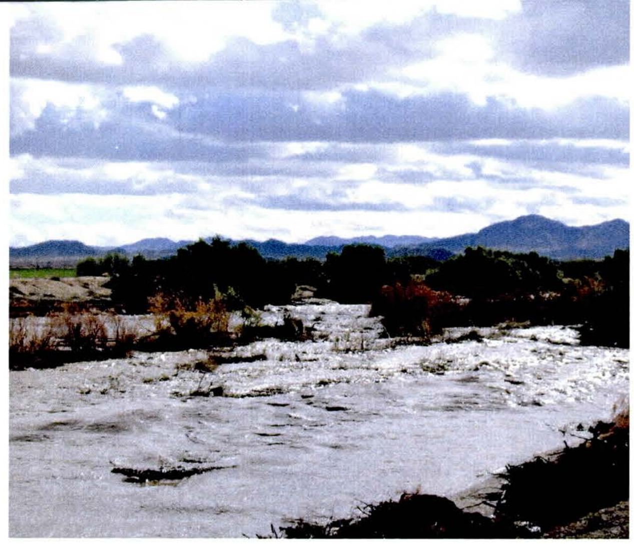

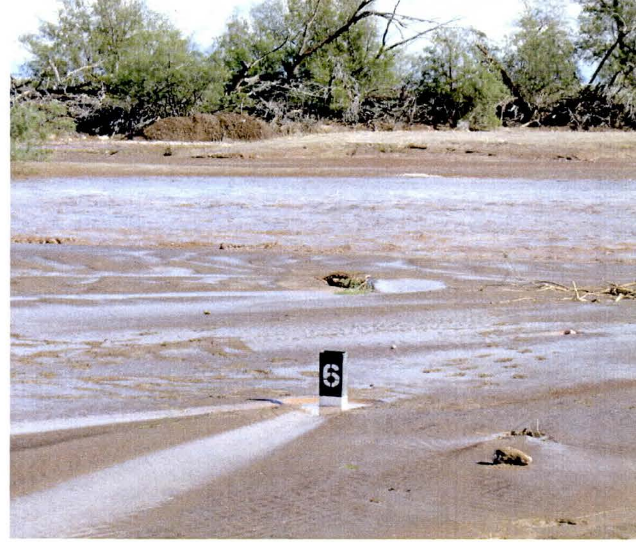

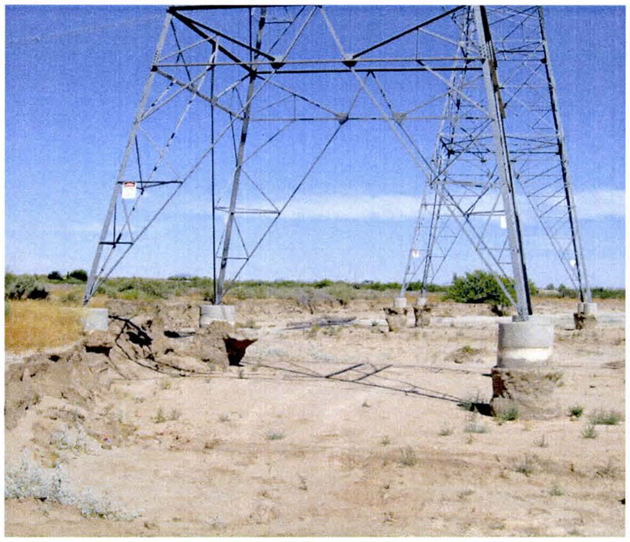

Lower Hassayampa Watercourse Master Plan, Phase 2

Technical Data Notebook

June 2013

Stantec

Flood Control District of Maricopa County

Stantec Project No. 181300279

Contract FCD 2009C024

Lower Hassayampa Watercourse Master Plan, Phase 2
Technical Data Notebook

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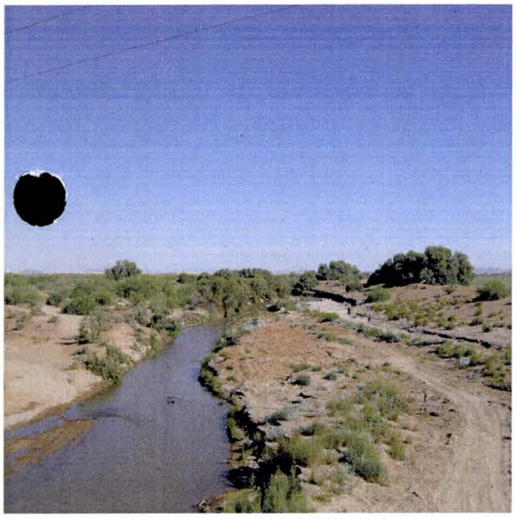

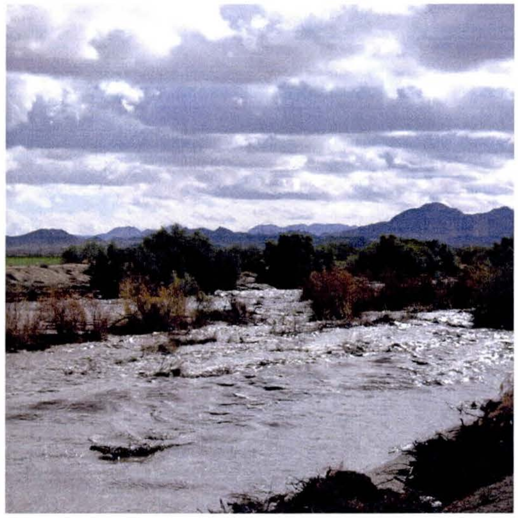

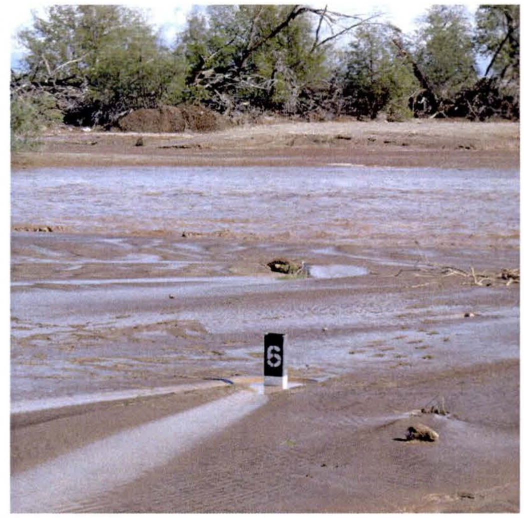

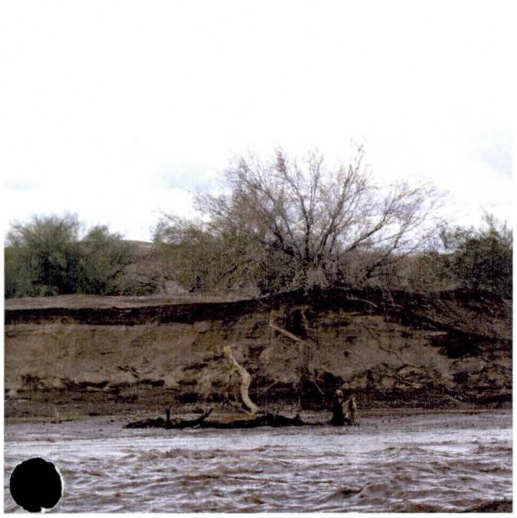

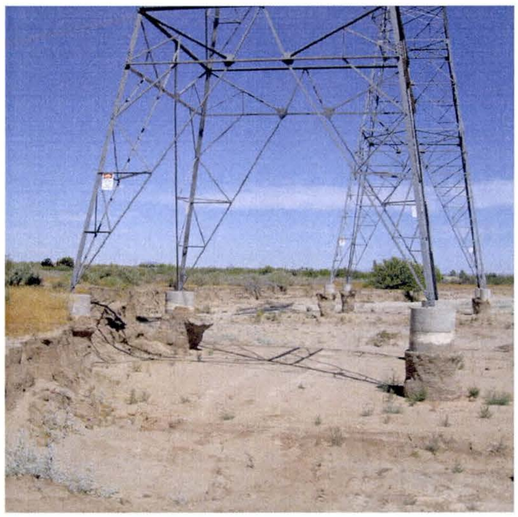

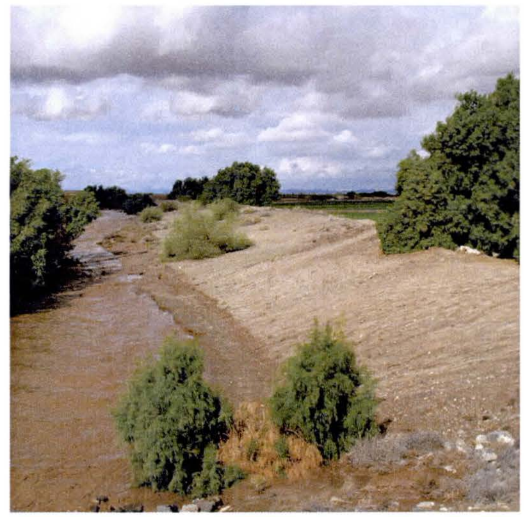

Lower Hassayampa Watercourse Master Plan, Phase 2

Technical Data Notebook

June 2013

Stantec

Stantec Project No. 181300279

Flood Control District of Maricopa County

Contract FCD 2009C024

Lower Hassayampa Watercourse Master Plan Phase 2

Technical Data Notebook

Prepared For:
Flood Control District
of Maricopa County

FCD 2009C024

PREPARED BY:

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February, 2013
Revised June, 2013

Stantec Consulting Inc.
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Date Signed 6/11/2013
ARIZONA U.S.A.
Expires 9/30/2015

EXECUTIVE SUMMARY

Phase 2 of the Lower Hassayampa Watercourse Master Plan (LHWCMP) project, located within the jurisdictions of the Town of Buckeye and unincorporated Maricopa County was conducted under contract FCD 2009C024. The Hassayampa River is an ephemeral stream, characterized by shifting braided to meandering sand channels, few bridge crossings and scattered sand and gravel operations. A typical response that has been observed from a runoff event is lateral migration of the main channel. Channel banks have migrated as much as 300 feet in a single flood event that was estimated to be about a 25-year event, exacerbating flood and erosion hazards on property adjacent to the watercourse.

Community's future growth plans will contribute to encroachments on the watercourse. Encroachments will be made to reclaim floodplain areas for developable property, to provide transportation and utility infrastructure corridors required to support growth and to provide sand and gravel required for construction of homes and infrastructure. The effect of future urbanization on the form and hydraulic function of the Hassayampa River are not known. The watercourse master plan will evaluate the effects of urbanization and provide a river management plan to address these effects. In the future there may be up to fifteen additional roadway bridge crossings within the study reach. Manmade impacts that have affected the characteristics of the river are vegetation clearing for agriculture and sand and gravel mining, sand and gravel mining and lateral migration of channel banks.

The goal of the LHWCMP is that when the plan is implemented residents, property, and infrastructure will be protected from the effects of flooding through fiscally responsible and sustainable floodplain management and flood hazards solutions. To achieve this goal understanding the rivers' form and function and how the river responds to physical changes brought on by urbanization is required. To this end hydraulic modeling of existing and proposed conditions are conducted to establish a baseline condition (existing condition) and a proposed condition. The existing condition model evaluates the current condition and proposed condition models evaluate the impact of physical changes to the river brought on by potential urbanization. The hydraulic performance of the river under proposed conditions is compared against the hydraulic performance under the existing condition to establish net changes. A number of proposed condition scenarios are evaluated to understand the effect that different urbanization scenarios would have on the watercourse. Specific alternatives that were evaluated are:

- Floodplain Management Alternative - The Floodplain Management Alternative allows for encroachment into the watercourse only at bridge locations. Between bridge locations the watercourse is to be maintained in a natural state by not allowing encroachments into or development within the FEMA Effective 100-year Floodplain. Sand and gravel operations are managed so that their impact to bridges and to the form and function of the watercourse are minimized. Through hydraulic analyses and an optimization process, recommended maximum encroachments into the floodplain for bridge approaches, bridge opening dimensions and bridge locations are established.

- Encroachment to the Effective and/or Phase 1 Floodway Limits - In two separate models this scenario evaluates the effect of encroachments to the FEMA Effective and Phase 1 Floodway Limits along with bridge dimensions established from the results of the Floodplain Management Model.

- Maximum Encroachment - This scenario allows for encroachment beyond the floodway limit along the entire study reach. The scenario evaluates different channelization's scenarios in conjunction with bridge locations and dimensions established from the Floodplain Management Model.
- No-Action Alternative - The No-Action (do nothing) Alternative provides flood control management based on current federal, state, and local floodplain management regulations that allow encroachment into the floodway fringe. The alternative allows for encroachment into the floodplain as long as Federal Emergency Management Agency (FEMA) guidelines are followed. Typically under the No-Action Alternative, piecemeal development occurs without a consistent approach in the design of flood hazard mitigation measures or evaluation of collective impacts to the form and function of the watercourse and to environmental and scenic resources.

Two other river management alternatives that are considered in the LHWCMP are the Floodplain and Erosion Management Alternative, and the River Corridor Management Alternative. The Floodplain and Erosion Hazard and the River Corridor Management alternatives allow for low density, low impact development within the floodway fringe and erosion hazard boundaries. Low impact development is defined as any activity within the floodway fringe or erosion hazard zone that does not significantly alter the natural form and function of the watercourse. Due to the low density classification impacts to the watercourse by these alternatives are considered minimal, therefore no specific hydraulic modeling was conducted. Descriptions of the alternatives are:

- Floodplain and Erosion Management Alternative - The Floodplain and Erosion Management allows for encroachment into the 100-year floodplain at bridges locations defined in the Floodplain Management Alternative and allows for low density, low impact development within the floodway fringe and erosion hazard boundaries.
- River Corridor Management Alternative -The River Corridor Management Alternative maintains that encroachment into the "river corridor" disrupts the biological, hydrologic and cultural connectivity of the river system. A river corridor can be loosely defined as an integrated system of biological, hydrologic, geomorphic and cultural factors. For this study, the river corridor management approach identified the alternative's limits through aerial imagery and field reconnaissance. The limit was determined by a combination of factors including, but not limited to, the extent of riparian-associated vegetation, minimum functional wildlife corridor widths and geomorphic factors such as dissected river terraces and banks and likely historic lateral migration extents. This alternative does not impede existing sand and gravel operations, future highway/roadway bridge infrastructure or existing development and agricultural lands and allows for low density, low impact development within the floodway fringe and erosion hazard boundaries. Bridge encroachments defined in the Floodplain Management Alternative are an element of this alternative.

Performance criteria were developed to determine optimum bridge opening dimensions and to evaluate a river management scenario. Changes in velocity, flow regimen, water surface elevation and stable slope relative to the existing condition were used as criteria. A change in velocity of greater than 10%, a change in flow regime, an increase in water surface elevation of more than a 1 foot and a change of more than 10% in stable slope were considered unacceptable with the exception of changes at bridge locations. If the change in hydraulic conditions was confined to 500 feet upstream and downstream of a bridge location and mitigation measures could be employed to minimize the impact due to the change in hydraulic condition the encroachment was considered acceptable.

Based on hydraulic modeling results and team collaboration optimum bridge locations and bridge opening widths were determined for 12 of the 15 proposed bridge locations. Due to existing and proposed sand and gravel operations channelization is recommended at 3 of the bridge locations. Results for the Floodway and Maximum Encroachment scenarios were found to be acceptable. The project team will utilize the results to formulate a River Management Plan for the Hassayampa River.

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Registered Professional Engineer (Civil) CERTIFICATE NO. 31680 PATRICK J. ELLISON Date Signed 6/12/13 ARIZONA U.S.A.

Expires 9/30/2015

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1.0 INTRODUCTION

1.1 PROJECT PURPOSE

The Lower Hassayampa Watercourse Master Plan (LHWCMP) study area and the watersheds draining to the watercourse are relatively undisturbed. Development that has occurred in the area is primarily single lot development. Due to the sparse development and few encroachments into the river, significant damage caused by flooding and/or erosion has not occurred. However, the effect of future urbanization including roadway and utility infrastructure crossings on the form and hydraulic function of the Hassayampa River are not known. The watercourse master plan will evaluate the effects of urbanization and provide a river management plan to address these effects (T. Pinto, 7/09/2010). The LHWCMP was conducted in two phases. Phase 1 tasks focused on defining the existing condition of the watercourse in terms of hydraulic performance and channel stability. Phase 1 was conducted under contract Flood Control District (FCD) 2004C001. The focus of Phase 2 tasks were to evaluate future conditions that may be imposed on the watercourse through urbanization and to determine the impacts of those conditions on the watercourse relative to the existing conditions defined in Phase 1. Through urbanization encroachments on the watercourse are made to produce developable property and to provide transportation and utility infrastructure required to support the community's plan for future growth. Review of Maricopa Association of Governments (MAG) Regional Transportation Plan, Town of Buckeye General Land Use Plan and Maricopa County's Future Land Use Plan indicate that there are up to 15 additional bridge crossings of the Hassayampa River planned in the future. The LHWCMP through hydraulic evaluations conducted in Phase 2 defines optimal bridge locations, bridge length and areas suitable to be reclaimed for potential development. Phase 2 is conducted under contract FCD 2009C024.

1.2 PURPOSE OF REPORT

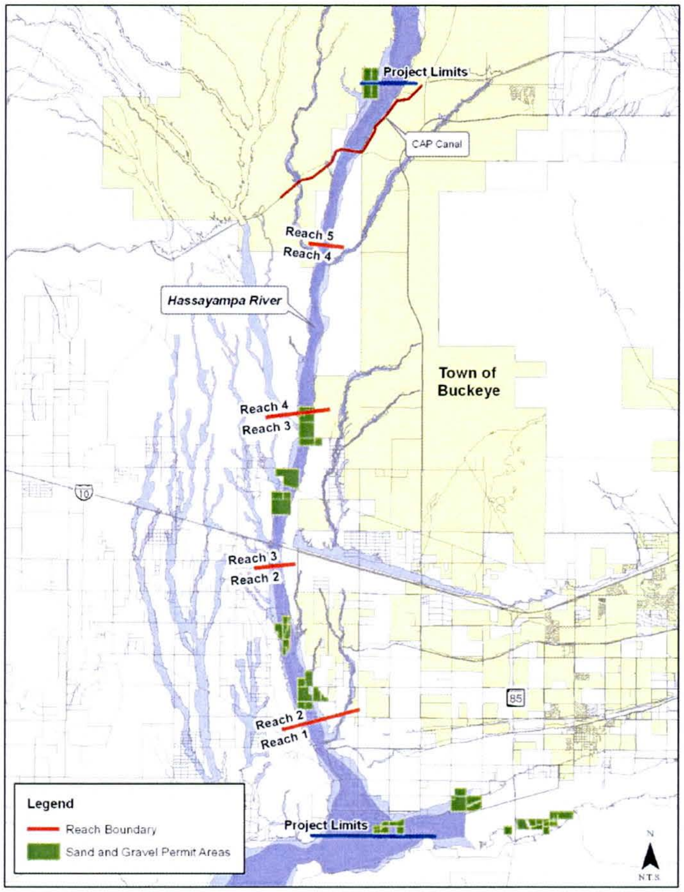
The following report is a comprehensive document that contains the results and supporting computations for the evaluations conducted for Phase 2 by Stantec Consulting Services. The report includes discussions on hydraulic evaluations conducted for the existing and potential future conditions; potential river management scenarios, criteria used to evaluate river management scenarios and evaluations conducted to support and evaluate a recommended river management approach.

1.3 DESCRIPTION OF PROJECT AREA

The LHWCMP study reach is within the jurisdictions of the Town of Buckeye and unincorporated Maricopa County and extends from the confluence with the Gila River to River Mile (RM) 27.89. RM 27.89 is located approximately at the Beardsley roadway alignment. The location of the study reach of the Hassayampa River is depicted in Figure 1.1. Major washes that drain to the Hassayampa River within the study reach include Jackrabbit Wash, Wagner Wash and Daggs Wash. During Phase 1, the study reach of the Hassayampa River was subdivided into five reaches based on similar physical and hydraulic characteristics. The sub reaches are depicted on Figure 1.1.

The subject reach of the Hassayampa River is an ephemeral stream, characterized by shifting braided to meandering sand channels, variable vegetation densities few bridge crossings and scattered sand and gravel operations. A typical response that has been observed in regards to river form from a runoff event is lateral migration of the main channel. Channel banks have migrated as much as 300 feet in a single flood event that was estimate to be about a 25-year event. Vegetation densities are spatially varied ranging from sparse vegetation to very dense over short distances. At the confluence with the Gila River the vegetation is very dense due to water availability. Upstream of the confluence vegetation densities are sparse to moderate. Currently there are three bridge crossings, one railroad bridge and two roadway bridges. In the future there may be up to fifteen additional roadway bridge crossings within the study reach. Manmade impacts that have affected the characteristics of the river are vegetation clearing for agriculture and sand and gravel mining. At locations sand and gravel mining operations have impacted channel geometry which will result spatially in changes to the hydraulic performance of the watercourse.

Figure 1.1
Project Location Map



1.4 CORRESPONDENCE

Correspondence that transpired during the course of this study that relates to scope, notice to proceed and review comments concerning the analyses documented in this report are provided in Appendix A.

1.5 HYDRAULIC ANALYSIS SCOPE

The goal of the LHWCMP is that when the plan is implemented residents, property, and infrastructure will be protected from the effects of flooding through fiscally responsible and sustainable floodplain management and flood hazards solutions (T. Pinto 2007). To achieve this goal understanding the rivers' form and function and how the river responds to physical changes brought on by urbanization is required. To this end hydraulic modeling of existing and proposed conditions are conducted to establish a baseline condition (existing condition) and a proposed condition. The existing condition model evaluates the current condition and proposed condition models evaluate the impact of physical changes to the river brought on by potential urbanization. The hydraulic performance of the river under proposed conditions is compared against the hydraulic performance under the existing condition to establish net changes. A number of proposed condition scenarios are evaluated to understand the effect that different urbanization scenarios would have on the watercourse. Specific scenarios that were evaluated are:

- Floodplain Management Model - The Floodplain Management scenario allows for encroachment into the watercourse at bridge locations, with no structural elements in the area between the bridges. The evaluations establish maximum encroachments allowed at a bridge locations and bridge opening dimensions that will be utilized in other river management scenarios.
- Encroachment to the Effective and Phase 1 Floodway Limits – In two separate models this scenario evaluates the effect of encroachments to the FEMA Effective and Phase 1 Floodway Limits along with bridge dimensions established from the results of the Floodplain Management Model. The reach downstream of the UPRR Bridge in both models is modeled as a "levee failed" condition (no lateral weirs) and the FEMA Effective Floodway limits will be used as the maximum encroachment limits. The floodway for the reach upstream of the UPRR Bridge will utilize the Effective Floodway limits in one model and Phase 1Floodway encroachment limits in the other model. Encroachment to the Floodway Alternative allows for encroachment to the floodway limits by placing earthen fill material within the floodway fringe so that the area is elevated above the 100-year water surface area. Bank armoring is provided to protect the filled floodway fringe area. Bridge encroachments defined in the Floodplain Management Alternative are an element of this alternative.
    - The Phase 1 floodway limits tend to meander more than the effective regulatory floodway. In many cases the Phase 1 floodway is narrower than the effective floodway (West, February 2006).
- Maximum Encroachment – This scenario allows for encroachment beyond the floodway limit along the entire study reach. The scenario evaluates different channelization's scenarios in conjunction with bridge locations and dimensions established from the Floodplain Management Model.

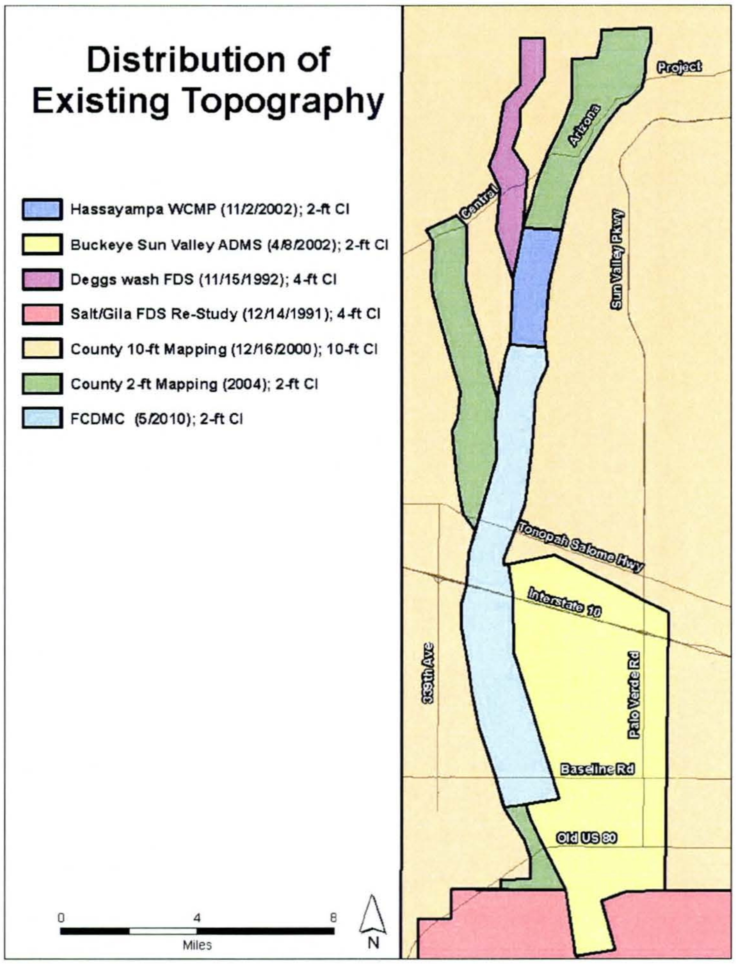
- No-Action Alternative -The No-Action (do nothing) Alternative provides flood control management based on current federal, state, and local floodplain management regulations that allow encroachment into the floodway fringe. The alternative allows for encroachment into the floodplain as long as Federal Emergency Management Agency (FEMA) guidelines are followed. Typically under the No-Action Alternative, piecemeal development occurs without a consistent approach in the design of flood hazard mitigation measures or evaluation of collective impacts to the form and function of the watercourse and to environmental and scenic resources.

2.0 MAPPING AND SURVEY INFORMATION

2.1 DESCRIPTION OF MAPPING

The District provided two sets of topographic mapping for the project area. One set was developed for the Hassayampa Watercourse Master Plan Phase 1 study. The other set was new topographic mapping flown in May of 2010 for a reach of the Hassayampa River commencing at River Mile (RM) 4.15 and extending to RM 18.81. The new topographic data was developed for Phase 2 after a runoff event that occurred in January of 2010. For Phase 2, multiple topographic data sources were utilized to develop a digital terrain model that represents the topography of the study area. Figure 2.1 shows the distribution of topography data sets that were compiled to develop a digital terrain model for the Phase 1 project area. Phase 1 and Phase 2 topographic data were compiled to develop a digital terrain model for Phase 2. The vertical datum for the data sets is NAVD88 and the horizontal datum is State Plane NAD 83, Arizona Central, International feet.

Figure 2.1 Topographic Data



3.0 FIELD RECONNAISSANCE MEMO

Field reconnaissance was conducted to determine if there have been physical changes to the project reach of the Hassayampa River since the Lower Hassayampa Watercourse Master Plan Phase 1 project was completed. Field reconnaissance included:

- Observation of channel and floodplain conditions for validation of Manning's "n" values
- Photographic documentation of floodplain characteristics;
- Verification of channel bank stations;
- Observation of possible overflow areas, inspection of flood control and bridge structures;
- Determine if any structures impacting flows, such as bridges, culverts, roads, etc., have been constructed since the development of the existing model;
- Determine if any other significant topographic changes, such as sand and gravel operations, major developments, etc., that have occurred in the river since the development of the Phase 1existing model that may have an impact on hydraulic conditions.

In addition to the field reconnaissance, the new topographic mapping developed for Phase 2 was compared to the Phase 1 topographic mapping to determine the physical changes that have occurred since the date of the Phase 1 topography.

Results of the field investigations were presented in a Field Reconnaissance Report. The report is included in this report as Appendix B.

4.0 HYDROLOGY

Hydrology utilized for this study is the FEMA Effective 100-year peak discharges developed for the Hassayampa River in 1988 for a Flood Insurance Study. A ratio of the 100-year event was taken to establish 10-year peak discharges. The ratio of 0.35 (Value from District's Hydrology Manual) was utilized. Table 4.1 lists 100-year and 10-year peak discharges utilized in the hydraulic evaluation.

The District has contracted with the USGS to update peak discharges for the Hassayampa River. The study is underway.

Table 4.1
Summary of Design Discharges by River Station

Location	100-year Peak Discharge (cfs)	10-year Peak Discharge (cfs)
27.89	57,854	20,249
25.06	57,230	20,030
21.93	56,604	19,811
18.81	55,980	19,593
15.49	76,120	26,642
15.21	75,574	26,451
12.94	75,164	26,307
10.87	74,970	26,239
9.93	74,572	26,100
7.94	73,966	25,888
4.91	73,500	25,725

5.0 HYDRAULIC ANALYSIS

5.1 INTRODUCTION

Hydraulic analyses were conducted for the project reach of the Hassayampa River for existing conditions and for different encroachment and channelization scenarios to determine potential impacts to the study reach due to urbanization. Elements of urbanization that could impact the watercourse include roadway encroachments, floodplain encroachments as a result of residential or commercial development, channelization, and sand and gravel operations. Channelization could be an option that development would incorporate into a plan to increase the amount of developable area. Hydraulic evaluations of sand and gravel operations were not included in the hydraulic analysis scope and therefore no technical evaluations were conducted.

5.2 METHOD DESCRIPTION

Hydraulic analysis is performed in accordance with applicable guidelines and criteria set forth in the *Guidelines and Specifications for Flood Hazard Mapping Partners (Federal Emergency Management Agency* (FEMA), 2003), and the District's Consultant Guidelines (Flood Control District of Maricopa County, 2003). The US Army COE HEC-RAS Computer Program, version 4.1.0, dated Jan 2010 was used to develop and evaluate hydraulic models that simulate the physical conditions of the watercourse under a runoff event. The HEC-RAS model data files developed for the project; both input and output, for the watercourse are provided digitally on a CD in Appendix C. PDF format files of the HEC-RAS input and output files are located in Appendix D. HEC-RAS project and plan names are listed in Table 5.1. Figure 5.1 depicts a HEC-RAS model development flow chart that shows the steps taken for model development. Work Maps depicting the location of HEC-RAS cross sections, bank stations, thalweg, topographic data, 100-year Effective FEMA Floodplain Zones, and lateral migration limits established by the District are provided as Plate 1 and Plate 2 (located in the back of the report). The difference between Plate 1 and Plate 2 are the locations of cross sections upstream and downstream of potential bridge locations. Based on conclusions from the first step in the Floodplain Management evaluation, bridge locations were moved due to physical and hydraulic conditions. Plate 2 presents the revised cross section locations based on relocating bridge alignments.

Table 5.1 Hassayampa River – Hydraulic Model Summary

Project Name (1)	Plan Name (2)	Geometry (3)	Steady Flow (4)	Description (5)
Phase 2 Existing Condition Model	1. Phase 1 Existing Condition 2. Phase 2 Existing Update	1. Lower Hassayampa-Final Model 2. .Phase 2 Existing Update	Hassayampa Flow Data	This project file has 2 Plans. One plan is the Final HEC-RAS Phase 1 model (Phase 1 Existing), the other plan is the Phase 2 model with updated geometry (Phase 2 Existing Update). After the runoff event in January of 2010 the District obtained new aerial mapping for a reach commencing at approximately RM 4.25 and extending to RM 18.71. The mapping was flown in May 2010. Vertical Datum: NAVD 88

Table 5.1 Hassayampa River – Hydraulic Model Summary (Continued)

Project Name (1)	Plan Name (2)	Geometry (3)	Steady Flow (4)	Description (5)
Floodplain Management Step 1	Floodplain Management Step 1	Phase 2 Bridge Encroachment	Hassayampa Flow Data 10-yr/100-yr	Additional cross sections are added to the Existing Condition Phase 2 Model at bridge locations to evaluate the impact of potential bridge encroachments on the hydraulic performance of the watercourse. This evaluation is the first step in determining a Floodplain Management Encroachment stations are utilized to define bridge abutments and ineffective flow areas for each bridge opening evaluated.
Floodplain Management Step 2	1. New Existing Condition 2. Floodplain Management Step 2	1. New Existing Condition 2. Floodplain Management Step 2	Hassayampa Flow Data	The Project File contains two plans. The first plan contains new cross section geometry data at proposed bridge locations. Proposed bridge locations were revised based on the results of Floodplain Management Step 1. The second plan models bridge alignments and bridge opening widths determined in Step 1 utilizing the HEC-RAS bridge routine.
Encroachment to the Floodway	1. New Existing Condition 2. Encroachment to the Floodway	1. New Existing Condition 2. LWCMP_Phase 2	Hassayampa Flow Data	The Project File contains two plans. The first plan is the New Existing condition plan described above and the second plan is the plan that models the FEMA Effective Floodway encroachments. See Section 1.5 for details.
LHWCMP Phase 1 FY EN Phase 2	1. New Existing Condition 2. LHWCMP Ph 1 FY EN_ Phase 2	1. New Existing Condition 2. LWCMP_Phase 2	Hassayampa Flow Data	The Project File contains two plans. The first plan is the New Existing condition plan described above and the second plan is the plan that models the Phase 1 Floodway encroachments. See Section 1.5 for details.

Table 5.1 Hassayampa River – Hydraulic Model Summary (Continued)

Project Name	Plan Name	Geometry	Steady Flow	Description
Maximum Encroachment Alternative	1. Structural Alternative Base 2. Maximum Alternative Alt A1 3. Maximum Alternative Alt B1	1. Maximum Alternative Base 2. Alt A1 3. Alt B1	Hassayampa Flow Data	The project contains 3 plans. The first plan is the Maximum Encroachment Alternative Base Plan. This plan contains the geometry utilized in the Encroachment to the Floodway. This geometry is then modified using the HEC-RAS channel modification routine to develop Plan 2 (Alt. A1) and Plan 3 (Alt. B1)
Max Encroachment, R 1 Gladden Channel	1. Encroachment to the Floodway 2. Gladden Channel	1. LHWCMP_Phase 2 2. Gladden Channel	Hassayampa Flow Data	Encroachment to the Floodway Plan serves as the base model. Typical trapezoidal channel sections are edited and channel alignment revised based on stakeholder comments. A new bridge crossing at Old US 80 is required.
Maximum Encroachment, R1 Channel Refinement	1. Encroachment to the Floodway 2. Reach 1 Channel Refinement	1. LHWCMP_Phase 2 2. Reach 1 Channel Refinement	Hassayampa Flow Data	Encroachment to the Floodway Plan serves as the base model. Typical trapezoidal channel sections are edited and channel alignment revised based on stakeholder comments. The existing bridge crossing of Old US 80 is utilized
Transition	Transition	Transition	Hassayampa Flow Data	In the event that multiple alternatives are employed within the Hassayampa River Corridor a hydraulic model was developed to evaluate the hydraulic conditions of a river reach where one alternative transitions to another.

Figure 5.1 HEC-RAS Model Development Flow Chart

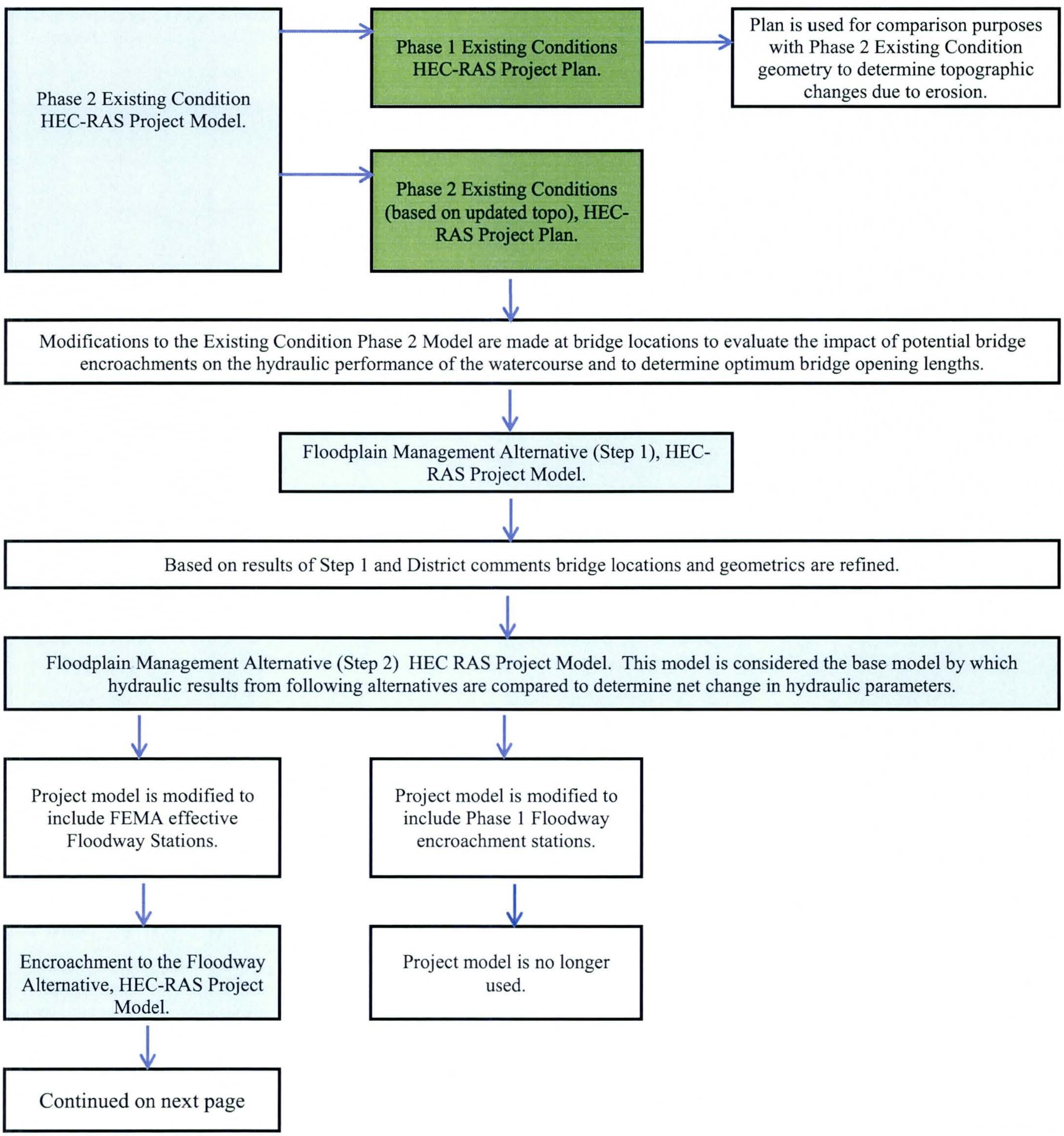
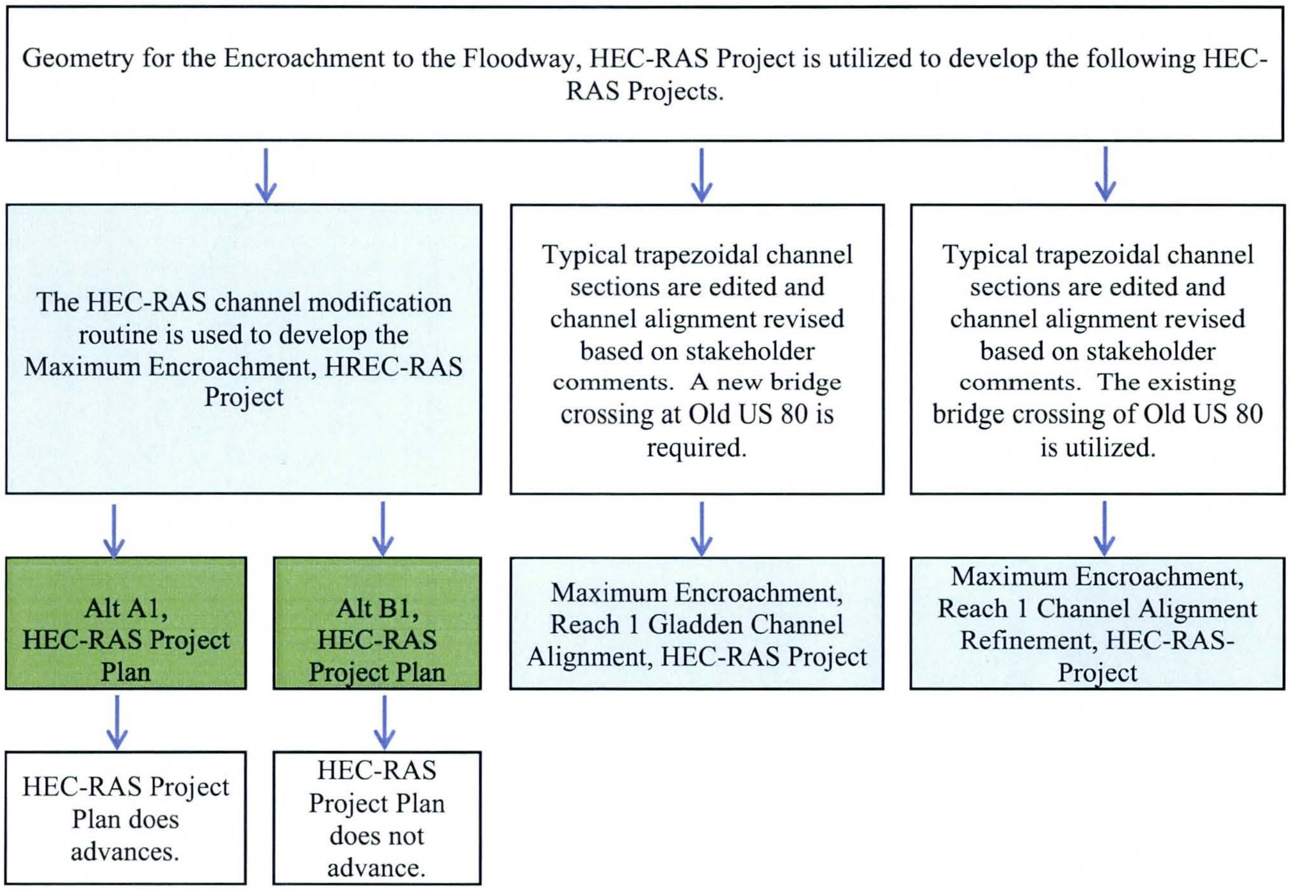


Figure 5.1 HEC-RAS Model Development Flow Chart Continued



5.3 PARAMETER ESTIMATION

5.3.1 Manning's n-Value

Manning's roughness coefficients ("n" values) and the distribution of the coefficients developed for Phase 1 were reviewed to determine if there has been significant physical change to merit revising the "n" value shape files developed for Phase 1. At locations Manning's roughness coefficients for the reach extending from RM 4.145 to 27.89 merited revisions based on physical changes to the water course due to erosion, sand and gravel mining, and agricultural clearing. The base roughness coefficients developed for the Phase 1 project were utilized where vegetation had been removed. Phase 1 Manning's roughness coefficients were estimated using a methodology that is the same as what is presented in "Selection of Manning's Roughness Coefficient for Natural and Constructed Vegetation and Non-Vegetated Channels and Vegetation Maintenance Plan Guidelines for Vegetated Channels in Central Arizona". See Appendix B - Field Reconnaissance Report for Manning n-value details. Maps depicting the distribution of Manning's roughness coefficients are provided in the Field Reconnaissance Report.

5.3.2 Expansion and Contraction Coefficients

The study reach is relatively free of any natural abrupt channel transitions, therefore, gradual contraction and expansion coefficients of 0.1 and 0.3, respectively, are used. At bridge locations where there is are abrupt channel transitions contraction and expansion coefficients of 0.3 and 0.5 are utilized.

5.4 MODELING DISCHARGES

Peak discharges cited in Section 4 are utilized in the hydraulic modeling.

5.5 CROSS SECTION DESCRIPTION

5.5.1 General

The HEC-RAS computer model utilizes geometric data at cross section alignments to facilitate hydraulic computations. Cross sections for the study reach are typically located at approximately 500-foot or less intervals, as well as at significant changes in channel slope and cross sectional area. Cross section alignments developed for the Hassayampa Watercourse Master Plan Phase 1 Study were augmented and utilized for the Phase 2 Study. For the Phase 2 study additional cross sections were required at proposed bridge locations.

For the reach upstream of the Union Pacific Railroad Bridge (RM 4.0) the digital terrain model developed for Phase 2 was utilized to determine cross sectional geometry. Cross sectional geometry was determined from a triangulated irregular network (TIN). The TIN is developed from the digital terrain model (DTM) using the 3D Analyst extension of ArcView GIS v3.2. Cross section numbering is expressed in river miles above the confluence with the Gila River. Cross section stationing is from left to right looking downstream. The 10,000 station defines the center of the channel, sometimes referred to as the thalweg or channel centerline.

Downstream of the Union Pacific Rail there are non-engineered levees that influence the distribution of flow in the channel and overbank areas. River management scenarios that are being evaluated include levee in and levee out scenarios. For levee in scenarios where the levee is modeled as functioning, geometry from the HEC-RAS model developed for Phase 1 was utilized. For the levee out scenarios where the levees do not function to contain flow, new cross section data was developed. New cross section alignments were developed utilizing the three sets of cross section used downstream of the Union Pacific Railroad in Phase 1 to define the distribution of flow. The alignments of the three sets (left bank, main channel, right bank) were combined so that cross sections extend the full length of the FEMA Effective Floodplain. Cross section alignments were then used to sample the TIN to obtain cross section geometric data. The Phase 2 Existing Condition Model and the Floodplain Management Models used the levee in scenario geometry whereas the Floodway Encroachments Models and Maximum Alternative Model utilized the levee out scenario geometry.

5.5.2 Channel and Overbanks

For the situation where the geometry from the Phase 1 Model was not utilized, cross section reach lengths and channel bank stations are determined using the HEC-GeoRAS extension for ArcView GIS. The process involves the layout of line work representing the hydraulic baseline (channel reach length), flow paths (overbank reach lengths) and bank stations. This data, along with cross sectional geometry is exported into a format required by HEC-RAS.

5.6 MODELING CONSIDERATIONS

5.6.1 Hydraulic Jump Analysis

The potential for a hydraulic jump was identified for certain bridge encroachment scenarios. The locations and the significance of the jump are discussed in the results section.

5.6.2 Bridges, Culverts and Constrictions

There are no culvert structures within the study watercourse, however there are three existing bridge crossings and fifteen proposed bridge crossings. The existing bridge crossings were modeled with the bridge routines in HEC-RAS. Bridge geometry data for the existing bridges were taken from the Phase 1 HEC-RAS Models. The proposed bridge crossings are modeled in a two step process. The first step is a bridge opening alternative analyses step, in which different openings for proposed bridge locations are modeled to determine a preferred opening width. Due to the number of bridges and the number of bridge openings to be evaluated for each bridge location, encroachment stations were used to simulate the abutments of the bridge. Encroachment stations were used to define the limits of a bridge opening and the ineffective flow areas upstream and downstream of a particular bridge opening scenario. Once a preferred bridge opening dimension was determined from Step 1, the HEC-RAS bridge geometry editor was used to define bridge geometry, and the ineffective flow routine was used upstream and downstream of the bridge to define ineffective flow areas during Step 2. Additional bridge modeling details are discussed in latter sections of this report.

5.6.3 Levees and Dikes

Downstream of the Union Pacific Railroad (at RM 3.72) along the left bank and downstream of Old US 80 (at RM 2.63) along the left and right banks, non-engineered levees have been constructed. For the Existing Condition HEC-RAS model and Floodplain Management models, the levees are modeled as structures. The Lateral Weir routine was utilized to estimate the flow that would drain over the levee in an overtopping scenario. For the Floodway Encroachments and Maximum Alternatives, the levee is modeled as a "levee failed" condition (no lateral weirs).

5.6.4 Islands and Flow Splits

Within the study reach of the Hassayampa River there are islands and split flow locations. The river is a braided river where there are areas between channel braids that are not inundated during a 100-year event. These island areas and channel braids do not pose any significant modeling concerns because the flow does not leave the drainage network. Downstream of the Union Pacific Railroad in the levee reach, split flow occurs when the levees are overtopped. Modeling approaches of the levee reach were discussed above.

5.6.5 Ineffective Flow Areas

The ineffective flow option of the geometry editor was utilized to define ineffective flow areas. Areas where this option was applied include areas upstream and downstream of bridges, sand and gravel mining areas where excavated pits occurred within the cross sections but out of the channel flow area, tributary drainage that parallels the river and behind manmade features that have created ineffective flow areas.

5.6.6 Supercritical Flow

Supercritical flow was only recorded at a few locations for the Existing Condition Phase 2 however the Phase 2 Floodplain Management model flow alternated between subcritical and supercritical for different bridge opening scenarios due to the extent of the encroachment. The Existing Condition Phase 2 model was run at a subcritical flow regime and the Phase 2 Floodplain Management model was run at a mixed flow regime.

5.7 PROBLEMS ENCOUNTERED DURING THE STUDY

5.7.1 Special Problems and Solutions

Special problems are limited to the levee reach. Modeling approach for the levee reach is discussed in Section 5.6.3.

5.8 CALIBRATION

There is no gauge data or observed water surface elevations for the events that are being modeled to calibrate the HEC-RAS model.

5.9 CHECKRAS MESSAGES

CHECKRAS, Versions 1.4 (FEMA, 2005, date modified 7/30/2008) was utilized to check the validity of input parameters in the HEC-RAS hydraulic models that were developed for the study watercourse. Copies of the CHECKRAS output files are provided in Appendix E.

5.10 MODEL WARNING AND ERROR MESSAGES

The HEC-RAS model for the study watercourse executed without error messages for the floodplain profiles. However, the models do report several different warning messages. In general, these messages are to be expected given the hydraulic characteristics of the watercourse.

5.11 HEC-RAS EXISTING CONDITION HYDRAULIC MODELING DETAILS AND RESULTS

The HEC-RAS Existing Condition hydraulic model will serve as the base condition by which the results of hydraulic models developed for alternative analyses will be compared to determine the effects of the alterative on the hydraulic performance of the river. The HEC-RAS model developed for the Phase 1 study forms the base for the existing condition model. The Phase 1 model was revised to include new topographic data from aerial mapping flown in May of 2010. The new topographic data was utilized for the reach commencing at River Mile (RM) 4.15 and extending to RM 18.81. The Field Investigation Report included in Appendix B presents a discussion of the topographic changes that have occurred between 2002 and 2010, and Manning's roughness coefficient details. Plate 1, Sheets 1 through 10 depicts Manning's "n" values, the location where lateral migration has occurred, cross section location with identifiers bank stations and lateral erosion limits estimated by the District. Digital files of the Existing Condition HEC-RAS model are provided in Appendix C. A HEC-RAS summary output is provided as Appendix D.

In order to summarize the change in hydraulic conditions between the Phase 1 and Phase 2 existing conditions models, a comparison of channel invert elevations and water surface elevations are made. The results of the comparisons are presented in Table 5.2. Overall change in channel invert elevation ranged between 1.58 and -14.26. Positive numbers indicate aggradation and negative numbers indicate degradation or locations where channel excavation has occurred. The overall trend for the watercourse is degradation. The greatest amount of degradation occurs upstream and downstream of sand and gravel operations where a pit was located within the channel. There are more locations of aggradation downstream of the Interstate 10 crossing than upstream. The Phase 2 Existing Condition 100-year water surface elevation is lower than the Phase 1 model 100-year water surface elevation. The change in water surface elevation ranged from approximately -5.7 to 0.4. The greatest change occurring in the vicinity of sand and gravel operation where there was a pit within the channel.

Table 5.2 Existing Condition Hydraulic Summary

	Phase 1		Phase 2			
River Sta (RM) (1)	Min Ch El (ft) (2)	W.S. Elev (ft) (3)	Min Ch El (ft) (4)	W.S. Elev (ft) (5)	Change in Profile (ft) (6)	Change in W.S. Elev (ft) (7)
27.89	1395.51	1400.3	1395.51	1400.4	0	0.1
27.75	1392.38	1397.78	1392.38	1397.56	0	-0.2
27.61	1388.48	1394.38	1388.48	1394.41	0	0.0
27.52	1386.23	1392.48	1386.23	1392.39	0	-0.1
27.43	1385.26	1390.81	1385.26	1390.62	0	-0.2
27.33	1383.49	1389.23	1383.49	1389.08	0	-0.2
27.23	1381.76	1386.78	1381.76	1386.69	0	-0.1
27.14	1377.23	1384.06	1377.23	1384.05	0	0.0
27.04	1373.37	1381.25	1373.37	1381.28	0	0.0
26.95	1371.08	1379.17	1371.08	1379.2	0	0.0
26.85	1370.4	1377.23	1370.4	1377.27	0	0.0
26.76	1367.67	1375.1	1367.67	1375.16	0	0.1
26.67	1364.77	1373.28	1364.77	1373.29	0	0.0
26.57	1362.61	1370.94	1362.61	1370.92	0	0.0
26.48	1359.31	1368.45	1359.31	1368.48	0	0.0
26.38	1357.56	1366.48	1357.56	1366.49	0	0.0
26.29	1356.27	1364.34	1356.27	1364.37	0	0.0
26.19	1353.76	1362.23	1353.76	1362.09	0	-0.1
26.1	1351.66	1359.81	1351.66	1359.69	0	-0.1
26	1348.84	1357.24	1348.84	1357.11	0	-0.1
25.91	1347.2	1355.1	1347.2	1354.74	0	-0.4
25.81	1345.28	1352.93	1345.28	1352.59	0	-0.3
25.72	1343.7	1351.39	1343.7	1351.05	0	-0.3
25.62	1340.14	1349.43	1340.14	1349.04	0	-0.4
25.53	1337.63	1346.92	1337.63	1346.52	0	-0.4
25.43	1335.06	1344.95	1335.06	1344.58	0	-0.4
25.34	1334.88	1343.38	1334.88	1343.03	0	-0.4
25.24	1333.03	1340.51	1333.03	1340.17	0	-0.3
25.15	1329.54	1337.04	1329.54	1336.85	0	-0.2
25.06	1328.1	1334.32	1328.1	1334.12	0	-0.2
24.96	1325.56	1332.44	1325.56	1332.33	0	-0.1
24.87	1323.11	1329.89	1323.11	1329.73	0	-0.2
24.77	1320.99	1327.53	1320.99	1327.44	0	-0.1
24.68	1318.96	1325.67	1318.96	1325.73	0	0.1
24.58	1316.66	1323.53	1316.66	1323.61	0	0.1
24.49	1314.27	1321.23	1314.26	1321.22	-0.01	0.0
24.39	1312.56	1319.63	1312.56	1319.66	0	0.0

Table 5.2 Existing Condition Hydraulic Summary (Continued)

River Sta (RM) (1)	Phase 1 Min Ch El (ft) (2)	Phase 1 W.S. Elev (ft) (3)	Phase 2 Min Ch El (ft) (4)	Phase 2 W.S. Elev (ft) (5)	Change in Profile (ft) (6)	Change in W.S. Elev (ft) (7)
24.3	1310.48	1316.92	1310.48	1316.79	0	-0.1
24.2	1308.19	1314.55	1308.19	1314.49	0	-0.1
24.11	1306.41	1312.28	1306.41	1312.28	0	0.0
24.01	1304.48	1310.54	1304.48	1310.56	0	0.0
23.92	1302.14	1308.65	1302.14	1308.59	0	-0.1
23.82	1299.85	1306.97	1299.85	1307	0	0.0
23.73	1298.69	1304.4	1298.69	1304.38	0	0.0
23.63	1296.68	1302.16	1296.68	1302.2	0	0.0
23.54	1294.2	1300.88	1294.21	1300.82	0.01	-0.1
23.45	1292.71	1299.3	1292.72	1299.28	0.01	0.0
23.35	1291.13	1297.39	1291.13	1297.34	0	-0.1
23.26	1288.72	1295.01	1288.72	1294.84	0	-0.2
23.16	1285.6	1291.81	1285.6	1291.82	0	0.0
23.07	1283.29	1289.3	1283.29	1289.37	0	0.1
22.97	1280.84	1287.68	1280.84	1287.65	0	0.0
22.88	1279.85	1285.59	1279.85	1285.72	0	0.1
22.78	1275.68	1283.8	1275.68	1283.69	0	-0.1
22.69	1274.23	1282.42	1274.23	1282.32	0	-0.1
22.59	1272.93	1280.72	1272.93	1280.66	0	-0.1
22.5	1270.46	1278.43	1270.46	1278.32	0	-0.1
22.4	1269	1275.62	1269	1275.54	0	-0.1
22.31	1266.56	1274.55	1266.56	1274.49	0	-0.1
22.21	1264.55	1271.47	1264.55	1271.43	0	0.0
22.12	1262.4	1269.79	1262.4	1269.77	0	0.0
22.03	1260.04	1266.81	1260.04	1266.83	0	0.0
21.93	1258.55	1264.3	1258.55	1264.31	0	0.0
21.84	1256.69	1262.99	1256.69	1263.02	0	0.0
21.74	1254.77	1261.19	1254.77	1261.07	0	-0.1
21.65	1252.52	1259.18	1252.52	1259.03	0	-0.2
21.55	1251.44	1257.71	1251.44	1257.62	0	-0.1
21.46	1249.51	1256.23	1249.51	1255.95	0	-0.3
21.36	1246.53	1254.6	1246.53	1254.43	0	-0.2
21.27	1244	1252.62	1244	1252.49	0	-0.1
21.17	1243.61	1250.91	1243.61	1250.82	0	-0.1
21.08	1242.35	1248.69	1242.35	1248.59	0	-0.1
20.98	1239.14	1245.67	1239.14	1245.66	0	0.0

Table 5.2 Existing Condition Hydraulic Summary (Continued)

	Phase 1		Phase 2			
River Sta (RM) (1)	Min Ch El (ft) (2)	W.S. Elev (ft) (3)	Min Ch El (ft) (4)	W.S. Elev (ft) (5)	Change in Profile (ft) (6)	Change in W.S. Elev (ft) (7)
20.89	1236.57	1243.32	1236.57	1243.43	0	0.1
20.8	1233.77	1240.63	1233.77	1240.39	0	-0.2
20.7	1230.92	1238.1	1230.92	1237.8	0	-0.3
20.61	1228.52	1236.21	1228.52	1235.89	0	-0.3
20.51	1227.19	1233.5	1227.2	1233.4	0.01	-0.1
20.42	1223.73	1231.5	1223.73	1231.71	0	0.2
20.32	1222.17	1229.8	1222.17	1229.92	0	0.1
20.3	1221.35	1228.13	1221.36	1228.26	0.01	0.1
20.23	1219.01	1227.26	1219.01	1227.2	0	-0.1
20.14	1217.45	1226.35	1217.45	1226.19	0	-0.2
19.94	1216.34	1224.86	1216.34	1224.87	0	0.0
19.85	1213.25	1223.49	1213.25	1223.69	0	0.2
19.75	1211.9	1221.32	1211.9	1221.46	0	0.1
19.66	1209.32	1217.46	1209.32	1217.2	0	-0.3
19.56	1206.48	1216.07	1206.48	1215.93	0	-0.1
19.47	1205.43	1213.55	1205.43	1213.33	0	-0.2
19.38	1203.67	1211.9	1203.66	1211.72	-0.01	-0.2
19.28	1202.5	1209.69	1202.5	1209.57	0	-0.1
19.19	1199.69	1206.33	1199.69	1206.13	0	-0.2
19.09	1195.97	1204.03	1195.97	1203.94	0	-0.1
19	1195.51	1202.72	1195.51	1202.61	0	-0.1
18.9	1194.59	1200.86	1193.58	1200.54	-1.01	-0.3
18.81	1191.45	1198.6	1191.11	1198.2	-0.34	-0.4
18.71	1188.58	1195.75	1188.99	1195.99	0.41	0.2
18.62	1187.76	1193.31	1186.36	1193.35	-1.4	0.0
18.52	1185.03	1192.26	1185.3	1192.26	0.27	0.0
18.43	1182.28	1189.75	1183.04	1190.36	0.76	0.6
18.33	1180.12	1187.46	1181.05	1187.16	0.93	-0.3
18.24	1177.35	1185.83	1178.93	1184.76	1.58	-1.1
18.14	1176.43	1183.04	1176.52	1182.62	0.09	-0.4
18.05	1173.93	1181.91	1173.79	1181.19	-0.14	-0.7
17.95	1172.25	1180.69	1171.42	1179.51	-0.83	-1.2
17.86	1170.37	1178.17	1169.13	1177.62	-1.24	-0.6
17.77	1168.26	1175.88	1167.51	1175.44	-0.75	-0.4
17.67	1165.43	1173.97	1166.07	1172.82	0.64	-1.2
17.58	1164.7	1171.21	1163.11	1170.55	-1.59	-0.7

Table 5.2 Existing Condition Hydraulic Summary (Continued)

	Phase 1		Phase 2			
River Sta (RM) (1)	Min Ch El (ft) (2)	W.S. Elev (ft) (3)	Min Ch El (ft) (4)	W.S. Elev (ft) (5)	Change in Profile (ft) (6)	Change in W.S. Elev (ft) (7)
17.48	1160.67	1168.44	1159.78	1168.46	-0.89	0.0
17.39	1159.03	1166.3	1157.51	1166	-1.52	-0.3
17.29	1156.84	1164.22	1155.6	1163.88	-1.24	-0.3
17.2	1155.61	1162.29	1154.65	1161.71	-0.96	-0.6
17.1	1153.56	1160.37	1152.82	1159.64	-0.74	-0.7
17.01	1151.51	1157.98	1151.29	1157.71	-0.22	-0.3
16.91	1148.87	1155.95	1148.65	1155.69	-0.22	-0.3
16.82	1146.45	1154.14	1145.41	1153.88	-1.04	-0.3
16.72	1145.31	1152.03	1143.02	1151.4	-2.29	-0.6
16.63	1143.31	1149.9	1141.67	1149.43	-1.64	-0.5
16.53	1141.73	1148.29	1141.07	1147.78	-0.66	-0.5
16.44	1139.63	1146.06	1137.72	1145.29	-1.91	-0.8
16.35	1136.86	1144.08	1136.53	1143.78	-0.33	-0.3
16.25	1134.96	1142.48	1134.12	1141.15	-0.84	-1.3
16.16	1134.1	1140.5	1132.27	1139.03	-1.83	-1.5
16.06	1132.06	1138.86	1129.37	1137.14	-2.69	-1.7
15.97	1130.05	1136.92	1126.3	1135.54	-3.75	-1.4
15.87	1127.94	1134.89	1123.3	1133.69	-4.64	-1.2
15.78	1125.94	1133.74	1119.52	1131.44	-6.42	-2.3
15.68	1124.44	1131.11	1114.78	1125.58	-9.66	-5.5
15.59	1122.02	1130.75	1104.22	1126.26	-17.8	-4.5
15.49	1120.29	1129.06	1106.02	1125.64	-14.27	-3.4
15.4	1118.56	1128.05	1102.93	1125	-15.63	-3.0
15.3	1116.87	1125.35	1101.57	1124.51	-15.3	-0.8
15.21	1114.92	1123.64	1107.1	1121.51	-7.82	-2.1
15.11	1112.01	1122.78	1106.85	1121.07	-5.16	-1.7
15.02	1109.51	1120.1	1105.2	1119.6	-4.31	-0.5
14.92	1106.87	1119.01	1104.05	1118.37	-2.82	-0.6
14.83	1104.69	1117.73	1102.55	1116.9	-2.14	-0.8
14.73	1103.87	1115.46	1101.2	1113.74	-2.67	-1.7
14.64	1101.85	1112.71	1099.41	1112.11	-2.44	-0.6
14.55	1100.51	1110.95	1098.82	1110.04	-1.69	-0.9
14.45	1098.14	1108.65	1098.22	1108.03	0.08	-0.6
14.36	1097.18	1106.55	1096.78	1106.35	-0.4	-0.2
14.27	1095.24	1103.52	1094.32	1103.29	-0.92	-0.2
14.17	1092.59	1101.29	1092.1	1100.6	-0.49	-0.7

Table 5.2 Existing Condition Hydraulic Summary (Continued)

	Phase 1		Phase 2			
River Sta (RM) (1)	Min Ch El (ft) (2)	W.S. Elev (ft) (3)	Min Ch El (ft) (4)	W.S. Elev (ft) (5)	Change in Profile (ft) (6)	Change in W.S. Elev (ft) (7)
14.08	1091.33	1099.21	1090.6	1098.8	-0.73	-0.4
13.98	1089.1	1096.59	1087.55	1095.94	-1.55	-0.6
13.89	1087.23	1094.83	1085.79	1093.21	-1.44	-1.6
13.79	1084.33	1092.43	1082.94	1091.6	-1.39	-0.8
13.7	1081.72	1090.21	1079.18	1087.91	-2.54	-2.3
13.61	1079.31	1088.61	1076.55	1085.37	-2.76	-3.2
13.51	1077.51	1085.13	1074.18	1081.81	-3.33	-3.3
13.42	1076.54	1083.09	1068.97	1077.4	-7.57	-5.7
13.32	1073.84	1081.14	1068.27	1076.04	-5.57	-5.1
13.23	1071.15	1079.52	1065.96	1075.23	-5.19	-4.3
13.13	1069.45	1077.4	1062.39	1075.02	-7.06	-2.4
13.04	1068.17	1075.23	1061.81	1073.77	-6.36	-1.5
12.94	1062.83	1072.28	1059.48	1072.33	-3.35	0.0
12.85	1060.78	1071.07	1058.26	1070.45	-2.52	-0.6
12.75	1058.21	1068.43	1056.04	1067.02	-2.17	-1.4
12.66	1055.88	1065.6	1052.74	1063.1	-3.14	-2.5
12.56	1053	1062.77	1050.76	1059.76	-2.24	-3.0
12.47	1049.18	1060.47	1046.2	1056.25	-2.98	-4.2
12.37	1044.71	1058.62	1041.2	1056.04	-3.51	-2.6
12.28	1044.61	1057.1	1041.36	1055.75	-3.25	-1.3
12.18	1044.37	1054.3	1038.28	1054.5	-6.09	0.2
12.09	1041.44	1052.6	1037.02	1052.21	-4.42	-0.4
12	1041.36	1050.49	1036.33	1049.75	-5.03	-0.7
11.9	1039.97	1047.82	1035.3	1046.92	-4.67	-0.9
11.81	1036.53	1046.11	1034.62	1045.38	-1.91	-0.7
11.71	1035.64	1044.11	1032.87	1043.98	-2.77	-0.1
11.62	1033.39	1041.78	1032.06	1041.72	-1.33	-0.1
11.52	1031.12	1040.3	1030.2	1039.57	-0.92	-0.7
11.43	1029.8	1038.09	1028.43	1036.98	-1.37	-1.1
11.33	1028.15	1036.73	1026.63	1035.01	-1.52	-1.7
11.24	1026.02	1034.94	1024.54	1033.69	-1.48	-1.3
11.16	1024.96	1032.75	1023.45	1031.6	-1.51	-1.2
11.09	1021.71	1031.33	1020.17	1030.54	-1.54	-0.8
11.01	1020.14	1029.85	1018.58	1029.07	-1.56	-0.8
11.005	Bridge					
11	1019.95	1029.28	1019.12	1028.46	-0.83	-0.8

Table 5.2 Existing Condition Hydraulic Summary (Continued)

	Phase 1		Phase 2			
River Sta (RM) (1)	Min Ch El (ft) (2)	W.S. Elev (ft) (3)	Min Ch El (ft) (4)	W.S. Elev (ft) (5)	Change in Profile (ft) (6)	Change in W.S. Elev (ft) (7)
10.99	1019.75	1029.05	1018.73	1028.28	-1.02	-0.8
10.985	Bridge					0.0
10.98	1019.02	1027.4	1018.42	1027.33	-0.6	-0.1
10.87	1016.65	1025.57	1016.43	1025.41	-0.22	-0.2
10.77	1014.8	1024.18	1014.79	1023.72	-0.01	-0.5
10.73	1013.66	1023.47	1013.43	1023.05	-0.23	-0.4
10.69	1012.07	1021.22	1011.94	1021.07	-0.13	-0.1
10.59	1010.65	1018.99	1009.56	1018.57	-1.09	-0.4
10.5	1008.21	1016.6	1008.6	1016.32	0.39	-0.3
10.4	1006.82	1014.46	1006.81	1014.24	-0.01	-0.2
10.31	1004.63	1012.6	1003.43	1012.13	-1.2	-0.5
10.21	1001.49	1010.69	1000.35	1010.04	-1.14	-0.7
10.12	998.79	1008.62	997.45	1007.98	-1.34	-0.6
10.02	996.2	1006.44	994.28	1005.6	-1.92	-0.8
9.93	994.29	1003.79	991.9	1003.44	-2.39	-0.3
9.83	992.44	1001.35	991.47	1000.49	-0.97	-0.9
9.74	990.33	999.3	989.53	998.98	-0.8	-0.3
9.64	987.61	996.45	988.06	996.7	0.45	0.3
9.55	985.36	995.37	986.17	995.17	0.81	-0.2
9.45	983.19	993.5	984	992.74	0.81	-0.8
9.36	981.13	991.79	980.24	990.65	-0.89	-1.1
9.27	978.72	989.29	976.22	989.25	-2.5	0.0
9.17	976.12	987.06	975.68	987.16	-0.44	0.1
9.08	974.16	984.93	973.63	985.08	-0.53	0.2
8.98	972.3	982.93	972.22	983.13	-0.08	0.2
8.89	970.31	981.26	970.72	981.32	0.41	0.1
8.79	968.53	979.42	968.31	979.25	-0.22	-0.2
8.7	966.9	977.31	966.27	977.48	-0.63	0.2
8.6	964.95	975.06	964.97	974.67	0.02	-0.4
8.51	963.63	972.68	963.51	971.65	-0.12	-1.0
8.41	962.19	970.65	961.32	970.07	-0.87	-0.6
8.32	959.8	968.81	960.2	967.77	0.4	-1.0
8.22	958.24	966.43	958.77	965.33	0.53	-1.1
8.13	955.79	964.26	956.4	963.05	0.61	-1.2
8.03	953.54	961.33	953.57	960.81	0.03	-0.5
7.94	951.2	958.95	951.07	958.41	-0.13	-0.5

Table 5.2 Existing Condition Hydraulic Summary (Continued)

	Phase 1		Phase 2			
River Sta (RM)	Min Ch El (ft)	W.S. Elev (ft)	Min Ch El (ft)	W.S. Elev (ft)	Change in Profile (ft)	Change in W.S. Elev (ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
7.84	949.97	956.99	949.31	956.19	-0.66	-0.8
7.75	948.21	954.72	947.72	954.3	-0.49	-0.4
7.66	945.86	952.29	945.43	951.29	-0.43	-1.0
7.56	943.79	950.19	942.83	949.62	-0.96	-0.6
7.47	941.7	948.54	940.48	947.9	-1.22	-0.6
7.37	939.18	946.45	938.94	946.02	-0.24	-0.4
7.28	936.68	944.49	936.72	944.1	0.04	-0.4
7.18	934.47	942.15	934.62	941.81	0.15	-0.3
7.09	931.92	939.68	931.93	939.37	0.01	-0.3
6.99	930.3	937.31	929.69	937.25	-0.61	-0.1
6.9	928.41	934.63	927.65	934.57	-0.76	-0.1
6.8	926.25	932.91	925.69	932.65	-0.56	-0.3
6.71	924.38	930.68	923.82	930.71	-0.56	0.0
6.61	921.79	928.91	920.73	928.49	-1.06	-0.4
6.52	920.05	927.16	919.3	926.71	-0.75	-0.4
6.42	918.04	924.19	917.93	924.23	-0.11	0.0
6.33	914.65	921.7	915.71	921.52	1.06	-0.2
6.23	912.84	919.5	913.15	919.47	0.31	0.0
6.14	910.6	917.84	910.83	917.87	0.23	0.0
6.05	907.4	915.92	907.59	916.31	0.19	0.4
5.95	905.82	914.77	905.29	914.79	-0.53	0.0
5.86	903.03	912.62	902.61	912.5	-0.42	-0.1
5.76	900.88	910.51	900.4	910.24	-0.48	-0.3
5.67	898.65	908.29	897.59	908.18	-1.06	-0.1
5.57	896.06	906.89	895.26	906.63	-0.8	-0.3
5.48	893.97	905.13	893.13	904.93	-0.84	-0.2
5.38	891.61	903.46	890.51	903.2	-1.1	-0.3
5.29	890.69	901.69	888.97	901.26	-1.72	-0.4
5.19	888.9	899.7	887.79	899.25	-1.11	-0.5
5.1	887.81	897.56	885.77	897.21	-2.04	-0.3
5	886.08	895.11	885.52	894.83	-0.56	-0.3
4.91	883.9	892.52	884.04	892.25	0.14	-0.3
4.82	881.62	890.32	882.05	890.08	0.43	-0.2
4.72	879.83	888.67	880.1	888.32	0.27	-0.3
4.63	877.37	885.91	878.05	885.34	0.68	-0.6
4.53	875.48	883.61	875.48	883.33	0	-0.3

Table 5.2 Existing Condition Hydraulic Summary (Continued)

	Phase 1		Phase 2			
River Sta (RM) (1)	Min Ch El (ft) (2)	W.S. Elev (ft) (3)	Min Ch El (ft) (4)	W.S. Elev (ft) (5)	Change in Profile (ft) (6)	Change in W.S. Elev (ft) (7)
4.44	873.06	881.62	873.24	881.38	0.18	-0.2
4.34	870.85	879.95	871.42	879.33	0.57	-0.6
4.25	867.33	878.08	868.53	877.83	1.2	-0.3
4.15	865.17	876.86	865.17	876.86	0	0.0
4.09	863.35	875.06	863.35	875.06	0	0.0
4.01	861.59	873.16	861.59	873.16	0	0.0

5.12 HEC-RAS FLOODPLAIN MANAGEMENT HYDRAULIC MODELING STEP 1 DETAILS AND RESULTS

The first step in Floodplain Management Model development was to hydraulically evaluate future bridge crossing of the Hassayampa River to determine optimal bridge dimensions relative to hydraulic impacts to the river. There are three existing bridge crossings and fifteen proposed bridge crossings. The locations of proposed bridges were determined from several land use and transportation plans. The land use and transportation plans reviewed include the Maricopa Association of Governments (MAG) Regional Transportation Plan (RTP) 2010 Update for the "Hassayampa Illustrative Corridors," the Interstate 10/Hassayampa Valley Roadway Framework Study titled "Conceptual Transportation Framework" dated 2007, the Town of Buckeye General Land Use Plan and the Maricopa County Future Land Use Plan. Copies of the data reviewed are provided in Appendix F. Table 5.3 lists the approximate bridge location (roadway crossing of the Hassayampa River) and the HEC-RAS river mile stationing. Future bridges proposed for Hummingbird Springs Road and SR 801 were not included in the initial Floodplain Management hydraulic evaluation because of unique conditions. At the Hummingbird Springs Road Bridge location flow is divided between a number of channels over the 3,600 foot wide floodplain and lends itself to a multi-drainage structure solution. The SR 801 location is in a levee reach where landowners have proposed a channelization option to mitigate flood hazards. The channelization will drive the bridge opening dimensions.

The location, size, and degree of encroachment of a bridge on a watercourse may have adverse impacts on the hydraulic performance of the watercourse. The impacts of a bridge could be restricted to local impacts that are easily mitigated or impacts that could extend some distance upstream and downstream resulting in the need for extensive structures or maintenance to mitigate the impact. Should bridges be spaced too close together the collective impacts of the bridges could disrupt the sediment balance and exacerbate aggradation and degradation trends.

The first step in the Floodplain Management analyses looks at various bridge span lengths and associated approach encroachments to determine a preferred bridge span. Bridge spans evaluated include 500, 750, 1000, 1250, 1500, 1750 and 2000 foot openings. Modifications to the Existing Condition Phase 2 Model are made at bridge locations to evaluate the impact of the bridge on the hydraulic performance of the watercourse. The following modifications were made:

- Additional cross sections were incorporated in the model at the upstream and downstream face of the bridge.
  - Where the roadway/bridge alignment was not perpendicular to the channel flow the cross section was skewed.
- Encroachment stations were used to define bridge abutments and ineffective flow areas for each bridge opening evaluated. A 1:1 contraction ratio and a 4:1 expansion ratio was applied to each proposed bridge. A GIS algorithm that utilizes a template where contraction and expansion limits are intersected with a cross-section alignment was used to determine an encroachment station.

Table 5.3 Bridge Locations

Bridge	**Station**
	River Mile
Hummingbird Springs Road	26.435
Bell Road	24.990
Greenway Road	23.870
Cactus Road	21.27
Olive Avenue	19.26
Northern Avenue	18.19
Glendale Avenue	17.17
Camelback Road	14.81
Indian School Road	13.78
McDowell Parkway	13.06
Interstate 10, Westbound[1]	11.005
Interstate 10, Eastbound[1]	10.985
Yuma Parkway	9.41
Broadway Road	7.26
Southern Avenue	5.99
Baseline Road	4.90
UPRR[1]	4.000
State Route 801	3.885
Old US 80[1]	2.650

[1] Existing Bridge

The Hassayampa River is an ephemeral stream, characterized by a shifting braided to meandering sand channel. Due do this nature the HEC-RAS procedure for determining the expansion length was not always followed. At some bridge locations the channel downstream meanders and both channel and overbank features would direct flow laterally behind expansion limits. At these locations the extent of the expansion limits were terminated where topographic feature directed flow behind the encroachment limits.

HEC-RAS model results for the 100-year and 10-year events were evaluated to determine the impacts of a particular bridge opening on the performance of the river. The 10-year and lesser events are considered channel forming events in the southwest. Maintaining hydraulic characteristics associated with the 10- year event are important so that impacts to the form and function of the watercourse are minimized. Changes in channel velocity, Froude Number, water surface elevation, top width and stable slope were evaluated.

5.12.1 Changes in Velocity, Froude Number and Water Surface Elevation

The change in velocity, Froude Number and water surface elevations are key hydraulic parameters used to evaluate that impact of a bridge or flood control facility on the form and function of the river. Increases in velocity indicate higher potential for erosion whereas decreases in velocity would indicate potential for aggradation to occur. Changes in the Froude Number indicate potential changes in flow regime and whether the flow will be tranquil or rapid. Rapid flow indicates a higher potential for erosion and the need for mitigation measures to minimize impacts to the watercourse. Changes in water surface elevations are important to document to determine the impact to flood hazards zones in regard to the depth and extent of the flood hazard on properties adjacent, upstream and downstream of a facility causing the change.

Tables 5.4 to 5.29 and associated inset figures depict the change in velocity, Froude Number, and Water Surface Elevation for the bridge locations evaluated. The table lists and the associated figures depicts hydraulic data for a cross section located upstream of the bridge (blue line work), at the upstream face of the bridge (red line work), downstream face of the bride (green line work) and downstream of the bridge (purple line work). Based on the review of data presented in the Summary of Hydraulic Parameters Tables and the slopes of charted lines depicting changes in hydraulic conditions through a bridge, changes in hydraulic parameters that would be considered significant because the change indicates a potential impact to the form, function and floodplain dimensions of the watercourse were determined. A change of 10 percent or more in velocity is considered significant, a change from tranquil flow (Froude Number less that 1) to rapid flow (Froude Number greater than 1) is considered significant, and a change in water surface elevation of greater than a foot is considered significant. A significant change indicates that either mitigation measures to mitigate associated impacts because of the change should be considered or the bridge opening length should be increased. Table 5.30 list recommended bridge opening dimensions and associated hydraulic parameters based on the evaluation of hydraulic parameters for different bridge opening dimensions.

The following observations are offered from review of the presented data:

- Bell Road Bridge
    - 100-year
        - There is a significant decrease in the upstream velocity and the velocity rate of change for all bridges with the exception of the 1000 foot

opening. The difference in the trend for the 1000 foot opening is because of the distribution of Manning's roughness coefficients in the cross section. The weighted "n" value calculated by the HEC-RAS model for the 1000 foot opening is less than what is calculated for the non-encroached condition.

        - There is a significant increase in downstream velocity and the velocity rate of change for bridge openings less than or equal to 1500 feet.
        - There is a increase in water surface elevation of greater than a 1' and an increase in the water surface elevation rate of change upstream and through the bridge for bridge openings less than or equal to 1500 feet.
        - There are minor changes in water surface elevations downstream of the bridge.
        - Changes in the Froude Number follow similar trends that velocity showed. Froude Numbers downstream of the bridge are supercritical for bridge openings less than or equal to 1500 feet and are subcritical upstream of the bridge for all bridge openings.
    - 10-year event
        - Changes in velocity, Froude Number and water surface elevations for the 10-year event show the same trends as the 100-year event.
        - There is significant change in velocity for bridge openings less than 1250 feet.
        - A significant change in water surface elevation is realized for bridge openings less than 1250 feet.
        - There is a change in Froude Number upstream and downstream for bridge openings equal to or less than the 1000. Downstream the flow is super critical.
- Greenway Road
    - 100-year
        - There is a significant decrease in velocity upstream of the bridge for bridge openings less than or equal to 1250 feet.
        - There is a significant increase in downstream velocity and the velocity rate of change for bridge openings less than or equal to 1500 feet.
        - There is an increase in water surface elevation of more than 1 foot and the water surface elevation rate of change upstream and through the bridge for bridge openings less than or equal to1250 feet.
        - Changes in the Froude Number follow similar trends that velocity showed. The Froude Number decreases upstream and increases downstream. For bridge openings less than or equal to1250 feet, downstream flow is supercritical.

- 10-year event
    - Flow remains subcritical for all encroachments scenarios.
    - There is significant change in velocity for bridge openings less than 1250 feet.
    - A change in water surface elevation of greater than a foot is realized for bridge openings less than or equal to a 1000 feet.
- Cactus Road
  - 100-year
    - There is a significant change in velocity for bridge openings less than or equal to 1500 feet
    - There is an increase in water surface elevation of greater than a foot, and an increase in the water surface elevation rate of change upstream and through the bridge for bridge openings less than or equal to 1250 feet.
    - For bridge openings less than 750 feet, downstream flow is supercritical.
  - 10-year event
    - Changes in velocity, Froude Number and water surface elevations for the 10-year event show the same trends as the 100-year event.
    - There is significant change in downstream velocity for bridge openings less than 1250 feet.
    - A change in water surface elevation of a foot or greater is realized for bridge openings equal to or less than 750 feet.
    - Flow upstream and downstream is subcritical.
    - There is a significant change in Froude Number upstream and downstream for bridge openings equal to or less than 500 feet.
- Olive Avenue
  - 100-year
    - There is a significant change in velocity and the rate of change for bridge openings less than 1500 feet.
    - There is an increase in water surface elevation of greater than 1 foot and an increase in the water surface elevation rate of change upstream and through the bridge for bridge openings less than 1500 feet.
    - For bridge openings less than 1250 feet, downstream flow is at or near supercritical.
  - 10-year event

- Changes in velocity, Froude Number and water surface elevations for the 10-year event show the same trends as the 100-year event.
- Downstream of the bridge there is significant change in velocity for bridge openings equal to or less than 1500 feet.
- A change in water surface elevation of greater than a foot is realized for bridge openings less than 1000 feet.
- Flow downstream is super critical for bridge openings equal to or less than 1000 feet.

- Northern Avenue
  - 100-year
    - There is a significant increase in velocity and the velocity rate of change for bridge openings less than 1500 feet.
    - There is an increase of water surface elevation upstream of greater than a foot for bridge openings less than 1000 feet.
    - Flow downstream of the bridge is super critical for bridge openings less than 1500 feet.
  - 10-year event
    - Upstream of the bridge there is a significant increase in velocity for bridge openings less than 1250 feet
    - Downstream of the bridge there is significant change in velocity for bridge openings less than 1250 feet.
    - A change in water surface elevation of greater than a foot for bridge openings less than equal to 750 feet.
    - Downstream flow is supercritical or near supercritical for bridge opening equal to or greater than 1000 feet.
- Glendale Avenue
  - 100-year
    - There are significant changes in velocity upstream and downstream of the bridge location for bridge openings less than or equal to 1500 feet.
    - There is an increase in water surface elevation upstream of greater than a foot and an increase in the water surface elevation rate of change upstream and through the bridge for bridge openings less than or equal to 1750 feet.
    - Flow through the bridge is near super critical of supercritical for bridge opening less than or equal to 1750.
  - 10-year event
    - There are significant changes in velocity upstream and downstream of the bridge location for bridge openings less than or equal to 1500 feet.

At the downstream face of the bridge for the 1500 foot bridge opening the velocity change is greater than 10%, however this could be mitigated through armoring.

        - There is an increase in water surface elevation upstream of greater than a foot for bridge openings less than or equal to 750 feet.
        - Flow is at or near supercritical downstream of the bridge for bridge openings less than or equal to 750 feet.

- Camelback Road
    - 100-year
        - There is a significant change in velocity for bridge openings less than 1250 feet.
        - There is an increase in water surface elevation of more than a foot for bridge openings equal to or less than 750 feet.
        - Flow is subcritical upstream for all bridge opening scenarios.
        - Flow is supercritical for the 500 foot bridge opening.
    - 10-year event
        - There is a significant change in velocity upstream of the bridge for the 500 foot bridge openings.
        - Downstream of the bridge there is significant change in velocity for bridge openings equal to or less than 750 feet.
        - Change in water surface elevation is less than a foot for all bridge openings. The rate of change in water surface elevation increases for bridge openings less than 1000 feet.
        - Flow upstream and downstream of the bridge is subcritical for all bridge openings.
- Indian School Road
    - 100-year
        - There are significant changes in velocity upstream and downstream for all bridge openings.
        - There is an increase in water surface elevation of water surface elevation of greater than a foot for all bridge openings.
        - At the downstream face of the bridge flow is super critical for the 1000 foot opening.
        - Flow is subcritical upstream and supercritical or near supercritical downstream for bridge openings less than or equal to 750 feet.
    - 10-year event

        - There are significant changes in velocity upstream and downstream for all bridge openings.
        - There is an increase in water surface elevation of greater than a foot for the 500 and 1000 foot openings.
        - Flow upstream and downstream of the bridge is subcritical for all bridge openings.
- McDowell Parkway
    - 100-year
        - There are significant changes in velocity upstream and downstream for all bridge openings.
        - There is an increase in water surface elevation of water surface elevation of greater than a foot for bridge openings less than 2000 feet.
        - Flow is subcritical upstream and supercritical or near supercritical downstream for bridge openings less than or equal to 750 feet.
    - 10-year event
        - There are significant changes in velocity upstream for all bridge openings less than 2000 feet.
        - Downstream of the bridge there is significant change in velocity for bridge openings less than or equal to 1500 feet.
        - There is an increase in water surface elevation of water surface elevation of greater than a foot for bridge openings less than 1750 feet.
- Yuma Parkway
    - 100-year
        - There is a significant change in velocity for bridge openings less than 1250 feet.
        - There is an increase in water surface elevation of greater than a foot for bridge openings equal to or less than 750 feet.
        - Flow is subcritical upstream and downstream for all bridge openings.
    - 10-year event
        - There is a significant change in velocity for bridge openings less than 1250 feet.
        - There is an increase in water surface elevation of greater than a foot for the 2000 foot bridge opening.
        - Flow is subcritical upstream and downstream for all bridge openings.

- Broadway Road
    - 100-year
        - There is a significant change in velocity for bridge openings less than 1750 feet.
        - There is an increase in water surface elevation of greater than a foot for bridge openings equal to or less than 1250 feet.
        - Flow is subcritical upstream and supercritical or near supercritical downstream for bridge openings less than or equal to 1feet.
    - 10-year event
        - There is a significant change in velocity for bridge openings less than 1250 feet.
        - There is an increase in water surface elevation of greater than a foot for bridge openings equal to or less than 1000 feet.
        - Flow upstream and downstream of the bridge is subcritical for all bridge openings.
- Southern Avenue
    - 100-year
        - There is a significant change in velocity for all bridge openings.
        - There is an increase in water surface elevation of greater than a foot for bridge openings equal to or less than 1250 feet.
        - Flow upstream and downstream of the bridge is subcritical for all bridge openings.
    - 10-year event
        - There is a significant change in velocity for all bridge openings.
        - There is an increase in water surface elevation of greater than a foot for the 500 foot bridge openings.
        - Flow upstream and downstream of the bridge is subcritical for all bridge openings with the exception of the 500 foot opening. Downstream of the bridge for the 500 foot opening supercritical flow is recorded.
- Baseline Road
    - 100-year event
        - There is a significant change in velocity for all bridge openings.
        - There is an increase in water surface elevation of greater than a foot for bridge openings equal to or less than 1250 feet.
        - Flow upstream and downstream of the bridge is supercritical for bridge openings less than or equal to a 1000 feet.

- 10-year event
    - There is a significant change in velocity for all bridge openings.
    - There is an increase in water surface elevation of greater than a foot for bridge openings equal to or less than 750 feet.
    - Flow upstream and downstream of the bridge is supercritical for all bridge openings.

Table 5–4

Summary of Hydraulic Parameters, 100-Year Event

Bell Road Bridge at RM 24.99

Change in Velocity

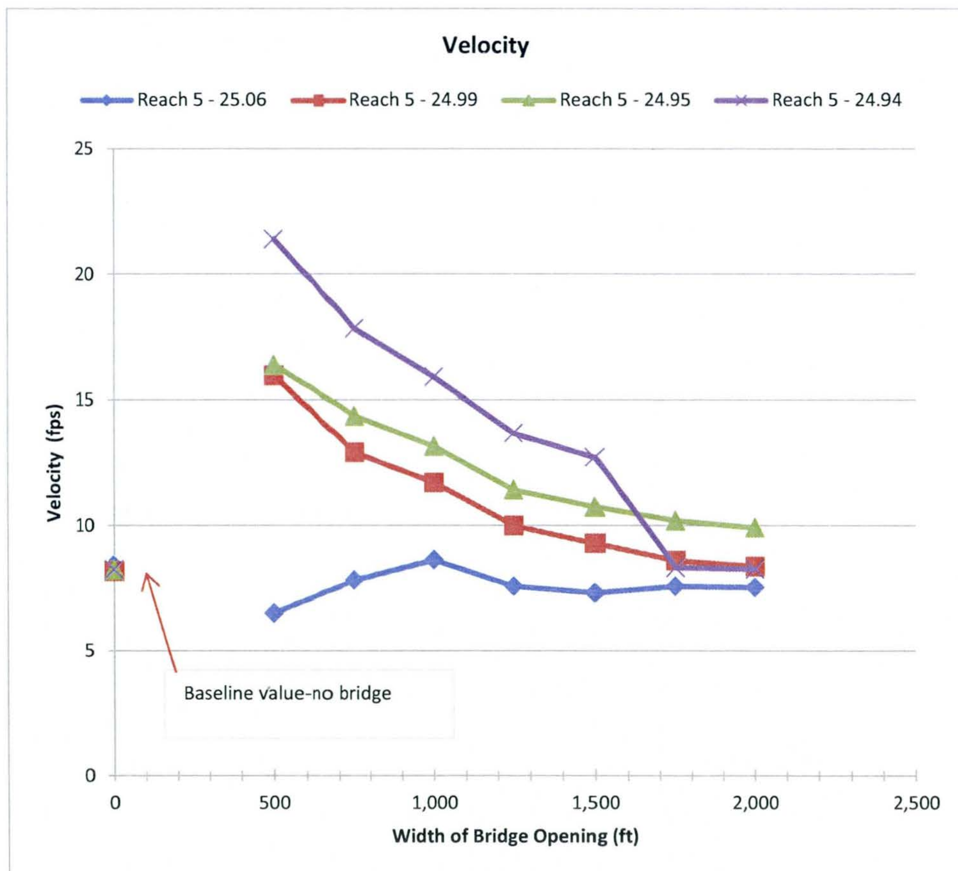
Bridge Opening Width feet	Reach 5 - 25.06 Velocity fps	Reach 5 - 25.06 Percent Change %	Reach 5 - 24.99 Velocity fps	Reach 5 - 24.99 Percent Change %	Reach 5 - 24.95 Velocity fps	Reach 5 - 24.95 Percent Change %	Reach 5 - 24.94 Velocity fps	Reach 5 - 24.94 Percent Change %
None[1]	8.42	—	8.19	—	8.26	—	8.26	—
500	6.50	-22.8	15.97	95.0	16.39	98.4	21.41	159.2
750	7.83	-7.0	12.91	57.6	14.37	74.0	17.83	115.9
1,000	8.64	2.6	11.72	43.1	13.16	59.3	15.91	92.6
1,250	7.58	-10.0	10.01	22.2	11.43	38.4	13.68	65.6
1,500	7.31	-13.2	9.30	13.6	10.75	30.1	12.71	53.9
1,750	7.58	-10.0	8.61	5.1	10.20	23.5	8.33	0.8
2,000	7.53	-10.6	8.38	2.3	9.92	20.1	8.27	0.1

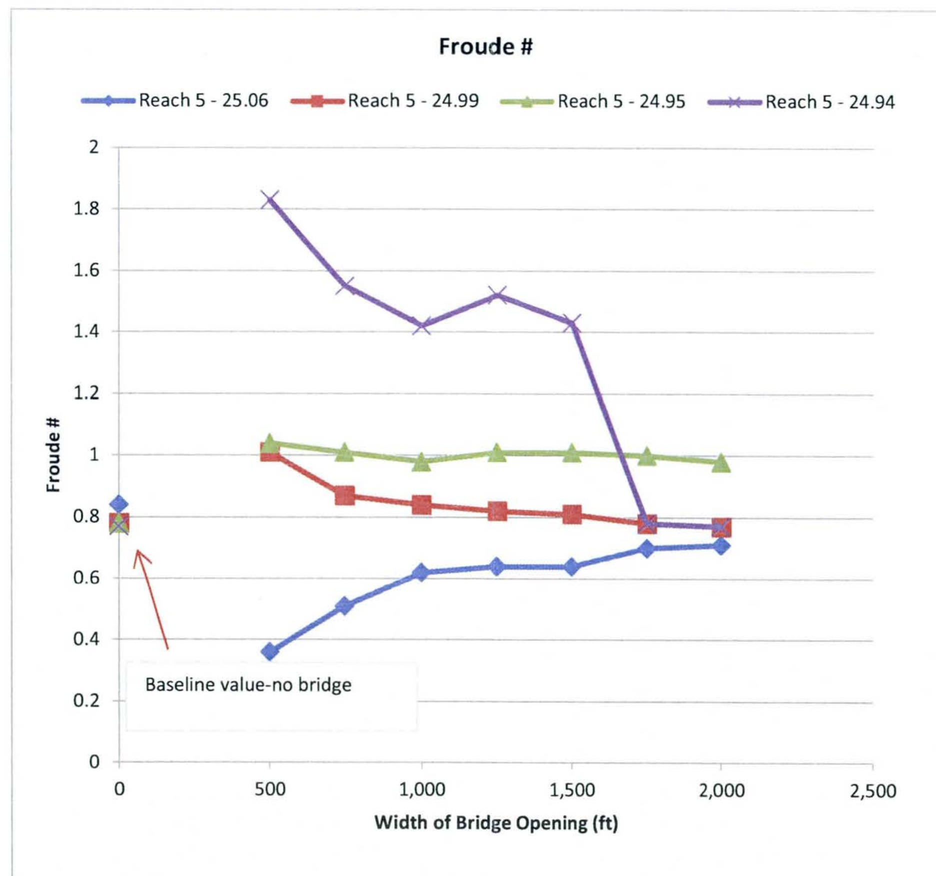
Change in Froude #

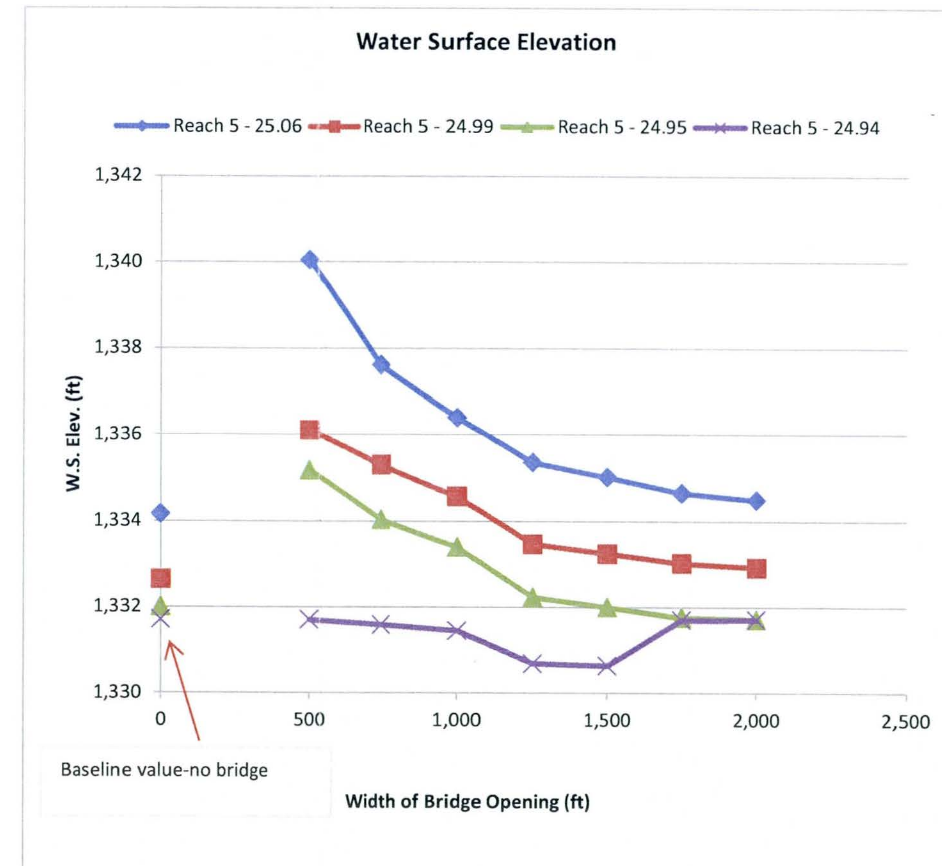
Bridge Opening Width feet	Reach 5 - 25.06 Froude # unitless	Reach 5 - 25.06 Percent Change %	Reach 5 - 24.99 Froude # unitless	Reach 5 - 24.99 Percent Change %	Reach 5 - 24.95 Froude # unitless	Reach 5 - 24.95 Percent Change %	Reach 5 - 24.94 Froude # unitless	Reach 5 - 24.94 Percent Change %
None[1]	0.84	—	0.78	—	0.78	—	0.77	—
500	0.36	-57.1	1.01	29.5	1.04	33.3	1.83	137.7
750	0.51	-39.3	0.87	11.5	1.01	29.5	1.55	101.3
1,000	0.62	-26.2	0.84	7.7	0.98	25.6	1.42	84.4
1,250	0.64	-23.8	0.82	5.1	1.01	29.5	1.52	97.4
1,500	0.64	-23.8	0.81	3.8	1.01	29.5	1.43	85.7
1,750	0.70	-16.7	0.78	0.0	1.00	28.2	0.78	1.3
2,000	0.71	-15.5	0.77	-1.3	0.98	25.6	0.77	0.0

Change in Water Surface Elevation

Bridge Opening Width feet	Reach 5 - 25.06 W.S.E. feet	Reach 5 - 25.06 Change in W.S.E. feet	Reach 5 - 24.99 W.S.E. feet	Reach 5 - 24.99 Change in W.S.E. feet	Reach 5 - 24.95 W.S.E. feet	Reach 5 - 24.95 Change in W.S.E. feet	Reach 5 - 24.94 W.S.E. feet	Reach 5 - 24.94 Change in W.S.E. feet
None[1]	1,334.16	—	1,332.65	—	1,332.01	—	1,331.71	—
500	1,340.05	5.89	1,336.11	3.46	1,335.18	3.17	1,331.70	-0.01
750	1,337.61	3.45	1,335.30	2.65	1,334.04	2.03	1,331.59	-0.12
1,000	1,336.40	2.24	1,334.57	1.92	1,333.40	1.39	1,331.45	-0.26
1,250	1,335.36	1.20	1,333.47	0.82	1,332.23	0.22	1,330.69	-1.02
1,500	1,335.02	0.86	1,333.25	0.60	1,332.00	-0.01	1,330.64	-1.07
1,750	1,334.65	0.49	1,333.03	0.38	1,331.76	-0.25	1,331.70	-0.01
2,000	1,334.49	0.33	1,332.93	0.28	1,331.72	-0.29	1,331.71	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–5

Summary of Hydraulic Parameters, 10-Year Event

Bell Road Bridge at RM 24.99

Change in Velocity

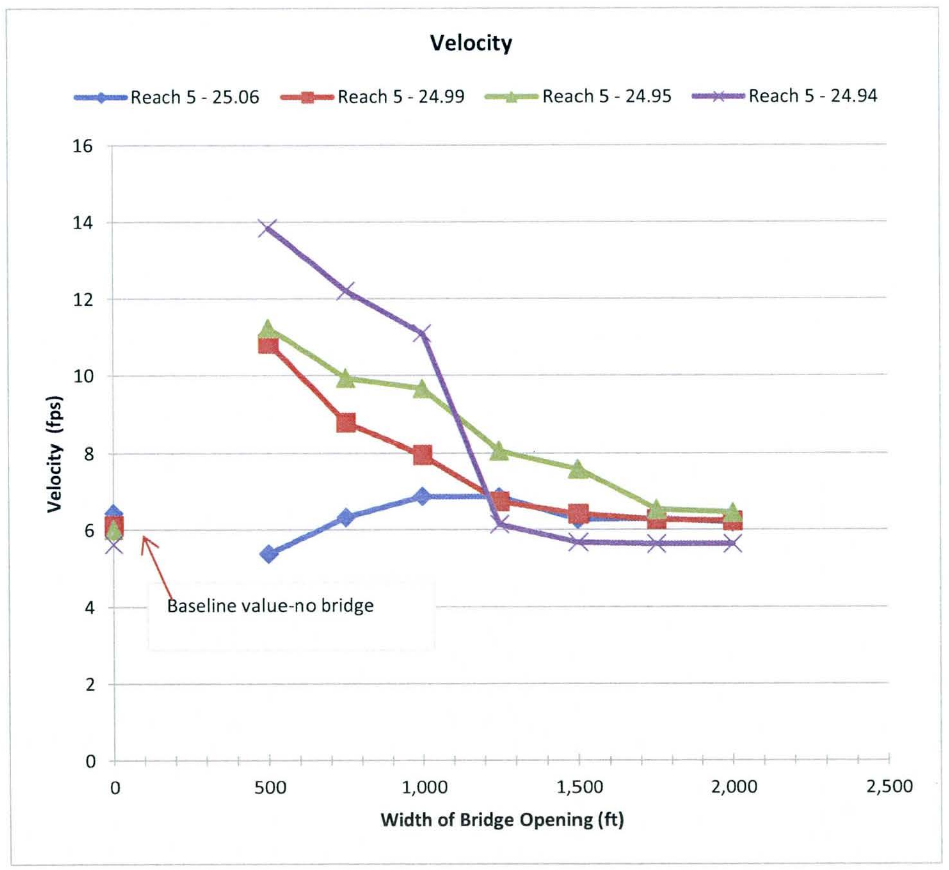
Bridge Opening Width	Reach 5 - 25.06		Reach 5 - 24.99		Reach 5 - 24.95		Reach 5 - 24.94	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	6.44	—	6.13	—	6.02	—	5.64	—
500	5.39	-16.3	10.84	76.8	11.25	86.9	13.85	145.6
750	6.33	-1.7	8.79	43.4	9.94	65.1	12.22	116.7
1,000	6.87	6.7	7.95	29.7	9.67	60.6	11.11	97.0
1,250	6.86	6.5	6.74	10.0	8.06	33.9	6.15	9.0
1,500	6.28	-2.5	6.42	4.7	7.59	26.1	5.68	0.7
1,750	6.30	-2.2	6.28	2.4	6.54	8.6	5.64	0.0
2,000	6.20	-3.7	6.24	1.8	6.46	7.3	5.64	0.0

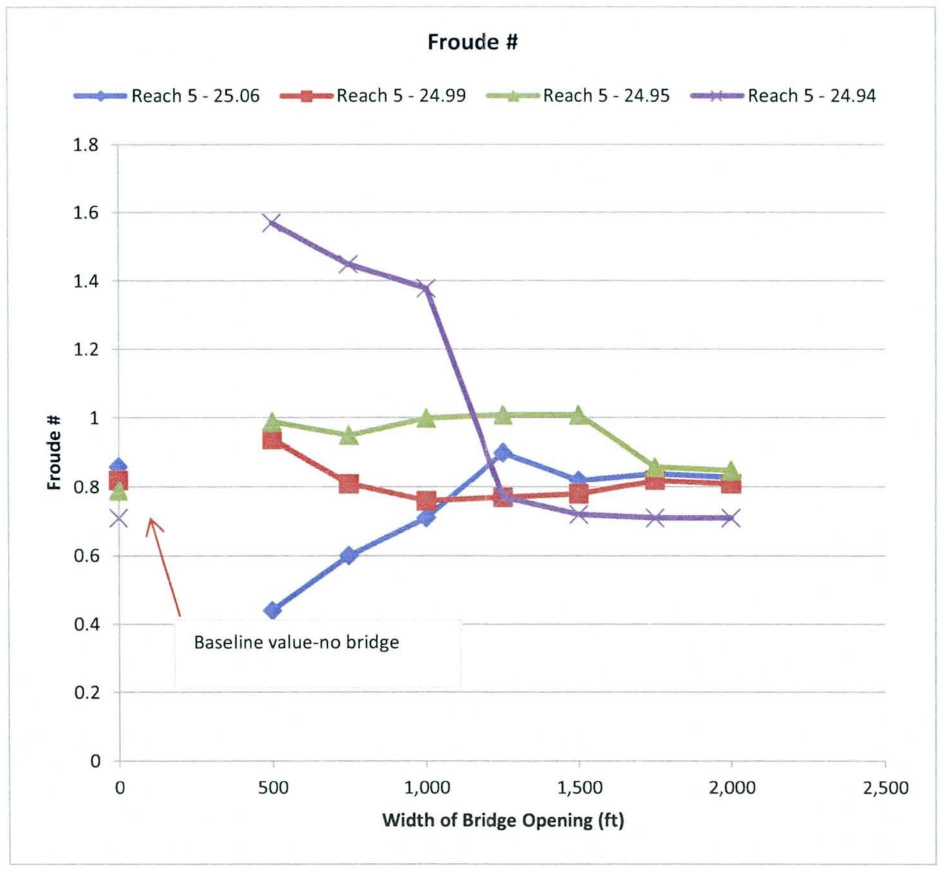
Change in Froude

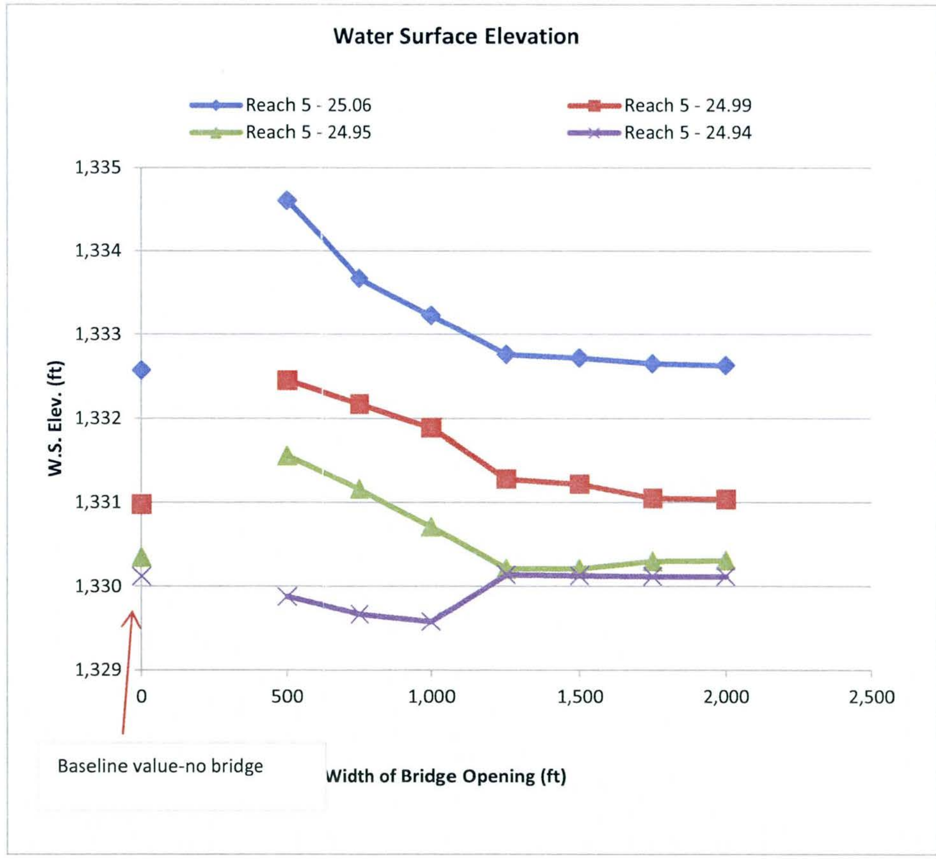
Bridge Opening Width	Reach 5 - 25.06		Reach 5 - 24.99		Reach 5 - 24.95		Reach 5 - 24.94	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.86	—	0.82	—	0.79	—	0.71	—
500	0.44	-48.8	0.94	14.6	0.99	25.3	1.57	121.1
750	0.60	-30.2	0.81	-1.2	0.95	20.3	1.45	104.2
1,000	0.71	-17.4	0.76	-7.3	1.00	26.6	1.38	94.4
1,250	0.90	4.7	0.77	-6.1	1.01	27.8	0.77	8.5
1,500	0.82	-4.7	0.78	-4.9	1.01	27.8	0.72	1.4
1,750	0.84	-2.3	0.82	0.0	0.86	8.9	0.71	0.0
2,000	0.83	-3.5	0.81	-1.2	0.85	7.6	0.71	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 5 - 25.06		Reach 5 - 24.99		Reach 5 - 24.95		Reach 5 - 24.94	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,332.57	—	1,330.98	—	1,330.35	—	1,330.12	—
500	1,334.60	2.03	1,332.45	1.47	1,331.56	1.21	1,329.88	-0.24
750	1,333.67	1.10	1,332.17	1.19	1,331.16	0.81	1,329.67	-0.45
1,000	1,333.23	0.66	1,331.89	0.91	1,330.71	0.36	1,329.58	-0.54
1,250	1,332.76	0.19	1,331.28	0.30	1,330.21	-0.14	1,330.14	0.02
1,500	1,332.72	0.15	1,331.22	0.24	1,330.21	-0.14	1,330.13	0.01
1,750	1,332.65	0.08	1,331.05	0.07	1,330.30	-0.05	1,330.12	0.00
2,000	1,332.63	0.06	1,331.04	0.06	1,330.31	-0.04	1,330.12	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–6

Summary of Hydraulic Parameters, 100-Year Event

Greenway Road Bridge at RM 23.87

Change in Velocity

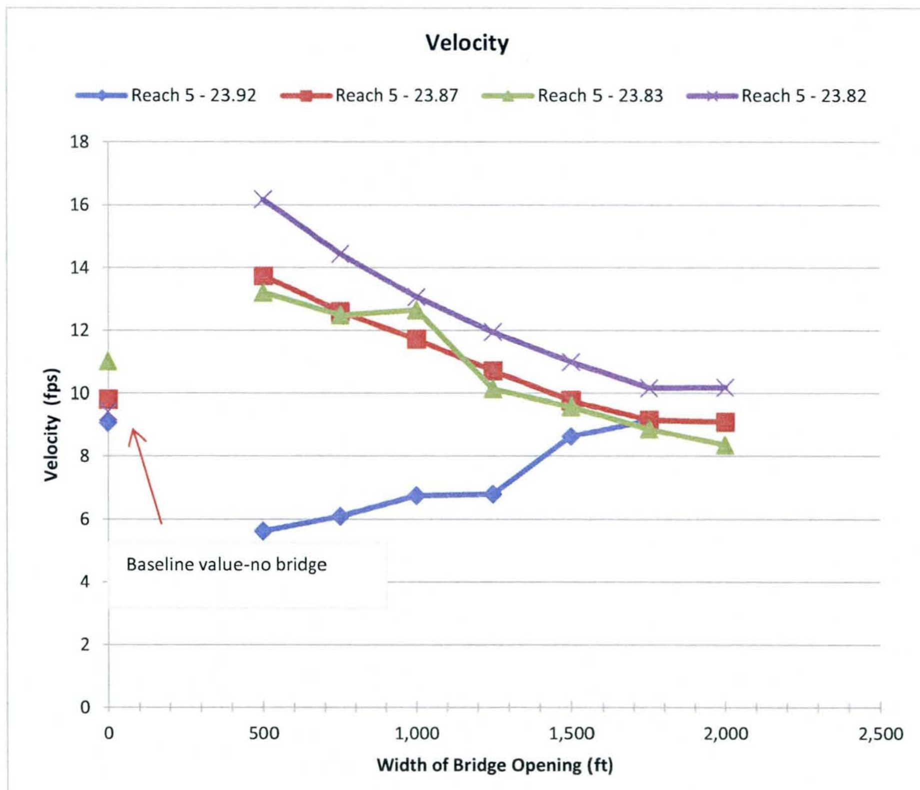
Bridge Opening Width	Reach 5 - 23.92		Reach 5 - 23.87		Reach 5 - 23.83		Reach 5 - 23.82	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	9.09	—	9.82	—	11.03	—	9.43	—
500	5.63	-38.1	13.75	40.0	13.21	19.8	16.18	71.6
750	6.10	-32.9	12.60	28.3	12.49	13.2	14.45	53.2
1,000	6.76	-25.6	11.72	19.3	12.65	14.7	13.07	38.6
1,250	6.81	-25.1	10.72	9.2	10.15	-8.0	11.95	26.7
1,500	8.65	-4.8	9.78	-0.4	9.59	-13.1	11.00	16.6
1,750	9.17	0.9	9.18	-6.5	8.88	-19.5	10.17	7.8
2,000	9.12	0.3	9.12	-7.1	8.37	-24.1	10.19	8.1

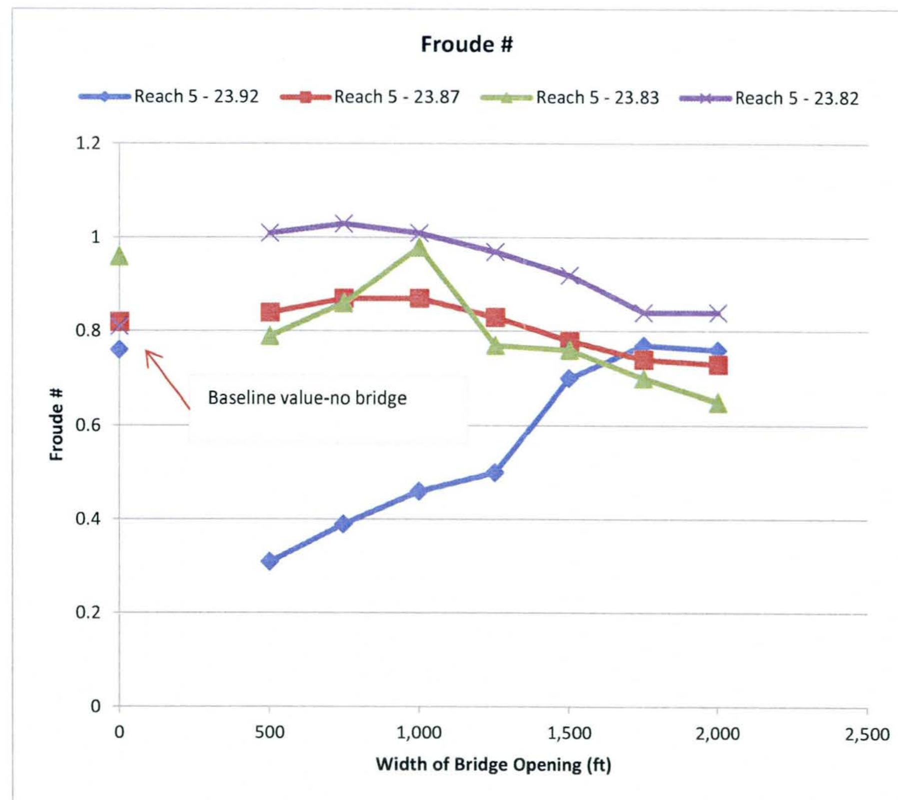
Change in Froude #

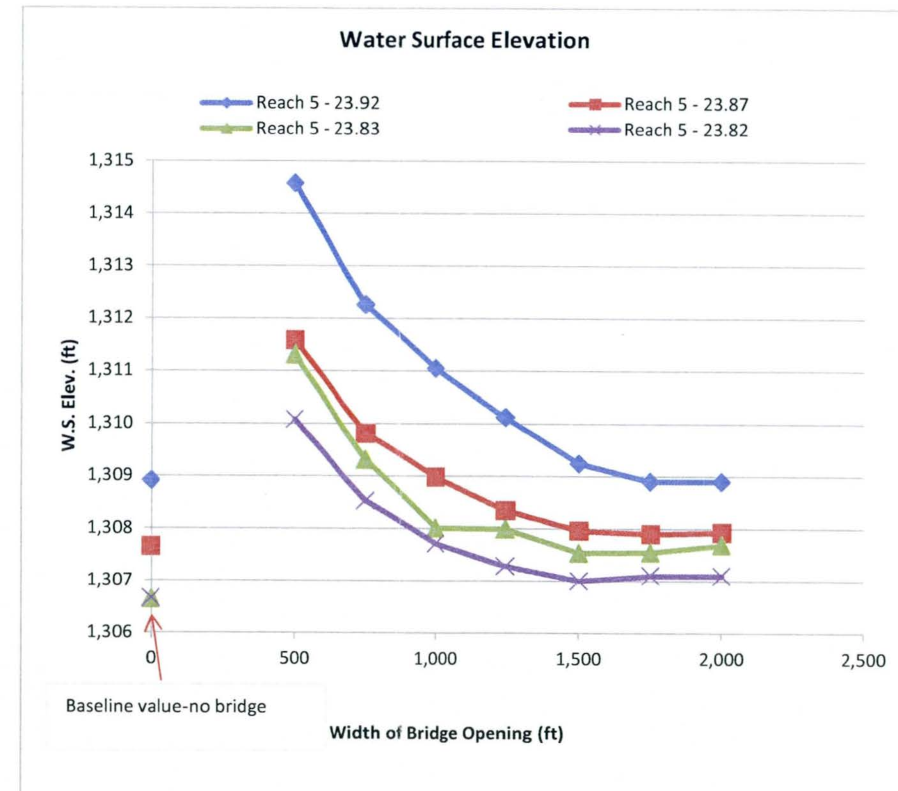
Bridge Opening Width	Reach 5 - 23.92		Reach 5 - 23.87		Reach 5 - 23.83		Reach 5 - 23.82	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.76	—	0.82	—	0.96	—	0.81	—
500	0.31	-59.2	0.84	2.4	0.79	-17.7	1.01	24.7
750	0.39	-48.7	0.87	6.1	0.86	-10.4	1.03	27.2
1,000	0.46	-39.5	0.87	6.1	0.98	2.1	1.01	24.7
1,250	0.50	-34.2	0.83	1.2	0.77	-19.8	0.97	19.8
1,500	0.70	-7.9	0.78	-4.9	0.76	-20.8	0.92	13.6
1,750	0.77	1.3	0.74	-9.8	0.70	-27.1	0.84	3.7
2,000	0.76	0.0	0.73	-11.0	0.65	-32.3	0.84	3.7

Change in Water Surface Elevation

Bridge Opening Width	Reach 5 - 23.92		Reach 5 - 23.87		Reach 5 - 23.83		Reach 5 - 23.82	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,308.91	—	1,307.65	—	1,306.65	—	1,306.66	—
500	1,314.58	5.67	1,311.58	3.93	1,311.30	4.65	1,310.08	3.42
750	1,312.25	3.34	1,309.81	2.16	1,309.31	2.66	1,308.53	1.87
1,000	1,311.04	2.13	1,308.98	1.33	1,308.01	1.36	1,307.71	1.05
1,250	1,310.12	1.21	1,308.35	0.70	1,307.99	1.34	1,307.28	0.62
1,500	1,309.24	0.33	1,307.96	0.31	1,307.54	0.89	1,307.00	0.34
1,750	1,308.90	-0.01	1,307.90	0.25	1,307.55	0.90	1,307.10	0.44
2,000	1,308.90	-0.01	1,307.93	0.28	1,307.69	1.04	1,307.10	0.44







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–7

Summary of Hydraulic Parameters, 10-Year Event

Greenway Road Bridge at RM 23.87

Change in Velocity

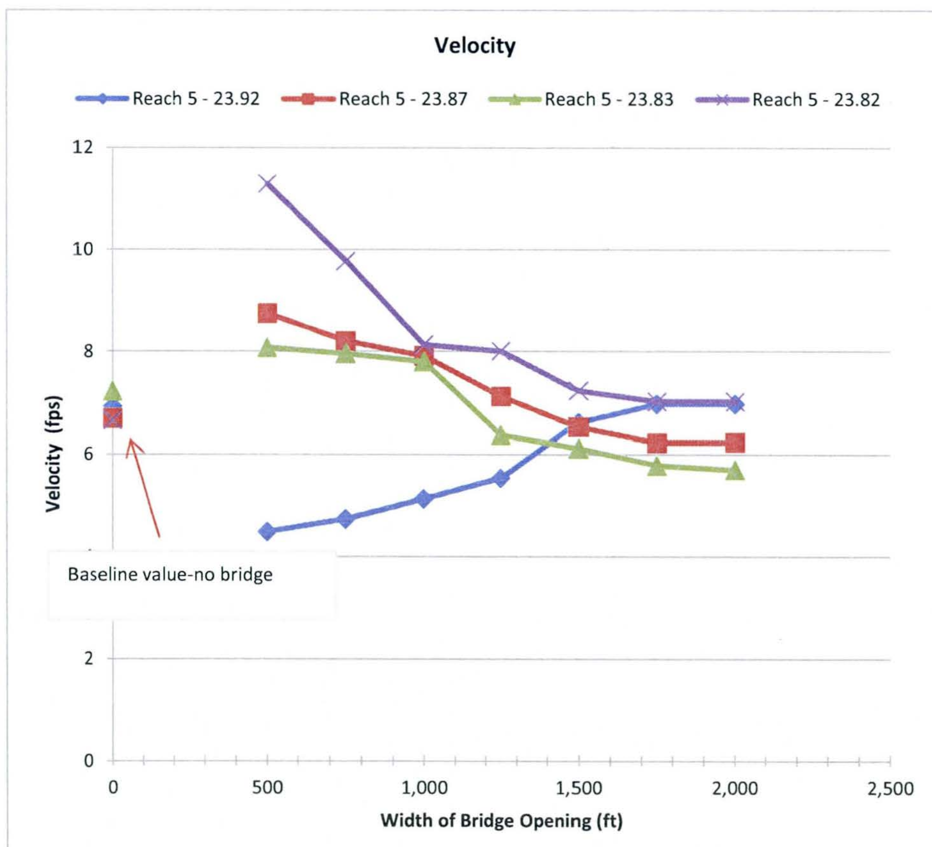
Bridge Opening Width	Reach 5 - 23.92		Reach 5 - 23.87		Reach 5 - 23.83		Reach 5 - 23.82	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	6.93	—	6.7	—	7.23	—	6.66	—
500	4.49	-35.2	8.76	30.7	8.08	11.8	11.29	69.5
750	4.74	-31.6	8.21	22.5	7.96	10.1	9.78	46.8
1,000	5.13	-26.0	7.92	18.2	7.81	8.0	8.14	22.2
1,250	5.54	-20.1	7.13	6.4	6.38	-11.8	8.01	20.3
1,500	6.62	-4.5	6.54	-2.4	6.12	-15.4	7.24	8.7
1,750	6.98	0.7	6.23	-7.0	5.79	-19.9	7.03	5.6
2,000	6.98	0.7	6.24	-6.9	5.70	-21.2	7.03	5.6

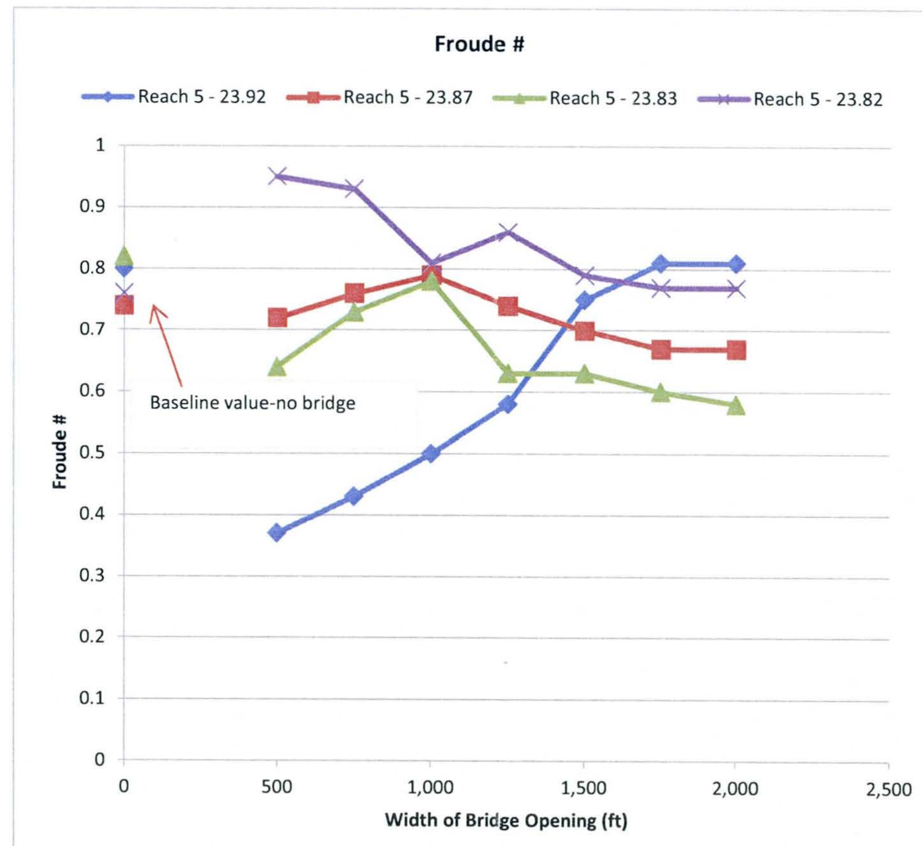
Change in Froude

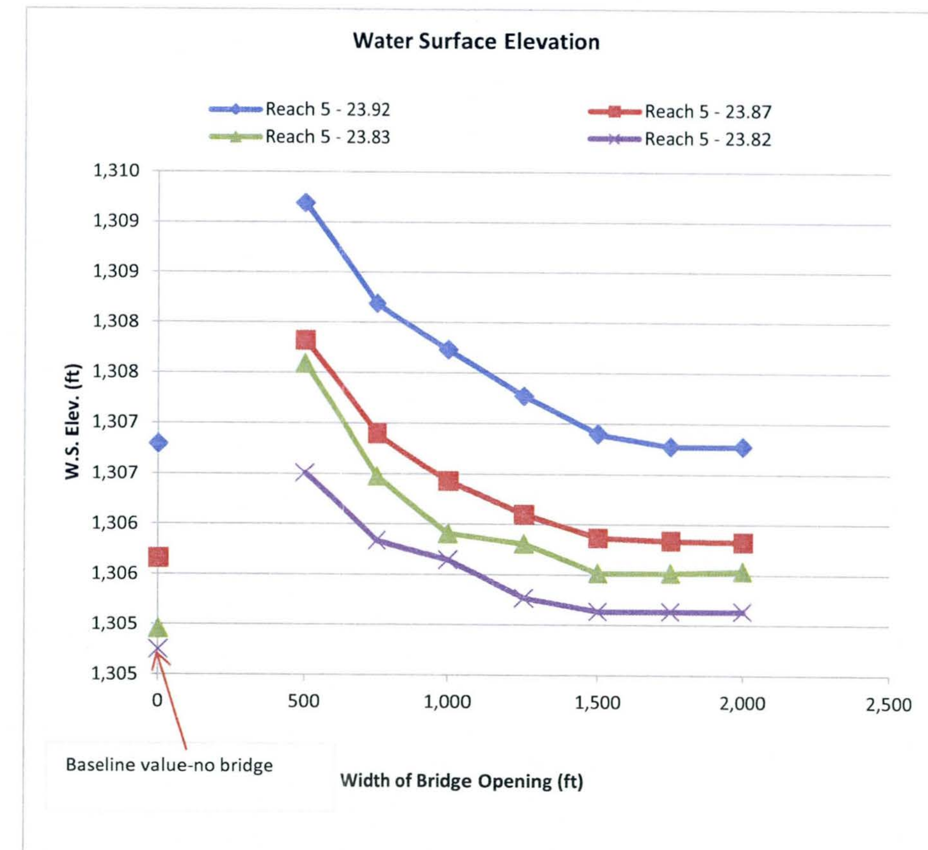
Bridge Opening Width	Reach 5 - 23.92		Reach 5 - 23.87		Reach 5 - 23.83		Reach 5 - 23.82	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.80	—	0.74	—	0.82	—	0.76	—
500	0.37	-53.8	0.72	-2.7	0.64	-22.0	0.95	25.0
750	0.43	-46.3	0.76	2.7	0.73	-11.0	0.93	22.4
1,000	0.50	-37.5	0.79	6.8	0.78	-4.9	0.81	6.6
1,250	0.58	-27.5	0.74	0.0	0.63	-23.2	0.86	13.2
1,500	0.75	-6.3	0.70	-5.4	0.63	-23.2	0.79	3.9
1,750	0.81	1.3	0.67	-9.5	0.60	-26.8	0.77	1.3
2,000	0.81	1.3	0.67	-9.5	0.58	-29.3	0.77	1.3

Change in Water Surface Elevation

Bridge Opening Width	Reach 5 - 23.92		Reach 5 - 23.87		Reach 5 - 23.83		Reach 5 - 23.82	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,306.80	—	1,305.66	—	1,304.96	—	1,304.75	—
500	1,309.19	2.39	1,307.82	2.16	1,307.59	2.63	1,306.51	1.76
750	1,308.19	1.39	1,306.90	1.24	1,306.48	1.52	1,305.84	1.09
1,000	1,307.73	0.93	1,306.43	0.77	1,305.91	0.95	1,305.65	0.90
1,250	1,307.27	0.47	1,306.10	0.44	1,305.81	0.85	1,305.27	0.52
1,500	1,306.90	0.10	1,305.87	0.21	1,305.52	0.56	1,305.14	0.39
1,750	1,306.78	-0.02	1,305.84	0.18	1,305.52	0.56	1,305.14	0.39
2,000	1,306.78	-0.02	1,305.83	0.17	1,305.54	0.58	1,305.14	0.39







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–8

Summary of Hydraulic Parameters, 100-Year Event

Cactus Road Bridge at RM 21.27

Change in Velocity

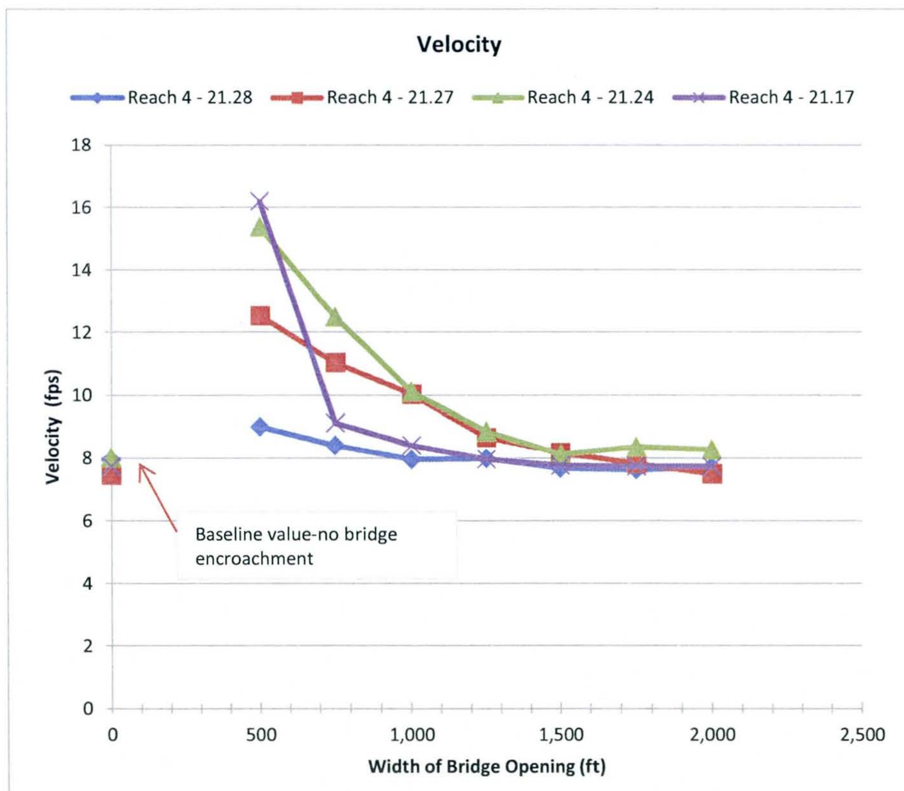
Bridge Opening Width	Reach 4 - 21.28 Velocity	Reach 4 - 21.28 Percent Change	Reach 4 - 21.27 Velocity	Reach 4 - 21.27 Percent Change	Reach 4 - 21.24 Velocity	Reach 4 - 21.24 Percent Change	Reach 4 - 21.17 Velocity	Reach 4 - 21.17 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	7.95	—	7.47	—	8.03	—	7.74	—
500	9.01	13.3	12.54	67.9	15.39	91.7	16.20	109.3
750	8.41	5.8	11.04	47.8	12.50	55.7	9.13	18.0
1,000	7.96	0.1	10.04	34.4	10.12	26.0	8.41	8.7
1,250	7.99	0.5	8.67	16.1	8.86	10.3	7.97	3.0
1,500	7.68	-3.4	8.19	9.6	8.13	1.2	7.77	0.4
1,750	7.63	-4.0	7.83	4.8	8.37	4.2	7.74	0.0
2,000	7.71	-3.0	7.50	0.4	8.28	3.1	7.74	0.0

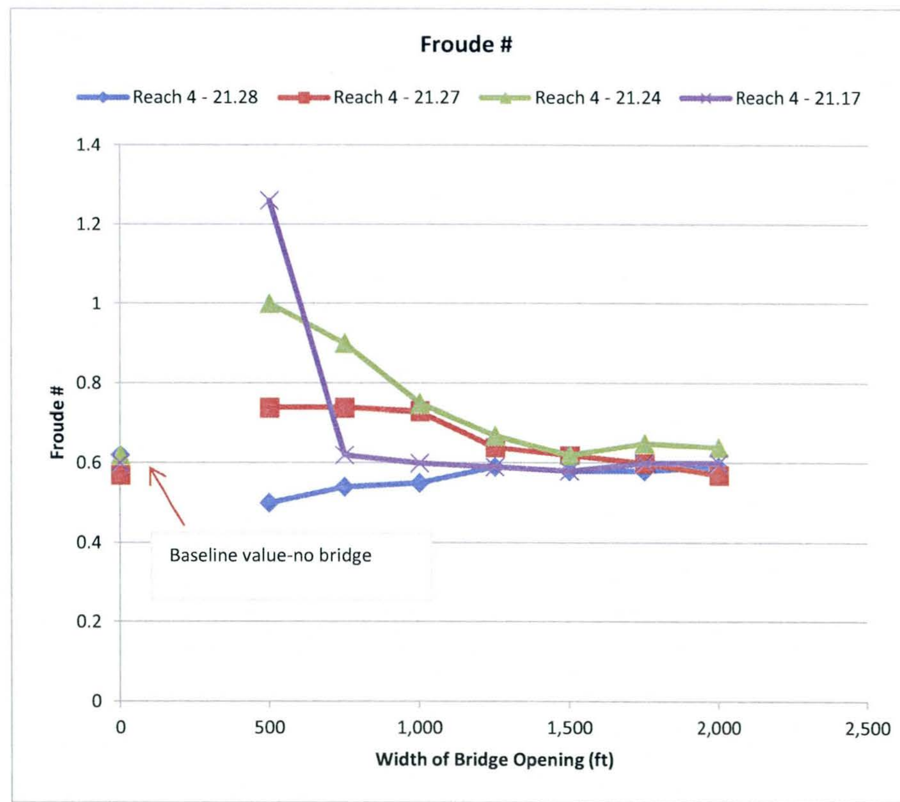
Change in Froude #

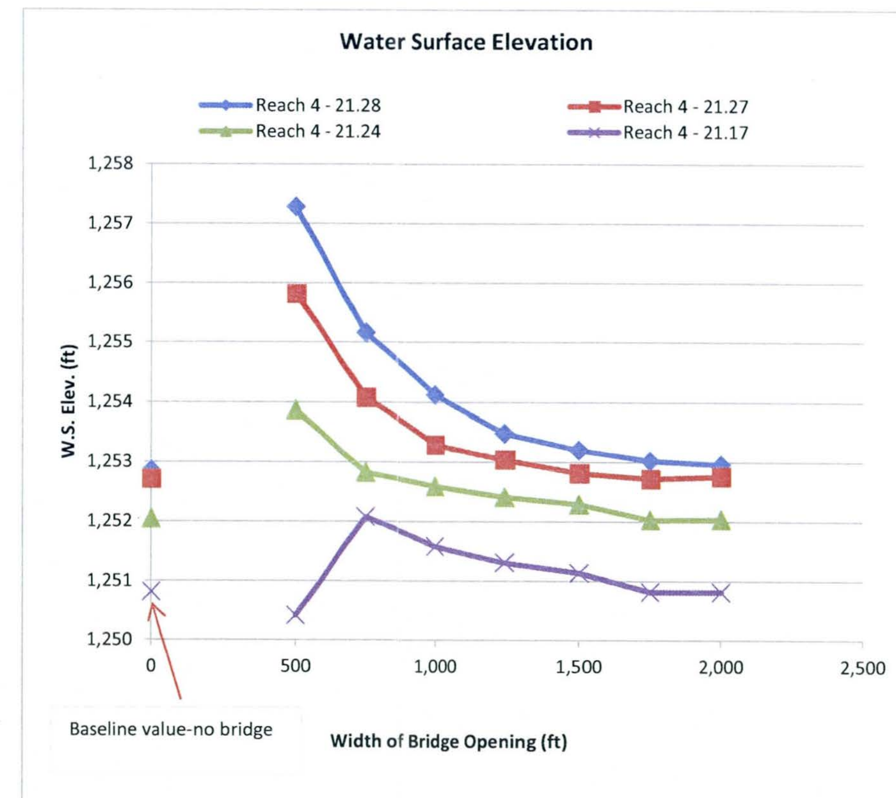
Bridge Opening Width	Reach 4 - 21.28 Froude #	Reach 4 - 21.28 Percent Change	Reach 4 - 21.27 Froude #	Reach 4 - 21.27 Percent Change	Reach 4 - 21.24 Froude #	Reach 4 - 21.24 Percent Change	Reach 4 - 21.17 Froude #	Reach 4 - 21.17 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.62	—	0.57	—	0.62	—	0.60	—
500	0.50	-19.4	0.74	29.8	1.00	61.3	1.26	110.0
750	0.54	-12.9	0.74	29.8	0.90	45.2	0.62	3.3
1,000	0.55	-11.3	0.73	28.1	0.75	21.0	0.60	0.0
1,250	0.59	-4.8	0.64	12.3	0.67	8.1	0.59	-1.7
1,500	0.58	-6.5	0.62	8.8	0.62	0.0	0.58	-3.3
1,750	0.58	-6.5	0.60	5.3	0.65	4.8	0.60	0.0
2,000	0.59	-4.8	0.57	0.0	0.64	3.2	0.60	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 21.28 W.S.E.	Reach 4 - 21.28 Change in W.S.E.	Reach 4 - 21.27 W.S.E.	Reach 4 - 21.27 Change in W.S.E.	Reach 4 - 21.24 W.S.E.	Reach 4 - 21.24 Change in W.S.E.	Reach 4 - 21.17 W.S.E.	Reach 4 - 21.17 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,252.86	—	1,252.71	—	1,252.05	—	1,250.82	—
500	1,257.28	4.42	1,255.82	3.11	1,253.87	1.82	1,250.42	-0.40
750	1,255.16	2.30	1,254.08	1.37	1,252.82	0.77	1,252.08	1.26
1,000	1,254.12	1.26	1,253.29	0.58	1,252.59	0.54	1,251.58	0.76
1,250	1,253.48	0.62	1,253.04	0.33	1,252.41	0.36	1,251.31	0.49
1,500	1,253.20	0.34	1,252.81	0.10	1,252.29	0.24	1,251.14	0.32
1,750	1,253.02	0.16	1,252.72	0.01	1,252.03	-0.02	1,250.82	0.00
2,000	1,252.96	0.10	1,252.76	0.05	1,252.04	-0.01	1,250.82	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–9
Summary of Hydraulic Parameters, 10-Year Event
Cactus Road Bridge at RM 21.27

Change in Velocity

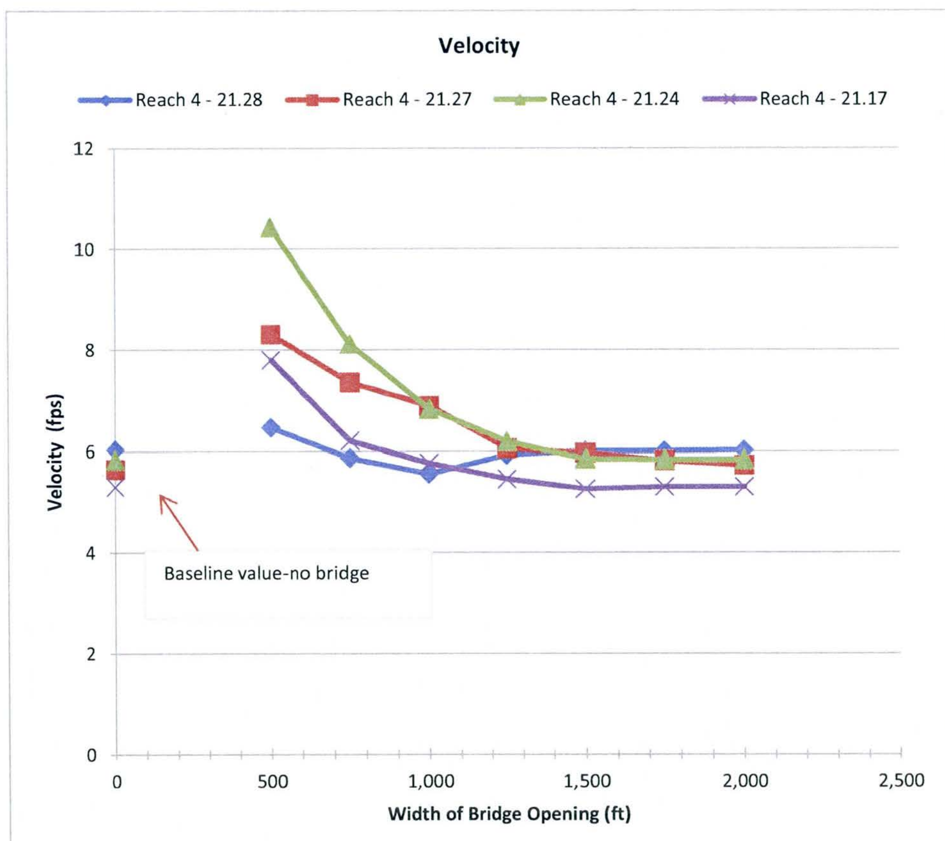
Bridge Opening Width	Reach 4 - 21.28		Reach 4 - 21.27		Reach 4 - 21.24		Reach 4 - 21.17	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	6.04	—	5.65	—	5.84	—	5.3	—
500	6.47	7.1	8.31	47.1	10.43	78.6	7.80	47.2
750	5.87	-2.8	7.36	30.3	8.12	39.0	6.21	17.2
1,000	5.56	-7.9	6.90	22.1	6.83	17.0	5.77	8.9
1,250	5.93	-1.8	6.06	7.3	6.20	6.2	5.46	3.0
1,500	6.01	-0.5	5.97	5.7	5.85	0.2	5.26	-0.8
1,750	6.01	-0.5	5.82	3.0	5.84	0.0	5.30	0.0
2,000	6.02	-0.3	5.73	1.4	5.84	0.0	5.30	0.0

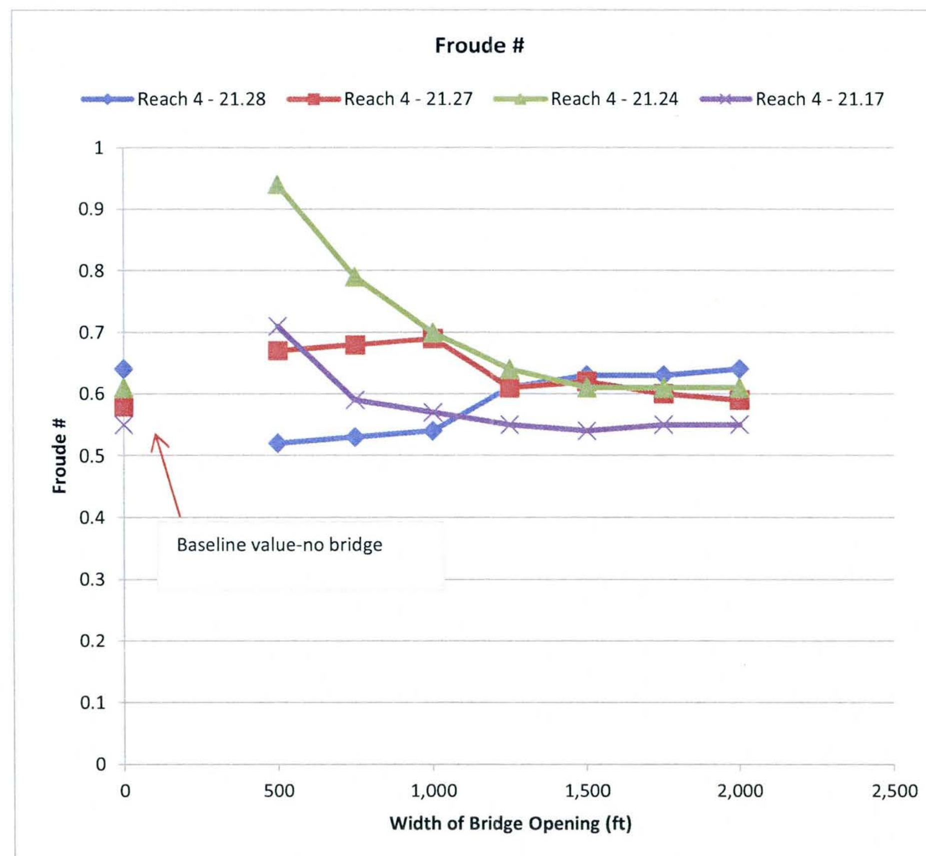
Change in Froude #

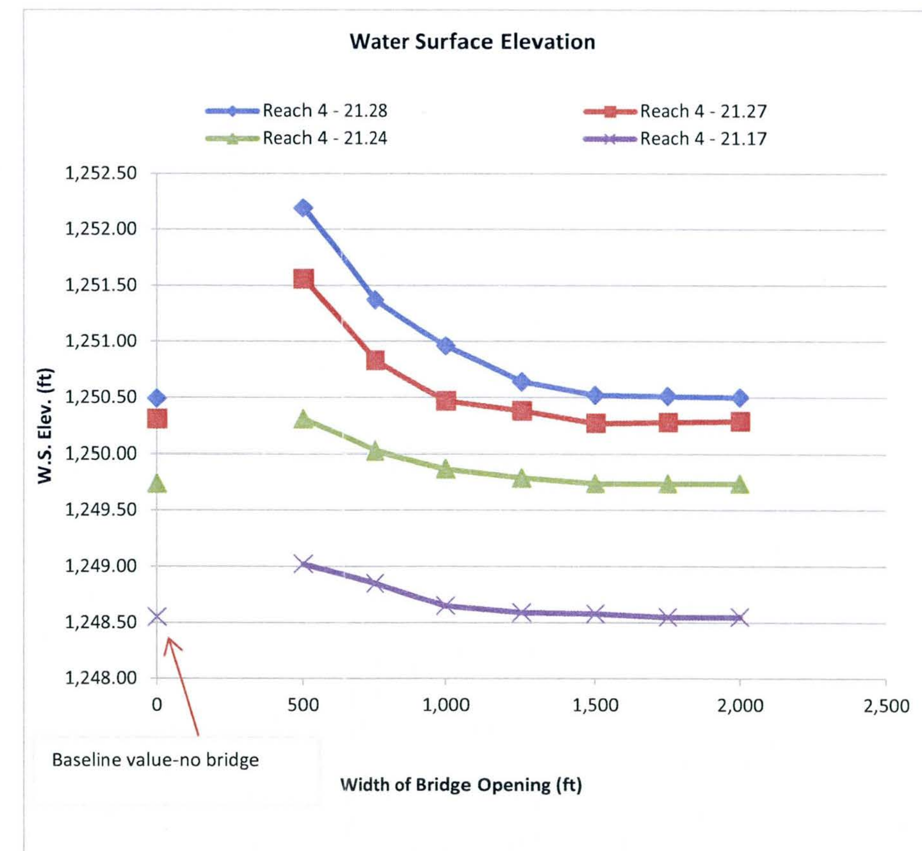
Bridge Opening Width	Reach 4 - 21.28		Reach 4 - 21.27		Reach 4 - 21.24		Reach 4 - 21.17	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.64	—	0.58	—	0.61	—	0.55	—
500	0.52	-18.8	0.67	15.5	0.94	54.1	0.71	29.1
750	0.53	-17.2	0.68	17.2	0.79	29.5	0.59	7.3
1,000	0.54	-15.6	0.69	19.0	0.70	14.8	0.57	3.6
1,250	0.61	-4.7	0.61	5.2	0.64	4.9	0.55	0.0
1,500	0.63	-1.6	0.62	6.9	0.61	0.0	0.54	-1.8
1,750	0.63	-1.6	0.60	3.4	0.61	0.0	0.55	0.0
2,000	0.64	0.0	0.59	1.7	0.61	0.0	0.55	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 21.28		Reach 4 - 21.27		Reach 4 - 21.24		Reach 4 - 21.17	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,250.49	—	1,250.31	—	1,249.74	—	1,248.55	—
500	1,252.19	1.70	1,251.56	1.25	1,250.31	0.57	1,249.02	0.47
750	1,251.37	0.88	1,250.83	0.52	1,250.03	0.29	1,248.85	0.30
1,000	1,250.96	0.47	1,250.47	0.16	1,249.87	0.13	1,248.65	0.10
1,250	1,250.64	0.15	1,250.38	0.07	1,249.79	0.05	1,248.59	0.04
1,500	1,250.52	0.03	1,250.27	-0.04	1,249.74	0.00	1,248.58	0.03
1,750	1,250.51	0.02	1,250.28	-0.03	1,249.74	0.00	1,248.55	0.00
2,000	1,250.50	0.01	1,250.29	-0.02	1,249.74	0.00	1,248.55	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–10
Summary of Hydraulic Parameters, 100-Year Event
Olive Avenue Bridge at RM 19.26

Change in Velocity

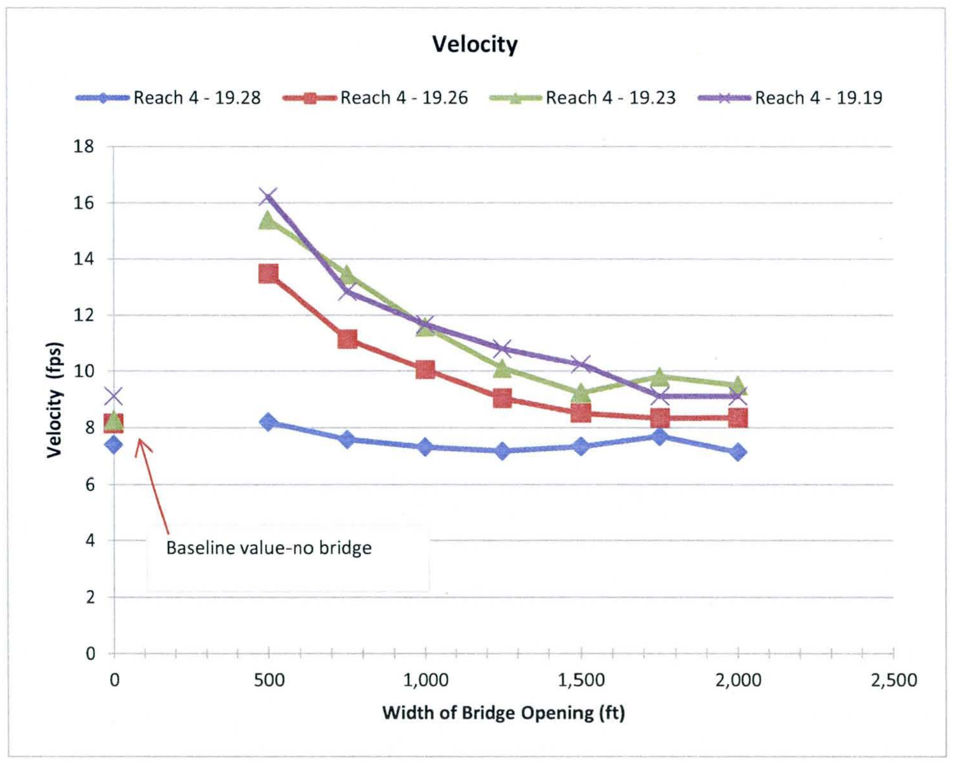
Bridge Opening Width	Reach 4 - 19.28 Velocity	Reach 4 - 19.28 Percent Change	Reach 4 - 19.26 Velocity	Reach 4 - 19.26 Percent Change	Reach 4 - 19.23 Velocity	Reach 4 - 19.23 Percent Change	Reach 4 - 19.19 Velocity	Reach 4 - 19.19 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	7.4	—	8.15	—	8.28	—	9.12	—
500	8.20	10.8	13.49	65.5	15.40	86.0	16.23	78.0
750	7.58	2.4	11.16	36.9	13.45	62.4	12.84	40.8
1,000	7.31	-1.2	10.07	23.6	11.59	40.0	11.68	28.1
1,250	7.17	-3.1	9.05	11.0	10.12	22.2	10.82	18.6
1,500	7.33	-0.9	8.52	4.5	9.24	11.6	10.26	12.5
1,750	7.69	3.9	8.34	2.3	9.81	18.5	9.12	0.0
2,000	7.13	-3.6	8.36	2.6	9.50	14.7	9.12	0.0

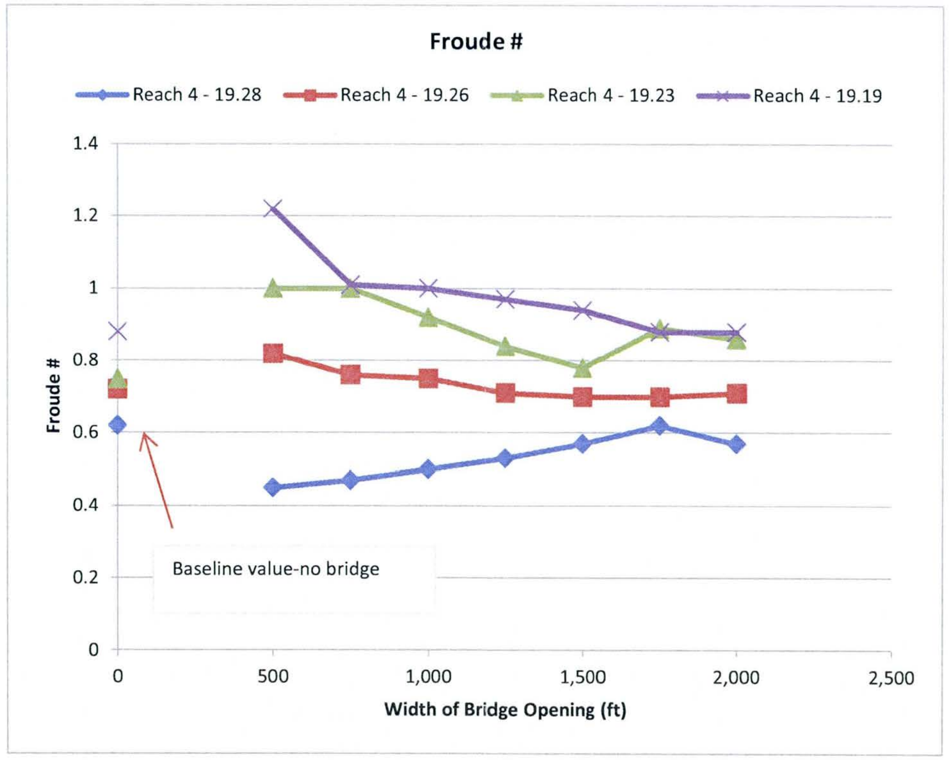
Change in Froude #

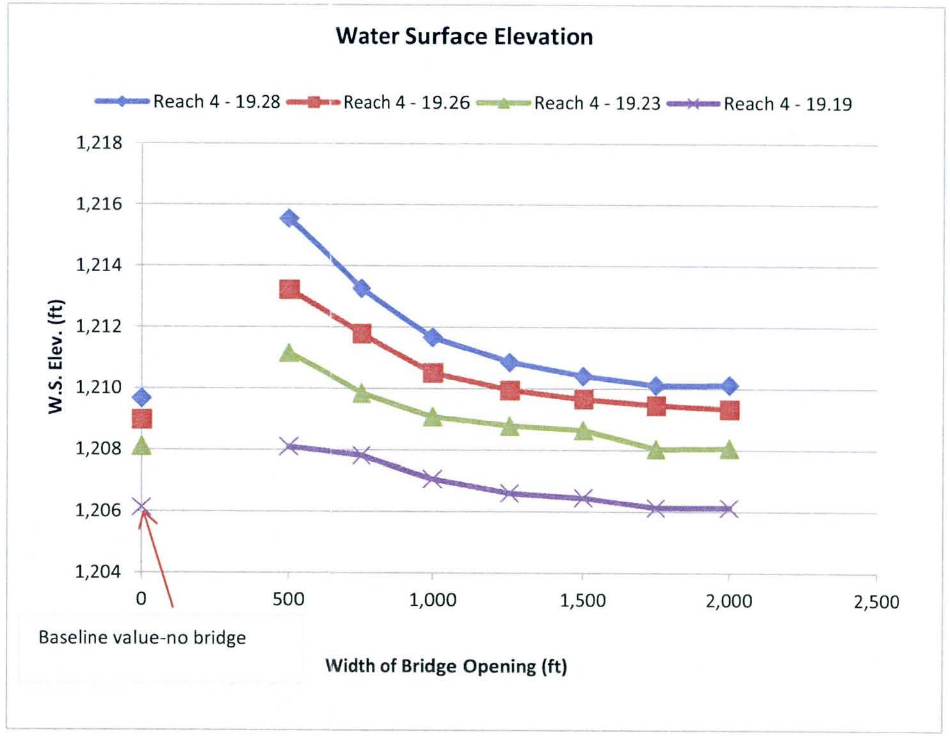
Bridge Opening Width	Reach 4 - 19.28 Froude #	Reach 4 - 19.28 Percent Change	Reach 4 - 19.26 Froude #	Reach 4 - 19.26 Percent Change	Reach 4 - 19.23 Froude #	Reach 4 - 19.23 Percent Change	Reach 4 - 19.19 Froude #	Reach 4 - 19.19 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.62	—	0.72	—	0.75	—	0.88	—
500	0.45	-27.4	0.82	13.9	1.00	33.3	1.22	38.6
750	0.47	-24.2	0.76	5.6	1.00	33.3	1.01	14.8
1,000	0.50	-19.4	0.75	4.2	0.92	22.7	1.00	13.6
1,250	0.53	-14.5	0.71	-1.4	0.84	12.0	0.97	10.2
1,500	0.57	-8.1	0.70	-2.8	0.78	4.0	0.94	6.8
1,750	0.62	0.0	0.70	-2.8	0.89	18.7	0.88	0.0
2,000	0.57	-8.1	0.71	-1.4	0.86	14.7	0.88	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 19.28 W.S.E.	Reach 4 - 19.28 Change in W.S.E.	Reach 4 - 19.26 W.S.E.	Reach 4 - 19.26 Change in W.S.E.	Reach 4 - 19.23 W.S.E.	Reach 4 - 19.23 Change in W.S.E.	Reach 4 - 19.19 W.S.E.	Reach 4 - 19.19 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,209.67	—	1,208.98	—	1,208.11	—	1,206.13	—
500	1,215.55	5.88	1,213.23	4.25	1,211.16	3.05	1,208.10	1.97
750	1,213.27	3.60	1,211.80	2.82	1,209.85	1.74	1,207.82	1.69
1,000	1,211.68	2.01	1,210.51	1.53	1,209.08	0.97	1,207.07	0.94
1,250	1,210.86	1.19	1,209.95	0.97	1,208.79	0.68	1,206.61	0.48
1,500	1,210.41	0.74	1,209.66	0.68	1,208.65	0.54	1,206.46	0.33
1,750	1,210.11	0.44	1,209.46	0.48	1,208.04	-0.07	1,206.13	0.00
2,000	1,210.12	0.45	1,209.34	0.36	1,208.06	-0.05	1,206.13	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–11

Summary of Hydraulic Parameters, 10-Year Event

Olive Avenue Bridge at RM 19.26

Change in Velocity

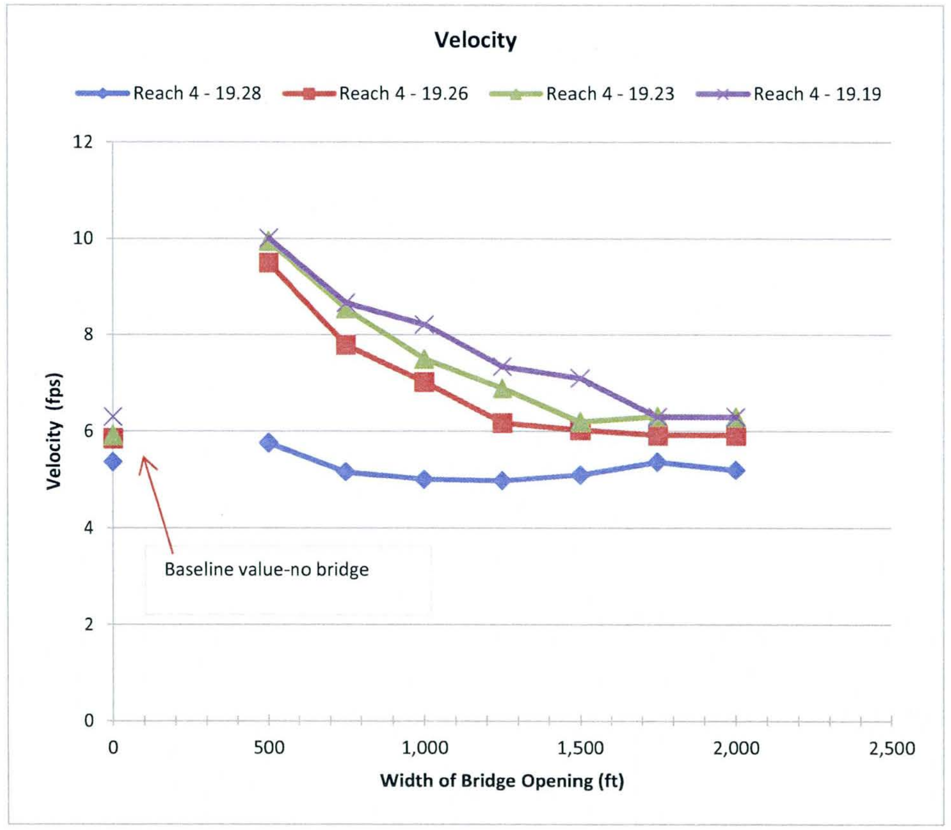
Bridge Opening Width	Reach 4 - 19.28		Reach 4 - 19.26		Reach 4 - 19.23		Reach 4 - 19.19	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	5.38	—	5.86	—	5.93	—	6.3	—
500	5.77	7.2	9.50	62.1	9.95	67.8	10.01	58.9
750	5.17	-3.9	7.79	32.9	8.55	44.2	8.67	37.6
1,000	5.02	-6.7	7.02	19.8	7.50	26.5	8.22	30.5
1,250	4.99	-7.2	6.18	5.5	6.89	16.2	7.34	16.5
1,500	5.11	-5.0	6.03	2.9	6.20	4.6	7.10	12.7
1,750	5.38	0.0	5.93	1.2	6.31	6.4	6.30	0.0
2,000	5.21	-3.2	5.93	1.2	6.30	6.2	6.30	0.0

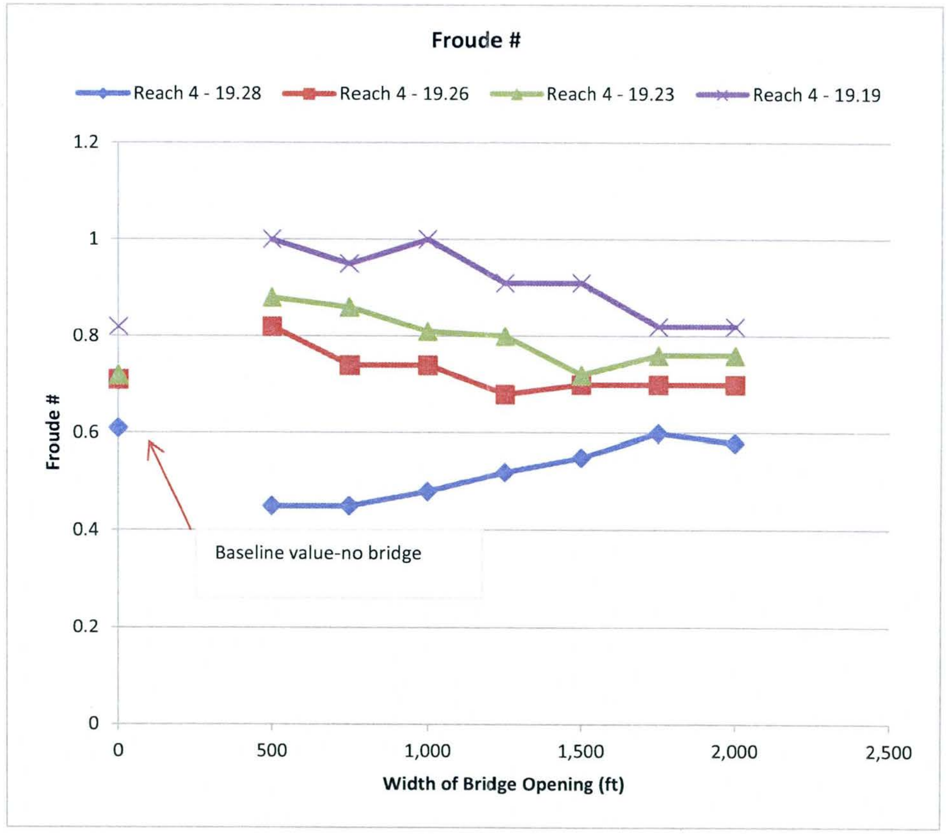
Change in Froude

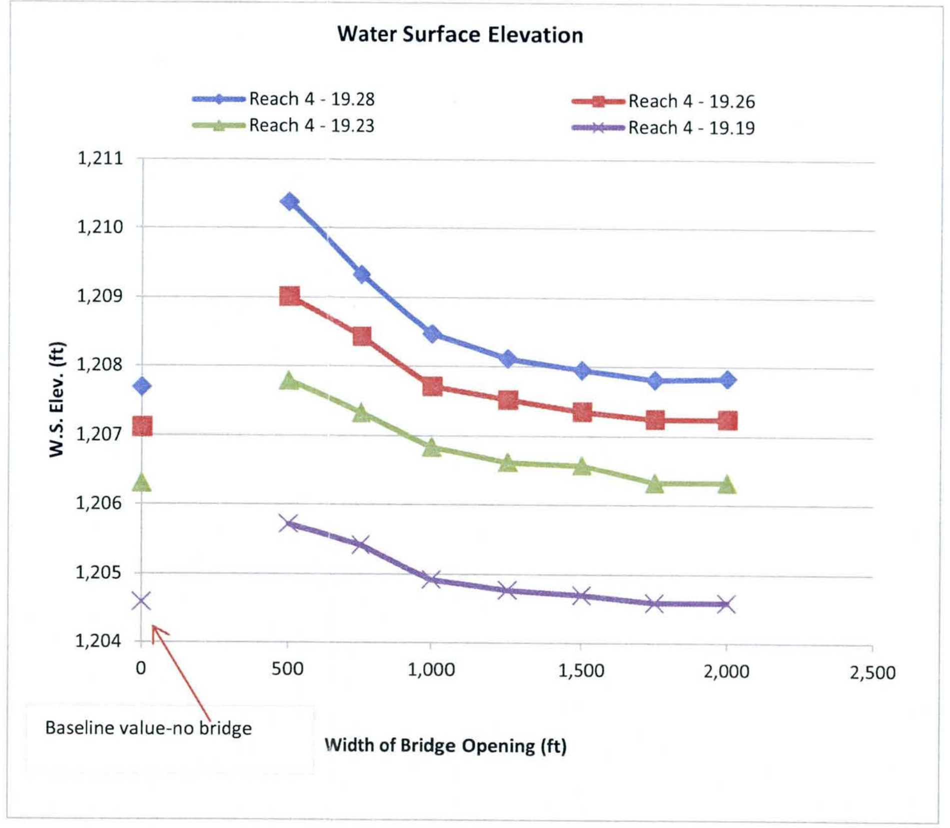
Bridge Opening Width	Reach 4 - 19.28		Reach 4 - 19.26		Reach 4 - 19.23		Reach 4 - 19.19	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.61	—	0.71	—	0.72	—	0.82	—
500	0.45	-26.2	0.82	15.5	0.88	22.2	1.00	22.0
750	0.45	-26.2	0.74	4.2	0.86	19.4	0.95	15.9
1,000	0.48	-21.3	0.74	4.2	0.81	12.5	1.00	22.0
1,250	0.52	-14.8	0.68	-4.2	0.80	11.1	0.91	11.0
1,500	0.55	-9.8	0.70	-1.4	0.72	0.0	0.91	11.0
1,750	0.60	-1.6	0.70	-1.4	0.76	5.6	0.82	0.0
2,000	0.58	-4.9	0.70	-1.4	0.76	5.6	0.82	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 19.28		Reach 4 - 19.26		Reach 4 - 19.23		Reach 4 - 19.19	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,207.69	—	1,207.12	—	1,206.31	—	1,204.59	—
500	1,210.38	2.69	1,209.01	1.89	1,207.79	1.48	1,205.72	1.13
750	1,209.33	1.64	1,208.43	1.31	1,207.33	1.02	1,205.42	0.83
1,000	1,208.47	0.78	1,207.71	0.59	1,206.84	0.53	1,204.92	0.33
1,250	1,208.11	0.42	1,207.52	0.40	1,206.62	0.31	1,204.77	0.18
1,500	1,207.95	0.26	1,207.35	0.23	1,206.58	0.27	1,204.70	0.11
1,750	1,207.81	0.12	1,207.24	0.12	1,206.33	0.02	1,204.59	0.00
2,000	1,207.83	0.14	1,207.24	0.12	1,206.33	0.02	1,204.59	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–12
Summary of Hydraulic Parameters, 100-Year Event
Northern Avenue Bridge at RM 18.19

Change in Velocity

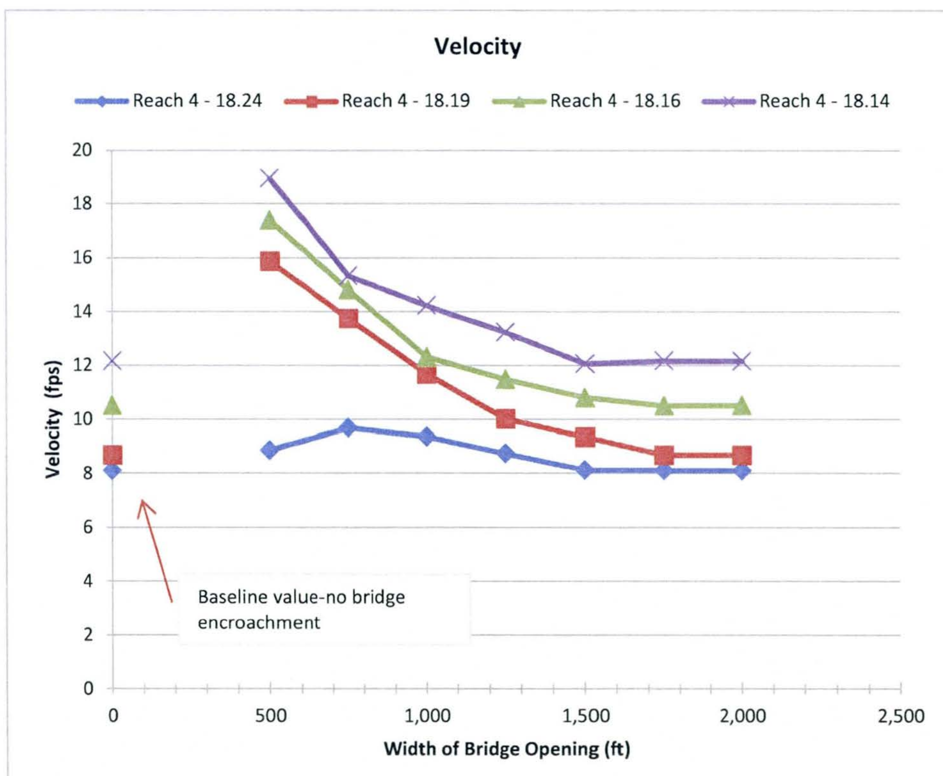
Bridge Opening Width	Reach 4 - 18.24		Reach 4 - 18.19		Reach 4 - 18.16		Reach 4 - 18.14	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	8.12	—	8.7	—	10.52	—	12.16	—
500	8.87	9.2	15.88	82.5	17.40	65.4	18.96	55.9
750	9.70	19.5	13.74	57.9	14.82	40.9	15.34	26.2
1,000	9.37	15.4	11.69	34.4	12.32	17.1	14.24	17.1
1,250	8.75	7.8	10.03	15.3	11.48	9.1	13.23	8.8
1,500	8.14	0.2	9.36	7.6	10.81	2.8	12.06	-0.8
1,750	8.13	0.1	8.70	0.0	10.51	-0.1	12.17	0.1
2,000	8.12	0.0	8.70	0.0	10.52	0.0	12.16	0.0

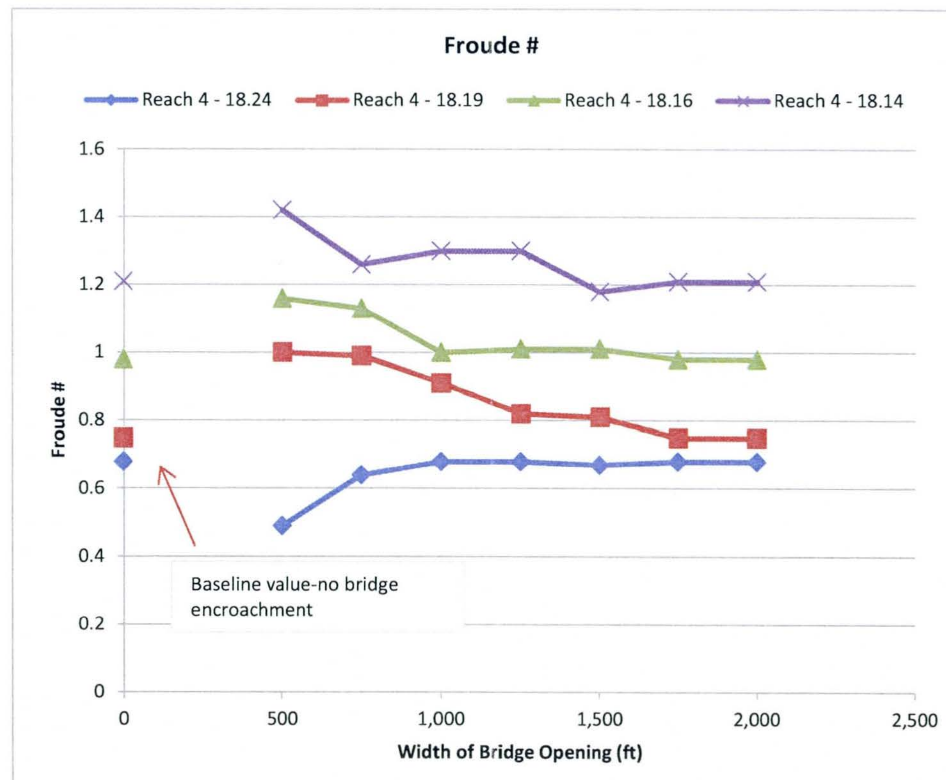
Change in Froude #

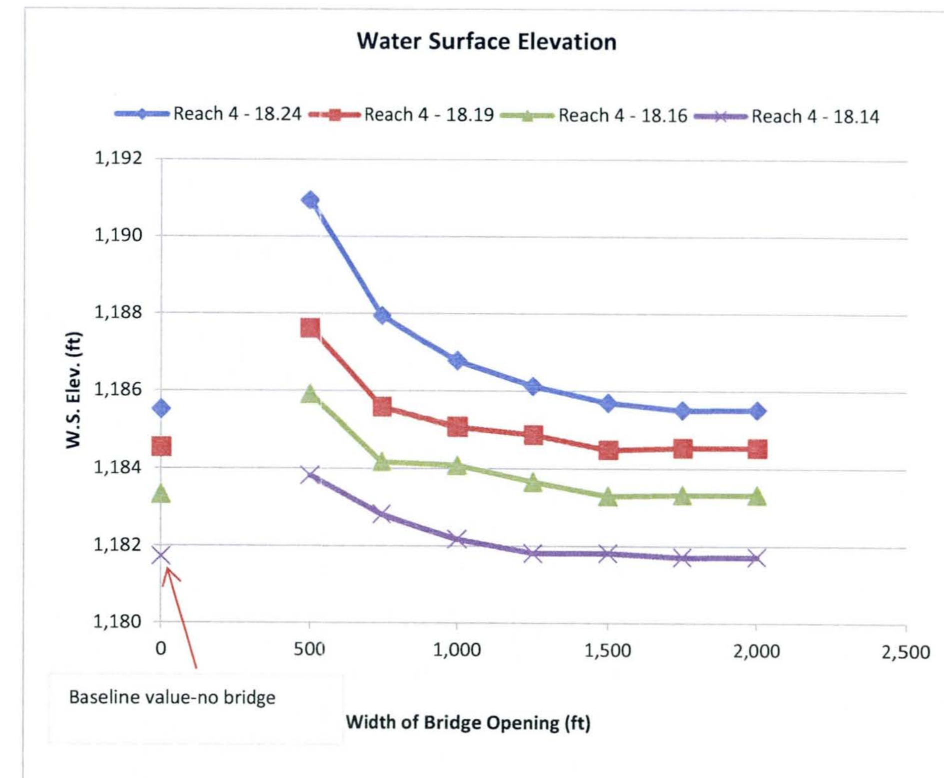
Bridge Opening Width	Reach 4 - 18.24		Reach 4 - 18.19		Reach 4 - 18.16		Reach 4 - 18.14	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.68	—	0.75	—	0.98	—	1.21	—
500	0.49	-27.9	1.00	33.3	1.16	18.4	1.42	17.4
750	0.64	-5.9	0.99	32.0	1.13	15.3	1.26	4.1
1,000	0.68	0.0	0.91	21.3	1.00	2.0	1.30	7.4
1,250	0.68	0.0	0.82	9.3	1.01	3.1	1.30	7.4
1,500	0.67	-1.5	0.81	8.0	1.01	3.1	1.18	-2.5
1,750	0.68	0.0	0.75	0.0	0.98	0.0	1.21	0.0
2,000	0.68	0.0	0.75	0.0	0.98	0.0	1.21	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 18.24		Reach 4 - 18.19		Reach 4 - 18.16		Reach 4 - 18.14	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,185.52	—	1,184.56	—	1,183.33	—	1,181.73	—
500	1,190.93	5.41	1,187.62	3.06	1,185.92	2.59	1,183.82	2.09
750	1,187.95	2.43	1,185.59	1.03	1,184.18	0.85	1,182.82	1.09
1,000	1,186.78	1.26	1,185.09	0.53	1,184.09	0.76	1,182.18	0.45
1,250	1,186.13	0.61	1,184.89	0.33	1,183.66	0.33	1,181.82	0.09
1,500	1,185.70	0.18	1,184.50	-0.06	1,183.30	-0.03	1,181.82	0.09
1,750	1,185.51	-0.01	1,184.56	0.00	1,183.33	0.00	1,181.72	-0.01
2,000	1,185.52	0.00	1,184.56	0.00	1,183.33	0.00	1,181.73	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–13

Summary of Hydraulic Parameters, 10-Year Event

Northern Avenue Bridge at RM 18.19

Change in Velocity

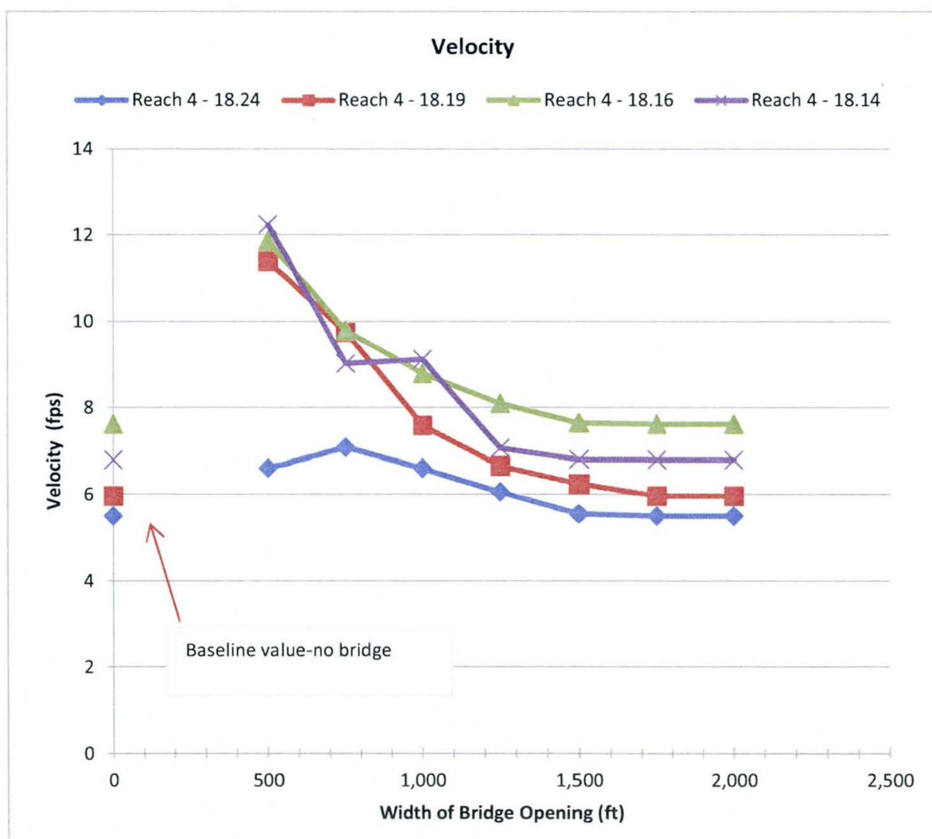
Bridge Opening Width	Reach 4 - 18.24		Reach 4 - 18.19		Reach 4 - 18.16		Reach 4 - 18.14	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	5.5	—	5.97	—	7.62	—	6.8	—
500	6.61	20.2	11.39	90.8	11.86	55.6	12.24	80.0
750	7.09	28.9	9.75	63.3	9.79	28.5	9.02	32.6
1,000	6.60	20.0	7.59	27.1	8.79	15.4	9.12	34.1
1,250	6.06	10.2	6.66	11.6	8.10	6.3	7.07	4.0
1,500	5.55	0.9	6.25	4.7	7.65	0.4	6.81	0.1
1,750	5.50	0.0	5.97	0.0	7.62	0.0	6.80	0.0
2,000	5.50	0.0	5.97	0.0	7.62	0.0	6.80	0.0

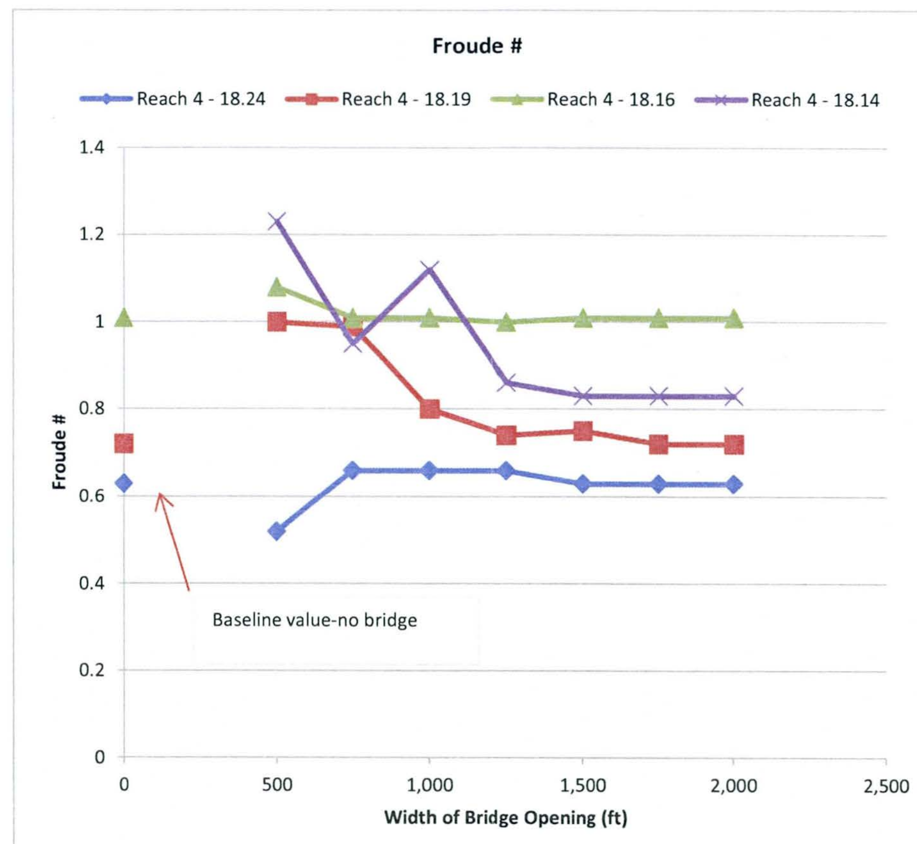
Change in Froude #

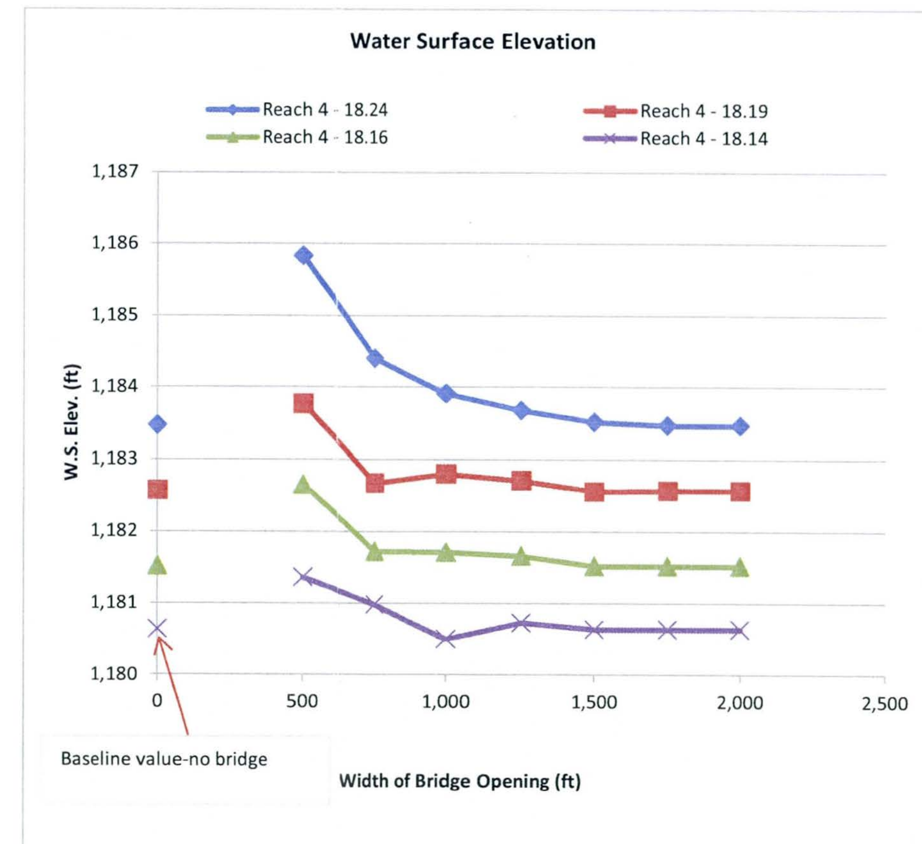
Bridge Opening Width	Reach 4 - 18.24		Reach 4 - 18.19		Reach 4 - 18.16		Reach 4 - 18.14	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.63	—	0.72	—	1.01	—	0.83	—
500	0.52	-17.5	1.00	38.9	1.08	6.9	1.23	48.2
750	0.66	4.8	0.99	37.5	1.01	0.0	0.95	14.5
1,000	0.66	4.8	0.80	11.1	1.01	0.0	1.12	34.9
1,250	0.66	4.8	0.74	2.8	1.00	-1.0	0.86	3.6
1,500	0.63	0.0	0.75	4.2	1.01	0.0	0.83	0.0
1,750	0.63	0.0	0.72	0.0	1.01	0.0	0.83	0.0
2,000	0.63	0.0	0.72	0.0	1.01	0.0	0.83	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 18.24		Reach 4 - 18.19		Reach 4 - 18.16		Reach 4 - 18.14	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,183.47	—	1,182.57	—	1,181.52	—	1,180.64	—
500	1,185.83	2.36	1,183.77	1.20	1,182.65	1.13	1,181.36	0.72
750	1,184.40	0.93	1,182.67	0.10	1,181.72	0.20	1,180.98	0.34
1,000	1,183.91	0.44	1,182.80	0.23	1,181.71	0.19	1,180.50	-0.14
1,250	1,183.68	0.21	1,182.71	0.14	1,181.66	0.14	1,180.73	0.09
1,500	1,183.52	0.05	1,182.56	-0.01	1,181.52	0.00	1,180.64	0.00
1,750	1,183.47	0.00	1,182.57	0.00	1,181.52	0.00	1,180.64	0.00
2,000	1,183.47	0.00	1,182.57	0.00	1,181.52	0.00	1,180.64	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–14

Summary of Hydraulic Parameters, 100-Year Event

Glendale Avenue Bridge at RM 17.17

Change in Velocity

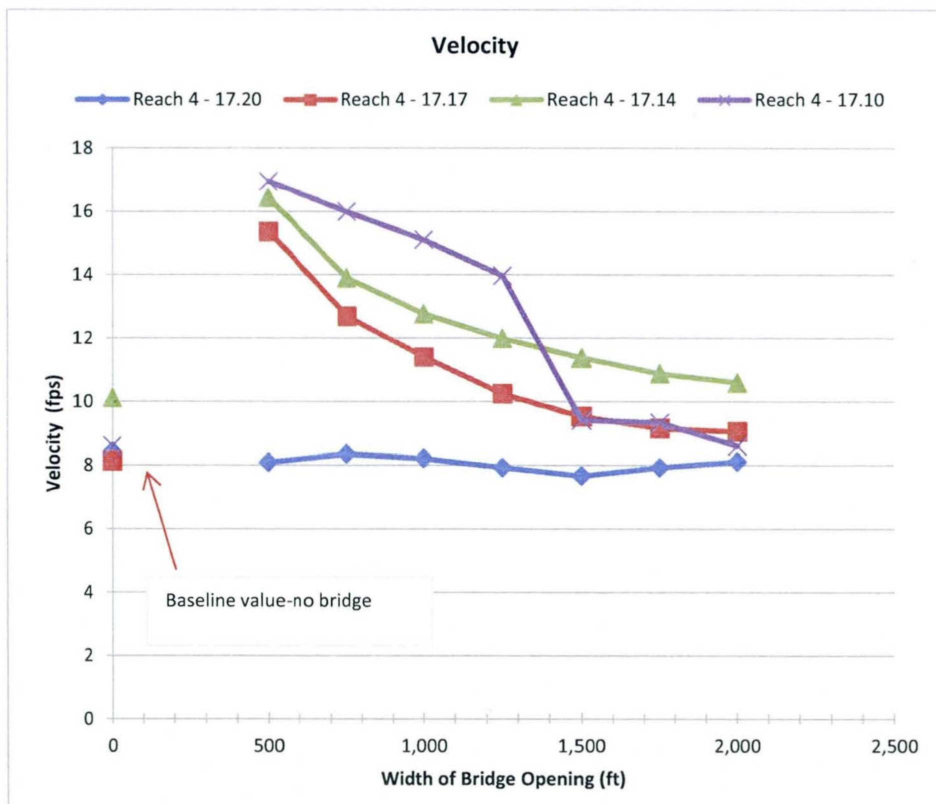
Bridge Opening Width	Reach 4 - 17.20		Reach 4 - 17.17		Reach 4 - 17.14		Reach 4 - 17.10	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	8.44	—	8.14	—	10.13	—	8.61	—
500	8.10	-4.0	15.37	88.8	16.44	62.3	16.96	97.0
750	8.36	-0.9	12.70	56.0	13.91	37.3	16.00	85.8
1,000	8.22	-2.6	11.41	40.2	12.78	26.2	15.11	75.5
1,250	7.94	-5.9	10.25	25.9	12.00	18.5	13.98	62.4
1,500	7.68	-9.0	9.54	17.2	11.38	12.3	9.42	9.4
1,750	7.94	-5.9	9.17	12.7	10.88	7.4	9.34	8.5
2,000	8.12	-3.8	9.07	11.4	10.60	4.6	8.61	0.0

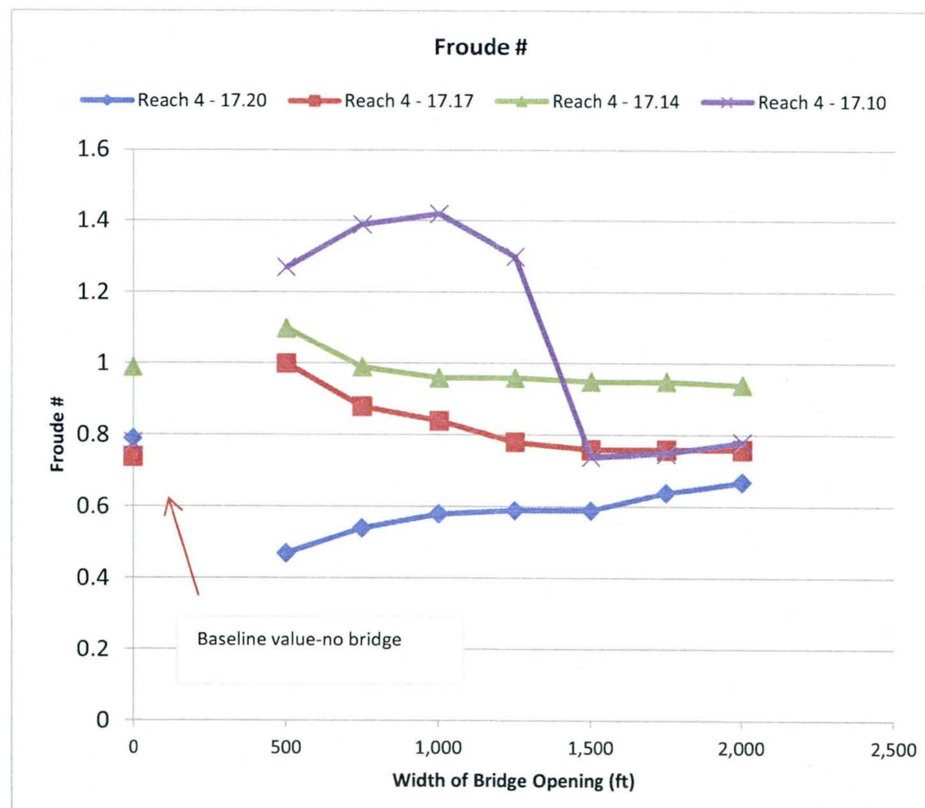
Change in Froude

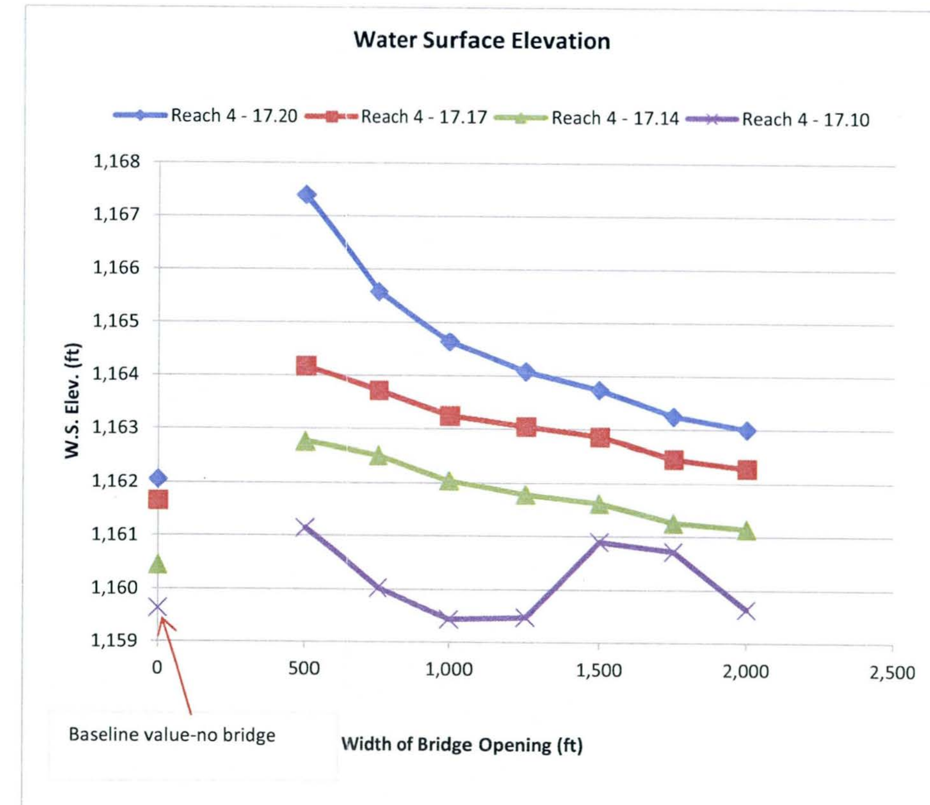
Bridge Opening Width	Reach 4 - 17.20		Reach 4 - 17.17		Reach 4 - 17.14		Reach 4 - 17.10	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.79	—	0.74	—	0.99	—	0.78	—
500	0.47	-40.5	1.00	35.1	1.10	11.1	1.27	62.8
750	0.54	-31.6	0.88	18.9	0.99	0.0	1.39	78.2
1,000	0.58	-26.6	0.84	13.5	0.96	-3.0	1.42	82.1
1,250	0.59	-25.3	0.78	5.4	0.96	-3.0	1.30	66.7
1,500	0.59	-25.3	0.76	2.7	0.95	-4.0	0.74	-5.1
1,750	0.64	-19.0	0.76	2.7	0.95	-4.0	0.75	-3.8
2,000	0.67	-15.2	0.76	2.7	0.94	-5.1	0.78	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 17.20		Reach 4 - 17.17		Reach 4 - 17.14		Reach 4 - 17.10	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,162.06	—	1,161.65	—	1,160.45	—	1,159.64	—
500	1,167.39	5.33	1,164.17	2.52	1,162.77	2.32	1,161.15	1.51
750	1,165.58	3.52	1,163.72	2.07	1,162.51	2.06	1,160.03	0.39
1,000	1,164.64	2.58	1,163.25	1.60	1,162.04	1.59	1,159.44	-0.20
1,250	1,164.08	2.02	1,163.05	1.40	1,161.78	1.33	1,159.48	-0.16
1,500	1,163.74	1.68	1,162.87	1.22	1,161.62	1.17	1,160.90	1.26
1,750	1,163.25	1.19	1,162.46	0.81	1,161.26	0.81	1,160.72	1.08
2,000	1,163.01	0.95	1,162.29	0.64	1,161.15	0.70	1,159.64	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–15

Summary of Hydraulic Parameters, 10-Year Event

Glendale Avenue Bridge at RM 17.17

Change in Velocity

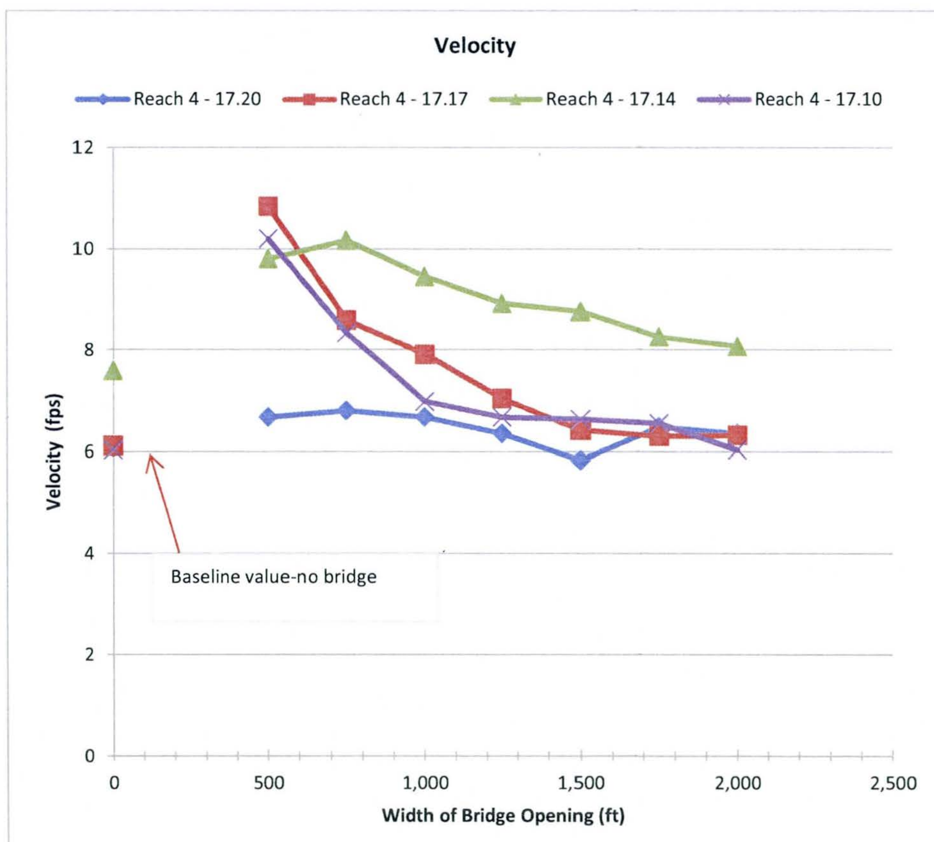
Bridge Opening Width	Reach 4 - 17.20 Velocity	Reach 4 - 17.20 Percent Change	Reach 4 - 17.17 Velocity	Reach 4 - 17.17 Percent Change	Reach 4 - 17.14 Velocity	Reach 4 - 17.14 Percent Change	Reach 4 - 17.10 Velocity	Reach 4 - 17.10 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	6.09	—	6.13	—	7.6	—	6.04	—
500	6.68	9.7	10.84	76.8	9.81	29.1	10.20	68.9
750	6.81	11.8	8.60	40.3	10.17	33.8	8.34	38.1
1,000	6.68	9.7	7.92	29.2	9.46	24.5	6.99	15.7
1,250	6.36	4.4	7.05	15.0	8.93	17.5	6.68	10.6
1,500	5.84	-4.1	6.43	4.9	8.77	15.4	6.64	9.9
1,750	6.49	6.6	6.31	2.9	8.27	8.8	6.56	8.6
2,000	6.36	4.4	6.33	3.3	8.08	6.3	6.04	0.0

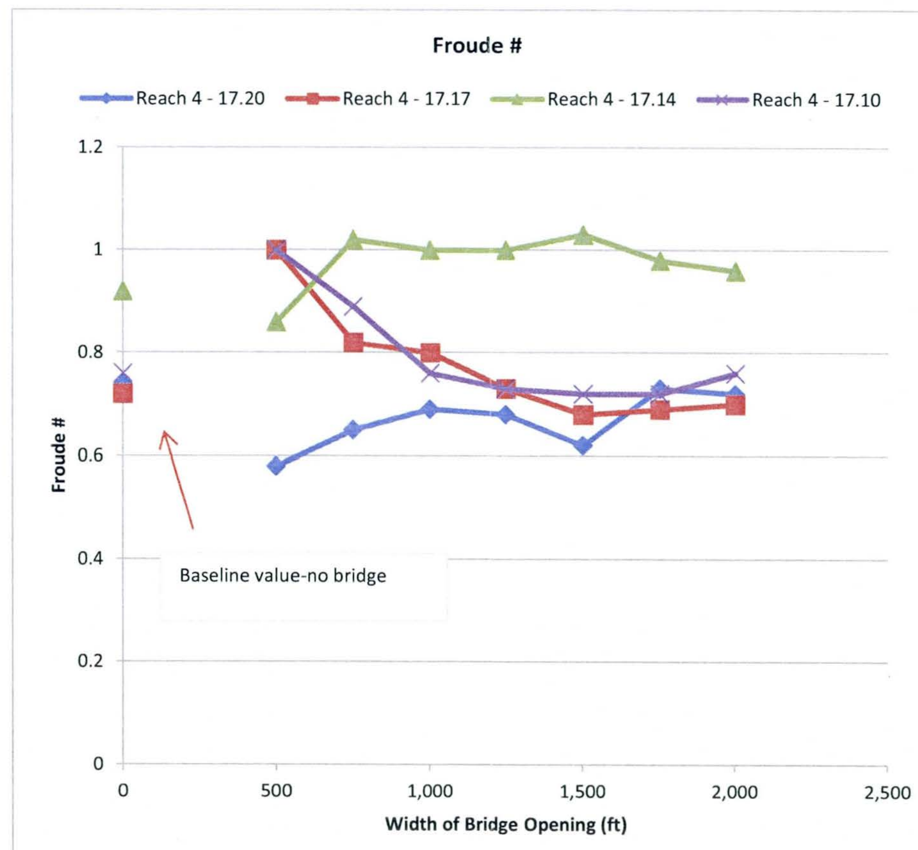
Change in Froude

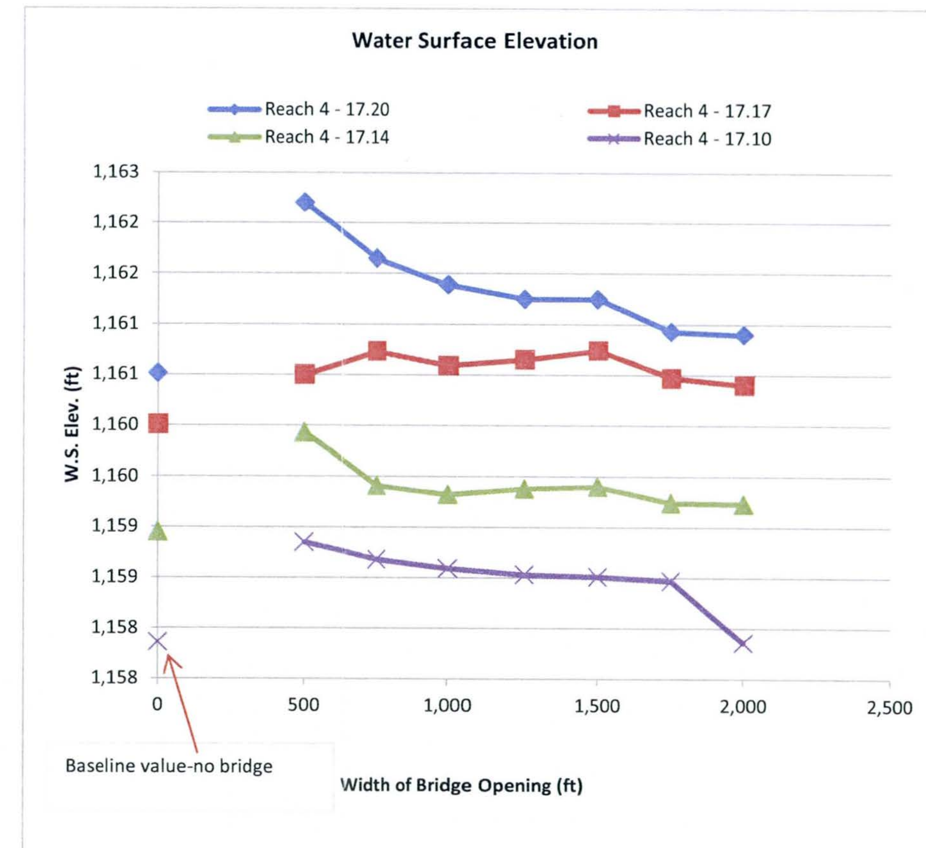
Bridge Opening Width	Reach 4 - 17.20 Froude #	Reach 4 - 17.20 Percent Change	Reach 4 - 17.17 Froude #	Reach 4 - 17.17 Percent Change	Reach 4 - 17.14 Froude #	Reach 4 - 17.14 Percent Change	Reach 4 - 17.10 Froude #	Reach 4 - 17.10 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.74	—	0.72	—	0.92	—	0.76	—
500	0.58	-21.6	1.00	38.9	0.86	-6.5	1.00	31.6
750	0.65	-12.2	0.82	13.9	1.02	10.9	0.89	17.1
1,000	0.69	-6.8	0.80	11.1	1.00	8.7	0.76	0.0
1,250	0.68	-8.1	0.73	1.4	1.00	8.7	0.73	-3.9
1,500	0.62	-16.2	0.68	-5.6	1.03	12.0	0.72	-5.3
1,750	0.73	-1.4	0.69	-4.2	0.98	6.5	0.72	-5.3
2,000	0.72	-2.7	0.70	-2.8	0.96	4.3	0.76	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 4 - 17.20 W.S.E.	Reach 4 - 17.20 Change in W.S.E.	Reach 4 - 17.17 W.S.E.	Reach 4 - 17.17 Change in W.S.E.	Reach 4 - 17.14 W.S.E.	Reach 4 - 17.14 Change in W.S.E.	Reach 4 - 17.10 W.S.E.	Reach 4 - 17.10 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,160.51	—	1,160.01	—	1,158.95	—	1,157.86	—
500	1,162.20	1.69	1,160.50	0.49	1,159.93	0.98	1,158.85	0.99
750	1,161.65	1.14	1,160.73	0.72	1,159.41	0.46	1,158.68	0.82
1,000	1,161.39	0.88	1,160.59	0.58	1,159.32	0.37	1,158.59	0.73
1,250	1,161.25	0.74	1,160.65	0.64	1,159.38	0.43	1,158.53	0.67
1,500	1,161.25	0.74	1,160.74	0.73	1,159.40	0.45	1,158.51	0.65
1,750	1,160.93	0.42	1,160.47	0.46	1,159.24	0.29	1,158.47	0.61
2,000	1,160.90	0.39	1,160.40	0.39	1,159.23	0.28	1,157.86	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5-16

Summary of Hydraulic Parameters, 100-Year Event

Camelback Road Bridge at RM 14.81

Change in Velocity

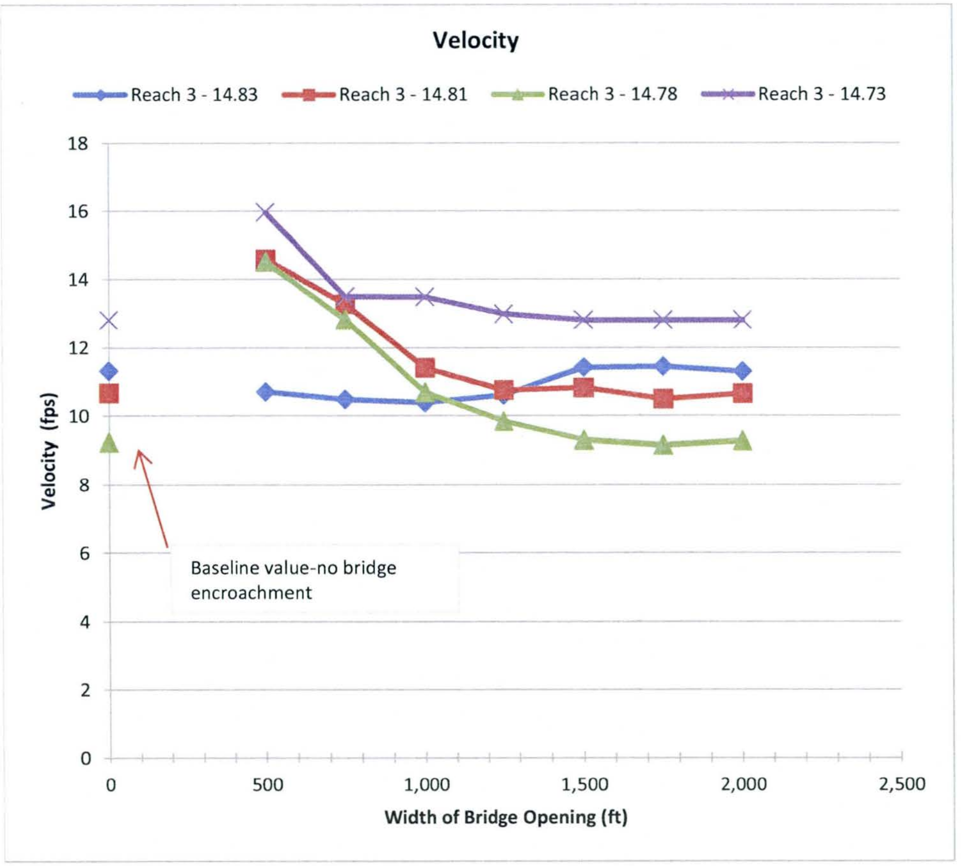
Bridge Opening Width	Reach 3 - 14.83		Reach 3 - 14.81		Reach 3 - 14.78		Reach 3 - 14.73	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	11.32	—	10.68	—	9.25	—	12.82	—
500	10.71	-5.4	14.60	36.7	14.52	57.0	15.98	24.6
750	10.49	-7.3	13.29	24.4	12.83	38.7	13.51	5.4
1,000	10.39	-8.2	11.41	6.8	10.70	15.7	13.50	5.3
1,250	10.61	-6.3	10.76	0.7	9.85	6.5	13.00	1.4
1,500	11.42	0.9	10.83	1.4	9.31	0.6	12.82	0.0
1,750	11.45	1.1	10.50	-1.7	9.16	-1.0	12.82	0.0
2,000	11.30	-0.2	10.66	-0.2	9.29	0.4	12.82	0.0

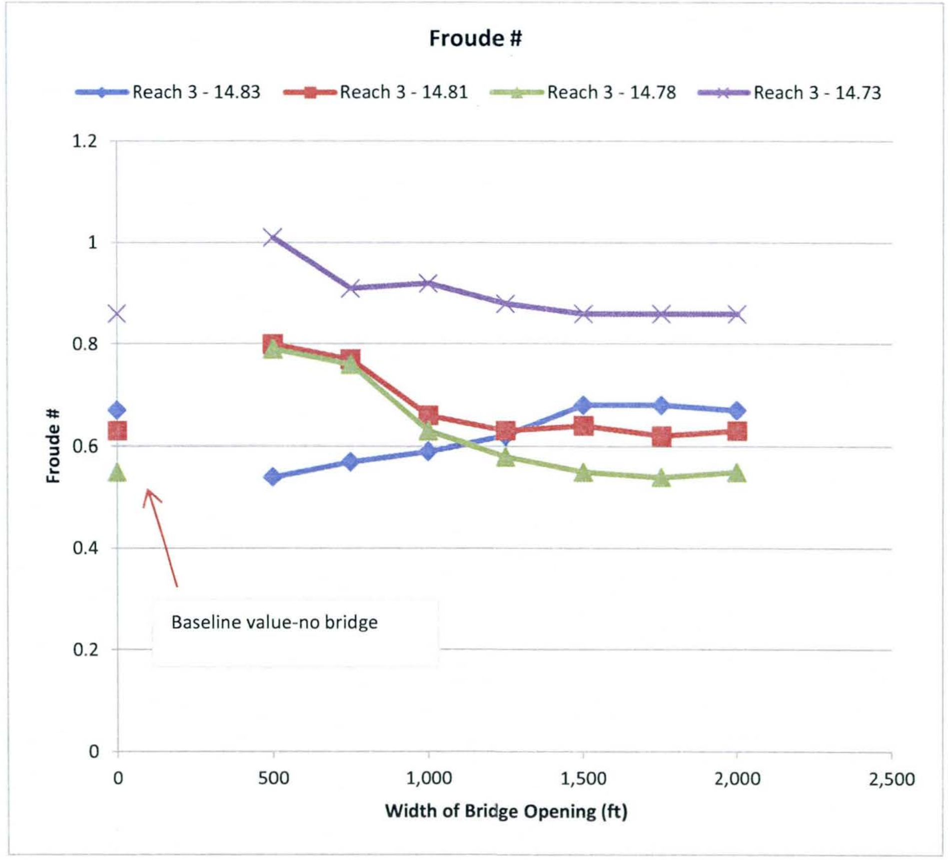
Change in Froude #

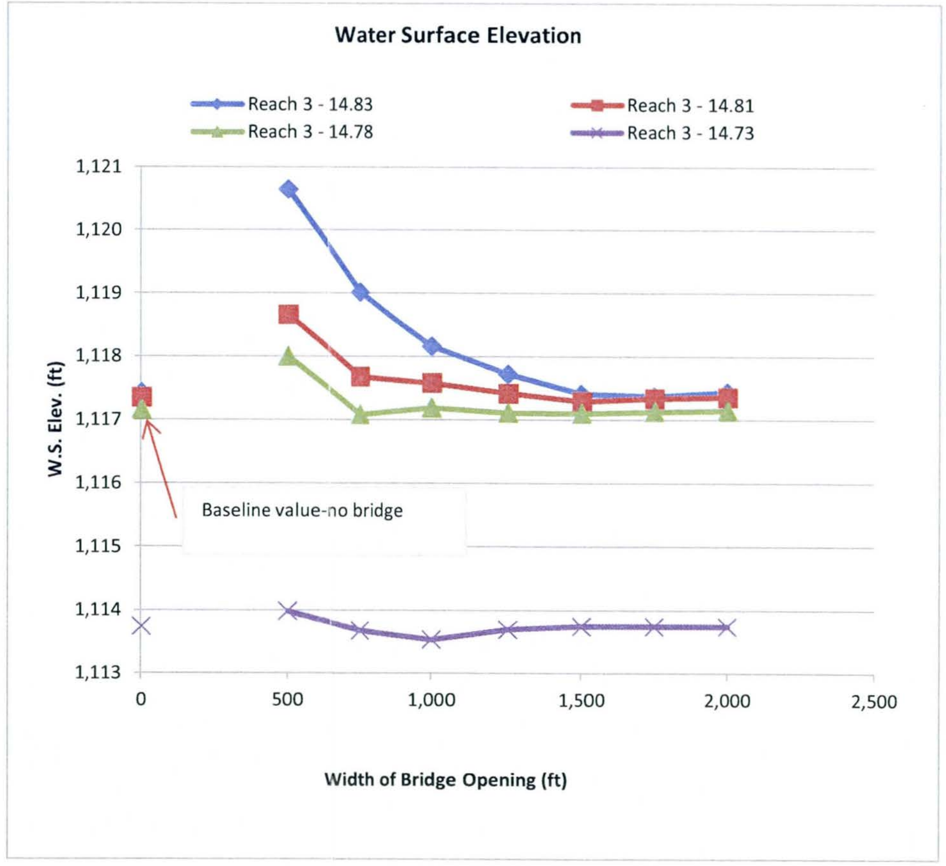
Bridge Opening Width	Reach 3 - 14.83		Reach 3 - 14.81		Reach 3 - 14.78		Reach 3 - 14.73	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.67	—	0.63	—	0.55	—	0.86	—
500	0.54	-19.4	0.80	27.0	0.79	43.6	1.01	17.4
750	0.57	-14.9	0.77	22.2	0.76	38.2	0.91	5.8
1,000	0.59	-11.9	0.66	4.8	0.63	14.5	0.92	7.0
1,250	0.62	-7.5	0.63	0.0	0.58	5.5	0.88	2.3
1,500	0.68	1.5	0.64	1.6	0.55	0.0	0.86	0.0
1,750	0.68	1.5	0.62	-1.6	0.54	-1.8	0.86	0.0
2,000	0.67	0.0	0.63	0.0	0.55	0.0	0.86	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 3 - 14.83		Reach 3 - 14.81		Reach 3 - 14.78		Reach 3 - 14.73	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,117.43	—	1,117.35	—	1,117.16	—	1,113.74	—
500	1,120.64	3.21	1,118.66	1.31	1,118.00	0.84	1,113.98	0.24
750	1,119.02	1.59	1,117.68	0.33	1,117.08	-0.08	1,113.67	-0.07
1,000	1,118.16	0.73	1,117.58	0.23	1,117.19	0.03	1,113.53	-0.21
1,250	1,117.72	0.29	1,117.42	0.07	1,117.11	-0.05	1,113.69	-0.05
1,500	1,117.41	-0.02	1,117.29	-0.06	1,117.10	-0.06	1,113.74	0.00
1,750	1,117.37	-0.06	1,117.34	-0.01	1,117.13	-0.03	1,113.74	0.00
2,000	1,117.44	0.01	1,117.36	0.01	1,117.15	-0.01	1,113.74	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–17
Summary of Hydraulic Parameters, 10-Year Event
Camelback Road Bridge at RM 14.81

Change in Velocity

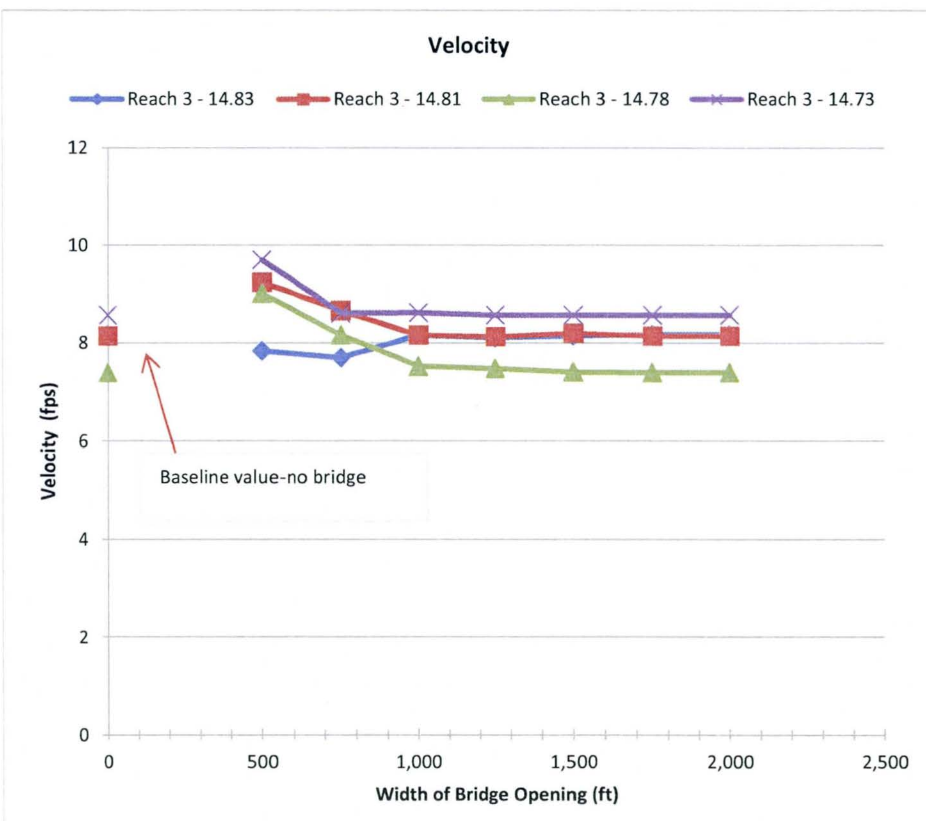
Bridge Opening Width	Reach 3 - 14.83 Velocity	Reach 3 - 14.83 Percent Change	Reach 3 - 14.81 Velocity	Reach 3 - 14.81 Percent Change	Reach 3 - 14.78 Velocity	Reach 3 - 14.78 Percent Change	Reach 3 - 14.73 Velocity	Reach 3 - 14.73 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	8.18	—	8.15	—	7.4	—	8.58	—
500	7.84	-4.2	9.25	13.5	9.02	21.9	9.71	13.2
750	7.70	-5.9	8.67	6.4	8.17	10.4	8.62	0.5
1,000	8.16	-0.2	8.17	0.2	7.53	1.8	8.63	0.6
1,250	8.11	-0.9	8.14	-0.1	7.48	1.1	8.58	0.0
1,500	8.15	-0.4	8.21	0.7	7.41	0.1	8.58	0.0
1,750	8.18	0.0	8.15	0.0	7.40	0.0	8.58	0.0
2,000	8.18	0.0	8.15	0.0	7.40	0.0	8.58	0.0

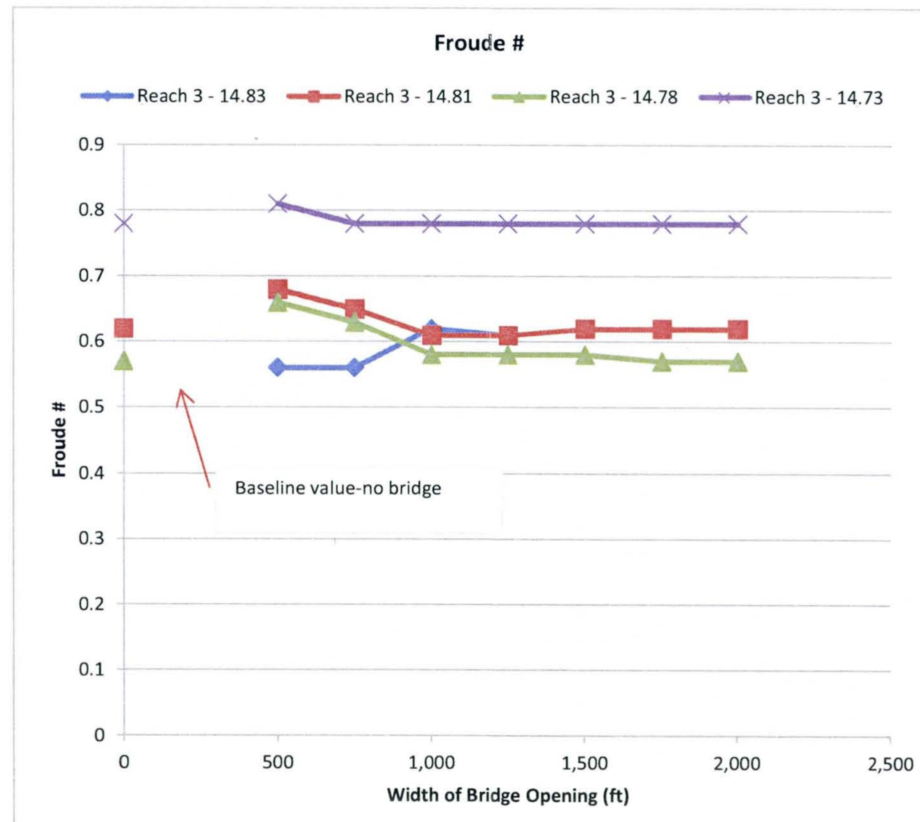
Change in Froude #

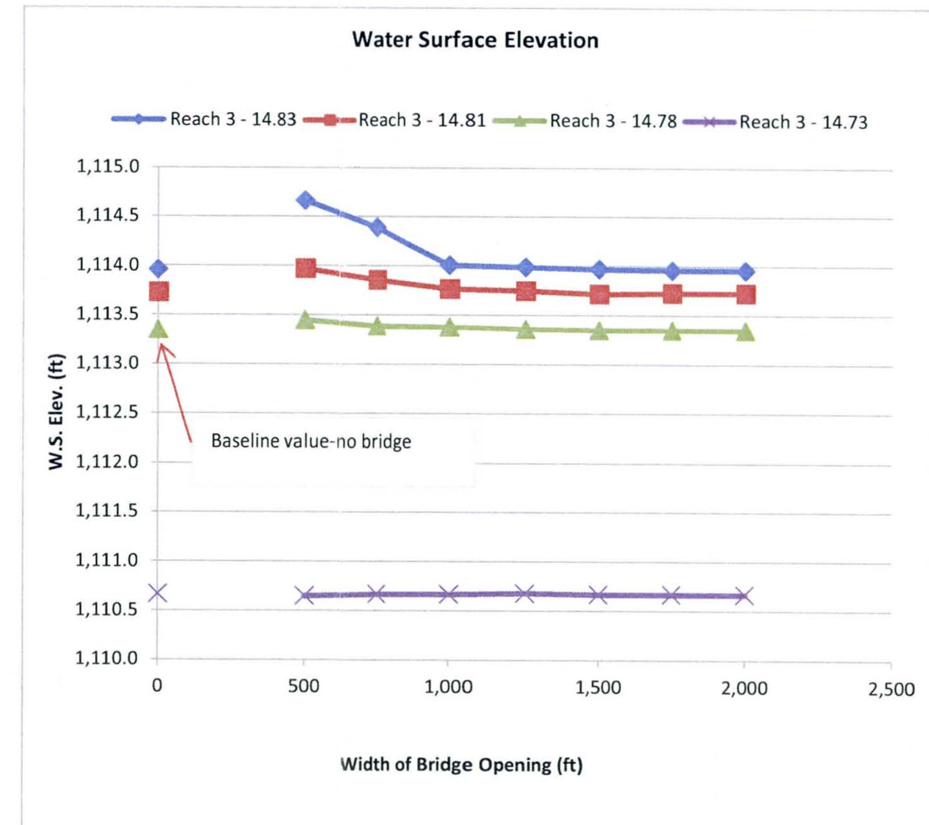
Bridge Opening Width	Reach 3 - 14.83 Froude #	Reach 3 - 14.83 Percent Change	Reach 3 - 14.81 Froude #	Reach 3 - 14.81 Percent Change	Reach 3 - 14.78 Froude #	Reach 3 - 14.78 Percent Change	Reach 3 - 14.73 Froude #	Reach 3 - 14.73 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.62	—	0.62	—	0.57	—	0.78	—
500	0.56	-9.7	0.68	9.7	0.66	15.8	0.81	3.8
750	0.56	-9.7	0.65	4.8	0.63	10.5	0.78	0.0
1,000	0.62	0.0	0.61	-1.6	0.58	1.8	0.78	0.0
1,250	0.61	-1.6	0.61	-1.6	0.58	1.8	0.78	0.0
1,500	0.62	0.0	0.62	0.0	0.58	1.8	0.78	0.0
1,750	0.62	0.0	0.62	0.0	0.57	0.0	0.78	0.0
2,000	0.62	0.0	0.62	0.0	0.57	0.0	0.78	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 3 - 14.83 W.S.E.	Reach 3 - 14.83 Change in W.S.E.	Reach 3 - 14.81 W.S.E.	Reach 3 - 14.81 Change in W.S.E.	Reach 3 - 14.78 W.S.E.	Reach 3 - 14.78 Change in W.S.E.	Reach 3 - 14.73 W.S.E.	Reach 3 - 14.73 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,113.96	—	1,113.73	—	1,113.35	—	1,110.67	—
500	1,114.66	0.70	1,113.97	0.24	1,113.45	0.10	1,110.65	-0.02
750	1,114.39	0.43	1,113.86	0.13	1,113.39	0.04	1,110.67	0.00
1,000	1,114.01	0.05	1,113.77	0.04	1,113.38	0.03	1,110.67	0.00
1,250	1,113.99	0.03	1,113.75	0.02	1,113.36	0.01	1,110.68	0.01
1,500	1,113.97	0.01	1,113.72	-0.01	1,113.35	0.00	1,110.67	0.00
1,750	1,113.96	0.00	1,113.73	0.00	1,113.35	0.00	1,110.67	0.00
2,000	1,113.96	0.00	1,113.73	0.00	1,113.35	0.00	1,110.67	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–18
Summary of Hydraulic Parameters, 100-Year Event
Indian School Road Bridge at RM 13.78

Change in Velocity

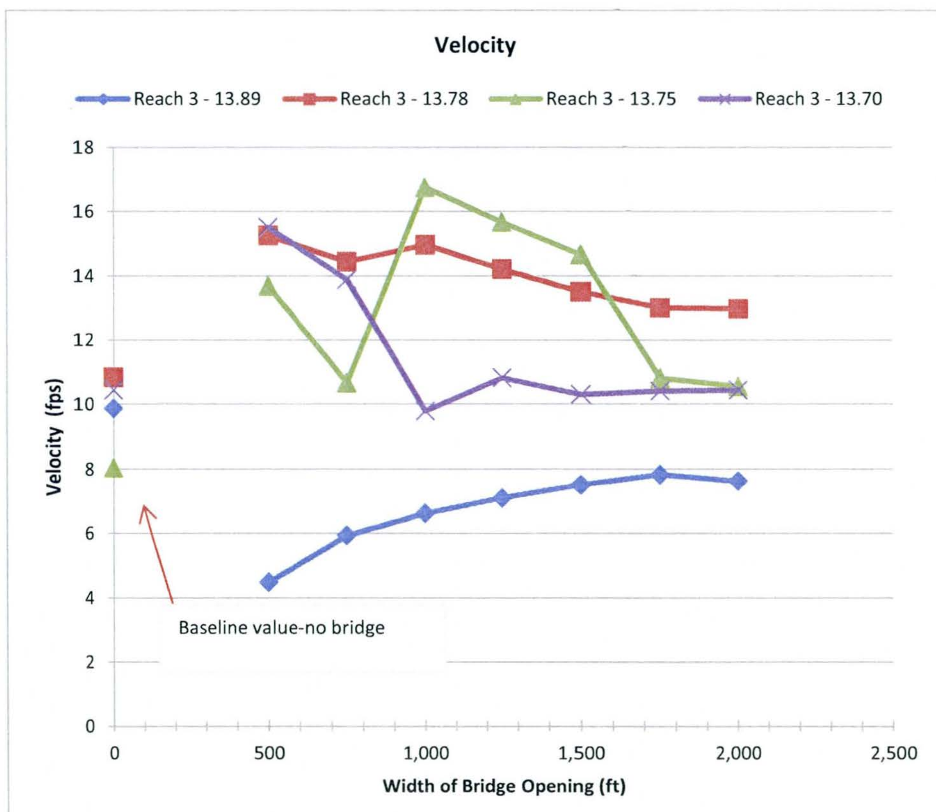
Bridge Opening Width	Reach 3 - 13.89		Reach 3 - 13.78		Reach 3 - 13.75		Reach 3 - 13.70	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	9.88	—	10.85	—	8.06	—	10.45	—
500	4.49	-54.6	15.26	40.6	13.69	69.9	15.51	48.4
750	5.94	-39.9	14.45	33.2	10.67	32.4	13.89	32.9
1,000	6.63	-32.9	14.98	38.1	16.76	107.9	9.80	-6.2
1,250	7.11	-28.0	14.22	31.1	15.68	94.5	10.83	3.6
1,500	7.52	-23.9	13.52	24.6	14.67	82.0	10.31	-1.3
1,750	7.84	-20.6	13.02	20.0	10.82	34.2	10.42	-0.3
2,000	7.63	-22.8	12.99	19.7	10.56	31.0	10.45	0.0

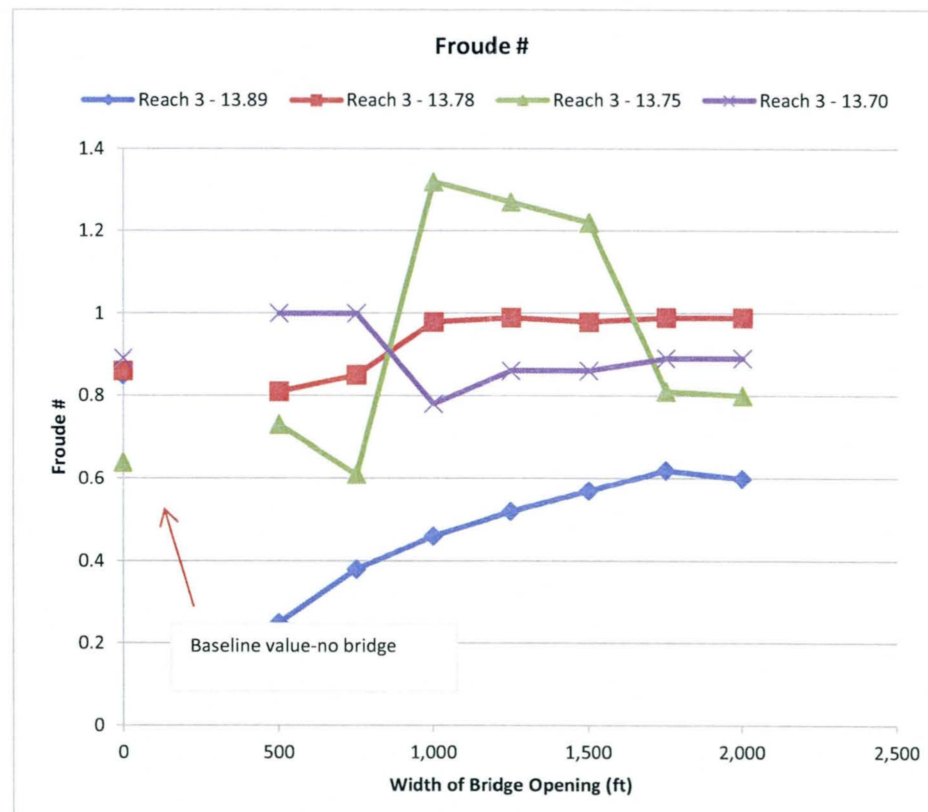
Change in Froude #

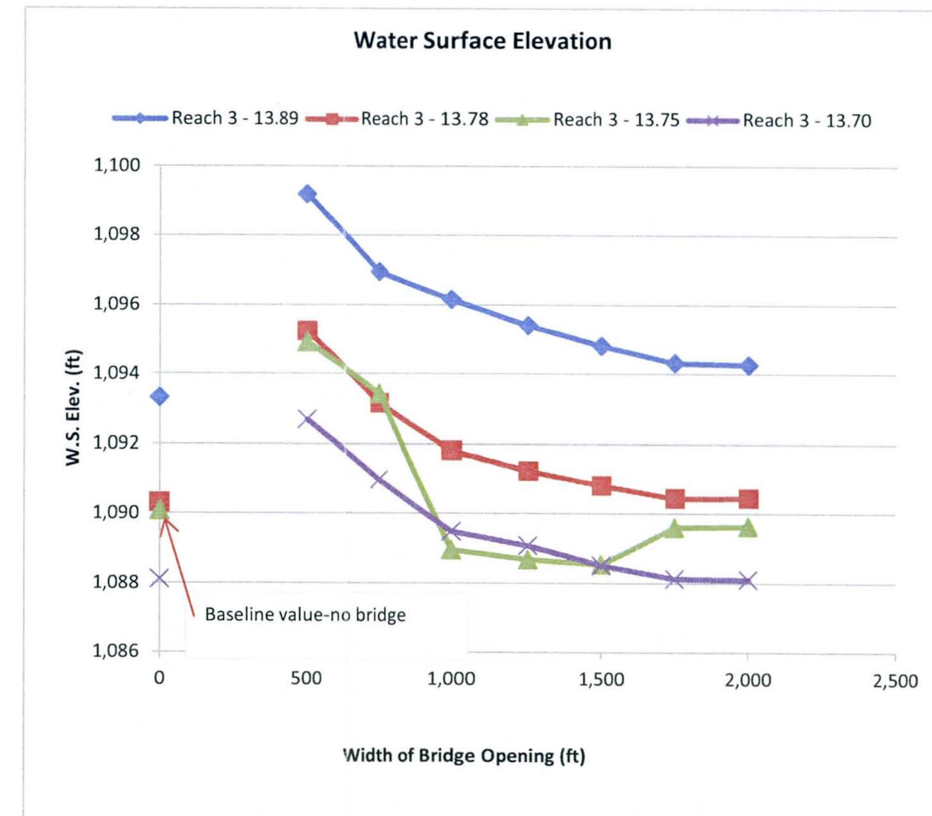
Bridge Opening Width	Reach 3 - 13.89		Reach 3 - 13.78		Reach 3 - 13.75		Reach 3 - 13.70	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.85	—	0.86	—	0.64	—	0.89	—
500	0.25	-70.6	0.81	-5.8	0.73	14.1	1.00	12.4
750	0.38	-55.3	0.85	-1.2	0.61	-4.7	1.00	12.4
1,000	0.46	-45.9	0.98	14.0	1.32	106.3	0.78	-12.4
1,250	0.52	-38.8	0.99	15.1	1.27	98.4	0.86	-3.4
1,500	0.57	-32.9	0.98	14.0	1.22	90.6	0.86	-3.4
1,750	0.62	-27.1	0.99	15.1	0.81	26.6	0.89	0.0
2,000	0.60	-29.4	0.99	15.1	0.80	25.0	0.89	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 3 - 13.89		Reach 3 - 13.78		Reach 3 - 13.75		Reach 3 - 13.70	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,093.32	—	1,090.32	—	1,090.08	—	1,088.11	—
500	1,099.18	5.86	1,095.24	4.92	1,094.92	4.84	1,092.69	4.58
750	1,096.94	3.62	1,093.16	2.84	1,093.44	3.36	1,090.97	2.86
1,000	1,096.15	2.83	1,091.81	1.49	1,088.96	-1.12	1,089.49	1.38
1,250	1,095.40	2.08	1,091.23	0.91	1,088.68	-1.40	1,089.08	0.97
1,500	1,094.81	1.49	1,090.81	0.49	1,088.54	-1.54	1,088.51	0.40
1,750	1,094.32	1.00	1,090.44	0.12	1,089.61	-0.47	1,088.13	0.02
2,000	1,094.27	0.95	1,090.45	0.13	1,089.64	-0.44	1,088.11	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–19

Summary of Hydraulic Parameters, 10-Year Event

Indian School Road Bridge at RM 13.78

Change in Velocity

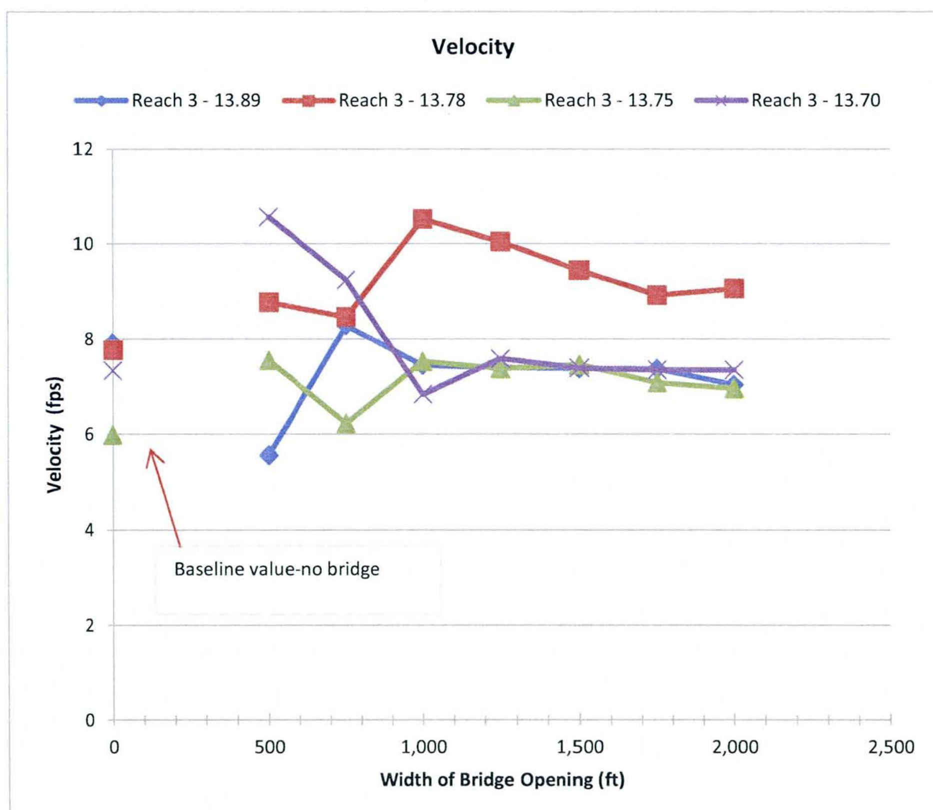
Bridge Opening Width	Reach 3 - 13.89 Velocity	Reach 3 - 13.89 Percent Change	Reach 3 - 13.78 Velocity	Reach 3 - 13.78 Percent Change	Reach 3 - 13.75 Velocity	Reach 3 - 13.75 Percent Change	Reach 3 - 13.70 Velocity	Reach 3 - 13.70 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	7.92	—	7.77	—	5.99	—	7.34	—
500	5.57	-29.7	8.78	13.0	7.55	26.0	10.57	44.0
750	8.29	4.7	8.47	9.0	6.23	4.0	9.25	26.0
1,000	7.45	-5.9	10.53	35.5	7.53	25.7	6.84	-6.8
1,250	7.40	-6.6	10.05	29.3	7.38	23.2	7.59	3.4
1,500	7.38	-6.8	9.45	21.6	7.46	24.5	7.39	0.7
1,750	7.37	-6.9	8.93	14.9	7.08	18.2	7.35	0.1
2,000	7.04	-11.1	9.07	16.7	6.96	16.2	7.35	0.1

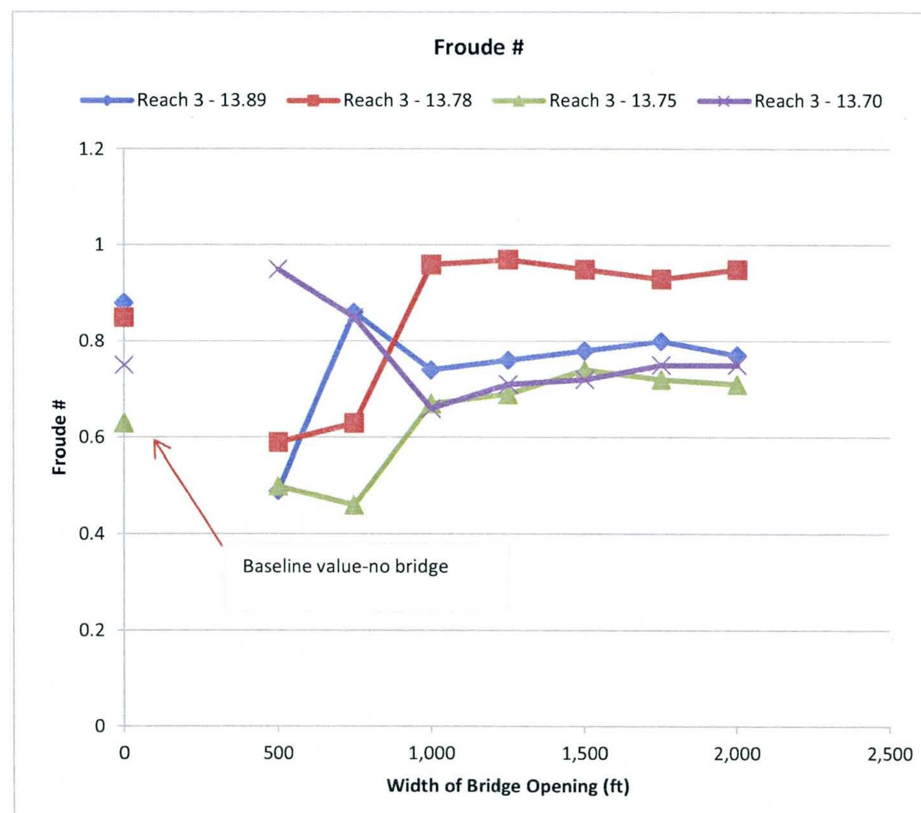
Change in Froude

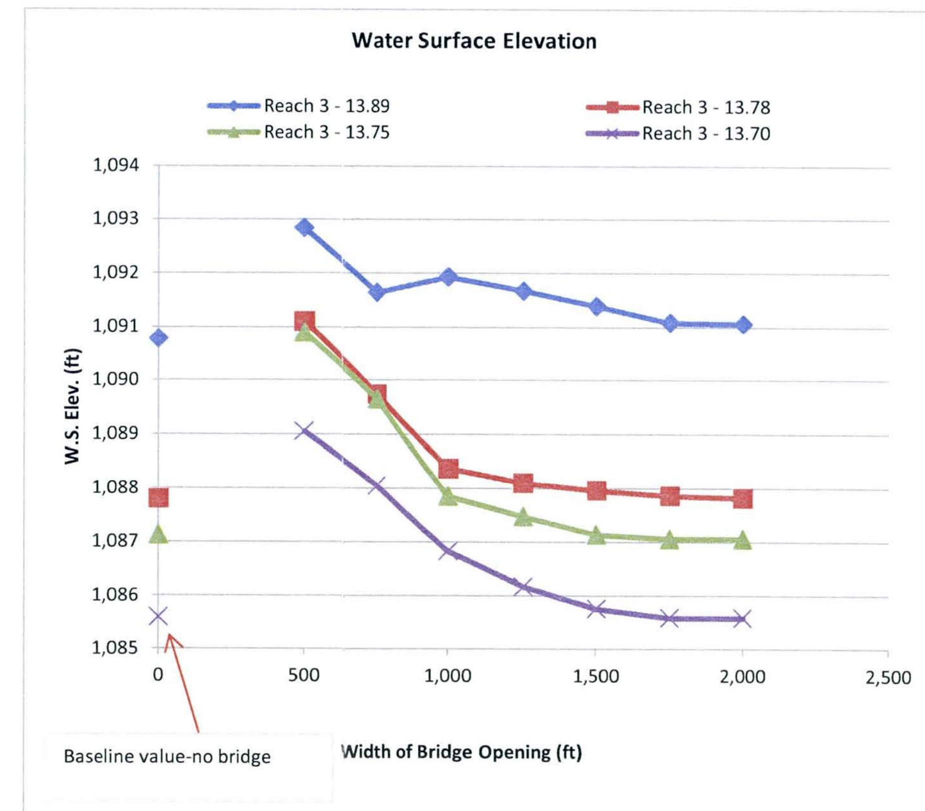
Bridge Opening Width	Reach 3 - 13.89 Froude #	Reach 3 - 13.89 Percent Change	Reach 3 - 13.78 Froude #	Reach 3 - 13.78 Percent Change	Reach 3 - 13.75 Froude #	Reach 3 - 13.75 Percent Change	Reach 3 - 13.70 Froude #	Reach 3 - 13.70 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.88	—	0.85	—	0.63	—	0.75	—
500	0.49	-44.3	0.59	-30.6	0.50	-20.6	0.95	26.7
750	0.86	-2.3	0.63	-25.9	0.46	-27.0	0.85	13.3
1,000	0.74	-15.9	0.96	12.9	0.67	6.3	0.66	-12.0
1,250	0.76	-13.6	0.97	14.1	0.69	9.5	0.71	-5.3
1,500	0.78	-11.4	0.95	11.8	0.74	17.5	0.72	-4.0
1,750	0.80	-9.1	0.93	9.4	0.72	14.3	0.75	0.0
2,000	0.77	-12.5	0.95	11.8	0.71	12.7	0.75	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 3 - 13.89 W.S.E.	Reach 3 - 13.89 Change in W.S.E.	Reach 3 - 13.78 W.S.E.	Reach 3 - 13.78 Change in W.S.E.	Reach 3 - 13.75 W.S.E.	Reach 3 - 13.75 Change in W.S.E.	Reach 3 - 13.70 W.S.E.	Reach 3 - 13.70 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,090.77	—	1,087.80	—	1,087.13	—	1,085.60	—
500	1,092.84	2.07	1,091.10	3.30	1,090.89	3.76	1,089.05	3.45
750	1,091.64	0.87	1,089.74	1.94	1,089.65	2.52	1,088.05	2.45
1,000	1,091.93	1.16	1,088.37	0.57	1,087.85	0.72	1,086.83	1.23
1,250	1,091.67	0.90	1,088.10	0.30	1,087.47	0.34	1,086.17	0.57
1,500	1,091.39	0.62	1,087.96	0.16	1,087.14	0.01	1,085.76	0.16
1,750	1,091.08	0.31	1,087.86	0.06	1,087.06	-0.07	1,085.59	-0.01
2,000	1,091.06	0.29	1,087.82	0.02	1,087.06	-0.07	1,085.59	-0.01







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–20

Summary of Hydraulic Parameters, 100-Year Event

McDowell Parkway Bridge at RM 13.06

Change in Velocity

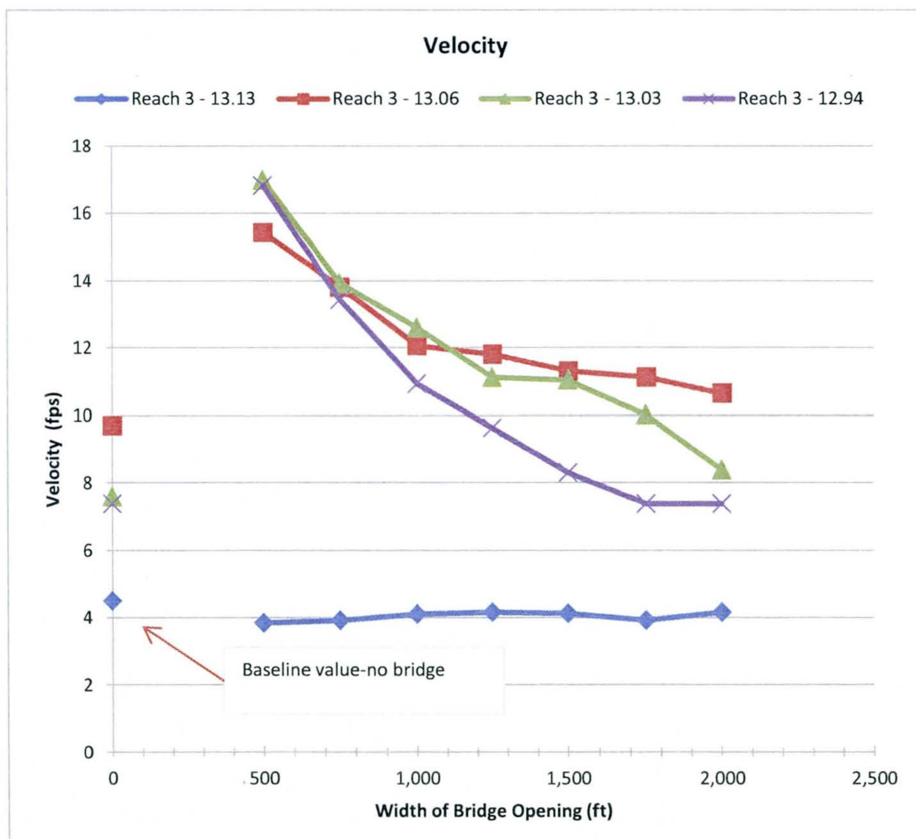
Bridge Opening Width	Reach 3 - 13.13 Velocity	Reach 3 - 13.13 Percent Change	Reach 3 - 13.06 Velocity	Reach 3 - 13.06 Percent Change	Reach 3 - 13.03 Velocity	Reach 3 - 13.03 Percent Change	Reach 3 - 12.94 Velocity	Reach 3 - 12.94 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	4.51	—	9.72	—	7.6	—	7.39	—
500	3.85	-14.6	15.44	58.8	16.99	123.6	16.82	127.6
750	3.92	-13.1	13.82	42.2	13.93	83.3	13.43	81.7
1,000	4.11	-8.9	12.07	24.2	12.60	65.8	10.94	48.0
1,250	4.16	-7.8	11.82	21.6	11.13	46.4	9.64	30.4
1,500	4.13	-8.4	11.32	16.5	11.05	45.4	8.31	12.4
1,750	3.92	-13.1	11.14	14.6	10.03	32.0	7.39	0.0
2,000	4.16	-7.8	10.66	9.7	8.39	10.4	7.39	0.0

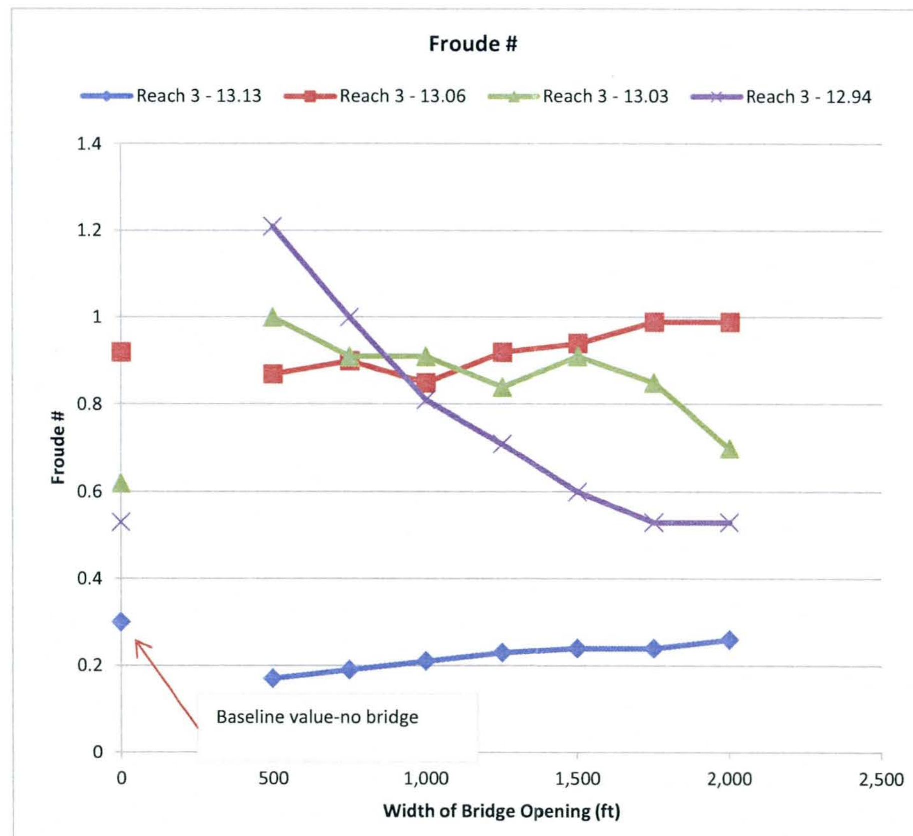
Change in Froude #

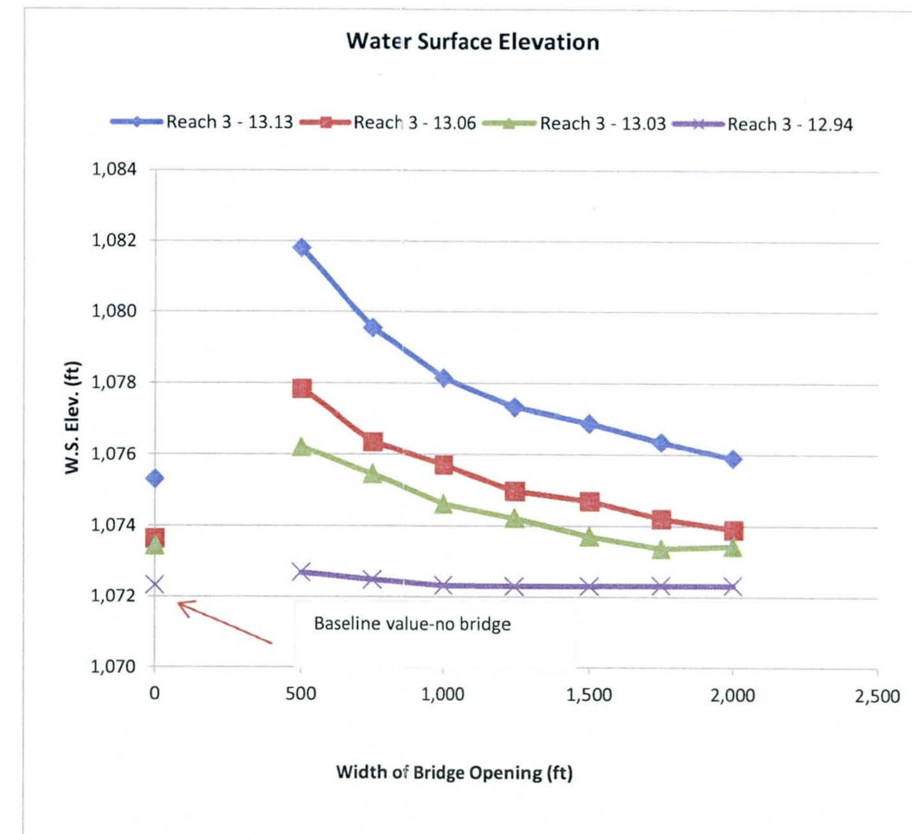
Bridge Opening Width	Reach 3 - 13.13 Froude #	Reach 3 - 13.13 Percent Change	Reach 3 - 13.06 Froude #	Reach 3 - 13.06 Percent Change	Reach 3 - 13.03 Froude #	Reach 3 - 13.03 Percent Change	Reach 3 - 12.94 Froude #	Reach 3 - 12.94 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.30	—	0.92	—	0.62	—	0.53	—
500	0.17	-43.3	0.87	-5.4	1.00	61.3	1.21	128.3
750	0.19	-36.7	0.90	-2.2	0.91	46.8	1.00	88.7
1,000	0.21	-30.0	0.85	-7.6	0.91	46.8	0.81	52.8
1,250	0.23	-23.3	0.92	0.0	0.84	35.5	0.71	34.0
1,500	0.24	-20.0	0.94	2.2	0.91	46.8	0.60	13.2
1,750	0.24	-20.0	0.99	7.6	0.85	37.1	0.53	0.0
2,000	0.26	-13.3	0.99	7.6	0.70	12.9	0.53	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 3 - 13.13 W.S.E.	Reach 3 - 13.13 Change in W.S.E.	Reach 3 - 13.06 W.S.E.	Reach 3 - 13.06 Change in W.S.E.	Reach 3 - 13.03 W.S.E.	Reach 3 - 13.03 Change in W.S.E.	Reach 3 - 12.94 W.S.E.	Reach 3 - 12.94 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,075.31	—	1,073.64	—	1,073.44	—	1,072.33	—
500	1,081.81	6.50	1,077.85	4.21	1,076.22	2.78	1,072.69	0.36
750	1,079.55	4.24	1,076.36	2.72	1,075.46	2.02	1,072.49	0.16
1,000	1,078.15	2.84	1,075.72	2.08	1,074.62	1.18	1,072.33	0.00
1,250	1,077.34	2.03	1,074.98	1.34	1,074.22	0.78	1,072.31	-0.02
1,500	1,076.89	1.58	1,074.70	1.06	1,073.71	0.27	1,072.32	-0.01
1,750	1,076.36	1.05	1,074.21	0.57	1,073.37	-0.07	1,072.33	0.00
2,000	1,075.90	0.59	1,073.91	0.27	1,073.43	-0.01	1,072.33	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–21

Summary of Hydraulic Parameters, 10-Year Event

McDowell Parkway Bridge at RM 13.06

Change in Velocity

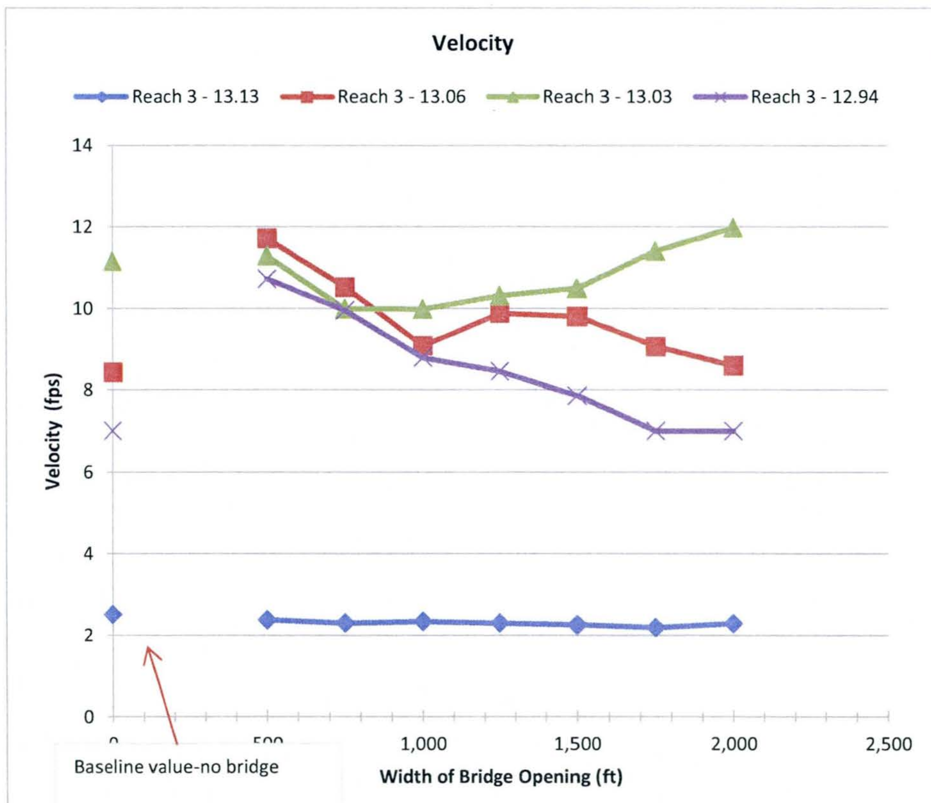
Bridge Opening Width	Reach 3 - 13.13 Velocity	Reach 3 - 13.13 Percent Change	Reach 3 - 13.06 Velocity	Reach 3 - 13.06 Percent Change	Reach 3 - 13.03 Velocity	Reach 3 - 13.03 Percent Change	Reach 3 - 12.94 Velocity	Reach 3 - 12.94 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	2.52	—	8.43	—	11.16	—	7	—
500	2.39	-5.2	11.72	39.0	11.29	1.2	10.73	53.3
750	2.31	-8.3	10.53	24.9	10.00	-10.4	9.96	42.3
1,000	2.35	-6.7	9.09	7.8	9.99	-10.5	8.79	25.6
1,250	2.31	-8.3	9.89	17.3	10.32	-7.5	8.46	20.9
1,500	2.27	-9.9	9.81	16.4	10.50	-5.9	7.86	12.3
1,750	2.20	-12.7	9.07	7.6	11.41	2.2	7.00	0.0
2,000	2.30	-8.7	8.60	2.0	11.98	7.3	7.00	0.0

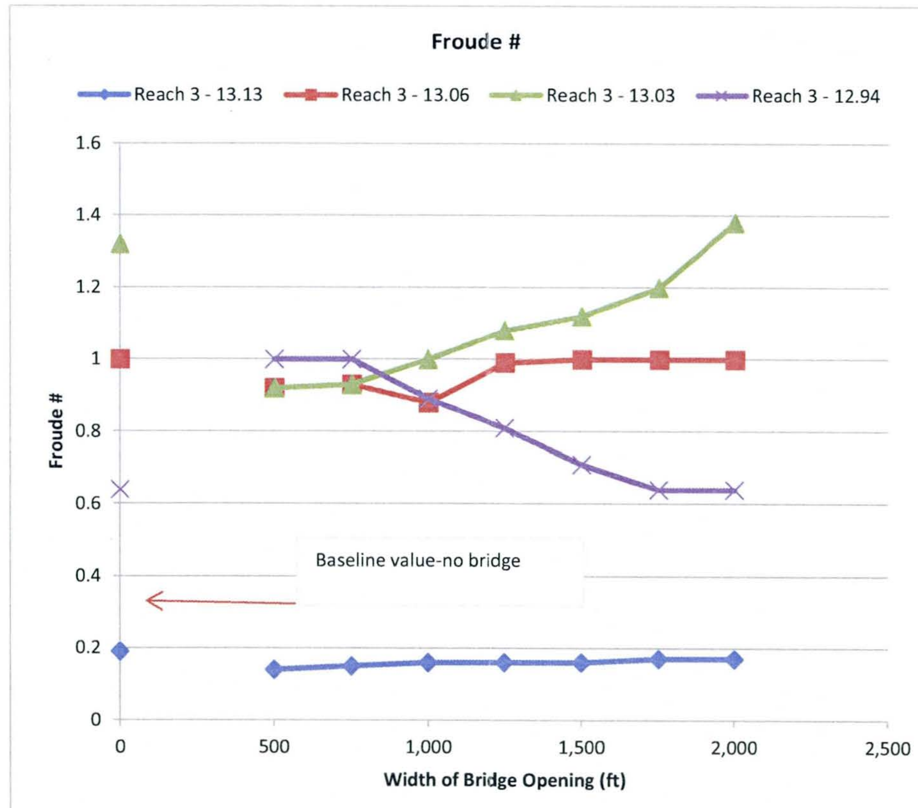
Change in Froude #

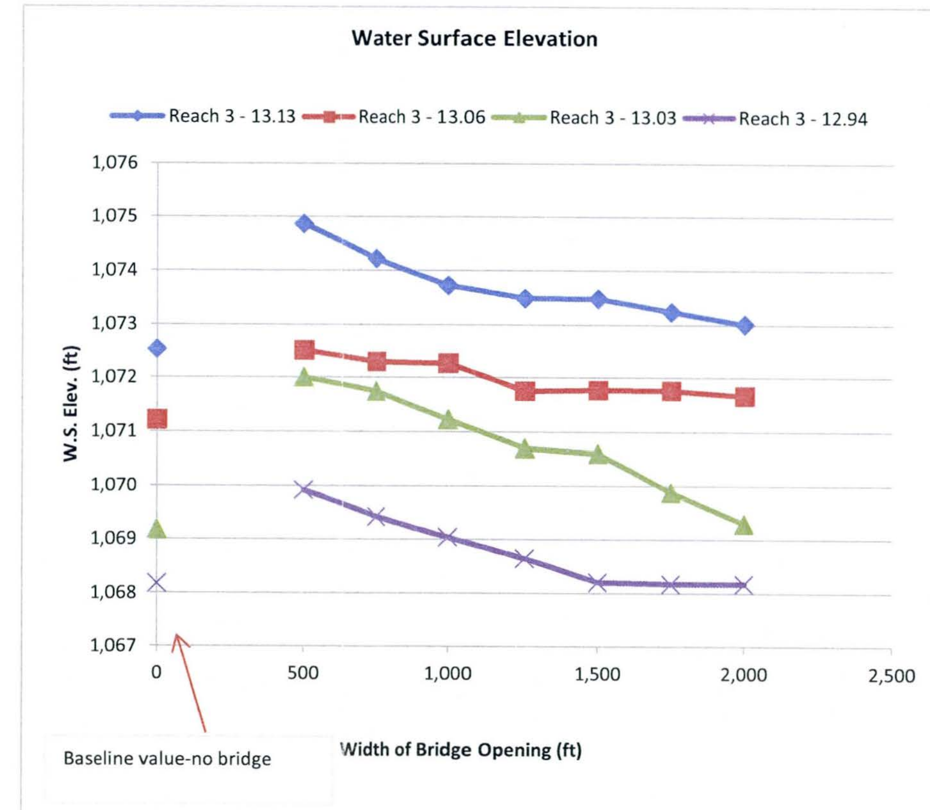
Bridge Opening Width	Reach 3 - 13.13 Froude #	Reach 3 - 13.13 Percent Change	Reach 3 - 13.06 Froude #	Reach 3 - 13.06 Percent Change	Reach 3 - 13.03 Froude #	Reach 3 - 13.03 Percent Change	Reach 3 - 12.94 Froude #	Reach 3 - 12.94 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.19	—	1.00	—	1.32	—	0.64	—
500	0.14	-26.3	0.92	-8.0	0.92	-30.3	1.00	56.3
750	0.15	-21.1	0.93	-7.0	0.93	-29.5	1.00	56.3
1,000	0.16	-15.8	0.88	-12.0	1.00	-24.2	0.89	39.1
1,250	0.16	-15.8	0.99	-1.0	1.08	-18.2	0.81	26.6
1,500	0.16	-15.8	1.00	0.0	1.12	-15.2	0.71	10.9
1,750	0.17	-10.5	1.00	0.0	1.20	-9.1	0.64	0.0
2,000	0.17	-10.5	1.00	0.0	1.38	4.5	0.64	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 3 - 13.13 W.S.E.	Reach 3 - 13.13 Change in W.S.E.	Reach 3 - 13.06 W.S.E.	Reach 3 - 13.06 Change in W.S.E.	Reach 3 - 13.03 W.S.E.	Reach 3 - 13.03 Change in W.S.E.	Reach 3 - 12.94 W.S.E.	Reach 3 - 12.94 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	1,072.53	—	1,071.22	—	1,069.18	—	1,068.18	—
500	1,074.87	2.34	1,072.51	1.29	1,072.01	2.83	1,069.92	1.74
750	1,074.22	1.69	1,072.30	1.08	1,071.75	2.57	1,069.42	1.24
1,000	1,073.73	1.20	1,072.27	1.05	1,071.23	2.05	1,069.04	0.86
1,250	1,073.49	0.96	1,071.76	0.54	1,070.70	1.52	1,068.65	0.47
1,500	1,073.48	0.95	1,071.78	0.56	1,070.60	1.42	1,068.21	0.03
1,750	1,073.24	0.71	1,071.77	0.55	1,069.88	0.70	1,068.18	0.00
2,000	1,073.01	0.48	1,071.67	0.45	1,069.30	0.12	1,068.18	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–22

Summary of Hydraulic Parameters, 100-Year Event

Yuma Parkway Bridge at RM 9.41

Change in Velocity

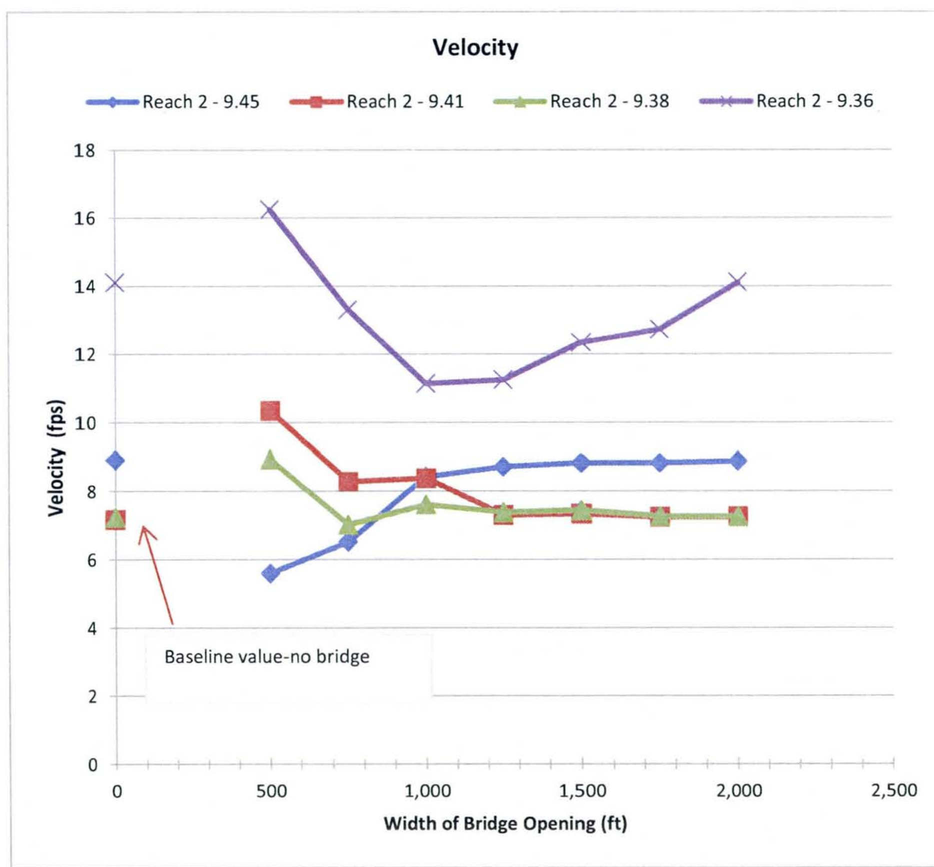
Bridge Opening Width	Reach 2 - 9.45		Reach 2 - 9.41		Reach 2 - 9.38		Reach 2 - 9.36	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	8.93	—	7.18	—	7.25	—	14.13	—
500	5.61	-37.2	10.36	44.3	8.95	23.4	16.26	15.1
750	6.53	-26.9	8.30	15.6	7.03	-3.0	13.32	-5.7
1,000	8.44	-5.5	8.40	17.0	7.62	5.1	11.15	-21.1
1,250	8.73	-2.2	7.31	1.8	7.40	2.1	11.26	-20.3
1,500	8.84	-1.0	7.35	2.4	7.46	2.9	12.36	-12.5
1,750	8.84	-1.0	7.25	1.0	7.28	0.4	12.75	-9.8
2,000	8.89	-0.4	7.26	1.1	7.27	0.3	14.13	0.0

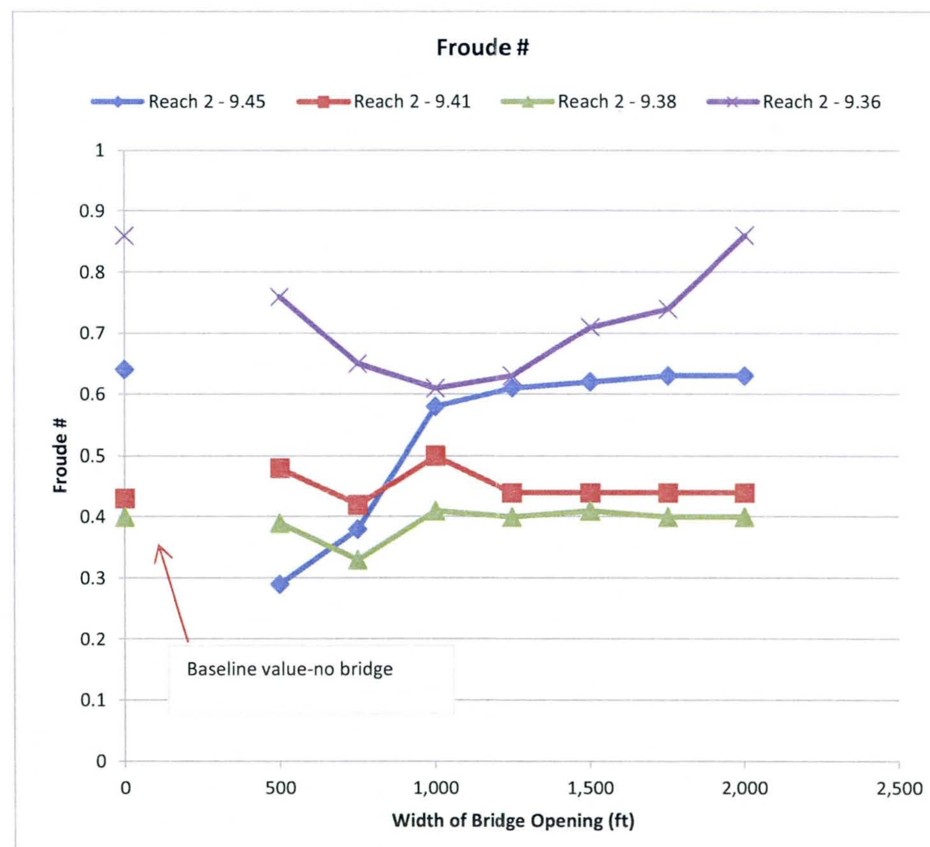
Change in Froude

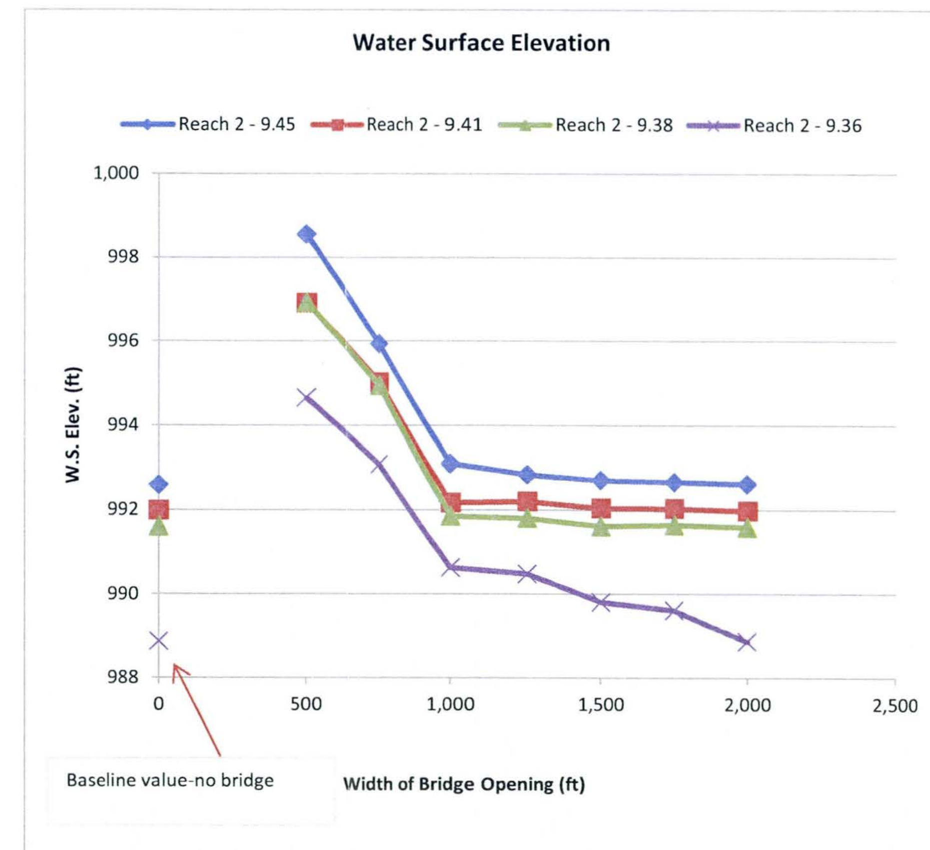
Bridge Opening Width	Reach 2 - 9.45		Reach 2 - 9.41		Reach 2 - 9.38		Reach 2 - 9.36	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.64	—	0.43	—	0.40	—	0.86	—
500	0.29	-54.7	0.48	11.6	0.39	-2.5	0.76	-11.6
750	0.38	-40.6	0.42	-2.3	0.33	-17.5	0.65	-24.4
1,000	0.58	-9.4	0.50	16.3	0.41	2.5	0.61	-29.1
1,250	0.61	-4.7	0.44	2.3	0.40	0.0	0.63	-26.7
1,500	0.62	-3.1	0.44	2.3	0.41	2.5	0.71	-17.4
1,750	0.63	-1.6	0.44	2.3	0.40	0.0	0.74	-14.0
2,000	0.63	-1.6	0.44	2.3	0.40	0.0	0.86	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 9.45		Reach 2 - 9.41		Reach 2 - 9.38		Reach 2 - 9.36	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	992.59	—	991.99	—	991.60	—	988.86	—
500	998.54	5.95	996.91	4.92	996.92	5.32	994.65	5.79
750	995.93	3.34	995.02	3.03	994.94	3.34	993.08	4.22
1,000	993.10	0.51	992.17	0.18	991.85	0.25	990.63	1.77
1,250	992.84	0.25	992.20	0.21	991.80	0.20	990.48	1.62
1,500	992.70	0.11	992.04	0.05	991.61	0.01	989.81	0.95
1,750	992.66	0.07	992.03	0.04	991.64	0.04	989.61	0.75
2,000	992.61	0.02	991.98	-0.01	991.59	-0.01	988.86	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–23
Summary of Hydraulic Parameters, 10-Year Event
Yuma Parkway Bridge at RM 9.41

Change in Velocity

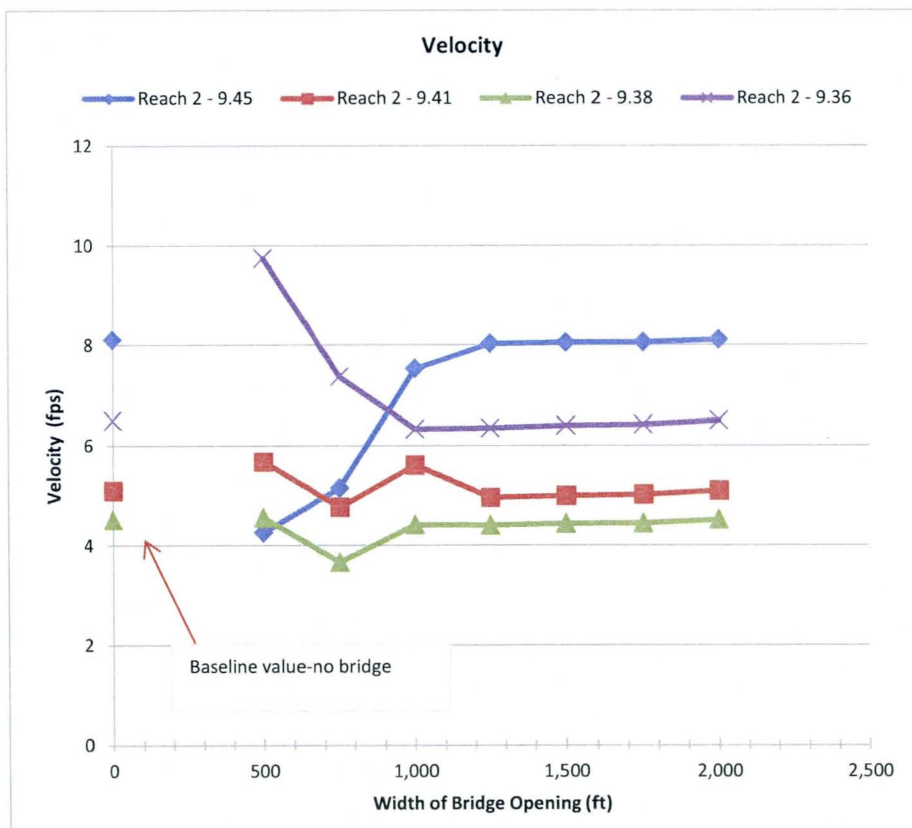
Bridge Opening Width	Reach 2 - 9.45 Velocity	Reach 2 - 9.45 Percent Change	Reach 2 - 9.41 Velocity	Reach 2 - 9.41 Percent Change	Reach 2 - 9.38 Velocity	Reach 2 - 9.38 Percent Change	Reach 2 - 9.36 Velocity	Reach 2 - 9.36 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	8.11	—	5.1	—	4.52	—	6.5	—
500	4.26	-47.5	5.68	11.4	4.56	0.9	9.75	50.0
750	5.15	-36.5	4.77	-6.5	3.67	-18.8	7.37	13.4
1,000	7.53	-7.2	5.61	10.0	4.42	-2.2	6.33	-2.6
1,250	8.03	-1.0	4.96	-2.7	4.41	-2.4	6.35	-2.3
1,500	8.05	-0.7	5.00	-2.0	4.44	-1.8	6.40	-1.5
1,750	8.06	-0.6	5.02	-1.6	4.45	-1.5	6.42	-1.2
2,000	8.11	0.0	5.10	0.0	4.52	0.0	6.50	0.0

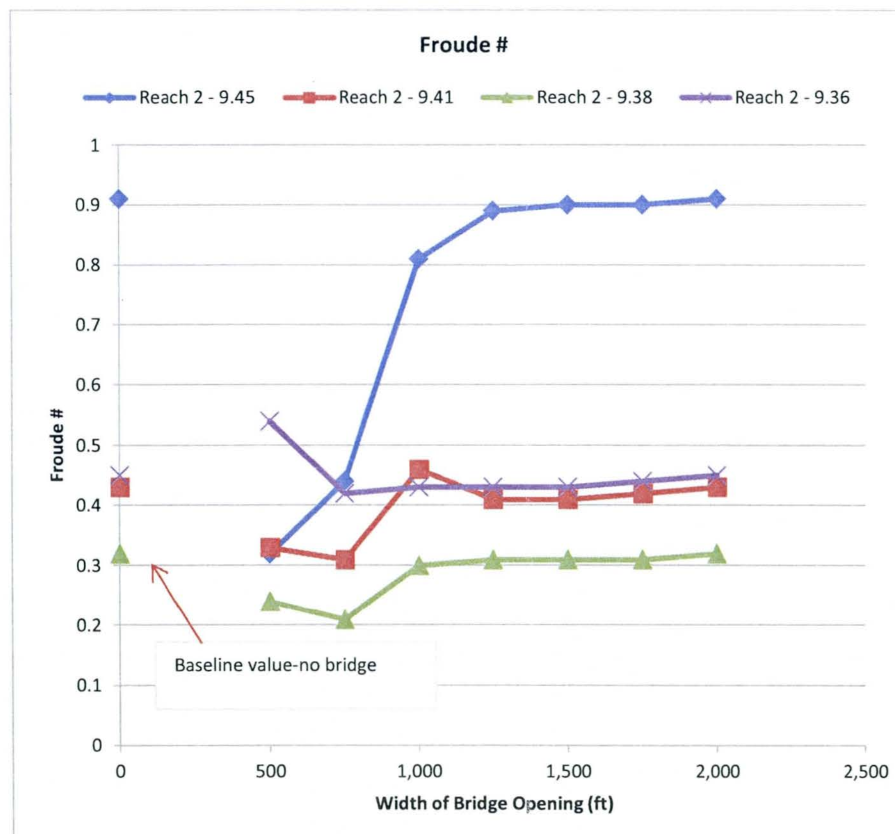
Change in Froude #

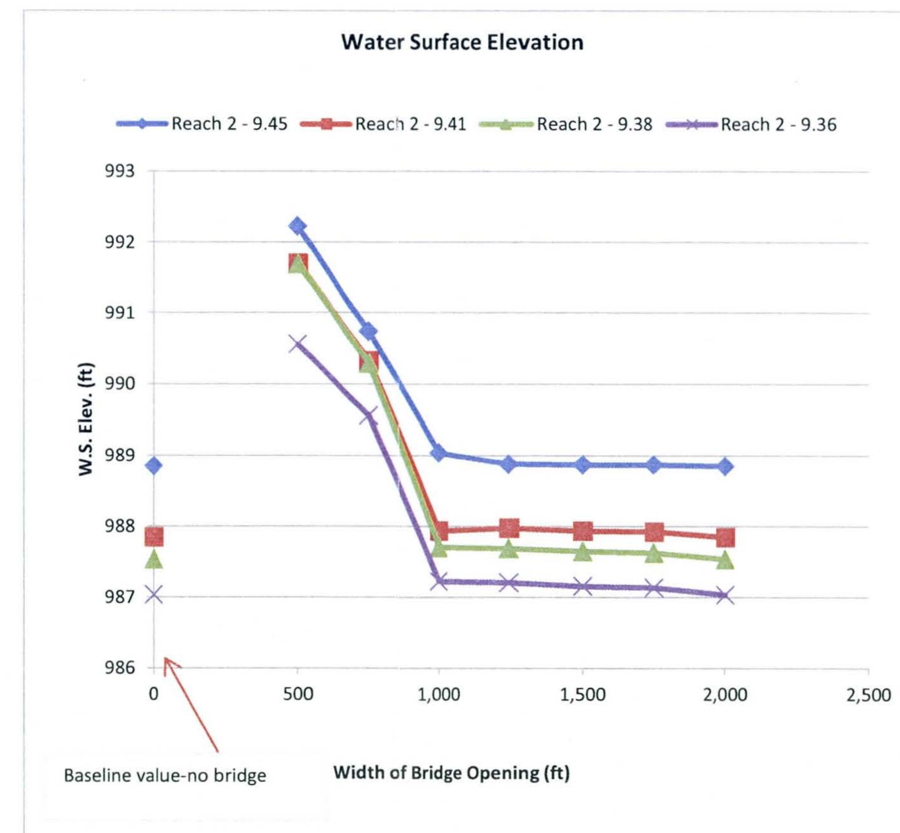
Bridge Opening Width	Reach 2 - 9.45 Froude #	Reach 2 - 9.45 Percent Change	Reach 2 - 9.41 Froude #	Reach 2 - 9.41 Percent Change	Reach 2 - 9.38 Froude #	Reach 2 - 9.38 Percent Change	Reach 2 - 9.36 Froude #	Reach 2 - 9.36 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.91	—	0.43	—	0.32	—	0.45	—
500	0.32	-64.8	0.33	-23.3	0.24	-25.0	0.54	20.0
750	0.44	-51.6	0.31	-27.9	0.21	-34.4	0.42	-6.7
1,000	0.81	-11.0	0.46	7.0	0.30	-6.3	0.43	-4.4
1,250	0.89	-2.2	0.41	-4.7	0.31	-3.1	0.43	-4.4
1,500	0.90	-1.1	0.41	-4.7	0.31	-3.1	0.43	-4.4
1,750	0.90	-1.1	0.42	-2.3	0.31	-3.1	0.44	-2.2
2,000	0.91	0.0	0.43	0.0	0.32	0.0	0.45	0.0

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 9.45 W.S.E.	Reach 2 - 9.45 Change in W.S.E.	Reach 2 - 9.41 W.S.E.	Reach 2 - 9.41 Change in W.S.E.	Reach 2 - 9.38 W.S.E.	Reach 2 - 9.38 Change in W.S.E.	Reach 2 - 9.36 W.S.E.	Reach 2 - 9.36 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	988.85	—	987.85	—	987.54	—	987.04	—
500	992.23	3.38	991.71	3.86	991.70	4.16	990.56	3.52
750	990.74	1.89	990.33	2.48	990.29	2.75	989.56	2.52
1,000	989.04	0.19	987.94	0.09	987.71	0.17	987.23	0.19
1,250	988.88	0.03	987.98	0.13	987.69	0.15	987.21	0.17
1,500	988.87	0.02	987.94	0.09	987.65	0.11	987.16	0.12
1,750	988.87	0.02	987.93	0.08	987.63	0.09	987.14	0.10
2,000	988.85	0.00	987.85	0.00	987.54	0.00	987.04	0.00







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–24

Summary of Hydraulic Parameters, 100-Year Event

Broadway Road Bridge at RM 7.26

Change in Velocity

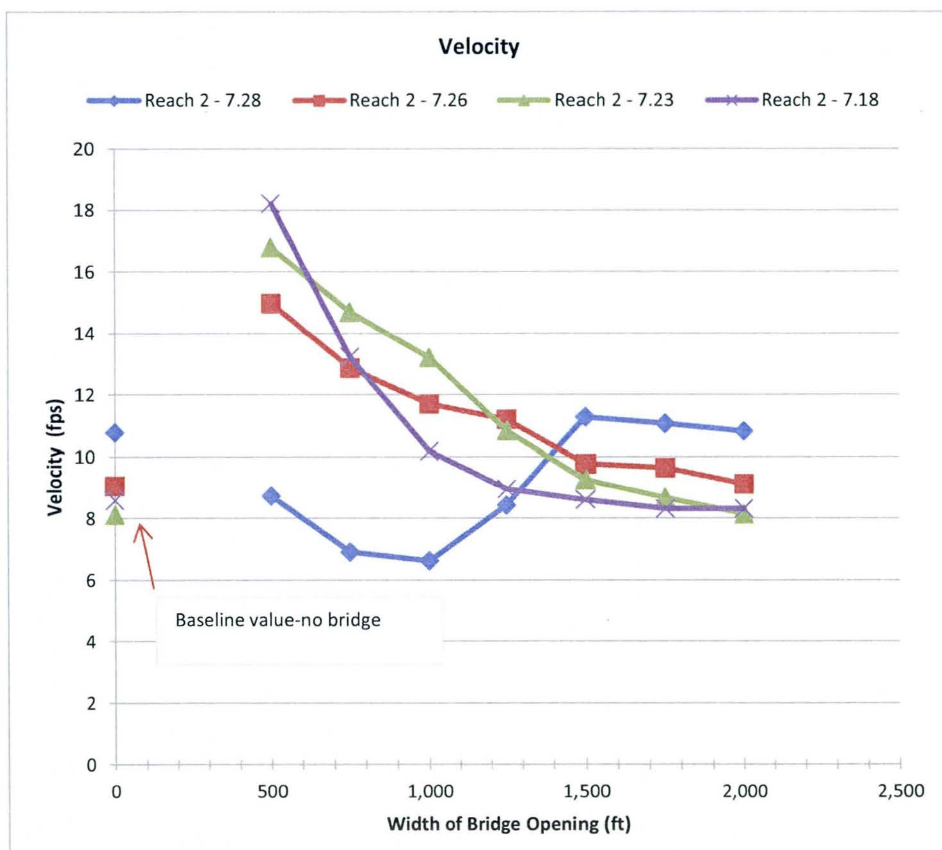
Bridge Opening Width	Reach 2 - 7.28		Reach 2 - 7.26		Reach 2 - 7.23		Reach 2 - 7.18	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	10.78	—	9.06	—	8.12	—	8.59	—
500	8.73	-19.0	14.98	65.3	16.80	106.9	18.22	112.1
750	6.92	-35.8	12.88	42.2	14.70	81.0	13.24	54.1
1,000	6.63	-38.5	11.71	29.2	13.22	62.8	10.19	18.6
1,250	8.43	-21.8	11.21	23.7	10.85	33.6	8.96	4.3
1,500	11.28	4.6	9.78	7.9	9.26	14.0	8.61	0.2
1,750	11.07	2.7	9.65	6.5	8.68	6.9	8.32	-3.1
2,000	10.82	0.4	9.12	0.7	8.15	0.4	8.32	-3.1

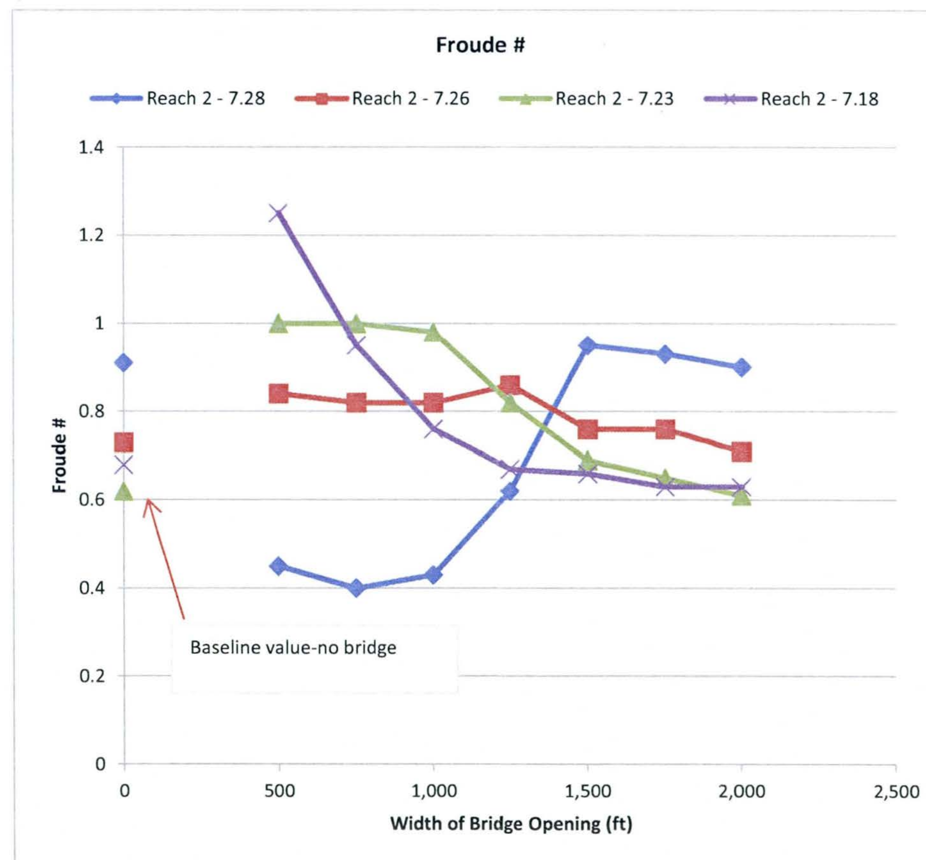
Change in Froude

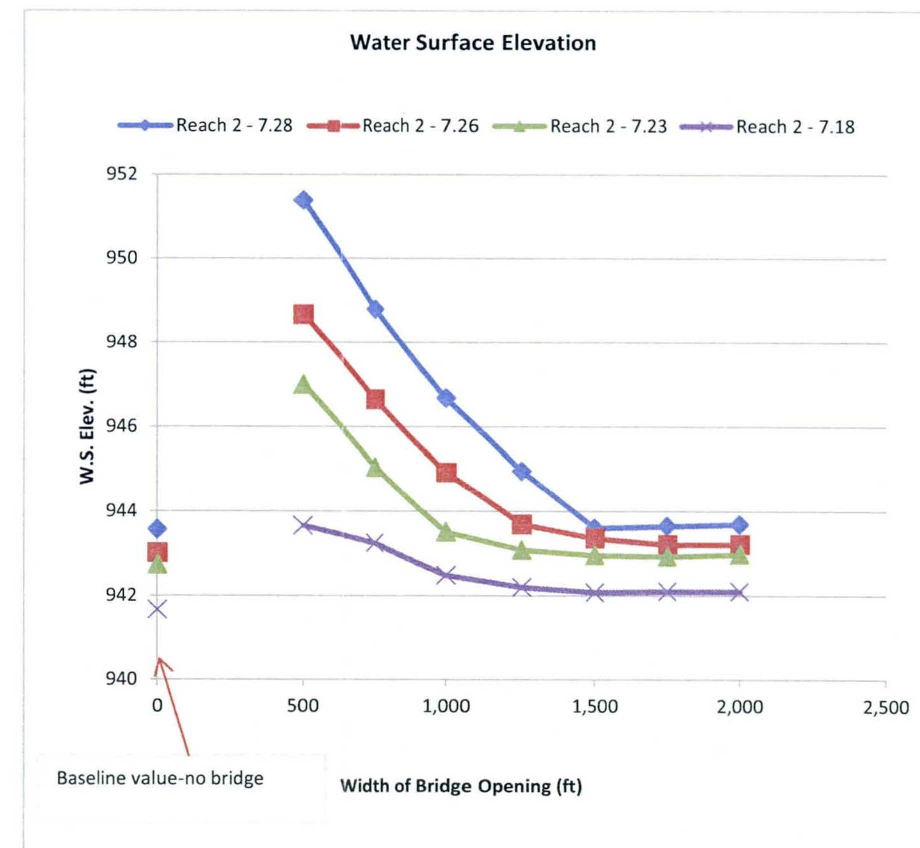
Bridge Opening Width	Reach 2 - 7.28		Reach 2 - 7.26		Reach 2 - 7.23		Reach 2 - 7.18	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.91	—	0.73	—	0.62	—	0.68	—
500	0.45	-50.5	0.84	15.1	1.00	61.3	1.25	83.8
750	0.40	-56.0	0.82	12.3	1.00	61.3	0.95	39.7
1,000	0.43	-52.7	0.82	12.3	0.98	58.1	0.76	11.8
1,250	0.62	-31.9	0.86	17.8	0.82	32.3	0.67	-1.5
1,500	0.95	4.4	0.76	4.1	0.69	11.3	0.66	-2.9
1,750	0.93	2.2	0.76	4.1	0.65	4.8	0.63	-7.4
2,000	0.90	-1.1	0.71	-2.7	0.61	-1.6	0.63	-7.4

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 7.28		Reach 2 - 7.26		Reach 2 - 7.23		Reach 2 - 7.18	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	943.57	—	943.01	—	942.73	—	941.66	—
500	951.38	7.81	948.67	5.66	947.00	4.27	943.66	2.00
750	948.79	5.22	946.64	3.63	945.05	2.32	943.25	1.59
1,000	946.67	3.10	944.92	1.91	943.51	0.78	942.48	0.82
1,250	944.95	1.38	943.69	0.68	943.08	0.35	942.20	0.54
1,500	943.60	0.03	943.36	0.35	942.96	0.23	942.08	0.42
1,750	943.65	0.08	943.21	0.20	942.93	0.20	942.10	0.44
2,000	943.69	0.12	943.22	0.21	942.98	0.25	942.10	0.44







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–25
Summary of Hydraulic Parameters, 10-Year Event
Broadway Road Bridge at RM 7.26

Change in Velocity

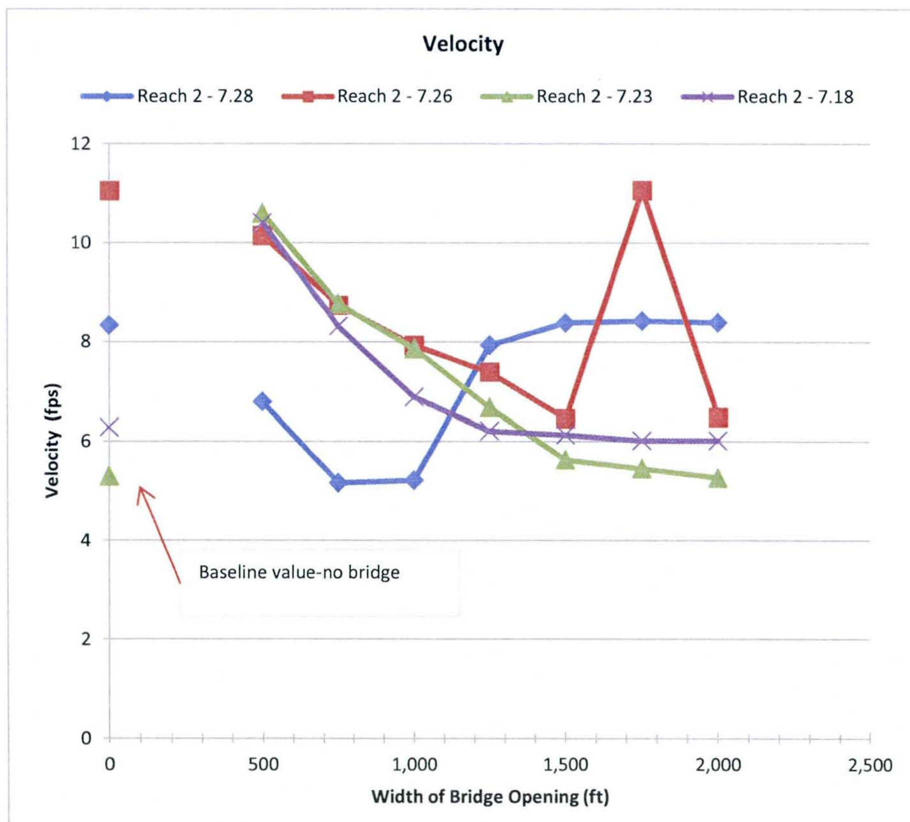
Bridge Opening Width	Reach 2 - 7.28		Reach 2 - 7.26		Reach 2 - 7.23		Reach 2 - 7.18	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	8.33	—	11.05	—	5.3	—	6.28	—
500	6.79	-18.5	10.15	-8.1	10.60	100.0	10.41	65.8
750	5.16	-38.1	8.74	-20.9	8.77	65.5	8.31	32.3
1,000	5.21	-37.5	7.93	-28.2	7.86	48.3	6.89	9.7
1,250	7.93	-4.8	7.39	-33.1	6.68	26.0	6.21	-1.1
1,500	8.38	0.6	6.46	-41.5	5.63	6.2	6.13	-2.4
1,750	8.42	1.1	11.06	0.1	5.45	2.8	6.02	-4.1
2,000	8.39	0.7	6.49	-41.3	5.27	-0.6	6.02	-4.1

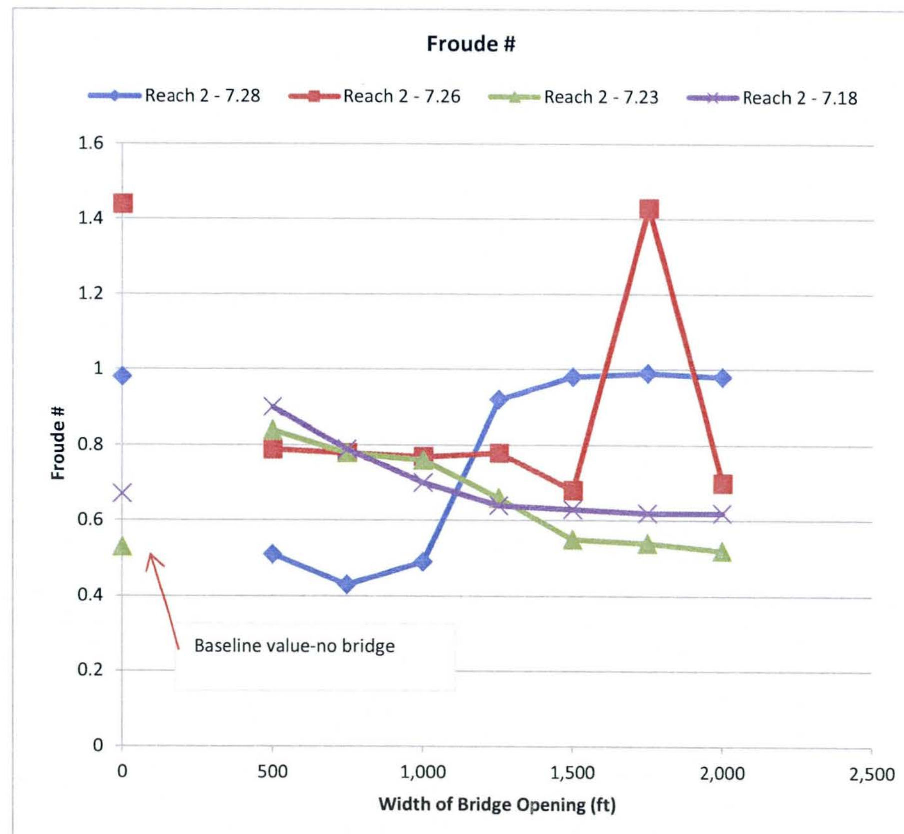
Change in Froude #

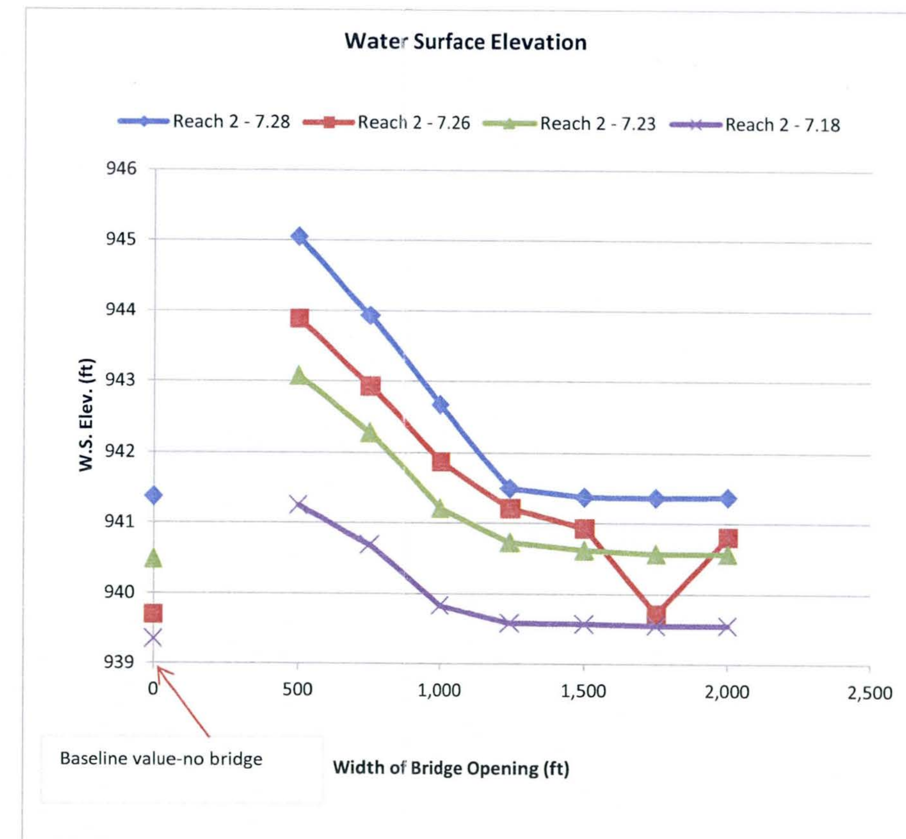
Bridge Opening Width	Reach 2 - 7.28		Reach 2 - 7.26		Reach 2 - 7.23		Reach 2 - 7.18	
	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.98	—	1.44	—	0.53	—	0.67	—
500	0.51	-48.0	0.79	-45.1	0.84	58.5	0.90	34.3
750	0.43	-56.1	0.78	-45.8	0.78	47.2	0.79	17.9
1,000	0.49	-50.0	0.77	-46.5	0.76	43.4	0.70	4.5
1,250	0.92	-6.1	0.78	-45.8	0.66	24.5	0.64	-4.5
1,500	0.98	0.0	0.68	-52.8	0.55	3.8	0.63	-6.0
1,750	0.99	1.0	1.43	-0.7	0.54	1.9	0.62	-7.5
2,000	0.98	0.0	0.70	-51.4	0.52	-1.9	0.62	-7.5

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 7.28		Reach 2 - 7.26		Reach 2 - 7.23		Reach 2 - 7.18	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	941.37	—	939.70	—	940.49	—	939.35	—
500	945.05	3.68	943.89	4.19	943.08	2.59	941.25	1.90
750	943.93	2.56	942.93	3.23	942.28	1.79	940.69	1.34
1,000	942.67	1.30	941.87	2.17	941.21	0.72	939.83	0.48
1,250	941.49	0.12	941.21	1.51	940.73	0.24	939.58	0.23
1,500	941.37	0.00	940.93	1.23	940.62	0.13	939.57	0.22
1,750	941.36	-0.01	939.72	0.02	940.57	0.08	939.55	0.20
2,000	941.37	0.00	940.81	1.11	940.57	0.08	939.55	0.20







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–26

Summary of Hydraulic Parameters, 100-Year Event

Southern Avenue Bridge at RM 5.99

Change in Velocity

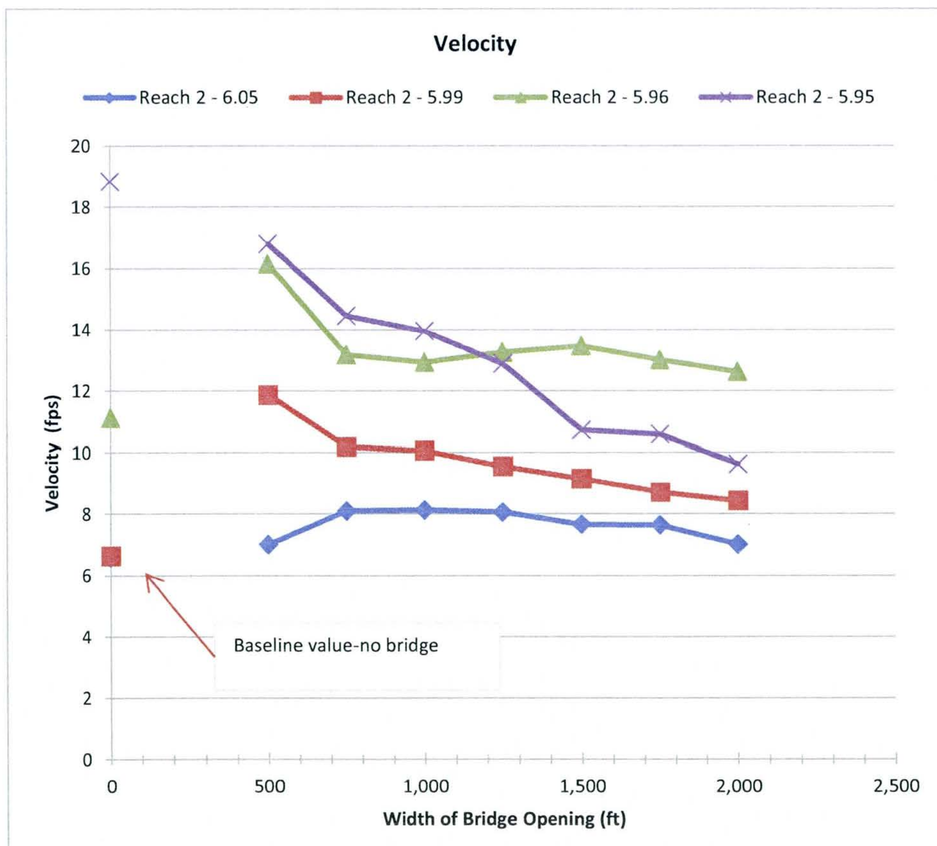
Bridge Opening Width	Reach 2 - 6.05		Reach 2 - 5.99		Reach 2 - 5.96		Reach 2 - 5.95	
	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	6.6	—	6.64	—	11.13	—	18.85	—
500	7.02	6.4	11.88	78.9	16.15	45.1	16.81	-10.8
750	8.11	22.9	10.20	53.6	13.19	18.5	14.46	-23.3
1,000	8.14	23.3	10.07	51.7	12.94	16.3	13.96	-25.9
1,250	8.07	22.3	9.56	44.0	13.27	19.2	12.89	-31.6
1,500	7.67	16.2	9.16	38.0	13.47	21.0	10.74	-43.0
1,750	7.65	15.9	8.72	31.3	13.02	17.0	10.60	-43.8
2,000	7.02	6.4	8.44	27.1	12.63	13.5	9.64	-48.9

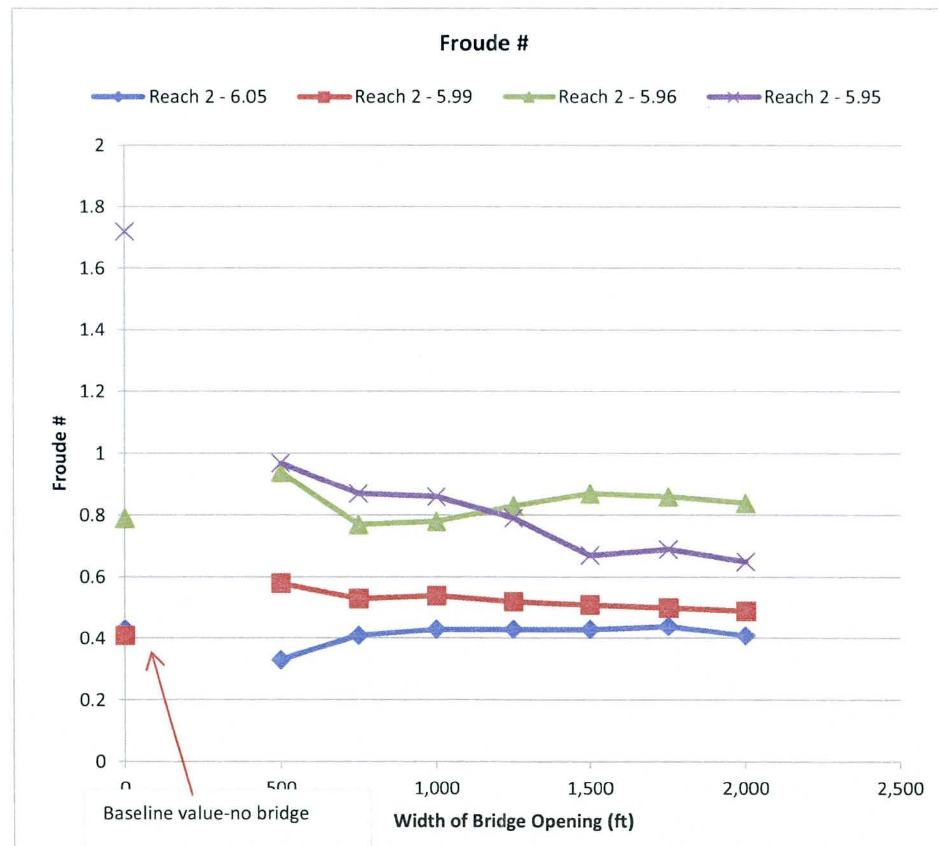
Change in Froude

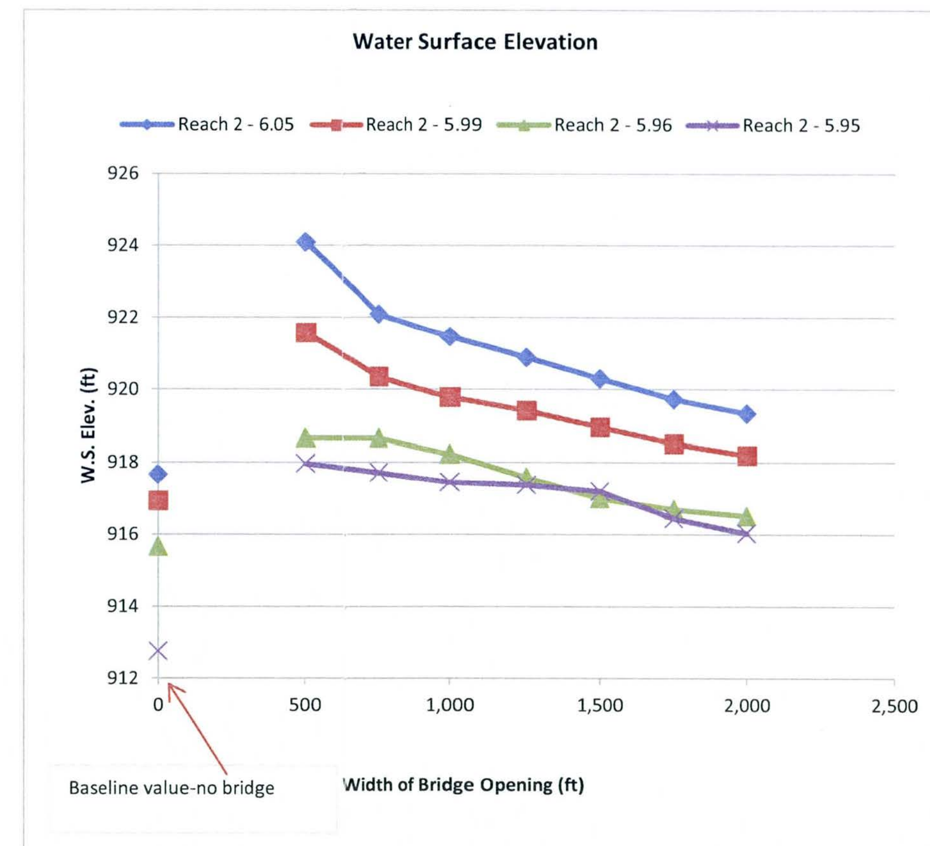
Bridge Opening Width	Reach 2 - 6.05		Reach 2 - 5.99		Reach 2 - 5.96		Reach 2 - 5.95	
	Froude #	Percent Change	Froude #	% Change	Froude #	Percent Change	Froude #	Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.43	—	0.41	—	0.79	—	1.72	—
500	0.33	-23.3	0.58	41.5	0.94	19.0	0.97	-43.6
750	0.41	-4.7	0.53	29.3	0.77	-2.5	0.87	-49.4
1,000	0.43	0.0	0.54	31.7	0.78	-1.3	0.86	-50.0
1,250	0.43	0.0	0.52	26.8	0.83	5.1	0.79	-54.1
1,500	0.43	0.0	0.51	24.4	0.87	10.1	0.67	-61.0
1,750	0.44	2.3	0.50	22.0	0.86	8.9	0.69	-59.9
2,000	0.41	-4.7	0.49	19.5	0.84	6.3	0.65	-62.2

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 6.05		Reach 2 - 5.99		Reach 2 - 5.96		Reach 2 - 5.95	
	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	917.66	—	916.92	—	915.66	—	912.75	—
500	924.09	6.43	921.57	4.65	918.66	3.00	917.96	5.21
750	922.09	4.43	920.35	3.43	918.66	3.00	917.71	4.96
1,000	921.47	3.81	919.79	2.87	918.22	2.56	917.45	4.70
1,250	920.89	3.23	919.42	2.50	917.58	1.92	917.37	4.62
1,500	920.30	2.64	918.96	2.04	916.99	1.33	917.19	4.44
1,750	919.73	2.07	918.51	1.59	916.69	1.03	916.44	3.69
2,000	919.34	1.68	918.19	1.27	916.51	0.85	916.03	3.28







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–27
Summary of Hydraulic Parameters, 10-Year Event
Southern Avenue Bridge at RM 5.99

Change in Velocity

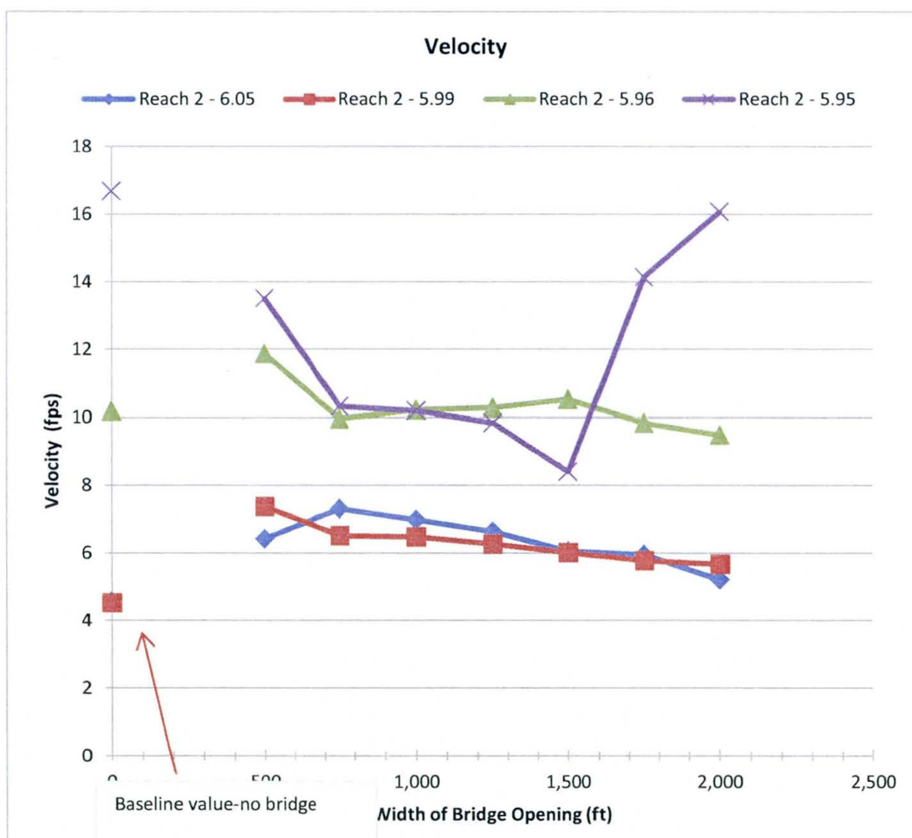
Bridge Opening Width	Reach 2 - 6.05 Velocity	Reach 2 - 6.05 Percent Change	Reach 2 - 5.99 Velocity	Reach 2 - 5.99 Percent Change	Reach 2 - 5.96 Velocity	Reach 2 - 5.96 Percent Change	Reach 2 - 5.95 Velocity	Reach 2 - 5.95 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	4.57	—	4.54	—	10.19	—	16.68	—
500	6.42	40.5	7.38	62.6	11.88	16.6	13.51	-19.0
750	7.31	60.0	6.52	43.6	9.97	-2.2	10.33	-38.1
1,000	6.98	52.7	6.48	42.7	10.23	0.4	10.20	-38.8
1,250	6.63	45.1	6.27	38.1	10.29	1.0	9.84	-41.0
1,500	6.06	32.6	6.02	32.6	10.53	3.3	8.40	-49.6
1,750	5.96	30.4	5.78	27.3	9.84	-3.4	14.15	-15.2
2,000	5.22	14.2	5.68	25.1	9.49	-6.9	16.07	-3.7

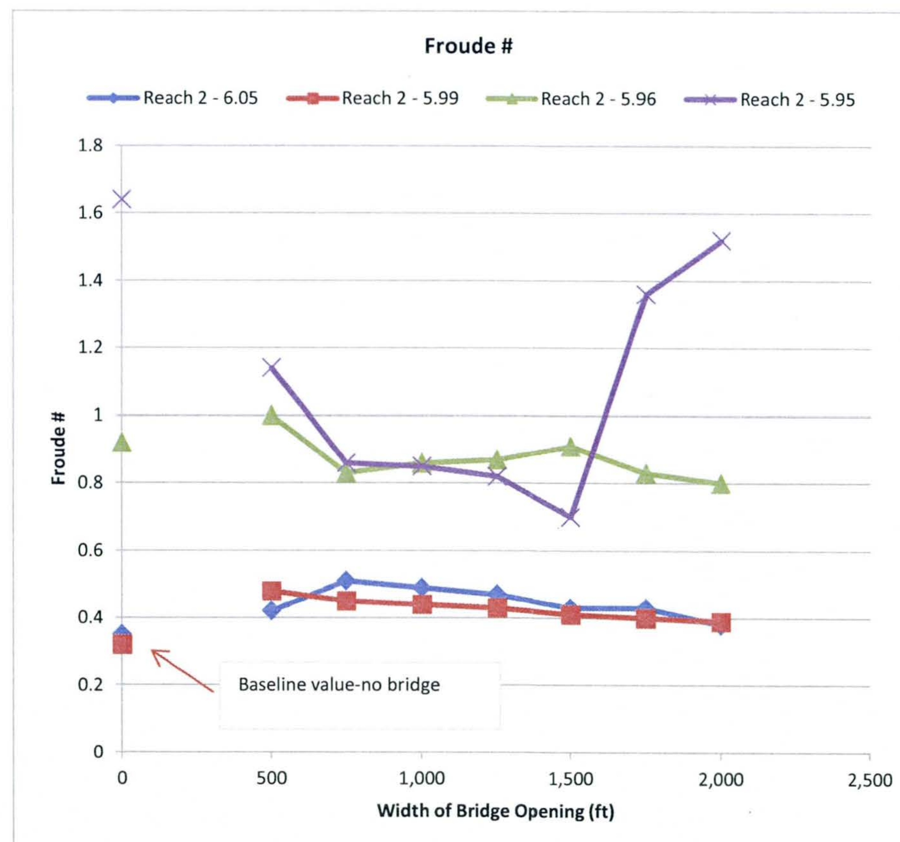
Change in Froude #

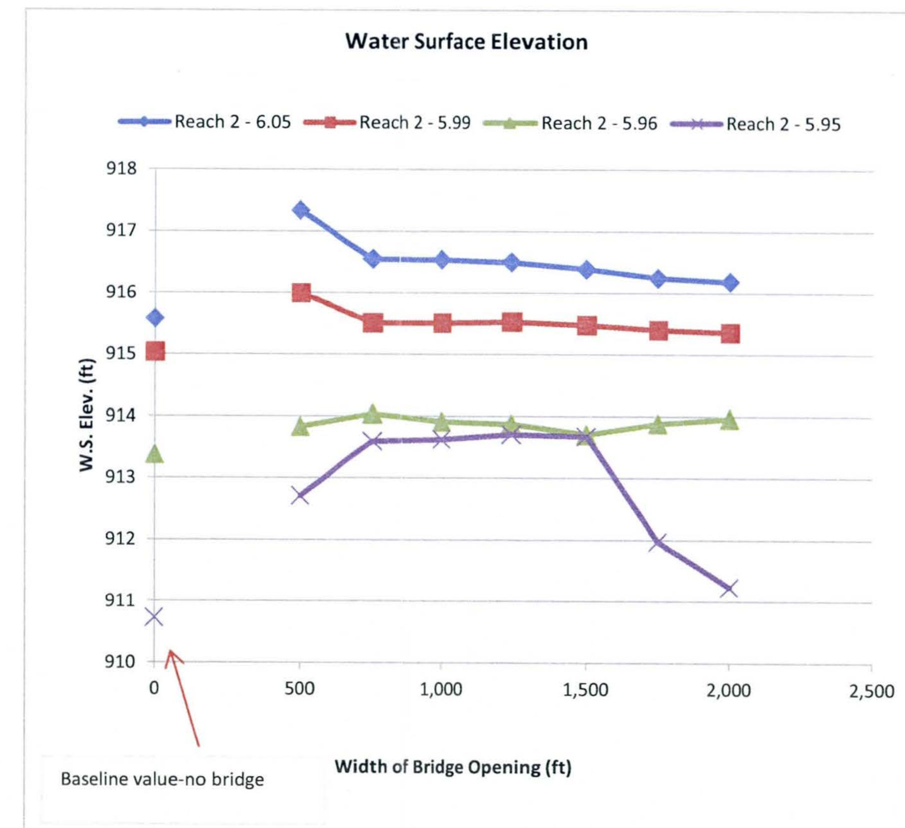
Bridge Opening Width	Reach 2 - 6.05 Froude #	Reach 2 - 6.05 Percent Change	Reach 2 - 5.99 Froude #	Reach 2 - 5.99 Percent Change	Reach 2 - 5.96 Froude #	Reach 2 - 5.96 Percent Change	Reach 2 - 5.95 Froude #	Reach 2 - 5.95 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.35	—	0.32	—	0.92	—	1.64	—
500	0.42	20.0	0.48	50.0	1.00	8.7	1.14	-30.5
750	0.51	45.7	0.45	40.6	0.83	-9.8	0.86	-47.6
1,000	0.49	40.0	0.44	37.5	0.86	-6.5	0.85	-48.2
1,250	0.47	34.3	0.43	34.4	0.87	-5.4	0.82	-50.0
1,500	0.43	22.9	0.41	28.1	0.91	-1.1	0.70	-57.3
1,750	0.43	22.9	0.40	25.0	0.83	-9.8	1.36	-17.1
2,000	0.38	8.6	0.39	21.9	0.80	-13.0	1.52	-7.3

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 6.05 W.S.E.	Reach 2 - 6.05 Change in W.S.E.	Reach 2 - 5.99 W.S.E.	Reach 2 - 5.99 Change in W.S.E.	Reach 2 - 5.96 W.S.E.	Reach 2 - 5.96 Change in W.S.E.	Reach 2 - 5.95 W.S.E.	Reach 2 - 5.95 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	915.58	—	915.04	—	913.38	—	910.73	—
500	917.34	1.76	916.00	0.96	913.84	0.46	912.71	1.98
750	916.55	0.97	915.51	0.47	914.04	0.66	913.60	2.87
1,000	916.54	0.96	915.51	0.47	913.92	0.54	913.63	2.90
1,250	916.50	0.92	915.53	0.49	913.88	0.50	913.71	2.98
1,500	916.39	0.81	915.48	0.44	913.71	0.33	913.68	2.95
1,750	916.25	0.67	915.40	0.36	913.89	0.51	911.97	1.24
2,000	916.19	0.61	915.36	0.32	913.97	0.59	911.23	0.50







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–28

Summary of Hydraulic Parameters, 100-Year Event

Baseline Road Bridge at RM 4.90

Change in Velocity

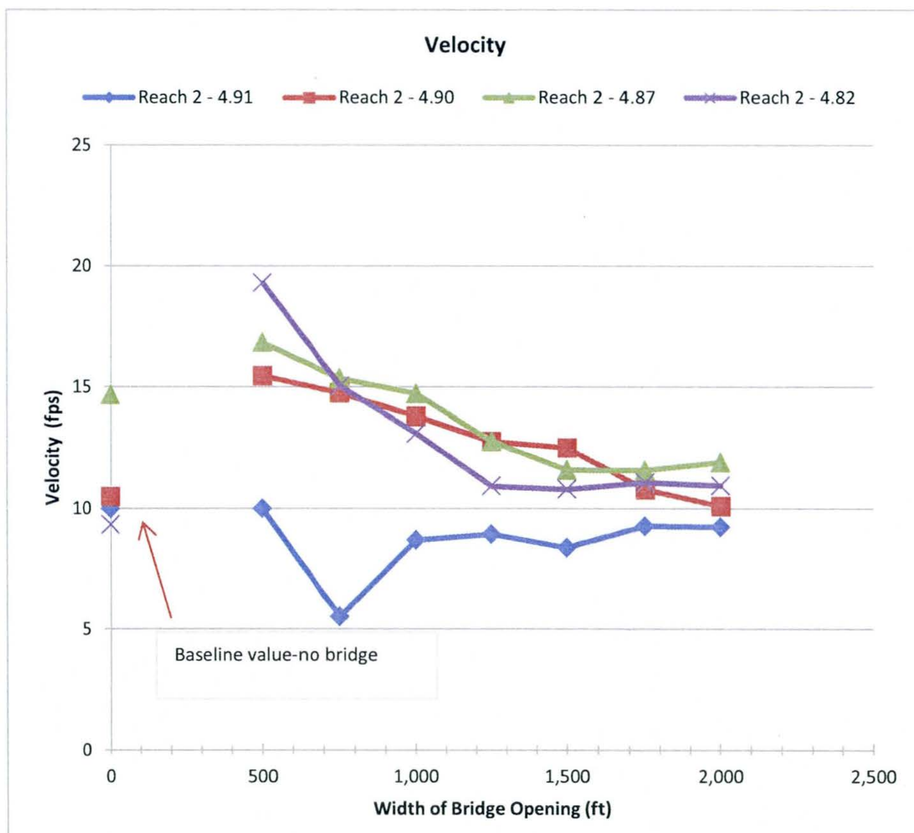
Bridge Opening Width	Reach 2 - 4.91 Velocity	Reach 2 - 4.91 Percent Change	Reach 2 - 4.90 Velocity	Reach 2 - 4.90 Percent Change	Reach 2 - 4.87 Velocity	Reach 2 - 4.87 Percent Change	Reach 2 - 4.82 Velocity	Reach 2 - 4.82 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	9.98	—	10.49	—	14.68	—	9.32	—
500	9.99	0.1	15.45	47.3	16.83	14.6	19.31	107.2
750	5.53	-44.6	14.76	40.7	15.35	4.6	15.04	61.4
1,000	8.70	-12.8	13.80	31.6	14.73	0.3	13.11	40.7
1,250	8.94	-10.4	12.77	21.7	12.77	-13.0	10.92	17.2
1,500	8.38	-16.0	12.51	19.3	11.58	-21.1	10.79	15.8
1,750	9.27	-7.1	10.78	2.8	11.57	-21.2	11.07	18.8
2,000	9.24	-7.4	10.10	-3.7	11.91	-18.9	10.94	17.4

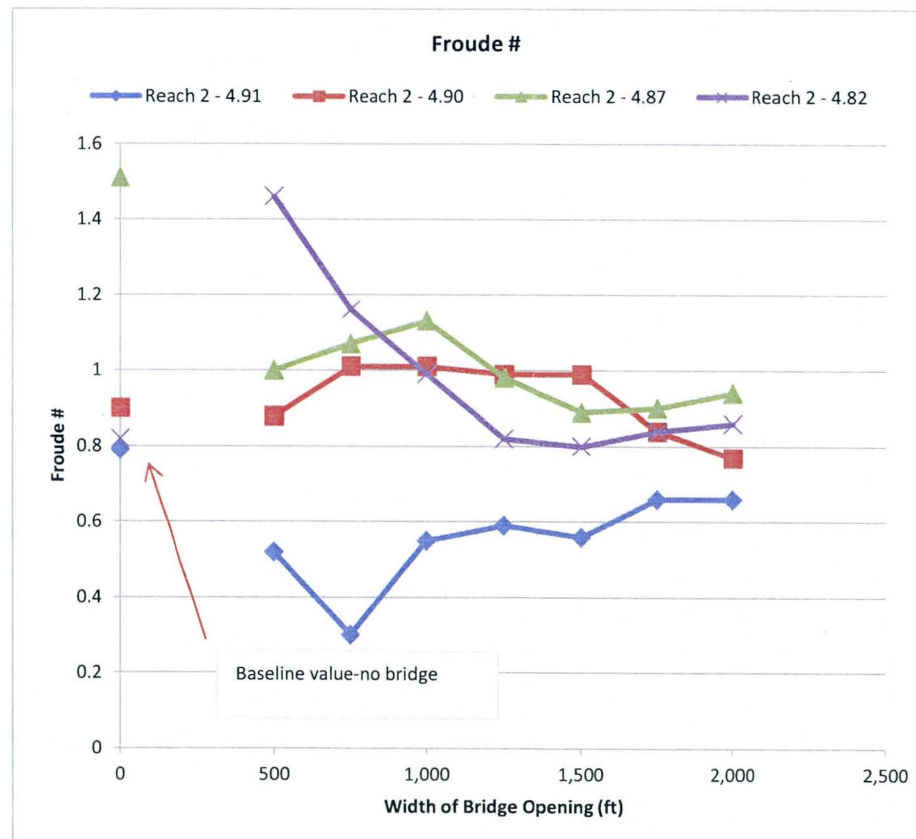
Change in Froude #

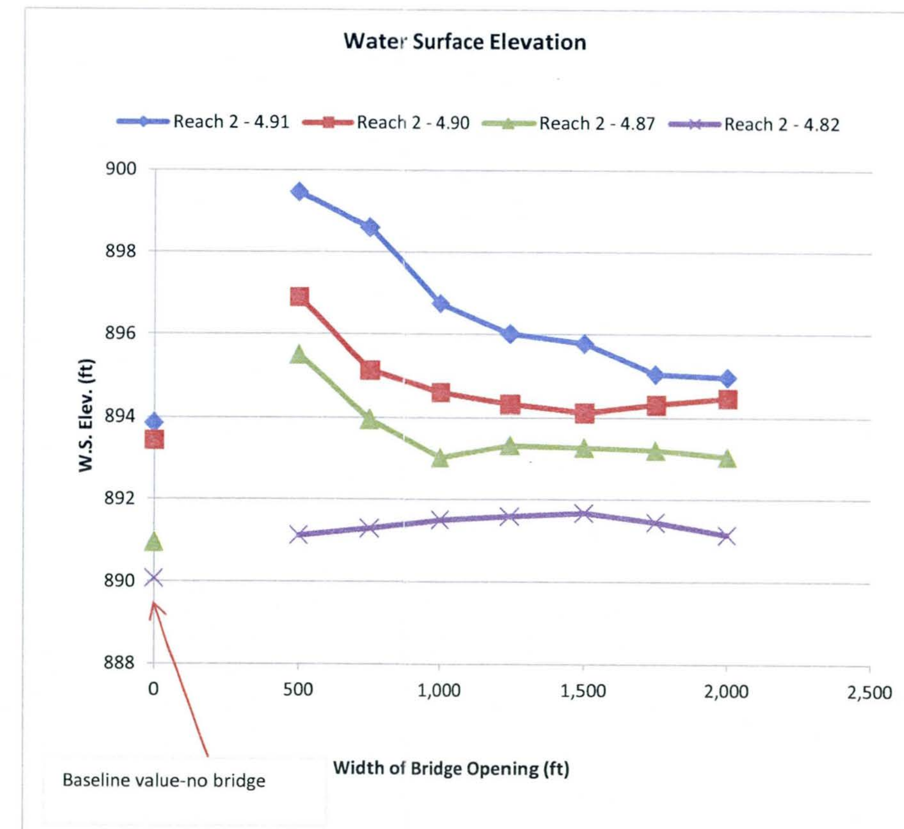
Bridge Opening Width	Reach 2 - 4.91 Froude #	Reach 2 - 4.91 Percent Change	Reach 2 - 4.90 Froude #	Reach 2 - 4.90 Percent Change	Reach 2 - 4.87 Froude #	Reach 2 - 4.87 Percent Change	Reach 2 - 4.82 Froude #	Reach 2 - 4.82 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.79	—	0.90	—	1.51	—	0.82	—
500	0.52	-34.2	0.88	-2.2	1.00	-33.8	1.46	78.0
750	0.30	-62.0	1.01	12.2	1.07	-29.1	1.16	41.5
1,000	0.55	-30.4	1.01	12.2	1.13	-25.2	0.99	20.7
1,250	0.59	-25.3	0.99	10.0	0.98	-35.1	0.82	0.0
1,500	0.56	-29.1	0.99	10.0	0.89	-41.1	0.80	-2.4
1,750	0.66	-16.5	0.84	-6.7	0.90	-40.4	0.84	2.4
2,000	0.66	-16.5	0.77	-14.4	0.94	-37.7	0.86	4.9

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 4.91 W.S.E.	Reach 2 - 4.91 Change in W.S.E.	Reach 2 - 4.90 W.S.E.	Reach 2 - 4.90 Change in W.S.E.	Reach 2 - 4.87 W.S.E.	Reach 2 - 4.87 Change in W.S.E.	Reach 2 - 4.82 W.S.E.	Reach 2 - 4.82 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	893.85	—	893.44	—	890.96	—	890.08	—
500	899.46	5.61	896.91	3.47	895.51	4.55	891.13	1.05
750	898.60	4.75	895.13	1.69	893.94	2.98	891.30	1.22
1,000	896.75	2.90	894.60	1.16	893.02	2.06	891.51	1.43
1,250	896.02	2.17	894.32	0.88	893.32	2.36	891.60	1.52
1,500	895.78	1.93	894.11	0.67	893.27	2.31	891.68	1.60
1,750	895.04	1.19	894.31	0.87	893.21	2.25	891.45	1.37
2,000	894.96	1.11	894.46	1.02	893.04	2.08	891.15	1.07







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5–29

Summary of Hydraulic Parameters, 10-Year Event

Baseline Road Bridge at RM 4.90

Change in Velocity

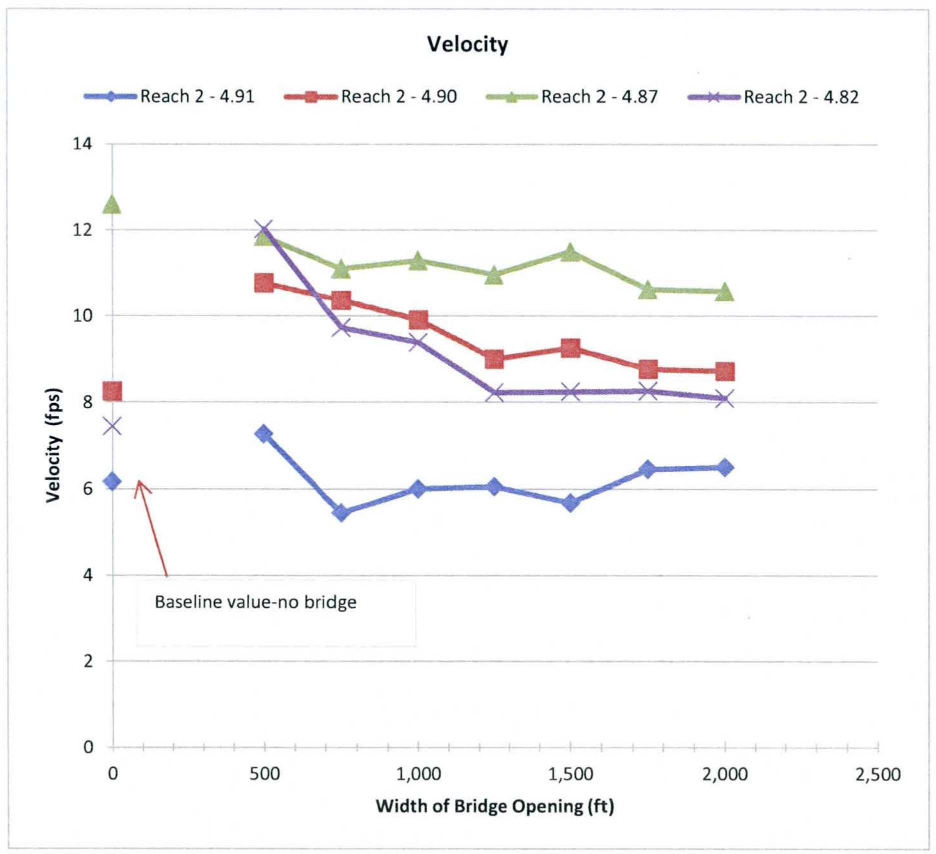
Bridge Opening Width	Reach 2 - 4.91 Velocity	Reach 2 - 4.91 Percent Change	Reach 2 - 4.90 Velocity	Reach 2 - 4.90 Percent Change	Reach 2 - 4.87 Velocity	Reach 2 - 4.87 Percent Change	Reach 2 - 4.82 Velocity	Reach 2 - 4.82 Percent Change
feet	fps	%	fps	%	fps	%	fps	%
None[1]	6.17	—	8.26	—	12.6	—	7.46	—
500	7.29	18.2	10.78	30.5	11.86	-5.9	12.03	61.3
750	5.45	-11.7	10.38	25.7	11.11	-11.8	9.73	30.4
1,000	6.01	-2.6	9.92	20.1	11.30	-10.3	9.39	25.9
1,250	6.06	-1.8	9.01	9.1	10.97	-12.9	8.23	10.3
1,500	5.68	-7.9	9.27	12.2	11.50	-8.7	8.25	10.6
1,750	6.46	4.7	8.78	6.3	10.63	-15.6	8.27	10.9
2,000	6.51	5.5	8.73	5.7	10.59	-16.0	8.10	8.6

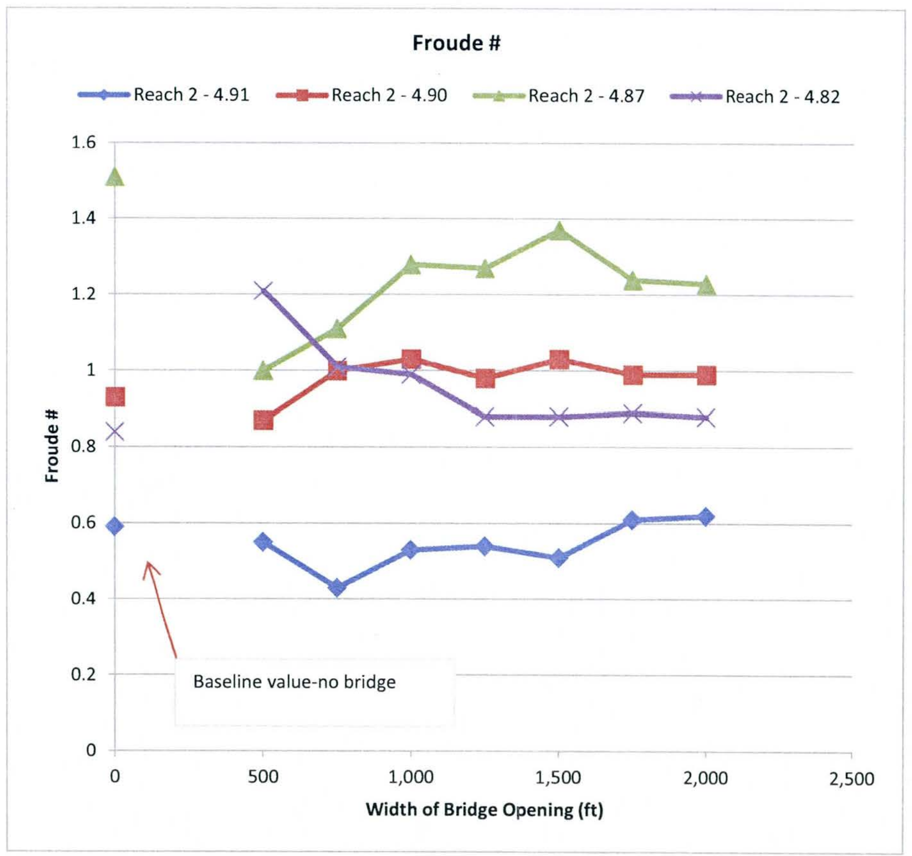
Change in Froude #

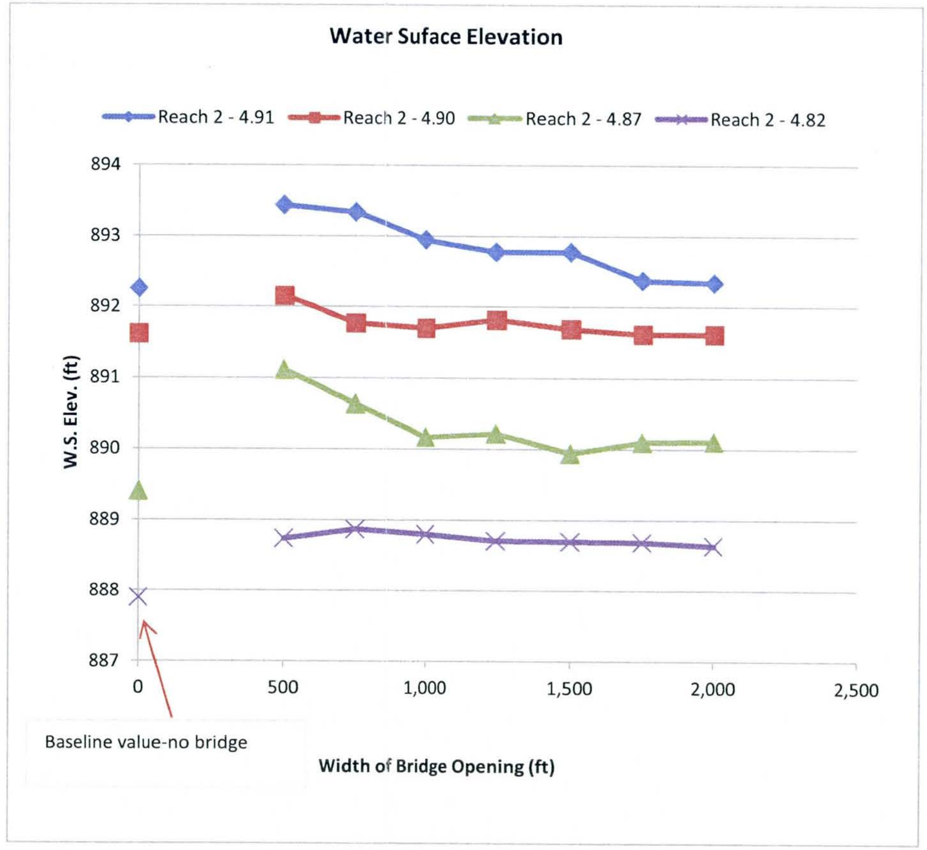
Bridge Opening Width	Reach 2 - 4.91 Froude #	Reach 2 - 4.91 Percent Change	Reach 2 - 4.90 Froude #	Reach 2 - 4.90 Percent Change	Reach 2 - 4.87 Froude #	Reach 2 - 4.87 Percent Change	Reach 2 - 4.82 Froude #	Reach 2 - 4.82 Percent Change
feet	unitless	%	unitless	%	unitless	%	unitless	%
None[1]	0.59	—	0.93	—	1.51	—	0.84	—
500	0.55	-6.8	0.87	-6.5	1.00	-33.8	1.21	44.0
750	0.43	-27.1	1.00	7.5	1.11	-26.5	1.01	20.2
1,000	0.53	-10.2	1.03	10.8	1.28	-15.2	0.99	17.9
1,250	0.54	-8.5	0.98	5.4	1.27	-15.9	0.88	4.8
1,500	0.51	-13.6	1.03	10.8	1.37	-9.3	0.88	4.8
1,750	0.61	3.4	0.99	6.5	1.24	-17.9	0.89	6.0
2,000	0.62	5.1	0.99	6.5	1.23	-18.5	0.88	4.8

Change in Water Surface Elevation

Bridge Opening Width	Reach 2 - 4.91 W.S.E.	Reach 2 - 4.91 Change in W.S.E.	Reach 2 - 4.90 W.S.E.	Reach 2 - 4.90 Change in W.S.E.	Reach 2 - 4.87 W.S.E.	Reach 2 - 4.87 Change in W.S.E.	Reach 2 - 4.82 W.S.E.	Reach 2 - 4.82 Change in W.S.E.
feet	feet	feet	feet	feet	feet	feet	feet	feet
None[1]	892.26	—	891.62	—	889.41	—	887.90	—
500	893.44	1.18	892.16	0.54	891.11	1.70	888.74	0.84
750	893.34	1.08	891.77	0.15	890.64	1.23	888.87	0.97
1,000	892.95	0.69	891.70	0.08	890.17	0.76	888.80	0.90
1,250	892.78	0.52	891.82	0.20	890.22	0.81	888.71	0.81
1,500	892.78	0.52	891.69	0.07	889.94	0.53	888.70	0.80
1,750	892.38	0.12	891.62	0.00	890.10	0.69	888.69	0.79
2,000	892.35	0.09	891.62	0.00	890.11	0.70	888.64	0.74







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5.30 Recommended Bridge Openings from Step 1 Evaluation of Hydraulic Parameters

Bridge Crossing	Cross Section	Recommended Width of Bridge Opening	100-Year Event						10-Year Event						Comments
			Change in Velocity		Change in Flow Regime		Change in Water Surface Elevation		Change in Velocity		Change in Flow Regime		Change in Water Surface Elevation		
			Up-stream	Down-stream	Up-stream	Down-stream	Up-stream	Down-stream	Upstream	Down-stream	Up-stream	Down-stream	Up-stream	Down-stream	
Hummingbird Springs Road	26.275														Not evaluated in Step 1
Bell Road	24.71		< 10%	< 10%	None	None	< 0.5 ft	< 0.3 ft	< 10%	< 10%	None	None	< 0.2 ft	< 0.1 ft	Significant increase in the change of hydraulic parameters for bridge openings equal to or less than 1500 '
Greenway Road	23.64	> 1500 feet	< 10%	> 10%[1]	None	None	< 0.4 ft	< 1 ft	< 10%	> 10%[1]	None	None	< 0.3 ft	< 0.6 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than or equal to 1500 '
Cactus Road	21.565	≥ 1500 feet	< 10%	> 10%[1]	None	None	< 0.4 ft	< 0.4 ft	< 10%	< 10%	None	None	< 0.1 ft	< 0.1 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than 1250 '
Olive Avenue	19.505	> 1500 feet	< 10%	> 10%[1]	None	in transitional range	< 1 ft	< 0.5 ft	< 10%	< 10%	None	None	< 0.3 ft	< 0.3 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than or equal to 1250 '
Northern Avenue	17.935	≥ 1500 feet	< 10%	< 10%	None	Change from transitional to supercritical	< 0.2 ft	< 0.1 ft	< 10%	< 10%	None	None	< 0.1 ft	0 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than 1500 '
Glendale Avenue	17.155	≥ 1750 feet	< 10%	> 10%[1]	None	None	< 1.2 ft	< 1.0 ft	< 10%	< 10%	None	None	< 0.7 ft	< 0.7 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than 1500'
Camelback Road	14.405	≥ 1250 feet	< 10%	< 10%	None	None	< 0.2 ft	< 0.2 ft	< 10%	< 10%	None	None	< 0.1 ft	< 0.1 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than 1250 '
Indian School Road	13.875	≥ 1500 feet													Due to constraints imposed by sand and gravel mining, channelization upstream and downstream of the bridge should be considered.
McDowell Parkway	13.035	≥ 1500 feet													Due to constraints imposed by sand and gravel mining, channelization upstream and downstream of the bridge should be considered.
Yuma Parkway	9.78	> 1250 feet	< 10%	< 10%	None	None	< 0.1 ft	< 0.3 ft	< 10%	< 10%	None	None	< 0.1 ft	< 0.1 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than 1000 '
Broadway Road	7.295	≥ 1500 feet	< 10%	> 10%	None	None	< 0.4 ft	< 0.5 ft	< 10%	< 10%	None	None	< 0 ft	< 0.2 ft	Significant increase in the rate of change for hydraulic parameters for bridge openings less than 1500 '
Southern Avenue	5.96	≥ 2000 feet	< 10%	> 10%	None	None	> 1 ft	> 1 ft	> 10%	> 10%	None	None	> 0. 6 ft	> 0. 6 ft	Due to future constraints imposed by sand and gravel mining, channelization upstream and downstream of the bridge should be considered.
Baseline Road	4.945	> 2000 feet	< 10%	> 10%	None	transitional to super	> 1 ft	> 1 ft	> 10%	> 10%	None	None	< 0.1 ft	< 0.8 ft	Due constraints imposed by Sand and gravel mining channelization upstream and downstream of the bridge should be considered.

1. Mitigation measures would be required to minimize the impact due to the change in hydraulic parameter. Mitigation measures could include channelization, channel armoring, grade control structures or purchase of additional right of way.

5.12.2 Changes in Stable Slope

Upstream and downstream of each bridge location the stable slope was estimated for the non-encroached and encroached conditions for each bridge opening scenario. The stable slope of an encroached condition is compared to the non-encroached condition to determine the effect of the change in stable slope that would occur due to the encroachment. Stable slope was estimated utilizing procedures listed in *Sediment and Erosion Design Guide, November 2008 by Mussetter Engineering Inc.* The following equation was utilized:

$$\mathbf{Ss = 18.28\, n^2\, F_D^{0.133}\, Fr^{2.133} Qdd^{-0.133}}$$

Where:

Ss = stable slope

n = Manning's roughness coefficient

F_D = width to depth ratio for the dominate discharge

Fr = channel Froude Number

Qdd = dominate discharge, the dominate discharge is taken to be the 10-year peak discharge.

Table 5.31 lists reach average stable slope estimates and existing channel slope estimates for the study reach of the Hassayampa River. The comparison between actual and stable slope estimates for reaches 3, 4, and 5 is within 10% whereas the comparison for reaches 1 and 2 resulted in a difference of greater than 10%. Levees constructed approximately 50 years ago in Reach 1 confine flow to a narrow channel and it would be expected that the channel has not reached a stable state and therefore, there would not be a good comparison between actual and stable slope. This conclusion for Reach 1 is supported in sediment transport evaluations conducted for the Phase 1 study where it was concluded that the reach was in a degradation mode. For the reaches upstream of the Union Pacific Railroad (Reaches 2, 3, 4 and 5) the Phase 1 study concluded that the reach trend is one of long term vertical stability. There is a 14% difference in the comparison of actual and stable slope estimates for Reach 2. Possible reasons for this, however uncertain, may be due to the effect of sand and gravel mining on the sediment balance. Given that the estimated stable slope compares within 10 percent of the actual slope, which is considered long term stable we believe that utilizing the procedure listed above for estimating stable slope is adequate for this planning level evaluation to determine the impact of a number of different river management scenarios on the existing form and function of the watercourse. The intent of utilizing this procedure is to provide a low cost method for evaluating potential changes in stable slope due to a flood mitigation measure being evaluated. Detail studies utilizing District approved methodology or sediment transport models should be used for design purpose.

One would always expect there to be some variability between the estimated stable slope and actual slope due to the dynamic nature of the watercourse in response to storms of varying magnitude, therefore a difference of greater than 10% would be considered significant changes and will be noted in following discussions.

Tables 5.32 through 5.44 lists a summary of the change in stable slope at each bridge location for the different bridge opening scenarios evaluated. The tables include the percent change in stable slope upstream and downstream of the bridge locations evaluated for each bridge opening scenario. The locations where the change in stable slope due to the bridge encroachment is less than 10 percent are the green shaded cells. Calculation sheets used to facilitate the estimation of stable slope are presented in Appendix G.

The following conclusions are made from the evaluation of stable slope:

- Typically there is a decrease in the stable slope upstream of a bridge encroachment and an increase downstream relative to the non-encroached condition.
- The greater the encroachment the greater the extent of the effect of the encroachment on the stable slope estimate both in an upstream and downstream direction.

Table 5.31 Actual Slope vs. Stable Slope

Reach	River Station	Reach Description	Mean Actual Slope	Stable Slope	Percent difference between actual slope and stable slope
	River Miles		ft/ft	ft/ft	%
1	0.35 to 4.63	Gila River to UPRR Bridge	0.00418	0.00351	19
2	4.72 to 10.21	UPRR Bridge to I-10	0.00409	0.00478	-14
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	0.00396	0.00441	-10
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	0.00452	0.00463	-2
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	0.00432	0.00451	-4

Table 5.32
Percent Change in Stable Slope Upstream and Downstream of Bell Road

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Bell Road	Upstream	25.62	0%	0%	0%	0%	0%	0%	0%
		25.53	0%	8%	5%	3%	3%	3%	3%
		25.43	0%	-7%	-2%	0%	0%	0%	0%
		25.34	3%	25%	15%	0%	3%	0%	3%
		25.24	-5%	-25%	-15%	-2%	-2%	-2%	-5%
		25.15	-21%	28%	13%	-5%	5%	5%	10%
		25.06	-86%	-68%	-44%	-4%	-12%	-7%	-12%
		24.99		-41%	-47%	-21%	-15%	5%	5%
	Downstream	24.95		8%	26%	31%	39%	17%	14%
		24.94	270%	217%	203%	18%	0%	0%	0%
		24.87	-11%	-7%	6%	0%	0%	0%	0%
		24.77	4%	-12%	-6%	0%	0%	0%	0%
		24.68	22%	22%	11%	0%	0%	0%	0%
		24.58	-12%	-12%	-4%	0%	0%	0%	0%
		24.49	22%	22%	12%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.33
Percent Change in Stable Slope Upstream and Downstream of Greenway Road

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Greenway Road	Upstream	24.39	-4%	-4%	0%	0%	0%	0%	0%
		24.30	9%	8%	2%	-4%	0%	0%	0%
		24.20	-10%	-10%	-3%	3%	0%	0%	0%
		24.11	-7%	0%	-13%	-12%	-3%	0%	0%
		24.01	-64%	-14%	20%	33%	7%	0%	3%
		23.92	-85%	-77%	-68%	-53%	-13%	0%	0%
		23.87	-29%	-9%	9%	-12%	-15%	-23%	-23%
	Downstream	23.83	-57%	-36%	-16%	-48%	-47%	-52%	-56%
		23.82	35%	35%	5%	24%	8%	2%	2%
		23.73	121%	28%	29%	10%	11%	11%	11%
		23.63	7%	-9%	-4%	13%	8%	8%	8%
		23.54	-1%	8%	18%	3%	0%	0%	0%
		23.45	6%	10%	8%	0%	0%	0%	0%
		23.35	13%	8%	0%	0%	0%	0%	0%
		23.26	9%	0%	0%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

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Table 5.34
Percent Change in Stable Slope Upstream and Downstream of Cactus Road

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Cactus Road	Upstream	21.84	4%	4%	3%	0%	0%	0%	0%
		21.74	-6%	-6%	0%	0%	0%	0%	0%
		21.65	7%	5%	0%	-2%	-2%	0%	0%
		21.55	-13%	-13%	-3%	3%	0%	0%	0%
		21.46	-9%	2%	-6%	-8%	-3%	0%	0%
		21.36	-66%	-34%	-7%	3%	3%	3%	0%
		21.28	-52%	-40%	-28%	-1%	0%	0%	0%
		21.27	-25%	4%	20%	10%	16%	8%	4%
	Downstream	21.24	42%	26%	8%	10%	0%	0%	0%
		21.17	33%	2%	1%	-1%	-4%	0%	0%
		21.08	-15%	24%	12%	3%	0%	0%	0%
		20.98	11%	0%	0%	0%	0%	0%	0%
		20.89	0%	0%	0%	0%	0%	0%	0%
		20.80	0%	0%	0%	0%	0%	0%	0%
		20.70	2%	0%	0%	0%	0%	0%	0%
		20.61	-3%	0%	0%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.35
Percent Change in Stable Slope Upstream and Downstream of Olive Avenue

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Olive Avenue	Upstream	19.75	0%	0%	0%	0%	0%	0%	0%
		19.66	0%	0%	0%	0%	-2%	-2%	0%
		19.56	-5%	-5%	5%	5%	0%	0%	0%
		19.47	-41%	-3%	-15%	-12%	-7%	0%	0%
		19.38	-74%	-41%	1%	14%	6%	-2%	6%
		19.28	-54%	-57%	-45%	-31%	-21%	-4%	-14%
		19.26	23%	-8%	-14%	-21%	-8%	-7%	-7%
	Downstream	19.23	17%	13%	-5%	7%	-8%	12%	12%
		19.19	12%	0%	18%	3%	10%	0%	0%
		19.09	1%	44%	9%	1%	-2%	0%	0%
		19.00	-22%	-12%	6%	-1%	14%	0%	0%
		18.90	31%	-3%	1%	17%	0%	0%	0%
		18.81	13%	32%	9%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.36
Percent Change in Stable Slope Upstream and Downstream of Northern Avenue

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Northern Avenue	Upstream	18.71	1%	-4%	29%	0%	0%	0%	0%
		18.62	18%	36%	0%	0%	0%	0%	0%
		18.52	-37%	-28%	6%	0%	0%	0%	0%
		18.43	-2%	-8%	-14%	4%	0%	0%	0%
		18.33	-54%	-30%	-19%	-22%	-3%	0%	0%
		18.24	-61%	-23%	1%	2%	-1%	0%	0%
		18.19	66%	79%	15%	1%	9%	0%	0%
	Downstream	18.16	-11%	-20%	-9%	-2%	0%	0%	0%
		18.14	79%	15%	16%	4%	0%	0%	0%
		18.05	61%	15%	7%	7%	0%	0%	0%
		17.95	-2%	17%	6%	0%	0%	0%	0%
		17.86	11%	6%	0%	0%	0%	0%	0%
		17.77	-3%	-11%	0%	0%	0%	0%	0%
		17.67	10%	8%	0%	0%	0%	0%	0%
		17.58	9%	-3%	8%	13%	13%	13%	6%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.37
Percent Change in Stable Slope Upstream and Downstream of Glendale Avenue

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Glendale Avenue	Upstream	17.77	-3%	-11%	0%	0%	0%	0%	0%
		17.67	10%	8%	0%	0%	0%	0%	0%
		17.58	9%	-3%	8%	13%	13%	13%	6%
		17.48	-31%	-23%	-33%	-28%	-25%	-28%	-16%
		17.39	74%	43%	30%	21%	15%	31%	13%
		17.29	-60%	-46%	-35%	-23%	-12%	-25%	-17%
		17.20	-48%	-31%	-19%	-19%	-34%	-5%	-7%
		17.17	73%	18%	16%	-2%	-14%	-10%	-7%
	Downstream	17.14	-26%	13%	12%	15%	26%	15%	10%
		17.10	57%	30%	-4%	-11%	-14%	-14%	0%
		17.01	-18%	-4%	-7%	-3%	10%	10%	0%
		16.91	58%	33%	41%	42%	16%	20%	0%
		16.82	24%	14%	4%	1%	41%	33%	0%
		16.72	17%	20%	20%	17%	0%	0%	0%
		16.63	-1%	-1%	3%	3%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.38
Percent Change in Stable Slope Upstream and Downstream of Camelback Road

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Camelback Road	Upstream	15.40	0%	0%	0%	0%	0%	0%	0%
		15.30	0%	0%	0%	0%	0%	0%	0%
		15.21	0%	0%	0%	0%	0%	0%	0%
		15.11	-6%	-3%	0%	0%	0%	0%	0%
		15.02	-18%	-6%	0%	0%	0%	0%	0%
		14.92	-45%	-24%	-3%	-3%	0%	0%	0%
		14.83	-24%	-21%	0%	-4%	0%	0%	0%
		14.81	25%	15%	0%	0%	4%	0%	0%
	Downstream	14.78	23%	24%	4%	0%	0%	0%	0%
		14.73	15%	3%	3%	0%	0%	0%	0%
		14.64	0%	0%	0%	0%	0%	0%	0%
		14.55	0%	0%	0%	0%	0%	0%	0%
		14.45	0%	0%	0%	0%	0%	0%	0%
		14.36	0%	0%	0%	0%	0%	0%	0%
		14.27	0%	3%	3%	0%	0%	0%	0%
		14.17	0%	-4%	-4%	-2%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.39
Percent Change in Stable Slope Upstream and Downstream of Indian School Road

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Indian School Road	Upstream	14.45	0%	0%	0%	0%	0%	0%	0%
		14.36	0%	0%	0%	0%	0%	0%	0%
		14.27	0%	3%	3%	0%	0%	0%	0%
		14.17	0%	-4%	-4%	-2%	0%	0%	0%
		14.08	-19%	14%	14%	7%	3%	-7%	-13%
		13.98	52%	-23%	-25%	-16%	-5%	14%	36%
		13.89	-68%	-46%	-43%	-35%	-20%	-20%	-28%
		13.78	-14%	-7%	30%	22%	17%	14%	17%
	Downstream	13.75	97%	121%	113%	72%	39%	33%	30%
		13.70	44%	35%	0%	7%	7%	0%	0%
		13.61	2%	2%	0%	0%	0%	0%	0%
		13.51	0%	0%	0%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.40
Percent Change in Stable Slope Upstream and Downstream of McDowell Parkway

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
McDowell Parkway	Upstream	13.61	2%	2%	0%	0%	0%	0%	0%
		13.51	0%	0%	0%	0%	0%	0%	0%
		13.42	-74%	2%	0%	0%	0%	0%	0%
		13.32	-84%	-73%	-57%	-49%	-47%	-30%	-15%
		13.23	-77%	-70%	-63%	-58%	-57%	-45%	-30%
		13.13	-61%	-52%	-43%	-43%	-41%	-30%	-20%
		13.06	-27%	-9%	-9%	27%	24%	16%	12%
	Downstream	13.03	-61%	-52%	-43%	-31%	-25%	-21%	-1%
		12.94	247%	285%	191%	106%	26%	0%	0%
		12.85	14%	0%	0%	0%	0%	0%	0%
		12.75	0%	0%	0%	0%	0%	0%	0%
		12.66	0%	0%	0%	0%	0%	0%	0%
		12.56	0%	0%	0%	0%	0%	0%	0%
		12.47	0%	0%	0%	0%	0%	0%	0%
		12.37	0%	0%	0%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.41
Percent Change in Stable Slope Upstream and Downstream of Yuma Parkway

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Yuma Parkway	Upstream	10.02	0%	0%	0%	0%	0%	0%	0%
		9.93	0%	0%	0%	0%	0%	0%	0%
		9.83	0%	0%	0%	0%	0%	0%	0%
		9.74	0%	0%	0%	0%	0%	0%	0%
		9.64	3%	3%	0%	0%	0%	0%	0%
		9.55	-26%	-14%	7%	0%	0%	0%	0%
		9.45	-53%	-23%	-15%	-3%	-3%	-3%	0%
		9.41	-42%	18%	13%	-5%	-5%	-5%	0%
	Downstream	9.38	-55%	9%	0%	0%	0%	0%	0%
		9.36	-52%	-16%	0%	-5%	0%	0%	0%
		9.27	-60%	1%	-14%	-14%	-10%	-11%	0%
		9.17	-94%	-1%	-1%	-1%	-5%	17%	0%
		9.08	-97%	-6%	-11%	-11%	-20%	0%	0%
		8.98	-98%	-2%	-7%	-8%	45%	0%	0%
		8.89	-99%	26%	31%	45%	0%	0%	0%
		8.79	-11%	0%	-2%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

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Table 5.42
Percent Change in Stable Slope Upstream and Downstream of Broadway Road

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Broadway Road	Upstream	7.84	-7%	-7%	-5%	-2%	-2%	0%	0%
		7.75	13%	10%	7%	3%	0%	0%	0%
		7.66	-30%	-17%	-12%	-2%	0%	2%	0%
		7.56	26%	-1%	7%	0%	0%	0%	0%
		7.47	-39%	21%	-22%	-10%	-3%	3%	3%
		7.37	-85%	-46%	103%	26%	0%	-3%	-3%
		7.28	-83%	-87%	-81%	-21%	0%	2%	0%
		7.26	2%	7%	14%	24%	-4%	3%	-3%
	Downstream	7.23	133%	109%	109%	64%	12%	4%	-4%
		7.18	50%	28%	8%	-10%	-13%	-16%	-16%
		7.09	20%	51%	1%	-10%	-10%	-10%	-10%
		6.99	49%	-6%	-2%	-2%	-2%	-2%	-2%
		6.90	-19%	-17%	-19%	-19%	-19%	-19%	-19%
		6.80	-36%	-12%	-17%	-17%	-17%	-14%	-38%
		6.71	0%	-1%	16%	13%	10%	4%	104%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.43
Percent Change in Stable Slope Upstream and Downstream of Southern Avenue

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Southern Avenue	Upstream	6.61	35%	27%	19%	24%	30%	46%	-10%
		6.52	0%	-18%	-20%	-17%	-16%	45%	26%
		6.42	-22%	-22%	-22%	-33%	-13%	-58%	-42%
		6.33	12%	7%	4%	-4%	-25%	3%	-24%
		6.23	30%	44%	53%	63%	44%	15%	28%
		6.14	-29%	-4%	4%	8%	25%	25%	31%
		6.05	46%	128%	109%	90%	56%	57%	19%
		5.99	189%	130%	119%	108%	87%	67%	67%
	Downstream	5.96	15%	-17%	-18%	-17%	4%	-15%	-22%
		5.95	-67%	-69%	-68%	-73%	-80%	-24%	-10%
		5.86	5%	16%	16%	16%	1%	-10%	-21%
		5.76	14%	2%	2%	2%	2%	29%	43%
		5.67	-11%	-11%	-8%	-6%	-3%	-15%	10%
		5.57	50%	14%	54%	22%	26%	116%	24%
		5.48	-9%	126%	-5%	98%	103%	-26%	-7%
		5.38	6%	-48%	-1%	-45%	-44%	-9%	-31%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

Table 5.44
Percent Change in Stable Slope Upstream and Downstream of Baseline Road

Bridge Location		Cross Section	Bridge Opening						
			500 (ft)	750 (ft)	1,000 (ft)	1,250 (ft)	1,500 (ft)	1,750 (ft)	2,000 (ft)
Baseline Road	Upstream	5.48	-9%	126%	-5%	98%	103%	-26%	-7%
		5.38	6%	-48%	-1%	-45%	-44%	-9%	-31%
		5.29	-10%	-15%	-15%	-18%	-21%	-23%	-17%
		5.19	-11%	5%	5%	6%	6%	3%	0%
		5.10	-6%	-9%	-9%	12%	16%	13%	13%
		5.00	-53%	-20%	-7%	-15%	-15%	-1%	-1%
		4.91	-27%	-55%	-22%	-15%	-29%	7%	12%
		4.90	-39%	8%	19%	19%	24%	14%	14%
	Downstream	4.87	-61%	-49%	-25%	-28%	-13%	-30%	-30%
		4.82	94%	49%	37%	12%	12%	14%	9%
		4.72	63%	34%	30%	30%	26%	30%	50%
		4.63	-13%	-7%	-1%	-1%	2%	-4%	0%
		4.53	7%	12%	11%	9%	2%	28%	6%
		4.44	23%	18%	9%	9%	28%	4%	0%
		4.34	-3%	-3%	8%	8%	0%	0%	0%
		4.25	7%	7%	0%	0%	0%	0%	0%
		4.15	0%	0%	0%	0%	0%	0%	0%

The locations where the change in stable slope due to the bridge encroachment is continuously less than 10 percent are highlighted in green. Cross sections highlighted in blue are cross sections at the face of the bridge.

5.12.3 Floodplain Management Summary and Conclusions

Table 5.45 lists a summary of the minimum bridge opening determined for each bridge location based on significant changes in hydraulic parameters and stable slope due to a bridge encroachment relative to a non-encroached condition. A 10% or greater change in velocity or stable slope value was considered a significant change. The evaluations of hydraulic parameters and stable slope did not yield the same results, therefore physical characteristics, and constraints such as the location and distribution of braided channels, floodway widths, and proximity of bridge location to sand and gravel operations at each site were reviewed to determine recommended bridge opening dimensions.

5.12.3.1 Hummingbird Springs Road Bridge

Figure 5.2 depicts the Hummingbird Springs Road area in plan view. As noted in the figure there are multiple flow paths crossing the alignment of Hummingbird Springs Road. Due to this physical condition a multi-bridge or a bridge with additional culverts in the floodplain is recommended. Developers of Douglas Ranch are proposing a 1650 foot bridge span and a box culvert. The box culvert is located in the main channel of the Hassayampa River.

5.12.3.2 Bell Road Bridge

Figure 5.3 depicts physical characteristics of the Hassayampa River in the Bell Road area. At this location the hydraulic analysis yielded a minimum bridge opening of greater than 1500 feet. The Douglas Ranch proposed bridge span for Bell Road is 950 feet. The greater than 1500 foot proposed bridge dimension is based on upstream rise in water surface elevation of greater than a foot and a significant increase in stable slope immediately downstream of the bridge for bridge dimensions less than 1500 feet. With mitigation measures (to be discussed in a latter section) that accommodate the rise in water surface elevation and increased downstream velocities a smaller bridge opening could be designed to minimize the impacts of the bridge encroachment on the watercourse. To maintain conveyance in overbank areas and to minimize the hydraulic impact due to the encroachment, culverts in addition to the bridge are recommended.

5.12.3.3 Greenway Road Bridge

Figure 5.3 depicts the Greenway Road area. The hydraulic analyses for the Greenway Road Bridge yielded a minimum bridge opening between 1500 and 1750 feet. There is a significant increase in the change in stable slope for bridge openings 1250 feet or less. With mitigation measures that accommodate the increased downstream velocities a bridge opening in the range of 1500 feet would be adequate to minimize the impacts of the bridge encroachment on the watercourse. The Douglas Ranch development proposed a bridge opening length of 900 feet. A 900 foot bridge opening could be adequate provided that conveyance in the overbank areas was maintained. Culvert structures in overbank areas would be required to maintain flow conveyance.

5.12.3.4 Cactus Road Bridge

Figure 5.4 depicts the Cactus Road area. At the location of the bridge the river channel is a single thread channel, the Effective Floodway with is 1127 feet and the Phase 1 Floodway Width is approximately 1680 feet. The hydraulic analyses for the Cactus Road Bridge yielded a bridge opening dimensions of 1500 feet or greater. The roadway crossing is between the confluence of the Hassayampa and Daggs Wash and the Hassayampa and Wagner Wash.

With mitigation measures that accommodate the rise in water surface elevation and increased downstream velocities, a bridge opening in the range of a 1500 feet would be adequate to minimize the impacts of the bridge encroachment on the watercourse. The Douglas Ranch development proposed a bridge opening length of 950 feet. In order to minimize impact to the bridge approach embankment, a collector channel to convey flow to the bridge opening or culvert structures through the embankment to maintain overbank conveyance are recommended.

5.12.3.5 Olive Avenue, Northern Avenue and Glendale Avenue Bridges

Figure 5.5 depicts the reach of the Hassayampa River where Olive, Northern and Glendale Avenues cross the river. In this reach the channel alternates between a single thread and multi-thread channels. Downstream of the Olive Avenue bridge location the channel bifurcates into two channels with the main channel trending towards the right bank. Since the development of the Phase 1 hydraulic models the left bank at the Olive Avenue alignment has migrated to the east and a ridge is forming in the channel at the bifurcation location. The ridge will direct low flow to the channel that trends along the left bank. Over time the channel along the left bank may become the dominate channel. At the location of the Northern Avenue Bridge there are currently two distinct channels with a ridge separating the channels. The more pronounced channel is the channel along the right bank. Due to the redirection of flow by the ridge to the left bank channel and widening of the left bank channel due to the increased flows over time the more pronounced channel may be the channel along the left bank. For this reach the hydraulic analysis yielded a minimum bridge opening of greater than 1500 feet for the Olive Avenue Bridge, greater than or equal to 1500 feet for the Northern Avenue Bridge and greater than or equal to 1750 feet for the Glendale Avenue Bridge. The bridge dimensions compare well with the Phase 2 Floodway dimensions. The 1500 foot bridge opening for the Northern Avenue Bridge will accommodate both left and right bank channels. A culvert in the right overbank area through the east approach embankment is recommended.

5.12.3.6 Camelback Road Bridge

Figure 5.6 depicts the reach of the Hassayampa River where Camelback Road crosses the river. The bridge is located just downstream of the confluence with Jackrabbit Wash. At this location the main channel is a single thread channel. Multiple Jackrabbit Wash channels impact the location. There is a sand and gravel operation located upstream of the bridge location. The Field Investigation Report (Appendix B) identified a tail cut, potentially due to the sand and gravel location extending from a pit to the location of the bridge. The hydraulic analyses for the Camelback Road Bridge yielded a minimum bridge opening greater than or equal to 1250 feet. In order to minimize impact to the bridge approach embankment from Jackrabbit Wash a diversion channel to convey flow to the bridge opening or culvert structures through the embankment to maintain overbank conveyance are recommended. The upstream sand and gravel operation will have an impact on total scour depths at the bridge.

5.12.3.7 McDowell Parkway and Indian School Road Bridges

Figure 5.7 depicts the reach of the Hassayampa River where McDowell Parkway and Indian School Road cross the river. The reach is dominated by sand and gravel activity which has greatly changed the form of the river and the hydraulic conditions in a runoff event. These alterations in the channel configurations and dimensions affect the stable slope as well. At the pit locations the effective channel has been widened. At locations where flow exits a pit, flow is concentrated to a single narrow channel. The hydraulic analyses for the McDowell Parkway and Indian School Road Bridges show that the backwater from the McDowell Parkway Bridge impacts the hydraulic conditions at the Indian School Road Bridge which results in unfavorable trends in the stable slope between the two bridges. Minimum bridge openings widths of 1500 feet along with some channelization and grade control structures to mitigate impacts from sand and gravel operations should be adequate to minimize the impacts of bridge locations on the watercourse.

5.12.3.8 Yuma Parkway Bridge

Figure 5.8 depicts the reach of the Hassayampa River in the vicinity of the Yuma Parkway crossing. At the location of the bridge the main channel is a single thread wide channel. The channel goes through an "S" curve at the location of the bridge. In addition to the constraints of the "S" curve, there are power lines and a 1000 psi natural gas line that cross the river at this location. The right bank at the location of the power lines migrated approximately 300 feet during a runoff event in January 2010. The recommended minimum bridge opening based on velocity, Froude Number and water surface elevation was estimated to be approximately 750 feet; however, based on the stable slope evaluation, the recommended minimum bridge opening is approximately 1750 feet. Furthermore, if a bridge is constructed at this proposed location in spite of the potential utility conflicts, a 1750 foot opening is recommended so the geometry of the river and potential lateral migration will be accommodated. Due to the constraints of the river geometry, power lines, and gas line, relocating the bridge should be considered.

5.12.3.9 Baseline Road, Southern Avenue and Broadway Road Bridges

Figure 5.9 depicts the reach where SR 801, Union Pacific Railroad, Baseline Road, Southern Avenue and Broadway Road cross the Hassayampa River. The SR 801 crossing of the river is in a reach where landowners plan to channelize the river as they develop their property. The geometry of the channelized reach will drive the dimensions of the SR 801 Bridge. The Union Pacific Railroad Bridge is an existing bridge. The results of the hydraulic analyses conducted for this reach showed that backwater from the Baseline Road Bridge location impacts the hydraulic condition of the Southern Avenue Bridge location and back water from the Southern Avenue Bridge location impacts the Broadway Road Bridge location. The minimum bridge opening evaluation for the Baseline Road and Southern Avenue was not conclusive for the range of bridge openings evaluated. The minimum bridge opening evaluation for Broadway Road yielded an opening of 1500 feet or greater. Existing sand and gravel operations in the reach do not have significant impacts to the watercourse, however if the sand and gravel pit expands, the impacts could be significant.

Table 5.45 Conclusion Summary

Bridge Location	River Sta (RM)	Effective floodway Width (ft)	Phase 1 Floodway Width (ft)	Minimum bridge opening based on change in vel. and WS Elev. (ft)	Minimum bridge opening based on change in stable slope. (ft)	Comments
Bell Road	24.99	1965	1763	> 1500	1250	Additional culvert structures in floodplain recommended
Greenway Road	23.87	1986	1285	> 1500	1500	Additional culvert structures in floodplain recommended
Cactus Road	21.27	1633	1127	≥ 1500	1250-1500	Collector channel and or culvert structures along approach embankments upstream are recommended.
Olive Avenue	19.26	1342	1792	> 1500	1500 - 1750	
Northern Avenue	18.19	1463	1500	≥ 1500	1500	Need a multi-bridge solution or channelization for bridge opening of less than 1250 feet
Glendale Avenue	17.17	2040	1988	≥ 1750	not conclusive	
Camelback Road	14.81	1822	930	≥ 1250	1000	Existing constraints include sand and gravel operations.
Indian School Road	13.78	1891	1671	≥ 1500	not conclusive	Some channelization required. Backwater from downstream bridge impacts bridge hydraulics. Existing constraints include sand and gravel operations.
McDowell Parkway	13.06	1976	2163	≥ 1500	not conclusive	Some channelization required. Existing constraints include sand and gravel operations.
Yuma Parkway	9.41	1984	1362	> 1250	1500-2000	Existing constraints include downstream sand and gravel operations and APS power lines.
Broadway Road	7.26	2478	1768	≥ 1500	1500 – 2000	Existing constraints include upstream sand and gravel operations.
Southern Avenue	5.99	3004	2709	≥ 2000	not conclusive	Need a multi-bridge solution or channelization. Existing constraints include sand and gravel operations (permits upstream and downstream).
Baseline Road	4.9	2686	2489	> 2000	not conclusive	Need a multi-bridge solution or channelization. Existing constraints include sand and gravel operations (permits upstream).

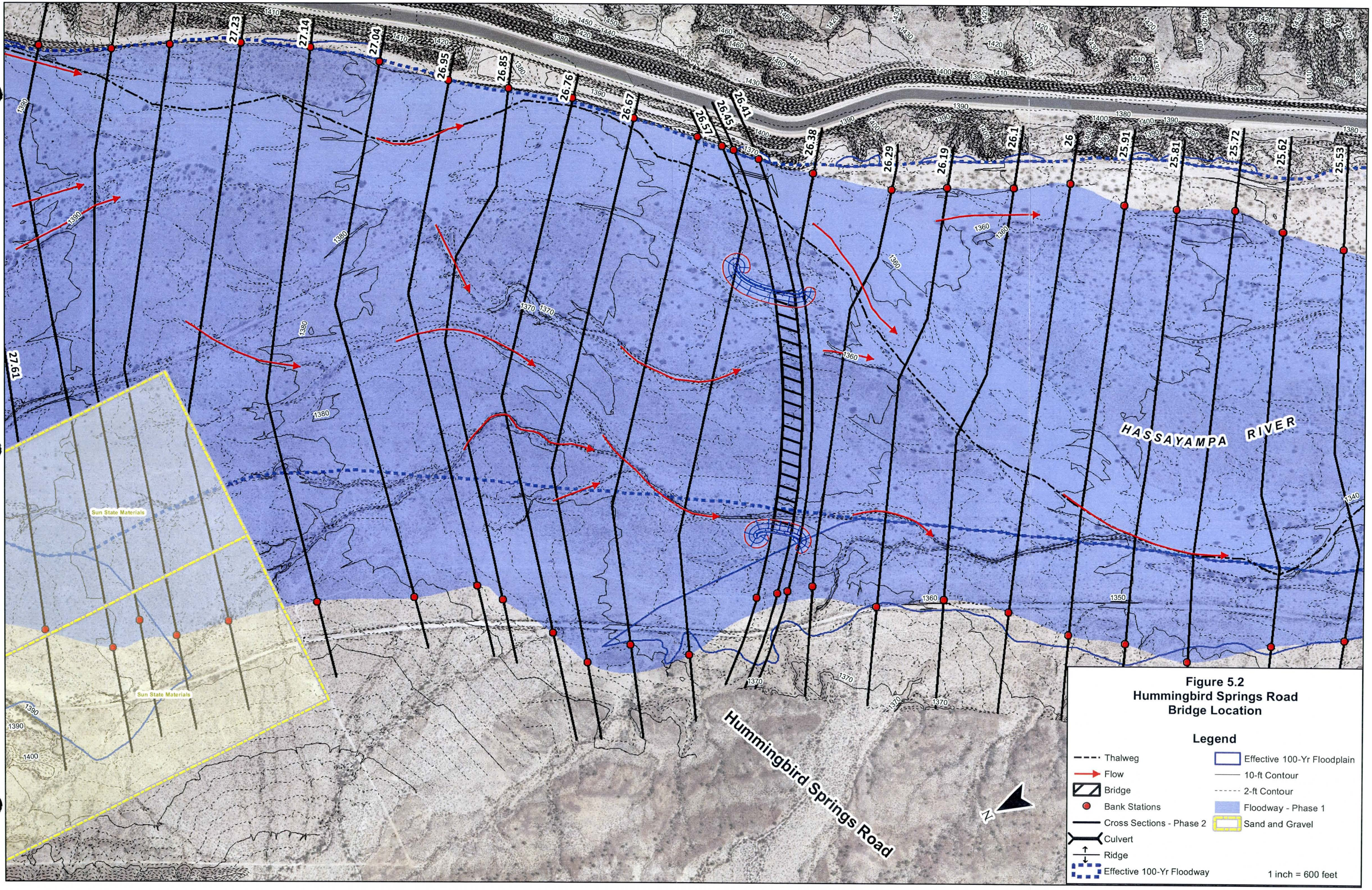


Figure 5.2
Hummingbird Springs Road
Bridge Location
Legend
Thalweg
Flow
Bridge
Bank Stations
Cross Sections - Phase 2
Culvert
Ridge
Effective 100-Yr Floodway
Effective 100-Yr Floodplain
10-ft Contour
2-ft Contour
Floodway - Phase 1
Sand and Gravel
1 inch = 600 feet
N
HASSAYAMPA RIVER
Hummingbird Springs Road
Sun State Materials
Sun State Materials
27.61
27.23
27.14
27.04
26.95
26.85
26.76
26.67
26.57
26.45
26.41
26.38
26.29
26.19
26.1
26
25.91
25.81
25.72
25.62
25.53

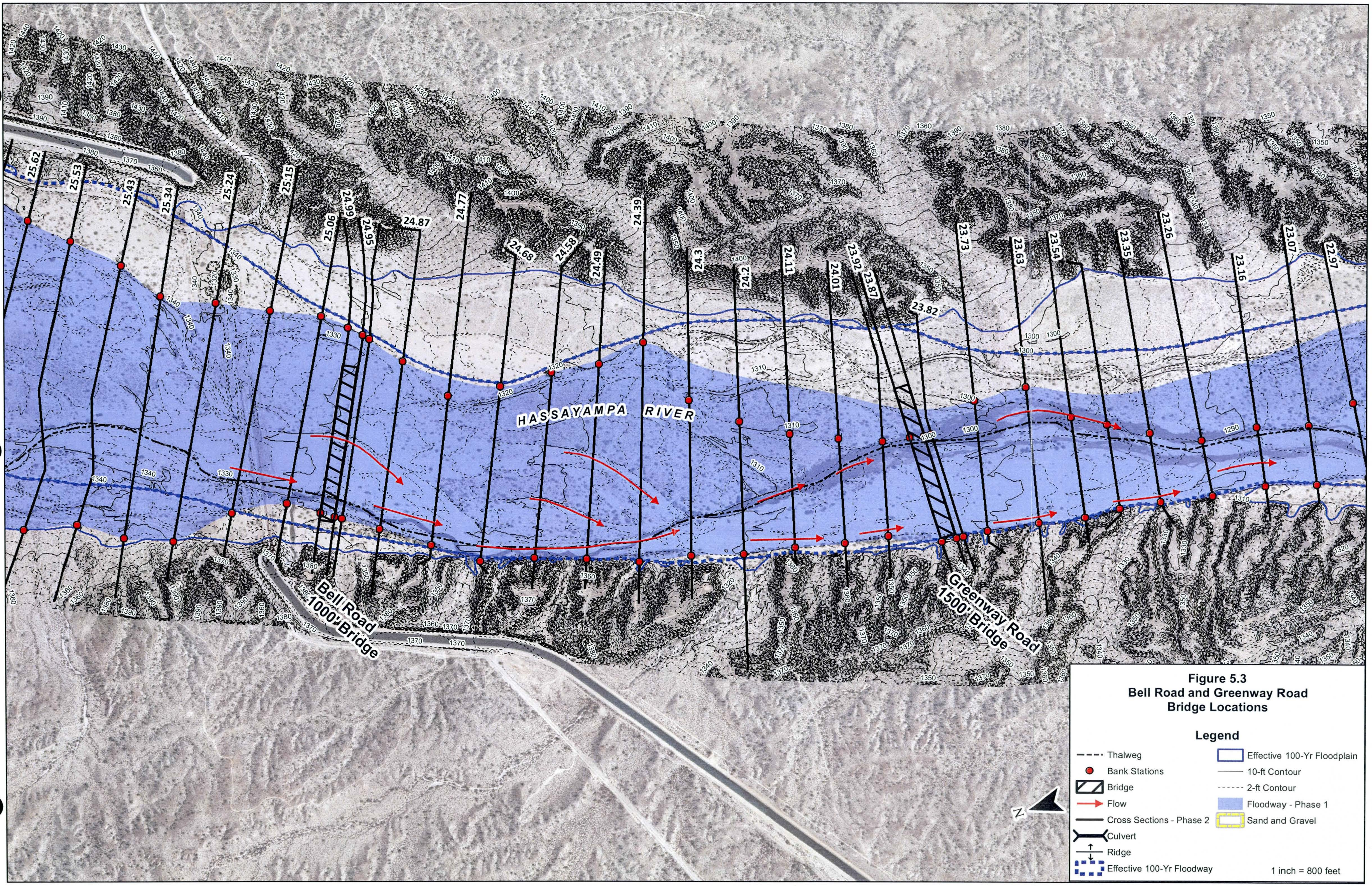


Figure 5.3
Bell Road and Greenway Road Bridge Locations

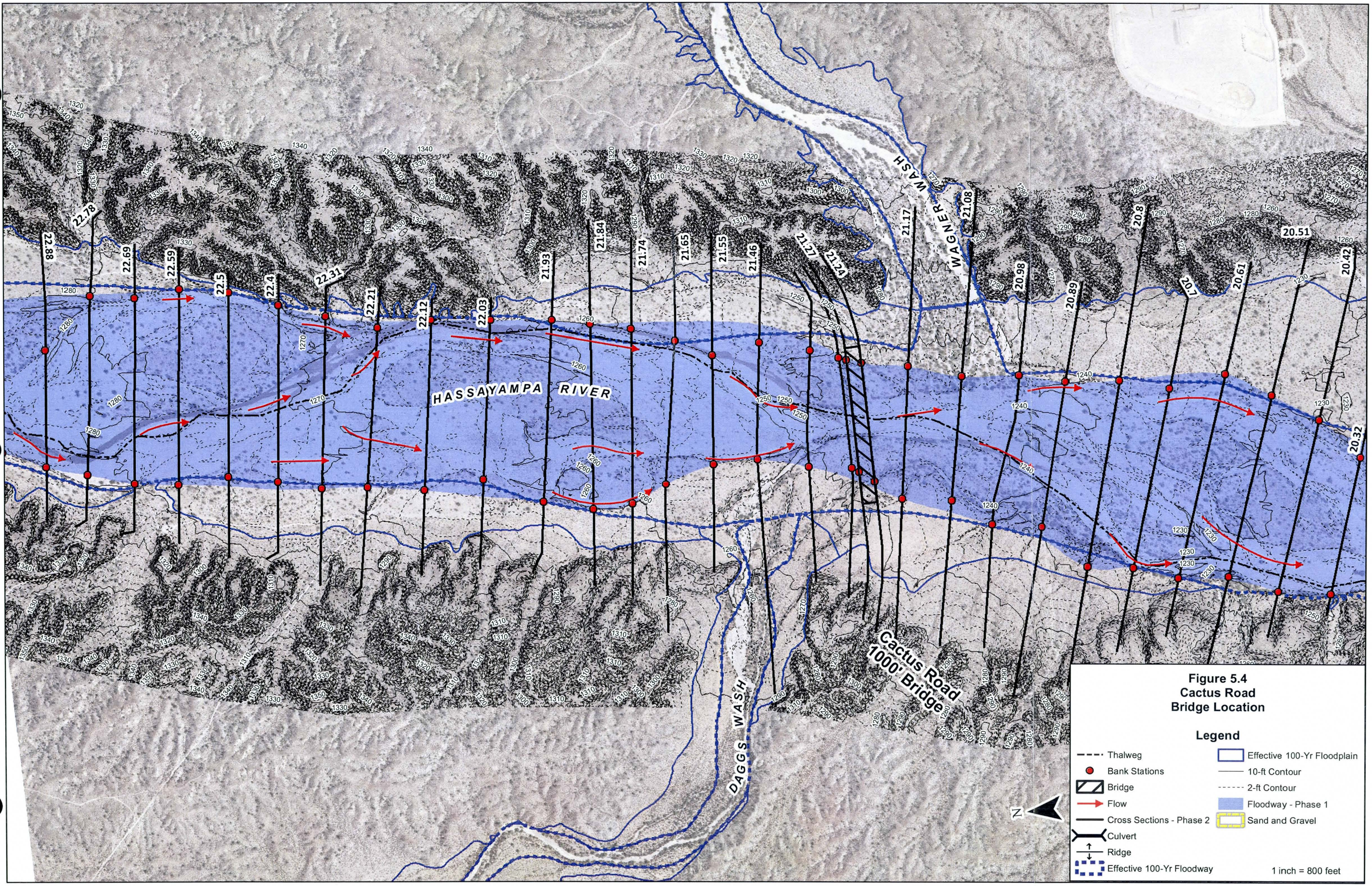


Figure 5.4
Cactus Road Bridge Location

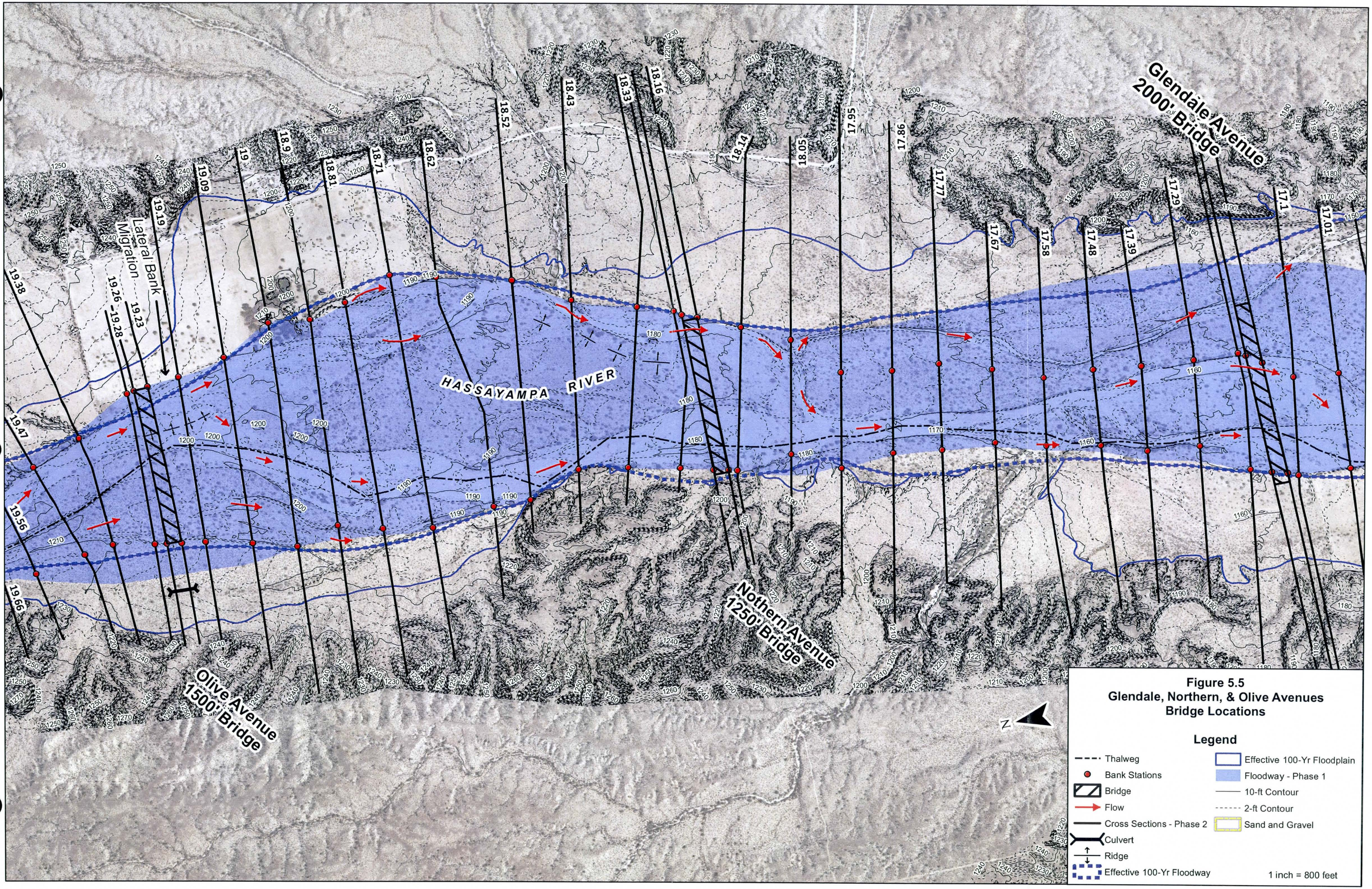


Figure 5.5
Glendale, Northern, & Olive Avenues Bridge Locations

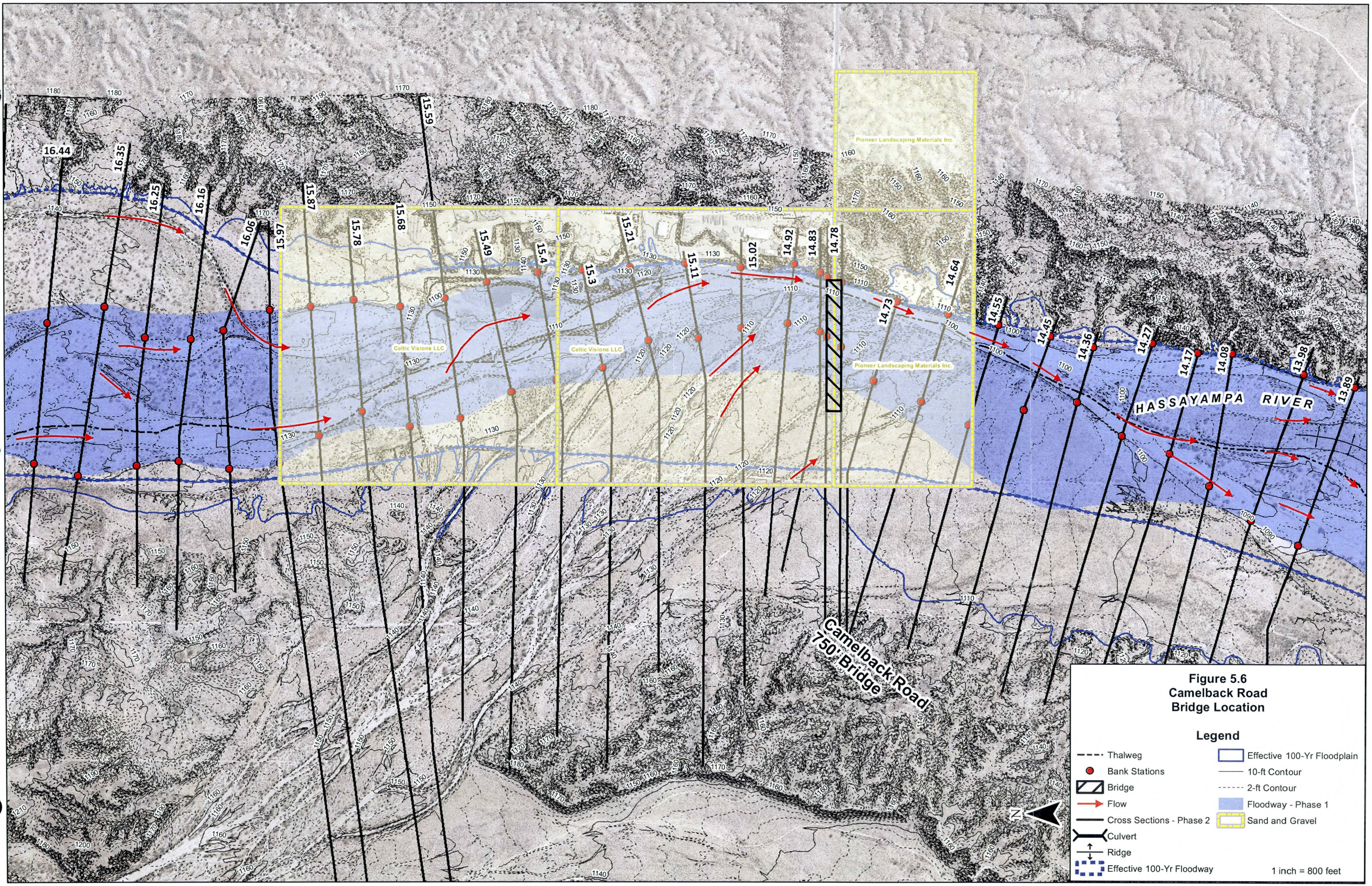


Figure 5.6
Camelback Road
Bridge Location

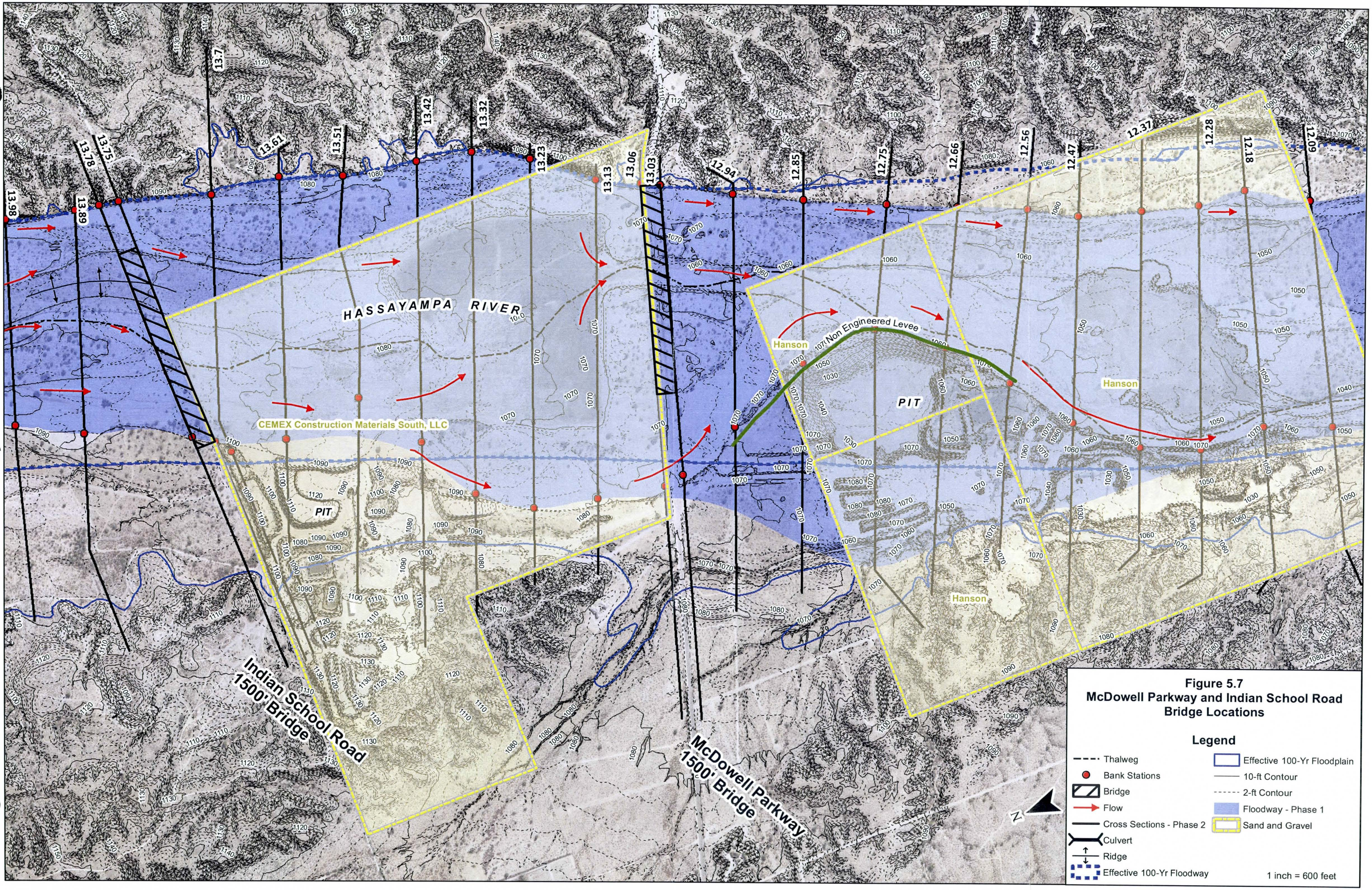


Figure 5.7
McDowell Parkway and Indian School Road Bridge Locations

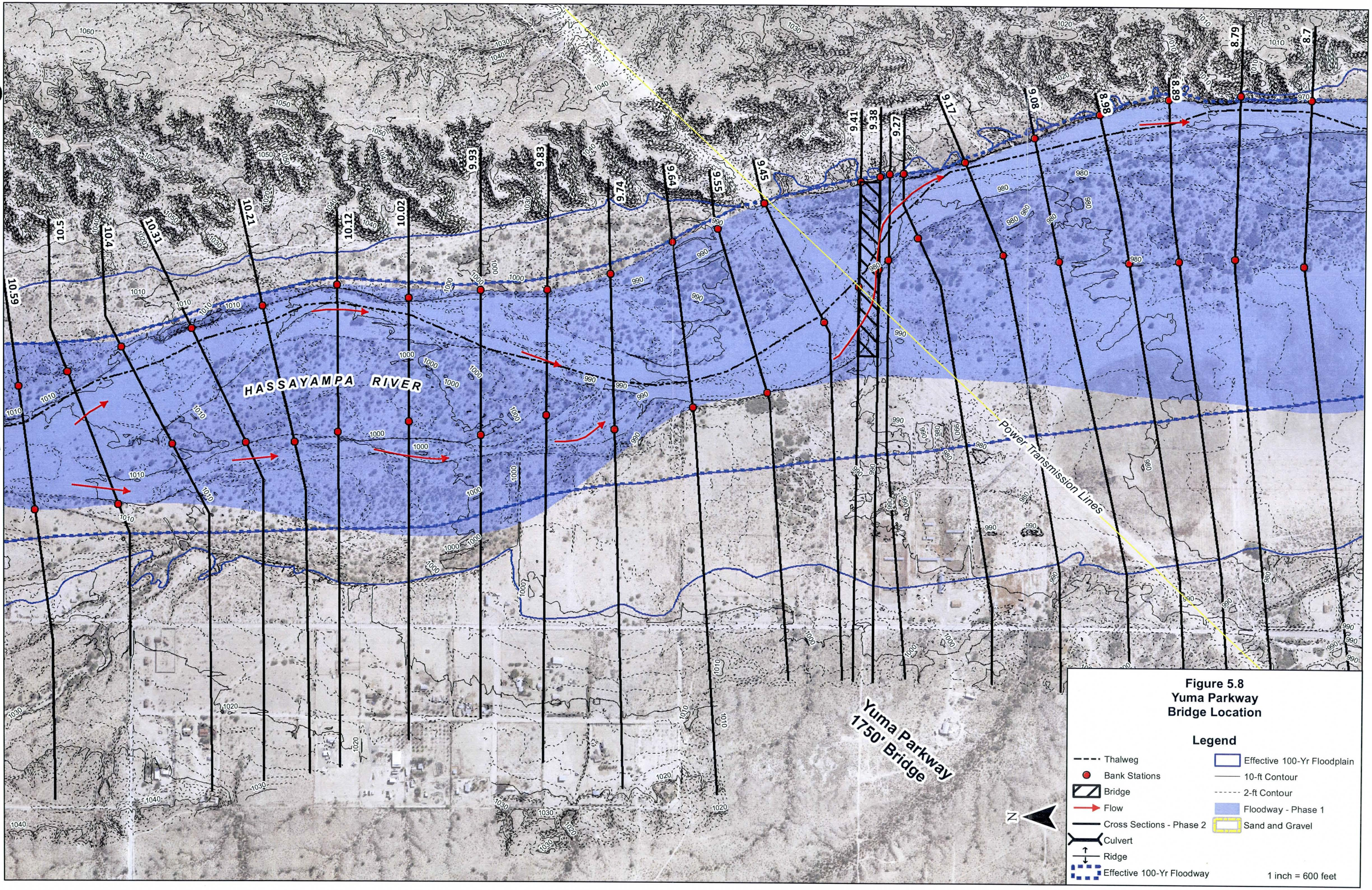


Figure 5.8
Yuma Parkway
Bridge Location

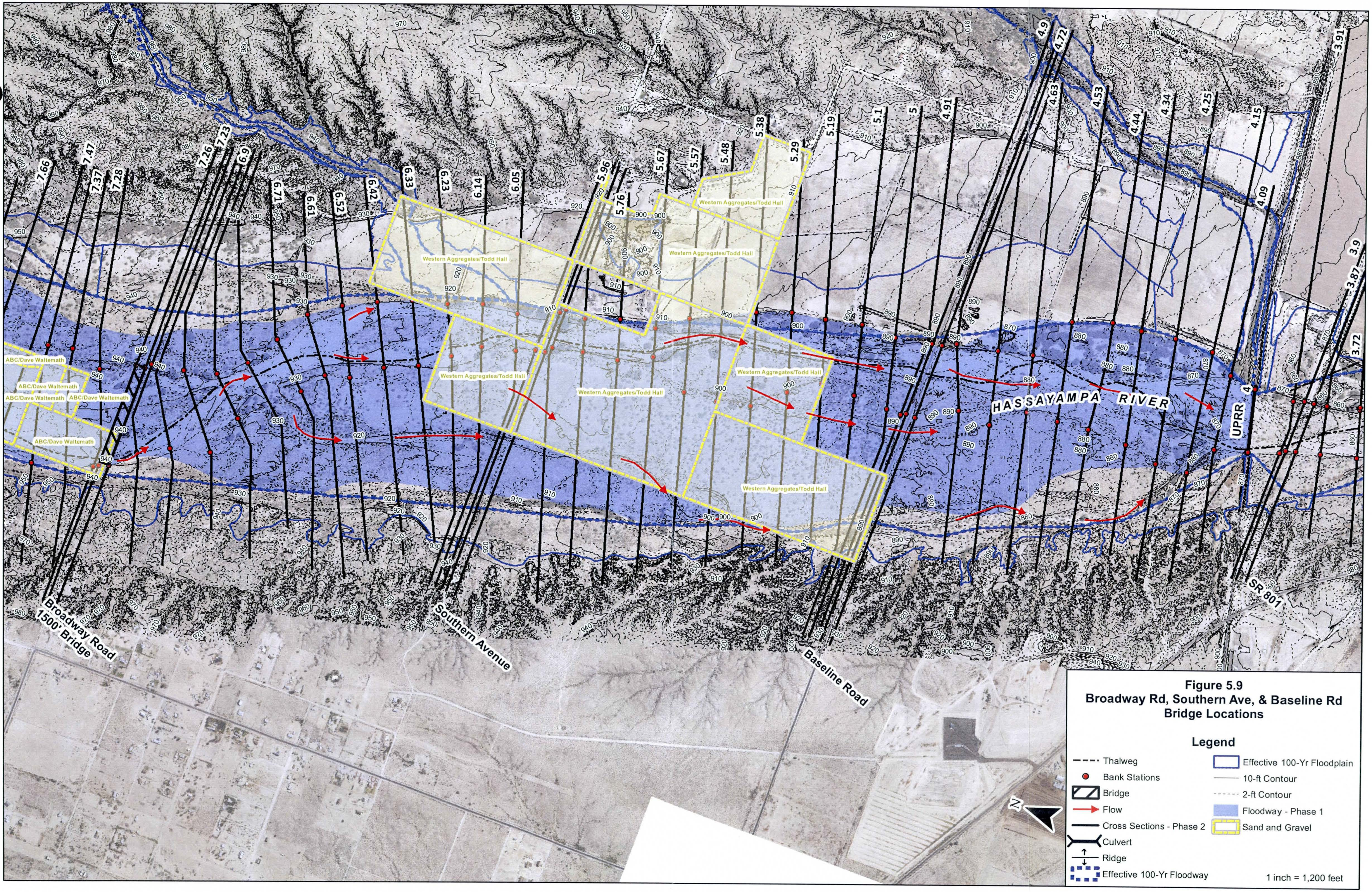


Figure 5.9
Broadway Rd, Southern Ave, & Baseline Rd Bridge Locations

5.12.4 Potential Sand and Gravel Opportunities at Bridge Encroachments

Ineffective flow areas upstream and downstream of a bridge location could provide opportunities for sand and gravel operations. Engineering solutions would need to be developed are to mitigate the potential impact that a sand and gravel operation would have on the structural integrity of the bridge should mining be allowed in the ineffective flow area. Ineffective flow areas are areas that are inundated during a runoff event; however the hydraulic performance of the watercourse is not dependent on flow conveyance occurring in the ineffective flow areas. Figure 5.10 depicts the ineffective flow area associated with a 1250 bridge opening at Bell Road Bridge crossing. The dark bluish green area approximately 36 acres in size is the ineffective flow area. Engineering solutions that would need to be implemented to protect the sand and gravel operation and the bridge include an armored levee along the boundary between the ineffective and effective flow (light blue area in Figure 5.10) areas. Table 5.46 lists the ineffective flow areas associated with bridge locations.

Figure 5.10
Ineffective flow area at proposed Bell Road Bridge crossing.

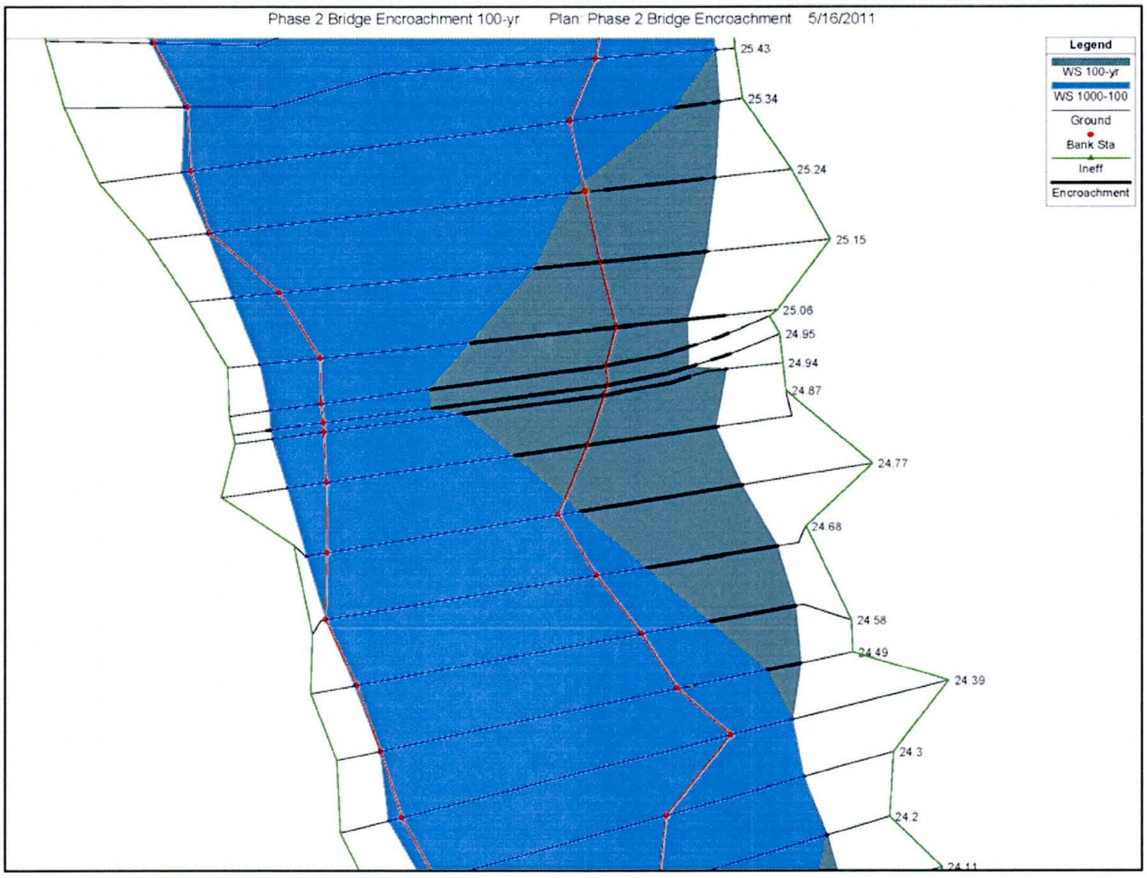


Table 5.46 Ineffective Flow Area

	Bridge Opening													
	500-ft		750-ft		1000-ft		1250-ft		1500-ft		1750-ft		2000-ft	
Bridge	**Left** acres	**Right** acres	**Left** acres	**Right** acres	**Left** acres	**Right** acres	**Left** acres	**Right** acres	**Left** acres	**Right** acres	**Left** acres	**Right** acres	**Left** acres	**Right** acres
	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bell Road	134	1	115	0	101	0	36	1	16	1	7	1	2	1
Greenway Road	62	38	49	22	35	14	14	8	11	6	2	5	0	5
Cactus Road	39	98	25	74	16	52	12	35	5	15	3	2	1	2
Olive Avenue	99	108	89	98	69	75	37	50	21	34	0	9	0	3
Northern Avenue	123	3	93	0	60	0	34	0	6	0	0	0	0	0
Glendale Avenue	174	58	153	36	120	29	96	21	69	17	60	8	22	1
Camelback Road	0	173	0	140	0	92	0	62	0	19	0	5	0	3
Indian School Road	43	74	34	57	15	50	21	51	15	37	13	30	4	1
McDowell Parkway	16	145	7	110	3	94	0	95	0	72	0	28	0	3
Yuma Parkway	10	275	4	255	1	201	1	123	1	84	1	47	1	17
Broadway Road	255	60	208	55	169	52	127	53	92	53	61	53	37	44
Southern Avenue	93	301	70	270	76	256	67	215	67	185	67	136	67	104
Baseline Road	170	260	144	226	141	208	140	161	128	130	104	106	85	77
Total	**1218**	**1594**	**991**	**1343**	**805**	**1123**	**585**	**874**	**431**	**653**	**318**	**430**	**220**	**260**

5.13 ESTIMATES OF PROBABLE COST FOR BRIDGE ENCROACHMENT SCENARIOS

The District conducted a Bridge Length Optimization evaluation to develop a simple and consistent means to compare cost of different bridge lengths based on roadway and bridge widths, length of the approach to the bridge that is within the 100-year floodplain and key hydraulic parameters (FCDMC, December 2012). Bridge lengths evaluated include 500, 750, 1000, 1250, 1500, 1750 and 2000 foot bridge openings. Results of the evaluation indicates that for bridge lengths below 1000 feet, decreases in the overall cost tend to become less and less significant with decreasing length and in some cases the costs of a shorter bridge actually begin to increase. The reasons for these trends is due to the change in hydraulic conditions imparted by a smaller bridge opening resulting in higher structural cost to mitigate the more severe hydraulic conditions.

5.14 HEC-RAS FLOODPLAIN MANAGEMENT HYDRAULIC MODELING STEP 2 DETAILS AND RESULTS

Step 2, the final step in the bridge encroachment analyses, incorporates the results and Districts comments for the Step 1 evaluations. Based on review by District's staff, bridge locations were moved due to potential sedimentation issues at confluences, proximity to the CAP siphon and topographic constraints at bridge locations. The significance of a bridge location near the CAP siphon is that a bridge may create an adverse impact to the siphon through erosion due to changes in hydraulic performance brought on by a bridge. Topographic constraints refer to bridge approaches from adjacent terraces that are 20 to 60 feet higher than the watercourse. In order to provide a smooth transitions form the terrace to a bridge location the bridge was moved to a location near the original location where topographic slopes were not as steep. The HEC-RAS Floodplain Management Step 1 model was revised to include the new locations of bridges that were moved. The HEC –RAS bridge routine was used to define bridge geometry and ineffective flow stations were used to define ineffective flow areas upstream and downstream of a bridge location. Bridge locations by River Mile are listed in Table 5.47. New cross section alignments are presented on Plate 2.

Table 5.47 Bridge Locations

Bridge	**Station** ***River Mile***
Hummingbird Springs Road	26.274
Bell Road	24.71
Greenway Road	23.64
Cactus Road	21.565
Olive Avenue	19.505
Northern Avenue	17.935
Glendale Avenue	17.155
Camelback Road	14.405
Indian School Road	13.875

Table 5.47 Bridge Locations Continued

Bridge	Station *River Mile*
McDowell Parkway	13.035
Interstate 10, Westbound[1]	11.005
Interstate 10, Eastbound[1]	10.985
Yuma Parkway	9.78
Broadway Road	7.295
Southern Avenue	5.96
Baseline Road	4.495
UPRR[1]	4.000
State Route 801[2]	
Old US 80[1]	2.650

[1] Existing Bridge
[2] To be included in Maximum alternative.

Initial hydraulic results from Step 2 yielded different results than in the Step 1 evaluation indicating that the bridge openings needed to be increased. The results at some bridge locations for the Step 2 evaluation were in excess of a 10% change in velocity, and an increase in water surface elevation of greater than 1 foot for the 100 year event. These changes typically extended more than 500 feet upstream and/or downstream. The difference between the results of Step 1 and Step 2 is due to modeling approaches. Step 2 modeled bridges using the HEC-RAS bridge routine whereas Step 1 did not. An iterative approach was taken to finalize the optimal bridge opening dimension. Bridge opening length was increased until the change in velocity (10% or greater) and water surface elevation (1 foot or greater) relative to the existing condition occurred within in an area 500 feet upstream and downstream of a bridge location. The rationale behind this approach is that for locations where the criteria was not met mitigation measures would be employed as part of the design to mitigate impacts because of the changed condition. Mitigation measures could include channelization, channel armoring, grade control structures or purchase of additional right of way. Mitigation measures will be discussed in a following section. Figures 5.11 through 5.18 depict the new locations of proposed bridges.

Table 5.48 list a summary of results for the Step 2 evaluation. Details of the results are present in Tables 5.49 through 5.76 following the discussion of floodway encroachment models. In these tables a comparison of the results between the Existing Condition, Bridge and Floodway Encroachment models at bridge locations are made.

5.15 HEC-RAS FLOODWAY ENCROACHMENT HYDRAULIC MODELING DETAILS AND RESULTS

Two Floodway Encroachment HEC-RAS models were developed to model the Effective Floodway and the Phase 1 Floodway in conjunction with bridge dimensions developed in the Step 2 Floodplain Management Evaluation.

5.15.1 Effective Floodway Model

The Floodplain Management Step 2 HEC-RAS model was revised to include the Effective Floodway encroachments. The following modifications were made to the model.

- The reach below the Union Pacific Railroad was modeled as a levee failed condition by removing the lateral weir structural elements in the HEC-RAS model and by creating continuous cross sections from edge of floodplain to opposite edge of floodplain instead of the approach that was used in the existing condition model of utilizing lateral weirs to estimate flow that was overtopping the levees and then draining to the Gila River in the Right and Left channels.
- Floodway encroachment stations are based on the location of the Effective Floodway. Stations were determined by calculating an encroachment station at the location where a cross section intersects with the Effective Floodway boundary.
- Expansion and contraction coefficients were revised at locations where there are no longer abrupt contractions and expansions due to location and distribution of floodway encroachment stations. This condition primarily occurred at bridge locations.

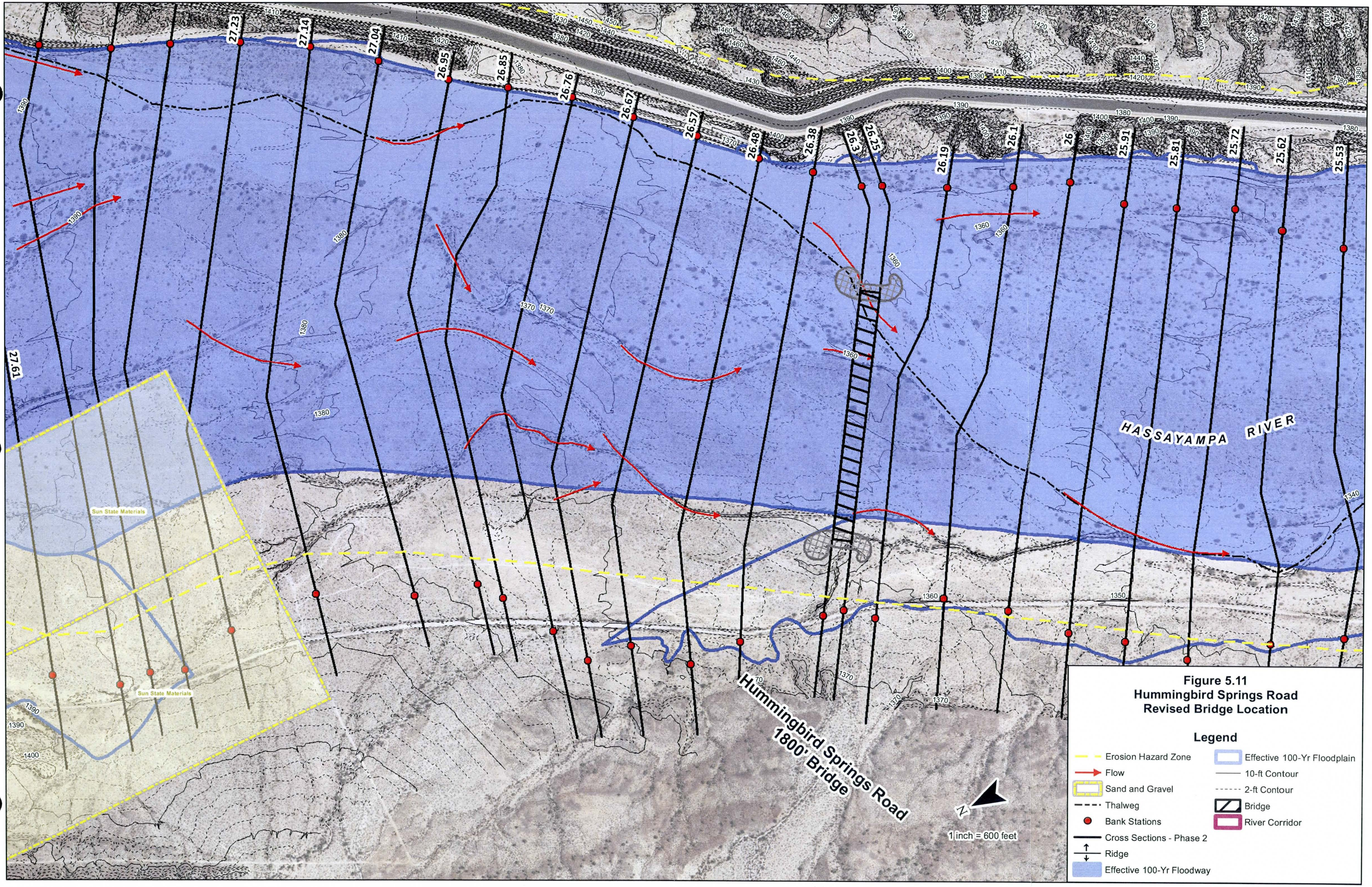


Figure 5.11
Hummingbird Springs Road
Revised Bridge Location
Legend
Erosion Hazard Zone
Flow
Sand and Gravel
Thalweg
Bank Stations
Cross Sections - Phase 2
Ridge
Effective 100-Yr Floodway
Effective 100-Yr Floodplain
10-ft Contour
2-ft Contour
Bridge
River Corridor
HASSAYAMPA RIVER
Hummingbird Springs Road
1800' Bridge
Sun State Materials
1 inch = 600 feet
N
27.61
27.23
27.14
27.04
26.95
26.85
26.76
26.67
26.57
26.48
26.38
26.3
26.25
26.19
26.1
26
25.91
25.81
25.72
25.62
25.53

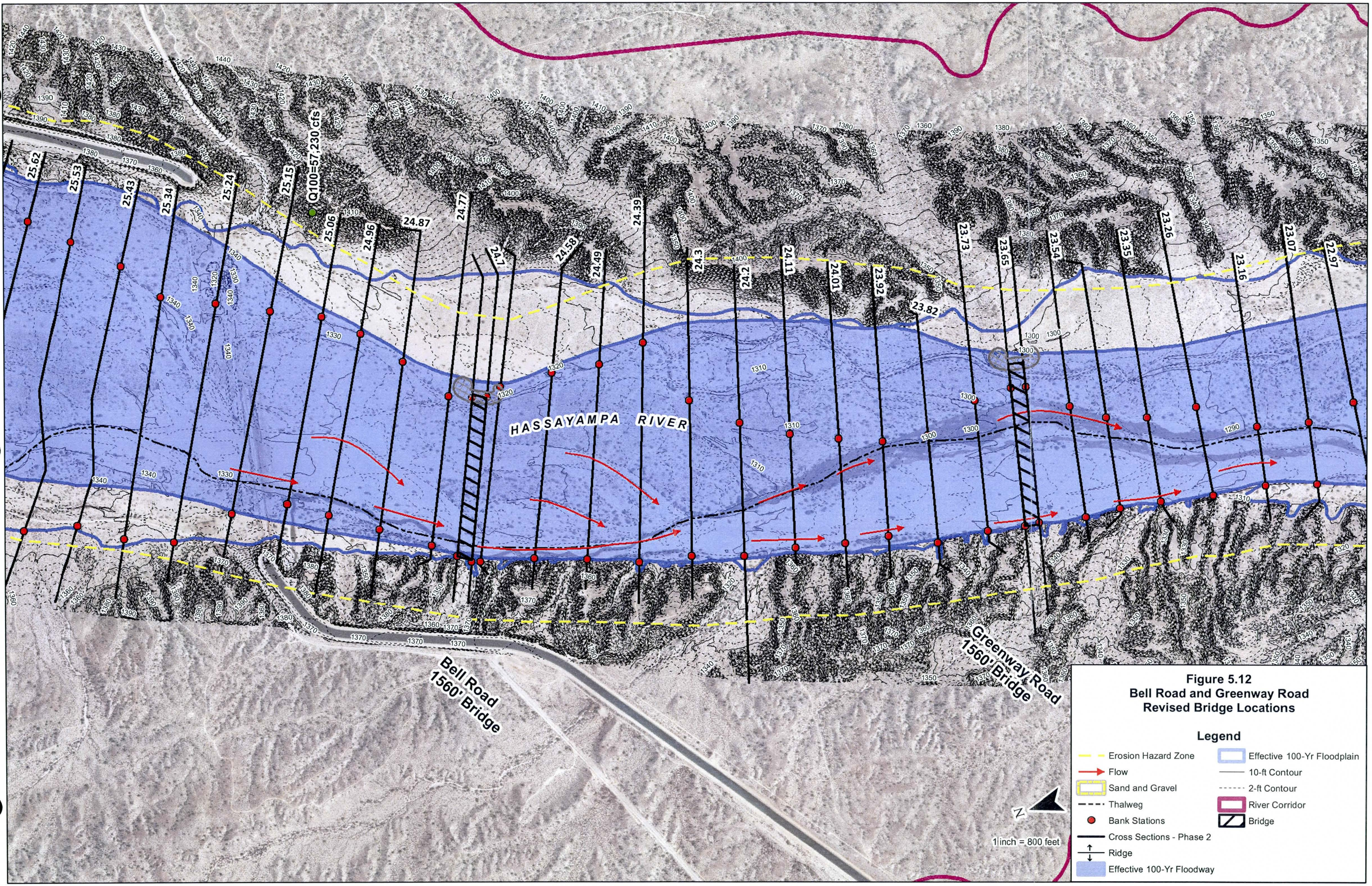


Figure 5.12
Bell Road and Greenway Road
Revised Bridge Locations

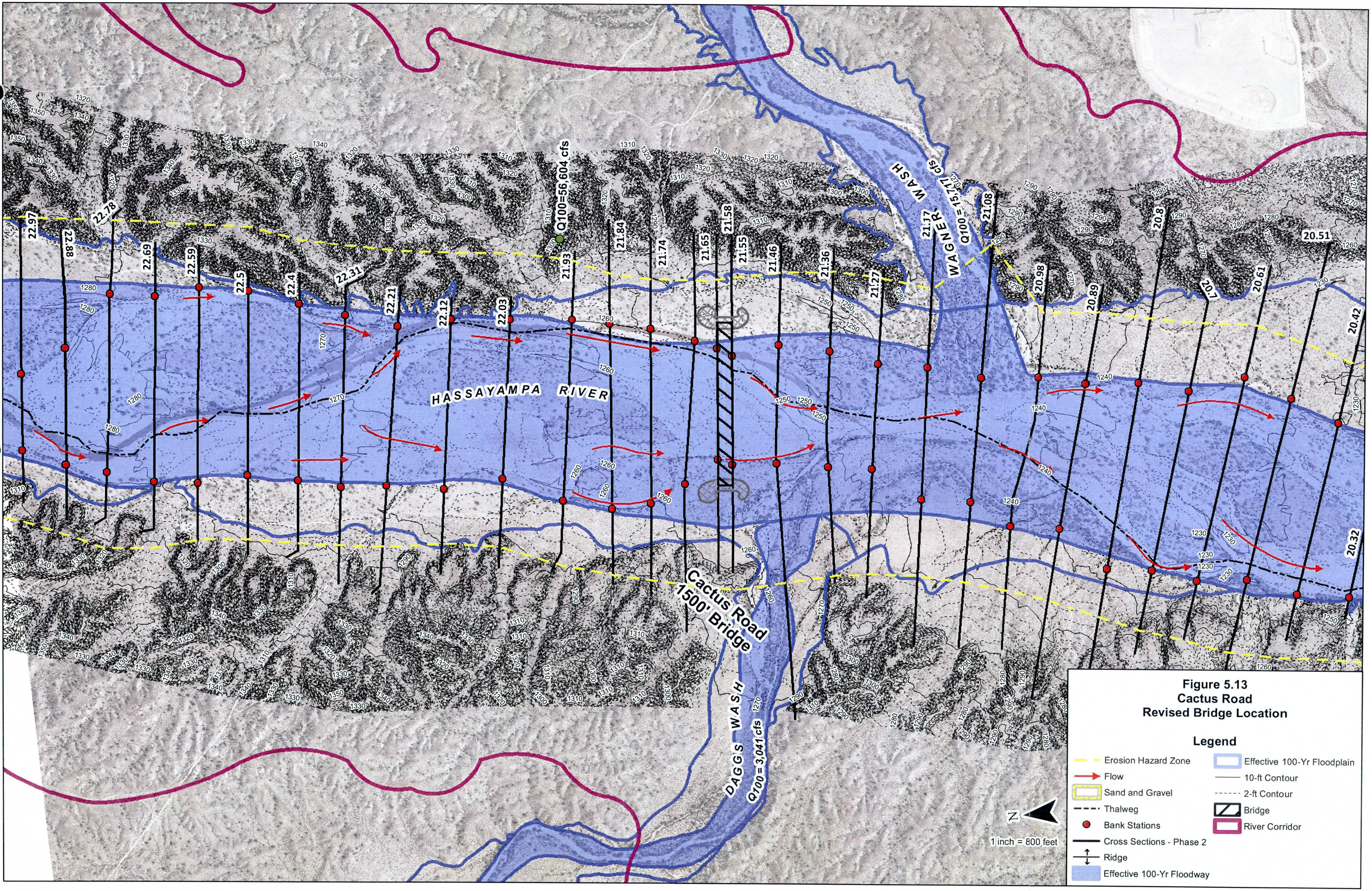


Figure 5.13
Cactus Road
Revised Bridge Location

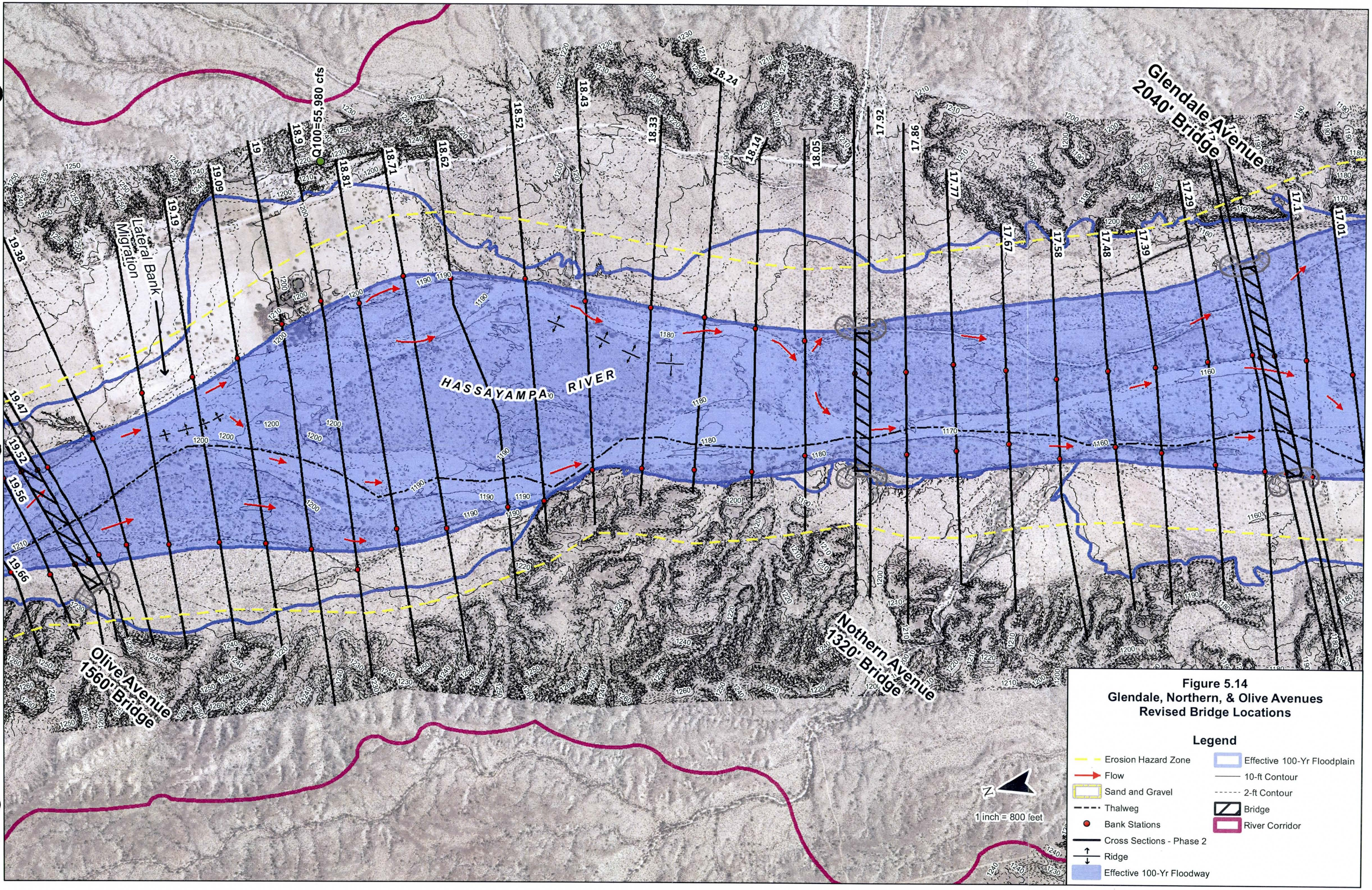


Figure 5.14
Glendale, Northern, & Olive Avenues
Revised Bridge Locations

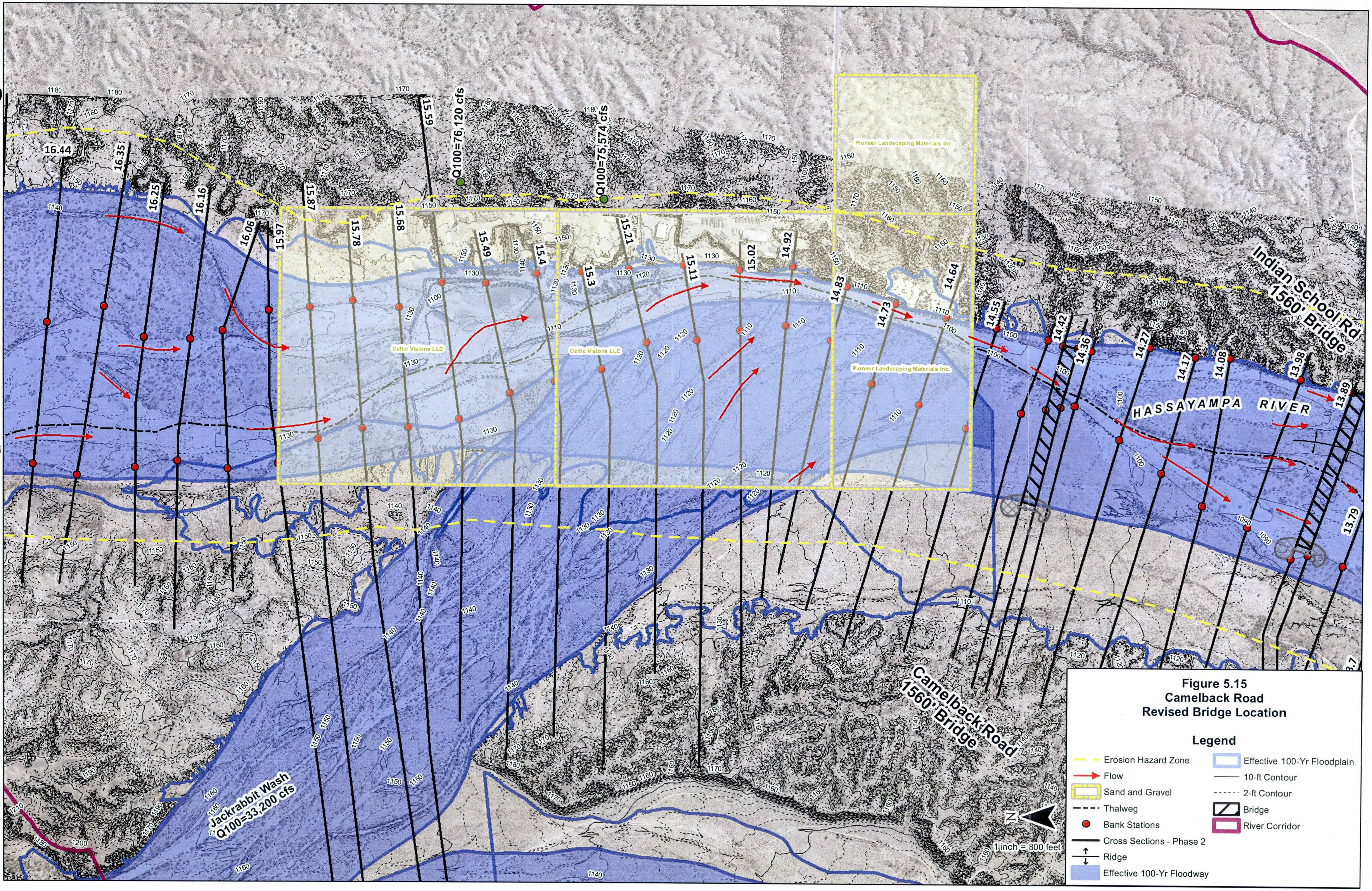


Figure 5.15
Camelback Road
Revised Bridge Location

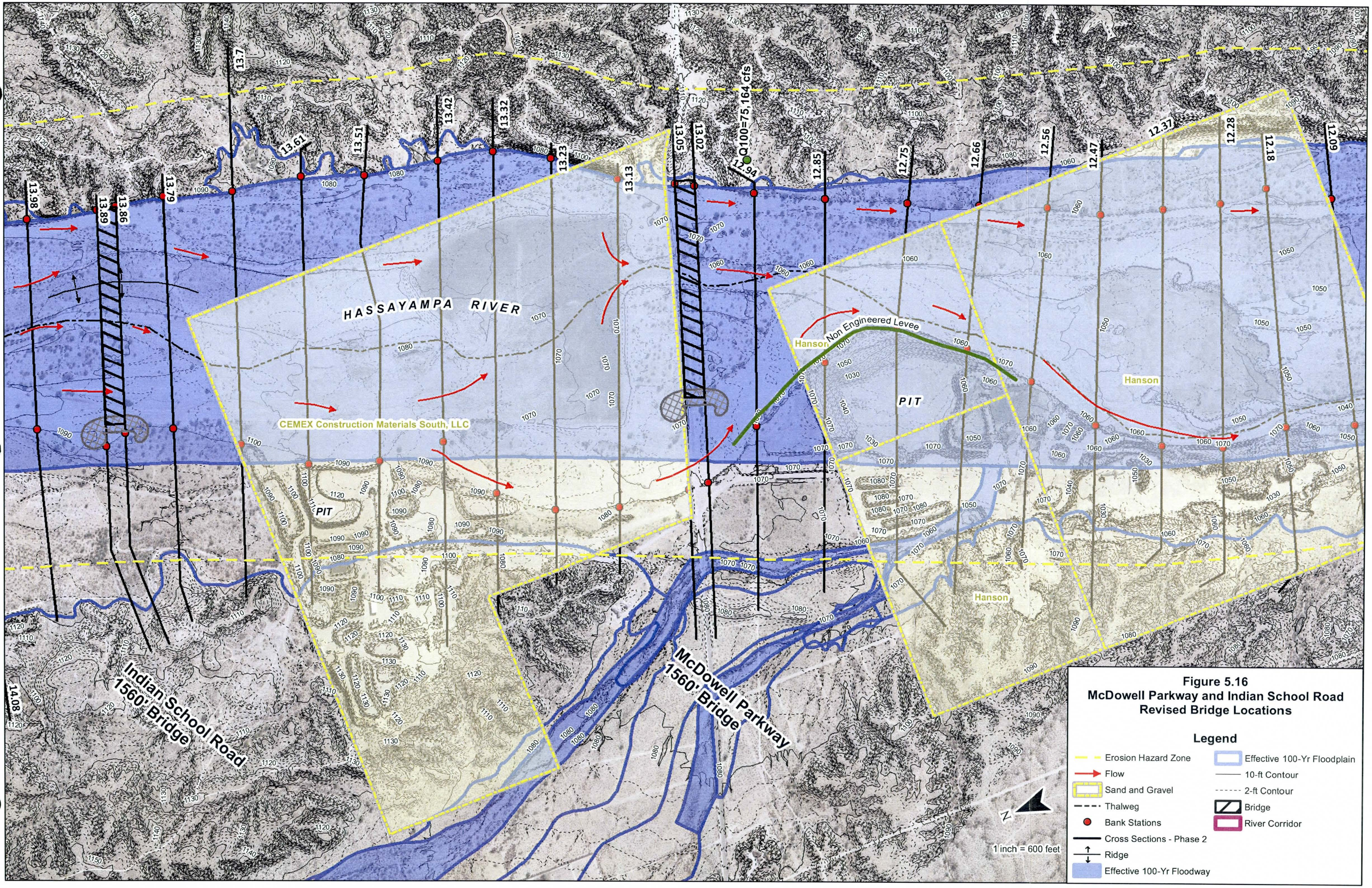


Figure 5.16
McDowell Parkway and Indian School Road Revised Bridge Locations

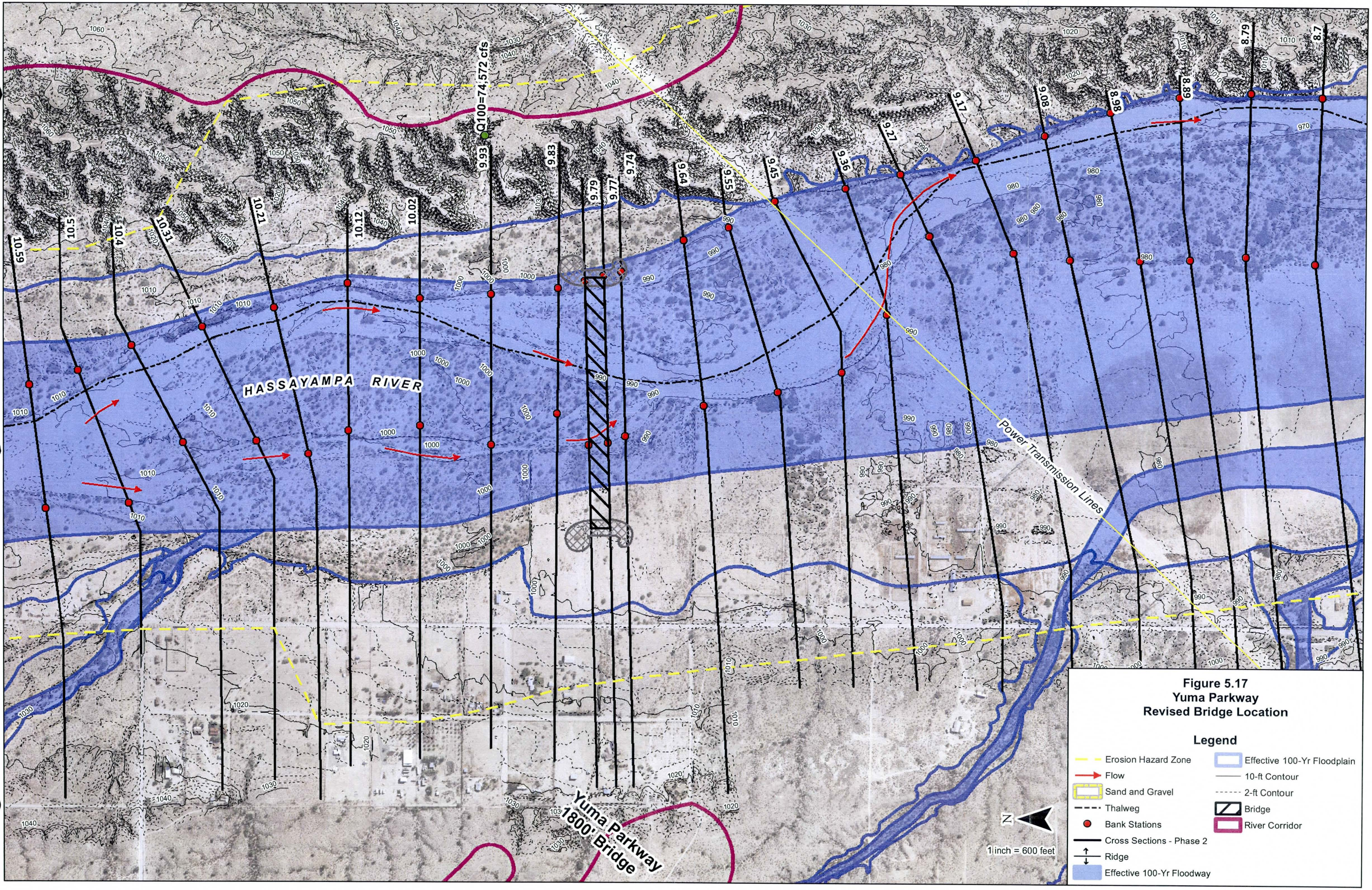


Figure 5.17
Yuma Parkway
Revised Bridge Location

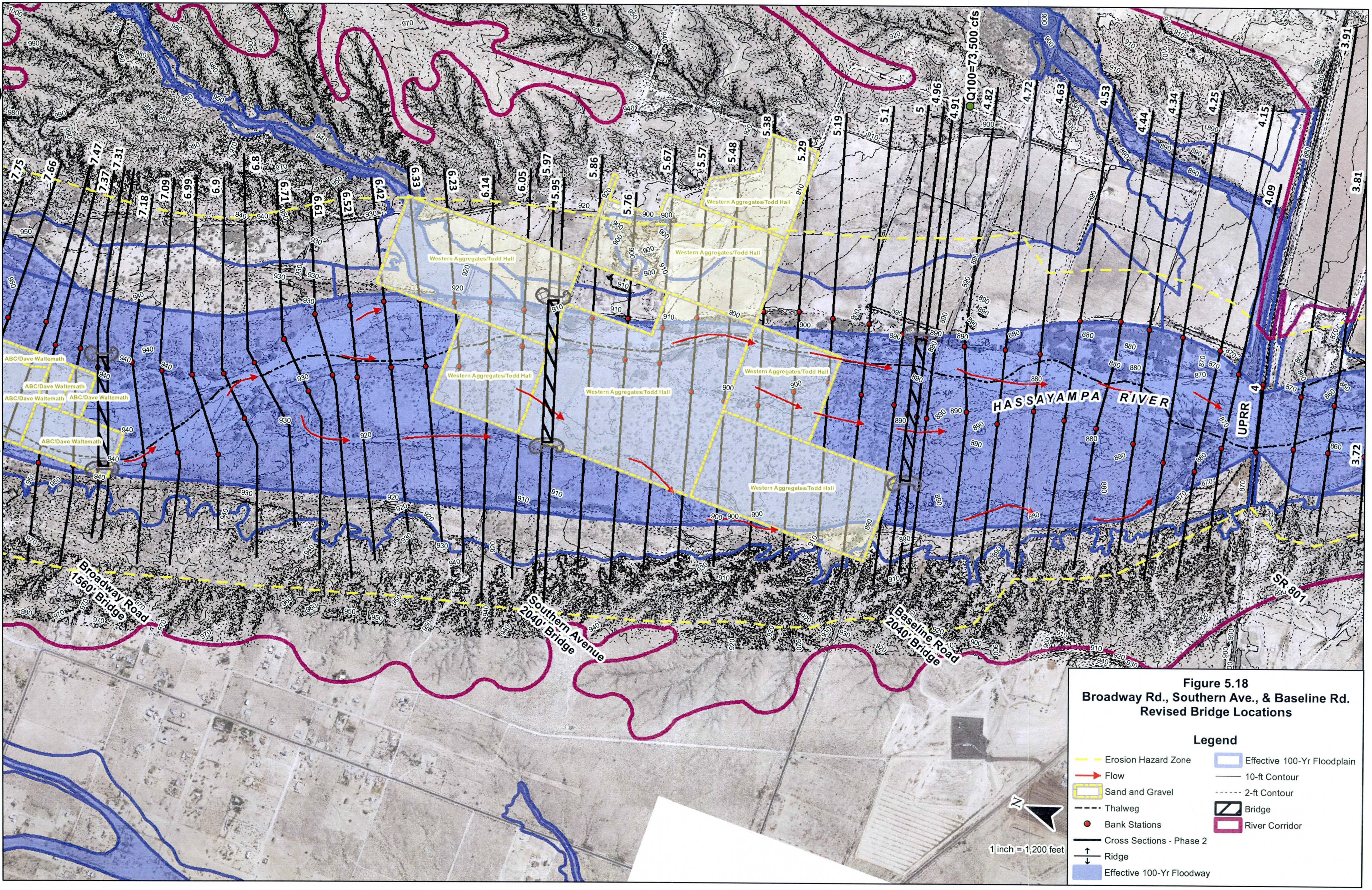


Figure 5.18
Broadway Rd., Southern Ave., & Baseline Rd. Revised Bridge Locations

Table 5.48 - Adjusted Bridge Opening Lengths and Hydraulic Summary Parameters for Step 2 Evaluations

Bridge Crossing	Cross Section	Recommended Width of Bridge Opening	*100-Year Event*						*10-Year Event*						Comments
			Change in Velocity		Change in Flow Regime		Change in Water Surface Elevation		Change in Velocity		Change in Flow Regime		Change in Water Surface Elevation		
		feet	Up-stream	Down-stream	Up-stream	Down-stream	Up-stream	Down-stream	Up-stream	Down-stream	Up-stream	Down-stream	Up-stream	Down-stream	
Humming Bird Springs Road	26.275	1,800	> 10%[1]	> 10%[1]	None	None	> 1 ft. at bridge face	< 0.2 ft	< 10%	> 10%[1]	None	None	< 1 ft	< 0.1 ft	Change in water surface elevation and velocity occurs within 400 feet upstream and 800 feet downstream of bridge.
Bell Road	24.71	1,560	> 10%[1]	> 10%[1]	None	None	> 1 ft. at bridge face	< 0.5 ft	> 10%[1]	< 10%	None	None	< 0.3 ft	< 0.1 ft	Change in water surface elevation and velocity occurs within 260 feet upstream and 100 feet downstream bridge.
Greenway Road	23.64	1,560	> 10%[1]	< 10%	None	None	> 1 ft. at bridge face	< 0.1 ft	> 10%[1]	< 10%	None	None	< 0.9 ft	< 0.1 ft	Change in water surface elevation and velocity occurs at face of bridge.
Cactus Road	21.565	1,560	> 10%[1]	< 10%	None	None	> 1 ft. at bridge face	< 0.1 ft	> 10%	< 10%	None	None	< 0.9 ft	< 0.1 ft	Change in water surface elevation and velocity occurs within 400 feet upstream of bridge.
Olive Avenue	19.505	1,560	> 10%[1]	< 10%	None	None	< 0.8 ft	< 0.8 ft	> 10%[1]	< 10%	None	None	< 0.4 ft	< 0.3 ft	Change in water surface elevation and velocity occurs within 200 feet upstream of bridge.
Northern Avenue	17.935	1,320	< 10%	> 10%[1]	None	None	> 1 ft. at bridge face	< 0.4 ft	> 10%[1]	< 10%	None	None	< 0.1 ft	< 0.1 ft	Change in water surface elevation and velocity occurs within 200 feet upstream of bridge.
Glendale Avenue	17.155	2,040	> 10%[1]	< 10%	None	Supercritical at downstream face of bridge	> 1	< 0.4 ft	> 10%[1]	< 10%	None	None	< 0.8 ft	< 0.1 ft	Change in water surface elevation and velocity occurs within 300 feet upstream of bridge.
Camelback Road	14.405	1,560	> 10%[1]	< 10%	None	None	> 1	< 0.1 ft	> 10%[1]	< 10%	None	None	< 0.5 ft	< 0.1 ft	Change in water surface elevation and velocity occurs within 160 feet upstream of bridge.
Indian School Road	13.875	1,560	> 10%[1]	< 10%	None	None	> 1 ft. at bridge face	< 0.1 ft	> 10%[1]	< 10%	None	None	> 1 ft at face of bridge	< 0.1 ft	Change in water surface elevation and velocity occurs within 500 feet upstream of bridge.
McDowell Parkway	13.035	1,560	> 10%	> 10%[1]	None	None	> 1	< 0.1 ft	> 10%	< 10%	None	None	> 1	< 0.1 ft	Due to constraints imposed by sand and gravel mining, channelization upstream and downstream of the bridge should be considered.
Yuma Parkway	9.78	1,800	> 10%[1]	< 10%	None	None	> 1	< 0.3 ft	> 10%[1]	< 10%	None	None	> 1 ft at face of bridge	< 0.1 ft	Change in water surface elevation and velocity occurs within 411 feet upstream of bridge.
Broadway Road	7.295	1,560	> 10%[1]	< 10%	None	None	> 1 ft. at bridge face	< 0.5 ft	> 10%[2]	< 10%	None	None	< 1 ft at face of bridge	< 0.2 ft	Change in water surface elevation and velocity occurs within 316 feet upstream of bridge.
Southern Avenue	5.96	2,040	> 10%	> 10%	None	None	> 1 ft	> 1 ft	> 10%	> 10%	None	None	>1	>1	Due to future constraints imposed by sand and gravel mining, channelization upstream and downstream of the bridge should be considered.
Baseline Road	4.945	2,040	> 10%	> 10%	None	None	> 1 ft	> 1 ft	> 10%	< 10%	None	None	>1	< 0.7 ft	Due to future constraints imposed by sand and gravel mining, channelization upstream and downstream of the bridge should be considered.

1. Mitigation measures would be required to minimize the impact due to the change in hydraulic parameter. Mitigation measures could include channelization, channel armoring, grade control structures or purchase of additional right of way.

5.15.2 Phase 1 Floodway Model

The Floodplain Management Step 2 HEC-RAS model was revised to include the Phase 1 Floodway encroachments. The same modifications that were made to develop the Effective Floodway model were made with the exception that Phase 1 floodway encroachment stations were used to develop the model. Floodway encroachment stations are based on the location of the Phase 1 Floodway stations taken from the Phase 1 HEC-RAS model.

5.15.3 Hydraulic Models Results at Bridge Locations

Tables 5.49 to 5.62 and associated inset figures depict the change in hydraulic parameters, velocity, Froude Number, and water surface elevation at bridge locations evaluated for the 100-year event. Tables 5.63 to 5.76 show hydraulic parameters for the 10-year event. The table lists and associated figures depict hydraulic data for cross sections located upstream and downstream of a bridge location for different encroachment scenarios. Hydraulic model results for the Bridge Maximum Encroachment (red line work), Effective Floodway Encroachment (green line work) and Phase 1 Floodway Encroachment (purple line work) are plotted against the Existing Condition models results to graphically show the difference between an encroached condition and the existing condition. The purpose of the tabulated data and figures is to facilitate comparisons between the bridge encroachment and the existing condition and between the floodway encroachments and the bridge encroachments. A summary of the comparison between the bridge encroachments and the existing condition was provided in Table 5.48. The following conclusions are offered from the review of the tabulated and graphical results:

- In general relative to the Floodplain Management Model results, at most bridge locations floodway encroachments facilitated flow being conveyed through a bridge. Velocities typically increased upstream of the bridge. Flow regime typically remained the same with the exception of two locations where there was a transition to supercritical flow for the 100-year event. The change in water surface elevation upstream of a bridge decreased or remained the same.
- Magnitudes of the change in velocity and water surface elevations differed at certain locations between the Effective Floodway Encroachment and the Phase 1 Encroachment relative to the Floodplain Management encroachment. Data in tables highlighted in yellow indicate that the change in the floodway encroachment hydraulic parameter relative to the bridge encroachment increased and data highlighted in blue indicate that there is a decrease. For the 100-year event at the locations of the bridges the Effective Floodway and Phase 1 Floodway encroachments produced similar hydraulic results. For the 10-year event the hydraulic results for the Phase 1 Encroachment had less of a change than the Effective Floodway Encroachments.

Table 5.49

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Humming Bird Springs RM 26.275

Change in Velocity

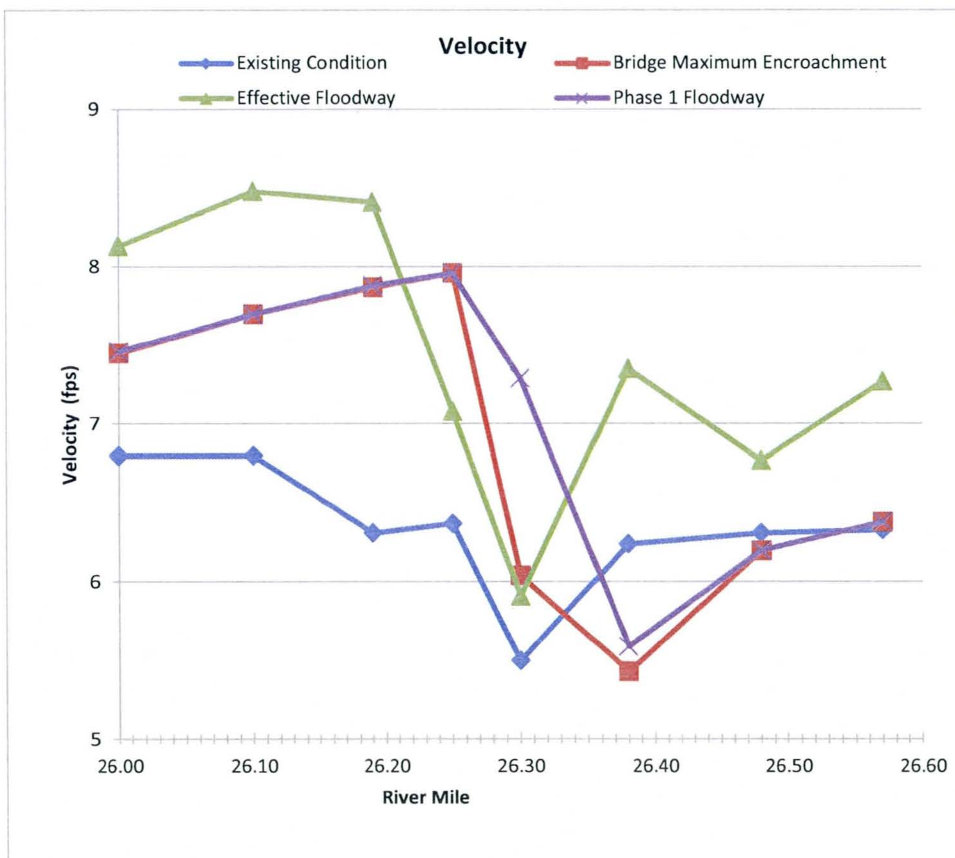
RM	Existing Condition Velocity fps	Existing Condition Percent Change %	Bridge Maximum Encroachment Velocity fps	Bridge Maximum Encroachment Percent Change %	Effective Floodway Velocity fps	Effective Floodway Percent Change %	Phase 1 Floodway Velocity fps	Phase 1 Floodway Percent Change %
26.00	6.80		7.45	9.6	8.13	19.6	7.46	9.7
26.10	6.80		7.70	13.2	8.48	24.7	7.70	13.2
26.19	6.31		7.87	24.7	8.41	33.3	7.88	24.9
26.25	6.37		7.96	25.0	7.08	11.1	7.96	25.0
26.30	5.50		6.04	9.8	5.91	7.5	7.29	32.5
26.38	6.24		5.43	-13.0	7.35	17.8	5.59	-10.4
26.48	6.31		6.20	-1.7	6.77	7.3	6.20	-1.7
26.57	6.33		6.38	0.8	7.27	14.8	6.38	0.8

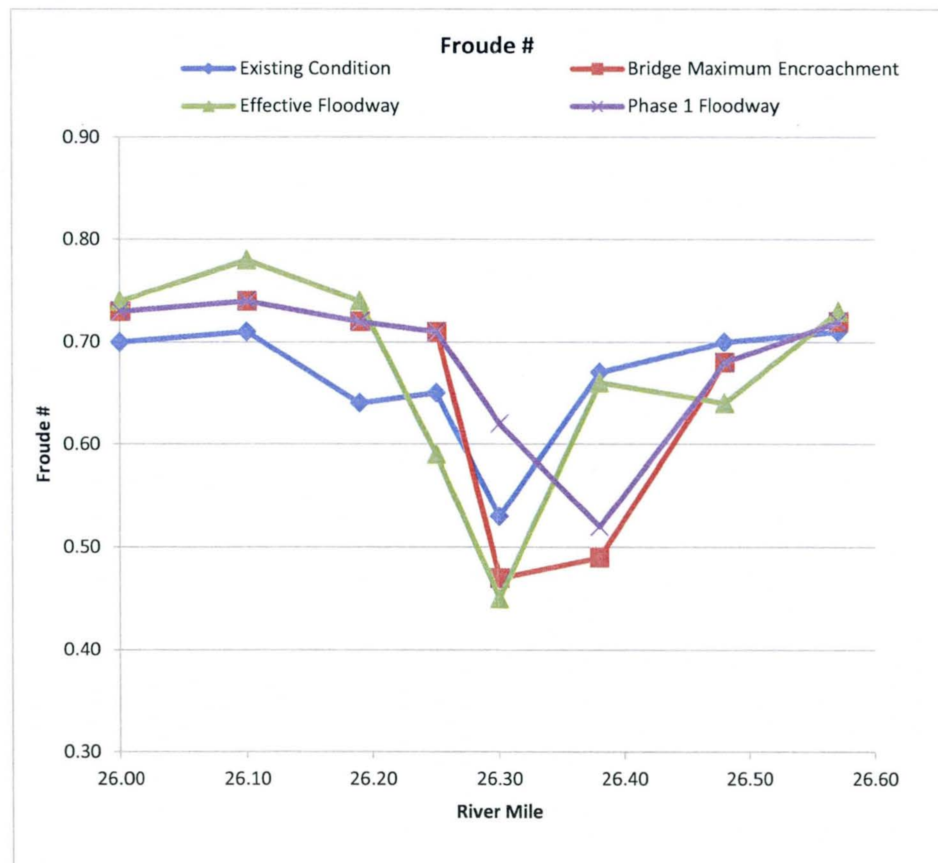
Change in Froude #

RM	Existing Condition Froude # unitless	Existing Condition Percent Change %	Bridge Maximum Encroachment Froude # unitless	Bridge Maximum Encroachment Percent Change %	Effective Floodway Froude # unitless	Effective Floodway Percent Change %	Phase 1 Floodway Froude # unitless	Phase 1 Floodway Percent Change %
26.000	0.70		0.73	4.3	0.74	5.7	0.73	4.3
26.100	0.71		0.74	4.2	0.78	9.9	0.74	4.2
26.190	0.64		0.72	12.5	0.74	15.6	0.72	12.5
26.250	0.65		0.71	9.2	0.59	-9.2	0.71	9.2
26.300	0.53		0.47	-11.3	0.45	-15.1	0.62	17.0
26.380	0.67		0.49	-26.9	0.66	-1.5	0.52	-22.4
26.480	0.70		0.68	-2.9	0.64	-8.6	0.68	-2.9
26.570	0.71		0.72	1.4	0.73	2.8	0.72	1.4

Change in Water Surface Elevation

RM	Existing Condition W.S.E. feet	Bridge Maximum Encroachment W.S.E. feet	Bridge Maximum Encroachment Change in W.S.E. feet	Effective Floodway W.S.E. feet	Effective Floodway Change in W.S.E. feet	Phase 1 Floodway W.S.E. feet	Phase 1 Floodway Change in W.S.E. feet
26.00	1,357.11	1357.08	-0.03	1357.61	0.50	1357.08	-0.03
26.10	1,359.69	1359.77	0.08	1360.18	0.49	1359.77	0.08
26.19	1,362.09	1362.25	0.16	1362.68	0.59	1362.25	0.16
26.25	1,363.37	1363.64	0.27	1364.16	0.79	1363.64	0.27
26.30	1,364.31	1365.77	1.46	1365.95	1.64	1364.88	0.57
26.38	1,366.34	1367.20	0.86	1367.27	0.93	1367.09	0.75
26.48	1,368.47	1368.54	0.07	1369.10	0.63	1368.53	0.06
26.57	1,370.87	1370.85	-0.02	1371.01	0.14	1370.85	-0.02





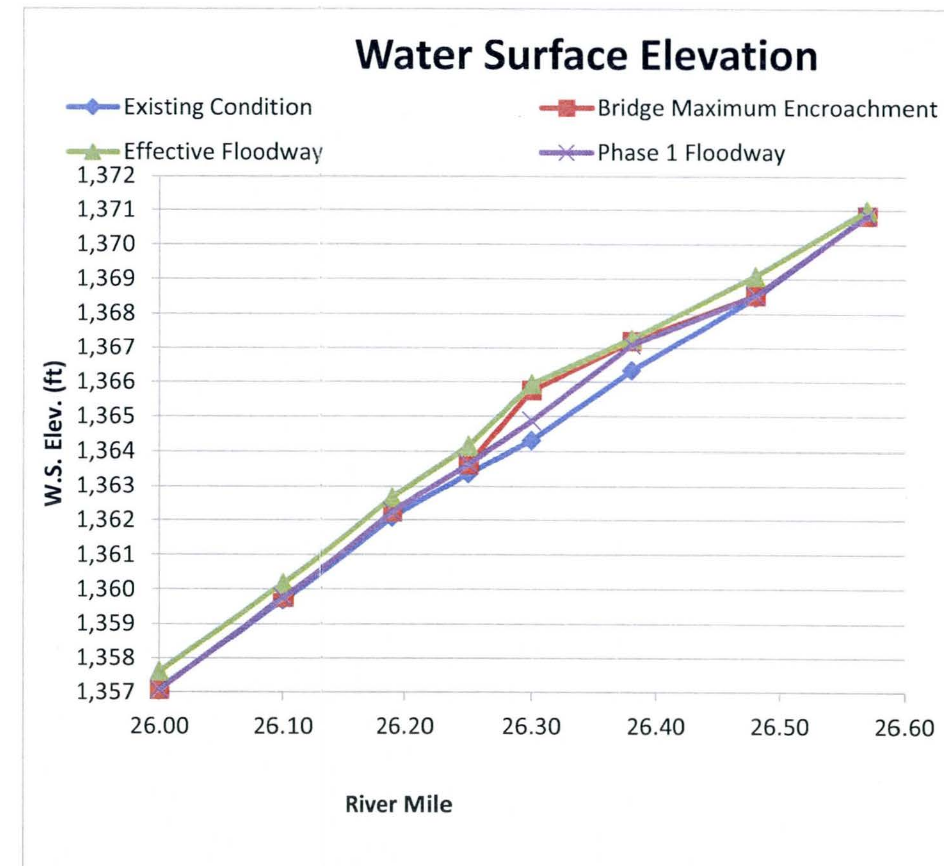


Table 5.50

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Bell Road Bridge at RM 24.71

Change in Velocity

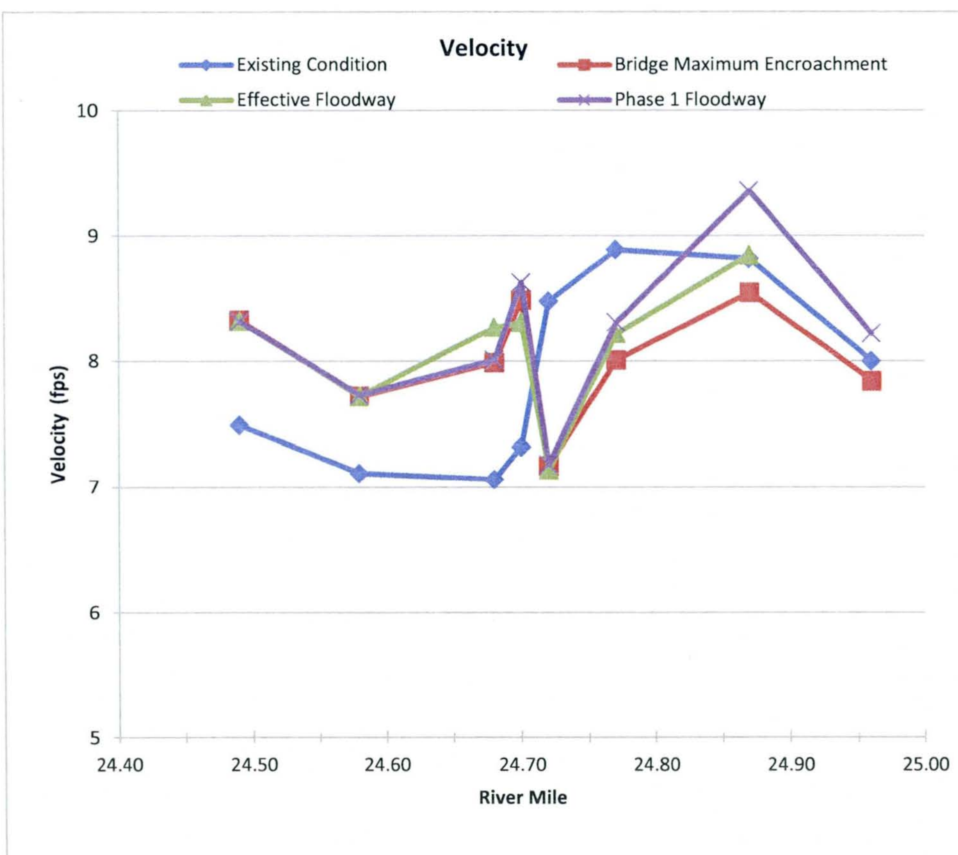
RM	Existing Condition Velocity fps	Existing Condition Percent Change %	Bridge Maximum Encroachment Velocity fps	Bridge Maximum Encroachment Percent Change %	Effective Floodway Velocity fps	Effective Floodway Percent Change %	Phase 1 Floodway Velocity fps	Phase 1 Floodway Percent Change %
24.49	7.49		8.33	11.2	8.32	11.1	8.32	11.1
24.58	7.11		7.72	8.6	7.72	8.6	7.73	8.7
24.68	7.06		7.99	13.2	8.27	17.1	8.01	13.5
24.70	7.32		8.49	16.0	8.31	13.5	8.63	17.9
24.72	8.48		7.17	-15.4	7.14	-15.8	7.18	-15.3
24.77	8.89		8.01	-9.9	8.22	-7.5	8.31	-6.5
24.87	8.82		8.55	-3.1	8.85	0.3	9.36	6.1
24.96	8.00		7.84	-2.0	8.18	2.3	8.22	2.8

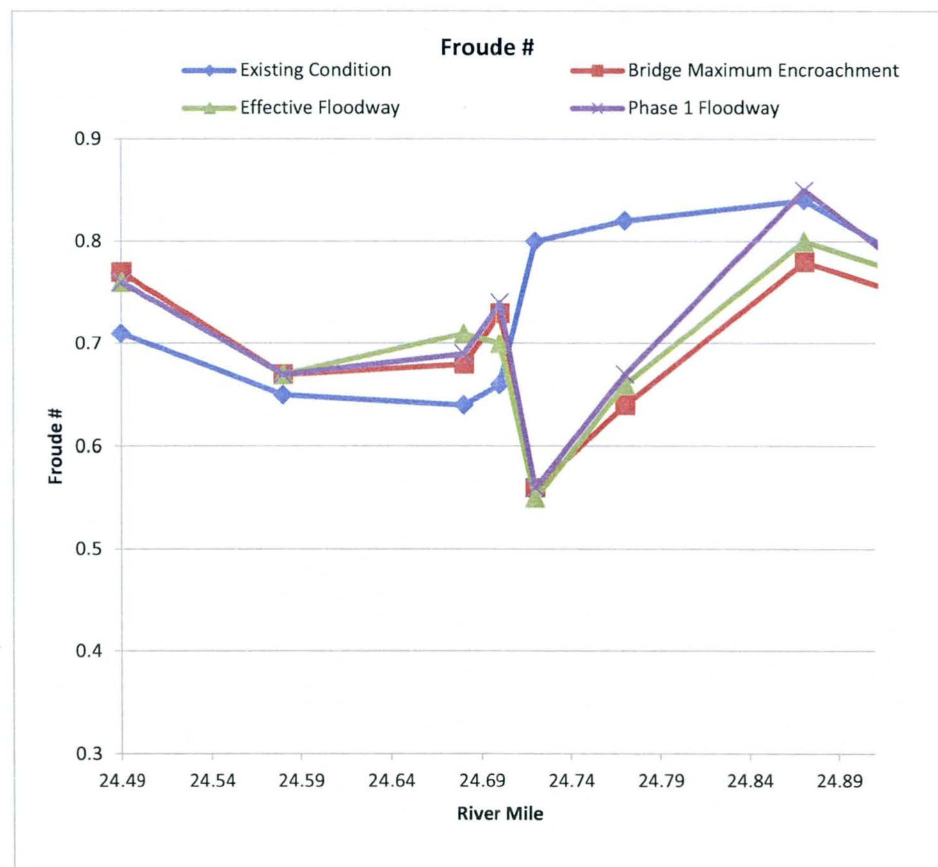
Change in Froude #

RM	Existing Condition Froude # unitless	Existing Condition Percent Change %	Bridge Maximum Encroachment Froude # unitless	Bridge Maximum Encroachment Percent Change %	Effective Floodway Froude # unitless	Effective Floodway Percent Change %	Phase 1 Floodway Froude # unitless	Phase 1 Floodway Percent Change %
24.490	0.71		0.77	8.5	0.76	7.0	0.76	7.0
24.580	0.65		0.67	3.1	0.67	3.1	0.67	3.1
24.680	0.64		0.68	6.3	0.71	10.9	0.69	7.8
24.700	0.66		0.73	10.6	0.70	6.1	0.74	12.1
24.720	0.80		0.56	-30.0	0.55	-31.3	0.56	-30.0
24.770	0.82		0.64	-22.0	0.66	-19.5	0.67	-18.3
24.870	0.84		0.78	-7.1	0.80	-4.8	0.85	1.2
24.960	0.75		0.73	-2.7	0.75	0.0	0.73	-2.7

Change in Water Surface Elevation

RM	Existing Condition W.S.E. feet	Bridge Maximum Encroachment W.S.E. feet	Bridge Maximum Encroachment Change in W.S.E. feet	Effective Floodway W.S.E. feet	Effective Floodway Change in W.S.E. feet	Phase 1 Floodway W.S.E. feet	Phase 1 Floodway Change in W.S.E. feet
24.49	1,321.22	1321.43	0.21	1321.45	0.23	1321.44	0.22
24.58	1,323.61	1324.08	0.47	1324.08	0.47	1324.08	0.47
24.68	1,325.73	1326.23	0.50	1326.27	0.54	1326.23	0.50
24.70	1,326.07	1326.52	0.45	1326.61	0.54	1326.47	0.40
24.72	1,326.40	1328.00	1.60	1328.02	1.62	1327.99	1.59
24.77	1,327.35	1328.47	1.12	1328.42	1.07	1328.39	1.04
24.87	1,329.76	1330.10	0.34	1330.13	0.37	1330.12	0.36
24.96	1,332.30	1332.40	0.10	1332.53	0.23	1332.74	0.44





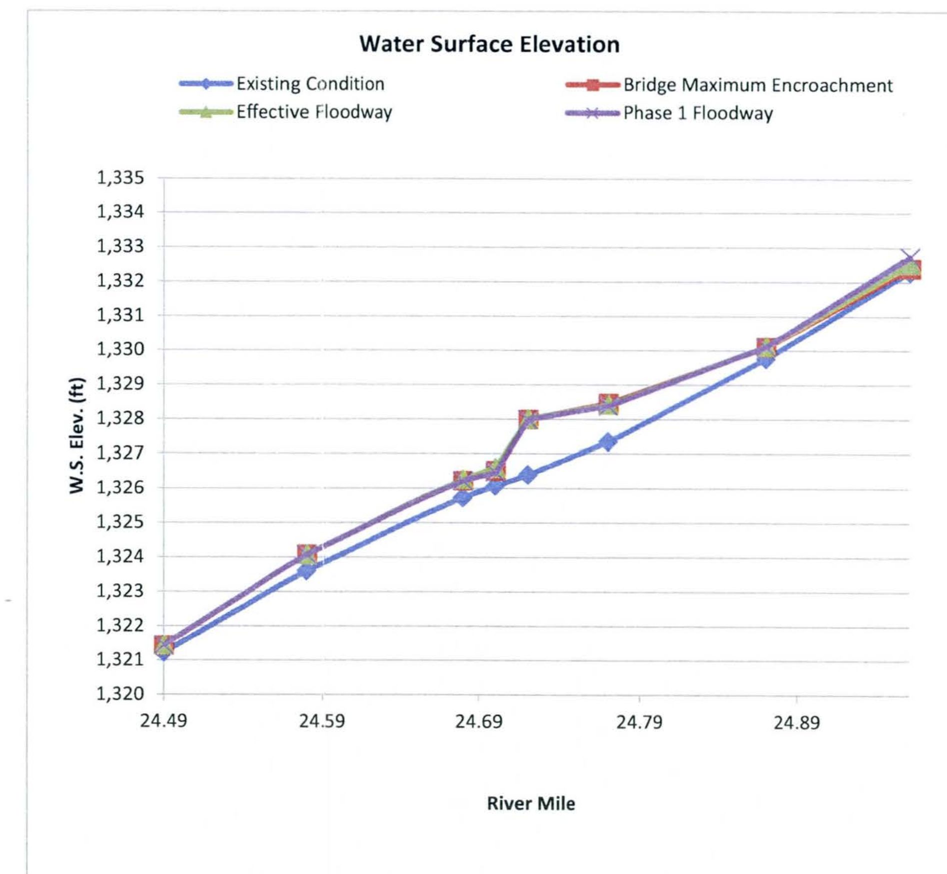


Table 5.51

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Greenway Road Bridge at RM 23.64

Change in Velocity

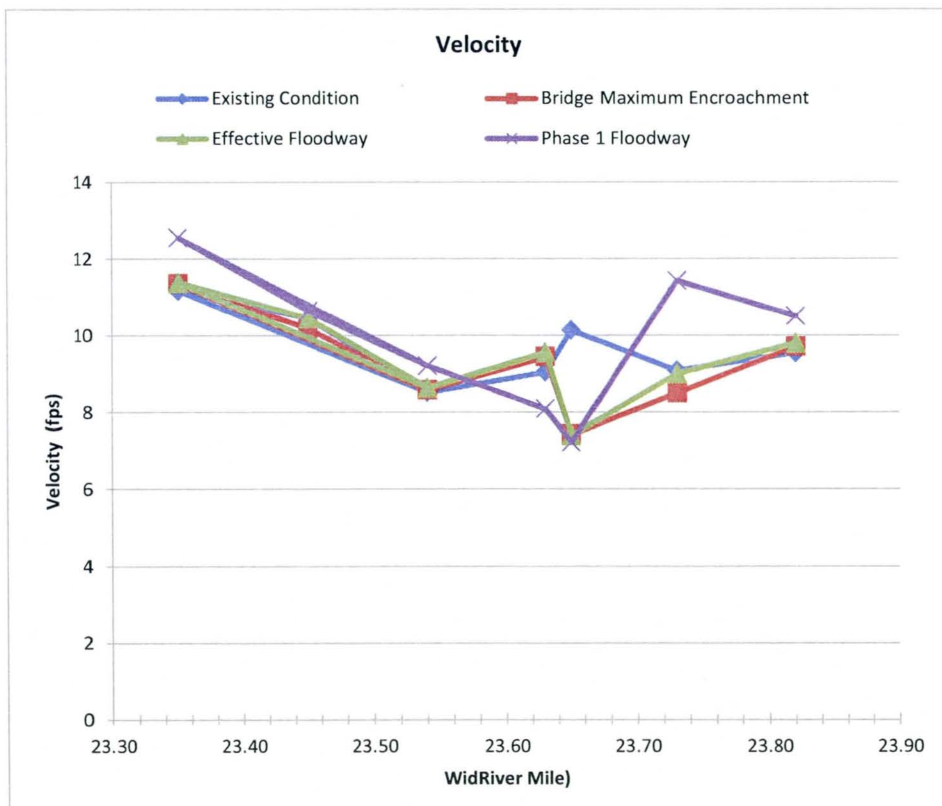
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
23.35	11.18		11.37	1.7	11.40	2.0	12.56	12.3
23.45	10.46		10.19	-2.6	10.46	0.0	10.65	1.8
23.54	8.53		8.59	0.7	8.65	1.4	9.22	8.1
23.63	9.05		9.45	4.4	9.57	5.7	8.09	-10.6
23.65	10.14		7.44	-26.6	7.42	-26.8	7.24	-28.6
23.73	9.09		8.51	-6.4	9.01	-0.9	11.44	25.9
23.82	9.55		9.72	1.8	9.81	2.7	10.51	10.1
23.92	9.80		9.72	-0.8	9.54	-2.7	10.95	11.7

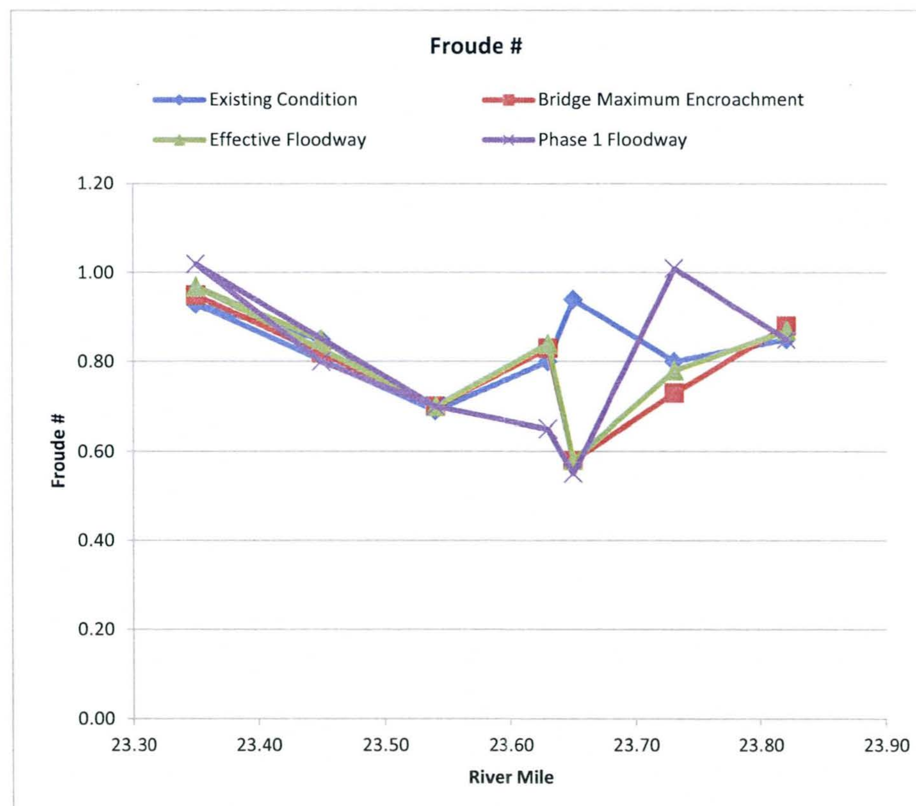
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
23.350	0.93		0.95	2.2	0.97	4.3	1.02	9.7
23.450	0.85		0.82	-3.5	0.85	0.0	0.80	-5.9
23.540	0.69		0.70	1.4	0.70	1.4	0.70	1.4
23.630	0.80		0.83	3.7	0.84	5.0	0.65	-18.8
23.650	0.94		0.58	-38.3	0.58	-38.3	0.55	-41.5
23.730	0.80		0.73	-8.8	0.78	-2.5	1.01	26.3
23.820	0.85		0.88	3.5	0.87	2.4	0.85	0.0
23.920	0.85		0.84	-1.2	0.81	-4.7	0.87	2.4

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
23.35	1,297.34	1297.30	-0.04	1297.16	-0.18	1297.65	0.31
23.45	1,299.28	1299.33	0.05	1299.24	-0.04	1300.02	0.74
23.54	1,300.82	1300.75	-0.07	1300.77	-0.05	1301.42	0.60
23.63	1,302.20	1302.20	0.00	1302.18	-0.02	1302.96	0.76
23.65	1,302.65	1304.19	1.54	1304.20	1.55	1304.39	1.74
23.73	1,304.75	1304.98	0.23	1304.93	0.18	1304.72	-0.03
23.82	1,306.79	1306.73	-0.06	1306.85	0.06	1307.59	0.80
23.92	1,308.63	1308.66	0.03	1308.76	0.13	1309.36	0.73





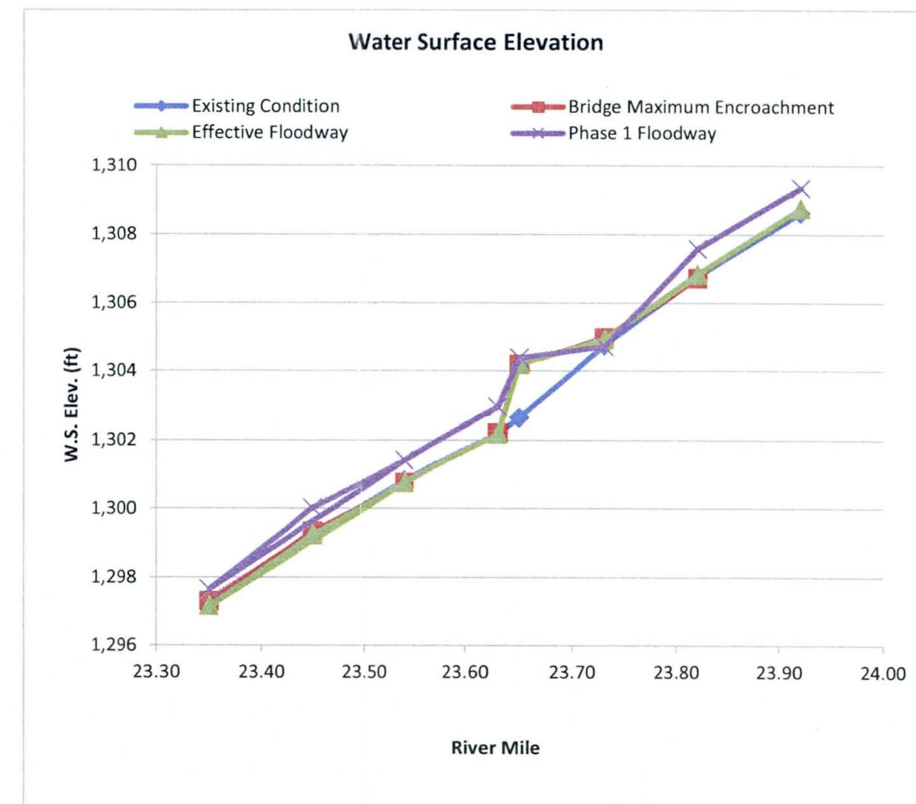


Table 5.52

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Cactus Road Bridge at RM 21.565

Change in Velocity

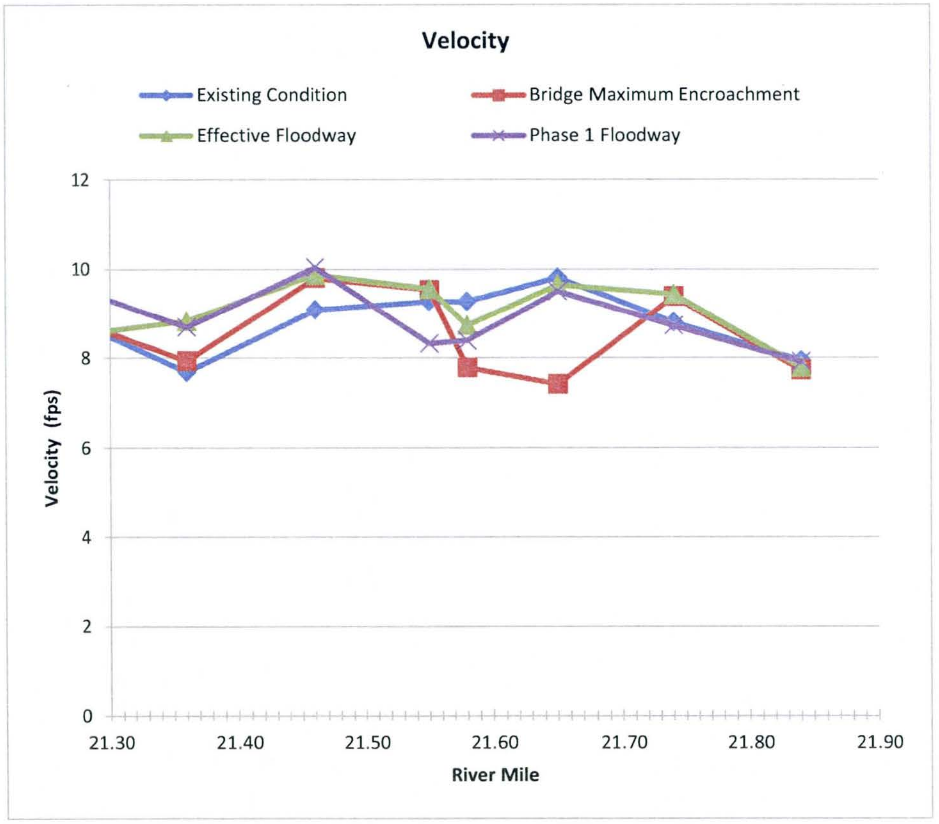
	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %
21.27	8.88		8.88	0.0	8.52	-4.1	9.59	8.0
21.36	7.69		7.94	3.3	8.84	15.0	8.70	13.1
21.46	9.09		9.80	7.8	9.88	8.7	10.04	10.5
21.55	9.27		9.54	2.9	9.56	3.1	8.33	-10.1
21.58	9.27		7.79	-16.0	8.74	-5.7	8.40	-9.4
21.65	9.81		7.42	-24.4	9.65	-1.6	9.50	-3.2
21.74	8.81		9.39	6.6	9.44	7.2	8.73	-0.9
21.84	7.95		7.73	-2.8	7.80	-1.9	7.92	-0.4

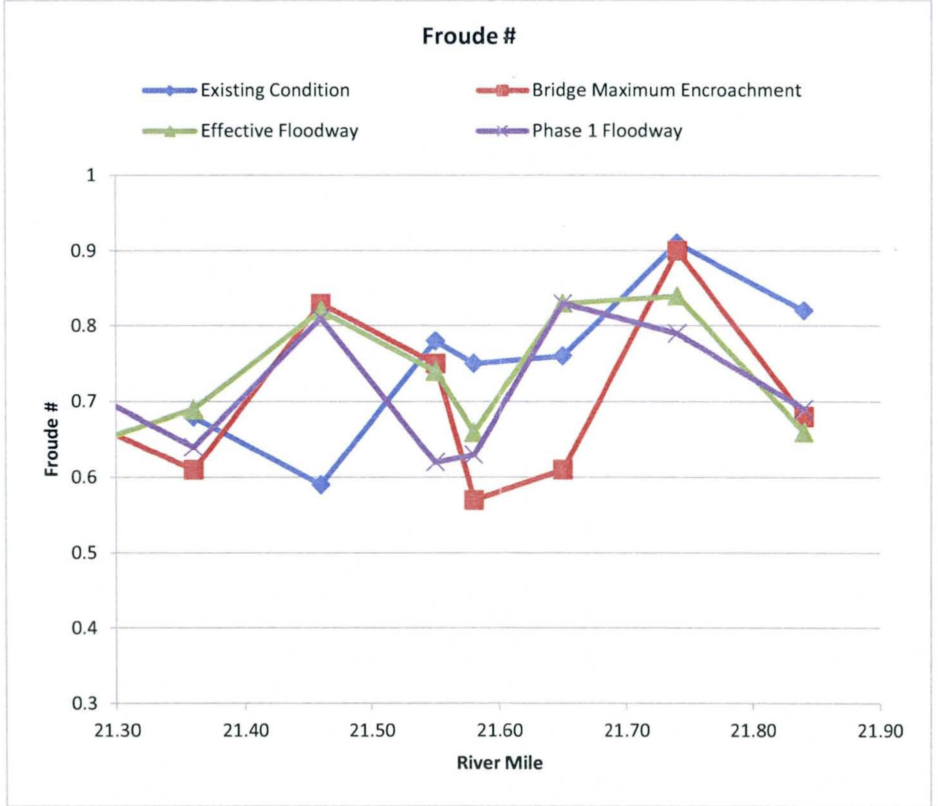
Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM feet	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %
21.270	0.68		0.68	0.0	0.64	-5.9	0.72	5.9
21.360	0.59		0.61	3.4	0.69	16.9	0.64	8.5
21.460	0.78		0.83	6.4	0.82	5.1	0.81	3.8
21.550	0.75		0.75	0.0	0.74	-1.3	0.62	-17.3
21.580	0.76		0.57	-25.0	0.66	-13.2	0.63	-17.1
21.650	0.91		0.61	-33.0	0.83	-8.8	0.83	-8.8
21.740	0.82		0.90	9.8	0.84	2.4	0.79	-3.7
21.840	0.71		0.68	-4.2	0.66	-7.0	0.69	-2.8

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet
21.27	1,252.48	1252.48	0.00	1252.65	0.17	1252.78	0.30
21.36	1,254.45	1254.43	-0.02	1254.37	-0.08	1254.91	0.46
21.46	1,255.95	1256.05	0.10	1256.27	0.32	1256.52	0.57
21.55	1,257.62	1257.89	0.27	1258.07	0.45	1258.50	0.88
21.58	1,258.14	1259.38	1.24	1259.05	0.91	1259.01	0.87
21.65	1,258.94	1259.96	1.02	1259.61	0.67	1259.44	0.50
21.74	1,261.13	1260.92	-0.21	1261.49	0.36	1261.34	0.21
21.84	1,262.99	1263.09	0.10	1263.53	0.54	1263.10	0.11





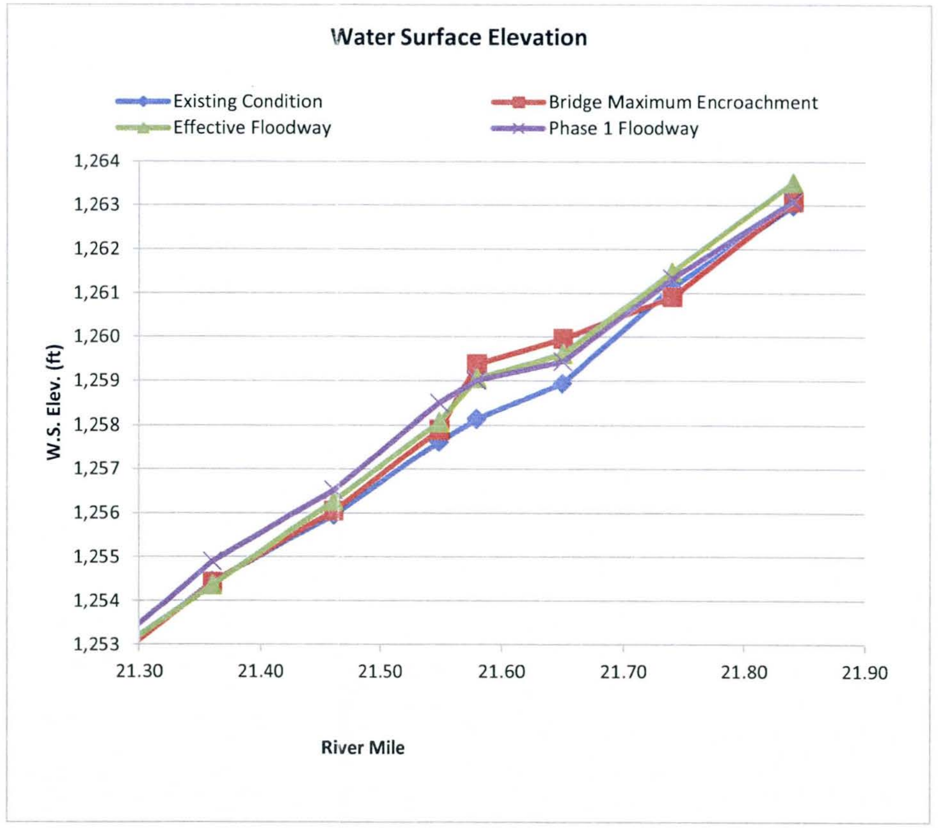


Table 5.53

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Olive Avenue Bridge at RM 19.505

Change in Velocity

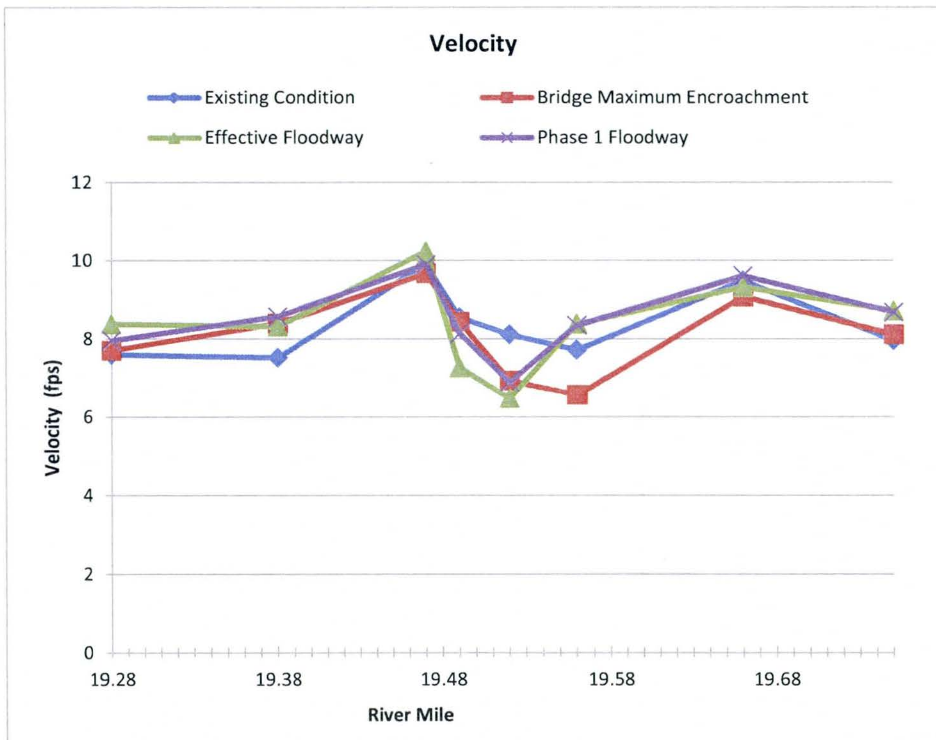
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
19.28	7.60		7.71	1.4	8.38	10.3	7.96	4.7
19.38	7.52		8.40	11.7	8.32	10.6	8.57	14.0
19.47	9.90		9.67	-2.3	10.24	3.4	9.90	0.0
19.49	8.55		8.44	-1.3	7.27	-15.0	8.14	-4.8
19.52	8.11		6.93	-14.5	6.48	-20.1	6.89	-15.0
19.56	7.72		6.57	-14.9	8.38	8.5	8.35	8.2
19.66	9.48		9.08	-4.2	9.32	-1.7	9.61	1.4
19.75	7.96		8.11	1.9	8.72	9.5	8.68	9.0

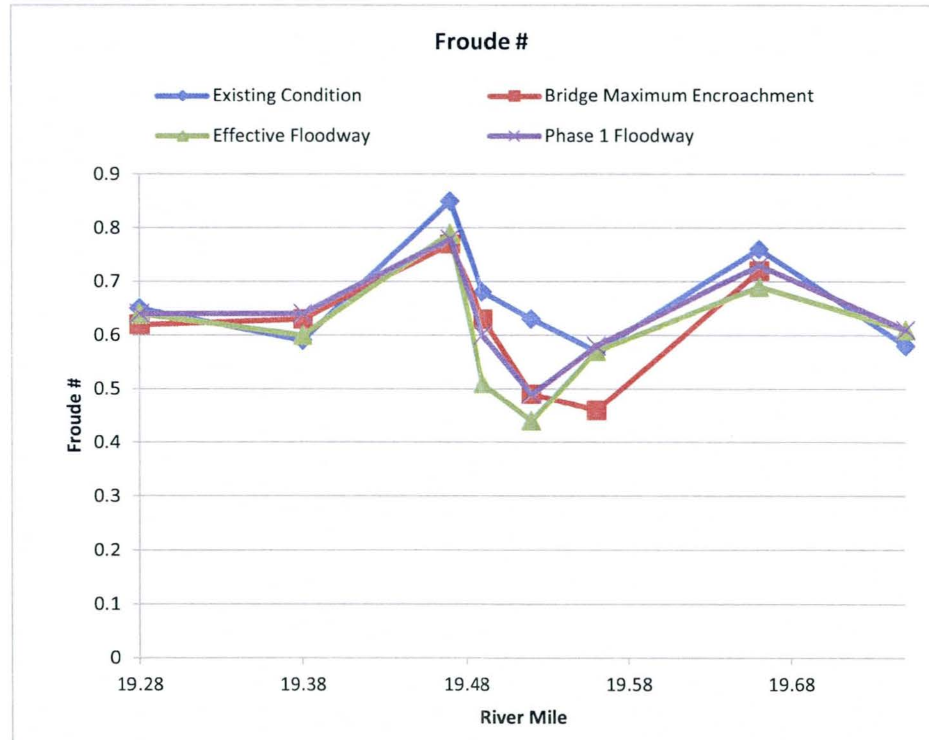
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
19.280	0.65		0.62	-4.6	0.64	-1.5	0.64	-1.5
19.380	0.59		0.63	6.8	0.60	1.7	0.64	8.5
19.470	0.85		0.77	-9.4	0.79	-7.1	0.78	-8.2
19.490	0.68		0.63	-7.4	0.51	-25.0	0.60	-11.8
19.520	0.63		0.49	-22.2	0.44	-30.2	0.49	-22.2
19.560	0.57		0.46	-19.3	0.57	0.0	0.58	1.8
19.660	0.76		0.72	-5.3	0.69	-9.2	0.73	-3.9
19.750	0.58		0.59	1.7	0.61	5.2	0.61	5.2

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
19.28	1,209.57	1210.08	0.51	1210.54	0.97	1210.05	0.48
19.38	1,211.72	1212.20	0.48	1212.76	1.04	1212.25	0.53
19.47	1,213.33	1214.04	0.71	1214.37	1.04	1214.11	0.78
19.49	1,214.26	1214.85	0.59	1215.63	1.37	1215.09	0.83
19.52	1,214.93	1215.93	1.00	1216.37	1.44	1216.04	1.11
19.56	1,215.73	1216.48	0.75	1216.55	0.82	1216.35	0.62
19.66	1,217.19	1217.36	0.17	1217.98	0.79	1217.82	0.63
19.75	1,221.47	1221.38	-0.09	1221.87	0.40	1221.93	0.46





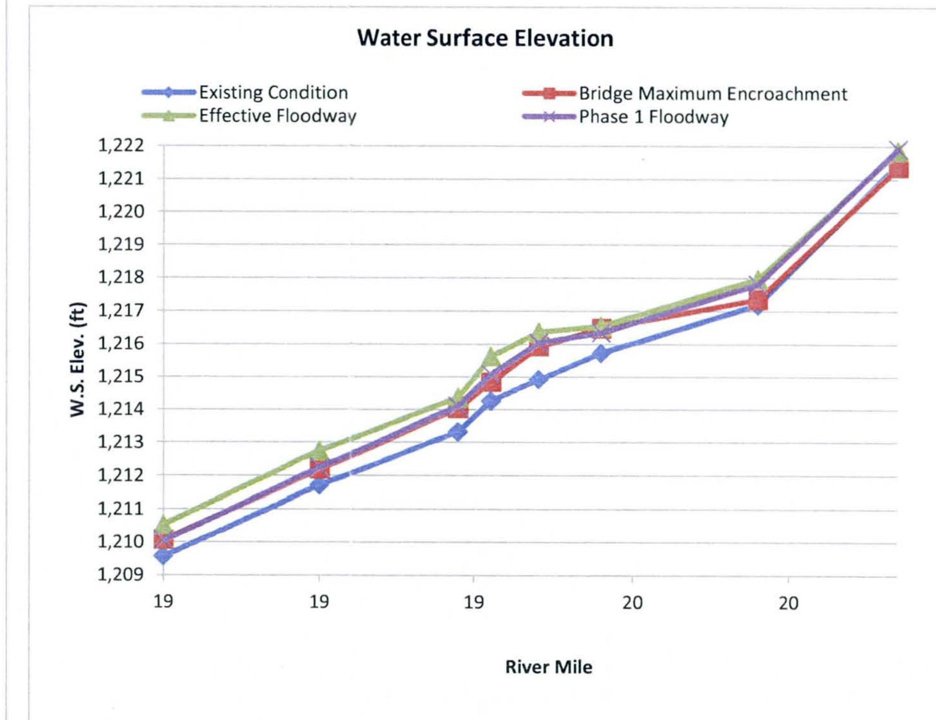


Table 5.54

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Northern Avenue Bridge at RM 17.935

Change in Velocity

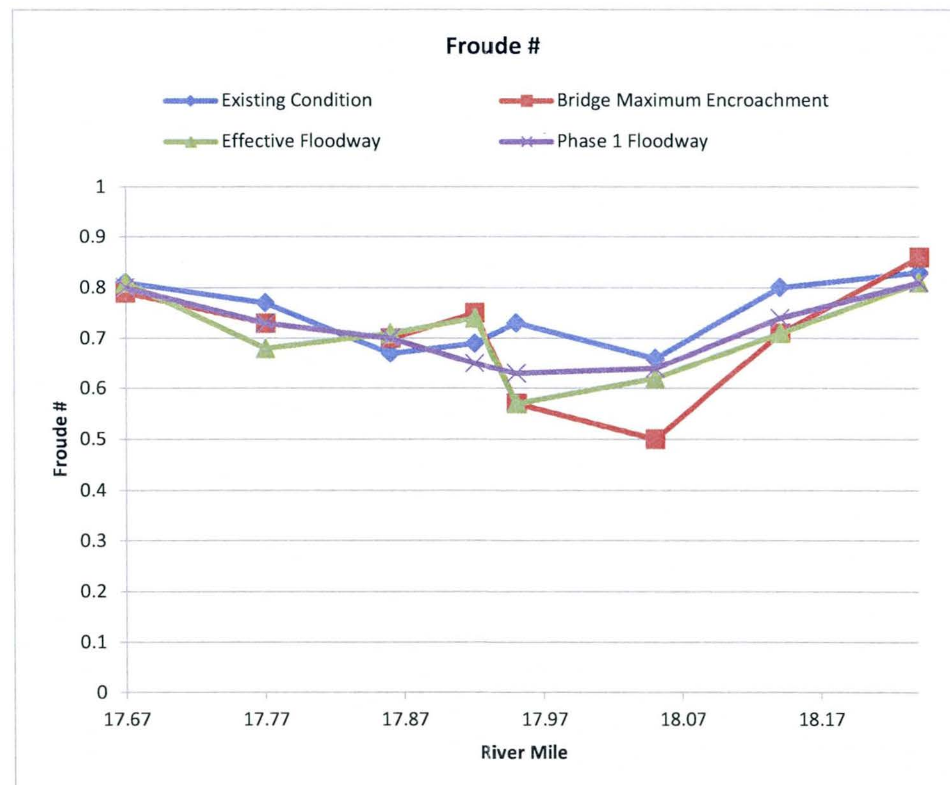
RM	Existing Condition Velocity	Existing Condition Percent Change	Bridge Maximum Encroachment Velocity	Bridge Maximum Encroachment Percent Change	Effective Floodway Velocity	Effective Floodway Percent Change	Phase 1 Floodway Velocity	Phase 1 Floodway Percent Change
	fps	%	fps	%	fps	%	fps	%
17.67	9.72		9.96	2.5	10.28	5.8	10.36	6.6
17.77	9.27		9.10	-1.8	8.65	-6.7	9.57	3.2
17.86	8.50		9.05	6.5	9.16	7.8	9.44	11.1
17.92	8.68		9.68	11.5	9.61	10.7	8.78	1.2
17.95	9.02		8.08	-10.4	8.07	-10.5	8.62	-4.4
18.05	8.38		6.99	-16.6	8.50	1.4	8.66	3.3
18.14	9.16		8.41	-8.2	8.62	-5.9	9.00	-1.7
18.24	9.23		9.50	2.9	9.22	-0.1	9.34	1.2

Change in Froude #

RM	Existing Condition Froude #	Existing Condition Percent Change	Bridge Maximum Encroachment Froude #	Bridge Maximum Encroachment Percent Change	Effective Floodway Froude #	Effective Floodway Percent Change	Phase 1 Floodway Froude #	Phase 1 Floodway Percent Change
	unitless	%	unitless	%	unitless	%	unitless	%
17.670	0.81		0.79	-2.5	0.81	0.0	0.80	-1.2
17.770	0.77		0.73	-5.2	0.68	-11.7	0.73	-5.2
17.860	0.67		0.70	4.5	0.71	6.0	0.70	4.5
17.920	0.69		0.75	8.7	0.74	7.2	0.65	-5.8
17.950	0.73		0.57	-21.9	0.57	-21.9	0.63	-13.7
18.050	0.66		0.50	-24.2	0.62	-6.1	0.64	-3.0
18.140	0.80		0.71	-11.3	0.71	-11.3	0.74	-7.5
18.240	0.83		0.86	3.6	0.81	-2.4	0.81	-2.4

Change in Water Surface Elevation

RM	Existing Condition W.S.E.	Bridge Maximum Encroachment W.S.E.	Bridge Maximum Encroachment Change in W.S.E.	Effective Floodway W.S.E.	Effective Floodway Change in W.S.E.	Phase 1 Floodway W.S.E.	Phase 1 Floodway Change in W.S.E.
	feet	feet	feet	feet	feet	feet	feet
17.67	1,172.83	1173.24	0.41	1173.39	0.56	1173.59	0.76
17.77	1,175.43	1175.76	0.33	1176.02	0.59	1176.20	0.77
17.86	1,177.62	1177.77	0.15	1177.81	0.19	1178.25	0.63
17.92	1,178.98	1179.25	0.27	1179.29	0.31	1179.77	0.79
17.95	1,179.48	1180.86	1.38	1180.87	1.39	1180.51	1.03
18.05	1,181.19	1182.12	0.93	1181.93	0.74	1181.79	0.60
18.14	1,182.61	1182.91	0.30	1183.19	0.58	1183.12	0.51
18.24	1,184.75	1184.65	-0.10	1184.91	0.16	1184.99	0.24



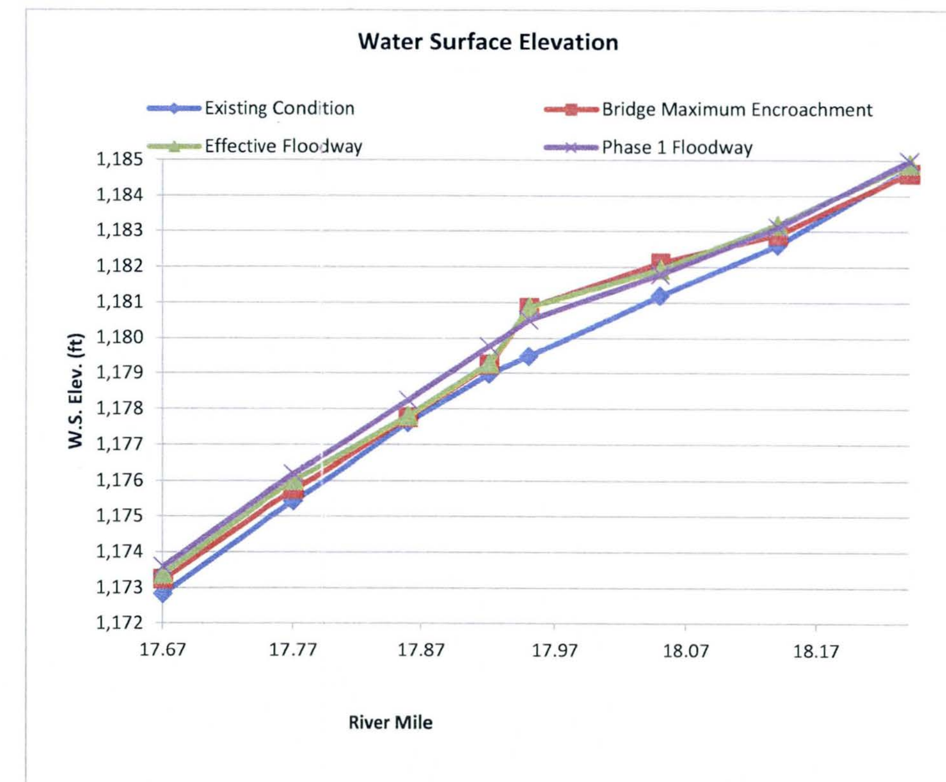


Table 5.55
Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event
Glendale Avenue Bridge at RM 17.155

Change in Velocity

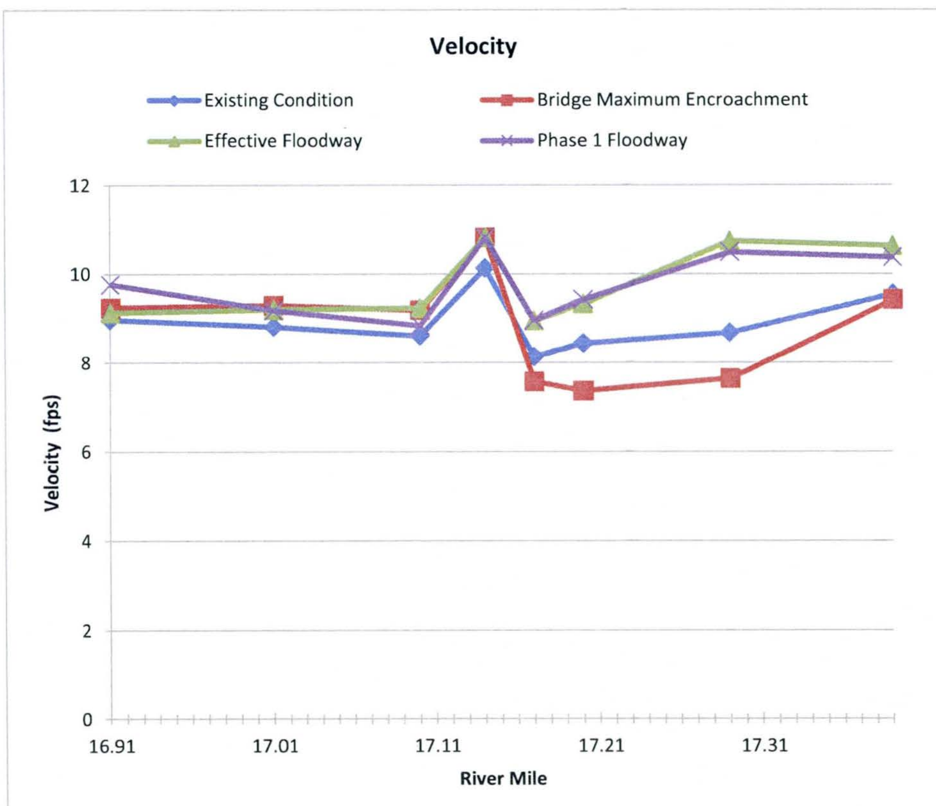
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
16.91	8.97		9.25	3.1	9.13	1.8	9.77	8.9
17.01	8.81		9.30	5.6	9.20	4.4	9.18	4.2
17.10	8.61		9.19	6.7	9.24	7.3	8.84	2.7
17.14	10.13		10.82	6.8	10.82	6.8	10.82	6.8
17.17	8.14		7.58	-6.9	8.95	10.0	8.96	10.1
17.20	8.44		7.37	-12.7	9.33	10.5	9.43	11.7
17.29	8.68		7.65	-11.9	10.74	23.7	10.49	20.9
17.39	9.55		9.42	-1.4	10.63	11.3	10.37	8.6

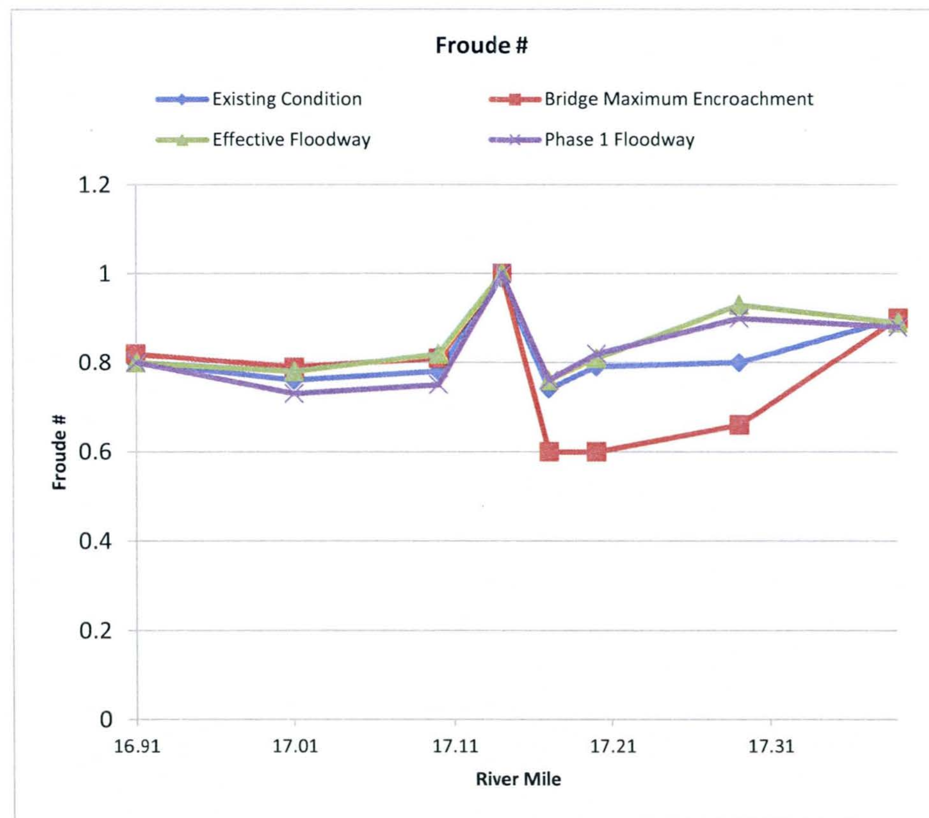
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
16.910	0.80		0.82	2.5	0.80	0.0	0.80	0.0
17.010	0.76		0.79	3.9	0.78	2.6	0.73	-3.9
17.100	0.78		0.81	3.8	0.82	5.1	0.75	-3.8
17.140	0.99		1.00	1.0	1.00	1.0	1.00	1.0
17.170	0.74		0.60	-18.9	0.76	2.7	0.76	2.7
17.200	0.79		0.60	-24.1	0.81	2.5	0.82	3.8
17.290	0.80		0.66	-17.5	0.93	16.3	0.90	12.5
17.390	0.90		0.90	0.0	0.89	-1.1	0.88	-2.2

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
16.91	1,155.69	1155.69	0.00	1155.84	0.15	1156.44	0.75
17.01	1,157.70	1157.81	0.11	1157.85	0.15	1158.45	0.75
17.10	1,159.64	1159.86	0.22	1159.85	0.21	1160.23	0.59
17.14	1,160.45	1160.82	0.37	1160.82	0.37	1160.82	0.37
17.17	1,161.65	1162.88	1.23	1162.20	0.55	1162.20	0.55
17.20	1,162.06	1163.23	1.17	1162.59	0.53	1162.57	0.51
17.29	1,163.85	1164.33	0.48	1164.35	0.50	1164.38	0.53
17.39	1,166.03	1165.95	-0.08	1166.97	0.94	1166.89	0.86





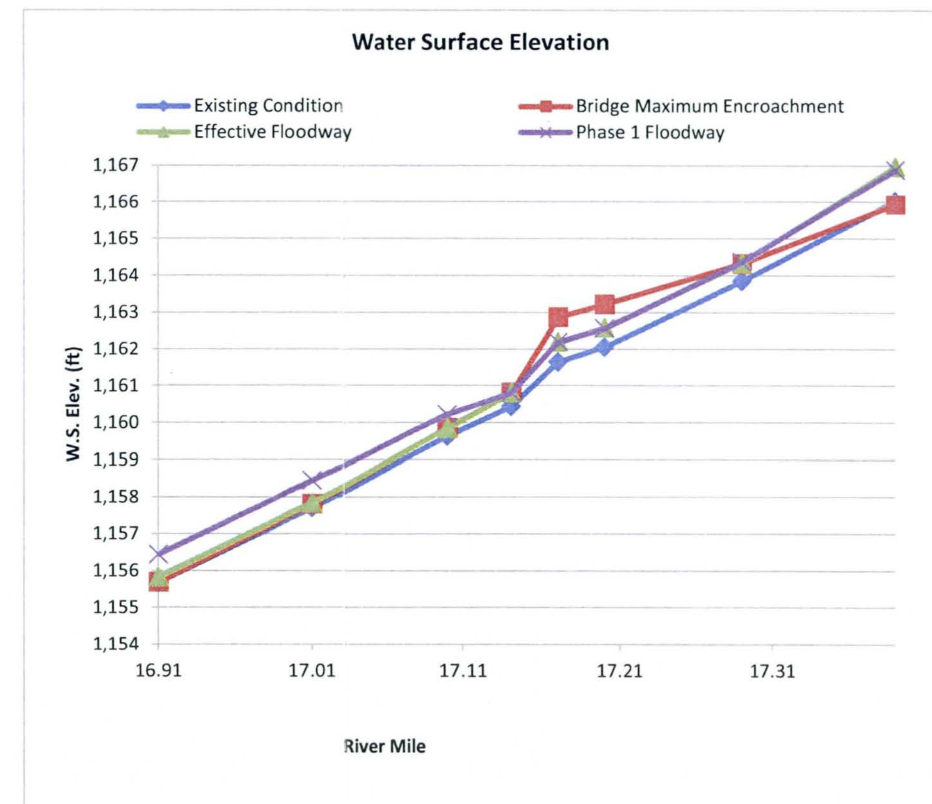


Table 5.56

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Camelback Road Bridge at RM 14.405

Change in Velocity

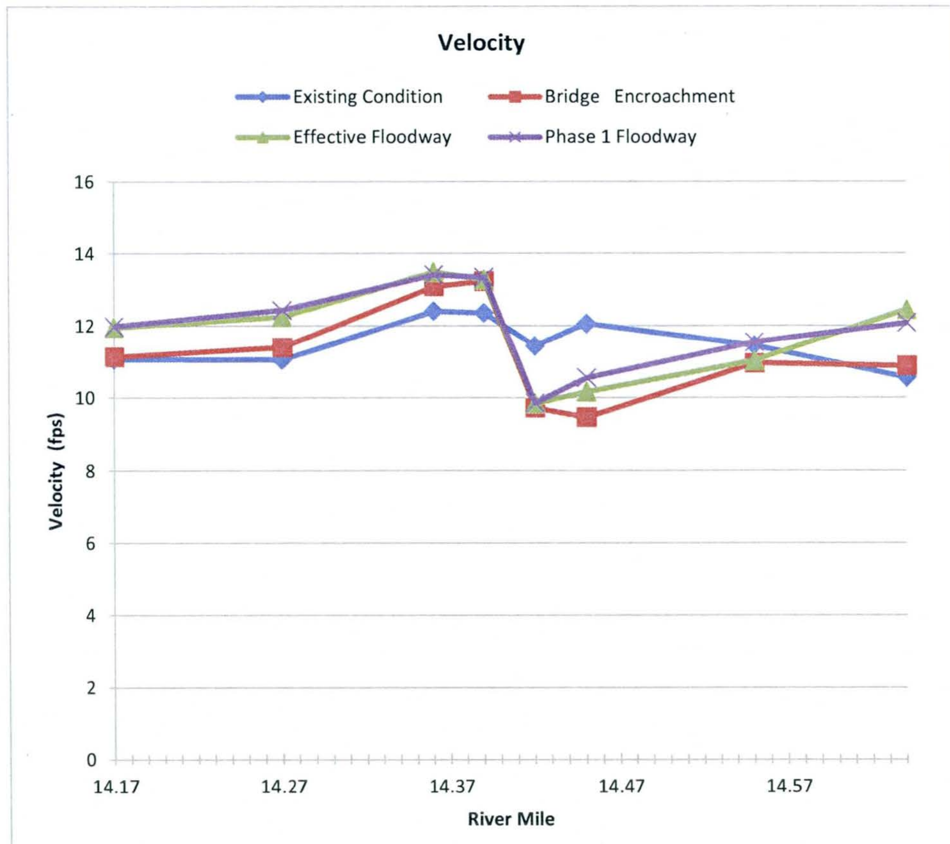
	Existing Condition		Bridge Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %
14.17	11.08		11.15	0.6	11.96	7.9	11.99	8.2
14.27	11.06		11.41	3.2	12.25	10.8	12.44	12.5
14.36	12.41		13.10	5.6	13.50	8.8	13.42	8.1
14.39	12.36		13.25	7.2	13.29	7.5	13.35	8.0
14.42	11.44		9.73	-14.9	9.85	-13.9	9.86	-13.8
14.45	12.06		9.47	-21.5	10.17	-15.7	10.56	-12.4
14.55	11.46		10.97	-4.3	11.04	-3.7	11.55	0.8
14.64	10.56		10.89	3.1	12.45	17.9	12.08	14.4

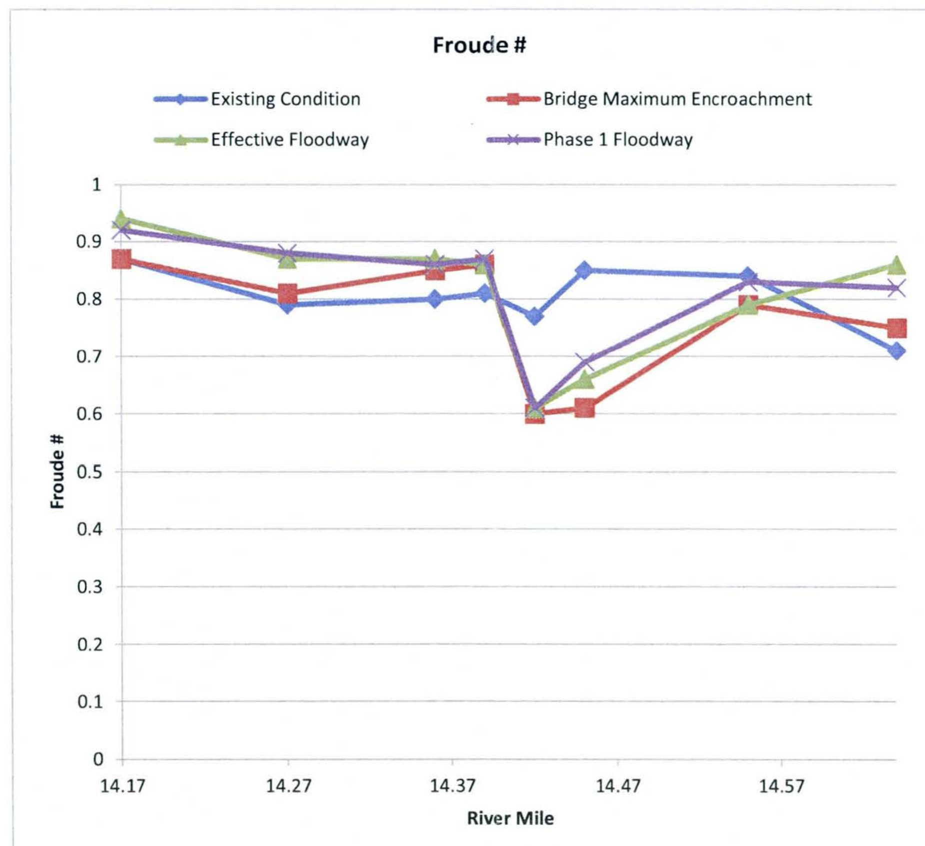
Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %
14.170	0.87		0.87	0.0	0.94	8.0	0.92	5.7
14.270	0.79		0.81	2.5	0.87	10.1	0.88	11.4
14.360	0.80		0.85	6.3	0.87	8.7	0.86	7.5
14.390	0.81		0.86	6.2	0.86	6.2	0.87	7.4
14.420	0.77		0.60	-22.1	0.61	-20.8	0.61	-20.8
14.450	0.85		0.61	-28.2	0.66	-22.4	0.69	-18.8
14.550	0.84		0.79	-6.0	0.79	-6.0	0.83	-1.2
14.640	0.71		0.75	5.6	0.86	21.1	0.82	15.5

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet
14.17	1,100.62	1100.60	-0.02	1100.57	-0.05	1100.76	0.14
14.27	1,103.29	1103.22	-0.07	1103.28	-0.01	1103.28	-0.01
14.36	1,106.35	1106.25	-0.10	1106.40	0.05	1106.38	0.03
14.39	1,106.78	1106.93	0.15	1106.96	0.18	1106.90	0.12
14.42	1,107.51	1108.81	1.30	1108.81	1.30	1108.79	1.28
14.45	1,108.04	1109.24	1.20	1109.12	1.08	1109.03	0.99
14.55	1,110.03	1110.19	0.16	1110.30	0.27	1110.27	0.24
14.64	1,112.12	1111.96	-0.16	1111.89	-0.23	1112.11	-0.01





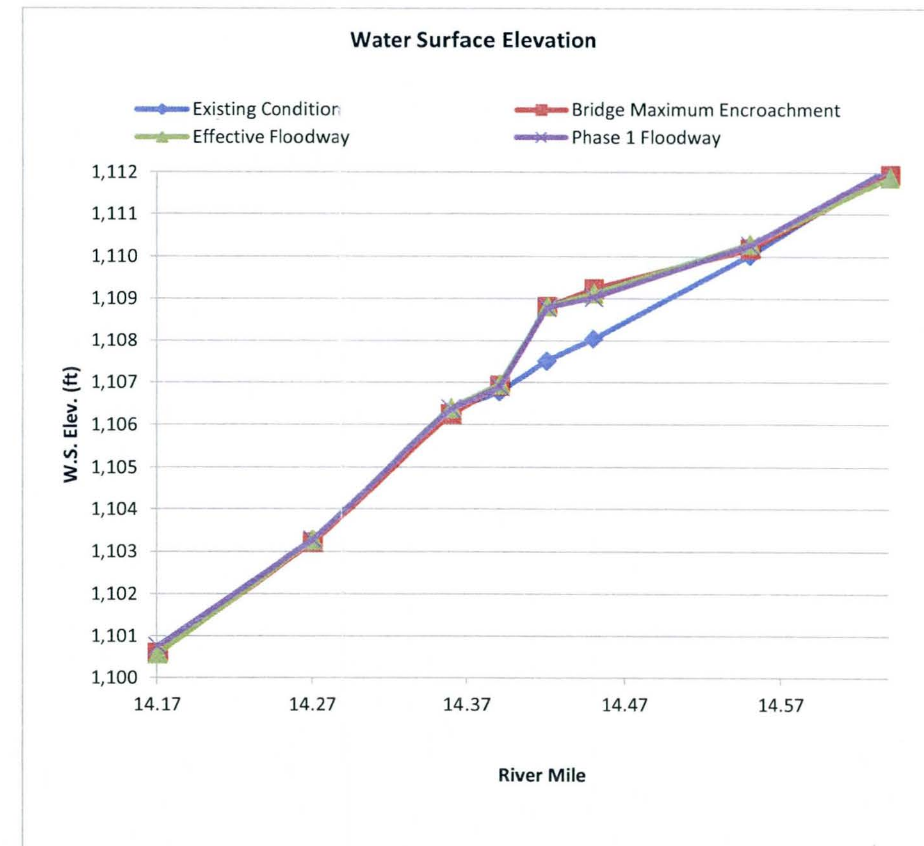


Table 5.57

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Indian School Road Bridge at RM 13.875

Change in Velocity

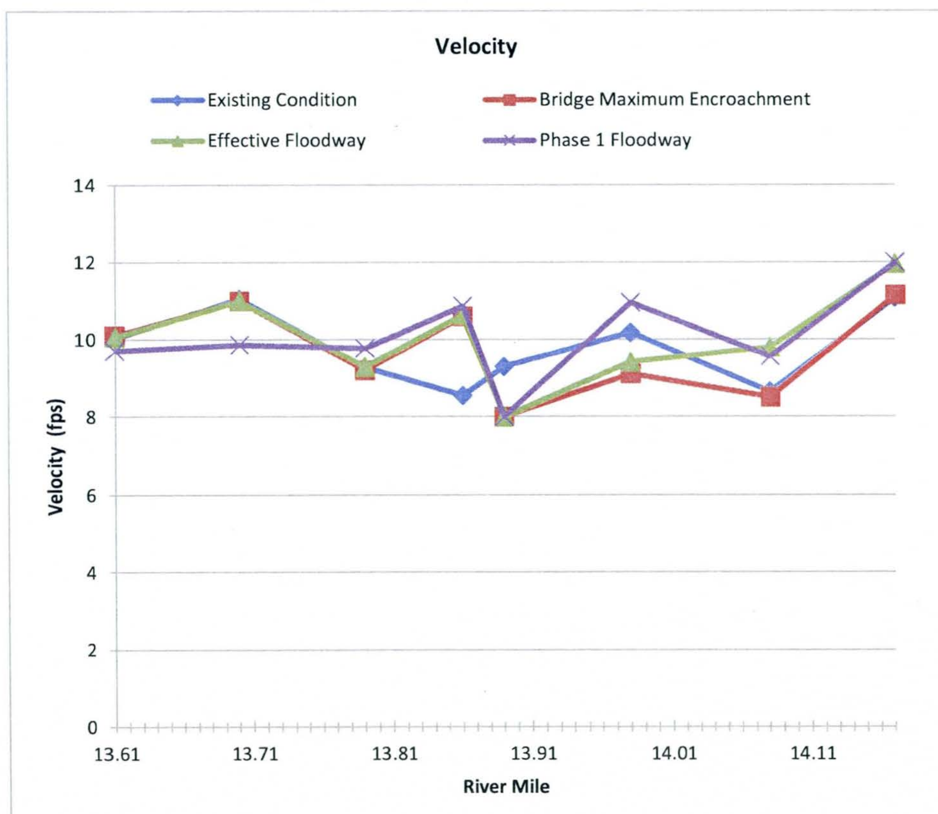
	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
	fps	%	fps	%	fps	%	fps	%
13.61	10.04		10.11	0.7	10.07	0.3	9.71	-3.3
13.70	11.05		11.00	-0.5	11.00	-0.5	9.87	-10.7
13.79	9.28		9.21	-0.8	9.30	0.2	9.78	5.4
13.86	8.55		10.60	24.0	10.64	24.4	10.87	27.1
13.89	9.30		8.01	-13.9	8.00	-14.0	8.01	-13.9
13.98	10.18		9.11	-10.5	9.42	-7.5	10.96	7.7
14.08	8.64		8.51	-1.5	9.80	13.4	9.56	10.6
14.17	11.08		11.15	0.6	11.96	7.9	11.99	8.2

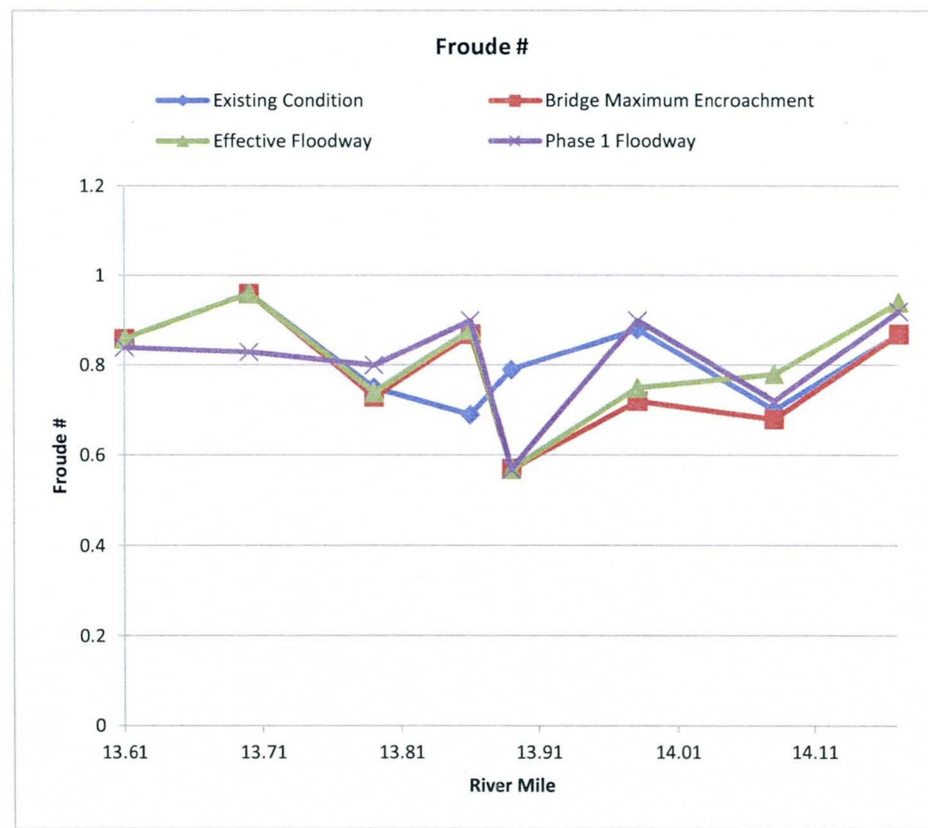
Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
	unitless	%	unitless	%	unitless	%	unitless	%
13.610	0.86		0.86	0.0	0.86	0.0	0.84	-2.3
13.700	0.96		0.96	0.0	0.96	0.0	0.83	-13.5
13.790	0.75		0.73	-2.7	0.74	-1.3	0.80	6.7
13.860	0.69		0.87	26.1	0.88	27.5	0.90	30.4
13.890	0.79		0.57	-27.8	0.57	-27.8	0.57	-27.8
13.980	0.88		0.72	-18.2	0.75	-14.8	0.90	2.3
14.080	0.70		0.68	-2.9	0.78	11.4	0.72	2.9
14.170	0.87		0.87	0.0	0.94	8.0	0.92	5.7

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
	feet	feet	feet	feet	feet	feet	feet
13.61	1,085.33	1085.33	0.00	1085.35	0.02	1086.02	0.69
13.70	1,087.92	1087.94	0.02	1087.94	0.02	1088.43	0.51
13.79	1,091.61	1091.67	0.06	1091.65	0.04	1091.42	-0.19
13.86	1,093.22	1093.06	-0.16	1093.07	-0.15	1093.02	-0.20
13.89	1,093.52	1095.33	1.81	1095.34	1.82	1095.33	1.81
13.98	1,095.79	1096.57	0.78	1096.56	0.77	1096.32	0.53
14.08	1,098.90	1098.95	0.05	1099.00	0.10	1099.54	0.64
14.17	1,100.62	1100.60	-0.02	1100.57	-0.05	1100.76	0.14





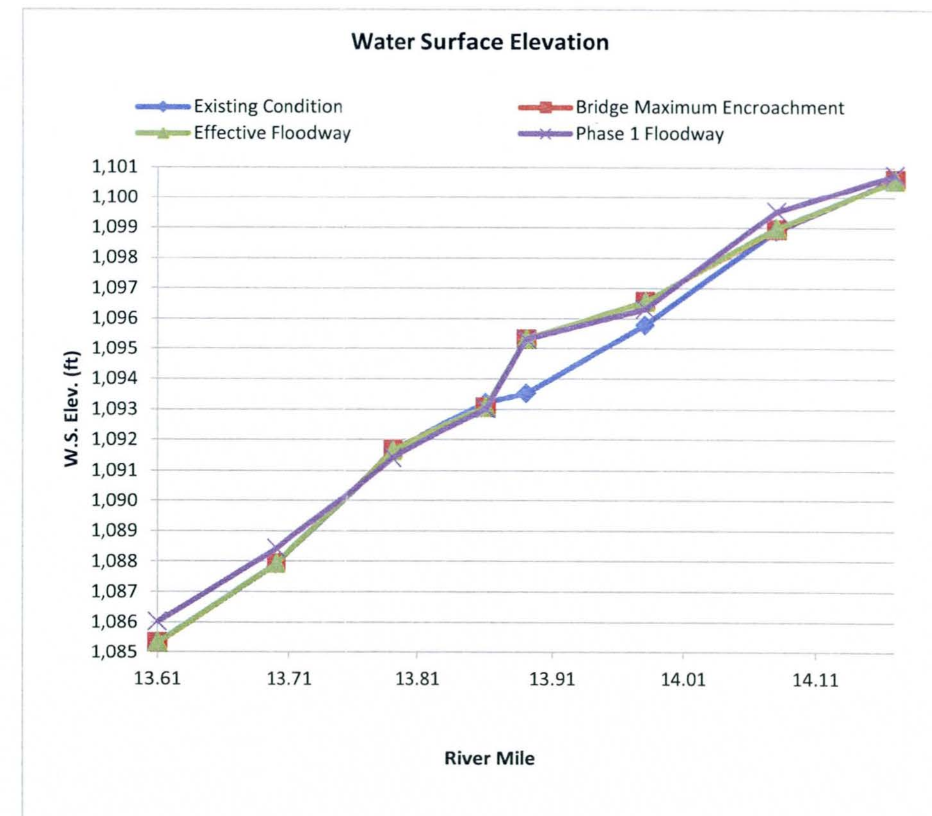


Table 5.58
Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event
McDowell Parkway Bridge at RM 13.035

Change in Velocity

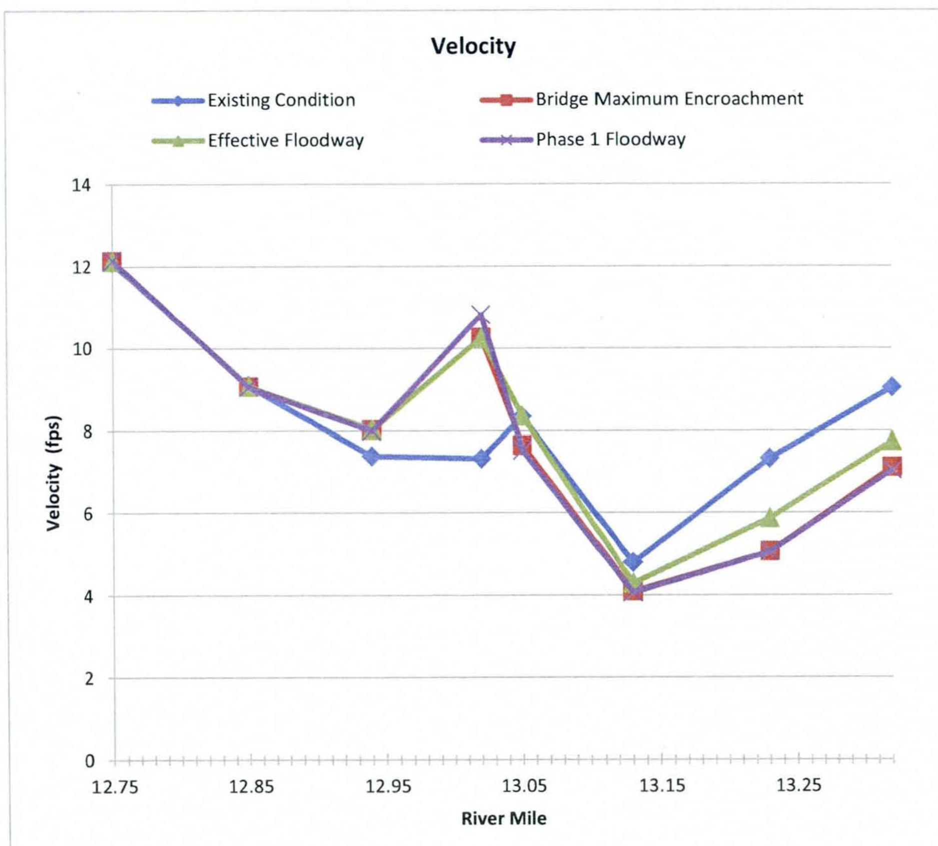
RM	Existing Condition Velocity fps	Existing Condition Percent Change %	Bridge Maximum Encroachment Velocity fps	Bridge Maximum Encroachment Percent Change %	Effective Floodway Velocity fps	Effective Floodway Percent Change %	Phase 1 Floodway Velocity fps	Phase 1 Floodway Percent Change %
12.75	12.10		12.13	0.2	12.13	0.2	12.14	0.3
12.85	9.09		9.07	-0.2	9.07	-0.2	9.06	-0.3
12.94	7.39		8.03	8.7	8.04	8.8	8.00	8.3
13.02	7.33		10.26	40.0	10.26	40.0	10.82	47.6
13.05	8.35		7.65	-8.4	8.36	0.1	7.53	-9.8
13.13	4.81		4.11	-14.6	4.31	-10.4	4.08	-15.2
13.23	7.33		5.07	-30.8	5.88	-19.8	5.07	-30.8
13.32	9.04		7.11	-21.3	7.75	-14.3	7.04	-22.1

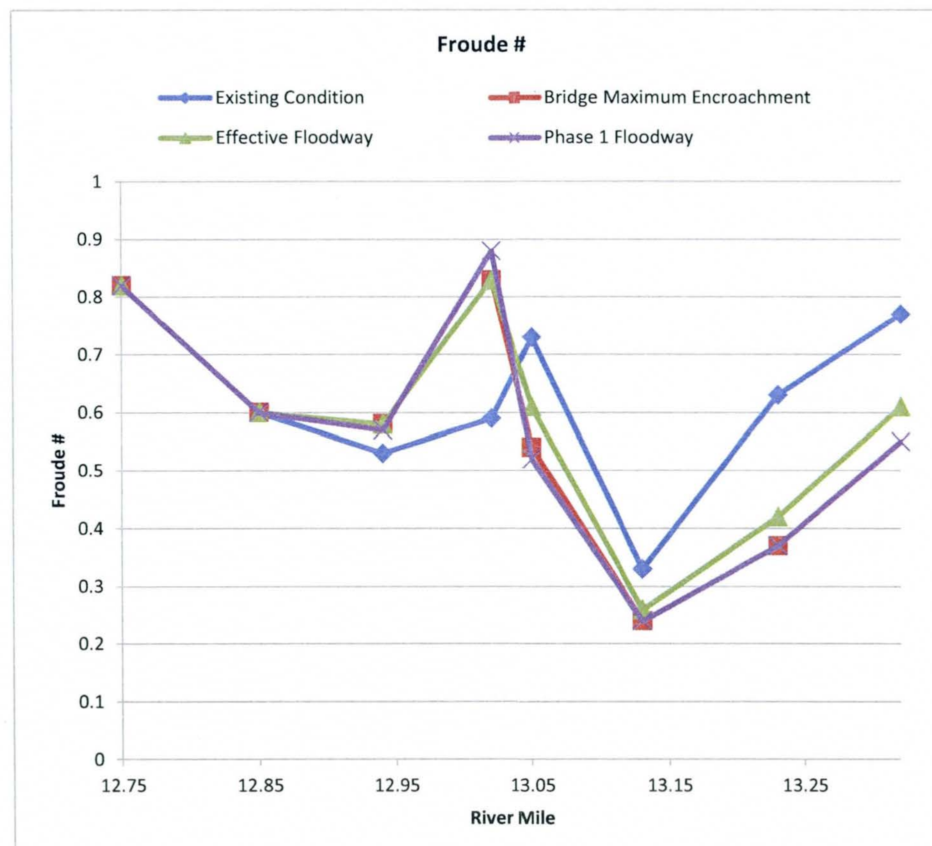
Change in Froude #

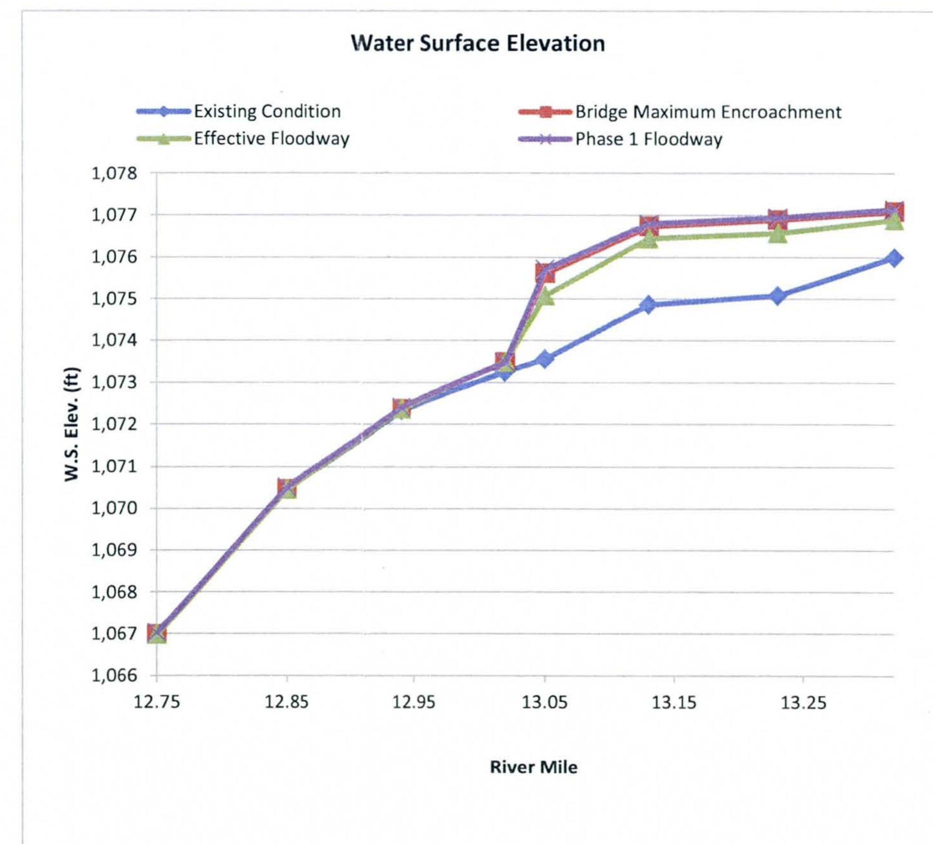
RM	Existing Condition Froude # unitless	Existing Condition Percent Change %	Bridge Maximum Encroachment Froude # unitless	Bridge Maximum Encroachment Percent Change %	Effective Floodway Froude # unitless	Effective Floodway Percent Change %	Phase 1 Floodway Froude # unitless	Phase 1 Floodway Percent Change %
12.750	0.82		0.82	0.0	0.82	0.0	0.82	0.0
12.850	0.60		0.60	0.0	0.60	0.0	0.60	0.0
12.940	0.53		0.58	9.4	0.58	9.4	0.57	7.5
13.020	0.59		0.83	40.7	0.83	40.7	0.88	49.2
13.050	0.73		0.54	-26.0	0.61	-16.4	0.52	-28.8
13.130	0.33		0.24	-27.3	0.26	-21.2	0.24	-27.3
13.230	0.63		0.37	-41.3	0.42	-33.3	0.37	-41.3
13.320	0.77		0.56	-27.3	0.61	-20.8	0.55	-28.6

Change in Water Surface Elevation

RM	Existing Condition W.S.E. feet	Bridge Maximum Encroachment W.S.E. feet	Bridge Maximum Encroachment Change in W.S.E. feet	Effective Floodway W.S.E. feet	Effective Floodway Change in W.S.E. feet	Phase 1 Floodway W.S.E. feet	Phase 1 Floodway Change in W.S.E. feet
12.75	1,067.00	1066.99	-0.01	1066.99	-0.01	1067.03	0.03
12.85	1,070.45	1070.46	0.01	1070.46	0.01	1070.51	0.06
12.94	1,072.33	1072.37	0.04	1072.37	0.04	1072.41	0.08
13.02	1,073.25	1073.49	0.24	1073.49	0.24	1073.48	0.23
13.05	1,073.56	1075.62	2.06	1075.09	1.53	1075.72	2.16
13.13	1,074.87	1076.74	1.87	1076.45	1.58	1076.80	1.93
13.23	1,075.09	1076.90	1.81	1076.58	1.49	1076.95	1.86
13.32	1,076.00	1077.10	1.10	1076.90	0.90	1077.15	1.15







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5.59

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Yuma Parkway Bridge at RM 9.78

Change in Velocity

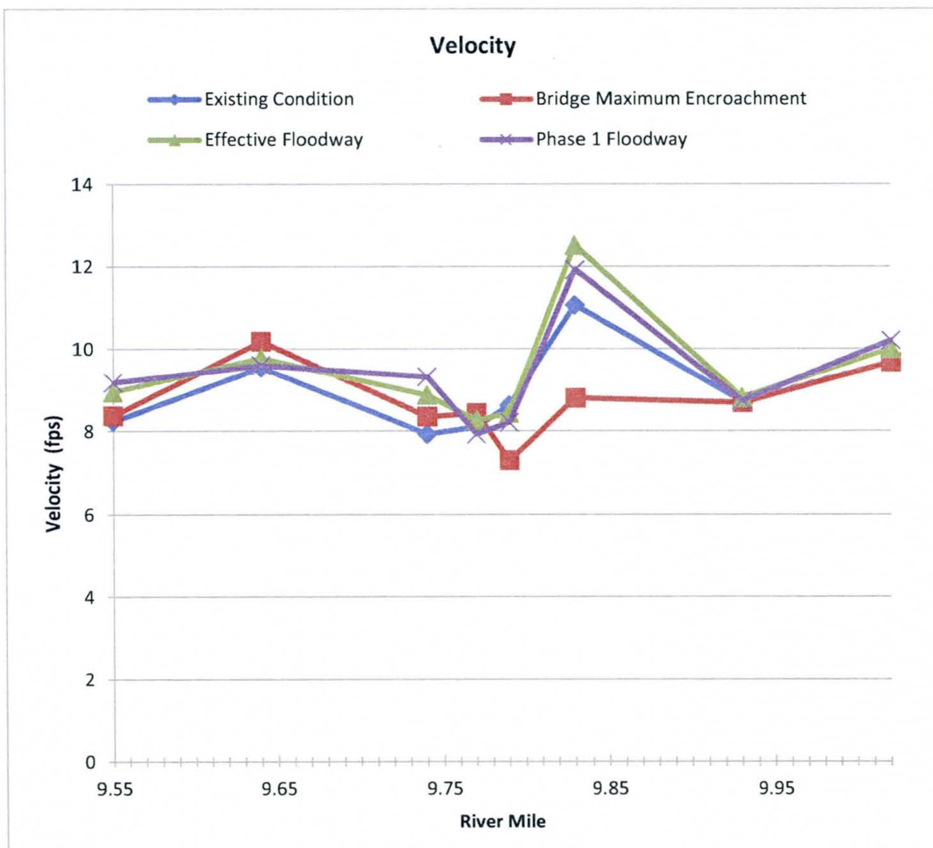
	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
	fps	%	fps	%	fps	%	fps	%
9.55	8.24		8.38	1.7	8.96	8.7	9.19	11.5
9.64	9.55		10.19	6.7	9.78	2.4	9.61	0.6
9.74	7.93		8.36	5.4	8.88	12.0	9.33	17.7
9.77	8.11		8.44	4.1	8.27	2.0	7.93	-2.2
9.79	8.63		7.30	-15.4	8.44	-2.2	8.22	-4.8
9.83	11.06		8.81	-20.3	12.51	13.1	11.92	7.8
9.93	8.72		8.70	-0.2	8.82	1.1	8.74	0.2
10.02	9.68		9.68	0.0	10.01	3.4	10.21	5.5

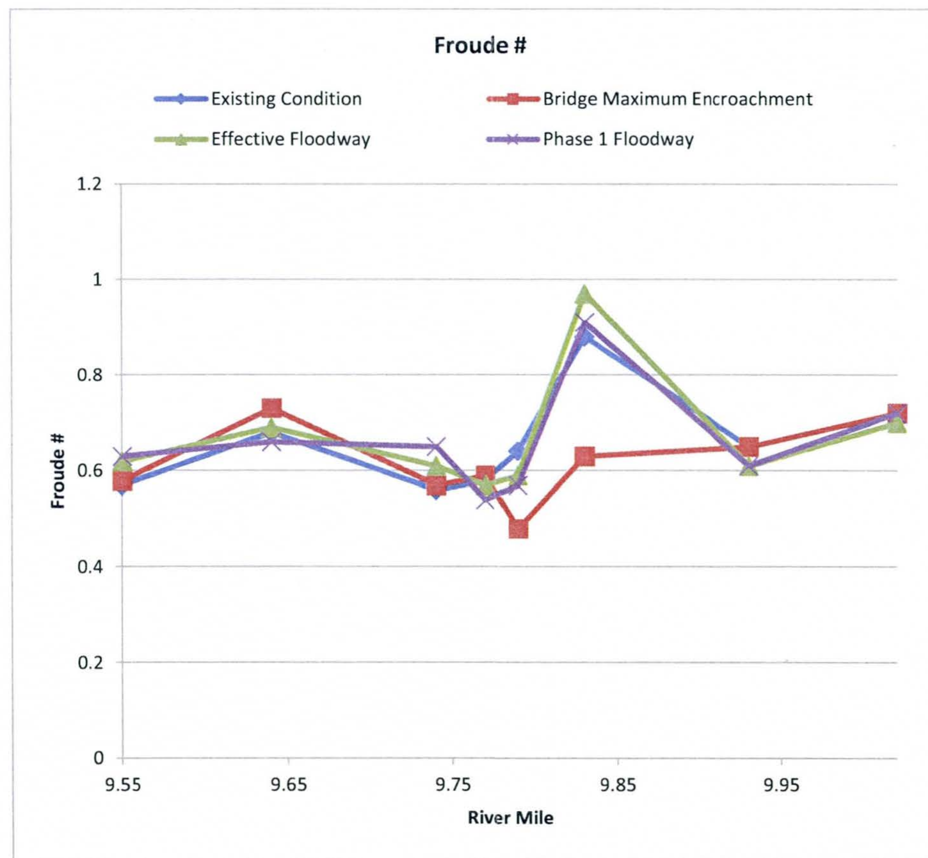
Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
	unitless	%	unitless	%	unitless	%	unitless	%
9.550	0.57		0.58	1.8	0.62	8.8	0.63	10.5
9.640	0.68		0.73	7.4	0.69	1.5	0.66	-2.9
9.740	0.56		0.57	1.8	0.61	8.9	0.65	16.1
9.770	0.58		0.59	1.7	0.57	-1.7	0.54	-6.9
9.790	0.64		0.48	-25.0	0.59	-7.8	0.57	-10.9
9.830	0.88		0.63	-28.4	0.97	10.2	0.91	3.4
9.930	0.65		0.65	0.0	0.61	-6.2	0.61	-6.2
10.020	0.72		0.72	0.0	0.70	-2.8	0.72	0.0

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
	feet	feet	feet	feet	feet	feet	feet
9.55	995.22	995.05	-0.17	995.20	-0.02	995.32	0.10
9.64	996.71	996.63	-0.08	996.95	0.24	997.12	0.41
9.74	998.98	999.30	0.32	999.19	0.21	999.17	0.19
9.77	999.37	999.71	0.34	999.83	0.46	1000.06	0.69
9.79	999.83	1001.27	1.44	1000.49	0.66	1000.64	0.81
9.83	1,000.57	1001.77	1.20	1000.82	0.25	1000.99	0.42
9.93	1,003.40	1003.40	0.00	1004.26	0.86	1004.12	0.72
10.02	1,005.60	1005.60	0.00	1006.27	0.67	1006.13	0.53





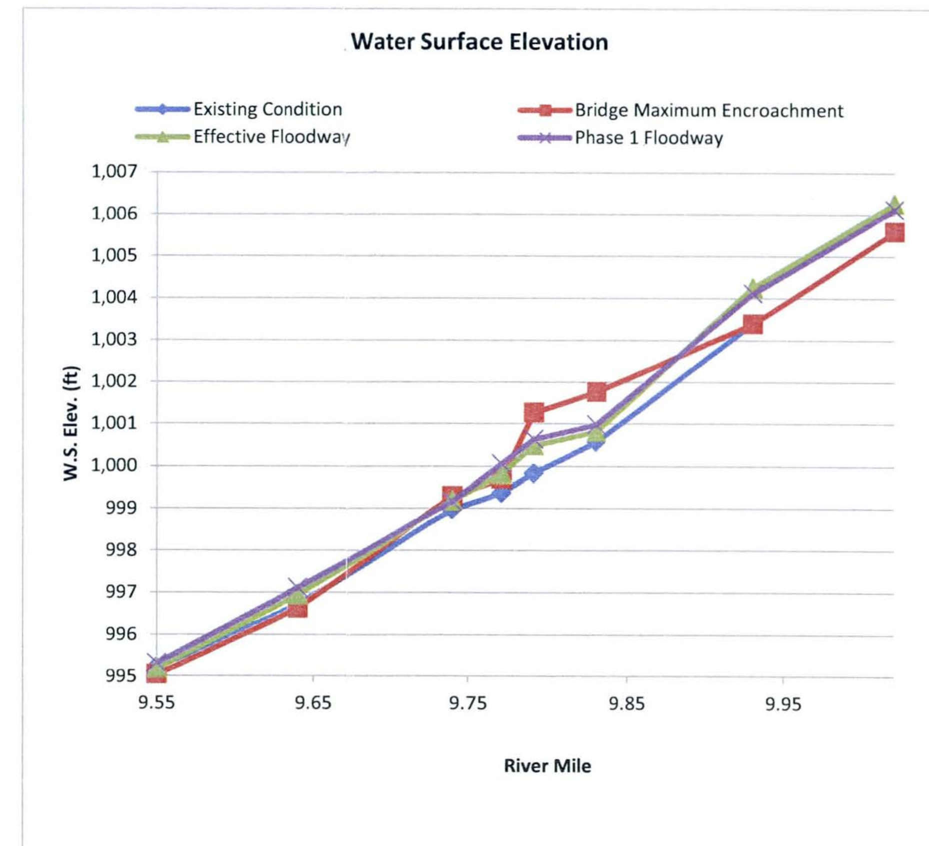


Table 5.60

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Broadway Road Bridge at RM 7.295

Change in Velocity

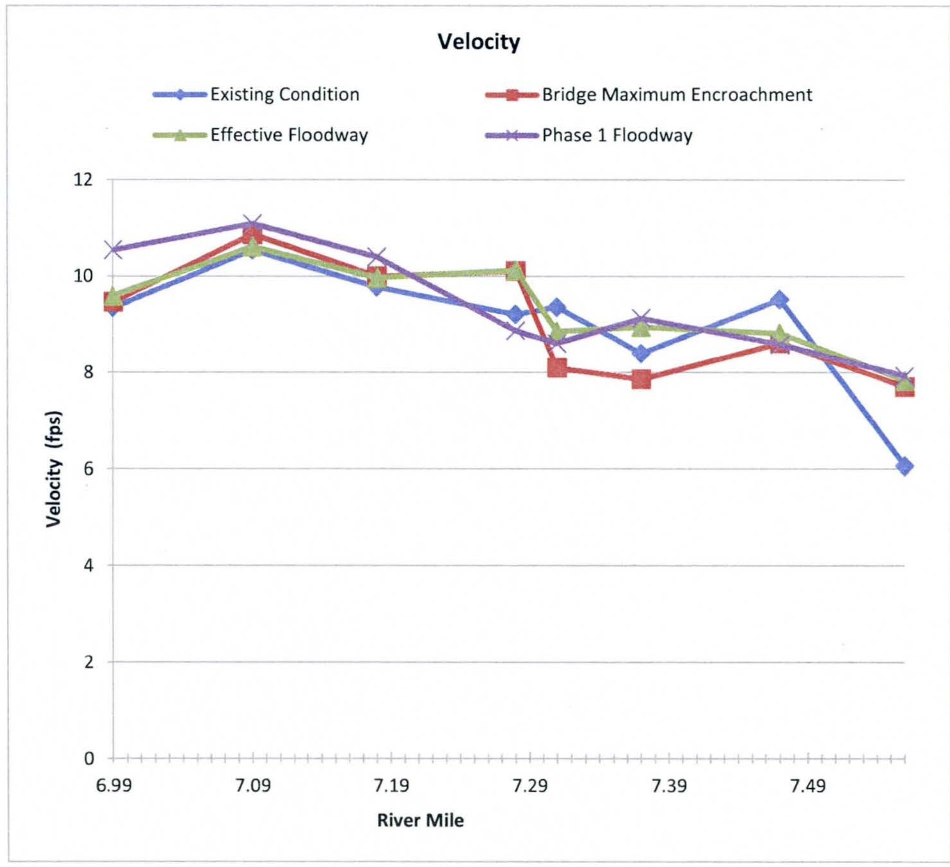
	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
	fps	%	fps	%	fps	%	fps	%
6.99	9.35		9.47	1.3	9.60	2.7	10.54	12.7
7.09	10.54		10.87	3.1	10.61	0.7	11.09	5.2
7.18	9.78		10.00	2.2	9.97	1.9	10.40	6.3
7.28	9.21		10.11	9.8	10.13	10.0	8.87	-3.7
7.31	9.36		8.10	-13.5	8.86	-5.3	8.61	-8.0
7.37	8.40		7.86	-6.4	8.95	6.5	9.13	8.7
7.47	9.52		8.62	-9.5	8.82	-7.4	8.59	-9.8
7.56	6.07		7.71	27.0	7.84	29.2	7.93	30.6

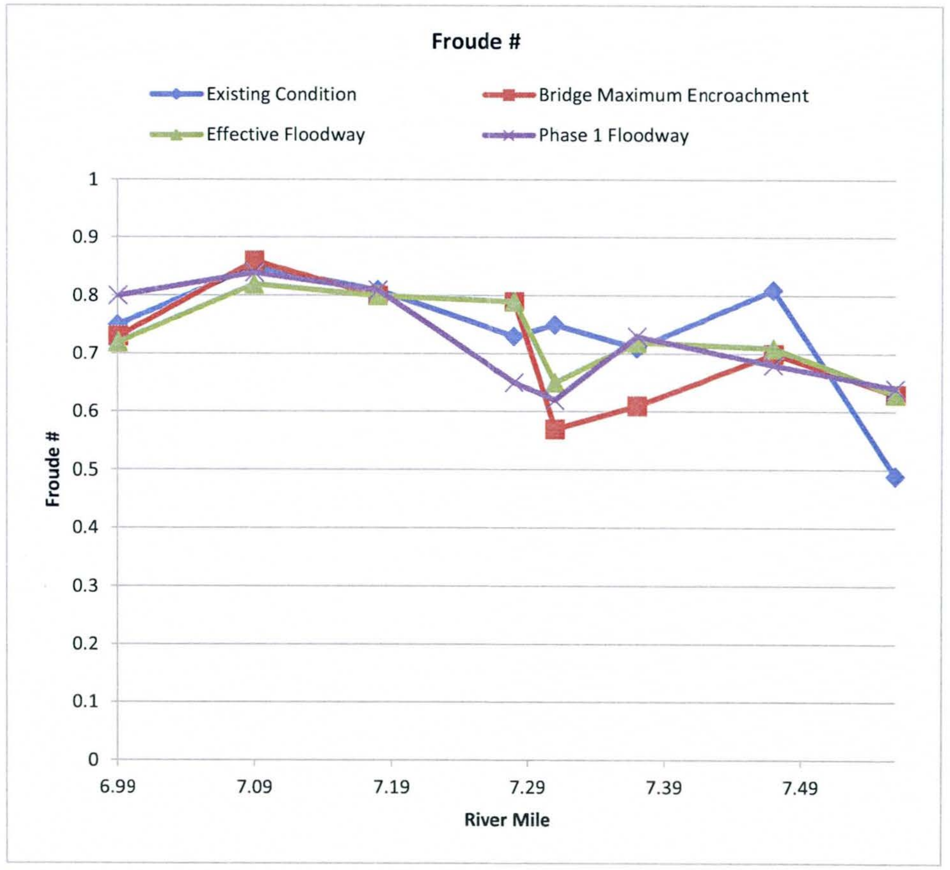
Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
	unitless	%	unitless	%	unitless	%	unitless	%
6.990	0.75		0.73	-2.7	0.72	-4.0	0.80	6.7
7.090	0.85		0.86	1.2	0.82	-3.5	0.84	-1.2
7.180	0.81		0.80	-1.2	0.80	-1.2	0.81	0.0
7.280	0.73		0.79	8.2	0.79	8.2	0.65	-11.0
7.310	0.75		0.57	-24.0	0.65	-13.3	0.62	-17.3
7.370	0.71		0.61	-14.1	0.72	1.4	0.73	2.8
7.470	0.81		0.70	-13.6	0.71	-12.3	0.68	-16.0
7.560	0.49		0.63	28.6	0.63	28.6	0.64	30.6

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
	feet	feet	feet	feet	feet	feet	feet
6.99	937.25	937.66	0.41	937.95	0.70	937.82	0.57
7.09	939.37	939.61	0.24	939.82	0.45	940.01	0.64
7.18	941.84	942.12	0.28	942.13	0.29	942.54	0.70
7.28	944.06	944.22	0.16	944.22	0.16	944.90	0.84
7.31	944.54	946.01	1.47	945.51	0.97	945.67	1.13
7.37	946.18	946.94	0.76	946.63	0.45	946.68	0.50
7.47	947.83	948.24	0.41	948.38	0.55	948.51	0.68
7.56	950.13	950.06	-0.07	950.22	0.09	950.21	0.08





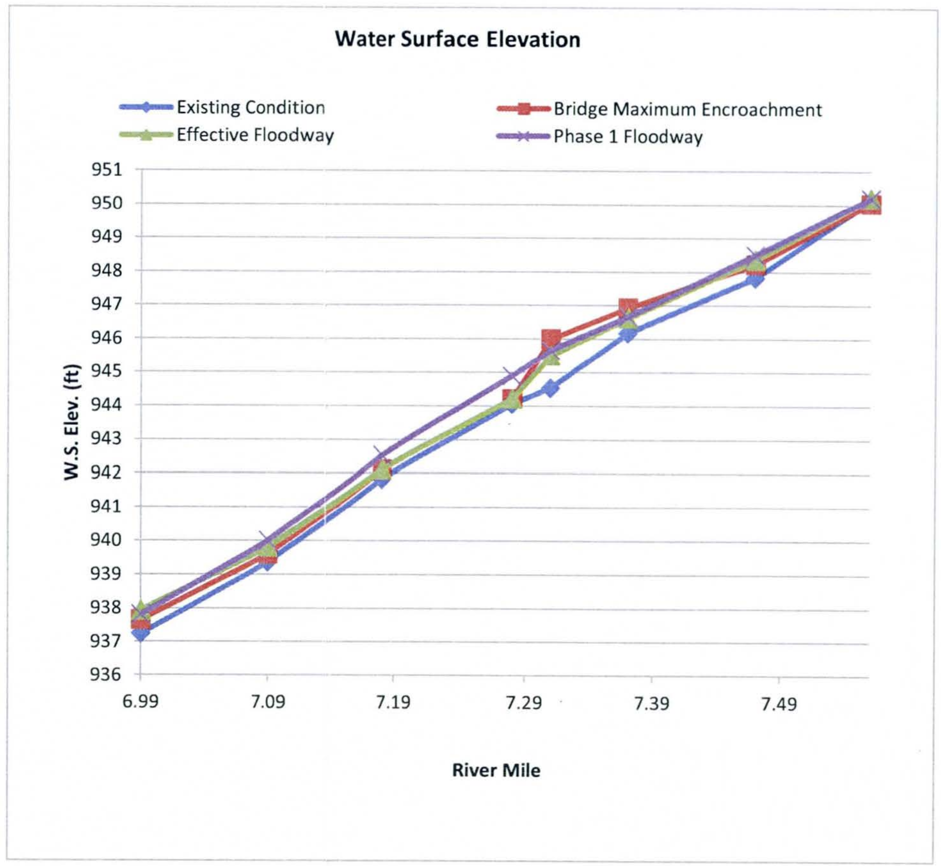


Table 5.61

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Southern Avenue Bridge at RM 5.96

Change in Velocity

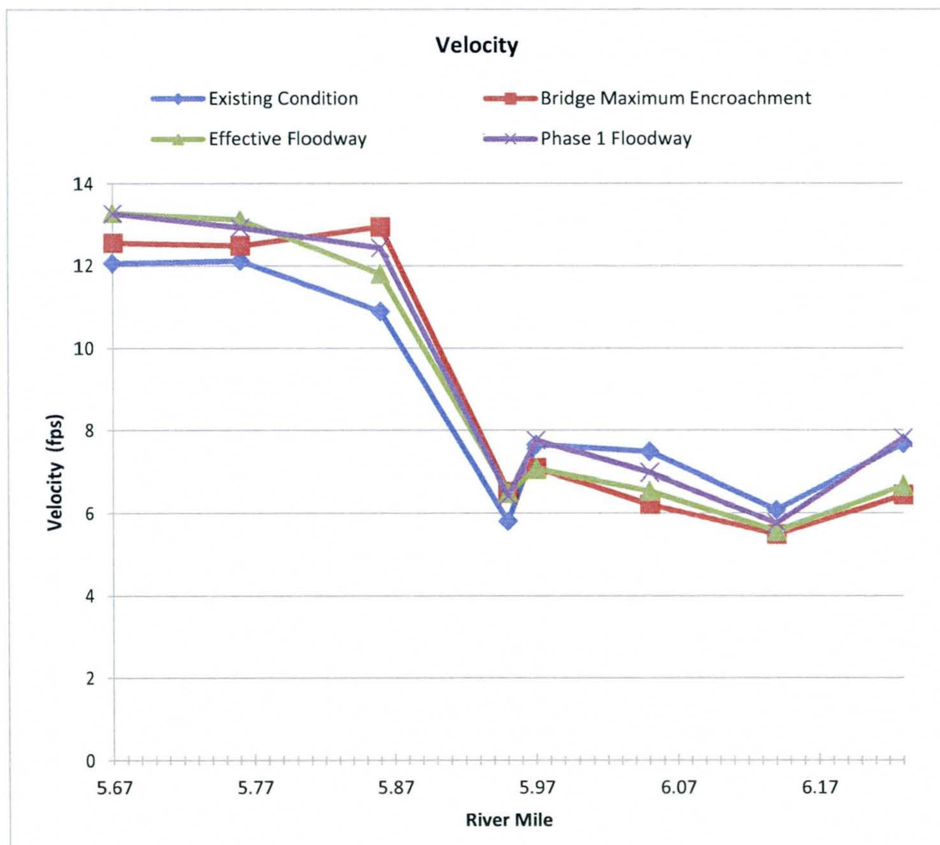
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
5.67	12.06		12.56	4.1	13.29	10.2	13.27	10.0
5.76	12.12		12.49	3.1	13.12	8.3	12.93	6.7
5.86	10.89		12.95	18.9	11.80	8.4	12.43	14.1
5.95	5.81		6.53	12.4	6.50	11.9	6.43	10.7
5.97	7.66		7.10	-7.3	7.08	-7.6	7.76	1.3
6.05	7.49		6.22	-17.0	6.55	-12.6	6.99	-6.7
6.14	6.09		5.49	-9.9	5.57	-8.5	5.76	-5.4
6.23	7.68		6.46	-15.9	6.68	-13.0	7.82	1.8

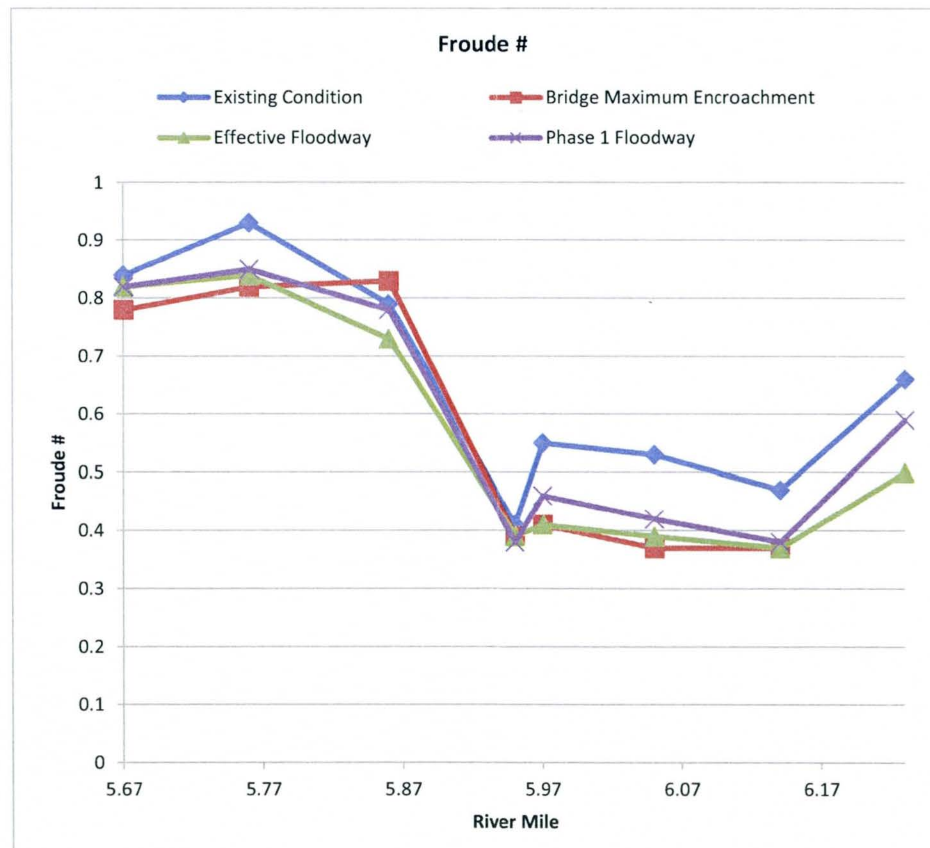
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
5.670	0.84		0.78	-7.1	0.82	-2.4	0.82	-2.4
5.760	0.93		0.82	-11.8	0.84	-9.7	0.85	-8.6
5.860	0.79		0.83	5.1	0.73	-7.6	0.78	-1.3
5.950	0.41		0.39	-4.9	0.39	-4.9	0.38	-7.3
5.970	0.55		0.41	-25.5	0.41	-25.5	0.46	-16.4
6.050	0.53		0.37	-30.2	0.39	-26.4	0.42	-20.8
6.140	0.47		0.37	-21.3	0.37	-21.3	0.38	-19.1
6.230	0.66		0.49	-25.8	0.50	-24.2	0.59	-10.6

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
5.67	908.13	909.98	1.85	909.94	1.81	909.95	1.82
5.76	910.14	912.05	1.91	912.20	2.06	912.10	1.96
5.86	912.55	914.10	1.55	914.69	2.14	914.45	1.90
5.95	914.80	917.29	2.49	917.31	2.51	917.39	2.59
5.97	915.14	918.30	3.16	918.32	3.18	917.81	2.67
6.05	916.27	919.02	2.75	918.98	2.71	918.66	2.39
6.14	918.19	919.95	1.76	920.01	1.82	919.89	1.70
6.23	919.61	920.71	1.10	920.79	1.18	920.76	1.15





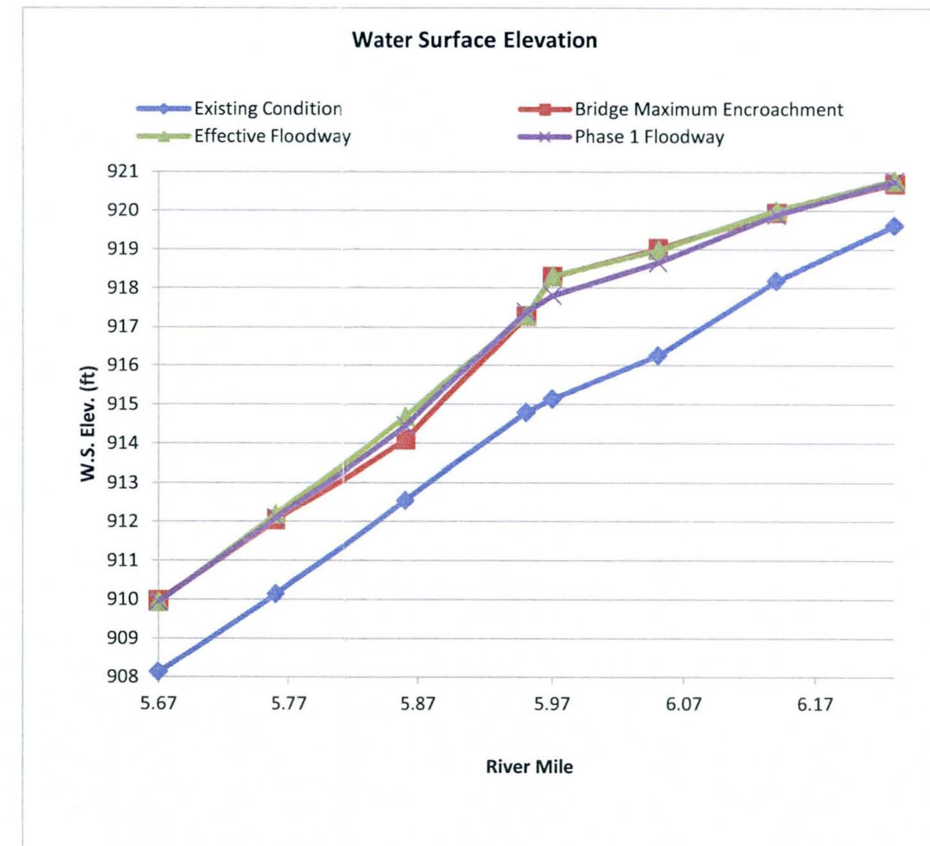


Table 5.62

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 100-Year Event

Baseline Road Bridge at RM 4.945

Change in Velocity

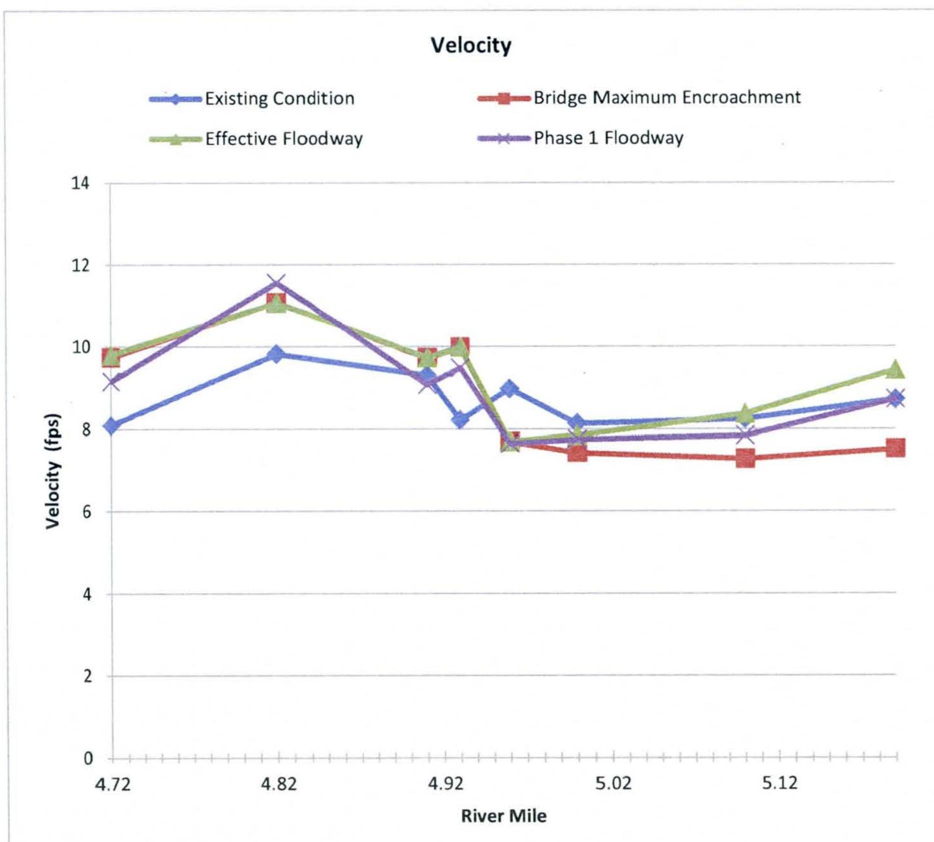
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
4.72	8.09		9.74	20.4	9.80	21.1	9.15	13.1
4.82	9.82		11.08	12.8	11.07	12.7	11.56	17.7
4.91	9.30		9.72	4.5	9.73	4.6	9.07	-2.5
4.93	8.21		9.98	21.6	9.99	21.7	9.48	15.5
4.96	8.97		7.69	-14.3	7.70	-14.2	7.65	-14.7
5.00	8.13		7.43	-8.6	7.85	-3.4	7.75	-4.7
5.10	8.24		7.28	-11.7	8.37	1.6	7.84	-4.9
5.19	8.71		7.52	-13.7	9.43	8.3	8.72	0.1

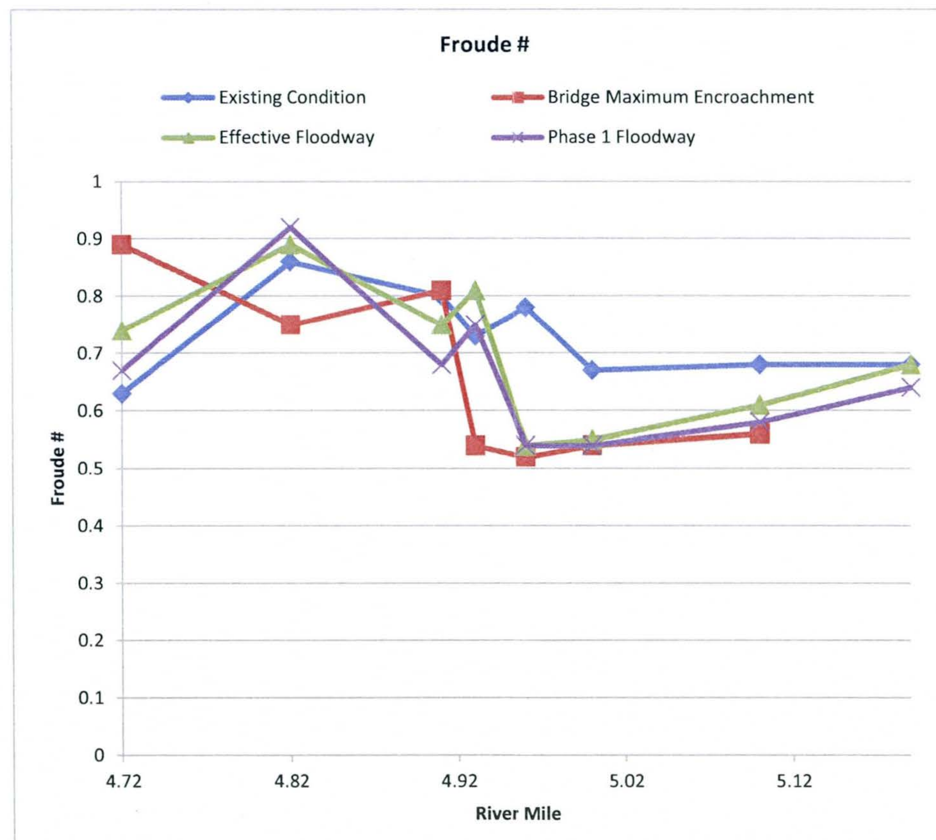
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
4.720	0.63		0.74	17.5	0.74	17.5	0.67	6.3
4.820	0.86		0.89	3.5	0.89	3.5	0.92	7.0
4.910	0.80		0.75	-6.3	0.75	-6.3	0.68	-15.0
4.930	0.73		0.81	11.0	0.81	11.0	0.75	2.7
4.960	0.78		0.54	-30.8	0.54	-30.8	0.54	-30.8
5.000	0.67		0.52	-22.4	0.55	-17.9	0.54	-19.4
5.100	0.68		0.54	-20.6	0.61	-10.3	0.58	-14.7
5.190	0.68		0.56	-17.6	0.68	0.0	0.64	-5.9

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
4.72	888.35	888.81	0.46	888.79	0.44	889.11	0.76
4.82	890.07	890.93	0.86	890.93	0.86	890.93	0.86
4.91	892.27	893.33	1.06	893.33	1.06	893.64	1.37
4.93	893.12	893.95	0.83	893.95	0.83	894.15	1.03
4.96	893.73	895.93	2.20	895.93	2.20	895.96	2.23
5.00	894.97	896.69	1.72	896.61	1.64	896.64	1.67
5.10	897.17	898.25	1.08	898.29	1.12	898.32	1.15
5.19	899.26	899.75	0.49	900.05	0.79	900.06	0.80





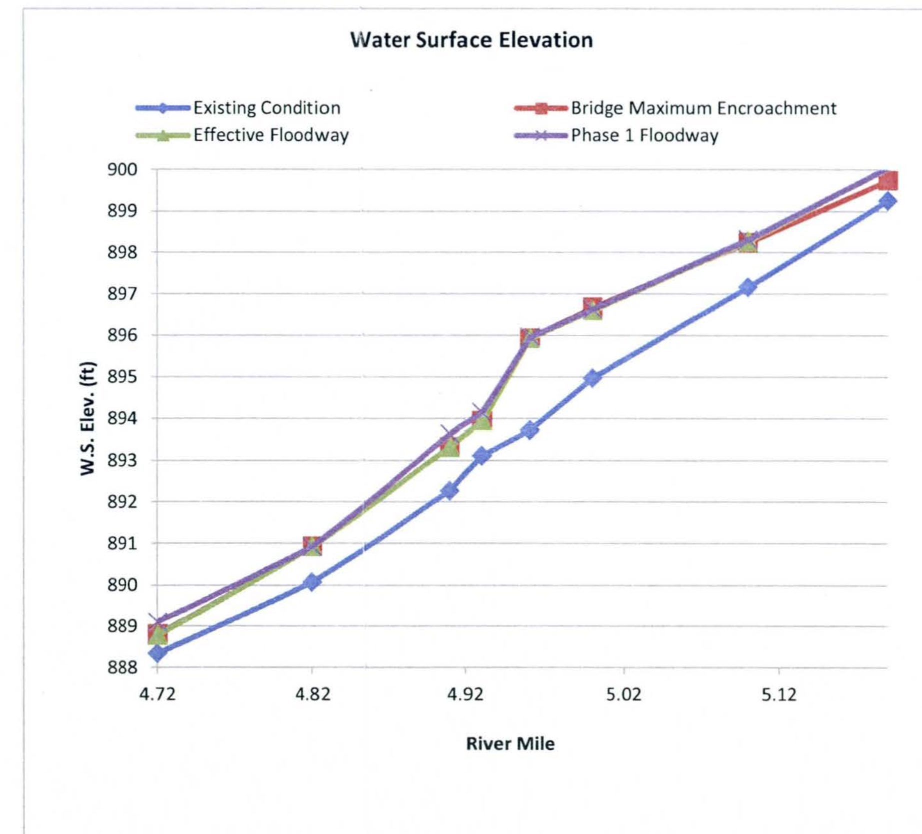


Table 5.63

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Hummingbird Springs RM 26.275

Change in Velocity

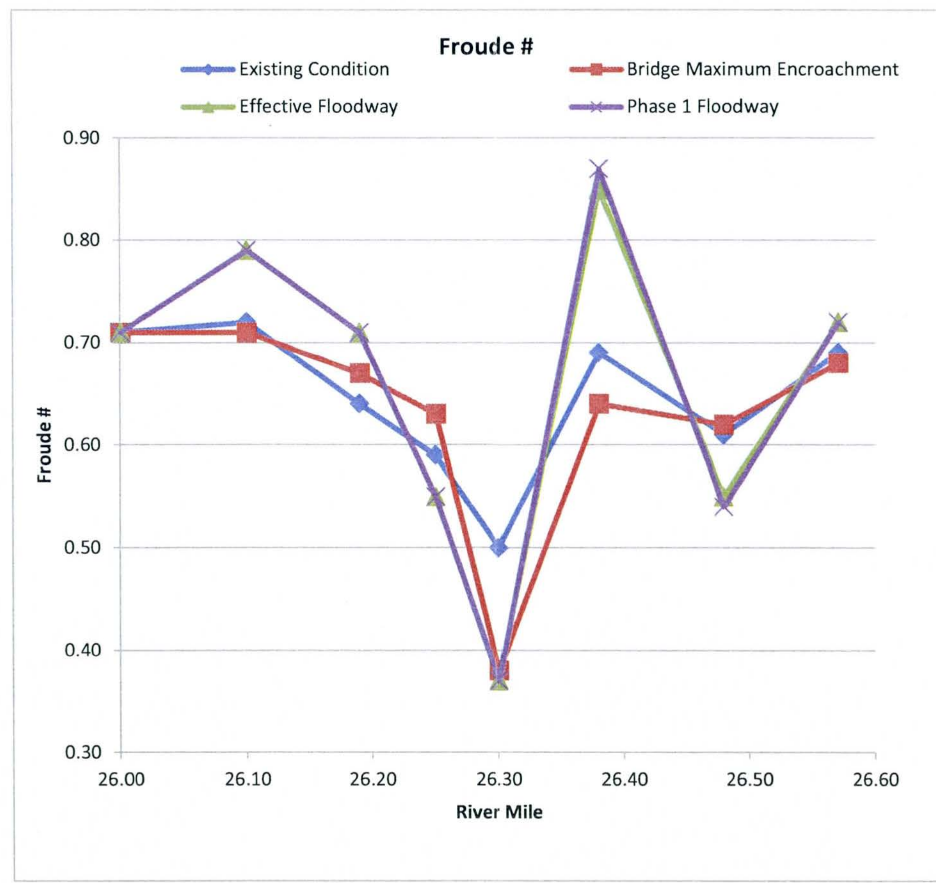
RM	Existing Condition Velocity fps	Existing Condition Percent Change %	Bridge Maximum Encroachment Velocity fps	Bridge Maximum Encroachment Percent Change %	Effective Floodway Velocity fps	Effective Floodway Percent Change %	Phase 1 Floodway Velocity fps	Phase 1 Floodway Percent Change %
26.00	5.51		5.60	1.6	6.02	9.3	6.02	9.3
26.10	5.35		5.59	4.5	6.29	17.6	6.29	17.6
26.19	4.66		5.31	13.9	5.74	23.2	5.74	23.2
26.25	4.50		5.23	16.2	4.84	7.6	4.77	6.0
26.30	3.87		3.70	-4.4	3.70	-4.4	3.66	-5.4
26.38	4.74		4.73	-0.2	6.29	32.7	6.41	35.2
26.48	4.27		4.33	1.4	4.32	1.2	4.29	0.5
26.57	4.57		4.53	-0.9	5.11	11.8	5.13	12.3

Change in Froude #

RM	Existing Condition Froude # unitless	Existing Condition Percent Change %	Bridge Maximum Encroachment Froude # unitless	Bridge Maximum Encroachment Percent Change %	Effective Floodway Froude # unitless	Effective Floodway Percent Change %	Phase 1 Floodway Froude # unitless	Phase 1 Floodway Percent Change %
26.000	0.71		0.71	0.0	0.71	0.0	0.71	0.0
26.100	0.72		0.71	-1.4	0.79	9.7	0.79	9.7
26.190	0.64		0.67	4.7	0.71	10.9	0.71	10.9
26.250	0.59		0.63	6.8	0.55	-6.8	0.55	-6.8
26.300	0.50		0.38	-24.0	0.37	-26.0	0.37	-26.0
26.380	0.69		0.64	-7.2	0.85	23.2	0.87	26.1
26.480	0.61		0.62	1.6	0.55	-9.8	0.54	-11.5
26.570	0.69		0.68	-1.4	0.72	4.3	0.72	4.3

Change in Water Surface Elevation

RM	Existing Condition W.S.E. feet	Bridge Maximum Encroachment W.S.E. feet	Bridge Maximum Encroachment Change in W.S.E. feet	Effective Floodway W.S.E. feet	Effective Floodway Change in W.S.E. feet	Phase 1 Floodway W.S.E. feet	Phase 1 Floodway Change in W.S.E. feet
26.00	1,355.24	1355.23	-0.01	1355.57	0.33	1355.57	0.33
26.10	1,357.97	1357.95	-0.02	1358.18	0.21	1358.18	0.21
26.19	1,360.43	1360.46	0.03	1360.74	0.31	1360.74	0.31
26.25	1,361.72	1361.79	0.07	1362.02	0.30	1362.02	0.30
26.30	1,362.55	1363.53	0.98	1363.61	1.06	1363.61	1.06
26.38	1,364.84	1364.94	0.10	1365.01	0.17	1364.98	0.14
26.48	1,367.19	1367.17	-0.02	1367.51	0.32	1367.52	0.33
26.57	1,369.55	1369.57	0.02	1369.46	-0.09	1369.45	-0.10



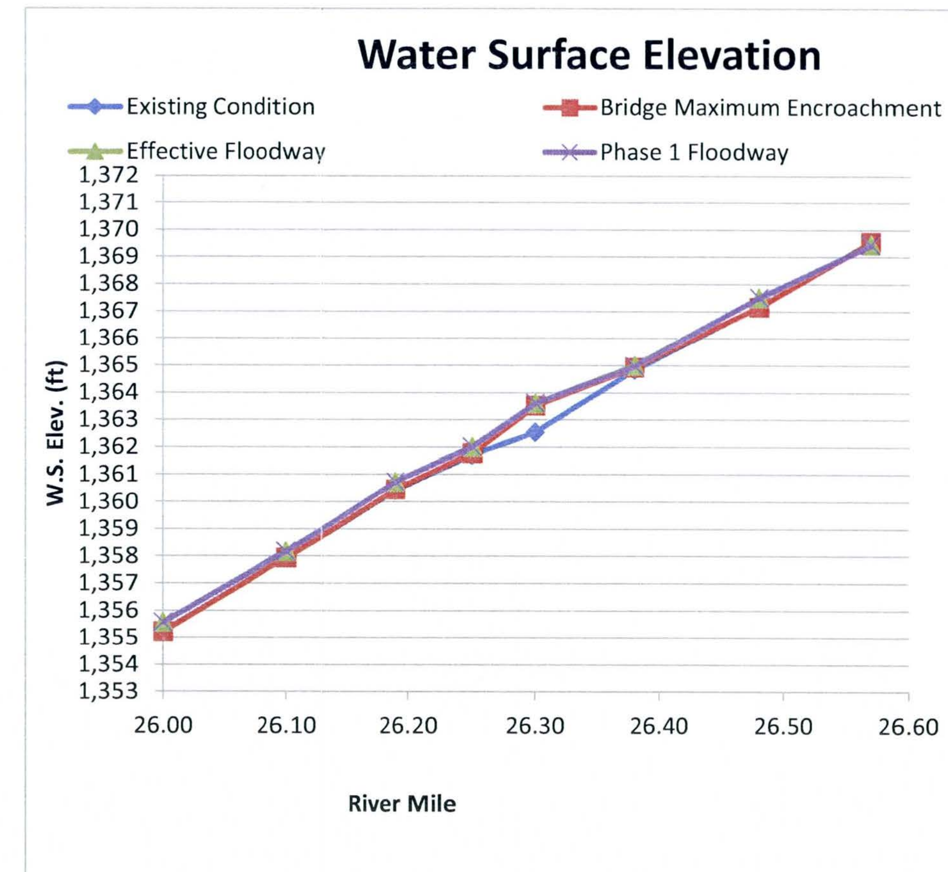


Table 5.64

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Bell Road Bridge at RM 24.71

Change in Velocity

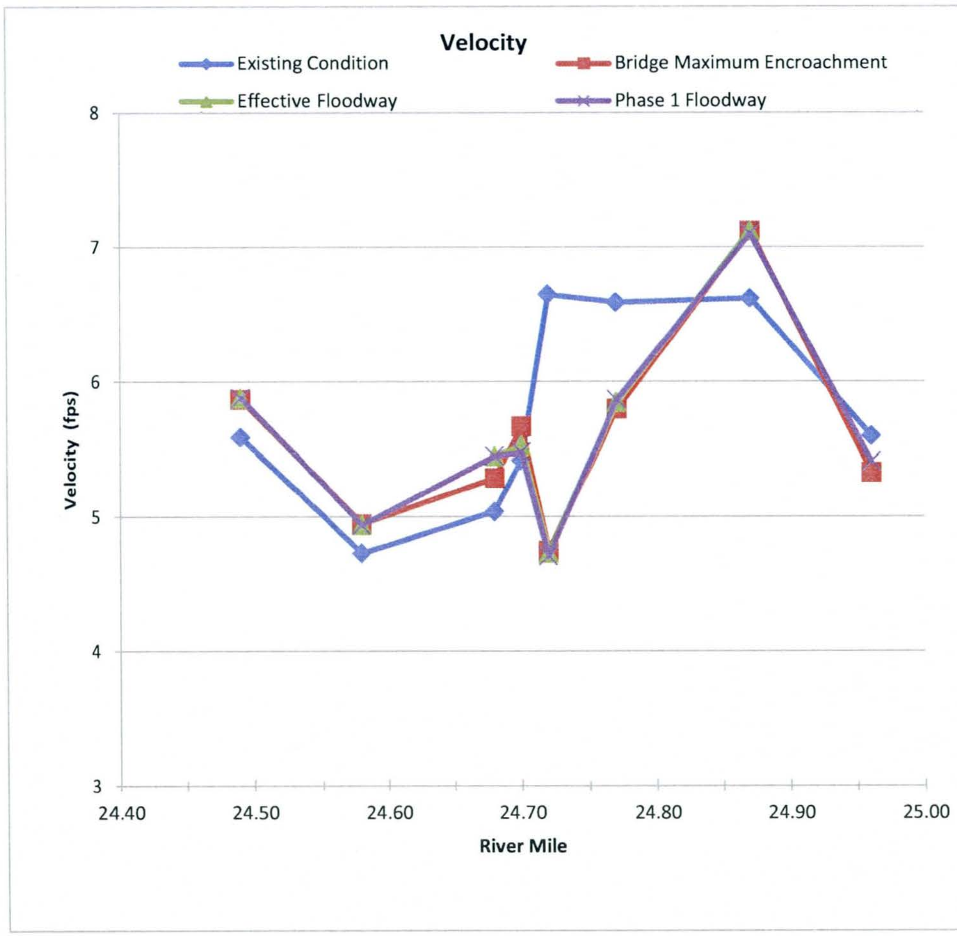
	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %
24.49	5.59		5.87	5.0	5.88	5.2	5.88	5.2
24.58	4.73		4.95	4.7	4.94	4.4	4.94	4.4
24.68	5.04		5.29	5.0	5.45	8.1	5.45	8.1
24.70	5.42		5.67	4.6	5.53	2.0	5.48	1.1
24.72	6.65		4.75	-28.6	4.73	-28.9	4.71	-29.2
24.77	6.59		5.80	-12.0	5.85	-11.2	5.87	-10.9
24.87	6.62		7.12	7.6	7.12	7.6	7.10	7.3
24.96	5.60		5.33	-4.8	5.41	-3.4	5.41	-3.4

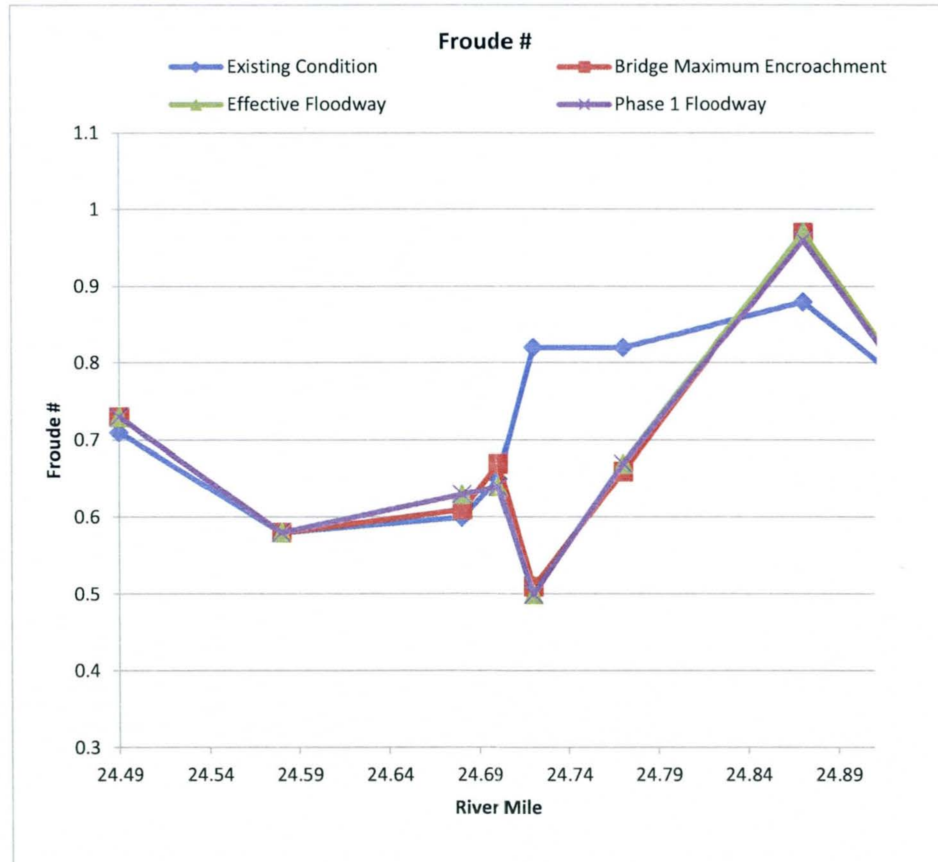
Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %
24.490	0.71		0.73	2.8	0.73	2.8	0.73	2.8
24.580	0.58		0.58	0.0	0.58	0.0	0.58	0.0
24.680	0.60		0.61	1.7	0.63	5.0	0.63	5.0
24.700	0.65		0.67	3.1	0.64	-1.5	0.64	-1.5
24.720	0.82		0.51	-37.8	0.50	-39.0	0.50	-39.0
24.770	0.82		0.66	-19.5	0.67	-18.3	0.67	-18.3
24.870	0.88		0.97	10.2	0.97	10.2	0.96	9.1
24.960	0.71		0.67	-5.6	0.67	-5.6	0.67	-5.6

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet
24.49	1,319.42	1319.57	0.15	1319.57	0.15	1319.57	0.15
24.58	1,321.99	1322.19	0.20	1322.20	0.21	1322.20	0.21
24.68	1,324.01	1324.23	0.22	1324.28	0.27	1324.28	0.27
24.70	1,324.30	1324.50	0.20	1324.57	0.27	1324.58	0.28
24.72	1,324.61	1325.60	0.99	1325.63	1.02	1325.63	1.02
24.77	1,325.62	1326.04	0.42	1326.02	0.40	1326.02	0.40
24.87	1,328.11	1328.02	-0.09	1328.03	-0.08	1328.03	-0.08
24.96	1,330.69	1330.78	0.09	1330.81	0.12	1330.81	0.12





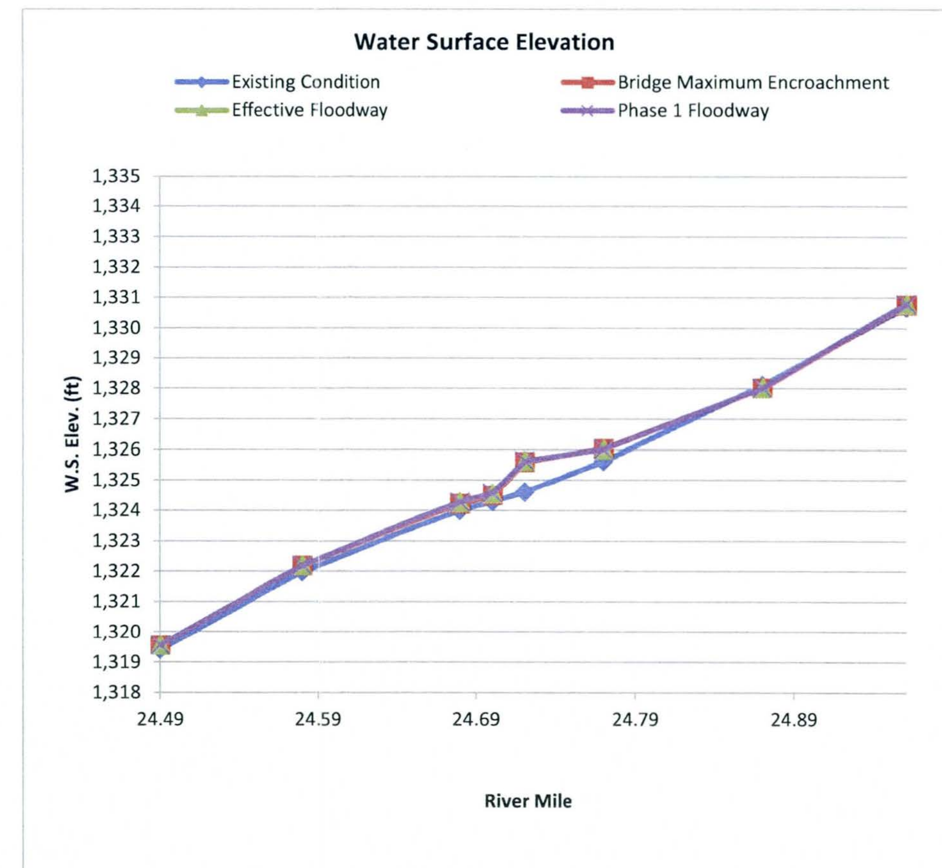


Table 5.65

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Greenway Road Bridge at RM 23.64

Change in Velocity

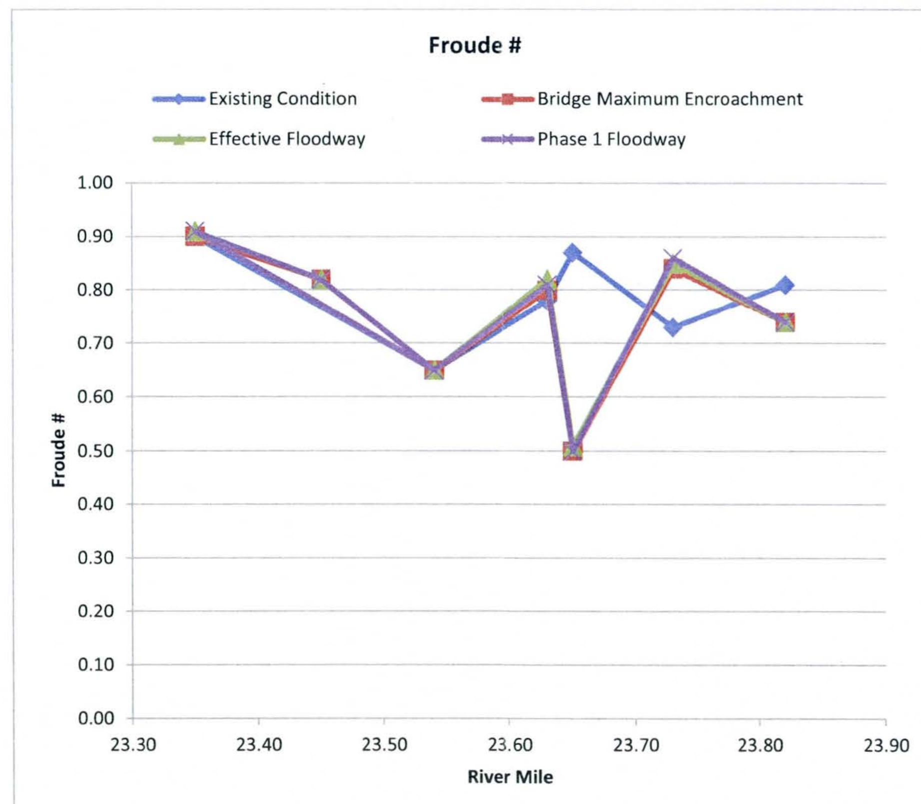
RM	Existing Condition Velocity	Existing Condition Percent Change	Bridge Maximum Encroachment Velocity	Bridge Maximum Encroachment Percent Change	Effective Floodway Velocity	Effective Floodway Percent Change	Phase 1 Floodway Velocity	Phase 1 Floodway Percent Change
	fps	%	fps	%	fps	%	fps	%
23.35	7.67		7.67	0.0	7.76	1.2	7.76	1.2
23.45	7.44		7.44	0.0	7.43	-0.1	7.43	-0.1
23.54	5.87		5.83	-0.7	5.80	-1.2	5.80	-1.2
23.63	6.37		6.49	1.9	6.65	4.4	6.57	3.1
23.65	6.83		4.78	-30.0	4.86	-28.8	4.78	-30.0
23.73	6.13		6.76	10.3	6.81	11.1	6.88	12.2
23.82	6.66		6.28	-5.7	6.39	-4.1	6.36	-4.5
23.92	6.61		6.80	2.9	6.77	2.4	6.78	2.6

Change in Froude #

RM	Existing Condition Froude #	Existing Condition Percent Change	Bridge Maximum Encroachment Froude #	Bridge Maximum Encroachment Percent Change	Effective Floodway Froude #	Effective Floodway Percent Change	Phase 1 Floodway Froude #	Phase 1 Floodway Percent Change
	unitless	%	unitless	%	unitless	%	unitless	%
23.350	0.90		0.90	0.0	0.91	1.1	0.91	1.1
23.450	0.82		0.82	0.0	0.82	0.0	0.82	0.0
23.540	0.65		0.65	0.0	0.65	0.0	0.65	0.0
23.630	0.78		0.80	2.6	0.82	5.1	0.81	3.8
23.650	0.87		0.50	-42.5	0.51	-41.4	0.50	-42.5
23.730	0.73		0.84	15.1	0.85	16.4	0.86	17.8
23.820	0.81		0.74	-8.6	0.74	-8.6	0.74	-8.6
23.920	0.75		0.78	4.0	0.77	2.7	0.77	2.7

Change in Water Surface Elevation

RM	Existing Condition W.S.E.	Bridge Maximum Encroachment W.S.E.	Bridge Maximum Encroachment Change in W.S.E.	Effective Floodway W.S.E.	Effective Floodway Change in W.S.E.	Phase 1 Floodway W.S.E.	Phase 1 Floodway Change in W.S.E.
	feet	feet	feet	feet	feet	feet	feet
23.35	1,295.17	1295.17	0.00	1295.14	-0.03	1295.14	-0.03
23.45	1,297.08	1297.08	0.00	1297.11	0.03	1297.11	0.03
23.54	1,298.57	1298.57	0.00	1298.57	0.00	1298.57	0.00
23.63	1,300.24	1300.25	0.01	1300.23	-0.01	1300.22	-0.02
23.65	1,300.95	1301.86	0.91	1301.85	0.90	1301.86	0.91
23.73	1,302.91	1302.72	-0.19	1302.72	-0.19	1302.71	-0.20
23.82	1,305.02	1305.14	0.12	1305.16	0.14	1305.17	0.15
23.92	1,306.89	1306.83	-0.06	1306.86	-0.03	1306.86	-0.03



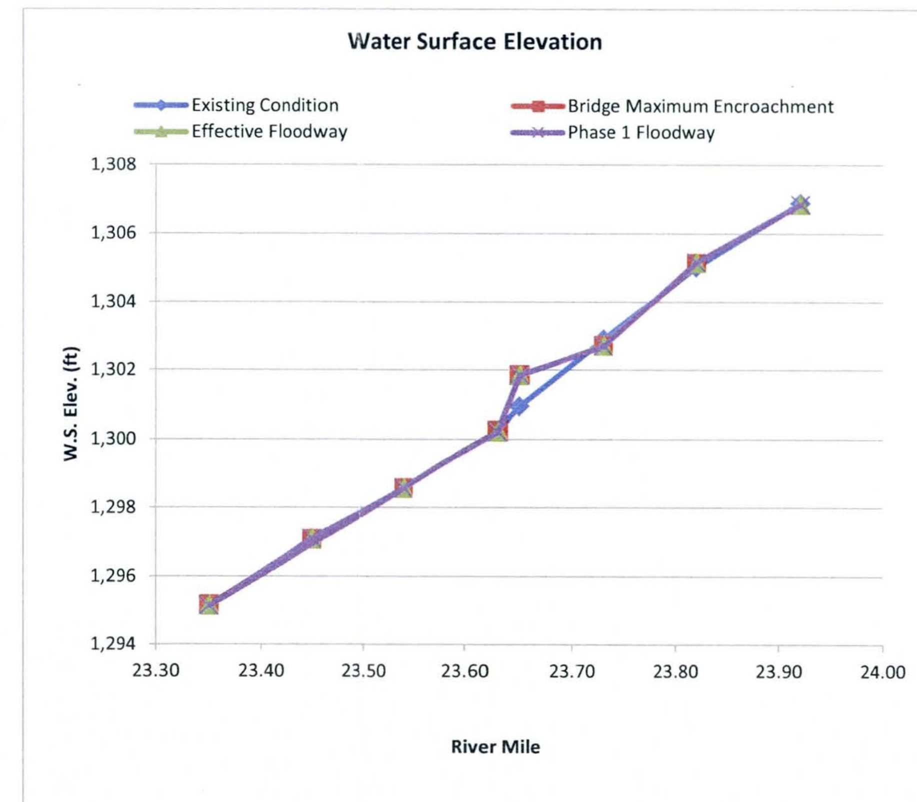


Table 5.66

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Cactus Road Bridge at RM 21.565

Change in Velocity

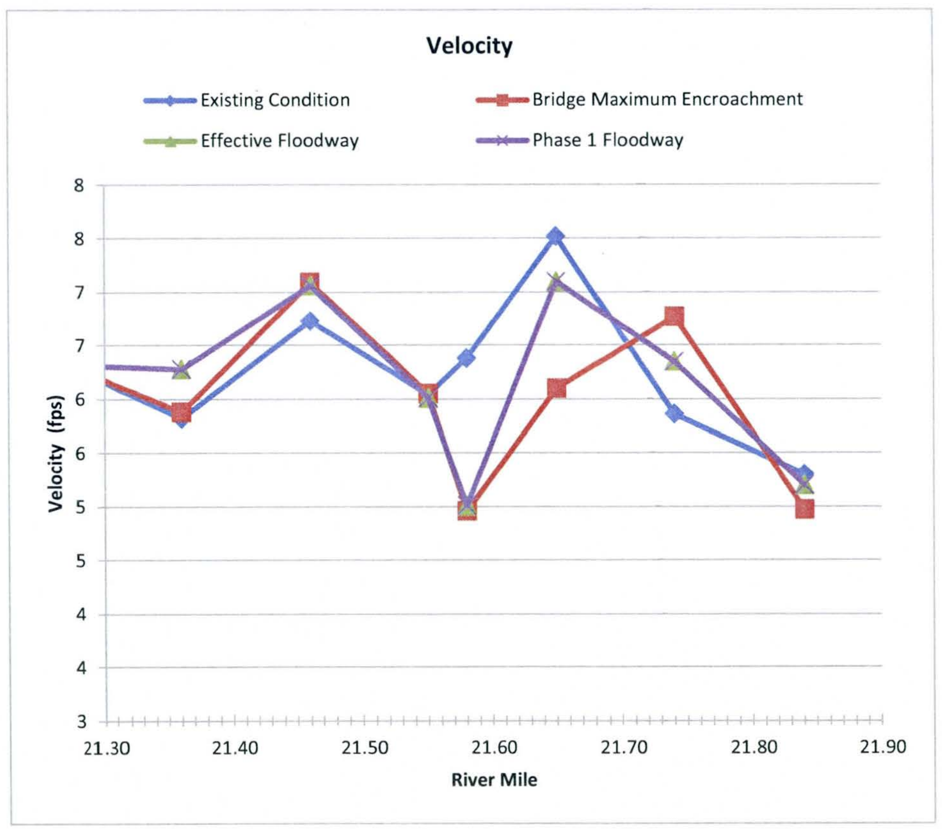
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
21.27	6.32		6.32	0.0	6.32	0.0	6.32	0.0
21.36	5.82		5.88	1.0	6.28	7.9	6.28	7.9
21.46	6.73		7.09	5.3	7.06	4.9	7.06	4.9
21.55	6.04		6.05	0.2	6.01	-0.5	6.01	-0.5
21.58	6.38		4.96	-22.3	5.01	-21.5	5.01	-21.5
21.65	7.52		6.10	-18.9	7.10	-5.6	7.10	-5.6
21.74	5.86		6.77	15.5	6.35	8.4	6.35	8.4
21.84	5.30		4.97	-6.2	5.20	-1.9	5.20	-1.9

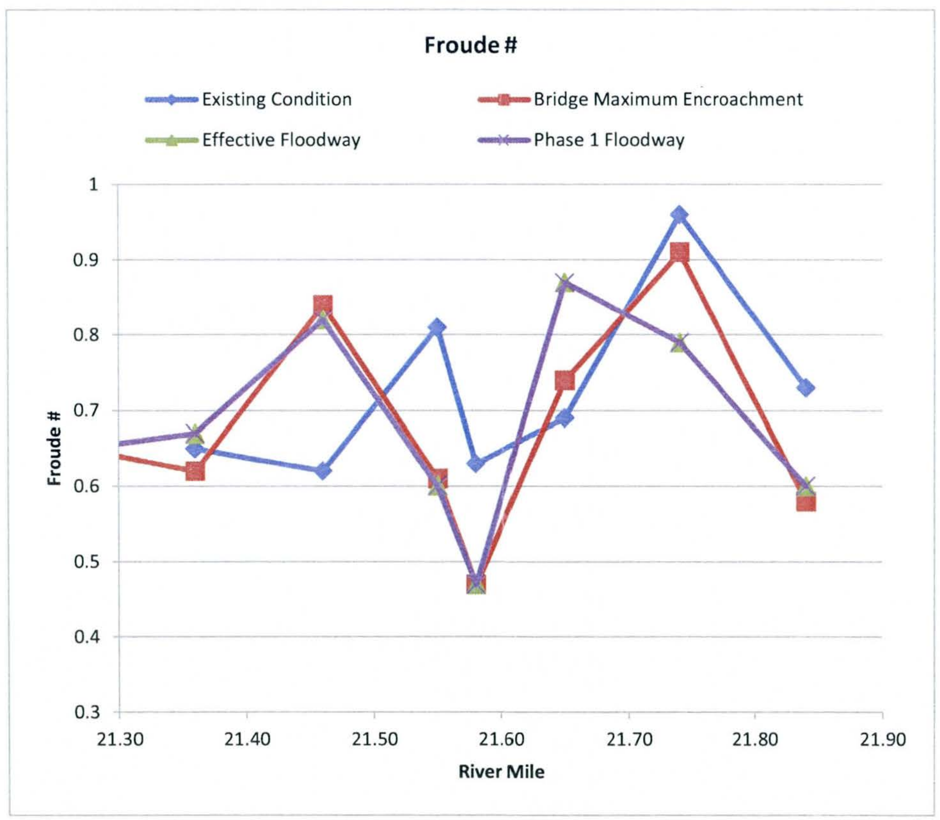
Change in Froude #

RM (feet)	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
21.270	0.65		0.65	0.0	0.65	0.0	0.65	0.0
21.360	0.62		0.62	0.0	0.67	8.1	0.67	8.1
21.460	0.81		0.84	3.7	0.82	1.2	0.82	1.2
21.550	0.63		0.61	-3.2	0.60	-4.8	0.60	-4.8
21.580	0.69		0.47	-31.9	0.47	-31.9	0.47	-31.9
21.650	0.96		0.74	-22.9	0.87	-9.4	0.87	-9.4
21.740	0.73		0.91	24.7	0.79	8.2	0.79	8.2
21.840	0.64		0.58	-9.4	0.60	-6.3	0.60	-6.3

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
21.27	1,250.13	1250.13	0.00	1250.13	0.00	1250.13	0.00
21.36	1,251.98	1251.99	0.01	1251.99	0.01	1251.99	0.01
21.46	1,253.90	1253.97	0.07	1254.09	0.19	1254.09	0.19
21.55	1,255.72	1255.89	0.17	1255.96	0.24	1255.96	0.24
21.58	1,256.15	1257.02	0.87	1257.06	0.91	1257.06	0.91
21.65	1,257.04	1257.43	0.39	1257.41	0.37	1257.41	0.37
21.74	1,259.49	1259.24	-0.25	1259.63	0.14	1259.63	0.14
21.84	1,261.17	1261.31	0.14	1261.45	0.28	1261.45	0.28





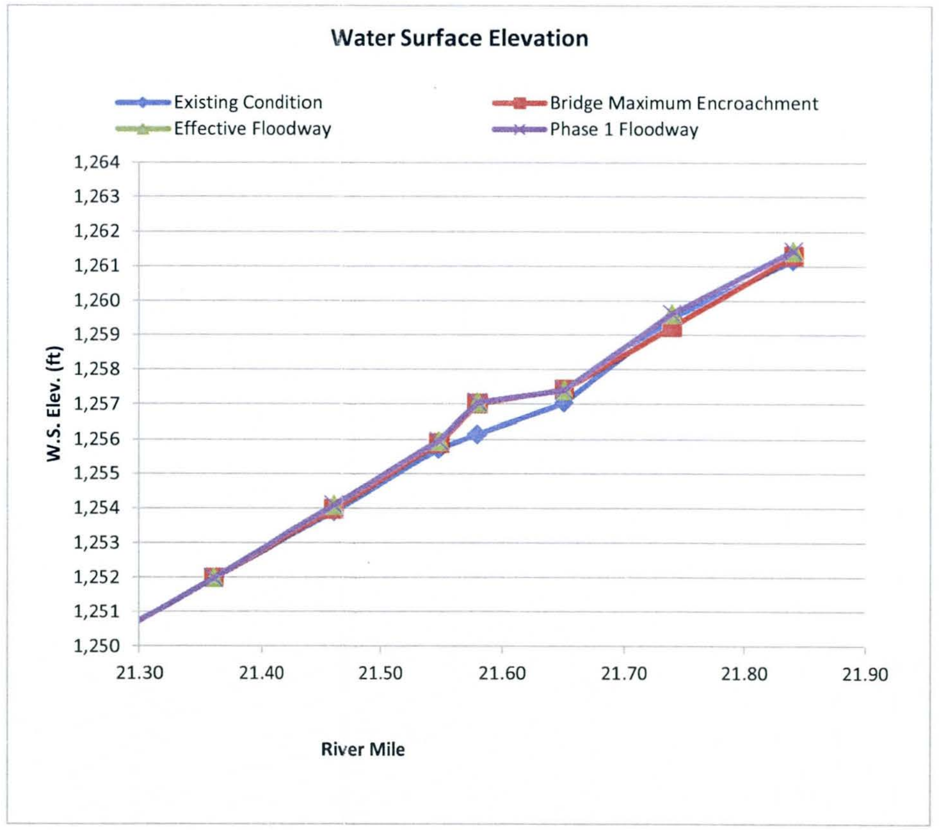


Table 5.67

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Olive Avenue Bridge at RM 19.505

Change in Velocity

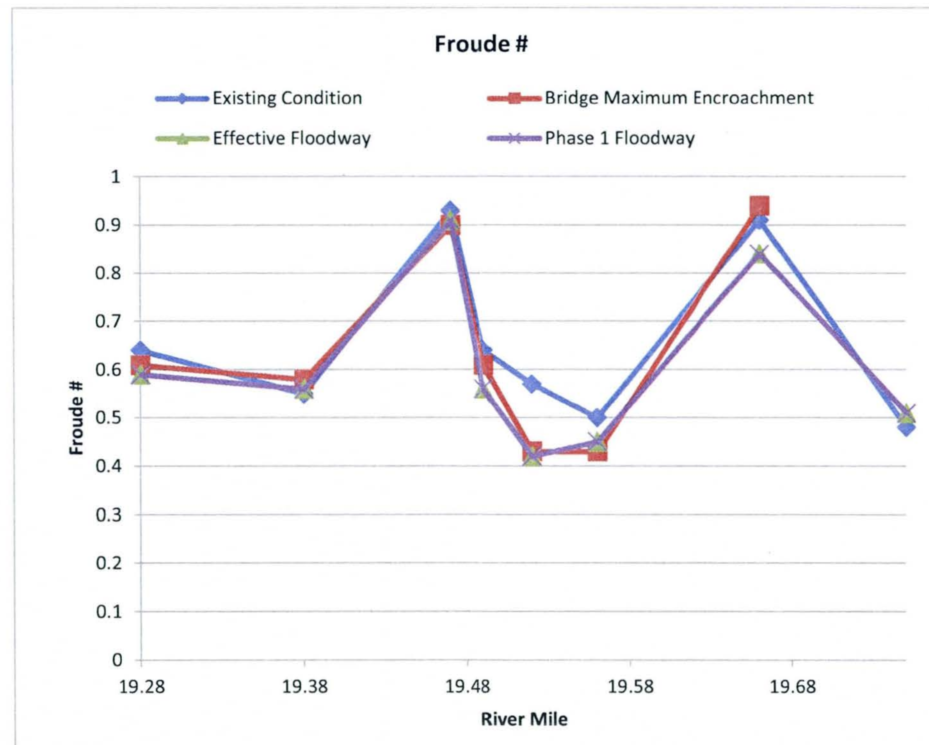
	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %	Velocity fps	Percent Change %
19.28	5.55		5.44	-2.0	5.58	0.5	5.58	0.5
19.38	5.47		5.88	7.5	5.72	4.6	5.72	4.6
19.47	8.07		8.00	-0.9	8.20	1.6	8.20	1.6
19.49	6.16		6.07	-1.5	5.75	-6.7	5.74	-6.8
19.52	5.64		4.69	-16.8	4.60	-18.4	4.60	-18.4
19.56	5.24		4.69	-10.5	5.14	-1.9	5.14	-1.9
19.66	7.90		8.06	2.0	7.52	-4.8	7.52	-4.8
19.75	5.19		5.15	-0.8	5.53	6.6	5.53	6.6

Change in Froude

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %	Froude # unitless	Percent Change %
19.280	0.64		0.61	-4.7	0.59	-7.8	0.59	-7.8
19.380	0.55		0.58	5.5	0.56	1.8	0.56	1.8
19.470	0.93		0.90	-3.2	0.91	-2.2	0.91	-2.2
19.490	0.64		0.61	-4.7	0.56	-12.5	0.56	-12.5
19.520	0.57		0.43	-24.6	0.42	-26.3	0.42	-26.3
19.560	0.50		0.43	-14.0	0.45	-10.0	0.45	-10.0
19.660	0.91		0.94	3.3	0.84	-7.7	0.84	-7.7
19.750	0.48		0.47	-2.1	0.51	6.3	0.51	6.3

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet	W.S.E. feet	Change in W.S.E. feet
19.28	1,207.60	1207.77	0.17	1208.05	0.45	1208.05	0.45
19.38	1,209.63	1209.75	0.12	1209.96	0.33	1209.96	0.33
19.47	1,211.33	1211.56	0.23	1211.61	0.28	1211.61	0.28
19.49	1,212.26	1212.48	0.22	1212.65	0.39	1212.65	0.39
19.52	1,212.80	1213.38	0.58	1213.45	0.65	1213.45	0.65
19.56	1,213.43	1213.76	0.33	1213.78	0.35	1213.78	0.35
19.66	1,214.69	1214.65	-0.04	1214.86	0.17	1214.86	0.17
19.75	1,219.18	1219.20	0.02	1219.21	0.03	1219.21	0.03



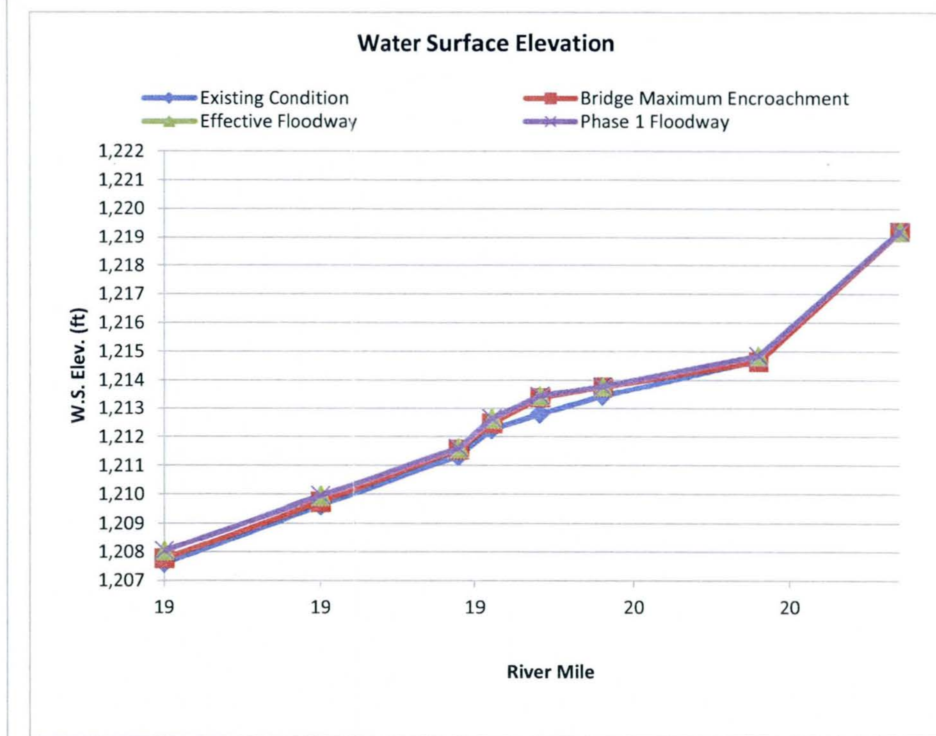


Table 5.68

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Northern Avenue Bridge at RM 17.935

Change in Velocity

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
	fps	%	fps	%	fps	%	fps	%
17.67	7.94		8.36	5.3	8.49	6.9	8.49	6.9
17.77	6.76		6.35	-6.1	6.27	-7.2	6.27	-7.2
17.86	7.04		7.05	0.1	7.16	1.7	7.16	1.7
17.92	6.92		7.21	4.2	7.35	6.2	7.20	4.0
17.95	7.21		5.59	-22.5	5.62	-22.1	5.59	-22.5
18.05	5.72		5.62	-1.7	5.95	4.0	5.97	4.4
18.14	6.81		6.86	0.7	6.56	-3.7	6.55	-3.8
18.24	5.91		5.89	-0.3	6.08	2.9	6.08	2.9

Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
	unitless	%	unitless	%	unitless	%	unitless	%
17.670	0.87		0.92	5.7	0.93	6.9	0.93	6.9
17.770	0.74		0.68	-8.1	0.67	-9.5	0.67	-9.5
17.860	0.76		0.77	1.3	0.78	2.6	0.78	2.6
17.920	0.74		0.78	5.4	0.79	6.8	0.78	5.4
17.950	0.80		0.54	-32.5	0.54	-32.5	0.54	-32.5
18.050	0.59		0.57	-3.4	0.61	3.4	0.61	3.4
18.140	0.83		0.84	1.2	0.79	-4.8	0.79	-4.8
18.240	0.70		0.70	0.0	0.73	4.3	0.73	4.3

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
	feet	feet	feet	feet	feet	feet	feet
17.67	1,170.94	1170.93	-0.01	1170.93	-0.01	1170.93	-0.01
17.77	1,173.50	1173.61	0.11	1173.65	0.15	1173.65	0.15
17.86	1,175.31	1175.26	-0.05	1175.24	-0.07	1175.24	-0.07
17.92	1,176.74	1176.73	-0.01	1176.73	-0.01	1176.73	-0.01
17.95	1,177.27	1178.01	0.74	1178.02	0.75	1178.01	0.74
18.05	1,179.06	1179.10	0.04	1179.11	0.05	1179.10	0.04
18.14	1,180.64	1180.62	-0.02	1180.73	0.09	1180.73	0.09
18.24	1,183.11	1183.12	0.01	1183.07	-0.04	1183.06	-0.05

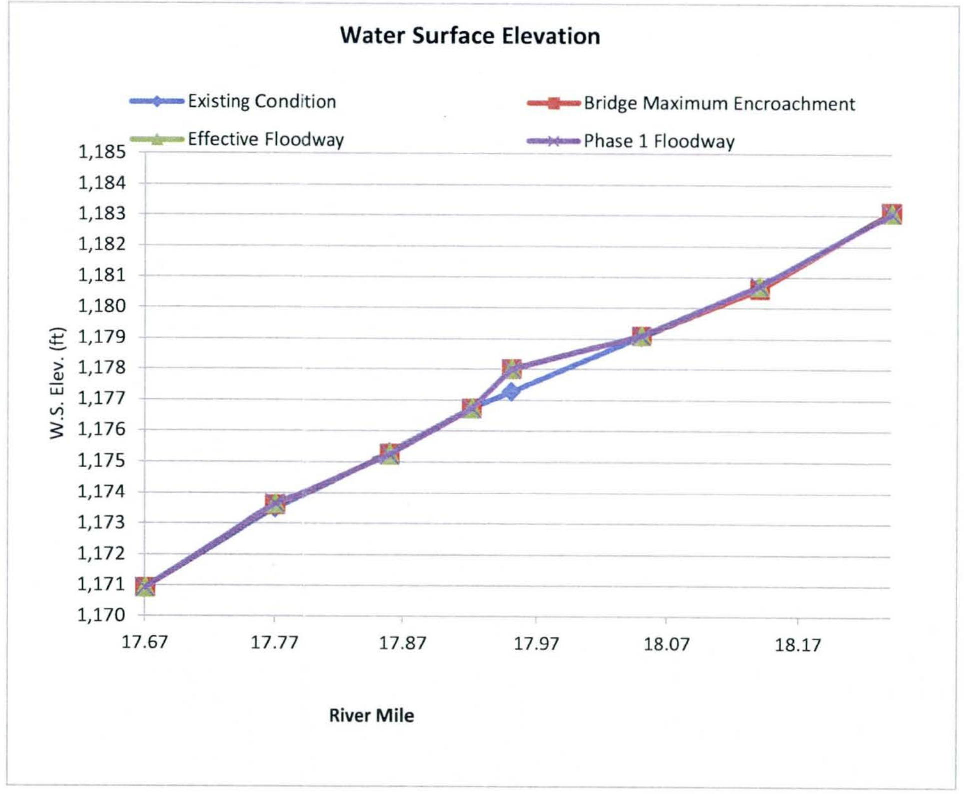


Table 5.69

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Glendale Avenue Bridge at RM 17.155

Change in Velocity

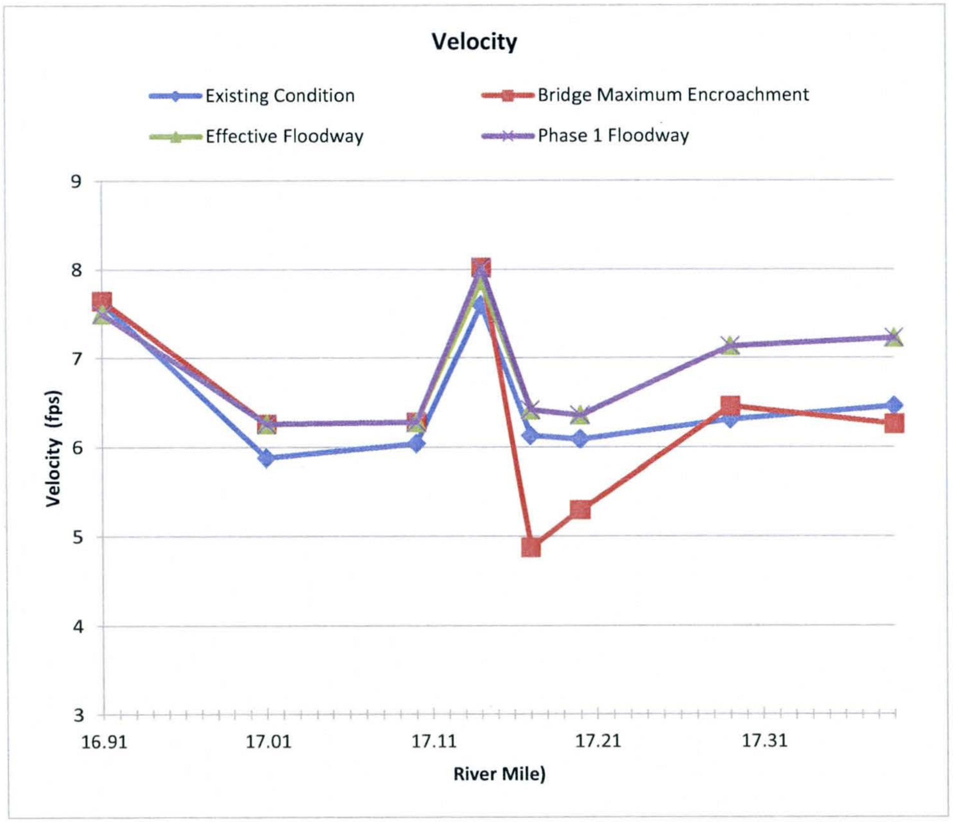
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
16.91	7.62		7.65	0.4	7.50	-1.6	7.50	-1.6
17.01	5.88		6.26	6.5	6.26	6.5	6.26	6.5
17.10	6.04		6.28	4.0	6.28	4.0	6.28	4.0
17.14	7.60		8.02	5.5	7.87	3.6	8.02	5.5
17.17	6.13		4.88	-20.4	6.42	4.7	6.42	4.7
17.20	6.09		5.30	-13.0	6.36	4.4	6.36	4.4
17.29	6.31		6.46	2.4	7.14	13.2	7.14	13.2
17.39	6.46		6.26	-3.1	7.23	11.9	7.23	11.9

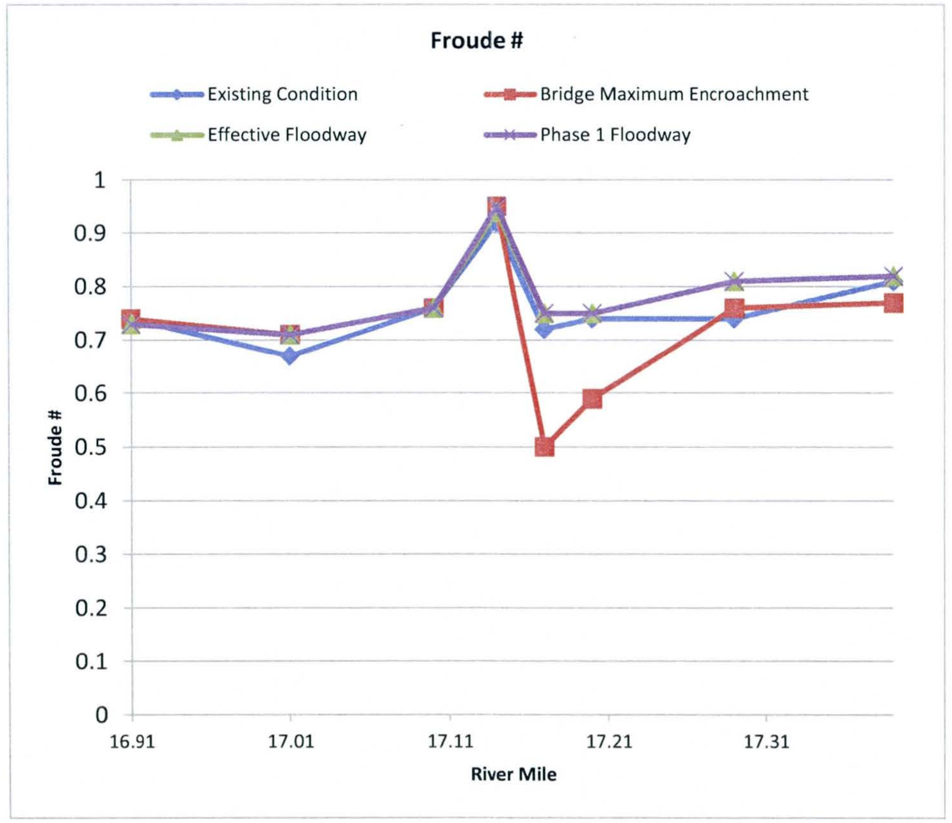
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
16.910	0.74		0.74	0.0	0.73	-1.4	0.73	-1.4
17.010	0.67		0.71	6.0	0.71	6.0	0.71	6.0
17.100	0.76		0.76	0.0	0.76	0.0	0.76	0.0
17.140	0.92		0.95	3.3	0.94	2.2	0.95	3.3
17.170	0.72		0.50	-30.6	0.75	4.2	0.75	4.2
17.200	0.74		0.59	-20.3	0.75	1.4	0.75	1.4
17.290	0.74		0.76	2.7	0.81	9.5	0.81	9.5
17.390	0.81		0.77	-4.9	0.82	1.2	0.82	1.2

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
16.91	1,153.73	1153.73	0.00	1153.81	0.08	1153.81	0.08
17.01	1,155.89	1155.93	0.04	1155.94	0.05	1155.94	0.05
17.10	1,157.86	1158.02	0.16	1158.02	0.16	1158.02	0.16
17.14	1,158.95	1159.02	0.07	1159.06	0.11	1159.02	0.07
17.17	1,160.01	1160.80	0.79	1160.18	0.17	1160.18	0.17
17.20	1,160.51	1161.03	0.52	1160.71	0.20	1160.71	0.20
17.29	1,162.34	1162.35	0.01	1162.57	0.23	1162.57	0.23
17.39	1,164.53	1164.57	0.04	1164.96	0.43	1164.96	0.43





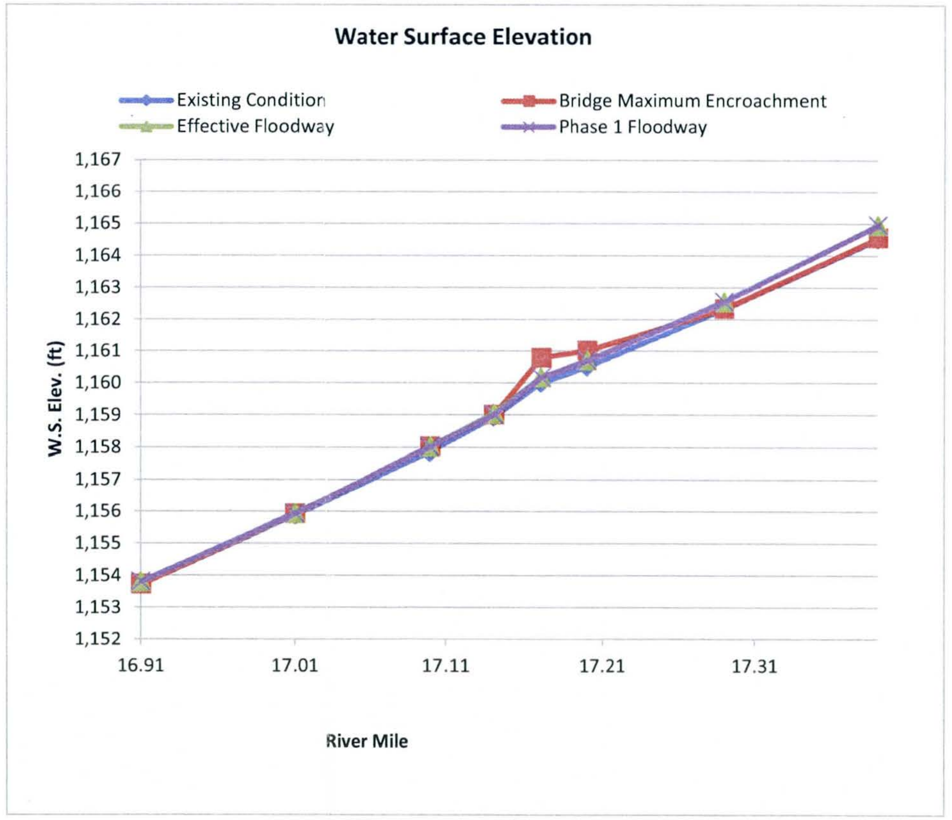


Table 5.70
Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event
Camelback Road Bridge at RM 14.405

Change in Velocity

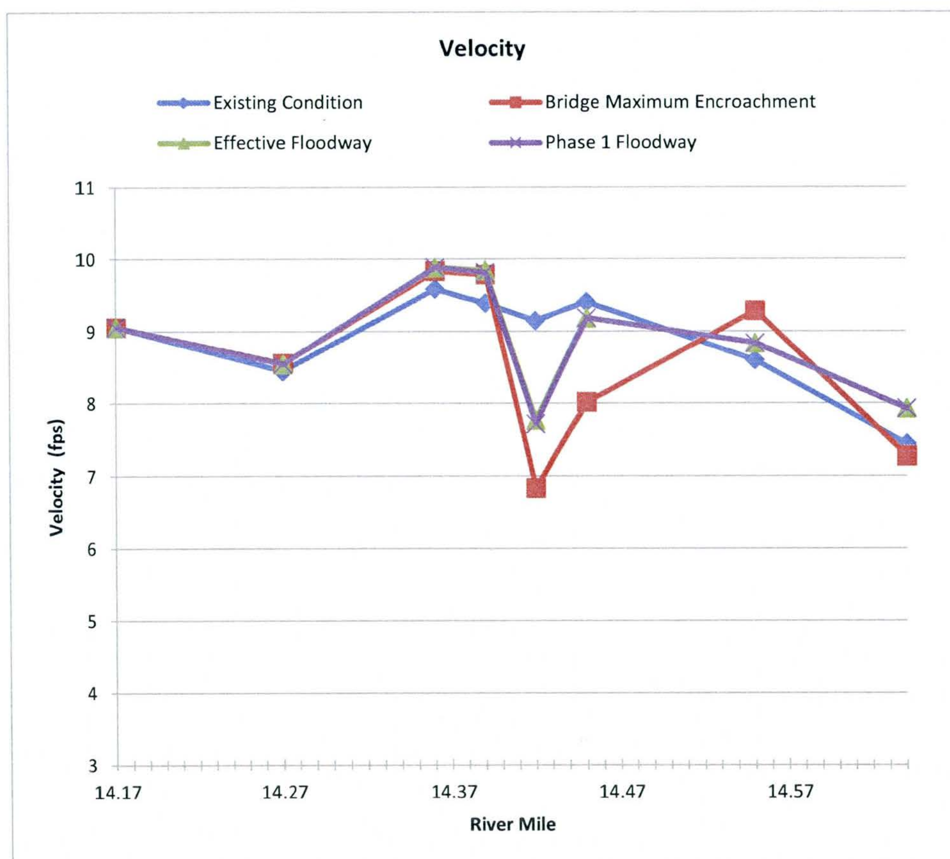
RM	Existing Condition Velocity fps	Existing Condition Percent Change %	Bridge Maximum Encroachment Velocity fps	Bridge Maximum Encroachment Percent Change %	Effective Floodway Velocity fps	Effective Floodway Percent Change %	Phase 1 Floodway Velocity fps	Phase 1 Floodway Percent Change %
14.17	9.06		9.06	0.0	9.06	0.0	9.06	0.0
14.27	8.45		8.56	1.3	8.55	1.2	8.55	1.2
14.36	9.59		9.84	2.6	9.89	3.1	9.89	3.1
14.39	9.39		9.79	4.3	9.85	4.9	9.82	4.6
14.42	9.15		6.84	-25.2	7.77	-15.1	7.72	-15.6
14.45	9.41		8.02	-14.8	9.19	-2.3	9.19	-2.3
14.55	8.60		9.29	8.0	8.84	2.8	8.84	2.8
14.64	7.44		7.28	-2.2	7.93	6.6	7.93	6.6

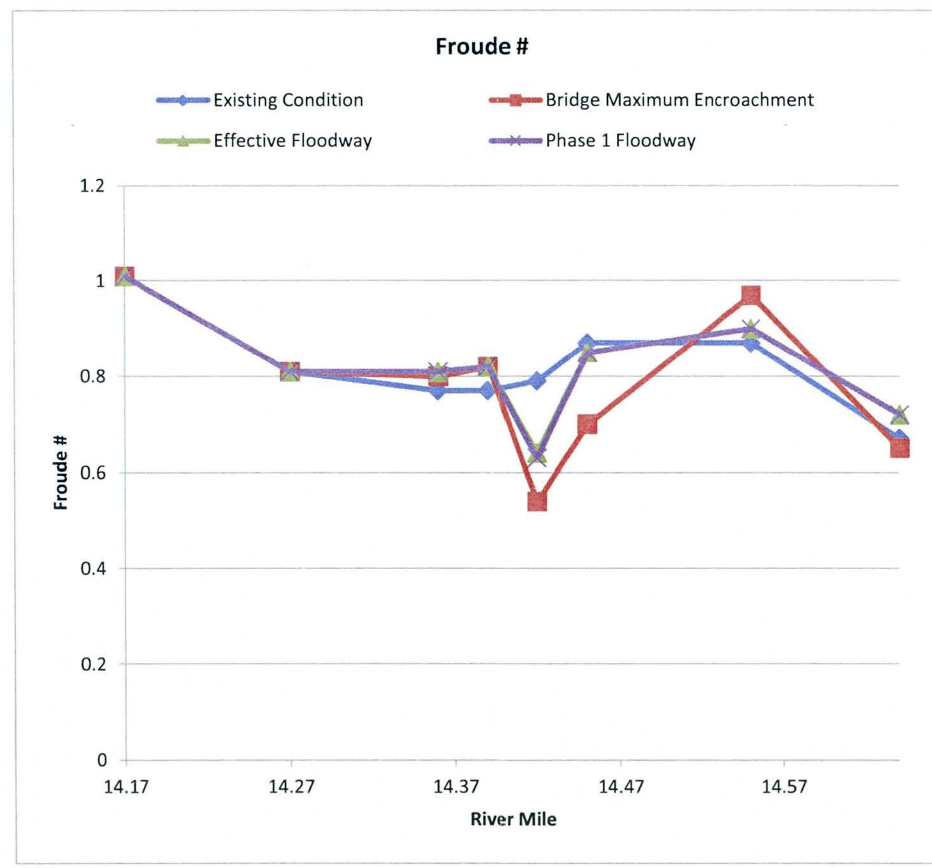
Change in Froude #

RM	Existing Condition Froude # unitless	Existing Condition Percent Change %	Bridge Maximum Encroachment Froude # unitless	Bridge Maximum Encroachment Percent Change %	Effective Floodway Froude # unitless	Effective Floodway Percent Change %	Phase 1 Floodway Froude # unitless	Phase 1 Floodway Percent Change %
14.170	1.01		1.01	0.0	1.01	0.0	1.01	0.0
14.270	0.81		0.81	0.0	0.81	0.0	0.81	0.0
14.360	0.77		0.80	3.9	0.81	5.2	0.81	5.2
14.390	0.77		0.82	6.5	0.82	6.5	0.82	6.5
14.420	0.79		0.54	-31.6	0.64	-19.0	0.63	-20.3
14.450	0.87		0.70	-19.5	0.85	-2.3	0.85	-2.3
14.550	0.87		0.97	11.5	0.90	3.4	0.90	3.4
14.640	0.67		0.65	-3.0	0.72	7.5	0.72	7.5

Change in Water Surface Elevation

RM	Existing Condition W.S.E. feet	Bridge Maximum Encroachment W.S.E. feet	Bridge Maximum Encroachment Change in W.S.E. feet	Effective Floodway W.S.E. feet	Effective Floodway Change in W.S.E. feet	Phase 1 Floodway W.S.E. feet	Phase 1 Floodway Change in W.S.E. feet
14.17	1,098.00	1098.00	0.00	1098.00	0.00	1098.00	0.00
14.27	1,100.59	1100.56	-0.03	1100.56	-0.03	1100.56	-0.03
14.36	1,103.64	1103.56	-0.08	1103.55	-0.09	1103.55	-0.09
14.39	1,104.20	1104.09	-0.11	1104.07	-0.13	1104.08	-0.12
14.42	1,104.79	1105.70	0.91	1105.31	0.52	1105.32	0.53
14.45	1,105.42	1105.88	0.46	1105.48	0.06	1105.48	0.06
14.55	1,107.34	1107.11	-0.23	1107.26	-0.08	1107.26	-0.08
14.64	1,109.11	1109.20	0.09	1109.08	-0.03	1109.08	-0.03





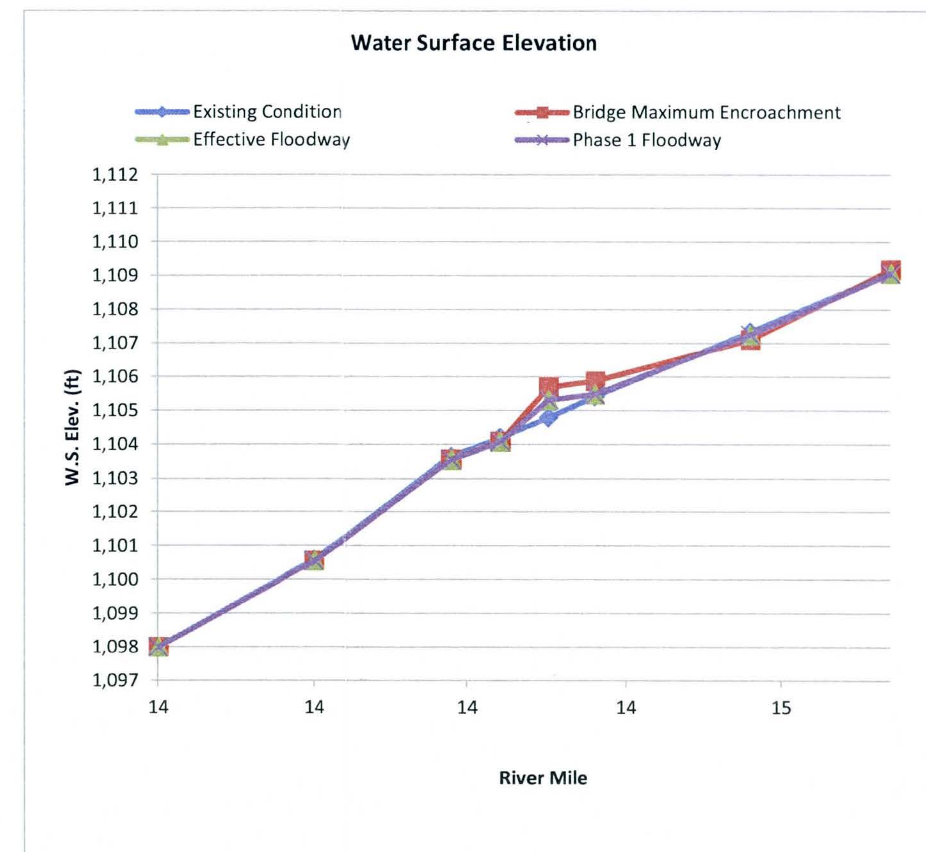


Table 5.71

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Indian School Road Bridge at RM 13.875

Change in Velocity

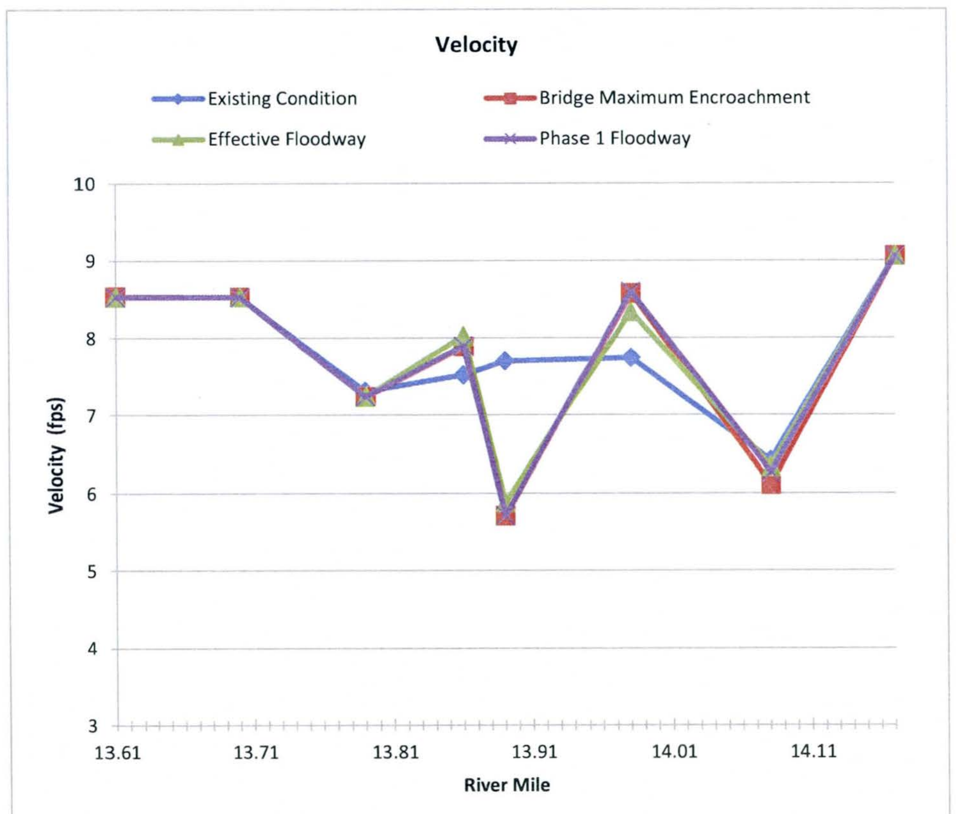
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
13.61	8.54		8.54	0.0	8.53	-0.1	8.53	-0.1
13.70	8.53		8.53	0.0	8.53	0.0	8.53	0.0
13.79	7.31		7.24	-1.0	7.24	-1.0	7.24	-1.0
13.86	7.52		7.89	4.9	8.03	6.8	7.90	5.1
13.89	7.70		5.71	-25.8	5.88	-23.6	5.71	-25.8
13.98	7.74		8.58	10.9	8.34	7.8	8.60	11.1
14.08	6.42		6.11	-4.8	6.34	-1.2	6.27	-2.3
14.17	9.06		9.06	0.0	9.06	0.0	9.06	0.0

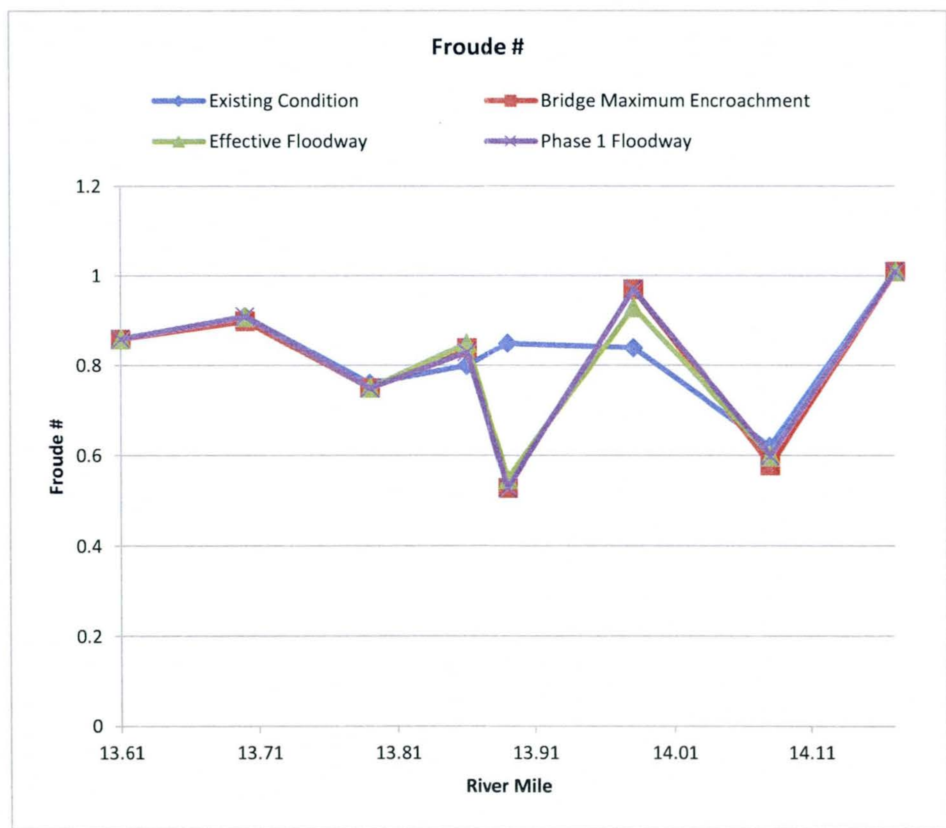
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
13.610	0.86		0.86	0.0	0.86	0.0	0.86	0.0
13.700	0.91		0.90	-1.1	0.91	0.0	0.91	0.0
13.790	0.76		0.75	-1.3	0.75	-1.3	0.75	-1.3
13.860	0.80		0.84	5.0	0.85	6.3	0.83	3.7
13.890	0.85		0.53	-37.6	0.55	-35.3	0.53	-37.6
13.980	0.84		0.97	15.5	0.93	10.7	0.97	15.5
14.080	0.62		0.58	-6.5	0.60	-3.2	0.60	-3.2
14.170	1.01		1.01	0.0	1.01	0.0	1.01	0.0

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
13.61	1,082.18	1082.18	0.00	1082.18	0.00	1082.18	0.00
13.70	1,085.21	1085.21	0.00	1085.21	0.00	1085.21	0.00
13.79	1,088.57	1088.60	0.03	1088.60	0.03	1088.60	0.03
13.86	1,090.25	1090.28	0.03	1090.30	0.05	1090.28	0.03
13.89	1,090.83	1092.07	1.24	1092.04	1.21	1092.07	1.24
13.98	1,093.69	1093.45	-0.24	1093.52	-0.17	1093.45	-0.24
14.08	1,096.66	1096.79	0.13	1096.77	0.11	1096.81	0.15
14.17	1,098.00	1098.00	0.00	1098.00	0.00	1098.00	0.00





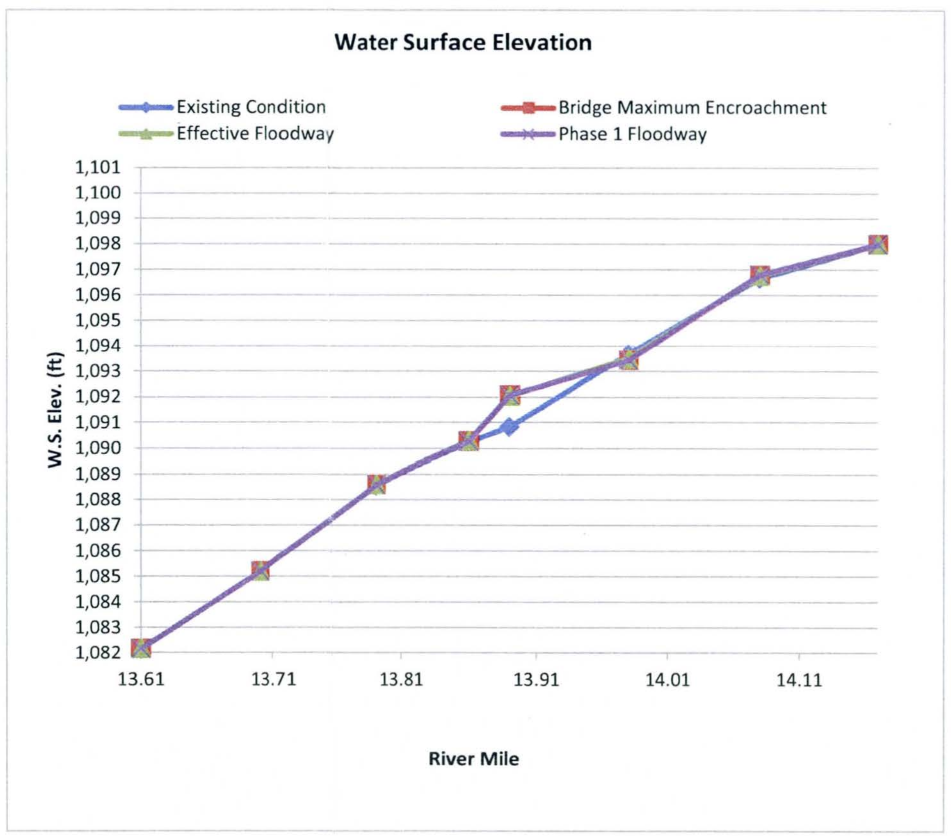


Table 5.72

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

McDowell Parkway Bridge at RM 13.035

Change in Velocity

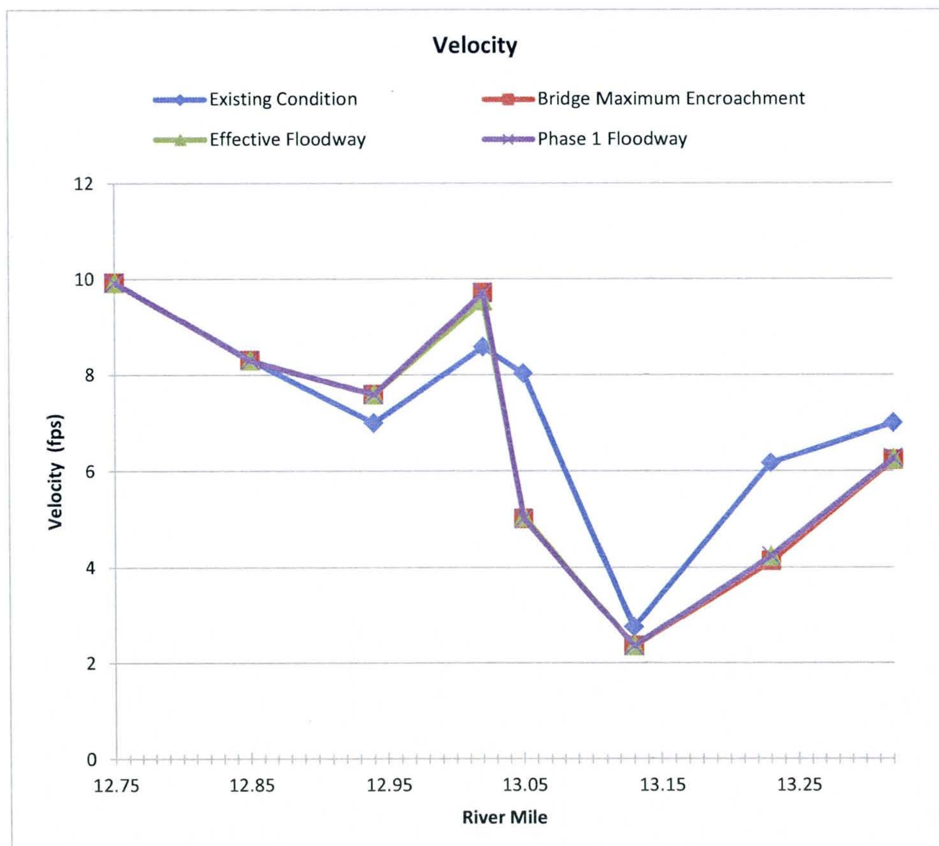
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
12.75	9.93		9.93	0.0	9.93	0.0	9.93	0.0
12.85	8.31		8.30	-0.1	8.30	-0.1	8.30	-0.1
12.94	7.00		7.59	8.4	7.59	8.4	7.59	8.4
13.02	8.58		9.72	13.3	9.55	11.3	9.72	13.3
13.05	8.03		5.01	-37.6	5.05	-37.1	5.01	-37.6
13.13	2.75		2.36	-14.2	2.36	-14.2	2.36	-14.2
13.23	6.18		4.13	-33.2	4.24	-31.4	4.24	-31.4
13.32	7.00		6.24	-10.9	6.27	-10.4	6.28	-10.3

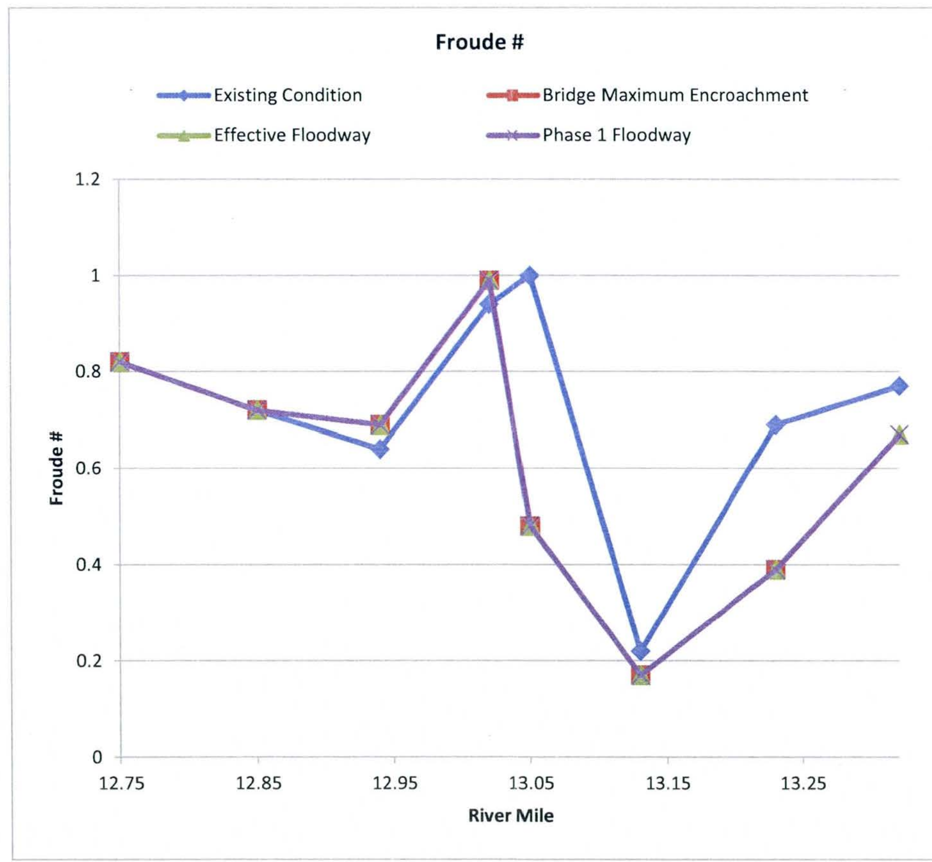
Change in Froude #

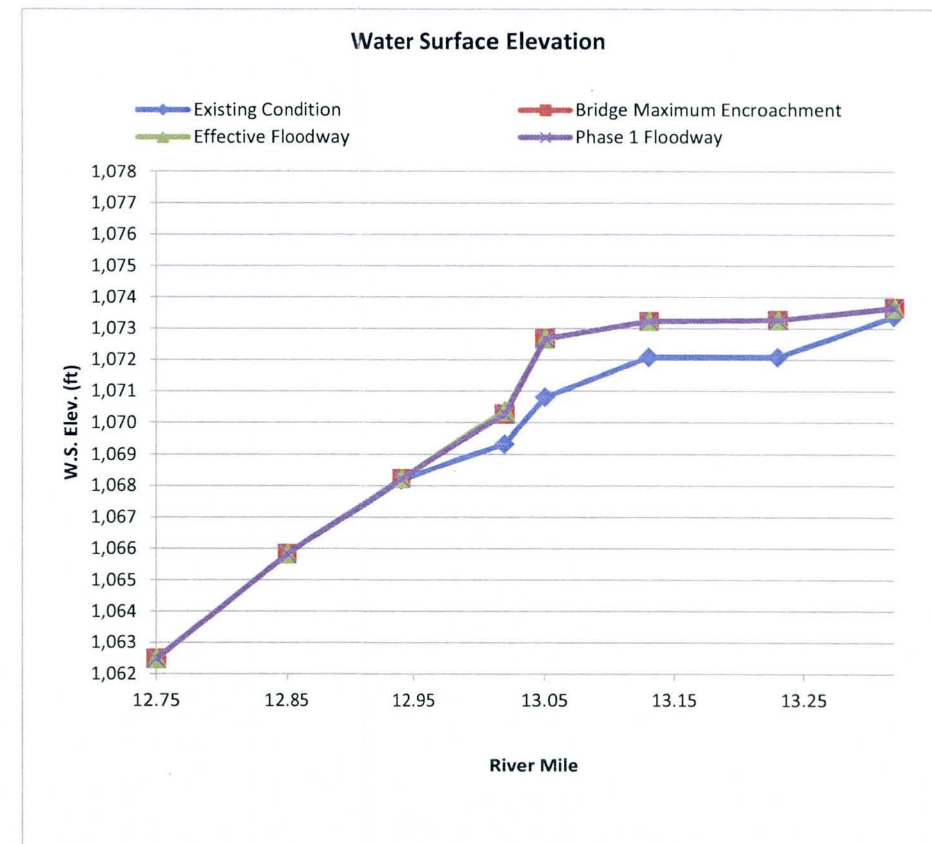
RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
12.750	0.82		0.82	0.0	0.82	0.0	0.82	0.0
12.850	0.72		0.72	0.0	0.72	0.0	0.72	0.0
12.940	0.64		0.69	7.8	0.69	7.8	0.69	7.8
13.020	0.94		0.99	5.3	0.99	5.3	0.99	5.3
13.050	1.00		0.48	-52.0	0.48	-52.0	0.48	-52.0
13.130	0.22		0.17	-22.7	0.17	-22.7	0.17	-22.7
13.230	0.69		0.39	-43.5	0.39	-43.5	0.39	-43.5
13.320	0.77		0.68	-11.7	0.67	-13.0	0.67	-13.0

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
12.75	1,062.49	1062.49	0.00	1062.49	0.00	1062.49	0.00
12.85	1,065.83	1065.83	0.00	1065.83	0.00	1065.83	0.00
12.94	1,068.18	1068.23	0.05	1068.23	0.05	1068.23	0.05
13.02	1,069.34	1070.27	0.93	1070.37	1.03	1070.27	0.93
13.05	1,070.81	1072.68	1.87	1072.67	1.86	1072.68	1.87
13.13	1,072.09	1073.23	1.14	1073.24	1.15	1073.23	1.14
13.23	1,072.09	1073.28	1.19	1073.27	1.18	1073.27	1.18
13.32	1,073.38	1073.68	0.30	1073.67	0.29	1073.67	0.29







[1] No bridge encroachment, plots on graphs at zero bridge width opening, along y-axis

Table 5.73

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Yuma Parkway Bridge at RM 9.78

Change in Velocity

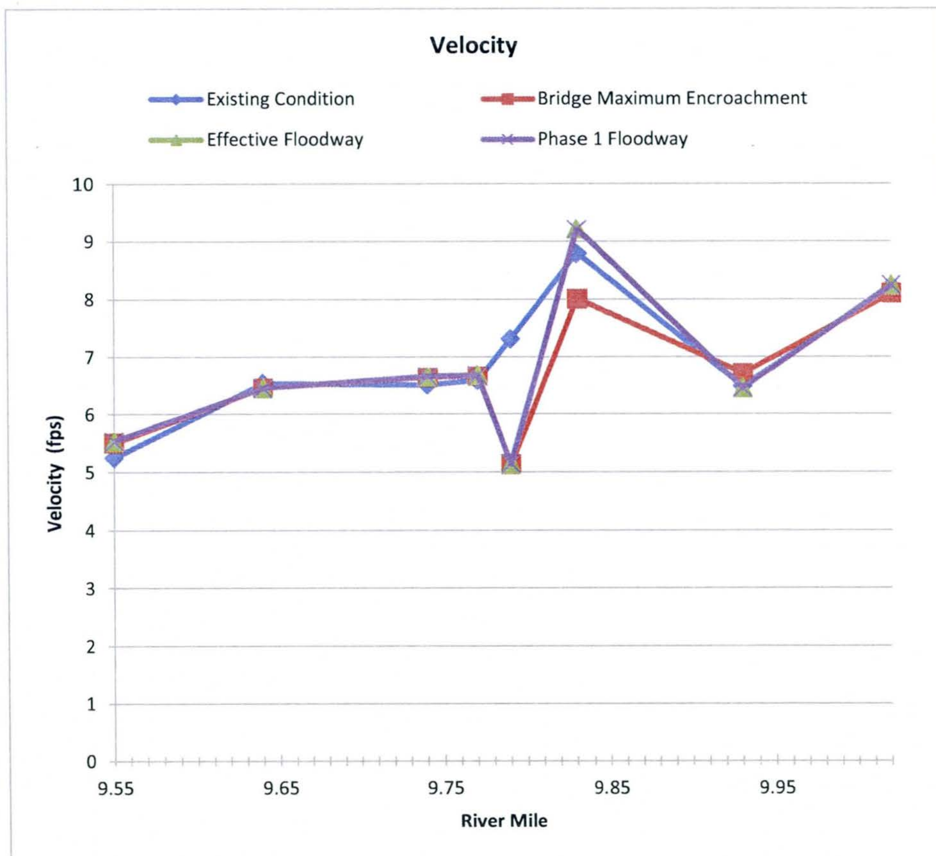
RM	Existing Condition Velocity fps	Existing Condition Percent Change %	Bridge Maximum Encroachment Velocity fps	Bridge Maximum Encroachment Percent Change %	Effective Floodway Velocity fps	Effective Floodway Percent Change %	Phase 1 Floodway Velocity fps	Phase 1 Floodway Percent Change %
9.55	5.25		5.51	5.0	5.54	5.5	5.54	5.5
9.64	6.54		6.46	-1.2	6.46	-1.2	6.46	-1.2
9.74	6.51		6.65	2.2	6.66	2.3	6.66	2.3
9.77	6.59		6.67	1.2	6.69	1.5	6.68	1.4
9.79	7.31		5.14	-29.7	5.15	-29.5	5.15	-29.5
9.83	8.79		8.01	-8.9	9.22	4.9	9.21	4.8
9.93	6.49		6.72	3.5	6.46	-0.5	6.46	-0.5
10.02	8.22		8.10	-1.5	8.25	0.4	8.24	0.2

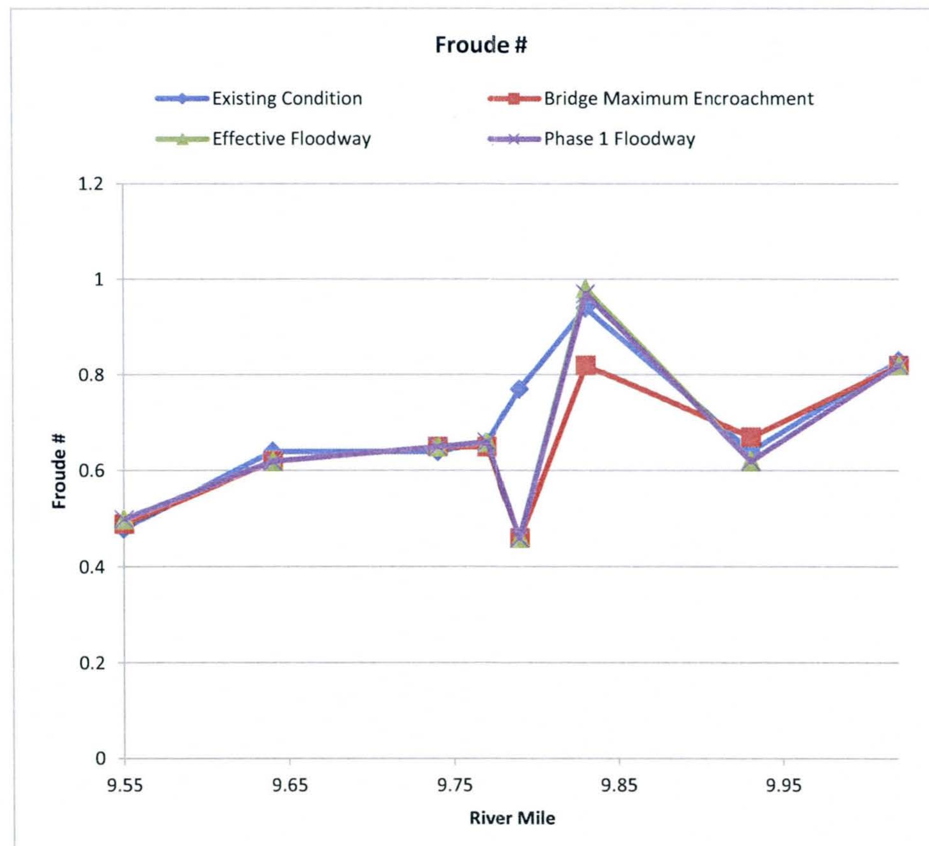
Change in Froude #

RM	Existing Condition Froude # unitless	Existing Condition Percent Change %	Bridge Maximum Encroachment Froude # unitless	Bridge Maximum Encroachment Percent Change %	Effective Floodway Froude # unitless	Effective Floodway Percent Change %	Phase 1 Floodway Froude # unitless	Phase 1 Floodway Percent Change %
9.550	0.48		0.49	2.1	0.50	4.2	0.50	4.2
9.640	0.64		0.62	-3.1	0.62	-3.1	0.62	-3.1
9.740	0.64		0.65	1.6	0.65	1.6	0.65	1.6
9.770	0.66		0.65	-1.5	0.66	0.0	0.66	0.0
9.790	0.77		0.46	-40.3	0.46	-40.3	0.46	-40.3
9.830	0.94		0.82	-12.8	0.98	4.3	0.97	3.2
9.930	0.64		0.67	4.7	0.62	-3.1	0.62	-3.1
10.020	0.83		0.82	-1.2	0.82	-1.2	0.82	-1.2

Change in Water Surface Elevation

RM	Existing Condition W.S.E. feet	Bridge Maximum Encroachment W.S.E. feet	Bridge Maximum Encroachment Change in W.S.E. feet	Effective Floodway W.S.E. feet	Effective Floodway Change in W.S.E. feet	Phase 1 Floodway W.S.E. feet	Phase 1 Floodway Change in W.S.E. feet
9.55	992.45	992.53	0.08	992.52	0.07	992.52	0.07
9.64	993.86	994.01	0.15	994.01	0.15	994.01	0.15
9.74	995.86	995.92	0.06	995.92	0.06	995.92	0.06
9.77	996.39	996.47	0.08	996.47	0.08	996.47	0.08
9.79	996.99	998.13	1.14	998.12	1.13	998.12	1.13
9.83	998.23	998.52	0.29	998.28	0.05	998.29	0.06
9.93	1,000.93	1000.85	-0.08	1001.17	0.24	1001.16	0.23
10.02	1,002.97	1003.00	0.03	1003.11	0.14	1003.11	0.14





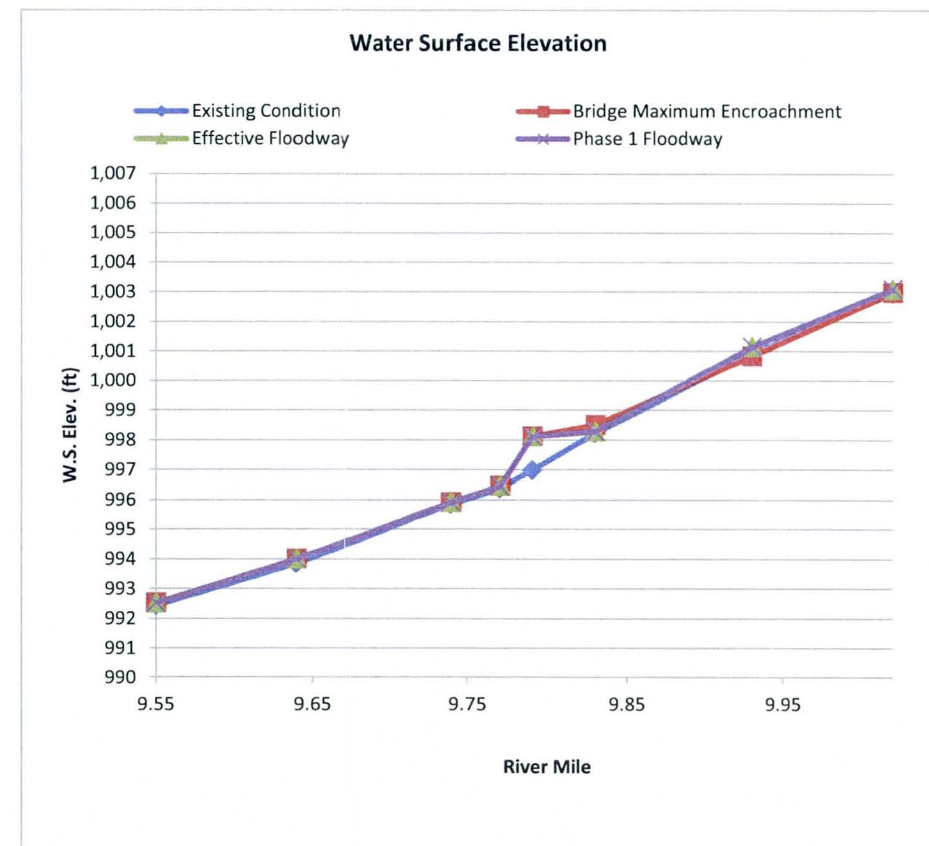


Table 5.74

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Broadway Road Bridge at RM 7.295

Change in Velocity

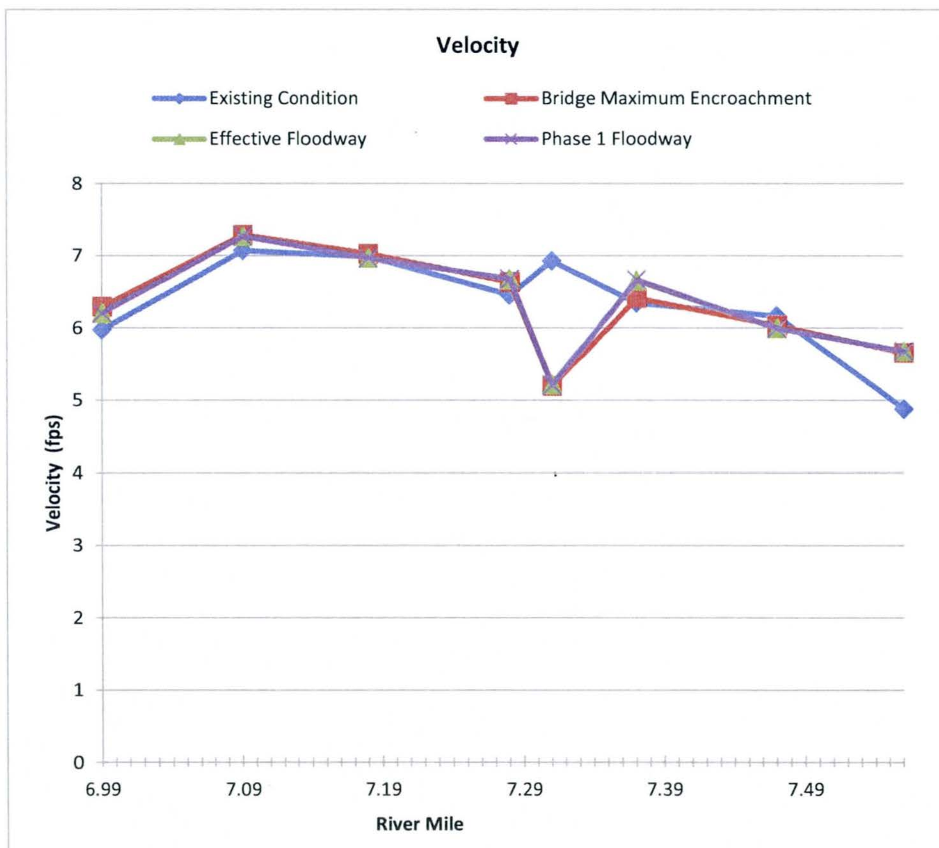
	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change	Velocity	Percent Change
	fps	%	fps	%	fps	%	fps	%
6.99	5.98		6.30	5.4	6.21	3.8	6.21	3.8
7.09	7.07		7.29	3.1	7.27	2.8	7.27	2.8
7.18	6.99		7.03	0.6	6.97	-0.3	6.97	-0.3
7.28	6.46		6.64	2.8	6.68	3.4	6.68	3.4
7.31	6.93		5.20	-25.0	5.22	-24.7	5.21	-24.8
7.37	6.35		6.42	1.1	6.66	4.9	6.67	5.0
7.47	6.17		6.04	-2.1	6.00	-2.8	6.00	-2.8
7.56	4.88		5.66	16.0	5.68	16.4	5.68	16.4

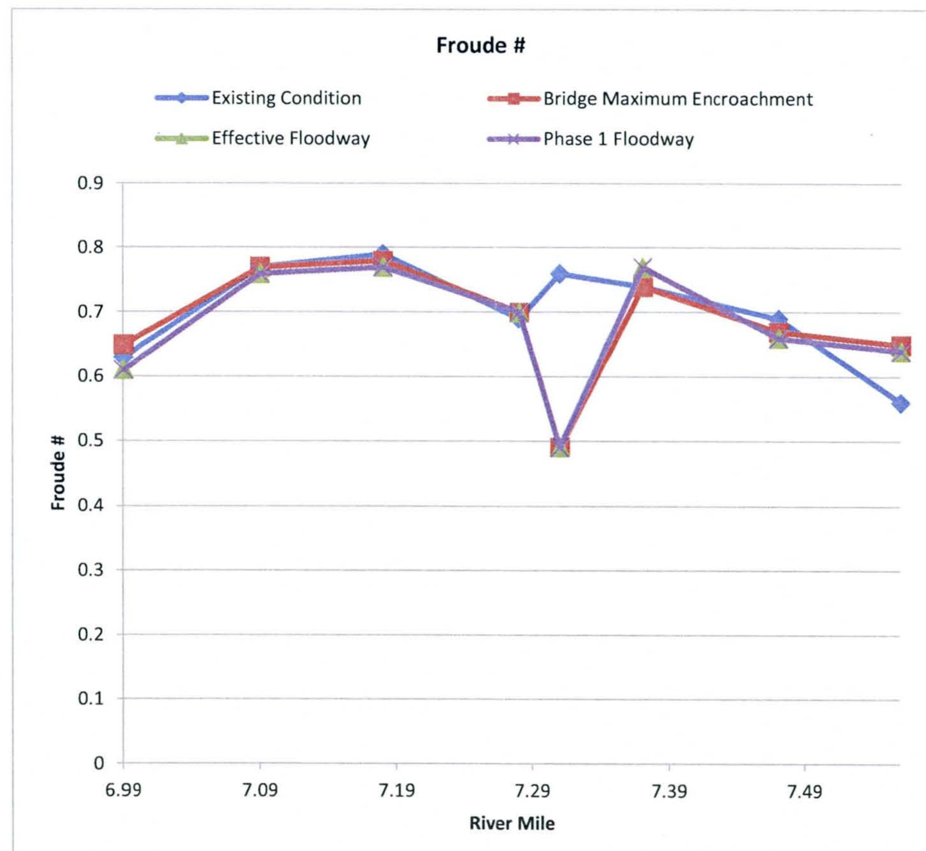
Change in Froude #

	Existing Condition		Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change	Froude #	Percent Change
	unitless	%	unitless	%	unitless	%	unitless	%
6.990	0.63		0.65	3.2	0.61	-3.2	0.61	-3.2
7.090	0.77		0.77	0.0	0.76	-1.3	0.76	-1.3
7.180	0.79		0.78	-1.3	0.77	-2.5	0.77	-2.5
7.280	0.69		0.70	1.4	0.70	1.4	0.70	1.4
7.310	0.76		0.49	-35.5	0.49	-35.5	0.49	-35.5
7.370	0.74		0.74	0.0	0.77	4.1	0.77	4.1
7.470	0.69		0.67	-2.9	0.66	-4.3	0.66	-4.3
7.560	0.56		0.65	16.1	0.64	14.3	0.64	14.3

Change in Water Surface Elevation

	Existing Condition	Bridge Maximum Encroachment		Effective Floodway		Phase 1 Floodway	
RM	W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.	W.S.E.	Change in W.S.E.
	feet	feet	feet	feet	feet	feet	feet
6.99	935.17	935.34	0.17	935.63	0.46	935.63	0.46
7.09	937.19	937.36	0.17	937.43	0.24	937.43	0.24
7.18	939.61	939.75	0.14	939.77	0.16	939.77	0.16
7.28	941.80	941.90	0.10	941.89	0.09	941.89	0.09
7.31	942.30	943.25	0.95	943.24	0.94	943.24	0.94
7.37	944.08	944.11	0.03	944.11	0.03	944.11	0.03
7.47	945.95	945.99	0.04	946.08	0.13	946.08	0.13
7.56	947.73	947.78	0.05	947.80	0.07	947.80	0.07





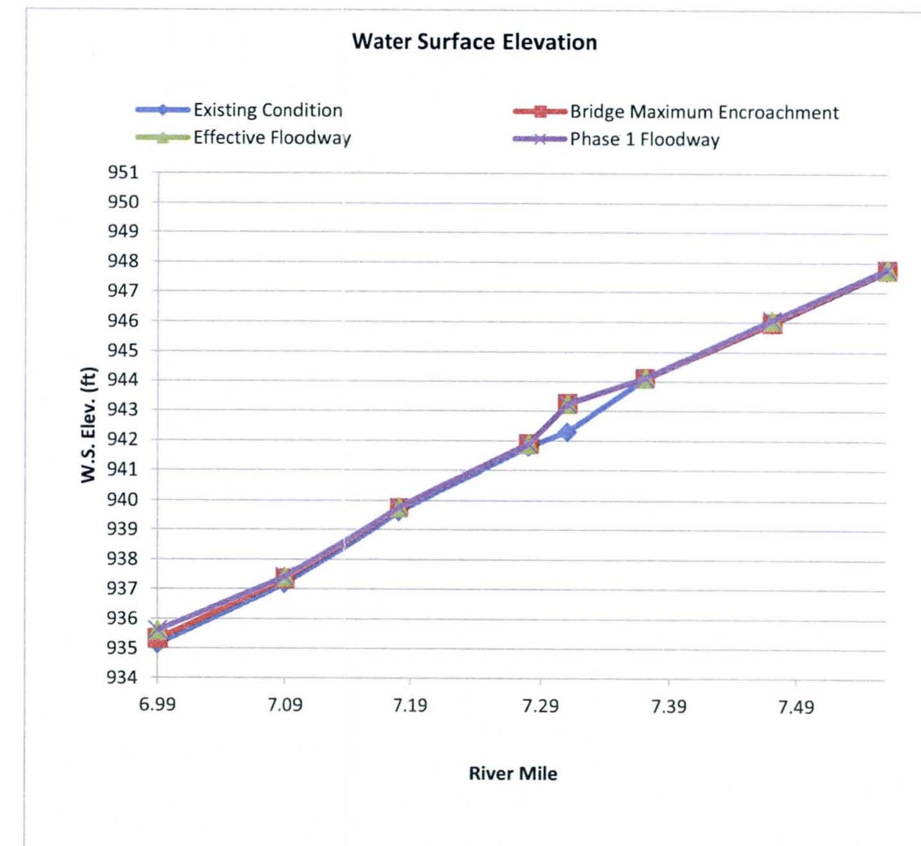


Table 5.75

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Southern Avenue Bridge at RM 5.96

Change in Velocity

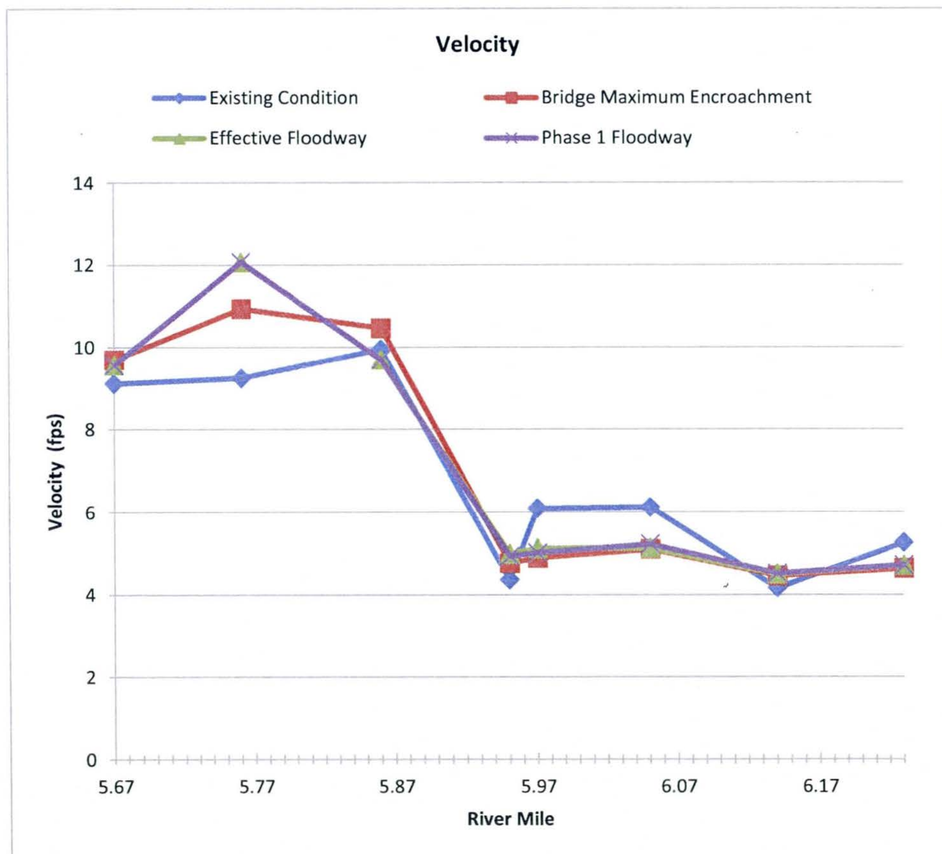
RM	Existing Condition Velocity (fps)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
5.67	9.12		9.70	6.4	9.57	4.9	9.57	4.9
5.76	9.25		10.94	18.3	12.07	30.5	12.07	30.5
5.86	9.95		10.47	5.2	9.70	-2.5	9.70	-2.5
5.95	4.37		4.77	9.2	5.00	14.4	4.94	13.0
5.97	6.10		4.90	-19.7	5.13	-15.9	5.02	-17.7
6.05	6.13		5.11	-16.6	5.14	-16.2	5.23	-14.7
6.14	4.17		4.47	7.2	4.51	8.2	4.52	8.4
6.23	5.27		4.64	-12.0	4.72	-10.4	4.72	-10.4

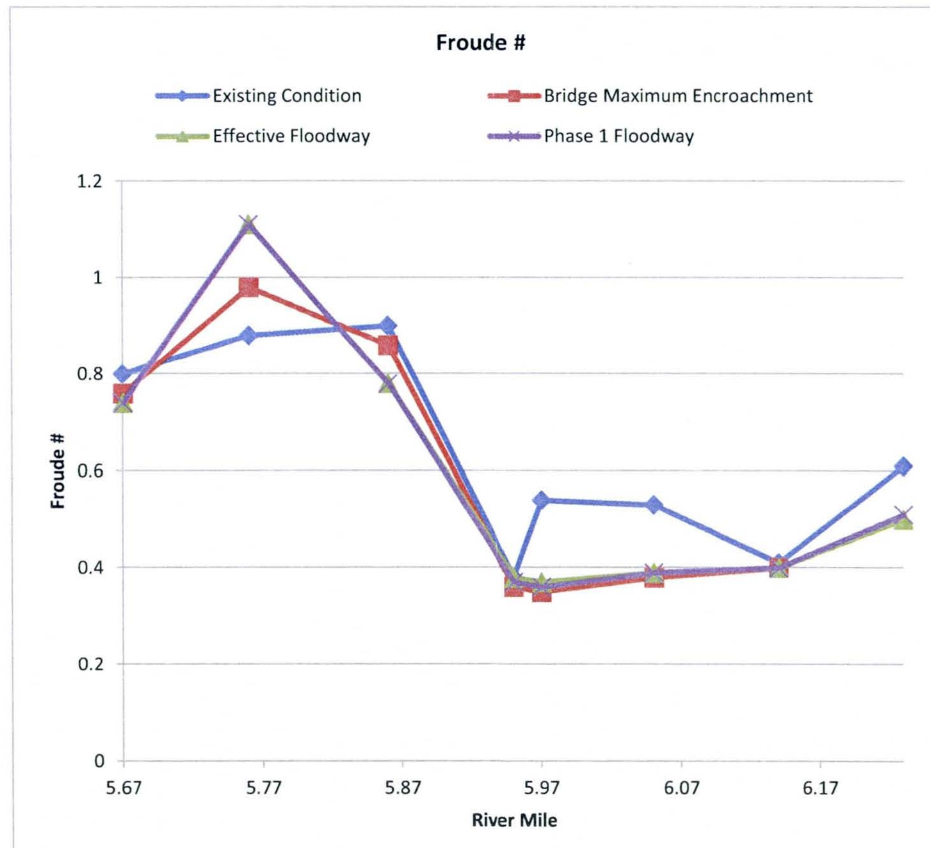
Change in Froude #

RM	Existing Condition Froude # (unitless)	Existing Condition Percent Change (%)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
5.670	0.80		0.76	-5.0	0.74	-7.5	0.74	-7.5
5.760	0.88		0.98	11.4	1.11	26.1	1.11	26.1
5.860	0.90		0.86	-4.4	0.78	-13.3	0.78	-13.3
5.950	0.38		0.36	-5.3	0.38	0.0	0.37	-2.6
5.970	0.54		0.35	-35.2	0.37	-31.5	0.36	-33.3
6.050	0.53		0.38	-28.3	0.39	-26.4	0.39	-26.4
6.140	0.41		0.40	-2.4	0.40	-2.4	0.40	-2.4
6.230	0.61		0.50	-18.0	0.50	-18.0	0.51	-16.4

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
5.67	905.59	906.71	1.12	906.77	1.18	906.77	1.18
5.76	907.93	908.51	0.58	908.17	0.24	908.17	0.24
5.86	910.22	911.14	0.92	911.41	1.19	911.41	1.19
5.95	912.76	914.20	1.44	914.10	1.34	914.09	1.33
5.97	913.05	915.17	2.12	915.10	2.05	915.09	2.04
6.05	914.26	915.69	1.43	915.69	1.43	915.64	1.38
6.14	916.18	916.88	0.70	916.90	0.72	916.89	0.71
6.23	917.46	917.90	0.44	917.95	0.49	917.95	0.49





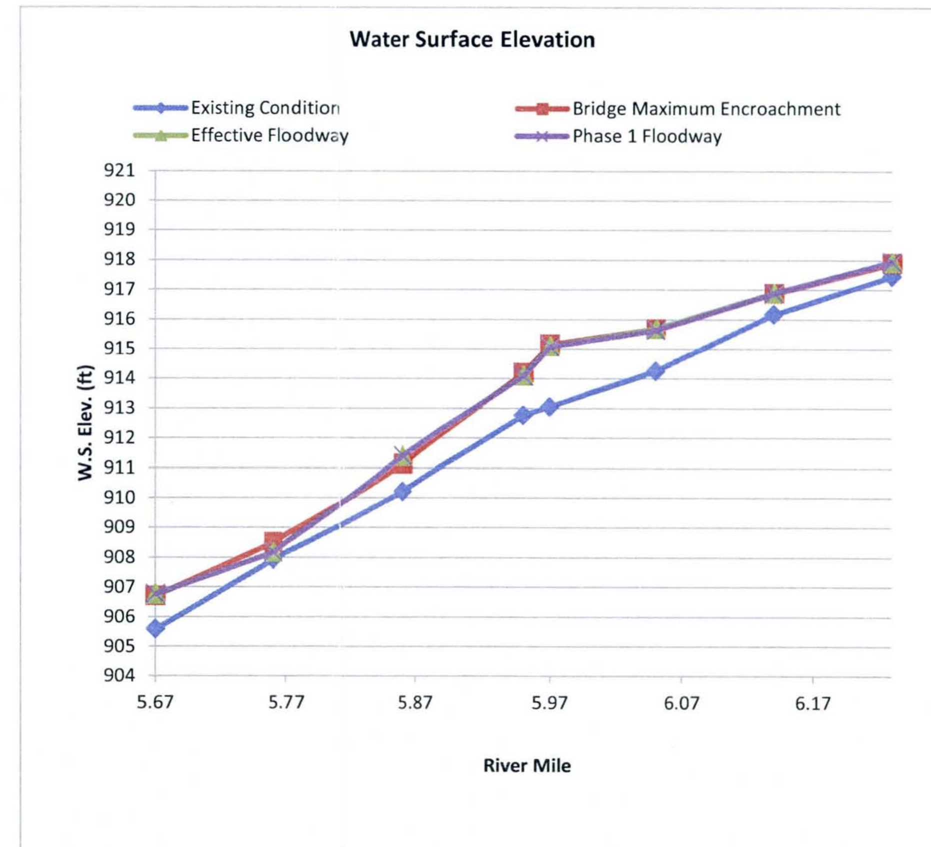


Table 5.76

Summary of Hydraulic Parameters for Bridge and Floodway Encroachments, 10-Year Event

Baseline Road Bridge at RM 4.945

Change in Velocity

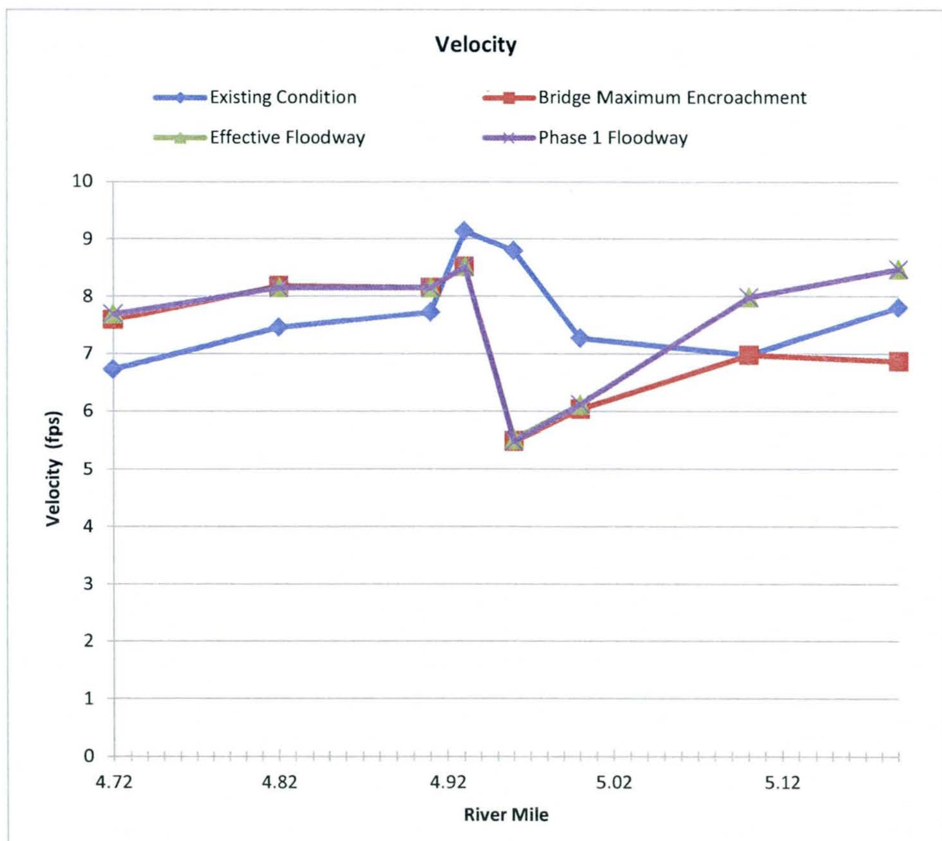
RM	Existing Condition Velocity (fps)	Bridge Maximum Encroachment Velocity (fps)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Velocity (fps)	Effective Floodway Percent Change (%)	Phase 1 Floodway Velocity (fps)	Phase 1 Floodway Percent Change (%)
4.72	6.73	7.60	12.9	7.70	14.4	7.70	14.4
4.82	7.46	8.19	9.8	8.16	9.4	8.16	9.4
4.91	7.73	8.16	5.6	8.16	5.6	8.16	5.6
4.93	9.14	8.52	-6.8	8.52	-6.8	8.52	-6.8
4.96	8.80	5.49	-37.6	5.52	-37.3	5.49	-37.6
5.00	7.27	6.04	-16.9	6.12	-15.8	6.12	-15.8
5.10	6.98	6.98	0.0	7.99	14.5	7.99	14.5
5.19	7.81	6.87	-12.0	8.48	8.6	8.48	8.6

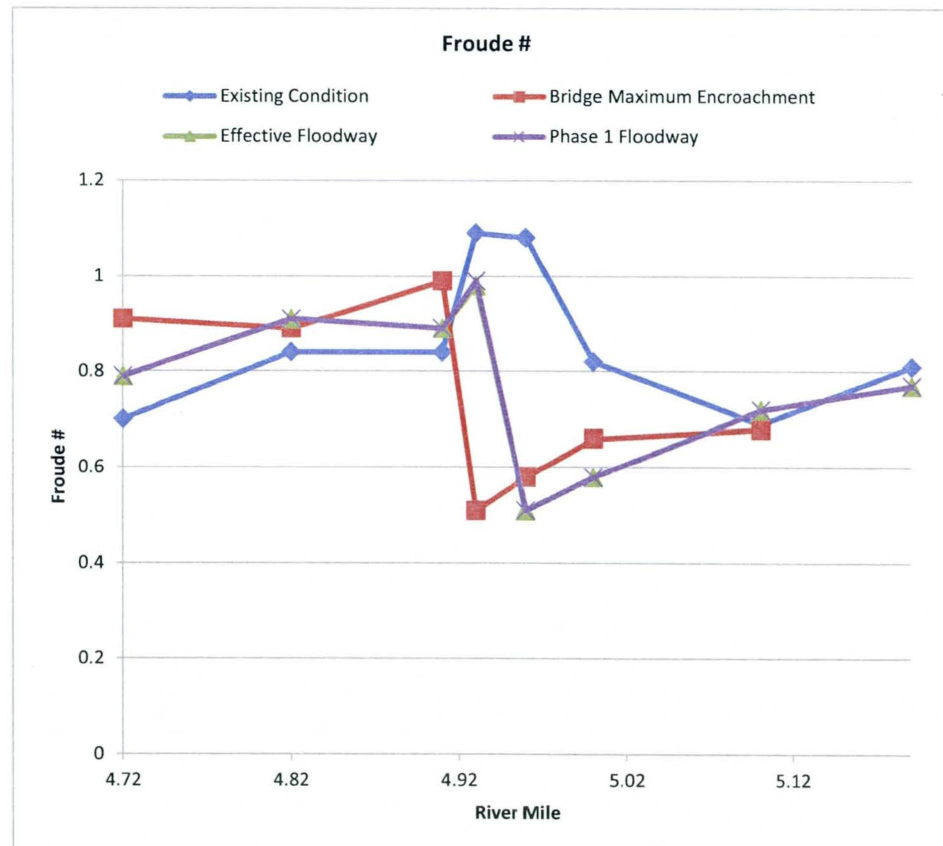
Change in Froude #

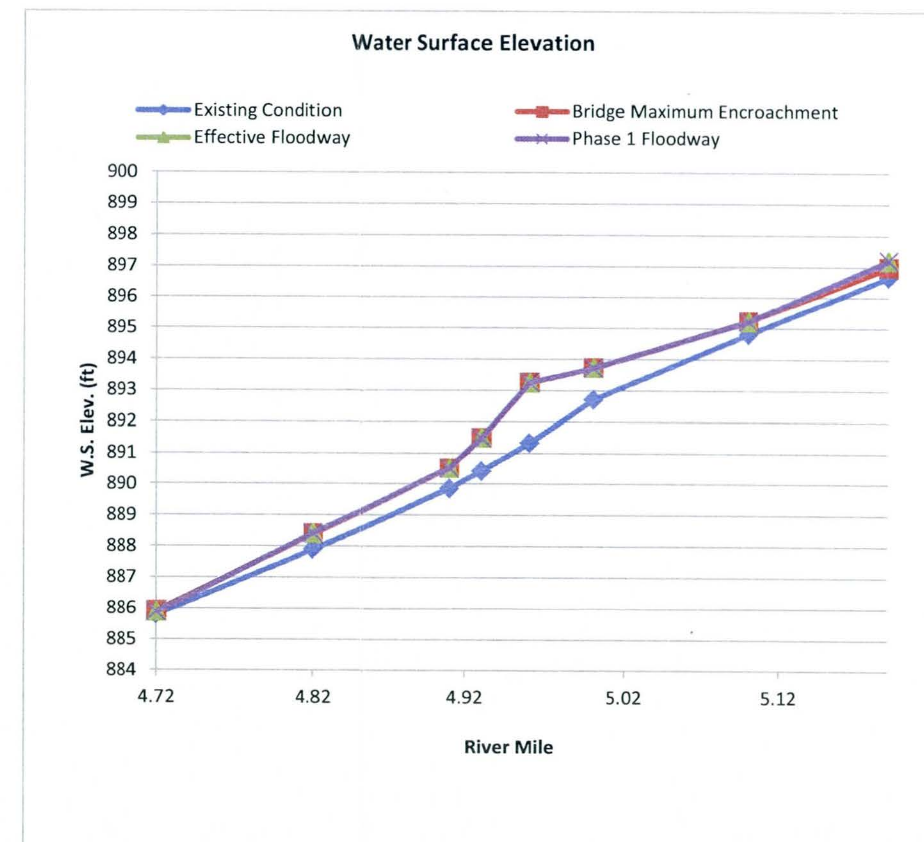
RM	Existing Condition Froude # (unitless)	Bridge Maximum Encroachment Froude # (unitless)	Bridge Maximum Encroachment Percent Change (%)	Effective Floodway Froude # (unitless)	Effective Floodway Percent Change (%)	Phase 1 Floodway Froude # (unitless)	Phase 1 Floodway Percent Change (%)
4.720	0.70	0.78	11.4	0.79	12.9	0.79	12.9
4.820	0.84	0.91	8.3	0.91	8.3	0.91	8.3
4.910	0.84	0.89	6.0	0.89	6.0	0.89	6.0
4.930	1.09	0.99	-9.2	0.98	-10.1	0.99	-9.2
4.960	1.08	0.51	-52.8	0.51	-52.8	0.51	-52.8
5.000	0.82	0.58	-29.3	0.58	-29.3	0.58	-29.3
5.100	0.69	0.66	-4.3	0.72	4.3	0.72	4.3
5.190	0.81	0.68	-16.0	0.77	-4.9	0.77	-4.9

Change in Water Surface Elevation

RM	Existing Condition W.S.E. (feet)	Bridge Maximum Encroachment W.S.E. (feet)	Bridge Maximum Encroachment Change in W.S.E. (feet)	Effective Floodway W.S.E. (feet)	Effective Floodway Change in W.S.E. (feet)	Phase 1 Floodway W.S.E. (feet)	Phase 1 Floodway Change in W.S.E. (feet)
4.72	885.81	885.93	0.12	885.89	0.08	885.89	0.08
4.82	887.90	888.41	0.51	888.43	0.53	888.43	0.53
4.91	889.86	890.52	0.66	890.52	0.66	890.52	0.66
4.93	890.42	891.50	1.08	891.51	1.09	891.50	1.08
4.96	891.33	893.26	1.93	893.25	1.92	893.26	1.93
5.00	892.72	893.73	1.01	893.73	1.01	893.73	1.01
5.10	894.82	895.24	0.42	895.23	0.41	895.23	0.41
5.19	896.67	896.99	0.32	897.21	0.54	897.21	0.54







5.15.4 Reach Average Hydraulic Model Results

Reach average hydraulic results for the Floodplain Management, Effective Floodway Encroachment and the Phase 1 Floodway Encroachment are provided in Table 5.77, 5.78 and 5.79 respectively. Reach average hydraulic parameters are presented to show the difference between the results of the floodway encroachments hydraulic models relative to the Floodplain Management model. Key hydraulic parameters evaluated are velocity, depth and top width. Changes in velocity relative to the base condition (Floodplain Management) are indicators of a potential change in the sediment transport capacity. Higher velocities typically indicate a greater potential for erosion whereas lower velocities indicate a potential for aggradation. The change in top width is a measure of the difference between floodplain widths between the encroachment scenarios being evaluated. The following conclusions are offered from review of the data:

- The change in reach average velocities relative to the Floodplain Management Alternative results is less than 6%.
- The Phase 1 Encroachment velocities are slightly higher than the Effective Floodway Encroachments velocities with the exception of Reach 5 where it is lower.
- Both floodway encroachments show that the change in top width ranges approximately between 20% and 50%. There is a greater change in top width for the Phase 1 Encroachment with the exception of Reach 5 where it is lower.

Table 5.77
Average Hydraulic Parameters Floodplain Management

Reach	**River Station**	**Reach Description**	**Floodplain Management Average Velocity**	**Floodplain Management Average Top Width**
	River Miles		(fps)	(ft)
1	0.35 to 4.63	Gila River to UPRR Bridge	7.2	5808
2	4.72 to 10.21	UPRR Bridge to I-10	8.9	3630
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	9.8	2130
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	8.6	2618
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	8	5376

Table 5.78
Average Hydraulic Parameters Effective Floodway Encroachment

Reach	River Station	Reach Description	Effective Floodway Encroachment Average Velocity	% Difference in Velocity Between Effective and Floodplain Management	Effective Floodway Encroachment Average Top Width	% Difference in Top Width Between Effective and Floodplain Management
	River Miles		(fps)		(ft)	
1	0.35 to 4.63	Gila River to UPRR Bridge	7.6	5.5	4601	-20.8
2	4.72 to 10.21	UPRR Bridge to I-10	9.3	4.7	2420	-33.3
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	9.9	1.6	1653	-22.4
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	8.9	3.9	1780	-32.0
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	8.1	5.2	2283	-57.5

Table 5.79
Average Hydraulic Parameters Phase 1 Encroachment

Reach	River Station	Reach Description	Phase 1 Floodway Encroachment Average Velocity	% Difference in Velocity Between Phase 1 and Floodplain Management	Phase 1 Floodway Encroachment Average Top Width	% Difference in Top Width Between Phase 1 and Floodplain Management
	River Miles		(fps)		(ft)	
1	0.35 to 4.63	Gila River to UPRR Bridge	7.6	5.4	4550	-21.7
2	4.72 to 10.21	UPRR Bridge to I-10	9.3	4.8	2221	-38.8
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	10.0	2.3	1512	-29.0
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	9.0	5.6	1603	-38.8
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	8.0	3.7	2416	-55.1

5.15.5 Floodway Encroachments Stable Slope

Reach average estimates for stable slope were determined using the procedures listed in Section 5.12.2 for each of the floodway encroachments. Stable slopes values listed in Table 5.80 are compared to the mean actual slope to determine the magnitude of the difference and whether an encroachment scenario has a greater impact than another. The comparison between actual and stable slope estimates for reaches 3, 4, and 5 is within 10% whereas the comparison for reaches 1 and 2 resulted in a difference of greater than 10%. Levees constructed approximately 50 years ago in Reach 1 confine flow to a narrow channel and it would be expected that the channel has not reached a stable state and therefore, there would not be a good comparison between actual and stable slope. There is very little difference between the stable slopes estimated for the two floodway encroachment scenarios. The results indicated that either encroachment scenario would result in a change to bed slope over time and that the change is relatively small. Both encroachment scenarios would have the same impact to channel slope.

Table 5.80 Floodway Encroachment Stable Slope

Reach	**River Station** River Miles	**Reach Description**	**Mean Actual Slope** ft/ft	**Stable Slope Effective Floodway** ft/ft	**% change between Effective Stable Slope and Mean Actual Slope** %	**Stable Slope Phase 1 Floodway** ft/ft	**% change between Phase 1 Stable Slope and Mean Actual Slope** %
1	0.35 to 4.63	Gila River to UPRR Bridge	0.00418	0.00504	20	0.00504	21
2	4.72 to 10.21	UPRR Bridge to I-10	0.00409	0.00467	14	0.00457	12
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	0.00396	0.00405	2	0.00406	3
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	0.00452	0.00459	2	0.00454	1
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	0.00432	0.00456	6	0.00449	4

5.15.6 Floodway Encroachment Bank Protection Estimates

Through Phase 1 evaluation's and field observations during and after flooding events on the Hassayampa River, it has been noted that lateral migration of banks of the watercourse has occurred at locations where a bank has migrated as much as 300 feet in a single event. In order to protect property that is being reclaimed by an encroachment, bank protection will be required. Per the scope of work the size and thickness of rip-rap was estimated for the two floodway encroachment scenarios. The riprap section includes freeboard and a minimum toe down depth of 10 feet.

Riprap design is based on the 100-year event. The riprap size for angular rock is based on the procedure presented in the District's River Mechanics Manual for DDMSW (FCDMC, 2009). The procedure includes the following equations for estimating the D_{50} size:

- D_{50} for Channel Banks on Straight Reach – for a straight reach or a mild curved reach of bend angle $\beta \leq 30$ degrees:

$$D_{50} = \frac{0.0191V_a^2}{\cos\varphi}\left(\frac{\gamma_w}{\gamma_s - \gamma_w}\right)$$

- D_{50} for Channel Banks on Curved Reach – for curved reach with a bend angle β of more than 30 degrees:

$$D_{50} = \frac{0.0372V_a^2}{\cos\varphi}\left(\frac{\gamma_w}{\gamma_s - \gamma_w}\right)$$

where:

D_{50} – the median riprap diameter, feet

V_a – average velocity, fps

γ_s – specific weight of stone, lb/ft^3, assumed to be 154 lb/ft^3

γ_w – specific weight of water, lb/ft^3, assumed to be 62.3 lb/ft^3

φ – bank angle, degrees, assumed to be 3H:1V slope

β – channel bend angle, degrees

The average velocity was based on the channel velocity within the main channel obtained from the HEC-RAS model. The riprap size ranges from 0.9- to 1.4-feet in diameter for angular rock. Table 5.81 includes a summary of reach average riprap size and Table 5.82 provides a summary of riprap quantities by reach. Excel spreadsheets developed to estimate the size and quantities are provided in Appendix H.

Table 5.81
Floodway Encroachment Riprap Size

Reach	River Station River Miles	Reach Description	Average Velocity Phase 1 (fps)	Average Velocity Effective (fps)	Median Diameter (D50) Phase 1 (ft)	Median Diameter (D50) Effective (ft)	Average Riprap Thickness Phase 1 (ft)	Average Riprap Thickness Effective (ft)
1	0.35 to 4.63	Gila River to UPRR Bridge	7.6	7.6	0.9	0.9	2.1	2.1
2	4.72 to 10.21	UPRR Bridge to I-10	9.3	9.3	1.2	1.2	2.7	2.7
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	10.0	9.9	1.4	1.4	3.1	3.1
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	9.1	8.9	1.1	1.1	2.5	2.5
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	8.0	8.1	0.9	0.9	2.1	2.1

Table 5.82
Floodway Encroachment Riprap Quantity

Reach	River Station River Miles	Reach Description	Phase 1 (yd^3)	Effective (yd^3)
1	0.35 to 4.63	Gila River to UPRR Bridge	307,545	310,008
2	4.72 to 10.21	UPRR Bridge to I-10	438,410	425,609
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	499,170	486,387
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	371,042	354,149
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	313,485	310,367
		Totals	1,929,652	1,886,520

5.16 MAXIMUM ENCROACHMENT SCENARIO, HEC-RAS MODELING DETAILS AND RESULTS

The Maximum Encroachment scenario allows for encroachment beyond the floodway limit along the entire study reach. The scenario evaluates different channelization scenarios in conjunction with bridge locations and dimensions established from the Floodplain Management Model. The channel modification tool in the HEC- RAS geometry editor was utilized to develop different channelization geometrics. Channel geometrics were developed for two channelization scenarios, Alternative A1 and Alternative B1. The following design aspects were used in the development and evaluation of the alternatives:

- Channel invert elevations remained the same as existing channel invert elevations.
- Channel side slopes are set to 3:1 (horizontal to vertical).
- The 801 Freeway Bridge is coded in downstream of the Union Pacific Railroad.
- Channel bottom width for Alternative A1 was set to the dominant bridge opening width of 1560 feet. At locations where the bridge dimensions differed from the dominate dimensions a transition from the channel section to the bridge section took place over three cross sections upstream and downstream of the bridge. Through the Union Pacific Rail Road downstream to the Gila River a channel bottom width of 1000 feet was used. Table 5.83 list bottom width dimensions utilized for Alternative A1.
- Channel bottom width for Alternative B1 was set to 80% of the channel bottom width used for Alternative A1.
- In order to restrict flow to the channelization section and eliminate low lying areas adjacent to the channels levee stations were used in the models.

Table 5.83
Alternative A1 Channel Bottom Widths

River Mile		River Mile	Channel Bottom Width (ft)
0.35	to	4.25	1000
4.25	to	4.63	1560
4.63	to	6.23	2040
6.23	to	9.64	1560
9.64	to	10.02	1800
10.02	to	10.77	1560
10.77	to	11.24	1000
11.24	to	16.91	1560
16.91	to	17.39	2000
17.39	to	17.77	1560
17.77	to	18.14	1320
18.24	to	26.1	1560
26.1	to	27.75	1800

5.16.1 Maximum Encroachment Reach Average HEC-RAS Models Results

Reach average hydraulic results for the Floodplain Management, Maximum Alternative A1 and Maximum Alterative B1 are provided in Table 5.84, 5.85 and 5.86 respectively. Reach average hydraulic parameters are presented to show the difference between the results of the channelization alternative hydraulic models relative to the Floodplain Management model. Key hydraulic parameters evaluated are velocity, depth and top width. Changes in velocity relative to the base condition (Floodplain Management) are indicators of a potential change in the sediment transport capacity. Higher velocities typically indicate a greater potential for erosion whereas lower velocities indicate a potential for aggradation. The change in top width is a measure of the difference between floodplain widths between the channelization alternatives being evaluated. The following conclusions are offered from review of the data:

- The change in reach average velocities relative to the Floodplain Management ranged between -10% and +40%.
- The Alternative A1 velocities are slightly lower than the Alternative B1 velocities.
- Both channelization alternatives show that the change in top width ranges approximately between 27% and 82%. There is a greater change in top width for Alternative B1.

Table 5.84
Reach Average Hydraulic Parameters for Floodplain Management Alternative

Reach	River Station River Miles	Reach Description	Floodplain Management Average Velocity (fps)	Floodplain Management Average Depth	Floodplain Management Average Top Width (ft)
1	0.35 to 4.63	Gila River to UPRR Bridge	7.3	14.0	5801.6
2	4.72 to 10.21	UPRR Bridge to I-10	8.9	9.4	3630.3
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	9.8	11.3	2129.3
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	8.6	7.8	2618.4
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	7.7	7.1	3015.8

Table 5.85
Reach Average Hydraulic Parameters for Maximum Encroachment Alt. A1

Reach	River Station	Reach Description	Maximum Encroachment Alt. A1 Average Velocity	% Difference in Velocity Between Alt. A1 and Floodplain Management	Maximum Encroachment Alt. A1 Average Top Width	% Difference in Top Width Between Alt. A1 and Floodplain Management
	River Miles		(fps)		(ft)	
1	0.35 to 4.63	Gila River to UPRR Bridge	9.1	25.2	1329	-77.1
2	4.72 to 10.21	UPRR Bridge to I-10	8.0	-10.2	1753	-51.7
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	8.1	-16.7	1535	-27.9
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	7.6	-11.9	1614	-38.4
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	7.6	-2.4	1657	-69.2

Table 5.86
Reach Average Hydraulic Parameters for Maximum Encroachment Alt. B1

Reach	River Station	Reach Description	Maximum Encroachment Alt. B1 Average Velocity	% Difference in Velocity Between Alt. B1 and Floodplain Management	Maximum Encroachment Alt. B1 Average Top Width	% Difference in Top Width Between Alt. B1 and Floodplain Management
	River Miles		(fps)		(ft)	
1	0.35 to 4.63	Gila River to UPRR Bridge	10.1	38.4	1140	-80.4
2	4.72 to 10.21	UPRR Bridge to I-10	8.7	-2.4	1411	-61.1
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	8.8	-9.9	1247	-41.4
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	8.2	-4.0	1300	-50.4
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	8.2	6.2	1333	-75.2

5.16.2 Maximum Encroachment Alternative Stable Slope

Reach average estimates for stable slope were determined using the procedures listed in Section 5.12.2 for each of the floodway encroachments. Stable slopes values listed in Table 5.87 are compared to the mean actual slope to determine the magnitude of the difference and whether an encroachment scenario has a greater impact than another. The difference between stable slope estimates and mean actual slope is less than 10%. There is very little difference between the stable slopes estimated for the two channel encroachment scenarios. The results indicated that either encroachment scenario would result in a change to bed slope over time and that the change is relatively small. Both encroachment scenarios would have the same impact to channel slope.

Table 5.87
Maximum Encroachment Stable Slope

Reach	River Station	Reach Description	Mean Actual Slope	Stable Slope Maximum Encroachment Alt. A1	% change between Alt. A1 Stable Slope and Mean Actual Slope	Stable Slope Maximum Alt. B1	% change between Alt. B1 Stable Slope and Mean Actual Slope
	River Miles		(ft/ft)	(ft/ft)	(%)	(ft/ft)	(%)
1	0.35 to 4.63	Gila River to UPRR Bridge	0.00418	0.00406	-2.8	0.00392	-6.1
2	4.72 to 10.21	UPRR Bridge to I-10	0.00409	0.00411	0.5	0.00405	-1.0
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	0.00396	0.00418	5.6	0.00412	4.0
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	0.00452	0.00475	5.0	0.00464	2.7
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	0.00432	0.00469	8.6	0.00460	6.4

5.16.3 Channelization Excavation Quantities

An output of the HEC-RAS Channel Modification tool is quantity of material that needs to be excavated to construct the channel. Table 5.88 summarizes by reach excavation quantities for Alternative A1 and Alternative B1.

Table 5.88
Excavation Quantities for Maximum Encroachment Alternatives

Reach	River Station River Miles	Reach Description	Earth Work Quantity Alt A1 cu yd	Earth Work Alt B1 cu yd
1	0.35 to 4.63	Gila River to UPRR Bridge	9,364,236	7,266,052
2	4.72 to 10.21	UPRR Bridge to I-10	10,392,337	8,464,392
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	10,532,228	8,015,524
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	6,915,288	5,337,875
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	7,678,739	6,064,519
		Totals	44,882,828	35,148,362

5.16.4 Channelization Bank Protection Estimates

In order to protect property that is being reclaimed by channelization bank protection will be required. Per the scope of work the size and thickness of rip-rap was estimated for the two channelization scenarios. Procedures discussed in Section 5.15.6 were utilized to estimate riprap size. Reach average riprap size for Alternative A1 ranges from 0.8- to 1.2-feet in diameter for angular rock and riprap reach average size for Alternative B1 ranges from 0.9 to 1.5 feet in diameter for angular rock. Table 5.89 includes a summary of the riprap size and Table 5.90 provides a summary of riprap quantities by reach. Excel spreadsheets developed to estimate the size and quantities are provided in Appendix H.

Table 5.89
Maximum Encroachment Alternative Riprap Size

Reach	River Station	Reach Description	Average Velocity		Median Diameter (D50)		Average Thickness for Angular Rock	
			ALT A1	ALT B1	ALT A1	ALT B1	ALT A1	ALT B1
	River Miles		(fps)	(fps)	(ft)	(ft)	(ft)	(ft)
1	0.35 to 4.63	Gila River to UPRR Bridge	9.1	10.1	1.2	1.5	2.7	3.2
2	4.72 to 10.21	UPRR Bridge to I-10	8.0	8.7	0.9	1.1	2.0	2.4
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	8.1	8.7	1.0	1.1	2.1	2.5
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	7.6	8.2	0.8	1.0	1.9	2.2
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	7.5	8.2	0.8	0.9	1.8	2.1

Table 5.90 Volume of Rip Rap by Reach
Maximum Encroachment Alternative

Reach	River Station	Reach Description	Alternative A1	Alternative B1
	River Miles		(yd^3)	(yd^3)
1	0.35 to 4.63	Gila River to UPRR Bridge	272,625	346,834
2	4.72 to 10.21	UPRR Bridge to I-10	237,044	297,417
3	10.31 to 15.68	I-10 Bridge to Jackrabbit Wash	243,406	308,694
4	15.78 to 21.65	Jackrabbit Wash to Wagner/Daggs Wash	225,570	263,131
5	21.74 to 27.89	Wagner/Daggs Wash to CAP Siphon	249,410	277,300
		Totals	1,228,054	1,493,377

5.17 REACH 1 MAXIMUM ENCROACHMENT ALTERNTIVE REFINEMENT

The Maximum Encroachment Alternative for Reach 1 was refined per recommendations provided by two of the land owners that farm the majority of the private land within Reach 1. Figure 5.19 and 5.20 presents two typical cross sections that were developed for the reach. Figure 5.19 depicts a 1050 foot (approximate, dimensions vary with topography) wide compound trapezoidal channel with 10-year and low flow inset channels. The low flow channel conveys irrigation tail water returns from the Buckeye Irrigation and Drainage District canal system and flow from the 10-year event. The low flow channel allows for channel restoration that could include riparian and wetland type vegetation. The overbanks of the 10-year channel convey the 100-year storm within sports fields. The compound channel is applied at locations where there is sufficient room for the channel. The compound channel transitions to a single channel downstream of the Arlington Canal and upstream of Old US 80 where it connects to the Union Pacific Railroad bridge crossing. Figure 5.20 depicts a typical section for the single channel. Two different channel alignment scenarios were modeled; one utilizing the existing Old US 80 bridge and another that would require a new bridge location. Figure 5.21 depicts the channel alignments for the Reach 1 Channel Refinement that utilizes the Old US 80 Bridge. Figure 5.22 depicts the Gladden Channel alignment which requires that a new bridge crossing for Old US 80 Bridge be constructed. The Gladden Channel scenario does not utilize the Old US 80 Bridge. The first channel scenario (Reach 1 Maximum Encroachment, Channel Refinement) extends from the Union Pacific Railroad to the Old US 80 bridge and then turns to the west following a trend that is adjacent and parallel to the toe of the slope of the Arlington Mesa. The second channel scenario (Maximum Encroachment, Gladden Channel) extends from the Union Pacific Railroad to the southwest towards the Arlington Mesa and then follows the Arlington Mesa toe of slope to the Gila River. This scenario would require a new bridge crossing for Old US 80.

5.17.1 Hydraulic Models

Hydraulic models were developed to evaluate the different channelization scenarios. The following design aspects and modeling approaches were used in the development and evaluation of the two channel scenarios:

- Reach 1 Channel Refinement
    - The Encroachment to the Floodway HEC-RAS model was used as the base hydraulic model and then was modified using the HEC-RAS channel modification routine. Overbank and channel flow length were adjusted to be consistent with proposed channel alignment.
    - Average channel slope is 0.00418 ft/ft.
    - Manning's roughness coefficients are set at 0.045 for the 10-year channel and 0.035 for the grass overbank areas.
    - Channel side slopes are set to 3:1 (horizontal to vertical).
    - The 801 Freeway Bridge is coded in downstream of the Union Pacific Railroad.
    - Downstream of RM 0.063 the channel lies within the Gila River Floodplain and transitions from a 10-year channel with an overbank area (compound

channel) that conveys the 100-year peak discharge to a single trapezoidal channel.

  - The HEC-RAS levee option was used to restrict flow to the channelization section and to eliminate flow in low lying areas adjacent to the proposed channel alignment. The levee option was not used downstream of RM 0.063 because the channel is within the Gila River Floodplain.
  - Upstream of River Mile 2.38 the compound channel transitions to a single channel to accommodate the Old US 80 Bridge opening.
  - Upstream of the Old US 80 Bridge the channel remains a single trapezoidal channel and transitions to the existing natural channel at the Union Pacific Railroad. A single trapezoidal channel was required for this reach in order to minimize the amount of earthen fill that would be required to raise adjacent property above the 100-year water surface elevation so that a levee condition is avoided.
  - A 6 cell 10'x 10' concrete box culvert was added to the Old US 80 bridge structure to lower upstream water surface elevations so that the need of levees are minimized.

- Gladden Channel
  - Due to the proposed alignment of the channel a new base model was developed. The following steps were taken in the development of the model:
    - Cross section alignments from the Encroachment to the Floodway HEC-RAS Model were extended to the west to cover the footprint of the proposed channel.
    - Additional cross sections and/or different locations for cross sections alignments were required along Old US 80 to model a new bridge location.
  - The base hydraulic model was modified using the HEC-RAS channel modification routine. Overbank and channel flow length were adjusted to be consistent with proposed channel alignment.
  - Average channel slope for the Gladden Channel scenario is 0.00464 ft/ft.
  - Manning's Roughness Coefficients for the 10-year channel are set at 0.045 and for the grass overbank areas a 0.035 coefficient was utilized.
  - Channel side slopes are set to 3:1 (horizontal to vertical).
  - The 801 Freeway Bridge is coded in downstream of the Union Pacific Railroad.
  - Downstream of RM 0.063 the channel lies within the Gila River Floodplain and transitions from a 10-year channel with an overbank area (compound channel) that conveys the 100-year peak discharge to a single trapezoidal channel.

- The Old US 80 Bridge is eliminated and a new bridge is coded in to the west of the old bridge. The bridge was sized to minimize backwater effects upstream of the bridge.

Figure 5.19 Typical Compound Channel Section

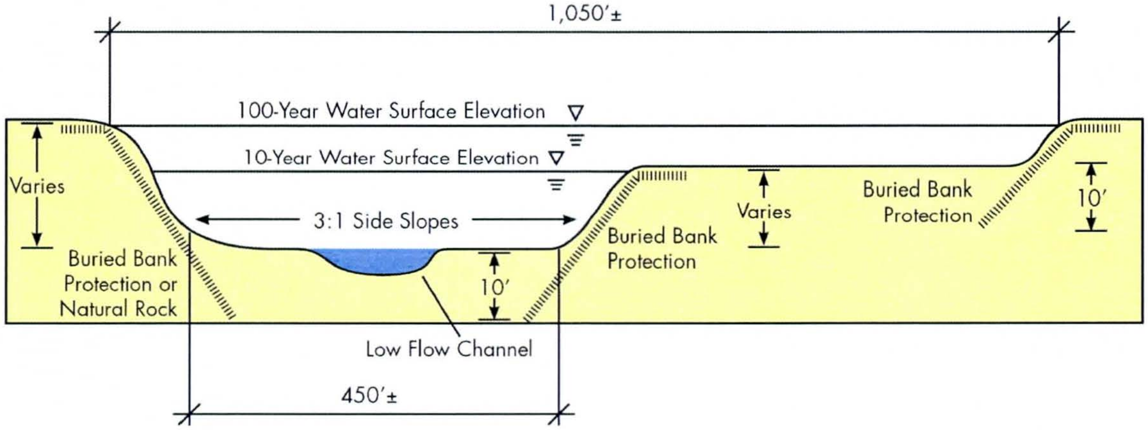
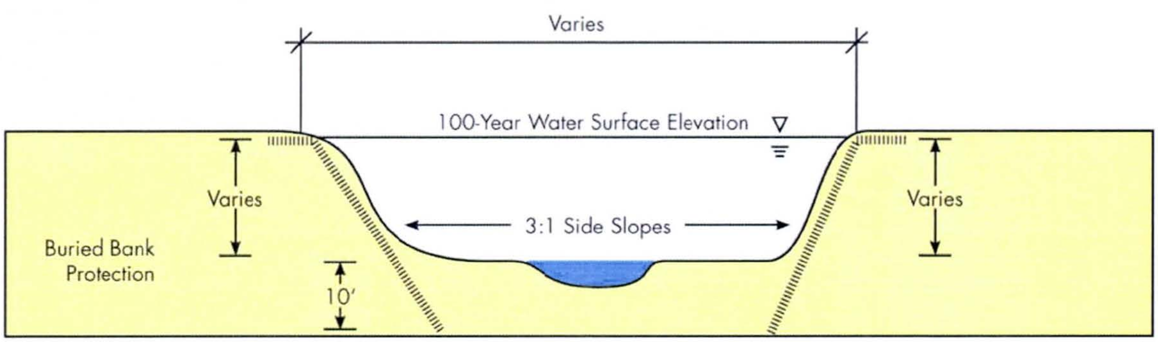


Figure 5.20 Typical Single Channel Section



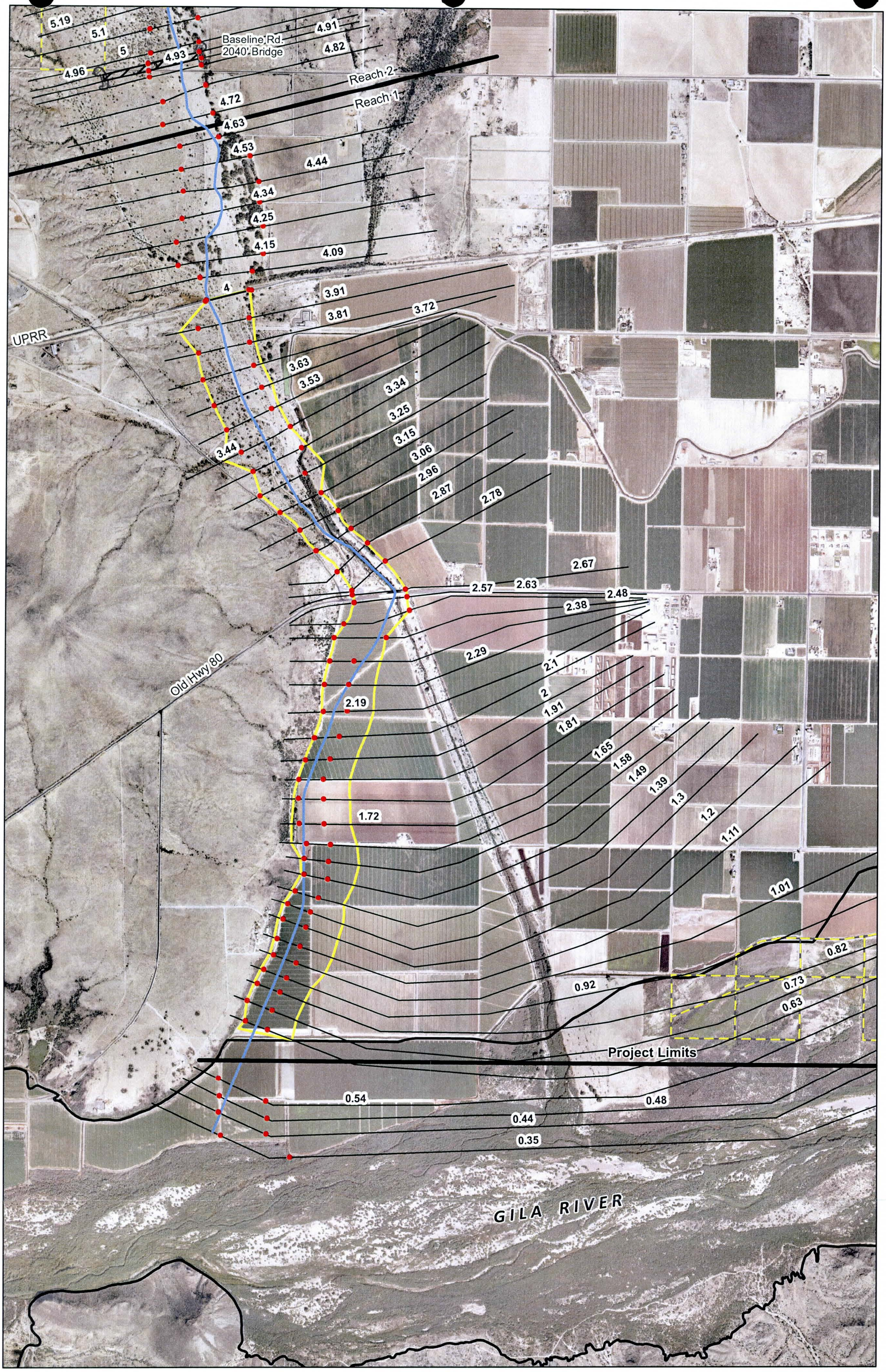


Figure 5.21
Maximum Encroachment,
Reach 1 Channel Alignment Refinement
Alternative

LEGEND

- Maximum Encroachment, Reach 1 Channel Alignment Refinement
- Bank Stations
- Thalweg
- Cross Section Alignments
- Gila River Floodplain
- Sand and Gravel Permit Areas

N

2,000 Feet

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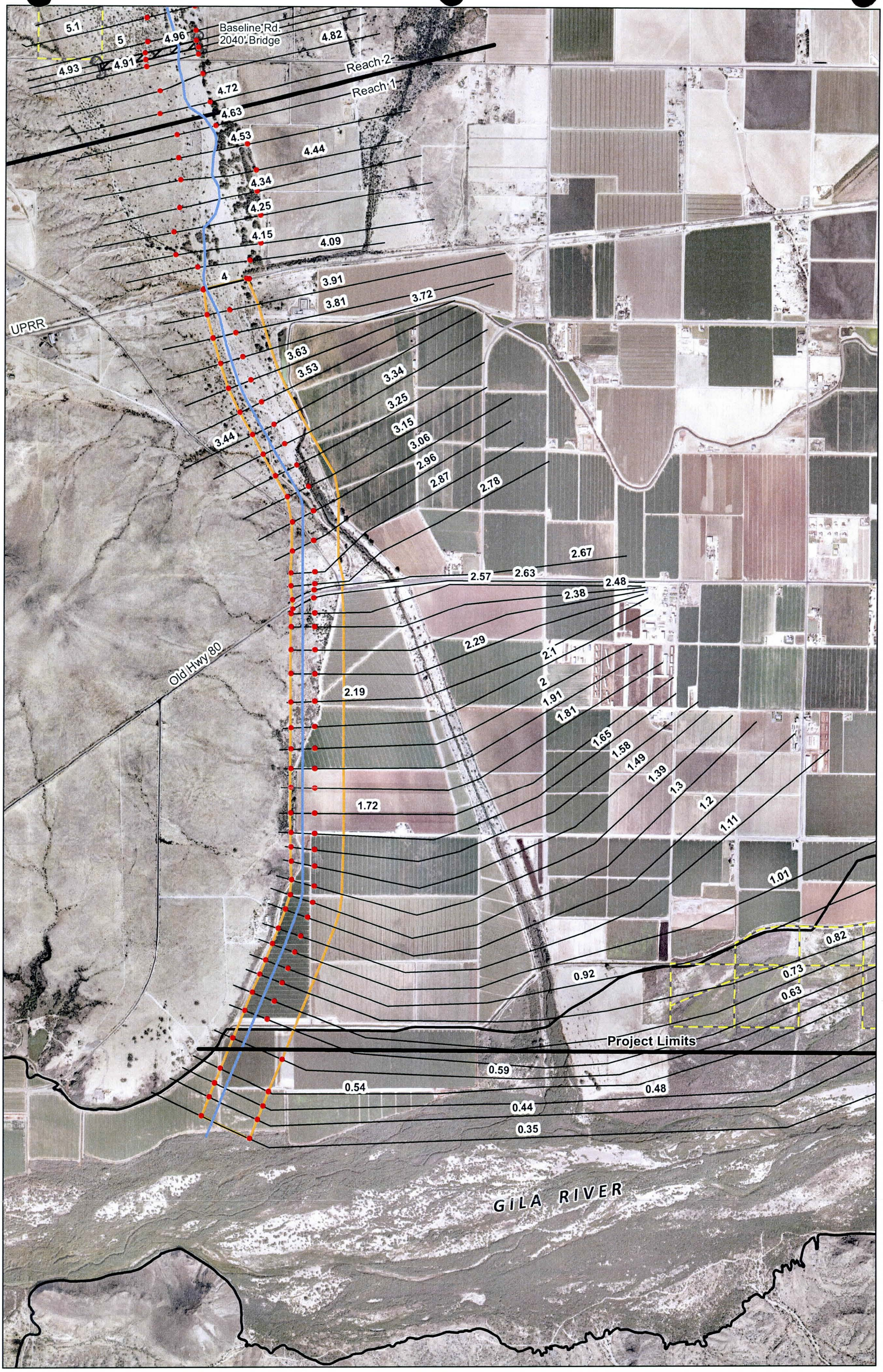

Figure 5.22
Maximum Encroachment,
Reach 1 Gladden Channel Alignment
Alternative

LEGEND

- Maximum Encroachment, Reach 1 Gladden Channel Alignment
- Thalweg
- Bank Stations
- Cross Section Alignments
- Gila River Floodplain
- Sand and Gravel Permit Areas

N

2,000 Feet

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5.17.2 Hydraulic Models Results

Reach average hydraulic results for the Reach 1 Channel Alignment Refinement are provided in Tables 5.91 and 5.92. The results for the Gladden Channel Alignment are provided in Tables 5.93 and 5.94. Reach average hydraulic parameters are presented to show the difference between the results of the Reach 1 Refined Structural and Gladden Channel hydraulic models relative to the Floodplain Management hydraulic model. Key hydraulic parameters evaluated are velocity, hydraulic depth and stable slope. Changes in velocity relative to the base condition (Floodplain Management) are indicators of a potential change in the sediment transport capacity. Higher velocities typically indicate a greater potential for erosion whereas lower velocities indicate a potential for aggradation.

Table 5.91 Reach 1 Channel Refinement Hydraulic Summary

Reach	River Station	Reach Description	Reach 1 Channel Refinement Average Channel Velocity	% change between Floodplain Management Velocity and Reach 1 Channel Refinement Velocity	Reach 1 Channel Refinement Average Hydraulic Depth	% change between Floodplain Management Hydraulic Depth and Reach 1 Channel Refinement Hydraulic Depth
			(fps)	%	(ft)	%
1	0.35 to 4.63	Gila River to UPRR Bridge	10.3	-12	10.2	-1

Table 5.92 Reach 1 Channel Refinement Stable Slope Summary

Reach	River Station	Reach Description	Proposed Slope	Stable Slope Floodplain Management	Stable Slope Reach 1 Channel Refinement	% change between Floodplain Management Stable Slope and Reach 1 Channel Refinement Stable Slope	% change between Proposed Slope and Reach 1 Channel Refinement Stable Slope
			(ft/ft)	(ft/ft)	(ft/ft)	(%)	(%)
1	0.35 to 4.63	Gila River to UPRR Bridge	0.00418	0.00367	0.00406	11	-3

Table 5.93 Gladden Channel Hydraulic Summary

Reach	River Station	Reach Description	Gladden Average Channel Velocity	% change between Floodplain Management Velocity and Gladden Channel Velocity	Gladden Channel Hydraulic Depth	% change between Floodplain Management Hydraulic Depth and Gladden Channel Hydraulic Depth
			(fps)	%	(ft)	%
1	0.35 to 4.63	Gila River to UPRR Bridge	9.8	-8	10.2	0

Table 5.94
Reach 1 Maximum Encroachment (Gladden Scenario) Stable Slope

Reach	River Station	Reach Description	Proposed Slope	Stable Slope Floodplain Management	Stable Slope Gladden Channel Refined Structural	% change between Floodplain Management Stable Slope and Gladden Channel Stable Slope	% change between Proposed Slope and Gladden Channel Stable Slope
			(ft/ft)	(ft/ft)	(ft/ft)	(%)	(%)
1	0.35 to 4.63	Gila River to UPRR Bridge	0.00464	0.00367	0.00450	22	-3

The existing Reach 1 channel modeled in the Floodplain Management Alternative is defined by non-engineered levees whereas the channels modeled in the Maximum Encroachment Reach 1 Channel Refinement and the Maximum Encroachment Gladden Channel are trapezoidal channels where the applications of levees to contain flow are minimized. An apple to apple comparison between the Reach 1 Channel Refinement and Gladden Channel Alternatives to the Floodplain Management Alternative is difficult because the existing levee condition does not contain the 100-year flow because there is insufficient flow capacity and the levees are overtopped. Both of the proposed Maximum Encroachment channels contain the 100-year flow within trapezoidal channels. Therefore the peak discharge used to estimate the hydraulic conditions between existing and proposed are different.

The estimated stable slope for the proposed channels are within 3% of the actual proposed slope indicating that there should not be significant change to channel slope should either channel be constructed.

5.17.3 Channelization Earthwork

Earthwork is an estimate of the amount of earthen material needed to be moved in order to construct a proposed facility. Earthwork estimates consist of estimating the amount of material that needs to be excavated and/or the amount of material required to fill an area to a design elevation. Quantities of moved material was estimated using output from the HEC-RAS Channel Modification routine and by creating Excel spread sheets using the average end area approach to calculate cut or fill areas. Excel spread sheets where used to estimate the amount of fill required (not reported in the HEC-RAS output) to raise the ground adjacent to the proposed channels to the 100-year water surface elevation. Table 5.95 summarizes earthwork quantities for the Reach 1 Channel refinement and the Gladden Channel.

5.17.4 Channelization Bank Protection Estimates

Bank protection for the Gladden channel and the Reach 1 Refined Structural channel is required to stabilize channel banks in a runoff event. Per the scope of work the size and thickness of rip-rap was estimated for the two channelization scenarios. Procedures discussed in Section 5.15.6 were utilized to estimate riprap size. The following are considerations employed in estimating the amount of required bank protection:

- Bank protection for the reach downstream of the Arlington Canal is not estimated because it is within the Gila River Floodplain and is considered a sacrificial pilot channel.
- There are two typical channel sections for the Gladden Channel and the Reach 1 Refined Structural Channel. Figure 5.19 depicts the typical section for the compound trapezoidal channel section where a 10-year event channel designed to convey frequent runoff events is proposed. Figure 5.20 depicts the typical section for the single trapezoidal channel section. Downstream of the Arlington Canal both channel alternatives transition from the compound trapezoidal channel to the single trapezoidal channel that outfall to the Gila River. Downstream of the Union Pacific Railroad the Gladden compound channel transitions to a single trapezoidal channel terminating at the Union Specific Railroad crossing. Downstream of the Old US 80 Bridge the Reach 1 Refined Structural channel transitions from the compound trapezoidal channel to a single trapezoidal channel and extends upstream to the Union Pacific Railroad.
- 10 foot nominal toe down depth
- Channel bank adjacent to the Arlington Mesa does not require bank protection.

Reach average riprap size and thickness for the Reach 1 Maximum Encroachment Channel Alignment Refinement and the Reach 1 Gladden Channel Alignment are listed in Tables 5.96 and 5.97 respectively. Table 5.98 provides a summary of riprap quantities of each channel alternatives. Excel spreadsheets developed to estimate the size and quantities are provided in Appendix H.

Table 5.95 Erath Work Quantities

Reach	River Station River Miles	Reach Description	Reach 1 Channel Refinement cu yd	Gladden Channel cu yd
1	0.35 to 3.91	Gila River to UPRR Bridge	7,529,340	6,679,251

Table 5.96
Reach 1 Channel Refinement Rip Rap Size

Portion	River Station River Miles	Average Velocity (ft/s)	Median Diameter (D50) (ft)	Average Thickness for Angular Rock (ft)
10-year Low Flow Channel of the Compound Channel	0.63 to 2.38	11.0	1.7	3.6
LOB area of the Compound Channel	0.63 to 2.38	6.25	0.5	1.4
Single Channel	2.48 to 3.91	8.00	0.9	2.1

Table 5.97
Reach 1 Maximum Encroachment Gladden Channel Rip Rap Size

Portion	River Station River Miles	Average Velocity GC ALT (ft/s)	Median Diameter (D50) GC ALT (ft)	Average Thickness for Angular Rock GC ALT (ft)
GC ALT - Low Flow	0.63 to 3.91	10.6	1.5	3.4
GC ALT - LOB	0.63 to 3.91	6.91	0.7	1.5

5.17.5 Design Considerations

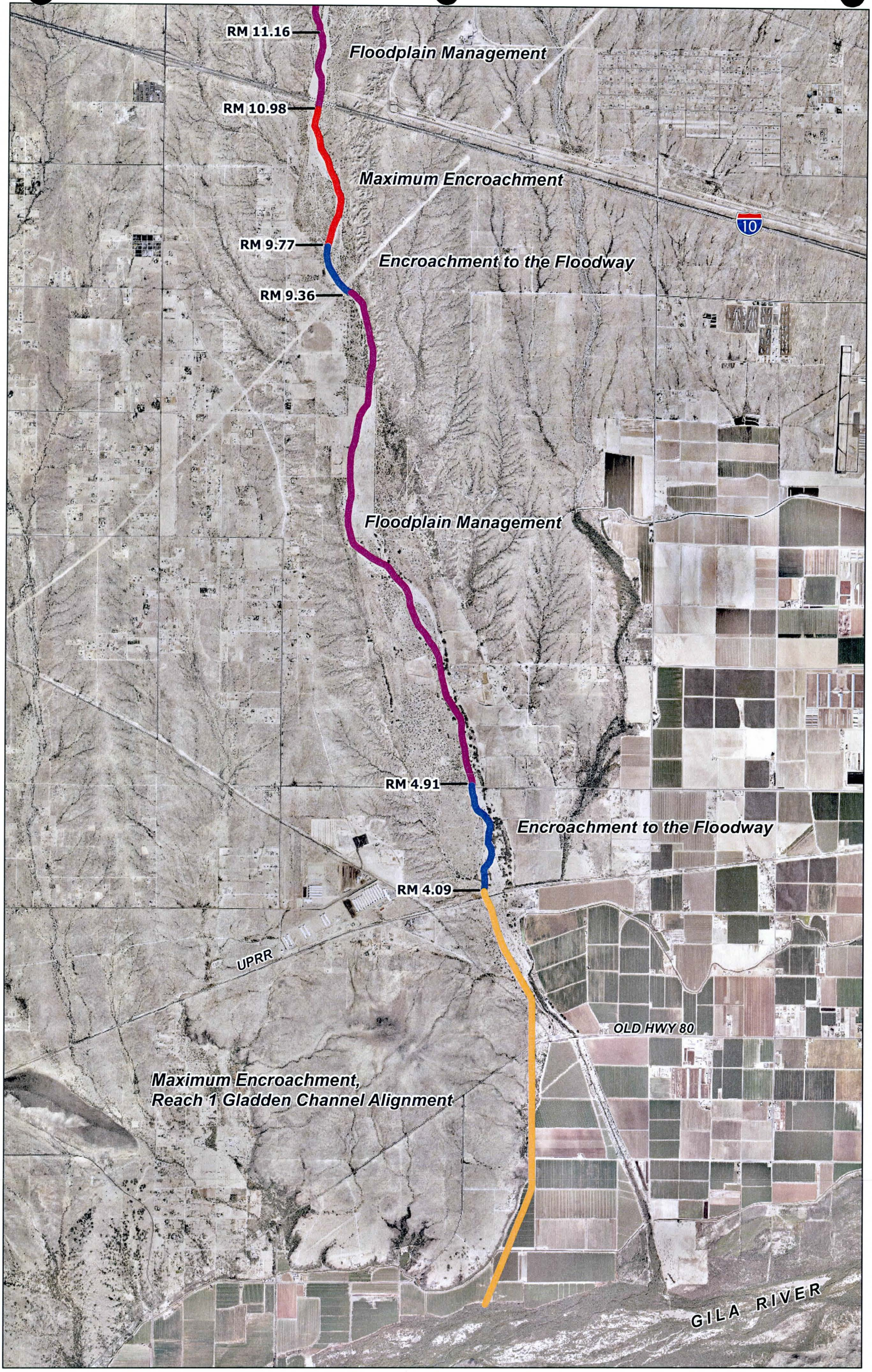
The following design considerations for channelization downstream of Old US 80 are offered as design elements that need additional evaluation should the channelization option be implemented in the future:

- The alignment of the Gladden Channel would require a realignment of Salome Highway.
- The Gladden Channel would require a new Old US 80 bridge crossing.
- The Reach 1 Channel Refinement Option would require modifications to the Old US 80 Bridge. The western most cell opening is currently blocked to prevent flow from damaging agricultural fields. This cell will need to be opened along with the placement of culverts under the western bridge approach to lower the 100-year water surface elevation so that levee like conditions are minimized upstream.
- Segments of the east bank in either channel option between the Union Pacific Railroad and Old US 80 will be in a levee like condition due to existing topography. Levees will need to be designed at a minimum to meet FEMA criteria.
- Some overbank areas primarily located to the east of either channel alignment will require fill to grade the surface to an elevation that is higher than the 100-year water surface elevation so that levee like situations are avoided.
- The out fall of either cannel to the Gila River will require maintenance activity to remove sediment accumulations.
- A siphon structure for the Arlington Cannel will required for either channelization option.
- Agricultural infrastructure will need to be relocated under either channelization option.
- HEC-RAS models conducted to estimate total scour at bridges and flood control facilities should be run in a Mixed Flow Regime.

5.18 TRANSITIONS FROM ONE ALTERNATIVE TO ANOTHER

In the event that multiple alternatives are employed within the Hassayampa River Corridor a hydraulic model was developed to evaluate the hydraulic conditions of a river reach where one alternative transitions to another. Alternatives that were considered are alternatives that impact the hydraulic conditions of the Hassayampa River relative to the Floodplain Management Alternative. Those alternatives are the Maximum Encroachment (Gladden Channel), Floodway, Floodplain Management and the Maximum Encroachment Alternatives. Figure 5.22 depicts the location of the channel transitions.

Reach average hydraulic results for transitions from one alternative to another are provided in Table 5.98. Reach average hydraulic parameters are presented to show the difference between the results of the Transition hydraulic model relative to the Floodplain Management hydraulic model. Key hydraulic parameters evaluated are velocity, hydraulic depth and stable slope. Changes in velocity relative to the base condition (Floodplain Management) are indicators of a potential change in the sediment transport capacity. Higher velocities typically indicate a greater potential for erosion whereas lower velocities indicate a potential for aggradation.



LEGEND

- Encroachment to the Floodway
- Floodplain Management
- Maximum Encroachment, Reach 1 Gladden Channel Alignment
- Maximum Encroachment

Figure 5.23
Potential Channel Transitions

N
N.T.S.

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Table 5.98 Reach Average Hydraulic Results for Transitions

River Station (River Mile)	Reach Description	Floodplain Management Velocity (fps)	Floodplain Management Hydraulic Depth (ft)	Stable Slope Floodplain Management (ft/ft)	Transition Model Velocity (fps)	Transition Model Hydraulic Depth (ft)	Transition Stable Slope (ft/ft)	% change between Floodplain Management Velocity and Transition Model Velocity %	% change between Floodplain Management Hydraulic Depth and Transition Model Hydraulic Depth %	% change between Floodplain Management Stable Slope and Transition Model Stable Slope %
4.09 to 4.91	Gladden Channel to Floodway Encroachment	8.8	5.5	0.00530	8.9	5.6	0.00515	1	1	-3
4.93 to 5.19	Floodplain Management	8.0	5.7	0.00572	8.0	5.7	0.00572	0	0	0
8.89 to 9.27	Downstream Floodplain Management	7.7	6.5	0.00474	7.7	6.5	0.00474	0	0	0
9.36 to 9.74	Floodway Encroachment	8.8	6.6	0.00473	8.8	6.5	0.00474	0	-1	0
9.77 to 10.87	Maximum Encroachment	9.5	6.1	0.00492	7.8	6.7	0.00398	-18	9	-19
10.98 to 11.09	Upstream Floodplain Management	9.81	6.482	0.00346	10.22	6.29	0.00516	4	-3	49
11.16 to 11.52	Upstream Floodplain Management	9.80	5.00	0.00539	9.80	5.00	0.00535	0	0	-1

Results listed in Table 5.98 shaded in green are for a reach that commences at RM 4.09 at the Union Pacific Railroad crossing of the Hassayampa River and extends to RM 5.19. In this reach alternatives modeled in the transition hydraulic model are the Floodway and the Floodplain Alterative Management Alternatives. The alternative modeled downstream of the Union Pacific Railroad is the Gladden Channel. There are no significant changes in hydraulic parameters relative to the Floodplain Management hydraulic model indicating that hydraulically the impact of this sequence of alternatives should they be implemented should not change the hydraulic performance of the river.

Results listed in Table 5.98 shaded in blue are for a reach that commences at RM 8.89 and extends through the bridges at the I10 crossing of the Hassayampa River to RM 11.52. Alternatives modeled in the transition hydraulic model in this reach are the Floodway, Maximum Encroachment and the Floodplain Alterative Management Alternatives. There is no significant change in hydraulic parameters relative to the Floodplain Management hydraulic model for the reach from RM 8.89 to 9.74 indicating that hydraulically the impact of the sequence of alternatives should they be implemented should not change the hydraulic performance of the river. There are significant changes in hydraulic parameters results in the river reach from RM 9.77 to RM 11.52. The changes relative to the Floodplain Management hydraulic model are in the Maximum Encroachment reach and the Floodplain Management reach located upstream of the Maximum Encroachment reach. The change in hydraulic performance within the Maximum Encroachment reach propagated upstream through the bridges into the Floodplain Management reach. Should the channel modifications in the Maximum Encroachment reach be implemented, significant changes in the hydraulic performance of the river upstream of the Maximum Encroachment reach would occur. Given that there is a reduction in flow velocity up stream of the Maximum Encroachment reach aggregation is likely to occur ultimately leading to loss of conveyance capacity for the reach.

The following considerations are offered from the hydraulic evaluation of multiple alternatives being implemented in a reach:

- No significant changes in hydraulic parameters are noted in the reach where transitions from the Floodway Alterative to the Floodplain Management Alternative were evaluated.
- In the transition from the Gladden Channel to the Floodway Alternative no significant changes in hydraulic parameters were noted whereas significant change was noted in the transition from the Maximum Encroachment to the Floodplain Management Alternatives.
- Detail hydraulic analyses should be conducted when considering the application of the Maximum Encroachment alternative within a reach of the Hassayampa River to determine the impacts to the watercourse and mitigations measures to counter the impacts.

5.19 CONCLUSIONS

Hydraulic modeling was conducted to determine the effect of future urbanization encroachments on the Hassayampa River. Urbanization encroachments on the watercourse are made to reclaim floodplain area for development and to provide transportation and utility infrastructure corridors required to support the community's plan for future growth. Hydraulic evaluations were conducted to define optimal bridge locations, bridge length and areas suitable to be reclaimed for potential development. The following summarizes conclusions determined from the Floodplain Management, Floodway Encroachment, Maximum Encroachment and Transition hydraulic analyses:

- Floodplain Management Model
    - Optimal bridge locations and openings were determined for 12 of the 15 future bridge locations.
        - Not all of the 12 bridges met the evaluation criteria; however the impact of the bridge on the hydraulic performance of the river was confined to an area 500 feet upstream or downstream of a bridge location. Mitigation measures would be required to minimize the impact due to the bridge encroachment. Mitigation measures could include channelization, channel armoring, grade control structures or purchase of additional right of way.
        - The three bridge locations where evaluations for bridge opening dimensions were not conclusive are the McDowell Parkway, Southern Avenue and Baseline Road Bridges.
            - Due to constraints imposed by sand and gravel mining at the McDowell Parkway bridge location, channelization upstream and downstream of the bridge should be considered.
            - Due the width of the existing floodplain and the braided nature of the Hassayampa River in the reach (RM 4.1 to RM 6.6) where the Southern Avenue and Baseline bridges are located, hydraulic evaluations for bridges spans up to 2040 feet yield results that did not meet evaluation criteria. Given the nature of river and the number and distribution of sand and gravel permits channelization should be considered in this reach.
- Floodway Encroachments Models
    - At bridge locations
        - In general relative to the Floodplain Management Model results, at most bridge locations floodway encroachments facilitated flow being conveyed through a bridge. Velocities typically increased upstream of the bridge. Flow regime typically remained the same with the exception of two locations where there was a transition to supercritical flow for the 100-year event. The change in water surface elevation upstream of a bridge decreased or remained the same.
        - Magnitudes of the change in velocity and water surface elevations differed at certain locations between the Effective Floodway Encroachment and the Phase 1 Encroachment relative to the Floodplain Management. For the 100-year event at the locations of the bridges the Effective Floodway and Phase 1 Floodway encroachments produced similar hydraulic results. For the 10-year event the hydraulic results for

the Phase 1 Encroachment had less of a change than the Effective Floodway Encroachments.

- Reach Average Hydraulic Conditions
  - The change in channel velocities and top width for the Effective Floodway and Phase 1 Floodway relative to the Floodplain Management hydraulic results were very similar. Either floodway encroachment would haves the same net effect on the form and functions of the river.
- Stable Slope
  - Stable slope evaluations for the Effective Floodway Encroachment and the Phase 1 Encroachment yielded very similar results. A differentiation between the two floodway encroachment scenarios could not be made based on the evaluation of stable slope.
  - For Reaches 3, 4 and 5, both floodway encroachment scenarios yielded stable slopes that were within 6% of actual slope. Implementation of either scenario would results in minor channel adjustments.
  - There is not a good comparison between actual and stable slopes estimates for Reaches 1 and 2. Actual slope is influenced by levees that were constructed over 50 years ago where flow is confined to a narrow section (approximately 300 feet). Flow is not confined to a narrow section for the floodway encroachment scenarios; therefore an apple to apples comparison cannot be made.
- Riprap Quantities
  - The quantity of riprap material required to armor channel banks was estimated for each floodway encroachment scenario. The riprap material required for the Effective Floodway encroachment is 1,886,520 cubic yards whereas for the Phase 1 Floodway encroachment 1,929,652 cubic yards. Using a 2010 (year) unit cost of $70.00 for dump angular riprap the cost for armoring the banks for the Effective Floodway Encroachment is approximately 132 million dollars whereas the cost for the Phase 1 Floodway encroachment is approximately 135 million dollars. Cost do not include cost for clearing and grubbing, structural fill, fill in the floodplain fringe, filter material, Right of Way, landscape aesthetics, utility conflicts, permits, contingencies and operation and maintenance.

- Maximum Encroachment Model
  - Two alternatives were evaluated for the Maximum Encroachment Scenario, Alternative A1 and Alternative B1. The channel bottom width of Alternative B1 is 20% smaller than the channel bottom width used for Alternative A1.
  - Reach Average Hydraulic Conditions

- The change in reach average velocities relative to the Floodplain Management ranged between -10% and +40%.
    - The higher value occurs in Reach 1, this would be expected because under the Maximum Encroachment Scenario all of the flow in contained between the channel banks whereas in the Floodplain Management Model flow overtops the levees and is not confined between the banks.
    - In Reaches 2, 3, 4 and 5 the difference in velocities between Alternative A1, Alternative B1 and the Floodplain Management model ranged between -17 and 6%. The negative values are primarily due to the wide channel bottom widths used in the channelization alternative relative to the existing condition represented in the Floodplain Management Model.
    - The Alternative A1 velocities are slightly lower than the Alternative B1 velocities. This is due to the difference in channel dimensions.
- Both channelization alternatives show that the change in top width relative to the Floodplain Management Model ranges approximately between 27% and 82%. There is a greater change in top width for Alternative B1 because the 100-year flow is confined to a smaller channel.

- Stable Slope
    - The difference between stable slope estimates and mean actual slope for Maximum Encroachment Alternative A1 and B1 is less than 10%. There is very little difference between the stable slopes estimated for the two channel encroachment scenarios. The results indicated that either encroachment scenario would result in a change to bed slope over time and that the change is relatively small. Both encroachment scenarios would have the same impact to channel slope.
- Channelization Earthwork

    Excavation quantities for Alternatives A1 and B1 are 44,882,828 cubic yards and 35,148,362 cubic yards respectively. Using a unit cost for excavation that was established in 2010 (year) of $12.00 a cubic foot (assuming a short haul distance for the material excavated where it is either placed or sold) the cost to excavate a channel under Alterative A1 and Alternative B1 is 538.5 million dollars and 421.7 million dollars respectively.
- Riprap Quantities
    - The quantity of riprap material required to armor channel banks was estimated for each channelization scenario. The riprap material required for Alternative A1 is 1,228,054 cubic yards whereas for the Alternative B1 is 1,493,377 cubic yards. Using a 2010 (year) unit cost

of $70.00 for dump angular riprap (does not include structural fill or filter material) the cost for armoring the banks for Alternative A1is approximately 85.9 million dollars whereas the cost for Alternative B1 is approximately 104.5 million dollars.

- Channel and Bank Protection Total Cost
  - Total cost for excavation and bank protection for Alternatives A1 and B1 are summarized below. Cost does not include cost for clearing and grubbing, structural fill, filter material, Right of Way, landscape esthetics, utility conflicts, permits, contingencies and operation and maintenance.

Alternative A1

Excavation	$ 538,500,000.00
Bank Protection	$ 85,900,000.00
Total	$ 624,400,000.00

Alternative B1

Excavation	$ 421,700,000.00
Bank Protection	$ 85,900,000.00
Total	$ 507,600,000.00

- Reach 1 Channel Refinement and Gladden Channel
  - Reach Average Hydraulic Conditions
    - The change in hydraulic conditions for the Reach 1 Channel Refinement and the Gladden Channel relative to the Floodplain Management alternative are not apple to apple comparison because channel dimensions and flow top width for the Floodplain Management Alternative are influenced by the presence of non-engineered levees that are overtopped in a 100-year event.
  - Stable Slope
    - The estimated stable slope for the proposed channels are within 3% of the actual proposed slope indicating that there should not be significant change to channel slope should either channel be constructed.
  - Channelization Earthwork
    - Excavation quantities for the Reach 1 Channel Refinement and the Gladden Channel are 7,529,340 cubic yards and 6,679,251 cubic yards respectively. Using a unit cost for excavation that was established in 2010 (year) of $12.00 a cubic foot (assuming a short haul distance for the material excavated where it is either placed or sold) the cost to excavate channels for the Reach 1 Channel Refinement and the Gladden Channel Alternatives are 90.4 million dollars and 80.1 million

dollars respectively. Earthwork cost could be offset if there is a market for the material excavated.

- Riprap Quantities
  - The quantity of riprap material required to armor cannel banks was estimated for each channelization scenario. The riprap material required for Reach 1 Channel Refinement is 174,129 cubic yards whereas for the Gladden Channel is 184,798 cubic yards. Using a 2010 (year) unit cost of $70.00 for dump angular riprap (does not include structural fill or filter material) the cost for armoring the banks for Reach 1 Channel Refinement is approximately 15,236,264 million dollars whereas the cost for the Gladden Channel is approximately 16,169,822 million dollars. Cost estimate includes a 1.25 multiplier for contingency.

- Total Cost
  - Total cost for excavation and bank protection for Reach 1 Channel Refinement and Gladden Channel are summarized below. Costs does not include cost for clearing and grubbing, structural fill, filter material, Right of Way, landscape esthetics, utility conflicts, permits, realignment of Salome Highway (Gladden Channel), bridge modifications and/or a new bridge for Old US 80 (Gladden Channel) and operation and maintenance.

Reach 1 Channel Refinement

Excavation	$ 90,352,080
Bank Protection	$ 15,236,264
Total	$ 105,588,344

Gladden Channel

Excavation	$ 80,151,016.52
Bank Protection	$ 16,169,822.42
Total	$ 96,320,838.94

5.20 RECOMMENDED RIVER MANAGEMENT PLAN CONSIDERATIONS

The development of the River Management Plan will take into consideration all scenarios evaluated and ultimately may consist of a combination of the scenarios. The following should be taken into consideration in the development of a River Management Plan.

- At the location of transitions between different river management scenarios, downstream of the Old US 80 Bridge and in the vicinity of sand and gravel operations the need for grade control structures should be evaluated.

- Appropriate transitions at the upstream end to the Hassayampa River and at the confluence with the Gila River will need to be developed to accommodate recommendations of the plan.
- Total scour analyses should be conducted for any river management scenario that may be implemented to better assess toe down depths for bank protections.
- Mitigation measures such as grade control structures may be required at confluences with tributary channels.

6.0REFERENCES

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Appendices and Plates are provided digitally on the Master DVD located at the front of report.