Stantec Consulting Inc.
8211 South 48th Street
Phoenix, AZ 85044
Tel: 602-438-2200
Fax: 602-431-9562

Stantec

21 July 2003

File: 81760038

City of Kingman
310 North Fourth Street
Kingman, AZ 86401

Attention: Mr. Peter R. Johnson, PE

Dear Mr. Johnson:

Reference: Railroad Diversion Channel
Amendment to Preliminary Design Report

Enclosed herewith are two (2) draft copies of the amendment to the final report for the above referenced project.

Please review and comment at your convenience. Give me a call to discuss if you have any questions or would like additional information.

Sincerely,

STANTEC CONSULTING INC.

James O. Hubbard
jhubbard@stantec.com

RAILROAD DIVERSION CHANNEL

PRELIMINARY DESIGN REPORT

AMENDMENT

DRAFT

Prepared For:

City of Kingman
310 North Fourth Street
Kingman, Arizona 86401

Prepared By:

Stantec Consulting Inc.
8211 South 48th Street
Phoenix, Arizona 85044
(602) 438-2200

PROJECT NO. 81760038

July 2003

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

1.0 INTRODUCTION

Stantec Consulting, Inc. (Stantec) was retained by the City of Kingman to evaluate channel alternatives for the Railroad Diversion Channel, a proposed channel along the south side of the BNSF Railway. The Draft Report was submitted to the City of Kingman and BNSF Railway in November 2000. Comments received from the City and BNSF Railway were incorporated into the Final Report that provided direction for the selection of a preferred alternative. The "Railroad Diversion Channel Preliminary Design Report" dated November 2001 is the Final Report that is referenced in this Amendment. Subsequent to the Final Report submittal, Stantec Consulting received comments from the City in January 2002 that prompted additional correspondence and coordination with the BNSF Railway. Further information received in December 2002 from BNSF Railway allows the Final Report to be amended. Specifically, the approval for the use of a concrete-lined channel and BNSF Railway's desire to have a channel with bank protection adjacent to their right-of-way or tracks requires the preferred alternative to be modified.

This report addresses the changes available from recommendations of the "Railroad Diversion Channel Preliminary Design Report" dated November 2001 for the Final Designer of the Railroad Diversion Channel. In addition, a revised preferred alternative along with an updated cost estimate is included for planning purposes.

The Final Designer will have the opportunity to review all alternatives and further evaluate the recommendations of this report based on detailed topographic surveys that will be required for final design. The preliminary design provides the framework needed to expedite coordination with BNSF and final design approval.

2.0 HYDRAULIC DESIGN CRITERIA

2.1 Hydraulic Criteria

The Final Report specified channel design that adhered to the criteria and design guidance set forth in the *Drainage Design Manual for Maricopa County, Volume II, Hydraulics* and *Hydraulic Design of Flood Control Channels, EM 1110-2-1601, Corps of Engineers*. Further investigation for design guidelines of concrete-lined channels revealed criteria used by Arizona Department of Transportation (ADOT). Chapter 600 – Highway Drainage Design of the Roadway Design Guidelines dated May, 1996 provides detailed information that ADOT uses for concrete-lined channels. These guidelines allow velocities to 30 fps, in lieu of the 20 fps used by the Flood Control District of Maricopa County.

This allows the typical sections for the concrete-lined channels to be reduced, which will mitigate utility and roadway conflicts, specifically through Reaches 1C, 2, 3, 4, 5A, 5B, 6A, 6B and 6C. Channel side slopes for concrete-lined channel is recommended to be 2:1 (H:V) and the minimum bottom width of 8 feet specified. The side slopes can be adjusted to 1.5:1 (H:V) to maintain a trapezoidal typical section.

Earthen channels can be used as specified in the Final Report, with the possibility of adding a gabion mattress along the bank adjacent to the BNSF Railway tracks and/or right-of-way. This composite section will essentially perform with the same hydraulic properties as the earthen channel, considering the limited amount of bank protection. This feature will need to be resolved during final design.

2.2 Hydraulic Analysis

Preliminary hydraulic analyses for the revised concrete-lined channel alternative using ADOT ciriteria was performed using *FlowMaster v6.0* design software by Haestad Methods. The analysis determined normal depth, Froude Number and velocity for the range of bottom widths for trapezoidal channels. Hydraulic analysis for the final design will need to insure that normal depth calculations for the water surface profiles of each reach is not impacted by upstream and downstream water surface profiles. Results of the hydraulic analysis for the concrete-lined channel alternative, as well as the earthen and gabion-lined channels for Reaches 1A through 9B are in Appendix B.

3.0 AMENDED CHANNEL ALTERNATIVE

3.1 General

Correspondence with the City and BNSF Railway after November 2001 renders the Preferred Channel Alternative selected in the Final Report obsolete. These letters and attachments are found in Appendix A. Consequently, a new alternative is presented in this report for reference and planning purposes to assist the City in future budgeting and project selection. The design engineer will select the final channel typical section and lining. However, the option to prepare alternative designs for selected reaches, such as Reaches 7 through 9, could allow the contractor to provide the most economical channel for the project. Table 3.1.1 summarizes the station limits, length, peak discharge, existing ground slope, and proposed design slope for each of the Reaches.

Table 3.1.1

Reach	Stationing	Length (feet)	Design Q (cfs)	Reach Slope (ft/ft)	Design Slope (ft/ft)
1A	99+76.9 to 127+00	2,723	679	0.0020	0.0020
1B	127+00 to 146+00	1,900	679	0.0020	0.0020
1C	146+00 to 157+00	1,100	679	0.0020	0.0020
2	157+00 to 175+00	1,800	1,590	0.0030	0.0043
3	175+00 to 185+00	1,000	1,994	0.0236	0.0181
4	185+00 to 218+00	3,300	2,196	0.0035	0.0035
5A	218+00 to 221+75	375	2,390	0.0090	0.0045
5B	221+75 to 229+30	755	2,390	0.0090	0.0025
6A	229+30 to 236+70	740	2,815	0.0090	0.0025
6B	236+70 to 241+65	495	2,815	0.0090	0.0120
6C	241+65 to 257+00	1,535	2,815	0.0090	0.0073
6D	257+00 to 274+43	1,743	2,815	0.0090	0.0018
7	274+43 to 321+16	4,673	3,921	0.0054	0.0017
8	321+16 to 383+57	6,241	5,703	0.0067	0.0016
9A	383+57 to 387+84	427	12,306	0.0067	0.0044
9B	387+84 to 393+83	599	12,306	0.0067	0.0128

The channel depth and geometry for each reach (and sub-reach) was optimized in order to minimize impact to existing infrastructure, excavation quantities and channel bank lining cost while also providing a

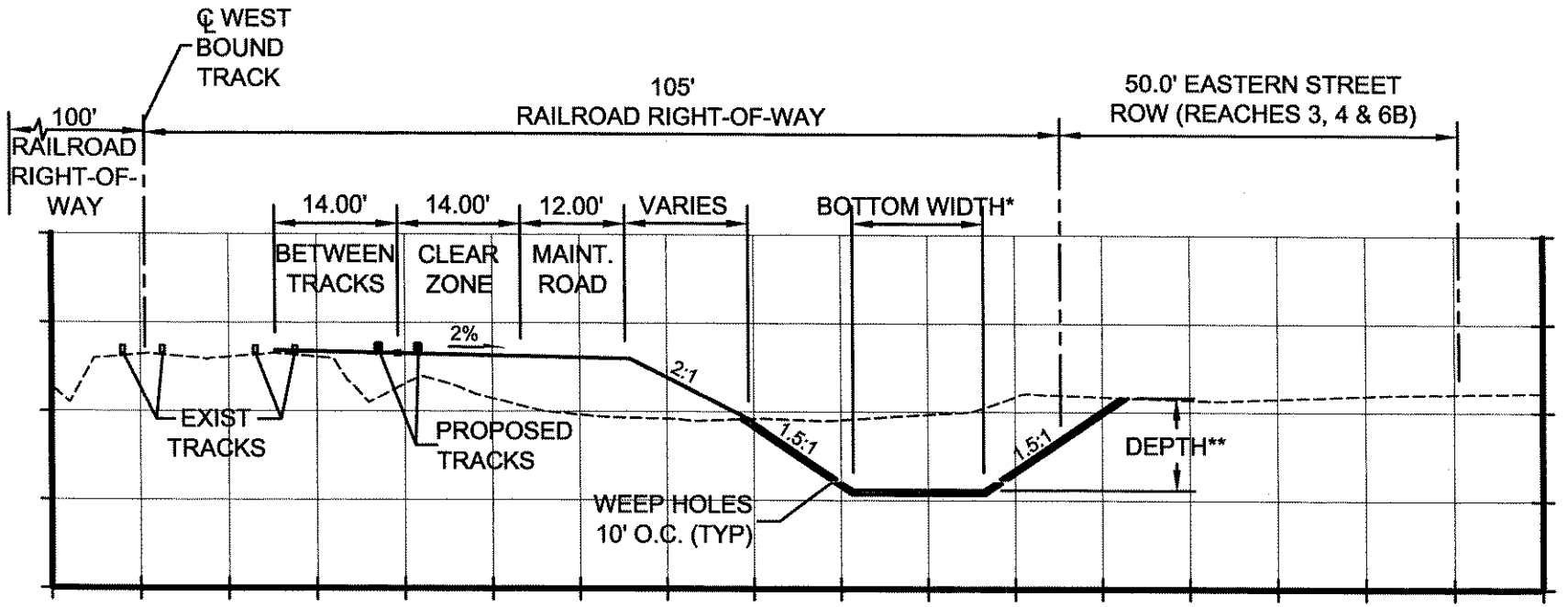
minimum of one foot of freeboard. Table 3.1.2 summarizes the bottom widths (BW), normal flow depth (FD), velocity (V) and lining type for each reach for the preferred alternative.

Table 3.1.2

Reach	BW (ft)	FD (ft)	V (fps)	Lining
1A	12.0	4.9	5.7	Earthen
1B	12.0	4.9	5.7	Earthen/BNSF Gabion
1C	9.0	4.9	8.6	Concrete
2	16.0	4.9	13.8	Concrete
3	8.0	5.0	25.8	Concrete
4	15.0	6.4	14.1	Concrete
5A	26.0	4.7	14.7	Concrete
5B	26.0	5.6	12.0	Concrete
6A	26.0	5.6	12.0	Concrete
6B	12.0	5.4	23.3	Concrete
6C	20.0	5.3	19.2	Concrete
6D	46.0	6.3	7.2	Earthen/BNSF Gabion
7	70.0	6.3	7.3	Earthen/BNSF Gabion
8	108.0	6.3	7.4	Earthen/BNSF Gabion
9A	150.0	6.2	12.0	Earthen/Gabion
9B	93.0	6.5	17.8	Gabion Mattress

Through Sections 18, 7, 8 and part of Section 5 (Township 21 North, Range 16 West), the horizontal alignment for the channel utilizes as much of the BNSF Railway right-of-way as possible. After passing through the residential areas, the channel alignment shifts completely outside of the BNSF railroad until outletting into Rattlesnake Hill Wash.

The daylight line for the channel cut-slope on the north side adjacent to the railroad provides room for a possible future third track and access road. The construction line and the channel centerline have been offset for several reaches in order to assist in establishing the cut-slope limits. Figure 3.1 provides the typical cross section of the channel to illustrate the close coordination with grading within the BNSF right-of-way adjacent to Eastern Street.



REACH	BOTTOM WIDTH*	DEPTH**
3	8.0'	6.0'
4	15.0'	7.4'
5A	26.0'	5.7'
6B	12.0'	6.4'
6C	20.0'	6.3'

Stantec

SCALE:
1"=20'

0 20'-0" 30'-0" 40'-0"

V:\52817\active\ROADWAY\28660038\drawings\exhibits\exhibit-channel.dwg

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
3.1

Title
CHANNEL TYPICAL SECTION
REACH 3, 4, 5A, 6B, and 6C
CONCRETE - LINED CHANNEL

3.2 Proposed Flood Control Measures

Normal depth calculations were performed iteratively to arrive at satisfactory channel geometry, longitudinal slopes and linings for each reach. This was done to conform to right-of-way constraints, channel hydraulic criteria, channel excavation, and possible backwater effects.

An earthen 2:1/3:1 trapezoidal channel is proposed to be used for Reaches 1A and 1B. Gabion mattress bank protection would be required for the 2:1 side slope bank within the BNSF right-of-way (Reach 1B). Stable, subcritical flow is achieved due to a relatively flat longitudinal slope. No drop structures are needed in these reaches.

Concrete-lining is utilized in Sub-reach 1C through Sub-reach 6C. Longitudinal slopes and channel geometry are set to insure stable flows (Froude Number lower than 0.85 or greater than 1.15). One drop structure is needed in Reach 3 and an energy dissipater will be required at the downstream end of Reach 6C. The alignment for Sub-reaches 5B and 6A swings the channel around the proposed Airway Avenue underpass of the railroad tracks, which lowers the longitudinal slope and transitions the hydraulic properties to an unstable flow regime with the Froude Number of 1.0. Additional freeboard will be required for these two (2) Sub-reaches.

An earthen 2:1/3:1 trapezoidal channel is proposed for Sub-reach 6D, Reaches 7 and 8 and Sub-reach 9A. Due to the available undeveloped open space and airport property, the channel right-of-way and alignment is shifted outside the BNSF Railway, which may eliminate the need for bank protection. The channel velocities are controlled by using a wider channel bottom and flatter longitudinal slopes that will require drop structures to control the gradient.

Gabion mattresses are to be used for Sub-reach 9B. This portion of the channel increases in slope to convey design flows under the railroad crossing at Rattlesnake Hill Wash. Due to the high velocities, energy dissipation should be considered downstream of the structure.

3.2.1 Reach 1

Reach 1 extends from the extension of Phoenix Avenue to Adams Street in the Hilltop area of the City. The channel at Station 99+76.94 ties into an existing unimproved channel that intercepts runoff from the north side of Haulapai Mountain Road (method of transitioning to this existing channel is left as an item for final design). From Station 99+76.94 to 157+00, the channel traverses across "Getz Station" and

crosses under Louise Avenue at approximately Station 113+65. North of Station 157+00, the 200 feet of railroad right-of-way that is centered on the westbound tracks is abutted by 20 feet of roadway right-of-way for Railroad Street within the Golden Gate Addition subdivision. The roadway is unpaved and the lots are undeveloped. The proposed channel longitudinal slope of 0.20% follows the existing ground slope of 0.20% (which maintains flow within the subcritical flow regime). Right-of-way acquisition across the Getz Station has been included in the cost estimate. A twin barrel 10' x 6' concrete box culvert is proposed for the crossing at Louise Avenue.

The typical section for Sub-reaches 1A and 1B is an earthen trapezoidal channel, 5.0 feet deep, with a 12.0 foot bottom width and 2:1 (H:V) side slope on the north side and 3:1 side slope on the south side. 6-inch thick gabion mattresses line the 2:1 side slope for Sub-reach 1B. Sub-reach 1C is concrete-lined with a bottom width of 9.0 feet.

3.2.2 Reach 2

Reach 2 begins at Adams Street and runs east 1,800 feet to the west side of Eastern Street. Adams Street will convey flows from a proposed detention basin and improvements to the roadway are currently being designed. From Station 157+00 to 166+00 the railroad right-of-way is abutted by 20 feet of roadway right-of-way for Railroad Street within the Golden Gate Addition subdivision. From Airfield Avenue to the east within Section 7, a 20-foot easement exists adjacent to the BNSF right-of-way. There are no structures along the alignment. However, one business (the tire store) at Station 164+00 may be impacted by the proposed improvements.

The typical channel section consists of concrete lining with a bottom width of 16.0 feet, side slopes of 1.5:1, a longitudinal slope of 0.43%, and a channel depth of 5.0 feet.

3.2.3 Reach 3

Reach 3 extends from the west side of Eastern Street to feet to Station 185+00, mid-block between Alpha Street and Evans Street. Eastern Street turns from a north-south alignment and runs easterly parallel to the BNSF Railway. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. Eastern Street has 50 feet of right-of-way adjacent to the railroad. This reach is unique due to the 2.36% longitudinal slope of the existing ground line. A channel slope of 1.81% is maintained through this reach which will require one drop structure at the downstream limit of Reach 3. The roadway is paved and the lots are undeveloped.

The typical channel section consists of concrete lining with a bottom width of 8.0 feet, side slopes of 1.5:1, and a channel depth of 5.0 feet.

3.2.4. Reach 4

Reach 4 begins at the mid-block between Alpha Street and Evans Street (Station 185+00) and extends to the east 3,300 feet to Station 218+00 at the intersection of Eastern Street, Kenwood Avenue and North Central Street. The railroad, Eastern Street, and proposed channel passes under Interstate 40 at Station 199+00. Eastern Street runs parallel to the BNSF Railway throughout this reach within a 50-foot roadway right-of-way. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. This reach has a 0.35% longitudinal slope for the existing ground line. Eastern Street roadway is paved and there are a few lots that have been developed south of Interstate 40. The concrete box culvert directing flows to the northwest to pass under the railroad and SR66 will be by-passed and abandoned.

The typical channel section consists of concrete lining with a bottom width of 15.0 feet, side slopes of 1.5:1, and a channel depth of 6.4 feet.

3.2.5 Reach 5

Reach 5 extends from the intersection of Eastern Street, Kenwood Avenue and North Central Street (Station 218+00) to the new Airway Avenue alignment (Station 229+30). Eastern Street runs parallel to the BNSF Railway throughout this reach within 50 feet of roadway right-of-way. The south side of the railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks. The existing ground line has a slope of 0.35% through this reach. This reach has been subdivided into two sub-reaches. Sub-reach 5A is parallel to the railroad and Sub-reach 5B covers that portion of the reach where the channel alignment veers away from the railroad to loop around the new Airway Avenue alignment. Eastern Street roadway is paved and there are a few lots that have been developed north of Interstate 40. In conjunction with the Airway Avenue Railroad Crossing project, new right-of-way for roadway and drainage purposes has been identified for Reach 5 in order to provide a drainage channel around the underpass site. Consequently, no additional right-of-way has been identified for this reach.

The typical channel section for Sub-reach 5A and 5B consists of a concrete-lined channel with a bottom width of 26.0 feet and 1.5:1 side slopes. Sub-reach 5A has a longitudinal slope of 0.45% that results in

a flow depth of 5.6 feet in the supercritical flow regime. Sub-reach 5B has a longitudinal slope of 0.25%, resulting in a flow depth and critical depth of 5.6 feet, which will require additional freeboard for this unstable flow regime.

3.2.6 Reach 6

Reach 6 begins at the new Airway Avenue alignment (Station 229+30) and extends easterly 4,513 feet (Station 274+43), just east of the extension of North Castle Rock Road along the railroad. Eastern Street runs parallel to the BNSF Railway with 50 feet of roadway right-of-way to the existing Airway Avenue alignment along the north line of Section 8. The railroad right-of-way provides approximately 85 feet on the south side of the eastbound tracks and a total of 200 feet. No additional right-of-way is existing adjacent to the railroad within Section 5. Section 4 has a 70-foot wide strip of existing right-of-way adjacent to the BNSF right-of-way. The prevailing longitudinal slope for the existing ground line through this reach is 0.70%. For this amended alternative, this reach was subdivided into four Sub-reaches, 6A, 6B, 6C and 6D. As discussed previously in Section 3.2.5, the land acquisition for the proposed Airway Avenue Railroad underpass will provide the needed right-of-way for the channel within Section 8. Right-of-way identified for this reach is all within Section 5. No building structures are impacted by the alignment through Reach 6.

The typical channel section for Sub-reach 6A is a concrete-lined channel with a bottom width of 26.0 feet, 1.5:1 (H:V) side slopes, a longitudinal slope of 0.25%, resulting in a channel depth of 5.6 feet and unstable flow. Additional freeboard will be required. The typical channel section for Sub-reaches 6B and 6C consists of a concrete-lined channel with 1.5:1 side slopes. Sub-reach 6B has a bottom width of 12.0 feet and a longitudinal slope of 1.20% that results in a flow depth of 5.4 feet in the supercritical flow regime. Sub-reach 6C has a bottom width of 20.0 feet and a longitudinal slope of 0.73%, resulting in supercritical flow with a flow depth of 5.3 feet. An energy dissipater will be required at the downstream end of Sub-reach 6C to transition flow to a tranquil, non-erosive flow.

The typical section for Sub-reach 6D is an earthen channel with a bottom width of 46 feet, 2:1 side slope on the north side, 3:1 side slope on the south side, a channel depth of 7.5 feet, a longitudinal slope of 0.18% and a corresponding flow depth of 6.3 feet. The flatter side slope on the south side aids in reducing bank scour from overland flows draining into the channel from the southeast. Though the flow velocity is slightly higher than desired (7.2 fps), the conditions are stabilized by providing four drop structures. The channel cut-slope limits requires a 130-foot wide strip of right-of-way from Station 257+00 to 268+00 and

a 90-foot wide strip of right-of-way from Station 268+00 to Station 274+43. The channel improvements, beginning at this sub-reach, do not fall within BNSF Railway right-of-way and remain outside of the BNSF Railway right-of-way to the end of the proposed channel. However, a 6-inch thick gabion mattress is proposed to line the 2:1 side slope (adjacent to BNSF right-of-way) for the reach.

3.2.7 Reach 7

Reach 7 begins at Station 274+43, just east of the extension of North Castle Rock Road and continues parallel with the railroad a distance of 4,673 feet to Station 321+16 at Diagonal Wash. Diagonal Wash will be diverted into the railroad channel and downstream drainage structures will be abandoned. The 70 feet of existing roadway right-of-way on the east side of the railroad right-of-way extends to Rae Drive which is the east-west mid-section line road for Section 4 (Station 280+00). Reach 7 enters Section 33 and onto Kingman Airport property at Station 310+55 (BNSF Railway's Berry Station has a total of 400 feet of right-of-way in Section 33 centered on their alignment, providing 200 feet on the south side). This reach has a 0.54% existing longitudinal slope. No building structures are impacted by the alignment through Reach 7.

The typical section for Reach 7 is an earthen channel having a bottom width of 70 feet, 2:1 side slope on the north side, 3:1 side slope on the south side, channel depth of 7.5 feet, a longitudinal slope of 0.17% and corresponding flow depth of 6.3 feet. Six drop structures are needed in this reach to maintain the channel slope of 0.17%. Due to the curvature of the channel within Reach 7, an additional 90 feet of right-of-way is needed beginning south of Rae Drive, an additional 160 feet of right-of-way is needed at Rae Drive and then an additional 260 feet is needed along the south boundary of the Kingman Airport property. The improvements along this reach are outside BNSF Railway existing right-of-way. A 6-inch thick gabion mattress line the 2:1 side slope (adjacent to BNSF right-of-way) for the reach.

3.2.8 Reach 8

Reach 8 begins at Station 321+16, Diagonal Wash, and passes adjacent to the BNSF Railway's Berry Station site through Kingman Airport property extending to Station 383+57 for a total distance of 6,241 feet. Total right-of-way width for the railroad and Berry Station within Section 33 is 400 feet, but reduces to 200 feet in Sections 34 and 27. The channel improvements for this reach do not fall within BNSF Railway existing right-of-way. This reach has a 0.67% existing longitudinal slope. A sand and gravel operation will be impacted by the channel improvements at Station 383+00.

An earthen channel is recommended for Reach 8 having a bottom width of 108 feet, a 2:1 side slope on the left side, a 3:1 side slope on the right side, a channel depth of 7.5 feet, a longitudinal slope of 0.16% and a corresponding flow depth of 6.3 feet. Ten drop structures are needed in this reach to maintain a channel slope of 0.16%. Reach 8 will require 200 feet of additional right-of-way through the Airport property increasing to 260 feet of right-of-way past the west line of Section 34. Approximately 227,825 cubic yards of waste material is generated for this reach. A 6-inch thick gabion mattress lining the 2:1 side slope is proposed to eliminate any maintenance and possible erosion of the bank adjacent to the BNSF right-of-way.

3.2.9 Reach 9

Reach 9 begins at Station 383+57 and terminates at Rattlesnake Hill Wash (1026 feet reach length). For the amended alternative, this reach was subdivided into two sub-reaches, 9A (427 feet) and 9B (599 feet). The entire reach has a 0.67% longitudinal slope for the existing ground line along a line parallel with the railroad (BNSF Railway right-of-way is a total of 200 feet adjacent to this reach).

As discussed previously, the railroad drainage structure at Rattlesnake Hill Wash was reconstructed in the late 1980s after a fire destroyed the previous wooden structure. The City of Kingman contributed funds to BNSF to increase the size of the new structure to accommodate additional flows from the future Railroad Diversion Channel. The structure was upsized and all parties agree in principal to divert all flows to this outfall. See Appendix D of the "Railroad Diversion Channel Preliminary Design Report".

The alignment illustrates the diversion channel curving around to meet up with Rattlesnake Hill Wash. Though some design recommendations are discussed below, further design elements will need to be evaluated at the junction of the diversion channel and the wash to mitigate scour and any significant sediment deposition. Right-of-way for this reach would need to extend from the Railroad right-of-way for a distance that would encompass the curvature of the channel as it redirects flow into the drainage structure. The right-of-way needed through the Airport property would be approximately 260 feet from the beginning of the reach to a maximum of 390 feet at the curve of the channel into Rattlesnake Hill Wash.

The typical section for Sub-reach 9A is an earthen channel with gabion mattress lined banks, a 150 foot bottom width, a 2:1 side slope on the left, a 3:1 side slope on the right, a 7.5 foot channel depth, a longitudinal slope of 0.44% and a corresponding flow depth of 6.2 feet. The design flow velocity is

approximately 11.4 fps. No drop structures will be needed. A total of 11,674 cubic yards of waste material is generated and 1,018 cubic yards of gabions are needed for the proposed improvements.

For Sub-reach 9B, a completely lined trapezoidal channel (gabion mattresses) is recommended due to the steeper slope. The steeper slope and one drop structure is necessary to lower the invert of the existing Rattlesnake Hill Wash at the railroad drainage structure. The typical section for this gabion-lined channel would have a bottom width transitioning from 150 feet to 93 feet, a 2:1 side slope on the left and right sides (with earthwork and channel transitioning on the right bank with the existing wash being left for final design), a 1.28% longitudinal slope, a transitioning channel depth from 7.5 feet to the depth at the bridge drainage structure, and an approximate flow depth of 6.5 feet. The 93 foot width matches the approximate width of the drainage structure underneath the railroad. A total of 5,248 cubic yards of waste material is generated and 3,138 cubic yards of gabions are needed for the proposed improvements.

The drop structure upstream of the railroad bridge at MP 590.1 will assist in providing energy dissipation, lower channel velocities, and lower the wash invert to provide the capacity at the structure.

4.0 AMENDED ALTERNATIVE COST ESTIMATE AND IMPLEMENTATION

Table 4-1 provides a summary of the construction and right-of-way cost estimates for each reach of the amended alternative along with the total project costs.

Table 4.1

REACH		*AMENDED ALTERNATIVE COST ($)*			
		EARTHEN	EARTHEN / BNSF GABION	CONCRETE	GABION MATTRESS
1A	Construction	74,925			
	Right-of-Way	16,500[1]			
1B	Construction		153,768		
	Right-of-Way				
1C	Construction			155,248	
	Right-of-Way				
2	Construction			288,881	
	Right-of-Way			0	
3	Construction			178,144	
	Right-of-Way			7,095	
4	Construction			619,216	
	Right-of-Way			18,160	
5A	Construction			82,928	
	Right-of-Way			0[2]	
5B	Construction			199,087	
	Right-of-Way			143,227[2]	
6A	Construction			186,943	
	Right-of-Way			91,185[2]	
6B	Construction			87,688	
	Right-of-Way			0[2]	
6C	Construction			261,331	
	Right-of-Way			75,365	
6D	Construction		247,197		
	Right-of-Way		245,960		
7	Construction		822,171		
	Right-of-Way		588,147		
8	Construction		1,564,080		
	Right-of-Way		1,240,371[3]		
9A	Construction				348,120
	Right-of-Way				119,495[3]
9B	Construction				323,886
	Right-of-Way				175,108[3]
Construction Cost +15%		**$74,925**	**$2,787,216**	**$2,059,466**	**$672,006**
Right-of-Way Cost		**$16,500**	**$834,107**	**$100,620**	**0**
TOTALS		**$91,425**	**$3,621,323**	**$2,160,086**	**$672,006**
GRAND TOTAL		**$6,544,840**			

[1]Right-of-way for Reaches 1A, 1B and 1C
[2]Right-of-way included with Airway Avenue improvements / Not Included in Cost Estimate
[3]Right-of-way on Airport Authority property / Not Included in Cost Estimate

Total construction cost for this amended alternative is $5,593,613 with a right-of-way cost of $951,227. Complete quantities and cost estimate for the preferred alternative is in Appendix C.

Unit prices for preparation of the cost estimates are as follows:

Earthwork – Excavation	$3.50 / cubic yard
Riprap	$85 / cubic yard
Gabions	$90 / cubic yard
Concrete	$160 / cubic yard
Drop Structures (Gabions)	$90 / cubic yard
Contingency	15%
Right-of-Way	$1.00 / square foot (BNSF $0.50 / square foot)

The total earthwork for the selected alternatives for the project is approximately 544,180 cubic yards. With the railroad embankment for the future 3rd track requiring roughly 100,000 cubic yards, an export of approximately 450,000 cubic yards would be yielded from the project. Earthwork comprises of over 30% of the construction cost.

Hydrologic analysis shows the need for the construction of the detention basins. The Southern Avenue – Eastern Street basin is bounded on the east by Eastern Street, to the south by Southern Avenue, to the north by Phoenix Avenue and to the west by Washington Street. The basin will eliminate storm water runoff through the Hilltop area and control the outlet by releasing the outfall into Adams Street, 650 feet west of the basin. Mohave Engineering has designed the East Golden Gate Addition Improvement District which designed Adams Street to convey an 85 cfs outlet discharge from the basin. Based on this study's results, spillway flow will not occur until the 100-year event.

The ADOT basin will provide additional protection downstream. Assumptions made for this study can be revisited and additional analysis can be undertaken to increase the drainage area that would drain into the facility. This would provide even more benefit to the overall area drainage master planning efforts.

The recommended alternative for the Railroad Diversion Channel meets all design criteria to assure FEMA approval for obtaining a Letter of Map Revision for the community. BNSF Railway will not have to be concerned with maintenance of drainage culverts along the 5.2 mile section of tracks. Finally, protection throughout the southeast side of the city is realized through the implementation of the Railroad Diversion Channel (and Basins) Project.

The project can be phased to begin providing a benefit to the community. The following provides an order to the implementation of the project.

(1) Right-of-way acquisition for the entire project would insure that the corridor is set aside for flood control improvements.
(2) Construction of the detention basin in order to coordinate with design assumptions of the East Golden Gate Addition Improvement District project.
(3) Construct Reach 5B and 6A with the Airway Avenue Grade Separation Project.
(4) Construct the project beginning with Reach 9 and continuing through to Reach 1.

The two major railroad drainage structures to be diverted into the channel are Diagonal Wash and the culvert at the north side of Interstate 40. Depending on available funds, providing project limits to capture these flows will greatly improve downstream drainage conditions.

APPENDIX A - CORRESPONDENCE

City of Kingman

310 NORTH FOURTH STREET • KINGMAN • ARIZONA • 86401 • 928 • 753-5561

January 15, 2002

RECEIVED

JAN 17 2002

STANTEC

Mr. James O. Hubbard, P.E.
Senior Associate
Stantec Consulting Inc.
8211 South 48th Street
Phoenix, Arizona 85044

FAX: (602) 431-9562

Re: Railroad Diversion Channel Design Report and Preliminary Plans

Dear Mr. Hubbard:

I have concerns about some items in the Design Report dated 11/30/01 and preliminary plans for the Railroad Diversion Channel:

Estimated Construction Costs; Changes have been made in the recommended channel sections resulting in substantial increases in the estimated construction costs. It appears some of these changes are in response to comments from the Burlington Northern Santa Fe Railway Company (BNSF) concerning a preferred channel lining within their right-of-way. Others may be the result of further flow condition analyses. A couple of specific comments/questions are;

- It is not clear why the gabian mattress lining is recommended for Reach 1. The concrete lining estimate is almost $300,000 lower. It also appears flow conditions would be acceptable with an earthen lining which has a much lower estimated construction cost than either of the lined options.

- The recommended lining for Reaches 2, 3, 4 and part 5 was changed to stacked gabian. We would ask why the concrete lining would not be acceptable, possibly preferable? Maybe the BNSF concerns about concrete lining could be addressed by specific lining design features. Again, there are significant differences in the estimated construction costs. It also appears a concrete lining may allow a narrower improvement width that could impact the next comment.

Channel Alignment Adjacent to Eastern Street; The proposed channel alignment adjacent to Eastern Street would appear to require relocation of the Eastern Street pavement, and the existing 12" sewer main between Sta. 178+00 and 222+00. It also appears the recommended additional right-of-way for Eastern between Pacific Avenue and I-40 would involve takes from three, possibly four, developed properties. Were these costs considered? In addition, it is not clear what is intended under I-40 as the indicated alignment would appear to put one set of bridge support columns within the proposed channel. Would it be possible to tie into and utilize the existing lined section?

January 15, 2002

Mr. James O. Hubbard, P.E.
page 2

We understand the design engineer should evaluate specific design factors for each reach, prior to construction, but have concern about possibly having only limited, costly options in some areas. Is there a practical alignment and channel section that could avoid relocation of the 12" sewer and acquisition of the developed properties?

Please let me know if you have any questions.

Sincerely,

Peter R. Johnson, P.E.
City Engineer

c: Dennis Roberts, Community Development Director
Jack Kramer, Public Works Director
file

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ 85044
Tel: (602) 438-2200 Fax: (602) 431-9562
stantec.com

Stantec

20 February 2002
File: 81760038

City of Kingman
310 N. Fourth Street
Kingman, AZ 86401

Attention: Mr. Peter R. Johnson, PE

Dear Mr. Johnson:

Reference: Railroad Diversion Channel Design Report and Preliminary Plan

Thank you for your letter and comments dated January 15, 2002 regarding the Design Report dated November 30, 2001. Your two (2) observations regarding substantial channel cost increase are correct. The "preferred alternative" incorporated BNSF comments concerning the channel lining and, secondly, further analysis of the flow conditions resulted in revised channel sections. As discussed on the telephone, Stantec will follow-up with Burlington Northern Santa Fe (BNSF) to explore other options to their request for an open-cell or flexible revetment bank lining in their letter dated March 24, 2001.

I have revisited the recommendations of the report based on your comments and offer the following comments:

Buildings

Environment

Industrial

Transportation

Urban Land

Reach 1 does not have to be gabion mattress lined. Our initial assumption that all channels on BNSF Railway property needed to have a flexible lining and that the entire Getz Station parcel is owned by BNSF is incorrect. As you pointed out, much of the Getz Station is not owned by the BNSF Railway.

The channel can be earthen or concrete-lined from the beginning at Station 99+77 to Station 127+00±. Between Stations 127+00 and 157+00 (Reach 2) the channel alignment is adjacent to the tracks and can be pulled away from the tracks to be located within the Getz Station parcel and/or private property.

Reaches 2, 3, 4 and 5 could be changed to a concrete-lined channel, pending design approval by BNSF. The concrete-lined alternative selected in the Preliminary Design Report permitted supercritical flow, less than 20 feet per second for Reaches 3 and 5. Final plans will need to design hydraulic structures

**Reference: Railroad Diversion Channel
Design Report and Preliminary Plan**

to transition flow from supercritical to subcritical. Based on physical constraints and longitudinal slopes, this would be the best alternative.

The stacked gabion typical section design maintained subcritical flow throughout the project. This accounts for the impact on Eastern Street, the developed property, and utilities. These costs were not included in the estimated construction cost, which was an oversight.

Final design may need to consider a rectangular concrete-lined open-channel section. Enclosed is a sketch to illustrate this alternative to insure the existing roadway, property, and utilities are not impacted. One further note, the engineer that does provide final design for the channel will need to agree with supercritical flow design.

I will forward additional information concerning preliminary design concepts for the I-40 area to address your comments at that location.

Thank you again for your review and insight on these issues. Don't hesitate to call if you have any questions.

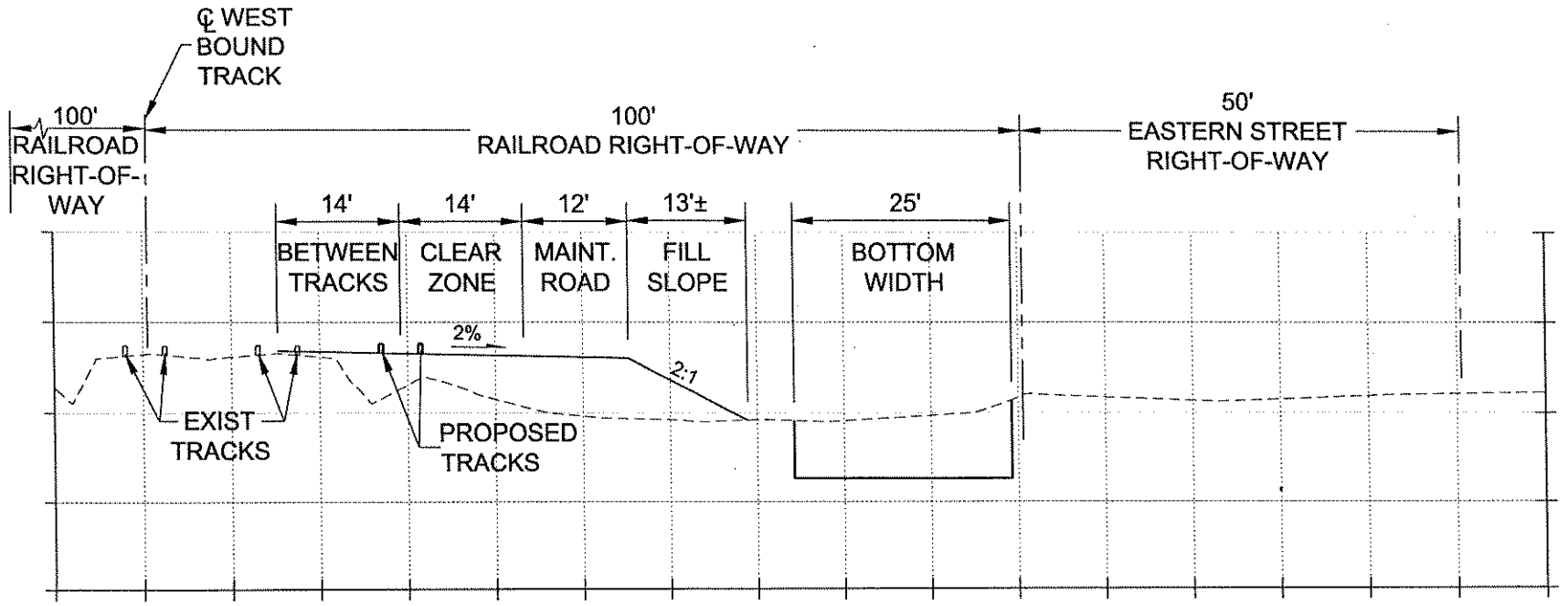
Sincerely,

STANTEC CONSULTING INC.

James O. Hubbard
Senior Associate

n:\roadway\81760038\correspondence\letters\peter johnson-city of kingman ltr 02-20-02.doc

Stantec



Stantec

SCALE:
1"=20'
0 20'-0" 30'-0" 40'-0"

n:\roadway\28660038\drawings\exhibits\exhib1a.dwg

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
5.1.2A

Title
CHANNEL TYPICAL SECTION REACH 3 AND 4 RECTANGULAR CONCRETE ALTERNATIVE

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ 85044
Tel: (602) 438-2200 Fax: (602) 431-9562
stantec.com

Stantec

20 February 2002
File: 81760038

BNSF Railway Company
Public Projects
1624 First Street Northwest
Albuquerque, NM 87102

Attention: Mr. Larry Delaney

Dear Mr. Delaney:

Reference: Railroad Diversion Channel Preliminary Design Report
Kingman, AZ

This letter is written to follow-up on your letter dated March 24, 2001 regarding the above referenced project. BNSF Railway offered comments regarding the preliminary drainage analysis and we appreciate the time and coordination of all who provided input. Stantec Consulting developed a preliminary channel alternative based on comments received in your letter and submitted the alternative to the City of Kingman for review and comment.

Estimated construction cost more than doubled, from approximately $3.5 million to $7.2 million. The cost to provide an open-cell flexible revetment bank lining on railway property is attributed for most of this increase.

The City commented on the fact that not all land at the Getz Station is railway property, which we had assumed and therefore, provided open-cell bank lining. Will BNSF require bank lining when the channel is not adjacent to the future third track?

As a designer, I am a proponent for open-cell, flexible revetment bank lining, such as cable concrete and gabions (wire-tied baskets with rock). However, due to the limited width of the drainage corridor through Reaches 2, 3, 4 and 5 (south of the Airway Avenue alignment), a concrete-lined channel with higher velocities allows the channel width to be narrower and eliminate the need to relocate Eastern Street and utilities. Weep holes and proper subsurface drainage will ensure free drainage, no backpressure and prevent undermining. We would appreciate knowing whether a properly designed, concrete-lined channel would be approved by the BNSF Railway based on these design comments.

Reference: Railroad Diversion Channel Preliminary Design Report
Kingman, AZ

Other reaches downstream where right-of way and existing land use is not a constraint, an earthen channel can be located outside of the BNSF right-of-way. This would mitigate impact to the railway, provide drainage protection for the tracks, and be a more economical design.

I have enclosed a copy of your March 24th letter and an exhibit to illustrate the alignment and reach locations for reference. If you have any questions or need additional information, please do not hesitate to e-mail or give me a call.

Thanks again for your time.

Sincerely,

STANTEC CONSULTING INC.

James O. Hubbard
Senior Associate

n:\roadway\81760038\correspondence\letters\delaney ltr 022002.doc

cc. Peter R. Johnson – City of Kingman

Stantec

BNSF

ENGINEERING SERVICES
Larry J. Delaney
Manager - Public Projects

The Burlington Northern and Santa Fe Railway Company

1624 First Street N. W.
Albuquerque, New Mexico 87102
Phone 505-767-6845

Fax 505-767-6838
E-mail Larry.Delaney@BNSF.com

December 3, 2002
File: 05040002

Mr. James O. Hubbard
Senior Associate
Stantec Consulting, Inc.
8211 South 48th Street
Phoenix, AZ 85004

RE: Railroad Diversion Channel Preliminary Design Report, Kingman, AZ.

Dear Mr. Hubbard:

Please accept my apologies for the delay in answering your last letter concerning the above captioned project.

Speaking to your question concerning whether or not BNSF will require bank lining when the proposed channel is not adjacent to the future third track location, the answer is yes. BNSF prefers that the storm drain channel be lined whenever the ditch parallels our property, even if the actual channel location is not within our right of way. Channel erosion, migration and degradation can take place very rapidly because of the highly erodable native soils and the high intensity storms common to the Kingman area. Because attrition occurs so quickly, the damage is done long before there is adequate time to react. Unless the banks are armored, we are concerned that a channel could migrate laterally onto BNSF right of way and threaten the safety of our train operations. BNSF cannot dictate channel design which is located off of our property, however, if the City chooses to save the cost of initial construction "with" bank armourment, then the City forever has the responsibility to control erosion such that it does not harm railroad facilities. Any such erosion control which might be required over "on" BNSF property would require an agreement between BNSF and the City's contractor, completion of Contractor Safety Orientation, and current insurance certificates for general liability, auto liability, workers comp. and Railroad Protective policies. The City must decide if the savings are worth the long-term risk. An unlined channel will require more frequent routine periodic maintenance and the City must weigh annual maintenance costs versus initial construction savings.

Answering your second question posed in paragraph four of your letter, BNSF does not object to a properly designed paved channel section. The design must dissipate the high-energy discharge velocity at the end of the concrete lined channel section.

Please feel free to contact me if there are additional questions.

Sincerely,

Larry J. Delaney
Manager – Public Projects

cc: Roger Swenson
City Manager
City of Kingman
310 North Fourth St.
Kingman, AZ 86401

Peter Johnson
City Engineer
City of Kingman
310 North Fourth St.
Kingman, AZ 86401

G. A. White – Belen
R. J. Boileau – Kansas City
M. R. Bader – Flagstaff
M. G. McCallister – Flagstaff
J. L. Hartley – Kansas City
J. C. Shurson – San Bernardino
C. J. Norris – Denver
D. E. Lozano – Kansas City
J. L. Hostler - Albuquerque

APPENDIX B – HYDRAULIC ANALYSIS

Reach 1A / Station 99+77 to 126+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 1A - Earthen
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.0020	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	12.00	ft
Discharge	679.0	cfs

Results		
Depth	4.93	ft
Flow Area	120.0	ft²
Wetted Perimeter	38.62	ft
Top Width	36.66	ft
Critical Depth	3.60	ft
Critical Slope	0.0071	ft/ft
Velocity	5.66	ft/s
Velocity Head	0.50	ft
Specific Energy	5.43	ft
Froude Number	0.55	
Flow Type	Subcritical	

Reach 1B / Station 126+00 to 146+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 1B - Earthen
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.0020	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	12.00	ft
Discharge	679.0	cfs

Results		
Depth	4.93	ft
Flow Area	120.0	ft²
Wetted Perimeter	38.62	ft
Top Width	36.66	ft
Critical Depth	3.60	ft
Critical Slope	0.0071	ft/ft
Velocity	5.66	ft/s
Velocity Head	0.50	ft
Specific Energy	5.43	ft
Froude Number	0.55	
Flow Type	Subcritical	

Notes: BNSF may require gabion mattress for bank protection on side slopes adjacent to their right-of-way.

Reach 1C / Station 146+00 to 157+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 1C - Concrete
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.016	
Slope	0.0020	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	9.00	ft
Discharge	679.0	cfs

Results		
Depth	4.85	ft
Flow Area	78.9	ft²
Wetted Perimeter	26.49	ft
Top Width	23.55	ft
Critical Depth	4.38	ft
Critical Slope	0.0030	ft/ft
Velocity	8.60	ft/s
Velocity Head	1.15	ft
Specific Energy	6.00	ft
Froude Number	0.83	
Flow Type	Subcritical	

Notes: BNSF may require gabion mattress for bank protection on side slopes adjacent to their right-of-way.

Reach 2 / Station 157+00 to 175+00 / Concrete Llined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 2 - Concrete
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.016	
Slope	0.0043	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	16.00	ft
Discharge	1,590.0	cfs

Results		
Depth	4.93	ft
Flow Area	115.2	ft²
Wetted Perimeter	33.76	ft
Top Width	30.78	ft
Critical Depth	5.62	ft
Critical Slope	0.0026	ft/ft
Velocity	13.80	ft/s
Velocity Head	2.96	ft
Specific Energy	7.89	ft
Froude Number	1.26	
Flow Type	Supercritical	

Reach 3 / Station 175+00 to 185+00 / Concrete Lined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 3 - Concrete
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.016	
Slope	0.0181	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	8.00	ft
Discharge	1,994.0	cfs

Results		
Depth	4.99	ft
Flow Area	77.2	ft²
Wetted Perimeter	25.98	ft
Top Width	22.96	ft
Critical Depth	7.93	ft
Critical Slope	0.0026	ft/ft
Velocity	25.83	ft/s
Velocity Head	10.36	ft
Specific Energy	15.35	ft
Froude Number	2.48	
Flow Type	Supercritical	

Reach 4 / Station 185+00 to 218+00 / Concrete Lined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 4 - Concr
Flow Element	Trapezoidal Cha
Method	Manning's Formi
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.016	
Slope	0.0035	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	15.00	ft
Discharge	?,196.0	cfs

Results		
Depth	6.35	ft
Flow Area	155.8	ft²
Wetted Perim	37.90	ft
Top Width	34.05	ft
Critical Depth	6.90	ft
Critical Slope	0.0025	ft/ft
Velocity	14.10	ft/s
Velocity Head	3.09	ft
Specific Energ	9.44	ft
Froude Numb	1.16	
Flow Type	Supercritical	

Reach 5A - Concrete Lined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 5A - Conc. Channel-revised 5-21-(
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.016	
Slope	0.004480	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	26.00	ft
Discharge	2,300.0	cfs

Results		
Depth	4.73	ft
Flow Area	156.5	ft²
Wetted Perimeter	43.05	ft
Top Width	40.19	ft
Critical Depth	5.57	ft
Critical Slope	0.002504	ft/ft
Velocity	14.70	ft/s
Velocity Head	3.36	ft
Specific Energy	8.09	ft
Froude Number	1.31	
Flow Type	Supercritical	

Reach 5B - Concrete Lined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 5B - Conc. Channel-revised 5-21-(
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.016	
Slope	0.002503	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	26.00	ft
Discharge	2,300.0	cfs

Results		
Depth	5.57	ft
Flow Area	191.5	ft²
Wetted Perimeter	46.10	ft
Top Width	42.72	ft
Critical Depth	5.57	ft
Critical Slope	0.002504	ft/ft
Velocity	12.01	ft/s
Velocity Head	2.24	ft
Specific Energy	7.82	ft
Froude Number	1.00	
Flow Type	Subcritical	

Reach 6A - Concrete Lined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 6A - Conc. Channel-revised 5-21-(
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.016	
Slope	0.002502	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	26.00	ft
Discharge	2,300.0	cfs

Results		
Depth	5.57	ft
Flow Area	191.6	ft²
Wetted Perimeter	46.10	ft
Top Width	42.72	ft
Critical Depth	5.57	ft
Critical Slope	0.002504	ft/ft
Velocity	12.01	ft/s
Velocity Head	2.24	ft
Specific Energy	7.82	ft
Froude Number	1.00	
Flow Type	Subcritical	

Reach 6B - Concrete Lined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 6B - Conc. Channel-revised 5-21-(
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.016	
Slope	0.012000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	12.00	ft
Discharge	2,550.0	cfs

Results		
Depth	5.43	ft
Flow Area	109.5	ft²
Wetted Perimeter	31.59	ft
Top Width	28.30	ft
Critical Depth	8.06	ft
Critical Slope	0.002522	ft/ft
Velocity	23.30	ft/s
Velocity Head	8.43	ft
Specific Energy	13.87	ft
Froude Number	2.09	
Flow Type	Supercritical	

Reach 6C / Station 241+65 to 257+00 / Concrete Lined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 6C - Con
Flow Element	Trapezoidal Cha
Method	Manning's Form
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.016	
Slope	0.0073	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	20.00	ft
Discharge	2,815.0	cfs

Results		
Depth	5.25	ft
Flow Area	146.3	ft²
Wetted Perim	38.93	ft
Top Width	35.75	ft
Critical Depth	7.07	ft
Critical Slope	0.0024	ft/ft
Velocity	19.24	ft/s
Velocity Head	5.75	ft
Specific Energ	11.00	ft
Froude Numb	1.68	
Flow Type	Supercritical	

Reach 6D / Station 257+00 to 274+43 / Earthen Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 6d - Earthen at 2:1/3:1 - 46' bw - subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.0018	ft/ft
Left Side Slope	2.0	H : V
Right Side Slope	3.0	H : V
Bottom Width	46.0	ft
Discharge	2,815.0	cfs

Results		
Depth	6.3	ft
Flow Area	389.0	ft²
Wetted Perimeter	80.0	ft
Top Width	77.5	ft
Critical Depth	4.5	ft
Critical Slope	0.0061	ft/ft
Velocity	7.2	ft/s
Velocity Head	0.8	ft
Specific Energy	7.1	ft
Froude Number	0.57	
Flow Type	Subcritical	

Notes: BNSF may require gabion mattress for bank protection on side slope adjacent to their right-of-way.

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

Reach 7 / Station 274+43 to 321+16 / Earthen Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 7 - Earthen at 2:1/3:1 - 70' bw - subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.0017	ft/ft
Left Side Slope	2.0	H : V
Right Side Slope	3.0	H : V
Bottom Width	70.0	ft
Discharge	3,921.0	cfs

Results		
Depth	6.3	ft
Flow Area	535.7	ft²
Wetted Perimeter	103.8	ft
Top Width	101.3	ft
Critical Depth	4.4	ft
Critical Slope	0.0060	ft/ft
Velocity	7.3	ft/s
Velocity Head	0.8	ft
Specific Energy	7.1	ft
Froude Number	0.56	
Flow Type	Subcritical	

Notes: BNSF may require gabion mattress for bank protection on side slope adjacent to their right-of-way.

Reach 8 / Station 321+16 to 383+57 / Earthen Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 8 - Earthen at 2:1/3:1 - 108' bw - su
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	0.0016	ft/ft
Left Side Slope	2.0	H : V
Right Side Slope	3.0	H : V
Bottom Width	108.0	ft
Discharge	5,703.0	cfs

Results		
Depth	6.3	ft
Flow Area	773.8	ft²
Wetted Perim	141.8	ft
Top Width	139.3	ft
Critical Depth	4.3	ft
Critical Slope	0.0059	ft/ft
Velocity	7.4	ft/s
Velocity Head	0.8	ft
Specific Energ	7.1	ft
Froude Numb	0.55	
Flow Type	Subcritical	

Notes: BNSF may require gabion mattress for bank protection on side slope adjacent to their right-of-way.

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

Reach 9A / Station 383+57 to 387+84 / Earthen Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 9 - Gabion/Earthen at 2:1/3:1 - 150' bw - subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.026	
Slope	0.0044	ft/ft
Left Side Slope	2.0	H : V
Right Side Slope	3.0	H : V
Bottom Width	150.0	ft
Discharge	12,306.0	cfs

Results		
Depth	6.2	ft
Flow Area	1,028.8	ft²
Wetted Perimeter	183.5	ft
Top Width	181.1	ft
Critical Depth	5.7	ft
Critical Slope	0.0058	ft/ft
Velocity	12.0	ft/s
Velocity Head	2.2	ft
Specific Energy	8.4	ft
Froude Number	0.88	
Flow Type	Subcritical	

Notes: Gabion Mattress on Side Slopes for Bank Protection.

Reach 9B / Station 387+84 to 393+83 / Gabion Llined Channel
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Reach 9 End - Gabion at 2:1/2:1 - 93' bw - supercritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.0128	ft/ft
Left Side Slope	2.0	H : V
Right Side Slope	2.0	H : V
Bottom Width	93.0	ft
Discharge	12,306.0	cfs

Results		
Depth	6.5	ft
Flow Area	691.4	ft²
Wetted Perimeter	122.2	ft
Top Width	119.1	ft
Critical Depth	7.7	ft
Critical Slope	0.0072	ft/ft
Velocity	17.8	ft/s
Velocity Head	4.9	ft
Specific Energy	11.4	ft
Froude Number	1.30	
Flow Type	Supercritical	

Notes: Side slopes and channel bottom are lined with Gabion Mattresses.

Stantec Consulting Inc.
8211 South 48th Street
Phoenix, AZ 85044
Tel: 602-438-2200
Fax: 602-431-9562

Stantec

6 December 2001

File: 81760038

City of Kingman
310 North Fourth Street
Kingman, AZ 86401

Attention: Mr. Peter R. Johnson, PE

Dear Mr. Johnson:

Reference: Railroad Diversion Channel
Preliminary Design Report

Enclosed herewith are two (2) copies of the final report and 10% plans for the above referenced project. Comments we received on the Draft report from BNSF Railway significantly changed the design concept for the Final report, most notably adding channel bank lining. We have addressed all comments and have developed a "Preferred Alternative" for the channel.

Thank you for your patience and providing us the additional time to complete this submittal. Please review and comment at your convenience. Give me a call to discuss if you have any questions or would like additional information.

Sincerely,

STANTEC CONSULTING INC.

James O. Hubbard
Senior Associate
jhubbard@stantec.com

RAILROAD DIVERSION CHANNEL

PRELIMINARY DESIGN REPORT

Prepared For:

City of Kingman
310 North Fourth Street
Kingman, Arizona 86401

Prepared By:

Stantec Consulting Inc.
8211 South 48th Street
Phoenix, Arizona 85044
(602) 438-2200

PROJECT NO. 81760038

November 2001

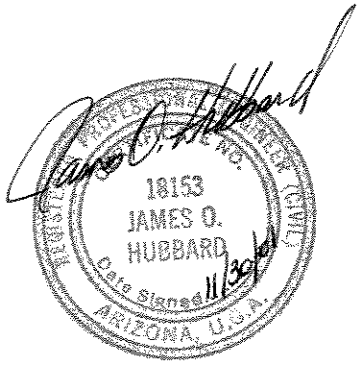


TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

EXHIBITS

APPENDIX

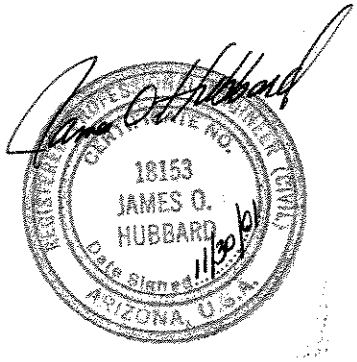
Appendix A	*HEC-1 Input/Output Diskette*
Appendix B	*Hydraulic Analysis*
Appendix C	*Quantities/Cost Estimates*
Appendix D	*Correspondence*

LIST OF PLATES

Plate 1	*Drainage Area/Sub-Basin Boundary Map*
Plate 2	*HEC-1 Routing Schematic*

PRELIMINARY PLANS

Sheets 1 to 21 *Under Separate Cover*



1.0 EXECUTIVE SUMMARY

Stantec Consulting, Inc. (Stantec) was retained by the City of Kingman to evaluate channel alternatives for the Railroad Diversion Channel, a proposed channel along the south side of the BNSF Railway. The channel was originally proposed in the Kingman Area Master Drainage Plan prepared by Boyle Engineering Corporation in June, 1988. The channel will intercept runoff from the southeast beginning approximately at the Southern Avenue alignment and direct flows northeasterly to outfall into Rattlesnake Hill Wash, located on the south side of the Kingman Airport property. This channel will alleviate flooding within the city, specifically the areas adjacent to Fairgrounds Boulevard and Bank Street north of the railroad. In addition, the BNSF Railway embankment will be protected and maintenance of the existing culverts will be eliminated. Channel improvements have been designed to intercept the 100-year runoff event.

The hydrologic analysis was based on modeling procedures and data recently developed for the Mohave Wash Channelization project for Mohave County Flood Control District by Stantec Consulting. This information is published in "Hydrology & Sediment Analysis, Mohave Wash Channelization, Kingman Area Master Plan Update, Mohave County, Arizona", October 8, 1999, Robert L. Ward, P.E. This analysis was adapted and modified slightly to evaluate detention basins near the railroad to further mitigate flooding upstream of the proposed channel and also to reduce the size of the channel at the upper end of the proposed improvements.

The channel was subdivided into nine reaches based on watershed delineation and contributing flows. Each reach was independently studied to determine solutions for economical channel configurations and bank linings, based on constraints each reach was subject to including available right-of-way, future railroad development and existing structures. A detention basin providing approximately 38 acre-feet of storage is also proposed, located on the parcel of land between Eastern Street, Southern Street, Washington Street, and Phoenix Street. This basin will reduce the size of the diversion channel, direct runoff north in Adams Street and eliminate nuisance drainage problems within a portion of the Hilltop area.

Initially, an alternative analysis was performed to determine the best channel improvement solution. This included developing typical sections for earthen, riprap-lined, gabion-lined and fully concrete-lined sections. After receiving comments from the City of Kingman and the BNSF Railway, the channel improvement solution determined from this initial alternative analysis was followed up by an effort to crystallize the solution into one that incorporated agency comments and addressed any further design concerns. This effort resulted in a "Preferred Alternative", a proposed solution for the channel improvements which economically incorporates several types of channel geometry and lining types to safely convey the 100-year design flows to Rattlesnake Hill Wash and under the railroad tracks.

2.0 INTRODUCTION

2.1 General

This report presents the results of the hydrologic and hydraulic analysis for the proposed drainage improvement alternatives for the Railroad Diversion Channel for the City of Kingman. This study was initiated by the City as a result of Stantec Consulting's contract with Mohave County Flood Control District for the "Kingman Area Master Plan – Mohave County Update", providing new hydrology for the channelization of Mohave Wash and other flood control alternatives including the Railroad Diversion Channel. In addition, coordination with the proposed roadway and drainage improvements for the East Golden Gate Addition Improvement District – Phase 1 project will provide additional protection for the Hilltop area.

2.2 Location

The Railroad Diversion Channel project is situated adjacent to and parallel with the south side of the BNSF Railway tracks within the City of Kingman. The proposed alignment begins on the upstream end at approximately Southern Avenue within the Hilltop area and extends downstream to Rattlesnake Hill Wash, located on the south side of the Kingman Airport within the Mohave County Airport Authority. A portion of the proposed channel improvements will lie within the BNSF Railway right-of-way. The channel will traverse diagonally through Sections 18, 7, 8, 5, and 4 of Township 21 North, Range 16 West and Sections 33, 34 and 27 of Township 22 North, Range 16 West of the Gila and Salt River Base and Meridian, Mohave County, Arizona within the Kingman City Limits (see Figure 1.1).

2.3 Project Description

The City of Kingman has experienced flooding of streets and neighborhoods as a result of storm water runoff that outlets through culverts that concentrate flows collected on the upstream side of the railroad tracks embankment. The Kingman Area Master Drainage Plan, June 1988, documented flooding problems for Fairgrounds Boulevard and Bank Street, both impacted by this watershed. In addition, the Hilltop area south of the railroad experiences nuisance flooding due to the sheet flow through the neighborhood. Also, BNSF Railway must maintenance the culverts which are always susceptible to major storms that would exceed the capacity of the existing drainage structures.

The Railroad Diversion Channel project would provide flood protection for areas north of the railroad and ultimately revise the FEMA Flood Insurance Rate Maps for the community. The current floodplain maps show Zone A floodplain delineation from Southern Avenue alignment to Louise Street and from Airway Avenue alignment to the Kino Drive alignment along the south side of the railroad. However, more significant is the impact north of the railroad. Currently, a Zone A delineation begins on the north side of SR66 behind the Denny's restaurant and extends northerly to Mohave Wash, impacting an area between Bank Street and Roosevelt Street. North of the City limits, Zone B delineation could be deleted for the area along Diagonal Wash.

All runoff would be intercepted by the proposed channel along the south side of the BNSF Railway and routed northeasterly to outfall into Rattlesnake Hill Wash. The channel was divided into nine (9) reaches based on concentration points for contributing storm water runoff peak discharges. Each reach has been analyzed for four (4) alternatives that studied different channel linings.

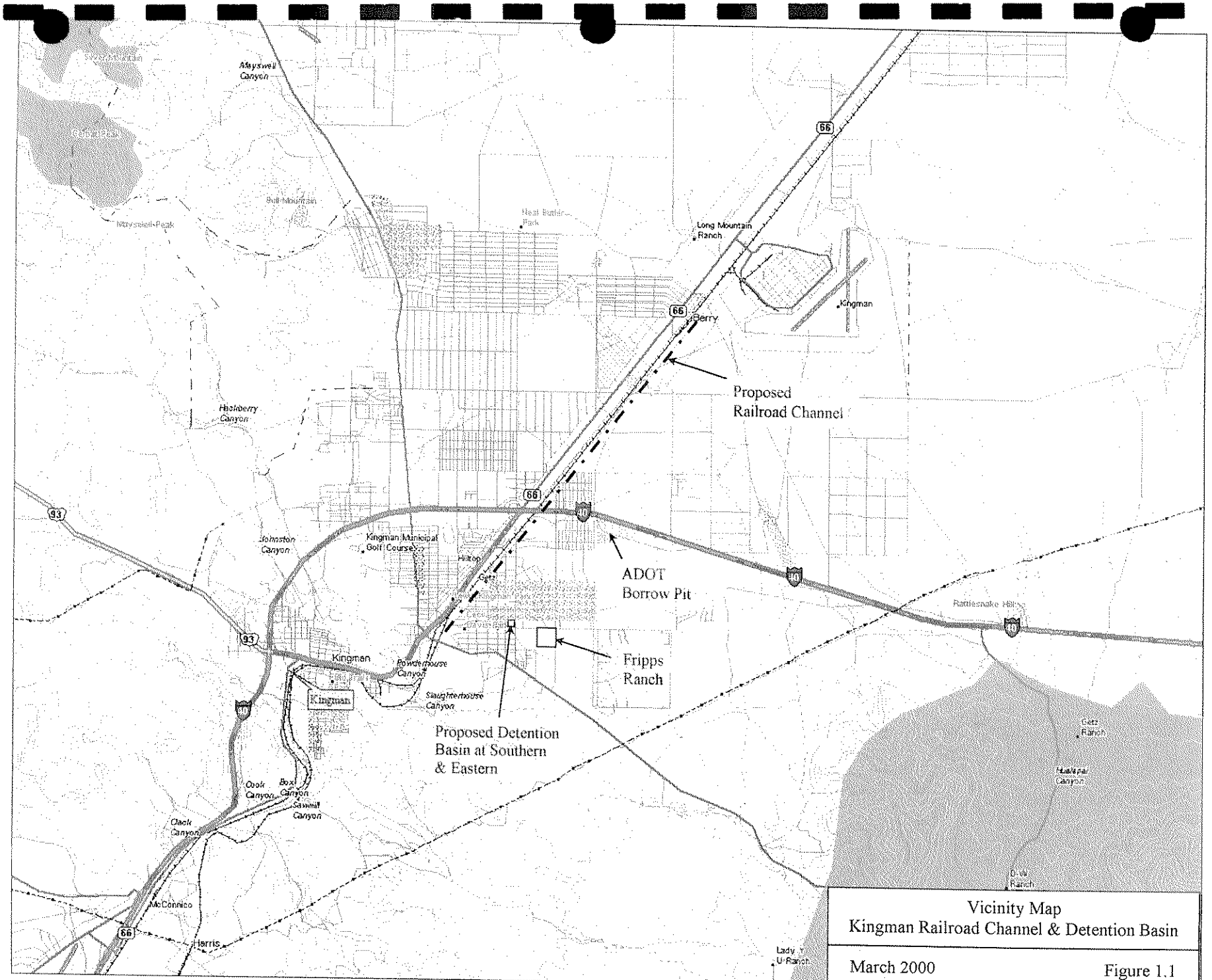
In addition to the channel, two detention basins were evaluated to analyze the impact on flows into the proposed channel and additional protection upstream of the Railroad Channel alignment. The first detention basin is located at the northwest corner of Eastern and Southern Streets. The second basin location, which already has detention capability, is an ADOT borrow pit within Section 9, south of Interstate 40 and approximately 1 mile east of the railroad alignment.

2.4 BNSF Railway Coordination

During preparation of the Kingman Area Master Plan, personnel from the railroad were contacted to apprise them of this potential project. In 1988, the City of Kingman contributed funds to Santa Fe (BNSF) to increase the size of the Rattlesnake Hill Wash structure that was being reconstructed. The structure was enlarged in order to accommodate additional flows from this project. Stantec has contacted BNSF Railway during this study to insure that the railroad continues to support this project and placement of the channel within the railroad right-of-way will be permitted. BNSF representatives acknowledged their support for this project citing that (1) the diversion channel will eliminate maintenance costs for the existing drainage structures under the tracks and (2) excavation from the channel could be used to construct the embankment for a possible future third track.

2.5 Purpose and Scope

The purpose of this report is to present the results of our hydrologic and hydraulic analysis for the Railroad Diversion Channel project. The recommendations of this report presents economical and feasible flood control alternatives which serve to eliminate and/or minimize the potential for flood damage within the City of Kingman. The approved or preferred alternative will serve as the basis to prepare initial (10%) plans for the channel alignment and an engineer's construction cost estimate to implement this flood control project.



Vicinity Map
Kingman Railroad Channel & Detention Basin

March 2000 Figure 1.1

3.0 HYDROLOGY

3.1 General

The purpose of this analysis is to provide hydrology information needed for the analysis of the proposed channel and possible detention basins within the watershed. The proposed detention basin sites are located at the northeast corner of the intersection of Southern Avenue and Eastern Street, and, at an abandoned ADOT borrow pit located south of I-40. Figure 1.1 shows the detention basin locations along with the proposed channel alignment.

As will be discussed in Section 3.3, the hydrology analysis also considered the storage effects of the proposed Fripps Ranch subdivision detention basin.

The following sections of this report discuss the hydrology analysis that was performed for this site. The hydrology analysis was based on modeling procedures and hydrologic data that was recently developed for a channel improvement project for Mohave County. This information is published in **Hydrology & Sediment Analysis, Mohave Wash Channelization, Kingman Area Master Plan Update, Mohave County, Arizona**, October 8, 1999, Robert L. Ward, P.E.

3.2 Hydrology Analysis

Computerized rainfall/runoff models were developed for the project watershed using the U.S. Army Corps of Engineers *Flood Hydrograph Package* (HEC-1). HEC-1 uses numerical parameters to describe the amount and temporal distribution of rainfall, the runoff characteristics of the watershed, and the hydraulic properties of channels that collect and convey direct runoff to concentration points. The computer output provides a runoff hydrograph at user-selected locations. The June 1992 version (4.0.3E) of HEC-1 was used for this analysis.

The hydrologic modeling procedures used in this study comply with those published in ***Highway Drainage Design Manual, Hydrology***, Arizona Department of Transportation (ADOT), October 22, 1992. The Clark unit hydrograph was used for generating runoff hydrographs and the Green-Ampt infiltration procedure was used for quantifying rainfall losses. As stated previously, these are the same procedures that were used for the 1999 **Kingman Area Master Plan Update**. Accordingly, the reader is referred to the 1999 report for detailed discussions of these hydrologic procedures.

3.2.1 Drainage Area Delineations

All drainage area boundaries were delineated from USGS quadrangle maps. The sub-basin boundaries are shown on Plate 1. The HEC-1 routing schematic, developed from Plate 1, is shown on Plate 2.

It should be noted that Plates 1 and 2 are taken from the previously referenced 1999 **Kingman Area Master Plan Update** report. Accordingly, these Plates include all the HEC-1 sub-basins that were used in this previous report. The majority of the sub-basins on Plates 1 and 2 are not related to the detention basin and flood control channel analysis presented in this report. The HEC-1 models that were created for this report also include these extra sub-basins.

3.2.2 Rainfall Data

Rainfall depths for the project drainage area were developed from isopluvial maps and regression equations presented in the **Precipitation-Frequency Atlas of the Western United States, NOAA Atlas 2, Volume III** – Arizona 1973. Table 3.2.1 summarizes point precipitation values for this watershed for several storm frequencies and durations. Rainfall depths for storm durations less than 1-hour were based on ratios of the 1-hour values using reduction ratios published by Arkell and Richards (1986).

The HEC-1 hypothetical rainfall distribution was used for this analysis. This rainfall distribution is created by sub-routines in the HEC-1 program, which are functions of the point rainfall depths for different time durations within the design storm period. Both the 6-hour and 24-hour storm durations were used in this study. The hypothetical rainfall distribution was simulated with a 5-minute calculation interval.

The data in Table 3.2.1 represents point rainfall depths. Adjustments for areal storm distribution were accomplished with the JD records in HEC-1. The use of JD records generates runoff hydrographs that reflect areally reduced rainfall values as a function of total contributing drainage area at any selected location within the watershed. This approach automatically generates a greater amount of reduction in point rainfall depths as runoff from multiple sub-basins is combined at HEC-1 concentration points. The areal rainfall reduction for individual sub-basins is based on the area of each sub-basin.

3.2.3 Channel Routing Operations

As stated previously, the Clark unit hydrograph procedure was used to develop a runoff hydrograph for all sub-basins in the project watershed. However, separate channel routing operations were required to route hydrographs between concentration points. The *"modified Puls, normal-depth, storage and outflow"*, and *"kinematic wave"* routing options in HEC-1 were used for these routing operations.

Table 3.2.1
Summary Of Point Rainfall Data
Kingman Area Master Plan Update
Mohave County, Arizona

Storm Return Interval (yrs)	Point Precipitation (inches)									
	5-min	10-min	15-min	30-min	1-Hr	2-Hr	3-Hr	6-Hr	12-Hr	24-Hr
2	0.34	0.51	0.61	0.81	0.99	1.10	1.17	1.30	1.45	1.59
5	0.44	0.66	0.82	1.10	1.36	1.51	1.62	1.81	2.03	2.25
10	0.50	0.77	0.97	1.30	1.61	1.80	1.92	2.15	2.42	2.69
25	0.60	0.92	1.17	1.57	1.96	2.19	2.34	2.62	2.96	3.30
50	0.67	1.03	1.32	1.79	2.23	2.49	2.66	2.99	3.38	3.76
100	0.75	1.15	1.47	2.00	2.50	2.79	2.98	3.35	3.79	4.23
500	0.92	1.42	1.83	2.49	3.11	3.48	3.73	4.19	4.75	5.31

2-Year, 6-Hour Rainfall = 1.30
2-Year, 24-Hour Rainfall = 1.59
100-Year, 6-Hour Rainfall = 3.35
100-Year, 24-Hour Rainfall = 4.23

File:Rainfall Data For 1999 Kingman Master Plan.xls

Short Duration
Rainfall Zone: 8

Note: Rainfall values from NOAA Atlas, Volume VIII, Arizona
Short duration rainfall ratios from Arkell & Richards, 1986.

3.3 Detention Basin Analysis

The following sections provide detailed discussions of the detention basins that were analyzed in this report.

3.3.1 Southern Avenue – Eastern Street Basin

Referring to Plate 2, this proposed detention basin is included in Sub-Basin DB1. The City of Kingman has expressed an interest in constructing a basin at this location in order to reduce discharges to Reach 1 of the proposed railroad flood control channel and reduces flows through the Hilltop area.

The natural ground through this area slopes from the southeast to the northwest. Accordingly, any detention basin construction at this site will result in a basin with a greater depth (below natural ground) at the southeast corner than at the northwest corner.

A detention basin at this location would be located on a rectangular plot of land that is approximately 640-feet long (east-west) by 470-feet wide (north-south). To simplify calculations at this preliminary level of analysis, an equivalent square basin, with a level ground surface, was used to develop an estimate of the elevation vs. flood control storage relationship that would be required for this basin. Table 3.3.1 presents the preliminary stage-storage relationship that was developed for use in this study. Table 3.3.1 also shows the average rectangular dimensions associated with this theoretical square basin. This data will require refinement as part of the final design process for this detention basin.

As evaluated in this study, the proposed detention basin is drained by 2-36" RCPs. Basin overflow would be controlled by a 10-foot wide concrete spillway with an invert elevation set 5-feet above the basin floor, i.e., the spillway would begin to operate when the basin storage depth exceeded 5-feet. The stage-discharge relationship associated with this configuration is also presented in Table 3.3.1.

The basin is presently configured to discharge west to Adams Street, where water would then flow north in Adams to the proposed railroad flood control channel. Table 3.3.2 summarizes the approximate performance characteristics of this basin, based on the equivalent square and level ground configuration used to prepare the storage and discharge data in Table 3.3.1.

Table 3.3.1
Stage / Storage / Discharge Data
Square Detention Basin Geometry
Proposed Detention Basin at Southern Avenue & Eastern Street
Kingman, Arizona

Storage Data

Basin Bottomwidth (ft)	Side-Slope	Water Depth (ft)	Storage Volume (AF)	Topwidth At Listed Water Depth (ft)	Surface Area At Listed Water Depth (acres)	Rectangular Bottom Dimensions		Verify Equivalent Square BW Dimension (ft)	Rectangular Top Dimensions At Listed Water Depth		Equivalent Square Top Dimension (ft)
						Width (ft)	Length (ft)		Topwidth (ft)	Top Length (ft)	
443	4	0	0	443	4.51	379.87	516.62	443.00	379.87	516.62	443.00
443	4	1	4.59	451	4.67	379.87	516.62	443.00	386.73	525.95	451.00
443	4	2	9.34	459	4.84	379.87	516.62	443.00	393.59	535.28	459.00
443	4	3	14.26	467	5.01	379.87	516.62	443.00	400.45	544.61	467.00
443	4	4	19.35	475	5.18	379.87	516.62	443.00	407.31	553.94	475.00
443	4	5	24.62	483	5.36	379.87	516.62	443.00	414.17	563.27	483.00
443	4	6	30.07	491	5.53	379.87	516.62	443.00	421.03	572.60	491.00
443	4	7	35.69	499	5.72	379.87	516.62	443.00	427.89	581.93	499.00

Discharge Data

2-36" RCP, Spillway BW = 10'

Headwater Depth (ft)	Pipe Flow (cfs)	Spillway Flow (cfs)	Total Flow (cfs)
0	0	0	0
1.5	22.4	0	22.4
2	37	0	37
3	68	0	68
4	98	0	98
5	120	0	120
6	140	28	168
7	156	79.2	235.2

Note: Spillway discharge is based on a weir coefficient of 2.8.

File: Table 3.1.xls

Table 3.3.2

Summary of Proposed Detention Basin Performance
Southern Avenue & Eastern Street
Kingman Railroad Channel & Detention Basin Project
Kingman, Arizona

HEC-1 File	Storm Duration (hrs)	Detention Basin Data At Southern & Eastern: Max Water Depth (ft)	Qin (cfs)	Qout (cfs)	Spillway Flow (cfs)	Storm Return Interval: 10-Yr	25-Yr	50-Yr	100-Yr
KGDET3D	24	5.84	619	160	22				X
KGDET350	24	5.10	522	124	1			X	
KGDET325	24	4.25	435	103	0		X		
KGDET310	24	3.21	326	74	0	X			
KGDET2D	6	5.46	583	141	9				X
KGDET250	6	4.69	491	113	0			X	
KGDET225	6	3.89	407	94	0		X		
KGDET210	6	2.91	300	65	0	X			

Note: Proposed detention basin has a 10-ft wide spillway set 5-ft above the bottom of the basin.
The basin is drained by 2-36" RCPs. Total basin storage at the spillway invert elevation is approximately 24.62 AF.
Fripps Ranch detention basin is assumed to be in-place.

File: Kingman RR Channel HEC-1 Data, Feb 2000 Update.xls

3.3.2 Fripps Ranch Detention Basin

The proposed Fripps Ranch subdivision is located in the NE ¼ of the NW ¼ of Section 20, T21N, R16E. The property is bounded on the south by Karen Avenue and on the north by Southern Avenue. The property abuts North Central Street on the east.

A drainage report, prepared by Mohave Engineering Associates, Inc., indicates that a detention basin will be constructed in the northwest corner of this subdivision (Sub-Basin 786 on Plate 2). Table 3.3.3 summarizes the storage and discharge data that was prepared for this detention basin by Mohave Engineering Associates.

As presently configured, the Fripps Ranch detention basin will be drained by a single 18" RCP, and will have a 20-foot wide spillway which will begin to flow when the water depth in the basin reaches elevation 3604.5-feet MSL (1.5-feet deep). The discharge column in Table 3.3.3 represents combined pipe and spillway flow.

Table 3.3.3
Fripps Ranch Detention Basin
Stage-Discharge-Storage Relationships
(provided by Mohave Engineering Associates)

HW Elevation (ft, MSL)	Discharge (cfs)	Storage Volume (AF)
3604.0	0	0
3604.5	0.78	0.2
3605.0	21.46	0.5
3605.5	60.54	0.9
3606.0	112.68	1.1

As modeled in this study, the Fripps Ranch detention basin discharges at a peak rate of 140 cfs during the 100-year, 24-hour storm and at a rate of 131 cfs during the 100-year, 6-hour storm. Referring to Table 3.3.3, it is obvious that the basin is exceeding the maximum spillway capacity (112.68 cfs) during both of these storm events. It should be noted that the HEC-1 model is extrapolating the listed storage-discharge curves to perform the reservoir routing operations for these two storms, i.e., the data provided by Mohave Engineering Associates does not extend above a maximum discharge of 112.68 cfs. Accordingly, this limitation will probably produce some minor degree of error in the downstream hydrologic calculations performed by the HEC-1 models that were used for this report.

3.3.3 ADOT Borrow Pit

The City of Kingman has expressed an interest in exploring the stormwater detention storage capabilities of an abandoned ADOT borrow pit, which is located immediately south of I-40 and approximately 1-mile east of Eastern Street. Presently, this pit provides approximately 32.11 AF of in-ground storage. This storage is divided among three excavation sites. The main portion of the borrow pit provides 30.29 AF of storage, while the two smaller excavations provide about 1.82 AF of storage.

For the purpose of this study, the borrow pit was analyzed in its present condition, and, for a possible future condition which could occur if the basin were to be enlarged. For comparison purposes, one model was also developed which completely ignored the storage capacity of the borrow pit.

For the existing condition analysis, only the 30.29 AF of storage in the main borrow pit was used for effective flood control storage. The 1.82 AF in the two smaller basins was ignored and was assumed to consumed as sediment storage.

For the future condition analysis, the borrow pit was assumed to be enlarged to a sufficient size to store all the runoff from the natural drainage area intercepted by the pit (Sub-Basins 830 and 840 on Plate 2).

Due to the non-availability of detailed topographic mapping of the entire drainage area intercepted by the borrow pit, it is not possible to accurately define the watershed area that might be controlled by this pit. For the purpose of this study, drainage boundaries were delineated from USGS quadrangle maps with 40-foot contour intervals. Based on the quadrangle maps, it appears that the borrow pits will intercept runoff from Sub-Basins 830 and 840, which have a combined drainage area of 1.2714 square miles. To compensate for possible drainage boundary errors (due to the large contour interval), it is further assumed that the runoff from these sub-basins will either naturally enter the main pit, or, be diverted to the main pit by future manmade diversion berms. A review of 2-foot contour mapping in the immediate vicinity of the borrow pit, indicates that (under existing conditions) manmade berms may indeed be required to divert 100-percent of the runoff from Sub-Basins 830 and 840 into the borrow pit.

During a 100-year, 24-hour storm, the direct runoff from Sub-Basins 830 and 840 is 99.96 AF. This is over three times the available capacity of the main ADOT borrow pit volume of 30.29 AF. As a result, the existing pit will spill during the 100-year, 24-hour storm. The peak discharge of this spill will be on the order of 600 cfs. However, as will be discussed in Section 3.4, the peak discharge from the pit is sufficiently delayed to cause a noticeable reduction in peak discharge at the Rattlesnake Hill Wash crossing of the BNSF railroad.

3.4 Railroad Channel

As stated previously, the proposed railroad channel would extend from near the extension of Southern Avenue to the Rattlesnake Hill Wash crossing of the BNSF railroad. The channel would be located on the south side of the railroad. Referring to Plate 2, the channel would extend from HEC-1 CP (Concentration Point) 752 to CP 1173. The total channel length is approximately 5.12 miles.

At the present time, there are wash crossings under the BNSF railroad at CP 752, 762, 1013, 1031, 1122, and 1173. With the proposed railroad channel in-place, all of these crossings would be blocked, with the exception of CP1173, which is the Rattlesnake Hill Wash crossing.

3.5 Summary of Modeling Results

Sixteen HEC-1 models were created to analyze the impact of different combinations of storms and detention basins on the proposed railroad flood control channel. Input/Output files are provided electronically on diskette in Appendix A. Table 3.5.1 presents a matrix of the different modeling assumptions and the peak discharges that occur at specific locations along the railroad channel. All scenarios listed in Table 3.5.1 assume the proposed Fripps Ranch detention basin is in-place.

The modeling variables in Table 3.5.1 are defined as follows:

- **Storm Duration** - Models are presented for both the 6-hour and 24-hour hypothetical storm distributions.
- **Storm Frequency** - Models are included for the 10-year, 25-year, 50-year, and 100-year storms.
- **Detention Basin at Southern & Eastern** - The 100-year storm is modeled both with and without this basin in order to evaluate the effectiveness of the basin on the peak discharges in the proposed railroad channel. All other storm scenarios assume that this detention basin is in-place.
- **ADOT Borrow Pit Detention Basin** - This basin is modeled in the following three conditions: 1) existing condition, with 30.29 AF of stormwater storage; 2) non-existent, i.e., no available flood control storage; and 3) being enlarged to retain 100-percent of the runoff from Sub-Basins 830 and 840. Only the 100-year, 24-hour storm is modeled for the future, enlarged condition.

A review of the discharges in Table 3.5.1 indicates that the proposed detention basin at Southern and Eastern causes a significant reduction in peak discharge through an approximate 6,000-foot length of the proposed railroad channel that extends from CP 775 to CP 1030.2.

For example, during the 100-year, 24-hour storm, the reduction in peak discharge varies from 22% at CP 775 to 14% at CP 1030.2. Downstream of CP 1030.2, the ADOT borrow pit also begins to exert an influence on the railroad channel discharges.

The impact of the ADOT borrow pit causes the peak 100-year, 24-hour discharge at the Rattlesnake Hill Wash crossing of the BNSF railroad to vary from 12,306 cfs (proposed pit enlargement) to 13,025 cfs (storage effects of the pit are ignored). Under existing borrow pit conditions, the peak 100-year, 24-hour discharge at the railroad crossing is 12,513 cfs. These discharges reflect the proposed detention basin being in-place at Southern and Eastern.

Table 3.5.1 provides a complete summary of the impact that the modeling variables will have on the proposed railroad channel design discharge. Table 3.2.2 provides the results of the reduction in peak discharge at the proposed detention basin at Eastern Street and Southern Avenue. The analysis illustrates the impact these basins have on not only the railroad channel, but the Hilltop area as well.

Table 3.5.1

Summary of Modeling Assumptions & Discharges
Kingman Railroad Channel & Detention Basin Project
Kingman, Arizona

HEC-1 File	Storm Duration (hrs)	Peak Discharge (cfs) At HEC-1 Concentration Points										Modeling Assumptions							
		752	794.5	775	804	1012	1030.2	1062	1092	1122	1173	Det. Basin At Southern & Eastern	With Existing ADOT Pit As Detention Basin	With Proposed Enlargement Of ADOT Pit As Detention Basin	Without ADOT Pit As Detention Basin	Storm Return Interval			
																10-Yr	25-Yr	50-Yr	100-Yr
KGDET3	24	679	879	2053	2454	2581	2786	3129	4144	5887	12,612		X						X
KGDET3D	24	679	321	1589	1994	2196	2390	2815	3921	5705	12,513	X	X						X
KGDET350	24	578	274	1341	1681	1842	2006	2331	3232	4599	9,694	X	X					X	
KGDET325	24	480	228	1098	1375	1500	1630	1873	2578	3614	7,258	X	X				X		
KGDET310	24	355	170	789	985	1070	1150	1304	1764	2383	4,537	X	X			X			
KGDET3	6	634	831	1915	2289	2392	2585	2867	3761	5249	10,809		X						X
KGDET3D	6	634	301	1476	1852	2026	2208	2558	3547	5076	10,719	X	X						X
KGDET350	6	538	256	1242	1554	1694	1844	2114	2912	4100	8,303	X	X					X	
KGDET325	6	445	212	1007	1258	1364	1479	1669	2279	3147	6,118	X	X				X		
KGDET310	6	326	156	714	890	963	1032	1148	1541	2041	3,718	X	X			X			
KGDET2	24	679	879	2053	2454	2581	2786	3452	4749	6637	13112				X				X
KGDET2D	24	679	321	1589	1994	2196	2390	3304	4577	6473	13025	X			X				X
KGDET250	24	578	274	1341	1681	1842	2006	2704	3730	5184	10168	X			X			X	
KGDET225	24	480	228	1098	1375	1500	1630	2168	2929	4031	7619	X			X		X		
KGDET210	24	355	170	789	985	1070	1150	1502	1968	2629	4766	X			X	X			
KGDET3D1	24	679	321	1589	1994	2196	2390	2815	3921	5703	12306	X		X					X

Note: Proposed detention basin has a 10-ft wide spillway set 5-ft above the bottom of the basin.
The basin is drained by 2-36" RCPs. Total basin storage at the spillway invert elevation is approximately 24.62 AF.
Fripps Ranch detention basin is in-place. Sub-Basin 786 uses 21.3% of impervious cover.

File: Kingman RR Channel HEC-1 Data, Feb 2000 Update.xls

4.0 HYDRAULIC DESIGN CRITERIA

4.1 Channel Design Criteria

The 100-year storm event is used for all flood control alternative evaluations. The channel will have an impact on FEMA floodplain delineation for the area adjacent to the BNSF, Mohave Wash due to the diversion of flow, and other areas of the community that have been delineated by the detailed Flood Insurance Rate Studies. Consequently, FEMA criteria to provide 1 foot of freeboard will be followed to insure the project will change the Flood Insurance Rate Maps in the future.

4.2 Hydraulic Criteria

Channel design adhered to the criteria and design guidance set forth in the *Drainage Design Manual for Maricopa County, Volume II, Hydraulics* and *Hydraulic Design of Flood Control Channels, EM 1110-2-1601, Corps of Engineers*. The primary criteria set forth in the design procedures from both of these references is to provide stable, uniform flow.

Stable flow is checked in hydraulic procedures by computing the Froude Number. The equation for the Froude Number is: $F = V / (gD)^{0.5}$, where V = channel velocity, g = 32.2 fps, and D is depth of flow. A Froude Number of 1.0 distinguishes between subcritical ($F < 1$) and supercritical ($F > 1$) flow. To insure flow is stable, tranquil or subcritical flow provides for an $F < 0.85$ and supercritical or rapid flow provides for an $F > 1.3$.

Design criteria for channel velocity is a function of the type of material used for lining the banks or banks and bottom. A minimum velocity of 5 feet/second is desired to minimize sediment deposition in the channel. Maximum allowable velocity is determined by ability of the channel lining material to resist erosive forces. Table 4.2.1 provides the parameters used for the design as well as the Manning's Roughness Coefficient.

Table 4.2.1

Channel Lining Material	Maximum Velocity	Manning's "n"
Earthen	6.0 fps	0.025
Gabion Banks	9.0 fps	0.030
Riprap Banks	9.0 fps	0.035
Concrete Banks & Bottom	20.0 fps	0.019

Channel side slopes for design varies depending on the channel lining material for stability. The earthen channel provides for a 2:1 (H:V) slope on the north side and a 3:1 (H:V) on the south side. The flatter slope on the south side reduces potential erosion from the sheet flow entering the channel. Gabion and riprap lined banks use 2:1 (H:V) slopes. The concrete-lined channel alternative steepens the side slopes to 1.5:1 (H:V).

4.3 Hydraulic Analysis

Preliminary hydraulic analyses for the alternatives of each reach were performed using *FlowMaster v6.0* design software by Haestad Methods. The analysis determined normal depth, Froude Number and velocity for the range of bottom widths for trapezoidal channels. *CulvertMaster v1.0* was used to analyze the box culvert at Louise Avenue. Hydraulic analysis for the preferred alternative will insure there is no backwater conditions and verify that normal depth calculations for the water surface profiles of each reach is not impacted by upstream and downstream analysis. Results of the hydraulic analysis for the preferred alternative and for the alternatives analysis for each of the reaches and the four channel material alternatives are in Appendix B.

5.0 ALTERNATIVES ANALYSIS

5.1 General

The hydrologic analysis provided nine concentration points along the BNSF Railway alignment from Hualapai Mountain Road to Rattlesnake Hill Wash. Table 3.5.1 provides the 100-year peak discharges for each of the concentration points. Design of the channel is divided into nine segments or Reaches based on the 100-year peak discharge. Table 5.1.1 identifies the Stationing from upstream to downstream for each of the 9 Reaches, length, the design peak discharge and the existing longitudinal slope that coincides with each reach.

Table 5.1.1

Reach	Stationing	Length	Design Discharge	Slope
1	5+00 to 57+00	5,200 ft	679 cfs	0.0020 ft/ft
2	57+00 to 75+00	1,800 ft	1,589 cfs	0.0030 ft/ft
3	75+00 to 85+00	1,000 ft	1,994 cfs	0.0236 ft/ft
4	85+00 to 118+00	3,300 ft	2,196 cfs	0.0035 ft/ft
5	118+00 to 130+00	1,200 ft	2,390 cfs	0.0090 ft/ft
6	130+00 to 176+71	4,671 ft	2,815 cfs	0.0090 ft/ft
7	176+71 to 223+21	4,650 ft	3,921 cfs	0.0054 ft/ft
8	223+21 to 287+21	6,400 ft	5,703 cfs	0.0067 ft/ft
9	287+21 to 293+17	596 ft	12,306 cfs	0.0067 ft/ft

The results of the analysis for each of the reaches are discussed in the following paragraphs. Several initial design iterations were performed to determine the size and profile of the channel to minimize earthwork and target at least 1 foot of freeboard for the 100-year water surface elevation to natural ground line on the south side of the bank. Table 5.1.2 summarizes the bottom widths (BW) in feet, hydraulic flow depth (FD) in feet, and velocity (V) in feet per second for each reach and alternative used for the initial design.

Table 5.1.2

	Earthen			Gabion			Rip Rap			Concrete		
Reach	BW	FD	V	BW	FD	V	BW	FD	V	BW	FD	V
1	10.0	5.19	5.70	15.0	5.25	5.08	18.0	5.30	4.49	9.0	5.29	7.58
2	10.0	7.01	8.25	15.0	7.26	7.41	18.0	7.39	6.57	9.0	7.27	10.99
3	22.0	6.54	7.95	15.0	6.59	10.75	18.0	6.18	10.62	9.0	5.70	19.95
4	22.0	6.87	8.17	15.0	8.2	8.55	18.0	8.36	7.58	10.0	8.39	11.62
5	42.0	5.49	7.82	30.0	5.48	10.65	35.0	5.54	9.35	18.0	5.61	16.14
6	44.0	6.25	7.56	30.0	6.25	10.59	35.0	5.99	10.00	18.0	6.05	17.20
7	96.0	5.03	7.18	70.0	5.04	9.71	80.0	5.12	8.49	45.0	5.01	14.90
8	108.0	5.87	7.93	70.0	5.89	11.85	80.0	5.98	10.37	45.0	5.85	18.12
9	108.0	6.45	15.36	80.0	8.53	14.85	94.0	8.55	12.94	50.0	8.61	22.71

The initial horizontal alignment for the channel utilized as much of the BNSF Railway right-of-way as possible. The daylight line for the channel cut-slope on the north side targeted to match at the future third track and access road embankment fill-slope limits. Figures 5.1.1 through 5.1.4 provide typical cross sections proposed for the channel to illustrate the close coordination with grading within the BNSF right-of-way. The railroad embankment quantity would require approximately 100,000 cubic yards of material.

5.2 Proposed Flood Control Alternatives

Four channel alternatives were considered for each of the 9 reaches; Earthen, Gabion, Riprap and Concrete. Hydraulic analysis to determine a range of channel geometry that would achieve stable flow was computed and reviewed. After an initial critique of the channel alternatives for each reach, not all of the alternatives were considered for further study due to physical constraints and engineering judgement.

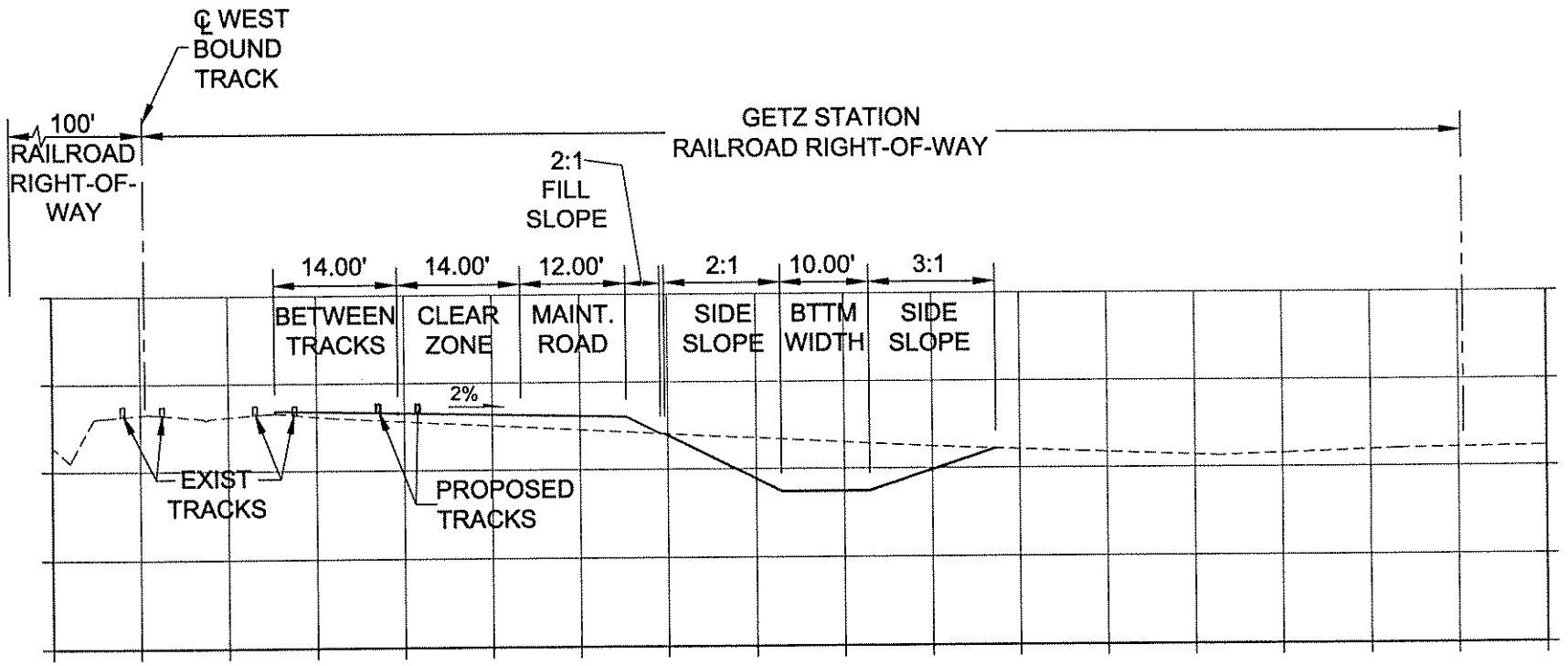
The Earthen alternative requires no bank protection by reducing channel velocity below the 6 fps erosive velocity design criteria. This is accomplished by using a wide typical section, flattening the longitudinal slope and providing drop structures where needed. This alternative typically requires additional right-of-way for the wider channel.

The Gabion alternative provides 1-foot wire-tied rock bank protection and an earthen channel bottom. The bank protection extends to 1-foot above the water surface elevation and a 6-foot apron along the toe of bank. Stable, subcritical flow is achieved by reducing the longitudinal slope and using drop structures.

The Riprap alternative also utilizes a natural bottom and has estimated a thickness of 18". Bank protection provides a toe down of 4 feet and extends to 1-foot above the water surface elevation. Drop structures were used to control the longitudinal slope to insure stable hydraulic flow.

Concrete channel alternative allows supercritical and subcritical flow. The entire channel will be lined to allow higher velocities and eliminates bank protection toe down. Cost estimates have used a slab thickness of 6" for this study. Bank protection will be keyed into the bank 1-foot above the water surface elevation. Longitudinal slopes and channel geometry is set to insure flows are not within the unstable flow range of the Froude Number (0.85 to 1.30).

Exhibits 5.1 through 5.4 provides the channel alignments for Earthen, Gabion, Riprap, and Concrete alternatives, respectively.



Stantec

SCALE:
1"=20'

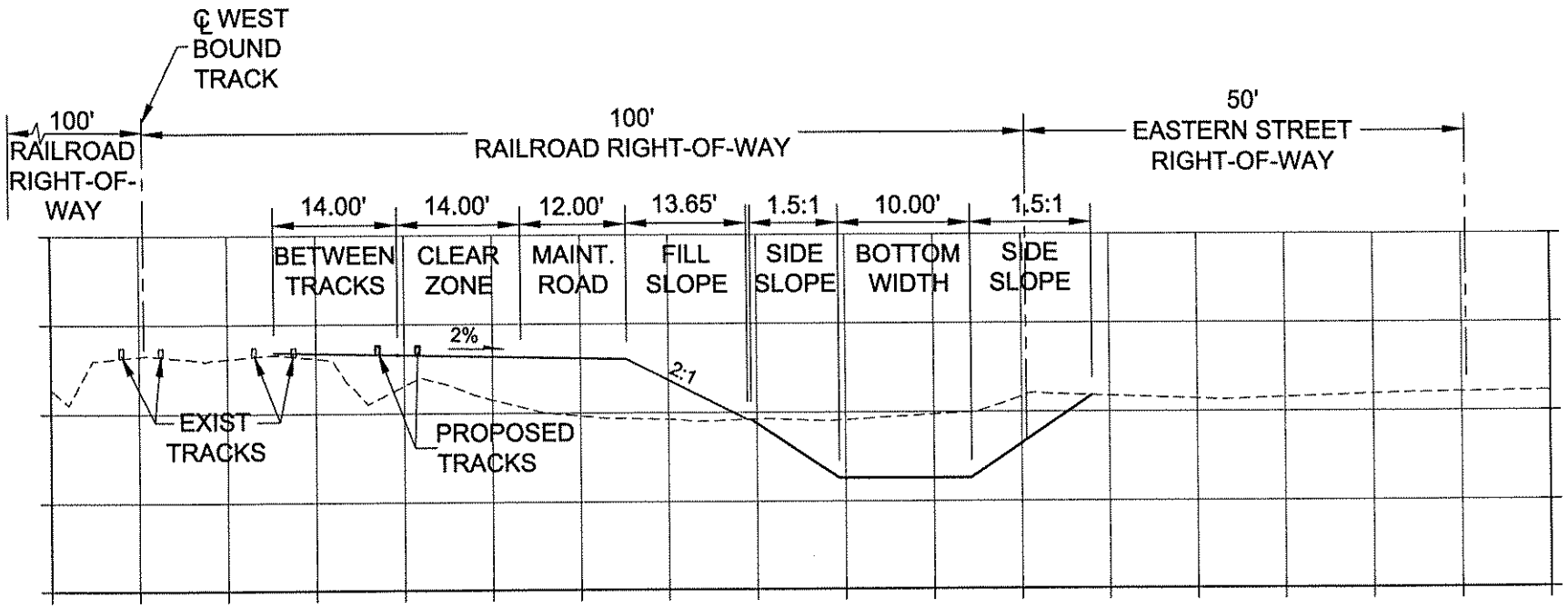
0 20'-0" 30'-0" 40'-0"

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
5.1.1

Title
CHANNEL TYPICAL SECTION REACH 1 AND 2 EARTHEN ALTERNATIVE

n:\roadway\28660038\drawings\exhibits\exhib1.dwg



Stantec

n:\roadway\28660038\drawings\exhibits\exhib1a.dwg

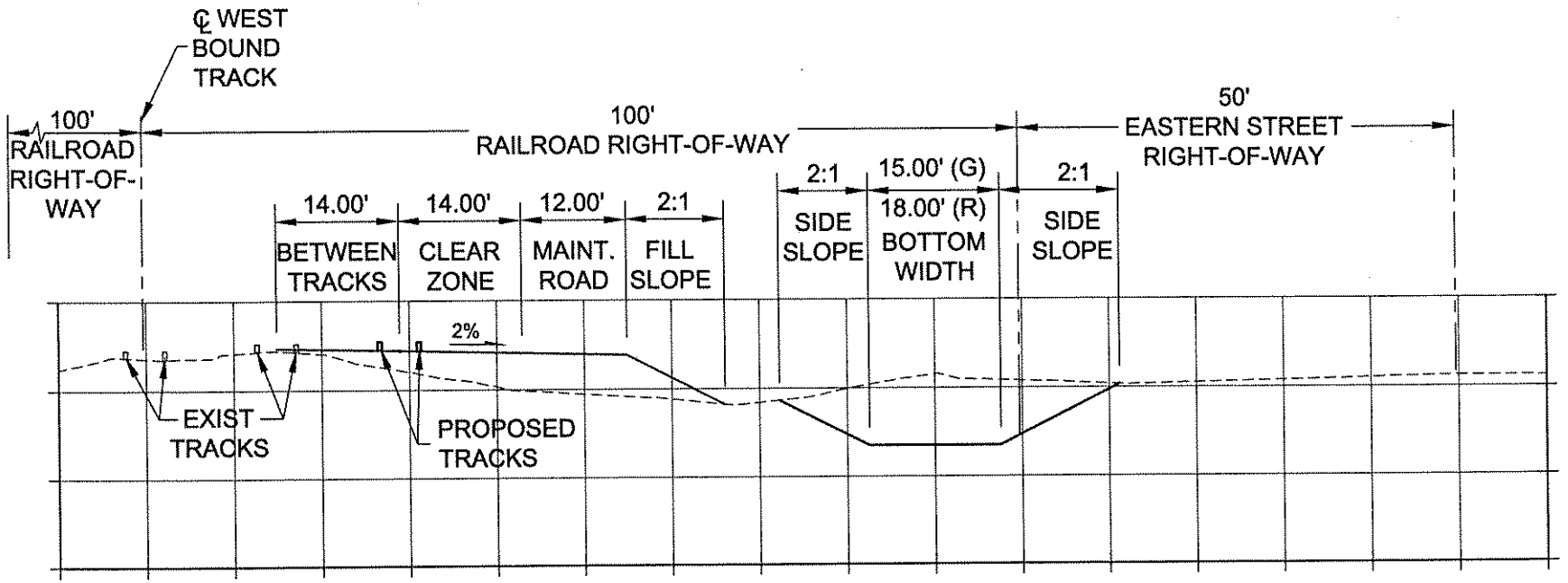
SCALE:
1"=20'

0 20'-0" 30'-0" 40'-0"

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
5.1.2

Title
CHANNEL TYPICAL SECTION REACH 3 AND 4 CONCRETE ALTERNATIVE



Stantec

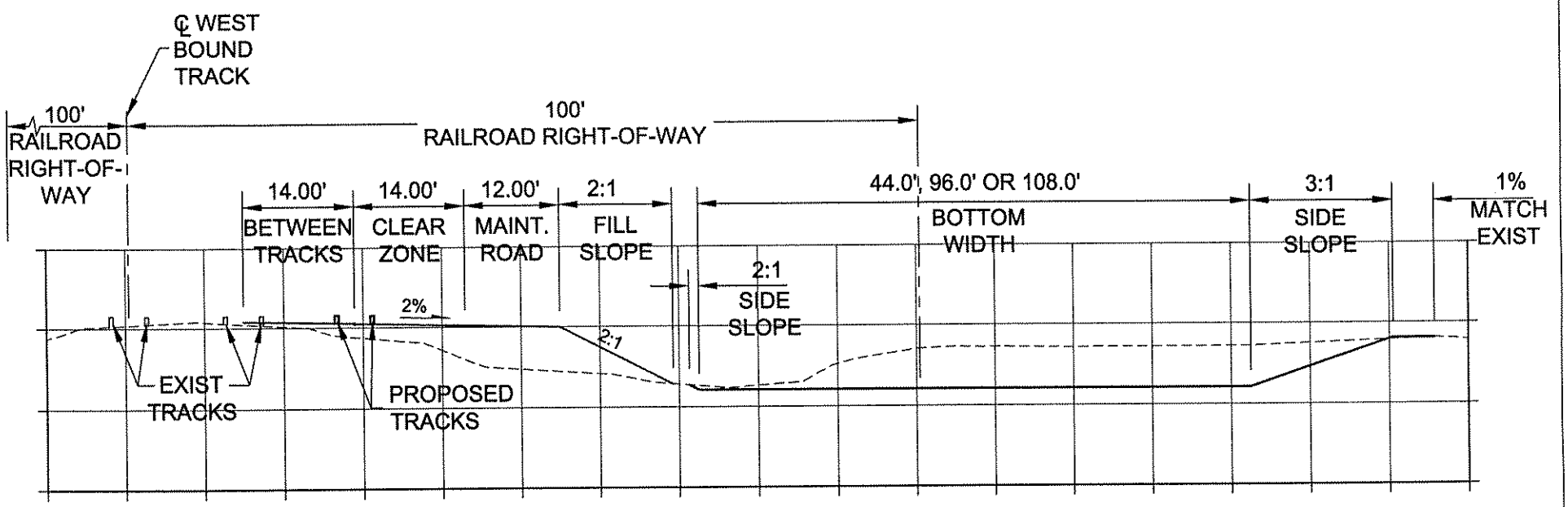
SCALE:
1"=20'
0 20'-0" 30'-0" 40'-0"

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
5.1.3

Title
CHANNEL TYPICAL SECTION REACH 4 AND 5 GABION OR RIP RAP ALTERNATIVE

n:\roadway\28660038\drawings\exhibits\exhib2.dwg



Stantec

SCALE:
1"=20'

0 20'-0" 30'-0" 40'-0"

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
5.1.4

Title
CHANNEL TYPICAL SECTION REACH 6,7 AND 8 EARTHEN ALTERNATIVE

n:\roadway\28660038\drawings\exhibits\exhib4.dwg

5.2.1 Reach 1

5.2.1.1 General

Reach 1 extends from the extension of Phoenix Avenue to Adams Street in the Hilltop area of the City. The channel at Station 5+00 ties into an existing unimproved channel that intercept runoff from the north side of Haulapai Mountain Road. From Station 5+00 to 47+00, the channel traverses across the BNSF Railway Getz Station and crosses under Louise Avenue at Station 15+20. North of Station 47+00, the 200 feet of railroad right-of-way that is centered on the westbound tracks is abutted by 20 feet of roadway right-of-way for Railroad Street within the Golden Gate Addition subdivision. The roadway is unpaved and the lots are undeveloped. The proposed channel longitudinal slope of 0.20% follows the existing ground slope of 0.20% and allows flows to be within the subcritical flow regime. Right-of-way or easement acquisition from BNSF Railway across the Getz Station was assumed to be no-cost for the alternative selection.

A twin barrel 10' x 6' concrete box culvert is proposed for the crossing at Louise Avenue. This structure would be used for any of the channel alternatives.

5.2.1.2 Earthen Channel

The typical section for the earthen-lined channel alternative provides for a 10-foot bottom width, flow depths of 5.19 feet, and an average top width of 40.97 feet. The channel cut-slope limits extend into the Railroad Street right-of-way and would require acquisition of private property for drainage right-of-way and relocation of Railroad Street. Earthwork for this alternative would produce approximately 63,826 cubic yards of waste material.

5.2.1.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 15 feet to insure a flow depth of 5.25 feet and 1 foot of freeboard. The channel cut-slope limits extend into the Railroad Street right-of-way and would require acquisition of private property for drainage right-of-way and relocation of Railroad Street. A total of 62,163 cubic yards of waste material is generated from the proposed improvements.

5.2.1.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 18 feet. The channel cut-slope limits extends into Railroad Street right-of-way and will require additional right-of-way for the roadway relocation. The total earthwork waste for this alternative is 67,951 cubic yards.

5.2.1.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 9 feet and an average top width of 27.88 feet through Reach 1. The channel is contained all within BNSF right-of-way. Total excavation is 42,387 cubic yards.

5.2.1.6 Cost Estimates & Recommendation

Table 5.2.1 provides the cost estimates for each of the alternatives for Reach 1. A 15% contingency has been added to the estimated construction cost. The Earthen alternative is the recommended channel.

Table 5.2.1

	Earthen	Gabion	Riprap	Concrete
Construction Cost	$314,400	$1,104,060	$1,352,530	$789,410
Right-of-Way	$16,475	$5,680	$8,250	$0
Total Cost	$330,875	$1,109,740	$1,360,780	$789,410

5.2.2 Reach 2

5.2.2.1 General

Reach 2 begins at Adams Street and runs east 1,800 feet to the west side of Eastern Street. Adams Street will convey flows from a proposed detention basin and improvements to the roadway are currently being designed. The channel longitudinal slope of 0.30% provides for subcritical flow for all of the alternatives. From Station 57+00 to 66+00 the railroad right-of-way is abutted by 20 feet of roadway right-of-way for Railroad Street within the Golden Gate Addition subdivision. From Airfield Avenue to the east within Section 7, a 20-foot easement is adjacent to the BNSF right-of-way. There are no structures along the alignment. However, one business (the tire store) at Station 64+00 may be impacted by the proposed improvements.

5.2.2.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 10 feet would be required with the top width of 50.03 feet to daylight the slopes. The Earthen channel alternative will use the existing Railroad Street right-of-way and require an additional 20 feet of right-of-way. A total of 26,545 cubic yards of waste material is generated from the proposed improvements.

5.2.2.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 15 feet to insure a flow depth of 7.26 feet and 1 foot of freeboard. The channel cut-slope limits extends into Railroad Street right-of-way and will require 10 feet of additional right-of-way. A total of 25,761 cubic yards of waste material is generated from the proposed improvements.

5.2.2.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 18 feet that provides a flow depth of 7.39 feet. The channel cut-slope limits for this alternative also extends into Railroad Street right-of-way and will also require an additional 10 feet of right-of-way. The total earthwork waste for this alternative is 28,037 cubic yards.

5.2.2.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 9 feet and an average top width of 33.81 feet through Reach 2. The channel is contained all within BNSF right-of-way. Total excavation is 17,844 cubic yards.

5.2.2.6 Cost Estimates & Recommendation

Table 5.2.2 provides the cost estimates for each of the alternatives for Reach 2. Construction cost includes 15% contingency. The Earthen alternative is the recommended channel.

Table 5.2.2

	Earthen	Gabion	Riprap	Concrete
Construction Cost	$106,850	$441,375	$557,820	$309,905
Right-of-Way	$32,002	$16,027	$16,026	$0
Total Cost	$138,855	$457,400	$573,845	$309,905

5.2.3 Reach 3

5.2.3.1 General

Reach 3 extends from the west side of Eastern Street to the east 1,000 feet to Station 85+00, mid-block between Alpha Street and Evans Street. Eastern Street turns from a north-south alignment and runs easterly parallel to the BNSF Railway. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. Eastern Street has 50 feet of right-of-way adjacent to the railroad. This reach is unique due to the 2.36% longitudinal slope for the existing ground line. Drop structures must be used to design for subcritical flow velocities. The roadway is paved and the lots are undeveloped.

5.2.3.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 22 feet would be required with 8 drop structures. The Earthen channel alternative was eliminated from further study for this reach due to the hydraulic parameters from the longitudinal slope.

5.2.3.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 15 feet with 5 drop structures to insure a flow depth of 6.59 feet and 1 foot of freeboard. The channel cut-slope limits extends into Eastern Street right-of-way and will require additional right-of-way. A total of 7,870 cubic yards of waste material is generated from the proposed improvements.

5.2.3.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 18 feet and 4 drop structures for a flow depth of 6.18 feet. The channel cut-slope limits extends into Eastern Street right-of-way and will require additional right-of-way for the roadway relocation. The total earthwork waste for this alternative is 10,298 cubic yards.

5.2.3.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 9 feet, an average top width of 29.10 feet and 2 drop structures through Reach 3. This channel alternative will also require additional right-of-way. Total excavation is 7,247 cubic yards.

5.2.3.6 Cost Estimates & Recommendation

Table 5.2.3 provides the cost estimates for each of the alternatives for Reach 3. The Concrete alternative is the recommended channel.

Table 5.2.3

	Earthen	Gabion	Riprap	Concrete
Construction Cost	N/A	$231,370	$282,845	$165,725
Right-of-Way	N/A	$15,271	$22,620	$7,095
Total Cost	N/A	$246,640	$305,465	$172,820

5.2.4 Reach 4

5.2.4.1 General

Reach 4 begins at the mid-block between Alpha Street and Evans Street (Station 85+00) and extends to the east 3,300 feet to Station 118+00, the intersection of Eastern Street, Kenwood Avenue and North Central Street. The railroad, Eastern Street, and proposed channel passes under Interstate 40 at Station 99+00. Eastern Street runs parallel to the BNSF Railway throughout this reach within a 50-foot roadway right-of-way. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. This reach has a 0.35% longitudinal slope for the existing ground line. Eastern Street roadway is paved and there are a few lots that have been developed south of Interstate 40. The concrete box culvert directing flows to the northwest to pass under the railroad and SR66 will be by-passed and abandoned.

5.2.4.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 22 feet would be required with a top width of 61.37 feet to daylight the slopes and 2 drop structures to maintain grade. The Earthen channel alternative was eliminated from further study for this reach since the channel would require excessive right-of-way acquisition and the restricted area under I-40 will require a narrower alternative.

5.2.4.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 15 feet to insure a flow depth of 8.2 feet and 1 foot of freeboard. The limits for the channel cut-slope will require right-of-way acquisition. A total of 29,257 cubic yards of waste material is generated from the proposed improvements.

5.2.4.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 18 feet which provides a flow depth of 8.36 feet. The channel cut-slope limits extends into Eastern Street right-of-way and will require additional right-of-way for the roadway relocation. The total earthwork waste for this alternative is 32,878 cubic yards.

5.2.4.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 10 feet, an average top width of 38.16 feet and 1 drop structure through Reach 4. The concrete channel will impact Eastern Street right-of-way and will require acquisition. Total excavation is 29,913 cubic yards.

5.2.4.6 Cost Estimates & Recommendation

Table 5.2.4 provides the cost estimates for each of the alternatives for Reach 4. The construction cost estimate includes a 15% contingency. The Concrete alternative is the recommended channel.

Table 5.2.4

	Earthen	Gabion	Riprap	Concrete
Construction Cost	N/A	$708,425	$1,049,185	$616,700
Right-of-Way	N/A	$37,548	$57,641	$18,160
Total Cost	N/A	$745,975	$1,106,825	$634,860

5.2.5 Reach 5

5.2.5.1 General

Reach 5 extends from the intersection of Eastern Street, Kenwood Avenue and North Central Street (Station 118+00) to the new Airway Avenue alignment (Station 132+00). Eastern Street runs parallel to the BNSF Railway throughout this reach within 50 feet of roadway right-of-way. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. This reach has a 0.35% longitudinal slope for the existing ground line. Eastern Street roadway is paved and there are a few lots that have been developed south of Interstate 40.

In conjunction with the Airway Avenue Railroad Crossing project, new right-of-way for roadway and drainage purposes has been identified for Reach 5 in order to provide a drainage channel around the underpass site. Consequently, no additional right-of-way has been identified for this reach.

5.2.5.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 42 feet would be required with a top width of 74.43 feet to daylight the slopes and 3 drop structures to maintain grade. The Earthen channel alternative was eliminated from further study for this reach due to the curvilinear alignment requirement for bank protection at the Airway Avenue railroad underpass.

5.2.5.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 30 feet to insure a flow depth of 5.48 feet and 1 foot of freeboard. A total of 25,713 cubic yards of waste material is generated from the proposed improvements for this alternative.

5.2.5.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 35 feet. This provides a flow depth of 5.54 feet for the riprap alternative and a total channel topwidth of 61.2 feet. The total earthwork waste for this alternative is 27,604 cubic yards.

5.2.5.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 18 feet and an average top width of 37.82 feet through Reach 5. Total excavation is 18,571 cubic yards.

5.2.5.6 Cost Estimates & Recommendation

Table 5.2.5 provides the cost estimates for each of the alternatives for Reach 5. The Concrete alternative is the recommended channel.

Table 5.2.5

	Earthen	Gabion	Riprap	Concrete
Construction Cost	N/A	$300,000	$361,720	$251,835
Right-of-Way	N/A	N/A	N/A	N/A
Total Cost	N/A	$300,000	$361,720	$251,835

5.2.6 Reach 6

5.2.6.1 General

Reach 6 begins at the new Airway Avenue alignment (Station 132+00) and extends easterly 4,500 feet (Station 177+00), just east of the extension of North Castle Rock Road along the railroad. Eastern Street runs parallel to the BNSF Railway with 50 feet of roadway right-of-way to the existing Airway Avenue alignment in Section 8. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. No additional right-of-way is existing north of Section 8 within Section 5. Section 4 has a 70-foot wide strip of existing right-of-way adjacent to the BNSF right-of-way. This reach has a 0.70% longitudinal slope for the existing ground line. As discussed previously in Section 5.2.5.1, the land acquisition for the proposed Airway Avenue Railroad underpass will provide the needed right-of-way for the channel within Section 8. Right-of-way identified for this reach is all within Section 5. No building structures are impacted by the alignment through Reach 6.

5.2.6.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 44 feet would be required with a top width of 80.24 feet to daylight the slopes and 12 drop structures to maintain grade. The Earthen channel alternative was eliminated from further study for this reach due to the curvilinear channel alignment requirement for bank protection.

5.2.6.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 30 feet and 3 drop structures to insure a flow depth of 6.25 feet and 1 foot of freeboard. The channel cut-slope limits requires a 40-foot wide strip of right-of-way within Section 5 with the remainder of the improvements within BNSF Railway and/or existing roadway right-of-way. A total of 84,483 cubic yards of waste material is generated from the proposed improvements.

5.2.6.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 35 feet. The riprap alternative requirements are the same as the gabion alternative. The total earthwork waste for this alternative is 84,369 cubic yards.

5.2.6.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 18 feet and an average top width of 39.14 feet through Reach 6. The channel would require a 20-foot strip along the south side of the BNSF right-of-way within Section 5. Total excavation is 49,038 cubic yards.

5.2.6.6 Cost Estimates & Recommendation

Table 5.2.6 provides the construction cost estimate with 15% contingency and right-of-way cost for each of the alternatives for Reach 6. The Earthen alternative is the recommended channel alternative.

Table 5.2.6

	Earthen	Gabion	Riprap	Concrete
Construction Cost	$480,630	$1,169,735	$1,370,235	$921,210
Right-of-Way	$184,090	$184,535	$184,537	$126,687
Total Cost	$664,720	$1,354,275	$1,554,775	$1,047,900

5.2.7 Reach 7

5.2.7.1 General

Reach 7 begins at Station 177+00, just east of the extension of North Castle Rock Road and continues parallel with the railroad a distance of 4,621 feet to Station 223+21, which is Diagonal Wash. Diagonal Wash will be diverted into the railroad channel and downstream drainage structures will be abandoned. The 70 feet of existing roadway right-of-way on the east side of the railroad right-of-way extends to Rae Drive, the east-west mid-section line road for Section 4 at Station 182+00. Reach 7 enters Section 33 and onto Kingman Airport property at Station 211+00 and BNSF Railway's Berry Station has a total of 400 feet of right-of-way in Section 33 centered on their alignment, providing 200 feet on the south side. All of the alternatives will require right-of-way and grading outside of the proposed right-of-way to provide for the design channel depth. This reach has a 0.54% longitudinal slope for the existing ground line. No building structures are impacted by the alignment through Reach 7.

5.2.7.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 96 feet would be required with a top width of 126 feet to daylight the slopes and 8 drop structures. This will maintain a longitudinal slope of 0.2% in order to meet the hydraulic design criteria. Reach 7 begins with needing 30 feet of right-of-way south of Rae Drive and then expands to 110 feet until reaching Section 33. Within the Berry Station area and on airport property, the earthen alternative will require only a 20-foot strip of new right-of-way.

5.2.7.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 70 feet to insure a flow depth of 5.04 feet and 1 foot of freeboard. Reach 7 gabion alternative will only require a 70-foot strip of right-of-way in the north half of Section 4. A total of 28,869 cubic yards of waste material is generated from the proposed improvements.

5.2.7.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 80 feet for a flow depth of 5.12 feet and 1 foot of freeboard. Reach 7 requires an 80-foot strip of right-of-way within the north half of Section 4. The total earthwork waste for this alternative is 38,961 cubic yards.

5.2.7.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 45 feet and an average top width of 63 feet through Reach 7. 50 feet of right-of-way is required in the north half of Section 4. Total excavation is 25,050 cubic yards.

5.2.7.6 Cost Estimates & Recommendation

Table 5.2.7 provides the cost estimates, including 15% contingency for the construction cost, for each of the Reach 7 alternatives. The Earthen channel is the recommended alternative for this reach due to the construction cost and potential to reduce right-of-way acquisition cost.

Table 5.2.7

	Earthen	Gabion	Riprap	Concrete
Construction Cost	$320,715	$917,020	$1,148,135	$1,191,665
Right-of-Way	$356,511	$202,465	$231,384	$144,618
Total Cost	$677,225	$1,119,485	$1,379,520	$1,336,285

5.2.8 Reach 8

5.2.8.1 General

Reach 8 begins at Station 223+21, Diagonal Wash, and passes through the BNSF Railway's Berry Station site and Kingman Airport property extending to Station 287+21 for a total distance of 6,400 feet. Total right-of-way width for the railroad and Berry Station within Section 33 is 400 feet, but reduces to 200 feet in Sections 34 and 27. This reach has a 0.67% longitudinal slope for the existing ground line. At Station 285+00, a sand and gravel operation may be impacted by this reach.

5.2.8.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 108 feet resulting in a top width of 142 feet and 15 drop structures to maintain a longitudinal slope of 0.2% will be needed to meet design criteria. Reach 8 earthen alternative will require 20 feet of right-of-way through the Berry Station in Section 33 and increases to 130 feet at the west line of Section 34. The new right-of-way increases to 140 feet approximately 300 feet east of the section line and extends into Section 27. Approximately 230,565 cubic yards of waste material is generated from the alternative.

5.2.8.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provides a bottom width of 70 feet to insure a flow depth of 5.89 feet and 1 foot of freeboard. At the west line of Section 34, an 80-foot strip of right-of-way will be needed. The new right-of-way increases to 90 feet approximately 300 feet east of the section line and extends into Section 27 to the terminus of Reach 8. A total of 144,955 cubic yards of waste material is generated from the proposed improvements.

5.2.8.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 80 feet to provide a flow depth of 5.98 feet. At the west line of Section 34, a 90-foot strip of right-of-way will be needed. The new right-of-way increases to 100 feet approximately 300 feet east of the section line and extends into Section 27 to the terminus of Reach 8. The total earthwork waste for this alternative is 164,960 cubic yards.

5.2.8.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 45 feet and an average top width of 66 feet through Reach 8. At the west line of Section 34, a 50-foot strip of right-of-way will be required. The new right-of-way increases to 60 feet approximately 300 feet east of the section line and extends into Section 27 to the terminus of Reach 8. Total excavation is 94,536 cubic yards.

5.2.8.6 Cost Estimates & Recommendation

Table 5.2.8 provides the cost estimates for each of the alternatives for Reach 8. The construction cost estimate includes a 15% contingency. The Earthen channel is the recommended alternative for Reach 8.

Table 5.2.8

	Earthen	Gabion	Riprap	Concrete
Construction Cost	$1,005,915	$1,714,710	$2,105,395	$1,973,755
Right-of-Way	$508,987	$282,484	$314,830	$186,207
Total Cost	$1,514,900	$1,997,195	$2,420,225	$2,159,960

5.2.9 Reach 9

5.2.9.1 General

Reach 9 begins Station 287+21 and terminates within 500 feet at Rattlesnake Hill Wash. This reach has a 0.67% longitudinal slope for the existing ground line along a line parallel with the railroad. BNSF Railway right-of-way is a total of 200 feet through this reach. As discussed previously, the railroad drainage structure at Rattlesnake Hill Wash was reconstructed in the early 1990s after a fire destroyed the previous wooden structure. The City of Kingman contributed funds to BNSF to increase the size of the new structure to accommodate additional flows from the future Railroad Diversion Channel. The structure was upsized and all parties agree in principal to divert all flows to this outfall.

All of the alternatives illustrate the channel outfalling into Rattlesnake Hill Wash essentially at a right angle to the wash. Preliminary design will need to study alternatives to direct flows from the diversion channel downstream into the main wash to mitigate scour and any significant sediment deposition. Right-of-way has been illustrated for the channel only, but computed for 200 feet for all of the alternatives in order to accommodate the confluence works.

5.2.9.2 Earthen Channel

Hydraulic analysis determined that a channel bottom width of 108 feet would be required with a top width of 145 feet to daylight the slopes. Channel right-of-way is illustrated at 140 feet. A total of 15,146 cubic yards of waste material is generated from the proposed improvements.

5.2.9.3 Gabion Bank-lined Channel

The typical section for the gabion alternative provided a bottom width of 80 feet to insure a flow depth of 8.53 feet and 1 foot of freeboard. Channel right-of-way parallel to the railroad right-of-way is 90 feet. A total of 10,768 cubic yards of waste material is generated from the proposed improvements.

5.2.9.4 Riprap Bank-lined Channel

The typical section for the riprap bank-lined alternative uses a bottom width of 94 feet for a flow depth of 8.55 feet. Channel right-of-way is illustrated at 100 feet. The total earthwork waste for this alternative is 12,466 cubic yards.

5.2.9.5 Concrete Channel

The concrete-lined channel alternative provides for a bottom width of 50 feet and an average top width of 79 feet through Reach 9. This reach's right-of-way requirements for the channel are 60 feet. The concrete channel alternative was eliminated from further study as an alternate for this reach due to the proximity to the railroad structure and confluence with the main wash.

5.2.9.6 Cost Estimates & Recommendation

Table 5.2.8 provides the cost estimates for each of the alternatives for Reach 9. Construction cost estimate includes a 15% contingency. The Earthen channel, modified to provide gabion bank protection, is the recommended alternative for the confluence structure.

Table 5.2.9

	Earthen	Gabion	Riprap	Concrete
Construction Cost	$185,750	$168,545	$214,640	N/A
Right-of-Way*	$218,175	$218,175	$218,175	N/A
Total Cost	$403,925	$386,720	$432,815	N/A

* 200' wide right-of-way through Reach 9 for all alternatives

6.0 RESULTS: ALTERNATIVES ANALYSIS

Table 6-1 provides a summary of the construction and right-of-way cost estimates for each reach and alternative along with the total project costs for each alternative. The recommended alternative for each reach has been identified in Table 6-2. Total construction cost for the recommended alternatives for the project is $3,445,520 and right-of-way cost is $1,341,495. Complete quantities and cost estimate for each reach and alternative is found in Appendix C.

Table 6-1

REACH		*ALTERNATIVE COST ($)*			
		EARTHEN	**GABION**	**RIP-RAP**	**CONCRETE**
1	Construction	314,400	1,104,060	1,352,530	789,410
	Right-of-Way	16,475	5,680	8,250	0
2	Construction	106,850	441,375	557,820	309,905
	Right-of-Way	32,002	16,027	16,026	0
3	Construction	N/A	231,370	282,845	165,725
	Right-of-Way	N/A	15,271	22,620	7,095
4	Construction	N/A	708,425	1,049,185	616,700
	Right-of-Way	N/A	37,548	57,641	18,160
5	Construction	N/A	300,000	361,720	251,835
	Right-of-Way	N/A	N/A	N/A	N/A
6	Construction	480,630	1,169,735	1,370,235	921,210
	Right-of-Way	184,090	184,535	184,537	126,687
7	Construction	320,715	917,020	1,148,135	1,191,665
	Right-of-Way	356,511	202,465	231,384	144,618
8	Construction	1,005,915	1,714,710	2,105,395	1,973,755
	Right-of-Way	508,987	282,484	314,830	186,207
9	Construction	185,750	168,545	214,640	N/A
	Right-of-Way	218,175	218,175	218,175	N/A
TOTALS					

Unit prices for preparation of the cost estimates are as follows:

Earthwork – Excavation	$3.50/cubic yard
Riprap	$85/cubic yard
Gabions	$90/cubic yard
Concrete	$160/cubic yard
Drop Structures (Concrete)	$250/cubic yard
Contingency	15%
Right-of-Way	$1.00/square foot

Table 6-2

REACH	*SELECTED ALTERNATIVE COST*		
	Selected Alternative	**Construction Cost**	**Right-of-Way Cost**
1	Earthen	314,400	16,475
2	Earthen	106,850	32,002
3	Concrete	162,725	7,095
4	Concrete	616,700	18,160
5	Concrete	251,835	0
6	Earthen	480,630	184,090
7	Earthen	320,715	356,511
8	Earthen	1,005,915	508,987
9	Earthen w/Gabions	185,750	218,175
TOTALS		**$3,445,520**	**$1,341,495**

The total earthwork for the selected alternatives for the project is 575,325 cubic yards. With the railroad embankment requiring roughly 100,000 cubic yards, an export of approximately 475,000 cubic yards would be yielded from the project. Earthwork alone makes up 67% of the construction cost.

Use of the Earthen alternative will save significant construction cost, but will require more maintenance cost to clean out and reshape slopes on a periodic basis. One advantage to an earthen channel is the possibility to grow native grass and allow vegetation to reduce erosion. The concrete alternative will be virtually maintenance free for Reaches 3, 4 and 5.

Hydrologic analysis revealed the need for the construction of the detention basins. The Southern Avenue – Eastern Street basin is bounded on the east by Eastern Street, to the south by Southern Avenue, to the north by Phoenix Avenue and to the west by Washington Street. The basin will eliminate storm water runoff through the Hilltop area and control the outlet by releasing the outfall into Adams Street, 650 feet west of the basin. Mohave Engineering is proceeding with the design of East Golden Gate Addition Improvement District which will design Adams Street to convey an 85 cfs outlet discharge from the basin. The preliminary analysis will be revised during final design to size the outfall structure and basin to meet the outfall criteria and provide complete protection for the 50-year event. Based on this study's results, spillway flow will not occur until the 100-year event. A rough cost estimate for the detention basin and drainage facilities is approximately $400,000.

The ADOT basin will provide additional protection downstream. Assumptions made for this study can be revisited and additional analysis can be undertaken to increase the drainage area that would drain into the facility. This would provide even more benefit to the overall area drainage master planning efforts.

The recommended alternatives for each reach of the channel meets all design criteria to assure FEMA approval for obtaining a Letter of Map Revision for the community. BNSF Railway would be relieved of maintenance along this 5.15 mile section of tracks. Finally, protection throughout the southeast side of the city is realized through the implementation of the Railroad Diversion Channel (and Basins) Project.

7.0 PREFERRED CHANNEL ALTERNATIVE

7.1 General

The channel design for the preferred alternative was based not only on the findings from the alternatives analysis discussed in Section 5.0 and 6.0 of this report, but also on comments from the City of Kingman and from the BNSF Railway. Specifically, BNSF required that any channel design within their right-of-way would incorporate a pervious, flexible, bank channel lining (i.e. an earthen channel design alone would not be satisfactory). One possible armoring solution mentioned was an articulated revetment type of lining. This type of lining consists of approximately square, pre-fabricated, interlocking concrete blocks which are reinforced by longitudinal and lateral cables. Though construction costs would be expensive, this type of lining would satisfy the hydraulic design requirements of the proposed channel. However, an articulated revetment lining requires a side slope that is reasonable with respect to steepness (3:1 or 4:1 and not more than 2:1). Therefore, due to right-of-way requirements of new channel construction not impeding future railway track improvements within the middle reaches of the proposed channel, a stacked gabion configuration was selected to minimize the channel widths required. Gabions provide the characteristics desired in a flexible, yet protective bank lining (i.e. permits free drainage, reduces backpressure and allows for quick coverage with vegetation). The hydrologic analysis specified nine concentration points along the BNSF Railway alignment from Hualapai Mountain Road to Rattlesnake Hill Wash. Table 3.5.1 provides the 100-year peak discharges for each of the concentration points. Channel design is therefore divided into nine reaches based on the watershed delineation and concentration point locations. The stationing, length, peak discharge and longitudinal slope for each of the nine reaches is listed in Table 7.1.1 (this stationing is different than the stationing used for the alternatives analysis by a value of 100+00 due to incorporating extra reach length for Reach 1 into the preferred alternative).

Table 7.1.1

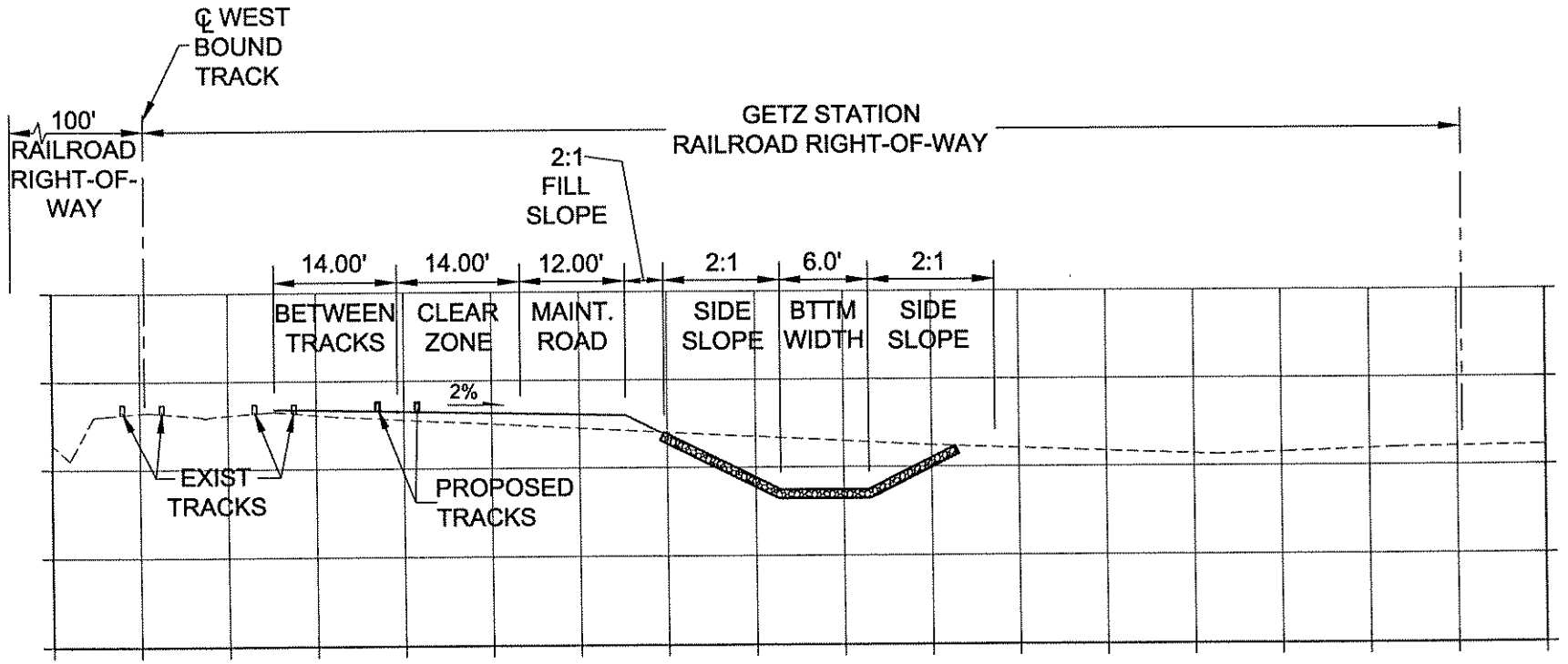
Reach	Stationing	Length	Design Discharge	Design Slope
1	99+76.94 to 157+00	5,723.06 ft	679 cfs	0.0020 ft/ft
2	157+00 to 175+00	1,800 ft	1,589 cfs	0.0030 ft/ft
3	175+00 to 185+00	1,000 ft	1,994 cfs	0.0040 ft/ft
4	185+00 to 218+00	3,300 ft	2,196 cfs	0.0035 ft/ft
5a	218+00 to 221+75	375 ft	2,390 cfs	0.0045 ft/ft
5b	221+75 to 229+30	755 ft	2,390 cfs	0.0025 ft/ft
6a	229+30 to 236+70	740 ft	2,815 cfs	0.0025 ft/ft
6b	236+70 to 241+65	495 ft	2,815 cfs	0.0062 ft/ft
6c	241+65 to 257+00	1,535 ft	2,815 cfs	0.0038 ft/ft
6d	257+00 to 274+43	1,743 ft	2,815 cfs	0.0018 ft/ft
7	274+43 to 321+16	4,673 ft	3,921 cfs	0.0017 ft/ft
8	321+16 to 383+57	6,241 ft	5,703 cfs	0.0016 ft/ft
9a	383+57 to 387+84	427 ft	12,306 cfs	0.0044 ft/ft
9b	387+84 to 393+83	599 ft	12,306 cfs	0.0128 ft/ft

The channel depth and geometry for each reach (and sub-reach) was optimized in order to minimize excavation quantities and channel bank lining cost while also providing a minimum of one foot of freeboard. Table 7.1.2 summarizes the bottom widths (BW), normal flow depth (FD), velocity (V) and lining type for each reach for the preferred alternative.

Table 7.1.2

Reach	BW (ft)	FD (ft)	V (fps)	Lining
1	6.0	6.5	5.5	Gabion Mattress
2	28.0	6.8	7.7	Stacked Gabions
3	35.0	6.2	8.8	Stacked Gabions
4	40.0	5.9	8.9	Stacked Gabions
5a	40.0	5.8	9.9	Stacked Gabions
5b	26.0	6.3	10.8	Concrete
6a	32.0	6.2	11.0	Concrete
6b	40.0	5.8	11.7	Stacked Gabions
6c	50.0	5.7	9.7	Stacked Gabions
6d	46.0	6.3	7.2	Earthen
7	70.0	6.3	7.3	Earthen
8	108.0	6.3	7.4	Earthen
9a	150.0	6.2	12.0	Gabion/Earthen
9b	93.0	6.5	17.8	Gabion Mattress

Through Section 8 and part of Section 5 (Township 21 North, Range 16 West), the horizontal alignment for the channel utilizes as much of the BNSF Railway right-of-way as possible. After passing through the residentially areas, the channel alignment falls completely outside of the BNSF railroad until outletting into Rattlesnake Hill Wash. The daylight line for the channel cut-slope on the north side adjacent to the railroad provides room for a possible future third track and access road. The construction line and the channel centerline have been offset for several reaches in order to assist in establishing the cut-slope limits. Figures 7.1.1 through 7.1.3 provide typical cross sections of the channel to illustrate the close coordination with grading within the BNSF right-of-way.



Stantec

SCALE:
1"=20'

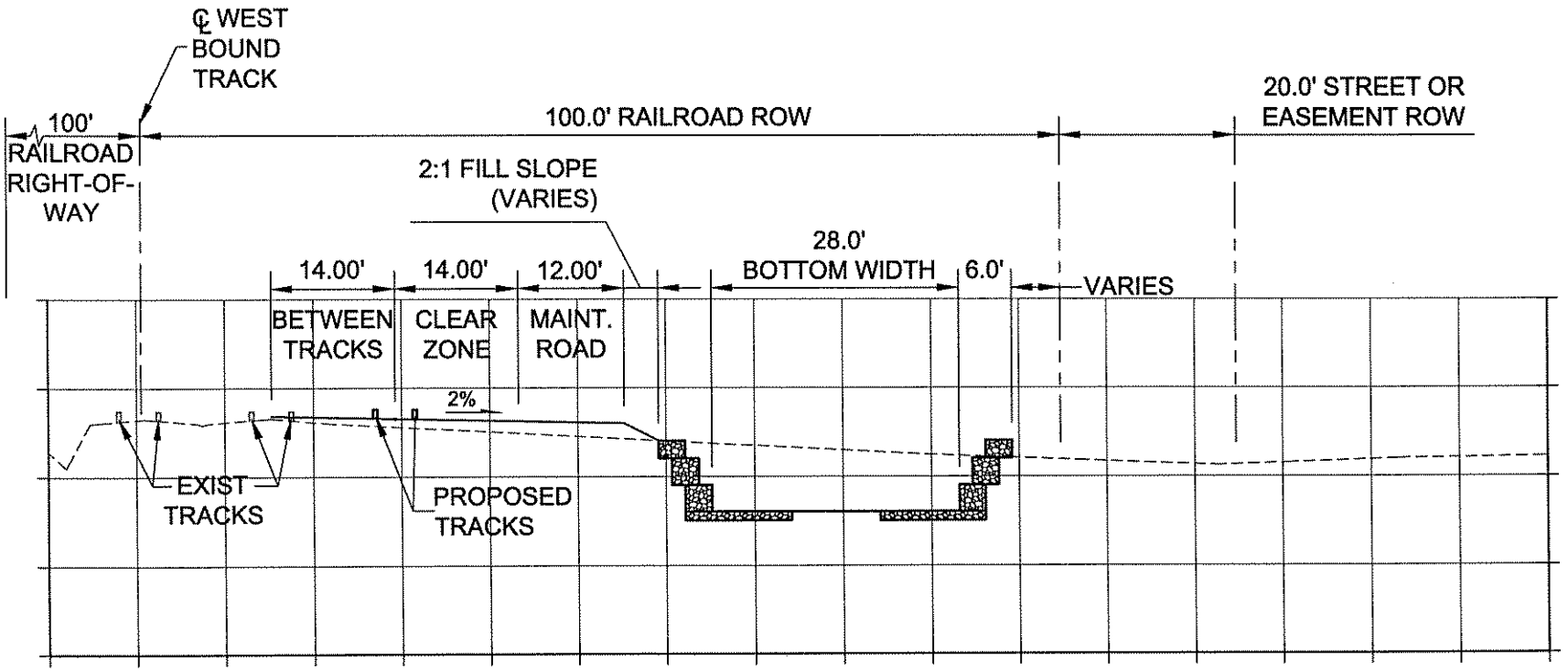
0 20'-0" 30'-0" 40'-0"

n:\roadway\28660038\drawings\exhibits\exhib10.dwg

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
7.1.1

Title
CHANNEL TYPICAL SECTION
REACH 1
GABION MATTRESS



Stantec

SCALE:
1"=20'

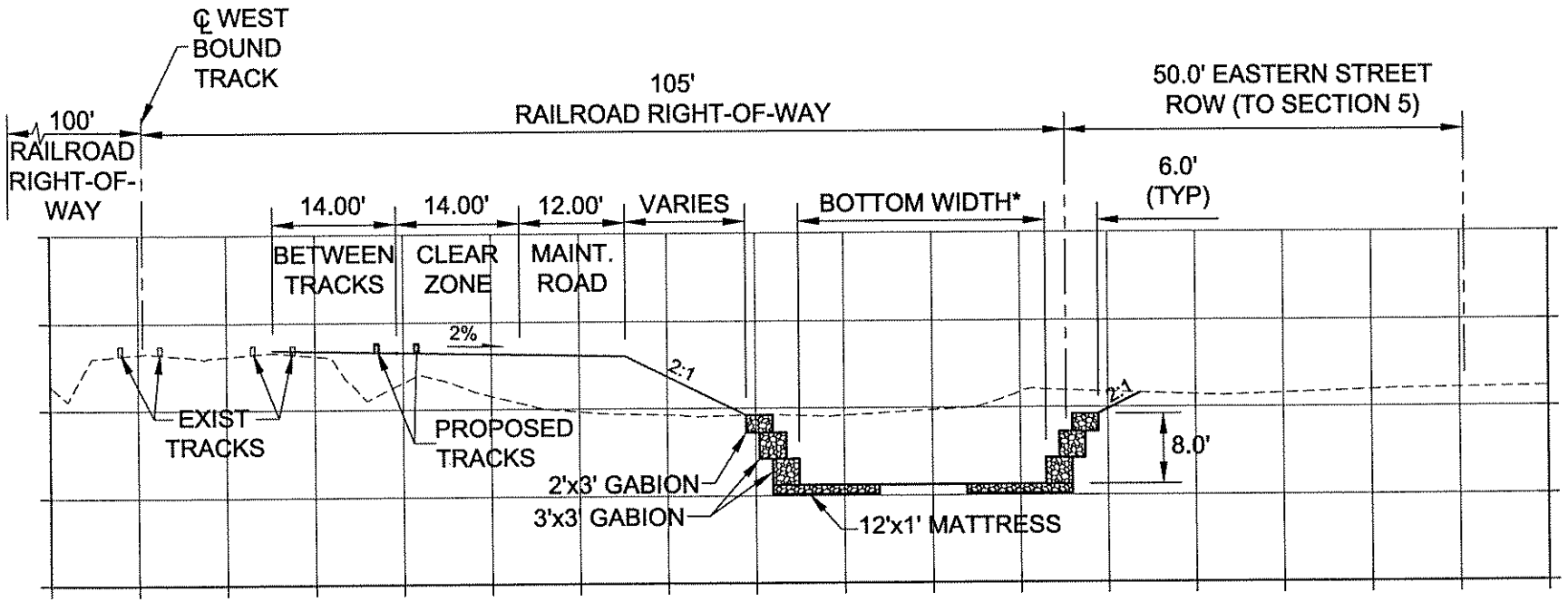
0 20'-0" 30'-0" 40'-0"

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
7.1.2

Title
CHANNEL TYPICAL SECTION
REACH 2
STACKED GABIONS

n:\roadway\28660038\drawings\exhibits\exhib11.dwg



REACH	BOTTOM WIDTH*
3	35.0'
4	40.0'
5a	40.0'
6b	40.0'
6c	50.0'

Stantec

SCALE:
1"=20'

0 20'-0" 30'-0" 40'-0"

n:\roadway\28660038\drawings\exhibits\exhib11a.dwg

Client/Project
CITY OF KINGMAN
RAILROAD CHANNEL

Figure No.
7.1.3

Title
CHANNEL TYPICAL SECTION REACH 3, 4, 5a, 6b, and 6c STACKED GABIONS

7.2 Proposed Flood Control Measures

Normal depth calculations were performed iteratively to arrive at satisfactory channel geometry, longitudinal slopes and linings for each reach. This was done to conform to right-of-way constraints and minimize flow velocities, channel excavation, and backwater effects.

Gabion mattresses, lining a 2:1 trapezoidal channel, are proposed to be used for Reach 1. The channel is 7.5 feet deep with bank protection that extends across a six foot channel bottom and side slopes. Stable, subcritical flow is achieved due to a relatively flat longitudinal slope (0.20%). No drop structures are needed in this reach.

Stacked gabions are utilized in Reaches 2, 3 and 4, and in Sub-reaches 5a, 6b and 6c. Stacked gabions provide a stable and flexible bank lining while also maximizing the channel bottom width (the sides can be nearly vertical). One 2'x3'x6' and two 3'x3'x6' rectangular gabions are staggered and stacked upon one another to a height of eight feet providing a minimum of one foot of freeboard. A 12'x1' gabion mattress extends from under the bottom stacked gabion into the channel for scour protection. The stacked gabions run longitudinally along the reach with filter fabric being used throughout. One gabion drop structure is needed in Reach 2. Due to the existing slope in Reach 3, five gabion drop structures are needed. Reach 4 and Sub-reach 5a have one gabion drop structure total. Sub-reaches 6b and 6c incorporate three gabion drop structures total.

Concrete channel lining with 26-foot and 32-foot bottom widths and a 7.5-foot channel depth is used in Reaches 5b and 6a for the portion of the channel alignment that meanders around the proposed Airway Avenue and through the proposed box culvert at that location. The velocity increases slightly through these reaches, but remains in the subcritical flow regime. The cost estimate uses a 6" slab thickness with the concrete bank protection keyed into the top of bank. The 7.5-foot channel depth allows for a minimum of one foot of freeboard above the water surface elevation. Longitudinal slopes and channel geometry are set to insure flows are stable (Froude Number of 0.85 or lower). No drop structures are needed in these two Sub-reaches.

An earthen channel is proposed for Sub-reach 6d, Reaches 7 and 8 and Sub-reach 9a. Due to the available undeveloped open space and airport property, the channel right-of-way and alignment is shifted outside the BNSF Railway, eliminating the need for bank protection. The channel velocities are controlled by using a wider channel bottom and flatter longitudinal slopes (flatter slopes are obtained by using gabion drop structures).

Gabion mattresses are to be used for Sub-reach 9b. This portion of the channel increases in slope to convey design flows under the railroad crossing at Rattlesnake Hill Wash. Due to the high velocities, energy dissipation should be considered downstream of the structure. Exhibit 7.1 depicts the channel alignment for the preferred alternative.

7.2.1 Reach 1

7.2.1.1 General

Reach 1 extends from the extension of Phoenix Avenue to Adams Street in the Hilltop area of the City. The channel at Station 99+76.94 ties into an existing unimproved channel that intercepts runoff from the north side of Haulapai Mountain Road (method of transitioning to this existing channel is left as an item for final design). From Station 99+76.94 to 157+00, the channel traverses across the BNSF Railway Getz Station and crosses under Louise Avenue at approximately Station 113+65. North of Station 157+00, the 200 feet of railroad right-of-way that is centered on the westbound tracks is abutted by 20 feet of roadway right-of-way for Railroad Street within the Golden Gate Addition subdivision. The roadway is unpaved and the lots are undeveloped. The proposed channel longitudinal slope of 0.20% follows the existing ground slope of 0.20% (which maintains flow within the subcritical flow regime). Right-of-way acquisition from BNSF Railway across the Getz Station has been included in the cost estimate. A twin barrel 10' x 6' concrete box culvert is proposed for the crossing at Louise Avenue.

7.2.1.2 Gabion Mattresses

The typical section for Reach 1 is a trapezoidal channel, 7.5 feet deep, with a 6.0 foot bottom width and 2:1 (H:V) side slopes. One-foot thick gabion mattresses line the sides and bottom of the channel. A flow depth of 6.5 feet allows for a minimum of one foot of freeboard. The channel cut-slope limits extend into the Railroad Street right-of-way and would require acquisition of private property for drainage right-of-way and relocation of Railroad Street. A total of 47,890 cubic yards of waste material is generated and 8,380 cubic yards of gabions are needed for the proposed improvements.

7.2.1.3 Cost Estimate

Table 7.2.1 provides the cost estimate for Reach 1. A 15% contingency has been added to the estimated construction cost.

Table 7.2.1

	Gabion Mattresses
Construction Cost	$1,066,954
Right-of-Way	$16,472
BNSF Right-of-Way	$163,800 ($0.50/SF)
Total Cost	$1,247,226

7.2.2 Reach 2

7.2.2.1 General

Reach 2 begins at Adams Street and runs east 1,800 feet to the west side of Eastern Street. Adams Street will convey flows from a proposed detention basin and improvements to the roadway are currently being designed. From Station 157+00 to 166+00 the railroad right-of-way is abutted by 20 feet of roadway right-of-way for Railroad Street within the Golden Gate Addition subdivision. From Airfield Avenue to the east within Section 7, a 20-foot easement exists adjacent to the BNSF right-of-way. There are no structures along the alignment. However, one business (the tire store) at Station 164+00 may be impacted by the proposed improvements.

7.2.2.2 Stacked Gabions

The typical channel section consists of stacked gabions with a bottom width of 28.0 feet, a longitudinal slope of 0.30%, a channel depth of 8.0 feet and a corresponding flow depth of 6.8 feet. The channel cut-slope limits extends into Railroad Street right-of-way and will require 20 feet of additional right-of-way. A total of 20,496 cubic yards of waste material is generated and 4,800 cubic yards of gabions are needed for the proposed improvements.

7.2.2.3 Cost Estimate

Table 7.2.2 provides the cost estimate for Reach 2. Construction cost includes a 15% contingency.

Table 7.2.2

	Stacked Gabions
Construction Cost	$587,346
Right-of-Way	$32,003
Total Cost	$619,349

7.2.3 Reach 3

7.2.3.1 General

Reach 3 extends from the west side of Eastern Street to feet to Station 185+00, mid-block between Alpha Street and Evans Street. Eastern Street turns from a north-south alignment and runs easterly parallel to the BNSF Railway. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. Eastern Street has 50 feet of right-of-way adjacent to the railroad. This reach is unique due to the 2.36% longitudinal slope of the existing ground line. A channel slope of 0.40% is maintained through this reach by using drop structures. This keeps the velocities in the subcritical flow regime. The roadway is paved and the lots are undeveloped.

7.2.3.2 Stacked Gabions

The typical section for Reach 3 is a 15-foot wide earthen bottom with stacked gabion banks. The channel depth is 8.0 feet. Five drop structures are used within this reach to maintain a design slope of 0.40%. The normal depth is 6.2 feet. The channel cut-slope limits extends into Eastern Street right-of-way and will require an additional 40.0 feet of right-of-way. A total of 16,608 cubic yards of waste material is generated and 2,667 cubic yards of gabions are needed for the proposed improvements.

7.2.3.3 Cost Estimate

Table 7.2.3 provides the cost estimate for Reach 3.

Table 7.2.3

	Stacked Gabions
Construction Cost	$391,171
Right-of-Way	$36,916
Total Cost	$428,087

7.2.4. Reach 4

7.2.4.1 General

Reach 4 begins at the mid-block between Alpha Street and Evans Street (Station 185+00) and extends to the east 3,300 feet to Station 218+00 at the intersection of Eastern Street, Kenwood Avenue and North Central Street. The railroad, Eastern Street, and proposed channel passes under Interstate 40 at Station 199+00. Eastern Street runs parallel to the BNSF Railway throughout this reach within a 50-foot roadway right-of-way. The south side railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks and a total of 200 feet. This reach has a 0.35% longitudinal slope for the existing ground line. Eastern Street roadway is paved and there are a few lots that have been developed south of Interstate 40. The concrete box culvert directing flows to the northwest to pass under the railroad and SR66 will be by-passed and abandoned.

7.2.4.2 Stacked Gabions

The typical channel section consists of stacked gabions with a bottom width of 40.0 feet, a longitudinal channel slope of 0.35%, a channel depth of 8.0 feet and a flow depth of 5.9 feet. The limits for the channel cut-slope will require 30 to 40 feet of right-of-way acquisition. A total of 58,719 cubic yards of waste material is generated and 8,800 cubic yards of gabions will be needed for the proposed improvements.

7.2.4.3 Cost Estimate

Table 7.2.4 provides the cost estimate for Reach 4. The construction cost estimate includes a 15% contingency.

Table 7.2.4

	Stacked Gabions
Construction Cost	$1,158,474
Right-of-Way	$61,223
Total Cost	$1,219,697

7.2.5 Reach 5

7.2.5.1 General

Reach 5 extends from the intersection of Eastern Street, Kenwood Avenue and North Central Street (Station 218+00) to the new Airway Avenue alignment (Station 229+30). Eastern Street runs parallel to the BNSF Railway throughout this reach within 50 feet of roadway right-of-way. The south side of the railroad right-of-way provides approximately 85 feet from the centerline of the eastbound tracks. The existing ground line has a slope of 0.35% through this reach. For the preferred alternative, this reach has been subdivided into two sub-reaches. Sub-reach 5a is parallel to the railroad and Sub-reach 5b covers that portion of the reach where the channel alignment veers away from the railroad to loop around the new Airway Avenue alignment. Eastern Street roadway is paved and there are a few lots that have been developed north of Interstate 40. In conjunction with the Airway Avenue Railroad Crossing project, new right-of-way for roadway and drainage purposes has been identified for Reach 5 in order to provide a drainage channel around the underpass site. Consequently, no additional right-of-way has been identified for this reach.

7.2.5.2 Stacked Gabions

The typical channel section for Sub-reach 5a consists of stacked gabions with a bottom width of 40.0 feet, a longitudal slope of 0.45%, a channel depth of 8.0 feet and a flow depth of 5.8 feet. A total of 7,186 cubic yards of waste material is generated and 1,000 cubic yards of gabions are needed for the proposed improvements for this sub-reach.

7.2.5.3 Concrete Channel

The typical channel section for Sub-reach 5b consists of a concrete-lined channel with a bottom width of 26 feet, side slopes of 1.5:1 (H:V), a longitudinal slope of 0.20%, a channel depth of 7.5 feet and corresponding flow depth of 6.3 feet. Total excavation is 17,636 cubic yards and the total concrete needed is 742 cubic yards.

7.2.5.4 Cost Estimate

Table 7.2.5 provides the cost estimate for both sub-reaches of Reach 5.

Table 7.2.5

	5a-Stacked Gabions	5b-Concrete
Construction Cost	$132,424	$207,439
Right-of-Way	$0	$0
Total Cost	$132,424	$207,439

7.2.6 Reach 6

7.2.6.1 General

Reach 6 begins at the new Airway Avenue alignment (Station 229+30) and extends easterly 4,513 feet (Station 274+43), just east of the extension of North Castle Rock Road along the railroad. Eastern Street runs parallel to the BNSF Railway with 50 feet of roadway right-of-way to the existing Airway Avenue alignment along the north line of Section 8. The railroad right-of-way provides approximately 85 feet on the south side of the eastbound tracks and a total of 200 feet. No additional right-of-way is existing adjacent to the railroad within Section 5. Section 4 has a 70-foot wide strip of existing right-of-way adjacent to the BNSF right-of-way. The prevailing longitudinal slope for the existing ground line through this reach is 0.70%. For the preferred alternative, this reach was subdivided into four Sub-reaches, 6a, 6b, 6c and 6d. As discussed previously in Section 5.2.5.1, the land acquisition for the proposed Airway Avenue Railroad underpass will provide the needed right-of-way for the channel within Section 8. Right-of-way identified for this reach is all within Section 5. No building structures are impacted by the alignment through Reach 6.

7.2.6.2 Concrete Channel

The typical channel section for Sub-reach 6a is a concrete-lined channel with a bottom width of 32 feet, 1.5:1 (H:V) slide slopes, a longitudinal slope of 0.25% a channel depth of 7.5 feet and a corresponding flow depth of 6.2 feet. Total waste material generated is 16,288 cubic yards and the total concrete needed is 809 cubic yards.

7.2.6.3 Stacked Gabions

The typical section for Sub-reach 6b consists of stacked gabions with a bottom width of 40 feet, a channel depth of 8.0 feet, a longitudinal slope of 0.62% and a corresponding flow depth of 5.8 feet. There are two drop structures within this sub-reach. The channel cut-slope limits requires a 30-foot wide strip of right-of-way within Section 5 with the remainder of the improvements within BNSF Railway and/or existing roadway right-of-way. A total of 5,439 cubic yards of waste material is generated and 1,320 cubic yards of gabions are needed for the proposed improvements.

7.2.6.4 Stacked Gabions

The typical section for Sub-reach 6c consists of stacked gabions with a bottom width of 50 feet, a channel depth of 8.0 feet, a longitudinal slope of 0.38% and a corresponding flow depth of 5.7 feet. There is one drop structure within this sub-reach. The channel cut-slope limits requires a 60-foot wide strip of right-of-way within Section 5 with the remainder of the improvements within BNSF Railway and/or existing roadway right-of-way. A total of 20,403 cubic yards of waste material is generated and 4,093 cubic yards of gabions are needed for the proposed improvements.

7.2.6.5 Earthen Channel

The typical section for Sub-reach 6d is an earthen channel with a bottom width of 46 feet, 2:1 side slope on the north side, 3:1 side slope on the south side, a channel depth of 7.5 feet, a longitudinal slope of 0.18% and a corresponding flow depth of 6.3 feet. The flatter side slope on the south side aids in reducing bank scour from overland flows draining into the channel from the southeast. Though the flow velocity is slightly higher than desired (7.2 fps), the conditions are stabilized by providing four gabion drop structures. The channel cut-slope limits requires a 130-foot wide strip of right-of-way from Station 257+00 to 268+00 and a 90-foot wide strip of right-of-way from Station 268+00 to Station 274+43. The channel improvements, beginning at this sub-reach, do not fall within BNSF Railway right-of-way and remain outside of the BNSF Railway right-of-way to the end of the proposed channel. A total of 24,061 cubic yards of waste material is generated and approximately 500 cubic yards of gabions are needed for the drop structures for this sub-reach.

7.2.6.6 Cost Estimate

Table 7.2.6 provides the construction cost estimate with 15% contingency and right-of-way cost for Reach 6.

Table 7.2.6

	Concrete	Stacked Gabions	Earthen
Construction Cost	$214,886	$705,004	$152,572
Right-of-Way	$0	$75,364	$245,960
Total Cost	$214,886	$780,368	$398,532

7.2.7 Reach 7

7.2.7.1 General

Reach 7 begins at Station 274+43, just east of the extension of North Castle Rock Road and continues parallel with the railroad a distance of 4,673 feet to Station 321+16 at Diagonal Wash. Diagonal Wash will be diverted into the railroad channel and downstream drainage structures will be abandoned. The 70 feet of existing roadway right-of-way on the east side of the railroad right-of-way extends to Rae Drive which is the east-west mid-section line road for Section 4 (Station 280+00). Reach 7 enters Section 33 and onto Kingman Airport property at Station 310+55 (BNSF Railway's Berry Station has a total of 400 feet of right-of-way in Section 33 centered on their alignment, providing 200 feet on the south side). This reach has a 0.54% existing longitudinal slope. No building structures are impacted by the alignment through Reach 7.

7.2.7.2 Earthen Channel

The typical section recommended for Reach 7 is an earthen channel having a bottom width of 70 feet, a 2:1 side slope on the left side, a 3:1 side slope on the right side, a channel depth of 7.5 feet, a longitudinal slope of 0.17% and corresponding flow depth of 6.3 feet. Six gabion drop structures are needed in this reach to maintain the channel slope of 0.17%. Due to the curvature of the channel within Reach 7, an additional 90 feet of right-of-way is needed beginning south of Rae Drive, an additional 160 feet of right-of-way is needed at Rae Drive and then an additional 260 feet is needed right before entering Kingman Airport property. The improvements along this reach do not fall within BNSF Railway existing right-of-way. A total of 110,818 cubic yards of waste material is generated and 1,120 cubic yards of gabions are needed for the drop structures for this reach.

7.2.7.3 Cost Estimate

Table 7.2.7 summarizes the cost estimate, including 15% contingency for the construction cost, for Reach 7.

Table 7.2.7

	Earthen
Construction Cost	$568,499
Right-of-Way	$588,147
Total Cost	$1,156,646

7.2.8 Reach 8

7.2.8.1 General

Reach 8 begins at Station 321+16, Diagonal Wash, and passes adjacent to the BNSF Railway's Berry Station site through Kingman Airport property extending to Station 383+57 for a total distance of 6,241 feet. Total right-of-way width for the railroad and Berry Station within Section 33 is 400 feet, but reduces to 200 feet in Sections 34 and 27. The channel improvements for this reach do not fall within BNSF Railway existing right-of-way. This reach has a 0.67% existing longitudinal slope. A sand and gravel operation will be impacted by the channel improvements at Station 383+00.

7.2.8.2 Earthen Channel

An earthen channel is recommended for Reach 8 having a bottom width of 108 feet, a 2:1 side slope on the left side, a 3:1 side slope on the right side, a channel depth of 7.5 feet, a longitudinal slope of 0.16% and a corresponding flow depth of 6.3 feet. Ten gabion drop structures are needed in this reach to maintain a channel slope of 0.16%. Reach 8 will require 200 feet of additional right-of-way through the Airport property increasing to 260 feet of right-of-way past the west line of Section 34. Approximately 227,825 cubic yards of waste material is generated and 2,880 cubic yards of gabions are needed for the drop stuctures for this reach.

7.2.8.3 Cost Estimate

Table 7.2.8 provides the cost estimate for Reach 8. The construction cost estimate includes a 15% contingency.

Table 7.2.8

	Earthen
Construction Cost	$1,225,287
Total Cost	$1,225,287

7.2.9 Reach 9

7.2.9.1 General

Reach 9 begins at Station 383+57 and terminates at Rattlesnake Hill Wash (1026 feet reach length). For the preferred alternative, this reach was subdivided into two sub-reaches, 9a (427 feet) and 9b (599 feet). The entire reach has a 0.67% longitudinal slope for the existing ground line along a line parallel with the railroad (BNSF Railway right-of-way is a total of 200 feet adjacent to this reach).

As discussed previously, the railroad drainage structure at Rattlesnake Hill Wash was reconstructed in the late 1980s after a fire destroyed the previous wooden structure. The City of Kingman contributed funds to BNSF to increase the size of the new structure to accommodate additional flows from the future Railroad Diversion Channel. The structure was upsized and all parties agree in principal to divert all flows to this outfall. See Appendix D for correspondence.

The preferred alternative illustrates the diversion channel curving around to meet up with Rattlesnake Hill Wash. Though some design recommendations are discussed below, further design elements will need to be evaluated at the junction of the diversion channel and the wash to mitigate scour and any significant sediment deposition. Right-of-way for this reach would need to extend from the Railroad right-of-way for a distance that would encompass the curvature of the channel as it redirects flow into the drainage structure. The right-of-way needed through the Airport property would be approximately 260 feet from the beginning of the reach to a maximum of 390 feet at the curve of the channel into Rattlesnake Hill Wash.

7.2.9.2 Earthen Channel with Gabion Mattresses

The typical section for Sub-reach 9a is an earthen channel with gabion mattress lined banks, a 150 foot bottom width, a 2:1 side slope on the left, a 3:1 side slope on the right, a 7.5 foot channel depth, a longitudinal slope of 0.44% and a corresponding flow depth of 6.2 feet. The flow velocities would be approximately 11.4 fps. No drop structures would be needed. A total of 11,674 cubic yards of waste material is generated and 1,018 cubic yards of gabions are needed for the proposed improvements.

7.2.9.3 Gabion Mattresses

For Sub-reach 9b, a completely lined trapezoidal channel (gabion mattresses) is recommended due to the steeper slope. The steeper slope and one drop structure is necessary to lower the invert of the existing Rattlesnake Hill Wash at the railroad drainage structure. The typical section for this gabion-lined channel would have a bottom width transitioning from 150 feet to 93 feet, a 2:1 side slope on the left and right sides (with earthwork and channel transitioning on the right bank with the existing wash being left for final design), a 1.28% longitudinal slope, a transitioning channel depth from 7.5 feet to the depth at the brodge drainage structure, and an approximate flow depth of 6.5 feet. The 93 foot width matches the approximate width of the drainage structure underneath the railroad. A total of 5,248 cubic yards of waste material is generated and 3,138 cubic yards of gabions are needed for the proposed improvements.

The drop structure upstream of the railroad bridge at MP 590.1 will assist in providing energy dissipation, lower channel velocities, and lower the wash invert to provide the capacity at the structure.

7.2.9.4 Cost Estimate

Table 7.2.8 provides the cost estimate for Reach 9. Construction cost estimate includes a 15% contingency.

Table 7.2.9

	Earthen w/Gabions	Gabions
Construction Cost	$155,288	$358,150
Total Cost	$155,288	$358,150

8.0 PREFERRED ALTERNATIVE RESULTS AND IMPLEMENTATION

Table 8-1 provides a summary of the construction and right-of-way cost estimates for each reach of the preferred alternative along with the total project costs. Total construction cost for the preferred alternative is $7,105,079 with a right-of-way cost of $1,219,885. Complete quantities and cost estimate for the preferred alternative is in Appendix C.

Table 8.1

REACH		*PREFERRED ALTERNATIVE COST ($)*			
		GABION MATTRESS	**STACKED GABIONS**	**CONCRETE**	**EARTHEN**
1	Construction	1,066,954			
	Right-of-Way	180,272			
2	Construction		587,346		
	Right-of-Way		32,003		
3	Construction		391,171		
	Right-of-Way		36,916		
4	Construction		1,158,474		
	Right-of-Way		61,223		
5a	Construction		132,424		
	Right-of-Way		0[1]		
5b	Construction			207,439	
	Right-of-Way			0[1]	
6a	Construction			214,886	
	Right-of-Way			0[1]	
6b	Construction		181,586		
	Right-of-Way		0[1]		
6c	Construction		705,004		
	Right-of-Way		75,364		
6d	Construction				152,572
	Right-of-Way				245,960
7	Construction				568,499
	Right-of-Way				588,147
8	Construction				1,225,287
	Right-of-Way				0[2]
9a	Construction	155,288			
	Right-of-Way	0[2]			
9b	Construction	358,150			
	Right-of-Way	0[2]			
TOTALS		**$1,760,664**	**$3,361,511**	**$422,325**	**$2,780,465**
GRAND TOTAL		**$8,324,965**			

[1]Right-of-way included with Airway Avenue improvements.
[2]Right-of-way on Airport Authority property.

Unit prices for preparation of the cost estimates are as follows:

Earthwork – Excavation	$3.50 / cubic yard
Riprap	$85 / cubic yard
Gabions	$90 / cubic yard
Concrete	$160 / cubic yard
Drop Structures (Gabions)	$90 / cubic yard
Contingency	15%
Right-of-Way	$1.00 / square foot (BNSF $0.50 / square foot)

The total earthwork for the selected alternatives for the project is 602,575 cubic yards. With the railroad embankment requiring roughly 100,000 cubic yards, an export of approximately 500,000 cubic yards would be yielded from the project. Earthwork comprises nearly 30% of the construction cost.

Hydrologic analysis shows the need for the construction of the detention basins. The Southern Avenue – Eastern Street basin is bounded on the east by Eastern Street, to the south by Southern Avenue, to the north by Phoenix Avenue and to the west by Washington Street. The basin will eliminate storm water runoff through the Hilltop area and control the outlet by releasing the outfall into Adams Street, 650 feet west of the basin. Mohave Engineering is proceeding with the design of East Golden Gate Addition Improvement District which will design Adams Street to convey an 85 cfs outlet discharge from the basin. The preliminary analysis will be revised during final design to size the outfall structure and basin to meet the outfall criteria and provide complete protection for the 50-year event. Based on this study's results, spillway flow will not occur until the 100-year event. A rough cost estimate for the detention basin and drainage facilities is approximately $400,000.

The ADOT basin will provide additional protection downstream. Assumptions made for this study can be revisited and additional analysis can be undertaken to increase the drainage area that would drain into the facility. This would provide even more benefit to the overall area drainage master planning efforts.

The recommended alternative for the Railroad Diversion Channel meets all design criteria to assure FEMA approval for obtaining a Letter of Map Revision for the community. BNSF Railway will not have to be concerned with maintenance of drainage culverts along the 5.2 mile section of tracks. Finally, protection throughout the southeast side of the city is realized through the implementation of the Railroad Diversion Channel (and Basins) Project.

The project can be phased to begin providing a benefit to the community. The following provides an order to the implementation of the project.

(1) Right-of-way acquisition for the entire project would insure that the corridor is set aside for flood control improvements.
(2) Construction of the detention basin in order to coordinate with design assumptions of the East Golden Gate Addition Improvement District project.
(3) Construct Reach 5b and 6a with the Airway Avenue Grade Separation Project.
(4) Construct the project beginning with Reach 9 and continuing through to Reach 1.

The two major railroad drainage structures to be diverted into the channel are Diagonal Wash and the culvert at the north side of Interstate 40. Depending on available funds, providing project limits to capture these flows will greatly improve downstream drainage conditions.

9.0 REFERENCES

1. Arizona Department of Transportation. *Highway Drainage Design Manual, Hydrology, Standard Edition.* December, 1994.

2. Arizona Department of Transportation. *Design Procedures Manual.* 1990 Edition.

3. Flood Control District of Maricopa County. *Drainage Design Manual for Maricopa County, Arizona, Volume II Hydraulics.* November, 1991.

4. Haestad Methods. *FlowMaster for Windows, Design and Analysis Software.* 1995.

5. Haestad Methods. *Culvert Master for Windows, Design and Analysis Software.* 1995.

6. Haestad Methods. *StormCAD for Windows, Design and Analysis Software.* 1995.

7. U.S. Army Corps of Engineers, The Hydrologic Engineering Center. *HEC-1 Flood Hydrograph Package Users Manual.* September, 1990.

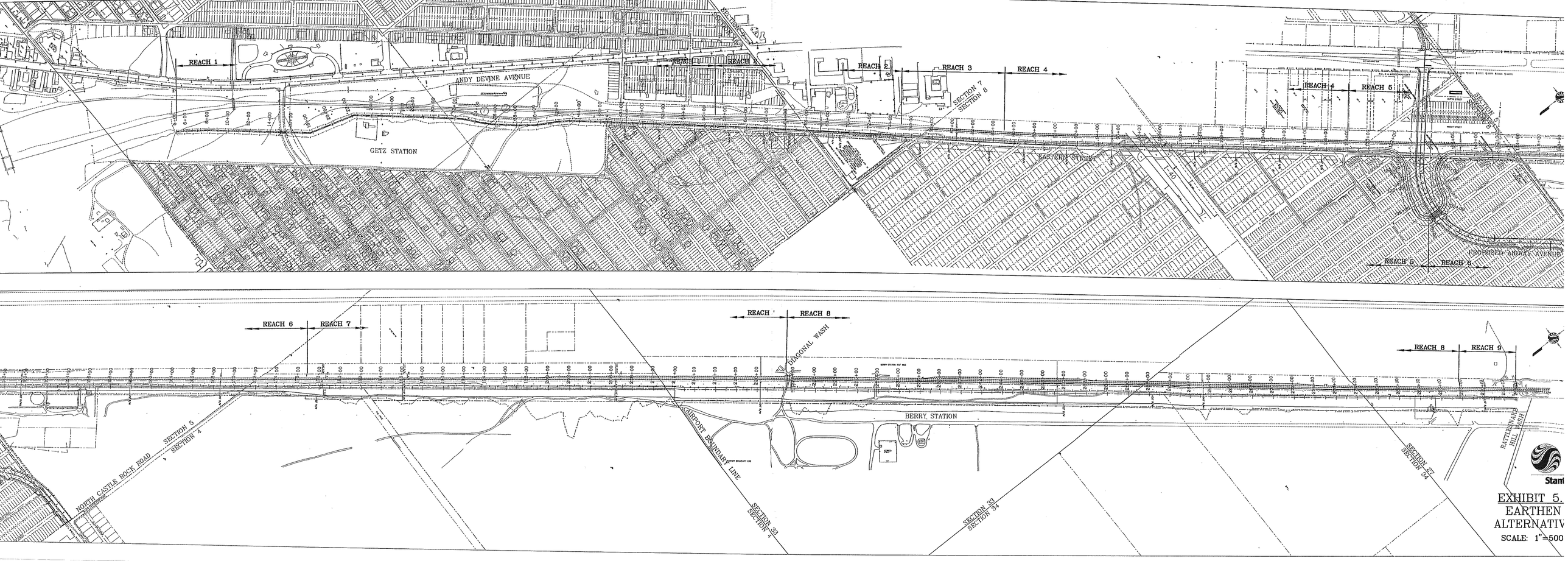
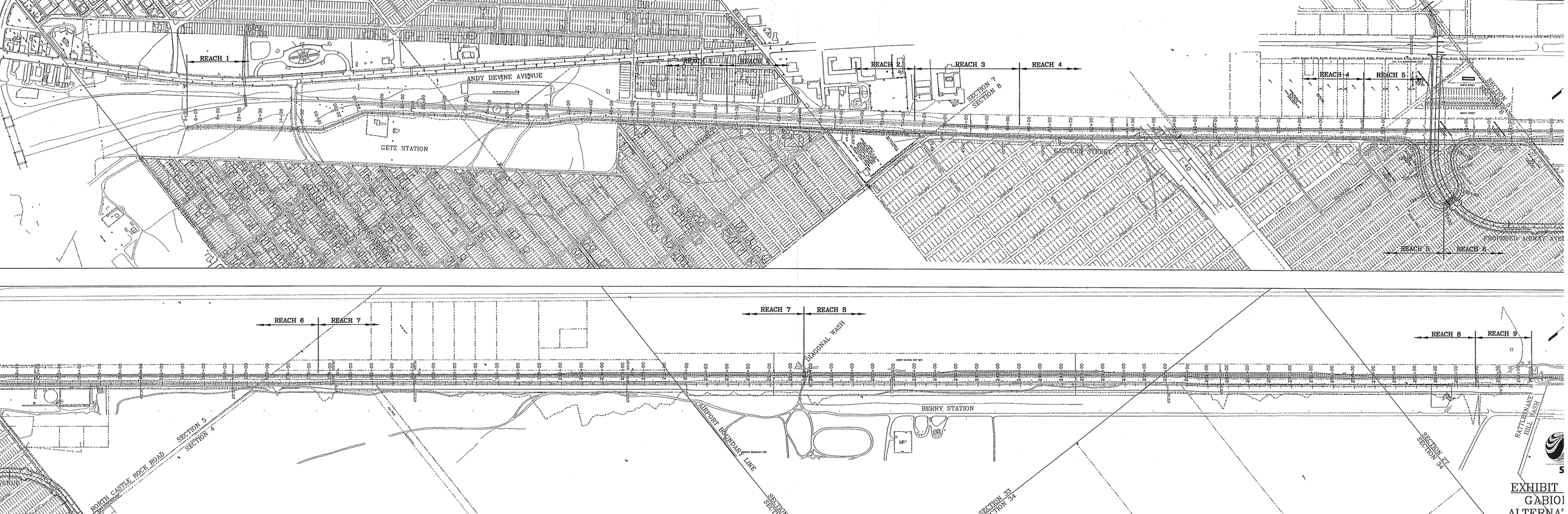
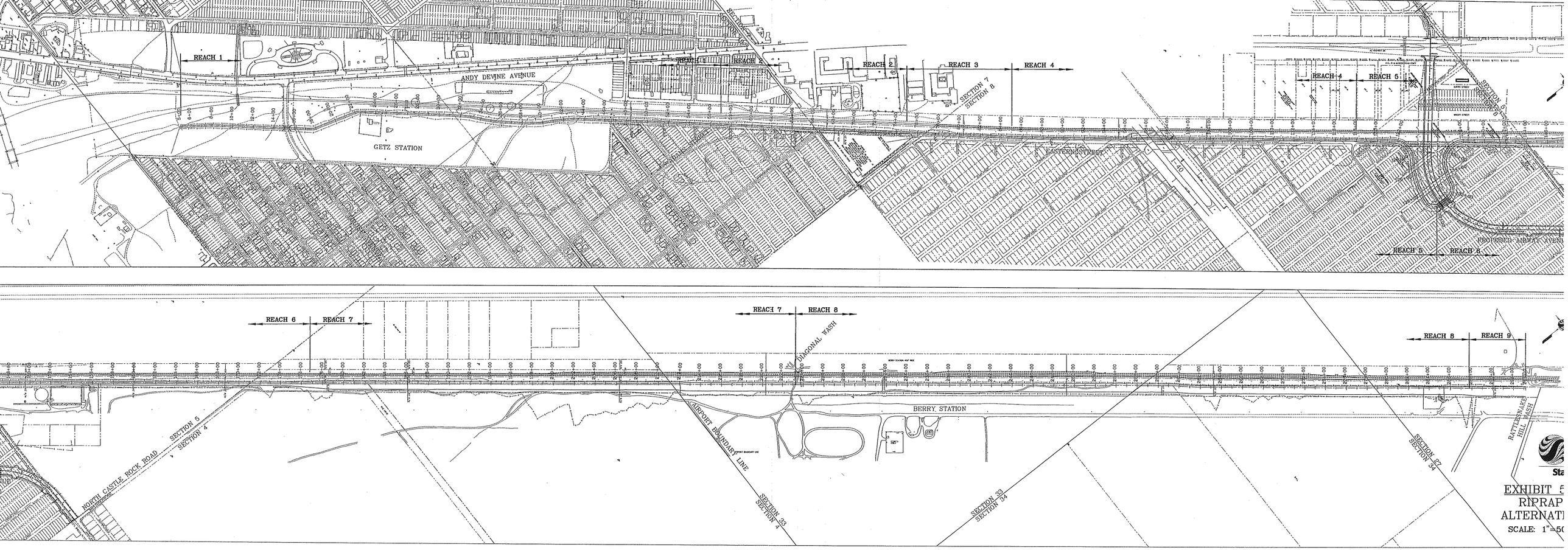
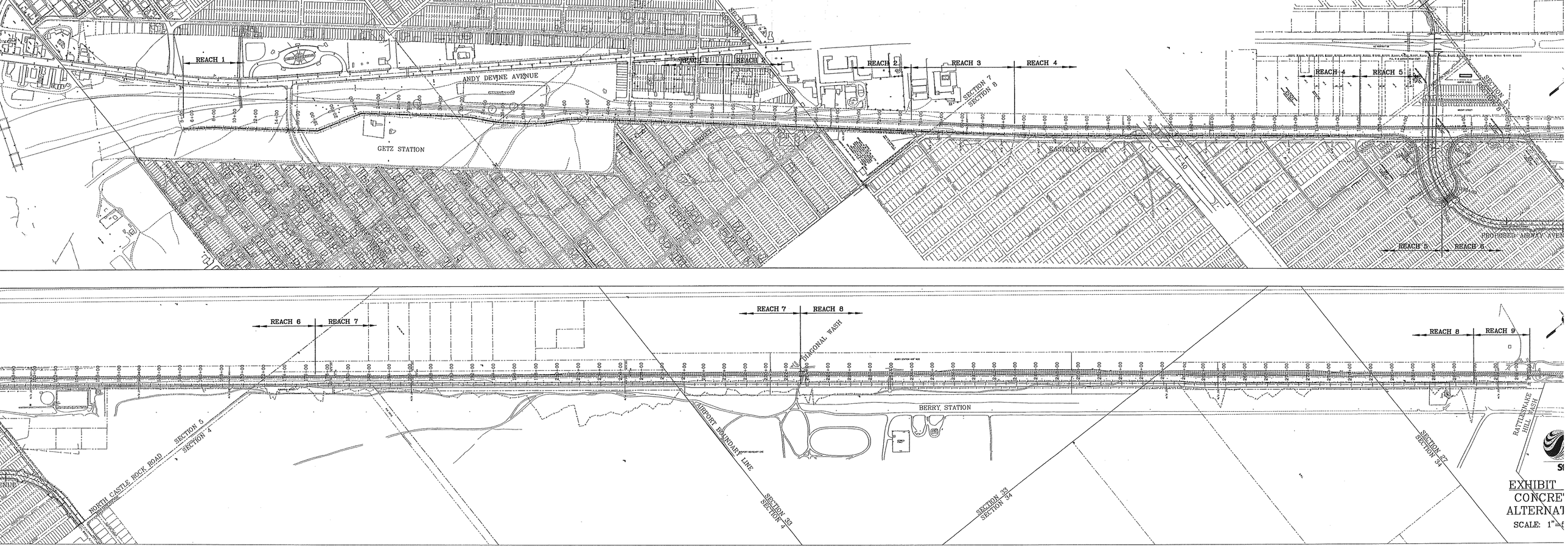


EXHIBIT 5.
EARTHEN
ALTERNATIV

SCALE: 1"=500


REACH 1
REACH 2
REACH 3
REACH 4
REACH 5
REACH 6
REACH 7
REACH 8
REACH 9
ANDY DEVINE AVENUE
GETZ STATION
EASTERN STREET
DIAGONAL WASH
BERRY STATION
AIRPORT BOUNDARY LINE
NORTH CASTLE ROCK ROAD
RATTLESNAKE HILL WASH
SECTION 1
SECTION 2
SECTION 3
SECTION 4
SECTION 5
SECTION 6
SECTION 7
SECTION 8
SECTION 33
SECTION 34
SECTION 35
SECTION 36
SECTION 37
EXHIBIT
GABIO
ALTERNA
SCALE: 1"=


REACH 1
REACH 2
REACH 3
REACH 4
REACH 5
REACH 6
REACH 7
REACH 8
REACH 9
ANDY DEVINE AVENUE
GETZ STATION
EASTERN STREET
PROPOSED RIDWAY AVENU
DIAGONAL WASH
BERRY STATION
AIRPORT BOUNDARY LINE
NORTH CASTLE ROCK ROAD
RATTLESNAKE HILL WASH
SECTION 4
SECTION 5
SECTION 6
SECTION 7
SECTION 8
SECTION 26
SECTION 27
SECTION 33
SECTION 34
EXHIBIT 5
RIPRAP
ALTERNATI
SCALE: 1"=50


REACH 1
REACH 2
REACH 3
REACH 4
REACH 5
REACH 6
REACH 7
REACH 8
REACH 9
ANDY DEVINE AVENUE
GETZ STATION
EASTERN STREET
DIAGONAL WASH
BERRY STATION
AIRPORT BOUNDARY LINE
NORTH CASTLE ROCK ROAD
RATTLESNAKE HILL WASH
SECTION 1
SECTION 2
SECTION 3
SECTION 4
SECTION 5
SECTION 6
SECTION 7
SECTION 8
SECTION 27
SECTION 32
SECTION 33
SECTION 34
PROPOSED AIRWAY AVEN
EXHIBIT
CONCRET
ALTERNAT
SCALE: 1"=

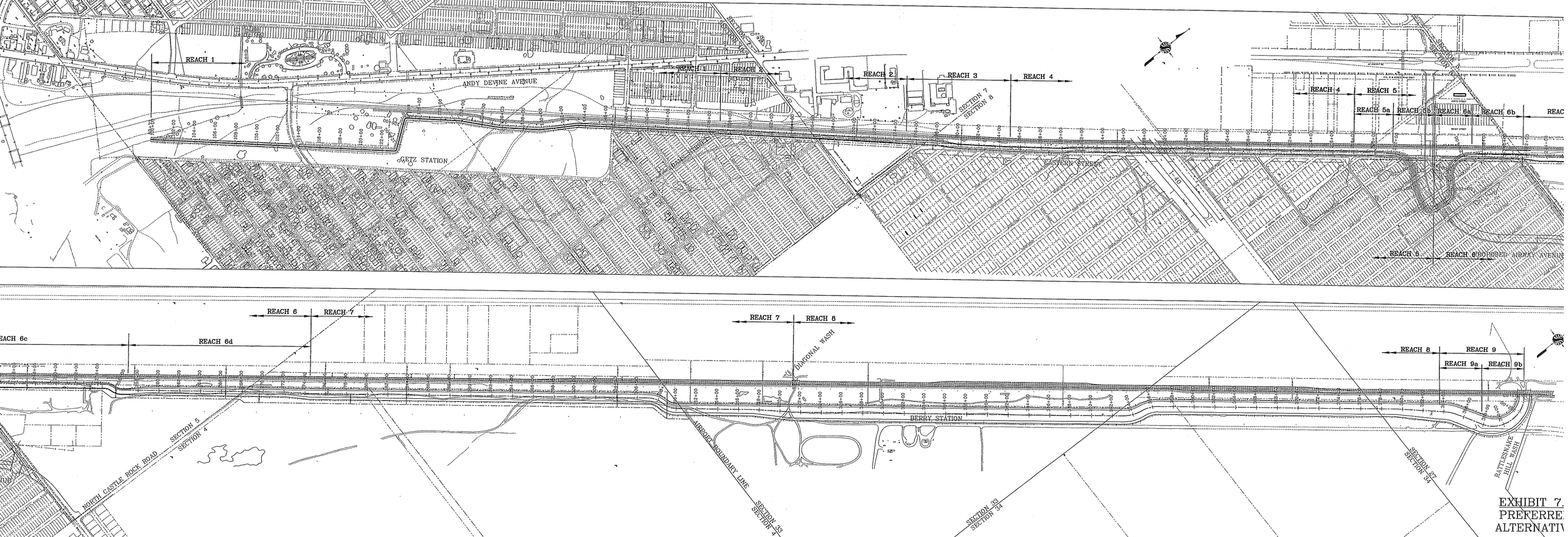
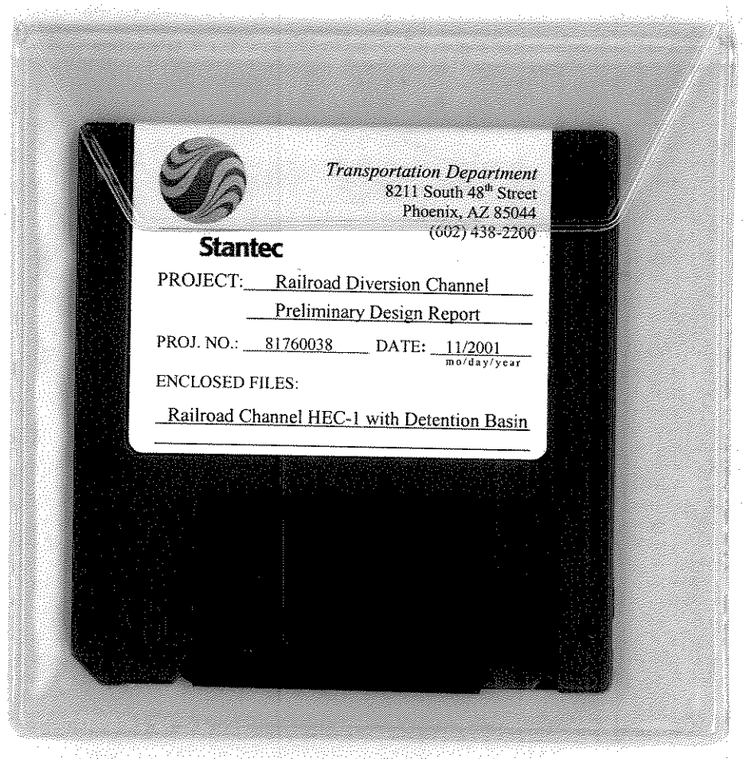


EXHIBIT 7.
PREFERRE
ALTERNATIV

SCALE: 1"=500



Appendix A

HEC-1 INPUT/OUTPUT
3.5" Diskette

```
ID       KINGMAN AREA MASTER PLAN UPDATE, MOHAVE COUNTY, ARIZONA
ID       PLAN No.1 MODEL WITH PROPOSED CITY OF KINGMAN RAILROAD CHANNEL.
ID       ADOT BORROW PIT MODELED AS ACTUAL RETENTION BASIN.
ID
ID       PROPOSED DETENTION BASIN IN-PLACE AT INTXN OF SOUTHERN & EASTERN
ID       REVISED ON 2/15/2000
ID
ID       USES 1992 ADOT HYDROLOGY MANUAL PROCEDURES.
ID       CLARK UNIT HYDROGRAPH & GREEN-AMPT INFILTRATION.
ID
ID       GREEN-AMPT NUMBERS BASED ON DATA FROM:
ID       "GENERAL SOIL MAP & INTERPRETATIONS, MOHAVE COUNTY, ARIZONA, 1974"
ID
ID       PREPARED BY ROBERT L. WARD, P.E.
ID
ID       MODEL KGDET3D.24I, BASE MODEL WAS KGDET3.24I
ID
ID       100-YEAR, 24-HOUR HYPOTHETICAL STORM
ID
ID       RAINFALL FROM NOAA ATLAS,  ARKELL & RICHARDS SHORT DURATION RATIOS
ID
*DIAGRAM
IT     4 15FEB00        0     370
IO     5        0
*
JD          .0001
PH             0     .75    1.47    2.50    2.79    2.98    3.35    3.79    4.23
JD           .001
JD            .01
JD             .1
JD              1
JD             10
JD             50
JD            100
*NOLIST
*
KK  5000
KM       RUNOFF FROM SUB-BASIN 5000
BA1.0689
LG   .20      .35    4.05    .425    13.1
UC  .664     .299
UA     0        3       5       8       12       20       43       75       90       96
UA   100
*
KK  5011       CP
KM       ROUTE SUB 5000 TO CP 5011
RK  1050   .0018    .016            TRAP       10        2
*
KK  5010      SUB
KM       RUNOFF FROM SUB 5010
BA .8924
LG   .20      .35    3.90    .505    32.4
UC  .513     .301
*
KK  5020      SUB
KM       RUNOFF FROM SUB 5020
BA .4821
```

```
ID      KINGMAN AREA MASTER PLAN UPDATE, MOHAVE COUNTY, ARIZONA
ID      PLAN No.1 MODEL WITH PROPOSED CITY OF KINGMAN RAILROAD CHANNEL.
ID      ADOT BORROW PIT NOT MODELED AS A RETENTION BASIN.
ID
ID      PROPOSED DETENTION BASIN IN-PLACE AT INTXN OF SOUTHERN & EASTERN
ID      REVISED ON 2/15/2000.
ID
ID      USES 1992 ADOT HYDROLOGY MANUAL PROCEDURES.
ID      CLARK UNIT HYDROGRAPH & GREEN-AMPT INFILTRATION.
ID
ID      GREEN-AMPT NUMBERS BASED ON DATA FROM:
ID      "GENERAL SOIL MAP & INTERPRETATIONS, MOHAVE COUNTY, ARIZONA, 1974"
ID
ID      PREPARED BY ROBERT L. WARD, P.E.
ID
ID      MODEL KGDET2D.24I, BASE MODEL WAS KGDET2.24I
ID
ID      100-YEAR, 24-HOUR HYPOTHETICAL STORM
ID
ID      RAINFALL FROM NOAA ATLAS,  ARKELL & RICHARDS SHORT DURATION RATIOS
ID
*DIAGRAM
IT     4 15FEB00        0     370
IO     5        0
*
JD          .0001
PH             0     .75    1.47    2.50    2.79    2.98    3.35    3.79    4.23
JD           .001
JD            .01
JD             .1
JD              1
JD             10
JD             50
JD            100
*NOLIST
*
KK  5000
KM      RUNOFF FROM SUB-BASIN 5000
BA1.0689
LG   .20      .35    4.05    .425    13.1
UC  .664     .299
UA     0        3       5       8      12      20      43      75      90      96
UA   100
*
KK  5011       CP
KM      ROUTE SUB 5000 TO CP 5011
RK  1050   .0018    .016            TRAP      10       2
*
KK  5010      SUB
KM      RUNOFF FROM SUB 5010
BA .8924
LG   .20      .35    3.90    .505    32.4
UC  .513     .301
*
KK  5020      SUB
KM      RUNOFF FROM SUB 5020
BA .4821
```

```
ID      KINGMAN AREA MASTER PLAN UPDATE, MOHAVE COUNTY, ARIZONA
ID      PLAN No.1 MODEL WITH PROPOSED CITY OF KINGMAN RAILROAD CHANNEL.
ID      ADOT BORROW PIT MODELED AS ACTUAL RETENTION BASIN.
ID
ID      PROPOSED DETENTION BASIN IN-PLACE AT INTXN OF SOUTHERN & EASTERN
ID      REVISED ON 2/15/2000
ID
ID      USES 1992 ADOT HYDROLOGY MANUAL PROCEDURES.
ID      CLARK UNIT HYDROGRAPH & GREEN-AMPT INFILTRATION.
ID
ID      GREEN-AMPT NUMBERS BASED ON DATA FROM:
ID      "GENERAL SOIL MAP & INTERPRETATIONS, MOHAVE COUNTY, ARIZONA, 1974"
ID
ID      PREPARED BY ROBERT L. WARD, P.E.
ID
ID      MODEL KGDET3D.6I, BASE MODEL WAS KGDET3.24I
ID
ID      100-YEAR, 6-HOUR HYPOTHETICAL STORM
ID
ID      RAINFALL FROM NOAA ATLAS,  ARKELL & RICHARDS SHORT DURATION RATIOS
ID
*DIAGRAM
IT     4 15FEB00       0     370
IO     5       0
*
JD          .0001
PH              0     .75    1.47    2.50    2.79    2.98    3.35
JD           .001
JD            .01
JD             .1
JD              1
JD             10
JD             50
JD            100
*NOLIST
*
KK  5000
KM      RUNOFF FROM SUB-BASIN 5000
BA1.0689
LG   .20      .35    4.05    .425    13.1
UC  .664     .299
UA     0        3       5       8       12      20      43      75      90      96
UA   100
*
KK  5011       CP
KM      ROUTE SUB 5000 TO CP 5011
RK  1050   .0018    .016            TRAP      10       2
*
KK  5010      SUB
KM      RUNOFF FROM SUB 5010
BA .8924
LG   .20      .35    3.90    .505    32.4
UC  .513     .301
*
KK  5020      SUB
KM      RUNOFF FROM SUB 5020
BA .4821
```

APPENDIX B

HYDRAULIC ANALYSIS OUTPUT

RR Channel - Preferred Alternative

Label	Worksheet Type	Discharge (cfs)	Slope (ft/ft)	Mannings Coefficient	Bottom Width (ft)	Left Side Slope (H : V)	Right Side Slope (H : V)	Velocity (ft/s)	Depth (ft)	Water Surface Elevation (ft)	Top Width (ft)	Flow Area (ft^2)	Wetted Perimeter (ft)	Froude Number	Flow Type
Reach 1 - Gabion Mattresses at 2:1 - 6' bw -	Trapezoid	679.0	0.0020	0.028	6.0	2.0	2.0	5.5	6.5		32.0	123.6	35.1	0.49	Subcritical
Reach 2 - Stacked Gabions - 28' bw - subcrit	Irregular	1,589.0	0.0030	0.028				7.7		6.8	34.0	205.2	47.2	0.56	Subcritical
Reach 3 - Stacked Gabions - 35' bw - subcrit	Irregular	1,994.0	0.0040	0.028				8.8		6.2	40.9	225.7	52.8	0.66	Subcritical
Reach 4 - Stacked Gabions - 40' bw - subcrit	Irregular	2,196.0	0.0035	0.027				8.9		5.9	43.1	246.8	54.6	0.66	Subcritical
Reach 5a - Stacked Gabions - 40' bw - subcr	Irregular	2,390.0	0.0045	0.027				9.9		5.8	43.1	240.2	54.3	0.74	Subcritical
Reach 5b - Concrete - 26' bw - subcritical	Trapezoid	2,390.0	0.0025	0.019	26.0	1.5	1.5	10.8	6.3		44.8	222.0	48.6	0.85	Subcritical
Reach 6a - Concrete - 32' bw - subcritical	Trapezoid	2,815.0	0.0025	0.019	32.0	1.5	1.5	11.0	6.2		50.6	256.1	54.4	0.86	Subcritical
Reach 6b - Stacked Gabions - 40' bw - subcr	Irregular	2,815.0	0.0062	0.027				11.7		5.8	43.1	240.8	54.3	0.87	Subcritical
Reach 6c - Stacked Gabions - 50' bw - subcr	Irregular	2,815.0	0.0038	0.026				9.7		5.7	53.1	291.1	64.0	0.73	Subcritical
Reach 6d - Earthen at 2:1/3:1 - 46' bw - subc	Trapezoid	2,815.0	0.0018	0.025	46.0	2.0	3.0	7.2	6.3		77.5	389.0	80.0	0.57	Subcritical
Reach 7 - Earthen at 2:1/3:1 - 70' bw - subcr	Trapezoid	3,921.0	0.0017	0.025	70.0	2.0	3.0	7.3	6.3		101.3	535.7	103.8	0.56	Subcritical
Reach 8 - Earthen at 2:1/3:1 - 108' bw - subc	Trapezoid	5,703.0	0.0016	0.025	108.0	2.0	3.0	7.4	6.3		139.3	773.8	141.8	0.55	Subcritical
Reach 9 - Gabion/Earthen at 2:1/3:1 - 150' b	Trapezoid	12,306.0	0.0044	0.026	150.0	2.0	3.0	12.0	6.2		181.1	028.8	183.5	0.88	Subcritical
Reach 9 End - Gabion at 2:1/2:1 - 93' bw - su	Trapezoid	12,306.0	0.0128	0.030	93.0	2.0	2.0	17.8	6.5		119.1	691.4	122.2	1.30	Supercritic

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 1 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 1)-Earthen-su
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	680.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	30.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
5.00	5.95	5.75	118.2	37.11	34.74
6.00	5.78	5.75	118.3	37.22	34.92
7.00	5.63	5.74	118.5	37.37	35.13
8.00	5.48	5.73	118.8	37.56	35.38
9.00	5.33	5.71	119.0	37.78	35.66
10.00	5.19	5.70	119.4	38.03	35.97
11.00	5.06	5.68	119.7	38.32	36.31
12.00	4.94	5.66	120.1	38.64	36.68
13.00	4.81	5.64	120.5	38.99	37.07
14.00	4.70	5.62	121.0	39.37	37.50
15.00	4.59	5.60	121.5	39.78	37.95
16.00	4.48	5.57	122.0	40.21	38.42
17.00	4.38	5.55	122.6	40.67	38.92
18.00	4.29	5.52	123.2	41.15	39.44
19.00	4.20	5.49	123.8	41.66	39.98
20.00	4.11	5.47	124.4	42.18	40.55
21.00	4.03	5.44	125.0	42.73	41.13
22.00	3.95	5.41	125.7	43.30	41.73
23.00	3.87	5.38	126.4	43.88	42.34
24.00	3.79	5.35	127.1	44.49	42.97
25.00	3.72	5.32	127.8	45.10	43.62
26.00	3.66	5.29	128.5	45.74	44.28
27.00	3.59	5.26	129.2	46.39	44.96
28.00	3.53	5.23	130.0	47.05	45.65
29.00	3.47	5.20	130.7	47.73	46.35
30.00	3.41	5.17	131.5	48.42	47.06

BR1-1

City of Kingman - RR Channel / Reach 1 / Station 5+00 to 57+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 1)-Earthen-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	20.00	ft
Discharge	680.00	cfs

Results		
Depth	4.11	ft
Flow Area	124.4	ft²
Wetted Perimeter	42.18	ft
Top Width	40.55	ft
Critical Depth	2.90	ft
Critical Slope	0.007217	ft/ft
Velocity	5.47	ft/s
Velocity Head	0.46	ft
Specific Energy	4.57	ft
Froude Number	0.55	
Flow Type	Subcritical	

BR 1-2

City of Kingman - RR Channel / Reach 1 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 1)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	680.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	10.00	30.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
10.00	5.98	5.18	131.3	36.74	33.92
15.00	5.25	5.08	133.7	38.46	35.99
20.00	4.67	4.96	137.1	40.89	38.68
25.00	4.22	4.82	141.0	43.86	41.86
30.00	3.85	4.68	145.2	47.22	45.40

City of Kingman - RR Channel / Reach 1 / Station 5+00 to 57+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 1)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	15.00	ft
Discharge	680.00	cfs

Results		
Depth	5.25	ft
Flow Area	133.7	ft²
Wetted Perimeter	38.46	ft
Top Width	35.99	ft
Critical Depth	3.41	ft
Critical Slope	0.010262	ft/ft
Velocity	5.08	ft/s
Velocity Head	0.40	ft
Specific Energy	5.65	ft
Froude Number	0.46	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 1 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 1)-F
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	680.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	2.00	35.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
2.00	8.06	4.66	146.1	38.05	34.24
3.00	7.83	4.66	146.0	38.00	34.31
4.00	7.60	4.66	146.0	38.00	34.41
5.00	7.39	4.66	146.1	38.03	34.55
6.00	7.18	4.65	146.2	38.11	34.72
7.00	6.98	4.65	146.3	38.22	34.92
8.00	6.79	4.64	146.6	38.37	35.16
9.00	6.61	4.63	146.9	38.56	35.44
10.00	6.44	4.62	147.2	38.78	35.74
11.00	6.27	4.61	147.6	39.04	36.08
12.00	6.11	4.59	148.0	39.33	36.44
13.00	5.96	4.58	148.5	39.65	36.84
14.00	5.81	4.56	149.0	40.00	37.26
15.00	5.68	4.55	149.6	40.39	37.71
16.00	5.54	4.53	150.2	40.80	38.18
17.00	5.42	4.51	150.8	41.23	38.68
18.00	5.30	4.49	151.5	41.70	39.19
19.00	5.18	4.47	152.2	42.18	39.73
20.00	5.07	4.45	153.0	42.69	40.29
21.00	4.97	4.42	153.7	43.22	40.87
22.00	4.87	4.40	154.5	43.77	41.47
23.00	4.77	4.38	155.3	44.34	42.09
24.00	4.68	4.36	156.1	44.93	42.72
25.00	4.59	4.33	157.0	45.53	43.37
26.00	4.51	4.31	157.8	46.16	44.03
27.00	4.43	4.29	158.7	46.79	44.70
28.00	4.35	4.26	159.6	47.45	45.39
29.00	4.27	4.24	160.4	48.11	46.09
30.00	4.20	4.21	161.4	48.79	46.81
31.00	4.13	4.19	162.3	49.48	47.53
32.00	4.07	4.17	163.2	50.18	48.26
33.00	4.00	4.14	164.1	50.90	49.01
34.00	3.94	4.12	165.0	51.62	49.76
35.00	3.88	4.10	166.0	52.36	50.52

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

BR1-5

City of Kingman - RR Channel / Reach 1 / Station 5+00 to 57+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 1)-Riprap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	680.00	cfs

Results		
Depth	5.07	ft
Flow Area	153.0	ft²
Wetted Perimeter	42.69	ft
Top Width	40.29	ft
Critical Depth	2.97	ft
Critical Slope	0.014086	ft/ft
Velocity	4.45	ft/s
Velocity Head	0.31	ft
Specific Energy	5.38	ft
Froude Number	0.40	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 1 / Concrete
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 1)-Concrete-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	002000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Discharge	680.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	2.00	30.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
2.00	7.06	7.65	88.9	27.45	23.18
3.00	6.76	7.66	88.7	27.36	23.27
4.00	6.47	7.67	88.7	27.33	23.41
5.00	6.20	7.66	88.7	27.37	23.61
6.00	5.95	7.65	88.9	27.46	23.86
7.00	5.72	7.63	89.1	27.62	24.15
8.00	5.50	7.61	89.3	27.82	24.50
9.00	5.29	7.58	89.7	28.09	24.88
10.00	5.10	7.55	90.1	28.40	25.31
11.00	4.92	7.51	90.5	28.75	25.77
12.00	4.76	7.47	91.0	29.15	26.27
13.00	4.60	7.43	91.6	29.59	26.80
14.00	4.46	7.38	92.1	30.06	27.37
15.00	4.32	7.33	92.8	30.57	27.96
16.00	4.19	7.28	93.4	31.11	28.57
17.00	4.07	7.23	94.1	31.68	29.22
18.00	3.96	7.17	94.8	32.28	29.88
19.00	3.85	7.12	95.5	32.90	30.56
20.00	3.76	7.06	96.3	33.54	31.27
21.00	3.66	7.01	97.0	34.20	31.99
22.00	3.57	6.95	97.8	34.89	32.72
23.00	3.49	6.90	98.6	35.59	33.47
24.00	3.41	6.84	99.4	36.30	34.24
25.00	3.34	6.79	100.2	37.04	35.01
26.00	3.27	6.74	101.0	37.78	35.80
27.00	3.20	6.68	101.8	38.54	36.60
28.00	3.14	6.63	102.6	39.31	37.41
29.00	3.08	6.58	103.4	40.09	38.23
30.00	3.02	6.53	104.2	40.88	39.05

BR1-7

City of Kingman - RR Channel / Reach 1 / Station 5+00 to 57+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 1)-Concrete-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.019	
Slope	0.002000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	10.00	ft
Discharge	680.00	cfs

Results		
Depth	5.10	ft
Flow Area	90.1	ft²
Wetted Perimeter	28.40	ft
Top Width	25.31	ft
Critical Depth	4.21	ft
Critical Slope	0.004188	ft/ft
Velocity	7.55	ft/s
Velocity Head	0.89	ft
Specific Energy	5.99	ft
Froude Number	0.71	
Flow Type	Subcritical	

BRI-8

City of Kingman - RR Channel / Reach 2 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 2)-Earthen-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	003000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	,590.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	35.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
5.00	7.82	8.29	191.8	47.19	44.08
6.00	7.64	8.29	191.9	47.26	44.21
7.00	7.48	8.28	192.1	47.36	44.38
8.00	7.31	8.27	192.3	47.49	44.57
9.00	7.16	8.26	192.5	47.64	44.79
10.00	7.01	8.25	192.8	47.83	45.03
11.00	6.86	8.23	193.2	48.04	45.30
12.00	6.72	8.22	193.5	48.28	45.60
13.00	6.58	8.20	194.0	48.54	45.92
14.00	6.45	8.18	194.4	48.83	46.26
15.00	6.33	8.16	194.9	49.15	46.63
16.00	6.20	8.13	195.5	49.49	47.02
17.00	6.09	8.11	196.0	49.85	47.43
18.00	5.97	8.09	196.6	50.24	47.86
19.00	5.86	8.06	197.3	50.64	48.31
20.00	5.76	8.03	197.9	51.07	48.78
21.00	5.65	8.00	198.6	51.52	49.27
22.00	5.56	7.98	199.4	51.99	49.78
23.00	5.46	7.95	200.1	52.47	50.30
24.00	5.37	7.92	200.9	52.98	50.84
25.00	5.28	7.88	201.7	53.50	51.40
26.00	5.19	7.85	202.5	54.04	51.97
27.00	5.11	7.82	203.3	54.59	52.55
28.00	5.03	7.79	204.1	55.16	53.15
29.00	4.95	7.76	205.0	55.74	53.77
30.00	4.88	7.72	205.9	56.34	54.39
31.00	4.81	7.69	206.8	56.95	55.03
32.00	4.74	7.66	207.7	57.57	55.68
33.00	4.67	7.62	208.6	58.20	56.34
34.00	4.60	7.59	209.5	58.85	57.02
35.00	4.54	7.56	210.4	59.51	57.70

City of Kingman - RR Channel / Reach 2 / Station 57+00 to 75+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 2)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.003000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	15.00	ft
Discharge	1,590.00	cfs

Results		
Depth	6.33	ft
Flow Area	194.9	ft²
Wetted Perimeter	49.15	ft
Top Width	46.63	ft
Critical Depth	5.26	ft
Critical Slope	0.006357	ft/ft
Velocity	8.16	ft/s
Velocity Head	1.03	ft
Specific Energy	7.36	ft
Froude Number	0.70	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 2 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 2)-Gabion-sul
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.030	
Slope	003000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,590.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	10.00	60.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
10.00	8.10	7.49	212.2	46.22	42.40
15.00	7.26	7.41	214.5	47.49	44.06
20.00	6.57	7.30	217.9	49.40	46.29
25.00	6.00	7.16	222.2	51.85	49.01
30.00	5.53	7.00	227.0	54.73	52.12
35.00	5.13	6.85	232.3	57.95	55.53
40.00	4.79	6.69	237.8	61.44	59.18
45.00	4.51	6.53	243.4	65.15	63.03
50.00	4.26	6.38	249.1	69.04	67.03
55.00	4.04	6.24	254.8	73.07	71.16
60.00	3.85	6.10	260.5	77.21	75.39

City of Kingman - RR Channel / Reach 2 / Station 57+00 to 75+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 2)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.003000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	15.00	ft
Discharge	1,590.00	cfs

Results		
Depth	7.26	ft
Flow Area	214.5	ft²
Wetted Perimeter	47.49	ft
Top Width	44.06	ft
Critical Depth	5.49	ft
Critical Slope	0.009151	ft/ft
Velocity	7.41	ft/s
Velocity Head	0.85	ft
Specific Energy	8.12	ft
Froude Number	0.59	
Flow Type	Subcritical	

D 07 11

City of Kingman - RR Channel / Reach 2 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 2)-R
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	003000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,590.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	30.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
5.00	9.71	6.71	237.1	48.42	43.84
6.00	9.49	6.70	237.2	48.45	43.97
7.00	9.28	6.70	237.3	48.51	44.13
8.00	9.08	6.70	237.5	48.60	44.31
9.00	8.88	6.69	237.7	48.72	44.53
10.00	8.69	6.68	238.0	48.87	44.77
11.00	8.51	6.67	238.3	49.05	45.03
12.00	8.33	6.66	238.7	49.25	45.32
13.00	8.16	6.65	239.2	49.49	45.63
14.00	7.99	6.63	239.7	49.75	45.97
15.00	7.83	6.62	240.2	50.03	46.34
16.00	7.68	6.60	240.8	50.35	46.72
17.00	7.53	6.58	241.5	50.68	47.13
18.00	7.39	6.57	242.2	51.04	47.55
19.00	7.25	6.55	242.9	51.42	48.00
20.00	7.12	6.53	243.7	51.83	48.47
21.00	6.99	6.50	244.5	52.26	48.96
22.00	6.87	6.48	245.3	52.70	49.46
23.00	6.75	6.46	246.2	53.17	49.98
24.00	6.63	6.44	247.0	53.65	50.52
25.00	6.52	6.41	248.0	54.15	51.08
26.00	6.41	6.39	248.9	54.67	51.65
27.00	6.31	6.36	249.9	55.21	52.23
28.00	6.21	6.34	250.9	55.76	52.83
29.00	6.11	6.31	251.9	56.33	53.44
30.00	6.02	6.29	252.9	56.91	54.07

007_C

City of Kingman - RR Channel / Reach 2 / Station 57+00 to 75+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 2)-Riprap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.003000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	1,590.00	cfs

Results		
Depth	7.12	ft
Flow Area	243.7	ft²
Wetted Perimeter	51.83	ft
Top Width	48.47	ft
Critical Depth	4.90	ft
Critical Slope	0.012464	ft/ft
Velocity	6.53	ft/s
Velocity Head	0.66	ft
Specific Energy	7.78	ft
Froude Number	0.51	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 2 / Concrete
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 2)-Concrete-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	003000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Discharge	,590.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	2.00	30.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
2.00	9.17	11.01	144.4	35.06	29.51
3.00	8.86	11.02	144.2	34.93	29.57
4.00	8.56	11.03	144.1	34.86	29.68
5.00	8.27	11.04	144.1	34.83	29.82
6.00	8.00	11.03	144.1	34.86	30.01
7.00	7.75	11.02	144.2	34.93	30.24
8.00	7.50	11.01	144.4	35.05	30.50
9.00	7.27	10.99	144.7	35.21	30.81
10.00	7.05	10.96	145.0	35.42	31.15
11.00	6.84	10.93	145.4	35.66	31.52
12.00	6.64	10.90	145.9	35.95	31.93
13.00	6.46	10.86	146.4	36.27	32.37
14.00	6.28	10.82	147.0	36.63	32.83
15.00	6.11	10.77	147.6	37.03	33.33
16.00	5.95	10.72	148.3	37.45	33.85
17.00	5.80	10.67	149.0	37.91	34.40
18.00	5.66	10.62	149.8	38.39	34.97
19.00	5.52	10.56	150.6	38.90	35.56
20.00	5.39	10.50	151.4	39.44	36.17
21.00	5.27	10.44	152.2	39.99	36.80
22.00	5.15	10.38	153.1	40.57	37.45
23.00	5.04	10.32	154.0	41.17	38.12
24.00	4.93	10.26	155.0	41.79	38.80
25.00	4.83	10.20	155.9	42.43	39.50
26.00	4.74	10.14	156.8	43.08	40.21
27.00	4.65	10.07	157.8	43.75	40.94
28.00	4.56	10.01	158.8	44.44	41.67
29.00	4.47	9.95	159.8	45.13	42.42
30.00	4.39	9.89	160.8	45.84	43.18

City of Kingman - RR Channel / Reach 2 / Station 57+00 to 75+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 2)-Concrete-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.019	
Slope	0.003000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	10.00	ft
Discharge	1,590.00	cfs

Results		
Depth	7.05	ft
Flow Area	145.0	ft²
Wetted Perimeter	35.42	ft
Top Width	31.15	ft
Critical Depth	6.66	ft
Critical Slope	0.003787	ft/ft
Velocity	10.96	ft/s
Velocity Head	1.87	ft
Specific Energy	8.92	ft
Froude Number	0.90	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 3 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 3)-Earthen-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	002500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	,995.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	10.00	40.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
10.00	8.09	8.16	244.3	53.65	50.43
11.00	7.93	8.15	244.7	53.83	50.67
12.00	7.79	8.14	245.0	54.04	50.93
13.00	7.64	8.13	245.4	54.26	51.22
14.00	7.51	8.11	245.9	54.52	51.53
15.00	7.37	8.10	246.4	54.79	51.86
16.00	7.24	8.08	246.9	55.09	52.20
17.00	7.11	8.06	247.5	55.41	52.57
18.00	6.99	8.04	248.1	55.75	52.96
19.00	6.87	8.02	248.8	56.11	53.37
20.00	6.76	8.00	249.4	56.49	53.80
21.00	6.65	7.98	250.1	56.89	54.24
22.00	6.54	7.95	250.9	57.31	54.71
23.00	6.44	7.93	251.6	57.75	55.18
24.00	6.34	7.90	252.4	58.20	55.68
25.00	6.24	7.88	253.2	58.68	56.19
26.00	6.14	7.85	254.1	59.16	56.72
27.00	6.05	7.83	254.9	59.67	57.26
28.00	5.96	7.80	255.8	60.19	57.81
29.00	5.88	7.77	256.7	60.72	58.38
30.00	5.79	7.74	257.7	61.27	58.96
31.00	5.71	7.71	258.6	61.83	59.56
32.00	5.63	7.69	259.6	62.41	60.16
33.00	5.56	7.66	260.5	62.99	60.78
34.00	5.48	7.63	261.5	63.59	61.41
35.00	5.41	7.60	262.5	64.21	62.05
36.00	5.34	7.57	263.5	64.83	62.70
37.00	5.27	7.54	264.6	65.46	63.36
38.00	5.21	7.51	265.6	66.11	64.03
39.00	5.14	7.48	266.7	66.76	64.71
40.00	5.08	7.45	267.7	67.42	65.40

City of Kingman - RR Channel / Reach 3 / Station 75+00 to 85+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 3)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.002500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	20.00	ft
Discharge	1,995.00	cfs

Results		
Depth	6.76	ft
Flow Area	249.4	ft²
Wetted Perimeter	56.49	ft
Top Width	53.80	ft
Critical Depth	5.37	ft
Critical Slope	0.006176	ft/ft
Velocity	8.00	ft/s
Velocity Head	0.99	ft
Specific Energy	7.75	ft
Froude Number	0.65	
Flow Type	Subcritical	

1.28%

Existing Longitudinal Slope = ~~2.36%~~

(0.0198 - 0.0025) = 16.3'

(1000')(~~0.236~~ - 0.0025) = ~~24.1~~

2'

Provide ~~3~~' drop structures (~~3.01'~~ 2.038')

8

7 drop-structures

1000/9 = 111.11' INTERVAL

1000 ÷ 7 = 142.86' interval

City of Kingman - RR Channel / Reach 3 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 3)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.007000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	1,995.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	10.00	30.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
10.00	7.39	10.88	183.3	43.07	39.58
15.00	6.59	10.75	185.7	44.47	41.36
20.00	5.93	10.55	189.1	46.53	43.73
25.00	5.40	10.32	193.2	49.14	46.59
30.00	4.96	10.08	197.9	52.17	49.83

RR3-3

City of Kingman - RR Channel / Reach 3 / Station 75+00 to 85+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 3)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.007000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	15.00	ft
Discharge	1,995.00	cfs

Results		
Depth	6.59	ft
Flow Area	185.7	ft²
Wetted Perimeter	44.47	ft
Top Width	41.36	ft
Critical Depth	6.21	ft
Critical Slope	0.008885	ft/ft
Velocity	10.75	ft/s
Velocity Head	1.79	ft
Specific Energy	8.38	ft
Froude Number	0.89	
Flow Type	Subcritical	

(0.0128)
(1000')(.0236 - 0.007) = 16.6

* (7) drop structures
2.37' each

* (5 DROP STRUCTURES USED)

142.85' interval

202-11

City of Kingman - RR Channel / Reach 3 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 3)-R
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	009500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,995.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	30.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
5.00	8.38	10.93	182.5	42.49	38.53
6.00	8.17	10.93	182.6	42.54	38.69
7.00	7.97	10.92	182.7	42.63	38.87
8.00	7.77	10.91	182.9	42.75	39.08
9.00	7.58	10.89	183.2	42.90	39.33
10.00	7.40	10.87	183.5	43.09	39.60
11.00	7.23	10.85	183.9	43.31	39.90
12.00	7.06	10.82	184.3	43.56	40.23
13.00	6.90	10.80	184.8	43.84	40.59
14.00	6.74	10.77	185.3	44.15	40.97
15.00	6.59	10.73	185.9	44.49	41.38
16.00	6.45	10.70	186.5	44.85	41.81
17.00	6.32	10.66	187.1	45.24	42.26
18.00	6.18	10.62	187.8	45.66	42.74
19.00	6.06	10.58	188.5	46.09	43.23
20.00	5.94	10.54	189.3	46.55	43.75
21.00	5.82	10.50	190.0	47.04	44.29
22.00	5.71	10.45	190.9	47.54	44.84
23.00	5.60	10.41	191.7	48.06	45.42
24.00	5.50	10.36	192.6	48.60	46.00
25.00	5.40	10.31	193.4	49.16	46.61
26.00	5.31	10.27	194.3	49.74	47.23
27.00	5.22	10.22	195.3	50.33	47.87
28.00	5.13	10.17	196.2	50.94	48.51
29.00	5.04	10.12	197.2	51.56	49.18
30.00	4.96	10.07	198.1	52.19	49.85

Notes: Existing Longitudinal Slope = 2.36%

207

City of Kingman - RR Channel / Reach 3 / Station 75+00 to 85+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 3)-Riprap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.009500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	1,995.00	cfs

Results		
Depth	5.94	ft
Flow Area	189.3	ft²
Wetted Perimeter	46.55	ft
Top Width	43.75	ft
Critical Depth	5.57	ft
Critical Slope	0.012083	ft/ft
Velocity	10.54	ft/s
Velocity Head	1.73	ft
Specific Energy	7.66	ft
Froude Number	0.89	
Flow Type	Subcritical	

$(1000')(0.0158 - 0.0095) = 9.3'$

2' drop structures ⇒ 4 DROP STRUCTURES AT 2.325 ft.

7 total

142.85' interval

DR2-1.

City of Kingman - RR Channel / Reach 3 / Concrete
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 3) - Concrete Subcritical w/ Hig
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	012800	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Discharge	,995.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	8.00	30.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
8.00	5.91	20.01	99.7	29.31	25.73
9.00	5.70	19.95	100.0	29.55	26.10
10.00	5.50	19.87	100.4	29.83	26.50
11.00	5.32	19.78	100.8	30.16	26.95
12.00	5.14	19.69	101.3	30.54	27.42
13.00	4.98	19.58	101.9	30.95	27.93
14.00	4.83	19.47	102.5	31.40	28.48
15.00	4.68	19.35	103.1	31.88	29.04
16.00	4.55	19.23	103.8	32.39	29.64
17.00	4.42	19.10	104.5	32.94	30.26
18.00	4.30	18.97	105.2	33.51	30.90
19.00	4.19	18.83	105.9	34.10	31.57
20.00	4.08	18.70	106.7	34.72	32.25
21.00	3.98	18.56	107.5	35.36	32.95
22.00	3.89	18.43	108.3	36.02	33.67
23.00	3.80	18.29	109.1	36.70	34.40
24.00	3.72	18.15	109.9	37.40	35.15
25.00	3.64	18.02	110.7	38.11	35.91
26.00	3.56	17.88	111.6	38.84	36.68
27.00	3.49	17.75	112.4	39.58	37.46
28.00	3.42	17.61	113.3	40.33	38.26
29.00	3.35	17.48	114.1	41.09	39.06
30.00	3.29	17.35	115.0	41.87	39.87

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 3 / Station 75+00 to 85+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 3) - Concrete Subcritical w/ Hig
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	0.012800	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	9.00	ft
Discharge	,995.00	cfs

Results		
Depth	5.70	ft
Flow Area	100.0	ft²
Wetted Perim	29.55	ft
Top Width	26.10	ft
Critical Depth	7.70	ft
Critical Slope	0.003703	ft/ft
Velocity	19.95	ft/s
Velocity Head	6.18	ft
Specific Ener	11.88	ft
Froude Numb	1.80	
Flow Type	Supercritical	

$(1000')(0.0188 - 0.0128) = 6'$

2 - 3' DROPS

(AT END OF REACH?)

City of Kingman - RR Channel / Reach 4 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 4)-Earthen-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	002500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	,200.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	35.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
5.00	9.28	8.40	261.9	55.12	51.42
6.00	9.11	8.40	262.0	55.16	51.54
7.00	8.94	8.39	262.1	55.23	51.68
8.00	8.77	8.39	262.3	55.33	51.84
9.00	8.60	8.38	262.5	55.45	52.02
10.00	8.45	8.37	262.8	55.60	52.23
11.00	8.29	8.36	263.1	55.77	52.46
12.00	8.14	8.35	263.5	55.96	52.72
13.00	8.00	8.34	263.9	56.18	52.99
14.00	7.86	8.32	264.4	56.42	53.29
15.00	7.72	8.31	264.9	56.68	53.61
16.00	7.59	8.29	265.4	56.97	53.94
17.00	7.46	8.27	266.0	57.27	54.30
18.00	7.34	8.25	266.6	57.60	54.68
19.00	7.21	8.23	267.2	57.95	55.07
20.00	7.10	8.21	267.9	58.31	55.49
21.00	6.98	8.19	268.6	58.70	55.92
22.00	6.87	8.17	269.3	59.11	56.37
23.00	6.77	8.15	270.1	59.53	56.83
24.00	6.66	8.12	270.9	59.97	57.31
25.00	6.56	8.10	271.7	60.43	57.81
26.00	6.46	8.07	272.6	60.90	58.32
27.00	6.37	8.05	273.4	61.39	58.85
28.00	6.28	8.02	274.3	61.89	59.39
29.00	6.19	7.99	275.3	62.41	59.95
30.00	6.10	7.97	276.2	62.95	60.51
31.00	6.02	7.94	277.2	63.49	61.09
32.00	5.94	7.91	278.1	64.05	61.69
33.00	5.86	7.88	279.1	64.63	62.29
34.00	5.78	7.85	280.1	65.21	62.91
35.00	5.71	7.82	281.2	65.81	63.53

City of Kingman - RR Channel / Reach 4 / Station 85+00 to 115+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 4)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.002500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	30.00	ft
Discharge	2,200.00	cfs

Results		
Depth	6.10	ft
Flow Area	276.2	ft²
Wetted Perimeter	62.95	ft
Top Width	60.51	ft
Critical Depth	4.79	ft
Critical Slope	0.006154	ft/ft
Velocity	7.97	ft/s
Velocity Head	0.99	ft
Specific Energy	7.09	ft
Froude Number	0.66	
Flow Type	Subcritical	

Notes: Natural Ground Slope = 0.35%
Flattened longitudinal slope to provide 8 fps or less.
Drop Structures

I-40 @ STATION 99+00

MUST USE CONCRETE

THIS ALT. WILL NOT "FIT" WITH RR & EASTERN

(3300')(0.0035 − 0.0025) = 3.3' ~~5'~~

1.65' HIGH ~~4.5' High~~

2 drops ~~3 drops~~

INTERVAL = 1100' ~~1500'~~

RD11-7

City of Kingman - RR Channel / Reach 4 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 4)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.003500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	2,200.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	50.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
5.00	10.10	8.65	254.3	50.15	45.38
10.00	9.07	8.62	255.2	50.56	46.27
15.00	8.20	8.55	257.4	51.66	47.79
20.00	7.47	8.44	260.8	53.39	49.86
25.00	6.85	8.30	265.1	55.64	52.40
30.00	6.33	8.14	270.2	58.32	55.33
35.00	5.89	7.98	275.7	61.35	58.57
40.00	5.52	7.81	281.6	64.67	62.07
45.00	5.19	7.65	287.7	68.23	65.77
50.00	4.91	7.49	293.9	71.97	69.65

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

RR4-3

City of Kingman - RR Channel / Reach 4 / Station 85+00 to 115+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 4)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.003500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	2,200.00	cfs

Results		
Depth	7.47	ft
Flow Area	260.8	ft²
Wetted Perimeter	53.39	ft
Top Width	49.86	ft
Critical Depth	5.89	ft
Critical Slope	0.008761	ft/ft
Velocity	8.44	ft/s
Velocity Head	1.11	ft
Specific Energy	8.57	ft
Froude Number	0.65	
Flow Type	Subcritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

BR4-4

City of Kingman - RR Channel / Reach 5 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 5)-Earthen-Su
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	002500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	,390.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	20.00	50.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
20.00	7.39	8.40	284.6	59.92	56.97
21.00	7.28	8.38	285.3	60.29	57.40
22.00	7.17	8.35	286.1	60.69	57.83
23.00	7.06	8.33	286.8	61.10	58.29
24.00	6.95	8.31	287.6	61.53	58.76
25.00	6.85	8.29	288.5	61.97	59.24
26.00	6.75	8.26	289.3	62.43	59.74
27.00	6.65	8.24	290.2	62.91	60.26
28.00	6.56	8.21	291.1	63.40	60.79
29.00	6.47	8.18	292.0	63.91	61.33
30.00	6.38	8.16	293.0	64.43	61.89
31.00	6.29	8.13	294.0	64.96	62.45
32.00	6.21	8.10	294.9	65.51	63.04
33.00	6.13	8.08	296.0	66.07	63.63
34.00	6.05	8.05	297.0	66.64	64.23
35.00	5.97	8.02	298.0	67.22	64.85
36.00	5.89	7.99	299.1	67.82	65.47
37.00	5.82	7.96	300.1	68.43	66.11
38.00	5.75	7.93	301.2	69.05	66.75
39.00	5.68	7.91	302.3	69.67	67.41
40.00	5.61	7.88	303.4	70.31	68.07
41.00	5.55	7.85	304.5	70.96	68.75
42.00	5.49	7.82	305.7	71.62	69.43
43.00	5.42	7.79	306.8	72.28	70.12
44.00	5.36	7.76	307.9	72.96	70.82
45.00	5.30	7.73	309.1	73.64	71.52
46.00	5.25	7.70	310.2	74.33	72.24
47.00	5.19	7.68	311.4	75.03	72.96
48.00	5.14	7.65	312.6	75.73	73.69
49.00	5.08	7.62	313.7	76.45	74.42
50.00	5.03	7.59	314.9	77.17	75.16

DUE TO WIDTH OF REACH 3

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 5 / Station 115+00 to 125+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 5)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.002500	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	35.00	ft
Discharge	2,390.00	cfs

Results		
Depth	5.97	ft
Flow Area	298.0	ft²
Wetted Perimeter	67.22	ft
Top Width	64.85	ft
Critical Depth	4.67	ft
Critical Slope	0.006120	ft/ft
Velocity	8.02	ft/s
Velocity Head	1.00	ft
Specific Energy	6.97	ft
Froude Number	0.66	
Flow Type	Subcritical	

Natural Slope = 0.90%

1200 (0.009 - 0.0025) = 5.4'

~~(1000)(0.009 - 0.0025) = 6.5'~~ 1.8' ~~2.17'~~

3 drop structures

~~1000 ÷ 3~~ = 333.33' interval

1200 / 4 = 300' INTERVAL

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 5 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 5)-Gabion-sul
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.030	
Slope	007000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,390.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	5.00	100.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
5.00	9.04	11.45	208.7	45.44	41.17
10.00	8.04	11.40	209.7	45.95	42.16
15.00	7.21	11.28	212.0	47.23	43.83
20.00	6.52	11.10	215.4	49.15	46.08
25.00	5.95	10.88	219.6	51.62	48.81
30.00	5.48	10.65	224.5	54.51	51.92
35.00	5.09	10.40	229.7	57.74	55.34
40.00	4.75	10.16	235.2	61.25	59.00
45.00	4.47	9.93	240.8	64.97	62.86
50.00	4.22	9.70	246.5	68.86	66.87
55.00	4.00	9.48	252.2	72.90	71.01
60.00	3.81	9.27	257.8	77.05	75.25
65.00	3.64	9.07	263.4	81.30	79.57
70.00	3.49	8.89	268.9	85.62	83.97
75.00	3.36	8.71	274.4	90.01	88.43
80.00	3.23	8.54	279.7	94.47	92.94
85.00	3.12	8.39	285.0	98.97	97.49
90.00	3.02	8.24	290.1	103.51	102.08
95.00	2.93	8.10	295.2	108.09	106.71
100.00	2.84	7.96	300.2	112.70	111.36

City of Kingman - RR Channel / Reach 5 / Station 115+00 to 125+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 5)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.007000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	2,390.00	cfs

Results		
Depth	6.52	ft
Flow Area	215.4	ft²
Wetted Perimeter	49.15	ft
Top Width	46.08	ft
Critical Depth	6.17	ft
Critical Slope	0.008664	ft/ft
Velocity	11.10	ft/s
Velocity Head	1.91	ft
Specific Energy	8.43	ft
Froude Number	0.90	
Flow Type	Subcritical	

Notes: Exisiting Longitudinal Slope = 0.90%
Slope decreased to insure subcritical, stable flow

$(1000')(0.009 - 0.007) = 2'$

6-25-00

X drop structure ← (DROP STRUCTURE REMOVED)

10'00' interval (@ STATION 115+00) (?)

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 5 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 5)-F
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	007000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,390.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	10.00	40.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
10.00	8.63	10.16	235.2	48.58	44.51
11.00	8.44	10.15	235.5	48.76	44.78
12.00	8.27	10.13	235.9	48.97	45.07
13.00	8.10	10.11	236.4	49.21	45.39
14.00	7.93	10.09	236.9	49.47	45.73
15.00	7.77	10.07	237.4	49.76	46.09
16.00	7.62	10.04	238.0	50.07	46.48
17.00	7.47	10.01	238.7	50.41	46.89
18.00	7.33	9.99	239.3	50.78	47.32
19.00	7.19	9.96	240.1	51.16	47.77
20.00	7.06	9.92	240.8	51.57	48.23
21.00	6.93	9.89	241.6	52.00	48.72
22.00	6.81	9.86	242.5	52.44	49.23
23.00	6.69	9.82	243.3	52.91	49.76
24.00	6.57	9.79	244.2	53.40	50.30
25.00	6.46	9.75	245.1	53.91	50.85
26.00	6.36	9.71	246.1	54.43	51.43
27.00	6.25	9.67	247.1	54.97	52.01
28.00	6.15	9.64	248.0	55.52	52.62
29.00	6.06	9.60	249.1	56.09	53.23
30.00	5.96	9.56	250.1	56.68	53.86
31.00	5.87	9.52	251.2	57.27	54.50
32.00	5.79	9.48	252.2	57.88	55.15
33.00	5.70	9.44	253.3	58.51	55.82
34.00	5.62	9.39	254.4	59.15	56.49
35.00	5.54	9.35	255.5	59.79	57.18
36.00	5.47	9.31	256.6	60.45	57.87
37.00	5.39	9.27	257.8	61.12	58.58
38.00	5.32	9.23	258.9	61.80	59.29
39.00	5.25	9.19	260.1	62.49	60.01
40.00	5.19	9.15	261.2	63.19	60.74

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 5 / Station 115+00 to 125+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 5)-R
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	007000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	,390.00	cfs

Results		
Depth	7.06	ft
Flow Area	240.8	ft²
Wetted Perim	51.57	ft
Top Width	48.23	ft
Critical Depth	6.17	ft
Critical Slope	0.011793	ft/ft
Velocity	9.92	ft/s
Velocity Head	1.53	ft
Specific Energ	8.59	ft
Froude Numb	0.78	
Flow Type	Subcritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 5 / Concrete
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 5)-Concrete-sup
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	0.007000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Discharge	,390.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	10.00	40.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
10.00	6.99	16.68	143.3	35.22	30.98
11.00	6.79	16.63	143.7	35.47	31.36
12.00	6.59	16.58	144.2	35.76	31.77
13.00	6.40	16.52	144.7	36.08	32.21
14.00	6.23	16.45	145.3	36.45	32.68
15.00	6.06	16.38	145.9	36.84	33.17
16.00	5.90	16.30	146.6	37.27	33.70
17.00	5.75	16.22	147.3	37.73	34.25
18.00	5.61	16.14	148.1	38.21	34.82
19.00	5.47	16.06	148.9	38.73	35.41
20.00	5.34	15.97	149.7	39.26	36.03
21.00	5.22	15.88	150.5	39.82	36.66
22.00	5.11	15.79	151.4	40.41	37.32
23.00	4.99	15.69	152.3	41.01	37.98
24.00	4.89	15.60	153.2	41.63	38.67
25.00	4.79	15.50	154.2	42.27	39.37
26.00	4.69	15.41	155.1	42.93	40.08
27.00	4.60	15.31	156.1	43.60	40.81
28.00	4.52	15.22	157.1	44.28	41.55
29.00	4.43	15.12	158.0	44.98	42.30
30.00	4.35	15.03	159.0	45.70	43.06
31.00	4.28	14.93	160.1	46.42	43.83
32.00	4.20	14.84	161.1	47.16	44.61
33.00	4.13	14.75	162.1	47.91	45.40
34.00	4.07	14.65	163.1	48.66	46.20
35.00	4.00	14.56	164.1	49.43	47.01
36.00	3.94	14.47	165.1	50.21	47.82
37.00	3.88	14.38	166.2	50.99	48.64
38.00	3.82	14.29	167.2	51.78	49.47
39.00	3.77	14.21	168.2	52.58	50.30
40.00	3.71	14.12	169.3	53.39	51.14

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

BR5-7

City of Kingman - RR Channel / Reach 5 / Station 115+00 to 125+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 5)-Concrete-sup
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	007000	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	30.00	ft
Discharge	,390.00	cfs

Results		
Depth	4.35	ft
Flow Area	159.0	ft²
Wetted Perim	45.70	ft
Top Width	43.06	ft
Critical Depth	5.30	ft
Critical Slope	0.003517	ft/ft
Velocity	15.03	ft/s
Velocity Head	3.51	ft
Specific Energ	7.86	ft
Froude Numb	1.38	
Flow Type	Supercritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 6 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 6)-Earthen-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	,815.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	25.00	55.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
25.00	7.88	7.99	352.2	67.53	64.39
26.00	7.77	7.97	353.0	67.95	64.86
27.00	7.67	7.95	353.9	68.39	65.33
28.00	7.56	7.93	354.9	68.84	65.82
29.00	7.47	7.91	355.8	69.30	66.33
30.00	7.37	7.89	356.8	69.78	66.84
31.00	7.27	7.87	357.8	70.27	67.37
32.00	7.18	7.84	358.8	70.78	67.91
33.00	7.09	7.82	359.9	71.29	68.47
34.00	7.01	7.80	361.0	71.82	69.03
35.00	6.92	7.78	362.0	72.37	69.61
36.00	6.84	7.75	363.1	72.92	70.20
37.00	6.76	7.73	364.3	73.49	70.79
38.00	6.68	7.70	365.4	74.06	71.40
39.00	6.60	7.68	366.6	74.65	72.02
40.00	6.53	7.65	367.7	75.25	72.65
41.00	6.46	7.63	368.9	75.85	73.28
42.00	6.39	7.61	370.1	76.47	73.93
43.00	6.32	7.58	371.3	77.10	74.58
44.00	6.25	7.56	372.6	77.73	75.24
45.00	6.18	7.53	373.8	78.38	75.91
46.00	6.12	7.51	375.0	79.03	76.59
47.00	6.06	7.48	376.3	79.69	77.28
48.00	5.99	7.46	377.5	80.36	77.97
49.00	5.93	7.43	378.8	81.03	78.67
50.00	5.88	7.41	380.1	81.72	79.38
51.00	5.82	7.38	381.4	82.41	80.09
52.00	5.76	7.36	382.6	83.11	80.81
53.00	5.71	7.33	383.9	83.81	81.54
54.00	5.65	7.31	385.2	84.52	82.27
55.00	5.60	7.28	386.5	85.24	83.01

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 6 / Station 125+00 to 167+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 6)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	25.00	ft
Discharge	2,815.00	cfs

Results		
Depth	7.88	ft
Flow Area	352.2	ft²
Wetted Perimeter	67.53	ft
Top Width	64.39	ft
Critical Depth	5.97	ft
Critical Slope	0.005907	ft/ft
Velocity	7.99	ft/s
Velocity Head	0.99	ft
Specific Energy	8.87	ft
Froude Number	0.60	
Flow Type	Subcritical	

Airway Ave @ STA 134+00

Natural Slope = 0.90 %

4671.26 (0.00734 - 0.002) = 24.945'

~~4200' (0.009 - .002) = 29.4'~~

~~15 drop structures~~ 12 DROP STRUCTURES

~~14 @ 2'~~

~~1 @ 1.4'~~

12 @ 2.079'

~~INTERVAL = 4200 ÷ 15 = 280'~~

4671.26 / 13 = 359.33'

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

R Rio - 2

City of Kingman - RR Channel / Reach 6 / Gabions
Rating Table for Trapezoidal Channel

STA 125+00 TO STA 167+00

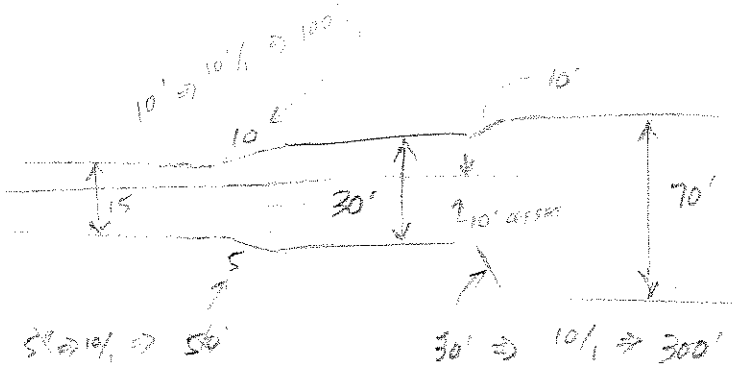
Project Description	
Worksheet	2:1 slopes (Reach 6)-Gabion-sui
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.030	
Slope	006000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,815.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	10.00	100.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
10.00	8.97	11.22	250.8	50.14	45.90
15.00	8.11	11.12	253.1	51.26	47.43
20.00	7.38	10.98	256.5	53.00	49.51
25.00	6.77	10.79	260.8	55.27	52.07
30.00	6.25	10.59	265.8	57.97	55.01
35.00	5.82	10.37	271.3	61.02	58.27
40.00	5.45	10.16	277.2	64.36	61.79
45.00	5.13	9.94	283.2	67.92	65.50
50.00	4.85	9.73	289.4	71.68	69.39
55.00	4.60	9.52	295.6	75.59	73.42
60.00	4.39	9.33	301.8	79.63	77.55
65.00	4.20	9.14	308.0	83.77	81.79
70.00	4.02	8.96	314.1	88.00	86.10
75.00	3.87	8.79	320.2	92.31	90.48
80.00	3.73	8.63	326.2	96.68	94.92
85.00	3.60	8.48	332.1	101.11	99.41
90.00	3.48	8.33	337.9	105.58	103.94
95.00	3.38	8.19	343.6	110.10	108.51
100.00	3.28	8.06	349.2	114.66	113.11

USE THIS



City of Kingman - RR Channel / Reach 6 / Station 125+00 to 167+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 6)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.006000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	2,815.00	cfs

Results		
Depth	7.38	ft
Flow Area	256.5	ft²
Wetted Perimeter	53.00	ft
Top Width	49.51	ft
Critical Depth	6.75	ft
Critical Slope	0.008478	ft/ft
Velocity	10.98	ft/s
Velocity Head	1.87	ft
Specific Energy	9.25	ft
Froude Number	0.85	
Flow Type	Subcritical	

4200 (0.009 - 0.006) = 12.60'

12.60/6 = 2.1'

6 STRUCTURES (3 6-25.00 STRUCTURES USED)

INTERVAL = 4200/6 STRUCTURES = 700'

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 6 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 6)-ri
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	007340	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,815.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	15.00	45.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
15.00	8.32	10.69	263.2	52.21	48.28
16.00	8.16	10.67	263.8	52.50	48.65
17.00	8.01	10.64	264.4	52.82	49.04
18.00	7.86	10.62	265.1	53.16	49.45
19.00	7.72	10.59	265.8	53.52	49.88
20.00	7.58	10.56	266.6	53.91	50.33
21.00	7.45	10.53	267.4	54.31	50.80
22.00	7.32	10.49	268.3	54.74	51.28
23.00	7.20	10.46	269.1	55.19	51.79
24.00	7.08	10.42	270.0	55.65	52.31
25.00	6.96	10.39	271.0	56.13	52.85
26.00	6.85	10.35	271.9	56.63	53.40
27.00	6.74	10.31	272.9	57.15	53.97
28.00	6.64	10.28	273.9	57.68	54.55
29.00	6.54	10.24	275.0	58.23	55.14
30.00	6.44	10.20	276.0	58.79	55.75
31.00	6.34	10.16	277.1	59.37	56.37
32.00	6.25	10.12	278.2	59.96	57.01
33.00	6.16	10.08	279.3	60.56	57.65
34.00	6.08	10.04	280.4	61.17	58.31
35.00	5.99	10.00	281.6	61.80	58.97
36.00	5.91	9.96	282.8	62.44	59.65
37.00	5.83	9.91	283.9	63.09	60.34
38.00	5.76	9.87	285.1	63.75	61.03
39.00	5.68	9.83	286.3	64.42	61.74
40.00	5.61	9.79	287.5	65.10	62.45
41.00	5.54	9.75	288.7	65.79	63.17
42.00	5.48	9.71	289.9	66.49	63.90
43.00	5.41	9.67	291.2	67.19	64.64
44.00	5.35	9.63	292.4	67.91	65.39
45.00	5.28	9.59	293.7	68.63	66.14

City of Kingman - RR Channel / Reach 6 / Station 125+00 to 167+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 6)-ri
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	007340	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	20.00	ft
Discharge	,815.00	cfs

Results		
Depth	7.58	ft
Flow Area	266.6	ft²
Wetted Perim	53.91	ft
Top Width	50.33	ft
Critical Depth	6.75	ft
Critical Slope	0.011540	ft/ft
Velocity	10.56	ft/s
Velocity Head	1.73	ft
Specific Energ	9.31	ft
Froude Numb	0.81	
Flow Type	Subcritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 6 / Station 125+00 to 167+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 6)-Concrete-sup
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	007340	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	30.00	ft
Discharge	,815.00	cfs

Results		
Depth	4.72	ft
Flow Area	175.0	ft²
Wetted Perim	47.01	ft
Top Width	44.16	ft
Critical Depth	5.86	ft
Critical Slope	0.003438	ft/ft
Velocity	16.09	ft/s
Velocity Head	4.02	ft
Specific Energ	8.74	ft
Froude Numb	1.43	
Flow Type	Supercritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 7 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 7)-Earthen-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	,920.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	70.00	100.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
70.00	5.97	7.73	507.1	102.23	99.85
71.00	5.93	7.71	508.6	102.99	100.63
72.00	5.88	7.69	510.1	103.76	101.41
73.00	5.84	7.66	511.6	104.53	102.20
74.00	5.80	7.64	513.1	105.30	102.99
75.00	5.76	7.62	514.6	106.08	103.78
76.00	5.72	7.60	516.1	106.86	104.58
77.00	5.68	7.57	517.6	107.64	105.38
78.00	5.64	7.55	519.1	108.43	106.19
79.00	5.60	7.53	520.7	109.22	106.99
80.00	5.56	7.51	522.2	110.02	107.80
81.00	5.52	7.49	523.7	110.82	108.62
82.00	5.49	7.46	525.2	111.62	109.44
83.00	5.45	7.44	526.7	112.43	110.25
84.00	5.42	7.42	528.2	113.24	111.08
85.00	5.38	7.40	529.7	114.05	111.90
86.00	5.35	7.38	531.3	114.86	112.73
87.00	5.31	7.36	532.8	115.68	113.56
88.00	5.28	7.34	534.3	116.50	114.40
89.00	5.25	7.32	535.8	117.32	115.23
90.00	5.21	7.30	537.3	118.15	116.07
91.00	5.18	7.28	538.8	118.98	116.91
92.00	5.15	7.26	540.3	119.81	117.76
93.00	5.12	7.24	541.8	120.64	118.60
94.00	5.09	7.22	543.3	121.48	119.45
95.00	5.06	7.20	544.8	122.32	120.30
96.00	5.03	7.18	546.3	123.16	121.16
97.00	5.00	7.16	547.8	124.00	122.01
98.00	4.97	7.14	549.3	124.85	122.87
99.00	4.95	7.12	550.8	125.70	123.73
100.00	4.92	7.10	552.2	126.55	124.59

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

R 27-1

City of Kingman - RR Channel / Reach 7 / Station 167+00 to 213+50
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 7)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	60.00	ft
Discharge	3,920.00	cfs

Results		
Depth	6.46	ft
Flow Area	492.2	ft²
Wetted Perimeter	94.89	ft
Top Width	92.31	ft
Critical Depth	4.76	ft
Critical Slope	0.005871	ft/ft
Velocity	7.96	ft/s
Velocity Head	0.99	ft
Specific Energy	7.45	ft
Froude Number	0.61	
Flow Type	Subcritical	

NATURAL SLOPE = 0.54%

STATION 167+00 TO 213+00

DROP STRUCTURES @ ~~661.75'~~ 516.67' INTERVAL → 4650/9

8 DROP STRUCTURES

4650 (0.0054 - 0.002) = 15.81'/8 = 1.98 (2' ±)

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 7 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 7)-Gabion-sui
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.030	
Slope	005400	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,920.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	20.00	120.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
20.00	8.95	11.55	339.4	60.04	55.81
25.00	8.27	11.40	343.8	62.00	58.10
30.00	7.69	11.23	349.0	64.40	60.76
35.00	7.19	11.04	354.9	67.15	63.75
40.00	6.75	10.85	361.3	70.20	67.01
45.00	6.37	10.65	368.0	73.50	70.49
50.00	6.04	10.46	374.9	77.01	74.16
55.00	5.75	10.26	382.0	80.69	77.98
60.00	5.48	10.07	389.2	84.52	81.93
65.00	5.25	9.89	396.3	88.48	86.00
70.00	5.04	9.71	403.5	92.53	90.16
75.00	4.85	9.55	410.6	96.68	94.39
80.00	4.68	9.38	417.7	100.91	98.70
85.00	4.52	9.23	424.8	105.20	103.07
90.00	4.37	9.08	431.7	109.55	107.49
95.00	4.24	8.94	438.6	113.95	111.95
100.00	4.11	8.80	445.3	118.40	116.46
105.00	4.00	8.67	452.0	122.89	121.00
110.00	3.89	8.55	458.6	127.41	125.57
115.00	3.79	8.43	465.1	131.97	130.17
120.00	3.70	8.31	471.5	136.55	134.80

← USE THIS

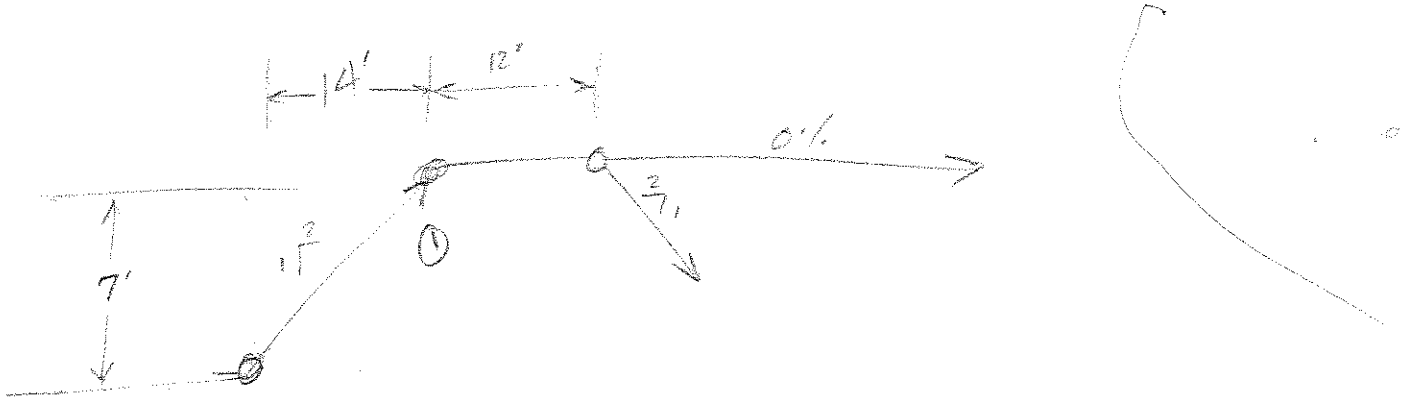
Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 7 / Station 167+00 to 213+50
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 7)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.005400	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	30.00	ft
Discharge	3,920.00	cfs

Results		
Depth	7.69	ft
Flow Area	349.0	ft²
Wetted Perimeter	64.40	ft
Top Width	60.76	ft
Critical Depth	6.89	ft
Critical Slope	0.008124	ft/ft
Velocity	11.23	ft/s
Velocity Head	1.96	ft
Specific Energy	9.65	ft
Froude Number	0.83	
Flow Type	Subcritical	



Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 7 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 7)-R
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	005400	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,920.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	60.00	90.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
60.00	5.99	9.09	431.4	86.80	83.97
61.00	5.94	9.05	432.9	87.57	84.76
62.00	5.89	9.02	434.5	88.34	85.56
63.00	5.84	8.99	436.0	89.11	86.35
64.00	5.79	8.96	437.5	89.89	87.16
65.00	5.74	8.93	439.0	90.67	87.96
66.00	5.69	8.90	440.5	91.46	88.77
67.00	5.65	8.87	442.1	92.25	89.59
68.00	5.60	8.84	443.6	93.05	90.40
69.00	5.56	8.81	445.1	93.85	91.22
70.00	5.51	8.78	446.6	94.65	92.05
71.00	5.47	8.75	448.2	95.46	92.88
72.00	5.43	8.72	449.7	96.27	93.71
73.00	5.39	8.69	451.2	97.09	94.54
74.00	5.35	8.66	452.7	97.91	95.38
75.00	5.31	8.63	454.2	98.73	96.22
76.00	5.27	8.60	455.7	99.55	97.07
77.00	5.23	8.57	457.3	100.38	97.91
78.00	5.19	8.54	458.8	101.21	98.76
79.00	5.15	8.52	460.3	102.05	99.62
80.00	5.12	8.49	461.8	102.89	100.47
81.00	5.08	8.46	463.3	103.73	101.33
82.00	5.05	8.43	464.8	104.57	102.19
83.00	5.01	8.41	466.3	105.42	103.05
84.00	4.98	8.38	467.8	106.27	103.92
85.00	4.95	8.35	469.3	107.12	104.78
86.00	4.91	8.33	470.8	107.97	105.65
87.00	4.88	8.30	472.3	108.83	106.52
88.00	4.85	8.27	473.8	109.69	107.40
89.00	4.82	8.25	475.2	110.55	108.27
90.00	4.79	8.22	476.7	111.41	109.15

City of Kingman - RR Channel / Reach 7 / Station 167+00 to 213+50
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 7)-Riprap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.005400	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	40.00	ft
Discharge	3,920.00	cfs

Results		
Depth	7.35	ft
Flow Area	402.3	ft²
Wetted Perimeter	72.89	ft
Top Width	69.42	ft
Critical Depth	6.01	ft
Critical Slope	0.011148	ft/ft
Velocity	9.74	ft/s
Velocity Head	1.48	ft
Specific Energy	8.83	ft
Froude Number	0.71	
Flow Type	Subcritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 7 / Concrete
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 7)-Concrete-sup
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	005400	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Discharge	,920.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	15.00	90.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
15.00	8.36	17.03	230.2	45.14	40.08
20.00	7.49	16.75	234.0	47.01	42.47
25.00	6.79	16.41	238.8	49.47	45.36
30.00	6.21	16.04	244.4	52.41	48.64
35.00	5.74	15.65	250.4	55.70	52.23
40.00	5.35	15.27	256.7	59.28	56.04
45.00	5.01	14.90	263.2	63.07	60.03
50.00	4.72	14.54	269.7	67.03	64.17
55.00	4.47	14.20	276.1	71.13	68.42
60.00	4.26	13.87	282.6	75.35	72.77
65.00	4.06	13.57	288.9	79.65	77.19
70.00	3.89	13.28	295.2	84.03	81.68
75.00	3.74	13.01	301.3	88.48	86.21
80.00	3.60	12.75	307.4	92.98	90.80
85.00	3.47	12.51	313.3	97.52	95.42
90.00	3.36	12.28	319.1	102.11	100.07

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 7 / Station 167+00 to 213+50
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 7)-Concrete-supercritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.019	
Slope	0.005400	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	15.00	ft
Discharge	3,920.00	cfs

Results		
Depth	8.36	ft
Flow Area	230.2	ft²
Wetted Perimeter	45.14	ft
Top Width	40.08	ft
Critical Depth	9.42	ft
Critical Slope	0.003352	ft/ft
Velocity	17.03	ft/s
Velocity Head	4.51	ft
Specific Energy	12.87	ft
Froude Number	1.25	
Flow Type	Supercritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 8 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 8)-Earthen-Su
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	,705.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	95.00	120.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
95.00	6.29	8.19	697.0	128.98	126.47
96.00	6.26	8.16	698.7	129.78	127.29
97.00	6.22	8.14	700.5	130.59	128.12
98.00	6.19	8.12	702.2	131.41	128.94
99.00	6.15	8.10	703.9	132.22	129.77
100.00	6.12	8.08	705.7	133.04	130.60
101.00	6.09	8.06	707.4	133.86	131.43
102.00	6.05	8.04	709.1	134.68	132.27
103.00	6.02	8.03	710.9	135.51	133.11
104.00	5.99	8.01	712.6	136.33	133.95
105.00	5.96	7.99	714.3	137.16	134.79
106.00	5.93	7.97	716.1	138.00	135.63
107.00	5.90	7.95	717.8	138.83	136.48
108.00	5.87	7.93	719.5	139.67	137.33
109.00	5.84	7.91	721.3	140.50	138.18
110.00	5.81	7.89	723.0	141.34	139.03
111.00	5.78	7.87	724.7	142.19	139.89
112.00	5.75	7.85	726.4	143.03	140.74
113.00	5.72	7.84	728.1	143.88	141.60
114.00	5.69	7.82	729.8	144.73	142.46
115.00	5.66	7.80	731.6	145.58	143.32
116.00	5.64	7.78	733.3	146.43	144.18
117.00	5.61	7.76	735.0	147.28	145.05
118.00	5.58	7.74	736.7	148.14	145.91
119.00	5.56	7.73	738.4	148.99	146.78
120.00	5.53	7.71	740.1	149.85	147.65

Notes: Natural ground slope is 0.67%. Slope flattened to provide a channel velocity 8 fps or less.

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 8 / Station 213+50 to 278+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 8)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.002000	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	100.00	ft
Discharge	5,705.00	cfs

Results		
Depth	6.12	ft
Flow Area	705.7	ft²
Wetted Perimeter	133.04	ft
Top Width	130.60	ft
Critical Depth	4.48	ft
Critical Slope	0.005815	ft/ft
Velocity	8.08	ft/s
Velocity Head	1.02	ft
Specific Energy	7.14	ft
Froude Number	0.61	
Flow Type	Subcritical	

Notes: Existing Ground Slope = 0.67%. Channel velocity at this slope would be erosive. Therefore, slope is flattened to provide a velocity of 8 fps.

$(6450')(0.0067 - 0.002) = 30.32'$

$30.32 \div 2.02 = 15$ drop structures ✓

$6450/16 = 403.13'$

INTERVAL $= 6450 \div 15 = 430'$

City of Kingman - RR Channel / Reach 8 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 8)-Gabion-sul
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.030	
Slope	006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,705.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	20.00	120.00	10.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
20.00	10.22	13.81	413.0	65.69	60.86
30.00	8.86	13.49	422.8	69.62	65.44
40.00	7.83	13.10	435.5	75.00	71.30
50.00	7.03	12.67	450.1	81.43	78.11
60.00	6.40	12.25	465.6	88.60	85.58
70.00	5.89	11.85	481.4	96.33	93.55
80.00	5.47	11.47	497.3	104.45	101.87
90.00	5.12	11.12	512.9	112.89	110.47
100.00	4.82	10.80	528.3	121.55	119.28
110.00	4.56	10.50	543.4	130.40	128.25
120.00	4.34	10.22	558.1	139.40	137.35

USE THIS

City of Kingman - RR Channel / Reach 8 / Station 213+50 to 278+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 8)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	40.00	ft
Discharge	5,705.00	cfs

Results		
Depth	7.83	ft
Flow Area	435.5	ft²
Wetted Perimeter	75.00	ft
Top Width	71.30	ft
Critical Depth	7.52	ft
Critical Slope	0.007750	ft/ft
Velocity	13.10	ft/s
Velocity Head	2.67	ft
Specific Energy	10.49	ft
Froude Number	0.93	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 8 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 8) - R
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	,705.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	70.00	100.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
70.00	6.44	10.70	533.4	98.78	95.75
71.00	6.39	10.66	535.1	99.56	96.55
72.00	6.34	10.63	536.8	100.35	97.36
73.00	6.29	10.60	538.4	101.14	98.17
74.00	6.24	10.56	540.1	101.93	98.98
75.00	6.20	10.53	541.8	102.72	99.80
76.00	6.15	10.50	543.5	103.52	100.62
77.00	6.11	10.46	545.2	104.33	101.44
78.00	6.07	10.43	546.9	105.13	102.27
79.00	6.02	10.40	548.5	105.94	103.10
80.00	5.98	10.37	550.2	106.76	103.93
81.00	5.94	10.34	551.9	107.57	104.77
82.00	5.90	10.31	553.6	108.39	105.61
83.00	5.86	10.27	555.2	109.21	106.45
84.00	5.82	10.24	556.9	110.04	107.29
85.00	5.78	10.21	558.6	110.87	108.14
86.00	5.75	10.18	560.3	111.70	108.99
87.00	5.71	10.15	561.9	112.53	109.84
88.00	5.67	10.12	563.6	113.37	110.69
89.00	5.64	10.09	565.3	114.21	111.55
90.00	5.60	10.06	566.9	115.05	112.41
91.00	5.57	10.03	568.6	115.90	113.27
92.00	5.53	10.00	570.3	116.74	114.13
93.00	5.50	9.98	571.9	117.59	115.00
94.00	5.47	9.95	573.6	118.44	115.86
95.00	5.43	9.92	575.2	119.30	116.73
96.00	5.40	9.89	576.9	120.15	117.60
97.00	5.37	9.86	578.5	121.01	118.48
98.00	5.34	9.83	580.1	121.87	119.35
99.00	5.31	9.81	581.8	122.74	120.23
100.00	5.28	9.78	583.4	123.60	121.11

City of Kingman - RR Channel / Reach 8 / Station 213+50 to 278+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 8)-riprap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	50.00	ft
Discharge	5,705.00	cfs

Results		
Depth	7.66	ft
Flow Area	500.5	ft²
Wetted Perimeter	84.27	ft
Top Width	80.65	ft
Critical Depth	6.73	ft
Critical Slope	0.010641	ft/ft
Velocity	11.40	ft/s
Velocity Head	2.02	ft
Specific Energy	9.68	ft
Froude Number	0.81	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 8 / Concrete
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 8)-Concrete-sup
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.019	
Slope	006700	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Discharge	,705.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	20.00	100.00	5.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
20.00	8.62	20.09	284.0	51.09	45.87
25.00	7.85	19.75	288.9	53.32	48.56
30.00	7.22	19.36	294.7	56.02	51.65
35.00	6.69	18.95	301.0	59.11	55.06
40.00	6.24	18.53	307.8	62.49	58.71
45.00	5.85	18.12	314.8	66.11	62.56
50.00	5.52	17.72	322.0	69.92	66.57
55.00	5.24	17.33	329.2	73.88	70.71
60.00	4.98	16.96	336.3	77.97	74.95
65.00	4.76	16.61	343.4	82.17	79.28
70.00	4.56	16.28	350.5	86.45	83.68
75.00	4.38	15.96	357.5	90.80	88.15
80.00	4.22	15.66	364.3	95.22	92.66
85.00	4.07	15.38	371.1	99.68	97.22
90.00	3.94	15.11	377.7	104.20	101.81
95.00	3.81	14.85	384.2	108.75	106.44
100.00	3.70	14.61	390.6	113.34	111.10

City of Kingman - RR Channel / Reach 8 / Station 213+50 to 278+00
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 8)-Concrete-supercritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.019	
Slope	0.006700	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	32.00	ft
Discharge	5,705.00	cfs

Results		
Depth	6.99	ft
Flow Area	297.2	ft²
Wetted Perimeter	57.22	ft
Top Width	52.98	ft
Critical Depth	8.64	ft
Critical Slope	0.003130	ft/ft
Velocity	19.20	ft/s
Velocity Head	5.73	ft
Specific Energy	12.72	ft
Froude Number	1.43	
Flow Type	Supercritical	

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 9 / Earthen
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 9)-Earthen-St
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.025	
Slope	.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Discharge	2,300.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	95.00	129.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
95.00	6.92	15.83	776.9	132.35	129.59
96.00	6.88	15.79	778.8	133.14	130.40
97.00	6.84	15.76	780.6	133.93	131.21
98.00	6.80	15.72	782.5	134.73	132.02
99.00	6.77	15.68	784.3	135.53	132.83
100.00	6.73	15.65	786.2	136.33	133.65
101.00	6.69	15.61	788.0	137.13	134.47
102.00	6.66	15.57	789.9	137.94	135.29
103.00	6.62	15.54	791.7	138.75	136.11
104.00	6.59	15.50	793.6	139.56	136.94
105.00	6.55	15.46	795.4	140.38	137.77
106.00	6.52	15.43	797.3	141.19	138.60
107.00	6.49	15.39	799.1	142.01	139.43
108.00	6.45	15.36	801.0	142.83	140.26
109.00	6.42	15.32	802.8	143.66	141.10
110.00	6.39	15.29	804.7	144.48	141.94
111.00	6.36	15.25	806.5	145.31	142.78
112.00	6.32	15.22	808.3	146.14	143.62
113.00	6.29	15.18	810.2	146.97	144.47
114.00	6.26	15.15	812.0	147.81	145.31
115.00	6.23	15.11	813.9	148.65	146.16
116.00	6.20	15.08	815.7	149.48	147.01
117.00	6.17	15.05	817.5	150.32	147.87
118.00	6.14	15.01	819.4	151.17	148.72
119.00	6.12	14.98	821.2	152.01	149.58
120.00	6.09	14.95	823.0	152.86	150.43
121.00	6.06	14.91	824.8	153.71	151.29
122.00	6.03	14.88	826.6	154.56	152.15
123.00	6.00	14.85	828.5	155.41	153.02
124.00	5.98	14.81	830.3	156.26	153.88
125.00	5.95	14.78	832.1	157.11	154.74
126.00	5.92	14.75	833.9	157.97	155.61
127.00	5.90	14.72	835.7	158.83	156.48
128.00	5.87	14.69	837.5	159.69	157.35
129.00	5.84	14.65	839.3	160.55	158.22

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 9 / Station 278+00 to Rattlesnake Hill Wash
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1/3:1 slopes (Reach 9)-Earthen-Subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Slope	0.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	100.00	ft
Discharge	12,300.00	cfs

Results		
Depth	6.73	ft
Flow Area	786.2	ft²
Wetted Perimeter	136.33	ft
Top Width	133.65	ft
Critical Depth	7.30	ft
Critical Slope	0.005066	ft/ft
Velocity	15.65	ft/s
Velocity Head	3.80	ft
Specific Energy	10.53	ft
Froude Number	1.14	
Flow Type	Supercritical	

City of Kingman - RR Channel / Reach 9 / Gabions
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 9)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	12,300.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	50.00	160.00	10.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
50.00	10.75	16.00	768.8	98.09	93.01
60.00	9.88	15.62	787.6	104.16	99.50
70.00	9.15	15.23	807.6	110.90	106.59
80.00	8.53	14.85	828.3	118.16	114.13
90.00	8.01	14.48	849.4	125.83	122.05
100.00	7.56	14.13	870.6	133.82	130.25
110.00	7.17	13.79	891.7	142.07	138.68
120.00	6.83	13.48	912.5	150.53	147.31
130.00	6.52	13.18	933.1	159.17	156.09
140.00	6.25	12.90	953.4	167.96	165.01
150.00	6.01	12.64	973.3	176.87	174.03
160.00	5.79	12.39	992.9	185.88	183.15

City of Kingman - RR Channel / Reach 9 / Station 278+00 to Rattlesnake Hill Wash
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 9)-Gabion-subcritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Slope	0.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	60.00	ft
Discharge	12,300.00	cfs

Results		
Depth	9.88	ft
Flow Area	787.6	ft²
Wetted Perimeter	104.16	ft
Top Width	99.50	ft
Critical Depth	9.75	ft
Critical Slope	0.007017	ft/ft
Velocity	15.62	ft/s
Velocity Head	3.79	ft
Specific Energy	13.67	ft
Froude Number	0.98	
Flow Type	Subcritical	

City of Kingman - RR Channel / Reach 9 / Concrete
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 9)-Concrete-supercritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.019	
Slope	0.006700	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Discharge	12,300.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	50.00	150.00	10.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)
50.00	8.61	22.71	541.6	81.04	75.82
60.00	7.81	21.96	560.1	88.16	83.43
70.00	7.17	21.24	579.2	95.86	91.52
80.00	6.65	20.56	598.3	103.98	99.95
90.00	6.22	19.93	617.3	112.41	108.65
100.00	5.85	19.34	635.9	121.08	117.54
110.00	5.53	18.80	654.1	129.94	126.59
120.00	5.25	18.31	671.9	138.94	135.76
130.00	5.01	17.85	689.2	148.07	145.04
140.00	4.80	17.42	706.1	157.30	154.39
150.00	4.60	17.02	722.5	166.60	163.81

City of Kingman - RR Channel / Reach 9 / Station 278+00 to Rattlesnake Hill Wash
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	1.5:1 slopes (Reach 9)-Concrete-supercritical
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.019	
Slope	0.006700	ft/ft
Left Side Slope	1.50	H : V
Right Side Slope	1.50	H : V
Bottom Width	100.00	ft
Discharge	12,300.00	cfs

Results		
Depth	5.85	ft
Flow Area	635.9	ft²
Wetted Perimeter	121.08	ft
Top Width	117.54	ft
Critical Depth	7.48	ft
Critical Slope	0.002915	ft/ft
Velocity	19.34	ft/s
Velocity Head	5.81	ft
Specific Energy	11.66	ft
Froude Number	1.47	
Flow Type	Supercritical	

City of Kingman - RR Channel / Reach 9 / Riprap
Rating Table for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 9)-R
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coeffic	0.035	
Slope	.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Discharge	2,300.00	cfs

Attribute	Minimum	Maximum	Increment
Bottom Width (ft)	70.00	100.00	1.00

Bottom Width (ft)	Depth (ft)	Velocity (ft/s)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)
70.00	9.98	13.70	897.6	114.62	109.91
71.00	9.91	13.67	899.7	115.31	110.63
72.00	9.84	13.64	901.9	116.00	111.35
73.00	9.77	13.61	904.0	116.69	112.08
74.00	9.70	13.57	906.2	117.39	112.81
75.00	9.64	13.54	908.3	118.09	113.54
76.00	9.57	13.51	910.5	118.80	114.28
77.00	9.51	13.48	912.7	119.51	115.02
78.00	9.44	13.44	914.9	120.23	115.77
79.00	9.38	13.41	917.1	120.95	116.52
80.00	9.32	13.38	919.3	121.68	117.28
81.00	9.26	13.35	921.5	122.41	118.04
82.00	9.20	13.32	923.7	123.14	118.80
83.00	9.14	13.28	925.9	123.88	119.57
84.00	9.08	13.25	928.1	124.63	120.34
85.00	9.03	13.22	930.3	125.37	121.11
86.00	8.97	13.19	932.6	126.12	121.89
87.00	8.92	13.16	934.8	126.88	122.67
88.00	8.86	13.13	937.0	127.64	123.45
89.00	8.81	13.10	939.3	128.40	124.24
90.00	8.76	13.06	941.5	129.16	125.03
91.00	8.71	13.03	943.7	129.93	125.82
92.00	8.65	13.00	946.0	130.70	126.62
93.00	8.60	12.97	948.2	131.48	127.42
94.00	8.55	12.94	950.5	132.26	128.22
95.00	8.51	12.91	952.7	133.04	129.02
96.00	8.46	12.88	954.9	133.82	129.83
97.00	8.41	12.85	957.2	134.61	130.64
98.00	8.36	12.82	959.4	135.40	131.45
99.00	8.32	12.79	961.7	136.19	132.27
100.00	8.27	12.76	963.9	136.99	133.08

Stantech Consulting Inc
37 Brookside Road Waterbury, CT 06708 USA (203) 755-1666

City of Kingman - RR Channel / Reach 9 / Station 278+00 to Rattlesnake Hill Wash
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	2:1 slopes (Reach 9)-Riprap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.006700	ft/ft
Left Side Slope	2.00	H : V
Right Side Slope	2.00	H : V
Bottom Width	100.00	ft
Discharge	12,300.00	cfs

Results		
Depth	8.27	ft
Flow Area	963.9	ft²
Wetted Perimeter	136.99	ft
Top Width	133.08	ft
Critical Depth	7.39	ft
Critical Slope	0.009888	ft/ft
Velocity	12.76	ft/s
Velocity Head	2.53	ft
Specific Energy	10.80	ft
Froude Number	0.84	
Flow Type	Subcritical	

Appendix C

QUANTITIES/COST ESTIMATES

Railroad Channel Costs

PREFERRED ALTERNATIVE

Reach	COST Excavation ($)	COST Lining ($)	Drop Structures ($)	TOTAL CONSTRUCTION COST ($)	CONSTRUCTION COST w/ 15% ($)	RIGHT-OF-WAY COST ($)	TOTAL
1	173,467	754,319	0	927,786	1,066,954	16,472	1,083,426
2	72,016	432,000	6,720	510,736	587,346	32,003	619,349
3	58,149	240,000	42,000	340,149	391,171	36,916	428,087
4	205,769	792,000	9,600	1,007,369	1,158,474	61,223	1,219,697
5a	25,151	90,000	0	115,151	132,424	*0*[1]	132,424
5b	61,726	118,656	0	180,382	207,439	*143227*[1]	207,439
6a	57,404	129,454	0	186,858	214,886	*91185*[1]	214,886
6b	19,901	118,800	19,200	157,901	181,586	*0*[1]	181,586
6c	74,746	368,400	12,000	455,146	523,418	75,364	598,782
6d	88,512	0	44,160	132,672	152,572	245,960	398,532
7	393,547	0	100,800	494,347	568,499	588,147	1,156,646
8	806,267	0	259,200	1,065,467	1,225,287	*1,240,371*[2]	1,225,287
9a	43,386	91,647	0	135,033	155,288	*119,495*[2]	155,288
9b	28,973	282,461	0	311,434	358,150	*175,108*[2]	358,150
	$2,109,013	**$3,417,737**	**$493,680**	**$6,020,430**	**$6,923,494**	**$1,056,085**	**$7,979,579**

[1]ROW for Reaches 5a, 5b, 6a and 6b is being acquired for the Airway Avenue improvements and is not included in the estimate total.

[2]ROW for Reaches 7, 8, 9a and 9b falls completely within Airport property and is not included in the estimate total.

Railroad Channel Earthwork

PREFERRED ALTERNATIVE

Reach	Lining Type	Excavation (cu yd)	Unit Cost of Excavation ($/cu yd)	Excavation Cost ($)	Fill (cu yd)	Waste (cu yd)
1	Gabion Mattresses	49562	3.50	173,467	1672	47890
2	Stacked Gabions	20576	3.50	72,016	80	20496
3	Stacked Gabions	16614	3.50	58,149	6	16608
4	Stacked Gabions	58791	3.50	205,769	72	58719
5a	Stacked Gabions	7186	3.50	25,151	0	7186
5b	Concrete	17636	3.50	61,726	0	17636
6a	Concrete	16401	3.50	57,404	113	16288
6b	Stacked Gabions	5686	3.50	19,901	247	5439
6c	Stacked Gabions	21356	3.50	74,746	953	20403
6d	Earthen	25289	3.50	88,512	1228	24061
7	Earthen	112442	3.50	393,547	1624	110818
8	Earthen	230362	3.50	806,267	2537	227825
9a	Gabion Mattresses / Earthen	12396	3.50	43,386	722	11674
9b	Gabion Mattresses	8278	3.50	28,973	3030	5248
	Totals:	602,575		2,109,013	12,284	590,291

Railroad Channel Bank Lining Material - Preferred Alternative

Reach	from Station	to Station	Length (ft)	Lining Type	Channel Depth (ft)	Side Slope (x :1)	Length of Side Slopes (ft)	Lining Bottom Width (ft)	Lining Cross-Sectional Area (sq ft)	Lining Thickness (ft)	Lining Volume (cu yd)	Unit Cost Lining ($/cu yd)	TOTAL COST ($)
1	99+76.94	157+00.00	5,723.06	Gabion Mattresses	7.5	2	16.77	6.0	39.54	1.0	8381	90	754,319
2	157+00.00	175+00.00	1,800	Stacked Gabions	n/a	n/a	n/a	n/a	72.00	n/a	4800	90	432,000
3	175+00.00	185+00.00	1,000	Stacked Gabions	n/a	n/a	n/a	n/a	72.00	n/a	2667	90	240,000
4	185+00.00	218+00.00	3,300	Stacked Gabions	n/a	n/a	n/a	n/a	72.00	n/a	8800	90	792,000
5a	218+00.00	221+75.00	375	Stacked Gabions	n/a	n/a	n/a	n/a	72.00	n/a	1000	90	90,000
5b	221+75.00	229+30.00	755	Concrete	7.5	1.5	13.52	26.0	26.52	0.5	742	160	118,656
6a	229+30.00	236+70.00	740	Concrete	7.5	1.5	13.52	32.0	29.52	0.5	809	160	129,454
6b	236+70.00	241+65.00	495	Stacked Gabions	n/a	n/a	n/a	n/a	72.00	n/a	1320	90	118,800
6c	241+65.00	257+00.00	1,535	Stacked Gabions	n/a	n/a	n/a	n/a	72.00	n/a	4093	90	368,400
6d	257+00.00	274+43.00	1,743	Earthen	7.5	2.5	20.19	0.0	0.00	0.0	0	0	0
7	274+43.00	321+16.00	4,673	Earthen	7.5	2.5	20.19	0.0	0.00	0.0	0	0	0
8	321+16.00	383+57.00	6,241	Earthen	7.5	2.5	20.19	0.0	0.00	0.0	0	0	0
9a	383+57.00	387+84.00	427	Gabion Mattresses / Earthen	7.5	2.5	20.19	24.0	64.39	1.0	1018	90	91,647
9b	387+84.00	393+83.00	599	Gabion Mattresses	9.0	2.5	24.23	93.0	141.47	1.0	3138	90	282,461
													3,417,737

Reach	No. of Drops in Reach (ea)	Cubic Yards of Gabions in Drop	Gabion Unit Cost ($/cu yd)	Total Drop Structure Cost ($)
1	0			0.00
2	1	74.67	90.00	6,720.00
3	5	93.33	90.00	42,000.00
4	1	106.67	90.00	9,600.00
5a	0			0.00
5b	0			0.00
6a	0			0.00
6b	2	106.67	90.00	19,200.00
6c	1	133.33	90.00	12,000.00
6d	4	122.67	90.00	44,160.00
7	6	186.67	90.00	100,800.00
8	10	288.00	90.00	259,200.00
9a	0			0.00
9b	0			0.00
				493,680.00

Railroad Channel Preferred Alternative Right-of-Way Costs

	RIGHT-OF-WAY ACQUISITION (SF)	
REACH #	ROW AREAS	Cost ($)
1	5,202	
1	5,267	
1	5,267	
1	736	
Reach 1 totals:	**16,472**	16,472.00
2	4,531	
2	5,267	
2	5,258	
2	16,947	
Reach 2 totals:	**32,003**	32,003.00
3	1,776	
3	35,140	
Reach 3 totals:	**36,916**	36,916.00
4	1,540	
4	12,327	
4	5,317	
4	8,390	
4	9,639	
4	6,830	
4	9,639	
4	7,541	
Reach 4 totals:	**61,223**	61,223.00
5a	0	
5b	143,227	
Reach 5 totals:	**143,227**	143,227.10
6a	91,185	
6b	0	
6c	75,364	
6d	245,960	
Reach 6 totals:	**412,509**	412,508.90
7	100,655	
7	487,492	
7	*173,326*	
Reach 7 totals:	**761,473**	761,473.00
8	*1,240,371*	
Reach 8 totals:	**1,240,371**	1,240,371.00
9a	*119,495*	
9b	*175,108*	
Reach 9 totals:	**294,603**	294,603.00
Totals (all reaches):	**2,998,797**	2,998,797.00

Railroad Channel Alternative Costs

CONCRETE

Reach	Concrete EX. (cu yd)	Unit Cost of Ex.($/cu yd)	COST Concrete Excavation ($)	COST Concrete Material ($)	Drop Structures/ Etc.	TOTAL CONSTRUCTION COST ($)	CONSTRUCTION COST W/ 15%	RIGHT-OF-WAY COST ($)	TOTAL
Reach 1	42387	3.5	148,355	488,090	50,000	686,444	789,411	0	789,411
Reach 2	17844	3.5	62,454	207,029	0	269,483	309,905	0	309,905
Reach 3	7247	3.5	25,365	98,244	20,500	144,108	165,724	7,095	172,819
Reach 4	29913	3.5	104,696	428,815	2,750	536,261	616,700	18,160	634,860
Reach 5	18571	3.5	64,999	148,738	5,250	218,987	251,835	139,065	390,900
Reach 6	49038	3.5	171,633	600,921	28,500	801,054	921,212	126,687	1,047,899
Reach 7	25050	3.5	87,675	918,556	30,000	1,036,231	1,191,665	144,618	1,336,283
Reach 8	94536	3.5	330,876	1,321,681	63,750	1,716,307	1,973,753	186,207	2,159,960
Reach 9	6581	3.5	23,034	149,484	0	172,518	198,396	32,726	231,122
	291,167	3.5	***1,019,085***	***4,361,558***	***200,750***	**5,581,393**	**6,418,602**	**654,558**	7,073,160

GABION

Reach	Gabion EX. (cu yd)	Unit Cost of Ex.($/cu yd)	COST Gabion Excavation ($)	COST Gabion Material ($)	Drop Structures/ Etc.	TOTAL CONSTRUCTION COST ($)	CONSTRUCTION COST W/ 15%	RIGHT-OF-WAY COST ($)	TOTAL
Reach 1	62163	3.5	217,571	692,481	50,000	960,052	1,104,060	5,679	1,109,739
Reach 2	25761	3.5	90,164	293,639	0	383,803	441,373	16,027	457,400
Reach 3	7870	3.5	27,545	153,145	20,500	201,190	231,369	15,271	246,640
Reach 4	34481	3.5	120,684	492,588	2,750	616,022	708,425	37,548	745,973
Reach 5	26201	3.5	91,704	163,918	5,250	260,871	300,002	149,067	449,069
Reach 6	84856	3.5	296,996	691,666	28,500	1,017,162	1,169,736	184,537	1,354,273
Reach 7	46493	3.5	162,726	604,681	30,000	797,407	917,018	202,463	1,119,481
Reach 8	146845	3.5	513,958	913,344	63,750	1,491,052	1,714,710	282,484	1,997,194
Reach 9	10871	3.5	38,049	108,511	0	146,559	168,543	49,089	217,632
	445,541	3.5	***1,559,394***	***4,113,974***	***200,750***	**5,874,117**	**6,755,235**	**942,165**	7,697,400

RIP-RAP

Reach	Rip-Rap EX. (cu yd)	Unit Cost of Ex.($/cu yd)	COST Rip-Rap Excavation ($)	COST Rip-Rap Material ($)	Drop Structures/ Etc.	TOTAL CONSTRUCTION COST ($)	CONSTRUCTION COST W/ 15%	RIGHT-OF-WAY COST ($)	TOTAL
Reach 1	67951	3.5	237,829	888,284	50,000	1,176,112	1,352,529	8,250	1,360,779
Reach 2	28037	3.5	98,130	386,930	0	485,060	557,819	16,026	573,845
Reach 3	10298	3.5	36,043	189,408	20,500	245,951	282,844	22,620	305,464
Reach 4	37889	3.5	132,612	776,972	2,750	912,334	1,049,184	57,641	1,106,825
Reach 5	28062	3.5	98,217	211,071	5,250	314,538	361,718	144,067	505,785
Reach 6	84865	3.5	297,028	865,983	28,500	1,191,510	1,370,237	184,537	1,554,774
Reach 7	54778	3.5	191,723	776,655	30,000	998,378	1,148,134	231,384	1,379,518
Reach 8	166242	3.5	581,847	1,185,180	63,750	1,830,777	2,105,393	314,830	2,420,223
Reach 9	12550	3.5	43,925	142,717	0	186,642	214,639	54,543	269,182
	490,672	3.5	***1,717,352***	***5,423,200***	***200,750***	**7,341,302**	**8,442,497**	**1,033,898**	9,476,395

EARTHEN

Reach	Earthen EX. (cu yd)	Unit Cost of Ex.($/cu yd)	COST Earthen Excavation ($)	COST Material ($)	Drop Structures/ Etc.	TOTAL CONSTRUCTION COST ($)	CONSTRUCTION COST W/ 15%	RIGHT-OF-WAY COST ($)	TOTAL
Reach 1	63826	3.5	223,391		50,000	273,391	314,400	16,474	330,874
Reach 2	26545	3.5	92,908		0	92,908	106,844	32,002	138,846
Reach 3	13959	3.5	48,857		20,500	69,357	79,760	30,917	110,677
Reach 4	47665	3.5	166,828		2,750	169,578	195,014	78,408	273,422
Reach 5	34588	3.5	121,058		5,250	126,308	145,254	0	145,254
Reach 6	111268	3.5	389,438		28,500	417,938	480,629	184,092	664,721
Reach 7	71109	3.5	248,882		30,000	278,882	320,714	356,511	677,225
Reach 8	231702	3.5	810,957		63,750	874,707	1,005,913	508,987	1,514,900
Reach 9	15146	3.5	53,011		0	53,011	60,963	76,361	137,324
	615,808	3.5	***2,155,328***	***0***	***200,750***	**2,356,078**	**2,709,490**	**1,283,752**	3,993,242

Railroad Channel Earthwork

	Reach	Excavation (cu yd)	Unit Cost of Excavation ($/cu yd)	Excavation Cost ($)	Fill (cu yd)	Waste (cu yd)
CONCRETE	Reach 1	42387	3.50	148,355	0	42387
	Reach 2	17844	3.50	62,454	0	17844
	Reach 3	7247	3.50	25,365	2941	4306
	Reach 4	29913	3.50	104,696	3191	26722
	Reach 5	18571	3.50	64,999	295	18276
	Reach 6	49038	3.50	171,633	688	48350
	Reach 7	25050	3.50	87,675	23208	1842
	Reach 8	94536	3.50	330,876	4062	90474
	Reach 9	6581	3.50	23,034	142	6439
		291167	3.50	***1,019,085***	34527	256640
	Reach	**Excavation (cu yd)**	**Unit Cost of Excavation ($/cu yd)**	**Excavation Cost ($)**	**Fill (cu yd)**	**Waste (cu yd)**
GABION	Reach 1	62163	3.50	217,571	0	62163
	Reach 2	25761	3.50	90,164	0	25761
	Reach 3	7870	3.50	27,545	0	7870
	Reach 4	34481	3.50	120,684	5224	29257
	Reach 5	26201	3.50	91,704	488	25713
	Reach 6	84856	3.50	296,996	373	84483
	Reach 7	46493	3.50	162,726	17624	28869
	Reach 8	146845	3.50	513,958	1890	144955
	Reach 9	10871	3.50	38,049	103	10768
		445541	3.50	***1,559,394***		
	Reach	**Excavation (cu yd)**	**Unit Cost of Excavation ($/cu yd)**	**Excavation Cost ($)**	**Fill (cu yd)**	**Waste (cu yd)**
RIP-RAP	Reach 1	67951	3.50	237,829	0	67951
	Reach 2	28037	3.50	98,130	0	28037
	Reach 3	10298	3.50	36,043	0	10298
	Reach 4	37889	3.50	132,612	5011	32878
	Reach 5	28062	3.50	98,217	458	27604
	Reach 6	84865	3.50	297,028	496	84369
	Reach 7	54778	3.50	191,723	15817	38961
	Reach 8	166242	3.50	581,847	1282	164960
	Reach 9	12550	3.50	43,925	84	12466
		490672	3.50	***1,717,352***		
	Reach	**Excavation (cu yd)**	**Unit Cost of Excavation ($/cu yd)**	**Excavation Cost ($)**	**Fill (cu yd)**	**Waste (cu yd)**
EARTHEN	Reach 1	63826	3.50	223,391	0	63826
	Reach 2	26545	3.50	92,908	0	26545
	Reach 3	13959	3.50	48,857	0	13959
	Reach 4	47665	3.50	166,828	820	46845
	Reach 5	34588	3.50	121,058	178	34410
	Reach 6	111268	3.50	389,438	0	111268
	Reach 7	71109	3.50	248,882	10807	60302
	Reach 8	231702	3.50	810,957	1137	230565
	Reach 9	15146	3.50	53,011	30	15116
		615808	3.50	***2,155,328***		

Railroad Channel Bank Lining Material

Reach	Station	to	Station	Length (ft)
1	5+00	to	57+00	5200
2	57+00		75+00	1800
3	75+00		85+00	1000
4	85+00		118+00	3300
5	118+00		130+00	1200
6	130+00		176+71	4671
7	176+71		223+21	4650
8	223+21		287+21	6400
9	287+21		293+17	596

Reach	Gabion Flow Depth + 1' (ft)	Gabion Side Slope (x :1)	Gabion Length of Side Slopes (ft)	Gabion Apron Width (ft)	Gabion Area (sq ft)	Gabion Thickness (ft)	Gabion Volume (cu yd)	Unit Cost Gabion ($/cu yd)	COST Gabion ($)
1	6.25	2	13.98	6	207744	1.0	7694	90	692,481
2	8.26	2	18.47	6	88092	1.0	3263	90	293,639
3	7.59	2	16.97	6	45944	1.0	1702	90	153,145
4	7.33	2	16.39	6	147776	1.0	5473	90	492,588
5	6.48	2	14.49	6	49175	1.0	1821	90	163,918
6	7.25	2	16.21	6	207500	1.0	7685	90	691,666
7	6.04	2	13.51	6	181404	1.0	6719	90	604,681
8	6.89	2	15.41	6	274003	1.0	10148	90	913,344
9	9.53	2	21.31	6	32553	1.0	1206	90	108,511
									4,113,974
						GABION TOTAL	**45711**		

Reach	Station	to	Station	Length (ft)
1	5+00	to	57+00	5200
2	57+00		75+00	1800
3	75+00		85+00	1000
4	85+00		118+00	3300
5	118+00		130+00	1200
6	130+00		176+71	4671
7	176+71		223+21	4650
8	223+21		287+21	6400
9	287+21		293+17	596

Reach	Rip-Rap Flow Depth + 1' (ft)	Rip-Rap Side Slope (x :1)	Rip-Rap Length of Side Slopes (ft)	Rip-Rap Toe Down (ft)	Rip-Rap Area (sq ft)	Rip-Rap Thickness (ft)	Rip-Rap Volume (cu yd)	Unit Cost Rip-Rap ($/cu yd)	COST Rip-Rap ($)
1	6.30	2	18.09	4	188107	1.5	10450	85	888,284
2	8.39	2	22.76	4	81938	1.5	4552	85	386,930
3	7.18	2	20.05	4	40110	1.5	2228	85	189,408
4	9.36	2	24.93	4	164535	1.5	9141	85	776,972
5	6.54	2	18.62	4	44697	1.5	2483	85	211,071
6	6.99	2	19.63	4	183385	1.5	10188	85	865,983
7	6.12	2	17.68	4	164488	1.5	9137	85	776,655
8	6.98	2	19.61	4	250979	1.5	13943	85	1,185,180
9	9.55	2	25.35	4	30223	1.5	1679	85	142,717
									5,423,200
						RIP-RAP TOTAL	**63802**		

Reach	Station	to	Station	Length (ft)
1	5+00	to	57+00	5200
2	57+00		75+00	1800
3	75+00		85+00	1000
4	85+00		118+00	3300
5	118+00		130+00	1200
6	130+00		176+71	4671
7	176+71		223+21	4650
8	223+21		287+21	6400
9	287+21		293+17	596

Reach	Concrete Flow Depth + 1' (ft)	Concrete Side Slope (x :1)	Concrete Length of Side Slopes (ft)	Concrete Bottom Width (ft)	Concrete Area (sq ft)	Concrete Thickness (ft)	"Lining" Concrete Volume (cu yd)	Drop Structure Volume (cu yd)	Reach Total Concrete Volume (cu yd)	Unit Cost "Lining" Concrete ($/cu yd)	COST "Lining" Concrete ($)	Unit Cost Drop Structure Concrete ($/cu yd)	COST Drop Structure Concrete ($)	TOTAL CONCRETE COST ($)
1	6.29	1.5	11.34	9	164730	0.5	3051	0	3051	160	488,090	250.00	0.00	488,090
2	8.27	1.5	14.91	9	69872	0.5	1294	0	1294	160	207,029	250.00	0.00	207,029
3	6.70	1.5	12.08	9	33157	0.5	614	82	696	160	98,244	250.00	20500.00	118,744
4	9.39	1.5	16.93	10	144725	0.5	2680	11	2691	160	428,815	250.00	2750.00	431,565
5	6.61	1.5	11.92	18	50199	0.5	930	21	951	160	148,738	250.00	5250.00	153,988
6	7.05	1.5	12.71	18	202811	0.5	3756	114	3870	160	600,921	250.00	28500.00	629,421
7	6.01	1.5	10.83	45	310013	0.5	5741	120	5861	160	918,556	250.00	30000.00	948,556
8	6.85	1.5	12.35	45	446067	0.5	8261	255	8516	160	1,321,681	250.00	63750.00	1,385,431
9	9.61	1.5	17.32	50	50451	0.5	934	0	934	160	149,484	250.00	0.00	149,484
														4,512,308
						CONCRETE "Lining" TOTAL	**27260**							
						CONCRETE "Drop" Total	**603**							
								CONCRETE Lining + Drop	**27863**					

Railroad Channel Right-of-Way Costs

	RIGHT-OF-WAY ACQUISITION (SF)							
REACH #	RIPRAP ALT.	Cost ($)	GABION ALT.	Cost ($)	EARTHEN ALT.	Cost ($)	CONCRETE ALT.	Cost ($)
1	2,571.28		0.00		5,201.84		0.00	
1	2,634.00		2,634.00		5,267.96		0.00	
1	2,634.22		2,634.22		5,268.50		0.00	
1	410.72		410.72		735.87		0.00	
Reach 1 totals:	**8,250.22**	8,250.22	**5,678.94**	5,678.94	**16,474.17**	16,474.17	**0.00**	0.00
2	2,223.12		2,223.12		4,531.71		0.00	
2	2,632.30		2,632.30		5,264.54		0.00	
2	2,654.75		2,654.75		5,257.82		0.00	
2	8,516.80		8,516.80		16,948.06		0.00	
Reach 2 totals:	**16,026.97**	16,026.97	**16,026.97**	16,026.97	**32,002.13**	32,002.13	**0.00**	0.00
3	946.40		946.40		1,775.86		0.00	
3	4,641.09		3,094.11		6,188.03		1,547.08	
3	9,187.10		6,124.74		12,249.47		3,062.37	
3	7,845.30		5,105.95		10,703.79		2,485.71	
Reach 3 totals:	**22,619.89**	22,619.89	**15,271.20**	15,271.20	**30,917.15**	30,917.15	**7,095.16**	7,095.16
4	1,311.78		971.30		1,530.32		508.90	
4	8,974.07		5,836.74		12,109.32		2,696.36	
4	5,317.43		3,339.13		7,501.56		1,566.66	
4	8,390.00		5,380.37		11,580.89		2,583.71	
4	9,638.67		6,425.78		12,851.56		3,212.89	
4	6,829.87		4,347.65		9,517.68		2,071.03	
4	9,638.66		6,425.77		12,851.55		3,212.89	
4	7,540.50		4,821.41		10,465.18		2,307.91	
Reach 4 totals:	**57,640.98**	57,640.98	**37,548.15**	37,548.15	**78,408.06**	78,408.06	**18,160.35**	18,160.35
5	38,185.53		40,684.78		0.00		38,185.53	
5	77,531.59		77,531.59		0.00		75,030.55	
5	28,349.57		30,850.47		0.00		25,848.62	
Reach 5 totals:	**144,066.69**	144,066.69	**149,066.84**	149,066.84	**0.00**	0.00	**139,064.70**	139,064.70
6	54,180.89		54,180.89		0.00		54,180.89	
6	23,921.77		23,921.77		0.00		18,877.91	
6	50,559.29		50,559.29		87,647.48		25,437.98	
6	55,874.79		55,874.79		96,445.11		28,189.92	
Reach 6 totals:	**184,536.74**	184,536.74	**184,536.74**	184,536.74	**184,092.59**	184,092.59	**126,686.70**	126,686.70
7	0.00		0.00		16,186.99		0.00	
7	231,384.33		202,462.52		318,147.63		144,617.85	
7	0.00		0.00		22,176.45		0.00	
Reach 7 totals:	**231,384.33**	231,384.33	**202,462.52**	202,462.52	**356,511.07**	356,511.07	**144,617.85**	144,617.85
8	0.00		0.00		63,507.34		0.00	
8	35,578.45		30,802.74		56,737.65		17,709.44	
8	192,201.27		172,979.46		269,092.23		115,316.28	
8	87,050.39		78,702.30		119,649.54		53,182.10	
Reach 8 totals:	**314,830.11**	314,830.11	**282,484.50**	282,484.50	**508,986.76**	508,986.76	**186,207.82**	186,207.82
9	54,543.42		49,089.07		76,360.78		32,726.05	
Reach 9 totals:	**54,543.42**	54,543.42	**49,089.07**	49,089.07	**76,360.78**	76,360.78	**32,726.05**	32,726.05
Totals (all reaches):	**1,033,899.35**	1,033,899.35	**942,164.93**	942,164.93	**1,283,752.71**	1,283,752.71	**654,558.63**	654,558.63

Stantech Consulting

Project: _____ Project Number: _____

Notes: LOUISE AVENUE CROSSING Scale: _____

Page 1 of 2 Page(s)

Computed By: _____ Date: _____ Checked By: _____ Date: _____

CULVERT QUANTITIES

USED TWO - 10' x 6' BOXES (DOUBLE BARREL)

ALL FILL LESS THAN 10 ft. ∴ TABLE 1 USED

PER B-02.70 (FOR QUANTITIES), DOUBLE BARREL, 10' x 6', TABLE 1:

CONCRETE = 2.270 CY/L.F.

STEEL = 330.70 LBS/L.F.

TOTAL LENGTH OF CULVERT = 50.31 LF

TOTAL CONCRETE: 2.270 CY/L.F. x 50.31 LF = 114.20 CY

TOTAL STEEL: 330.70 LBS/LF x 50.31 LF = 16637.52 LBS

COST

CONCRETE: 114.20 CY x $250.00/CY = $28550.93

STEEL: 16637.52 LBS x $0.50/CY = $8318.76

TOTAL COST OF BOX = $36,869.69

INLET WINGS QUANTITIES

(PER B-05.20, 4:1 SLOPE, 45° SKEW)

10' x 6', DOUBLE BARREL

CONCRETE: 1 BARREL = 15.67 CY

PER EXTRA BARREL = 1.99 CY

TOTAL CONCRETE = 17.66 CY

STEEL: 1 BARREL = 1202 LBS

PER EXTRA BARREL = 217 LBS

TOTAL STEEL = 1419 LBS

COST

CONCRETE: 17.66 CY x $250.00/CY = $4415.00

STEEL: 1419 LBS x $0.50/LBS = $709.50

TOTAL COST OF INLET WINGS = $5124.50

ARIZONA
7776 Pointe Parkway
West., Suite 290
Phoenix, AZ 85044
Voice (602) 438-2200
Fax (602) 431-9562

NEVADA
1100 Grier Drive
Las Vegas, NV 89119
(702) 361-9050
Fax (702) 361-0659

950 Industrial Way
Sparks, NV 89431
(702) 358-6931
Fax (702) 358-6954

Stantec

Project: Project Number:

Notes: LOUISE AVENUE Scale:

Page 2 of 2 Page(s)

Computed By: Date: Checked By: Date:

OUTLET WINGS QUANTITIES
(PER B-05.20, 4:1 SLOPES, 45° SKEW)
10' x 6', DOUBLE BARREL

CONCRETE: 1 BARREL = 22.27 CY
PER EXTRA BARREL = 3.54 CY
TOTAL CONCRETE = 25.81 CY

STEEL: 1 BARREL = 1684 LBS
PER EXTRA BARREL = 344 LBS
TOTAL STEEL = 2028 LBS

COST

CONCRETE = 25.81 CY x $250.00/CY = 6,452.50

STEEL = 2028 LBS x $0.50/LB = $1,014.00

TOTAL COST OF OUTLET WINGS: $7466.50

TOTAL COST OF BOX CULVERT AT LOUISE AVE:

BOX = 36,369.69

INLET WINGS = 5,124.50

OUTLET WINGS = 7,466.50

TOTAL = 49,960.69

SAY: $50,000

APPENDIX D

CORRESPONDENCE

City of Kingman
310 NORTH FOURTH STREET • KINGMAN • ARIZONA • 86401 • 520 • 753-5561

July 31, 2001

RECEIVED
AUG 08 2001
STANTEC

Mr. James O. Hubbard, P.E.
Senior Associate
Stantec Consulting Inc.
8211 South 48th Street
Phoenix, Arizona 85044

Re: Railroad Diversion Channel Preliminary Design

Dear Mr. Hubbard:

Enclosed, for your information, are copies of materials related to a zoning and conditional use permit request for property just north of Louise Avenue and west of Railroad Street. This site is in the area of the proposed Railroad Diversion Channel alignment.

Please let me know if you have any questions.

Sincerely,

Peter R. Johnson, P.E.
City Engineer

enclosure

c: file

PLANNING AND ZONING DEPARTMENT
MEMORANDUM

DATE: July 25, 2001

TO:
City Manager
Community Dev. Director
City Engineer
City Surveyor
City Police Department
City Fire Department
City Building Official
City Public Works Department
Arizona Dept. of Transportation
Mohave County Flood Control
Mohave County Planning and Zoning
Citizens Utilities Company, Electric
Citizens Utilities Company, Gas
Citizens Utilities Company, Telephone
Kingman Cablevision

FROM: Kent Jarcik, Kingman Planning and Zoning Department

RE: **Amendment to the General Plan; Rezoning Case Z-01-14; CU-01-04**

Public Hearing on Amending the Kingman General Plan 1990-2010 To consider changing the projected land use of a 3.49 acre property at the northwest corner of Louise Avenue and Railroad Street from Light Industrial to Community Commercial. This would allow for the consideration of a proposed rezoning from I-1: Light Industry to C-3: Commercial Service Business for the development of a commercial retail and service center. The property is further described as Parcel "B" of a Record of Survey in Book 21, Page 2, being a Portion of the W1/2 of Section 18, T.21N., R.16W., of the G.&S.R.M. Mohave County, Arizona.

If the Amendment to the Kingman General Plan is approved, the following 2 cases will be heard.

REZONING CASE: Z-01-15: A request from Lingenfelter Family Trust, applicant and property owner, to rezone certain property as described above from I:1: Light Industry to C-3: Commercial, Service Business. This rezoning is proposed to allow for the development of a convenience store, fast food restaurant, laundry facility, gas station, and car wash.

CONDITIONAL USE CASE: CU-01-04: A request from Lingenfelter Family Trust, applicant and property owner, for a Conditional Use permit to allow for the construction of a car wash on certain property proposed to be rezoned from I-1: Light Industry to C-3: Commercial, Service Business as described above.

Please refer any comments regarding this information, relating to the jurisdiction of your agency, to the Kingman Planning and Zoning Department by **Tuesday, August 6th, 2001**. If no comments are received by that date, it will be assumed that you have no objections. If you have any questions, please contact me at 753-8130.

Thank you,

Kent Jarcik
Planner

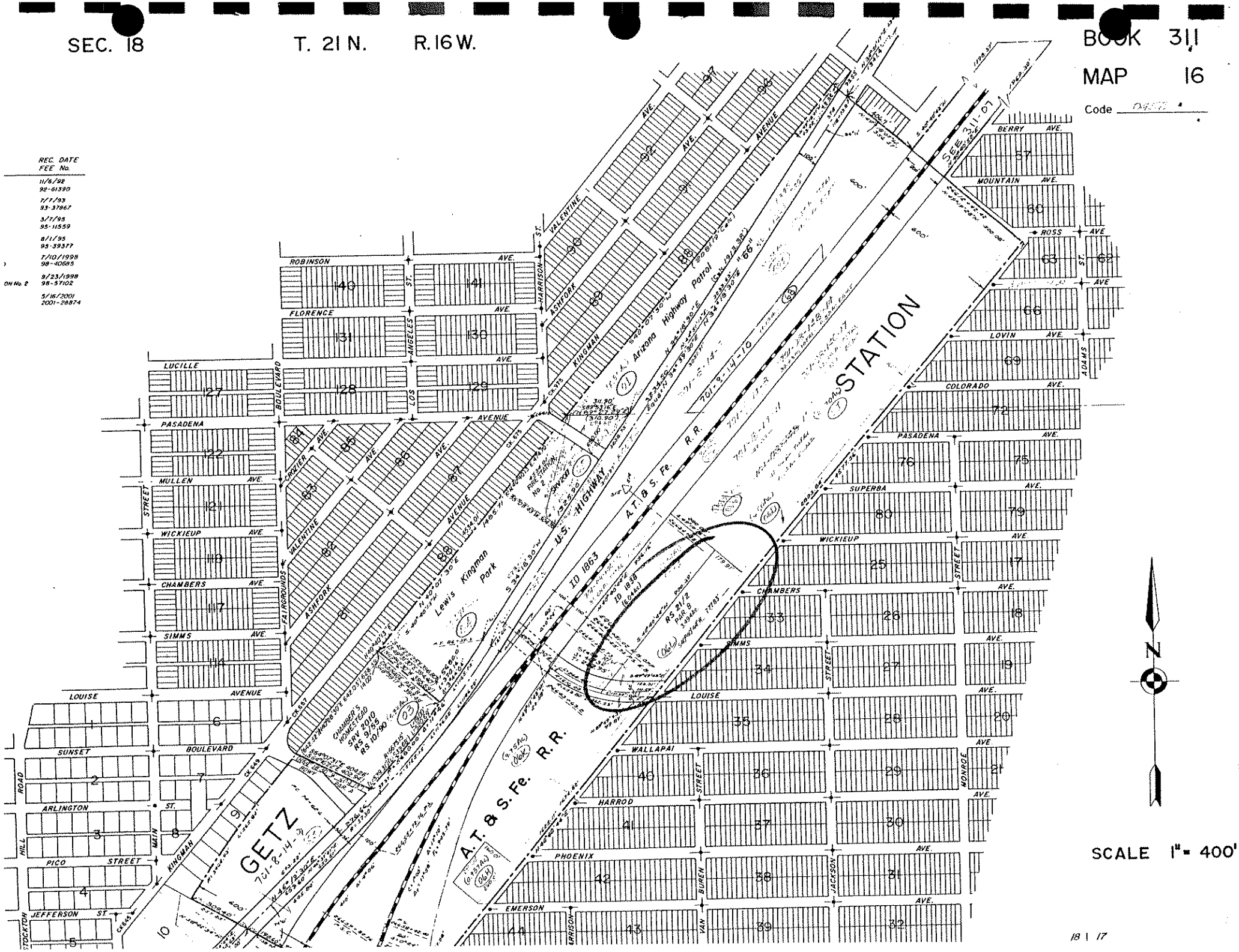
SEC. 18 T. 21 N. R. 16 W.

BOOK 311

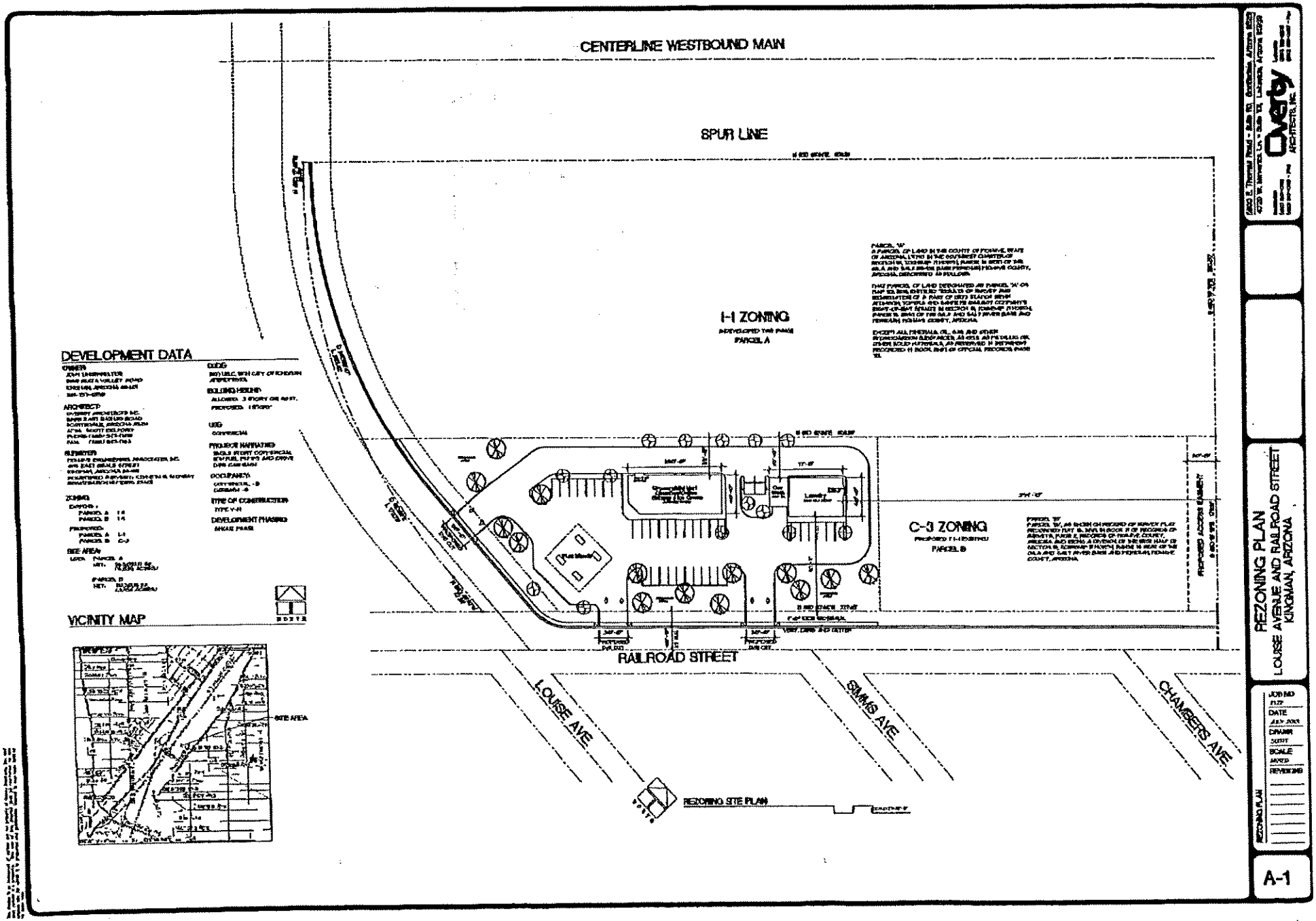
MAP 16

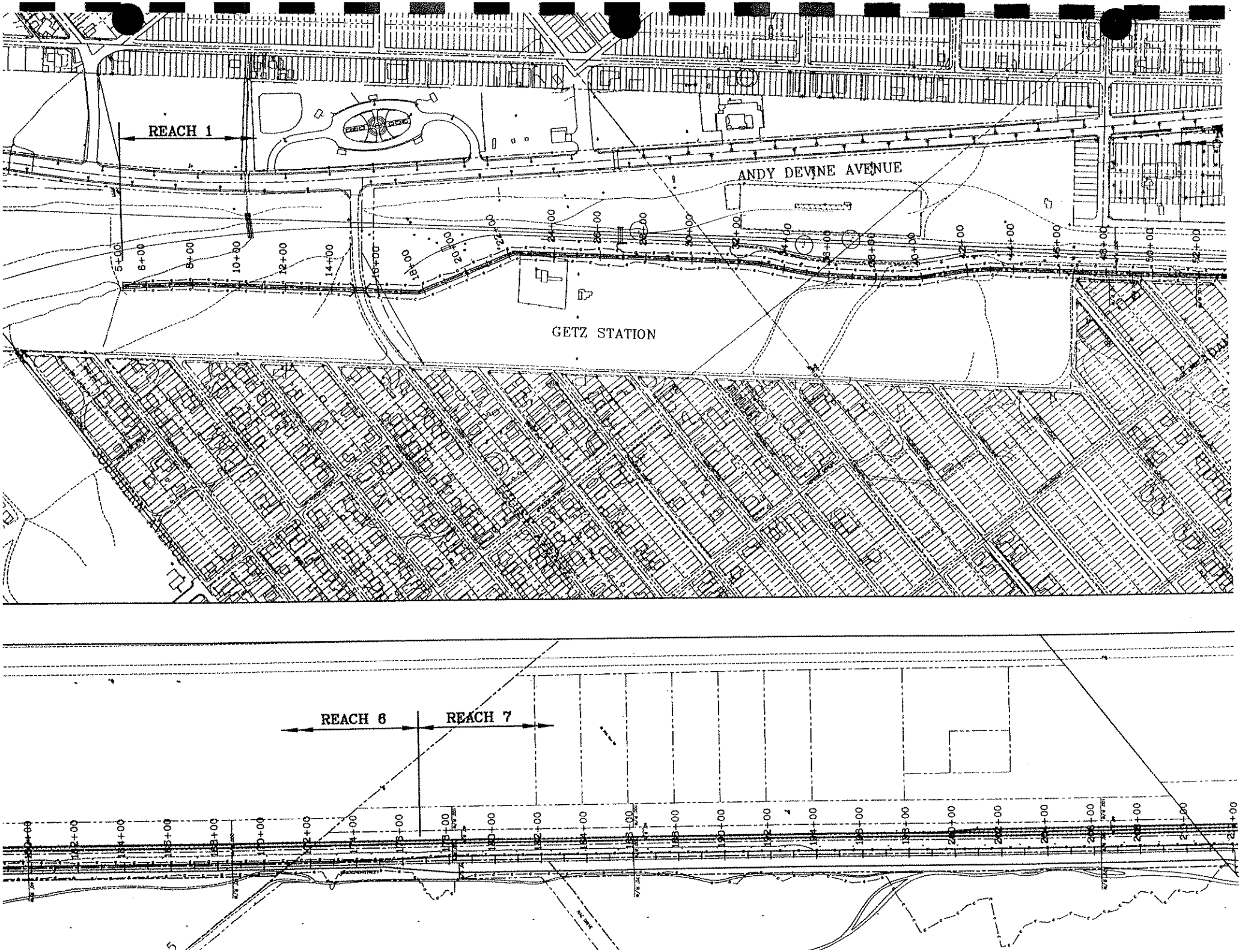
Code _____

REC. DATE	FEE No.
11/6/98	98-61390
7/7/93	93-37867
3/7/95	95-11559
8/1/95	95-39377
7/10/1998	98-40685
OH No. 2 9/23/1998	98-57102
5/16/2001	2001-28874



18 | 17


CENTERLINE WESTBOUND MAIN
SPUR LINE
I-1 ZONING
PARCEL A
C-3 ZONING
PROPOSED I-1 ZONING
PARCEL B
RAILROAD STREET
LOUISE AVE.
SIMMS AVE.
CHAMBERS AVE.
REZONING SITE PLAN
DEVELOPMENT DATA
VICINITY MAP
SITE AREA
REZONING PLAN
LOUISE AVENUE AND RAILROAD STREET
KINGMAN, ARIZONA
A-1


REACH 1
ANDY DEVINE AVENUE
GETZ STATION
REACH 6
REACH 7

BNSF

ENGINEERING SERVICES
Larry J. Delaney
Manager - Public Projects

The Burlington Northern and Santa Fe Railway Company

1624 First Street N. W.
Albuquerque, New Mexico 87102
Phone 505-767-6845

Fax 505-767-6838
E-mail Larry.Delaney@BNSF.com

MAR 27 2001

March 24, 2001
File: ljdDesk

James O. Hubbard, PE
Senior Associate
Stantec Consulting, Inc.
8211 South 48th Street
Phoenix, AZ 85044

RE: Railroad Diversion Channel Preliminary Design Report; Kingman, AZ

Dear Mr. Hubbard:

Please refer to your letter of December 6, 2000 and furnished Draft copy of the above captioned design report. BNSF has reviewed the project based on the document and offers the following preliminary but not all-inclusive comments:

- The drainage ditch should be located as far as practical from BNSF's facilities, i.e. tracks, signals, bungalows, etc. The side of the channel abutting railway property will require protection. An earthen slope will not be allowed in this location but rather should be some type of flexible revetment such as Cable Concrete or Armorflex and should be toed in at top and bottom. Mats of this type are preferred over slope paving (curtains) as they conform to the existing ground contour, permit free drainage and discourage backpressure which causes undermining. The open cell mats also allow for quick coverage with vegetation.

- Bridge 509.1, which is the structure where all water will cross under BNSF tracks, will need extensive modifications. The existing capacity is less than 8,000 cfs with 8.5 feet of center height. The calculated "Q" for the 100 year event is in excess of 12,000 cfs which means that the channel beneath the bridge will need to be lowered 3 feet or the channel lined to increase the velocity. The existing earthen channel will not withstand the velocity. Were it lowered or lined as an alternative, the channel from Br. 509.1 to at least Highway 66, which is 800 to 1000 feet downstream, would need to be improved in like manner to maintain that capacity. The structure beneath Highway 66 would need to be evaluated to determnine existing capacity. There very probably needs to be an energy dissipation mechanism if the water is to be discharged into an earthen channel to avoid headcut. Upstream, the runoff also needs to be turned 90 degrees ahead of 509.1 to redirect it under the bridge. The turning mechanism must be designed and maintained by the City.

- It will be the City of Kingman's responsibility to assure that the calculations are correct and conservative and that future development of Kingman will not cause an increase in the volume or velocity of water entering BNSF property or into the channel. BNSF does not know if the Master Drainage Plan does indeed reflect actual current conditions or if the City will control development in the future such that the Master Plan will remain valid.

- A Construction and Maintenance Agreement will be required between the City and BNSF. Said Agreement among other requirements will require complete maintainence of the channel, including the improved channel under Bridge 509.1, at City expense. Failure to maintain would give BNSF the authority to enter the facility with men, equipment and materials to maintain, reconstruct, clean, grade, etc. and the public agency would be responsible for all costs. The public agency would be responsible for all damages to the railway, including derailments, if the channel overflow was due to underdesign or changes in the drainage basin characteristics or any other factor.

- Assurance that the upstream detention basins will be maintained to maximum allowable bed elevation will be required.

- Drop structures may need to be located in other locations in the channel to control erosion.

- Two 10' by 6' concrete boxes are recommended at the Louise Avenue crossing.

- City of Kingman should not consider that all channel location within BNSF right of way will be at "no cost" to the agency. The proposed channel through some areas does impact BNSF's customers and our access to the tracks. These would be items for negotiation between BNSF and the City.

As stated earlier, these are preliminary comments and are by no means all-inclusive. BNSF welcomes the opportunity to consider this project with the City of Kingman and you are welcome to contact me at any time at 505-767-6845.

Sincerely,

Larry J. Delaney
Manager – Public Projects

cc: R. G. Almaguer – Winslow
D. F. Riker – Winslow
M. R. Bader – Flagstaff
S. L. Marino – Kingman
M. G. McCallister – Flagstaff
K. R. Dout – Albuquerque
D. E. Lozano – Kansas City
R. M. Kadota – Kansas City
J. C. Walters – Winslow
J. L. Hartley – Kansas City
R. J. Boileau – Kansas City
J. C. Shurson – San Bernardino

City of Kingman
310 NORTH FOURTH STREET • KINGMAN • ARIZONA • 86401 • 520 • 753-5561

December 19, 2000

Mr. James O. Hubbard, P.E.
Senior Associate
Stantec Consulting Inc.
8211 South 48th Street
Phoenix, Arizona 85044

Re: Railroad Diversion Channel Preliminary Design

Dear Mr. Hubbard:

We have reviewed the Preliminary Design Report for the referenced project and offer a few comments for your consideration:

1. The proposed channel alignment just north of Louise Avenue appears to bisect parcel 311-16-06F which is currently being used as a landscape materials storage and sales yard. Possibly some route changes would lessen adverse impacts on this property.

2. Input from the BNSF Railway Co. is essential in determining appropriate channel alignment and sections along much of the proposed route.

3. One of the reviewers requested evaluation (or at least discussion) of the relative operation and maintenance requirements and costs for the different channel sections.

4. Some information was included regarding the proposed small detention basin at Fripps Ranch. Would you see any significant benefits in possibly deepening this basin so it will provide additional detention capacity?

5. We request a preliminary design layout for the proposed detention basin at Southern Avenue and Eastern Street. The City has purchased this property and is committed to constructing a detention facility at this location. The proposed improvement district for this area is still proceeding (slowly), and could be at the Resolution of Intention stage within 1 - 2 months. We plan to request a proposal from you for the final design of this basin, once a determination is made on the improvement district project.

6. We definitely want to expand the detention capacity of the ADOT borrow pit. It appears this can be easily accomplished with a small dike at the northwest corner of the excavated area. It appears sub-basins 830 and 840 already discharge into this area so there should be no need for the City to provide any drainage works within these areas. We would also like to consider

directing flows from at least portions of sub-basins 810 and 820 to the pit area. There is an existing drainage and public utilities easement along the east line of Section 17 and one of the more well defined natural channels crosses this section line less than 1000' south of the City property.

7. We should look at the possibility os locating the channel from Sta. 212 to Rattlesnake Wash on Airport rather than railroad property. The Airport property could be probably be dedicated with no cost to the City.

8. Is it anticipated that all flow under the railroad at Diagonal Wash is to be discontinued and retained in the proposed Railroad Diversion Channel?

It would helpful in developing implementation plans to identify any segments that might be constructed separate from the entire channel project and the benefits they might provide.

Please let me know if you have any questions.

Sincerely,

Peter R. Johnson

Peter R. Johnson, P.E.
City Engineer

c: Dennis Roberts, Community Development Director
file

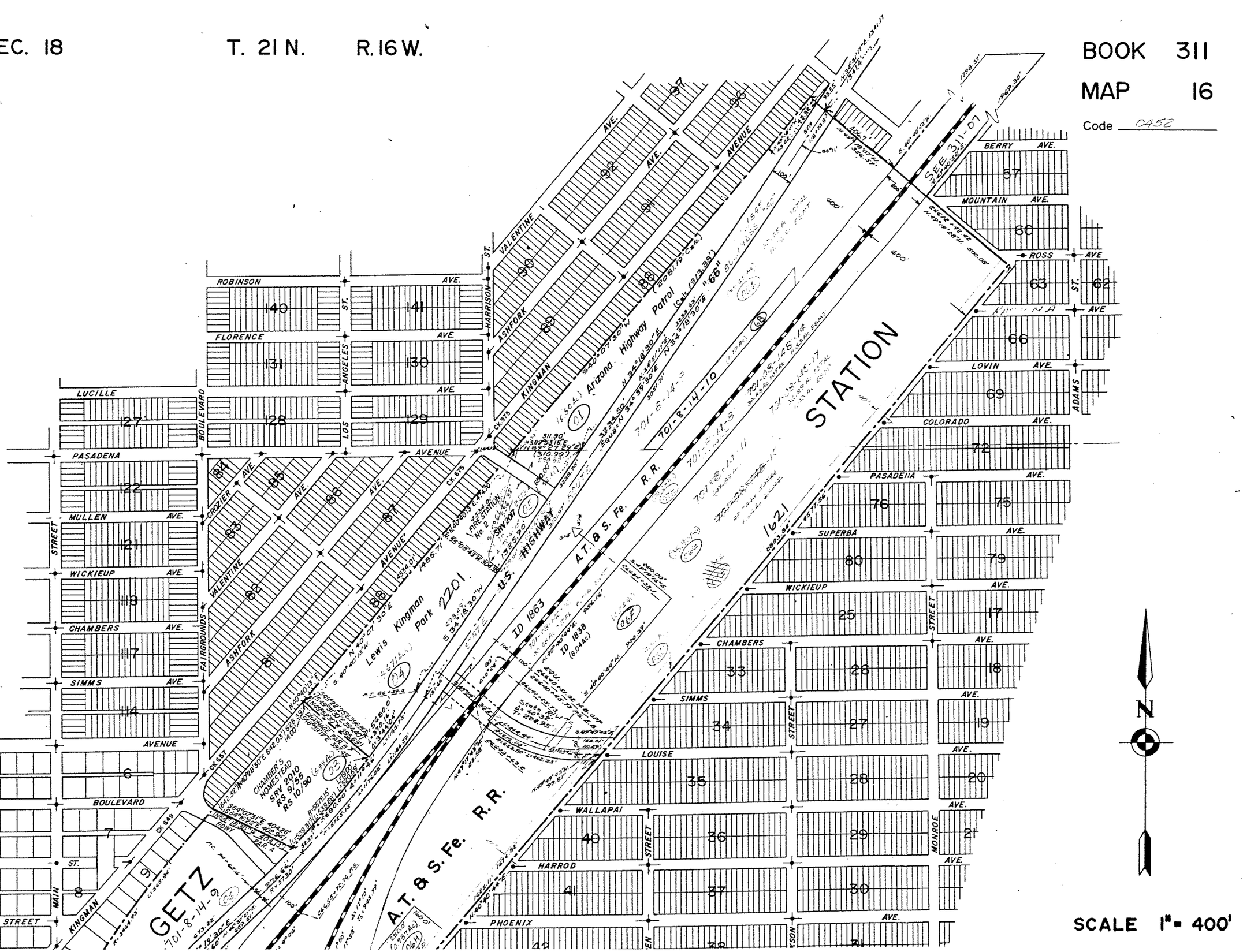
SEC. 18 T. 21 N. R. 16 W.

BOOK 311

MAP 16

Code 0452

PLAT LOCATION	REC. DATE FEE No.
R.S. 9/55 Par. 003	11/6/92 92-61390
R.S. 10/90 Par. 003	7/7/93 93-37867
ID 1838 GETZ STATION	3/7/95 95-11559
ID 1863 GETZ STATION	8/1/95 95-39377
SRV 2010 CHAMBER'S HOMESTEAD	7/10/1998 98-40685
SRV 2017 KINGMAN FIRE DEPT. STATION No. 2	9/23/1998 98-57102



City of Kingman
310 NORTH FOURTH STREET • KINGMAN • ARIZONA • 86401 • 520 • 753-5561

December 15, 2000

DEC 2 2 2000

Mr. James O. Hubbard, P.E.
Senior Associate
Stantec Consulting Inc.
8211 South 48th Street
Phoenix, Arizona 85044

Re: Railroad Diversion Channel Preliminary Design

Dear Mr. Hubbard:

Pursuant to our telephone conversation, yesterday, enclosed are copies of several documents and letters concerning the City's participation in the cost of reconstructing Santa Fe Railway Company Bridge 509 at Rattlesnake Wash. As you will note, the agreement dated July 11, 1988, called for the City to pay $100,000 for expanding the bridge to handle increased flows resulting from the Railroad Diversion Channel. It appears the work was completed in July and the funds were transferred to Santa Fe in December 1988.

I did not find any hydraulic capacity calculations for the structure, but the May 3, 1988 letter from Kenneth V. Lewis, Boyle Engineering Corporation to the Santa Fe Railway Company identifies the 100-year flow at 12,068 cfs which corresponds with the number in the Master Drainage Plan Report. We believed it was also used for bridge design.

Please let me know if you have any questions.

Sincerely,

Peter R. Johnson, P.E.
City Engineer

enclosures

c: Dennis Roberts, Community Development Director
file

December 23, 1988

Mr. A.K. Pottorff
Assistant General Manager
Maintenance
The Atchison, Topeka and Santa Fe Railway Company
One Santa Fe Plaza
5200 East Sheila Street
Los Angeles, California 90040

RE: File: 05005760-56

Dear Mr. Pottorff:

In accordance with the provisions of the agreement entered into by the City of Kingman and Santa Fe Railway Company on July 8, 1988, please find enclosed a check for $100,000.00 covering the City's cost of expanding Bridge 509.1 by 28 feet.

Since the funds for this project derived from the Mohave County Flood Control District, the City must maintain a record that the monies were spent for flood control projects. Therefore, I would appreciate it if you could forward to me either a receipt for the funds, or a letter acknowledging receipt of the funds and fulfillment of our July 8th, 1988 agreement.

Your cooperation and assistance on this project has been greatly appreciated.

Sincerely,

Dennis E. Roberts
Director of Community Development

c.County Engineering

CITY OF KINGMAN

KINGMAN, ARIZONA

CLAIM NUMBER 37316

DATE 12/28/88

CHECK NUMBER 37316

PAY One Hundred Thousand Dollars & 00/100s

$100,000.00

CITY OF KINGMAN

GENERAL

TO THE ORDER OF
The Atchison Topeka & Santa Fe RR Co
Attn: A K Potterff Asst GM, MT
One Santa Fe Plaza
5200 E Sheila St
Los Angeles, CA 90040

CITY TREASURER

COUNTERSIGNED

"037316" :122100024: 9012"6976"

DATE	INVOICE NUMBER	INVOICE AMOUNT	AMOUNT PAID	REMARKS
			100,000.00	Payment for expansion of Bridge 509.1 as outlined in agreement dated 7/8/88 Santa Fe File 05005760-56

UNITED STATES POSTAL SERVICE
OFFICIAL BUSINESS

SENDER INSTRUCTIONS
Print your name, address, and ZIP Code in the space below.
- Complete items 1, 2, 3, and 4 on the reverse.
- Attach to front of article if space permits, otherwise affix to back of article.
- Endorse article "Return Receipt Requested" adjacent to number.

RETURN TO

U.S.MAIL

PENALTY FOR PRIVATE USE, $300

Print Sender's name, address, and ZIP Code in the space below.

CITY OF KINGMAN
310 N 4th St
KINGMAN AZ 86401

ATTN DENNIS ROBERTS

Sent to ATSF RR Co
Street and No. 5200 E Sheila
P.O. State and ZIP Code LOS ANGELES CA
Postage $.25
Certified Fee .85
Special Delivery Fee

RECEIPT FOR CERTIFIED MAIL
NO INSURANCE COVERAGE PROVIDED
NOT FOR INTERNATIONAL MAIL
(See Reverse)

P 904 021 391

8. Travel expense to attend WACOG meeting
Dick Tomlin is asking for travel expenses of $40 to attend the WACOG meeting in Parker. Expense sheet enclosed.

9. Travel expense to attend Chamber Retreat - Anderson
Mayor Anderson is asking for travel expenses of $216.31 to atttend the Chamber retreat. Expense sheet enclosed.

10. Resolution No. 1234 - Agreement with SF Rwy. for City to participate in expansion of RR bridge to accommodate drainage
As you may be aware, Santa Fe lost a bridge just north of the City limits adjacent to the airport to fire. The wash under this bridge had been identified as a possible outlet for the east-side drainage plan. Santa Fe officials had been contacted with regard to the drainage plan and were aware that a crossing was desired in the location of this bridge. A meeting was set up to discuss this with City, County, Santa Fe and Boyle Engineering people. As a result of this meeting, it is estimated that it would cost approximately $100,000 to lengthen the bridge crossing for the drainage channel. Santa Fe is willing to include this in their plan providing the City /county pay any additional costs. During preparation of requests for County budget, the City staff submitted a request for County Flood Control District funds of $100,000 to use for purchase of right-of-way for the proposed Drainage Plan. It would appear at this time that it would be advantageous to work with Santa Fe while they are re-building their bridge and lengthen the structure for the future drainage crossing. Therefore, it is recommended that Council authorize staff to request an amendment with Mohave County to use the funds for this bridge lengthening project. A copy of the Memo from Dennis Roberts explaining this activity is included in the packet. It is important that we move forward on this as quickly as possible as Santa Fe is is moving ahead with the construction in order to open the wash before the expected rains this summer.

11. Set Special Council Meeting/Study Session/Master Drainage Study

12. Direction to the City Manager

13. Motion to go into Executive Session at the next meeting

JUNE CLAIMS - Certifiers are Budd and Frazza

CITIZENS COMMUNICATIONS/PETITIONS

14. DEPARTMENT REPORTS

15. BOARD/COMMISSION MINUTES
The following minutes are included in the packet:

Clean City	5/19 & 26	P & R	6/15
MUC	6/23	P & Z	5/26

16. EXECUTIVE SESSION (ARS 38-431.03 A. 3 & 7)
--litigation - Ron Lewis settlement (letter enclosed)
--property negotiations - information on this activity will be provided to the City Council.

9. Travel expense to attend Chamber of Commerce Retreat - Anderson

Mayor Anderson turned the gavel over to Vice-Mayor Budd and said she would abstain from discussion and voting on this item. A motion by Frazza to approve travel expense of $216.31 for Anderson to attend the Chamber of Commerce Retreat was seconded by Wienke, and the members voted approval, except Anderson, who abstained.

10. Resolution No. 1234 - Agreement with Santa Fe Railway Co. whereby City agrees to financially participate in the expansion of a railroad bridge to accommodate drainage flows

Sorensen said a Santa Fe bridge that burned recently was a bridge that had been identified in the Drainage Study, so the staff asked Santa Fe if they would consider lengthening the bridge when they rebuild to accommodate the drainage needs. He said the staff has also asked the Board of Supervisors to modify the City's request for Flood Control funding to allow the requested $100,000 to be used for expanding this bridge, and this Resolution has been prepared to reflect this. A motion by Wienke for adoption of the Resolution was seconded by Budd, and the members voted unanimous approval.

(RESOLUTION NO. 1234)

11. Set Special Council Meeting/Study Session for presentation of the Master Drainage Study

Sorensen said he would like the Council to go through this, so they can decide whether they want to adopt or reject it. He said it represents a commitment of $30-40 million dollars. The meeting was scheduled for 7 P. M., Monday July 11.

12. Direction to the City Manager

Frazza, referring to the firemen who died in the explosion 15 years ago, said he had great respect for the police and firemen who lay their lives on the line. He said he would like to see what the City could do about providing facilities and programs to keep them in good physical condition. Sorensen said he is very aware of this; there is obviously room for improvement, but it always is a matter of budget. McBrayer asked the Manager to have figures on what it would cost for bullet proof vests by the July 18th meeting. Tomlin said it doesn't take any special equipment other than a pair of soft shoes to help prevent heart attacks. Tomlin challenged McBrayer to pledge an amount for the laps he is going to do for the Dolphin Swim Team. McBrayer said he would go 25¢ a lap. He said he already pledged to an 11-year-old who swam 185 laps, and he challenged Tomlin to do as well.

Chief Kinsey said the whole fire service is dealing with the question of fitness right now, but is leaving it up to cities to adopt their own fitness programs. He said the City gives firemen one hour a day to walk, run, lift weights or play racquet ball, and they have 75-80% participation. He said they are also looking at a training room when the police facility is built.

McBrayer asked the staff to check into the salaries that were set for Mayor and Council back in 1986. He said, as he remembered, salaries were to go from $100 to $200 in 1988 -- not from $100 to $300.

CITY OF KINGMAN

RESOLUTION NO. 1234

A RESOLUTION BY THE MAYOR AND COMMON COUNCIL OF THE CITY OF KINGMAN, ARIZONA; RELATED TO AN AGREEMENT BETWEEN THE CITY AND SANTA FE RAILWAY COMPANY, WHEREBY THE CITY AGREES TO FINANCIALLY PARTICIPATE IN THE EXPANSION OF A RAILROAD BRIDGE TO ACCOMMODATE DRAINAGE FLOWS

WHEREAS, the City of Kingman and the County of Mohave have engaged in the master planning of drainage control for the Kingman Area, through the development of the Kingman Area Master Drainage Study, and

WHEREAS, the Kingman Area Master Drainage Study has identified the need for a drainage channel parallel to the the east side of the Santa Fe Railway Company's right-of-way, running from Louise Avenue northerly to a drainage crossing of the railroad near Thompson Avenue, and

WHEREAS, to implement this drainage channel, its outlet at the railroad drainage crossing near Thompson Avenue, would require the enlargement of the railroad bridge, and

WHEREAS, on June 23rd, 1988 this bridge crossing was destroyed by fire, creating the situation whereby Santa Fe Railway Company must construct a new bridge at this location immediately, and

WHEREAS, Santa Fe Railway Company being aware of the City and County plans to develop a drainage channel parallel to the railroad right-of-way which would carry drainage flows under the bridge crossing near Thompson Avenue requiring the expansion of this bridge structure by approximately 24 feet, they have approached the City and County to participate in this enlargement during this emergency reconstruction, and

WHEREAS, to participate in the enlargement of this bridge construction the City and/or County would be required to participate financially, by paying for the cost of the additional 24 foot extension.

NOW THEREFORE, BE IT RESOLVED by the Mayor and Common Council of the City of Kingman, Arizona, that it is recognized that this bridge expansion is necessary in order to implement the proposed drainage plan identified in the Kingman Area Master Drainage Study, and that the City should participate in the expansion of this bridge at this time through the use of the City's requested $100,000 of 1988/89 Special Project Funds of the Mohave County Flood Control District.

BE IT FURTHER RESOLVED, that the Common Council of the City of Kingman, Arizona, by passing this Resolution, hereby authorizes (1) the City Staff to request the Mohave County Board of Supervisors to allow the City to modify its Flood Control funding request for 1988/89 to allow the use of the requested $100,000 to be used for expanding the above discussed railroad bridge, and (2) authorizes the Mayor, on behalf of the City, to enter into an agreement with Santa Fe Railway Company, whereby the City agrees to participate in the funding of the "24" foot bridge enlargement through the use of Special Project Funds from the Mohave County Flood Control District.

PASSED AND ADOPTED by the Mayor and Common Council of the City of Kingman, Arizona this 5th day of July, 1988.

APPROVED:

Carol S. Anderson

CAROL S. ANDERSON, MAYOR

ATTEST:

Dorothy Helmer

DOROTHY HELMER
CITY CLERK

APPROVED AS TO FORM:

James Chavez

JAMES CHAVEZ
CITY ATTORNEY

Dennis

The Atchison, Topeka and Santa Fe Railway Company

One Santa Fe Plaza
5200 East Sheila Street
Los Angeles, California 90040

213/267-5406

July 8, 1988

File: 05005760-56

Mr. Dennis E. Roberts
Community Development Director
City of Kingman
310 North Fourth Street
Kingman, AZ 86401

Mr. Kenneth V. Lewis, P.E.
Boyle Engineering Corporation
7600 North 16th Street, Suite 110
Phoenix, AZ 85020

Mr. T. M. Walton
Supervisor Structures
A.T.&S.F. Railway Co.
c/o Regional Yard Office
4th and Andy Devine
Kingman, AZ 86401

Gentlemen:

Reference previous discussions and correspondence regarding rebuilding Santa Fe's Bridge 509.1 and increasing its capacity to facilitate a City drainage project.

I am attaching a four page letter agreement outlining how Santa Fe can accommodate the City project at this time. The status of the bridge rebuilding is such that we MUST decide on the evening of Monday, July 11 whether to build a 98-foot bridge or a 126-foot bridge.

Mr. Walton, who is in direct supervision of the bridge rebuilding, will come to the City Hall late Monday. At that time, Mr. Walton will either expect to receive an acknowledged and accepted copy of the agreement from the City or he will have to extend his regrets that we cannot expand the bridge at this time.

It is unfortunate that we must come to terms so hastily but the pile driving equipment is committed to a timetable and the bridge rebuilding must be completed before we are caught by storms.

Very truly yours,

A. K. Pottorff

A. K. Pottorff
Assistant General Manager
Maintenance

The Atchison, Topeka and Santa Fe Railway Company

One Santa Fe Plaza
5200 East Sheila Street
Los Angeles, California 90040

File: 05005760–56

July 8, 1988

AGREEMENT

Santa Fe is forced to replace its Bridge 509.1 on an emergency basis. The bridge was a 98 foot long, three–track, ballast deck pile trestle. Santa Fe had intended to replace the bridge with a 98 foot long, three–track, ballast deck, T rail trestle with similar vertical clearance beneath bridge as that of the former trestle.

City of Kingman proposes to construct a drainage diversion channel upstream of Santa Fe's track for approximately five miles. Diversion channel will terminate opposite Bridge 509.1 and direct additional water through Bridge 509.1. The amount of water that could thereafter be expected to pass through Bridge 509.1 exceeds the capacity of the structure intended to be constructed by Santa Fe to serve only the natural drainage area.

City of Kingman has asked Santa Fe to construct a bridge of greater capacity than Santa Fe intended. Santa Fe is willing to do so under the following conditions:

1. Santa Fe will construct and thereafter maintain a three–track bridge, 98 feet in length, at its sole expense.

2. Santa Fe will construct, at the expense of the City of Kingman, and thereafter maintain at Santa Fe expense a three–track bridge of 28 foot extended length.

3. The City of Kingman and Santa Fe desire to affix a cost and remove any uncertainties. Therefore, Santa Fe will construct the extended length bridge for the lump sum of $100,000. Payment will be made by the City to Santa Fe in the month of DECEMBER, 1988.

4. Prior to constructing expected channel improvements across Santa Fe's right of way and beneath Bridge 509.1, City of Kingman will enter into a Construction and Maintenance Agreement with Santa Fe for those improvements. It is expected that there may be additional work required to be performed upon Bridge 509.1 by Santa Fe at City of Kingman's expense to accommodate the channel improvements. This could include, but not be limited to, addition of concrete collars at flow line elevation of pile columns and installation of longitudinal bracing between pile columns, both of which may be required by reason of a lower channel elevation than heretofore existed.

File: 05005760-56

5. The vertical clearance beneath the replacement bridge and the extended length bridge will be re-established by Santa Fe similar to the former trestle. At such time as the channel improvements are made, that vertical clearance will be agreed to by the parties but it is expected to look like the attached drawing, identified by the title BRIDGE 509.1 WATERWAY REQUIREMENT and hereby made a part of this agreement.

To indicate that the foregoing conditions are satisfactory, please endorse your approval on the acknowledgment section of this letter and return one copy to Santa Fe, at which time we will schedule for construction.

Very truly yours,

A. K. Pottorff

A. K. Pottorff
Assistant General Manager
Maintenance

ACKNOWLEDGED AND ACCEPTED

This 11th day of July, 1988

By Carol L. Anderson

Its Mayor

7301e

File: 05005760

The A.T. & S.F. Railway Co.

ESTIMATE

To construct a 3 track, ballast deck, T-rail trestle of 28 foot extended length on force account basis for City of Kingman.

Cost per foot of bridge, per track:

Labor	$ 864.30
Material.....	355.04
Operating (remove and replace track, ballast).....	80.81
	$1,300.15

Cost of extended length:

$1,300.15 x 28 feet x 3 tracks = $109,212

Manager Structures Western Region
Los Angeles, California
July 8, 1988

7371e

Boyle Engineering Corporation

consulting engineers and architects

[illegible] 341-8300

July 5, 1988

Community Development Director
CITY OF KINGMAN
Attention: Mr. Dennis Roberts
310 North Fourth Street
Kingman, Arizona 86401

AT&SF Bridge 509.1

Enclosed herewith is a copy of an elevation view of the proposed new bridge at 509.1. I have indicated the required number of bays and a range of depths for the future diversion channel.

I have spoken to Jack King of AT&SF regarding the flexibility of depth under the bridge. He assured me that a range of 10-15' will not present a problem. Due to the required depth, which includes a "velocity head" safety factor, struts and concrete collars will be required. Mr. King said that these can be constructed in conjunction with the future channel improvements and are not required now.

Please note I have copied this letter and sketch to Mr. Pottorff of AT&SF.

Should you require any further help in this matter, please let me know.

BOYLE ENGINEERING CORPORATION

Kenneth V Lewis

Kenneth V. Lewis, P.E.
Senior Civil Engineer

sja

Enclosure

cc: A. K. Pottorff

PH-K01-100-01

A18-0109

The Atchison, Topeka and Santa Fe Railway Company

One Santa Fe Plaza
5200 East Sheila Street
Los Angeles, California 90040

213/267-5444

May 3, 1988

File: 11006476-69

Mr. D. E. Roberts
Director of Community Develpment
City of Kingman
310 North Fourth Street
King,man, AZ 86401

Dear Mr. Roberts:

The information and calculations forwarded by Boyle Engineering Corporation regarding the Southeast Area Drain of the City of Kingman and Mojave County's Master Drainage Plans have been reviewed. We have no objection to the proposed storm drain channel contiguous to and, in some areas, partially on our right of way. At the proper time, our representative will meet with you at the site to work out any required details and legal agreement to cover the encroachment.

The proposed upgrading of our Br. 509.1 to carry the 100-year storm flow by the addition of a 70-foot bay to the existing structure is not satisfactory. The existing bridge is a 10-10 ft. timber spans with T-rail stringers. Some of the spans are supported by timber framed bents on concrete footings and carry three tracks. This bridge is neither of the design nor of the integrity to carry the volumes and velocities the drainage plan will produce here. A new structure will be required. This office will work with you in design and construction of a new structure.

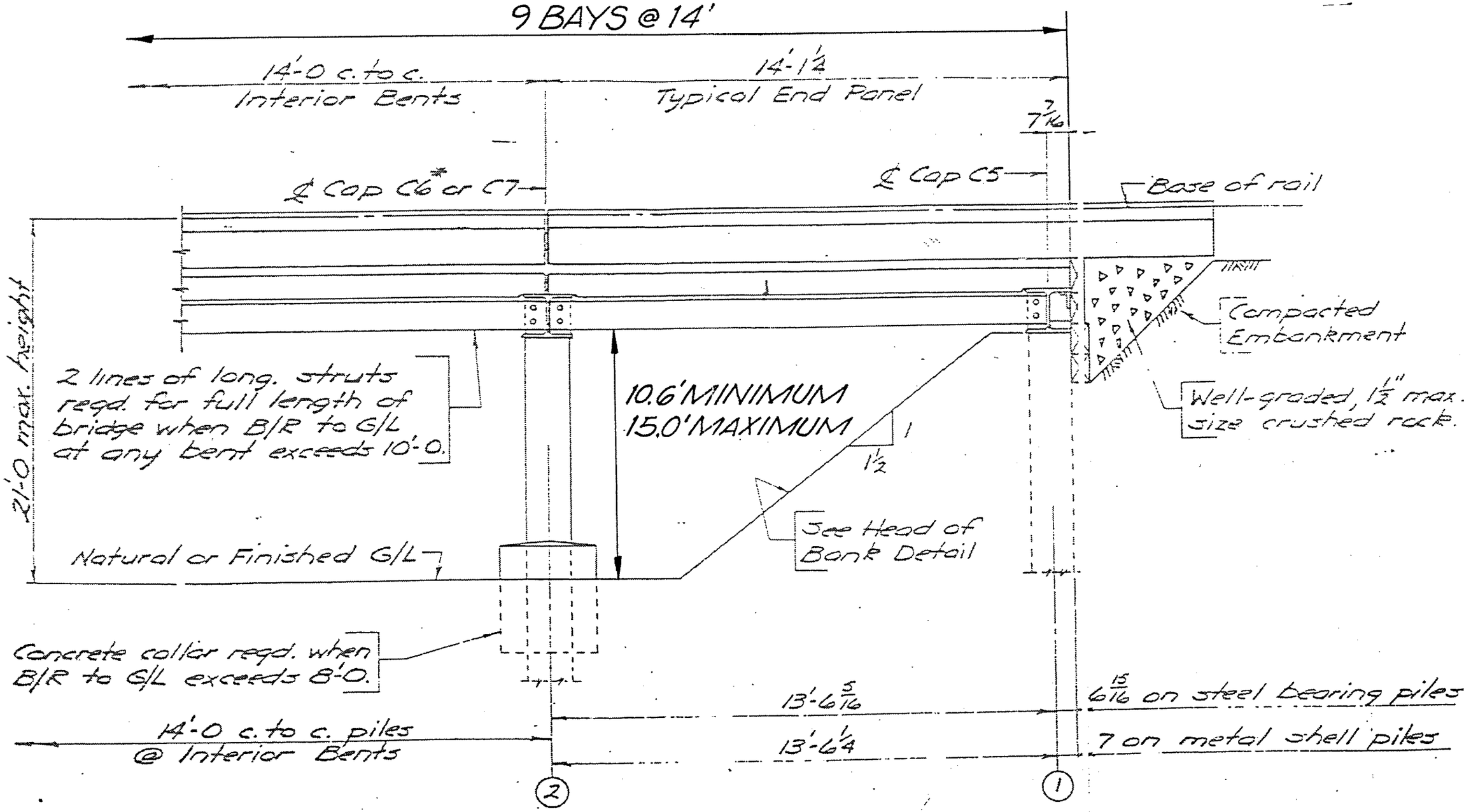
If you have any questions, or need further assistance involving this subject matter, please contact this office or call our Bridge Engineer B. J. King at the above telephone number.

Very truly yours,

A. K. Pottorff

A. K. Pottorff
Assistant General Manager
Engineering

cc: Mr. K. V. Lewis, Project Manager
Boyle Engineering Corp.
7600 North 16th St., Suite 110
Phoenix, AZ 85020



ELEVATION – MULTIPLE PANELS

BRIDGE 509.1
WATERWAY REQUIREMENT

Boyle Engineering Corporation

Suite 110
2500 North 15th Street
Phoenix, Arizona 85020

consulting engineers / architects

602 / 943-6800

THE ATCHISON, TOPEKA and SANTA FE
RAILWAY COMPANY
Attention: Mr. A. K. Pottorff
Assistant General Manager
One Santa Fe Plaza
5200 East Sheila Street
Los Angeles, California 90040

May 3, 1988

Kingman Railway Channel between MP 509.1 and 514.3

With reference to a phone conversation with Mr. King on May 3, 1988, I attach herewith Exhibit 2 of the Kingman Area Master Drainage Plan and the relevant hydrologic information from Appendix "A".

With reference to Exhibit 2, the 100-year design discharges for specific channel sections are shown below:

Channel Section	Area (sq. mi.)	100-Year Runoff (cfs)
50 - 100	31.0	12,068
100 - 110	16.7	7,316
110 - 120	7.8	3,980
120 - 130	5.0	2,675
130 - 140	2.4	1,289
140 - 150	1.0	300

If you require any further information on the above project, let me know.

BOYLE ENGINEERING CORPORATION

Kenneth V. Lewis

Kenneth V. Lewis, P.E.

sja

Enclosures

cc: Pete Johnson (City of Kingman) (w/o enclosures)

PH-K01-100-01

A18-0100

HE INTERIOR
SURVEY

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

KINGMAN AIRPORT QUADRANGLE
ARIZONA—MOHAVE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

STOCKTON HILL QUADRANGLE
ARIZONA—MOHAVE CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

3154 I NE
(ELEMENTS CANYON)

PIERCE FERRY ROAD 10 MI

3254 IV NW
(LONG MOUNTAIN)

R. 16 W. R. 15 W.

420 000 FEET

460 000 FEET

114°00'

113°57'30"

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1967. Field checked 1968

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, west zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

To place on the predicted North American Datum 1983 move the projection lines 2 meters north and 71 meters east as shown by dashed corner ticks

Fine red dashed lines indicate selected fence lines

SCALE 1:24 000

1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 1 5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GN 14°41' 30 MILS MN 14°E 258 MILS

UTM GRID AND 1980 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

ROAD CLASSIFICATION

Heavy-duty ——— Light-duty .....
Medium-duty ——— Unimproved dirt - - - -
U.S. Route State Route
Interstate Route

ARIZONA

QUADRANGLE LOCATION

WIDE WORLD OF MAPS, INC.
1440 S. Country Club Dr.
Mesa, AZ 85210
(602) 644-1134

KINGMAN, ARIZ.
N3507.5—W11400/7.5

1967
PHOTOREVISED 1980
DMA 3154 II NE—SERIES V898

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

Revisions shown in purple compiled from aerial photographs taken 1978 and other source data. This information not field checked. Map edited 1980

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1967. Field checked 1968

Polyconic projection. 1927 North American datum
10,000-foot grid based on Arizona coordinate system, west zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

To place on the predicted North American Datum 1983 move the projection lines 2 meters north and 71 meters east as shown by dashed corner ticks

Fine red dashed lines indicate selected fence lines

SCALE 1:24000

1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 1 5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GN 14°41' 30 MILS MN 14° 249 MILS

UTM GRID AND 1980 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

ROAD CLASSIFICATION

Heavy-duty ——— Light-duty .....
Medium-duty ——— Unimproved dirt - - - -
Interstate Route U.S. Route

ARIZONA

QUADRANGLE LOCATION

WIDE WORLD OF MAPS, INC.
1440 S. Country Club Dr.
Mesa, AZ 85210
(602) 644-1134

RATTLESNAKE HILL, AR
35113-B8-TF-024

1968
PHOTOREVISED 1980
DMA 3254 III NW—SERIES V898

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

Revisions shown in purple compiled from aerial photographs taken 1978 and other source data. This information not field checked. Map edited 1980

Drainage Sub-Basin Boundaries

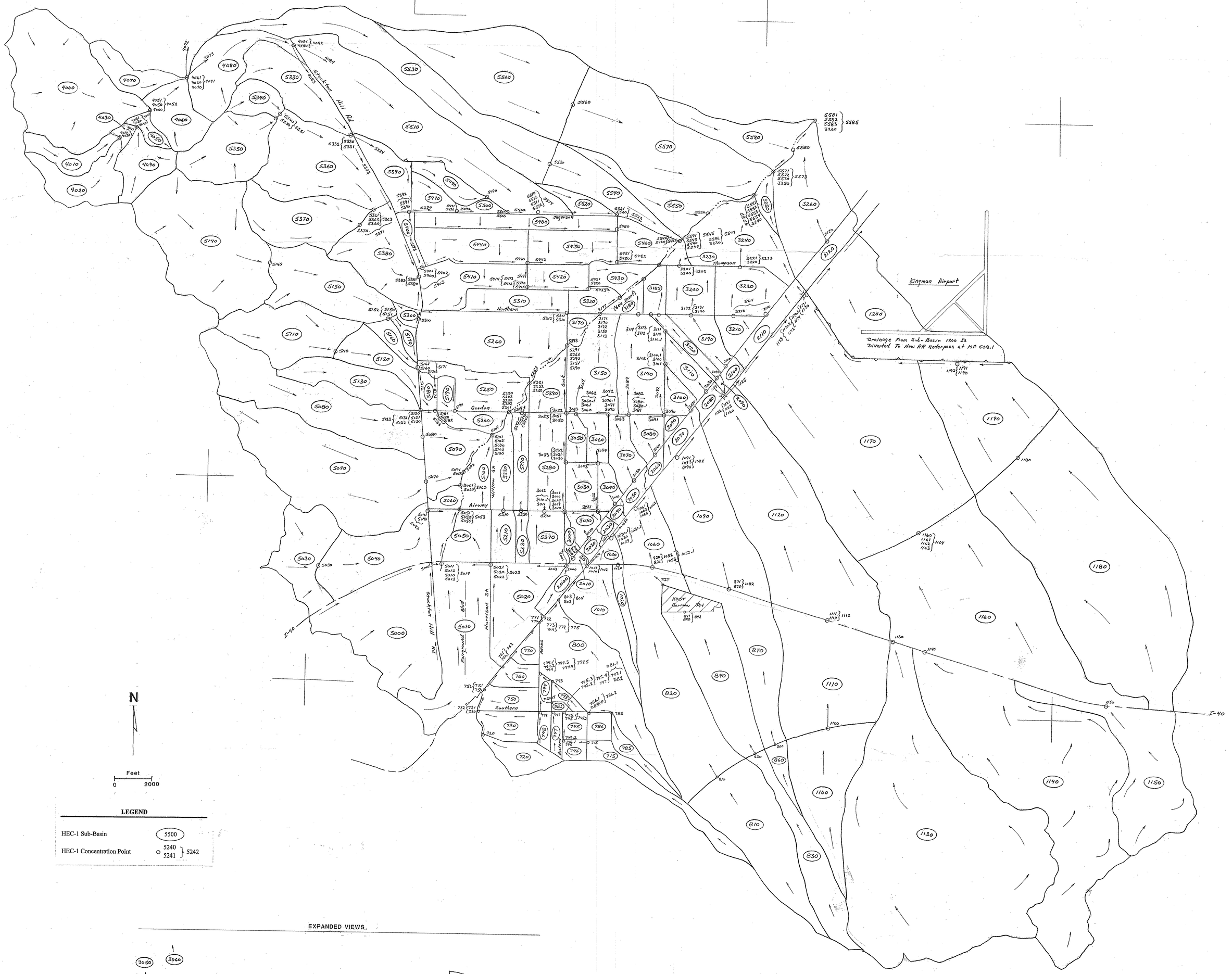
Mohave Wash Channel Improvement Project

Kingman Area Master Drainage Plan Update

Mohave County, Arizona

October-99 **PLATE**

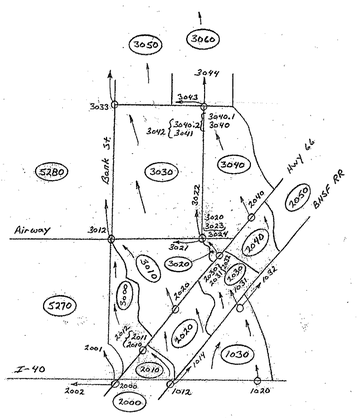
11

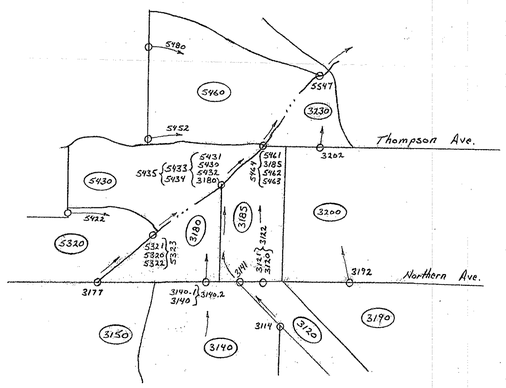


LEGEND

HEC-1 Sub-Basin	5500
HEC-1 Concentration Point	5240, 5241 } 5242

EXPANDED VIEWS





Note: CP 5433 is at the upstream side of the confluence with Diagonal Way Channel.

CP 5435 is at the downstream side of the confluence with Diagonal Way Channel.

HEC-1 Routing Schematic
Mohave Wash Channel Improvement Project
Kingman Area Master Drainage Plan Update
Mohave County, Arizona
October-99 **PLATE 2**

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ 85044 U.S.A.
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Stantec

CITY OF KINGMAN FOUNDED 1882

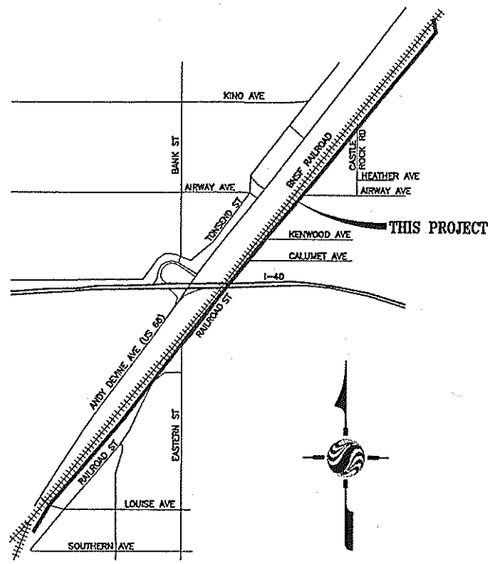
MAYOR
LESTER BYRAM

COUNCIL MEMBERS
HOMER JOHNSTON
DAVE FRENCH
MONICA GATES
TOM SPEAR
PHILLIP MOON
FRANK MCVEY

CITY MANAGER
LOUIS SORENSEN, P.E.

CITY ENGINEER
PETER R. JOHNSON, P.E.

PUBLIC WORKS DIRECTOR
JACK KRAMER



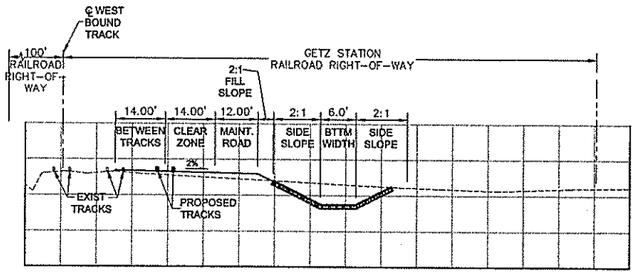
VICINITY MAP
NO SCALE

CITY OF KINGMAN
PUBLIC WORKS DEPARTMENT
310 N. Fourth Street
Kingman, AZ 86401
520-753-8122

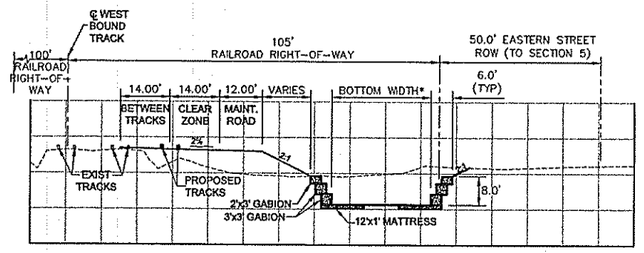
Railroad Diversion Channel

NOVEMBER 2001
STANTEC JOB NO.: 81760038

SHEET INDEX

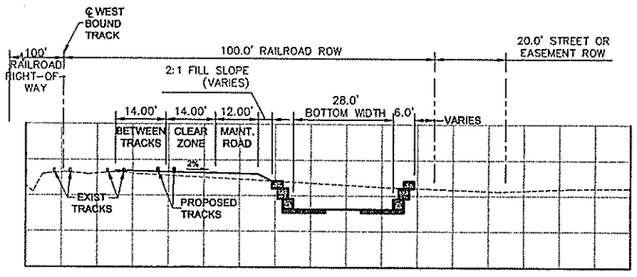


REACH 1
GABION MATTRESS

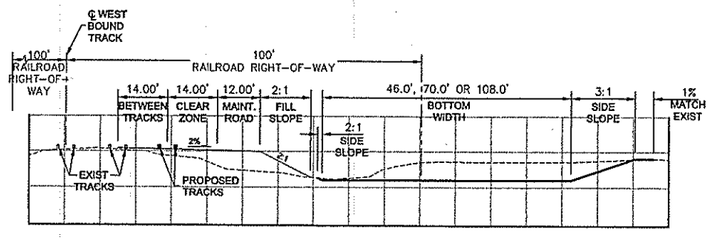


REACH 3, 4, 5A, 6B, AND 6C
STACKED GABIONS

REACH	BOTTOM WIDTH*
3	35.0'
4	40.0'
5a	40.0'
6b	40.0'
6c	50.0'



REACH 2
STACKED GABIONS



REACH 6D, 7, AND 8
EARTHEN CHANNEL

Stantec
Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Legend

Notes

Revision	By	Appd.	Date
0:1			
0:2			
0:3			
0:4			
0:5			
A1			

Issued	By	Appd.	Date
File Name	Dwn.	Dsgn.	Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

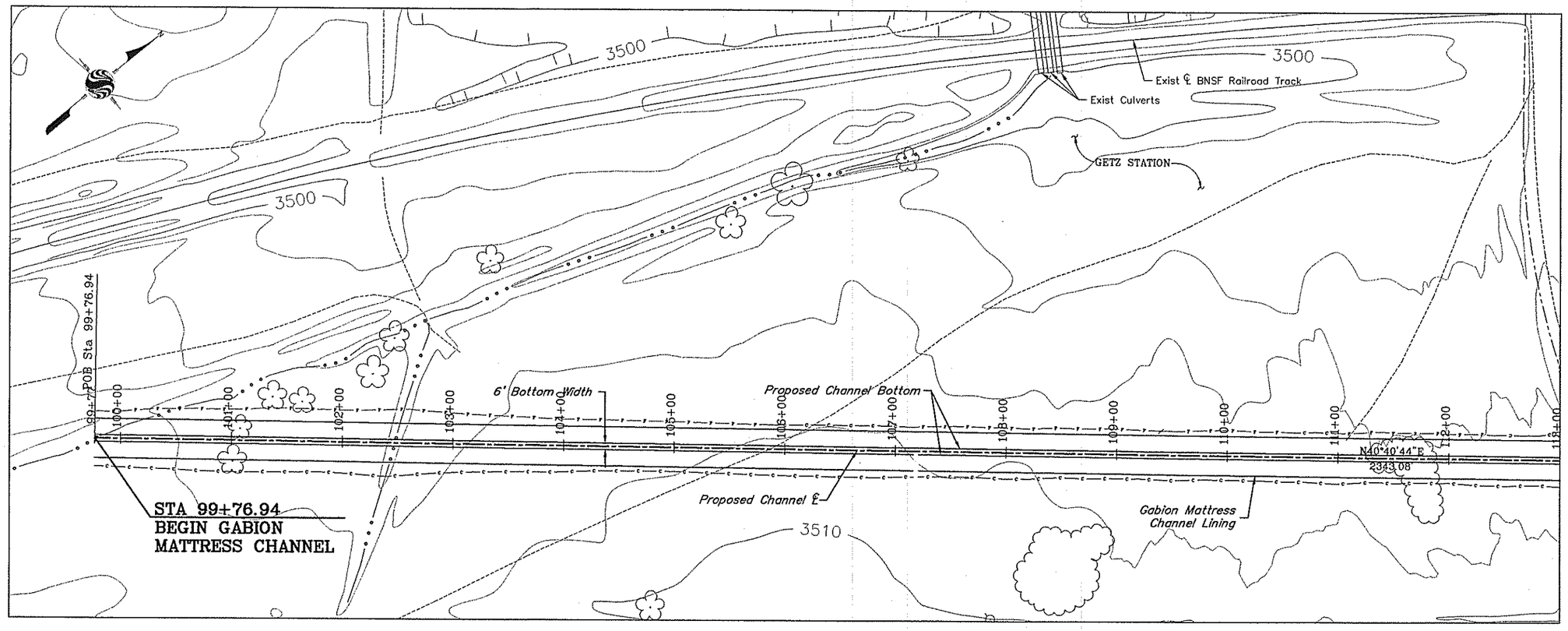
Kingman, Arizona

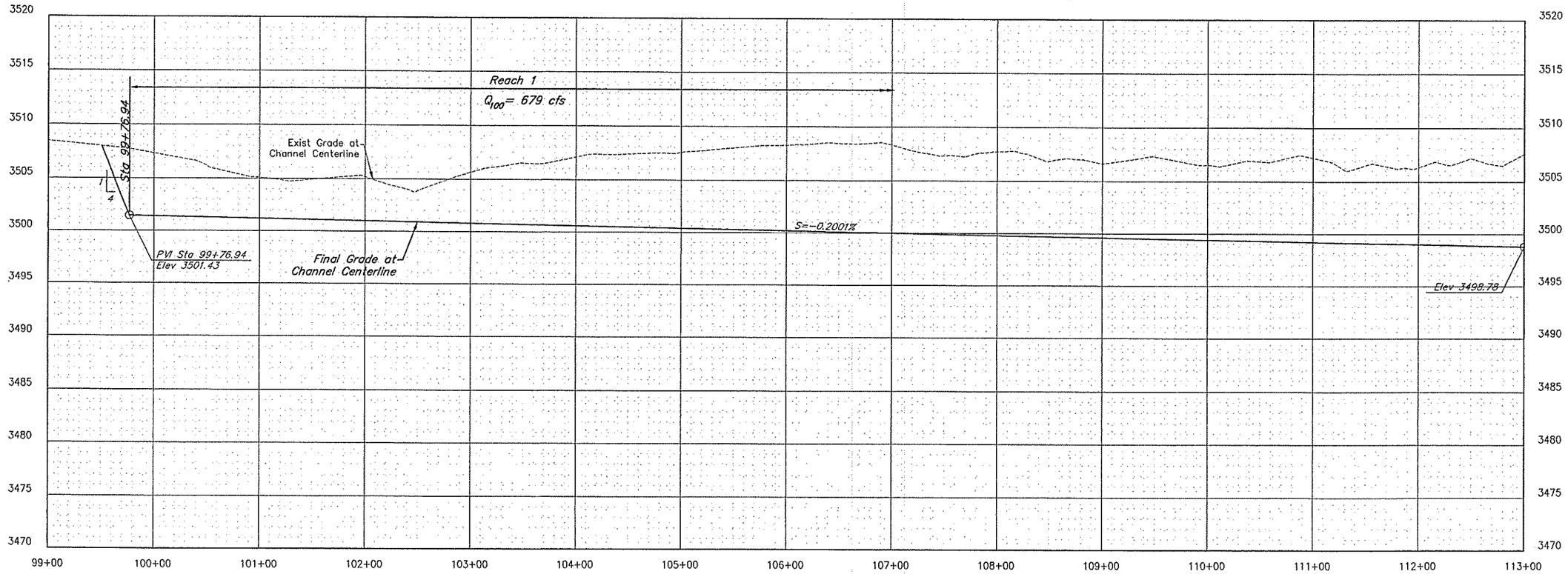
Title
CHANNEL TYPICAL SECTIONS

Scale
1"=20'

Drawing No.	Sheet	Revision
TYP1	II / II	0

ORIGINAL SHEET - D N:\PROJECTS\81760038\PLANNING\PLOTTING\TYP1.DWG





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date

No.	Issued	By	Appd.	Date

File Name — Dwn. — Dsgn. — Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

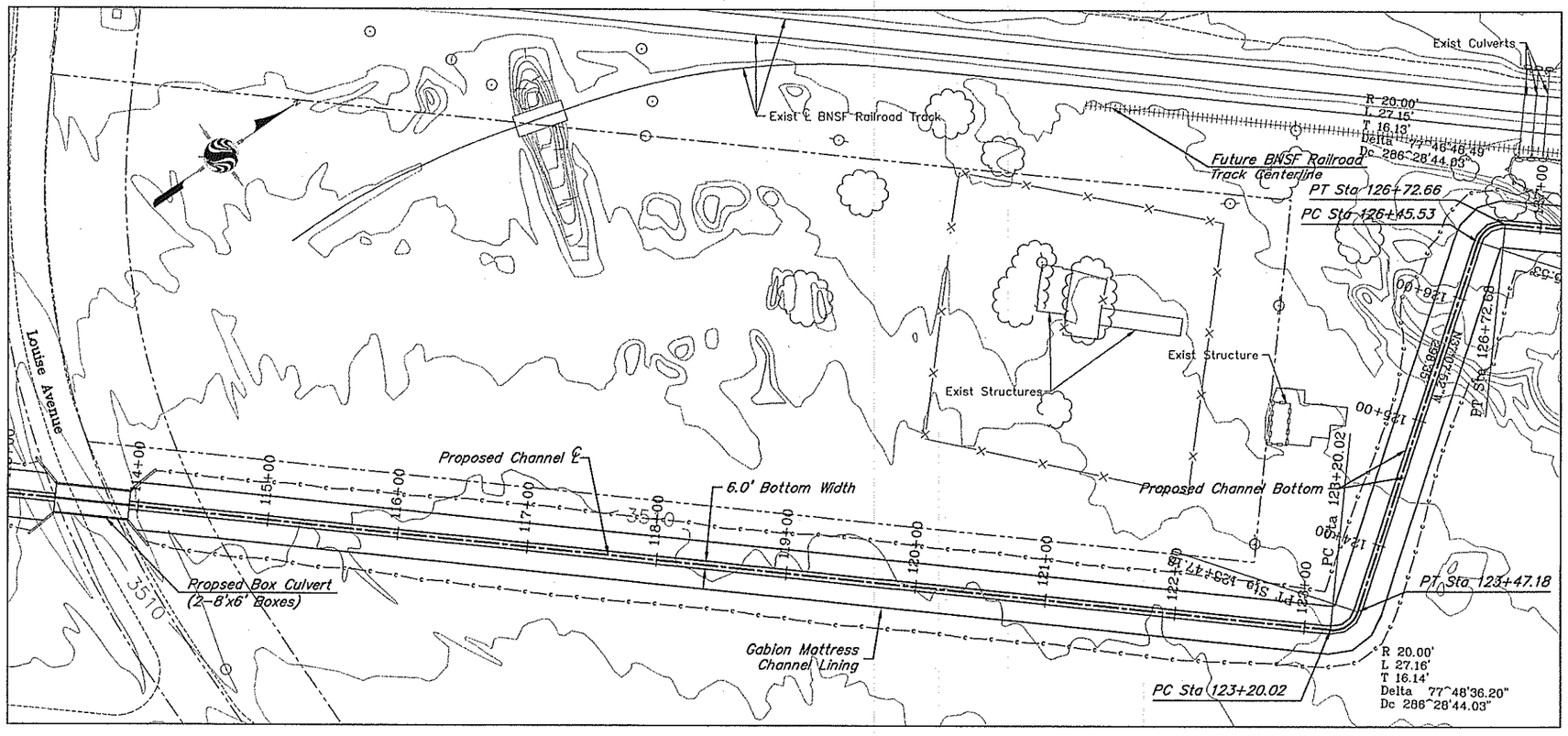
Kingman, Arizona

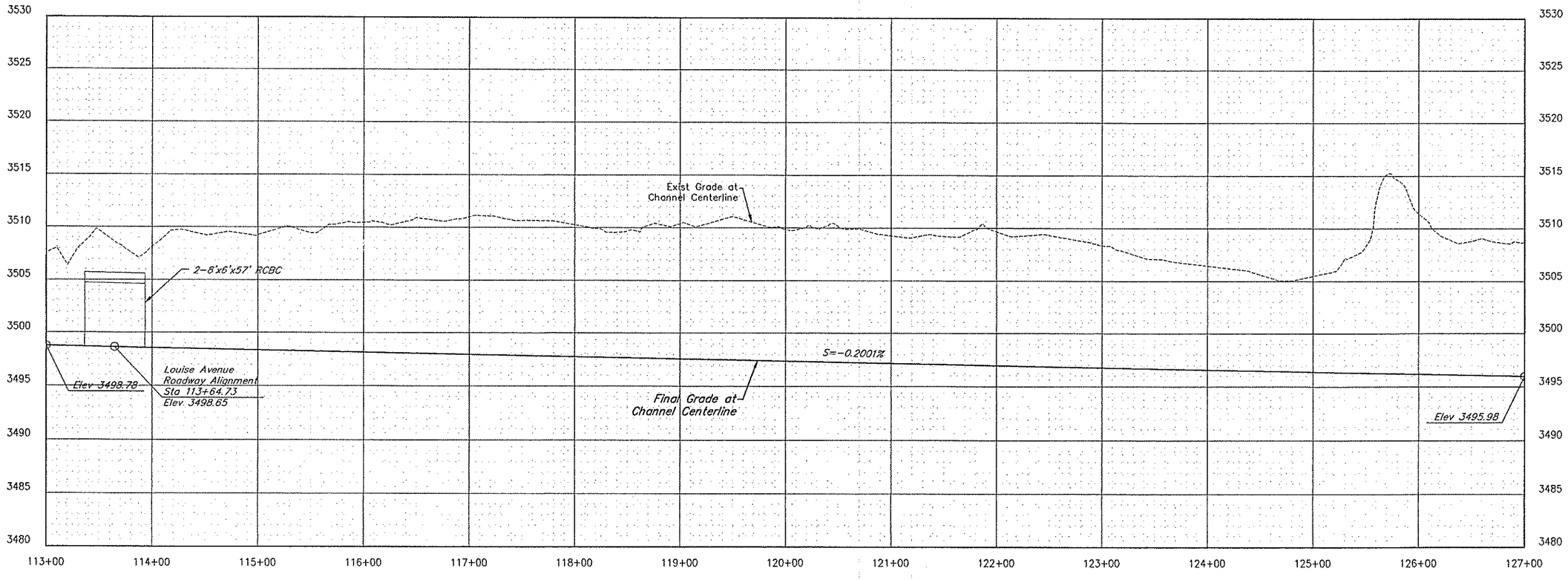
Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No. — Sheet — Revision
1 — 1 / 21 — 0

ORIGINAL SHEET - D CAD NAME (FULL PATH)





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date
3				
2				
1				
A	Issued			

File Name | Dwn. | Dsgn. | Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

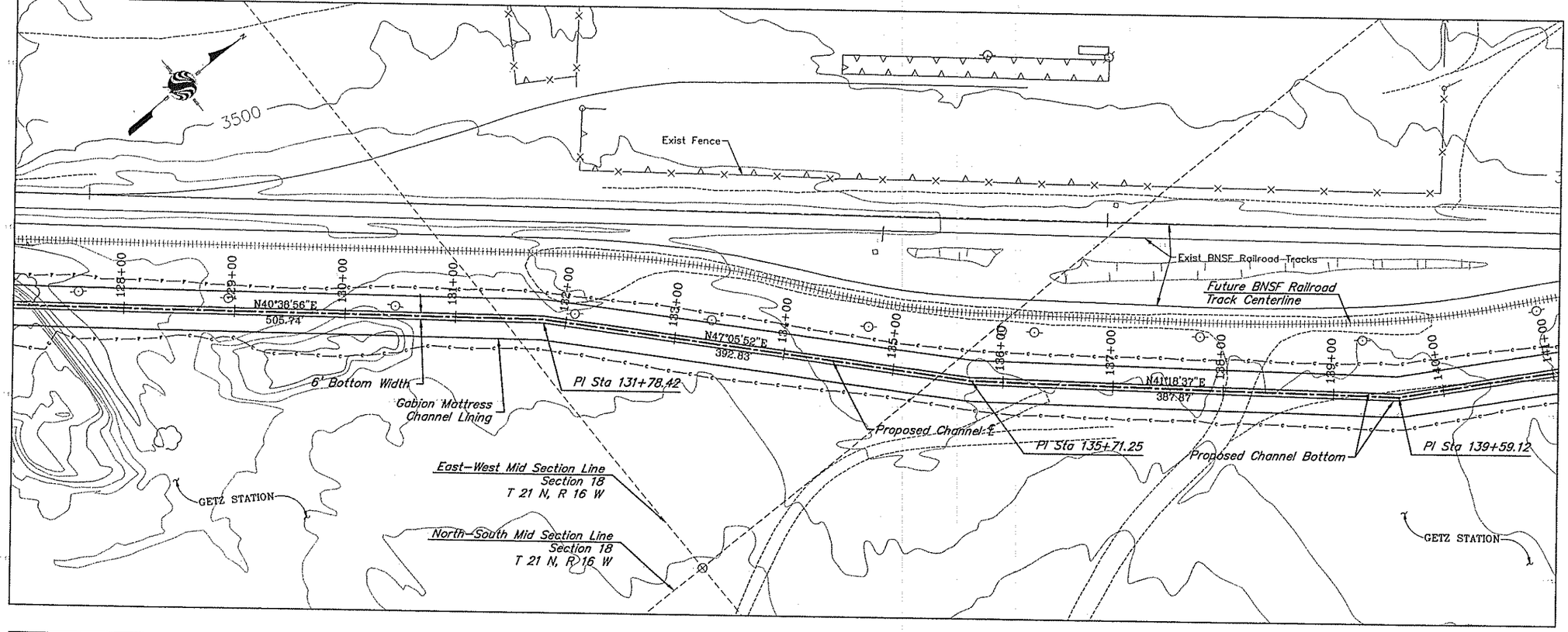
Kingman, Arizona

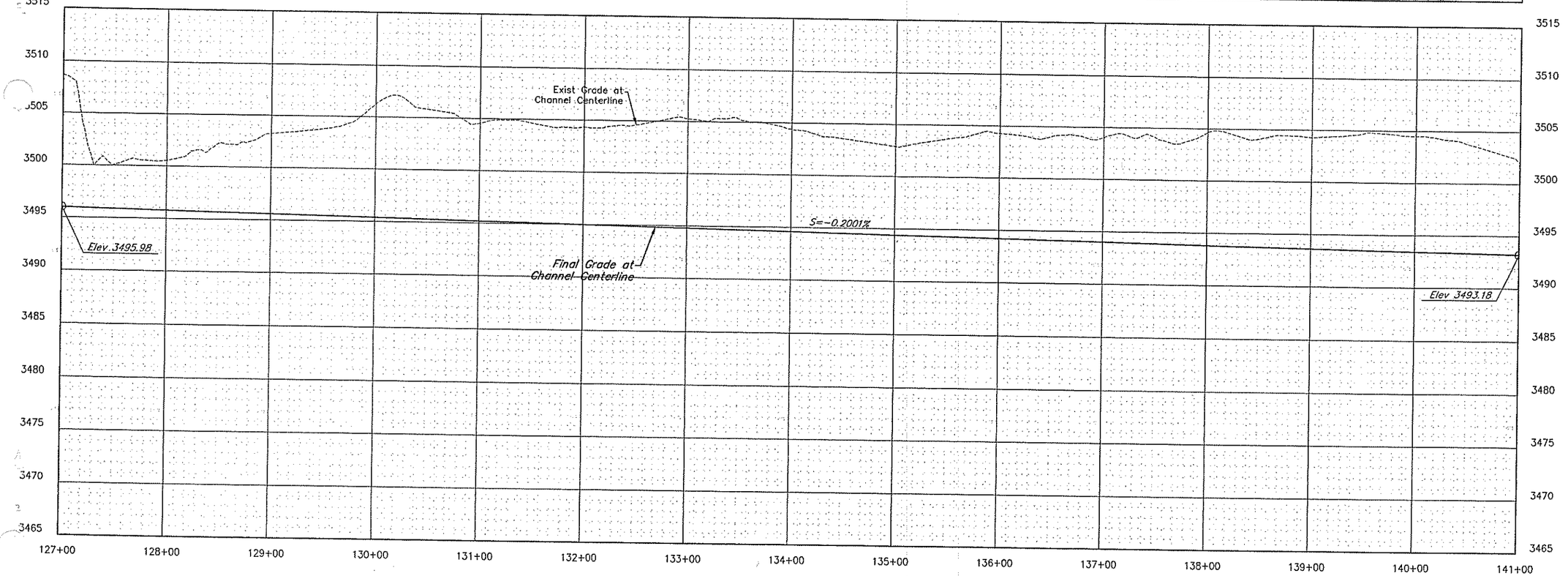
Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No. 1 | Sheet 2 / 21 | Revision 0

ORIGINAL SHEET - D DGN NAME (FULL PATH)





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date
0.1				

No.	Issued	By	Appd.	Date

File Name

Dwn.	Dsgn.	Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

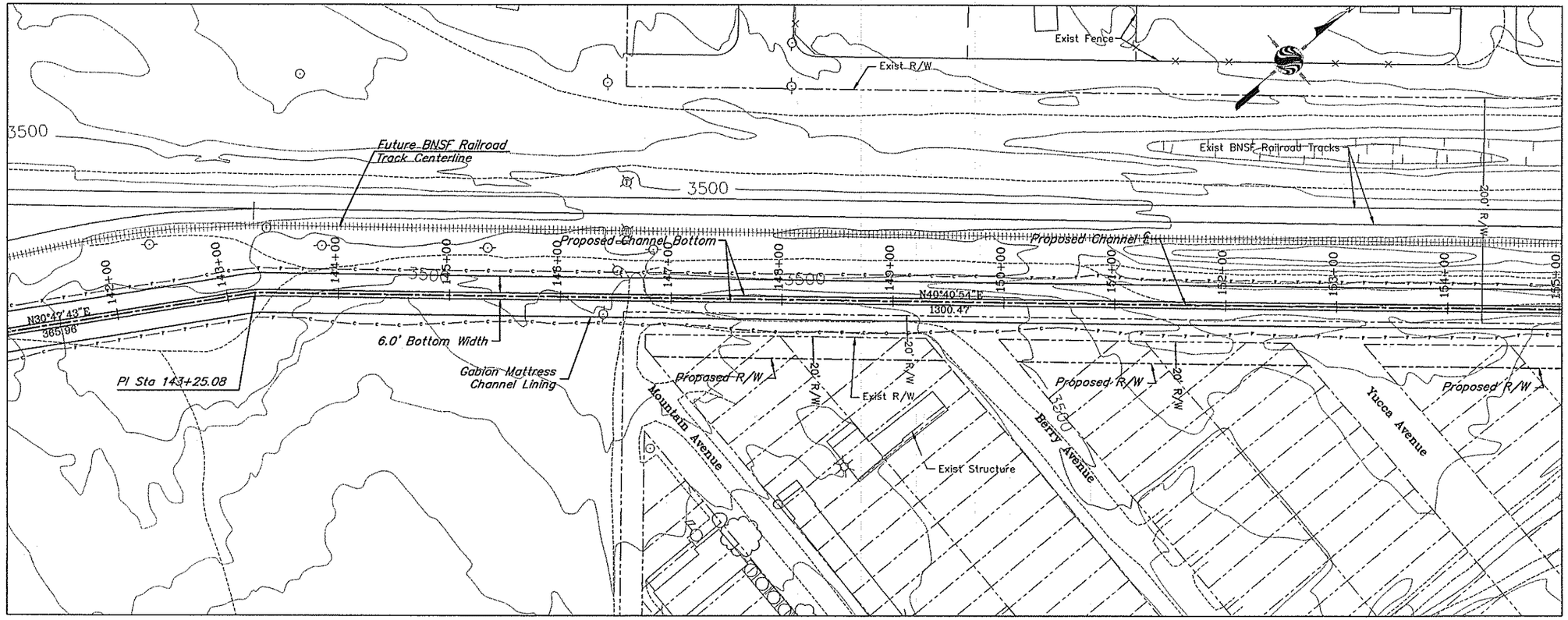
Railroad Diversion Channel

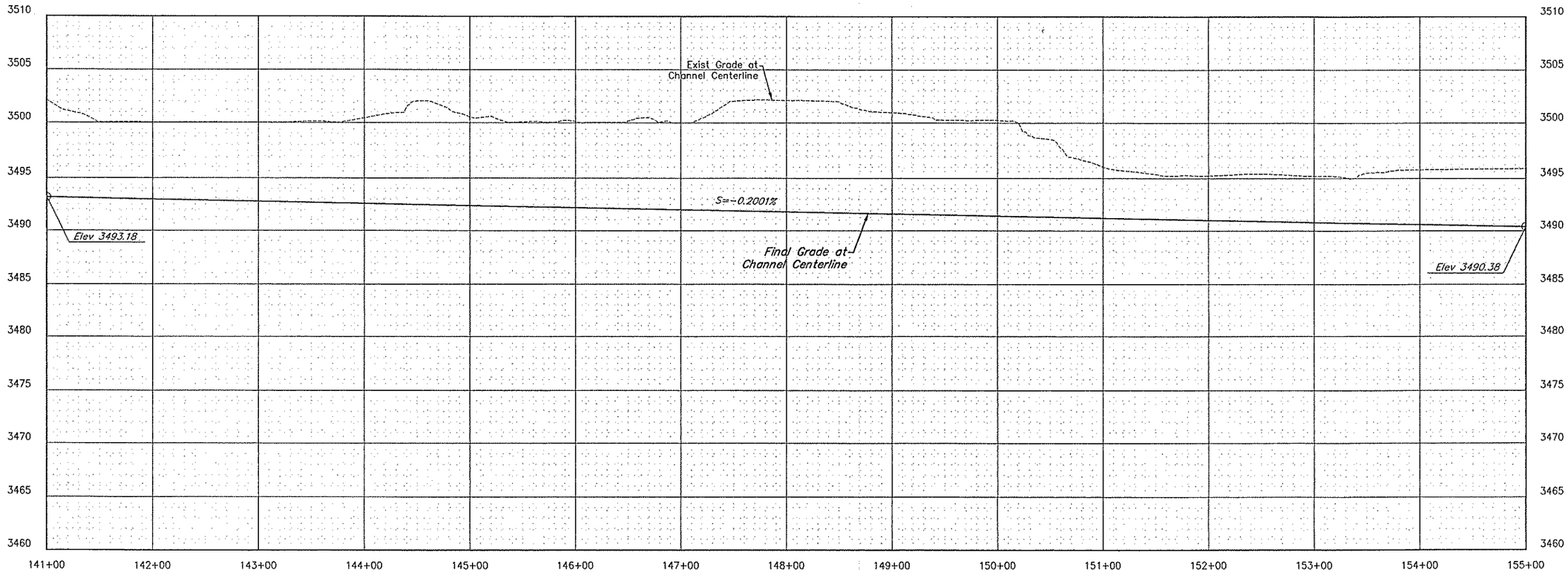
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	3 / 21	0





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
0			

Issued	By	Appd.	Date
A			

File Name | Dsn. | Dsgn. | Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

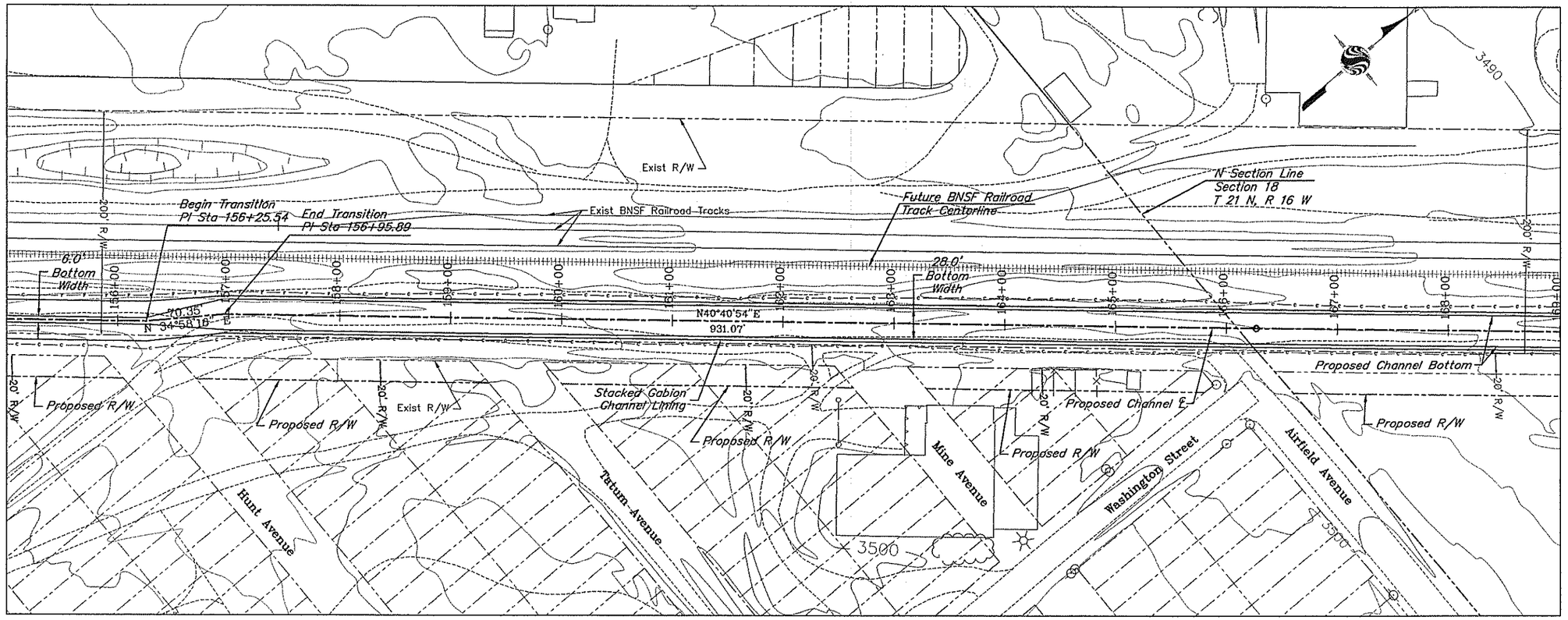
Kingman, Arizona

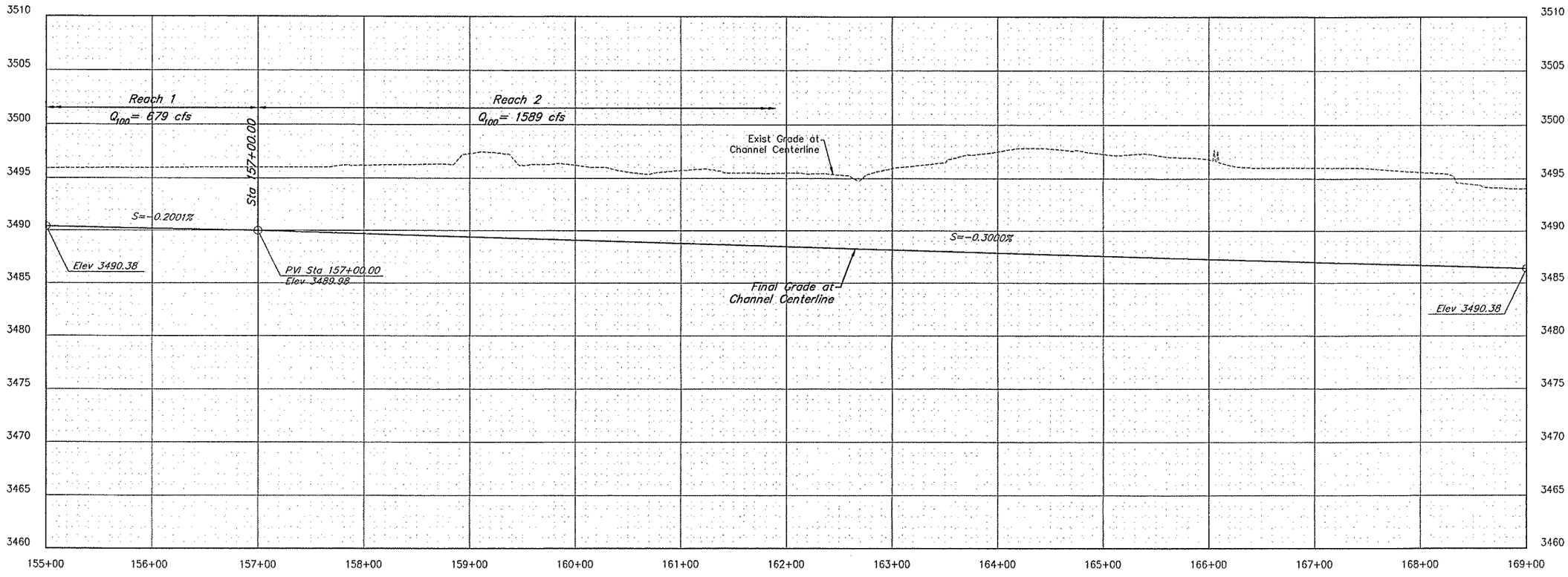
Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	4 / 21	0

ORIGINAL SHEET - D CAD NAME (FULL PATH)





ORIGINAL SHEET - D CKD MAR (FULL NOV)

Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
0			
A			

Issued	By	Appd.	Date
File Name	Dwn.	Dsgn.	Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

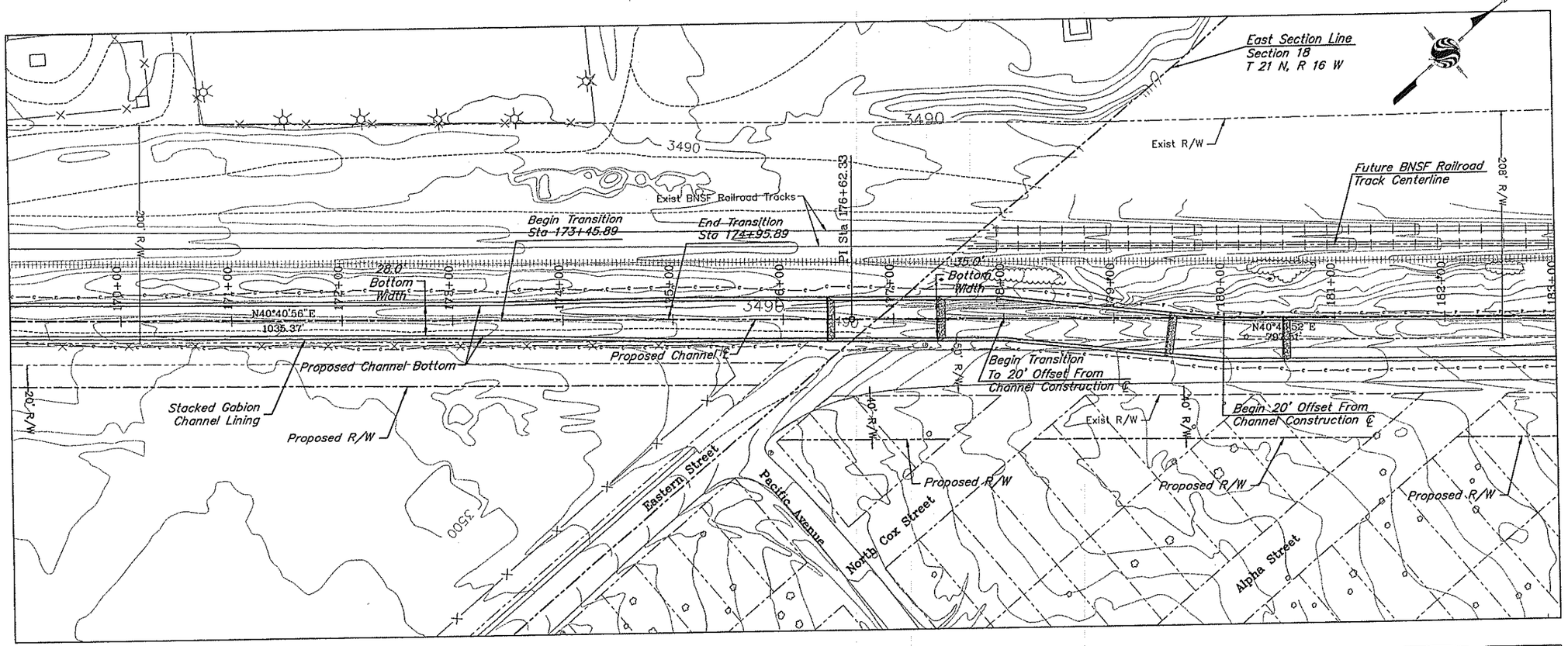
Railroad Diversion Channel

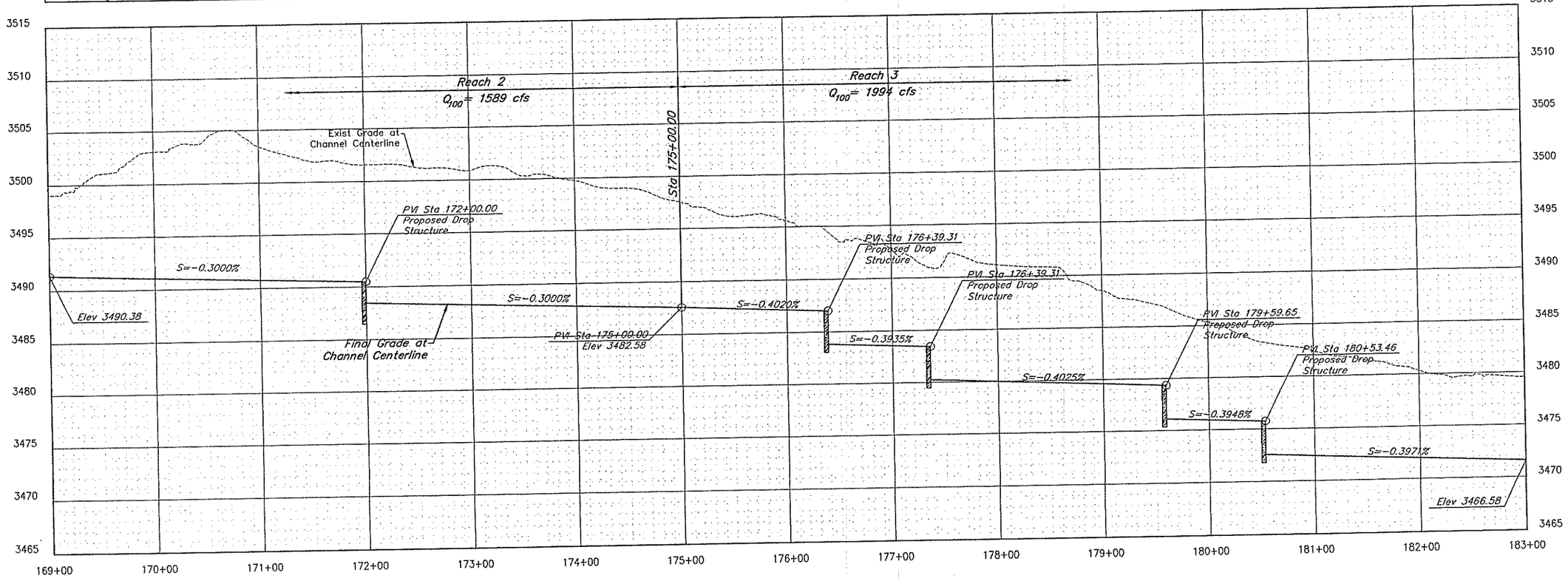
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	5 / 21	0





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date
0				
A	Issued			

File Name — Dwn. — Dsgn. — Date

Seal

Project No. 81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

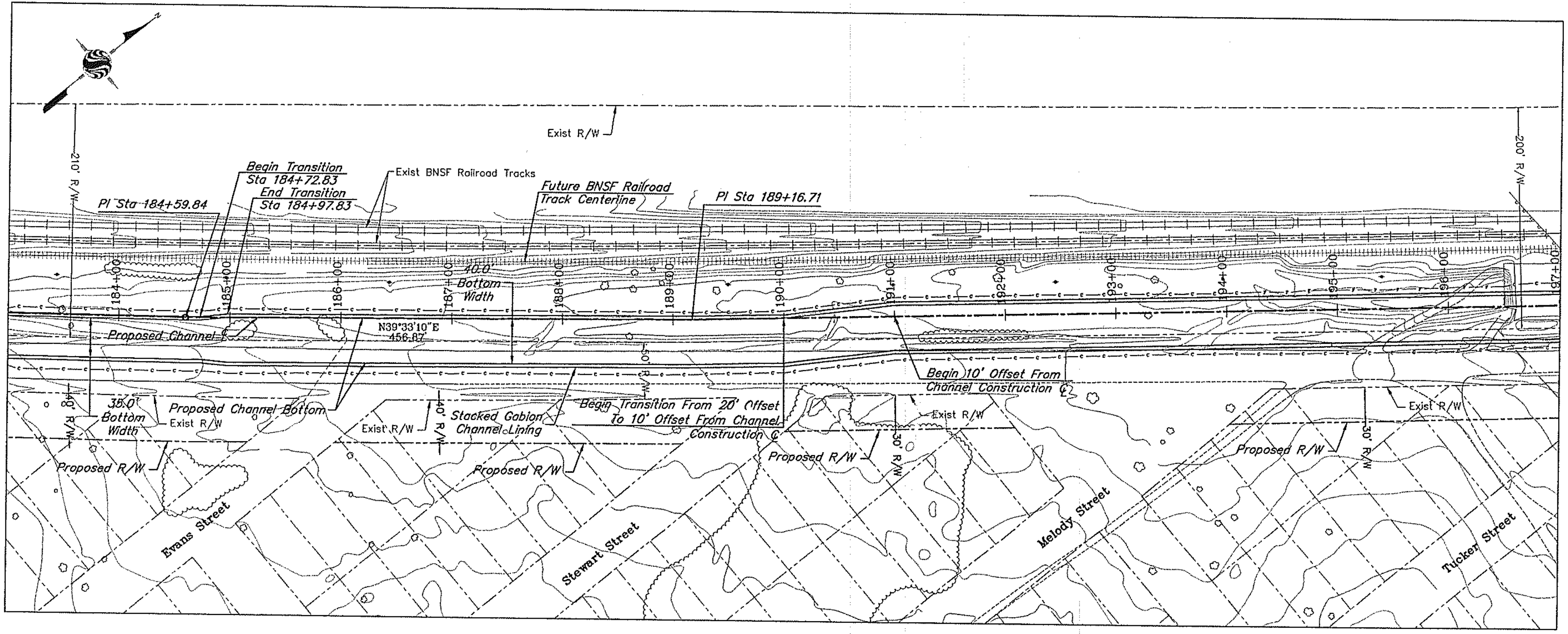
Kingman, Arizona

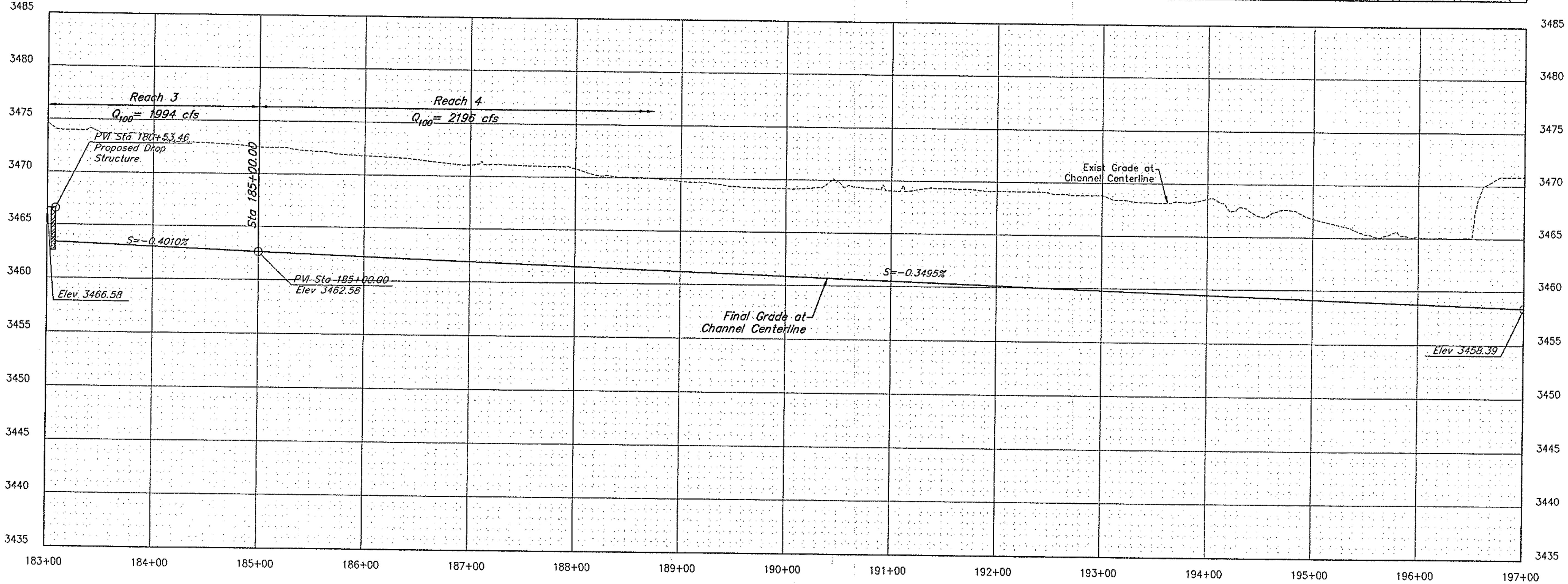
Title
PLAN & PROFILE SHEETS

Scale 1"=50'

Drawing No. 1 — Sheet 6 / 21 — Revision 0

CAD NAME [FULL PATH]





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision | By | Appd. | Date

Issued | By | Appd. | Date

File Name | Dwn. | Dsgn. | Date

Seal

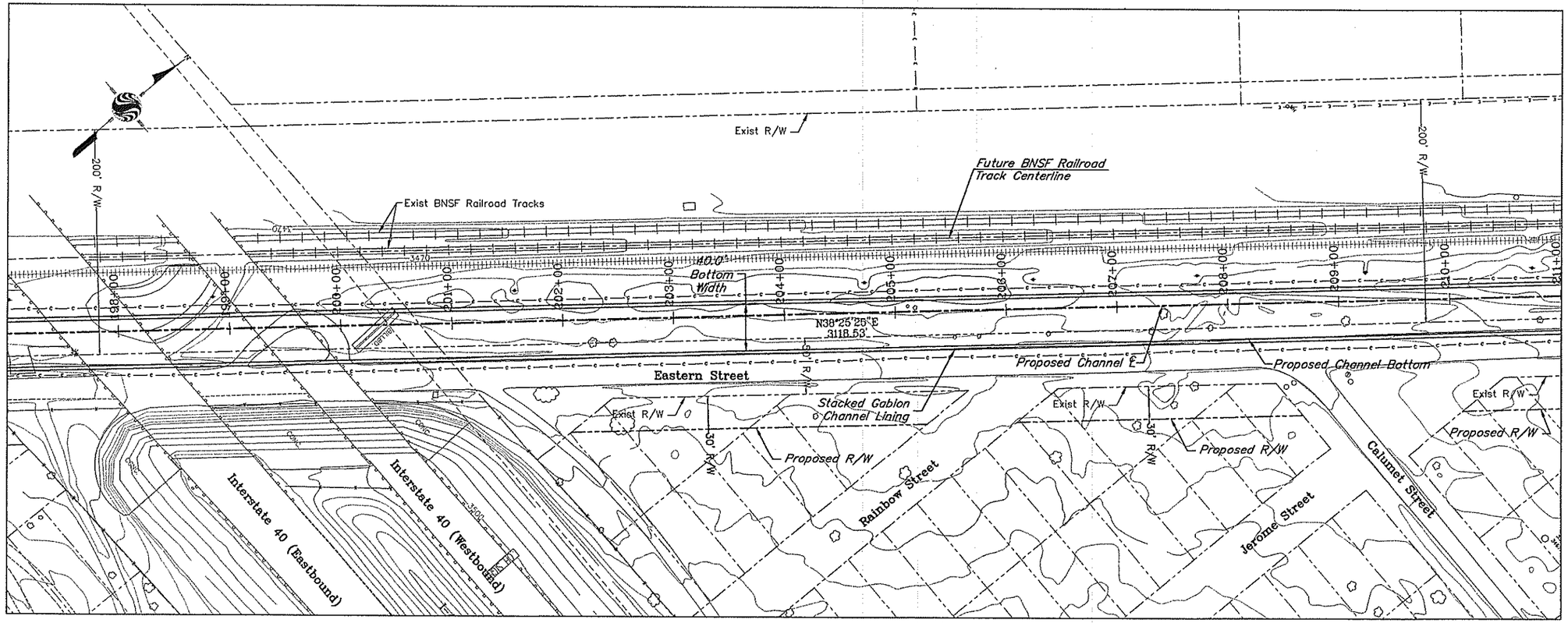
Project No.
81760038

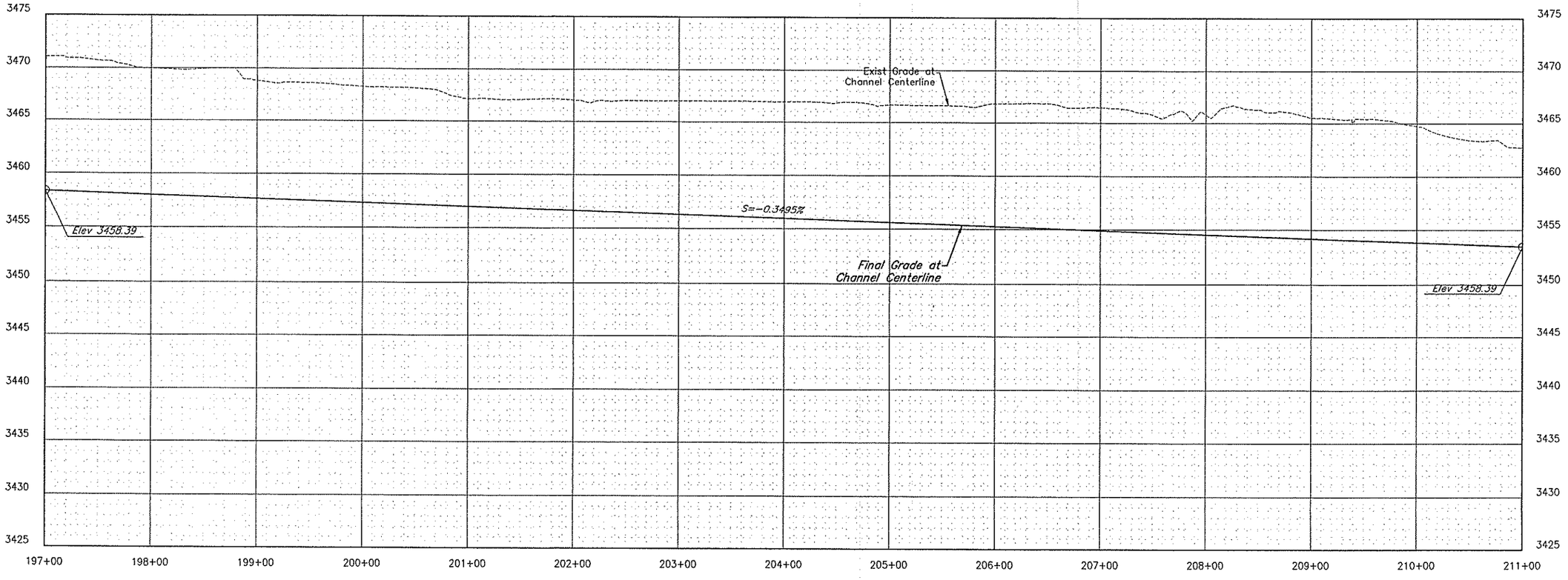
Client/Project
CITY OF KINGMAN
Railroad Diversion Channel
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	7 / 21	0





Stantec

Stantec Consulting Inc.
6211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
0.			
1.			
2.			
3.			
4.			
5.			
A.			

Issued	By	Appd.	Date
File Name		Dwn.	Dsgn.
Seal			

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

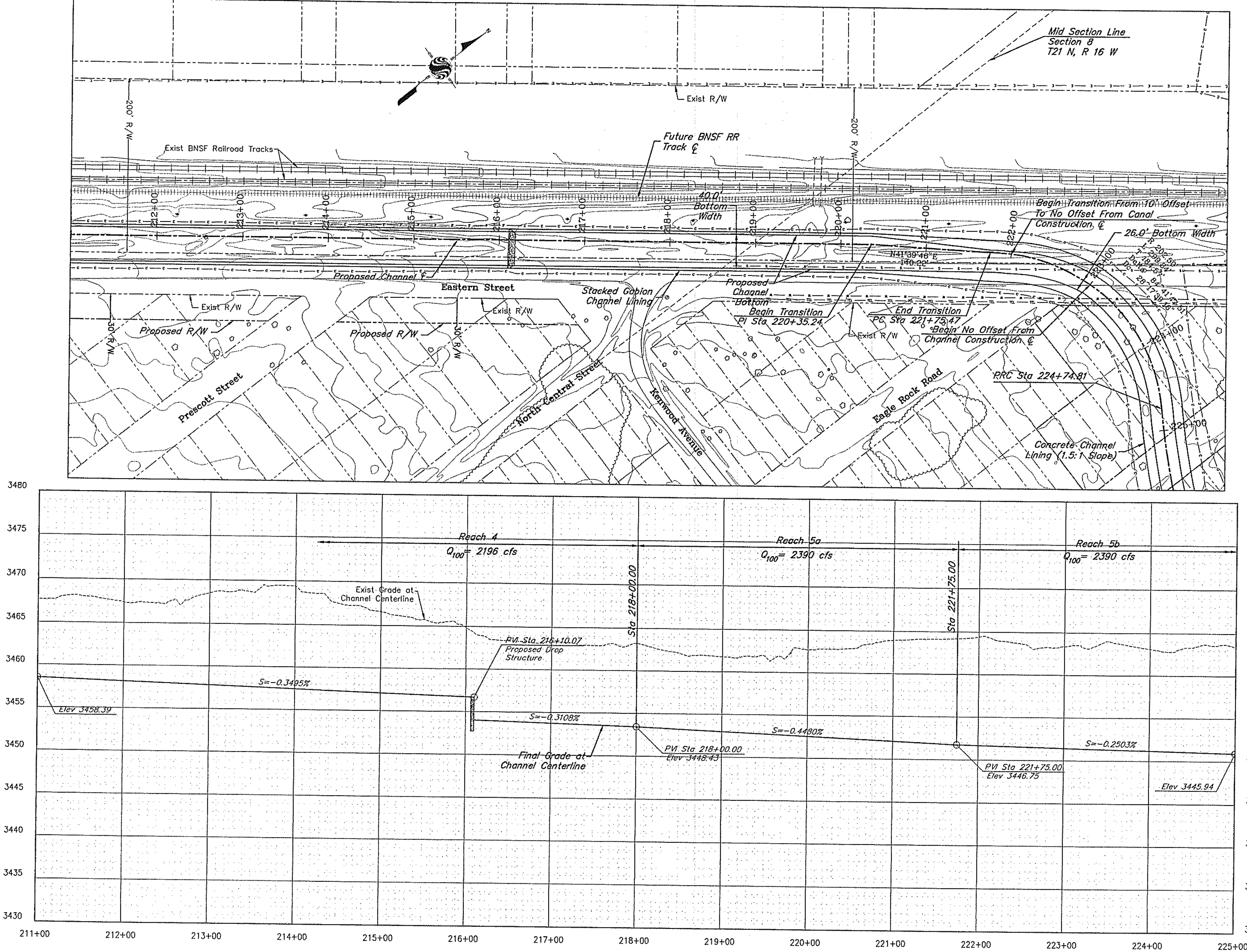
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	8 / 21	0

ORIGINAL SHEET - D CAD NAME (FULL PATH)



Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision | By | Appd. | Date

Issued | By | Appd. | Date

File Name | Dwn. | Dsgn. | Date

Seal

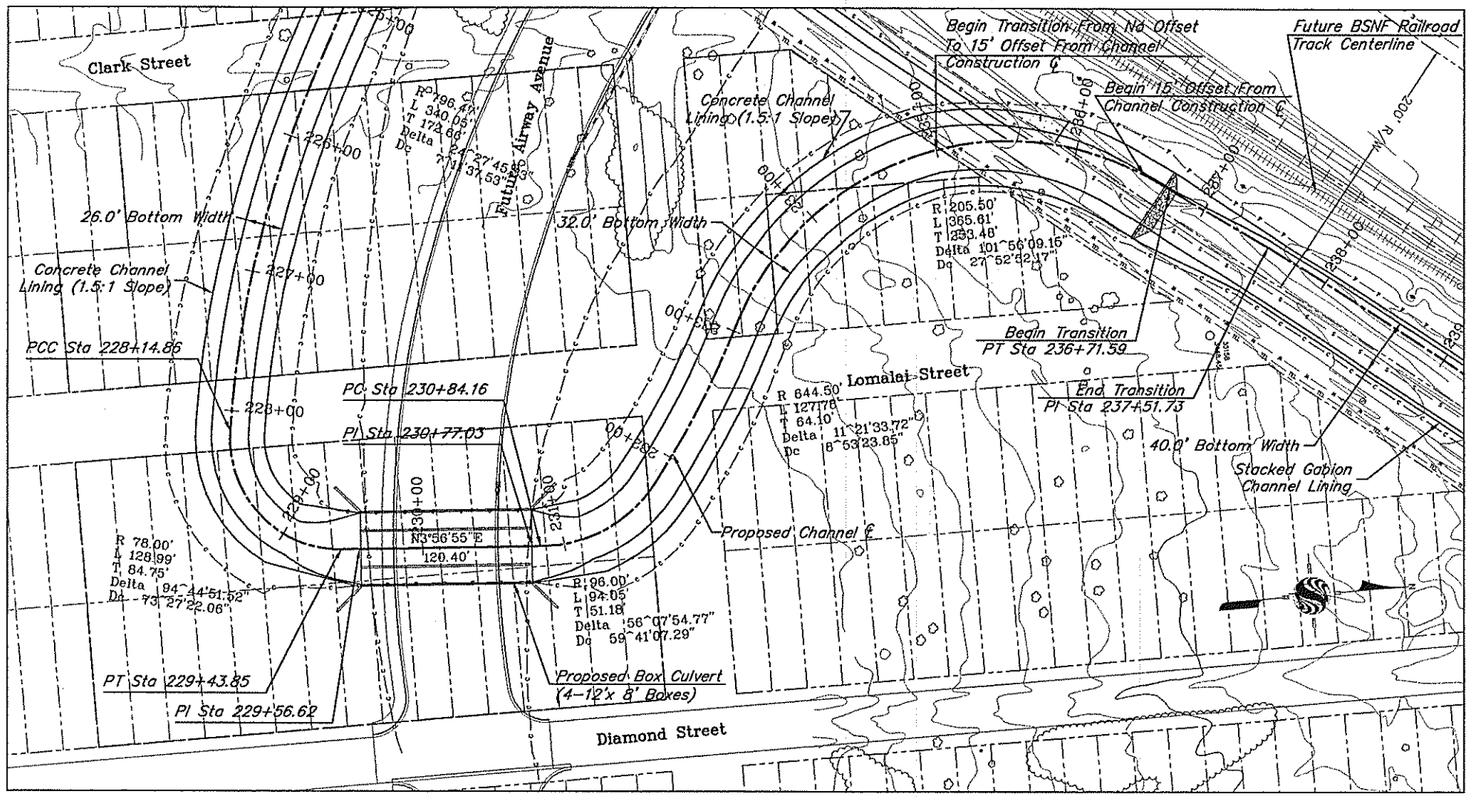
Project No.
81760038

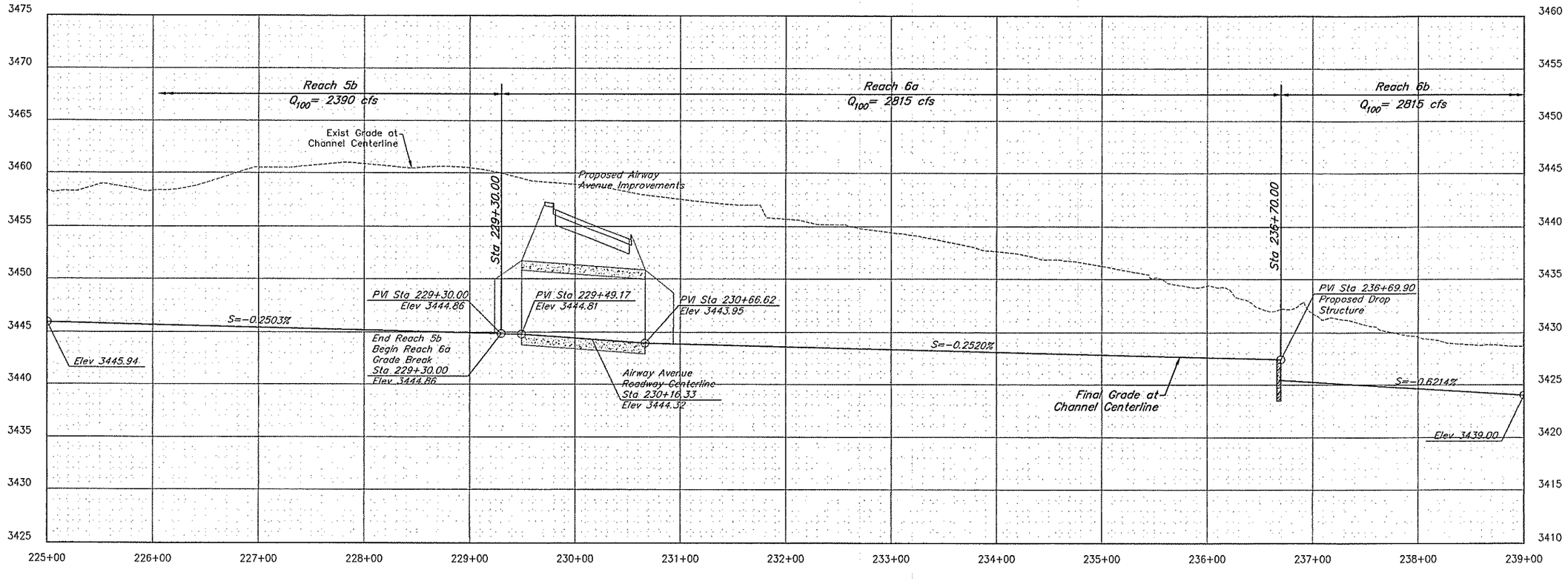
Client/Project
CITY OF KINGMAN
Railroad Diversion Channel
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No. 1 | Sheet 9 / 21 | Revision 0





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
2.			
1.			
A.			

Issued	By	Appd.	Date
File Name		Dwn.	Dsgn.
Seal			

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

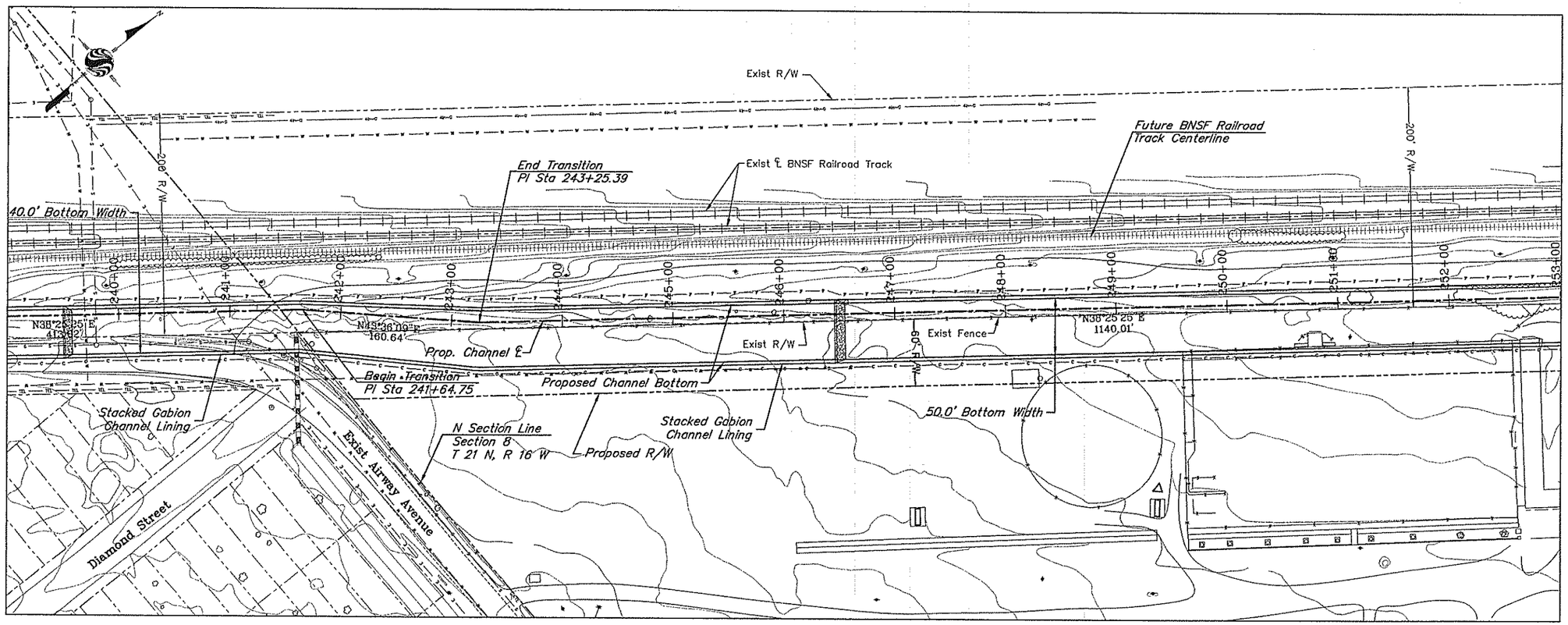
Kingman, Arizona

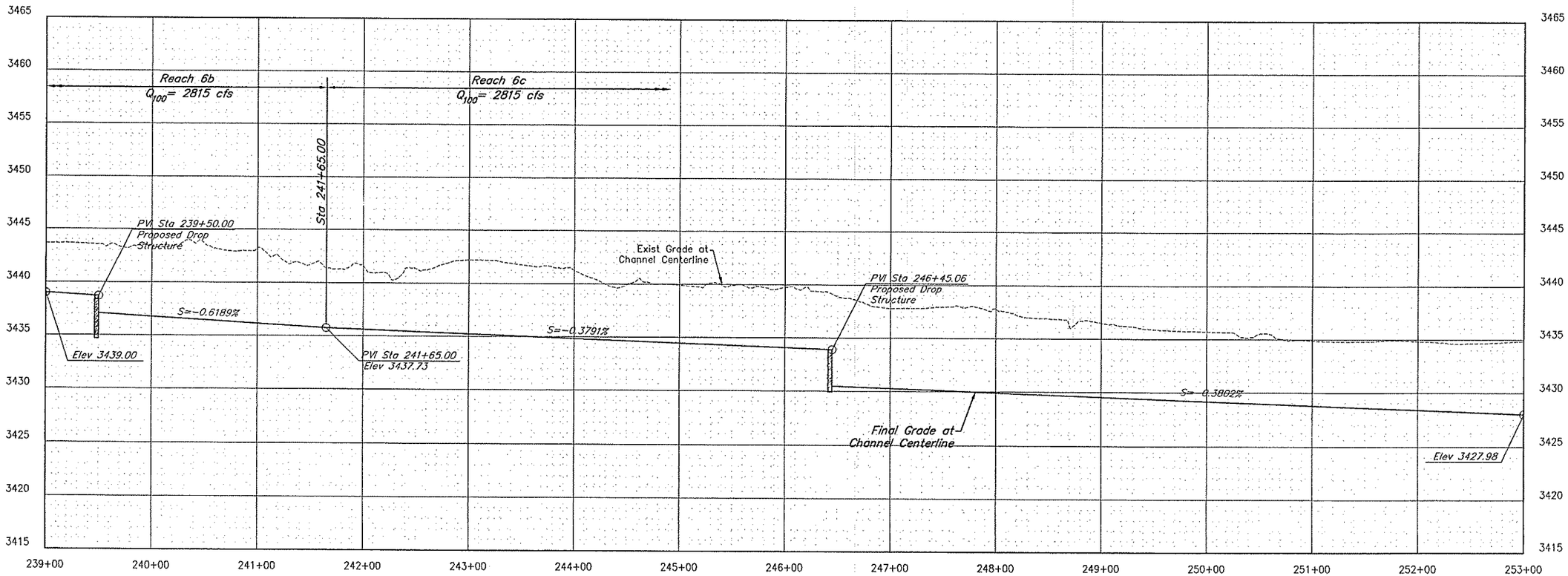
Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	10 / 21	0

DWGNAL SHEET NO. - 0 CAD FILE NO.





ORIGINAL SHEET - D CAD NAME (FULL PATH)

Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date
0				

No.	Issued	By	Appd.	Date
A				

File: Name | Dwn. | Dsgn. | Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

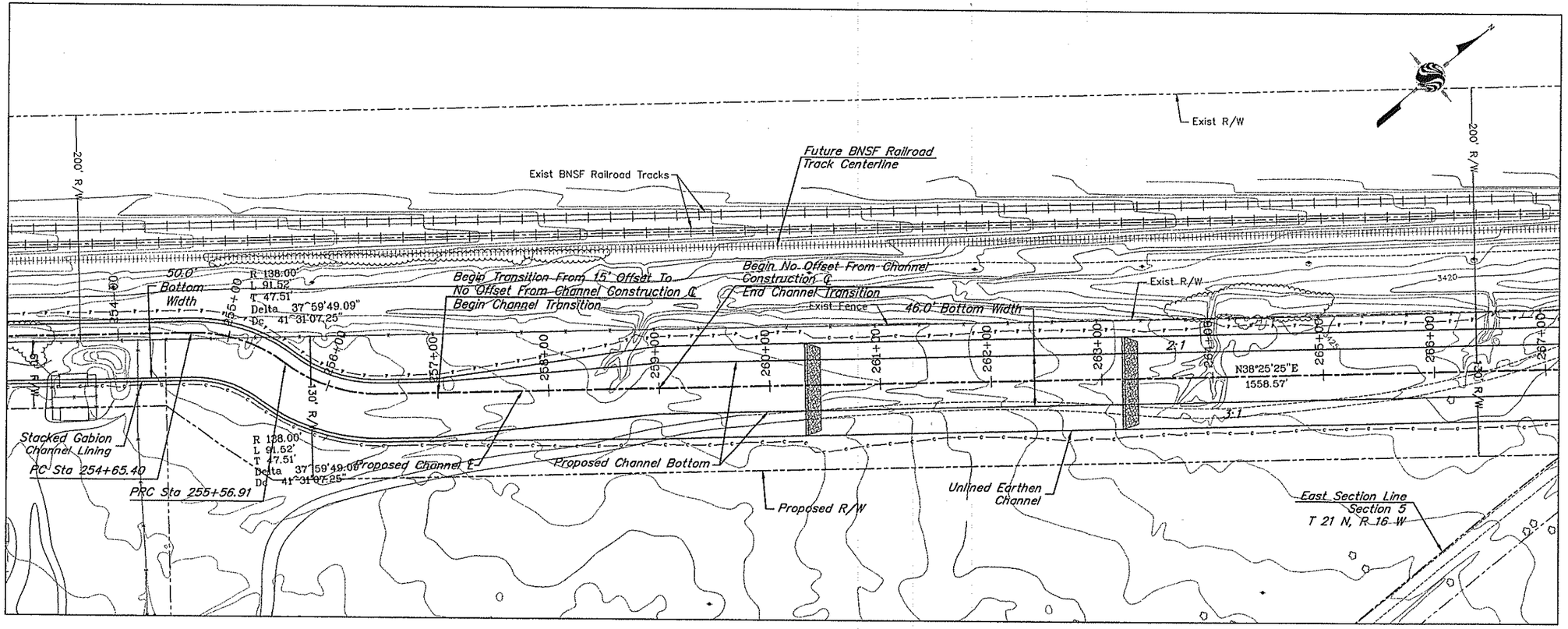
Railroad Diversion Channel

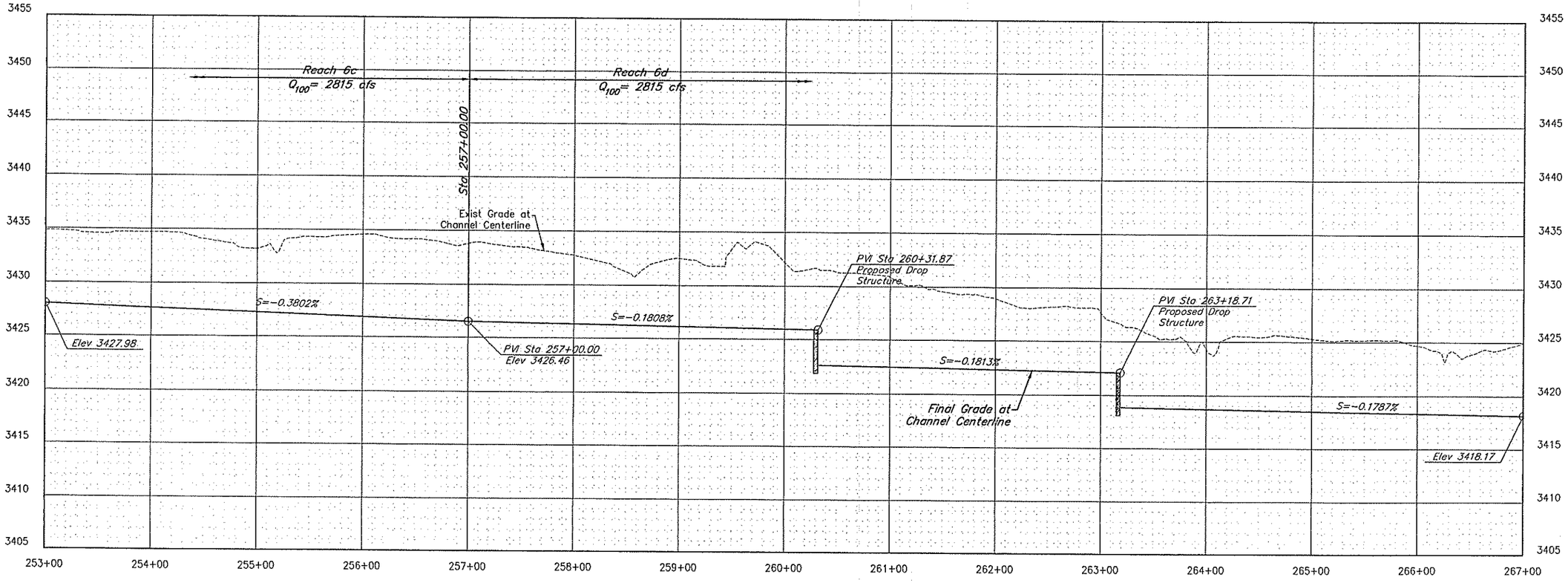
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	11/21	0





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
0			
1			
2			
3			
4			
5			
A			

Issued	By	Appd.	Date

File Name
Dwn. Dsgn. Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

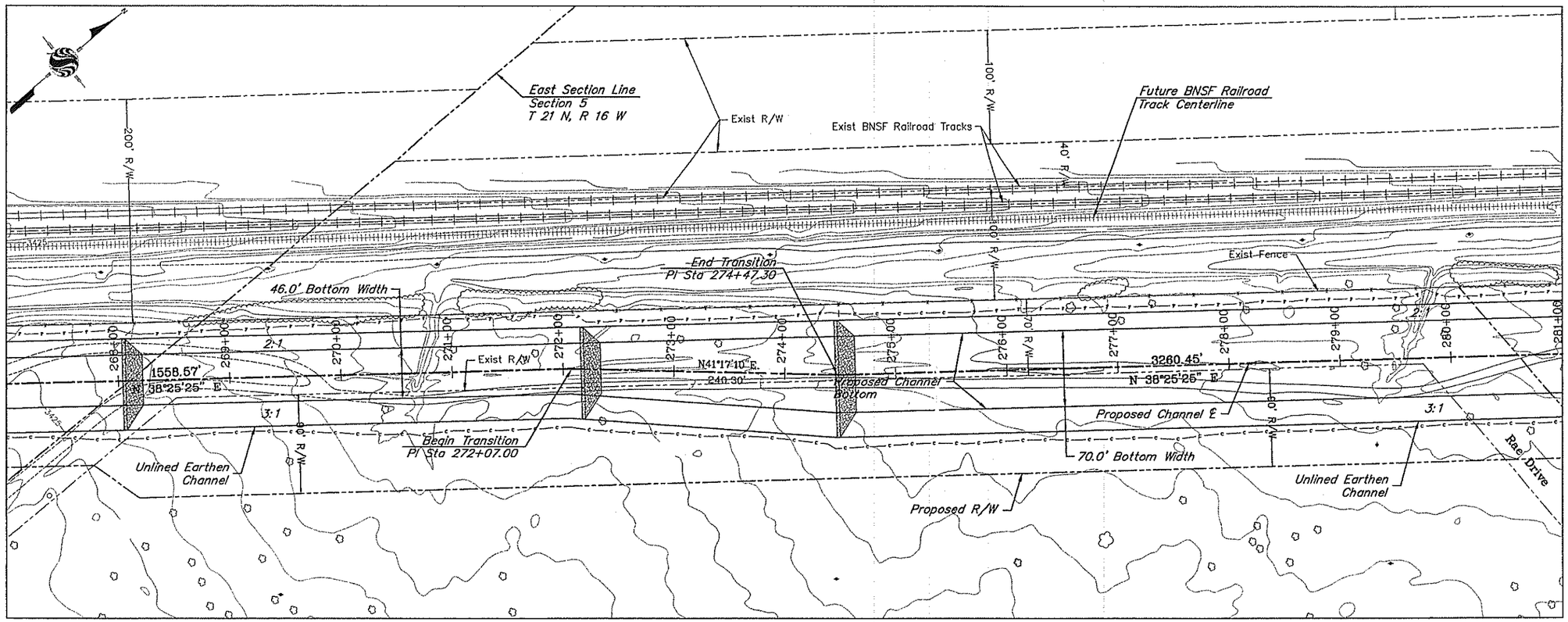
Kingman, Arizona

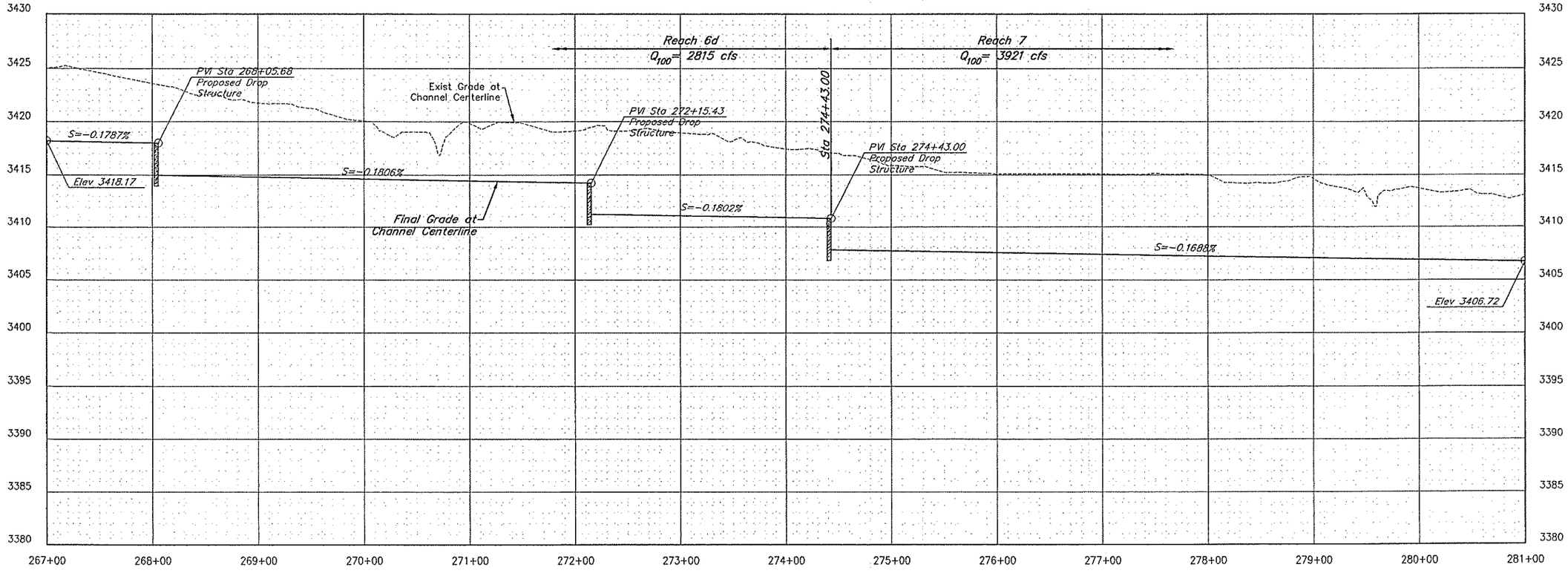
Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	12 / 21	0

ORIGINAL SHEET - D 0300 MAE (FULL PSW)





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
0			

Issued	By	Appd.	Date
A			

File Name | Dsn. | Dsgn. | Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

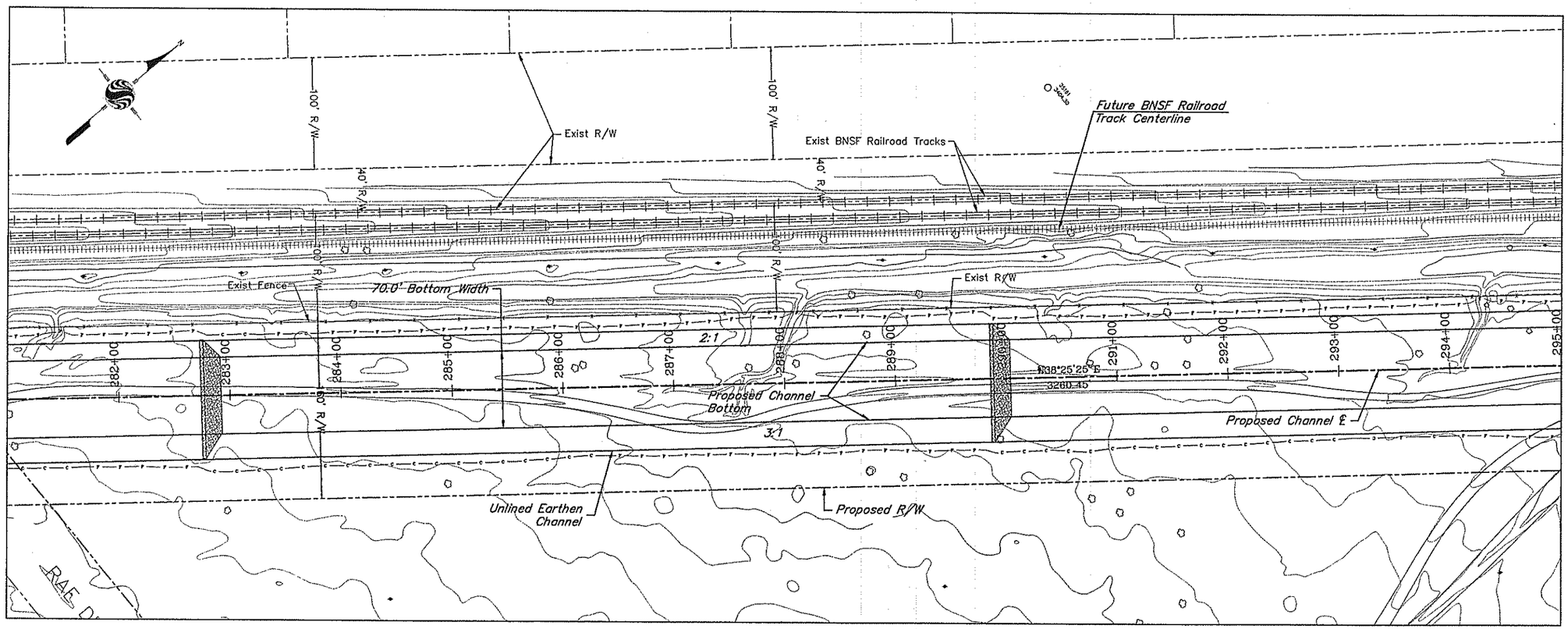
Railroad Diversion Channel

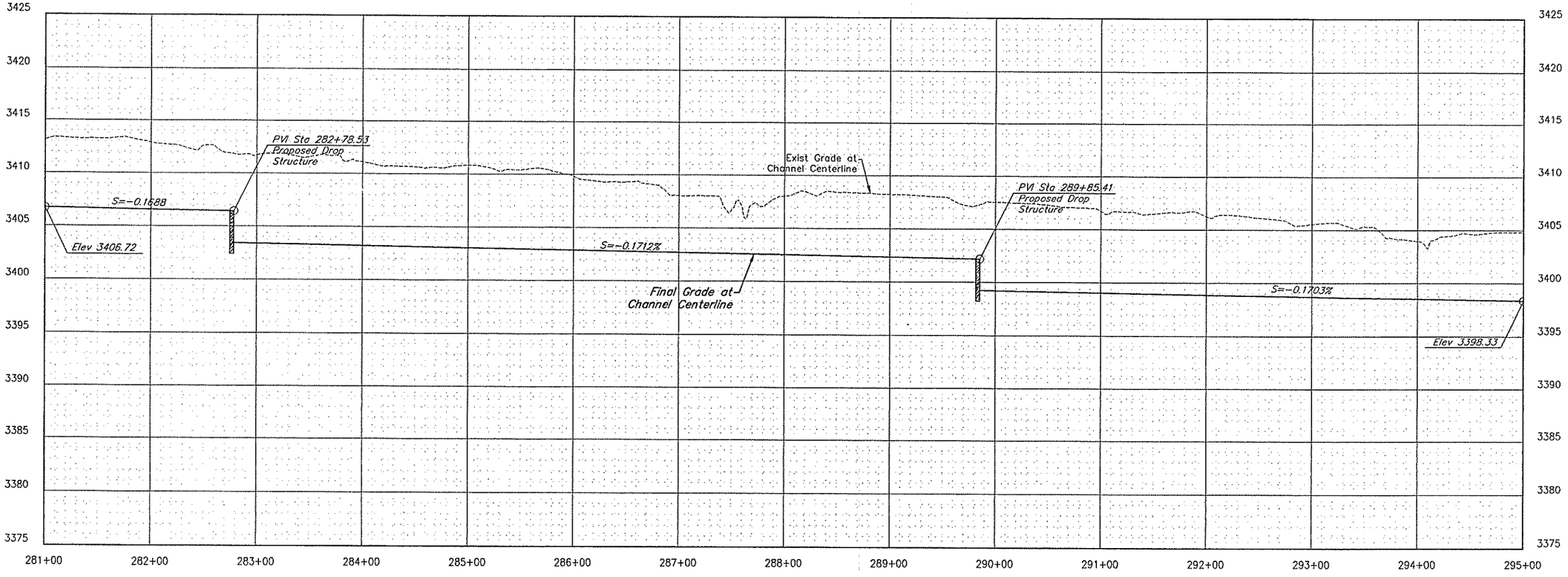
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	13 / 21	0





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
3			
2			
1			
0			

Issued	By	Appd.	Date
A			

File Name	Dsn.	Dsgn.	Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

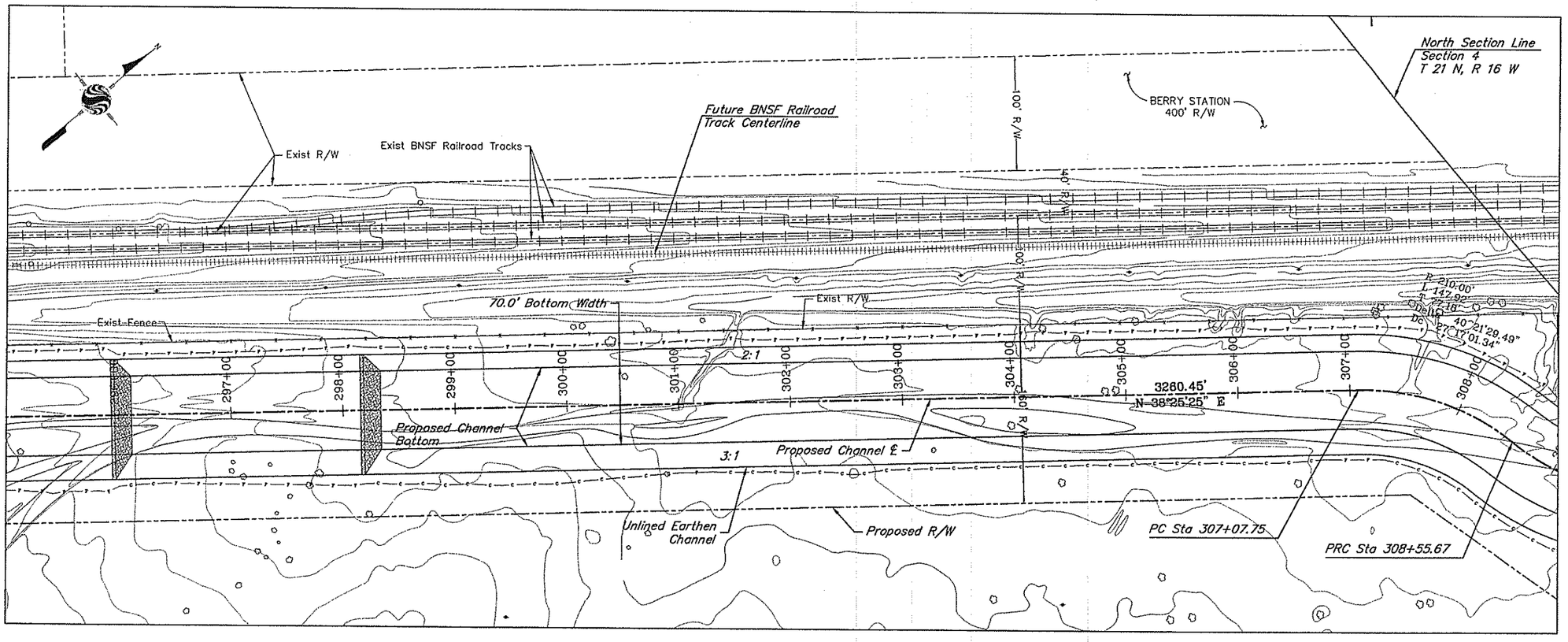
Kingman, Arizona

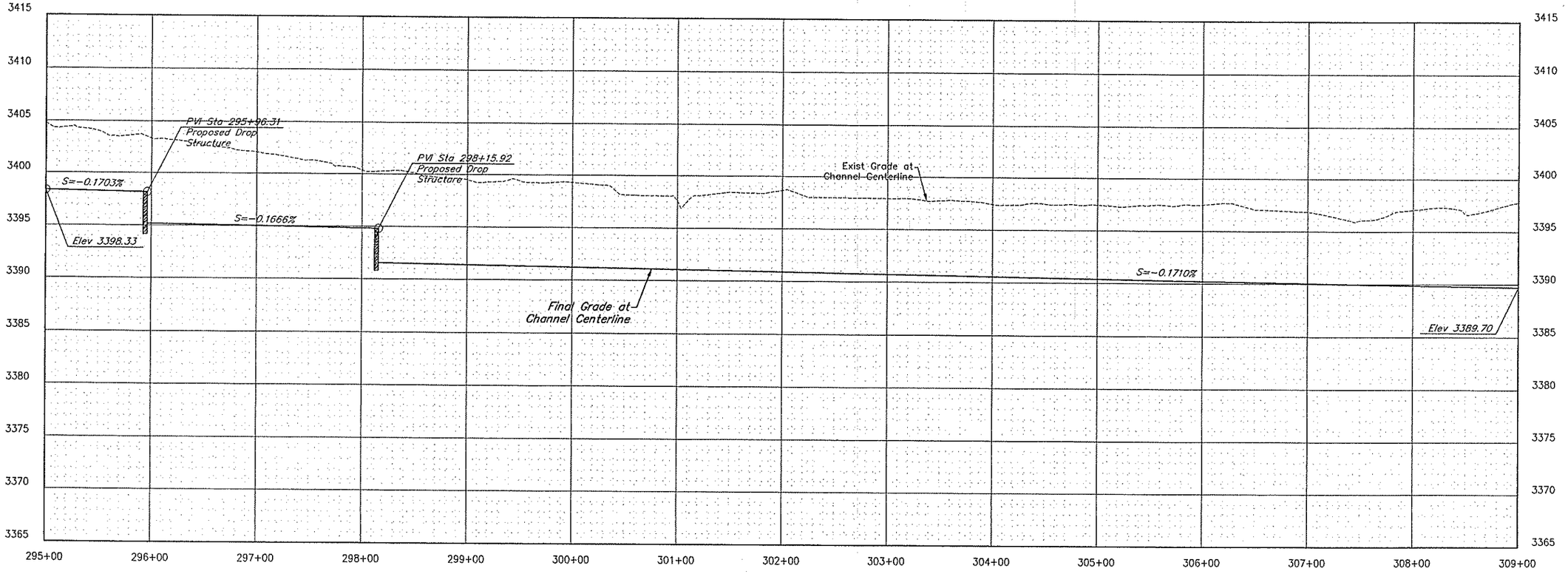
Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	14 / 21	0

ORIGINAL SHEET - D CAD NAME (FULL PATH)





ORIGINAL SHEET - D CAD NAME (FULL PATH)

Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
A.1			
A.2			
A.3			
A.4			
A.5			
A.6			
A.7			
A.8			
A.9			
A.10			

Issued	By	Appd.	Date
File Name		Dsn.	Dsgn.

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

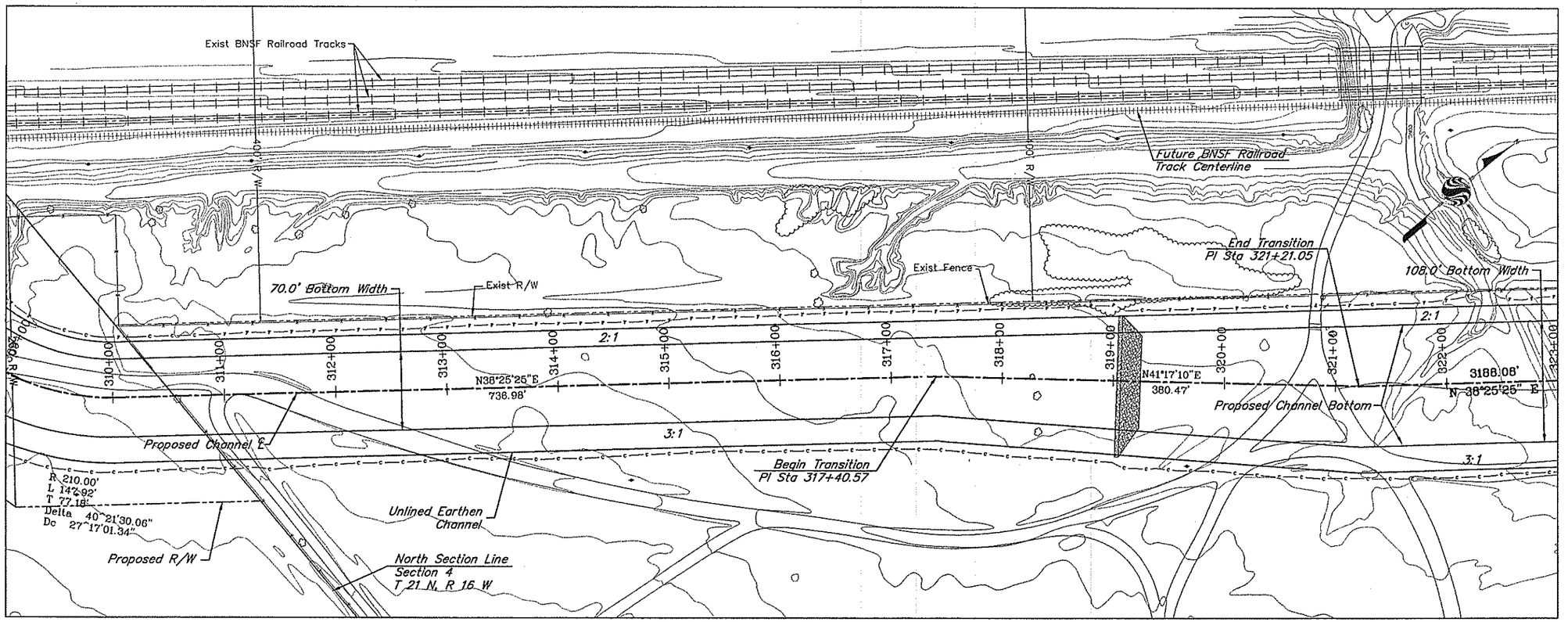
Railroad Diversion Channel

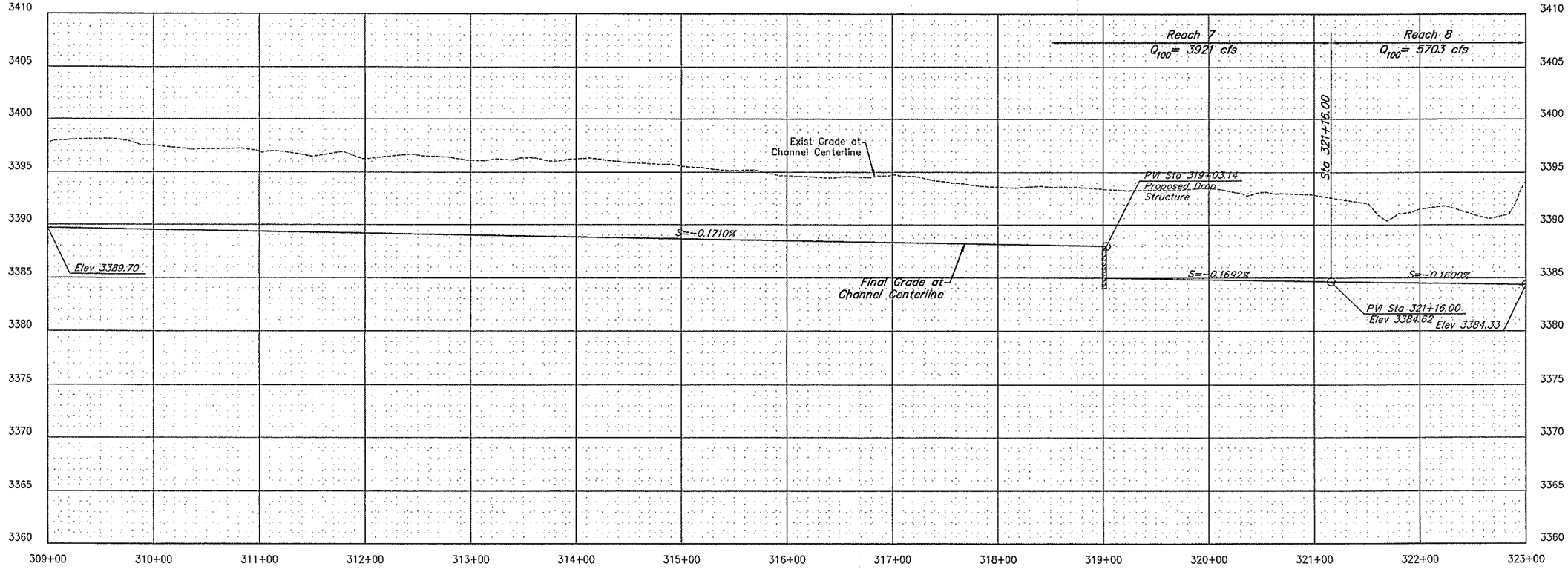
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	15 / 21	0





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
A1			
Issued	By	Appd.	Date
File Name	Dwn.	Dsgn.	Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

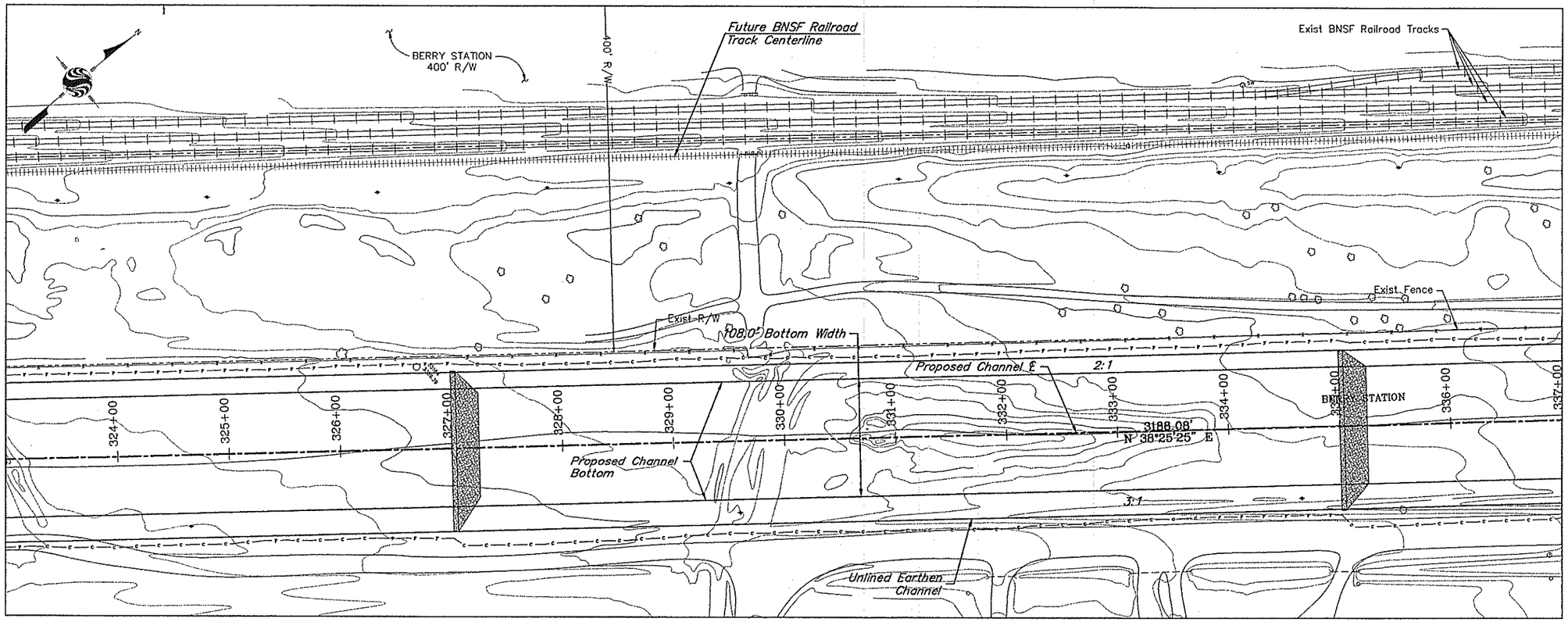
Kingman, Arizona

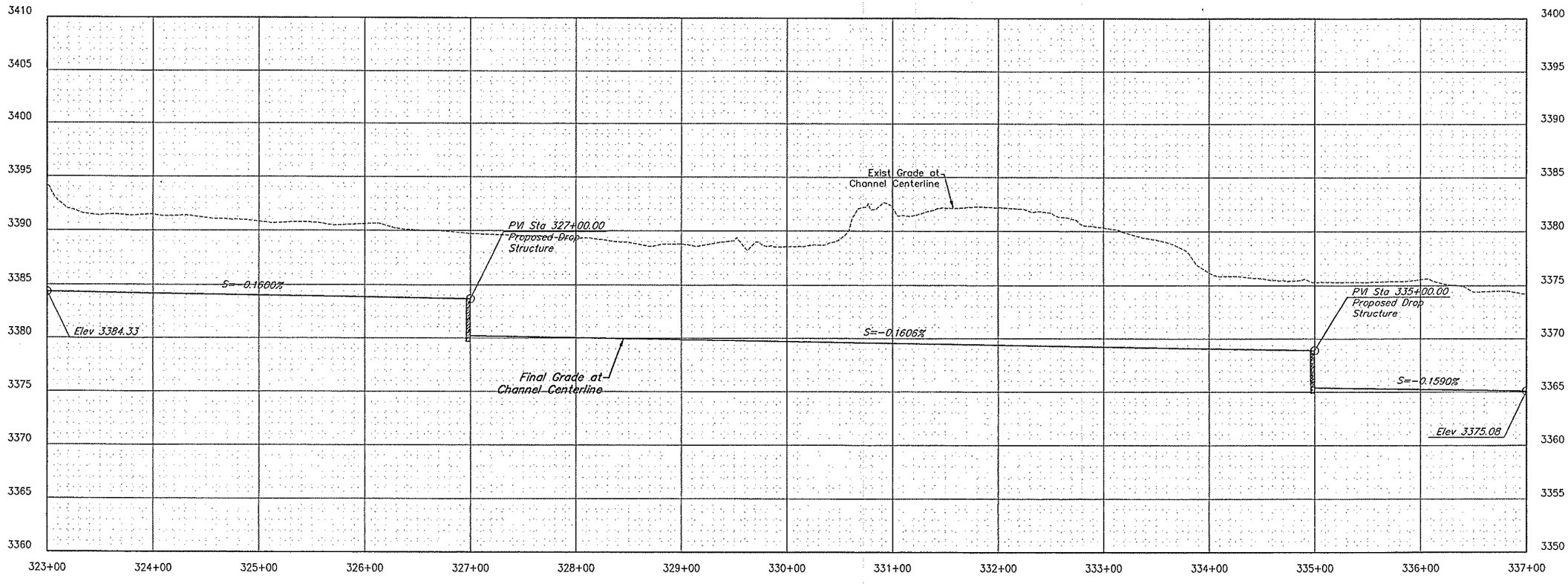
Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	16 / 21	0

ORIGINAL SHEET - D DWG NAME (FULL PATH)





ORIGINAL SHEET - D CAD NAME (FULL PATH)

Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

Revision	By	Appd.	Date
6			
5			
4			
3			
2			
1			
A			

Issued	By	Appd.	Date

File Name | Dwn. | Dsgn. | Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

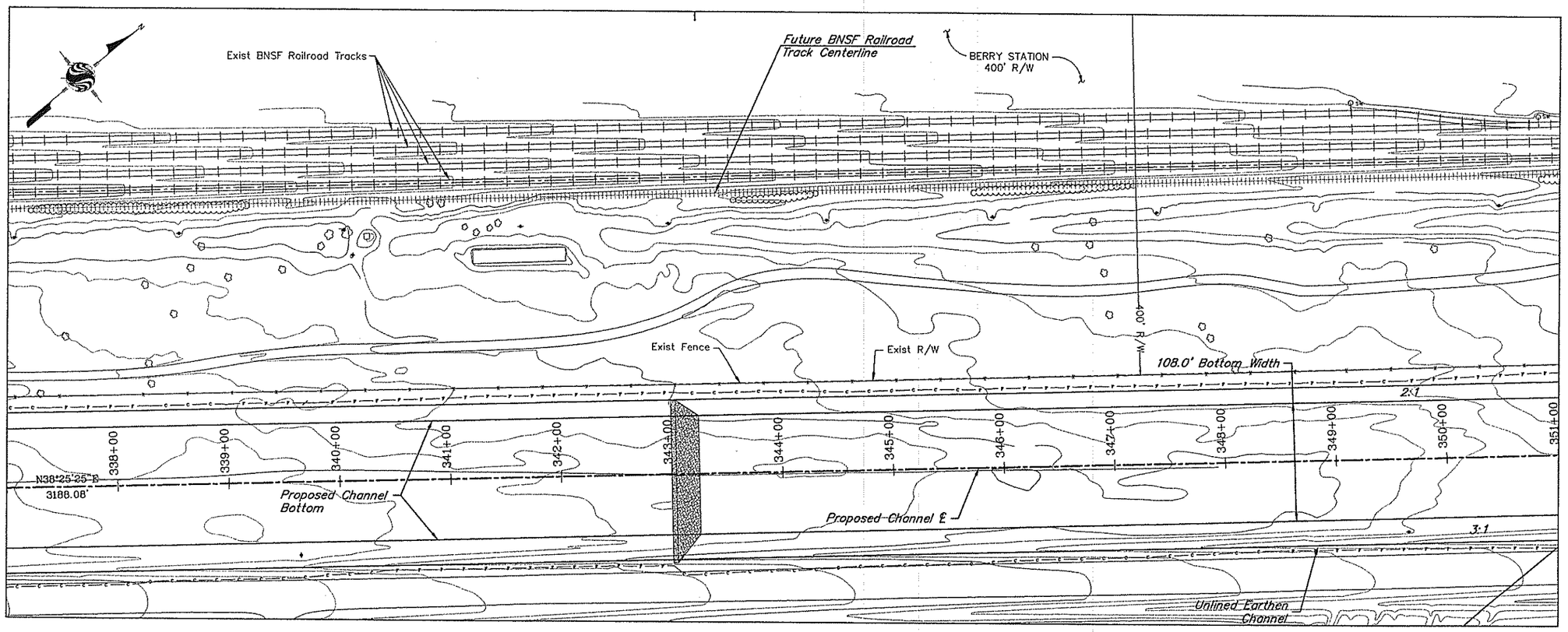
Railroad Diversion Channel

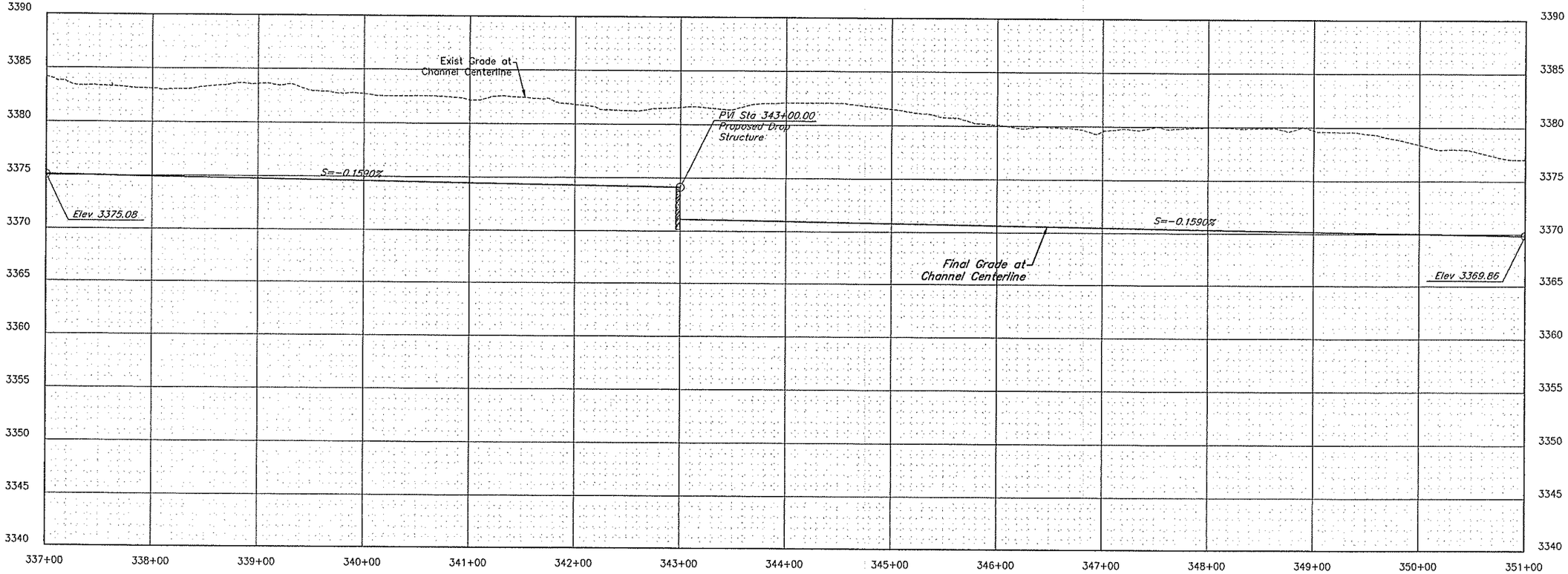
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	17 / 21	0





ORIGINAL SIZE - D CADD NAME (FULL PATH)

Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date

No.	Issued	By	Appd.	Date
A				

File Name | Dwn. | Dsgn. | Date

Seal

Project No.
81760038

Client/Project
CITY OF KINGMAN

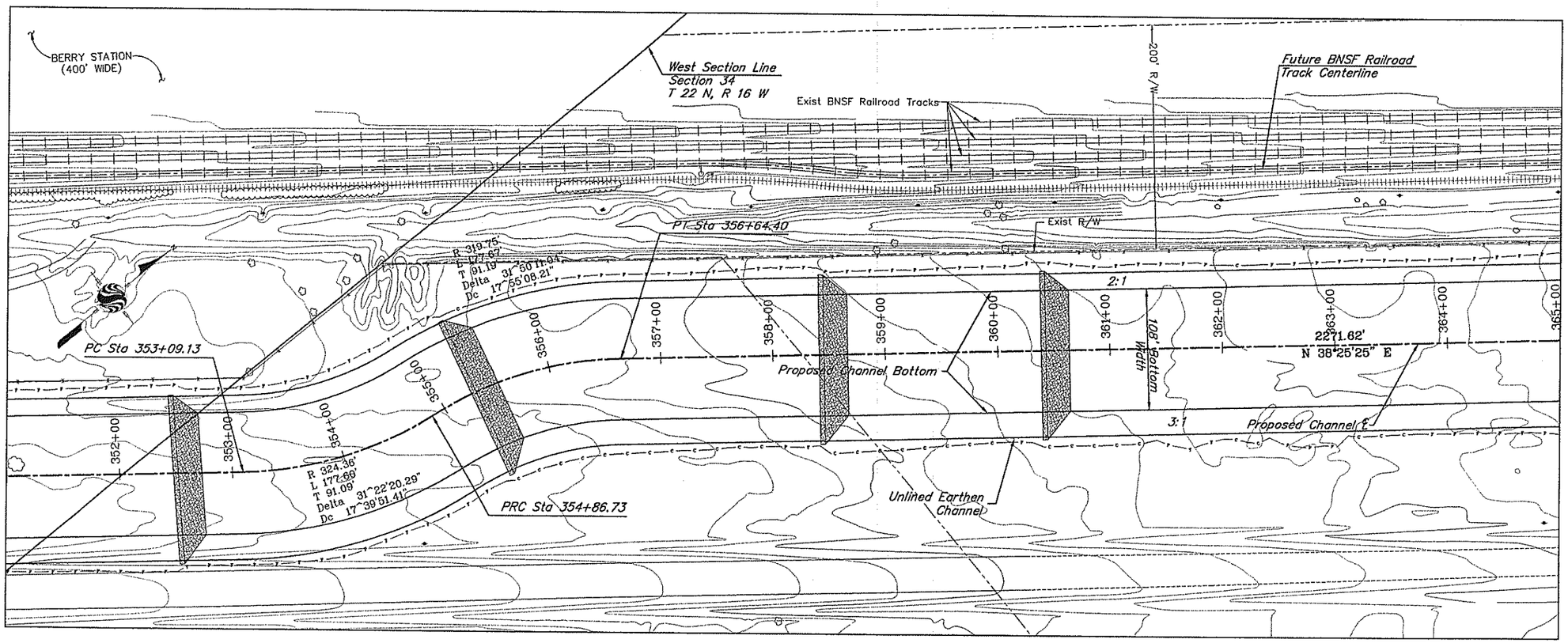
Railroad Diversion Channel

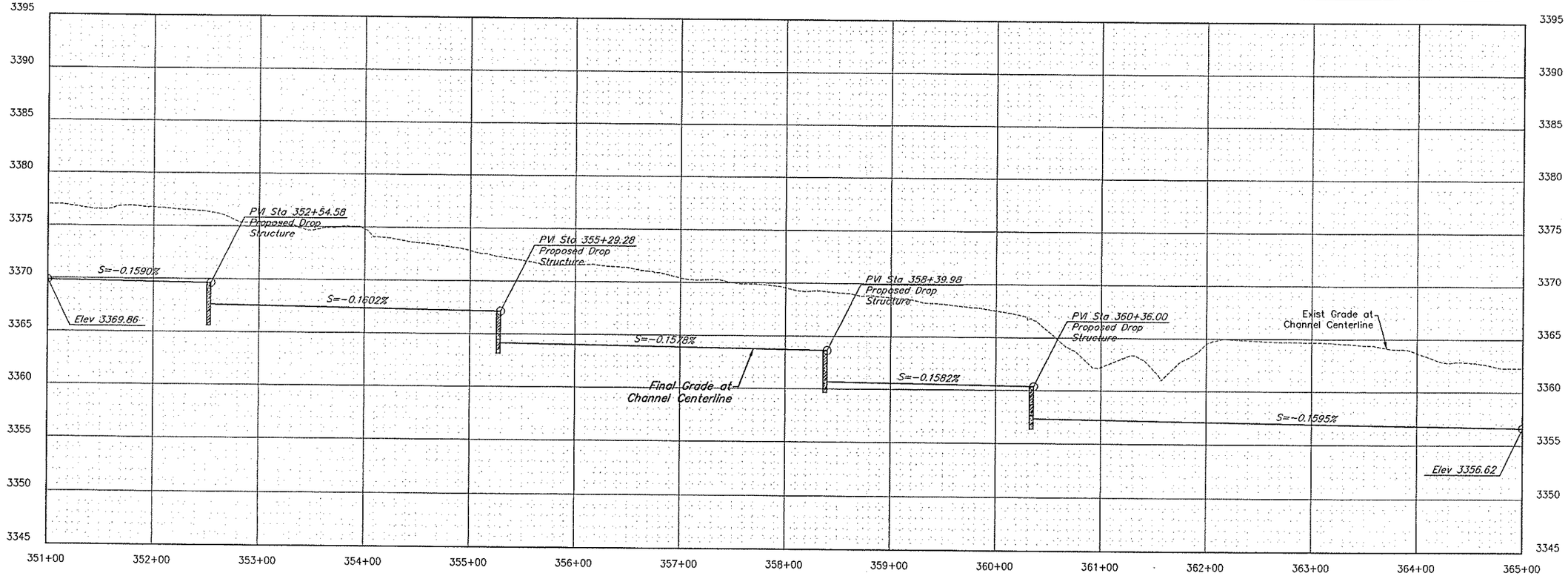
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale
1"=50'

Drawing No.	Sheet	Revision
1	18 / 21	0





ORIGINAL SHEET - D (22 X 34 IN)

Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date
1				
0				
A	Issued			

File Name | Dwn. | Dsgn. | Date

Seal

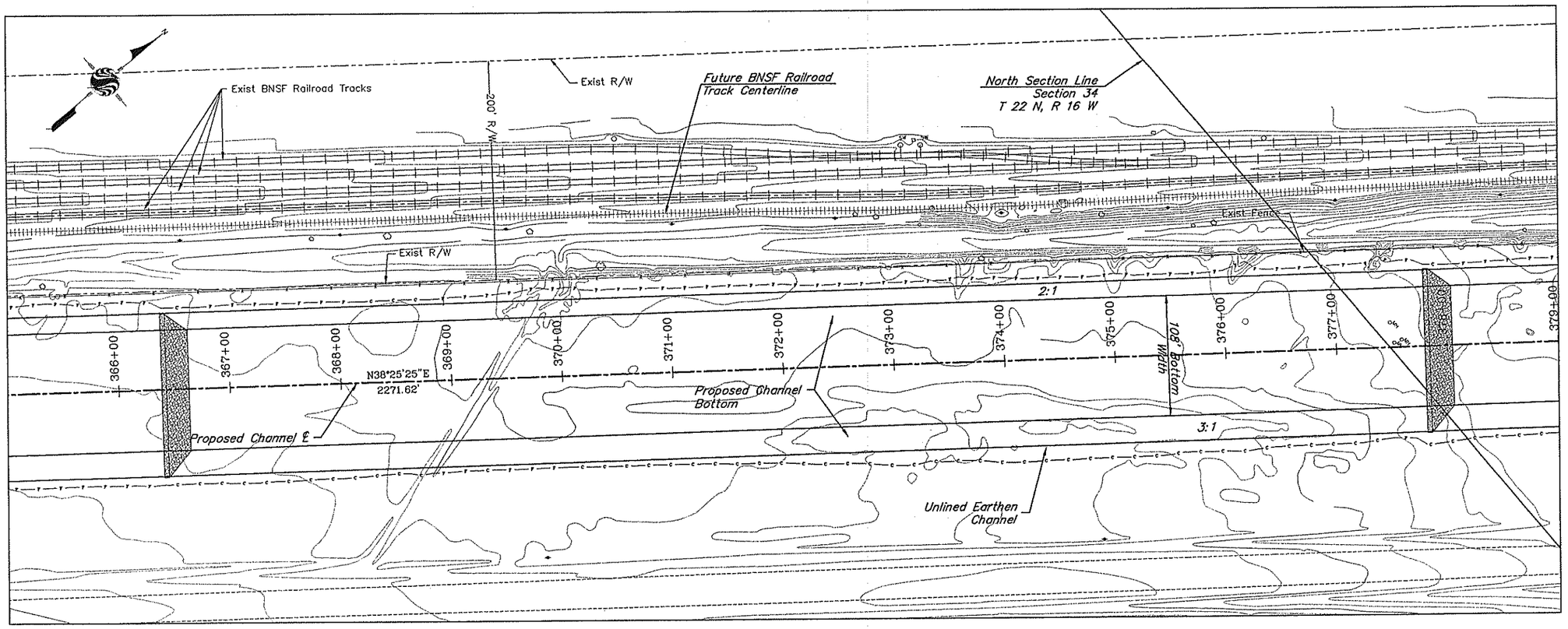
Project No. 81760038

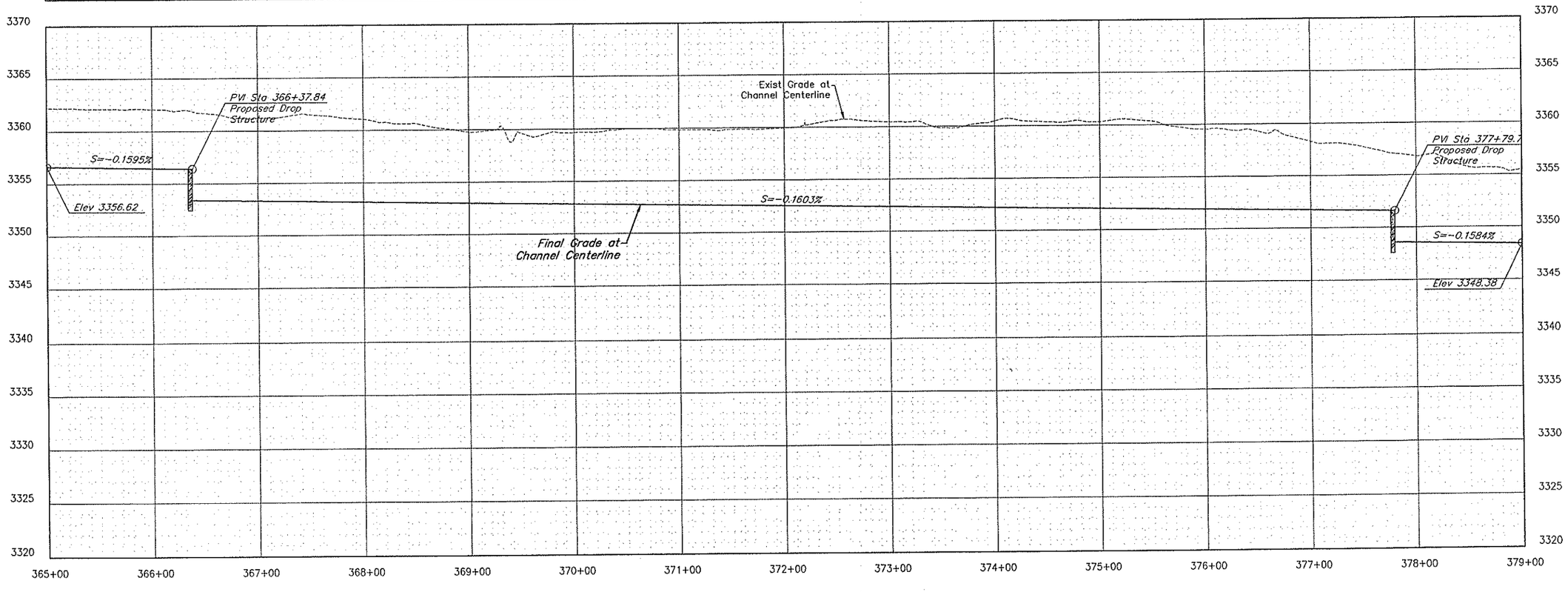
Client/Project
CITY OF KINGMAN
Railroad Diversion Channel
Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale 1"=50'

Drawing No.	Sheet	Revision
1	19 / 21	0





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date
0				
A	Issued			

File: Home

Dwn.	Dsgn.	Date

Seal

Project No. 81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

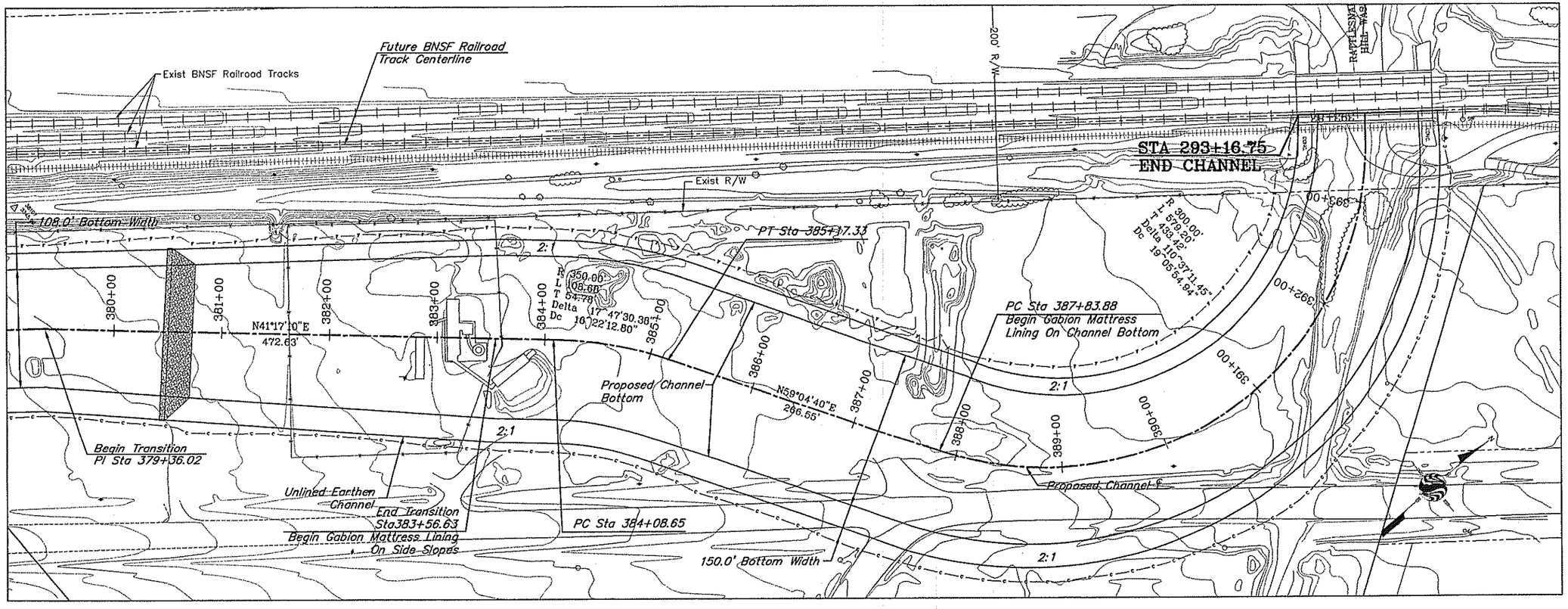
Kingman, Arizona

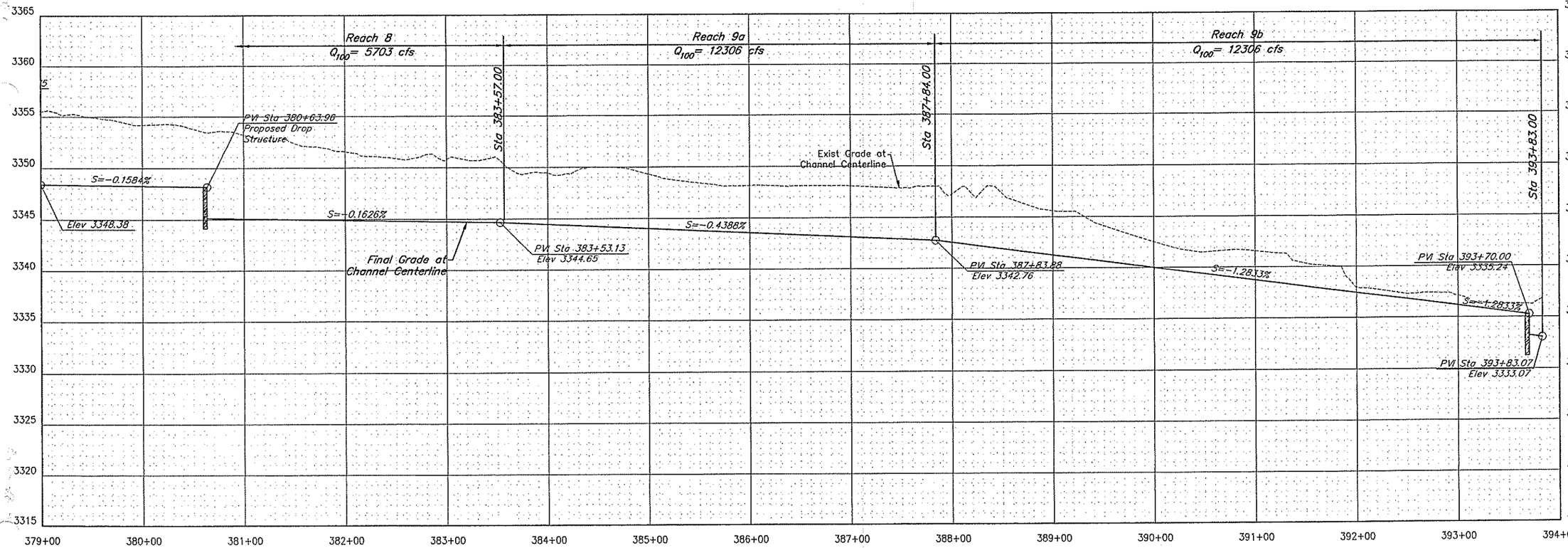
Title
PLAN & PROFILE SHEETS

Scale 1"=50'

Drawing No.	Sheet	Revision
1	20 / 21	0

ORIGINAL SHEET - D CAD NAME (FULL PATH)





Stantec

Stantec Consulting Inc.
8211 South 48th Street
Phoenix AZ U.S.A.
85044
Tel. 602.438.2200
Fax. 602.431.9562
www.stantec.com

Consultants

No.	Revision	By	Appd.	Date
A:				

Issued	By	Appd.	Date
File Name	Dwn.	Dsgn.	Date

Seal

Project No. 81760038

Client/Project
CITY OF KINGMAN

Railroad Diversion Channel

Kingman, Arizona

Title
PLAN & PROFILE SHEETS

Scale 1"=50'

Drawing No.	Sheet	Revision
1	21/21	0

ORIGINAL SHEET - D CAD NAME (FULL PATH)