Appendix F – Technical Appendices

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

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GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

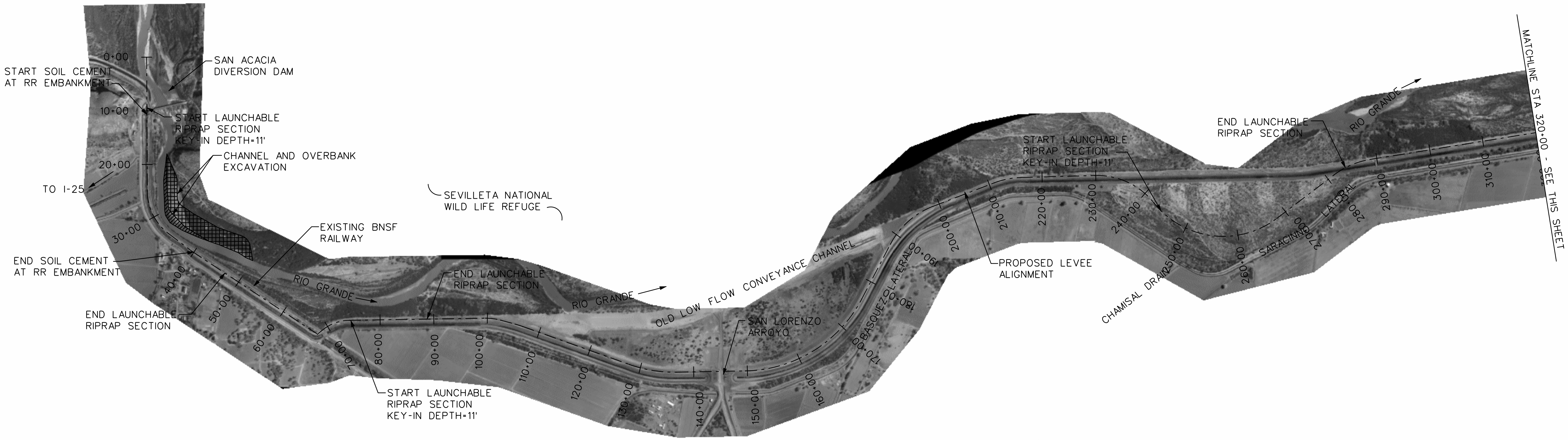
RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

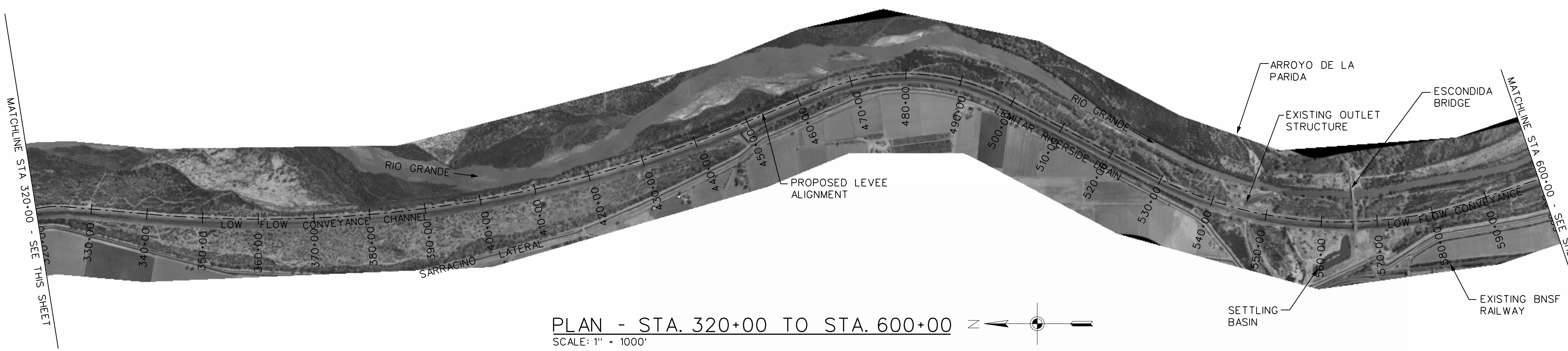
APPENDIX F-1

Civil Engineering



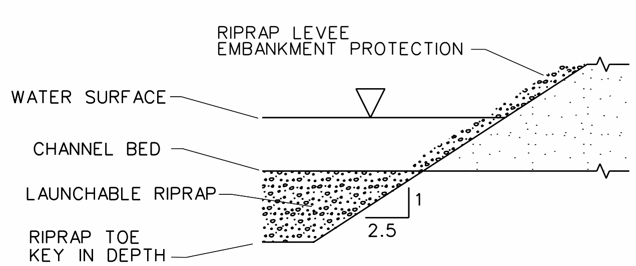
PLAN - STA. 0+00 TO STA. 320+00

SCALE: 1" = 1000'



PLAN - STA. 320+00 TO STA. 600+00

SCALE: 1" = 1000'



TYPICAL LAUNCHABLE RIPRAP SECTION

SCALE: 1" = 10'

GENERAL NOTES

1. ORTHOGRAPHY PHOTOGRAHY PROVIDED BY INTERGRAPH SERVICES COMPANY (ISC) COLLECTED ON FEBRUARY 2007 FOR THE US ARMY CORP OF ENGINEERS DEVELOPED USING DIGITAL ORTHOGRAPHY, NEW MEXICO CENTRAL PLANE, NAD 83.
2. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.

1" = 1000'   0 500' 1000' 2000' 3000'

PRELIMINARY

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr.

File Name: sn01c-101.dgn
Plot Scale: 1:2000
Plot Date: AUGUST 2006
CWIS NO.: 074778
P2 NO.: 104542
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: B. ALANIS

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO

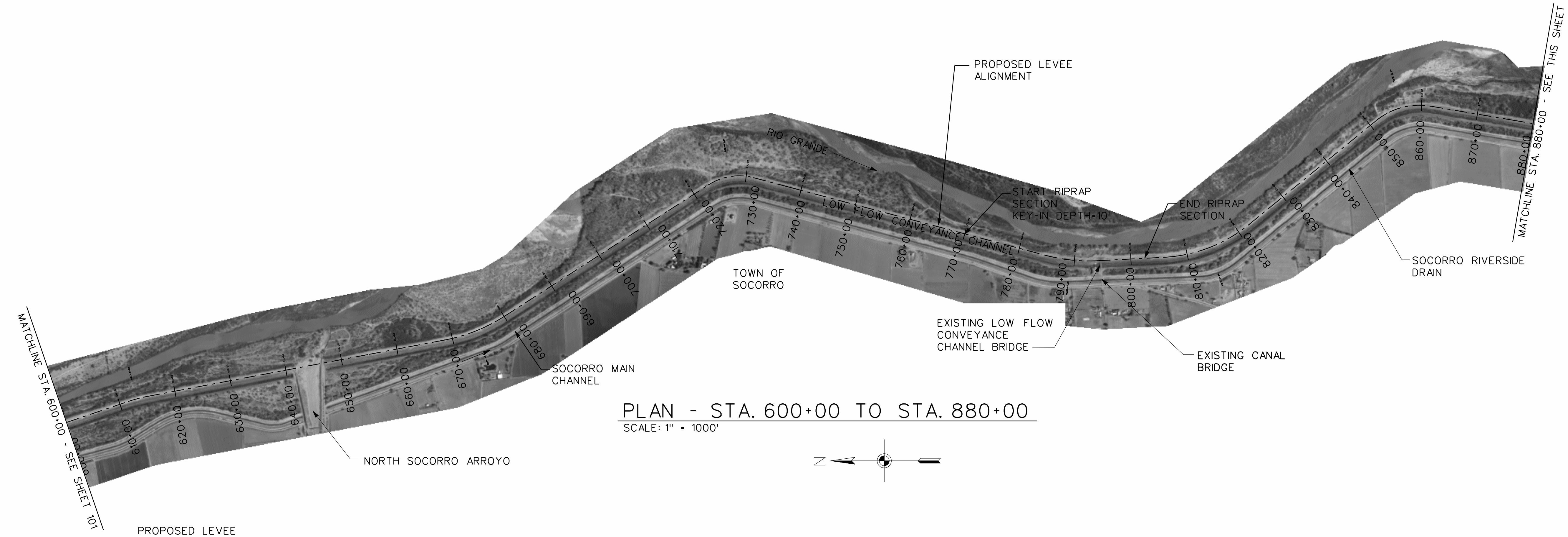
CHIEF, GENERAL ENGINEERING SECTION
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN - STA. 0+00 TO STA. 600+00

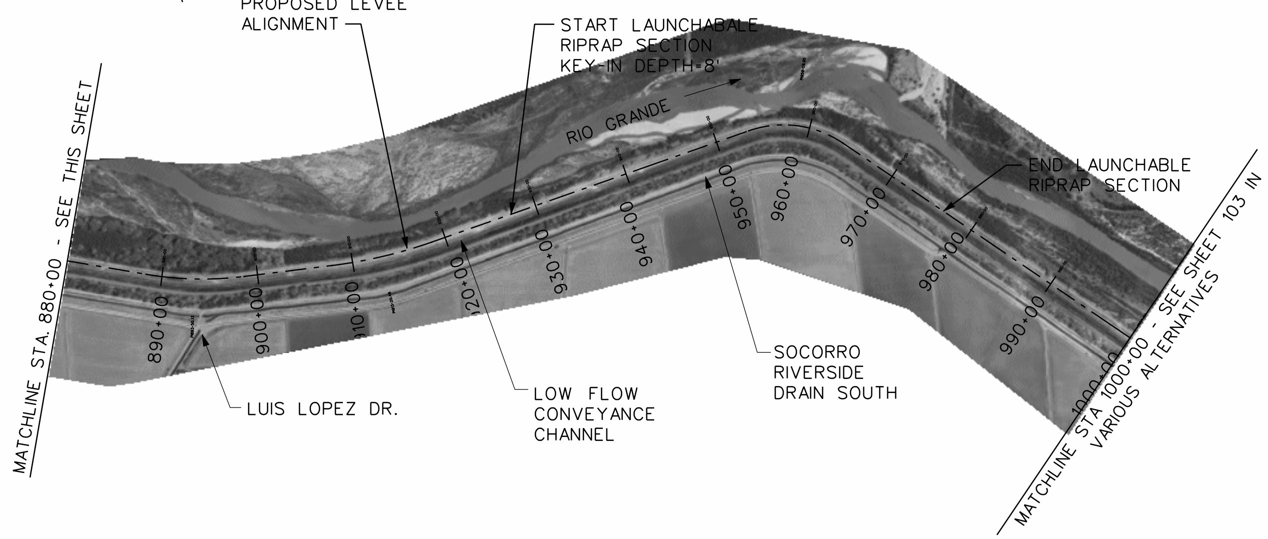
SHEET NO.
C-101
X OF X

SEQUENCE NO.
1



PLAN - STA. 600+00 TO STA. 880+00

SCALE: 1" = 1000'



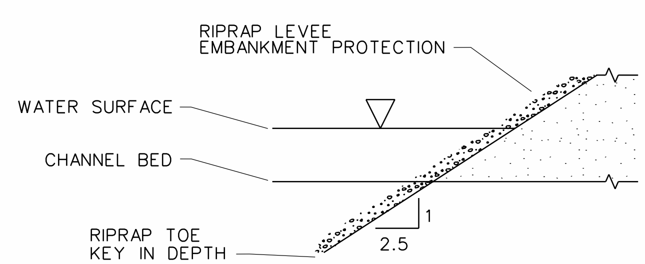
PLAN - STA. 880+00 TO STA. 1000+00

SCALE: 1" = 1000'

GENERAL NOTES

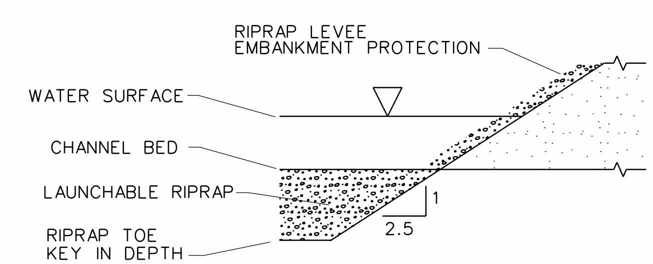
1. ORTHOGRAPHY PHOTOGRAPHY PROVIDED BY INTERGRAPH SERVICES COMPANY (ISC) COLLECTED ON FEBRUARY 2007 FOR THE US ARMY CORP OF ENGINEERS DEVELOPED USING DIGITAL ORTHOGRAPHY, NEW MEXICO CENTRAL PLANE, NAD 83.

2. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.



TYPICAL RIPRAP SECTION

SCALE: 1" = 10'



TYPICAL LAUNCHABLE RIPRAP SECTION

SCALE: 1" = 10'

1" = 1000' 0 500' 1000' 2000' 3000'

PRELIMINARY

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr.

File Name: xxxxc-xxx.dgn
Plot Scale: 1:2000
Plot Date: AUGUST 2006
CWIS NO.: 074778
P2 NO.: 104542
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. CHAVEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

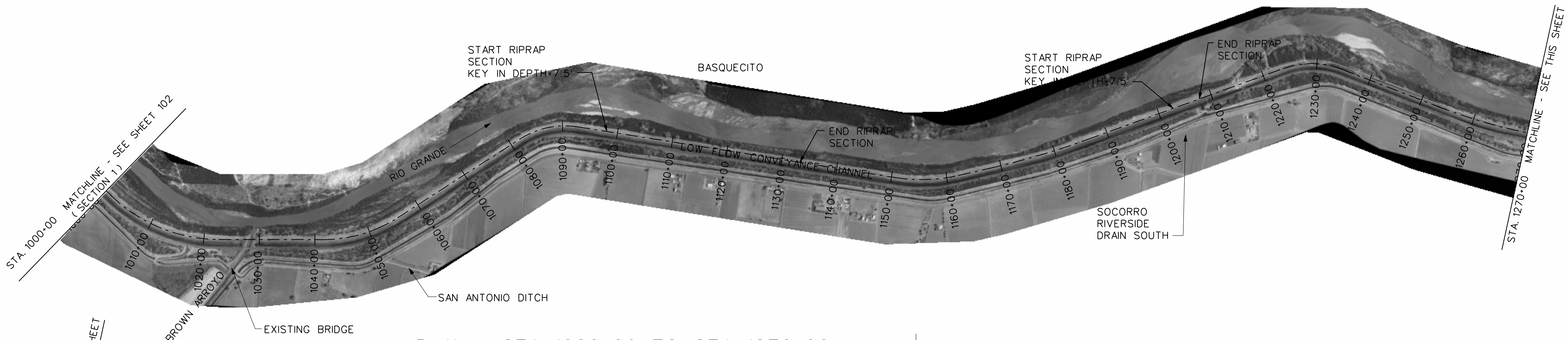
CHIEF, GENERAL ENGINEERING SECTION
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 600+00 TO STA. 1000+00

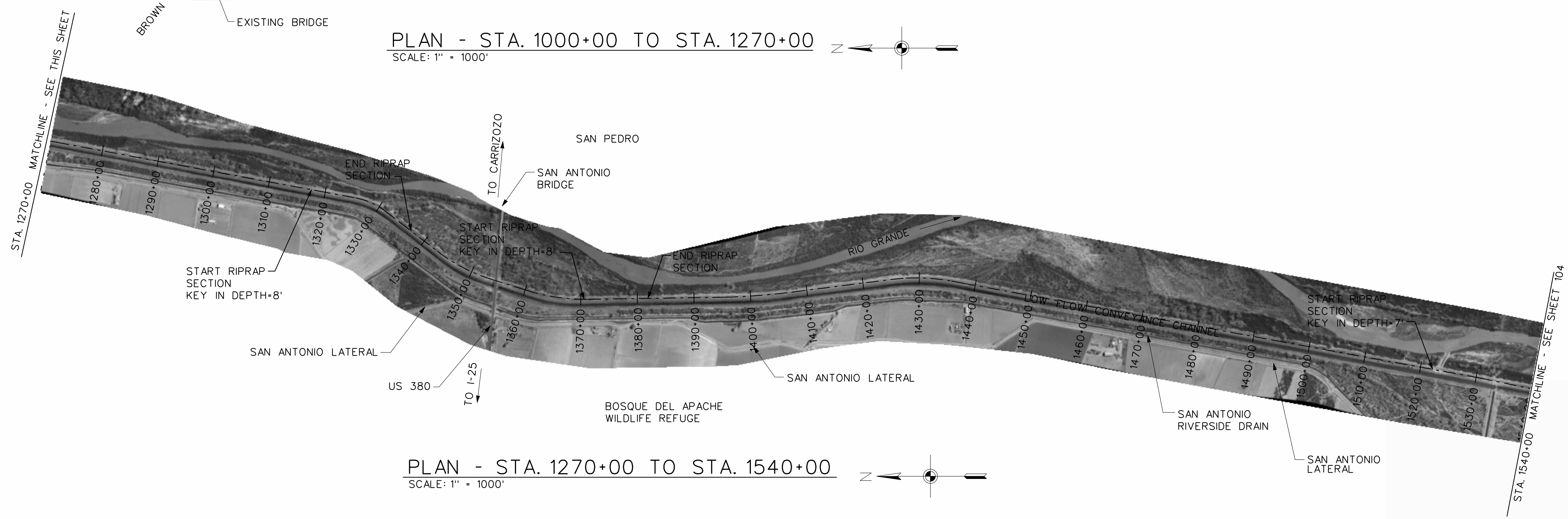
SHEET NO.
C-102
X OF X

SEQUENCE NO.
2



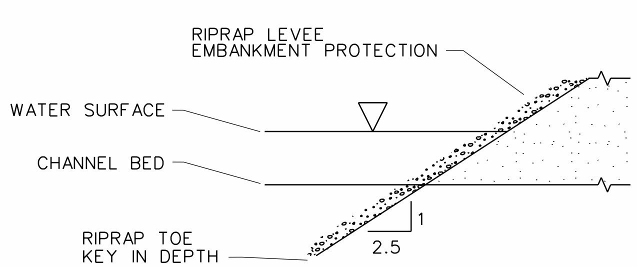
PLAN - STA. 1000+00 TO STA. 1270+00

SCALE: 1" = 1000'



PLAN - STA. 1270+00 TO STA. 1540+00

SCALE: 1" = 1000'



TYPICAL RIPRAP SECTION

SCALE: 1" = 10'

GENERAL NOTES

1. ORTHOGRAPHY PHOTOGRAPHY PROVIDED BY INTERGRAPH SERVICES COMPANY (ISC) COLLECTED ON FEBRUARY 2007 FOR THE US ARMY CORP OF ENGINEERS DEVELOPED USING DIGITAL ORTHOGRAPHY, NEW MEXICO CENTRAL PLANE, NAD 83.

2. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.

1" = 1000' 0 500' 1000' 2000' 3000'

PRELIMINARY

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr

File Name: SN01c-103.dgn
Plot Scale: 1:2000
Plot Date: AUGUST 2006
CWIS NO.: 074778
P2 NO.: 104542
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: B. ALANIS

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

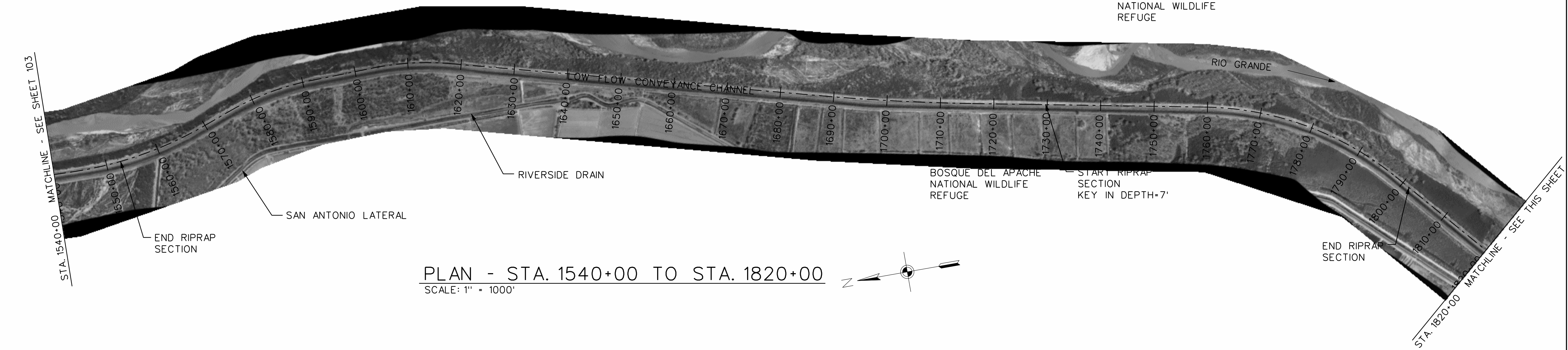
CHIEF, GENERAL ENGINEERING SECTION
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 1000+00 TO STA. 1540+00

SHEET NO.
C-103
X OF X

SEQUENCE NO.
3

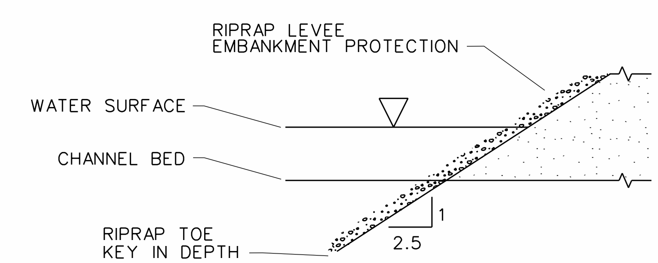


PLAN - STA. 1540+00 TO STA. 1820+00
SCALE: 1" = 1000'

PLAN - STA. 1820+00 TO STA. 2110+00
SCALE: 1" = 1000'

GENERAL NOTES

1. ORTHOGRAPHY PHOTOGRAHY PROVIDED BY INTERGRAPH SERVICES COMPANY (ISC) COLLECTED ON FEBRUARY 2007 FOR THE US ARMY CORP OF ENGINEERS DEVELOPED USING DIGITAL ORTHOGRAPHY, NEW MEXICO CENTRAL PLANE, NAD 83.
2. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.



TYPICAL RIPRAP SECTION
SCALE: 1" = 10'

PRELIMINARY

US Army Corps of Engineers
Albuquerque District

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: B. ALANIS

CWIS NO.: 074778
P2 NO.: 104542
Plot Date: AUGUST 2006

Zero Accidents
Zero Tolerance

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

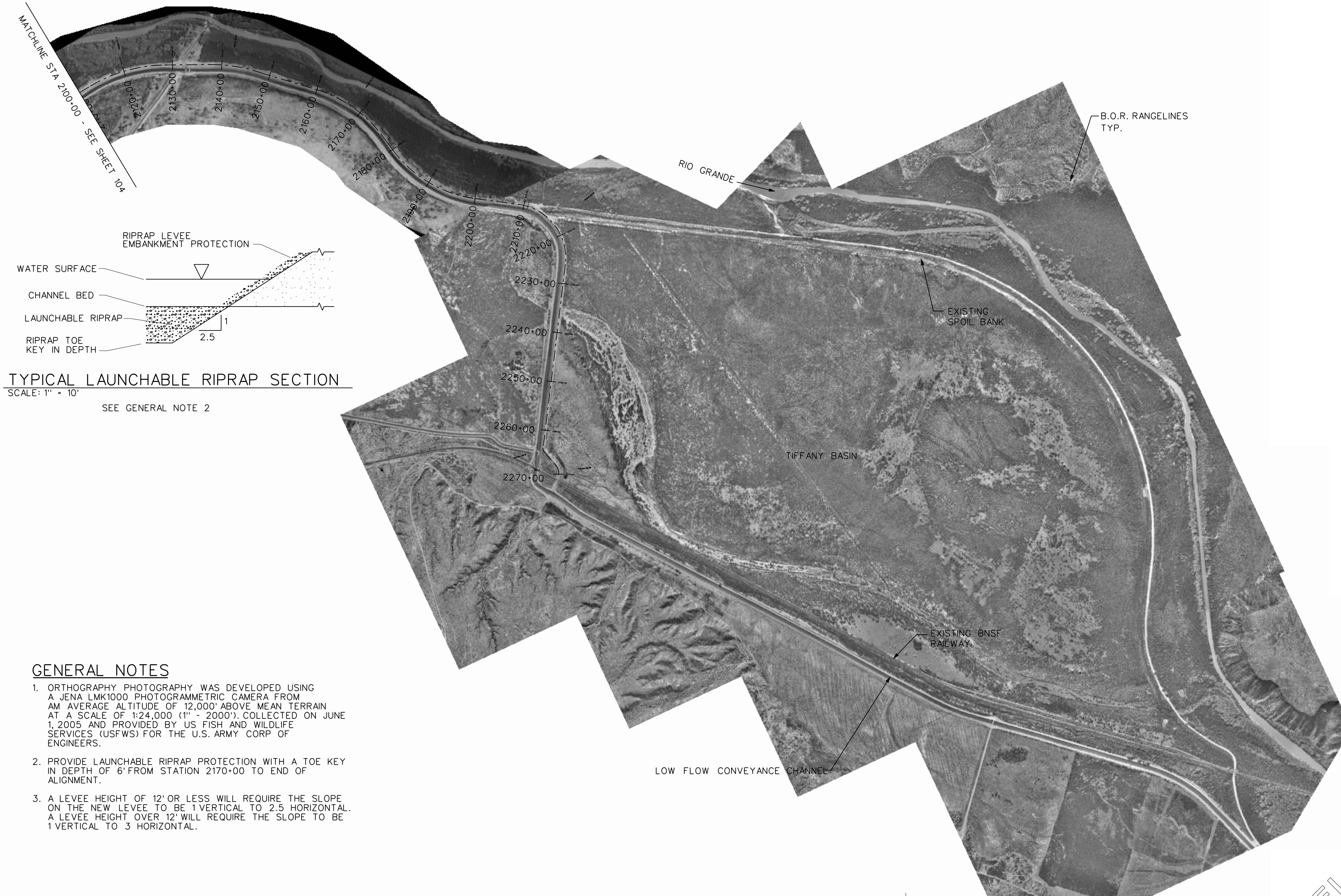
CHIEF, GENERAL ENGINEERING SECTION
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 1540+00 TO STA. 2110+00

SHEET NO.
C-104
X OF X

SEQUENCE NO.
4



TYPICAL LAUNCHABLE RIPRAP SECTION

SCALE: 1" = 10'

SEE GENERAL NOTE 2

GENERAL NOTES

1. ORTHOGRAPHY PHOTOGRAPHY WAS DEVELOPED USING A JENA LMK1000 PHOTOGRAMMETRIC CAMERA FROM AM AVERAGE ALTITUDE OF 12,000' ABOVE MEAN TERRAIN AT A SCALE OF 1:24,000 (1" = 2000'). COLLECTED ON JUNE 1, 2005 AND PROVIDED BY US FISH AND WILDLIFE SERVICES (USFWS) FOR THE U.S. ARMY CORP OF ENGINEERS.
2. PROVIDE LAUNCHABLE RIPRAP PROTECTION WITH A TOE KEY IN DEPTH OF 6' FROM STATION 2170+00 TO END OF ALIGNMENT.
3. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.

PLAN - STA. 2100+00 TO STA. 2270+00

SCALE: 1" = 1000'

1" = 1000' 0 500' 1000' 2000' 3000'

PRELIMINARY

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN01c-105.dgn
Plot Scale: 1-2000
Plot Date: AUGUST 2006
CWIS NO.: 074778
P2 NO.: 104542
Zero Accidents / Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: B. ALANIS

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

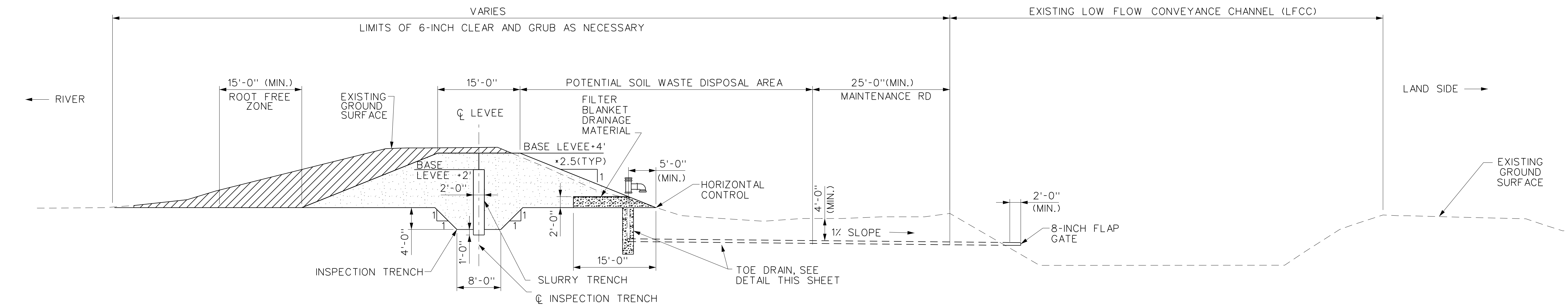
CHIEF, GENERAL ENGINEERING SECTION
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

PLAN-STA. 2100+00 TO STA. 2270+00

SHEET NO.
C-105
X OF X

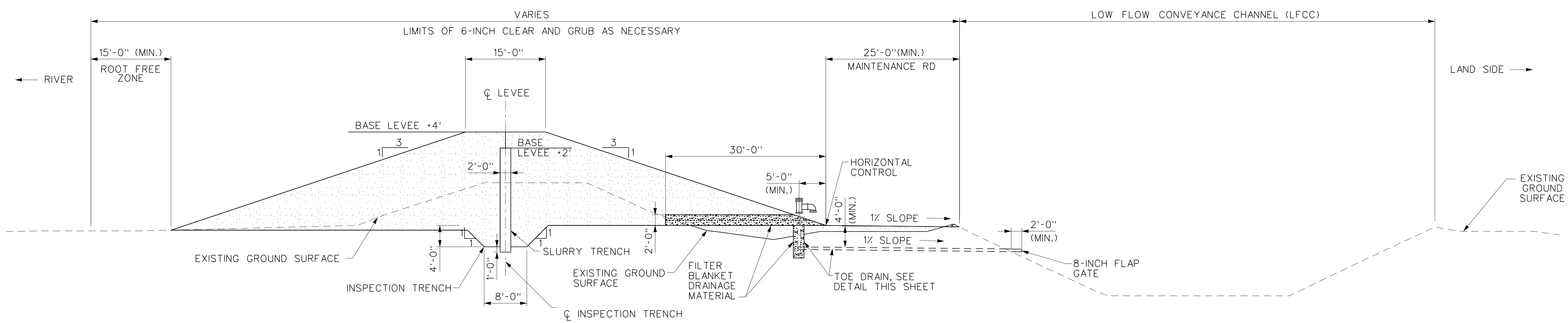
SEQUENCE NO.
5



TYPICAL LEVEE REPLACEMENT SECTION-A

SCALE: 1" = 10'

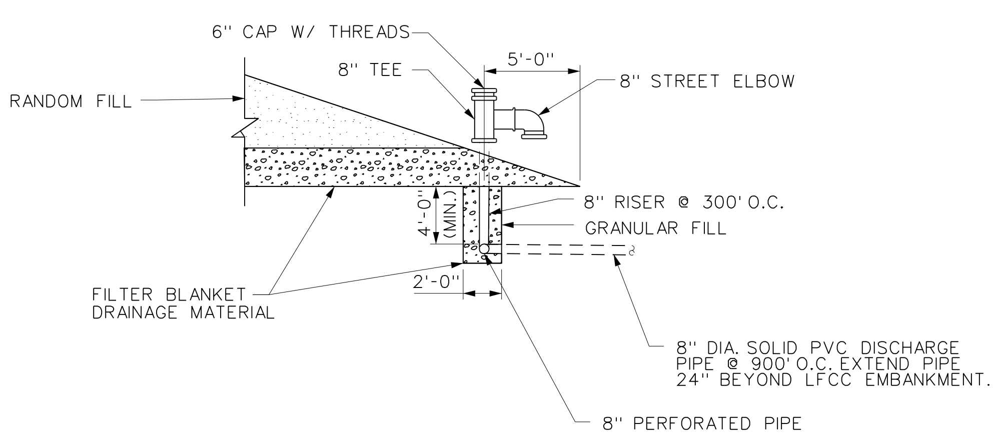
* SEE GENERAL NOTE NO. 1



TYPICAL LEVEE REPLACEMENT SECTION-B

SCALE: 1" = 10'

* SEE GENERAL NOTE NO. 1



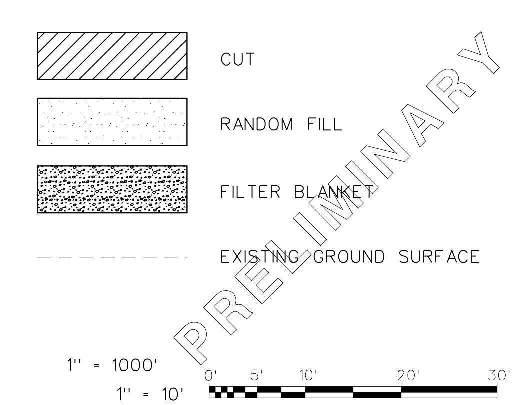
TYPICAL TOE DRAIN DETAIL

SCALE: NOT TO SCALE

GENERAL NOTES

1. A LEVEE HEIGHT OF 12' OR LESS WILL REQUIRE THE SLOPE ON THE NEW LEVEE TO BE 1 VERTICAL TO 2.5 HORIZONTAL. A LEVEE HEIGHT OVER 12' WILL REQUIRE THE SLOPE TO BE 1 VERTICAL TO 3 HORIZONTAL.
2. DELETE TOE DRAIN, SLURRY TRENCH AND INSPECTION TRENCH WHEN HEIGHT OF LEVEE IS 5' OR LESS.
3. EXISTING SPOIL BANK WILL BE DEMOLISHED TO CONSTRUCT NEW LEVEE.
4. GRADING REQUIREMENTS ARE AS SHOWN AND DEPEND ON LEVEE HEIGHT.
5. HORIZONTAL CONTROL WILL BE SET AT THE EXISTING LAND SIDE LEVEE TOE WHEN LEVEE HEIGHT IS SMALLER OR EQUAL TO THE EXISTING LEVEE HEIGHT. HORIZONTAL CONTROL WILL SHIFT TOWARDS LFCC AS LEVEE HEIGHT INCREASES. NEW LEVEE LAND SIDE TOE WILL BE AT MINIMUM 25' FROM LFCC BANK.
6. "TYPICAL LEVEE REPLACEMENT SECTION-A" IS TYPICAL OF THE NEW LEVEE APPROXIMATELY THE SAME HEIGHT OF THE EXISTING LEVEE OR SMALLER. APPROXIMATELY STA. 80+00 (BOR 1219) TO STA. 1900+00 (BOR 1588).
7. "TYPICAL LEVEE REPLACEMENT SECTION-B" IS TYPICAL OF THE NEW LEVEE AT A HEIGHT LARGER THAN THE EXISTING LEVEE. APPROXIMATELY STA. 1900+00 (BOR 1588) TO STA. 2260+00 (BOR 1654).

LEGEND



US Army Corps of Engineers
Albuquerque District

File Name: SN02C-141.DGN
Plot Scale: 100:1
Plot Date: AUGUST 2006
CWIS NO.: 074778
P2 NO.: 104542
Zero Accidents Zero Tolerance

DESIGN BY: SEE COVER
DRAWN BY: SEE COVER
REVIEWED BY: SEE COVER

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

CHIEF:
DATE:

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
LIMITED RE-EVALUATION REPORT

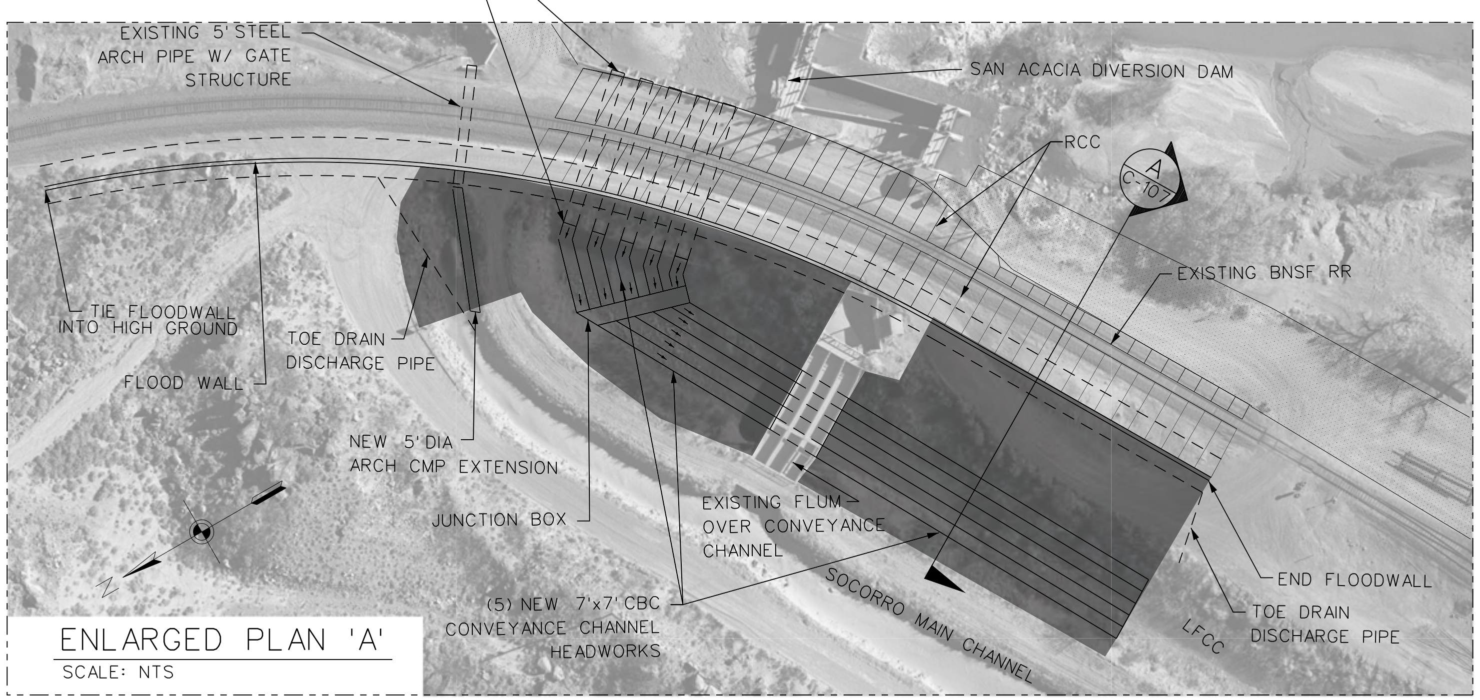
LEVEE SECTIONS AND DETAILS

SHEET NO.
C-106
x OF x

SEQUENCE NO.
6

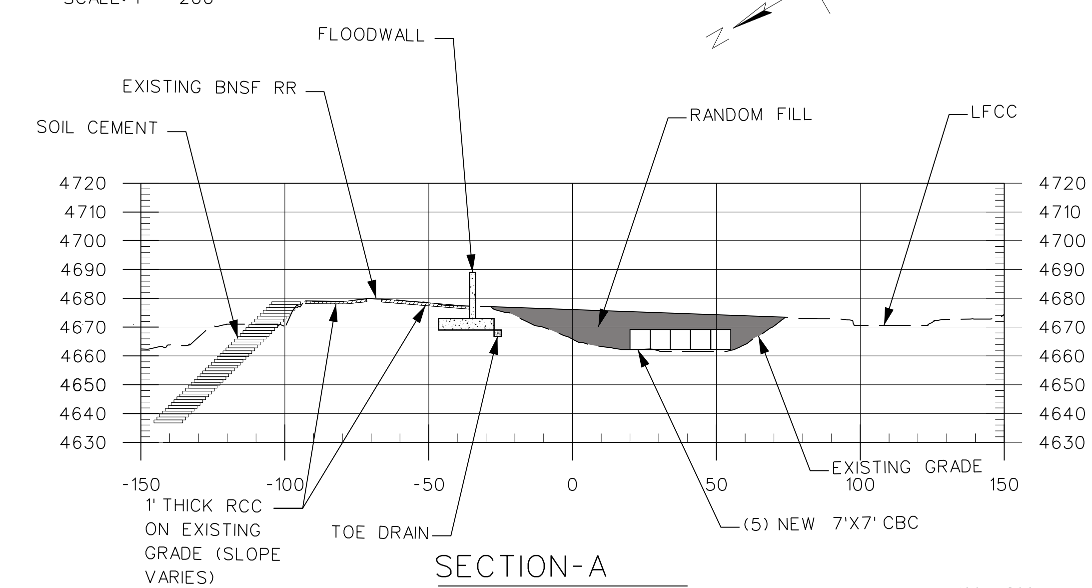
SITE PLAN -SAN ACACIA DIVERSION DAM

SCALE: 1" = 200'



ENLARGED PLAN 'A'

SCALE: NTS



SECTION-A

SCALE: NTS

1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr.

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

File Name: sn02c-107.dgn
Plot Date: January 2012
Plot Scale: 2001
CWIS NO.
P2 NO.

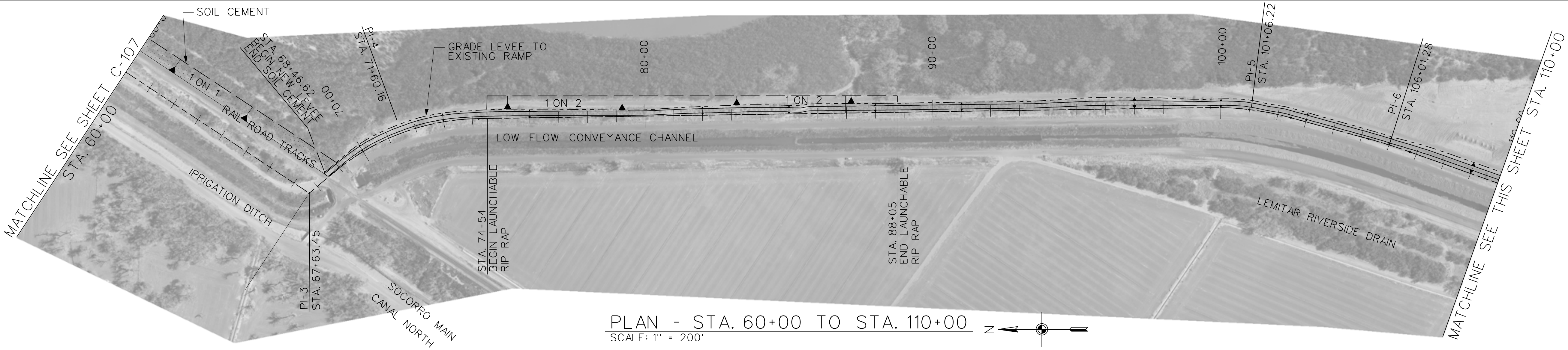
Zero Accidents
Zero Tolerance

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

SAN ACACIA DIVERSION DAM
- SITE PLAN

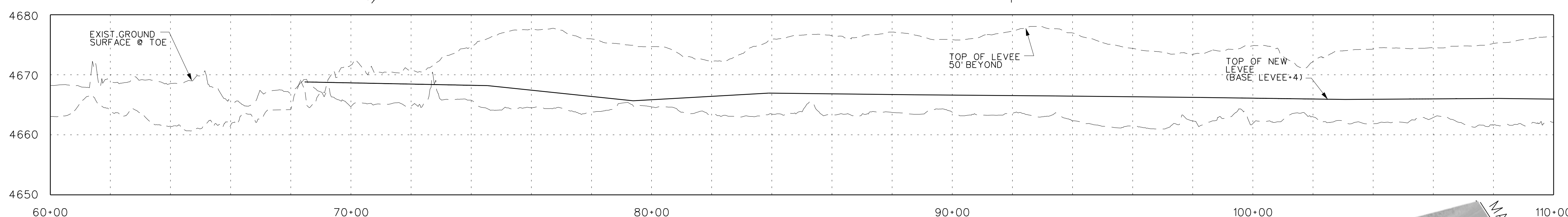
SHEET NO.
C-107
X OF X

SEQUENCE NO.
7



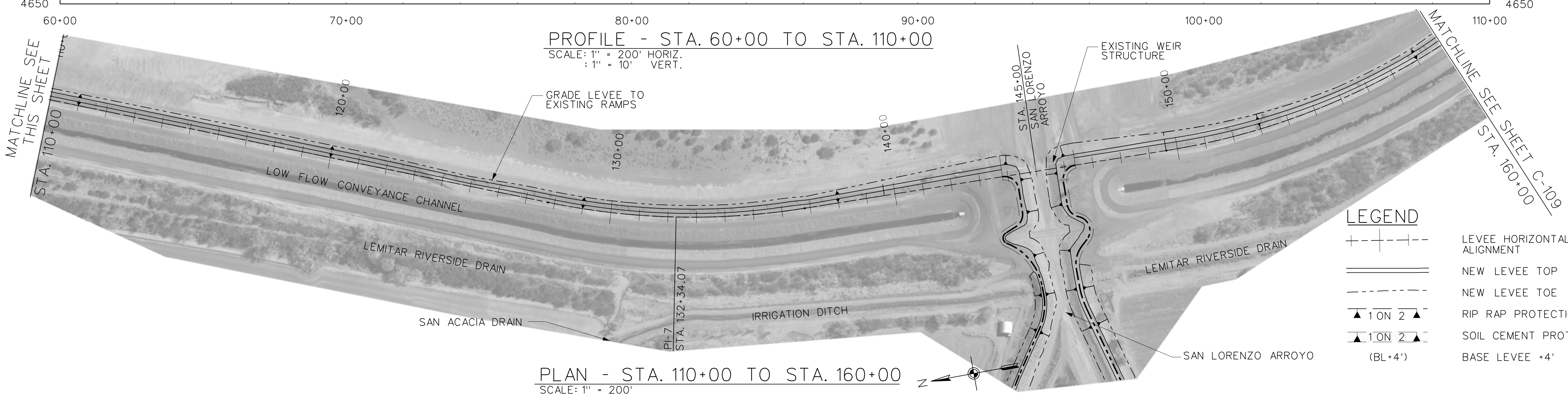
PLAN - STA. 60+00 TO STA. 110+00

SCALE: 1" = 200'



PROFILE - STA. 60+00 TO STA. 110+00

SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

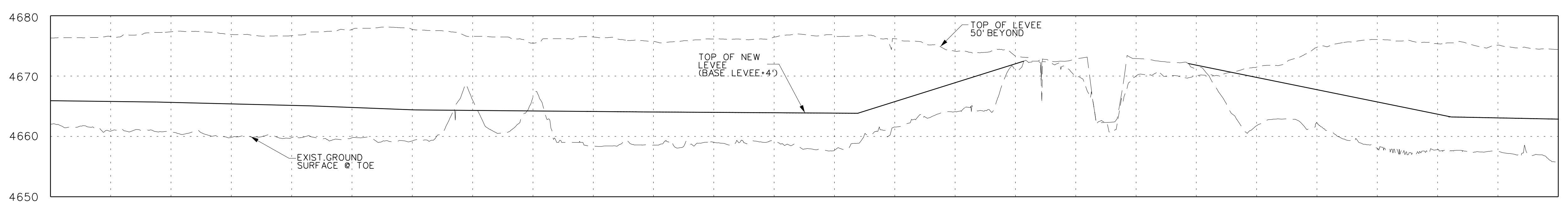


PLAN - STA. 110+00 TO STA. 160+00

SCALE: 1" = 200'

LEGEND

	LEVEE HORIZONTAL ALIGNMENT
	NEW LEVEE TOP
	NEW LEVEE TOE
1 ON 2	RIP RAP PROTECTION
1 ON 2	SOIL CEMENT PROTECTION
(BL+4')	BASE LEVEE +4'



PROFILE - STA. 110+00 TO STA. 160+00

SCALE: 1" = 200' HORIZ.
: 1" = X' VERT.

1" = 40' 0' 20' 40' 80' 120'

1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-108.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

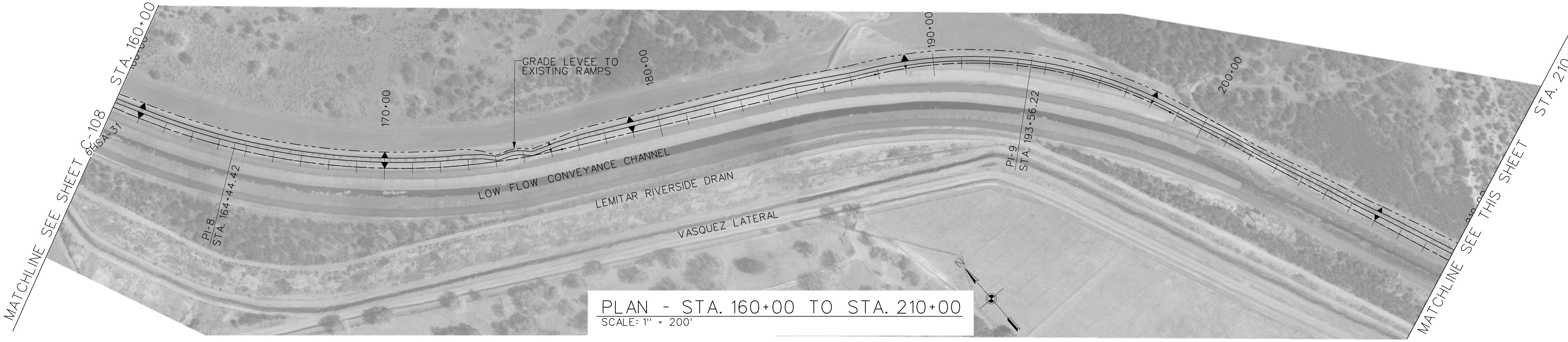
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

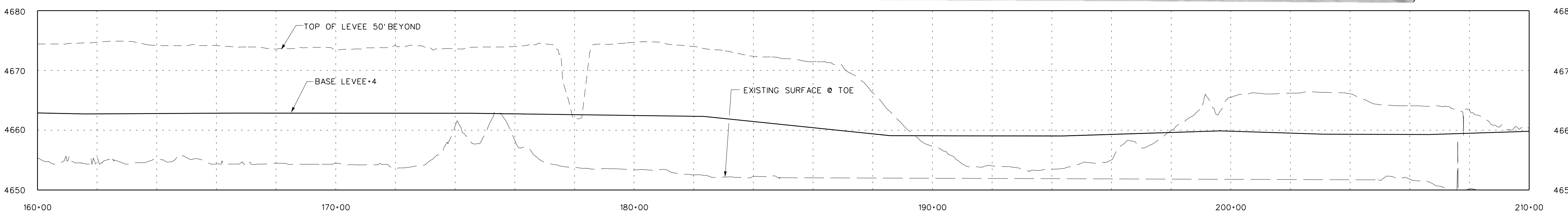
PLAN AND PROFILE
STA. 60+00 TO STA. 160+00

SHEET NO.
C-108
X OF X

SEQUENCE NO.
8



PLAN - STA. 160+00 TO STA. 210+00
SCALE: 1" = 200'

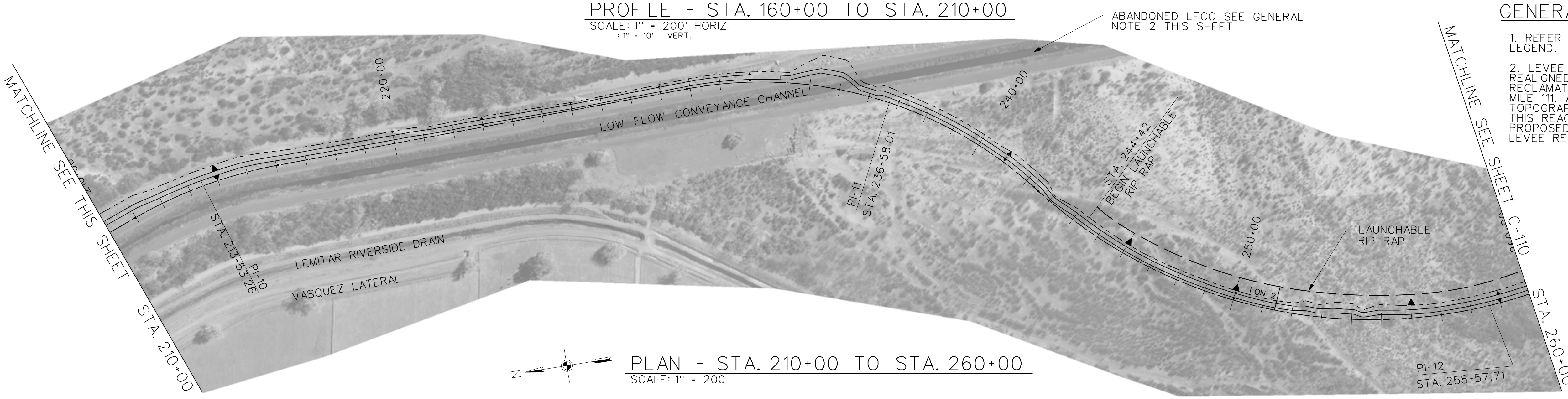


PROFILE - STA. 160+00 TO STA. 210+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

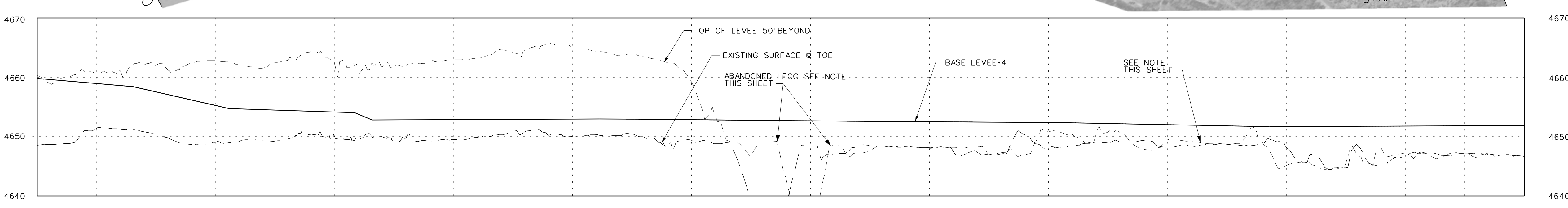
GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

2. LEVEE AND LFCC HAVE BEEN REALIGNED BY BUREAU OF RECLAMATION (BOR) AT RIVER MILE 111. AERIAL PHOTO AND TOPOGRAPHY PROVIDED ALONG THIS REACH IS NOT CURRENT. PROPOSED LEVEE FOLLOWS BOR LEVEE REALIGNMENT.



PLAN - STA. 210+00 TO STA. 260+00
SCALE: 1" = 200'



PROFILE - STA. 210+00 TO STA. 260+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

1" = 200'
0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-113.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

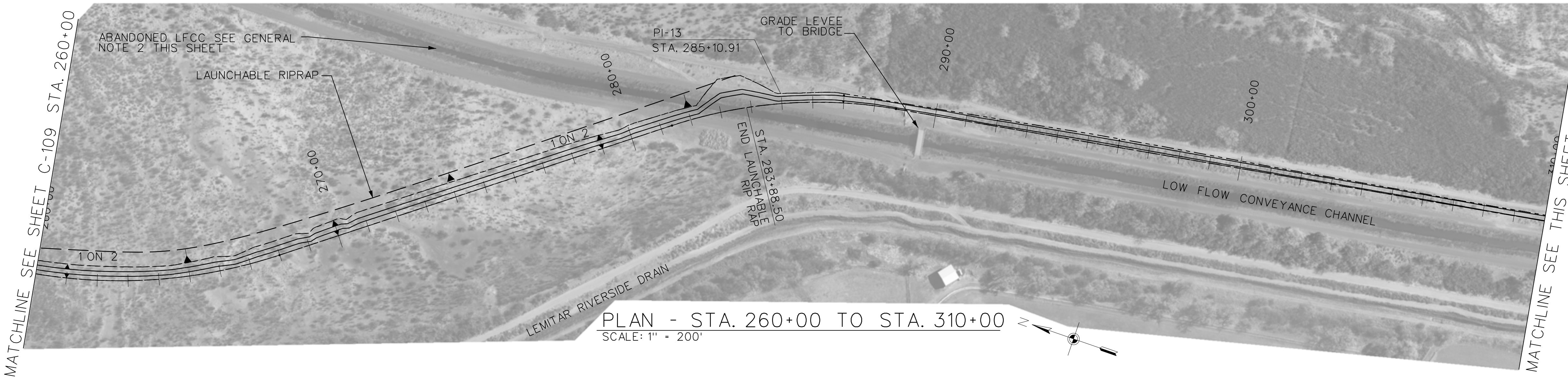
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

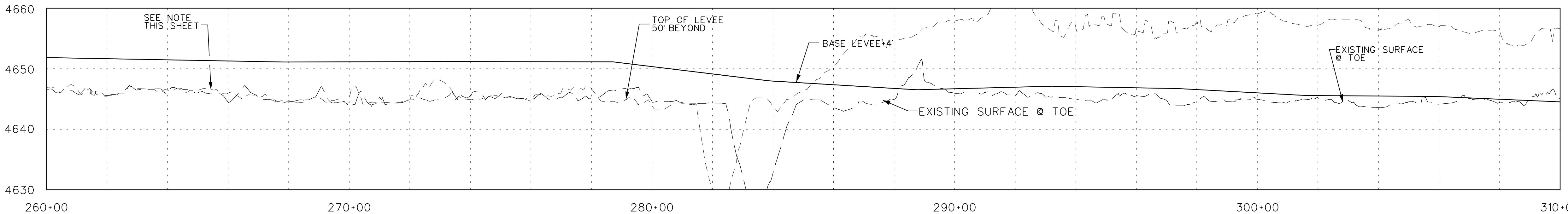
PLAN AND PROFILE
STA. 160+00 TO STA. 260+00

SHEET NO.
C-109
X OF X

SEQUENCE NO.
9



PLAN - STA. 260+00 TO STA. 310+00
SCALE: 1" = 200'

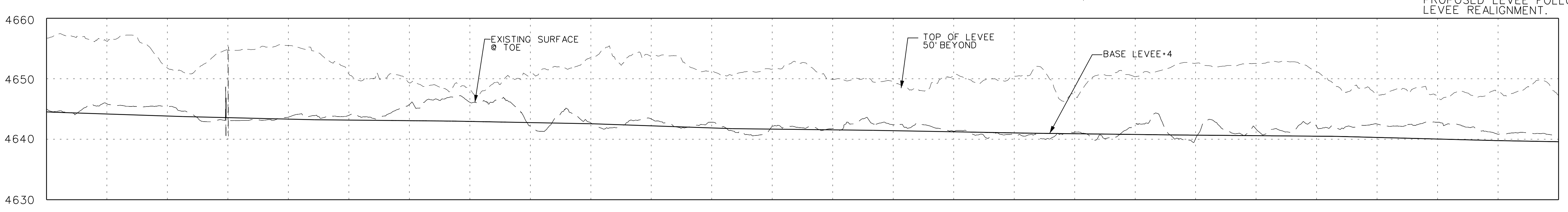


PROFILE - STA. 260+00 TO STA. 310+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

PLAN - STA. 310+00 TO STA. 360+00
SCALE: 1" = 200'

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.
2. LEVEE AND LFCC HAVE BEEN REALIGNED BY BUREAU OF RECLAMATION (BOR) AT RIVER MILE 111. AERIAL PHOTO AND TOPOGRAPHY PROVIDED ALONG THIS REACH IS NOT CURRENT. PROPOSED LEVEE FOLLOWS BOR LEVEE REALIGNMENT.



PROFILE - STA. 310+00 TO STA. 360+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

1" = 10' 0' 5' 10' 20' 30'
1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-114.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

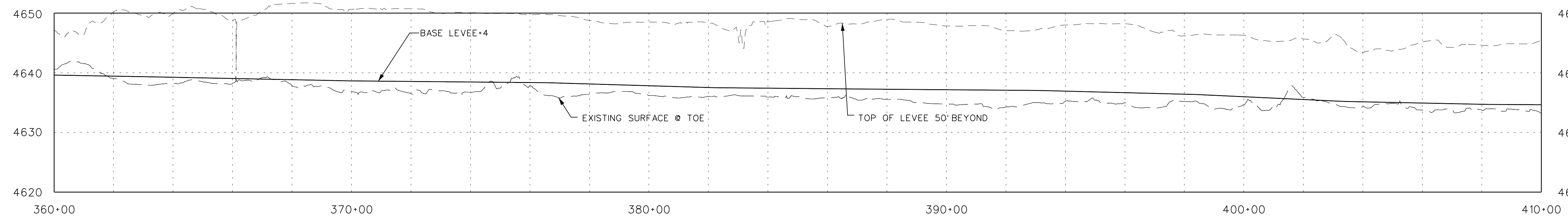
PLAN AND PROFILE
STA. 260+00 TO STA. 360+00

SHEET NO.
C-110
X OF X

SEQUENCE NO.
10

PLAN - STA. 360+00 TO STA. 410+00

SCALE: 1" = 200'

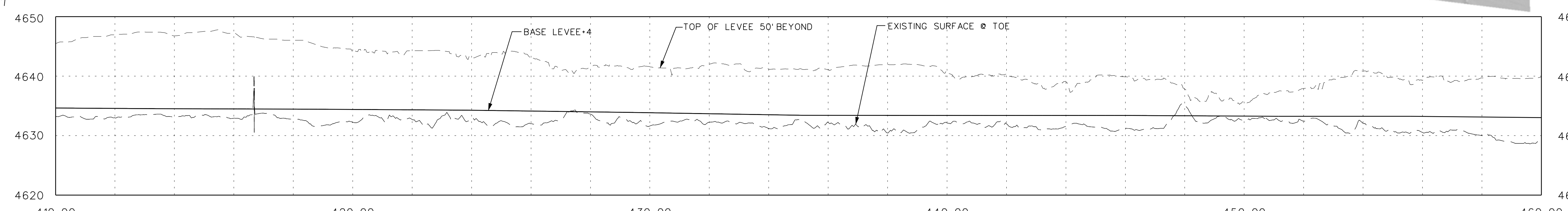


PROFILE - STA. 360+00 TO STA. 410+00

SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

PLAN - STA. 410+00 TO STA. 460+00

SCALE: 1" = 200'



PROFILE - STA. 410+00 TO STA. 460+00

SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' — 0' 5' 10' 20' 30'

1" = 200' — 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-115.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

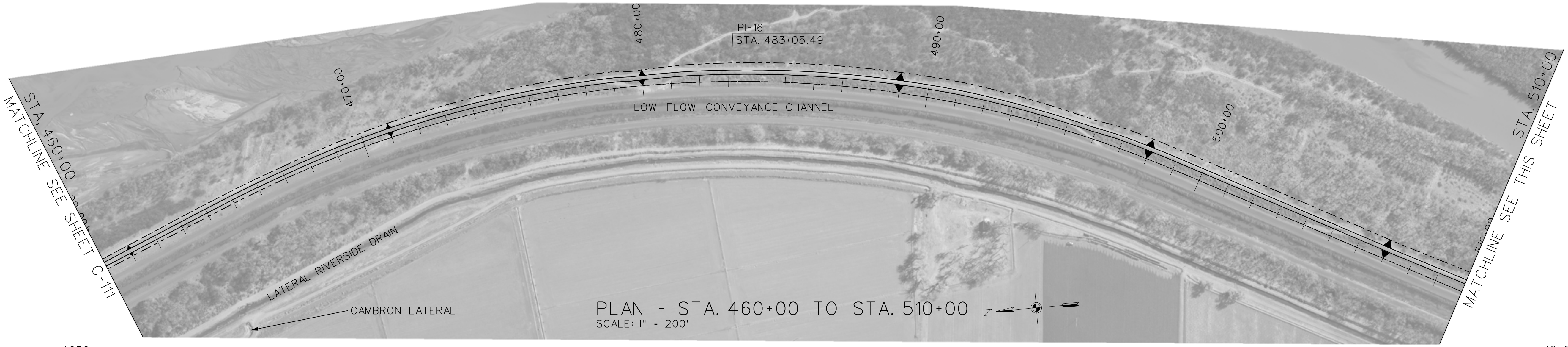
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

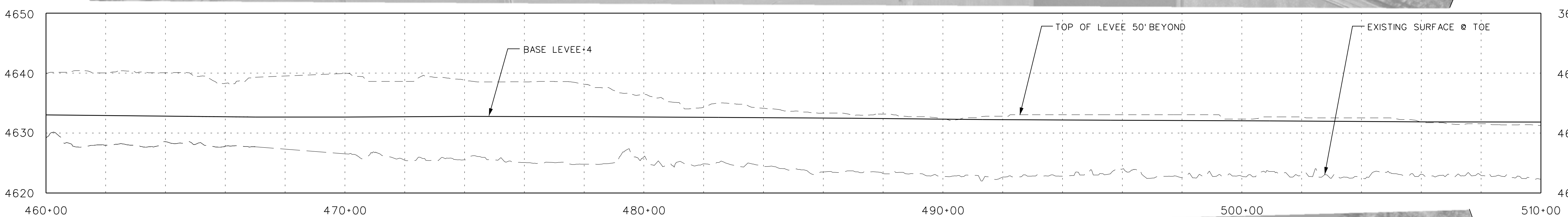
PLAN AND PROFILE
STA. 360+00 TO STA. 460+00

SHEET NO.
C-111
x OF x

SEQUENCE NO.
11

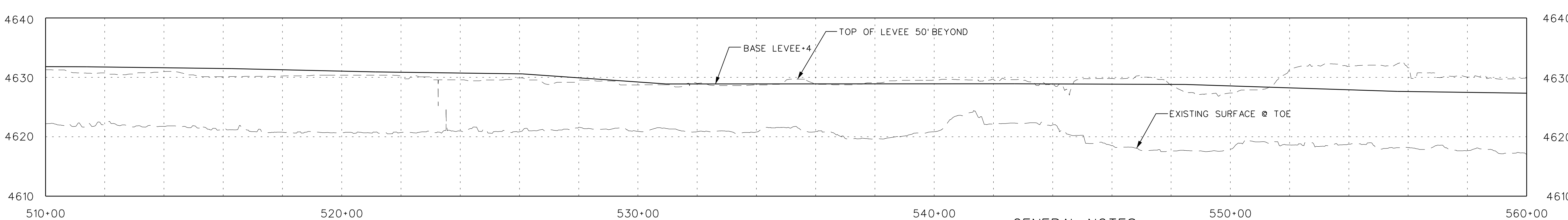


PLAN - STA. 460+00 TO STA. 510+00
SCALE: 1" = 200'



PROFILE - STA. 560+00 TO STA. 510+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

PLAN - STA. 510+00 TO STA. 560+00
SCALE: 1" = 200'



PROFILE - STA. 510+00 TO STA. 560+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'

1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-116.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

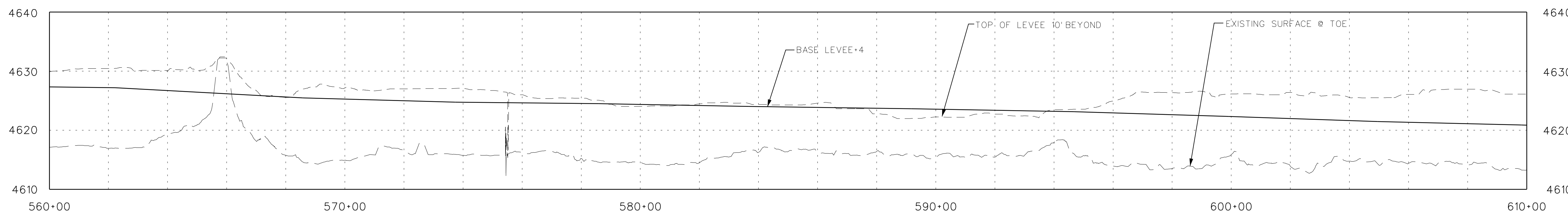
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 460+00 TO STA. 560+00

SHEET NO.
C-112
X OF X

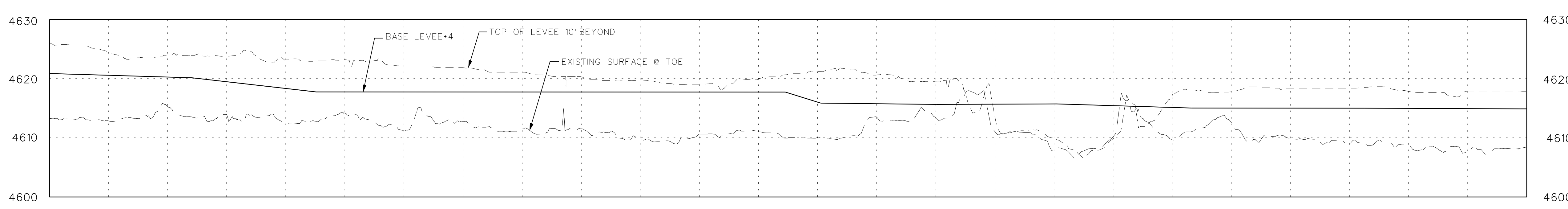
SEQUENCE NO.
12

PLAN - STA. 560+00 TO STA. 610+00
SCALE: 1" = 200'



PROFILE - STA. 560+00 TO STA. 610+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

PLAN - STA. 610+00 TO STA. 660+00
SCALE: 1" = 200'



PROFILE - STA. 610+00 TO STA. 660+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' — 0' 5' 10' 20' 30'
1" = 200' — 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-117.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

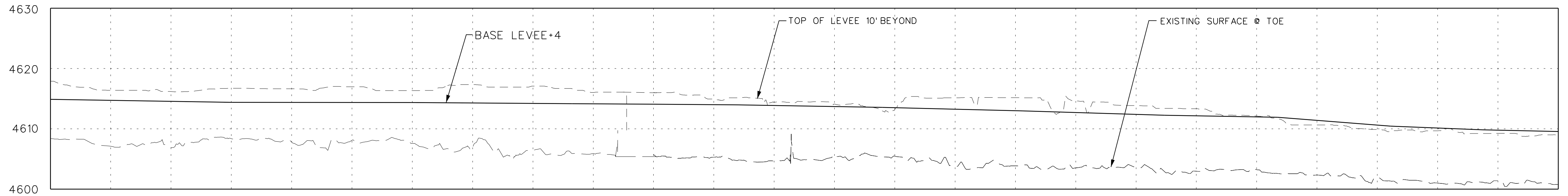
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
PLAN AND PROFILE
STA. 560+00 TO STA. 660+00

SHEET NO.
C-113
X OF X

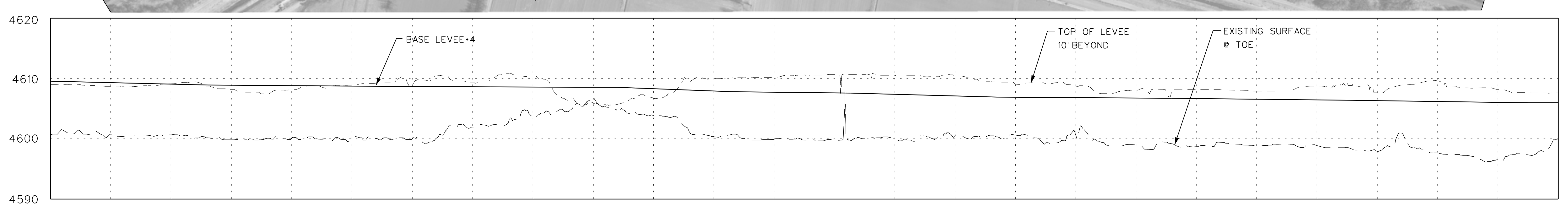
SEQUENCE NO.
13

PLAN - STA. 660+00 TO STA. 710+00
SCALE: 1" = 200'



PROFILE - STA. 660+00 TO STA. 710+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

PLAN - STA. 710+00 TO STA. 760+00
SCALE: 1" = 200'



PROFILE - STA. 710+00 TO STA. 760+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' — 0' 5' 10' 20' 30'
1" = 200' — 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-118.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

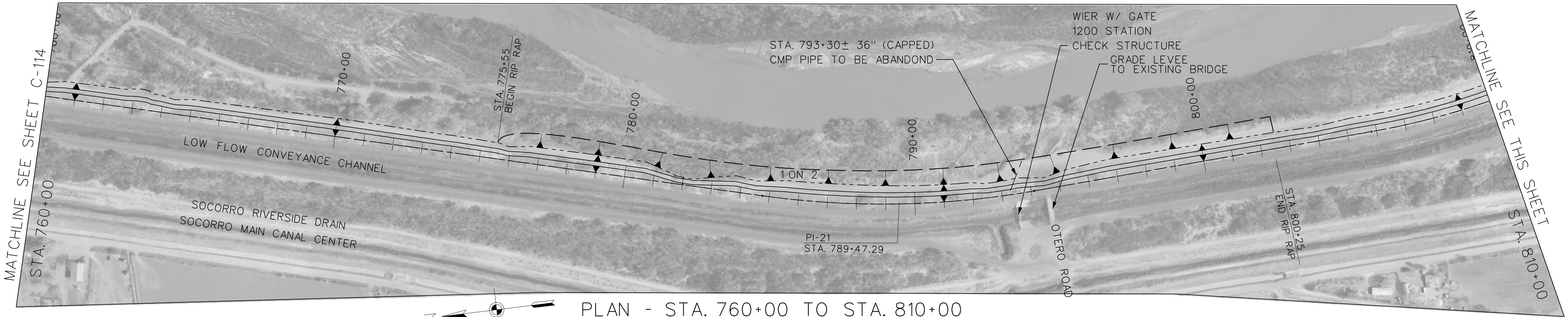
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

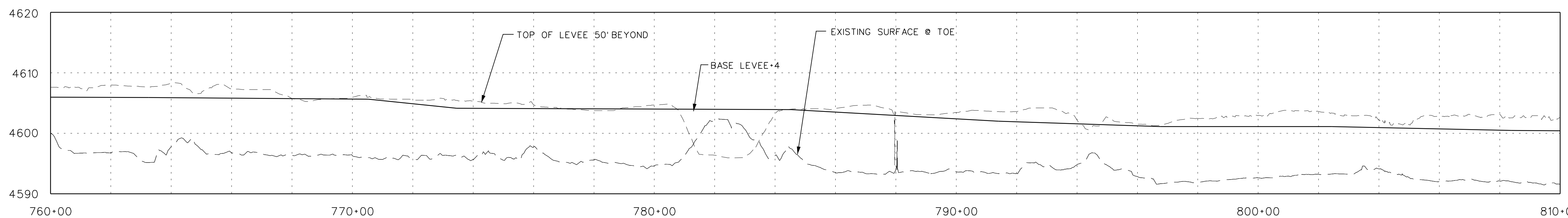
PLAN AND PROFILE
STA. 660+00 TO STA. 760+00

SHEET NO.
C-114
X OF X

SEQUENCE NO.
14

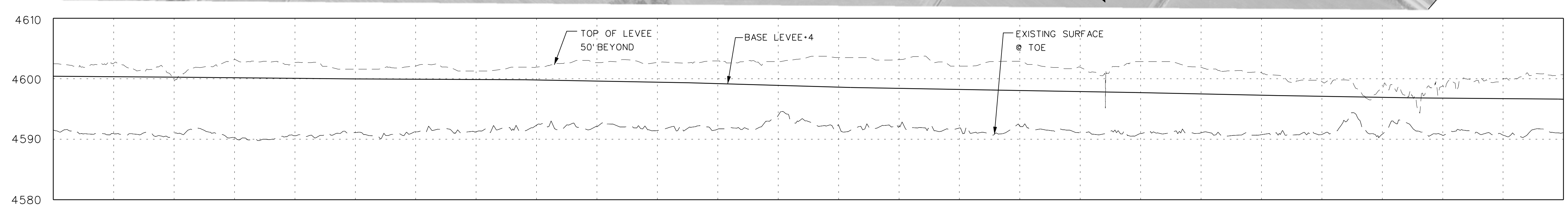


PLAN - STA. 760+00 TO STA. 810+00
SCALE: 1" = 200'



PROFILE - STA. 760+00 TO STA. 810+00
SCALE: 1" = 200' HORIZ.
: 1" = X' VERT.

PLAN - STA. 810+00 TO STA. 860+00
SCALE: 1" = 200'



PROFILE - STA. 810+00 TO STA. 860+00
SCALE: 1" = 200' HORIZ.
: 1" = X' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'
1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-120.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

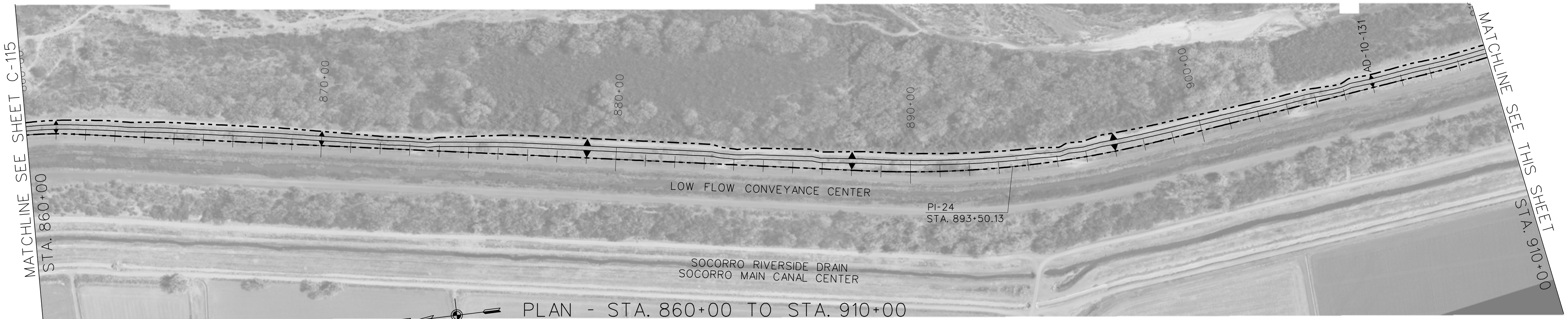
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

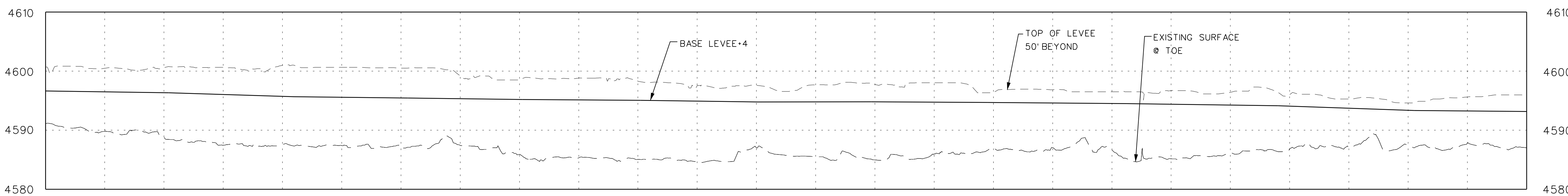
PLAN AND PROFILE
STA. 760+00 TO STA. 860+00

SHEET NO.
C-115
X OF X

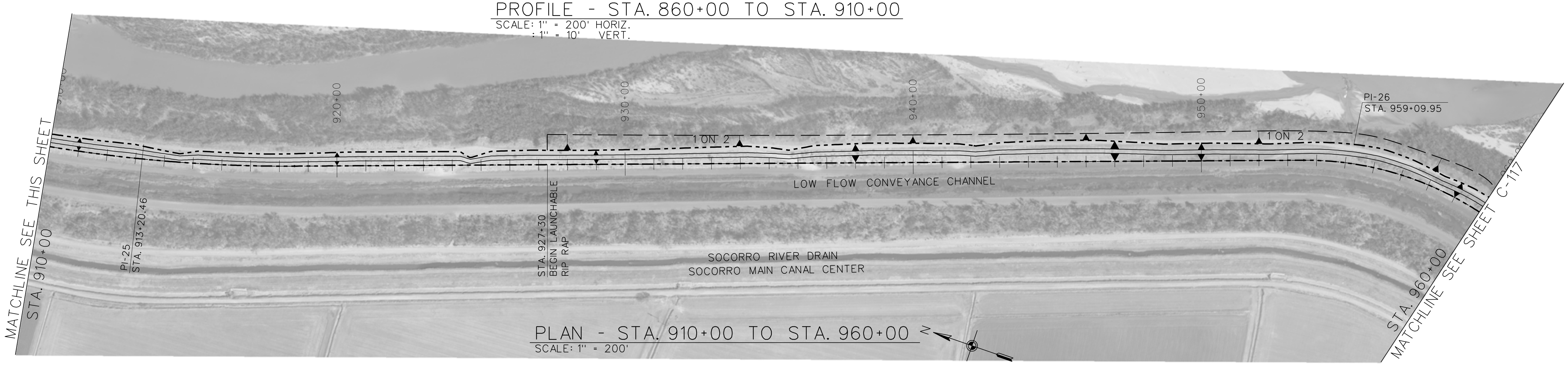
SEQUENCE NO.
15



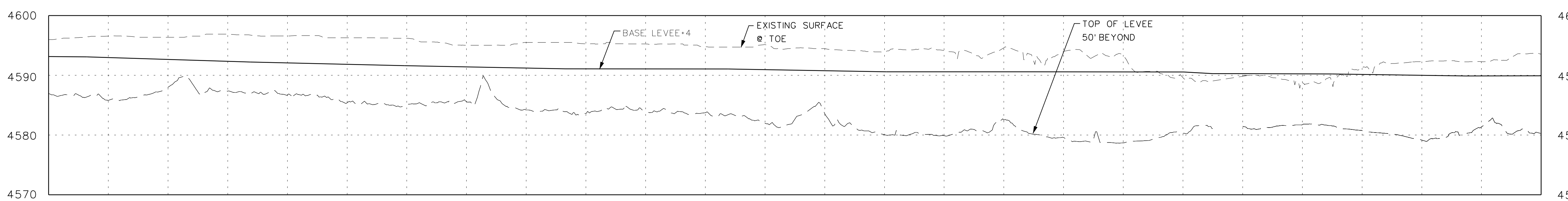
PLAN - STA. 860+00 TO STA. 910+00
SCALE: 1" = 200'



PROFILE - STA. 860+00 TO STA. 910+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.



PLAN - STA. 910+00 TO STA. 960+00
SCALE: 1" = 200'



PROFILE - STA. 910+00 TO STA. 960+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' (0' 5' 10' 20' 30')
1" = 200' (0' 100' 200' 400' 600')

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-121.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

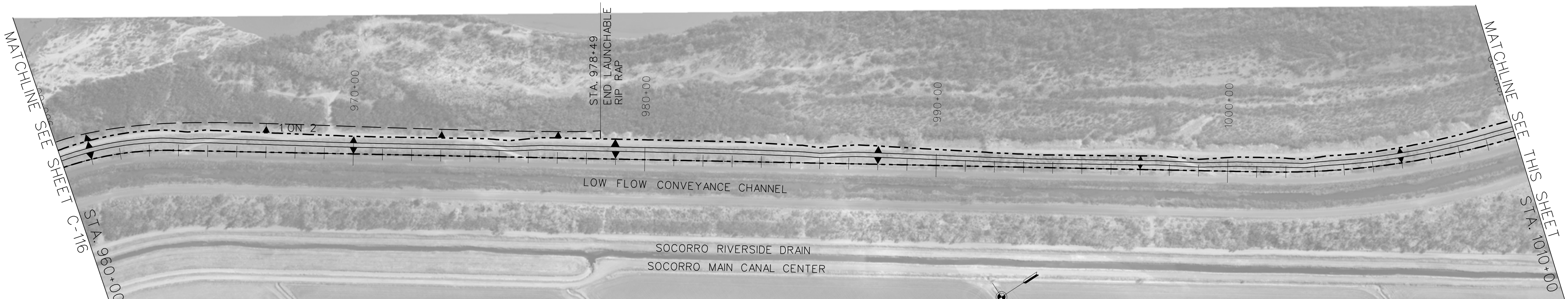
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

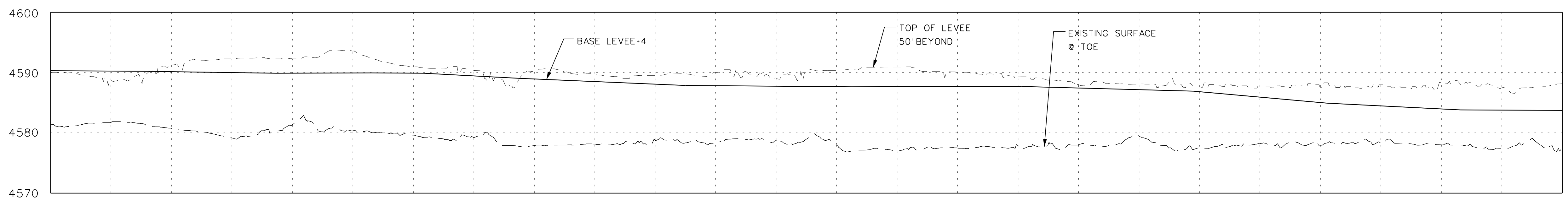
PLAN AND PROFILE
STA. 860+00 TO STA. 960+00

SHEET NO.
C-116
X OF X

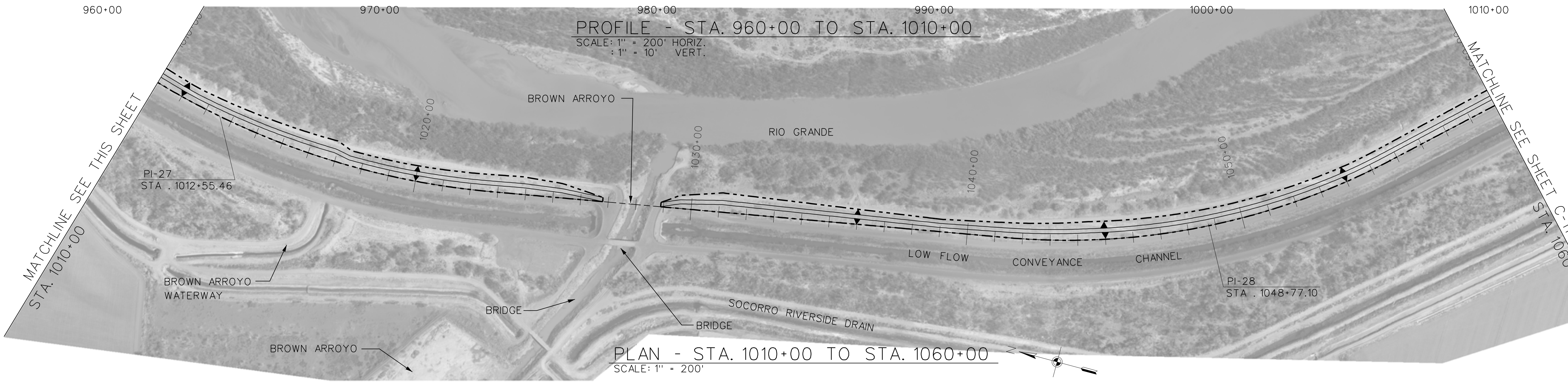
SEQUENCE NO.
16



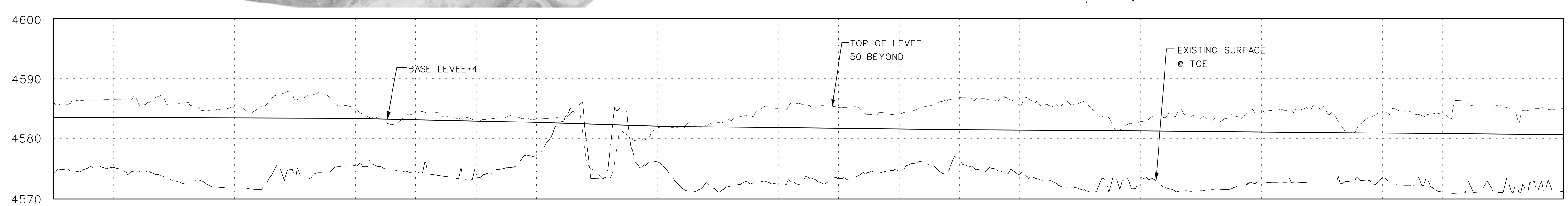
PLAN - STA. 960+00 TO STA. 1010+00
SCALE: 1" = 200'



PROFILE - STA. 960+00 TO STA. 1010+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.



PLAN - STA. 1010+00 TO STA. 1060+00
SCALE: 1" = 200'



PROFILE - STA. 1010+00 TO STA. 1060+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' — 0' 5' 10' 20' 30'

1" = 200' — 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-101.DGN
Plot Date: January 2012
Plot Scale: 200:1
CWIS NO.
P2 NO.

Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

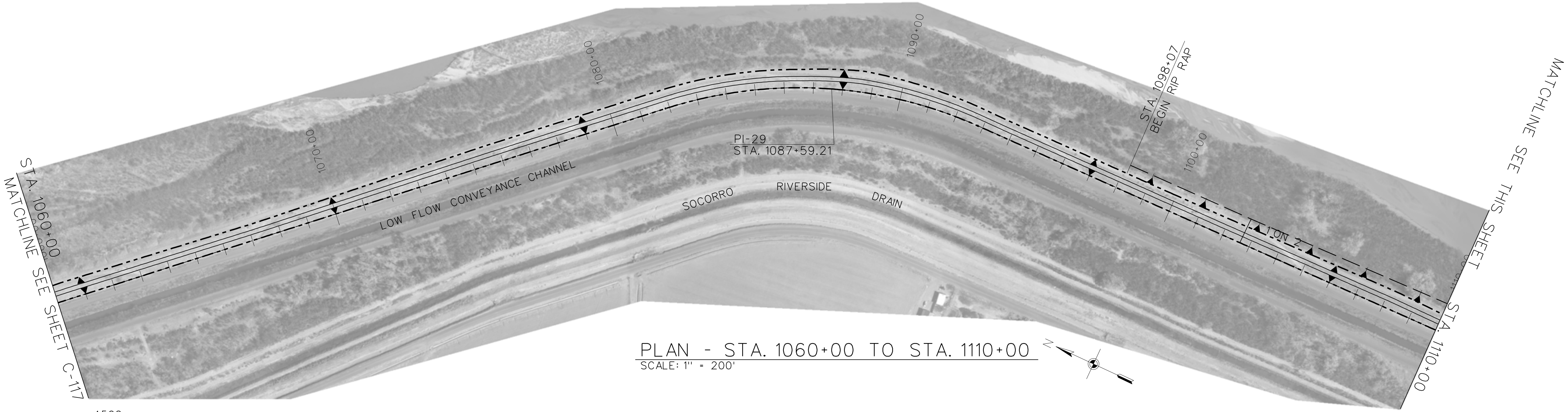
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

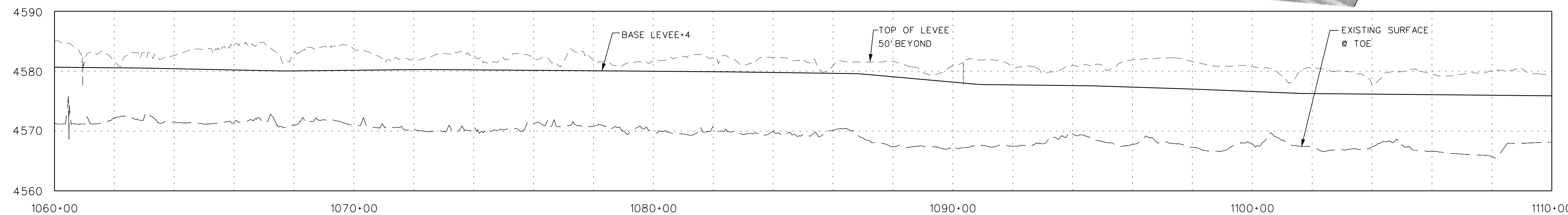
PLAN AND PROFILE
STA. 960+00 TO STA. 1060+00

SHEET NO.
C-117
X OF X

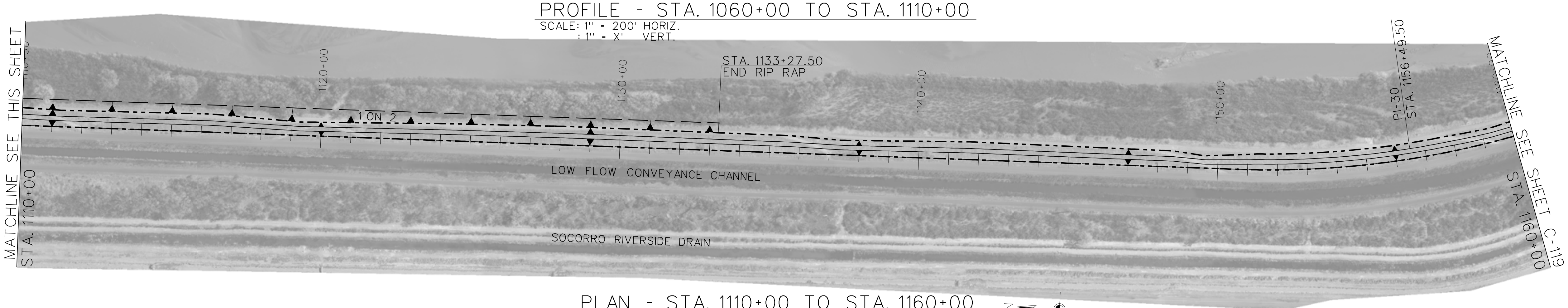
SEQUENCE NO.
17



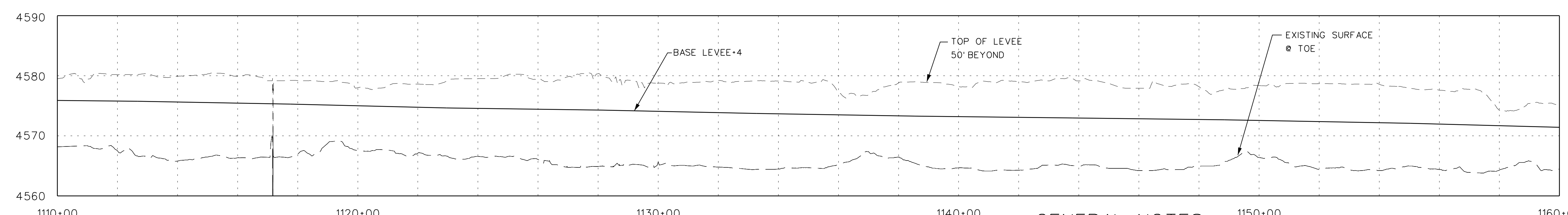
PLAN - STA. 1060+00 TO STA. 1110+00
SCALE: 1" = 200'



PROFILE - STA. 1060+00 TO STA. 1110+00
SCALE: 1" = 200' HORIZ.
: 1" = X' VERT.



PLAN - STA. 1110+00 TO STA. 1160+00
SCALE: 1" = 200'



PROFILE - STA. 1110+00 TO STA. 1160+00
SCALE: 1" = 200' HORIZ.
: 1" = X' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'
1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr.

File Name: SN02C-122.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

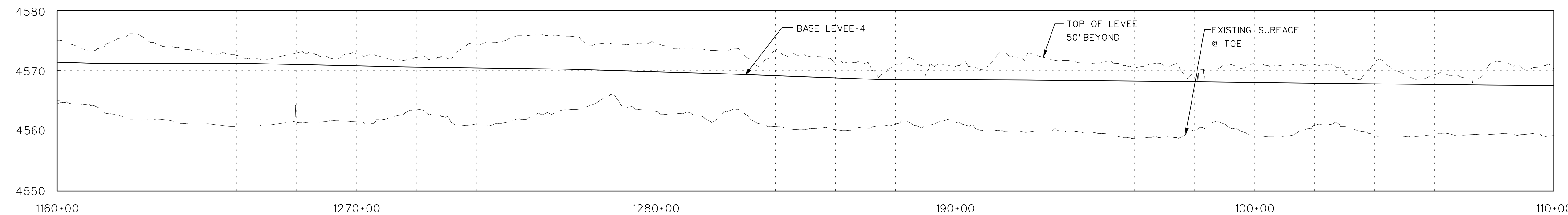
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1060+00 TO STA. 1160+00

SHEET NO.
C-118
X OF X

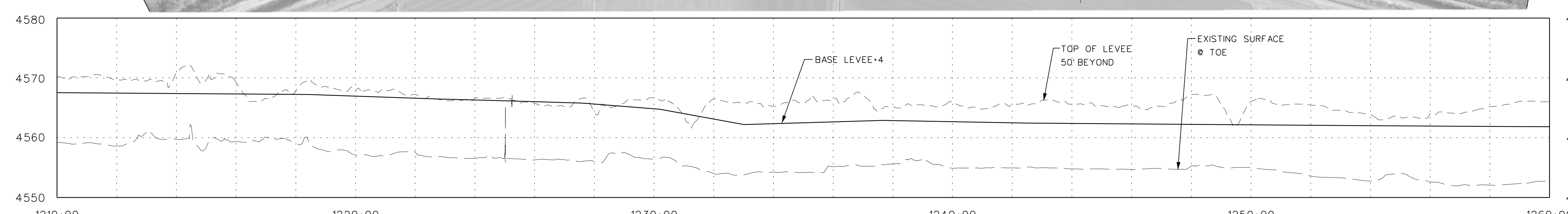
SEQUENCE NO.
18

PLAN - STA. 1160+00 TO STA. 1210+00
SCALE: 1" = 200'



PROFILE - STA. 1160+00 TO STA. 1210+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

PLAN - STA. 1210+00 TO STA. 1260+00
SCALE: 1" = 200'



PROFILE - STA. 1210+00 TO STA. 1260+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' — 0' 5' 10' 20' 30'
1" = 200' — 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-124.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

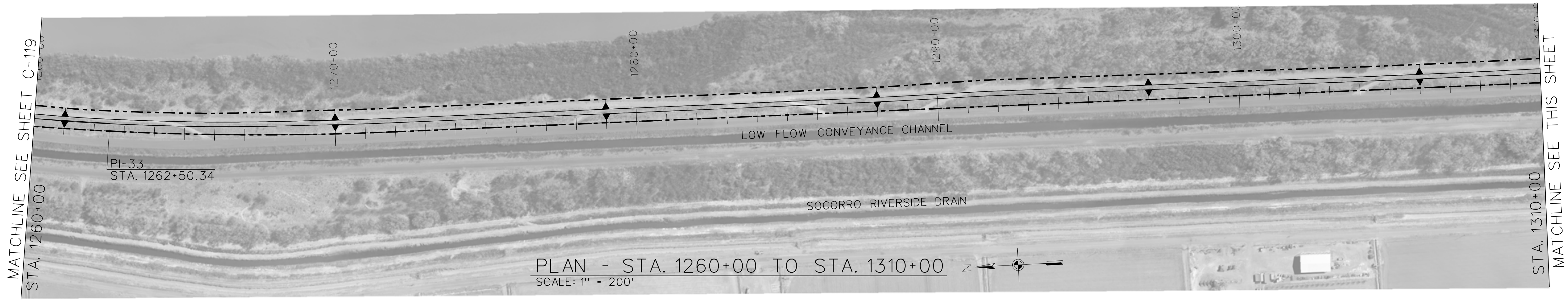
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

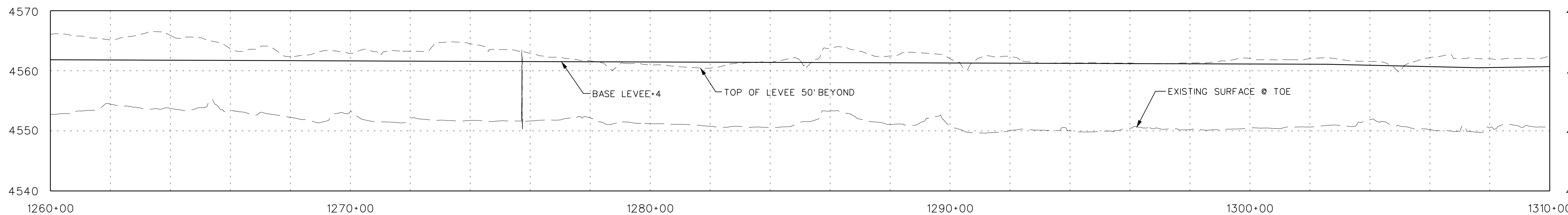
PLAN AND PROFILE
STA. 1160+00 TO STA. 1260+00

SHEET NO.
C-119
X OF X

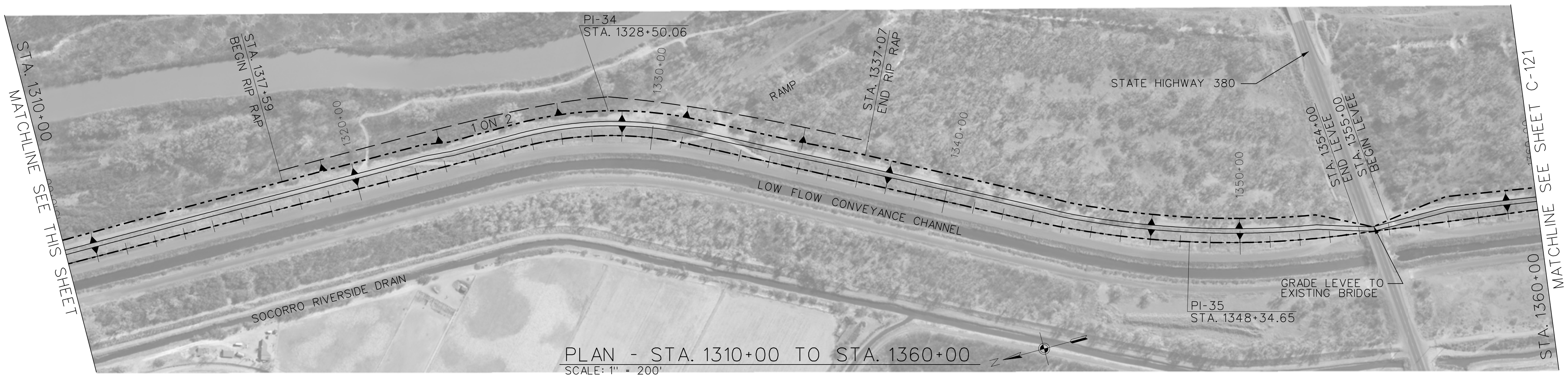
SEQUENCE NO.
19



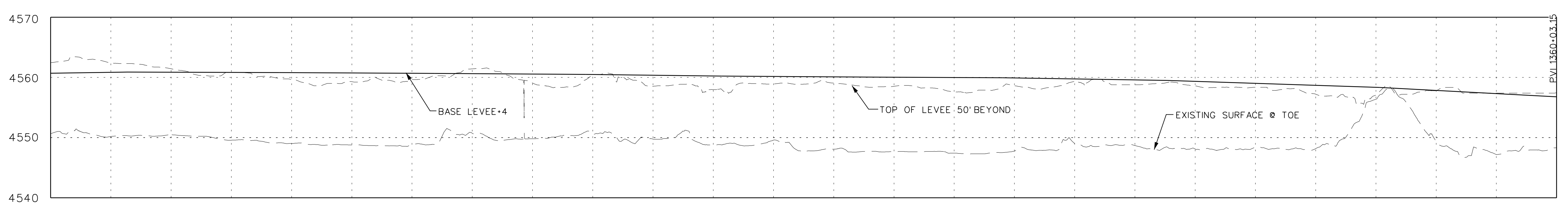
PLAN - STA. 1260+00 TO STA. 1310+00
SCALE: 1" = 200'



PROFILE - STA. 1260+00 TO STA. 1310+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.



PLAN - STA. 1310+00 TO STA. 1360+00
SCALE: 1" = 200'



PROFILE - STA. 1310+00 TO STA. 1360+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'

1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-124.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

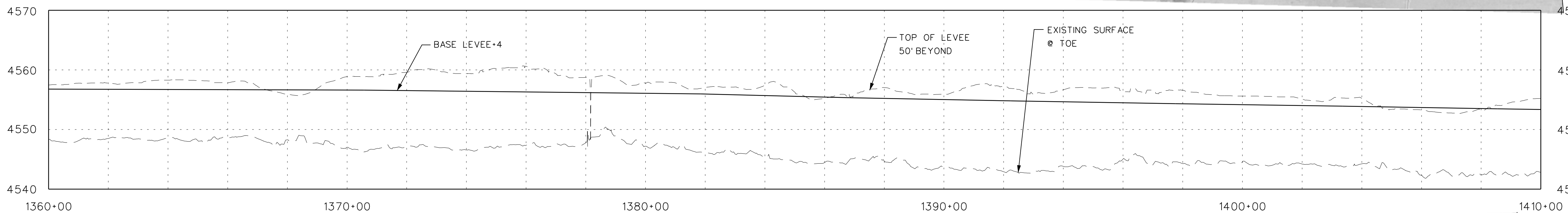
RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1260+00 TO STA. 1360+00

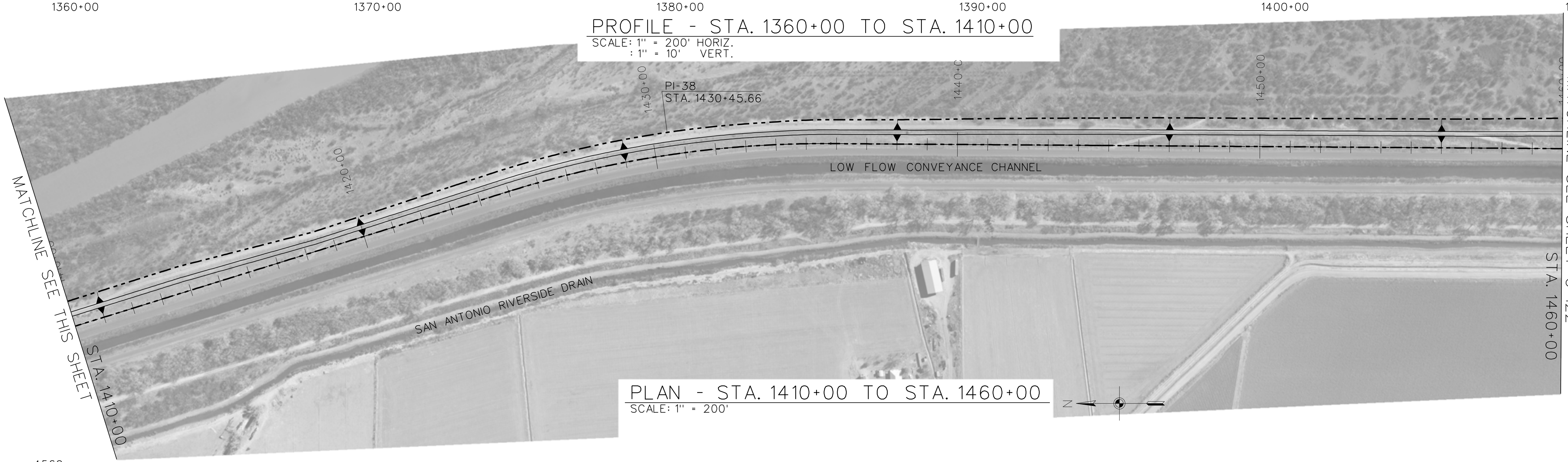
SHEET NO.
C-120
X OF X

SEQUENCE NO.
20

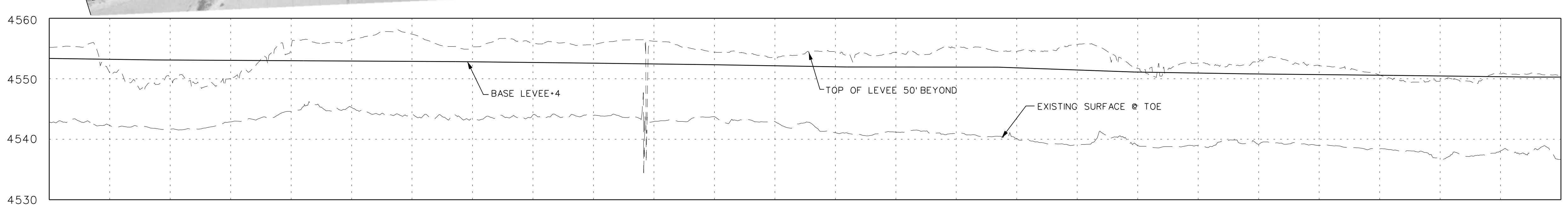
PLAN - STA. 1360+00 TO STA. 1410+00
SCALE: 1" = 200'



PROFILE - STA. 1360+00 TO STA. 1410+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.



PLAN - STA. 1410+00 TO STA. 1460+00
SCALE: 1" = 200'



PROFILE - STA. 1410+00 TO STA. 1460+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'
1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-126.DGN
Plot Date: January 2012
Plot Scale: 200:1
CWIS NO.
P2 NO.
Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

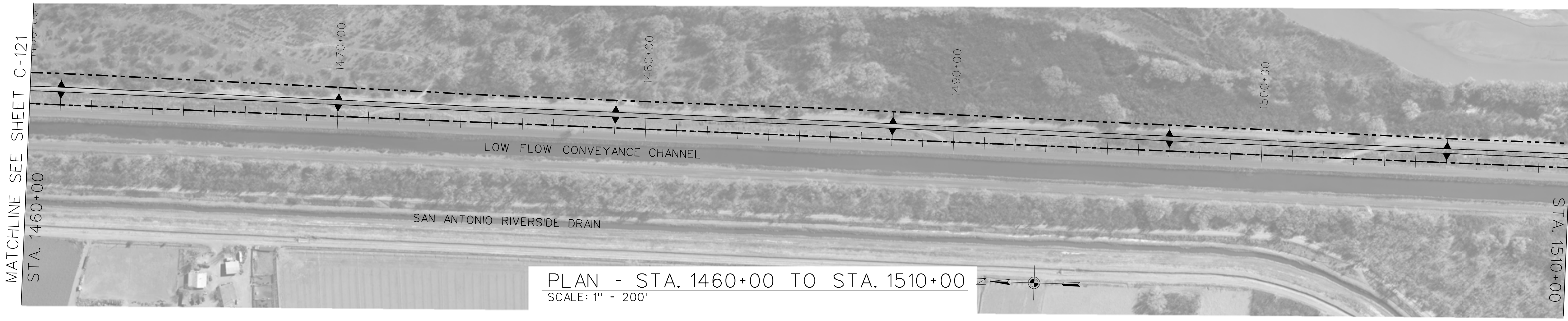
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1360+00 TO STA. 1460+00

SHEET NO.
C-121
X OF X

SEQUENCE NO.
21



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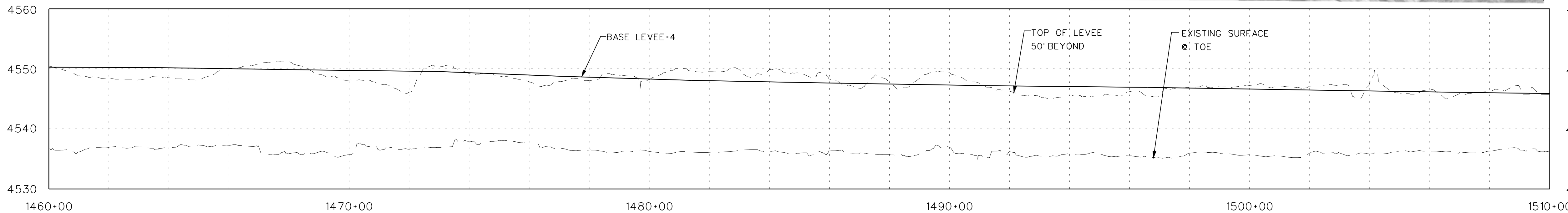

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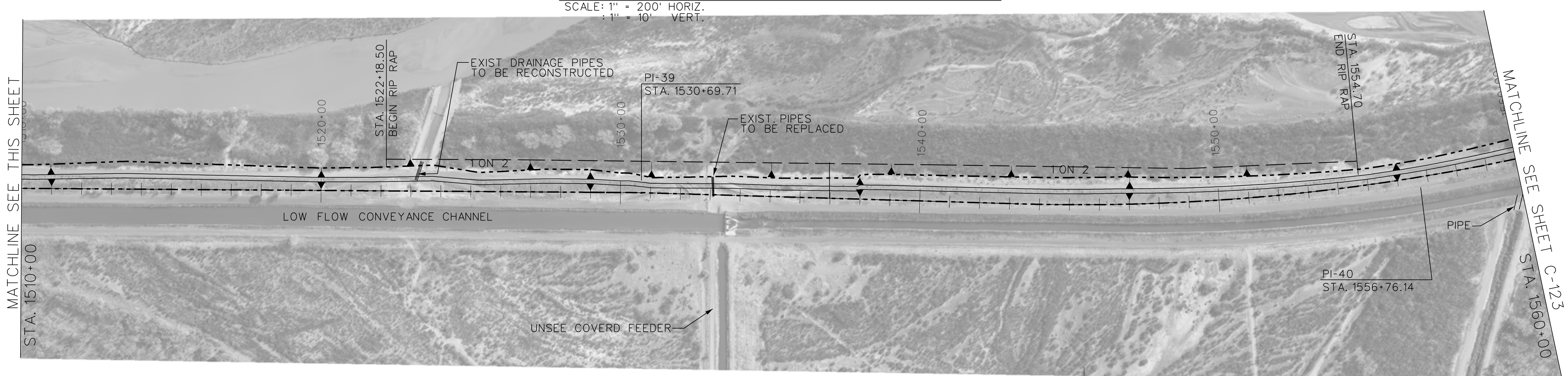
: 1" = 10' VERT.



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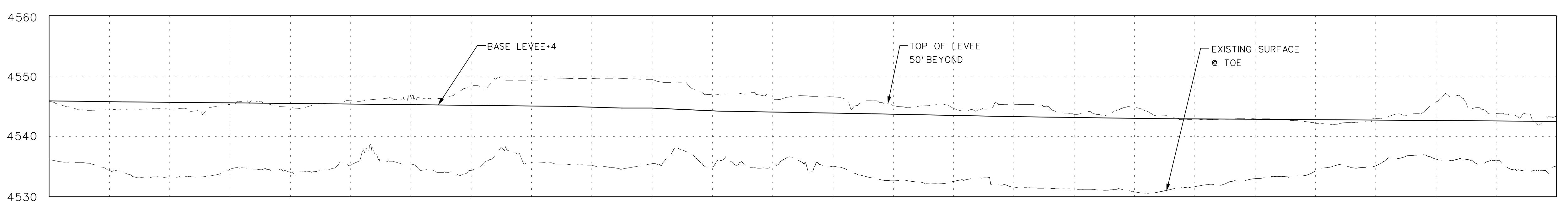

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SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'
1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-126.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

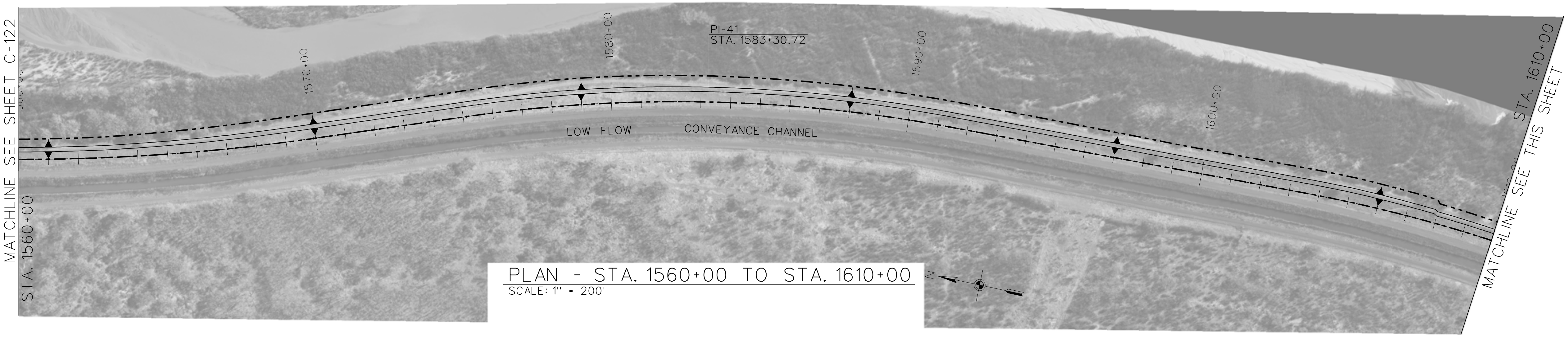
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1460+00 TO STA. 1560+00

SHEET NO.
C-122
X OF X

SEQUENCE NO.
22



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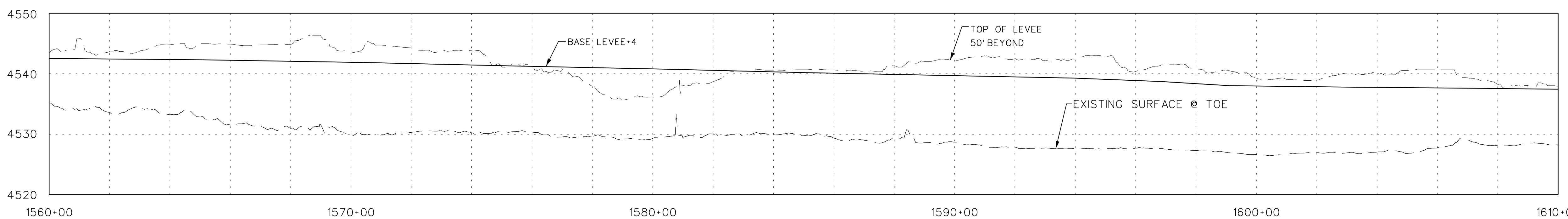

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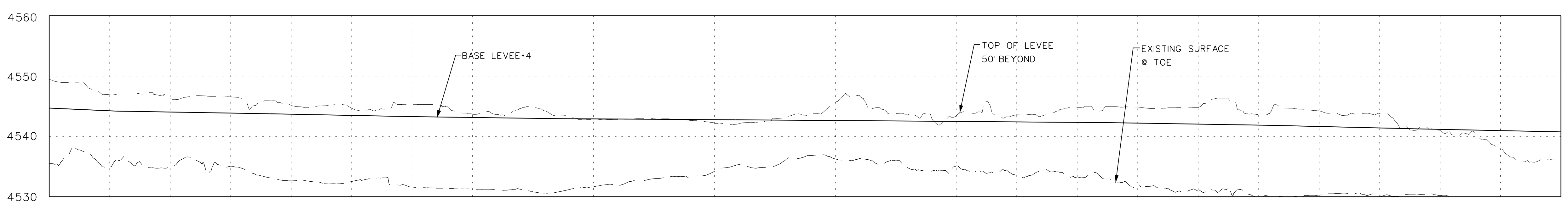
SCALE: 1" = 200'



PROFILE - STA. 1610+00 TO STA. 1660+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'
1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr.

File Name: SN02C-123.DGN
Plot Date: January 2012
Plot Scale: 200:1
CWIS NO.
P2 NO.
Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

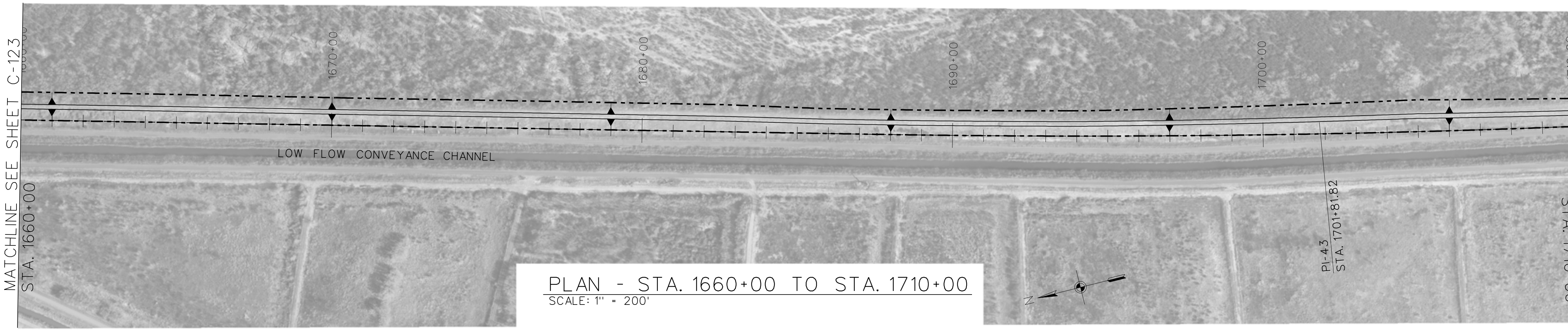
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1560+00 TO STA. 1660+00

SHEET NO.
C-123
X OF X

SEQUENCE NO.
23



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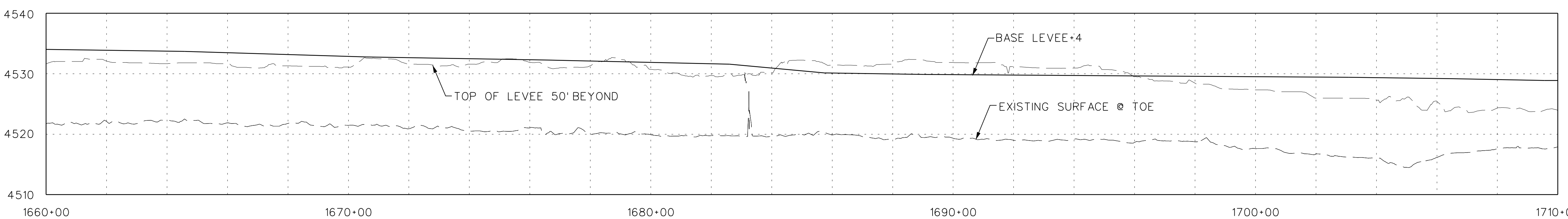

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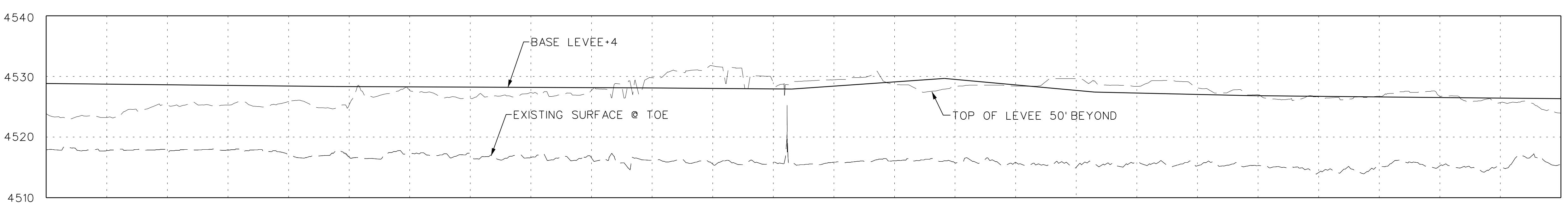
: 1" = 10' VERT.

PLAN - STA. 1710+00 TO STA. 1760+00
SCALE: 1" = 200'



PROFILE - STA. 1710+00 TO STA. 1760+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'
1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-128.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents
Zero Tolerance

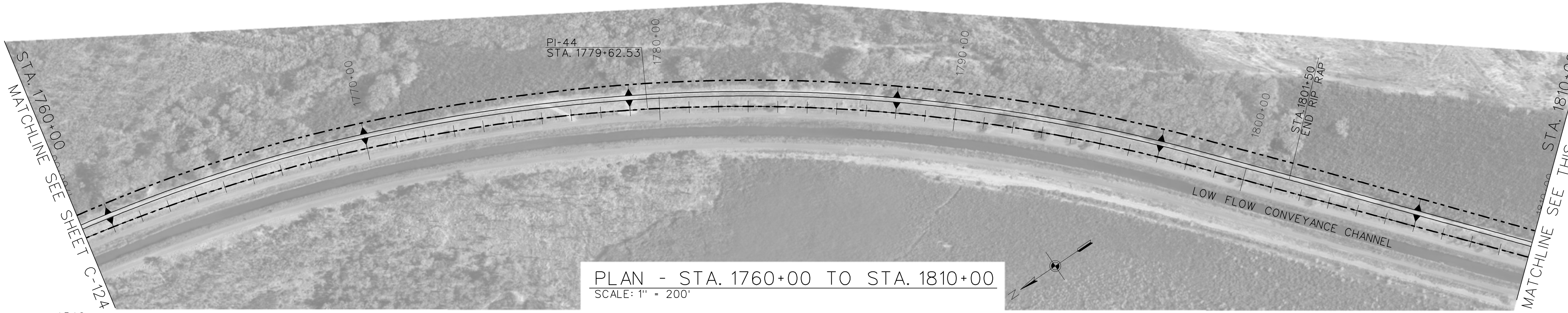
DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM
PLAN AND PROFILE
STA. 1660+00 TO STA. 1760+00

SHEET NO.
C-124
X OF X

SEQUENCE NO.
24



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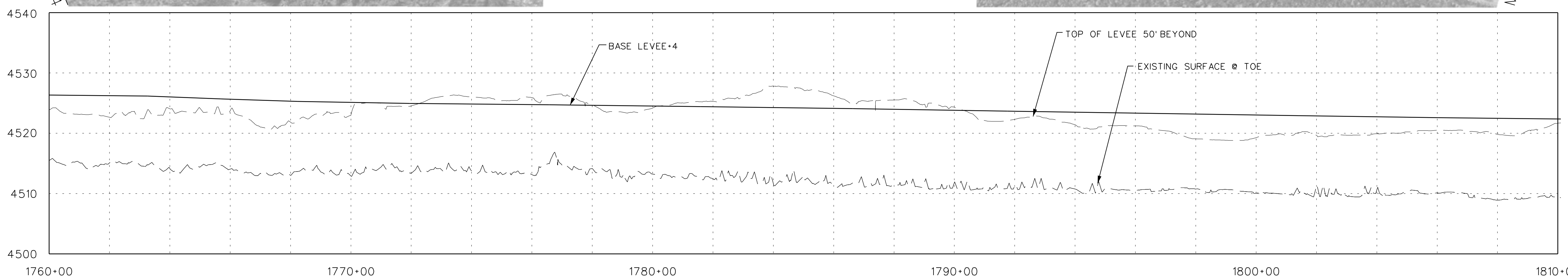

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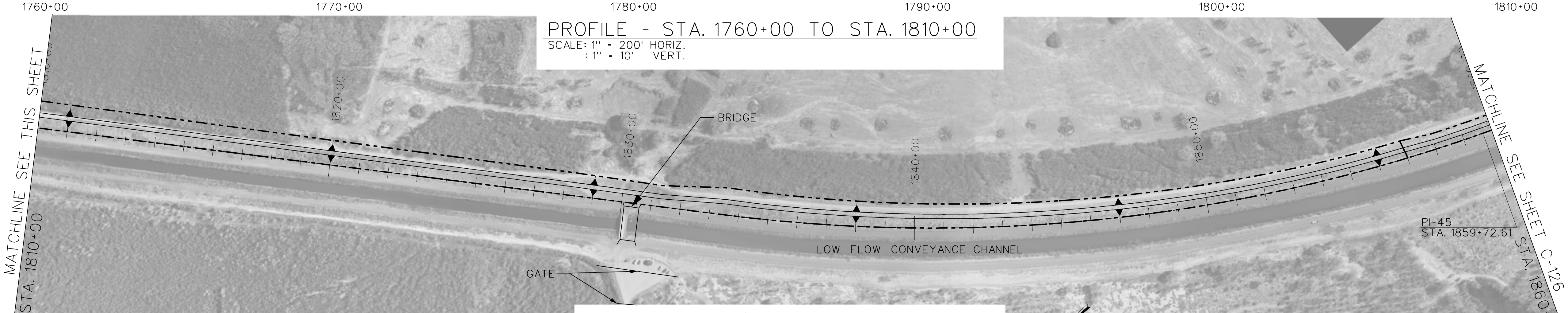

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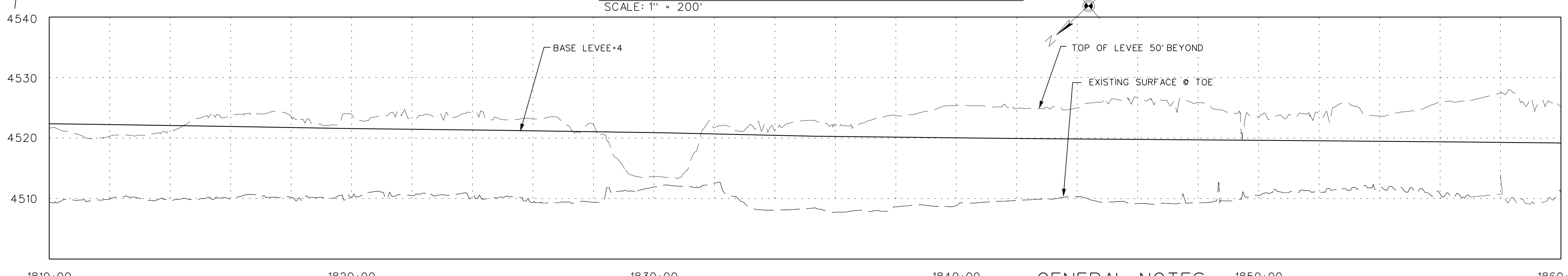


PROFILE - STA. 1810+00 TO STA. 1860+00

SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 10' 0' 5' 10' 20' 30'

1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

File Name: SN02C-129.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

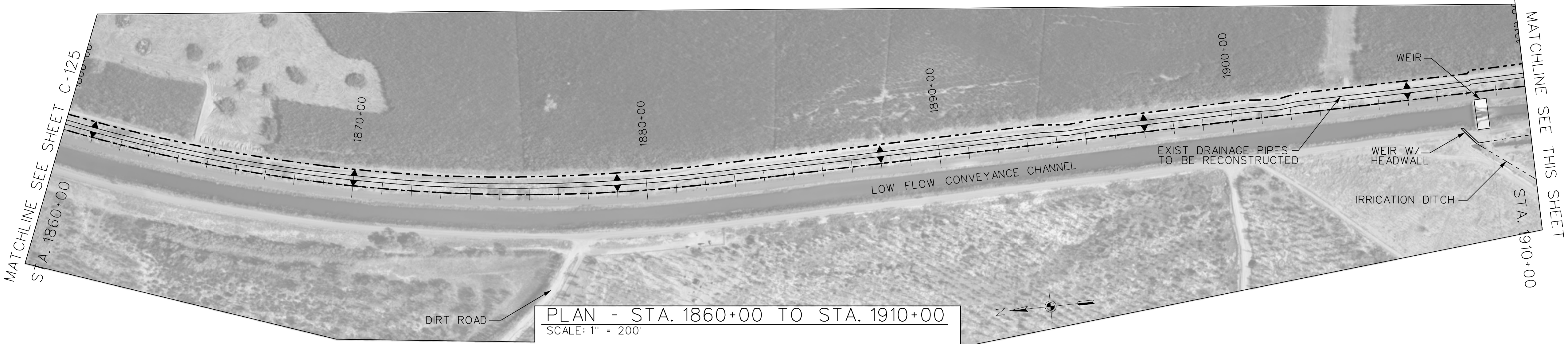
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1760+00 TO STA. 1860+00

SHEET NO.
C-125
X OF X

SEQUENCE NO.
25



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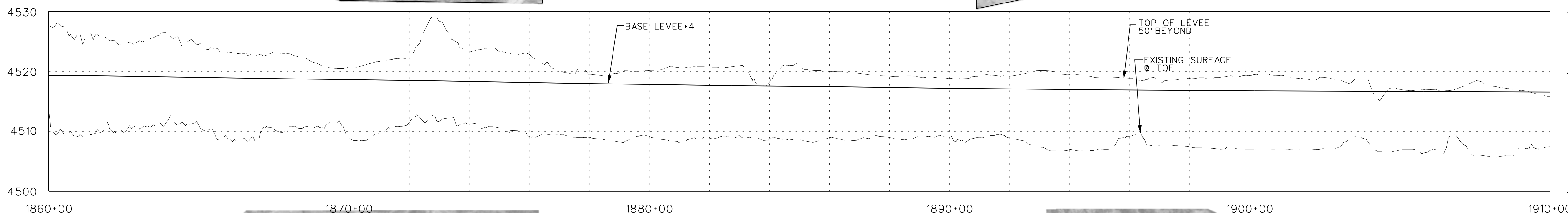

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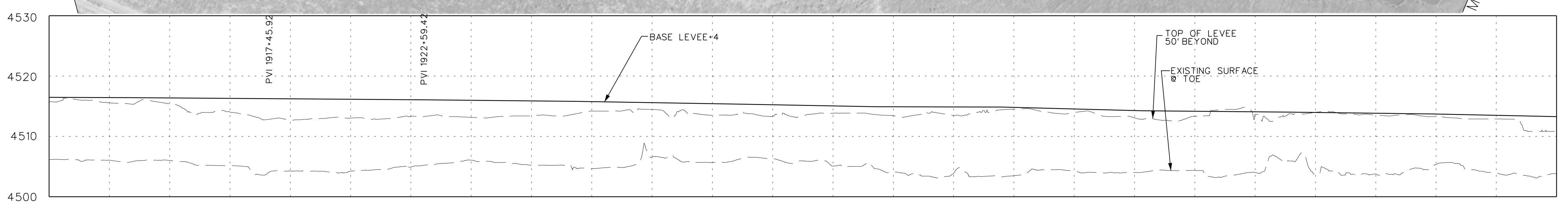
SCALE: 1" = 200'



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SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 200' 0' 100' 200' 400' 600'

1" = 10' 0' 5' 10' 20' 30'

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr.

File Name: SN02C-130.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

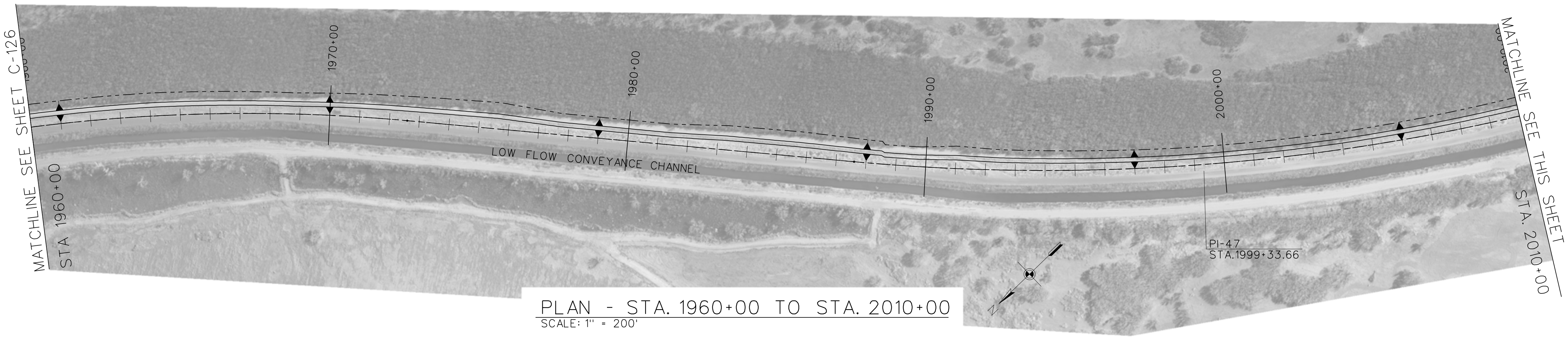
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1860+00 TO STA. 1960+00

SHEET NO.
C-126
X OF X

SEQUENCE NO.
26



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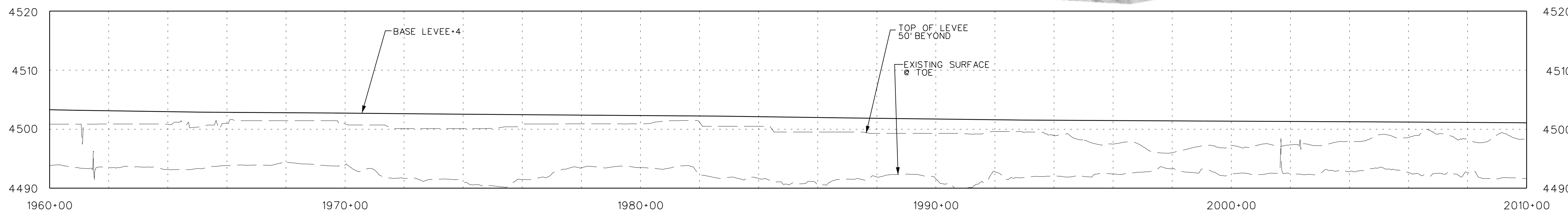

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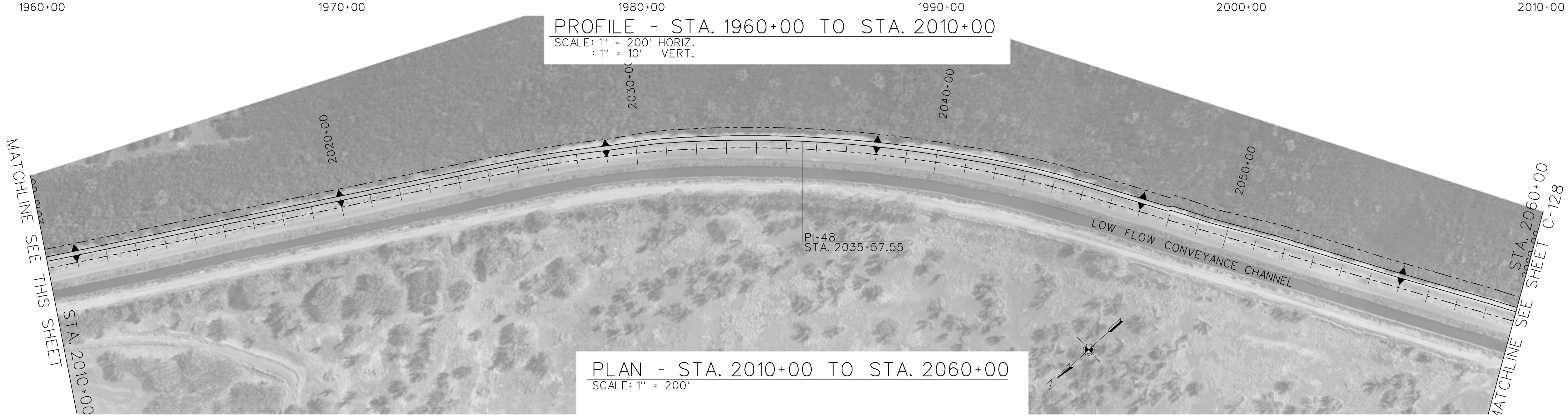
: 1" = 10' VERT.



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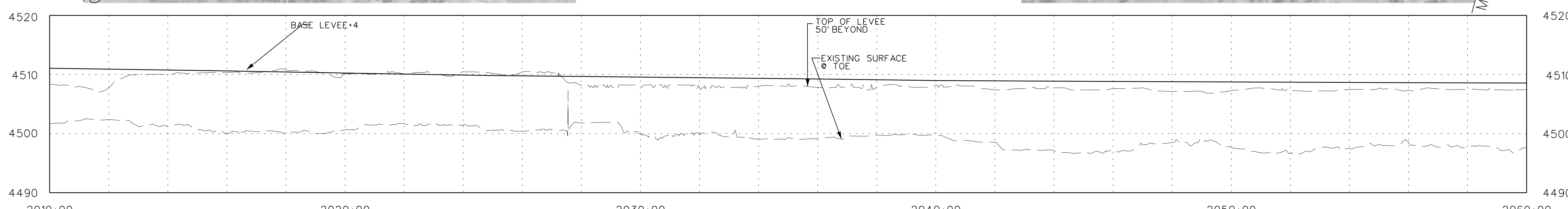


PROFILE - STA. 2010+00 TO STA. 2060+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 200' 0' 100' 200' 400' 600'

1" = 10' 0' 5' 10' 20' 30'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-1312DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.
Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

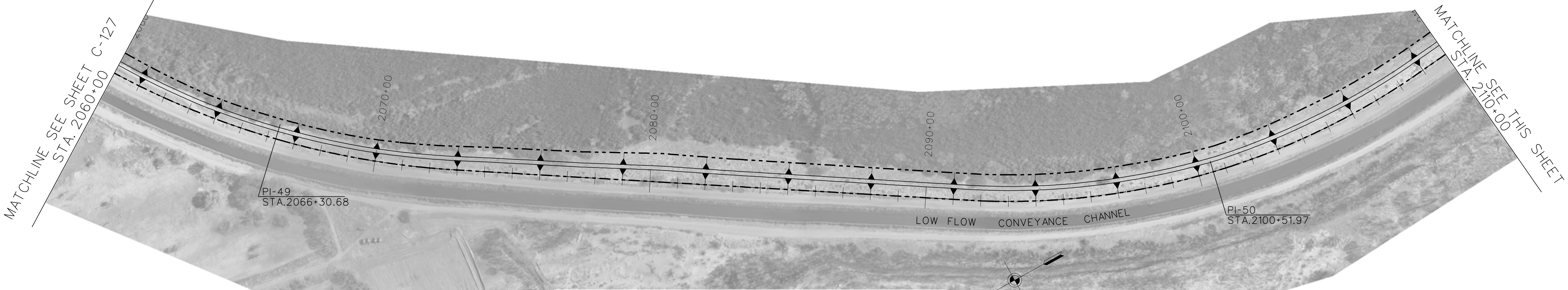
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 1960+00 TO STA. 2060+00

SHEET NO.
C-127
X OF X

SEQUENCE NO.
27



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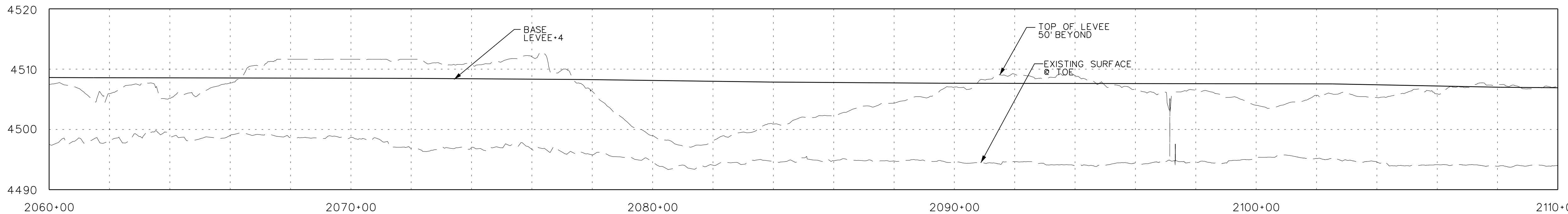
SCALE: 1" = 200'



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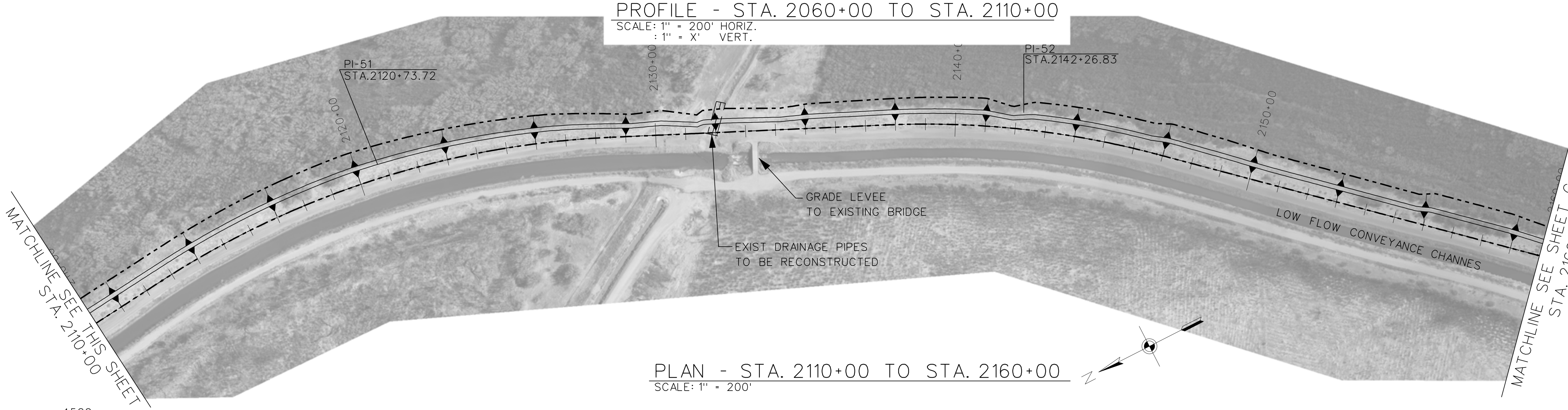
SCALE: 1" = 200' HORIZ.
: 1" = X' VERT.



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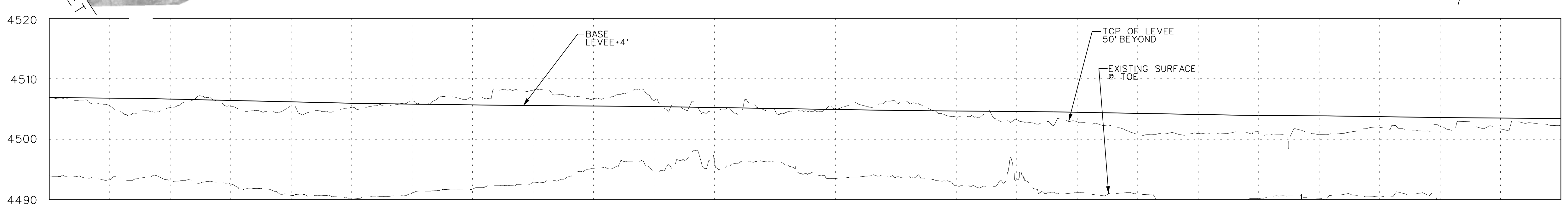
SCALE: 1" = 200'



PROFILE - STA. 2110+00 TO STA. 2160+00

SCALE: 1" = 200' HORIZ.
: 1" = X' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 200' 0' 100' 200' 400' 600'

US Army Corps of Engineers
Albuquerque District

Mark | Description | Date | Appr.

File Name: SN02C-132.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

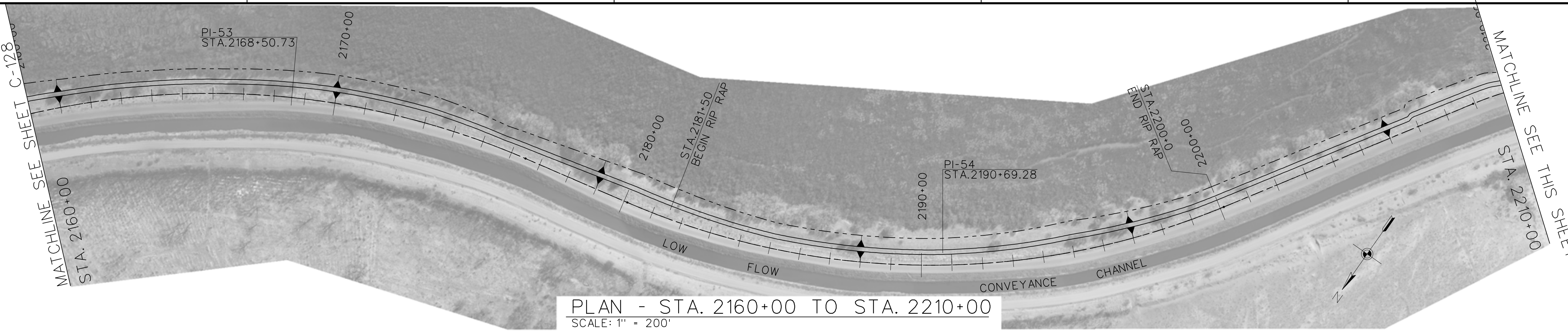
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 2060+00 TO STA. 2160+00

SHEET NO.
C-128
X OF X

SEQUENCE NO.
28



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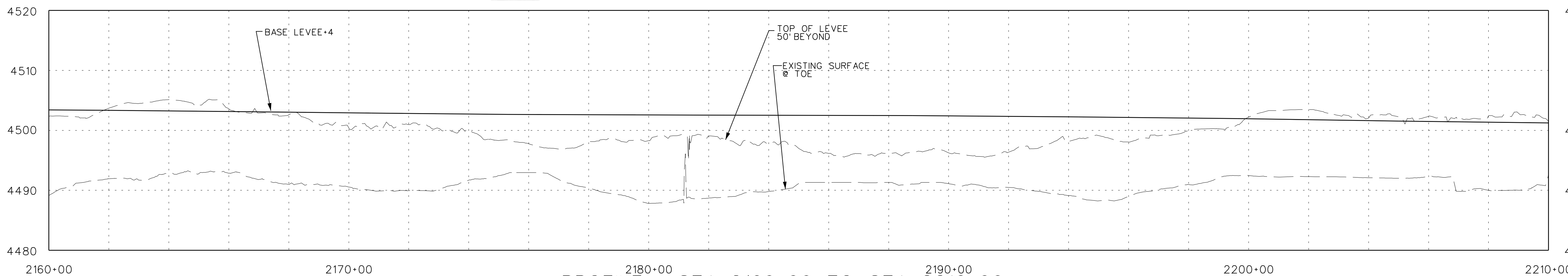
SCALE: 1" = 200'



PROFILE - STA. 2160+00 TO STA. 2210+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

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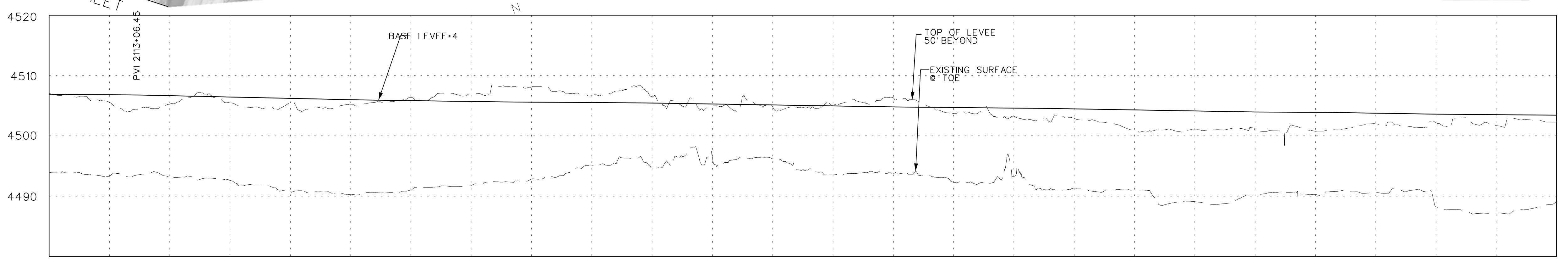
SCALE: 1" = 200'



PROFILE - STA. 2210+00 TO STA. 2260+00
SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

1" = 200' 0' 100' 200' 400' 600'

1" = 10' 0' 5' 10' 20' 30'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-133.DGN
Plot Scale: 1:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents
Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

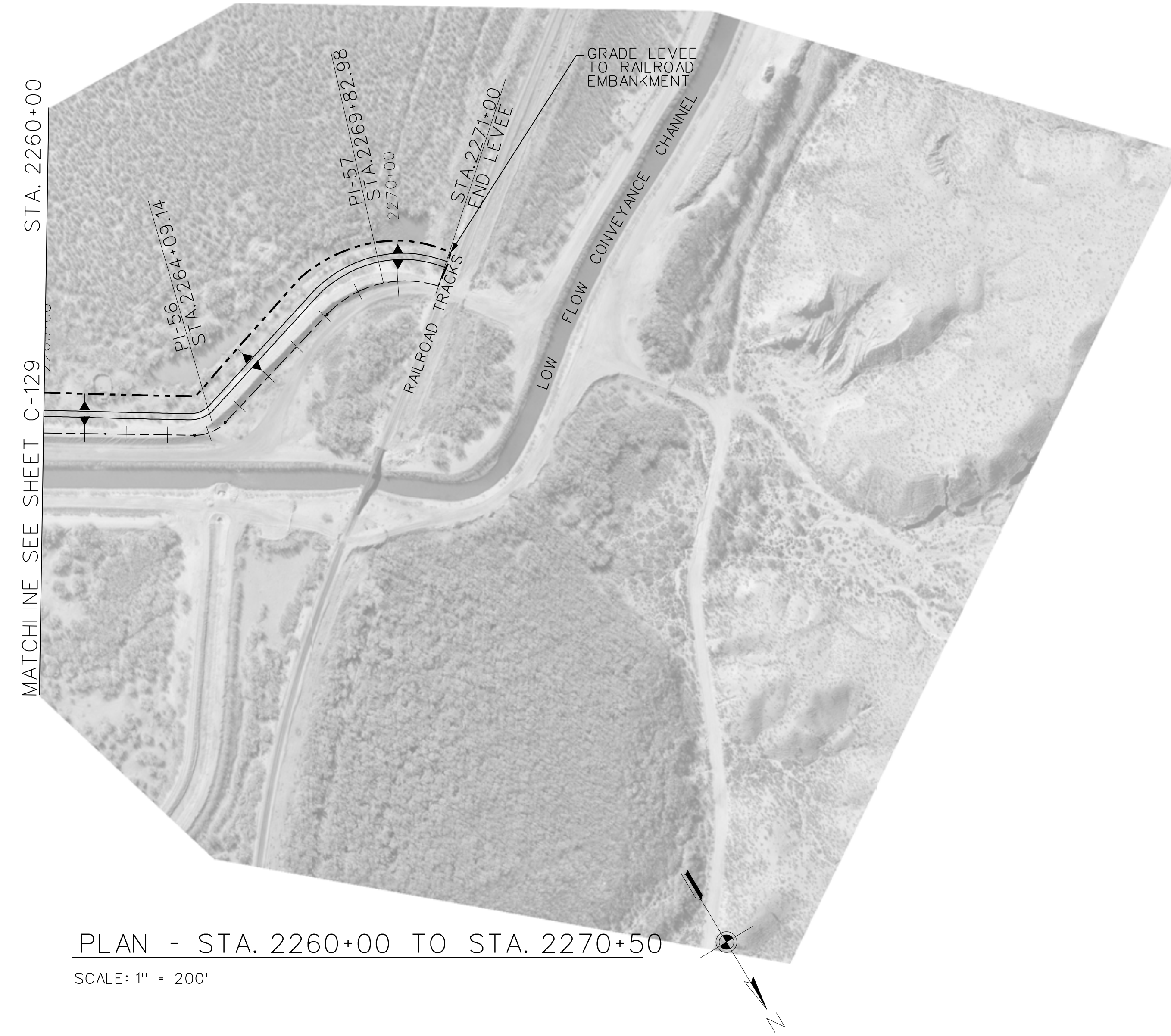
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 2160+00 TO STA. 2260+00

SHEET NO.
C-129
X OF X

SEQUENCE NO.
29



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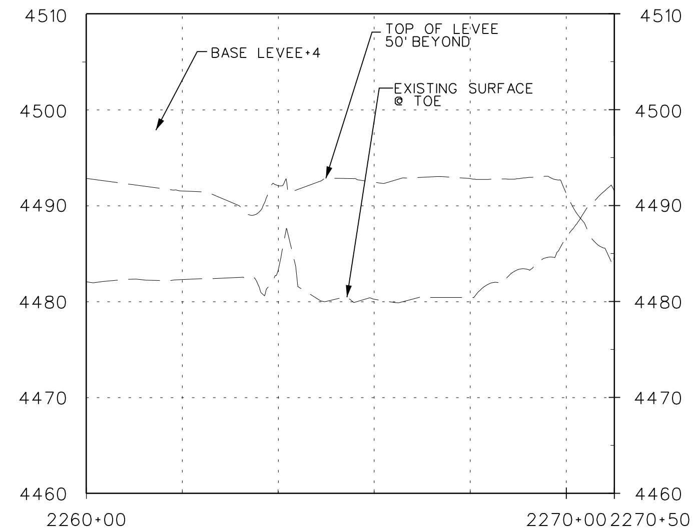
SCALE: 1" = 200'



PROFILE - STA. 2260+00 TO STA. 2270+50

SCALE: 1" = 200' HORIZ.
: 1" = 10' VERT.

GENERAL NOTES

1. REFER TO SHEET C-108 FOR LEGEND.

1" = 200' 0' 100' 200' 400' 600'

1" = 10' 0' 5' 10' 20' 30'

US Army Corps of Engineers
Albuquerque District

Mark	Description	Date	Appr.

File Name: SN02C-134.DGN
Plot Scale: 200:1
Plot Date: January 2012
CWIS NO.
P2 NO.

Zero Accidents Zero Tolerance

DESIGN BY: C. CHAVEZ
DRAWN BY: G. EDWARDS
REVIEWED BY: C. VELASQUEZ

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE FLOODWAY
SAN ACACIA TO BOSQUE DEL APACHE UNIT, NM

PLAN AND PROFILE
STA. 2260+00 TO STA. 2270+50

SHEET NO.
C-130
x OF x

SEQUENCE NO.
30

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-2 & 3

Hydrology & Hydraulics

and Sedimentation

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TABLE OF CONTENTS

FIGURES

TABLES

ATTACHMENT

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HYDROLOGY, HYDRAULICS, AND SEDIMENTATION

1 INTRODUCTION

1.1 PURPOSE OF HYDROLOGIC, HYDRAULIC & SEDIMENT ANALYSES

Hydrologic and hydraulic analyses of a watershed provide an estimate of the potential for flooding and the expected flood peaks, volumes, durations, and corresponding river depths and velocities associated with the flood. The study reach extends along the Rio Grande from the San Acacia Diversion Dam, located north of the city of Socorro, and near the historic community of San Acacia, downstream past the Bosque del Apache National Wildlife Refuge to the headwaters of Elephant Butte Reservoir, south of the former village of San Marcial. The 58-mile reach is located in the southern-most section of the Middle Rio Grande Valley in New Mexico. The study area watershed consists of the Rio Grande and two large ephemeral tributaries, the Rio Puerco and the Rio Salado. Historically, floods in the study area have been associated with two types of events: (1) spring snowmelt runoff from the upper Rio Grande watershed and (2) monsoonal floods primarily contributed from the Rio Puerco and Rio Salado watersheds. Sediment is provided primarily by the uncontrolled tributary flows from the Rio Puerco and the Rio Salado. Sedimentation within the study area has played an important role historically and is anticipated to do so into the foreseeable future. An evaluation of sedimentation provides insight into the episodic and long-term impact of sediment movement and deposition within the channel and floodway. Sediment movement and deposition influences river hydraulics, including flood routing and stage, and the functionality and longevity of proposed project features.

The U.S. Army Corps of Engineers (Corps), Albuquerque District, addressed the hydrology, hydraulics, and sedimentation in previous studies, most recently in the draft *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro, NM, Flood Damage Reduction Project, Limited Reevaluation Study* completed in 1999. However, both new data and improved analytical techniques are available that have allowed the Corps to refine the analyses and design. The Corps revised the hydrologic and subsequent hydraulic analyses for this report based on work initiated in 2003, and updated sediment information was prepared in support of these activities. The scope of the sedimentation work focuses primarily on long-term trends in the study reach, particularly aggradation, which affects hydrograph routing behavior as well as river stage and required levee height. Additionally, the report provides supporting sediment information for bridge alternative evaluation and the development of Risk and Uncertainty Analysis parameters.

The hydrology and hydraulics analyses address existing and future without-project conditions and future with-project conditions. The Corps estimates future conditions to be the existing conditions at a time 50 years into the future, measured from the completion of project construction. Future with-project conditions include projected sedimentation. The with-project analysis includes the significant impacts of the proposed design alternatives so that specific design features can be evaluated. The differences in floodplain depth and extent between the without-project and with-project conditions support the evaluation of the benefits of the proposed project features.

1.2 WATERSHED AREA

The 58-mile study reach is located in the southern-most section of the Middle Rio Grande Valley. The Rio Grande watershed at San Acacia measures 26,770 square miles, including 2,940 square miles in a closed basin in the San Luis Valley, Colorado. Elevations range from over 14,000 feet in the Colorado mountains to 4,660 feet at San Acacia. Upstream flow on the Rio Grande is controlled by Cochiti Dam and Lake, Jemez Canyon Reservoir, Galisteo Dam, and Abiquiu Reservoir. The contributing, uncontrolled drainage area below the dams measures 3,580 square miles in the Rio Grande watershed, 7,350 square miles in the Rio Puerco watershed, and 1,395 square miles in the Rio Salado watershed. The Rio Puerco and the Rio Salado join the Rio Grande approximately 10 miles and two miles, respectively, upstream of San Acacia. The city of Albuquerque is located on the Rio Grande approximately 70 miles upstream of the study area. The Rio Grande watershed between Albuquerque and San Acacia consists of a strip of land bounded by mountains on the east and west. The climate is generally arid or semiarid. Figure 1 shows the study area and the watershed upstream of San Acacia. The following characteristics apply to the study reach:

- The Rio Grande is laden with sediment contributed by the Rio Puerco and the Rio Salado. These tributaries are intermittent and have some of the highest sediment concentrations in the world. No other large tributaries contribute within the study area.

- Present water management in the Middle Rio Grande Valley includes flood risk and sediment management dams and reservoirs, irrigation storage reservoirs, levees, channel maintenance, irrigation diversions, drainage systems, and runoff conveyance systems.

- The Low Flow Conveyance Channel (LFCC) was constructed by the U.S. Bureau of Reclamation (Reclamation) west of the river to efficiently convey up to 2,000 cubic feet per second (cfs) of Rio Grande water from the San Acacia Diversion Dam downstream to Elephant Butte Reservoir. Reclamation does not currently use the LFCC for that purpose, and the LFCC presently conveys only groundwater and local drainage. When Reclamation constructed the LFCC, a spoil-bank levee between the river and the LFCC was constructed using the excavated material.

- The Rio Grande floodway includes the river and the floodplain to the east of the spoil-bank levee. The spoil-bank levee limits meandering to the areas east of the levee and controls the degradation and aggradation processes. The floodway has aggraded because of the sediment that has accumulated in the avulsing system so that the floodway is elevated as much as 15 feet above the historic floodplain.

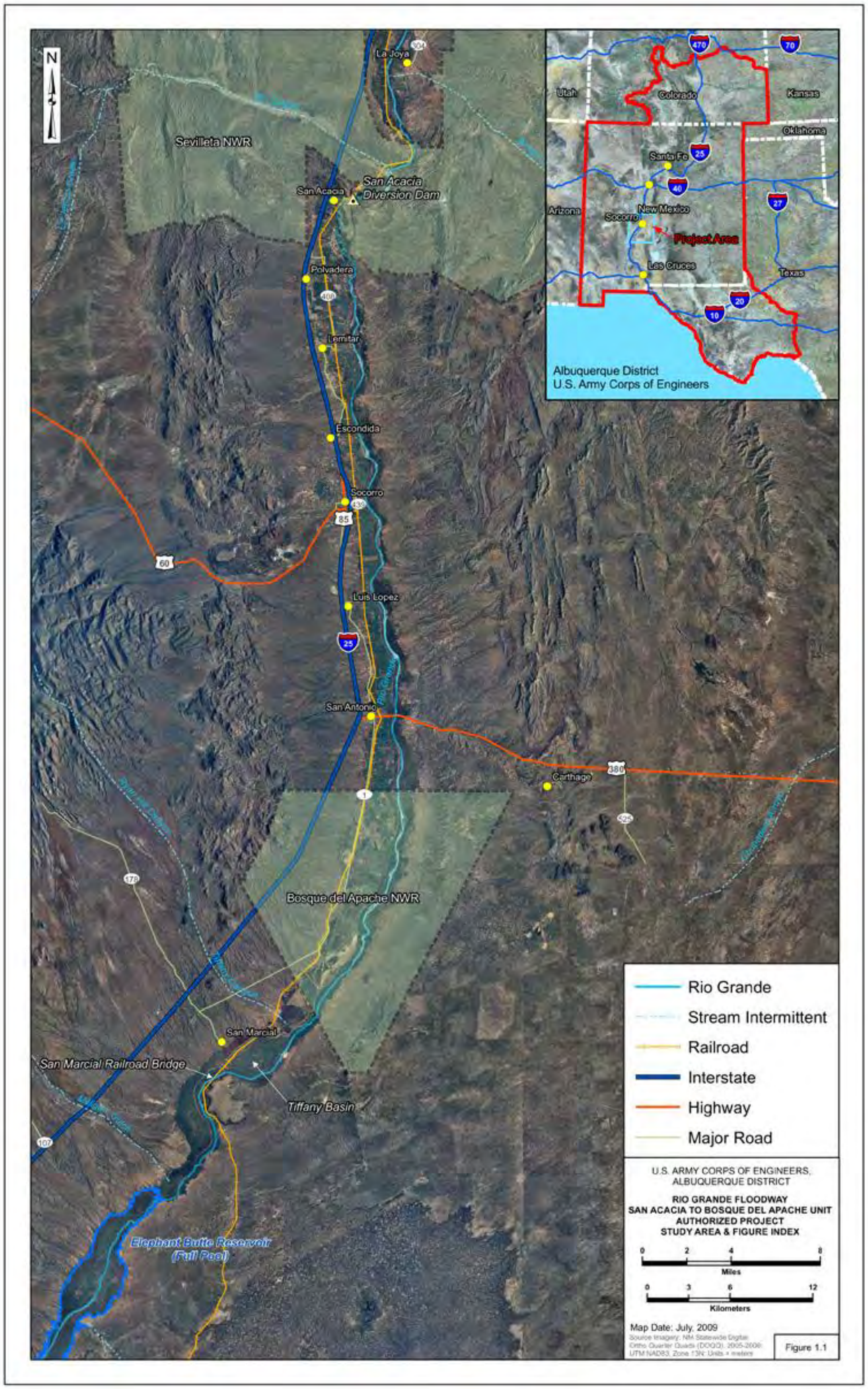


Figure 1. Study Area.

2 PREVIOUS HYDROLOGY, HYDRAULIC, AND SEDIMENT ANALYSES

The Flood Control Act of 1948 authorized construction of the Rio Grande Floodway, which extended for approximately 213 miles from Velarde, New Mexico, to Elephant Butte Reservoir. The San Acacia to Bosque del Apache Unit Project was part of this comprehensive flood risk management plan. To address the San Acacia to Bosque del Apache Unit, the Corps designed a project, the Authorized Project, to reduce the risk of flooding along the Rio Grande from a 0.5%-chance flood event. The Authorized Project consisted of a levee extending from the San Acacia Diversion Dam to Elephant Butte Reservoir, a distance of approximately 58 miles. The Corps designed the levee using the freeboard concept to account for hydrologic, hydraulic, economic, and geotechnical uncertainties. The levee would replace the spoil-bank levee that exists between the LFCC and the Rio Grande floodway. The Middle Rio Grande Conservancy District would be the project sponsor. However, because funds for construction of levees for the San Acacia to Bosque del Apache Unit were not appropriated, this section of levee was never constructed.

In 1988, the Corps issued a Decision Document that reaffirmed the original Authorized Project. In 1994, new issues and information emerged, and the Corps temporarily halted the study. These issues and information include:

- A levee design criteria to address long duration flows has been adopted by the Corps since 1993. Any proposed plan would have to incorporate design features to prevent seepage through the levee or its foundation due to prolonged flow against the riverward toe.

- Identification within the study area of three threatened or endangered species: the Rio Grande silvery minnow, the Southwestern Willow Flycatcher, and the Pecos Sunflower.

- Elimination of the Tiffany Junction-to-Elephant Butte Reservoir reach of the project based on Rio Grande inundation of the lower 12 miles of levee during several wet years and high water levels in Elephant Butte Reservoir, reducing the project reach length to 43 miles.

- Realignment of the LFCC at two locations and shortening of the length of levee at the downstream end.

- The availability of a longer period of hydrologic records to permit improved and updated hydrologic analysis.

- A new data set for the Reclamation Aggradation/Degradation lines permitted further assessment of long-term sedimentation trends within the study area.

Accordingly, the Draft *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro, NM, Flood Damage Reduction Project, Limited Reevaluation Report* (LRR) was recommended and initiated to determine the feasibility and implementation of an alternative plan that would address the new information. During the course of the LRR, Reclamation initiated a study to address the feasibility of abandoning the LFCC. In 1999, the Corps recommended postponing the completion of the LRR until a Reclamation decision was made. In 2002, the Corps received a

letter from Reclamation indicating their continued operation of the LFCC as a passive drain to intercept and convey groundwater and irrigation return flows downstream to Elephant Butte Reservoir, and the Corps reinitiated the LRR in 2003. The current GRR incorporates the new and improved hydrologic and hydraulic analytical techniques. The GRR describes the existing and future without-project and future with-project conditions in the study area and explains the array of alternative plans considered for modification of the Authorized Project.

The Corps previously performed hydrologic and hydraulic analyses for the study area, and the sedimentation issues have been analyzed. Recent Corps reports include:

- The initial hydrologic analysis was presented in the report *Rio Grande Basin, New Mexico, Rio Puerco and Rio Salado Watersheds, Design Memorandum No. 1, Hydrology* (DM No. 1), issued by the Corps in 1979.

- The hydraulic analysis supporting the recommendation for an earthen levee extending 58 miles along the west bank of the Rio Grande from the San Acacia Diversion Dam to the downstream end of the LFCC at the headwaters of Elephant Butte Reservoir appears in the report *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, NM, General Design Memorandum* (GDM No. 1), issued in 1990, and the report *Rio Grande Floodway, San Acacia to Bosque del Apache Unit, NM, Feature Design Memorandum No. 2,* issued in 1991.

- A detailed sediment study concluded by Simons, Li, and Associates, Inc., in 1981 is described in GDM No. 1.

3 SUMMARY OF HYDROLOGIC ANALYSIS

Details of the most recent hydrologic analysis are included in the Attachment to Appendix F-2, *Rio Grande Floodway: San Acacia to Bosque del Apache Unit, Socorro, NM, Flood Damage Reduction Project, Hydrologic Analysis (Hydrologic Analysis)*, completed by the Corps and dated December 2004. Pertinent information and methodology from the Attachment are summarized in the following sections.

3.1 HYDROLOGIC CHARACTERISTICS

Flood flows in the Middle Rio Grande are of two general types. One type commonly occurs from April through June as a result of snowmelt, which may be augmented by general precipitation. Spring flows are characterized by gradually rising hydrographs, moderate discharge rates, and large runoff volumes. Upstream flow regulation on the Rio Grande substantially limits the potential for spring flooding through the study area. The other type of flow is summer monsoonal flash floods that normally occur from May through October. Summer monsoonal flows are characterized by sharp, high peak flows that recede quickly and generally have smaller runoff volumes than the snowmelt flows. However, the majority of the floods that produce the greatest damage within the study area have been caused by summer storms and subsequent floods contributed by the Rio Puerco and the Rio Salado tributaries.

For the hydrologic analysis, the Corps divided the area into four watersheds including (1) the Rio Puerco tributary; (2) the Rio Salado tributary; (3) the regulated Albuquerque drainage area, which

includes contribution from Cochiti Dam and Lake, Jemez Canyon Reservoir, Galisteo Dam, and Abiquiu Reservoir and their watersheds; and (4) the unregulated Rio Grande watershed downstream of Albuquerque. Runoff events from snowmelt that produce peaks at San Acacia originate in the regulated portion of the watershed and generally represent steady flows released from the dams. The maximum reservoir release, because of gate constraints at the dams, is 10,000 cfs. The Corps assumed that flood flows of 10,000 cfs or less measured at San Acacia originate from snowmelt event dam releases. These releases occur over an extended period of time, and attenuation throughout the study reach was assumed to be minimal for these high-volume, lesser-peak events.

For flood events at San Acacia of magnitude greater than 10,000 cfs, flooding is caused by rainfall events that originate in the unregulated watershed downstream of Albuquerque and from the Rio Puerco and the Rio Salado. General storms, which cover a large areal extent compared to localized thunderstorms, rarely occur in the San Acacia watershed, but could produce very high flow events. If a general storm were to occur, flooding from all of the major watersheds could coincidently contribute to the flow hydrograph at San Acacia. The volume of the resulting flood hydrograph would be much greater than a hydrograph generated by a single localized event. Therefore, the Corps adopted the conservative approach and assumed that this generalized flooding will occur with very high flows. This assumption is supported by accounts of floods of record in the study area that resulted from general storms in 1895, 1929, 1936, 1941, 1955, 1967, and 1972. The 1979 Design Memorandum No. 1 describes these events.

3.2 FLOOD FREQUENCY AT SAN ACACIA

To determine flood frequency flows at the upstream end of the study area, the Corps developed a discharge frequency relationship for the Rio Grande at San Acacia. The U.S. Geological Survey (USGS) has operated the stream gage, *Rio Grande Floodway at San Acacia*, Station 08354900, during most of the period from 1936 to present. In 1965, the USGS stopped publishing instantaneous annual peak flows but continued to provide mean daily stream flow data. The Corps obtained the peak flow record from the USGS web site. The annual instantaneous peak flow record was revised to fill data gaps, and additional peak data were acquired from other sources including the USGS and the Corps Reservoir Control Branch. The flow data include flow peaks occurring prior to 1975, when Cochiti Dam and Lake began the regulation of Rio Grande flows. The Corps computed an adjusted record of peak flows so that peaks represent regulated conditions resulting from the construction of the upstream reservoirs. The Corps used the adjusted record of annual maximum instantaneous peaks as the basis for the discharge frequency analysis.

The Corps evaluated the affect of the major unregulated tributaries, the Rio Puerco and Rio Salado, on the frequency analysis at San Acacia. The Corps estimated secondary peaks from these tributaries by routing recorded flows from the tributaries and combining them with coincident recorded flows on the Rio Grande. The Corps developed flood hydrographs required for the routings for the Rio Grande at San Acacia based on peak and volume frequency relationships. The Corps used the USGS stream gages *Rio Puerco near Bernardo* (Station 08353000) and *Rio Salado near San Acacia* (Station 0835400) to estimate mean daily flows to develop the hydrograph volumes, and instantaneous peak data were used with the mean daily flows to estimate the shape of the hydrographs. The Corps used FLO-2D, a two-dimensional unsteady flow model, to route and combine hydrographs. More information about FLO-2D and

the routing process can be found in the attachment to this appendix, *Hydrologic Analysis*. When secondary peaks from the unregulated tributaries were of greater magnitude than the adjusted peaks from the regulated area, the secondary peaks were used in the frequency analysis.

The Corps attempted to use the Flood Frequency Analysis (FFA) program, developed by the Corps Hydrologic Engineering Center, to perform the flood frequency analyses in accordance with Bulletin 17B, *Guidelines for Determining Flood Flow Frequency*. However, the principles applied by Bulletin #17B require homogenous data. Because the peak flows at San Acacia represent both snowmelt and rain flood data and flow from both regulated and unregulated areas from the Rio Grande, the Rio Puerco and Rio Salado, the Corps computed a graphical frequency relationship instead of using the FFA program. The graphical frequency curve incorporates the following assumptions:

- The analysis revised the instantaneous peak flow record to represent present conditions
- The analysis included a single historic peak, the 1929 estimated flood peak
- The analysis used median plotting positions

Figure 2 displays the graphical frequency curve, and Table 1 summarizes the results of the frequency analysis at San Acacia.

3.3 FLOOD FREQUENCY DOWNSTREAM OF SAN ACACIA

Throughout the project area, the Rio Puerco, the Rio Salado, and the Rio Grande upstream of San Acacia provide the only significant sources of flood flows. Because these flows enter the study reach upstream of San Acacia, the Corps routed the computed flood hydrographs from the upstream reach to estimate flood frequencies at locations within the study area from San Acacia downstream to San Marcial. The Corps used FLO-2D for routing and estimating floods at the downstream locations. Hydrologic routing models represent existing without- and with-project conditions (without and with the proposed levees).

Routing of the flood hydrographs, both with and without the proposed levee, shows a significant attenuation of the higher-peak, lesser-volume (monsoonal) events within the study reach. The high amount of attenuation is largely due to the relatively low volume of the rainfall flood peak flows. In some cases, the routed frequency rainfall flood flows are of lesser magnitude than the corresponding frequency snowmelt floods because the snowmelt events experience no significant attenuation. For these situations, the snowmelt event was used as the flood flow at the selected location.

Attenuation is also related to flow in the floodplain and overbanks in both the without- and with-project conditions, and significant storage in the overbank area can greatly reduce the flood peak. Although the overbank area is reduced in the with-project condition, in some places the proposed levee is offset 500 feet or more from the river and offers considerable storage area. The without-project flood routing is the extreme case. It reflects the assumption that the spoil-bank levees fail completely. Floodwaters flow from the perched floodway onto the historic floodplain, which is approximately 10 to 15 feet lower than the floodway. The floodplain ranges up to three miles in width in the lower reach of the study area. More than 25,000 acres of floodplain are inundated in the 0.1% exceedance probability without-project flood event. Because the channel is perched, the flow that leaves the channel in the without-project condition does not directly return to the

channel. A significant volume of floodwaters remains in the floodplain and is lost to the river system. The without-project flood wave attenuation is greatly increased because of these losses.

Table 2 shows the without-project routed Rio Grande flood peaks at selected locations between San Acacia and San Marcial; Table 3 displays the with-project routed peak flows at the same locations between San Acacia and San Marcial.

Table 1. Flood Flow Frequency at San Acacia

Return Period Flood Event	Percent Chance Exceedance	Flow in CFS
500 Year	0.2	43500
200 Year	0.5	35300
100 Year	1.0	29900
50 Year	2.0	25000
20 Year	5.0	19200
10 Year	10.0	15400
5 Year	20.0	11800
2 Year	50.0	7380
1.25 Year	80.0	4770
1.11 Year	90.0	3860
1.05 Year	95.0	3260
1.01 Year	99.0	2420

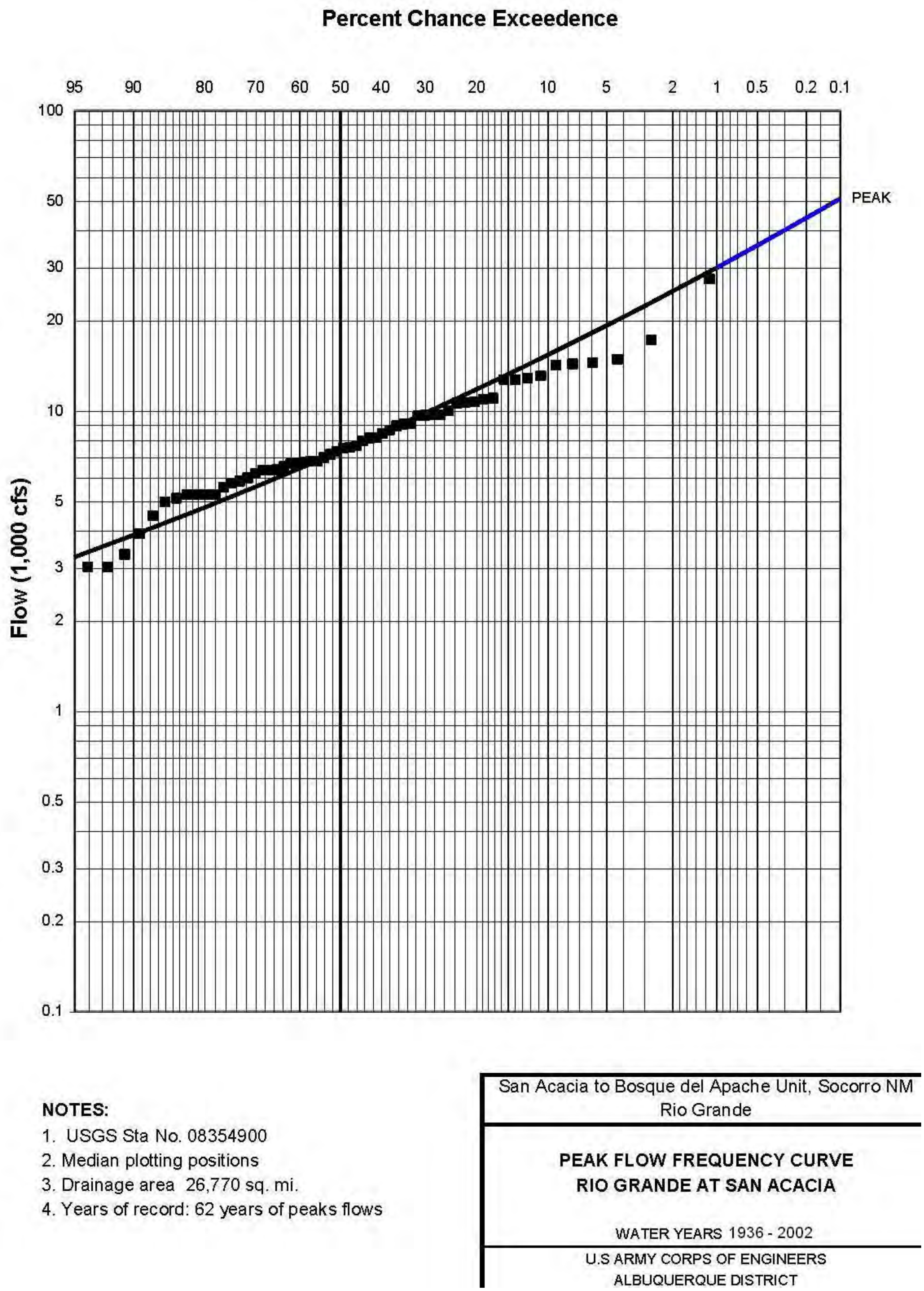


Figure 2. Peak Flow Frequency Curve for the Rio Grande at San Acacia

Table 2. Without-Project (No Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

Reclamation Range Lines	Landmarks	0.5%-Chance Peak Flow (cfs)	1.0%-Chance Peak Flow (cfs)	10.0%-Chance Peak Flow (cfs)	50.0%-Chance Peak Flow (cfs)
SA 1206 - SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 - SO 1308		33710	28760	14635	7380
SO 1309 - SO 1327	Upstream of the Escondida Bridge to the N. Socorro Div. Channel	25725	20905	11910	7380
SO 1328 - SO 1389	Socorro	23485	18880	10575	7380
SO 1390 – SO 1429		21360	17100	10000	7380
SO 1430 – SO 1474		20715	16575	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	18605	14930	10000	7380
SO 1511 – SO 1568	Bosque del Apache	18025	14605	10000	7380
SO 1569 – SO 1649	Bosque del Apache	12670	10415	10000	7380
SO 1650 – SO 1669	Bosque del Apache	11990	10000	10000	7380
SO 1670 to SO 1709	From Tiffany Junction downstream to below San Marcial Railroad Bridge	11185	10000	10000	7380

Table 3. With-Project (With Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

Reclamation Range Lines	Landmarks	0.5%-Chance Peak Flow (CFS)	1.0%-Chance Peak Flow (CFS)	10.0%-Chance Peak Flow (CFS)	50%-Chance Peak Flow (CFS)
SA 1206 – SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 – SO 1308		34050	28670	14635	7380
SO 1309 – SO 1327	Upstream of the Escondida Bridge to the North Socorro Diversion Channel	27000	21650	11980	7380
SO 1328 – SO 1389	Socorro	26170	20440	11110	7380
SO 1390 – SO 1429		25280	19895	10000	7380
SO 1430 – SO 1474		24390	19350	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	22150	17655	10000	7380
SO 1511 – SO 1568	Bosque del Apache	21590	17310	10000	7380
SO 1569 – SO 1649	Bosque del Apache	21030	16960	10000	7380
SO 1650 – SO 1669	Bosque del Apache	20475	16615	10000	7380
SO 1670 – SO 1709	From Tiffany Junction downstream to below San Marcial Railroad Bridge	18565	14890	10000	7380

4 HYDRAULIC ANALYSIS

4.1 OVERVIEW OF HYDRAULIC ANALYSIS

The hydraulic analysis, used in conjunction with the sediment analysis, contributes to the evaluation of the potential for flooding and the proposed actions to alleviate high-water conditions. Specific applications for the hydraulic analysis in the project area include:

- Generation of with- and without-project floodplains
- Contribution to the economic analysis
- Contribution to risk assessment used in the determination of damage-frequency relationships, characterization of uncertainties, and design parameters such as levee heights
- Evaluation of impacts and performance of the proposed Tiffany Basin sediment management feature
- Evaluation of impacts and performance of the proposed replacement of the San Marcial Railroad Bridge
- Evaluation of environmental impacts of other proposed project alternative features
- Evaluation of potential induced damages of proposed project alternative features

The Corps used the following two numeric models, each with advantages for particular applications, for the hydraulic analysis:

- HEC-RAS, the River Analysis System, is software provided by the Corps' Hydrologic Engineering Center. HEC-RAS is widely used for one-dimensional hydraulic modeling. The Corps used HEC-RAS primarily to establish water-surface profiles for the alternatives evaluated and to determine parameters for alternative feature design.

- FLO-2D is an unsteady two-dimensional hydraulic model. The Corps used FLO-2D for hydrologic routing, for with- and without-project floodplain determination, and to supplement the discharge-stage rating curves for economic evaluation. FLO-2D routes one or more hydrographs in a time series simulation using a two-dimensional geometry. The floodplain is represented by a numbered grid, and each grid element has associated with it a physical location, elevation, and roughness (Manning's *n*) coefficient. For this project, the model uses 500-foot-square grids. Smaller topographic features such as roadway embankments were field verified and manually added to the FLO-2D grid. The channel is located within the grid, and the channel hydraulics are calculated using a cross section in each grid that has a channel element. One of the salient features of FLO-2D is that it conserves volume. More information about FLO-2D can be found in the Attachment, *Hydrologic Analysis*, found at the end of this appendix.

The advantage of HEC-RAS is its ability to compute water surface elevations. The water surface elevations predicted by HEC-RAS and FLO-2D did not always correlate, due in large part to differing algorithmic and reporting approaches as well as to data sources and assumptions. For the most part, however, the two models were in general agreement for comparable conditions, and significant effort went into understanding the logical reasons where substantial differences did exist. For the majority of the project design, the Corps used HEC-RAS because of its well-established acceptance, as well as its appropriateness to the confined floodway of the with-project

condition. Figure 3 illustrates the geographic relationship of the two model types, with the FLO-2D grid-cell extents overlain by the HEC-RAS cross-sectional representation.

The two-dimensional FLO-2D model offers a superior tool to evaluate flood location and extent than would be possible with a one-dimensional hydraulic model. Because the Rio Grande floodway is elevated, or *perched*, above the floodplain by as much as 10 to 15 feet in the study area, the without-project flow is divided between the floodway and the floodplain. One of the benefits of the FLO-2D model is the ability to evaluate floodplain flow versus floodway flow throughout the study reach. FLO-2D provides a means to estimate the flow that leaves the floodway and is lost from the river.

In collaboration with Federal and state agencies, the Corps originally developed a FLO-2D model for the Upper Rio Grande Water Operations Project (URGWOP) to evaluate water operations in the upper Rio Grande. The URGWOP model is documented in the report titled *Development of the Middle Rio Grande FLO-2D Flood Routing Model Cochiti Dam to Elephant Butte Reservoir,* prepared by TetraTech, Inc., in 2002. The Corps used the URGWOP FLO-2D model as the basis for the San Acacia to San Marcial FLO-2D model. The San Acacia to San Marcial study requires models representing both without-project and with-project conditions. The with-project FLO-2D model for the San Acacia to San Marcial reach is very similar to the URGWOP FLO-2D model. The URGWOP FLO-2D model represents existing conditions and uses the assumption that the spoil-bank levee is a viable levee. The Corps made two significant revisions to adapt the URGWOP FLO-2D model for use as the without-project San Acacia to San Marcial model. First, the Corps removed the spoil-bank levees to reflect the assumption that the spoil-bank levees will fail when in contact with floodwaters. Second, because the extent of the URGWOP model grid was not adequate for the without-project conditions, the Corps extended the grid to the west to encompass the historic floodplain.

The Corps evaluated both existing- and future-conditions models for the without-project hydraulic analysis and present- and future-conditions models for the with-project hydraulic analysis. The present-conditions with-project model represents existing conditions but with the proposed levee in place. The future-conditions models represent the channel and floodplain 50 years into the future. The lower portion of the watershed, in particular, is expected to experience significant changes based on the sedimentation patterns of the past. Development of future-conditions models is addressed in Section 5, *Sedimentation Analysis.*

The Corps selected reaches for the hydraulic analysis of the Rio Grande between San Acacia and San Marcial in terms of reach similarity based on the following key hydraulic parameters:

- Maximum channel velocity
- Maximum flow depth in the channel and expanded floodplain
- Maximum discharge in the channel
- Slope

The FLO-2D routing for a steady 10,000 cfs flow was the basis for evaluating velocity, flow depth, and maximum discharge. Table 4 shows the performance locations that were used and the reference range lines and grid cells associated with each location.

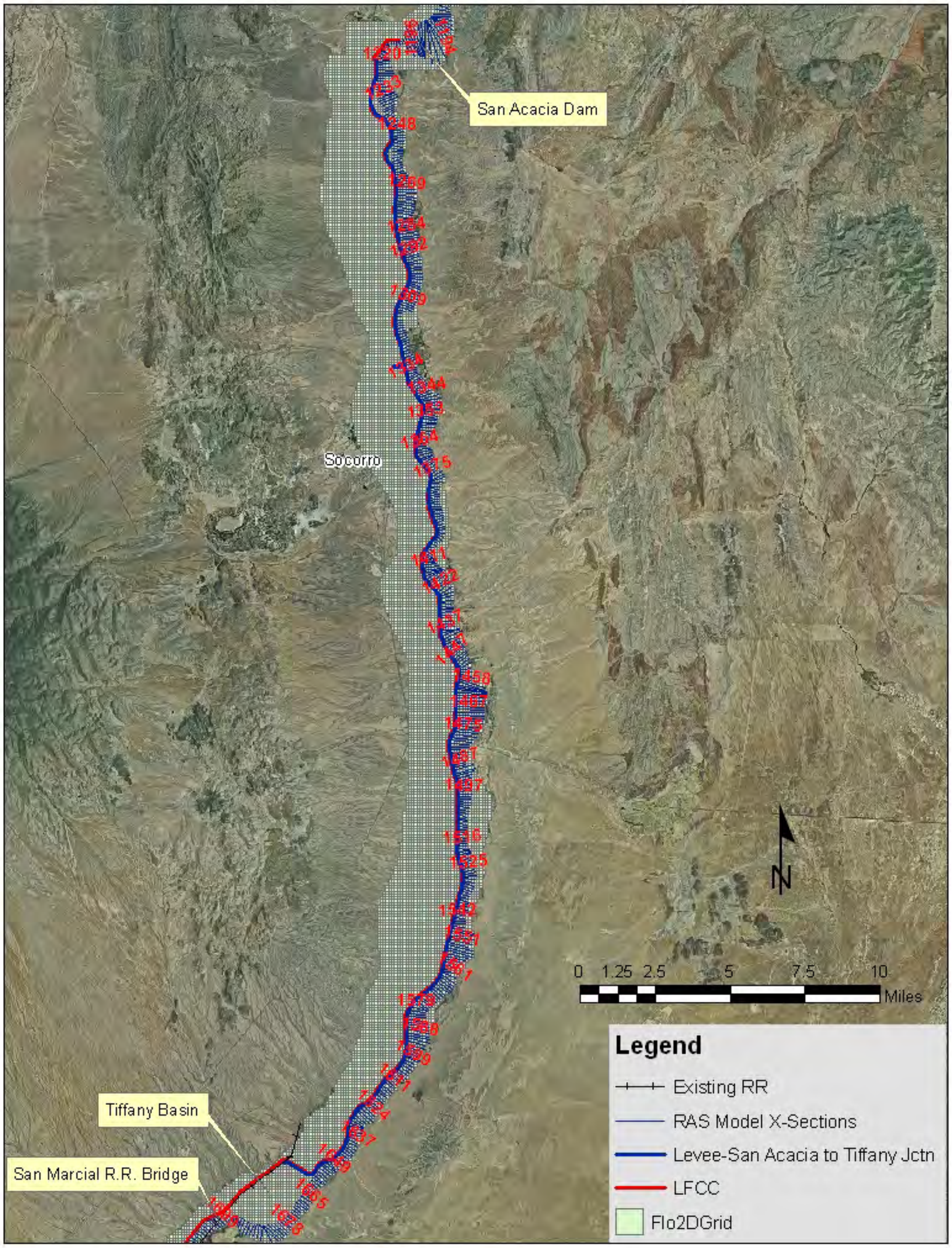


Figure 3. HEC-RAS and FLO-2D modeling extents.

Table 4. Reaches for FLO-2D Hydraulic Analysis San Acacia to Bosque del Apache

Performance Location	Description	Reference Range Lines			Reference Grid Cells	
		U/S	D/S	Typical	U/S	D/S
1	U/S of San Acacia Div. Dam	CO 1174	SA 1210	RP 1190	23372	23797
2	D/S of San Acacia Div. Dam	SA 1210	SA 1232	SA 1218	23797	24195
3		SA 1232	SA 1259	SA 1256	24195	24447
4		SA 1259	SO 1298	SA 1268	24447	24800
5		SO 1298	SO 1304	SO 1299	24800	24851
6	Escondida Bridge	SO 1304	SO 1324	SO 1320	24851	25013
7	Socorro North Div. Channel	SO 1324	SO 1337	SO 1327	25013	25072
8		SO 1337	SO 1340	SO 1339	25072	25091
9		SO 1340	SO 1349	SO 1346	25091	25159
10	Socorro area	SO 1349	SO 1368	SO 1360	25159	25249
11		SO 1368	SO 1400	SO 1394	25249	25405
12		SO 1400	SO 1409	SO 1401	25405	25478
13		SO 1409	SO 1419	SO 1414	25478	25543
14		SO 1419	SO 1472	SO 1450	25543	25936
15	Hwy. 380 Bridge	SO 1472	SO 1484	SO1482.6	25936	26039
16		SO 1484	SO 1498	SO 1491	26039	26162
17	BDANWR	SO 1498	SO 1531	SO 1517.2	26162	26477
18	BDANWR	SO 1531	SO 1595	SO 1550	26477	26929
19	BDANWR D/S of RM 78	SO 1595	SO 1616	SO 1603.7	26929	27086
20	BDANWR South Boundary	SO 1616	SO 1652	SO 1641	27086	27704
21		SO 1652	SO 1682	SO 1662	27704	28414
22	San Marcial Railroad Bridge	SO 1682	EB 14	SO 1701.3	28414	28433

4.2 WITHOUT-PROJECT HYDRAULIC ANALYSIS

4.2.1 WITHOUT-PROJECT HYDRAULIC MODELS

The Corps used FLO-2D to model the flooding locations and extents for the without-project analysis, whereas HEC-RAS was implemented to model bridges and in-stream structures in the without-project analysis. FLO-2D does not directly model structures as does HEC-RAS; FLO-2D uses rating tables to describe the structures. The Corps used the HEC-RAS results to construct rating tables to be used in the FLO-2D model. As explained in Section 4.1, *Overview of Hydraulic Analysis*, the Corps modified an existing FLO-2D model to meet the needs of this project.

4.2.2 DATA USED FOR WITHOUT-PROJECT HYDRAULIC MODELS

Geographic data are represented in the FLO-2D model in two ways. The floodplain is characterized using a grid, which covers the entire floodplain. The size of the grid is 500 feet square. Like HEC-RAS, FLO-2D represents the channel using cross-sections. The vertical datum used for the FLO-2D model is North American Vertical Datum of 1988 (NAVD 1988), and the horizontal datum is New Mexico State Plane Central North American Datum of 1983 (NAD 1983). The mapping data that were used to generate the original URGWOP FLO-2D grid

in the study area were derived from several sources. The without-project floodplain to the west of the levee in the study area was extended and added to the model using the best available elevation data. The best available data proved to be the USGS 10-meter Digital Elevation Model data.

The FLO-2D model has a channel cross section every 500 to 800 feet. The channel cross sections were surveyed between 1997 and 2004 at intervals of approximately 2,000 feet. Intervening cross sections were interpolated. In the FLO-2D model, the Manning's *n* value and infiltration parameters in the floodplains were estimated based on field observations and land-use identification. Aerial photography was used to identify land use. Floodplain features such as major berms, including roadway and railroad embankments, were entered in the without-project FLO-2D model. Culverts located in the field were added to the model to account for the movement of flows between areas that would otherwise trap floodwaters.

4.2.3 MODEL ASSUMPTIONS

The Corps used the following assumptions to develop the without-project hydraulic models for the study reaches:

- The present non-engineered spoil-banks will fail to confine flood flows to the perched floodway, and were removed from the model
- Infiltration losses are included (FLO-2D)
- Evaporation losses are not included

4.3 WITH-PROJECT HYDRAULIC ANALYSIS

4.3.1 WITH-PROJECT HYDRAULIC MODELS

The Corps used HEC-RAS to produce water-surface profile calculations and, subsequently, to support levee-height selection. The Corps used the FLO-2D model to determine the areal extent of flooding to plot floodplains for the with-project conditions.

4.3.2 DATA USED AND/OR MODIFIED FOR WITH-PROJECT HYDRAULIC MODELS

Reclamation obtains cross section (range-line) surveys approximately every 10 years within the floodway in the study area for the purpose of evaluating aggradation and degradation of sediment in the Rio Grande channel and floodway. Reclamation cross sections are separated by approximately 500 feet and are referenced to the NAVD 1988. Reclamation uses aerial photography to obtain these data; therefore, the under-water bathymetry is not captured. The Corps used the photogrammetrically surveyed 2002 Reclamation cross-sectional data for the with-project HEC-RAS model, supplemented with additional field-collected and photogrammetrically-obtained topographic information.

FLO-2D elevation data exist both in extended floodplains outside the floodway and also in detailed surveyed channel sections, and the FLO-2D data were used where Reclamation range-line data were not complete. The Corps measured the dimensions of bridges within the study

reach, and the San Marcial Railroad Bridge was modeled based on the then-current level of design.

4.3.3 HEC-RAS MODELING

The HEC-RAS models represent terrain as a series of cross sections in the river corridor perpendicular to the assumed flow direction. The HEC-RAS model used Reclamation's 2002 channel cross sections located approximately every 500 feet. Intervening cross sections were interpolated. Manning's *n* values were estimated based on field observations and on land-use identification. The Corps used aerial photography to identify land-use conditions.

The under-water channel prism was calculated based on an assumed trapezoidal shape. The Corps used the flow conditions at the time of photography and relevant Manning's *n* values to calculate a flow area. The portion of the channel underwater at the time of the aerial survey was subsequently edited to represent this flow area.

All significant bridges and structures within the study reach were modeled. These included the San Acacia Diversion Dam at the upstream end of the project, Escondida Bridge near Socorro, Highway 380 Bridge, and the Burlington Northern Santa Fe (BNSF) Railroad Bridge at San Marcial.

4.3.4 FLO-2D MODELING

The FLO-2D model determined the aerial extent of flooding to plot floodplains for the with-project conditions. Additionally, the FLO-2D model supplemented the discharge-stage rating curves for economic evaluation. The Corps did not use the FLO-2D model for design of levee heights or other structures.

4.3.5 MODEL ASSUMPTIONS

The Corps used the following assumptions to develop the with-project hydraulic models:

- Linearly-varied peak discharge between hydrologic flow nodes
- Future sediment deposition distributed uniformly across cross-sections

For the with-project conditions, the Corps determined that interior drainage does not pose flooding problems behind the leveed areas of the study reach. Also, relatively few damageable properties exist within the floodway that would be impacted by an increase in stage due to the constructed levee.

4.3.6 DOWNSTREAM EFFECTS

The San Marcial (BNSF) Railroad Bridge is located at the downstream end of the San Acacia to San Marcial study reach. The Corps analyzed the bridge to determine the probability of flooding at the bridge under existing conditions and the probability of flooding after construction of the proposed levee project, to evaluate potential 5th Amendment *takings*.

BNSF provided the Corps with three conditions for which flood water at the San Marcial Railroad Bridge would be assumed to cause (1) closure and service interruption, (2) damage to the bridge, and (3) bridge destruction. The BNSF defined the three conditions and their associated water surface elevations as follows:

- Closure Elevation: Elevation at the bottom chord, or low steel, of the bridge. When the water surface reaches this elevation, the bridge would hypothetically be closed to traffic.

- Damage Elevation: Elevation at which structural damage to the bridge was estimated to begin occurring. This elevation is achieved when the water surface reaches one foot above the low chord of the bridge.

- Destruction Elevation: Elevation at which the bridge was estimated to be destroyed. This occurs when the water surface reaches one foot above the bridge deck, or "top of rail".

To determine the probability of the water surface reaching these damaging elevations for the without- and with-project conditions, the Corps created a HEC-RAS model of the existing San Marcial Railroad Bridge. The Corps used the HEC-RAS model to develop a rating curve to determine the water surface elevation at the bridge for various flows. The bridge is difficult to model for several reasons, including the orientation of the bridge, the channel-elevation variation at the bridge, and the absence of actual high flows within recent history to use for calibration purposes. The Corps created separate geometry files within the HEC-RAS model to characterize the range of possible conditions at the bridge. The various geometry files consider pressure flow, scour under the bridge, and weir flow over the bridge and embankment. The results from these models were combined to represent the expected water surface elevations associated with a large range of flows and the different conditions. The stage-discharge rating curve incorporating the results of the expected conditions is presented in Figure 4. Figure 4 also displays the three water surface elevations that the BNSF predicts would cause closure, damage, and destruction to the San Marcial Railroad Bridge. Figure 4 shows that the water surface elevation will reach the low chord, or closure elevation, of the bridge during a flow of approximately 2,500 cfs. The water surface will reach the damaging elevation during a flow of approximately 4,600 cfs. The water surface will reach the bridge destruction elevation during a flow of approximately 19,000 cfs.

The Corps routed the 0.50%-, 0.10%-, 1.0%-, and 0.5%-chance mean flood flows through the study area and to the San Marcial Railroad Bridge for both the without-project and with-project conditions. Tables 9 and 10 of the Attachment, *Hydrologic Analysis*, present the flows associated with these frequencies. The Corps plotted the flows and their associated probabilities on log-Pearson type III probability paper and correlated the probabilities with the stages attained by the discharge frequency flows to determine the probability of the frequency flows affecting the San Marcial Railroad Bridge under the three thresholds for the without-project and with-project conditions.

Table 5 shows the annual probability of the flows damaging the existing San Marcial Railroad Bridge under the three events for the existing and future without-project models and the present and future with-project models. No difference exists in the annual probability of a closure event or damage event occurring with or without the project. The annual probability of a destruction event occurring increases from 0.002 to 0.005 with the project levees in place. For future

conditions, the San Marcial Railroad Bridge flow conveyance capacity is expected to be virtually eliminated by sediment deposition. If the historic rate of aggradation in this reach continues, the Rio Grande channel invert elevation would reach the elevation of the low chord of the bridge in approximately 20 years. Thus, the annual probabilities of reaching any of the three analysis conditions approach unity by year 50, with or without the project.

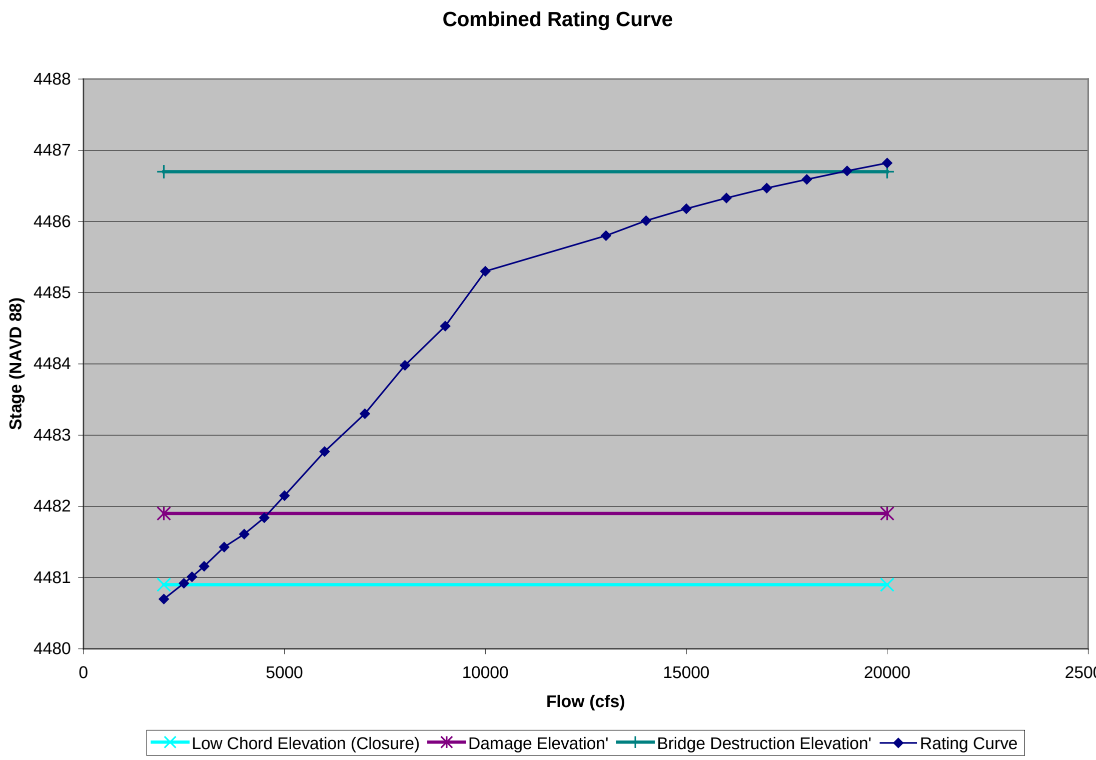


Figure 4. Combined Rating Curve

Table 5. Annual Probability that Flood Event Affects San Marcial Railroad Bridge

ANNUAL PROBABILITY THAT FLOOD EVENT AFFECTS BRIDGE				
	Without Project Year 1	*Without Project* Year 50	*With Levee Project* Year 1	*With Levee Project* Year 50
Closure Event (low chord)	>0.5	0.99	>0.5	0.99
Damage Event (low chord + 1’)	>0.5	0.99	>0.5	0.99
Destruction Event (top of rail + 1’)	<0.002	0.99	0.005	0.99

4.4 ALTERNATIVE PLANS AND DESIGN FEATURES

The Corps formulated and evaluated a range of alternative plans to address flood risk management in the Rio Grande. In addition, the Corps evaluated design features that would meet objectives other than flood risk management, and these features are grouped into two distinct categories: the acquisition and rehabilitation of 2,053 acres within the Tiffany Basin and the replacement of the railroad bridge at San Marcial.

4.4.1 SAN MARCIAL RAILROAD BRIDGE EVALUATION

The existing San Marcial Railroad Bridge, originally constructed in 1929, is a significant restriction to passing flood flows through the study area. The restriction limits the capacity of the channel to pass flood flow downstream and augments the deposition of sediment and aggradation of the river channel and floodplain. A potential interruption to railroad traffic over the bridge would occur if the bridge were to fail. Sedimentation impacts in the immediate vicinity of the existing San Marcial Railroad Bridge have been significant, and increasing as time goes on in terms of conveyance capacity and maintenance. The Corps examined the sedimentation impacts under the assumption that the sediment would continue to deposit and that the floodway would continue to aggrade at historic rates. For conditions 50 years into the future, the Corps assumed that the BNSF will replace the bridge at some point during the intervening years, presumably with a bridge configuration that would not suffer from the conveyance inefficiencies of the current bridge. A review of the probabilities shown in Table 5 supports this assumption.

The Corps analyzed the San Marcial Railroad Bridge feature to determine the probability of flooding the bridge under without- and with-project conditions to address the possible replacement of the bridge. The Corps used HEC-RAS to model the bridge alternatives (placed at a new alignment to the river channel), and the Corps analyzed the alternatives to determine the required span and elevation of the bridge to pass flows and the hydraulic variables for scour and sediment transport calculations. The modeling predicted the effect the bridge would have on upstream water surface elevations for the various alternatives.

Bridge replacement alternatives considered a variation in the number of bridge spans. Based on structural design recommendations, the Corps assumed an 88-foot maximum clear span between bridge piers. The minimum number of spans considered was three with a total bridge span of 270 feet. The Corps also considered five, seven, and nine bridge spans with total spans of 450 feet, 630 feet, and 810 feet, respectively. The Corps made comparisons between the alternatives for the present-conditions sedimentation. HEC-RAS modeling showed little difference in the backwater effects among alternatives except for the three-span bridge, which, when considering the 1.0%-chance flood discharge, increased the water surface elevation upstream of the bridge approximately two to three feet above the water surface elevation produced by the other alternatives. The Corps performed a sediment continuity analysis for the different span alternatives, and the analysis is discussed in detail in Section 5.4, *Bridge Replacement Alternative Capacity Evaluation*. As a result of this analysis, the Corps selected the seven-span bridge alternative.

The Corps determined the bridge height using the 1.0% exceedance probability discharge after 50 years of predicted sediment aggradation. The Corps set the low chord of the bridge one foot

above the water surface elevation, based on design guidance received from BNSF. The design height of the relocated bridge would be approximately 10 feet higher than the existing bridge relative to the channel invert elevation.

4.4.2 TIFFANY BASIN SEDIMENT MANAGEMENT FEATURE EVALUATION

The Corps considered the Tiffany Basin sediment management feature to help control sediment aggradation within the Rio Grande. Tiffany Basin exists on the west side of the river channel, near the Tiffany Junction railroad siding and immediately upstream of the San Marcial Railroad Bridge. The basin is bounded on all sides by either spoil-bank levees or railroad embankment and is generally isolated from sediment-laden river flows. The existing spoil-bank levee splits at the upstream end of Tiffany Basin, and the west spoil-bank levee combines with the railroad embankment to separate the basin from the LFCC west of the basin. The existing east spoil-bank levee, on the east and south sides of the basin, separates the basin from the Rio Grande floodway. The absence of frequent alluvial deposition has left this basin at a significantly lower elevation as compared to the adjacent river floodway. The Tiffany Basin sediment management feature would allow controlled routing (and settlement) of a portion of the sediment-laden river through the basin, and would serve to decrease the sediment deposition in the project reach of the Rio Grande immediately upstream of the basin, as well as downstream and within Elephant Butte Reservoir.

The Tiffany Basin and downstream project area received a considerable amount of scrutiny primarily because of concerns that uncontrolled flows entering the lower-elevation areas beyond the existing spoil bank levees in this vicinity had the potential to initiate a significant headcut. Development of a deep cut in this area would subsequently put the foundation of the new engineered levee at risk. The most economical means of mitigating this as a risk to the upstream engineered levee, or to what level, was not clear early on. Options available include (a) construct a hardened grade control across the floodway at the upstream end of Tiffany Basin, (b) add toe protection in the form of riprap to the engineered levee a short distance upstream of the basin, (c) add height and/or functional integrity to the inner spoil-bank levee, or (d) accept the finite risk that a short portion of the downstream end could require repair or replacement during the project life. From among the options evaluated, armoring of a length of the downstream engineered levee toe appears most cost effective and was selected for the recommended alternative.

4.4.3 ARRAY OF ALTERNATIVE PLANS

The Corps assembled an array of alternatives, mixing various proposed features at the downstream end of the proposed levee project, for evaluation to determine the various benefits and opportunities associated with the features. The Corps evaluated hydrodynamic performance of the majority of these alternatives, including the “No Action Alternative” for completeness and to serve as a baseline for comparison. (Some additional alternatives were subsequently added to the array, but did not require hydraulic evaluation due to their similarity to other alternatives already considered.) The following narrative describes the alternatives evaluated, describes the methodology and assumptions used to evaluate their performance, and summarizes the major differences between the alternatives from a hydrologic and hydraulic perspective. Table 6 lists the significant features of the alternatives, and Figures 5.1, 5.2, and 5.3 display the alternatives. Because the proposed levee reconstruction feature upstream of Tiffany Basin is common to all alternatives that include the engineered levee, Figures 5.1, 5.2, and 5.3 show only the proposed features within the Tiffany Basin area where the variation occurs.

- No Action Alternative: This alternative illustrates the expected performance of the lower reach of the project with the existing east spoil-bank levee separating the river floodway from the lower-elevation Tiffany Basin and with the existing BNSF railroad bridge in place. The No Action Alternative is synonymous with the without-project condition, and the Corps evaluated the alternative to represent the conditions currently present without the engineered levee upstream of Tiffany Junction. Without the engineered levee in place, the evaluation hydrographs for the higher magnitude rainfall storms (0.05 through 0.002 exceedance probability) display a more pronounced attenuation of their peaks when compared to the condition with the engineered levee in place. The more frequent events (0.50 and 0.10 exceedance probability) represent long-duration spring snowmelt floods and do not experience a significant difference in attenuation between the without- and with-levee conditions.

- Alternative A: This alternative includes a 43-mile engineered levee extending from the San Acacia Diversion Dam downstream to Tiffany Junction, which is located north of the basin. The new levee embankment material would be obtained by reconstructing the existing spoil-bank levee located between the floodway and the LFCC. Alternative A is otherwise similar to the No Action Alternative, which includes the existing railroad bridge and the existing east spoil-bank levee between Tiffany Basin and the floodway. With this alternative, attenuation is reduced for the rainfall storms when the flows are contained by the proposed upstream engineered levee.

- Alternative B: Alternative B is similar to Alternative A and includes the upstream 43-mile engineered levee and the existing railroad bridge, but adds the Tiffany Basin sediment management feature. With this alternative, attenuation is reduced for the rainfall storms when the flows are contained by the proposed upstream engineered levee.

- Alternative C: Alternative C is similar to Alternative A and includes the upstream 43-mile engineered levee and the existing east spoil-bank levee between Tiffany Basin and the floodway, but with the addition of the San Marcial Railroad Bridge feature to remove the existing San Marcial Railroad Bridge and construct a new railroad bridge in a more efficient location. With this alternative, attenuation is reduced for the rainfall storms when the flows are contained by the proposed upstream engineered levee.

- Alternative D: Alternative D is similar to Alternative A and includes the upstream 43-mile engineered levee from San Acacia Diversion Dam to Tiffany Junction, but with the addition of the Tiffany Basin sediment management feature and the San Marcial Railroad Bridge replacement feature.

- Alternative E: This alternative is similar to the No Action Alternative, with no upstream engineered levee and with the existing east spoil-bank levee between Tiffany Basin and the floodway, but with the addition of the San Marcial Railroad Bridge replacement feature.

- Alternative F: Alternative F is similar to Alternative E, with no upstream engineered levee, but with the new San Marcial Railroad Bridge and the Tiffany Basin sediment management features.

- Alternative G: Alternative G includes an upstream engineered 43-mile levee, but extends the engineered levee downstream along the west side of Tiffany Basin to the new bridge location. The levee extension serves to protect the railroad tracks from sedimentation and flooding that originates in the Tiffany Basin. The alternative includes the new San Marcial Railroad Bridge and the Tiffany Basin sediment management features.

- Alternative H: Alternative H is similar to Alternative G, with the upstream engineered levee and the Tiffany Basin sediment management feature. However, Alternative H does not include the San Marcial Railroad Bridge replacement feature, and the engineered levee is extended downstream along the west side of Tiffany Basin to the existing railroad bridge.

- Alternative I: Alternative I includes the extension of the upstream engineered levee downstream to the new railroad bridge along the west side of Tiffany Basin similar to Alternative G; however, Alternative I does not include the Tiffany Basin sediment management feature. Therefore, Alternative I features the east spoil-bank levee between Tiffany Basin and the floodway.

- Alternative J: This alternative is similar to Alternative I, with the upstream engineered levee extending downstream to the new San Marcial Railroad Bridge feature; however, the levee is extended along the existing east spoil-bank levee alignment between Tiffany Basin and the floodway. Alternative J does not include the Tiffany Basin sediment management feature.

- Alternative K: This alternative is similar to Alternative J, extending the engineered levee along the east spoil-bank levee between Tiffany Basin and the floodway, but the levee extends downstream to the existing railroad bridge. Alternative K does not include the Tiffany Basin sediment management feature or the San Marcial Railroad Bridge replacement feature.

Table 6. Significant Features of the Alternatives

Alternative	Includes Engineered Levee down to Tiffany Junction	Includes Extended Engineered Levee to Bridge along West Alignment	Includes Extended Engineered Levee to Bridge along East Alignment	Includes Tiffany Basin Sediment Management Feature	Includes New San Marcial Railroad Bridge Feature
No Action	No	No	No	No	No
A	Yes	No	No	No	No
B	Yes	No	No	Yes	No
C	Yes	No	No	No	Yes
D	Yes	No	No	Yes	Yes
E	No	No	No	No	Yes
F	No	No	No	Yes	Yes
G	Yes	Yes	No	Yes	Yes
H	Yes	Yes	No	Yes	No
I	Yes	Yes	No	No	Yes
J	Yes	No	Yes	No	Yes
K	Yes	No	Yes	No	No

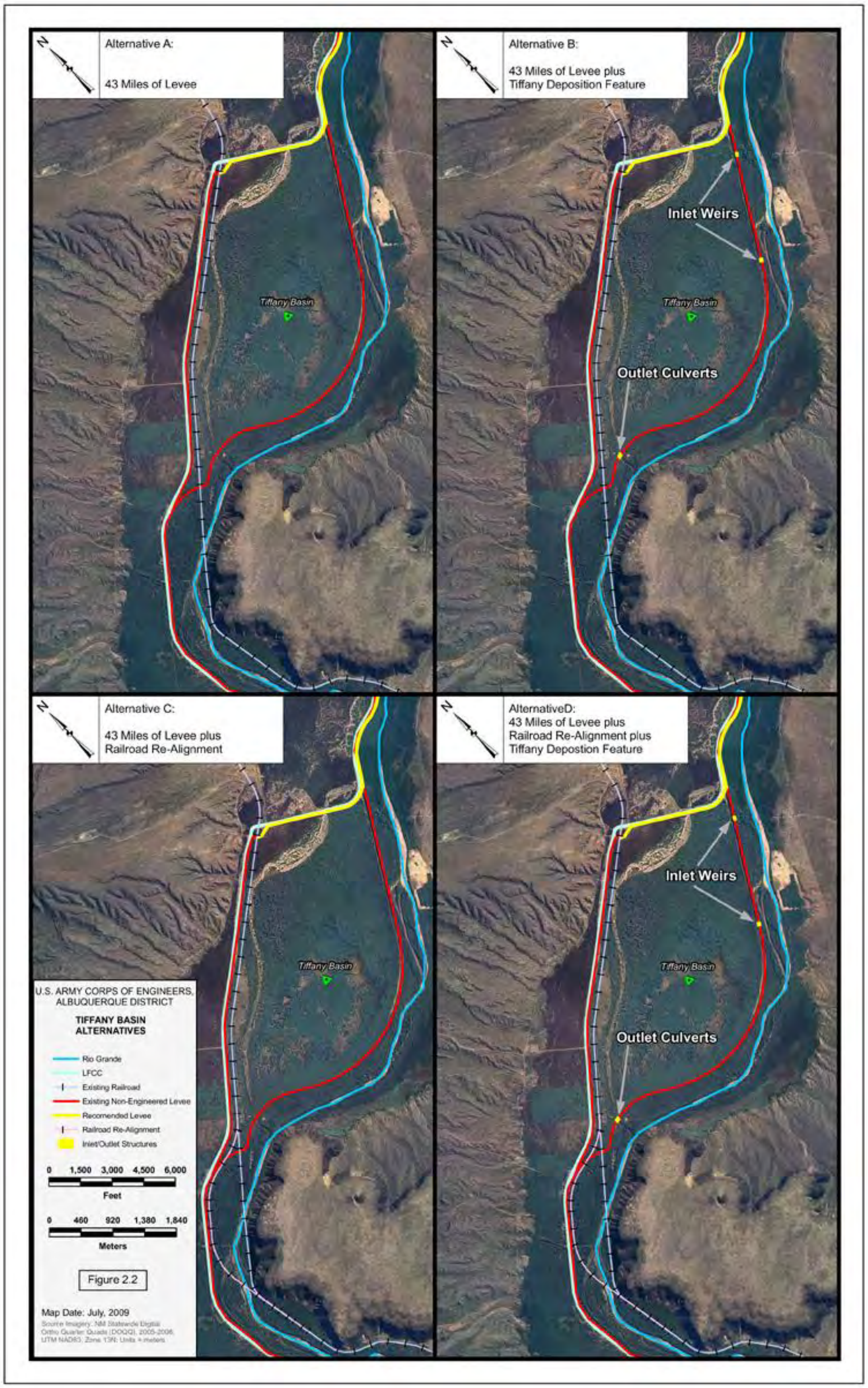


Figure 5.1. Alternatives A, B, C, and D

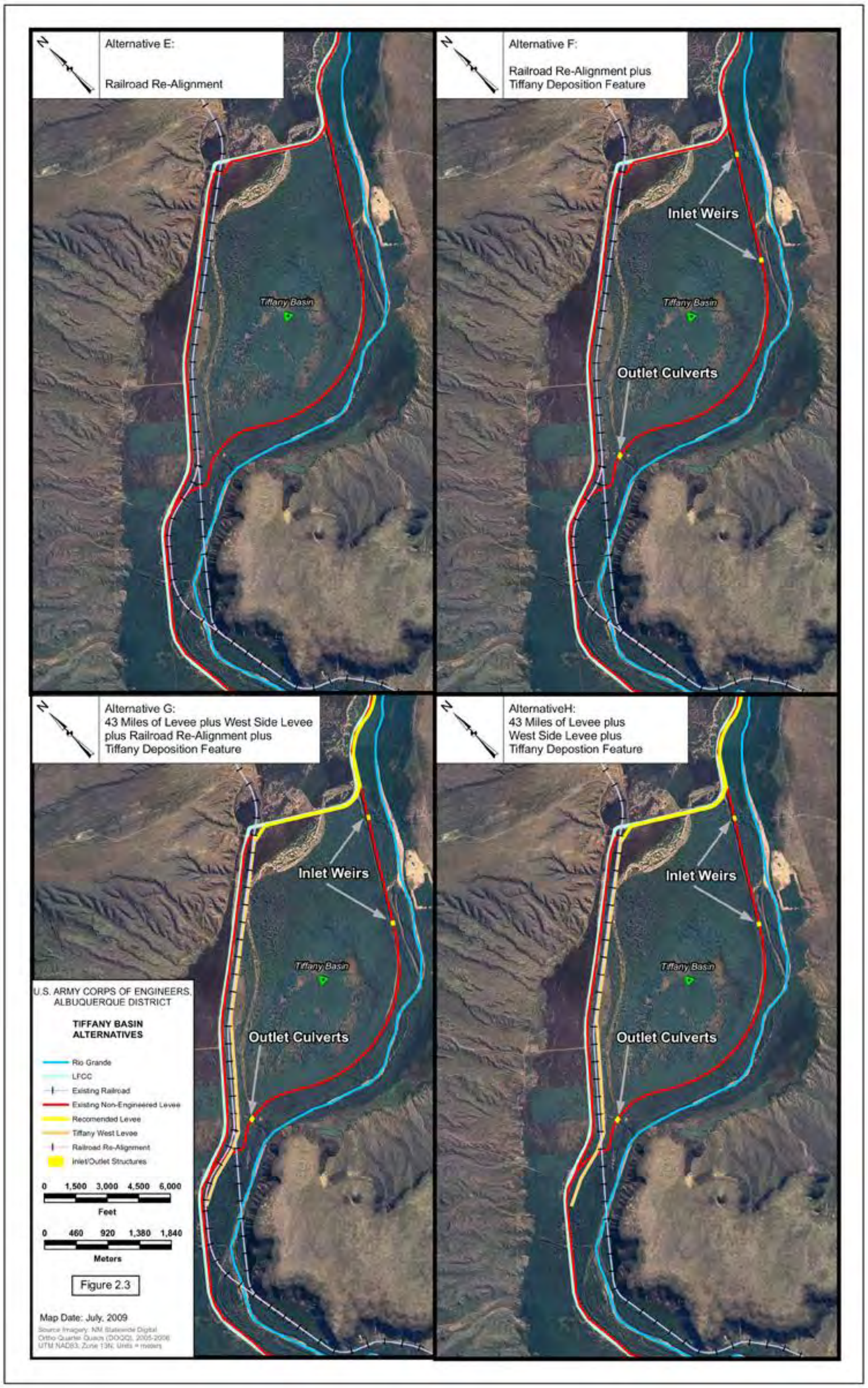


Figure 5.2. Alternatives E, F, G, and H

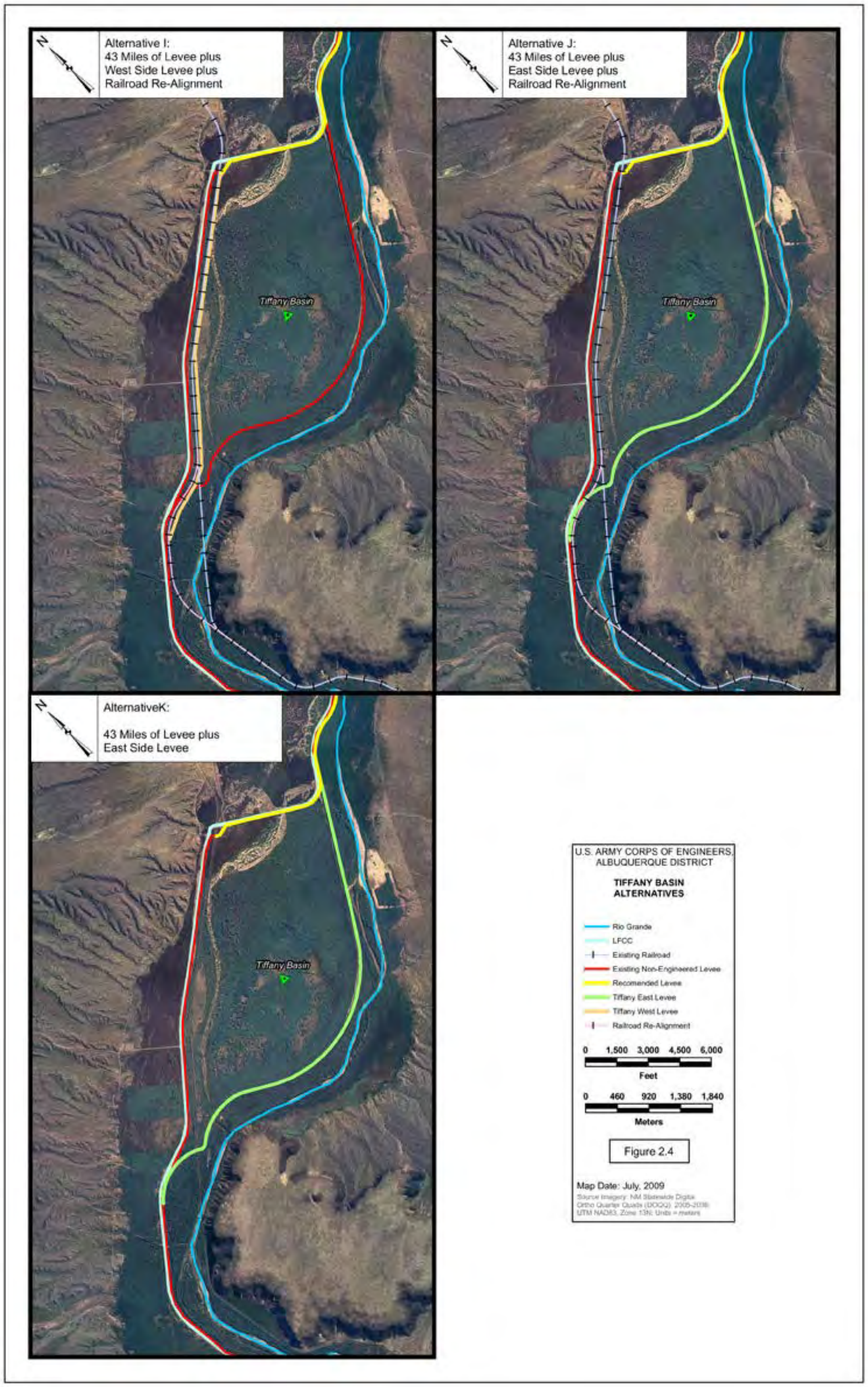


Figure 5.3. Alternatives I, J, and K

4.4.3.1 Evaluation Methodology

The Corps evaluated the significant performance differences between the alternatives by evaluating the assortment of existing and potential feature combinations in the Tiffany Basin area because the proposed levee reconstruction feature upstream of this areas was the same for all of the alternative plans that included the engineered levee.

It should be noted that the spoil-banks were treated somewhat differently for the downstream alternative array evaluation and boundary condition development than for the flood risk evaluations of the overall project reach. The following discussion illustrates the logic of considering these differing behaviors for the various evaluation scenarios. During the 2005 spring runoff, Reclamation devoted considerable effort in the field to prevent the collapse and subsequent overtopping/breaching of the east spoil-bank levee. Significant seepage through the material and sloughing on the land-side occurred during the event. Reclamation's effort and the relatively short duration of the event averted failure; however, Corps policy dictates that the measure of performance of features cannot depend on flood fighting. For without-project conditions, and for damage assessment in the areas adjacent to the existing spoil-bank levees but downstream of the proposed levee alternatives, the Corps assumed that the spoil-bank levees would fail. However, the spoil-bank levees could remain in place for some period of time before failure and result in an increased stage in the upstream (engineered) levee cross section. Therefore, for the with-project conditions, spoil-bank levees downstream of the proposed levee alternatives were modeled and assumed not to fail when determining stage information within the upstream reach to account for the uncertainty of the spoil-bank behavior, and achieve more resilient and robust project design.

4.4.3.2 Inflow hydrographs

The Corps routed the appropriate 0.50-through-0.002-probability with-project and without-project hydrographs to determine water-surface profiles for levee design in the reach from the San Acacia Diversion Dam downstream to Tiffany Junction for the alternative evaluations based on whether or not the alternative included the upstream engineered levee. The proposed engineered levee has a significant impact on the hydrologic routing and subsequent attenuation of larger floods originating upstream of the study area. This impact was quantified in the hydrologic analysis and is illustrated in Tables 2 and 3 in Section 3.2, *Flood Frequency at San Acacia*.

The routing differences are most pronounced for the high-peak, low-volume hydrographs associated with the monsoonal rainfall events contributed by the Rio Puerco and Rio Salado upstream of San Acacia. Conversely, the high-volume and extended-duration snowmelt floods do not experience significant attenuation. Therefore, the 0.50- and 0.10-chance inflow hydrographs generated by snowmelt are the same for the without-project and with-project conditions evaluated in the array of alternatives. Despite the lack of difference in these hydrographs associated with the upstream levee condition, their high volumes serve to illustrate the performance differences between the various alternatives. The inflow hydrograph boundary conditions used for the array of alternatives are consistent with the hydrologic analysis.

4.4.3.3 Modeling parameters

Because the various components of the alternatives were all located at the downstream end of the project, the evaluation described in this section was focused on the areas above and below the railroad bridge and the Tiffany basin area and floodway upstream. A significant effort went into simulating the potential breaching of the existing spoil-bank levee on the east side of Tiffany Basin (between Tiffany Basin and the floodway) for many of the alternatives, in order to illustrate the potential temporal influence the Tiffany Basin storage volume could exhibit on the flood volumes, between the various alternatives. Also of concern was the potential for flows to overtop the railroad embankment that runs along the west side of Tiffany basin at an elevation of 4485 feet (NGVD).

The Corps calculated hydraulic conditions for a “unit” (one-foot width) overflow, assumed to behave as broad-crested-weir flow, of a typical prism of the existing spoil-bank levee for various overflow depths. The resulting hydraulic variables were applied, using a sediment transport relationship based on a Yang transport function, to calculate transport rates and associated times required to mobilize the volumes of one-foot vertical increments of the assumed typical spoil-bank prism. Given the construction of the spoil-bank from predominantly sand-sized alluvial material, the Yang transport function was judged as an appropriate basis for modeling this behavior. The Corps used a table of averages from the distribution of the results of these various iterations to approximate the time required to erode one-foot-deep segments from the top of the spoil-bank levee, to evaluate the breaching process from a surface water hydraulics perspective, and tracked the duration of overtopping and flow into the basin at two locations within the Tiffany east levee. Testing of the initial and incremental width variables’ influence on breach propagation was undertaken and, based largely on professional judgment, an initial breach width of 100 feet was adopted at initiation of breaching, with an increase in width of 10 feet for each additional hour of flow through the breach. [Note that this is a departure from the *study reach* hydraulic modeling described in other areas of this Appendix, where spoil banks were assumed to fail and were not defined as confining features within the FLO-2D or HEC-RAS models for without-project conditions.] The approach employed for this alternative array evaluation has some limitations in that the approach does not account for geotechnical failures of the spoil-bank levee prior to overtopping, especially those associated with the seepage and saturation that would be expected under spring runoff conditions. Nevertheless, it was employed to help illustrate a range of differing temporal behaviors among the array of alternatives that is intended to be representative of the hydrodynamic behaviors.

4.4.3.4 Results

This section summarizes the significant performance characteristics and contrasts them with the alternatives. The No Action Alternative exhibits a variety of unfavorable conditions for the snowmelt events. At the 50%-chance exceedance probability and with the existing constrictive railroad bridge, the river stages remain just below the point of overtopping the east spoil-bank levee, and hypothetical breaching does not occur. Similar to the experience during the spring of 2005 at this location, the event caused considerable activity, but a breach into Tiffany Basin did not occur. At the higher discharge 10.0%-chance exceedance probability, breaching in the two modeled potential locations does occur and reaches a point sufficient to divert all of the river flow into the Tiffany Basin. The basin fills to the point of overtopping the railroad tracks adjacent to the basin. For the lower-volume rainfall events, breaching does not occur until the 0.5%-chance flood. The volume of this event that flows into Tiffany Basin is also sufficient to spill over the adjacent railroad tracks. The 0.2%-chance event yields similar results, but more quickly and with higher magnitude.

Alternative A behaves the same as the No Action Alternative for the 50.0%- and 10.0%-chance events and with the same results. The rainfall events experience less attenuation due to the upstream engineered levee, and breaching of the east spoil bank occurs at a lesser frequency, the 2.0%-chance event, in addition to the 1.0%-, 0.5%-, and 0.2%-chance simulations. The associated impacts of the east spoil bank breaching are similar to those for the No Action Alternative, with Tiffany Basin filling and spilling over the adjacent railroad tracks.

Alternative E exhibits behavior similar to the No Action Alternative, except that the changes in impacts from the new railroad bridge are suggested. For this alternative, the model indicates sufficient reduction in the river stage to preclude breaching of the inner spoil-bank levee for the 10.0%-chance event, but with the flow scarcely at 0.2 feet below the threshold spoil-bank levee crest. This small increment of safety is well within the error range of uncertainties, and the result should not be viewed in an absolute sense. The spoil-bank levee would probably not survive a mean water surface elevation within 0.2 feet of the crest for this duration, even if the other aspects of the determination were certain. Rather, the simulation results illustrate that replacement of the existing railroad bridge has positive water-surface-profile impacts within this area of concern. Because this alternative does not include the upstream engineered levee, prevention of breaching until the 0.2%-chance rainfall event further illustrates the difference that the new railroad bridge can play in the alternative array.

Similarly, Alternative C can minimally pass the 10%-chance event without breaching the inner (*i.e.*, east) spoil-bank levee, again reflecting the change in the water-surface profile associated with the new railroad bridge at critical locations along the inner spoil-bank. The higher-peaked rainfall inflow hydrographs, however, result in a spoil bank breach starting with the 1.0%-chance event, although this results in only partial diversion of river flows into Tiffany Basin. The basin does not fill to the point of overtopping the adjacent railroad tracks until the 0.5%-chance event, as it does for the 0.2%-chance event; however, the overtopping occurs more quickly.

Alternative I performs similarly to Alternative C; however, breaching of the inner spoil-bank levee does not result in overtopping of the railroad tracks adjacent to the basin because the extended engineered levee exists in this reach, protecting the track section. Again, the 1.0%-chance-event spoil bank breach does not fully develop, resulting in only partial filling of the basin. The 0.5%- and 0.2%-chance events fill the basin; however, escaping flows return to the floodway.

Alternatives J and K restrict flows to the floodway with an engineered inner levee and preclude breaching or filling of the basin for the events considered. These two alternatives are essentially the same in terms of basin and adjacent railroad impacts. The differences between the two are limited to the changes in river stage associated with the bridge configuration (existing bridge versus new bridge) as they translate upstream for a limited distance.

Alternatives B, D, F, G, and H include the Tiffany Basin sediment management feature. These alternatives easily handle the 5.0%-chance event hydrograph, diverting enough flow into the basin to keep river stages along the inner spoil-bank levee at a level lower than the simulations without the Tiffany Basin sediment management feature. In addition, the alternatives handle the 10.0%-chance event without attaining spoil bank breach elevation thresholds; however, the margin is considerably less because the 10.0%-chance conditions control the configuration of this feature to function as planned due to the extended duration of the hydrograph. The primary

differences for the alternatives at the 10.0%-chance level is in the volume diverted to Tiffany Basin (and corresponding peak stage within the basin) as a result of the differences in inflow hydrographs (with or without the upstream engineered levee) and the different river stage-discharge relationships associated with the bridge condition (existing bridge versus new bridge). For all of the rainfall events simulated up through the 0.2%-chance event, the stage elevations within the basin never exceed 4483 feet because of the smaller volumes of the rainfall hydrographs. For all of the rainfall events simulated up through the 0.2%-chance event, this stage elevation within the basin of 4483 feet is 2 feet below the threshold railroad embankment elevation noted above. Some of these rainfall events do exhibit sufficient river stages, over shorter periods, to initiate overtopping and breaching of the inner spoil-bank levee.

This risk to the inner spoil-bank levee is minimal (0.2%-chance exceedance probability) for Alternative F, which incorporates the new railroad bridge and experiences the lower-magnitude peaks associated with no engineered levee upstream. Alternatives D and G exhibit an increased risk, with potential for overtopping for the 1.0%-chance event through 0.2%-chance event simulations. Alternatives B and H, which do not include the new railroad bridge, exhibit the highest risk to the spoil bank, starting at the 2.0%-chance event.

4.4.4 DOWNSTREAM LEVEE TIE-BACK ANALYSIS

The LFCC constituted a major factor in the choice of a tie-back alternative. The LFCC will be protected by the proposed levee because the proposed levee is located between the LFCC and the floodway. In order to connect the levee to high ground, the levee would be required to cross the LFCC at the downstream end. A LFCC crossing would include a gated closure of some type. The LFCC is constantly recharged from groundwater and maintains a relatively-constant flow, and any closure of the LFCC would cause water to back up behind the closure. Therefore, the alternatives analyzed must consider flooding induced by closure of the LFCC. The Corps considered ending the levee without a tieback to high ground; however, this could conceivably produce a backwater effect from a flood event traveling down the Rio Grande. The Corps considered the following three closure alternatives for the downstream end of the levee for each of the alternative levee alignments:

- Closure Alternative 1: Connect the levee to high ground at the upper end of Tiffany Basin. This would require crossing the LFCC immediately south of the existing railroad bridge crossing of the LFCC. The closure structure would include three eight-foot-diameter gated culverts that would remain open except during high flow events on the Rio Grande. Closure of the gates during a high flow event would cause water flowing down the LFCC to back up behind the closure structure.

- Closure Alternative 1a: Same as Alternative 1, but the alternative includes a pump at the closure structure in the LFCC. The pump would be used during high flow events on the Rio Grande when the gates are closed. The pump would pump water flowing in the LFCC through the closure structure to prevent water backing up behind the closure structure.

- Closure Alternative 2: Continue the levee to the existing railroad alignment at the north end of Tiffany Basin at a location where the railroad embankment is elevated above the selected frequency water surface elevation. The levee would tie to the railroad

embankment at that location and would not connect to high ground to the west. Because the LFCC is located to the west of the railroad alignment, the levee would not cross the LFCC.

4.4.4.1 Tie-back Alternative Selection

The Corps used the two-dimensional FLO-2D model to evaluate the extent of backwater flooding for the closure alternatives. The Corps selected Closure Alternative 2 because modeling shows it to have minimal backwater flooding upstream of the connection to high ground, and Alternative 2 is in all probability the least costly alternative. Figure 6 displays the floodplain maximum flow depths associated with Closure Alternative 2.

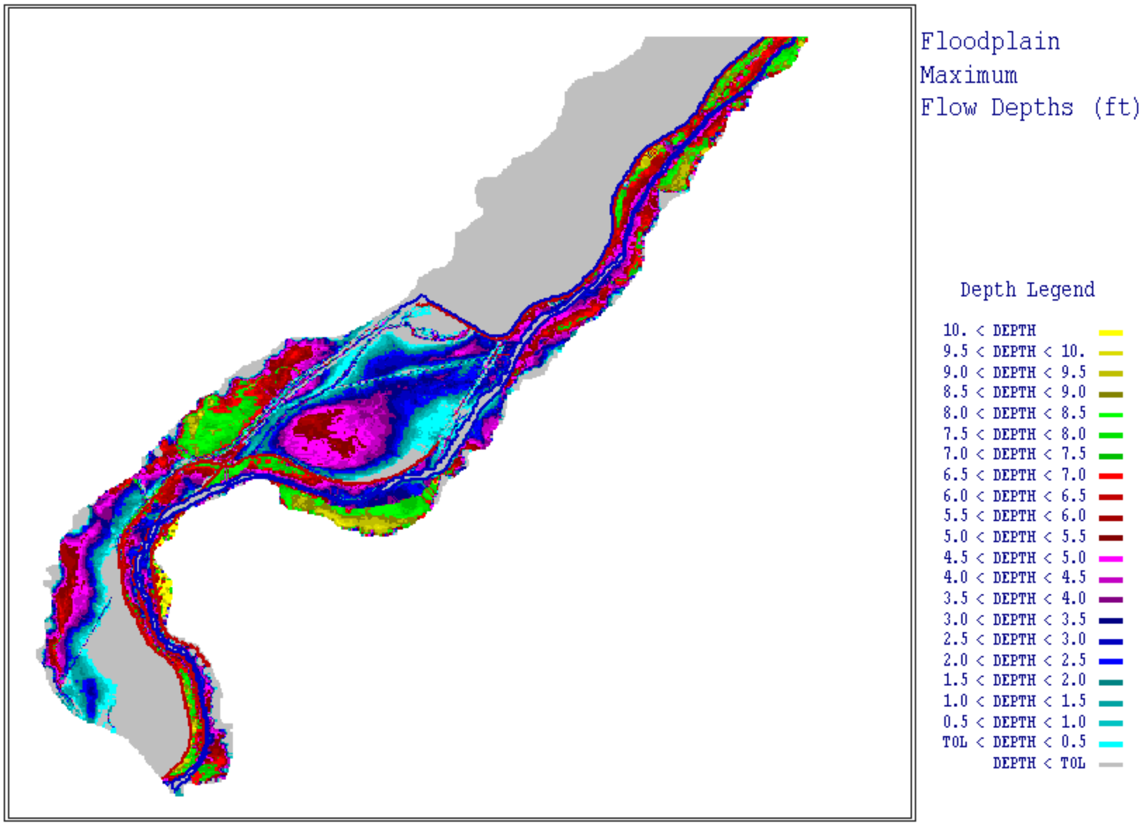


Figure 6. Floodplain Maximum Flow Depths for Closure Alternative 2Showing No Backwater Effect Upstream of Tiffany Basin

5 SEDIMENTATION ANALYSIS

Sedimentation within the study area has exhibited a significant influence on historical channel profiles and river stages, and is well-documented, particularly within the lower reach, by Leopold *et al* (1990), Vanoni (1977), and many others. From a flood risk management perspective, the primary influence is clearly the reduction in slope and floodway capacity, and coincident increase in stage, progressing from the downstream end of the study reach, associated with the long-term

aggradational regime. The Corps utilized numerical modeling and analyzed historic sedimentation trends to predict future sedimentation-related water surface impacts for the without- and with-project conditions. General Design Memorandum No. 1 describes a detailed sediment study conducted by Simons, Li, and Associates, Inc. (SLA, 1981). However, as presented in the 1999 draft LRR, analysis of the Reclamation range-line surveys of 1972 and 1992 show that aggradation during this 20-year period somewhat exceeded the predicted SLA aggradation rates. A subsequent analysis conducted for the current study of the 1972 and 2002 Reclamation range-line surveys confirms that long-term aggradation is the factor with the highest potential to affect water-surface elevations and, consequently, levee performance over the life of the project.

5.1 OVERVIEW OF SEDIMENTATION ANALYSIS

For the 1999 draft LRR, the Corps performed an analysis of the cross-sectional areal and volumetric changes for the Middle Rio Grande using the 1972 and 1992 Reclamation *aggradation/degradation* range-line surveys within the San Acacia study reach. The Corps updated the analysis for the current study using the newly available 2002 Reclamation range-line surveys. Areal changes between the 1972 and 2002 range lines were computed and combined with the reach lengths between adjacent range lines to arrive at volumetric changes for the period. The Corps divided the volumetric changes by the product of their respective lengths and average top widths to arrive at an average deposition depth. Dividing the average deposition depth by the 40-year period between range-line surveys produced an average annual deposition depth. The Corps divided the information into representative subreaches, developed a mathematical relationship to project this trend, and computed average values along the subreaches. The average values were multiplied by an assumed 50-year project life for the proposed levee in order to evaluate project performance. The Corps applied the calculated depositional values to edit the associated geometry files in the hydrologic routing (FLO-2D) and hydraulic water surface profile (HEC-RAS) numeric models to raise the elevation of the entire floodway for the future conditions scenarios, in order to assess the impacts associated with the primary long-term sedimentation trend.

5.2 WITHOUT-PROJECT SEDIMENTATION ANALYSIS

5.2.1 WITHOUT-PROJECT SEDIMENTATION DATA

The Corps used surveyed range lines provided by Reclamation from 1972, 1992, and 2002 to analyze the long-term aggradational and degradational trends for the study reach to determine without-project sediment trends. The Corps calculated the cross-sectional area between an arbitrary bounding elevation (5,500 feet) and the cross-section elevations for each range line, for each survey year. The Corps used the year-to-year differences between these cross-sectional areas as the basis to analyze the trends.

5.2.2 WITHOUT-PROJECT SEDIMENT ANALYSIS METHODOLOGY

The Corps compared the cross-sectional areas for each year for the periods 1972 to 1992, 1972 to 2002, and 1992 to 2002. In each case, the area of the later year was subtracted from the area of the earlier year. A positive value indicated an aggradational trend for that range line, and a

negative value indicated a degradational trend. The Corps plotted these values against the longitudinal reach parameter to determine where the reach had a general aggradational or degradational trend. A plot of the annualized values obtained from this analysis is shown in Figure 7, below. Though there is significant scatter for the various periods, overall the analysis showed that the reach somewhat consistently had a slight general degradational to neutral trend upstream of range line 1412 and a somewhat pronounced aggradational trend downstream of range line 1412. Range line 1412 is located approximately 10 miles south of the Escondida Bridge, and corresponds to somewhat left-of-center on the x-axis of Figure 7 (about 696,000 ft.).

The Corps analyzed the reach downstream of range line 1412 to range line 1781, approximately seven miles south of the San Marcial Railroad Bridge, to quantify the aggradational trend. The Corps performed a regression analysis on each data set (1972 to 1992, 1992 to 2002, and 1972 to 2002). The 1972 to 2002 data set was ultimately used because of less confidence in the quality of the 1992 survey data . In addition, the 1972 to 2002 data set provides the longest period of record.

The Corps developed a regression relationship between the rate of aggradation to the position in the reach. The error associated with this relationship was incorporated into the risk analysis (see sections **7.1** and **7.2**) for future condition alternative evaluations. Figure 8 shows the projected 50-year aggradation at range lines along the aggradational reach used to account for this trend. The Corps applied the predicted 50-year aggradation to the future-conditions models. In both the HEC-RAS and the FLO-2D future-conditions models, the Corps raised the entire floodway by an amount corresponding to its position in the aggradational reach. For floodplain calculation and economic analysis, the Corps used the future-conditions FLO-2D model and applied degradation to the channel only in the degradational reach.

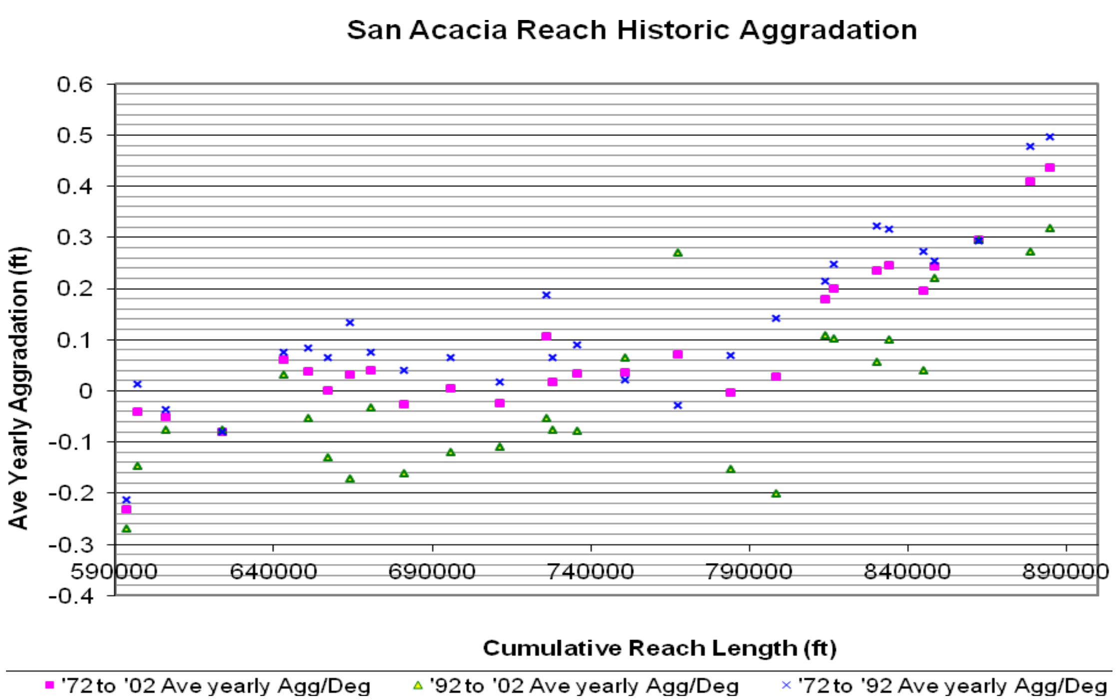


Figure 7. Measured periodic aggradation trends.

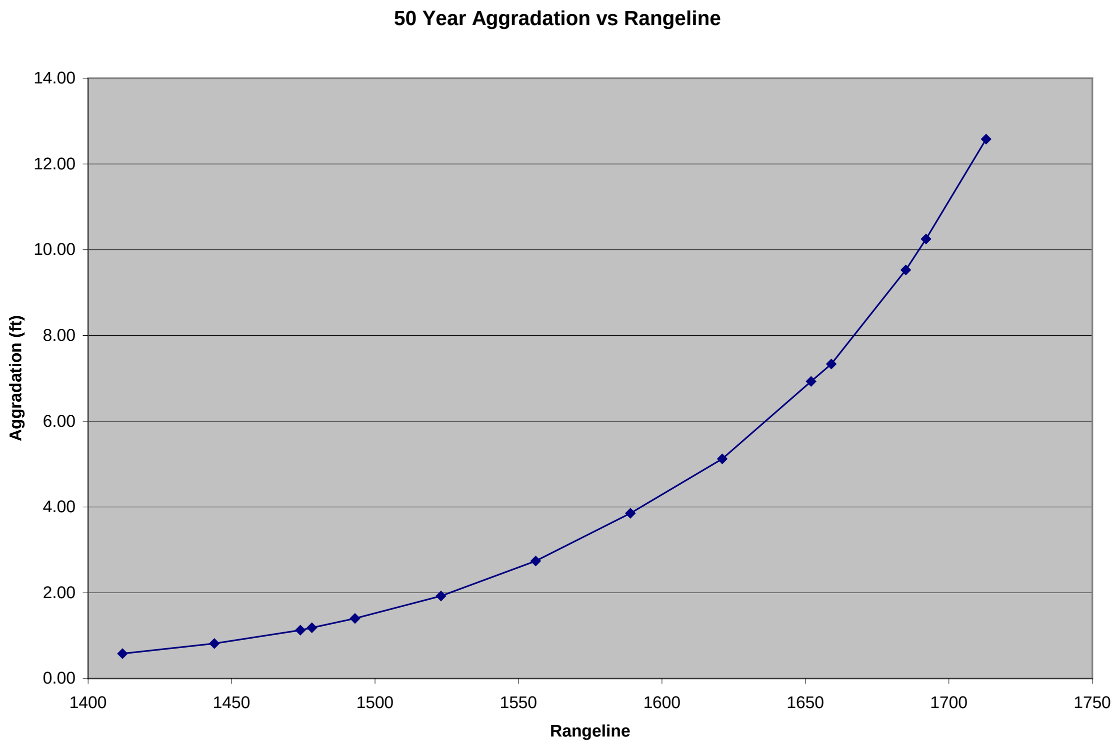


Figure 8. Projected 50-Year Aggradation for Selected Range Lines along the Study Reach

5.2.3 WITHOUT-PROJECT SEDIMENT ANALYSIS ASSUMPTIONS

The Corps assumed that the rate of aggradation observed from analysis of the somewhat short 1972-through-2002 data set would continue in the future. The Corps compared the calculated rate of aggradation with historic long-term rates observed by Leopold (Leopold *et al.*, 1992) in the San Marcial vicinity, and the rates proved consistent. In addition, agreement exists between the calculated rate of aggradation and circumstantial evidence, including measured floodplain elevations within and outside of the existing spoil-bank levees and historic documentation of bridge elevation changes.

The Corps assumed that long-term aggradation occurs evenly across the entire floodway, including the current overbank areas, through avulsion and lateral migration processes. This assumption could cause the model to under-predict the aggradation of the channel in the short term because the majority of sediment deposition occurs within the channel and on the overbank areas immediately adjacent to the channel. Channel deposition can raise the channel to an elevation greater than the floodplain elevation and create the perched channel, such as the one that exists in much of the project area. However, in time, the channel will avulse to the lower overbank areas and deposit material there as it has in the past. Thus, the decision was made to distribute the aggradation evenly across the cross section within the floodway.

5.3 WITH-PROJECT SEDIMENTATION ANALYSIS

5.3.1 WITH-PROJECT SEDIMENT ANALYSIS DATA AND METHODOLOGY

The Corps completed the with-project analysis employing essentially the same data and methodology used for the without-project analysis. The Corps assumed the same aggradational rates for the with-project conditions, with the exception of the with-project alternatives that include the Tiffany Basin sediment management feature. For the HEC-RAS future-conditions models, the Corps raised the entire floodway, based on the same logic described in section **5.2.3**, by an amount corresponding to its position in the aggradational reach. The future-conditions HEC-RAS model ignored degradation in the upper reach, in order to produce more robust alternative designs in relation to this uncertainty.

5.3.2 TIFFANY BASIN SEDIMENT MANAGEMENT FEATURE ASSUMPTIONS

The Corps calculated transport rates from various sources, primarily from Reclamation functions derived from measured data. For the purposes of plan formulation, two assumptions controlled the design of the Tiffany Basin sediment management feature and evaluation of its performance. The first assumption is that the Tiffany Basin would fill with sediment to an elevation equal to the predicted future-conditions floodplain elevation within the existing floodway during the 50-year evaluation period of the project. This assumption is based on the predicted diversion concentrations, ponded conditions, and near 100% trap efficiency that would be expected for the feature. The second assumption is that the proposed Tiffany Basin sediment management feature is expected to alleviate some of the aggradation of the Rio Grande channel and floodway within the 50-year life of the project, based on the lowered volume associated with the first assumption. For the purpose of plan formulation and levee design heights, the Corps subtracted 50% of the volume of sediment expected to be trapped in Tiffany Basin from the volume of the Rio Grande floodway in the aggradational reach, from the San Marcial Railroad Bridge (range line 1706.6) upstream to approximately range line 1412. The Corps only credited 50% of the predicted volume-removal to account for uncertainties associated with the proposed project feature's performance as it relates to levee height impacts. Figure 9 displays the range lines' 50-year expected aggradation considering the conditions; without Tiffany Basin, with Tiffany Basin (not used), and with Tiffany Basin at 50% trap efficiency.

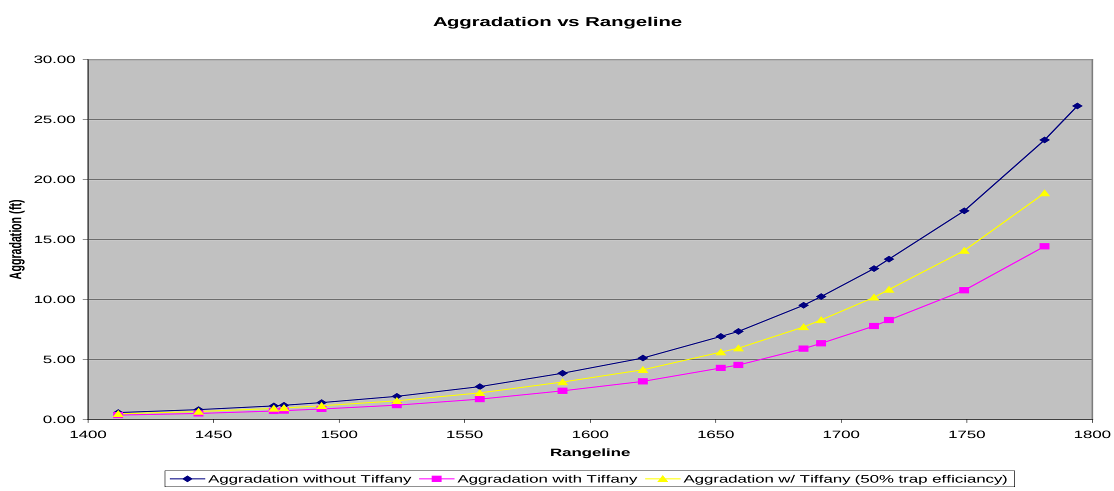


Figure 9. Aggradation versus Range line for with-project scenarios

5.4 BRIDGE REPLACEMENT ALTERNATIVE CAPACITY EVALUATION

Sedimentation impacts in the immediate vicinity of the existing San Marcial Railroad Bridge have been significant, and increasing as time goes on, in terms of conveyance capacity and maintenance. The Corps examined the sedimentation impacts of the various proposed BNSF San Marcial Railroad Bridge replacement alternatives. Four alternatives, each with 88-foot bays, were examined: (1) a three-bay bridge, (2) a five-bay bridge, (3) a seven-bay bridge, and (4) a nine-bay bridge. The examination consisted of a basic sediment continuity analysis using hydraulic parameters from the present-conditions with-project HEC-RAS model at four representative cross sections approaching and within the bridge crossing. The Corps developed sediment transport rating curves using the software program SAM, *Hydraulic Design Package for Channels,* created by the Corps Coastal and Hydraulics Laboratory, Engineer Research and Development Center (CHL-ERDC, 2002) and spreadsheets for the four cross sections using Yang's (d50) and Brownlie's transport functions. Annual yield rates, calculated in tons per year, were determined for the four cross sections and compared successively by subtracting the current cross section supply rate from the next upstream cross section supply rate to determine scour and deposition rates for each of the bridge-span alternatives. The transport calculations were not calibrated to measured data, and the magnitudes are not exact; however, the relative trends are useful in discerning between the bridge-span alternatives.

The Yang and Brownlie functions are both judged applicable for describing transport of material in the sand size range, the predominant bed material within the channel, for the hydraulic conditions within the bridge subreach. The two different functions were used to assess the sensitivity of the results to the transport function. Tables 7 and 8 show the results of the calculations for the Brownlie transport function. The Yang calculations produced comparable ordinal results with regard to the number-of-spans. Table 7 illustrates the potential for influencing the transport approaching and through the bridge by varying the number of bays. For example, at cross section 1706.65, the contraction, and consequent acceleration, of flow for the three-bay alternative yields a dramatically higher transport rate through the bridge than the wide nine-bay alternative by an order of magnitude. Table 8 shows that the relative scour and deposition differences between cross sections are also affected by the bridge alternatives. The three-bay alternative indicates a scour condition, of relatively high magnitude, at the bridge cross section 1706.65 that could present additional risk to the bridge piers. The five-bay configuration also yields a scour situation at the bridge. Based on these results, the seven-bay alternative appears to perform best in terms of overall sediment transport balance. The least magnitude absolute value of the summation indicates the seven-bay configuration would have the least scour or deposition and be the lowest maintenance alternative. An expectation for some deposition exists at the bridge given that the value is positive; however, this reach is depositional and has been so historically, and the depositional rate for the bridge section is the lowest magnitude of the alternatives. The Corps selected the seven-bay bridge alternative for alternative cost development, because the alternative appears to provide the advantages of reduced maintenance and low potential for increased impacts to the structural integrity of the bridge.

Table 7. Annual Transport Yields (Brownlie) by Cross-section

Cross Section	3-Bay (Ton/year)	5-Bay (Ton/year)	7-Bay (Ton/Year)	9-Bay (Ton/Year)	Comment
1618	552,283	552,283	552,283	552,283	Upstream Tiffany
1650	524,826	524,826	524,826	524,826	Mid Tiffany
1698	457,002	457,002	457,002	457,002	Lower Tiffany
1706	403,014	393,365	380,588	374,119	Approach
1706.65	2,084,608	816,336	371,842	235,739	Bridge

Table 8. Annual Scour (-) / Deposition (+) Rates (Brownlie)

Cross Section	3-Bay (Ton/Year)	5-Bay (Ton/Year)	7-Bay (Ton/Year)	9-Bay (Ton/Year)	Comment
1650	27,457	27,457	27,457	27,457	Mid Tiffany
1698	67,824	67,824	67,824	67,824	Lower Tiffany
1706	53,988	63,637	76,414	82,883	Approach
1706.65	-1,681,595	-422,971	8,746	138,380	Bridge
Summation	-1,532,326	-264,053	180,441	316,543	

6 FLOODPLAINS

The Corps used the FLO-2D model to generate floodplains. For the 10.0%-chance event, the flood hydrograph from rainfall events attenuates below 10,000 cfs within the project area. Downstream of the location where this occurs, the 10.0%-chance snowmelt hydrograph measuring a constant 10,000 cfs dominates. Therefore, floodplains are mapped for rainfall events upstream and snowmelt events downstream of this location.

For the without-project condition, the Corps assumed that the existing spoil-bank levees would not contain flood flows, and the spoil-bank levees were completely removed from the without-project model. For the with-project conditions, the Corps assumed that the existing spoil-bank levees beyond the downstream end of the project would not contain flood flows. Because this would potentially create a backwater effect beyond the downstream end of the constructed levee, the Corps created a separate FLO-2D model with a 100-foot grid to model the backwater effect of the spoil-bank levee failure beyond the downstream end of the project and to plot the floodplain in this area.

The active floodway is expected to change geomorphically in the future, and the Corps created a future-conditions model in which individual cross section were uniformly raised or lowered to account for predicted aggradation and degradation 50 years into the future. The channel is expected to degrade in the upper reach immediately downstream of the San Acacia Diversion Dam. The channel becomes fairly stable for the remaining upper third of the project area. Downstream from approximately the Socorro area, the channel and floodplain within the floodway become aggradational.

Floodplains for the 0.2%-chance event for the without-project condition and the with-project condition, representative of Alternative A, are presented in Figures 9.1 through 9.7. Alternative A includes the 43-mile engineered levee extending from the San Acacia Diversion Dam to Tiffany Junction. The floodplains are computer generated using flood elevations in the 500-foot computational grid and the best available mapping data. The floodplains do not comply with FEMA standards.

7 RISK AND UNCERTAINTY

The Corps acknowledges risk and uncertainty in the prediction of floods and their impacts. Historically, the Corps relied on the application of safety factors and freeboard, designing for worst-case conditions and other indirect solutions to compensate for uncertainty. These indirect approaches were necessary because of the lack of technical knowledge of the complex interaction of uncertainties. However, with advances in statistical hydrology and the availability of analysis tools, it is now possible to describe the uncertainty in the choice of hydrologic and hydraulic functions. The policies, methods, and procedures for the risk-based analysis are detailed in Engineering Regulation (ER) 1105-2-101, *Risk Analysis for Flood Damage Reduction Studies*, and in Engineering Manual (EM) 1110-2-1619, *Risk-Based Analysis for Flood Damage Reduction Studies.* The risk analysis considers present and future conditions for both without-project and with-project models.

Hydrologic risk analysis estimates the variability in the predicted peak discharges and volumes of the flood hydrographs generated by the watershed. The primary source of hydrologic uncertainty in the analysis is the length of the stream gage record used to compute a discharge-frequency relationship. The Corps computed the hydrologic uncertainty for the study area using an equivalent record length of 61 years based on stream gage and historical information. The Corps does not anticipate a significant increase in development within the watershed, and peak discharges are not expected to increase. Therefore, the Corps used the same discharges for the existing- and future-conditions models. Although some of the decisions made in the hydrologic analysis predate the adoption of risk analysis, the assumptions incorporated in the analysis, including reservoir releases and rates of hydrograph attenuation and evaporation and infiltration losses, represent expected performance and lie within appropriate limits of confidence.

A primary purpose of the hydraulic risk analysis is to estimate the variability of the water surface to complete the stage-discharge relationship. The parameter used to define the uncertainty of the stage-discharge relationship is standard deviation. Hydraulic uncertainties that affect the water surface elevations include channel and overbank Manning's *n* values, modeling geometry sources (*e.g.*, mapping), debris, and sedimentation. The Corps developed stage standard deviation estimates for both present and future conditions. Because watershed development is not anticipated, the Corps does not expect the hydrologic parameters to change in the future conditions model. However, aggradational and degradational changes within the floodway are expected in the future, and the future-conditions model includes estimated future sedimentation. The performance locations described in Section 4, *Hydraulic Analysis*, were used as locations to develop the standard deviations of the water surface elevations. These standard deviations can then be used in the evaluation of project performance and economic risk.

7.1 WITHOUT-PROJECT HYDRAULIC RISK

Without-project risk was considered from a number of perspectives following Corps guidance. The Corps investigated several relationships used to compute the standard deviation for the uncertainties and compared the results to adopt the most reasonable standard deviations to use in the risk analysis. To account for variabilities expected over time, two "snapshots" were characterized at each end of an assumed linearly varied project evaluation period. The snapshots are labeled as *present* and *future* and depict the beginning and end, respectively, of a 50-year evaluation period. EM 1110-2-1619, *Engineering and Design - Risk-Based Analysis for Flood Damage Reduction Studies* (USACE 1996), provides numerous relationships that can be used for quantifying stage uncertainty in terms of hydraulic variables.

As presented in EM 1110-2-1619, Freeman *et al.* (1996) categorized uncertainty into three classes denoted as "natural", "measurement", and "modeling". Using data from 116 river gage records along with HEC-2 model runs, Freeman derived a relationship based on the derived maximum stage range, the basin area, and the 1.0%-chance flood discharge to account for these three uncertainty sources and compute the standard deviation (U_S). Freeman presented the relationship in equation form:

$$U_s = \left[0.07208 - 2.2626x10^{-7} A_{Basin} + 0.0216 H_{Range} + 1.419x10^{-5} Q_{100} + 0.04936 I_{Bed}\right]^2$$

$$U_S = Standard\ Deviation\ of\ Stage - Discharge\ Uncertainty$$
$$H_{Range} = Maximum\ Stage\ Range\ (m)$$

$$A_{Basin} = Basin\ Area\ Above\ Gage\ (km^2)$$
$$Q_{Max} = 100\ Year\ Flood\ Flow\ \left(\frac{m^3}{s}\right)$$
$$I_{Bed} = Bed\ Identifier$$

Based on this relationship, and the fact that the 1.0%-chance flood discharge remains the same for present and future conditions, the Corps calculated a standard deviation (U_S) of approximately 0.38 feet using the study area variables for both present and future conditions.

EM 1110-2-1619 also provides Equation 5-6 which illustrates a method for combining various sources, or categories, of uncertainty to arrive at a composite estimate of standard deviation (S_{total}) in stage:

$$S_t = \sqrt{S_{natural}^2 + S_{model}^2 +}$$

S_t is standard deviation of the total uncertainty (S_{total})
$S_{natural}$ is natural uncertainty
S_{model} is modeling uncertainty

Table 5-2 of EM 1110-2-1619 provides *minimum* values of standard deviation (S_{min}) based on parameters largely associated with mapping and modeling uncertainty. For this study, the without-project FLO-2D models incorporated cross-sectional geometry based on topographic mapping consistent with the accuracy of a topographic map with 2-5 foot contours. Table 5-2 assigns a minimum standard deviation range between 0.6 and 1.5 for this condition. The standard deviation is further dependant on Manning's n-value coefficient reliability. Available prototype stage information, within the project effective range, is essentially non-existent, resulting in a Manning's n-value rating of "Poor" (Table 5-2). The "Poor" Manning's n-value reliability limits the *minimum* standard deviation to the threshold value of 1.5 feet.

The sensitivity of the computed water-surface elevations to modeling uncertainties was determined by modeling "high" and "low" conditions. As previously described, the FLO-2D model is capable of addressing the perched channel and split flows that exist in the without-project condition. The Corps modified the hydraulic parameters in the 1.0%-chance existing-condition FLO-2D model to estimate the variability of water-surface elevations for the without-project condition to estimate the "reasonable bounds" that would be expected to capture the majority of variability in computed stages associated with modeling uncertainty. The modified modeling parameters include the channel Manning's *n* value, the overbank Manning's *n* value, the hydraulic conductivity in the channel, and the sediment. Table 9 shows the changes that were made to the model to develop high-water and low-water conditions. The expected column is the without-project model. These "reasonable bounds" were assumed to capture approximately 95%, or approximately two standard deviations, in water surface elevation variability for the without-project present condition. Using this range of "reasonable bounds" to represent the 95% confidence interval (in addition to other simplifying assumptions) allows estimation of modeling standard deviations (S_{model}) using Equation 5-7 from EM 1110-2-1619:

$$S = \frac{E_{mean}}{4}$$

S is the standard deviation of modeling uncertainty (S_{model})
E_{mean} *is the mean stage difference between the "high" and "low" modeling conditions*

In his presentation, *Uncertainty in Stage-Discharge Relationships*, Brunner (HEC undated) also reported a relationship developed to account for uncertainty associated with the terrain standard deviation (S_{ter}) related to photogrammetry in the form:

$$SD = 0.0657 \; x \; S_0^{0.592} \; x \; S_n^{0.738}$$

SD is the standard deviation of terrain uncertainty (S_{ter})
S_0 is stream slope (feet/mile)
S_n is the underlying mapping contour interval (feet) divided by 10
(Within the study area, the values of S_0 and S_n are 4 and 0.2, respectively)

With these two sources of uncertainty (*i.e.*, modeling and terrain) determined, attention turned to a third uncertainty that would be associated with the "natural" category described previously. An important area of "natural" uncertainty in the study area is sedimentation. Sedimentation, in particular aggradation, has the potential to significantly affect water surface elevations over the life of the proposed project and is an important source of uncertainty. The Rio Grande within the study reach has a long history of pronounced aggradation, as documented by Leopold *et al.* (1992) as far back as the late 1890s. And while anthropogenic effects have added more and more complexity to this behavior, the overall trend has remained aggradational over long-term periods. Projection of future sedimentation for this study relied on historical cross-sectional measurements throughout the study area to develop a mathematical relationship using a logarithmic transformation.

The Corps computed a standard deviation ($S_{ag/deg}$) to account for the aggradation uncertainty by statistical analysis of the residuals of the log-transform function developed. The standard deviation value computed for this function was 0.045 feet/year. For the present condition with-project, a zero value was used for $S_{ag/deg}$ as there was no cross sectional adjustment for aggradation.

The Corps combined the three uncertainty source standard deviations, using Equation 5-6, to arrive at a total standard deviation (S_{total}) to account for the hydraulic uncertainties. The three uncertainty sources include the terrain standard deviation from Brunner's equation (S_{ter}), the "reasonable bounds" modeling standard deviation (S_{model}) estimate, and the sedimentation standard deviation ($S_{ag/deg}$) values. The resulting composite hydraulic standard deviation values computed for each Performance Location were compared (along with the combined values computed using the Freeman equation) to the minimum standard deviation threshold presented in Table 5-2 of EM 1110-2-1619. Because the computed standard deviations fall below the minimum standard deviation threshold, the Corps adopted the minimum standard deviation of 1.5

feet. Tables 10 and 11 show the various computed standard deviations using the methods described above, and the adopted standard deviation values used to characterize the hydraulic uncertainty for the present condition of the without-project period. Standard deviations expected for the water level in the channel/floodway are shown in Table 10. Standard deviations expected for the water level in the floodplain are shown in Table 11.

For the future condition, the FLO-2D model geometry was first adjusted to simulate long-term aggradation. Long-term aggradational trends, derived from measured data as described in Section 5, *Sediment Analysis*, were developed and used to estimate future conditions. The same hydraulic modeling parameters, described above and shown in Table 9, were then modified to again estimate high- and low-stage ranges.

Because the log-transform aggradation function was derived to estimate an average *annual* cross-sectional elevation change throughout the study reach, the resulting standard deviation ($S_{ag/deg}$) value of 0.045 feet/year was multiplied by 50 to arrive at a standard deviation value of 2.24 feet for the aggradation projection uncertainty. In addition, while there is a clear positive correlation between changes in the hydraulic model geometry elevations and changes in computed water surface elevations, there is also some uncertainty associated with this water surface response as it relates to geometry elevation changes. To account for the uncertainty associated with cross-sectional elevation change and associated water surface elevation change, another statistical analysis was performed on the differences between present and future modeled water surface elevations minus the present and future minimum channel elevations (*i.e.*, the differences between the present and future computed maximum channel flow depths). As described under sections 5.1 through 5.3, the model geometries were adjusted for the future conditions to account for expected depositional changes to the floodway, and the consequent changes is floodway water surface profiles. Evaluation of these results for the 1.0% exceedance event yielded a deviation value of 0.28 feet. The 0.28 feet value for elevation-water surface deviation was combined with the 2.24 feet value above, by way of the square-root-of-the-sum-of-squares form shown in Equation 5-6. The adopted standard deviation values of 2.25 to 2.26 feet reflect the total standard deviation computed using Equation 5.6 that combines the three uncertainty source standard deviations, and represents the widest range of deviation expected in the floodway (*i.e.*, channel) based on the uncertainties. Table 12 shows the resulting computed standard deviations and the adopted standard deviation values computed for each Performance Location and used to characterize the hydraulic uncertainty in the floodway for the future condition of the with-project period. Sedimentation is not anticipated to significantly influence the expected water surface within the floodplain, and the standard deviations computations and adopted values (Table 13) more closely follow the present-condition characterization, described above, with the minimum threshold values from *EM 1110-2-1619* Table 5-2 values receiving priority.

7.2 WITH-PROJECT HYDRAULIC RISK

Paralleling the without-project risk characterization, the with-project hydraulic uncertainties were also considered from a number of perspectives following Corps guidance. The Corps investigated several relationships used to compute the standard deviation and compared the results to adopt the most reasonable standard deviations to use in the risk analysis for the with-project condition. To account for variabilities expected over time, two “snapshots” were again characterized at each end of an assumed linearly varied project evaluation period. The snapshots are labeled as *present*

and *future,* as in the without-project description, above, and depict the beginning and end, respectively, of a 50-year evaluation period.

For this study, the with-project HEC-RAS models incorporated cross-sectional geometry based on aerial topographic surveys. Table 5-2 assigns a *minimum* standard deviation range between 0.3 and 1.3 for this condition. The standard deviation is further dependant on Manning's n-value coefficient reliability. Available prototype stage information, within the project effective range, is essentially non-existent, resulting in a Manning's n-value rating of "Poor" (Table 5-2). The "Poor" Manning's n-value reliability limits the minimum standard deviation to the threshold value of 1.3 feet.

The Corps modified the hydraulic parameters in the 1.0%-chance present-condition HEC-RAS model, based largely on professional judgment, condition to estimate the "reasonable bounds" that would be expected to capture the majority of variability in computed stages associated with modeling uncertainty. Table 12 shows the changes that were made to the model to develop high-stage and low-stage conditions for the present-condition with-project models.

For the future condition, the FLO-2D model geometry was first adjusted to simulate long-term aggradation. Long-term aggradational trends, derived from measured data as described in Section 5, *Sediment Analysis*, were developed and used to estimate future conditions. The same hydraulic modeling parameters, described above and shown in Table 9, were then modified to again estimate high- and low-stage ranges.

The adopted standard deviation values of 2.25 to 2.30 feet reflect the total standard deviation computed using Equation 5.6 that combines the three uncertainty source standard deviations, and represents the widest range of deviation expected based on the uncertainties. Table 14 shows the resulting computed standard deviations and the adopted standard deviation values computed for each Performance Location and used to characterize the hydraulic uncertainty for the future condition of the with-project period.

Table 9. Hydraulic Parameters Varied for the Risk Analysis Hydraulic Models for the Without-Project Condition

Risk Parameter	Risk Scenario		
	Low	Expected	High
Channel n-value	-0.005 (n>0.015)	0.016-0.038	+0.005
Overbank n-value	-0.02	0.065/0.1	+0.02
Infiltration - Hydraulic Conductivity in Channel	0.11	0.1	0.09
Sediment	N/A	N/A	Simulated sediment plug in the Tiffany reach

Table 10. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Channel for the Present Without-Project Condition

Channel Hydraulic Uncertainty

Present Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.82	0.38	0.21	0.00	0.05	0.21	1.50	1.50
3	0.53	0.38	0.13	0.00	0.05	0.15	1.50	1.50
4	0.69	0.38	0.17	0.00	0.05	0.18	1.50	1.50
5	0.74	0.38	0.19	0.00	0.05	0.20	1.50	1.50
6	0.14	0.38	0.03	0.00	0.05	0.07	1.50	1.50
7	0.01	0.38	0.00	0.00	0.05	0.06	1.50	1.50
8	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
9	0.17	0.38	0.04	0.00	0.05	0.08	1.50	1.50
10	0.30	0.38	0.08	0.00	0.05	0.10	1.50	1.50
11,12	0.41	0.38	0.10	0.00	0.05	0.12	1.50	1.50
13	0.18	0.38	0.05	0.00	0.05	0.08	1.50	1.50
14	0.15	0.38	0.04	0.00	0.05	0.07	1.50	1.50
15	0.18	0.38	0.05	0.00	0.05	0.08	1.50	1.50
16	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
17	0.01	0.38	0.00	0.00	0.05	0.06	1.50	1.50
18	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
19	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
20	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
21	0.16	0.38	0.04	0.00	0.05	0.08	1.50	1.50
22	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50

Notes (Channel Present Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty (E_{mean}/4) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (Rangeline survey evaluation)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5’ Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 11. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Floodplain for the Present Without-Project Condition

Floodplain Hydraulic Uncertainty Present Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	1.26	0.38	0.32	0.00	0.05	0.32	1.50	1.50
3	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
4	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
5	0.88	0.38	0.22	0.00	0.05	0.23	1.50	1.50
6	0.80	0.38	0.20	0.00	0.05	0.21	1.50	1.50
7	1.20	0.38	0.30	0.00	0.05	0.31	1.50	1.50
8	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
9	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
10	1.01	0.38	0.25	0.00	0.05	0.26	1.50	1.50
11,12	3.06	0.38	0.76	0.00	0.05	0.77	1.50	1.50
13	0.77	0.38	0.19	0.00	0.05	0.20	1.50	1.50
14	0.43	0.38	0.11	0.00	0.05	0.13	1.50	1.50
15	0.26	0.38	0.07	0.00	0.05	0.09	1.50	1.50
16	0.31	0.38	0.08	0.00	0.05	0.10	1.50	1.50
17	0.35	0.38	0.09	0.00	0.05	0.11	1.50	1.50
18	0.10	0.38	0.03	0.00	0.05	0.07	1.50	1.50
19	0.14	0.38	0.03	0.00	0.05	0.07	1.50	1.50
20	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
21	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
22	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50

Notes (Floodplain Present Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty (E_{mean}/4) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (Rangeline survey evaluation)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5' Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 12. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Channel for the Future Without-Project Condition

Channel Hydraulic Uncertainty Future Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.82	0.38	0.21	2.25	0.05	2.26	1.50	2.26
3	0.53	0.38	0.13	2.25	0.05	2.26	1.50	2.26
4	0.69	0.38	0.17	2.25	0.05	2.26	1.50	2.26
5	0.74	0.38	0.19	2.25	0.05	2.26	1.50	2.26
6	0.14	0.38	0.03	2.25	0.05	2.25	1.50	2.25
7	0.01	0.38	0.00	2.25	0.05	2.25	1.50	2.25
8	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
9	0.17	0.38	0.04	2.25	0.05	2.25	1.50	2.25
10	0.30	0.38	0.08	2.25	0.05	2.25	1.50	2.25
11,12	0.41	0.38	0.10	2.25	0.05	2.26	1.50	2.26
13	0.18	0.38	0.05	2.25	0.05	2.25	1.50	2.25
14	0.15	0.38	0.04	2.25	0.05	2.25	1.50	2.25
15	0.18	0.38	0.05	2.25	0.05	2.25	1.50	2.25
16	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
17	0.01	0.38	0.00	2.25	0.05	2.25	1.50	2.25
18	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
19	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
20	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25
21	0.16	0.38	0.04	2.25	0.05	2.25	1.50	2.25
22	0.00	0.38	0.00	2.25	0.05	2.25	1.50	2.25

Notes (Channel Future Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty (E_{mean}/4) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (Rangeline survey evaluation)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5’ Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 13. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Floodplain for the Future Without-Project Condition

Floodplain Hydraulic Uncertainty Future Conditions Without Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	1.26	0.38	0.32	0.00	0.05	0.32	1.50	1.50
3	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
4	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
5	0.88	0.38	0.22	0.00	0.05	0.23	1.50	1.50
6	0.80	0.38	0.20	0.00	0.05	0.21	1.50	1.50
7	1.20	0.38	0.30	0.00	0.05	0.31	1.50	1.50
8	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
9	1.18	0.38	0.30	0.00	0.05	0.30	1.50	1.50
10	1.01	0.38	0.25	0.00	0.05	0.26	1.50	1.50
11,12	3.06	0.38	0.76	0.00	0.05	0.77	1.50	1.50
13	0.77	0.38	0.19	0.00	0.05	0.20	1.50	1.50
14	0.43	0.38	0.11	0.00	0.05	0.13	1.50	1.50
15	0.26	0.38	0.07	0.00	0.05	0.09	1.50	1.50
16	0.31	0.38	0.08	0.00	0.05	0.10	1.50	1.50
17	0.35	0.38	0.09	0.00	0.05	0.11	1.50	1.50
18	0.10	0.38	0.03	0.00	0.05	0.07	1.50	1.50
19	0.14	0.38	0.03	0.00	0.05	0.07	1.50	1.50
20	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
21	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50
22	0.00	0.38	0.00	0.00	0.05	0.06	1.50	1.50

Notes (Floodplain Future Without-Project Condition):

b Difference between high- and low-risk conditions using present-condition FLO-2D model (Table 9)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty (E_{mean}/4) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (Rangeline survey evaluation)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, 2-5' Contour Accuracy (EM 1110-2-1619, Table 5-2)

Table 14. Hydraulic Parameters Varied for the Risk Analysis Hydraulic Models for the With-Project Condition

Risk Parameter	Risk Scenario		
	Low	Expected	High
Channel n-value	0.012 – 0.030	0.013 – 0.033	0.014 – 0.036
Overbank n-value	0.045 – 0.09	0.05 – 0.10	0.055 – 0.11
Infiltration - Hydraulic Conductivity in Channel	N/A	N/A	N/A
Sediment	N/A	N/A	Simulated Sediment Plug in the Tiffany Reach

Table 15. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Present With-Project Condition

Hydraulic Uncertainty Present Conditions With Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.65	0.38	0.16	0.00	0.05	0.17	1.30	1.30
3	0.37	0.38	0.09	0.00	0.05	0.10	1.30	1.30
4	0.66	0.38	0.17	0.00	0.05	0.17	1.30	1.30
5	0.75	0.38	0.19	0.00	0.05	0.19	1.30	1.30
6	1.01	0.38	0.25	0.00	0.05	0.26	1.30	1.30
7	0.81	0.38	0.20	0.00	0.05	0.21	1.30	1.30
8	0.45	0.38	0.11	0.00	0.05	0.12	1.30	1.30
9	0.43	0.38	0.11	0.00	0.05	0.12	1.30	1.30
10	0.00	0.38	0.00	0.00	0.05	0.05	1.30	1.30
11,12	0.36	0.38	0.09	0.00	0.05	0.10	1.30	1.30
13	0.45	0.38	0.11	0.00	0.05	0.12	1.30	1.30
14	0.40	0.38	0.10	0.00	0.05	0.11	1.30	1.30
15	0.68	0.38	0.17	0.00	0.05	0.18	1.30	1.30
16	0.53	0.38	0.13	0.00	0.05	0.14	1.30	1.30
17	0.51	0.38	0.13	0.00	0.05	0.14	1.30	1.30
18	0.50	0.38	0.13	0.00	0.05	0.13	1.30	1.30
19	0.74	0.38	0.18	0.00	0.05	0.19	1.30	1.30
20	0.69	0.38	0.17	0.00	0.05	0.18	1.30	1.30
21	0.64	0.38	0.16	0.00	0.05	0.17	1.30	1.30
22	2.24	0.38	0.56	0.00	0.05	0.56	1.30	1.30

Notes (Present With-Project Conditions):

b Difference between high- and low-risk conditions using present-condition HEC-RAS model (Table 14)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty (E_{mean}/4) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (Rangeline survey evaluation)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, Aerial Spot Elevation conditions (EM 1110-2-1619, Table 5-2)

Table 16. Variation in Water Surface Elevations and Standard Deviations Expected for the Water Surface in the Future- With-Project Condition

Hydraulic Uncertainty Future Conditions With Project								
a	b	c	d	e	f	g	h	i
Performance Location ID	E_{mean} (Feet)	U_s (Feet)	SD1 S_{model} (Feet)	SD2 $S_{ag/deg}$ (Feet)	SD3 S_{ter} (Feet)	SD S_{total} (Feet)	SD S_{min} (Feet)	Adopted Standard Deviation (Feet)
2	0.64	0.38	0.16	2.25	0.05	2.26	1.30	2.26
3	0.37	0.38	0.09	2.25	0.05	2.26	1.30	2.26
4	0.66	0.38	0.16	2.25	0.05	2.26	1.30	2.26
5	0.73	0.38	0.18	2.25	0.05	2.26	1.30	2.26
6	0.87	0.38	0.22	2.25	0.05	2.26	1.30	2.26
7	0.69	0.38	0.17	2.25	0.05	2.26	1.30	2.26
8	0.45	0.38	0.11	2.25	0.05	2.26	1.30	2.26
9	0.43	0.38	0.11	2.25	0.05	2.26	1.30	2.26
10	0.00	0.38	0.00	2.25	0.05	2.25	1.30	2.25
11,12	0.36	0.38	0.09	2.25	0.05	2.26	1.30	2.26
13	0.44	0.38	0.11	2.25	0.05	2.26	1.30	2.26
14	0.41	0.38	0.10	2.25	0.05	2.26	1.30	2.26
15	0.69	0.38	0.17	2.25	0.05	2.26	1.30	2.26
16	0.53	0.38	0.13	2.25	0.05	2.26	1.30	2.26
17	0.52	0.38	0.13	2.25	0.05	2.26	1.30	2.26
18	0.51	0.38	0.13	2.25	0.05	2.26	1.30	2.26
19	0.77	0.38	0.19	2.25	0.05	2.26	1.30	2.26
20	0.63	0.38	0.16	2.25	0.05	2.26	1.30	2.26
21	0.35	0.38	0.09	2.25	0.05	2.26	1.30	2.26
22	1.76	0.38	0.44	2.25	0.05	2.30	1.30	2.30

Notes (Future With-Project Condition):

b Difference between high- and low-risk conditions using future-condition HEC-RAS model (Table 14)
c Standard deviation of stage-discharge uncertainty (Freeman et. al.)
d Standard deviation for hydraulic model uncertainty (E_{mean}/4) (EM 1110-2-1619, Equation 5-7)
e Standard deviation for aggradation/degradation uncertainty (Rangeline survey evaluation)
f Standard deviation for terrain uncertainty (Brunner, undated)
g Square root of sum of squares of columns d, e, and f (EM 1110-2-1619, Equation 5-6)
h Minimum Standard deviation for Poor n Reliability, Aerial Spot Elevation conditions (EM 1110-2-1619, Table 5-2)

Figure 10.1. Without-Project Floodplain and With-Project Floodplain index

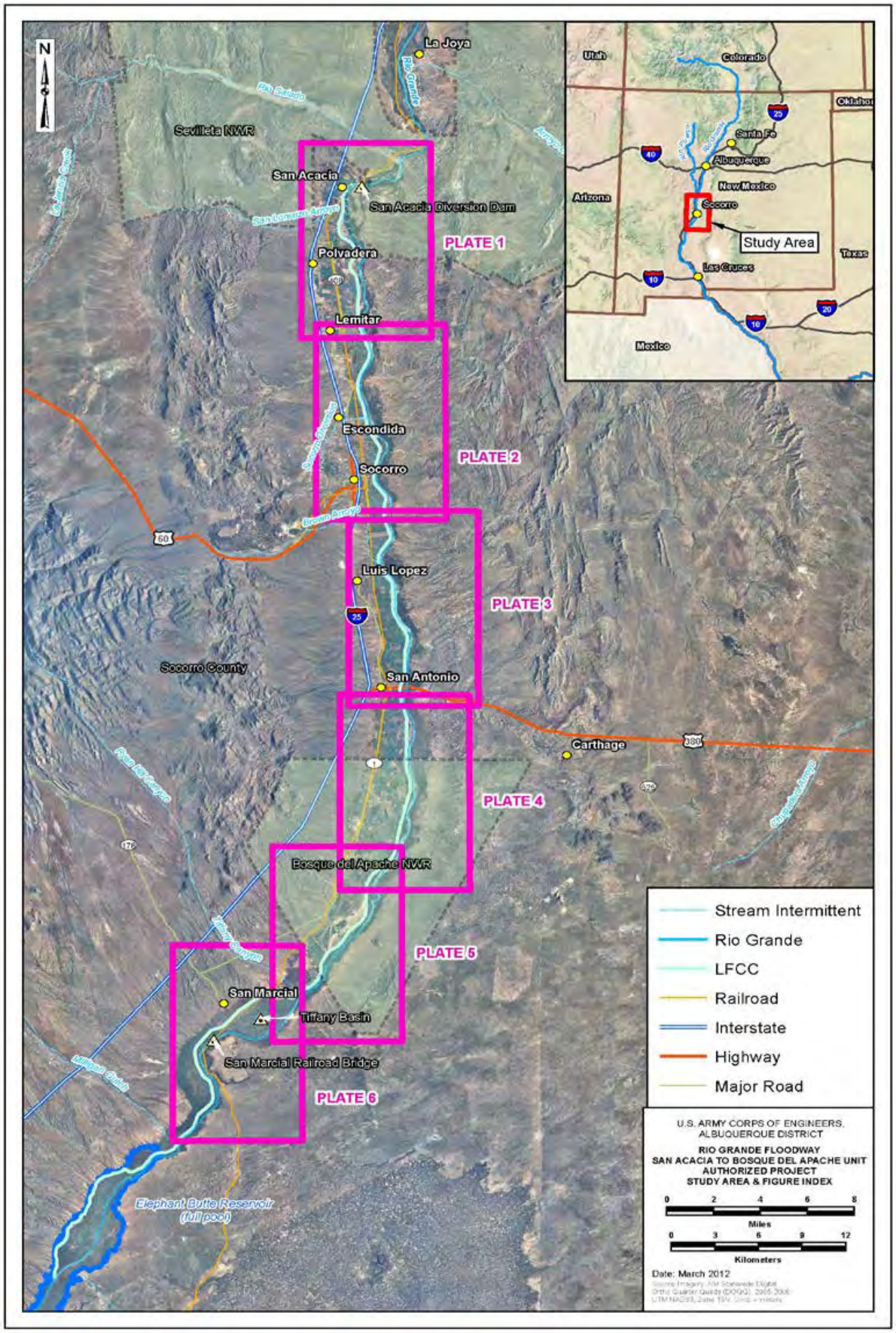


Figure 10.2. Without-Project Floodplains and With-Project Floodplains (Alternative A)

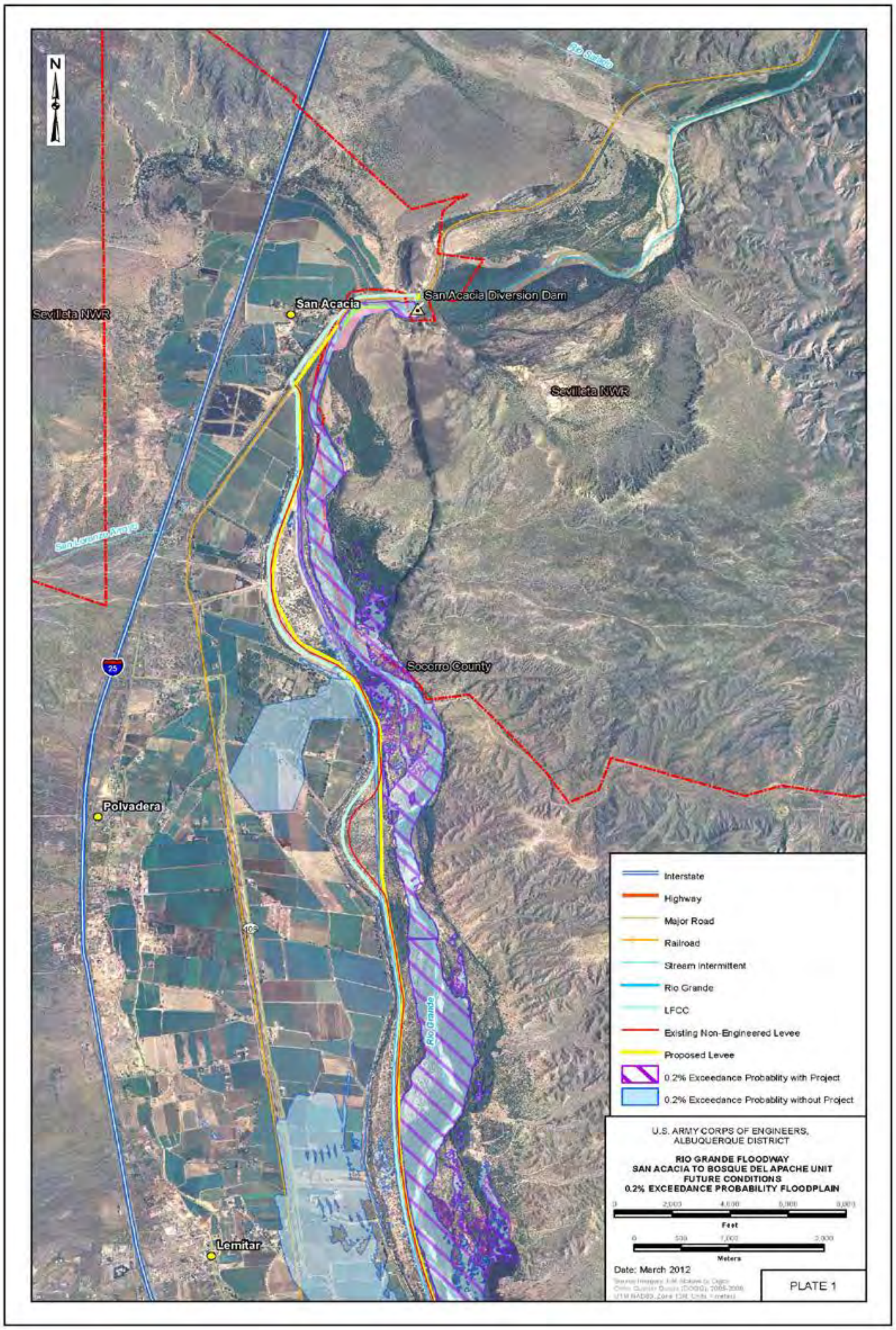


Figure 10.3. Without-Project Floodplains and With-Project Floodplains (Alternative A)

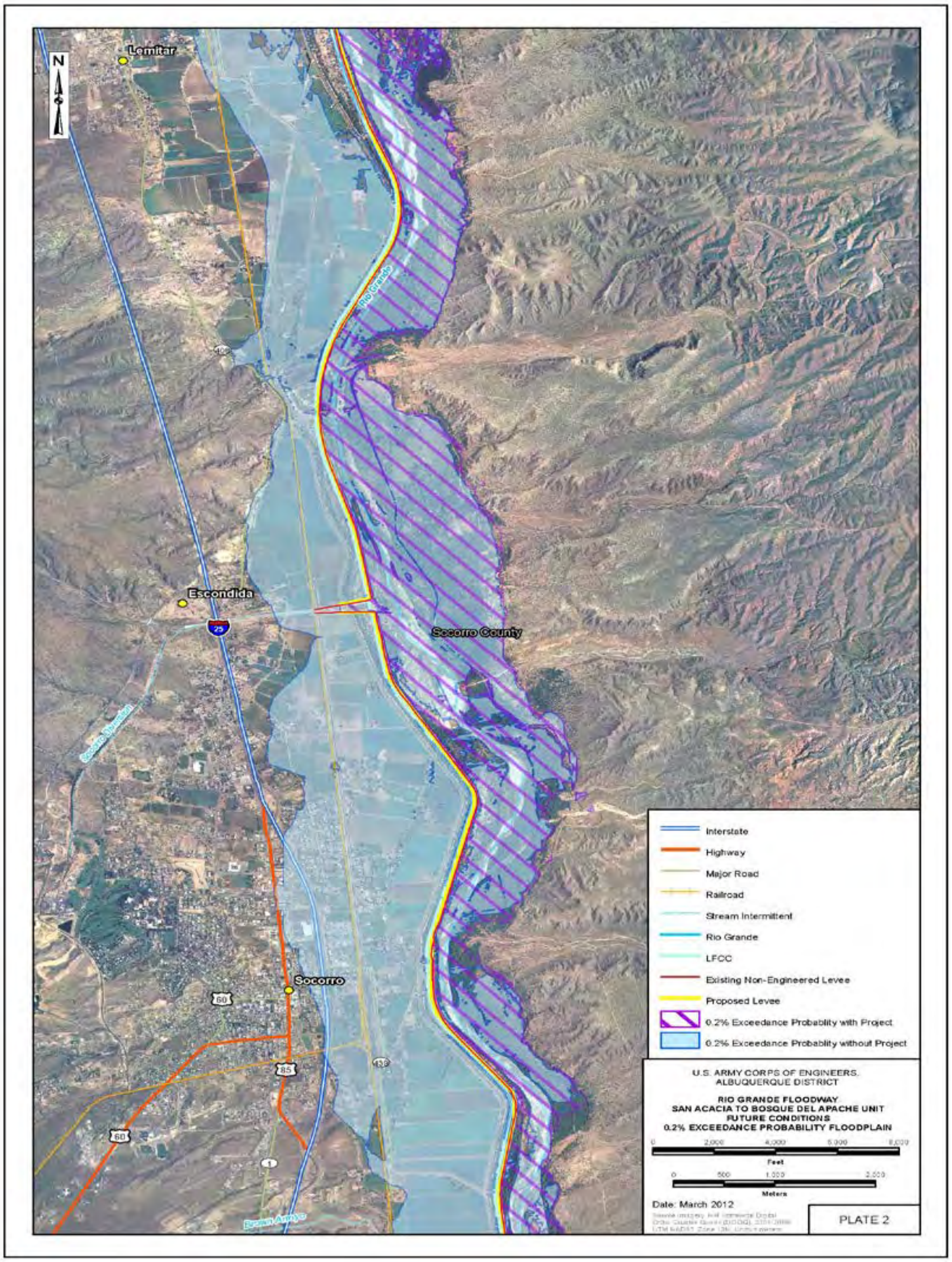


Figure 10.4. Without-Project Floodplains and With-Project Floodplains (Alternative A)

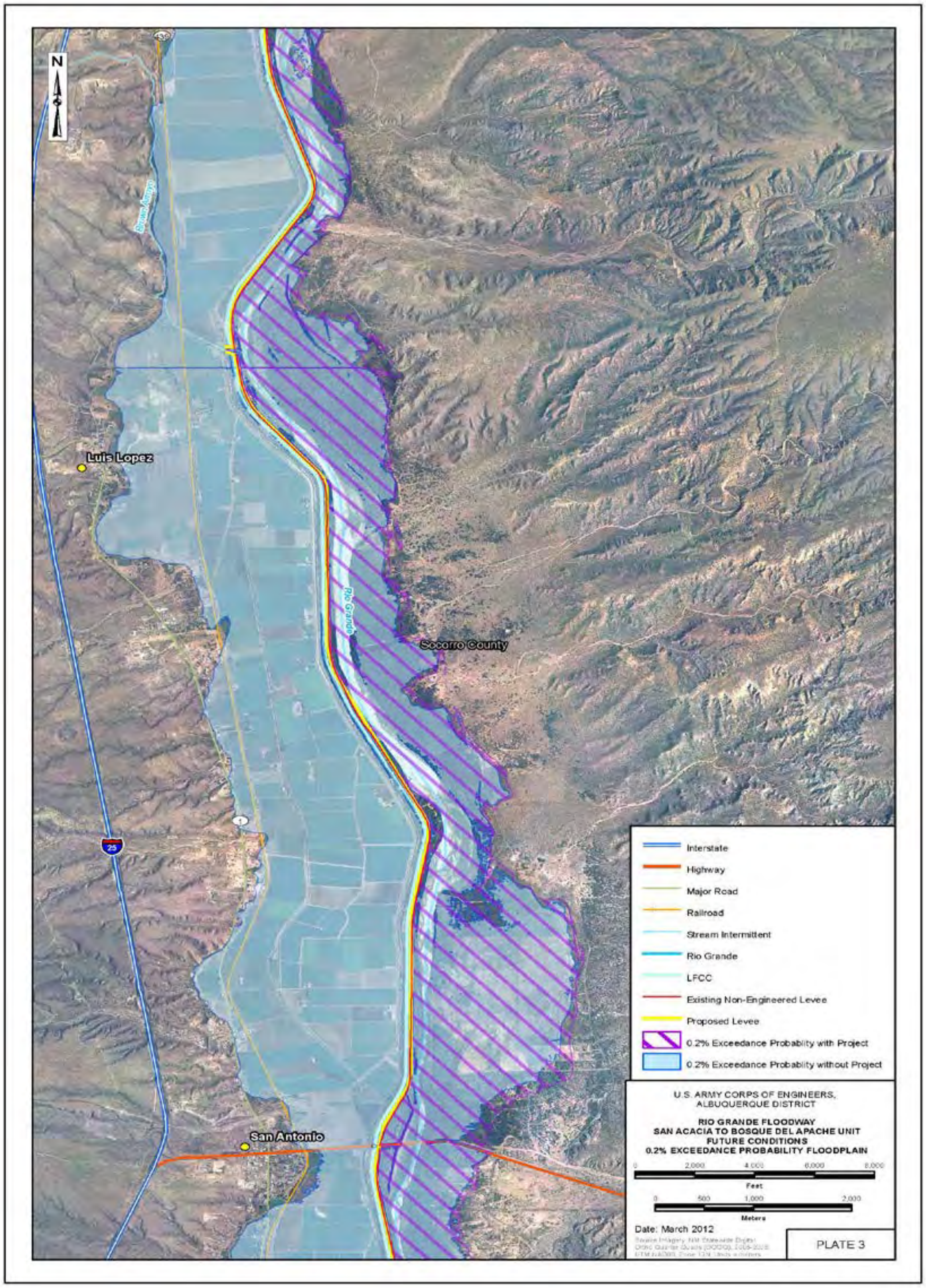


Figure 10.5. Without-Project Floodplains and With-Project Floodplains (Alternative A)

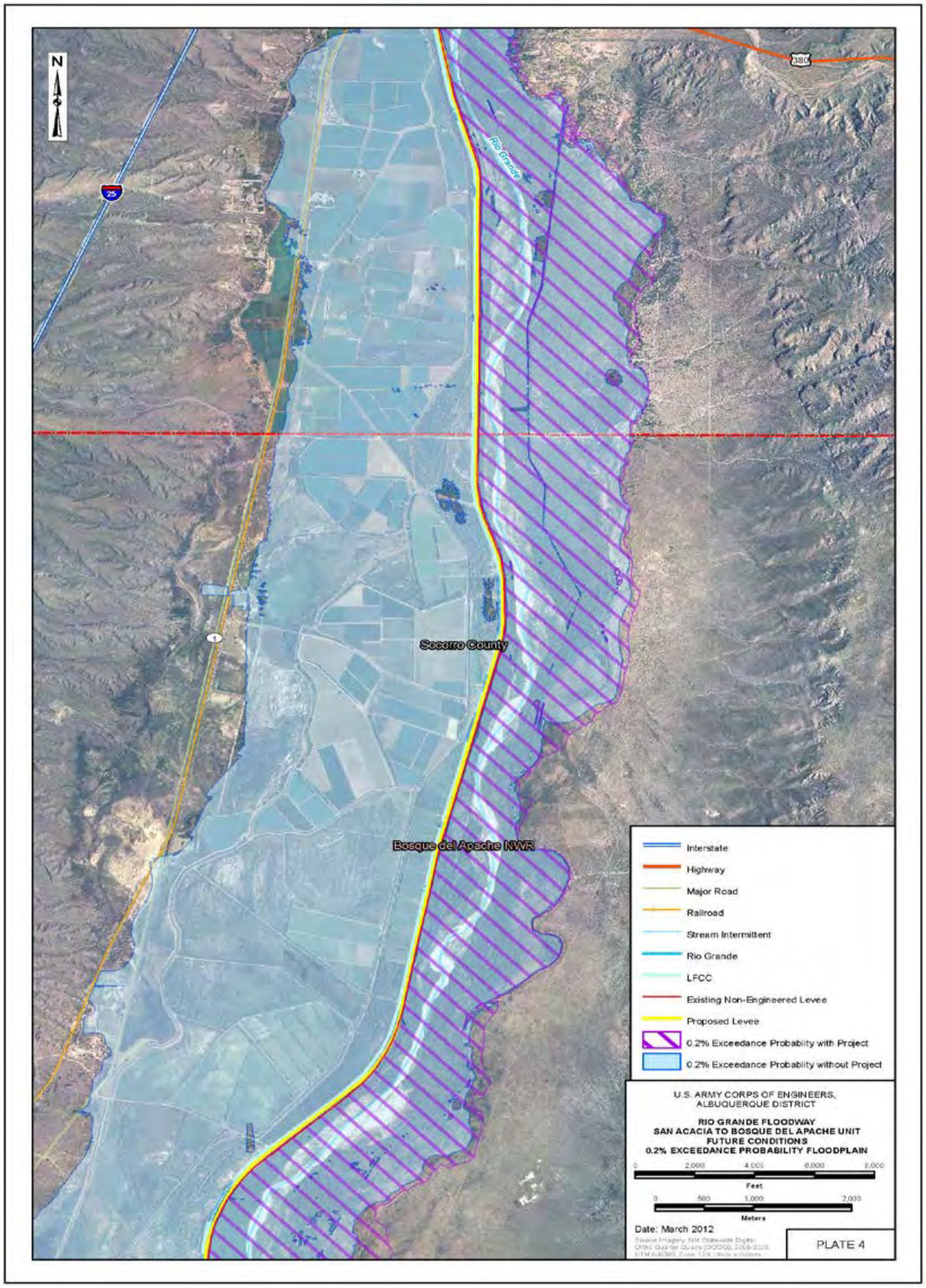


Figure 10.6. Without-Project Floodplains and With-Project Floodplains (Alternative A)

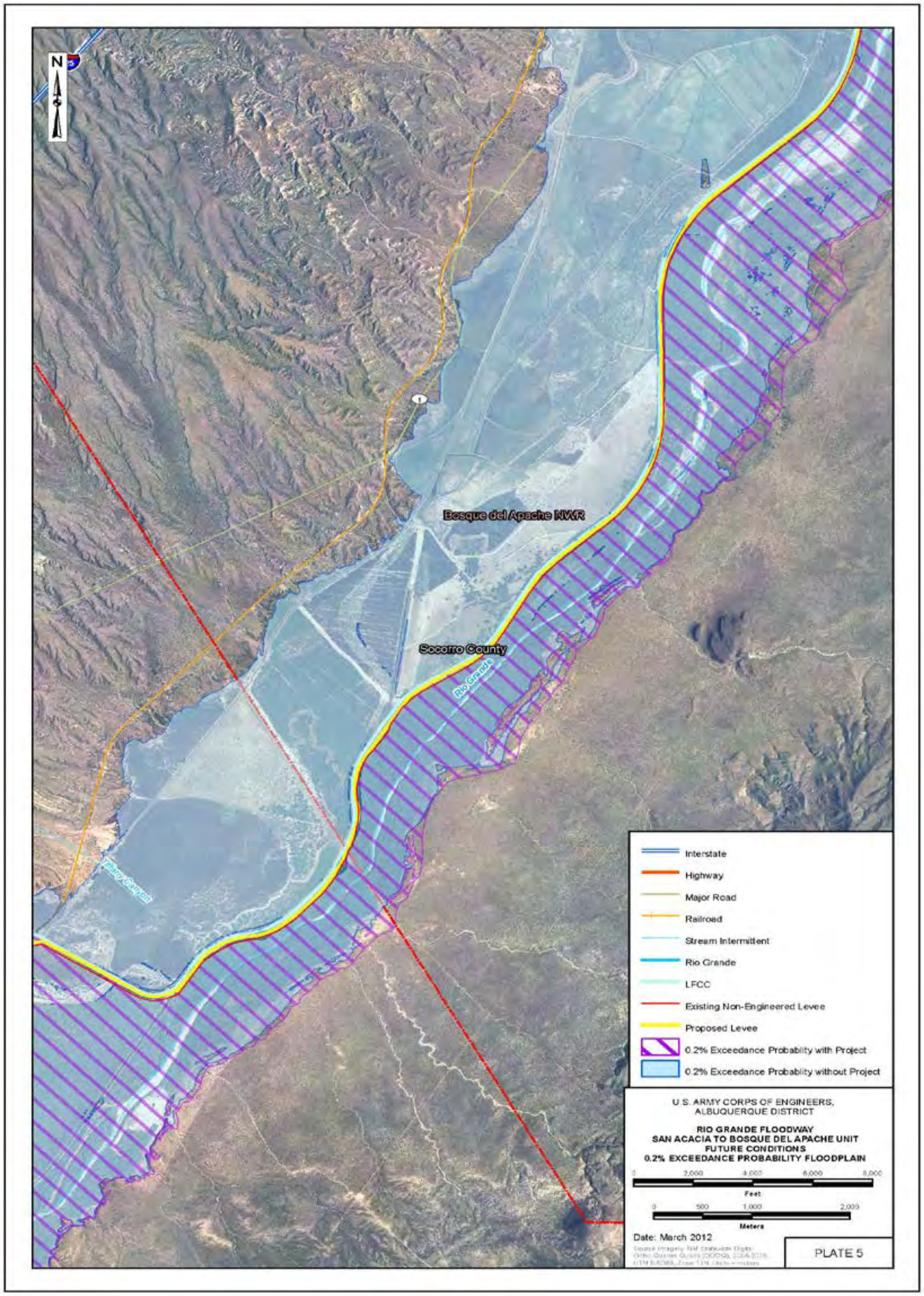
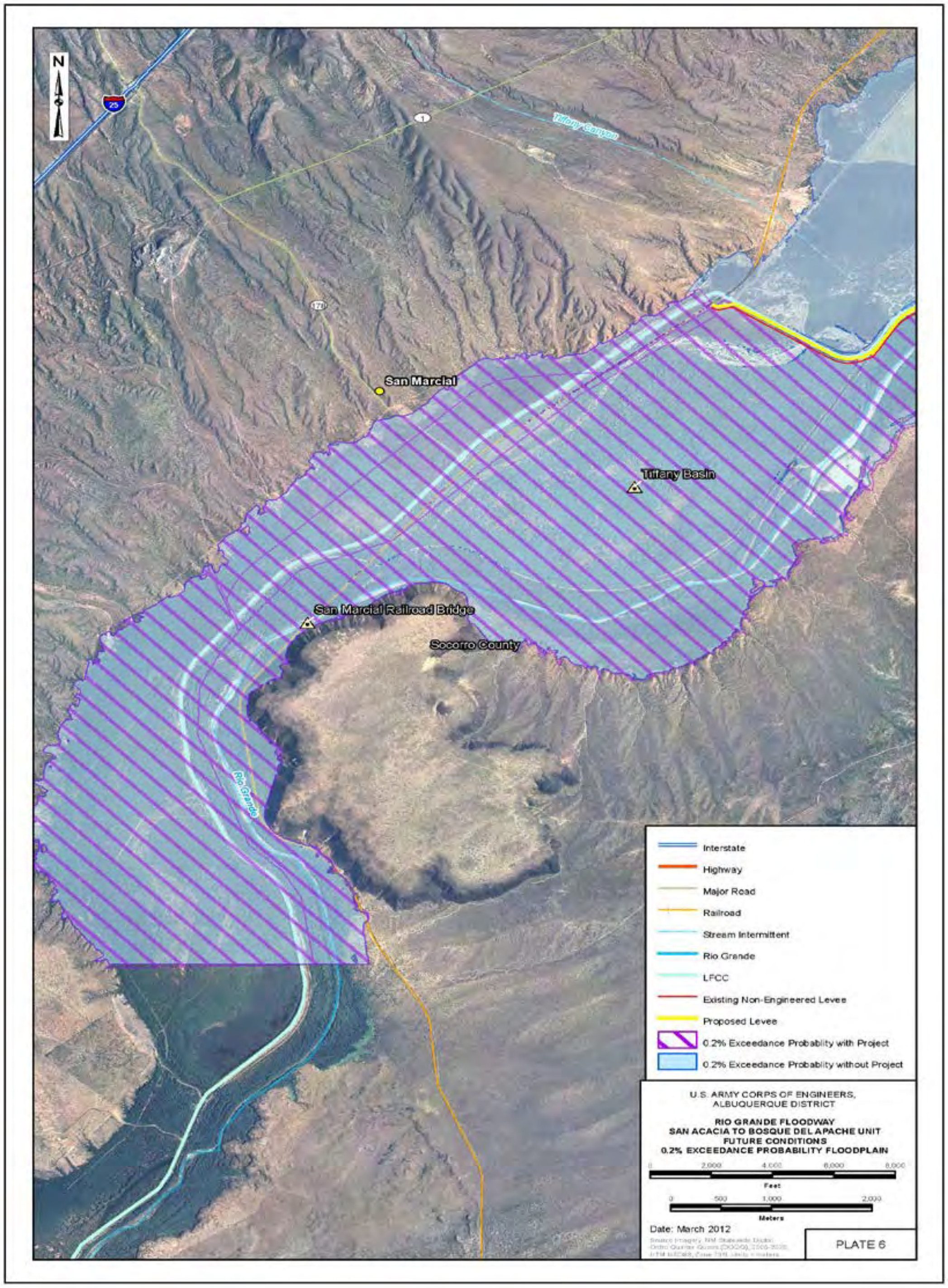


Figure 10.7. Without-Project Floodplains and With-Project Floodplains (Alternative A)



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Appendix F-2, F3, Hydrology, Hydraulics, and Sedimentation

ATTACHMENT

Rio Grande Floodway
San Acacia to Bosque del Apache Unit, Socorro, NM
Flood Damage Reduction Project

HYDROLOGIC ANALYSIS

Feasibility Report

Limited Reevaluation Report

Supplemental Environmental Impact Statement
for the Authorized
Rio Grande Floodway: San Acacia to Bosque del Apache Unit, Socorro NM,
Flood Damage Reduction Project

Hydrologic Analysis

Hydrology
Rio Grande Floodway: San Acacia to San Marcial, Socorro County, N.M

Feasibility Report

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1.0 Purpose and Scope of Report. The scope of this report is to present a hydrologic analysis for the Rio Grande floodway between San Acacia and San Marcial.

1.1. Summary of Hydrologic Analysis

In order to estimate the hydrology for the project area, the following tasks were accomplished:

- Discharge frequency relationships were developed for the Rio Grande at San Acacia. An adjusted record of annual maximum instantaneous peaks was developed and used as the basis of the discharge frequency analysis. The adjustments to peak flows were made so that peaks represent regulated conditions. Whenever secondary peaks from unregulated areas were of greater magnitude than the adjusted peaks, the secondary peaks were used.
- Secondary peaks were estimated by routing recorded flows from major unregulated tributaries and combining them with coincident recorded flows on the mainstem Rio Grande. FLO-2D, a 2-dimensional unsteady flow model, was used to route and combine hydrographs representing the relevant gage data.
- Design hydrographs were developed for the Rio Grande at San Acacia based on peak and volume frequency relationships.
- Flood frequencies for the project area from San Acacia to San Marcial were determined by routing the design hydrographs downstream using FLO-2D.

The results of the frequency analysis at San Acacia are summarized in Table 1. A complete discussion of the analytic methods and the rationale for using these methods is presented in following sections of this report.

1.2. Primary Purpose of Hydrology: Feasibility Evaluation of Proposed Corps of Engineers Flood Damage Reduction Project

The *Rio Grande Floodway: San Acacia to Bosque del Apache Unit, Socorro NM, Flood Damage Reduction Project*, is a reevaluation of a Corps of Engineers flood protection project that was last proposed in 1999. There are several previous project reports.

- In 1999 a Limited Reevaluation Report and Supplemental Environmental Impact Statement (LRR/SEIS) was issued, with a recommendation for an earthen levee extending 43.5 miles along the west bank of the Rio Grande from the San Acacia Diversion Dam to approximately 3 miles north of the San Marcial railroad bridge. The Tiffany sediment control area was also recommended in this report.
- In 1992 a SEIS was issued.
- In 1991 a General Design Memorandum (GDM #2) was issued, with a recommendation for an earthen levee extending 54.3 miles along the west bank of the Rio Grande from the San Acacia Diversion dam to the end of the Low Flow Conveyance Channel at the headwaters of Elephant Butte Lake. In 1992 the corresponding SEIS was issued.

The project area is the Rio Grande and its associated floodplain beginning at the diversion dam at San Acacia and extending to San Marcial, in the headwaters of Elephant Butte Lake, Socorro County, NM. The length of the project area is approximately 48 river miles. Project features that will be evaluated include:

1) Engineered levees on the west side of the Rio Grande floodway. The floodway is bounded to the east by high ground.
2) A sediment control area at Tiffany, immediately upstream of San Marcial.
3) Relocation of a railroad bridge at San Marcial. The San Marcial railroad bridge is virtually parallel to the Rio Grande, intersecting the river at an angle of 70 degrees to the perpendicular. In the past 100 years, approximately 24 feet of sediment have accumulated at the location of the railroad bridge, and it has been raised twice to accommodate the aggrading riverbed. There is a proposal to move the bridge to a location where it will be approximately perpendicular to the flow.

Table 1. Flood Flow Frequency at San Acacia

Return Period Flood Event	Percent Chance Exceedance	Flow in CFS
500 yr	.2	43500
200 yr	.5	35300
100 yr	1.0	29900
50 yr	2.0	25000
20 yr	5.0	19200
10 yr	10.0	15400
5 yr	20.0	11800
2 yr	50.0	7380
1.25 yr	80.0	4770
1.11 yr	90.0	3860
1.05 yr	95.0	3260
1.01 yr	99.0	2420

1.3. Secondary Purpose of Hydrology: Compare This Analysis to Other Federal Hydrologic Studies that Pertain to the Project Area and Provide Perspective on the Differences

The hydrology of the Rio Grande in the project area has been studied for many years by various Federal, State and local government agencies, including the Corps of Engineers. Some of the Federal agencies that have responsibilities for river information and management in the Rio Grande watershed are:

- Bureau of Reclamation (BOR)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Geological Survey (USGS)
- U.S. Army Corps of Engineers (COE)

Each of these entities has performed independent hydrologic analyses. For this reason there are several different versions of flood hydrology for the project area. In each case, these analyses meet the agency needs, but there is not much consistency in approach or in results between the various versions.

One of the most important developments in recent years is a growing public interest in the water resources of the Rio Grande river basin, as part of an increased emphasis on protecting the environment. The past few years have been relatively dry ones. There has been a significant amount of public attention focused on the implications for the environment, for endangered species, for preservation of native plants and wildlife, for meeting New Mexico’s commitment to deliver river water in accordance with the Rio Grande Compact for commercial and residential water use, for recreation, and for support of traditional lifestyles such as farming and ranching.

Flood hydrology in the Rio Grande watershed has, over time, been complicated by a number of factors, such as the construction of dams that regulate flows and movement of sediment. Different ways of addressing these factors have contributed to the differences in the hydrologic analyses. However, given the level of public attention to river resource management, hydrologists and engineers at some of the Federal agencies have agreed that it will be useful to explore whether newly available analytic tools can be used to provide insight into apparent inconsistencies. Perhaps some of the differences in the analyses can be more easily understood and the applicability of these analyses can be clarified.

This subject is discussed further in Section 6 below, together with a discussion of results of this analysis. Table 9 in Section 6 provides a summary of hydrologic estimates for San Acacia peak flows from Federal agencies, including the results of this study.

2.0. Watershed Characteristics

2.1. Basin characteristics

The size of the watershed at San Acacia is 26,770 square miles, including 2,940 square miles in a closed basin in San Luis Valley, CO. A watershed map is provided in Figure 1.

The climate is generally arid or semiarid. Elevations range from over 14,000 feet in the Colorado mountains to 4,660 feet at San Acacia. Vegetation is sparse in much of the watershed, other than at high elevations. Shrubs and grasses dominate the lower elevations. Junipers and pinions are common at intermediate elevations, while pine and fir forests are found at high elevations.

The Rio Grande rift is a geologic feature that separates the Great Plains from the Colorado Plateau and defines the location of the river. The Rio Grande valley in New Mexico flows in the rift through a system of linked basins flanked by uplifts. Over time, the Rio Grande rift has filled with several thousand feet of sediments. Near Albuquerque, the depth of alluvium is more than 5,000 feet.

A system of drains and spoil bank levees was completed in 1936 in much of the Rio Grande floodplain, confining much of the floodway. Since the levees were constructed, the sediment moving through the river has deposited within the levees and created a floodway that is higher than the floodplain outside the levees in many places. Another effect of the levee system has been to disconnect the river from smaller tributaries that had been a source of inflow and sediment.

It is important to note that one of the authorized purposes of Cochiti, Jemez and Galisteo dams is to regulate sediment. An estimated 1000 acre-feet of sediment reaches Cochiti Dam each year. The dams control approximately 80% of the sediment inflow above Albuquerque. At the time that the dams were constructed, the floodway was aggrading to the extent that it had become perched in most locations between Cochiti and the project area. Where there were engineered levees, there was concern that the increasing sediment in the floodway would prevent the levees from containing high flow events. Examples of the impacts of reduced sediment include channelization of the river and decreased connection between the river and its floodplain. The effect of the sediment reduction arguably extends south beyond Albuquerque.

In order to address the hydrology, the area was divided into four subwatersheds. They include the watersheds of two major tributaries, the Rio Puerco and the Rio Salado; the Albuquerque drainage area, including the Cochiti, Jemez and Galisteo watersheds; and the mainstem Rio Grande downstream of Albuquerque. Table 2 provides some characteristics of the subwatersheds.

2.1.1. Rio Puerco and Rio Salado Subwatersheds

The Rio Puerco and the Rio Salado watersheds are drainage areas of two major tributaries to the Rio Grande that have their confluences immediately upstream of the project area, both within 12 river miles. They are unregulated and are significant in size, 7,350 and 1,395 square miles respectively.

Table 2. Subwatershed Attributes

Subwatershed Attribute	Rio Puerco Subwatershed	Rio Salado Subwatershed	Albuquerque Subwatershed	RG Subwatrshed Albuquerque - San Acacia (w/o RP and RS subwatersheds)
Size (mi^2)	7,350	1,395	17,440	3,580
Stream Length (mi)	140	70	320	67
Ave. Slope	32 ft/mi	53 ft/mi	22.5 ft/mi	4.3 ft/mi
Record Peak Flow and Date	35,000 cfs Sept. 23, 1929	36,200 cfs July 31, 1965	25,000 cfs April 24, 1942	53,400 cfs Aug. 13, 1929

These areas are lightly populated. Commercial activities are primarily livestock and mining. The subwatersheds are contiguous and comprise much of the westernmost watershed. The lands are 20% tribal, and include reservation land belonging to the Navajo and Jicarilla Apache, and the Acoma, Isleta, Jemez, Laguna Pueblos.

The Rio Puerco subwatershed extends to the Continental Divide on the west and to the Jemez Mountains on the north. It includes 1360 square miles of non-contributing area. The Rio Puerco is an ephemeral stream with a winding and steep-walled channel. There are extensive lava flows with absorptive characteristics. Much of the flow from upstream locations greatly attenuates in this subwatershed. The soils are generally highly erosive alluvium soils and a great deal of sediment is produced by flows from the Rio Puerco.

The Rio Salado subwatershed is located to the west of San Acacia. It is bordered on the south by the Lemitar Mountains and the Gallinas Mountains, on the southwest by the Datil Mountains, on the west by the North Plains, and on the northwest by the Ladron Mountains. It is an ephemeral stream with deeply entrenched arroyos. Given the steep terrain, it is flash flood prone, with high peak flows.

2.1.2. Albuquerque Subwatershed.

Albuquerque is located on the Rio Grande, 70 river miles upstream of the project area. Flow on the Albuquerque subwatershed is directly controlled by three dams: Cochiti, Jemez Canyon, and Galisteo. The Albuquerque subwatershed comprises 65% of the San Acacia drainage area.

Cochiti Dam is the most significant of the upstream structures, located on the mainstem Rio Grande 58 miles upstream of Albuquerque. The headwaters of the Rio Grande above Cochiti Dam are in the San Juan Mountains of south-central Colorado. There are several major tributaries in the 15,900 square mile watershed above Cochiti Dam, including some that are themselves regulated.

- The Rio Chama is regulated at the El Vado Reservoir and at Abiquiu Reservoir. Heron Lake, upstream of the El Vado Reservoir, receives interbasin transfer water from the San Juan River. The Rio Chama drainage area is 3,144 square miles at Chamita, near its confluence with the Rio Grande.
- The Conejos River in Colorado is regulated by an upstream dam, Platoro Dam.
- Other upstream reservoirs include Wagon Wheel Gap Reservoir, near Creede, CO., also the Santa Maria Reservoir, Continental Reservoir and Rio Grande Reservoir.
- Major unregulated tributaries to the Rio Grande upstream of Cochiti Dam in New Mexico include the Santa Fe River, Santa Cruz River, Embudo Creek, Rio Taos, Rio Hondo, and

the Red River. In Colorado, the La Jara Creek and Alamosa Creek are major unregulated tributaries.

Two major tributaries between Cochiti Dam and Albuquerque are regulated: the Jemez River and Galisteo Creek. Reservoir discharges from the 3 dams, including Cochiti, are coordinated to limit the flow at Albuquerque to 7000 cfs. Other major tributaries to the Rio Grande in Albuquerque are the Tonque Arroyo, North and South Diversion Channels in Albuquerque. These disconnected arroyos can contribute locally high flows on the Rio Grande, but the flood hydrographs attenuate rapidly once they reach the Rio Grande river channel.

2.1.3. Rio Grande Subwatershed from Albuquerque to San Acacia (without the Rio Puerco and Rio Salado subwatersheds)

The remainder of the Rio Grande watershed between Albuquerque and San Acacia, not including the Rio Puerco and the Rio Salado subwatersheds, consists of a strip of land approximately 70 miles long that includes the Rio Grande valley and is bounded by mountains on the east and west. Its total area is 3,580 square miles, 12% of the San Acacia watershed. The drainage is characterized by relatively short, steep arroyos that have high peak flows and low volume. The largest of these is Abo Arroyo, located about 9 miles upstream of Bernardo to the east, with a drainage area of 290 square miles. Most of the tributaries are not directly connected to the river. Instead they disgorge onto the valley floor, which is lower than the Rio Grande floodway and separated from it by spoil bank levees.

2.2. **Precipitation**.

Average annual rainfall in the watershed varies from over 40 inches near the Continental Divide in Colorado to less than 8 inches in some of the valleys.

Winter is the driest season. Winter storms typically come from the Pacific Ocean, moving from west to east. Winter precipitation is mostly in the form of snow, and quantity varies dramatically over the watershed. Average annual snowfall in Cuba, NM, is 40 inches, 30 inches at Bandelier National Monument, NM, and in Magdalena, NM, it is 18 inches. At Red River, NM, the average annual snowfall is 136 inches, and at Cumbres, CO, the average annual snowfall is 289 inches.

Approximately half the total annual precipitation occurs during July through October, when inflows of moist air from the Gulf of Mexico or the Gulf of California may take place. The resulting convective thunderstorm activity can produce intense but short-lived rainfall events. In some cases, air masses associated with hurricanes in the Gulf of Mexico have produced general storms over much of the watershed. Historic high magnitude flood events have occurred during these months.

Figure 2 shows the 100-year 24-hour isopluvials in New Mexico.

2.3. Runoff

Historically, two types of runoff events have occurred in the project area.

Snowmelt events of significance originate in the Albuquerque subwatershed, and are thus presently regulated. Regulated peak flows have been held to 7000 cfs at the Albuquerque gage. However, the Albuquerque District has a stated goal of releasing 10000 cfs, and that would allow the reservoirs to draw down faster. A second advantage to a higher reservoir release is that the flow could better resemble the natural hydrograph, which would provide environmental benefits.

The Rio Grande watershed can produce a large volume of snowmelt. Attachment 3 shows historic Cochiti releases. There are several years when the duration of the snowmelt release was longer than a month. These data demonstrate that when high flows occur over an extended period, there are virtually no losses between Cochiti Dam to San Marcial, at the lower end of the project area.

Rainfall runoff events occur primarily in the July to October timeframe. Rainfall runoff of magnitude has come from both the Rio Puerco and the Rio Salado subwatersheds. These subwatersheds are unregulated and they enter the mainstem Rio Grande in close proximity to the project area. The Rio Puerco and Rio Salado subwatersheds are therefore expected to be the source for high flow events in the Rio Grande at San Acacia.

There are historic accounts of general storms in the Rio Grande watershed that led to great damages in the project area. One of these occurred in 1904, and two occurred in 1929. Because of the time that has elapsed since these events, reliable rainfall and river flows generally cannot be obtained. The Albuquerque subwatershed was not regulated at that time.

Rain on snow events have not had impact on the project area in the past, mostly because of the watershed characteristics and the typical spring weather patterns.

2.4. Features of the Project Area

The project area is the Rio Grande floodway extending from the diversion dam at San Acacia to San Marcial, Socorro County, N.M. The length of the project area is approximately 49 river miles. The elevation at the upper end of the project area is 4,660 ft. (NGVD 1929 datum), and at San Marcial the elevation is 4,460 ft. The area is lightly populated and primarily agricultural. Located at the lower end of the project area is the Bosque del Apache National Wildlife Refuge. At the most downstream end of the project area, at San Marcial, there is a railroad bridge that crosses the river at an angle that is 70 degrees from the perpendicular.

Throughout the project area, the river is presently bounded on the west by a spoil bank levee. On the east side of the floodway, the floodplain is generally narrow with little development.

To the east, a series of arroyos drain relatively small watersheds. When a storm occurs in these areas, the inflow of sediment can result in local high water at the confluence of the arroyo with the Rio Grande. The larger of the arroyos draining into the project area are located on the west side. Only 2 of these, Nogal Arroyo and Socorro Canyon, are greater than 100 square miles in size.

To the west side of the levee, the floodplain is as much as 10 to 15 feet lower in elevation than the river bed, due to sediment deposition in the Rio Grande floodway. A riverside drain is located on the west side of the levee.

The Low Flow Conveyence Channel (LFCC) is also located on the west side of the levee. The San Acacia Diversion Dam is the upstream end of the LFCC. It was designed for efficient conveyence of 2000 cfs of river water downstream to Elephant Butte Lake in order to meet New Mexico's obligations for water delivery downstream. The LFCC was constructed in 1958 and operated to convey 2000 cfs until 1979. Since 1985 the LFCC has not been operated to convey Rio Grande water.

The San Acacia Diversion Dam, located at the upstream end of the project area, is operated by the Middle Rio Grande Conservancy District (MRGCD). It impounds a small volume of water and sediment. River water is diverted to the Socorro Main Canal North at this location. The diversion to the LFCC is also located at this facility.

"With project" and "without project" conditions are Corps of Engineers scenarios used for project evaluation. Because the present spoil bank levee will not reliably contain flood waters, "without project" conditions represent the assumption that there is no levee on the west side of the Rio Grande. "With project" implies that a new levee has been constructed to the west of the river, and it will be similar in location to the present spoil bank levee.

3.0. Methods of Hydrologic Analysis

There are several methods for estimating peak flows that are widely used, and all have applicability, depending on the watershed characteristics, including the size of the watershed, whether the watershed is gaged, and the purpose of the hydrologic analysis. The frequently used methods include:

- Flood frequency analysis. Wherever there is adequate river gage data, this statistical method of analysis is considered the most accurate. Because the underlying assumption is that present and future flood flows can be estimated based on past flow peaks, the watershed should be stable in terms of hydrologic parameters, such as land use. It is also important that a long enough stream gage record is available to statistically represent typical flows. Low frequency flood events are often not estimated well using this method. However, the range of events that result in high flows is best captured in this method of analysis.
- Estimation of storm runoff, including rainfall runoff models. Some of the commonly used rainfall runoff computer models are HEC-1 and HMS, and TR-20. These models estimate watershed runoff from subwatersheds, then mathematically store, combine and route the flows to mimic physical processes. The estimated rainfall may be live rainfall data, historic storm data, or a synthetic storm. Adjustments can be made to account for anticipated land use changes. However, in watersheds where snowmelt is a factor, synthetic storms may give only partial information. Also, if there are not adequate rain gage data and high water marks to use for calibration, this method is only as good as the assumed model parameters.
- Regional flood-frequency equations using generalized least-squares regression are frequently used for smaller ungaged watersheds. These equations are generally not used for large and nonhomogeneous watershed like the Rio Grande above San Acacia.
- Flows are sometimes estimated using known flow frequencies at upstream or downstream locations. A multiplier can be derived to apply to peak flows to translate them to a location upstream or downstream. The multiplier is characteristically based on the ratio of the drainage areas, and a regional exponent is applied. It is implied that the hydrologic and meteorological characteristics of both the upstream and downstream areas are similar. The ratio of the upstream and downstream drainage areas should be between 0.5 and 1.5.

4.0. Issues Relating to Application of Analytic Methods in the Project Area

Flood flow frequency analysis was selected as the method for hydrologic analysis at the most upstream location in the study area, San Acacia. Hypothetical flood flow hydrographs were generated at San Acacia and routed downstream to estimate flood flow frequencies at other locations within the project area.

In order to verify that flood frequency analysis is applicable, "Guidelines for Determining Flood Flow Frequency", Bulletin 17-B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data was referenced. Bulletin 17B provides a consistent approach to applying flood flow frequency analysis for Federal agencies. Its purpose is to present currently accepted methods for analyzing peak flow frequency data in order to promote uniformity of application within Federal agencies.

Another reference that was used to verify applicability of flood frequency analysis was Corps of Engineers Regulation No. 1110-2-1450, “Engineering and Design Hydrologic Frequency Estimates”.

4.1. Watershed Regulation and Flood Flow Frequency Analysis

Of the subwatersheds to the Rio Grande watershed at San Acacia, the area upstream of Albuquerque is the only portion that is regulated by reservoirs. The other major subwatersheds, the Rio Puerco and the Rio Salado, are unregulated.

The three reservoirs that directly control flow at Albuquerque are: Cochiti, Jemez Canyon and Galisteo. Of these, Cochiti regulates 85% of the watershed area and is the most significant in size. The reservoirs have been operated for flood control to achieve a maximum flow of 7,000 cfs at Albuquerque.

Bulletin 17B provides the following guidance:

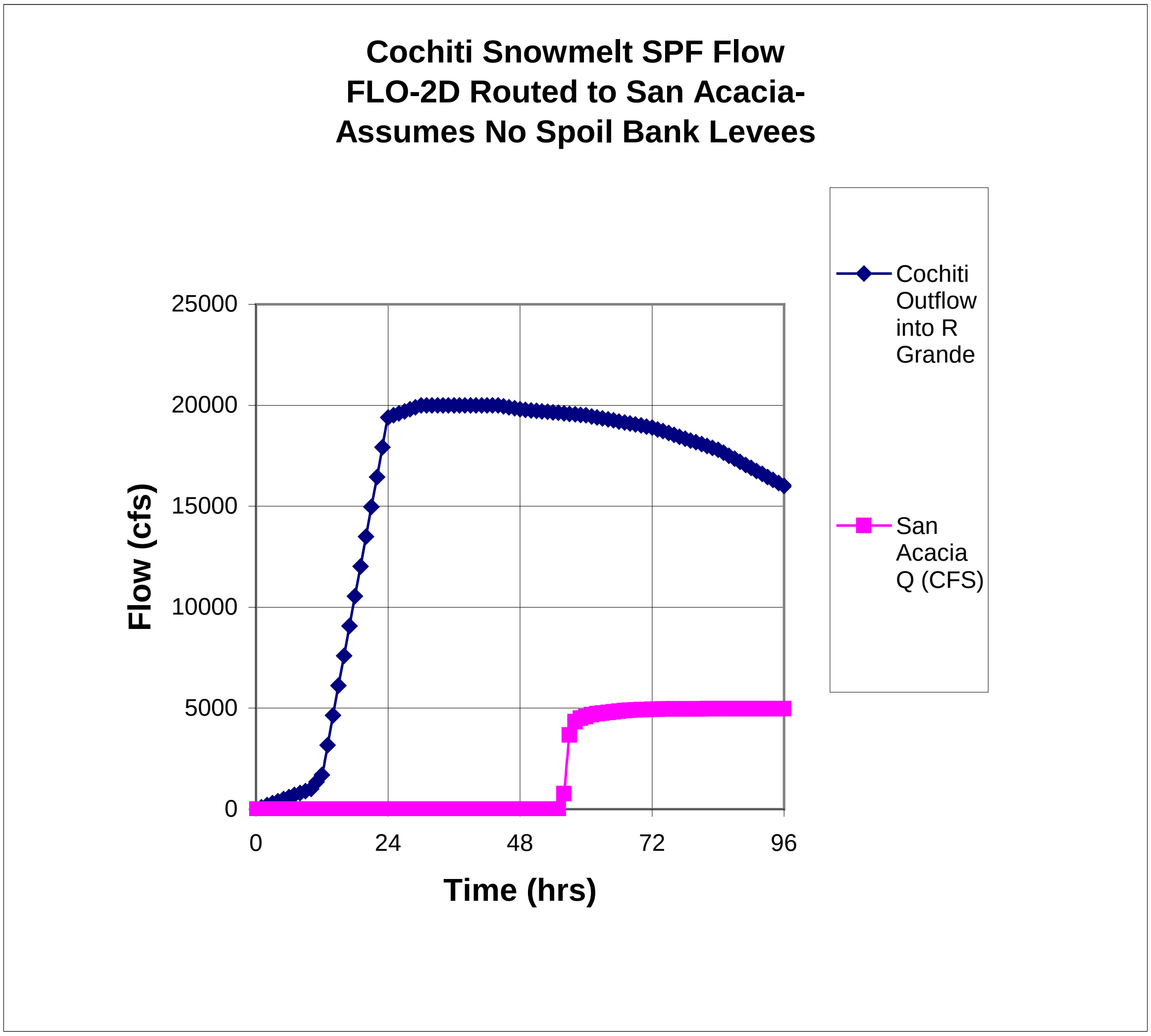
> “It is becoming increasingly difficult to find watersheds in which the flow regime has not been altered by man’s activity…. Special effort should be made to identify those records which are not homogeneous. Only records which represent relatively constant watershed conditions should be used for frequency analysis.”

The records that are used for flood flow frequency analysis are instantaneous peak flows. In order to use records that represent constant watershed conditions, the instantaneous peak flow record was adjusted to represent current regulated flow conditions. Peaks that occurred prior to operation of Cochiti were reviewed. Peak flows that originated upstream of Albuquerque were adjusted to reflect the maximum flow of 7,000 cfs at Albuquerque. The Cochiti Water Control Manual states that all previous high flow events would have been completely controlled by Cochiti Dam, and so it was assumed that 7,000 cfs at Albuquerque would have been achieved for these runoff events. In some cases, secondary high flows originating in the Rio Puerco or the Rio Salado would have become the peak flow at San Acacia. These secondary San Acacia peaks were estimated as described below in Section 4.5 and used to revise the record to reflect present flow conditions. The adjustments that were made to the annual peak flow record are provided in Section 5.1.

In order to evaluate the effect of Cochiti Dam on large flood flows at San Acacia, 115 river miles downstream, a FLO-2D model was used to route standard project flood (SPF) hydrographs originating at Cochiti Dam downstream to San Acacia. The SPF flood hydrographs that were modeled were those presented in the Cochiti Water Control Manual, both for the snowmelt SPF flood and for the summer rainfall runoff SPF flood. The hydrographs include the peak flows and are lengthy enough to route the peaks to San Acacia. Figures 3 and 4 show the Cochiti SPF hydrographs and routed hydrographs at San Acacia. Both for snowmelt and summer floods, the peak flows that result from the SPF floods at Cochiti attenuate to approximately 5,000 cfs at San Acacia. This flow is less than the 2-year flood event at San Acacia. (Note: An assumption made for routing the flows is that the spoil bank levees do not remain viable during a high water event.)

It is significant that high flow events originating in the controlled portion of the watershed attenuate to such a degree by the time they reach San Acacia. It can be concluded that large flood flow events at San Acacia and downstream, under present regulated conditions, originate in the uncontrolled areas.

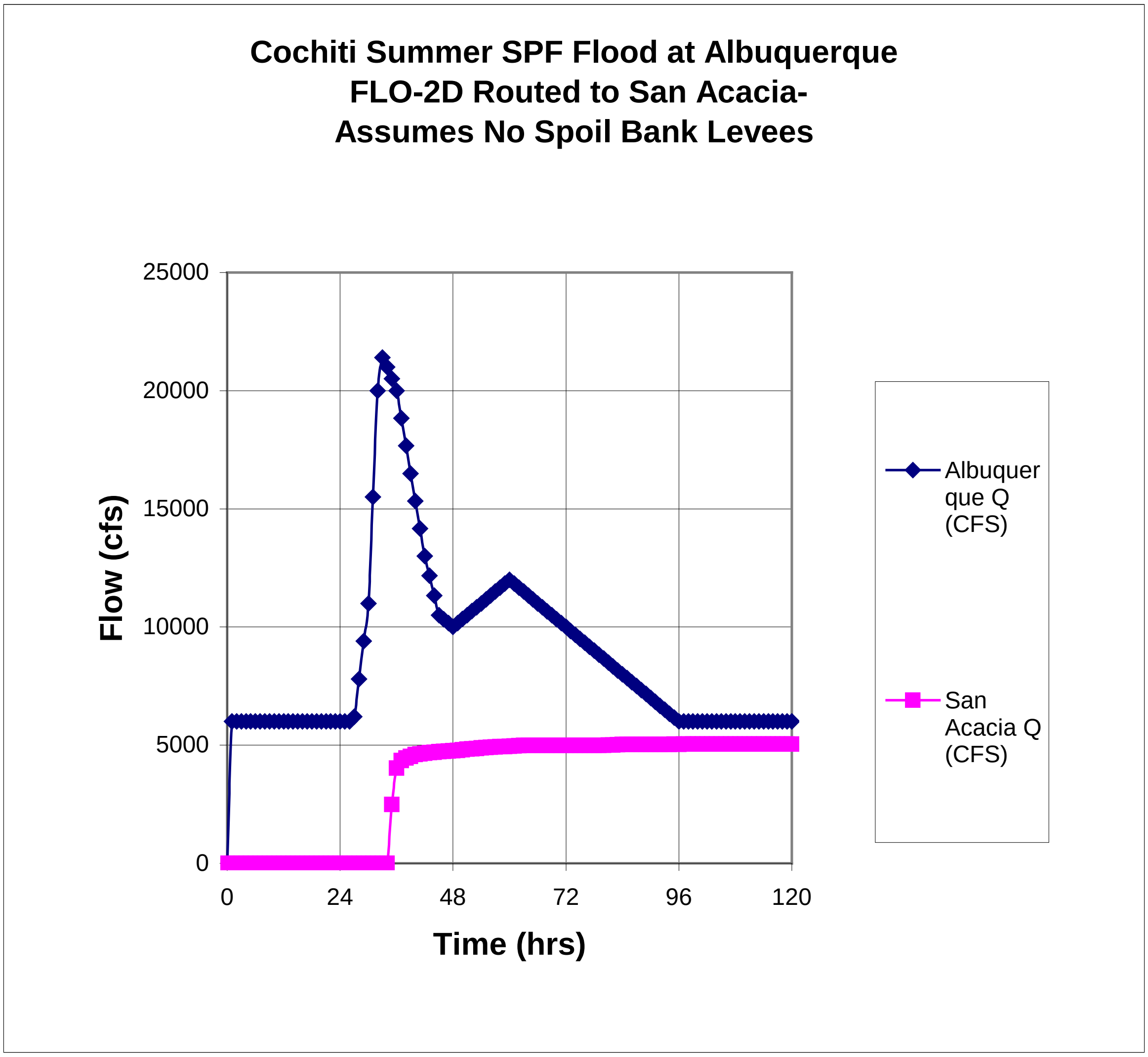
Figure 3. Cochiti Snowmelt SPF Flow Routed to Downstream Locations



4.2. Length of Record and Quality of Peak Flow Data at San Acacia

The USGS river gage at San Acacia has been in operation during most of the period from 1936 to present. Beginning in 1965, the USGS stopped publishing instantaneous annual peak flows but continued to provide mean daily stream flow. Instantaneous peaks should be used for a peak flood flow frequency analysis. The instantaneous peaks that were used for the flood flow frequency analysis were adjusted to reflect present regulated flow conditions. A detailed explanation of the adjustment process is presented in Section 5.1.

Figure 4. Cochiti Summer SPF Flow Routed to Downstream Locations



The San Acacia Diversion Dam, located 0.2 miles upstream from the gage, is operated by the Middle Rio Grande Conservancy District (MRGCD). It impounds a small volume of water and sediment. Periodically, the MRGCD releases a surge of water and sediment. The USGS adjusts the data to account for the instantaneous peaks that are caused by the MRGCD releases. Because the volume of water and sediment that is contained behind this dam is relatively small, it was assumed not to be significant for the purposes of this analysis.

Two diversions exist at the San Acacia Diversion Dam: the Low Flow Conveyance Channel, and the Socorro Main Canal North. These diversions do not affect gage data, since the diversions will typically be closed during high water events to prevent large amounts of sediment from entering the channels.

It should be noted that estimates of flow at stream gages are made on the basis of stage data. However, because of the volume of sediment that moves through the Rio Grande system, the

easily erodable streambanks, and the variable channel scour, the correlation between stage and flow in the Rio Grande is not as well established as in other environments.

A stream gage is also located at San Marcial, immediately downstream of the railroad bridge. The floodway has aggraded at San Marcial, and the riverbed rose approximately 24 feet between 1895 and 1989. The gage data at San Marcial do not correlate well with other gage data in the watershed and so these data were not considered in this study.

4.3. Statistical Independence of Subwatersheds

The result of regulation for the Albuquerque subwatershed is that the portion of high flow events coming from upstream of Albuquerque is no longer a significant factor at San Acacia. Section 4.1 above provides an explanation of the reduced contribution of the Albuquerque subwatershed to high flows at San Acacia. The remaining contributing areas for high flows at San Acacia are: the Rio Puerco and Rio Salado subwatersheds and the remaining Rio Grande subwatershed below Albuquerque.

It can be assumed that coincidence of high flows from these 3 contributing areas is embedded in the peak flow data at San Acacia, and does not therefore affect the frequency analysis. However, the shape and volume of the hydrographs that are used to estimate high flow flows downstream of San Acacia are impacted by coincidence of flows from these areas. Flood routing hydrographs are discussed further in Section 4.5 below.

Table 3 below summarizes the data available for high flow events from the Rio Puerco and the Rio Salado relating to coincidence of flows from other areas. Bernardo data prior to reservoir regulation was not included, and so these high flow data represent current regulated conditions. These data support the assumption that the contributing areas are statistically independent. No high flow event greater than the 5-year event from any contributing area corresponds to a similarly high flow event from one of the other contributing areas.

4.4. Use of FLO-2D for Flood Flow Routing

4.4.1. The FLO-2D Model

FLO-2D is a two-dimensional hydraulic model that estimates routing of one or more inflows over a grid system representing the floodplain. It includes a one-dimensional hydraulic model for channels. FLO-2D uses volume conservation and the momentum equation as the basis for a time sequence simulation model of unconfined flows. Channel and floodplain flows are calculated using standard hydraulic parameters. FLO-2D can be applied to analyze split channel flows, sediment movement, mud and debris flows, and flows over alluvial fans. A detailed FLO-2D model could simulate rainfall and infiltration, and flows with respect to levees, hydraulic structures, streets, buildings and flow obstructions.

FLO-2D numerically routes one or more hydrographs that can be introduced to the channel or floodplain at any location and at any time in the simulation. It accounts for tributary flow and interaction of high flows with the other flows in the system. FLO-2D provides an estimate for hydraulic parameters such as flow depth, velocity and area of inundation. The model is an effective tool for predicting channel and overbank flow.

The FLO-2D model of the channel-floodplain interface provides for flow exchange in both directions based on the difference in water surface elevations. The diffusive wave equation and the floodplain roughness are the basis of the computation. The elevation of the channel bank is found in the channel cross-section data.

Table 3. Instantaneous Peak Flows Greater Than 5-Year Event from Major Tributaries with Coincident Mean Daily Peaks from Other Contributing Areas

Rio Puerco Flow (cfs)	Date	Frequency of Rio Puerco Flow Event	Coincident Mean Daily Flow at Bernardo (cfs)	Frequency of Bernardo Flow Event	Coincident Mean Daily Flow on Rio Salado (cfs)	Frequency of Rio Salado Flow Event
18800	9/23/1941	1.5%	No Data	N/A	No Data	N/A
12900	10/25/1941	3.6%	3960	57%	No Data	N/A
11100	6/30/1943	5.3%	No Data	N/A	No Data	N/A
9220	9/14/1972	7.9%	0	~100%	1330	28%
9020	8/23/1947	8.3%	1450	93%	No Data	N/A
8000	8/12/1955	10.6%	1120	96%	570	60%
7920	9/27/1954	11%	No Data	N/A	480	66%
7860	8/13/1967	11.2%	1750	90%	314	79%
7200	8/27/1940	14.2%	No Data	N/A	No Data	N/A
6940	10/24/1969	14.5%	1170	96%	3	~100%
6260	10/19/1944	17%	1830	88%	No Data	N/A
5800	8/11/1946	19.6%	23	~100%	No Data	N/A
5680	8/18/1957	20.1%	2750	76%	610	58%
Rio Salado Flow (cfs)	Date	Frequency of Rio Salado Flow Event	Coincident Mean Daily Flow at Bernardo (cfs)	Frequency of Bernardo Flow Event	Coincident Mean Daily Flow on Rio Puerco (cfs)	Frequency of Rio Puerco Flow Event
36200	7/31/1965	1.8%	9	~100%	140	~100%
27400	8/12/1929	5.5%	No Data	N/A	No Data	N/A
22000	10/13/1972	9.9%	0	~100%	305	~100%
18500	9/11/1972	14.5%	0	~100%	2080	30%
17400	8/10/1967	16.2%	2190	85%	775	76%
16600	6/25/1954	18%	No Data	N/A	0	~100%
15400	8/21/1975	20.8%	214	~100%	1.2	~100%

In order to prevent numeric surging, FLO-2D balances the relationship between slope, flow area and roughness throughout the simulation. Internal to the calculation, Mannings n is adjusted accordingly. These adjustments are explained in the "FLO-2D User's Manual".

The Grid Developer System (GDS) is a FLO-2D preprocessor that generates the FLO-2D grid. It uses a set of digital terrain model (DTM) points, overlays the grid onto the DTM, interpolates and assigns elevations to each grid element. A statistical distribution of random elevation points is generated for each grid elements. A data filter can be used to eliminate points that would distort the average elevation, such as elevations of treetops and rooftops. The elevation is then calculated using inverse weighted distance averaging.

The most recent version of the "FLO-2D User's Manual" was released in 2003. It provides an explanation of the governing equations, model logic, limits and assumptions, as well as application of specific model components.

4.4.2. The Middle Rio Grande FLO-2D Flood Routing Model

A FLO-2D model of the Rio Grande was developed and calibrated as part of an interagency project, the Upper Rio Grande Watershed Operations Review (URGWOPs). The Corps of

Engineers is one of the participating Federal agencies in the URGWOPs project. The URGWOPs FLO-2D model extends from Cochiti Dam downstream through the project area.

The URGWOPs model was ideal as the basis for a flood flow routing model for the study area. It uses the following base data:

- A 500-ft grid system with elevations from various sources. In the project area the majority of the elevations were developed using a 1991 BOR DTM. The vertical datum was converted from NGVD 29 to NAVD 88.
- Parameters related to the grid and channel system that were initially estimated based on engineering judgment. Channel roughness and infiltration have since been calibrated.
- Channel sections that have been surveyed over the past 5 years. Intermediate sections are interpolated from the surveyed sections.
- Levee elevation data obtained from surveys and DTMs.

Survey data and mapping that was used to develop the URGWOPs model channel and grid can be obtained from the BOR in Albuquerque or from Tetra Tech, Inc., in Albuquerque, NM. The FLO-2D grid that was used can be obtained from the Albuquerque District Corps of Engineers or from Tetra Tech, Inc., in Albuquerque, NM.

"Development of the Middle Rio Grande FLO-2D Flood Routing Model Cochiti Dam to Elephant Butte Reservoir" is a 2004 report by Tetra Tech, Inc., that documents the URGWOPs model. It provides a description of the data used to develop the model, its components, and some of its applications.

The model was calibrated using 1997, 1998 and 2001 gage data and aerial photographs. Parameters that were adjusted include channel roughness and channel infiltration, in order to improve hydrograph timing, shape and volume. The calibration data did not represent a large flood event, since no high flows of significance have occurred in the past 30 years. The data that were used for calibration were gage data, since no high water marks were available. When more flood data become available, additional calibration will be done. Information about the model calibration is provided in a 2002 report titled "Development and Calibration of the Middle Rio Grande FLO-2D Flood Routing Model", by TetraTech, Inc.

A new version of the FLO-2D model was released in 2003, after the model calibrations described above were performed. It is the 2003 version of FLO-2D that was used for the hydrologic routing described in this report. Tetratech has stated that none of the changes to the model made in 2003 would affect the results of the Middle Rio Grande FLO-2D calibration that was done previously.

4.4.3. FLO-2D Flood Routing Model for the Project Area

The URGWOPs FLO-2D model was modified to meet project needs, then the resulting FLO-2D models were used to route flood flow hydrographs.

The "With-Project" FLO-2D Model. The URGWOPs FLO-2D model is based on the assumption that the existing levees are viable, and so existing spoil bank levees are represented as the levee system. Because the proposed "with-project" levee will be constructed on approximately the same alignment as the existing spoil bank levee, the URGWOPs model provides a good representation of "with-project" conditions.

- The levee data in this "with-project" model was modified by increasing levee height in some locations so that overtopping would not result from the design flows. The "with-project" levee height has yet to be determined, and so this change was consistent with the purpose of the flood routing model.
- The URGWOPs model infiltration parameters, like the values for Manning's n, have been calibrated. When applied, they show significant losses during high flow events due to

infiltration. The more conservative assumption is that the floodplain is saturated and that infiltration losses are not a factor. Because the purpose of this project is design, the more conservative modeling approach was used and infiltration was assumed not to be a factor.

The "Without-Project" FLO-2D Model. Removal of the levee data from the URGWOPs model in the project area results in a model that, for the most part, represents the project area without a levee. However, there are sections of the URGWOPs grid that were based on BOR elevation data, collected only within the floodway. For that part of the project area, there is no floodplain represented outside the levee in the URGWOPs model.

- In order to have a FLO-2D model represent "without-project conditions", the grid system for the URGWOPs model was extended to include the remaining floodplain. Elevation data for the extended grid were derived from the USGS Digital Elevation Models (DEMs).
- With the spoil bank levee removed, as much as ¾ of the flow is relocated from the floodway to the floodplain. The floodplain is as much as 10 to 15 feet lower in elevation than the floodway. It was assumed that infiltration would not be a factor because the floodplain would become saturated in a high water event.

The URGWOPs FLO-2D model was also modified to route flood flows to San Acacia from upstream locations, such as Cochiti Dam and the confluence of the Rio Grande and the Rio Puerco. The spoil bank levees in the Rio Grande floodway upstream of the project area were removed from the FLO-2D model except for the reaches that have engineered levees. This was done to represent the assumption that non-engineered levees will fail during flood events.

4.5. Hydrographs Used for FLO-2D Routing and Volume Frequency

FLO-2D routing was used for 2 different purposes in this analysis:

- Estimation of secondary peak flows at San Acacia based on recorded upstream flows from the contributing areas. These secondary peaks were used as part of the San Acacia instantaneous peak record, for flood frequency analysis.
- Estimation of peak flows downstream of San Acacia during hypothetical flood events.

4.5.1. Estimation of Secondary Peak Flows at San Acacia

In order to evaluate San Acacia flows during high flow events from the Rio Salado and the Rio Puerco, a hydrograph from each of the contributing areas was estimated. USGS gage-based data records from the three contributing areas, Rio Salado, the Rio Puerco, and the Rio Grande at Bernardo, were the basis of the estimated hydrographs. The estimated hydrographs were routed by the FLO-2D model over a simulated period of 96 hours.

Mean daily flow records provided a basis for estimating flow volume for each of the 3 contributing areas. Instantaneous peak data, wherever available, were used along with the mean daily flows to estimate a hydrograph from each contributing area such that the peak and mean flows corresponded with the recorded peak and mean flows.

The estimated hydrographs were routed downstream to San Acacia using FLO-2D in order to estimate a peak at San Acacia that corresponded to the recorded flows upstream. Secondary peaks that would have been the peak flow under present regulated flow conditions were used to adjust the San Acacia peak flow record to reflect regulated conditions. The adjusted peaks are provided in Section 5.1.

An example of routing to estimate a secondary peak using USGS recorded data is shown in Attachment 4.

4.5.2. Estimation of Hypothetical Peak Flood Events at San Acacia

Throughout the project area, the Rio Grande upstream of Bernardo, the Rio Puerco and the Rio Salado are the only significant sources of flood flows. For this reason, it was valid to estimate flow frequencies at locations downstream from San Acacia by routing flood hydrographs downstream through the project area. FLO-2D was used to route flood flows. FLO-2D routings were performed for frequency flood events at San Acacia, using both a with-project (with levee) model and a without-project (no levee) model.

The hydrograph volume has a great impact on the amount of attenuation that takes place as the flood wave moves downstream. Volumes for the 1-day, 2-day and 3-day flood events were evaluated for the Rio Grande at San Acacia rainfall-runoff events, and for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande. These volumes were then used in developing routing hydrographs. In analyzing flood volumes, only rainfall-runoff events were considered at San Acacia, because the Rio Puerco and Rio Salado high flows are comprised exclusively of rainfall runoff. The 1-day, 2-day and 3-day flood volume frequency analysis is provided in more detail in Section 5.2.

Runoff events from snowmelt that produce peaks at San Acacia originate in the regulated portion of the watershed, and are steady releases from the dams. The maximum snowmelt flood, because of gate constraints at the dams, is 10,000 cfs. It was assumed that flood flows of 10,000 cfs or less originate from snowmelt event dam releases. These releases occur over an extended period and do not attenuate.

For flood events of magnitude greater than 10000 cfs, flooding is caused by rainfall events that originate in the unregulated areas, the Rio Puerco and the Rio Salado. In order to estimate the effect of these rainfall events downstream of San Acacia, hypothetical flood hydrographs were developed to use for FLO-2D routing.

General storms occur rarely in the San Acacia watershed, but are a possible scenario leading to very high flow events. If a general storm were to occur, flooding from all of the major subwatersheds could contribute to the flow hydrograph at San Acacia at the same time. The volume of the resulting flood hydrograph would be much greater than it would if it resulted from a single localized event. The conservative approach is therefore to assume that this generalized flooding will occur with very high flows. This assumption is supported by accounts of floods of record described in the 1979 Albuquerque District report , “Rio Grande Basin, New Mexico, Rio Puerco and Rio Salado Watersheds Design Memorandum No. 1.” Flood events in the project area resulted from general storms in 1895, 1929, 1936, 1941, 1955, 1967, and 1972.

Table 4 shows a tabulation of the flow coincidence that was assumed for development of flood hydrographs at San Acacia, together with associated flood volumes. These volumes in turn were used to adjust the frequency hydrographs. Adjusted frequency hydrographs used for routing flood flows downstream from San Acacia through the project area are shown in Figure 5.

The steps that were taken to develop the 96-hour high flow flood hydrographs are:

- Peak flows for various return periods were selected from the San Acacia flood flow frequency analysis provided in Table 1.
- For the 100-year event, a hypothetical flood hydrograph was produced that attained the 100-year peak. It was adjusted to have the same volumes as the 1-day, 2-day and 3-day estimated flood volumes given in Table 4.
- The resulting 100-year hydrograph was scaled to peak flows for other frequency events. If needed these hydrographs were adjusted to attain the flood volumes shown in Table 4.

Figure 5. Hydrographs Used for Routing Flood Flows from San Acacia Downstream

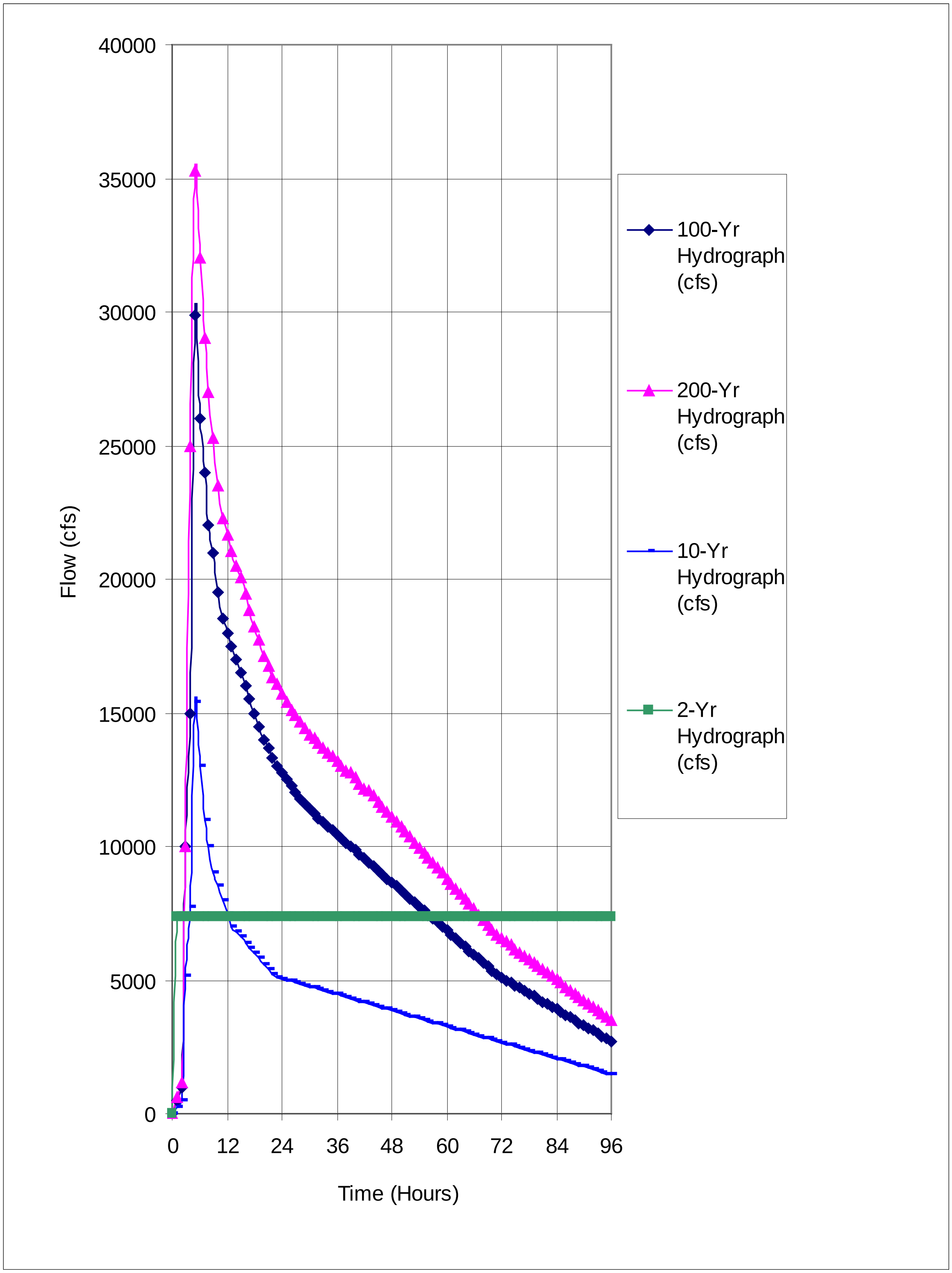


Table 4. Tabulation of Assumed Flood Flow Coincidence of Tributaries with Corresponding Daily Flows and Flood Volumes Used for Development of Flood Routing Hydrographs

ASSUMED COINCIDENCE OF FLOODING FROM CONTRIBUTING WATERSHEDS									
Contributing Watersheds	200-Yr Flood Event			100-Yr Flood Event			10-Yr Flood Event		
	Return Pd.	Average Daily Flow in cfs		Return Pd.	Average Daily Flow in cfs		Return Pd.	Average Daily Flow in cfs	
Rio Puerco (Greatest Volume Flooding)	200	1-Day	10900	100	1-Day	8810	10	1-Day	3700
		2-Day	8730		2-Day	7070		2-Day	2990
		3-Day	6520		3-Day	5380		3-Day	2400
Rio Salado (Coincident Volume Flood)	20	1-Day	2900	10	1-Day	2270	2	1-Day	752
		2-Day	2240		2-Day	1730		2-Day	543
		3-Day	1810		3-Day	1380		3-Day	414
Rio Grande (Coincident Volume Flood- no R Puerco/ R Salado Component)	20	1-Day	5790	10	1-Day	4870	2	1-Day	2510
		2-Day	5340		2-Day	4450		2-Day	2210
		3-Day	5220		3-Day	4300		3-Day	2040
TOTAL HYDROGRAPH VOLUME	Return Pd.	Ave. Daily Volume in cfs-day		Return Pd.	Ave. Daily Volume in cfs-day		Return Pd.	Ave. Daily Volume in cfs-day	
	200	1-Day	19590	100	1-Day	18220	10	1-Day	6950
		2-Day	16965		2-Day	13250		2-Day	5735
		3-Day	13550		3-Day	11060		3-Day	4855

5.0. Analysis

Peak flood flow frequency analyses are presented below for the Rio Grande at San Acacia, and for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande. Frequency analyses were performed to obtain volume frequencies for one-day, two-day and three-day rainfall events at the same locations as the peak flows. For high flow floods, frequency flood hydrographs representing rainfall events at San Acacia were estimated using the peak flow frequencies together with volume frequencies. These hydrographs were routed using FLO-2D to estimate flood frequencies at locations in the project area downstream of San Acacia.

Flooding from snowmelt originates in the regulated watershed upstream of Albuquerque and produces flood peaks of 10,000 cfs or less. To be conservative, floods of 10,000 cfs or less at San Acacia were treated in this hydrologic analysis as snowmelt floods. These are steady flows that can last for many weeks and do not attenuate significantly.

The HEC FFA program, provided by the Corps of Engineers Hydrologic Engineering Center, was used to perform frequency analyses in accordance with Bulletin 17B. Attachment 2 provides more information about FFA.

5.1. Peak Flow Frequency Analysis

5.1.1. Peak Flow Frequency Analysis at San Acacia

The peak flow record, used as a basis of the frequency analysis, was obtained from the USGS web site. Before applying FFA, the following steps were taken:

- Data were adjusted to account for watershed regulation, as explained below in Section 5.1.1.1. These data were flow peaks prior to 1975, when regulation of Rio Grande flows began at Cochiti Dam.
- The annual instantaneous peak flow record was revised to fill in data gaps. Additional peak data were acquired from other sources.

Table 5 summarizes the data revisions.

The peak flows at San Acacia are mixed in that they represent both snowmelt and rainflood data, and in that they represent flooding from regulated and unregulated areas. A graphical frequency curve was therefore drawn instead of using the FFA program to apply principles from Bulletin 17B that relate to homogenous data. Assumptions are:

- The instantaneous peak flow record was revised to represent present conditions.
- A single historic peak, the 1929 estimated flood peak, was included.
- Median plotting positions were used.

The data and analytic results are summarized in Table 6. The peak flow frequency curve at San Acacia is shown in Figure 6.

5.1.1.1. Adjustment of Annual Peaks to Estimate Effect of Watershed Regulation

For years when there were high flows that originated upstream of Albuquerque and there were no significant high flows from the Rio Puerco or the Rio Salado, the assumption was made that the flow peak would have been reduced in accordance with the Cochiti Dam operations policies. Under normal conditions, the Cochiti release is made to keep flows at Albuquerque at 7000 cfs or less. A FLO-2D model was used to route a flow of 7000 cfs from Albuquerque, in order to estimate the flow that would result at San Acacia. The routed hydrograph produced a flow of 5250 cfs at San Acacia. Therefore, for years when the annual flood peak would have been regulated by Cochiti Dam, the flow at San Acacia was estimated to be 5250 cfs.

For some of the record, after peak flows were adjusted downward as described above, there were secondary peaks that replaced the recorded annual instantaneous peaks. The secondary peaks were not available from the gage records. Instead, secondary peaks were estimated by routing recorded peak flows from the Rio Puerco and the Rio Salado. FLO-2D was used to route hydrographs that represented peak flows from the contributing areas in order to estimate the flow at San Acacia. Section 4.5 provides an explanation of the development of these hydrographs.

5.1.1.2. Adjustment of Annual Peaks due to Data Gaps

In 1965, the USGS stopped publishing annual instantaneous peak flow data at San Acacia. For some post-1965 years, instantaneous peak flows have been obtained from a variety of other reliable sources. The USGS has provided some instantaneous flow peaks, both in email and telephone communications. The COE Reservoir Control Section maintains a database of gage data from key locations that updates on a regular basis using satellite transmissions. For the most recent years, instantaneous peak flows could be obtained from that database. For the years 1981 and 1986 through 1989, no instantaneous peak flows were available, and so those years were omitted from the record.

Previous COE frequency analyses included two historic peaks. The first of these was a 1904 peak flow of 60,000 cfs at San Acacia, and the USGS was not able to verify this peak. The 1904 historic peak was therefore not included with the FFA data. The second historic peak occurred in 1929. The USGS verified the 1929 peak, and it was included in this analysis.

Table 5. Adjusted Annual Peak Flows Used for Peak Flood Frequency Analysis at San Acacia

Water Year	Date	Annual Instantaneous Peak Q from USGS Gage Data (cfs)	Estimated Annual Peak Flow (cfs) Used for FFA	Notes
1929	8/13/1929	N/A	53400	Historic event verified by USGS
1936	8/5/1936	27400	27400	Gage Data Unchanged
1937	5/28/1937	18600	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1938	5/22/1938	10500	10000	Re-estimated for max Albuquerque flow of 7000 cfs
1939	8/4/1939	12700	12700	Gage Data Unchanged
1940	8/24/1940	10600	10600	Gage Data Unchanged
1941	9/24/1941	25400 on 5/18/41	9610	Basis: FLO-2D estimated flows
1942	10/26/1941	22000 on 4/25/42	9710	Basis: FLO-2D estimated flows
1943	6/29/1943	9660	9660	Gage Data Unchanged
1944	7/22/1944	10300 on 5/28/44	8400	Basis: FLO-2D estimated flows
1945	5/14/1945	11000	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1946	8/11/1946	3900	3900	Gage Data Unchanged
1947	8/18/1947	6170	6170	Gage Data Unchanged
1948	5/28/1948	11000	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1949	6/24/1949	10300	6330	Adjusted for Upstream Control
1950	8/3/1950	5110	5110	Gage Data Unchanged
1951	8/24/1951	5550	5550	Gage Data Unchanged
1952	6/3/1952	8210	6650	Adjusted for Upstream Control
1953	7/19/1953	7150	7150	Gage Data Unchanged
1954	9/26/1954	10700	10700	Gage Data Unchanged
1955	8/12/1955	12800	12800	Gage Data Unchanged
1956	8/18/1956	4960	4960	Gage Data Unchanged
1957	8/31/1957	12700	12700	Gage Data Unchanged
1958	6/1/1958	11200	5250	Re-estimated for max Albuquerque flow of 7000 cfs
1959	5/24/1959	6050	6680	Adjusted for Upstream Control
1960	6/11/1960	8900	8900	Gage Data Unchanged
1961	9/11/1961	8620	8620	Gage Data Unchanged
1962	4/24/1962	7920	7920	Gage Data Unchanged
1963	8/29/1963	11000	11000	Gage Data Unchanged
1964	7/13/1964	3020	3020	Gage Data Unchanged
1965	8/1/1965	Not Available	17200	Adjusted for Upstream Control
1966	9/19/1966	Not Available	7550	Adjusted for Upstream Control
1967	8/14/1967	Not Available	13050	Basis: FLO-2D estimated flows

Table 5, Continued. Adjusted Annual Peak Flows Used for Peak Flood Frequency Analysis at San Acacia

Water Year	Date	Annual Instantaneous Peak Flow from Gage Data (cfs)	Estimated Annual Peak Flow (cfs) Used for FFA	Notes
1968	8/14/1968	Not Available	8140	Adjusted for Upstream Control
1969	7/31/1969	Not Available	8100	Adjusted for Upstream Control
1970	10/24/1969	Not Available	10640	Adjusted for Upstream Control
1971	8/29/1971	Not Available	2530	Adjusted for Upstream Control
1972	9/11/1972	Not Available	14810	Basis: FLO-2D estimated flows
1973	10/13/1972	Not Available	14430	Basis: FLO-2D estimated flows
1974	8/3/1974	Not Available	3020	Adjusted for Upstream Control
1975	9/11/1975	Not Available	14200	Adjusted for Upstream Control
1976	7/24/1976	Not Available	6980	Adjusted for Upstream Control
1977		Not Available	9030	Adjusted for Upstream Control
1978	5/21/1978	Not Available	2750	Adjusted for Upstream Control
1979	June/1979	Not Available	6780	Adjusted for Upstream Control
1980	6/9/1980	Not Available	14300	Adjusted for Upstream Control
1982	10/11/1981	Not Available	9690	Adjusted for Upstream Control
1983	8/3/1983	Not Available	6750	Adjusted for Upstream Control
1984	8/6/1984	Not Available	10910	Basis: FLO-2D estimated flows
1985		Not Available	7500	Basis: “Historic Cochiti Releases”
1990	7/16/1990	Not Available	3320	Basis: Direct Contact with USGS
1991	6/15/1991	Not Available	5970	Basis: Direct Contact with USGS
1992	5/12/1992	Not Available	6320	Basis: Direct Contact with USGS
1993	6/7/1993	Not Available	6510	Basis: Direct Contact with USGS
1994	5/12/1994	Not Available	7650	Basis: Direct Contact with USGS
1995	5/26/1995	Not Available	6350	Basis: Direct Contact with USGS
1996	6/28/1996	Not Available	7325	Basis: COE Reservoir Control Data
1997	7/30/1997	Not Available	5720	Basis: Direct Contact with USGS
1998	7/28/1998	Not Available	5831	Basis: COE Reservoir Control Data
1999	8/11/1999	Not Available	9020	Basis: Direct Contact with USGS
2000	5/25/2000	Not Available	1830	Basis: Direct Contact with USGS
2001	5/24/2001	Not Available	4460	Basis: COE Reservoir Control Data
2002	9/11/2002	Not Available	6790	Basis: COE Reservoir Control Data

5.1.2. Rio Puerco and Rio Salado Peak Flow Frequency Analysis

The FFA program was applied to evaluate peak flow frequencies for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande, Bernardo and San Acacia, respectively. Instantaneous peak data from the USGS web site were used for the analysis. The skews that were calculated within the FFA program were applied to the frequency curves.

The instantaneous peak data and analytic results are summarized in Tables 7 and 8. Peak flow frequency curves for the Rio Puerco and the Rio Salado at their confluences with the Rio Grande are shown in Figures 7 and 8, together with 1-day, 2-day and 3-day flow frequency curves.

5.2. 1-Day, 2-Day and 3-Day Volume Frequency Analysis

The purpose of the multiple-day frequencies is to estimate probable peak flood volumes. Peak flood volumes are of importance because they have a significant impact on the amount of attenuation that can be expected as the flood wave moves downstream.

1-day, 2-day and 3-day peak flows were computed using spreadsheets to calculate multiple-day volumes and annual peaks. FFA software was used to perform the frequency analyses. Peak flow data are provided in Tables 6 through 8. The source data were USGS mean daily peaks that were obtained from the USGS web site. The gages that were used were the Rio Grande at San Acacia, the Rio Puerco at Bernardo (confluence with the Rio Grande), and the Rio Salado at San Acacia (confluence with the Rio Grande). Peak floods at San Acacia, for large events, originate in the Rio Puerco and the Rio Salado watersheds. Large floods are therefore all rainfall runoff events, not snowmelt events.

In order to be consistent, snowmelt peaks for the Rio Grande at San Acacia were eliminated from the data set. Peaks that occurred before 1975 on the Rio Grande were removed from the record, in order that the Rio Grande flow data would reflect only regulated rainfall events. However, it should be noted that flows that occurred at San Acacia since 1975 are not representative of the complete period of record. Since 1975, no flows from any of the contributing watersheds have exceeded the 10-year event. This phenomenon is thought to be related to the hydrologic cycle. Land use changes are not well documented, but could also be a contributing factor. The 1-day, 2-day and 3-day volume frequencies based on flow data since 1975 are therefore expected to be appreciably lower than those that would have been attained from a longer period of record, had the data been available.

The analytic results are summarized in Tables 6 through 8. Rio Puerco and Rio Salado volume frequency curves are plotted together with peak flood frequency curves in Figures 7 and 8. The Rio Grande volume frequency curves were not plotted.

5.3. Flood Flow Frequency in the Project Area Downstream of San Acacia

There are no significant sources of inflow to the Rio Grande within the project area, and so the only source of major flood flows is the watershed upstream of San Acacia. Flow frequencies downstream from San Acacia were estimated using the following procedure:

- Hydrographs representing frequency event flood flows at San Acacia from rainfall floods were developed to be consistent with peak frequencies, as described in Section 4.5.
- The hydrographs were routed using the FLO-2D model from San Acacia downstream through the project area to estimate the response of the channel and overbanks during the corresponding storm event.

Table 6. Peak Flow Data and Flood Frequency Statistics for the Rio Grande at San Acacia

Annual Peak Flows at San Acacia Used as Basis for Flood Frequency Analyses							
Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
8/5/1936	27400						
5/28/1937	5250						
5/22/1938	10000						
8/4/1939	12700						
8/24/1940	10600						
9/24/1941	9610						
10/26/1941	9710						
6/29/1943	9660						
7/22/1944	8400						
5/14/1945	5250						
8/11/1946	3900						
8/18/1947	6170						
5/28/1948	5250						
6/24/1949	6330						
8/3/1950	5110						
8/24/1951	5550						
6/3/1952	6650						
7/19/1953	7150						
9/26/1954	10700						
8/12/1955	12800						
8/18/1956	4960						
8/31/1957	12700						
6/1/1958	5250						
5/24/1959	6680						
6/11/1960	8900						
9/11/1961	8620						
4/24/1962	7920						
8/29/1963	11000						
7/13/1964	3020						
8/1/1965	17200						
9/19/1966	7550						
8/14/1967	13050						
8/14/1968	8140						
7/31/1969	8100						
10/24/1969	10640						
7/31/1971	2530						
9/11/1972	14810						
10/13/1972	14430						
8/4/1974	3020						
9/11/1975	14200	9/12/1975	5080	9/12/1975	4100	9/11/1975	3703
7/24/1976	6980	11/3/1975	895	11/2/1975	789	11/2/1975	691
8/12/1977	9030	8/14/1977	3460	8/14/1977	2450	8/13/1977	1818

NOTE: Water Years 1936 – 1974 were omitted from the volume frequency analysis because the volumes from these years are not consistent with volumes from later years.

Data from water years prior to 1975 represent unregulated flow conditions. Current regulated flow conditions are represented by water years beginning in 1975, as are other flood data in this analysis.

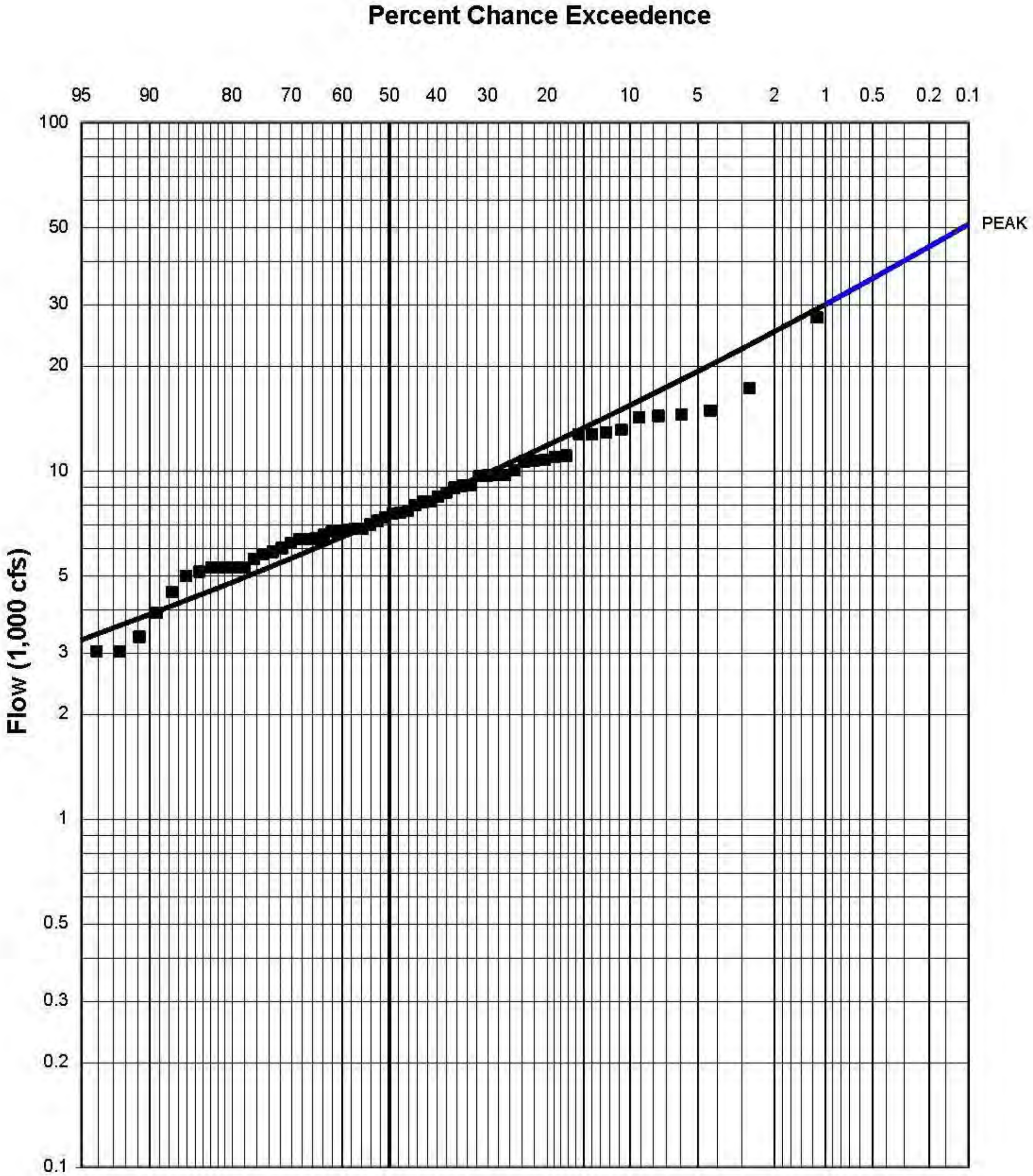
Table 6, Cont. Peak Flow Data and Flood Frequency Statistics for the Rio Grande at San Acacia

Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
5/21/1978	2750	7/25/1978	335	7/24/1978	312	7/24/1978	292
6/1/1979	6780	8/17/1979	1040	8/17/1979	747	8/17/1979	598
6/9/1980	14300	9/9/1980	1990	9/9/1980	1750	9/9/1980	1590
10/11/1981	9690	7/12/1981	1840	7/12/1981	1028	7/12/1981	811
6/11/1983	6750	9/21/1982	5040	9/21/1982	4270	9/21/1982	3907
8/6/1984	10910	11/13/1982	1850	11/13/1982	1785	11/12/1982	1727
6/11/1985	7500	11/18/1983	1060	11/17/1983	1030	11/16/1983	952
7/16/1990	3320	9/22/1985	3020	9/22/1985	2975	9/22/1985	2870
6/15/1991	5970	7/2/1986	5250	7/5/1986	5180	7/6/1986	5137
5/12/1992	6320	7/20/1987	5240	7/23/1987	5120	7/22/1987	5117
6/7/1993	6510	9/15/1988	4160	9/14/1988	4080	9/13/1988	3880
5/12/1994	7650	11/16/1988	2190	11/16/1988	2040	11/16/1988	1890
5/26/1995	6350	7/16/1990	2490	7/15/1990	2175	7/14/1990	1920
6/28/1996	7325	8/8/1991	4080	7/26/1991	3935	7/26/1991	3807
7/30/1997	5720	11/17/1991	2670	11/13/1991	2480	11/13/1991	2467
7/28/1998	5831	8/27/1993	3700	8/28/1993	3300	8/28/1993	2903
8/11/1999	9020	8/18/1994	3100	8/17/1994	2650	8/16/1994	2467
5/25/2000	1830	11/20/1994	2220	11/19/1994	2160	11/19/1994	2053
5/24/2001	4460	11/3/1995	1300	11/2/1995	1285	11/2/1995	1223
9/11/2002	6790	9/21/1997	3890	9/21/1997	3075	9/21/1997	2717

Flood Frequency Statistics at San Acacia

	Instantaneous Peak	1-Day Peak	2-Day Peak	3-Day Peak
Pct. Chance Exceedence	Frequency Curve	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve
0.2	43500	9880	9400	9400
0.5	35300	8730	8240	8240
1	29900	7850	7370	7340
2	25000	6970	6500	6420
5	19200	5790	5340	5220
10	15400	4870	4450	4300
20	11800	3920	3540	3370
50	7380	2510	2210	2040
80	4770	1540	1320	1190
90	3860	1180	993	877
95	3260	934	778	677
99	2420	592	481	406
Systematic Events	62	28	28	28
Mean	3.8791	3.3869	3.3309	3.2968
Std. Deviation	0.235	0.2415	0.255	0.2704
Computed Skew	0.2899	-0.2946	-0.2527	-0.27
Adopted Skew	0.3	-0.3	-0.3	-0.3

Figure 6. Peak Flow Frequency Curve for the Rio Grande at San Acacia



NOTES:

1. USGS Sta No. 08354900
2. Median plotting positions
3. Drainage area 26,770 sq. mi.
4. Years of record: 62 years of peaks flows

San Acacia to Bosque del Apache Unit, Socorro NM Rio Grande
PEAK FLOW FREQUENCY CURVE **RIO GRANDE AT SAN ACACIA** WATER YEARS 1936 - 2002
U.S ARMY CORPS OF ENGINEERS ALBUQUERQUE DISTRICT

Table 7. Peak Flow Data and Flood Frequency Statistics for the Rio Puerco at Bernardo (Confluence with the Rio Grande)

Annual Peak Flows for the Rio Puerco at Bernardo- Used as Basis for Flood Frequency Analyses							
Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
8/27/1940	7200						
9/23/1941	18800	5/5/1941	5980	5/5/1941	3655	5/3/1941	2873
10/25/1941	12900	10/25/1941	3850	10/4/1941	3285	10/4/1941	2314
6/30/1943	11100	6/29/1943	2510	6/29/1943	2440	6/29/1943	1752
7/22/1944	11000	7/22/1944	4300	7/21/1944	3340	7/21/1944	2357
10/19/1944	6260	8/13/1945	1320	8/14/1945	1047	10/17/1944	861
8/11/1946	5800	8/11/1946	2820	8/10/1946	1750	8/10/1946	1304
8/23/1947	9020	8/17/1947	4630	8/17/1947	3620	8/17/1947	3337
9/26/1948	1570	9/27/1948	503	9/26/1948	385	9/26/1948	298
7/24/1949	3220	7/24/1949	1540	7/24/1949	941	7/24/1949	759
9/21/1950	4140	9/20/1950	1560	9/20/1950	1455	9/20/1950	1018
8/2/1951	4450	8/2/1951	1830	8/24/1951	1144	8/23/1951	1186
9/23/1952	1820	7/9/1952	557	7/8/1952	525	7/7/1952	496
7/19/1953	5490	7/19/1953	3380	7/18/1953	2515	7/18/1953	1900
9/27/1954	7920	9/27/1954	4400	9/26/1954	3885	9/26/1954	2778
8/12/1955	8000	8/12/1955	4100	8/11/1955	3485	7/27/1955	2550
8/18/1956	5200	8/18/1956	1830	8/18/1956	1033	8/1/1956	911
8/7/1957	5680	8/7/1957	5010	8/7/1957	4070	8/6/1957	3230
10/21/1957	5340	10/21/1957	3600	10/21/1957	2910	10/20/1957	2543
5/24/1959	4020	8/26/1959	1380	8/8/1959	1053	8/8/1959	990
3/10/1960	3880	3/10/1960	1480	3/9/1960	1455	3/9/1960	1367
8/19/1961	2470	10/19/1960	1200	8/19/1961	1175	8/19/1961	882
9/29/1962	900	9/28/1962	430	9/28/1962	428	9/28/1962	380
8/5/1963	1210	8/5/1963	900	8/31/1963	779	8/31/1963	682
7/13/1964	2640	8/14/1964	1660	8/14/1964	1232	8/13/1964	999
8/3/1965	3210	8/3/1965	2850	8/2/1965	2570	8/2/1965	2113
8/31/1966	1800	8/3/1966	1060	8/2/1966	649	8/2/1966	490
8/13/1967	7860	8/13/1967	4770	8/13/1967	3585	8/13/1967	3223
8/8/1968	3420	8/13/1968	1760	8/12/1968	1500	8/13/1968	1145
9/21/1969	3580	8/2/1969	1720	8/31/1969	1180	8/31/1969	829
10/24/1969	6940	10/24/1969	4600	10/23/1969	3860	10/22/1969	2900
8/24/1971	1300	8/24/1971	496	8/24/1971	368	8/23/1971	323
9/14/1972	9220	9/14/1972	4930	9/13/1972	4315	9/12/1972	3620
7/16/1973	3920	10/20/1972	1620	10/20/1972	1615	10/20/1972	1366
8/4/1974	2980	8/4/1974	1140	8/4/1974	779	8/4/1974	546
9/12/1975	3520	9/13/1975	1560	9/12/1975	1545	9/11/1975	1507
8/20/1976	2280	8/21/1976	896	8/20/1976	784	8/20/1976	606
8/13/1977	3010	8/13/1977	1290	8/13/1977	1235	8/13/1977	1046
10/6/1977	1330	7/23/1978	321	7/23/1978	212	7/23/1978	145
2/17/1979	1960	2/17/1979	1130	2/16/1979	1033	2/16/1979	845
9/11/1980	2450	9/11/1980	950	9/10/1980	911	9/9/1980	708
9/7/1981	1620	9/7/1981	1060	9/7/1981	822	9/7/1981	728

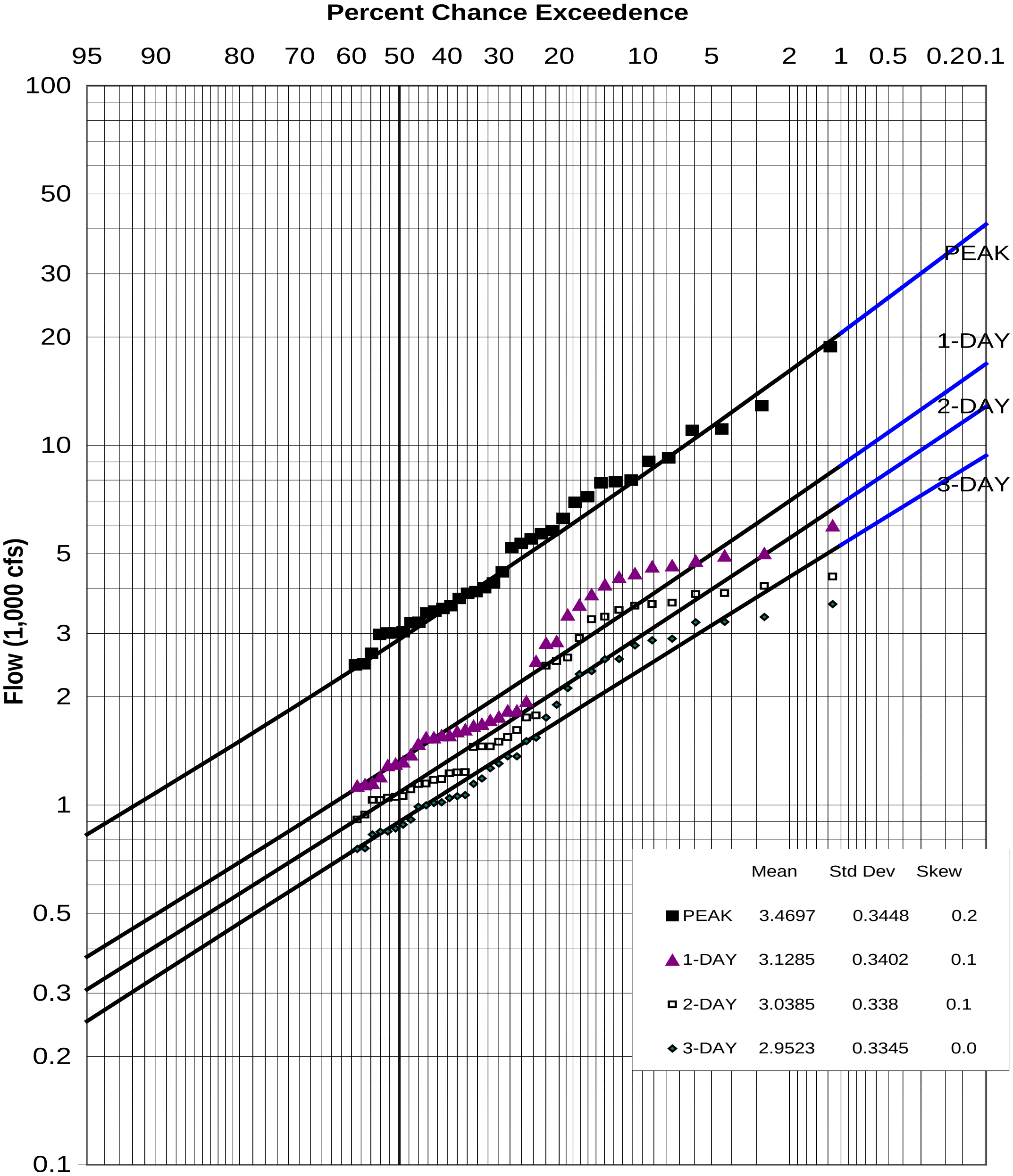
Table 7, Continued. Peak Flow Data and Flood Frequency Statistics for the Rio Puerco at Bernardo (Confluence with the Rio Grande)

Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date	Peak Q (cfs)	Date	1-Day Q (cfs)
9/19/1982	3460	9/19/1982	1540	8/27/1982	1148	9/19/1982	1013
6/26/1983	1580	8/4/1983	458	8/4/1983	329	8/3/1983	249
8/24/1984	1690	10/3/1983	882	10/2/1983	677	10/2/1983	485
3/14/1985	1400	3/14/1985	947	3/14/1985	674	4/30/1985	576
7/6/1986	1170	7/6/1986	1060	7/6/1986	620	7/5/1986	452
11/5/1986	2260	10/14/1986	988	10/14/1986	888	10/13/1986	755
8/8/1988	3750	9/15/1988	1940	9/14/1988	1775	8/27/1988	1540
8/2/1989	912	8/2/1989	623	8/2/1989	614	8/2/1989	472
7/15/1990	1100	9/23/1990	670	9/23/1990	605	9/22/1990	570
7/26/1991	3030	7/26/1991	1600	7/26/1991	1450	7/25/1991	1267
8/27/1992	997	8/27/1992	743	8/26/1992	690	8/26/1992	505
6/20/1993	1400	8/31/1993	771	8/30/1993	721	8/30/1993	661
8/18/1994	3010	8/18/1994	1680	8/17/1994	1059	8/16/1994	844
8/29/1995	662	8/29/1995	325	8/28/1995	288	8/27/1995	237
6/28/1996	1330	6/29/1996	1300	6/28/1996	1225	8/24/1996	1067
9/25/1997	1280	9/24/1997	912	9/23/1997	760	9/22/1997	658
7/29/1998	640	7/28/1998	433	7/28/1998	331	7/28/1998	311
8/6/1999	1330	8/5/1999	1150	8/5/1999	1105	8/5/1999	1058
		4/2/2000	391	4/2/2000	360	4/2/2000	289
		8/16/2001	381	8/15/2001	280	8/14/2001	260
		9/14/2002	424	9/13/2002	408	9/12/2002	362

Flood Frequency Statistics for the Rio Puerco at Bernardo

	Instantaneous Peak	1-Day Peak	2-Day Peak	3-Day Peak
Pct. Chance Exceedence	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q
0.2	33800	14100	11300	8230
0.5	25700	10900	8730	6520
1	20500	8810	7070	5380
2	16100	7000	5630	4360
5	11300	4980	4020	3180
10	8260	3700	2990	2400
20	5710	2590	2100	1710
50	2890	1330	1080	896
80	1500	693	566	469
90	1080	497	407	334
95	829	379	311	252
99	510	230	189	149
Systematic Events	60	62	62	62
Mean	3.4697	3.1285	3.0385	2.9523
Std. Deviation	0.3448	0.3402	0.338	0.3345
Computed Skew	0.1586	0.0961	0.0512	-0.0315
Adopted Skew	0.1586	0.1	0.1	0

Figure 7. Peak and Duration Flow Frequency Curves for the Rio Puerco at Bernardo



NOTES:

1. USGS Station 08353000
2. Median plotting positions
3. Drainage area 7350 sq. mi.
4. Years of Record- 60 Inst. Pks
5. Years of Record- 62 Mean Daily Pks

San Acacia to Bosque del Apache Unit, Socorro NM Rio Grande
RIO PUERCO NR BERNARDO, NM **RIO GRANDE UNIT** WATER YEARS 1941 - 2002
U.S ARMY CORPS OF ENGINEERS ALBUQUERQUE DISTRICT

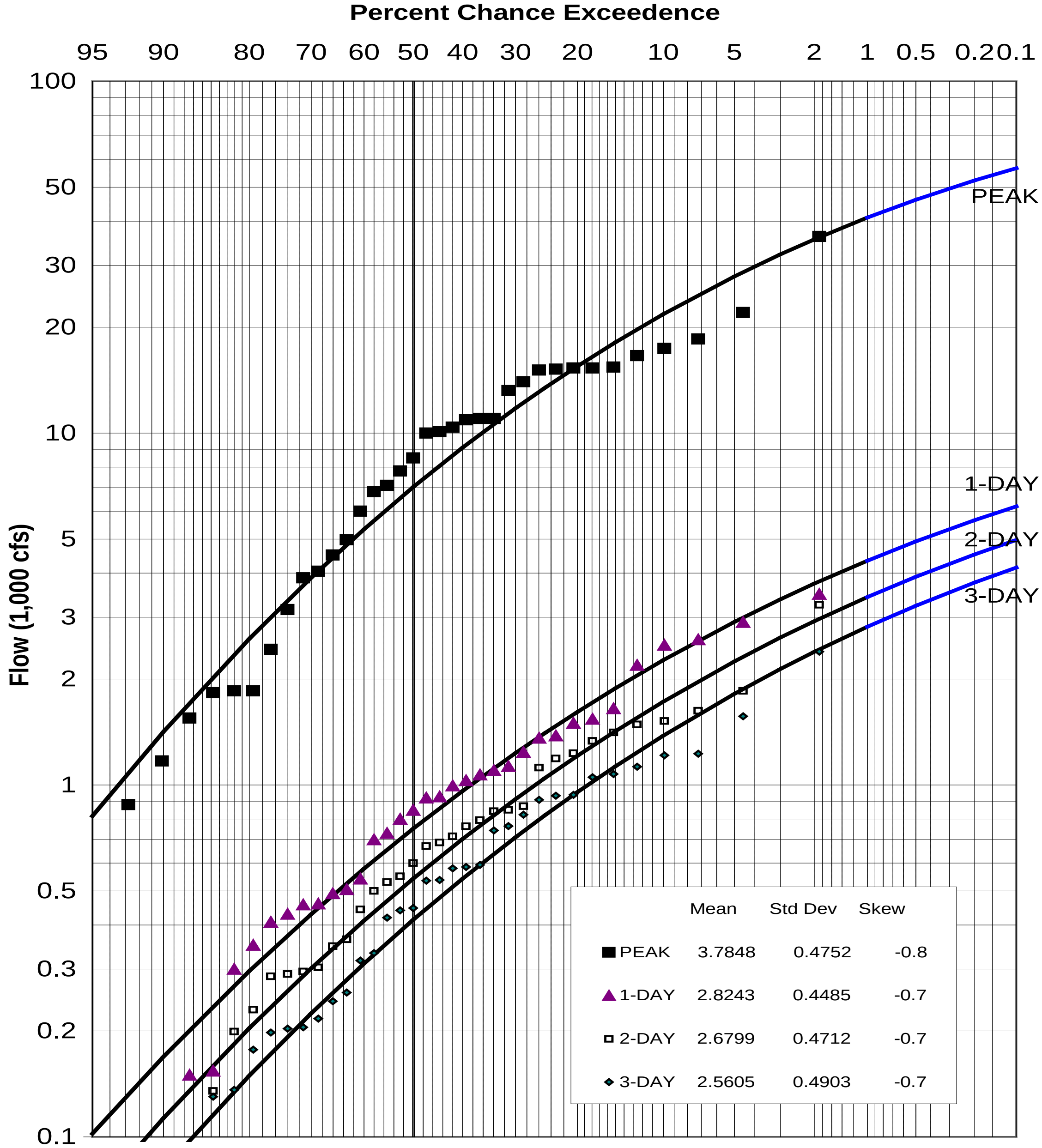
Table 8. Peak Flow Data and Flood Frequency Statistics for the Rio Salado at San Acacia (Confluence with the Rio Grande)

Annual Peak Flows for Rio Salado at San Acacia- Used as Basis for Flood Frequency Analyses							
Instantaneous Peak Flow		Peak 1-Day Mean Daily Flow		Peak 2-Day Mean Daily Flow		Peak 3-Day Mean Daily Flow	
Date	Peak Q (cfs)	Date	1-Day Q (cfs)	Date (1st Day of Event)	2-Day Q (cfs)	Date (1st Day of Event)	3-Day Q (cfs)
9/26/1948	1830	9/26/1948	351	9/26/1948	199	9/26/1948	136
7/13/1949	4050	7/23/1949	492	7/22/1949	348	7/21/1949	243
9/24/1950	3150	9/24/1950	408	9/24/1950	286	9/23/1950	198
8/24/1951	8500	8/2/1951	848	8/23/1951	842	8/22/1951	823
7/14/1952	13200	7/14/1952	430	7/14/1952	295	7/14/1952	217
8/13/1953	7800	8/13/1953	1070	8/13/1953	763	8/12/1953	535
9/25/1954	16600	9/25/1954	1500	9/25/1954	1485	9/24/1954	1227
8/20/1955	11000	8/20/1955	1650	8/20/1955	1625	8/19/1955	1127
7/30/1956	4500	8/2/1956	505	8/1/1956	364	7/3/1956	257
8/24/1957	7100	7/26/1957	1100	7/26/1957	600	7/24/1957	585
10/13/1957	636	10/13/1957	90	10/12/1957	83	10/11/1957	55
8/6/1959	15200	8/7/1959	700	8/6/1959	550	8/6/1959	440
9/10/1960	6000	9/10/1960	995	9/10/1960	500	9/9/1960	333
9/11/1961	10900	8/23/1961	1240	10/17/1960	715	10/17/1960	537
8/21/1962	6820	9/25/1962	920	9/24/1962	870	9/24/1962	593
8/29/1963	15300	9/22/1963	1130	8/30/1963	795	8/29/1963	743
9/12/1964	10000	9/12/1964	800	7/12/1964	530	7/11/1964	420
7/31/1965	36200	8/1/1965	2500	7/31/1965	1850	7/31/1965	1567
8/10/1966	3880	8/10/1966	730	8/9/1966	670	8/8/1966	447
8/10/1967	17400	8/10/1967	926	8/10/1967	686	8/10/1967	764
8/2/1968	10400	8/2/1968	541	8/1/1968	443	8/1/1968	317
7/31/1969	10100	9/12/1969	460	9/11/1969	230	9/12/1969	177
8/16/1970	4980	8/16/1970	1030	8/16/1970	850	8/16/1970	580
8/29/1971	1850	10/4/1970	300	10/4/1970	290	10/3/1970	205
9/11/1972	18500	8/26/1972	3490	8/26/1972	3250	8/26/1972	2393
10/13/1972	22000	10/13/1972	2590	10/13/1972	1335	10/13/1972	908
8/3/1974	1850	8/3/1974	457	8/2/1974	303	8/2/1974	203
8/21/1975	15400	9/12/1975	2190	9/11/1975	1231	9/10/1975	1075
6/8/1976	2430	6/8/1976	70	6/8/1976	40	9/22/1976	30
8/14/1977	11000	8/14/1977	1380	8/14/1977	1190	8/14/1977	938
10/6/1977	368	10/6/1977	82	10/5/1977	52	10/5/1977	35
9/14/1979	880	6/8/1979	99	6/8/1979	52	6/8/1979	35
6/10/1980	15300	9/9/1980	1360	9/9/1980	1120	9/9/1980	932
7/12/1981	1170	7/12/1981	154	7/12/1981	135	7/12/1981	130
8/26/1982	15100	9/21/1982	2900	8/25/1982	1520	8/24/1982	1215
8/3/1983	1550	9/9/1983	150	9/9/1983	85	9/9/1983	58
8/5/1984	14000	8/5/1984	1540	8/5/1984	1410	8/4/1984	1052

Table 8, Continued. Peak Flow Data and Flood Frequency Statistics for the Rio Salado at San Acacia (Confluence with the Rio Grande)

Flood Frequency Statistics for the Rio Salado at San Acacia				
	Instantaneous Peak	1-Day Peak	2-Day Peak	3-Day Peak
Pct. Chance Exceedence	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q	Frequency Curve Computed Q
0.2	49500	5580	4460	3710
0.5	44100	4880	3870	3200
1	39600	4310	3400	2790
2	34600	3720	2910	2380
5	27500	2900	2240	1810
10	21700	2270	1730	1380
20	15500	1620	1210	957
50	7080	752	543	414
80	2610	295	203	149
90	1410	168	113	81
95	809	102	67	47
99	252	36	22	15
Systematic Events	37	37	37	37
Mean	3.7848	2.8243	2.6799	2.5605
Standard Deviation	0.4752	0.4485	0.4712	0.4903
Computed Skew	-0.831	-0.6843	-0.7245	-0.7299
Adopted Skew	-0.831	-0.7	-0.7	-0.7

Figure 8. Peak and Duration Flow Frequency Curves for the Rio Salado at San Acacia



NOTES:

1. USGS Sta No. 08354000
2. Median plotting positions
3. Drainage area 1395 sq. mi.
4. Years of Record 38

Socorro NM

Rio Grande

RIO SALADO NEAR SAN ACACIA, NM

RIO GRANDE UNIT

WATER YEARS 1948-1984

U.S ARMY CORPS OF ENGINEERS
ALBUQUERQUE DISTRICT

Table 9. Without-Project (No Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

BOR Range Lines	Landmarks	200-Year Peak Flow (CFS)	100-Year Peak Flow (CFS)	10-Year Peak Flow (CFS)	2-Year Peak Flow (CFS)
SA 1206 - SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 - SO 1308		33710	28760	14635	7380
SO 1309 - SO 1327	Upstream of the Escondida Bridge to the N. Socorro Div. Channel	25725	20905	11910	7380
SO 1328 - SO 1389	Socorro	23485	18880	10575	7380
SO 1390 – SO 1429		21360	17100	10000	7380
SO 1430 – SO 1474		20715	16575	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	18605	14930	10000	7380
SO 1511 – SO 1568	Bosque del Apache	18025	14605	10000	7380
SO 1569 – SO 1649	Bosque del Apache	12670	10415	10000	7380
SO 1650 – SO 1669	Bosque del Apache	11990	10000	10000	7380
SO 1670 to SO 1709	From Tiffany Junction downstream to below San Marcial RR Bridge	11185	10000	10000	7380

- Routed flood flows provide an estimate of corresponding flood flows at downstream locations for various frequencies. In some cases the routed flood flows are of lesser magnitude than the corresponding frequency snowmelt event, since the snowmelt events have no significant attenuation. The snowmelt event was then used as the flood flow.

“Without-project” (no levee) and “with-project” (with levee) flows were estimated separately for purposes of the Corps of Engineers feasibility economic evaluation. The separate FLO-2D models representing these scenarios, without and with the proposed levee, are described in Section 4.4. The FLO-2D model routing results are shown in Tables 9 and 10 for “without-project” and “with-project” conditions, respectively.

Routing results, both with and without the proposed levee, show that there is significant attenuation in the 48-mile project reach. The high amount of attenuation is primarily due to the relatively low volume of the peak flows. It is also related to flow in the floodplain and overbanks. There is significant storage in the overbanks, even for the “with-project” model.

The without-project flood routing is the extreme case. It reflects the assumption that the spoil bank levees fail completely. Floodwaters would flow from the perched floodway to the historic floodplain, which is approximately 10 to 15 feet lower than the floodway. The floodplain ranges

Table 10. With-Project (With Levee) Routed Peak Flows on the Rio Grande between San Acacia and San Marcial

BOR Range Lines	Landmarks	200-Year Peak Flow (CFS)	100-Year Peak Flow (CFS)	10-Year Peak Flow (CFS)	2-Year Peak Flow (CFS)
SA 1206 - SA 1234	From the San Acacia Diversion Dam downstream	35300	29900	15400	7380
SA 1235 - SO 1308		34050	28670	14635	7380
SO 1309 - SO 1327	Upstream of the Escondida Bridge to the North Socorro Diversion Channel	27000	21650	11980	7380
SO 1328 - SO 1389	Socorro	26170	20440	11110	7380
SO 1390 – SO 1429		25280	19895	10000	7380
SO 1430 – SO 1474		24390	19350	10000	7380
SO 1475 – SO 1510	Hwy. 380 Bridge to the north boundary of the Bosque del Apache	22150	17655	10000	7380
SO 1511 – SO 1568	Bosque del Apache	21590	17310	10000	7380
SO 1569 – SO 1649	Bosque del Apache	21030	16960	10000	7380
SO 1650 – SO 1669	Bosque del Apache	20475	16615	10000	7380
SO 1670 to SO 1709	From Tiffany Junction downstream to below San Marcial RR Bridge	18565	14890	10000	7380

to 3 miles in width in the lower end of the watershed, and more than 25,000 acres of floodplain are inundated in the 100-year without-project flood event. Because the channel is perched, the flow that leaves the channel in the without-project scenario does not directly return to the channel. A significant volume of floodwaters remains in the floodplain and is lost to the river system. As an example, the model results show that more than 40% of the 100-year flood volume remains in the floodplain at the end of the 108-hour 100-year flood simulation. The without-project flood wave attenuation greatly increases as floodwaters are lost from the floodway.

The with-project FLO-2D routing scenario is very similar to the URGWOPs scenario, which represents existing conditions and assumes that the spoil bank levee remains viable. The assumption that infiltration will not be a factor in flood routing is the most significant difference between the FLO-2D routing model and the URGWOPs FLO-2D model. Even with levees in place, in many locations the river is 500 feet or more away from the levees. This leads to overbank flow that greatly reduces the flood peak. As an example, the model results show that more than 10,000 acres of floodplain are inundated during the 108-hour 100-year flood simulation

5.4. Verification of Analytic Results: Comparison of 100-Year Flood Events and Flood Routings from the Rio Puerco, the Rio Salado and the Rio Grande at San Acacia

One unexpected result of the frequency analyses described above was that the Rio Salado 100-year peak of 39,600 cfs is greater than the downstream 100-year peak of 29,900 cfs at San Acacia. Even though the Rio Salado peaks are low in volume, the confluence of the Rio Salado with the Rio Grande is approximately 2 miles upstream of the gage at San Acacia. The attenuation that would occur in the Rio Grande between the two locations is limited by distance.

In order to check that the results of the frequency analyses at the Rio Salado and at San Acacia are consistent with one another, hydrographs representing 100-year flood events from the Rio Puerco and the Rio Salado were constructed and routed downstream to San Acacia. FLO-2D was used for routing. The routing results from the tributary peaks were compared with the expected 100-year peak at San Acacia. In both cases the result of the flood flow routing is consistent with the hydrologic analyses presented above for the Rio Grande at San Acacia.

The flood hydrographs were formulated to be consistent with instantaneous peaks and 1-day, 2-day and 3-day floods, shown in Tables 7 and 8. It was assumed that a moderate baseflow in the Rio Grande floodway (500 cfs) was coincident with the San Acacia flood events.

The 100-year flood originating in the Rio Salado, in order to attain the instantaneous peak of 39,600 cfs and mean daily one-day peak of 4310 cfs, is a fairly low volume hydrograph with a very short duration peak flow. That is consistent with the topography of the Rio Salado watershed, which is flash-flood prone, extremely steep and having roughly equal major flow paths. Figure 9 shows the 100-year flood hydrograph originating in the Rio Salado watershed together with the routed Rio Salado 100-year flood hydrograph routed to San Acacia and the 100-year San Acacia flood hydrograph, for comparison. The FLO-2D model provides an estimate of the 39,600 cfs flood flow from the Rio Salado attenuating to 12,140 cfs at San Acacia. The confluence of the Rio Salado is approximately 2 miles upstream of San Acacia. Even so, there is extreme attenuation. This is due to the low volume of the flood peak along with two other factors. One, the Rio Grande channel is wider then the Rio Salado channel and thus accommodates more flow. More importantly, the flood flow coming from the Rio Salado would not enter the Rio Grande and flow directly downstream. Instead it would flow both upstream and downstream, and would cause backwater effects approximately 5 miles upstream of the confluence of the Rio Salado with the Rio Grande. The FLO-2D model is able to capture this phenomenon.

Figure 10 shows the 100-year flood hydrograph originating in the Rio Puerco watershed together with the routed Rio Puerco 100-year flood hydrograph routed to San Acacia and the 100-year San Acacia flood hydrograph. The Rio Puerco watershed is very large (7350 square miles), with many losses and a complicated flow network. Flood flows from the Rio Puerco do not peak as sharply as those from the Rio Salado, and Rio Puerco flood flows have greater flood volumes than do those from the Rio Salado watershed. The confluence of the Rio Puerco is approximately 11 miles upstream of San Acacia. Again, the attenuation is extreme. In routing the Rio Puerco flood flow entering the Rio Grande, the assumption was again made that flow in the Rio Grande would be 500 cfs at Bernardo. The FLO-2D flood flow routing showed that the flood wave would move upstream approximately 4 miles, in addition to flowing in the downstream direction, contributing to the attenuation of the flood peak.

Figure 9. Graphical Comparison: Routed 100-Yr Flow from the Rio Salado to San Acacia Compared with 100-Yr San Acacia Flow

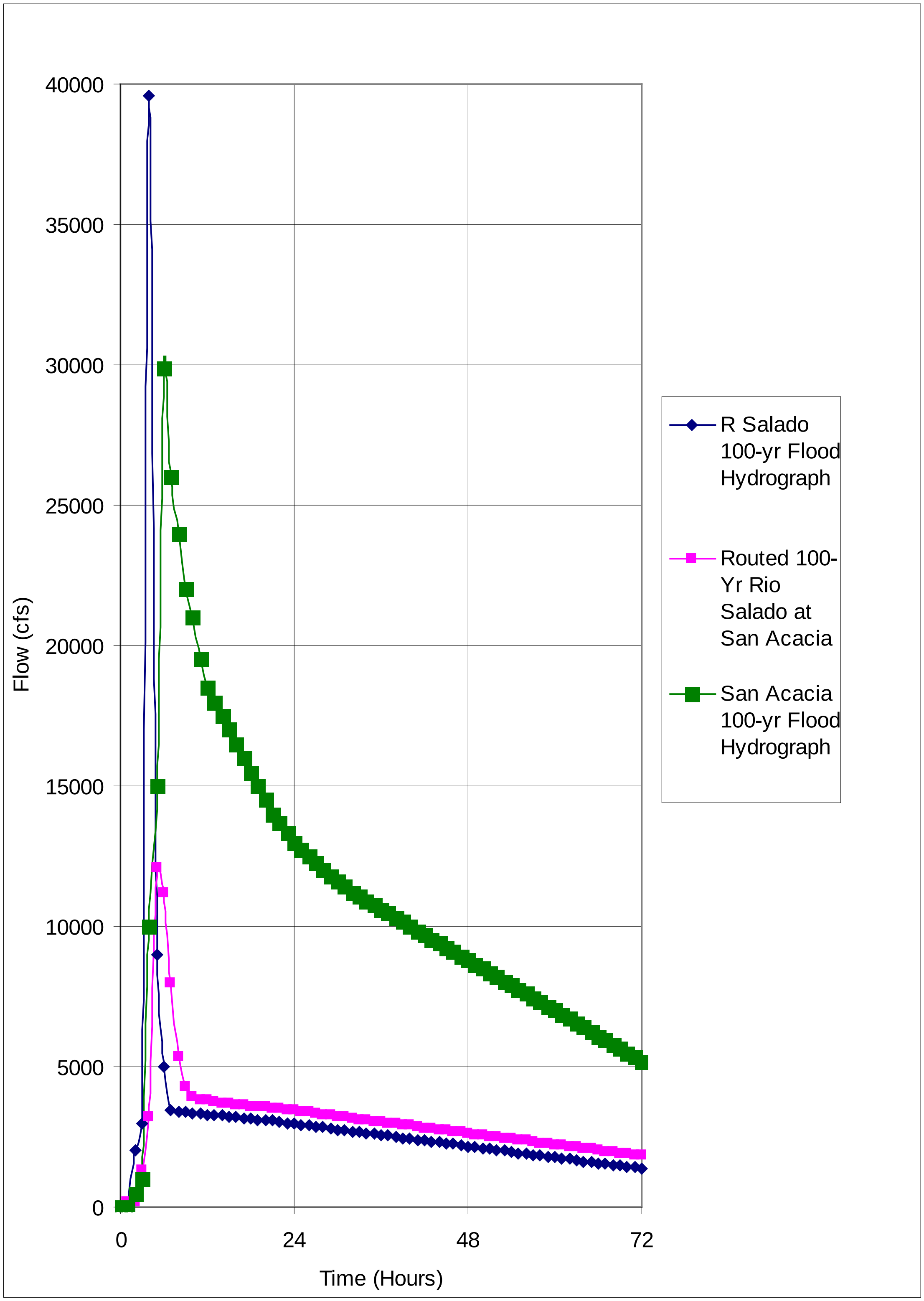
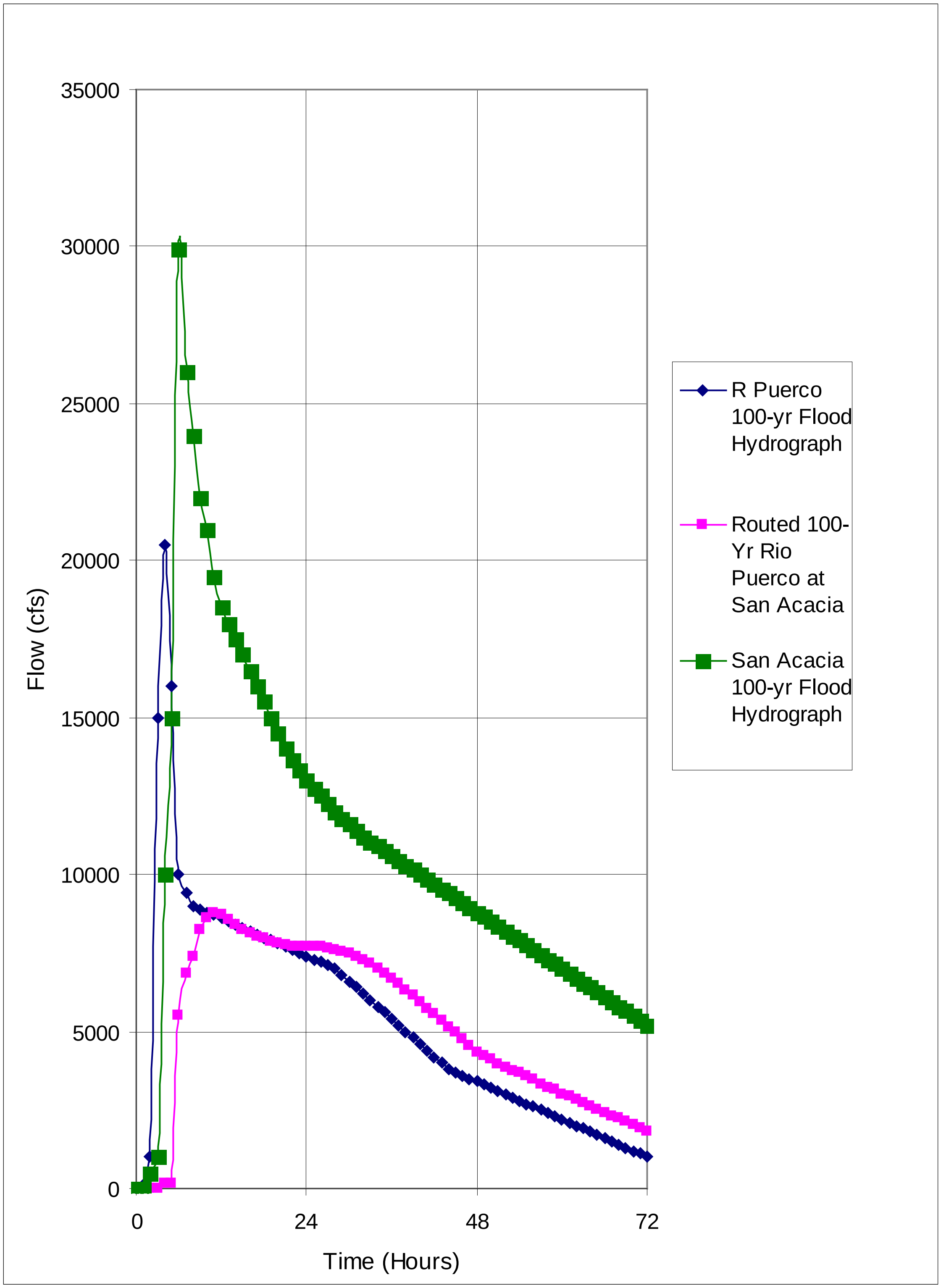


Figure 10. Graphical Comparison: Routed 100-Yr Flow from the Rio Puerco to San Acacia Compared with 100-Yr San Acacia Flow



6.0 Conclusions

6.1. Effect of Assumptions on Analytic Results

In applying flood frequency analysis at San Acacia, several assumptions were made that affect results of the frequency analysis and its applicability. Major assumptions are:

- Peak flow data were adjusted to represent regulated flow conditions. Therefore, the flow frequency applies to present conditions only.
- Spoil bank levees, common throughout the watershed, fail when floodwaters reach them. This assumption has an effect on routing of flows, particularly since the floodway is perched above the floodplain in many areas. It leads to significantly more attenuation than would be the case if it were assumed that the spoil bank levees remain viable.
- Flow diversions are not in use within the project area. It was assumed that during high flow events all diversions are closed, and that flow diversions are therefore not a complicating factor in the analysis. Annual peaks for frequently occurring events may be misrepresented by not including diversion data.

6.2 Comparison of Analysis with Other Federal Agency Hydrologic Analyses

As was noted above, some Federal agencies that are engaged in river information and management for the Rio Grande are:

- Bureau of Reclamation
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- U.S. Army Corps of Engineers

Each of these agencies has its own focus and set of responsibilities, and to some extent these mesh. In order to meet their own responsibilities, the Federal agencies have performed independent hydrologic analyses. As a result, there are several different versions of hydrology for the project area. Table 11 provides estimates of flow frequency at San Acacia from some of the agencies. In each case, the analyses meet the agency needs, but they are not consistent with one another in approach or in results.

The USGS has performed flood flow frequency analyses for the Rio Grande at San Acacia using the instantaneous peak flow gage data that is available. These gage data were collected prior to Cochiti Dam being built, and results are thus applicable to pre-regulation hydrology.

The US Fish and Wildlife Service and the Bureau of Reclamation have focused on the most frequently occurring high flows, such as the bankfull discharge. The bankfull discharge is approximately the same as the mean annual flood, with a recurrence interval from 1.5 to 2.33 years. Peak flows in the range of the bankfull discharge are of great importance to the native vegetation, fish and wildlife.

Several hydrologic analyses are in use by the Bureau of Reclamation, the most prominent of which was written by Bullard and Lane in 1992. This hydrology is widely applied in sedimentation studies and low flow analyses.

Another BOR hydrologic analysis was completed in 2000. It is titled “Middle Rio Grande Low Range Peak Flow Frequency Study Estimating Peak Flows in the Range 1.1 – 5.0 Years Return Periods for Regulated Conditions and with Wet and Dry Cycles”. It is a peak flow frequency analysis, but with separate partial duration series for wet and dry hydrologic cycles. Partial duration frequency analyses are especially applicable to low flow conditions. This report refines the estimates for low flow years provided in the 1992 Bullard and Lane report.

Table 11. San Acacia Peak Flows from Federal Agencies

Return Period Flood Event	Percent Chance Exceednce	Current Study-Corps of Engineers Flow (CFS)	BOR 1992 Bullard and Lane Report-Regulated Flow (CFS)	BOR 1992 Bullard and Lane Report-Unregulatd Flow (CFS)	BOR 2000 Partial Series Wet Cycle Peak Flows-Regulated (CFS)	USGS 2003 Flood Frequency Analysis-Unregulatd Flow (CFS)
500 yr	.2	43500				41,770
200 yr	.5	35300				35,750
100 yr	1.0	29900	20,790	30,833		31,450
50 yr	2.0	25000	19,820	28,057		27,330
20 yr	5.0	19200				
10 yr	10.0	15400	16,450	21,061		18,380
5 yr	20.0	11800	13,620	17,649	6759	14,660
2 yr	50.0	7380	9,100	12,239	3836	9,513
1.25 yr	80.0	4770				6,175
1.11 yr	90.0	3860			391	4,927
1.05 yr	95.0	3260				4,089
1.01 yr	99.0	2420				2,883

There is some consistency in results among the agencies. For the 50-year flood and greater flood events at San Acacia, the USGS flood frequencies and COE flood frequencies are within 10% of one another. Additionally, the Bullard and Lane unregulated flood frequencies are within 5% of the USGS flood frequencies for the 50-year and greater flood events at San Acacia.

6.3. Applicability of Different Frequency Analyses

The mission of the agencies provides the basis for the assumptions found in the hydrologic studies, and may best explain the differences in the results.

The purpose of this Corps of Engineers analysis is the design of structures that will provide flood damage reduction. The focus is prevention of damages from flood events that will occur only rarely. The Corps of Engineers will turn over maintenance responsibilities to a local government agency. A goal for the COE is to construct facilities that will function for 50 years into the future. Flow estimates focus on rare flood events and are meant to be conservative, but not so much as to add unnecessary costs to proposed construction. All the assumptions that are summarized in Section 6.1 pertain to design of effective flood control structures.

It follows that the frequency estimates provided by the Corps of Engineers are likely most applicable to significant flood conditions. The COE frequency estimates should be considered conservative at San Acacia and applicable to present watershed conditions. “Without-project” conditions leading to routed flow frequencies at downstream locations provides too much attenuation to be meaningful for wide application, although this scenario is needed for the COE analysis. “With-project” conditions for routed flow within the project area may provide reasonable expected frequency estimates for present perched-floodway conditions if the spoil bank levees remain intact.

One purpose for the Bureau of Reclamation activities in the mainstem Rio Grande is to maintain the channel and floodway. Low flows occur the majority of the time, and pertain to the activities of the BOR from year to year. Therefore the BOR estimates, particularly those derived from partial duration series, are very applicable for frequent flood events.

Attachment 1

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Attachment 2

Model Overview: HEC-FFA

HEC-FFA, the Flood Frequency Analysis computer program developed at the Corps of Engineers Hydrologic Engineering Center, was used for this frequency analysis.

The FFA analytic method is in accordance with the methodology presented in Bulletin 17B, “Guidelines for Determining Flood Flow Frequency Analysis,” by the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data. Bulletin 17B provides a standard technique for determining flood flow frequency to be used in all Federal planning involving water and related land resources, and is widely used outside the Federal government as well. In accordance with these guidelines, the log-Pearson Type III distribution is used to compute the frequency curve.

FFA is applicable to gage data where there is an adequate period of record for a gage. The FFA program is meant for use with instantaneous annual peak flows to compute flood flow frequency curves. The skew coefficient can be input as part of the data, and the program weights it with the calculated skew coefficient.

A broken record is analyzed as a continuous record. Historic events are included in the analysis. The .05 and .95 confidence limit curves are computed and plotted along with the frequency curve.

The data may be arrayed and plotted using the Weibull, median or Hazen formulae. In this case the Weibull method was selected.

Attachment 3

Historic Cochiti Releases

Year	Maximum Discharge at Cochiti	Average Discharge at Cochiti	Duration in Days	Maximum Discharge at San Marcial
1973	8,100 cfs	7,660 cfs	5	7,660 cfs
1979	6,280 cfs	5,850 cfs	100	6,260 cfs
1980	6,840 cfs	6,250 cfs	51	6,040 cfs
1983	6,670 cfs	6,060 cfs	38	4,990 cfs
1984	8,000 cfs	7,580 cfs	23	7,580 cfs
1985	8,290 cfs	7,440 cfs	30	7,440 cfs
1992	5,580 cfs	5,210 cfs	19	5,150 cfs
1993	7,230 cfs	7,140 cfs	7	7,140 cfs
1994	6.230 cfs	5,200 cfs	49	5,440 cfs
1995	6,410 cfs	5,520 cfs	59	4,880 cfs
1997	6,610 cfs	5,850 cfs	29	4,320 cfs

Attachment 4

Example of Routing to Estimate a Secondary Peak Using Recorded Flows

The following is an example to demonstrate the methodology for determining FLO-2D inflow hydrographs that were used to estimate secondary peaks.

The high flow event was August 10 – 14, 1967.

The river gages and associated data are shown in Table 4-1.

Table 4-1. River Gage Data, August 10 – 14, 1967

River Gage	Date	Mean Daily Peak Flow (cfs)	Instantaneous Peak Flow (cfs)
Rio Grande at Bernardo	8/10/1967	2190	
	8/11/1967	4670	
	8/12/1967	2320	
	8/13/1967	1750	
	8/14/1967	2640	
Rio Puerco at Bernardo	8/10/1967	775	
	8/11/1967	931	
	8/12/1967	1700	
	8/13/1967	4770	7860
	8/14/1967	2400	
Rio Salado at San Acacia	8/10/1967	926	17400
	8/11/1967	446	
	8/12/1967	919	
	8/13/1967	314	
	8/14/1967	3.9	

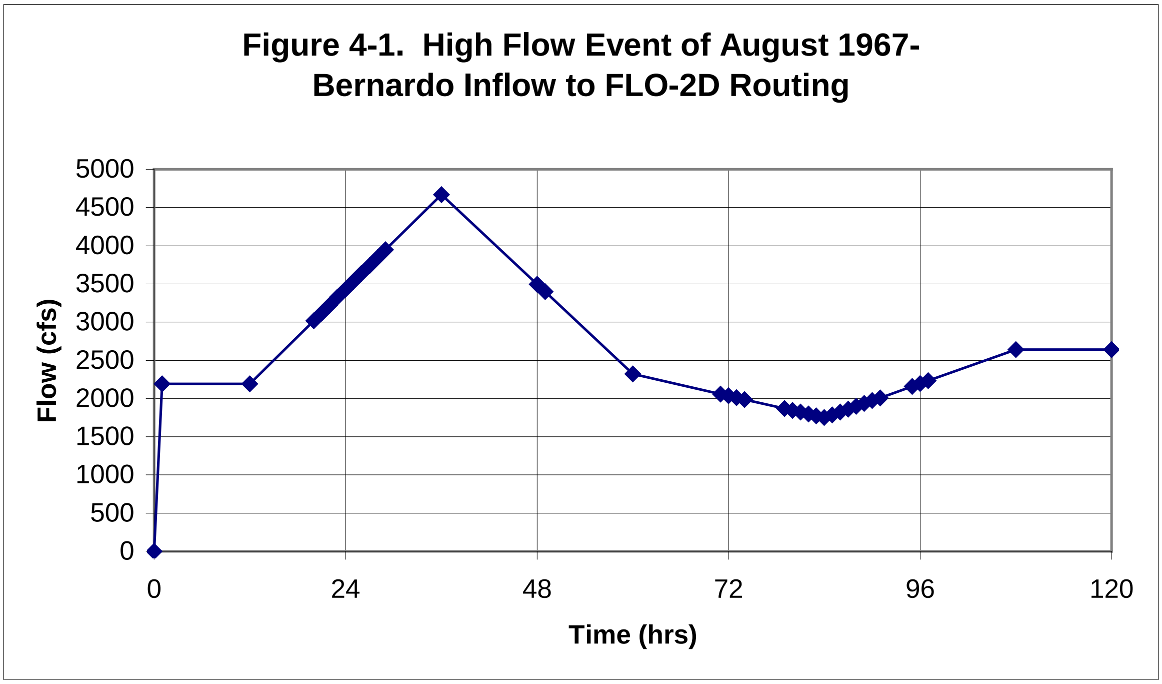
The inflow data file is given in Table 4-2, with explanatory comments in italics.

Table 4-2. FLO-2D Inflow Data File

Data Records			Explanatory Comment
3	0	0	3 Inflow Hydrographs in File
C	0	21129	Inflow 1- Bernardo
H	0	0	1st hydrograph record is time=0 and q=0
H	1	2190	2nd hydrograph record is time=1 and q=2190
H	12	2190	
H	36	4670	
H	60	2320	
H	84	1750	
H	108	2640	
H	120	2640	Last hydrograph record is time=120 and q=2640
C	0	22198	Inflow 2- Rio Puerco at the Rio Grande
H	0	0	1st hydrograph record is time=0 and q=0
H	1	775	
H	12	775	

Table 4-2, continued. FLO-2D Inflow Data File			
Data Records			Explanatory Comment
H	36	931	
H	60	1700	
H	71	1700	
H	72	3000	
H	73	3500	
H	74	3600	
H	79	3600	
H	80	3700	
H	81	4500	
H	82	6000	
H	83	7400	Hour 83- Instantaneous Peak
H	84	7860	
H	85	7800	
H	86	7400	
H	87	6500	
H	88	5500	
H	89	4500	
H	90	3720	
H	91	3600	
H	95	3600	
H	96	3500	
H	97	2400	
H	120	2400	Last hydrograph record is time=120 and q=2400
C	0	23428	Inflow 3- Rio Salado at the Rio Grande
H	0	0	1st hydrograph record is time=0 and q=0
H	20	0	
H	21	100	
H	22	3000	
H	23	17400	Hour 23- Instantaneous Peak
H	24	3500	
H	25	1500	
H	26	700	
H	27	400	
H	28	325	
H	29	300	
H	48	300	
H	49	919	
H	72	919	
H	73	314	
H	96	314	
H	97	3.9	
H	120	3.9	Last hydrograph record is time=120 and q=3.9

Figures 4-1 through 4-3 provide hydrographs showing these data.



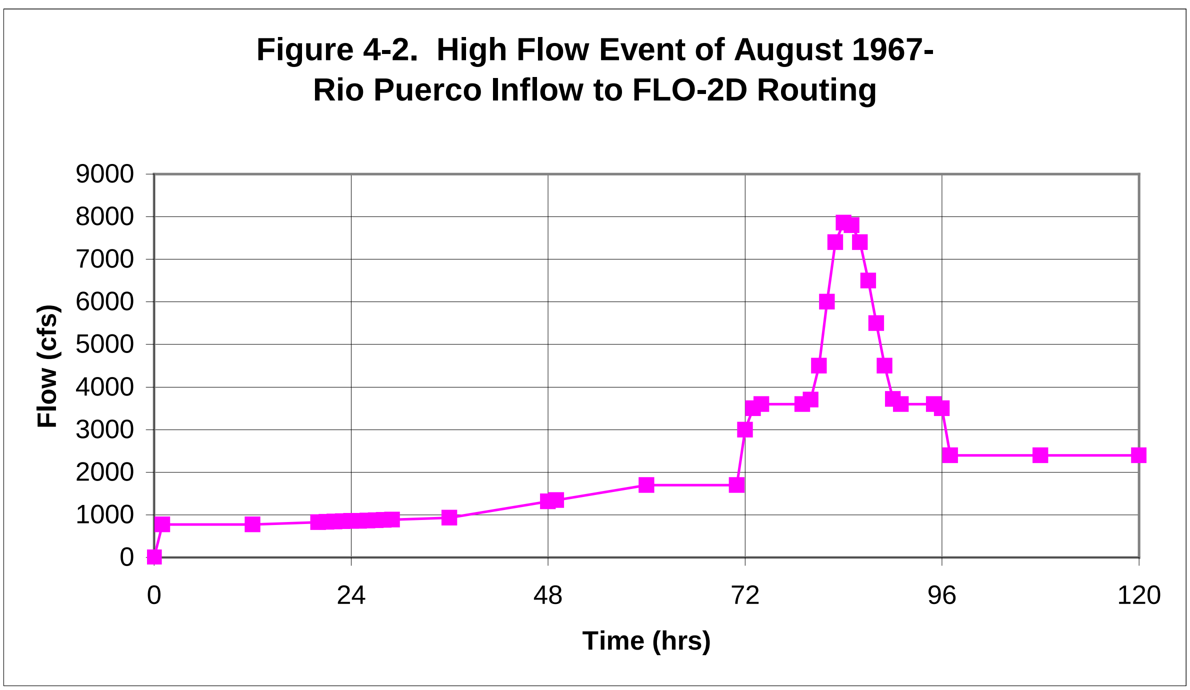
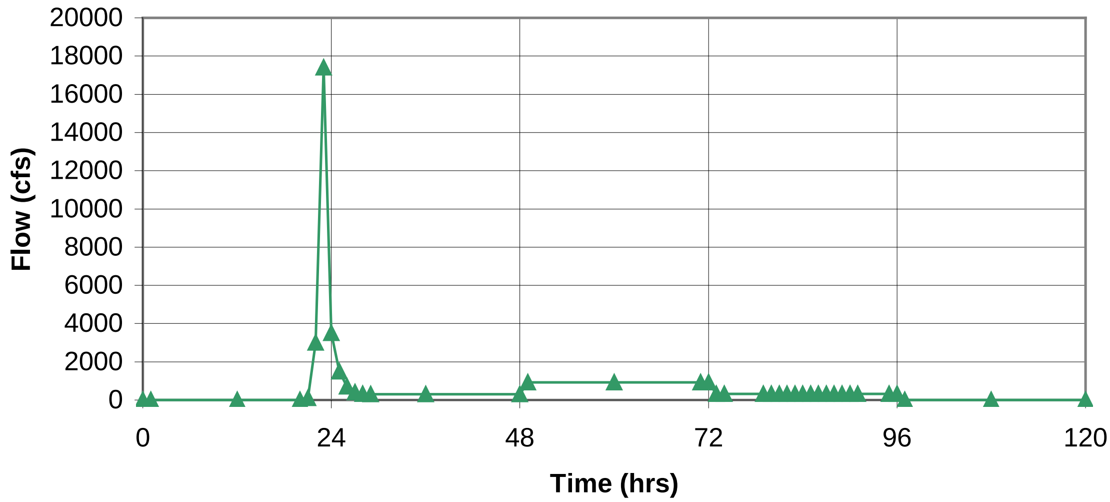


**Figure 4-3. High Flow Event of August 1967-
Rio Salado Inflow to FLO-2D Routing**



GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-4

Mitigation Plan

APPENDIX F-4

MITIGATION PLAN

1. INTRODUCTION

The study area for the Rio Grande Floodway, San Acacia to Bosque del Apache Unit, Socorro County, New Mexico Project comprises a reach of the Rio Grande extending from the San Acacia Diversion Dam (SADD) south to the headwaters of Elephant Butte Reservoir. The study area is entirely contained within Socorro County, New Mexico.

The proposed plan entails the replacement of approximately 43 miles of spoil bank along the west side of the Rio Grande floodway with an engineered levee along the same alignment. (See Section 5.1 of the *General Reevaluation Report / Supplemental Environmental Impact Statement-II* [GRR/SEIS-II] for a detailed project description.) This appendix describes the mitigation plan for the recommended plan.

The Endangered Species Act (ESA) requires Federal agencies to "insure that any action authorized, funded, or carried out ... is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species." A Biological Assessment for the proposed action was completed in May 2012 and a final Programmatic Biological Opinion was issued by the U.S. Fish and Wildlife Service (Service) in February 2013 (USFWS 2013; see Appendix C of the GRR/SEIS-II). This mitigation plan includes requirements in the Biological Opinion, as well as coordination with the Sevilleta and Bosque del Apache National Wildlife Refuges.

The alignment of the proposed levee construction traverses portions of the Sevilleta and Bosque del Apache National Wildlife Refuges (NWRs), and nearly all unavoidable effects associated with the proposed action occur on lands administered by the Service. By the authority of the National Wildlife Refuge System Administration Act of 1966, the Endangered Species Act (ESA) of 1973, and Executive Orders establishing these NWRs as refuges and breeding grounds for migratory birds and other wildlife, the Refuge Managers are directed to determine the compatibility of the proposed project with refuge purposes. Service policy also requires that a proposed action on a refuge be consistent with refuge objectives. A draft Determination of Compatibility is included in the final GRR/SEIS-II.

This mitigation plan conforms to requirements in the Corps' *Planning Guidance Notebook* (ER 1105-2-100) as well as Section 2036 of the Water Resources Development Act of 2007.

2. MITIGATION PLANNING OBJECTIVES

The *Planning Guidance Notebook* states that mitigation includes:

- Avoiding the impact altogether by not taking a certain action or part of an action;
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;

- Compensating for the impact by replacing or providing substitute resources or environments.

Projects implemented through the Corps of Engineers' Civil Works program are required to minimize and avoid damages to all significant terrestrial and aquatic ecological resources where possible, and to mitigate any remaining unavoidable damages. The Corps utilizes the mitigation planning process to compensate for impacts to aquatic and terrestrial resources to ensure that the project will not have significant adverse impacts on ecological resources.

Following are project-specific mitigation planning objectives:

A. Avoid or minimize potential adverse effects to riparian, wetland, and aquatic resources in the project area by incorporating avoidance principles in the design and layout of the proposed levee.

B. Minimize the extent of disturbance of the substrate and vegetation during construction activities.

C. Avoid or minimize the potential for adverse effects to water quality during construction.

D. Avoid or minimize potential adverse effects to air quality during construction.

E. Minimize the potential for inducing or increasing the potential for the establishment of invasive species in areas disturbed during construction.

F. Avoid or minimize the potential for direct effects to listed species and designated critical habitat.

G. Mitigate, through replacement or otherwise, any unavoidable adverse impacts to vegetation and other fish and wildlife habitat resources.

H. Per planning guidance, cost effectiveness and incremental cost analysis will be used to identify least-cost mitigation plans.

3. UNCERTAINTIES

Uncertainties associated with this preliminary mitigation plan include the preliminary nature of the levee design at this early stage of the plan, the long project construction period, and gaps in knowledge with respect to habitat requirements for endangered species in the project area.

The need for, and extent of, mitigative activities were based on effects determinations by both the Corps and Service of the feasibility-level design of the proposed plan. The final design of project features may result in slightly different resource effects. Both the effects determinations and the mitigation needs will be revised as needed through the design process and construction.

Because of the relatively long, 20-year construction period for the proposed project, it is difficult at this time to accurately predict the exact condition of certain ecological resources at the time that they actually will be affected by construction activities. For instance, the location of breeding flycatchers within the southern portion of the project area varies from year-to-year based on slight changes in inundation and vegetation response. The distribution of suitable riparian patches needed to maintain a viable Rio Grande flycatcher population requires additional analysis. Flycatchers along the Rio Grande have demonstrated the ability to quickly colonize areas of developing vegetation, as well as a readiness to abandon stands of over-mature vegetation. Therefore, both the project effects determinations and the mitigation plan will be revised as needed during the construction period.

The value of overbanking floods into riparian vegetation to create suitable habitat for juvenile silvery minnow recruitment needs quantification. Levee construction will have minimal effect to flooded

overbank habitat area for silvery minnow recruitment. Evaluation of habitat restoration projects and water management strategies for recruitment should quantify the relationships of flow magnitude, flow duration, and inundation area to recruitment.

4. MITIGATION ACTIVITIES

4.1 Levee Design Considerations

Variation from the alignment of the existing spoil bank was minimized to prevent significant alteration of riparian and aquatic habitats. Minimizing the amount of off-site waste spoil disposal estimated in preliminary plans was facilitated by NED plan selection process. (These activities contribute to mitigation planning objectives A, B and F.)

4.2 Best Management Practices

Best Management Practices to avoid and minimize soil erosion and other potentially adverse effects to water quality, air quality, and other resources will be included in project specifications and their accompanying Stormwater Pollution Prevention Plan and/or Environmental Protection Plan. The following best management practices would be incorporated:

1. Silt curtains, cofferdams, dikes, wattles, straw bales and other suitable erosion control measures shall be employed to prevent sediment-laden runoff or contaminants from entering the Rio Grande floodway, the Low-Flow Conveyance Channel (LFCC), and any natural or man-made watercourse. (Contributes to mitigation planning objectives C and F.)

2. Work shall be performed below the elevation of the ordinary high water mark only during low-flow periods. Flowing water shall be temporarily diverted around the work area, but shall remain within the existing channel to minimize erosion and turbidity, and to provide for aquatic life movement. The streambed shall be contoured so that fish can migrate through the project area during and after construction. Stream flow shall be maintained at all times. (Contributes to mitigation planning objectives C and F.)

3. Diversion structures shall be non-erodible, such as sand bags, water bladders, concrete barriers, or channel lined with geotextile or plastic sheeting. Earthen cofferdams are not acceptable diversion structures. The temporary river crossing shall be located perpendicular to and at a narrow point of the channel to minimize disturbance. Heavy equipment shall be operated from the bank or work platforms and not enter surface water. Heavy equipment shall not be parked within the stream channel. (Contributes to mitigation planning objectives C and F.)

4. Poured concrete shall be fully contained in mortar-tight forms and/or shall be placed behind non-erodible cofferdams to prevent discharge contact with surface or groundwater. Wastewater from concrete batching, vehicle washdown, and aggregate processing shall be contained, and treated, or removed for off-site disposal. (Contributes to mitigation planning objectives C and F.)

5. Fuel, oil, lubricants, hydraulic fluids and other petrochemicals shall be stored westward of the LFCC and at least 100 feet from surface water (including ditches, drains, and the LFCC). The fuel storage facility shall have a secondary containment system capable of containing twice the volume of the product. (Contributes to mitigation planning objectives C and F.)

6. Fueling of wheeled construction vehicles shall only be permitted within the staging area, or off-site at least 100 feet from the LFCC or ant natural or man-made watercourse. Only tracked vehicles may be fueled within the construction area via a fuel tender with a maximum fuel capacity of 500 gallons, thereby minimizing the consequences of any accidental spill. Refueling of all vehicles and equipment shall be performed at least 100 feet from any natural or man-made watercourse. (Contributes to mitigation planning objectives C and F.)

7. The temporary river crossing shall be located perpendicular to and at a narrow point of the channel to minimize disturbance. Heavy equipment shall be operated from the bank or work platforms and not enter surface water. Heavy equipment shall not be parked within the stream channel.

8. All heavy equipment used in the project area shall be pressure washed and/or steam cleaned before the start of the project, and again just prior to leaving the project area. All heavy equipment shall be inspected daily for leaks. A written log of inspections and maintenance shall be completed and maintained throughout the project period. Leaking equipment shall not be used in or near surface water. (Contributes to mitigation planning objectives C and F.)

9. Only uncontaminated earth or crushed rock for backfills would be used. (Contributes to mitigation planning objectives C and F.)

10. Water quality would be monitored during construction to ensure compliance with state water quality standards for turbidity, pH, temperature, and dissolved solids. (Contributes to mitigation planning objectives C and F.)

11. Excavations, embankments, stockpiles, haul roads, access roads, staging areas, borrow areas, and all other work areas within or without project boundaries would be required to be maintained to prevent hazardous or nuisance airborne particulate matter. Sprinkling water or other approved temporary dust suppression methods, such as chemical treatment, light bituminous treatment, or similar methods, would be used to control dust. (Contributes to mitigation planning objective D.)

12. All areas disturbed by construction activities would be revegetated with native grasses and forbs following construction to stabilize the substrate in these disturbed areas, reduce the likelihood of invasive species establishment. These areas include staging and access areas, the Vegetation-free Zone (the levee itself and the 15-foot-wide strip adjacent to each toe), and the eastside overbank lowering area. (Contributes to mitigation planning objectives C, D, E and G.)

13. Treatments to minimize colonization by invasive plant species and noxious weeds would be included in the contract specifications. During the establishment of a satisfactory stand of native vegetation, colonization of invasive species within these areas would be minimized by periodic mowing and, if necessary, herbicidal treatment. The operations, maintenance, repair, rehabilitation and replacement (OMRR&R) manual will require the local sponsor to continue weed-prevention treatments (primarily mowing and herbicidal treatment) of the Vegetation-free Zone. (Contributes to mitigation planning objectives E and G.)

14. Stream flow would be maintained at all times during construction and the streambed contoured so that fish can migrate through the project area during and after construction. (Contributes to mitigation planning objective F.)

15. Levee construction may occur throughout the calendar year; however, no construction would be performed on levee segments within 0.25 mile of occupied Southwestern Willow Flycatcher

breeding territories (generally, May through August). Traffic associated with construction activities may continue along the construction alignment adjacent to occupied flycatcher breeding territories after 9:00 am. (Contributes to mitigation planning objective F.)

16. Vegetation removal and clearing-and-grubbing activities shall be performed only between August 15 and April 15. If needed, vegetation removal in small areas between April 15 and August 15 shall only be performed after inspection by the Corps determines that breeding birds are not present within the vegetation patch to be removed. (Contributes to mitigation planning objective F.)

4.3 Fish and Wildlife Resources

4.3.1 Mitigative vegetation planting measures

After determining the habitat potentially by the proposed project, the following measures were formulated to compensate for adverse effects to fish and wildlife habitat, including listed species and their designated critical habitat. (Revegetation methodologies are described in Section 4.3.2.)

Measure B: Willow bank stabilization

A 3.08-acre portion of the eastside terrace (vertically) below the Overbank Excavation area would also be excavated. Currently, this area is inundated by discharges larger than the 20%-chance event. The area is currently vegetated by sparse salt cedar and, at the lowest elevation, sparse coyote willow.

After excavation, approximately 2.00 acres would lie below the water surface elevation of the 50%-chance event (which also defines the Ordinary High Water Mark in this reach), and would be part of the active channel of the Rio Grande. The upper 1.08 acres of the excavated area would occupy the zone of inundation of the 20%- to 50%-chance discharges. It is recommended that willows be planted throughout the upper 1.08-acre portion of this area to help stabilize the bank in this degradational reach, and to partially replace riparian vegetation usable by fish and wildlife. Coyote willow (*Salix exigua*) whips would be planted at a density of 300 stems/acre.

Measure S: Riparian shrub planting in area gained from spoil bank removal

Approximately 7.66 acres of the area gained after removal of the spoil bank (see Measure G) would be suitable to plant with willow whips (300 stems per acre) and rooted stems of other riparian shrub species ("tall-pots" 50 stems per acre).

Measure G: Grass seeding in area gained from spoil bank removal

The basal width of the existing spoil bank is frequently wider than that of the proposed levee, especially in the northern (upstream) portion of the reach. A total of 85.75 acres is expected to be exposed following construction, of which approximately 50.61 acres would lie within 15 feet of the riverward levee toe and would be planted with native forbs and grasses. The remaining 35.14 acres would also require planting to minimize erosion, to minimize colonization by invasive weed species, and to provide wildlife habitat. The majority of this area, totaling 27.81 acres, is currently vegetated by salt cedar, and the soil appears too dry to easily revegetate with native riparian shrubs. Therefore, these 27.81 acres would be seeded with appropriate grass and herbaceous species.

Measure T: Replacement of temporarily disturbed riparian shrubs

Along the base of the proposed soil cement embankment at the northern end of the project, approximately 1.82 acres of riparian shrubs would be removed to accommodate construction access. This area would be replanted with willow whips (300 stems per acre) and rooted stems of seep-willow (*Baccharis* sp., 50 stems per acre).

Measure D: Riparian tree and dense shrub planting

Within the reach near the Bosque del Apache NWR, breeding Southwestern Willow Flycatchers currently occupy the riparian vegetation. The footprint of the proposed levee and attendant Vegetation-Free Zone would displace approximately 39.3 acres of riparian vegetation consisting primarily of dense shrubs. Approximately 8.4 acres of the removed vegetation consists of suitable or moderately suitable flycatcher habitat. Most of the measures above would provide riparian grass habitat, but only a small amount of shrub habitat that could be utilized by breeding flycatchers and other species. This measure entails planting 42.74[1] acres of coyote willow and seep-willow along with cottonwood and Goodding's willow poles to provide no more than 30% tree canopy cover, in order to recreate shrub nesting habitat.

Two alternative locations were analyzed for these tree and shrub plantings. Measure D1 would plant vegetation within the Rio Grande floodway, primarily within Bosque del Apache NWR. Site preparation would require the removal of saltcedar, followed by root-plowing and raking to prevent sprouting from buried root crown. Planted areas would likely be inundated by fairly low discharge rates; however the extent and duration of inundation would vary annually. To assure sufficient root growth to reach the varying depth to the water table in this area, approximately 10% of the pole and whip plantings would require supplemental watering (through buried perforated pipes) over the first two years following installation. Plant material would include Rio Grande cottonwood (*Populus fremontii* var. *wizlezenii*) and Goodding willow (*S. gooddingii*) poles planted at 30 per acre, coyote willow whips planted at 300 stems per care, and tall-pots of other shrub species planted at 100 stems per acre.

Measure D2 entailed the planting of trees and shrubs just west of the LFCC within irrigable portions of the BDANWR. Here, site preparation would be easier and the depth to the water table is more consistent. The capability to irrigate planted areas not only facilitates high survival and growth of planted grass and woody material, but also provides a mechanism for enhancing germination of local, wind-blown tree and shrub seeds, thus increasing the expected stem density. Plant material quantities would be similar to that of measure D1.

4.3.2 Revegetation Methods

All proposed vegetation planting and establishment methods have been proven to be successful and cost effective due to their development and refinement over the past 20 years in restoration activities conducted by Federal and non-Federal agencies along the Rio Grande (Crawford *et al.* 1993, Taylor and McDaniel 1998, Fenchel *et al.* 2007, Los Lunas Plant Materials Center 2007, USACE and USBR 2002, USBR 2007, USACE 2011). Following is a summary of proposed revegetation methods.

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[1] Measures S and D together provide the target 50.4 acres of shrub habitat determined to be necessary in the Biological Opinion (USFWS 2013).

Grass and forb seeding in level areas largely devoid of woody plants will be accomplished with a seed drill, and include mulching with crimped hay. To assure the development of vigorous growth, these areas would be supplementally watered as needed over the first two growing seasons.

Seed mixes would be applied in quantities of 10 to 16 pounds of pure-live-seed per acre. Species planted will vary throughout the project area depending on local soil type and moisture. In actively managed areas, species in a given seed mix will be approved by the managing entity (*e.g.*, Bureau of Land Management, Sevilleta NWR, Bosque del Apache NWR). To facilitate germination and minimize the invasion of weed species, a nursery crop of sterile wheat (*Triticum* sp.) would be included in seed mixes where it is deemed advantageous.

Coyote willow shrubs will be established through the installation of dormant whips (up to 10-ft long). Whips would be installed in holes augered to intercept the local water table. Dormant poles (up to 20-ft long) of tree species — Rio Grande cottonwood and Goodding willow— would be installed similarly. Dormant woody material would be installed during November through mid-March. In areas of sandy soil or infrequent inundation, whips and poles would be supplementally watered for two growing seasons through perforated PVC tubes installed adjacent to the stem. Woody plantings proposed landward of the LFCC (Measure D2) would be located in areas capable of being periodically irrigated. It was estimated that up to 2-ft of water per acre per year would be applied through the first 5 years of growth, and up to 1-ft of water per acre per year following that, as needed. Inundation by high river flow or irrigation during June and July will increase the likelihood of natural germination of local grass, forb, and woody species. To deter the invasion and growth of weed species, all areas planted with woody material would be manually seeded with native grasses and forbs.

Other native shrub species would be installed in containerized pots (“tall-pots”; Los Lunas Plant Materials Center 2007). Grown in narrow plastic tubes to develop long (*ca*. 3 feet) root systems, these shrubs would be installed in holes augered to the water table. Plants grown with long above-ground stems would be used in areas with deeper water tables. Tall-pots may be planted throughout the calendar year,

Construction contracts will include warranties or performance standards for the establishment of vegetation. For seeding, the requirements will specify that planted areas will exhibit vigorous growth after a one-year establishment period. Requirements typically will include stem density or percent cover measures which the Contracting Officer Representative will use to verify that the performance standards have been, or have not been, met. Any additional planting activities to meet the performance standard will be performed at the contractor’s expense. The stem density or percent cover criteria included in each contract will vary depending on location-specific soil and moisture conditions, as well as the specified seed mix.

For woody plantings (trees and shrubs), the performance standard will require at least 85% survival of planted material at the end of the third growing season following planting. If survival is less than this criterion, the contractor will install additional plantings to assure at least 85% living tress or shrubs.

In all planted areas, invasive weeds would be treated with manually applied, appropriate and approved herbicides when needed over the first 10 years following planting. Treatment would be applied to germinated or resprouted herbaceous species and saltcedar.

4.3.3 Cost Effectiveness / Incremental Cost Analysis.

Sufficient long-term monitoring has been conducted in habitats within the river corridor of the Middle Rio Grande valley of New Mexico that the value of various riparian types is well documented for animal communities, especially birds (Hink and Ohmart 1984, Thompson *et al*. 1994, HAI 2012). Avian

densities have been determined for a large number of riparian communities and correlated with floristic and structural characteristics. These scaled indexes have been frequently used in plan formulation and cost effectiveness analyses for USACE restoration projects and mitigation plans (*e.g.*, USACE 2008, 2011). Table 1 summarizes breeding-season avian density values over an array of habitat types found within the project area. Avian density values were used to determine the abundance of breeding-season birds within a given area of affected habitat types, as well as in proposed post-construction plantings.

Table 1. Summer breeding-bird densities (birds per 100 acres) in floristic / structural vegetation types found in the project area.

Existing habitat type[a]	Equivalent type in literature	Birds per 100 ac.	Literature source, surveyed habitat type, observed birds/100 ac.
Mature trees (>40-ft tall); dense shrub layer:			
C / SC 1	C / SC-RO 1	265	Thompson[b]: C / SC-RO1 182, 263 Thompson: C / RO-SC1 349
C / SC-B-SBM-NMO 1	C / NMO-__ 1	482	Thompson: C / NMO-SE1 607 Thompson: C / RO / NMO1 346, 493
C / SC-RO 1	C / SC-RO 1	265	Thompson: C / SC-RO1 182, 263 Thompson: C / RO-SC1 349
Mature trees (>40-ft tall); sparse shrub layer:			
C 2; C / TW 2; C-TW 2	C 2	233	Thompson: 233
Mid-successional tree layer (20-40 ft tall); dense shrub layer:			
C / SC3S	C / SC 3	209	Thompson: C / SC3 209
C / SC-C 3F	C / SC 3	209	Thompson: C / SC3 209
C-SC / C-SC 3	C / SC 3	209	Thompson: C / SC3 209
RO-C / SC 3	C / SC 3	209	Thompson: C / SC3 209
SC / SC 3	C / SC 3	209	Thompson: C / SC3 209
SC / SC-CW 3	C / CW-SC 3	221	Thompson
SC-TW-C / SC-B 3	C / SC 3	209	Thompson: C / SC3 209
Mid-successional tree layer (20-40 ft tall); sparse shrub layer:			
SC 4	SC 4	180	Thompson
Tall shrub layer (5-15 ft tall) of variable density:			
SC 5	CW or TW 5	213	Thompson
CW 5	CW or TW 5	213	Thompson
SC 5	SC5	200	HAI[b]: 207; H&O[d]: 142; Thompson: 84, 364
SC-ATX 5	SC5	200	HAI: 207; H&O: 142; Thompson: 84, 364
SC-B 5	SC5	200	HAI: 207; H&O: 142; Thompson: 84, 364
SC-RO-B 5	SC5	200	HAI: 207; H&O: 142; Thompson: 84, 364
Short (<5-ft tall) shrub layer of variable density:			
SC 6	SC 6	120	H&O
Non-woody habitats:			
OP (herbaceous or bare)	OP	222	HAI: 253; H&O: 191 DryOP
Mowed grassland	Mowed river edge	190	Thompson (2 transects
Rio Grande channel (OW)	RV	47	H&O

[a] Habitat types follow Hink and Ohmart (1984).
[b] Thompson: Thompson *et al*. (1994): Pooled density from two consecutive years of survey.
[c] HAI: Hawks Aloft, Inc. (2010): Average of 4 to 9 consecutive years of surveys.
[d] Hink and Ohmart (1984): Pooled density from two consecutive years of survey.

The costs of vegetation planting measures were estimated using MCASES Version MII software. All costs include material and installation, weed-control maintenance, success monitoring, contingency (15.8%), contract supervision and administration, and sponsor operation and maintenance. Implementation and O&M costs were annualized over the expected life of the project and the average annual cost served as model input for each measure. Summer bird abundance served as the quantitative output value in incremental cost analysis. IWR-Plan software was used to perform cost effectiveness and incremental cost analyses. Results are displayed in Table 2 and Figure 1.

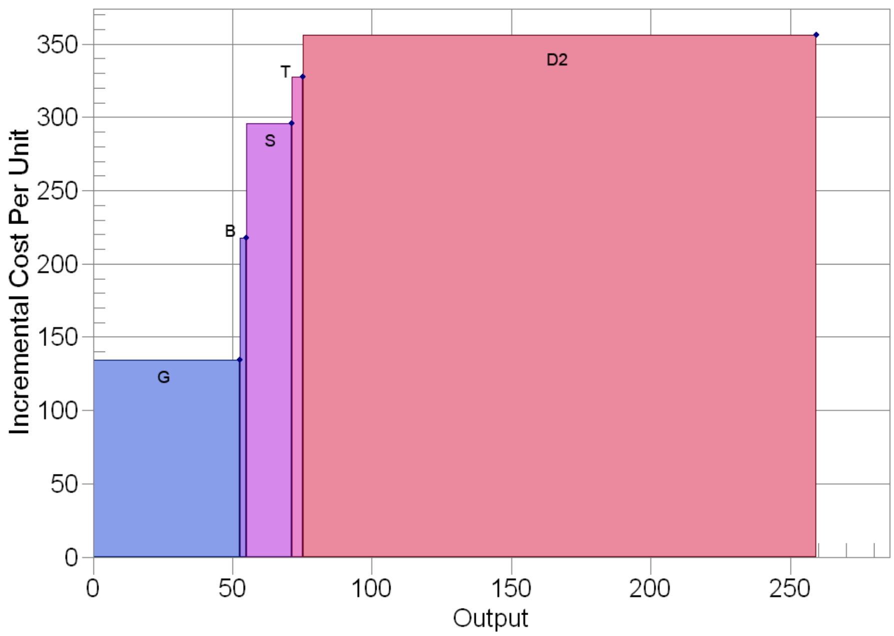

Figure 1. Incremental cost per unit of output (bird abundance) of “best buy” solutions.

Measure G entails seeding to establish grass and herbaceous vegetation and had the lowest incremental cost per unit. Measures B, S, and T entail the establishment of shrubs in various portions of the project area, and their incremental cost per unit output increases with successively dense planting prescriptions. Measure D entails tree and dense shrub plantings. Although a common index of bird abundance was used to characterize the value of these habitats, it should be acknowledged that grassland and shrub habitats support a different suite of bird species, and that each type is necessary to mitigate for unavoidable effects.

The model added measures in ascending order of their incremental cost per unit area. All additive solutions shown in Figure 1 and Table 2 were determined to be cost effective and “best buy” solutions. In all comparisons of combinations, measure D2 was selected over measure D1 as the cost effective alternative for dense shrub and tree plantings. Measure D also provides habitat most suitable for use by Southwestern Willow Flycatchers that inhabit the project area.

Table 2. "Best buy" plans from incremental cost analysis, implementation costs, and OMRR&R costs.

Code	Measure	Cumulative annual cost	Cumulative bird abundance	Average annual cost	Incremental annual cost	Incremental bird abundance	Incremental cost per bird abundance unit	Implementation cost	Cumulative implementation cost	Operation & maintenance cost
--	No Action Plan	$0	0	$0	$0	0	$0	$0	$0	$0
G	Grass seeding in area gained from spoilbank removal	$7080	52.8	$134	$7,080	52.8	$134	$139,670	$139,670	$33,320
B	Willow bank stabilization (Channel excavation area)	$7581	55.1	$138	$5014	2.3	$218	$9,920	$149,600	$0
S	Shrub planting in area gained from spoilbank removal	$12,404	71.4	$174	$4,823	16.3	$296	$97,290	$246,880	$9,180
T	Replacement of temporarily disturbed riparian shrubs	$13,681	75.3	$182	$1,277	3.9	$327	$25,220	$272,100	$2,180
D2	Riparian shrub and tree planting – landside	$79,435	259.6	$306	$65,664	184.3	$356	$1,049,800	$1,321,890	$283,400
Not cost effective:										
D1	Riparian shrub and tree planting - floodway	--	--	--	$81,622	147.5	$553	$1,418,080	--	--

Incremental cost analysis utilizes the average annual cost of each measure. Implementation costs entail the total dollar expenditure for planting, and monitoring for five years. OMRR&R costs entail the total expenditure for maintenance and monitoring in years 6 through 15 following planting.

4.3.4 Project features with incidental benefits to fish and wildlife resources

The following planting activities were included in project features to minimize the potential for post-construction erosion and reduce the potential for colonization by invasive species based on State of New Mexico water quality, air quality, and invasive species regulations. However, the resulting habitats also provide incidental benefits to wildlife (included Table 3).

Grass seeding along 77.9 acres of the riverside corridor of the Vegetation-free Zone: The 15-foot-wide corridor along the riverside toe of the proposed levee would be seeded with suitable riparian grass species following the requirements of Engineer Technical Letter (ETL) 1110-2-571, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures* (USACE 2009).

Grass and shrub seeding of the Eastside Overbank Excavation area: Immediately downstream from the San Acacia Diversion Dam, approximately 9.27 acres along the east bank of the river would be excavated to form a terrace that more efficiently conveys the 10%-chance and less frequent events, and lowers velocities of the design event along the western bank in this reach. This area within the Sevilleta NWR would is currently vegetated by relict stands of salt cedar of varying densities. Channel degradation in this reach has been sufficient to remove this area from the immediate riparian zone; that is, the area is above the water surface elevation of the 20%-chance event. Even after the proposed terracing, the growing season water table would likely be sufficiently deep to prevent the establishment of native riparian vegetation. Seeding is proposed to establish upland grasses and shrubs (e.g., four-winged saltbush, with winterfat and Woods' rose) suitable to the sandy substrate.

Grass and shrub seeding at Tiffany Basin spoil deposition area: Excess soil material from the excavated spoil bank would be deposited within a 300-acre area located at Tiffany Basin. The area is currently vegetated with salt cedar of varying density, and is not inundated by flows smaller than the 10%-chance event. The fill material would be revegetated to minimize erosion, to decrease the potential for colonization by invasive weeds, and to replace shrubby wildlife habitat. Following fill deposition, the disturbed area would be seeded with a mixture of grass, herbaceous and shrub species.

4.3.5 Compensatory value of proposed features and mitigation measures

The Corps *Planning Guidance Notebook* and Section 2036 of WRDA 2007 state that losses of fish and wildlife resources will be mitigated in-kind, or include compensatory measures that provide no less than the in-kind condition, to the extent possible. In the proposed project, a relatively large area of shrub-dominated habit will be converted to grassland per the requirements of ETL 1110-2-571, and the unsuitability of some areas to support native shrub species (as opposed to exotic salt cedar). Woody riparian vegetation has been included in mitigation measures to more fully compensate for the unavoidable effects on those habitat types in general, and Southwestern Willow Flycatcher breeding habitat specifically. Table 3 summarizes the area and relative bird abundance of habitats affected by the proposed project and revegetated areas (including both recommended mitigation measures and incidental wildlife benefits). The overall post-project bird abundance of 959 represents a 35% increase above the existing value of 712.

4.3.6 Mitigation planting success and monitoring

The success of mitigative revegetation measures will be based on the acceptable development of vegetation and its likelihood of continued development into a mature stand. As required by the Service's Biological Opinion (USFWS 2013), the exact criteria for success will be determined in coordination with the New Mexico Ecological Services Field Office, and with the Sevilleta and Bosque del Apache NWRs.

Avian utilization of revegetated areas will be documented through variable-distance point counts (Ralph *et al*., 1993; Martin *et al*., 1997; Bibby *et al*., 2000; Buckland *et al*., 2001), and vegetation characteristics will be measured using commensurate methods (James and Shugart, 1970; Noon, 1981; Martin *et al*., 1997). Photographs will be taken at permanently established photo points. Approximately 12 plots will be established for periodic surveys, including at least three in existing and nearby reference habitat.

Table 3. Vegetation and channel habitat affected by the proposed project, and area revegetated (acres).

	Affected areas					Revegetated areas	
Habitat type	Temporarily disturbed vegetation (soil cement installation)	Vegetation altered in Vegetation-free Zone	East side overbank & channel excavation	Tiffany Basin spoil deposition area	Area lost due to footprint of levee, soil cement, and floodwall	Area gained by spoil bank removal & channel excavation	Other revegetated area
RIPARIAN VEGETATION:							
Native-dominated shrub/tree	0.4	2.8	0.8	--	0.9	7.7	45.6
Mixed native/exotic shrub/tree	0.5	3.7	0.0	--	0.0	0.0	0.0
Exotic-dominated shrub	1.0	19.8	0.0	--	12.1	0.0	0.0
Herbaceous / bare	0.0	1.3	0.0	--	0.0	27.8	75.9
Total Riparian Vegetation	1.8	27.6	0.8	0.0	13.0	35.5	121.6
UPLAND VEGETATION:							
Native-dominated shrub/tree	0.0	0.0	0.0	300.0	0.2	0.0	309.3
Mixed native/exotic shrub/tree	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Exotic-dominated shrub	0.0	0.9	11.6	0.0	15.2	0.0	0.0
Herbaceous / bare	0.0	1.1	0.0	0.0	1.0	0.1	1.9
Total Upland Vegetation	0.0	1.9	11.6	300.0	16.4	0.1	311.2
RIO GRANDE CHANNEL:	0.0	0.0	0.0	0.0	0.6	2.0	0.0
Total (ac.)	1.8	29.5	12.4	300.0	30.0	37.6	432.7
	373.7					470.3	
Bird abundance	3.5	65.7	20.0	600.0	22.8	199.8	759.6
	712.0					959.4	

Avian and vegetation plots will be monitored during the summer growing season for in years 1, 3, 5, 7, 9 12 and 15 following planting. Monitoring will be conducted by the Corps for up to five years following plantings, and by the project sponsor thereafter.

An annual report on monitoring activities will be prepared. Copies of field data sheets and photographs taken will be included. Copies of the report will be furnished to the project sponsors, and pertinent Federal and local resource agencies.

4.3.7 Operation and maintenance

The Corps will be responsible for maintenance and monitoring costs for up to five years following plantings. These activities include weed control (localized manual application of acceptable herbicide), and vegetation-growth and avian monitoring (during three growing seasons).

Local sponsors would assume maintenance and monitoring responsibilities after the Corps fiscally transfer of the project to them, expected to occur in sequence for each the six construction segments. These activities would included vegetation-growth and avian monitoring during four growing seasons in the 6th through 15th year following planting, and, if necessary, weed control. Operation costs also entail the annual provision a total of approximately 43 acre-feet of irrigation water, if needed to promote and sustain tree-and-shrub plantings (measure D2). The Corps will provide the sponsor with an operation and maintenance manual describing these requirements, and including best management practices to minimize disturbance of listed species and their critical habitats.

The total operation and maintenance costs over the 50-year life of the project is $328,070 (averaging $7,290 per year over 45 years). Table 2 lists operation and maintenance costs for the individual mitigation measures.

4.4 Real Estate Considerations

The majority of the acreage proposed for vegetation plantings lies within the existing areas managed by the Bureau of Reclamation, the Middle Rio Grande Conservancy District (project sponsor), Sevilleta NWR, and/or Bosque del Apache NWR. Access and conduct of the proposed project and mitigation activities will be formalized in a Determination of Compatibility with each respective NWR.

The acquisition of 300 acres for the Tiffany Basin spoil deposition site is described in detail in the Real Estate Plan for the proposed project. Included is an estate for two acres specifically for vegetation plantings outside of the spoil deposition area footprint.

5. MONITORING AND STUDIES FOR LISTED SPECIES

The incidental take statement of the Service's Programmatic Biological Opinion (USFWS 2013) for the proposed project stipulates several reasonable and prudent measures to minimize the potential for take (through harm or harassment) of the Southwestern Willow Flycatcher, the Rio Grande silvery minnow, and their designated critical habitats. This section summarizes these activities and their costs.

The Southwestern Willow Flycatcher is an obligate riparian species and nests in dense shrubs within the Rio Grande floodway in the project area. Beginning with the breeding season prior to the initiation of proposed construction, the Corps would perform or fund annual protocol surveys (5 visits per season) within the floodway from San Acacia to San Marcial. Annual surveys would continue until the completion of construction and would continue for three years following the phased construction of each levee-construction segment. Information resulting from these surveys would be used to update resource conditions, avoid direct effects from construction activities, and to revise the determination of effects of the proposed project, if needed. The total cost for surveys is estimated to be $1,274,400 over a 23-year period.

The Rio Grande silvery minnow is restricted to a variably perennial reach of the Rio Grande in New Mexico with critical habitat that overlaps the project area. Monitoring activities during construction —

particularly during dewatering and construction near the channel — entails $85,000. Additionally, monitoring for potentially adverse effects of alkalinity ($34,160) would be performed during construction of the soil-cement floodwall downstream from the San Acacia Diversion Dam.

Groundwater and vegetation monitoring would be performed during dewatering for placement of buried riprap along the levee toe ($149,275). Monitoring information would be used to minimize the potential for adverse impacts on the silvery minnow, and critical habitat of both the minnow and flycatcher.

The Corps will conduct a study to clarify the processes and interaction of sedimentation, groundwater levels, and vegetation response within the project area ($300,000). Information from the study will be used to affirm or modify the potential adverse effects of the proposed action.

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GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-5

Geotechnical Engineering

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

April 2012

Appendix F-5
Geotechnical Studies in Support of the Rio Grande Floodway General Re-evaluation Report

US Army Corps of Engineers
Albuquerque District
South Pacific Division

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GEOTECHNICAL EVALUATION OF EFFECTS OF ALTERNATIVES, AND THE RECOMMENDED PLAN*

1. PHYSICAL ENVIRONMENT

1.1 GEOLOGY

Geologic conditions remain the same as presented in the approved General Design Memorandum (GDM), May 1990, and do not require further discussion in the General Reevaluation Report (GRR).

1.2 SOILS - GENERAL

The overall project consists of rehabilitating, by removing and reconstructing, 43 miles of levees along the west bank of the Rio Grande from the Middle Rio Grande Conservancy District's San Acacia Diversion Works to the northern boundary of Bosque del Apache National Wildlife Refuge, just upstream of the headwaters of Elephant Butte Lake. The recommended levees would provide the Base Levee +4 feet of protection. The levee system will provide flood protection for the U.S. Bureau of Reclamation's low flow conveyance channel, several small villages, unincorporated areas, the city of Socorro, and the U.S. Fish and Wildlife Service's Bosque del Apache National Wildlife Refuge. This GRR address conditions that have changed since the submittal of the General Design Memorandum (GDM) for this project.

1.3 SUBSURFACE INVESTIGATIONS

In 2006, 2008, 2010, additional subsurface investigations were conducted along the proposed levee alignment to indentify foundation conditions and spoil bank levee soil condition in accordance with ETL 1110-2-569 Engineering and Design: Design Guidance for Levee Underseepage.

Drilling was conducted using an 8-inch ID hollow-stem auger, sampling every 2.5 feet using a 2-inch OD by 24-inch long standard split-spoon sampler. Borings were advanced in the area of the levee alignment, to depths of 15 feet to 35 feet. Drill log data disclosed that soils would provide suitable foundation material for the proposed levee. Foundation materials may require special preparation at locations of low density foundation material. The foundation materials, generally speaking, were found to be poorly sorted sand/silty sand (SP-SM) with areas of CH, CL, CL-ML, ML, SC, SM, SP, SC-SM, SW-SM, GP, GW, and GP-GM. Relative densities, determined from correlation from Standard Penetration Tests (SPT), varied from soft/loose to hard/very dense. Generally speaking, soils were soft/loose at depths less than 50 feet with increasing relative densities with depth. Weak clay layers composed of high-plasticity clay are also present in the foundation. Exploration indicates that the layers are generally randomly located, are relatively thin, and have sand layers above and below that allow dissipation of excess

pore pressures upon construction of new levee, leading to consolidation and increased strength. Soil samples obtained during drilling were subjected to visual classification, moisture content, particle size analysis (sieve) and Atterburg limits.

1.4 EXISTING SPOIL BANK LEVEE

As described in the GDM, the existing spoil bank levee vary from approximately 3 to 18 feet in height, have a variable crest width of approximately 12 to 27 feet with side slopes of 1V:2H or flatter on both the landside and riverside. The existing spoil bank levee is not an engineered structure. The levee was constructed from spoil materials obtained originally from the construction of the riverside drain by MRGCD. The height of the levee was increased as part of the low-flow conveyance channel construction performed by the U.S. Bureau of Reclamation. No consideration was made for material selection or foundation preparation during either initial construction or the subsequent raise of the levee. Subsurface explorations disclosed that the density for the majority of materials for the existing levee is very loose to loose and were not properly compacted during construction. Also, during the investigations, large trees were found to be growing adjacent to and on the levee. Based on information obtained during these subsurface investigations, the existing levee would be removed and a new levee constructed. The PGL 26 developed as part of the 1999 LRR established the Probable Non-failure Point (PNP) and the Probable Failure Point (PFP). The locations of the points are still valid based on condition witnessed since its development. An updated H&H analysis of the PNP and PFP is included with this appendix. It was decided not to perform a geotechnical risk and uncertainty analysis on the existing levee as part of the GRR preparation because of the non-engineered nature of the levee.

1.5 NEW LEVEE EMBANKMENT SECTIONS

The area available for construction of a new levee of the proposed project is along the current alignment of the existing levee.

Because the design duration of the river flow against the levee was increased due to a balanced hydrograph, after GDM preparation. The Supplement To Report For San Acacia Levee Options For Providing Stability For Long Term Water Containment Discussion Of Finding, January 1995, it was determined that a “slurry trench” would be constructed to provide seepage control. The slurry trench would extend from two feet below the levee embankment crest to five feet into the foundation material. Foundation excavation for the slurry trench would also intercept any undesirable subsurface features prior to embankment placement. Because the proposed levee embankment would be constructed on thick deposits of pervious materials overlain with little or no impervious material, foundation seepage is a serious problem. A method of protecting the levee embankment toe from seepage and a method of intercepting shallow foundation seepage is required. Several seepage control measures were considered during design and it was determined that a network of subsurface seepage collector pipes and a landside drainage blanket, as previously used in the Albuquerque and Corrales reaches of the flood control

project, would be the best alternative. The new levees embankment would include a landside foundation drainage blanket, extending approximately 1/3 the foundation width, and a network of toe collector pipes and drains to control seepage and eliminate sloughing. Crest width, levee embankment-low flow conveyance channel clearance, embankment slopes, slurry trench and seepage control measures as discussed above are considered the minimum required to provide a stable levee structure for flood control purposes. Minor changes to the cross section may be required in future analysis.

1.6 BORROW AREAS

During the preparation of the GDM, twenty-four potential borrow areas were identified along the length of the project. These borrow areas are located in the bosque area between the previous levee alignment and the Rio Grande channel. The majority of the materials required for the construction of the levee and railroad/levee embankments was expected to be obtained from these borrow areas. However, because of environmental concerns, the borrow areas located within the bosque areas, as shown in the GDM, were eliminated as borrow sources. During FY97, eleven potential borrow areas were identified as having suitable materials for construction. These potential borrow areas were on private, Bureau of Land Management, (BLM), U.S. Fish and Wildlife Service's Bosque del Apache National Wildlife Refuge lands or lands under control of the Bureau of Reclamation (BOR). Four of these potential borrow areas were designated for use during construction; two are on BLM lands, one is at the outfall channel near the Socorro and one is the borrow area currently being used by the BOR. One additional borrow area was identified and could be used to obtain material. This borrow area is located in the middle of the U.S. Fish and Wildlife Service's Bosque del Apache National Wildlife Refuge and consists of an existing berm that the Refuge has requested be removed during construction of the new levees/railroad embankment (circa 1997). The berm was sampled and although the material in this berm is not the best for construction, an attempt could be made to use the material during construction. Specific borrow areas to be used for construction should be identified during preparation of the FDM. It is not projected that the tentatively selected plan will require any additional embankment material to construct the levee. Borrow materials will be required for slope/head cut protection and drainage/filter material. Location of a possible source of rock has been located, but further investigations are required.

1.7 ADDITIONAL SUBSURFACE EXPLORATIONS

- Additional subsurface investigations along the final alignment of the levee will be required to fulfill the requirements of EC 1110-2-6067" USACE Process for the National Flood Insurance Program (NFIP) Levee System Evaluation, 9.h. Geotechnical Evaluation Guidance.

CESWA-ED-TS 23 October 1995

MEMORANDUM THRU

Chief Design Branch

Chief Planning Branch

FOR Chief Formulation Section

SUBJECT: San Acacia to Bosque del Apache, PGL-26

1. The San Acacia to Bosque del Apache project, as originally proposed, consisted of reconstructing 54.6 miles of levees. The project extended from San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir downstream of the town of Tiffany. However, the lower reach of the project has been deferred until the Bureau of Reclamation completes a three year sediment study which may result in the realignment of the lower end of the low flow conveyance channel. Currently, an existing spoil levee is present for almost the entire length of the project. Subsurface investigations were conducted for the entire length of the project. The project was originally divided into five areas for continuity but the last area is not discussed because it has been deferred as discussed above. The first area extends from San Acacia Dam, Station 14+00 to Station 73+10. This area is the very constricted area immediately downstream of San Acacia Dam and includes the dam, low flow channel and irrigation control structures and the railroad embankment and track. The second reach runs from Station 73+10 to Station 1816+50 (approximately 33 miles) and represents an area where the levee would be constructed on typical alluvial river deposits. The third reach runs from Station 1816+50 to Station 2191+00 and is an area where existing levee and borrow materials, as well as the foundations, are quite sandy. The fourth area is identified as the Tiffany Reach, Station 2191+00 to Station 2414+00. The levee alignment in this area follows an un-maintained existing levee. The last area is from Station 2414+00 to Station 2897+14.

2. Subsurface investigations of the existing levees for the GDM were conducted by Albuquerque District, U.S. Army Corps of Engineers, in 1988 and 1989. Borings were drilled at 1250 to 1500-foot spacings, using an eight-inch diameter hollow stem auger. The borings were advanced to a maximum depth of forty feet. The soils were continuously examined, classified and logged. Standard penetration tests were taken at five-foot intervals and disturbed samples obtained for mechanical analysis, Atterberg limits and moisture contents. Results of this investigation were presented in the GDM. Additional investigations were conducted in 1990 and 1991 for the F.D.M. These investigations were for the proposed Tie Back levees and the Low Flow Channel Control Structures, located at the upper and lower end of the project and for off-site borrow areas. The results of the investigations are discussed below.

3. Area Number 1 - San Acacia Dam and Vicinity. Two borings were located within this area. The borings reached refusal at depths of four and four and one half feet. Materials were silty sands and sandy clays. Visual inspection

of this area was performed to supplement the borings. The inspection, which looked at the existing low flow channel and river bank, indicates that foundations are alluvial materials, which in this area are predominantly fine silty sands and sand with traces of silts, clays and gravels. The soils are typically very loose to medium dense. Two additional borings were drilled later for the F.D.M. The borings are located at the irrigation and low flow channel control structure location (Station 32+00). The borings were drilled to a maximum depth of twenty five feet. Materials encountered are sands and silty sands of low to medium density with blow counts ranging from a low of six to twenty two.

4. Area Number 2 - Station 73+10 to Station 1816+50. This area, approximately 33 miles long, runs along the right Rio Grande riverbank. An existing spoil bank levee is present for this entire reach. One hundred and fifty-two borings were drilled for the GDM with an eight-inch auger through the existing spoil bank levee, to a maximum depth of twenty feet. Two-inch split spoon samples with standard penetration tests were taken every five feet in depth or at change of material. The subsurface explorations disclosed that the existing spoil bank levees were constructed of sands, silty sands and clayey sands. Random layers of clay were found. A review of the standard penetration test data indicate the materials range from very loose to medium (blow counts 2 to 17 per foot). The majority of the materials are very loose to loose. Foundation materials are generally sands, silty sands and sandy clays. Blow counts for the foundation materials are the same to somewhat higher than the blow counts in the spoil bank levee. Weak clay layers composed of high plasticity clay are present in the foundation. Exploration indicates that, in general, the layers are randomly located and relatively thin. The clay layers noted above could not be related to any large areal deposits. Typical river alluviums and soil deposits are quite variable and discontinuous. New exploration for the F.D.M. consisted of two holes in this reach. The first was drilled at Station 625+00 in the vicinity of the Socorro Outfall Channel and was drilled through a surface layer of sandy clay into alternating layers of silty sands and sands with blow counts from five to sixteen. The second hole was drilled at Station 1008+50 in the vicinity of the Browns Arroyo Levee tie back and was drilled through a four-foot surface layer of clay into silty and coarse sands. Blow counts varied from six to twenty three per foot. Thin clay seams were noted.

5. Area Number 3 - Station 1816+50 to Station 2191+00. This area is located within the southern half of the Bosque del Apache Refuge and continues to the start of the "Tiffany" reach. The boundaries for this area were selected because spoil levee surface materials appear to be sandier. The spoil levee materials which are obtained from excavation of the low flow channel are therefore also representative of the foundation materials. Nineteen borings were drilled within this reach. The borings were drilled to a maximum depth of forty feet below the top of the spoil bank levee. Materials ranged from loose to medium dense silty sands and sands with a few layers of sandy clay. A few thin layers of medium plasticity clay were found. The majority of the levee and foundation materials are judged to be very loose to loose based on low blow count data. Blow counts varied from a low of two to an average of eight per foot. In two borings, blow counts of twenty five were recorded in a thin layer of the foundation. Layering within the levee section is not as evident as for the previous area.

6. Area Number 4 - Station 2191+00 to Station 2414+00. This area consists of the abandoned "Tiffany" levee. Maintenance of this levee is not current and the levee has been breached near the lower limits. Ten borings to a maximum depth of twenty-four feet were drilled. Materials ranged from very loose to loose sands, silty sands and sandy clays. All materials were in relatively thin layers (less than 5 feet thick) with the exception of a sandy clay layer in one of the borings, which extended from the surface to the maximum drilled depth of fourteen feet. Blow counts varied from a low of zero to six blows per foot. Blow counts of sixteen were recorded in the foundation of one boring at a depth of twenty three feet. These borings illustrate the variability of the alluvial foundation deposits.

7. Area Number 5 - Station 2414+00 to End of Project. This area was not evaluated because the area is not included in the project as currently proposed.

8. Existing levees vary from approximately three to eighteen feet in height, have a variable crest width of twelve to twenty seven feet, with side slopes which are generally 1 vertical on 2 horizontal or flatter on the landslide and somewhat steeper on the riverside. The levees are generally overbuilt in the upper reach of the project. In place materials are sands, silty and clayey sands and sandy clays. Standard penetration tests performed during the subsurface investigations disclosed that the density of the majority of the existing levee material ranged from very loose to loose. Materials were layered, indicating that construction was perhaps phased. No identifiable zoning or seepage control measures were noted. The levees as constructed are not considered adequate to withstand water near or against the levees.

9. Discussions with Bureau of Reclamation personnel disclosed that extensive flood fighting has been required to prevent failure of the existing levees along the proposed project. Specific examples provided include two major flood fights that occurred between 1966 and 1969 in the Tiffany Junction area where large quantities of sand and rock were placed to prevent failure. The area was later lined with riprap. In 1973, water against the levee near Brown Arroyo, south of Socorro, eroded 90% of the levee between the hours of 0900 and 1430. Emergency construction was required throughout the night to save the levee. Twice between 1984 and 1989 jetty jacks and riprap had to be placed in the area between San Acacia and Polvadera to keep the saturated levee from failing. At Socorro, a training dike had to be constructed to protect the levee from flood waters. The Bureau continuously hauled granular materials between the years of 1989 and 1991 to maintain the required levee height at the lower reach of the project. During this period and in the same area, there was a levee breach and an almost complete washout of the railroad. Stabilization of the land side low flow conveyance channel, due to seepage, has been a continuing maintenance problem during flows of a frequency as low as two years. Bureau personnel indicated that these are just a few of many examples of flood fighting within the project limits required because of the poor condition of the existing spoil bank levees and without the flood fighting the levees would certainly have failed.

10. Based on subsurface exploration results, the above observations and past experience during high flows in the river, the Probable Non-failure Point (PNP) is designated as some point within the river channel. Failure could possibly occur due to foundation seepage, piping and sloughing of the land

side low flow conveyance channel, before flows break out of the river channel. The Probable Failure Point (PFP) is designated as a point at the toe of the existing levee just above the point where the water first breaks out of the river channel. As previously stated, it is strongly felt that if the levee and the low flow conveyance channel are not stabilized during possible flood fighting activities, failure will occur at some point, when the water reaches the toe of the levee.

11. If there are any questions, please contact Jimmy Medina at 766-2717.

Dwayne E. Lillard
DWAYNE E. LILLARD, P.E.
CH, GEOTECHNICAL SECTION

CESPA-PM-LH 29 June 2007

Memorandum for Record

Subject: San Acacia to Bosque del Apache LRR; PGL-26, Hydraulic Analysis of Probable Non-failure Point (PNP) and Probable Failure Point (PFP) of existing spoil bank levee

A memorandum dated 23 October 1995 discussed the geotechnical investigations of the San Acacia to Bosque del Apache project. Based on their subsurface exploration results, visual observations and experience, the following recommendations for the PNP and PFP were made:

> The PNP is designated as some point within the river channel. Failure could possibly occur due to foundation seepage, piping and sloughing of the land side low flow conveyance channel, before flows break out the (active) river channel.
>
> The PFP is designated at a point at the toe of the existing levee, just above the point where the water first breaks out of the (active) river channel.

A HEC-RAS hydraulic model using the Bureau of Reclamation's 2002 range line data was used for evaluation of the PNP and PFP. The model calculated water surfaces for cross sections along the entire reach from downstream of the San Acacia Diversion Dam to just upstream of the San Marcial Railroad Bridge. The discharge that produced a water surface that would come into contact with the existing spoil bank levee was determined for each cross section. A graph showing this discharge at each cross section (labeled by range line) is attached.

As can be seen in Figure 1, in the lower reach (from approximately range line 1500 to 1700) there are several (18) cross sections for which a discharge of 2000 cubic feet per second (cfs) would produce a water surface elevation putting water against the toe of the existing spoil bank levee. A discharge of 2000 cfs will therefore be designated as the PFP producing discharge. The probability associated with this discharge is more likely than a 50% chance-exceedance, or 2-year return frequency, based on the certified project hydrology. {It should be pointed out that a significant spring runoff in 2005 resulted in changes to the channel geometry that is not captured in the available 2002 range line geometry dataset. For example, channel incision in the lower end of the project reach in the vicinity of the Railroad Bridge (MEI, 2007), and a 'sediment plug' filled the active channel adjacent to the Tiffany basin. These changes would effect some, though not all, of the 18 cross sections described above, and were viewed as transient localized changes that were not used to represent 'typical' conditions.}

A 2000 cfs discharge could very likely be produced by a long duration snowmelt event. This would put water against the toe of the existing spoil bank levee at the PFP for an extended and constant duration, increasing the likelihood of a failure.

Another result of the long duration of a snowmelt event is the lessened attenuation of the hydrograph peak. In performing the hydrologic analysis for the LRR, long-duration, high-volume snowmelt events on the mainstem Rio Grande were considered in addition to flashy, low-volume, high-intensity summer rainfall events on the large tributaries (Rio Puerco, Rio Salado). The higher of these two types was selected for each return frequency evaluated to arrive at the representative discharge-frequency curve for the project. An assumption made for a high-volume, long-duration hygrograph was that the peak discharge would be essentially uniform as it moves down the reach, having sufficient volume to fill up the off-channel storage areas that would cause a short-duration rainfall hydrograph to attenuate significantly as it moved downstream. This is significant to note because it simplifies the analysis. For a significantly attenuated study area hydrograph (*e.g.*, a summer rainstorm event originating on a tributary), a given discharge value would have multiple exceedance probabilities depending on where within the study reach it was assessed. For a snowmelt event, a given discharge, in this case the PFP-producing discharge, has roughly the same probability of occurring throughout the project reach. Therefore, the determination of the most likely occurrence of a failure point is dependent only on the channel capacity and geometry of that location, and not on the possible attenuation resulting from the distance from the upstream end of the study reach.

A discharge of 1500 cfs will be designated as the PNP producing discharge since modeling indicated that this flow was contained in the active channel throughout the reach. It should be noted that in areas where the active river channel is directly adjacent to the existing spoil bank levee, defining the “levee toe” becomes imprecise. Thus, the potential for failure due to foundation seepage, piping and sloughing of the land side low flow conveyance channel increases even at very low flows. However, the Bureau of Reclamation monitors these areas closely, thus reducing the risk of failure.

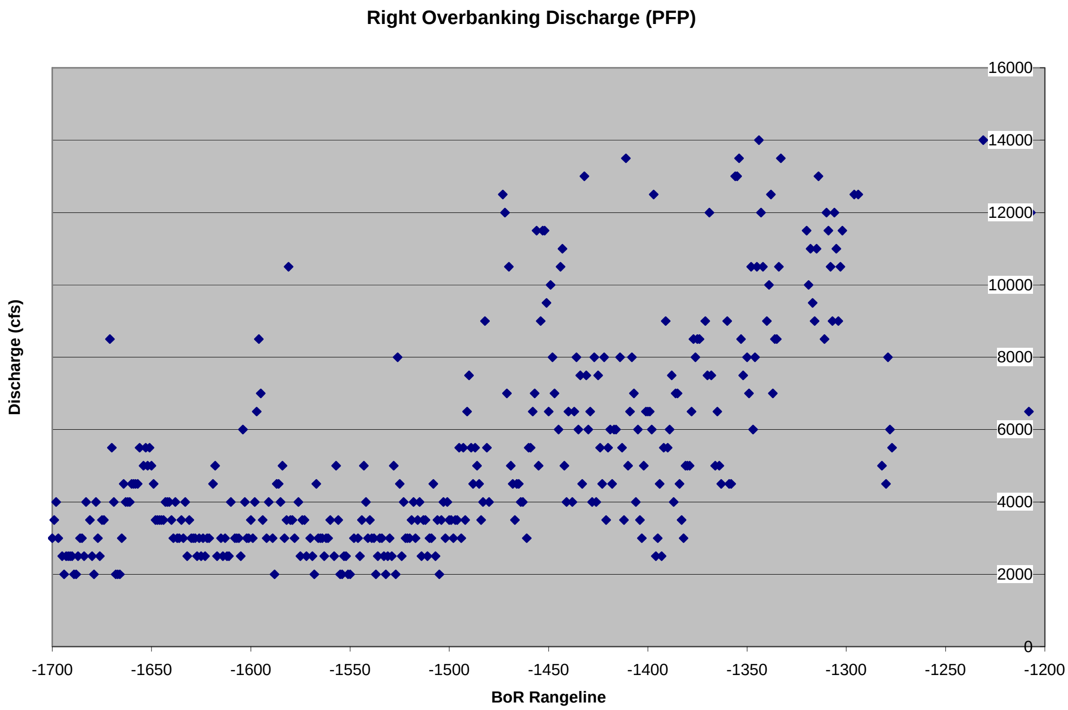

Figure 1 Discharge that would produce a water surface coming into contact with the existing spoil bank levee

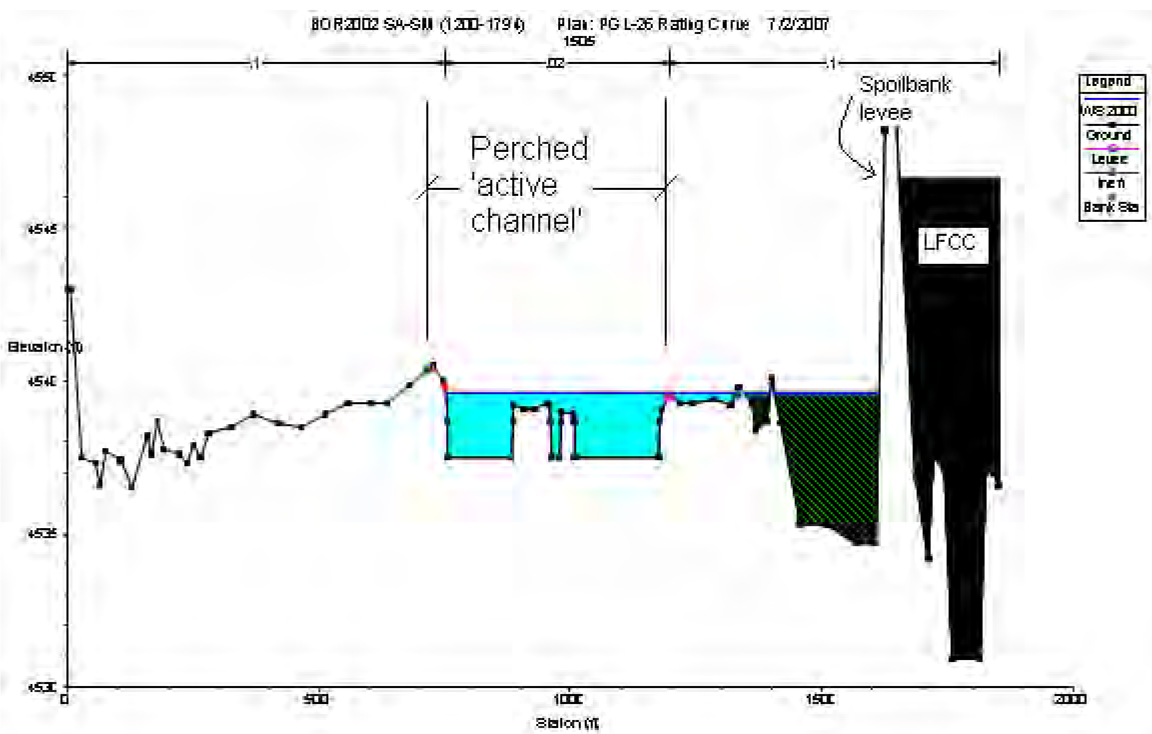

Figure 2 Typical cross section showing water against the toe of the existing spoil bank levee at a discharge of 2000 cfs.

REFERENCE

Mussetter Engineering, Inc. (MEI). *Assessment of Potential Impacts of San Acacia to Bosque del Apache Flood Damage Reduction Project on the San Marcial Railroad Bridge*, 2007.

GENERAL REEVALUATION REPORT AND

SUPPLEMENTAL ENVIRONMENTAL

IMPACT STATEMENT II:

RIO GRANDE FLOODWAY,

SAN ACACIA TO BOSQUE DEL APACHE UNIT,

SOCORRO COUNTY, NEW MEXICO

APPENDIX F-6

HTRW

PHASE I ENVIRONMENTAL SITE ASSESSMENT

SAN ACACIA to BOSQUE DEL APACHE

FLOOD CONTROL PROJECT

NEW MEXICO

Prepared for:

US Army Corps
of Engineers ®

United States Army Corps of Engineers
Albuquerque District
4101 Jefferson Plaza NE
Albuquerque, New Mexico

Contract No. W912PP-05-T-0043

Prepared by:

Echota
Technologies

Echota Technologies Corporation
372 S. Washington Street
Maryville, Tennessee 37804

Echota Project No. 6002-02

FINAL
September 1, 2005

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ACRONYMS

ASTM	American Society for Testing & Materials
AT&SF	Atchison, Topeka & Santa Fe Railroad Co.
BNSF	Burlington Northern & Santa Fe Railroad Co.
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, & Liability Information System
DHHS	US Dept. of Health & Human Services
ECHOTA	Echota Technologies Corporation
EDAC	Engineering Data Analysis Center
EPA	United States Environmental Protection Agency
ERNS	Emergency Response Notification System
EDR	Environmental Data Resources, Inc.
ESA	Environmental Site Assessment
GIS	Geographical Information System
HTRW	Hazardous, Toxic, and Radioactive Waste
LUST	Leaking Underground Storage Tank
MRGCD	Middle Rio Grande Conservancy District
NFRAP	No Further Remedial Action Planned
NMED	New Mexico Environment Department
NMSEO	New Mexico State Engineer Office
NPL	National Priority List
PSTB	Petroleum Storage Tank Bureau
RCRA	Resource Conservation and Recovery Act
RCRIS	Resource Conservation and Recovery Information System
TSD	Treatment, Storage, or Disposal
UNM	University of New Mexico
US	United States
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
UST	Underground Storage Tank

EXECUTIVE SUMMARY

This report presents the results of a Phase I Environmental Site Assessment (ESA) of a tract of land located along the Rio Grande in south central New Mexico. The land is designated for improvement as part of a planned flood control project that will be managed by the United States Army Corps of Engineers (USACE), Albuquerque District. This assessment was conducted in conformance with the scope and limitations of the American Society for Testing & Materials (ASTM) Standard E 1527-00, USACE Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects, designated as ER 1165-2-132, and the US Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), designated as 42 USC 9601, Section 120 (h). The purpose of this Phase I ESA was to evaluate the potential for the presence of HTRW within the limits of the planned civil works project.

The land included within the project extends from the San Acacia Diversion Dam (located on the Rio Grande north of the City of Socorro, New Mexico), south to the Burlington Northern and Santa Fe Railway Co. (BNSF) bridge that crosses the Rio Grande near San Marcial, New Mexico. This 45-mile portion of the Rio Grande is located at the southern end of the Middle Rio Grande Valley in south central New Mexico. The width of the valley in the project area varies from eight to twelve miles, with the flood plain varying from one to three miles wide. A series of flood control and drainage levies are located along the west side of the river.

A site reconnaissance of the project corridor was conducted on July 20, and August 8, 2005 Land within the project boundaries is mostly rural and is not developed for industrial or commercial uses other than agricultural and low density residential. The BNSF operates a primary rail line through most of the project site. This rail line is currently used as the primary north – south line connecting El Paso, Texas and Belen, New Mexico. The railroad has been in continuous use for approximately 100 years. Currently, there are no railroad depots or maintenance facilities within the project limits; however a review of available historical information indicates that portions of the property at San Marcial were developed as a railroad maintenance shop and roundhouse in the early 1900s. These maintenance facilities were abandoned in place during a massive flood that occurred in August of 1929. These facilities have remained buried in silt and river deposits through the present. At this time, it is not known whether past land usage at the San Marcial railroad facility has environmentally impacted the site.

The U.S. Bureau of Reclamation (USBR) operates two maintenance and storage facilities on or adjacent to the project area. According to regulatory documentation, both facilities were listed as Leaking Underground Storage Tank (LUST) sites. According to records from the New Mexico Environment Department (NMED) Petroleum Storage Tank Bureau (PSTB) there is no evidence that a release of product from these facilities has impacted the environment within the project site. Additional regulatory information about these sites may be available at PSTB and at the USBR or USFWS.

1.0 INTRODUCTION

1.1 Objective

Echota Technologies, Inc. (Echota) was retained by the USACE under Contract No. W912PP-T-0043 to perform a Phase I ESA of a tract of land located in south central New Mexico. The land is designated for improvement as part of a planned flood control project that will be managed by the USACE, Albuquerque District. The purpose of this Phase I ESA was to evaluate the potential for the presence of HTRW within the limits of the planned civil works project.

In addition to the spoil levy alignment from San Acacia to San Marcial, other areas of interest included the proposed re-alignment of the conveyance channel near San Acacia; the proposed realignment of the BNSF siding and bridge; the former town site of San Marcial; and the Tiffany land acquisition area.

1.2 Scope of Work

The scope of this ESA included the following activities as specified in ASTM E 1527-00:

- An assessment of present surface and subsurface conditions from published data
- A historical review of past land use
- A site reconnaissance to observe existing conditions in the field
- A review of documents pertaining to the environmental condition of the site and site vicinity.

These activities were conducted in accordance with the following requirements:

- US EPA CERCLA Regulations designated as 42 USC 9601, Section 120 (h).
- USACE HTRW Guidance for Civil Works Projects, designated as ER 1165-2-132 (Sections 6 and 7).

1.3 Limitations

This Phase I ESA report has been prepared for the exclusive use of USACE to support planned civil works projects within the study area. This report may be used within a reasonable time following its issuance. Land use, site conditions (both off-site and on-site), or other factors may change over time; additional work may be required with the passage of time. Any other use of the report may be inappropriate.

Assessment results are based on the observations of the investigators at the time of the site visit, on reviews of publicly available information, and on information provided by persons familiar with the property. Unless contradicted by conflicting data obtained independently during the conduct of the work, all information obtained has been accepted at face value. The information obtained during interviews and from files and databases is sometimes inaccurate and/or incomplete. The information and conclusions in this report are subject to the accuracy, completeness, and availability of such data. Except as set forth in this report, Echota made no independent investigations as to the accuracy and completeness of the information derived from the listed sources.

All findings, observations, conclusions, and recommendations stated in this report are based on

the data; circumstances; applicable federal, state and local laws, rules, and regulations; and generally accepted national standards for such services in existence at the time that the report was prepared. Topics not explicitly discussed within this report should not be assumed to have been investigated or tested. This assessment does not guarantee current compliance with federal, state, or local laws, rules, or regulations.

The findings, observations, conclusions, and recommendations presented in this report, unless otherwise stated, are based solely on the information obtained and presented herein. Implementation of the recommendations contained in this report does not ensure that all environmental risks will be eliminated or that all legal obligations will be met.

This ESA did not address non-scope considerations as discussed in ASTM E 1527-00, Paragraph 12. These limitations include, but are not limited to, chemical analysis of groundwater, air or soils at the site; radiometric surveys for radon gas; asbestos/lead-based paint investigations; and evaluation of drinking water quality. This investigation was limited to non-intrusive assessments.

1.4 Limiting Conditions

Echota's on-site inspection included a walking and driving inspection of areas that were accessible, and a drive-by inspection of surrounding and adjacent properties including any properties identified in the environmental database search. No conditions that would limit Echota personnel's ability to complete the scope of work were encountered during the performance of this Phase I ESA. Due to dense forest growth and restricted access to private property in the Tiffany area and San Marcial town site, aerial photographs, review of topographic map changes, and interviews of local personnel were used to conduct portions of the investigation.

1.5 Definitions

Our investigation consisted of an integration of data from four areas of influence, as defined below:

- "site" "property" and "subject property" refers to land within the specified boundaries of the properties described in Section 2.0 of this report.
- "adjacent sites" refers to properties immediately bordering the site
- "site area" refers to properties within a one-quarter mile radius of the site.
- "site vicinity" indicates properties within a two-mile radius of the site.

The term "recognized environmental conditions" is defined by ASTM Standard E 1527-00 to mean the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property. The term includes hazardous substances or petroleum products even under conditions in compliance with the law. The term is not intended to include de minimis conditions that generally do not present a material risk of harm to public health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Conditions determined to be de minimis are not recognized environmental conditions. (ASTM, 2000).

2.0 SITE LOCATION AND DESCRIPTION

2.1 Location and Description

The project site extends from the San Acacia Diversion Dam (located on the Rio Grande north of the City of Socorro, New Mexico) south to the BNSF Bridge No. 1006A, near San Marcial, New Mexico. This 45-mile portion of the Rio Grande is located at the southern end of the Middle Rio Grande Valley in south central New Mexico. The width of the valley in the project area varies from eight to twelve miles, with the flood plain varying from one to three miles wide. In addition, an approximate 2,000- acre tract of land designated as the Tiffany Area is located at the southern end of the project site.

Figure 1 – Project Site Map

2.2 Vicinity and Site Characteristics

The project site includes the Rio Grande valley and its flood plain. The floodplain and bordering terraces are mostly rural and used for irrigated farmland, livestock grazing and wildlife conservation and enhancement. The project area lies within Socorro County, New Mexico with a 2000 census population of 18,078. The county seat and major population center is the city of Socorro with a 2000 census population of 8,877. Smaller communities in the area include San Acacia, Polvadera, San Luis, Lemitar, Escondida, San Pedro and San Antonio.

2.3 Current Use of the Property

Land within the project corridor is mostly rural and is not developed for industrial or commercial uses other than agricultural and low-density residential use. The BNSF operates a primary rail line through most of the project site. This rail line is currently used as the primary north – south line connecting El Paso Texas and Belen New Mexico. Railroad use has been continuous for approximately 100 years. Currently, there are no railroad depots or maintenance facilities within the project limits. Additionally, a series of flood control and drainage levees are located along the west side of the river. The levees were constructed by the USBR and the USACE in the late 1930s and early 1940s. Currently, the levees are under the jurisdiction of the Middle Rio Grande Conservancy District (MRGCD), the USBR and the USACE.

The USBR owns and operates two small maintenance facilities within the project area. These facilities are used to store equipment and vehicles used for construction and maintenance activities for the river levees. Other property uses include agriculture, residential and wildlife preserves.

2.4 Descriptions of Structures, Roads, Other Improvements on the Site

Figure 2 - San Acacia Diversion Works

There are two major structures located within the project site. The levee system extends from near San Acacia at the northern end of the project through San Marcial at the southern end. The levee system consists of a linear earthen bank approximately 15 feet in height and approximately 40 feet wide at the toe. This “spoil bank” levee is continuous along the west side of the river from San Acacia to the Nogal Arroyo just north of Socorro. The levee continues from the Nogal Arroyo outlet through the Bosque Del Apache National Wildlife refuge to the proposed new BNSF Railroad bridge site. This levee system includes a low flow conveyance channel, various interior drain channels and diversion structures. The largest structure associated with the levee system is the San Acacia diversion dam located at the northern end of the project. Smaller diversion structures used for irrigation and flood control along the flood plain are located throughout the project area.

The BNSF Railroad main line is located on the west side of the Rio Grande and extends along the west toe of the levee. Portions of the rail line are located outside of the project limits south of San Acacia and north of Socorro. The portion of the rail line located within the project limits includes an elevated rail bed with one pair of tracks and a double pair of tracks or sidings located at approximate 10-mile intervals. The only structures associated with the railroad (within the project limits) are small utility buildings or sheds located at each siding.

Other developments within the project area include widely spaced single-family homes, secondary roadways and irrigation systems. No evidence of mining, mineral exploration, or other large-scale development was observed.

2.5 Current Uses of the Adjoining Properties

The area to the west of the project limits consists of low hills and arid terraces. Most of the developed land adjacent to the project site (including Socorro, San Antonio and smaller communities) is located on or west of the terraces. There is virtually no development of properties along the east side of the project corridor. This area consists mostly of arid hills and playas. Adjoining properties located within the river valley are densely vegetated with trees, shrubs and grasses. Large wetland areas are also located along the valley, particularly in the Bosque Del Apache Wildlife Refuge.

3.0 RECORDS REVIEW

Various databases were reviewed to obtain information on the physical setting, past land ownership, and environmental conditions within the project site and vicinity. The following information was reviewed:

- A series of aerial photographs from the years 1935, 1953, 1972, 1973, and 1996
- Sanborn Fire Insurance maps
- USGS 7.5' topographic maps for the project area
- City directories (none were available for the project site)
- Published geologic/hydrologic reports
- An Environmental Data Resources, Inc (EDR) Site Assessment Report for the location
- MRGCD land ownership maps
- Various references providing information on the history of San Marcial.

3.1 Physical Setting

Topography, drainage patterns, soil types, depth to groundwater, groundwater flow direction and gradient, and other factors can affect the transport of HTRW on and beneath the ground surface. An understanding of the geologic, surface water and hydrogeologic settings can help in evaluating the susceptibility of the property to contamination. Typically, contaminants migrate vertically through porous soils to the water table (unconfined aquifer conditions), and then travel with the flow of groundwater. Locally, man-made conduits such as sewers, water lines, or wells can divert subsurface transport. Poorly constructed groundwater wells can serve as conduits for vertical transport of contaminants. Available data pertaining to the geologic and hydrogeologic setting of the property are provided in the following sections.

3.1.1 Geologic Setting

The project corridor is situated in the lower middle section of the Rio Grande Valley. The Socorro Mountains are the source of alluvial deposits that underlie the higher elevations of the river valley. The Socorro Mountains are a remnant of the northeast edge of the 25-mile long Socorro Cauldron and associated volcanic field consisting of rhyolitic ignimbrite (tuffs), trachyte and andesite. This portion of the Rio Grande Valley is one of the most seismically active areas in New Mexico. (New Mexico Bureau of Mines & Mineral Resources, 1977). The master fault of the Rio Grande rift underlies the axis of the river valley and is interconnected with extensional fault systems, which have extended to the east and west of the rift.

Surface deposits include alluvial fan and eolian deposits that are locally composed of interbedded silty to clayey sands with some gravel and occasional layers of sandy silts or clays. Beneath the alluvial fan deposits are older Santa Fe Group deposits. (Lindsey, 1999)

Figure 3 –Section of Low Flow Conveyance Channel

3.1.2 Surface Water, Topography, and Drainage

Topography within the site vicinity consists of a floodplain that slopes to the west. Surface run-off along the west side of the Rio Grande is directed to numerous small arroyos and drainage ditches. All of the runoff is channeled into the Rio Grande or the low flow conveyance channel. Elevation within the project area

ranges from 4,676 feet above mean sea level at the northern end of the project area to 4,450 feet near San Marcial at the southern end. (Lindsey, 1999)

3.1.3 Groundwater

The Socorro graben basin contains the aquifer that underlies the project site. The Socorro Basin is divided into several smaller basins including the Jornado del Muerto Basin and the San Marcial Basin. According to information provided by the New Mexico State Engineer Office (NMSEO), and EDR, the depth to groundwater within the project site ranges from 5 to 30 feet below the surface. Groundwater data from Lindsey (1999) indicates a general groundwater flow direction of west-southwest. The alluvial groundwater is generally of a chemical quality suitable for domestic and industrial use.

3.2 Historical Use Information

The original town of San Marcial had its beginning in the early 1850s on the east bank of the Rio Grande a few miles south of what was then Fort Conrad. In 1866, the town was wiped away by a flood. Fort Conrad had been relocated to the west bank of the Rio Grande a few years before the flood. This provided reason to rebuild San Marcial on the west bank and the people lost no time in re-establishing their community. No sooner had the new town began to grow than, in July of 1881, it was nearly totally destroyed by fire. Once again, the town was rebuilt and grew to a community of a thousand residents and became the center for agricultural and irrigation projects. By 1929 the population peaked at fourteen hundred. Then on the night of August 13, the waters of the mighty Rio Grande began to rise and soon reached flood stage. By the next morning the town was submerged up to the second floor of the buildings. Most of the residents, seeing their homes a total loss, left. The only visual evidence remaining today is a lonely cemetery hidden in the mesquite. (Chenoweth, 2005).

This study evaluated the history of the site utilizing aerial photographs, topographic maps, fire insurance rate maps, and city directories. Additional information related to historical use of the property is provided in the Interviews Section of this report (Section 4.0).

3.2.1 Topographic Map Review

U.S. Geological Survey (USGS) 7.5-minute topographical quadrangle maps reviewed for this assessment include the following:

- San Acacia, NM, published in 1952 and photo revised in 1971
- Lemitar, NM, published in 1959 and photo revised in 1971
- Socorro, NM, published in 1959 and photo revised in 1979
- San Antonio, NM, published in 1981
- San Antonio SE, NM, published in 1982
- San Marcial, NM, published in 1948 and photo revised in 1982

A review of historic and current USGS maps show the project site has remained relatively unchanged from the earliest available edition of these maps through the current editions. When comparing the earliest editions of the maps to the most current edition, the following data points become clear:

- The Village of San Acacia appears to have decreased in population as indicated by fewer structures or homes shown on the latest San Acacia map. All of the structures depicted within the project site on the San Acacia map appear to be single-family homes.
- The Lemitar area shows very limited growth and consists primarily of ranches and ranch homes with no indication of retail or industrial facilities within the project site.
- The Socorro map shows scattered ranch homes and single-family homes located within one mile of the Rio Grande. The area shows significant growth that is contained primarily along the I-25 corridor and outside the project site.
- The San Antonio and San Antonio SE maps show the village of San Antonio located approximately one half mile to the west of the Rio Grande with no residential or commercial development within the project site.
- The 1948 edition of the San Marcial USGS map shows that numerous structures indicated as “ruins” were located within the project limits. The ruins are depicted near the villages of Valverde, Tiffany, and San Marcial.

All of the topographic maps reviewed for this project show that drainage canals and flood control structures were constructed prior to the earliest available edition (1948) of these maps. The BNSF Railroad, formerly Atchison, Topeka & Santa Fe Railroad (AT&SF), is depicted in the earliest edition of maps as well. The maps do not indicate the presence of any bulk oil storage, manufacturing, or mining activities. Current topographic maps are included in Appendix A. (USGS, various years)

3.2.2 Fire Insurance Rate Maps

Sanborn Fire Insurance maps were compiled from the late 1800s to the early 1970s for medium and large sized cities across the United States. These maps provide baseline information on construction materials used in developed areas within city limits. Sanborn maps can provide information about historic land use and possible environmental concerns.

An inquiry with EDR Sanborn, Inc., as to the availability of Sanborn maps for the area revealed that historic Sanborn maps were produced for the town of San Marcial for the years 1893, 1898, 1902 and 1908 as shown in Figure 28 in Appendix F. A review of these maps shows that San Marcial was a relatively large town with an 1898 population of 896. These maps depict a relatively large “new town” in addition to an old town located northeast of the railroad depot. Several two and three story commercial structures are located along Main Street in addition to numerous smaller commercial and residential structures. These historic maps are available from the Map and Geographic Information Library at the University of New Mexico (UNM). Photos of all referenced maps are included on the attached DVD-ROM. (EDR Sanborn, 1893, 1898, 1902, and 1908)

3.2.3 MRGCD Maps

The MRGCD maintains a set of maps for the portion of the Rio Grande Valley under jurisdiction of the conservancy district. The first set of MRGCD maps were published in 1926 and 1927. The maps of the project area were updated in the mid-1930’s as plans for the San Marcial Channel were being developed. No specific date was available for the update, but Mr. Doug Strech (2005), the Geographical Information Systems (GIS) Coordinator for MRGCD estimated that the update was performed in 1932, based on known dates for the planning stages. These maps were not updated again due to a shift of jurisdiction upon the establishment of the Bosque del

Apache National Wildlife Refuge in 1939.

A review of these historic maps for the project site show the town of Marcial located along the west side of the Rio Grande and approximately one mile north of the railroad bridge (Bridge No. 1006A). A review of the 1926 map shows that a large AT&SF Railroad maintenance facility was located in San Marcial. The facility included maintenance shops, a round house, offices and living quarters. The maintenance facility appears to be located adjacent to the west side of the Rio Grande, approximately one mile north of Bridge No. 1006A.

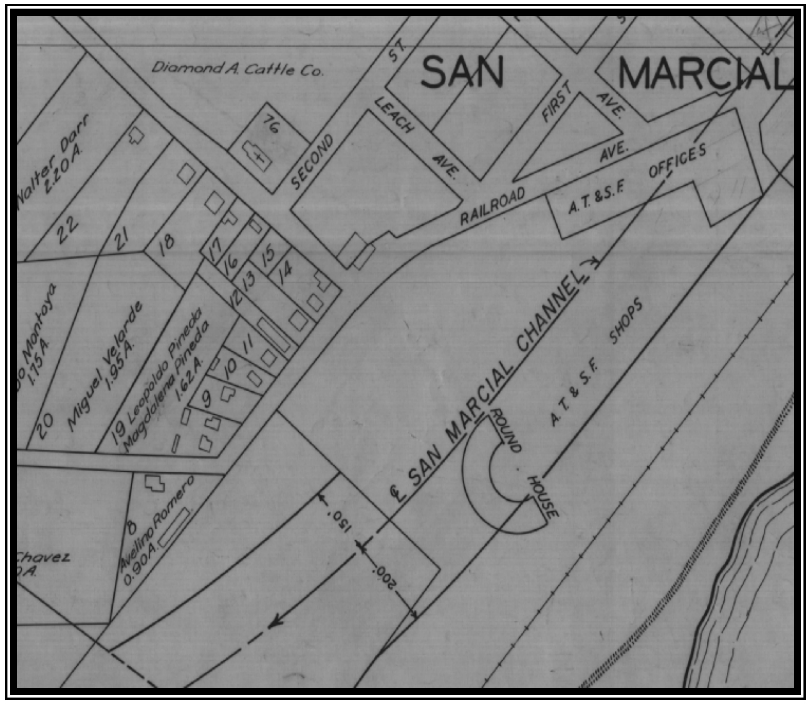

Figure 4 - 1926 MRGCD Map No. 187 (Revised mid-1930's)

When this map was revised in the mid-1930s during the planning stages of the San Marcial channel and the low flow conveyance channel. It indicates the centerline of the San Marcial channel to be immediately north of the roundhouse and maintenance shop facilities. The exact location of the AT&SF Railroad maintenance facility could not be determined using this map alone. Figure 16 in Appendix A shows the Figure 4 superimposed on a 1982 USGS 7.5 min topographic map of San Marcial, NM, providing an estimated location of the facilities. The MRGCD maps also show extensive development of properties along the west side of the Rio Grande extending into the planned Tiffany land acquisition area. Additional property development includes single-family homes, commercial/retail buildings and hotels.

Historic MRGCD maps showing the Rio Grande Valley north of San Marcial do not indicate significant change in land use from 1926 through the present. With the exception of the San Marcial area, properties along the Rio Grande appear to have remained undeveloped or used for agricultural purposes. The maps used to make these determinations are included in Appendix A and on the attached DVD-ROM.

3.2.4 Aerial Photographs

Aerial photographs were examined to assist in determining past and current uses of the property. The effectiveness of this technique depends on the scale and quality of the photographs and the available coverage. Readily available aerial photographs for this site were obtained from the Earth Data Analysis Center (EDAC) at UNM. The photographs reviewed were generally clear and of fair-to-good quality. Three sets of historical aerial photographs from 1935 (the earliest readily available) to 2004 (the latest available photograph) were reviewed to evaluate past land use at the site and in the surrounding area. The photos reviewed are summarized in the following paragraphs and selected aerial photographs are provided in Appendix B.

1935 Available 1935 photographs do not provide coverage of the entire project site. The portions of the site that were not available include an approximate six-mile area north of the San Antonio Bridge. A review of this series of photographs shows most of the property within the Rio Grande flood plain as undeveloped. Exceptions include isolated agricultural areas near Socorro, San Antonio and San Marcial. The adjacent photograph shows the remains of the San Marcial town site including the post-flood ruins of the AT&SF round house.

Figure 5 - 1935 Aerial Photo of San Marcial, NM

Figure 6 - 1953 Aerial Photo of Socorro area

1953 The 1953 photographic series shows low-density development of properties along the Rio Grande in the vicinity of San Acacia, Socorro and San Antonio. This development is mostly agricultural with associated access roads and widely spaced single-family homes. This series of photographs also shows that extensive flood control measures were in place along the river from San Acacia to San Marcial. Small diversion dams, levees and drainage channels were constructed prior to the date of these photographs.

1972 - 1973 Photographs taken in 1972 and 1973 show little change along the Rio Grande valley compared to the 1953 series of photographs. There is no evidence of extensive property development adjacent to the Rio Grande. The Nogal Arroyo outlet levees near Socorro appear to have been expanded with the construction of Interstate Highway 25 west of the property. The 1973 photographs show additional development of properties near the town of Socorro. This new development is confined to the Interstate 25 corridor and does not appear to have included property within the project limits.

Figure 7 - 1996 Aerial Photo of San Marcial

1996 The 1996 series of photographs show the Rio Grande Valley as it currently exists. No additional development along the Rio Grande was noted in these photographs. Most of the modern development appears to be taking place along the Interstate 25 corridor and not in the river valley.

The 1996 photograph of the San Marcial town site shows no remains or ruins of the former town. The town site appears to have been covered with silt and vegetation prior to the date of this photograph. Bridge No. 1006A and the rail siding, however, are visible in this photograph.

None of the photographs indicate any evidence of landfills, impoundments, pits, or quarries. Additional aerial photographs used to make this determination are included in Appendix D and on the attached DVD-ROM.

3.2.5 City Directories

A review of city directories for the project site revealed no listings for the property. These directories are available in the Special Collections Branch of the Albuquerque Public Library, and in Zimmerman Library, Southwest Collections at UNM.

3.3 Environmental Database Review

Regulatory databases were reviewed as part of this assessment. An EDR Site Assessment Report was obtained on August 4, 2005. This report, presented in Appendix C, contains the following information sources:

- CERCLIS - Comprehensive Environmental Response, Compensation, and Liability Information System
- CERCLIS NFRAP – Comprehensive Environmental Response, Compensation, and Liability Information System No Further Action Planned
- CONSENT - Superfund (CERCLA) Consent Decrees
- CORRACTS - Corrective Action Report
- ERNS - Emergency Response Notification System
- FINDS - Facility Index System
- HMIRS - Hazardous Materials Information Reporting System
- MLTS - Material Licensing Tracking System
- NPL - National Priority List
- Delisted NPL - NPL Deletions
- NPL Lien - Federal Superfund Liens
- PADS - PCB Activity Database System
- RAATS - RCRA Administrative Action Tracking System
- RCRIS SQG - Resource Conservation and Recovery Information System Small Quantity Generator
- RCRIS LQG - Resource Conservation and Recovery Information System Large Quantity Generator
- RCRIS-TSD - Resource Conservation and Recovery Information System Transportation, Storage, Disposal Facility
- ROD - Records of Decision
- SHWS - State Hazardous Waste Sites
- SWF/LF - Solid Waste Facilities / Landfills
- TRIS - Toxic Chemical Release Inventory System
- TSCA - Toxic Substances Control Act

Minimum database search distances utilized for this ESA meet or exceed the standards outlined in ASTM E 1527-00 as summarized in Table 1.

TABLE 1: Records Search Distances

RECORD	ASTM MINIMUM SEARCH DISTANCE (miles)	ECHOTA SEARCH DISTANCE (miles)
Federal NPL Site List	1.0	1.00
Federal CERCLIS List	0.5	0.50
Federal RCRA Corrective Action List	1.0	1.00
Federal RCRA TSD Facilities List	0.5	0.50
Federal RCRA Generators List	Property/adjoining property.	0.25
Federal ERNS List	Property only	0.50
State Leaking UST List	0.5	0.50
State Registered UST List	Property/adjoining property.	0.25
State Hazardous Waste Investigation and/or Remediation	1.0	1.00
State Solid Waste Disposal Site List	0.5	0.50

Pertinent information included in the EDR report is summarized in the following sections.

3.3.1 CERCLIS/NPL

The US EPA maintains the CERCLIS/NPL compilation of sites that (1) meet or exceed a predetermined hazard ranking system score, (2) are chosen as top priority sites by the state, or (3) meet specific criteria established by the U.S. Department of Health and Human Services (DHHS) jointly with the US EPA. These sites are identified for priority remedial action under the Federal Superfund program.

The project site was not on this list and there are no NPL sites listed within one mile of the site.

3.3.2 RCRA CORRACTS Facilities

The RCRA CORRACTS Facilities are facilities that treat, store, and dispose of hazardous waste, and that have been subject to a corrective action by the US EPA in the past.

The site was not listed in the EDR report as a RCRA CORRACTS site.

3.3.3 RCRA Treatment, Storage, and Disposal Facilities

The EPA maintains a database of all RCRA-regulated TSD facilities in the United States. RCRA-regulated facilities are those that treat, store, dispose of, or transport hazardous wastes.

The site was not listed in the EDR report as a RCRA TSD site and no RCRA TSD sites are listed within the search distance.

3.3.4 Emergency Response Notification System /RCRA Generators

The ERNS database contains information from spill reports made to the EPA, the U.S. Coast Guard, the National Response Center, and the U.S. Department of Transportation.

The site was not listed in the EDR report as an ERNS site and the site was not listed in the EDR report as a RCRA generator.

3.3.5 Underground Storage Tanks/Leaking Underground Storage Tanks

NMED PSTB maintains a list of sites where releases of petroleum products have occurred from USTs. The property is not listed as a current UST facility.

Although no UST facilities or LUST facilities were identified in the EDR Report, two LUST facilities were identified on the NMED PSTB historic list included in Appendix E. Both facilities were owned and operated by the USBR and are described below:

- San Acacia Bureau of Reclamation Yard - Located 0.15-mile west of San Acacia Diversion dam near the west perimeter of the project limits, this facility was removed in 1991 and a release was reported at the time of removal. According to information contained in the NMED PSTB list of former LUST sites (NMED PSTB, 2005 [2 references]), there is no evidence that a release of product from these facilities has impacted the environment within the project site.

- San Marcial Bureau of Reclamation Yard - Located 0.49-mile north/northwest of the low flow conveyance channel near the Tiffany area, this facility was removed in 1991 and a release was reported at the time of removal. According to information contained in the NMED PSTB list of former LUST sites (NMED PSTB, 2005 [2 references]), there is no evidence that a release of product from these facilities has impacted the environment within the project site.

If additional regulatory information is desired for these sites, a lead-time of approximately ninety days is required for State personnel at the PSTB to extract it from archived records.

3.3.6 Landfills/Solid Waste Disposal Facilities

According to the EDR report, there are no permitted or listed landfills or specified solid waste disposal facilities within the 0.5-mile search distance from the site.

3.3.7 Other Facilities

3.3.7.1 Formerly Used Defense Sites (FUDS)

According to the EDR database, there is one FUDS, EPA ID No. 1007212188, identified as “Kirtland AFB PBR 19 TRGT S-6” located near the project site. Information provided by EDR indicates that this site is located in San Acacia and is currently being investigated by the USACE-Albuquerque District. Additional information supplied by the Albuquerque District indicates that the site was a former bombing target for the former Kirtland Army Airfield, identified as “S6-PBR-19”. This site is located 10.8 miles northwest of San Acacia, with the closest point at 7.8 miles from the site vicinity.

3.3.7.2 Orphan Sites

The EDR Database Report listed 10 orphan sites, of which two are also referred to as LUST sites and are addressed previously in Section 3.3.5 of this report. The remaining eight orphan sites are located outside of the project site.

3.4 Prior Assessment Reports

No prior ESA reports were identified during this study.

An archeological report prepared by Ms. Karen Van Citters with Van Citters Historic Preservation LLC., was made available from the University Of New Mexico Office Of Contract Archeology. According to this report, San Marcial was founded in 1854 and experienced extensive growth in the 1880s with the establishment of a major railroad facility. AT&SF Railroad constructed and operated a repair shop and roundhouse in San Marcial from about 1880 to 1929 when the site was abandon. Successive floods from 1929 through the 1950s have covered most of the former town site, including the railroad facilities, with approximately 30 feet of sediment. Presently, there are no indications of former structures on the surface in the vicinity of Bridge 1006A. Aerial photographs in Appendix B and Figure 16 provide the best location information currently available.

Fig. 8-1929 Photo of Round House at San Marcial

Figure 9 - 1929 Photo of San Marcial Main Street

4.0 INTERVIEWS

Interviews were conducted, as appropriate, with local residents, property owners, workers, and public agencies. The intent of interviews was to gain information regarding current and past land use, potential contamination, and any history of HTRW use or releases. Results of these interviews are presented below.

<u>Mr. Bob Miller, NMED PSTB, Phone: (505) 462-3597</u>, was interviewed by telephone concerning the USBR sites on or near the project site. According to Mr. Miller, the PSTB no longer has records of the removal of the USTs on the Bureau of Reclamation sites. Mr. Miller further stated that he was not aware of any LUST sites located on or near the project site.

<u>Mr. Chris Gorbach, USBR, Phone: (505) 462-3553</u>, was interviewed by telephone concerning the underground fuel tanks formerly located at the San Acacia and San Marcial sites. According to Mr. Gorbach, USTs were removed from both locations in about 1991. However, Mr. Gorbach stated that at this time, there are no records on file that would indicate the condition of the removed tanks or if there was any indication of a release at either site.

Mr. Doug Strech, MRGCD GIS Coordinator Phone: (505) 565-8453, was interviewed in person concerning historic land use on the project site. According to Mr. Strech, there has been no development of properties along the Rio Grande Valley in the vicinity of the project site that would be classified as industrial or large-scale commercial projects. Mr. Strech stated that the only portion of the property that was developed for industrial/commercial uses was the former town of San Marcial. Mr. Strech provided historic MRGCD land use maps for the entire project site including the San Marcial and Tiffany areas.

Mr. Rob Larner, BNSF Railroad, Phone: (505) , was interviewed by telephone concerning possible environmental issues associated with current and past operations of the BNSF Railroad. According to Mr. Larner, there are no records of reportable spills or releases associated with either the BNSF or AT&SF Railroads. Mr. Larner also stated that the BNSF Railroad does not currently operate UST facilities within the project limits. In addition, Mr. Larner stated that he was not aware of any HTRW in the vicinity of the project site.

Mr. John Schelberg, USACE Albuquerque District, Archeologist, Phone: (505) 342-3359, was interviewed by telephone concerning possible environmental issues within the project limits. According to Mr. Schelberg no HTRW were encountered during the recently complete archeological survey of the project site.

Ms. Karen Van Citters, CSI, CDT, Van Citters Historic Preservation, LLC, Phone: (505) 268-1324, was interviewed by telephone concerning historic land use on the project site. According to Ms. Van Citters, operations at the former railroad maintenance facility likely included the use of petroleum products and lubricants. Ms. Van Citters further stated that, historically, if a roundhouse was included with railroad maintenance facilities, usually extensive overhauling and rebuilding operations were conducted at the facility. Ms. Van Citters also provided several circa 1920 photographs of the railroad facility.

Figure 10 - 1929 Photo of Round House

Mr. Tony Hernandez, BNSF line maintenance, Phone: (505) 864-5114, was interviewed in person at the time of our site reconnaissance. Mr. Hernandez stated that he has been in charge of the Bridge No. 1006A and San Marcial section of trestle for approximately 20 years. According to Mr. Hernandez, portions of the former roundhouse were visible on the surface until about 1990. After 1990 the vicinity was overgrown with Russian Olive and Salt Cedar trees and was no longer visible. Mr. Hernandez identified the location of the roundhouse during our site visit.

Figure 11 – Location identified as Roundhouse

5.0 SITE RECONNAISSANCE

A site reconnaissance of the project corridor was completed on July 20, and August 8, 2005. Personnel included Mr. Tony Apodaca with the USACE, Mr. Darrell Nicholas with Echota and Mr. James Criss with AMEC, subcontracted to Echota. The site visit consisted of traverses along the perimeter and interior portions of the project site in addition to a visual survey of adjacent sites and properties in the site vicinity. The intent of the site reconnaissance was to visually observe any indication of the potential presence of HTRW. The reconnaissance was non-intrusive. Results are discussed in the following paragraphs.

Figure 12 - San Acacia Diversion Works (8/05)

At the time of our site reconnaissance the property was mostly undeveloped with isolated areas of irrigated farmland. The undeveloped area consists of riparian woodlands and isolated wetlands. Developed sections of the property consist of flood control structures including the San Acacia Diversion, numerous levees, and drainage canals. Other developed areas include widely scattered single-family homes associated with farms or ranches usually located on or near the terraces. The USBR is currently improving the low flow conveyance channel in a section between Socorro and San Acacia. Improvements include construction of a new channel in sections adjacent to the existing channel and replacing tracts of Salt Cedar with native trees and shrubs. The construction yards associated with this project appear to be organized and well maintained with no evidence of improper environmental practices.

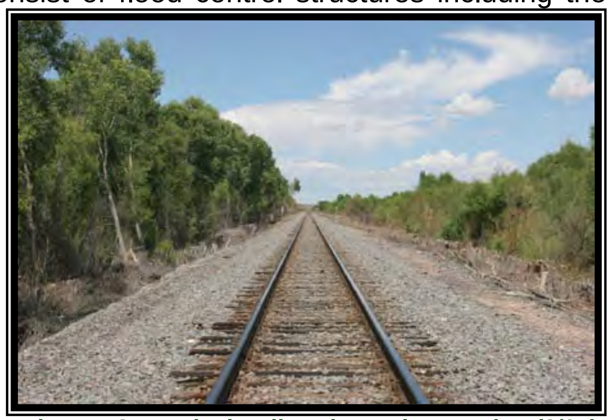

Figure 13 - Typical Railroad Trestle Location (8/05)

A visual survey of the BNSF Railroad trestle located along most of the project area did not indicate the improper use of HTRW associated with present day rail traffic. There was no evidence of USTs, dumpsites or spills along the railroad.

A visual survey of the Tiffany Land Acquisition area and the proposed new railroad alignment did not indicate the improper use of HTRW or the existence of dumpsites in this section of the project area. Dense Salt Cedar and Cottonwood trees cover most of the Tiffany area. A complete visual survey of the Tiffany Area was impractical at this time due to dense vegetation.

Figure 14 - Tiffany land Acquisition Area (8/05)

Adjacent properties along the east side of the

Rio Grande are not developed and there is no indication of historical development of these properties. Adjacent property to the west is developed near the Interstate 25 corridor and near towns and villages such as Socorro and San Antonio. There was no evidence of HTRW in this portion of the project site.

The following general observations were noted during the site reconnaissance:

- There was no observed HTRW on the site
- There was no observed underground or aboveground storage tanks
- There was no observed large capacity containers or drums on the site
- There was no observed evidence of improper waste disposal practices
- There was no observed evidence of solid waste disposal on the property
- There was no observed evidence of pits, ponds, lagoons, or effluent disposal systems
- There was no observed evidence of chemical spills
- There was no observed evidence of discolored or stained soils
- There was no observed evidence of dry wells on the site

Additional photographs taken during the site reconnaissance are provided in Figure 27, Appendix D. Additional photographs not included in the report are provided on the enclosed DVD-ROM.

6.0 FINDINGS AND CONCLUSIONS

We have performed a Phase I Environmental Site Assessment in conformance with the scope and limitations of ASTM Standard E 1527-2000 of the project site. Any exceptions to, or deletions from, this practice are described in Section 1.3 of this report. This assessment has revealed no evidence of recognized environmental conditions in connections with the property except for the following:

1. No evidence of HTRW or other recognized environmental conditions or CERCLA 120(h) concerns were identified on this property.

2. A review of historical information indicates that the town site of San Marcial was formerly developed with industrial facilities associated with the railroad. Although physical evidence of the facilities is not available, historical records suggest that the roundhouse and maintenance shops were abandoned in place in 1929 and have since been covered by approximately 30 feet of silt and mud. It is possible that historic use of this site has environmentally impacted the property in the past. However, the proximity of the river and San Marcial channel combined with a shallow water table would result in flushing and biodegradation of most HTRW that was likely to have been present. At this time there is no evidence that indicates these facilities have adversely impacted the project site.

3. According to information provided by the NMED PSTB, two LUST facilities were removed from USBR properties on or adjacent to the project area. According to available records from there is no evidence that a release of product from these facilities has impacted the environment within the project site. However, the magnitude of a past release or impact to the soil and groundwater beneath these sites is not specified. The report in Appendix E gives some indication that both facilities were investigated in 1991 when the UST facilities were decommissioned. The findings of this report indicate that as of 1993, “no further action [is] required”. Additional regulatory information about these

sites can be obtained through the PSTB and possibly the USBR.

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8.0 QUALIFICATIONS OF REPORT PREPARER

Mr. James E. Criss prepared this report. His qualifications include the following:

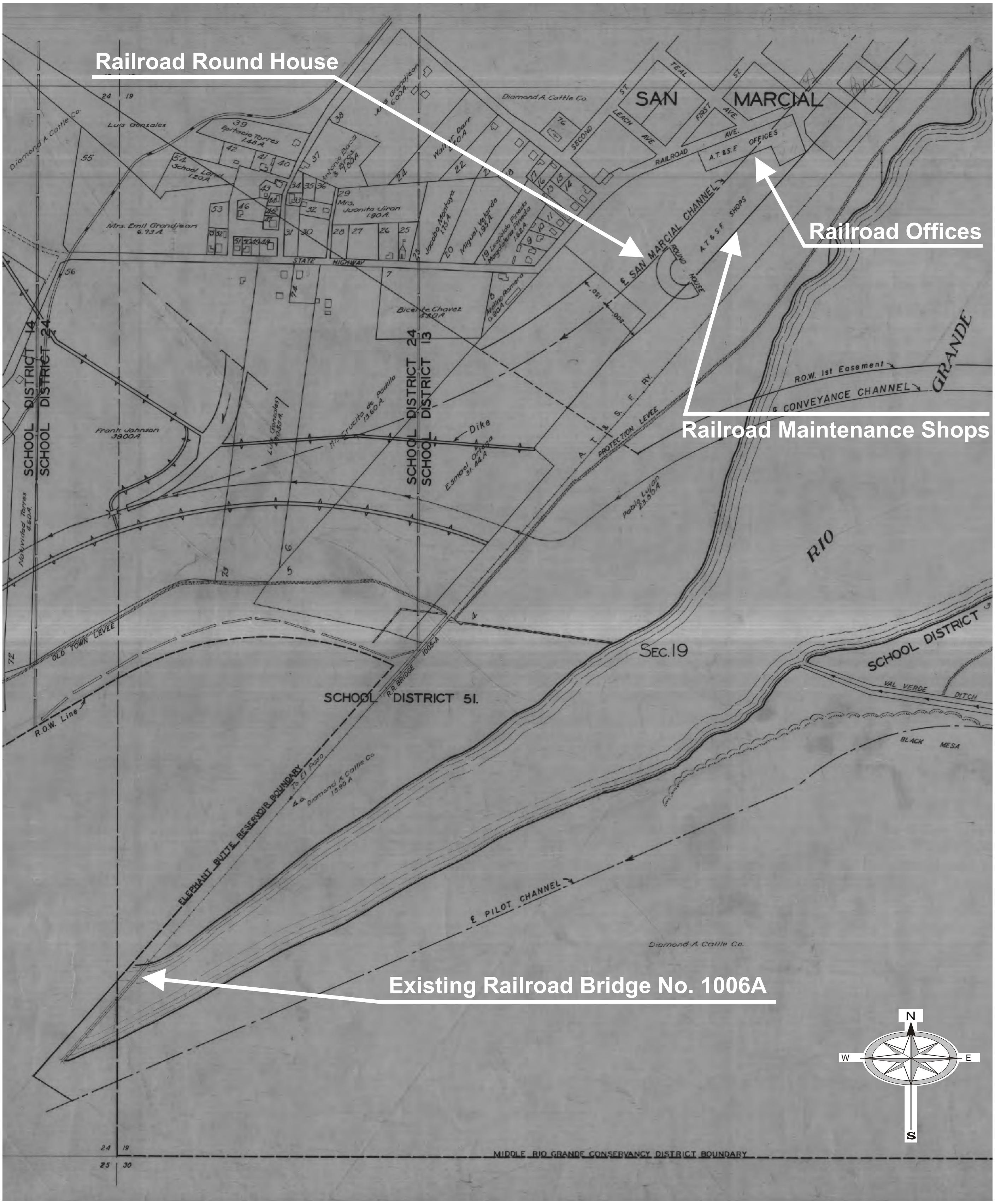
- Bachelor of Science in Environmental Studies from the University of New Mexico 1984.
- Certificate in Hazardous Materials Management from BLM National Training Center Environmental Site Assessment Training from Government Institutes.
- Completion of over 300 Phase I and II Site Investigations and Phase III Remedial Actions.

9.0 APPROVALS

Prepared By	
Name: James E. Criss	Date: September 1, 2005
Signature: /s/	Title: Environmental Specialist
Reviewed By	
Name: Michael Schulz, PMP	Date: September 1, 2005
Signature: /s/	Title: Senior Scientist
Approved By	
Name: Darrell Nicholas, P.E.	Date: September 1, 2005
Signature: /s/	Title: Project Manager

APPENDIX A

Site Maps



1926 MRGCD Land Use Map No. 187, Provided by MRGCD GIS Section, ABQ Office

Photograph Provided By: MRGCD Albuquerque Office

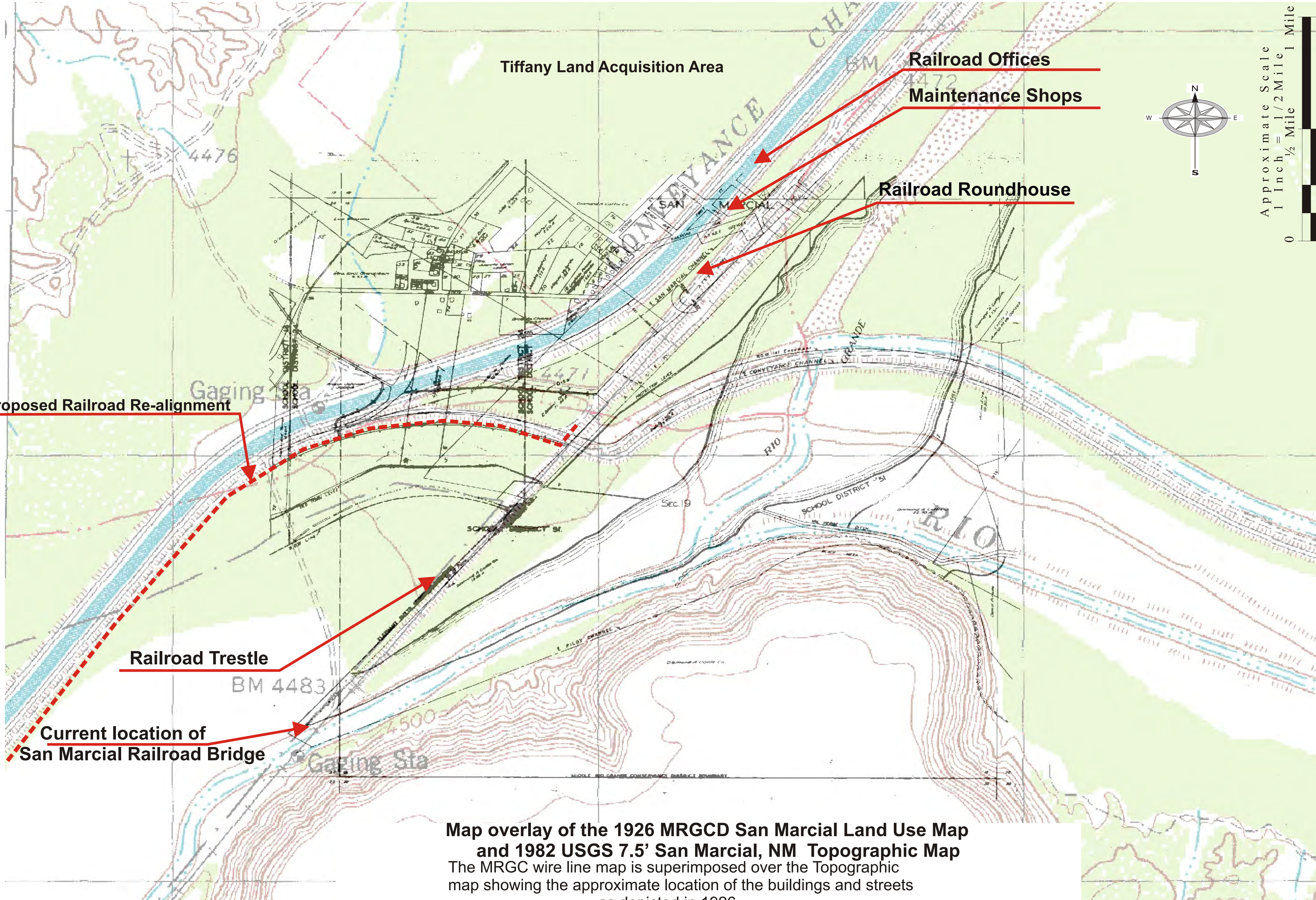
Drawn by: JC: File P:\consulting\05\5517000130\graphx\1926sanmarcial.cdr 08-18-05

Prepared For
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Figure 15 - Historic Land use Map: San Marcial, NM

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

Prepared by
Echota Technologies Corporation



Map overlay of the 1926 MRGCD San Marcial Land Use Map and 1982 USGS 7.5' San Marcial, NM Topographic Map

The MRGC wire line map is superimposed over the Topographic map showing the approximate location of the buildings and streets as depicted in 1926.

Prepared For:
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

US Army Corps of Engineers

Drawn by: JC: File P:\consulting\05\5517000130\graphx\Overlay-7.cdr 08-18-05

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Echota Technologies Corporation
372 S. Washington Street
Maryville, Tennessee

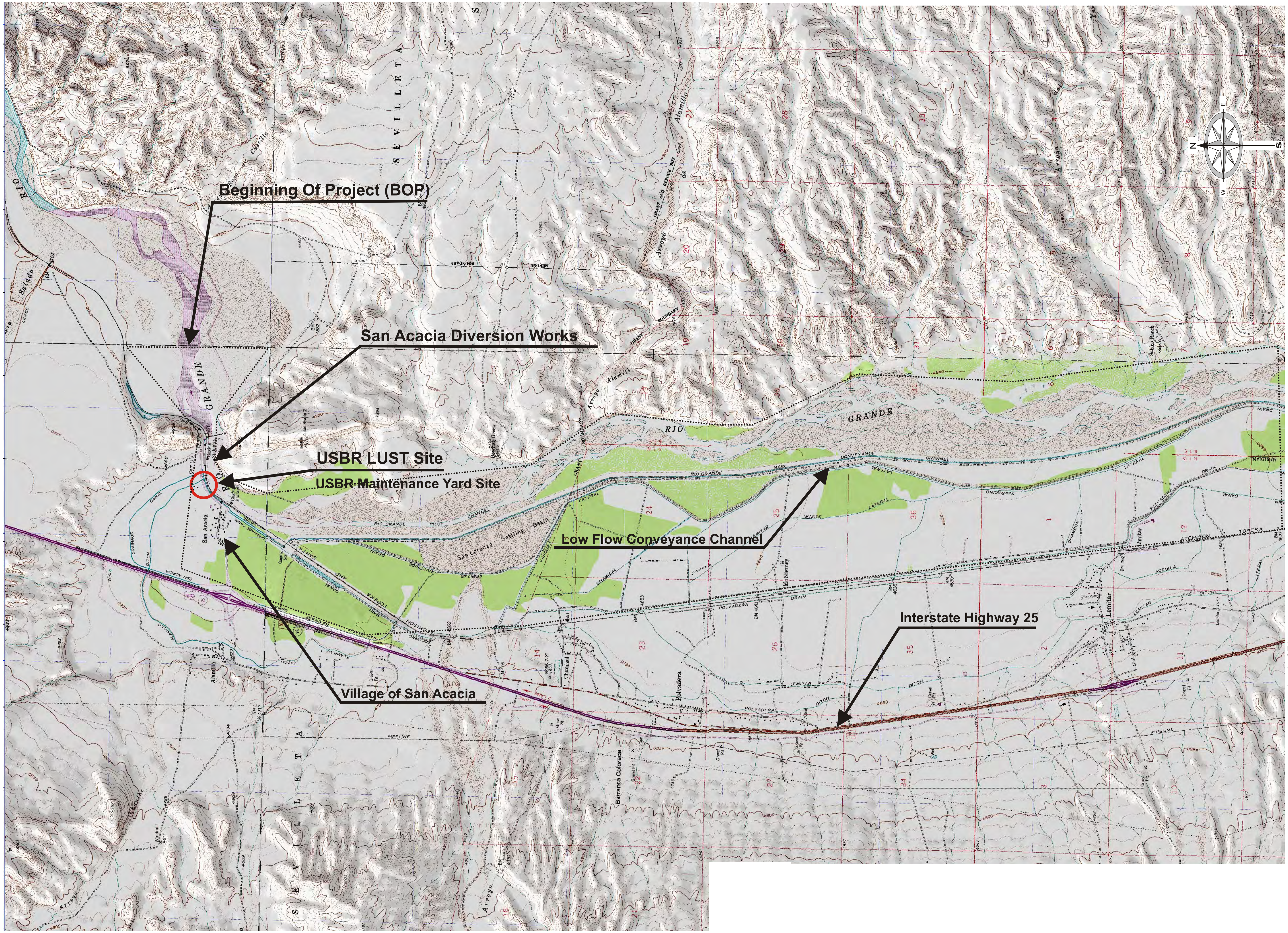
amec

Echota Technologies

Figure 16 - MRGCD Land Use Map Overlay of Topographic Map

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

Page A-2



Continued on Figure 18

USGS 7.5' San acacia, NM Photo revised 1971

Approximate Scale
1 Inch = 1 Mile
0 1 Mile 2 Miles

Note: All boundaries and locations are approximate

Figure 17 - Topographic Map

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico
Project No. 6002-02

Page A-3

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Prepared For:
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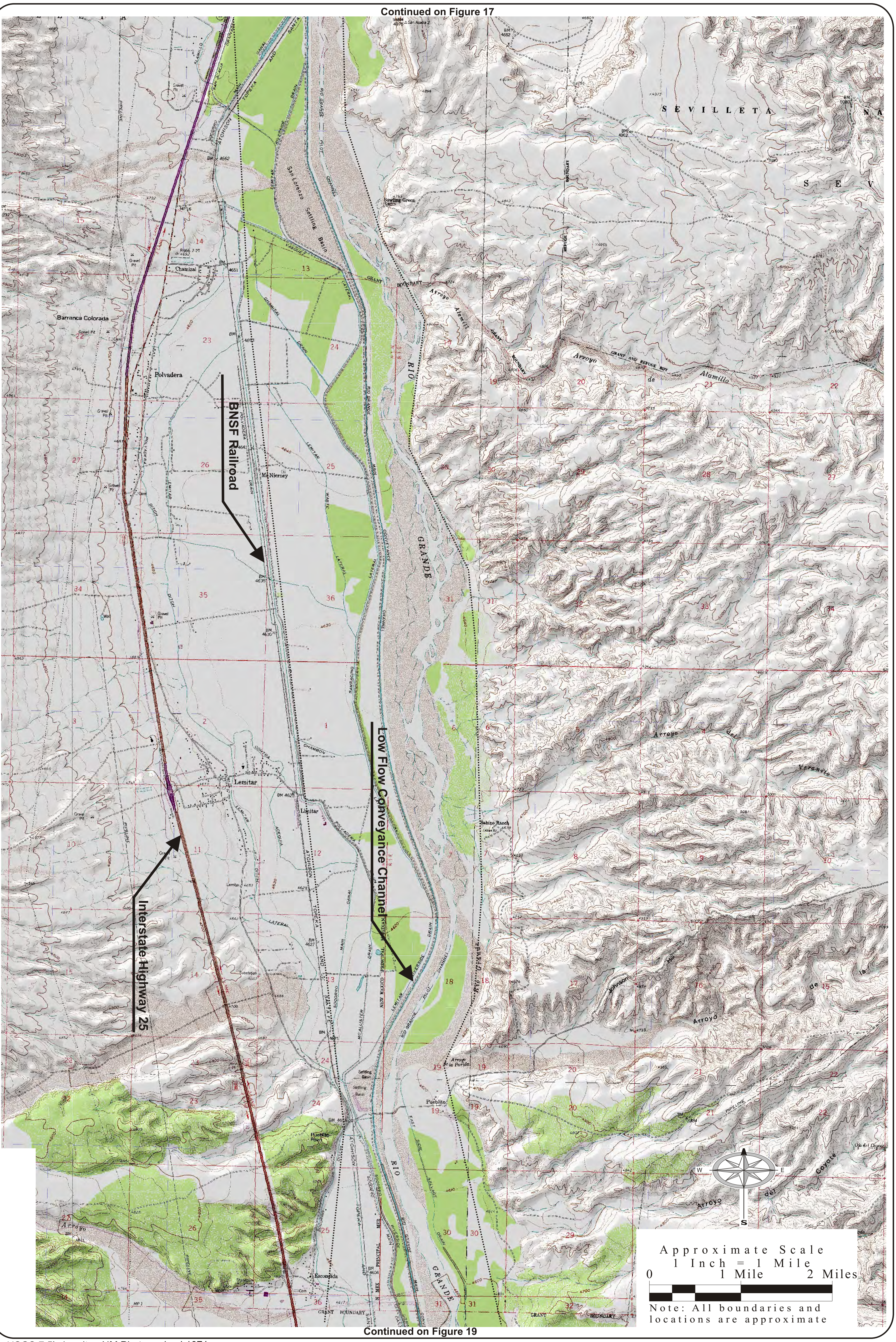
Contract No. W912PP-05-T-0043

Drawn by: JC: File P:\consulting\05\5517000130\graphx\Topo-1.cdr 08-18-05

Continued on Figure 17



Continued on Figure 19

USGS 7.5', Lemitar, NM Photo revised 1971

Figure 18 - Topographic Map

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico
Project No. 6002-02

Page A-4

Prepared by:
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Maryville, Tennessee

Prepared For:
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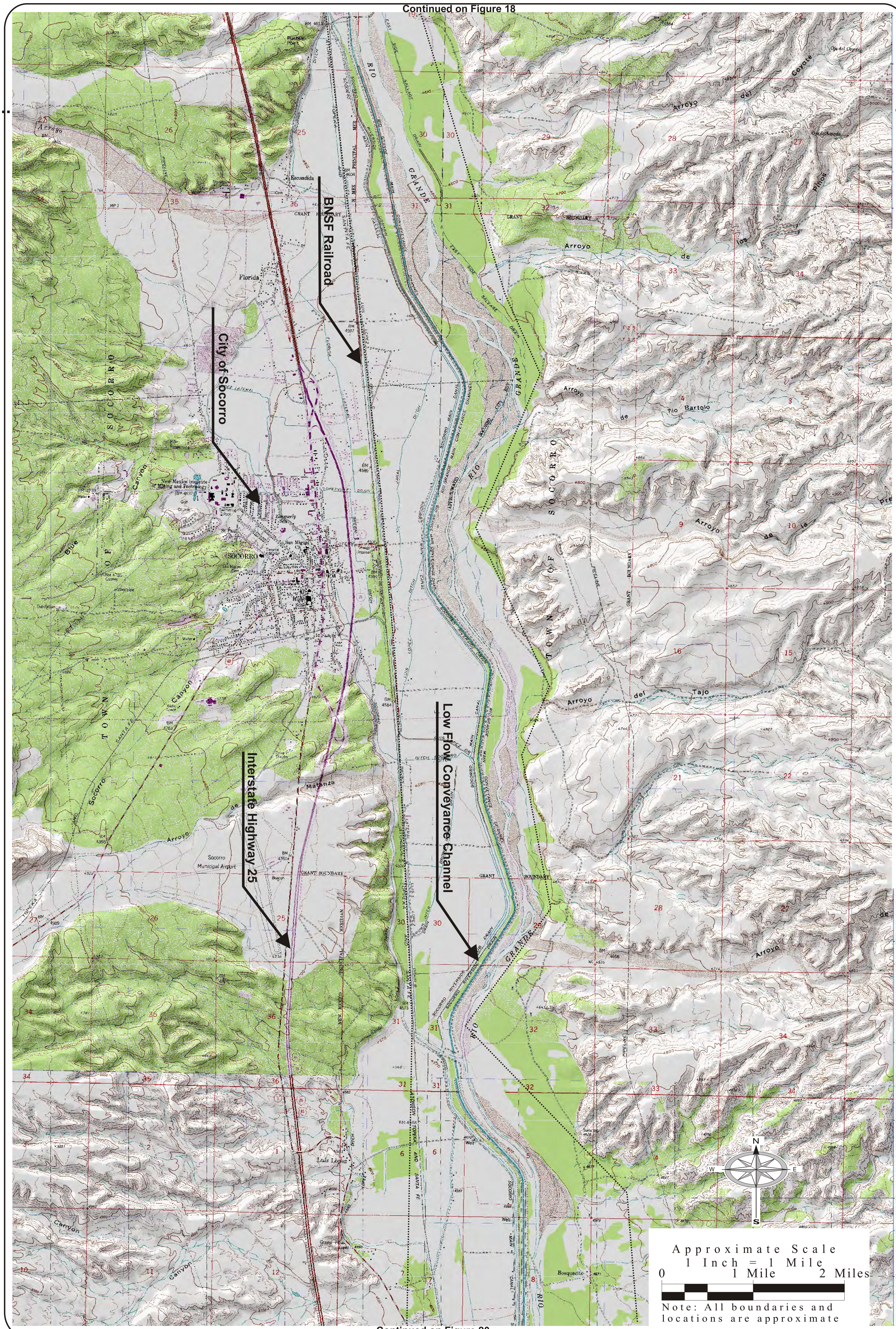
Albuquerque District
Contract No. W912PP-05-T-0043

Drawn by: JC: File P:\consulting\05\5517000130\graphx\Topo-2.cdr 08-18-05

Continued on Figure 18



Continued on Figure 20

USGS 7.5', Socorro, NM Photo revised 1979

Figure 19 - Topographic Map

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico
Project No. 6002-02

Page A-5

Prepared by:
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Prepared For:
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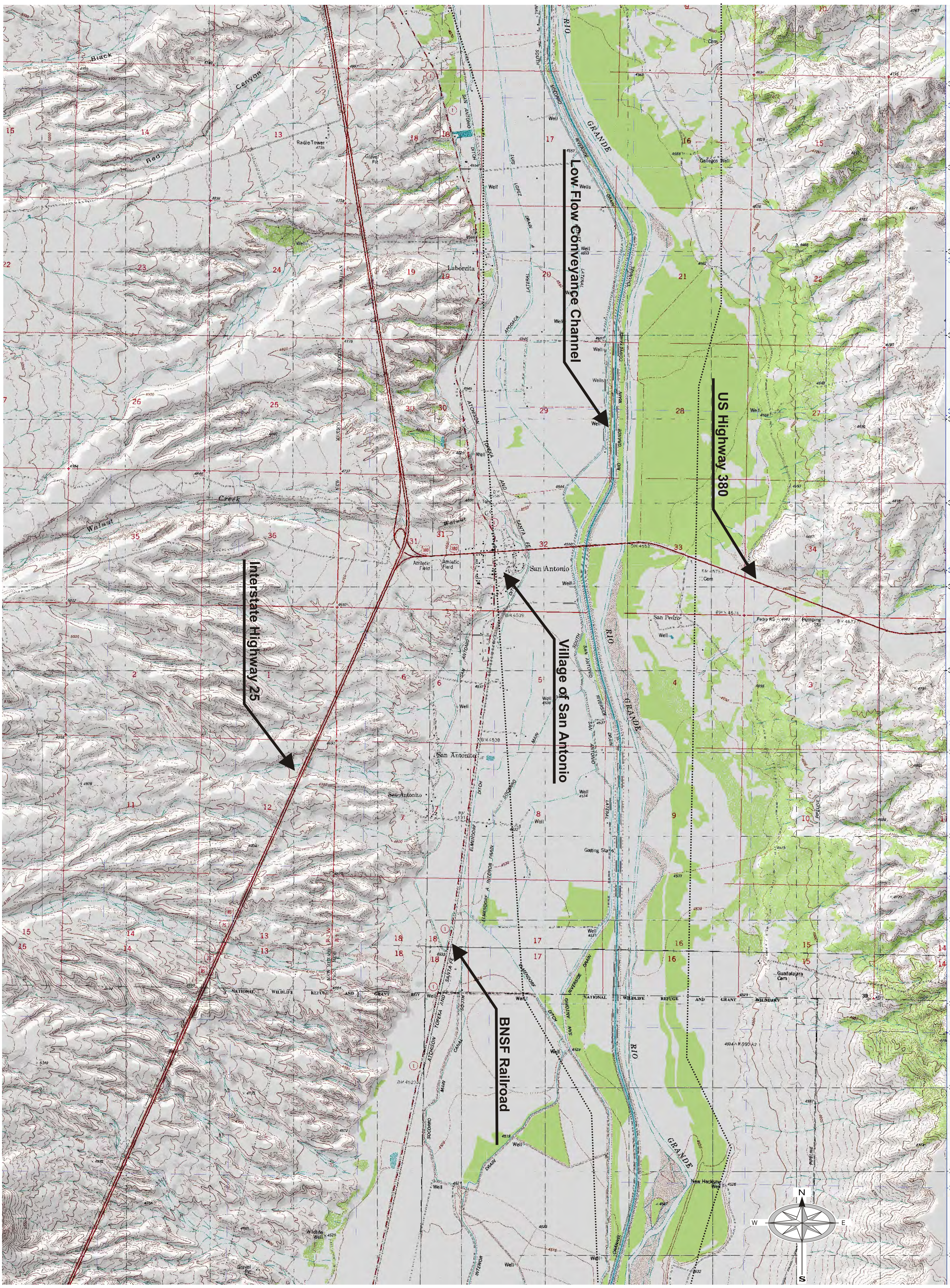
Albuquerque District
Contract No. W912PP-05-T-0043

Drawn by: JC: File P:\consulting\05\5517000130\graphx\Topo-3.cdr 08-18-05

Continued on Figure 19



Continued on Figure 21

Approximate Scale
1 Inch = 1 mile
0 1 Mile 2 Miles

Note: All boundaries and locations are approximate

USGS 7.5', San Antonio, NM Photo revised 1981

Figure 20 - Topographic Map

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico
Project No. 6002-02

Page A-6

Prepared by:
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Prepared For:
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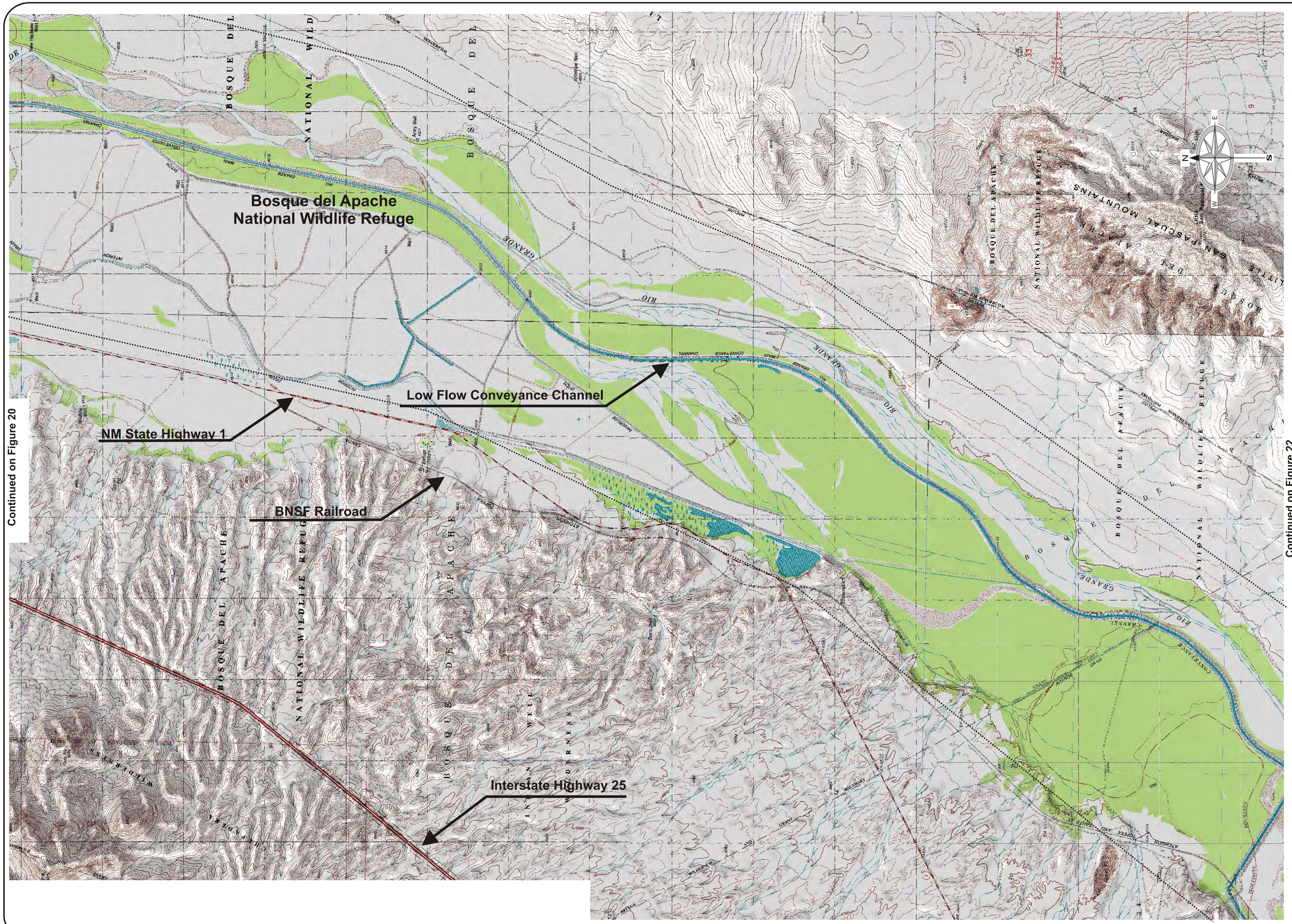
Albuquerque District
Contract No. W912PP-05-T-0043

Drawn by: JC: File P:\consulting\05\5517000130\graphx\Topo-4.cdr 08-18-05



Continued on Figure 20

Continued on Figure 22

USGS 7.5', San Antonio SE, NM Photo revised 1982

Figure 21 - Topographic Map

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico
Project No. 6002-02

Page A-7

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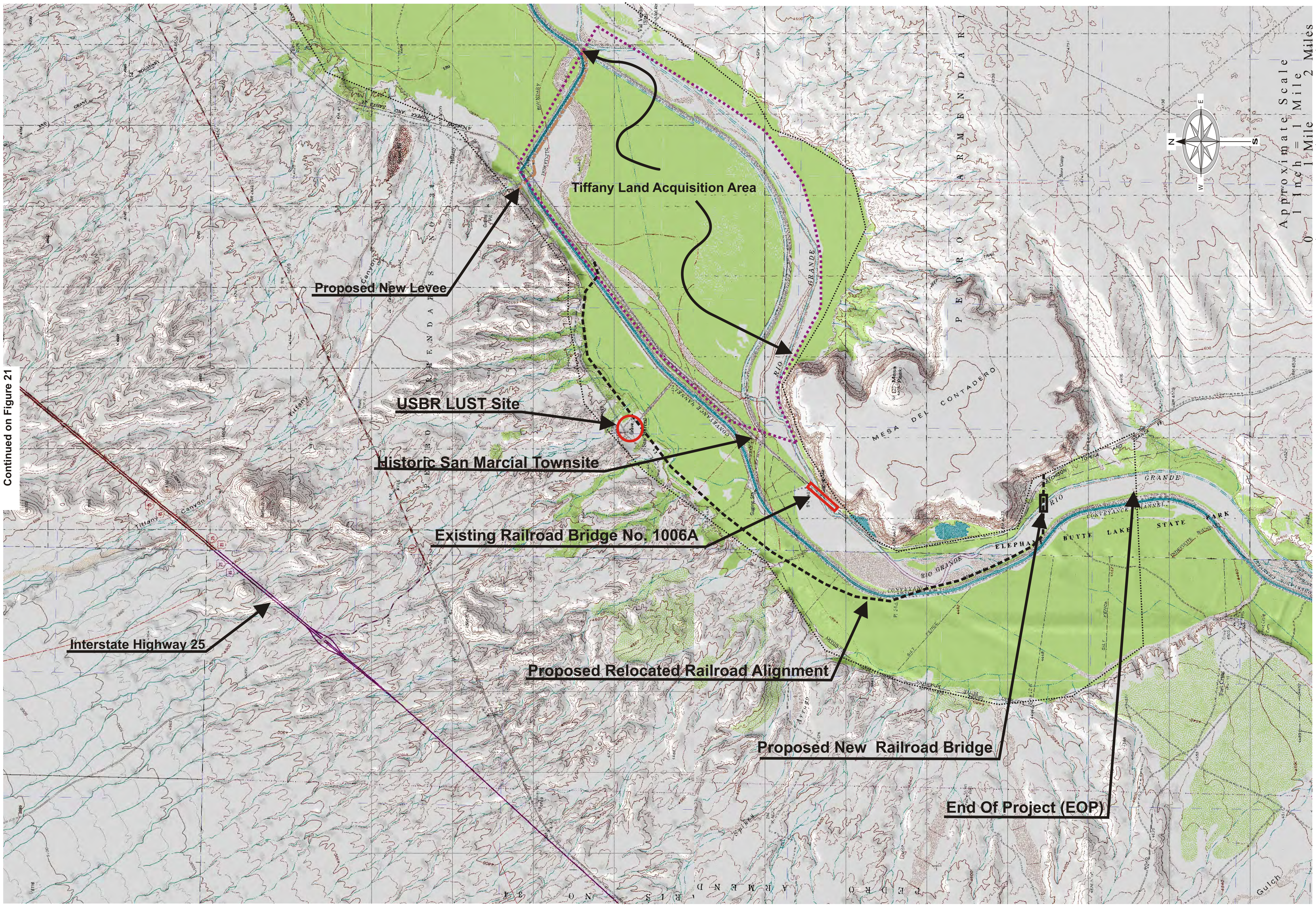
Contract No. W912PP-05-T-0043

Drawn by: JC: File P:\consulting\05\5517000130\graphx\Topo-5.cdr 08-18-05



Continued on Figure 21

USGS 7.5', San Marcial, NM Photo revised 1982

Figure 22 - Topographic Map

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico
Project No. 6002-02

Page A-8

Prepared by:
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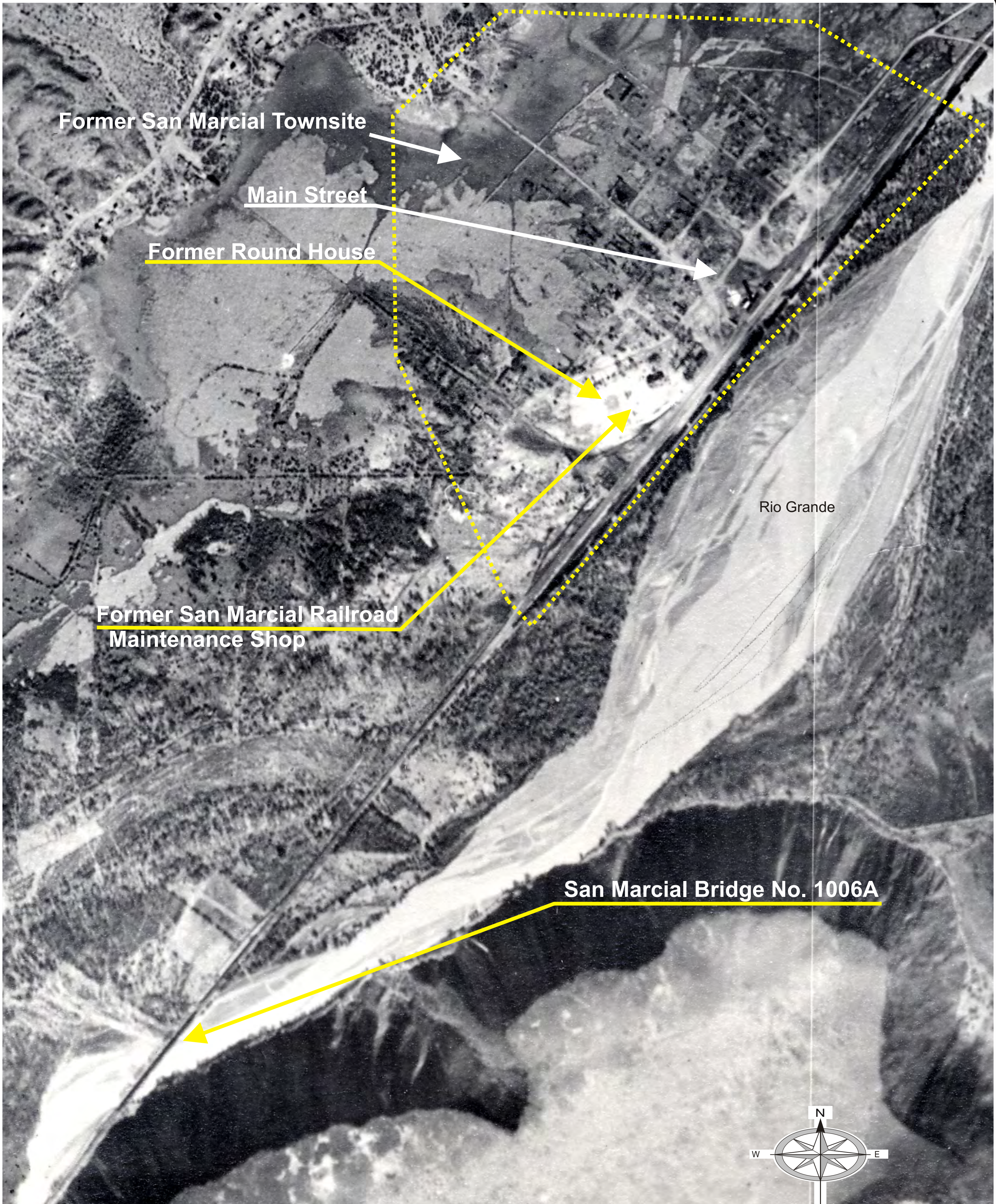
Prepared For:
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Drawn by: JC; File P:\consulting\05\551700130\graphx\location-workplan.cdr 08-03-05

APPENDIX B

Aerial Photographs



FLIGHT DATE: 1935:
PHOTOGRAPH PROVED BY: UNM-EDAC

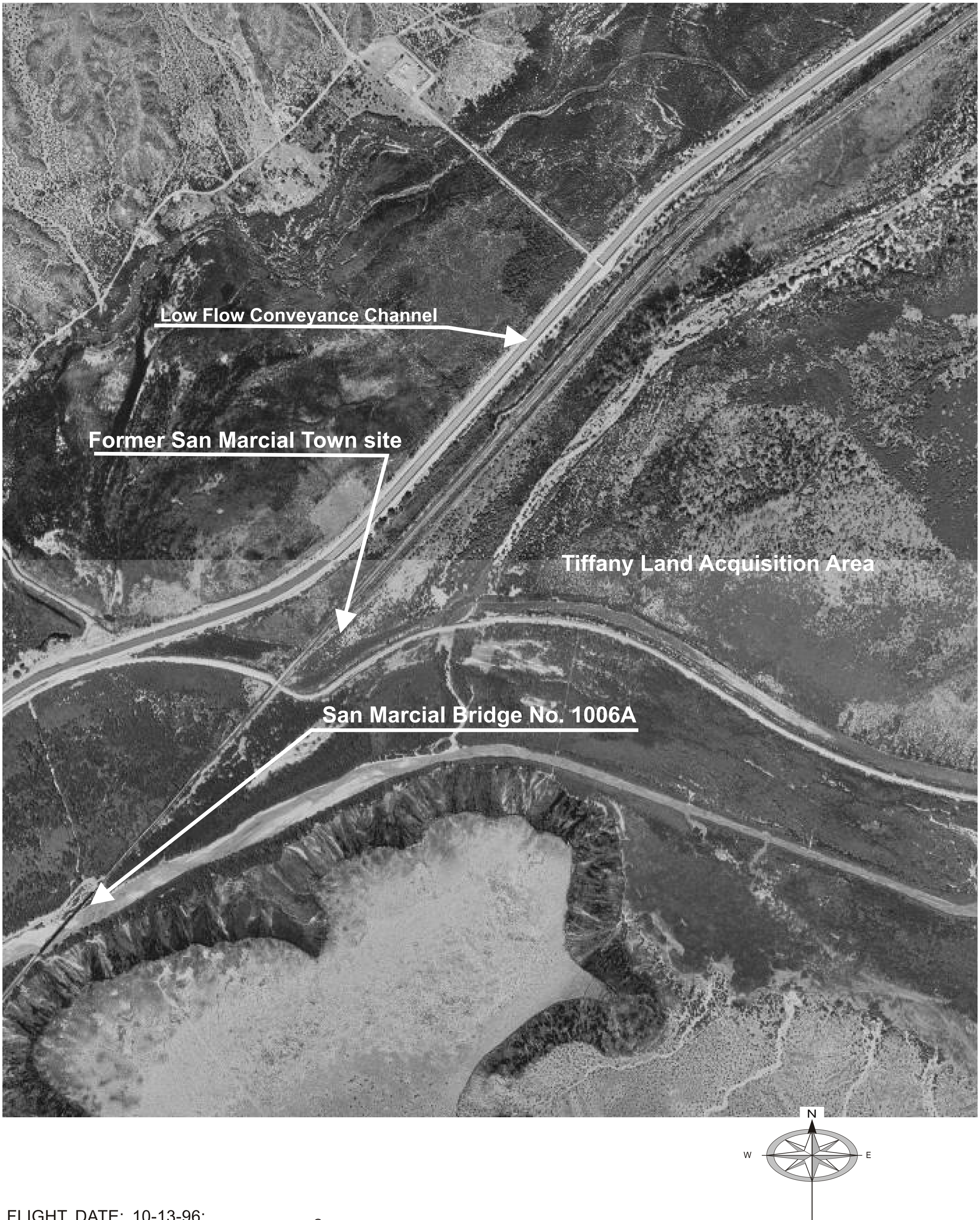
Drawn by: JC: File P:\consulting\05\5517000130\graphx\1935aerial.cdr 08-18-05

Prepared For
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Figure 23 - 1935 AERIAL PHOTOGRAPH OF SAN MARCIAL

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

Prepared by
Echota Technologies Corporation



FLIGHT DATE: 10-13-96:
PHOTOGRAPH PROVED BY Microsoft® Terraserver

Prepared For
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Albuquerque District
Contract No. W912PP-05-T-0043

Figure 24 - 1996 AERIAL PHOTOGRAPH OF SAN MARCIAL

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

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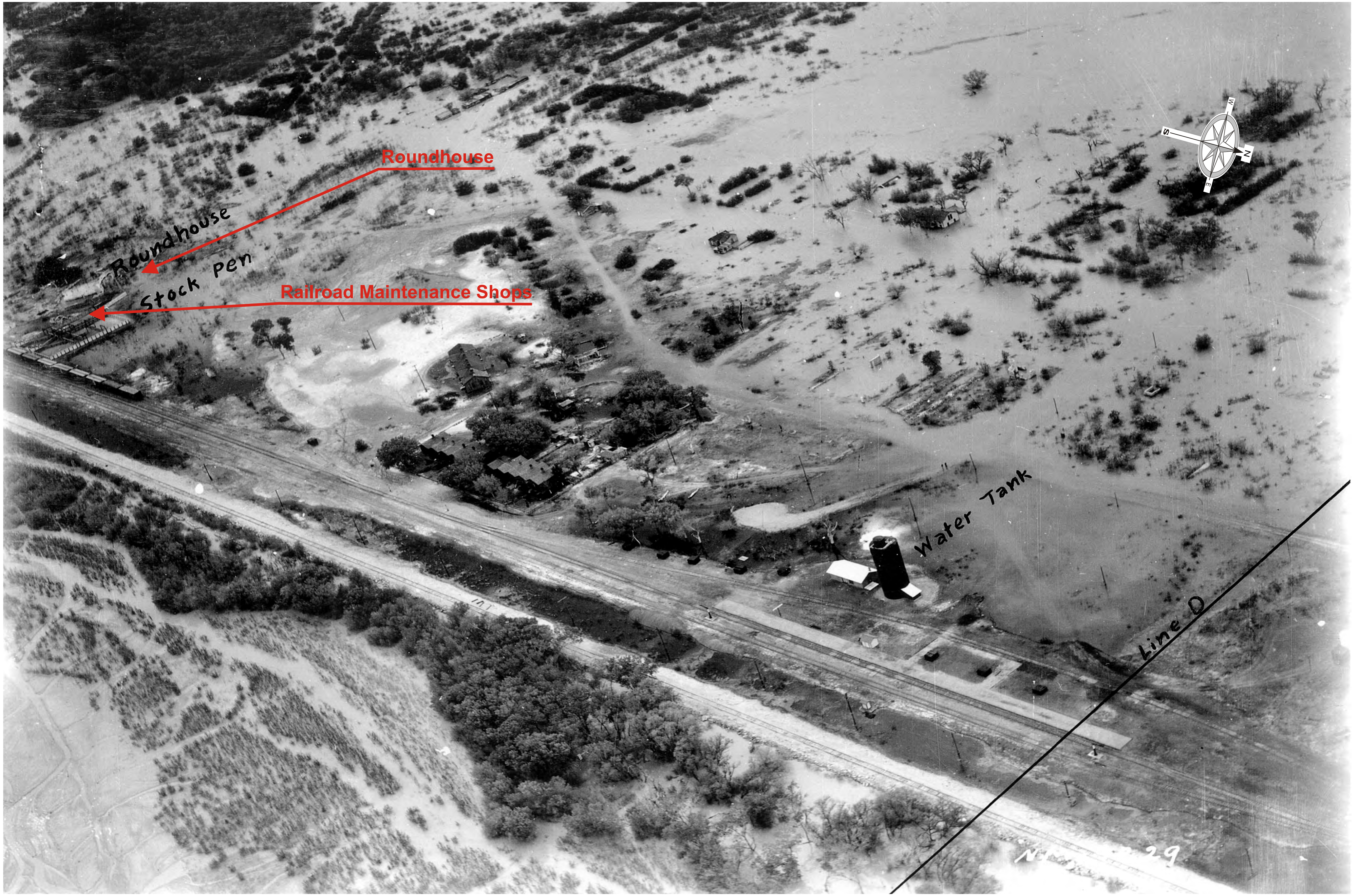

Prepared For:
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Prepared by:
Echota Technologies Corporation
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Maryville, Tennessee

Figure 25 - 1936 Photograph of San Marcial

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico
Project No. 6002-02

Page B-3

Drawn by: JC: File P:\consulting\05\5517000130\graphx\1936 Photo.cdr 08-18-05

APPENDIX C

Environmental Data Resources Data Base Review Report

EDR® Environmental Data Resources Inc

EDR DataMap™ Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache
Socorro, NM

August 04, 2005

Inquiry number 01479183.1r

The Standard in Environmental Risk Management Information

440 Wheelers Farms Road
Milford, Connecticut 06460

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802
Internet: www.edrnet.com

FOCUS MAP SUMMARY

Database	Total Plotted
FEDERAL ASTM STANDARD	
NPL	0
Proposed NPL	0
CERCLIS	0
CERC-NFRAP	0
CORRACTS	0
RCRA TSD	0
RCRA Lg. Quan. Gen.	0
RCRA Sm. Quan. Gen.	0
ERNS	0
STATE ASTM STANDARD	
State Haz. Waste	N/A
State Landfill	0
LUST	0
UST	0
INDIAN UST	0
VCP	0
INDIAN LUST	0
FEDERAL ASTM SUPPLEMENTAL	
CONSENT	0
ROD	0
Delisted NPL	0
FINDS	0
HMIRS	0
MLTS	0
MINES	0
NPL Liens	0
PADS	0
DOD	0
FUDS	1
US ENG CONTROLS	0
ODI	0
UMTRA	0
INDIAN RESERV	0
RAATS	0
TRIS	0
TSCA	0
SSTS	0
FTTS	0
STATE OR LOCAL ASTM SUPPLEMENTAL	
AST	0

FOCUS MAP SUMMARY

Database	Total Plotted
LAST	0
SPILLS	0

BROWNFIELDS DATABASES

Database	Total Plotted
US BROWNFIELDS	0
US INST CONTROL	0
VCP	0
INST CONTROL	0

NOTES:

Sites may be listed in more than one database

N/A = This State does not maintain a SHWS list. See the Federal CERCLIS list.

EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc. (EDR).

TARGET PROPERTY INFORMATION

ADDRESS

RIO GRANDE, NM 87801

DATABASES WITH NO MAPPED SITES

No mapped sites were found in EDR's search of available ("reasonably ascertainable ") government records within the requested search area for the following databases:

FEDERAL ASTM STANDARD

NPL	National Priority List
Proposed NPL	Proposed National Priority List Sites
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CERC-NFRAP	CERCLIS No Further Remedial Action Planned
CORRACTS	Corrective Action Report
RCRA-TSDF	Resource Conservation and Recovery Act Information
RCRA-LQG	Resource Conservation and Recovery Act Information
RCRA-SQG	Resource Conservation and Recovery Act Information
ERNS	Emergency Response Notification System

STATE ASTM STANDARD

SHWS	This state does not maintain a SHWS list. See the Federal CERCLIS list and Federal NPL list.
SWF/LF	Solid Waste Facilities
LUST	Leaking Underground Storage Tank Priorization Database
UST	Listing of Underground Storage Tanks
INDIAN UST	USTs on Indian Land
VCP	Voluntary Remediation Program Sites
INDIAN LUST	Leaking Underground Storage Tanks on Indian Land

FEDERAL ASTM SUPPLEMENTAL

CONSENT	Superfund (CERCLA) Consent Decrees
ROD	Records Of Decision
Delisted NPL	National Priority List Deletions
FINDS	Facility Index System/Facility Registry System
HMIRS	Hazardous Materials Information Reporting System
MLTS	Material Licensing Tracking System

EXECUTIVE SUMMARY

MINES Mines Master Index File
NPL Liens Federal Superfund Liens
PADS PCB Activity Database System
DOD Department of Defense Sites
US ENG CONTROLS Engineering Controls Sites List
ODI Open Dump Inventory
UMTRA Uranium Mill Tailings Sites
INDIAN RESERV Indian Reservations
RAATS RCRA Administrative Action Tracking System
TRIS Toxic Chemical Release Inventory System
TSCA Toxic Substances Control Act
SSTS Section 7 Tracking Systems
FTTS INSP FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)

STATE OR LOCAL ASTM SUPPLEMENTAL

AST Aboveground Storage Tanks List
LAST Leaking Aboveground Storage Tank Sites
SPILLS Spill Data

BROWNFIELDS DATABASES

US BROWNFIELDS A Listing of Brownfields Sites
US INST CONTROL Sites with Institutional Controls
VCP Voluntary Remediation Program Sites
INST CONTROL Sites with Institutional Controls

SURROUNDING SITES: SEARCH RESULTS

Surrounding sites were identified.

The Map ID column refers to the Map ID-Focus Map(s) of the listed site.

Sites listed in ***bold italics*** are in multiple databases.

Unmappable (orphan) sites are not considered in the foregoing analysis.

FEDERAL ASTM SUPPLEMENTAL

FUDS: The Listing includes locations of Formerly Used Defense Sites Properties where the US Army Corps Of Engineers is actively working or will take necessary cleanup actions.

A review of the FUDS list, as provided by EDR, and dated 12/31/2003 has revealed that there is 1 FUDS site within the searched area.

Site	Address	Map ID
KIRTLAND AFB PBR 19 TRGT S-6		1-3

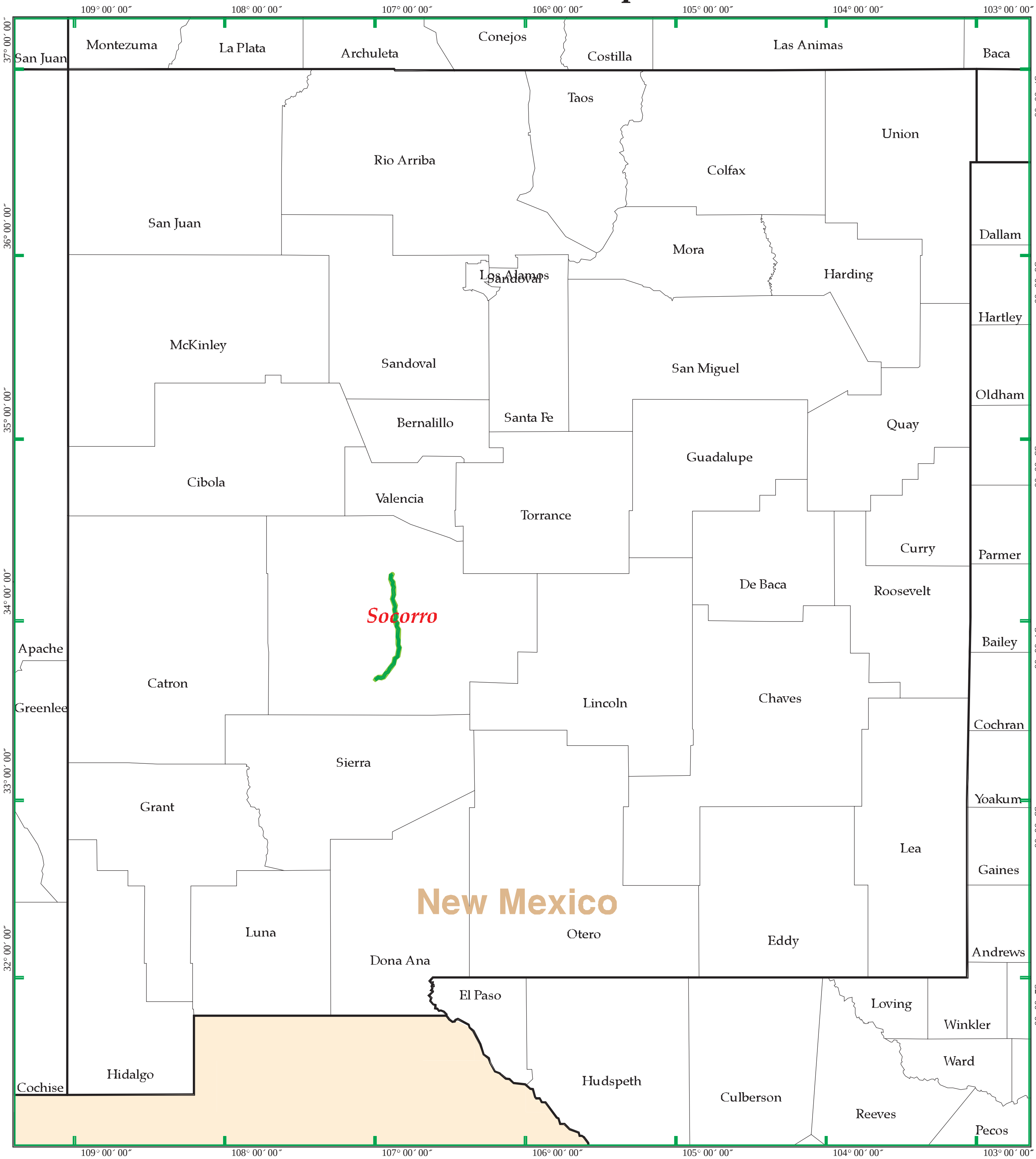
EXECUTIVE SUMMARY

Please refer to the end of the findings report for unmapped orphan sites due to poor or inadequate address information.

Section 1

Overview and Key Map

Overview Map



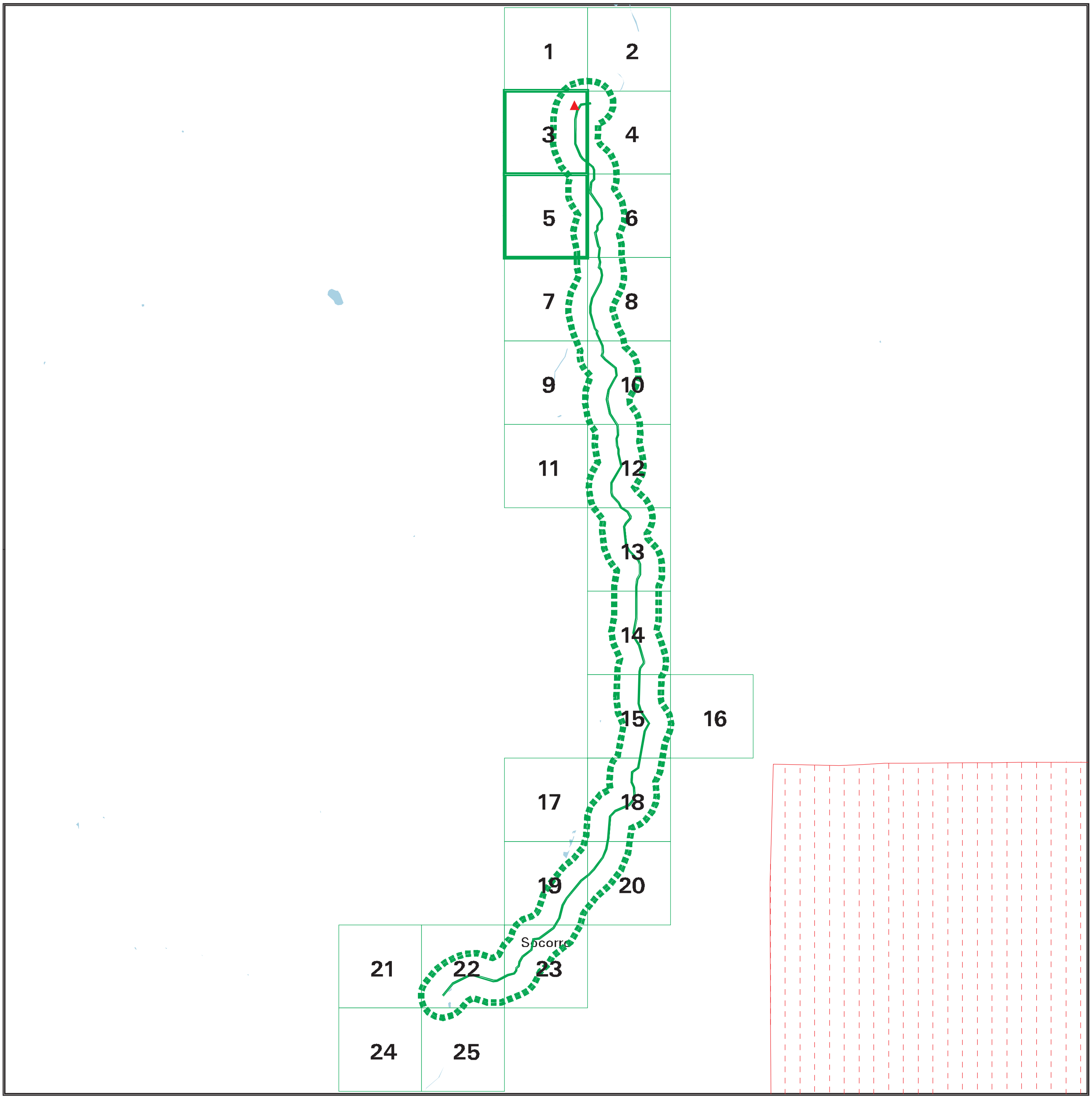
EDR DataMap(TM) - Environmental Atlas(TM)

Rio Grande Levees-San Acacia-Bosque Del Apache

EDR Environmental Data Resources Inc

N

Key Map



EDR DataMap(TM) - Environmental Atlas(TM)

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

- Roads
- Major Roads
- Contour Lines
- Waterways
- Railroads
- Study Boundary
- Powerlines
- Pipelines
- Fault Lines
- Indian Reservations BIA
- Water
- Superfund Sites
- Federal DOD Sites
- Listed Sites

N

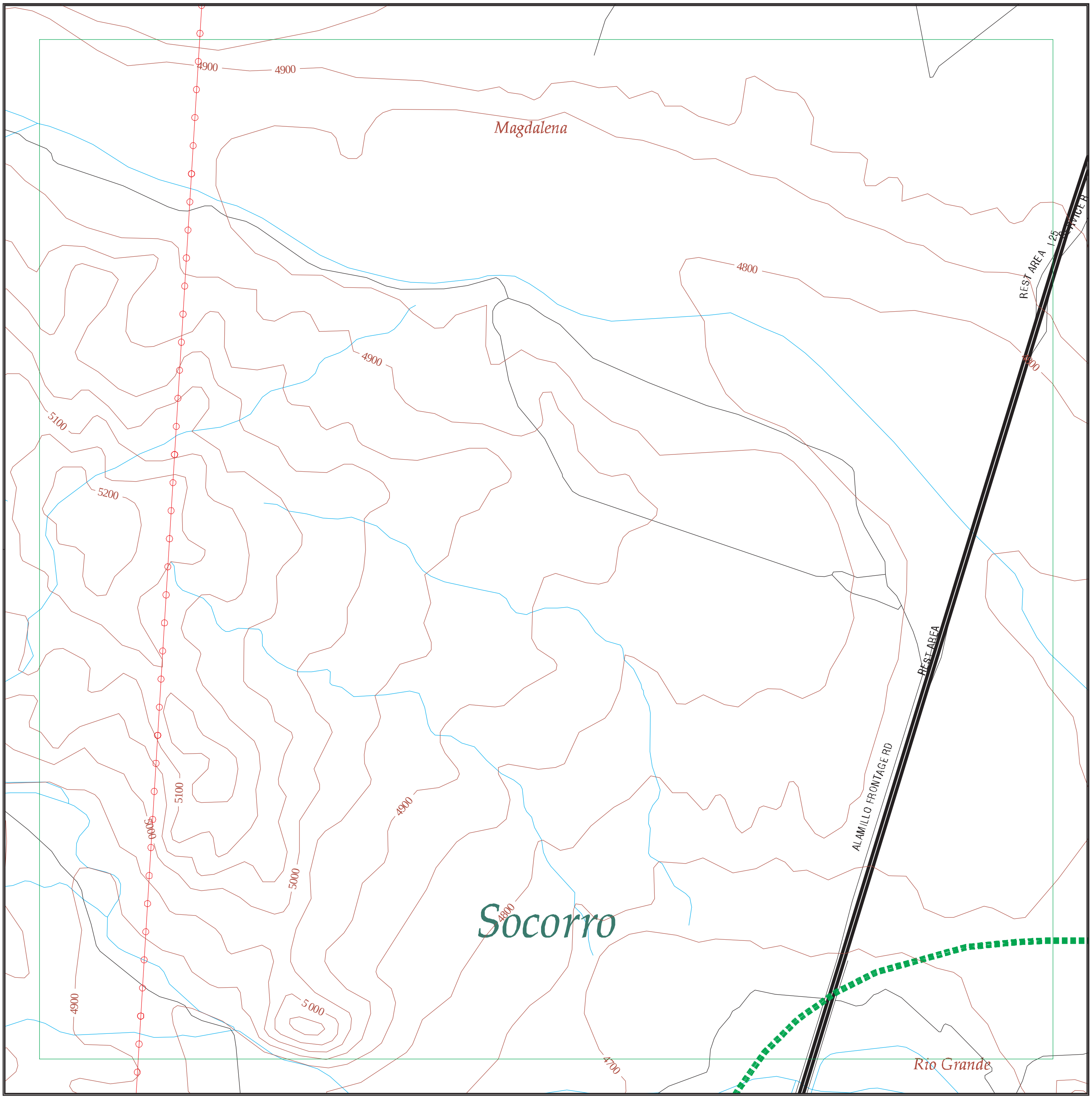
0 5 10

Scale in Miles

Section 2

Focus Maps and Findings

Focus Map 1



EDR DataMap™ - Environmental Atlas™

EDR® Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads
Waterways
Powerlines
Water
Listed Sites
Major Roads
Railroads
Pipelines
Superfund Sites
Contour Lines
Study Boundary
Fault Lines
Federal DOD Sites
Indian Reservations BIA

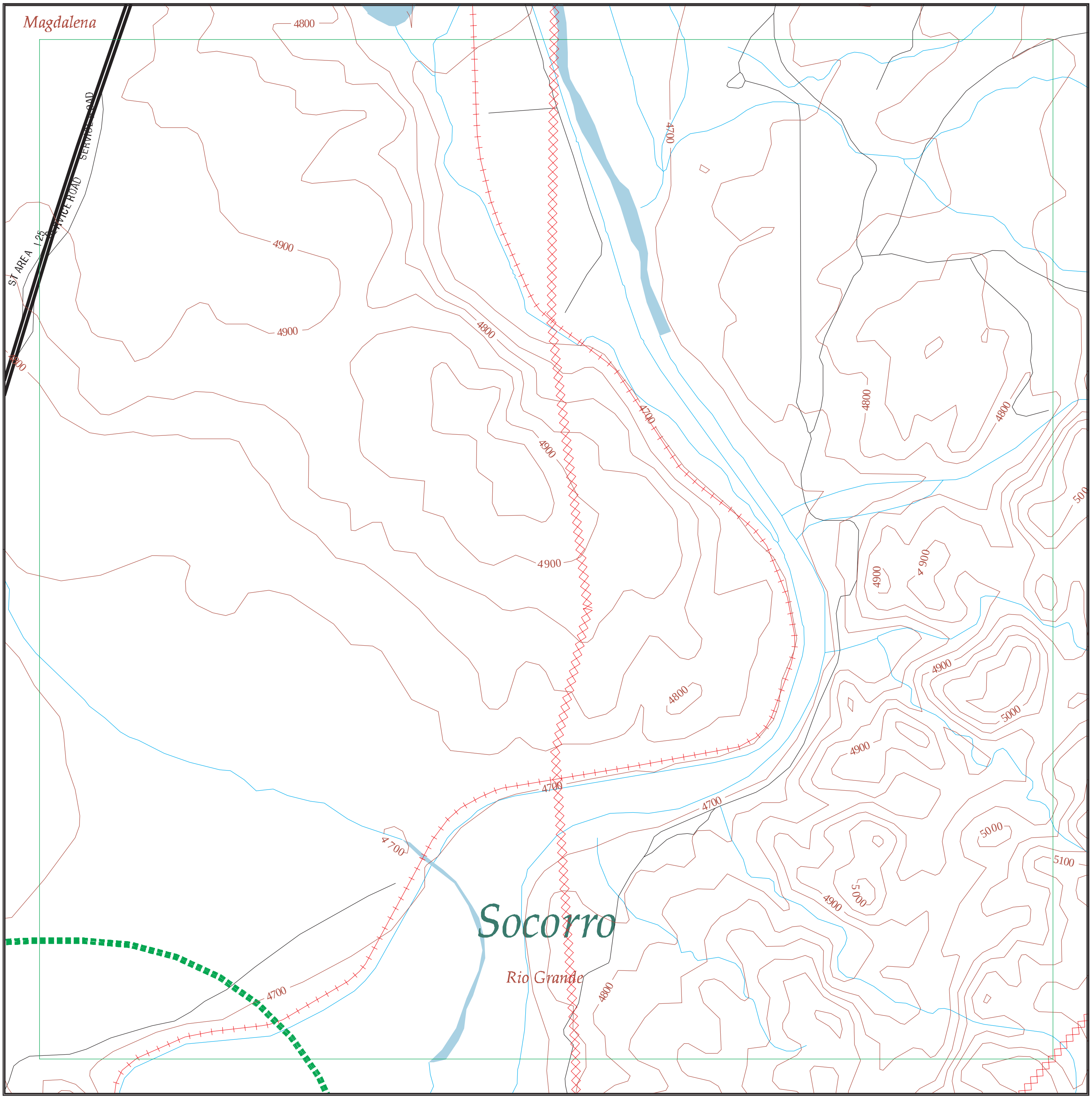
0 1/2 1

Scale in Miles

FOCUS MAP 1 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SAN ACACIA	1004754094	CHEVRON PIPE LINE VAL VERDE STA	5M E 10M SE I-25	87831	RCRA-SQG, FINDS
SAN ACACIA	U003192792	US FISH AND WILDLIFE SAN ACACIA	E OF I 25 EXIST	87831	UST
SAN ACACIA	S105510982	SEVILLITA NWR	E OF I 25 EXIST	87831	LUST

Focus Map 2



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

N

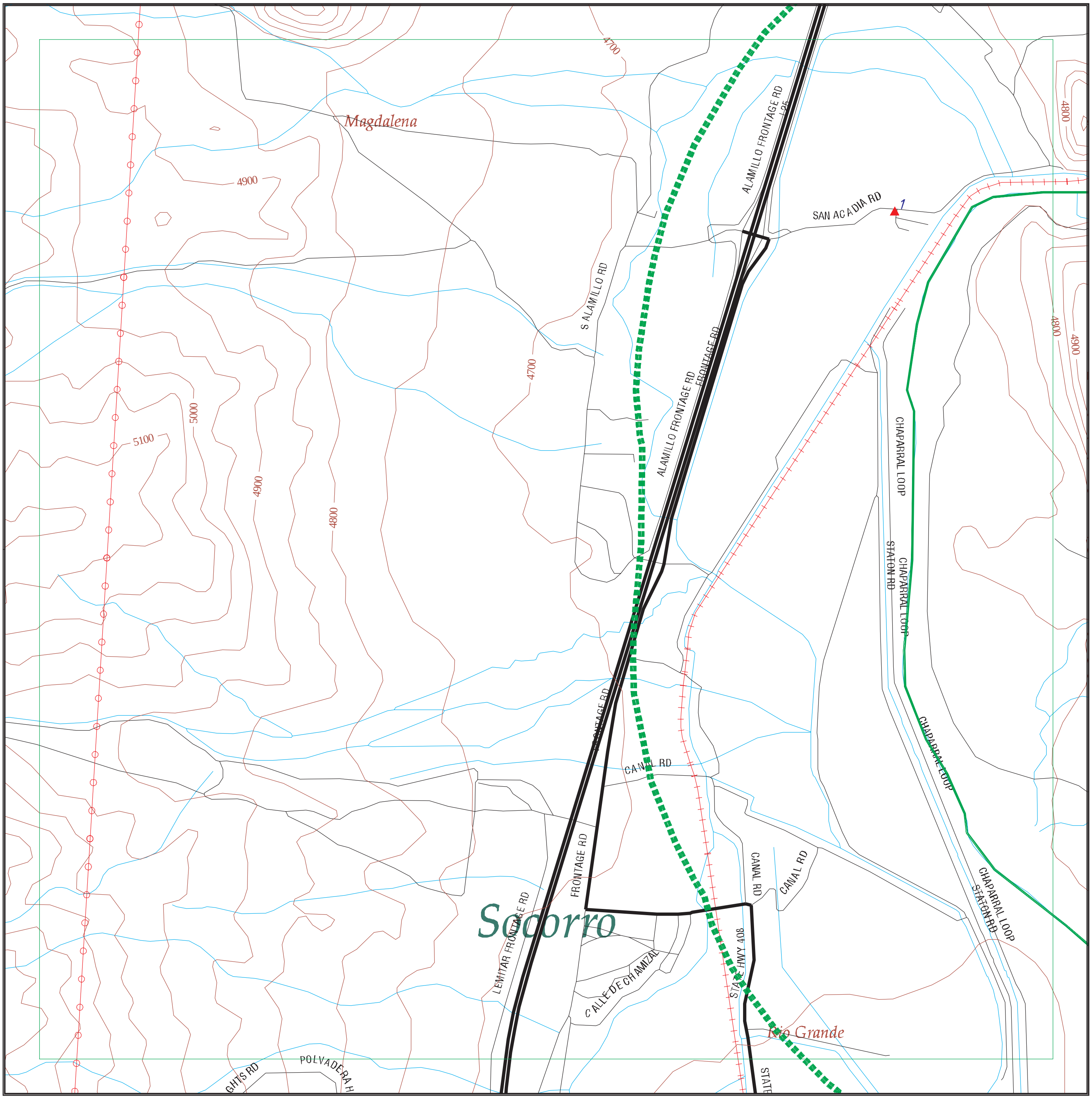
0 1/2 1

Scale in Miles

FOCUS MAP 2 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SAN ACACIA	1004754094	CHEVRON PIPE LINE VAL VERDE STA	5M E 10M SE I-25	87831	RCRA-SQG, FINDS
SAN ACACIA	U003192792	US FISH AND WILDLIFE SAN ACACIA	E OF I 25 EXIST	87831	UST
SAN ACACIA	S105510982	SEVILLITA NWR	E OF I 25 EXIST	87831	LUST

Focus Map 3



EDR DataMap™ - Environmental Atlas™

EDR® Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads	Waterways	Powerlines	Water	Listed Sites
Major Roads	Railroads	Pipelines	Superfund Sites	
Contour Lines	Study Boundary	Fault Lines	Federal DOD Sites	
		Indian Reservations BIA		

N

0 1/2 1

Scale in Miles

FOCUS MAP 3 SUMMARY

	Database	Total Plotted
FEDERAL ASTM STANDARD		
	NPL	0
	Proposed NPL	0
	CERCLIS	0
	CERC-NFRAP	0
	CORRACTS	0
	RCRA TSD	0
	RCRA Lg. Quan. Gen.	0
	RCRA Sm. Quan. Gen.	0
	ERNS	0
STATE ASTM STANDARD		
	State Haz. Waste	N/A
	State Landfill	0
	LUST	0
	UST	0
	INDIAN UST	0
	VCP	0
	INDIAN LUST	0
FEDERAL ASTM SUPPLEMENTAL		
	CONSENT	0
	ROD	0
	Delisted NPL	0
	FINDS	0
	HMIRS	0
	MLTS	0
	MINES	0
	NPL Liens	0
	PADS	0
	DOD	0
	FUDS	1
	US ENG CONTROLS	0
	ODI	0
	UMTRA	0
	INDIAN RESERV	0
	RAATS	0
	TRIS	0
	TSCA	0
	SSTS	0
	FTTS	0
STATE OR LOCAL ASTM SUPPLEMENTAL		
	AST	0

FOCUS MAP 3 SUMMARY

Database	Total Plotted
LAST	0
SPILLS	0

BROWNFIELDS DATABASES

Database	Total Plotted
US BROWNFIELDS	0
US INST CONTROL	0
VCP	0
INST CONTROL	0

NOTES:

Sites may be listed in more than one database

N/A = This State does not maintain a SHWS list. See the Federal CERCLIS list.

Map ID	Site	Database(s)	EPA ID Number

Coal Gas Site Search: EDR does not presently have coal gas site information available in this state.

1	**KIRTLAND AFB PBR 19 TRGT S-6**	**FUDS**	**1007212188** **N/A**

SAN ACACIA, NM

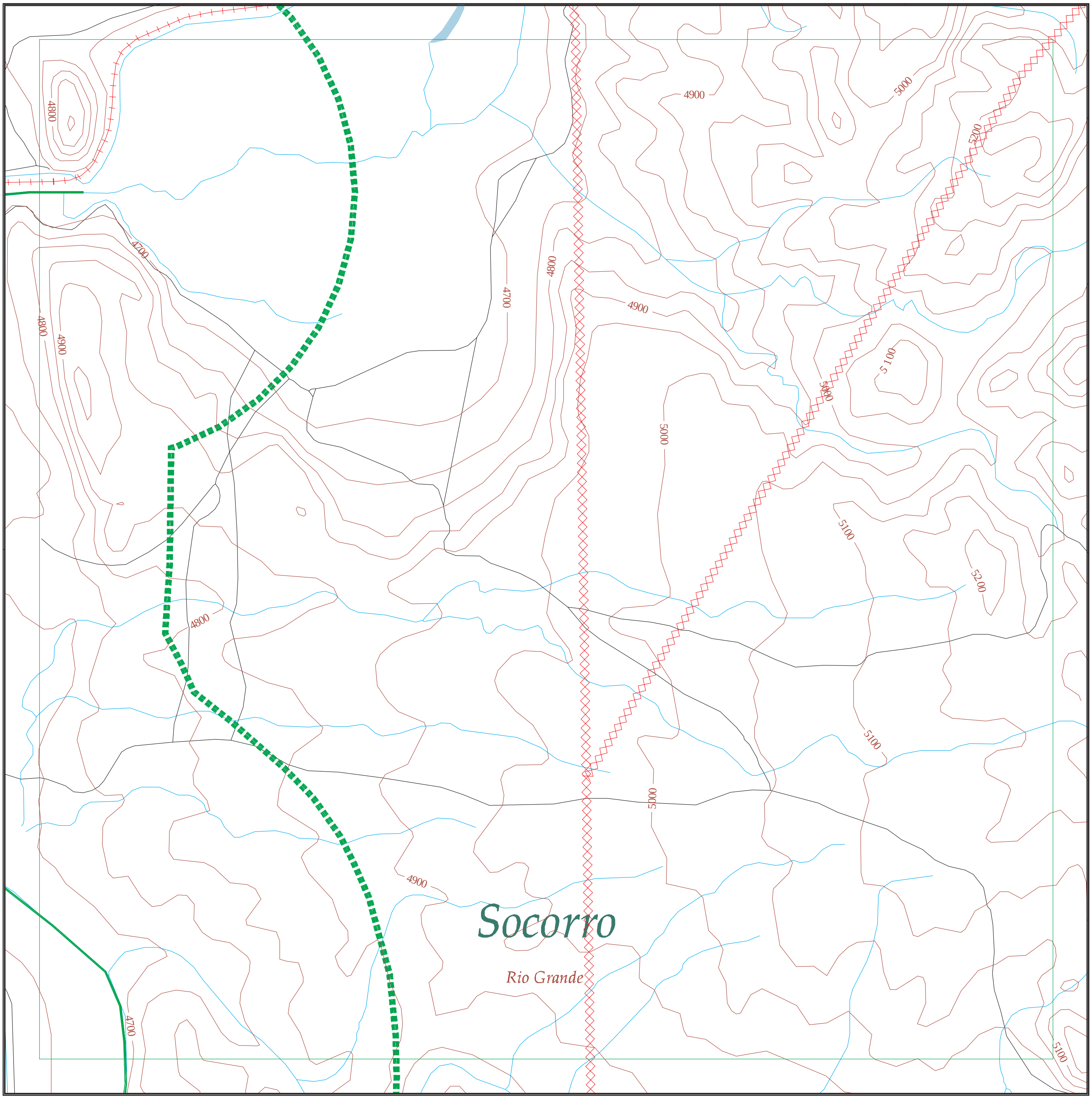
FUDS:

Federal Facility ID:	NM9799F9081
Facility Name:	KIRTLAND AFB PBR 19 TRGT S-6
City:	SAN ACACIA
State:	NM
EPA Region:	6
County:	SOCORRO
Congressional District:	02
US Army District:	Albuquerque District (SPA)
Fiscal Year:	2003
First Name:	MONIQUE
Last name:	OSTERMANN
Phone:	505-342-3171
Inst ID:	54401
CTC:	Not reported
RAB:	Not reported

FOCUS MAP 3 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SAN ACACIA	1004754094	CHEVRON PIPE LINE VAL VERDE STA	5M E 10M SE I-25	87831	RCRA-SQG, FINDS
SAN ACACIA	U003192792	US FISH AND WILDLIFE SAN ACACIA	E OF I 25 EXIST	87831	UST
SAN ACACIA	S105510982	SEVILLITA NWR	E OF I 25 EXIST	87831	LUST

Focus Map 4



EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

0 1/2 1

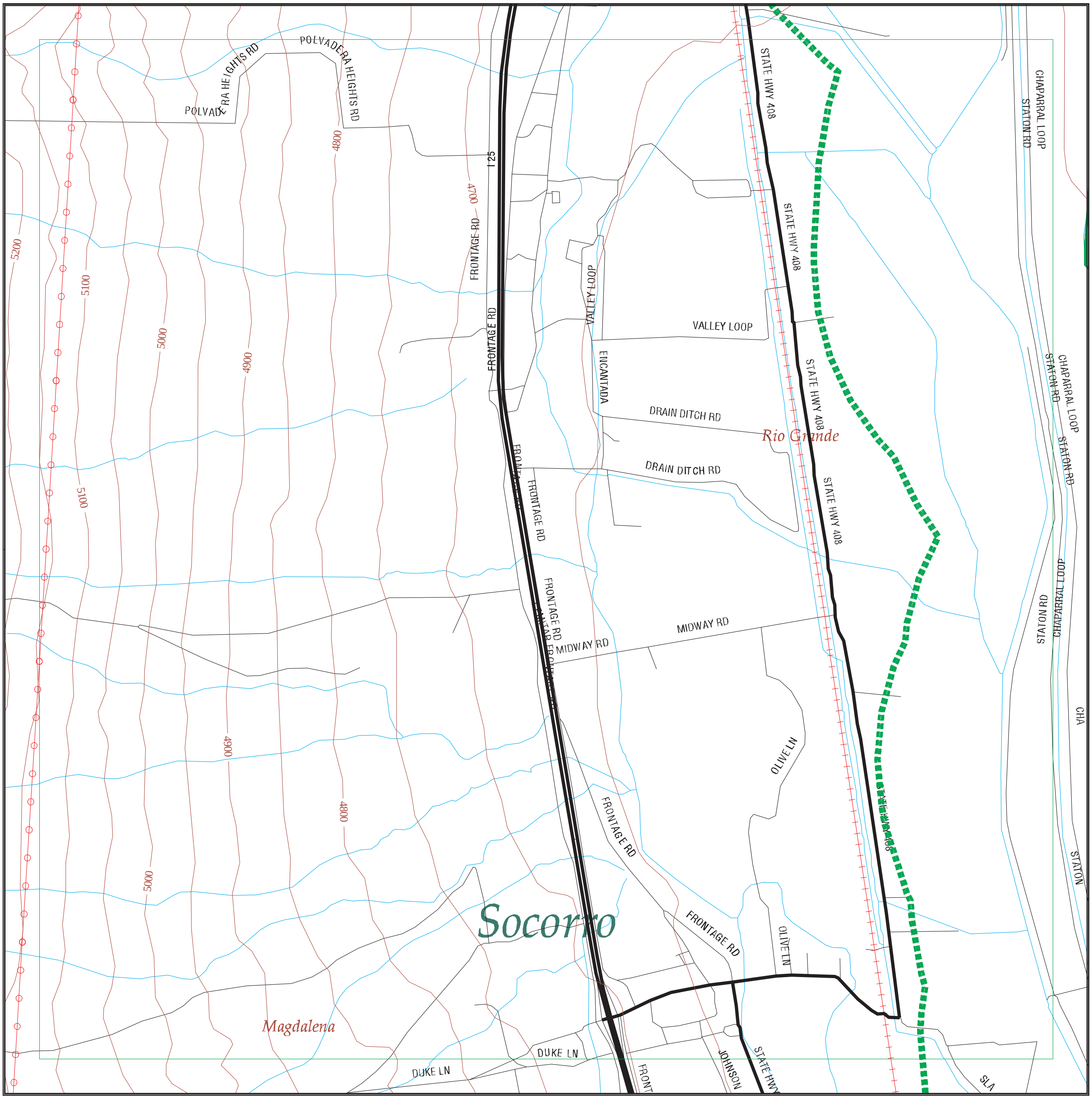
Scale in Miles

N

FOCUS MAP 4 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
		NO SITES FOUND			

Focus Map 5



EDR DataMap™ - Environmental Atlas ™

EDR® Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

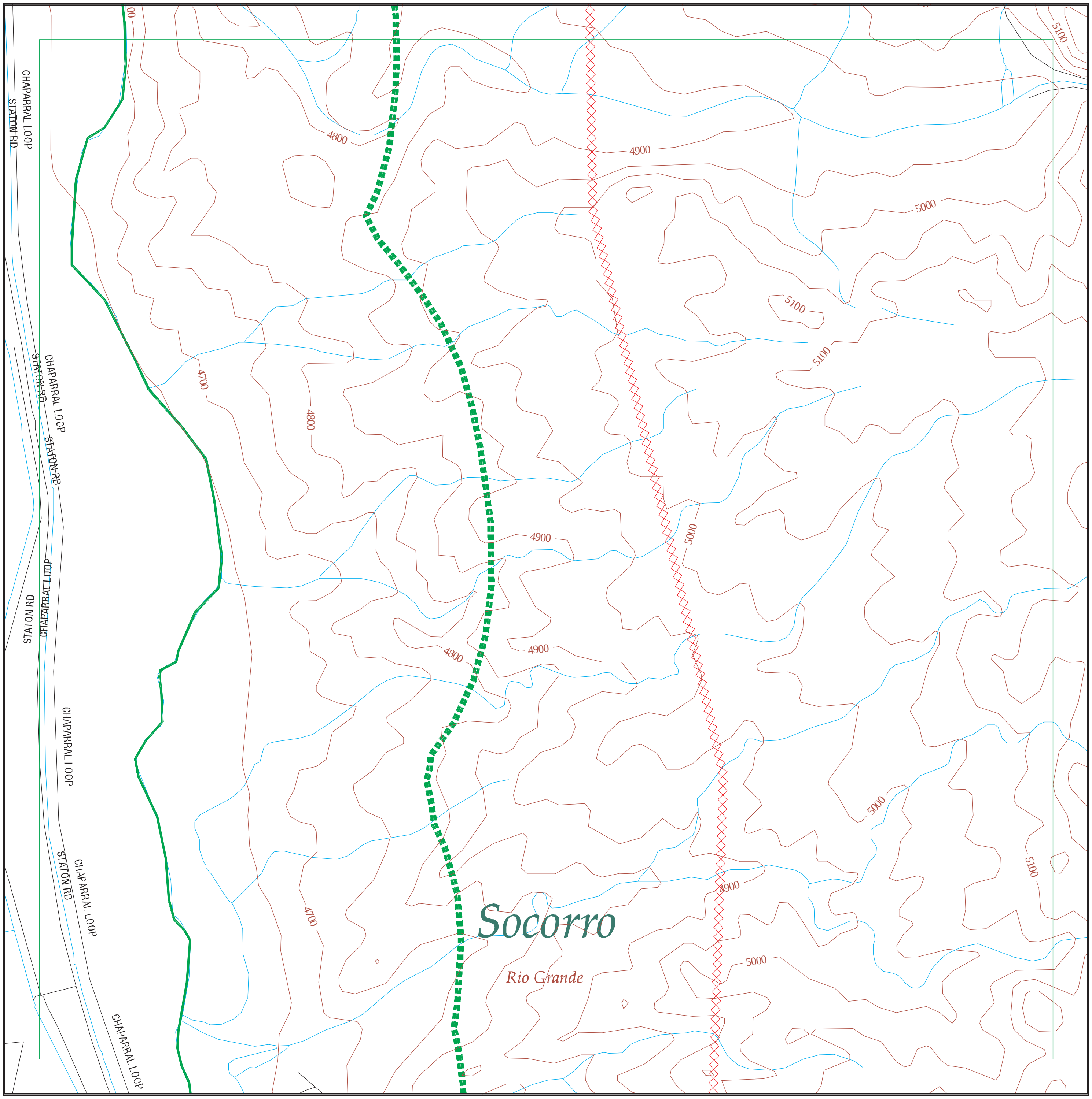
0 1/2 1

Scale in Miles

FOCUS MAP 5 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
LEMITAR	U003192053	SOCORRO RADIO	W OF I 25	87823	UST
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SAN ACACIA	1004754094	CHEVRON PIPE LINE VAL VERDE STA	5M E 10M SE I-25	87831	RCRA-SQG, FINDS
SAN ACACIA	U003192792	US FISH AND WILDLIFE SAN ACACIA	E OF I 25 EXIST	87831	UST
SAN ACACIA	S105510982	SEVILLITA NWR	E OF I 25 EXIST	87831	LUST
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87823	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1004754292	UNITED PARCEL SERVICE	S AIRPORT FRONTAGE RD	87801	RCRA-SQG, FINDS
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 6



EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

N

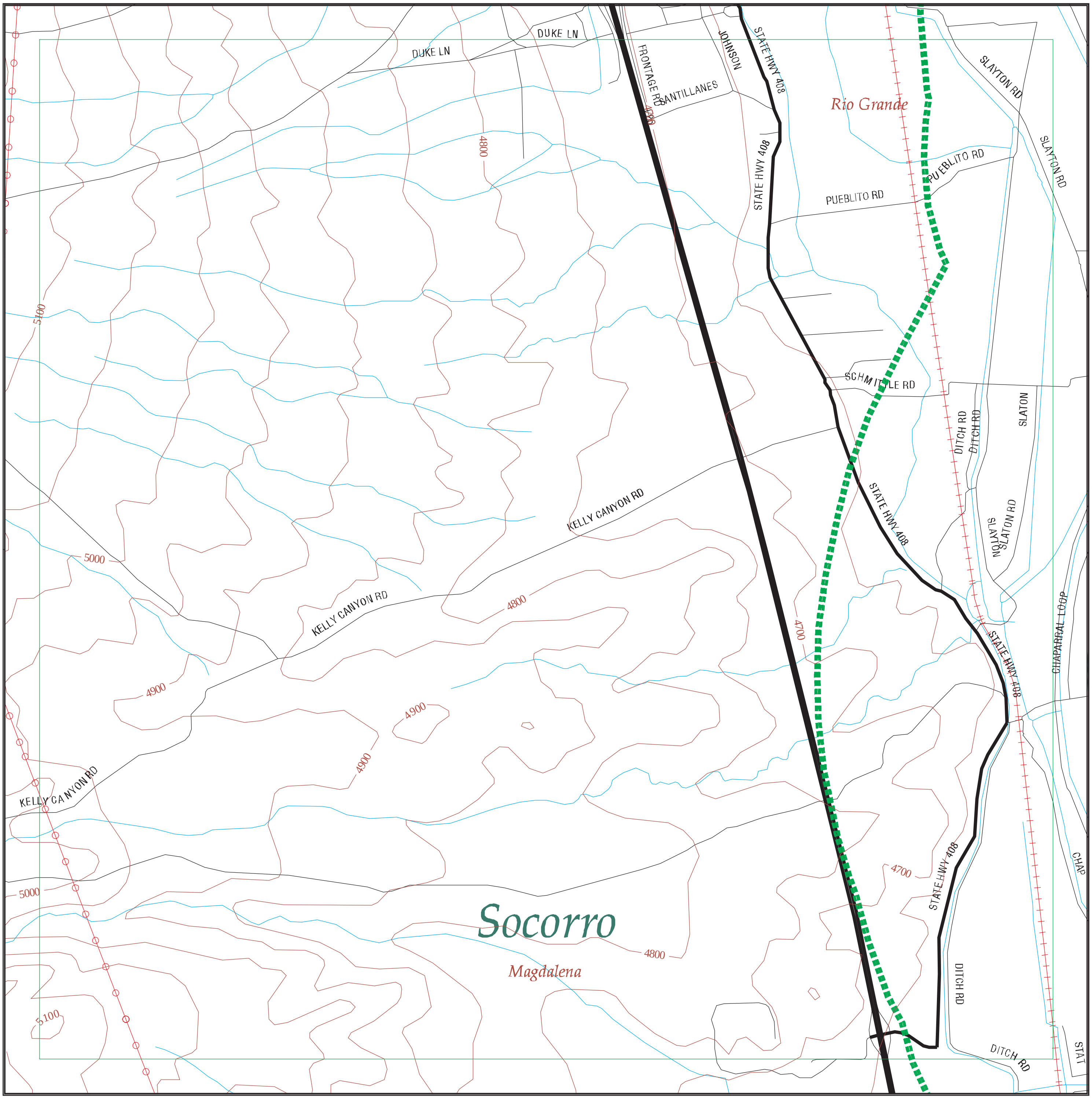
0 1/2 1

Scale in Miles

FOCUS MAP 6 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 7



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads	Waterways	Powerlines	Water	Listed Sites
Major Roads	Railroads	Pipelines	Superfund Sites	
Contour Lines	Study Boundary	Fault Lines	Federal DOD Sites	
		Indian Reservations BIA		

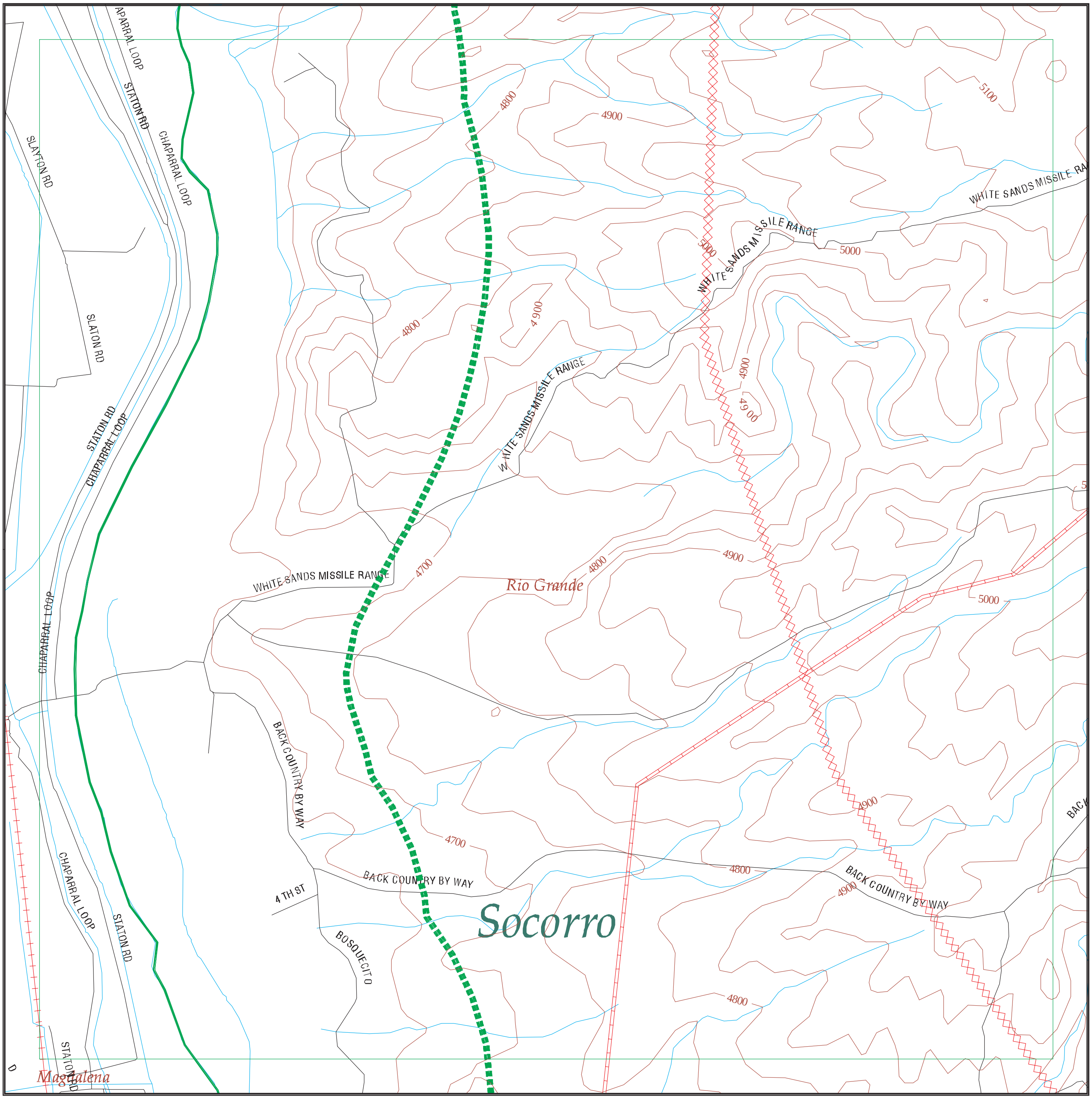
0 1/2 1

Scale in Miles

FOCUS MAP 7 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
LEMITAR	U003192053	SOCORRO RADIO	W OF I 25	87823	UST
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SAN ACACIA	1004754094	CHEVRON PIPE LINE VAL VERDE STA	5M E 10M SE I-25	87831	RCRA-SQG, FINDS
SAN ACACIA	U003192792	US FISH AND WILDLIFE SAN ACACIA	E OF I 25 EXIST	87831	UST
SAN ACACIA	S105510982	SEVILLITA NWR	E OF I 25 EXIST	87831	LUST
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87823	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1004754292	UNITED PARCEL SERVICE	S AIRPORT FRONTAGE RD	87801	RCRA-SQG, FINDS
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 8



EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

N

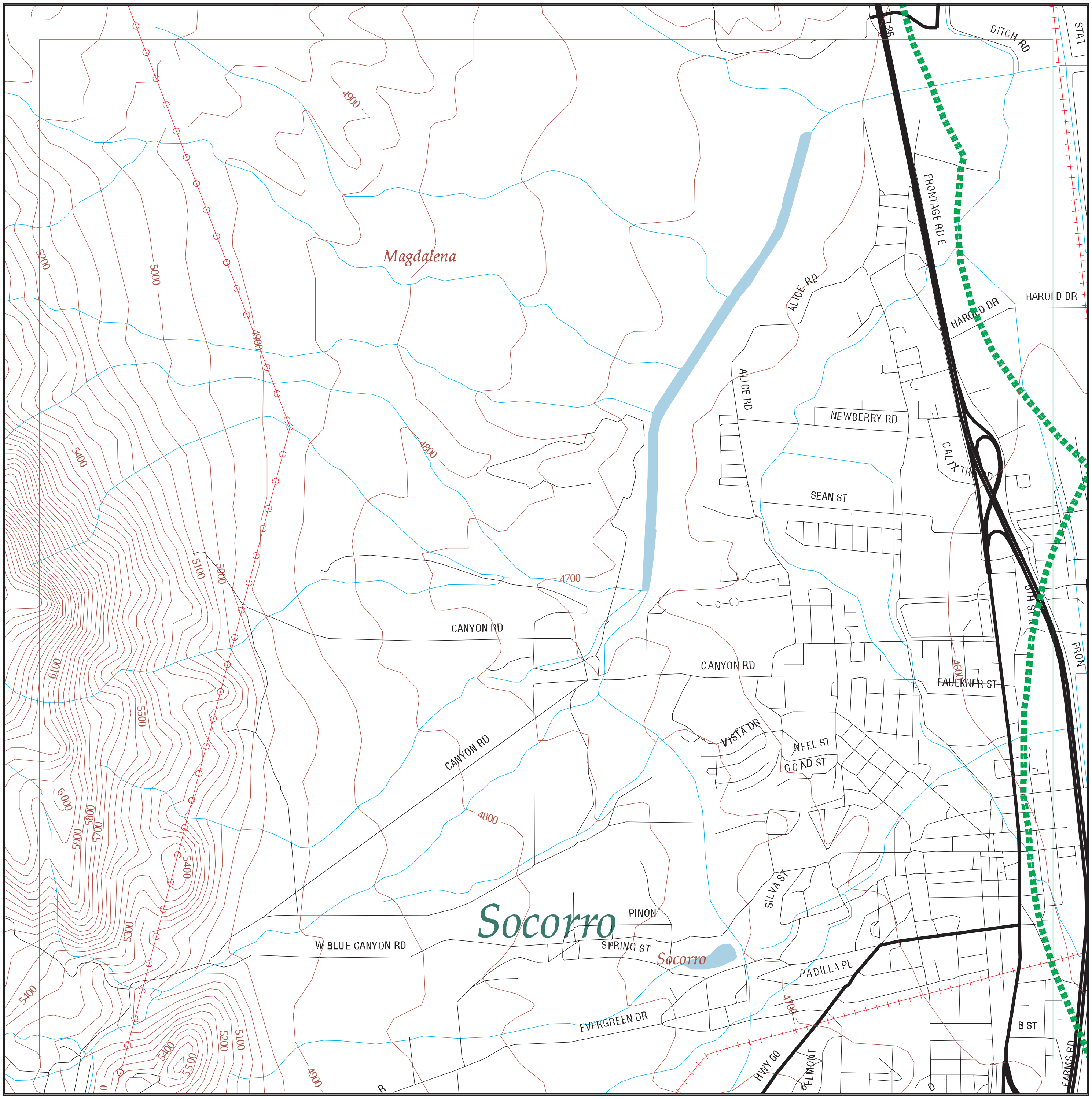
0 1/2 1

Scale in Miles

FOCUS MAP 8 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 9



EDR DataMap™ - Environmental Atlas ™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads	Waterways	Powerlines	Water	Listed Sites
Major Roads	Railroads	Pipelines	Superfund Sites	
Contour Lines	Study Boundary	Fault Lines	Federal DOD Sites	
		Indian Reservations BIA		

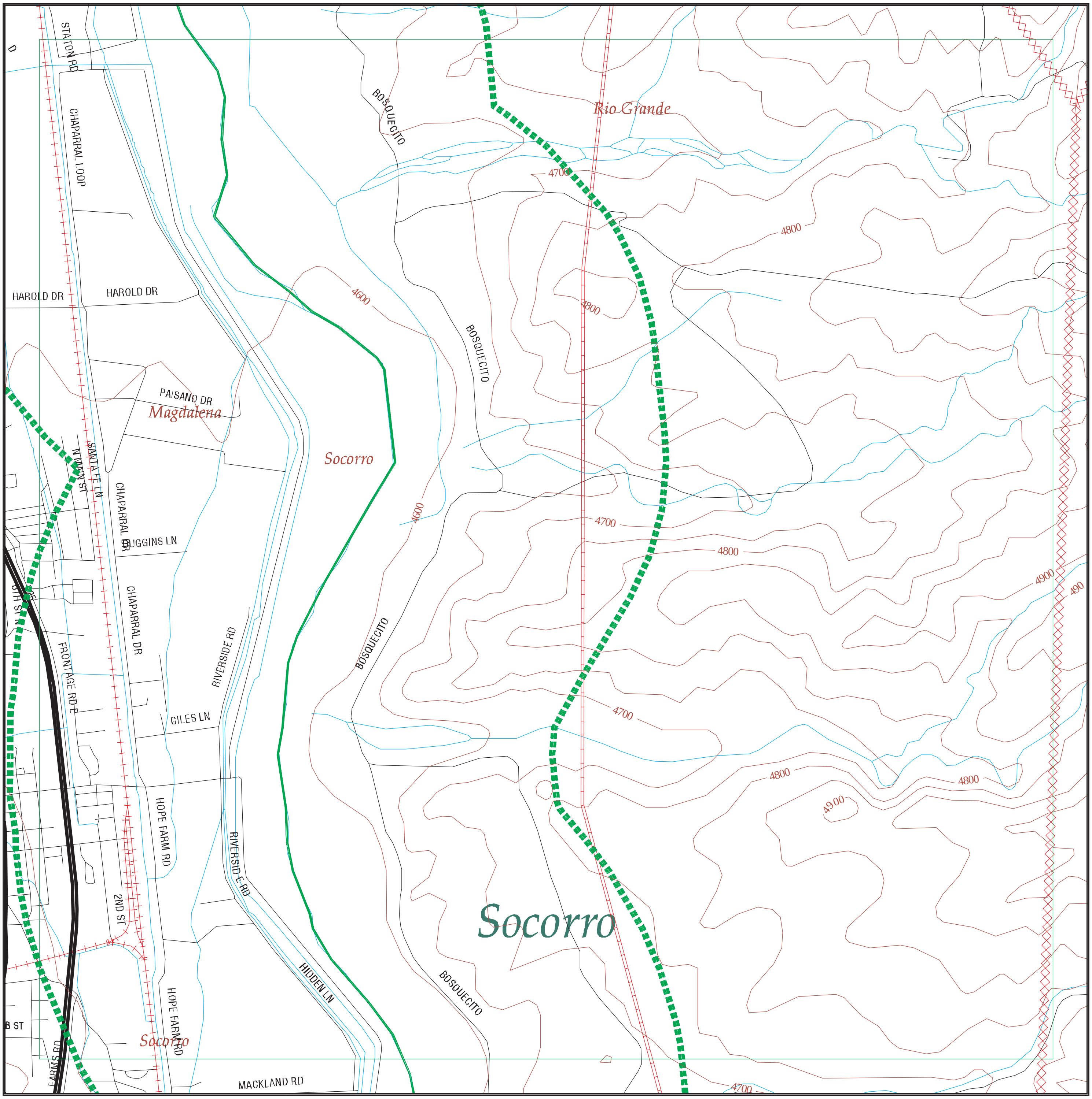
N

0 1/2 1

Scale in Miles

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
ESCONDIDA	1004754041	A T & T CORP	2 MILES SOUTH OF TOWN	87801	RCRA-SQG, FINDS
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	S105770580	ALAMO TRADING POST	P.O. BOX 1472	87825	INDIAN UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1004754292	UNITED PARCEL SERVICE	S AIRPORT FRONTAGE RD	87801	RCRA-SQG, FINDS
SOCORRO	1000401419	NEW MEXICO INS OF MINING & TECH	LEROY AVE	87801	RCRA-SQG, FINDS
SOCORRO	S106426145	ELECTRIC COOP	215 MANZANARES NE	87801	LUST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 10



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

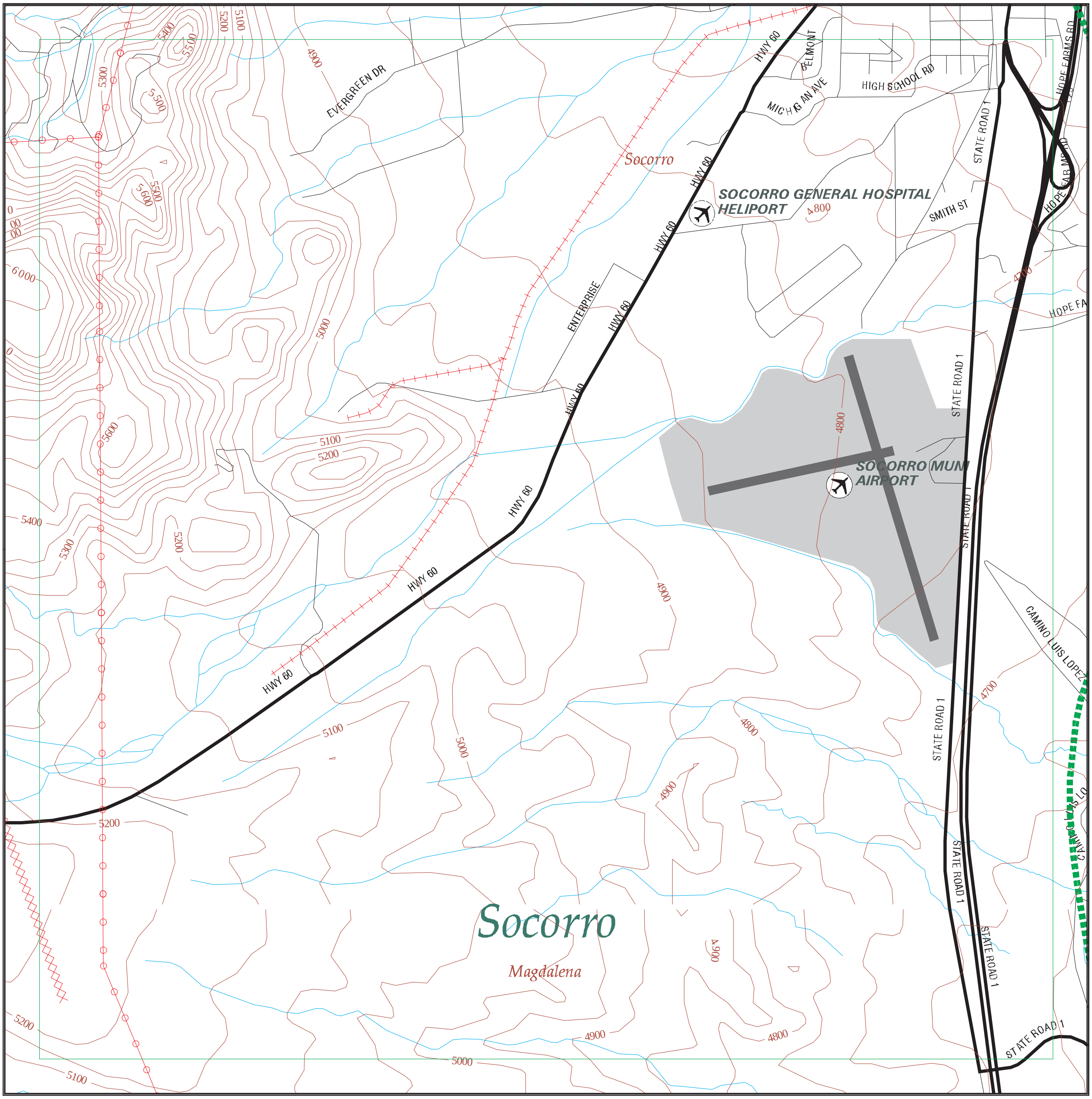
0 1/2 1

Scale in Miles

FOCUS MAP 10 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
POLVADERA	1000304236	WYNN BUS LINES	MAIN ST	87828	RCRA-SQG, FINDS
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1004754292	UNITED PARCEL SERVICE	S AIRPORT FRONTAGE RD	87801	RCRA-SQG, FINDS
SOCORRO	S106426075	SAN MIGUEL SHOPPING CENTER	913 CALIFORNIA STREET (3 SEPARATE P	87801	VCP
SOCORRO	S106426145	ELECTRIC COOP	215 MANZANARES NE	87801	LUST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 11



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads | Waterways | Powerlines | Water | Listed Sites
Major Roads | Railroads | Pipelines | Superfund Sites
Contour Lines | Study Boundary | Fault Lines | Federal DOD Sites
Indian Reservations BIA

N

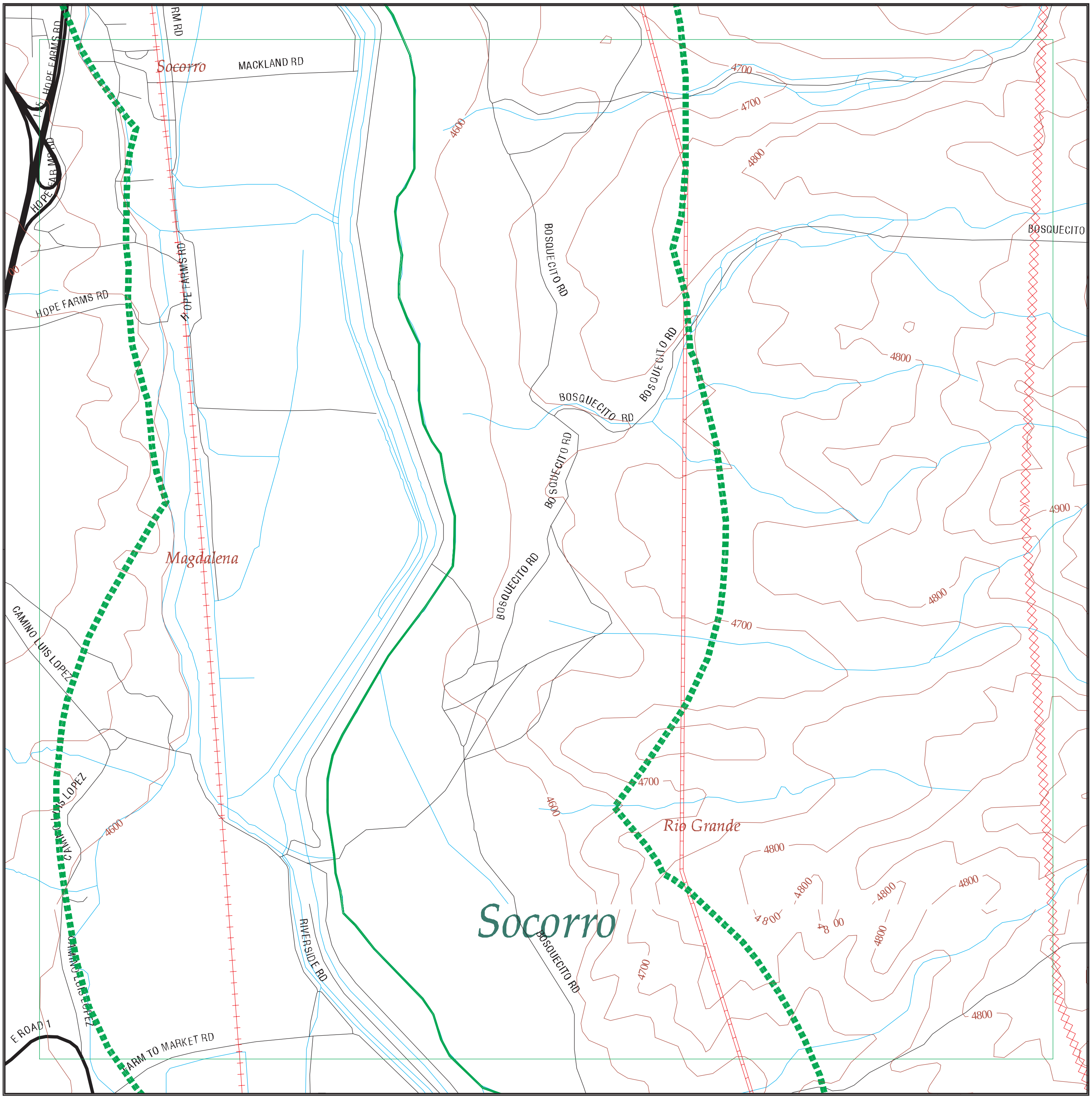
0 1/2 1

Scale in Miles

FOCUS MAP 11 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873636	BLM-WASTE ELECTRIC SITE #1	10 MI SW OF SOCORRO	87801	CERC-NFRAP
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 12



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads
Major Roads
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Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

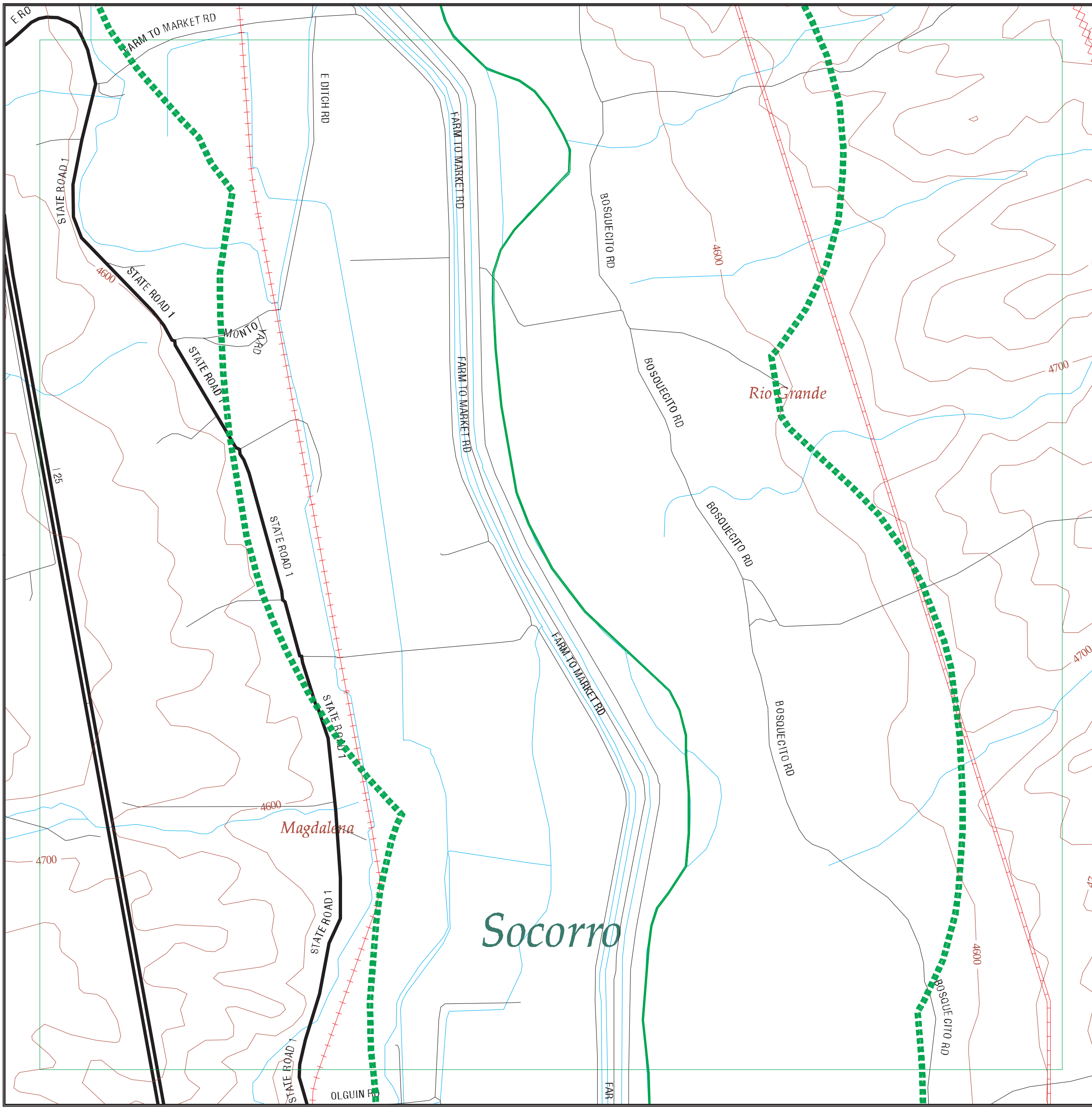
0 1/2 1

Scale in Miles

FOCUS MAP 12 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 13



EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads
Waterways
Powerlines
Water
Listed Sites
Major Roads
Railroads
Pipelines
Superfund Sites
Contour Lines
Study Boundary
Fault Lines
Federal DOD Sites
Indian Reservations BIA

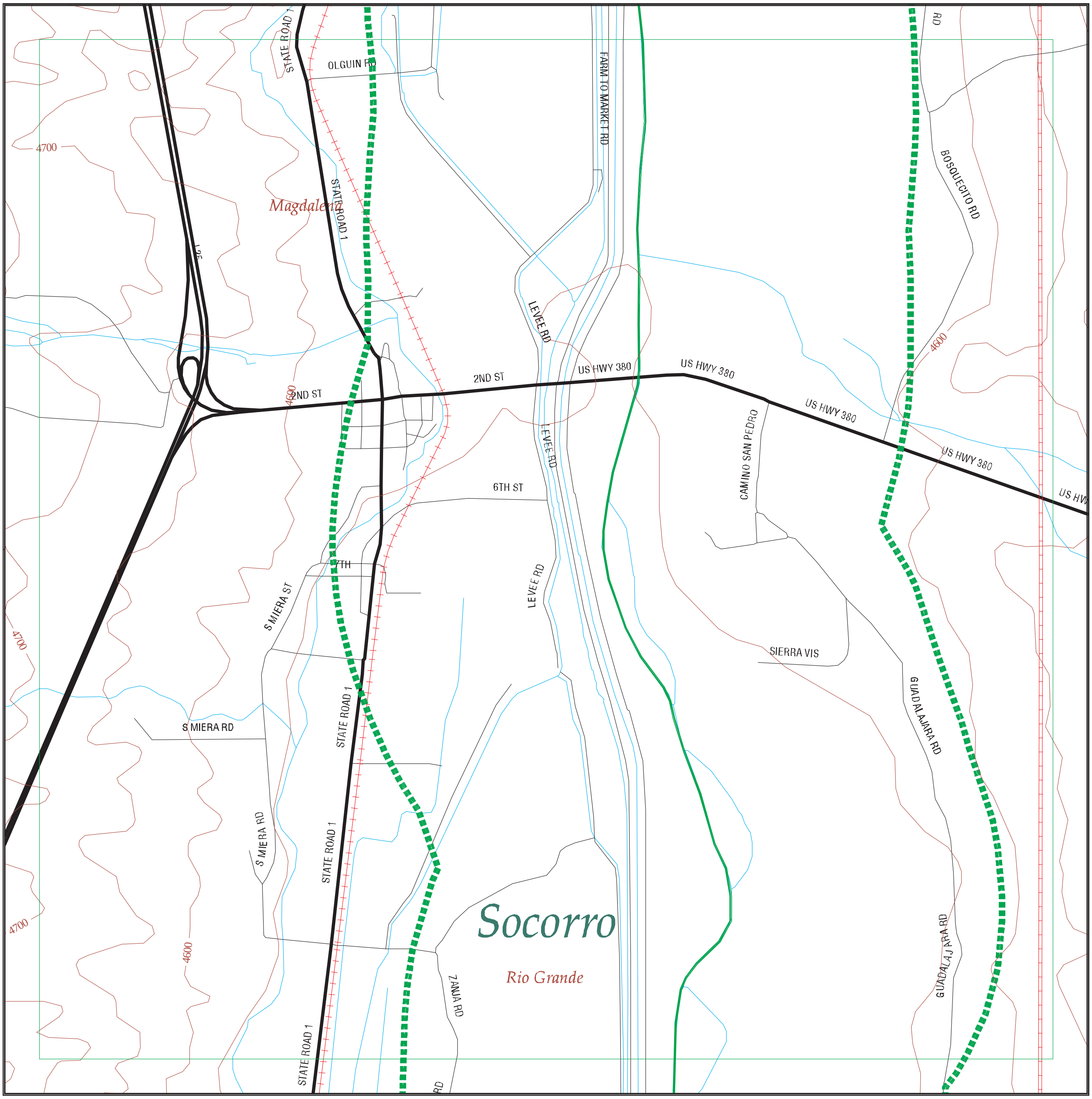
0 1/2 1

Scale in Miles

FOCUS MAP 13 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 14



EDR Environmental Data Resources Inc

EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads	Waterways	Powerlines	Water	Listed Sites
Major Roads	Railroads	Pipelines	Superfund Sites	
Contour Lines	Study Boundary	Fault Lines	Federal DOD Sites	
		Indian Reservations BIA		

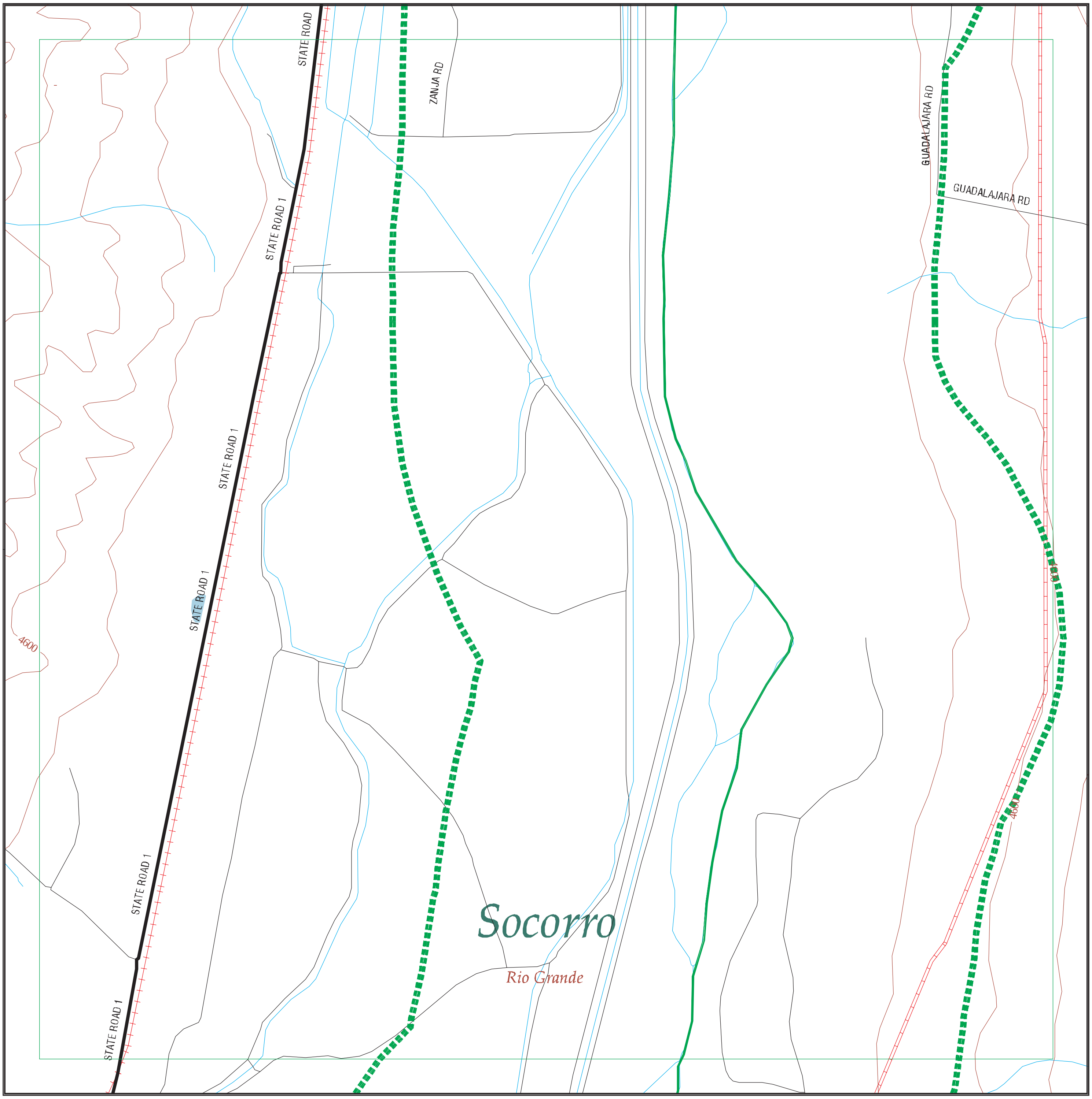
0 1/2 1

Scale in Miles

FOCUS MAP 14 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
LAS NUTRIAS	U003191990	LAS NUTRIAS RS	S OF US 60	87801	UST
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	U003192224	NMDOT MAGDALENA PATROL YARD 41 55	US 60 MP 112 63	87825	UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	U003192225	OLD GULF STATION	SW CORNER OF US	87825	UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP
SOCORRO	1003873683	BILLING SMELTER	1.8 MI W OF INTERS. U/US 60	87801	CERC-NFRAP

Focus Map 15



EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads	Waterways	Powerlines	Water	Listed Sites
Major Roads	Railroads	Pipelines	Superfund Sites	
Contour Lines	Study Boundary	Fault Lines	Federal DOD Sites	
		Indian Reservations BIA		

0 1/2 1

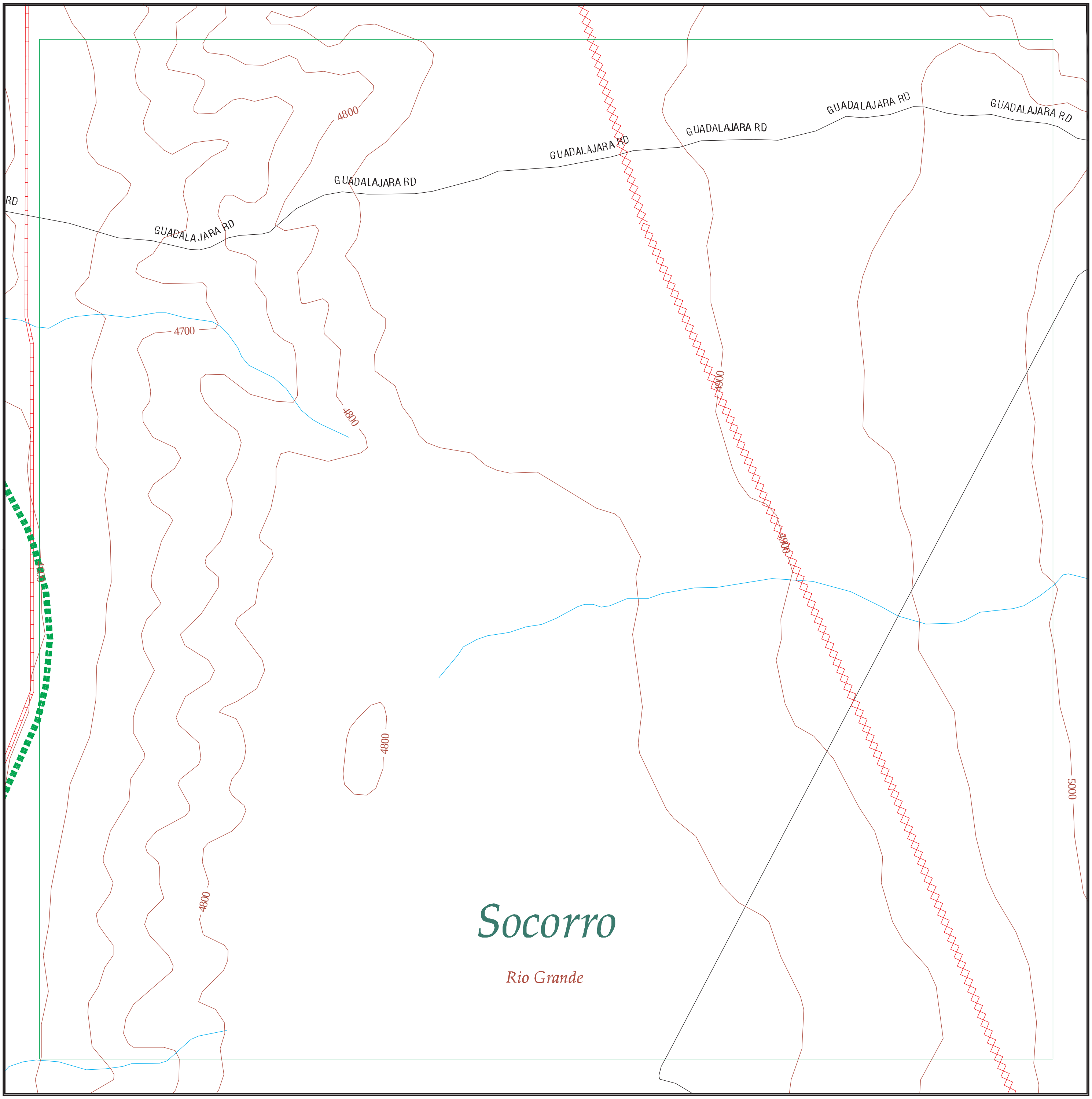
Scale in Miles

N

FOCUS MAP 15 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873636	BLM-WASTE ELECTRIC SITE #1	10 MI SW OF SOCORRO	87801	CERC-NFRAP
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 16



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads	Waterways	Powerlines	Water	Listed Sites
Major Roads	Railroads	Pipelines	Superfund Sites	
Contour Lines	Study Boundary	Fault Lines	Federal DOD Sites	
		Indian Reservations BIA		

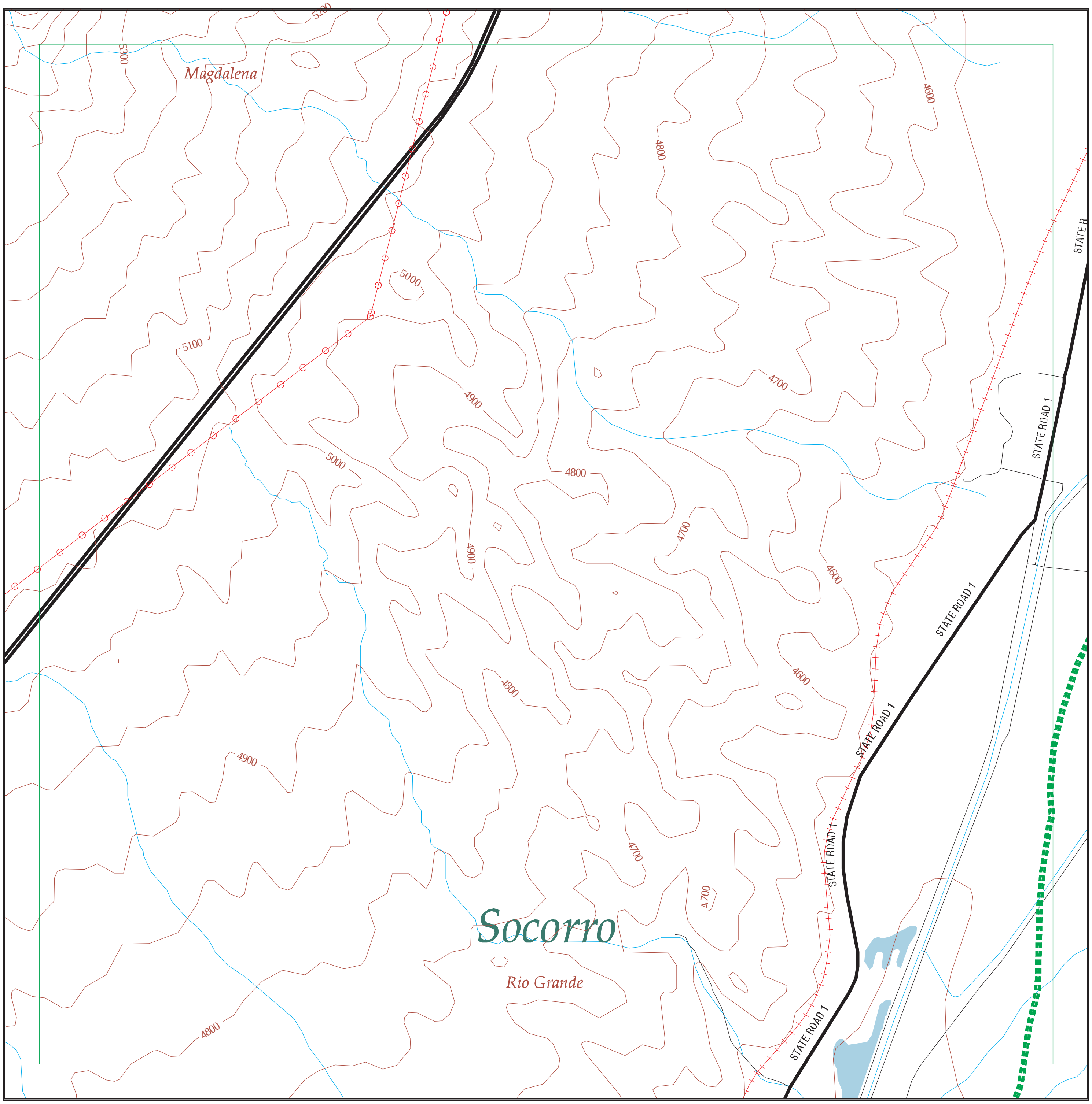
0 1/2 1

Scale in Miles

FOCUS MAP 16 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 17



EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

- Roads
- Major Roads
- Contour Lines
- Waterways
- Railroads
- Study Boundary
- Powerlines
- Pipelines
- Fault Lines
- Indian Reservations BIA
- Water
- Superfund Sites
- Federal DOD Sites
- Listed Sites

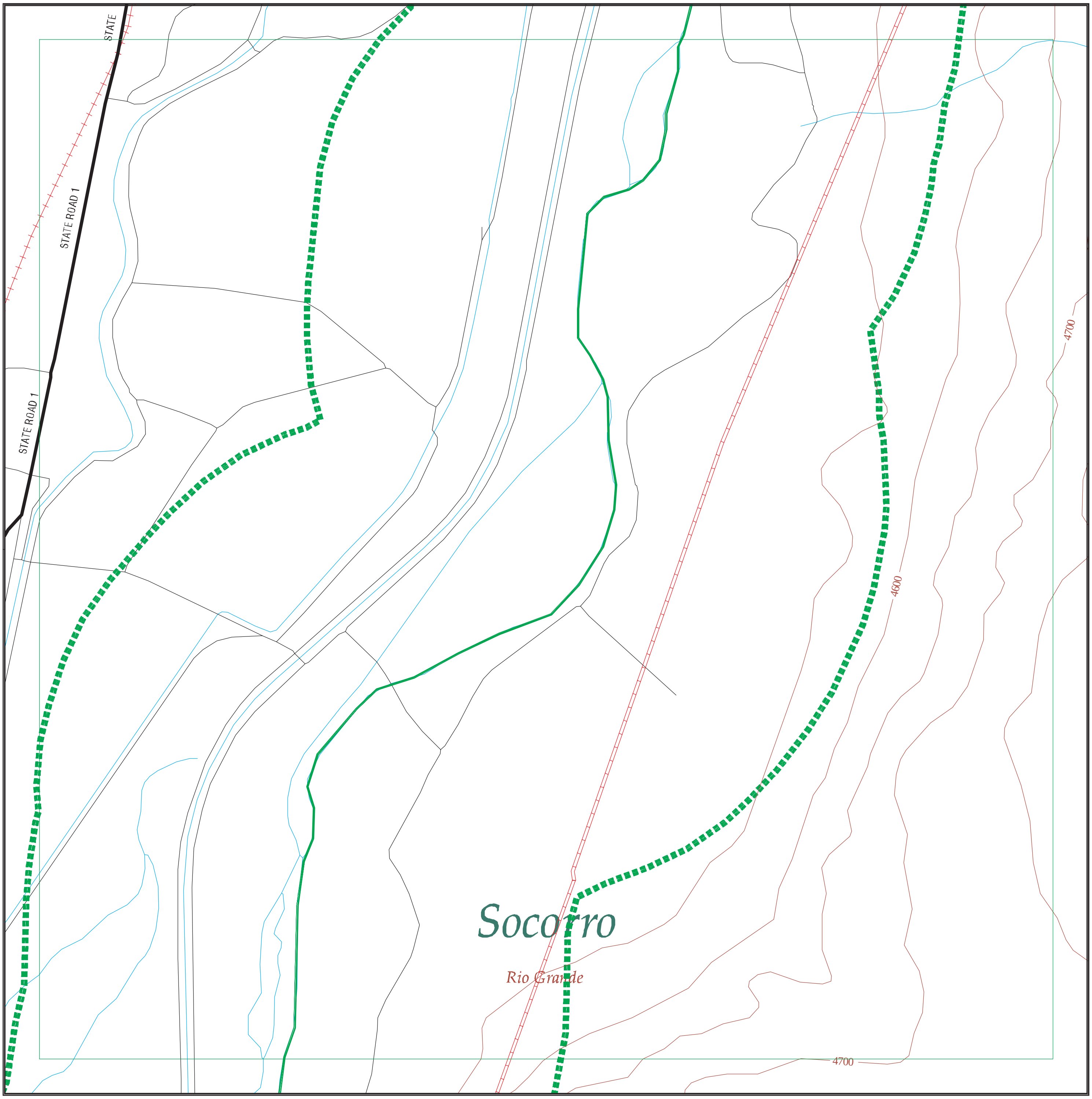
0 1/2 1

Scale in Miles

FOCUS MAP 17 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

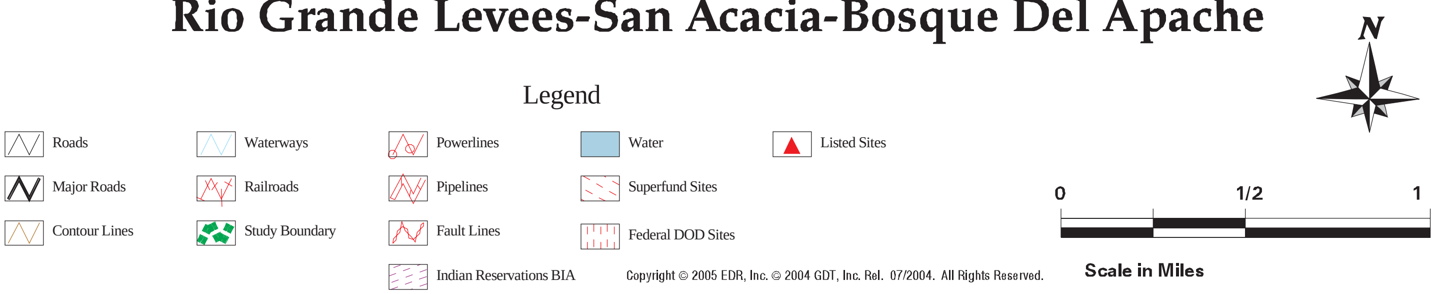
Focus Map 18



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

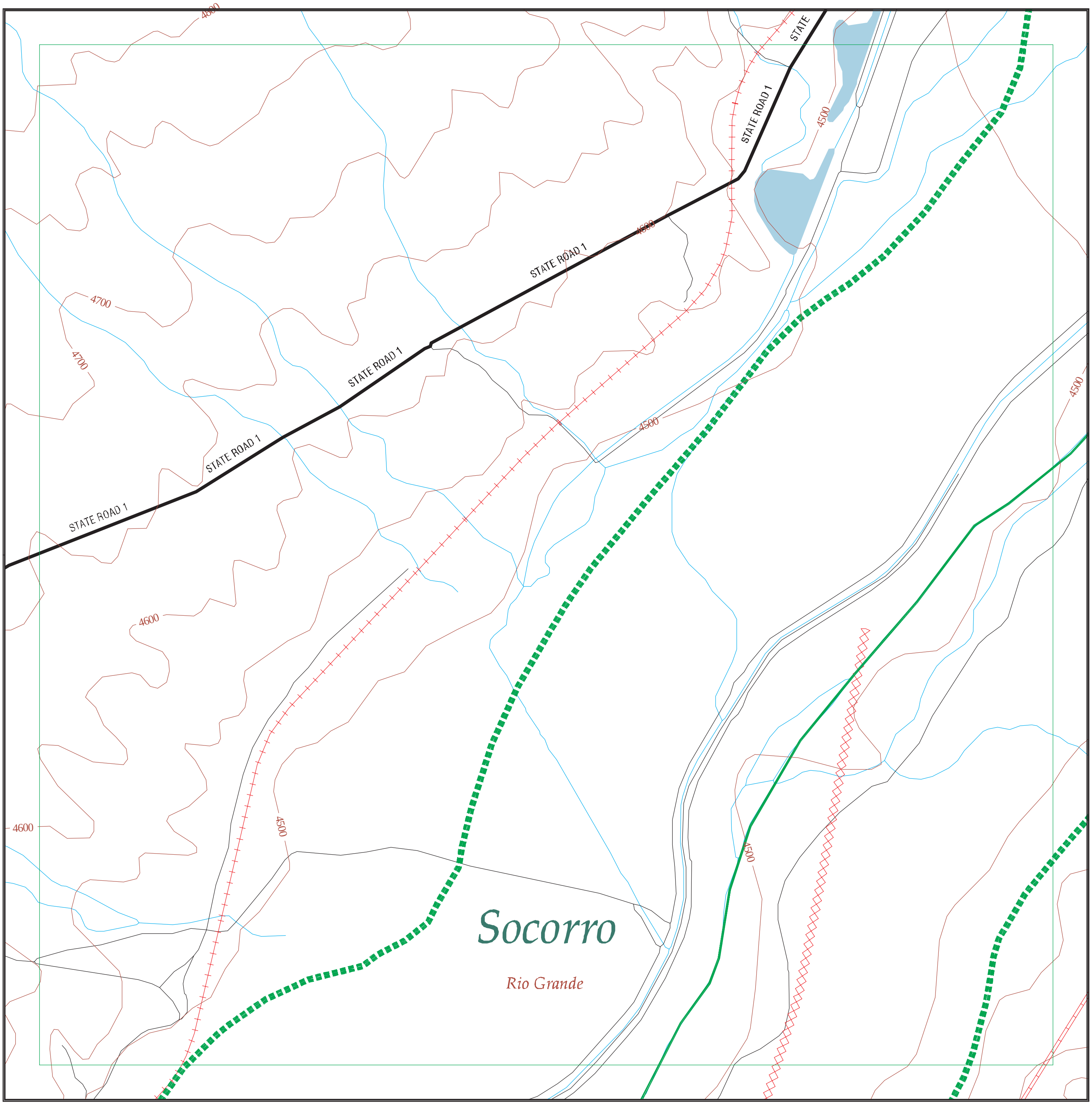
Rio Grande Levees-San Acacia-Bosque Del Apache



FOCUS MAP 18 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 19



EDR DataMap™ - Environmental Atlas ™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

- Roads
- Waterways
- Powerlines
- Water
- Listed Sites
- Major Roads
- Railroads
- Pipelines
- Superfund Sites
- Contour Lines
- Study Boundary
- Fault Lines
- Federal DOD Sites
- Indian Reservations BIA

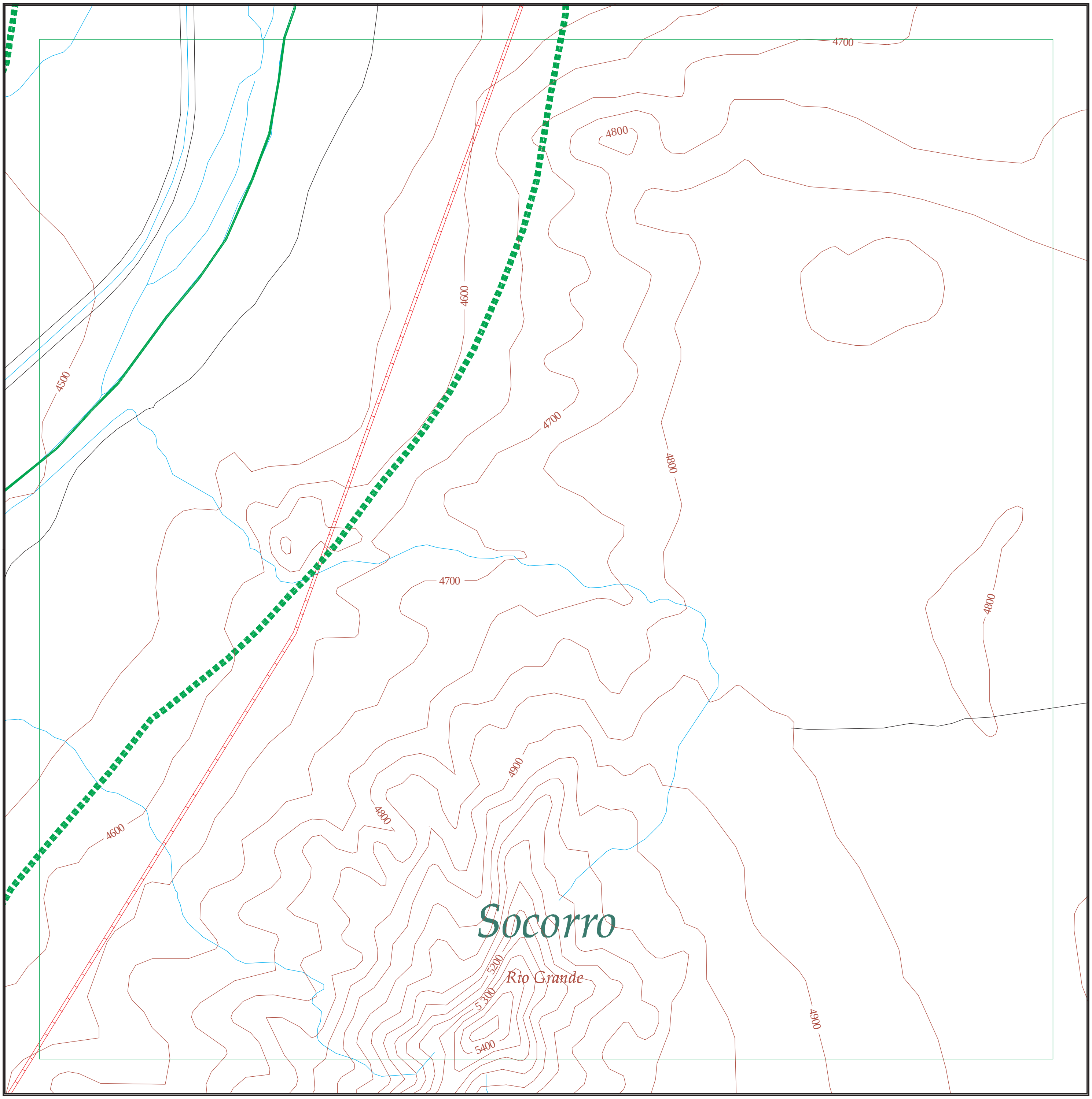
0 1/2 1

Scale in Miles

FOCUS MAP 19 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 20



EDR DataMap™ - Environmental Atlas ™

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads
Waterways
Powerlines
Water
Listed Sites
Major Roads
Railroads
Pipelines
Superfund Sites
Contour Lines
Study Boundary
Fault Lines
Federal DOD Sites
Indian Reservations BIA

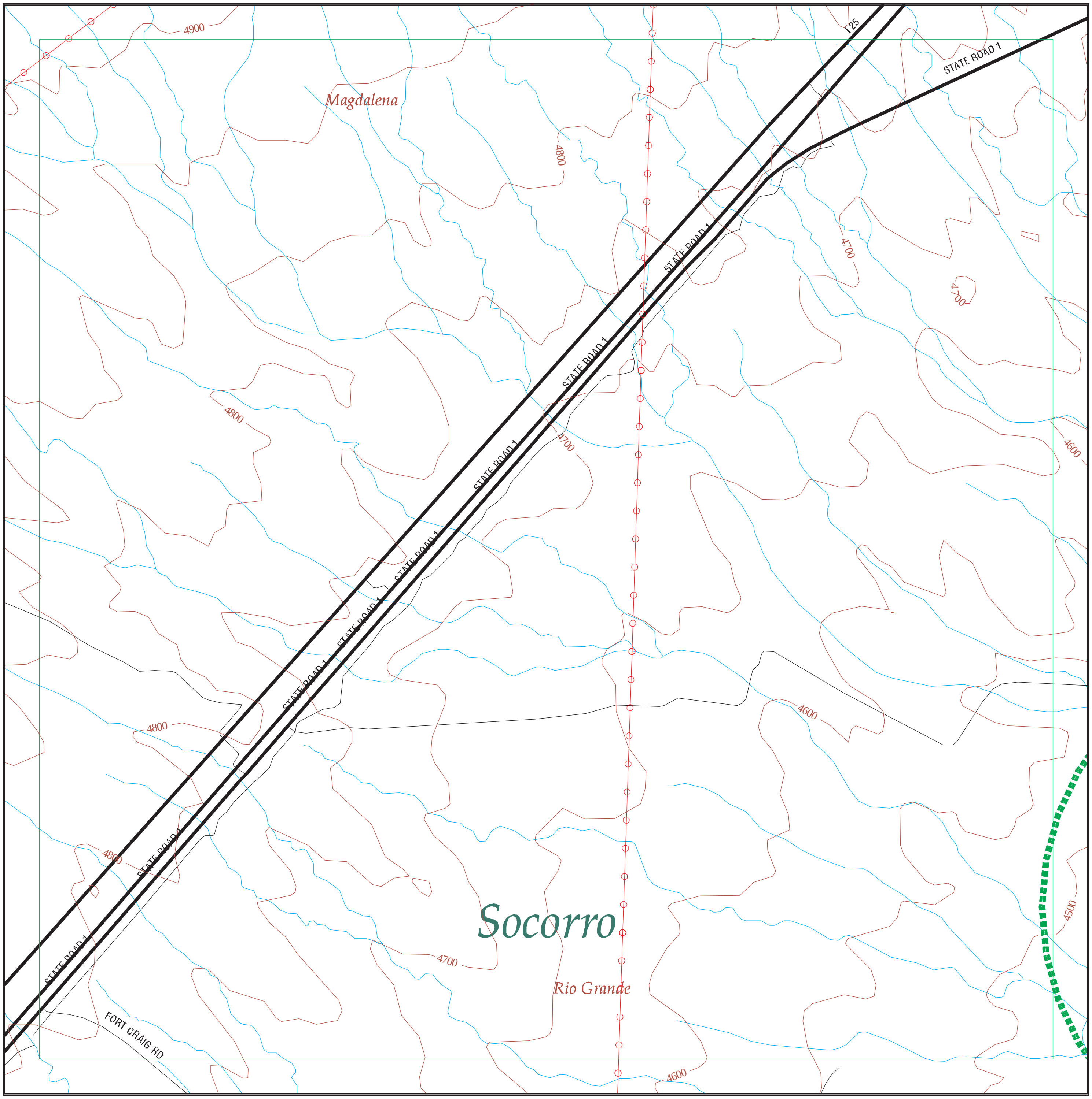
0 1/2 1

Scale in Miles

FOCUS MAP 20 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

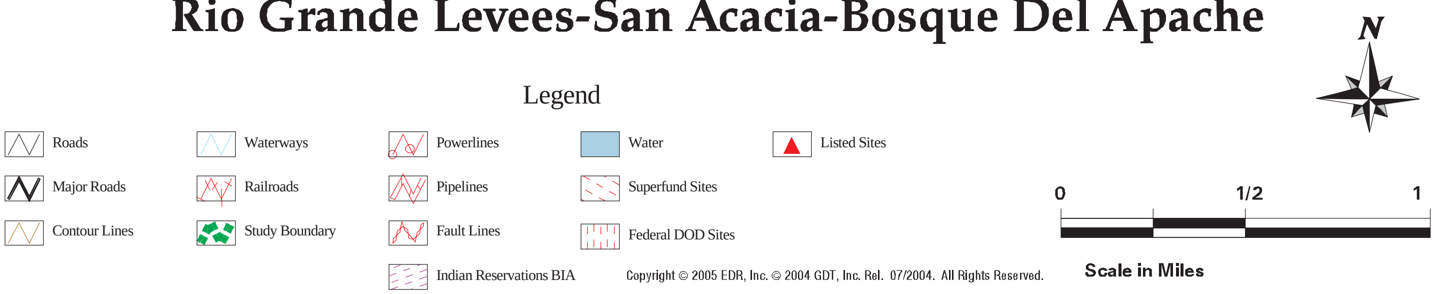
Focus Map 21



EDR DataMap™ - Environmental Atlas™

Rio Grande Levees-San Acacia-Bosque Del Apache

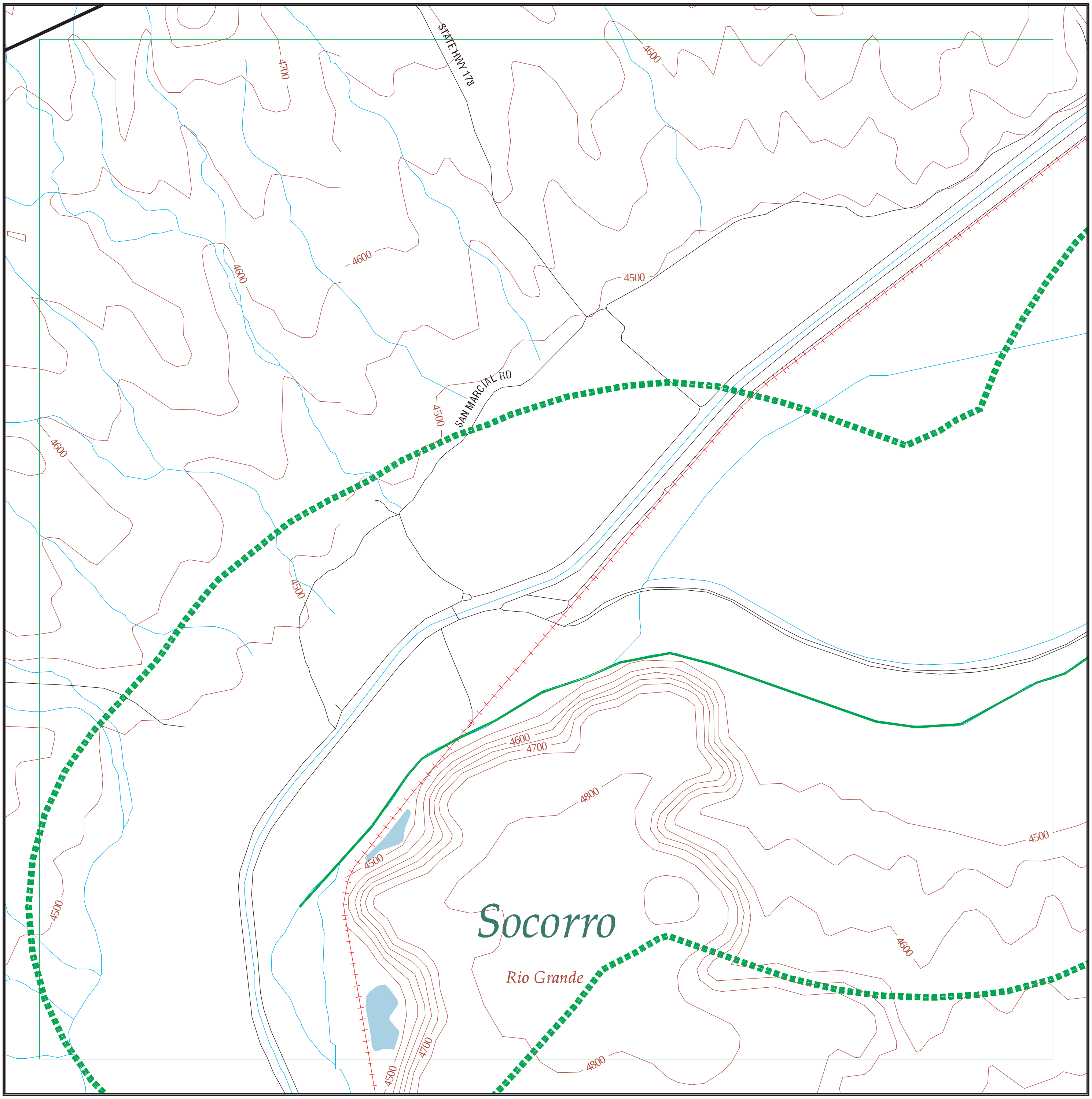
Legend



FOCUS MAP 21 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
MAGDALENA	1001222076	ALAMO NAVAJO SCHOOL BOARD INC	HWY 169 ALAMO RESERVATION	87825	RCRA-SQG, FINDS
MAGDALENA	S105770465	ALAMO NAVAJO COMMUNITY SCHOOL	HIGHWAY 52	87825	INDIAN UST
MAGDALENA	S106612421	CONOCO DEALER	HWY 60 / RODEO RD	87825	LUST, LAST
MAGDALENA	1004754617	ALAMO NAVAJO SCHOOL BOARD INC	ALAMO RESERVATION HWY 169	87825	RCRA-SQG
MAGDALENA	U003192226	TRIANGLE C RANCH A	BEAVERHEAD RT	87825	UST
MAGDALENA	U003192216	ADOBE RANCH	CATRON COUNTY STATE RD 59	87825	LUST, UST
MAGDALENA	S106105640	MAGDALENA CONSTRUCTION & DEMOLITION LAND	1/2 MILE NORTH OF MAGDALENA	87825	SWF/LF
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
MAGDALENA	1007985374	ALAMO SPRINGS DIP VAT	24 M. NORTHWEST OF MAGDALENA	87825	CERCLIS
MAGDALENA	S106612424	PHILIPS 66 DEALER	RODEO RD HWY 60	87825	LUST, LAST
MAGDALENA	1000106102	HOP CANYON MILL	1.7MI SSE OF JNCT WITH US60	87825	CERCLIS, FINDS
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 22



EDR DataMap™ - Environmental Atlas™

EDR® Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

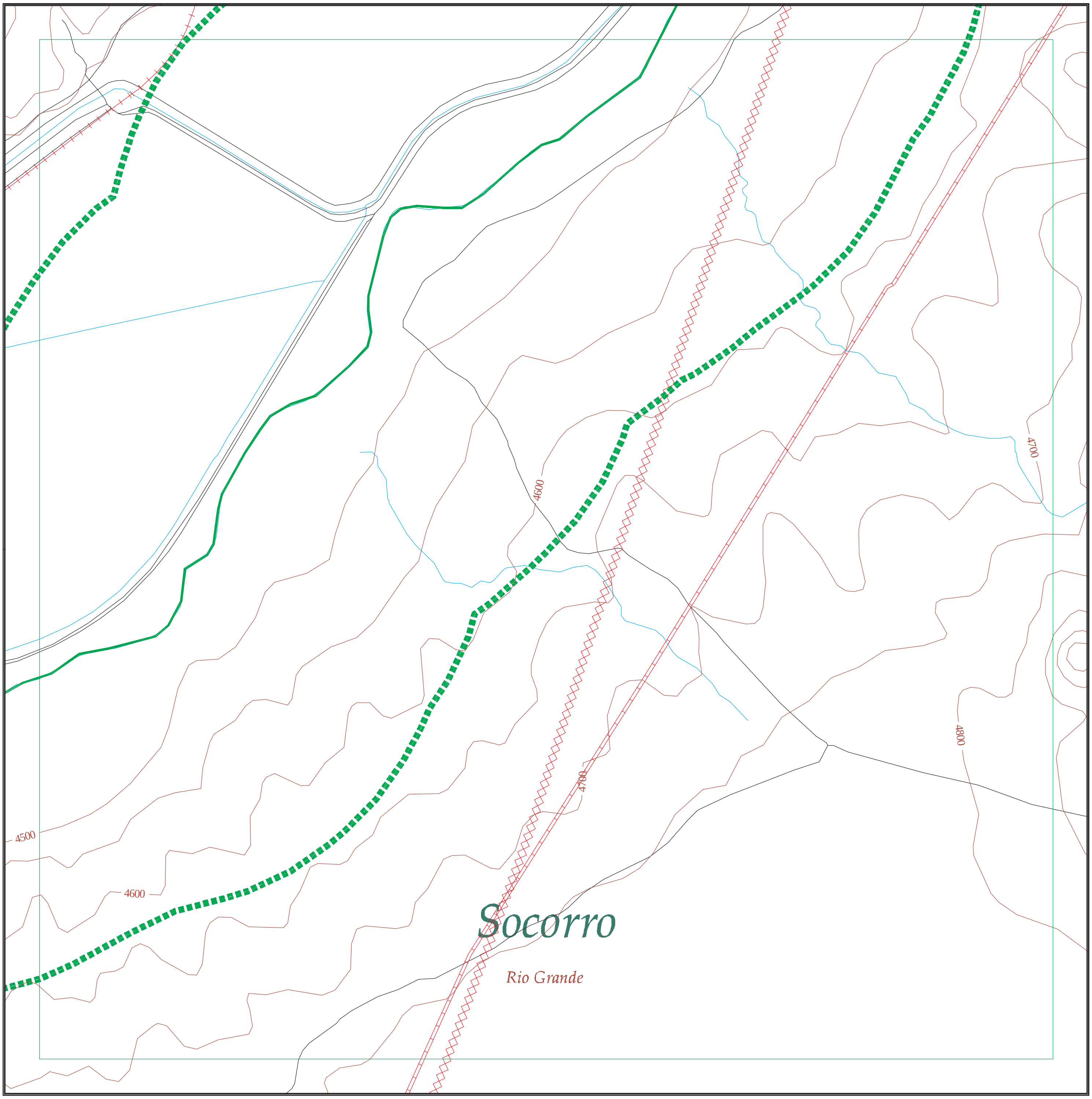
0 1/2 1

Scale in Miles

FOCUS MAP 22 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 23



EDR DataMap™ - Environmental Atlas ™

EDR® Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

- Roads
- Major Roads
- Contour Lines
- Waterways
- Railroads
- Study Boundary
- Powerlines
- Pipelines
- Fault Lines
- Indian Reservations BIA
- Water
- Superfund Sites
- Federal DOD Sites
- Listed Sites

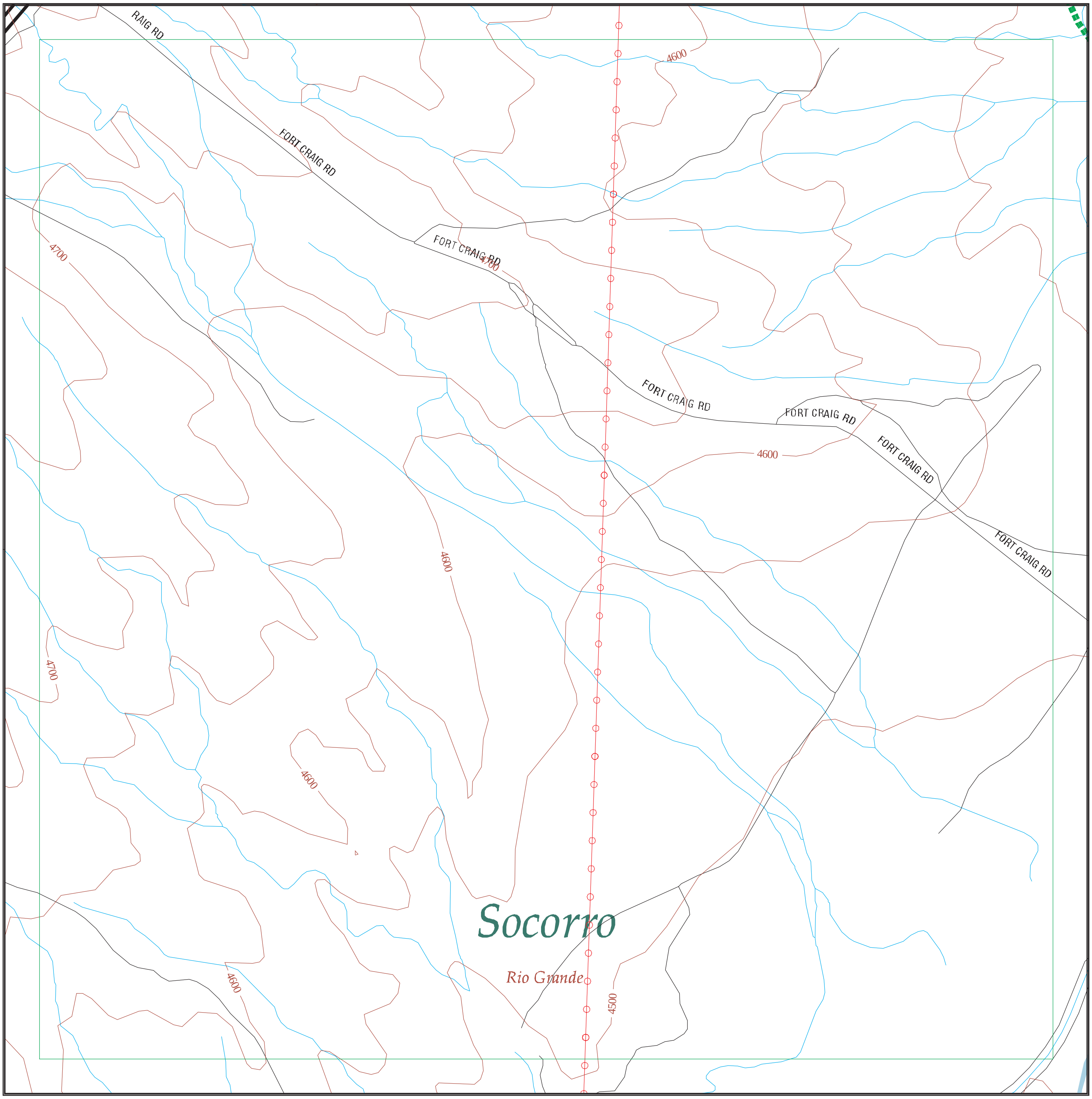
0 1/2 1

Scale in Miles

FOCUS MAP 23 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 24



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

Legend

Roads	Waterways	Powerlines	Water	Listed Sites
Major Roads	Railroads	Pipelines	Superfund Sites	
Contour Lines	Study Boundary	Fault Lines	Federal DOD Sites	
		Indian Reservations BIA		

0 1/2 1

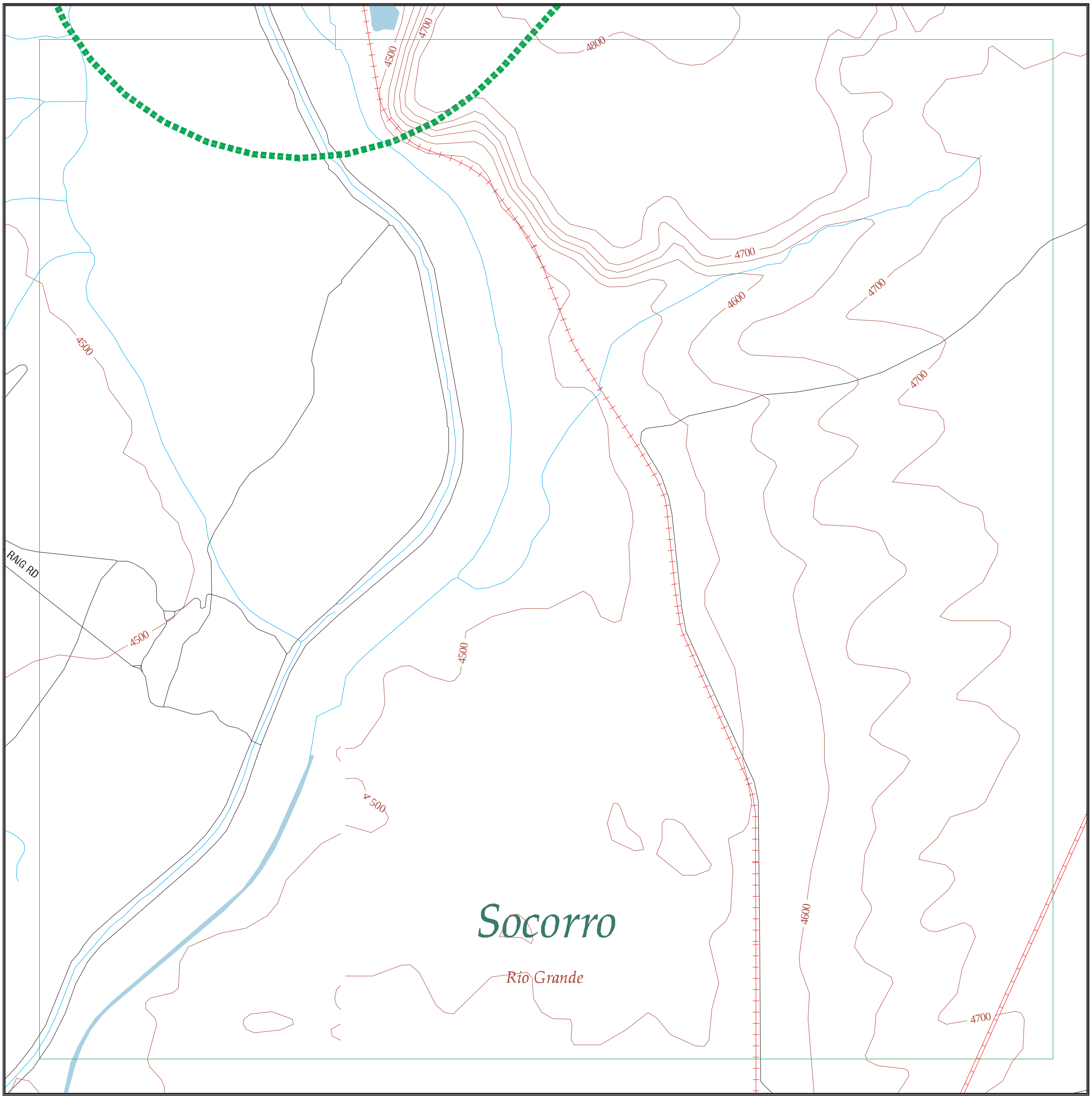
Scale in Miles

N

FOCUS MAP 24 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
ESCONDIDA	1004754095	CHEVRON PIPE LINE ESCONDIDA STA	8M NE 18M SE OF I-25	87801	RCRA-SQG, FINDS
MAGDALENA	S105427028	NAT'L RADIO OBS	25 MILES W OF MAGDALENA, OFF NWY 60	87801	LUST
SOCORRO	U003732568	ROADRUNNER TRAVEL CENTER INC	I 25 EXIT 156 W FRONTAGE RD	87801	UST
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Focus Map 25



EDR DataMap™ - Environmental Atlas™

EDR Environmental Data Resources Inc

Rio Grande Levees-San Acacia-Bosque Del Apache

N

Legend

Roads
Major Roads
Contour Lines
Waterways
Railroads
Study Boundary
Powerlines
Pipelines
Fault Lines
Indian Reservations BIA
Water
Superfund Sites
Federal DOD Sites
Listed Sites

0 1/2 1

Scale in Miles

FOCUS MAP 25 ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
SOCORRO	S105426906	CHEVRON SOUTH	I 25 AND HWY 25 S	87801	LUST
SOCORRO	U003193101	CHEVRON 75976	I 25 AND HWY 25 S	87801	UST
SOCORRO	U003913193	ALAMO NAVAJO RESERVATION	HWY 52	87801	UST
SOCORRO	1000227944	DICAPERL-SOCORRO PLANT	HWY 60 3.5M SW	87801	RCRA-SQG, FINDS
SOCORRO	1000341840	SOCORRO GEN HOSP	HWY 60 W 2.5M W	87801	RCRA-SQG, FINDS
SOCORRO	U003193115	JIM WOODS WAREHOUSE	HWY 85 S	87801	UST
SOCORRO	1003873638	WASTE OIL DISPOSAL SITE	N OF HWY 60 W OF TOWN	87801	CERC-NFRAP
SOCORRO	U003193112	FT CRAIG PATROL YARD	NW OF INTERSECTION HWY 107	87801	UST
SOCORRO	S106105650	SOCORRO CITY LANDFILL	STATE RD 1 SOUTH OF SOCORRO	87801	SWF/LF
SOCORRO	1003873682	TECH METALS	2 MI W OF CITY ON US RTE 60/846 GRANADA	87801	CERC-NFRAP

Section 3

County Level Orphan Sites

SOCORRO COUNTY, NM - ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
5 MI SOUTH SAN ACICA	8869706	LOW FLOW CONDEYANCE CHANNEL I-25	LOW FLOW CONDEYANCE CHANNEL I-25		ERNS
ANCHO	99607191	HIGHWAY 54 MM:143	HIGHWAY 54 MM:143		ERNS
SAN ACACIA	2000536205	SAN ACACIA	SAN ACACIA	0	ERNS
SOCORRO	S106237830		ASBESTOS ABATEMENT BY KEERS ENVIRON		SPILLS
SOCORRO	S106426075	SAN MIGUEL SHOPPING CENTER	913 CALIFORNIA STREET (3 SEPARATE P		VCP
SOCORRO	94385672	CHEVRON STATION ON MAIN STREET	CHEVRON STATION ON MAIN STREET		ERNS
SOCORRO	2000669508	DDRESS: UNKNOWN	DDRESS: UNKNOWN		ERNS
SOCORRO	S106894819		ESCONDIDO		SPILLS
SOCORRO	S106237160		FENCED LOT W/ CHAIN LINK FENCE NEAR		SPILLS
SOCORRO	8718436	S HWY 380	S HWY 380		ERNS
SOCORRO	S106237238		KICK SERVICE STATION NEAR CALIFORNI		SPILLS
SOCORRO	S106561295		801 LOPEZ PLACE, SOCORRO		SPILLS
SOCORRO	S106237799		PRIVATE LAND OUTSIDE OF SOCORROA P-		SPILLS
SOCORRO	S106894770		SOCORRO		SPILLS
SOCORRO	2000532800	STREET ADDRESS: UNKNOWN	STREET ADDRESS: UNKNOWN	0	ERNS
SOCORRO COUNTY	89129664	NW QUARTER OF STALLION RANGE CENTER	NW QUARTER OF STALLION RANGE CENTER		ERNS

Section 4

EPA Waste Code Addendum

SECTION 4 - EPA WASTE CODES

There are no epa codes to report for this search area.

Section 5

Databases Searched and Update Dates

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Elapsed ASTM days: Provides confirmation that this EDR report meets or exceeds the 90-day updating requirement of the ASTM standard.

FEDERAL ASTM STANDARD RECORDS

NPL: National Priority List
Source: EPA
Telephone: N/A
National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by EPA's Environmental Photographic Interpretation Center (EPIC) and regional EPA offices.

Date of Government Version: 04/28/05
Date Made Active at EDR: 05/16/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 05/04/05
Elapsed ASTM days: 12
Date of Last EDR Contact: 05/04/05

NPL Site Boundaries

Sources:

EPA's Environmental Photographic Interpretation Center (EPIC)
Telephone: 202-564-7333

EPA Region 1
Telephone 617-918-1143

EPA Region 3
Telephone 215-814-5418

EPA Region 4
Telephone 404-562-8033

EPA Region 6
Telephone: 214-655-6659

EPA Region 8
Telephone: 303-312-6774

Proposed NPL: Proposed National Priority List Sites
Source: EPA
Telephone: N/A

Date of Government Version: 04/27/05
Date Made Active at EDR: 05/16/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 05/04/05
Elapsed ASTM days: 12
Date of Last EDR Contact: 05/04/05

CERCLIS: Comprehensive Environmental Response, Compensation, and Liability Information System
Source: EPA
Telephone: 703-413-0223
CERCLIS contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLIS contains sites which are either proposed to or on the National Priorities List (NPL) and sites which are in the screening and assessment phase for possible inclusion on the NPL.

Date of Government Version: 02/15/05
Date Made Active at EDR: 04/06/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 03/22/05
Elapsed ASTM days: 15
Date of Last EDR Contact: 07/22/05

CERCLIS-NFRAP: CERCLIS No Further Remedial Action Planned
Source: EPA
Telephone: 703-413-0223
As of February 1995, CERCLIS sites designated "No Further Remedial Action Planned" (NFRAP) have been removed from CERCLIS. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund action or NPL consideration. EPA has removed approximately 25,000 NFRAP sites to lift the unintended barriers to the redevelopment of these properties and has archived them as historical records so EPA does not needlessly repeat the investigations in the future. This policy change is part of the EPA's Brownfields Redevelopment Program to help cities, states, private investors and affected citizens to promote economic redevelopment of unproductive urban sites.

Date of Government Version: 03/22/05
Date Made Active at EDR: 04/06/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 04/01/05
Elapsed ASTM days: 5
Date of Last EDR Contact: 06/20/05

CORRACTS: Corrective Action Report
Source: EPA
Telephone: 800-424-9346
CORRACTS identifies hazardous waste handlers with RCRA corrective action activity.

Date of Government Version: 03/29/05
Date Made Active at EDR: 05/16/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 04/11/05
Elapsed ASTM days: 35
Date of Last EDR Contact: 06/05/05

RCRA: Resource Conservation and Recovery Act Information
Source: EPA
Telephone: 800-424-9346
RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. RCRAInfo replaces the data recording and reporting abilities of the Resource Conservation and Recovery Information System (RCRIS). The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Conditionally exempt small quantity generators (CESQGs) generate less than 100 kg of hazardous waste, or less than 1 kg of acutely hazardous waste per month. Small quantity generators (SQGs) generate between 100 kg and 1,000 kg of hazardous waste per month. Large quantity generators (LQGs) generate over 1,000 kilograms (kg) of hazardous waste, or over 1 kg of acutely hazardous waste per month. Transporters are individuals or entities that move hazardous waste from the generator off-site to a facility that can recycle, treat, store, or dispose of the waste. TSDFs treat, store, or dispose of the waste.

Date of Government Version: 05/20/05
Date Made Active at EDR: 06/09/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 05/24/05
Elapsed ASTM days: 16
Date of Last EDR Contact: 05/24/05

ERNS: Emergency Response Notification System
Source: National Response Center, United States Coast Guard
Telephone: 202-260-2342
Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 12/31/04
Date Made Active at EDR: 03/24/05
Database Release Frequency: Annually
Date of Data Arrival at EDR: 01/27/05
Elapsed ASTM days: 56
Date of Last EDR Contact: 07/25/05

FEDERAL ASTM SUPPLEMENTAL RECORDS

BRS: Biennial Reporting System
Source: EPA/NTIS
Telephone: 800-424-9346
The Biennial Reporting System is a national system administered by the EPA that collects data on the generation and management of hazardous waste. BRS captures detailed data from two groups: Large Quantity Generators (LQG) and Treatment, Storage, and Disposal Facilities.

Date of Government Version: 12/01/01
Database Release Frequency: Biennially
Date of Last EDR Contact: 06/17/05
Date of Next Scheduled EDR Contact: 09/12/05

CONSENT: Superfund (CERCLA) Consent Decrees
Source: Department of Justice, Consent Decree Library
Telephone: Varies
Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: 12/14/04
Database Release Frequency: Varies
Date of Last EDR Contact: 07/25/05
Date of Next Scheduled EDR Contact: 10/24/05

ROD: Records Of Decision
Source: EPA
Telephone: 703-416-0223
Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

Date of Government Version: 03/07/05
Database Release Frequency: Annually
Date of Last EDR Contact: 07/06/05
Date of Next Scheduled EDR Contact: 10/03/05

DELISTED NPL: National Priority List Deletions
Source: EPA
Telephone: N/A
The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

Date of Government Version: 04/28/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 05/04/05
Date of Next Scheduled EDR Contact: 08/01/05

FINDS: Facility Index System/Facility Registry System
Source: EPA
Telephone: N/A
Facility Index System. FINDS contains both facility information and 'pointers' to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Data System).

Date of Government Version: 04/11/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 07/05/05
Date of Next Scheduled EDR Contact: 10/03/05

HMIRS: Hazardous Materials Information Reporting System
Source: U.S. Department of Transportation
Telephone: 202-366-4555
Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 12/31/04
Database Release Frequency: Annually
Date of Last EDR Contact: 07/22/05
Date of Next Scheduled EDR Contact: 10/17/05

MLTS: Material Licensing Tracking System
Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/14/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 07/05/05
Date of Next Scheduled EDR Contact: 10/03/05

MINES: Mines Master Index File
Source: Department of Labor, Mine Safety and Health Administration
Telephone: 303-231-5959
Contains all mine identification numbers issued for mines active or opened since 1971. The data also includes violation information.

Date of Government Version: 02/11/05
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 06/27/05
Date of Next Scheduled EDR Contact: 09/26/05

NPL LIENS: Federal Superfund Liens
Source: EPA
Telephone: 202-564-4267
Federal Superfund Liens. Under the authority granted the USEPA by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner receives notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/91
Database Release Frequency: No Update Planned
Date of Last EDR Contact: 05/23/05
Date of Next Scheduled EDR Contact: 08/22/05

PADS: PCB Activity Database System
Source: EPA
Telephone: 202-564-3887
PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 03/30/05
Database Release Frequency: Annually
Date of Last EDR Contact: 05/10/05
Date of Next Scheduled EDR Contact: 08/08/05

DOD: Department of Defense Sites
Source: USGS
Telephone: 703-692-8801
This data set consists of federally owned or administered lands, administered by the Department of Defense, that have any area equal to or greater than 640 acres of the United States, Puerto Rico, and the U.S. Virgin Islands.

Date of Government Version: 10/01/03
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 05/13/05
Date of Next Scheduled EDR Contact: 08/08/05

UMTRA: Uranium Mill Tailings Sites
Source: Department of Energy
Telephone: 505-845-0011
Uranium ore was mined by private companies for federal government use in national defense programs. When the mills shut down, large piles of the sand-like material (mill tailings) remain after uranium has been extracted from the ore. Levels of human exposure to radioactive materials from the piles are low; however, in some cases tailings were used as construction materials before the potential health hazards of the tailings were recognized. In 1978, 24 inactive uranium mill tailings sites in Oregon, Idaho, Wyoming, Utah, Colorado, New Mexico, Texas, North Dakota, South Dakota, Pennsylvania, and on Navajo and Hopi tribal lands, were targeted for cleanup by the Department of Energy.

Date of Government Version: 12/29/04
Database Release Frequency: Varies
Date of Last EDR Contact: 07/05/05
Date of Next Scheduled EDR Contact: 09/19/05

ODI: Open Dump Inventory
Source: Environmental Protection Agency
Telephone: 800-424-9346
An open dump is defined as a disposal facility that does not comply with one or more of the Part 257 or Part 258 Subtitle D Criteria.

Date of Government Version: 06/30/85
Database Release Frequency: No Update Planned
Date of Last EDR Contact: 05/23/95
Date of Next Scheduled EDR Contact: N/A

FUDS: Formerly Used Defense Sites
Source: U.S. Army Corps of Engineers
Telephone: 202-528-4285
The listing includes locations of Formerly Used Defense Sites properties where the US Army Corps of Engineers is actively working or will take necessary cleanup actions.

Date of Government Version: 12/31/03
Database Release Frequency: Varies
Date of Last EDR Contact: 06/29/05
Date of Next Scheduled EDR Contact: 10/03/05

INDIAN RESERV: Indian Reservations
Source: USGS
Telephone: 202-208-3710
This map layer portrays Indian administered lands of the United States that have any area equal to or greater than 640 acres.

Date of Government Version: 10/01/03
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 05/13/05
Date of Next Scheduled EDR Contact: 08/08/05

US ENG CONTROLS: Engineering Controls Sites List
Source: Environmental Protection Agency
Telephone: 703-603-8867
A listing of sites with engineering controls in place. Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health.

Date of Government Version: 01/10/05
Database Release Frequency: Varies
Date of Last EDR Contact: 07/05/05
Date of Next Scheduled EDR Contact: 10/03/05

RAATS: RCRA Administrative Action Tracking System
Source: EPA
Telephone: 202-564-4104
RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA. For administration actions after September 30, 1995, data entry in the RAATS database was discontinued. EPA will retain a copy of the database for historical records. It was necessary to terminate RAATS because a decrease in agency resources made it impossible to continue to update the information contained in the database.

Date of Government Version: 04/17/95
Database Release Frequency: No Update Planned
Date of Last EDR Contact: 06/06/05
Date of Next Scheduled EDR Contact: 09/05/05

TRIS: Toxic Chemical Release Inventory System
Source: EPA
Telephone: 202-566-0250
Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/02
Database Release Frequency: Annually
Date of Last EDR Contact: 07/13/05
Date of Next Scheduled EDR Contact: 09/19/05

TSCA: Toxic Substances Control Act
Source: EPA
Telephone: 202-260-5521
Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

Date of Government Version: 12/31/02
Database Release Frequency: Every 4 Years
Date of Last EDR Contact: 07/18/05
Date of Next Scheduled EDR Contact: 10/17/05

FTTS INSP: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
Source: EPA
Telephone: 202-566-1667

Date of Government Version: 04/13/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 06/20/05
Date of Next Scheduled EDR Contact: 09/19/05

SSTS: Section 7 Tracking Systems
Source: EPA
Telephone: 202-564-4203
Section 7 of the Federal Insecticide, Fungicide and Rodenticide Act, as amended (92 Stat. 829) requires all registered pesticide-producing establishments to submit a report to the Environmental Protection Agency by March 1st each year. Each establishment must report the types and amounts of pesticides, active ingredients and devices being produced, and those having been produced and sold or distributed in the past year.

Date of Government Version: 12/31/03
Database Release Frequency: Annually
Date of Last EDR Contact: 07/18/05
Date of Next Scheduled EDR Contact: 10/17/05

FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
Source: EPA/Office of Prevention, Pesticides and Toxic Substances
Telephone: 202-566-1667
FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act). To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/13/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 06/20/05
Date of Next Scheduled EDR Contact: 09/19/05

STATE OF NEW MEXICO ASTM STANDARD RECORDS

SHWS: This state does not maintain a SHWS list. See the Federal CERCLIS list and Federal NPL list.
Source: EPA
Telephone: 703-413-0223
State Hazardous Waste Sites. State hazardous waste site records are the states' equivalent to CERCLIS. These sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup using state funds (state equivalent of Superfund) are identified along with sites where cleanup will be paid for by potentially responsible parties. Available information varies by state.

Date of Government Version: N/A
Date Made Active at EDR: N/A
Database Release Frequency: N/A
Date of Data Arrival at EDR: N/A
Elapsed ASTM days: N/A
Date of Last EDR Contact: 07/25/05

SWF/LF: Solid Waste Facilities
Source: New Mexico Environment Department
Telephone: 505-827-0347
Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 12/23/03
Date Made Active at EDR: 01/20/04
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 12/23/03
Elapsed ASTM days: 28
Date of Last EDR Contact: 07/18/05

LUST: Leaking Underground Storage Tank Priorization Database
Source: New Mexico Environment Department
Telephone: 505-984-1741
Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 05/03/05
Date Made Active at EDR: 05/17/05
Database Release Frequency: Varies
Date of Data Arrival at EDR: 05/04/05
Elapsed ASTM days: 13
Date of Last EDR Contact: 05/02/05

UST: Listing of Underground Storage Tanks
Source: New Mexico Environment Department
Telephone: 505-984-1741
Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 05/03/05
Date Made Active at EDR: 05/19/05
Database Release Frequency: Varies

Date of Data Arrival at EDR: 05/04/05
Elapsed ASTM days: 15
Date of Last EDR Contact: 05/02/05

INDIAN UST: Underground Storage Tanks on Indian Land
Source: EPA Region 9
Telephone: 415-972-3368

Date of Government Version: 04/18/05
Date Made Active at EDR: 06/02/05
Database Release Frequency: Varies

Date of Data Arrival at EDR: 05/16/05
Elapsed ASTM days: 17
Date of Last EDR Contact: 05/16/05

INDIAN LUST: Leaking Underground Storage Tanks on Indian Land
Source: Environmental Protection Agency
Telephone: 415-972-3372
LUSTs on Indian land in Arizona, California, New Mexico and Nevada

Date of Government Version: 06/02/05
Date Made Active at EDR: 06/28/05
Database Release Frequency: Varies

Date of Data Arrival at EDR: 06/03/05
Elapsed ASTM days: 25
Date of Last EDR Contact: 05/25/05

INDIAN UST: USTs on Indian Land
Source: Environmental Protection Agency, Region 6
Telephone: 214-665-7591

Date of Government Version: 01/04/05
Date Made Active at EDR: 02/28/05
Database Release Frequency: Varies

Date of Data Arrival at EDR: 01/14/05
Elapsed ASTM days: 45
Date of Last EDR Contact: 06/22/05

VCP: Voluntary Remediation Program Sites
Source: Environment Department
Telephone: 505-827-2754
Sites involved in the Voluntary Remediation Program.

Date of Government Version: 03/31/05
Date Made Active at EDR: 05/13/05
Database Release Frequency: Varies

Date of Data Arrival at EDR: 05/02/05
Elapsed ASTM days: 11
Date of Last EDR Contact: 07/25/05

INDIAN LUST: Leaking Underground Storage Tanks on Indian Land
Source: EPA Region 6
Telephone: 214-665-6597
LUSTs on Indian land in New Mexico and Oklahmoa.

Date of Government Version: 01/04/05
Date Made Active at EDR: 02/28/05
Database Release Frequency: Varies

Date of Data Arrival at EDR: 01/21/05
Elapsed ASTM days: 38
Date of Last EDR Contact: 06/22/05

STATE OF NEW MEXICO ASTM SUPPLEMENTAL RECORDS

AST: Aboveground Storage Tanks List
Source: Environment Department
Telephone: 505-984-1926
Aboveground tanks that have been inspected by the State Fire Marshal.

Date of Government Version: 06/27/05
Database Release Frequency: Varies

Date of Last EDR Contact: 06/27/05
Date of Next Scheduled EDR Contact: 09/26/05

LAST: Leaking Aboveground Storage Tank Sites
Source: Environment Department
Telephone: 505-984-1926
A listing of leaking aboveground storage tank sites.

Date of Government Version: 05/03/05 | Date of Last EDR Contact: 05/02/05
Database Release Frequency: Quarterly | Date of Next Scheduled EDR Contact: 08/01/05

SPILLS: Spill Data
Source: Environment Department
Telephone: 505-827-0166
Hazardous materials spills data.

Date of Government Version: 05/24/05 | Date of Last EDR Contact: 07/25/05
Database Release Frequency: Varies | Date of Next Scheduled EDR Contact: 10/24/05

EDR PROPRIETARY HISTORICAL DATABASES

Former Manufactured Gas (Coal Gas) Sites: The existence and location of Coal Gas sites is provided exclusively to EDR by Real Property Scan, Inc. ©Copyright 1993 Real Property Scan, Inc. For a technical description of the types of hazards which may be found at such sites, contact your EDR customer service representative.

Disclaimer Provided by Real Property Scan, Inc.

The information contained in this report has predominantly been obtained from publicly available sources produced by entities other than Real Property Scan. While reasonable steps have been taken to insure the accuracy of this report, Real Property Scan does not guarantee the accuracy of this report. Any liability on the part of Real Property Scan is strictly limited to a refund of the amount paid. No claim is made for the actual existence of toxins at any site. This report does not constitute a legal opinion.

BROWNFIELDS DATABASES

US BROWNFIELDS: A Listing of Brownfields Sites
Source: Environmental Protection Agency
Telephone: 202-566-2777
Included in the listing are brownfields properties addresses by Cooperative Agreement Recipients and brownfields properties addressed by Targeted Brownfields Assessments. Targeted Brownfields Assessments-EPA's Targeted Brownfields Assessments (TBA) program is designed to help states, tribes, and municipalities--especially those without EPA Brownfields Assessment Demonstration Pilots--minimize the uncertainties of contamination often associated with brownfields. Under the TBA program, EPA provides funding and/or technical assistance for environmental assessments at brownfields sites throughout the country. Targeted Brownfields Assessments supplement and work with other efforts under EPA's Brownfields Initiative to promote cleanup and redevelopment of brownfields. Cooperative Agreement Recipients-States, political subdivisions, territories, and Indian tribes become Brownfields Cleanup Revolving Loan Fund (BCRLF) cooperative agreement recipients when they enter into BCRLF cooperative agreements with the U.S. EPA. EPA selects BCRLF cooperative agreement recipients based on a proposal and application process. BCRLF cooperative agreement recipients must use EPA funds provided through BCRLF cooperative agreement for specified brownfields-related cleanup activities.

Date of Government Version: 01/10/05 | Date of Last EDR Contact: 06/13/05
Database Release Frequency: Semi-Annually | Date of Next Scheduled EDR Contact: 09/12/05

VCP: Voluntary Remediation Program Sites
Source: Environment Department
Telephone: 505-827-2754
Sites involved in the Voluntary Remediation Program.

Date of Government Version: 03/31/05 | Date of Last EDR Contact: 07/25/05
Database Release Frequency: Varies | Date of Next Scheduled EDR Contact: 10/24/05

US INST CONTROL: Sites with Institutional Controls
Source: Environmental Protection Agency
Telephone: 703-603-8867
A listing of sites with institutional controls in place. Institutional controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on site. Deed restrictions are generally required as part of the institutional controls.

Date of Government Version: 01/10/05
Database Release Frequency: Varies
Date of Last EDR Contact: 07/05/05
Date of Next Scheduled EDR Contact: 10/03/05

INST CONTROL: Sites with Institutional Controls
Source: Environment Department
Telephone: 505-827-2754
Sites included in the Voluntary Cleanup listing that have Institutional Controls in place.

Date of Government Version: 03/31/05
Database Release Frequency: Varies
Date of Last EDR Contact: 07/25/05
Date of Next Scheduled EDR Contact: 10/24/05

OTHER DATABASE(S)

Depending on the geographic area covered by this report, the data provided in these specialty databases may or may not be complete. For example, the existence of wetlands information data in a specific report does not mean that all wetlands in the area covered by the report are included. Moreover, the absence of any reported wetlands information does not necessarily mean that wetlands do not exist in the area covered by the report.

Sensitive Receptors: There are individuals deemed sensitive receptors due to their fragile immune systems and special sensitivity to environmental discharges. These sensitive receptors typically include the elderly, the sick, and children. While the location of all sensitive receptors cannot be determined, EDR indicates those buildings and facilities - schools, daycares, hospitals, medical centers, and nursing homes - where individuals who are sensitive receptors are likely to be located.

AHA Hospitals:
Source: American Hospital Association, Inc.
Telephone: 312-280-5991
The database includes a listing of hospitals based on the American Hospital Association's annual survey of hospitals.

Medical Centers: Provider of Services Listing
Source: Centers for Medicare & Medicaid Services
Telephone: 410-786-3000
A listing of hospitals with Medicare provider number, produced by Centers of Medicare & Medicaid Services, a federal agency within the U.S. Department of Health and Human Services.

Nursing Homes
Source: National Institutes of Health
Telephone: 301-594-6248
Information on Medicare and Medicaid certified nursing homes in the United States.

Public Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on elementary and secondary public education in the United States. It is a comprehensive, annual, national statistical database of all public elementary and secondary schools and school districts, which contains data that are comparable across all states.

Private Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on private school locations in the United States.

Daycare Centers: Licensed Child Day Care Providers
Source: Office of Child Development
Telephone: 505-827-7946

Flood Zone Data: This data, available in select counties across the country, was obtained by EDR in 1999 from the Federal Emergency Management Agency (FEMA). Data depicts 100-year and 500-year flood zones as defined by FEMA.

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002 from the U.S. Fish and Wildlife Service.

STREET AND ADDRESS INFORMATION

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

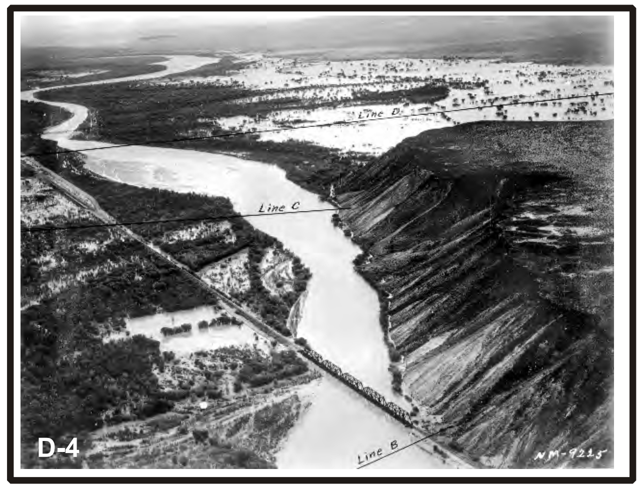
APPENDIX D

Site Photographs

1929 Photograph of the San Marcial Roundhouse

1929 Photograph of San Marcial

1929 Photograph of the construction of Bridge No. 1006A



1940 aerial photograph of Bridge No. 1006A
and the ruins of San Marcial

1930 View of Main Street after the flooding

View of the Harvey House before the 1929 flood

Photographs provided by the University of New Mexico
Office of Contract Archaeology

Prepared For
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Figure 26 - Historic Photographs of the San Marcial Area

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

Prepared by
Echota Technologies Corporation

View of the San Acacia Diversion Works
Facing Southeast

The Low Flow Conveyance Channel Inlet at San Acacia
Facing Northeast

Downstream View of the San Acacia Diversion Dam
Facing Southeast

Upstream View of the San Acacia Diversion Dam
Facing Southeast

Low Flow Conveyance Channel Inlet
Facing North

San Acacia Diversion Dam Reservoir
Facing North

Prepared For
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Figure 27 - Recent Site Photographs

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

Prepared by
Echota Technologies Corporation

View of the Central Portion of the Project Site
Facing Northeast

The Low Flow Conveyance Channel USBR Construction Site
Facing Northwest

South end of the Tiffany area
Facing south

Typical section of the Low Flow Conveyance Channel
and MRGC Spoil Levee

Low Flow Conveyance Channel South of Socorro
Facing Southeast

Typical section of the BNSF Railroad grade and Trestle
Facing North

Prepared For
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Figure 27 - Recent Site Photographs

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

Prepared by
Echota Technologies Corporation

View of the Rio Grande near San Marcial
Facing Northeast

North end the BNSF Railroad Bridge No. 1006A
Facing Southwest

North end of Bridge No. 1006A
Facing south

View of the South end of Bridge No. 1006A
Facing Southeast

River channel and low clearance of Bridge No. 1006A
Facing Southeast

View of the former town site of San Marcial

Prepared For
United States Army Corps of Engineers
Albuquerque District
Contract No. W912PP-05-T-0043

Figure 27 - Recent Site Photographs

Phase I Environmental Site Assessment
San Acacia to Bosque Del Apache
Flood Control Project
South Central New Mexico

Prepared by
Echota Technologies Corporation

APPENDIX E

NMED PSTB LUST Reports

All Tanks in New Mexico (excerpts for Project Area)

Report Generated by NMED PSTB on Apr 05, 2005 05:02 pm
Downloaded August 30, 2005 from the NMED PSTB Website: http://www.nmenv.state.nm.us/ust/alltan.html

FACILITY ID	FACILITY NAME	FACILITY ADDRESS	FACILITY CITY	FACILITY STATE	ZIP	
31383	**US FISH AND WILDLIFE SAN ACACIA**	E OF I 25 EXIST	SAN ACACIA	NM	87831	
OWNER ID	OWNER NAME	OWNER ADDRESS1	OWNER CITY	OWNER STATE	ZIP	OWNER PHONE
15537	US FISH AND WILDLIFE SAN ACACIA	GENERAL DELIVERY	SAN ACACIA	NM	87831	505-864-4021
TANK ID	TANK TYPE	TANK STATUS	TANK CAPACITY	TANK CONTENTS		
22391	Underground	REMOVED	2000	UNLEADED GASOLINE		
22392	Underground	REMOVED	1500	DIESEL		
22393	Underground	REMOVED	2000	UNLEADED GASOLINE		

FACILITY ID	FACILITY NAME	FACILITY ADDRESS	FACILITY CITY	FACILITY STATE	ZIP	
27162	**BUREAU OF RECLAMATION SAN MARCIAL YARD**	UNKNOWN	SOCORRO	NM	87801	
OWNER ID	OWNER NAME	OWNER ADDRESS1	OWNER CITY	OWNER STATE	ZIP	OWNER PHONE
14317	BUREAU OF RECLAMATION SOCORRO	PO BOX VV	SOCORRO	NM	87801	505-766-1746
TANK ID	TANK TYPE	TANK STATUS	TANK CAPACITY	TANK CONTENTS		
32163	Underground	REMOVED	2000	DIESEL		
32164	Underground	REMOVED	1000	UNLEADED GASOLINE		

Note: This report has been formatted for presentation purposes using data from the referenced report with minor Spelling or Grammar changes only.

Past and Current Leak Sites by City (Excerpts from)

Report Generated by NMED PSTB Apr 05, 2005 04:57 pm

Downloaded August 30, 2005 from the NMED PSTB Website: http://www.nmenv.state.nm.us/ust/leakcity.html

Key: LUST Sites identified in EDR Report

RANK	PRIORITY	SCORE	RELEASE ID	RELEASE NAME	FACILITY ID	PHYSICAL ADDRESS	CITY	ST	ZIP	COUNTY	REPORT DATE	CURRENT STATUS	STATUS DATE	STAFF
			761	Sevillita NWR	31383	E Of I 25 Exist	San Acacia	NM	87831	Socorro	7/1/1991	No Further Action Required	2/4/1993	UNKNOWN
230	3	807	408	Bar F 31 Socorro	27619	907 N California	Socorro	NM	87801	Socorro	5/9/1984	Cleanup, State Lead with CAF	10/1/1995	Patrick De Gruyter
			1021	Bor/Fld Off Yd	27162	Unknown	Socorro	NM	87801	Socorro	1/17/1992	No Further Action Required	4/13/1992	UNKNOWN
			3921	Caldwell Motor Co	50188	800 N California	Socorro	NM	87801	Socorro	12/4/2001	Investigation, Responsible Party	8/6/2003	Patrick De Gruyter
494	3	250	454	Chevron 75865 Socorro	27329	1101 California NW	Socorro	NM	87801	Socorro	9/14/1981	Aggr Cleanup Completed, Resp Party	9/17/1986	James Mullany
			281	Chevron South	26296	I 25 And Hwy 25 S	Socorro	NM	87801	Socorro	11/16/1990	No Further Action Required	4/8/1991	UNKNOWN
			891	Circle K 290	1081	805 California	Socorro	NM	87801	Socorro	10/17/1991	Cleanup, Responsible Party	5/18/2000	Patrick De Gruyter
			1771	Circle W	27381	1104 California Ave	Socorro	NM	87801	Socorro	3/11/1993	Investigation, Responsible Party	3/16/1993	Patrick De Gruyter
			1187	Coronado Village	26393	500 6th St	Socorro	NM	87801	Socorro	4/8/1992	No Further Action Required	6/13/1994	Steven Jetter
			2784	Diamond Shamrock 1295	27619	907 N California	Socorro	NM	87801	Socorro	10/2/1995	Investigation, Responsible Party	1/12/1996	Patrick De Gruyter
			50	Electric Coop	30665	215 Manzanares Ne	Socorro	NM	87801	Socorro	9/11/1989	Aggr Cleanup Completed, Resp Party	10/22/1992	Patrick De Gruyter
344	3	540	398	Jennings Prop	27825	900 California	Socorro	NM	87801	Socorro	7/28/1988	Cleanup, State Lead with CAF	10/1/1995	Patrick De Gruyter
102	2	2794	2562	Mike's Texaco	31068	1105 California St	Socorro	NM	87801	Socorro	3/10/1995	Investigation, Responsible Party	5/17/1995	Bruce Furst
508	3	237	1302	MRGCD Socorro	29506	703 Manzanares Ne	Socorro	NM	87801	Socorro	6/5/1992	Investigation, Responsible Party	6/15/1995	Lane Andress
			1537	NMSHTD Socorro	29676	NM 1 MP 604	Socorro	NM	87801	Socorro	9/25/1992	No Further Action Required	11/5/1992	UNKNOWN
			845	Phillips 66 Soc	28401	401 California Nw	Socorro	NM	87801	Socorro	9/16/1991	Cleanup, Responsible Party	5/17/2001	Bruce Furst
			504	San Marcial Yd	27162	Unknown	Socorro	NM	87801	Socorro	3/2/1990	No Further Action Required	1/15/1993	UNKNOWN
			431	Santa Fe Diner & Truckstop	8976	PO Box 770, Exit 115 I-25	Socorro	NM	87801	Socorro	5/19/1998	No Further Action Required	4/29/1999	Thomas Leck
			870	Socorro Auto Cl	30659	210 California St	Socorro	NM	87801	Socorro	10/4/1991	No Further Action Required	11/1/1991	UNKNOWN
			744	Socorro Shell	26357	408 California Ave	Socorro	NM	87801	Socorro	12/28/1994	Investigation, Responsible Party	12/29/1994	Bruce Furst
260	3	700	2172	Sonny's Pump N Save	30671	201 N California St NE	Socorro	NM	87801	Socorro	2/4/1994	Investigation, Responsible Party	8/15/1995	Lane Andress
			997	St Police	27683	I 25 At Exit 152	Socorro	NM	87801	Socorro		No Further Action Required	1/3/1996	UNKNOWN
			3061	Texaco Mini-Mart	30574	924 S Hwy 85	Socorro	NM	87801	Socorro	10/16/1996	No Further Action Required	11/18/1996	Norman Pricer
200	3	1045	346	Vagabond Prop/F	31434	1015 California NW	Socorro	NM	87801	Socorro	7/28/1989	Aggr Cleanup Completed, Resp Party	6/17/2004	Thomas Williams
			859	Vagabond/Lube N	31433	1013 California	Socorro	NM	87801	Socorro	7/28/1989	Cleanup, Responsible Party	5/21/1999	Thomas Williams

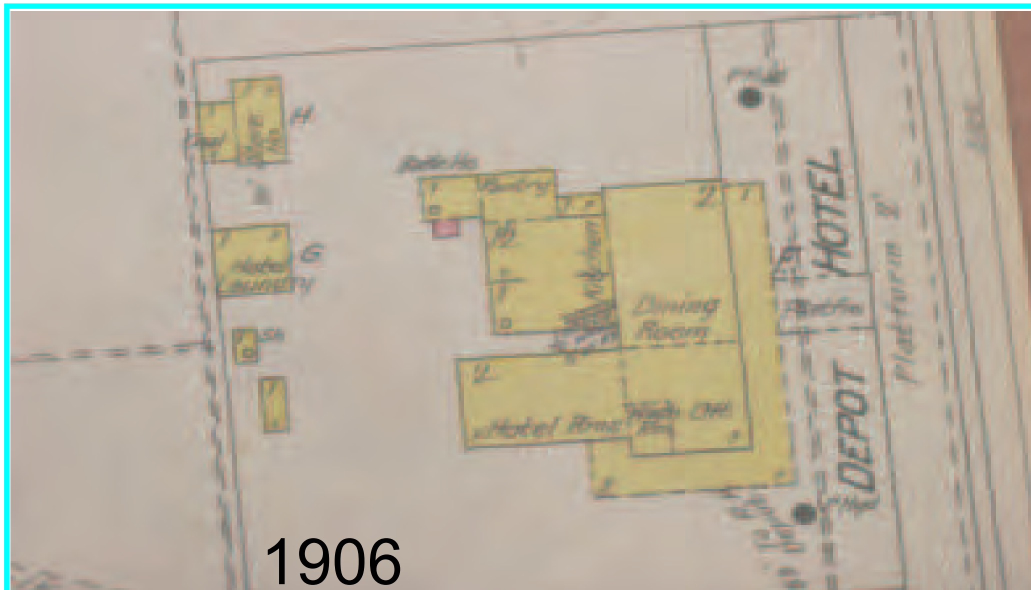
Note: Spelling and Format corrections, as well as the color coding were made to this report for presentation purposes without change to the original data

APPENDIX F

Sanborn Fire Insurance Maps

1893

1893



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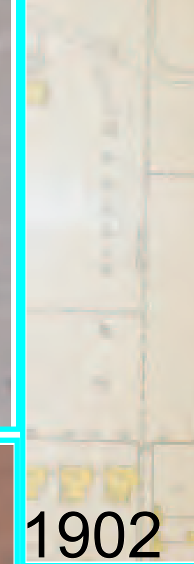
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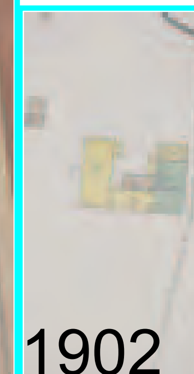
1902


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Sanborn Fire Insurance Maps