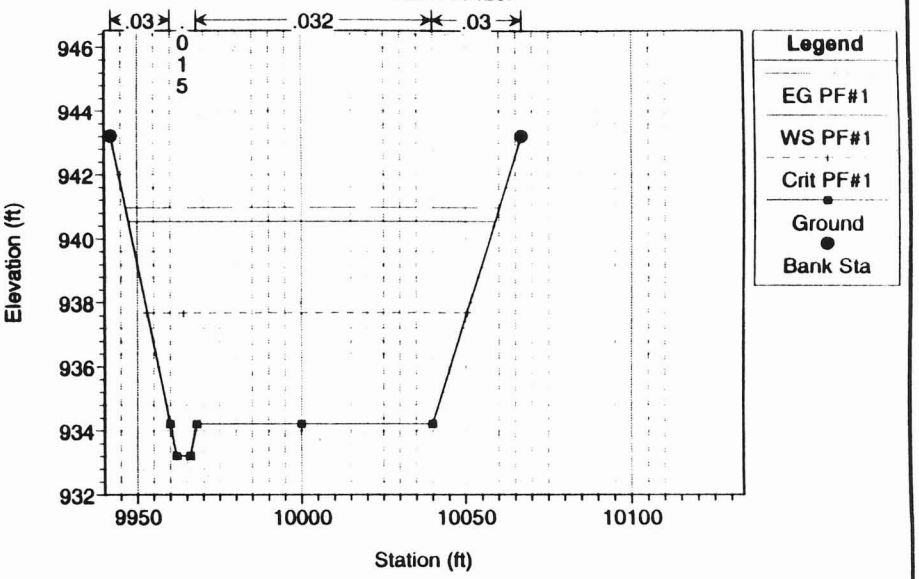
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Transition RS = 11300



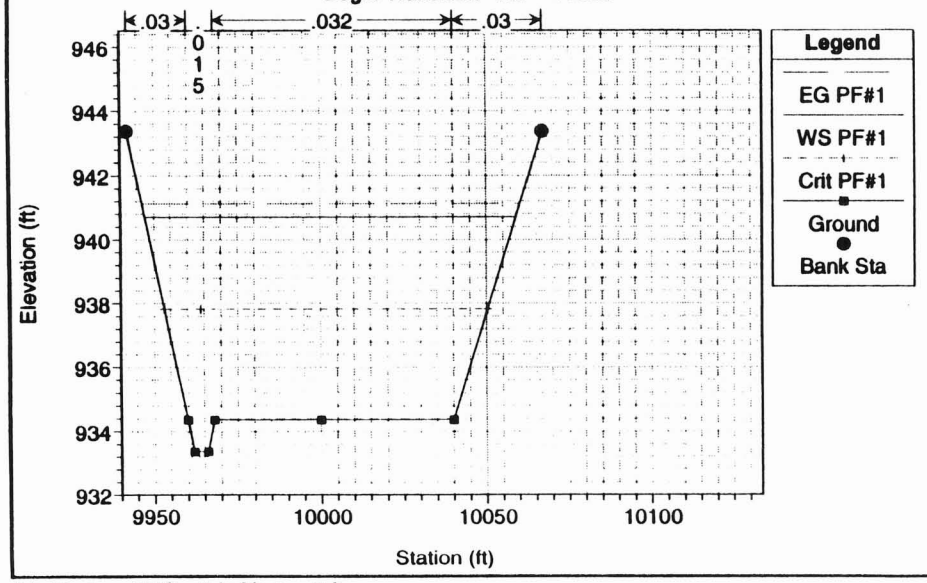
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

RS = 11425.*



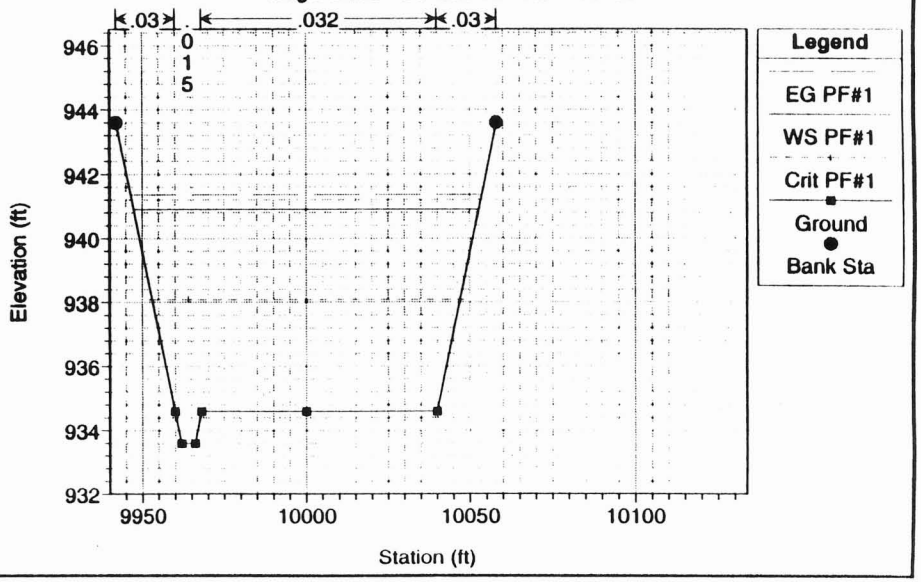
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Transition RS = 11550



Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

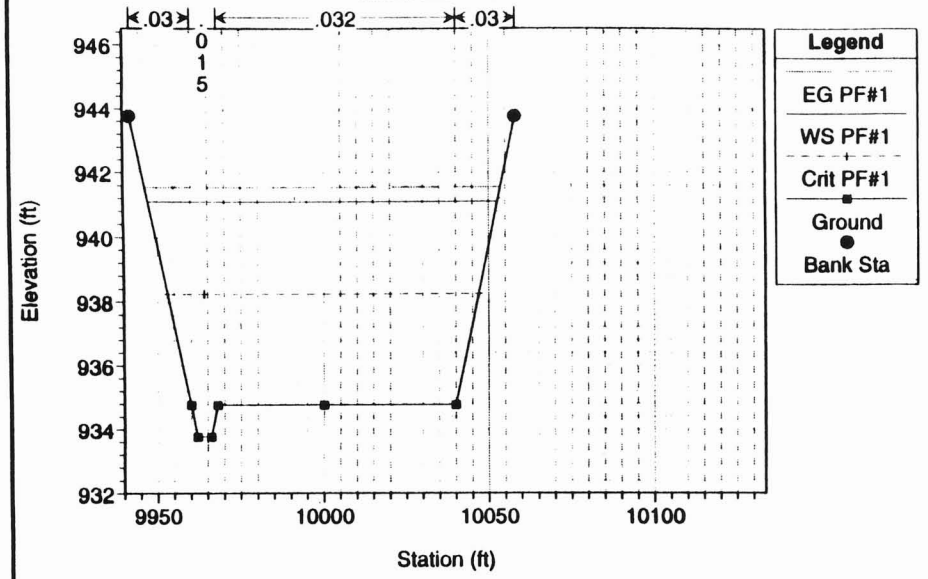
Begin Bend - Seciton C2 RS = 11735



1 in Horiz. = 60 ft 1 in Vert. = 6 ft

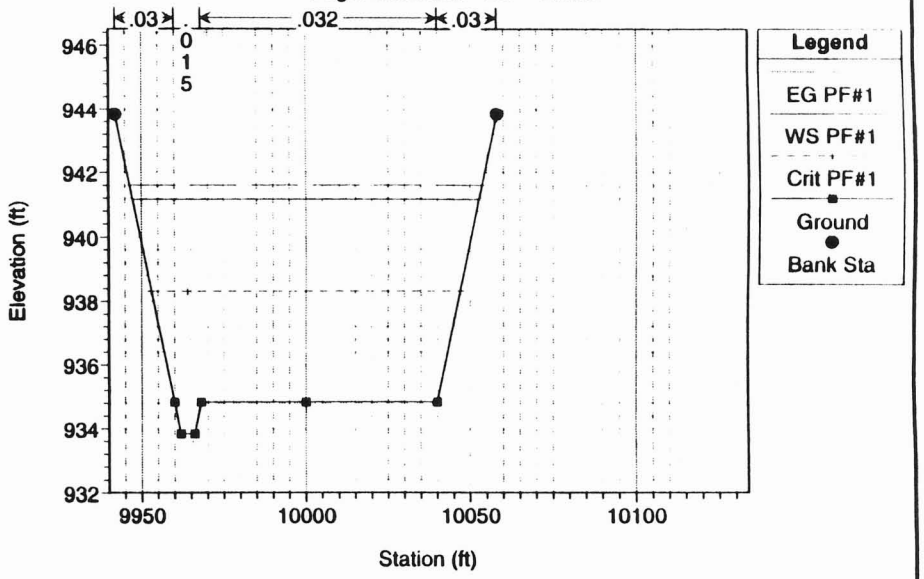
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

End Bend RS = 11883



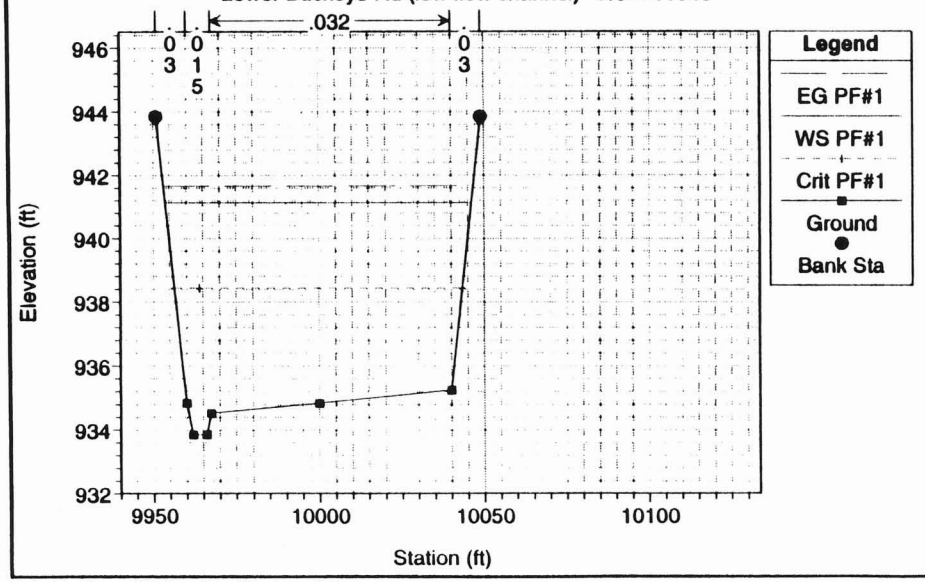
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Begin Transition RS = 11932



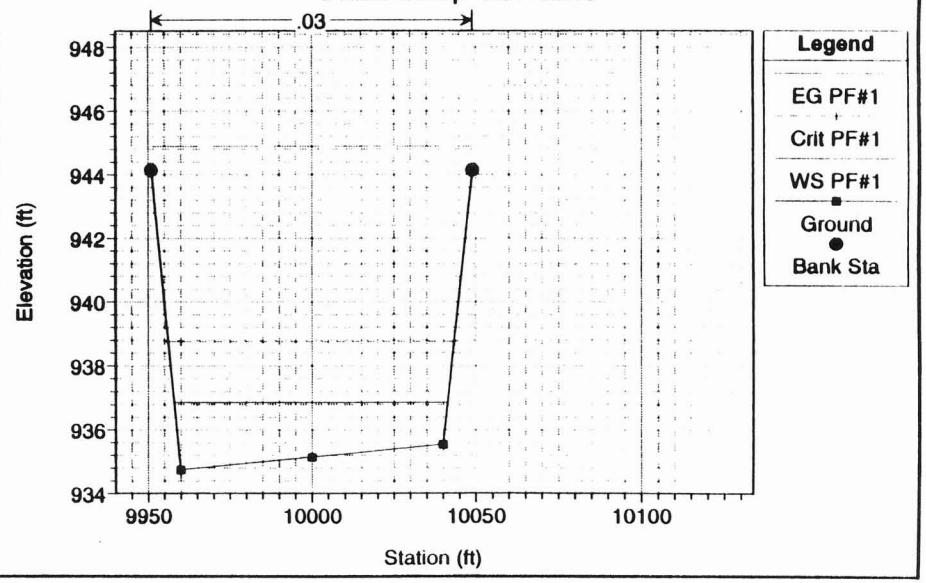
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

Lower Buckeye Rd (low flow channel) RS = 11943

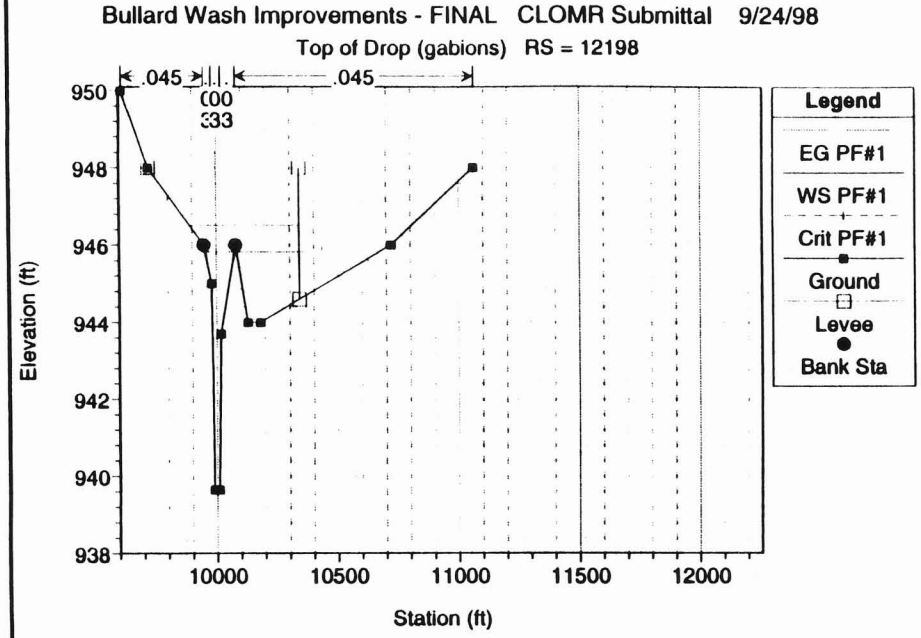


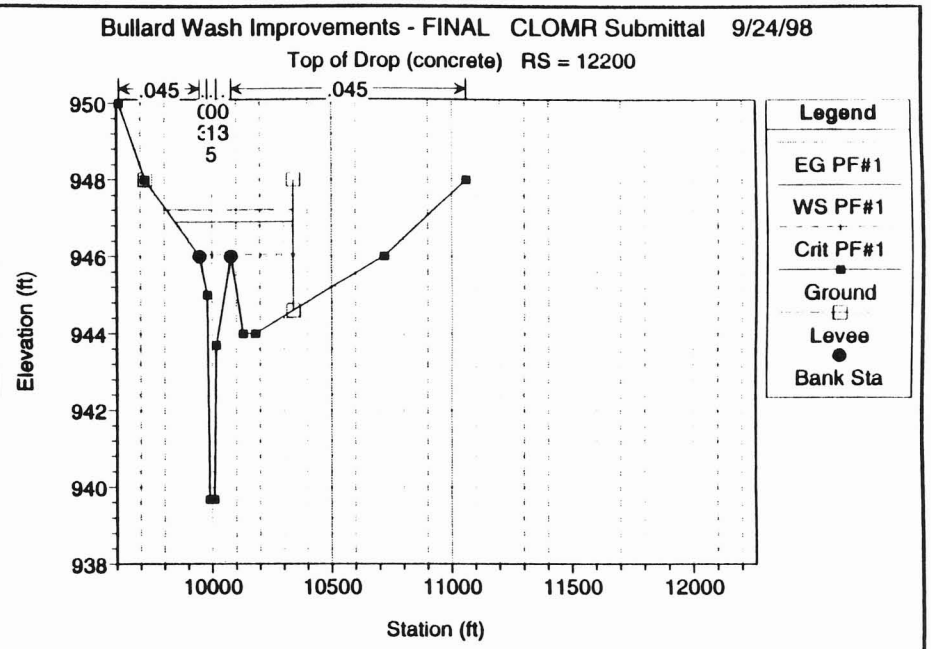
Bullard Wash Improvements - FINAL CLOMR Submittal 9/22/98

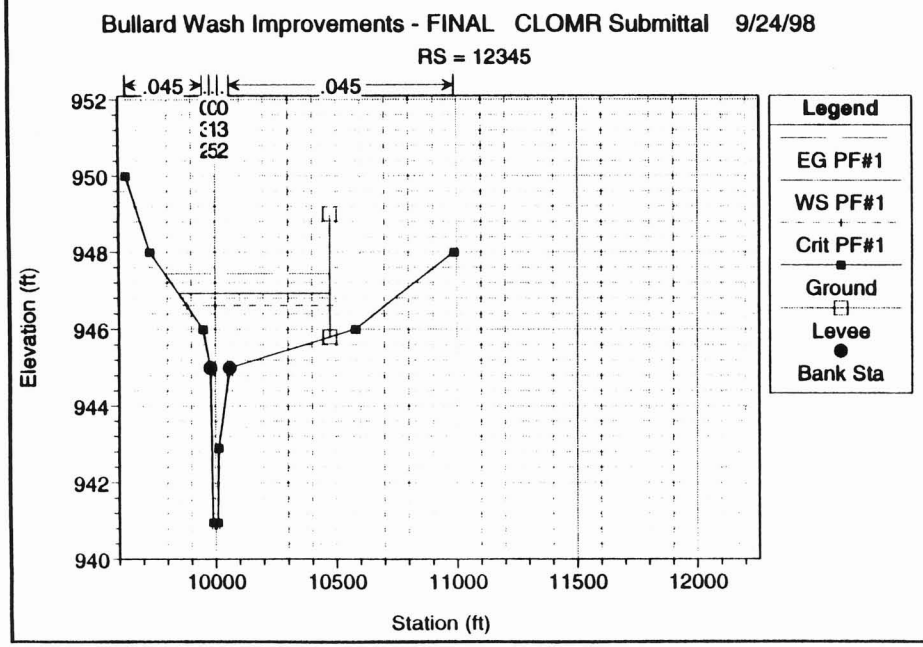
Bottom of Drop RS = 12195

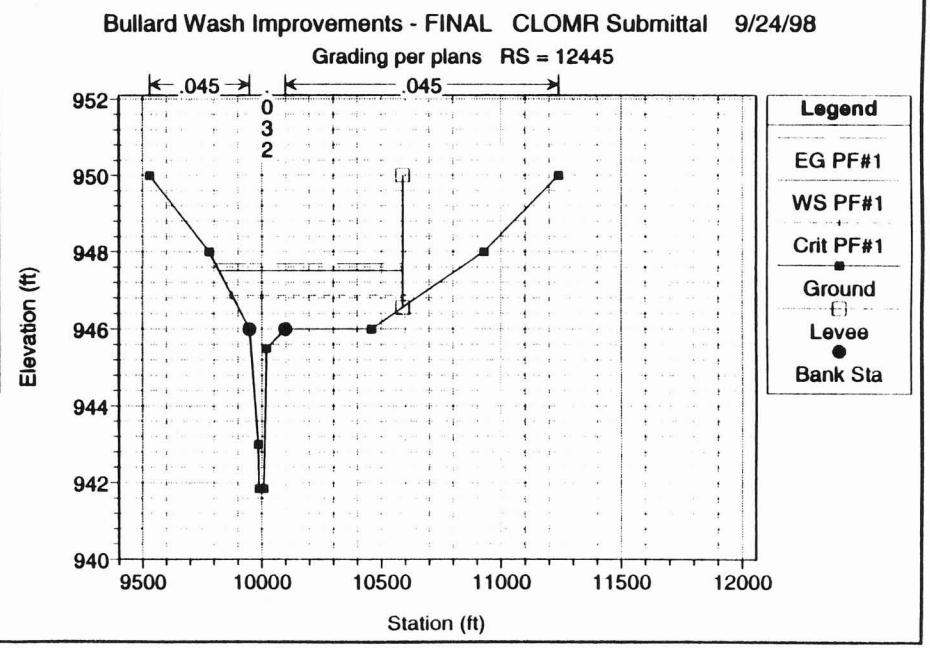


1 in Horiz. = 60 ft 1 in Vert. = 6 ft

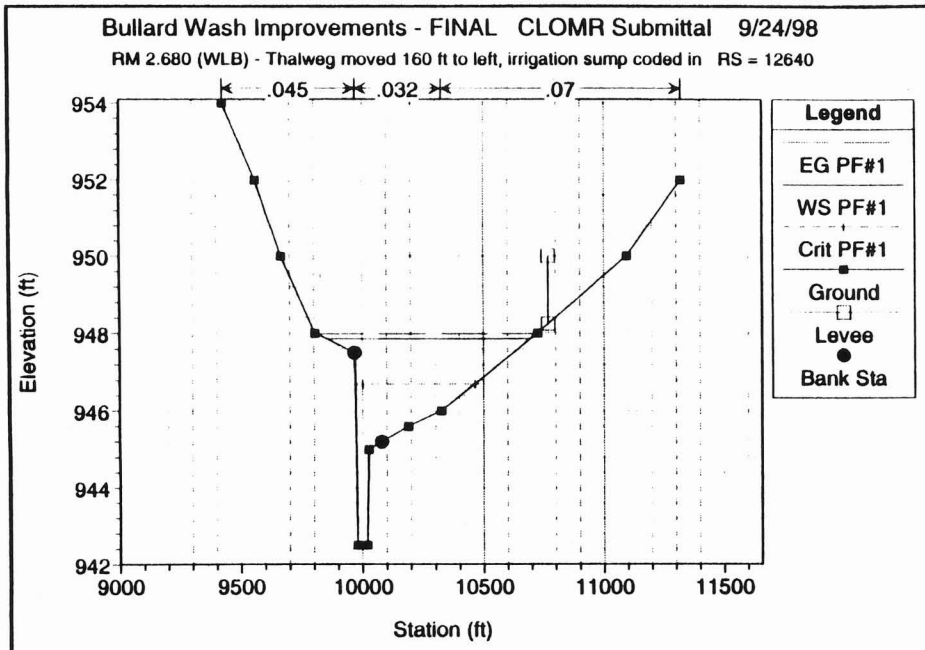


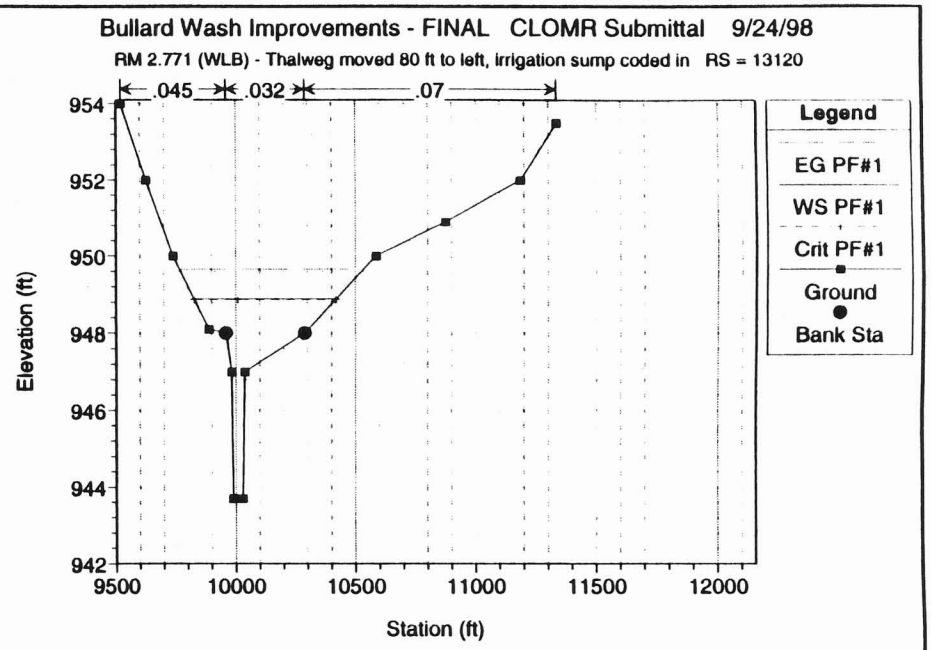


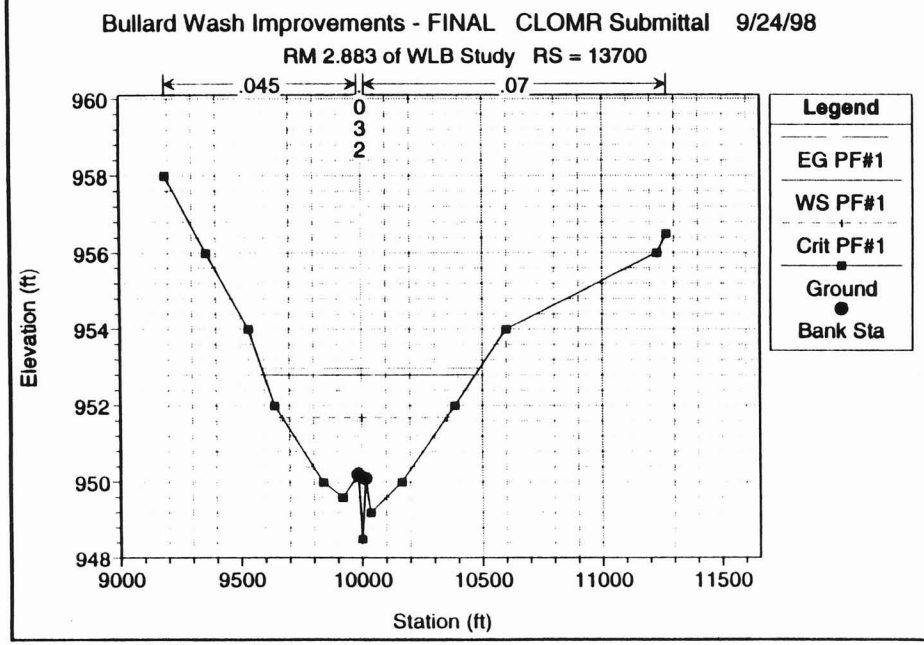




1 in Horiz. = 800 ft 1 in Vert. = 5 ft







1 in Horiz. = 800 ft 1 in Vert. = 5 ft

Appendix E3

Expansion and Contraction Coefficients

TABLE E3
Summary of Expansion and Contraction Coefficients

From Station	To Station	Channel Description	Assigned coefficients Contraction	Assigned coefficients Expansion
25+00.00	28+60.56	Gradual transitions, box culvert outlet to Gila River	0.1	0.3
28+60.56	29+11.00	4 barrel Box Culvert under BID bypass road	0.3	0.5
29+11.00	29+95.26	Gradual transitions, sloping drop structure	0.1	0.3
29+95.26	30+02.33	Expansion / transition from BID overchute to sloping drop	0.3	0.5
30+02.33	30+64.67	Gradual transitions, BID Overchute	0.1	0.3
30+64.67	30+88.94	Contraction / transition from trap channel to BID overchute	0.3	0.5
30+88.94	72+47.00	Gradual transitions, MC 85 Bridge to Overchute transition	0.1	0.3
72+47.00	72+80.00	Expansion / transition D/S of MC 85 bridge	0.3	0.5
72+80.00	80+80.00	Gradual transitions, sloping drop structure & bridges	0.1	0.3
80+80.00	81+00.00	Contraction / transition U/S of sloping drop structure	0.3	0.5
81+00.00	119+32.00	Gradual transitions, Lower Buckeye Rd to U/S of bridges	0.1	0.3
119+32.00	126+40.00	Channel inlet area to Lower Buckeye Road	0.3	0.5
126+40.00	137+00.00	Gradual transitions, U/S of inlet area	0.1	0.3

References: Flood Control District of Maricopa County, Drainage Design Manual - Volume II, Hydraulics, January 1996
US Army Corps of Engineers, HEC-2 Water Surface Profiles User's Manual, September 1990

Appendix E4

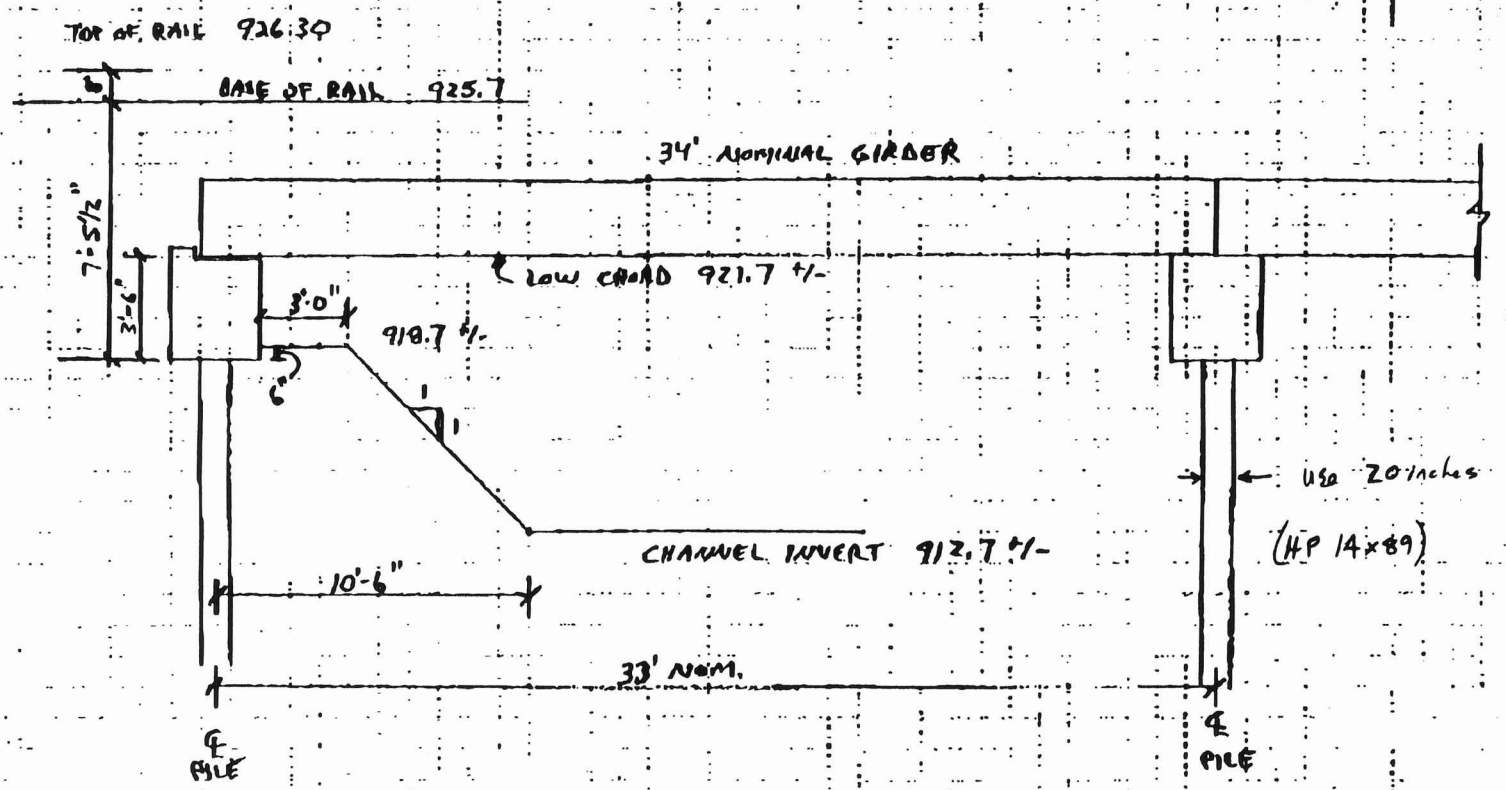
Analysis of Structures

There are not any separate hydraulic modeling of structures within this study reach. Refer to Appendix E5 for HEC-RAS analysis of structures.

UNION PACIFIC RAILROAD

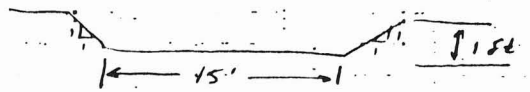
FORM 24000 (Rev. 3-94)
OFFICE OF V.P. ENGINEERING
OMAHA, NEBRASKA

PROJECT: BR. 887.30 PHOENIX LINE
SHEET NUMBER ____ OF ____ W.O. ____
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
FILE NUMBER ____



100'
-21
79

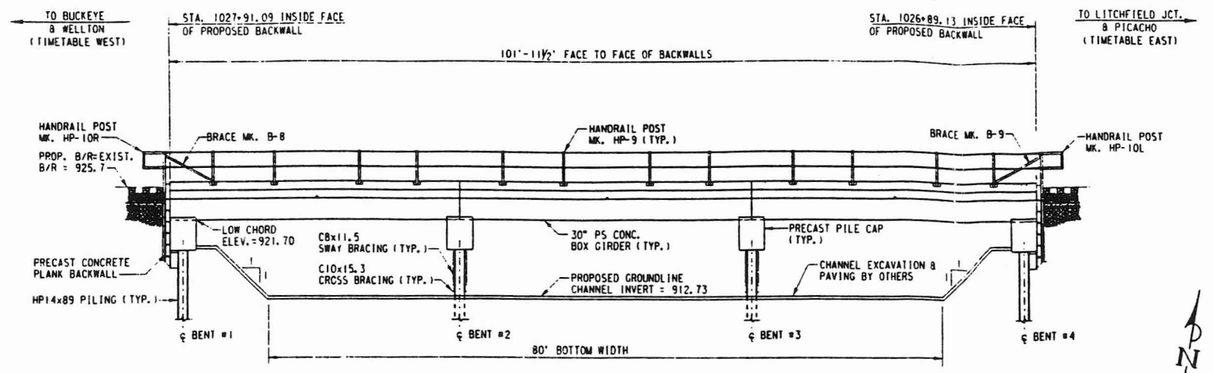
Equestrian Path in West bay of RR bridge for 10' clearance.



NOTES:

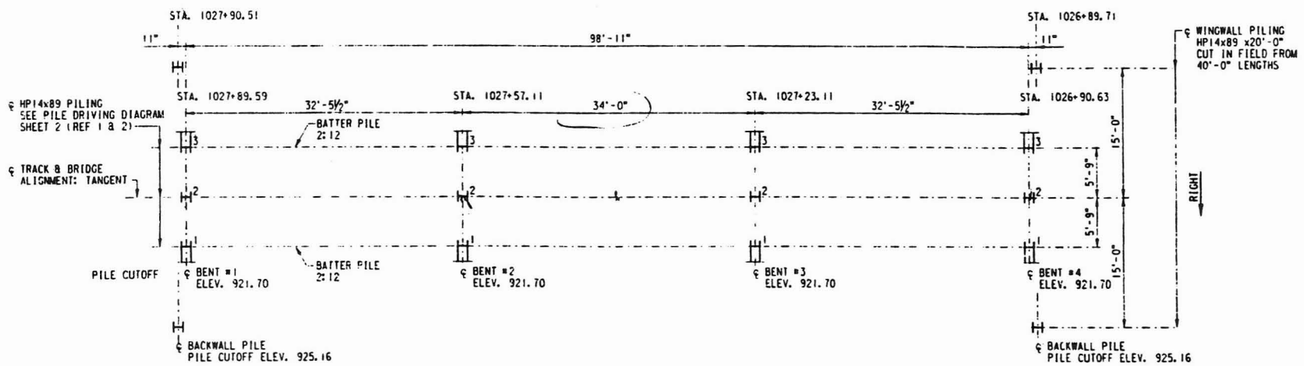
TO: BRAD OLBERT

FROM: GARY VOGEL



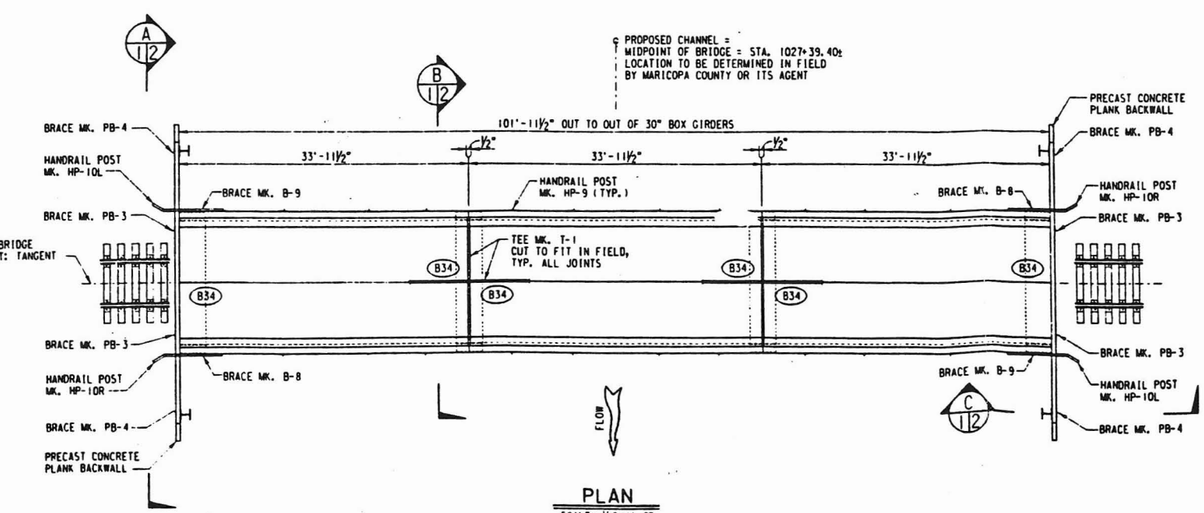
ELEVATION

SCALE: ⅛"=1'-0"



PILE LAYOUT

SCALE: ⅛"=1'-0"
(AT PILE CUTOFF ELEVATION)



PLAN

SCALE: ⅛"=1'-0"

BILL OF MATERIAL

	REQ'D	UNIT	DESCRIPTION	STORE ITEM NO.	ORDERED BY
PRECAST CONCRETE	6	EA.	30"x33'-11½" PRESTRESSED CONCRETE BOX GIRDER MK. B34, TYPE 1 W/ CURB, WITH 65 ½" DIA. 270 KSI STRANDS (REF. 3 & 4)	511-0141	MANAGER STRUCTURAL PROJECTS
	3	EA.	3'-0"X3'-6"X16'-0" PRECAST CONCRETE PILE CAP (REF. 5)	511-0475	
	4	EA.	6"X1'-10"X 6'-6" PRECAST CONCRETE BACKALL PLANK (REF. 6)	511-0206	
	4	EA.	6"X1'-4"X 12'-0" PRECAST CONCRETE BACKALL PLANK (REF. 6)	511-0202	
	4	EA.	6"X1'-4"X 16'-0" PRECAST CONCRETE BACKALL PLANK (REF. 6)	511-0204	
PILING	26	EA.	HP14X89X40'-0" STEEL PILING (PLAIN, REF. 1 & 2)	510-7556	
	12	EA.	PILE SPLICER FOR HP14X89 STEEL PILE, PER DETAIL SHEET NO. 1	510-8051	
STEEL BRACING	4	EA.	C8X11.5X13'-0" SWAY BRACE (A36, PLAIN)	247-6367	
	4	EA.	C10X15.3X13'-6" CROSS BRACE (A36, PLAIN)	247-6649	
	24	EA.	HANDRAIL POST MK. HP-9 (GALV., PER DETAIL, REF. 8)	513-2020	
	2	EA.	HANDRAIL POST MK. HP-10L (GALV., PER DETAIL, REF. 7)	513-2040	
	2	EA.	HANDRAIL POST MK. HP-10R (GALV., PER DETAIL, REF. 7)	513-2050	
	2	EA.	BRACE MK. PB-3 (GALV., PER DETAIL, REF. 10)	513-0600	
	2	EA.	BRACE MK. PB-4 (GALV., PER DETAIL, REF. 10)	513-0610	
	2	EA.	BRACE MK. B-8 (GALV., PER DETAIL, REF. 9)	513-0540	
	2	EA.	BRACE MK. B-9 (GALV., PER DETAIL, REF. 9)	513-0550	
MISC. STEEL, WIRE ROPE & FASTENERS	9	EA.	¾" DIA. X 1¾" A325 HVY. HEX BOLT, TYPE 1 W/ HVY. HEX NUT (A563, LUBRICATED) AND FLAT CIRCULAR WASHER (F436), EACH COMPONENT HOT DIP OR MECHANICALLY ZINC COATED	513-1168	
	50	EA.	¾" DIA. X 11" A307 HVY. HEX GRADE A BOLT, W/ HVY. HEX ELASTIC LOCKNUT (MIL-N-25027) & FLAT CIRCULAR WASHER (F436), EA. COMPONENT HOT DIP OR MECHANICALLY ZINC COATED	134-6585	
	9	EA.	¾" DIA. X 8" A307 HVY. HEX GRADE A BOLT, W/ HVY. HEX ELASTIC LOCKNUT (MIL-N-25027) & FLAT CIRCULAR WASHER (F436), EA. COMPONENT HOT DIP OR MECHANICALLY ZINC COATED	134-6552	
	5	EA.	¾" DIA. X 9" A307 HVY. HEX GRADE A BOLT, W/ HVY. HEX ELASTIC LOCKNUT (MIL-N-25027) & FLAT CIRCULAR WASHER (F436), EA. COMPONENT HOT DIP OR MECHANICALLY ZINC COATED	134-6554	
	424	LIN. FT.	⅜" NOMINAL DIAMETER WIRE ROPE, 7 WIRE, GALV. STEEL STRAND, SIEMENS MARTINS GRADE, A-COATING (4 - 106' LENGTHS)	050-5394	
	70	EA.	GALV. MALLEABLE IRON U-BOLT W/ 2 ELASTIC LOCKNUTS (MIL-N-25027), ZINC PLATED, FOR ⅜" DIA WIRE ROPE	050-6370	
	8	EA.	HEAVY PATTERN - HEAVY DUTY GALV. CARBON STEEL WIRE ROPE THIMBLE (ZINC PLATED) FOR ⅜" DIA. WIRE ROPE	050-7821	
	8	EA.	½" DIA. EYEBOLT, 2" LONG SHANK WITH 1" I.D. EYE, PLAIN PATTERN, GALV., DROP FORGED STEEL (A489), WITH ZINC PLATED HEX NUT (A563) & ZINC PLATED FLAT CIRCULAR WASHER (F436)	130-0370	
	15	EA.	STEEL TEE MK. T-1 (GALV., PER DETAIL, REF. 10) ASTM A569	513-6000	
	8	EA.	½"X4"X3'-0" ELASTOMERIC BEARING PAD (50 DUROMETER)	510-3640	
	12	EA.	½"X8"X6'-8" ELASTOMERIC BEARING PAD (50 DUROMETER)	510-3645	
	2	EA.	BRIDGE MARKER PER ENGINEERING STANDARDS DRAWING NO. 0507	513-0955	

EST. WT. OF PILING = 92,560 LB.
EST. WT. OF MISC. STEEL (NOT INCL. BOLTS CLIPS & WIRE ROPE) = 1,480 LB.
EST. WT. OF CROSS & SWAY BRACING = 1,425 LB.

DRAWING SCHEDULE

	SHEET NO.	DESCRIPTION
THIS SET	1	GENERAL ARRANGEMENT & BILL OF MATERIAL
	2	MISCELLANEOUS SECTIONS, DETAILS & TOP OF RAIL PROFILE

	NO.	DWG. NO.	SHEET NO.	REV. NO.	DESCRIPTION
REF.	1	104537	-	-	HP14x89 STEEL PILE
	2	104552	-	-	HP14x89 STEEL TEMPLATE DETAILS
	3	114915	1	-	30" DP. PRESTRESSED CONC. DBL. BOX GIRDER
	4	114915	2	-	30" DP. PRESTRESSED CONC. DBL. BOX GIRDER
	5	104258	3	3	STEEL PILE PRECAST ABUT. FOR 30" BOX GIRDERS
	6	114258	8	2	STEEL PILE PRECAST CAP FOR 30" BOX GIRDERS
	7	114268	1	1	END HANDRAIL POST DETAILS
	8	114268	2	3	INTERIOR HANDRAIL POST DETAILS
	9	114268	3	3	HANDRAIL POST BRACING DETAILS
	10	114268	5	4	MISCELLANEOUS STEEL DETAILS

CONSTRUCTION NOTES

GENERAL:

Field verify all dimensions, stations and elevations prior to start of construction.

For information on, and relocation of, fiber optic cable call 1-800-336-3193.

SITE LAYOUT INFORMATION:

Rail raise: No change in mainline elevation.

Track Alignment: Field verify prior to start of construction

Elevations taken from drawings Titled "BULLARD WASH CHANNEL, FINAL: DESIGN" as prepared by Sverdrup Corporation 2-5-98.

Rail stationing based on stationing of the west backwall of Bridge no. 887.39 as shown on the UPRR Right-Of-Way And Track Map. (Sta. 1025+34.6)

Right Of Way: 100' Right of track centerline
100' Left of track centerline

PILE DRIVING:

All numbered pile shall be driven to 120 ton capacity. If any numbered pile cannot be driven to this capacity the Office Of Chief Engineer Structures must be notified.

FIELD WELDING:

Welding must be accomplished with the SMAW Process. Welding must be in compliance with the requirements specified in AWS D1.5-95, except ⅜ in. fillet welds may be made with a single pass. Welding electrodes must be E7018. Welders must possess valid certification.

DESIGN NOTES

This structure was designed for Cooper E80 Live Load with 30" ballast and impact.

Design Pile Load: End Bent = 77 Ton
Interior Bent = 120 Ton

LETTER SERIES
SHEET NO. CUT ON
SHEET NO. SHOWN ON

SECTION DESIGNATION

EST. WT. OF CONC. BOX GIRDER

NO.	DATE	REVISIONS
		MK. B-34 = 38,500 LBS (19.3 TONS)
	/ /	
	/ /	
	/ /	
	/ /	

SP ROUTE SYMBOL R

UNION PACIFIC RAILROAD — OFFICE OF CHIEF ENGINEER DESIGN

LOCATION: BRIDGE 887.34 GILA (PHOENIX) SUB. 2.0 MILES WEST OF LITCHFIELD, AZ.

FACILITY: 3 SPAN 34' x 30" DEEP DOUBLE BOX GIRDER B.D.

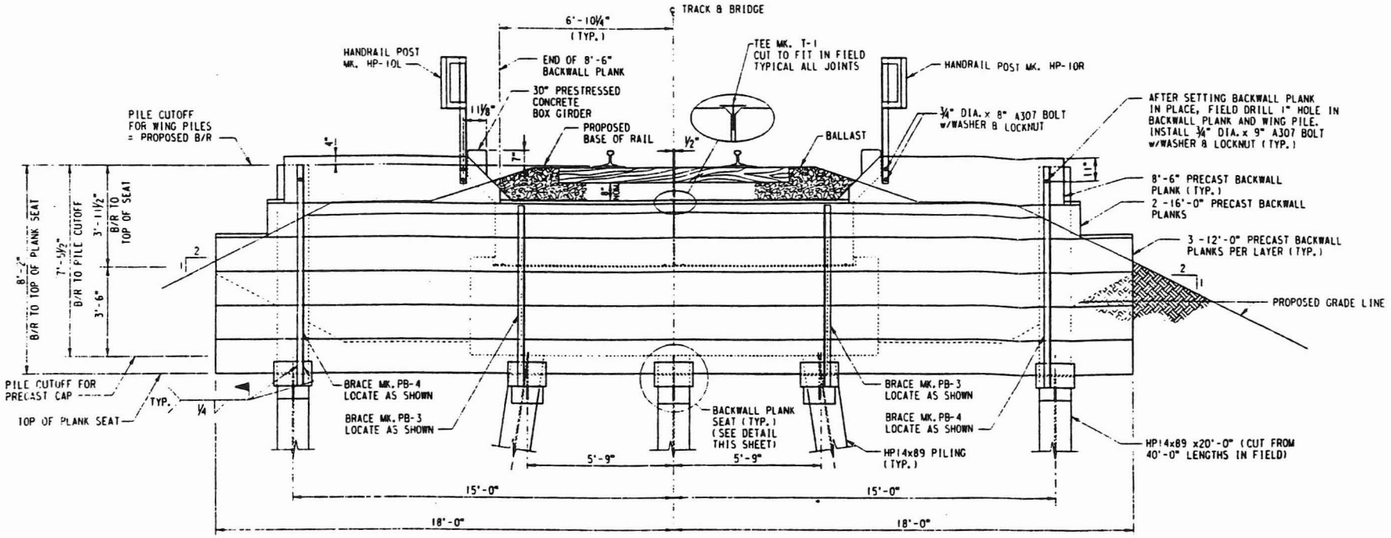
DWG. TITLE: GENERAL ARRANGEMENT & BILL OF MATERIAL

WORK ORDER: 79264
ENGR JOB NO: 001
DESIGN BY: GEV
CHECKED BY: GEV
DRAWN BY: RRC
CHECKED BY: GEV
SCALE: ⅛"=1'-0" AS SHOWN

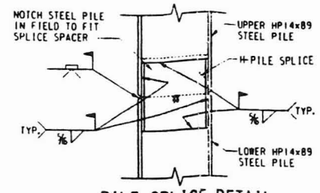
DWG. SEQUENCE: 1 of 2

C.E. NUMBER: 115073

APPROVED: FOR CHIEF ENGINEER DESIGN — 16 June 1998 DATE



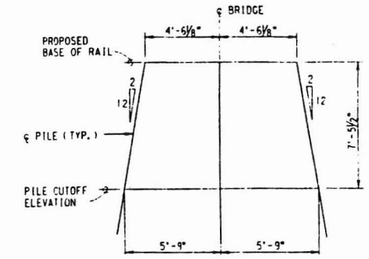
SECTION A 1/2
SCALE: ⅛" = 1'-0"



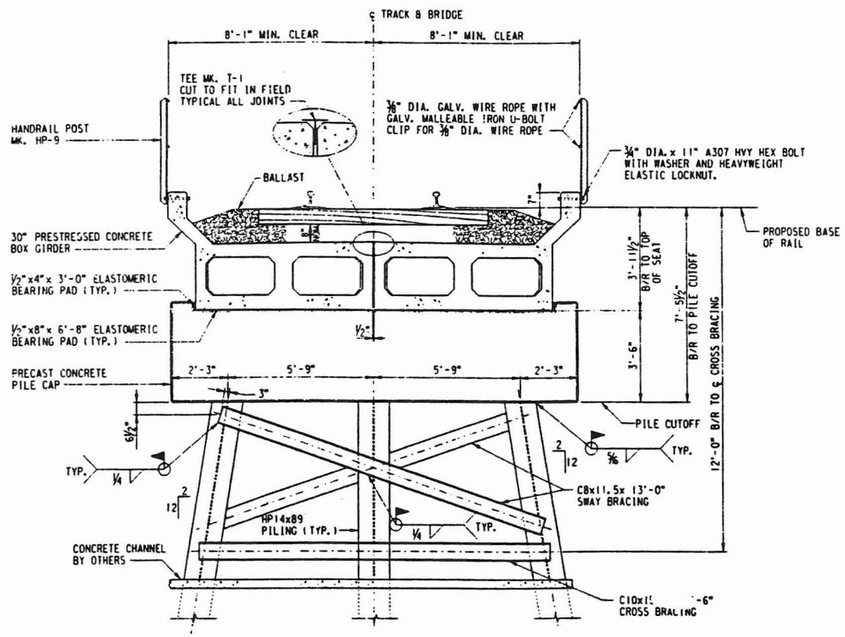
PILE SPLICE DETAIL
SCALE: ⅜" = 1'-0"

PILE SPLICING:
PILE SPLICE FOR HP14X89 INSTALLATION INSTRUCTIONS:

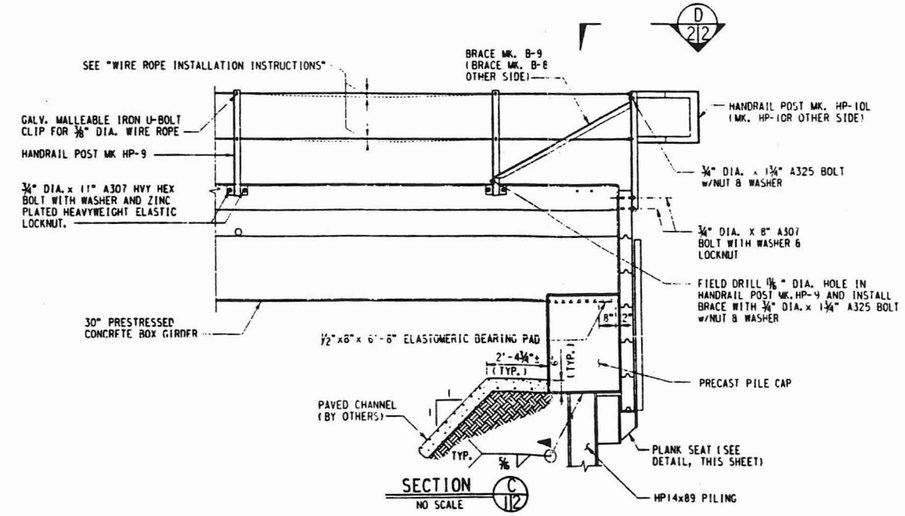
1. NOTCH THE END OF UPPER LENGTH OF H-PILE (TO ACCOMODATE THE SPACER BAR).
2. FIT SPLICE OVER NOTCHED END OF UPPER H-PILE, AND WELD IN PLACE.
3. PLACE THE UPPER SECTION INTO POSITION ON THE LOWER SECTION.
4. TO COMPLETE THE SPLICE, WELD SPLICE TO LOWER H-PILE AND WELD FLANGES AS SHOWN.



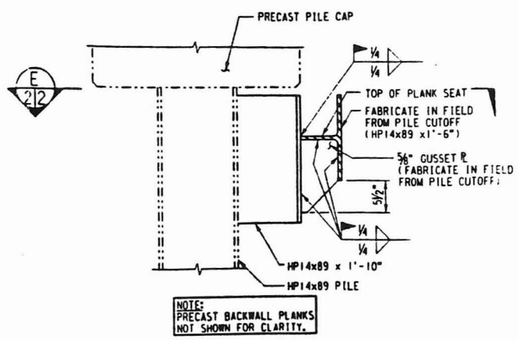
3 PILE DRIVING DIAGRAM
BENTS # 1 THRU # 4
NO SCALE



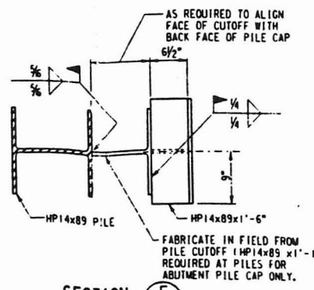
SECTION B 1/2
NO SCALE



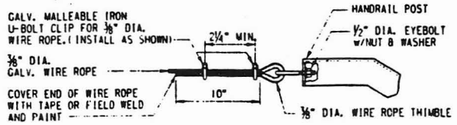
SECTION C 1/2
NO SCALE



PLANK SEAT DETAIL
NO SCALE



SECTION E 2/2
NO SCALE



VIEW D 2/2
SCALE: 1½"=1'-0"

WIRE ROPE INSTALLATION INSTRUCTIONS:

1. THREAD WIRE ROPE THROUGH ALL CLIPS AND TIGHTEN CLIPS AND EYEBOLTS ON ONE END HANDRAIL POST.
2. AFTER INSTALLING BRACES, STRETCH WIRE ROPE, HANG A MINIMUM OF 10 LBS. ON CABLE BETWEEN TWO POSTS, AND REMOVE ALL SAG TO A MAXIMUM OF 2 INCHES.
3. TIGHTEN CLIPS & EYEBOLTS AT REMAINING END HANDRAIL POST.
4. REMOVE WEIGHTS.
5. TIGHTEN CLIPS AT INTERMEDIATE POSTS.

NO.	DATE	REVISIONS
	/ /	
	/ /	
	/ /	
	/ /	

SP ROUTE SYMBOL R

UNION PACIFIC RAILROAD — OFFICE OF CHIEF ENGINEER DESIGN

LOCATION: BRIDGE 887.34 GILA (PHOENIX) SUB. 2.0 MILES WEST OF LITCHFIELD, AZ.

FACILITY: 3 SPAN 34' x 30" DEEP DOUBLE BOX GIRDER B.D.

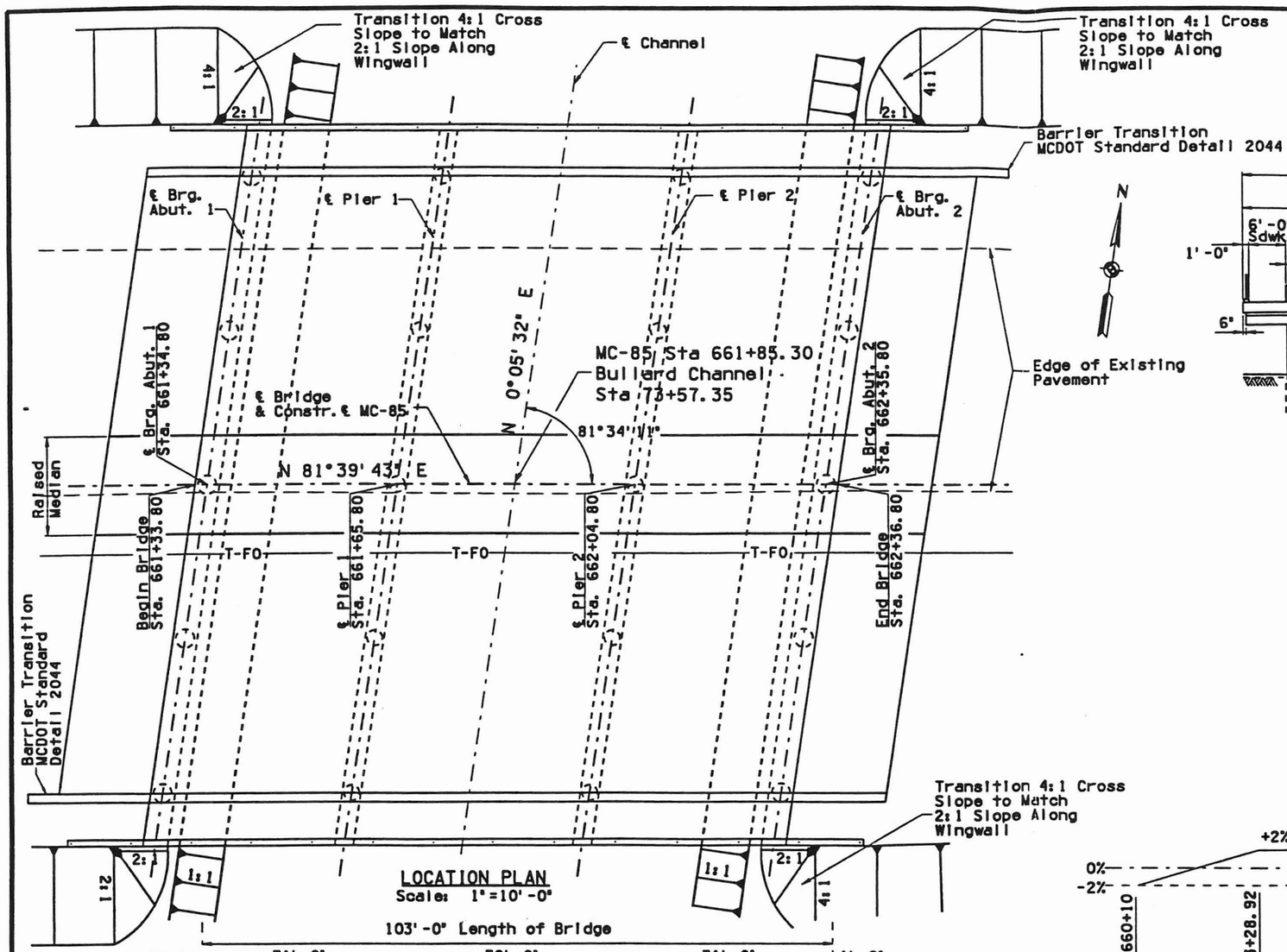
DWG. TITLE: MISCELLANEOUS SECTIONS AND DETAILS

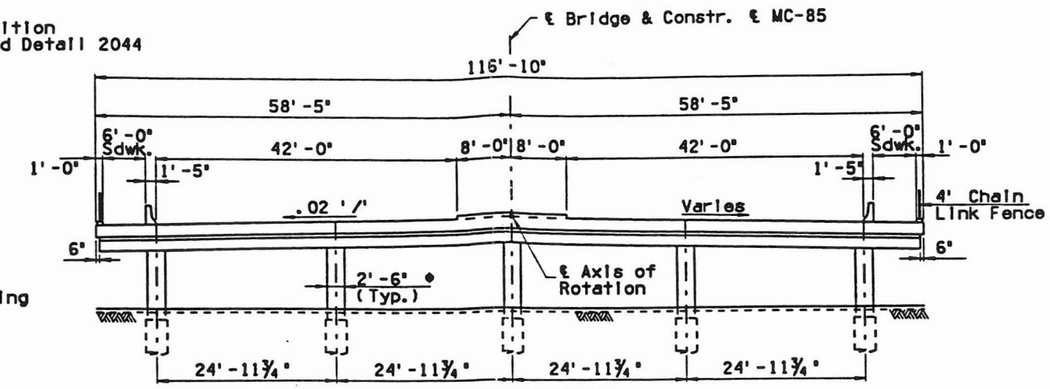
WORK ORDER: 29264
ENGR. JOB NO: 001
DESIGN BY: GEV
CHECKED BY: GEV
DRAWN BY: KDF
CHECKED BY: GEV
SCALE: AS SHOWN

DWG. SEQUENCE: 2 of 2
U.E. NUMBER: 115073

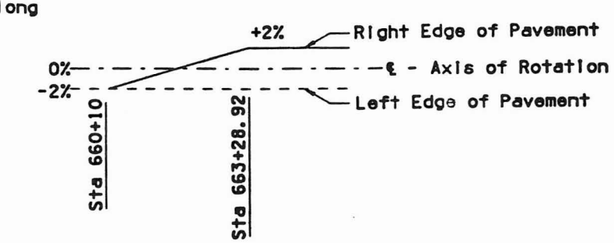
APPROVED: FOR CHIEF ENGINEER DESIGN — 16 June 1986 DATE

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.	68877	106	150	

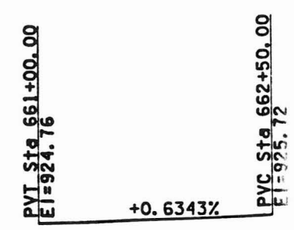




TYPICAL SECTION
Scale: 1"=10'-0"



SUPERELEVATION DIAGRAM



PROFILE GRADE

SHEET LIST

TITLE	NO.
General Plan	106
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NO.	REVISION	BY	DATE
1			
2			
3			

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION

ESTRELLA PARKWAY
BUCKEYE CANAL TO ELWOOD STREET
PROJECT NO. 68877

PRELIMINARY NOT FOR CONSTRUCTION

	BY	DATE
DESIGNED	C. RODRIGUEZ	8/27/98
DRAWN	R. SHISHIDO	8/27/98
CHECKED	J. FISCHER	8/27/98

Sverdrup CORPORATION

MC-85 BULLARD WASH BRIDGE
GENERAL PLAN

SHEET OF 106 150

TRACS NO.

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Plotted by: shishidr Date: 15-SEP-1998 09:26

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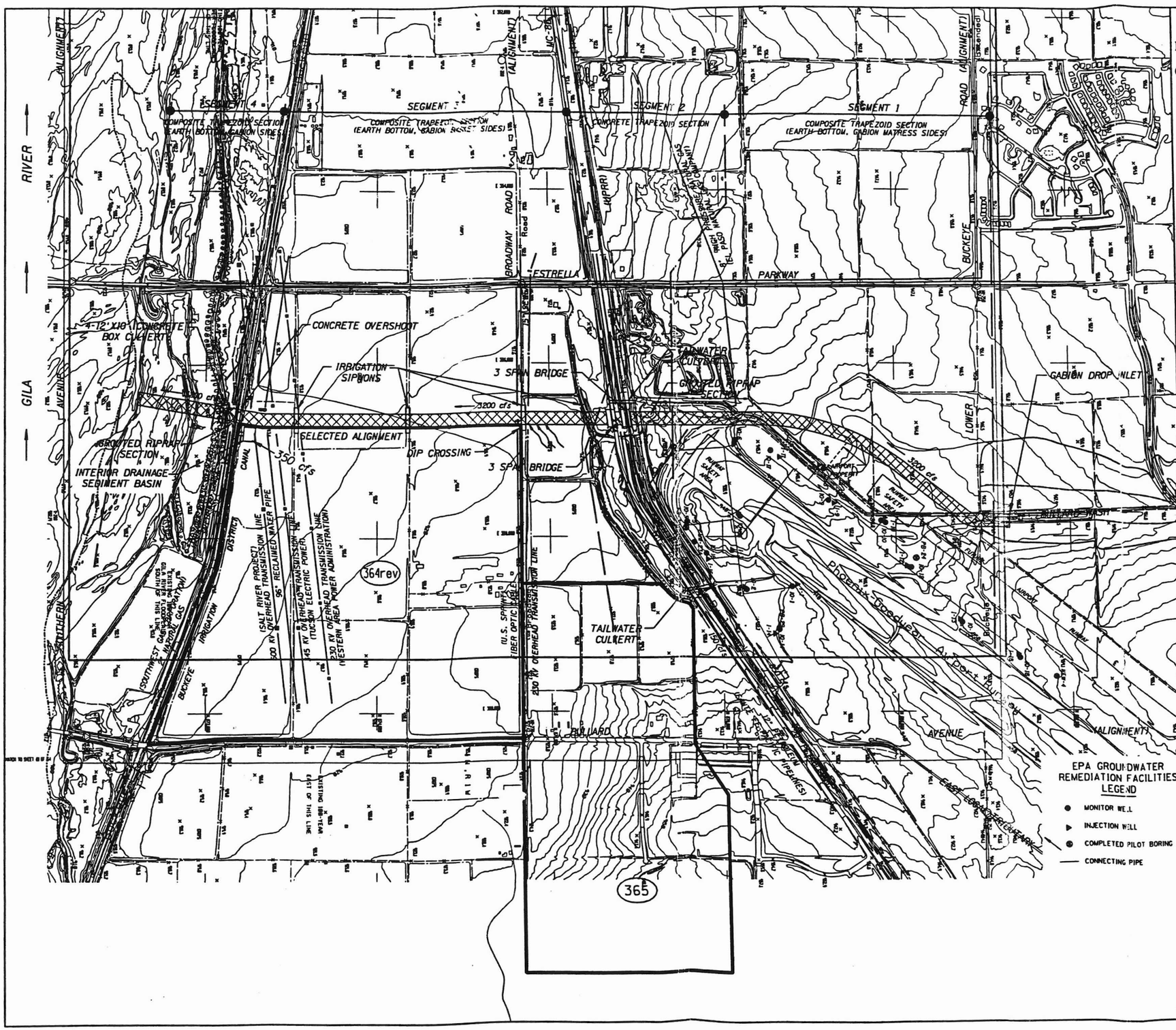


BULLARD WASH OUTFALL CHANNEL IMPROVEMENTS

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CONTRACT FCD #95-39

NOTES:

1. CHANNEL ALIGNMENTS ARE ILLUSTRATIVE AND DO NOT REPRESENT ACTUAL WIDTH.
2. DESIGN DISCHARGES ARE BASED ON WHITE TANKS/AGUA FRIA ADMS HEC-1 MODEL BY THE WLB GROUP REVISED BY STANLEY CONSULTANTS TO REFLECT FUTURE DYSART DRAIN AND WHITE TANKS #2 FLOOD CONTROL PROJECTS.

LEGEND

- SELECTED CHANNEL ALIGNMENT LOCATION
- CULVERT OR BRIDGE
- 3200 cfs — DESIGN DISCHARGE AND FLOW DIRECTION
- SEGMENT LIMITS
- OVERHEAD ELECTRIC (WITH SELECTED POLES\TOWERS)
- FIBER OPTIC CABLE (U.S. SPRINT) — UTILITY / UTILITY OWNER
- CORPS 404 WATERS OF THE U.S. JURISDICTIONAL LIMIT
- BULLARD WASH OR LOCALIZED FLOODPLAIN LIMIT
- BULLARD WASH FLOODWAY LIMIT
- SUB BASIN BOUNDARY
- 365 — SUB BASIN ID

N

400 200 0 400 800 1200

CONTOUR INTERVAL=2'

BASE MAP: WHITE TANKS/AGUA FRIA ADMS AND BULLARD WASH OUTFAL FEASIBILITY STUDY

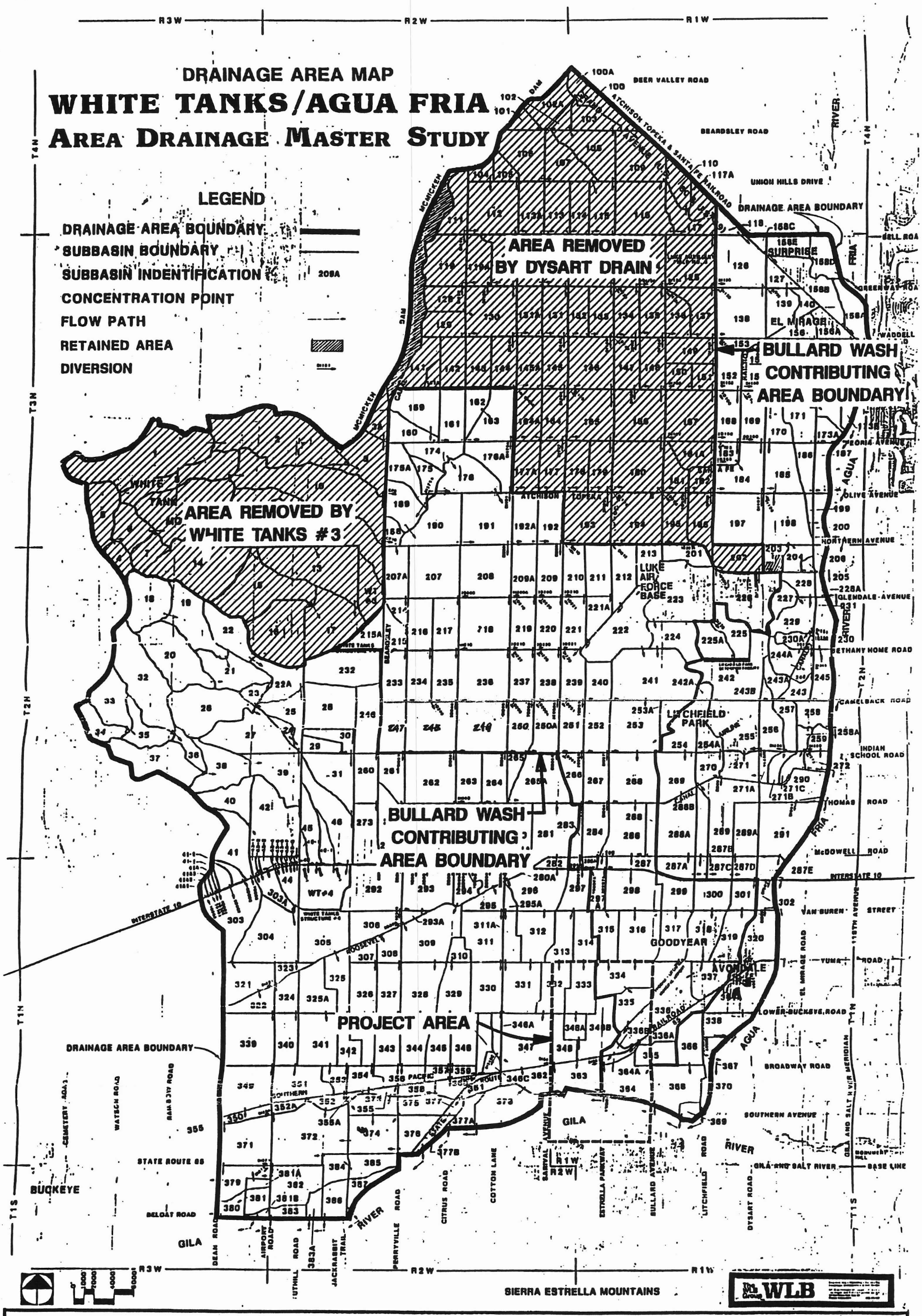
MAPPING COMPANY: COOPER AERIAL OF PHOENIX INC. FLIGHT DATE 12-22-89

EXHIBIT A

SURFACE DRAINAGE MAP FOR INTERRIOR SEDIMENT BASIN

WOOD, PATEL & ASSOCIATES, INC.
1550 EAST MISSOURI, SUITE 203
PHOENIX, ARIZONA (602) 234-1344

DES. J.K.M.	CKD. A.C.P.
DRN. T.Y.	APP.
DATE 4-29-98	
SHEET 1 OF 1	
DWG.	
PROJ. NO. 96-464	



ORIGINAL WHITE TANKS/AGUA FRIA ADMS DRAINAGE AREA

BULLARD WASH OUTFALL FEASIBILITY STUDY CONTRIBUTING AREA

BULLARD WASH OUTFALL FEASIBILITY STUDY PROJECT AREA

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FCD 94-06

STANLEY CONSULTANTS, INC.
2929 EAST CAMELBACK ROAD, SUITE 190
PHOENIX, ARIZONA 85016
(602) 912-6500

FIGURE 3

Appendix E5

Hydraulic Calculations for Bullard Wash Outfall Channel

This appendix contains HEC-RAS output tables and water surface profile plots for the mixed flow analysis of this study reach. Refer to the diskette holder for an electronic copy of the HEC-RAS model.

This appendix also contains:

- Freeboard considerations
- Hydraulic jump calculations
- Drop inlet weir flow calculations for the channel inlet area north of Lower Buckeye Road.

TABLE E5.1
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Final Hydraulic Profile (100-yr Q) for sub & supercritical flow conditions
Bullard Wash from Gila River to Lower Buckeye Road

Profile Output Table - Standard Table 1

HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel Run Date: 24-Sep-98

Reach	River Sta	Q Total (ft/sec)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/sec)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Outfall Channel	2500.00	3200.00	900.69	906.58	904.30	907.20	0.002001	6.33	505.71	91.78	0.48
Outfall Channel	2660.00	3200.00	901.02	906.90	904.63	907.52	0.002012	6.34	504.81	91.76	0.48
Outfall Channel	2860.56	3200.00	901.42	907.30	905.03	907.92	0.002008	6.33	505.14	91.76	0.48
Outfall Channel	2877.74	3200.00	901.45	906.45	906.38	908.87	0.003534	12.49	256.13	51.29	0.99
Outfall Channel	2901.4	Culvert									
Outfall Channel	2901.49	3200.00	901.50	909.45	906.43	910.41	0.000565	7.85	407.69	51.34	0.49
Outfall Channel	2911.00	3200.00	901.97	909.93	906.59	910.52	0.002140	6.19	517.19	76.95	0.42
Outfall Channel	2995.26	3200.00	906.15	909.69	910.46	912.71	0.027315	13.95	229.31	70.12	1.36
Outfall Channel	3002.33	3200.00	906.48	910.82	910.82	913.01	0.004132	11.87	269.55	62.12	1.00
Outfall Channel	3049.67	3200.00	906.56	911.59	910.90	913.22	0.002630	10.26	311.95	62.14	0.81
Outfall Channel	3064.67	3200.00	906.58	911.65	910.92	913.25	0.002564	10.17	314.59	62.14	0.80
Outfall Channel	3088.94	3200.00	906.62	912.81	910.65	913.55	0.000767	6.88	464.86	82.29	0.51
Outfall Channel	3141.00	3200.00	906.70	912.84	910.74	913.59	0.000800	6.98	458.73	82.15	0.52
Outfall Channel	3266.00	3200.00	906.90	912.92	910.94	913.71	0.000857	7.13	448.90	81.90	0.54
Outfall Channel	3330.00	3200.00	907.00	913.25	910.70	913.78	0.000544	5.84	547.68	98.51	0.44
Outfall Channel	3372.00	3200.00	907.06	913.35	910.61	913.82	0.001435	5.49	582.76	105.31	0.41
Outfall Channel	3562.61*	3200.00	907.34	913.62	910.89	914.09	0.001440	5.50	582.08	105.28	0.41
Outfall Channel	3753.23*	3200.00	907.62	913.90	911.17	914.37	0.001444	5.50	581.51	105.26	0.41
Outfall Channel	3943.84*	3200.00	907.89	914.17	911.45	914.64	0.001441	5.50	581.89	105.23	0.41
Outfall Channel	4134.46*	3200.00	908.17	914.45	911.72	914.92	0.001445	5.50	581.33	105.21	0.41
Outfall Channel	4325.07*	3200.00	908.45	914.72	912.00	915.19	0.001449	5.51	580.85	105.19	0.41
Outfall Channel	4515.69*	3200.00	908.73	915.00	912.28	915.47	0.001452	5.51	580.45	105.18	0.41
Outfall Channel	4706.30*	3200.00	909.00	915.28	912.56	915.75	0.001447	5.51	580.99	105.15	0.41
Outfall Channel	4896.92*	3200.00	909.28	915.55	912.83	916.02	0.001450	5.51	580.55	105.14	0.41
Outfall Channel	5087.53*	3200.00	909.56	915.83	913.11	916.30	0.001453	5.52	580.18	105.12	0.41
Outfall Channel	5278.15*	3200.00	909.84	916.11	913.39	916.58	0.001456	5.52	579.87	105.11	0.41
Outfall Channel	5468.76*	3200.00	910.11	916.38	913.67	916.85	0.001450	5.51	580.48	105.09	0.41
Outfall Channel	5659.38*	3200.00	910.39	916.66	913.95	917.13	0.001453	5.52	580.11	105.08	0.41
Outfall Channel	5850.00	3200.00	910.67	916.94	914.23	917.41	0.001456	5.52	579.79	105.06	0.41
Outfall Channel	5900.00	3200.00	910.74	917.01	914.30	917.48	0.001453	5.52	580.08	105.07	0.41

TABLE E5.1
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Final Hydraulic Profile (100-yr Q) for sub & supercritical flow conditions
Bullard Wash from Gila River to Lower Buckeye Road

Profile Output Table - Standard Table 1
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel Run Date: 24-Sep-98

Reach	River Sta	Q Total (ft/sec)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/sec)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Outfall Channel	6020.00	3200.00	910.92	917.18	914.48	917.66	0.001458	5.52	579.49	105.05	0.41
Outfall Channel	6220.00	3200.00	911.21	917.47	914.77	917.95	0.001457	5.52	579.65	105.06	0.41
Outfall Channel	6322.00	3200.00	911.36	917.62	914.92	918.10	0.001464	5.53	578.67	105.02	0.42
Outfall Channel	6400.00	3200.00	911.45	917.74	915.00	918.21	0.001434	5.49	582.59	105.17	0.41
Outfall Channel	6510.*	3200.00	911.58	917.90	915.14	918.37	0.001409	5.46	585.99	105.30	0.41
Outfall Channel	6620.00	3200.00	911.70	918.07	915.26	918.52	0.001378	5.42	590.28	105.46	0.40
Outfall Channel	6776.75*	3200.00	911.88	918.29	915.44	918.74	0.001348	5.38	594.59	105.63	0.40
Outfall Channel	6933.5*	3200.00	912.05	918.50	915.61	918.95	0.001314	5.34	599.54	105.81	0.40
Outfall Channel	7090.25*	3200.00	912.23	918.71	915.79	919.15	0.001295	5.31	602.52	105.93	0.39
Outfall Channel	7247.00	3200.00	912.40	918.92	915.96	919.35	0.001269	5.28	606.45	106.07	0.39
Outfall Channel	7280.00	3200.00	912.34	918.90	916.10	919.42	0.000506	5.79	552.83	92.80	0.42
Outfall Channel	7300.00	3200.00	912.36	918.91	916.13	919.43	0.000508	5.79	552.23	92.87	0.42
Outfall Channel	7357	Bridge									
Outfall Channel	7417.00	3200.00	912.49	919.26	916.26	919.75	0.000452	5.59	572.76	93.23	0.40
Outfall Channel	7440.00	3200.00	912.51	919.27	916.27	919.76	0.000454	5.60	571.91	93.22	0.40
Outfall Channel	7500.00	3200.00	912.58	919.30	916.35	919.79	0.000465	5.64	567.47	93.13	0.40
Outfall Channel	7523.00	3200.00	911.82	919.34	916.19	919.80	0.000427	5.49	583.30	93.14	0.39
Outfall Channel	7533	Bridge									
Outfall Channel	7543.00	3200.00	911.84	919.43	916.22	919.89	0.000410	5.42	590.61	93.30	0.38
Outfall Channel	7558.00	3200.00	912.65	919.42	916.43	919.91	0.000453	5.59	572.39	93.23	0.40
Outfall Channel	7605.00	3200.00	912.70	919.44	916.44	919.93	0.000454	5.59	572.13	93.11	0.40
Outfall Channel	7700.00	3200.00	912.81	919.47	916.58	919.98	0.000477	5.69	565.67	106.75	0.41
Outfall Channel	7744.00	3200.00	914.81	917.48	918.40	920.70	0.039657	14.39	222.35	86.61	1.58
Outfall Channel	7771.64	3200.00	916.00	918.71	919.58	921.77	0.037273	14.05	227.82	88.13	1.54
Outfall Channel	7925.82*	3200.00	922.67	925.06	926.25	929.04	0.056647	16.01	199.91	87.18	1.86
Outfall Channel	8080.00	3200.00	929.34	932.41	932.92	934.77	0.024601	12.33	259.54	89.20	1.27
Outfall Channel	8100.00	3200.00	930.20	933.73	933.73	935.35	0.014641	10.20	313.66	97.66	1.00
Outfall Channel	8210.00	3200.00	929.33	935.30	933.80	936.03	0.002797	6.88	464.86	104.83	0.58
Outfall Channel	8348.*	3200.00	929.50	935.74	933.95	936.39	0.002329	6.48	493.77	106.20	0.53
Outfall Channel	8486.*	3200.00	929.66	936.10	934.12	936.70	0.002049	6.21	515.06	107.19	0.50

TABLE E5.1
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Final Hydraulic Profile (100-yr Q) for sub & supercritical flow conditions
Bullard Wash from Gila River to Lower Buckeye Road

Profile Output Table - Standard Table 1
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel Run Date: 24-Sep-98

Reach	River Sta	Q Total (ft/sec)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/sec)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Outfall Channel	8624.*	3200.00	929.83	936.41	934.29	936.97	0.001882	6.04	529.81	107.88	0.48
Outfall Channel	8762.*	3200.00	929.99	936.69	934.45	937.23	0.001750	5.90	542.77	108.48	0.46
Outfall Channel	8900.00	3200.00	930.16	936.94	934.62	937.46	0.001663	5.80	552.02	108.90	0.45
Outfall Channel	9000.00	3200.00	930.29	937.09	934.77	937.64	0.001710	5.96	537.11	103.19	0.46
Outfall Channel	9080.00	3200.00	930.38	937.24	934.86	937.78	0.001653	5.89	543.08	103.42	0.45
Outfall Channel	9200.00	3200.00	930.55	937.44	935.03	937.97	0.001621	5.85	546.60	103.56	0.45
Outfall Channel	9372.00	3200.00	930.74	937.77	935.21	938.24	0.001441	5.53	578.90	110.13	0.42
Outfall Channel	9529.*	3200.00	930.93	938.00	935.38	938.47	0.001407	5.48	583.51	110.34	0.42
Outfall Channel	9686.*	3200.00	931.12	938.22	935.58	938.68	0.001379	5.45	587.44	110.52	0.42
Outfall Channel	9843.*	3200.00	931.31	938.44	935.77	938.90	0.001356	5.42	590.81	110.67	0.41
Outfall Channel	10000.00	3200.00	931.50	938.66	935.96	939.11	0.001337	5.39	593.57	110.80	0.41
Outfall Channel	10100.00	3200.00	931.62	938.77	936.10	939.26	0.001396	5.57	574.10	104.62	0.42
Outfall Channel	10200.00	3200.00	931.74	938.92	936.22	939.39	0.001379	5.55	576.38	104.71	0.42
Outfall Channel	10300.00	3200.00	931.86	939.09	936.33	939.53	0.001283	5.32	601.72	111.16	0.40
Outfall Channel	10430.*	3200.00	932.02	939.26	936.49	939.70	0.001278	5.31	602.47	111.20	0.40
Outfall Channel	10560.*	3200.00	932.17	939.43	936.62	939.86	0.001266	5.29	604.44	111.29	0.40
Outfall Channel	10690.*	3200.00	932.33	939.59	936.79	940.03	0.001263	5.29	604.95	111.31	0.40
Outfall Channel	10820.00	3200.00	932.49	939.76	936.95	940.19	0.001260	5.29	605.42	111.33	0.40
Outfall Channel	11000.00	3200.00	932.71	939.98	937.17	940.42	0.001255	5.28	606.17	111.36	0.40
Outfall Channel	11100.00	3200.00	932.83	940.09	937.31	940.55	0.001318	5.47	585.11	105.04	0.41
Outfall Channel	11200.00	3200.00	932.95	940.22	937.43	940.68	0.001309	5.46	586.48	105.09	0.41
Outfall Channel	11300.00	3200.00	933.07	940.39	937.54	940.81	0.001223	5.23	611.40	111.60	0.39
Outfall Channel	11425.*	3200.00	933.22	940.54	937.69	940.97	0.001221	5.23	611.73	111.61	0.39
Outfall Channel	11550.00	3200.00	933.37	940.70	937.82	941.12	0.001220	5.23	612.02	111.63	0.39
Outfall Channel	11735.00	3200.00	933.60	940.90	938.08	941.36	0.001286	5.43	589.83	105.22	0.40
Outfall Channel	11883.00	3200.00	933.77	941.10	938.25	941.55	0.001271	5.40	592.17	105.31	0.40
Outfall Channel	11932.00	3200.00	933.84	941.16	938.32	941.61	0.001276	5.41	591.35	105.28	0.40
Outfall Channel	11943.00	3200.00	933.85	941.13	938.44	941.67	0.001481	5.89	543.54	92.44	0.43
Outfall Channel	12195.00	3200.00	934.75	936.92	938.76	944.47	0.096977	22.04	145.19	83.52	2.95
Outfall Channel	12198.00	3200.00	939.65	945.82	945.82	946.51	0.004752	7.95	639.60	375.21	0.94

TABLE E5.1
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Final Hydraulic Profile (100-yr Q) for sub & supercritical flow conditions
Bullard Wash from Gila River to Lower Buckeye Road

Profile Output Table - Standard Table 1
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel Run Date: 24-Sep-98

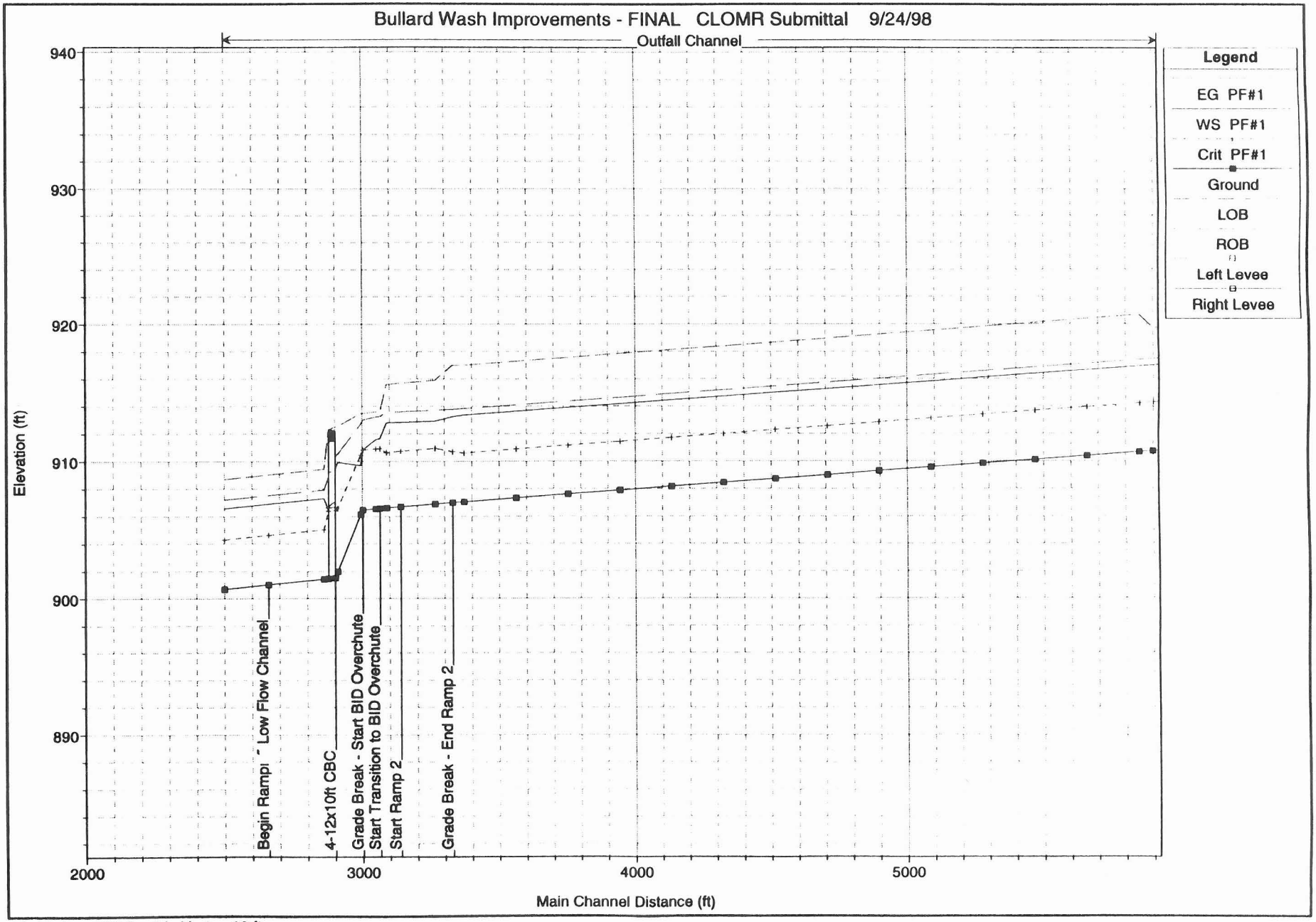
Reach	River Sta	Q Total (ft/sec)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/sec)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	
Outfall Channel	12200.00	3200.00	939.68	946.90	946.05	947.22	0.000625	5.41	1105.85	493.50	0.54	b
Outfall Channel	12345.00	3200.00	940.96	946.92	946.61	947.43	0.001100	6.87	1038.34	626.70	0.61	
Outfall Channel	12445.00	3200.00	941.85	947.51	946.86	947.68	0.002032	4.15	1222.28	768.39	0.44	
Outfall Channel	12640.00	3200.00	942.50	947.85	946.69	947.98	0.001103	3.69	1321.56	839.61	0.34	
Outfall Channel	13120.00	4906.00	943.70	948.89	948.87	949.66	0.009993	7.21	784.66	594.41	0.91	
Outfall Channel	13700.00	4906.00	948.50	952.80	951.68	952.97	0.003333	6.13	1818.94	873.00	0.58	c

Notes: * Denotes HEC-RAS Interpolated Cross Section

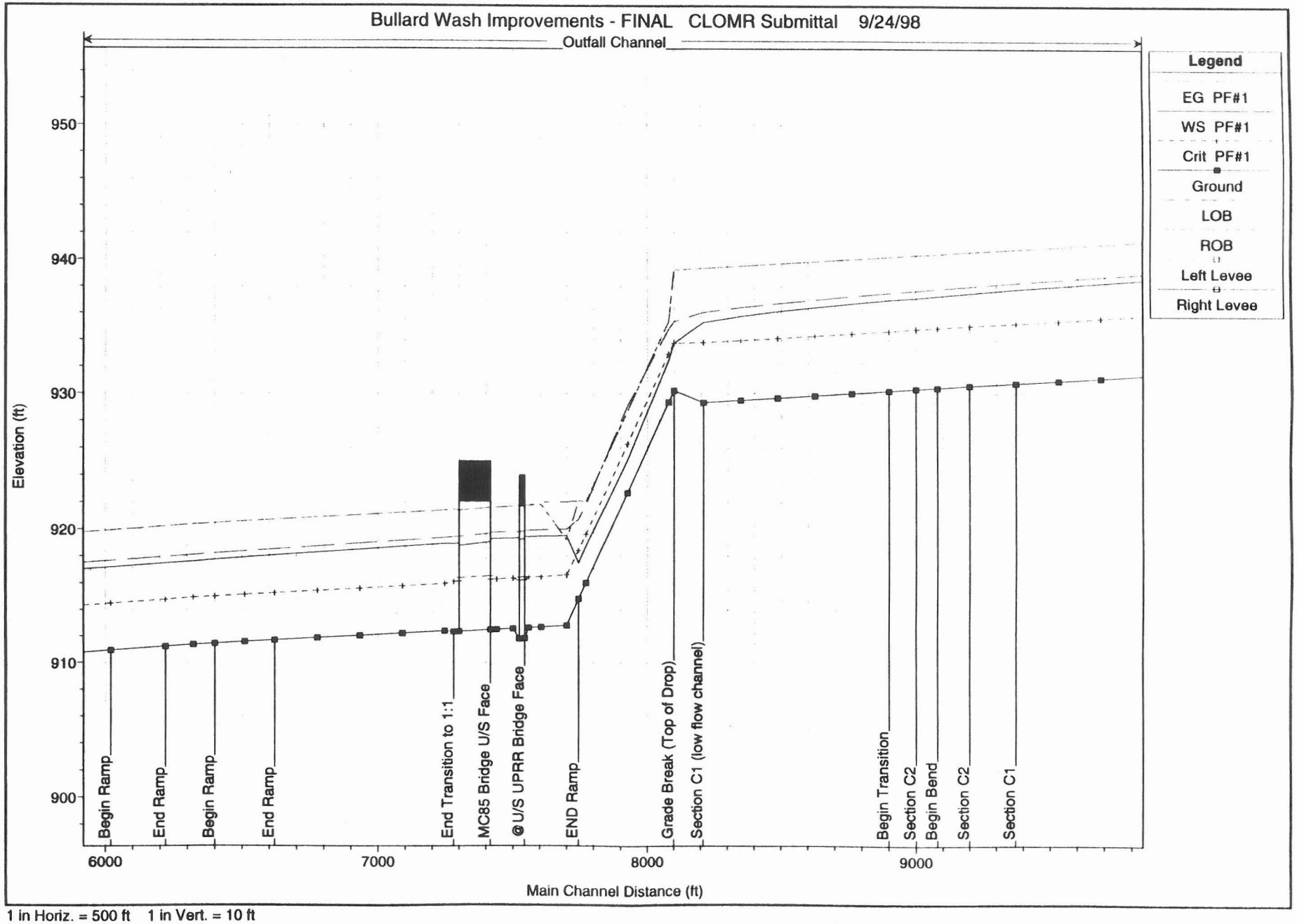
a) Station 25+00 downstream starting WSEL using slope area method with channel slope = 0.002 ft/ft is 906.58 ft
10-yr WSEL in Gila River is 906.3 ft per FEMA study of record by Dames & More.
Slope area with channel slope yields 100-yr WSEL in Bullard Wash of 906.58 ft @ STA 25+00.

b) Station 122+00 known WSEL is 946.9 based on uneven weir flow ponding elevation for the drop inlet structure

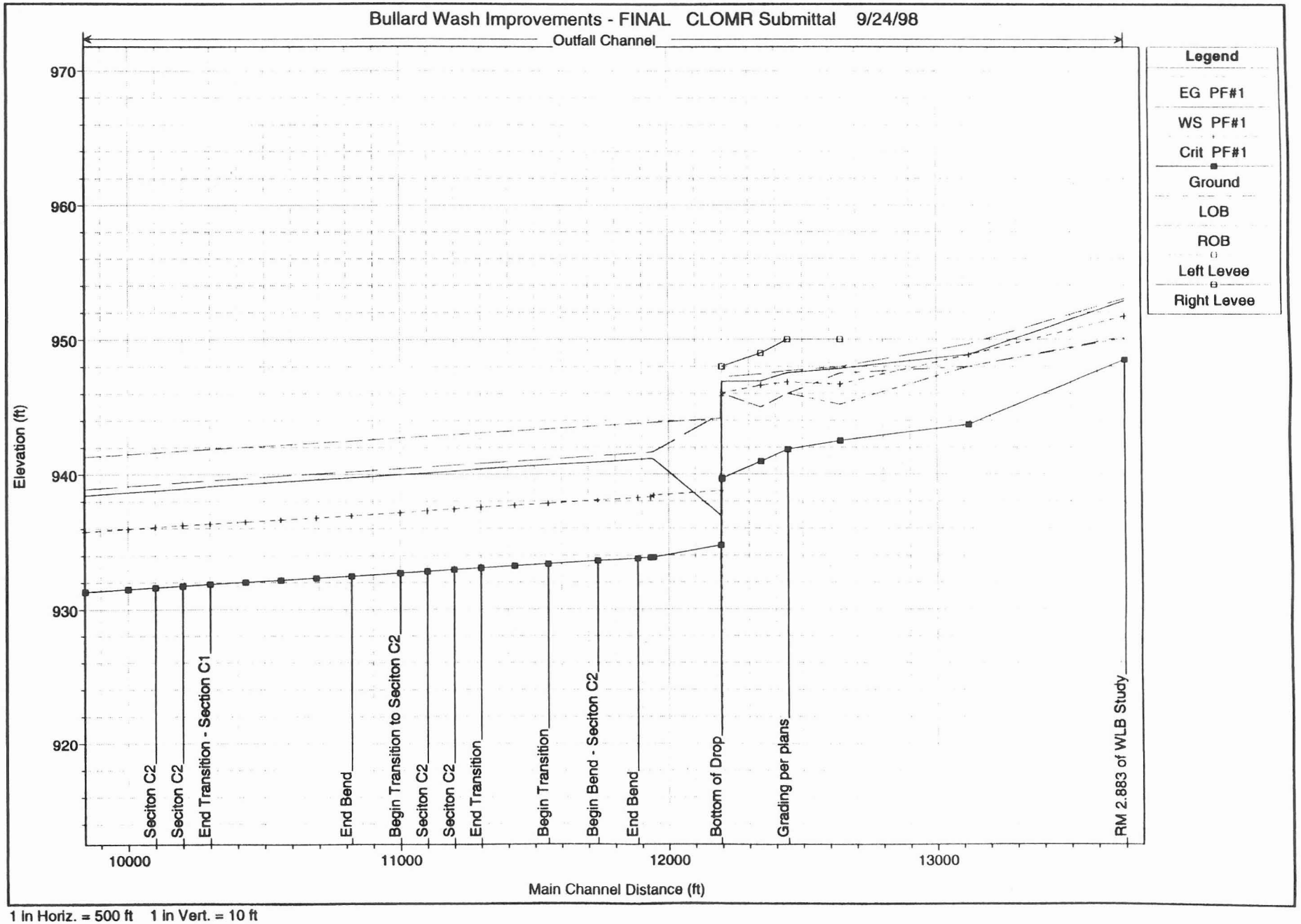
c) Station 137+00 (RM 2.883) upstream starting WSEL is known elevation of 952.8 ft per WLB Study.



1 in Horiz. = 500 ft 1 in Vert. = 10 ft



1 in Horiz. = 500 ft 1 in Vert. = 10 ft



1 In Horiz. = 500 ft 1 in Vert. = 10 ft

TABLE E5.2
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Bullard Wash from Gila River to Lower Buckeye Road - Floodway Data

Profile Output Table - Encroachment 1

HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel

Run Date: 24-Sep-98

Reach	River Sta	W.S. Elev (ft)	Prof Delta WS (ft)	E.G. Elev (ft)	Top Wdth Act (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Enc Sta L (ft)	Ch Sta L (ft)	Ch Sta R (ft)	Enc Sta R (ft)
Outfall Channel	2500	906.58	0.00	907.20	91.78		3200.00		9952.00	9952.00	10048.00	10048.00
Outfall Channel	2660	906.90	0.00	907.52	91.76		3200.00		9952.00	9952.00	10048.00	10048.00
Outfall Channel	2860.56	907.30	0.00	907.92	91.76		3200.00		9952.00	9952.00	10048.00	10048.00
Outfall Channel	2877.74	906.45	0.00	908.87	51.29		3200.00		9974.30	9974.30	10025.70	10025.70
Outfall Channel	2901.4	Culvert										
Outfall Channel	2901.49	909.45	0.00	910.41	51.34		3200.00		9974.30	9974.30	10025.70	10025.70
Outfall Channel	2911	909.93	0.00	910.52	76.95		3200.00		9957.60	9957.60	10042.40	10042.40
Outfall Channel	2995.26	909.68	0.00	912.71	70.11		3200.00		9959.30	9959.30	10040.70	10040.70
Outfall Channel	3002.33	910.82	0.00	913.01	62.12		3200.00		9968.90	9968.90	10031.10	10031.10
Outfall Channel	3049.67	911.59	0.00	913.22	62.14		3200.00		9968.90	9968.90	10031.10	10031.10
Outfall Channel	3064.67	911.65	0.00	913.25	62.14		3200.00		9968.90	9968.90	10031.10	10031.10
Outfall Channel	3088.94	912.81	0.00	913.55	82.29		3200.00		9956.00	9956.00	10044.00	10044.00
Outfall Channel	3141	912.84	0.00	913.59	82.15		3200.00		9956.00	9956.00	10044.00	10044.00
Outfall Channel	3266	912.92	0.00	913.71	81.90		3200.00		9956.00	9956.00	10044.00	10044.00
Outfall Channel	3330	913.25	0.00	913.78	98.51		3200.00		9945.00	9945.00	10055.00	10055.00
Outfall Channel	3372	913.35	0.00	913.82	105.31		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	3562.61*	913.62	0.00	914.09	105.28		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	3753.23*	913.90	0.00	914.37	105.26		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	3943.84*	914.17	0.00	914.64	105.23		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	4134.46*	914.45	0.00	914.92	105.21		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	4325.07*	914.72	0.00	915.19	105.19		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	4515.69*	915.00	0.00	915.47	105.18		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	4706.30*	915.28	0.00	915.75	105.15		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	4896.92*	915.55	0.00	916.02	105.14		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	5087.53*	915.83	0.00	916.30	105.12		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	5278.15*	916.11	0.00	916.58	105.11		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	5468.76*	916.38	0.00	916.85	105.09		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	5659.38*	916.66	0.00	917.13	105.08		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	5850	916.94	0.00	917.41	105.06		3200.00		9940.00	9940.00	10060.00	10060.00
Outfall Channel	5900	917.01	0.00	917.48	105.07		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	6020	917.18	0.00	917.66	105.05		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	6220	917.47	0.00	917.95	105.06		3200.00		9942.00	9942.00	10058.00	10058.00

TABLE E5.2
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Bullard Wash from Gila River to Lower Buckeye Road - Floodway Data

Profile Output Table - Encroachment 1
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel Run Date: 24-Sep-98

Reach	River Sta	W.S. Elev (ft)	Prof Delta WS (ft)	E.G. Elev (ft)	Top Wdth Act (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Enc Sta L (ft)	Ch Sta L (ft)	Ch Sta R (ft)	Enc Sta R (ft)
Outfall Channel	6322	917.62	0.00	918.10	105.02		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	6400	917.74	0.00	918.21	105.17		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	6510.*	917.90	0.00	918.37	105.30		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	6620	918.07	0.00	918.52	105.46		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	6776.75*	918.29	0.00	918.74	105.63		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	6933.5*	918.50	0.00	918.95	105.81		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	7090.25*	918.71	0.00	919.15	105.93		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	7247	918.92	0.00	919.35	106.07		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	7280	918.90	0.00	919.42	92.80		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7300	918.91	0.00	919.43	92.87		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7357 BR D	918.77	0.00	919.43	84.58		3200.00			9951.00	10049.00	
Outfall Channel	7357 BR U	919.04	0.00	919.68	84.78		3200.00			9951.00	10049.00	
Outfall Channel	7417	919.26	0.00	919.75	93.23		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7440	919.27	0.00	919.76	93.22		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7500	919.30	0.00	919.79	93.13		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7523	919.34	0.00	919.80	93.14		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7533 BR D	919.22	0.00	919.80	85.50		3200.00			9951.00	10049.00	
Outfall Channel	7533 BR U	919.25	0.00	919.83	85.54		3200.00			9951.00	10049.00	
Outfall Channel	7543	919.43	0.00	919.89	93.30		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7558	919.42	0.00	919.91	93.23		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7605	919.44	0.00	919.93	93.11		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7700	919.47	0.00	919.98	106.75		3196.09	3.91	9951.00	9951.00	10046.00	10063.00
Outfall Channel	7744	917.48	0.00	920.70	86.61		3200.00		9951.00	9951.00	10049.00	10063.00
Outfall Channel	7771.64	918.71	0.00	921.77	88.13		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	7925.82*	925.06	0.00	929.04	87.18		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	8080	932.41	0.00	934.77	89.20		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	8100	933.73	0.00	935.35	97.66		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	8210	935.30	0.00	936.03	104.83		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	8348.*	935.74	0.00	936.39	106.20		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	8486.*	936.10	0.00	936.70	107.19		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	8624.*	936.41	0.00	936.97	107.88		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	8762.*	936.69	0.00	937.23	108.48		3200.00		9942.00	9942.00	10067.00	10067.00

TABLE E5.2
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Bullard Wash from Gila River to Lower Buckeye Road - Floodway Data

Profile Output Table - Encroachment 1
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel Run Date: 24-Sep-98

Reach	River Sta	W.S. Elev (ft)	Prof Delta WS (ft)	E.G. Elev (ft)	Top Wdth Act (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Enc Sta L (ft)	Ch Sta L (ft)	Ch Sta R (ft)	Enc Sta R (ft)
Outfall Channel	8900	936.94	0.00	937.46	108.90		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	9000	937.09	0.00	937.64	103.19		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	9080	937.24	0.00	937.78	103.42		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	9200	937.44	0.00	937.97	103.56		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	9372	937.77	0.00	938.24	110.13		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	9529.*	938.00	0.00	938.47	110.34		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	9686.*	938.22	0.00	938.68	110.52		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	9843.*	938.44	0.00	938.90	110.67		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	10000	938.66	0.00	939.11	110.80		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	10100	938.77	0.00	939.26	104.62		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	10200	938.92	0.00	939.39	104.71		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	10300	939.09	0.00	939.53	111.16		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	10430.*	939.26	0.00	939.70	111.20		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	10560.*	939.43	0.00	939.86	111.29		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	10690.*	939.59	0.00	940.03	111.31		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	10820	939.76	0.00	940.19	111.33		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	11000	939.98	0.00	940.42	111.36		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	11100	940.09	0.00	940.55	105.04		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	11200	940.22	0.00	940.68	105.09		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	11300	940.39	0.00	940.81	111.60		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	11425.*	940.54	0.00	940.97	111.61		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	11550	940.70	0.00	941.12	111.63		3200.00		9942.00	9942.00	10067.00	10067.00
Outfall Channel	11735	940.90	0.00	941.36	105.22		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	11883	941.10	0.00	941.55	105.31		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	11932	941.16	0.00	941.61	105.28		3200.00		9942.00	9942.00	10058.00	10058.00
Outfall Channel	11943	941.13	0.00	941.67	92.44		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	12195	936.92	0.00	944.47	83.52		3200.00		9951.00	9951.00	10049.00	10049.00
Outfall Channel	12198	945.82	0.00	946.51	375.21		2097.39	1102.61	9610.00	9950.00	10080.00	11060.00
Outfall Channel	12200	947.50	0.60	948.19	130.00		3200.00		9950.00	9950.00	10080.00	10080.00
Outfall Channel	12345	947.87	0.95	948.37	225.00	136.00	2479.17	584.83	9955.00	9980.00	10060.00	10180.00
Outfall Channel	12445	948.30	0.79	948.55	300.00		2389.73	810.27	9950.00	9950.00	10100.00	10250.00
Outfall Channel	12640	948.67	0.82	948.76	415.00	17.91	1444.95	1737.14	9950.00	9970.00	10080.00	10365.00

TABLE E5.2
HEC-RAS Output for Bullard Wash Outfall Channel Improvements
Bullard Wash from Gila River to Lower Buckeye Road - Floodway Data

Profile Output Table - Encroachment 1
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel Run Date: 24-Sep-98

Reach	River Sta	W.S. Elev (ft)	Prof Delta WS (ft)	E.G. Elev (ft)	Top Wdth Act (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Enc Sta L (ft)	Ch Sta L (ft)	Ch Sta R (ft)	Enc Sta R (ft)
Outfall Channel	13120	949.04	0.15	949.79	365.00	30.24	4831.24	44.52	9950.00	9960.00	10290.00	10315.00
Outfall Channel	13700	953.80	1.00	954.04	350.00	2350.78	799.77	1755.45	9830.00	9985.00	10015.00	10180.00 a

Notes: * Denotes HEC-RAS Interpolated Cross Section
a) Station 137+00 (RM 2.883) encroachment elevation is 953.8 ft per WLB Study.

TABLE E5.3
HEC-RAS Output for Bridge Crossings
Bullard Wash Outfall Channel from Gila River to Lower Buckeye Road

Profile Output Table - Six XS Bridge
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel

Reach	River Sta		E.G. Elev (ft)	W.S. Elev (ft)	Crit W.S. (ft)	Frctn Loss (ft)	C & E Loss (ft)	Top Width (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Vel Chnl (ft/s)
Outfall Channel	7280		919.42	918.9	916.1	0.03	0.04	92.8		3200		5.79
Outfall Channel	7300		919.43	918.91	916.13	0.01	0	92.87		3200		5.79
Outfall Channel	7357	BR D	919.43	918.77	916.38			84.58		3200		6.55
Outfall Channel	7357	BR U	919.68	919.04	916.51			84.78		3200		6.39
Outfall Channel	7417		919.75	919.26	916.26			93.23		3200		5.59
Outfall Channel	7440		919.76	919.27	916.27	0.01	0	93.22		3200		5.6
Outfall Channel	7500		919.79	919.3	916.35	0.03	0	93.13		3200		5.64
Outfall Channel	7523		919.8	919.34	916.19	0.01	0	93.14		3200		5.49
Outfall Channel	7533	BR D	919.8	919.22	916.41			85.5		3200		6.1
Outfall Channel	7533	BR U	919.83	919.25	916.45			85.54		3200		6.09
Outfall Channel	7543		919.89	919.43	916.22			93.3		3200		5.42
Outfall Channel	7558		919.91	919.42	916.43	0.01	0.01	93.23		3200		5.59

Profile Output Table - Bridge Only
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel

Reach	River Sta	E.G. US. (ft)	Min El Prs (ft)	BR Open Area (sq ft)	Prs O WS (ft)	Q Total (cfs)	Min Top Rd (ft)	Q Weir (cfs)	Delta EG (ft)
Outfall Channel	7357	919.75	922.06	765.43		3200.00	925.03		0.32
Outfall Channel	7533	919.89	921.70	740.90		3200.00	924.00		0.09

TABLE E5.4
HEC-RAS Output for Culvert Crossings
Bullard Wash Outfall Channel from Gila River to Lower Buckeye Road

Profile Output Table - Four XS Culvert
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel

Reach	River Sta	E.G. Elev (ft)	W.S. Elev (ft)	Vel. Head (ft)	Frctn Loss (ft)	C & E Loss (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Top Width (ft)
Outfall Channel	2860.56	907.92	907.3	0.62	0.40	0.00		3200		91.76
Outfall Channel	2877.74	908.87	906.45	2.42	0.04	0.90		3200		51.29
Outfall Channel	2901.4	Culvert								
Outfall Channel	2901.49	910.41	909.45	0.96				3200		51.34
Outfall Channel	2911	910.52	909.93	0.59	0.01	0.11		3200		76.95

Profile Output Table - Culvert Only
HEC-RAS Plan: Final(9/98) River: Bullard Wash Reach: Outfall Channel

Reach	River Sta	E.G. US. (ft)	W.S. US (ft)	E.G. IC (ft)	E.G. OC (ft)	Min Top Rd (ft)	Culv Q (cfs)	Q Weir (cfs)	Delta WS (ft)	Culv Vel In (ft/s)	Culv Vel Out (ft/s)
Outfall Channel	2901.4 Culvert #1	910.41	909.45	909.79	910.41	912.30	3200.00		3.00	11.99	12.90

TABLE 5.5
Summary of Errors, Warnings and Notes for Bullard Wash Outfall Channel

Errors Warnings and Notes for Plan : Final(9/98)

River: Bullard Wash Reach: Outfall Channel RS: 13700 Profile: PF#1
- Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
- Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
- Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
- Note - The user has entered a known water surface elevation at this cross section.

River: Bullard Wash Reach: Outfall Channel RS: 13120 Profile: PF#1
- Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
- Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
- Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

River: Bullard Wash Reach: Outfall Channel RS: 12445 Profile: PF#1
- Warning - The cross-section end points had to be extended vertically for the computed water surface.

River: Bullard Wash Reach: Outfall Channel RS: 12345 Profile: PF#1
- Warning - The cross-section end points had to be extended vertically for the computed water surface.

River: Bullard Wash Reach: Outfall Channel RS: 12200 Profile: PF#1
- Warning - The cross-section end points had to be extended vertically for the computed water surface.
- Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
- Note - The user has entered a known water surface elevation at this cross section.

River: Bullard Wash Reach: Outfall Channel RS: 12198 Profile: PF#1
- Warning - The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
- Warning - Divided flow computed for this cross-section.
- Warning - The cross-section end points had to be extended vertically for the computed water surface.
- Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
- Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
- Warning - During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program defaulted to critical depth.
- Note - Multiple critical depths were found at this location. The critical depth with the lowest, valid, water surface was used.

River: Bullard Wash Reach: Outfall Channel RS: 12195 Profile: PF#1
- Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
- Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
- Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
- Note - Program found supercritical flow starting at this cross section.

River: Bullard Wash Reach: Outfall Channel RS: 11943 Profile: PF#1
- Note - Manning's n values were composited to a single value in the main channel.
- Note - Hydraulic jump has occurred between this cross section and the previous upstream section.

River: Bullard Wash Reach: Outfall Channel RS: 11932 Profile: PF#1

TABLE 5.5

Summary of Errors, Warnings and Notes for Bullard Wash Outfall Channel

Errors Warnings and Notes for Plan : Final(9/98)

Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11883 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11735 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11550 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11425.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11300 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11200 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11100 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 11000 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10820 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10690.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10560.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10430.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10300 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10200 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10100 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 10000 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 9843.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 9686.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 9529.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 9372 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 9200 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 9080 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 9000 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 8900 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 8762.* Profile: PF#1

TABLE 5.5

Summary of Errors, Warnings and Notes for Bullard Wash Outfall Channel

Errors Warnings and Notes for Plan : Final(9/98)

Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 8624.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 8486.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 8348.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 8210 Profile: PF#1
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 8100 Profile: PF#1
Warning - The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Warning - During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program defaulted to critical depth.
River: Bullard Wash Reach: Outfall Channel RS: 8080 Profile: PF#1
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Note - Program found supercritical flow starting at this cross section.
River: Bullard Wash Reach: Outfall Channel RS: 7925.82* Profile: PF#1
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
River: Bullard Wash Reach: Outfall Channel RS: 7771.64 Profile: PF#1
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
River: Bullard Wash Reach: Outfall Channel RS: 7744 Profile: PF#1
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
River: Bullard Wash Reach: Outfall Channel RS: 7700 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
Note - Hydraulic jump has occurred between this cross section and the previous upstream section.
River: Bullard Wash Reach: Outfall Channel RS: 7605 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7558 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7543 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7533 Profile: PF#1 Upstream
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7533 Profile: PF#1 Downstream

TABLE 5.5

Summary of Errors, Warnings and Notes for Bullard Wash Outfall Channel

Errors Warnings and Notes for Plan : Final(9/98)

Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7523 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7500 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7440 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7417 Profile: PF#1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7357 Profile: PF#1 Upstream
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7357 Profile: PF#1 Downstream
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7300 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7280 Profile: PF#1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7247 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 7090.25* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6933.5* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6776.75* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6620 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6510.* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6400 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6322 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6220 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 6020 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 5900 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 5850 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 5659.38* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 5468.76* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 5278.15* Profile: PF#1

TABLE 5.5

Summary of Errors, Warnings and Notes for Bullard Wash Outfall Channel

Errors Warnings and Notes for Plan : Final(9/98)

Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 5087.53* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 4896.92* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 4706.30* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 4515.69* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 4325.07* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 4134.46* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3943.84* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3753.23* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3562.61* Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3372 Profile: PF#1
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3330 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3266 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3141 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3088.94 Profile: PF#1
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3064.67 Profile: PF#1
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3049.67 Profile: PF#1
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Note - Manning's n values were composited to a single value in the main channel.
River: Bullard Wash Reach: Outfall Channel RS: 3002.33 Profile: PF#1
Warning - The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
Warning - During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program defaulted to critical depth.
Note - Manning's n values were composited to a single value in the main channel.

TABLE 5.5
Summary of Errors, Warnings and Notes for Bullard Wash Outfall Channel

Errors Warnings and Notes for Plan : Final(9/98)

River: Bullard Wash Reach: Outfall Channel RS: 2995.26 Profile: PF#1
- Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
- Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
- Note - Manning's n values were composited to a single value in the main channel.

River: Bullard Wash Reach: Outfall Channel RS: 2911 Profile: PF#1
- Warning - The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections.
- Note - Manning's n values were composited to a single value in the main channel.
- Note - Hydraulic jump has occurred between this cross section and the previous upstream section.

River: Bullard Wash Reach: Outfall Channel RS: 2877.74 Profile: PF#1
- Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
- Note - Manning's n values were composited to a single value in the main channel.

River: Bullard Wash Reach: Outfall Channel RS: 2860.56 Profile: PF#1
- Note - Manning's n values were composited to a single value in the main channel.

River: Bullard Wash Reach: Outfall Channel RS: 2660 Profile: PF#1
- Note - Manning's n values were composited to a single value in the main channel.

River: Bullard Wash Reach: Outfall Channel RS: 2500 Profile: PF#1
- Note - Manning's n values were composited to a single value in the main channel.

Wood, Patel & Associates, Inc.

TABLE E5.6
Summary of Freeboard Considerations for Bullard Wash

Project: FCDMC: Bullard Wash - CLOMR Submittal
River Reach: Gila River Outfall to Lower Buckeye Road
Date: 24-Sep-98
Reference: FCDMC, Drainage Design Manual, Volume II - Hydraulics, January 1996

Equations Used:

Freeboard: $FB = 0.25 (Y + V^2 / 2g) + dY$ for both subcritical & supercritical flow
Superelevation: $dY = (V^2 * T) / (g * Rc)$ for channel bends
subcritical flow, min FB = 1.0 ft — supercritical flow, min FB = 2.0 ft
Bridges, min FB = 2.0 ft — Levees, min FB = 3.0 ft

Stationing, in feet		Channel Elev., in feet		WSEL	Velocity	Froude	Freeboard, in feet			Background DATA				
										Radius	Top Width	Rc/T	Super Elev	Calculated
2500.00	25+00.00	900.69	908.69	906.58	6.33	0.48	1.63	2.11		none	91.78	--	n/a	1.628
2660.00	26+60.00	901.02	909.02	906.90	6.34	0.48	1.63	2.12		none	91.76	--	n/a	1.626
2860.56	28+60.56	901.42	909.42	907.30	6.33	0.48	1.63	2.12		none	91.76	--	n/a	1.626
2877.74	28+77.74	901.45	909.45	906.45	12.49	0.99	2.00	3.00	a	none	51.29	--	n/a	1.856
2901.40	29+01.40	901.50	912.54						a	4 barrel 10'x12' concrete box culvert				
2901.49	29+01.49	901.50	912.54	909.45	7.85	0.49	2.23	3.09	a	none	51.34	--	n/a	2.227
2911.00	29+11.00	901.97	912.54	909.93	6.19	0.42	2.14	2.61		none	76.95	--	n/a	2.139
2995.26	29+95.26	906.15	913.41	909.69	13.95	1.36	2.00	3.72		none	70.12	--	n/a	1.640
3002.33	30+02.33	906.48	913.48	910.82	11.87	1.00	2.00	2.66		none	62.12	--	n/a	1.632
3049.67	30+49.67	906.56	913.58	911.59	10.26	0.81	1.67	1.99		none	62.14	--	n/a	1.666
3064.67	30+64.67	906.58	913.58	911.65	10.17	0.80	1.67	1.93		none	62.14	--	n/a	1.669
3088.94	30+88.94	906.62	915.62	912.81	6.88	0.51	1.73	2.81		none	82.29	--	n/a	1.731
3141.00	31+41.00	906.70	915.70	912.84	6.98	0.52	1.97	2.86		500	82.15	6.09	0.25	1.724
3266.00	32+66.00	906.90	915.90	912.92	7.13	0.54	1.96	2.98		500	81.90	6.11	0.26	1.702
3330.00	33+30.00	907.00	917.00	913.25	5.84	0.44	3.00	3.75		none	98.51	--	n/a	1.695
3372.00	33+72.00	907.06	917.06	913.35	5.49	0.41	3.00	3.71		none	105.31	--	n/a	1.690
3562.61*	3562.61*	907.34	917.34	913.62	5.50	0.41	3.00	3.72		none	105.28	--	n/a	1.687
3753.23*	3753.23*	907.62	917.62	913.90	5.50	0.41	3.00	3.72		none	105.26	--	n/a	1.687
3943.84*	3943.84*	907.89	917.89	914.17	5.50	0.41	3.00	3.72		none	105.23	--	n/a	1.687
4134.46*	4134.46*	908.17	918.17	914.45	5.50	0.41	3.00	3.72		none	105.21	--	n/a	1.687
4325.07*	4325.07*	908.45	918.45	914.72	5.51	0.41	3.00	3.73		none	105.19	--	n/a	1.685
4515.69*	4515.69*	908.73	918.73	915.00	5.51	0.41	3.00	3.73		none	105.18	--	n/a	1.685
4706.30*	4706.30*	909.00	919.00	915.28	5.51	0.41	3.00	3.72		none	105.15	--	n/a	1.688
4896.92*	4896.92*	909.28	919.28	915.55	5.51	0.41	3.00	3.73		none	105.14	--	n/a	1.685
5087.53*	5087.53*	909.56	919.56	915.83	5.52	0.41	3.00	3.73		none	105.12	--	n/a	1.686
5278.15*	5278.15*	909.84	919.84	916.11	5.52	0.41	3.00	3.73		none	105.11	--	n/a	1.686
5468.76*	5468.76*	910.11	920.11	916.38	5.51	0.41	3.00	3.73		none	105.09	--	n/a	1.685
5659.38*	5659.38*	910.39	920.39	916.66	5.52	0.41	3.00	3.73		none	105.08	--	n/a	1.686
5850.00	58+50.00	910.67	920.67	916.94	5.52	0.41	3.00	3.73		none	105.06	--	n/a	1.686
5900.00	59+00.00	910.74	919.74	917.01	5.52	0.41	1.69	2.73		none	105.07	--	n/a	1.686
6020.00	60+20.00	910.92	919.92	917.18	5.52	0.41	1.68	2.74		none	105.05	--	n/a	1.683
6220.00	62+20.00	911.21	920.21	917.47	5.52	0.41	1.68	2.74		none	105.06	--	n/a	1.683
6322.00	63+22.00	911.36	920.36	917.62	5.53	0.42	1.68	2.74		none	105.02	--	n/a	1.684
6400.00	64+00.00	911.45	920.45	917.74	5.49	0.41	1.69	2.71		none	105.17	--	n/a	1.690
6510.*	6510.*	911.58	920.58	917.90	5.46	0.41	1.70	2.68		none	105.30	--	n/a	1.696
6620.00	66+20.00	911.70	920.70	918.07	5.42	0.40	1.71	2.63		none	105.46	--	n/a	1.707

TABLE E5.6
Summary of Freeboard Considerations for Bullard Wash

Project: FCDMC: Bullard Wash - CLOMR Submittal
River Reach: Gila River Outfall to Lower Buckeye Road
Date: 24-Sep-98
Reference: FCDMC, Drainage Design Manual, Volume II - Hydraulics, January 1996

Equations Used:

Freeboard: $FB = 0.25 (Y + V^2 / 2g) + dY$ for both subcritical & supercritical flow
Superelevation: $dY = (V^2 * T) / (g * Rc)$ for channel bends
subcritical flow, min FB = 1.0 ft — supercritical flow, min FB = 2.0 ft
Bridges, min FB = 2.0 ft — Levees, min FB = 3.0 ft

Stationing, in feet		Channel Elev., in feet		WSEL	Velocity	Froude	Freeboard, in feet			Background DATA				
										Radius	Top Width	Rc/T	Super Elev	Calculated
6776.75*	6776.75*	911.88	920.88	918.29	5.38	0.40	1.72	2.59		none	105.63	--	n/a	1.715
6933.5*	6933.5*	912.05	921.05	918.50	5.34	0.40	1.72	2.55		none	105.81	--	n/a	1.723
7090.25*	7090.25*	912.23	921.23	918.71	5.31	0.39	1.73	2.52		none	105.93	--	n/a	1.729
7247.00	72+47.00	912.40	921.40	918.92	5.28	0.39	1.74	2.48		none	106.07	--	n/a	1.738
7280.00	72+80.00	912.34	921.34	918.90	5.79	0.42	1.77	2.44		none	92.80	--	n/a	1.770
7300.00	73+00.00	912.36	922.06	918.91	5.79	0.42	2.00	3.15	b	none	92.87	--	n/a	1.768
7357.00	73+57.00	912.43	922.06						b		MC 85 bridge			
7417.00	74+17.00	912.49	922.06	919.26	5.59	0.40	2.00	2.80	b	none	93.23	--	n/a	1.814
7440.00	74+40.00	912.51	921.51	919.27	5.60	0.40	1.81	2.24		none	93.22	--	n/a	1.812
7500.00	75+00.00	912.58	921.58	919.30	5.64	0.40	1.80	2.28		none	93.13	--	n/a	1.803
7523.00	75+23.00	911.82	921.70	919.34	5.49	0.39	2.00	2.36	c	none	93.14	--	n/a	1.997
7543.00	75+43.00	911.83	921.70						c		UPRR bridge			
7543.00	75+43.00	911.84	921.70	919.43	5.42	0.38	2.01	2.27	c	none	93.30	--	n/a	2.012
7558.00	75+58.00	912.65	921.65	919.42	5.59	0.40	1.81	2.23		none	93.23	--	n/a	1.814
7605.00	76+05.00	912.70	921.70	919.44	5.59	0.40	1.81	2.26		none	93.11	--	n/a	1.806
7700.00	77+00.00	912.81	921.81	919.47	5.69	0.41	1.79	2.34		none	106.75	--	n/a	1.791
7744.00	77+44.00	914.81	921.97	917.48	14.39	1.58	2.00	4.49		none	86.61	--	n/a	1.471
7771.64	77+71.64	916.00	922.00	918.71	14.05	1.54	2.00	3.29		none	88.13	--	n/a	1.444
7925.82*	7925.82*	922.67	928.67	925.06	16.01	1.86	2.00	3.61		none	87.18	--	n/a	1.593
8080.00	80+80.00	929.34	935.34	932.41	12.33	1.27	2.00	2.93		none	89.20	--	n/a	1.358
8100.00	81+00.00	930.20	939.20	933.73	10.20	1.00	2.00	5.47		none	97.66	--	n/a	1.286
8210.00	82+10.00	930.33	939.33	935.30	6.88	0.58	1.43	4.03	d	none	104.83	--	n/a	1.426
8348.*	8348.*	930.50	939.50	935.74	6.48	0.53	1.47	3.76	d	none	106.20	--	n/a	1.473
8486.*	8486.*	930.66	939.66	936.10	6.21	0.50	1.51	3.56	d	none	107.19	--	n/a	1.510
8624.*	8624.*	930.83	939.83	936.41	6.04	0.48	1.54	3.42	d	none	107.88	--	n/a	1.537
8762.*	8762.*	930.99	939.99	936.69	5.90	0.46	1.56	3.30	d	none	108.48	--	n/a	1.560
8900.00	89+00.00	931.16	940.16	936.94	5.80	0.45	1.58	3.22	d	none	108.90	--	n/a	1.576
9000.00	90+00.00	931.29	940.29	937.09	5.96	0.46	1.59	3.20	d	none	103.19	--	n/a	1.588
9080.00	90+80.00	931.38	940.38	937.24	5.89	0.45	1.60	3.14	d	none	103.42	--	n/a	1.600
9200.00	92+00.00	931.55	940.55	937.44	5.85	0.45	1.65	3.11	d	2650	103.56	25.59	0.04	1.605
9372.00	93+72.00	931.74	940.74	937.77	5.53	0.42	1.67	2.97	d	2650	110.13	24.06	0.04	1.626
9529.*	9529.*	931.93	940.93	938.00	5.48	0.42	1.67	2.93	d	2650	110.34	24.02	0.04	1.634
9686.*	9686.*	932.12	941.12	938.22	5.45	0.42	1.68	2.90	d	2650	110.52	23.98	0.04	1.640
9843.*	9843.*	932.31	941.31	938.44	5.42	0.41	1.69	2.87	d	2650	110.67	23.95	0.04	1.647
10000.00	100+00.00	932.50	941.50	938.66	5.39	0.41	1.69	2.84	d	2650	110.80	23.92	0.04	1.653
10100.00	101+00.00	932.62	941.62	938.77	5.57	0.42	1.70	2.85	d	2650	104.62	25.33	0.04	1.658

Wood, Patel & Associates, Inc.

TABLE E5.6
Summary of Freeboard Considerations for Bullard Wash

Project: FCDMC: Bullard Wash - CLOMR Submittal
River Reach: Gila River Outfall to Lower Buckeye Road
Date: 24-Sep-98
Reference: FCDMC, Drainage Design Manual, Volume II - Hydraulics, January 1996

Equations Used:

Freeboard: $FB = 0.25 (Y + V^2 / 2g) + dY$ for both subcritical & supercritical flow
Superelevation: $dY = (V^2 * T) / (g * Rc)$ for channel bends
subcritical flow, min FB = 1.0 ft — supercritical flow, min FB = 2.0 ft
Bridges, min FB = 2.0 ft — Levees, min FB = 3.0 ft

Stationing, in feet		Channel Elev., in feet		WSEL	Velocity	Froude	Freeboard, in feet			Background DATA				
										Radius	Top Width	Rc/T	Super Elev	Calculated
10200.00	102+00.00	932.74	941.74	938.92	5.55	0.42	1.70	2.82	d	2650	104.71	25.31	0.04	1.665
10300.00	103+00.00	932.86	941.86	939.09	5.32	0.40	1.70	2.77	d	2650	111.16	23.84	0.04	1.667
10430.*	10430.*	933.02	942.02	939.26	5.31	0.40	1.71	2.76	d	2650	111.20	23.83	0.04	1.669
10560.*	10560.*	933.17	942.17	939.43	5.29	0.40	1.71	2.74	d	2650	111.29	23.81	0.04	1.674
10690.*	10690.*	933.33	942.33	939.59	5.29	0.40	1.71	2.74	d	2650	111.31	23.81	0.04	1.674
10820.00	108+20.00	933.49	942.49	939.76	5.29	0.40	1.71	2.73	d	2650	111.33	23.80	0.04	1.676
11000.00	110+00.00	933.71	942.71	939.98	5.28	0.40	1.68	2.73	d	none	111.36	--	n/a	1.676
11100.00	111+00.00	933.83	942.83	940.09	5.47	0.41	1.68	2.74	d	none	105.04	--	n/a	1.681
11200.00	112+00.00	933.95	942.95	940.22	5.46	0.41	1.68	2.73	d	none	105.09	--	n/a	1.683
11300.00	113+00.00	934.07	943.07	940.39	5.23	0.39	1.69	2.68	d	none	111.60	--	n/a	1.686
11425.*	11425.*	934.22	943.22	940.54	5.23	0.39	1.69	2.68	d	none	111.61	--	n/a	1.686
11550.00	115+50.00	934.37	943.37	940.70	5.23	0.39	1.69	2.67	d	none	111.63	--	n/a	1.689
11735.00	117+35.00	934.60	943.60	940.90	5.43	0.40	2.12	2.70	d	225	105.22	2.14	0.43	1.689
11883.00	118+83.00	934.77	943.77	941.10	5.40	0.40	2.12	2.67	d	225	105.31	2.14	0.42	1.696
11932.00	119+32.00	934.84	943.84	941.16	5.41	0.40	1.69	2.68	d	none	105.28	--	n/a	1.694
11943.00	119+43.00	933.85	942.85	941.13	5.89	0.43	n/a	n/a	e	none	92.44	--	n/a	1.955
12195.00	121+95.00	934.75	943.75	936.92	22.04	2.95	n/a	n/a	e	none	83.52	--	n/a	2.428
12198.00	121+98.00	939.65	944.15	945.82	7.95	0.94	n/a	n/a	e	none	375.21	--	n/a	1.788
12200.00	122+00.00	939.68	944.18	946.90	5.41	0.54	n/a	n/a	e	none	493.50	--	n/a	1.919
12345.00	123+45.00	940.96	945.46	946.92	6.87	0.61	n/a	n/a	e	none	626.70	--	n/a	1.673
12445.00	124+45.00	941.85	946.35	947.51	4.15	0.44	n/a	n/a	e	none	768.39	--	n/a	1.482
12640.00	126+40.00	942.50	947.00	947.85	3.69	0.34	n/a	n/a	e	none	839.61	--	n/a	1.390
13120.00	131+20.00	943.70	948.20	948.89	7.21	0.91	n/a	n/a	e	none	594.41	--	n/a	1.499
13700.00	n/a	948.50	953.00	952.80	6.13	0.58	n/a	n/a	f	none	873.00	--	n/a	1.221

Notes: * Denotes HEC-RAS Interpolated Cross Section
a) STA 28+78.74 to 29+01.49, 4 - 12'x10' concrete box culvert
b) STA 73+00 to 74+30, Maricopa County 85 slab bridge, low chord elevation is 922.06.
c) STA 75+33 to 75+53, UPRR precast bridge, low chord elevation is 921.7, designed by others.
d) STA 82+20 to 119+43, low flow channel invert reported by HEC-RAS, however freeboard calculations based on centerline invert of main channel.
e) Channel Inlet Area - flow is expected to weir over banks into Bullard Wash upstream of Lower Buckeye Road.
f) Tie into existing FEMA regulated floodplain @ RM 2.883

HYDRAULIC JUMP CALCULATIONS

PROJECT Bullard Wash Outfall Channel Improvements

PROJECT NO. FCD #95-39 SHEET NO. 1 OF 2

CALCULATED BY S Z DATE 6-15-98 CHECKED BY [illegible] DATE 6/99

Hydraulic Jump Evaluation

1) Jump Height

For $Fr_1 > 1.7$, $\quad y_2 = \frac{y_1}{2}\left[(1+8Fr_1^2)^{1/2}-1\right]$ (7.2)

For $Fr \le 1.7$, $\quad y_2 = y_1 Fr_1^2$ (7.4)

2) Jump Length

The length of a hydraulic jump can be determined from Figure 7.9 for non-rectangular channels.

Location (1) Hydraulic Jump at up-stream of the 4-12x10 CBC near BID Canal.

@ Station 29+95.33

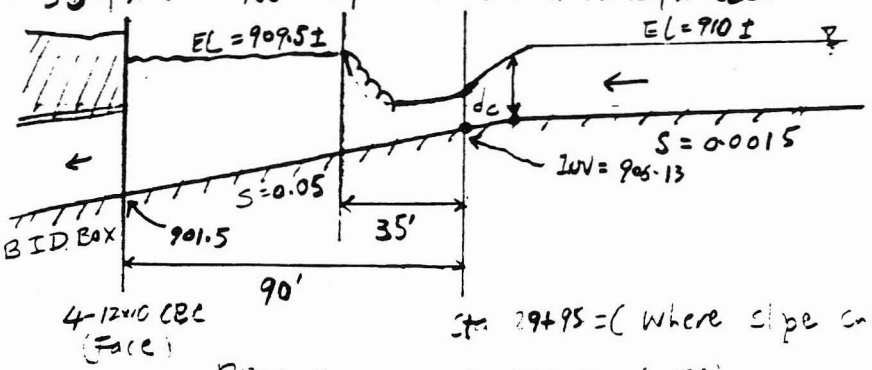
$Fr_1 = 1.40 < 1.7$, $\quad y_1 = 3.46$ ft, $\quad b = 60$ ft, $\quad z = 1$

$y_2 = 3.46 \times 1.40^2 = 6.78$ ft

$t = \frac{b}{zy} = \frac{60}{1 \times 3.46} = 17.3$

$L/y_1 = 10$, (Fig. 7.9)

$L = 10 \times 3.46 = 35$ ft. No impact on the 4-12x10 ft CBC.



Sta. 29+95 = (where slope changes > Sc

PROJECT _____

PROJECT NO. _____ SHEET NO. 2 OF 2

CALCULATED BY _____ DATE _____ CHECKED BY _____ DATE _____

Location (2) Hydraulic Jump near UPRR

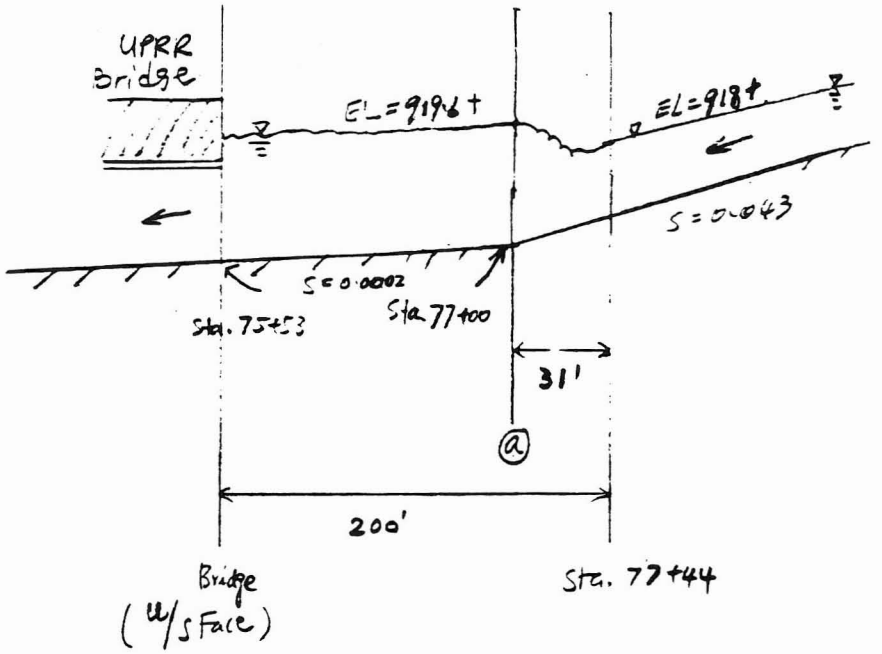
$Fr_1 = 1.65 < 1.7$, $y_1 = 2.6$ ft, $b = 75$ ft, $z = 2$

$y_2 = 2.6 \times 1.65^2 = 7.1$ ft

$t = \frac{b}{zy} = \frac{75}{2 \times 2.6} = 14.4$

$L/y_1 = 12$ (Fig. 7.9)

$L = 12 \times 2.6 = 31$ ft. No impact on the downstream bridge



Profile looking West
NTS

ⓐ Approximate station where TW Elev. = Elev. of :

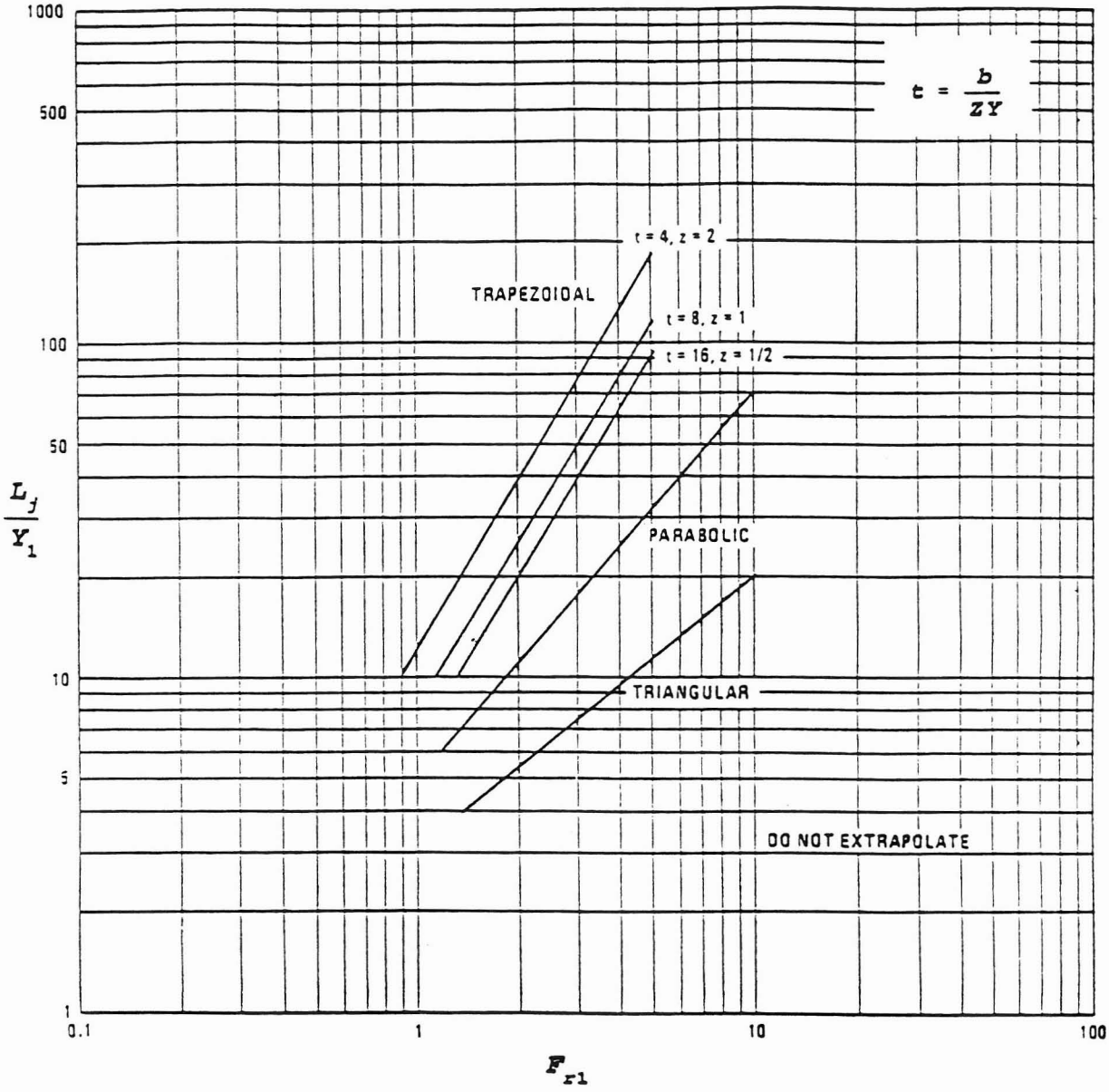


Figure 7.9
Length of a Hydraulic Jump for Non-Rectangular Channels
(USDOT, FHWA, HEC-14, 1983)

BULLARD WASH GABION INLET HYDRAULICS

WOOD/PATEL

CIVIL ENGINEERS • HYDROLOGISTS • LAND SURVEYORS

PROJECT Bullard Wash

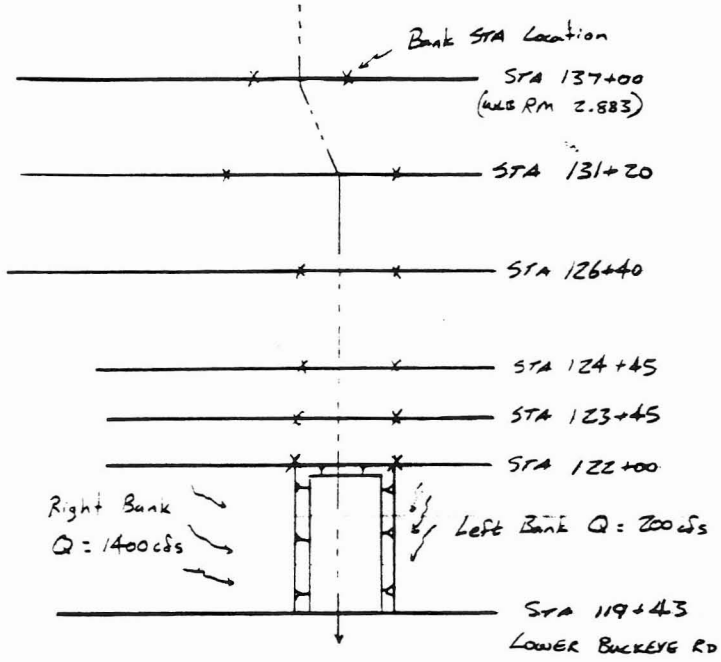
PROJECT NO. 96464 SHEET NO. 1 OF 1

CALCULATED BY DTP DATE 4 Sep 98 CHECKED BY _____ DATE _____

Bullard Wash - Phase 2

Gabion Inlet Hydraulics

Reference: US Army Corps of Engineers Uneven Weir micro computer program Fortran version 1.0



N

N.T.S.

Summary of Flow Distribution

Station	Q_{Left}	Q_{Main}	Q_{Right}	
137+00	2500	640	1770	4
131+20	200	4610	50	4
126+40	0	1500	1700	3
124+45	130	1730	1340	3
123+45	100	2340	770	3
122+00	0	2530	670	3

Note: It seems reasonable that STA 124+45 represents flow distrib approaching gabion drop inlet struct

Q_{Left} = 130 cfs ⇒ use Q = 2

Q_{Right} = 1340 cfs ⇒ use Q = 14

Uneven Weir Results

Right Bank (West side) Q = 1400 cfs

Ponding EL = 946.9

Left Bank (East Side) Q = 200 cfs

Ponding EL = 944.5

```
*********************************************
    UNEVEN WEIR FLOW PROGRAM
    FORTRAN VERSION 1.0
*********************************************

    PROJECT:  Bullard Wash Outfall Channel          Drop inlet on west side
    ENGINEER:  dtp
    DATE:   9/ 4/1998
    TIME:  11:42. 4

---------------------------------------------
    INPUT PARAMETERS
---------------------------------------------

    STARTING WSEL:        944.90
    MAXIMUM WSEL:         947.70
    STEP SIZE:              0.10
    BREADTH OF WEIR:       20.00

*********************************************
    INPUT ELEVATION/STATION TABLE.
    PROJECT:  Bullard Wash Outfall Channel          Drop inlet on west side
    DATE:   9/ 4/1998
    TIME:  11:42. 4
*********************************************
```

POINT	ELEVATION	STATION
1	950.00	11942.00
2	946.20	11943.00
3	944.97	12043.84
4	945.30	12200.00
5	950.00	12201.00

```
*********************************************
    WEIR COEFFICIENT TABLE
    PROJECT:  Bullard Wash Outfall Channel          Drop inlet on west side
    DATE:    9/ 4/1998
    TIME:  11:42. 4
*********************************************
```

REFERENCE: COE CHART - UPPER CURVE

POINT	HEAD	COEFFICIENT	POINT	HEAD	COEFFICIENT
1	0.00	2.5000	16	1.50	2.7500
2	0.10	2.5167	17	1.60	2.7667
3	0.20	2.5333	18	1.70	2.7833
4	0.30	2.5500	19	1.80	2.8000
5	0.40	2.5667	20	1.90	2.8167
6	0.50	2.5833	21	2.00	2.8333
7	0.60	2.6000	22	2.10	2.8500
8	0.70	2.6167	23	2.20	2.8667
9	0.80	2.6333	24	2.30	2.8833
10	0.90	2.6500	25	2.40	2.9000
11	1.00	2.6667	26	2.50	2.9167
12	1.10	2.6833	27	2.60	2.9333
13	1.20	2.7000	28	2.70	2.9500
14	1.30	2.7167			
15	1.40	2.7333			

```
*********************************************
    UNEVEN WEIR FLOW PROGRAM
    FORTRAN VERSION 1.0
    PROJECT:  Bullard Wash Outfall Channel          Drop inlet on west side
    DATE:    9/ 4/1998
    TIME:  11:42. 4
*********************************************
```

ELEVATION	DISCHARGE (CFS)	ELEVATION	DISCHARGE (CFS)
944.90	0.00	946.40	813.32
945.00	0.09	946.50	928.03
945.10	3.40	946.60	1049.12
945.20	14.19	946.70	1176.45
945.30	35.10	946.80	1309.89
945.40	66.92	946.90	1449.35
945.50	107.48	947.00	1594.76
945.60	155.96	947.10	1746.04
945.70	212.05	947.20	1903.15
945.80	275.60	947.30	2066.03
945.90	346.55	947.40	2234.66
946.00	424.91	947.50	2409.00
946.10	510.71	947.60	2589.03
946.20	604.02		
946.30	705.22		

1400 cfs in right bank (west side) will overtop O&M road @ ELEV = 946.90

```
*********************************************
    UNEVEN WEIR FLOW PROGRAM
    FORTRAN VERSION 1.0
*********************************************

    PROJECT:  Bullard Wash Outfall Channel        Drop inlet weir on east
    ENGINEER:  dtp
    DATE:   9/ 4/1998
    TIME:  11:49.44


---------------------------------------------
    INPUT PARAMETERS
---------------------------------------------

    STARTING WSEL:        943.80
    MAXIMUM WSEL:         946.50
    STEP SIZE:              0.10
    BREADTH OF WEIR:       10.00


1


*********************************************
    INPUT ELEVATION/STATION TABLE.
    PROJECT:  Bullard Wash Outfall Channel        Drop inlet weir on east
    DATE:   9/ 4/1998
    TIME:  11:49.44
*********************************************

    POINT    ELEVATION    STATION
    -----    ---------    -------
        1       948.00   11942.00
        2       943.85   11943.00
        3       944.20   12200.00
        4       948.00   12201.00
```

```
*******************************************
    WEIR COEFFICIENT TABLE
    PROJECT:  Bullard Wash Outfall Channel        Drop inlet weir on east
    DATE:   9/ 4/1998
    TIME:  11:49.44
*******************************************
```

REFERENCE: COE CHART - UPPER CURVE

POINT	HEAD	COEFFICIENT	POINT	HEAD	COEFFICIENT
1	0.00	2.5000	16	1.50	3.0000
2	0.10	2.5333	17	1.60	3.0022
3	0.20	2.5667	18	1.70	3.0044
4	0.30	2.6000	19	1.80	3.0067
5	0.40	2.6333	20	1.90	3.0089
6	0.50	2.6667	21	2.00	3.0111
7	0.60	2.7000	22	2.10	3.0133
8	0.70	2.7333	23	2.20	3.0156
9	0.80	2.7667	24	2.30	3.0178
10	0.90	2.8000	25	2.40	3.0200
11	1.00	2.8333	26	2.50	3.0222
12	1.10	2.8667	27	2.60	3.0244
13	1.20	2.9000	28	2.70	3.0267
14	1.30	2.9333			
15	1.40	2.9667			

```
*******************************************
    UNEVEN WEIR FLOW PROGRAM
    FORTRAN VERSION 1.0
    PROJECT:  Bullard Wash Outfall Channel        Drop inlet weir on east
    DATE:   9/ 4/1998
    TIME:  11:49.44
*******************************************
```

ELEVATION	DISCHARGE (CFS)	ELEVATION	DISCHARGE (CFS)
943.80	0.00	945.30	1085.30
943.90	0.41	945.40	1228.98
944.00	6.46	945.50	1380.57
944.10	23.32	945.60	1528.27
944.20	54.44	945.70	1677.18
944.30	100.96	945.80	1830.83
944.40	159.14	945.90	1989.08
944.50	227.44	946.00	2151.85
944.60	305.11	946.10	2319.02
944.70	391.66	946.20	2490.51
944.80	486.79	946.30	2666.23
944.90	590.28	946.40	2846.10
945.00	701.97	946.50	3030.06
945.10	821.75		
945.20	949.54		

200 cfs in left bank (east side) will overtop gabion inlet structure @ ELEV = 944.5

Appendix E6

Hydraulic Calculations for East Tributary Channel

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: ETRIB 0+40 - 8+60

Comment: EAST TRIB CHANNEL STA 8+60 - 10+00

Solve For Depth

Given Input Data:

Bottom Width.....	15.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.019
Channel Slope....	0.0020 ft/ft
Discharge.....	850.00 cfs

Computed Results:

Depth.....	4.88 ft
Velocity.....	7.81 fps
Flow Area.....	108.78 sf
Flow Top Width...	29.63 ft
Wetted Perimeter.	32.58 ft
Critical Depth...	4.03 ft
Critical Slope...	0.0040 ft/ft
Froude Number....	0.72 (flow is Subcritical)

Open Channel Flow Module, Version 3.43 (c) 1991
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: ETRIB 8+60-1000

Comment: EAST TRIB CHANNEL STA 8+60 - 10+00

Solve For Depth

Given Input Data:

Bottom Width.....	15.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.019
Channel Slope....	0.0025 ft/ft
Discharge.....	850.00 cfs

Computed Results:

Depth.....	4.59 ft
Velocity.....	8.46 fps
Flow Area.....	100.44 sf
Flow Top Width...	28.77 ft
Wetted Perimeter.	31.55 ft
Critical Depth...	4.03 ft
Critical Slope...	0.0040 ft/ft
Froude Number....	0.80 (flow is Subcritical)

Open Channel Flow Module, Version 3.43 (c) 1991
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

7/27/92

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: ETRIB 10+20-2162

Comment: EAST TRIB CHANNEL STA 10+20 - 21+62

Solve For Depth

Given Input Data:

Bottom Width.....	15.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.019
Channel Slope....	0.0020 ft/ft
Discharge.....	850.00 cfs

Computed Results:

Depth.....	4.88 ft
Velocity.....	7.81 fps
Flow Area.....	108.78 sf
Flow Top Width...	29.63 ft
Wetted Perimeter.	32.58 ft
Critical Depth...	4.03 ft
Critical Slope...	0.0040 ft/ft
Froude Number....	0.72 (flow is Subcritical)

Open Channel Flow Module, Version 3.43 (c) 1991
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

7/27/92

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: ETRIB CHL INLET

Comment: E TRIB INLET (shallow V-ditch bottom)

Solve For Depth

Given Input Data:

Bottom Width.....	40.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.019
Channel Slope....	0.0055 ft/ft
Discharge.....	850.00 cfs

36 ft → D = 2.22 ft
V = 9.16 fps
F_r = 1.13

Computed Results:

Depth.....	2.16 ft
Velocity.....	9.08 fps
Flow Area.....	93.62 sf
Flow Top Width...	46.49 ft
Wetted Perimeter.	47.81 ft
Critical Depth...	2.34 ft
Critical Slope...	0.0042 ft/ft
Froude Number....	1.13 (flow is Supercritical)

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7/21/98

Appendix E7

Hydraulic Calculations for Interior Drainage Outlet Structure

Culvert Designer/Analyzer Report
Pipe P12, Sta 30+65 Rt, BID Spillway

Comments: Spillway is located on north bank of BID Canal and east of new Bullard Wash Channel.

The high water at the inlet exceeds the elevation of the farm road that separates Pipe 2 from Pipe 12. Therefore, both sets of of pipes are modeled together.

Pipe 12 inlets and outlets are mitered to conform to 2:1 spillway banks. Pipe 12 will outlet onto spillway to spread flows before entering the canal.

Overtopping wier is concrete, trapezoidal, 40' bottom width, and approximately 7 percent sideslopes to North Maintenance Road grade.

A 4:1 slope on shotcrete spillway into BID canal.

Tailwater elevation is BID overchute structure low chord elevation = 905.5 (Plunge flow at outlet).

Pipe 2 overtops the farm road (approximately 26 cfs). Design flow for Pipe 12 is the condition where the spillway crest is just overtopped. Check flow is 100-yr, 24-hr storm with 100% saturation in the watershed.

Analysis Component			
Storm Event	Check	Discharge	366.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	105.00 cfs	Check Discharge	366.00 cfs

..ilwater Conditions: Constant Tailwater	
Tailwater Elevation	903.50 ft

Name	Description	Discharge	HW Elev	Velocity
Culvert-1	3-24 inch Circular	93.91 cfs	913.30 ft	10.21 ft/s
Culvert-2	1-24 inch Circular	32.45 cfs	913.30 ft	13.55 ft/s
Weir	Roadway	239.81 cfs	913.30 ft	N/A
Total	————	366.17 cfs	913.30 ft	N/A

Culvert Designer/Analyzer Report
Pipe P12, Sta 30+65 Rt, BID Spillway

ponent:Culvert-1

Culvert Summary					
Computed Headwater Elevation	913.30	ft	Discharge	93.91	cfs
Inlet Control HW Elev	913.30	ft	Tailwater Elevation	903.50	ft
Outlet Control HW Elev	912.91	ft	Control Type	Inlet Control	
Headwater Depth/ Height	2.64				

Grades					
Upstream Invert	908.01	ft	Downstream Invert	907.78	ft
Length	45.00	ft	Constructed Slope	0.005111	ft/ft

Hydraulic Profile					
Profile	CompositeM2Pressure		Depth, Downstream	1.88	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	1.88	ft
Velocity Downstream	10.21	ft/s	Critical Slope	0.016549	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	3				

Outlet Control Properties					
Outlet Control HW Elev	912.91	ft	Upstream Velocity Head	1.54	ft
Ke	0.50		Entrance Loss	0.77	ft

Inlet Control Properties					
Inlet Control HW Elev	913.30	ft	Flow Control	Submerged	
Inlet Type	End-Section Conforming to fill slope		Area Full	9.4	ft^2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

Culvert Designer/Analyzer Report
Pipe P12, Sta 30+65 Rt, BID Spillway

ponent:Culvert-2

Culvert Summary					
Computed Headwater Elevation	913.30	ft	Discharge	32.45	cfs
Inlet Control HW Elev	913.30	ft	Tailwater Elevation	903.50	ft
Outlet Control HW Elev	912.22	ft	Control Type	Inlet Control	
Headwater Depth/ Height	2.78				

Grades					
Upstream Invert	907.74	ft	Downstream Invert	904.42	ft
Length	110.00	ft	Constructed Slope	0.030182	ft/ft

Hydraulic Profile					
Profile	S2		Depth, Downstream	1.43	ft
Slope Type	Steep		Normal Depth	1.39	ft
Flow Regime	Supercritical		Critical Depth	1.90	ft
Velocity Downstream	13.55	ft/s	Critical Slope	0.017808	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	2.00	ft
Section Size	24 inch		Rise	2.00	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev	912.22	ft	Upstream Velocity Head	1.73	ft
Ke	0.50		Entrance Loss	0.86	ft

Inlet Control Properties					
Inlet Control HW Elev	913.30	ft	Flow Control	Submerged	
Inlet Type	End-Section Conforming to fill slope		Area Full	3.1	ft^2
K	0.00980		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	1	
C	0.03980		Equation Form	1	
Y	0.67000				

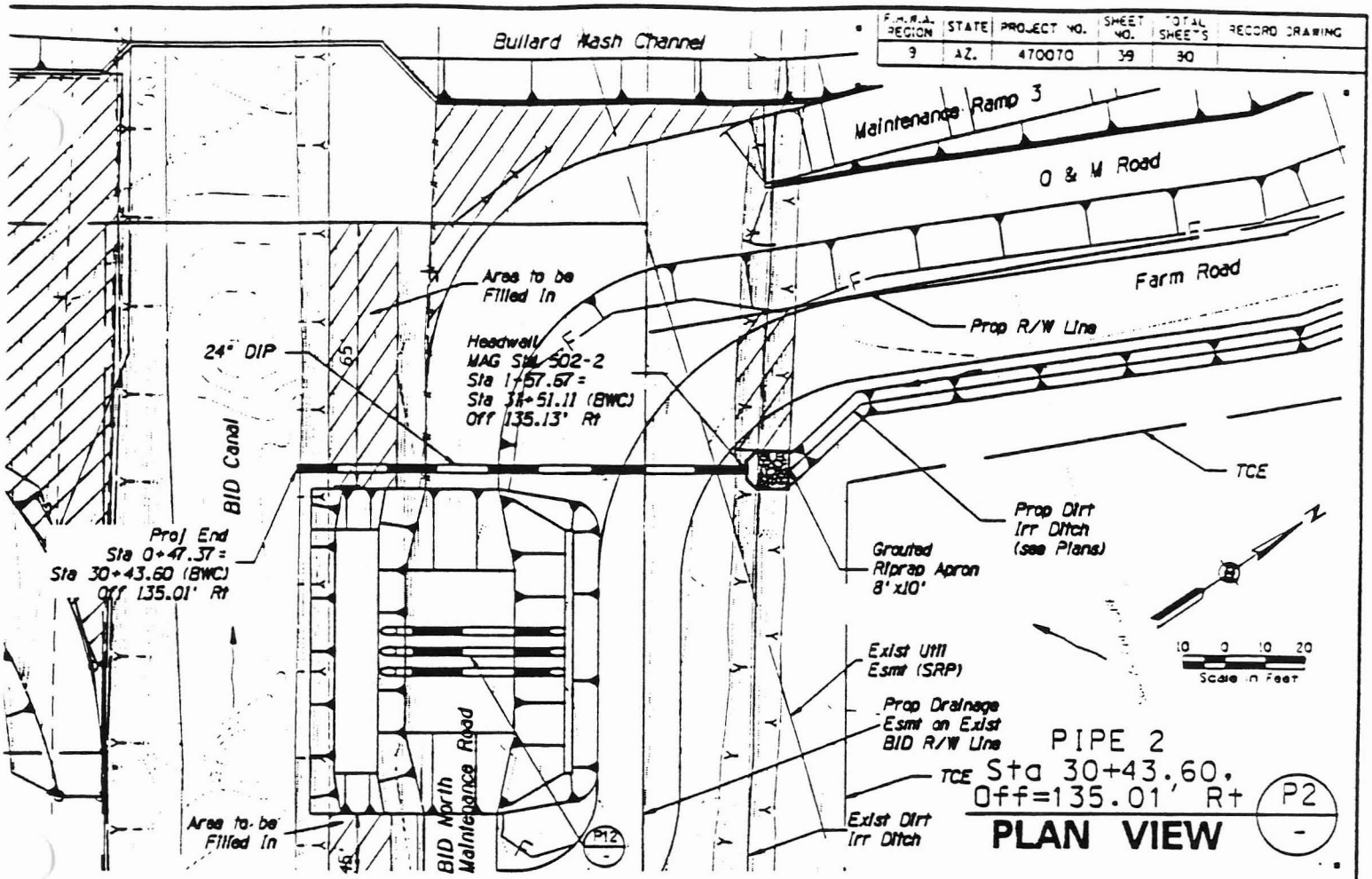
Culvert Designer/Analyzer Report
Pipe P12, Sta 30+65 Rt, BID Spillway

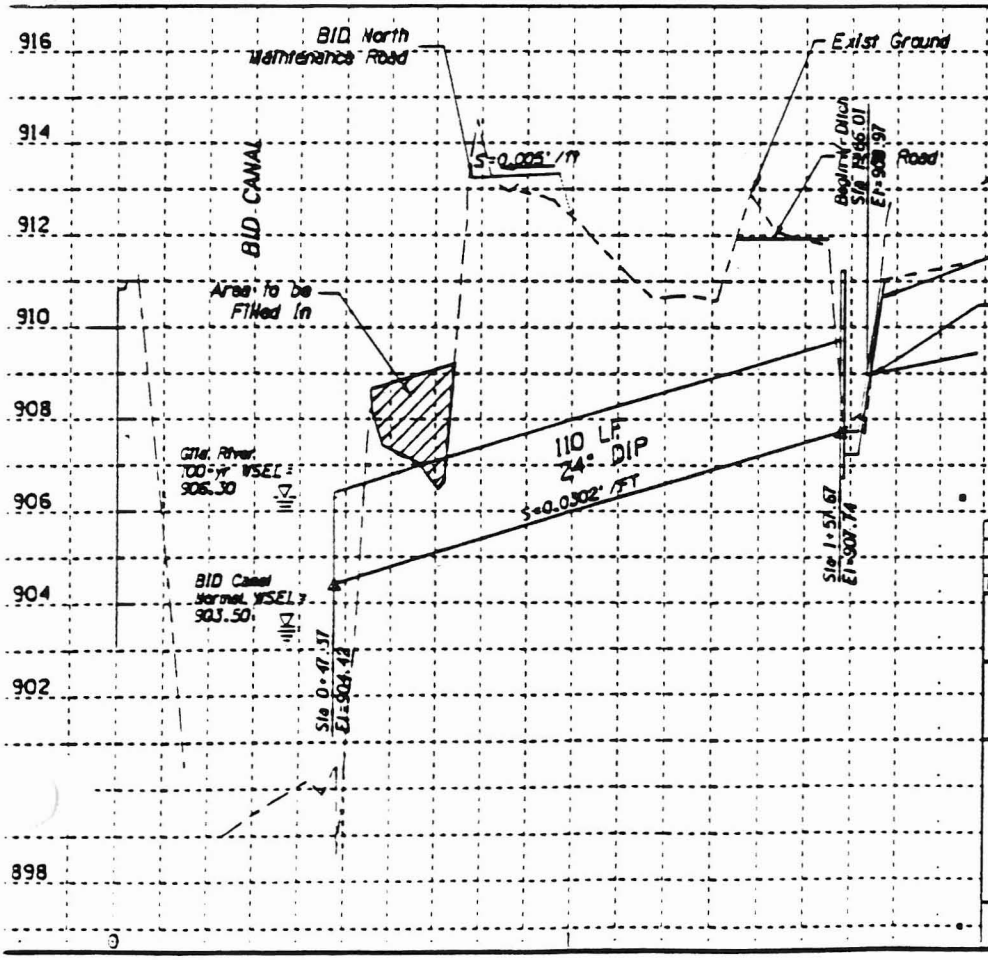
ıponent:Weir

Hydraulic Component(s): Roadway					
Discharge	239.81	cfs	Allowable HW Elevation	913.30	ft
Roadway Width	27.00	ft	Overtopping Coefficient	3.03	US
Low Point	912.00	ft	Headwater Elevation	913.30	ft
Discharge Coefficient (Cr)	3.03		Submergence Factor (Kt)	1.00	
Tailwater Elevation	903.50	ft			

Sta (ft)	Elev (ft)
140.00	913.35
160.00	912.00
200.00	912.00
220.00	913.35

FEDERAL REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.	470070	39	30	





NO.	REVISION	BY	DATE

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

BULLARD WASH
CHANNEL IMPROVEMENTS PROJECT
PROJECT NO. 470070

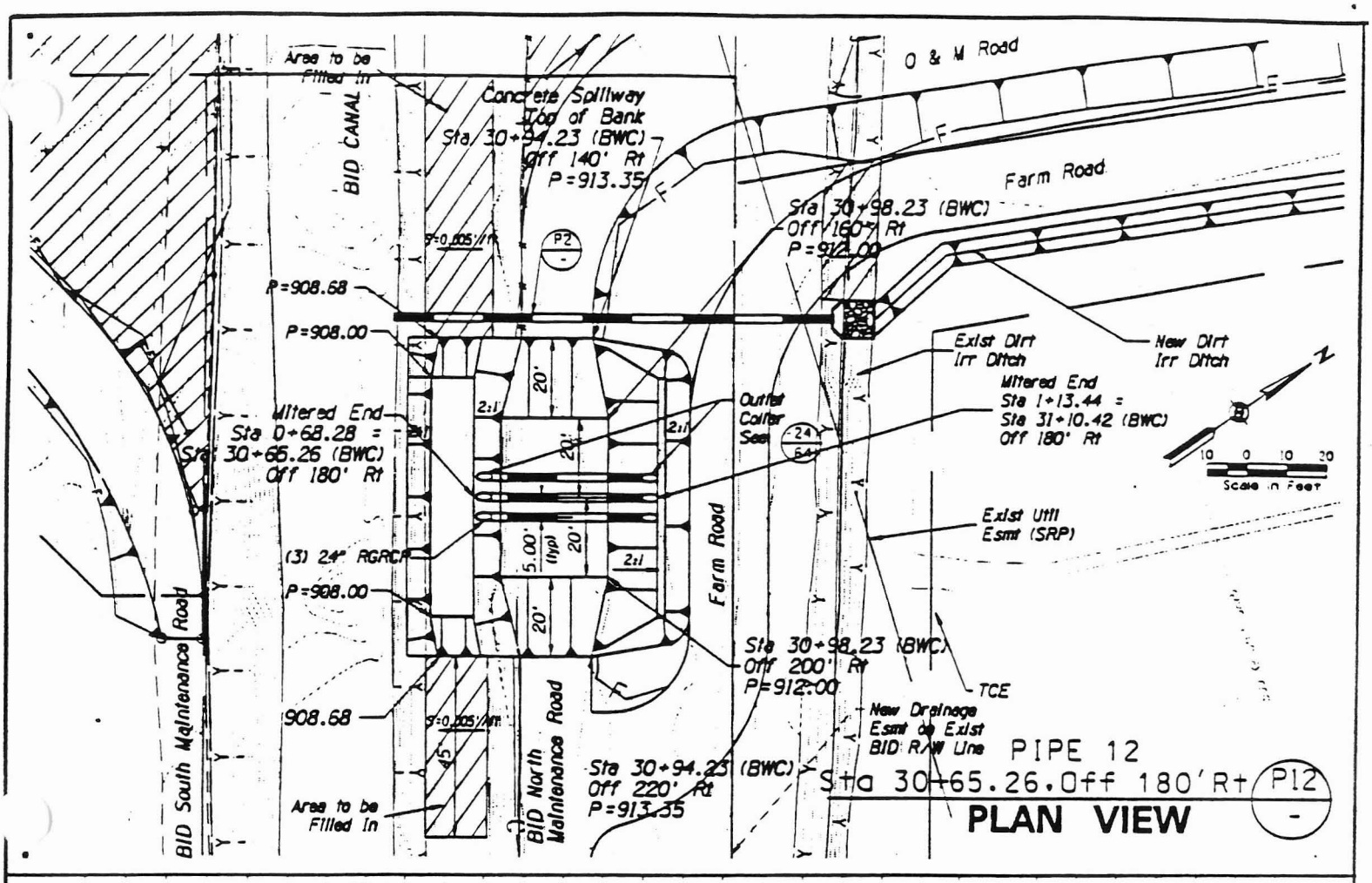
PRELIMINARY NOT FOR CONSTRUCTION

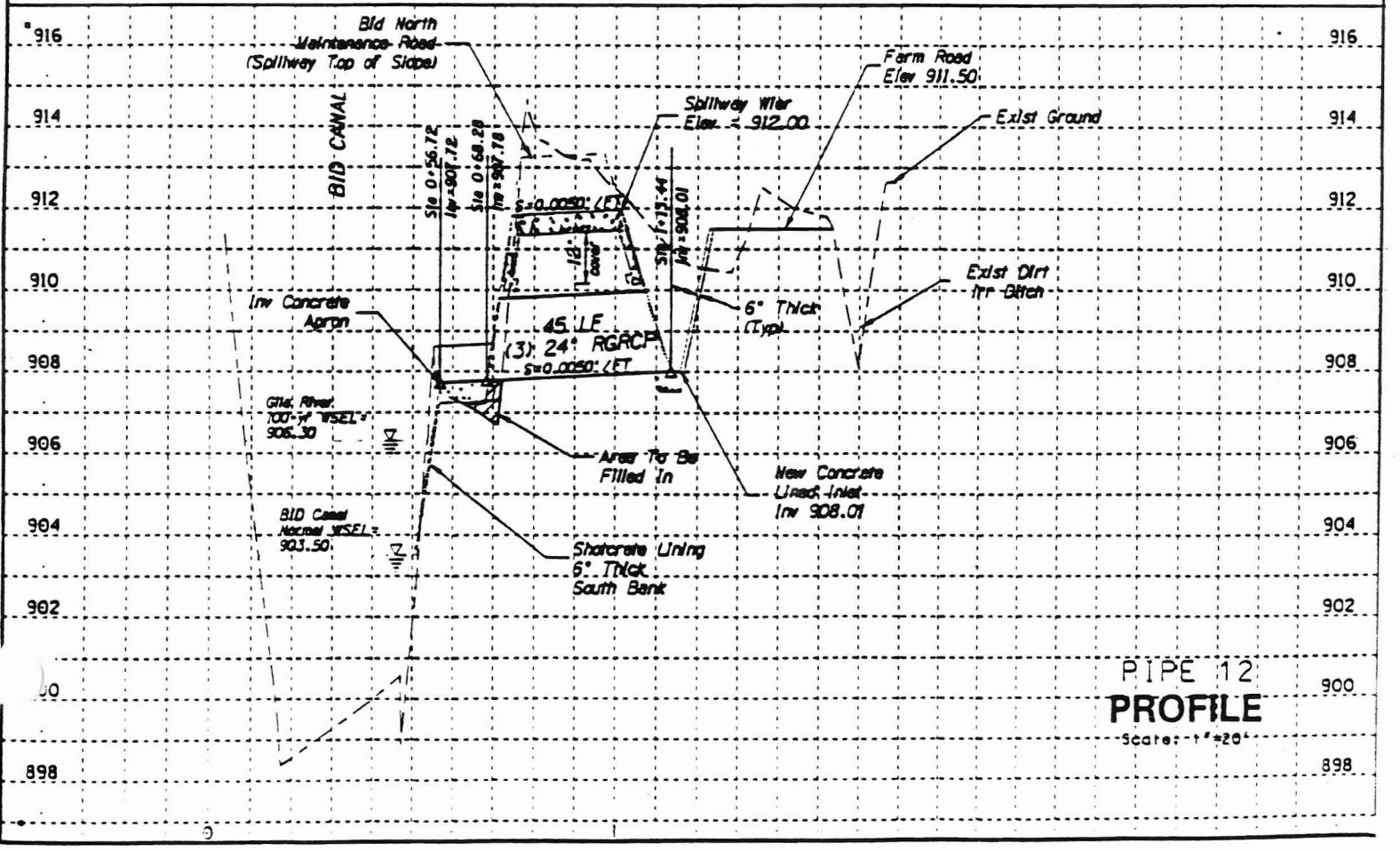
	BY	DATE
DESIGNED	O. STOUGH	7/07/98
DRAWN	B. EDGAR	7/07/98
CHECKED	B. OLBERT	7/07/98

Sverdrup CORPORATION

PIPE PROFILE
PIPE 2 and PIPE 12

SHEET 39 OF 30


Area to be Filled In
BID CANAL
Concrete Spillway Top of Bank
Sta 30+94.23 (BWC)
Off 140' Rt
P=913.35
O & M Road
Farm Road
Sta 30+98.23 (BWC)
Off 160' Rt
P=912.00
S=0.005'/ft
P2
P=908.68
P=908.00
Exist Dirt Irr Ditch
New Dirt Irr Ditch
Mitered End
Sta 1+13.44 =
Sta 31+10.42 (BWC)
Off 180' Rt
Mitered End
Sta 0+68.28 =
Sta 30+65.26 (BWC)
Off 180' Rt
Outlet Collar See
Scale in Feet
Exist Util Esmt (SRP)
(3) 24" RGRCP
5.00' (typ)
20'
2:1
Farm Road
P=908.00
Sta 30+98.23 (BWC)
Off 200' Rt
P=912.00
TCE
BID South Maintenance Road
908.68
New Drainage Esmt on Exist BID R/W Line
BID North Maintenance Road
Sta 30+94.23 (BWC)
Off 220' Rt
P=913.35
Area to be Filled In
PIPE 12
Sta 30+65.26 Off 180' Rt
PLAN VIEW


Bid North Maintenance Road (Spillway Top of Slope)
BID CANAL
Sta 0+56.12
Inv=901.12
Sta 0+68.28
Inv=907.78
S=0.0050'/FT
Spillway Weir Elev = 912.00
Farm Road Elev 911.50
Exist Ground
Sta 1+13.44
Inv=904.01
12" Culvert
Exist Dirt Irr Ditch
Inv Concrete Apron
6" Thick (Typ)
45 LF
(3) 24" RGRCP
S=0.0050'/FT
Gila River 100-yr WSEL= 906.30
Area To Be Filled In
New Concrete Lined Inlet Inv 908.01
BID Canal Normal WSEL= 903.50
Shotcrete Lining 6" Thick South Bank
PIPE 12
PROFILE
Scale: 1"=20'
916
914
912
910
908
906
904
902
900
898

Appendix F

Erosion and Sedimentation Analysis

This appendix contains the local scour calculations for the Ford crossing at Broadway Road and the BID Bypass Road CBC. Also included are the calculations for rip rap sizing for the grouted rip rap portions of this study reach. A section documenting the gabion mattress design is also included here. Refer to the Sediment Transport & Scour Analysis (under separate cover) for the remainder of the erosion and sedimentation analyses.

LOCAL SCOUR ESTIMATION

PROJECT Bullard wash channel.

PROJECT No. FCD # 95-39 SHEET No. 1 OF 2

CALCULATED BY SZ DATE 6-30 CHECKED BY [illegible] DATE 6/98

Local scour Depth at Downstream of Broadway Road

Method: Veronese (1937)

Local scour (Sill scour) depth = 4.1 ft (see attached spreadsheet)

From sediment transport and scour analysis report.

Long-term degradation = 2.12 ft.

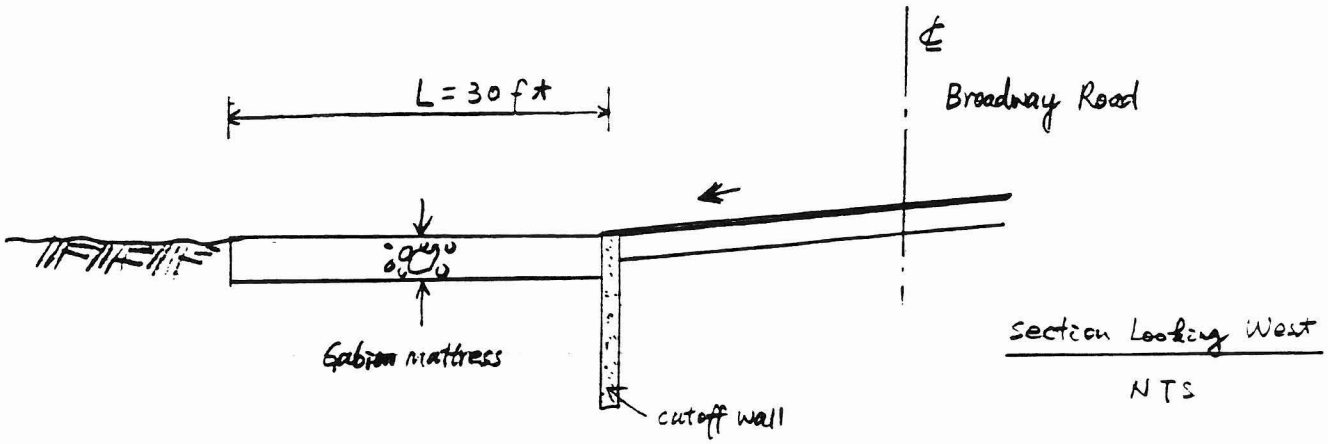
Bedform troughs = 0.54 ft

Low flow incisement = 1.0 ft

Total scour depth at station 63+60 (localized conditions)

= { long-term degradation + bedform troughs + low flow incisement + local scour (Sill scour) } × safety factor

= { 2.12 + 0.54 + 1.0 + 4.1 } × 1.3 = 10.1 ft



In order to stabilize the local scour immediately below Broadway Road, a gabion mattress protection anchoring with proposed 4' deep cutoff wall is recommended. The width of the gabion mattress should be the same as the channel bottom width.
Because gabion is flexible, it will adjust to downstream potential scour development.

Sill Scour Computation Sheet

100-year Scour Estimate Downstream of Broadway Road (Sta. 63+22)

Methodology from "Computing Degradation and Local Scour" by E. Pemberton and J. Lara, 1984, Technical Guideline for Bureau of Reclamation, pages 40-45, equation type "D"

100-year discharge =	3,200	cfs	Long-term degradation =	1.60	ft
Total flow area (u/s) =	557.07	ft^2	Total flow area (d/s) =	556.99	ft^2
Total top width (u/s) =	92.89	ft	Total top width (d/s) =	92.89	ft
Mean flow depth (u/s) =	6.00	ft	Mean flow depth (d/s) =	6.00	ft
Discharge per foot =	34.45	cfs/ft	WSEL (u/s) =	917.80	ft
			WSEL (d/s) =	917.65	ft

Veronese (1937)

$$d_s = KH_T^{0.225} q^{0.54} - d_m$$

ds = 4.1 ft

d_s = depth of scour (ft)		
K =	1.32	1.32 inch-pound units
H_T =	1.75	head from U/S to D/S
q =	34.45	discharge per unit width (cfs per ft)
d_m =	6.00	D/S mean water depth

WOOD/PATEL

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PROJECT Ballard wash channel

PROJECT NO. _____ SHEET NO. 1 OF 3

CALCULATED BY SZ DATE 6-30 CHECKED BY _____ DATE _____

Local scour depth at downstream of CCC

Method: Veronese (1937)

Local scour (sill scour) depth = 5.0 ft (see attached spreadsheet)

No long-term degradation/aggredation, bedform trough, and low flow incisement are applicable, therefore,

Total scour depth = local scour × safety factor

= 5.0 × 1.3 = 6.5 ft.

Sill Scour Computation Sheet

100-year Scour Estimate Downstream of 4-12x10 ft CBC (Sta. 28+71.74)

Methodology from "Computing Degradation and Local Scour" by E. Pemberton and J. Lara, 1984, Technical Guideline for Bureau of Reclamation, pages 40-45, equation type "D"

100-year discharge =	3,200	cfs	Long-term degradation =	0.00	ft
Total flow area (u/s) =	309.12	ft^2	Total flow area (d/s) =	505.60	ft^2
Total top width (u/s) =	57.14	ft	Total top width (d/s) =	91.77	ft
Mean flow depth (u/s) =	5.41	ft	Mean flow depth (d/s) =	5.51	ft
Discharge per foot =	56.00	cfs/ft	WSEL (u/s) =	906.85	ft
			WSEL (d/s) =	907.26	ft

Veronese (1937)

$$d_s = KH_T^{0.225} q^{0.54} - d_m$$

ds = 5.0 ft

d_s = depth of scour (ft)		
K =	1.32	1.32 inch-pound units
H_T =	0.63	head from U/S to D/S
q =	56.00	discharge per unit width (cfs per ft)
d_m =	5.51	D/S mean water depth

WOOD/PATEL

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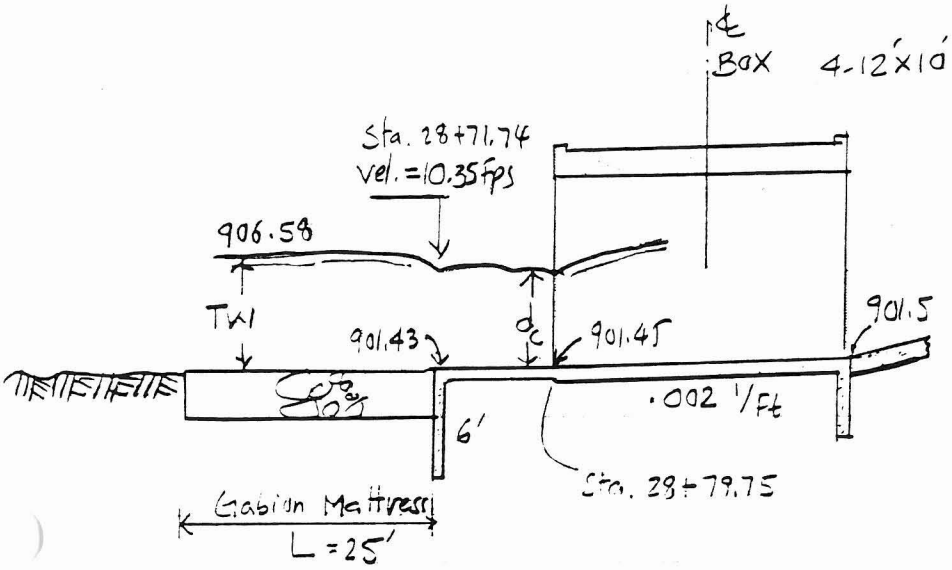
PROJECT Bullard Wash Channel

PROJECT NO. _____ SHEET NO. 3 OF 3

CALCULATED BY [illegible] DATE 6/98 CHECKED BY SZ DAT 6-30

BID Maintenance Road Box Culvert, Outlet Protection



Profile Looking West

From HEC-RAS, @ 28+79.75
$Y_1 = 5.11$ (d_c)
$V_1 = 12.22$ fps
$F_r = 0.95$ ($\cong d_c$)

① Tailwater based on Q_{10} in Gila River = 906.3

or, ② " " slope area method for the outfall channel for Q_{100} in Bullard Wash channel = 906.58

∴ condition ② is controlling, use 906.58 as the SWSEL

Since velocity at the downstream edge of concrete apron is subcritical (10.35 fps per HEC-RAS), a gabion mattress is recommended to stabilize scour.

Provide 25 ft long gabion mattress. The mattress should be anchored to the apron cut-off wall. The mattress should be placed for the full width of channel bottom

WOOD/PATEL

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PROJECT Bullard Wash Channel

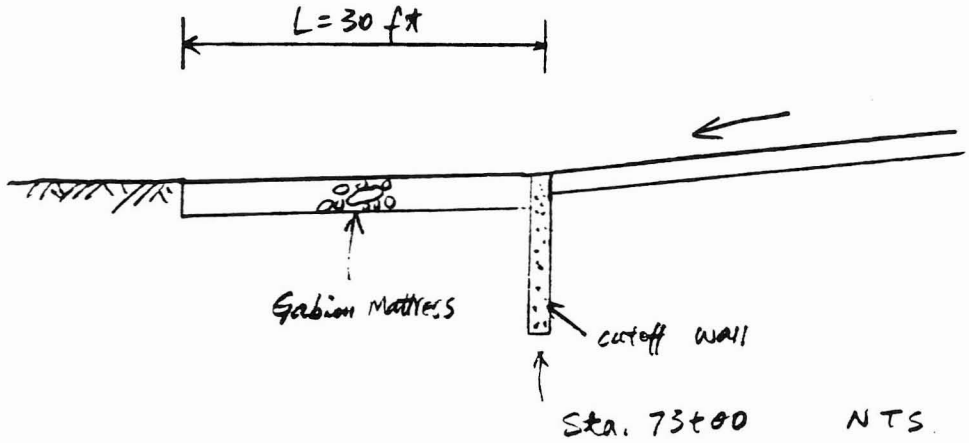
PROJECT No. FCD# 95-39 SHEET No. 1 OF 1

CALCULATED BY SZ DATE 7-2 CHECKED BY _____ DATE _____

Local scour Depth at Sta. 73+00

The calculated toe down depth from the sediment Transport & scour Analysis Report is 11.9 ft at this location.

It is recommended that a gibion mattress protection anchoring with proposed 4' deep cutoff wall be constructed. The width of the gibion mattress is the same as the channel bottom width.



RIPRAP DESIGN

Reference: "Drainage Design Manual for Maricopa County, AZ, Vol. I, Hydraulics" Jan. 1996. FCDMC.

Design of Grouted Riprap Lining

1). Channel section near BID Canal

The highest velocity in this area is 16.47 ft/s at station 29+80.

The estimated riprap thickness is 2.1 ft from Figure 6-10, P6-49 of the Reference.

D50 can be calculated by the following Eq.

$$\text{Riprap thickness} = 1.5 \times D_{50}$$

$$D_{50} = \frac{2.1}{1.5} = 1.4 \text{ ft} = 17 \text{ in}$$

For rock riprap, the Manning "n" value varies with mean stone size as follows (HEC 11, FHWA):

$$n = 0.0395 \times D_{50}^{1/6}$$

$$n = 0.0395 \times 1.4^{1/6} = 0.042$$

Substituting n = 0.042 into the HEC-RAS model yields the new highest flow velocity of 15.14 ft/s in this area.

Repeat the above steps, we have.

Riprap thickness = 1.25 ft = 20 in

$D_{50} = 15$ in.

$n = 0.041$.

Substituting $n = 0.041$ into the HEC-RAS model gives the new highest flow velocity of 15.22 ft/s in this area, which is close to the previous run. Therefore, the final design parameters should be:

Riprap thickness = 22 in. and
$D_{50} = 15$ in.

2) <u>Channel Section near UPRR</u>

The highest velocity in this area is 16.52 ft/s at station 79+53.

Following the above procedures, the estimated parameters are:

Riprap thickness = 2.1 ft = 25 in.

$D_{50} = 1.4$ ft = 17 in.

$n = 0.042$.

Substituting $n = 0.042$ into the HEC-RAS model yields the new highest flow velocity of 15.56 ft/s in this area.

Repeat the above steps. the final design parameters are:

Riprap thickness = 22 in. and

D_{50} = 15 in.

3) Gradation of Riprap

The median rock size should not exceed 0.67 times the blanket thickness and the largest rock used should not exceed the thickness. Table 6-4 of the Reference can be used as the guideline in preparing the riprap rocks. As a practical matter, the recommended minimum size is one-half of the D_{50} for (grouted) riprap. i.e. 8 in. for the subject project.

Stone Size Range (in)			Percent of Gradation
20	to	22	100
17	to	19	85
14	to	16	50
8	to	10	15

4) Filter Blanket Requirements

A well-graded gravel filter should be placed over the channel bed prior to channel lining with grouted riprap in order to protect the underlying soil from washing away by seepage force and provide a base on which grouted riprap will rest. Equations 6-15a & 6-15b of the Reference can be used to determine the gradation of the filter rocks. For simplic Tables 6-5 and 6-6 are used for the design of the filter blanket layers. Because the designed thickness of the riprap is about 24", and the channel soil is fine grain, the thickness requirements for gravel bedding are (Table 6-6): Type I: 4", Type II: 6".

The Type I bedding is designed to be the lower layer in a two-layer filter for protecting fine grained soils. and Type II is between the grouted riprap and Type I bedding. Their gradations are shown in Table 6-5.

5 of 8

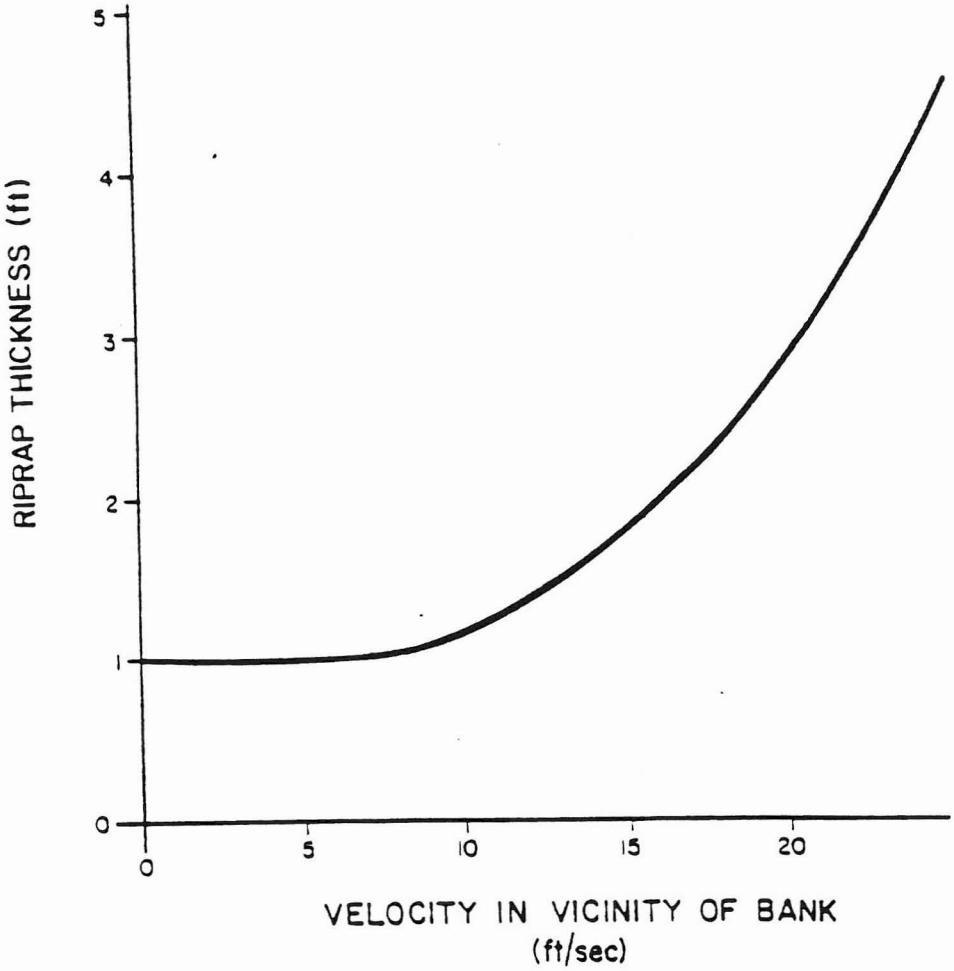


Figure 6.10
Required Blanket Thickness of Grouted Rock
(USDOT, FHWA, HEC-11, 1989)

6.5.5 Wire Enclosed Rock (Gabion Baskets)

6.5.5.1 General: Wire enclosed rock refers to rocks that are confined by a wire basket so that they act as a single unit. The wire mesh enclosed rock units are also known as gabion baskets or gabion mattresses. One of the major advantages of wire enclosed rock is that it provides an alternative in situations where available rock sizes are too small for ordinary riprap. Another advantage is the versatility that results from the regular geometric shapes of wire enclosed rock. The rectangular blocks and mats can be fashioned into almost any shape that can be formed with concrete. The durability of wire enclosed rock is generally limited by the service life of the galvanized binding wire which, under normal conditions, is considered to be about 15 years. Water carrying silt, sand or gravel can reduce the service life of the wire. Also, water which rolls or otherwise moves cobbles and large stones breaks the wire with a hammer and anvil action and considerably shortens the life of the wire. The wire has been found to be susceptible to corrosion by various chemical agents and is particularly affected by high

If the designer has no knowledge of the erodibility of the soil at a particular channel site, a reasonable estimate of d_{max} may be obtained by interpolating half-way between the "erosion resistant" and "erodible" lines of the maximum permissible depth charts (except Chart 27 for rock riprap, where no range is given because the underlying soil has no influence on the erosion resistance of the riprap lining).

Hydraulic Resistance

The flow velocity charts were developed to define the relationship between the hydraulic radius of the channel, R, longitudinal slope of the channel, S_o, and mean channel velocity, V, for a given channel lining. For some linings, such as rock riprap of a given size and fiber glass roving tacked with asphalt, the Manning equation may be used since the n value is essentially constant. For rock riprap, the Manning n value varies with mean stone size, as follows (6):

$$n = 0.0395\ D_{50}^{1/6}$$

Thus, the following n values apply for common stone sizes:

D_{50} (ft.)	n
0.25	0.0314
0.50	0.0352
0.75	0.0377
1.00	0.0395
1.50	0.0423
2.00	0.0442

For fiber glass roving tacked with asphalt, Cox (4) found that the Manning n value was approximately a constant:

	Smooth Rolled Channels	Channels with Clods and Tracks
Single layer	0.030	0.035
Double layer	0.020	0.025

The higher values of n were used in the development of Charts 5 and 6, assuming that most highway channels will be rather rough after seeding and mulching.

Table 6.4
Riprap Gradation Limits
(USDOT, FHWA, HEC-11)

Stone Size Range	Stone Weight Range	Percent of Gradation
1.5 d_{50} to 1.7 d_{50}	3.0 W_{50} to 5.0 W_{50}	100
1.2 d_{50} to 1.4 d_{50}	2.0 W_{50} to 2.75 W_{50}	85
1.0 d_{50} to 1.15 d_{50}	1.0 W_{50} to 1.5 W_{50}	50
0.4 d_{50} to 0.6 d_{50}	0.1 W_{50} to 0.2 W_{50}	15

The gradation coefficient, G, should equal 1.5.

$$G = 0.5(d_{84}/d_{50} + d_{50}/d_{16}) \tag{6.14}$$

Table 6.4 provides design gradations for riprap. As a practical matter, the designer should check with local quarries and suppliers regarding the classes and quality of riprap available near the site.

Thickness: The riprap-layer thickness shall be the greater of 1.0 times the d_{100} value, or 1.5 times the d_{50} value. But the thickness need not exceed twice the d_{100} value. The thickness is measured perpendicular to the slope upon which the riprap is placed.

Filter Blanket Requirements: The purpose of granular filter blankets underlying riprap is two-fold. First, they protect the underlying soil from washing out; and, second, they provide a base on which the riprap will rest. The need for a filter blanket is a function of particle-size ratios between the riprap and the underlying soil which comprise the channel bank. The inequalities that must be satisfied are as follows:

$$\frac{(d_{15})_{filter}}{(d_{85})_{base}} < 5 < \frac{(d_{15})_{filter}}{(d_{15})_{base}} < 40 \tag{6.15a}$$

$$\frac{(d_{50})_{filter}}{(d_{50})_{base}} < 40 \tag{6.15b}$$

Table 6.5
Gradation for Gravel Bedding
(Simons, Li and Associates, 1989)

Standard Sieve Size	Type I (1)	Type II (1)
3 inches	-	90 to 100
1-1/2 inches	-	-
3/4 inch	-	20 to 90
3/8 inch	100	-
#4 (4.75 mm)	95 to 100	0 to 20
#16 (1.18 mm)	45 to 80	-
#50 (0.30 mm)	10 to 30	-
#100 (0.15 mm)	2 to 10	-
#200 (0.075 mm)	0 to 2	0 to 3

(1) Percent passing by weight

Table 6.6
Thickness Requirements for Gravel Bedding

Riprap Classification	Minimum Bedding Thickness, inches		
	Fine Grain Native Soils		Coarse Grain Native Soils
	Type I	Type II	Type III
6", 8"	4	4	6
12"	4	4	6
18"	4	6	8
24"	4	6	8
30"	4	8	10
36"	4	8	10

GABION MATTRESS DESIGN

SVERDRUP

JOB BULLARD WASH CHANNEL

COMPUTATIONS FOR GABION BASKET DESIGN

SHEET NO. 1 OF

DATE 4-27-98

BY DES CHKD 4/29/98

DESIGN PROCEDURE FOR GABION BASKETS

1) CALCULATE SHEAR STRESS

WHERE $\tau_b = \gamma_w * y_{100} * i$ (1)

τ_b ≡ shear stress exerted on gabion structure

$\gamma_w = 62.4\ lb/ft^3$

γ_w ≡ unit weight of water (l

$y_{100} = 7.20\ ft$ (100-YR HEC RAS xSEC 24.00 worst case)

y_{100} ≡ 100-year water depth (ft

$i = 0.0020\ ft/ft$

i ≡ streambed gradient (ft

$\therefore \tau_b = 62.4 \frac{lb}{ft^3} * 7.20\ ft * 0.0020\ ft/ft$

$\tau_b = 0.899\ lb/ft^2$

SET SHEAR STRESS EQUAL TO CRITICAL SHEAR STRESS

$\tau_b = \tau_c = C(\gamma_s - \gamma_w) d_{50}$ (2)

τ_c ≡ critical shear stress (lb,

$C = 0.10$ (for gabions)

C ≡ Shields Coefficient

$\gamma_s = 170\ lb/ft^3$ (SG ≥ 2.6)

γ_s ≡ unit weight, stones (lb/ft

SOLVE FOR d_{50}

d_{50} ≡ median size of riprap ste (feet)

$$d_{50} = \frac{\tau_b}{C(\gamma_s - \gamma_w)} = \frac{0.899}{0.1(170 - 62.4)}$$

$d_{50} = 0.084\ ft \simeq 1.0$ inch

however minimum mesh size: 2.5 i (use inches to describe rock filler

GABION BASKETS $d_{min} = 4$ inches w/ $D_{50} = 6.0$ inches, $D_{max} = 8$ inches

RENO MATTRESS $d_{min} = 3$ inches w/ $D_{50} = 4.5$ inches, $D_{max} = 6''$

SVERDRUP

JOB BULLARD WASH CHANNEL

COMPUTATIONS FOR GABION BASKET DESIGN

SHEET NO. 2 OF

DATE 4-27-98

BY DES CHKD BDO 4/29/98

GABION BASKET SIZE IS DICTATED BY CHANNEL CROSS-SECTION REQUIREMENTS (SS=1:1), 50% OVERLAP

∴ USE 1.5' Thick x 3.0' Wide x 12.0' Long on above ground courses of stepped gabions

RENO MATTRESS (SLOPE BLANKET GABION) SIZE IS DICTATED BY 1.5 TIMES THE MAX ROCK SIZE

∴ $T_{RENO\ MAT.} = 1.5 * 6$ inches $= 9$ inches (standard thickness)

NOTE: Although rock size was calculated to be 1.0 inch, the thicker gabion mattress will provide additional erosion protection for the channel banks.

VERIFY THE RANGE OF ROCK SIZES FOR GABIONS

SELECT ΔZ SUCH THAT:

$$\frac{\Delta Z}{d_{50}} \leq 2\left(\frac{t}{d_{50}} - 1\right)$$ (3)

WHERE ΔZ = stone diameter range
t = mattress thickness
d_{50} = median stone diameter

FOR GABION BASKETS ($d_{50} = 6''$)

Manufacturers guidelines (Table 4) show a range of 4"-8" for 18" gabion

check $\frac{(0.66' - 0.33')}{0.5'} \leq 2\left(\frac{1.5'}{0.5'} - 1\right)$

$0.66 \leq 4.0$ OK $\rightarrow d_{min} = 4''$ $d_{max} = 8''$

Similarly for 9" gabion mattress, $d_{50} = 4.5'' \rightarrow$ range is 3"-6"

check $\frac{0.5' - 0.25'}{0.38'} \leq 2\left(\frac{0.75}{0.38'} - 1\right)$

$0.66 \leq 1.95$ OK $\rightarrow d_{min} = 3''$, $d_{max} = 6''$

SVERDRUP

JOB BULLARD WASH CHANNEL

COMPUTATIONS FOR GABION BASKET DESIGN

SHEET NO. 3 OF

DATE 4-27-98

BY DES CHKD [illegible] 4/29/98

DETERMINE ROUGHNESS COEFFICIENT

$$n_b = \frac{D_{90}^{1/6}}{26}$$

$D_{90} \equiv$ rock diam in meters

FOR GABION BASKETS $D_{90} = 6$ inches $= 0.152$ meters

$$n_b = \frac{(0.152)^{1/6}}{26} = 0.028$$

FOR RENO MATTRESSES $D_{90} = 5$ inches $= 0.127$ meters

$$n_b = \frac{(0.127)^{1/6}}{26} = 0.027$$

FILTER FABRIC REQUIREMENT

$$V_b = \frac{1.486}{n_f} * \left(\frac{d_{50}}{2}\right)^{2/3} s^{1/2}$$

$n_f = 0.020 \equiv$ Channel bed roughne

$S \equiv$ steepest slope of streambe

$$= \frac{1.486}{0.020} * \left(\frac{0.42}{2}\right)^{2/3} * (0.0020)^{1/2}$$

$V_b = 1.17$ feet/second

FOR NON-COHESIVE SOILS, CALCULATE ALLOWABLE VELOCITY

$$V_e = 1.67 * d^{1/2}$$

where $d \equiv$ soil particle size (mm) (use 0.06mm for Bullard Wash per sieve analysis)

$$= 1.67 * (0.06\text{ mm})^{1/2}$$

$V_e = 0.40$ feet/second

$V_b > V_e \rightarrow$ FILTER FABRIC REQUIRED (per manufacturer's guidelines)

$$\tau_c = C^*(\gamma_s - \gamma_w)d_m \qquad (39)$$

where, C^* is the Shields coefficient (equal to 0.10);

γ_s = unit weight of the ~~soil~~ rock (lb/ft^3)

γ_w = unit weight of water (lb/ft^3)

d_m = median size of the filling rocks (feet)

set $\tau_b = \tau_c \rightarrow$ solve for $d_{50} = \frac{\gamma_w \cdot y \cdot i}{0.10(\gamma_s - \gamma_w)} = \frac{y \cdot i}{0.047}$

The check is satisfied when the hydraulic shear stress, τ_b is less than the critical shear stress, τ_c. The Shields coefficient for gabions is approximately 0.10, for rip rap it is reduced to 0.047. This means that for any given hydraulic condition the average size of the rocks needed in gabion mattresses is roughly one third of that required for rip rap (*Figure 59*).

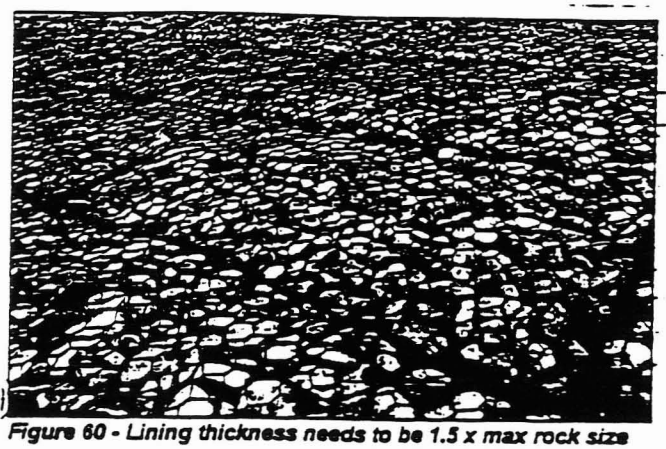


Figure 60 - Lining thickness needs to be 1.5 x max rock size

Determining The Rock Size And Lining Thickness

To match the critical shear stress to the required hydraulic shear stress, the appropriate median rock size needs to be determined. Once the required rock size has been determined, the thickness of the lining can then be evaluated. Maccaferri recommends that the thickness of the lining be 1.5 times larger than the maximum size of the rock used in filling the gabion mattress (assuming a variable range of rock size is used). For instance, if a 4-8 inch rock size is used, the minimum thickness of the basket should not be less than 12 inches.

It is also important to use a rock size that is not less than the nominal size of the gabion mesh openings. For gabions, it is recommended to use a minimum rock size of not less than four inches and for Reno mattresses a minimum rock size not less than three inches.

Critical Velocity vs. Limit Velocity

When further increases in shear stress go beyond the critical shear stress (or when the water velocity becomes supercritical), rocks within the gabion mattress begin to start moving towards the downstream end of the basket. At this point the gabion basket begins to deform until a new equilibrium is reached (*Figure 61*). This deformation however, does not significantly affect the mattresses from providing a similar degree of protection to the bedding material, as long as the deformation does not reduce the lining thickness

USE L.A. abrasion >10. S.G. ≥ 2.6

Type	Thickness of Lining		Filling Stones				Critical Velocity†		Limit Velocity†	
	(mm)	(in)	Stone Size		d_{50}		(m/s)	(ft/sec)	(m/s)	(ft/sec)
			(mm)	(in)	(mm)	(in)				
Reno Mattresses	150	6	70 - 100	3 - 4	85	3.5	3.5	11.5	4.2	13.8
			70 - 150	3 - 6	110	4.5	4.2	13.8	4.5	14.8
	230	9	70 - 100	3 - 4	85	3.5	3.6	11.8	5.5	18.0
			70 - 150	3 - 6	120	4.5	4.5	14.8	6.1	20.0
Gabions or Gabion Mats	300	12	70 - 120	3 - 5	100	4	4.2	13.8	5.5	18.0
			100 - 150	4 - 6	125	5	5.0	16.4	6.4	21.0
Gabions	500	18	100 - 200	4 - 8	150	6	5.8	19.0	7.6	24.9
			120 - 250	5 - 10	190	7.5	6.4	21.0	8.0	26.2

†The values of velocity reported were obtained experimentally for Froude numbers ≤ 1; values > have to be intended as purely indicative and approximated.

Table 4 - The required lining thicknesses and median stone size required for various critical water velocities

$D_{max} \approx 2/3$ HEAD ⇒ BIGGEST D_{50} → FOR HIGH FLOWS

1) Find T
2) Find D_{50} and D_{max}

EXHIBIT A

Hydrology Maps

The following maps are provided:

- Interior Drainage Watershed Map
- A copy (24 x 36) of the White Tanks/Agua Fria ADMS Drainage Area Map

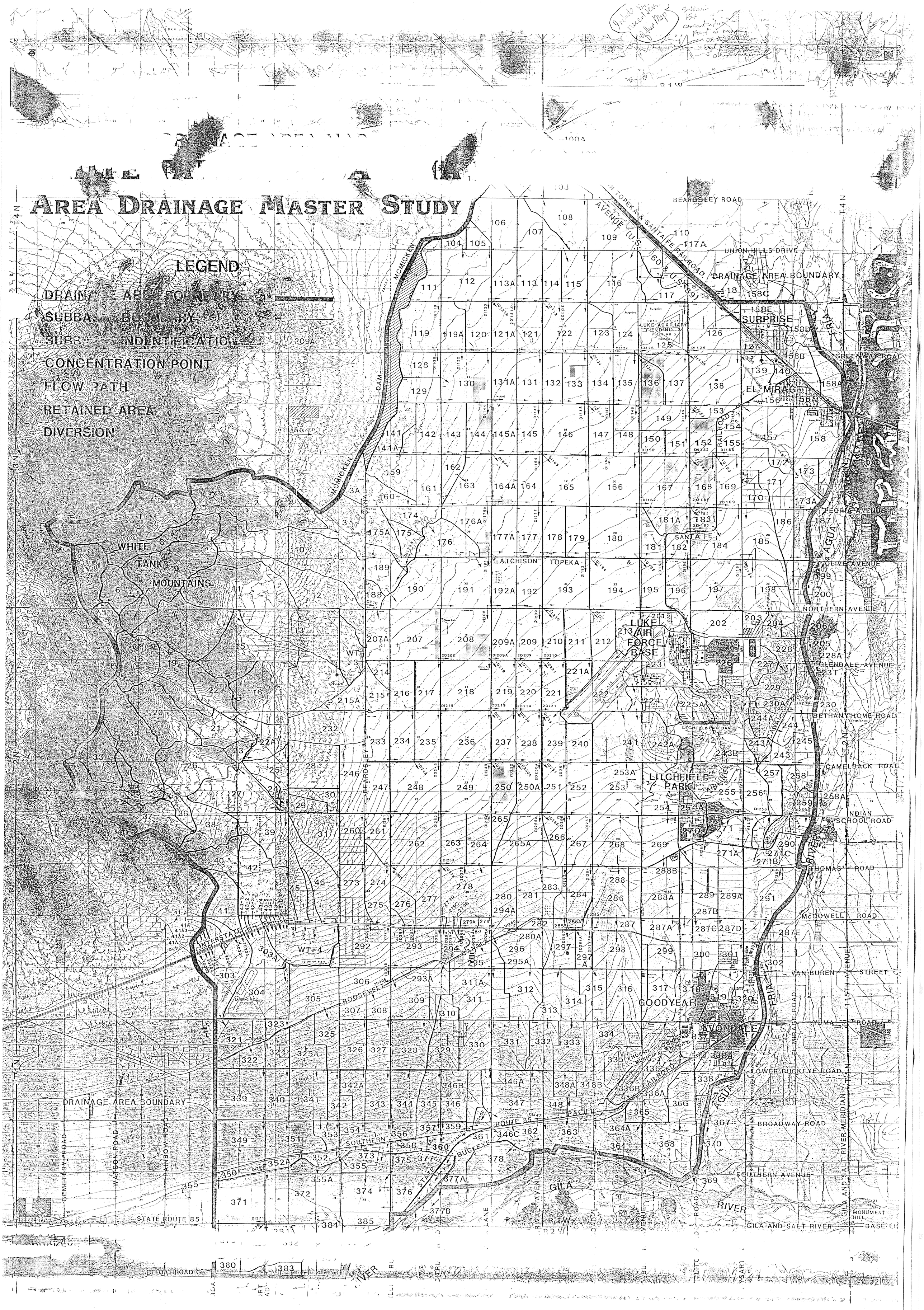

AREA DRAINAGE MASTER STUDY
LEGEND
DRAINAGE AREA BOUNDARY
SUBBASIN BOUNDARY
SUBBASIN IDENTIFICATION
CONCENTRATION POINT
FLOW PATH
RETAINED AREA
DIVERSION
DRAINAGE AREA BOUNDARY
WHITE TANK MOUNTAINS
LUKE AIR FORCE BASE
LITCHFIELD PARK
GOODYEAR
AVONDALE
SURPRISE
EL MIRAGE
GILA RIVER
AGUA FRIA RIVER
McMICKEN DAM
McMICKEN CANAL
WT #3
WT #4
ATCHISON TOPEKA & SANTA FE RAILROAD
INTERSTATE 10
ROOSEVELT CANAL
SOUTHERN PACIFIC RAILROAD
STATE ROUTE 85
BUCKEYE ROAD
BEARDSLEY ROAD
UNION HILLS DRIVE
GREENWAY ROAD
PEORIA AVENUE
OLIVE AVENUE
NORTHERN AVENUE
GLENDALE AVENUE
BETHANY HOME ROAD
CAMELBACK ROAD
INDIAN SCHOOL ROAD
THOMAS ROAD
McDOWELL ROAD
VAN BUREN STREET
YUMA ROAD
LOWER BUCKEYE ROAD
BROADWAY ROAD
SOUTHERN AVENUE
GILA AND SALT RIVER
BASE LINE
GILA AND SALT RIVER MERIDIAN
116TH AVENUE
EL MIRAGE ROAD
CEMETERY ROAD
WATSON ROAD
RAINBOW ROAD
BELOA ROAD
T4N
T3N
T2N
T1N
R1W
R2W

EXHIBIT B

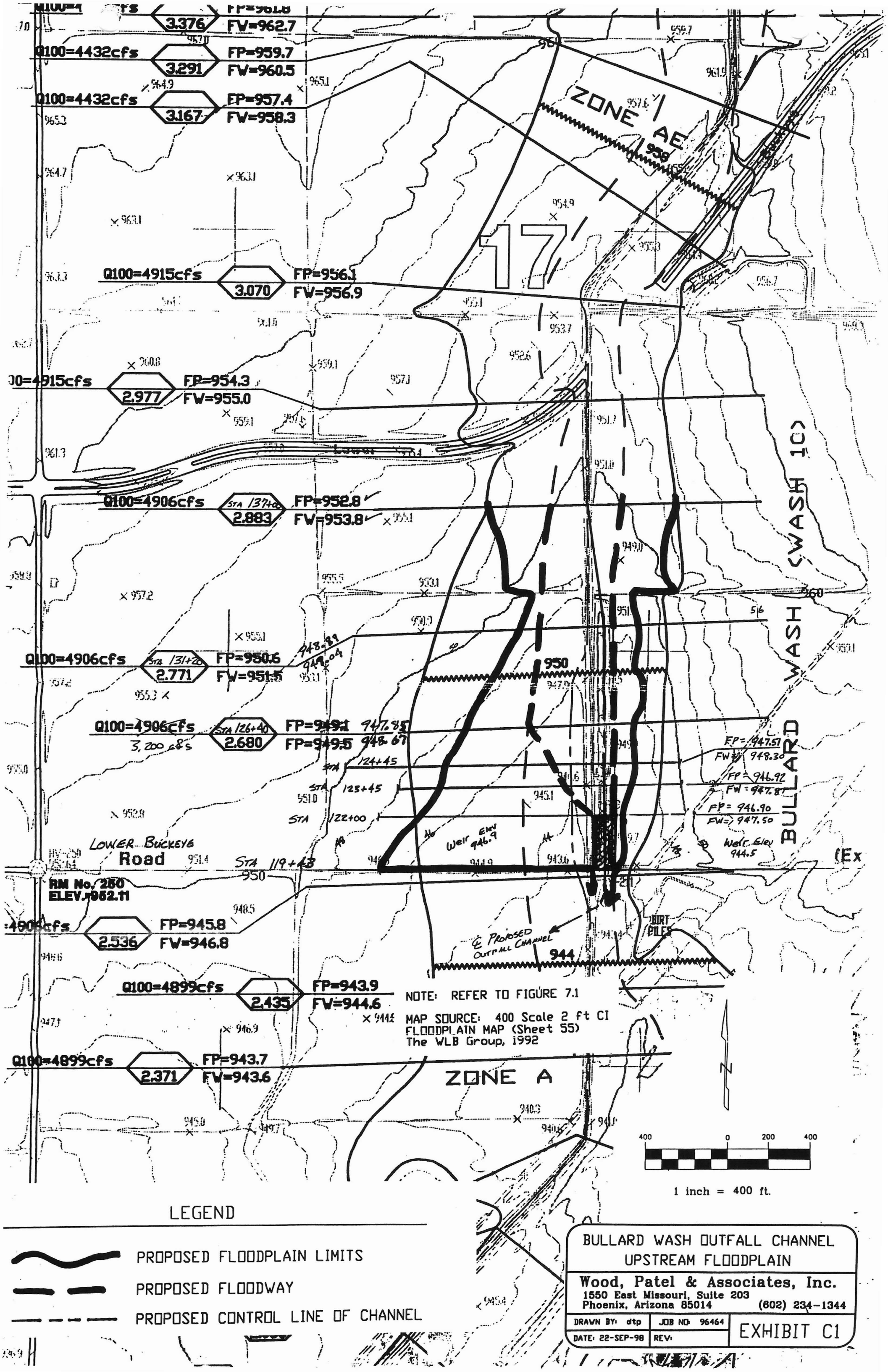
Proposed Construction Plans

The construction plan set: *Bullard Wash Channel Improvement Project (FCD 98-15), Final Submittal*, dated September 1989, is submitted under separate cover.

EXHIBIT C

Proposed Floodway Work Maps

Two detailed maps are provided. One showing the floodplain limits at the upstream end of this project and how the proposed floodplain ties into the FEMA regulated floodplain. The second map shows the new ponding limits caused by the interior drain located north east corner of the intersection of the BID and the proposed Bullard Wash Outfall Channel. Refer to Figure 7.1 for the proposed and existing floodplain map of the entire area.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FP=959.7
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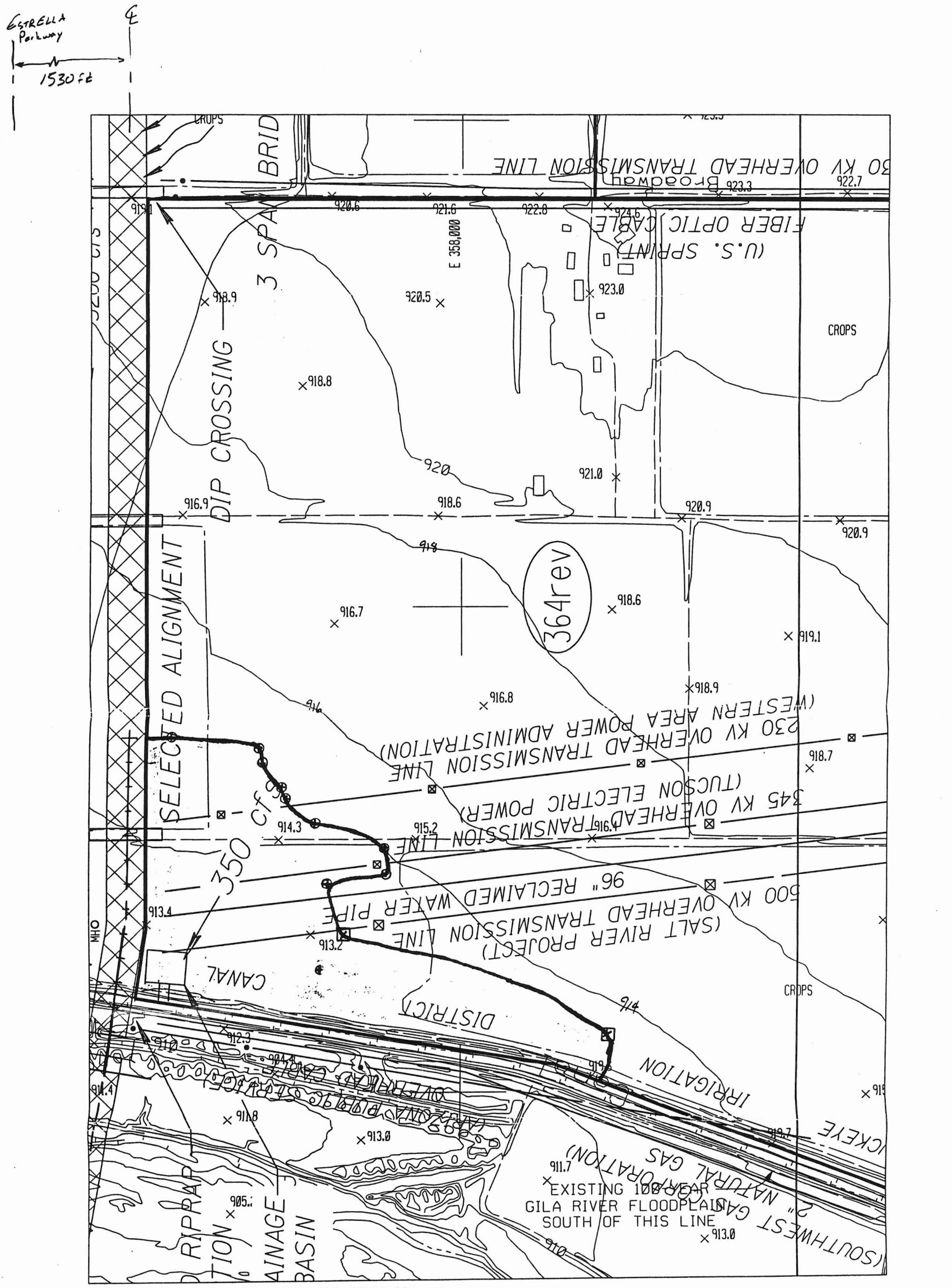
3.167
FP=957.4
FW=958.3
ZONE AE
17'
Q100=4915cfs
3.070
FP=956.1
FW=956.9
Q100=4915cfs
2.977
FP=954.3
FW=955.0
Q100=4906cfs
STA 137+00
2.883
FP=952.8
FW=953.8
Q100=4906cfs
STA 131+20
2.771
FP=950.6
FW=951.5
948.89
949.04
950
Q100=4906cfs
3,200 cfs
STA 126+40
2.680
FP=949.1
FP=949.5
947.85
948.67
STA 124+45
STA 123+45
STA 122+00
FP=947.51
FW=948.30
FP=946.92
FW=947.87
FP=946.90
FW=947.50
Weir Elev 946.9
Weir Elev 944.5
LOWER BUCKEYE Road
STA 119+43
950
RM No. 250
ELEV.=952.11
Q100=4906cfs
2.536
FP=945.8
FW=946.8
℄ PROPOSED OUTFALL CHANNEL
944
DIRT PILES
Q100=4899cfs
2.435
FP=943.9
FW=944.6
Q100=4899cfs
2.371
FP=943.7
FW=943.6
ZONE A
BULLARD WASH (WASH 10)
NOTE: REFER TO FIGURE 7.1
MAP SOURCE: 400 Scale 2 ft CI
FLOODPLAIN MAP (Sheet 55)
The WLB Group, 1992
400 0 200 400
1 inch = 400 ft.
LEGEND
PROPOSED FLOODPLAIN LIMITS
PROPOSED FLOODWAY
PROPOSED CONTROL LINE OF CHANNEL
BULLARD WASH OUTFALL CHANNEL
UPSTREAM FLOODPLAIN
Wood, Patel & Associates, Inc.
1550 East Missouri, Suite 203
Phoenix, Arizona 85014
(602) 234-1344
DRAWN BY: dtp
JOB NO: 96464
DATE: 22-SEP-98
REV:
EXHIBIT C1



v:/980102/hydro1.dgn Jul. 29, 1998 18:15:29

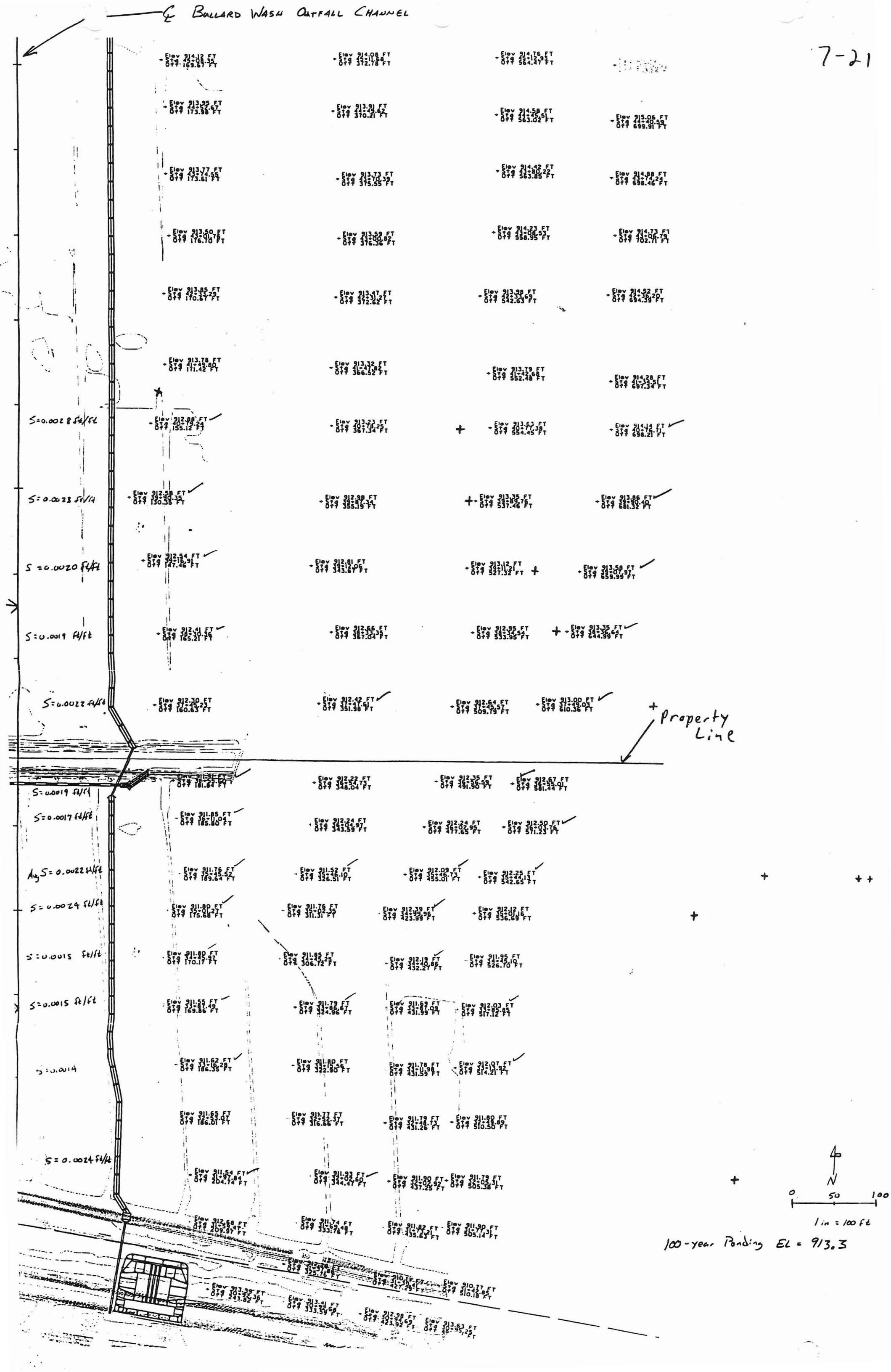
Mapping: Cooper Aerial of Phoenix Az.

Flight Date: 12/22/89

⊕ Ponding Elevation based from 1998 Survey data.

☒ Ponding Elevation based on 1989 Topography.

Limits of 100-year ponding, Ponding elevation is 913.3 ft.


℄ Ballard Wash Outfall Channel
Elev 914.12 FT Stg 45+08.35 Off 169.87 FT
Elev 914.08 FT Stg 44+11.58 Off 372.78 FT
Elev 914.76 FT Stg 43+12.91 Off 564.47 FT
Elev 913.95 FT Stg 42+57.67 Off 173.98 FT
Elev 913.91 FT Stg 44+49.62 Off 370.21 FT
Elev 914.58 FT Stg 43+45.51 Off 563.02 FT
Elev 915.06 FT Stg 42+40.59 Off 699.91 FT
Elev 913.77 FT Stg 42+74.55 Off 173.61 FT
Elev 913.73 FT Stg 43+70.39 Off 375.55 FT
Elev 914.42 FT Stg 43+80.22 Off 563.85 FT
Elev 914.88 FT Stg 42+74.24 Off 698.46 FT
Elev 913.50 FT Stg 42+01.78 Off 176.10 FT
Elev 913.59 FT Stg 43+00.82 Off 376.56 FT
Elev 914.23 FT Stg 43+06.53 Off 558.95 FT
Elev 914.73 FT Stg 42+06.79 Off 702.71 FT
Elev 913.85 FT Off 170.67 FT
Elev 913.47 FT Stg 42+31.21 Off 372.62 FT
Elev 913.38 FT Stg 42+35.69 Off 542.63 FT
Elev 914.52 FT Stg 42+36.20 Off 694.39 FT
Elev 913.78 FT Stg 41+49.80 Off 171.42 FT
Elev 913.32 FT Stg 41+47.82 Off 366.52 FT
Elev 913.79 FT Stg 41+42.68 Off 552.48 FT
Elev 914.28 FT Stg 41+35.5 Off 697.34 FT
S=0.0028 ft/ft
Elev 912.88 FT Stg 40+79.24 Off 155.12 FT
Elev 913.23 FT Stg 40+78.25 Off 367.34 FT
Elev 913.63 FT Stg 40+77.38 Off 554.45 FT
Elev 914.14 FT Stg 40+76.1 Off 698.21 FT
S=0.0023 ft/ft
Elev 912.58 FT Stg 39+90.35 Off 130.35 FT
Elev 912.98 FT Stg 39+87.34 Off 355.19 FT
Elev 913.35 FT Stg 39+89.78 Off 537.46 FT
Elev 913.86 FT Stg 39+90.40 Off 681.32 FT
S=0.0020 ft/ft
Elev 912.54 FT Stg 39+16.91 Off 147.46 FT
Elev 912.81 FT Stg 39+12.06 Off 343.67 FT
Elev 913.12 FT Stg 39+11.21 Off 527.32 FT
Elev 913.58 FT Stg 39+07.97 Off 659.99 FT
S=0.0019 ft/ft
Elev 912.41 FT Stg 38+30.16 Off 165.21 FT
Elev 912.66 FT Off 367.04 FT
Elev 912.95 FT Stg 38+34.59 Off 533.95 FT
Elev 913.35 FT Stg 38+36.62 Off 644.99 FT
S=0.0022 ft/ft
Elev 912.30 FT Stg 37+45.23 Off 160.63 FT
Elev 912.42 FT Stg 37+47.61 Off 351.98 FT
Elev 912.64 FT Stg 37+45.57 Off 509.79 FT
Elev 913.00 FT Stg 37+49.03 Off 610.36 FT
Property Line
S=0.0019 ft/ft
Elev 911.91 FT Stg 36+55.60 Off 181.84 FT
Elev 912.22 FT Stg 36+54.73 Off 348.04 FT
Elev 912.35 FT Stg 36+56.59 Off 491.90 FT
Elev 912.67 FT Stg 36+55.01 Off 581.44 FT
S=0.0017 ft/ft
Elev 911.85 FT Stg 36+11.04 Off 185.80 FT
Elev 912.24 FT Stg 36+01.97 Off 343.59 FT
Elev 912.24 FT Stg 36+02.95 Off 477.65 FT
Elev 912.50 FT Stg 36+03.76 Off 571.23 FT
Avg S=0.0022 ft/ft
Elev 911.76 FT Stg 35+45.52 Off 189.64 FT
Elev 911.52 FT Stg 35+46.10 Off 326.51 FT
Elev 912.09 FT Stg 35+46.73 Off 455.01 FT
Elev 912.25 FT Stg 35+44.13 Off 542.65 FT
S=0.0024 ft/ft
Elev 911.80 FT Stg 35+01.27 Off 175.88 FT
Elev 911.76 FT Stg 35+02.35 Off 311.31 FT
Elev 912.39 FT Stg 34+99.96 Off 423.99 FT
Elev 912.12 FT Stg 35+01.16 Off 536.69 FT
S=0.0015 ft/ft
Elev 911.80 FT Stg 34+45.91 Off 170.17 FT
Elev 911.85 FT Stg 34+45.24 Off 306.72 FT
Elev 912.19 FT Stg 34+40.86 Off 432.27 FT
Elev 911.95 FT Stg 34+45.10 Off 526.70 FT
S=0.0015 ft/ft
Elev 911.55 FT Stg 33+87.49 Off 169.86 FT
Elev 911.79 FT Stg 33+86.67 Off 324.96 FT
Elev 911.69 FT Stg 33+87.03 Off 431.99 FT
Elev 912.03 FT Stg 33+85.85 Off 517.12 FT
S=0.0019
Elev 911.62 FT Stg 33+16.28 Off 186.35 FT
Elev 911.80 FT Stg 33+15.56 Off 322.90 FT
Elev 911.78 FT Stg 33+14.98 Off 431.55 FT
Elev 912.07 FT Stg 33+13.92 Off 514.21 FT
Elev 911.65 FT Stg 32+97.07 Off 186.01 FT
Elev 911.77 FT Stg 32+95.37 Off 316.66 FT
Elev 911.79 FT Stg 32+98.73 Off 431.26 FT
Elev 911.80 FT Stg 32+99.69 Off 510.50 FT
S=0.0024 ft/ft
Elev 911.54 FT Stg 32+57.84 Off 204.74 FT
Elev 911.83 FT Stg 32+62.60 Off 344.47 FT
Elev 911.90 FT Stg 32+62.92 Off 457.25 FT
Elev 911.79 FT Stg 32+63.31 Off 565.38 FT
Elev 912.68 FT Stg 32+39.47 Off 209.97 FT
Elev 911.74 FT Stg 32+69.48 Off 333.76 FT
Elev 911.82 FT Stg 32+72.21 Off 455.63 FT
Elev 911.90 FT Stg 32+77.31 Off 565.14 FT
Elev 912.38 FT Off 325.76 FT
Elev 910.15 FT Off 427.29 FT
Elev 910.77 FT Stg 32+42.85 Off 510.18 FT
Elev 913.39 FT Stg 30+92.36 Off 243.82 FT
Elev 913.41 FT Stg 30+92.68 Off 333.59 FT
Elev 912.98 FT Stg 30+91.69 Off 423.92 FT
Elev 913.63 FT Stg 30+95.25 Off 48
N
0 50 100
1 in = 100 ft
100-year Ponding EL = 913.3