Conditional Letter of Map Revision (CLOMR) Application

SALT RIVER - SKY HARBOR INTERNATIONAL AIRPORT RUNWAY SAFETY AREA IMPROVEMENTS

Job # 9008E
March 2009

Prepared for :

Aviation Department
3400 East Sky Harbor Boulevard
Phoenix, AZ 85034

Prepared by :

PACE
Advanced Water Engineering

One Gateway
426 North 44th St., Suite 200
Phoenix, AZ 85008
www.pacewater.com

City of Phoenix
Floodplain Management, 200 W. Washington St., Phoenix, AZ 85003
Phone: (602) 262-4960 Fax: (602) 262-7322

March 27, 2009

FEMA DEPOT
3601 Eisenhower Avenue
Alexandria, Virginia 22304

Attn: LOMR Depot

RE: CONDITIONAL LETTER OF MAP REVISION (CLOMR)
SALT RIVER – SKY HARBOR INTERNATIONAL AIRPORT (RSA), PHOENIX, AZ
PANELS 04013C 2165 H and 2145 H, SEPTEMBER 30, 2005

Please find the enclosed Conditional Letter of Map Revision (CLOMR) application for Salt River – Sky Harbor International Airport in Phoenix, Arizona. The following items are included with this application.

ITEMS

1. Overview & Concurrence Form (MT-2 Form 1)
2. Riverine Hydrology & Hydraulics Form (MT-2 Form 2)
3. Riverine Structures Form (MT-2 Form 3)
4. Annotated FIRM panels (Appendix C)
5. Annotated Floodway Data Table (Section 7)
6. Annotated Flood Profiles (Appendix C)
7. Effective Hydraulic Model (Appendix B)
8. Corrected Effective Hydraulic Model (Appendix B)
9. Topographic Work Map
10. Geotechnical Evaluation (Appendix F)
11. CLOMR Application on CD

If you have any technical questions regarding this project, please contact Mr. Dennis L. Richards, PE, PACE Engineering, Inc., phone number (602) 275-8066. If you have any other questions, please contact this office at (602) 262-4960.

Sincerely,

Hasan Mushtaq, PE, PhD, CFM
Floodplain Manager

cc: Mr. Brian Cosson, CFM, Arizona Department of Water Resources
Mr. Tim Murphy, PE, CFM, Flood Control District of Maricopa County
Mr. Dennis L. Richards, PE, PACE Engineering, Inc.
Ms. Karen Apple, CM, Aviation Dept, City Of Phoenix

City of Phoenix
AVIATION DEPARTMENT
PLANNING & ENVIRONMENTAL DIVISION

March 26, 2009

FEMA Depot
3601 Eisenhower Avenue
Alexandria, Virginia 22304

Re: Phoenix Sky Harbor International Airport - Runway Safety Area Improvements, Fee Exemption for Map Changes

Attention: LOMR Depot

The Runway Safety Area (RSA) project being proposed by the City of Phoenix Aviation Department includes extension of the north embankment of the Salt River, east of Interstate 10. The Federal Aviation Administration (FAA) has committed to provide Airport Improvement Program funds that will cover 75 percent of the estimated project costs.

The City of Phoenix requests a CLOMR fee exemption based on the amount of federal funding the FAA has committed to the proposed project in accordance with *44 CFR 72.5 (d) of the National Flood Insurance Program Regulations.*

If you require any additional information regarding our federal funding for this project, please contact me at 602-683-3786.

Sincerely,

Karen J. Apple, C.M.
Project Manager

Enclosures

cc: Mr. Hasan Mushtaq – City of Phoenix
Mr. Dennis Richards – Pace Advanced Water Engineering

3400 E. Sky Harbor Boulevard, Suite 3300 • Phoenix, Arizona 85034-4405 • (602) 273-3340 • FAX (602) 273-3472 • TTY (800) 781-1010

Recycled Paper

Conditional Letter of Map Revision (CLOMR) Application

Salt River - Sky Harbor International Airport

Runway Safety Area Improvements

City of Phoenix

March 2009

Prepared For:

City of Phoenix
Aviation Department
3400 East Sky Harbor Boulevard
Phoenix, AZ 85034

Prepared by:

PACE
Advanced Water Engineering

Pacific Advanced Civil Engineering, Inc.
426 N. 44th Street, Suite 120
Phoenix, AZ 85008
602.275.8066

Subconsultant to:

HUITT-ZOLLARS

Huitt-Zollars, Inc.
426 N. 44th Street, Suite 300
Phoenix, AZ 85008
602.952.9123

Contact Person:
Dennis L. Richards, PE, D.WRE
Erica Rodriguez, CFM

Dennis L. Richards

Registered Professional Engineer (Civil)
CERTIFICATE NO.
21560
DENNIS L.
RICHARDS
Date Signed 3/25/09
ARIZONA, U.S.A.

EXPIRES 3/31/2010

PACE JN 9008E

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Registered Professional Engineer (Civil)
CERTIFICATE NO.
21560
DENNIS L.
RICHARDS
Date Signed 3/25/09
ARIZONA, U.S.A.

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F. Geotechnical Evaluation

Enclosures

CD containing:

A. GIS Dataset
   a. Topographic Work map
   b. Annotated FIRM

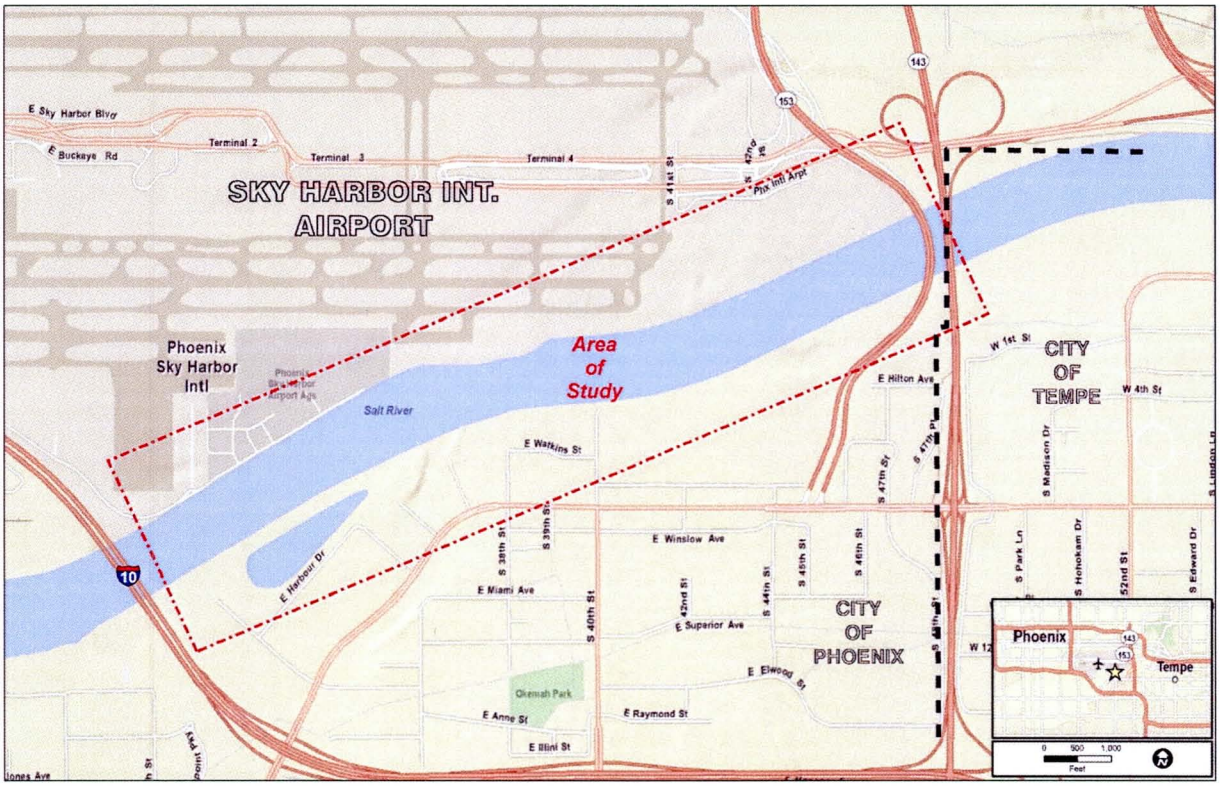
B. HEC-RAS Version 2.2 Model

C. HEC-RAS Version 4.0 Models

1 Introduction

Pacific Advanced Civil Engineering, Inc. (PACE) was retained by the City of Phoenix Aviation Department under subcontract to Huitt-Zollars to prepare a Conditional Letter of Map Revision (CLOMR) package in support of the proposed bank realignment of the north bank of the Salt River.

The CLOMR study focuses on the proposed cement stabilized alluvium embankment within the Salt River and the associated grading within the channel. The Salt River flows from east to west in the project reach. The hydraulic study limits along the Salt River extend from about one-half mile upstream of Highway 143 to one-tenth mile downstream of Interstate 10, a total distance of three (3) miles. The proposed cement stabilized alluvium embankment will be installed along the north bank of the Salt River between River Station 217.66 and 218.14. The embankment will encroach into the existing river in order to create more area to extend the adjacent runway at Sky Harbor Airport. A vicinity map showing the location of the proposed embankment and grading improvements to the Salt River is shown in the figure below.



The vertical datum of the existing Flood Insurance Study (FIS) hydraulic models is NGVD 1929 according to the published flood insurance profiles for the Salt River (FEMA, 2005). The new topography for the project site is based on the 1988 North American Vertical Datum (NAVD88). The hydraulic models for the proposed and existing condition are also based on NAVD88. The datum correction being used is 2.12 feet, where NAVD 88 is equivalent to NGVD 29 plus 2.12 feet.

The hydrologic data (1% annual-chance event discharge) for this project were obtained from the effective Flood Insurance Study (FEMA, 2005). Water surface elevations at the upstream and downstream limits were tied-in to those of the duplicate effective model, which is the basis for the existing FIS.

The purpose of the study is to delineate the 1% annual-chance floodplain and floodway along the Salt River with the proposed cement stabilized alluvium embankment in place along the north bank and associated grading, and prepare a CLOMR application.

Downstream towards the project reach, with the airport in the background

2 Forms

Table 1 - Study Documentation Abstracts 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 Contact(s) Address Phone Internal Reference Number									
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									
2.1.7	Reach Description									
2.1.8	USGS Quad Sheet(s) with original photo date & latest photo revision date									
2.1.9	Unique Conditions and Problems									
2.1.10	Coordination of Q's Discharges (Agency, Date, Comments)									

2.1 FEMA Forms

U.S. DEPARTMENT OF HOMELAND SECURITY - FEDERAL EMERGENCY MANAGEMENT AGENCY

OVERVIEW & CONCURRENCE FORM

O.M.B No. 1660-0016
Expires: 12/31/2010

PAPERWORK BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, U.S. Department of Homeland Security, Federal Emergency Management Agency, 500 C Street, SW, Washington DC 20472, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

A. REQUESTED RESPONSE FROM DHS-FEMA

This request is for a (check one):

☒ CLOMR: A letter from DHS-FEMA commenting on whether a proposed project, if built as proposed, would justify a map revision, or proposed hydrology changes (See 44 CFR Ch. 1, Parts 60, 65 & 72).

☐ LOMR: A letter from DHS-FEMA officially revising the current NFIP map to show the changes to floodplains, regulatory floodway or flood elevations. (See 44 CFR Ch. 1, Parts 60, 65 & 72)

B. OVERVIEW

1. The NFIP map panel(s) affected for all impacted communities is (are):

Community No.	Community Name	State	Map No.	Panel No.	Effective Date
Ex: 480301	City of Katy	TX	480301	0005D	02/08/83
480287	Harris County	TX	48201C	0220G	09/28/90
040051	City of Phoenix	AZ	04013C	2165H	09/30/2005
040051	City of Phoenix	AZ	04013C	2145H	09/30/2005

2. a. Flooding Source: Salt River

   b. Types of Flooding: ☒ Riverine ☐ Coastal ☐ Shallow Flooding (e.g., Zones AO and AH)

   ☐ Alluvial fan ☐ Lakes ☐ Other (Attach Description)

3. Project Name/Identifier: Sky Harbor Runway Extension

4. FEMA zone designations affected: AE, X (choices: A, AH, AO, A1-A30, A99, AE, AR, V, V1-V30, VE, B, C, D, X)

5. Basis for Request and Type of Revision:

   a. The basis for this revision request is (check all that apply)

   ☒ Physical Change ☐ Improved Methodology/Data ☒ Regulatory Floodway Revision ☐ Base Map Changes

   ☐ Coastal Analysis ☒ Hydraulic Analysis ☐ Hydrologic Analysis ☐ Corrections

   ☐ Weir-Dam Changes ☒ Levee Certification ☐ Alluvial Fan Analysis ☐ Natural Changes

   ☐ New Topographic Data ☐ Other (Attach Description)

   Note: A photograph and narrative description of the area of concern is not required, but is very helpful during review.

   b. The area of revision encompasses the following structures (check all that apply)

   Structures: ☒ Channelization ☒ Levee/Floodwall ☐ Bridge/Culvert

   ☐ Dam ☐ Fill ☐ Other (Attach Description)

C. REVIEW FEE

Has the review fee for the appropriate request category been included? ☐ Yes Fee amount: $

☒ No, Attach Explanation

Please see the DHS-FEMA Web site at http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm for Fee Amounts and Exemptions.

D. SIGNATURE

All documents submitted in support of this request are 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: Karen J. Apple, C.M., Project Manager	Company: City of Phoenix Aviation Department	
Mailing Address: 3400 E. Sky Harbor Boulevard Suite 3300 Phoenix, Arizona 85034-4405	Daytime Telephone No.: (602) 683-3786	Fax No.: (602) 273-3472
	E-Mail Address: karen.apple@phoenix.gov	
Signature of Requester (required): Karen J. Apple	Date: 3.27.09	

As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision (LOMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirement that no fill be placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title: Hasan Mushtaq, Floodplain Manager	Community Name: City of Phoenix Street Transportation Department	
Mailing Address: 200 W. Washington Street, 5th Floor Phoenix, AZ 85003-1611	Daytime Telephone No.: (602) 262-4960	Fax No.: (602) 262-7322
	E-Mail Address: hasan.mushtaq@phoenix.gov	
Community Official's Signature (required): Hmushtaq	Date: 3/27/09	

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting data. All documents submitted in support of this request are correct to the best of my knowledge. All analyses have been performed correctly and in accordance with sound engineering practices. All project works are designed in accordance with sound engineering practices to provide protection from the 1% annual chance flood. If "as-built" conditions data/plan provided, then the structure(s) has been built according to the plans being certified, is in place, and is fully functioning. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: Dennis Richards, PE	License No.: 21560	Expiration Date: 03/31/2010
Company Name: Pacific Advanced Civil Engineering, Inc. (PACE)	Telephone No.: (602) 275-8066	Fax No.: (602) 393-3026
Signature: Dennis L. Richards		Date: 3/25/2009

Ensure the forms that are appropriate to your revision request are included in your submittal.

Form Name and (Number)	Required if ...
☒ Riverine Hydrology and Hydraulics Form (Form 2)	New or revised discharges or water-surface elevations
☒ Riverine Structures Form (Form 3)	Channel is modified, addition/revision of bridge/culverts, addition/revision of levee/floodwall, addition/revision of dam
☐ Coastal Analysis Form (Form 4)	New or revised coastal elevations
☐ Coastal Structures Form (Form 5)	Addition/revision of coastal structure
☐ Alluvial Fan Flooding Form (Form 6)	Flood control measures on alluvial fans

Dennis L. Richards

Registered Professional Engineer (Civil) CERTIFICATE NO. 21560 DENNIS L. RICHARDS Date Signed 3/25/09 ARIZONA, U.S.A.

EXPIRES 3/31/2010

U.S. DEPARTMENT OF HOMELAND SECURITY - FEDERAL EMERGENCY MANAGEMENT AGENCY

RIVERINE *HYDROLOGY & HYDRAULICS FORM*

O.M.B No. 1660-0016
Expires: 12/31/2010

PAPERWORK REDUCTION ACT

Public reporting burden for this form is estimated to average 3.25 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, U.S. Department of Homeland Security, Federal Emergency Management Agency, 500 C Street, SW, Washington DC 20472, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

Flooding Source: Salt River
Note: Fill out one form for each flooding source studied

A. HYDROLOGY

1. Reason for New Hydrologic Analysis (check all that apply)

☒ Not revised (skip to section B) ☐ No existing analysis ☐ Improved data
☐ Alternative methodology ☐ Proposed Conditions (CLOMR) ☐ Changed physical condition of watershed

2. Comparison of Representative 1%-Annual-Chance Discharges

Location	Drainage Area (Sq. Mi.)	Effective/FIS (cfs)	Revised (cfs)

3. Methodology for New Hydrologic Analysis (check all that apply)

☐ Statistical Analysis of Gage Records ☐ Precipitation/Runoff Model
☐ Regional Regression Equations ☐ Other (please attach description)

Please enclose all relevant models in digital format, maps, computations (including computation of parameters) and documentation to support the new analysis.

4. Review/Approval of Analysis

If your community requires a regional, state, or federal agency to review the hydrologic analysis, please attach evidence of approval/review.

5. Impacts of Sediment Transport on Hydrology

Was sediment transport considered? ☐ Yes ☐ No If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation for why sediment transport was not considered.

B. HYDRAULICS

1. Reach to be Revised

	Description	Cross-section	Water-Surface Elevations (ft.) **(NAVD 88)**	
			Effective	Proposed/Revised
Downstream Limit	Just upstream of I-10 Bridge	217.57	1112.45	1110.19
Upstream Limit	Just downstream of SR 153 Bridge	218.96	1128.15	1127.89

2. Hydraulic Method/Model Used

HEC-RAS 4.0

B. HYDRAULICS (CONTINUED)

3. Pre-Submittal Review of Hydraulic Models

DHS-FEMA has developed two review programs, CHECK-2 and CHECK-RAS, to aid in the review of HEC-2 and HEC-RAS hydraulic models, respectively. These review programs may help verify that the hydraulic estimates and assumptions in the model data are in accordance with NFIP requirements, and that the data are comparable with the assumptions and limitations of HEC-2/HEC-RAS. CHECK-2 and CHECK-RAS identify areas of potential error or concern. **These tools do not replace engineering judgment.** CHECK-2 and CHECK-RAS can be downloaded from http://www.fema.gov/plan/prevent/fhm/frm_soft.shtm. We recommend that you review your HEC-2 and HEC-RAS models with CHECK-2 and CHECK-RAS. Review of your submittal and resolution of valid modeling discrepancies may result in reduced review time.

4.

Models Submitted	Natural Run	Datum
Duplicate Effective Model*	DupEff_Salt.prj	NGVD 1929
Corrected Effective Model*	Corr_Effective_SkyHarbor.prj	NAVD 1988
Existing Condition Model	Existing_SkyHarbor.prj	NAVD 1988
Proposed Condition Model	Proposed_SkyHarbor.prj	NAVD 1988

* For details, refer to the corresponding section of the instructions.

☒ Digital Models Submitted? (Required)

C. MAPPING REQUIREMENTS

A **certified topographic map** must be submitted showing the following information (where applicable): the boundaries of the effective, existing, and proposed conditions 1%-annual-chance floodplain (for approximate Zone A revisions) or the boundaries of the 1%- and 0.2%-annual-chance floodplains and regulatory floodway (for detailed Zone AE, AO, and AH revisions); location and alignment of all cross-sections with stationing control indicated; stream, road, and other alignments (e.g., dams, levees, etc.); current community easements and boundaries; boundaries of the requester's property; certification of a registered professional engineer registered in the subject State; location and description of reference marks; and the referenced vertical datum (NGVD, NAVD, etc.).

☒ Digital Mapping (GIS/CADD) Data Submitted

Note that the boundaries of the existing or proposed conditions floodplains and regulatory floodway to be shown on the revised FIRM and/or FBFM must tie-in with the effective floodplain and regulatory floodway boundaries. Please attach **a copy of the effective FIRM and/or FBFM,** annotated to show the boundaries of the revised 1%- and 0.2%-annual-chance floodplains and regulatory floodway that tie-in with the boundaries of the effective 1%- and 0.2%-annual-chance floodplain and regulatory floodway at the upstream and downstream limits of the area of revision.

☒ Annotated FIRM and/or FBFM (Required)

D. COMMON REGULATORY REQUIREMENTS*

1. For LOMR/CLOMR requests, do Base Flood Elevations (BFEs) increase? ☒ Yes ☐ No

   a. For CLOMR requests, if either of the following is true, please submit **evidence of compliance with Section 65.12 of the NFIP regulations**:
      - The proposed project encroaches upon a regulatory floodway and would result in increases above 0.00 foot.
      - The proposed project encroaches upon a SFHA with or without BFEs established and would result in increases above 1.00 foot.

   b. For LOMR requests, does this request require property owner notification and acceptance of BFE increases? ☐ Yes ☐ No
      If Yes, please attach **proof of property owner notification and acceptance (if available)**. Elements of and examples of property owner notification can be found in the MT-2 Form 2 Instructions.

2. Does the request involve the placement or proposed placement of fill? ☒ Yes ☐ No

   If Yes, the community must be able to certify that the area to be removed from the special flood hazard area, to include any structures or proposed structures, meets all of the standards of the local floodplain ordinances, and is reasonably safe from flooding in accordance with the NFIP regulations set forth at 44 CFR 60.3(a)(3), 65.5(a)(4), and 65.6(a)(14). Please see the MT-2 instructions for more information.

3. For LOMR requests, is the regulatory floodway being revised? ☐ Yes ☐ No

   If Yes, attach **evidence of regulatory floodway revision notification**. As per Paragraph 65.7(b)(1) of the NFIP Regulations, notification is required for requests involving revisions to the regulatory floodway. (Not required for revisions to approximate 1%-annual-chance floodplains [studied Zone A designation] unless a regulatory floodway is being added. Elements and examples of regulatory floodway revision notification can be found in the MT-2 Form 2 Instructions.)

4. For LOMR/CLOMR requests, does this request have the potential to impact an endangered species? ☐ Yes ☒ No

   If Yes, please submit documentation to the community to show that you have complied with Sections 9 and 10 of the Endangered Species Act (ESA). Section 9 of the ESA prohibits anyone from "taking" or harming an endangered species. If an action might harm an endangered species, a permit is required from U.S. Fish and Wildlife Service or National Marine Fisheries Service under Section 10 of the ESA.

   For actions authorized, funded, or being carried out by Federal or State agencies, please submit documentation from the agency showing its compliance with Section 7(a)(2) of the ESA.

* Not inclusive of all applicable regulatory requirements. For details, see 44 CFR parts 60 and 65.

U.S. DEPARTMENT OF HOMELAND SECURITY - FEDERAL EMERGENCY MANAGEMENT AGENCY

RIVERINE STRUCTURES FORM

O.M.B No. 1660-0016
Expires: 12/31/2010

PAPERWORK REDUCTION ACT

Public reporting burden for this form is estimated to average 7 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, U.S. Department of Homeland Security, Federal Emergency Management Agency, 500 C Street, SW, Washington DC 20472, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

Flooding Source: Salt River
Note: Fill out one form for each flooding source studied

A. GENERAL

Complete the appropriate section(s) for each Structure listed below:

Channelization..... complete Section B
Bridge/Culvert..... complete Section C
Dam/Basin..... complete Section D
Levee/Floodwall..... complete Section E
Sediment Transport..... complete Section F (if required)

Description Of Structure

1. **Name of Structure: Cement stabilized alluvium levee**

   Type (check one): ☒ Channelization ☐ Bridge/Culvert ☒ Levee/Floodwall ☐ Dam/Basin

   Location of Structure: Cement stabilized alluvium levee on north bank of Salt River

   Downstream Limit/Cross-Section: 217.66

   Upstream Limit/Cross-Section: 218.14

2. **Name of Structure:**

   Type (check one): ☐ Channelization ☐ Bridge/Culvert ☐ Levee/Floodwall ☐ Dam/Basin

   Location of Structure:

   Downstream Limit/Cross-Section:

   Upstream Limit/Cross-Section:

3. **Name of Structure:**

   Type (check one) ☐ Channelization ☐ Bridge/Culvert ☐ Levee/Floodwall ☐ Dam/Basin

   Location of Structure:

   Downstream Limit/Cross-Section:

   Upstream Limit/Cross-Section:

NOTE: For more structures, attach additional pages as needed.

B. CHANNELIZATION

Flooding Source: Salt River

Name of Structure: Cement stabilized alluvium

1. Accessory Structures

The channelization includes (check one):

- ☐ Levees [Attach Section E (Levee/Floodwall)]
- ☐ Superelevated sections
- ☐ Debris basin/detention basin [Attach Section D (Dam/Basin)]
- ☒ Other (Describe): Cement stabilized alluvium or gabions
- ☐ Drop structures
- ☐ Transitions in cross-sectional geometry
- ☐ Energy dissipater

2. Drawing Checklist

Attach the plans of the channelization certified by a registered professional engineer, as described in the instructions.

3. Hydraulic Considerations

The channel was designed to carry 169,000 (cfs) and/or the 100-year flood.

The design elevation in the channel is based on (check one):

☒ Subcritical flow ☐ Critical flow ☐ Supercritical flow ☐ Energy grade line

If there is the potential for a hydraulic jump at the following locations, check all that apply and attach an explanation of how the hydraulic jump is controlled without affecting the stability of the channel.

☐ Inlet to channel ☐ Outlet of channel ☐ At Drop Structures ☐ At Transitions
☐ Other locations (specify):

4. Sediment Transport Considerations

Was sediment transport considered? ☒ Yes ☐ No If Yes, then fill out Section F (Sediment Transport).
If No, then attach your explanation for why sediment transport was not considered.

C. BRIDGE/CULVERT

Flooding Source:

Name of Structure:

1. This revision reflects (check one):

- ☐ Bridge/culvert not modeled in the FIS
- ☐ Modified bridge/culvert previously modeled in the FIS
- ☐ Revised analysis of bridge/culvert previously modeled in the FIS

2. Hydraulic model used to analyze the structure (e.g., HEC-2 with special bridge routine, WSPRO, HY8):
If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structures. Attach justification.

3. Attach plans of the structures certified by a registered professional engineer. The plan detail and information should include the following (check the information that has been provided):

- ☐ Dimensions (height, width, span, radius, length)
- ☐ Shape (culverts only)
- ☐ Material
- ☐ Beveling or Rounding
- ☐ Wing Wall Angle
- ☐ Skew Angle
- ☐ Distances Between Cross-Sections
- ☐ Erosion Protection
- ☐ Low Chord Elevations – Upstream and Downstream
- ☐ Top of Road Elevations – Upstream and Downstream
- ☐ Structure Invert Elevations – Upstream and Downstream
- ☐ Stream Invert Elevations – Upstream and Downstream
- ☐ Cross-Section Locations

4. Sediment Transport Considerations

Was sediment transport considered? ☐ Yes ☐ No If yes, then fill out Section F (Sediment Transport).
If No, then attach your explanation for why sediment transport was not considered.

D. DAM/BASIN

Flooding Source:

Name of Structure:

1. This request is for (check one): ☐ Existing dam ☐ New dam ☐ Modification of existing dam

2. The dam was designed by (check one): ☐ Federal agency ☐ State agency ☐ Local government agency ☐ Private organization

   Name of the agency or organization:

3. The Dam was permitted as (check one):

   a. ☐ Federal Dam ☐ State Dam

      Provide the permit or identification number (ID) for the dam and the appropriate permitting agency or organization

      Permit or ID number _____ Permitting Agency or Organization _____

   b. ☐ Local Government Dam ☐ Private Dam

      Provided related drawings, specification and supporting design information.

4. Does the project involve revised hydrology? ☐ Yes ☐ No

   If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2).

   Was the dam/basin designed using critical duration storm?

   ☐ Yes, provide supporting documentation with your completed Form 2.

   ☐ No, provide a written explanation and justification for not using the critical duration storm.

5. Does the submittal include debris/sediment yield analysis? ☐ Yes ☐ No

   If yes, then fill out Section F (Sediment Transport).
   If No, then attach your explanation for why debris/sediment analysis was not considered.

6. Does the Base Flood Elevation behind the dam or downstream of the dam change?

   ☐ Yes ☐ No If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2) and complete the table below.

   Stillwater Elevation Behind the Dam

FREQUENCY (% annual chance)	FIS	REVISED
10-year (10%)		
50-year (2%)		
100-year (1%)		
500-year (0.2%)		
Normal Pool Elevation		

7. Please attach a copy of the formal Operation and Maintenance Plan

E. LEVEE/FLOODWALL

1. System Elements

a. This Levee/Floodwall analysis is based on (check one):

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

b. Levee elements and locations are (check one):

☐ earthen embankment, dike, berm, etc.	Station to
☐ structural floodwall	Station to
☒ Other (describe): Cement Stabilized Alluvium	Station 218.14 to 217.66

c. Structural Type (check one):

☐ monolithic cast-in place reinforced concrete
☐ reinforced concrete masonry block
☐ sheet piling
☐ Other (describe):

d. Has this levee/floodwall system been certified by a Federal agency to provide protection from the base flood?

☐ Yes ☒ No

If Yes, by which agency?

e. Attach certified drawings containing the following information (indicate drawing sheet numbers):

1. Plan of the levee embankment and floodwall structures. Sheet Numbers:
2. A profile of the levee/floodwall system showing the Base Flood Elevation (BFE), levee and/or wall crest and foundation, and closure locations for the total levee system. Sheet Numbers:
3. A profile of the BFE, closure opening outlet and inlet invert elevations, type and size of opening, and kind of closure. Sheet Numbers:
4. A layout detail for the embankment protection measures. Sheet Numbers:
5. Location, layout, and size and shape of the levee embankment features, foundation treatment, floodwall structure, closure structures, and pump stations. Sheet Numbers:

2. Freeboard

a. The minimum freeboard provided above the BFE 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 within 100 feet upstream of all structures and/or constrictions	☐ Yes	☐ No

Coastal

1.0 foot above the height of the one percent wave associated with the 1%-annual-chance stillwater surge elevation or maximum wave runup (whichever is greater).	☐ Yes	☐ No
2.0 feet above the 1%-annual-chance stillwater surge elevation	☐ Yes	☐ No

2. Freeboard (continued)

Please note, occasionally exceptions are made to the minimum freeboard requirement. If an exception is requested, attach documentation addressing Paragraph 65.10(b)(1)(ii) of the NFIP Regulations.

If No is answered to any of the above, please attach an explanation.

b. Is there an indication from historical records that ice-jamming can affect the BFE? ☐ Yes ☒ No

If Yes, provide ice-jam analysis profile and evidence that the minimum freeboard discussed above still exists.

3. Closures

a. Openings through the levee system (check one): ☐ exists ☐ does not exist

If opening exists, 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 needed and reference)

Note: Geotechnical and geologic data

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

4. Embankment Protection

a. The maximum levee slope landside is: 2:1 (H : V)

b. The maximum levee slope floodside is: 2:1 (H : V)

c. The range of velocities along the levee during the base flood is: (min.) to (max.)

d. Embankment material is protected by (describe what kind):

e. Riprap Design Parameters (check one): ☐ Velocity ☐ Tractive stress
Attach references

Reach		Sideslope	Flow Depth	Velocity	Curve or Straight	Stone Riprap			Depth of Toedown
						D_{100}	D_{50}	Thickness	
Sta	to					16"	8"	12"	
Sta	to								
Sta	to								

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

4. Embankment Protection (continued)

f. Is a bedding/filter analysis and design attached? ☐ Yes ☒ No

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

Attach engineering analysis to support construction plans.

5. Embankment And Foundation Stability

a. Identify locations and describe the basis for selection of critical location for analysis:

☒ Overall height: Sta. ; height 30 ft.

☐ Limiting foundation soil strength:

Sta. , depth to

strength ϕ = 39 degrees, c = 0 psf

slope: SS = 2 (h) to 1 (v)

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

b. Specify the embankment stability analysis methodology used (e.g., circular arc, sliding block, infinite slope, etc.):

c. Summary of stability analysis results:

Case	Loading Conditions	Critical Safety Factor	Criteria (Min.)
I	End of construction	2.4	1.3
II	Sudden drawdown	2.1	1.0
III	Critical flood stage		1.4
IV	Steady seepage at flood stage	1.9	1.4
VI	Earthquake (Case I)	1.6	1.0

(Reference: USACE EM-1110-2-1913 Table 6-1)

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

If Yes, describe methodology used: See Report Text

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

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

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

h. The duration of the base flood hydrograph against the embankment is 24 hours.

Attach engineering analysis to support construction plans.

6. Floodwall And Foundation Stability

a. Describe analysis submittal based on Code (check one):

☐ UBC (1988) or ☐ Other (specify):

b. Stability analysis submitted provides for:

☐ Overturning ☐ Sliding If not, explain:

c. Loading included in the analyses were:

☐ Lateral earth @ P_A = psf; P_p = psf

☐ Surcharge-Slope @ , ☐ surface psf

☐ Wind @ P_w = psf

☐ Seepage (Uplift); ☐ Earthquake @ P_{eq} = %g

☐ 1%-annual-chance significant wave height: ft.

☐ 1%-annual-chance significant wave period: sec.

d. Summary of Stability Analysis Results: Factors of Safety.

Itemize for each range in site layout dimension and loading condition limitation for each respective reach.

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

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

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

e. Foundation bearing strength for each soil type:

Bearing Pressure	Sustained Load (psf)	Short Term Load (psf)
Computed design maximum	6,000	8,000
Maximum allowable		

f. Foundation scour protection ☐ is, ☐ is not provided. If provided, attach explanation and supporting documentation:

Attach engineering analysis to support construction plans.

7. Settlement

a. Has anticipated potential settlement been determined and incorporated into the specified construction elevations to maintain the established freeboard margin? ☐ Yes ☐ No

b. The computed range of settlement is 0.1 ft. to 0.15 ft.

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

☐ Foundation consolidation
☒ Embankment compression
☐ Other (Describe):

d. Differential settlement of floodwalls ☒ has ☐ has not been accommodated in the structural design and construction.

Attach engineering analysis to support construction plans.

8. Interior Drainage **See Interior Drainage explanation below.**

a. Specify size of each interior watershed:

Draining to pressure conduit: acres
Draining to ponding area: acres

b. Relationships Established

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

c. The river flow duration curve is enclosed: ☐ Yes ☐ No

d. Specify the discharge capacity of the head pressure conduit: cfs

e. Which flooding conditions were analyzed?

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

If No for any of the above, attach explanation.

f. 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, attach explanation.

g. The rate of seepage through the levee system for the base flood is cfs

h. The length of levee system used to drive this seepage rate in item g: ft.

Interior Drainage Explanation

The proposed structure is being constructed in an existing river and there is over three feet of freeboard and the existing natural ground beyond the structure is higher than the embankment being built in the river.

There is one location upstream where there is a storm water retention area behind the north river embankment with conduit outfalls into the channel at River Mile 218.50 and 218.54. These conduits are protected from back flow by flap gates on the outfall structures. These structures are east of the area impacted by the water surface changes occurring because of the proposed structure.

8. Interior Drainage (continued)

i. Will pumping plants 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 operation be automatic? ☐ Yes ☐ No

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

(Reference: USACE EM-1110-2-3101, 3102, 3103, 3104, and 3105)

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.

9. Other Design Criteria

a. The following items have been addressed as stated:

Liquefaction ☐ 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

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

See report text for explanation

Attach supporting documentation

c. 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

d. Sediment Transport Considerations:

Was sediment transport considered? ☒ Yes ☐ No If Yes, then fill out Section F (Sediment Transport).
If No, then attach your explanation for why sediment transport was not considered.

E. LEVEE/FLOODWALL (CONTINUED)

10. Operational Plan And Criteria

    a. Are the planned/installed works in full compliance with Part 65.10 of the NFIP Regulations? ☒ Yes ☐ No

    b. Does the operation plan incorporate all the provisions for closure devices as required in Paragraph 65.10(c)(1) of the NFIP regulations? ☒ Yes ☐ No

    c. Does the operation plan incorporate all the provisions for interior drainage as required in Paragraph 65.10(c)(2) of the NFIP regulations? ☒ Yes ☐ No

    If the answer is No to any of the above, please attach supporting documentation.

11. Maintenance Plan

    a. Are the planned/installed works in full compliance with Part 65.10 of the NFIP Regulations? ☒ Yes ☐ No
    If No, please attach supporting documentation.

12. Operations and Maintenance Plan

    Please attach a copy of the formal Operations and Maintenance Plan for the levee/floodwall.

F. SEDIMENT TRANSPORT

Flooding Source: Salt River

Name of Structure: Cement Stabilized Alluvium

If there is any indication from historical records that sediment transport (including scour and deposition) can affect the Base Flood Elevation (BFE); and/or based on the stream morphology, vegetative cover, development of the watershed and bank conditions, there is a potential for debris and sediment transport (including scour and deposition) to affect the BFEs, then provide the following information along with the supporting documentation:

Sediment load associated with the base flood discharge: Volume acre-feet

Debris load associated with the base flood discharge: Volume acre-feet

Sediment transport rate (percent concentration by volume)

Method used to estimate sediment transport:

Most sediment transport formulas are intended for a range of hydraulic conditions and sediment sizes; attach a detailed explanation for using the selected method.

Method used to estimate scour and/or deposition:

Method used to revise hydraulic or hydrologic analysis (model) to account for sediment transport:
Please note that bulked flows are used to evaluate the performance of a structure during the base flood; however, FEMA does not map BFEs based on bulked flows.

If a sediment analysis has not been performed, an explanation as to why sediment transport (including scour and deposition) will not affect the BFEs or structures must be provided.

Please see Section 6 Scour and Sediment Transport Page 27 of CLOMR application for more detailed explanation for sediment transport section.

3 Surveying and Mapping Information

3.1 Field Survey Information

A field survey was conducted by Woolpert, Inc.

3.2 Mapping

A field survey was conducted on July 29 and 30, 2008. The topography and all elevations are in North American Vertical Datum (NAVD) 1988 in. This is located in the Arizona Central Zone. It is important to note that FEMA's effective study results are shown in North Geodetic Vertical Datum (NGVD) 1929. Datum shift is NAVD minus 2.12 ft = NGVD.

The map and digital terrain model were compiled from aerial photography dated June 12 and June 19, 2006 and April 28, 2007. The mapping has a scale of one inch equals forty feet and the terrain model produces one-foot contours.

4 Hydrology

The current FEMA regulatory 1% annual-chance discharge for the Salt River study reach is 169,000 cfs, with a drainage area of 12,783 square miles (FEMA, 2005). There are no flow change locations within this study reach for either the existing or proposed condition HEC-RAS models. Table 2 lists the discharges for the various return frequencies for this reach of the Salt River.

Table 2 - Salt River Discharges

Location	Drainage Area (Square Miles)	Peak Discharges (cfs)			
		10 %	2 %	1%	0.2 %
At Mill Avenue Bridge	12,783	55,000	140,000	169,000	243,000

5 Hydraulics

5.1 Method Description

Five hydraulic models for the Salt River are referenced in this report. The first model is the FIS HEC-RAS model; the second and third models are required as part of the CLOMR process. The other models were developed by PACE using HEC-RAS version 4.0 (U.S. Army Corps of Engineers, 2008). Below is a brief description of the hydraulic models referenced in this report:

a. Effective Model: The effective model is obtained from FEMA library and reproduced to produce the duplicate effective model.

b. Duplicate Effective Model: The duplicate effective model is a copy of the hydraulic analysis used in the effective FIS. The effective model was run in a version prior to 3.0 because it contains a zero distance between the upstream cross-section and the face of the bridge.

c. Corrected Effective Model: The Corrected Effective Model is the model that corrects any errors that occur in the Duplicate Effective Model, such as the zero distance error we encounter when using a more recent version of HEC-RAS 4.0.

d. Existing Conditions Model: A hydraulic model using updated topography to represent the current condition of the study reach. The Existing Conditions Model reflects any physical changes since the date of the effective model.

e. Proposed Conditions Model: A hydraulic model with the proposed cement stabilized alluvium embankment along the north bank and channel grading. This was constructed using the most recent topography, in addition to the design plans of the proposed embankment.

A comparison between the water surface elevations obtained using the duplicate effective and corrected effective models can be seen in Table 3. These two models were created to comply with FEMA requirements for this CLOMR. The existing conditions model was used to establish the current hydraulics. The proposed conditions model established the future hydraulics. The most pertinent comparison is between the proposed conditions and the existing condition models. The differences show the impacts of the project. Comparison of surcharges between the existing and proposed conditions encroached models was conducted for floodway analysis. This was done to verify the effect of the proposed embankment on surcharge. A detailed description of the floodway analysis is given in Section 5.6.

The vertical datum of the FIS model was NGVD 1929 according to the published flood insurance profiles for the Salt River (FEMA, 2005). The new topography for the project site is based on the 1988 North American Vertical Datum (NAVD88). The hydraulic models for the proposed and existing condition are also based on NAVD88. The datum correction being used is 2.12 feet, where NAVD 88 is equivalent to NGVD 29 plus 2.12 feet.

5.1.1 Duplicate Effective Model and Corrected Effective Model

The effective flood insurance model for the Salt River was based on an older version of HEC-RAS. The model obtained from FEMA library was run in version 2.2 and in NGVD 1929. Minor corrections were made to this model to create a corrected effective model.

A corrected effective model was created for the Salt River using the duplicate effective model by opening the HEC-RAS model geometry into HEC-RAS version 4.0 and adding 2.12 ft to convert to 1988 NAVD. The base-flood water surface elevations for the HEC-RAS corrected effective models were within 0.01 feet of the duplicate effective model elevations at every cross-section. Table 3 compares the results for the duplicate effective and corrected effective models for the 1% annual-chance floodplain within this study reach.

Table 3 - Comparison of Duplicate Effective and Corrected Effective Models

Corrected Effective NGVD 1929 HEC-RAS 4.0		Duplicate Effective NGVD 1929 HEC-RAS 2.2		Corrected Minus Duplicate
River Station	W.S. Elevation (ft)	River Station	W.S. Elevation (ft)	Delta W.S. Elevation (ft)
218.97		218.97	Bridge	
218.96	1126.03	218.96	1126.03	0.00
218.80	1124.77	218.80	1124.77	0.00
218.71	1123.63	218.71	1123.63	0.00
218.61	1122.61	218.61	1122.61	0.00
218.52	1121.59	218.52	1121.59	0.00
218.42	1120.20	218.42	1120.20	0.00
218.33	1119.49	218.33	1119.49	0.00
218.24	1118.20	218.24	1118.20	0.00
218.14	1117.26	218.14	1117.26	0.00

Corrected Effective NGVD 1929 HEC-RAS 4.0		Duplicate Effective NGVD 1929 HEC-RAS 2.2		Corrected Minus Duplicate
River Station	W.S. Elevation (ft)	River Station	W.S. Elevation (ft)	Delta W.S. Elevation (ft)
218.04	1116.28	218.04	1116.28	0.00
217.95	1115.57	217.95	1115.57	0.00
217.86	1114.83	217.86	1114.83	0.00
217.76	1111.73	217.76	1111.73	0.00
217.66	1111.44	217.66	1111.44	0.00
217.57	1110.33	217.57	1110.33	0.00

5.1.2 *Existing and Proposed Condition Models*

The existing condition model is necessary because channel improvements occurred along the north bank of Salt River that is not reflected in the effective FIRM panel mapping as indicated in the topographic work map (See Appendix C Maps and Exhibits). The existing condition model was generated using recent topography for cross-section information. Cross-sections were created at the same location as in the effective hydraulic model. Additional interim sections were added for the existing conditions model. Bridges and structural improvements to the river were already included in the effective model and no changes to these items were made for the existing condition model.

In the proposed conditions model, channel improvements including the cement stabilized alluvium embankment and channel grading will occur between River Stations 217.66 to 218.14. The proposed condition includes cut and fill in the channel used to create more flow area and to fill in the scour hole located near the 40th Street access point. A comparison of the existing and proposed conditions model is provided in Table 4 below.

Table 4 - Comparison of Proposed and Existing Conditions

	Proposed Project NAVD 1988 HEC-RAS 4.0	Existing Condition NAVD 1988 HEC-RAS 4.0	Proposed Minus Existing
River Station	W.S. Elevation (ft)	W.S. Elevation (ft)	Delta W.S. Elevation (ft)
218.96	1127.89	1127.87	0.02
218.80	1125.82	1125.78	0.04
218.77	1125.30	1125.26	0.04
218.71 AR	1124.67	1124.62	0.05
218.66	1124.15	1124.10	0.05
218.61	1123.54	1123.47	0.07
218.57	1122.97	1122.89	0.08
218.52	1122.42	1122.33	0.09
218.47	1122.07	1121.97	0.10
218.42	1121.32	1121.19	0.13
218.38	1120.82	1120.66	0.16

	Proposed Project NAVD 1988 HEC-RAS 4.0	Existing Condition NAVD 1988 HEC-RAS 4.0	Proposed Minus Existing
River Station	W.S. Elevation (ft)	W.S. Elevation (ft)	Delta W.S. Elevation (ft)
218.33	1120.57	1120.19	0.38
218.29	1120.30	1119.59	0.71
218.24 AQ	1120.12	1119.13	0.99
218.19	1119.93	1118.69	1.24
218.14	1119.57	1118.13	1.44
218.09	1118.70	1117.52	1.18
218.04	1118.36	1117.05	1.31
218.00	1118.00	1116.74	1.26
217.95	1116.82	1116.09	0.73
217.91	1116.54	1115.89	0.65
217.86	1115.44	1115.36	0.08
217.81	1114.19	1114.73	(0.54) *
217.76 AP	1111.76	1112.79	(1.03)
217.71	1111.42	1112.26	(0.84)
217.66	1110.70	1111.01	(0.31)
217.62	1110.67	1110.50	0.17
217.57	1110.19	1110.19	0.00

* (X.XX) represents a negative value

5.1.3 *Proposed Condition vs. Corrected Effective*

A comparison was done between the proposed condition model and the corrected effective model to see if there were any increased impacts. There exists one location where the water surface elevation increased by 0.19 ft at River Station 218.14 as indicated on Table 5 below.

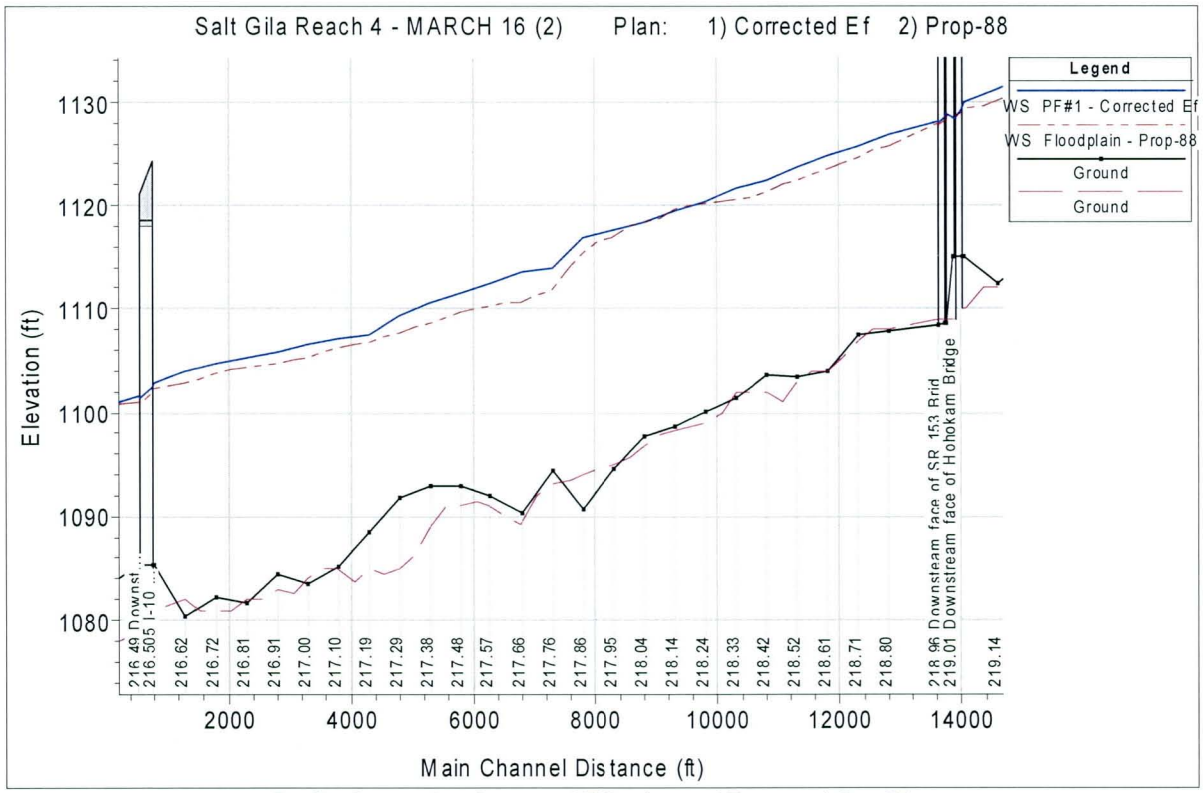
Table 5 - Comparison of Proposed and Existing Conditions

Proposed Condition NAVD 1988		Corrected Effective NAVD 1988		Proposed Minus Corrected
River Station	W.S. Elevation (ft)	River Station	W.S. Elevation (ft)	Delta W.S. Elevation (ft)
218.96	1127.89	218.96	1128.15	(0.26)
218.80	1125.82	218.80	1126.89	(1.07)
218.71 AR	1124.67	218.71	1125.75	(1.08)
218.61	1123.54	218.61	1124.73	(1.19)
218.52	1122.42	218.52	1123.71	(1.29)
218.42	1121.32	218.42	1122.32	(1.00)
218.33	1120.57	218.33	1121.61	(1.04)

Proposed Condition NAVD 1988		Corrected Effective NAVD 1988		Proposed Minus Corrected
River Station	W.S. Elevation (ft)	River Station	W.S. Elevation (ft)	Delta W.S. Elevation (ft)
218.24 AQ	1120.12	218.24	1120.32	(0.20)
218.14	1119.57	218.14	1119.38	0.19
218.04	1118.36	218.04	1118.40	(0.04)
217.95	1116.82	217.95	1117.69	(0.87)
217.86	1115.44	217.86	1116.95	(1.51)
217.76 AP	1111.76	217.76	1113.85	(2.09)
217.66	1110.70	217.66	1113.56	(2.86)
217.57	1110.19	217.57	1112.45	(2.26)
217.48	1109.67	217.48	1111.60	(1.93)

* (X.XX) represents a negative value

The minimum decreased water surface elevation occurs at River Station 218.04 with a decreased valued of 0.04 ft. The maximum decreased water surface elevation occurs at River Station 217.66 with a decreased valued of 2.86 ft. When comparing the Corrected Effective water surface profile with the proposed condition, it is observed that the channel invert is generally lower in the proposed condition which is part of the reason why the proposed condition water surface elevations are lower than that of the corrected effective results. In the figure below, the proposed condition water surface elevation and channel invert are illustrated by dashed lines.



Profile Comparing Corrected Effective and Proposed Condition

5.2 Topographic Work Map

The proposed conditions study area is shown on the topographic work map. The full-size 24" by 36" plot, at 1" = 500' scale, is included in the Maps and Exhibits Appendix following the Appendices. The proposed cement stabilized alluvium embankment is shown on the work map between River Station sections 218.14 to 217.66. The proposed conditions 1% annual-chance floodplain and floodway boundaries are shown on the work study maps. The thalweg of the channel is shown as indicated by the legend. Each cross-section is geo-referenced and labeled with final computed floodplain and floodway water surface elevations for the 1% annual-chance storm event. The 1% annual-chance floodplain limits are shown on the annotated FIRM panel included in the Maps and Exhibits Appendix.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

For the river reach that was modeled in the existing and proposed conditions models, the Manning's n-values were based on those found in the Flood Insurance Study HEC-RAS model. The channel n-values were 0.03 to 0.035 for the main channel and 0.025 to 0.05 for the overbank areas throughout the reach. These same channel and overbank n-values were applied to the existing and proposed conditions model. The roughness coefficient was verified by comparing the work map to aerial photographs and topography.

5.3.2 Expansion and Contraction Coefficients

Contraction and expansion coefficients of 0.1 and 0.3, respectively, were used in the final proposed conditions model along the study reach. Since the bridge abutments do not encroach into the channel, the contraction and expansion coefficients were not revised at cross-sections adjacent to bridges.

5.4 Cross-Section Descriptions

The existing and proposed conditions hydraulic models for Salt River have twenty-nine (29) cross-sections at the same location as the FIS that were updated to newer topography. In addition to the twenty-nine sections, twenty-three (23) cross-sections were added within the study reach located between the previous FIS cross-sections. All cross-sections were cut using HEC-GeoRAS extension of ArcView GIS. The cross-section alignment is shown on the HEC-RAS work map included in the Maps and Exhibits Appendix following the appendices. All cross-sections are oriented looking downstream, so the south river bank corresponds to the left bank of the cross-sections.

5.5 Modeling Considerations

5.5.1 Hydraulic Jump and Drop Analysis

There are no hydraulic jumps that exist in the existing or proposed models. Froude numbers are well below 1.0.

5.5.2 Bridges and Culverts

In the effective FIS HEC-RAS model of the Salt River, there are fourteen (14) bridges in the hydraulic analysis. In the existing and proposed condition models, a smaller portion of the river reach was analyzed which does not include any bridges. Information on the existing bridges bounding the project that were included in the existing and proposed conditions models are included in Table 6.

Table 6 - Salt River Bridge Data

River Station	Bridge Name	Min. Deck Elev	Max Soffit Elev.	Deck Thickness	Pier Data
216.51	I-10	1124.28	1118.05	7.1 feet	7- 6.0 feet piers
218.97	Sky Harbor Exp.	1147.92	1146.55	6.7 feet	8- 6.5 feet piers
219.02	Hohokam Exp.	1146.22	1142.20	6.7 feet	8 – 5.66 feet piers

5.5.3 Levees and Dikes

The effective FIRM panel depicts levees through a large portion of the Salt River on both the north and south banks. The levees begin upstream of the this study reach, and end about .5 mile and 1 mile upstream of Interstate Freeway 10 on the north and south banks, respectively. Per FEMA regulations, all sections meet the minimum 3 feet of freeboard as indicated by the table below.

Table 7 - Available Freeboard along Salt River Banks

River Station	W.S. Elevation (ft)	South Bank (ft)	North Bank (ft)
218.96	1127.89	9.11	9.11
218.8	1125.82	8.81	9.25
218.77	1125.30	9.19	9.48
218.71 AR	1124.67	10.05	9.33
218.66	1124.15	8.89	9.85
218.61	1123.54	8.49	10.47
218.57	1122.97	9.11	10.03
218.52	1122.42	11.25	9.58
218.47	1122.07	10.91	9.93
218.42	1121.32	10.35	9.68
218.38	1120.82	8.18	9.18
218.33	1120.57	7.43	9.43
218.29	1120.30	3.70	7.70
218.24 AQ	1120.12	3.88	5.88
218.19	1119.93	3.07	6.07
218.14	1119.57	4.43	5.27
218.09	1118.70	5.30	4.57
218.04	1118.36	4.64	4.27
218	1118.00	5.40	4.11
217.95	1116.82	6.19	4.64
217.91	1116.54	6.46	4.28
217.86	1115.44	7.56	4.78
217.81	1114.19	7.81	5.51
217.76 AP	1111.76	9.65	11.24
217.71	1111.42	10.96	9.08
217.66	1110.70	10.74	9.60
217.62	1110.67	9.33	9.33
217.57	1110.19	8.82	8.82

5.5.4 *Islands and Split Flows*

The floodplain is contained within the banks of the river without creating islands or split flow. No additional models were needed since these conditions were not present in the Salt River.

5.5.5 *Ineffective Flow Areas*

Ineffective flow areas were not used at the three bridges modeled for the existing and proposed conditions. The bridge abutments do not encroach into the channel and therefore do not create areas of ineffective flow.

5.5.6 *Supercritical Flow*

Subcritical flow regime was modeled in HEC-RAS. No supercritical condition is allowed.

5.6 Floodway Modeling

The original floodway was modeled so that the encroached water surface elevations would not be more than one foot higher than the base flood elevations. The increase in the encroached proposed conditions water surface elevations compared to the existing conditions was less than or equal to one foot within the project reach. For the proposed condition model, it is assumed that the levees will be certified therefore not having a floodplain outside of the banks. In this situation, the floodplain is the floodway. A summary of the floodway water surface profile for the proposed condition model is included in Table 8.

Table 8 - Salt River Proposed Floodway Summary

Cross - Section	Width (ft)	Section Area (sq ft)	Mean Velocity (ft/s)	Without Floodway (ft)	With Floodway (ft)	Increase (ft)
218.96	1100.71	16485.75	10.25	1127.89	1127.89	0.00
218.80	997.44	14428.82	11.71	1125.82	1125.82	0.00
218.77	1006.60	14472.36	11.68	1125.30	1125.30	0.00
218.71 AR	993.67	14241.25	11.87	1124.67	1124.67	0.00
218.66	991.33	14426.76	11.71	1124.15	1124.15	0.00
218.61	998.45	14315.17	11.81	1123.54	1123.54	0.00
218.57	1004.14	14306.08	11.81	1122.97	1122.97	0.00
218.52	1001.71	14343.32	11.78	1122.42	1122.42	0.00
218.47	1005.53	14987.92	11.28	1122.07	1122.07	0.00
218.42	1013.30	14392.91	11.74	1121.32	1121.32	0.00
218.38	1037.01	14655.81	11.53	1120.82	1120.82	0.00
218.33	1053.04	15930.25	10.61	1120.57	1120.57	0.00
218.29	1042.57	16515.95	10.23	1120.30	1120.30	0.00
218.24 AQ	1043.28	17826.88	9.48	1120.12	1120.12	0.00
218.19	1049.41	18553.65	9.11	1119.93	1119.93	0.00
218.14	995.26	17912.79	9.43	1119.57	1119.57	0.00
218.09	871.96	15328.93	11.02	1118.70	1118.70	0.00
218.04	847.06	15593.00	10.84	1118.36	1118.36	0.00
218.00	813.76	15409.99	10.97	1118.00	1118.00	0.00
217.95	760.68	13252.92	12.75	1116.82	1116.82	0.00
217.91	714.64	13956.36	12.11	1116.54	1116.55	0.00
217.86	661.60	12414.99	13.61	1115.44	1115.45	0.00
217.81	623.28	11163.53	15.14	1114.19	1114.20	0.00

Cross - Section	Width (ft)	Section Area (sq ft)	Mean Velocity (ft/s)	Without Floodway (ft)	With Floodway (ft)	Increase (ft)
217.76 AP	642.35	9639.93	17.53	1111.76	1111.77	0.01
217.71	691.26	10669.79	15.84	1111.42	1111.43	0.01
217.66	747.35	11196.61	15.09	1110.70	1110.72	0.02
217.62	831.27	13050.95	12.95	1110.67	1110.69	0.02
217.57	927.54	13740.29	12.30	1110.19	1110.21	0.02

5.7 Problems Encountered During the Study

5.7.1 Special Problems and Solutions

There were no special situations encountered during the preparation of this application. A comparison of water surface elevations was made between existing and proposed conditions because the proposed embankment will encroach into the Salt River. The proposed project encroaches upon a regulatory floodway and will cause an increase in base flood elevations (between existing and proposed). The requirements of section 65.12 of the National Flood Insurance Program (NFIP) are enclosed in Appendix D.

5.7.2 Modeling Warning and Error Messages

HEC-RAS generated several warning messages along the study reach of the proposed conditions model. Model tolerances were slightly exceeded at a few cross-section locations for conveyance ratio, changes in velocity head, or changes in energy losses. The cross-sections are located less than 300 feet apart and additional cross-sections were already added to the existing and proposed condition model. Additional cross-sections would not have avoided these warnings. Although the model tolerances were slightly exceeded, the hydraulic computations are acceptable and these warnings are not a source of concern.

5.8 Calibration

The purpose of a duplicate effective model is to calibrate the hydraulic models to that of the effective. The results were within the .5 ft allowance therefore no additional adjustments are needed.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

A comparison of water surface elevations was made between existing and proposed conditions because the proposed embankment will encroach into the Salt River.

A summary table of the proposed condition (without floodway encroachment) hydraulic results for the 1% annual-chance event is presented in Table 9. The table summarizes the following variables by cross-section: water surface elevation, critical water surface elevation, average channel velocity, top width, hydraulic depth, and Froude number.

Table 9 - Hydraulic Results for 1% annual-chance event Proposed Condition

River Station	W.S. Elev (ft)	Crit W.S. (ft)	Vel Chnl (ft/s)	Top Width (ft)	Froude # Chl
218.96	1127.89	1121.69	10.25	1100.71	0.47
218.80	1125.82	1120.90	11.71	997.44	0.54
218.77	1125.30	1120.38	11.68	1006.59	0.54
218.71 AR	1124.67	1119.84	11.87	993.66	0.55
218.66	1124.15	1119.06	11.71	991.32	0.54
218.61	1123.54	1118.53	11.81	998.44	0.55
218.57	1122.97	1118.11	11.81	1004.14	0.55
218.52	1122.42	1117.53	11.78	1001.70	0.55
218.47	1122.07	1116.52	11.28	1005.52	0.51
218.42	1121.32	1116.46	11.74	1013.29	0.55
218.38	1120.82	1115.92	11.53	1037.00	0.54
218.33	1120.57	1114.53	10.61	1053.03	0.48
218.29	1120.30	1113.59	10.23	1042.56	0.45
218.24 AQ	1120.12	1112.15	9.48	1043.27	0.40
218.19	1119.93	1111.06	9.11	1049.41	0.38
218.14	1119.57	1110.93	9.44	995.26	0.39
218.09	1118.70	1111.41	11.03	871.96	0.46
218.04	1118.36	1110.40	10.84	847.06	0.45
218.00	1118.00	1109.75	10.97	813.75	0.44
217.95	1116.82	1110.52	12.75	760.67	0.54
217.91	1116.54	1108.68	12.11	714.63	0.48
217.86	1115.44	1109.06	13.61	661.58	0.55
217.81	1114.19	1109.21	15.14	623.27	0.63
217.76 AP	1111.76	1109.61	17.55	642.30	0.80
217.71	1111.42	1108.12	15.85	691.20	0.71
217.66	1110.70	1107.32	15.11	747.27	0.69
217.62	1110.67	1105.77	12.97	831.22	0.58
217.57	1110.19	1105.43	12.32	927.48	0.56

5.9.2 Verification of Results

The results generated by the hydraulic models were reasonable and within expected parameters.

6 Scour and Sediment Transport

Scour analyses were conducted to establish toe-down depths and design toe elevations for the bank stabilization measures within the project reach. Sediment transport modeling was not performed for this phase of the project but will be conducted during the final design phase to provide a more detailed evaluation of long-term degradation and general scour.

The total scour depth is the sum of the following scour components: 1) long-term degradation, 2) general scour; 3) local scour; 4) bed-form scour; 5) bend scour; 6) low-flow incisement; and 7) factor of safety. Scour depths were established based on hydraulic conditions for the 100-year design event. Table 10

provides the estimated scour depths for the project reach. The following paragraphs the scour components evaluated and the procedure used to establish the scour depth for the components.

Table 10 - Total Scour Depth

River Station	Long-Term Degradation (ft)	General Scour (ft)	Low Flow Incis. (ft)	Bend Scour (ft)	Bedform Scour (ft)	Factor of Safety (ft)	Grade Control Scour (ft)	Total Scour (ft)
218.80	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.77	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.71	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.66	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.61	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.57	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.52	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.47	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.42	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.38	0.0	2.7	2.0	0.0	1.9	1.4		8.0
218.33	0.0	2.4	2.0	0.0	1.9	1.3		7.6
218.29	0.0	2.4	2.0	0.0	1.9	1.3		7.6
218.24	0.0	3.5	2.0	0.0	1.9	1.6		9.0
218.19	0.0	3.5	2.0	0.0	1.9	1.6		9.0
218.14	0.0	3.5	2.0	0.0	1.9	1.6		9.0
218.09	0.0	3.5	2.0	0.0	1.9	1.6		9.0
218.04	0.0	3.5	2.0	0.0	1.9	1.6		9.0
218.00	0.0	5.9	2.0	0.0	1.9	2.3		12.1
217.95	0.0	5.9	2.0	0.0	3.1	2.7		13.7
217.91	0.0	5.9	2.0	0.0	3.1	2.7		13.7
217.86	0.0	5.9	2.0	0.0	3.1	2.7		13.7
217.81	0.0	5.9	2.0	0.0	3.1	2.7		13.7
217.76							22.0	
217.71							16.0	
217.66	0.0	3.3	2.0	0.0	3.1	1.9		10.3
217.62	0.0	3.3	2.0	0.0	2.3	1.7		9.3
217.57	0.0	3.3	2.0	0.0	2.3	1.7		9.3

6.1 Long-Term Degradation

Aggradation and degradation are long-term changes in streambed elevation due to natural or man-induced causes and can affect a long reach of the river. The changes generally occur over a long period of time and are not the result of a single flood event.

Two grade-control structures exist within the study reach of this project. The structures were constructed about 1990 in conjunction with a channelization project by the Arizona Department of Transportation (ADOT). The grade-control structures are located at River Station 217.76 (Grade-Control Structure No. 1) and River Station 218.8 (Grade-Control Structure No. 2). The bed elevations along the project reach were compared using the current project mapping and the ADOT as-built plans. The comparison indicates little change in the elevation of the channel for this period. Long-term degradation was established as 0.0 feet along the project based on the comparison of the two sets of mapping. Long-term degradation will be further evaluated by sediment transport modeling during final design of the project.

6.2 General Scour

General scour refers to the vertical lowering of the channel bed over relatively short time periods, for example, the general scour in a given reach after passage of a single flood event. Contraction scour can be defined as a special case of general scour. General scour of a contraction occurs because the flow area becomes smaller than the upstream channel and the average velocity and bed shear increase, hence there is an increase in stream power at the contraction and more bed material is transported through the contracted section than is transported into the section. As the bed level is lowered, velocity decreases, shear stress decreases. Equilibrium is restored when the transport rate through the contracted section is equal to the incoming rate.

General scour was estimated by two different methods. One method was a procedure included in the Los Angeles County Department of Public Works "Sedimentation Manual," March 2006, which uses a curve relating average velocity to general scour. The second method was to calculate contraction scour using procedures included in the Federal Highway Administration's Hydraulic Engineering Circular No. 18, "Evaluating Scour at Bridges," 2001. The larger of the two values was used as the general scour depth used for establishing the toe-down depth.

6.3 Low-flow Incisement

A low-flow channel may develop when large width-depth ratios exist. There are no rigorous methodologies for the prediction of low-flow channel incisement. A review of existing field conditions and experience from previous projects along the Salt River indicate a low flow incisement depth of 2 to 3 feet may develop. A low-flow channel does not exist in the project reach, possibly due to the presence of grade-control structures. However, to be conservative during this preliminary design phase, a low-flow incisement depth of 2 feet was used to establish the toe-down depth.

6.4 Bend Scour

Bend scour occurs in channel bends which induce transverse or "secondary" currents which, in turn, scour sediments from the outside of a bend and cause it to be deposited along the inside of the bend. Bend scour was not included in establishing toe-down depths as no significant curvature of the channel occurs within the project reach.

6.5 Bedform Scour

The bedform scour component was estimated by calculating both dune and anti-dune scour. Dune scour was calculated using a relationship developed by Yalin and anti-dune scour was calculated using a relationship developed by Kennedy. The actual type of bedform present is a function of the flow regime. Since the flow regime may change with the fluctuating discharges of the flood hydrograph, both bedforms could be present in the project reach during a flood event. The maximum scour depth calculated with the above relationships, for the 100-year design hydraulic conditions, was used as the bedform scour.

6.6 Local Scour/Grade-Control Scour

Local scour is the scour resulting from an obstruction and abrupt change in the direction of flow. Local scour is caused by acceleration of flow and resulting vortices induced by the obstructions. It occurs at bridge piers, abutments, embankments, and other structures obstructing flow. No local obstructions exist within the project reach.

Scour on the downstream side of grade-control structures is a special case of local scour. Local scour was estimated at Grade-Control Structure No. 1 and Grade-Control Structure No. 2 using an equation developed for local scour downstream of soil-cement grade-control structures.

In the absence of bridge piers and/or abutments, the depth of scour below grade-control structures is not added to the other scour components. Rather, the depth of scour caused by the grade-control structure is compared to the design depth of scour which incorporates general scour, local scour, bedform scour,

bend scour, low-flow incisement, and other local scour components. The larger of the two values is then used for toe-down design.

6.7 Factor of Safety

A factor of safety was included to account for non-uniform flow distributions typical of alluvial channels. A factor of safety of 1.3 (30% increase) was applied to the general scour, and bedform scour components.

6.8 Total Scour

The total scour is the sum of long-term degradation, general scour, low-flow incisement, bend scour, and bed form scour plus the factor of safety. The bank protection toe down will be, at a minimum, the depth of total scour below the channel invert elevation at each station.

7 Draft FIS Report Data

7.1 Summary of Discharges

The 1% annual-chance flowrate used for the entire project reach of the Salt River is 169,000 cfs for both the existing and proposed condition. A summary of additional discharges studied are shown in the table below.

Table 11 - Summary of Discharges

Location	Drainage Area (Square Miles)	Peak Discharges (cfs)			
		10 %	2 %	1%	0.2 %
At Mill Avenue Bridge	12,783	55,000	140,000	169,000	243,000

7.2 Floodway Data

The proposed floodway data is listed in Table 12. The table summarizes the following variables for the floodway by cross-section: width, section area, and mean velocity. The table also lists by cross-section the base floodwater surface elevations for floodway and floodplain, and the corresponding water surface elevation increase.

Table 12 - Salt River Floodway Data Table NAVD 1988

Salt River	Floodway			Base Flood Water Surface Elevation		
Cross-Section	Width (ft)	Section Area (sq ft)	Mean Velocity (ft/s)	Without Floodway (ft)	With Floodway (ft)	Increase (ft)
218.96	1100.71	16485.75	10.25	1127.89	1127.89	0.00
218.80	997.44	14428.82	11.71	1125.82	1125.82	0.00
218.77	1006.60	14472.36	11.68	1125.30	1125.30	0.00
218.71 AR	993.67	14241.25	11.87	1124.67	1124.67	0.00
218.66	991.33	14426.76	11.71	1124.15	1124.15	0.00
218.61	998.45	14315.17	11.81	1123.54	1123.54	0.00
218.57	1004.14	14306.08	11.81	1122.97	1122.97	0.00
218.52	1001.71	14343.32	11.78	1122.42	1122.42	0.00
218.47	1005.53	14987.92	11.28	1122.07	1122.07	0.00
218.42	1013.30	14392.91	11.74	1121.32	1121.32	0.00

Salt River	Floodway			Base Flood Water Surface Elevation		
Cross-Section	Width (ft)	Section Area (sq ft)	Mean Velocity (ft/s)	Without Floodway (ft)	With Floodway (ft)	Increase (ft)
218.38	1037.01	14655.81	11.53	1120.82	1120.82	0.00
218.33	1053.04	15930.25	10.61	1120.57	1120.57	0.00
218.29	1042.57	16515.95	10.23	1120.30	1120.30	0.00
218.24 AQ	1043.28	17826.88	9.48	1120.12	1120.12	0.00
218.19	1049.41	18553.65	9.11	1119.93	1119.93	0.00
218.14	995.26	17912.79	9.43	1119.57	1119.57	0.00
218.09	871.96	15328.93	11.02	1118.70	1118.70	0.00
218.04	847.06	15593.00	10.84	1118.36	1118.36	0.00
218.00	813.76	15409.99	10.97	1118.00	1118.00	0.00
217.95	760.68	13252.92	12.75	1116.82	1116.82	0.00
217.91	714.64	13956.36	12.11	1116.54	1116.55	0.00
217.86	661.60	12414.99	13.61	1115.44	1115.45	0.00
217.81	623.28	11163.53	15.14	1114.19	1114.20	0.00
217.76 AP	642.35	9639.93	17.53	1111.76	1111.77	0.01
217.71	691.26	10669.79	15.84	1111.42	1111.43	0.01
217.66	747.35	11196.61	15.09	1110.70	1110.72	0.02
217.62	831.27	13050.95	12.95	1110.67	1110.69	0.02
217.57	927.54	13740.29	12.30	1110.19	1110.21	0.02

7.3 Annotated Flood Insurance Rate Maps

A copy of the annotated FIRM is included in the Maps and Exhibits following the Appendices.

7.4 Flood Profiles

Proposed flood profiles are included in the Maps and Exhibits following the Appendices.

PACE
Advanced Water Engineering

Survey Field Notes

Appendix A – Procedure Memorandum 41

US. Department of Homeland Security
500 C Street, SW
Washington, DC 20472

FEMA

MEMORANDUM FOR: Mitigation Division Directors
Regions I - X

FROM: Michael F. Howard, Chief
Risk Identification Branch

SUBJECT: Procedure Memorandum No. 41 – North American Vertical Datum of 1988 (NAVD88) Policy

Background: Historically, the most common vertical datum used by FEMA has been National Geodetic Vertical Datum of 1929 (NGVD29). However, the NAVD88 datum is more compatible with modern surveying and mapping technologies like Global Positioning Systems and Light Detection and Ranging (LIDAR), more accurate than NGVD29, and it is the only official vertical datum for the continental United States (http://www.ngs.noaa.gov/PUBS_LIB/FedRegister/FRdoc93-14922.pdf).

It is important that FEMA accomplish this conversion now for the following reasons:

- The old datum, NGVD29, is obsolete and no longer supported by the National Geodetic Survey (NGS).
- As time passes it will be substantially more difficult to obtain reliable elevations referenced to NGVD29.
- Previously published heights on NGS benchmarks will not be updated. These old heights have greater errors than new NAVD88 heights, are not maintained and become less reliable as they age.
- As reference marks are disturbed or destroyed, there will be fewer and fewer NGVD29 reference points available.
- Eventually professional surveyors may have difficulty certifying elevations reference to NGVD29.

Issue: Map Modernization projects are currently being undertaken using either NGVD29 or NAVD88. FEMA wants new flood map projects to use only NAVD88.

Action Taken: The purpose of this memorandum is to communicate FEMA's Flood Hazard Mapping Program policy regarding the NAVD88. This memorandum supersedes the decision making criteria for conversion of vertical datum outlined in Appendix B of the Guidelines and Specifications for Flood Hazard Mapping Partners, April 2003. For areas within the continental United States, all new flood maps and updates that revise the majority of the map panels must be referenced to NAVD88.

Distribution List (electronic distribution only)

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Risk Assessment Branch

Risk Identification Branch

Risk Communications Branch

Federal Insurance and Mitigation Divisions in FEMA Regional Offices

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Map Service Center

Cooperating Technical Partners

FEMA Contractors

Appendix A – VERTCON Datum Conversion

Questions concerning the VERTCON process may be mailed to NGS

Latitude: 33 24 56

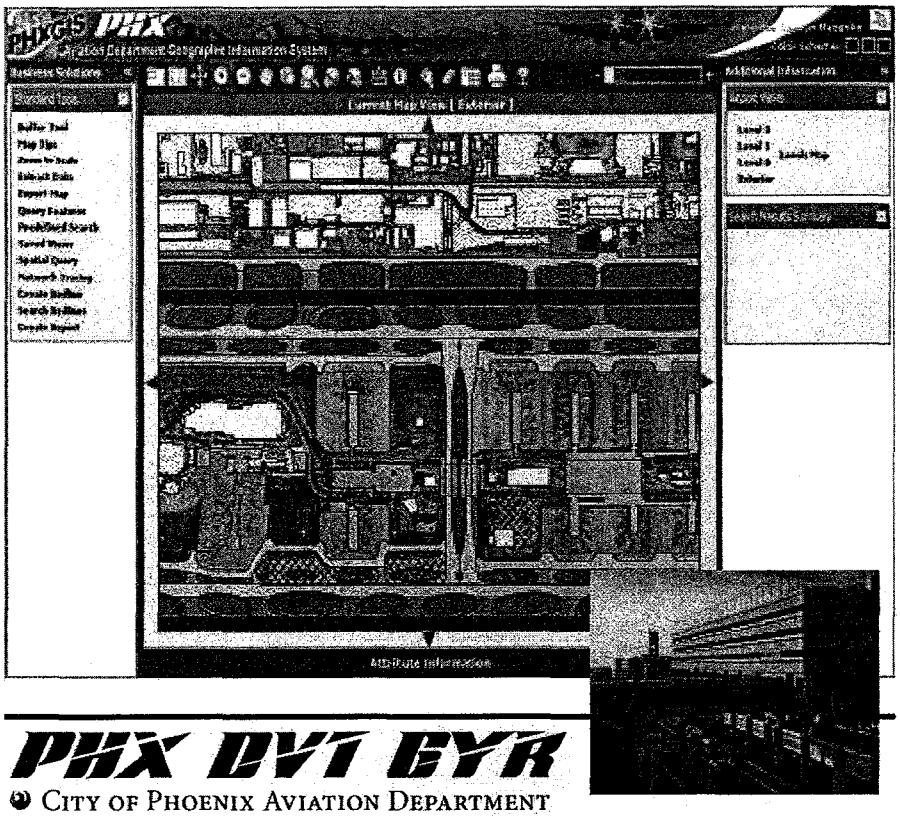
Longitude: 112 00 31.5

NGVD 29 height: ft

Datum shift(NAVD 88 minus NGVD 29): 2.123 feet

Appendix A – Testing Certification

TESTING & CERTIFICATION REPORT – PHOTOGRAMMETRIC MAPPING OF THE OPERATING EXTENTS



PHX DVT GYR

CITY OF PHOENIX AVIATION DEPARTMENT

Geographic Information System Implementation Project

Phoenix Sky Harbor International Airport
City of Phoenix, Arizona

August 2008

TESTING & CERTIFICATION REPORT – PHOTOGRAMMETRIC MAPPING OF THE OPERATING EXTENTS

PHX DVT GYR

CITY OF PHOENIX AVIATION DEPARTMENT

Geographic Information System Implementation Project

Phoenix Sky Harbor International Airport
City of Phoenix, Arizona

August 2008

Prepared by Woolpert, Inc.
4050 East Cotton Center Boulevard
Building 3, Suite 39
Phoenix, Arizona 85040
www.woolpert.com

REGISTERED LAND SURVEYOR
CERTIFICATE NO.
18539
GARY C.
BILOW
Date Signed 08-22-2008
ARIZONA U.S.A.
Expires 03-31-2011

QUALITY

At Woolpert, quality is the cornerstone of our business. We invite your comments and suggestions for improving this document.

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1. INTRODUCTION

1.1 BACKGROUND

Woolpert, Inc (Woolpert) is assisting the City of Phoenix (the City) in its project to develop an enterprise information management system using Geographic Information System (GIS) technology for Sky Harbor International Airport. Woolpert's tasks include providing aerial photography and photogrammetrically-derived map products. Map products are required to meet American Society for Photogrammetry and Remote Sensing (ASPRS) Class 1 Accuracy Standards.

Woolpert delivered the planimetric mapping and digital terrain data to the City on several dates in 2007. The mapping and the terrain model were compiled from aerial photography captured in June 2006 and April 2007. Delivery was made electronically in the form of Environmental Systems Research Institute (ESRI)-formatted feature, grid and triangulated irregular network (TIN) layers loaded to the City's GIS servers. This report covers only mapping of the operating extents of the airport as identified by the City of Phoenix, Aviation Department and the features compiled photogrammetrically as listed in Appendix A. This mapping was designed for a scale of one inch equals forty feet and the terrain model designed to produce one-foot contours.

In July 2008, the City determined that certification of the photogrammetrically-produced data in the airport operating extents by an Arizona Registered Land Surveyor was needed. Woolpert proposed a certification plan which included testing the positional accuracy of the delivered data for conformance to the ASPRS standards. The plan was submitted in Woolpert Request for Information (RFI) #21 and approved on July 18, 2008. (The RFI is included in Appendix B.) This report (with appendices) serves as certification of the map and digital terrain model features compiled from aerial photography dated June 12 and June 19, 2006 and April 28, 2007, as listed in Appendix A.

1.2 PURPOSE

Prepared by Gary C. Bilow, a Registered Land Surveyor (RLS) certified by the State of Arizona and employed by Woolpert, this report details the testing and certification of photogrammetric mapping of the operating extents of Sky Harbor International Airport located in Phoenix, Arizona, based on aerial photography captured in June 2006 and April 2007.

1.3 SCOPE

This report provides an overview of how the photogrammetric mapping of the operating extents of Sky Harbor International Airport in 2006 and 2007 processes were tested and certified, along with analysis and conclusions. Supporting materials for this report are included in the appendices of this document.

1.4 RELATED DOCUMENTS

- City of Phoenix Request for Proposal (RFP) for GIS Implementation
- Woolpert Scope of Work For Phoenix Sky Harbor International Airport GIS Implementation
- 05.1.1.F Aerial Photography Standards
- 05.3.1.1.F Survey Control for Aerial Photography

1.5 DOCUMENT ORGANIZATION

This document is divided into two sections with six appendices that contain supporting documents, as detailed below:

- **Section 1 – Introduction.** Discusses the background, scope and purpose of this document.
- **Section 2 – Testing and Certification.** Provides an overview of steps involved in testing and certifying the photogrammetric mapping of the operating extents of Phoenix Sky Harbor International Airport, including:
    - Test design and planning,
    - Field survey,
    - Data processing, and
    - Analysis and conclusions.
- **Appendix A:** A table detailing the certified operating extent data delivered in 2007.
- **Appendix B:** An RFI regarding certification of 2007 photogrammetric mapping.
- **Appendix C** – A *Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy* document, as released by the Subcommittee for Base Cartographic Data of the Federal Geographic Data Committee, FGDC STD-007.3-1998.
- **Appendix D** – A graphic illustrating the test point layout for certification of 2007 photogrammetrically-derived mapping for Phoenix Sky Harbor International Airport's operating extents.
- **Appendix E** – A *GPS Calibration Report* generated on 8/4/08.
- **Appendix F** – An analysis of map errors contained in the 2006/2007 photogrammetric mapping.

2. TESTING AND CERTIFICATION

This section provides an overview of steps involved in testing and certifying the photogrammetric mapping of the operating extents of Phoenix Sky Harbor International Airport, including:

- Test design and planning,
- Field survey,
- Data processing, and
- Analysis and conclusions.

Refer to the appendices for documents that provide additional information on the items contained in this section.

2.1 TEST DESIGN AND PLANNING

The Federal Geographic Data Committee (FGDC) published National Standards for Spatial Data Accuracy (NSSDA) as Part 3 of their Geospatial Positioning Accuracy Standards (FGDC-STD-007.3-1998). The NSSDA "implements a statistical and testing methodology for estimating the positional accuracy of points on maps and in digital geospatial data, with respect to georeferenced ground positions of higher accuracy". It does not define accuracy threshold values, leaving that to the end-user of the map product. The NSSDA simply "provides a common language for reporting accuracy to facilitate the identification of spatial data for geographic applications". This language includes specifying accuracy at the 95% confidence level in units of ground measure. (The NSSDA is included in Appendix C.)

The NSSDA requires testing a minimum of 20 well-defined points distributed over the geographic area of interest — in this case, the operating extents. Testing guidelines in Appendix 3-C of the standard state "A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself."

Woolpert added additional conditions for point selection including:

1. Not in the Security Identification Display Area
2. Minimal impact on traffic and airport operations
3. Easy access via passenger vehicle
4. Good visibility for Global Positioning System (GPS) receiver
5. Well-defined both horizontally and vertically

Woolpert's test was designed to exceed the NSSDA minimum. A rough grid was established over the 2007 orthoimage of the operating extents. The grid has five rows and ten columns with each cell roughly 2500 feet square. Two well-defined points were selected in each grid cell except where points meeting all conditions could not be found in a cell. All points are within the operating extents polygon contained in the current query database of GIS data. Woolpert intended to test only one point per grid cell but selected two as a way to minimize the impact of losing a point due to access or feature change since the original photography.

ESRI ArcMap version 9.2 software was used to build a map of potential test points. To minimize the number of features in the map, photogrammetrically-produced shapefiles named All_points and All_lines were used with the orthophoto to identify potential test points. These intermediate files served as the basis for extraction of the several features delivered to the City.

We determined that most point features contained too much uncertainty horizontally to qualify as well-defined points in mapping at this scale. In addition, many points could not be occupied directly by the test equipment. Intersecting lines appeared to present the most reliable test points for this analysis.

A shapefile of test points was created and populated by editing within ArcMAP. Potential test points were snapped to the vertices of intersecting line features. Edges of sidewalks, corners of paved areas, ends of retaining walls and fence corners were the most commonly used features. Potential test points were attributed with a point number (between 600 and 700) and a brief description. Elevations of the potential test points were extracted from the TIN layer using an automated tool that reads the TIN at the horizontal coordinates of the point.

A Real-Time Kinematic (RTK) GPS was selected to determine the position and elevation of test points to a higher accuracy. RTK GPS requires two GPS receivers, one remaining at a fixed, and preferably known position (base) and the other moving to the points of interest (rover). The AZGPS, LLC network of Continuously Operating Reference Stations (CORS) was chosen to provide the base data. This system is capable of delivering centimeter-level (0.03 foot) positioning.

To eliminate any small systematic differences between the AZGPS CORS network and the coordinate system in place at Sky Harbor, the RTK GPS measurements will be site-calibrated to photo control points used in the mapping. Eight existing photo control points surrounding the operating extents were identified for survey. A map showing the grid, control points and potential test point locations is included Appendix D.

Finally, to assist the field surveyor, ArcMap screen shots of all test and control point locations with the All_Lines, city street centerline and orthophoto layers were assembled. Coordinates of control and test points were exported to a hand-held GPS receiver with city street maps loaded as an aid to navigation.

2.2 FIELD SURVEY

A field survey was conducted on July 29 and 30, 2008. A Trimble R8 dual frequency GPS receiver on a two-meter fixed-height rod was employed as the rover. A Trimble TSC2 field computer running Trimble Survey Controller version 12 was used for data storage and processing. The receiver was connected to the AZGPS CORS network base via cellular modem to the internet.

Coordinates of test points and control points were attached as reference files to the survey project in the TSC2. Both types were measured as "Control Points" for this survey. Points were occupied a minimum of 180 epochs. With the R8 setup to report measurements one per second, each point was occupied for at least three minutes. Difficulty in radio communications around the airport resulted in one point only having 120 epochs of data. No obvious increase in positional error was seen on this point.

Field surveyed points were numbered by adding 1000 to the test point or photo control point number. A short description was added. Field notes were taken recording the two numbers, adding descriptive text and listing any offsets from the surveyed point to the described test point. Four of the grids required selection of a new test point by the field surveyor. Two were moved due to accessibility/survey issues and two moved to minimize uncertainty in the elevation. One photo control point was not accessible due to construction activities. It was replaced with a point within the operating extent. After each point was surveyed, an inverse

was computed to the map-derived or published control point coordinates to insure no blunder had occurred. Finally, the data was checked for completeness before ending the field survey.

A total of 58 points were surveyed, 50 test points and eight photo control points.

2.3 DATA PROCESSING

Data from the field survey was transferred to the office computer for processing using the Data Transfer Utility in Trimble Geomatics Office (TGO) software version 1.63. Various site calibrations were tested in TGO with the goal of using the calibration that best represents the transformation between the AZGPS CORS network and the Sky Harbor coordinate system. In this case, the selection was made based on minimizing the residuals in the observations on the control points. Six of the eight photo control points were used in the site calibration. The calibration included no rotation and no translation in the horizontal position, a horizontal scale factor of 1.00000586, a vertical separation at the origin of 0.09 foot with the reference plane sloping north at 7.927 parts per million (ppm) and east at 3.837 ppm. Trimble's Site Calibration Report is included in Appendix E.

Coordinates on test points were re-calculated based on the site calibration. Point numbers, coordinates and descriptions were exported to a comma-delimited ASCII file. The surveyed positions were adjusted by the small amounts recorded in the field notes, as needed. This file of adjusted positions and the file of test point positions and elevations derived from the photogrammetric mapping were combined in a Microsoft Office Excel 2003 SP3 spreadsheet for analysis. This spreadsheet is included in Appendix F.

2.4 Analysis and Conclusions

While NSSDA describes a testing method, the actual accuracy threshold for this project was described in the original RFP as ASPRS Class 1. The specified map scale for the operating extents was 1 inch equals 40 feet, or 1:480. The TIN was to support 1 foot contours. While ASPRS no longer publishes map standards, the 1990 ASPRS Accuracy Standards for Large-Scale Maps are included in Appendix 3-D of the NSSDA. This standard sets a Class 1 limiting Root-Mean-Square Error (RMSE) for X and Y coordinates at 0.4 feet for 1:480 scale maps. To meet the Class 1 vertical standard, the limiting RMSE for elevations is one-third the contour interval – in this case 0.33 feet.

RMSE is calculated separately for X, Y and Elevation to determine if the ASPRS Standard has been met. This value is the square root of the sum of the differences between the map-derived coordinate and the test coordinate squared divided by the number of test points. This requires evaluating three equations as follows:

$$RMSE(X)= \sqrt{[\sum(X(mapi)-X(surveyedi)^2/n]}$$
$$RMSE(Y)= \sqrt{[\sum(Y(mapi)-Y(surveyedi)^2/n]}$$
$$RMSE(Z)= \sqrt{[\sum(Z(mapi)-Z(surveyedi)^2/n]}$$

Equation Key: X = East Coordinate, Y = North Coordinate, Z = Elevation, I = observation number (integer between 1 and n) and n = integer number of observations

Woolpert computed the RMSE values for 50 test points as follows:

RMSE(X) = 0.279	Limiting RMSE(X) = 0.400
RMSE(Y) = 0.286	Limiting RMSE(Y) = 0.400
RMSE(Z) = 0.279	Limiting RMSE(Z) = 0.333

The RMSE values for the test points fall below the limiting RMSE values for the 1990 ASPRS Class 1 Standard indicating that the standard has been met. Refer to Appendix F for a spreadsheet of calculations.

The NSSDA requires that accuracies be expressed in ground units at the 95% confidence level. They also use a single number to represent horizontal accuracy. These numbers can be calculated from the RMSE values used to determine the ASPRS classification as follows:

Horizontal Accuracy — Since RMSE(X) ≠ RMSE(Y) and the ratio 0.279/0.286 is between 0.6 and 1.0 (actually 0.98), the NSSDA specifies the following formula be used:

NSSDA Accuracy ~ 2.477 * 0.5 * [RMSE(X) + RMSE(Y)]
2.477 * 0.5 * [0.279 + 0.286] = 0.70 foot

Vertical Accuracy — NSSDA Accuracy = 1.96 * RMSE(Z)
1.96 * 0.279 = 0.55 foot

Since Woolpert delivered the photogrammetrically-derived data digitally, there is no map on which to affix a certification and seal. Woolpert offers the following certification which applies to the tested digital map products:

The digital data consisting of map features and a digital terrain model covering the operating extents of Phoenix Sky Harbor International Airport listed in Appendix A, compiled photogrammetrically from aerial photography dated June 12 and June 19, 2006 and April 28, 2007, and delivered to the City of Phoenix, Aviation Department on various dates in 2007, was checked and found to conform to the ASPRS Standard for Class 1 Map Accuracy dated 1990. In addition, the data tested 0.70 foot horizontal accuracy at the 95% confidence level and tested 0.55 foot vertical accuracy at the 95% confidence level as defined in Part 3: National Standards for Spatial Data Accuracy of the FGDC's Geospatial Positioning Accuracy Standards dated 1998.

REGISTERED LAND SURVEYOR
CERTIFICATE NO.
18539
GARY C.
BILOW
Date Signed 08-22-2008
ARIZONA U.S.A.
Expires 03-31-2011

Gary C. Bilow

Gary C. Bilow, AZ RLS # 18539

Appendix A: Certified Operating Extent Data

Certified Operating Extent Data Delivered in 2007		
TABLE_NAME	FEATURE	STATUS
AIRFIELDELECLIGHT	Airfield Electric Light	VALID
AIRFIELDPAVEMENTMARKING	Airfield Pavement Marking	VALID
AIRFIELDRUNWAYPAVEMENTMARKING	Airfield Runway Pavement Marking	VALID
AIRFIELDWEATHEREQUIPMENT	Airfield Weather Equipment	VALID
AIRPORTHELIPADMARKING	Airport Helipad Marking	VALID
APRON	Apron	VALID
BUILDING	Building	VALID
BUILDINGSPOTELEVATION	Building Spot Elevation	VALID
CONSTRUCTIONAREA	Construction Area	VALID
ELEVATIONBREAKLINE	Elevation Breakline	VALID
ELEVATIONCONTOUR	Elevation Contour	VALID
FENCE	Fence	VALID
GATE	Gate	VALID
HELIPAD	Helipad	VALID
INFIELD	Infield	VALID
MASSPOINT	Mass Point	VALID
NAVAIDEQUIPMENT	NAVAID Equipment	VALID
PARKINGLOT	Parking Lot	VALID
RAILROADCENTERLINE	Railroad Centerline	VALID
RAILROADYARD	Railroad Yard	VALID
RUNWAYBLASTPAD	Runway Blast Pad	VALID
RUNWAYSEGMENT	Runway Segment	VALID
SHOULDER	Shoulder	VALID
SPOTELEVATION	Spot Elevation	VALID
SURFACEWATERAREA	Surface Water Area	VALID
SURFACEWATERLINE	Surface Water Centerline	VALID
TAXIWAYSEGMENT	Taxiway Segment	VALID
UNDERCONSTRUCTION	Under Construction	VALID
PHEDGEOFPAVEMENT	PH Edge Of Pavement	VALID
PHELECTRICTRANSFORMER	PH Electric Transformer	VALID
PHELECTRICTRANSMISSIONTOWER	PH Electric Transmission Tower	VALID
PHJETFUELHYDRANT	PH Jet Fuel Hydrant	VALID
PHMANHOLE	PH Manhole	VALID
PHPAVEMENTCENTERLINE	PH Pavement Centerline	VALID
PHSTORAGETANK	PH Storage Tank	VALID
PHSTORMENDTREATMENT	PH Storm End Treatment	VALID
PHSTORMINLET	PH Storm Inlet	VALID
PHSTORMOUTLET	PH Storm Outlet	VALID
PHUNKNOWNUTILITY	PH Unknown Utility	VALID
PHUTILITYCABINET	PH Utility Cabinet	VALID
PHUTILITYPOLE	PH Utility Pole	VALID
PHWATERHYDRANT	PH Water Hydrant	VALID
PHWATERVALVEBOX	PH Water Valve Box	VALID
OPERATING EXTENTS DTM	Terrain Model InTIN Format	VALID
OPERATING EXTENTS DTM	Terrain Model In GRID format – 5' Cells	VALID

Appendix B: RFI # 21 — Certification of 2007 Photogrammetric Mapping

WOOLPERT

Request for Information

Phoenix Sky Harbor International Airport - GIS Implementation Project, Contract No. 118083

TO: Ted Melnik	Design Project Manager
FROM: Kevin Shirer	Project Manager
DATE REQUIRED: 07/23/08	

REQUEST / SUBJECT: RFI #21 – Certification of 2007 Photogrammetric Mapping

The purpose of this Request for Information is to obtain formal approval via an RFI regarding certification of the 2007 photogrammetric mapping of the operating extents. This effort has been discussed verbally and through email with the City's decision to move forward expressed in an e-mail from Mike Youngs dated 7/10/08 (sees following page). Funding source is identified as the supplemental services budget with a fixed fee amount of $5,400.00.

Certification will be in the form of a report documenting the results of testing of the 2007 mapping. The report will be sealed and signed by an Arizona Registered Land Surveyor. Testing will meet the Federal Geographic Data Committee Geospatial Positioning Accuracy Standards Part 3: National Standards for Spatial Data Accuracy (FGDC-STD-007.3-1998).

Testing will include the following tasks:

1. Select 30-50 well-defined points in the 2007 mapping of the operating extents. Selected points will be scattered throughout the extents with the additional criteria of GPS satellite visibility, likely survival since 2007 and easy accessibility from public roads. These will be potential test points.
2. Extract horizontal coordinates and elevations of potential test points.
3. Select 6-8 photo control points from the original mapping to serve as control for the test. Control points will be selected to generally surround the operating extents.
4. Search out and survey using survey-grade RTK GPS 4-6 photo control points and at least 25-35 test points. Survey will be site-calibrated to a minimum of four photo control points.
5. Prepare a spreadsheet comparing surveyed with photogrammetrically-derived coordinates. Analyze comparison to produce error estimates at the 95% Confidence level.

The report will included the pertinent portions of the FGDC Standards and a narrative describing the conduct of the test. Results will be explained and compared to the ASPRS Class 1 requirements specified in the original RFP. A certification statement will be drafted stating the mapping has been tested and found to conform to the ASPRS standard.

NAME:	Kevin Shirer	DATE:	07/17/08

1 of 3

WOOLPERT, INC.
4050 E. Cotton Center Blvd. Bldg 3 Ste 39 - Phoenix Arizona 85040

From: mike.youngs@phoenix.gov
Sent: Thursday, July 10, 2008 12:15 PM
To: Shirer, Kevin
Cc: Bilow, Gary; jamie.ritchie@phoenix.gov; Gerhard, John; Przybyla, John; ted.melnik@phoenix.gov
Subject: RE: "Certification" of Topographic Data

Kevin,
Please move forward with this work. Submit an invoice to me once completed, and we will use the same mechanism used for onsite staff to pay for Gary's work.
Thanks,

From :"Shirer, Kevin" <Kevin.Shirer@Woolpert.com>
Sent: 07/08/2008 04:35 PM
To: Mike Youngs/AVN/PHX@PHX
Cc: Ted Melnik/AVN/PHX@PHXENT, "Bilow,Gary" <Gary.Bilow@Woolpert.com>, "Przybyla, John" <John.Przybyla@Woolpert.com>,"Gerhard, John" <John.Gerhard@Woolpert.com>, Jamie Ritchie/AVN/PHX@PHXENT
Subject: RE: "Certification" of Topographic Data

Mike;
Getting back with you regarding the "Certification" of the April 2007 topo data so it could be used by Z&H Engineering and others for engineering purposes.

I've been coordinating with our legal department and Gary Bilow, our Registered Land Surveyor in our Phoenix office. In order to certify the data and attest to its accuracy to meet Arizona Revised Statutes, Gary would need to validate the April 2007 data through some field work and would seal a paper deliverable. He would certify the entire April 2007 topo delivery, not just the river bottom area of immediate concern to Z&H.

To validate the 2007 data, Gary would need to obtain survey equipment and conduct a couple of days of field work to validate the operating extent topo data in various locations. Then he'd write up a report that could be sealed consisting of a report narrative, a numeric analysis of the survey points and topo data, and a graphic of the entire topo data set.

Since Gary is an RLS, his hourly rate is $155.96/hr, and we estimate the field work at 23 hours and the office work at 12 hours. So, we estimate this could be done in 35 hours or less for a maximum fee of $5456.60. Please let me know if you'd like us to put together something more formal in an RFI.

Additionally;
Ted also asked if we could provide some language that the City could add in to future topo data contracts since our current contract does not require certification (only that the data needed to comply with ASPRS Class I standards).

I'm not an attorney so I recommend your attorneys do the final wordsmithing. But I believe something along the following lines may be appropriate to get "certified" topo data from photogrammetry work in the future. Add a requirement that topographic data (contours) be certified

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by a Registered Land Surveyor to meet the requirements of Arizona Revised Statutes Title 32, Chapter 1.

ARS 32.151 provides:
"The use of the word "certify" or "certification" by a person or firm that is registered or certified by the board is an expression of professional opinion regarding facts or findings that are the subject of the certification and does not constitute an express or implied warranty or guarantee."

Kevin Shirer, AAE
Project Manager - Enterprise Information Management

RESPONSE:

This request is approved. Payment will be made from Contract amendment Time & material budget. Please coordinate with Mike Youngs.

NAME:	Ted Melnik	DATE:	7/18/2008

COPIES:		ATTACHMENTS:	

WOOLPERT, INC.
4050 E. Cotton Center Blvd. Bldg 3 Ste 39 - Phoenix Arizona 85040
602.426.8900 - Fax 602.426.8910 - www.woolpert.com

APPENDIX C: GEOSPATIAL POSITIONING ACCURACY STANDARDS, PART 3

FGDC-STD-007.3-1998

NSDI

National Spatial Data Infrastructure

Geospatial Positioning Accuracy Standards
Part 3: National Standard for Spatial Data Accuracy

Subcommittee for Base Cartographic Data
Federal Geographic Data Committee

Federal Geographic Data Committee
Department of Agriculture • Department of Commerce • Department of Defense • Department of Energy
Department of Housing and Urban Development • Department of the Interior • Department of State
Department of Transportation • Environmental Protection Agency
Federal Emergency Management Agency • Library of Congress
National Aeronautics and Space Administration • National Archives and Records Administration
Tennessee Valley Authority

Federal Geographic Data Committee

Established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data.

The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, the Interior, State, and Transportation; the Environmental Protection Agency; the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space Administration; the National Archives and Records Administration; and the Tennessee Valley Authority. Additional Federal agencies participate on FGDC subcommittees and working groups. The Department of the Interior chairs the committee.

FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees establish and implement standards for data content, quality, and transfer; encourage the exchange of information and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working groups are established for issues that transcend data categories.

For more information about the committee, or to be added to the committee's newsletter mailing list, please contact:

Federal Geographic Data Committee Secretariat
c/o U.S. Geological Survey
590 National Center
Reston, Virginia 22092

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Internet (electronic mail): gdc@usgs.gov
Anonymous FTP: ftp://fgdc.er.usgs.gov/pub/gdc/
World Wide Web: http://fgdc.er.usgs.gov/fgdc.html

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3.1 Introduction

3.1.1 Objective

The National Standard for Spatial Data Accuracy (NSSDA) implements a statistical and testing methodology for estimating the positional accuracy of points on maps and in digital geospatial data, with respect to georeferenced ground positions of higher accuracy.

3.1.2 Scope

The NSSDA applies to fully georeferenced maps and digital geospatial data, in either raster, point, or vector format, derived from sources such as aerial photographs, satellite imagery, and ground surveys. It provides a common language for reporting accuracy to facilitate the identification of spatial data for geographic applications.

This standard is classified as a **Data Usability Standard** by the Federal Geographic Data Committee Standards Reference Model . A Data Usability Standard describes how to express "the applicability or essence of a dataset or data element" and includes "data quality, assessment, accuracy, and reporting or documentation standards" (FGDC, 1996, p. 8)

This standard does not define threshold accuracy values. Agencies are encouraged to establish thresholds for their product specifications and applications and for contracting purposes. Ultimately, users identify acceptable accuracies for their applications. Data and map producers must determine what accuracy exists or is achievable for their data and report it according to NSSDA.

3.1.3 Applicability

Use the NSSDA to evaluate and report the positional accuracy of maps and geospatial data produced, revised, or disseminated by or for the Federal Government. According to Executive Order 12906, Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure (Clinton, 1994, Sec. 4. Data Standards Activities, item d), "Federal agencies collecting or producing geospatial data, either directly or indirectly (e.g. through grants, partnerships, or contracts with other entities), shall ensure, prior to obligating funds for such activities, that data will be collected in a manner that meets all relevant standards adopted through the FGDC process."

Accuracy of new or revised spatial data will be reported according to the NSSDA. Accuracy of existing or legacy spatial data and maps may be reported, as specified, according to the NSSDA or the accuracy standard by which they were evaluated.

3.1.4 Related Standards

Data producers may elect to use conformance levels or accuracy thresholds in standards such as the National Map Accuracy Standards of 1947 (U.S. Bureau of the Budget, 1947) or Accuracy Standards for Large-Scale Maps [American Society for Photogrammetry and Remote Sensing (ASPRS) Specifications and Standards Committee, 1990] if they decide that these values are truly applicable

for digital geospatial data.

Positional accuracy of geodetically surveyed points is reported according to Part 2, Standards for Geodetic Control Networks (Federal Geographic Data Committee, 1998), Geospatial Positioning Accuracy Standards. Ground coordinates of points collected according to Standards and Specifications for Geodetic Control Networks (Federal Geodetic Control Committee, 1984) are used in the National Spatial Reference System (NSRS). NSRS is a consistent national coordinate system that defines latitude, longitude, height, scale, gravity, and orientation throughout the Nation, and how these values change with time. Consequently, it ties spatial data to georeferenced positions. NSRS points may be selected as an independent source of higher accuracy to test positional accuracy of maps and geospatial data according to the NSSDA.

Part 4, Standards for A/E/C and Facility Management (Facilities Working Group, 1997), uses the NSSDA for accuracy testing and verification. The NSSDA may be used for fully georeferenced maps for A/E/C and Facility Management applications such as preliminary site planning and reconnaissance mapping.

3.1.5 Standards Development Procedures

The National Standard for Spatial Data Accuracy was developed by the FGDC *ad hoc* working group on spatial data accuracy, with the intent to update the United States National Map Accuracy Standards (NMAS) (U.S. Bureau of the Budget, 1947). The ASPRS Accuracy Standards for Large-Scale Maps (ASPRS Specifications and Standards Committee, 1990) formed the basis for update of the NMAS. The NSSDA, in its former version as the draft National Cartographic Standards for Spatial Accuracy (NCSSA), extended the ASPRS Accuracy Standards to map scales smaller than 1:20,000. The NCSSA were released for public review through the Federal Geographic Data Committee and were substantially rewritten as a result.

The geospatial data community has diversified to include many data producers with different product specifications and many data users with different application requirements. The NSSDA was developed to provide a common reporting mechanism so that users can directly compare datasets for their applications. It was realized that map-dependent measures of accuracy, such as publication scale and contour interval, were not fully applicable when digital geospatial data can be readily manipulated and output to any scale or data format. Principal changes included requirements to report numeric accuracy values; a composite statistic for horizontal accuracy, instead of component (x,y) accuracy, and alignment with emerging Federal Geographic Control Subcommittee (FGCS) accuracy standards (FGDC, 1998). The NCSSA was renamed the National Standard for Spatial Data Accuracy to emphasize its applicability to digital geospatial data as well as graphic maps.

3.1.6 Maintenance

The U.S. Department of the Interior, U.S. Geological Survey (USGS), National Mapping Division, maintains the National Standard for Spatial Data Accuracy (NSSDA) for the Federal Geographic Data Committee. Address questions concerning the NSSDA to: Chief, National Mapping Division, USGS, 516 National Center, Reston, VA 20192.

3.2 Testing Methodology And Reporting Requirements

3.2.1 Spatial Accuracy

The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points[1].

Accuracy is reported in ground distances at the 95% confidence level. Accuracy reported at the 95% confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product.

3.2.2 Accuracy Test Guidelines

According to the Spatial Data Transfer Standard (SDTS) (ANSI-NCITS, 1998), accuracy testing by an independent source of higher accuracy is the preferred test for positional accuracy. Consequently, the NSSDA presents guidelines for accuracy testing by an independent source of higher accuracy. The independent source of higher accuracy shall the highest accuracy feasible and practicable to evaluate the accuracy of the dataset.[2]

The data producer shall determine the geographic extent of testing. Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points[3] in the dataset with coordinates of the same points from an independent source of higher accuracy. Vertical accuracy shall be tested by comparing the elevations in the dataset with elevations of the same points as determined from an independent source of higher accuracy.

Errors in recording or processing data, such as reversing signs or inconsistencies between the dataset and independent source of higher accuracy in coordinate reference system definition, must be corrected before computing the accuracy value.

A minimum of 20 check points shall be tested, distributed to reflect the geographic area of interest and the distribution of error in the dataset.[4] When 20 points are tested, the 95% confidence level allows one point to fail the threshold given in product specifications.

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1 see Appendix 3-A

2 see Appendix 3-C, section 2

3 see Appendix 3-C, section 1

4 see Appendix 3-C, section 3

If fewer than twenty points can be identified for testing, use an alternative means to evaluate the accuracy of the dataset. SDTS (ANSI-NCITS, 1998) identifies these alternative methods for determining positional accuracy:

- Deductive Estimate
- Internal Evidence
- Comparison to Source

3.2.3 Accuracy Reporting

Spatial data may be compiled to comply with one accuracy value for the vertical component and another for the horizontal component. If a dataset does not contain elevation data, label for horizontal accuracy only. Conversely, when a dataset, e.g. a gridded digital elevation dataset or elevation contour dataset, does not contain well-defined points, label for vertical accuracy only.

A dataset may contain themes or geographic areas that have different accuracies. Below are guidelines for reporting accuracy of a composite dataset:

- If data of varying accuracies can be identified separately in a dataset, compute and report separate accuracy values.
- If data of varying accuracies are composited and cannot be separately identified AND the dataset is tested, report the accuracy value for the composited data.
- If a composited dataset is not tested, report the accuracy value for the least accurate dataset component.

Positional accuracy values shall be reported in ground distances. Metric units shall be used when the dataset coordinates are in meters. Feet shall be used when the dataset coordinates are in feet. The number of significant places for the accuracy value shall be equal to the number of significant places for the dataset point coordinates.

Accuracy reporting in ground distances allows users to directly compare datasets of differing scales or resolutions. A simple statement of conformance (or omission, when a map or dataset is non-conforming) is not adequate in itself. Measures based on map characteristics, such as publication scale or contour interval, are not longer adequate when data can be readily manipulated and output to any scale or to different data formats.

Report accuracy at the 95% confidence level for data *tested* for both horizontal and vertical accuracy as:

Tested ____ (meters, feet) horizontal accuracy at 95% confidence level
____ (meters, feet) vertical accuracy at 95% confidence level

Use the "compiled to meet" statement below when the above guidelines for testing by an independent source of higher accuracy cannot be followed and an alternative means is used to evaluate accuracy. Report accuracy at the 95% confidence level for data *produced according to procedures that have been demonstrated to produce data with particular horizontal and vertical accuracy values* as:

Compiled to meet ____ (meters, feet) horizontal accuracy at 95% confidence level
____ (meters, feet) vertical accuracy at 95% confidence level

Report accuracy for data *tested* for horizontal accuracy and *produced according to procedures that have been demonstrated to comply with a particular vertical accuracy value* as:

Tested ____ (meters, feet) horizontal accuracy at 95% confidence level
Compiled to meet ____ (meters, feet) vertical accuracy at 95% confidence level

Show similar labels when data are *tested* for vertical accuracy and *produced according to procedures that have been demonstrated to produce data with a particular horizontal accuracy value.*

For digital geospatial data, report the accuracy value in digital geospatial metadata (Federal Geographic Data Committee, 1998, Section 2), as appropriate to dataset spatial characteristics:

(Data_Quality_Information/Positional_Accuracy/Horizontal_Positional_Accuracy/Horizontal_Positional_Accuracy_Assessment/Horizontal_Positional_Accuracy_Value)
and/or
(Data_Quality_Information/Positional_Accuracy/Vertical_Positional_Accuracy/Vertical_Positional_Accuracy_Assessment/Vertical_Positional_Accuracy_Value)

Enter the text "National Standard for Spatial Data Accuracy" for these metadata elements (Federal Geographic Data Committee, 1998, Section 2), as appropriate to dataset spatial characteristics:

(Data_Quality_Information/Positional_Accuracy/Horizontal_Positional_Accuracy/Horizontal_Positional_Accuracy_Assessment/Horizontal_Positional_Accuracy_Explanation)
and/or
(Data_Quality_Information/Positional_Accuracy/Vertical_Positional_Accuracy/Vertical_Positional_Accuracy_Assessment/Vertical_Positional_Accuracy_Explanation)

Regardless of whether the data was tested by a independent source of higher accuracy or evaluated for accuracy by alternative means, provide a complete description on how the values were determined in metadata, as appropriate to dataset spatial characteristics (Federal Geographic Data Committee, 1998, Section 2):

(Data_Quality_Information/Positional_Accuracy/Horizontal_Positional_Accuracy/Horizontal_Positional_Accuracy_Report)
and/or
(Data_Quality_Information/Positional_Accuracy/Vertical_Positional_Accuracy/Vertical_Positional_Accuracy_Report)

3.3 NSSDA and Other Map Accuracy Standards

Accuracy of new or revised spatial data will be reported according to the NSSDA. Accuracy of existing or legacy spatial data and maps may be reported, as specified, according to the NSSDA or the accuracy standard by which they were evaluated. Appendix 3-D describes root mean square error (RMSE) as applied to individual x-, y- components, former NMAS, and ASPRS Accuracy Standards for Large-Scale Maps. These standards, their relationships to NSSDA, and accuracy labeling are described to ensure that users have some means to assess positional accuracy of spatial data or maps for their applications.

If accuracy reporting cannot be provided using NSSDA or other recognized standards, provide information to enable users to evaluate how the data fit their applications requirements. This information may include descriptions of the source material from which the data were compiled, accuracy of ground surveys associated with compilation, digitizing procedures, equipment, and quality control procedures used in production.

No matter what method is used to evaluate positional accuracy, explain the accuracy of coordinate measurements and describe the tests in digital geospatial metadata (Federal Geographic Data Committee, 1998, Section 2), as appropriate to dataset spatial characteristics:

(Data_Quality_Information/Positional_Accuracy/Horizontal_Positional_Accuracy/Horizontal_Positional_Accuracy_Report)
and/or

(Data_Quality_Information/Positional_Accuracy/Vertical_Positional_Accuracy/Vertical_Positional_Accuracy_Report)

Provide information about the source data and processes used to produce the dataset in data elements of digital geospatial metadata (Federal Geographic Data Committee, 1998, Section 2) under (Data_Quality_Information/Lineage).

References

American National Standards Institute, Information Technology - Spatial Data Transfer Standard (SDTS) (ANSI-NCITS 320:1998): New York, New York.

American Society for Photogrammetry and Remote Sensing (ASPRS) Specifications and Standards Committee, 1990, ASPRS Accuracy Standards for Large-Scale Maps: Photogrammetric Engineering and Remote Sensing, v. 56, no. 7, p. 1068-1070.

Clinton, William J., 1994, Executive Order 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure: Washington, DC, Federal Register, Volume 59, Number 71, pp. 17671-17674.

Facilities Working Group, 1997, Part 4, Draft Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management, Geospatial Positioning Accuracy Standards: Washington, DC, U.S. Army Corps of Engineers, 21 p.

Federal Geodetic Control Committee, 1984, Standards and Specifications for Geodetic Control Networks: Silver Spring, Md., National Geodetic Survey, National Oceanic and Atmospheric Administration, 29 p.

Federal Geographic Data Committee, 1998, Content Standards for Digital Geospatial Metadata (version 2.0), FGDC-STD-001-1998: Washington, D.C., Federal Geographic Data Committee, 65 p.

Federal Geographic Data Committee, 1998, Part 2, Standards for Geodetic Networks, Geospatial Positioning Accuracy Standards, FGDC-STD-007.2-1998: Washington, D.C., Federal Geographic Data Committee, 9 p.

Federal Geographic Data Committee, 1996, FGDC Standards Reference Model: Reston, Va., Federal Geographic Data Committee, 24 p.

Greenwalt, C.R. and M.E. Schultz, 1968, Principles and Error Theory and Cartographic Applications, ACIC Technical Report No. 96: St. Louis, Mo., Aeronautical Chart and Information Center, U.S. Air Force, 89 p.

National Mapping Division, 1987, Procedure Manual for Map Accuracy Testing (*draft*): U.S. Geological Survey, Reston, Va.

U.S. Bureau of the Budget, 1947, United States National Map Accuracy Standards: U.S. Bureau of the Budget, Washington, D.C.

Appendix 3-A
Accuracy Statistics
(normative)

EXPLANATORY COMMENTS

1. Horizontal Accuracy

Let:

$RMSE_x = sqrt[\sum(x_{data,i} - x_{check,i})^2/n]$
$RMSE_y = sqrt[\sum(y_{data,i} - y_{check,i})^2/n]$

where:
$x_{data,i}$, $y_{data,i}$ are the coordinates of the i th check point in the dataset
$x_{check,i}$, $y_{check,i}$ are the coordinates of the i th check point in the independent source of higher accuracy
n is the number of check points tested
i is an integer ranging from 1 to n

Horizontal error at point i is defined as $sqrt[(x_{data,i} - x_{check,i})^2 + (y_{data,i} - y_{check,i})^2]$. Horizontal RMSE is:

$RMSE_r = sqrt[\sum((x_{data,i} - x_{check,i})^2 + (y_{data,i} - y_{check,i})^2)/n]$
$= sqrt[RMSE_x^2 + RMSE_y^2]$

Case 1: Computing Accuracy According to the NSSDA when $RMSE_x = RMSE_y$

If $RMSE_x = RMSE_y$,
$RMSE_r = sqrt(2*RMSE_x^2) = sqrt(2*RMSE_y^2)$
$= 1.4142*RMSE_x = 1.4142*RMSE_y$

It is assumed that systematic errors have been eliminated as best as possible. If error is normally distributed and independent in each the x- and y-component and error, the factor 2.4477 is used to compute horizontal accuracy at the 95% confidence level [Greenwalt and Schultz, 1968]. When the preceding conditions apply, $Accuracy_r$, the accuracy value according to NSSDA, shall be computed by the formula:

$Accuracy_r = 2.4477 * RMSE_x = 2.4477 * RMSE_y$
$= 2.4477 * RMSE_r / 1.4142$
$Accuracy_r = 1.7308 * RMSE_r$

Case 2: Approximating circular standard error when $RMSE_x \neq RMSE_y$

If $RMSE_{min}/RMSE_{max}$ is between 0.6 and 1.0 (where $RMSE_{min}$ is the smaller value between $RMSE_x$ and $RMSE_y$ and $RMSE_{max}$ is the larger value), circular standard error (at 39.35% confidence) may be approximated as $0.5*(RMSE_x + RMSE_y)$ (Greenwalt and Schultz, 1968). If error is normally distributed and independent in each the x- and y-component and error, the accuracy value according to NSSDA may be approximated according to the following formula:

$$Accuracy_r \sim 2.4477 * 0.5 * (RMSE_x + RMSE_y)$$

2. Vertical Accuracy

Let:

$$RMSE_z = sqrt[\sum(z_{data\,i} - z_{check\,i})^2/n]$$

where

$z_{data\,i}$ is the vertical coordinate of the i th check point in the dataset.
$z_{check\,i}$ is the vertical coordinate of the i th check point in the independent source of higher accuracy
n = the number of points being checked
i is an integer from 1 to n

It is assumed that systematic errors have been eliminated as best as possible. If vertical error is normally distributed, the factor 1.9600 is applied to compute linear error at the 95% confidence level (Greenwalt and Schultz, 1968). Therefore, vertical accuracy, $Accuracy_z$, reported according to the NSSDA shall be computed by the following formula:

$$Accuracy_z = 1.9600 * RMSE_z$$

Appendix 3-B
Horizontal Accuracy Computations
(informative)

Horizontal Accuracy Computations

The data for horizontal accuracy computations come from the draft National Mapping Program (NMP) Technical Instructions, Procedure Manual for Map Accuracy Testing (National Mapping Division, 1987). Positions on the Crider, Kentucky 1:24,000-scale USGS topographic quadrangle were tested against a triangulated solution of positions independent of the control solution used to produce the map. The photography used to collect the independent source was different from that used for the map compilation, and a different control configuration was utilized.

- Coordinates are on the State Plane Coordinate System (south zone), based on NAD 27. Units are in feet.
- x (computed) and y (computed) are coordinate values from the triangulated solution.
- x (map) and y (map) are coordinate values for map positions.

Table 1 assumes that $RMSE_x = RMSE_y$. Therefore, the accuracy value according to the NSSDA, at 95% confidence, is computed by the formula given in Case 1 in Appendix 3-A (normative). The accuracy value according to the NSSDA is 35 feet. Of twenty-five points tested, only point # 10360 has a positional error that exceeds 35 feet.

Table 2 uses the formula given in Case 2 in Appendix 3-A (normative) to estimate accuracy when $RMSE_x \neq RMSE_y$. The accuracy value according to the NSSDA, at 95% confidence, is 35 feet.

Table 1.
Accuracy Calculations for Crider, Kentucky USGS 1:24,000-scale Topographic Quadrangle
$RMSE_x = RMSE_y$ assumed

Number	Description	x (computed)	x (map)	diff in x	squared diff in x (1)	y (computed)	y (map)	diff in y	squared diff in y (2)	(1)+(2)	square root of [(1)+(2)]
10351	T-RD-W	1373883	1373894	11	121	298298	298297	-1	1	122	11.05
10352	T-RD-E	1370503	1370486	-17	289	303727	303747	20	400	689	26.25
10353	RD AT RR	1361523	1361537	14	196	302705	302705	0	0	196	14.00
10354	T-RD-SW	1357653	1357667	14	196	298726	298746	20	400	596	24.41
10355	T-RD-SE	1348121	1348128	7	49	299725	299755	30	900	949	30.81
10356	RD AT RR	1345601	1345625	24	576	309911	309910	-1	1	577	24.02
10357	T-RD-E	1350505	1350507	2	4	318478	318477	-1	1	5	2.24
10358	X-RD	1351781	1351792	11	121	307697	307698	1	1	122	11.05
10359	T-RD-E	1352361	1352379	18	324	311109	311099	-10	100	424	20.59
10360	X-RD	1360657	1360645	-12	144	316720	316761	41	1681	1825	42.72
10361	Y-RD-SW	1368215	1368202	-13	169	309842	309869	27	729	898	29.97
10362	T-RD-W	1370299	1370282	-17	289	316832	316849	17	289	578	24.04
10363	T-RD-S	1373855	1373839	-16	256	319893	319886	-7	49	305	17.46
10364	Y-RD-W	1379981	1379962	-19	361	311641	311633	-8	64	425	20.62
10365	T-RD-E	1378625	1378628	3	9	334995	335010	15	225	234	15.30
10366	T-RD-SE	1374735	1374742	7	49	333909	333922	13	169	218	14.76
10367	T-RD-NW	1370581	1370576	-5	25	324098	324095	-3	9	34	5.83
10368	Y-RD-SE	1359379	1359387	8	64	328690	328691	1	1	65	8.06
10369	T-RD-S	1346459	1346479	20	400	330816	330812	-4	16	416	20.40
10370	T-RD-E	1347101	1347109	8	64	335869	335850	-19	361	425	20.62
10371	T-RD-SE	1350733	1350748	15	225	332715	332725	10	100	325	18.03
10372	T-RD-N	1354395	1354411	16	256	335337	335345	8	64	320	17.89
10373	T-RD-S	1358563	1358570	7	49	335398	335406	8	64	113	10.63
10374	X-RD	1365561	1365574	13	169	333873	333877	4	16	185	13.60
10375	X-RD	1373645	1373643	-2	4	339613	339609	-4	16	20	4.47
									sum	10066	
									average	402.64	
									RMSEr	20.07	
									Accuracy per NSSDA (2.4477 * RMSEr)	35	

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Table 2.
Accuracy Computations for Crider, Kentucky USGS 1:24,000-scale Topographic Quadrangle
$RMSE_x + RMSE_y$

Number	Description	x (computed)	x (map)	diff in x	squared diff in x	y (computed)	y (map)	diff in y	squared diff in y
10351	T-RD-W	1373883	1373894	11	121	298298	298297	-1	1
10352	T-RD-E	1370503	1370486	-17	289	303727	303747	20	400
10353	RD AT RR	1361523	1361537	14	196	302705	302705	0	0
10354	T-RD-SW	1357653	1357667	14	196	298726	298746	20	400
10355	T-RD-SE	1348121	1348128	7	49	299725	299755	30	900
10356	RD AT RR	1345601	1345625	24	576	309911	309910	-1	1
10357	T-RD-E	1350505	1350507	2	4	318478	318477	-1	1
10358	X-RD	1351781	1351792	11	121	307697	307698	1	1
10359	T-RD-E	1352361	1352379	18	324	311109	311099	-10	100
10360	X-RD	1360657	1360645	-12	144	316720	316761	41	1681
10361	Y-RD-SW	1368215	1368202	-13	169	309842	309869	27	729
10362	T-RD-W	1370299	1370282	-17	289	316832	316849	17	289
10363	T-RD-S	1373855	1373839	-16	256	319893	319886	-7	49
10364	Y-RD-W	1379981	1379962	-19	361	311641	311633	-8	64
10365	T-RD-E	1378625	1378628	3	9	334995	335010	15	225
10366	T-RD-SE	1374735	1374742	7	49	333909	333922	13	169
10367	T-RD-NW	1370581	1370576	-5	25	324098	324095	-3	9
10368	Y-RD-SE	1359379	1359387	8	64	328690	328691	1	1
10369	T-RD-S	1346459	1346479	20	400	330816	330812	-4	16
10370	T-RD-E	1347101	1347109	8	64	335869	335850	-19	361
10371	T-RD-SE	1350733	1350748	15	225	332715	332725	10	100
10372	T-RD-N	1354395	1354411	16	256	335337	335345	8	64
10373	T-RD-S	1358563	1358570	7	49	335398	335406	8	64
10374	X-RD	1365561	1365574	13	169	333873	333877	4	16
10375	X-RD	1373645	1373643	-2	4	339613	339609	-4	16
				sum	4409				5657
				average	176.36				226.28
				RMSE	13.28				15.04
				$RMSE_{min}/RMSE_{max}$					0.88

Since $RMSE_{min}/RMSE_{max}$ is between 0.6 and 1.0, the formula $Accuracy_r = 2.4477 * 0.5 * (RMSE_x + RMSE_y)$ may be used to estimate accuracy according to the NSSDA.
$Accuracy_r$ ~35 feet.

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Appendix 3-C.
Testing guidelines
(informative)

1. Well-Defined Points

A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself. Graphic contour data and digital hypsographic data may not contain well-defined points.

The selected points will differ depending on the type of dataset and output scale of the dataset. For graphic maps and vector data, suitable well-defined points represent right-angle intersections of roads, railroads, or other linear mapped features, such as canals, ditches, trails, fence lines, and pipelines. For orthoimagery, suitable well-defined points may represent features such as small isolated shrubs or bushes, in addition to right-angle intersections of linear features. For map products at scales of 1:5,000 or larger, such as engineering plats or property maps, suitable well-defined points may represent additional features such as utility access covers and intersections of sidewalks, curbs, or gutters.

2. Data acquisition for the independent source of higher accuracy

The independent source of higher accuracy shall be acquired separately from data used in the aerotriangulation solution or other production procedures. The independent source of higher accuracy shall be of the highest accuracy feasible and practicable to evaluate the accuracy of the dataset.

Although guidelines given here are for geodetic ground surveys, the geodetic survey is only one of many possible ways to acquire data for the independent source of higher accuracy. Geodetic control surveys are designed and executed using field specifications for geodetic control surveys (Federal Geodetic Control Committee, 1984). Accuracy of geodetic control surveys is evaluated using Part 2, Standards for Geodetic Networks (Federal Geographic Data Committee, 1998). To evaluate if the accuracy of geodetic survey is sufficiently greater than the positional accuracy value given in the product specification, compare the FGCS **network accuracy** reported for the geodetic survey with the accuracy value given by the product specification for the dataset.

Other possible sources for higher accuracy information are Global Positioning System (GPS) ground surveys, photogrammetric methods, and data bases of high accuracy point coordinates.

3. Check Point Location

Due to the diversity of user requirements for digital geospatial data and maps, it is not realistic to include statements in this standard that specify the spatial distribution of check points. Data and/or map producers must determine check point locations. This section provides guidelines for distributing the check point locations.

Check points may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. When data exist for only a portion of the dataset, confine test points to that area. When the distribution of error is likely to be nonrandom, it may

be desirable to locate check points to correspond to the error distribution.

For a dataset covering a rectangular area that is believed to have uniform positional accuracy, check points may be distributed so that points are spaced at intervals of at least 10 percent of the diagonal distance across the dataset *and* at least 20 percent of the points are located in each quadrant of the dataset.

Appendix 3-D.
Other Accuracy Standards
(informative)

1. Root-Mean-Square Error (RMSE) Component Accuracy

1.1 Relationship between NSSDA (horizontal) and RMSE (x or y)

From Appendix 3-A, Section 1, assuming $RMSE_x = RMSE_y$ and error is normally distributed and independent in each the x- and y-component, $RMSE_x$ and $RMSE_y$ can be estimated from $RMSE_r$ using:

$$RMSE_x = RMSE_y = RMSE_r / 1.4142$$

Using the same assumptions, $RMSE_x$ and $RMSE_y$ can also be computed from $Accuracy_r$, the accuracy value according to NSSDA:

$$RMSE_x = RMSE_y = Accuracy_r / 2.4477$$

1.2 Relationship between NSSDA (vertical) and RMSE (vertical)

From Appendix 3-A, Section 2, if vertical error is normally distributed, $RMSE_z$ can be determined from $Accuracy_z$, vertical accuracy reported according to the NSSDA:

$$RMSE_z = Accuracy_z / 1.9600$$

1.3 RMSE Accuracy Reporting

Label data or maps as described in Section 3.2.3, "Accuracy Reporting," but substitute "RMSE" for "accuracy at 95% confidence level." For horizontal accuracy, provide separate statements for each RMSE component.

For digital geospatial metadata, follow the guidelines for preparing metadata in Section 3.2.3, "Accuracy Reporting," but substitute "Root-Mean-Square Error" for "National Standard for Spatial Data Accuracy" for these metadata elements (Federal Geographic Data Committee, 1998, Section 2), as appropriate to dataset spatial characteristics:

(Data_Quality_Information/Positional_Accuracy/Horizontal_Positional_Accuracy/Horizontal_Positional_Accuracy_Assessment/Horizontal_Positional_Accuracy_Explanation)
and/or
(Data_Quality_Information/Positional_Accuracy/Vertical_Positional_Accuracy/Vertical_Positional_Accuracy_Assessment/Vertical_Positional_Accuracy_Explanation)

2. Former National Map Accuracy Standards (NMAS)

2.1 Relationship between NSSDA and NMAS (horizontal)

NMAS (U.S. Bureau of the Budget, 1947) specifies that 90% of the well-defined points that are tested must fall within a specified tolerance:

- For map scales larger than 1:20,000, the NMAS horizontal tolerance is 1/30 inch, measured at publication scale.
- For map scales of 1:20,000 or smaller, the NMAS horizontal tolerance is 1/50 inch, measured at publication scale.

If error is normally distributed in each the x- and y-component and error for the x-component is equal to and independent of error for the y-component, the factor 2.146 is applied to compute circular error at the 90% confidence level (Greenwalt and Schultz, 1968). The circular map accuracy standard (CMAS) based on NMAS is:

$$\begin{aligned} CMAS &= 2.1460 * RMSE_x = 2.1460 * RMSE_y \\ &= 2.1460 * RMSE_r / 1.4142 \\ &= 1.5175 * RMSE_r \end{aligned}$$

The CMAS can be converted to accuracy reported according to NSSDA, $Accuracy_r$, using equations from Appendix 3-A, Section 1:

$$Accuracy_r = 2.4477/2.1460 * CMAS = 1.1406 * CMAS.$$

Therefore, NMAS horizontal accuracy reported according to the NSSDA is:

1.1406* [S * (1/30")/12"] feet, or 0.0032 * S, for map scales larger than 1:20,000
1.1406* [S * (1/50")/12"] feet, or 0.0019 * S, for map scales of 1:20,000 or smaller

where S is the map scale denominator.

2.2 Relationship between NSSDA and NMAS (vertical)

NMAS (U.S. Bureau of the Budget, 1947) specifies the maximum allowable *vertical* tolerance to be one half the contour interval, at all contour intervals. If vertical error is normally distributed, the factor 1.6449 is applied to compute vertical accuracy at the 90% confidence level (Greenwalt and Schultz, 1968). Therefore, the Vertical Map Accuracy Standard (VMAS) based on NMAS is estimated by the following formula:

$$VMAS = 1.6449 * RMSEz$$

The VMAS can be converted to $Accuracy_z$, accuracy reported according to the NSSDA using equations from Appendix 3-A, Section 2:

$$Accuracy_z = 1.9600/1.6449 * VMAS = 1.1916 * VMAS.$$

Therefore, vertical accuracy reported according to the NSSDA is (1.1916)/2 * CI = 0.5958 * CI, where CI is the contour interval.

2.3 NMAS Reporting

Map labels provide a statement of conformance with NMAS, rather than reporting the accuracy value. Label maps, as appropriate to dataset spatial characteristics:

This map complies with National Map Accuracy Standards of 1947 for horizontal accuracy
OR
This map complies with National Map Accuracy Standards of 1947 for vertical accuracy
OR
This map complies with National Map Accuracy Standards of 1947 for horizontal and vertical accuracy

For digital geospatial data evaluated by the NMAS, follow the guidelines for preparing metadata in Section 3.2.3, "Accuracy Reporting," but substitute "U.S. National Map Accuracy Standards of 1947" for "National Standard for Spatial Data Accuracy" for these metadata elements (Federal Geographic Data Committee, 1998, Section 2), as appropriate to dataset spatial characteristics:

(Data_Quality_Information/Positional_Accuracy/Horizontal_Positional_Accuracy/Horizontal_Positional_Accuracy_Assessment/Horizontal_Positional_Accuracy_Explanation)
and/or
(Data_Quality_Information/Positional_Accuracy/Vertical_Positional_Accuracy/Vertical_Positional_Accuracy_Assessment/Vertical_Positional_Accuracy_Explanation)

3. American Society for Photogrammetry and Remote Sensing (ASPRS) Accuracy Standards for Large-Scale Maps

3.1 Explanation of ASPRS Accuracy Standards for Large-Scale Maps

ASPRS Accuracy Standards for Large-Scale Maps (ASPRS Specifications and Standards Committee, 1990) provide accuracy tolerances for maps at 1:20,000-scale or larger "prepared for special purposes or engineering applications." RMSE is the statistic used by the ASPRS standards. Accuracy is reported as Class 1, Class 2, or Class 3. Class 1 accuracy for horizontal and vertical components is discussed below. Class 2 accuracy applies to maps compiled within limiting RMSE's twice those allowed for Class 1 maps. Similarly, Class 3 accuracy applies to

maps compiled within limiting RMSE's three times those allowed for Class 1 maps.

3.2 Relationship between NSSDA and ASPRS Accuracy Standards for Large-Scale Maps (horizontal)

ASPRS Accuracy Standards for Large-Scale Maps (ASPRS Specifications and Standards Committee, 1990) evaluates positional accuracy for the x-component and the y-component individually. Positional accuracy is reported at ground scale. Table 3 shows Class 1 planimetric limiting RMSE *in feet* associated with typical map scales, while Table 4 shows Class 1 planimetric limiting RMSE *in meters* associated with typical map scales.

Table 3
ASPRS Accuracy Standards for Large-Scale Maps
Class 1 horizontal (x or y) limiting RMSE for various map scales
at ground scale for *feet* units

Class 1 Planimetric Accuracy, limiting RMSE (feet)	Map Scale
0.05	1:60
0.1	1:120
0.2	1:240
0.3	1:360
0.4	1:480
0.5	1:600
1.0	1:1,200
2.0	1:2,400
4.0	1:4,800
5.0	1:6,000
8.0	1:9,600
10.0	1:12,000
16.7	1:20,000

Table 4
ASPRS Accuracy Standards for Large-Scale Maps
Class 1 horizontal (x or y) limiting RMSE for various map scales
at ground scale for *metric* units

Class 1 Planimetric Accuracy Limiting RMSE (meters)	Map Scale
0.0125	1:50
0.025	1:100
0.050	1:200
0.125	1:500
0.25	1:1,000
0.50	1:2,000
1.00	1:4,000
1.25	1:5,000
2.50	1:10,000
5.00	1:20,000

See Section 1.1 of this appendix on the relationship between horizontal accuracy reported according to the NSSDA and RMSE.

3.3 Relationship between NSSDA and ASPRS Accuracy Standards for Large-Scale Maps (vertical)

Vertical map accuracy is defined by the ASPRS Accuracy Standards (ASPRS Specifications and Standards Committee, 1990) as the RMSE in terms of the project's elevation datum for well-defined points only. See Section 1.3 of this appendix on the relationship between vertical accuracy reported according to the NSSDA and RMSE.

For Class 1 maps according to the ASPRS Accuracy Standards, the limiting RMSE is set at one-third the contour interval. Spot elevations shall be shown on the map with a limiting RMSE of one-sixth the contour interval or less.

3.4 ASPRS Accuracy Standards for Large-Scale Maps Reporting

Maps evaluated according to ASPRS Accuracy Standards for Large-Scale Maps are labeled by a conformance statement, rather than a numeric accuracy value.

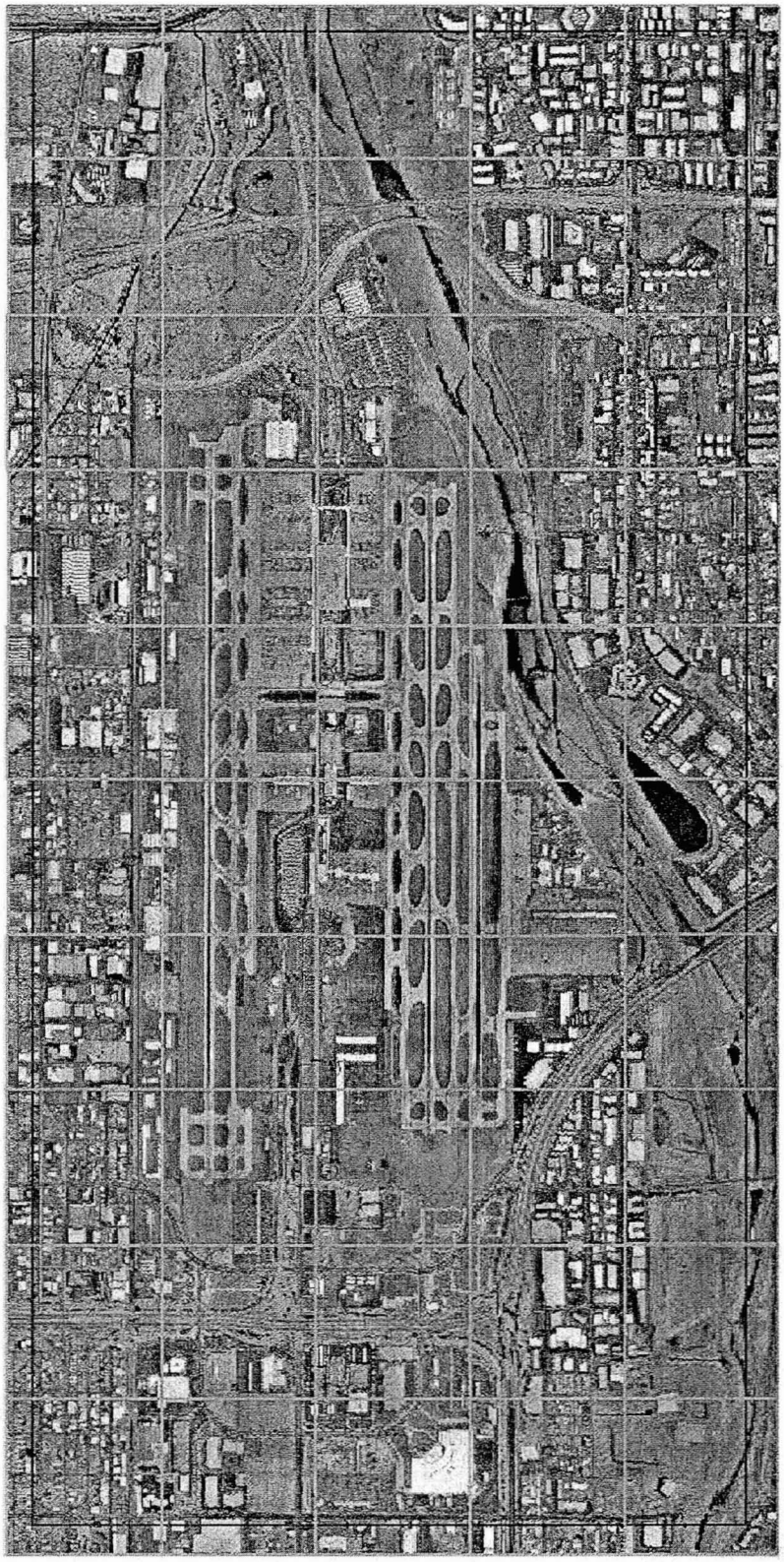
Label maps produced according to this standard:

THIS MAP WAS COMPILED TO MEET THE ASPRS
STANDARD FOR CLASS (1., 2., 3.) MAP ACCURACY

Label maps checked and found to confirm to this standard:

THIS MAP WAS CHECKED AND FOUND TO CONFORM
TO THE ASPRS
STANDARD FOR CLASS (1., 2., 3.) MAP ACCURACY

APPENDIX D: TEST POINT LAYOUT FOR 2007 CERTIFICATION



Test Point Layout for Certification of 2007 Photogrammetrically-derived Mapping
Sky Harbor International Airport Operating Extents , Phoenix, Arizona

North

WOOLPERT

gcb - 23-Jul-08

APPENDIX E: GPS CALIBRATION REPORT

GPS Calibration Report

Project : 2007_MapTest

User name	bilow	**Date & Time**	2:26:33 PM 8/4/2008
Coordinate System	Site	**Zone**	Arizona Central 0202(2)(2)
Project Datum	calibration		
Vertical Datum	NAVD88	**Geoid Model**	GEOID03 (Conus)
Coordinate Units	International feet		
Distance Units	International feet		
Height Units	International feet		

Contents

Datum Transformation Parameters
Updated Default Projection Definition
Horizontal Adjustment Parameters
Vertical Adjustment Parameters
Geoid Model Definition
Residual Differences Between GPS And Known Coordinates

Datum Transformation Parameters

Method	Three Parameter
Translation along x axis	-30.602ift
Translation along y axis	-75.721ift
Translation along z axis	53.823ift

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Updated Default Projection (Transverse Mercator) Definition

Updated default projection not requested

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Horizontal Adjustment Parameters

Northing coordinate of rotation center	885764.411ift
Easting coordinate of rotation center	669731.674ift
Rotation about the center point	0°00'00"
Translation north	0.000ift
Translation east	0.000ift
Scale factor	1.00000586

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Vertical Adjustment Parameters

Northing coordinate of origin point	891465.798ift
Easting coordinate of origin point	659936.791ift
Vertical separation at origin	0.088ift
Slope north	7.927ppm
Slope east	3.837ppm

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Geoid Model Definition

GEOID03 (Conus)

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Residual Differences Between GPS And Known Coordinates

Summary

	Maximum error	Root Mean Square error	Point
Horizontal	0.091ift	0.019	1157
Vertical	0.051ift	0.009	1126
Three-dimensional	0.092ift	0.021	1157

Point Residuals

GPS point		Calculated point		Control point	
Point	1101	Northing	891465.798ift	Point	101
Latitude	33°27'01.80883"N	Easting	659936.791ift	Northing	891465.792ift
Longitude	112°02'52.86637"W	Elevation	1094.424ift	Easting	659936.812ift
Height	996.454ift	Horizontal error	0.022ift	Elevation	1094.430ift
				Type	Horz and Vert
		Vertical error	0.006ift	Point quality	Survey quality
		3D error	0.022ift		
Point	1108	Northing	889096.444ift	Point	108
Latitude	33°26'38.48057"N	Easting	670496.199ift	Northing	889096.399ift
Longitude	112°00'48.20793"W	Elevation	1119.267ift	Easting	670496.184ift
Height	1021.447ift	Horizontal error	0.047ift	Elevation	1119.270ift
				Type	Horz and Vert
		Vertical error	0.003ift	Point quality	Survey quality
		3D error	0.047ift		
Point	1116	Northing	891532.566ift	Point	116
Latitude	33°27'02.67864"N	Easting	683775.173ift	Northing	891532.534ift
Longitude	111°58'11.50268"W	Elevation	1202.414ift	Easting	683775.248ift
Height	1104.716ift	Horizontal error	0.082ift	Elevation	1202.430ift
				Type	Horz and Vert
		Vertical error	0.016ift	Point quality	Survey quality
		3D error	0.084ift		

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Point	1126	Northing	884902.133ift	Point	126
Latitude	33°25'56.86834"N	Easting	660058.645ift	Northing	884902.161ift
Longitude	112°02'51.33065"W	Elevation	1093.831ift	Easting	660058.591ift
Height	995.921ift	Horizontal error	0.060ift	Elevation	1093.780ift
				Type	Horz and Vert
		Vertical error	0.051ift	Point quality	Survey quality
		3D error	0.079ift		

Point	1133	Northing	?	Point	133
Latitude	33°25'53.20319"N	Easting	?	Northing	884510.536ift
Longitude	111°58'04.83874"W	Elevation	?	Easting	684336.285ift
Height	1042.552ift	Horizontal error	?	Elevation	1140.000ift
		Vertical error	?	Type	(Ignored)
		3D error	?	Point quality	Survey quality

Point	1153	Northing	?	Point	153
Latitude	33°24'55.96006"N	Easting	?	Northing	878733.475ift
Longitude	112°00'31.50257"W	Elevation	?	Easting	671902.509ift
Height	1012.322ift	Horizontal error	?	Elevation	1110.180ift
		Vertical error	?	Type	(Ignored)
		3D error	?	Point quality	Survey quality

Point	1157	Northing	878790.220ift	Point	157
Latitude	33°24'56.60353"N	Easting	683832.204ift	Northing	878790.303ift
Longitude	111°58'10.75303"W	Elevation	1140.228ift	Easting	683832.167ift
Height	1042.591ift	Horizontal error	0.091ift	Elevation	1140.210ift
				Type	Horz and Vert
		Vertical error	0.018ift	Point quality	Survey quality
		3D error	0.092ift		

Point	1150	Northing	878799.306ift	Point	150
Latitude	33°24'56.48864"N	Easting	660291.033ift	Northing	878799.277ift
Longitude	112°02'48.49830"W	Elevation	1089.696ift	Easting	660291.042ift
Height	991.862ift	Horizontal error	0.030ift	Elevation	1089.740ift
				Type	Horz and Vert
		Vertical error	0.044ift	Point quality	Survey quality
		3D error	0.053ift		

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APPENDIX F: ANALYSIS OF MAP ERRORS

Sky Harbor International Airport
2006/2007 Photogrammetric Mapping

Analysis of Map Error

	Coordinates from Map				Surveyed Coordinates				Surveyed- Map					
Pt ID	Northing or Y	Easting or X	Elevation o	Description	Pt ID	Northing or Y	Easting or X	Elevation or Z	Description	Delta Y	Delta X	Delta Z	(Delta Y)^2	(Delta X)^2	(Delta Z)^2
600	890231.990	661049.209	1096.233	E ed dr at s ed walk	1600	890231.485	661048.789	1096.084	ed dr -walk	-0.505	-0.420	-0.149	0.255025	0.176400	0.022201
602	889517.319	662564.704	1099.701	NE cor conc dr	1602	889516.957	662564.746	1099.694	cor conc-rd	-0.362	0.042	-0.007	0.131044	0.001764	0.000049
605	889910.025	665722.614	1106.277	SW cor conc dr	1605	889909.811	665723.089	1106.356	cor conc	-0.214	0.475	0.079	0.045796	0.225625	0.006241
606	890520.504	668852.770	1113.274	Corner Walk	1606	890520.457	668852.830	1113.133	cor walk	-0.047	0.060	-0.141	0.002209	0.003600	0.019881
609	889201.744	670574.846	1121.377	SE cor walk	1609	889201.768	670574.974	1121.189	cor walk	0.024	0.128	-0.188	0.000576	0.016384	0.035344
610	889885.970	673476.272	1124.841	SE cor conc	1610	889886.415	673476.092	1124.688	cor conc	0.445	-0.180	-0.153	0.198025	0.032400	0.023409
613	889925.871	675936.085	1131.845	cor walks	1613	889925.723	675936.626	1131.959	cor conc	-0.148	0.541	0.114	0.021904	0.292681	0.012996
616	889871.424	678021.072	1137.753	W ed dr at N ed walk	1616	889871.341	678021.586	1138.162	cor walk-dr	-0.083	0.514	0.409	0.006889	0.264196	0.167281
618	890000.222	681697.192	1170.244	cor walk	1618	890000.386	681697.581	1170.363	cor walk	0.164	0.389	0.119	0.026896	0.151321	0.014161
620	889263.828	683229.066	1177.683	bend in walk	1620	889264.360	683229.055	1177.952	cor walk	0.532	-0.011	0.269	0.283273	0.000125	0.072361
622	888921.397	683488.458	1138.447	NW cor curb	1622	888922.019	683488.647	1138.698	cor dr	0.622	0.189	0.251	0.386884	0.035721	0.063001
623	887976.979	681188.244	1140.390	E ed walk at N ed dr	1623	887976.627	681188.540	1140.247	cor walk-dr	-0.352	0.296	-0.143	0.123904	0.087616	0.020449
625	887312.532	678198.376	1128.446	SE cor conc rd	1625	887312.657	678198.007	1128.913	cor conc	0.125	-0.369	0.467	0.015625	0.136161	0.218089
627	888695.716	675914.707	1130.970	end barrier	1627	888695.754	675913.947	1131.606	end barrier	0.038	-0.760	0.636	0.001444	0.577600	0.404496
630	888618.977	673826.168	1125.528	E end fence	1630	888618.987	673826.354	1125.424	cor dr	-0.010	0.186	-0.104	0.000100	0.034596	0.010816
632	888620.859	669672.714	1115.855	cor bit parking	1632	888620.869	669673.232	1115.910	cor parking	0.010	0.518	0.055	0.000100	0.268324	0.003025
634	886563.646	668753.924	1112.241	NW cor conc slab	1634	886563.642	668753.957	1112.125	cor conc	-0.004	0.033	-0.116	0.000016	0.001089	0.013456
635	886813.146	666188.424	1106.641	SE cor pavement change	1635	886813.150	666188.499	1106.101	cor conc	0.004	0.075	0.460	0.000016	0.005625	0.211600
637	888003.056	662893.463	1100.002	NE cor bit parking	1637	888002.726	662893.191	1100.042	cor bit parking	-0.330	-0.272	0.040	0.108900	0.073984	0.001600
640	887575.313	660890.291	1095.608	SW cor walk	1640	887575.060	660889.923	1095.594	cor walk	-0.253	-0.368	-0.014	0.064009	0.135424	0.000196
642	885074.831	661317.643	1097.383	S cor walk	1642	885075.000	661317.629	1097.597	cor walk	0.169	-0.014	0.214	0.028561	0.000196	0.045796
643	884437.551	662751.158	1095.939	SE cor walk	1643	884437.394	662751.018	1096.155	cor walk	-0.157	-0.140	0.216	0.024649	0.019600	0.046656
646	885987.846	665588.777	1103.439	E ed dr at N ed walk	1646	885987.776	665588.497	1104.000	cor walk-dr	-0.070	-0.280	0.561	0.004900	0.078400	0.314721
648	885937.046	667243.724	1108.441	N end wall	1648	885937.301	667243.765	1108.492	N end wall	0.255	0.041	0.051	0.065025	0.001681	0.002601
650	886246.979	671106.869	1119.182	NW cor cross-hatched bit	1650	886246.965	671106.643	1119.506	cor parking	-0.014	-0.226	0.324	0.000196	0.051076	0.104976
651	886061.946	673572.024	1109.630	Cor dr apron	1651	886061.198	673572.193	1110.064	cor dr	0.252	0.169	0.434	0.063504	0.028561	0.188356
653	885968.284	676133.687	1115.359	NE cor island	1653	885968.459	676133.891	1115.640	cor island	0.175	0.204	0.281	0.030625	0.041616	0.078961
656	885594.046	678243.587	1145.859	SW cor walk	1656	885594.052	678243.528	1146.348	cor dr	0.006	-0.059	0.489	0.000036	0.003481	0.239121
658	885259.384	679998.787	1129.159	cor pavement	1658	885259.768	679998.845	1129.503	cor parking	0.384	0.058	0.344	0.147456	0.003364	0.118336
659	885327.146	683765.287	1157.627	fence cor	1659	885326.955	683765.930	1157.909	cor fence	-0.191	0.643	0.282	0.036481	0.413449	0.079524
661	882573.573	682841.250	1140.906	NE cor walk	1661	882573.128	682841.223	1141.287	cor walk	-0.445	-0.027	0.381	0.198025	0.000729	0.145161
663	883271.427	680245.179	1132.616	cor parking	1663	883271.432	680245.119	1132.423	cor bit parking	0.005	-0.060	-0.193	0.000025	0.003600	0.037249
666	881343.726	678450.301	1126.459	E ed dr at S ed walk	1666	881343.686	678450.235	1126.448	ed walk-dr	-0.040	-0.066	-0.011	0.001600	0.004356	0.000121
667	882356.101	675738.238	1121.517	SE cor walk	1667	882356.074	675738.093	1121.558	cor walk	-0.027	-0.145	0.041	0.000729	0.021025	0.001681
669	881811.438	673375.957	1112.199	NE cor parking bay	1669	881811.698	673375.837	1112.446	cor bit parking	0.260	-0.120	0.247	0.067600	0.014400	0.061009
671	882344.665	670054.691	1111.853	SW cor fence	1671	882344.271	670054.699	1111.884	cor fence	-0.394	0.008	0.231	0.155236	0.000064	0.053361
673	881821.059	667872.599	1108.640	cor conc pad in walk	1673	881821.413	667872.689	1108.864	cor conc	0.354	0.090	0.224	0.125316	0.008100	0.050176
675	882111.421	665616.792	1099.952	NW cor wall	1675	882110.984	665616.167	1100.389	cor bit parking	-0.437	0.375	0.437	0.190969	0.140625	0.190969
678	882507.100	662991.690	1092.075	NW cor walk	1678	882506.993	662991.483	1092.123	cor walk	-0.107	-0.227	0.048	0.011449	0.051529	0.002304
680	882422.763	661143.577	1090.599	NE cor fence	1680	882422.583	661143.708	1090.643	cor fence	-0.180	0.131	0.044	0.032400	0.017161	0.001936
682	880516.367	659925.004	1085.221	SE cor wall	1682	880515.385	659925.066	1084.742	cor wall	-0.982	0.062	-0.479	0.964324	0.003844	0.229441
684	880840.614	663027.778	1094.879	cor fence	1684	880840.267	663027.540	1094.423	cor fence	-0.347	-0.238	-0.456	0.120409	0.056644	0.207936
686	880539.904	665214.421	1098.006	cor fence	1686	880539.762	665214.746	1097.608	cor fence	-0.142	0.325	-0.398	0.020164	0.105625	0.158404
687	880741.383	668814.783	1106.409	intersection fences	1687	880741.398	668814.738	1106.499	cor fences	0.015	-0.045	0.090	0.000225	0.002025	0.008100
690	879704.017	670359.930	1110.175	N cor walks	1690	879703.925	670359.962	1110.502	cor walk	-0.092	0.032	0.327	0.008464	0.002704	0.106929
692	880144.391	673235.580	1113.526	NW cor walks	1692	880144.112	673235.173	1113.623	cor walk	-0.279	-0.407	0.097	0.077841	0.166649	0.009409
693	879662.490	675438.878	1125.900	SW cor conc pad	1693	879662.341	675438.757	1125.800	cor conc	-0.149	0.079	-0.100	0.022201	0.006241	0.010000
695	880664.288	677932.326	1130.422	W ed dr at S ed walk	1695	880664.271	677932.264	1130.609	cor walk-dr	-0.017	-0.062	0.187	0.000289	0.003844	0.034969
697	880117.163	680474.424	1133.919	N cor walks	1697	880117.150	680474.456	1134.091	cor walk	-0.013	0.032	0.172	0.000169	0.001024	0.029584
699	879602.267	683113.655	1136.126	NW cor walks	1699	879602.337	683113.987	1136.045	cor walk	0.070	0.332	-0.081	0.004900	0.110224	0.006561
									Sum of Squares/n				0.061528	0.077629	0.077700
									RMSE				**0.286**	**0.279**	**0.279**

PACE
Advanced Water Engineering

Hydraulics Supporting Documentation

Appendix B – Proposed Output 1988 NAVD

HEC-RAS Plan: Prop-88 River: Salt Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	219.51 AT	Floodplain	169000.00	1116.00	1134.18	1128.58	1136.13	0.001904	11.21	15076.53	1004.83	0.51
1	219.51 AT	10 %	55000.00	1116.00	1126.66	1123.36	1127.46	0.001832	7.18	7660.01	971.93	0.45
1	219.51 AT	2 %	140000.00	1116.00	1132.54	1127.44	1134.23	0.001902	10.42	13434.13	998.96	0.50
1	219.51 AT	0.2 %	243000.00	1116.00	1137.83	1131.31	1140.43	0.001936	12.94	18773.69	1018.87	0.53
1	219.46	Floodplain	169000.00	1115.00	1133.77	1128.17	1135.70	0.001889	11.15	15150.64	1010.89	0.51
1	219.46	10 %	55000.00	1115.00	1126.26	1122.96	1127.05	0.001810	7.14	7703.74	976.08	0.45
1	219.46	2 %	140000.00	1115.00	1132.13	1127.09	1133.80	0.001890	10.37	13495.19	1005.25	0.50
1	219.46	0.2 %	243000.00	1115.00	1137.43	1130.84	1140.00	0.001918	12.88	18866.86	1023.69	0.53
1	219.42	Floodplain	169000.00	1115.00	1133.10	1127.86	1135.13	0.002043	11.42	14799.38	1010.89	0.53
1	219.42	10 %	55000.00	1115.00	1125.62	1122.57	1126.48	0.002099	7.46	7372.14	977.66	0.48
1	219.42	2 %	140000.00	1115.00	1131.46	1126.70	1133.22	0.002065	10.65	13143.30	1005.28	0.52
1	219.42	0.2 %	243000.00	1115.00	1136.74	1130.57	1139.42	0.002049	13.14	18498.51	1024.42	0.54
1	219.38	Floodplain	169000.00	1115.00	1132.73	1127.33	1134.67	0.001958	11.20	15095.78	1031.27	0.52
1	219.38	10 %	55000.00	1115.00	1125.19	1122.20	1126.03	0.002031	7.34	7490.94	993.80	0.47
1	219.38	2 %	140000.00	1115.00	1131.07	1126.10	1132.76	0.001982	10.45	13392.63	1023.99	0.51
1	219.38	0.2 %	243000.00	1115.00	1136.38	1129.99	1138.95	0.001959	12.86	18900.44	1048.09	0.53
1	219.33	Floodplain	169000.00	1114.00	1132.09	1126.85	1134.11	0.002085	11.40	14820.40	1031.29	0.53
1	219.33	10 %	55000.00	1114.00	1124.58	1121.73	1125.45	0.002193	7.55	7280.31	979.64	0.49
1	219.33	2 %	140000.00	1114.00	1130.43	1125.71	1132.20	0.002120	10.68	13108.40	1019.61	0.52
1	219.33	0.2 %	243000.00	1114.00	1135.75	1129.64	1138.40	0.002059	13.05	18620.44	1046.80	0.55
1	219.29	Floodplain	169000.00	1114.00	1131.60	1126.46	1133.64	0.002119	11.45	14761.94	1032.92	0.53
1	219.29	10 %	55000.00	1114.00	1124.03	1121.23	1124.94	0.002276	7.65	7191.22	976.04	0.50
1	219.29	2 %	140000.00	1114.00	1129.92	1125.31	1131.71	0.002178	10.74	13030.00	1024.46	0.53
1	219.29	0.2 %	243000.00	1114.00	1135.28	1129.23	1137.93	0.002060	13.08	18584.96	1049.06	0.55
1	219.24	Floodplain	169000.00	1113.00	1131.12	1125.88	1133.14	0.002086	11.40	14821.39	1031.18	0.53
1	219.24	10 %	55000.00	1113.00	1123.51	1120.68	1124.41	0.002214	7.59	7243.61	974.41	0.49
1	219.24	2 %	140000.00	1113.00	1129.42	1124.72	1131.20	0.002133	10.70	13079.15	1017.77	0.53
1	219.24	0.2 %	243000.00	1113.00	1134.80	1128.63	1137.41	0.002053	13.03	18650.37	1048.04	0.54
1	219.19	Floodplain	169000.00	1113.00	1130.64	1125.21	1132.61	0.002000	11.28	14986.38	1028.77	0.52
1	219.19	10 %	55000.00	1113.00	1123.00	1120.01	1123.86	0.002073	7.45	7383.28	973.08	0.48
1	219.19	2 %	140000.00	1113.00	1128.93	1124.07	1130.66	0.002040	10.58	13238.84	1015.68	0.52
1	219.19	0.2 %	243000.00	1113.00	1134.32	1128.00	1136.92	0.001984	12.92	18812.02	1045.43	0.54
1	219.14	Floodplain	169000.00	1112.00	1130.11	1124.77	1132.10	0.002016	11.32	14930.88	1023.38	0.52
1	219.14	10 %	55000.00	1112.00	1122.42	1119.61	1123.31	0.002218	7.58	7258.35	980.48	0.49
1	219.14	2 %	140000.00	1112.00	1128.38	1123.62	1130.14	0.002082	10.63	13169.70	1016.64	0.52
1	219.14	0.2 %	243000.00	1112.00	1133.79	1127.47	1136.40	0.002000	12.98	18724.51	1037.14	0.54
1	219.09	Floodplain	169000.00	1112.00	1129.67	1124.27	1131.62	0.002001	11.22	15057.50	1039.99	0.52
1	219.09	10 %	55000.00	1112.00	1121.90	1119.13	1122.79	0.002259	7.60	7237.30	986.16	0.49
1	219.09	2 %	140000.00	1112.00	1127.91	1123.15	1129.65	0.002079	10.57	13242.14	1030.32	0.52
1	219.09	0.2 %	243000.00	1112.00	1133.38	1126.95	1135.93	0.001971	12.82	18948.29	1058.17	0.53
1	219.03 AS	Floodplain	169000.00	1110.00	1129.36	1123.02	1131.02	0.001558	10.33	16362.43	1060.53	0.46
1	219.03 AS	10 %	55000.00	1110.00	1121.46	1118.07	1122.18	0.001664	6.80	8084.70	1033.92	0.43
1	219.03 AS	2 %	140000.00	1110.00	1127.58	1121.94	1129.03	0.001592	9.67	14481.05	1054.31	0.46
1	219.03 AS	0.2 %	243000.00	1110.00	1133.10	1125.66	1135.31	0.001586	11.94	20346.10	1570.97	0.48
1	219.02		Bridge									
1	219.01	Floodplain	169000.00	1109.00	1128.72	1122.71	1130.48	0.001665	10.58	15978.55	1051.26	0.48
1	219.01	10 %	55000.00	1109.00	1120.92	1117.69	1121.68	0.001797	6.98	7874.73	1026.60	0.44
1	219.01	2 %	140000.00	1109.00	1126.96	1121.61	1128.48	0.001706	9.91	14132.44	1045.73	0.47
1	219.01	0.2 %	243000.00	1109.00	1132.35	1125.31	1134.68	0.001710	12.27	19812.30	1063.25	0.50
1	218.96	Floodplain	169000.00	1109.00	1126.68	1121.96	1130.26	0.001447	10.08	16770.87	1067.82	0.45
1	218.96	10 %	55000.00	1109.00	1120.85	1116.92	1121.49	0.001352	6.40	8592.11	1031.16	0.39
1	218.96	2 %	140000.00	1109.00	1126.91	1120.83	1128.28	0.001441	9.39	14904.13	1051.84	0.44
1	218.96	0.2 %	243000.00	1109.00	1132.33	1124.53	1134.46	0.001522	11.74	20706.37	1087.81	0.47
1	218.975		Bridge									
1	218.98	Floodplain	169000.00	1109.00	1127.89	1121.89	1129.52	0.001594	10.25	16485.61	1100.71	0.47
1	218.98	10 %	55000.00	1109.00	1120.26	1116.85	1120.95	0.001617	6.66	8254.17	1066.87	0.42
1	218.98	2 %	140000.00	1109.00	1126.16	1120.65	1127.59	0.001606	9.59	14602.51	1084.74	0.46
1	218.98	0.2 %	243000.00	1109.00	1131.94	1124.29	1134.02	0.001513	11.58	20982.60	1120.33	0.47
1	218.8	Floodplain	169000.00	1108.00	1125.82	1120.90	1127.95	0.002185	11.71	14428.45	997.44	0.54
1	218.8	10 %	55000.00	1108.00	1118.43	1115.71	1119.35	0.002328	7.70	7140.35	974.63	0.50
1	218.8	2 %	140000.00	1108.00	1124.12	1119.73	1125.99	0.002254	10.99	12736.79	992.10	0.54
1	218.8	0.2 %	243000.00	1108.00	1129.85	1123.60	1132.52	0.002043	13.12	18515.00	1024.58	0.54
1	218.77	Floodplain	169000.00	1108.00	1125.30	1120.38	1127.41	0.002188	11.68	14471.99	1005.59	0.54
1	218.77	10 %	55000.00	1108.00	1117.84	1115.18	1118.78	0.002384	7.75	7095.61	976.94	0.51
1	218.77	2 %	140000.00	1108.00	1123.57	1119.22	1125.45	0.002262	10.98	12745.41	996.88	0.54
1	218.77	0.2 %	243000.00	1108.00	1129.39	1123.05	1132.02	0.002025	13.02	18667.34	1040.42	0.54
1	218.71 AR	Floodplain	169000.00	1107.00	1124.67	1119.84	1126.85	0.002208	11.87	14240.89	993.66	0.55

HEC-RAS Plan: Prop-88 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	218.71 AR	10 %	55000.00	1107.00	1117.22	1114.57	1118.18	0.002424	7.86	6998.76	955.80	0.51
1	218.71 AR	2 %	140000.00	1107.00	1122.93	1118.66	1124.87	0.002344	11.18	12525.70	980.74	0.55
1	218.71 AR	0.2 %	243000.00	1107.00	1128.79	1122.57	1131.50	0.002057	13.22	18381.30	1012.20	0.55
1	218.66	Floodplain	169000.00	1105.19	1124.15	1119.06	1126.28	0.002167	11.71	14426.39	991.32	0.54
1	218.66	10 %	55000.00	1105.19	1116.68	1113.75	1117.59	0.002175	7.63	7212.26	949.17	0.49
1	218.66	2 %	140000.00	1105.19	1122.39	1117.88	1124.28	0.002217	11.02	12702.55	973.97	0.54
1	218.66	0.2 %	243000.00	1105.19	1128.34	1121.77	1130.98	0.001979	13.03	18647.72	1019.06	0.54
1	218.61	Floodplain	169000.00	1104.00	1123.54	1118.53	1125.70	0.002245	11.81	14314.68	998.44	0.55
1	218.61	10 %	55000.00	1104.00	1116.04	1113.32	1116.93	0.002356	7.80	7050.31	951.99	0.51
1	218.61	2 %	140000.00	1104.00	1121.75	1117.42	1123.66	0.002317	11.15	12550.88	976.63	0.55
1	218.61	0.2 %	243000.00	1104.00	1127.82	1121.34	1130.45	0.001990	13.03	18550.30	1023.43	0.54
1	218.57	Floodplain	169000.00	1104.00	1122.97	1118.11	1125.14	0.002264	11.81	14305.46	1004.14	0.55
1	218.57	10 %	55000.00	1104.00	1115.39	1112.83	1116.37	0.002545	7.97	6904.68	959.04	0.52
1	218.57	2 %	140000.00	1104.00	1121.14	1116.93	1123.09	0.002389	11.21	12482.56	982.58	0.56
1	218.57	0.2 %	243000.00	1104.00	1127.34	1120.86	1129.95	0.001963	12.96	18749.96	1027.27	0.53
1	218.52	Floodplain	169000.00	1103.00	1122.42	1117.53	1124.58	0.002239	11.78	14342.71	1001.70	0.55
1	218.52	10 %	55000.00	1103.00	1114.72	1112.25	1115.72	0.002612	8.06	6821.27	941.95	0.53
1	218.52	2 %	140000.00	1103.00	1120.55	1116.35	1122.50	0.002307	11.21	12493.88	981.49	0.55
1	218.52	0.2 %	243000.00	1103.00	1126.89	1120.22	1129.46	0.001918	12.87	18887.84	1028.16	0.53
1	218.47	Floodplain	169000.00	1101.00	1122.07	1116.52	1124.04	0.001941	11.28	14987.31	1005.52	0.51
1	218.47	10 %	55000.00	1101.00	1114.28	1111.20	1115.15	0.002055	7.48	7356.22	957.15	0.48
1	218.47	2 %	140000.00	1101.00	1120.17	1115.36	1121.95	0.002036	10.69	13100.39	988.11	0.52
1	218.47	0.2 %	243000.00	1101.00	1126.60	1119.22	1128.99	0.001694	12.40	19593.96	1027.19	0.50
1	218.42	Floodplain	169000.00	1102.00	1121.32	1116.46	1123.46	0.002246	11.74	14332.04	1013.29	0.55
1	218.42	10 %	55000.00	1102.00	1113.33	1111.21	1114.44	0.003170	8.47	6474.77	969.89	0.55
1	218.42	2 %	140000.00	1102.00	1119.34	1115.29	1121.32	0.002467	11.28	12407.21	995.30	0.56
1	218.42	0.2 %	243000.00	1102.00	1126.02	1119.17	1128.51	0.001833	12.65	19202.96	1035.67	0.52
1	218.38	Floodplain	169000.00	1102.00	1120.82	1115.92	1122.89	0.002182	11.53	14654.93	1037.00	0.54
1	218.38	10 %	55000.00	1102.00	1112.14	1110.68	1113.49	0.004376	9.35	5883.68	964.42	0.67
1	218.38	2 %	140000.00	1102.00	1118.75	1114.78	1120.69	0.002468	11.18	12524.33	1019.03	0.56
1	218.38	0.2 %	243000.00	1102.00	1125.67	1118.55	1128.02	0.001728	12.32	19730.35	1059.92	0.50
1	218.33	Floodplain	169000.00	1101.96	1120.57	1114.53	1122.31	0.001687	10.61	15929.22	1053.03	0.48
1	218.33	10 %	55000.00	1101.96	1111.33	1109.36	1112.46	0.003417	8.53	6449.40	1008.71	0.59
1	218.33	2 %	140000.00	1101.96	1118.44	1113.39	1120.06	0.001858	10.21	13716.22	1033.53	0.49
1	218.33	0.2 %	243000.00	1101.96	1125.49	1117.10	1127.54	0.001392	11.48	21172.86	1075.01	0.46
1	218.29	Floodplain	169000.00	1100.00	1120.30	1113.59	1121.93	0.001475	10.23	16514.79	1042.56	0.45
1	218.29	10 %	55000.00	1100.00	1110.70	1107.88	1111.73	0.002885	8.15	6747.92	995.34	0.55
1	218.29	2 %	140000.00	1100.00	1118.14	1112.45	1119.64	0.001624	9.81	14277.25	1033.96	0.47
1	218.29	0.2 %	243000.00	1100.00	1125.28	1116.26	1127.20	0.001308	11.14	21813.99	1111.48	0.44
1	218.24 AQ	Floodplain	169000.00	1098.99	1120.12	1112.15	1121.51	0.001144	9.45	17825.74	1043.27	0.40
1	218.24 AQ	10 %	55000.00	1098.99	1110.28	1106.20	1111.05	0.001607	7.07	7775.80	999.16	0.45
1	218.24 AQ	2 %	140000.00	1098.99	1117.94	1110.98	1119.19	0.001217	9.00	15563.36	1033.40	0.41
1	218.24 AQ	0.2 %	243000.00	1098.99	1125.11	1114.79	1126.83	0.001023	10.52	23144.04	1115.24	0.40
1	218.19	Floodplain	169000.00	1098.59	1119.93	1111.06	1121.22	0.001011	9.11	18552.50	1049.41	0.38
1	218.19	10 %	55000.00	1098.59	1109.99	1104.84	1110.64	0.001314	6.46	8516.34	985.35	0.39
1	218.19	2 %	140000.00	1098.59	1117.74	1109.93	1118.89	0.001033	8.60	16282.84	1021.14	0.38
1	218.19	0.2 %	243000.00	1098.59	1124.96	1113.77	1126.56	0.000920	10.17	23961.96	1122.15	0.38
1	218.14	Floodplain	169000.00	1098.28	1119.57	1110.93	1120.95	0.001061	9.44	17911.57	995.26	0.39
1	218.14	10 %	55000.00	1098.28	1109.60	1104.57	1110.29	0.001416	6.70	8209.86	950.58	0.40
1	218.14	2 %	140000.00	1098.28	1117.39	1109.74	1118.61	0.001101	8.86	15754.31	985.61	0.39
1	218.14	0.2 %	243000.00	1098.28	1124.57	1113.69	1126.31	0.000990	10.59	22964.50	1049.21	0.39
1	218.09	Floodplain	169000.00	1097.95	1118.70	1111.41	1120.50	0.001501	11.03	15327.65	871.96	0.46
1	218.09	10 %	55000.00	1097.95	1108.89	1104.73	1109.85	0.002024	7.88	6977.97	825.62	0.48
1	218.09	2 %	140000.00	1097.95	1116.58	1110.08	1118.25	0.001556	10.38	13483.03	853.06	0.46
1	218.09	0.2 %	243000.00	1097.95	1123.58	1114.41	1125.66	0.001406	12.38	19634.45	922.51	0.46
1	218.04	Floodplain	169000.00	1096.77	1118.36	1110.40	1120.18	0.001363	10.84	15591.65	847.06	0.45
1	218.04	10 %	55000.00	1096.77	1108.48	1103.63	1109.33	0.001588	7.41	7427.06	805.07	0.43
1	218.04	2 %	140000.00	1096.77	1116.23	1109.07	1117.83	0.001385	10.15	13798.44	833.44	0.44
1	218.04	0.2 %	243000.00	1096.77	1123.23	1113.49	1125.58	0.001318	12.29	19801.21	983.81	0.45
1	218	Floodplain	169000.00	1095.73	1118.00	1109.75	1119.86	0.001347	10.97	15408.70	813.75	0.44
1	218	10 %	55000.00	1095.73	1108.17	1102.89	1108.98	0.001392	7.23	7608.30	773.14	0.41
1	218	2 %	140000.00	1095.73	1115.89	1108.40	1117.51	0.001347	10.22	13703.26	805.22	0.44
1	218	0.2 %	243000.00	1095.73	1122.82	1112.94	1125.26	0.001342	12.54	19414.46	920.75	0.46
1	217.95	Floodplain	169000.00	1094.98	1116.82	1110.52	1119.34	0.002024	12.75	13251.34	760.67	0.54
1	217.95	10 %	55000.00	1094.98	1107.32	1102.83	1108.48	0.002032	8.64	6362.83	659.08	0.49
1	217.95	2 %	140000.00	1094.98	1114.77	1109.05	1116.99	0.002068	11.97	11700.54	752.16	0.53
1	217.95	0.2 %	243000.00	1094.98	1121.51	1114.02	1124.74	0.001939	14.40	16871.13	786.88	0.55
1	217.91	Floodplain	169000.00	1094.49	1110.54	1108.68	1118.82	0.001578	12.11	13954.70	714.63	0.48

HEC-RAS Plan: Prop-88 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	217.91	10 %	55000.00	1094.49	1107.13	1101.70	1107.99	0.001269	7.42	7412.84	675.95	0.39
1	217.91	2 %	140000.00	1094.49	1114.52	1107.20	1116.46	0.001530	11.19	12516.24	706.31	0.47
1	217.91	0.2 %	243000.00	1094.49	1121.18	1112.15	1124.24	0.001650	14.04	17319.66	771.74	0.51
1	217.86	Floodplain	169000.00	1093.99	1115.44	1109.06	1118.32	0.002104	13.61	12413.21	661.58	0.55
1	217.86	10 %	55000.00	1093.99	1106.59	1101.72	1107.63	0.001593	8.10	6713.11	625.41	0.44
1	217.86	2 %	140000.00	1093.99	1113.55	1107.48	1115.99	0.002020	12.54	11165.79	653.84	0.53
1	217.86	0.2 %	243000.00	1093.99	1119.79	1112.72	1123.69	0.002241	15.85	15327.32	679.89	0.59
1	217.81	Floodplain	169000.00	1093.49	1114.19	1109.21	1117.75	0.002773	15.14	11161.25	623.27	0.63
1	217.81	10 %	55000.00	1093.49	1106.03	1101.64	1107.25	0.001914	8.86	6207.25	589.58	0.48
1	217.81	2 %	140000.00	1093.49	1112.47	1107.61	1115.46	0.002618	13.87	10092.68	616.46	0.60
1	217.81	0.2 %	243000.00	1093.49	1118.12	1112.99	1123.05	0.003045	17.82	13639.92	638.69	0.68
1	217.76 AP	Floodplain	169000.00	1093.00	1111.78	1109.61	1116.54	0.004698	17.55	9631.85	642.30	0.80
1	217.76 AP	10 %	55000.00	1093.00	1104.72	1102.22	1106.44	0.003355	10.51	5235.22	587.67	0.62
1	217.76 AP	2 %	140000.00	1093.00	1110.29	1108.05	1114.32	0.004479	16.11	8692.01	636.54	0.77
1	217.76 AP	0.2 %	243000.00	1093.00	1115.18	1113.27	1121.71	0.005020	20.51	11849.02	655.78	0.85
1	217.71	Floodplain	169000.00	1092.00	1111.42	1108.12	1115.32	0.003693	15.85	10659.50	691.20	0.71
1	217.71	10 %	55000.00	1092.00	1104.30	1100.89	1105.66	0.002565	9.34	5889.85	645.30	0.54
1	217.71	2 %	140000.00	1092.00	1109.89	1106.58	1113.19	0.003535	14.57	9607.30	684.95	0.69
1	217.71	0.2 %	243000.00	1092.00	1115.06	1111.69	1120.32	0.003859	18.41	13202.39	705.83	0.75
1	217.66	Floodplain	169000.00	1089.30	1110.70	1107.32	1114.25	0.003491	15.11	11181.92	747.27	0.69
1	217.66	10 %	55000.00	1089.30	1103.61	1100.40	1104.92	0.002792	9.20	5978.81	714.71	0.56
1	217.66	2 %	140000.00	1089.30	1109.14	1105.81	1112.17	0.003413	13.97	10020.07	741.31	0.67
1	217.66	0.2 %	243000.00	1089.30	1114.51	1110.62	1119.15	0.003464	17.29	14057.46	761.84	0.71
1	217.62	Floodplain	169000.00	1090.00	1110.67	1105.77	1113.28	0.002421	12.97	13033.59	831.22	0.58
1	217.62	10 %	55000.00	1090.00	1103.30	1099.36	1104.27	0.001971	7.88	6977.87	811.29	0.47
1	217.62	2 %	140000.00	1090.00	1109.03	1104.47	1111.26	0.002380	12.00	11689.02	827.20	0.56
1	217.62	0.2 %	243000.00	1090.00	1114.70	1108.83	1118.11	0.002377	14.82	16398.58	840.79	0.59
1	217.57	Floodplain	169000.00	1091.00	1110.19	1105.43	1112.54	0.002363	12.32	13717.42	927.48	0.56
1	217.57	10 %	55000.00	1091.00	1102.66	1099.29	1103.67	0.002349	8.05	6833.92	877.06	0.51
1	217.57	2 %	140000.00	1091.00	1108.48	1104.22	1110.54	0.002417	11.53	12138.23	923.02	0.56
1	217.57	0.2 %	243000.00	1091.00	1114.39	1108.26	1117.34	0.002154	13.77	17642.13	937.92	0.56
1	217.53	Floodplain	169000.00	1091.50	1110.10	1104.33	1111.98	0.001809	11.01	15343.48	1008.71	0.50
1	217.53	10 %	55000.00	1091.50	1102.37	1098.85	1103.18	0.001883	7.20	7641.49	985.48	0.46
1	217.53	2 %	140000.00	1091.50	1108.34	1103.18	1109.99	0.001851	10.31	13575.01	1003.51	0.49
1	217.53	0.2 %	243000.00	1091.50	1114.42	1106.99	1116.78	0.001648	12.31	19735.43	1020.66	0.49
1	217.48	Floodplain	169000.00	1091.00	1109.67	1104.03	1111.51	0.001813	10.88	15532.02	1045.77	0.50
1	217.48	10 %	55000.00	1091.00	1101.83	1098.76	1102.67	0.002117	7.38	7453.80	1012.98	0.48
1	217.48	2 %	140000.00	1091.00	1107.88	1102.87	1109.51	0.001885	10.24	13668.49	1038.48	0.50
1	217.48	0.2 %	243000.00	1091.00	1114.09	1106.65	1116.34	0.001604	12.04	20190.25	1064.04	0.49
1	217.43	Floodplain	169000.00	1091.00	1109.10	1103.87	1111.04	0.001986	11.20	15090.72	1041.52	0.52
1	217.43	10 %	55000.00	1091.00	1101.07	1098.69	1102.07	0.002791	8.02	6854.92	1010.98	0.54
1	217.43	2 %	140000.00	1091.00	1107.28	1102.73	1109.02	0.002110	10.61	13199.99	1035.22	0.52
1	217.43	0.2 %	243000.00	1091.00	1113.60	1106.48	1115.93	0.001694	12.27	19812.44	1056.63	0.50
1	217.38	Floodplain	169000.00	1089.00	1108.65	1102.99	1110.50	0.001824	10.93	15463.51	1037.82	0.50
1	217.38	10 %	55000.00	1089.00	1100.39	1097.87	1101.34	0.002556	7.83	7024.95	1004.90	0.52
1	217.38	2 %	140000.00	1089.00	1105.79	1101.87	1108.45	0.001926	10.34	13546.20	1030.35	0.50
1	217.38	0.2 %	243000.00	1089.00	1113.23	1105.65	1115.46	0.001574	11.99	20261.40	1057.08	0.48
1	217.34	Floodplain	169000.00	1086.21	1108.19	1102.39	1110.04	0.001784	10.92	15478.82	1022.45	0.49
1	217.34	10 %	55000.00	1086.21	1099.71	1097.18	1100.68	0.002585	7.91	6954.74	987.91	0.53
1	217.34	2 %	140000.00	1086.21	1106.31	1101.23	1107.96	0.001880	10.32	13565.46	1014.80	0.50
1	217.34	0.2 %	243000.00	1086.21	1112.83	1105.05	1115.06	0.001543	11.99	20269.77	1041.68	0.47
1	217.29 AO	Floodplain	169000.00	1085.00	1107.75	1101.80	1109.61	0.001754	10.95	15439.97	1008.13	0.49
1	217.29 AO	10 %	55000.00	1085.00	1099.06	1096.48	1100.05	0.002609	7.99	6885.22	967.66	0.53
1	217.29 AO	2 %	140000.00	1085.00	1105.86	1100.63	1107.51	0.001840	10.33	13552.13	993.33	0.49
1	217.29 AO	0.2 %	243000.00	1085.00	1112.43	1104.50	1114.65	0.001530	12.05	20173.43	1091.61	0.48
1	217.24	Floodplain	169000.00	1084.46	1107.33	1101.07	1109.17	0.001681	10.90	15510.49	979.68	0.48
1	217.24	10 %	55000.00	1084.46	1098.44	1095.70	1099.41	0.002438	7.90	6958.60	943.90	0.51
1	217.24	2 %	140000.00	1084.46	1105.42	1099.83	1107.06	0.001747	10.26	13649.11	972.13	0.48
1	217.24	0.2 %	243000.00	1084.46	1112.06	1103.84	1114.31	0.001486	12.04	20186.89	998.75	0.47
1	217.19	Floodplain	169000.00	1085.00	1106.79	1100.70	1108.72	0.001756	11.16	15150.15	955.07	0.49
1	217.19	10 %	55000.00	1085.00	1097.62	1095.26	1098.72	0.002885	8.40	6547.73	920.69	0.56
1	217.19	2 %	140000.00	1085.00	1104.88	1099.50	1106.59	0.001827	10.50	13328.14	947.98	0.49
1	217.19	0.2 %	243000.00	1085.00	1111.55	1103.50	1113.91	0.001546	12.31	19742.51	973.54	0.48
1	217.15	Floodplain	169000.00	1083.72	1106.64	1099.02	1108.30	0.001337	10.34	16340.29	935.93	0.44
1	217.15	10 %	55000.00	1083.72	1097.39	1093.03	1098.15	0.001544	7.01	7844.77	900.61	0.42
1	217.15	2 %	140000.00	1083.72	1104.72	1097.79	1106.16	0.001335	9.62	14552.51	928.89	0.43
1	217.15	0.2 %	243000.00	1083.72	1111.41	1101.87	1113.52	0.001263	11.65	20851.85	954.87	0.44
1	217.1	Floodplain	169000.00	1085.00	1106.26	1093.37	1107.93	0.001300	10.25	16329.61	916.89	0.43

HEC-RAS Plan: Prop-88 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	217.1	10 %	55000.00	1085.00	1097.00	1092.75	1097.73	0.001399	6.87	8000.71	881.01	0.40
1	217.1	2 %	140000.00	1085.00	1104.36	1097.15	1105.79	0.001283	9.60	14588.87	909.24	0.42
1	217.1	0.2 %	243000.00	1085.00	1111.04	1101.30	1113.17	0.001248	11.71	20755.09	937.28	0.44
1	217.05	Floodplain	169000.00	1085.00	1105.84	1098.43	1107.60	0.001415	10.64	15876.67	912.07	0.45
1	217.05	10 %	55000.00	1085.00	1096.55	1092.80	1097.37	0.001664	7.26	7573.07	875.35	0.44
1	217.05	2 %	140000.00	1085.00	1103.95	1097.18	1105.46	0.001407	9.89	14155.11	904.42	0.44
1	217.05	0.2 %	243000.00	1085.00	1110.63	1101.32	1112.85	0.001334	11.98	20290.01	932.08	0.45
1	217	Floodplain	169000.00	1084.00	1105.39	1098.39	1107.23	0.001526	10.91	15483.22	909.76	0.47
1	217	10 %	55000.00	1084.00	1095.98	1092.76	1096.91	0.002029	7.73	7116.98	871.97	0.48
1	217	2 %	140000.00	1084.00	1103.50	1097.12	1105.10	0.001528	10.16	13781.71	902.08	0.46
1	217	0.2 %	243000.00	1084.00	1110.20	1101.30	1112.51	0.001408	12.20	19922.50	929.42	0.46
1	216.96	Floodplain	169000.00	1082.60	1105.17	1097.14	1106.83	0.001269	10.33	16359.40	906.14	0.43
1	216.96	10 %	55000.00	1082.60	1095.69	1091.43	1096.44	0.001405	6.93	7942.00	869.64	0.40
1	216.96	2 %	140000.00	1082.60	1103.28	1095.87	1104.70	0.001241	9.55	14654.52	898.76	0.42
1	216.96	0.2 %	243000.00	1082.60	1110.01	1100.05	1112.13	0.001219	11.69	20799.59	926.63	0.43
1	216.91	Floodplain	169000.00	1083.00	1104.84	1096.78	1106.49	0.001268	10.32	16372.64	909.25	0.43
1	216.91	10 %	55000.00	1083.00	1095.31	1090.87	1096.06	0.001471	6.96	7899.61	869.69	0.41
1	216.91	2 %	140000.00	1083.00	1102.96	1095.54	1104.37	0.001238	9.54	14669.71	900.84	0.42
1	216.91	0.2 %	243000.00	1083.00	1109.69	1099.73	1111.81	0.001212	11.66	20835.67	929.09	0.43
1	216.86	Floodplain	169000.00	1082.00	1104.62	1095.84	1106.16	0.001118	9.95	16992.03	907.79	0.41
1	216.86	10 %	55000.00	1082.00	1095.07	1090.13	1095.72	0.001104	6.45	8522.36	866.97	0.36
1	216.86	2 %	140000.00	1082.00	1102.75	1094.57	1104.05	0.001073	9.15	15298.02	898.71	0.39
1	216.86	0.2 %	243000.00	1082.00	1109.49	1098.77	1111.48	0.001098	11.32	21460.91	1268.81	0.42
1	216.81 AN	Floodplain	169000.00	1082.00	1104.40	1095.03	1105.87	0.001030	9.74	17349.89	898.67	0.39
1	216.81 AN	10 %	55000.00	1082.00	1094.87	1089.25	1095.45	0.000904	6.11	8999.65	854.62	0.33
1	216.81 AN	2 %	140000.00	1082.00	1102.54	1093.73	1103.77	0.000972	8.92	15686.63	888.20	0.37
1	216.81 AN	0.2 %	243000.00	1082.00	1109.26	1097.99	1111.20	0.001035	11.16	21779.79	1087.32	0.40
1	216.77	Floodplain	169000.00	1081.00	1104.20	1094.38	1105.60	0.000958	9.50	17784.87	907.25	0.38
1	216.77	10 %	55000.00	1081.00	1094.69	1088.60	1095.22	0.000785	5.85	9400.02	857.91	0.31
1	216.77	2 %	140000.00	1081.00	1102.35	1093.10	1103.52	0.000898	8.69	16115.09	896.62	0.36
1	216.77	0.2 %	243000.00	1081.00	1109.07	1097.34	1110.92	0.000970	10.92	22257.67	1125.72	0.39
1	216.72	Floodplain	169000.00	1081.00	1103.92	1094.40	1105.36	0.001002	9.53	17553.73	906.69	0.39
1	216.72	10 %	55000.00	1081.00	1094.46	1088.67	1095.02	0.000848	5.98	9201.48	860.85	0.32
1	216.72	2 %	140000.00	1081.00	1102.09	1093.13	1103.29	0.000942	8.80	15901.99	897.19	0.37
1	216.72	0.2 %	243000.00	1081.00	1108.79	1097.36	1110.68	0.001007	11.04	22017.31	1120.60	0.40
1	216.67	Floodplain	169000.00	1081.00	1103.37	1095.23	1105.05	0.001275	10.41	16234.48	893.54	0.43
1	216.67	10 %	55000.00	1081.00	1094.02	1089.45	1094.74	0.001269	6.79	8104.44	848.16	0.39
1	216.67	2 %	140000.00	1081.00	1101.58	1093.95	1103.00	0.001214	9.56	14648.30	884.42	0.41
1	216.67	0.2 %	243000.00	1081.00	1108.21	1098.22	1110.37	0.001232	11.79	20619.14	1464.75	0.44
1	216.62	Floodplain	169000.00	1082.00	1102.95	1095.27	1104.71	0.001380	10.64	15877.17	898.50	0.45
1	216.62	10 %	55000.00	1082.00	1093.59	1089.48	1094.39	0.001512	7.15	7690.59	849.82	0.42
1	216.62	2 %	140000.00	1082.00	1101.19	1094.00	1102.68	0.001323	9.79	14301.77	885.74	0.43
1	216.62	0.2 %	243000.00	1082.00	1107.82	1098.26	1110.04	0.001301	11.97	20304.32	920.32	0.45
1	216.52	Floodplain	169000.00	1081.00	1102.44	1093.78	1103.99	0.001145	9.99	17006.67	994.29	0.41
1	216.52	10 %	55000.00	1081.00	1093.03	1087.95	1093.68	0.001083	6.45	8528.26	856.74	0.36
1	216.52	2 %	140000.00	1081.00	1100.70	1092.47	1102.00	0.001087	9.15	15306.28	944.04	0.39
1	216.52	0.2 %	243000.00	1081.00	1107.41	1096.73	1109.35	0.001052	11.23	22043.81	1025.03	0.41
1	216.505	Bridge										
1	216.49	Floodplain	169000.00	1079.00	1101.27	1093.20	1102.92	0.001270	10.31	16454.24	1001.34	0.43
1	216.49	10 %	55000.00	1079.00	1092.09	1087.48	1092.79	0.001243	6.70	8213.59	863.72	0.38
1	216.49	2 %	140000.00	1079.00	1099.60	1091.94	1100.98	0.001201	9.42	14856.81	909.84	0.41
1	216.49	0.2 %	243000.00	1079.00	1106.20	1096.16	1108.25	0.001149	11.53	21439.90	1019.24	0.43
1	216.42 AM	Floodplain	169000.00	1078.00	1100.93	1092.48	1102.46	0.001173	9.92	17053.81	985.02	0.41
1	216.42 AM	10 %	55000.00	1078.00	1091.73	1086.82	1092.37	0.001111	6.41	8578.69	885.18	0.36
1	216.42 AM	2 %	140000.00	1078.00	1099.26	1091.24	1100.55	0.001097	9.06	15459.59	939.26	0.39
1	216.42 AM	0.2 %	243000.00	1078.00	1105.95	1095.41	1107.82	0.001070	11.02	22506.71	1104.99	0.41
1	216.36	Floodplain	169000.00	1078.00	1100.76	1091.96	1102.19	0.001074	9.59	17644.22	986.08	0.40
1	216.36	10 %	55000.00	1078.00	1091.53	1086.38	1092.12	0.001000	6.14	8951.55	910.17	0.35
1	216.36	2 %	140000.00	1078.00	1099.11	1090.72	1100.29	0.001002	8.73	16034.82	961.47	0.38
1	216.36	0.2 %	243000.00	1078.00	1105.77	1094.75	1107.57	0.001000	10.77	22703.31	1028.22	0.40

HEC-RAS Plan: Prop-88 River: Salt Reach: 1

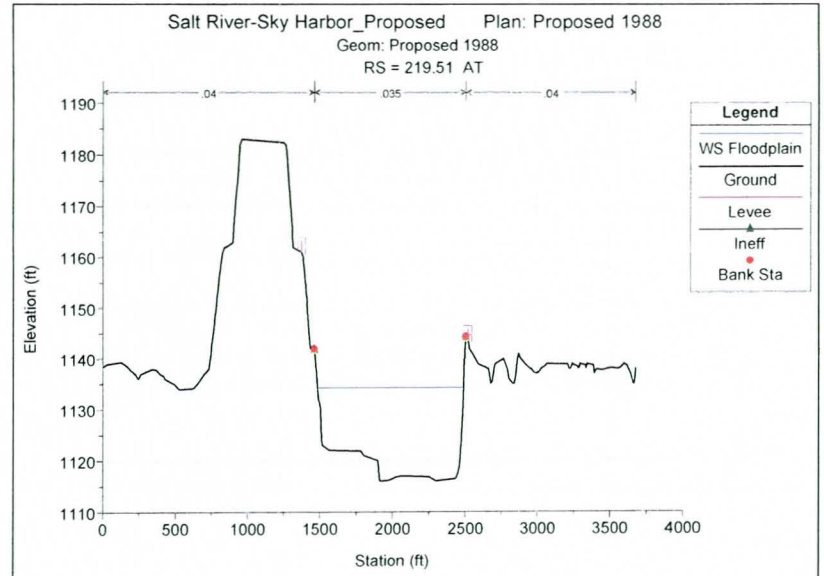
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	219.51 AT	Floodplain	169000.00	1116.00	1134.18	1128.58	1136.13	0.001904	11.21	15076.53	1004.83	0.51
1	219.51 AT	Floodway	169000.00	1116.00	1134.27	1128.58	1136.20	0.001867	11.14	15168.17	1005.16	0.51
1	219.46	Floodplain	169000.00	1115.00	1133.77	1128.17	1135.70	0.001889	11.15	15150.64	1010.89	0.51
1	219.46	Floodway	169000.00	1115.00	1133.87	1128.17	1135.78	0.001848	11.08	15253.45	1011.22	0.50
1	219.42	Floodplain	169000.00	1115.00	1133.10	1127.86	1135.13	0.002043	11.42	14799.38	1010.89	0.53
1	219.42	Floodway	169000.00	1115.00	1133.23	1127.86	1135.22	0.001988	11.32	14925.15	1011.32	0.52
1	219.38	Floodplain	169000.00	1115.00	1132.73	1127.33	1134.67	0.001958	11.20	15095.78	1031.27	0.52
1	219.38	Floodway	169000.00	1115.00	1132.86	1127.33	1134.77	0.001899	11.09	15238.45	1031.87	0.51
1	219.33	Floodplain	169000.00	1114.00	1132.09	1126.85	1134.11	0.002085	11.40	14820.40	1031.29	0.53
1	219.33	Floodway	169000.00	1114.00	1132.26	1126.85	1134.23	0.002008	11.27	14993.56	1031.98	0.52
1	219.29	Floodplain	169000.00	1114.00	1131.60	1126.46	1133.64	0.002119	11.45	14761.94	1032.92	0.53
1	219.29	Floodway	169000.00	1114.00	1131.80	1126.46	1133.78	0.002027	11.29	14965.41	1033.79	0.52
1	219.24	Floodplain	169000.00	1113.00	1131.12	1125.88	1133.14	0.002086	11.40	14821.39	1031.18	0.53
1	219.24	Floodway	169000.00	1113.00	1131.34	1125.88	1133.30	0.001984	11.23	15053.63	1032.26	0.52
1	219.19	Floodplain	169000.00	1113.00	1130.64	1125.21	1132.61	0.002000	11.28	14986.38	1028.77	0.52
1	219.19	Floodway	169000.00	1113.00	1130.89	1125.21	1132.80	0.001891	11.08	15249.50	1029.94	0.51
1	219.14	Floodplain	169000.00	1112.00	1130.11	1124.77	1132.10	0.002016	11.32	14930.86	1023.38	0.52
1	219.14	Floodway	169000.00	1112.00	1130.41	1124.77	1132.32	0.001888	11.09	15236.59	1024.49	0.51
1	219.09	Floodplain	169000.00	1112.00	1129.67	1124.27	1131.62	0.002001	11.22	15057.50	1039.99	0.52
1	219.09	Floodway	169000.00	1112.00	1130.00	1124.27	1131.87	0.001857	10.97	15408.61	1041.68	0.50
1	219.03 AS	Floodplain	169000.00	1110.00	1129.36	1123.02	1131.02	0.001558	10.33	16362.43	1060.53	0.46
1	219.03 AS	Floodway	169000.00	1110.00	1129.73	1123.02	1131.31	0.001443	10.09	16751.04	1061.84	0.45
1	219.00		Bridge									
1	218.91	Floodplain	169000.00	1109.00	1128.72	1122.71	1130.46	0.001665	10.58	15978.55	1051.26	0.48
1	218.91	Floodway	169000.00	1109.00	1128.72	1122.71	1130.46	0.001665	10.58	15978.67	1051.26	0.48
1	218.86	Floodplain	169000.00	1109.00	1128.68	1121.95	1130.26	0.001447	10.08	16770.87	1067.82	0.45
1	218.86	Floodway	169000.00	1109.00	1128.68	1121.95	1130.26	0.001447	10.08	16770.99	1067.83	0.45
1	218.975		Bridge									
1	218.98	Floodplain	169000.00	1109.00	1127.80	1121.69	1129.52	0.001594	10.25	16485.61	1100.71	0.47
1	218.98	Floodway	169000.00	1109.00	1127.89	1121.69	1129.52	0.001594	10.25	16485.75	1100.71	0.47
1	218.8	Floodplain	169000.00	1108.00	1125.82	1120.90	1127.95	0.002185	11.71	14428.45	997.44	0.54
1	218.8	Floodway	169000.00	1108.00	1125.82	1120.90	1127.95	0.002185	11.71	14428.82	997.44	0.54
1	218.77	Floodplain	169000.00	1108.00	1125.30	1120.38	1127.41	0.002188	11.68	14471.99	1006.59	0.54
1	218.77	Floodway	169000.00	1108.00	1125.30	1120.38	1127.42	0.002188	11.68	14472.36	1006.60	0.54
1	218.71 AR	Floodplain	169000.00	1107.00	1124.67	1119.84	1126.85	0.002268	11.87	14240.89	993.66	0.55
1	218.71 AR	Floodway	169000.00	1107.00	1124.67	1119.84	1126.85	0.002267	11.87	14241.25	993.67	0.55
1	218.66	Floodplain	169000.00	1105.19	1124.15	1119.06	1126.28	0.002167	11.71	14426.39	991.32	0.54
1	218.66	Floodway	169000.00	1105.19	1124.15	1119.06	1126.28	0.002167	11.71	14426.76	991.33	0.54
1	218.61	Floodplain	169000.00	1104.00	1123.54	1118.53	1125.70	0.002245	11.81	14314.68	998.44	0.55
1	218.61	Floodway	169000.00	1104.00	1123.54	1118.53	1125.70	0.002245	11.81	14315.17	998.45	0.55
1	218.57	Floodplain	169000.00	1104.00	1122.97	1118.11	1125.14	0.002264	11.81	14305.46	1004.14	0.55
1	218.57	Floodway	169000.00	1104.00	1122.97	1118.11	1125.14	0.002264	11.81	14305.08	1004.14	0.55
1	218.52	Floodplain	169000.00	1103.00	1122.42	1117.53	1124.58	0.002239	11.78	14342.71	1001.70	0.55
1	218.52	Floodway	169000.00	1103.00	1122.42	1117.53	1124.58	0.002238	11.78	14343.32	1001.71	0.55
1	218.47	Floodplain	169000.00	1101.00	1122.07	1116.52	1124.04	0.001941	11.26	14987.31	1005.52	0.51
1	218.47	Floodway	169000.00	1101.00	1122.07	1116.52	1124.05	0.001941	11.26	14987.92	1005.53	0.51
1	218.42	Floodplain	169000.00	1102.00	1121.32	1116.46	1123.46	0.002246	11.74	14392.04	1013.29	0.55
1	218.42	Floodway	169000.00	1102.00	1121.32	1116.46	1123.46	0.002246	11.74	14392.91	1013.30	0.55
1	218.38	Floodplain	169000.00	1102.00	1120.82	1115.92	1122.89	0.002182	11.53	14654.93	1037.00	0.54
1	218.38	Floodway	169000.00	1102.00	1120.82	1115.92	1122.89	0.002182	11.53	14655.81	1037.01	0.54
1	218.33	Floodplain	169000.00	1101.96	1120.57	1114.53	1122.31	0.001687	10.61	15929.22	1053.03	0.48
1	218.33	Floodway	169000.00	1101.96	1120.57	1114.53	1122.31	0.001687	10.61	15930.25	1053.04	0.48
1	218.29	Floodplain	169000.00	1100.00	1120.30	1113.59	1121.93	0.001475	10.23	16514.79	1042.56	0.45
1	218.29	Floodway	169000.00	1100.00	1120.30	1113.59	1121.93	0.001474	10.23	16515.95	1042.57	0.45
1	218.24 AD	Floodplain	169000.00	1098.99	1120.12	1112.15	1121.51	0.001144	9.48	17825.74	1043.27	0.40
1	218.24 AD	Floodway	169000.00	1098.99	1120.12	1112.15	1121.51	0.001143	9.48	17826.88	1043.28	0.40

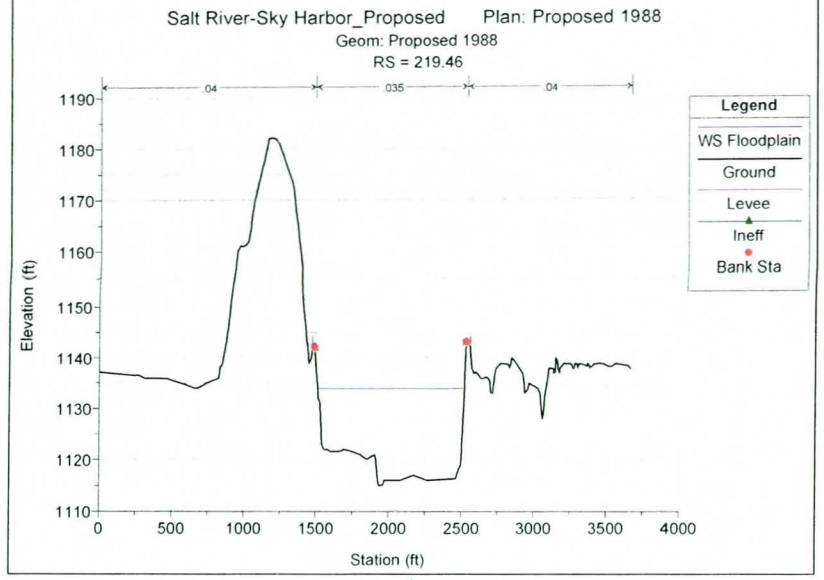
HEC-RAS Plan: Prop-88 River: Salt Reach: 1 (Continued)

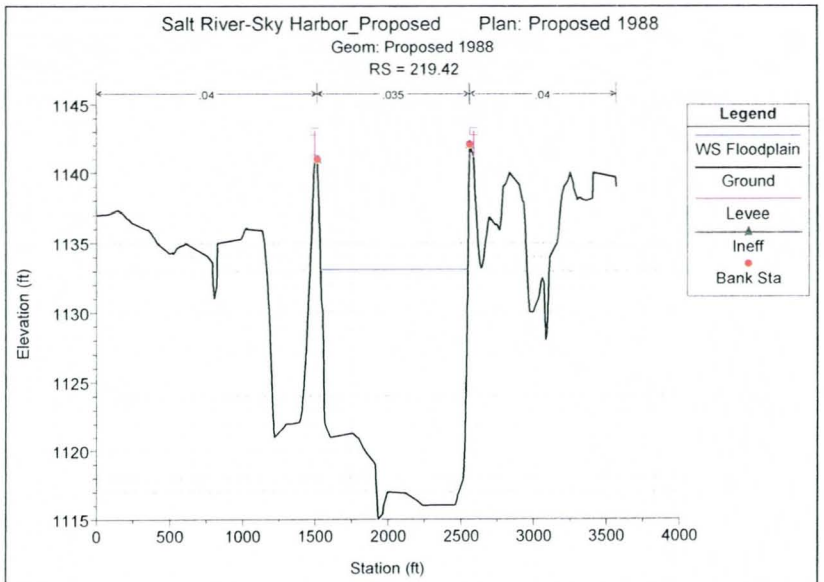
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	218.19	Floodplain	169000.00	1098.59	1119.93	1111.06	1121.22	0.001011	9.11	18552.50	1049.41	0.38
1	218.19	Floodway	169000.00	1098.59	1119.93	1111.06	1121.22	0.001011	9.11	18553.65	1049.41	0.38
1	218.14	Floodplain	169000.00	1098.28	1119.57	1110.93	1120.95	0.001061	9.44	17911.57	995.26	0.39
1	218.14	Floodway	169000.00	1098.28	1119.57	1110.93	1120.95	0.001061	9.43	17912.79	995.26	0.39
1	218.09	Floodplain	169000.00	1097.95	1118.70	1111.41	1120.59	0.001501	11.03	15327.65	871.96	0.46
1	218.09	Floodway	169000.00	1097.95	1118.70	1111.41	1120.59	0.001500	11.02	15328.93	871.96	0.45
1	218.04	Floodplain	169000.00	1096.77	1118.36	1110.40	1120.18	0.001363	10.84	15591.65	847.06	0.45
1	218.04	Floodway	169000.00	1096.77	1118.36	1110.40	1120.18	0.001363	10.84	15593.00	847.06	0.45
1	218	Floodplain	169000.00	1095.73	1118.00	1109.75	1119.86	0.001348	10.97	15408.70	813.75	0.44
1	218	Floodway	169000.00	1095.73	1118.00	1109.75	1119.86	0.001348	10.97	15409.99	813.76	0.44
1	217.95	Floodplain	169000.00	1094.98	1116.82	1110.52	1119.34	0.002024	12.75	13251.34	760.67	0.54
1	217.95	Floodway	169000.00	1094.98	1116.82	1110.52	1119.34	0.002023	12.75	13252.92	760.68	0.54
1	217.91	Floodplain	169000.00	1094.49	1116.54	1108.68	1118.82	0.001578	12.11	13954.79	714.63	0.48
1	217.91	Floodway	169000.00	1094.49	1116.55	1108.68	1118.82	0.001577	12.11	13956.36	714.64	0.48
1	217.88	Floodplain	169000.00	1093.99	1115.44	1109.06	1118.32	0.002104	13.61	12413.21	661.58	0.55
1	217.88	Floodway	169000.00	1093.99	1115.45	1109.06	1118.32	0.002103	13.61	12414.99	661.60	0.55
1	217.81	Floodplain	169000.00	1093.49	1114.19	1109.21	1117.75	0.002773	15.14	11161.25	623.27	0.63
1	217.81	Floodway	169000.00	1093.49	1114.20	1109.21	1117.76	0.002771	15.14	11163.53	623.28	0.63
1	217.76 AP	Floodplain	169000.00	1093.00	1111.76	1109.61	1116.54	0.004698	17.55	9631.85	642.30	0.80
1	217.75 AP	Floodway	169000.00	1093.00	1111.77	1109.61	1116.55	0.004695	17.53	9639.93	642.35	0.80
1	217.71	Floodplain	169000.00	1092.00	1111.42	1108.12	1115.32	0.003993	15.85	10659.50	691.20	0.71
1	217.71	Floodway	169000.00	1092.00	1111.43	1108.12	1115.33	0.003991	15.84	10669.79	691.26	0.71
1	217.66	Floodplain	169000.00	1089.30	1110.70	1107.32	1114.25	0.003491	15.11	11181.92	747.27	0.69
1	217.66	Floodway	169000.00	1089.30	1110.72	1107.32	1114.26	0.003476	15.09	11196.61	747.35	0.69
1	217.62	Floodplain	169000.00	1090.00	1110.67	1105.77	1113.28	0.002421	12.97	13033.59	831.22	0.58
1	217.62	Floodway	169000.00	1090.00	1110.69	1105.77	1113.30	0.002410	12.95	13050.95	831.27	0.58
1	217.57	Floodplain	169000.00	1091.00	1110.19	1105.43	1112.54	0.002363	12.32	13717.42	927.48	0.56
1	217.57	Floodway	169000.00	1091.00	1110.21	1105.43	1112.56	0.002350	12.30	13740.29	927.54	0.56
1	217.53	Floodplain	169000.00	1091.50	1110.10	1104.33	1111.98	0.001809	11.01	15343.48	1008.71	0.50
1	217.53	Floodway	169000.00	1091.50	1110.12	1104.33	1112.00	0.001799	11.00	15369.71	1008.78	0.50
1	217.48	Floodplain	169000.00	1091.00	1109.67	1104.03	1111.51	0.001813	10.88	15532.02	1045.77	0.50
1	217.48	Floodway	169000.00	1091.00	1109.70	1104.03	1111.53	0.001801	10.86	15562.66	1045.89	0.50
1	217.43	Floodplain	169000.00	1091.00	1109.10	1103.87	1111.04	0.001986	11.20	15090.72	1041.52	0.52
1	217.43	Floodway	169000.00	1091.00	1109.13	1103.87	1111.07	0.001970	11.17	15127.09	1041.64	0.52
1	217.38	Floodplain	169000.00	1089.00	1108.65	1102.99	1110.50	0.001824	10.93	15463.51	1037.62	0.50
1	217.38	Floodway	169000.00	1089.00	1108.69	1102.99	1110.53	0.001809	10.90	15504.56	1037.98	0.50
1	217.34	Floodplain	169000.00	1086.21	1108.19	1102.39	1110.04	0.001784	10.92	15478.82	1022.45	0.49
1	217.34	Floodway	169000.00	1086.21	1108.23	1102.39	1110.07	0.001767	10.89	15524.38	1022.64	0.49
1	217.29 AD	Floodplain	169000.00	1085.00	1107.75	1101.80	1109.61	0.001754	10.95	15439.97	1008.13	0.49
1	217.29 AD	Floodway	169000.00	1085.00	1107.80	1101.80	1109.65	0.001738	10.91	15490.18	1008.73	0.49
1	217.24	Floodplain	169000.00	1084.46	1107.33	1101.07	1109.17	0.001661	10.90	15510.49	979.68	0.48
1	217.24	Floodway	169000.00	1084.46	1107.39	1101.07	1109.22	0.001662	10.86	15554.91	979.90	0.48
1	217.19	Floodplain	169000.00	1085.00	1106.79	1100.70	1108.72	0.001756	11.16	15150.15	955.07	0.49
1	217.19	Floodway	169000.00	1085.00	1106.86	1100.70	1108.77	0.001734	11.11	15211.01	955.31	0.49
1	217.15	Floodplain	169000.00	1083.72	1106.64	1099.02	1108.30	0.001337	10.34	16340.29	935.93	0.44
1	217.15	Floodway	169000.00	1083.72	1106.70	1099.02	1108.35	0.001321	10.30	16402.00	936.17	0.43
1	217.1	Floodplain	169000.00	1085.00	1106.26	1098.37	1107.93	0.001300	10.35	16329.61	916.89	0.43
1	217.1	Floodway	169000.00	1085.00	1106.34	1098.37	1107.99	0.001283	10.31	16394.98	917.19	0.43
1	217.05	Floodplain	169000.00	1085.00	1105.84	1098.43	1107.60	0.001415	10.64	15876.67	912.07	0.45
1	217.05	Floodway	169000.00	1085.00	1105.92	1098.43	1107.66	0.001395	10.60	15948.15	912.39	0.45
1	217	Floodplain	169000.00	1084.00	1105.39	1098.39	1107.23	0.001526	10.91	15493.22	909.73	0.47
1	217	Floodway	169000.00	1084.00	1105.47	1098.39	1107.30	0.001501	10.85	15572.64	910.12	0.46
1	216.96	Floodplain	169000.00	1082.60	1105.17	1097.14	1106.83	0.001269	10.33	16359.40	906.14	0.43
1	216.96	Floodway	169000.00	1082.60	1105.26	1097.14	1106.90	0.001248	10.26	16442.26	906.54	0.43
1	216.91	Floodplain	169000.00	1083.00	1104.84	1096.78	1106.49	0.001268	10.32	16372.64	909.25	0.43
1	216.91	Floodway	169000.00	1083.00	1104.94	1096.78	1106.57	0.001246	10.27	16461.56	909.68	0.43
1	216.85	Floodplain	169000.00	1082.00	1104.62	1095.84	1106.16	0.001116	9.95	16992.03	907.79	0.41

HEC-RAS Plan: Prop-88 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	216.86	Floodway	169000.00	1082.00	1104.73	1095.84	1106.25	0.001098	9.89	17084.69	908.25	0.40
1	216.81 AN	Floodplain	169000.00	1082.00	1104.40	1095.03	1105.87	0.001030	9.74	17349.89	898.67	0.39
1	216.81 AN	Floodway	169000.00	1082.00	1104.51	1095.03	1105.96	0.001012	9.69	17445.47	899.24	0.39
1	216.77	Floodplain	169000.00	1081.00	1104.20	1094.38	1105.60	0.000958	9.50	17784.87	907.25	0.38
1	216.77	Floodway	169000.00	1081.00	1104.31	1094.38	1105.70	0.000941	9.45	17884.92	907.88	0.38
1	216.72	Floodplain	169000.00	1081.00	1103.92	1094.40	1105.36	0.001002	9.63	17553.73	905.69	0.39
1	216.72	Floodway	169000.00	1081.00	1104.04	1094.40	1105.46	0.000983	9.57	17659.14	907.29	0.38
1	216.67	Floodplain	169000.00	1081.00	1103.37	1095.23	1105.05	0.001275	10.41	16234.48	893.54	0.43
1	216.67	Floodway	169000.00	1081.00	1103.50	1095.23	1105.15	0.001246	10.34	16350.04	894.20	0.43
1	216.62	Floodplain	169000.00	1082.00	1102.85	1095.27	1104.71	0.001380	10.64	15877.17	898.50	0.45
1	216.62	Floodway	169000.00	1082.00	1103.09	1095.27	1104.82	0.001345	10.56	16004.56	899.15	0.44
1	216.52	Floodplain	169000.00	1081.00	1102.44	1093.78	1103.99	0.001145	9.99	17006.67	994.29	0.41
1	216.52	Floodway	169000.00	1081.00	1102.59	1093.78	1104.12	0.001122	9.93	17027.67	915.02	0.41
1	216.505		Bridge									
1	216.49	Floodplain	169000.00	1079.00	1101.27	1093.20	1102.92	0.001270	10.31	16454.24	1001.34	0.43
1	216.49	Floodway	169000.00	1079.00	1102.17	1093.20	1103.67	0.001085	9.82	17212.99	914.35	0.40
1	216.42 AM	Floodplain	169000.00	1078.00	1100.93	1092.48	1102.46	0.001173	9.92	17053.81	885.02	0.41
1	216.42 AM	Floodway	169000.00	1078.00	1101.90	1092.48	1103.28	0.000993	9.42	17943.54	951.11	0.38
1	216.38	Floodplain	169000.00	1078.00	1100.76	1091.96	1102.19	0.001074	9.59	17644.22	986.08	0.40
1	216.38	Floodway	169000.00	1078.00	1101.78	1091.96	1103.04	0.000906	9.09	18597.83	971.24	0.37



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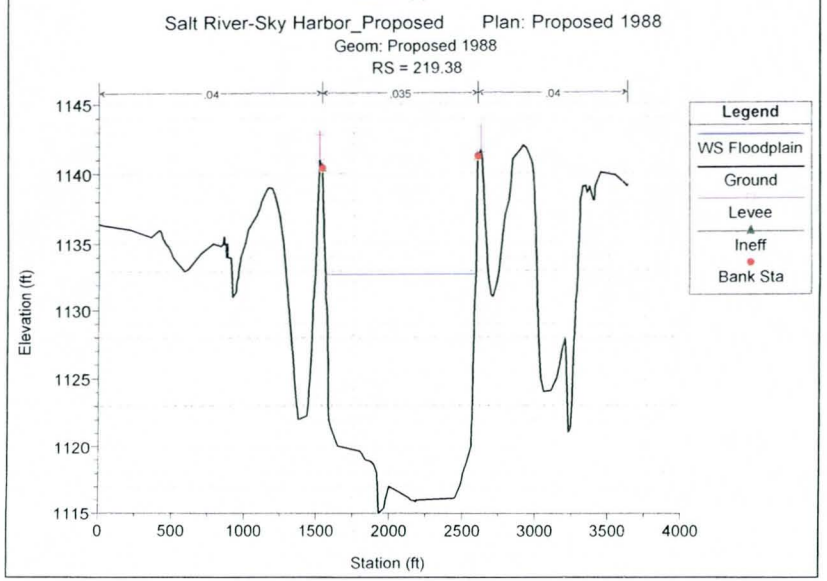
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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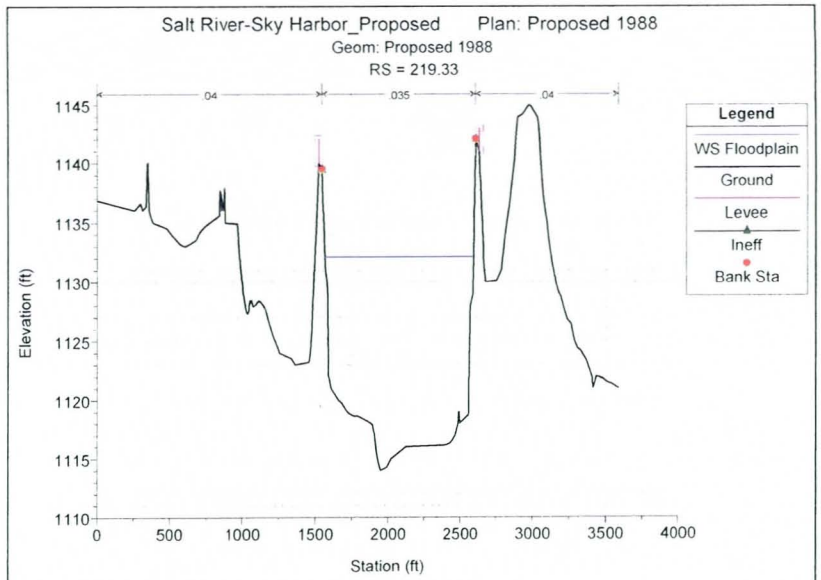
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 219.33
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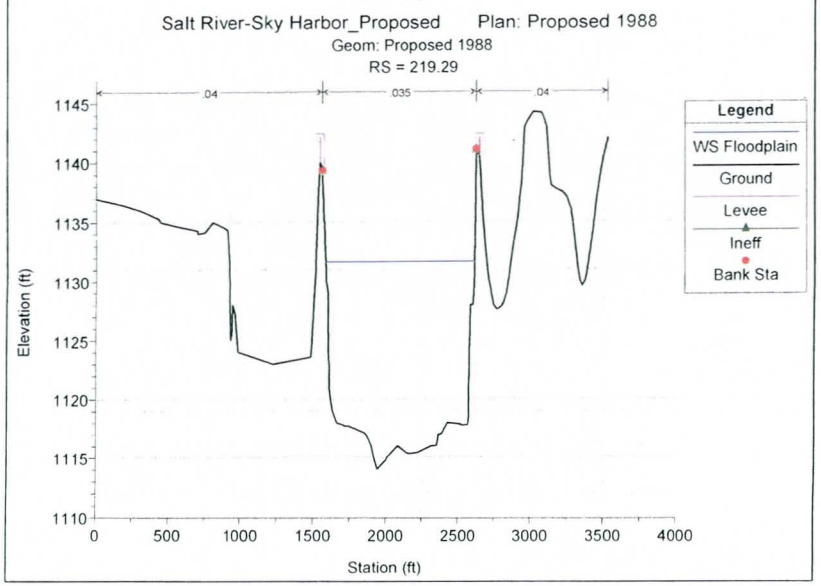
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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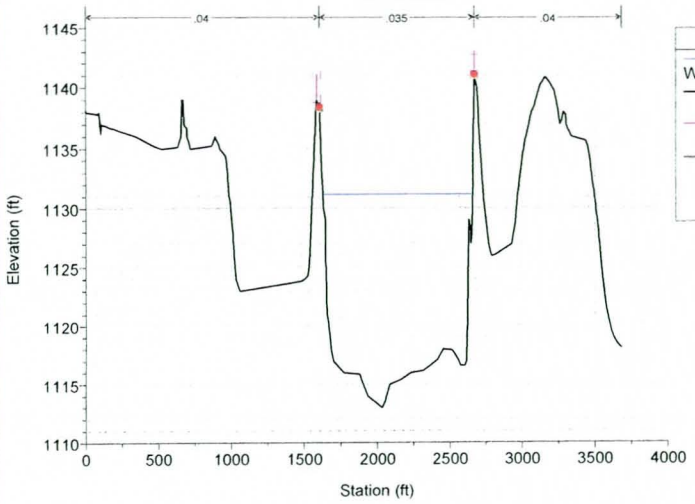
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Levee
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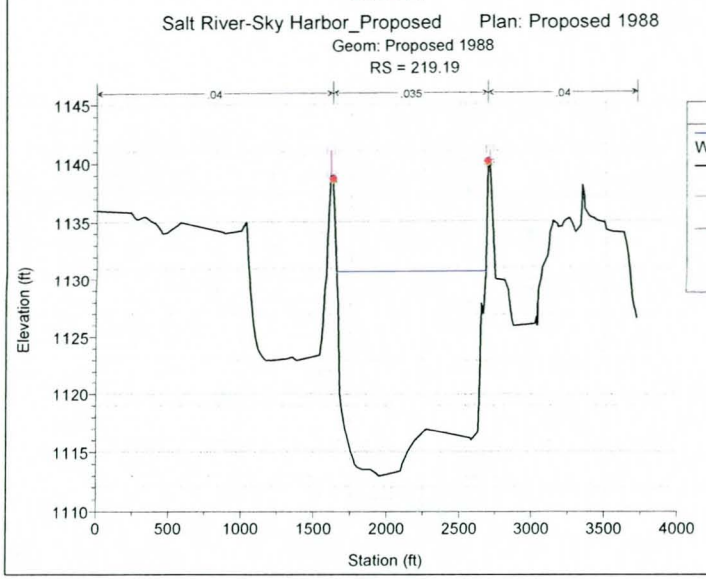
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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Levee
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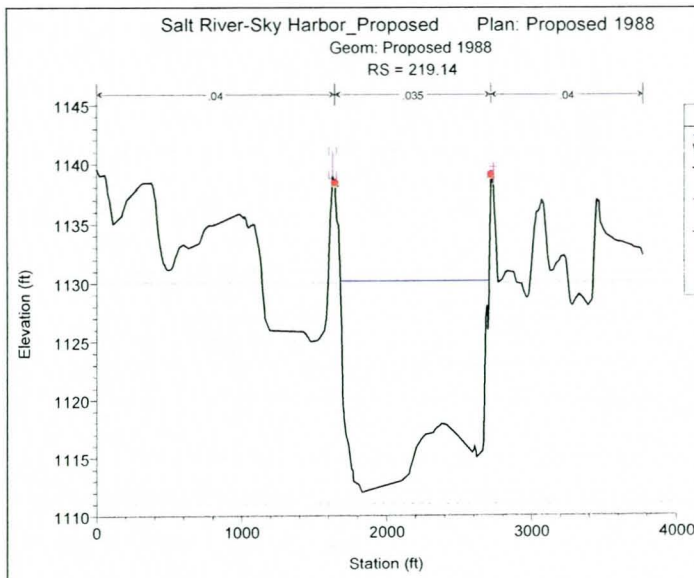
Bank Sta
Elevation (ft)
Station (ft)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Levee
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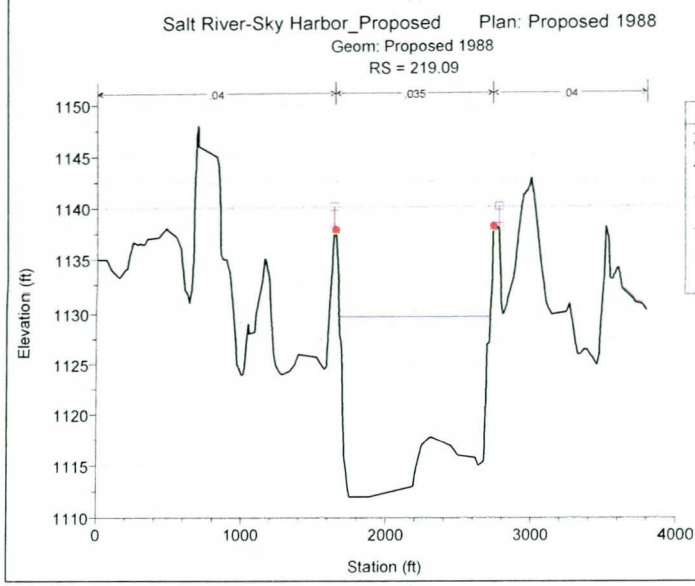
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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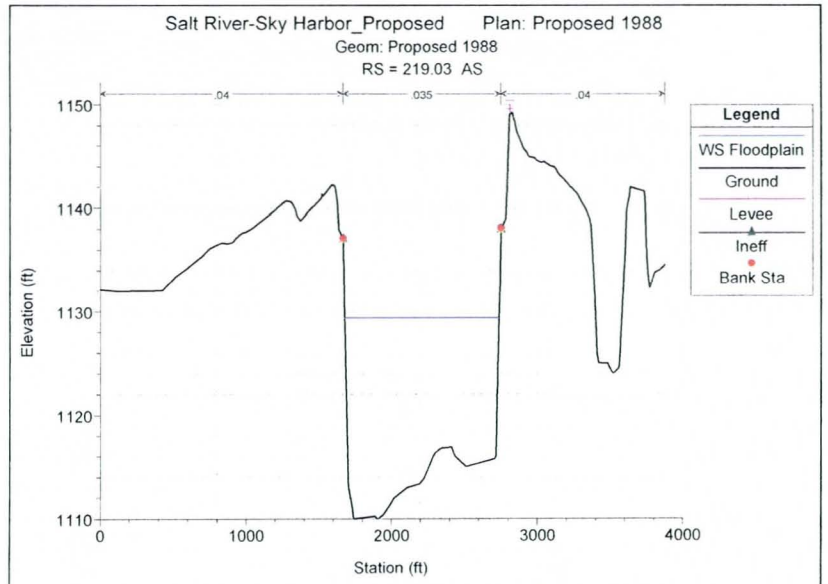
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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Legend
WS Floodplain
Ground
Levee
Ineff
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Elevation (ft)
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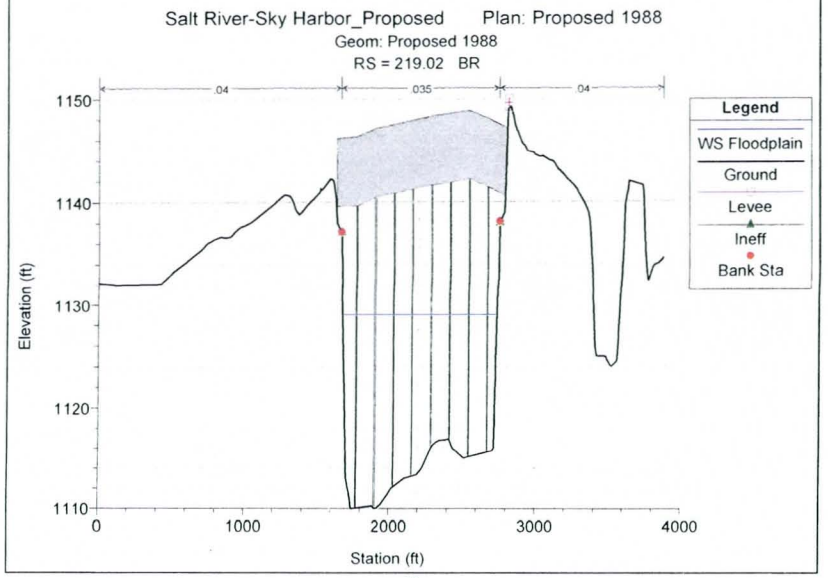
3000
4000
Station (ft)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RS = 219.02 BR
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WS Floodplain
Ground
Levee
Ineff
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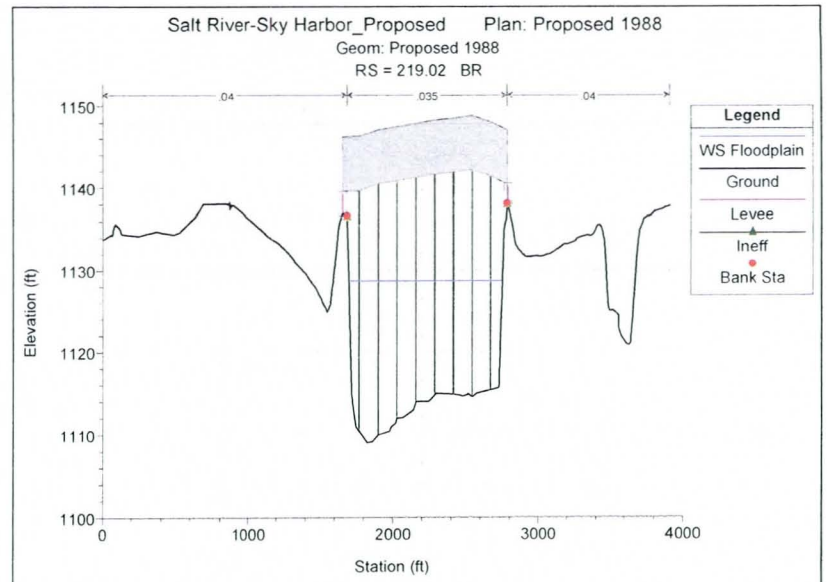
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 219.02 BR
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WS Floodplain
Ground
Levee
Ineff
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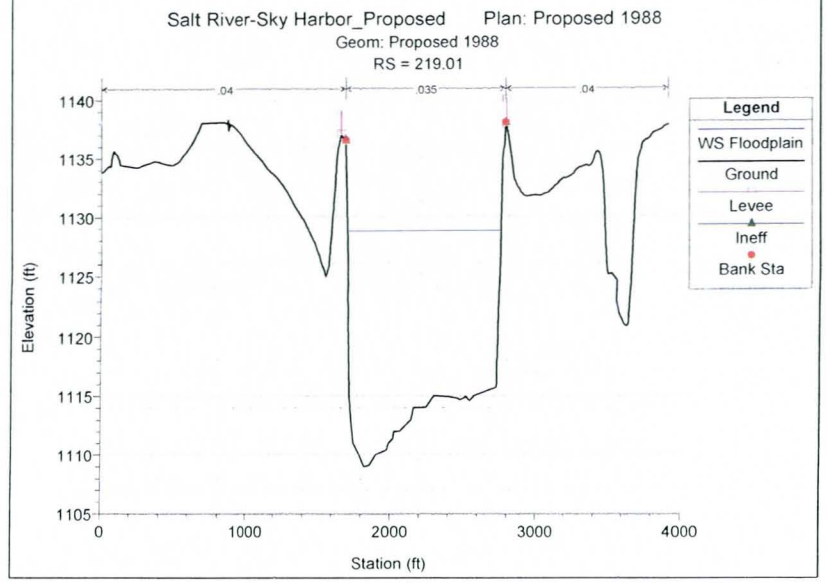
Station (ft)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WS Floodplain
Ground
Levee
Ineff
Bank Sta
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3000
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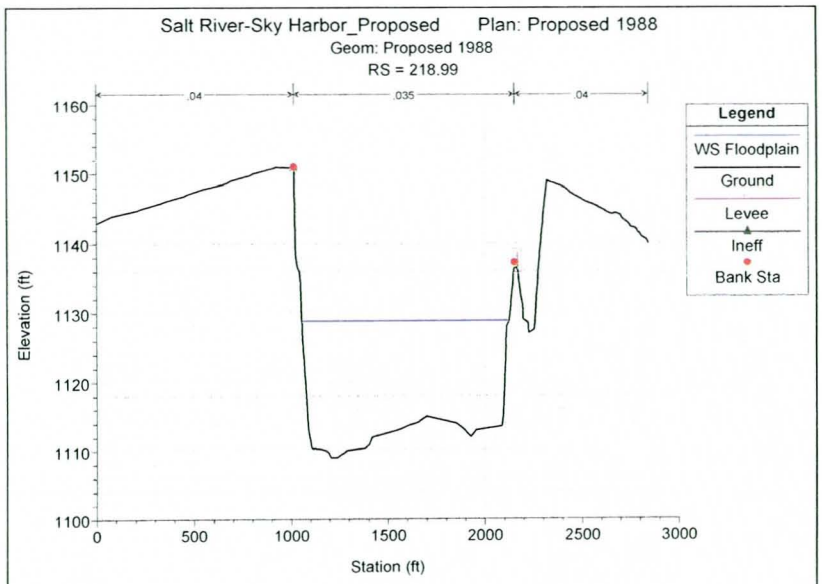
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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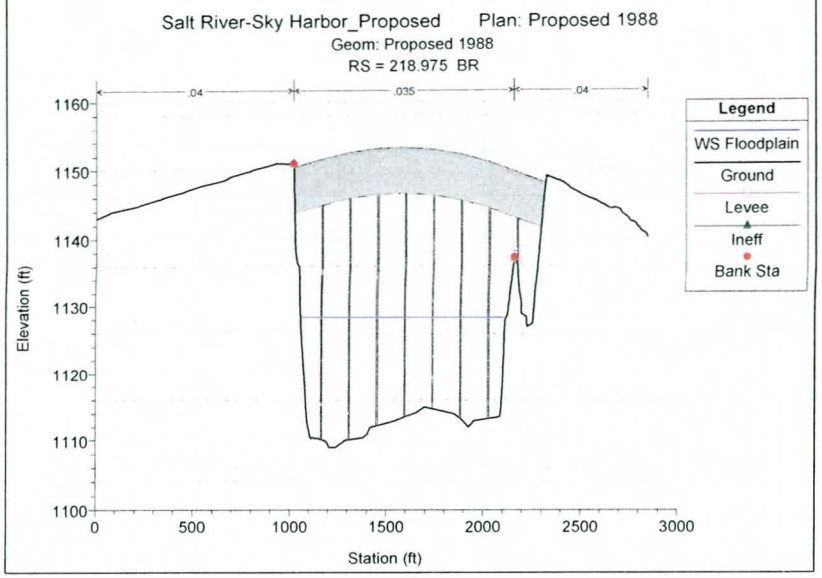
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
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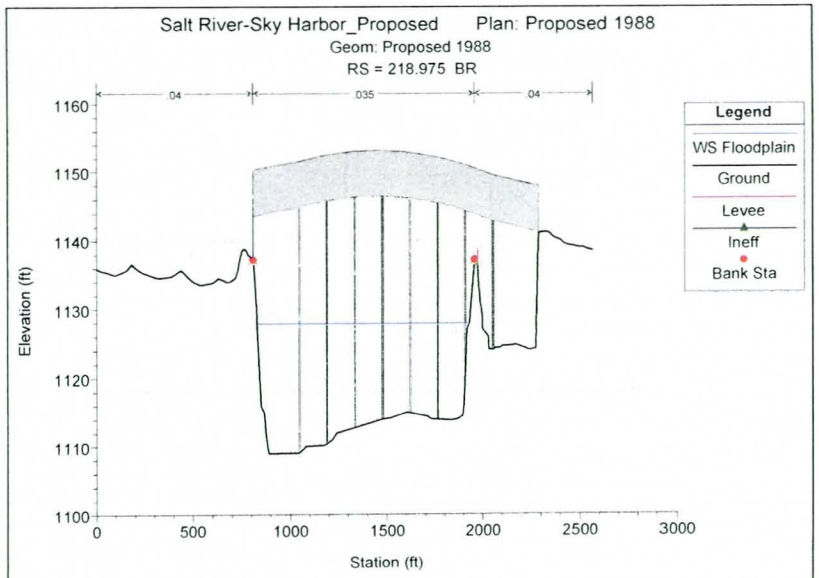
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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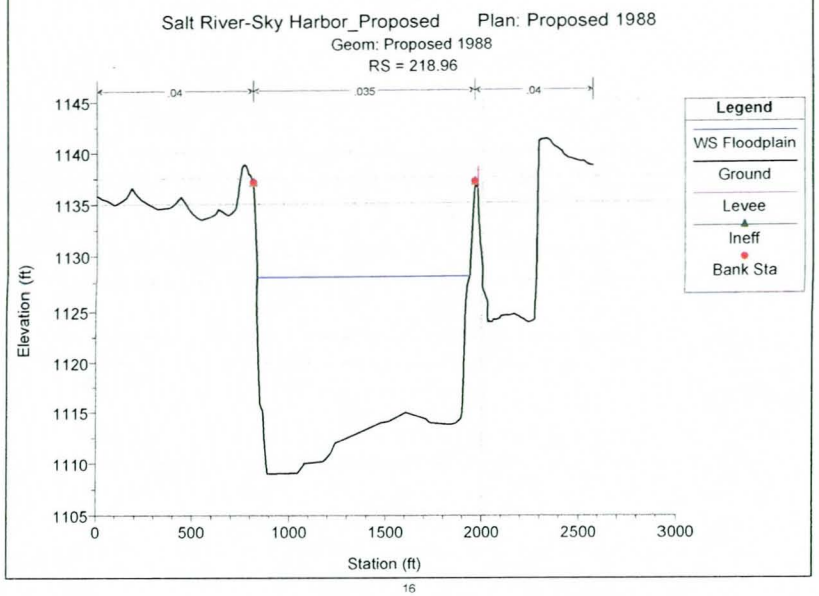
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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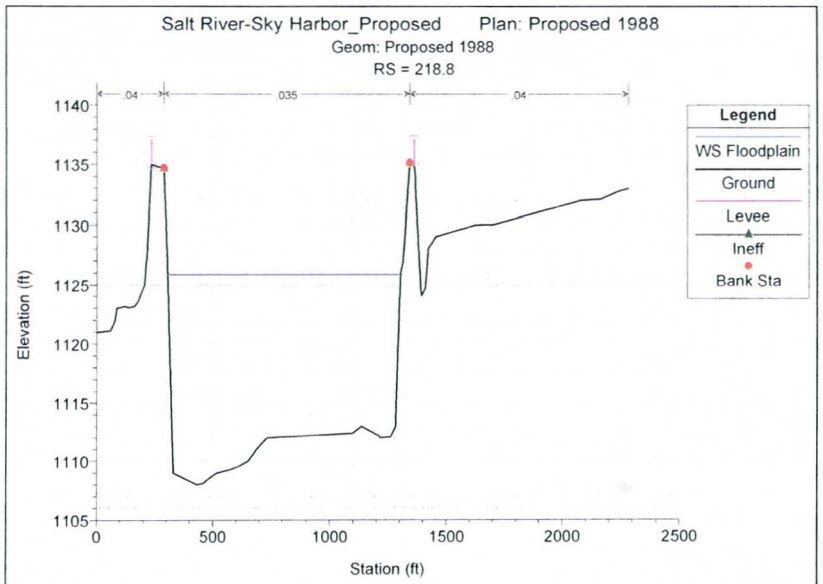
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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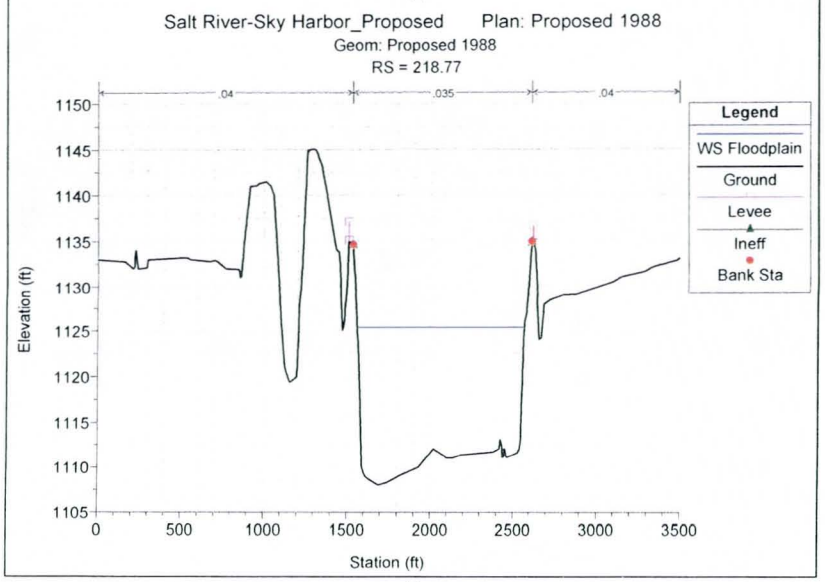
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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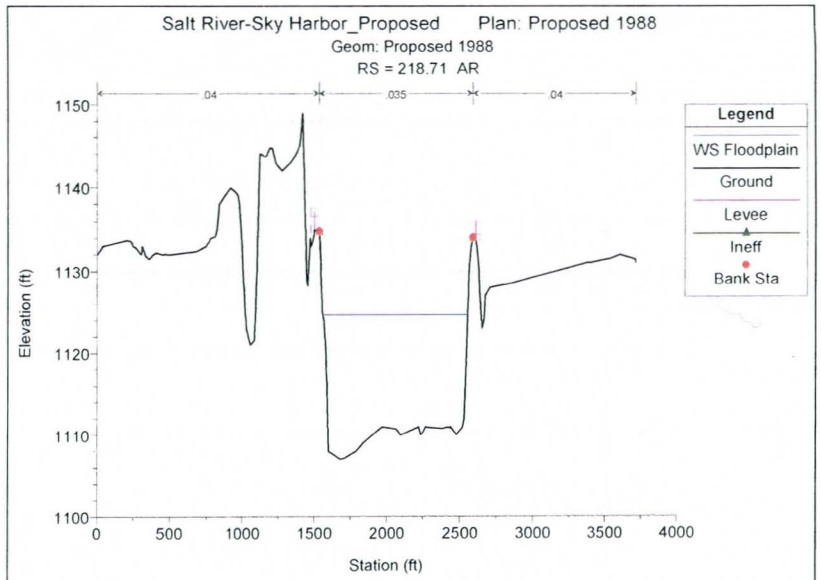
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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Levee
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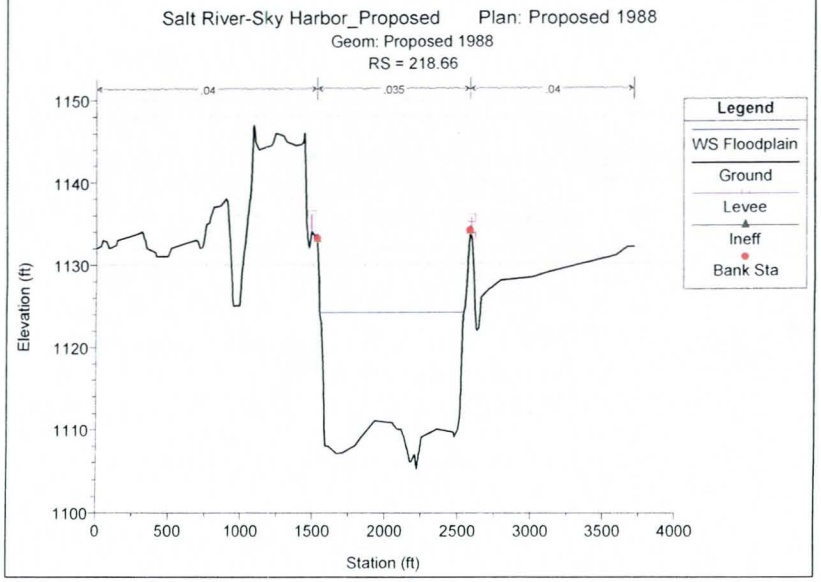
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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Ground
Levee
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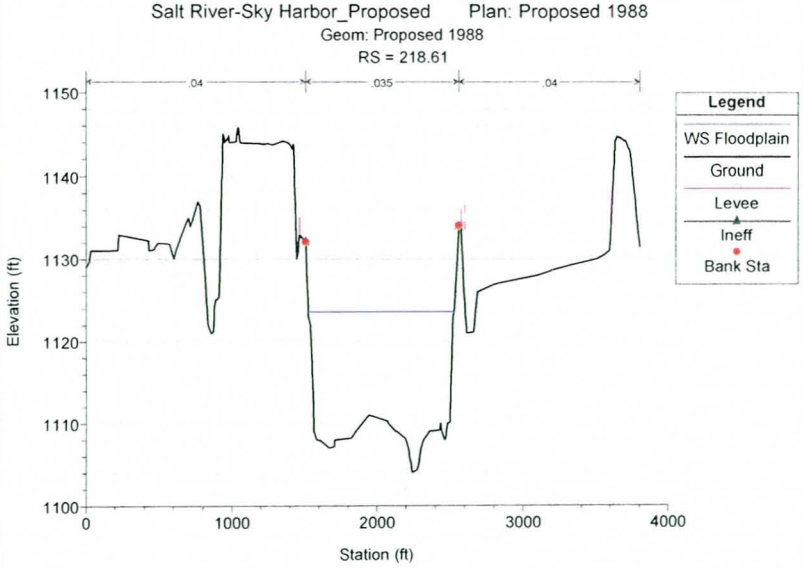
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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WS Floodplain
Ground
Levee
Ineff
Bank Sta
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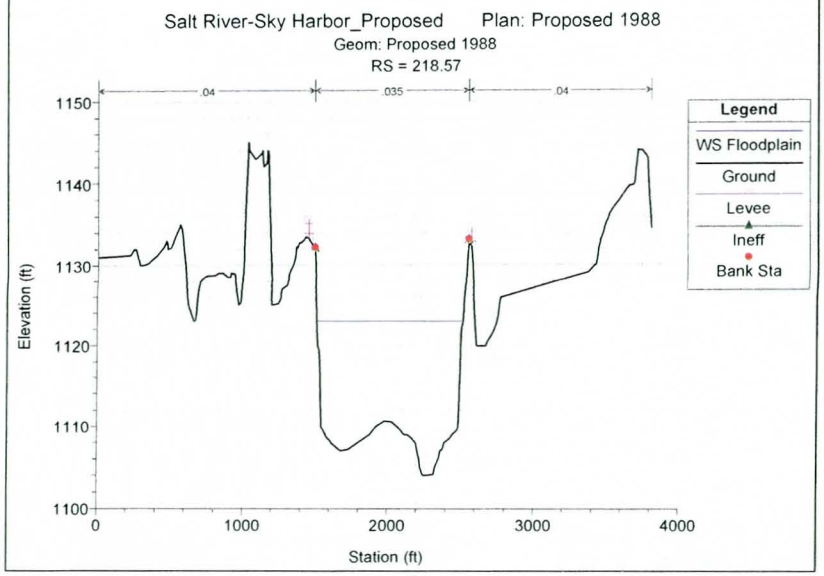
3000
4000
Station (ft)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Levee
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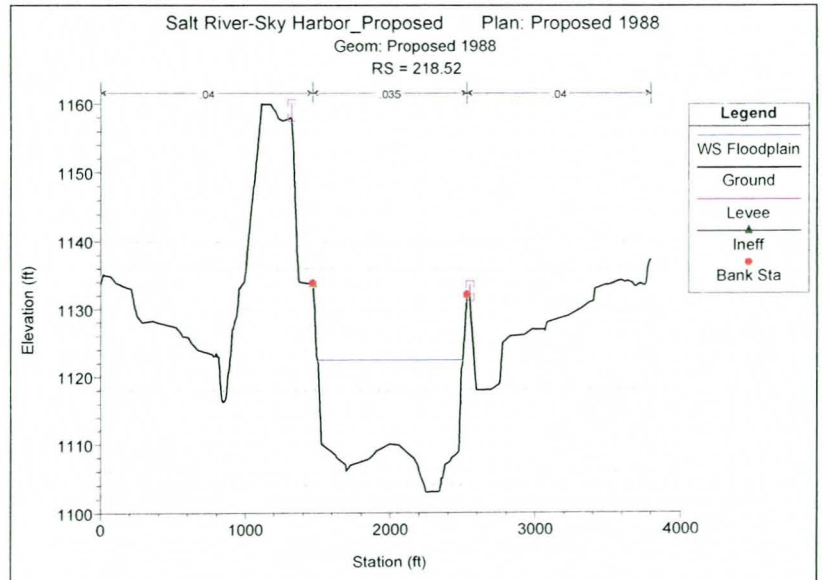
Station (ft)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Geom: Proposed 1988
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WS Floodplain
Ground
Levee
Ineff
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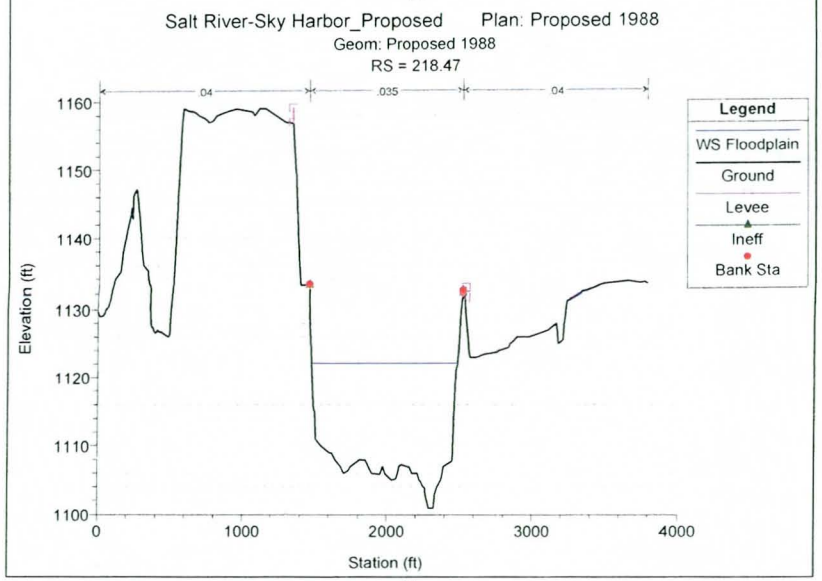
Station (ft)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Geom: Proposed 1988
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Levee
Ineff
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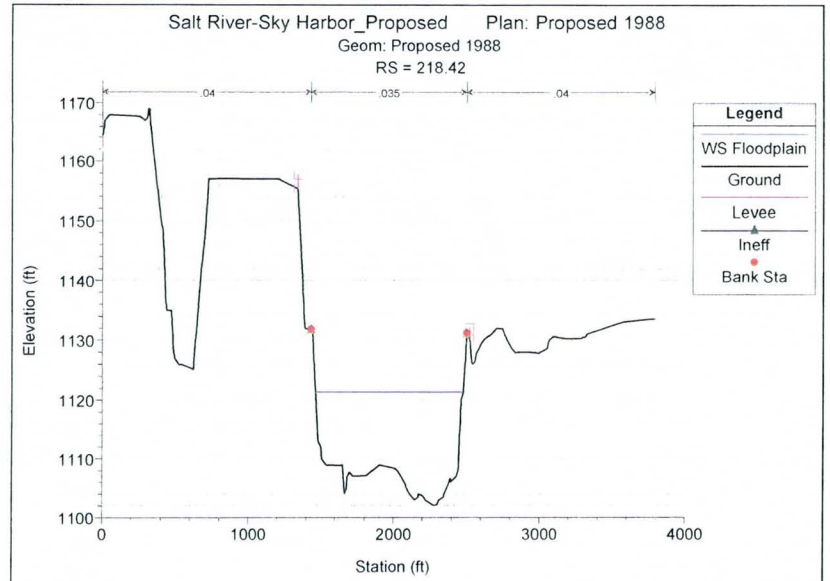
Station (ft)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Levee
Ineff
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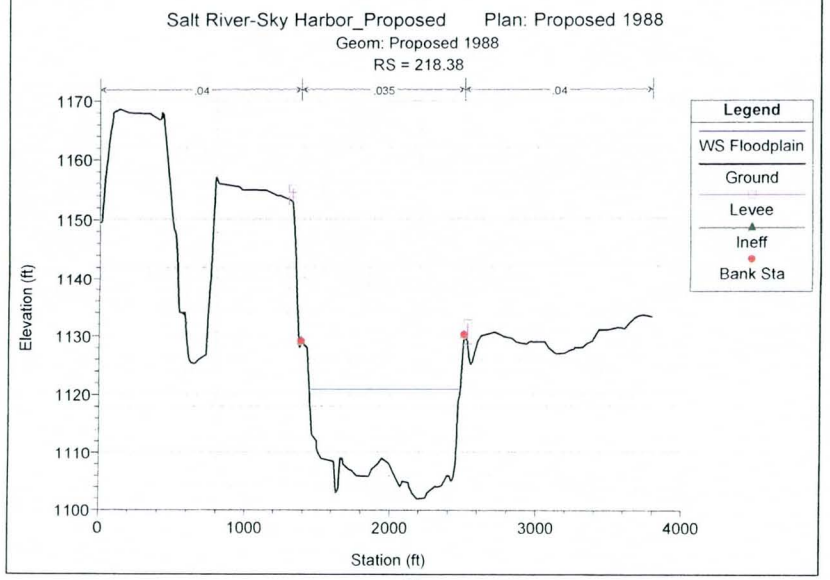
Station (ft)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Geom: Proposed 1988
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WS Floodplain
Ground
Levee
Ineff
Bank Sta
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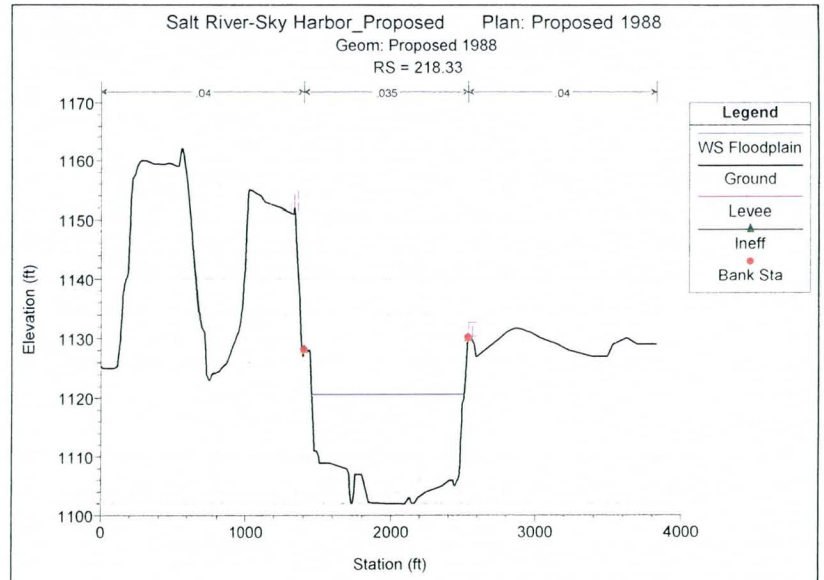
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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Legend
WS Floodplain
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Levee
Ineff
Bank Sta
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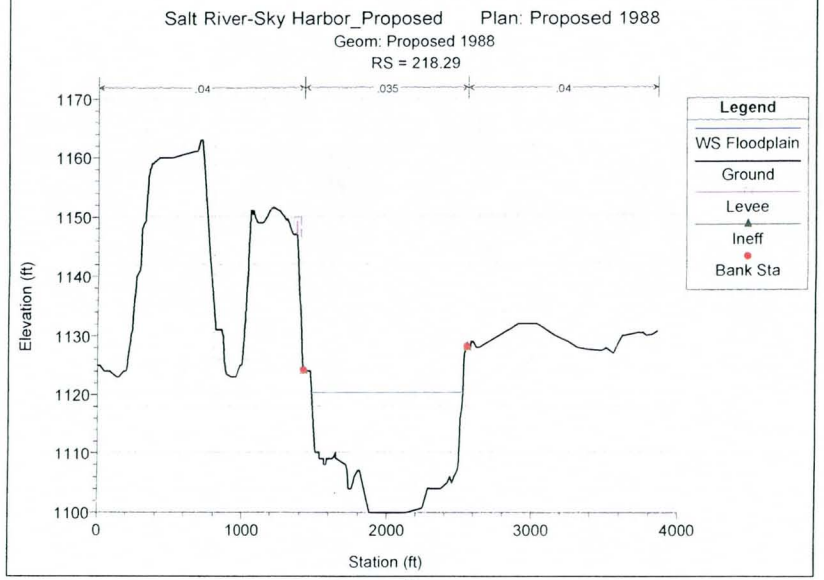
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 218.29
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Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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1100
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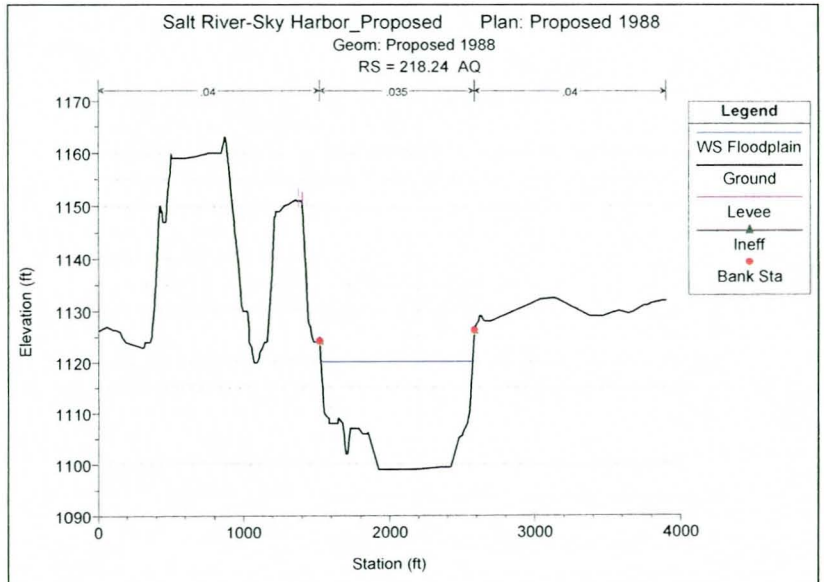
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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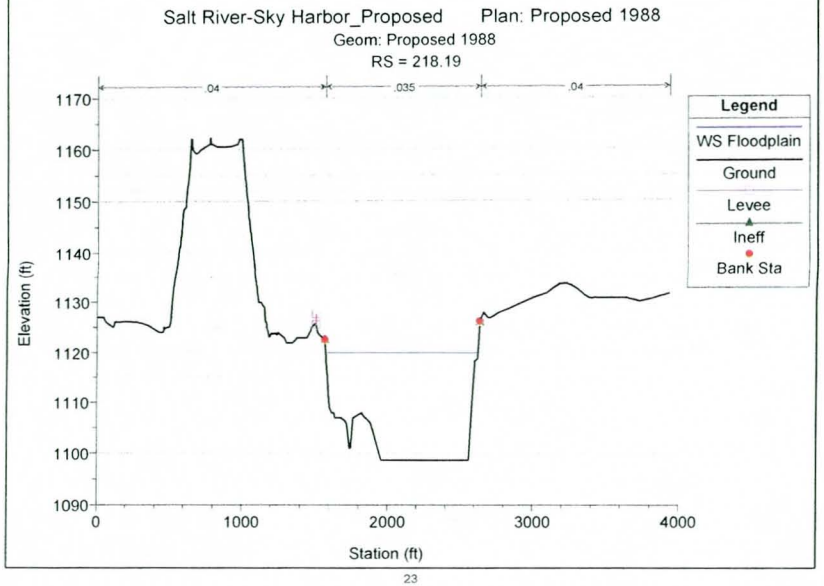
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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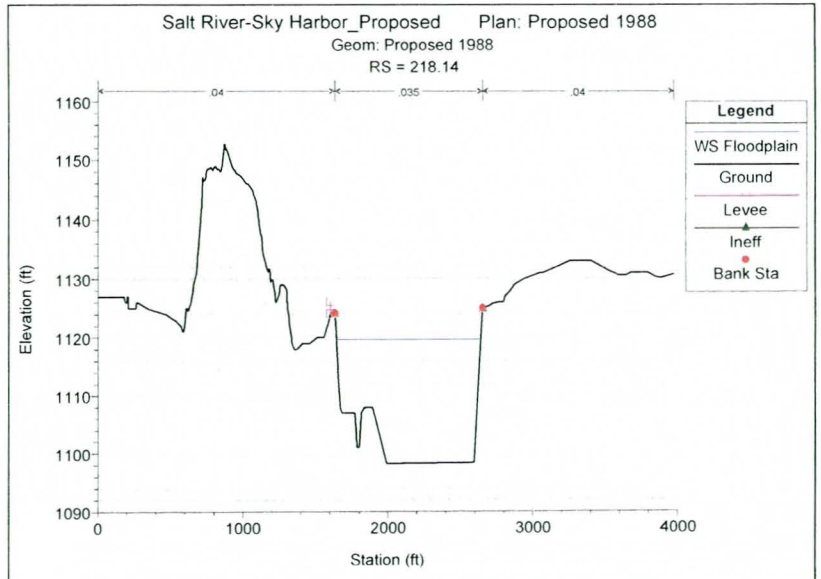
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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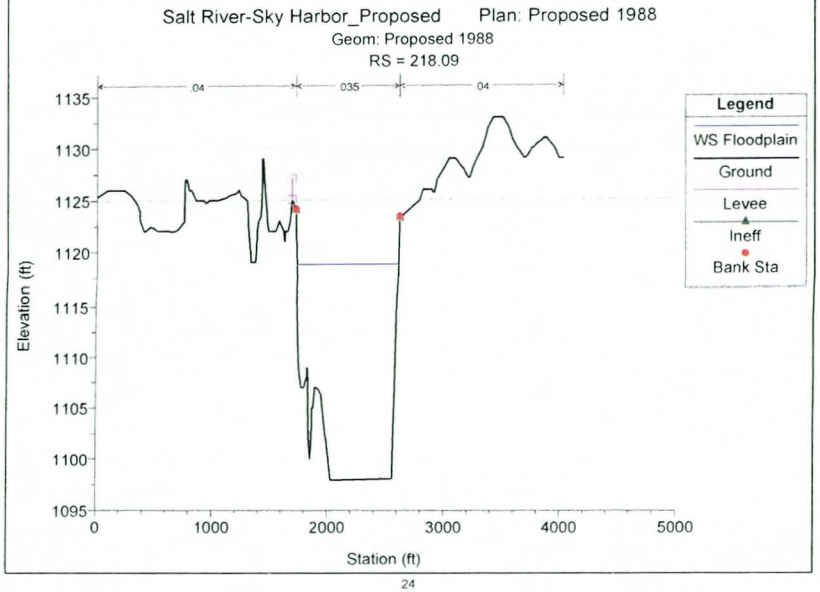
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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Legend
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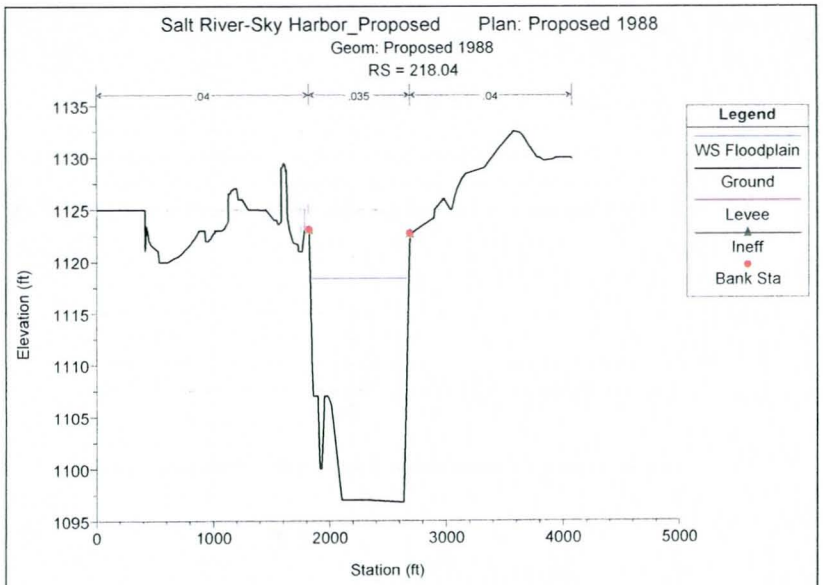
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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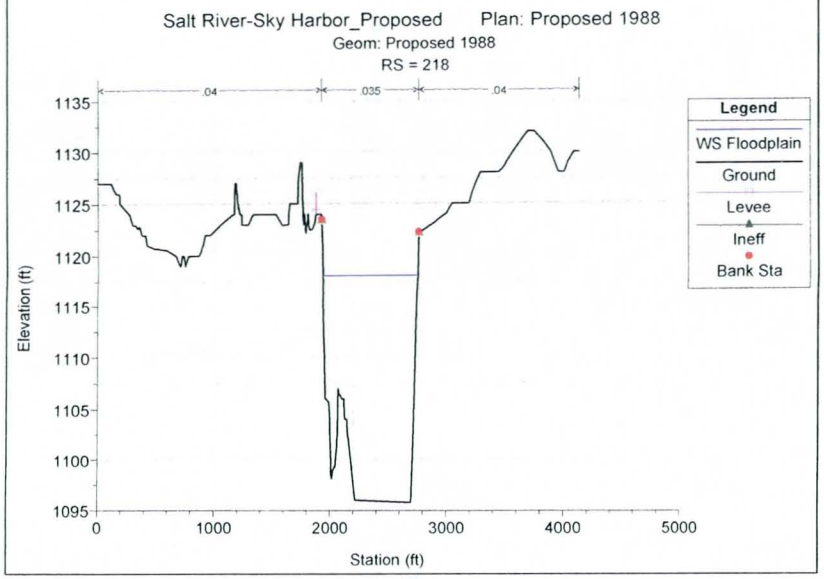
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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Legend
WS Floodplain
Ground
Levee
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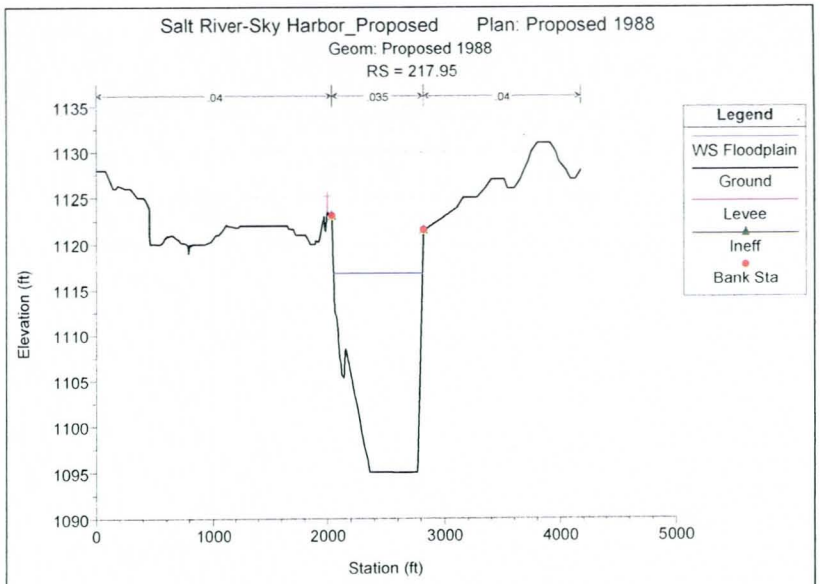
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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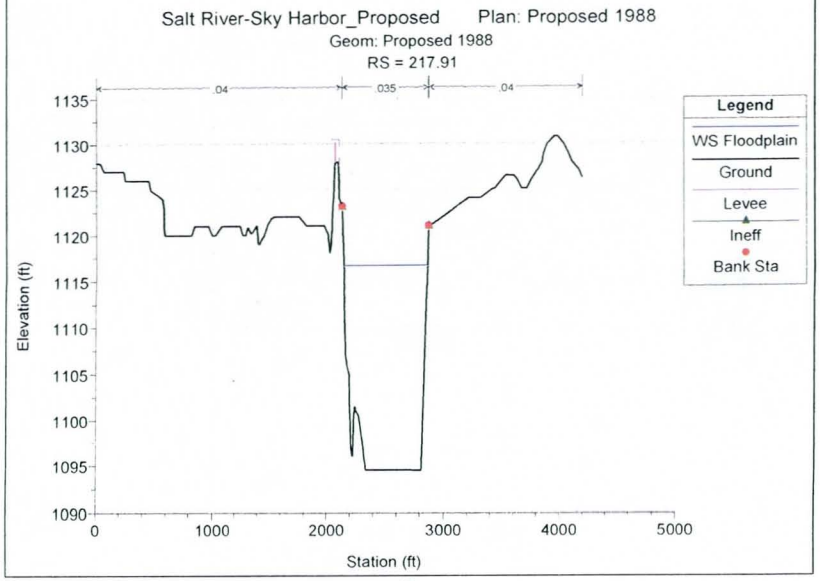
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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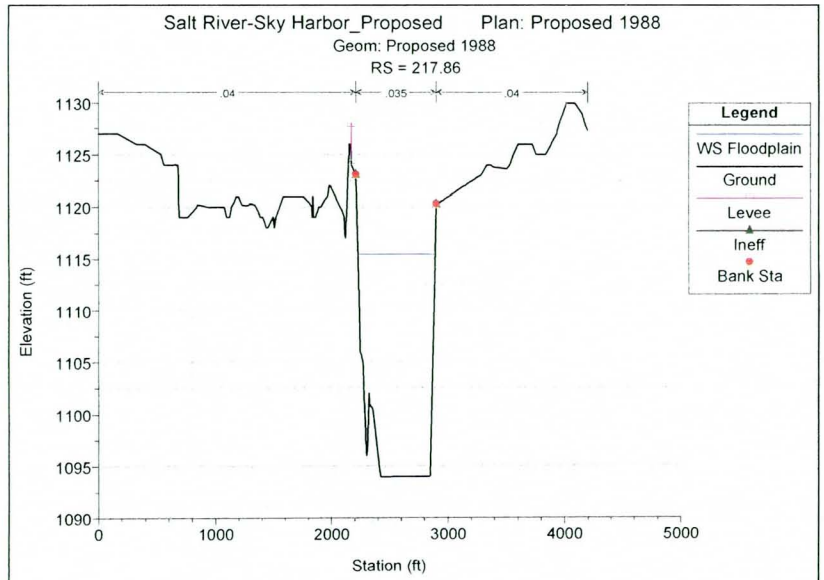
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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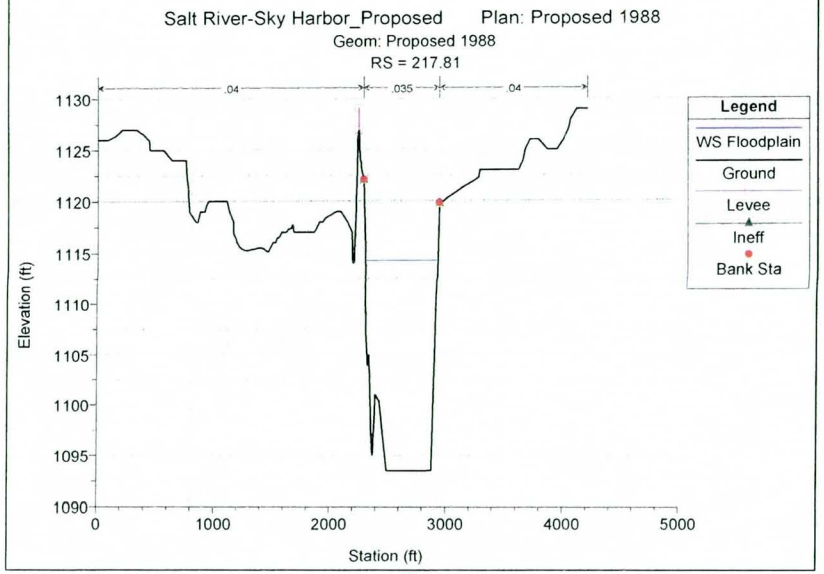
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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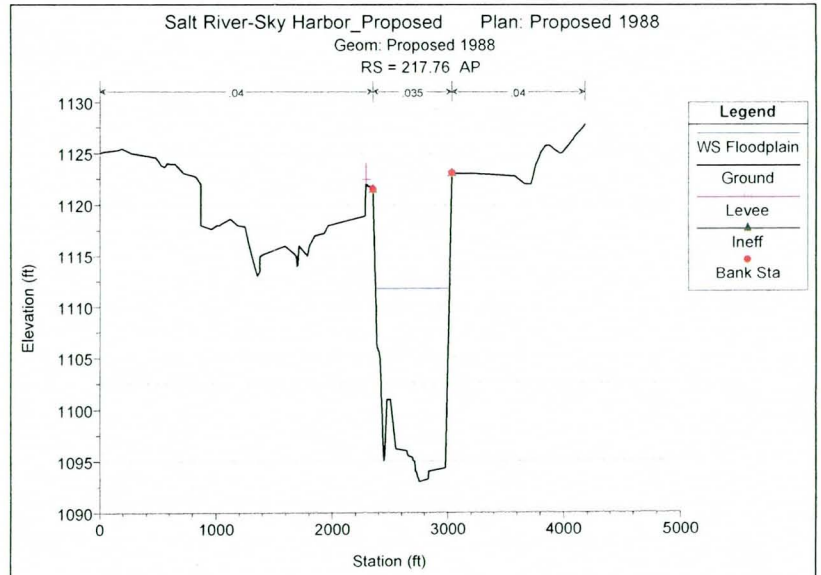
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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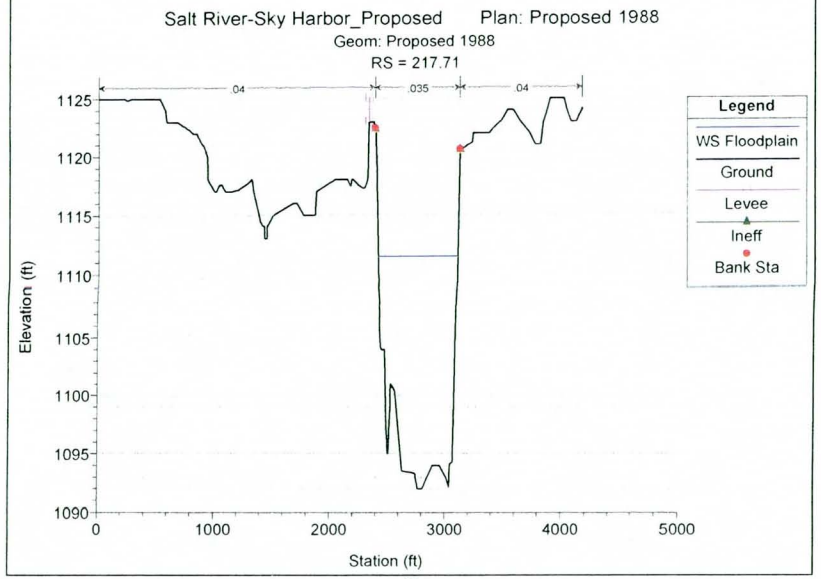
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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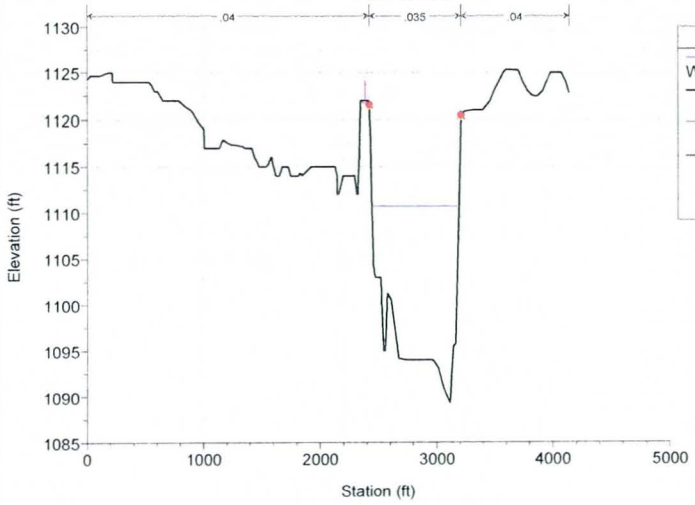
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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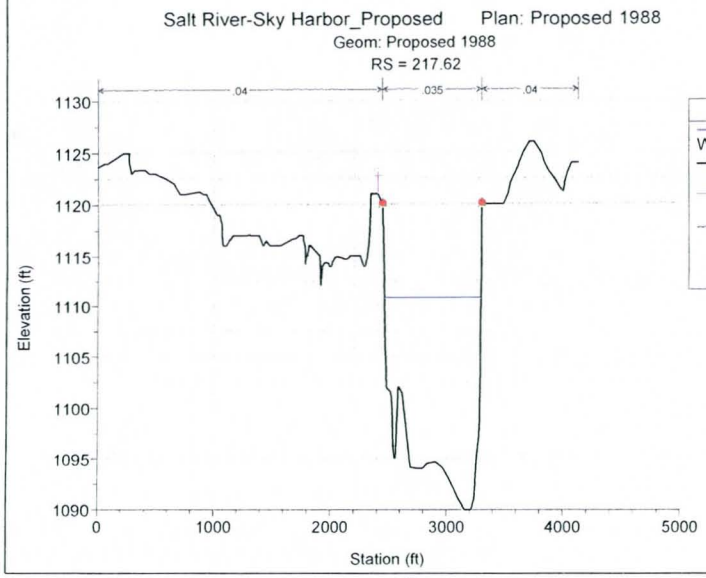
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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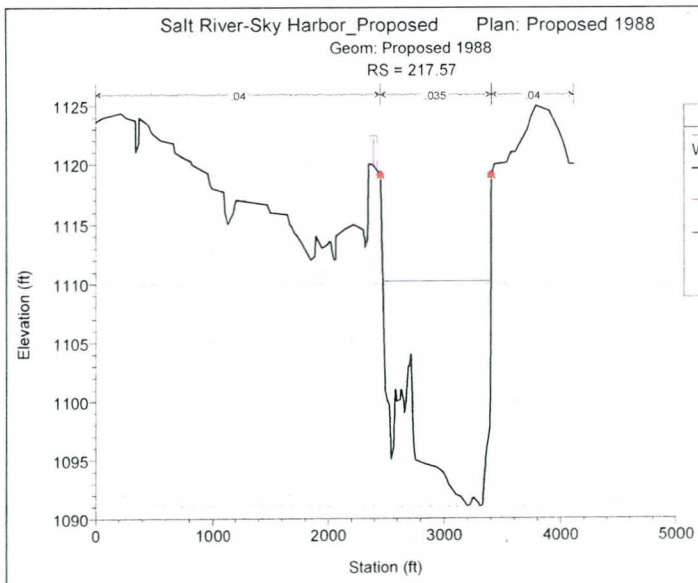
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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Ground
Levee
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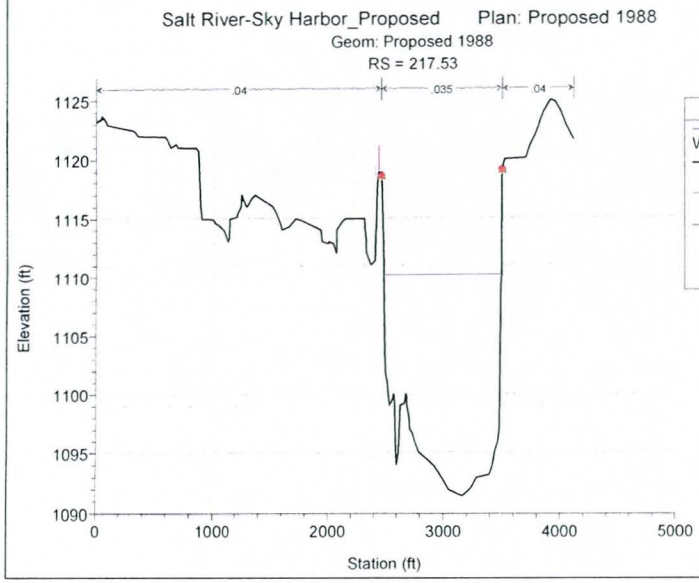
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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.04
Legend
WS Floodplain
Ground
Levee
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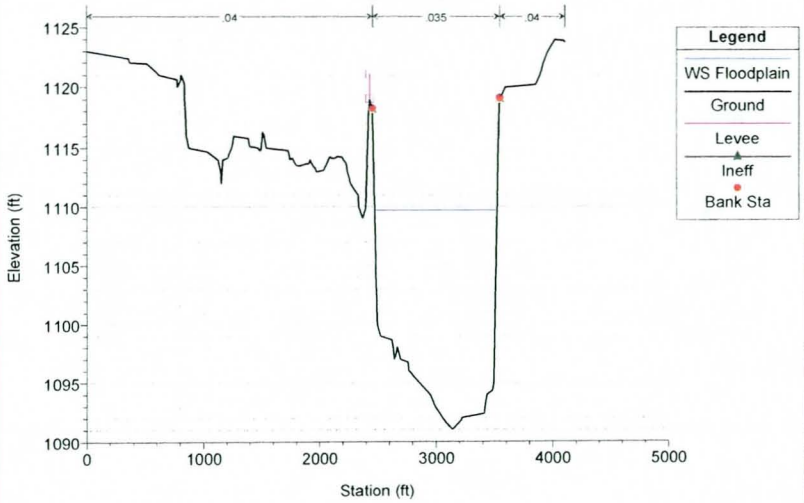
Bank Sta
Elevation (ft)
Station (ft)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Geom: Proposed 1988
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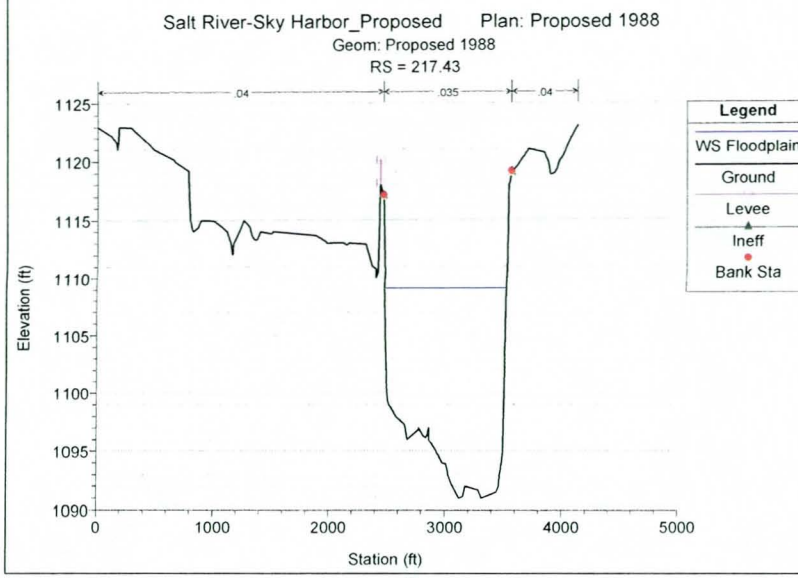
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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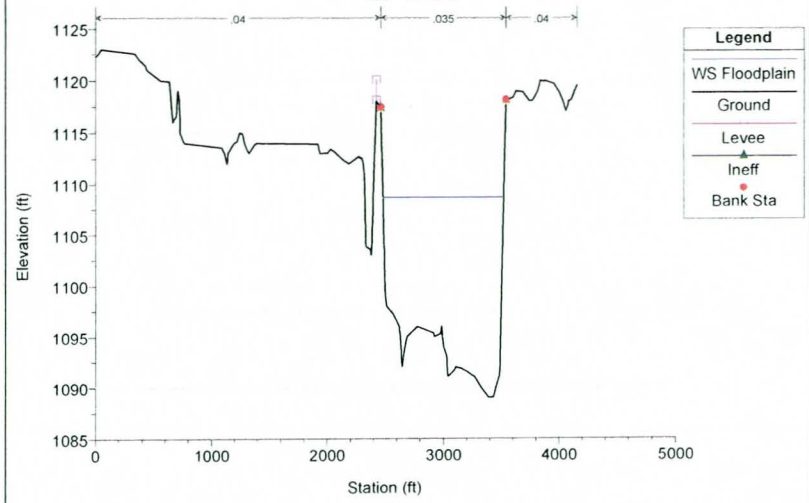
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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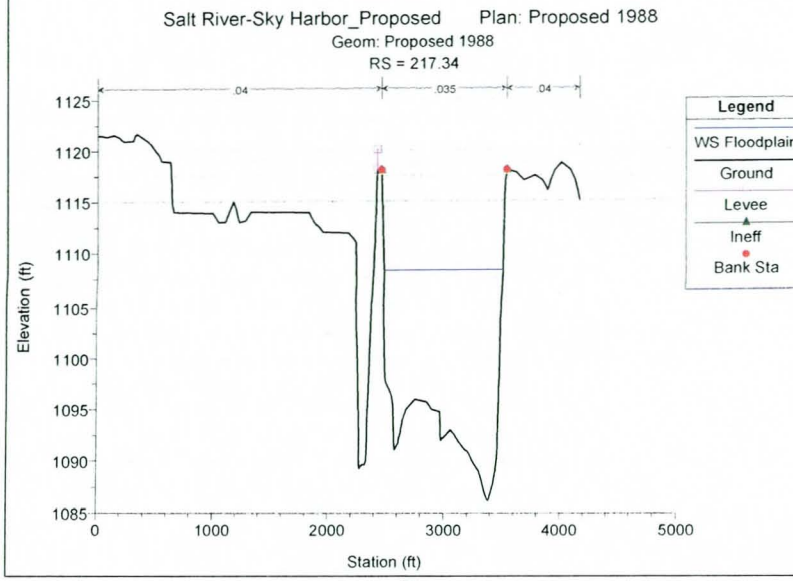
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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Legend
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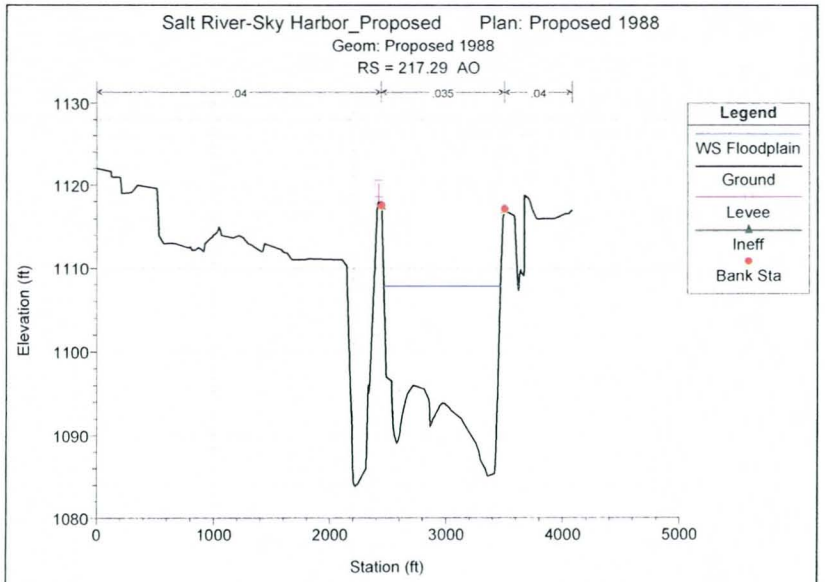
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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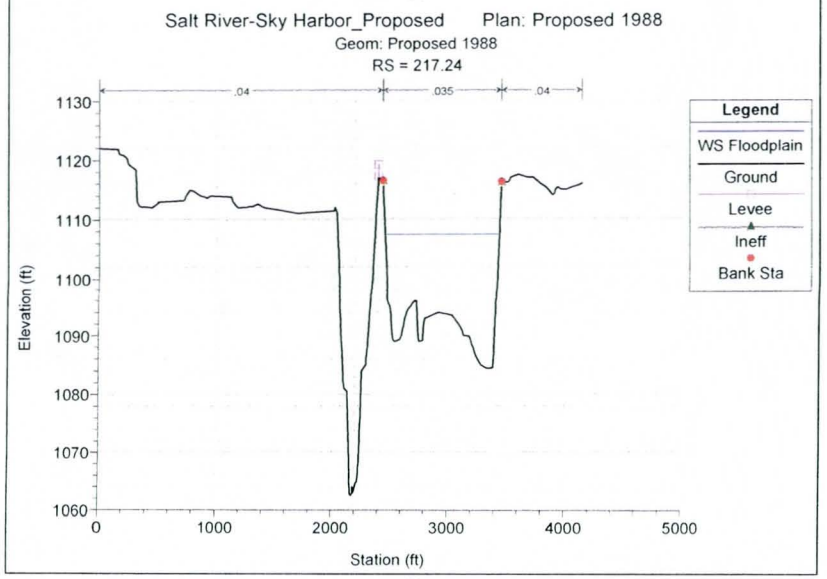
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 217.24
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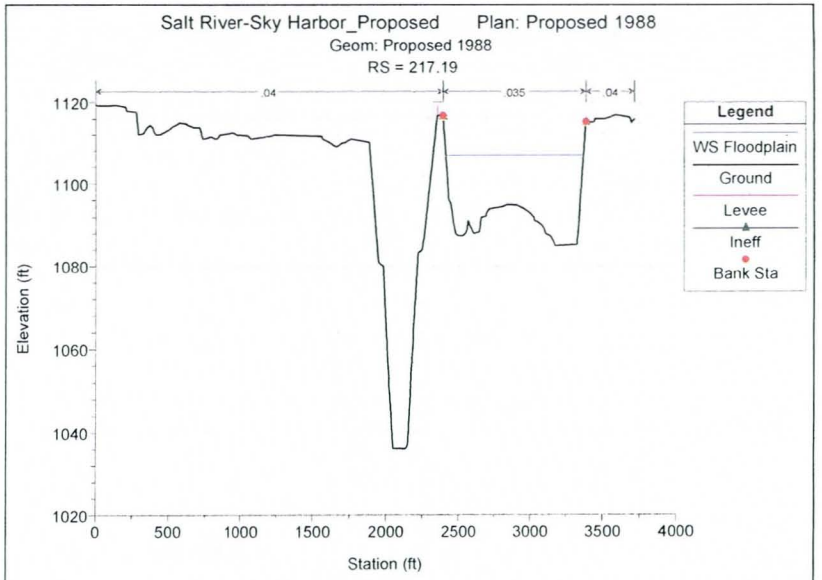
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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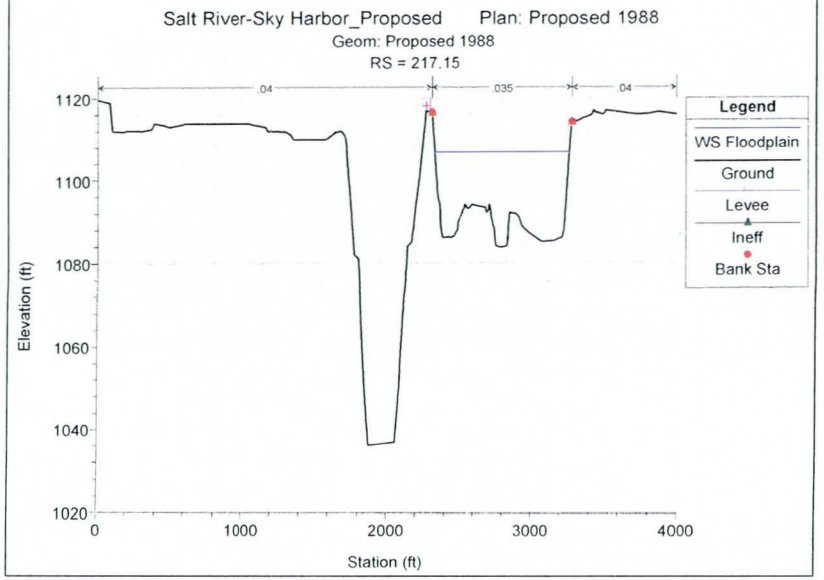
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
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.04
Legend
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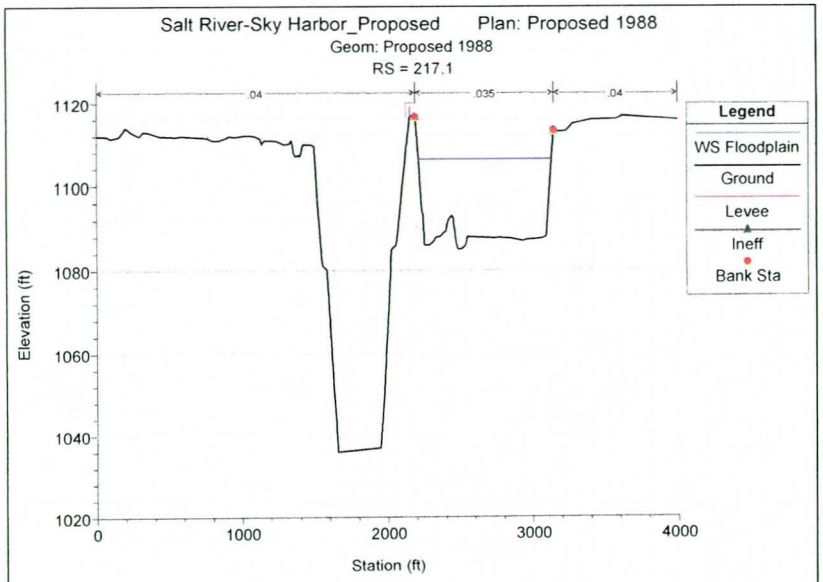
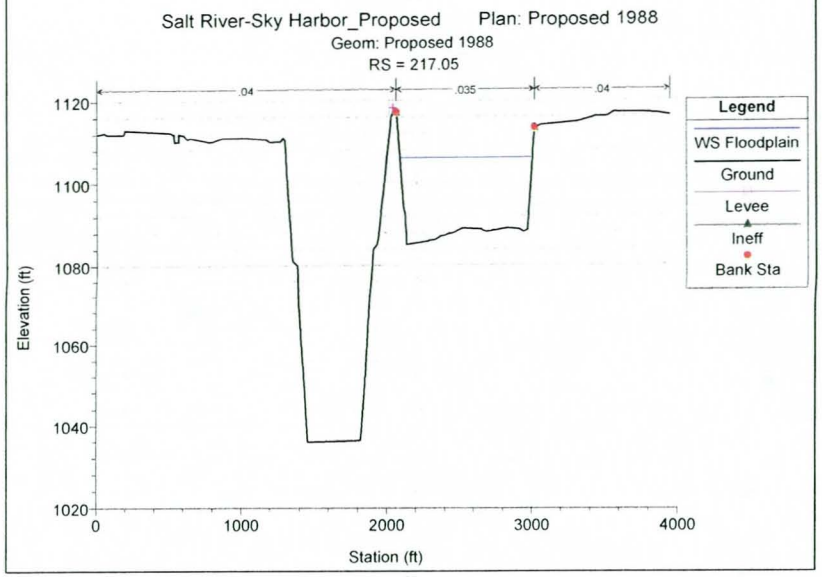
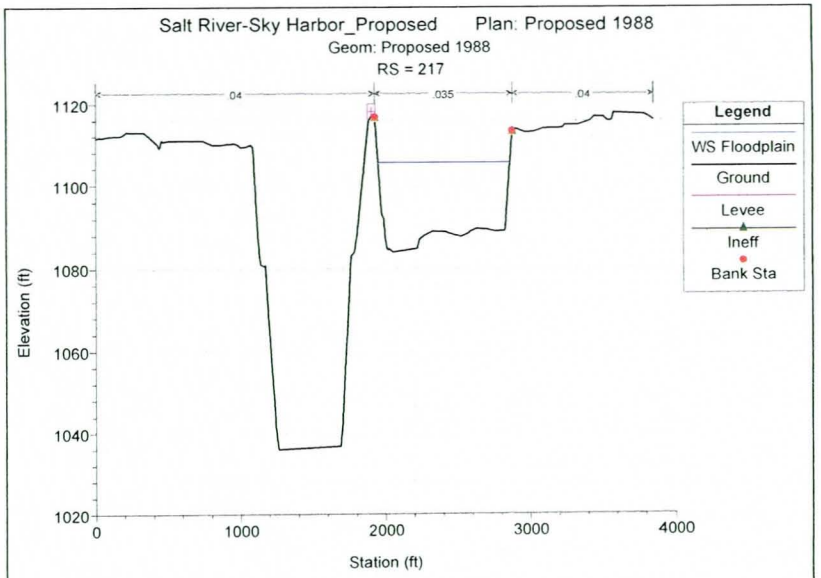
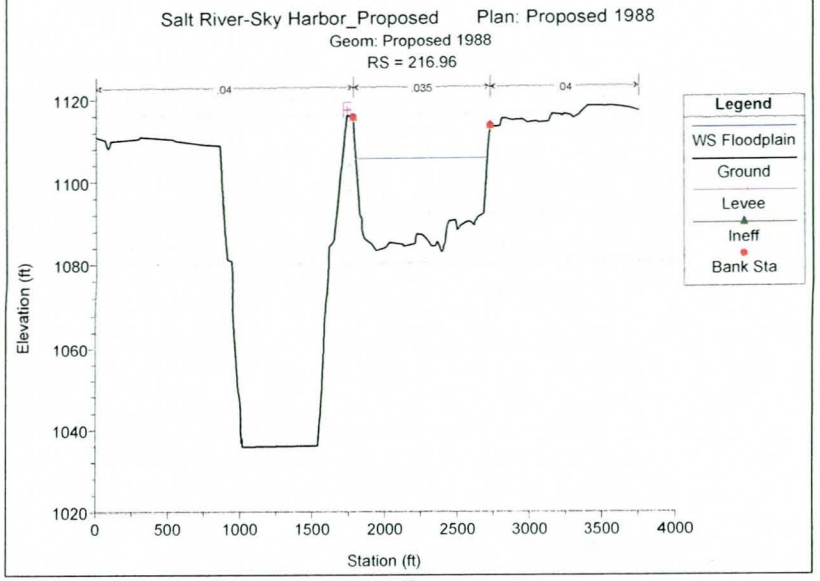
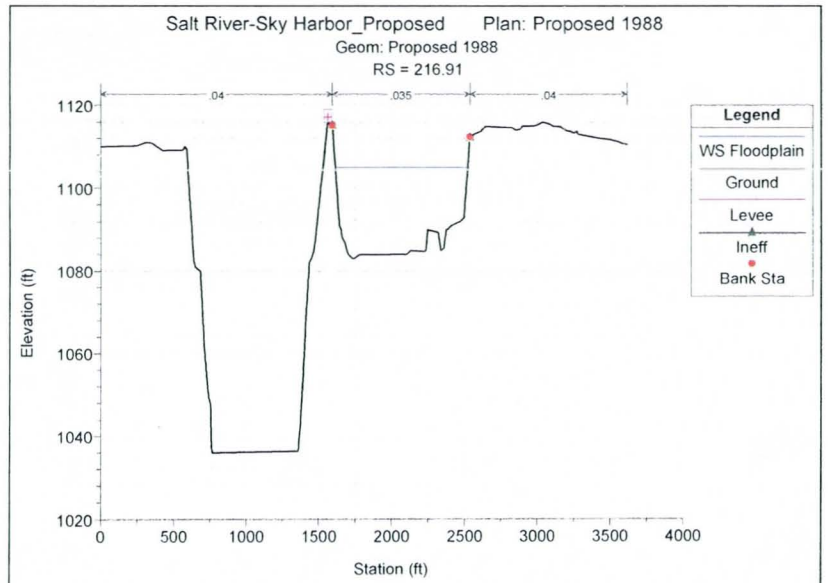
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 217.1
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
1000
2000
3000
4000
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 217.05
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
1000
2000
3000
4000
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 217
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
1000
2000
3000
4000
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.96
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
500
1000
1500
2000
2500
3000
3500
4000
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.91
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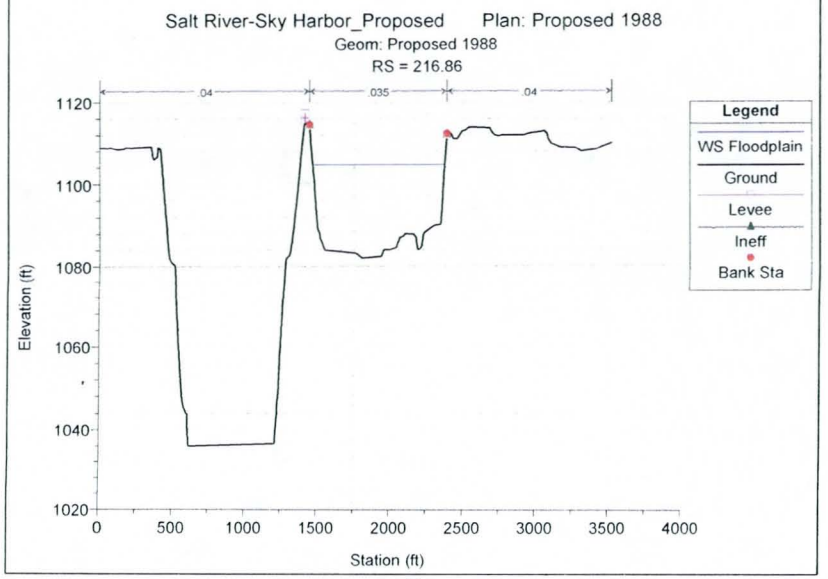
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.86
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.035
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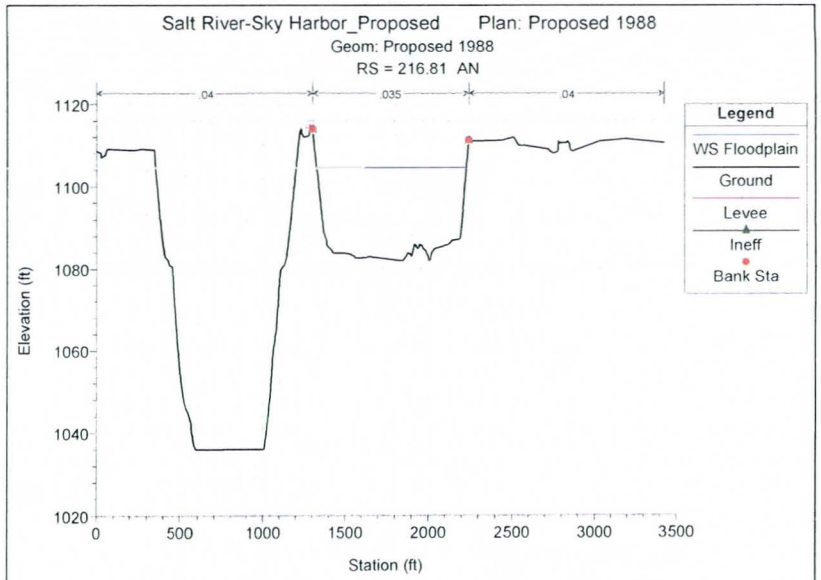
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.81 AN
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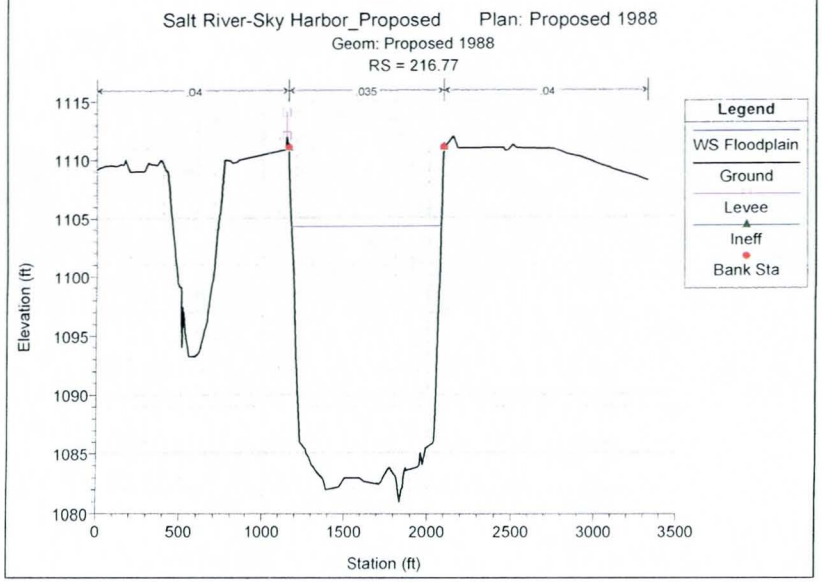
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.77
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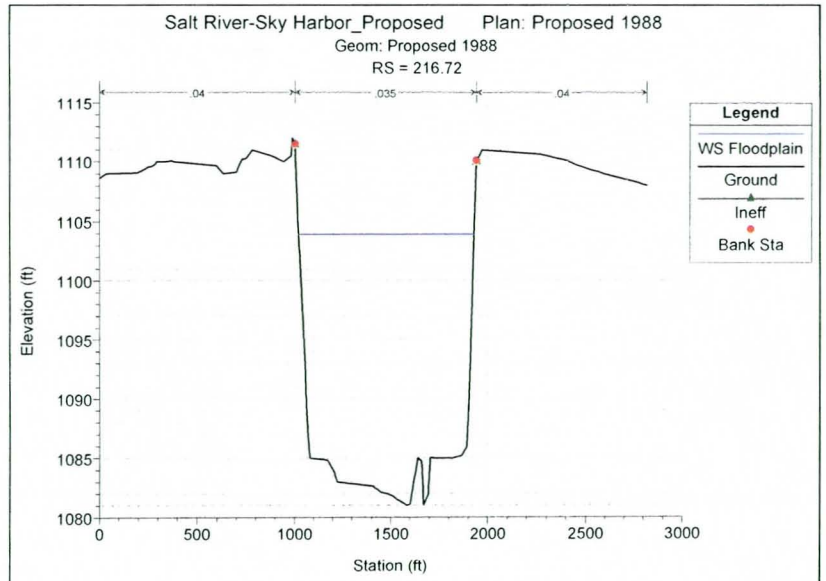
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.72
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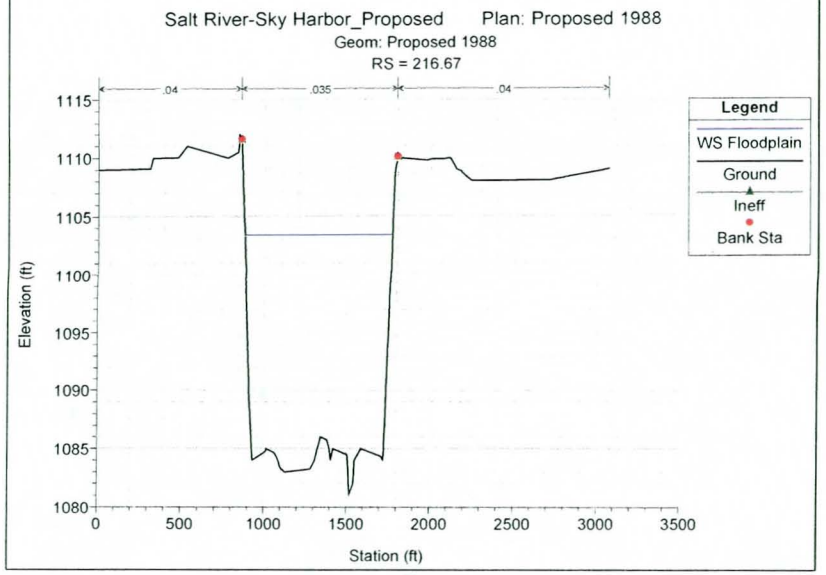
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
1115
1110
1105
1100
1095
1090
1085
1080
0
500
1000
1500
2000
2500
3000
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.67
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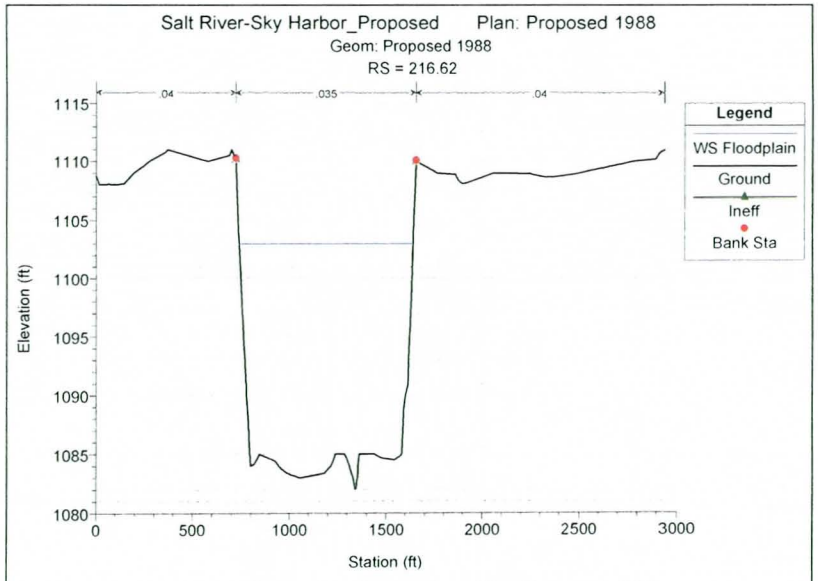
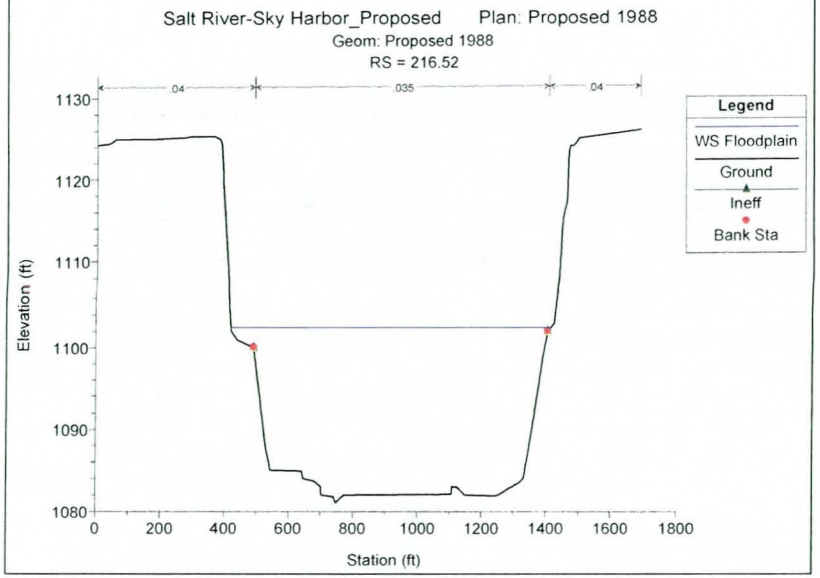
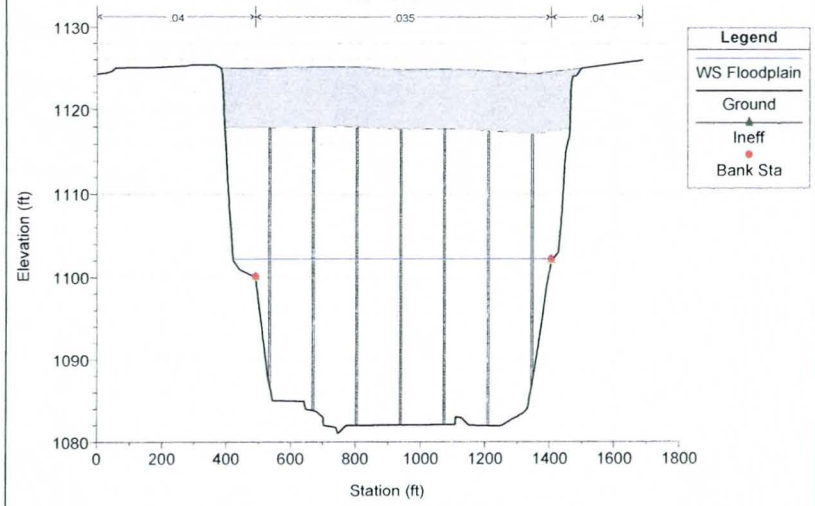
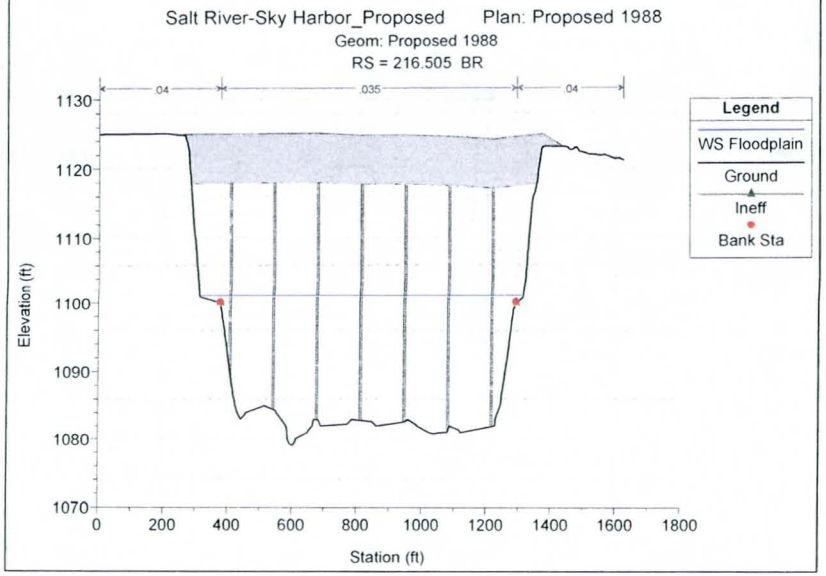
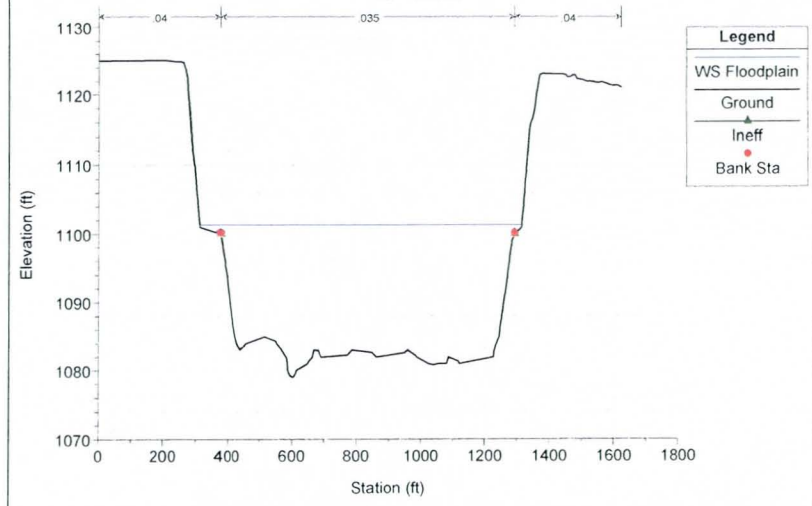
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
1115
1110
1105
1100
1095
1090
1085
1080
0
500
1000
1500
2000
2500
3000
3500
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.62
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
1115
1110
1105
1100
1095
1090
1085
1080
0
500
1000
1500
2000
2500
3000
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.52
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
1130
1120
1110
1100
1090
1080
0
200
400
600
800
1000
1200
1400
1600
1800
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.505 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.505 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.49
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.035
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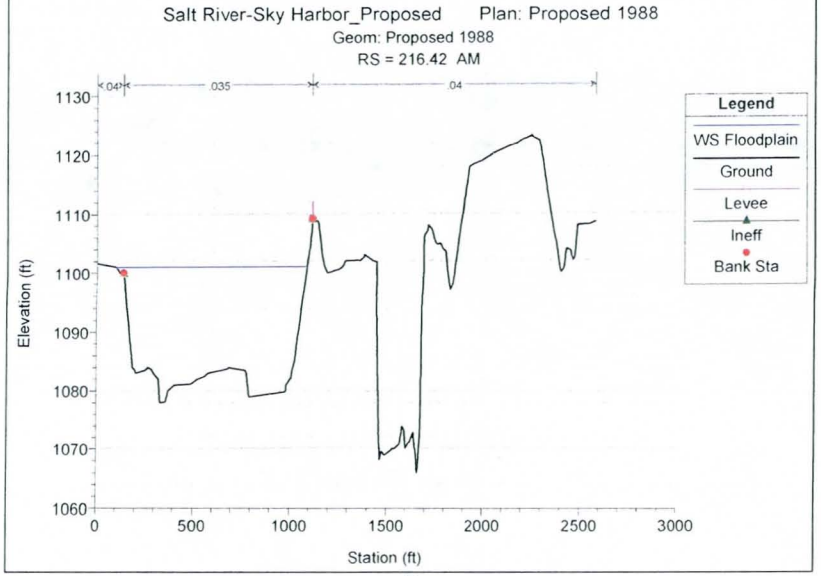
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.42 AM
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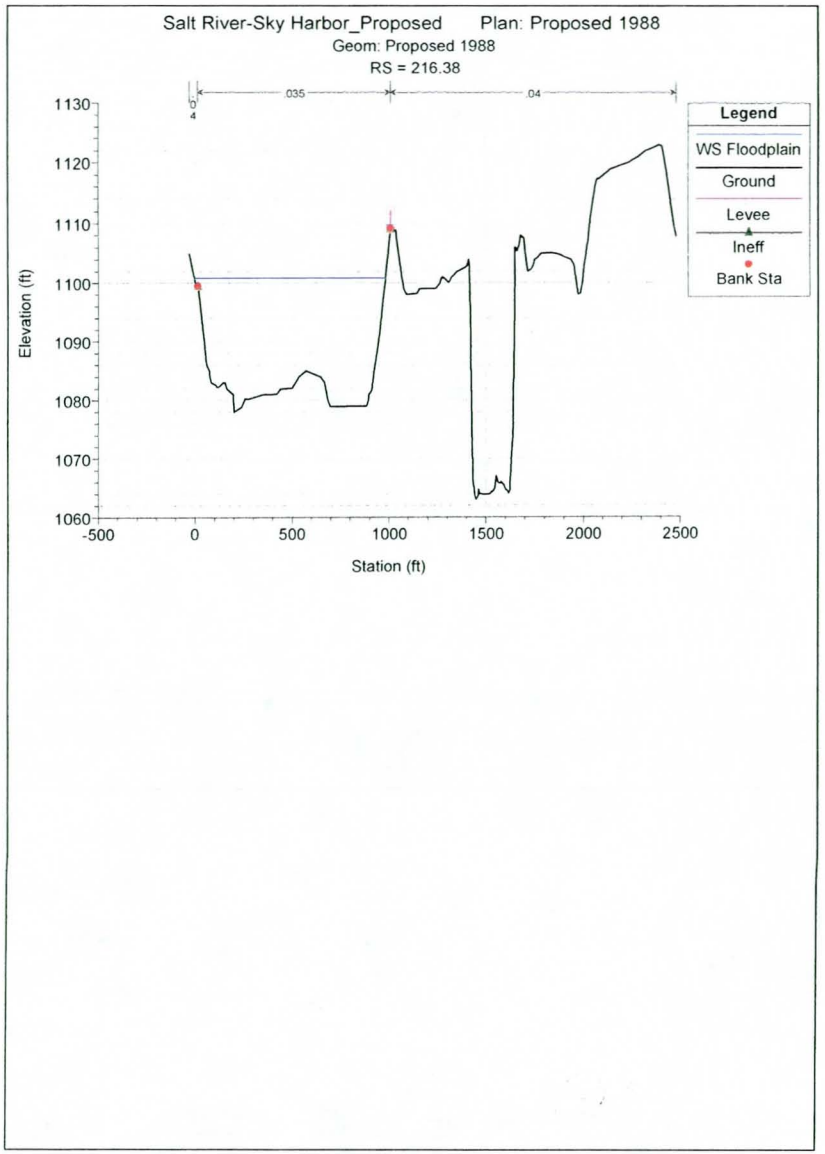
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Proposed Plan: Proposed 1988
Geom: Proposed 1988
RS = 216.38
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1130
1120
1110
1100
1090
1080
1070
1060
-500
0
500
1000
1500
2000
2500

Appendix B – Existing Output 1988 NAVD

HEC-RAS Plan: Existing 1988 River: Salt Reach: 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	219.51 AT	Floodplain	169000.00	1116.00	1134.17	1128.58	1136.13	0.001906	11.21	15073.09	1004.82	0.51
1	219.51 AT	10 %	55000.00	1116.00	1126.66	1123.36	1127.46	0.001832	7.18	7660.48	971.93	0.45
1	219.51 AT	2 %	140000.00	1116.00	1132.54	1127.44	1134.23	0.001901	10.42	13437.42	998.97	0.50
1	219.51 AT	0.2 %	243000.00	1116.00	1137.78	1131.31	1140.40	0.001954	12.98	18719.84	1018.66	0.53
1	219.46	Floodplain	169000.00	1115.00	1133.77	1128.17	1135.70	0.001891	11.16	15146.69	1010.88	0.51
1	219.46	10 %	55000.00	1115.00	1126.26	1122.96	1127.05	0.001809	7.14	7704.33	976.08	0.45
1	219.46	2 %	140000.00	1115.00	1132.13	1127.00	1133.80	0.001888	10.37	13498.87	1005.26	0.50
1	219.46	0.2 %	243000.00	1115.00	1137.37	1130.84	1139.96	0.001937	12.92	18807.51	1023.49	0.53
1	219.42	Floodplain	169000.00	1115.00	1133.10	1127.86	1135.12	0.002045	11.42	14794.69	1010.87	0.53
1	219.42	10 %	55000.00	1115.00	1125.62	1122.67	1126.48	0.002098	7.46	7372.97	977.66	0.48
1	219.42	2 %	140000.00	1115.00	1131.46	1126.70	1133.22	0.002062	10.65	13147.96	1005.30	0.52
1	219.42	0.2 %	243000.00	1115.00	1136.67	1130.57	1139.37	0.002075	13.19	18427.50	1024.11	0.55
1	219.38	Floodplain	169000.00	1115.00	1132.72	1127.33	1134.67	0.001960	11.20	15090.49	1031.25	0.52
1	219.38	10 %	55000.00	1115.00	1125.19	1122.20	1126.03	0.002030	7.34	7492.03	993.81	0.47
1	219.38	2 %	140000.00	1115.00	1131.07	1126.19	1132.77	0.001980	10.45	13398.00	1024.02	0.51
1	219.38	0.2 %	243000.00	1115.00	1136.31	1129.99	1138.90	0.001986	12.91	18821.13	1047.77	0.54
1	219.33	Floodplain	169000.00	1114.00	1132.09	1126.85	1134.11	0.002088	11.41	14813.98	1031.26	0.53
1	219.33	10 %	55000.00	1114.00	1124.56	1121.73	1125.45	0.002192	7.55	7281.75	979.64	0.49
1	219.33	2 %	140000.00	1114.00	1130.43	1125.71	1132.20	0.002116	10.67	13115.25	1019.70	0.52
1	219.33	0.2 %	243000.00	1114.00	1135.66	1129.64	1138.33	0.002093	13.12	18526.78	1046.44	0.55
1	219.29	Floodplain	169000.00	1114.00	1131.60	1126.46	1133.63	0.002123	11.45	14754.50	1032.88	0.53
1	219.29	10 %	55000.00	1114.00	1124.04	1121.23	1124.94	0.002274	7.65	7193.13	976.05	0.50
1	219.29	2 %	140000.00	1114.00	1129.93	1125.31	1131.72	0.002174	10.74	13038.13	1024.57	0.53
1	219.29	0.2 %	243000.00	1114.00	1135.17	1129.23	1137.86	0.002120	13.15	18476.27	1048.65	0.55
1	219.24	Floodplain	169000.00	1113.00	1131.11	1125.88	1133.13	0.002090	11.41	14812.83	1031.14	0.53
1	219.24	10 %	55000.00	1113.00	1123.51	1120.68	1124.41	0.002212	7.59	7246.11	974.42	0.49
1	219.24	2 %	140000.00	1113.00	1129.43	1124.72	1131.21	0.002128	10.70	13088.59	1017.90	0.53
1	219.24	0.2 %	243000.00	1113.00	1134.68	1128.63	1137.35	0.002097	13.11	18528.60	1047.57	0.55
1	219.19	Floodplain	169000.00	1113.00	1130.63	1125.21	1132.60	0.002005	11.28	14976.58	1028.73	0.52
1	219.19	10 %	55000.00	1113.00	1123.00	1120.01	1123.86	0.002070	7.45	7386.60	973.09	0.48
1	219.19	2 %	140000.00	1113.00	1128.94	1124.07	1130.67	0.002034	10.57	13247.75	1015.75	0.52
1	219.19	0.2 %	243000.00	1113.00	1134.19	1128.00	1136.82	0.002031	13.01	18676.53	1044.86	0.54
1	219.14	Floodplain	169000.00	1112.00	1130.10	1124.77	1132.09	0.002021	11.33	14919.37	1023.34	0.52
1	219.14	10 %	55000.00	1112.00	1122.42	1119.61	1123.31	0.002214	7.57	7263.01	980.49	0.49
1	219.14	2 %	140000.00	1112.00	1128.39	1123.62	1130.14	0.002075	10.62	13182.97	1016.69	0.52
1	219.14	0.2 %	243000.00	1112.00	1133.64	1127.47	1136.30	0.002054	13.09	18569.83	1036.58	0.54
1	219.09	Floodplain	169000.00	1112.00	1129.65	1124.27	1131.61	0.002006	11.23	15044.30	1039.92	0.52
1	219.09	10 %	55000.00	1112.00	1121.90	1119.13	1122.80	0.002252	7.59	7243.68	986.18	0.49
1	219.09	2 %	140000.00	1112.00	1127.93	1123.15	1129.66	0.002072	10.56	13257.61	1030.53	0.52
1	219.09	0.2 %	243000.00	1112.00	1133.21	1126.95	1135.81	0.002031	12.94	18773.07	1057.37	0.54
1	219.03 AS	Floodplain	169000.00	1110.00	1129.35	1123.02	1131.01	0.001562	10.34	16347.80	1060.48	0.46
1	219.03 AS	10 %	55000.00	1110.00	1121.47	1118.07	1122.18	0.001658	6.80	8093.16	1033.95	0.43
1	219.03 AS	2 %	140000.00	1110.00	1127.60	1121.94	1129.05	0.001586	9.66	14498.55	1054.37	0.46
1	219.03 AS	0.2 %	243000.00	1110.00	1132.92	1125.66	1135.18	0.001635	12.06	20155.90	1558.45	0.48
1	219.02		Bridge									
1	219.01	Floodplain	169000.00	1109.00	1128.70	1122.71	1130.45	0.001671	10.59	15951.48	1051.21	0.48
1	219.01	10 %	55000.00	1109.00	1120.93	1117.69	1121.69	0.001788	6.97	7885.51	1026.64	0.44
1	219.01	2 %	140000.00	1109.00	1126.98	1121.61	1128.50	0.001698	9.89	14153.24	1045.79	0.47
1	219.01	0.2 %	243000.00	1109.00	1132.14	1125.31	1134.53	0.001774	12.40	19589.27	1062.48	0.51
1	218.99	Floodplain	169000.00	1109.00	1128.66	1121.95	1130.24	0.001451	10.09	16753.27	1067.49	0.45
1	218.99	10 %	55000.00	1109.00	1120.86	1116.92	1121.50	0.001347	6.39	8603.32	1031.20	0.39
1	218.99	2 %	140000.00	1109.00	1126.93	1120.83	1128.30	0.001434	9.38	14925.44	1051.91	0.44
1	218.99	0.2 %	243000.00	1109.00	1132.11	1124.53	1134.30	0.001577	11.87	20475.55	1086.86	0.48
1	218.975		Bridge									
1	218.96	Floodplain	169000.00	1109.00	1127.87	1121.69	1129.51	0.001601	10.26	16464.92	1100.42	0.47
1	218.96	10 %	55000.00	1109.00	1120.27	1116.85	1120.96	0.001608	6.65	8267.59	1066.91	0.42
1	218.96	2 %	140000.00	1109.00	1126.18	1120.65	1127.61	0.001598	9.57	14626.75	1084.81	0.46
1	218.96	0.2 %	243000.00	1109.00	1131.70	1124.29	1133.84	0.001575	11.73	20723.71	1119.22	0.48
1	218.8	Floodpain	169000.00	1108.00	1125.78	1120.90	1127.92	0.002202	11.74	14394.73	997.34	0.54
1	218.8	10 %	55000.00	1108.00	1118.46	1115.71	1119.37	0.002290	7.66	7175.80	974.74	0.50
1	218.8	2 %	140000.00	1108.00	1124.16	1119.73	1126.02	0.002229	10.95	12779.67	992.23	0.54
1	218.8	0.2 %	243000.00	1108.00	1129.47	1123.60	1132.26	0.002187	13.41	18127.52	1022.73	0.56
1	218.77	Floodplain	169000.00	1108.00	1125.26	1120.38	1127.39	0.002207	11.71	14432.44	1006.25	0.54
1	218.77	10 %	55000.00	1108.00	1117.90	1115.18	1118.82	0.002328	7.70	7146.66	977.11	0.50
1	218.77	2 %	140000.00	1108.00	1123.62	1119.22	1125.48	0.002232	10.94	12796.65	997.10	0.54
1	218.77	0.2 %	243000.00	1108.00	1128.95	1123.05	1131.72	0.002186	13.33	18223.67	1037.66	0.56
1	218.71 AR	Floodplain	169000.00	1107.00	1124.62	1119.84	1126.82	0.002291	11.91	14193.23	993.10	0.56

HEC-RAS Plan: Existing 1988 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	218.71 AR	10 %	55000.00	1107.00	1117.29	1114.57	1118.23	0.002343	7.78	7071.58	956.12	0.50
1	218.71 AR	2 %	140000.00	1107.00	1122.99	1118.66	1124.91	0.002306	11.12	12589.16	981.04	0.55
1	218.71 AR	0.2 %	243000.00	1107.00	1128.29	1122.57	1131.16	0.002252	13.59	17876.38	1010.44	0.57
1	218.66	Floodplain	169000.00	1105.19	1124.10	1119.06	1126.24	0.002192	11.76	14371.48	990.56	0.54
1	218.66	10 %	55000.00	1105.19	1116.78	1113.75	1117.66	0.002083	7.53	7307.98	949.48	0.48
1	218.66	2 %	140000.00	1105.19	1122.47	1117.88	1124.34	0.002176	10.96	12777.11	974.29	0.53
1	218.66	0.2 %	243000.00	1105.19	1127.78	1121.77	1130.59	0.002185	13.44	18081.35	1016.38	0.56
1	218.61	Floodplain	169000.00	1104.00	1123.47	1118.53	1125.65	0.002278	11.86	14247.06	997.63	0.55
1	218.61	10 %	55000.00	1104.00	1116.19	1113.32	1117.10	0.002209	7.65	7189.10	952.57	0.49
1	218.61	2 %	140000.00	1104.00	1121.84	1117.42	1123.75	0.002262	11.07	12645.44	977.06	0.54
1	218.61	0.2 %	243000.00	1104.00	1127.17	1121.34	1130.00	0.002234	13.51	17987.33	1020.20	0.57
1	218.57	Floodplain	169000.00	1104.00	1122.89	1118.11	1125.08	0.002304	11.88	14224.24	1003.02	0.56
1	218.57	10 %	55000.00	1104.00	1115.60	1112.83	1116.53	0.002308	7.73	7112.31	959.62	0.50
1	218.57	2 %	140000.00	1104.00	1121.26	1116.93	1123.18	0.002315	11.10	12609.24	988.04	0.55
1	218.57	0.2 %	243000.00	1104.00	1126.61	1120.86	1129.44	0.002237	13.50	17999.53	1023.60	0.57
1	218.52	Floodplain	169000.00	1103.00	1122.33	1117.53	1124.51	0.002285	11.86	14248.01	1000.37	0.55
1	218.52	10 %	55000.00	1103.00	1115.04	1112.25	1115.96	0.002301	7.71	7129.23	963.06	0.50
1	218.52	2 %	140000.00	1103.00	1120.70	1116.35	1122.61	0.002278	11.08	12639.96	981.93	0.54
1	218.52	0.2 %	243000.00	1103.00	1126.07	1120.22	1128.89	0.002219	13.46	18051.59	1024.44	0.57
1	218.47	Floodplain	169000.00	1101.00	1121.97	1116.52	1123.97	0.001985	11.36	14882.39	1004.70	0.52
1	218.47	10 %	55000.00	1101.00	1114.68	1111.26	1115.46	0.001743	7.11	7734.69	958.56	0.44
1	218.47	2 %	140000.00	1101.00	1120.34	1115.36	1122.07	0.001955	10.55	13266.29	988.72	0.51
1	218.47	0.2 %	243000.00	1101.00	1125.73	1119.22	1128.35	0.001968	13.00	18697.74	1023.03	0.54
1	218.42	Floodplain	169000.00	1102.00	1121.19	1116.46	1123.37	0.002316	11.85	14257.01	1012.65	0.56
1	218.42	10 %	55000.00	1102.00	1113.98	1111.21	1114.90	0.002335	7.72	7127.28	972.58	0.50
1	218.42	2 %	140000.00	1102.00	1119.57	1115.29	1121.48	0.002327	11.08	12631.10	996.17	0.55
1	218.42	0.2 %	243000.00	1102.00	1124.98	1119.17	1127.77	0.002204	13.40	18133.29	1030.98	0.56
1	218.38	Floodplain	169000.00	1102.00	1120.66	1115.92	1122.78	0.002264	11.66	14489.79	1036.27	0.55
1	218.38	10 %	55000.00	1102.00	1113.38	1110.68	1114.31	0.002438	7.74	7105.45	996.67	0.51
1	218.38	2 %	140000.00	1102.00	1119.03	1114.78	1120.88	0.002298	10.94	12801.24	1020.26	0.54
1	218.38	0.2 %	243000.00	1102.00	1124.53	1118.55	1127.20	0.002116	13.12	18524.85	1054.33	0.55
1	218.33	Floodplain	169000.00	1102.00	1120.19	1115.18	1122.20	0.002115	11.36	14874.24	1051.37	0.53
1	218.33	10 %	55000.00	1102.00	1112.82	1110.05	1113.70	0.002281	7.54	7297.34	1013.92	0.50
1	218.33	2 %	140000.00	1102.00	1118.54	1114.04	1120.30	0.002138	10.64	13151.97	1033.84	0.53
1	218.33	0.2 %	243000.00	1102.00	1124.11	1117.79	1126.64	0.001970	12.77	19029.51	1068.85	0.53
1	218.29	Floodplain	169000.00	1100.00	1119.59	1114.87	1121.70	0.002262	11.65	14504.34	1039.70	0.55
1	218.29	10 %	55000.00	1100.00	1112.17	1109.71	1113.15	0.002632	7.91	6951.49	1000.87	0.53
1	218.29	2 %	140000.00	1100.00	1117.92	1113.73	1119.79	0.002345	10.96	12777.64	1032.73	0.55
1	218.29	0.2 %	243000.00	1100.00	1123.54	1117.54	1126.17	0.002128	13.03	18646.42	1077.75	0.55
1	218.24 AQ	Floodplain	169000.00	1099.00	1119.13	1113.90	1121.09	0.002000	11.24	15040.80	1038.79	0.52
1	218.24 AQ	10 %	55000.00	1099.00	1111.61	1108.67	1112.48	0.002190	7.47	7358.31	1005.59	0.49
1	218.24 AQ	2 %	140000.00	1099.00	1117.44	1112.76	1119.16	0.002049	10.53	13294.56	1031.15	0.52
1	218.24 AQ	0.2 %	243000.00	1099.00	1123.12	1116.53	1125.60	0.001870	12.64	19220.25	1055.67	0.52
1	218.19	Floodplain	169000.00	1098.62	1118.69	1113.28	1120.59	0.001922	11.08	15255.17	1044.51	0.51
1	218.19	10 %	55000.00	1098.62	1111.11	1108.12	1111.95	0.002082	7.35	7479.13	1008.23	0.48
1	218.19	2 %	140000.00	1098.62	1116.98	1112.13	1118.66	0.001968	10.38	13482.32	1035.88	0.51
1	218.19	0.2 %	243000.00	1098.62	1122.72	1115.91	1125.13	0.001792	12.46	19501.32	1069.86	0.51
1	218.14	Floodplain	169000.00	1098.00	1118.13	1112.93	1120.09	0.002014	11.25	15016.68	1039.11	0.52
1	218.14	10 %	55000.00	1098.00	1110.47	1107.35	1111.38	0.002381	7.66	7183.11	1007.26	0.51
1	218.14	2 %	140000.00	1098.00	1116.41	1111.81	1118.14	0.002086	10.58	13234.40	1032.29	0.52
1	218.14	0.2 %	243000.00	1098.00	1122.20	1115.56	1124.67	0.001851	12.60	19286.85	1055.36	0.52
1	218.09	Floodplain	169000.00	1098.00	1117.52	1112.51	1119.58	0.002116	11.49	14703.68	1021.65	0.53
1	218.09	10 %	55000.00	1098.00	1109.77	1107.08	1110.75	0.002676	7.98	6893.20	990.98	0.53
1	218.09	2 %	140000.00	1098.00	1115.79	1111.35	1117.61	0.002205	10.82	12934.62	1015.17	0.53
1	218.09	0.2 %	243000.00	1098.00	1121.64	1115.17	1124.19	0.001945	12.83	18938.03	1045.31	0.53
1	218.04	Floodplain	169000.00	1097.00	1117.05	1111.77	1118.99	0.001970	11.17	15128.61	1041.09	0.52
1	218.04	10 %	55000.00	1097.00	1109.07	1106.11	1110.04	0.002535	7.89	6972.69	979.90	0.52
1	218.04	2 %	140000.00	1097.00	1115.28	1110.62	1117.00	0.002063	10.54	13267.37	1034.23	0.52
1	218.04	0.2 %	243000.00	1097.00	1121.23	1114.40	1123.64	0.001783	12.45	19520.48	1057.77	0.51
1	218	Floodplain	169000.00	1095.85	1116.74	1110.74	1118.52	0.001716	10.71	15774.99	1040.49	0.48
1	218	10 %	55000.00	1095.85	1108.65	1105.06	1109.48	0.002000	7.32	7511.25	986.50	0.47
1	218	2 %	140000.00	1095.85	1114.94	1109.65	1116.51	0.001771	10.06	13915.12	1033.29	0.48
1	218	0.2 %	243000.00	1095.85	1120.96	1113.44	1123.20	0.001592	12.03	20204.30	1057.51	0.48
1	217.95	Floodplain	169000.00	1092.00	1116.09	1110.56	1118.00	0.001915	11.10	15230.36	1038.45	0.51
1	217.95	10 %	55000.00	1092.00	1107.88	1103.90	1108.85	0.002447	7.90	6966.38	953.63	0.51
1	217.95	2 %	140000.00	1092.00	1114.26	1109.41	1115.97	0.002021	10.49	13342.52	1030.83	0.51
1	217.95	0.2 %	243000.00	1092.00	1120.37	1113.28	1122.73	0.001715	12.32	19718.76	1055.77	0.50
1	217.91	Floodplain	169000.00	1089.00	1115.89	1109.14	1117.49	0.001446	10.16	16638.89	1044.67	0.45

HEC-RAS Plan: Existing 1988 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	218.71 AR	10 %	55000.00	1107.00	1117.29	1114.57	1118.23	0.002343	7.78	7071.58	956.12	0.50
1	218.71 AR	2 %	140000.00	1107.00	1122.99	1118.66	1124.91	0.002306	11.12	12589.16	981.04	0.55
1	218.71 AR	0.2 %	243000.00	1107.00	1128.29	1122.57	1131.16	0.002252	13.59	17876.38	1010.44	0.57
1	218.66	Floodplain	169000.00	1105.19	1124.10	1119.06	1126.24	0.002192	11.76	14371.48	990.56	0.54
1	218.66	10 %	55000.00	1105.19	1116.78	1113.75	1117.66	0.002063	7.53	7307.98	949.46	0.48
1	218.66	2 %	140000.00	1105.19	1122.47	1117.88	1124.34	0.002176	10.96	12777.11	974.29	0.53
1	218.66	0.2 %	243000.00	1105.19	1127.78	1121.77	1130.59	0.002185	13.44	18081.35	1016.38	0.56
1	218.61	Floodplain	169000.00	1104.00	1123.47	1118.53	1125.65	0.002278	11.86	14247.06	997.63	0.55
1	218.61	10 %	55000.00	1104.00	1116.19	1113.32	1117.10	0.002209	7.65	7189.10	952.57	0.49
1	218.61	2 %	140000.00	1104.00	1121.84	1117.42	1123.75	0.002262	11.07	12645.44	977.06	0.54
1	218.61	0.2 %	243000.00	1104.00	1127.17	1121.34	1130.00	0.002234	13.51	17987.33	1020.20	0.57
1	218.57	Floodplain	169000.00	1104.00	1122.89	1118.11	1125.08	0.002304	11.88	14224.24	1003.02	0.56
1	218.57	10 %	55000.00	1104.00	1115.60	1112.83	1116.53	0.002308	7.73	7112.31	959.62	0.50
1	218.57	2 %	140000.00	1104.00	1121.26	1116.93	1123.18	0.002315	11.10	12609.24	988.04	0.55
1	218.57	0.2 %	243000.00	1104.00	1126.61	1120.86	1129.44	0.002237	13.50	17999.53	1023.60	0.57
1	218.52	Floodplain	169000.00	1103.00	1122.33	1117.53	1124.51	0.002285	11.86	14248.01	1000.37	0.55
1	218.52	10 %	55000.00	1103.00	1115.04	1112.25	1115.96	0.002301	7.71	7129.23	963.08	0.50
1	218.52	2 %	140000.00	1103.00	1120.70	1116.35	1122.61	0.002278	11.08	12639.96	981.93	0.54
1	218.52	0.2 %	243000.00	1103.00	1126.07	1120.22	1128.89	0.002219	13.46	18051.59	1024.44	0.57
1	218.47	Floodplain	169000.00	1101.00	1121.97	1116.52	1123.97	0.001985	11.36	14882.39	1004.70	0.52
1	218.47	10 %	55000.00	1101.00	1114.68	1111.26	1115.46	0.001743	7.11	7734.69	958.55	0.44
1	218.47	2 %	140000.00	1101.00	1120.34	1115.36	1122.07	0.001955	10.55	13266.29	986.72	0.51
1	218.47	0.2 %	243000.00	1101.00	1125.73	1119.22	1128.35	0.001968	13.00	18697.74	1023.03	0.54
1	218.42	Floodplain	169000.00	1102.00	1121.19	1116.46	1123.37	0.002316	11.85	14257.01	1012.85	0.56
1	218.42	10 %	55000.00	1102.00	1113.98	1111.21	1114.90	0.002335	7.72	7127.28	972.58	0.50
1	218.42	2 %	140000.00	1102.00	1119.57	1115.29	1121.48	0.002327	11.08	12631.10	996.17	0.55
1	218.42	0.2 %	243000.00	1102.00	1124.98	1119.17	1127.77	0.002204	13.40	18133.29	1030.98	0.56
1	218.38	Floodplain	169000.00	1102.00	1120.66	1115.92	1122.78	0.002264	11.66	14489.79	1036.27	0.55
1	218.38	10 %	55000.00	1102.00	1113.38	1110.68	1114.31	0.002438	7.74	7105.45	996.67	0.51
1	218.38	2 %	140000.00	1102.00	1119.03	1114.78	1120.88	0.002298	10.94	12801.24	1020.26	0.54
1	218.38	0.2 %	243000.00	1102.00	1124.53	1118.55	1127.20	0.002116	13.12	18524.85	1054.33	0.55
1	218.33	Floodplain	169000.00	1102.00	1120.19	1115.18	1122.20	0.002115	11.36	14874.24	1051.37	0.53
1	218.33	10 %	55000.00	1102.00	1112.82	1110.05	1113.70	0.002281	7.54	7297.34	1013.92	0.50
1	218.33	2 %	140000.00	1102.00	1118.54	1114.04	1120.30	0.002138	10.64	13151.97	1033.84	0.53
1	218.33	0.2 %	243000.00	1102.00	1124.11	1117.79	1126.64	0.001970	12.77	19029.51	1068.85	0.53
1	218.29	Floodplain	169000.00	1100.00	1119.59	1114.87	1121.70	0.002262	11.65	14504.34	1039.70	0.55
1	218.29	10 %	55000.00	1100.00	1112.17	1109.71	1113.15	0.002632	7.91	8951.49	1000.87	0.53
1	218.29	2 %	140000.00	1100.00	1117.92	1113.73	1119.79	0.002343	10.96	12777.64	1032.73	0.55
1	218.29	0.2 %	243000.00	1100.00	1123.54	1117.54	1126.17	0.002128	13.03	18646.42	1077.75	0.55
1	218.24 AQ	Floodplain	169000.00	1099.00	1119.13	1113.90	1121.09	0.002000	11.24	15040.80	1038.79	0.52
1	218.24 AQ	10 %	55000.00	1099.00	1111.61	1108.67	1112.46	0.002190	7.47	7358.31	1005.59	0.49
1	218.24 AQ	2 %	140000.00	1099.00	1117.44	1112.76	1119.16	0.002049	10.53	13294.56	1031.15	0.52
1	218.24 AQ	0.2 %	243000.00	1099.00	1123.12	1116.53	1125.80	0.001870	12.64	19220.25	1056.87	0.52
1	218.19	Floodplain	169000.00	1098.62	1118.69	1113.28	1120.59	0.001922	11.08	15255.17	1044.51	0.51
1	218.19	10 %	55000.00	1098.62	1111.11	1108.12	1111.95	0.002082	7.35	7479.13	1008.23	0.48
1	218.19	2 %	140000.00	1098.62	1116.98	1112.13	1118.66	0.001968	10.38	13482.32	1035.88	0.51
1	218.19	0.2 %	243000.00	1098.62	1122.72	1115.91	1125.13	0.001792	12.46	19501.32	1069.88	0.51
1	218.14	Floodplain	169000.00	1098.00	1118.13	1112.93	1120.09	0.002014	11.25	15016.68	1039.11	0.52
1	218.14	10 %	55000.00	1098.00	1110.47	1107.35	1111.38	0.002381	7.66	7183.11	1007.28	0.51
1	218.14	2 %	140000.00	1098.00	1116.41	1111.81	1118.14	0.002086	10.58	13234.40	1032.29	0.52
1	218.14	0.2 %	243000.00	1098.00	1122.20	1115.56	1124.67	0.001851	12.60	19286.85	1055.36	0.52
1	218.09	Floodplain	169000.00	1098.00	1117.52	1112.51	1119.58	0.002116	11.49	14703.68	1021.65	0.53
1	218.09	10 %	55000.00	1098.00	1109.77	1107.08	1110.75	0.002676	7.98	6893.20	990.98	0.53
1	218.09	2 %	140000.00	1098.00	1115.79	1111.35	1117.61	0.002205	10.82	12934.62	1015.17	0.53
1	218.09	0.2 %	243000.00	1098.00	1121.64	1115.17	1124.19	0.001945	12.83	18938.03	1045.31	0.53
1	218.04	Floodplain	169000.00	1097.00	1117.05	1111.77	1118.99	0.001970	11.17	15128.61	1041.09	0.52
1	218.04	10 %	55000.00	1097.00	1109.07	1106.11	1110.04	0.002535	7.89	6972.69	979.90	0.52
1	218.04	2 %	140000.00	1097.00	1115.28	1110.62	1117.00	0.002063	10.54	13287.37	1034.23	0.52
1	218.04	0.2 %	243000.00	1097.00	1121.23	1114.40	1123.64	0.001783	12.45	19520.48	1057.77	0.51
1	218	Floodplain	169000.00	1095.85	1116.74	1110.74	1118.52	0.001716	10.71	15774.99	1040.49	0.48
1	218	10 %	55000.00	1095.85	1108.65	1105.06	1109.48	0.002000	7.32	7511.25	986.50	0.47
1	218	2 %	140000.00	1095.85	1114.94	1109.65	1116.51	0.001771	10.06	13915.12	1033.29	0.48
1	218	0.2 %	243000.00	1095.85	1120.96	1113.44	1123.20	0.001592	12.03	20204.30	1057.51	0.48
1	217.95	Floodplain	169000.00	1092.00	1116.09	1110.56	1118.00	0.001915	11.10	15230.36	1038.45	0.51
1	217.95	10 %	55000.00	1092.00	1107.88	1103.90	1108.85	0.002447	7.90	6966.38	953.63	0.51
1	217.95	2 %	140000.00	1092.00	1114.26	1109.41	1115.97	0.002021	10.49	13342.52	1030.83	0.51
1	217.95	0.2 %	243000.00	1092.00	1120.37	1113.28	1122.73	0.001715	12.32	19718.76	1055.77	0.50
1	217.91	Floodplain	169000.00	1089.00	1115.89	1109.14	1117.49	0.001446	10.16	16638.89	1044.67	0.45

HEC-RAS Plan: Existing 1988 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	217.91	10 %	55000.00	1089.00	1107.57	1102.13	1108.29	0.001611	6.80	8089.06	1008.81	0.42
1	217.91	2 %	140000.00	1089.00	1114.05	1108.00	1115.45	0.001478	9.51	14720.12	1037.25	0.44
1	217.91	0.2 %	243000.00	1089.00	1120.21	1111.77	1122.25	0.001368	11.47	21193.47	1061.93	0.45
1	217.86	Floodplain	169000.00	1090.00	1115.36	1109.27	1117.10	0.001651	10.58	15966.05	1040.84	0.48
1	217.86	10 %	55000.00	1090.00	1106.94	1101.77	1107.81	0.002228	7.50	7331.81	1006.87	0.49
1	217.86	2 %	140000.00	1090.00	1113.51	1108.13	1115.05	0.001722	9.97	14039.91	1033.86	0.48
1	217.86	0.2 %	243000.00	1090.00	1119.72	1111.90	1121.89	0.001511	11.83	20535.75	1057.84	0.47
1	217.81	Floodplain	169000.00	1090.21	1114.73	1108.80	1116.72	0.001824	11.32	14933.72	948.51	0.50
1	217.81	10 %	55000.00	1090.21	1106.47	1101.23	1107.37	0.002041	7.60	7241.55	913.10	0.48
1	217.81	2 %	140000.00	1090.21	1112.92	1107.57	1114.66	0.001857	10.59	13223.29	941.31	0.50
1	217.81	0.2 %	243000.00	1090.21	1118.98	1111.58	1121.52	0.001734	12.79	19001.90	965.24	0.51
1	217.76 AP	Floodplain	169000.00	1093.00	1112.79	1109.01	1115.89	0.003115	14.13	11961.87	811.60	0.65
1	217.76 AP	10 %	55000.00	1093.00	1105.22	1101.97	1106.56	0.003128	9.28	5928.42	761.49	0.59
1	217.76 AP	2 %	140000.00	1093.00	1111.14	1107.69	1113.83	0.003141	13.17	10627.29	806.73	0.64
1	217.76 AP	0.2 %	243000.00	1093.00	1116.70	1112.13	1120.69	0.002995	16.03	15157.89	823.80	0.66
1	217.71	Floodplain	169000.00	1090.00	1112.26	1107.85	1115.16	0.002745	13.66	12370.09	802.65	0.61
1	217.71	10 %	55000.00	1090.00	1104.75	1100.40	1105.87	0.002360	8.51	6464.36	766.13	0.52
1	217.71	2 %	140000.00	1090.00	1110.61	1106.48	1113.10	0.002717	12.67	11051.82	798.04	0.60
1	217.71	0.2 %	243000.00	1090.00	1116.18	1111.01	1119.98	0.002715	15.64	15537.41	813.51	0.63
1	217.66	Floodplain	169000.00	1089.13	1111.01	1107.50	1114.30	0.003325	14.57	11597.10	787.07	0.67
1	217.66	10 %	55000.00	1089.13	1103.85	1100.18	1105.15	0.003964	9.12	6027.71	766.88	0.57
1	217.66	2 %	140000.00	1089.13	1109.43	1106.14	1112.26	0.003299	13.52	10359.95	783.21	0.66
1	217.66	0.2 %	243000.00	1089.13	1114.86	1110.65	1119.13	0.003225	16.59	14646.25	796.49	0.68
1	217.62	Floodplain	169000.00	1090.00	1110.50	1106.58	1113.46	0.002973	13.79	12252.96	830.81	0.63
1	217.62	10 %	55000.00	1090.00	1103.24	1099.76	1104.43	0.002786	8.74	6290.83	811.10	0.55
1	217.62	2 %	140000.00	1090.00	1108.88	1105.26	1111.44	0.002980	12.84	10907.32	826.79	0.62
1	217.62	0.2 %	243000.00	1090.00	1114.49	1109.61	1118.27	0.002812	15.59	15589.74	840.31	0.64
1	217.57	Floodplain	169000.00	1091.00	1110.19	1105.43	1112.54	0.002363	12.32	13717.42	927.48	0.56
1	217.57	10 %	55000.00	1091.00	1102.66	1099.29	1103.67	0.002349	8.05	6833.92	877.06	0.51
1	217.57	2 %	140000.00	1091.00	1106.46	1104.22	1110.54	0.002417	11.53	12138.68	923.02	0.56
1	217.57	0.2 %	243000.00	1091.00	1114.39	1108.26	1117.34	0.002155	13.77	17640.98	937.91	0.58
1	217.53	Floodplain	169000.00	1091.50	1110.10	1104.33	1111.86	0.001809	11.01	15343.48	1008.71	0.50
1	217.53	10 %	55000.00	1091.50	1102.37	1098.85	1103.18	0.001883	7.20	7641.49	985.48	0.46
1	217.53	2 %	140000.00	1091.50	1108.34	1103.16	1109.99	0.001851	10.31	13575.50	1003.51	0.49
1	217.53	0.2 %	243000.00	1091.50	1114.42	1108.99	1116.78	0.001849	12.31	19734.05	1020.68	0.49
1	217.48	Floodplain	169000.00	1091.00	1109.67	1104.03	1111.51	0.001813	10.88	15532.02	1045.77	0.50
1	217.48	10 %	55000.00	1091.00	1101.83	1098.76	1102.67	0.002117	7.38	7453.80	1012.98	0.48
1	217.48	2 %	140000.00	1091.00	1107.89	1102.87	1109.51	0.001885	10.24	13689.12	1038.48	0.50
1	217.48	0.2 %	243000.00	1091.00	1114.09	1108.85	1116.34	0.001604	12.04	20188.68	1064.04	0.49
1	217.43	Floodplain	169000.00	1091.00	1109.10	1103.87	1111.04	0.001986	11.20	15090.72	1041.52	0.52
1	217.43	10 %	55000.00	1091.00	1101.07	1098.69	1102.07	0.002791	8.02	6854.92	1010.98	0.54
1	217.43	2 %	140000.00	1091.00	1107.28	1102.73	1109.02	0.002109	10.61	13200.75	1035.22	0.52
1	217.43	0.2 %	243000.00	1091.00	1113.60	1108.48	1115.93	0.001695	12.27	19810.63	1056.62	0.50
1	217.38	Floodplain	169000.00	1089.00	1108.65	1102.99	1110.50	0.001824	10.93	15463.51	1037.82	0.50
1	217.38	10 %	55000.00	1089.00	1100.39	1097.87	1101.34	0.002556	7.83	7024.96	1004.90	0.52
1	217.38	2 %	140000.00	1089.00	1106.79	1101.87	1108.45	0.001925	10.33	13547.08	1030.35	0.50
1	217.38	0.2 %	243000.00	1089.00	1113.23	1105.65	1115.46	0.001575	11.99	20259.46	1057.07	0.48
1	217.34	Floodplain	169000.00	1086.21	1108.19	1102.39	1110.04	0.001784	10.92	15478.82	1022.45	0.49
1	217.34	10 %	55000.00	1086.21	1099.71	1097.18	1100.68	0.002585	7.91	6954.74	987.91	0.53
1	217.34	2 %	140000.00	1086.21	1106.31	1101.23	1107.97	0.001879	10.32	13566.44	1014.81	0.50
1	217.34	0.2 %	243000.00	1086.21	1112.83	1105.06	1115.06	0.001544	11.99	20257.59	1041.67	0.48
1	217.29 AO	Floodplain	169000.00	1085.00	1107.75	1101.80	1109.61	0.001754	10.95	15439.97	1008.13	0.49
1	217.29 AO	10 %	55000.00	1085.00	1099.06	1096.48	1100.05	0.002609	7.99	6885.10	967.66	0.53
1	217.29 AO	2 %	140000.00	1085.00	1105.86	1100.63	1107.51	0.001839	10.33	13553.22	993.34	0.49
1	217.29 AO	0.2 %	243000.00	1085.00	1112.43	1104.50	1114.69	0.001531	12.05	20171.07	1091.60	0.48
1	217.24	Floodplain	169000.00	1084.46	1107.33	1101.07	1109.17	0.001681	10.90	15510.49	979.68	0.48
1	217.24	10 %	55000.00	1084.46	1098.44	1095.70	1099.41	0.002439	7.90	6958.49	943.90	0.51
1	217.24	2 %	140000.00	1084.46	1105.43	1099.83	1107.06	0.001746	10.26	13650.41	972.14	0.48
1	217.24	0.2 %	243000.00	1084.46	1112.06	1103.84	1114.31	0.001486	12.04	20184.45	998.74	0.47
1	217.19	Floodplain	169000.00	1085.00	1106.79	1100.70	1108.72	0.001756	11.16	15150.15	955.07	0.49
1	217.19	10 %	55000.00	1085.00	1097.62	1095.28	1098.72	0.002885	8.40	6547.51	920.68	0.56
1	217.19	2 %	140000.00	1085.00	1104.88	1099.50	1106.59	0.001826	10.50	13329.64	947.98	0.49
1	217.19	0.2 %	243000.00	1085.00	1111.55	1103.50	1113.90	0.001546	12.31	19739.89	973.52	0.48
1	217.15	Floodplain	169000.00	1083.72	1106.64	1099.02	1108.30	0.001337	10.34	16340.29	935.93	0.44
1	217.15	10 %	55000.00	1083.72	1097.39	1093.03	1098.15	0.001544	7.01	7844.44	900.61	0.42
1	217.15	2 %	140000.00	1083.72	1104.72	1097.79	1106.16	0.001334	9.62	14554.10	928.81	0.43
1	217.15	0.2 %	243000.00	1083.72	1111.41	1101.87	1113.52	0.001264	11.66	20849.29	954.86	0.44
1	217.1	Floodplain	169000.00	1085.00	1106.26	1098.37	1107.93	0.001300	10.35	16329.61	916.89	0.43

HEC-RAS Plan: Existing 1988 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S	E.G. Elev	E.G. Slope	Vel Chnl	Flow Areal	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	217.1	10 %	55000.00	1085.00	1097.00	1092.75	1097.73	0.001400	6.87	8000.39	881.01	0.40
1	217.1	2 %	140000.00	1085.00	1104.36	1097.15	1105.79	0.001282	9.60	14590.53	909.25	0.42
1	217.1	0.2 %	243000.00	1085.00	1111.03	1101.30	1113.16	0.001248	11.71	20752.36	937.27	0.44
1	217.05	Floodplain	169000.00	1085.00	1105.84	1098.43	1107.60	0.001415	10.64	15878.67	912.07	0.45
1	217.05	10 %	55000.00	1085.00	1096.55	1092.80	1097.37	0.001664	7.28	7572.75	875.34	0.44
1	217.05	2 %	140000.00	1085.00	1103.95	1097.18	1105.47	0.001406	9.69	14156.88	904.42	0.44
1	217.05	0.2 %	243000.00	1085.00	1110.62	1101.32	1112.85	0.001334	11.98	20287.06	932.07	0.45
1	217	Floodplain	169000.00	1084.00	1105.39	1098.39	1107.23	0.001526	10.91	15493.22	909.78	0.47
1	217	10 %	55000.00	1084.00	1095.98	1092.76	1096.91	0.002030	7.73	7116.45	871.97	0.48
1	217	2 %	140000.00	1084.00	1103.50	1097.12	1105.10	0.001527	10.16	13783.69	902.09	0.46
1	217	0.2 %	243000.00	1084.00	1110.20	1101.30	1112.51	0.001409	12.20	19919.21	929.41	0.46
1	216.96	Floodplain	169000.00	1082.60	1105.17	1097.14	1106.83	0.001269	10.33	16359.40	906.14	0.43
1	216.96	10 %	55000.00	1082.60	1095.69	1091.43	1096.43	0.001405	6.93	7941.36	869.64	0.40
1	216.96	2 %	140000.00	1082.60	1103.28	1095.87	1104.70	0.001241	9.55	14656.60	898.77	0.42
1	216.96	0.2 %	243000.00	1082.60	1110.00	1100.05	1112.13	0.001219	11.69	20787.20	926.61	0.43
1	216.91	Floodplain	169000.00	1083.00	1104.84	1096.78	1106.49	0.001268	10.32	16372.64	909.25	0.43
1	216.91	10 %	55000.00	1083.00	1095.31	1090.87	1096.06	0.001429	6.96	7898.87	869.68	0.41
1	216.91	2 %	140000.00	1083.00	1102.96	1095.54	1104.37	0.001238	9.54	14672.02	900.86	0.42
1	216.91	0.2 %	243000.00	1083.00	1109.69	1099.73	1111.80	0.001213	11.66	20832.04	929.07	0.43
1	216.86	Floodplain	169000.00	1082.00	1104.62	1095.84	1106.16	0.001118	9.95	16992.03	907.79	0.41
1	216.86	10 %	55000.00	1082.00	1095.07	1090.13	1095.71	0.001104	6.45	8521.51	866.97	0.36
1	216.86	2 %	140000.00	1082.00	1102.75	1094.57	1104.05	0.001072	9.15	15300.43	898.72	0.39
1	216.86	0.2 %	243000.00	1082.00	1109.49	1098.77	1111.48	0.001098	11.32	21457.17	1268.24	0.42
1	216.81 AN	Floodplain	169000.00	1082.00	1104.40	1095.03	1105.87	0.001030	9.74	17349.89	898.67	0.39
1	216.81 AN	10 %	55000.00	1082.00	1094.86	1089.25	1095.44	0.000904	6.11	8998.82	854.61	0.33
1	216.81 AN	2 %	140000.00	1082.00	1102.54	1093.73	1103.78	0.000972	8.92	15689.13	888.21	0.37
1	216.81 AN	0.2 %	243000.00	1082.00	1109.26	1097.99	1111.19	0.001036	11.16	21775.98	1086.40	0.40
1	216.77	Floodplain	169000.00	1081.00	1104.20	1094.38	1105.60	0.000958	9.50	17784.87	907.25	0.38
1	216.77	10 %	55000.00	1081.00	1094.66	1088.60	1095.22	0.000785	5.85	9399.08	857.90	0.31
1	216.77	2 %	140000.00	1081.00	1102.35	1093.10	1103.52	0.000868	8.69	16117.61	896.84	0.36
1	216.77	0.2 %	243000.00	1081.00	1109.07	1097.34	1110.92	0.000971	10.92	22253.70	1124.77	0.39
1	216.72	Floodplain	169000.00	1081.00	1103.92	1094.40	1105.36	0.001002	9.63	17553.73	906.89	0.39
1	216.72	10 %	55000.00	1081.00	1094.48	1088.67	1095.02	0.000848	5.98	9200.54	860.65	0.32
1	216.72	2 %	140000.00	1081.00	1102.09	1093.13	1103.30	0.000941	8.80	15904.62	897.20	0.37
1	216.72	0.2 %	243000.00	1081.00	1108.78	1097.36	1110.67	0.001008	11.04	22013.24	1119.19	0.40
1	216.67	Floodplain	169000.00	1081.00	1103.37	1095.23	1105.05	0.001275	10.41	16234.48	893.54	0.43
1	216.67	10 %	55000.00	1081.00	1094.02	1089.45	1094.74	0.001270	6.79	8103.30	848.15	0.39
1	216.67	2 %	140000.00	1081.00	1101.59	1093.85	1103.00	0.001214	9.56	14651.21	884.43	0.41
1	216.67	0.2 %	243000.00	1081.00	1108.20	1098.22	1110.36	0.001233	11.79	20614.67	1463.73	0.44
1	216.62	Floodplain	169000.00	1082.00	1102.95	1095.27	1104.71	0.001380	10.64	15877.17	898.50	0.45
1	216.62	10 %	55000.00	1082.00	1093.59	1089.48	1094.39	0.001513	7.15	7689.24	849.81	0.42
1	216.62	2 %	140000.00	1082.00	1101.19	1094.00	1102.68	0.001322	9.79	14305.03	889.75	0.43
1	216.62	0.2 %	243000.00	1082.00	1107.81	1098.26	1110.04	0.001302	11.97	20299.49	920.30	0.45
1	216.52	Floodplain	169000.00	1081.00	1102.44	1093.78	1103.99	0.001145	9.99	17006.67	994.29	0.41
1	216.52	10 %	55000.00	1081.00	1093.03	1087.95	1093.68	0.001063	6.45	8526.59	856.73	0.38
1	216.52	2 %	140000.00	1081.00	1100.70	1092.47	1102.00	0.001086	9.15	15310.20	944.27	0.39
1	216.52	0.2 %	243000.00	1081.00	1107.40	1096.73	1109.34	0.001053	11.23	22037.93	1025.00	0.41
1	216.505		Bridge									
1	216.49	Floodplain	169000.00	1079.00	1101.27	1093.20	1102.92	0.001270	10.31	16454.24	1001.34	0.43
1	216.49	10 %	55000.00	1079.00	1092.09	1087.48	1092.78	0.001244	6.70	8211.69	863.71	0.38
1	216.49	2 %	140000.00	1079.00	1099.60	1091.94	1100.98	0.001200	9.42	14860.93	909.89	0.41
1	216.49	0.2 %	243000.00	1079.00	1106.20	1096.16	1108.25	0.001150	11.54	21433.43	1019.22	0.43
1	216.42 AM	Floodplain	169000.00	1078.00	1100.93	1092.48	1102.46	0.001173	9.92	17053.81	985.02	0.41
1	216.42 AM	10 %	55000.00	1078.00	1091.72	1086.82	1092.36	0.001112	6.41	8576.41	885.17	0.36
1	216.42 AM	2 %	140000.00	1078.00	1099.28	1091.24	1100.55	0.001096	9.05	15464.17	939.32	0.39
1	216.42 AM	0.2 %	243000.00	1078.00	1105.94	1095.41	1107.81	0.001071	11.03	22499.29	1104.97	0.41
1	216.38	Floodplain	169000.00	1078.00	1100.76	1091.96	1102.19	0.001074	9.59	17644.22	986.08	0.40
1	216.38	10 %	55000.00	1078.00	1091.53	1086.38	1092.12	0.001001	6.15	8949.66	910.16	0.35
1	216.38	2 %	140000.00	1078.00	1099.12	1090.72	1100.30	0.001001	8.73	16039.75	961.52	0.38
1	216.38	0.2 %	243000.00	1078.00	1105.77	1094.75	1107.56	0.001001	10.77	22696.28	1028.19	0.40

HEC-RAS Plan: Existing 1988 River: Salt Reach: 1

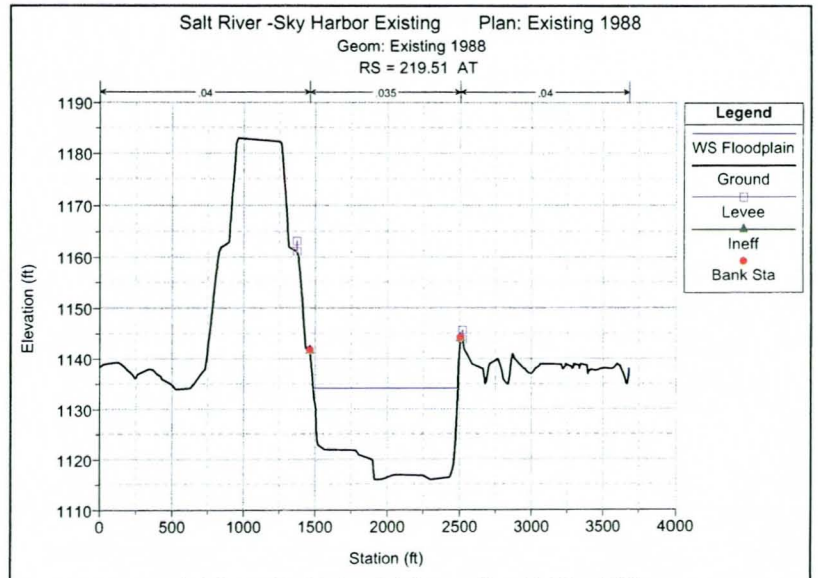
Reach	River Sta	Profile	W.S. Elev (ft)	Prof Delta WS (ft)	E.G. Elev (ft)	Top Width Act (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Enc Sta L (ft)	Ch Sta L (ft)	Ch Sta R (ft)	Enc Sta R (ft)
1	219.51 AT	Floodplain	1134.17		1136.13	1004.82		169000.00			1461.98	2505.89	
1	219.51 AT	Floodway	1134.27	0.09	1136.19	1005.15		169000.00		1461.98	1461.98	2505.89	2505.89
1	219.46	Floodplain	1133.77		1135.70	1010.88		169000.00			1488.84	2534.47	
1	219.46	Floodway	1133.87	0.10	1135.78	1011.21		169000.00		1488.84	1488.84	2534.47	2534.47
1	219.42	Floodplain	1133.10		1135.12	1010.87		169000.00			1514.45	2561.84	
1	219.42	Floodway	1133.22	0.12	1135.21	1011.30		169000.00		1514.45	1514.45	2561.84	2561.84
1	219.38	Floodplain	1132.72		1134.67	1031.25		169000.00			1532.93	2601.11	
1	219.38	Floodway	1132.86	0.14	1134.77	1031.84		169000.00		1532.93	1532.93	2601.11	2601.11
1	219.33	Floodplain	1132.09		1134.11	1031.26		169000.00			1543.82	2609.52	
1	219.33	Floodway	1132.26	0.17	1134.23	1031.95		169000.00		1543.82	1543.82	2609.52	2609.52
1	219.29	Floodplain	1131.60		1133.63	1032.88		169000.00			1554.67	2621.55	
1	219.29	Floodway	1131.79	0.20	1133.78	1033.75		169000.00		1554.67	1554.67	2621.55	2621.55
1	219.24	Floodplain	1131.11		1133.13	1031.14		169000.00			1605.46	2672.31	
1	219.24	Floodway	1131.33	0.22	1133.29	1032.21		169000.00		1605.46	1605.46	2672.31	2672.31
1	219.19	Floodplain	1130.63		1132.60	1028.73		169000.00			1622.76	2689.99	
1	219.19	Floodway	1130.88	0.26	1132.79	1029.89		169000.00		1622.76	1622.76	2689.99	2689.99
1	219.14	Floodplain	1130.10		1132.09	1023.34		169000.00			1648.12	2719.27	
1	219.14	Floodway	1130.39	0.30	1132.31	1024.45		169000.00		1648.12	1648.12	2719.27	2719.27
1	219.09	Floodplain	1129.65		1131.61	1039.92		169000.00			1648.11	2731.10	
1	219.09	Floodway	1129.99	0.34	1131.86	1041.61		169000.00		1648.11	1648.11	2731.10	2731.10
1	219.03 AS	Floodplain	1129.35		1131.01	1060.48		169000.00			1665.49	2751.49	
1	219.03 AS	Floodway	1129.71	0.37	1131.30	1061.79		169000.00		1660.35	1665.49	2751.49	2756.64
1	219.02 BR U	Floodplain	1129.00		1130.90	1013.96		169000.00			1665.49	2751.49	
1	219.02 BR U	Floodway	1129.32	0.32	1131.14	1015.11		169000.00		1660.35	1665.49	2751.49	2756.64
1	219.02 BR D	Floodplain	1128.87		1130.58	1005.83		169000.00			1686.60	2782.89	
1	219.02 BR D	Floodway	1128.81	-0.06	1130.54	1005.83		169000.00		1686.60	1686.60	2782.89	2782.89
1	219.01	Floodplain	1128.70		1130.45	1051.21		169000.00			1686.60	2782.89	
1	219.01	Floodway	1128.71	0.00	1130.45	1051.21		169000.00		1686.60	1686.60	2782.89	2782.89
1	218.99	Floodplain	1128.66		1130.24	1067.49		169000.00			1017.22	2153.61	
1	218.99	Floodway	1128.66	0.00	1130.24	1067.49		169000.00		1011.91	1017.22	2153.61	2158.92
1	218.975 BR U	Floodplain	1128.34		1130.14	1015.69		169000.00			1017.22	2153.61	
1	218.975 BR U	Floodway	1128.34	0.00	1130.14	1015.69		169000.00		1011.91	1017.22	2153.61	2158.92
1	218.975 BR D	Floodplain	1127.72		1129.53	1052.73		169000.00			810.45	1957.46	
1	218.975 BR D	Floodway	1127.72	0.00	1129.53	1052.73		169000.00		810.45	810.45	1957.46	1957.46
1	218.96	Floodplain	1127.87		1129.51	1100.42		169000.00			810.45	1957.46	
1	218.96	Floodway	1127.87	0.00	1129.51	1100.43		169000.00		810.45	810.45	1957.46	1957.46
1	218.8	Floodplain	1126.78		1127.92	997.34		169000.00			290.28	1342.60	
1	218.8	Floodway	1126.78	0.00	1127.92	997.34		169000.00		290.28	290.28	1342.60	1342.60
1	218.77	Floodplain	1126.26		1127.39	1006.25		169000.00			1530.76	2608.83	
1	218.77	Floodway	1126.26	0.00	1127.39	1006.25		169000.00		1530.76	1530.76	2608.83	2608.83
1	218.71 AR	Floodplain	1124.82		1126.82	993.10		169000.00			1533.78	2587.68	
1	218.71 AR	Floodway	1124.82	0.00	1126.82	993.10		169000.00		1533.78	1533.78	2587.68	2587.68
1	218.66	Floodplain	1124.10		1126.24	990.58		169000.00			1528.22	2575.56	
1	218.66	Floodway	1124.10	0.00	1126.24	990.58		169000.00		1528.22	1528.22	2575.56	2575.56
1	218.61	Floodplain	1123.47		1125.65	997.63		169000.00			1509.13	2560.00	
1	218.61	Floodway	1123.47	0.00	1125.65	997.84		169000.00		1509.13	1509.13	2560.00	2560.00
1	218.57	Floodplain	1122.89		1125.08	1003.02		169000.00			1490.24	2545.87	
1	218.57	Floodway	1122.89	0.00	1125.08	1003.03		169000.00		1490.24	1490.24	2545.87	2545.87
1	218.52	Floodplain	1122.33		1124.51	1000.37		169000.00			1466.67	2528.10	
1	218.52	Floodway	1122.33	0.00	1124.51	1000.38		169000.00		1466.67	1466.67	2528.10	2528.10
1	218.47	Floodplain	1121.97		1123.97	1004.70		169000.00			1457.49	2512.97	
1	218.47	Floodway	1121.97	0.00	1123.97	1004.71		169000.00		1457.49	1457.49	2512.97	2512.97
1	218.42	Floodplain	1121.19		1123.37	1012.65		169000.00			1433.40	2501.22	
1	218.42	Floodway	1121.19	0.00	1123.37	1012.65		169000.00		1433.40	1433.40	2501.22	2501.22
1	218.38	Floodplain	1120.66		1122.78	1036.27		169000.00			1385.66	2505.04	
1	218.38	Floodway	1120.67	0.00	1122.78	1036.27		169000.00		1385.66	1385.66	2505.04	2505.04
1	218.33	Floodplain	1120.19		1122.20	1051.37		169000.00			1400.65	2531.99	
1	218.33	Floodway	1120.19	0.00	1122.20	1051.37		169000.00		1400.65	1400.65	2531.99	2531.99
1	218.29	Floodplain	1119.59		1121.70	1039.70		169000.00			1424.08	2551.08	
1	218.29	Floodway	1119.59	0.00	1121.70	1039.71		169000.00		1424.08	1424.08	2551.08	2551.08
1	218.24 AQ	Floodplain	1119.13		1121.09	1038.79		169000.00			1520.28	2583.54	

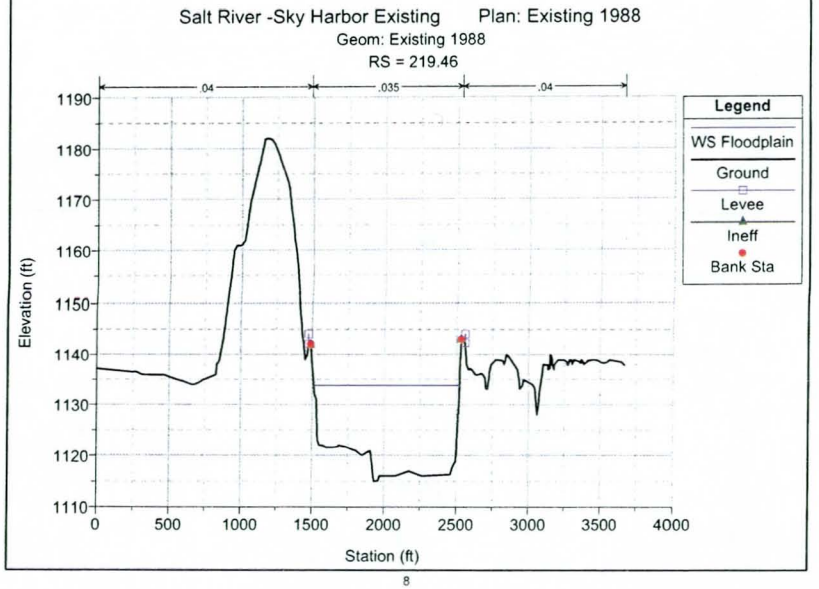
HEC-RAS Plan: Existing 1988 River: Salt Reach: 1 (Continued)

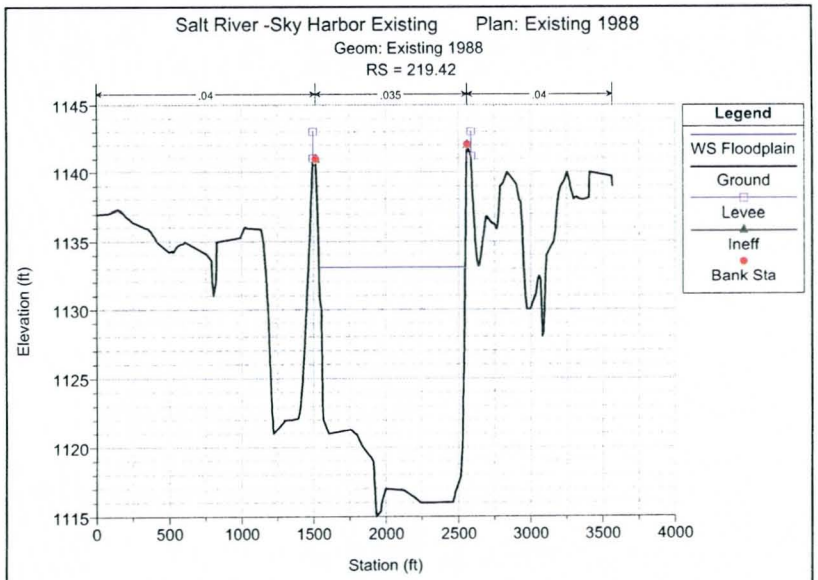
Reach	River Sta	Profile	W.S. Elev (ft)	Prof Delta WS (ft)	E.G. Elev (ft)	Top Width Act (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Enc Sta L (ft)	Ch Sta L (ft)	Ch Sta R (ft)	Enc Sta R (ft)
1	218.24 AQ	Floodway	1119.13	0.00	1121.09	1038.80		169000.00		1520.28	1520.28	2583.54	2583.54
1	218.19	Floodplain	1118.69		1120.59	1044.51		169000.00			1567.89	2634.23	
1	218.19	Floodway	1118.69	0.00	1120.59	1044.52		169000.00		1567.89	1567.89	2634.23	2634.23
1	218.14	Floodplain	1118.13		1120.09	1039.11		169000.00			1635.73	2700.88	
1	218.14	Floodway	1118.13	0.00	1120.10	1039.12		169000.00		1635.73	1635.73	2700.88	2700.88
1	218.09	Floodplain	1117.52		1119.58	1021.85		169000.00			1715.94	2782.78	
1	218.09	Floodway	1117.53	0.00	1119.58	1021.86		169000.00		1715.94	1715.94	2782.78	2782.78
1	218.04	Floodplain	1117.05		1118.99	1041.09		169000.00			1824.87	2902.72	
1	218.04	Floodway	1117.05	0.00	1118.99	1041.11		169000.00		1824.87	1824.87	2902.72	2902.72
1	218	Floodplain	1116.74		1118.52	1040.49		169000.00			1919.28	2989.05	
1	218	Floodway	1116.74	0.00	1118.52	1040.50		169000.00		1919.28	1919.28	2989.05	2989.05
1	217.95	Floodplain	1116.09		1118.00	1038.45		169000.00			2039.94	3108.65	
1	217.95	Floodway	1116.09	0.00	1118.00	1038.47		169000.00		2039.94	2039.94	3108.65	3108.65
1	217.91	Floodplain	1115.89		1117.49	1044.87		169000.00			2124.80	3202.35	
1	217.91	Floodway	1115.89	0.00	1117.49	1044.89		169000.00		2124.80	2124.80	3202.35	3202.35
1	217.86	Floodplain	1115.38		1117.10	1040.84		169000.00			2211.24	3283.62	
1	217.86	Floodway	1115.37	0.01	1117.11	1040.88		169000.00		2211.24	2211.24	3283.62	3283.62
1	217.81	Floodplain	1114.73		1116.72	948.51		169000.00			2283.70	3364.63	
1	217.81	Floodway	1114.74	0.01	1116.72	948.53		169000.00		2283.70	2283.70	3364.63	3364.63
1	217.76 AP	Floodplain	1112.79		1115.89	811.60		169000.00			2352.26	3192.57	
1	217.76 AP	Floodway	1112.80	0.01	1115.89	811.63		169000.00		2352.26	2352.26	3192.57	3192.57
1	217.71	Floodplain	1112.26		1115.16	802.65		169000.00			2381.92	3227.54	
1	217.71	Floodway	1112.27	0.01	1115.16	802.68		169000.00		2381.92	2381.92	3227.54	3227.54
1	217.66	Floodplain	1111.01		1114.30	787.07		169000.00			2419.16	3237.78	
1	217.66	Floodway	1111.03	0.02	1114.32	787.12		169000.00		2419.16	2419.16	3237.78	3237.78
1	217.62	Floodplain	1110.50		1113.46	830.81		169000.00			2441.12	3294.47	
1	217.62	Floodway	1110.52	0.02	1113.47	830.86		169000.00		2441.12	2441.12	3294.47	3294.47
1	217.57	Floodplain	1110.19		1112.54	927.48		169000.00			2454.05	3403.98	
1	217.57	Floodway	1110.21	0.03	1112.56	927.54		169000.00		2454.05	2454.05	3403.98	3403.98
1	217.53	Floodplain	1110.10		1111.98	1008.71		169000.00			2457.23	3494.42	
1	217.53	Floodway	1110.12	0.03	1112.00	1008.78		169000.00		2457.23	2457.23	3494.42	3494.42
1	217.48	Floodplain	1109.67		1111.51	1045.77		169000.00			2456.00	3543.88	
1	217.48	Floodway	1109.70	0.03	1111.53	1045.88		169000.00		2456.00	2456.00	3543.88	3543.88
1	217.43	Floodplain	1109.10		1111.04	1041.52		169000.00			2460.09	3554.27	
1	217.43	Floodway	1109.13	0.04	1111.07	1041.84		169000.00		2460.09	2460.09	3554.27	3554.27
1	217.38	Floodplain	1108.85		1110.50	1037.82		169000.00			2462.08	3541.87	
1	217.38	Floodway	1108.89	0.04	1110.53	1037.98		169000.00		2462.08	2462.08	3541.87	3541.87
1	217.34	Floodplain	1108.19		1110.04	1022.46		169000.00			2452.58	3528.72	
1	217.34	Floodway	1108.25	0.05	1110.07	1022.64		169000.00		2452.58	2452.58	3528.72	3528.72
1	217.29 AQ	Floodplain	1107.78		1109.61	1000.54		169000.00			2442.85	3501.92	
1	217.29 AQ	Floodway	1107.85	0.08	1109.68	1000.73		169000.00		2442.85	2442.85	3501.92	3501.92
1	217.24	Floodplain	1107.33		1109.17	979.88		169000.00			2438.98	3453.79	
1	217.24	Floodway	1107.39	0.06	1109.22	979.90		169000.00		2438.98	2438.98	3453.79	3453.79
1	217.19	Floodplain	1106.79		1108.72	955.07		169000.00			2389.07	3382.49	
1	217.19	Floodway	1106.86	0.06	1108.77	955.31		169000.00		2389.07	2389.07	3382.49	3382.49
1	217.15	Floodplain	1106.64		1108.30	935.53		169000.00			2301.76	3274.76	
1	217.15	Floodway	1106.70	0.07	1108.35	936.17		169000.00		2301.76	2301.76	3274.76	3274.76
1	217.1	Floodplain	1106.26		1107.93	918.89		169000.00			2188.24	3143.45	
1	217.1	Floodway	1106.33	0.07	1107.98	917.18		169000.00		2188.24	2188.24	3143.45	3143.45
1	217.05	Floodplain	1105.84		1107.60	912.07		169000.00			2058.05	3014.33	
1	217.05	Floodway	1105.92	0.08	1107.68	912.39		169000.00		2058.05	2058.05	3014.33	3014.33
1	217	Floodplain	1105.39		1107.23	909.78		169000.00			1926.21	2875.18	
1	217	Floodway	1105.47	0.09	1107.30	910.11		169000.00		1926.21	1926.21	2875.18	2875.18
1	216.96	Floodplain	1105.17		1106.83	906.14		169000.00			1774.02	2718.45	
1	216.96	Floodway	1105.26	0.09	1106.90	906.53		169000.00		1774.02	1774.02	2718.45	2718.45
1	216.91	Floodplain	1104.84		1106.49	909.25		169000.00			1591.95	2538.12	
1	216.91	Floodway	1104.94	0.10	1106.57	909.67		169000.00		1591.95	1591.95	2538.12	2538.12
1	216.86	Floodplain	1104.62		1106.16	907.79		169000.00			1443.55	2388.16	
1	216.86	Floodway	1104.73	0.10	1106.24	908.24		169000.00		1443.55	1443.55	2388.16	2388.16
1	216.81 AN	Floodplain	1104.40		1105.87	898.67		169000.00			1301.46	2239.38	
1	216.81 AN	Floodway	1104.50	0.11	1105.96	899.23		169000.00		1301.46	1301.46	2239.38	2239.38

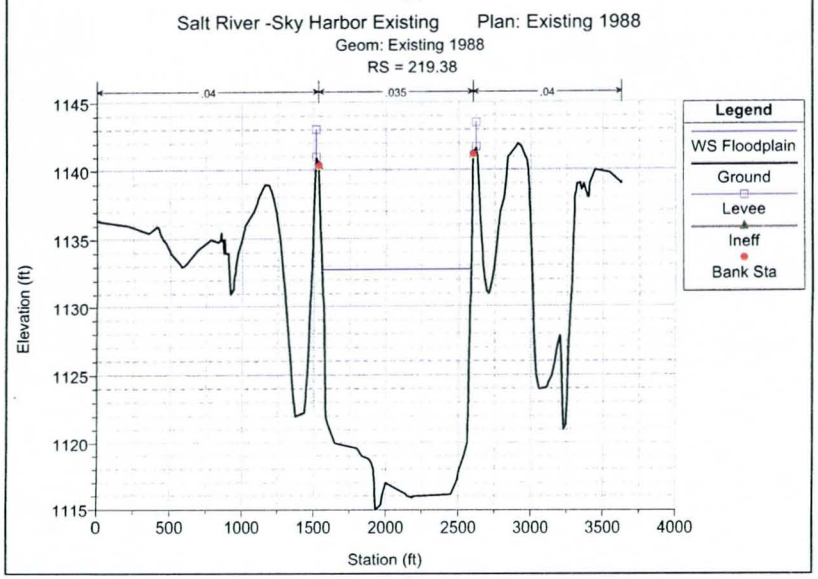
HEC-RAS Plan: Existing 1988 River: Salt Reach: 1 (Continued)

Reach	River Sta	Profile	W.S. Elev (ft)	Prof Delta WS (ft)	E.G. Elev (ft)	Top Width 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)
1	218.77	Floodplain	1104.20		1105.60	907.25		169000.00			1154.94	2092.58	
1	218.77	Floodway	1104.31	0.11	1105.70	907.88		169000.00		1154.94	1154.94	2092.58	2092.58
1	218.72	Floodplain	1103.92		1105.36	906.69		169000.00			1004.49	1840.66	
1	218.72	Floodway	1104.04	0.12	1105.48	907.29		169000.00		1004.49	1004.49	1840.66	1840.66
1	218.67	Floodplain	1103.37		1105.05	893.54		169000.00			856.52	1799.71	
1	218.67	Floodway	1103.50	0.13	1105.15	894.20		169000.00		856.52	856.52	1799.71	1799.71
1	218.62	Floodplain	1102.95		1104.71	898.50		169000.00			724.22	1654.97	
1	218.62	Floodway	1103.09	0.14	1104.82	899.15		169000.00		724.22	724.22	1654.97	1654.97
1	218.52	Floodplain	1102.44		1103.99	994.29	201.19	168797.90	0.90		490.09	1405.11	
1	218.52	Floodway	1102.59	0.15	1104.12	915.02		169000.00		490.09	490.09	1405.11	1405.11
1	218.505 BR U	Floodplain	1102.15		1103.91	944.62	187.06	168812.90	0.03		490.09	1405.11	
1	218.505 BR U	Floodway	1102.38	0.23	1104.10	873.02		169000.00		490.09	490.09	1405.11	1405.11
1	218.505 BR D	Floodplain	1101.08		1102.93	958.64	44.70	168938.50	16.81		377.67	1292.02	
1	218.505 BR D	Floodway	1102.06	0.98	1103.72	872.35		169000.00		377.67	377.67	1292.02	1292.02
1	218.49	Floodplain	1101.27		1102.92	1001.34	58.90	168922.70	20.40		377.67	1292.02	
1	218.49	Floodway	1102.17	0.90	1103.67	914.35		169000.00		377.67	377.67	1292.02	1292.02
1	218.42 AM	Floodplain	1100.93		1102.46	985.02	29.65	168970.40			137.00	1112.38	
1	218.42 AM	Floodway	1101.90	0.97	1103.28	951.11		169000.00		137.00	137.00	1112.38	1112.38
1	218.38	Floodplain	1100.76		1102.19	988.08	17.80	168982.20			14.17	1008.74	
1	218.38	Floodway	1101.76	1.00	1103.04	971.24		169000.00		14.17	14.17	1008.74	1008.74






Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 219.42
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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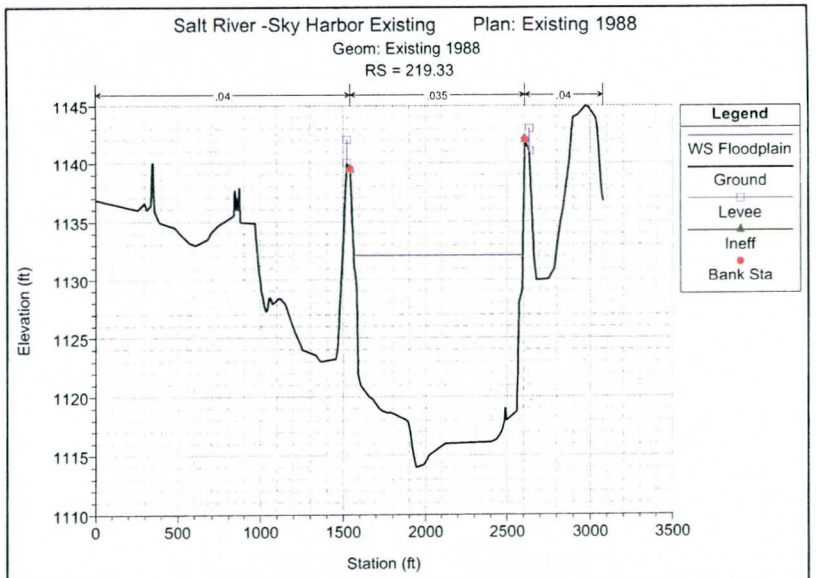
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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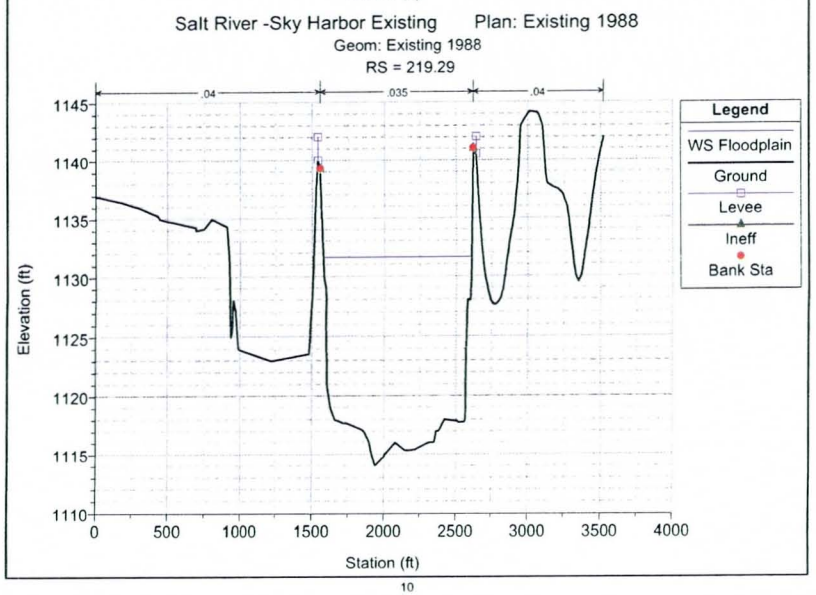
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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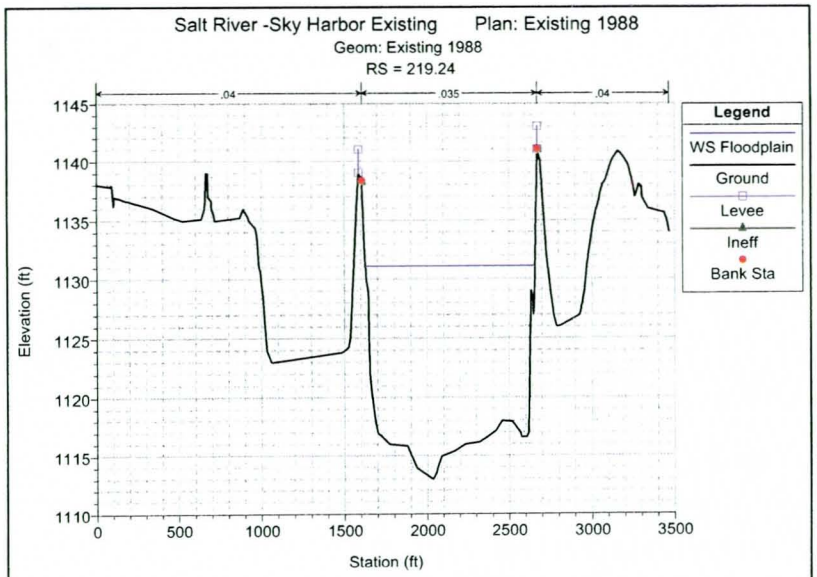
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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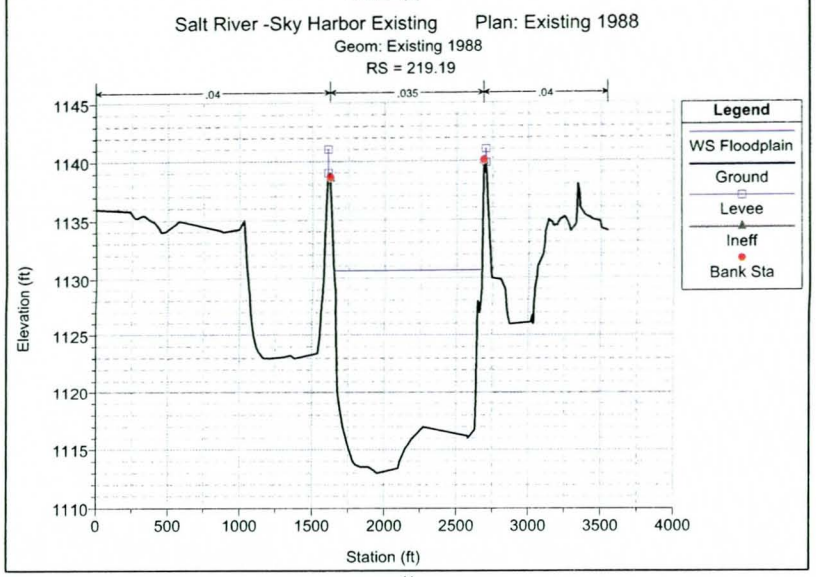
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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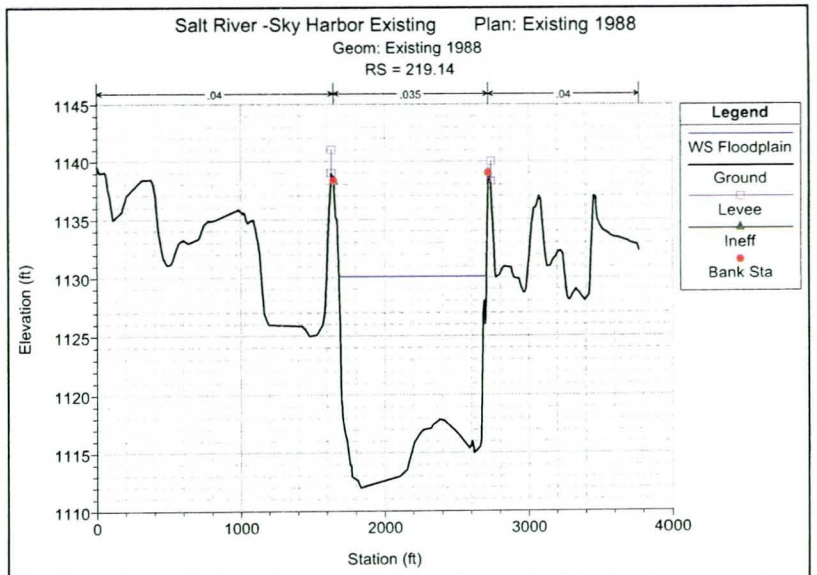
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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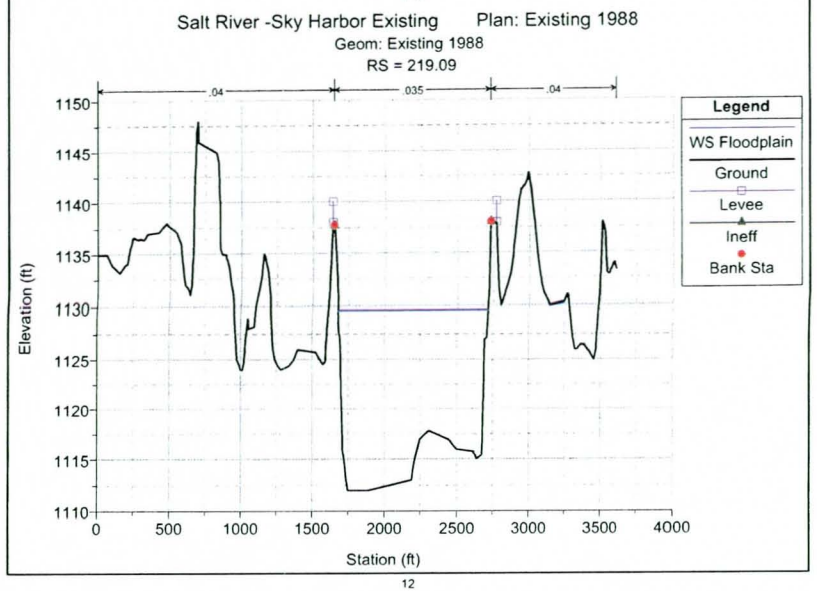
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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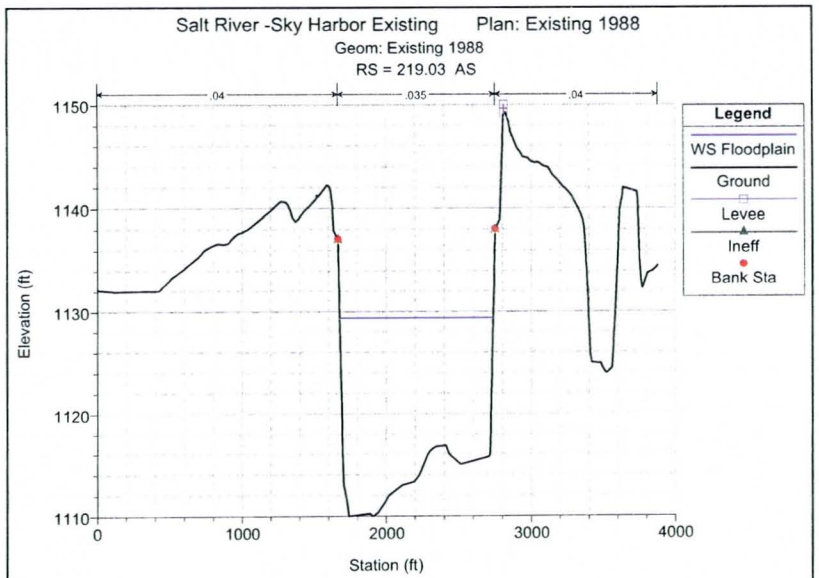
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)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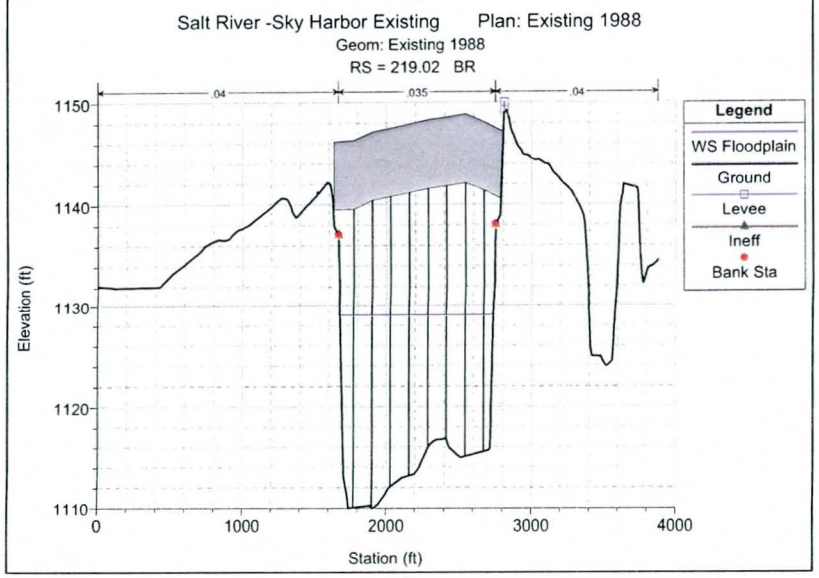
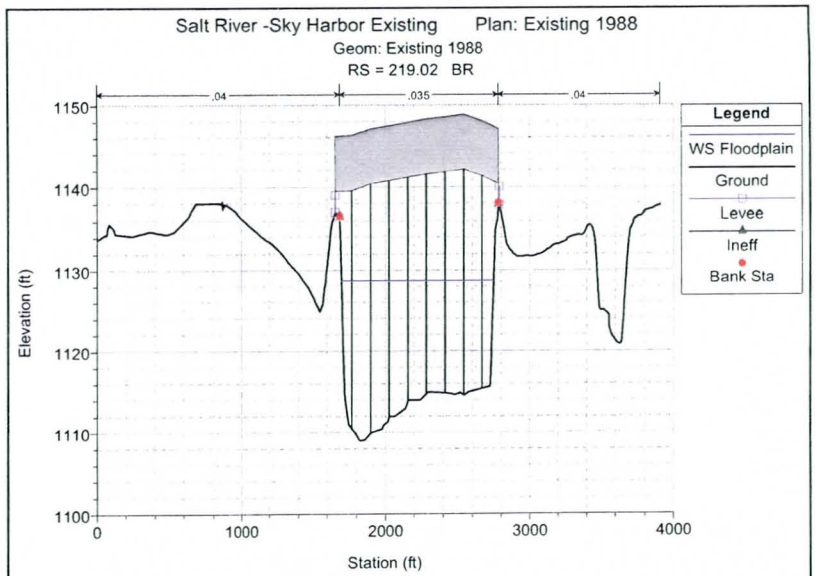
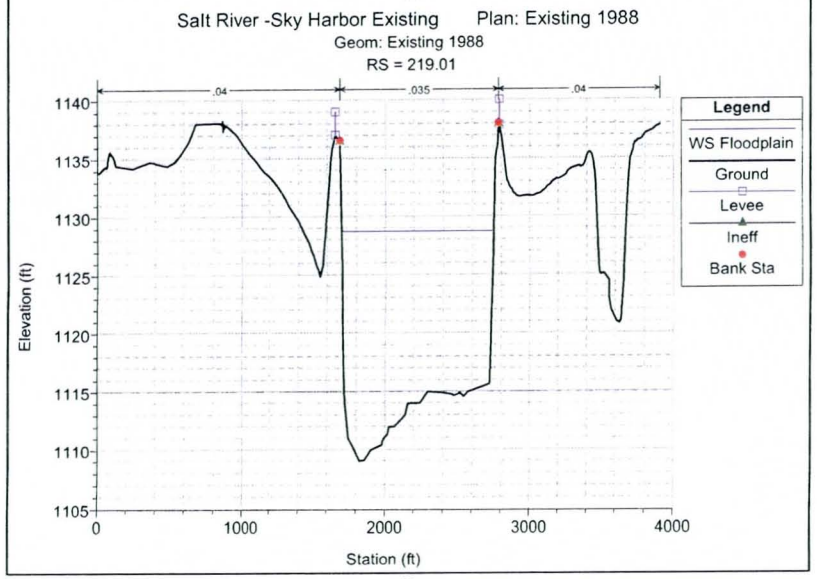
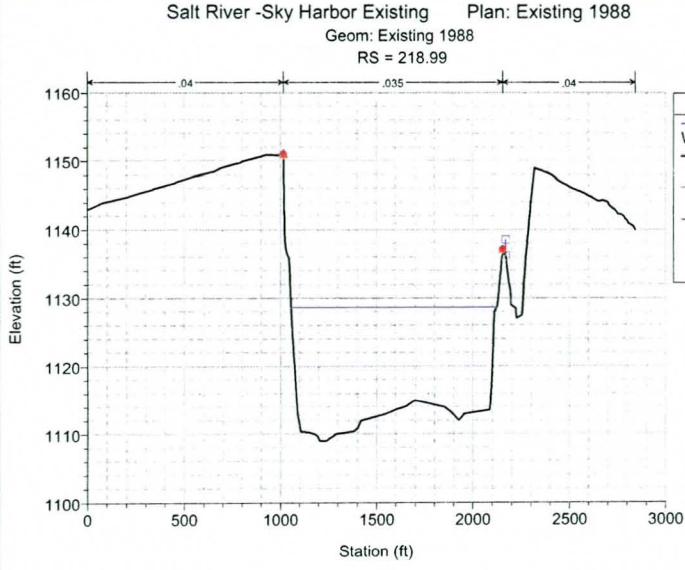
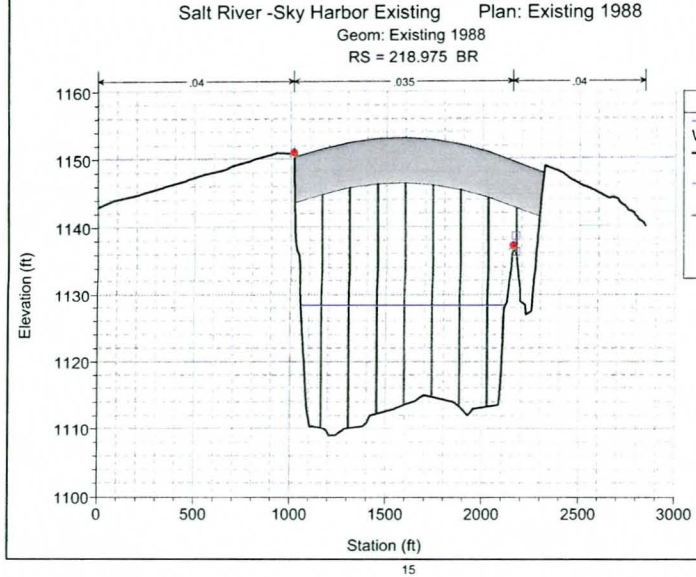
Geom: Existing 1988
RS = 219.03 AS
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1150
1140
1130
1120
1110
0
1000
2000
3000
4000
Station (ft)

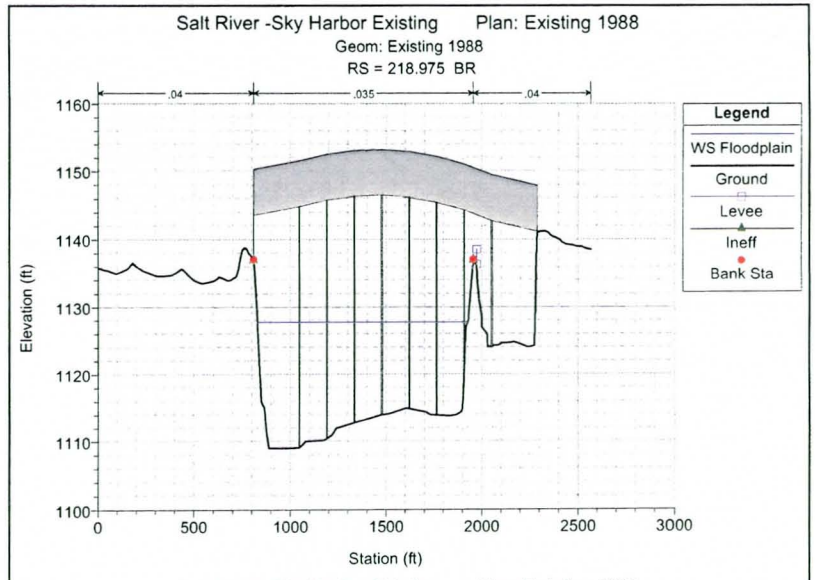

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 219.02 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1150
1140
1130
1120
1110
0
1000
2000
3000
4000
Station (ft)

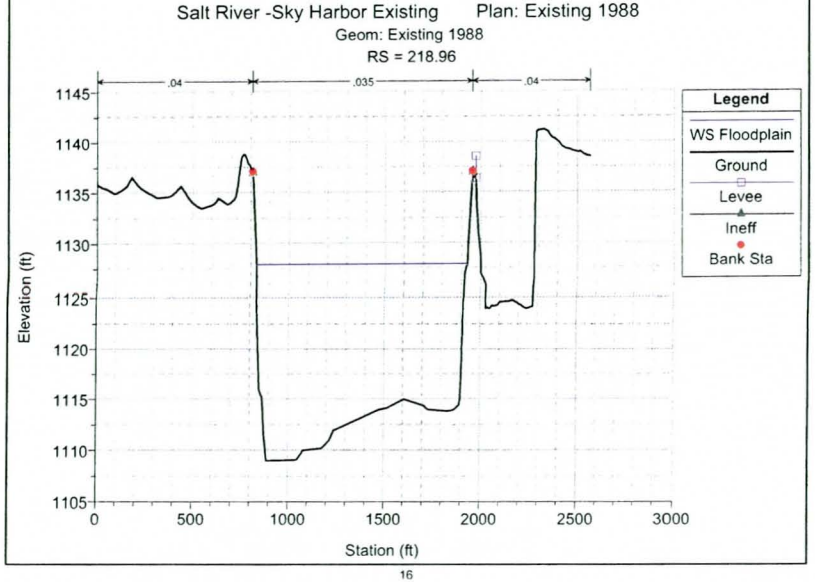

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 219.02 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1150
1140
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)

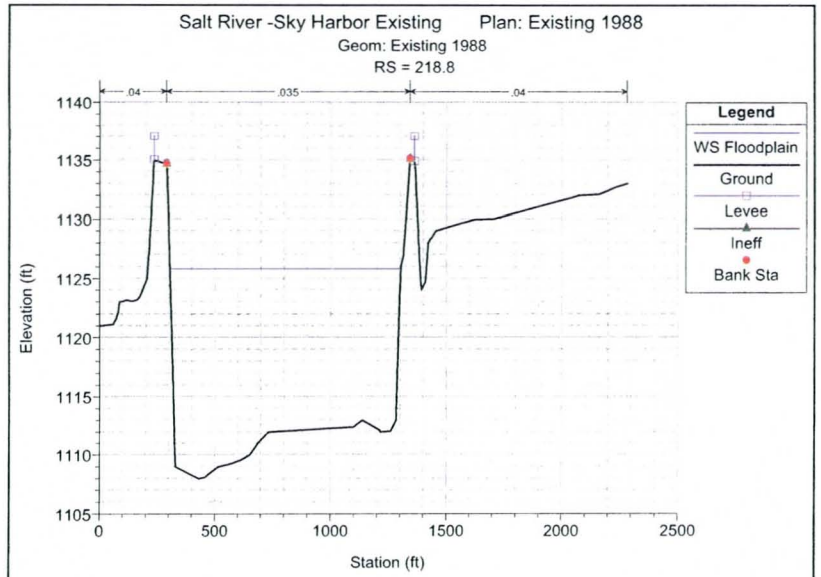

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 219.01
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1140
1135
1130
1125
1120
1115
1110
1105
0
1000
2000
3000
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.99
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1160
1150
1140
1130
1120
1110
1100
0
500
1000
1500
2000
2500
3000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.975 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1160
1150
1140
1130
1120
1110
1100
0
500
1000
1500
2000
2500
3000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.975 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1160
1150
1140
1130
1120
1110
1100
0
500
1000
1500
2000
2500
3000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.96
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1145
1140
1135
1130
1125
1120
1115
1110
1105
0
500
1000
1500
2000
2500
3000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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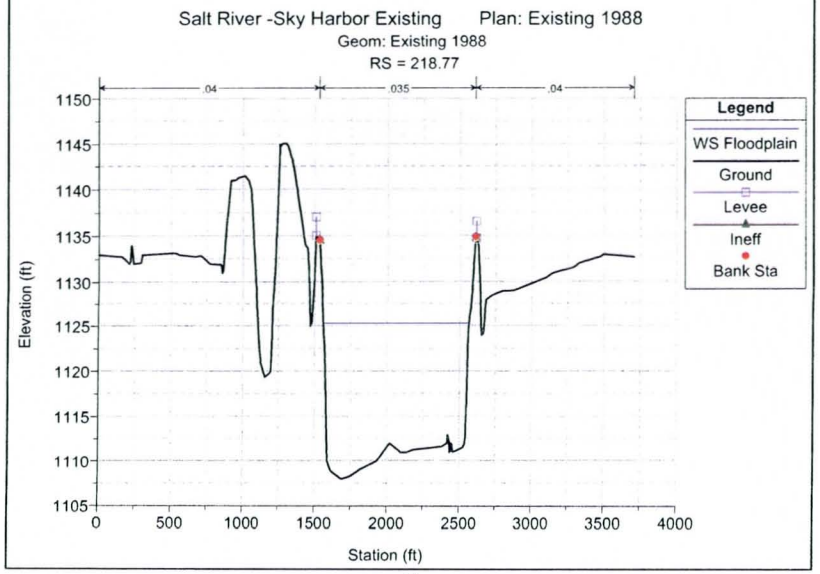
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.77
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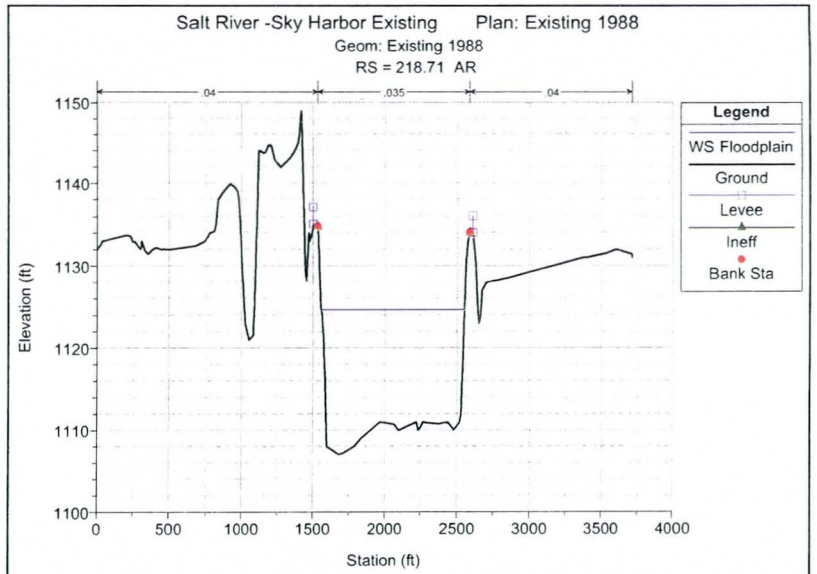
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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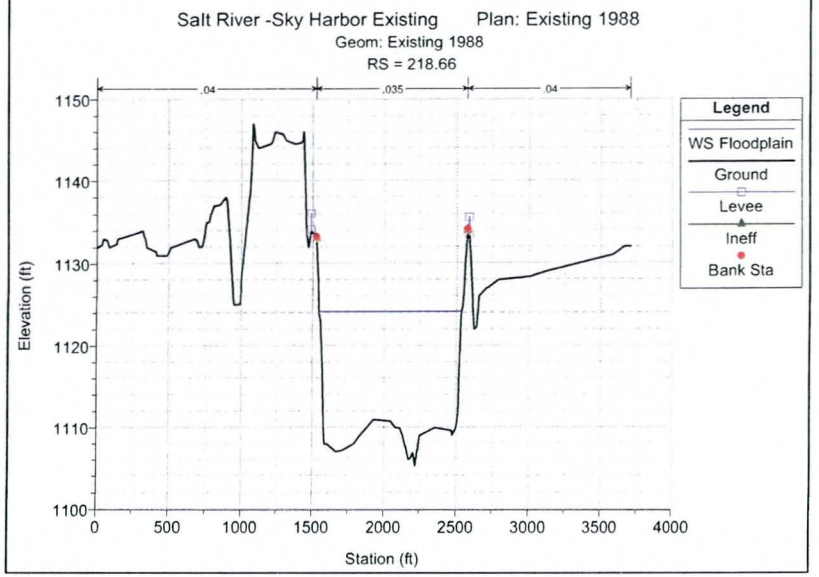
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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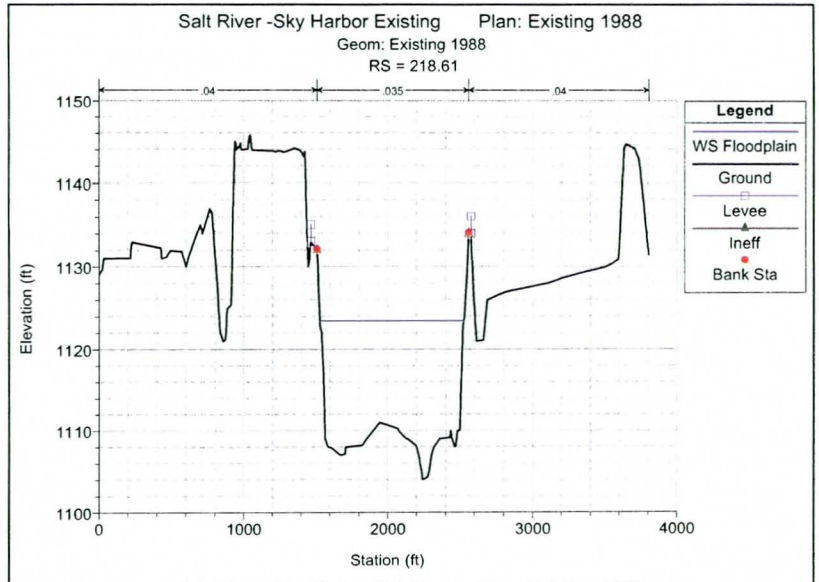
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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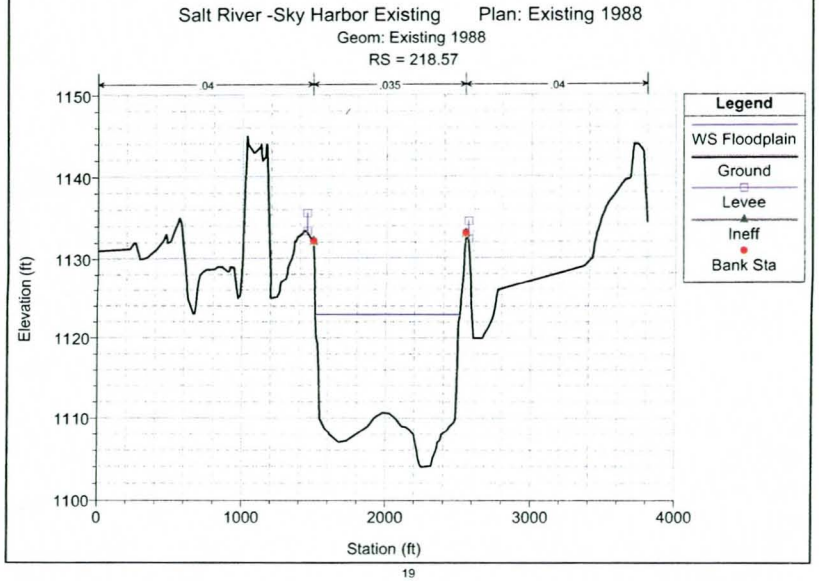
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1150
1140
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1150
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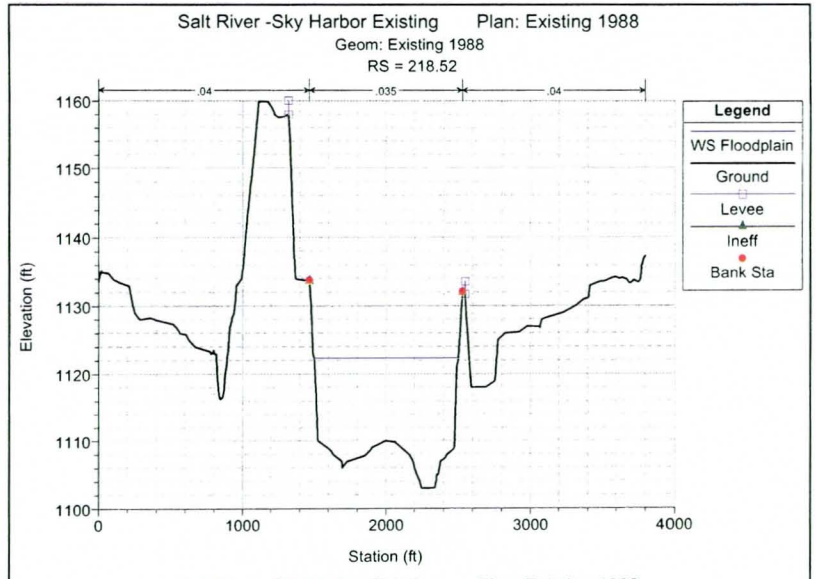
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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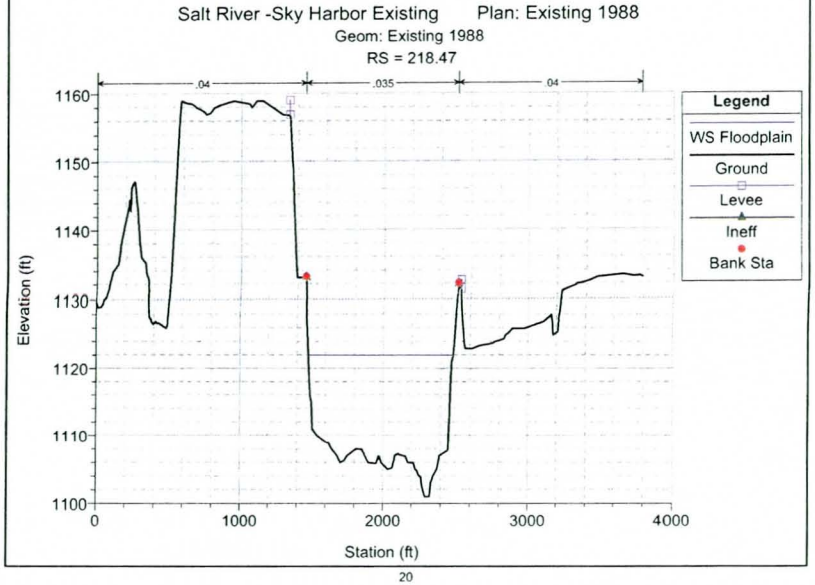
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1160
1150
1140
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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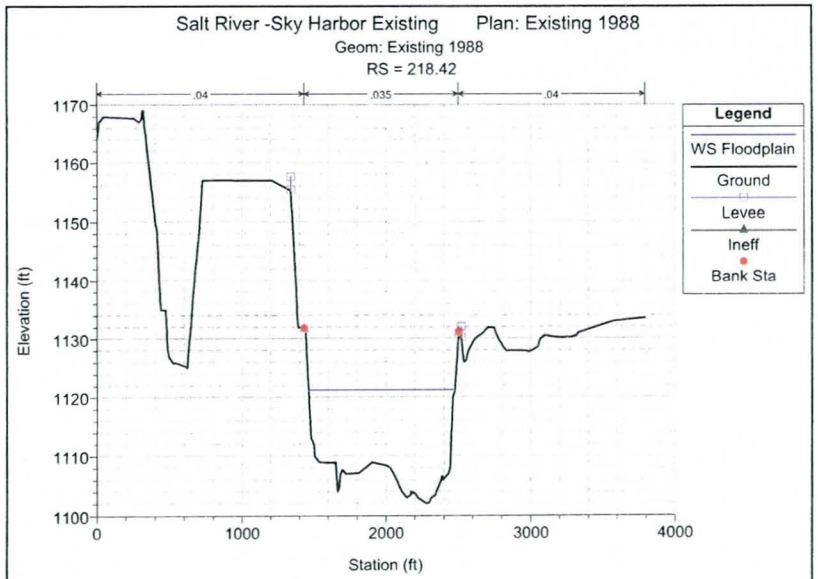
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1160
1150
1140
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
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.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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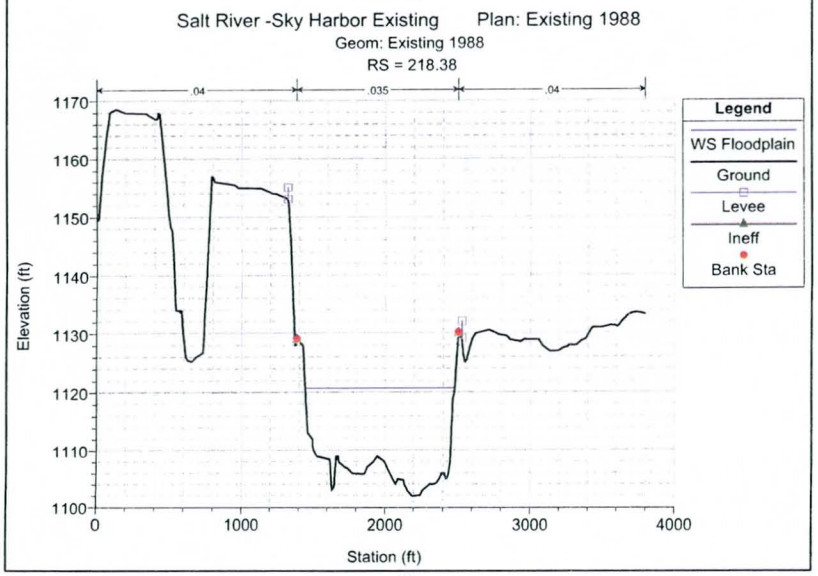
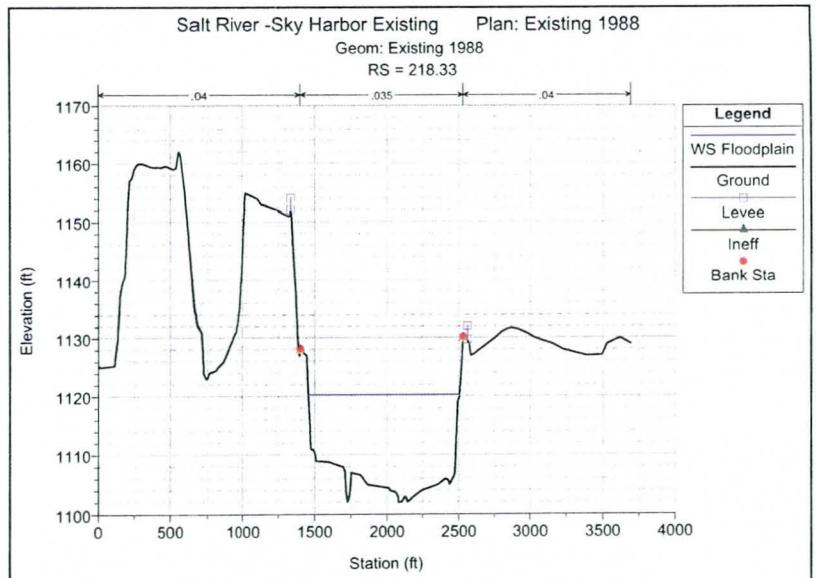
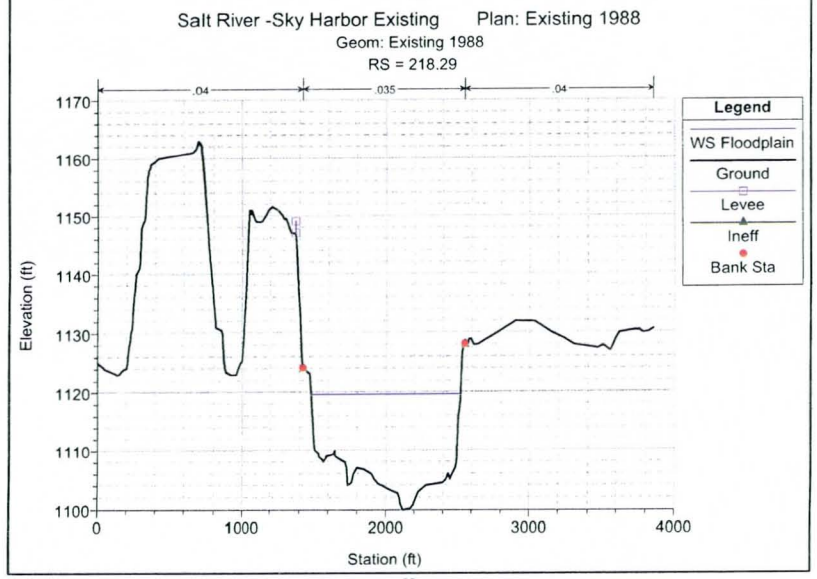
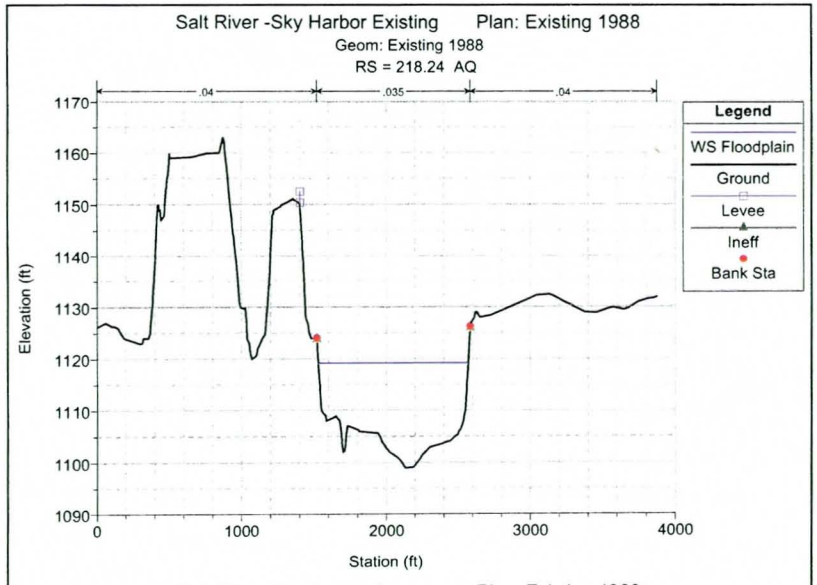
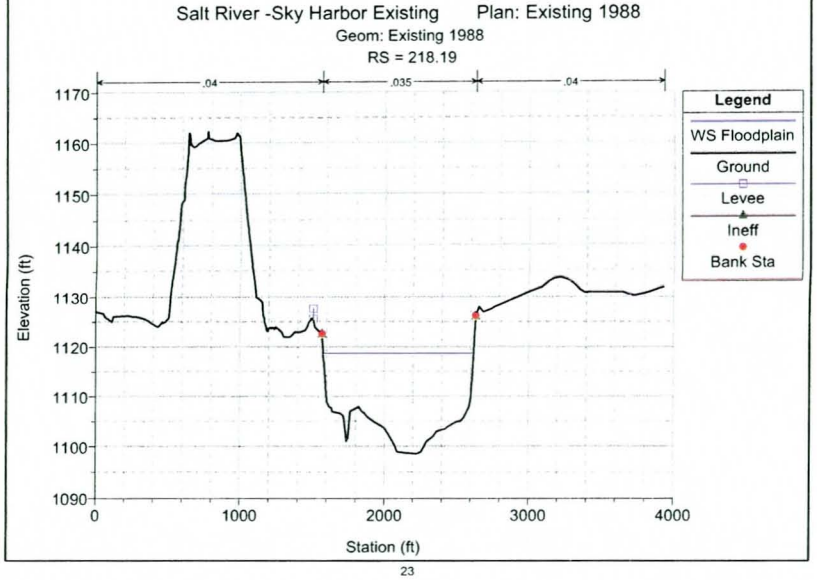
1160
1150
1140
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)

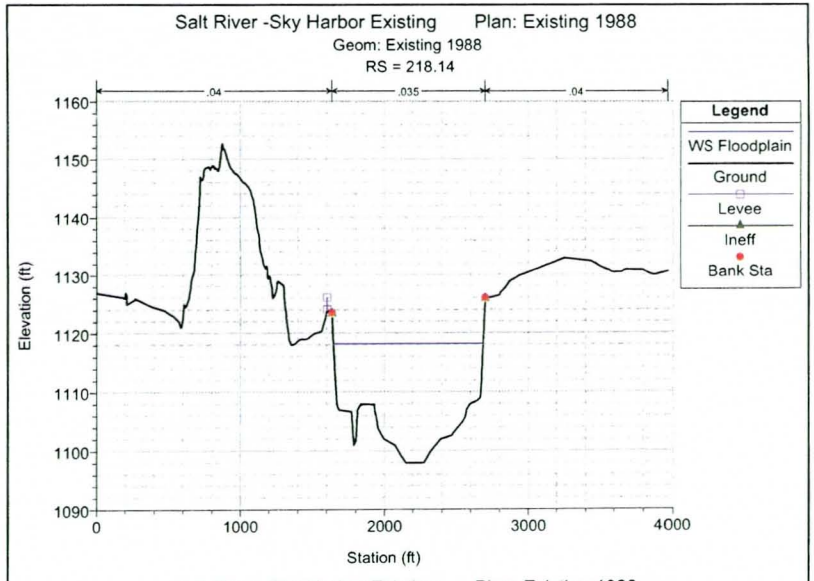

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.38
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1170
1160
1150
1140
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.33
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1170
1160
1150
1140
1130
1120
1110
1100
0
500
1000
1500
2000
2500
3000
3500
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.29
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1170
1160
1150
1140
1130
1120
1110
1100
0
1000
2000
3000
4000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.24 AQ
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.19
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.14
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.035
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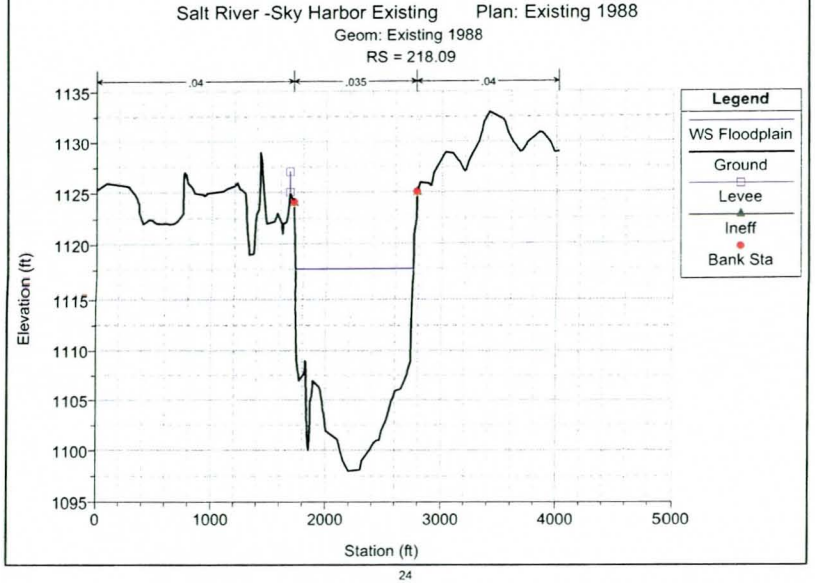
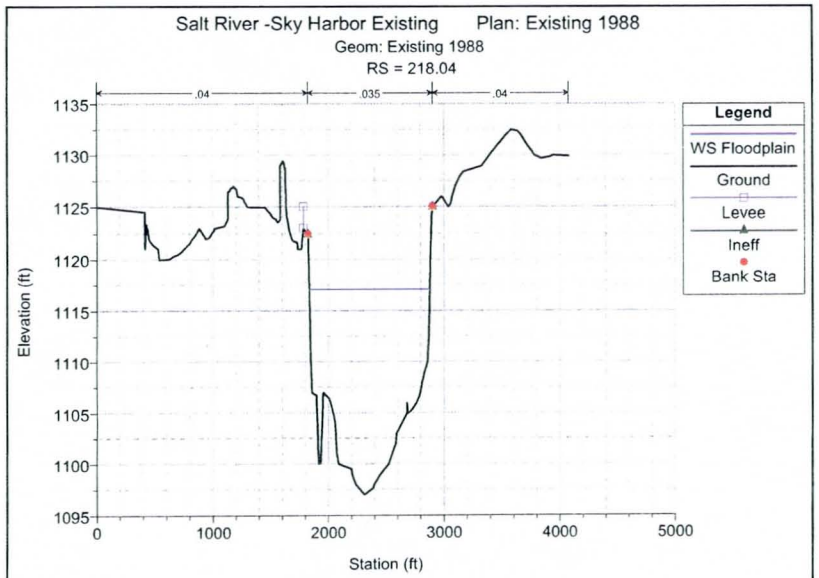
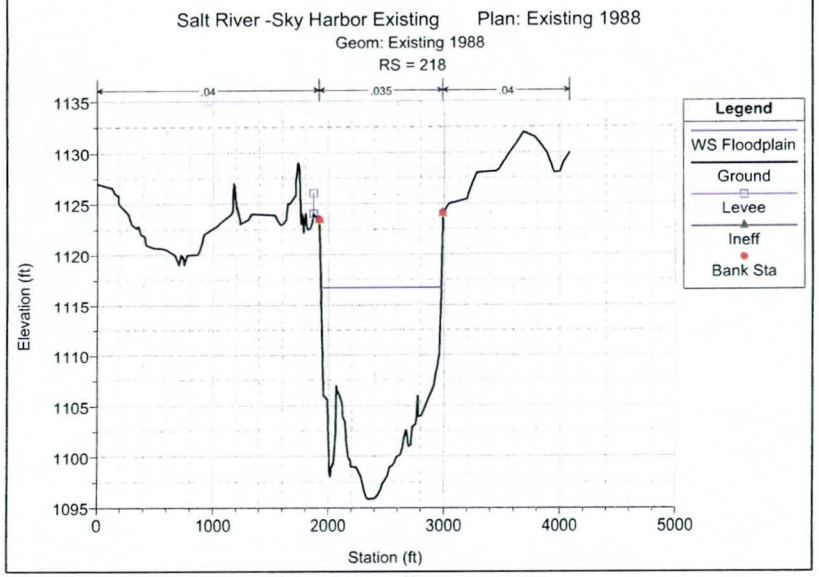
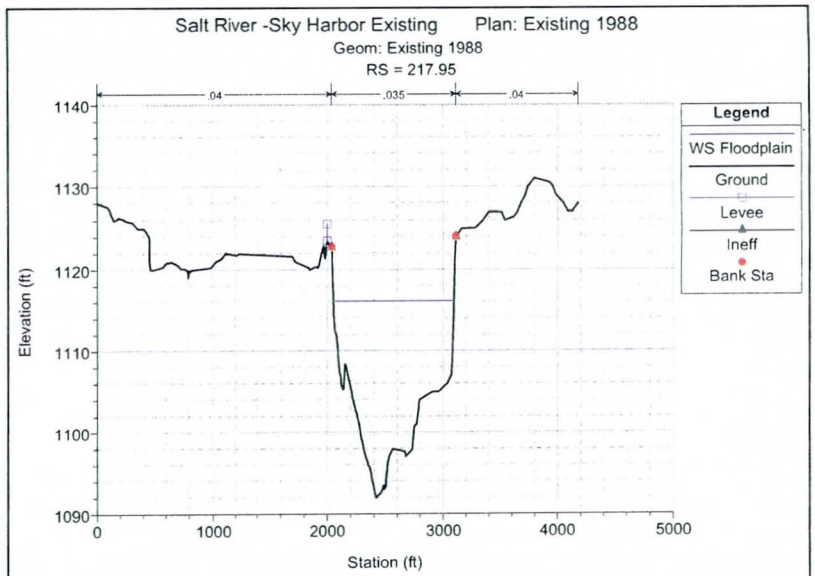
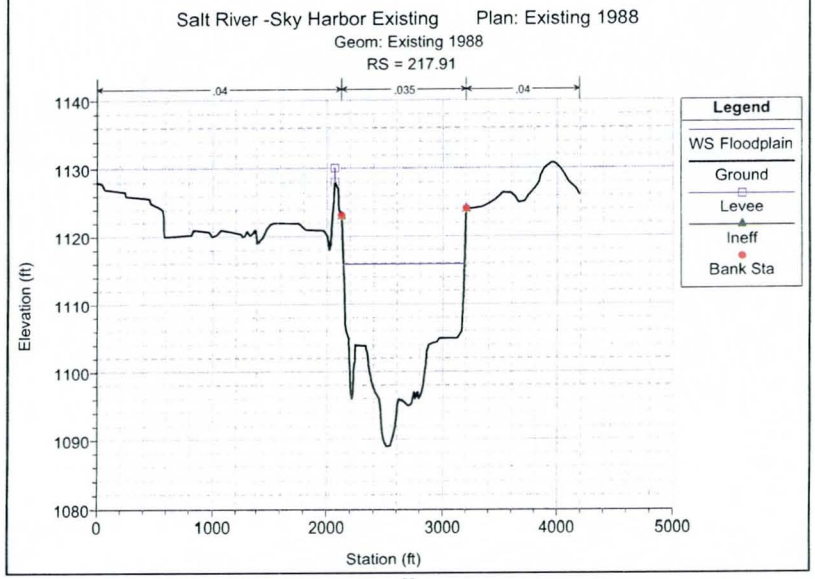
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

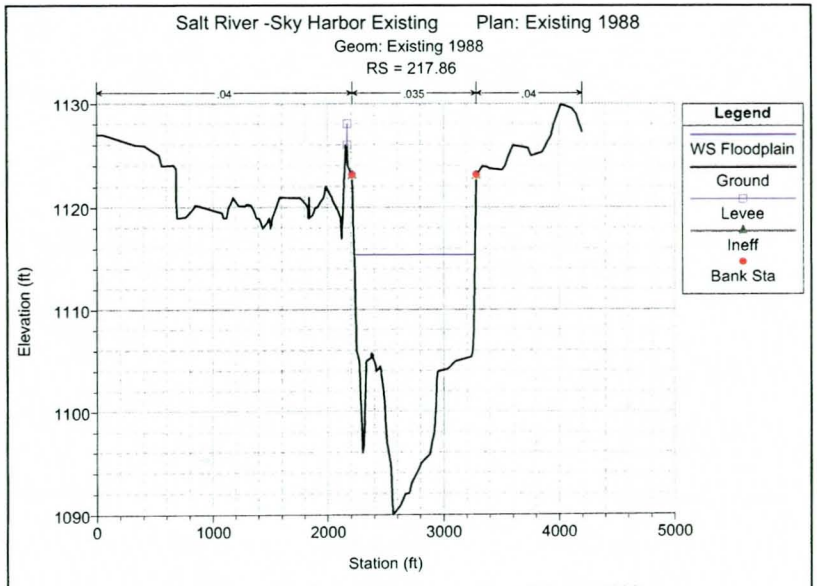

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.09
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

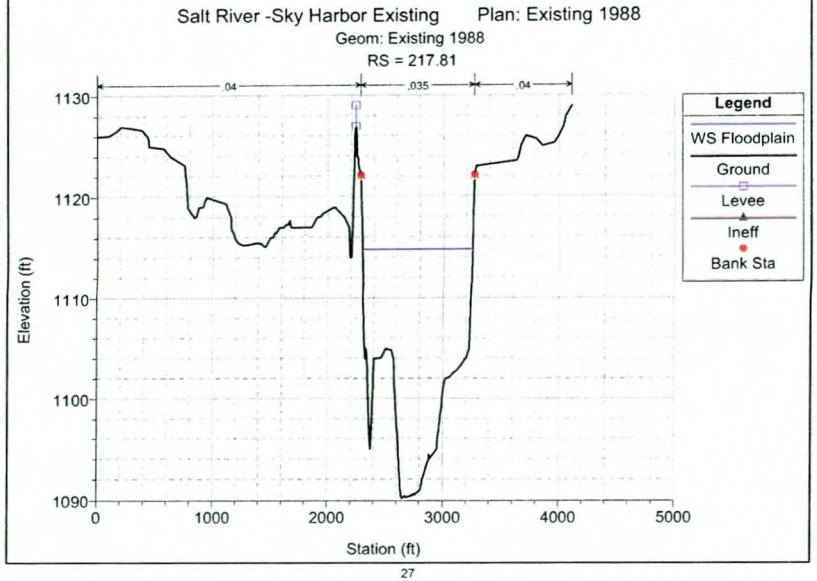

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218.04
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

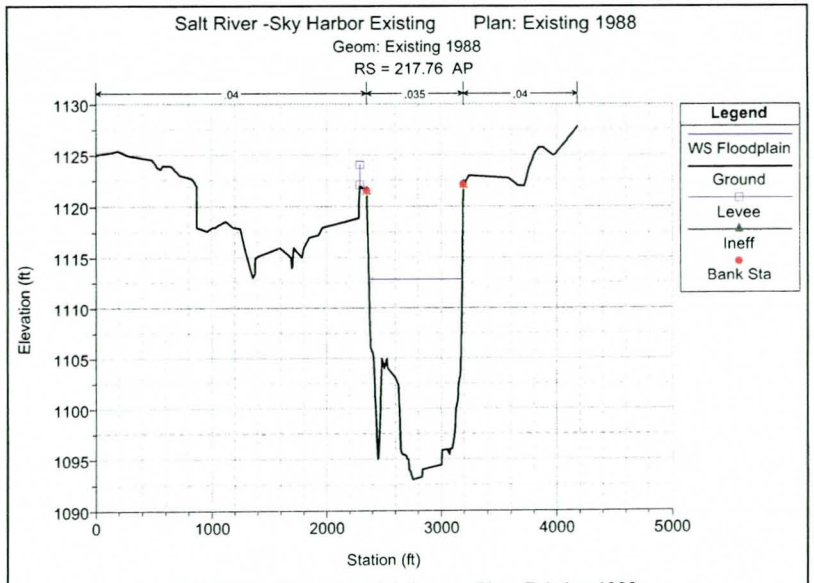

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 218
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

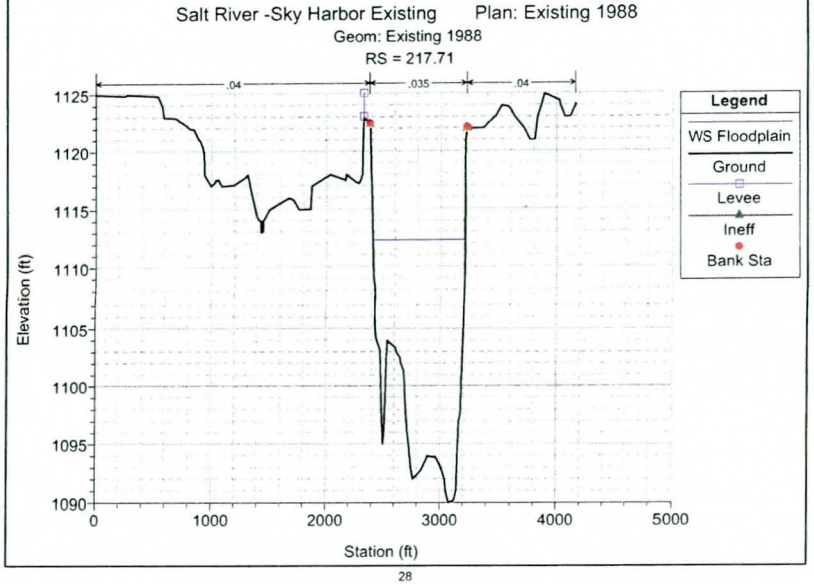

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.95
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

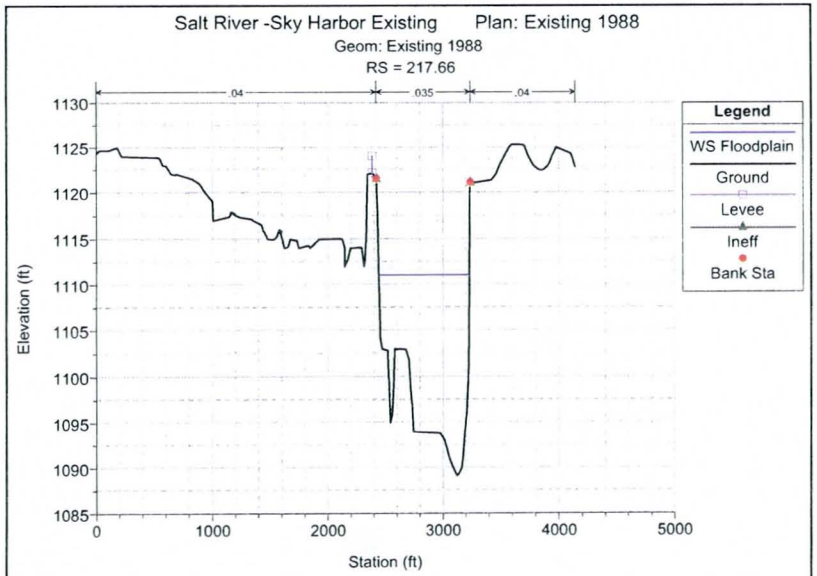

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.91
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

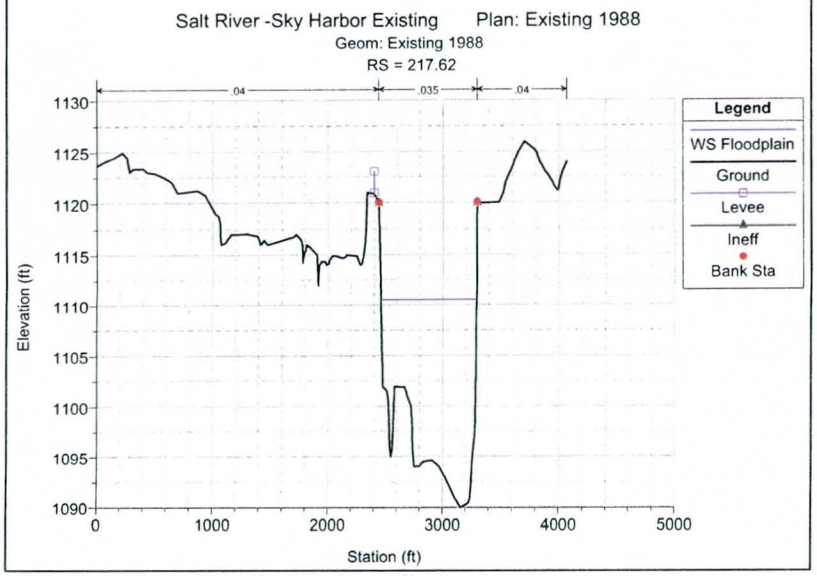

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.86
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1130
1120
1110
1100
1090
0
1000
2000
3000
4000
5000
Station (ft)

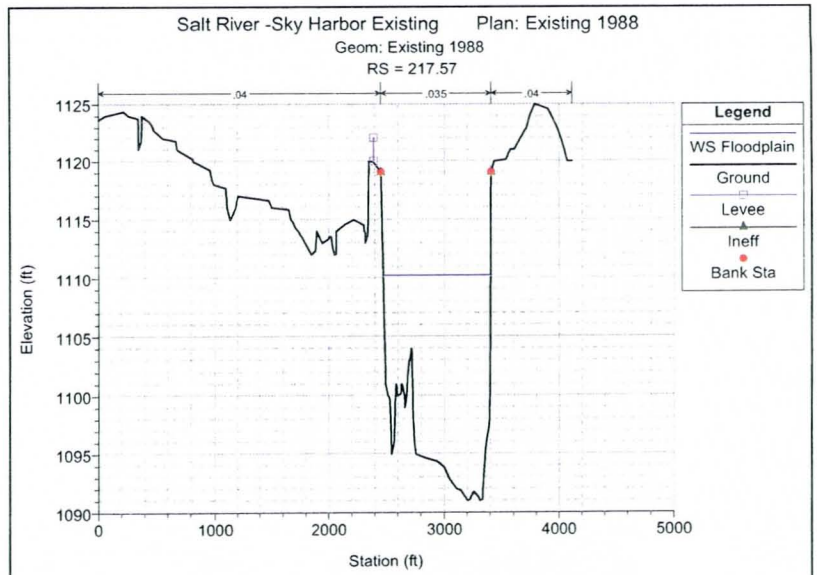

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.81
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1130
1120
1110
1100
1090
0
1000
2000
3000
4000
5000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.76 AP
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1130
1125
1120
1115
1110
1105
1100
1095
1090
0
1000
2000
3000
4000
5000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.71
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1125
1120
1115
1110
1105
1100
1095
1090
0
1000
2000
3000
4000
5000
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.66
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.62
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.57
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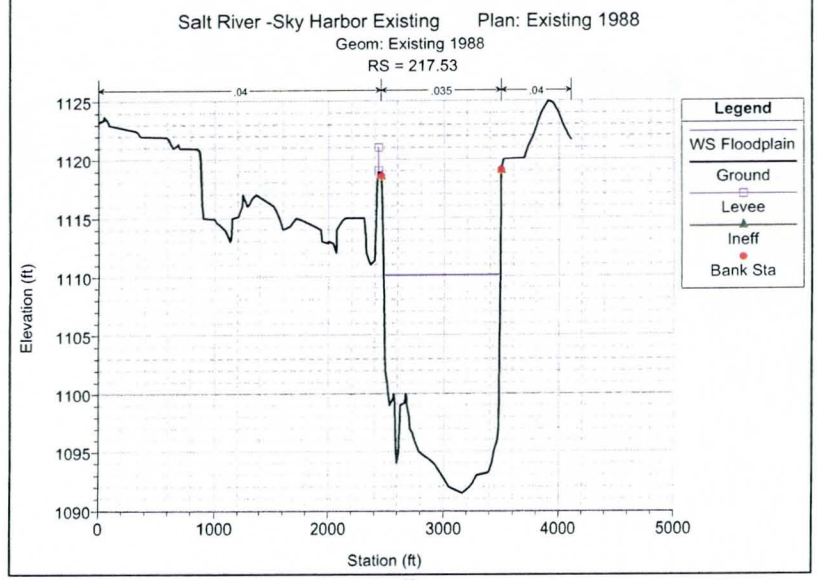
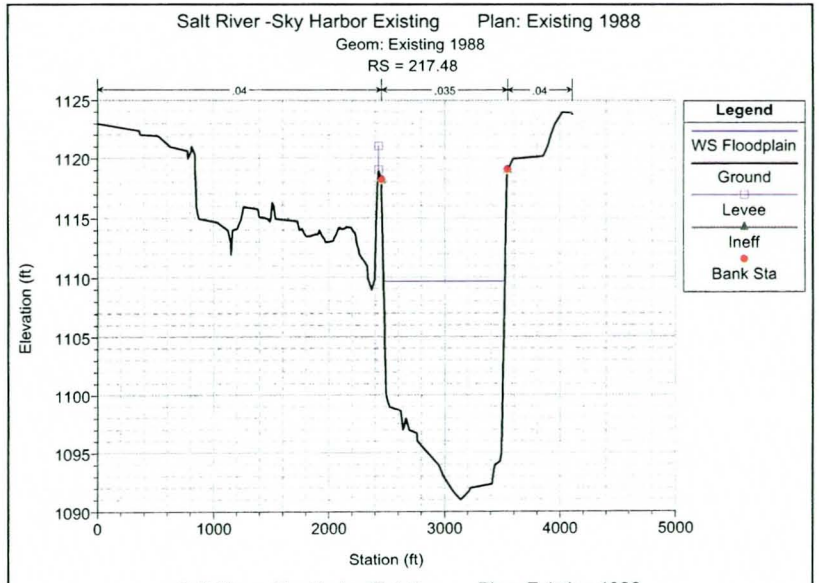
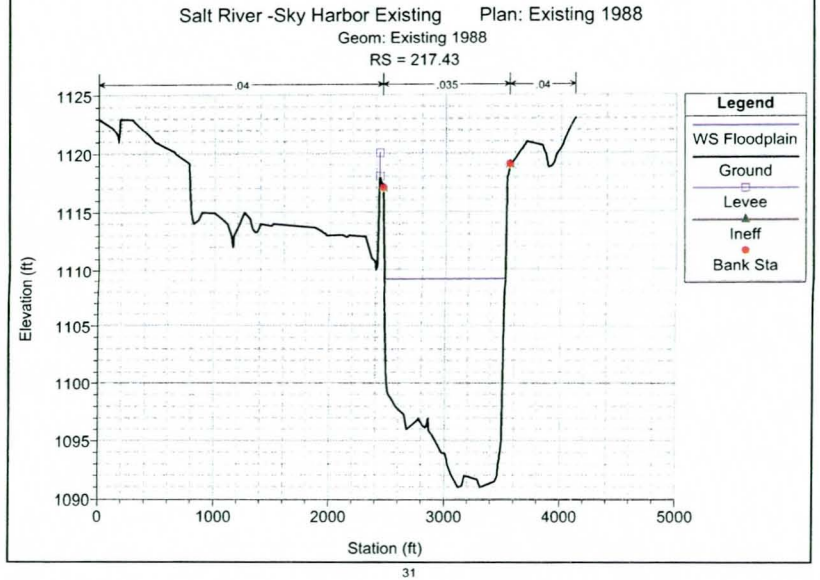
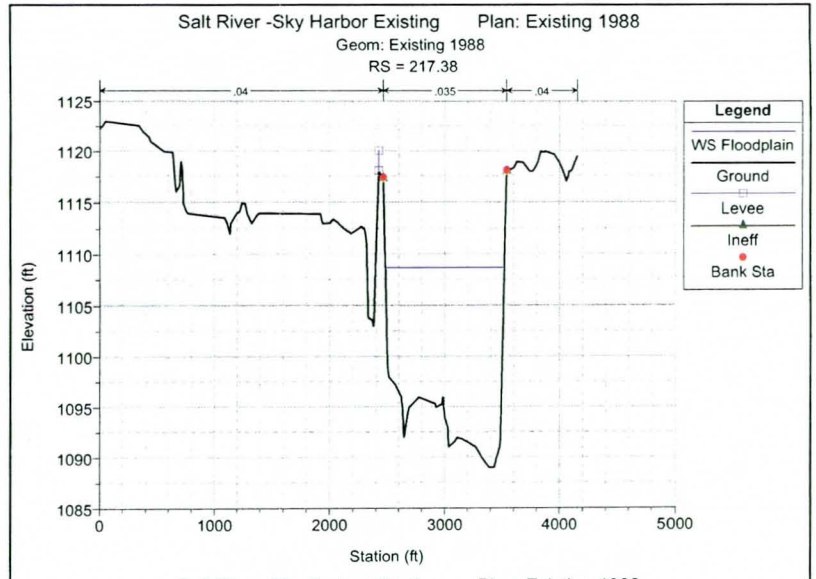
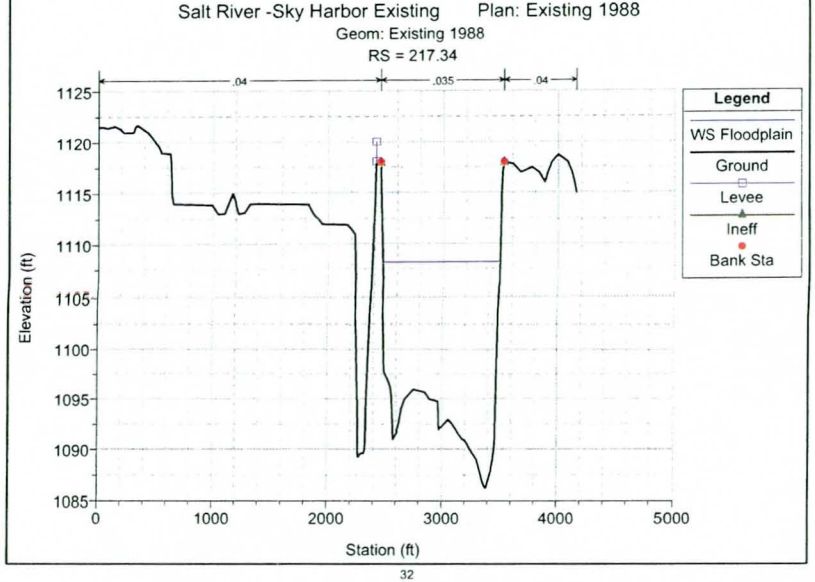
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

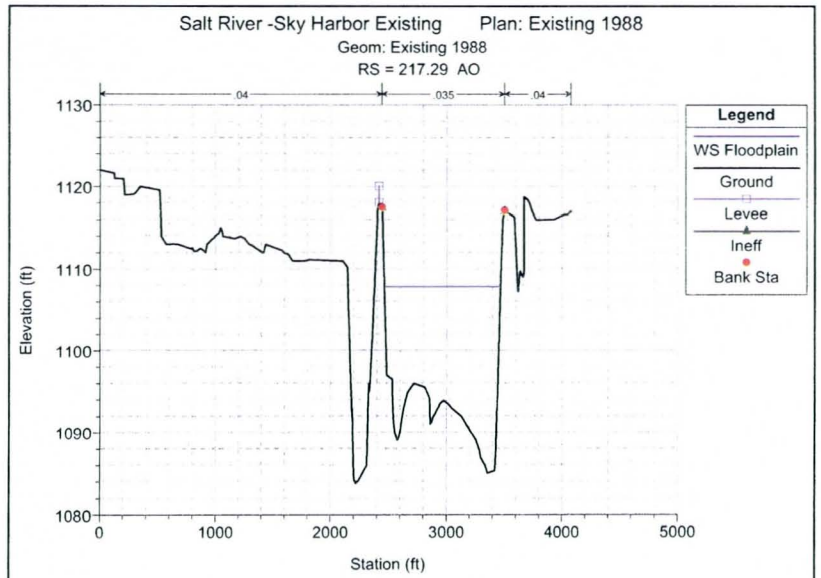

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.53
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

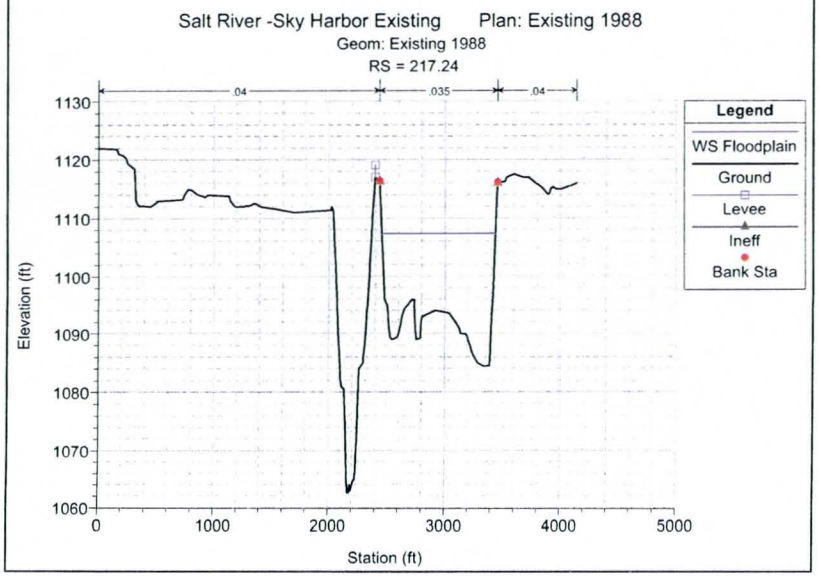

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.48
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.43
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

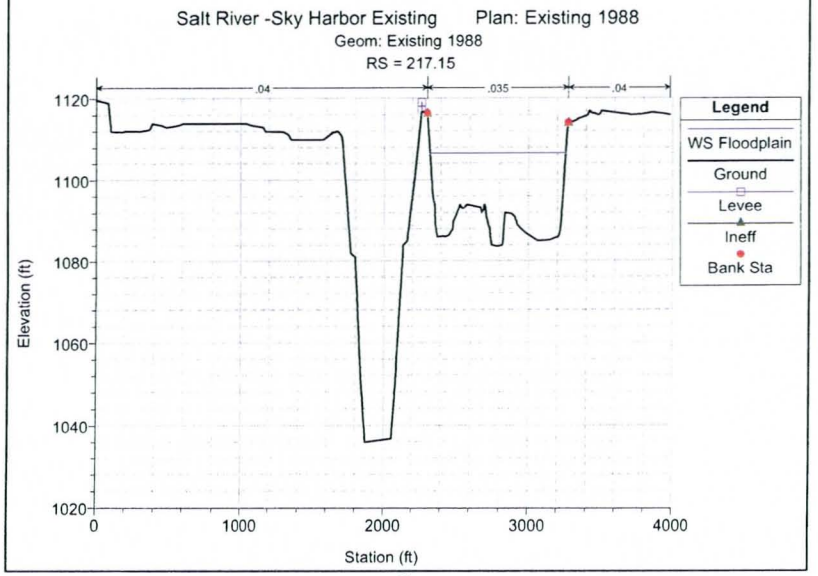

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.38
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

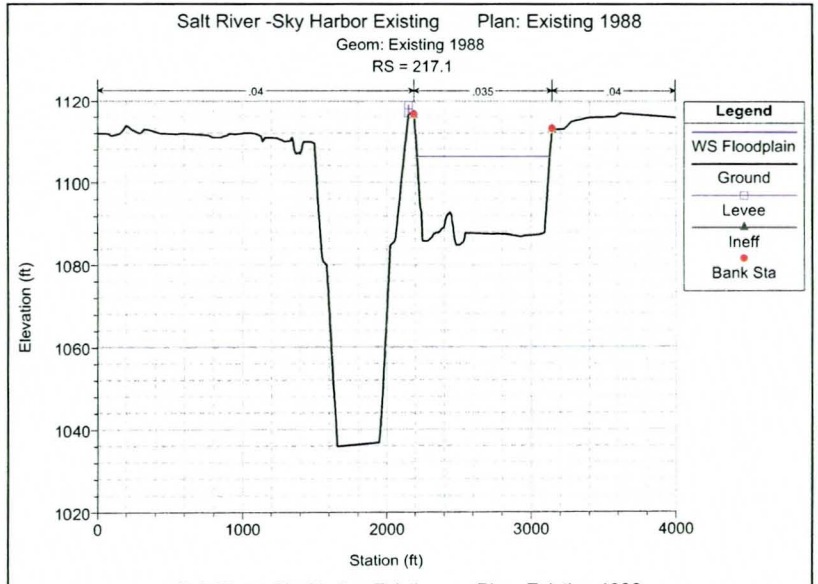

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.34
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

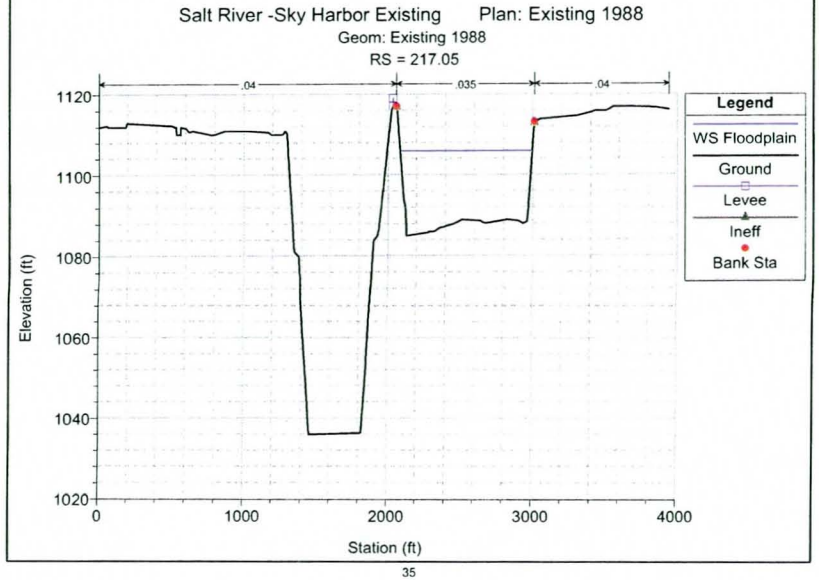

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.29 AO
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

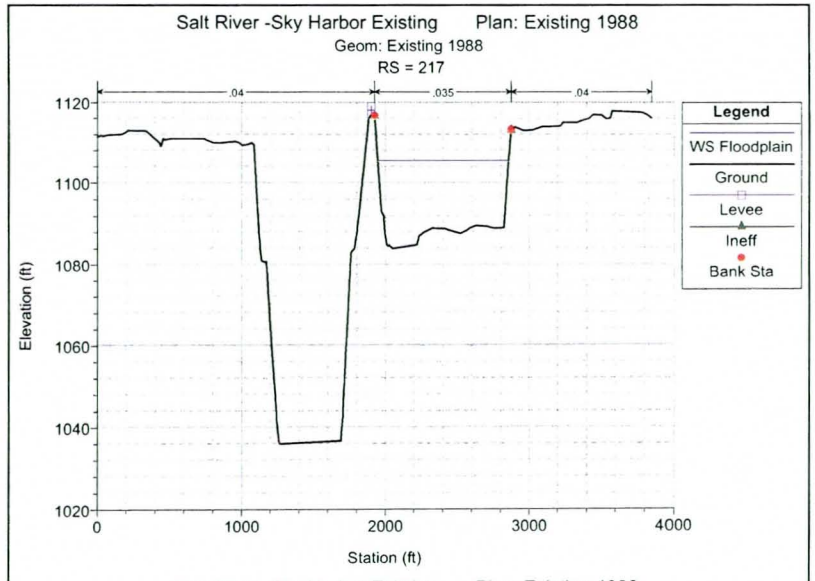

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.24
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

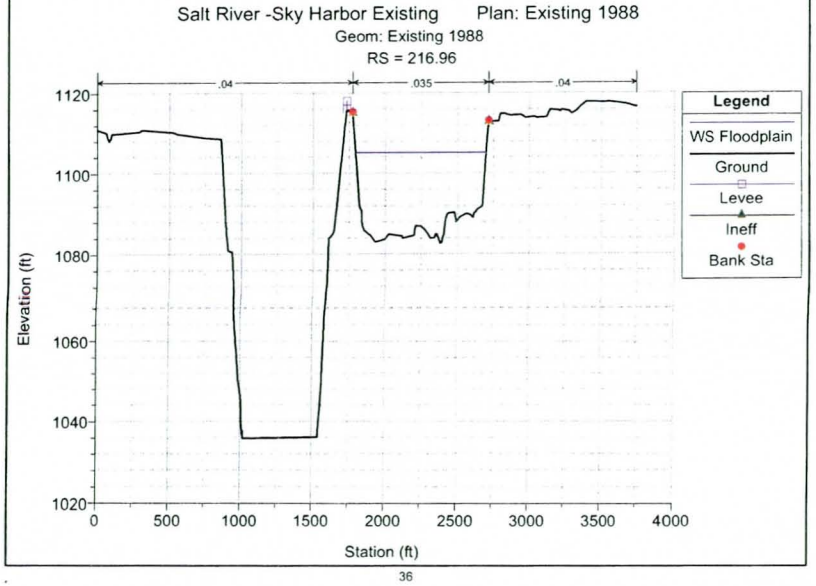
Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.19
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

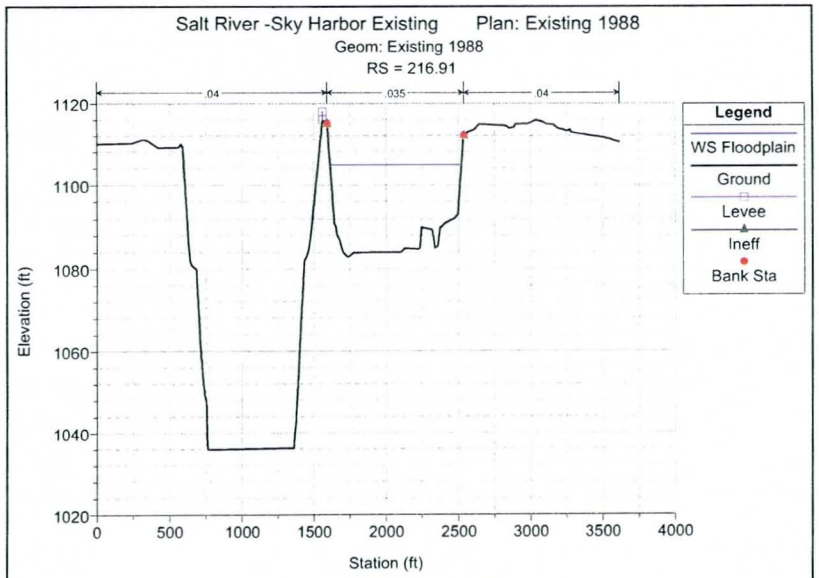

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.15
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

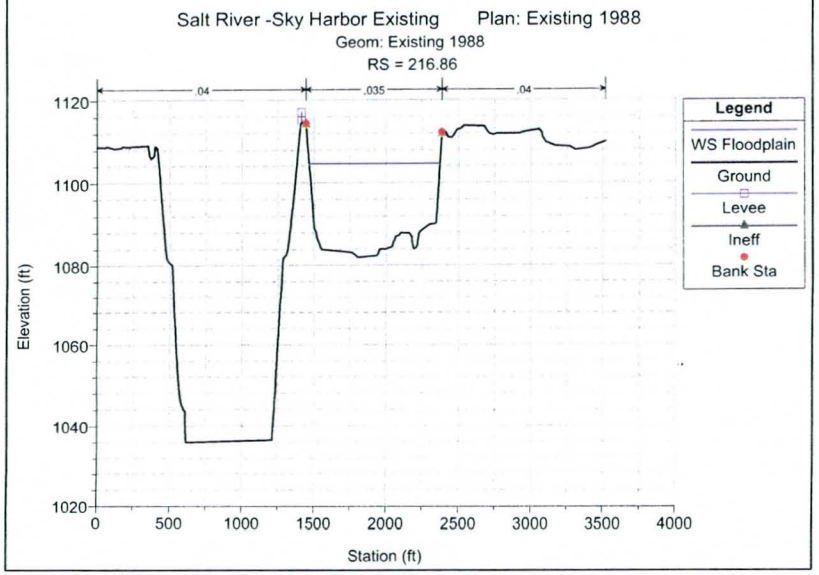

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.1
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
1000
2000
3000
4000
Station (ft)

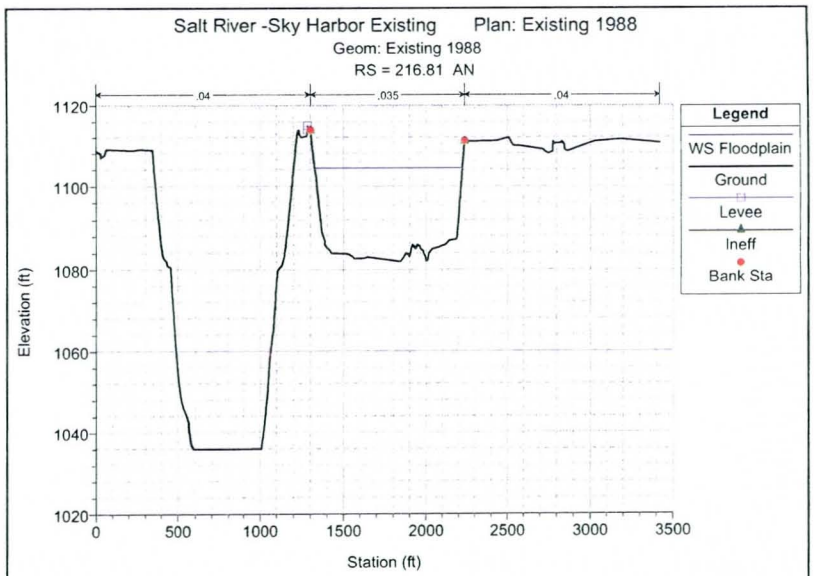

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217.05
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
1000
2000
3000
4000
Station (ft)

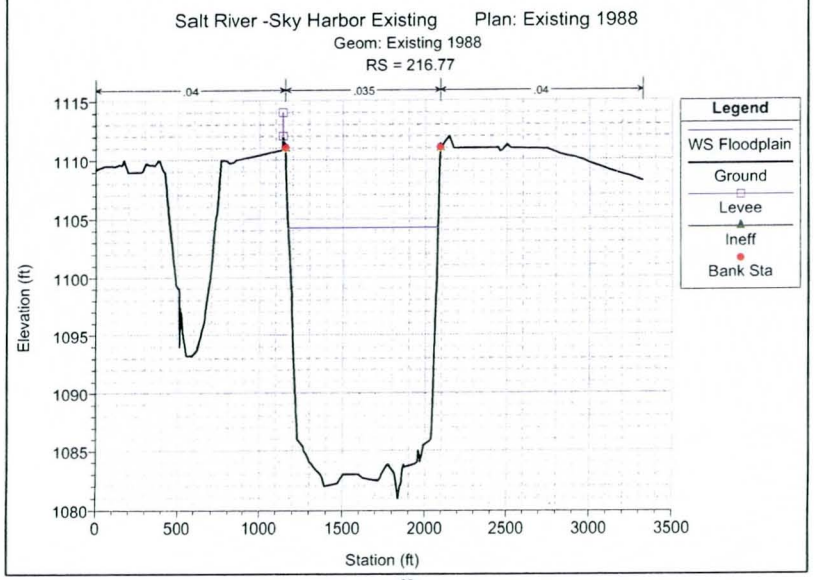

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 217
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
1000
2000
3000
4000
Station (ft)

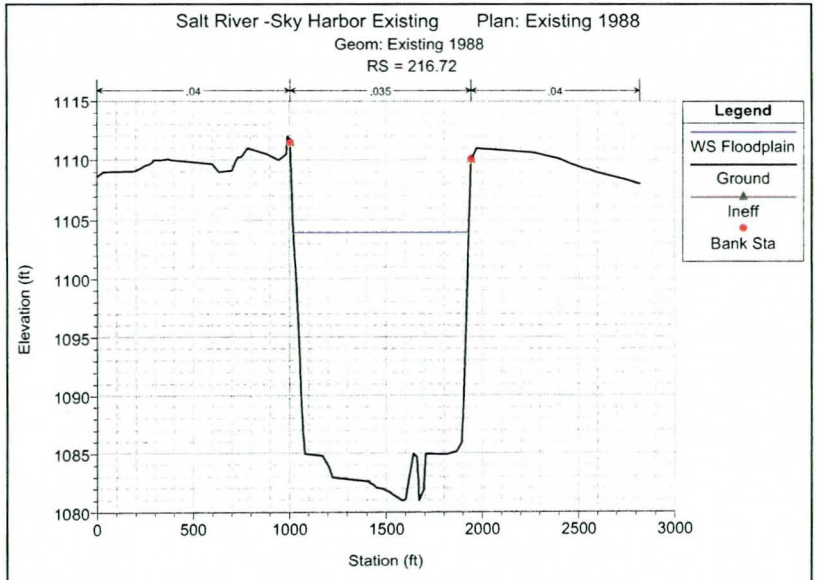

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.96
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1120
1100
1080
1060
1040
1020
0
500
1000
1500
2000
2500
3000
3500
4000
Station (ft)

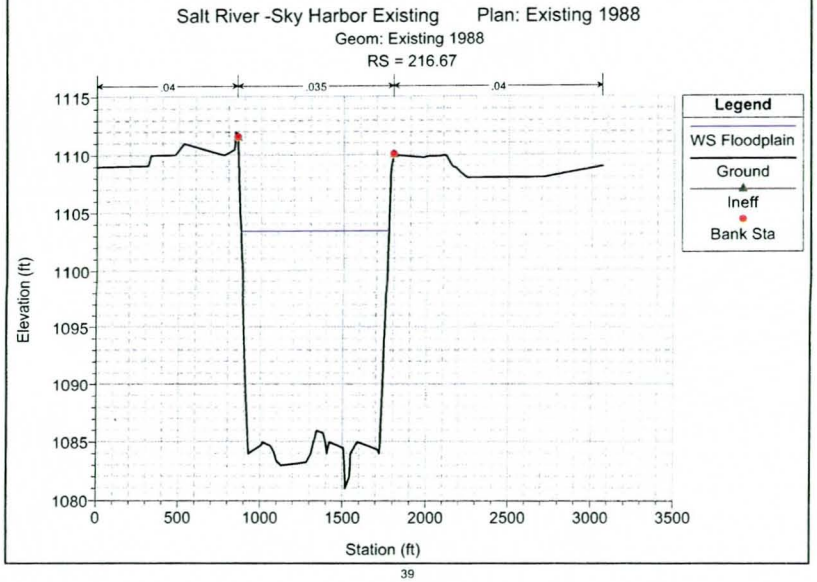

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.91
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

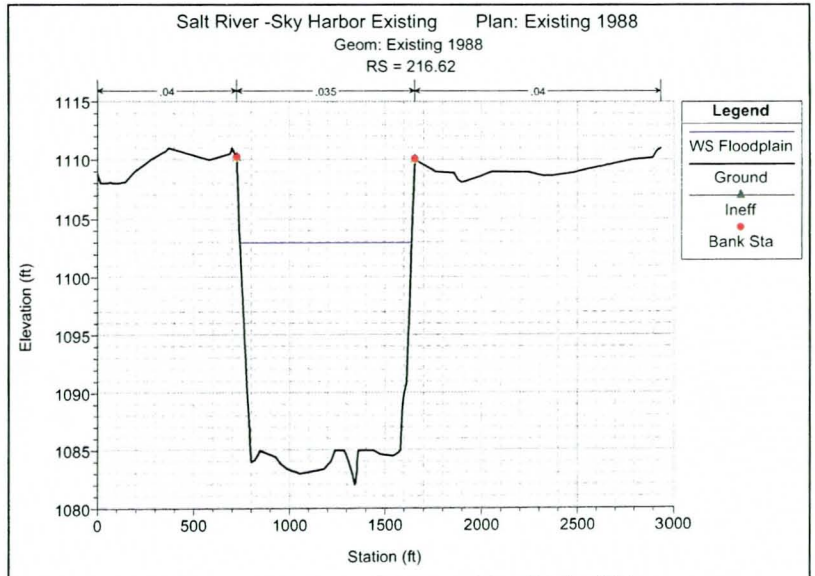

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.86
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)

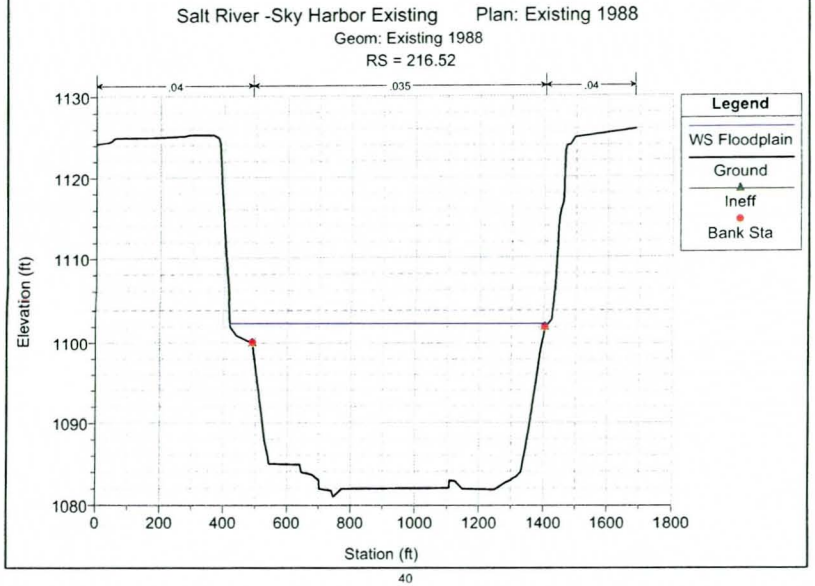

Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.81 AN
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.77
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.72
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.67
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.62
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.52
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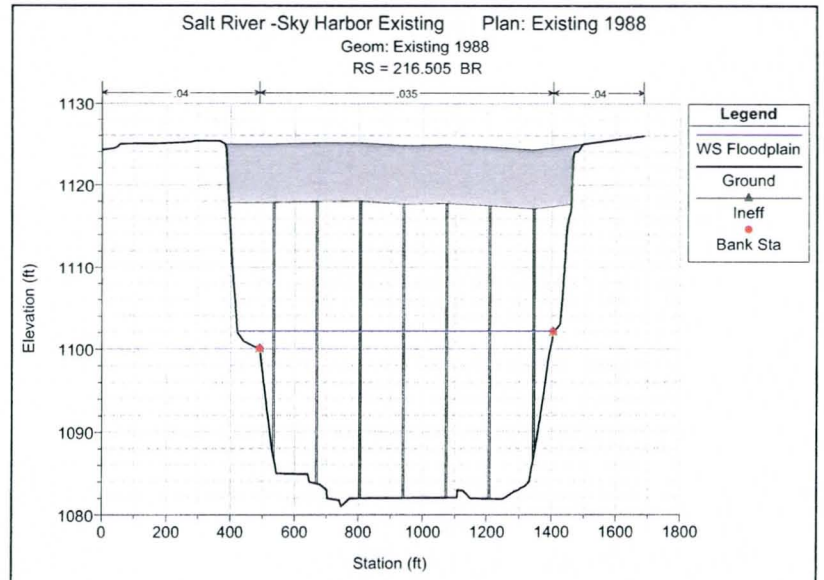
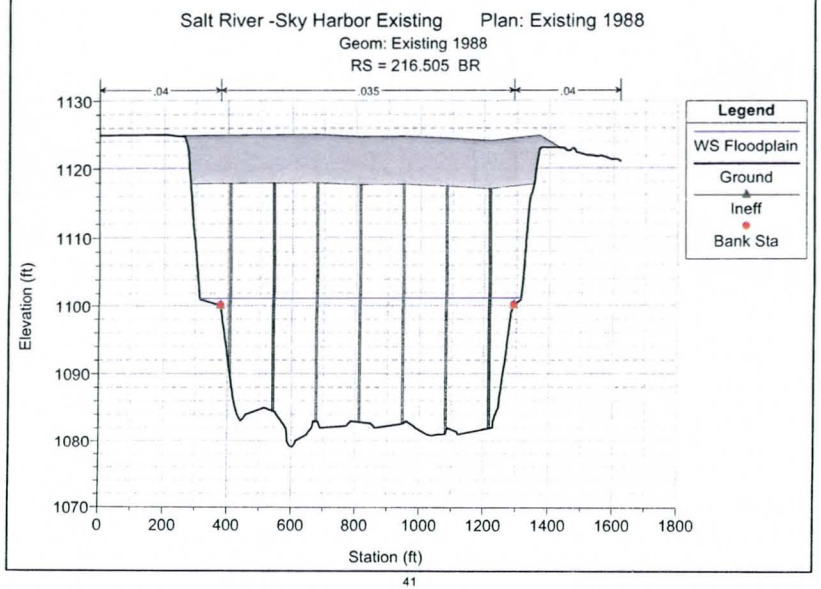
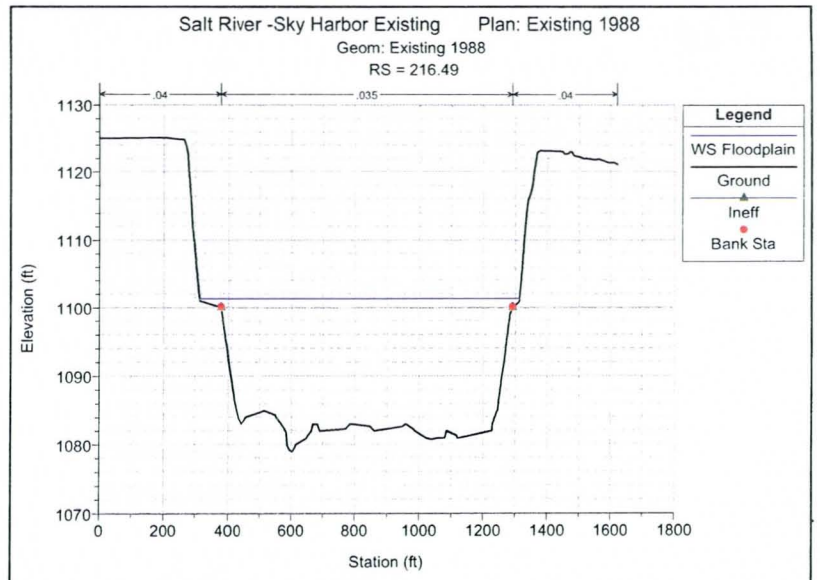
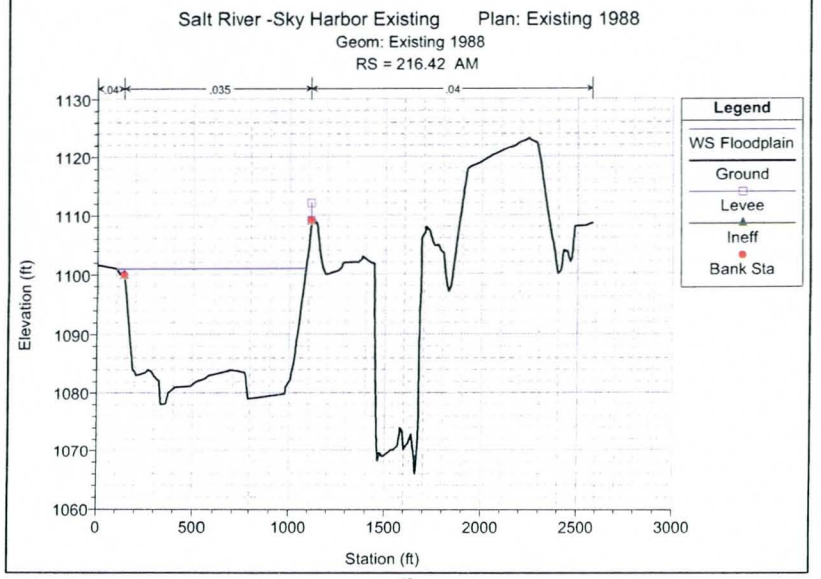
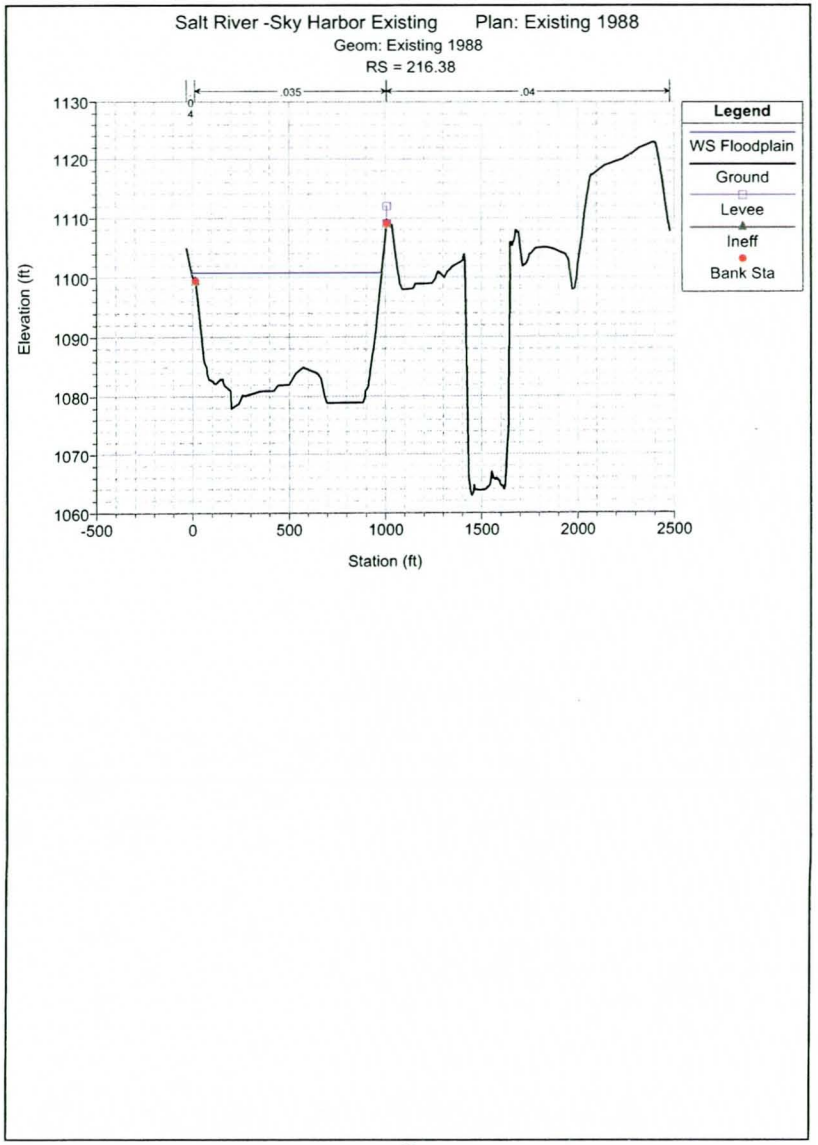
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.505 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.505 BR
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.49
.04
.035
.04
Legend
WS Floodplain
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.42 AM
.04
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River -Sky Harbor Existing Plan: Existing 1988
Geom: Existing 1988
RS = 216.38
.035
.04
Legend
WS Floodplain
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1130
1120
1110
1100
1090
1080
1070
1060
-500
0
500
1000
1500
2000
2500

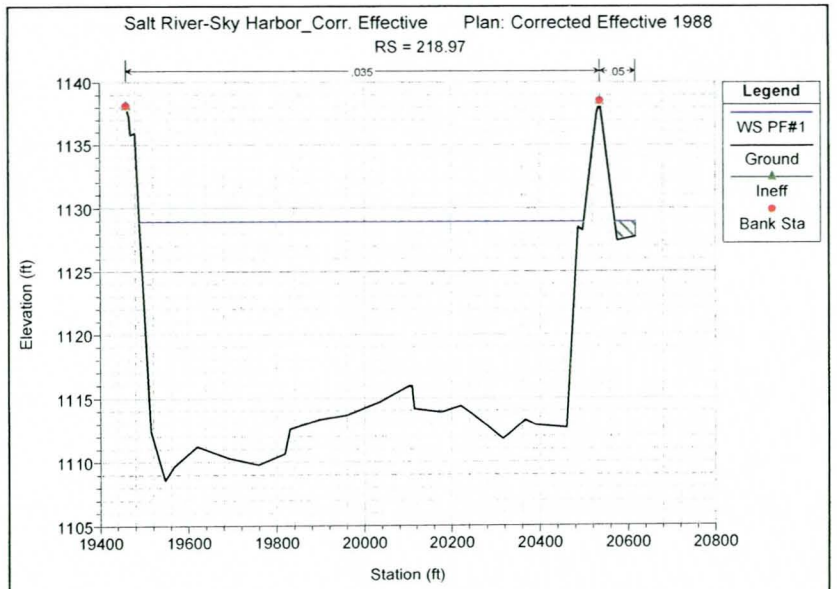
Appendix B – Corrected Effective Output 1988 NAVD

HEC-RAS Plan: CorrEff-1988 River: Salt Reach: 1 Profile: PF#1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	225.30	PF#1	172000.00	1148.58	1179.47	1164.82	1179.88	0.000188	5.15	33422.66	1883.46	0.20
1	225.19	PF#1	172000.00	1152.57	1178.78	1167.85	1179.67	0.000493	7.56	22739.53	1212.92	0.31
1	225.11	PF#1	172000.00	1150.28	1178.83	1165.82	1179.42	0.000279	6.15	27955.07	1609.78	0.24
1	225	PF#1	172000.00	1140.48	1178.98	1162.18	1179.22	0.000106	3.91	44039.72	2462.93	0.15
1	224.90	PF#1	172000.00	1149.88	1178.71	1165.89	1179.12	0.000239	5.13	33545.73	3005.66	0.22
1	224.82	PF#1	172000.00	1151.39	1178.67	1164.96	1178.99	0.000235	4.53	37947.40	2819.02	0.19
1	224.71	PF#1	172000.00	1143.89	1178.67	1160.91	1178.86	0.000112	3.51	49037.55	3514.15	0.13
1	224.62	PF#1	172000.00	1145.13	1178.58	1162.11	1178.80	0.000135	3.77	45606.50	3108.02	0.14
1	224.52	PF#1	172000.00	1149.60	1178.51	1160.53	1178.73	0.000118	3.79	45384.80	3145.39	0.14
1	224.42	PF#1	172000.00	1148.94	1178.36	1160.48	1178.66	0.000146	4.35	39500.05	2946.38	0.15
1	224.31	PF#1	172000.00	1147.72	1177.92	1162.20	1178.51	0.000307	6.13	28045.73	2559.17	0.22
1	224.22	PF#1	172000.00	1150.80	1177.77	1162.35	1178.36	0.000321	6.15	27964.68	1204.04	0.22
1	224.21		Bridge									
1	224.20	PF#1	172000.00	1151.06	1177.48		1178.22	0.000412	6.90	24936.19	1087.88	0.25
1	224.19	PF#1	172000.00	1151.26	1177.43	1163.12	1178.18	0.000410	6.96	24729.48	1061.97	0.25
1	224.175		Bridge									
1	224.16	PF#1	172000.00	1150.55	1177.33		1178.06	0.000392	6.87	25043.49	1057.54	0.25
1	224.14	PF#1	172000.00	1148.02	1177.32	1161.74	1178.01	0.000355	6.65	25869.23	1064.06	0.24
1	224.13		Bridge									
1	224.12	PF#1	172000.00	1147.53	1177.32		1177.87	0.000272	5.95	28900.35	1152.56	0.21
1	224.06	PF#1	172000.00	1147.72	1176.71	1162.43	1177.70	0.000512	8.00	21513.37	1373.07	0.28
1	223.96	PF#1	172000.00	1144.42	1176.66	1159.81	1177.46	0.000268	7.16	24011.43	1815.69	0.24
1	223.86	PF#1	172000.00	1143.08	1176.23	1159.99	1177.25	0.000414	8.13	21156.52	1139.06	0.28
1	223.77	PF#1	172000.00	1141.31	1175.64	1160.42	1176.97	0.000640	9.28	18529.95	1291.19	0.31
1	223.67	PF#1	172000.00	1140.38	1174.63	1161.99	1176.46	0.001519	10.85	15846.05	946.36	0.38
1	223.58	PF#1	172000.00	1146.17	1172.82	1164.23	1175.43	0.002452	12.96	13274.15	990.08	0.49
1	223.48	PF#1	172000.00	1137.82	1172.36	1160.42	1174.25	0.001548	11.03	15600.01	932.68	0.39
1	223.38	PF#1	172000.00	1136.74	1171.94	1159.27	1173.43	0.001141	9.78	17587.78	1660.34	0.35
1	223.29	PF#1	172000.00	1142.02	1171.46	1159.53	1172.86	0.001115	9.48	18139.39	2257.55	0.35
1	223.19	PF#1	172000.00	1143.12	1171.41	1157.80	1172.27	0.000631	7.44	23102.99	2090.38	0.27
1	223.09	PF#1	172000.00	1148.42	1169.13	1165.19	1171.51	0.002888	12.40	13873.47	1221.77	0.61
1	223.085		Bridge									
1	223.08	PF#1	172000.00	1148.42	1165.17	1165.17	1170.03	0.008433	17.68	9726.08	1000.81	1.00
1	223.02	PF#1	172000.00	1142.12	1165.67	1156.36	1166.89	0.000943	8.86	19419.72	1524.52	0.37
1	222.93	PF#1	172000.00	1139.82	1165.17	1154.29	1166.44	0.000836	9.04	19036.99	2119.95	0.35
1	222.83	PF#1	172000.00	1130.04	1165.02	1151.56	1166.01	0.000578	8.01	21475.98	2187.69	0.30
1	222.74	PF#1	172000.00	1136.28	1164.71	1152.58	1165.71	0.000642	8.03	21416.29	2043.49	0.31
1	222.65	PF#1	172000.00	1140.87	1164.35	1153.74	1165.38	0.000706	8.15	21093.26	2093.81	0.33
1	222.55	PF#1	172000.00	1141.72	1164.22	1153.50	1165.03	0.000433	7.24	23782.41	1818.08	0.29
1	222.45	PF#1	172000.00	1141.66	1164.05	1153.19	1164.79	0.000416	6.90	24916.89	1643.69	0.29
1	222.36	PF#1	172000.00	1140.99	1163.41	1154.05	1164.51	0.000648	8.41	20462.33	1414.78	0.36
1	222.27	PF#1	172000.00	1141.31	1162.76	1154.30	1164.13	0.000822	9.37	18355.76	1214.19	0.40
1	222.17	PF#1	172000.00	1139.28	1162.32	1153.38	1163.73	0.000793	9.52	18073.77	1227.63	0.40
1	222.09	PF#1	172000.00	1138.12	1162.26	1150.96	1163.39	0.000568	8.50	20236.65	1233.94	0.34
1	222.085		Bridge									
1	222.08	PF#1	172000.00	1138.12	1162.05	1150.96	1163.20	0.000588	8.59	20015.19	1231.16	0.35
1	221.99	PF#1	172000.00	1140.26	1161.11	1153.45	1162.80	0.001084	10.44	16482.55	1183.96	0.46
1	221.89	PF#1	172000.00	1138.32	1160.19	1153.84	1162.16	0.001350	11.24	15302.29	1151.31	0.50
1	221.80	PF#1	172000.00	1138.47	1159.48	1152.75	1161.50	0.001319	11.41	15078.67	1212.25	0.50
1	221.70	PF#1	172000.00	1136.42	1158.83	1151.75	1160.82	0.001283	11.30	15219.41	1465.14	0.49
1	221.61	PF#1	172000.00	1136.10	1157.80	1151.83	1160.09	0.001594	12.12	14186.94	1387.36	0.55
1	221.50	PF#1	172000.00	1136.20	1156.72	1151.30	1159.12	0.001738	12.44	13828.11	1332.12	0.57
1	221.40	PF#1	172000.00	1135.33	1155.81	1150.00	1158.09	0.002233	12.11	14199.93	1061.33	0.55
1	221.31	PF#1	172000.00	1133.55	1154.45	1148.95	1156.91	0.002386	12.58	13675.83	1151.47	0.57
1	221.26	PF#1	169000.00	1126.41	1154.85	1144.76	1156.19	0.000960	9.29	18186.91	1086.41	0.38
1	221.25		Bridge									
1	221.24	PF#1	169000.00	1126.41	1154.52	1144.76	1155.91	0.001016	9.46	17867.07	1071.29	0.39
1	221.2	PF#1	169000.00	1130.12	1154.30	1144.48	1155.71	0.001064	9.55	17703.85	1104.39	0.39
1	221.195		Bridge									
1	221.19	PF#1	169000.00	1130.12	1153.93	1144.48	1155.41	0.001132	9.74	17348.56	1048.68	0.41
1	221.06	PF#1	169000.00	1128.12	1153.20	1143.15	1154.69	0.001074	9.77	17291.38	1352.68	0.40
1	221.055		Bridge									
1	221.05	PF#1	169000.00	1128.12	1152.96	1143.15	1154.48	0.001100	9.90	17069.98	1318.22	0.40
1	221.02	PF#1	169000.00	1132.18	1152.48	1144.72	1154.25	0.001403	10.69	15806.15	1161.03	0.45
1	220.92	PF#1	169000.00	1131.28	1151.51	1144.65	1153.46	0.001666	11.22	15057.50	1071.91	0.49
1	220.82	PF#1	169000.00	1131.68	1150.65	1143.86	1152.59	0.001688	11.19	15099.36	1082.75	0.49
1	220.73	PF#1	169000.00	1129.81	1149.71	1143.21	1151.74	0.001716	11.43	14781.34	1018.33	0.49
1	220.63	PF#1	169000.00	1129.22	1148.86	1142.38	1150.87	0.001735	11.38	14855.51	981.88	0.49
1	220.54	PF#1	169000.00	1129.44	1147.96	1141.68	1149.99	0.001789	11.42	14796.15	1107.01	0.50
1	220.45	PF#1	169000.00	1127.55	1147.09	1140.70	1149.11	0.001759	11.39	14836.93	1293.60	0.50
1	220.35	PF#1	169000.00	1126.11	1146.36	1139.27	1148.23	0.001554	10.95	15436.48	1375.56	0.47
1	220.25	PF#1	169000.00	1126.13	1145.26	1139.23	1147.35	0.001891	11.59	14575.96	1743.43	0.51
1	220.16	PF#1	169000.00	1126.70	1143.86	1139.05	1146.26	0.002358	12.44	13590.45	1469.55	0.57
1	220.06	PF#1	169000.00	1125.02	1142.84	1137.54	1145.11	0.002142	12.08	13991.42	909.53	0.54
1	220.05		Bridge									
1	220.03	PF#1	169000.00	1125.02	1141.86	1137.54	1144.44	0.002655	12.90	13098.31	906.62	0.60
1	219.88	PF#1	169000.00	1121.62	1139.57	1135.63	1142.23	0.002848	13.11	12892.65	2003.97	0.62
1	219.79	PF#1	169000.00	1121.42	1138.08	1134.41	1140.81	0.003007	13.26	12747.96	2039.45	0.63
1	219.70	PF#1	169000.00	1117.93	1136.76	1132.78	1139.34	0.002805	12.91	13092.49	2045.91	0.61
1	219.61	PF#1	169000.00	1114.51	1135.98	1130.68	1138.05	0.002050	11.54	14650.81	2912.69	0.53

HEC-RAS Plan: CorrEff-1988 River: Salt Reach: 1 Profile: PF#1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	219.51	PF#1	169000.00	1113.76	1135.05	1129.53	1137.02	0.001942	11.27	14994.09	1910.45	0.51
1	219.42	PF#1	169000.00	1113.95	1134.12	1128.52	1136.06	0.001898	11.18	15122.13	2400.95	0.51
1	219.33	PF#1	169000.00	1115.52	1133.22	1127.68	1135.16	0.001929	11.17	15131.65	2726.07	0.51
1	219.24	PF#1	169000.00	1114.22	1132.28	1126.81	1134.24	0.001988	11.23	15051.63	2682.76	0.52
1	219.14	PF#1	169000.00	1112.52	1131.32	1125.69	1133.23	0.001887	11.10	15230.14	2551.62	0.51
1	219.03	PF#1	169000.00	1115.02	1129.92	1125.29	1132.07	0.002299	11.76	14369.97	1026.67	0.55
1	219.02		Bridge									
1	219.01	PF#1	169000.00	1115.02	1128.48	1125.29	1131.15	0.003274	13.10	12896.89	1022.15	0.65
1	218.97	PF#1	169000.00	1108.57	1128.86	1122.45	1130.62	0.001620	10.65	15870.35	1056.96	0.47
1	218.965		Bridge									
1	218.96	PF#1	169000.00	1108.43	1128.15	1122.81	1130.14	0.002010	11.32	14931.15	1096.74	0.52
1	218.80	PF#1	169000.00	1107.82	1126.89	1120.39	1128.62	0.001572	10.55	16025.08	2479.22	0.47
1	218.71	PF#1	169000.00	1107.50	1125.75	1120.26	1127.75	0.001938	11.35	14891.77	3165.43	0.51
1	218.61	PF#1	169000.00	1104.03	1124.73	1119.25	1126.75	0.001987	11.40	14827.74	3020.81	0.52
1	218.52	PF#1	169000.00	1103.49	1123.71	1118.33	1125.74	0.002038	11.43	14789.68	2019.27	0.53
1	218.42	PF#1	169000.00	1103.68	1122.32	1117.87	1124.60	0.002467	12.11	13956.58	1630.11	0.57
1	218.33	PF#1	169000.00	1101.42	1121.61	1115.79	1123.42	0.001772	10.78	15675.25	1051.47	0.49
1	218.24	PF#1	169000.00	1100.09	1120.32	1115.55	1122.42	0.002216	11.61	14553.05	1209.42	0.55
1	218.14	PF#1	169000.00	1098.70	1119.38	1114.09	1121.33	0.001975	11.22	15057.21	1392.55	0.52
1	218.04	PF#1	169000.00	1097.63	1118.40	1113.04	1120.33	0.001943	11.14	15166.22	1038.72	0.51
1	217.95	PF#1	169000.00	1094.59	1117.69	1111.28	1119.37	0.001553	10.40	16247.95	1042.17	0.46
1	217.86	PF#1	169000.00	1090.72	1116.95	1110.49	1118.61	0.001531	10.34	16338.86	1206.98	0.46
1	217.76	PF#1	169000.00	1094.31	1113.85		1117.27	0.003709	14.83	11392.71	823.79	0.70
1	217.66	PF#1	169000.00	1090.26	1113.56	1108.16	1115.53	0.001960	11.25	15025.17	1099.78	0.52
1	217.57	PF#1	169000.00	1092.02	1112.45	1107.49	1114.48	0.002115	11.42	14803.02	1041.20	0.53
1	217.48	PF#1	169000.00	1092.92	1111.60	1106.12	1113.48	0.001879	11.00	15368.59	1524.28	0.51
1	217.38	PF#1	169000.00	1092.82	1110.55	1105.24	1112.50	0.001968	11.20	15093.85	1100.29	0.52
1	217.29	PF#1	169000.00	1091.82	1109.29	1104.45	1111.45	0.002236	11.78	14340.42	1217.45	0.55
1	217.19	PF#1	169000.00	1088.55	1107.44	1103.66	1110.09	0.002945	13.06	12942.85	1368.81	0.62
1	217.10	PF#1	169000.00	1085.12	1107.18	1099.25	1108.85	0.001306	10.37	16300.07	1514.17	0.43
1	217.00	PF#1	169000.00	1083.42	1106.62	1098.28	1108.23	0.001205	10.18	16607.83	1669.76	0.42
1	216.91	PF#1	169000.00	1084.44	1105.74	1098.47	1107.54	0.001457	10.77	15692.78	1823.38	0.46
1	216.81	PF#1	169000.00	1081.67	1105.25	1096.54	1106.82	0.001158	10.08	16768.70	1751.01	0.41
1	216.72	PF#1	169000.00	1082.29	1104.79	1095.31	1106.25	0.001012	9.69	17444.24	899.78	0.39
1	216.62	PF#1	169000.00	1080.45	1104.00	1095.79	1105.63	0.001420	10.24	16498.00	1128.48	0.45
1	216.52	PF#1	169000.00	1085.32	1102.87	1096.42	1104.79	0.001837	11.11	15204.69	1001.89	0.50
1	216.505		Bridge									
1	216.49	PF#1	169000.00	1085.32	1101.52	1096.42	1103.83	0.002471	12.20	13853.79	992.02	0.58
1	216.42	PF#1	169000.00	1084.12	1100.98	1095.20	1103.05	0.001943	11.56	14613.77	1034.26	0.52
1	216.33	PF#1	169000.00	1082.92	1100.48	1093.54	1102.11	0.001446	10.25	16490.19	1473.76	0.45
1	216.23	PF#1	169000.00	1080.62	1100.11	1091.51	1101.40	0.001058	9.13	18502.61	1738.54	0.39
1	216.13	PF#1	169000.00	1080.12	1099.66	1090.86	1100.85	0.000954	8.75	19304.38	2129.81	0.37
1	216.04	PF#1	169000.00	1079.62	1099.05	1090.65	1100.34	0.001041	9.13	18516.63	1448.65	0.39
1	215.94	PF#1	169000.00	1079.92	1095.82	1092.97	1099.20	0.004116	14.74	11462.69	984.02	0.73
1	215.84	PF#1	169000.00	1077.92	1093.84	1090.87	1097.06	0.003648	14.42	11721.58	870.82	0.69
1	215.82	PF#1	169000.00	1078.12	1093.96	1089.16	1096.49	0.002408	12.76	13249.64	860.86	0.57
1	215.815		Bridge									
1	215.81	PF#1	169000.00	1078.12	1092.93	1089.16	1095.83	0.003024	13.67	12363.78	860.84	0.64
1	215.75	PF#1	169000.00	1075.72	1090.57	1088.96	1094.68	0.005283	16.27	10385.48	854.81	0.82
1	215.65	PF#1	169000.00	1070.42	1090.40	1084.55	1092.58	0.001959	11.87	14233.05	890.00	0.52
1	215.56	PF#1	169000.00	1068.22	1090.11	1081.33	1091.67	0.001145	10.02	16880.06	907.88	0.41
1	215.46	PF#1	169000.00	1066.72	1089.73	1079.80	1091.10	0.000932	9.38	18010.01	916.86	0.37
1	215.36	PF#1	169000.00	1065.12	1089.46	1077.50	1090.61	0.000701	8.61	19624.38	3559.81	0.33
1	215.27	PF#1	169000.00	1065.62	1088.96	1078.17	1090.23	0.000846	9.02	18737.07	3991.57	0.36
1	215.18	PF#1	169000.00	1064.32	1083.99	1081.57	1089.03	0.004582	18.01	9383.28	686.95	0.80
1	215.09	PF#1	169000.00	1063.82	1083.21	1078.51	1086.89	0.002894	15.38	10986.15	619.02	0.64
1	214.99	PF#1	169000.00	1063.42	1082.04	1077.72	1085.29	0.002926	14.48	11673.56	727.59	0.64
1	214.9	PF#1	169000.00	1063.32	1080.25	1077.08	1083.64	0.003588	14.78	11435.69	934.52	0.69
1	214.79	PF#1	169000.00	1059.72	1080.51	1072.85	1081.95	0.001221	9.62	17558.59	1056.42	0.42
1	214.785		Bridge									
1	214.78	PF#1	169000.00	1060.92	1080.18	1072.86	1081.68	0.001306	9.83	17191.94	1054.44	0.43
1	214.71	PF#1	169000.00	1057.22	1079.60	1071.44	1081.27	0.001272	10.38	16287.08	901.57	0.43
1	214.61	PF#1	169000.00	1052.52	1079.37	1066.42	1080.68	0.000723	9.21	18346.35	792.44	0.34
1	214.52	PF#1	169000.00	1050.12	1079.47	1062.78	1080.27	0.000391	7.19	23492.42	928.22	0.25
1	214.42	PF#1	169000.00	1050.32	1079.44	1061.53	1080.05	0.000288	6.27	26966.64	1193.48	0.22
1	214.33	PF#1	169000.00	1050.62	1079.00	1062.57	1079.85	0.000413	7.40	22823.47	1266.44	0.26
1	214.23	PF#1	169000.00	1050.82	1078.05	1065.00	1079.51	0.000784	9.71	17406.42	1126.00	0.35
1	214.14	PF#1	169000.00	1050.82	1077.61	1064.82	1079.11	0.000805	9.84	17171.67	1257.06	0.36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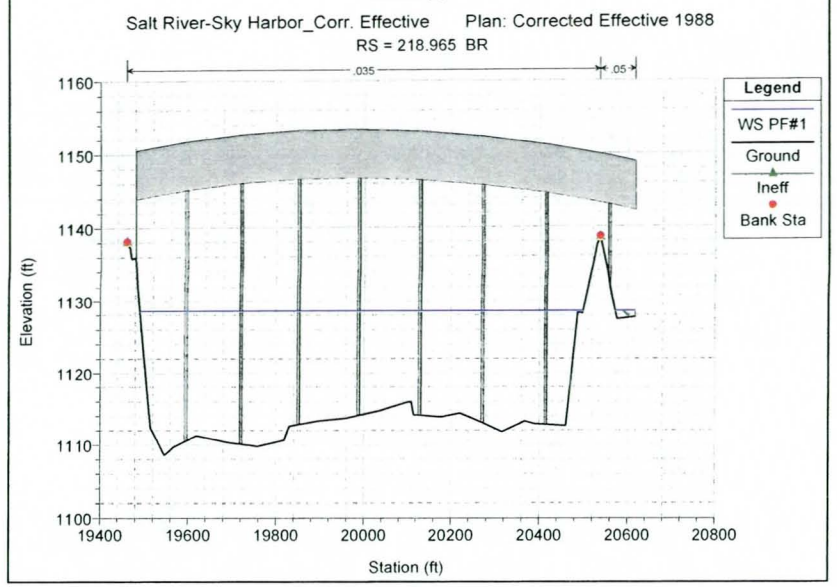
.05
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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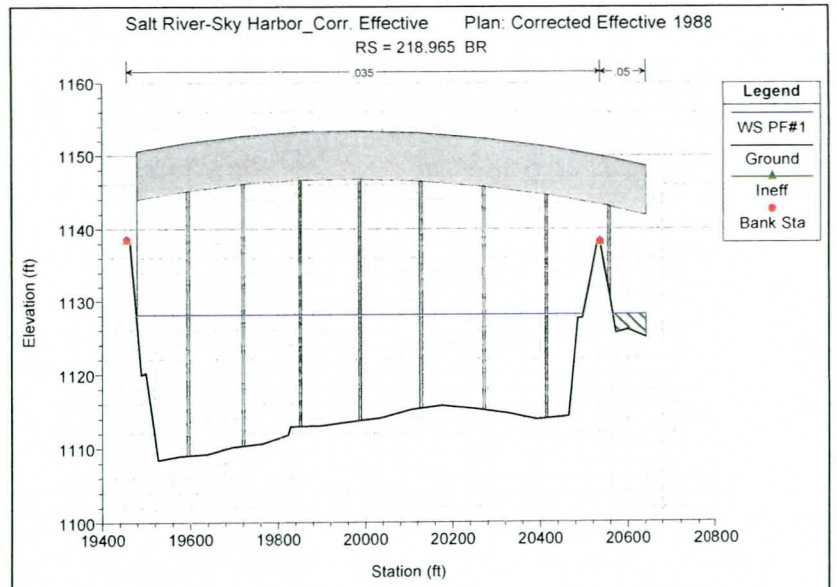
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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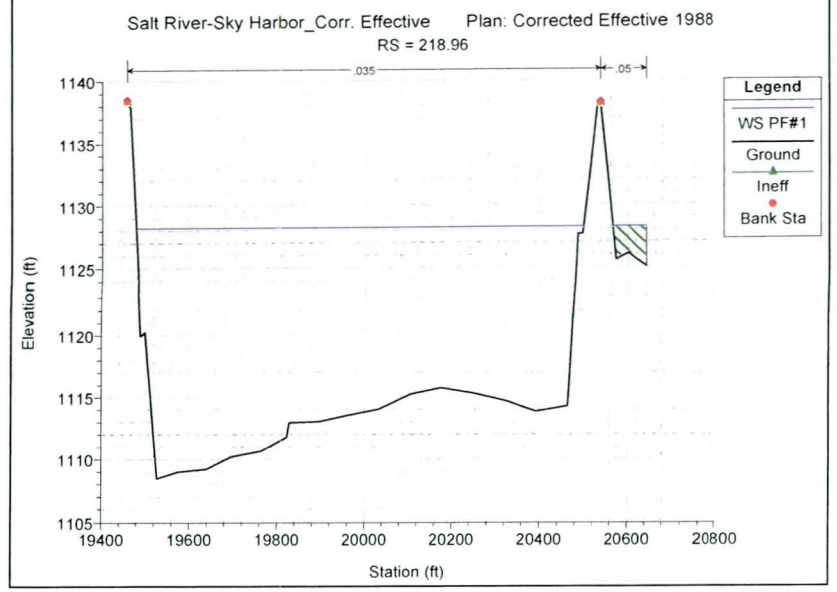
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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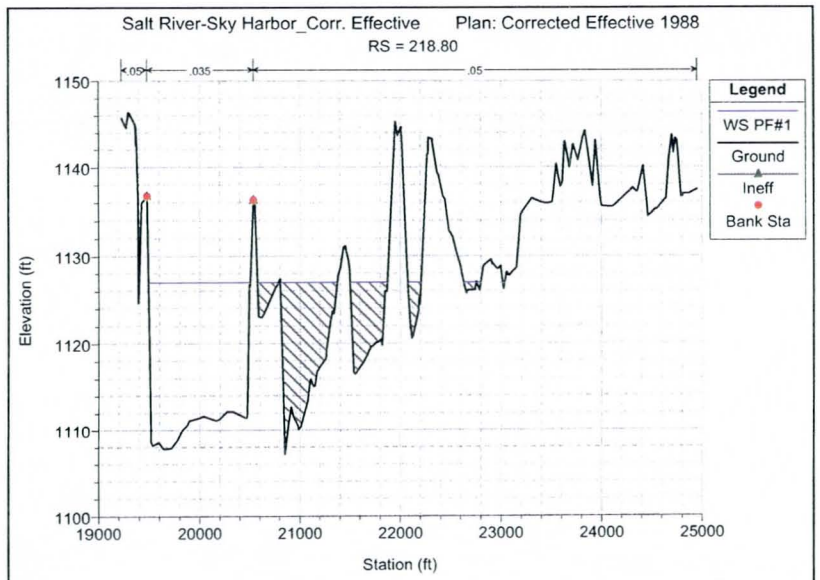
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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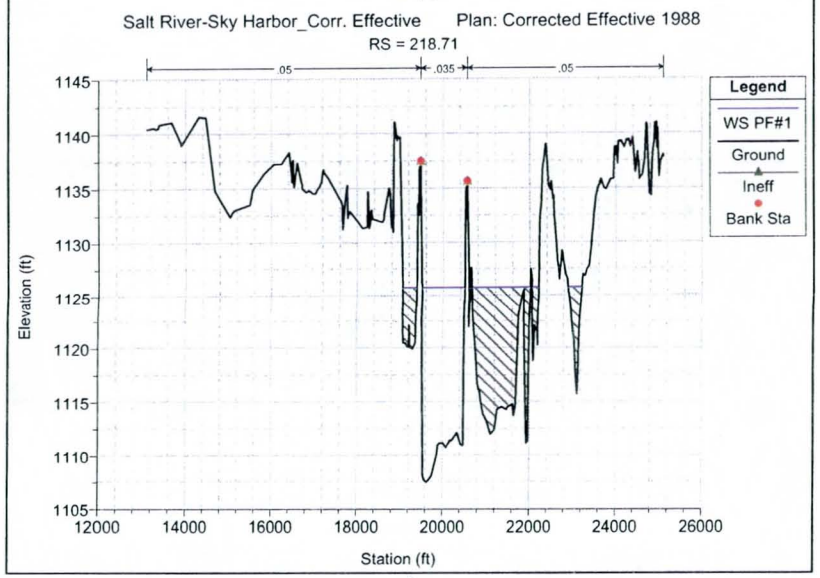
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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.035
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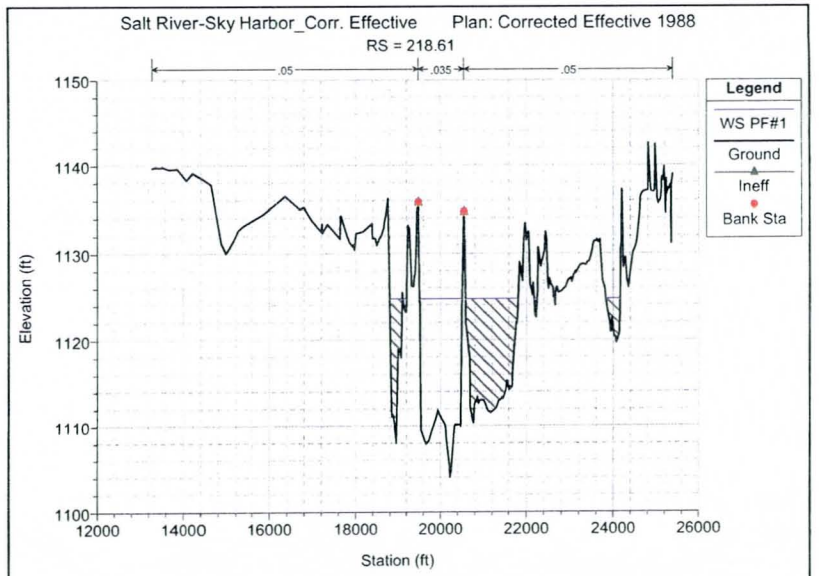
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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.035
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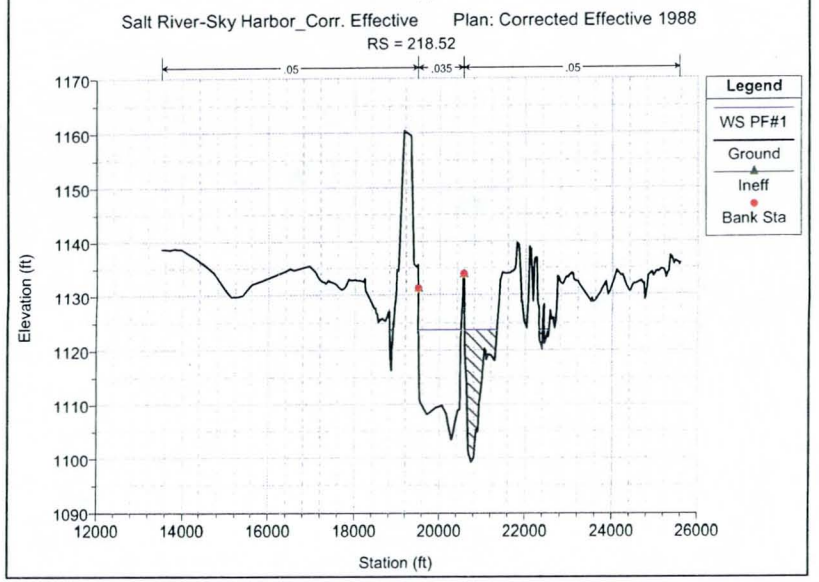
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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.035
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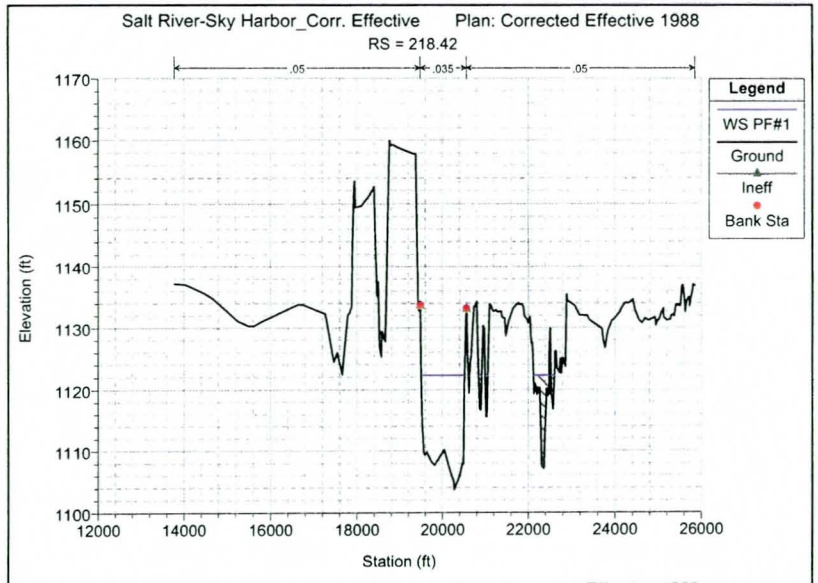
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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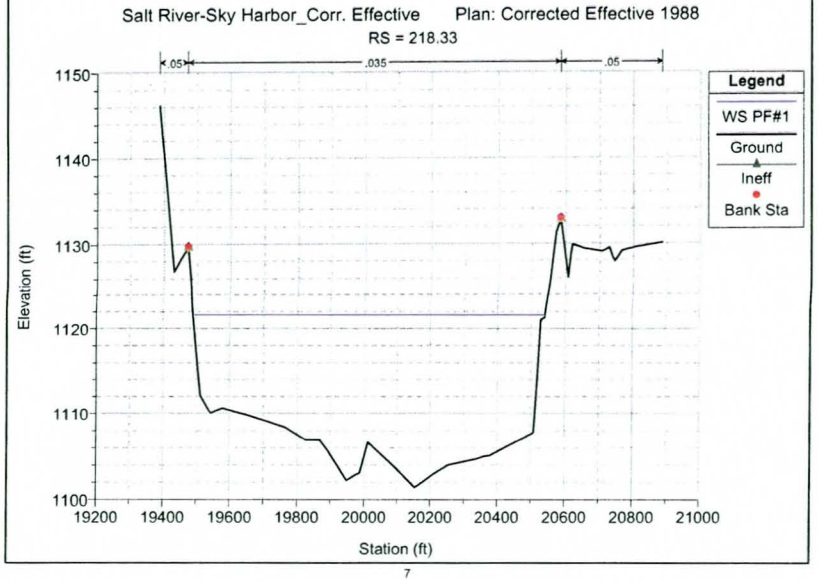
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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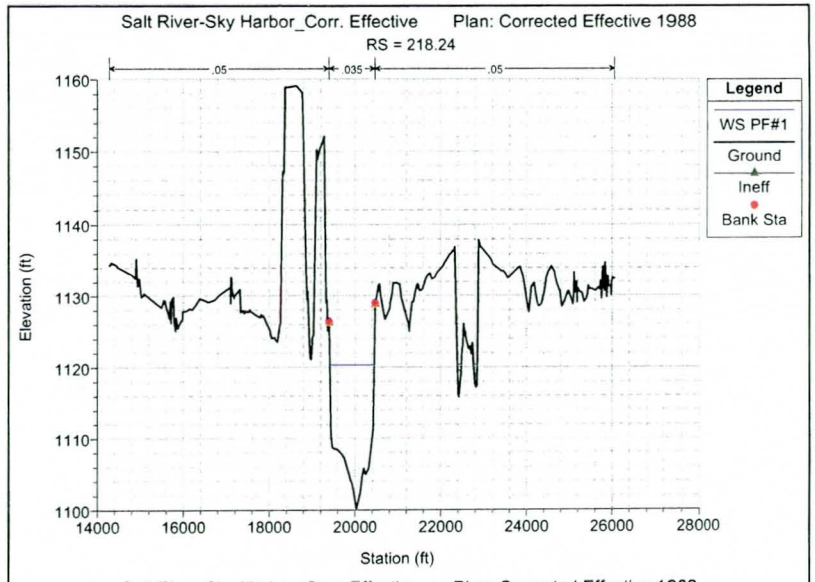
.035
.05
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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.035
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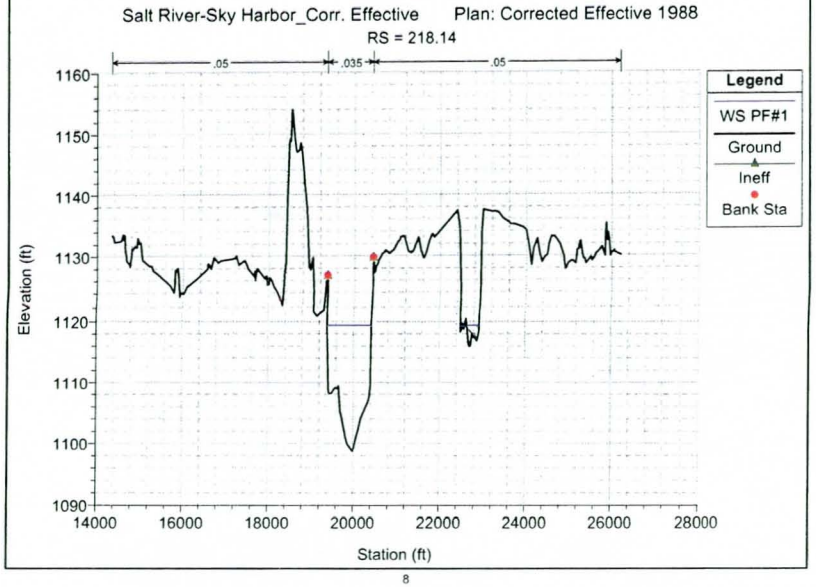
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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.035
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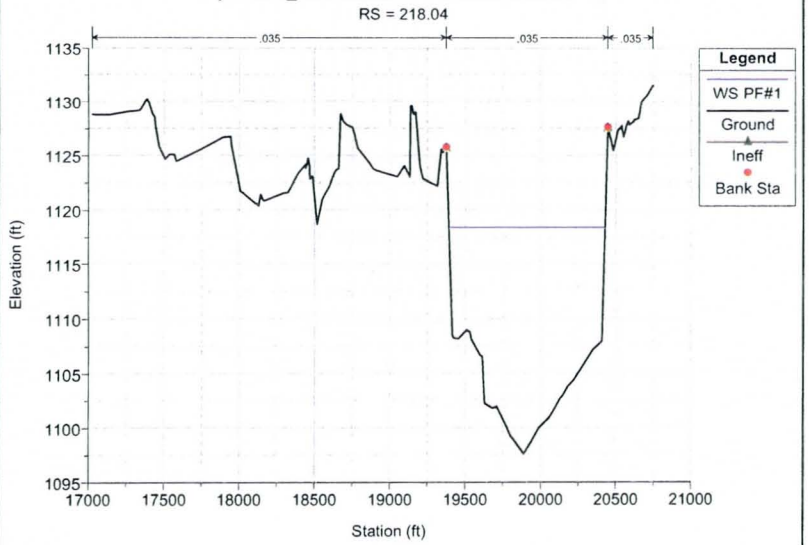
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Corr. Effective Plan: Corrected Effective 1988
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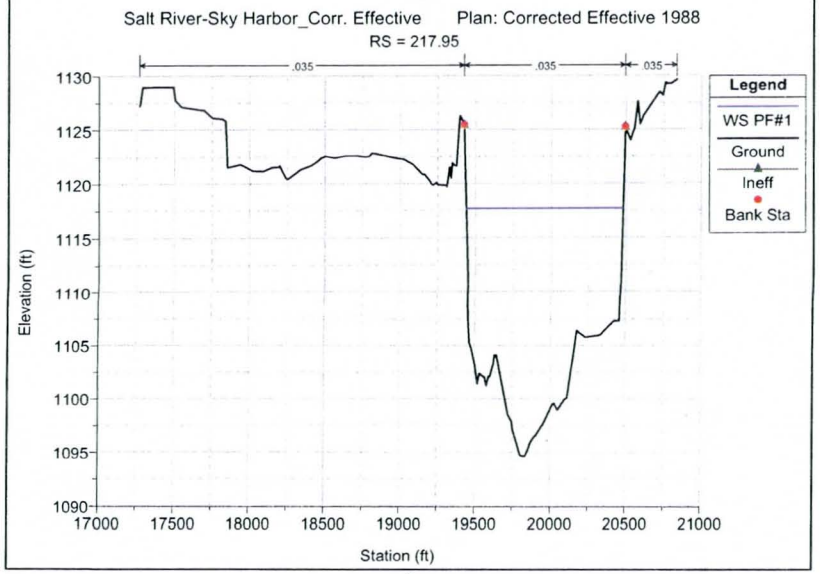
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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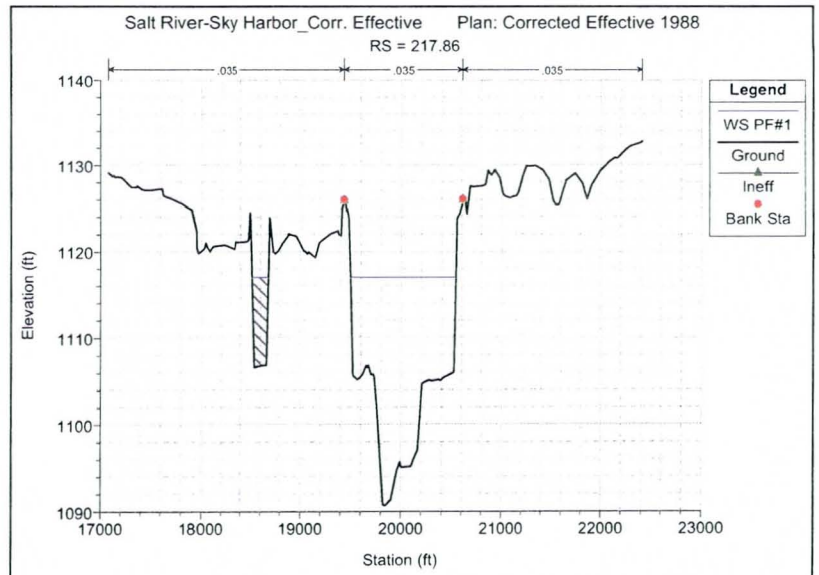
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Legend
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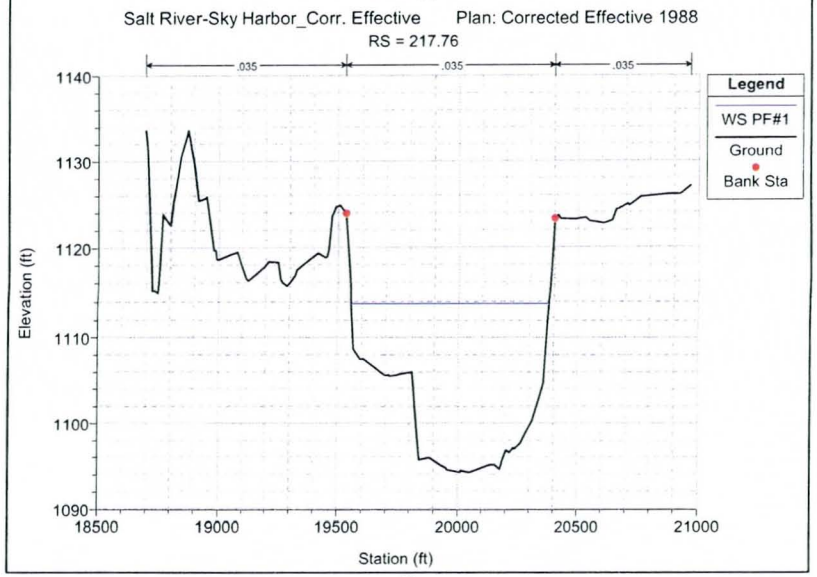
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Salt River-Sky Harbor_Corr. Effective Plan: Corrected Effective 1988
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.035
.035
.035
Legend
WS PF#1
Ground
Bank Sta
Elevation (ft)
Station (ft)

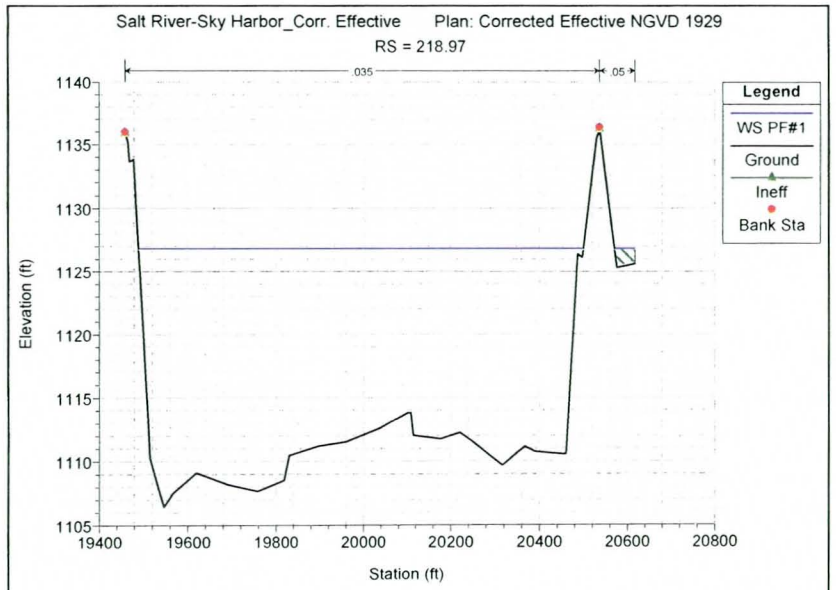
Appendix B – Corrected Effective Output 1929 NGVD

HEC-RAS Plan: NGVD 1929 River: Salt Reach: 1 Profile: PF#1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	225.30	PF#1	172000.00	1146.46	1177.35	1162.70	1177.76	0.000188	5.15	33422.86	1883.46	0.20
1	225.19	PF#1	172000.00	1150.45	1176.66	1165.73	1177.55	0.000492	7.56	22739.68	1212.92	0.31
1	225.11	PF#1	172000.00	1148.16	1176.71	1163.70	1177.30	0.000279	6.15	27955.23	1609.78	0.24
1	225	PF#1	172000.00	1138.36	1176.86	1160.06	1177.10	0.000106	3.91	44039.97	2462.93	0.15
1	224.90	PF#1	172000.00	1147.76	1176.59	1163.77	1177.00	0.000239	5.13	33545.96	3005.66	0.22
1	224.82	PF#1	172000.00	1149.27	1176.55	1162.84	1176.87	0.000235	4.53	37947.67	2819.03	0.19
1	224.71	PF#1	172000.00	1141.77	1176.55	1158.79	1176.74	0.000112	3.51	49037.81	3514.16	0.13
1	224.62	PF#1	172000.00	1143.01	1176.46	1159.99	1176.68	0.000135	3.77	45606.78	3108.03	0.14
1	224.52	PF#1	172000.00	1147.48	1176.39	1158.41	1176.61	0.000118	3.79	45385.03	3145.40	0.14
1	224.42	PF#1	172000.00	1146.82	1176.24	1158.37	1176.54	0.000146	4.35	39500.25	2946.38	0.15
1	224.31	PF#1	172000.00	1145.60	1175.80	1160.08	1176.39	0.000307	6.13	28045.87	2559.19	0.22
1	224.22	PF#1	172000.00	1148.68	1175.65	1160.23	1176.24	0.000321	6.15	27964.83	1204.04	0.22
1	224.21		Bridge									
1	224.20	PF#1	172000.00	1148.94	1175.36		1176.10	0.000412	6.90	24936.33	1087.88	0.25
1	224.19	PF#1	172000.00	1149.14	1175.31	1161.00	1176.06	0.000410	6.96	24729.62	1061.97	0.25
1	224.175		Bridge									
1	224.16	PF#1	172000.00	1148.43	1175.21		1175.95	0.000392	6.87	25043.63	1057.54	0.25
1	224.14	PF#1	172000.00	1145.90	1175.20	1159.62	1175.89	0.000355	6.65	25869.36	1064.06	0.24
1	224.13		Bridge									
1	224.12	PF#1	172000.00	1145.41	1175.20		1175.75	0.000272	5.95	28900.50	1152.56	0.21
1	224.06	PF#1	172000.00	1145.60	1174.59	1160.31	1175.58	0.000512	7.99	21513.47	1373.07	0.28
1	223.96	PF#1	172000.00	1142.30	1174.54	1157.66	1175.34	0.000268	7.16	24011.54	1815.70	0.24
1	223.86	PF#1	172000.00	1140.96	1174.11	1157.87	1175.13	0.000414	8.13	21156.63	1139.07	0.28
1	223.77	PF#1	172000.00	1139.19	1173.52	1158.30	1174.86	0.000640	9.28	18530.04	1291.20	0.31
1	223.67	PF#1	172000.00	1138.26	1172.51	1159.87	1174.34	0.001519	10.85	15846.13	946.36	0.38
1	223.58	PF#1	172000.00	1144.05	1170.70	1162.11	1173.31	0.002452	12.96	13274.22	990.09	0.49
1	223.48	PF#1	172000.00	1135.70	1170.24	1158.31	1172.13	0.001548	11.03	15600.10	932.71	0.39
1	223.38	PF#1	172000.00	1134.62	1169.82	1157.15	1171.31	0.001141	9.78	17587.87	1660.56	0.35
1	223.29	PF#1	172000.00	1139.90	1169.34	1157.41	1170.74	0.001115	9.48	18139.49	2257.57	0.35
1	223.19	PF#1	172000.00	1141.00	1169.29	1155.69	1170.15	0.000631	7.44	23103.13	2090.43	0.27
1	223.09	PF#1	172000.00	1146.30	1167.01	1163.07	1169.39	0.002888	12.40	13873.60	1221.80	0.61
1	223.085		Bridge									
1	223.08	PF#1	172000.00	1146.30	1163.05	1163.05	1167.91	0.008433	17.68	9726.08	1000.81	1.00
1	223.02	PF#1	172000.00	1140.00	1163.55	1154.24	1164.77	0.000943	8.86	19419.72	1524.52	0.37
1	222.93	PF#1	172000.00	1137.70	1163.05	1152.17	1164.32	0.000836	9.04	19036.99	2119.95	0.35
1	222.83	PF#1	172000.00	1127.92	1162.90	1149.46	1163.89	0.000578	8.01	21475.99	2187.69	0.30
1	222.74	PF#1	172000.00	1134.16	1162.59	1150.47	1163.59	0.000642	8.03	21416.30	2043.49	0.31
1	222.65	PF#1	172000.00	1138.75	1162.23	1151.62	1163.26	0.000706	8.15	21093.27	2093.81	0.33
1	222.55	PF#1	172000.00	1139.60	1162.10	1151.38	1162.91	0.000433	7.24	23762.42	1818.08	0.29
1	222.45	PF#1	172000.00	1139.54	1161.93	1151.07	1162.67	0.000416	6.90	24916.90	1643.69	0.29
1	222.36	PF#1	172000.00	1138.87	1161.29	1151.93	1162.39	0.000648	8.41	20462.33	1414.78	0.36
1	222.27	PF#1	172000.00	1139.19	1160.64	1152.23	1162.01	0.000822	9.37	18355.76	1214.19	0.40
1	222.17	PF#1	172000.00	1137.16	1160.20	1151.25	1161.61	0.000793	9.52	18073.77	1227.65	0.40
1	222.09	PF#1	172000.00	1136.00	1160.14	1148.85	1161.27	0.000568	8.50	20236.65	1233.94	0.34
1	222.085		Bridge									
1	222.08	PF#1	172000.00	1136.00	1159.93	1148.85	1161.08	0.000588	8.59	20015.19	1231.16	0.35
1	221.99	PF#1	172000.00	1138.14	1158.99	1151.33	1160.68	0.001084	10.44	16482.55	1183.96	0.45
1	221.89	PF#1	172000.00	1136.20	1158.07	1151.72	1160.04	0.001350	11.24	15302.17	1151.30	0.50
1	221.80	PF#1	172000.00	1136.35	1157.35	1150.63	1159.38	0.001319	11.41	15078.55	1212.24	0.50
1	221.70	PF#1	172000.00	1134.30	1156.71	1149.63	1158.70	0.001283	11.30	15219.30	1465.14	0.49
1	221.61	PF#1	172000.00	1133.98	1155.68	1149.71	1157.97	0.001594	12.12	14186.83	1387.36	0.55
1	221.50	PF#1	172000.00	1134.08	1154.60	1149.19	1157.00	0.001738	12.44	13828.00	1332.12	0.57
1	221.40	PF#1	172000.00	1133.21	1153.69	1147.88	1155.97	0.002233	12.11	14199.82	1061.33	0.55
1	221.31	PF#1	172000.00	1131.43	1152.33	1146.83	1154.79	0.002386	12.58	13675.72	1151.46	0.57
1	221.26	PF#1	169000.00	1124.29	1152.73	1142.64	1154.07	0.000960	9.29	18186.80	1086.41	0.38
1	221.25		Bridge									
1	221.24	PF#1	169000.00	1124.29	1152.40	1142.64	1153.79	0.001016	9.46	17866.95	1071.28	0.39
1	221.2	PF#1	169000.00	1128.00	1152.18	1142.36	1153.59	0.001064	9.55	17703.73	1104.39	0.39
1	221.195		Bridge									
1	221.19	PF#1	169000.00	1128.00	1151.81	1142.36	1153.29	0.001132	9.74	17348.45	1048.67	0.41
1	221.06	PF#1	169000.00	1126.00	1151.08	1141.03	1152.57	0.001074	9.77	17291.27	1352.67	0.40
1	221.055		Bridge									
1	221.05	PF#1	169000.00	1126.00	1150.84	1141.03	1152.36	0.001100	9.90	17069.98	1318.22	0.40
1	221.02	PF#1	169000.00	1130.06	1150.36	1142.60	1152.13	0.001403	10.69	15806.15	1161.03	0.45
1	220.92	PF#1	169000.00	1129.16	1149.39	1142.53	1151.34	0.001666	11.22	15057.52	1071.91	0.49
1	220.82	PF#1	169000.00	1129.56	1148.53	1141.75	1150.47	0.001688	11.19	15099.48	1082.76	0.49
1	220.73	PF#1	169000.00	1127.69	1147.59	1141.07	1149.62	0.001716	11.43	14781.46	1018.33	0.49
1	220.63	PF#1	169000.00	1127.10	1146.74	1140.26	1148.75	0.001735	11.38	14855.51	981.88	0.49
1	220.54	PF#1	169000.00	1127.32	1145.84	1139.56	1147.87	0.001789	11.42	14796.15	1107.01	0.50
1	220.45	PF#1	169000.00	1125.43	1144.97	1138.58	1146.99	0.001759	11.39	14836.93	1293.60	0.50
1	220.35	PF#1	169000.00	1123.99	1144.24	1137.16	1146.11	0.001554	10.95	15436.48	1375.56	0.47
1	220.25	PF#1	169000.00	1124.01	1143.14	1137.11	1145.23	0.001891	11.59	14575.96	1743.43	0.51
1	220.16	PF#1	169000.00	1124.58	1141.74	1136.93	1144.14	0.002358	12.44	13590.46	1469.55	0.57
1	220.06	PF#1	169000.00	1122.90	1140.72	1135.42	1142.99	0.002142	12.08	13991.42	909.53	0.54
1	220.05		Bridge									
1	220.03	PF#1	169000.00	1122.90	1139.74	1135.42	1142.32	0.002655	12.90	13098.31	906.62	0.60
1	219.88	PF#1	169000.00	1119.50	1137.45	1133.48	1140.11	0.002848	13.11	12892.77	2003.98	0.62
1	219.79	PF#1	169000.00	1119.30	1135.96	1132.29	1138.69	0.003007	13.26	12747.96	2039.45	0.63
1	219.70	PF#1	169000.00	1115.81	1134.64	1130.66	1137.22	0.002805	12.91	13092.49	2045.91	0.61
1	219.61	PF#1	169000.00	1112.39	1133.86	1128.54	1135.93	0.002050	11.54	14650.83	2912.69	0.53

HEC-RAS Plan: NGVD 1929 River: Salt Reach: 1 Profile: PF#1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
1	219.51	PF#1	169000.00	1111.64	1132.93	1127.41	1134.90	0.001942	11.27	14994.10	1910.45	0.51
1	219.42	PF#1	169000.00	1111.83	1132.00	1126.40	1133.94	0.001898	11.18	15122.13	2400.95	0.51
1	219.33	PF#1	169000.00	1113.40	1131.10	1125.56	1133.04	0.001929	11.17	15131.65	2726.07	0.51
1	219.24	PF#1	169000.00	1112.10	1130.16	1124.69	1132.12	0.001988	11.23	15051.63	2682.76	0.52
1	219.14	PF#1	169000.00	1110.40	1129.20	1123.57	1131.11	0.001887	11.10	15230.14	2551.62	0.51
1	219.03	PF#1	169000.00	1112.90	1127.80	1123.17	1129.95	0.002299	11.76	14369.97	1026.67	0.55
1	219.02		Bridge									
1	219.01	PF#1	169000.00	1112.90	1126.36	1123.17	1129.03	0.003274	13.10	12896.89	1022.15	0.65
1	218.97	PF#1	169000.00	1106.45	1126.74	1120.33	1128.50	0.001620	10.65	15870.35	1056.96	0.47
1	218.965		Bridge									
1	218.96	PF#1	169000.00	1106.31	1126.03	1120.69	1128.02	0.002010	11.32	14931.15	1096.74	0.52
1	218.80	PF#1	169000.00	1105.70	1124.77	1118.27	1126.50	0.001572	10.55	16025.08	2479.22	0.47
1	218.71	PF#1	169000.00	1105.38	1123.63	1118.14	1125.63	0.001939	11.35	14891.77	3165.43	0.51
1	218.61	PF#1	169000.00	1101.91	1122.61	1117.13	1124.63	0.001987	11.40	14827.75	3020.81	0.52
1	218.52	PF#1	169000.00	1101.37	1121.59	1116.22	1123.62	0.002038	11.43	14789.69	2019.27	0.53
1	218.42	PF#1	169000.00	1101.56	1120.20	1115.75	1122.48	0.002467	12.11	13956.46	1630.10	0.57
1	218.33	PF#1	169000.00	1099.30	1119.49	1113.67	1121.30	0.001772	10.78	15675.27	1051.47	0.49
1	218.24	PF#1	169000.00	1097.97	1118.20	1113.43	1120.30	0.002216	11.61	14553.05	1209.42	0.55
1	218.14	PF#1	169000.00	1096.58	1117.26	1111.95	1119.21	0.001975	11.22	15057.22	1392.55	0.52
1	218.04	PF#1	169000.00	1095.51	1116.28	1110.92	1118.21	0.001943	11.14	15166.22	1038.72	0.51
1	217.95	PF#1	169000.00	1092.47	1115.57	1109.19	1117.25	0.001553	10.40	16247.96	1042.17	0.46
1	217.86	PF#1	169000.00	1088.60	1114.83	1108.37	1116.49	0.001531	10.34	16338.88	1206.98	0.46
1	217.76	PF#1	169000.00	1092.19	1111.73		1115.15	0.003709	14.83	11392.72	823.79	0.70
1	217.66	PF#1	169000.00	1088.14	1111.44	1106.04	1113.41	0.001960	11.25	15025.17	1099.78	0.52
1	217.57	PF#1	169000.00	1089.90	1110.33	1105.37	1112.36	0.002115	11.42	14803.02	1041.20	0.53
1	217.48	PF#1	169000.00	1090.80	1109.48	1104.01	1111.36	0.001879	11.00	15368.60	1524.28	0.51
1	217.38	PF#1	169000.00	1090.70	1108.43	1103.12	1110.38	0.001968	11.20	15093.85	1100.29	0.52
1	217.29	PF#1	169000.00	1089.70	1107.17	1102.34	1109.33	0.002236	11.78	14340.42	1217.45	0.55
1	217.19	PF#1	169000.00	1086.43	1105.32	1101.58	1107.97	0.002945	13.06	12942.85	1368.81	0.62
1	217.10	PF#1	169000.00	1083.00	1105.06	1097.13	1106.73	0.001306	10.37	16300.07	1514.17	0.43
1	217.00	PF#1	169000.00	1081.30	1104.50	1096.16	1106.11	0.001205	10.18	16607.83	1669.76	0.42
1	216.91	PF#1	169000.00	1082.32	1103.62	1096.35	1105.42	0.001457	10.77	15692.78	1823.38	0.46
1	216.81	PF#1	169000.00	1079.55	1103.13	1094.42	1104.70	0.001158	10.08	16768.70	1751.01	0.41
1	216.72	PF#1	169000.00	1080.17	1102.67	1093.19	1104.13	0.001012	9.69	17444.24	899.78	0.39
1	216.62	PF#1	169000.00	1078.33	1101.88	1093.68	1103.51	0.001420	10.24	16498.01	1128.48	0.45
1	216.52	PF#1	169000.00	1083.20	1100.75	1094.30	1102.67	0.001837	11.11	15204.69	1001.89	0.50
1	216.505		Bridge									
1	216.49	PF#1	169000.00	1083.20	1099.40	1094.30	1101.71	0.002471	12.20	13853.79	992.02	0.58
1	216.42	PF#1	169000.00	1082.00	1098.86	1093.08	1100.93	0.001943	11.56	14613.77	1034.26	0.52
1	216.33	PF#1	169000.00	1080.80	1098.36	1091.42	1099.99	0.001446	10.25	16490.19	1473.76	0.45
1	216.23	PF#1	169000.00	1078.50	1097.99	1089.39	1099.28	0.001058	9.13	18502.61	1738.54	0.39
1	216.13	PF#1	169000.00	1078.00	1097.54	1088.74	1098.73	0.000954	8.75	19304.38	2129.81	0.37
1	216.04	PF#1	169000.00	1077.50	1096.93	1088.53	1098.22	0.001041	9.13	18516.63	1448.65	0.39
1	215.94	PF#1	169000.00	1077.80	1093.70	1090.85	1097.08	0.004116	14.74	11462.69	984.02	0.73
1	215.84	PF#1	169000.00	1075.80	1091.72	1088.75	1094.94	0.003648	14.42	11721.58	870.82	0.69
1	215.82	PF#1	169000.00	1076.00	1091.84	1087.04	1094.37	0.002408	12.76	13249.64	860.86	0.57
1	215.815		Bridge									
1	215.81	PF#1	169000.00	1076.00	1090.81	1087.04	1093.71	0.003024	13.67	12363.78	860.84	0.64
1	215.75	PF#1	169000.00	1073.60	1088.45	1086.84	1092.56	0.005283	16.27	10385.48	854.81	0.82
1	215.65	PF#1	169000.00	1068.30	1088.28	1082.43	1090.46	0.001959	11.87	14233.05	890.00	0.52
1	215.56	PF#1	169000.00	1066.10	1087.99	1079.21	1089.55	0.001145	10.02	16860.06	907.88	0.41
1	215.46	PF#1	169000.00	1064.60	1087.61	1077.69	1088.98	0.000932	9.38	18010.01	916.86	0.37
1	215.36	PF#1	169000.00	1063.00	1087.34	1075.38	1088.49	0.000701	8.61	19624.38	3559.81	0.33
1	215.27	PF#1	169000.00	1063.50	1086.84	1076.05	1088.11	0.000846	9.02	18737.07	3991.57	0.36
1	215.18	PF#1	169000.00	1062.20	1081.87	1079.47	1086.91	0.004582	18.01	9383.28	686.95	0.80
1	215.09	PF#1	169000.00	1061.70	1081.09	1076.39	1084.77	0.002894	15.38	10986.15	619.02	0.64
1	214.99	PF#1	169000.00	1061.30	1079.92	1075.60	1083.17	0.002926	14.48	11673.56	727.59	0.64
1	214.9	PF#1	169000.00	1061.20	1078.13	1074.96	1081.52	0.003588	14.78	11435.69	934.52	0.69
1	214.79	PF#1	169000.00	1057.60	1078.39	1070.73	1079.83	0.001221	9.62	17558.59	1056.42	0.42
1	214.785		Bridge									
1	214.78	PF#1	169000.00	1058.80	1078.06	1070.74	1079.56	0.001306	9.83	17191.94	1054.44	0.43
1	214.71	PF#1	169000.00	1055.10	1077.48	1069.32	1079.15	0.001272	10.38	16287.08	901.57	0.43
1	214.61	PF#1	169000.00	1050.40	1077.25	1064.30	1078.56	0.000723	9.21	18346.35	792.44	0.34
1	214.52	PF#1	169000.00	1048.00	1077.35	1060.66	1078.15	0.000391	7.19	23492.42	928.22	0.25
1	214.42	PF#1	169000.00	1048.20	1077.32	1059.41	1077.93	0.000288	6.27	26966.84	1193.48	0.22
1	214.33	PF#1	169000.00	1048.50	1076.88	1060.45	1077.73	0.000413	7.40	22823.47	1266.44	0.26
1	214.23	PF#1	169000.00	1048.70	1075.93	1062.88	1077.39	0.000784	9.71	17406.42	1126.00	0.35
1	214.14	PF#1	169000.00	1048.70	1075.49	1062.70	1076.99	0.000805	9.84	17171.67	1257.06	0.36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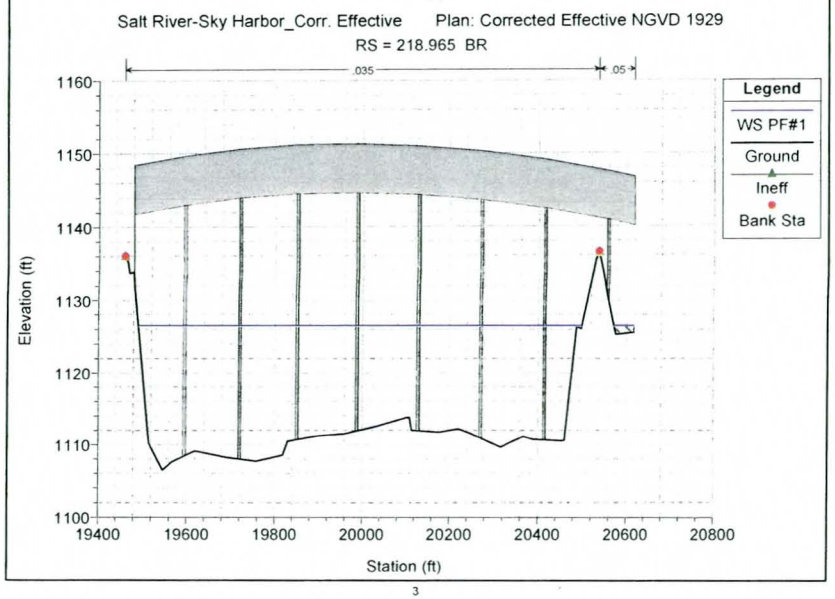
Legend
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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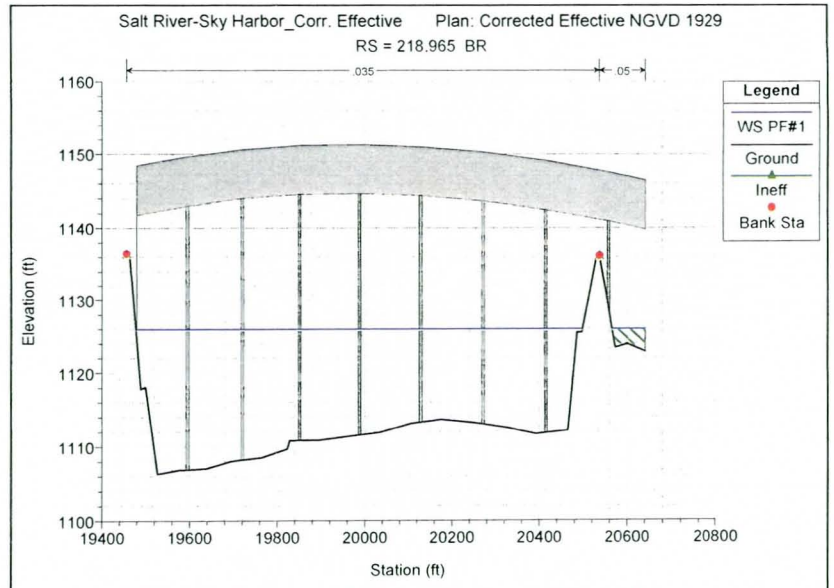
Bank Sta
Elevation (ft)
Station (ft)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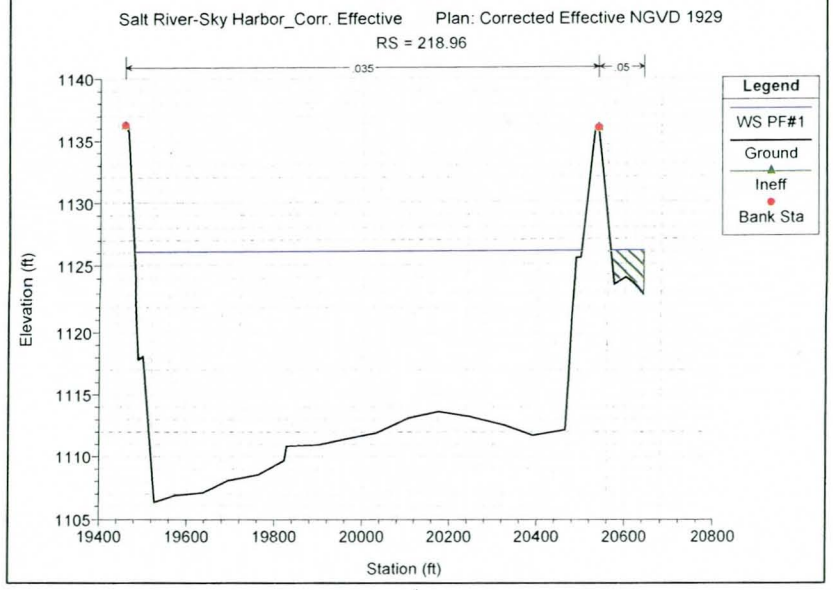
Bank Sta
Elevation (ft)
Station (ft)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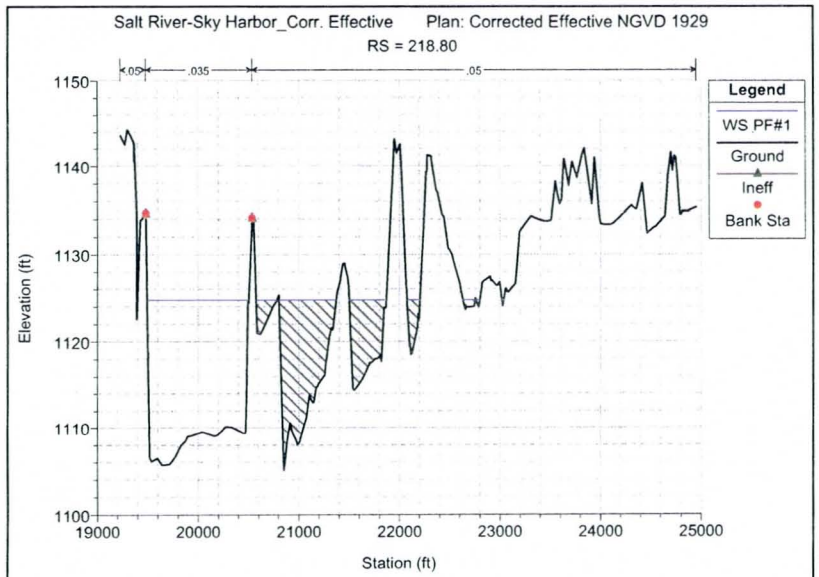
Ineff
Bank Sta
Elevation (ft)
Station (ft)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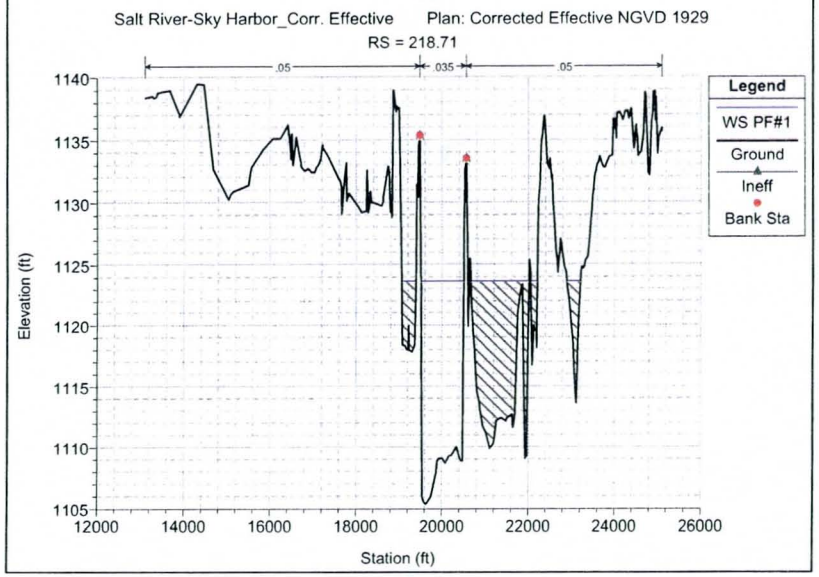
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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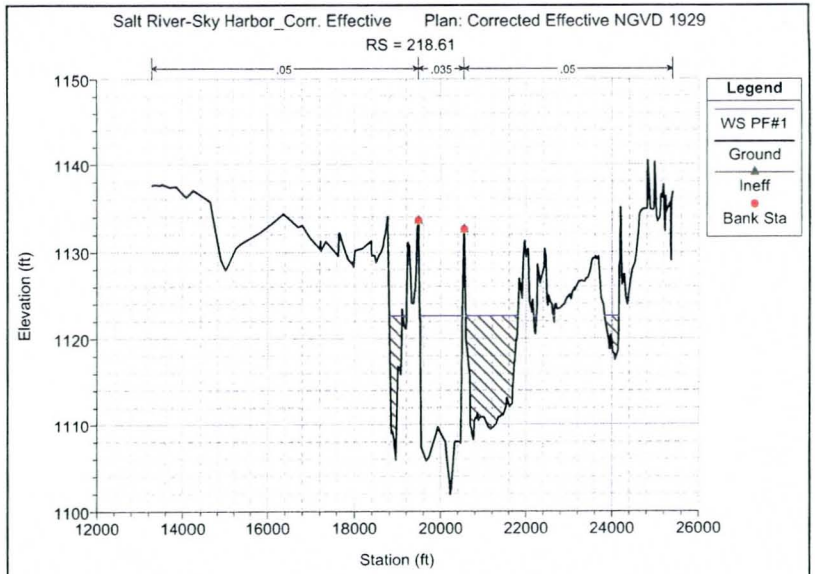
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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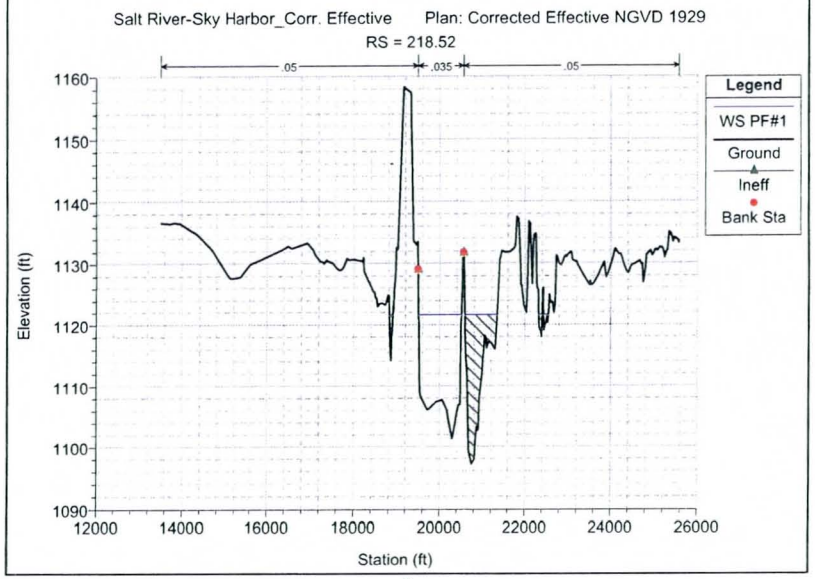
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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WS PF#1
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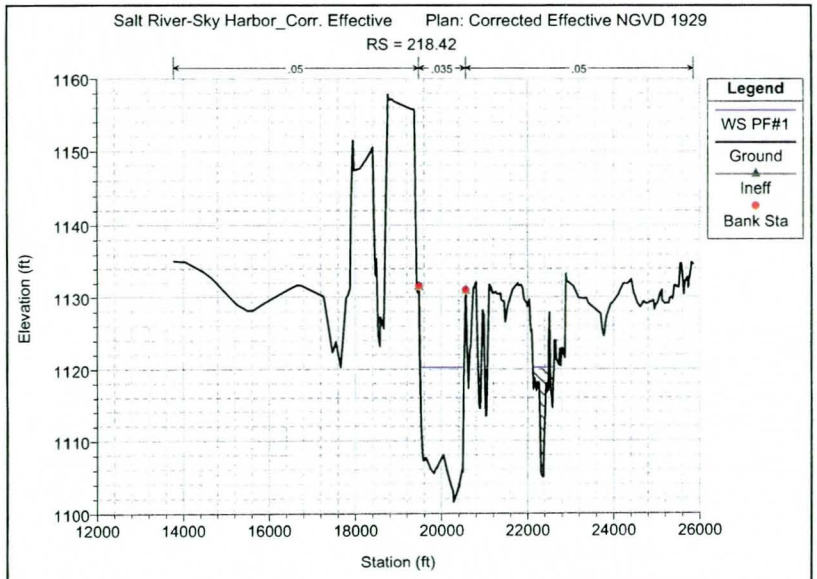
Ineff
Bank Sta
Elevation (ft)
Station (ft)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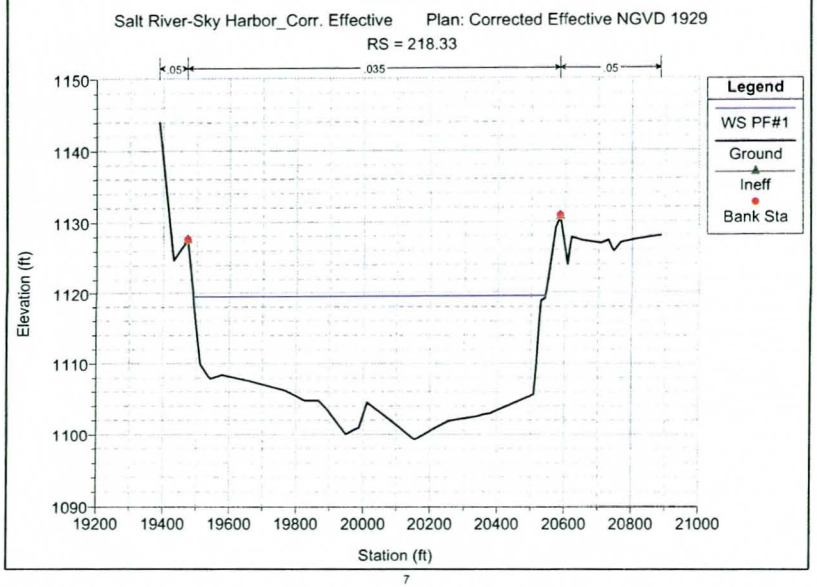
WS PF#1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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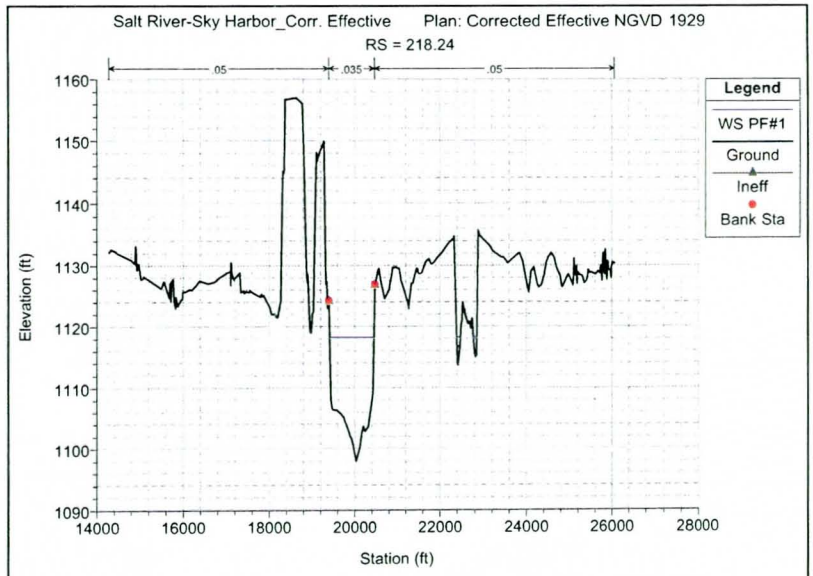
Ineff
Bank Sta
Elevation (ft)
Station (ft)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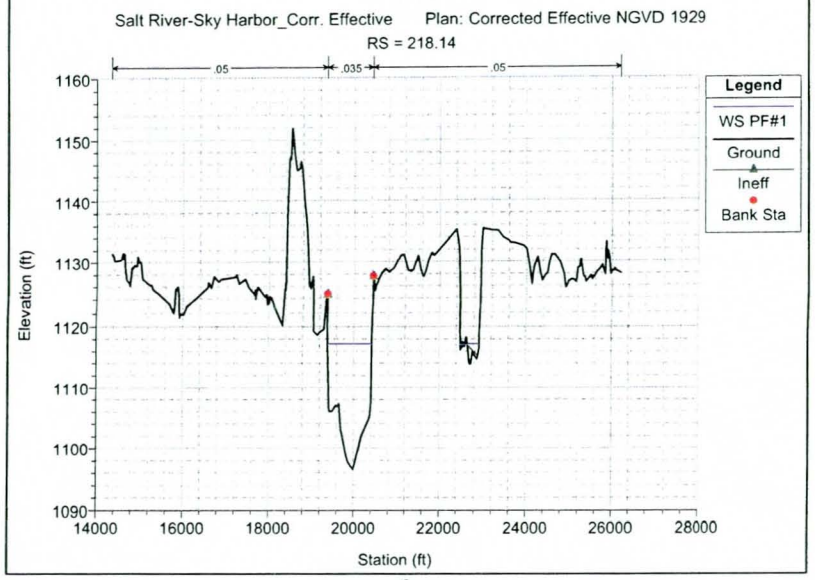
Ineff
Bank Sta
Elevation (ft)
Station (ft)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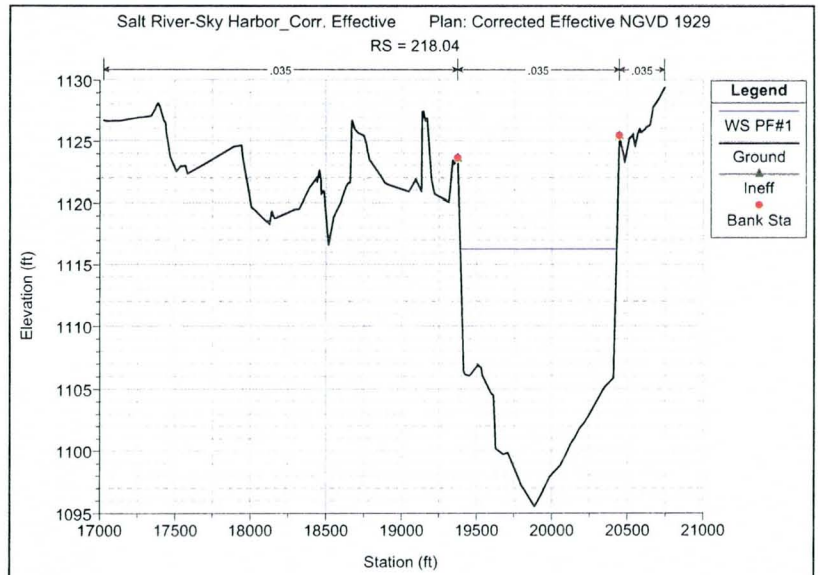
Ineff
Bank Sta
Elevation (ft)
Station (ft)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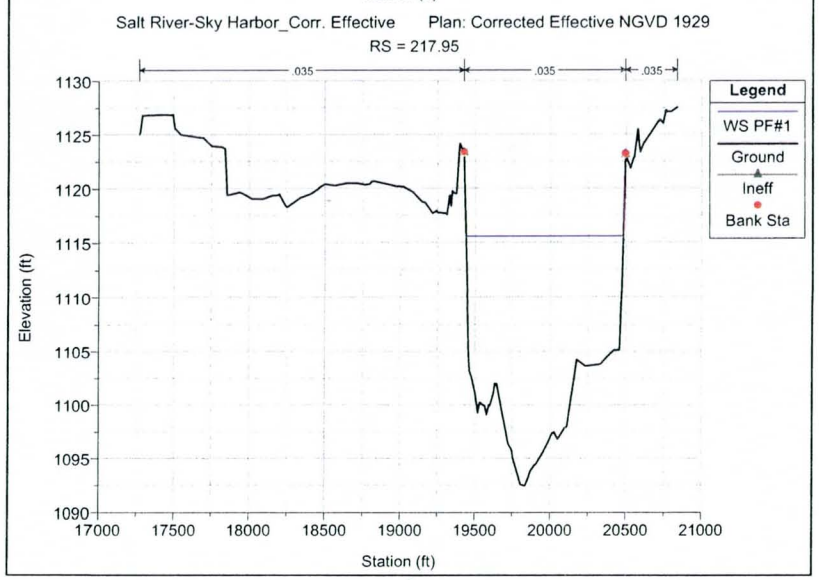
Bank Sta
Elevation (ft)
Station (ft)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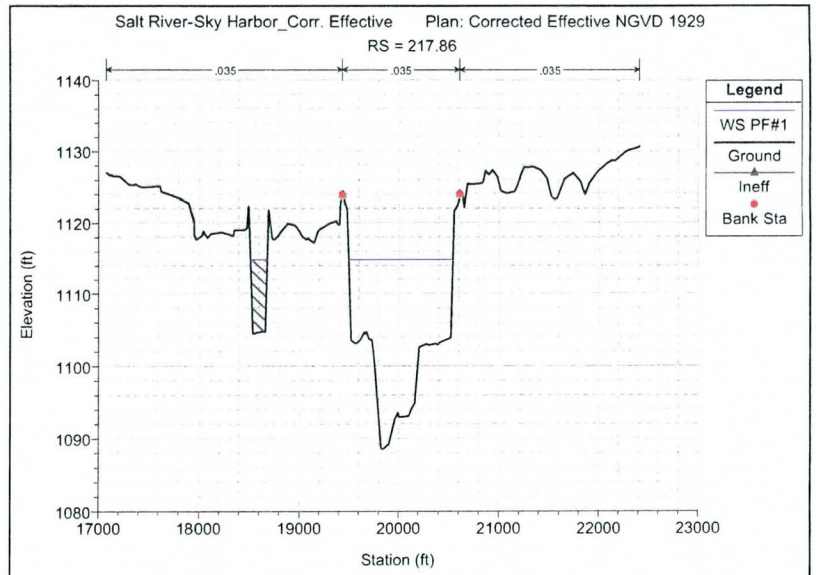
Bank Sta
Elevation (ft)
Station (ft)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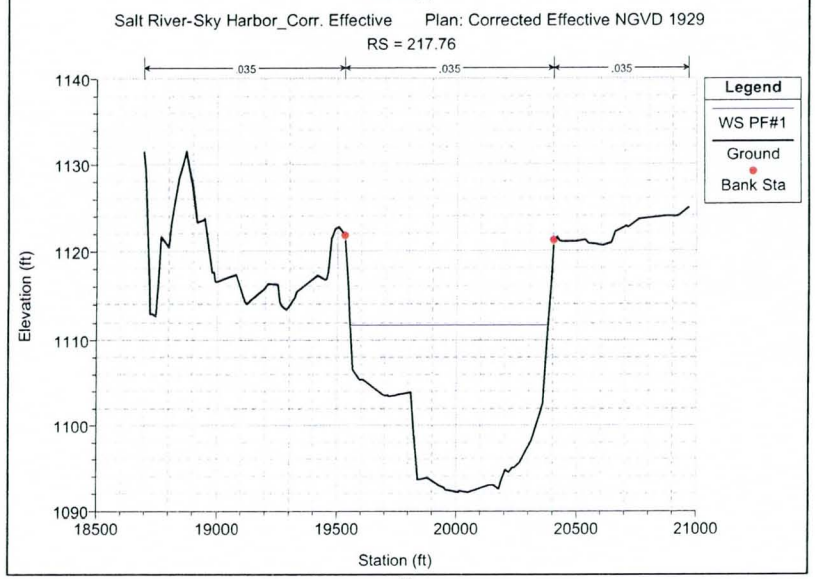
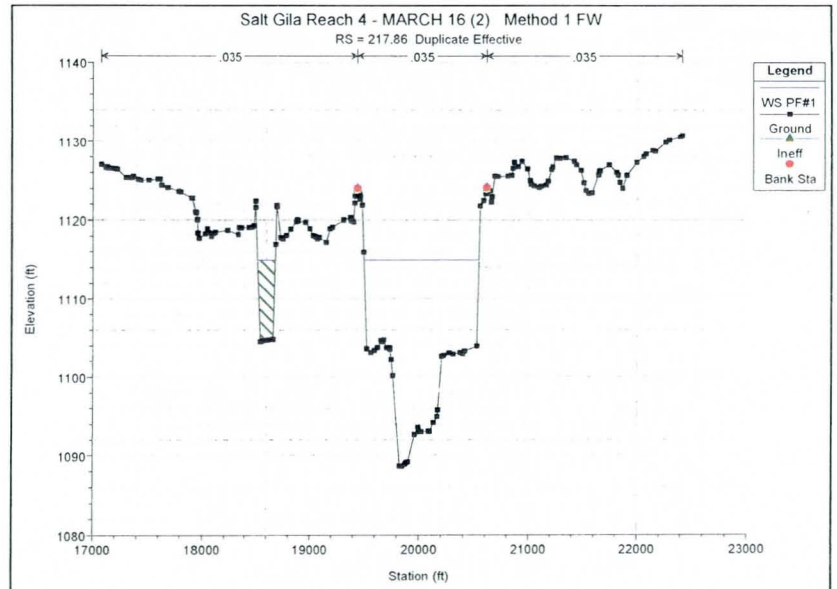
Ineff
Bank Sta
Elevation (ft)
Station (ft)

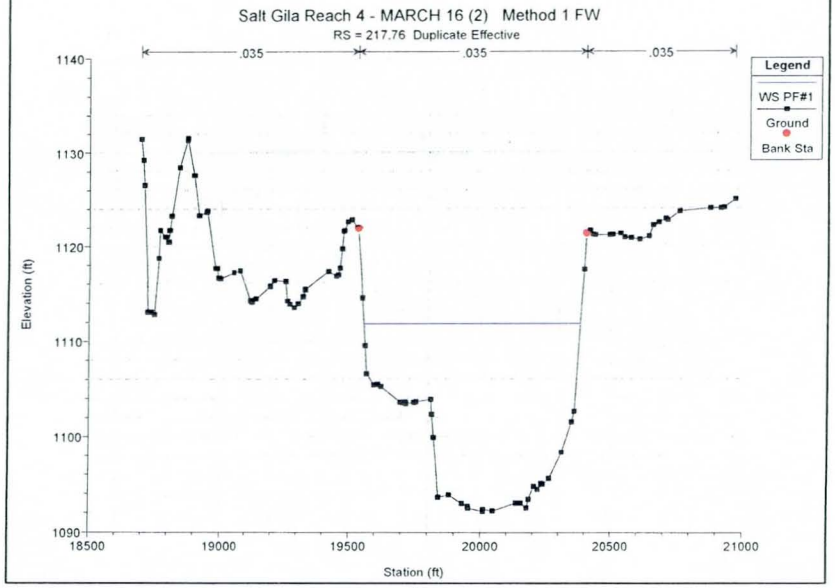

Salt River-Sky Harbor_Corr. Effective Plan: Corrected Effective NGVD 1929
RS = 217.76
.035
.035
.035
Legend
WS PF#1
Ground
Bank Sta
Elevation (ft)
Station (ft)

Appendix B – Duplicate Effective Output 1929 NGVD

HEC-RAS Plan: Method 1 FW River: Salt River Reach: Reach 4

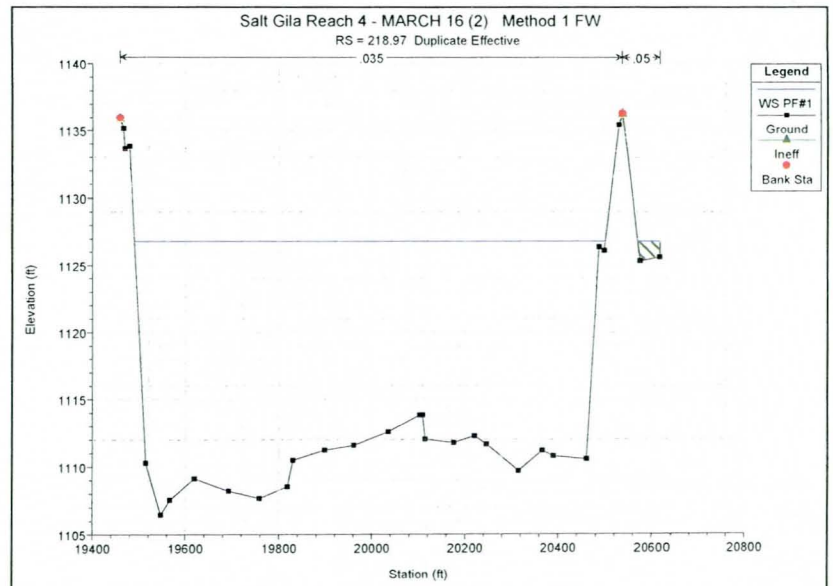
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 4	225.30	PF#1	172000.00	1146.46	1177.35	1162.72	1177.76	0.000188	5.15	33423.64	1883.46	0.20
Reach 4	225.19	PF#1	172000.00	1150.45	1176.66	1165.67	1177.55	0.000492	7.56	22740.30	1212.94	0.31
Reach 4	225.11	PF#1	172000.00	1148.16	1176.71	1163.67	1177.30	0.000279	6.15	27855.79	1609.78	0.24
Reach 4	225	PF#1	172000.00	1138.36	1176.86	1160.02	1177.10	0.000106	3.91	44041.00	2462.93	0.15
Reach 4	224.90	PF#1	172000.00	1147.76	1176.59	1163.77	1177.00	0.000239	5.13	33546.89	3005.67	0.22
Reach 4	224.82	PF#1	172000.00	1149.27	1176.55	1162.82	1176.87	0.000235	4.53	37949.14	2819.06	0.18
Reach 4	224.71	PF#1	172000.00	1141.77	1176.55	1158.72	1176.74	0.000112	3.51	49039.47	3514.23	0.13
Reach 4	224.62	PF#1	172000.00	1143.01	1176.46	1159.96	1176.68	0.000135	3.77	45608.09	3108.05	0.14
Reach 4	224.52	PF#1	172000.00	1147.48	1176.39	1158.39	1176.61	0.000118	3.79	45385.96	3145.40	0.14
Reach 4	224.42	PF#1	172000.00	1146.82	1176.24	1158.33	1176.54	0.000146	4.35	39501.05	2946.39	0.15
Reach 4	224.31	PF#1	172000.00	1145.60	1175.80	1160.06	1176.39	0.000307	6.13	28046.58	2559.24	0.22
Reach 4	224.22	PF#1	172000.00	1148.68	1175.65	1160.24	1176.24	0.000321	6.15	27965.27	1204.04	0.22
Reach 4	224.21		Bridge									
Reach 4	224.20	PF#1	172000.00	1148.94	1175.36		1176.10	0.000412	6.90	24936.73	1087.88	0.25
Reach 4	224.19	PF#1	172000.00	1149.14	1175.31	1160.99	1176.06	0.000410	6.96	24729.63	1061.97	0.25
Reach 4	224.175		Bridge									
Reach 4	224.16	PF#1	172000.00	1148.43	1175.21		1175.94	0.000392	6.87	25043.76	1057.54	0.25
Reach 4	224.14	PF#1	172000.00	1145.90	1175.20	1159.62	1175.89	0.000355	6.65	25869.50	1064.06	0.24
Reach 4	224.13		Bridge									
Reach 4	224.12	PF#1	172000.00	1145.41	1175.20		1175.75	0.000272	5.95	28900.78	1152.56	0.21
Reach 4	224.06	PF#1	172000.00	1145.60	1174.59	1160.26	1175.58	0.000511	7.99	21513.79	1373.10	0.28
Reach 4	223.96	PF#1	172000.00	1142.30	1174.54	1157.63	1175.34	0.000268	7.16	24011.87	1815.70	0.24
Reach 4	223.86	PF#1	172000.00	1140.96	1174.11	1157.82	1175.13	0.000414	8.13	21156.92	1139.08	0.28
Reach 4	223.77	PF#1	172000.00	1139.19	1173.52	1158.27	1174.85	0.000640	9.28	18530.30	1291.23	0.31
Reach 4	223.67	PF#1	172000.00	1138.26	1172.51	1159.87	1174.34	0.001519	10.85	15846.36	946.38	0.38
Reach 4	223.58	PF#1	172000.00	1144.05	1170.70	1162.04	1173.31	0.002451	12.96	13275.04	990.19	0.49
Reach 4	223.48	PF#1	172000.00	1135.70	1170.24	1158.21	1172.13	0.001547	11.02	15601.74	933.29	0.39
Reach 4	223.38	PF#1	172000.00	1134.62	1169.83	1157.04	1171.31	0.001141	9.78	17589.90	1665.59	0.35
Reach 4	223.29	PF#1	172000.00	1139.90	1169.35	1157.37	1170.74	0.001114	9.48	18141.91	2258.16	0.35
Reach 4	223.19	PF#1	172000.00	1141.00	1169.29	1155.62	1170.15	0.000631	7.44	23106.09	2091.50	0.27
Reach 4	223.09	PF#1	172000.00	1146.30	1167.01	1163.00	1169.40	0.002884	12.39	13879.32	1222.95	0.61
Reach 4	223.085		Bridge									
Reach 4	223.08	PF#1	172000.00	1146.30	1163.07	1163.07	1167.91	0.008376	17.64	9747.96	1001.37	1.00
Reach 4	223.02	PF#1	172000.00	1140.00	1163.55	1154.21	1164.76	0.000943	8.86	19418.38	1524.43	0.37
Reach 4	222.93	PF#1	172000.00	1137.70	1163.05	1152.09	1164.32	0.000836	9.04	19035.72	2119.92	0.35
Reach 4	222.83	PF#1	172000.00	1127.92	1162.90	1149.43	1163.89	0.000578	8.01	21474.69	2187.54	0.30
Reach 4	222.74	PF#1	172000.00	1134.16	1162.59	1150.45	1163.59	0.000642	8.03	21415.29	2043.47	0.31
Reach 4	222.65	PF#1	172000.00	1138.75	1162.23	1151.59	1163.26	0.000706	8.15	21092.08	2093.67	0.33
Reach 4	222.55	PF#1	172000.00	1139.60	1162.10	1151.35	1162.91	0.000433	7.24	23760.71	1818.05	0.29
Reach 4	222.45	PF#1	172000.00	1139.54	1161.93	1151.04	1162.67	0.000416	6.90	24914.87	1643.65	0.29
Reach 4	222.36	PF#1	172000.00	1138.87	1161.29	1151.87	1162.39	0.000648	8.41	20461.32	1414.74	0.36
Reach 4	222.27	PF#1	172000.00	1139.19	1160.64	1152.19	1162.01	0.000822	9.37	18354.18	1214.10	0.40
Reach 4	222.17	PF#1	172000.00	1137.16	1160.20	1151.21	1161.60	0.000794	9.52	18072.05	1227.36	0.40
Reach 4	222.09	PF#1	172000.00	1136.00	1160.14	1148.79	1161.26	0.000568	8.50	20234.88	1233.92	0.34
Reach 4	222.085		Bridge									
Reach 4	222.08	PF#1	172000.00	1136.00	1159.93	1148.80	1161.08	0.000588	8.59	20013.41	1231.13	0.35
Reach 4	221.99	PF#1	172000.00	1138.14	1158.99	1151.29	1160.68	0.001084	10.44	16480.45	1183.84	0.46
Reach 4	221.89	PF#1	172000.00	1136.20	1158.07	1151.65	1160.03	0.001351	11.24	15299.65	1151.06	0.50
Reach 4	221.80	PF#1	172000.00	1136.35	1157.35	1150.59	1159.37	0.001319	11.41	15075.93	1212.13	0.50
Reach 4	221.70	PF#1	172000.00	1134.30	1156.71	1149.59	1158.69	0.001284	11.30	15216.21	1465.08	0.50
Reach 4	221.61	PF#1	172000.00	1133.98	1155.68	1149.68	1157.96	0.001596	12.13	14181.29	1387.27	0.55
Reach 4	221.50	PF#1	172000.00	1134.08	1154.59	1149.15	1157.00	0.001741	12.45	13820.29	1331.97	0.57
Reach 4	221.40	PF#1	172000.00	1133.21	1153.68	1147.84	1155.96	0.002238	12.12	14189.74	1061.04	0.55
Reach 4	221.31	PF#1	172000.00	1131.43	1152.32	1146.78	1154.78	0.002394	12.59	13661.28	1150.47	0.57
Reach 4	221.26	PF#1	169000.00	1124.29	1152.72	1142.61	1154.06	0.000962	9.30	18172.91	1085.75	0.38
Reach 4	221.25		Bridge									
Reach 4	221.24	PF#1	169000.00	1124.29	1152.39	1142.62	1153.78	0.001018	9.46	17860.54	1070.97	0.39
Reach 4	221.2	PF#1	169000.00	1128.00	1152.17	1142.32	1153.59	0.001065	9.55	17696.37	1104.28	0.39
Reach 4	221.195		Bridge									
Reach 4	221.19	PF#1	169000.00	1128.00	1151.80	1142.33	1153.28	0.001134	9.75	17340.64	1048.37	0.41
Reach 4	221.06	PF#1	169000.00	1126.00	1151.07	1140.98	1152.56	0.001076	9.78	17282.71	1351.93	0.40
Reach 4	221.055		Bridge									
Reach 4	221.05	PF#1	169000.00	1126.00	1150.84	1140.99	1152.36	0.001100	9.90	17070.64	1318.35	0.40
Reach 4	221.02	PF#1	169000.00	1130.06	1150.36	1142.60	1152.13	0.001403	10.69	15806.92	1161.10	0.45
Reach 4	220.92	PF#1	169000.00	1129.16	1149.39	1142.46	1151.35	0.001666	11.27	15058.51	1072.33	0.49
Reach 4	220.82	PF#1	169000.00	1129.56	1148.53	1141.72	1150.47	0.001688	11.19	15100.60	1082.87	0.49
Reach 4	220.73	PF#1	169000.00	1127.69	1147.59	1141.05	1149.62	0.001715	11.43	14782.77	1018.38	0.49
Reach 4	220.63	PF#1	169000.00	1127.10	1146.74	1140.24	1148.75	0.001734	11.37	14857.16	981.94	0.49
Reach 4	220.54	PF#1	169000.00	1127.32	1145.84	1139.51	1147.86	0.001789	11.42	14796.15	1107.01	0.50
Reach 4	220.45	PF#1	169000.00	1125.43	1144.97	1138.52	1146.99	0.001759	11.39	14836.82	1293.58	0.50
Reach 4	220.35	PF#1	169000.00	1123.99	1144.24	1137.09	1146.10	0.001554	10.95	15436.37	1375.54	0.47
Reach 4	220.25	PF#1	169000.00	1124.01	1143.14	1137.06	1145.23	0.001890	11.59	14576.74	1743.60	0.51
Reach 4	220.16	PF#1	169000.00	1124.58	1141.74	1136.90	1144.14	0.002357	12.43	13591.57	1469.89	0.57
Reach 4	220.06	PF#1	169000.00	1122.90	1140.72	1135.39	1142.99	0.002141	12.08	13992.86	909.54	0.54
Reach 4	220.05		Bridge									
Reach 4	220.03	PF#1	169000.00	1122.90	1139.74	1135.40	1142.32	0.002656	12.90	13097.09	906.62	0.60
Reach 4	219.88	PF#1	169000.00	1119.50	1137.44	1133.46	1140.11	0.002850	13.11	12889.63	2003.65	0.62
Reach 4	219.79	PF#1	169000.00	1119.30	1135.96	1132.24	1138.69	0.003008	13.26	12747.50	2039.42	0.63
Reach 4	219.70	PF#1	169000.00	1115.81	1134.63	1130.64	1137.22	0.002805	12.91	13091.68	2045.78	0.61
Reach 4	219.61	PF#1	169000.00	1112.39	1133.86	1128.49	1135.93	0.002051	11.54	14649.74	2912.62	0.53

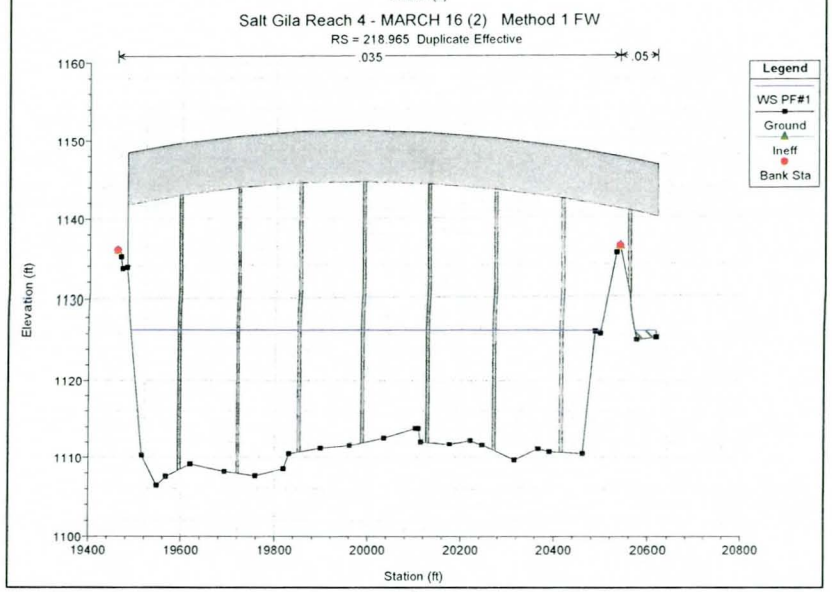


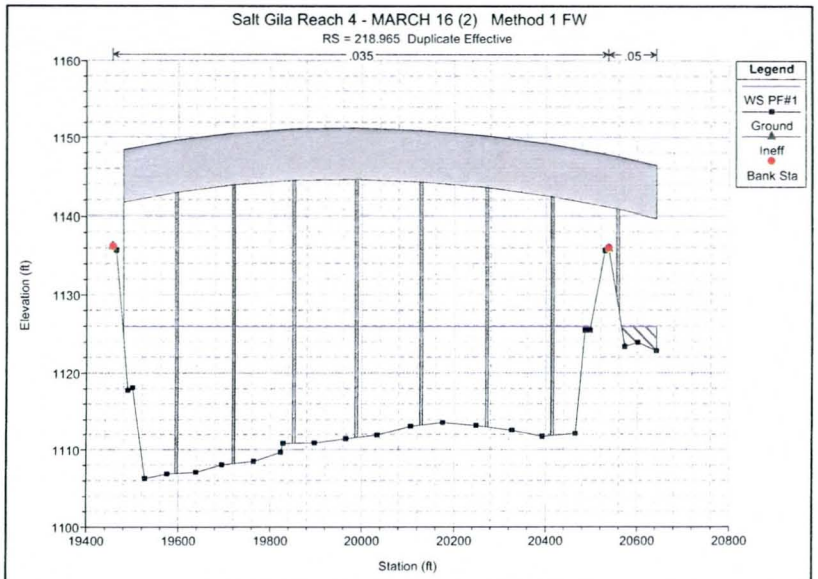


HEC-RAS Plan: Method 1 FW River: Salt River Reach: Reach 4 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 4	219.51	PF#1	169000.00	1111.64	1132.93	1127.37	1134.90	0.001942	11.27	14993.73	1910.40	0.51
Reach 4	219.42	PF#1	169000.00	1111.83	1132.00	1126.37	1133.94	0.001898	11.18	15121.63	2400.89	0.51
Reach 4	219.33	PF#1	169000.00	1113.40	1131.10	1125.53	1133.03	0.001929	11.17	15131.52	2726.06	0.51
Reach 4	219.24	PF#1	169000.00	1112.10	1130.16	1124.65	1132.12	0.001989	11.23	15051.51	2682.75	0.52
Reach 4	219.14	PF#1	169000.00	1110.40	1129.20	1123.56	1131.11	0.001887	11.10	15229.89	2551.53	0.51
Reach 4	219.03	PF#1	169000.00	1112.90	1127.80	1123.15	1129.94	0.002299	11.76	14369.34	1026.67	0.55
Reach 4	219.02		Bridge									
Reach 4	219.01	PF#1	169000.00	1112.90	1126.36	1123.16	1129.03	0.003271	13.10	12900.13	1022.15	0.65
Reach 4	218.97	PF#1	169000.00	1106.45	1126.74	1120.31	1128.50	0.001620	10.65	15870.96	1056.96	0.47
Reach 4	218.965		Bridge									
Reach 4	218.96	PF#1	169000.00	1106.31	1126.03	1120.64	1128.02	0.002010	11.32	14931.39	1096.74	0.52
Reach 4	218.80	PF#1	169000.00	1105.70	1124.77	1118.20	1126.50	0.001572	10.55	16025.58	2479.30	0.47
Reach 4	218.71	PF#1	169000.00	1105.38	1123.63	1118.10	1125.63	0.001938	11.35	14892.50	3165.49	0.51
Reach 4	218.61	PF#1	169000.00	1101.91	1122.61	1117.10	1124.63	0.001986	11.40	14828.60	3020.93	0.52
Reach 4	218.52	PF#1	169000.00	1101.37	1121.59	1116.20	1123.62	0.002037	11.43	14790.92	2019.39	0.53
Reach 4	218.42	PF#1	169000.00	1101.56	1120.20	1115.71	1122.48	0.002467	12.11	13956.46	1630.10	0.57
Reach 4	218.33	PF#1	169000.00	1099.30	1119.49	1113.65	1121.29	0.001772	10.78	15675.27	1051.46	0.49
Reach 4	218.24	PF#1	169000.00	1097.97	1118.20	1113.34	1120.30	0.002216	11.61	14552.93	1209.42	0.55
Reach 4	218.14	PF#1	169000.00	1096.58	1117.26	1111.91	1119.21	0.001975	11.22	15057.10	1392.54	0.52
Reach 4	218.04	PF#1	169000.00	1095.51	1116.28	1110.88	1118.21	0.001944	11.14	15165.97	1038.71	0.51
Reach 4	217.95	PF#1	169000.00	1092.47	1115.57	1109.16	1117.25	0.001554	10.40	16247.70	1042.17	0.46
Reach 4	217.86	PF#1	169000.00	1088.60	1114.83	1108.27	1116.49	0.001531	10.34	16338.62	1206.97	0.46
Reach 4	217.76	PF#1	169000.00	1092.19	1111.73		1115.15	0.003709	14.83	11392.22	823.79	0.70
Reach 4	217.66	PF#1	169000.00	1088.14	1111.44	1106.01	1113.41	0.001961	11.25	15024.30	1099.68	0.52
Reach 4	217.57	PF#1	169000.00	1089.90	1110.33	1105.33	1112.36	0.002116	11.42	14800.73	1041.19	0.53
Reach 4	217.48	PF#1	169000.00	1090.80	1109.47	1103.96	1111.35	0.001880	11.00	15365.66	1524.24	0.51
Reach 4	217.38	PF#1	169000.00	1090.70	1108.43	1103.09	1110.38	0.001969	11.20	15092.83	1100.28	0.52
Reach 4	217.29	PF#1	169000.00	1089.70	1107.17	1102.31	1109.33	0.002236	11.79	14339.93	1217.44	0.55
Reach 4	217.19	PF#1	169000.00	1086.43	1105.32	1101.53	1107.97	0.002945	13.06	12941.69	1368.79	0.62
Reach 4	217.10	PF#1	169000.00	1083.00	1105.06	1097.07	1106.73	0.001306	10.37	16299.18	1514.16	0.43
Reach 4	217.00	PF#1	169000.00	1081.30	1104.50	1096.14	1106.11	0.001205	10.18	16606.84	1669.75	0.42
Reach 4	216.91	PF#1	169000.00	1082.32	1103.62	1096.30	1105.42	0.001457	10.77	15691.56	1823.37	0.46
Reach 4	216.81	PF#1	169000.00	1079.55	1103.12	1094.35	1104.70	0.001159	10.08	16767.39	1751.00	0.41
Reach 4	216.72	PF#1	169000.00	1080.17	1102.67	1093.15	1104.13	0.001012	9.69	17442.59	899.77	0.39
Reach 4	216.62	PF#1	169000.00	1078.33	1101.87	1093.62	1103.50	0.001420	10.25	16495.79	1128.15	0.45
Reach 4	216.52	PF#1	169000.00	1083.20	1100.75	1094.26	1102.67	0.001838	11.12	15203.46	1001.88	0.50
Reach 4	216.505		Bridge									
Reach 4	216.49	PF#1	169000.00	1083.20	1099.40	1094.27	1101.71	0.002471	12.20	13853.43	992.00	0.58
Reach 4	216.42	PF#1	169000.00	1082.00	1098.86	1093.10	1100.93	0.001943	11.57	14613.30	1034.14	0.52
Reach 4	216.33	PF#1	169000.00	1080.80	1098.35	1091.37	1099.99	0.001446	10.25	16489.69	1473.62	0.45
Reach 4	216.23	PF#1	169000.00	1078.50	1097.99	1089.39	1099.28	0.001058	9.13	18502.08	1738.50	0.39
Reach 4	216.13	PF#1	169000.00	1078.00	1097.54	1088.70	1098.73	0.000954	8.75	19303.70	2129.80	0.37
Reach 4	216.04	PF#1	169000.00	1077.50	1096.93	1088.52	1098.22	0.001041	9.13	18515.97	1448.65	0.39
Reach 4	215.94	PF#1	169000.00	1077.80	1093.70	1090.81	1097.08	0.004117	14.74	11461.59	983.97	0.73
Reach 4	215.84	PF#1	169000.00	1075.80	1091.71	1088.70	1094.94	0.003651	14.42	11719.46	870.81	0.69
Reach 4	215.82	PF#1	169000.00	1076.00	1091.84	1087.02	1094.37	0.002409	12.76	13249.11	860.86	0.57
Reach 4	215.815		Bridge									
Reach 4	215.81	PF#1	169000.00	1076.00	1090.81	1087.03	1093.71	0.003024	13.67	12363.67	860.84	0.64
Reach 4	215.75	PF#1	169000.00	1073.60	1088.44	1086.81	1092.56	0.005283	16.27	10385.16	854.81	0.82
Reach 4	215.66	PF#1	169000.00	1068.30	1088.27	1082.38	1090.46	0.001959	11.87	14232.62	890.00	0.52
Reach 4	215.56	PF#1	169000.00	1066.10	1087.99	1079.15	1089.55	0.001145	10.02	16859.61	907.87	0.41
Reach 4	215.46	PF#1	169000.00	1064.60	1087.61	1077.65	1088.97	0.000932	9.38	18009.56	916.86	0.37
Reach 4	215.36	PF#1	169000.00	1063.00	1087.34	1075.36	1088.49	0.000701	8.61	19624.04	3559.77	0.33
Reach 4	215.27	PF#1	169000.00	1063.50	1086.84	1076.00	1088.10	0.000846	9.02	18736.49	3991.40	0.36
Reach 4	215.18	PF#1	169000.00	1062.20	1081.87	1079.42	1086.91	0.004584	18.01	9382.04	686.90	0.80
Reach 4	215.09	PF#1	169000.00	1061.70	1081.09	1076.37	1084.77	0.002894	15.38	10986.08	619.02	0.64
Reach 4	214.99	PF#1	169000.00	1061.30	1079.91	1075.58	1083.17	0.002926	14.48	11672.67	727.58	0.64
Reach 4	214.9	PF#1	169000.00	1061.20	1078.13	1074.91	1081.52	0.003589	14.78	11434.89	934.49	0.69
Reach 4	214.79	PF#1	169000.00	1057.60	1078.39	1070.68	1079.83	0.001221	9.63	17557.55	1056.41	0.42
Reach 4	214.785		Bridge									
Reach 4	214.78	PF#1	169000.00	1058.80	1078.06	1070.73	1079.56	0.001306	9.83	17192.07	1054.44	0.43
Reach 4	214.71	PF#1	169000.00	1055.10	1077.48	1069.29	1079.15	0.001272	10.38	16287.19	901.57	0.43
Reach 4	214.61	PF#1	169000.00	1050.40	1077.25	1064.26	1078.56	0.000723	9.21	18346.45	792.44	0.34
Reach 4	214.52	PF#1	169000.00	1048.00	1077.35	1060.59	1078.15	0.000391	7.19	23492.53	928.22	0.25
Reach 4	214.42	PF#1	169000.00	1048.20	1077.32	1059.39	1077.93	0.000288	6.27	26966.97	1193.48	0.22
Reach 4	214.33	PF#1	169000.00	1048.50	1076.88	1060.42	1077.73	0.000413	7.40	22823.58	1266.50	0.26
Reach 4	214.23	PF#1	169000.00	1048.70	1075.93	1062.84	1077.39	0.000784	9.71	17406.42	1126.00	0.35
Reach 4	214.14	PF#1	169000.00	1048.70	1075.49	1062.63	1076.99	0.000805	9.84	17171.67	1257.06	0.36



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Ground
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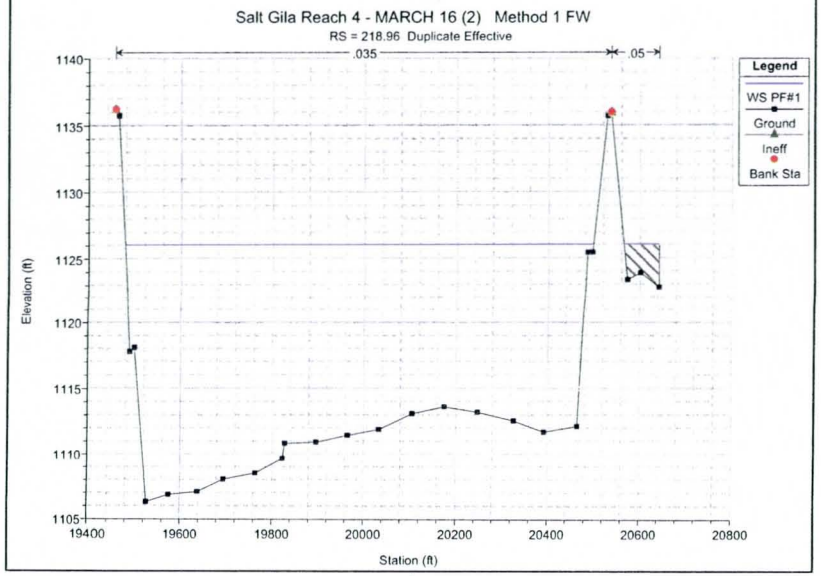
Bank Sta
Elevation (ft)
Station (ft)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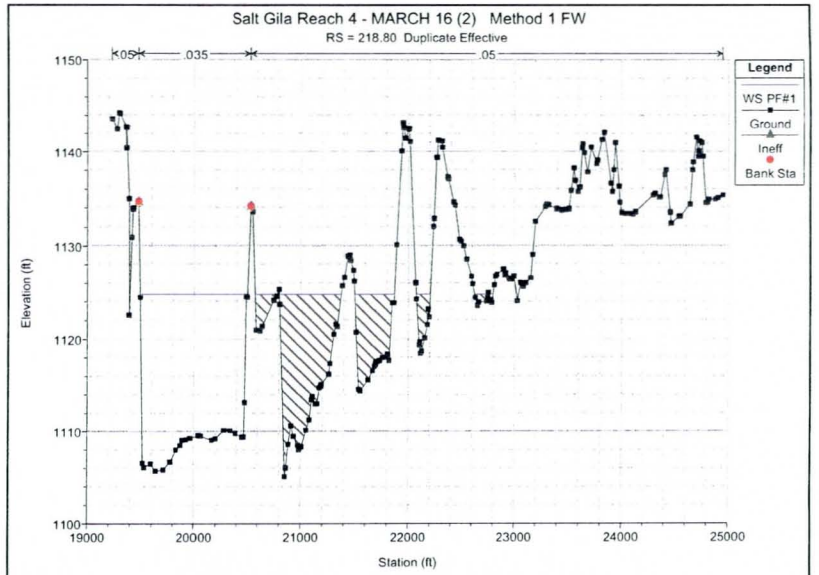
Station (ft)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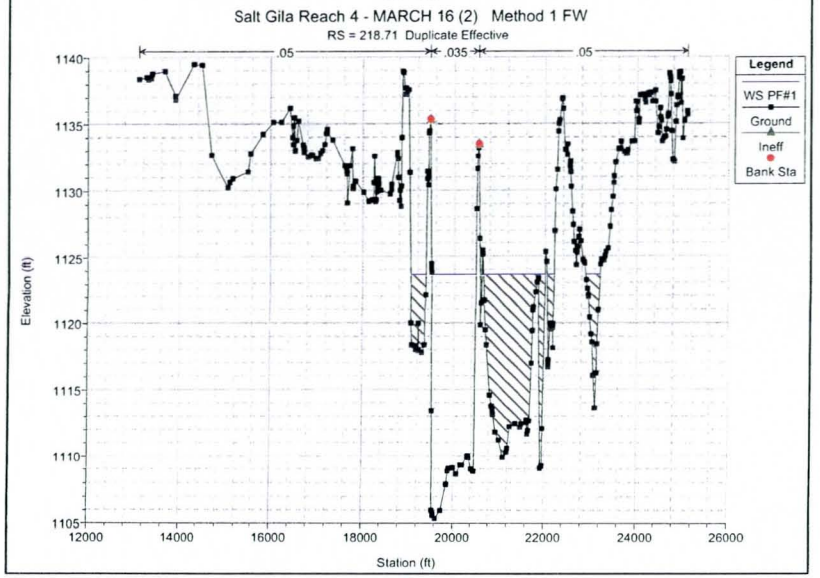
Elevation (ft)
Station (ft)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Bank Sta
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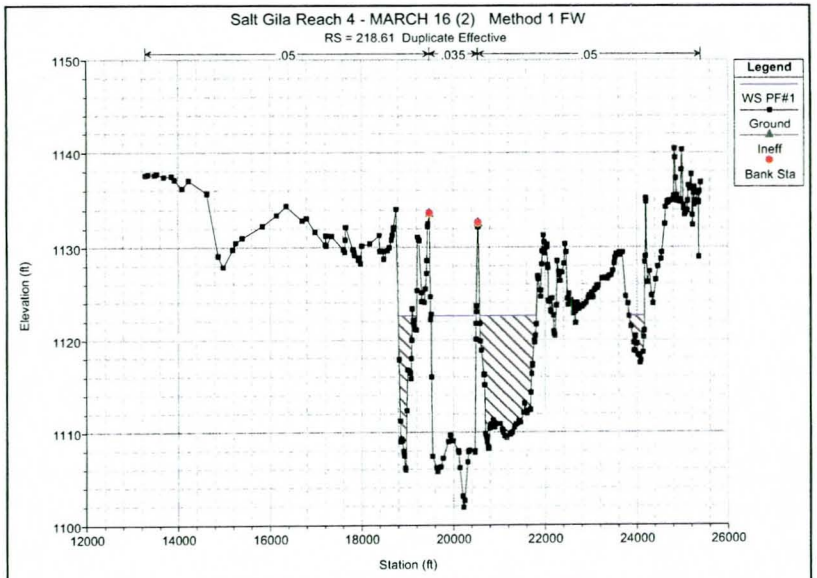
Station (ft)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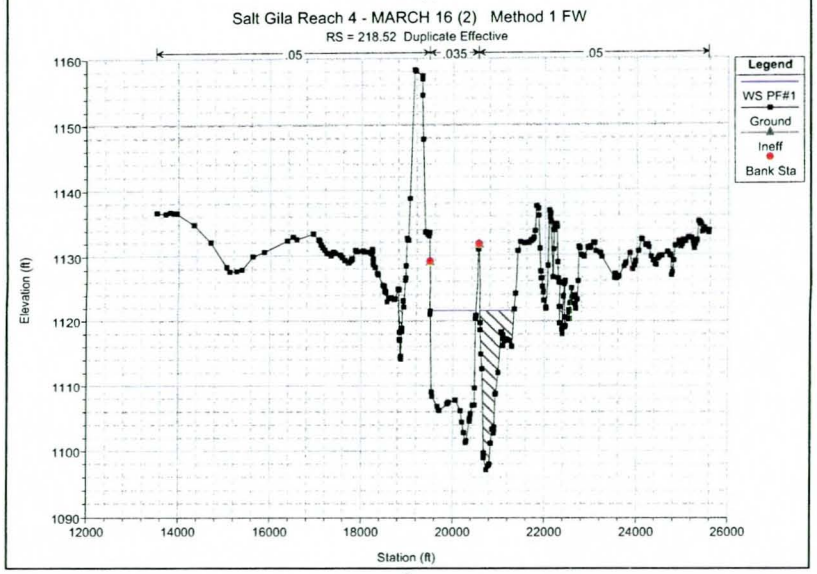
Ineff
Bank Sta
Elevation (ft)
Station (ft)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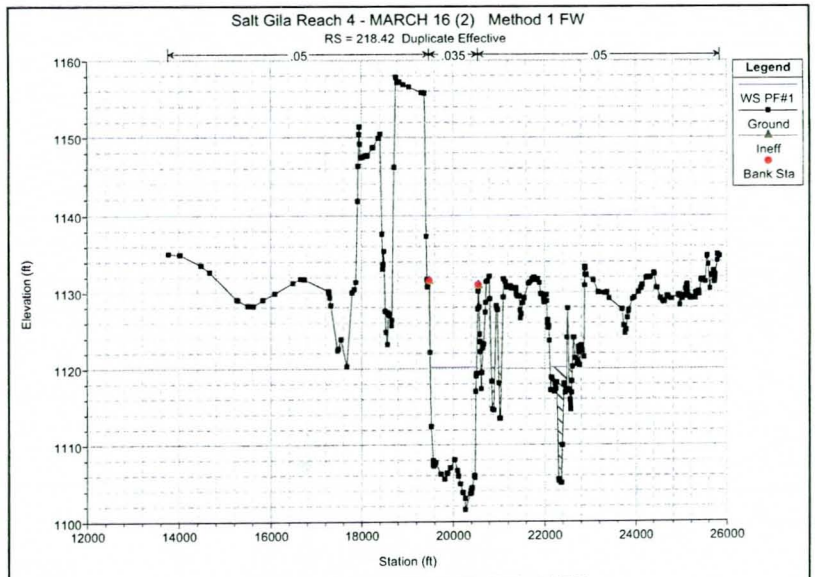
Bank Sta
Elevation (ft)
Station (ft)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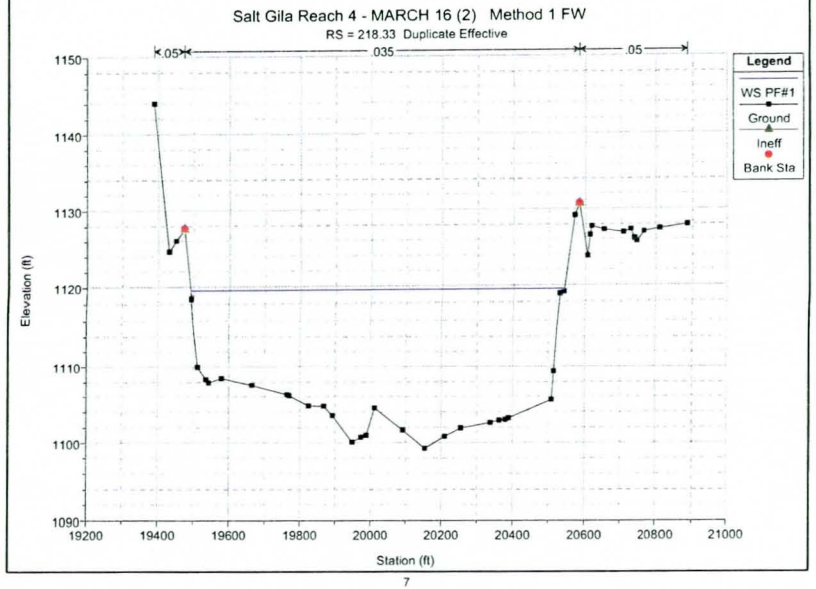
Ineff
Bank Sta
Elevation (ft)
Station (ft)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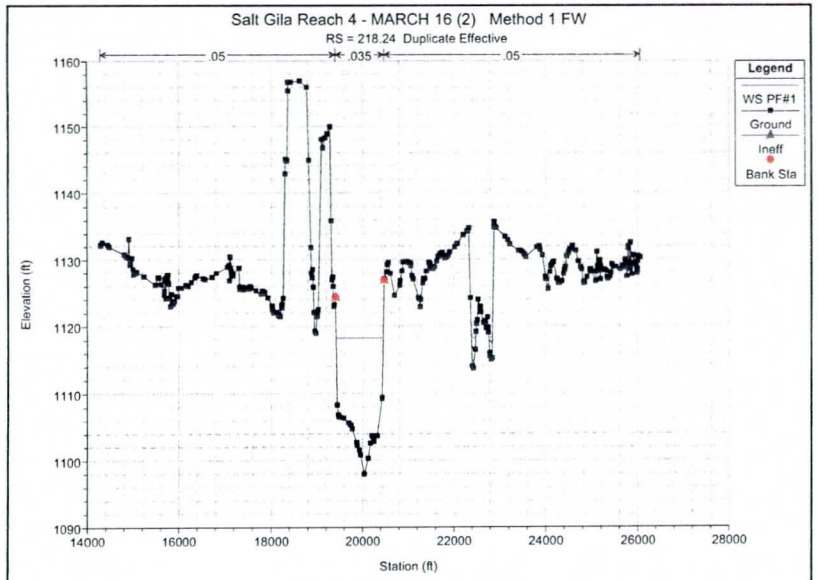
Station (ft)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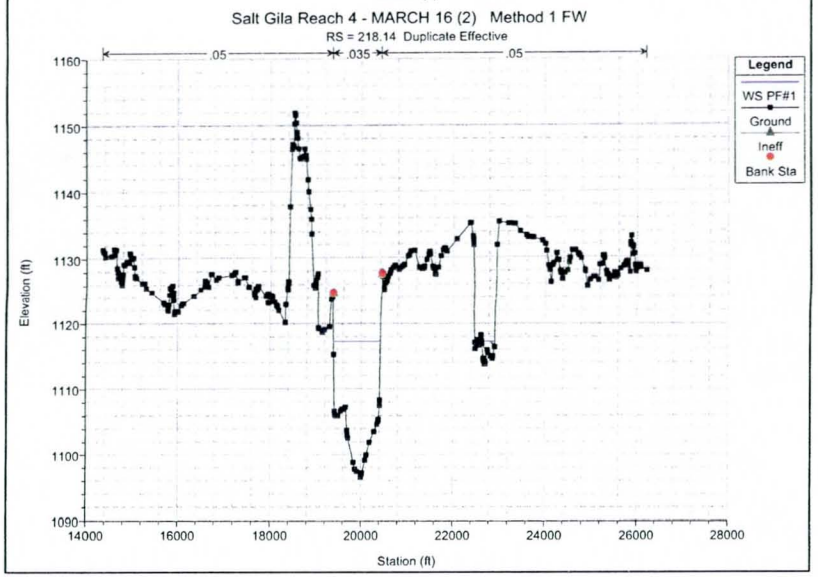
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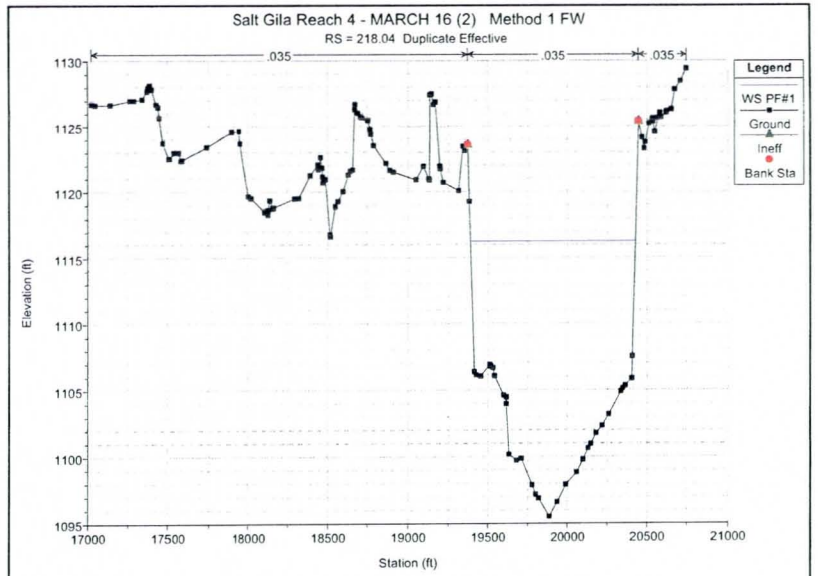
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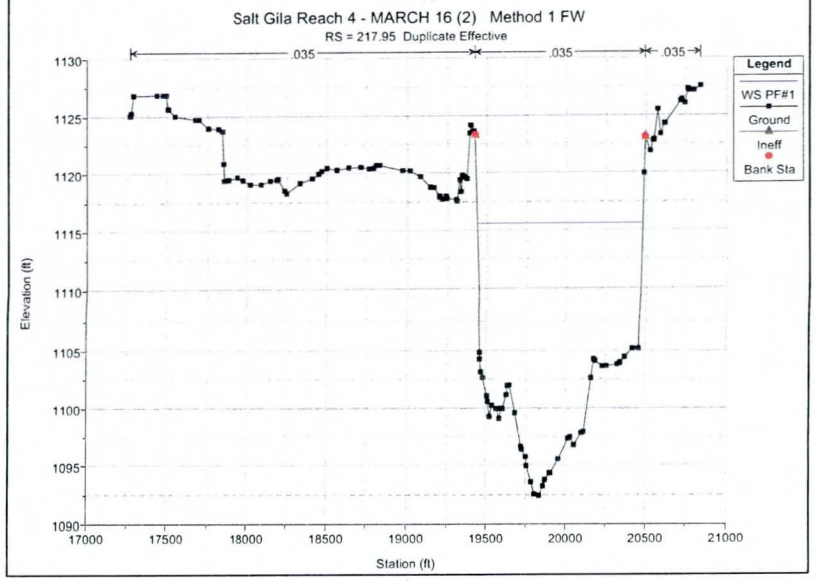
Station (ft)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Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)

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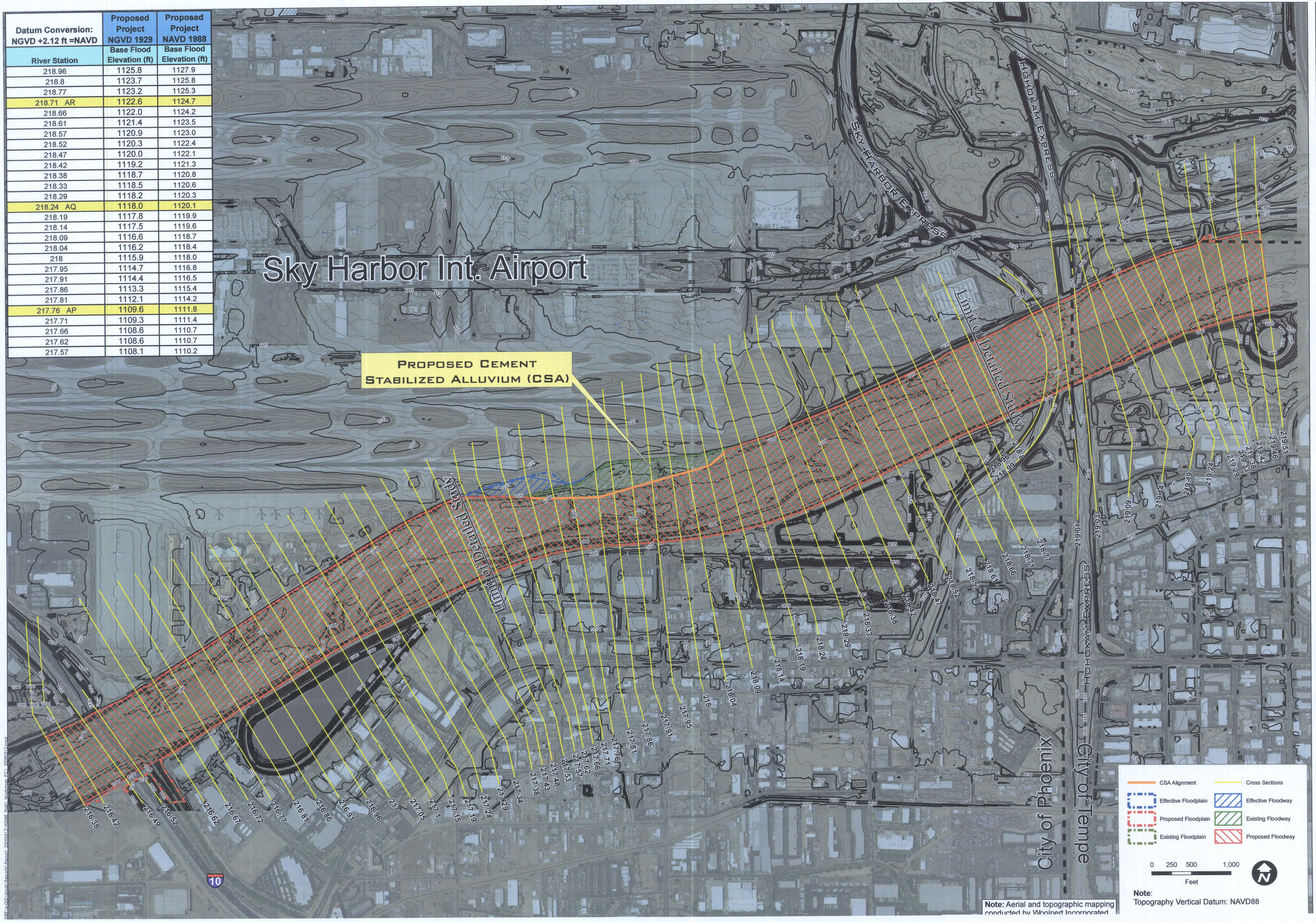
Maps & Exhibits

Appendix C – Topographic Work Map

Datum Conversion: NGVD +2.12 ft =NAVD	Proposed Project NGVD 1929	Proposed Project NAVD 1988
River Station	Base Flood Elevation (ft)	Base Flood Elevation (ft)
218.96	1125.8	1127.9
218.8	1123.7	1125.8
218.77	1123.2	1125.3
218.71 AR	1122.6	1124.7
218.66	1122.0	1124.2
218.61	1121.4	1123.5
218.57	1120.9	1123.0
218.52	1120.3	1122.4
218.47	1120.0	1122.1
218.42	1119.2	1121.3
218.38	1118.7	1120.8
218.33	1118.5	1120.6
218.29	1118.2	1120.3
218.24 AQ	1118.0	1120.1
218.19	1117.8	1119.9
218.14	1117.5	1119.6
218.09	1116.6	1118.7
218.04	1116.2	1118.4
218	1115.9	1118.0
217.95	1114.7	1116.8
217.91	1114.4	1116.5
217.86	1113.3	1115.4
217.81	1112.1	1114.2
217.76 AP	1109.6	1111.8
217.71	1109.3	1111.4
217.66	1108.6	1110.7
217.62	1108.6	1110.7
217.57	1108.1	1110.2



Note:
Topography Vertical Datum: NAVD88

TITLE
TOPOGRAPHIC WORKMAP

JOB
SKY HARBOR AIRPORT
PHOENIX AZ

SCALE	1" = 500'
DESIGNED	CD
DRAWING	CD
CHECKED	ER
DATE	03/12/09
JOB NO.	9008-E

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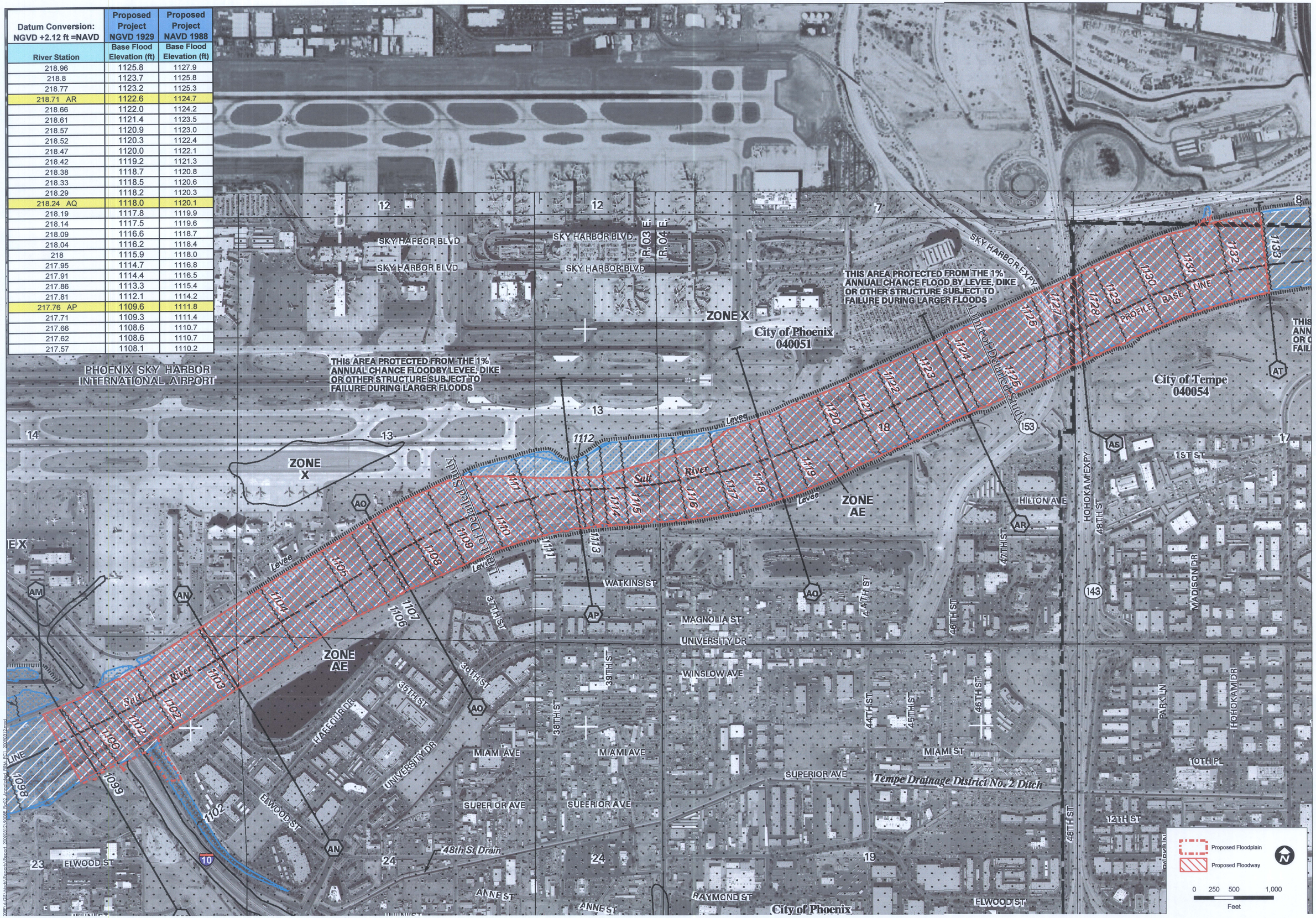
FIGURE
1

Appendix C – Annotated FIRM

Datum Conversion: NGVD +2.12 ft =NAVD	Proposed Project NGVD 1929	Proposed Project NAVD 1988
River Station	Base Flood Elevation (ft)	Base Flood Elevation (ft)
218.96	1125.8	1127.9
218.8	1123.7	1125.8
218.77	1123.2	1125.3
218.71 AR	1122.6	1124.7
218.66	1122.0	1124.2
218.61	1121.4	1123.5
218.57	1120.9	1123.0
218.52	1120.3	1122.4
218.47	1120.0	1122.1
218.42	1119.2	1121.3
218.38	1118.7	1120.8
218.33	1118.5	1120.6
218.29	1118.2	1120.3
218.24 AQ	1118.0	1120.1
218.19	1117.8	1119.9
218.14	1117.5	1119.6
218.09	1116.6	1118.7
218.04	1116.2	1118.4
218	1115.9	1118.0
217.95	1114.7	1116.8
217.91	1114.4	1116.5
217.86	1113.3	1115.4
217.81	1112.1	1114.2
217.76 AP	1109.6	1111.8
217.71	1109.3	1111.4
217.66	1108.6	1110.7
217.62	1108.6	1110.7
217.57	1108.1	1110.2



TITLE

ANNOTATED D-FIRM

AZ

SKY HARBOR AIRPORT

JOB PHOENIX

SCALE	1" = 500'
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DRAWING	CD
CHECKED	ER
DATE	03/23/09
JOB NO.	9009-E

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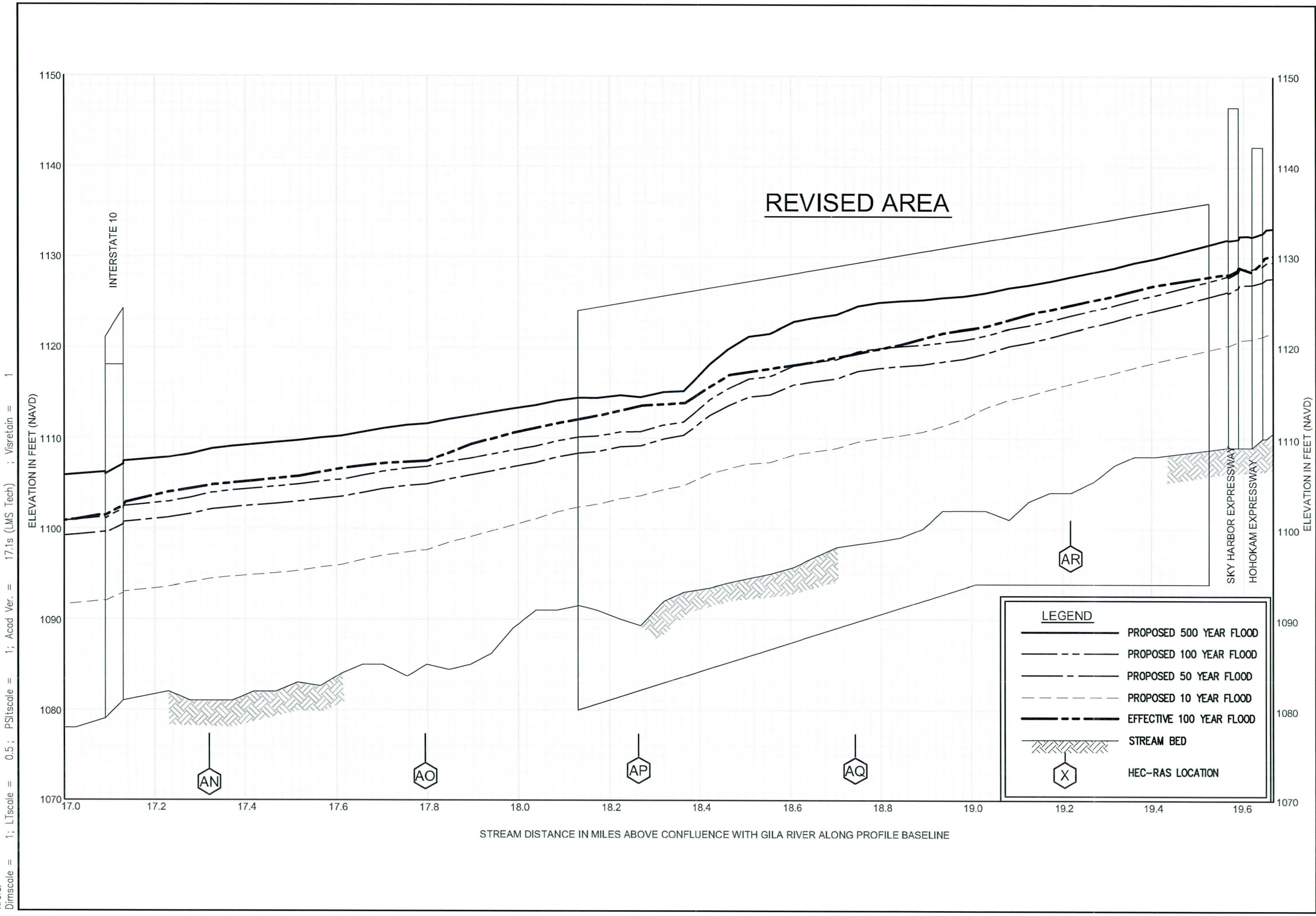
FIGURE 2

Appendix C – Flood Profiles



FLOOD PROFILES

SALT RIVER

PACE
Advanced Water Engineering
17520 Newhope Street, Suite 200 | Fountain Valley, CA 92708
P: (714) 481-7300 | www.pacewater.com

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARICOPA COUNTY, AZ

AND INCORPORATED AREAS

282P-283P

P:\9008E\Engineering\9008E-21 (CLOMR)\taskbase\9008E-Proposed_Profile.dwg

– Tab: Profile1 – by dpinkus on 03/25/09 at 1:18:21 PM

Xrefs:
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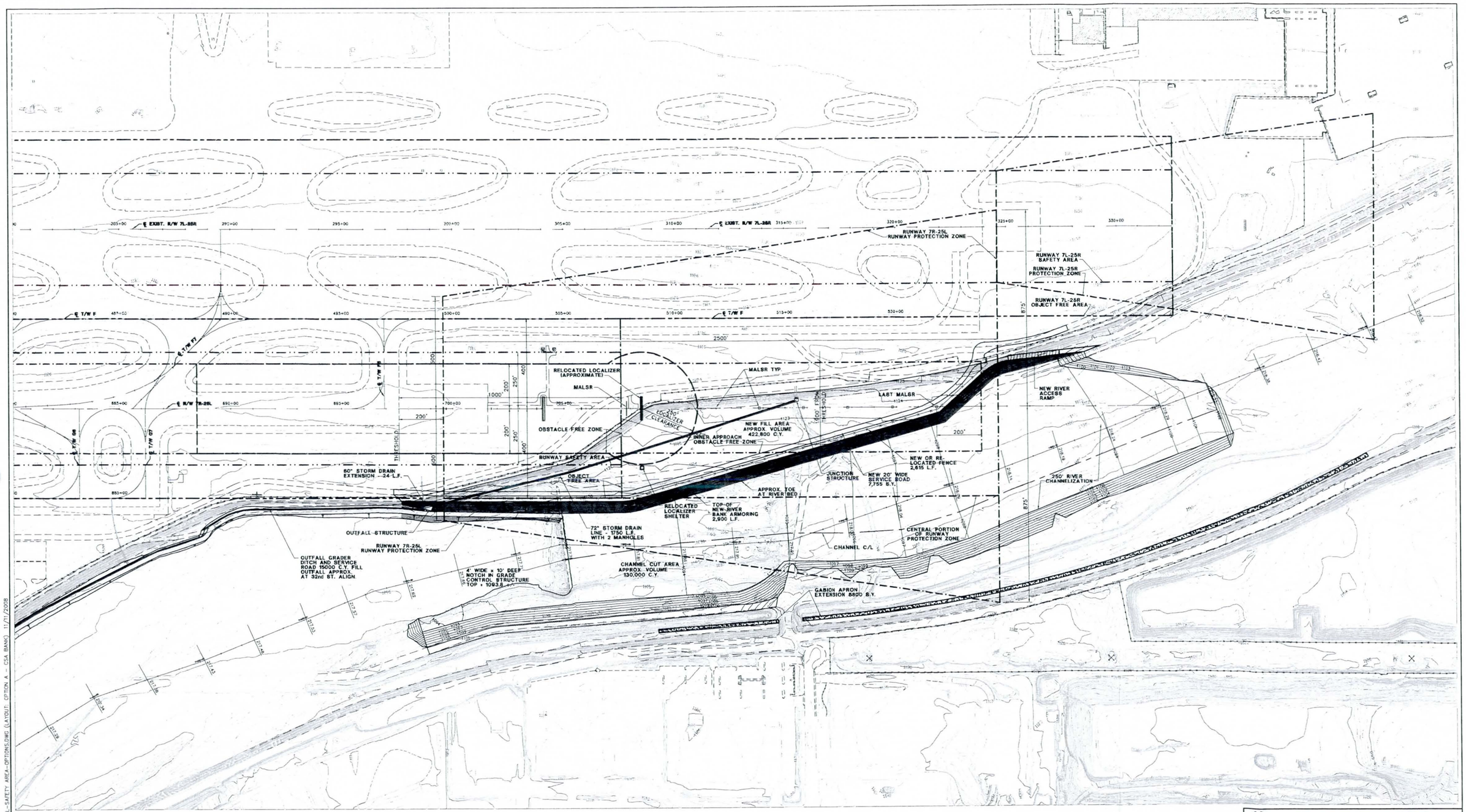
Appendix C – Proposed Channel Plans



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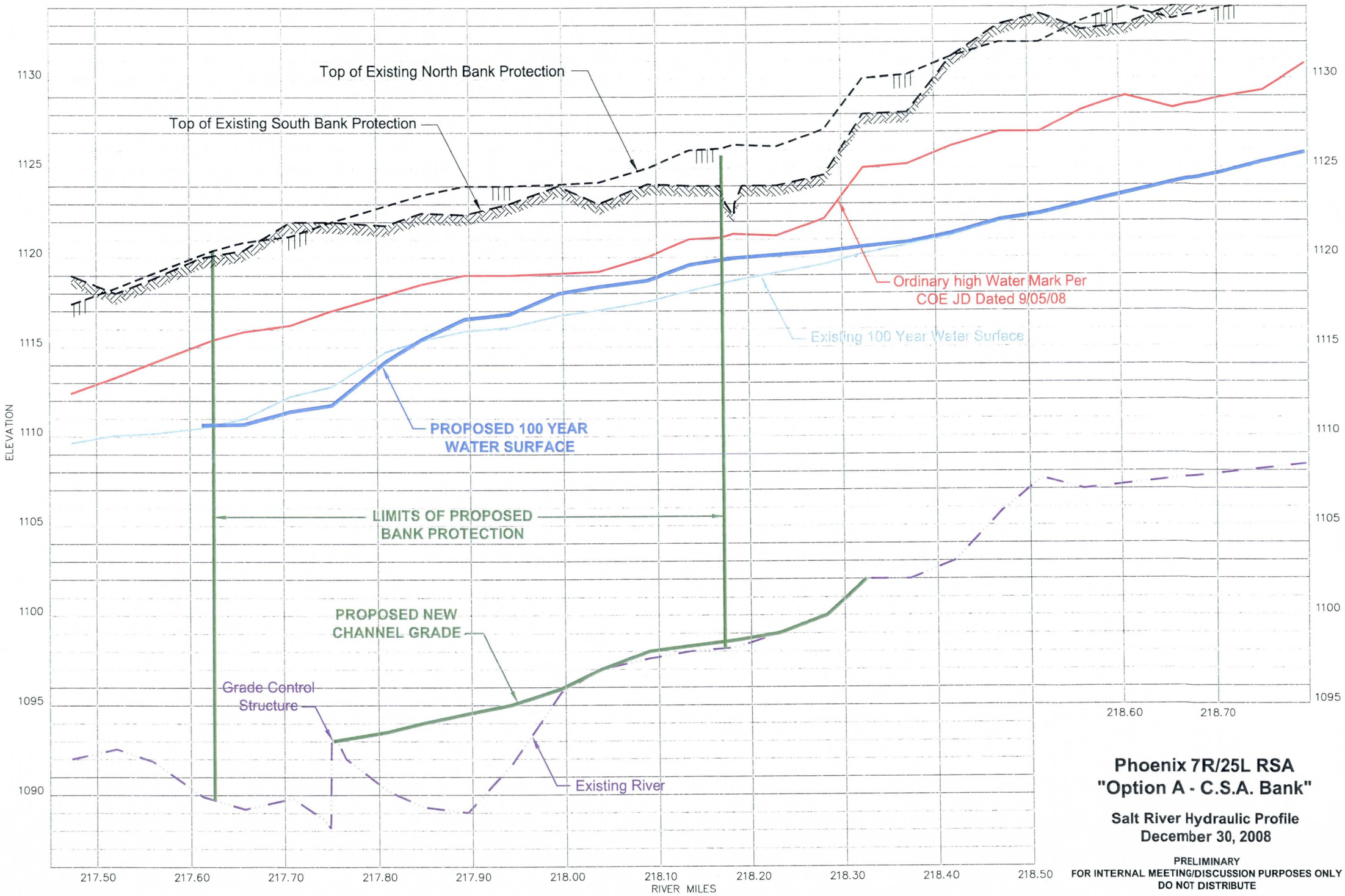
HUITT-ZOLLARS
Huitt-Zollars, Inc. Phoenix
426 North 44th Street, Suite 300
Phoenix, Arizona 85008-6596
Phone (602) 952-9123 Fax (602) 952-9124

CITY OF PHOENIX, ARIZONA
AVIATION DEPARTMENT ENGINEERING SECTION

PHOENIX SKY HARBOR INTERNATIONAL AIRPORT
RW 25L SAFETY AREA IMPROVEMENTS

FULL STANDARDS COMPLIANCE
OPTION A – C.S.A. BANK

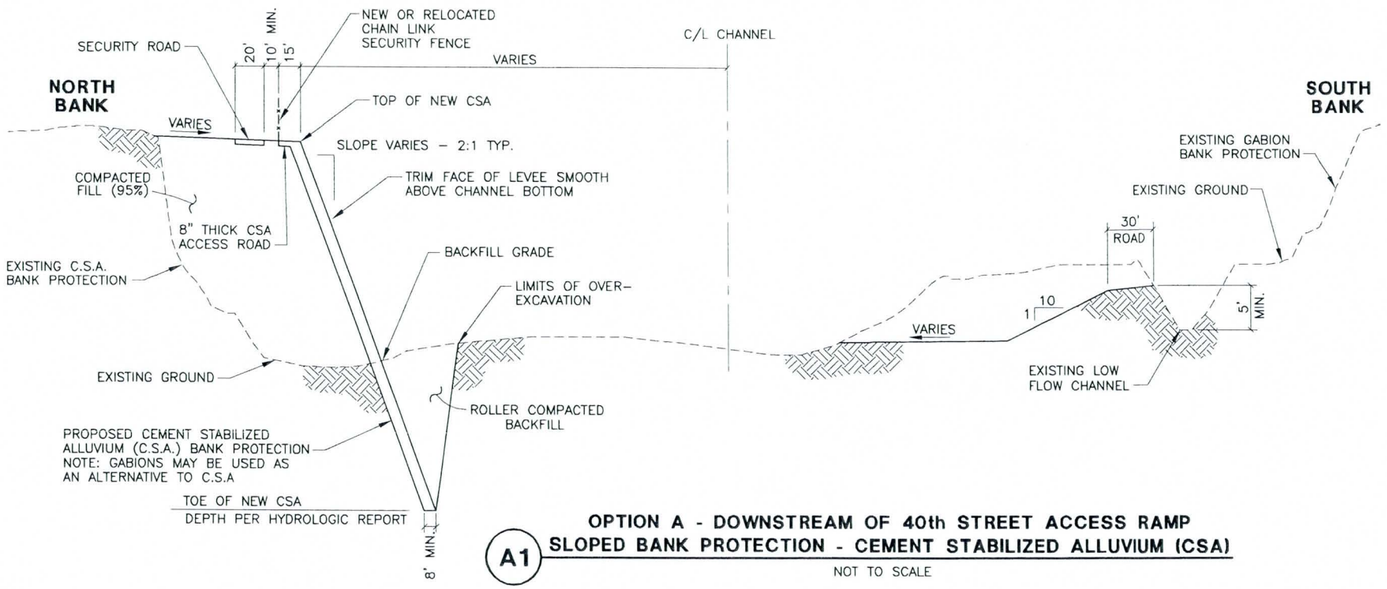
DR	DES	CHK	DRAWING NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
DATE 06/08	DATE 06/08	DATE 06/08				
A.I.P. NO. INDEX NO.				1	4	



Phoenix 7R/25L RSA
"Option A - C.S.A. Bank"

Salt River Hydraulic Profile
December 30, 2008

PRELIMINARY
FOR INTERNAL MEETING/DISCUSSION PURPOSES ONLY
DO NOT DISTRIBUTE



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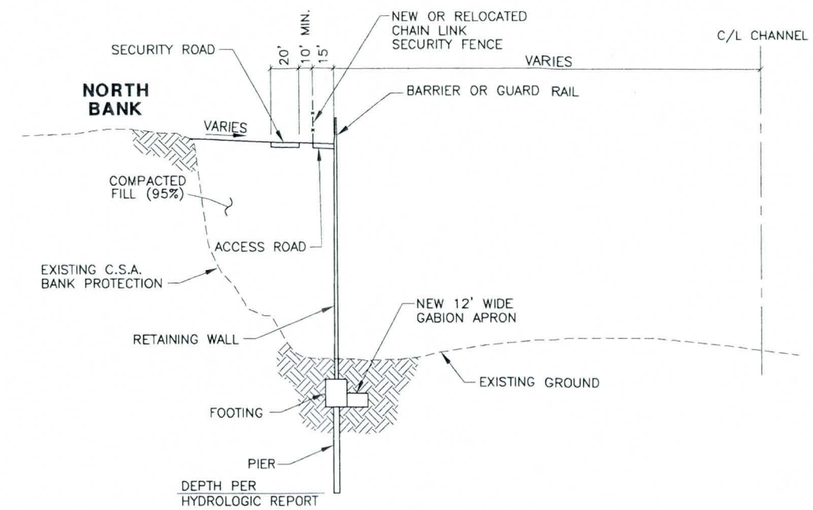
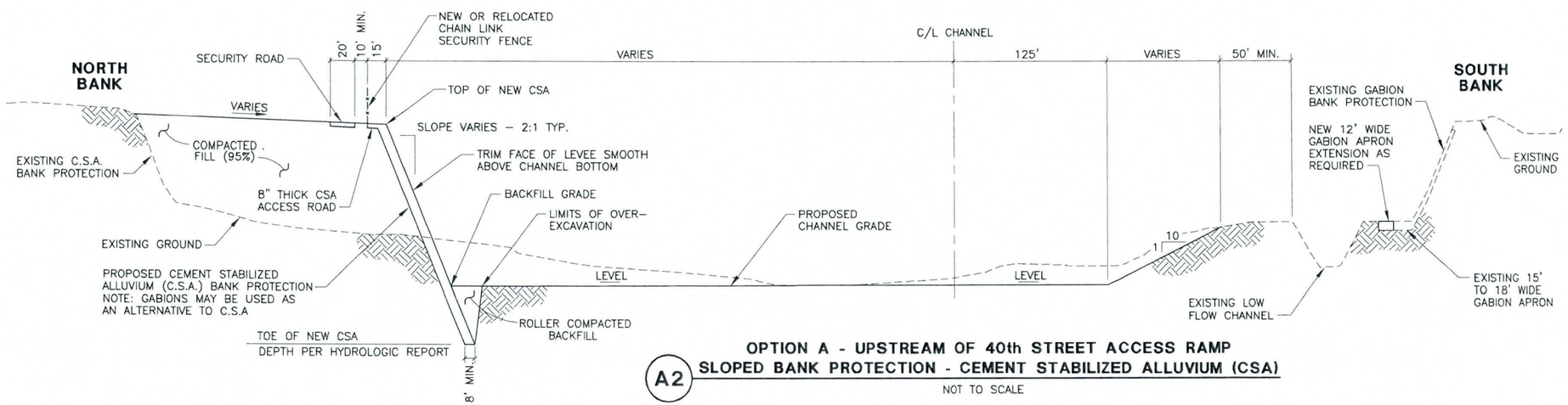
SLOPED BANK PROTECTION - CEMENT STABILIZED ALLUVIUM (CSA)
NOT TO SCALE



B OPTION B
VERTICAL BANK PROTECTION - RETAINING WALL
NOT TO SCALE



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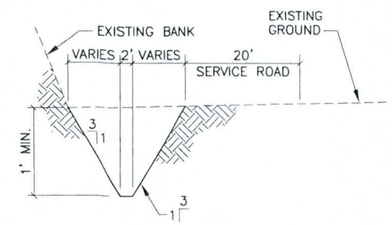

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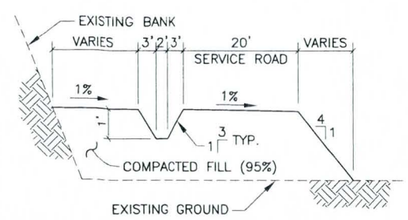
NOT TO SCALE



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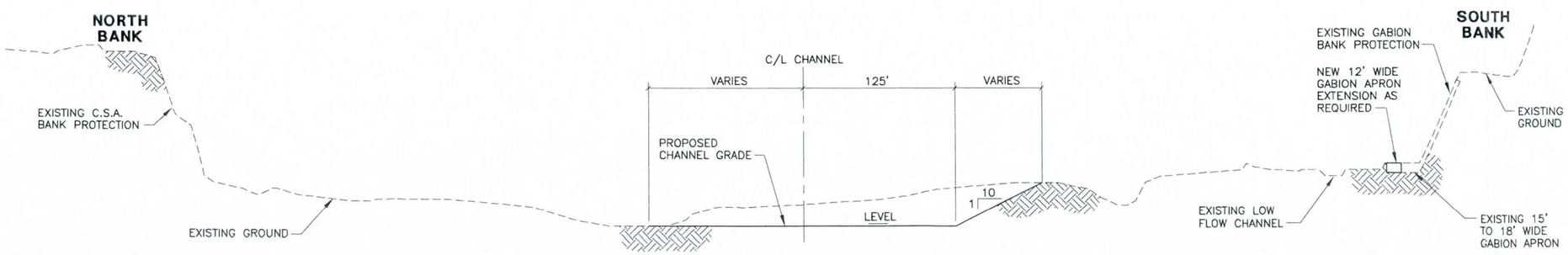

A3 OPTION A - UPSTREAM OF NEW NORTH BANK PROTECTION
SLOPED BANK PROTECTION - CEMENT STABILIZED ALLUVIUM (CSA)
NOT TO SCALE

HUITT-ZOLLARS
Huitt-Zollars, Inc. Phoenix
426 North 44th Street, Suite 300
Phoenix, Arizona 85008-6596
Phone (602) 952-9123 Fax (602) 952-9124

CITY OF PHOENIX, ARIZONA
AVIATION DEPARTMENT ENGINEERING SECTION

PHOENIX SKY HARBOR INTERNATIONAL AIRPORT
RW 25L SAFETY AREA IMPROVEMENTS

RIVER BANK PROTECTION OPTIONS
OPTIONS A AND B

DR	DES	CHK	DRAWING NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
DATE 10/08	DATE 10/08	DATE 10/08				
A.I.P. NO. INDEX NO.				1	1	

G:\PROJ\D51141107\DRAWINGS\PRELIMINARY\RW-25L-SAFETY AREA-SECTIONS.DWG (LAYOUT 3-NEW-SECTIONS) 11/12/2008

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Advanced Water Engineering

Requirements for 65.12 of NFIP

Appendix D – Evaluation of Alternatives

Draft 404(b)(1) Alternatives Analysis

FOR

Runway Safety Area Improvements
City of Phoenix Project Number: AV08000048

Prepared for:

City of Phoenix Aviation Department
Planning and Environmental Division
3400 East Sky Harbor Boulevard
Phoenix, Arizona 85034-4405

Prepared by:

AZTEC
4561 East McDowell Road
Phoenix, Arizona 85008
AZTEC Project Number: AZE0719-01

March 17, 2009

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1. Project Location

The project is located at the southern edge of Phoenix Sky Harbor International Airport (PHX) in Maricopa County, Arizona, along the Salt River between approximately Interstate 10 and State Route 143 (Figures 1 and 2) in Township 1 North, Range 3 East, portions of Sections 13, 14, 23, and 24; and Township 1 North, Range 4 East, portions of Sections 17 and 18 (Gila and Salt River Baseline and Meridian). The project would occur entirely on City of Phoenix property within and adjacent to the Salt River.

2. Proposed Project

The City of Phoenix Aviation Department is proposing to improve the Runway Safety Area (RSA) and Runway Object Free Area (ROFA) for Runway 7R-25L at PHX. The Federal Aviation Administration (FAA) describes an RSA as "A defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot overshoot, or excursion from the runway." Runway 7R-25L is the southern-most runway at PHX and the eastern end of the runway abuts the northern bank of the Salt River. Figure 3 illustrates existing conditions in the project area. The proposed improvements include:

- Extending the current north embankment into the Salt River to provide a standard RSA.
- Extending the current north embankment beyond the RSA and ROFA to support the navigational approach lighting system and perimeter fence.
- Relocating the perimeter fence, localizer antennae, and localizer shelter outside of the RSA and ROFA.
- Relocating the service road outside of the RSA.

3. Purpose and Need

PHX is an air carrier airport owned and operated by the City of Phoenix. The airport serves 23 domestic and international airlines. In 2008, over 520,000 operations were conducted and approximately 40 million passengers were served at PHX. As a result of providing facilities for this type of air carrier operations, PHX must comply with Public Law 109-115 and be certificated by the FAA. Both the law and the certification require that RSAs in accordance with FAA AC 150/5300 be provided. The existing RSA beyond Runway 25L does not meet the RSA grading or clearance requirements due to the location of the localizer, service roads, perimeter fence, and the Salt River.

While not required by certification or law, FAA airport design standards also include object clearing requirements for the ROFA. For aircraft operational safety purposes, objects which are higher than the edge of the RSA should be located outside the ROFA. The existing perimeter fence and localizer shelter are located within the ROFA beyond Runway 25L and therefore the clearance requirements are not met.

In addition, it is preferable from a security standpoint to have all airport facilities located within the perimeter fence, though this is not required by law. A portion of the existing approach lighting system for Runway 25L is on stilts located in the Salt River outside the airport perimeter fence. In order to improve security, the approach lighting system should be located within the airport perimeter fence.

Therefore, the proposed project is needed in order to:

- Comply with federal law.
- Enhance safety.
- Improve security.

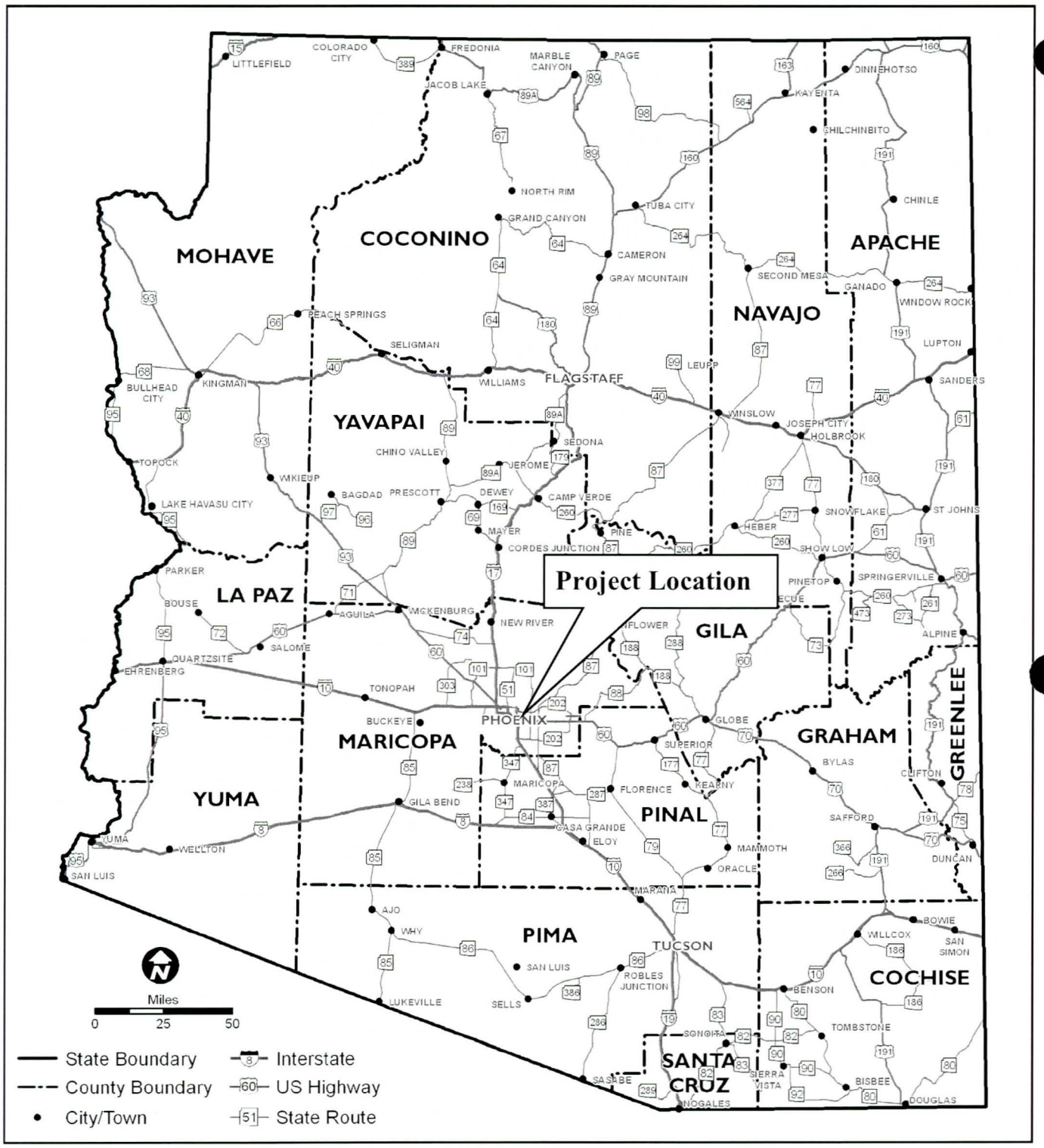
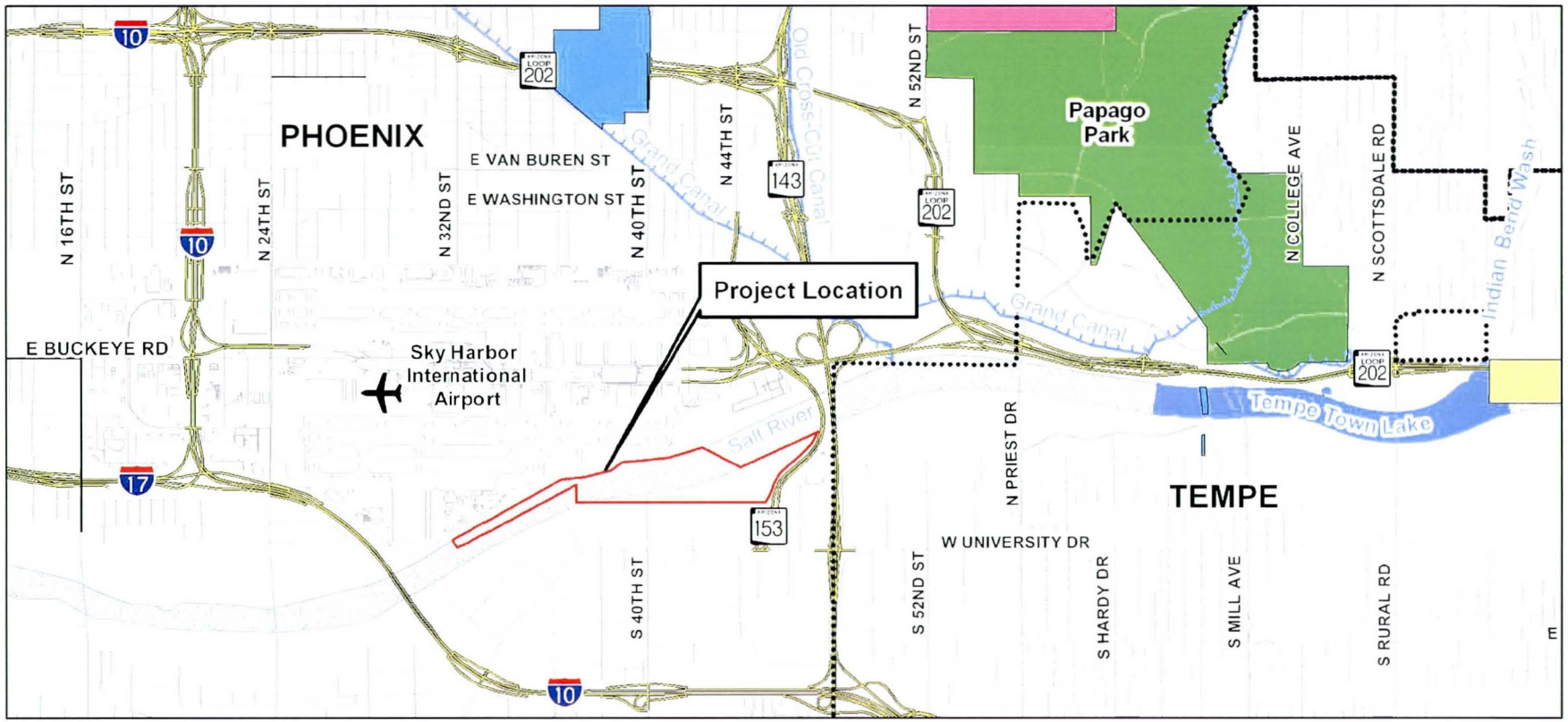


Figure 1. State Location Map



Source: Arizona Department of Transportation Arizona Transportation Information System Data 2007 and Arizona Land Resource Information System 2008

Project Location
AZ State Land Department
Private/Other Non-Federal Land
US Bureau of Land Management
US Department of Defense
City of Phoenix Papago Park
City Boundaries
Canal

Miles
0 0.5 1

Figure 2. Project Vicinity Map

Sources: ESRI Imagery (Aerial Photograph Date: May 15, 2007)

Feet
0 300 600

Figure 3. Existing Conditions Map

The purpose of the proposed project is to:

- Comply with Federal law by providing a standard RSA or equivalent for Runway 25L.
- Enhance safety by providing a ROFA that is clear of fixed objects for Runway 25L.
- Improve security by locating the Runway 25L approach lighting system within the airport perimeter fence.

Due to the proximity of the Salt River, the proposed project would involve work within waters of the US (WUS) as regulated by the US Army Corps of Engineers (Corps) under Section 404 of the Clean Water Act.

4. Relevant Corps Regulatory Actions in the Project Area

A jurisdictional delineation (JD) of the Salt River in the project area was approved by the Corps on October 13, 1999, and extended for five additional years on September 05, 2008 (Corps File Number: SPL-2000-000240-SDM). In addition, the City of Phoenix currently holds an Individual Section 404 permit (Corps File Number SPL-2000-00669) to eliminate bird habitat in the Salt River near PHX to reduce the potential for bird-strikes with aircraft. Permitted activities include continuous removal of vegetation (including wetland vegetation) and making minor alterations to the river channel in order to eliminate standing water.

5. Location Description

The project is located in an urbanized commercial/light industrial area. The Salt River near PHX is channelized with cement stabilized alluvium (CSA) banks, and the channel substrate consists of alluvium such as river cobble mixed with mud and sand (refer to Figure 3). The soils are classified as sandy, mixed, hyperthermic Torrifluvents. These soils are deep, excessively well-drained, are formed within the stratified stream alluvium, and are typically found in the floodplain (Hendricks 1985 and NRCS 2009).

The Salt River in the project area is ephemeral due to upstream dams and groundwater pumping, and only experiences bank to bank flows during precipitation events or upstream dam releases. However, some surface water is typically present in smaller sub-channels that were constructed to reduce standing water in the area, including the "low-flow channel" and two stormwater pipe outfall channels. The low-flow channel conveys lower volume dam releases from Tempe Town Lake, a man-made lake located within the Salt River channel 2.75 miles upstream. The two pipe outfall channels convey water discharged into the river from outfall pipes on the north bank to the low-flow channel near the south bank. Occasional pooling also occurs from these water sources collecting in scour holes.

The project area is located within the Lower Colorado River Valley subdivision of the Sonoran Desertscrub Biotic Community (Turner and Brown 1994), though little native vegetation is present aside from small patches of wetland vegetation in the Salt River channel. However, due to the existing City of Phoenix permit to continually remove wetland vegetation in the Salt River near PHX, wetlands are considered absent for purposes of Section 404 permitting for the RSA project.

6. Alternatives Comparison

Three alternatives, including the no action alternative and two action alternatives, were evaluated to determine the most practicable alternative that is least damaging to WUS. A practicable alternative as defined by the Corps is an alternative that is capable of being implemented after taking into consideration the cost, available technology, and logistics in light of the overall project purpose. The two action alternatives evaluated were Alternative A – Sloped Bank, and Alternative B – Vertical Bank. Both action alternatives would include the following work:

- Extending the current north embankment into the Salt River by placing fill material into the river to provide the RSA.
- Realigning the existing service road on the north bank of the Salt River to the perimeter of the new embankment.
- Constructing a new river access ramp at the eastern end of the new embankment to replace the existing river access ramp obliterated by the new embankment.
- Relocating the existing chain-link perimeter fence to the perimeter of the new embankment by installing new fencing or recycling the existing fencing.
- Relocating the localizer and localizer shelter.
- Extending two outfall pipes on the north bank to accommodate the new embankment width and installing new outfall structures at the ends of the extended pipes.
- Constructing an outfall ditch to channelize drainage from the two extended outfall pipes to the low-flow channel downstream of the RSA.
- Constructing a service road adjacent to the outfall ditch.
- Utilizing a primitive dirt road across the Salt River channel as a haul route for fill material and for general construction access
- Installing temporary culverts and fill material along the access road as necessary to maintain access.

The primary difference between the two action alternatives is that the southern edge of the new embankment for Alternative A would be sloped and protected with CSA, whereas the southern edge of the new embankment for Alternative B would consist of a vertical concrete retaining wall. Table 1 summarizes the estimated impacts to WUS and approximate costs for each of the alternatives. The differences between the alternatives are described in more detail below.

Table 1. Summary of Cost and Impact to Waters of the US for Each Alternative

Alternative	Approximate Cost	Permanent Impacts to Waters of the US (Acres)	Temporary Impacts to Waters of the US (Acres)	Total Impacts to Waters of the US (Acres)
No Action	$0.00	0.00	0.00	0.00
Alternative A – Sloped Bank	$9,263,319.00	54.45	38.86	93.31
Alternative B – Vertical Bank	$21,482,931.50	19.41	14.79	34.20

No Action Alternative

Under the No Action Alternative, no activities requiring authorization from the Corps under Section 404 of the Clean Water Act would occur (Appendix, Figure 4). The RSA and associated improvements would not be constructed under the No Action Alternative. Runway 7R-25L would continue to fall short of FAA standards and the safety of aircraft operations at the runway would continue to be compromised. Therefore, the No Action Alternative does not meet the overall project purpose and need.

No Action Alternative approximate cost: $0
Permanent impacts to WUS: 0.00 acres
Temporary impacts to WUS: 0.00 acres
Total impacts to WUS: 0.00 acres

Alternative A – Sloped Bank Alternative

The Sloped Bank alternative meets the project purpose and need. Under this alternative, a 16.60-acre embankment with sloping CSA bank protection would be constructed (Appendix, Figure 5). Other work specific to this alternative includes:

- Excavating native material from approximately 32.49 acres of the Salt River channel adjacent to the new embankment.
- Cutting a 4-foot-wide by 10-foot notch in the existing grade control structure at the downstream end of the channel excavation area.
- Laterally extending the toe of existing gabion apron along 3,100 linear feet of the south river bank.

Approximately 437,600 cubic yards (CY) of clean fill material from the Aviation Soil Stockpile (located on the south bank) would be discharged along the north bank of the river to construct the embankment, along with an estimated 130,000 CY of material excavated from the Salt River channel adjacent to the new embankment. Excavation of the river channel is necessary for this alternative in order to offset the loss of river hydraulic capacity created by encroachment of the new embankment into the river channel, and will also serve the secondary function of reducing pooling in the area that attracts birds. The notch cut in the existing grade control structure at the downstream end of the channel excavation area will also alleviate pooling in the area. Due to an increase in channel velocity expected to result from implementation of this alternative, the toe of existing gabion apron on the south bank must be extended to protect the south bank from undercutting during flood events.

Material would be excavated from the Aviation Soil Stockpile and the Salt River with conventional heavy equipment such as crawler excavators, gradall excavators, and backhoes. Once material is excavated it will be hauled and discharged into the RSA footprint. Boulders and large rocks from the excavated area will likely be temporarily stockpiled for potential use as riprap at drainage outfalls. Vibratory compactors would periodically compact the fill material in the RSA footprint for stabilization purposes.

Approximately 36,300 CY of additional clean fill from the Aviation Soil Stockpile would be mixed with cement and water to form the CSA, which would then be discharged on the RSA embankment slope as an 8-foot-thick layer of bank protection. Approximately 56,700 CY of river materials would be excavated at the new embankment toe-of-slope in order to extend the CSA bank protection below the channel bottom to protect the embankment from undercutting during flood events. This material would be temporarily side cast along the length of the new embankment, and once the below grade CSA has cured, the material would be backfilled and compacted in its original location.

The gabion apron extensions on the south bank would be approximately 12 feet wide and would be constructed using approximately 2,755 CY of native river rock, along with heavy wire mesh "boxes" and tie wire. Native material adjacent to the existing gabions would be excavated with a backhoe and temporarily side cast along the length of the gabions, then backfilled over the apron extensions once they are installed.

Alternative A – Sloped Bank approximate cost: $9,263,319.00
Permanent impacts to WUS: 54.45 acres
Temporary impacts to WUS: 38.86 acres
Total impacts to WUS: 93.31 acres

Alternative B – Vertical Bank Alternative

The Vertical Bank Alternative meets the project purpose and need. Under this alternative, a 12.35-acre embankment with a vertical concrete retaining wall would be constructed (Appendix, Figure 6). Because the embankment footprint for this alternative is smaller than that of the Sloped Bank Alternative, impacts to river hydraulic capacity resulting from the Vertical Bank Alternative are not substantial enough to require channel excavation (other than that necessary for construction of the retaining wall). In addition, no grade control structure notching or south bank gabion apron extension is required for the Vertical Bank Alternative.

Approximately 368,600 CY of clean fill material from the Aviation Soil Stockpile would be discharged along the north bank of the river to construct the new embankment under the Vertical Bank Alternative. Approximately 43,400 cubic yards of native materials would be excavated at the base of the retaining wall, to construct piers, footings, and gabion aprons below the existing grade. The excavated material would be backfilled over the footings. To construct the retaining wall, a total of 4,100,000 pounds of reinforced steel would be installed to form the retaining wall frame. A crane would lower and secure the steel frame in place. The steel frame would be temporarily encased, and approximately 15,300 cubic yards of concrete would be discharged over the enclosed steel frame.

Alternative B approximate cost: $21,482,931.50
Permanent impacts to WUS: 19.41 acres
Temporary impacts to WUS: 14.79 acres
Total impacts to WUS: 34.20 acres

7. Conclusion

The No Action Alternative is not practicable because it does not meet the purpose and need of the project. Both the Sloped Bank Alternative and the Vertical Bank Alternative meet the project purpose and need. Because the Sloped Bank Alternative requires a sloping bank, channel excavation, and extension of gabion aprons along the south bank of the river, the footprint is larger for the Sloped Bank Alternative. Although the Vertical Bank Alternative would impact 59.11 acres less WUS than the Sloped Bank Alternative, the Vertical Bank Alternative would cost approximately $12,219,612.50 more than the Sloped Bank Alternative. Therefore, Alternative A - Sloped Bank is the more practicable alternative.

8. References

Hendricks, D. M. 1985. Arizona Soils. A Centennial Publication of the College of Agriculture, University of Arizona, Tucson, Arizona.

Natural Resources Conservation Service. 2009. Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx).

Turner, R. M. and D. E. Brown. 1994. "Sonoran Desertscrub" in *Biotic Communities: Southwestern United States and Northwestern Mexico* (edited by D. E. Brown). University of Utah Press, Salt Lake City, Nevada. Section 154.1, pp. 181–192.

9. Signatures

Prepared By: Amanda Gagnon Date: March 17, 2009

Amanda Gagnon
Environmental Planner/Biologist
AZTEC

Michael J Myers Date: March 17, 2009

Mike Myers
Senior Biologist
AZTEC

APPENDIX

Alternative Impacts to Waters of the US

DRAFT

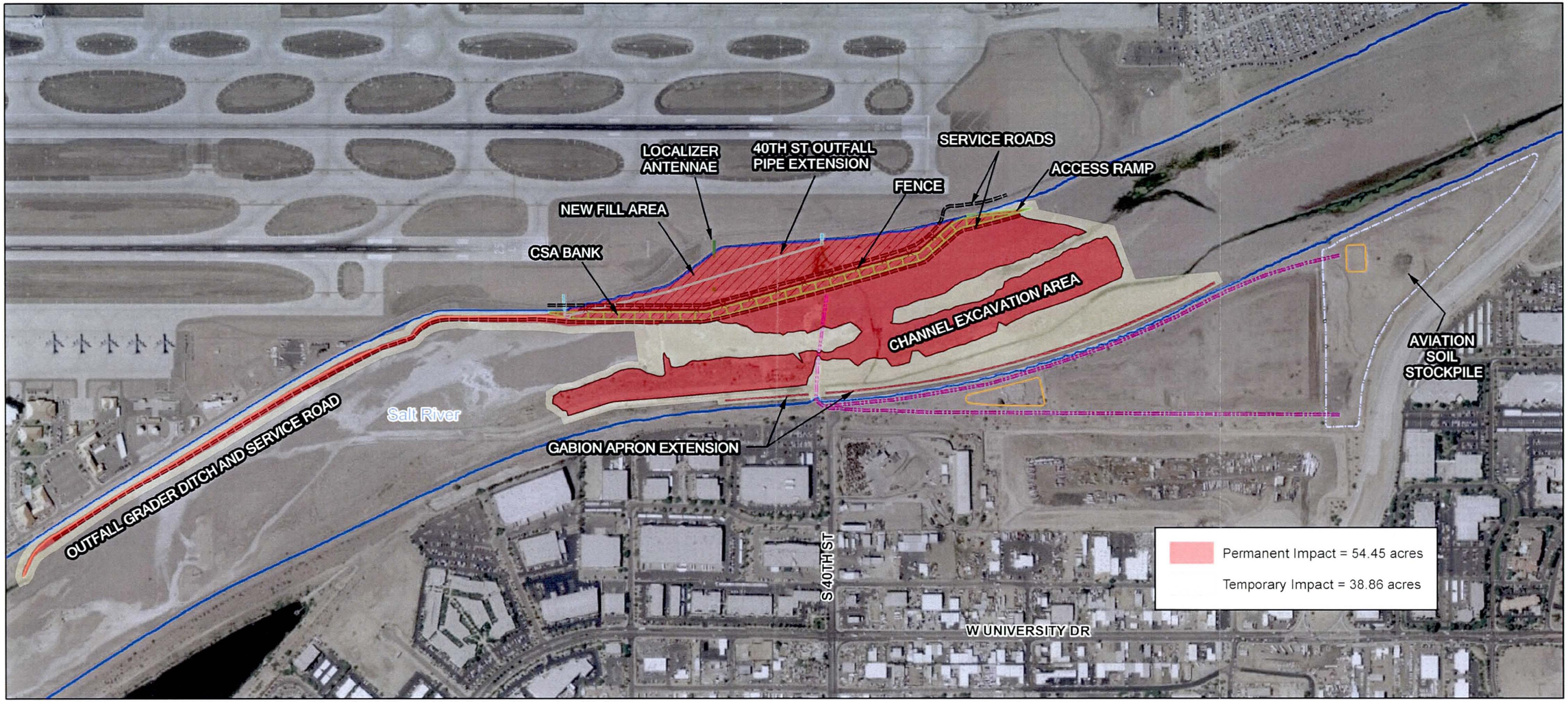
Sources: ESRI Imagery (Aerial Photograph Date: May 15, 2007)

Ordinary High Water Mark

NO IMPACTS TO WATERS OF THE US

Feet
0 300 600

Figure 4. No Action Alternative - No Impacts to Waters of the US

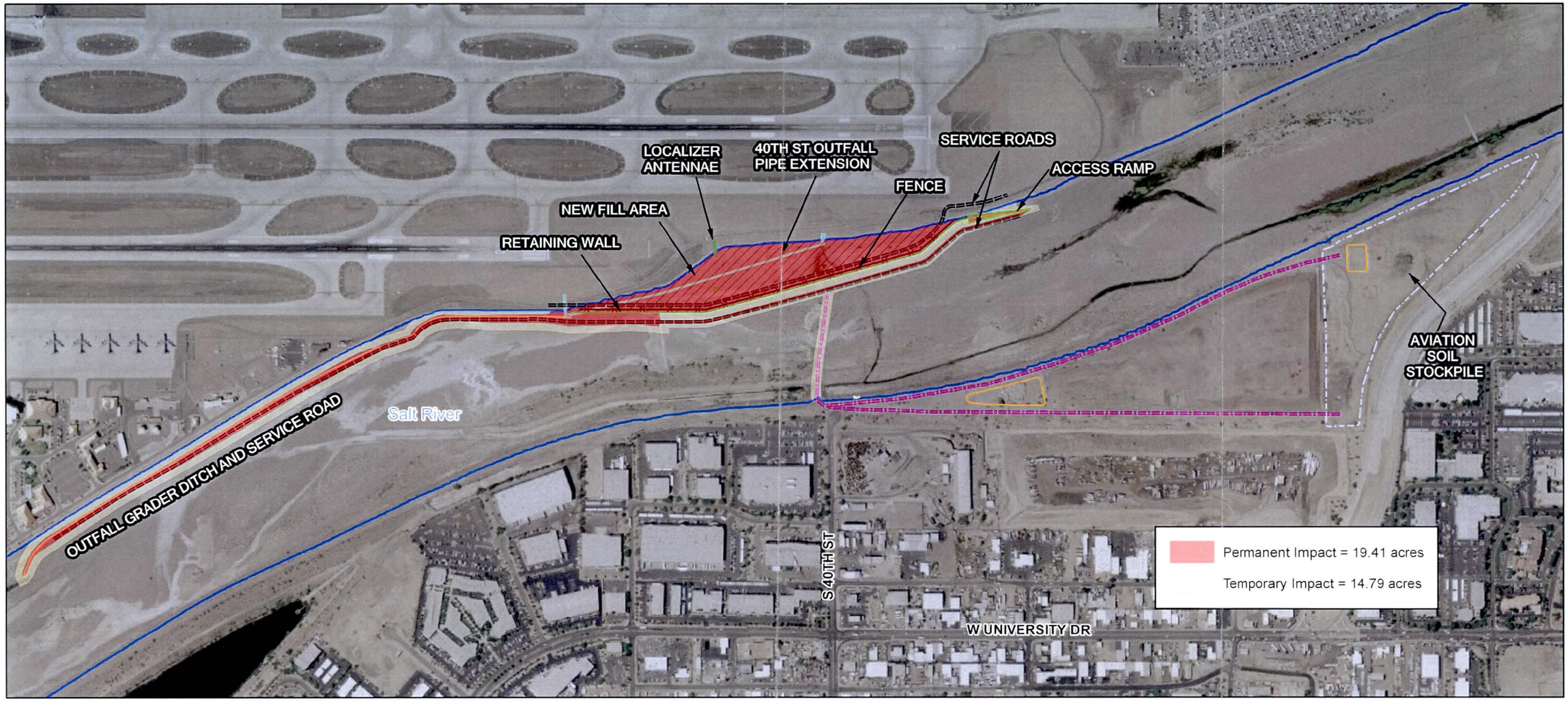


Sources: ESRI Imagery (Aerial Photograph Date: May 15, 2007) and Huitt-Zollars November 25, 2008

Ordinary High Water Mark
New Fill Area
CSA Bank
Channel Excavation
Service Road
Fence
Localizer
Pipe Extension
Outfall Grader Ditch
Haul Route
Aviation Soil Stockpile
Staging/Stockpiling Area

Feet
0 300 600

Figure 5. Alternative A – Sloped Bank Impacts to Waters of the US



Sources: ESRI Imagery (Aerial Photograph Date: May 15, 2007) and Huitt-Zollars November 25, 2008

Ordinary High Water Mark — Retaining Wall — Fence — Pipe Extension — Haul Route — Staging/Stockpiling Area

New Fill Area — Service Road — Localizer — Outfall Grader Ditch — Aviation Soil Stockpile

Feet
0 300 600

Figure 6. Alternative B – Vertical Bank Impacts to Waters of the US

Appendix D – Legal Notice & Concurrence

PACE
Advanced Water Engineering

March 17, 2009

Aviation Department
3400 East Sky Harbor Boulevard
Phoenix, AZ 85034

Re: Notification of Increases in 1% (100-year) Annual Chance Water-Surface Elevations #9008E

The Flood Insurance Rate Map (FIRM) for a community depicts land that has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to determine flood insurance rates and to help the community with floodplain management.

The City of Phoenix (City) is aware that Pacific Advanced Civil Engineering, Inc. (PACE) is applying for a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (DHS-FEMA) on behalf of the City of Phoenix to revise FIRM 04013C, Panel #2165H and Panel #2145H for Phoenix, Arizona along the Salt River. The City is proposing to construct Cement Stabilized Alluvium (CSA) bank protection as part of runway expansion at Sky Harbor International Airport.

The City is aware the proposed project will result in increases and decreases in the 1% annual chance water surface elevations for the Salt River with a maximum increase of 1.4 feet at a point approximately less than 1-mile downstream of Sky Harbor Expressway and a maximum decrease in the 1% annual chance water surface elevation of one foot at a point approximately over one mile downstream of Sky Harbor Expressway.

This letter is to inform you of the proposed increases in the 1% annual chance water surface elevations within the Salt River adjacent to your property at Sky Harbor International Airport

Sincerely,

Dennis L. Richards

Dennis L. Richards, PE, D.WRE
Vice President, Stormwater Management

P:\9008E\5-Administrative\Reports\CLOMR\Notification.doc

426 N. 44th Street, Suite 120 | Phoenix, AZ 85008
P: (602) 275-8066 F: (602) 393-3026 | www.pacewater.com

Appendix D – Certification: No Structure Impact

PACE
Advanced Water Engineering

March 17, 2009

Federal Emergency Management Agency
3601 Eisenhower Ave.
Alexandria, VA 22304-6425

Re: Sky Harbor Conditional Letter of Map Revision
National Flood Insurance Program Section 65.12 **#9008E**

Pacific Advanced Civil Engineering, Inc. (PACE) and the City of Phoenix (City) are aware that the cement stabilized alluvium bank protection for the Sky Harbor International Airport Runway Safety Area Improvements project causes an increase in Base Flood Elevation (BFEs). This study reach is in a Zone AE (Areas subject to inundation by the 1-percent-annual chance flood event with Base Flood Elevations) as determined by the proposed hydraulic model for this project. The City of Phoenix is the property owner for this reach of Salt River where the base flood elevation increases occur. Although the base flood elevations increase, the flood hazards are contained within the river banks. This letter is to confirm that there are no existing insurable structures affected by the increased water surface elevations.

Sincerely,

Dennis L. Richards

Dennis L. Richards, P.E., D.WRE
Vice President, Stormwater Management

Dennis L. Richards

Registered Professional Engineer (Civil)
CERTIFICATE NO.
21560
DENNIS L.
RICHARDS
Date Signed 3/19/09
ARIZONA, U.S.A.

EXPIRES 3/31/2010

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426 N. 44th Street, Suite 120 | Phoenix, AZ 85008
P: (602) 275-8066 F: (602) 393-3026 | www.pacewater.com

PACE
Advanced Water Engineering

Levee Operation & Maintenance Plan

LEVEE OPERATION & MAINTENANCE PLAN

1. Introduction

The levee system along Salt River provides protection to the Phoenix Sky Harbor International Airport from the 1% annual-chance (base flood). The operational and maintenance criteria established in this section must be implemented for the levee system to be recognized by FEMA. The City of Phoenix (City) participates in the National Flood Insurance Plan (NFIP) and has included these items as an addendum to the City's NFIP Operation & Maintenance Plan (O & M Plan).

2. Purpose

The Drainage and Levee O&M Plan is to encourage that all drainage facilities are maintained and kept clear from objects that may impede the flow of storm water runoff and ensure compliance with the criteria as set by FEMA. The policy includes provisions for the periodic inspection of any mechanized portion of the interior drainage associated with the levee system. This would include the flap gate valves on the storm drain outlets into the Salt River.

This policy must document the formal procedures that ensure the stability, height, and overall integrity of the levee system and its associated structures are maintained. The maintenance policy specifies the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance.

3. Inspection and Maintenance

1. The responsible person shall visually inspect each drainage facility annually.

2. The responsible person shall schedule the cleaning as needed but no more than the established service levels stated below, unless it follows a severe storm event. If this storm was determined and allowed to exist could become an obstruction to storm water drainage. Storm inspections will be conducted within twenty-four (24) hours of a severe storm event. A severe storm event is defined as a minimum of one-half (½) inch of rainfall in a twenty-four (24) hour period.

3. The responsibility for this policy is shared between the Aviation and City.

4. The inspections will be recorded on an appropriate **Inspection Log** and any maintenance performed as a result of the inspections will be recorded on the **Maintenance Log**. These logs should be kept on file at each respective flare station or other designated area.

5. The established service levels and responsible parties are presented in the following table.

Facility	Frequency	Responsible Party
Storm Drainage Inlets	Inspect annually and clean as needed	Off-site: On site:
Storm Drainage Outlets	Inspect annually and clean as needed	
Flap Gate Valves	Inspect annually and repair/service as needed	
Dedicated Natural Washes	Inspect annually and clean of debris as needed	
Manmade Drainage Channels	Inspect annually and clean as needed	On-site:
Manmade Detention Basins	Inspect annually and clean as needed	On-site:
The complete levee system	Inspect and document observations annually	
The stability and integrity of the levee and its associated structures	Inspect and document observations annually	

*Includes those components maintained by:

** Oversight of the structures associated with the levee system includes:

(1) the stability of the embankments from deterioration of the supporting earthen embankments,
(2) the stability of the embankments and grade control structure from deterioration of the cement stabilized alluvium requiring an engineering evaluation
(3) the integrity of the levee structures from degradation or aggradation of the river bed to provide the required freeboard
(4) the integrity of the embankments from change in height from landfill settlement

PACE
Advanced Water Engineering

Geotechnical Evaluation

SITE GEOTECHNICAL EVALUATION REPORT

River Protection Work at The Salt River Channel Near Third Runway Extension at SKY HARBOR INTERNATIONAL AIRPORT PHOENIX, ARIZONA

Prepared For:

City of Phoenix Street Transportation Department
1034 East Madison Street
Phoenix, Arizona

Prepared By:

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040
480-921-1368

HA Project Number 09006

March 17, 2009

HOQUE
& ASSOCIATES Consulting Geotechnical, Materials and Environmental Engineers

March 17, 2009

Mr. Chris Shaw
Civil Engineer I, City of Phoenix
Street Transportation Department
1034 East Madison Street
Phoenix, Arizona 85009

Subject: City of Phoenix Project No. AV000048
Site Geotechnical Evaluation Report for CLOMR for the Channel of the Salt River Near Sky Harbor International Airport, Phoenix

Dear Mr. Shaw:

Hoque & Associates, Inc. (HA) has completed a site geotechnical evaluation report for compliance with the Conditional Letter of Map Revision (CLOMR) for the Salt River for Federal Emergency Management Agency (FEMA) at the subject site. The CLOMR will be prepared for the channel of the Salt River as the third or the south runway safety area will be extended east that will impact the active river channel located south the airport. The work was verbally authorized by Mr. Chris Shaw of the city of Phoenix (city). The site geotechnical exploration program completed for this site consisted of excavation of 12 test pits, collection of soil samples, preparation and collection of dimensional measurements of the Salt River south bank scour protection structure at locations, field logging of the test pits, associated laboratory testing, engineering analyses, and preparation of this geotechnical evaluation report.

Based on the results of our field work and laboratory tests, HA believes that the river protection work at the south bank consists of gabion mattress laid at the bank to mimic natural slope of the bank equivalent to 2:1 (horizontal to vertical) and the apron of the gabion mattress extends to the channel bottom to a general length of 12 to 40 feet. The gabion mattress consists of river run cobbles and boulder sized material. The river bed materials within the depth of test pits consist of typical river run alluvium known as SGC, or sand, gravel and cobbles. A detailed description of the gabion mattress and the river sediments and their implication to the river protection works is provided in the body of the report.

HA is available to discuss our recommendations with you during the design stage and development of the specifications. If you require any assistance for this

4325 South 34th Street • Phoenix, Arizona 85040
Tel: 480-921-1368 • Fax: 480-921-0194 • e-mail: support@hoqueandassociates.com

project, or require additional studies or foundation analyses, we would be gratified to be of service.

HA appreciates the opportunity to work on your project. If you have any questions, or if we can be of any further assistance, please contact us at (480) 921-1368.

Sincerely,
Hoque & Associates, Inc.

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO.
20920
ENAMUL
HOQUE
Date Signed 3/17/09
ARIZONA U.S.A.

Enamul Hoque, P.E.
President

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1.0 INTRODUCTION

1.1 General

Hoque & Associates, Inc. (HA) has completed a site geotechnical evaluation program for the evaluation of existing river scour protection work associated with the extension of a third runway at Phoenix Sky Harbor International Airport in Phoenix, Arizona. The proposed site is located directly south of the airport within the active channel of the Salt River. The location of the subject site is illustrated in the Location Map contained in Appendix A.

Mr. Chris Shaw of the city verbally authorized the work. The geotechnical exploration program completed for this project consisted of utilities clearance, excavation of 10 test pits to depths of five to 10 feet below surface grade, collection of soil samples, field logging of the test pits, geotechnical laboratory tests, engineering analyses, and preparation of this geotechnical report.

1.2 Purpose and Scope of Work

The purpose of this geotechnical exploration program was to characterize the site surface and subsurface conditions with regard to the river scour system, and to prepare as-built drawings of the existing river protection work at the south bank of the Salt River. In addition, HA provides geotechnical data to assist in the design and construction of a scour protection system if needed. To fulfill this purpose, HA has completed the following scope of work:

- Review of the project background information provided by Pacific Advanced Civil Engineering, Inc. (PACE);
- Site reconnaissance to document site conditions including geologic and hydrologic conditions that could influence the construction and performance of the proposed development;
- Excavation of 10 test pits extended to depths of five to 10 feet below surface;
- Evaluated the stones placed within the gabion mattresses in south bank along with length, thickness and extent of gabions in the bottom of the channel.
- Laboratory tests, including pebble count, gradation, and fines content;
- Engineering analyses and discussions of laboratory and field data for slope stability and foundation stability for design and construction of bank protection work;
- Engineering analysis of existing scour protection structures and ancillary features; and,
- Preparation of this report.

1.3 Project Background

HA received project information from Mr. Chris Shaw of the city during telephone conversations and PACE Consultants. PACE provided as-built drawings of the project prepared during the early 1980's by HNTB Consultants. HA also had conversations with representatives of Huitt-Zollars, Inc.

Based on the provided information, HA understands that the city is planning to extend the south runway to the east. As such, the existing channel configuration of the adjacent Salt River had to be readjusted to accommodate the runway extension. The safety area of the runway will also be extended. The Salt River Channel immediately south of the extension area will be narrowed and deepened as the north bank protection work consisting of cement stabilized alluvium (CSA) shall be moved south of the existing bank. The deepening and narrowing will be gradual and shall start downstream of the State Route 153 and immediately east of existing south runway (approximately along the alignment of 43rd Street) and shall be extended to the alignment of 37th Street. The existing CSA along the north bank will be extended to the new extension of runway and will merge with the existing CSA east of the proposed alignment. The south bank will remain in place but will be required to be evaluated with new adjustment of the Salt River. The city shall have to prepare a CLOMR and submit to FEMA for approval prior to construction.

HA reviewed the requirements of Riverine Structures that will be included in the rivers and channels controlled by the United States of America. For levees and flood walls, according to the requirements stated in form DHS – FEMA Form 81-89B, Dec 07, complete structural, hydraulics and foundation stability analyses are required. According to the geotechnical issues, the following conditions of stability of the levees/scour protection work shall be included:

- Slope and foundation stability including seepage loading under sudden drawdown and during flood stage including end of construction. A seismic loading shall also be considered;
- Settlement of the levee or structures;
- Foundation stability under lateral load combined with seepage and wave action;
- Liquefaction analysis;
- Stability and uplift of the slope toe and back side of the structures; and
- Stability against other discernable geologic constraints.

The hydrologic design information to be submitted includes river discharge, river stage, sediment transportation rate, scour depth, height of levee, levee slope angle, longitudinal profiles and sections of levee, dimensions and elevations of scour protection device and all hydrologic information after the construction of the levee to evaluate the levee's impact on flood flow. The Salt River at the reach of the proposed modification consists of gabion mattress protection of the north and south banks and plan for future extension of the CSA on the north bank. The south bank gabion mattress protection will be kept as it is if not required to be modified. The gabion mattresses consist of rip rap placed within wire mesh which are being placed at the bank slopes and extended to the channel for protection against undermining of the slope protection system.

2.0 SITE CONDITIONS

2.1 Surface Conditions

A representative from HA visited the site during field exploration test pit operations to monitor test pit operation and collect bulk soil samples. HA also visited the site several times for clearance of underground utilities. During these visits, HA observed and documented existing site conditions. The site reconnaissance included observation of existing site features and structures that may influence the design and construction of the proposed safety area extension. Sketches of the gabion mattresses with thickness, length, and extent of gabions into river channel are provided in section 3.

At the time of HA's geotechnical exploration, the project site was observed to consist of improved south and north banks, undisturbed river bottom, and a constructed low flow channel at the south side of the Salt River. A constructed outfall channel was also in existence west of the project site. The river channel was free of vegetation and at the time of our investigation, no surface flow was observed to be present within the channel. Several bars and shoals formed by the flood flow were observed to be present at the site indicating a braided pattern of flow during low flow events.

Three damaged areas were observed on the south bank between test-pit 4 and test pit 5. Damaged areas consisted of a torn mattress stones removed and exposed geo-grid. The damaged areas were observed to be located at the mid-hieght of the slope. The damaged areas appeared to have been excavated and the rip rap has been removed day lighting the embankment side slopes. The rip rap bedding consisting of non-woven geotextile fabrics have also been damaged. In the areas of the damaged rip rap, the soil appeared to be moist to wet and some healthy vegetation growth were observed. These three excavated gabion areas cluster in a 100 foot area and appeared to have been excavated for inspection or to relieve water pressure associated with the drainage of the south side. South of the damaged areas and behind the levee, foundation pilasters of an abandoned/removed four legged tower was observed to exist and the area is excavated. This area seems to receive surface runoff from the surrounding area causing water accumulation which ultimately seeped to these damaged areas.

South bank looking south at abandoned foundation and damaged gabion mattress looking west.

On the north bank, several storm drain outfalls are located within the CSA between downstream of the SR 153 bridge and the cargo loading area on the west side. There were several grade control structures at this reach of the Salt River. The CSA within the north bank stopped at the location immediately south of Runway 25L and on the east side there is gabion mattress bank protection immediately downstream of the east economy parking lot. The proposed safety area extension will include construction of CSA at this location and backfilling of the back of the CSA with engineered fill. Approximately 400,000 cubic yards of fill materials will be placed in this area located back of the proposed CSA area.

Review of the existing hydrologic information reveals that the 100-year peak flow at this location is 169,000 cubic feet per second (cfs). The hydrograph and flow data indicate that the peak flow is reached within a very short time (such as 24 hours) and stays at that flow for a day or less. The hydrograph also depicts that multiple peak occurs within 10 to 15 days but other peak flow is usually less than 60 percent of the peak flow. Each of the peak flow remains at a high level of flow for less than 24 hours and the flow subsides to less than 20,000 cfs within two to three days. The water level at and around this portion of the channel remains at nine to 10 feet below the existing banks and the velocity of water is around 10 to 12 feet per second. The proposed condition will change the 100-year water level by little more than a foot to lower the existing water level by about a foot. The velocity of the water will, however, change to more than three feet per second more to almost two feet per second less than existing velocity. Therefore, it appears that the channelization may make the channel more efficient in conveying 100-year flood flow.

2.2 Geologic Conditions

The subject site is located within the eastern part of the Western Salt River Valley and straddles the Papago Mountain pediment within the Sonoran Desert Section of the Basin and Range Physiographic province of the western United States. The landforms within the general area consist of mountains and hills, river deposits, and river valleys.

The Salt River Valley is a typical alluvial basin in the Sonoran Desert Section of the Basin and Range Physiographic Province of the western United States. The Basin and Range province is characterized by a northwest-southeast trending rugged mountain system and broad and extensive alluvial valleys created by high angle normal faults during a time 15 to 17 million years ago. The valley portions dropped down while the mountains were pushed upwards. The valleys received sediments derived from these and distant mountains and the present landform was created.

The project site has a relatively monotonous geology with very dense sand, gravel, and cobbles (SGC) as predominant subsurface soils. However, as the river flow changed during the past in response to climatic conditions, occasional thin layers of sand and fines sediments are not uncommon. Some of these sand layers do not have any binder and may represent a hazard related to flow under favorable conditions. In addition, if the sand layer is thick and appears within the zone of stress influence, settlement from the sand may also affect the structures. This site, being very close and immediate downstream of Salt River Narrows and as depicted by previous borings, most likely does not have any thick deposits of sand layer. Additionally, large cobbles and even boulders of sizes larger than two to three feet may be present in the clasts of the SGC due to the weir effect of the Salt River Narrow.

2.3 Seismic Conditions

HA has completed a brief study of the seismicity and neo-tectonic faults in Arizona to evaluate the seismic conditions of the proposed project structures. As mentioned earlier, the proposed development is essentially an emergency facility as classified by FEMA. Failure or disruptions of emergency structures can have severe economic consequences and can also adversely affect the environment and quality of life. Based on these factors associated with emergency structures, federal and local agencies have been providing guidelines and codes for the design of these structures for earthquakes.

Legislation associated with the National Earthquake Hazard Reduction Program (NEHRP) and a Presidential Executive Order virtually mandates that all lifeline structure designs adopt available seismic design codes such as IBC or National BOCA Code in the design. The seismic hazard definitions in these codes are based on the probabilistic seismic hazard maps prepared for the site for ground shaking displaying contours of peak accelerations associated with a certain probability of non-exceedance during specified exposure times. The probabilistic approach uses recurrence rates based on historical seismicity to predict epicentral distances for the maximum credible earthquake (MCE) in each source zone and then predicts events of lesser magnitude and distance for a given probability of occurrence. These probabilistic events are then used to estimate potential loadings such as acceleration.

An alternate seismic hazard analysis known as deterministic seismic hazard analysis utilizes a direct and simple procedure. The deterministic seismic hazard analysis (DSHA) involves four simple steps including:

- Evaluation of local and regional seismo-tectonic features to identify and characterize earthquake sources capable of producing significant ground motion at the site. This includes definition of each source's geometry and earthquake potential;
- Selection of source to site distances expressed as epicentral or hypocentral distances;
- Selection of controlling earthquake in terms of its size and distance from the site; and,
- Determination or definition of the characteristics of seismic hazards such as peak acceleration, peak velocity, and response spectrum ordinates to be utilized for design of the structures.

In the following paragraphs, a brief summary of HA's evaluation of the DSHA steps is provided.

There are approximately 400 neo-tectonics faults present in the state of Arizona. These 400 faults are distributed in 12 zones located within northwestern, southwestern, and southeastern portions of the state and along the Transition Physiographic Province of Arizona. There is another source zone of earthquakes located in California related to the San Andreas and its associated faults. The detailed geologic and seismo-tectonic characteristics of the faults within this frame work are outside the scope of this study and can be reviewed from the final report "Development of Seismic Acceleration Contour Maps for Arizona" by the Arizona Department of Transportation, Report Number AZ92-344, dated September 1992.

Earthquakes related to the tectonic movement of faults in southern California are of a higher magnitude and have a more frequent recurrence interval than the Arizona faults. Based on the distance of the site from these causative faults and the attenuation relationships, it is not warranted to design this structure for seismic events emanating from southern California.

Based on this initial study and the seismic history of the area, further seismotectonic analysis including fault mapping is not warranted for this site.

In addition, as the study of the seismotectonic features coupled with earthquake history indicates the area is aseismic, HA recommends that the design of the structures include the International Building Code (IBC) or state derived codes. According to the IBC Seismic Hazard Map, the site is classified as **Site Class C** as the soil within the upper 200 feet is composed of stable gravel with sand and cobbles and its equivalent standard penetration test blow count is considered to be more than 50 (based on HA's experience with Becker Hammer Penetration corrected for SPT blow count) (IBC Section 1615). According to the FEMA derived spectral response map (utilized by IBC) prepared for California and its surrounding states, the spectral response acceleration for short periods (0.2 second) for this site is interpolated to be 0.21g for five percent critical damping. The spectral response acceleration for a 1.0 second period is 0.07g (IBC Figure 1615-1 and 2). These response accelerations place the site in the seismic design category of B and therefore either a rigorous seismic analysis or a simplified procedure to calculate base shear, seismic response coefficient, period determination, vertical and horizontal shear distribution, overturning, dynamic and accidental torsion, and drift determination should be completed (IBC Section 1616).

2.4 Geologic Constraints

Geologic constraints for this site include floods, settlement, fluidization and/or liquefaction, perched water table or groundwater table or water from flowing river, and ground fissures related to depletion of the ground water table.

As this structure is located within the flood channel, risk of flooding from rainfall exists and it will be designed to withstand a 100-year flood event. Therefore, no discussions are made herein.

Liquefaction or fluidization processes are related to seismic loading when subsurface soils are granular, saturated, and loose in place. Liquefaction and/or fluidization require a strong ground motion in soils which are fine to medium sand and silty soils. This site has a mix of very dense sand, gravel and cobble soils which is not typically liquefied and the possibility of a major earthquake causing

liquefaction or fluidization is highly unlikely. Therefore, HA believes that geologic hazards related to liquefaction are unlikely.

Earth Fissures and/or ground break related to decreases in ground water depth due to the withdrawal of water is widespread in central and southern Arizona. In the western and southeastern Salt River Valley, water levels have dropped more than 200 feet due to tapping of water for agricultural use during the last 50 to 100 years. This decrease in ground water depth has resulted in an increase in stress in the lithified earth materials. At the margins of the valleys or near the shallow bedrocks, the increased stress has caused earth fissures to develop. However, the project site is located very close to the Salt River where water level drops have not been recorded due to continuous recharge and less usage of groundwater for agriculture. Therefore, earth fissures related to ground water depth increases are not considered a concern to this project.

Ground shaking related to earthquake motion is considered a geologic hazard in areas where earthquakes are common, ground acceleration and particle velocities are high, and shear wave velocities of the subsurface media in which the structure will be located are low. These concerns are absent or minimal at the subject site.

Water from the groundwater table will not be a concern during the performance of the project, but during construction of CSA especially, to place the toe below the scour level, the water table might be encountered which could be dealt with using a temporary dewatering system. In addition, during construction of new utility lines and realignment of existing pipelines for sewer and storm water, a perched or temporary water table related to the flow of the Salt River will create complexity and delay the construction. The temporary perched water table could be mitigated by utilizing a sump and pump method or by routing the water to an infiltration gallery. This type of temporary water is not anticipated to affect the performance of the features.

3.0 GEOTECHNICAL CONDITIONS

Information on subsurface conditions was gathered by excavating 10 test pits located within the proposed site. The locations of the test pits are provided in Appendix B. Test pits extended to a depth range of five to 10 feet below site grade.

3.1 Field Exploration Methods

Information on subsurface conditions was gathered by excavating 10 Test pits located throughout the proposed site. Appendix B contains a test pit location diagram and soil classification and field methods.

Test pits excavated at this site extended to a depth range of five to 10 feet below site grades. A John Deere 710 J backhoe with a 24 inch bucket was provided by PSHIA Facilities. Excavations were conducted on the slope and toe of the south bank of the Salt River. Four additional test pits were conducted on the Salt River bed near the North CSA bank.

The excavation was monitored and documented by a Project Manager from HA. The Project Manager collected and classified the subsurface soil in the field utilizing the Unified Soil Classification System (USCS). Bulk soil samples were obtained at five and 10 foot vertical intervals. Representative bulk samples of soils were collected from the excavated sites. The soil samples collected during drilling were secured and transported to HA's laboratory for testing. Following completion of excavation, the test pits were backfilled with drill cuttings.

3.2 Subsurface Conditions

Detailed information regarding the subsurface conditions encountered at each test pit location is provided. A total of 10 test pits were excavated to depths ranging from five (5) to ten feet. Brief descriptions of subsurface conditions as depicted within the 10 test pits. In general, the soils in all borings extending from the surface to the depth of terminus were very dense sand, gravel, and cobbles locally known as Salt River Alluvium or SGC. The SGC soils in all test pits contained variable amounts of fines and the large gravels and cobble sized particles contained silty clay as a binder.

- Soils in boring TP-1 were brown, moist SGC from near surface to the entire depth of excavation (Approximately 10 feet). Soils within the upper 10 feet had trace fines whereas the soils from rest of the boring contained some clay to be classified as GP-GC. Visual observations included measurements of the gabion mattress which consisted of measuring a five foot by five foot section. Within these parameters contained 18 inch minus material encapsulated within the mattress. At the time of excavation, no municipal or construction debris was observed.

Test Pit 1 excavation and gabion mattress looking east.

- Soils in Test Pit-2 were observed to be below existing three foot thick cemented wash out material. Soils below the cementation were brown, moist SGC from near surface to the entire depth of excavation (approximately 10 feet). Visual observations included measurements of the gabion mattress within a five foot by five foot section. Within the parameters contained 18 inch minus material encapsulated within the mattress. At the time of excavation, no municipal or construction debris was observed.

Test Pit 2 cemented excavation and gabion mattress looking east.

- Soils in Test Pit-3 brown, moist SGC from near surface to the entire depth of excavation (approximately 8 feet). Visual observations included measurements of the gabion mattress within a five foot by five foot section. Within the measurement unit gabion contained 18 inch minus material encapsulated within the mattress. At the time of excavation, no municipal or construction debris was observed.

Test Pit 3 excavation near toe of mattress and Salt River South Bank looking east

- Soils in Test Pit-4 brown, moist SGC from near surface to the entire depth of excavation (approximately 5 feet). Visual observations included measurements of the gabion mattress within a five foot by five foot section. Within the measurement unit gabion contained 18 inch minus material encapsulated within the mattress. At the time of excavation, no municipal or construction debris was observed. Outfall channel present below slope near TP-4

Test Pit 4 Slope looking South and Outfall Channel looking west.

- Soils in Test Pit-5 brown, moist SGC from near surface to the entire depth of excavation (Approximately 10 feet). Soils within the upper 10 feet and had trace fines whereas the soils from rest of the boring contained some clay to be classified as GP-GM. Visual observations included measurements of the gabion mattress within a five foot by five foot section. Within the measurement unit gabion contained 18 inch minus material encapsulated within the mattress. At the time of excavation, no municipal or construction debris was observed.

Test Pit 5 Slope looking south and Test Pit 5 excavations.

- Soils in Test Pit-6 brown, moist SGC from near surface to the entire depth of excavation (approximately 10 feet). Soils within the upper 10 feet and had trace fines whereas the soils from rest of the boring contained some clay to be classified as SP-SM. Visual observations included measurements of the gabion mattress within a five foot by five foot section. Within the measurement unit gabion contained 18 inch minus material encapsulated within the mattress. At the time of excavation, no municipal or construction debris was observed.

Test Pit 6 Slope looking East and Gabion Mattress 18" minus Material.

- Soils in Test Pit-7 located in the river bed contained brown, moist SGC from near surface to the entire depth of excavation (approximately 10 feet). Soils within the upper 10 feet and had trace fines whereas the soils from rest of the boring contained some clay to be classified as GM. Visual observations included measurements of the river bed within a five foot by five foot section. Within the measurement unit material contained boulders, cobble, gravels and sand. At the time of excavation, no municipal or construction debris was observed.

Test Pit 7 looking east and excavated material...

- Soils in Test Pit-8 located in the river bed contained Brown, moist SGC from near surface to the entire depth of excavation (Approximately 10 feet). Soils within the upper 10 feet and had trace fines whereas the soils from rest of the boring contained some clay to be classified as GP-GC. Visual observations included measurements of the river bed within a five foot by five foot section. Within the measurement unit material contained boulders, cobble, gravels and sand. At the time of excavation, no municipal or construction debris was observed.

Test Pit 8 looking northeast and measurements and visual observations.

- Soils in Test Pit-9 located in the river bed contained brown, moist SGC from near surface to the entire depth of excavation (approximately 10'). Soils within the upper 10 feet and had trace fines whereas the soils from rest of the boring contained some clay to be classified as SP-SM. Visual observations included measurements of the river bed within a five foot by five foot section. Within the measurement unit material contained boulders, cobble, gravels and sand. At the time of excavation, no municipal or construction debris was observed.

Test Pit 9 looking west and excavated material.

- Soils in Test Pit-10 located in the river bed contained brown, moist SGC from near surface to the entire depth of excavation (approximately 10 feet). Soils within the upper 10 feet and had trace fines whereas the soils from rest of the boring contained some clay to be classified as GP-GM. Visual observations included measurements of the river bed within a five foot by five foot section. Within the measurement unit material contained boulders, cobble, gravels and sand. At the time of excavation, no municipal or construction debris was observed.
- .

Test Pit 10 looking south and excavation looking east.

3.3 Laboratory and Field Tests

The laboratory testing program for this project was designed to evaluate the physical properties of the subsurface soils. All other tests were performed on bulk samples collected from surface to five feet depth of the five test borings. Laboratory tests completed include:

- Six gradation tests (ASTM D 422);
- Six Atterberg Limits (ASTM D 4318); and
- One Proctor Compaction (ASTM D 698).

Detailed laboratory test results are presented in Appendix D. Some selected soil properties are provided in the following table:

Boring/Test Pit Number	Depth (feet)	Fines Content (% Passing #200 Sieve)	Liquid Limit (percent)	Plasticity Index	Soil Classification (USCS)
TP-5	0 – 5	5.3	-	NP	GP-GM
TP-6	0 – 5	8.3	-	NP	SP-SM
TP-7	0 – 5	13	-	NP	GM
TP-8	0 – 5	8.3	24	5	GP-GC
TP-9	0 – 5	5.8	-	NP	SP-SM
TP-10	0 – 5	16.4	-	NP	GP-GM

Gradation and Atterberg limits tests were conducted to classify the soil and estimate other physical properties by correlation such as strength, compressibility, and potential to change in volume due to exposure to environment especially excess water. Compaction test was conducted to estimate or evaluate the engineering characteristics of the soils. All the tests were performed in accordance with ASTM or other applicable standards. Detailed laboratory and field test results are contained in Appendix D.

The standard Proctor compaction test was completed on a bulk sample in the upper five feet of test pits. The Proctor test indicated a maximum dry unit weight

of 122.4 pounds per cubic feet (pcf) and an optimum moisture content of 10.2 percent.

4.0 DESIGN PARAMETERS AND CONSTRUCTION IN SGC

4.1 General

The results of the field exploration and our experience in the general area indicate that the on-site very dense SGC soil will support the levee protection including CSA and gabion mattresses. The soil has a very high bearing capacity and the CSA and gabion mattresses will not impart more than 100 pounds per square foot ground pressure and most of these features will be constructed in replaced soil. Therefore an insignificant amount of ground pressure is anticipated. The soil at the site is able to support more than 10,000 pounds per square foot.

Other geotechnical issues involved at the site include settlement due to presence of pockets of sandy soil and the scour of foundation soil during flood events and subsequent sedimentation with loose deposits. Sand pockets may undergo more settlement than the SGC due to difference in modulus values.

Groundwater or saturated conditions were not encountered during the geotechnical exploration for this project. However, groundwater was encountered during past drilling within the airport structures to be at approximately 75 feet below surface grade and was measured to have stabilized at approximately 55 feet below grade in wells located along the terminal buildings which are more than half a mile away from the project site.

4.2 Settlement

Whenever additional loads are applied to soils, the soils compress and cause settlement. Total and differential settlement that a structure will undergo depends on the type of soil or rock, subsurface conditions, type of structures, amount of loads, duration of loads, and infiltration of free moisture into the foundation subgrade.

Based on the subsurface soil conditions, HA estimates that the proposed foundation may undergo a total settlement of little more than 1.5 inches for the levees designed and constructed in compliance with the recommended earthwork recommendations. The differential settlement is anticipated to be less than 1/2 inch. As the soils are predominantly granular, the majority of the settlements are anticipated to be completed immediately after the dead and live loads are applied.

The settlement estimates provided herein do not include the affect of the presence of thick sand deposits within the zone of influence or the stress imparted by footings.

4.3 Slope Stability and Seepage Analysis

As discussed previously, gabion mattresses 12 to 18 inches thick have been placed and will be placed along the levee structures. These gabion mattresses will act as veneer slope surface due to possible slippage of the mattresses along the contact point with the earthen levee. The classical analysis for a veneer slope of finite length considers the stability of two blocks known as active and passive blocks. The active block is the mass of the gabion mattresses on slope. The passive block is the triangular area at the toe of the slope that will have to shear horizontally for failure to occur. The basic steps for veneer slope stability involve the following:

- Geometry of the slope;
- Material properties;
- Determining of active and passive pressure on active and passive blocks, respectively;
- Including seepage pressure and determination of a factor of safety for the equilibrium condition.

For this project, the geometry of the gabion mattresses was chosen based on field data and measurements. The slope angle was calculated based on as-built information created during 1980's by HNTB Consultants from Kansas. The soil properties were chosen from field soil type encountered during soil investigation and from the Arizona Department of Transportation Valley Wide Freeway Construction and Design Manual prepared by De Leau Cather and Associates in 1987. The material properties are shown below:

- Soil Type: SGC
- Unit Weight: 140 pounds per cubic foot
- Angle of Internal Friction: 39 degrees
- Interface Friction : 26 degrees

In addition, it was estimated that seepage force will act as full height of the gabion mattresses even though gabion mattresses are very permeable. Calculation of the slope stability is attached in appendix E. The calculation indicates that slopes will have a factor of safety of more than 2.8 for normal cases and more than 2.5 under full seepage forces.

HA also performed slope using STABL for Windows® Version 2.0, an analytical slope stability computer program developed by Purdue University. STABL can analyze slopes using a variety of two-dimensional, limit equilibrium methods including the Bishop Method, the Spencer Method, and the Janbu Method of Slices. STABL uses a unique random technique for randomly generating potential failure surfaces. A factor of safety is determined for each potential failure surface, defined as the ratio of the available shear strength to the shear strength that must be mobilized to maintain a condition of limiting equilibrium. Three types of failure surfaces can be specified in STABL; circular, sliding block, and general irregular surfaces of random shape. Specific trial failure surfaces can also be specified. STABL can account for heterogeneous soil profiles, anisotropic soil properties, excess pore water pressure due to shear, static ground water, surface water, pseudo-static loading from earthquakes, surcharge loads, tieback loads, soil nailing, and geosynthetic reinforcement of soil slopes.

STABL was utilized to perform slope stability analyses for two the following cases:

- Critical Flood Stage (Full Flood Condition)
- Earthquake (Pseodostatic)

The STABL input and output are included in Appendix E. The analyses indicate adequate factor of safety for these two cases of analyses.

Seepage analysis to determine the uplift pressure at the toe of the mattresses and toe of the CSA was not necessary as the saturation line within the embankment materials will cease in a short time and the flood events are only for a few days. In addition, the toe on the other side will be built above flood level and therefore will have more than 15 to 20 feet of soil or structures that will impart more than water pressure even under flood level.

The slope stability of the CSA was not performed due to high shear strength of the CSA compared to the surrounding soil. The CSA have more than a 750 pound per square inch strength, or more than 100,000 psf strength, and that is considered high for failure due to slope stability to occur unless a catastrophic event occurs at the site.

Gabion Mattress damage areas should be assessed to determine the reason of the rip rap removal and subsequently repaired properly and as quickly as possible before the next high flow event. It appeared that the excavated areas may have seepage water flowed out of the depressed areas that receives storm water run off from surrounding areas. Prior to repair of the damaged gabion, the

depressed areas should be graded so that it does not retain water to seep into the levee slope.

5.0 EARTHWORK CONSTRUCTION AND ENGINEERING FILL

The site of the proposed structure is developed and contains numerous above and below ground features. These features will interfere and may cause complications during excavation and site grading. Before site preparation begins, all below ground and above ground utilities should be marked and relocated away from the work areas. Site grading will require demolition and removal of existing structures. All concrete or metal pipes or foundations or other man-made features should be excavated and removed. After removal of features, the site grading and excavation will begin and a representative of a qualified geotechnical engineer should be at the site to observe and document fill placement.

5.1 On-Site Materials

On-site soils consist of predominantly sand, gravel, and cobble soils. Sometimes boulder-sized particles are present within the matrix of the SGC. These materials make an excellent base for roadways and subgrade for building pads, slabs or parking structures. Therefore, on-site sandy soils recovered from the grading work and free of oversized and deleterious materials can be utilized as fill. HA recommends that on-site soils are stockpiled for future use. In fact, the gravel and cobbles can also be processed for aggregate materials to be used as a mixture of concrete, asphalt or aggregate base course.

5.2 Fill Placement

Subgrade surfaces receiving fill should be scarified, moisture conditioned, and compacted to at least 95 percent of its standard Proctor maximum density placed at slightly below or above the optimum moisture content. On-site soil free of debris or large rock (10 inches in any dimension) or concrete pieces may be utilized as fill soil. Soils from the excavation of the river channels should be suitable as fill soil. If necessary, import soils may also be utilized as fill. The swell potential of the compacted import soil should be less than 1.5 percent when tested under a vertical pressure of 100 psf in accordance with ASTM D4546 procedures.

Based on the site conditions and presence of SGC soil, it is likely that compaction of fill materials may not be tested as testing is difficult, complicated, and time consuming. During placement of SGC as fill material the following minimum requirements must be complied with:

- The soil should be on-site river run SGC material and should be screened to be free of material larger than 10 inches. The material should preferably not contain more than 10 percent fines.
- The SGC material meeting the above gradation should be placed in 18 inches maximum loose horizontal lifts. The loose lifts should be compacted utilizing a vibratory compactor having a minimum weight of 20 tons. The compactor should have a speed of three to four miles per hour (approximately 300 feet per minute or the speed of walking) using a vibratory frequency of 80 to 120 hertz. A minimum of four passes should be made.
- The granular soil such as the Salt River SGC does not provide effective confinement during compaction. To alleviate this condition, HA recommends that the uppermost lift forming the immediately adjacent subgrade for foundations have a six inches thick aggregate base course type material or materials with some binder before compaction added.

The fill surface should be adequately maintained during construction in order to achieve acceptable compaction and interlift bonding. The surface should be sloped properly to prevent ponding and provide drainage of runoff water. If precipitation is anticipated, HA recommends that the fill surface be made smooth by rolling with a smooth drum roller.

Pipe backfill materials will normally be taken from the pipe trench excavations with plasticity indices less than 12, or alternatively, off-site granular import materials could be utilized.

Backfill materials should not be dropped directly on the pipelines. Hard materials larger than three inches in maximum dimensions should not be placed within six inches of the pipes. For pipes with tar or coal-tar coatings, hard materials larger than 1.5 inches in maximum dimension should not be used within six inches of the pipes.

Backfill materials surrounding the pipes should be placed and compacted in such a way that the elevations on two sides are even to ensure that the pipes are not displaced. Backfill over the pipe extending to 12 inches above the pipes should be placed and compacted slightly, carefully utilizing hand held devices such as power tampers so that the pipes are not stressed.

5.3 Construction Quality Control Testing

HA recommends that site preparation, subgrade preparation, backfill placement, re-compaction, and foundation subgrade be observed and/or tested by a qualified and experienced representative of the geotechnical engineer. This representative should at least observe and document the following:

- All deleterious objects are removed from the foundation, slabs, and pavement area subgrade;
- Foundations and other subgrade are compacted, firm, and do not contain deleterious objects;
- All compaction and moisture contents of backfill soils meet the specified minimum values;
- Footing excavations exposed the soil that was anticipated in the design and meet the recommended bearing values of 6000 psf;
- Perform on-site density testing on engineered fill or placement of ABC at every 2500 square feet in building areas and at every 5,000 square feet in other areas; and
- Prepare a final report documenting all on-site activities, test results, and conclusions.

The prepared fill, foundation excavations, and utility trenches should not be exposed to the environment for long periods as this can affect the moisture content and density of the fill. During unavoidable exposure to the environment, moisture conditioning of these features should be maintained.

5.4 Construction Dewatering

During construction of the CSA or placing gabion mattresses in the river channel, some construction dewatering may be required. For these types of water sources, a pump and sump may not be sufficient and a dewatering system may be required to be designed or installed. In the past if the contractor chose to do the construction during dry months, water was not encountered during CSA construction but it was a risky operation.

6.0 CONSTRUCTION CONSIDERATIONS/EXCAVATION SUPPORT

Excavation at the site should be able to be accomplished using conventional construction equipment. Soil disturbed during grading should be properly recompacted and the areas should be backfilled with compacted engineered fill in compliance with the earthwork construction procedures recommended herein. All the excess soil generated from the grading work should be removed and disposed of in an acceptable manner. Utility trenches or other confined excavation extending more then 4 feet should conform to OSHA safety regulations.

HA recommends that all excavation slopes should be maintained at 2:1 (horizontal to vertical) or flatter for the sand soils. If an excavation remains open for a long time, to avoid raveling and spall off or localized caving, HA recommends that all cut slopes be stabilized with application of shotcrete or gunite or polymer based spray. If excavations are required to be steeper than the recommended slope, HA recommends that a shoring system be designed and installed at the site. Earth pressure parameters for shoring design will be provided if requested. A shoring system may also have to be designed for vehicular traffic and highway loadings in excavations located within the vicinity of the roadways.

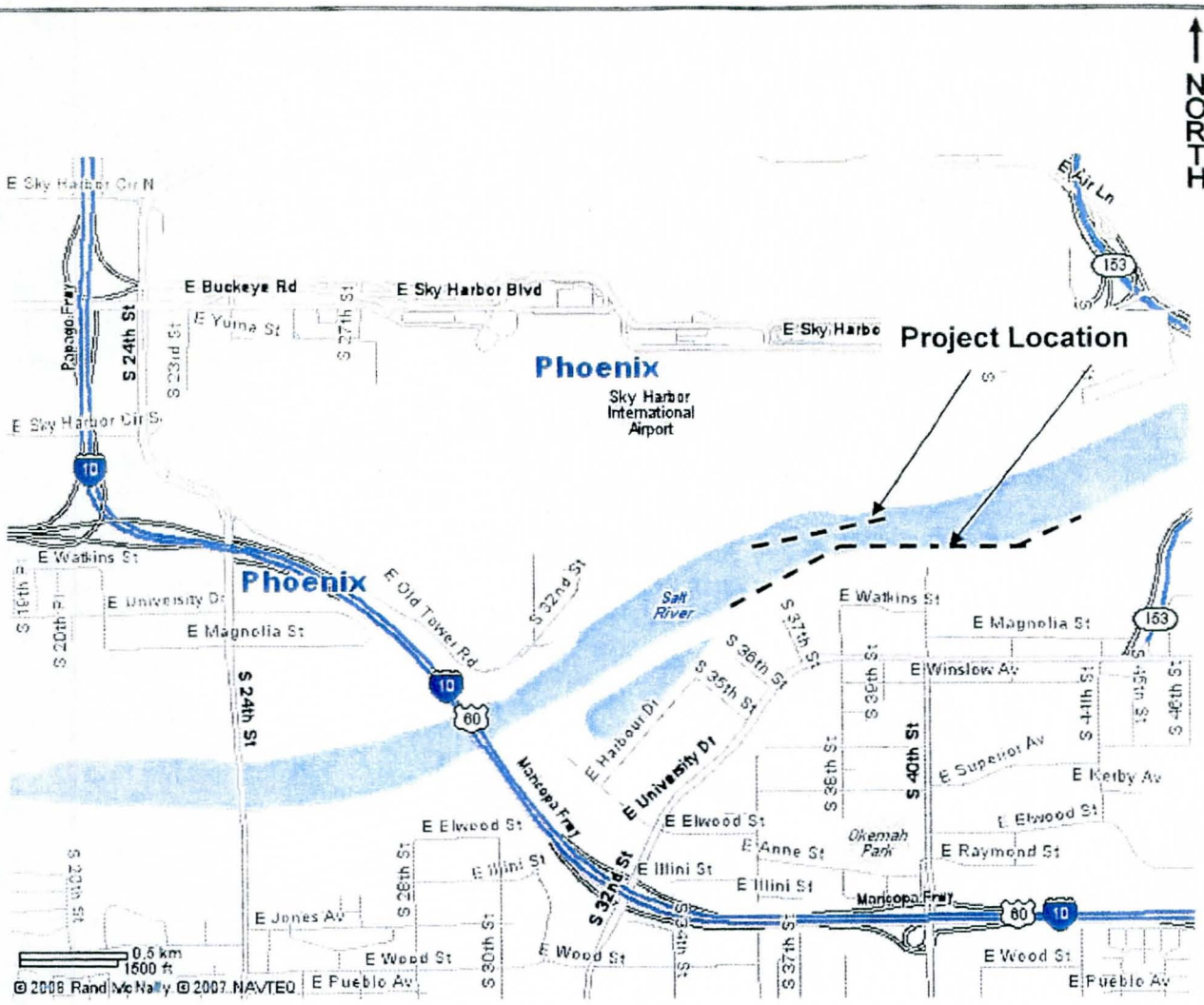
7.0 DISCLAIMER

Due to the inherent natural variations of the soil stratification and the nature of geotechnical exploration, there is always a possibility that conditions between borings may be different from those encountered at the boring locations. Additionally, our interpretation of subsurface conditions is derived from observations made on the materials recovered, and these materials are intermittent in nature and the micro or even macrostructures that would aid better identification were clouded by the drilling process. Interpretation and observation of soils recovered from the cyclone of the rig did not contain any information on the size of particles larger than six inches. Therefore, the logs and laboratory soil test results should be interpreted cautiously and should include the BHP numbers and experiences of the field personnel. This could be more efficiently done by drilling some large diameter test borings/shafts and by down-hole geologic observation by entering a secured excavation.

The practice of geotechnical engineering is such that the risks involved in building an efficient, functional, and economical structure cannot be assessed with confidence until construction begins. Therefore, during the design of the project, geotechnical input from the engineer on-record should be sought continuously by the design professionals.

Appendix A

Site Location Map



LOCATION MAP

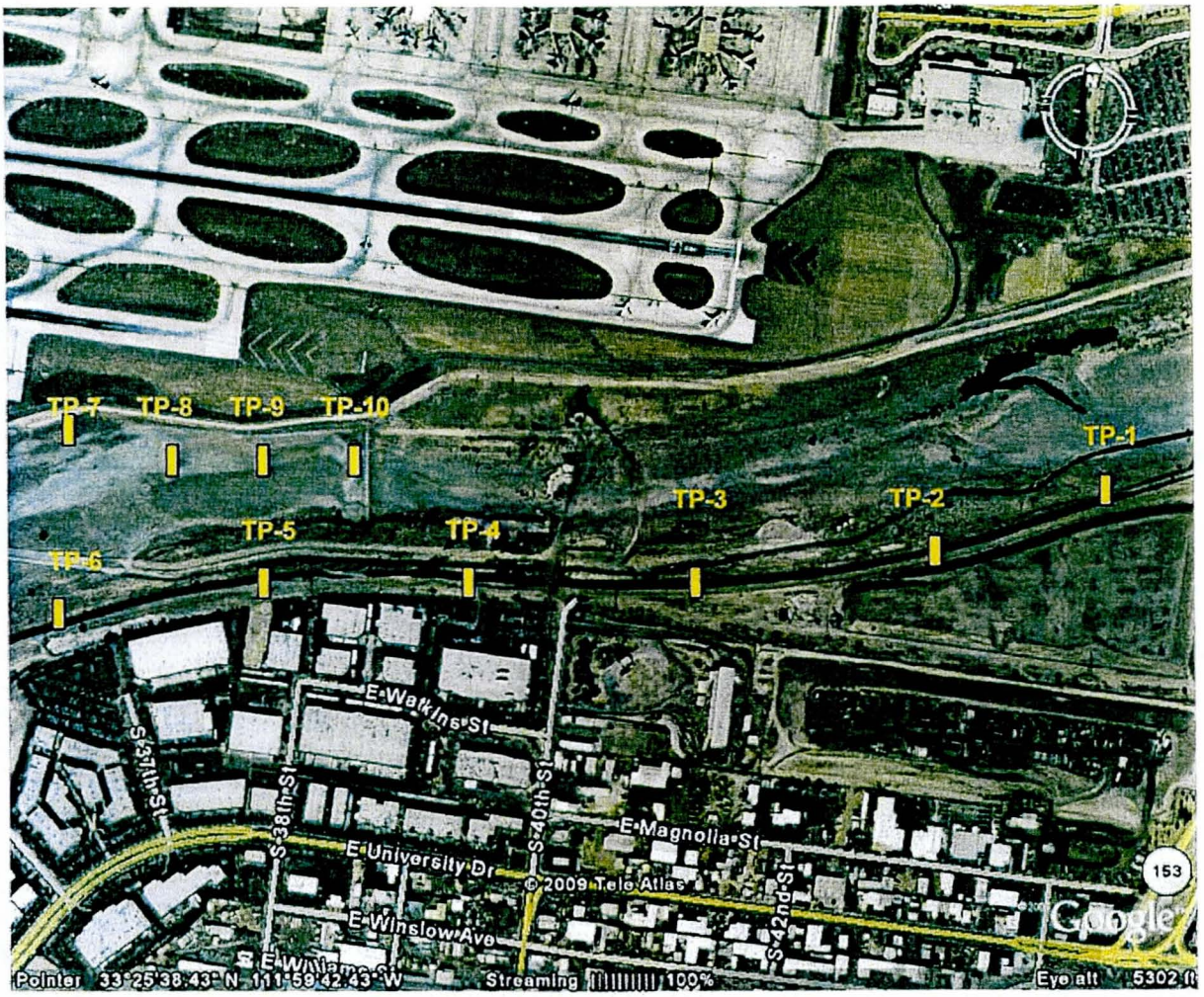
River Protection Work at Salt River Channel
Near Third Runway Extension at Sky Harbor
International Airport
Phoenix, Arizona
HA Project # 09006

Hoque & Associates, Inc.
Geotechnical, Materials, and Environmental Engineers
4325 South 34th Street
Phoenix, Arizona 85040
Tel: (480) 921-1368 Fax: (480) 921-0194
Email: Support@HoqueandAssociates.com

Appendix B

Test Pit Location Plan

NORTH



LEGEND

Approximate Test-Pit Location

TEST-PIT & LOCATION MAP

River Protection Work at Salt River Channel
Near Third Runway Extension at Sky Harbor
International Airport
Phoenix, Arizona
HA Project # 09006

Hoque & Associates, Inc.
Geotechnical, Materials, and Environmental Engineers
4325 South 34th Street
Phoenix, Arizona 85040
Tel: (480) 921-1368 Fax: (480) 921-0194
Email: Support@HoqueandAssociates.com

Appendix C

Soil Classification
And
Soil Investigation Methods

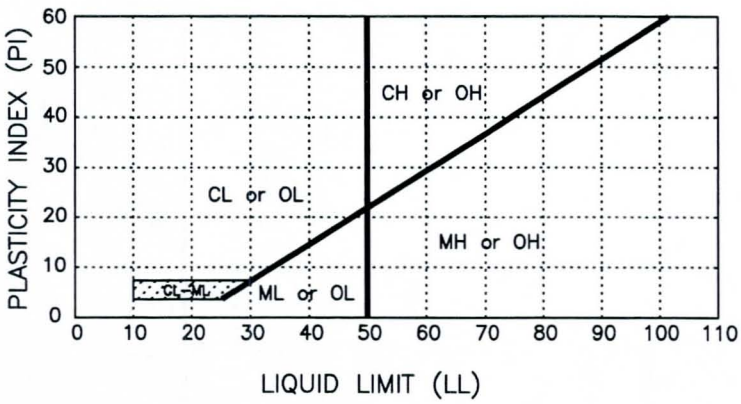
UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified by the United Soil Classification System (USCS) on the boring logs presented in this report. Grain size analysis and Atterberg limits tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" Corps of Engineers, US Army Technical Memorandum No. 3-357 (Revised April 1960) or ASTM Designation: D2487-66T.

MAJOR DIVISIONS				GROUP SYMBOL	TYPICAL NAMES
COARSE - GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
				GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot above the "A" line & hatched zone on plasticity chart	GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		SW	Well graded sands, gravelly sands.
				SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below the "A" line & hatched zone on plasticity chart	SM	Silty sands, sand-silt mixtures.
			Limits plot above the "A" line & hatched zone on plasticity chart	SC	Clayey sands, sand-clay mixtures.
FINE - GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (Limits Plot Below "A" Line & hatched Zone on Plasticity Chart)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)		ML	Inorganic silts, non-plastic or slightly plastic.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)		MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts.
	CLAYS (Limits Plot Above "A" Line & hatched Zone on Plasticity Chart)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)		CH	Inorganic clays of high plasticity, fat clays, sandy clays of high plasticity.

NOTE:
Coarse grained soils with between 5% & 12% passing the No. 200 sieve and fine grained soils with Atterberg limits plotting in the hatched zone on the plasticity chart shall have dual symbol. In Arizona, local streams contain sand, gravel & cobble type material, which are locally known as SGC or riverrun material. The USCS is not used to divide and symbolize this material.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No. 4 sieve
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt & clay)	Below No. 200 sieve
Clay	Smaller than 2 microns
Colloid	Smaller than 5 microns

Subsurface Investigation Methods

Subsurface investigation methods include displacement boring, wash boring, percussion drilling, rotary drilling, auger boring and continuous sampling. For a particular site exploration, the preference of the particular method and drilling equipment are dependent upon various factors. These factors may include equipment suitability, site accessibility, geological surroundings, environmental factors and economic considerations.

Displacement Borings

This technique is often used in preliminary exploration where prevalent subsurface information is required. Displacement borings are simple and most cost effective for non-caving ground. Without any effort to brace the borehole, sampling the soil at the desired depth is achieved by inserting samplers in the closed position, such as cup, piston or split tube samplers to the required depth.

Wash Borings

This procedure is advantageous in that the equipment is relatively inexpensive and easily transferable. Wash borings entail the insertion of steel casing and washing out the material to the bottom of the casing or a depth below the steel casing. A re-circulating fluid that carries the cuttings to the surface accomplishes this wash. The drill rod and chopping bits that are used in this procedure alternately raise and drop with slight rotation to anatomize the material within the casing.

Percussion Drilling

Also known as Churn or Cable Tool Drilling, this method is employed primarily in the well drilling industry. Due to potential sample disturbance, percussion drilling is not used extensively in geotechnical inquisitions. For this procedure, raising and dropping a heavy drill bit and removing the loose soil by bailing creates a borehole. Generally a traditional sampler is used in place of the drill bit to collect the sample after the slurry is removed.

Rotary Drilling

This technique is flexible and adaptable which may be used with different equipment models and sampling apparatus. By advancing a cased or uncased borehole by rapid rotation and pressure, grinded material or cuttings are created at the bottom of the borehole. The removal of these cuttings are achieved by pumping air, water or drilling mud from a reservoir on the surface through the drill rods to the bottom of the borehole. After obtaining the desired depth, a sampling mechanism is used.

Auger Boring

This method is popular because it is quick and economical in conducting subsurface investigations. Most often, augers are mounted on large rigs for rapid mobility. However, augers can be on track-mounted equipment as well. This type of boring is subdivided into three categories depending on the type of equipment used. These are construction augers, solid flight augers and hollow stem augers. Construction augers are usually large in diameter and primarily used for shallow inspection of soil. Although not designed for sampling, construction augers can be used for bulk sampling. Solid flight augers, sometimes called continuous flight augers are the most expedient of the augers in obtaining a borehole. Samples are obtained from auger flights. An improvement to the continuous auger is the hollow stem auger. A center plug that is removed from the auger permits sampling tools to be used in the borehole without the removal of the auger.

Continuous Sampling

This type of sampling may provide more infallible and detailed information about subsurface conditions than any other sampling. This reliability is enhanced because continuous sampling utilizes a variance of sampling tools and test boring procedures.

Soil Sampling Methods

Split-Spoon

The most common method for obtaining representative samples are done with the split-spoon. Associated with the Standard Penetration Test (SPT), split-spoon sampling is acquired immediately beneath the borehole near the ground surface.

Ring Sampling

Ring sampling consists of using six rings that are driven beneath the borehole to obtain an undisturbed sample. This type of representation is used in the laboratory to obtain parameters for foundation analysis.

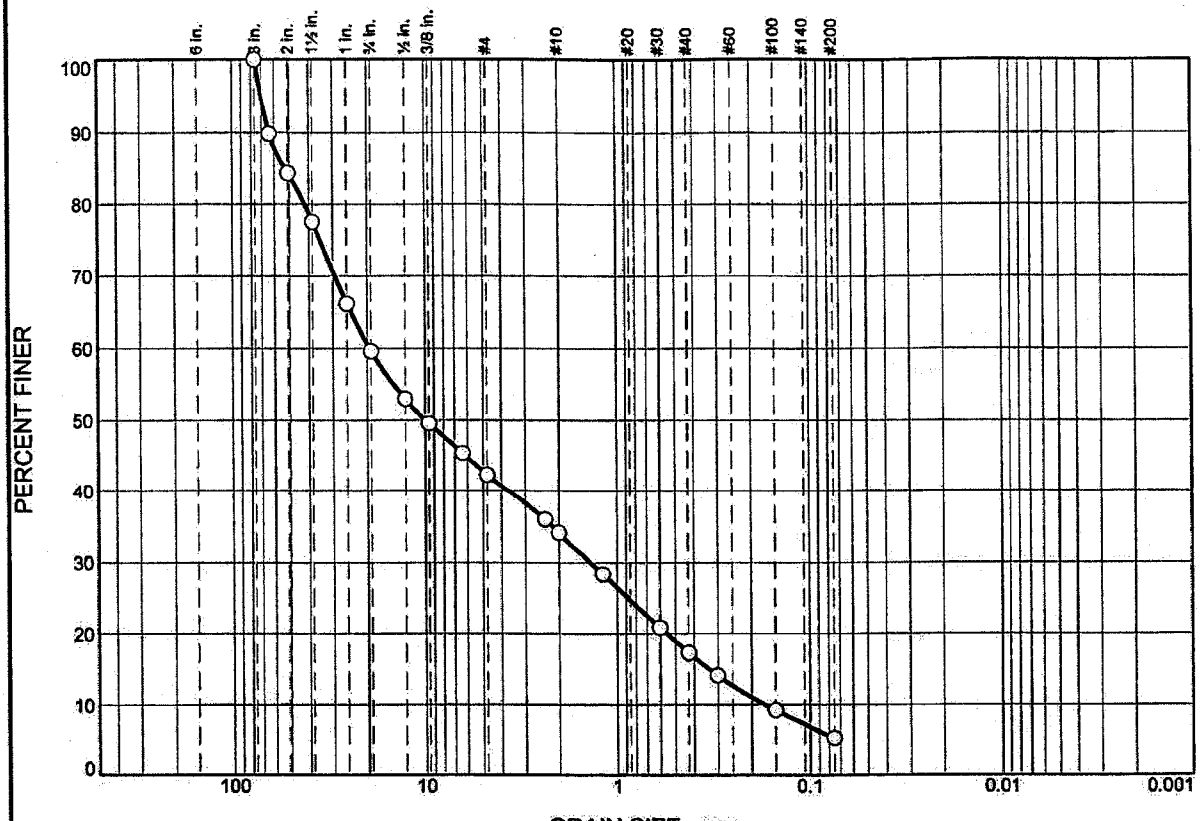
Bulk Sampling

Bulk sampling is performed when an undisturbed specimen is not required. This type of sampling is less time consuming and thus more cost efficient, and is desirable when a Proctor, gradation or plastic index is needed.

Appendix D

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	40	18	8	17	12	5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3"	100		
2-1/2"	90		
2"	84		
1-1/2"	77		
1"	66		
3/4"	60		
1/2"	53		
3/8"	50		
1/4"	45		
#4	42		
#8	36		
#10	34		
#16	28		
#30	21		
#40	17		
#50	14		
#100	9		
#200	5.3		

* (no specification provided)

Material Description

poorly graded gravel with silt and sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 63.7685 D_{85}= 52.6113 D_{60}= 19.4801
D_{50}= 9.9458 D_{30}= 1.3781 D_{15}= 0.3309
D_{10}= 0.1693 C_u= 115.04 C_c= 0.58

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

Sampled by: M. Verquer
Sample date: 2/6/09

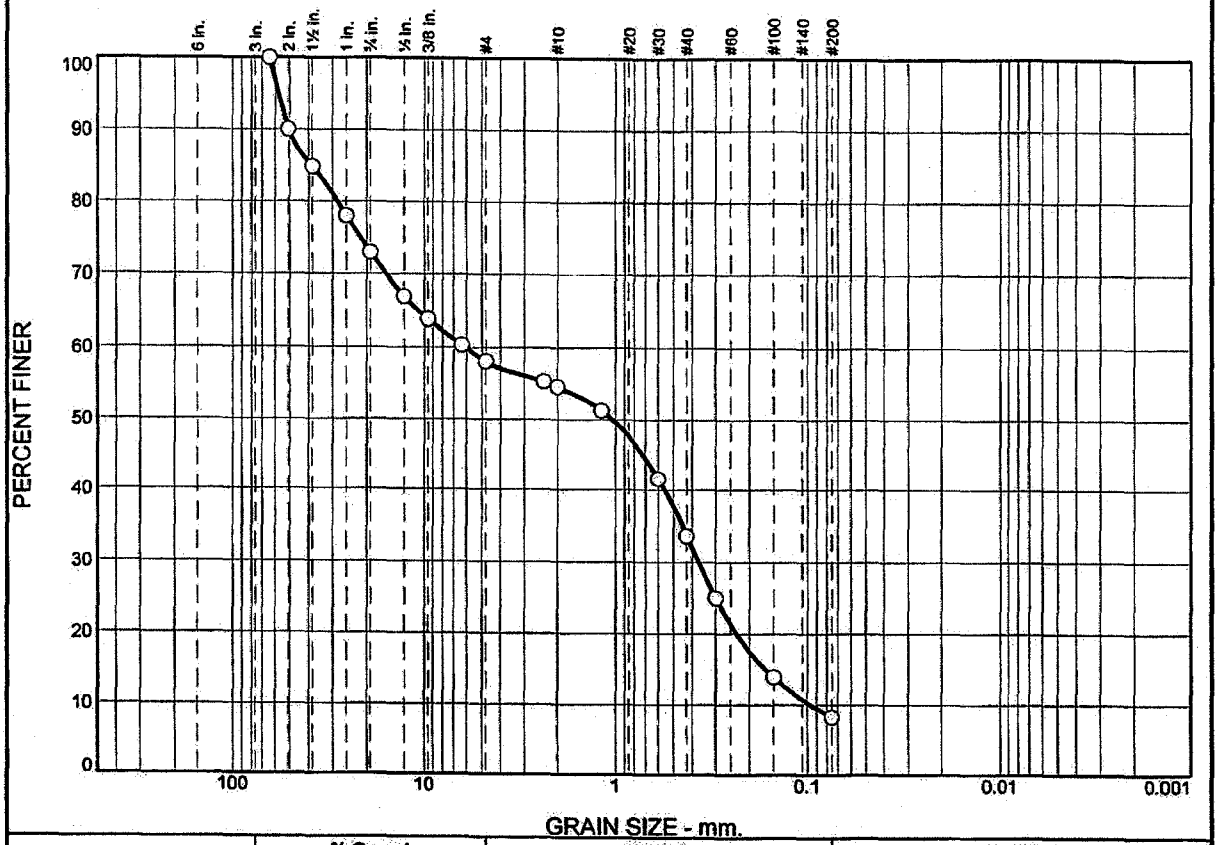
Location: T-5
Sample Number: 0047 **Depth:** 0-5' **Date:** 2/12/09

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040

Client: City of Phoenix
Project: Salt River Bank Stability
Clomar
Project No: 09006 **Lab Number** 09L0047

Tested By: A. Collinwood **Checked By:** R. Anderson

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	27	15	3	21	26	8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2-1/2"	100		
2"	90		
1-1/2"	85		
1"	78		
3/4"	73		
1/2"	67		
3/8"	64		
1/4"	60		
#4	58		
#8	55		
#10	55		
#16	51		
#30	42		
#40	34		
#50	25		
#100	14		
#200	8.3		

* (no specification provided)

Material Description

poorly graded sand with silt and gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 50.8074 D_{85}= 38.5965 D_{60}= 6.0952
D_{50}= 1.0335 D_{30}= 0.3685 D_{15}= 0.1645
D_{10}= 0.0957 C_u= 63.72 C_c= 0.23

Classification

USCS= SP-SM AASHTO= A-1-b

Remarks

Sampled by: M. Verquer
Sample date: 2/6/09

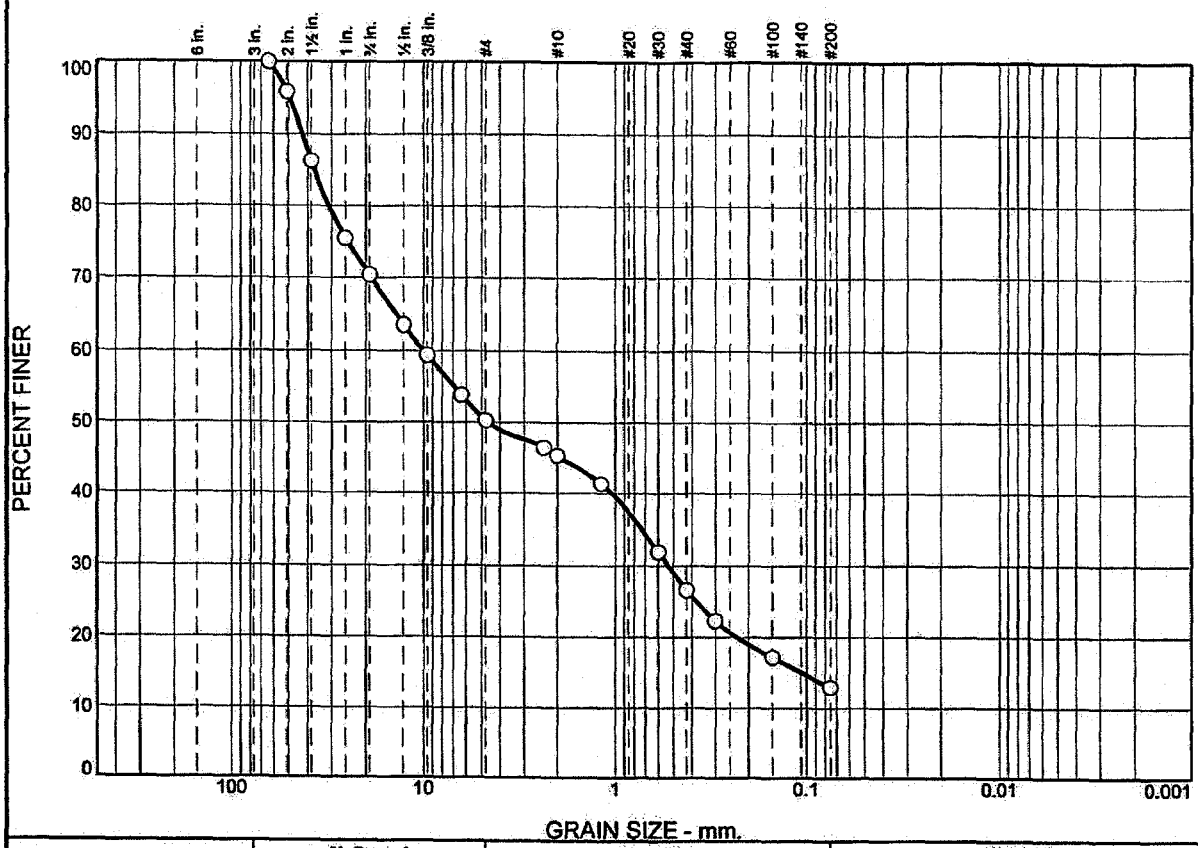
Location: T-6
Sample Number: 0048 **Depth:** 0-5' **Date:** 2/12/09

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040

Client: City of Phoenix
Project: Salt River Bank Stability
Clomar
Project No: 09006 **Lab Number** 09L0048

Tested By: A. Collinwood **Checked By:** R. Anderson

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	30	20	5	18	14	13	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2-1/2"	100		
2"	96		
1-1/2"	86		
1"	75		
3/4"	70		
1/2"	63		
3/8"	59		
1/4"	54		
#4	50		
#8	47		
#10	45		
#16	41		
#30	32		
#40	27		
#50	22		
#100	17		
#200	13		

* (no specification provided)

Material Description

silty gravel with sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 42.3961 D_{85}= 36.7660 D_{60}= 9.9837
D_{50}= 4.6089 D_{30}= 0.5328 D_{15}= 0.1044
D_{10}= C_u= C_c=

Classification

USCS= GM AASHTO= A-1-a

Remarks

Sampled by: M. Verquer
Sample date: 2/6/09

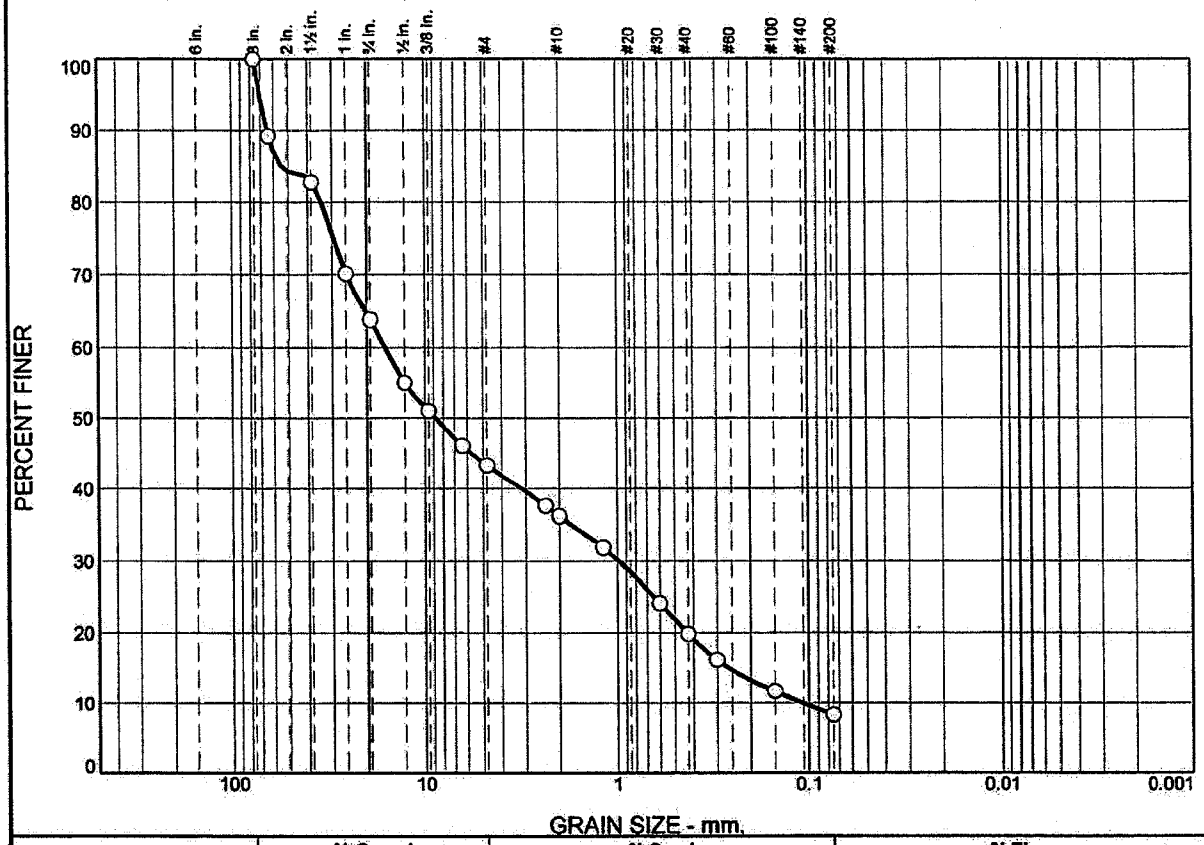
Location: T-7
Sample Number: 0049 **Depth:** 0-5' **Date:** 2/12/09

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040

Client: City of Phoenix
Project: Salt River Bank Stability
Clomar
Project No: 09006 **Lab Number** 09L0049

Tested By: F. Rahimi **Checked By:** R. Anderson

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	36	21	7	16	12	8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3"	100		
2-1/2"	89		
1-1/2"	83		
1"	70		
3/4"	64		
1/2"	55		
3/8"	51		
1/4"	46		
#4	43		
#8	38		
#10	36		
#16	32		
#30	24		
#40	20		
#50	16		
#100	12		
#200	8.3		

* (no specification provided)

Material Description

poorly graded gravel with siltyclay and sand

Atterberg Limits

PL= 19 LL= 24 PI= 5

Coefficients

D_{90}= 64.6764 D_{85}= 54.3539 D_{60}= 16.0705
D_{50}= 8.7938 D_{30}= 0.9817 D_{15}= 0.2596
D_{10}= 0.1069 C_u= 150.39 C_c= 0.56

Classification

USCS= GP-GC AASHTO= A-1-a

Remarks

Sampled by: M. Verquer
Sample date: 2/6/09

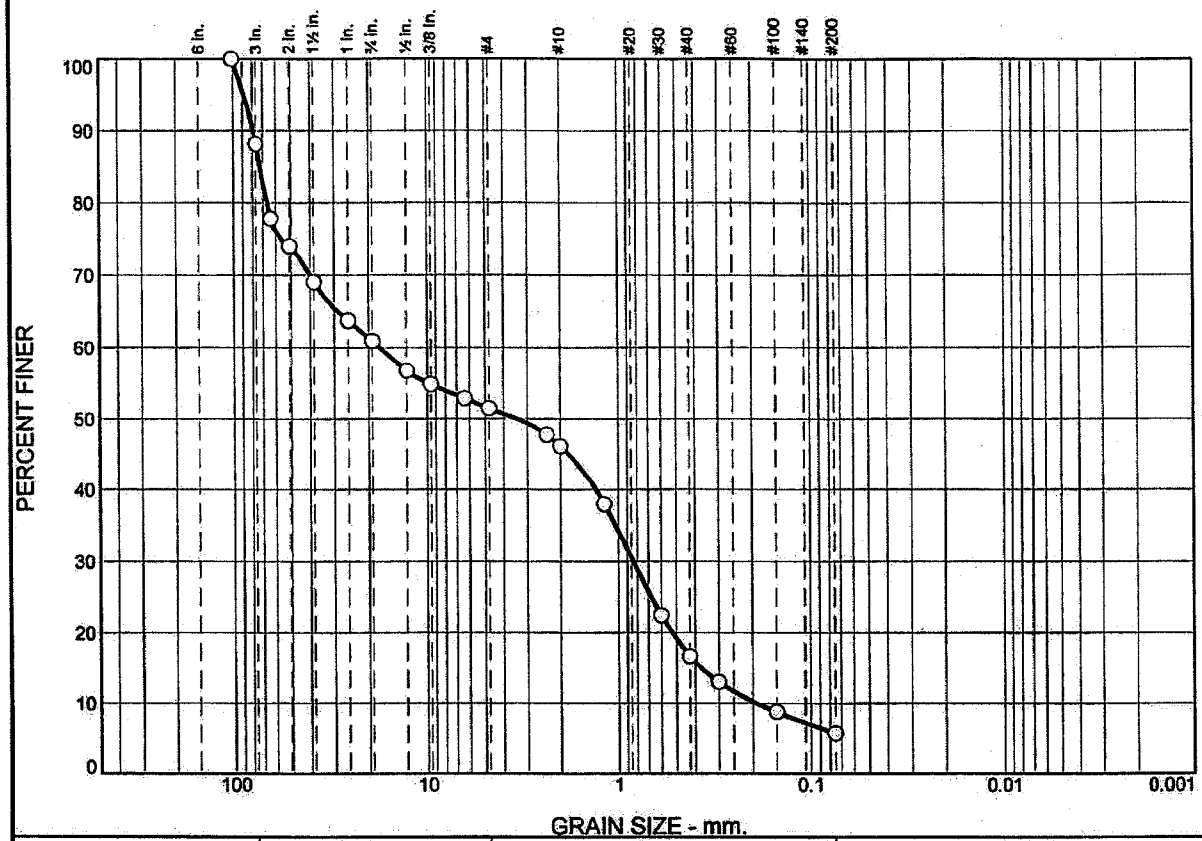
Location: T-8
Sample Number: 0050 **Depth:** 0-5' **Date:** 2/12/09

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040

Client: City of Phoenix
Project: Salt River Bank Stability
Clomar
Project No: 09006 **Lab Number** 09L0050

Tested By: F. Rahimi **Checked By:** R. Anderson

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
12	27	10	5	29	11	6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
4"	100		
3"	88		
2-1/2"	78		
2"	74		
1-1/2"	69		
1"	64		
3/4"	61		
1/2"	57		
3/8"	55		
1/4"	53		
#4	51		
#8	48		
#10	46		
#16	38		
#30	22		
#40	17		
#50	13		
#100	9		
#200	5.8		

* (no specification provided)

Material Description

poorly graded sand with silt and gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 78.8534 D_{85}= 72.3466 D_{60}= 17.5135
D_{50}= 3.3813 D_{30}= 0.8355 D_{15}= 0.3695
D_{10}= 0.1910 C_u= 91.70 C_c= 0.21

Classification

USCS= SP-SM AASHTO= A-1-b

Remarks

Sampled by: M. Verquer
Sample date: 2/6/09

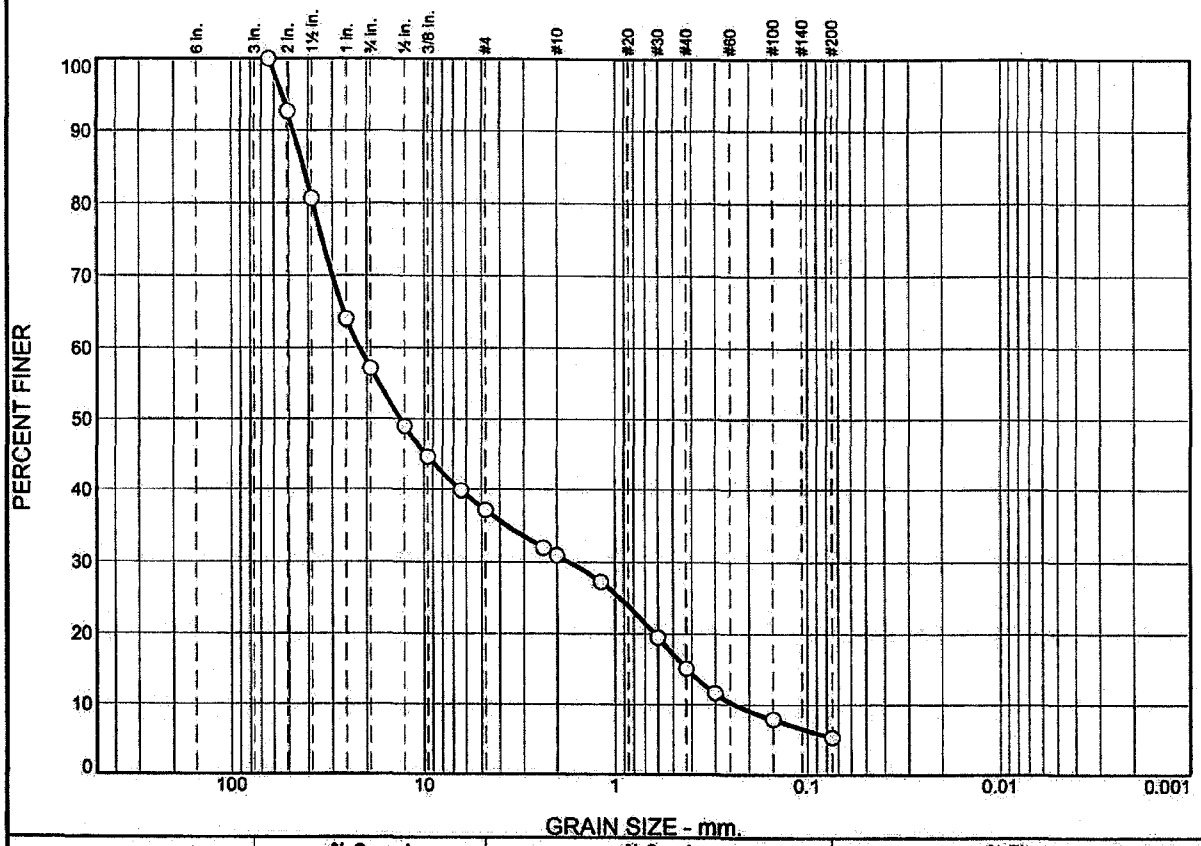
Location: T-9
Sample Number: 0051 **Depth:** 0-5' **Date:** 2/12/09

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040

Client: City of Phoenix
Project: Salt River Bank Stability
Clomar
Project No: 09006 **Lab Number** 09L0051

Tested By: R. Rahimi **Checked By:** R. Anderson

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	43	20	6	16	10	5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2-1/2"	100		
2"	93		
1-1/2"	81		
1"	64		
3/4"	57		
1/2"	49		
3/8"	45		
1/4"	40		
#4	37		
#8	32		
#10	31		
#16	27		
#30	20		
#40	15		
#50	12		
#100	8		
#200	5.3		

* (no specification provided)

Material Description

poorly graded gravel with silt and sand

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 47.4126 D_{85}= 42.0822 D_{60}= 21.8264
D_{50}= 13.4814 D_{30}= 1.7354 D_{15}= 0.4219
D_{10}= 0.2365 C_u= 92.29 C_c= 0.58

Classification

USCS= GP-GM AASHTO= A-1-a

Remarks

Sampled by: M. Verquer
Sample date: 2/6/09

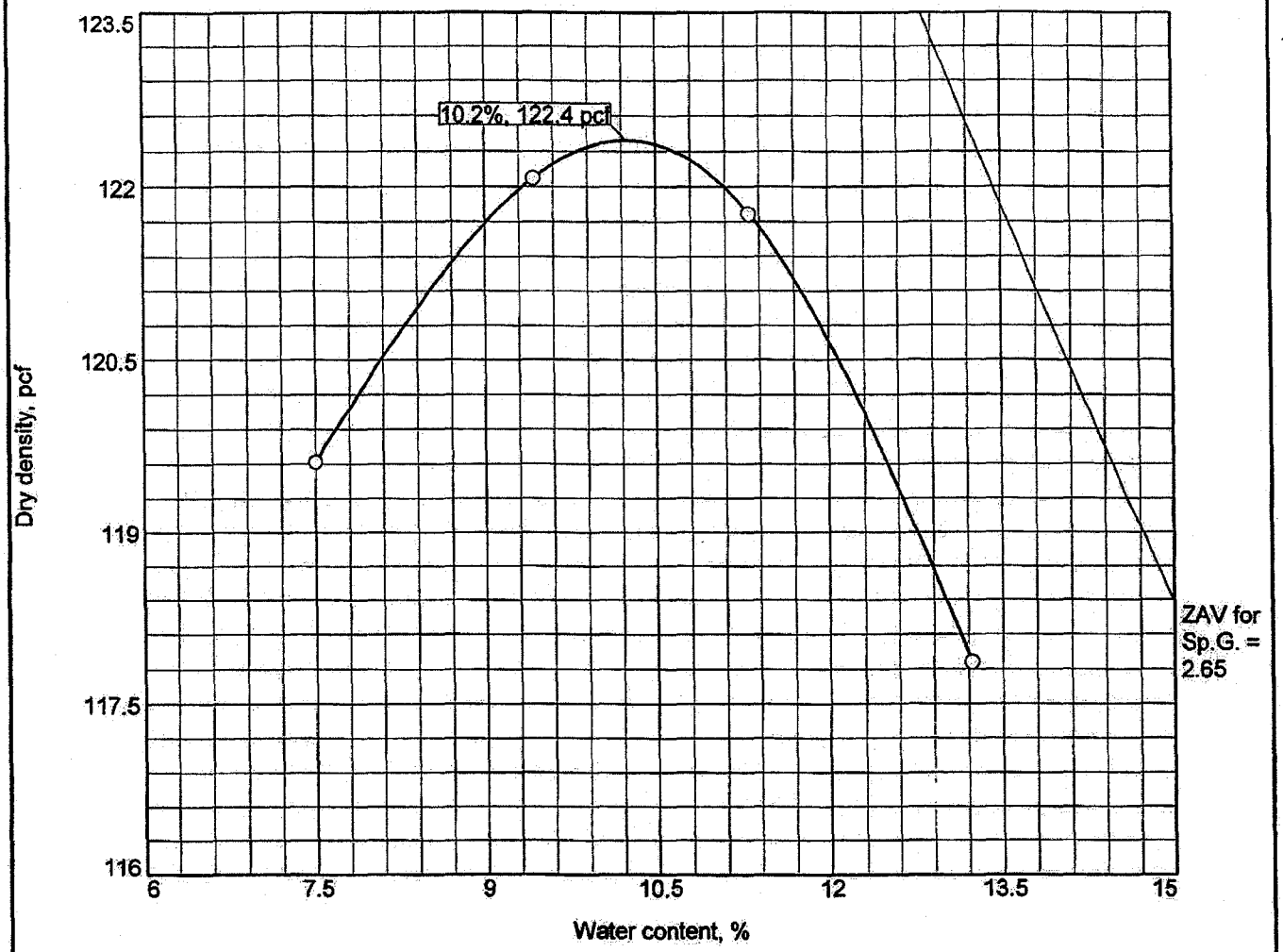
Location: T-10
Sample Number: 0052 **Depth:** 0-5' **Date:** 2/12/09

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040

Client: City of Phoenix
Project: Salt River Bank Stability
Clomar
Project No: 09006 **Lab Number** 09L0052

Tested By: A. Collinwood **Checked By:** R. Anderson

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
0-5'								

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 122.4 pcf Optimum moisture = 10.2 %	

Project No. 09006 **Client:** City of Phoenix
Project: Salt River Bank Stability
Clomar
○ **Loc.:** T-5 & T-6 Composite Sample **Depth:** 0-5' **Sample No.:** CS-1

Hoque & Associates, Inc.
4325 South 34th Street
Phoenix, Arizona 85040

Remarks:
Sampled by: M. Verquer
Sample date: 2/6/09

Lab Number CS-1

Tested By: F. Rahimi **Checked By:** R. Anderson

Appendix E

Slope Stability

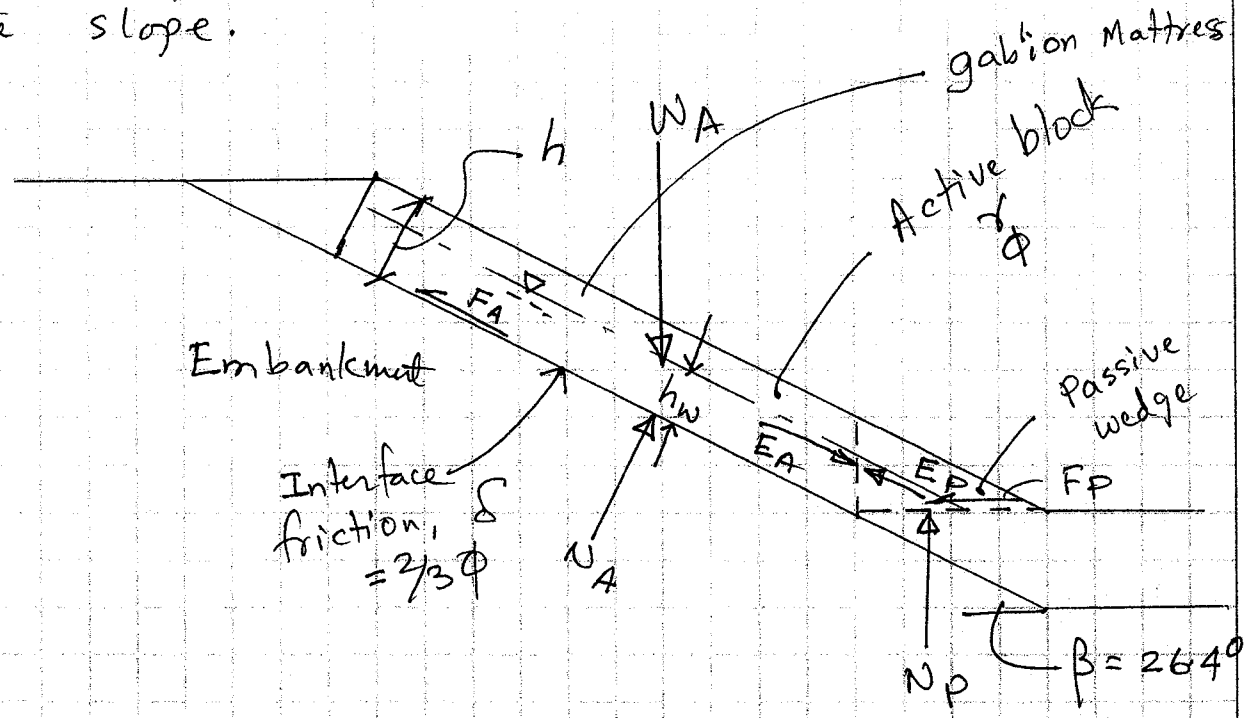
HOQUE & ASSOCIATES Consulting Engineers	Project Name: RW 25L Safety Area Improvement	
	Item: Geotechnical Analysis	Project No.: 09006
	Designed By: E. Hoque	Date: 2/17/09
	Checked By:	Date:

A. SLOPE STABILITY ANALYSIS FOR SOUTH BANK LEVEE

The existing south Bank of the Salt River opposite to the east end of runway RW25L has gabion mattress installed as levee protection. The gabion mattress is laid on the bank slope and levee slope and extend into the river bottom to create an apron. The apron falls in place as the scour occurs and create the inclined surface of the levee below the channel bottom to the scour depth and protect the levee from further scour. The gabion mattress is ~~cod~~ constructed of cobble size particles ~~caged~~ within wire meshed cage and the cage is installed at the ~~bank~~ created and graded bank wall. The levee/created bank wall is constructed of compacted on-site sand and gravel materials. Therefore the gabion mattress is acting as veneer cover and an infinite slope length.

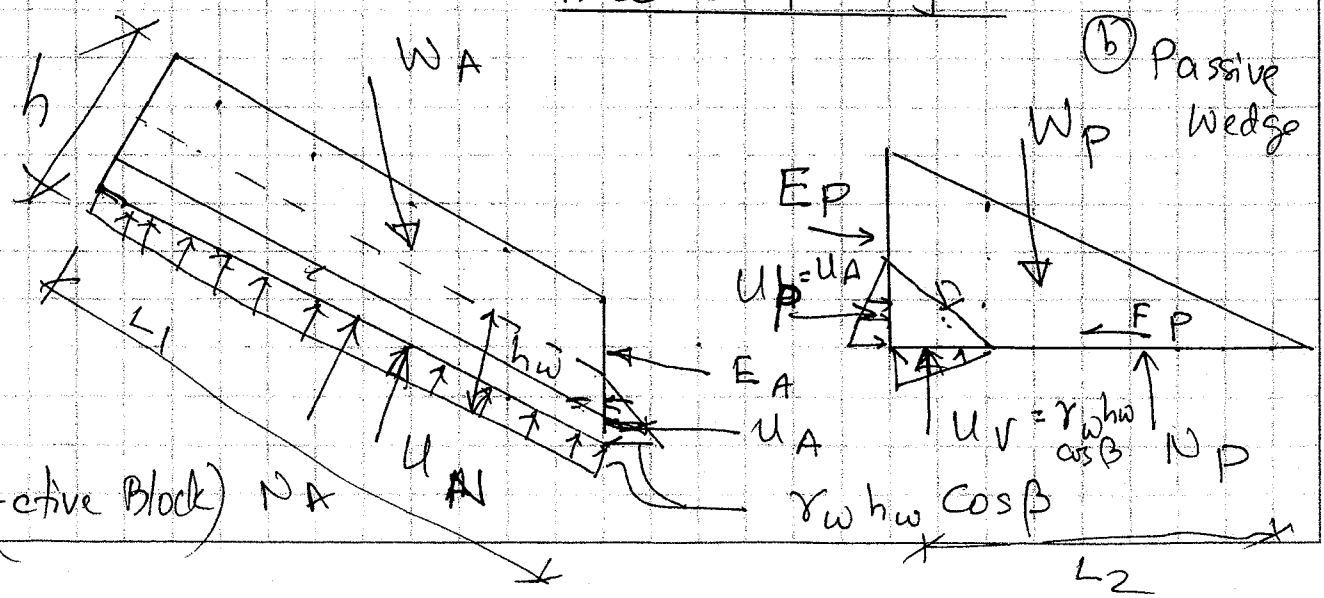
Classical analysis of veneer analysis includes the stability of two soil blocks denoted active and passive. The active block is the mass of soil/gabion mattress on the levee slope. The passive block or wedge is the traingular area of the gabion mattress at the toe that will have to shear/slide horizontally for failure to occur. It is

assumed that there is a vertical boundary between these two blocks, with equal but opposite forces, E_A and E_P, acting on these blocks as shown in sketch below. The direction of these forces is assumed parallel to the slope.



Generic Veneer Slope Definition

Free Body Diagram



HOQUE & ASSOCIATES Consulting Engineers	Project Name:	
	Item:	Project No.:
	Designed By:	Date:
	Checked By:	Date:

As shown in free body diagram:

h = Thickness of gabion mattress = 12" = 1 foot

F = resultant frictional force, subscripts A for active and P for passive blocks

N = resultant normal force

U = Resultant hydrostatic force

L_1 = Length of active block

L_2 = Length of passive wedge

γ_w = unit weight of water = 62.4 lb/cft

γ_s = unit weight of gabion mattress = 140 lb / cft

ϕ = angle of internal friction of gabion riprap = 39°

δ = interface shear angle between gabion mattress and level side slopp

$= 2/3\,\phi = 26^\circ$

B. Calculate Active & Passive Block Forces.

(1.) $$W_A = \gamma_s h^2 \left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2} \right)$$

$$= 140 \left(\frac{30}{1} - \frac{1}{\sin 26.4} - \frac{\tan 26.4}{2} \right)$$

$$= 140 (30 - 2.25 - 0.25)$$

$$= 3920 \text{ lb / ft.}$$

(2) Normal force, $N_A = W_A \cos 26.4$

$N_A = 3511$ lb/ft.

(3) Passive force, $W_p = \dfrac{\gamma_s h^2}{\sin 2\beta}$

$= \dfrac{140 \times 1^2}{\sin 52.8} = 175$ lb/ft.

(4) Hydrostatic force (full submergene, $h = h_w$) on slope caused by submergence of gabion mattress

$U_N = \gamma_w (h_6 \cos\beta) L_1$

$= 62.4 * 1 * \cos 26.4 * 30$

$= 1676.77$ lb/ft.

(5) $U_h = \dfrac{\gamma_w h_w^2}{2} = \dfrac{62.4}{2} * 1^2 = 31.4$ lb/ft

The above forces ~~are~~ E_A, N_A, and W_p are total forces. Now calculate effective forces:

2(a) Effective normal forces, N_A' at active wedge.

$N_A' = W_A \cos 26.4 - U_N + U_h \sin\beta$

$= 3511 - 1676.77 + 31.4 \sin 26.4$

$= 1884$ lb/ft.

3(a) Effective passive weight

$W_p = \dfrac{175}{140} \times (140 - 62.4) = 97$ lb/ft

HOQUE & ASSOCIATES
Consulting Engineers

Project Name:	
Item:	Project No.:
Designed By:	Date:
Checked By:	Date:

6. Hydrostatic uplift force on passive wedge,

$$U_v = \frac{U_h}{\tan\beta} = \frac{31.2}{\tan 26.4} = 62.85 \text{ lb/ft}$$

7. Effective force normal to bottom of passive wedge, $N_p = W_p + E_p \sin\beta - U_v$

$$N_p = 175 + E_p \sin 26.4 - 62.85$$

$$= 112.15 + 0.45 E_p$$

8. Calculate active block reaction force:

$$E_A = W_A \sin\beta - U_h \cos\beta - F_A$$

$$= W_A \sin\beta - U_h \cos\beta - \frac{N_A \tan\delta + C_a \cdot L_1}{FS}$$

FS = factor of safety,

9. Calculate passive block reaction force: E_p.

$$E_p = \frac{(W_p - U_v)\tan\phi - F_s U_h}{(FS)\cos\beta - \sin\beta \tan\phi}$$

10. Equate $E_A = E_p$ and solve for FS = Factor of Safety.

This results in a quadratic equation and according to the solution of quadratic equation.

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

where

$$a = U_h \sin^2\beta + W_A \sin\beta \cos\beta$$

$$b = \sin\beta \tan\phi \left(U_h \cos\beta - W_A \sin\beta\right) - \cos\beta \left(N_A \tan\delta + \underset{\overset{\parallel}{0}}{a} \cdot \frac{h}{\sin\beta}\right) - \tan\phi \left(W_p - U_v\right)$$

$$c = \sin\beta \tan\phi \left(N_A \tan\delta\right)$$

11. Calculate a, b, c.

$$a = 31.2 \cdot \sin^2 26.4 + 3920 \sin 26.4 \cos 26.$$
$$= 6.17 + 1561 = 1567.37$$

HOQUE & ASSOCIATES
Consulting Engineers

Project Name:	
Item:	Project No.:
Designed By:	Date:
Checked By:	Date:

$$b = \sin 26.4 \tan 39 \left(31.2 \cos 26.4 - 3920 \sin 26.4\right) - \cos 26.4 \left(3511 \tan 26\right) - \tan 39 \left(175 - 62.85\right)$$

$$= 0.36\left(28.13 - 1742.97\right) - 1533.84 - 90.81$$

$$= -2241$$

$$c = \sin 26.4 \tan 39 \left(3511 \tan 26\right)$$

$$= 616.57$$

$$\therefore FS = \frac{2241 + \sqrt{(2241)^2 - 4 \times 1567.37 \times 616.57}}{2 * 616.57}$$

$$= \frac{2241 + \sqrt{5022081 - 3865573}}{1233.14}$$

$$= 2.68 > 1.5 \quad \text{O.K}$$

Gabion Mattress and the Levee slope is safe against sudden drawdown as it will be the case due sudden flood of the Salt River.

HOQUE & ASSOCIATES Consulting Engineers	Project Name: RW 25L Safety Area Improvement	
	Item: Geotechnical Analysis	Project No.: 09006
	Designed By: E. Hoque	Date: 2/17/09
	Checked By:	Date:

Slope stability

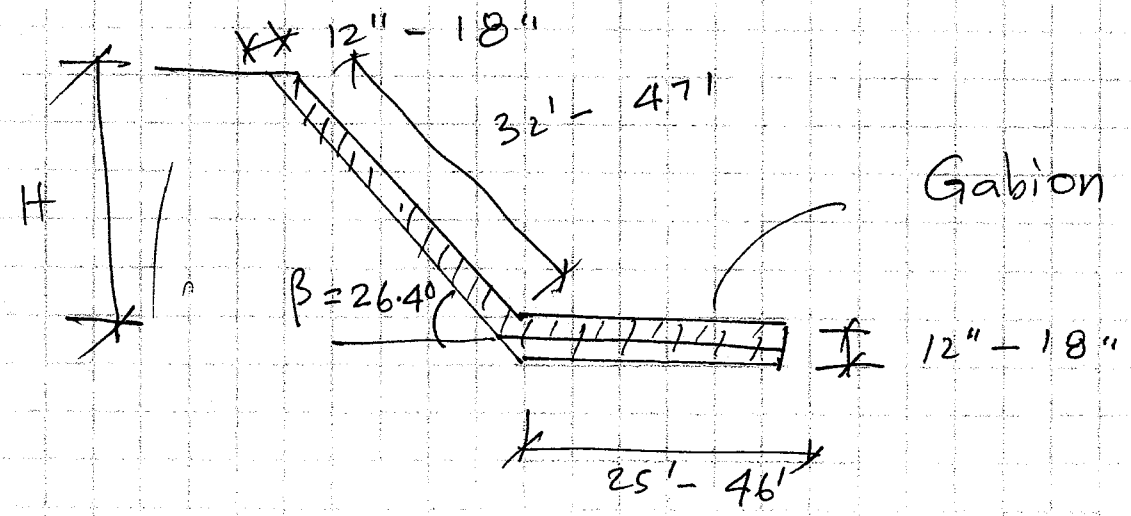
A. SOUTH BANK

1. Gabion Mattress (Without Seepage Force)

An infinite slope stability is completed for gabion mattress.

Gabion mattresses are of following dimensions :

- 12" and 18"
- Length of armoring 30', 40', 45'
- ~~slope~~ Apron Length 25, 30, 35, 40 & 45



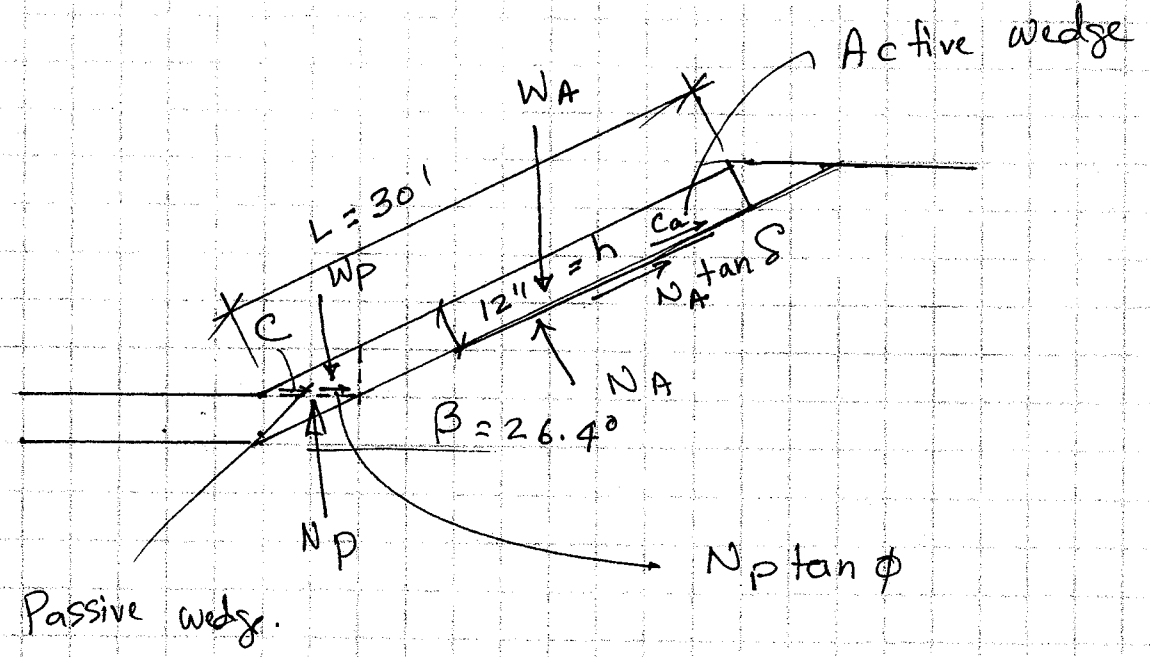
- Unit weight = 140 lb / cft
- Angle of friction --- ≈ 39° *

HOQUE & ASSOCIATES Consulting Engineers	Project Name: RW 25L Safety Area Improvement	
	Item: Geotechnical Design	Project No.: 09006
	Designed By: E. Hoque	Date: 2-17-09
	Checked By:	Date:

- Coheson intercept - - - none

* For angle of internal friction, Arizona Department of Transportations "Outloop Highway Geotechnical Design Criteria" prepared by DeLeau Calter, Inc., a Management consultant was utilized. ADOT Manual / Design criteria specify ϕ for SGC to be 39 - 54°.

- slope angle 2:1 (26.4°)



$$W_A = \gamma h^2 \left[\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2} \right]$$

$$= 140 * \left(\frac{12}{12}\right)^2 \left[\frac{30}{1} - \frac{1}{\sin 26.4} - \frac{\tan 26.4}{2} \right]$$

HOQUE & ASSOCIATES
Consulting Engineers

Project Name:	
Item:	Project No.:
Designed By:	Date:
Checked By:	Date:

$$W_A = 140\,(30 - 2.25 - 0.25)$$
$$= 140 * 28 = 3920 \text{ lb/ft}$$

$$N_A = W_A \cos 26.4 = 3551 \text{ lb/ft}$$

$$W_p = \frac{140 * \left(\frac{12}{12}\right)^2}{\sin 52.8} = 175 \text{ lb/ft}$$

$$a = (W_A - N_A \cos\beta)\cos\beta$$
$$= (3920 - 3551 \cos 26.4)\cos 26.4$$
$$= 662$$

$$b = -\left[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(c + W_p\tan\phi)\right]$$

$$= -\left[(3920 - 3551\cos 26.4)\sin 26.4\tan 39 + (3551\tan(\tfrac{2}{3}\phi) + 0)\sin 26.4\cos 26.4) + \sin 26.4\,(0 + 175\tan 39)\right]$$

$$= -\left[739 * .445 * .81 + (1731) * .445 * .79 + 63\right] = -\left[266 + 689 + 63\right) = -1018.77$$

$$c = (N_A \tan\delta + C_a) \sin^2\beta \tan\phi$$

$$= (3551 \tan 26 + 0) \sin^2 26.4 \tan 39$$

$$= 1731 * 0.1977 * 0.809 = 277.54$$

$$\therefore F.S. = \frac{1018.77 + \sqrt{(1018.77)^2 - 4*277.54*662}}{2*277.54}$$

$$= 2.83 >> 1.5 \quad \text{o.k.}$$

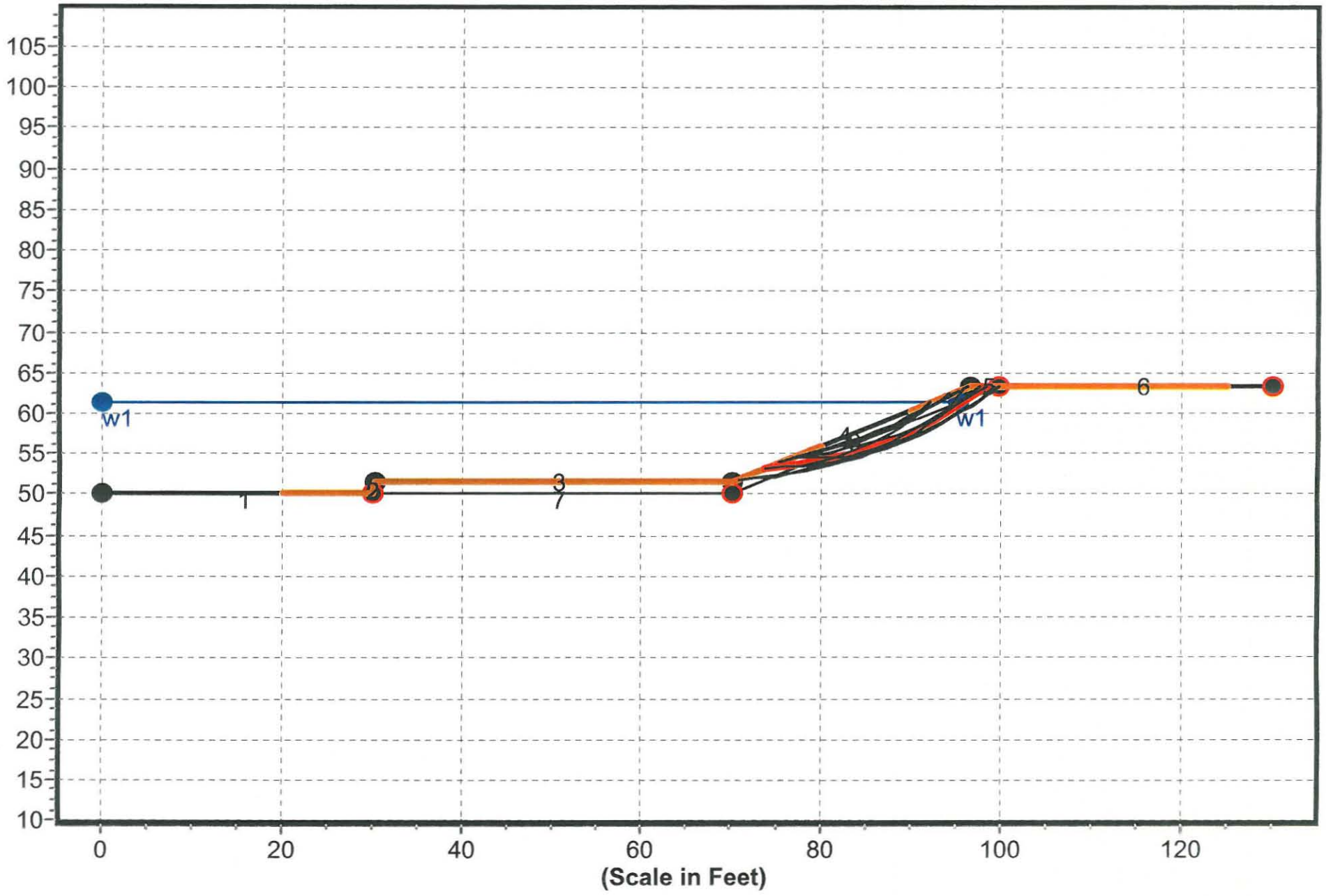
The gabion would be safe against sliding block type failure.

Note: (1) Here the adhesion force between the river bank side wall (embankment face) and the gabion wall is considered to be negligible.

(2) δ = the friction angle between the embankment and gabion mattress is considered to be 2/3 of the internal friction angle.

Geometry and Boundary Conditions

Problem: Rio Salado CLOMR Full Flood Condition 2:1 Slope Static - FS Min = 1.896



** PCSTABL6 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION Rio Salado CLOMR Full Flood Condition 2:
1 Slope Static

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	50.00	30.00	50.00	1
2	30.00	50.00	30.01	51.50	2
3	30.01	51.50	70.00	51.50	2
4	70.00	51.50	96.80	63.40	2
5	96.80	63.40	99.80	63.40	2
6	99.80	63.40	130.00	63.40	1
7	30.00	50.00	70.00	50.00	1
8	70.00	50.00	99.80	63.40	1

1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	130.0	140.0	0.0	39.0	0.00	0.0	1
2	145.0	145.0	0.0	42.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 65.20

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	61.40
2	95.40	61.40

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

1000 Trial Surfaces Have Been Generated.

25 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 20.00 ft.
and X = 80.00 ft.

Each Surface Terminates Between X = 90.00 ft.
and X = 125.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

2.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.85	53.21
2	75.84	53.41
3	77.81	53.70
4	79.78	54.09
5	81.72	54.56
6	83.64	55.13
7	85.53	55.78
8	87.39	56.51
9	89.21	57.33
10	91.00	58.24
11	92.74	59.22
12	94.43	60.29
13	96.07	61.43
14	97.66	62.64
15	98.56	63.40

Circle Center At X = 70.4 ; Y = 96.6 and Radius, 43.5

*** 1.896 ***

Individual data on the 19 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.0	98.3	1100.1	1055.0	0.0	0.0	0.0	0.0	0.0
2	2.0	279.3	969.5	1022.7	0.0	0.0	0.0	0.0	0.0
3	0.7	147.5	334.6	379.2	0.0	0.0	0.0	0.0	0.0
4	1.2	281.2	504.8	599.3	0.0	0.0	0.0	0.0	0.0
5	1.9	543.7	710.7	922.5	0.0	0.0	0.0	0.0	0.0
6	1.9	628.0	584.6	854.9	0.0	0.0	0.0	0.0	0.0
7	1.9	682.2	461.9	775.8	0.0	0.0	0.0	0.0	0.0
8	1.9	706.8	343.7	685.4	0.0	0.0	0.0	0.0	0.0
9	1.8	702.9	230.7	583.8	0.0	0.0	0.0	0.0	0.0
10	1.8	672.0	123.8	471.3	0.0	0.0	0.0	0.0	0.0
11	1.7	616.0	23.6	348.0	0.0	0.0	0.0	0.0	0.0
12	1.7	537.0	0.0	214.4	0.0	0.0	0.0	0.0	0.0
13	0.9	257.0	0.0	57.9	0.0	0.0	0.0	0.0	0.0
14	0.0	12.5	0.0	1.7	0.0	0.0	0.0	0.0	0.0
15	0.7	166.9	0.0	11.0	0.0	0.0	0.0	0.0	0.0
16	0.7	159.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.2	40.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.7	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.9	49.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Failure Surface Specified By 13 Coordinate Points

Point X-Surf Y-Surf

No.	(ft)	(ft)
1	76.92	54.57
2	78.91	54.79
3	80.89	55.11
4	82.84	55.53
5	84.77	56.05
6	86.67	56.68
7	88.54	57.39
8	90.37	58.21
9	92.15	59.11
10	93.88	60.11
11	95.56	61.19
12	97.19	62.37
13	98.47	63.40

Circle Center At X = 73.7 ; Y = 93.2 and Radius, 38.8

*** 1.898 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.77	51.84
2	72.76	52.01
3	74.75	52.28
4	76.71	52.63
5	78.66	53.07
6	80.59	53.60
7	82.49	54.22
8	84.37	54.92
9	86.20	55.71
10	88.00	56.59
11	89.76	57.54
12	91.47	58.57
13	93.14	59.69
14	94.75	60.87
15	96.30	62.13
16	97.73	63.40

Circle Center At X = 68.0 ; Y = 95.5 and Radius, 43.7

*** 1.898 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.77	51.84
2	72.76	52.00
3	74.75	52.24
4	76.72	52.56
5	78.68	52.96
6	80.63	53.43
7	82.55	53.98
8	84.45	54.60
9	86.32	55.30
10	88.17	56.08
11	89.98	56.92
12	91.76	57.84
13	93.50	58.83
14	95.20	59.88
15	96.85	61.00
16	98.46	62.19
17	99.98	63.40

Circle Center At X = 67.7 ; Y = 102.3 and Radius, 50.5

*** 1.947 ***

1

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.85	53.21
2	75.85	53.24
3	77.84	53.38
4	79.83	53.63
5	81.79	53.98
6	83.74	54.45
7	85.65	55.02
8	87.54	55.70
9	89.38	56.48
10	91.17	57.36
11	92.92	58.34
12	94.61	59.41
13	96.23	60.58
14	97.79	61.83
15	99.28	63.17
16	99.51	63.40

Circle Center At X = 74.3 ; Y = 89.4 and Radius, 36.2

*** 1.964 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	76.92	54.57
2	78.85	55.11
3	80.76	55.72
4	82.64	56.38
5	84.51	57.11
6	86.35	57.89
7	88.16	58.74
8	89.94	59.65
9	91.69	60.61
10	93.41	61.63
11	94.77	62.50

Circle Center At X = 61.5 ; Y = 113.4 and Radius, 60.9

*** 2.021 ***

1

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.85	53.21
2	75.84	53.29
3	77.83	53.54
4	79.79	53.94
5	81.71	54.50
6	83.58	55.20
7	85.39	56.06
8	87.12	57.06
9	88.77	58.19
10	90.32	59.45
11	91.77	60.83
12	92.28	61.39

Circle Center At X = 73.8 ; Y = 78.2 and Radius, 24.9

*** 2.029 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	75.39	53.89
2	77.33	54.36
3	79.26	54.89
4	81.16	55.50
5	83.05	56.17
6	84.90	56.92
7	86.73	57.73
8	88.53	58.60
9	90.29	59.54
10	92.02	60.55
11	93.72	61.61
12	95.37	62.74
13	95.44	62.80

Circle Center At X = 63.6 ; Y = 107.5 and Radius, 54.9

*** 2.034 ***

1

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	76.92	54.57
2	78.87	55.04
3	80.79	55.59
4	82.69	56.22
5	84.56	56.92
6	86.40	57.71
7	88.20	58.57
8	89.97	59.51
9	91.70	60.52
10	93.38	61.61
11	94.41	62.34

Circle Center At X = 66.9 ; Y = 100.9 and Radius, 47.4

*** 2.040 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	76.92	54.57
2	78.91	54.39
3	80.91	54.40
4	82.90	54.62
5	84.86	55.03
6	86.77	55.64
7	88.60	56.43
8	90.35	57.41
9	91.99	58.55
10	93.51	59.86
11	94.89	61.30
12	96.11	62.88
13	96.30	63.18

Circle Center At X = 79.8 ; Y = 74.3 and Radius, 20.0

*** 2.052 ***

```
          Y            A     X     I     S            F     T

          0.00      16.25     32.50     48.75     65.00     81.25
X      0.00 +---------+---------+---------+*------W-+---------+
```

```
                 -
                 -
                 -
                 -
                 -
        16.25 +
                 -                                .
                 -                              ...
                 -                             ....
                 -                            .....
                 -                          ......**
A       32.50 +                            .........
                 -                          .........
                 -                         ..........
                 -                        ...........
                 -                        ...........
                 -                       ............
X       48.75 +                         ............
                 -                       .............
                 -                       .............
                 -                       .............
                 -                      ...............
                 -                      ...............
I       65.00 +                        ...............
                 -                      ...............
                 -                      ............**
                 -                      .............31
                 -                      .............312
                 -                       ............12
S       81.25 +                         ............31.
                 -                       ............16
                 -                       ............116
                 -                        ...........126
                 -                         ..........5136
                 -                         ...........41w8
        97.50 +                            ...........52*
                 -                           ............*
                 -                            ............
                 -                             ...........
                 -                              ..........
                 -                               .........
F      113.75 +                                  .........
                 -                                 ........
                 -                                  ......
                 -                                     ...
                 -
T      130.00 +                                        *
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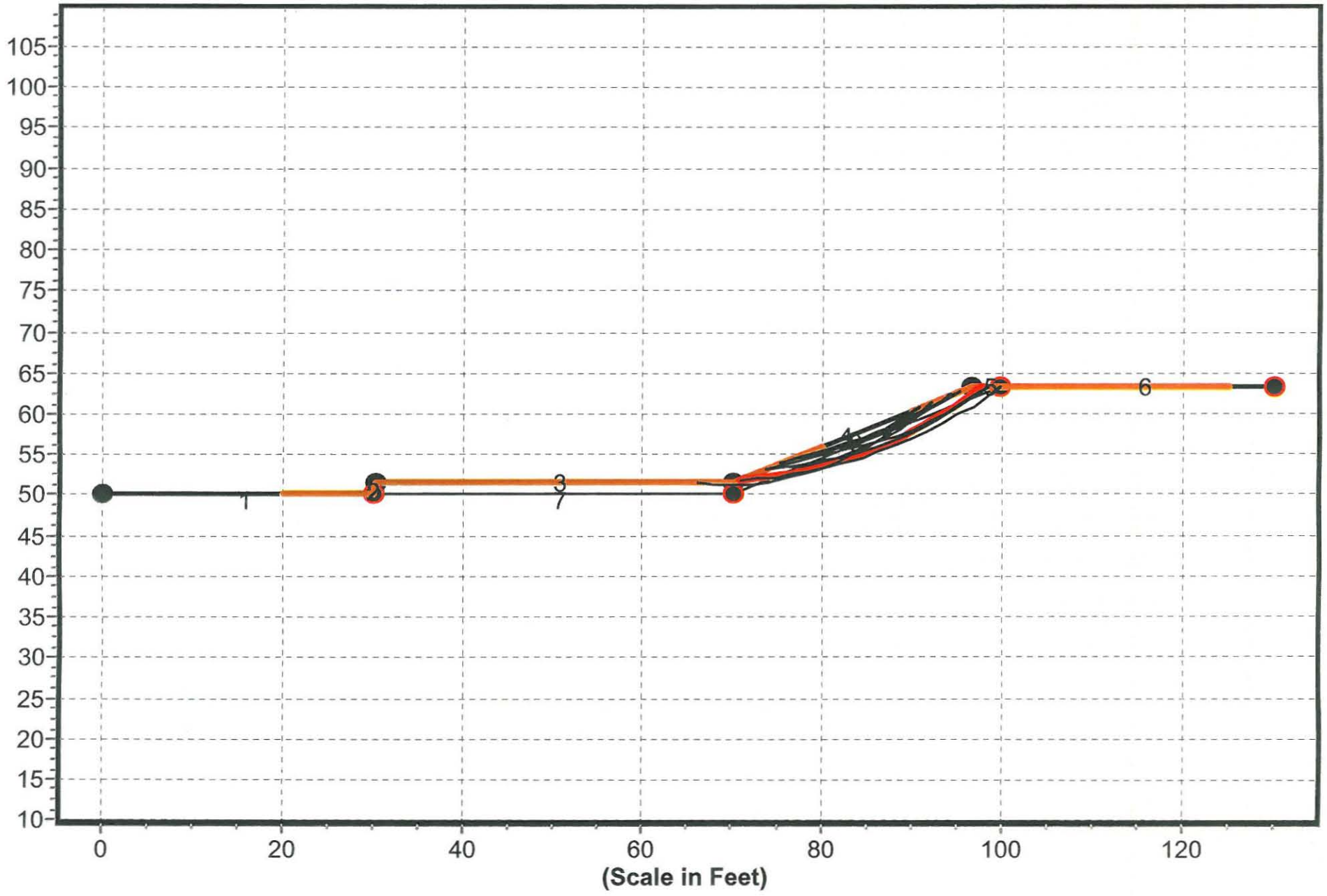
Geometry and Boundary Conditions

Problem: Rio Salado CLOMR No Water Condition 2:1 Slope Pseodostatic - FS Min = 1.636



** PCSTABL6 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: ENGLISH
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION Rio Salado CLOMR No Water Condition 2:1
Slope Pseodostatic

BOUNDARY COORDINATES

6 Top Boundaries
8 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	50.00	30.00	50.00	1
2	30.00	50.00	30.01	51.50	2
3	30.01	51.50	70.00	51.50	2
4	70.00	51.50	96.80	63.40	2
5	96.80	63.40	99.80	63.40	2
6	99.80	63.40	130.00	63.40	1
7	30.00	50.00	70.00	50.00	1
8	70.00	50.00	99.80	63.40	1

1

ISOTROPIC SOIL PARAMETERS

2 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	130.0	140.0	0.0	39.0	0.00	0.0	1
2	145.0	145.0	0.0	42.0	0.00	0.0	1

A Horizontal Earthquake Loading Coefficient
Of0.070 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of0.070 Has Been Assigned

Cavitation Pressure = 0.0 (psf)

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

1000 Trial Surfaces Have Been Generated.

25 Surfaces Initiate From Each Of 40 Points Equally Spaced
Along The Ground Surface Between X = 20.00 ft.
and X = 80.00 ft.

Each Surface Terminates Between X = 90.00 ft.
and X = 125.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = 0.00 ft.

2.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.77	51.84
2	72.76	52.01
3	74.75	52.28
4	76.71	52.63
5	78.66	53.07
6	80.59	53.60
7	82.49	54.22
8	84.37	54.92
9	86.20	55.71
10	88.00	56.59
11	89.76	57.54
12	91.47	58.57
13	93.14	59.69
14	94.75	60.87
15	96.30	62.13
16	97.73	63.40

Circle Center At X = 68.0 ; Y = 95.5 and Radius, 43.7

*** 1.636 ***

Individual data on the 18 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.0	103.1	0.0	0.0	0.0	0.0	7.2	7.2	0.0
2	2.0	294.0	0.0	0.0	0.0	0.0	20.6	20.6	0.0
3	0.5	106.3	0.0	0.0	0.0	0.0	7.4	7.4	0.0
4	1.4	344.1	0.0	0.0	0.0	0.0	24.1	24.1	0.0
5	2.0	566.3	0.0	0.0	0.0	0.0	39.6	39.6	0.0
6	1.9	653.4	0.0	0.0	0.0	0.0	45.7	45.7	0.0
7	1.9	712.4	0.0	0.0	0.0	0.0	49.9	49.9	0.0
8	1.9	743.6	0.0	0.0	0.0	0.0	52.1	52.1	0.0
9	1.8	747.9	0.0	0.0	0.0	0.0	52.4	52.4	0.0
10	1.8	726.6	0.0	0.0	0.0	0.0	50.9	50.9	0.0
11	1.8	681.2	0.0	0.0	0.0	0.0	47.7	47.7	0.0
12	1.7	613.6	0.0	0.0	0.0	0.0	43.0	43.0	0.0
13	1.7	526.0	0.0	0.0	0.0	0.0	36.8	36.8	0.0
14	1.6	420.9	0.0	0.0	0.0	0.0	29.5	29.5	0.0
15	0.7	152.8	0.0	0.0	0.0	0.0	10.7	10.7	0.0
16	0.8	146.5	0.0	0.0	0.0	0.0	10.3	10.3	0.0
17	0.5	67.9	0.0	0.0	0.0	0.0	4.8	4.8	0.0
18	0.9	56.1	0.0	0.0	0.0	0.0	3.9	3.9	0.0

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.85	53.21
2	75.84	53.41
3	77.81	53.70
4	79.78	54.09
5	81.72	54.56
6	83.64	55.13

7	85.53	55.78
8	87.39	56.51
9	89.21	57.33
10	91.00	58.24
11	92.74	59.22
12	94.43	60.29
13	96.07	61.43
14	97.66	62.64
15	98.56	63.40

Circle Center At X = 70.4 ; Y = 96.6 and Radius, 43.5

*** 1.652 ***

1

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	76.92	54.57
2	78.91	54.79
3	80.89	55.11
4	82.84	55.53
5	84.77	56.05
6	86.67	56.68
7	88.54	57.39
8	90.37	58.21
9	92.15	59.11
10	93.88	60.11
11	95.56	61.19
12	97.19	62.37
13	98.47	63.40

Circle Center At X = 73.7 ; Y = 93.2 and Radius, 38.8

*** 1.663 ***

Failure Surface Specified By 12 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.85	53.21
2	75.84	53.29
3	77.83	53.54
4	79.79	53.94
5	81.71	54.50
6	83.58	55.20
7	85.39	56.06
8	87.12	57.06
9	88.77	58.19
10	90.32	59.45
11	91.77	60.83
12	92.28	61.39

Circle Center At X = 73.8 ; Y = 78.2 and Radius, 24.9

*** 1.683 ***

1

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.77	51.84
2	72.76	52.00
3	74.75	52.24
4	76.72	52.56
5	78.68	52.96
6	80.63	53.43
7	82.55	53.98

8	84.45	54.60
9	86.32	55.30
10	88.17	56.08
11	89.98	56.92
12	91.76	57.84
13	93.50	58.83
14	95.20	59.88
15	96.85	61.00
16	98.46	62.19
17	99.98	63.40

Circle Center At X = 67.7 ; Y = 102.3 and Radius, 50.5

*** 1.690 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	76.92	54.57
2	78.85	55.11
3	80.76	55.72
4	82.64	56.38
5	84.51	57.11
6	86.35	57.89
7	88.16	58.74
8	89.94	59.65
9	91.69	60.61
10	93.41	61.63
11	94.77	62.50

Circle Center At X = 61.5 ; Y = 113.4 and Radius, 60.9

*** 1.698 ***

Failure Surface Specified By 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	75.39	53.89
2	77.33	54.36
3	79.26	54.89
4	81.16	55.50
5	83.05	56.17
6	84.90	56.92
7	86.73	57.73
8	88.53	58.60
9	90.29	59.54
10	92.02	60.55
11	93.72	61.61
12	95.37	62.74
13	95.44	62.80

Circle Center At X = 63.6 ; Y = 107.5 and Radius, 54.9

*** 1.711 ***

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	76.92	54.57
2	78.87	55.04
3	80.79	55.59
4	82.69	56.22
5	84.56	56.92
6	86.40	57.71
7	88.20	58.57
8	89.97	59.51

9	91.70	60.52
10	93.38	61.61
11	94.41	62.34

Circle Center At X = 66.9 ; Y = 100.9 and Radius, 47.4

*** 1.712 ***

1

Failure Surface Specified By 11 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	73.85	53.21
2	75.80	53.64
3	77.73	54.17
4	79.63	54.79
5	81.50	55.49
6	83.34	56.29
7	85.13	57.17
8	86.88	58.14
9	88.58	59.19
10	90.23	60.32
11	90.76	60.72

Circle Center At X = 65.7 ; Y = 94.4 and Radius, 42.0

*** 1.719 ***

Failure Surface Specified By 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	66.15	51.50
2	68.14	51.30
3	70.14	51.25
4	72.14	51.34
5	74.13	51.58
6	76.09	51.96
7	78.02	52.48
8	79.91	53.14
9	81.74	53.93
10	83.52	54.86
11	85.22	55.91
12	86.84	57.09
13	88.37	58.37
14	89.80	59.77
15	90.57	60.63

Circle Center At X = 69.9 ; Y = 78.8 and Radius, 27.6

*** 1.720 ***

1

```
            Y            A     X     I     S            F     T

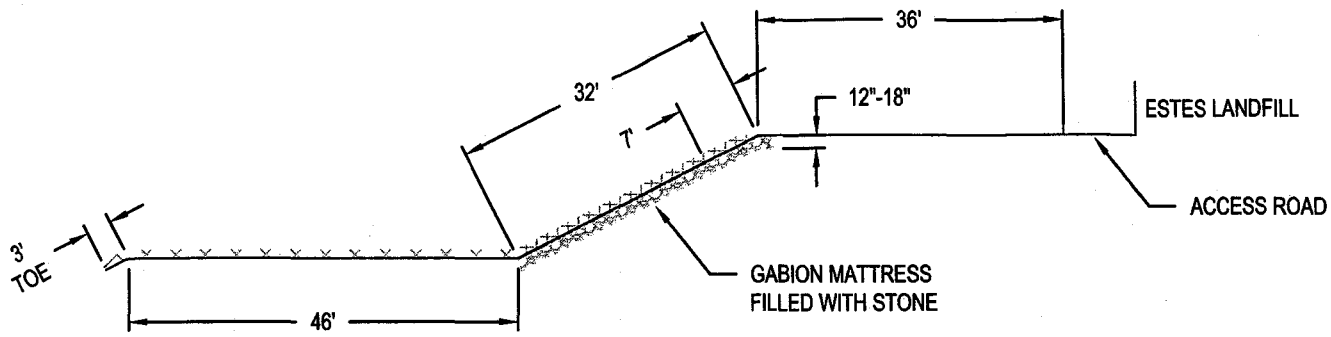
            0.00      16.25     32.50     48.75     65.00     81.25
X       0.00 +---------+---------+---------+*--------+---------+
             -
             -
             -
             -
             -
        16.25 +
             -                                 .
             -                               ...
             -                              ....
             -                             .....
             -                           ......**
A       32.50 +                           ........
```

```
                 -                    .........
                 -                   ..........
                 -                  ...........
                 -                  ...........
                 -                 ............
X       48.75 +                    ............
                 -                .............
                 -                .............
                 -                .............
                 -               ..............
                 -               ..............
I       65.00 +                  .............0
                 -               .............0
                 -               .............**
                 -               .............12
                 -               .............123
                 -                ............013
S       81.25 +                   .............12.
                 -                ..............16
                 -                ..............116
                 -                 .............134
                 -                  ............114
                 -                  ............5127
        97.50 +                    ..............1*
                 -                  ..............*
                 -                   .............
                 -                    ............
                 -                     ...........
                 -                      ..........
F      113.75 +                         ..........
                 -                        .........
                 -                         ........
                 -                          ......
                 -                             ...
                 -
T      130.00 +                                  *
```

Appendix F

Gabion Mattress As-Builts

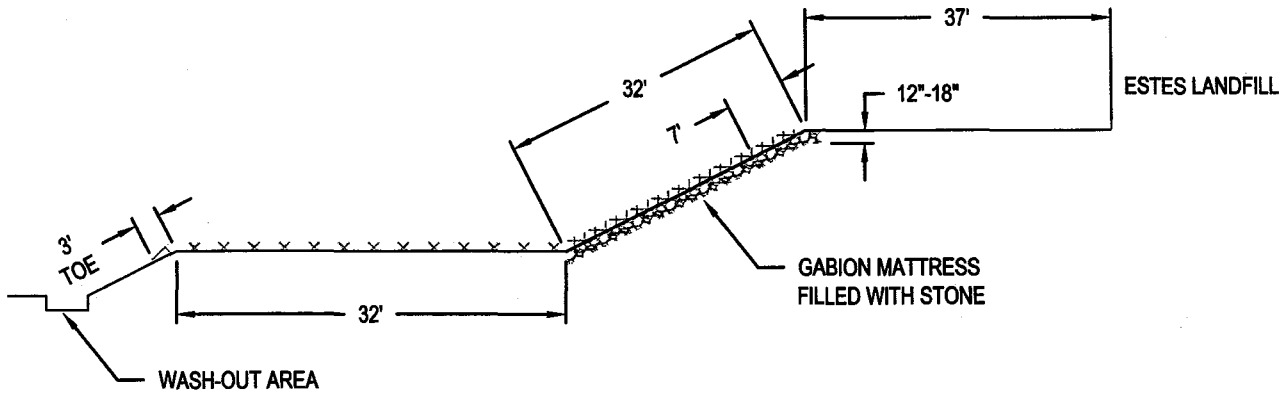
3.3 GABION MATTRESS AS-BUILTS



SIZE (DIAMETER)	# OF STONES
18"	4
12"	9
8"	67
6"	30
3"	10

d_{50} OF GABION =8"

AS-BUILT DETAILS AND STONE COUNT FOR TP-1



SIZE (DIAMETER)	# OF STONES
18"	2
12"	7
8"	40
6"	30
3"	16

d_{50} OF GABION =8"

AS-BUILT DETAILS AND STONE COUNT FOR TP-2

TEST-PIT DIAGRAM
RIVER PROTECTION WORK AT SALT RIVER CHANNEL NEAR THIRD RUNWAY AT SKY-HARBOR INTERNATIONAL AIRPORT PHOENIX, ARIZONA

HA Project # 09006

Hoque & Associates, Inc.
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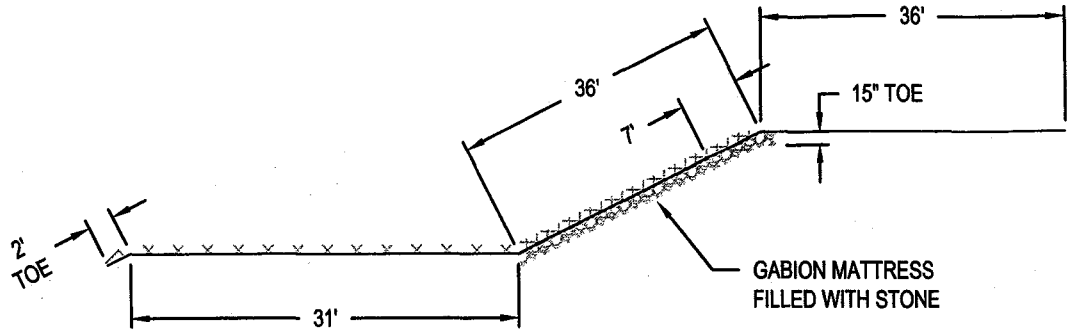
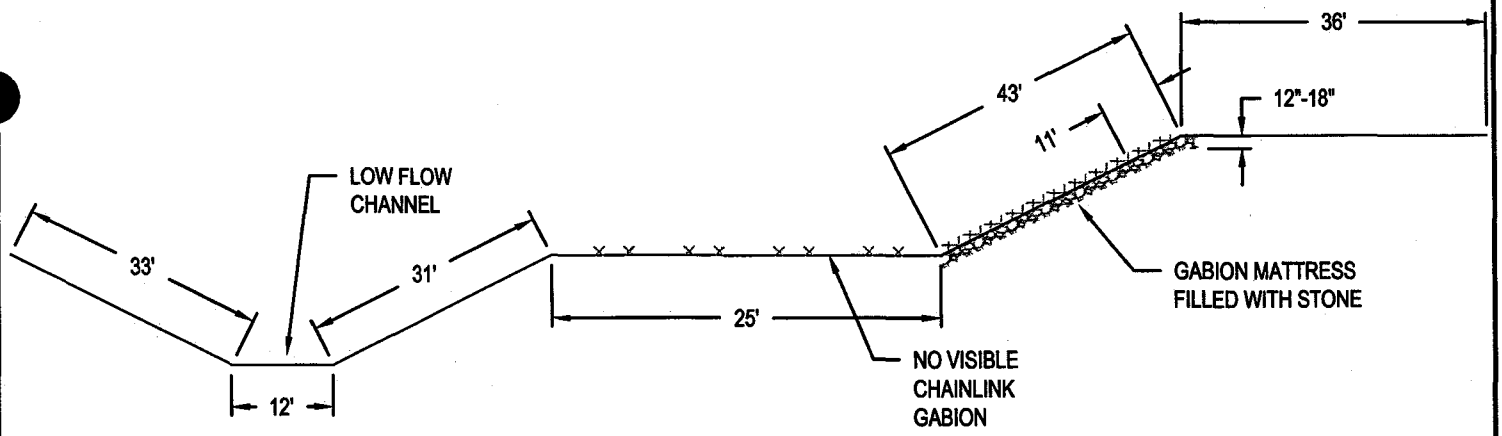
3.3 GABION MATTRESS AS-BUILTS



SIZE (DIAMETER)	# OF STONES
18"	4
12"	17
8"	45
6"	40
3"	17

d_{50} OF GABION =8"

AS-BUILT DETAILS AND STONE COUNT FOR TP-3



SIZE (DIAMETER)	# OF STONES
18"	--
12"	13
8"	50
6"	45
3"	20

d_{50} OF GABION =8"

AS-BUILT DETAILS AND STONE COUNT FOR TP-4

TEST-PIT DIAGRAM
RIVER PROTECTION WORK AT SALT RIVER CHANNEL NEAR THIRD RUNWAY AT SKY-HARBOR INTERNATIONAL AIRPORT PHOENIX, ARIZONA

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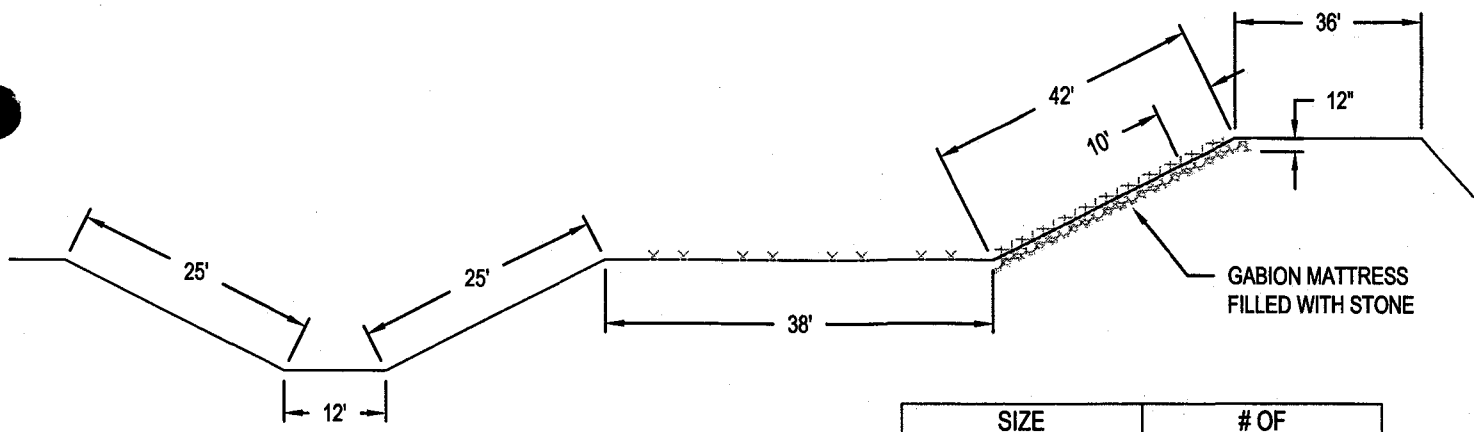
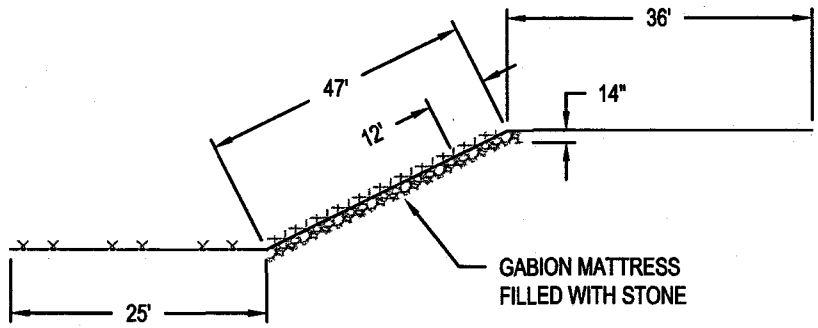
3.3 GABION MATTRESS AS-BUILTS



SIZE (DIAMETER)	# OF STONES
18"	–
12"	10
8"	40
6"	20
3"	14

d_{50} OF GABION =8"

AS-BUILT DETAILS AND STONE COUNT FOR TP-5



SIZE (DIAMETER)	# OF STONES
18"	2
12"	4
8"	55
6"	40
3"	20

d_{50} OF GABION =8"

AS-BUILT DETAILS AND STONE COUNT FOR TP-6

TEST-PIT DIAGRAM
RIVER PROTECTION WORK AT SALT RIVER CHANNEL NEAR THIRD RUNWAY AT SKY-HARBOR INTERNATIONAL AIRPORT PHOENIX, ARIZONA

HA Project # 09006

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