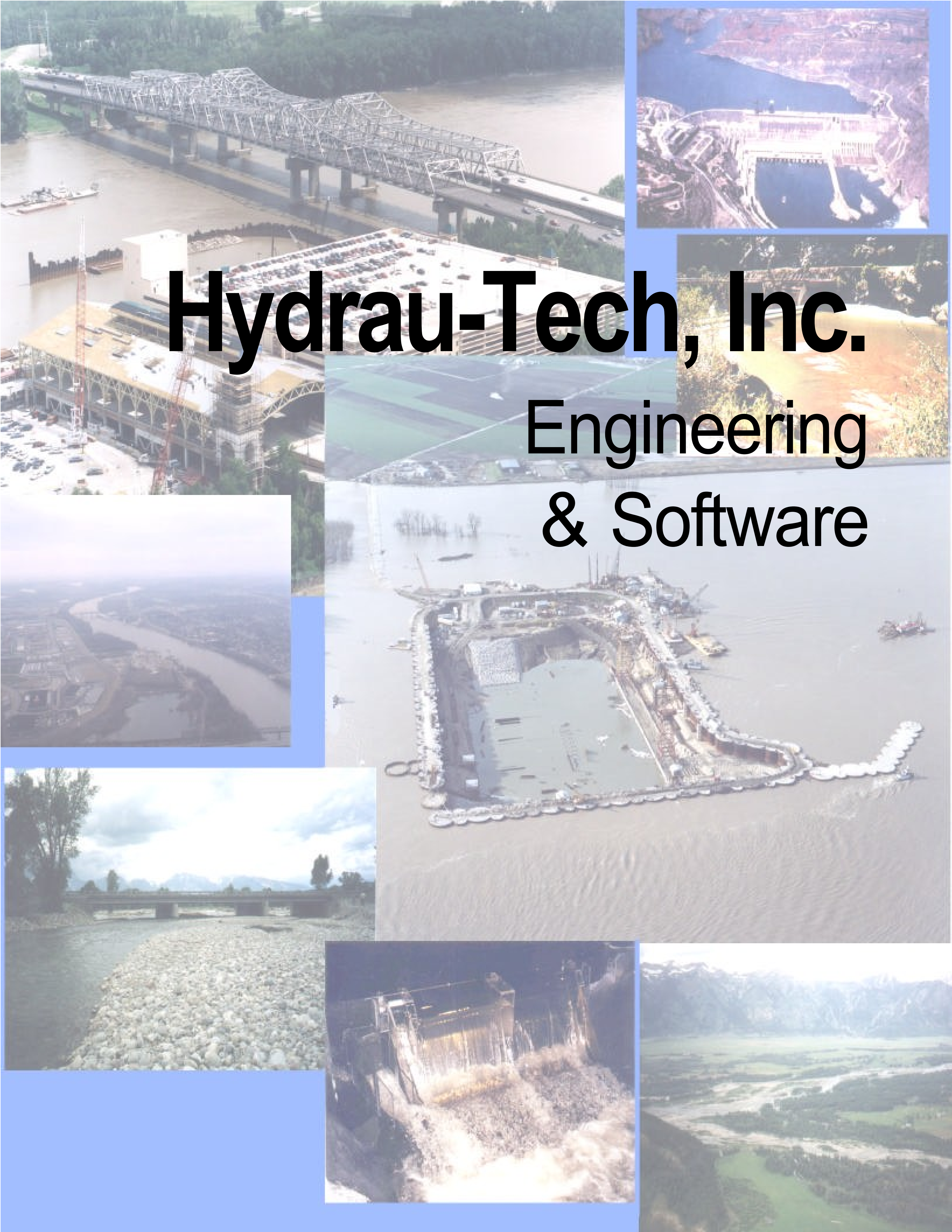


Hydrau-Tech, Inc.

Engineering & Software

HYDRAU-TECH, INC.

Hydrau-Tech, Inc. is an engineering consulting firm specializing in open channel hydraulics, watershed, river, and reservoir sedimentation, environmental river mechanics, river geomorphology and environmental management of sedimentation since 1986. Hydrau-Tech engineers have conducted extensive studies in pier and abutment scour, local scour due to reservoir power intakes, river sedimentation, and effects of sediment movement on hydraulic structures. They have also conducted basic research in measuring velocity and shear fields around bridge piers and abutments and channel contractions. In the field of numerical modeling, Hydrau-Tech engineers have developed the U.S. Bureau of Reclamation's GSTARS and Federal Highway Administration's BRI-STARS models. They also developed several well-known sediment transport and bridge scour relationships and authored the International Handbook of Reservoir Sedimentation. They have participated in numerous national and international projects and are recognized through their knowledge and expertise in the areas of:

- Numerical modeling of rivers, reservoirs, and watersheds
- Experimental and numerical modeling of bridge scour and hydraulics
- Erosion and Sedimentation
- Physical and numerical modeling of hydraulic structures
- Theoretical, experimental, and numerical Hydraulics
- Modeling of complex channel networks
- Hydraulics of dam failures and changes in channel morphology due to dam failures
- Hydrology
- River mechanics and river morphology
- Water Resources Planning and Management

Hydrau-Tech, Inc.'s past projects include software development, laboratory research and testing, physical modeling, mathematical modeling, engineering analysis and application:

- Laboratory Study for Effects of Gradation an Cohesion on Scour
- Physical Model Study of Rock Creek, Cresta and Poe Reservoir System
- BRI-STARS (Bridge Stream Tube Model for Alluvial River Simulations) Enhancement and Development
- Computer Analysis of Highway Encroachments on Mobile Boundary Streams
- Implementation of Lateral Inflow Option to the GSTARS Model
- Implementation of Mass-Wasting Algorithms into BRI-STARS Model
- Grand Teton National Park Materials Sources Study
- Implementation of the Sediment Routing Through Dendritic Channel Network Option to the GSTARS Model
- Application of Watershed Sediment Routing Model HEC1WS to Yazoo River Basin Bottomland Hardwoods Project
- Assessment of the Role of Bottomland Hardwoods in Sediments and Erosion Control.
- Plan of Action (POA) for scour Critical Bridges

OUR CLIENTELE

The clientele of Hydrau-Tech, Inc. include:

- Colorado Department of Transportation
- U.S. Fish And Wildlife Service
- U.S. Federal Highway Administration
- National Academy Of Sciences, Transportation Research Board
- U.S. Bureau Of Reclamation
- U.S. Geological Survey
- U.S Corps Of Engineers
- U.S. Environmental Protection Agency
- Pacific Gas & Electronic Company
- Private Civil Engineering Consulting Companies

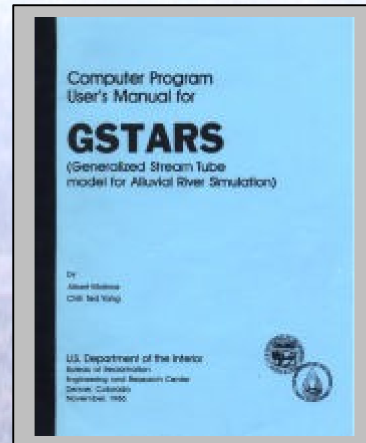
OUR SOFTWARE PRODUCTS

The commercial software products developed by Hydrau-Tech, Inc. are:

BRI-STARS	Enhanced version of Federal Highway Administration's **BRI-STARS** (BRIdge Stream Tube model for Alluvial River Simulation) model.
GSTARS	Visually interactive enhanced version of U.S. Bureau of Reclamation's **GSTARS** (Generalized Stream Tube model for Alluvial River Simulation) model.
SedWin	Visually Interactive **Sed**iment Transport Model for **Win**dows for computation of total and fractional sediment transport capacities.
SedBase	**Sed**iment Transport Data **Base** for laboratory and field measurements containing complete records of flow, bed material, transported sediment, and size distributions.
R-View	Channel **R**oughness **VIEW**er is based on US Geological Survey measurements for selecting Manning's roughness values in natural rivers and man-made channels using photographic information.

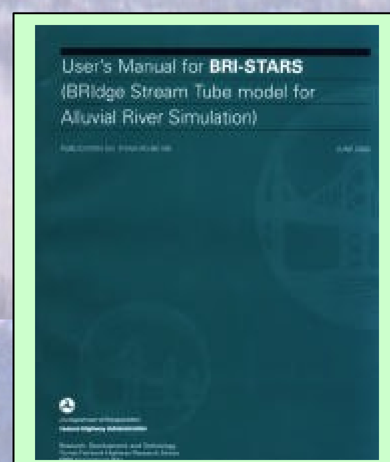
HYDRAU-TECH MANUALS AND CONFERENCE PROCEEDINGS

Hydrau-Tech, Inc. personnel have published numerous scientific articles that appeared in professional societal journals and conference proceedings. In addition to these publications, Hydrau-Tech personnel authored and co-authored series of Computer User's manuals, Conference Proceedings and participated in the preparation of textbooks and hndbooks.

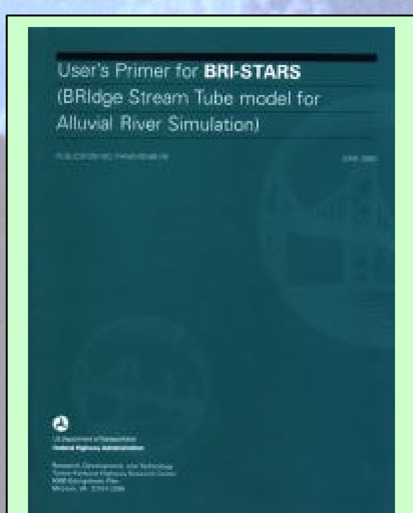


GSTARS
User's Manual
for U.S. Bureau
of Reclamation
by
Molinas and Yang

Proceedings of the International Conference on Reservoir Sedimentation for UNESCO & IAHR (Vols. 1, 2, and 3)
by
Albertson, Molinas and Hutchkiss



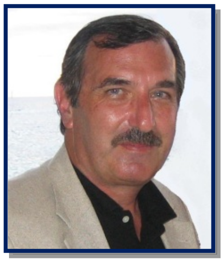
BRI-STARS
User's Manual
for
Federal Highway
Administration
By
Molinas



BRI-STARS
User's Primer
for
Federal Highway
Administration
By
Molinas

Hydrau-Tech, Inc.

Personnel



DR. ALBERT MOLINAS, P.E.

Dr. Molinas is the president of Hydrau-Tech, Inc. He has over 30 years of experience in the fields of river mechanics, open channel hydraulics and sedimentation, and has been the principal engineer of numerous projects ranging from physical and numerical modeling of rivers and watersheds to analytical studies of river behavior. Dr. Molinas has conducted the analysis, design, and laboratory testing of water resources projects, including reservoirs and dams, spillways, stream-environment structures, water supply and distribution systems, irrigation channels and control structures, hydro-electric facilities, and modeling of both water and sediment flows. He has been the principal investigator in numerous projects both at Colorado State University where he served as a professor since 1983, and at Hydrau-Tech, Inc., which he founded at 1986. Dr. Molinas' projects ranged from laboratory and numerical modeling to analytical studies of river and reservoir behavior, from geographic information systems to stream-classification expert systems.

For the past 30 years, Dr. Molinas has been involved in numerical sediment modeling studies for the National Cooperative Highway Research Program (NCHRP), Federal Highway Administration (FHWA), U.S. Bureau of Reclamation and the U.S. Geological Survey (USGS) and the World Bank. Through the NCHRP and the ensuing FHWA project, he developed the FHWA's Bridge Stream Tube model for Alluvial River Simulation (BRI-STARS) which utilizes existing bridge scour equations and the stream tube approach to predict aggradation/degradation for highway encroachments. This study included extensive literature searches, identification of potential sources of bridge scour data, and comparison and analysis of various bridge scour equations as well as state-of-the-art modeling approaches for channel stability. Two of his models, **STARS** and **GSTARS**, which were developed for the Bureau of Reclamation were among the "Twelve Selected Alluvial System Models in The United States" by the Federal Energy Regulatory Commission. Dr. Molinas' models have been, and are currently in use by various government agencies such as the Bureau of Reclamation, USGS, FWA, and various state DOTs as well as private agencies and foreign governments (China, Taiwan, Korea, France, Switzerland, and Venezuela).

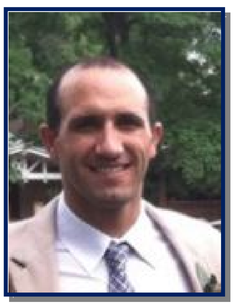
Dr. Molinas was also the principal investigator of the FHWA study "Effects of Gradation and Cohesion on Scour." This 7-year experimental study (1991–1998) was conducted through the Colorado State University Hydraulics laboratory and involved the use of large-scale modeling facilities. As a result of this research project, Dr. Molinas directed seven Ph.D. studies on bridge scour in cohesive materials and graded materials based on over 1,000 experimental points using large-scale experimental facilities. His experience on cohesive material scour uniquely contributes to the sediment transport modeling of cohesive material. Dr. Molinas authored/coauthored over 120 scientific journal articles and reports in his field expertise.

Dr. Molinas is the coauthor of Colorado Department of Transportation's Drainage Design Manual. He is currently the Co-Principal Engineer for developing Plan of Actions (POAs) for more than 120 Scour Critical Bridges and 19 Bridges with Unknown Foundations for Colorado. Dr. Molinas is the developer of the CDOT's Detour Drainage Design Procedure and is currently developing New Corrosion/Abrasion Guidelines for the Selection of Culvert Pipe Materials for CDOT. Through these projects, Dr. Molinas became very familiar with CDOT installations across the state. This knowledge will be very valuable in the proposed study.

MR. BILL BAILEY, P.E.

Mr. Bill Bailey is a hydraulic engineer with over 35 years of experience in hydraulics, hydrology, river mechanics, and sedimentation. He has conducted hundreds of bridge hydraulic design studies for the Wyoming DOT. In these studies he used various numerical models, including FHWA **WSPRO**, **FESWSM**, **BRI-STARS**, **WMS**, and **HYDRAIN**. Mr. Bailey is the author of the FHWA **CDS** model for drainage studies. He also authored a number of numerical models to solve particular bridge hydraulics, culvert hydraulics, local scour, and reservoir/detention pond problems encountered in highway applications. Mr. Bailey is extremely familiar with FHWA hydraulics/hydrology procedures and served AASHTO (American Association of State Highway Transportation Officials) Committee in hydraulics/hydrology in preparing their Drainage Design Manual. He also served as reviewer in developing the FHWAs **WSPRO**, **BRI-STARS**, **FESWMS**, and **WMS** models for practical applications.

Mr. Bailey was involved in the preparation of Plan of Actions (POAs) for the entire state of Wyoming, a neighboring state to Colorado with geographic regions similar to those encountered in Colorado. He was in charge of hydraulic, hydrologic, bridge scour computations and scour countermeasures in these POAs. Mr. Bailey has vast experience in stream stability and bridge scour countermeasures and studied the long-term effects of highway encroachments, bridges, and other hydraulic structures on Wyoming streams. Mr. Bailey, through various FHWA committee work, is very familiar with ongoing FHWA research on bridge pier and abutment scour including the wide-pier equation and Maryland ABSCOUR procedure to account for long-embankments on abutment scour distribution. This knowledge may be applicable for extreme cases where tradition scour equations may estimate unrealistic scour values. Also, through his expertise is in **WSPRO** modeling and the utility programs he developed to convert **WSPRO** data to **HEC-RAS**, many of CDOT's prior hydraulic studies at scour-critical bridge sites may be effectively translated into new computational environments.



ADAM PIERCE, M.S. – WATERSHED SCIENTIST, OFFICE MANAGER

Mr. Pierce graduated from Brevard College, NC, Environmental Sciences. He is currently finalizing his M.S. in Watershed Science at Colorado State University with an emphasis in water quality and GIS. Mr. Pierce has over eight years of experience in traditional land surveying, hydrologic stream surveying and bathymetric surveying (underwater). Additionally, Mr. Pierce has extensive experience in testing and analysis of storm water filtration systems, physical modeling and analysis of sediment transportation and a variety of water quality testing including magnesium chloride runoff testing, nitrate deposition in snow, selenium toxicity, and general surface water quality monitoring plans. Mr. Pierce currently manages and organizes the acquisition of field surveys, hydrologic analysis and prioritization and reporting of scour countermeasures following FHWA procedures. Mr. Pierce has worked on the completion of over eighty bridge hydraulic analysis and reports for CDOT's POA project.

BRETT SOLLENBERGER, EIT – HYDRAULIC / WATER RESOURCES ENGINEER

Mr. Sollenberger graduated from Colorado State University, Civil Engineering. He has five years of experience in hydraulic modeling and analysis. He has conducted laboratory modeling studies in performance testing and analysis of erosion control products such as articulated concrete blocks, turf-reinforcement mats, rolled erosion controlled products and soil analysis. Mr. Sollenberger has also worked on physical modeling of sediment transportation and scour analysis of river systems. At Hydrau-Tech, Inc. Mr. Sollenberger conducts land surveying, GIS analysis of topographic data, hydrologic and hydraulic analysis, stream scour analysis and scour countermeasure selection and design. Mr. Sollenberger has conducted over fifty bridge hydraulic analysis throughout mountain and plains regions of Colorado, and has implemented his findings in engineering reports and formalized CAD drawings.

DUSTIN LONDON, EIT – HYDRAULIC / WATER RESOURCES ENGINEER

Mr. London graduated from Colorado State University, Civil Engineering. He has four years of experience in hydraulic modeling and analysis. He has conducted laboratory modeling studies laboratory modeling studies in testing and analysis of erosion control products such as articulated concrete blocks, geo-textiles and hydro-mulch products. A variety of soil testing methods were directed by Mr. London that include plasticity, density, and grain size distribution analyses. At Hydrau-Tech, Inc. Mr. London works in land surveying, hydrologic and hydraulic analysis, stream scour analysis and scour countermeasure selection and design. Mr. London has conducted over twenty bridge hydraulic analysis throughout mountain and plains regions of Colorado, and has implemented his findings in engineering reports and formalized CAD drawings.

JAWID EBADI, M.S. – GEOLOGIST

Mr. Ebadi graduated from Kabul University, Afghanistan, Geology. He has two years of experience in developing preliminary drainage reports which include key research in subsurface investigation, site specific geology and watershed hydrologic characteristics. A variety of soil testing methods are conducted by Mr. Ebadi, including grain size distribution analyses. At Hydrau-Tech, Inc. Mr. Ebadi works in land surveying, hydrologic analysis and sediment analysis.

TYLER LIEBMAN – ENGINEERING TECHNICIAN

Mr. Liebman is currently finalizing a Hydrogeology bachelor's degree with two years of additional course work in Civil Engineering. Mr. Liebman has six years of experience in hydraulic and sedimentation physical modeling within a laboratory setting. Modeling studies include, the construction and analysis of bendway weirs on the effect of sedimentation and hydraulic properties, and performance testing of erosion control products which include articulated concrete blocks and turf reinforcement mats. Mr. Liebman also has experience in installation and performance testing of storm drain inlet structures. At Hydrau-Tech, Inc. Mr. Liebman conducts topographic land surveys of bridge and storm water structures for hydraulic analysis, and performs formalized CAD drafting for Plan of Action bridge scour analysis within the state of Colorado.

MICHAEL BOTELHO – WATER RESOURCES TECHNICIAN

Mr. Botelho is currently completing a Rangeland Ecology bachelor's degree, as well as a minor in Geospatial Information Systems (GIS). Mr. Botelho has 2 years of coursework in Civil Engineering at Colorado State University with an additional 3 years of experience in various forms of hydrologic modeling and testing in a hydraulic laboratory environment. Modeling studies include performance testing of erosion control products which involved articulated concrete blocks and turf reinforcement mats. Mr. Botelho also has experience with rainfall testing and data analysis on retention basin and inlet structures. At Hydrau-Tech, Mr. Botelho provides assistance in geospatial data projects, and provides background research in areas pertaining to debris flows, and stormwater infrastructure.

SCOTT REYMAN – GEOGRAPHIC INFORMATION SPECIALIST

Mr. Reyman graduated from Colorado State University, Natural Resources Management and Spatial Information Management Systems. Mr. Reyman is a Geographic Information Systems (GIS) specialist, visual resource technician, and environmental planner with an extensive range of experience, from natural resource recreation and management to GIS growth scenario modeling. He provides strong project support and leadership with his combined experience in GIS, regional land use planning, parks and recreation, and comprehensive planning. His expertise in GIS is focused on complex cartography, analysis/modeling, database management; and visual resources applications. Mr. Reyman has 7 years professional geospatial experience supporting the fields of energy, planning, environment, water resources and hazards mapping. He is an expert in designing complex GIS database and mapping solutions that exceed project requirements.

HYDRAU-TECH, INC.

TRANSPORTATION RELATED EXPERIENCE

NUMERICAL SIMULATION OF INTERSTATE 5 BRIDGE FAILURE NEAR COALINGA, CALIFORNIA

The Interstate 5 bridge that collapsed near Coalinga, California in 1998 carried up to 25,000 vehicles per day over Arroyo Pasajero Creek. Caltrans officials say they may never know why the bridge collapsed, but they have suggested two possible scenarios. According to the first scenario the water was so high and fast that it swept the bridge off its foundations; in the second scenario the intense flow scoured the bed below the pilings and knocked the foundation out from under the bridge. The bridge was built in 1967 and was 120 feet long and 40 feet wide. Pilings were 12 feet deep. Figures 1 through 3 show the failed bridge.

Figure 1. View of the failed bridge looking upstream.

Figure 2. View of the failed bridge from the channel facing downstream. Note the failed left abutment.

Figure 3. View of the failed bridge from the channel facing downstream. Note the failed left abutment.

As a part of **BRI-STARS** (BRIdge Stream Tube Alluvial River Simulation) model development and enhancement project, the Interstate 5 bridge and the Arroyo Pasajero Creek segments immediately upstream and downstream from the bridge were simulated. Using the topographic, hydrologic and sediment data provided by the U.S. Geological Survey, the magnitude of scour due to the scouring action of flows were computed to determine the cause of failure. Simulations showed that, up to 11 ft of additional scour took place at the bridge opening; and therefore the bridge failure was due to the scenario involving intense scour of foundation.

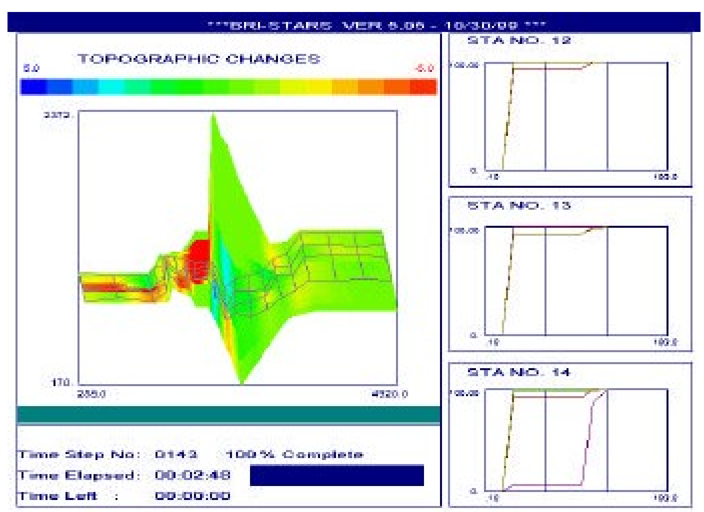


Figure 4. Topographic Changes window of BRI-STARS model showing the red-colored bridge scour zone and the blue-colored deposition immediately upstream from bridge for comparison with Figure 1.

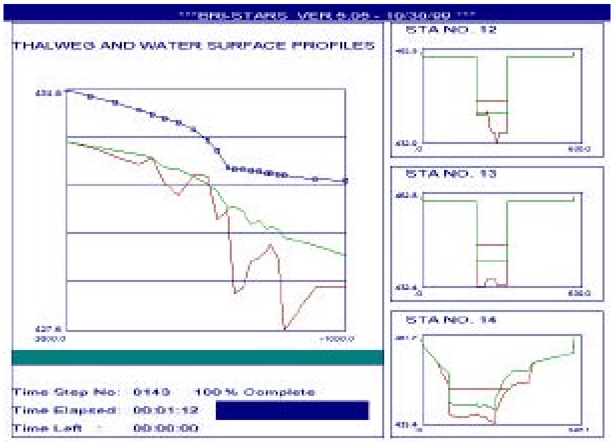


Figure 5. Thalweg and Water Surface Profiles window showing the initial (green) and final (red) ground profiles of study reach.

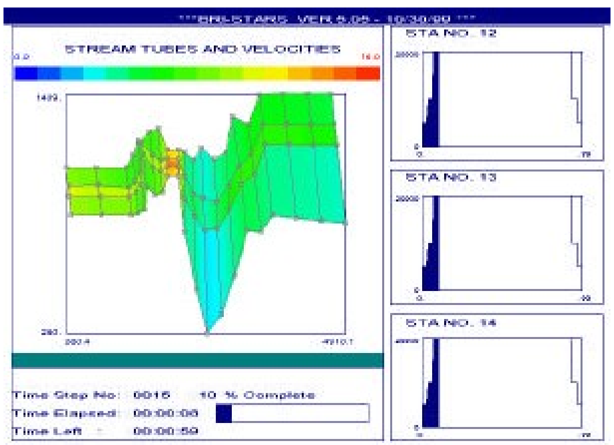


Figure 6. Stream Tubes and Velocities window showing the plan view of the study reach and color-coded velocity distribution.

BRI-STARS was developed by Dr. Albert Molinas, President, Hydrau-Tech, Inc. for the Federal Highway Administration (FHWA) to solve complex alluvial river sedimentation problems. This semi-two-dimensional model divides the stream channel into a series of stream tubes. Stream tubes are imaginary tubes bounded by streamlines. They carry a constant discharge along their length. Water and sediment is routed along each stream tube by satisfying the governing flow and sediment transport equations. BRI-STARS utilizes both the conservation of momentum and energy equations to compute water surface profiles through sub-critical, supercritical, and combination of both flow types involving hydraulic jumps. State-of-the art sediment transport equations, bridge scour relationships, sediment sorting algorithms are used in computing the various scour and deposition processes in river systems.

BRI-STARS is a visually interactive model; users can follow the progression of computations through simulation times. Lateral scouring and deposition process as well as longituduinal changes can be viewed through animation of cross section changes or the thalweg profiles. Changes in channel topographies, velocity variations along the channel and across the tubes are color coded and displayed in separate windows.

Figures 4 through 6 show the windows displaying the various aspects of computations during the simulation run for the Interstate 5 bridge scour study. Figure 4 shows computed scour patterns at the bridge site and vicinity. Figure 5 displays the thalweg profiles at the beginning and end of flooding event; it also shows cross sectional changes through the bridge and immediately downstream. Figure 6 displays computed 2 dimensional velocity field along the study reach through the contracted bridge opening.

The computed scour compared very closely with the measured scour determined from a detailed field analysis conducted at a later date by U.S. Geological Survey. The numerical simulation clearly demonstrated that the bridge failure was due to excessive scouring of the foundation.

DESIGN OF CROSS CULVERTS FOR COLORADO STATE HIGHWAY 82 PROJECT IN SNOWMASS CANYON

In this Colorado Department of Transportation project, large debris-flow culverts crossing the new four-lane State Highway 82 near Aspen, Colorado were designed. Along the project site, the highway passes through Snowmass Canyon along a series of small debris-producing watersheds as shown in Figures 1 and 2.

Culvert designs were based on computer modeling results from Federal Highway Administration's BRI-STARS model. As a part of the project, BRI-STARS model developed earlier by Dr. A. Molinas, Hydrau-Tech, was modified to accommodate debris flows by including various theoretical formulations. Traditional clear-water modeling results in considerably undersized culverts for debris flows; by using BRI-STARS modeling of viscous mudflows, culvert sizes that can pass the design discharges accurately can be computed.

Figure 1. View of State Highway 82 in Snowmass Canyon.

Figure 2. Debris flow fans along Colorado State Highway 82.

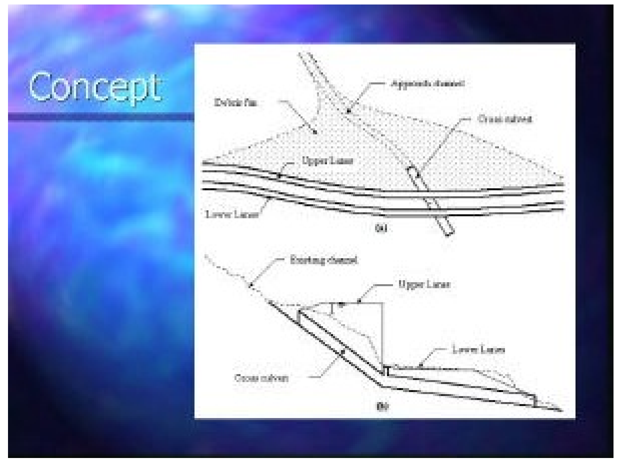


Figure 3. Conceptual design of highway cross culverts for passing upstream debris flows through.

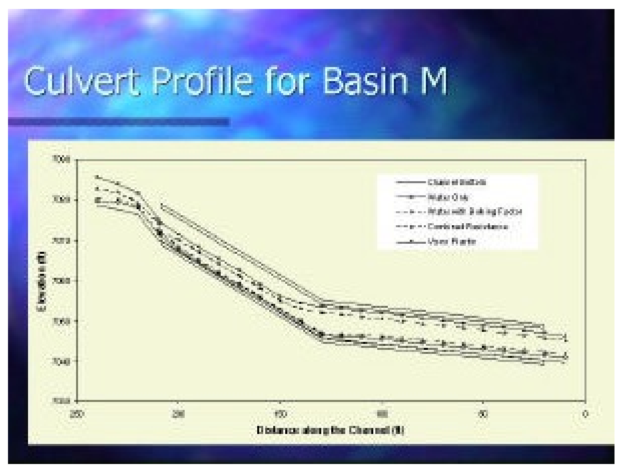


Figure 4. Computed debris flow profiles along with profiles computed using water only and bulked discharges

In order to widen the existing two-lane highway to four lanes along the narrow canyon, a split configuration was adopted. Space for the additional two lanes going from Glenwood Springs to Aspen, Colorado, were created by encroaching on the canyon wall by building a retaining wall and by elevating the upper lanes by as much as 30 feet. Along the path, at 8 locations basins producing debris fans border the highway. Potential debris flows from these basins are passed beneath the highway as shown in Figure 3 without interrupting traffic. Figure 4 shows the computed debris flow profiles for one of the basins. These flow profiles were generated by the enhanced BRI-STARS model by incorporating a visco-plastic fluid flow component.

Figures 5 and 6 show the elevated section of highway cutting through a debris fan at the base of Basin H.

Figure 7 shows a culvert design that does not require a break in the invert slope for the watershed identified as Basin I due to the location of the crossing. The cast-in-place culvert outlet and typical sections, as well as the construction of elevated sections of the highway are shown in Figures 8 and 9.

Figure 5. Elevated segment of State Highway 82 crosses a debris fan at the base of Basin H.

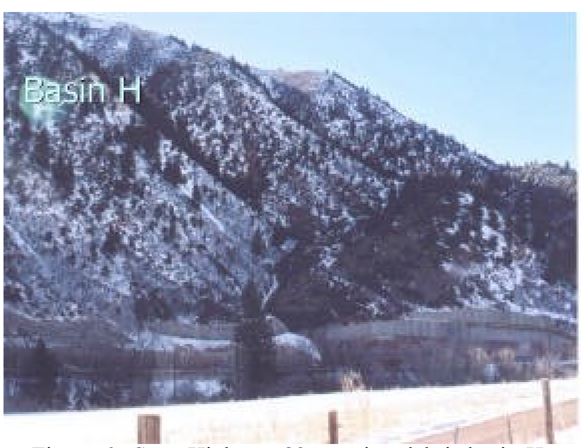


Figure 6. State Highway 82 crossing debris-basin H.

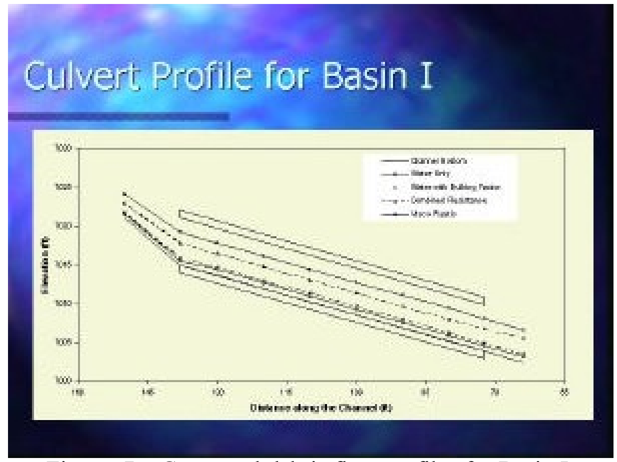


Figure 7. Computed debris flow profiles for Basin I.

Figure 8. Construction of upper lanes at Basin I.

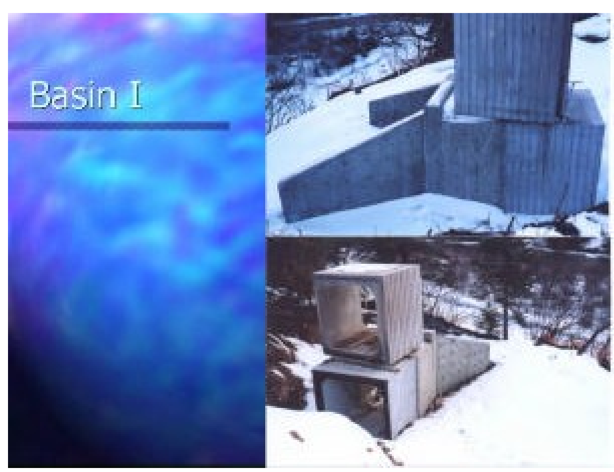


Figure 9. Culvert outlet and pre-fabricated culvert sections.

PLAN OF ACTION OF SCOUR CRITICAL BRIDGES

In 1991 the Federal Highway Administration (FHWA) required all states to provide Plans of Action (POA) for scour critical bridges. A nationwide mandated requirement by the FHWA, tasked the Colorado Department of Transportation (CDOT) to re-evaluate and develop POA reports for each of the 243 bridges identified as scour critical or structures with unknown foundations. CDOT created a program to address the scour critical bridges and created a multi-disciplinary POA team. As a part of this effort, Hydrau-Tech, Inc. was in charge of conducting 135 POA studies and developed individualized reports for each structure over a period of 3 years. As of September, 2013, Hydrau-Tech, Inc. has completed 113 POA reports for CDOT, along with an additional 19 reports for structures with unknown foundations.

In the following pages, summaries of several of these reports are presented. A full set of reports are available on Hydrau-Tech, Inc.'s FTP website at ftp://ftp.hydrau-tech.com/CDOT/. The instructions are:

1. Select an appropriate POA reports directory based on fiscal year.
2. Select the report of interest and save to a directory of your choice.

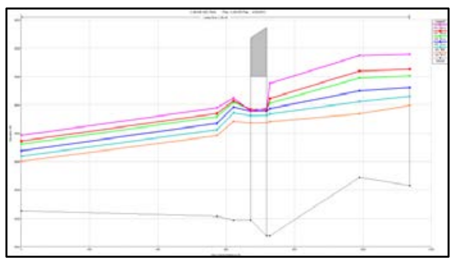
STATE HIGHWAY 131 BRIDGE C-09-AR OVER YAMPA RIVER, COLORADO

Bridge C-09-AR is located in Routt County on State Highway 131 ML where the highway crosses the Yampa River. Figure 1 shows Bridge C-09-AR over the Yampa River.

Hydrau-Tech, Inc. began the POA study of Bridge C-09-AR by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 5,650 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge C-09-AR over Yampa River



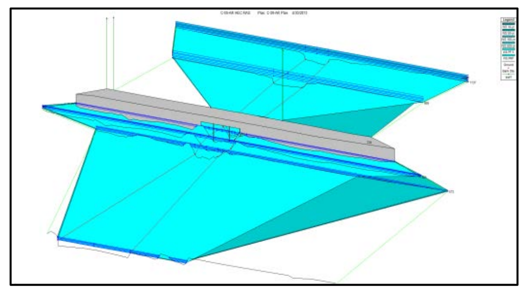


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure C-09-AR

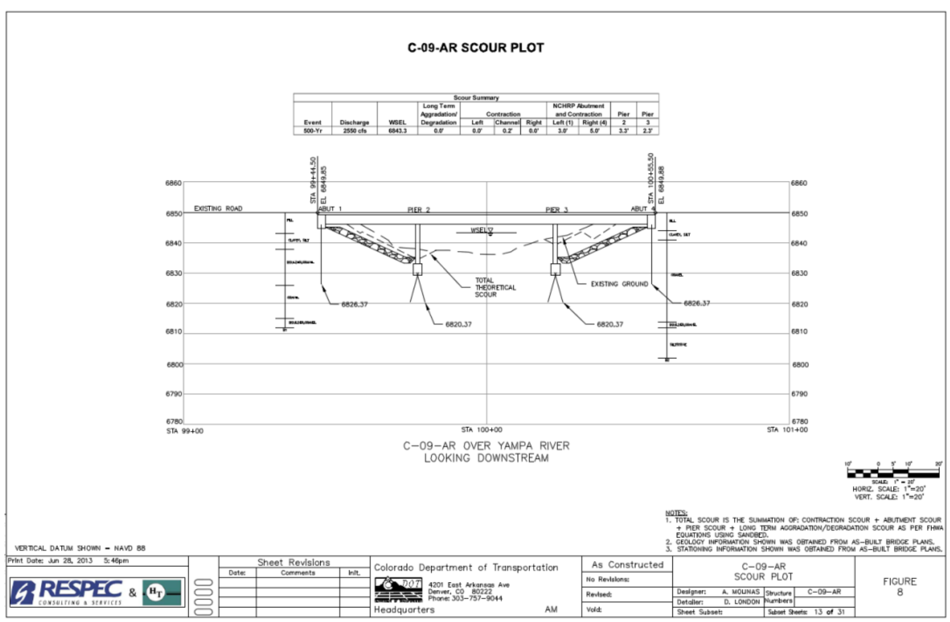


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap with upstream spur dikes were chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (both abutments and piers). Figure 5 shows an aerial image of structure C-09-AR with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

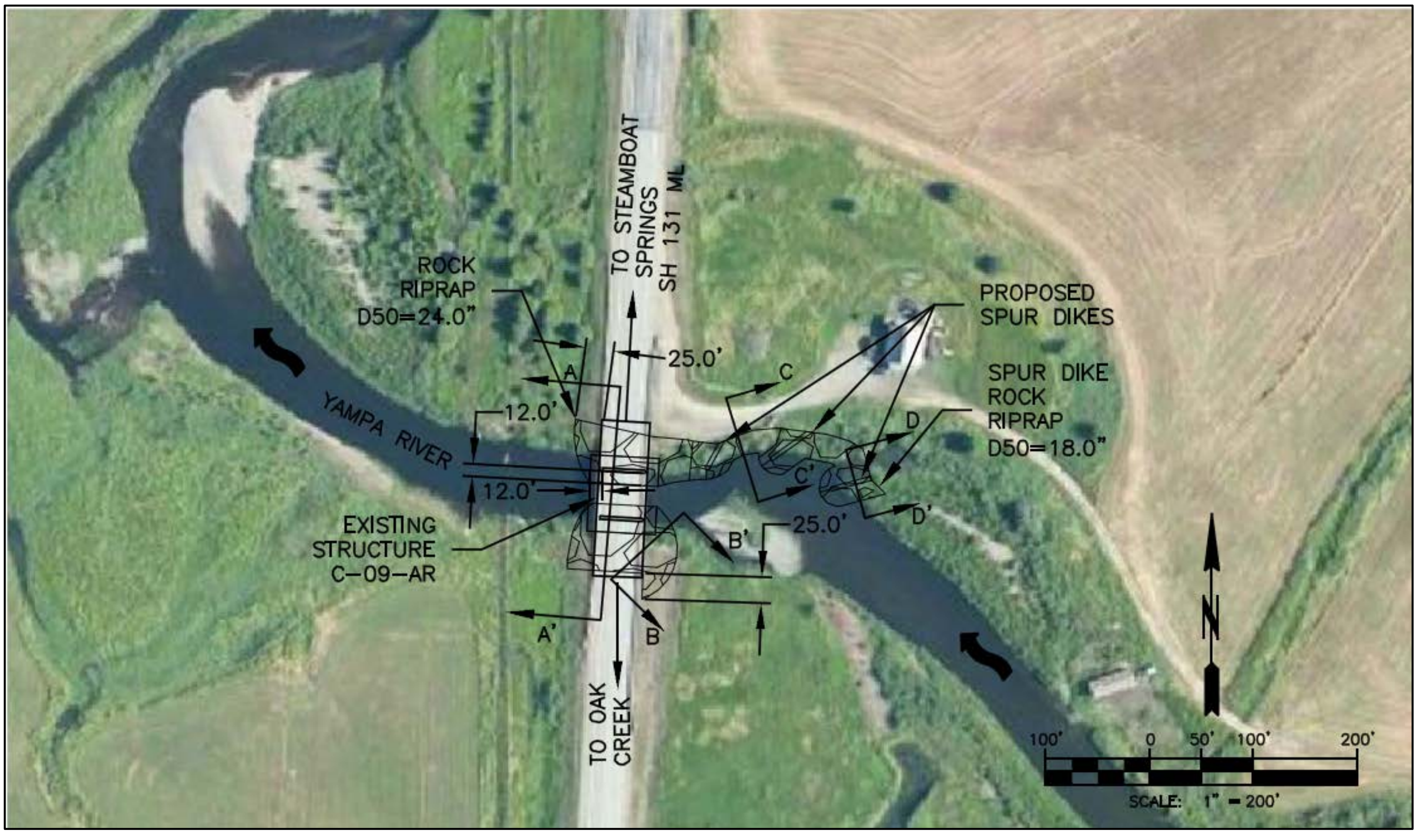


Figure 5. Plan view of Bridge C-09-AR with recommended hydraulic scour countermeasure locations

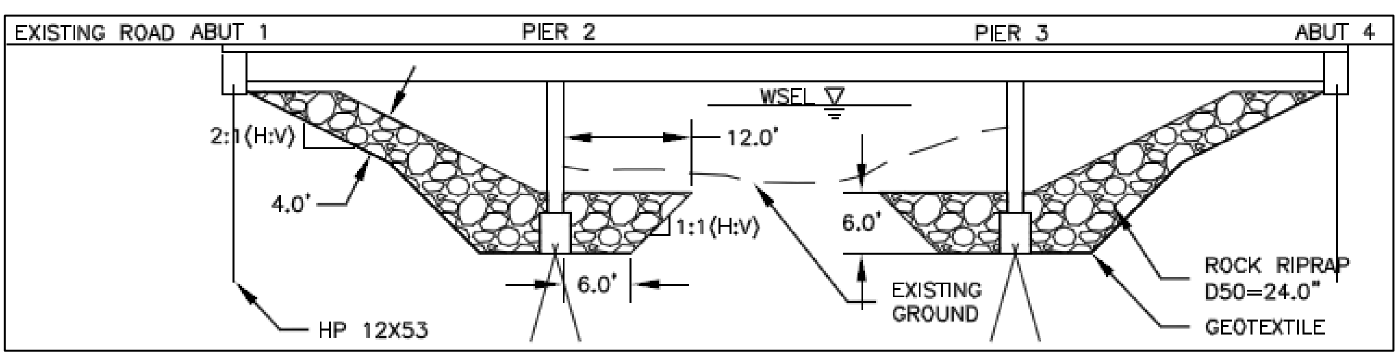


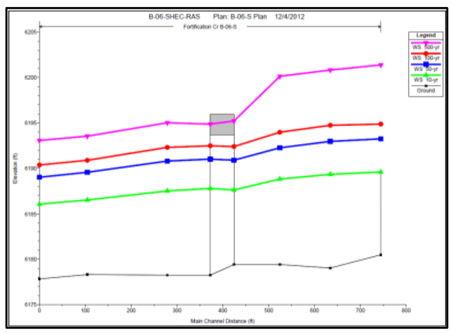
Figure 6. Cross-sectional view of Bridge C-09-AR with recommended hydraulic scour countermeasures

US HIGHWAY 40 BRIDGE B-06-S OVER FORTIFICATION CREEK, COLORADO

Bridge B-06-S is located in Moffat County on US Highway 40 ML where the highway crosses Fortification Creek. Figure 1 shows Bridge B-06-S over Fortification Creek.

Figure 1. Bridge B-06-S over Fortification Creek

Hydrau-Tech, Inc. began the POA study of Bridge B-06-S by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 7,510 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



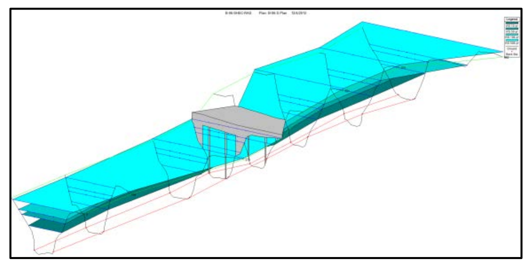


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure B-06-S

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

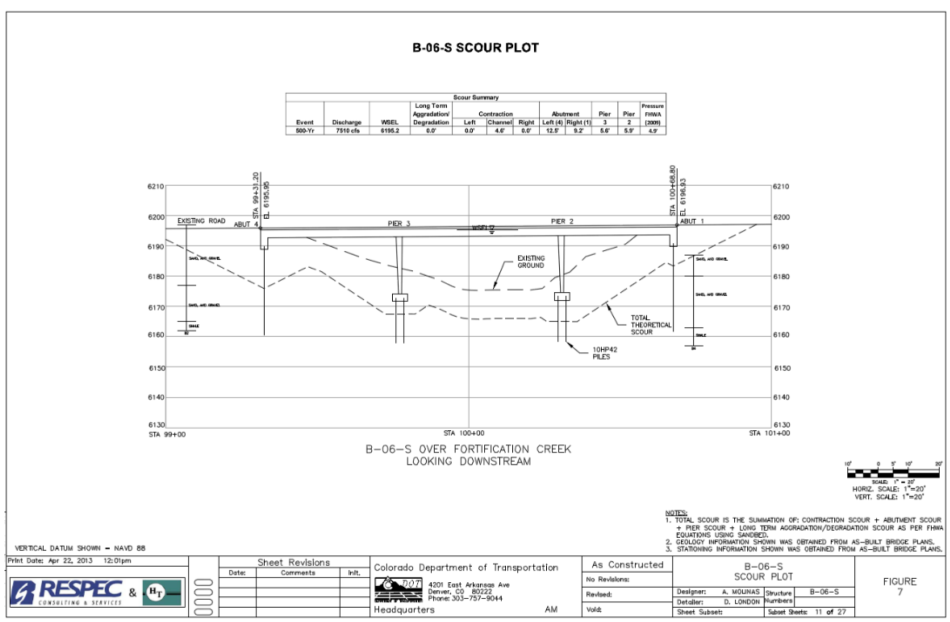


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (right abutment and pier 2). Figure 5 shows an aerial image of structure B-06-S with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge B-06-S with recommended hydraulic scour countermeasure locations

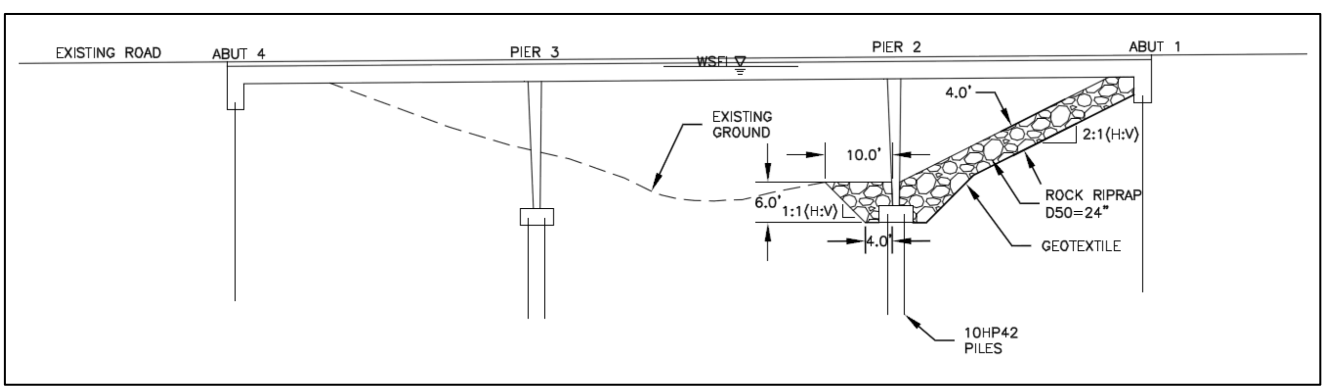


Figure 6. Cross-sectional view of Bridge B-06-S with recommended hydraulic scour countermeasures

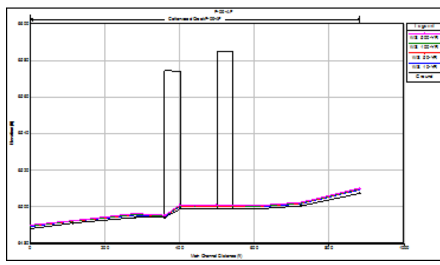
INTERSTATE 70 BRIDGE F-09-AF OVER COTTONWOOD CREEK, COLORADO

Bridge F-09-AF is located in Eagle County on Eastbound Interstate 70 ML where the interstate crosses Cottonwood Creek. Figure 1 shows Bridge F-09-AF over Cottonwood Creek.

Hydrau-Tech, Inc. began the POA study of Bridge F-09-AF by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 288 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge F-09-AF over Cottonwood Creek



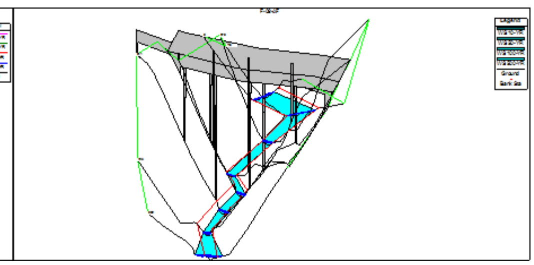


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure F-09-AF

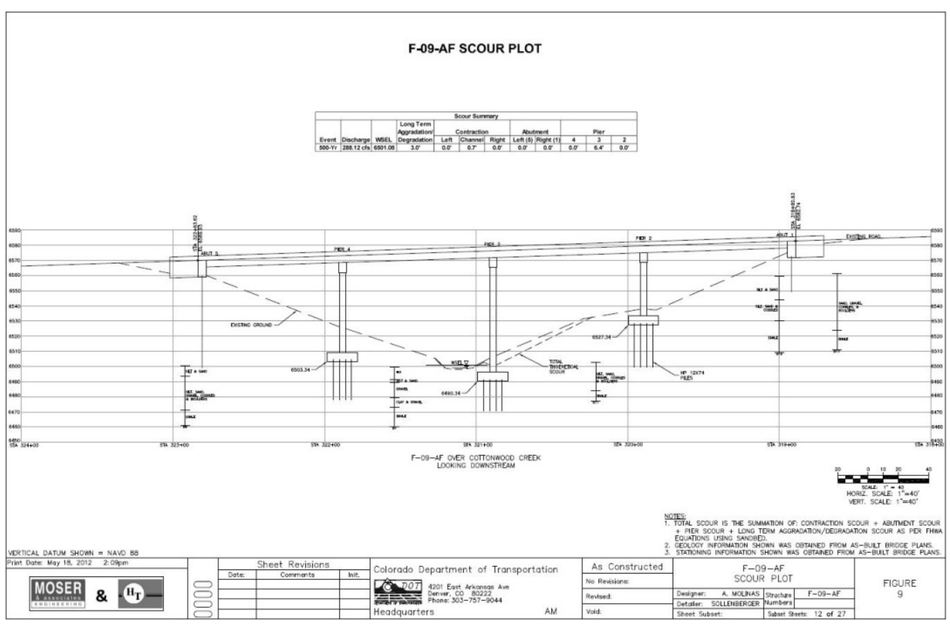


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.0 feet was used to design the pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at the critical location on the bridge (pier 3). Figure 5 shows an aerial image of structure F-09-AF with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

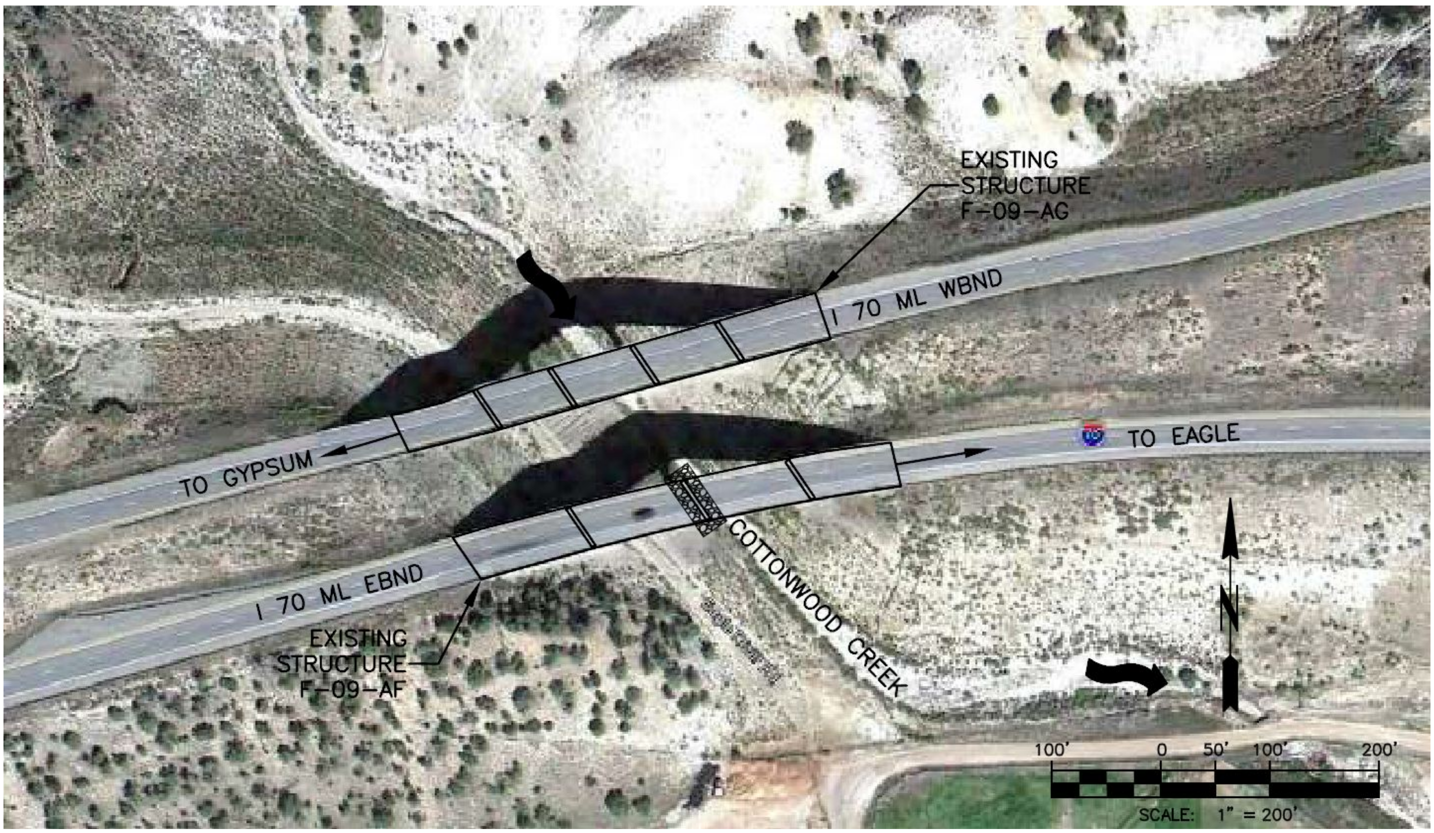


Figure 5. Plan view of Bridge F-09-AF with recommended hydraulic scour countermeasure locations

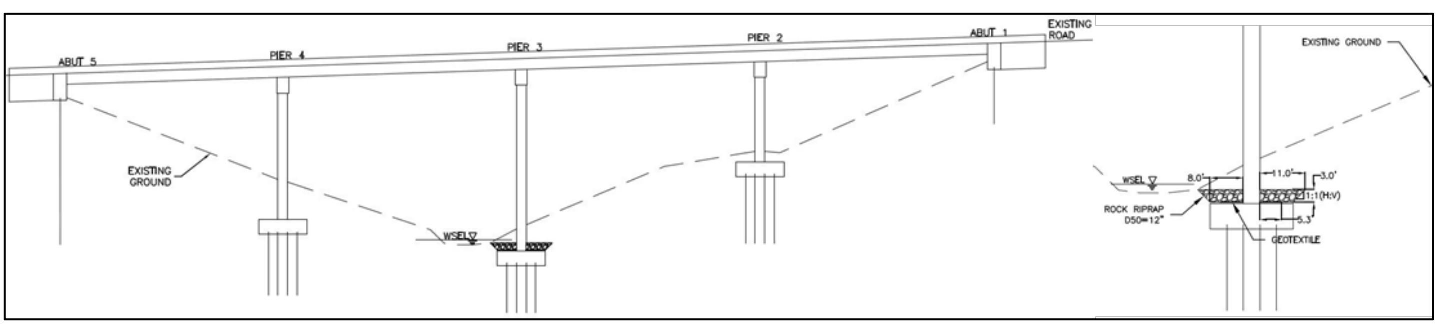


Figure 6. Cross-sectional view of Bridge F-09-AF with recommended hydraulic scour countermeasures (left) and detail of pier protection (right)

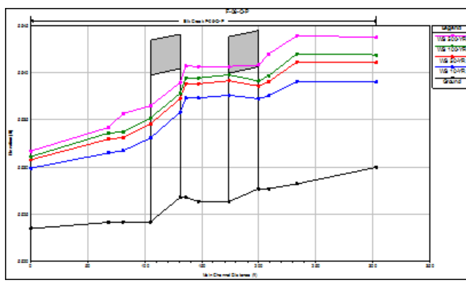
Interstate 70 Bridges F-06-O and F-06-P over Elk Creek, Colorado

Bridges F-06-O and F-06-P are located in Garfield County on Interstate 70 ML where the interstate crosses the Elk Creek. Figure 1 shows Bridges F-06-O and F-06-P over Elk Creek.

Hydrau-Tech, Inc. began the POA study of Bridges F-06-O and F-06-P by collecting information on the site and structures in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 3,410 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structures and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridges F-06-O and F-06-P over Elk Creek



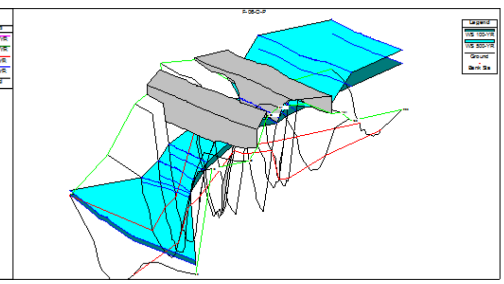


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structures F-06-O and F-06-P

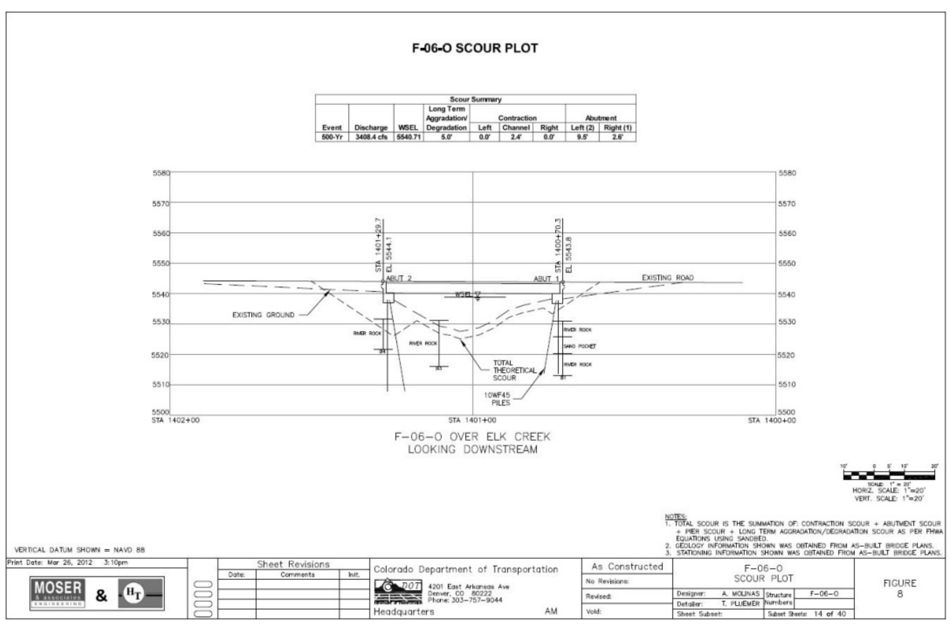


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the abutment and channel protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures along with a downstream vertical drop structure to prevent potential head cutting and affects from the Colorado River downstream. Figure 5 shows an aerial image of structures F-06-O and F-06-P with the recommended scour countermeasures. Figure 6 shows a cross-sectional view of the structures with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

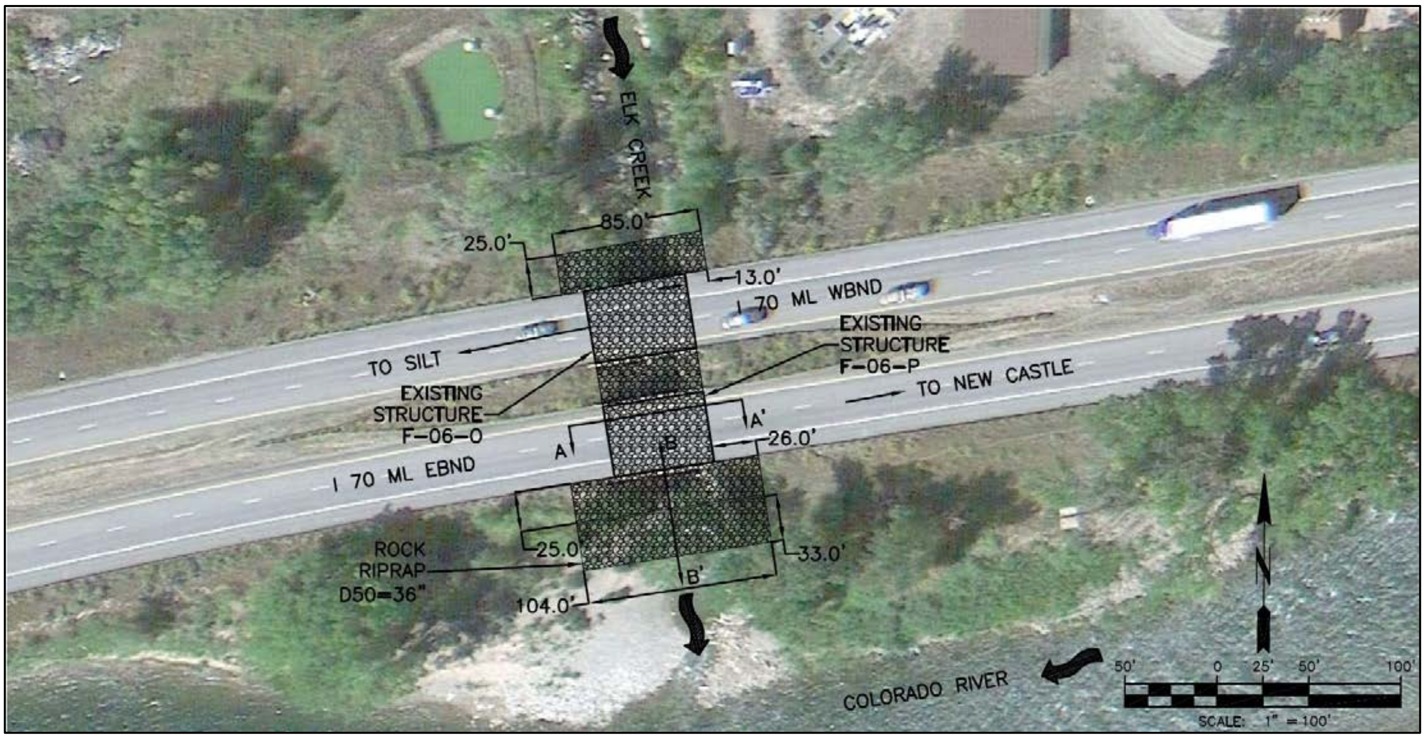


Figure 5. Plan view of Bridges F-06-O and F-06-P with recommended hydraulic scour countermeasure locations

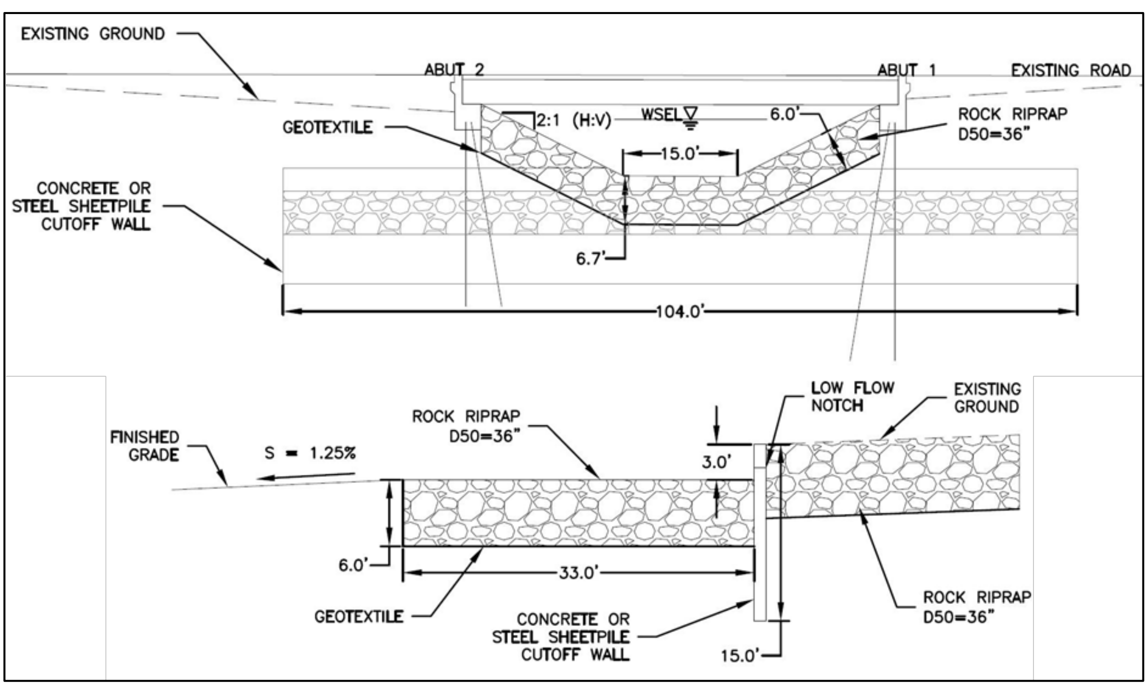


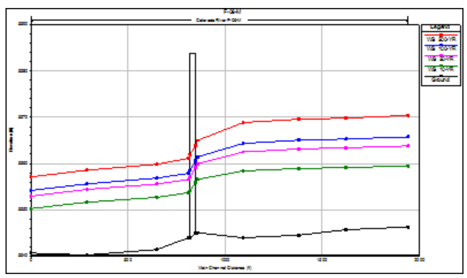
Figure 6. Cross-sectional view of recommended hydraulic scour countermeasures at Bridges F-06-O and F-06-P (above) and a profile view of the downstream drop structure (below)

INTERSTATE 70 ACCESS BRIDGE F-06-M OVER COLORADO RIVER, COLORADO

Bridge F-06-M is located in Garfield County on Interstate 70 access road where it crosses the Colorado River. Figure 1 shows Bridge F-06-M over the Colorado River.

Figure 1. Bridge F-06-M over the Colorado River

Hydrau-Tech, Inc. began the POA study of Bridge F-06-M by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. A Log Pearson III gage analysis was completed using two Colorado River gages, resulting in a 500-year flood discharge of 52,931 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



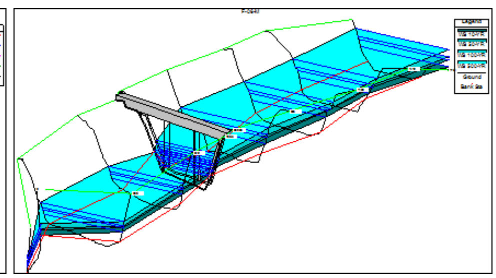


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure F-06-M

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

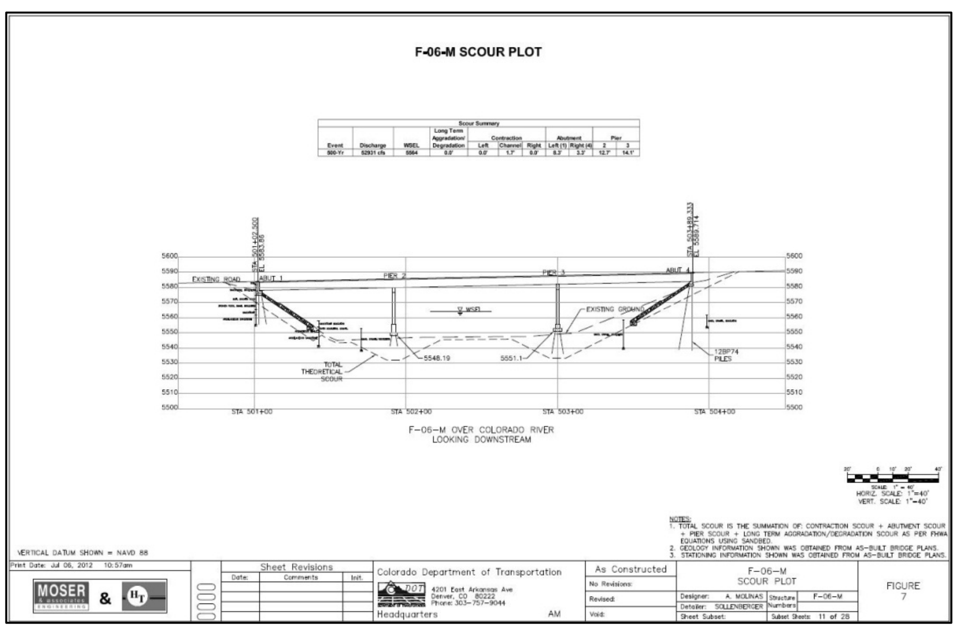


Figure 3. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap replenishment and pile cap extensions with attached caissons was chosen as the preferred hydraulic scour and structural stability countermeasure. Abutment riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the abutment protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the abutments on the bridge. Figure 5 shows an aerial image of structure F-06-M with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

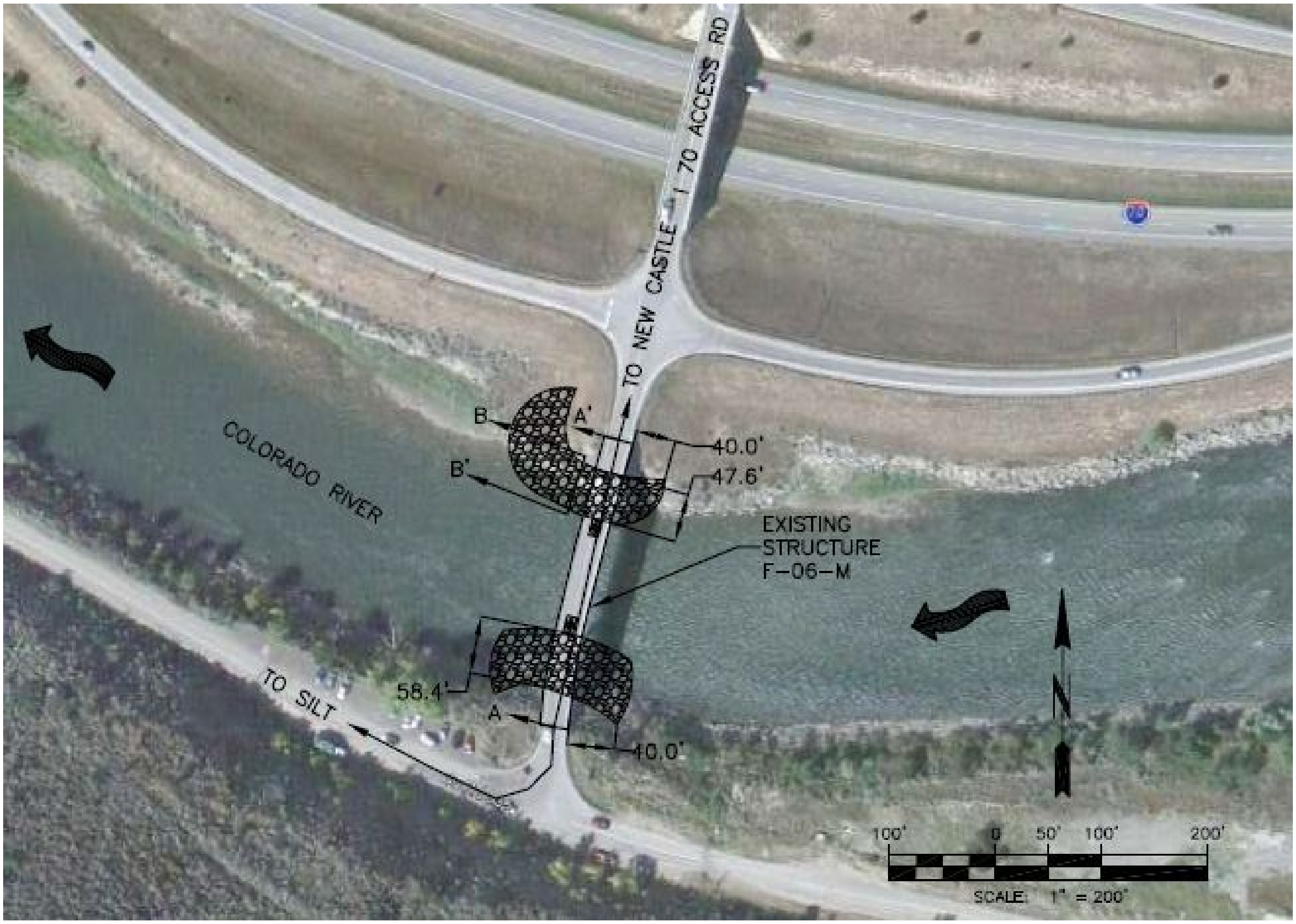


Figure 5. Plan view of Bridge F-06-M with recommended hydraulic scour countermeasure locations

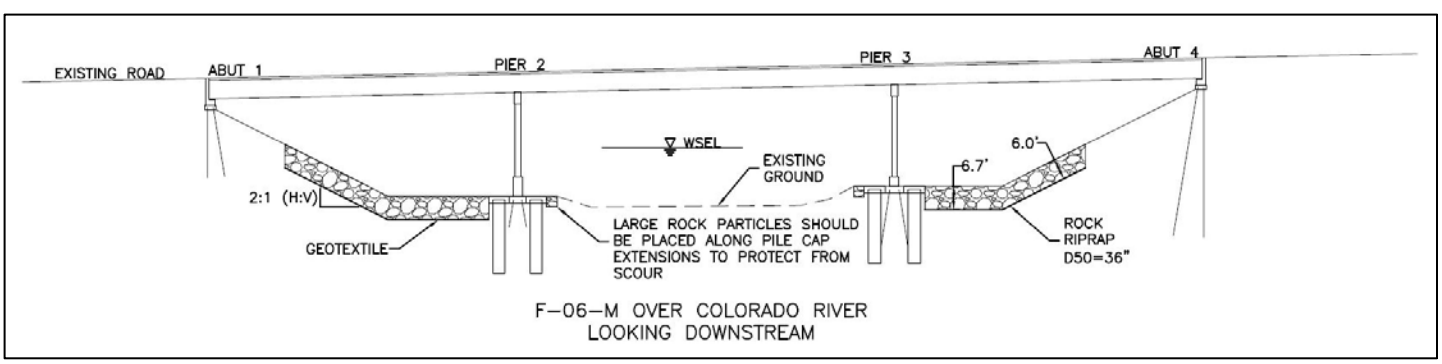


Figure 6. Cross-sectional view of Bridge F-06-M with recommended hydraulic scour countermeasures

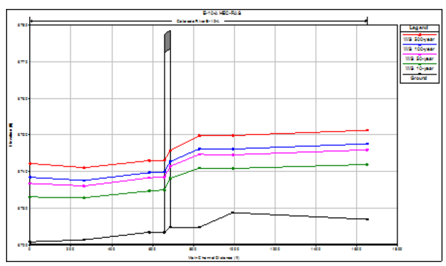
State Highway 131 Bridge E-10-A Over Colorado River, Colorado

Bridge E-10-A is located in Eagle County on State Highway 131 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge E-10-A over the Colorado River.

Hydrau-Tech, Inc. began the POA study of Bridge E-10-A by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 45,146 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge E-10-A over the Colorado River



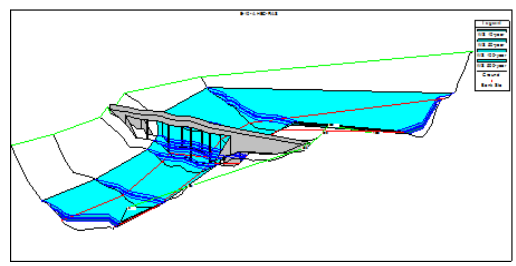


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure E-10-A

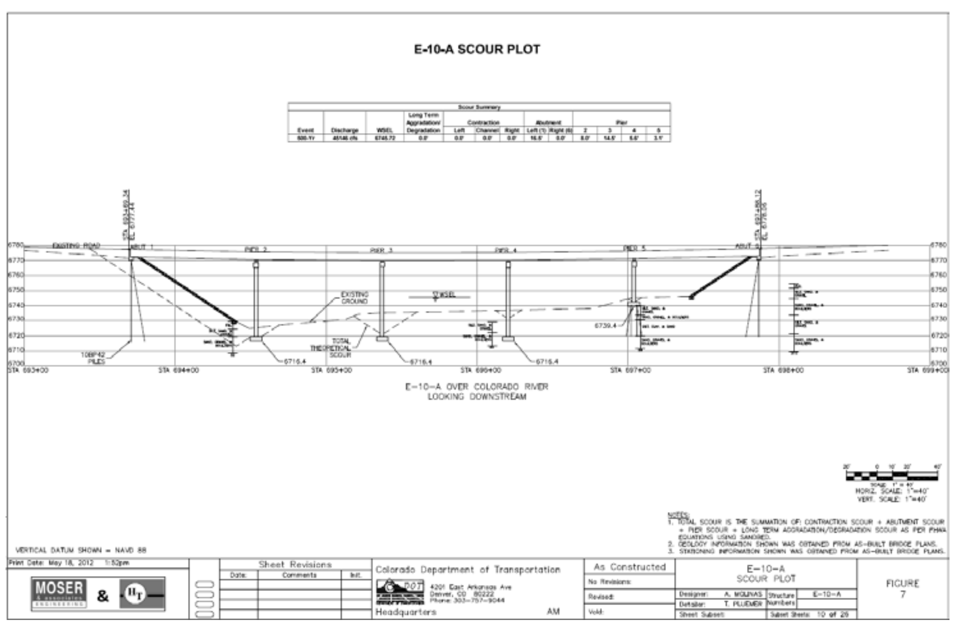


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, and pier 4). Figure 5 shows an aerial image of structure E-10-A with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

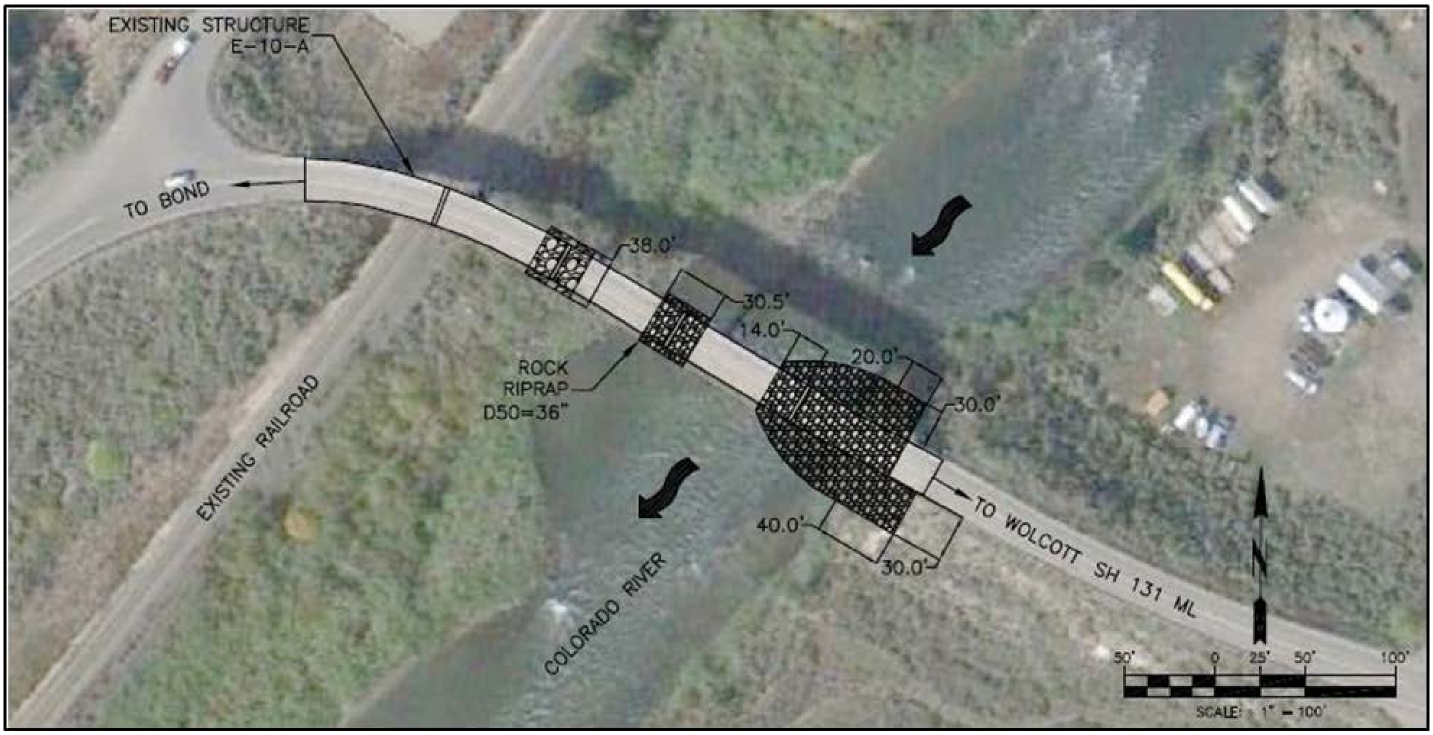


Figure 5. Plan view of Bridge E-10-A with recommended hydraulic scour countermeasure locations

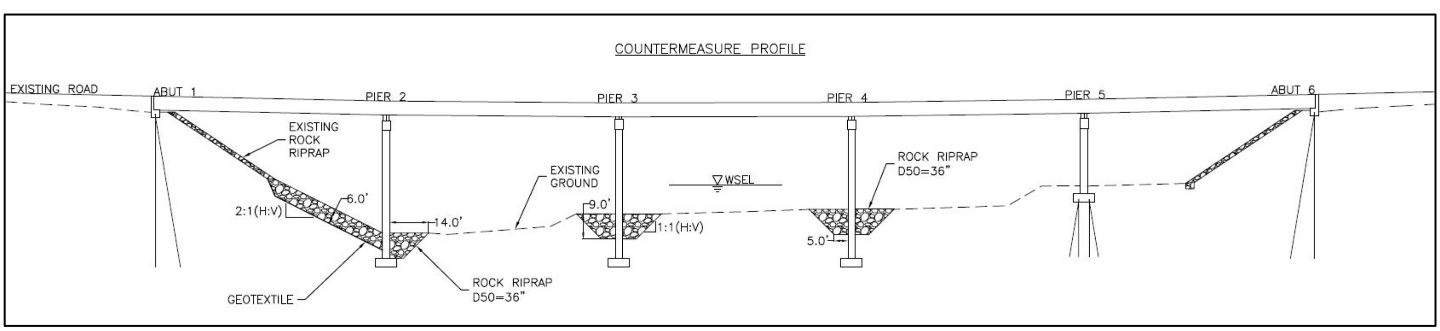


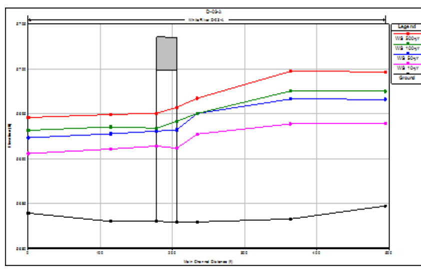
Figure 6. Cross-sectional view of Bridge E-10-A with recommended hydraulic scour countermeasures

STATE HIGHWAY 64 BRIDGE D-03-A OVER WHITE RIVER, COLORADO

Bridge D-03-A is located in Rio Blanco County on State Highway 64 ML where the highway crosses the White River. Figure 1 shows Bridge D-03-A over the White River.

Figure 1. Bridge D-03-A over the White River

Hydrau-Tech, Inc. began the POA study of Bridge D-03-A by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 21,400 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



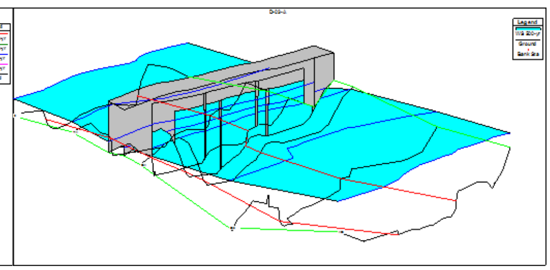


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure D-03-A

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

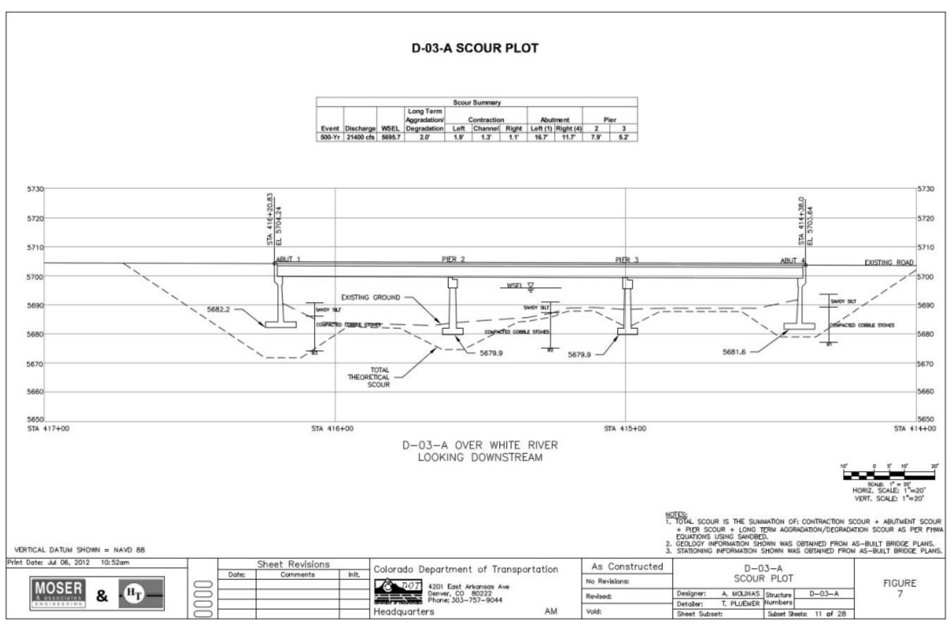


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the abutment and pier 3 protection. Riprap with a median grain size diameter of 2.0 feet was used on pier 2 along with sheet pile protection around the riprap. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, and pier 4). A guide bank was designed for Abutment 1 extending 220.0 feet upstream of the structure to help prevent shifting of the river that has been seen in the past. Due to the costs involved and the current condition of the structure, it was recommended that Bridge D-03-A be replaced entirely. Figure 5 shows an aerial image of structure D-03-A with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

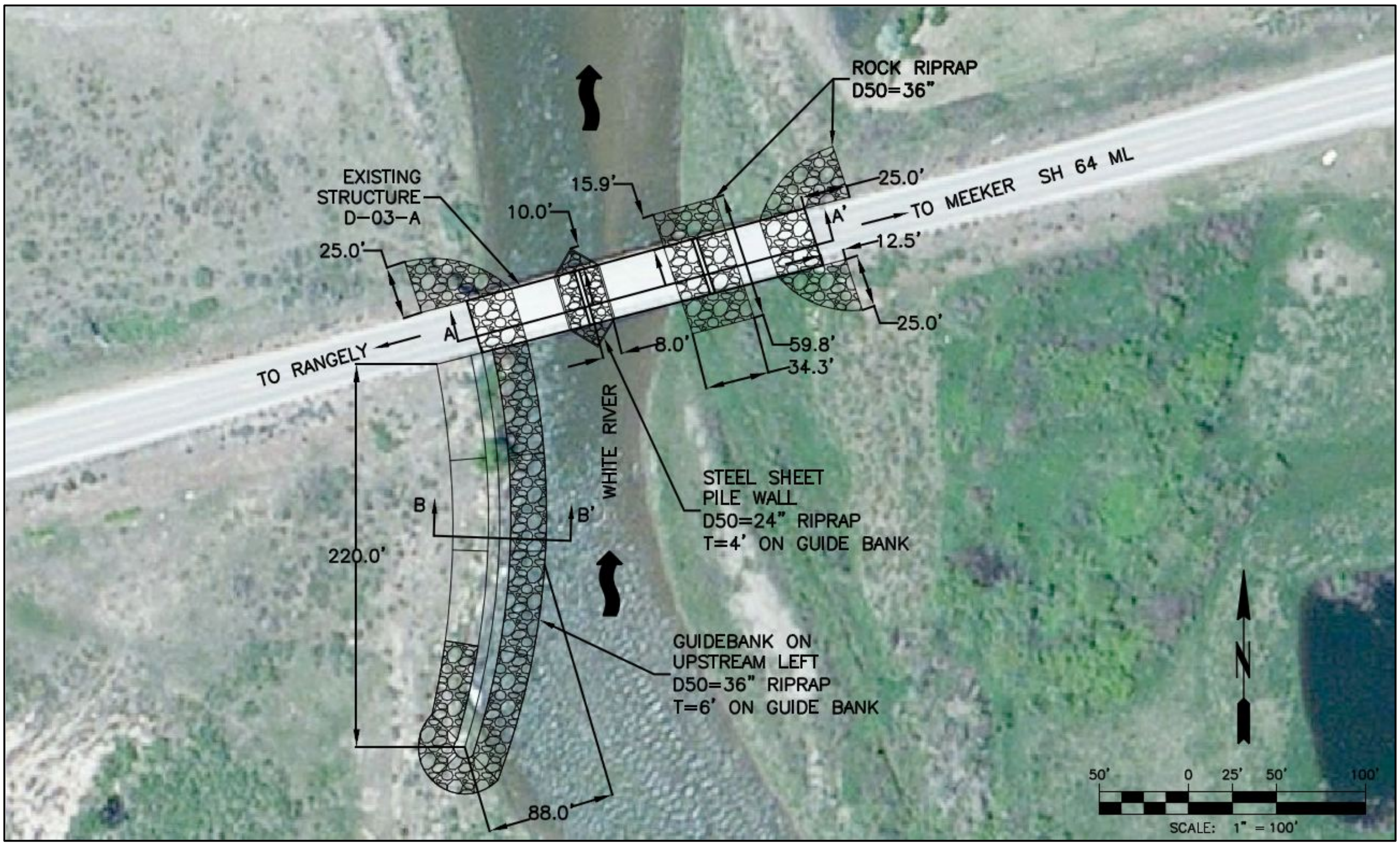


Figure 5. Plan view of Bridge D-03-A with designed hydraulic scour countermeasure locations

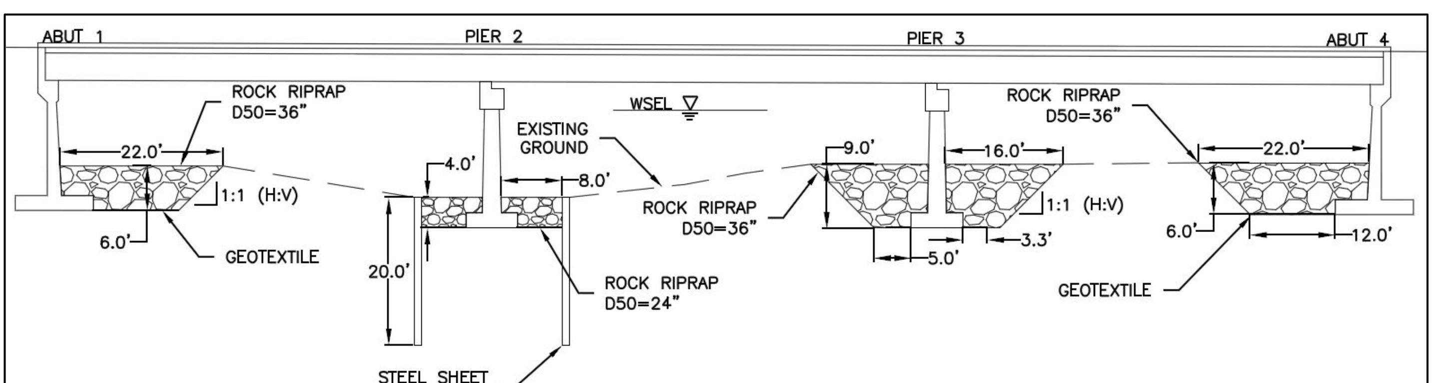


Figure 6. Cross-sectional view of Bridge D-03-A with designed hydraulic scour countermeasures

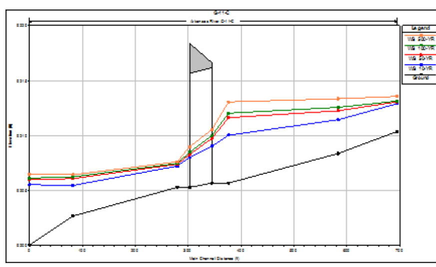
STATE HIGHWAY 24 BRIDGE G-11-C OVER THE EAST FORK ARKANSAS RIVER, COLORADO

Bridge G-11-C is located in Lake County on State Highway 24 ML where the highway crosses the East Fork Arkansas River. Figure 1 shows Bridge G-11-C over the East Fork Arkansas River.

Hydrau-Tech, Inc. began the POA study of Bridge G-11-C by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 1,070 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge G-11-C over the East Fork Arkansas River



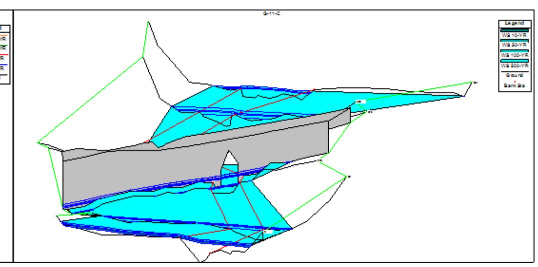


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-11-C

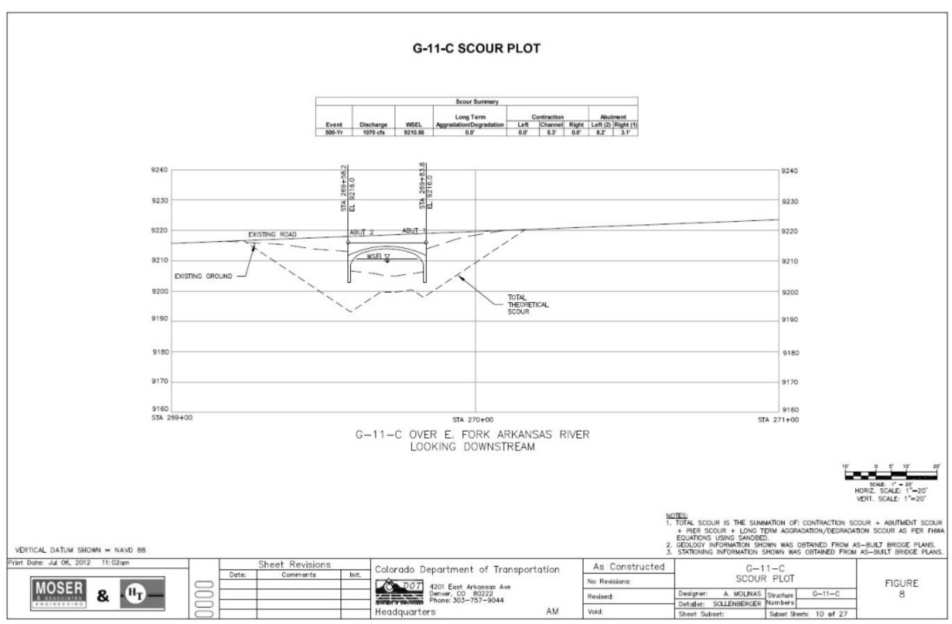


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Channel and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and channel protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (abutments, channel and upstream and downstream embankments). Figure 5 shows an aerial image of structure G-11-C with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

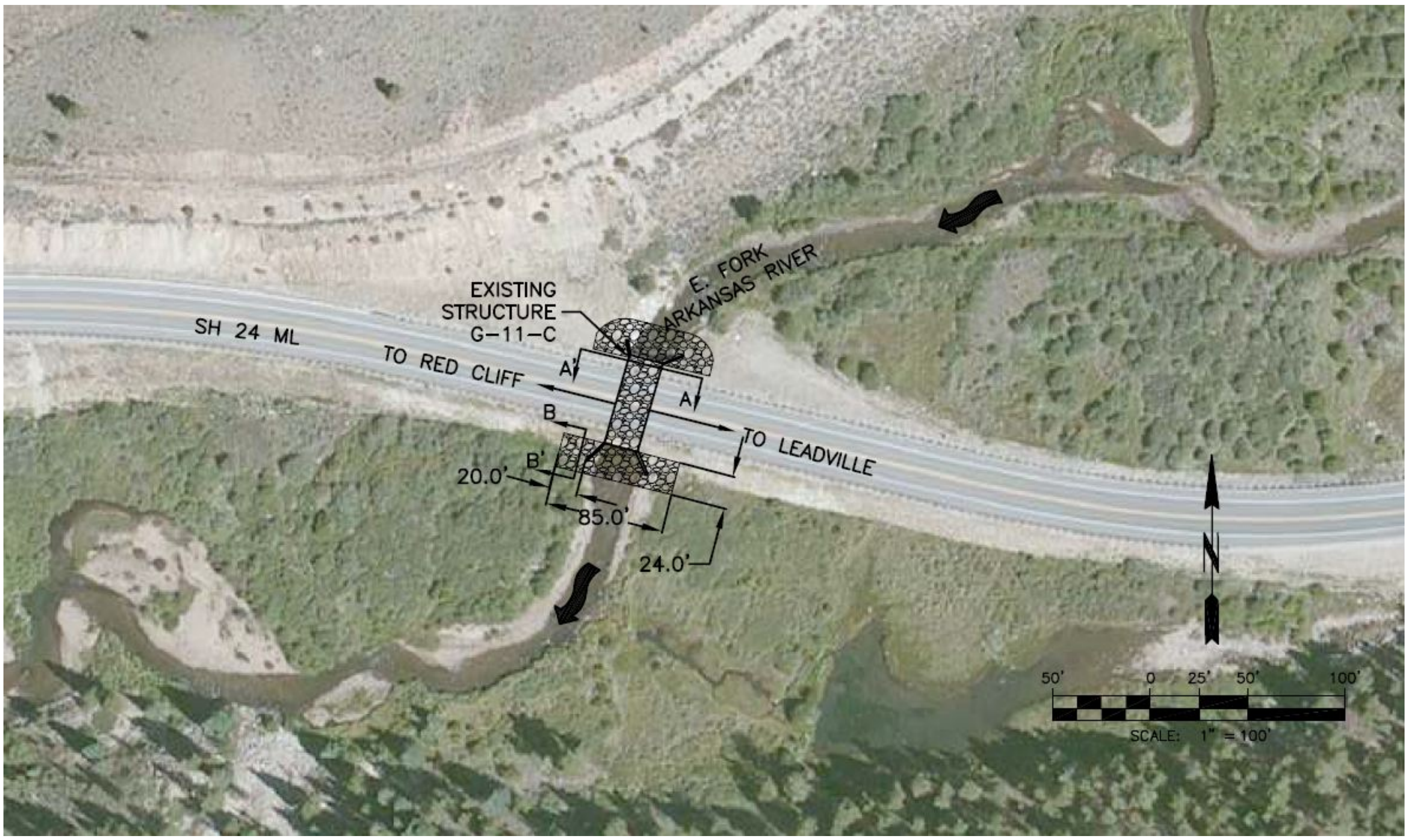


Figure 5. Plan view of Bridge G-11-C with recommended hydraulic scour countermeasure locations

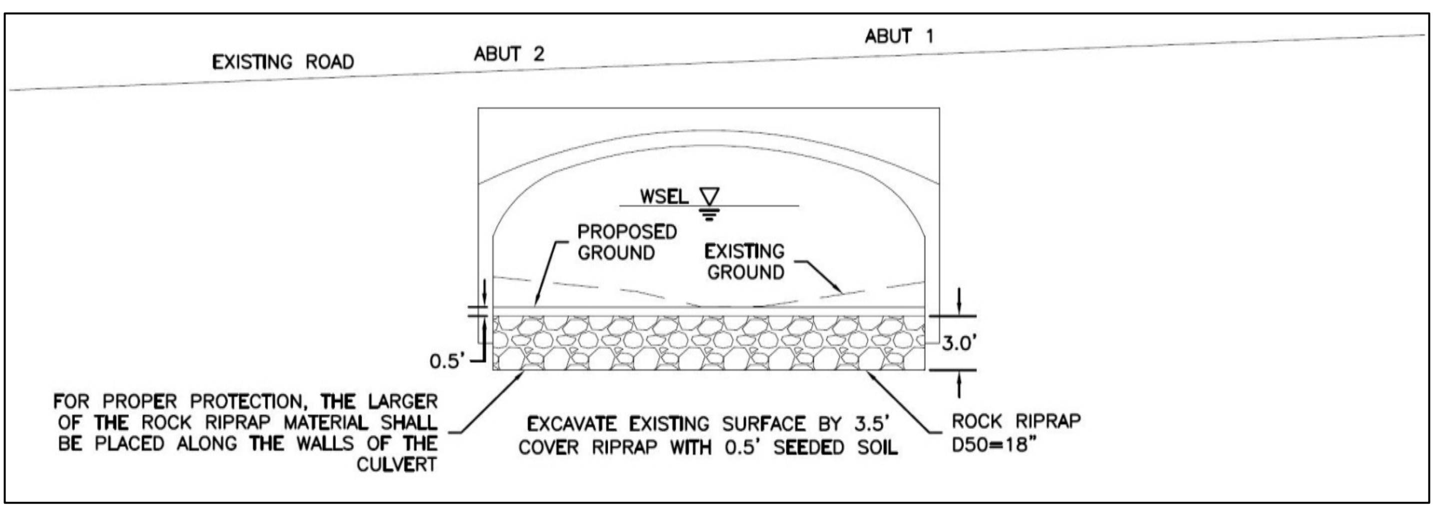


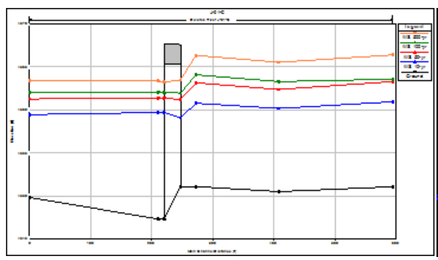
Figure 6. Cross-sectional view of Bridge G-11-C with recommended hydraulic scour countermeasures

State Highway 141 Bridge J-01-C Over the Dolores River, Colorado

Bridge J-01-C is located in Mesa County on State Highway 141 ML where the highway crosses the Dolores River. Figure 1 shows Bridge J-01-C over the Dolores River.

Figure 1. Bridge J-01-C over the Dolores River

Hydrau-Tech, Inc. began the POA study of Bridge J-01-C by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 25,936 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



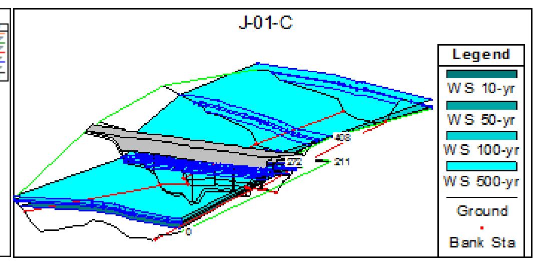


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure J-01-C

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

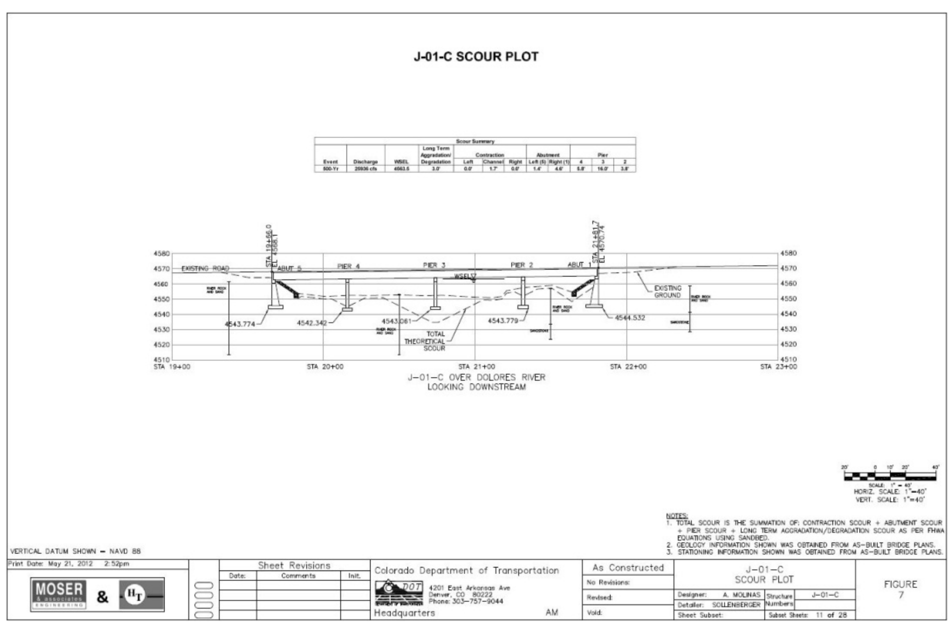


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at the critical location on the bridge (pier 3). Figure 5 shows an aerial image of structure J-01-C with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

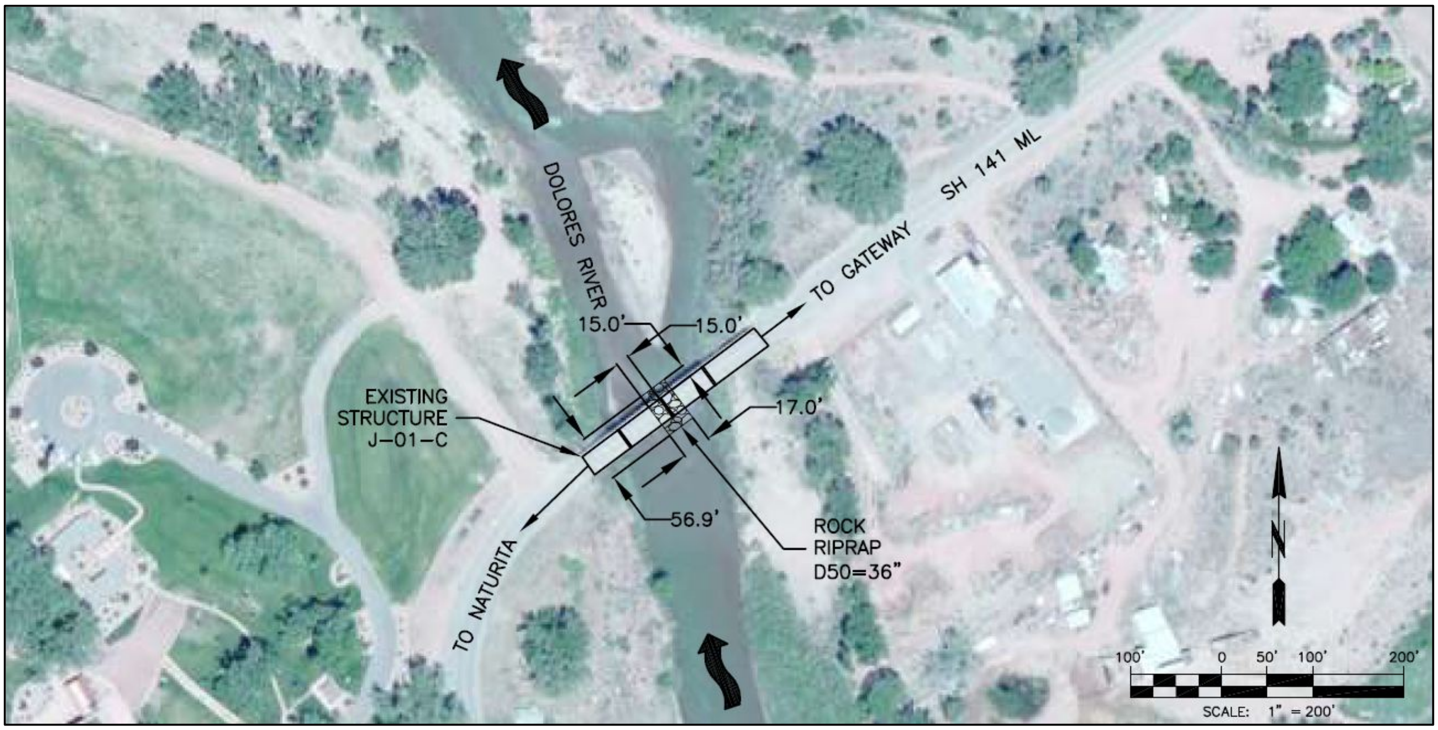


Figure 5. Plan view of Bridge J-01-C with recommended hydraulic scour countermeasure locations

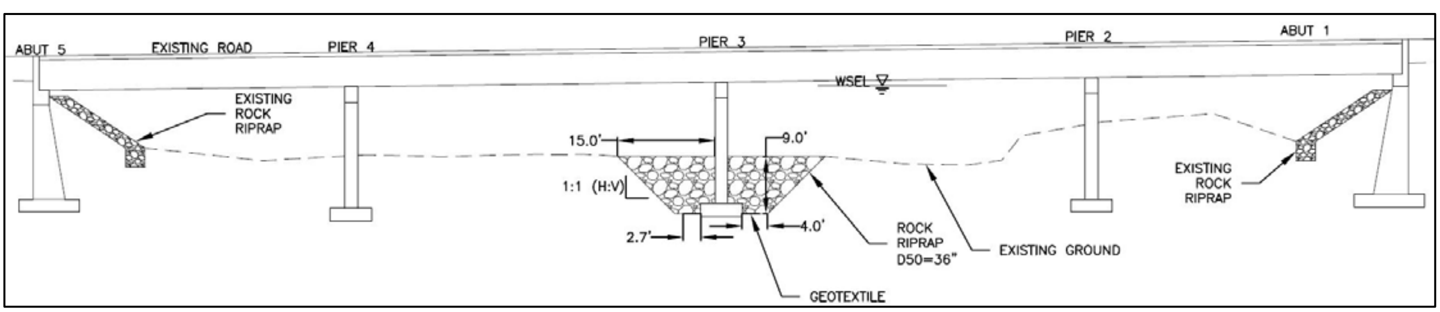


Figure 6. Cross-sectional view of Bridge J-01-C with recommended hydraulic scour countermeasures

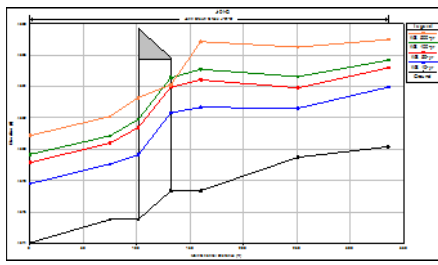
STATE HIGHWAY 141 BRIDGE J-01-D OVER JOHN BROWN CREEK, COLORADO

Bridge J-0-D is located in Mesa County on State Highway 141 ML where the highway crosses John Brown Creek. Figure 1 shows Bridge J-01-D over John Brown Creek.

Hydrau-Tech, Inc. began the POA study of Bridge J-01-D by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 2,080 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge J-01-D over John Brown Creek



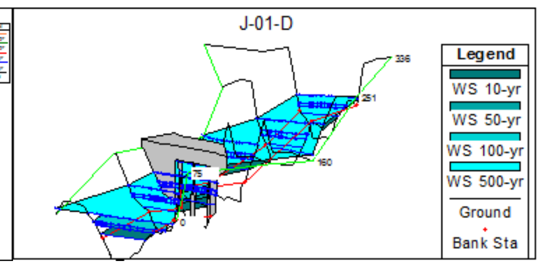


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure J-01-D

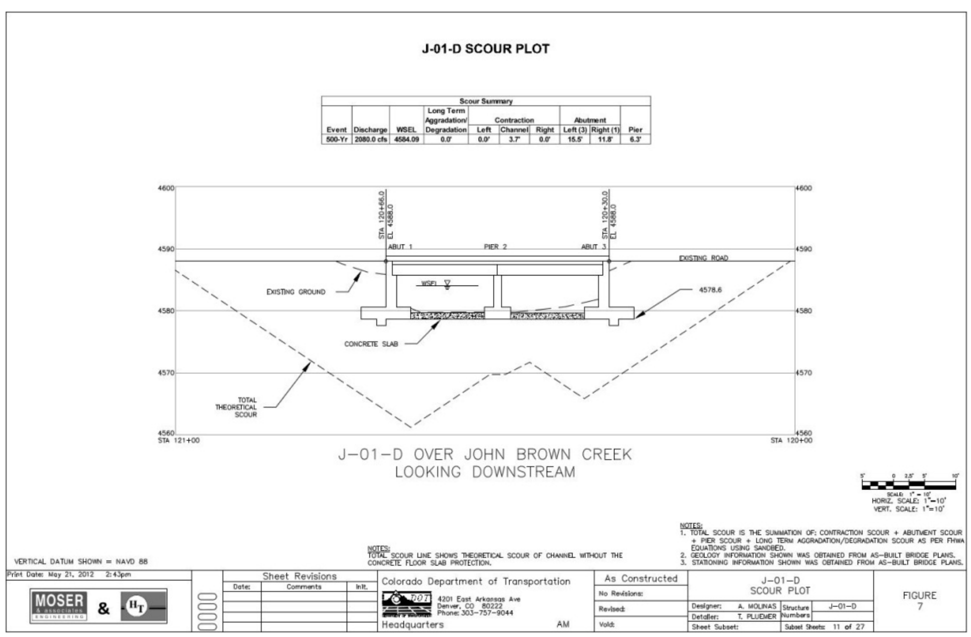


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. A Vertical downstream drop structure was chosen as the preferred hydraulic scour countermeasure. Pier riprap sizing for the drop structure was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.0 feet was used to design drop structure protection. Using the guidelines in HEC-23 for drop structure design, Hydrau-Tech, Inc. developed a preliminary drop structure design downstream of the bridge. Figure 5 shows an aerial image of structure J-01-D with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

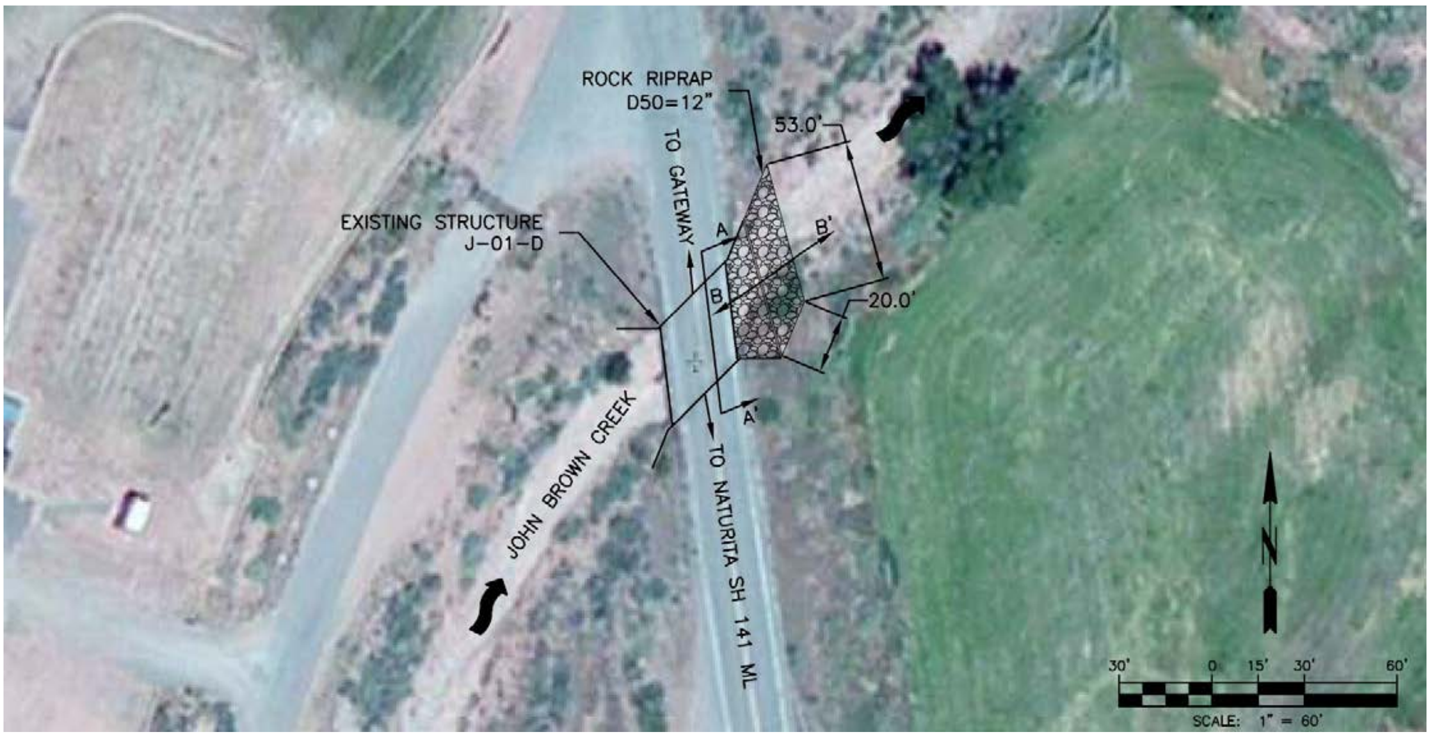


Figure 5. Plan view of Bridge J-01-D with recommended hydraulic scour countermeasure location

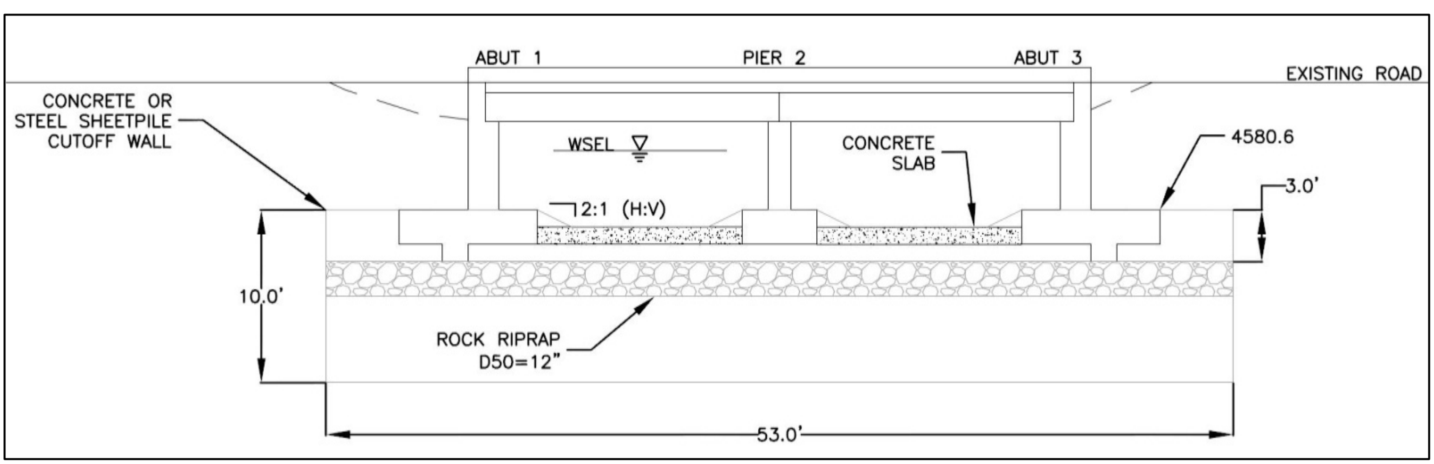


Figure 6. Cross-sectional view of Bridge J-01-D with recommended hydraulic scour countermeasure

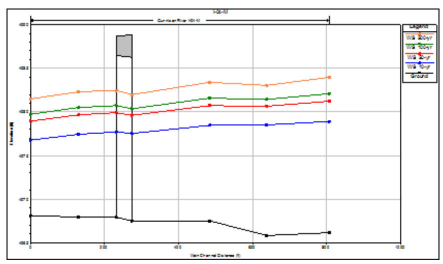
State Highway 65 Bridge I-04-M over the Gunnison River, Colorado

Bridge I-04-M is located in Delta County on State Highway 65 ML where the highway crosses the Gunnison River. Figure 1 shows Bridge I-04-M over the Gunnison River.

Hydrau-Tech, Inc. began the POA study of Bridge I-04-M by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 35,258 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge I-04-M over the Gunnison River



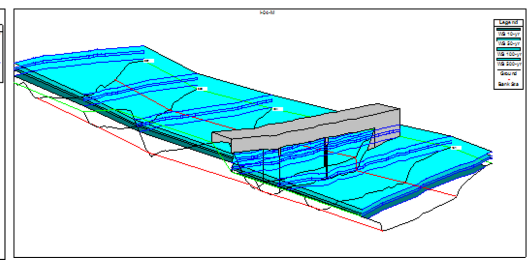


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure I-04-M

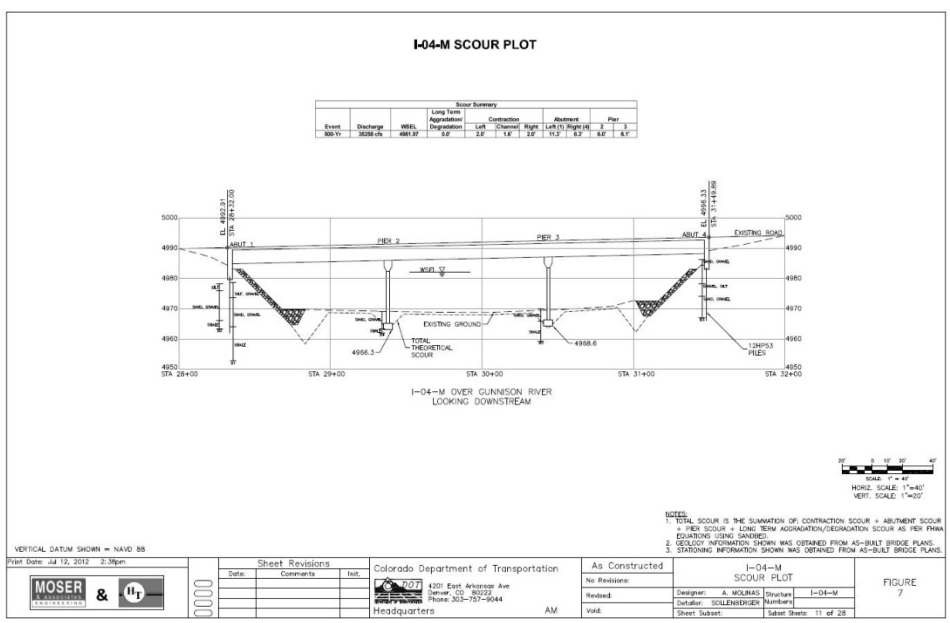


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the pier protection and riprap with a median grain size diameter of 1.5 feet was used to design the abutment protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (abutments and piers). Figure 5 shows an aerial image of structure I-04-M with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

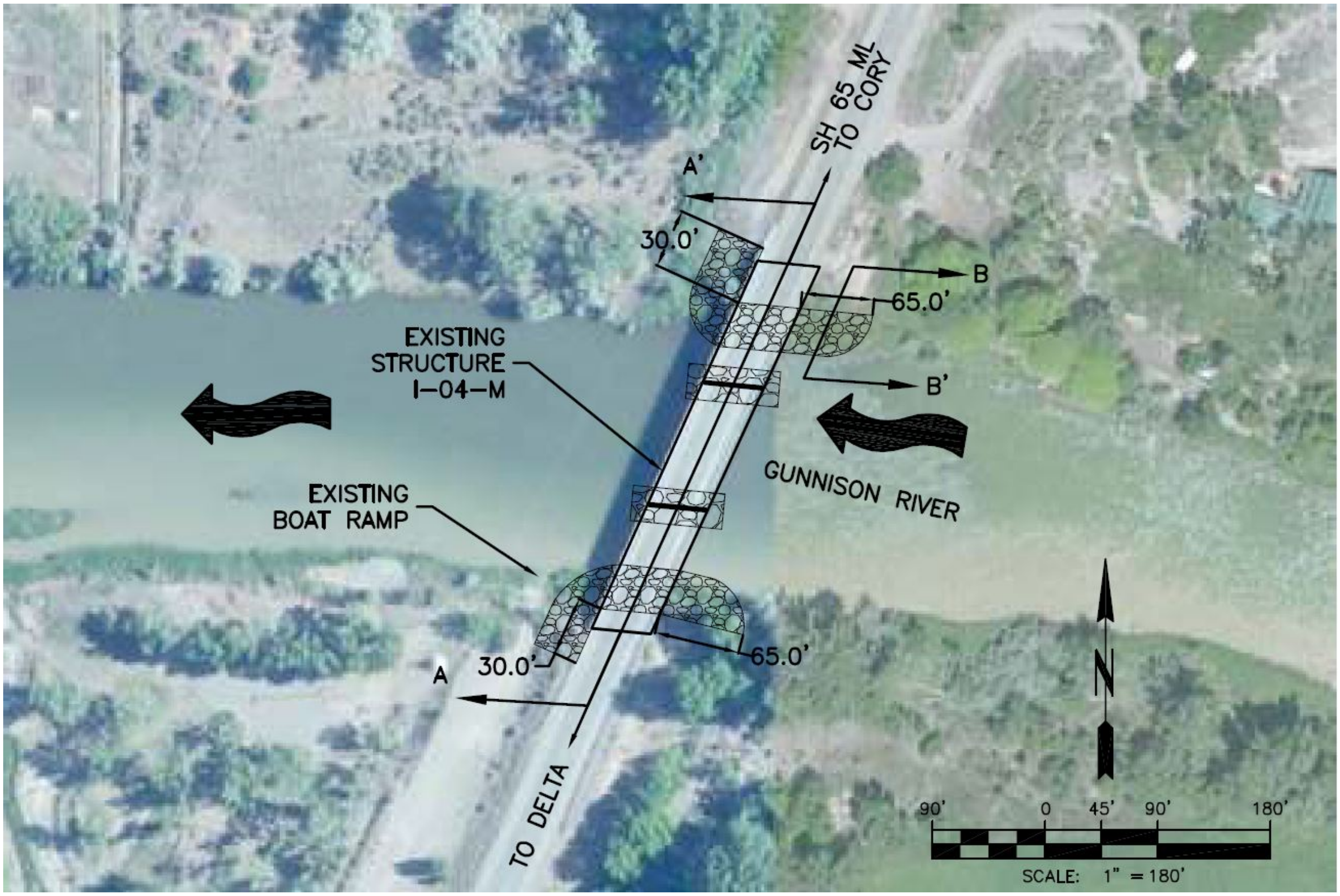


Figure 5. Plan view of Bridge I-04-M with recommended hydraulic scour countermeasure locations

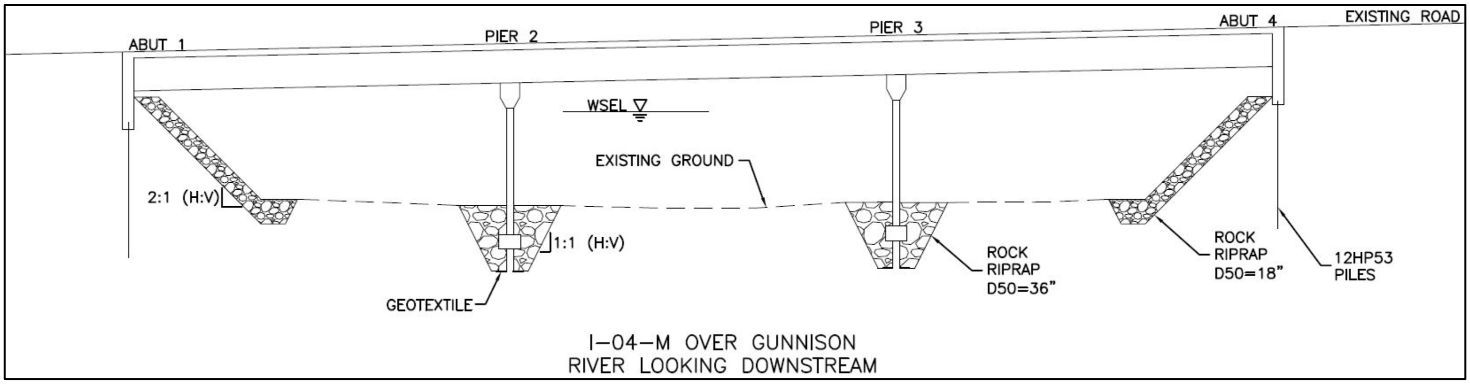


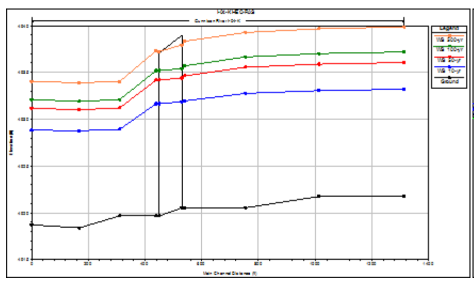
Figure 6. Cross-sectional view of Bridge I-04-M with recommended hydraulic scour countermeasures

US HIGHWAY 50 BRIDGE I-04-K OVER THE GUNNISON RIVER, COLORADO

Bridge I-04-K is located in Delta County on US Highway 50 ML where the highway crosses the Gunnison River. Figure 1 shows Bridge I-04-K over the Gunnison River.

Figure 1. Bridge I-04-K over the Gunnison River

Hydrau-Tech, Inc. began the POA study of Bridge I-04-K by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 35,258 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



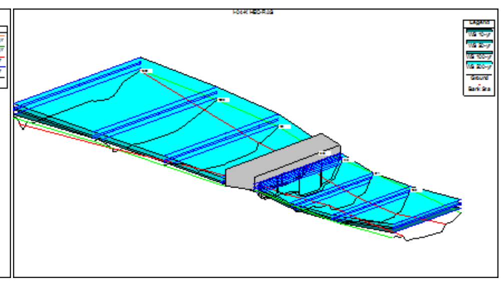


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure I-04-K

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

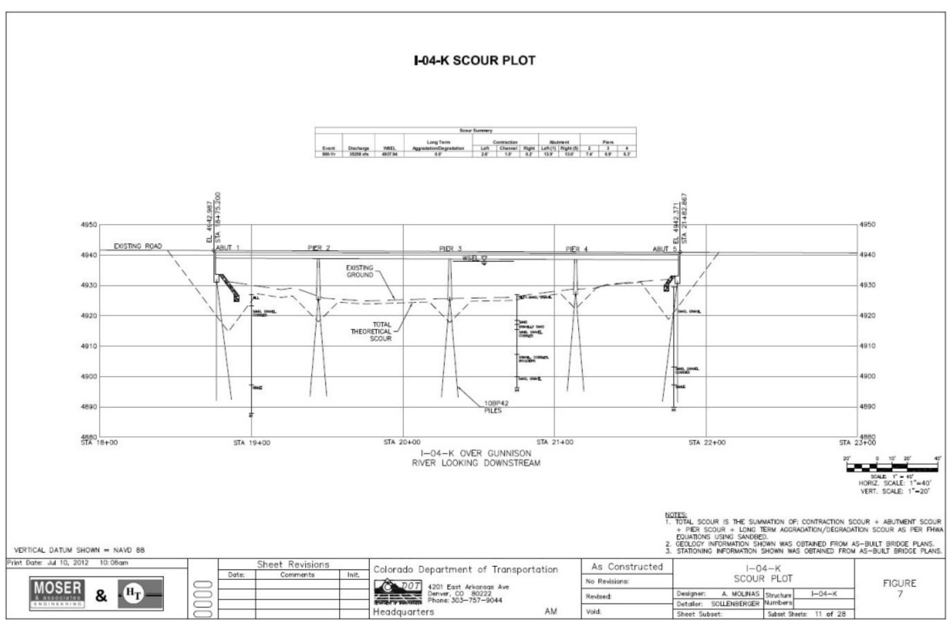


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the pier protection and riprap with a median grain size diameter of 1.0 feet was used to design the abutment protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (both abutments and piers). Figure 5 shows an aerial image of structure I-04-K with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

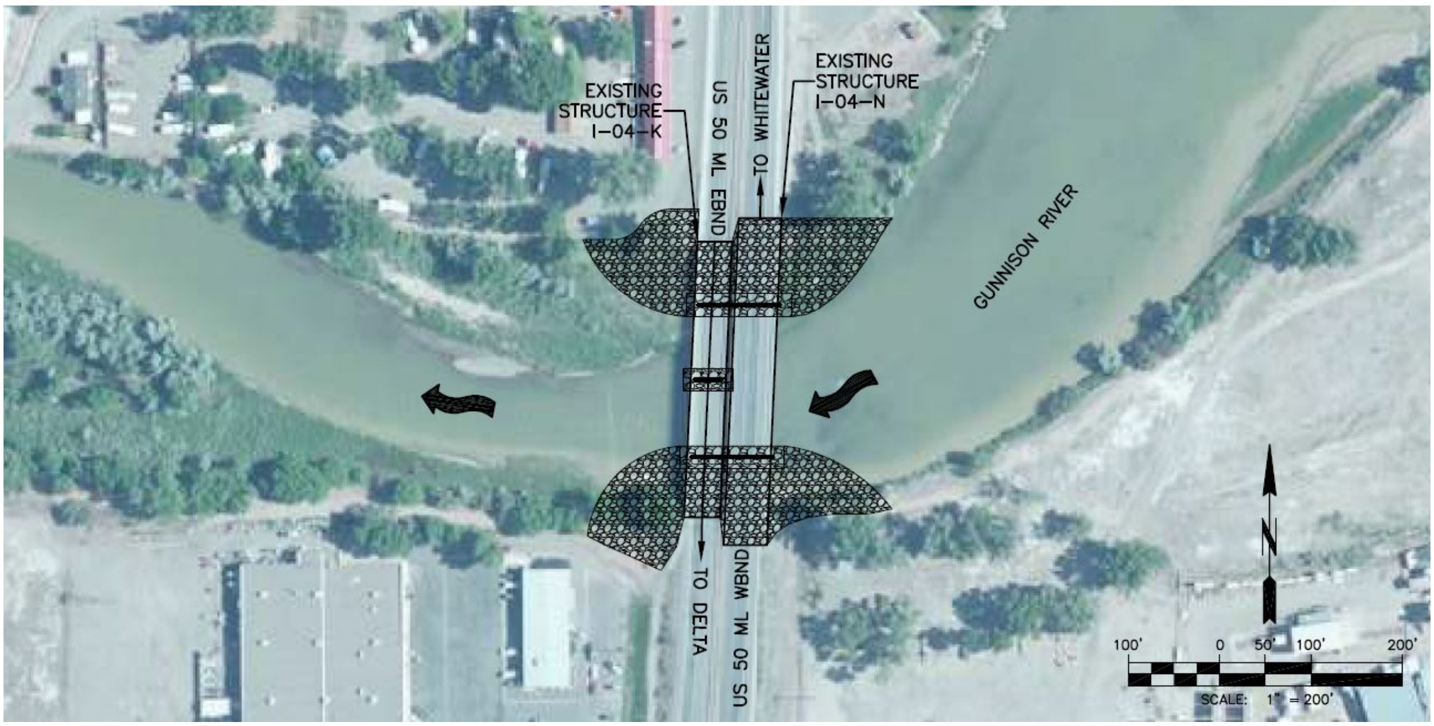


Figure 5. Plan view of Bridge I-04-K with recommended hydraulic scour countermeasure locations

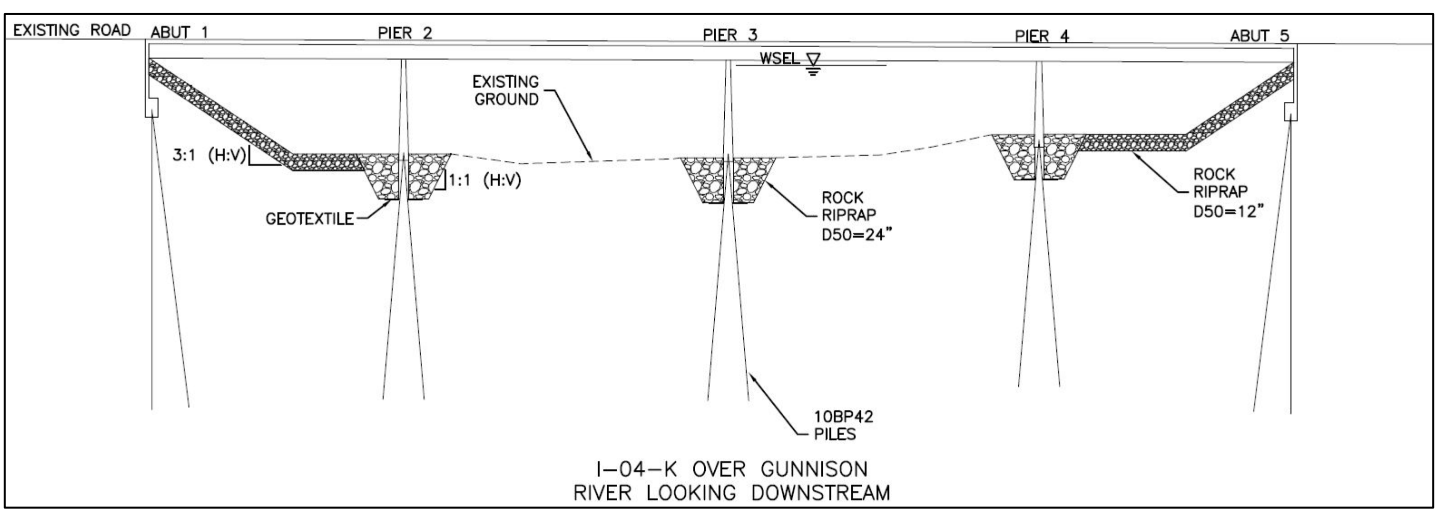


Figure 6. Cross-sectional view of Bridge I-04-K with recommended hydraulic scour countermeasures

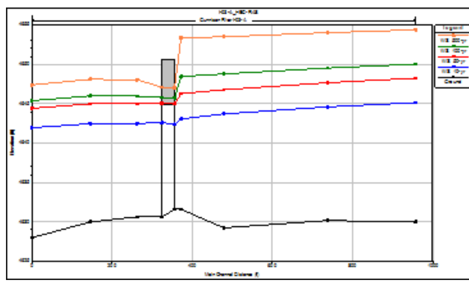
STATE HIGHWAY 141 BRIDGE I-03-A OVER THE GUNNISON RIVER, COLORADO

Bridge I-03-A is located in Mesa County on State Highway 141 ML where the highway crosses the Gunnison River. Figure 1 shows Bridge I-03-A over the Gunnison River.

Hydrau-Tech, Inc. began the POA study of Bridge I-03-A by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 49,970 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge I-03-A over the Gunnison River



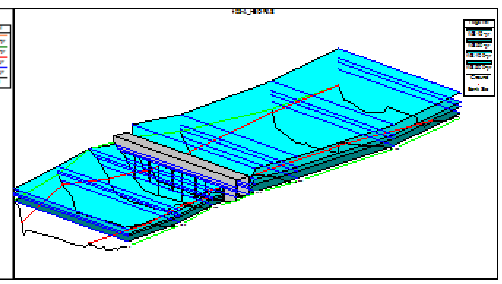


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure I-03-A

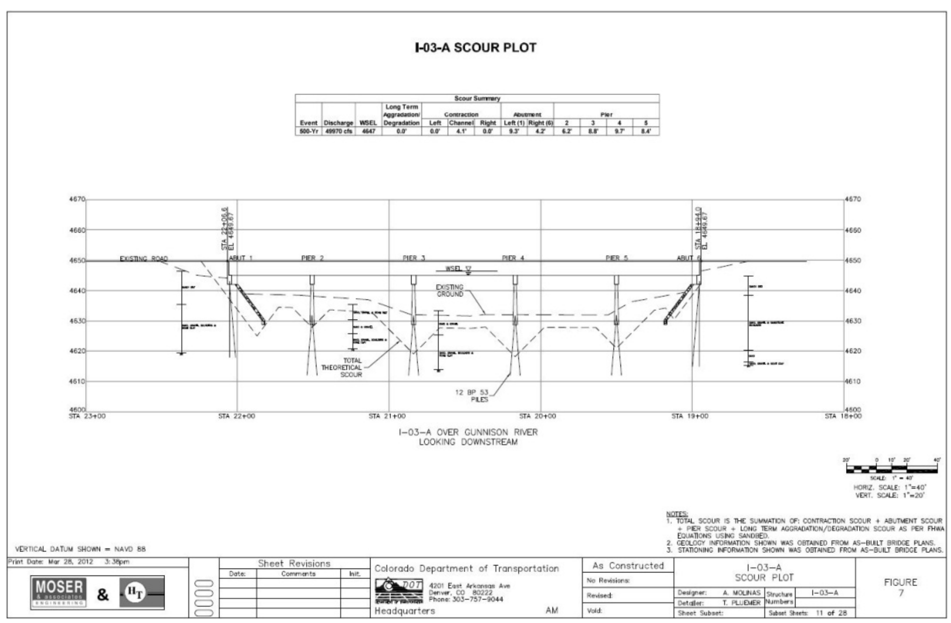


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (piers and abutments). Figure 5 shows an aerial image of structure I-03-A with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

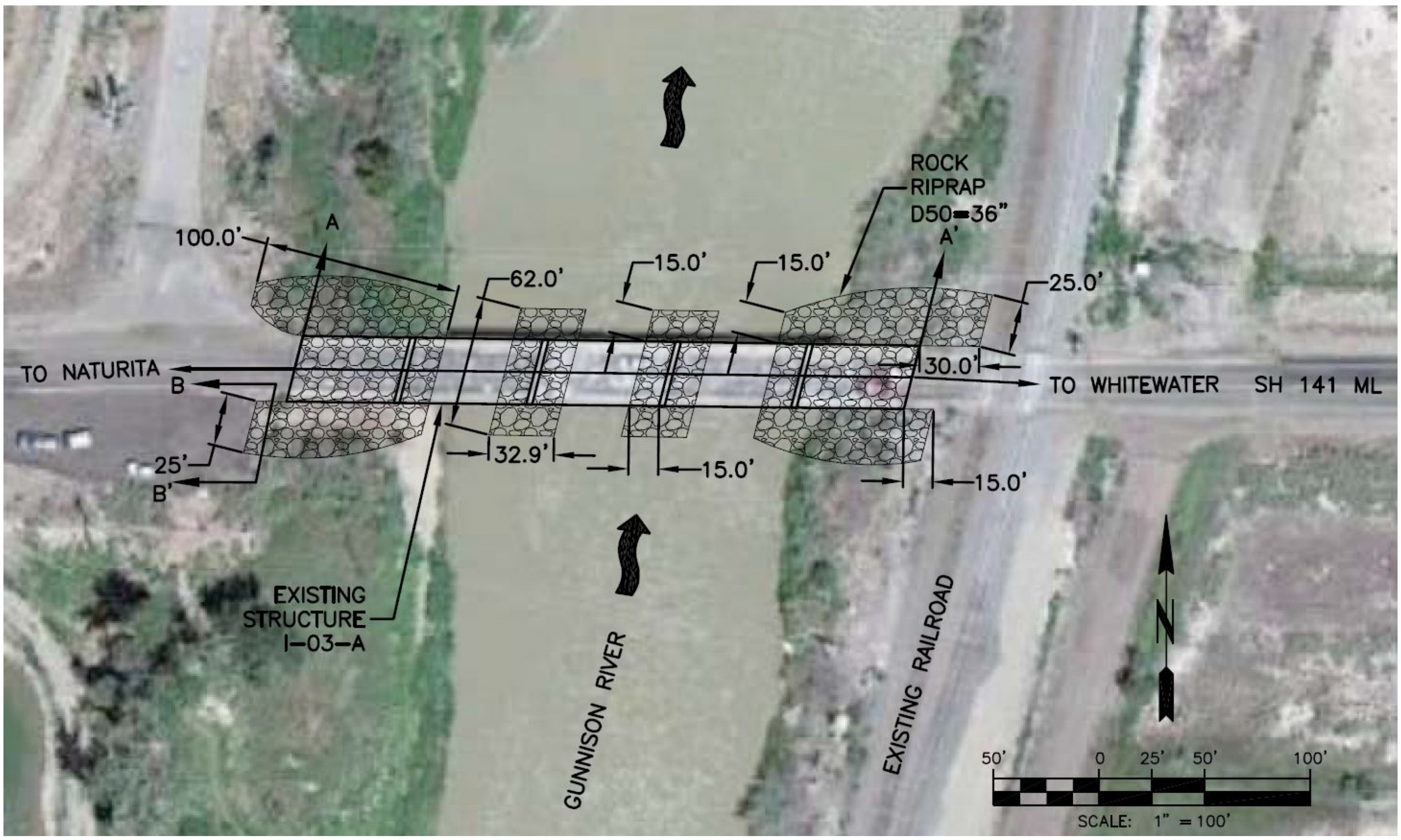


Figure 5. Plan view of Bridge I-03-A with recommended hydraulic scour countermeasure locations

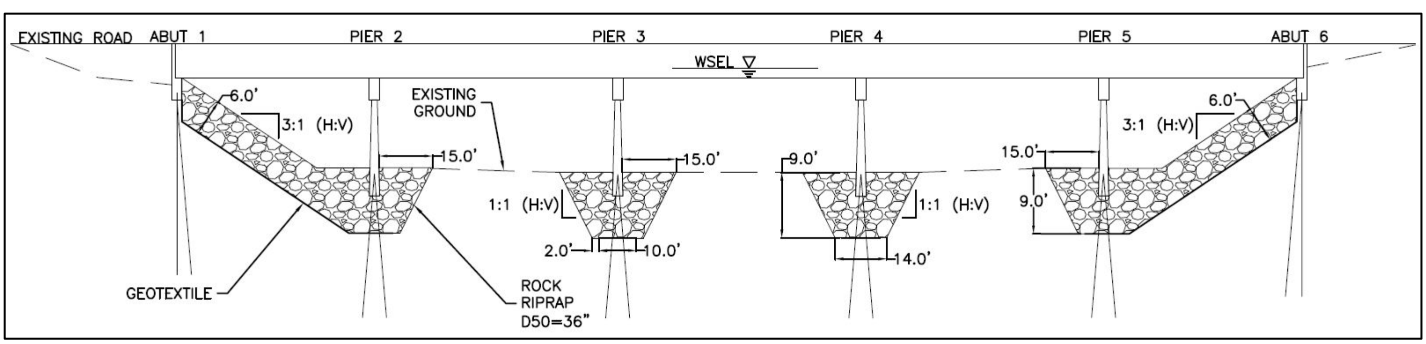


Figure 6. Cross-sectional view of Bridge E-10-A with recommended hydraulic scour countermeasures

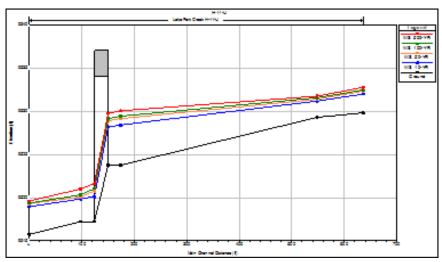
STATE HIGHWAY 300 BRIDGE H-11-U OVER LAKE FORK CREEK, COLORADO

Bridge H-11-U is located in Lake County on State Highway 300 ML where the highway crosses Lake Fork Creek. Figure 1 shows Bridge H-11-U over Lake Fork Creek.

Hydrau-Tech, Inc. began the POA study of Bridge H-11-U by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 860 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge H-11-U over Lake Fork Creek



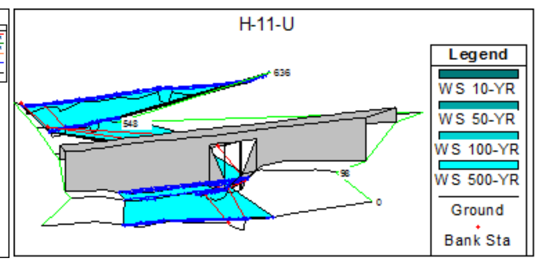


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure H-11-U

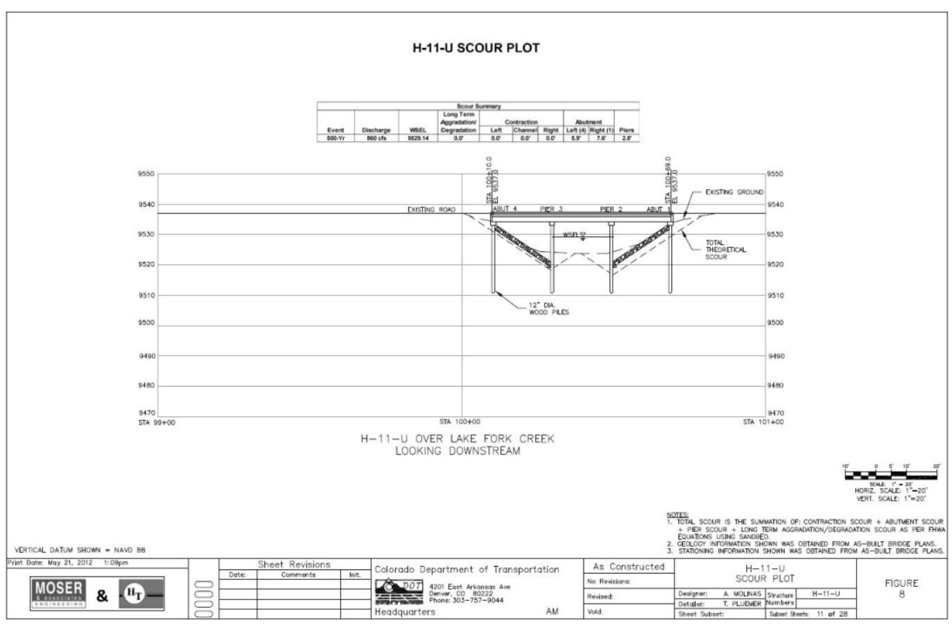


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (abutments and piers). Figure 5 shows an aerial image of structure H-11-U with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

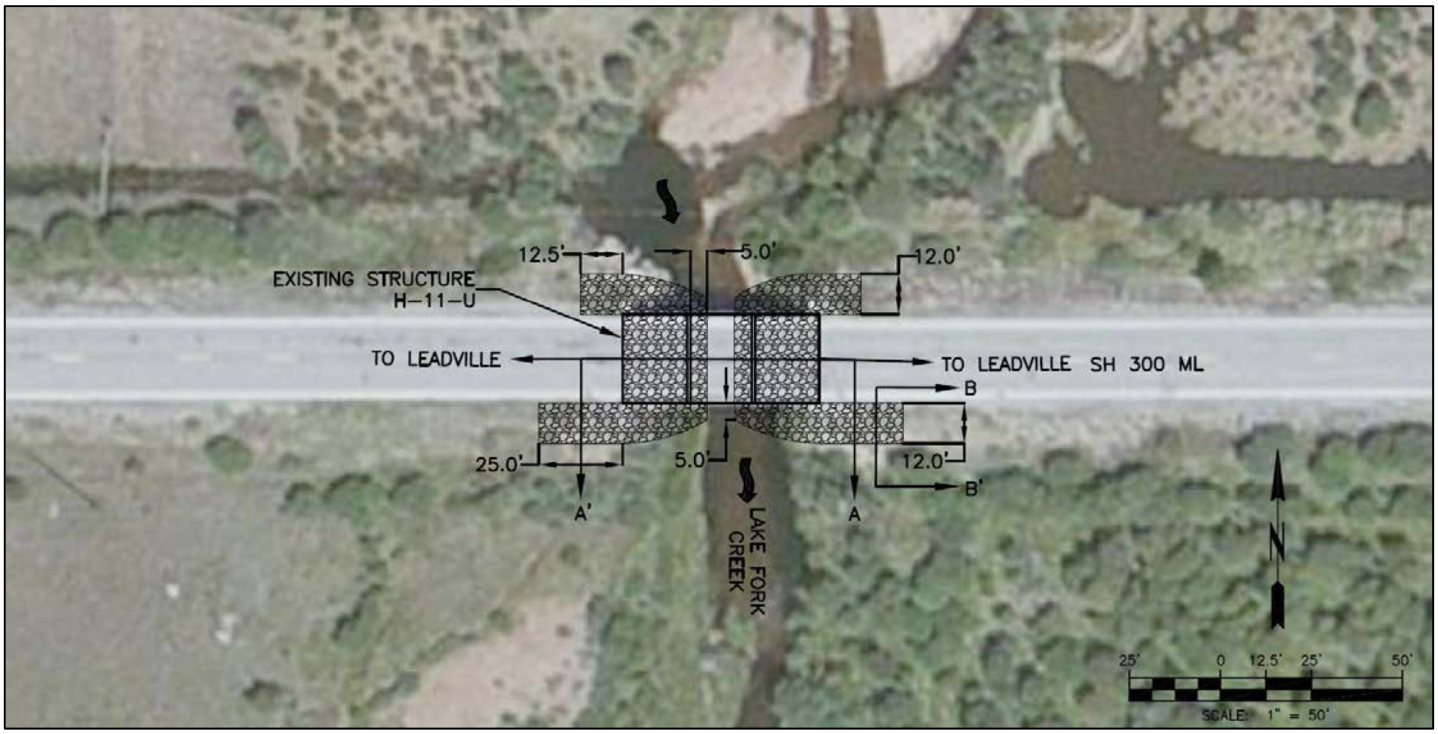


Figure 5. Plan view of Bridge H-11-U with recommended hydraulic scour countermeasure locations

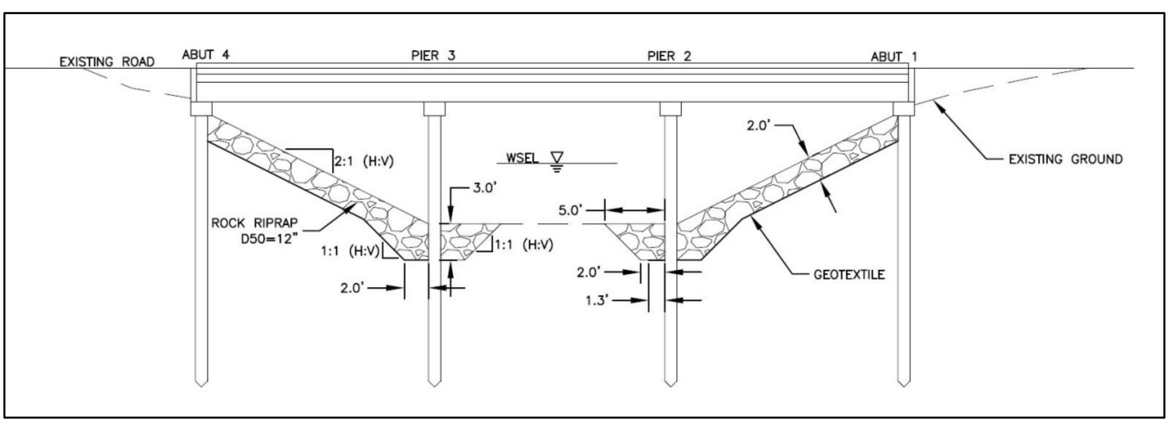


Figure 6. Cross-sectional view of Bridge H-11-U with recommended hydraulic scour countermeasures

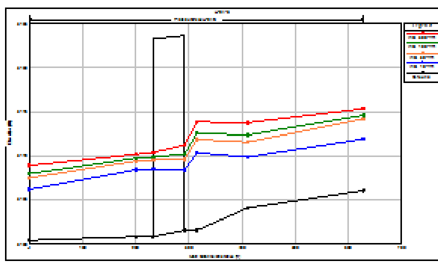
State Highway 330 Bridge H-04-Z over Plateau Creek, Colorado

Bridge H-04-Z is located in Mesa County on State Highway 330 ML where the highway crosses Plateau Creek. Figure 1 shows Bridge H-04-Z over Plateau Creek.

Hydrau-Tech, Inc. began the POA study of Bridge H-04-Z by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 6,790 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge H-04-Z over Plateau Creek



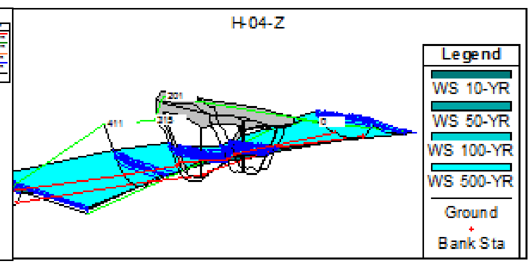


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure H-04-Z

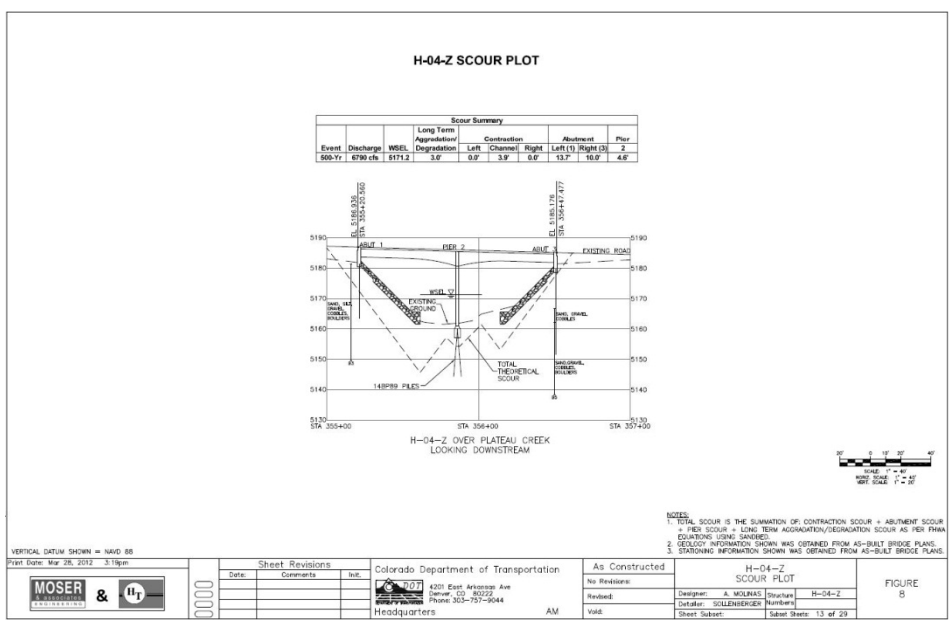


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at the critical locations on the bridge (pier 2). Figure 5 shows an aerial image of structure H-04-Z with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

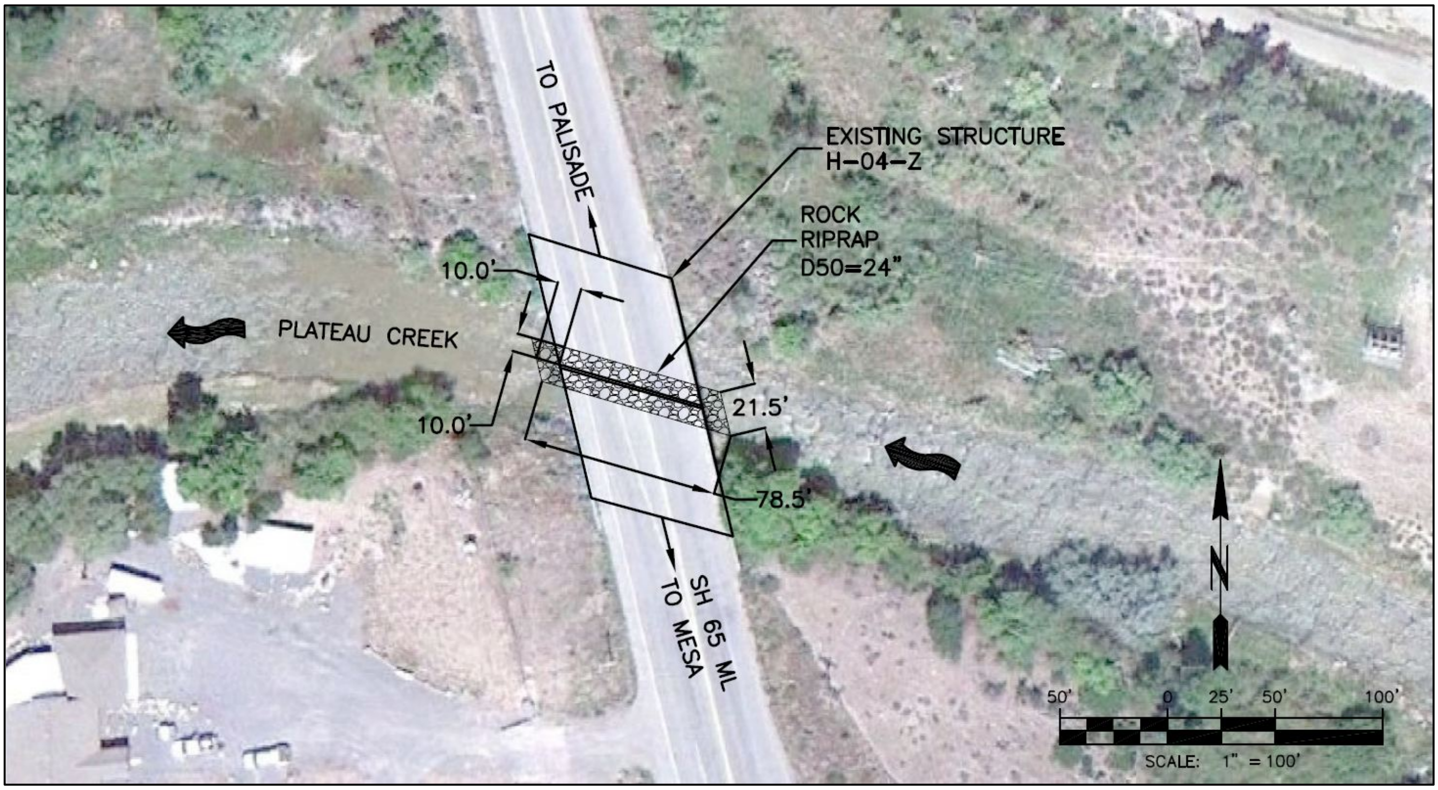


Figure 5. Plan view of Bridge H-04-Z with recommended hydraulic scour countermeasure locations

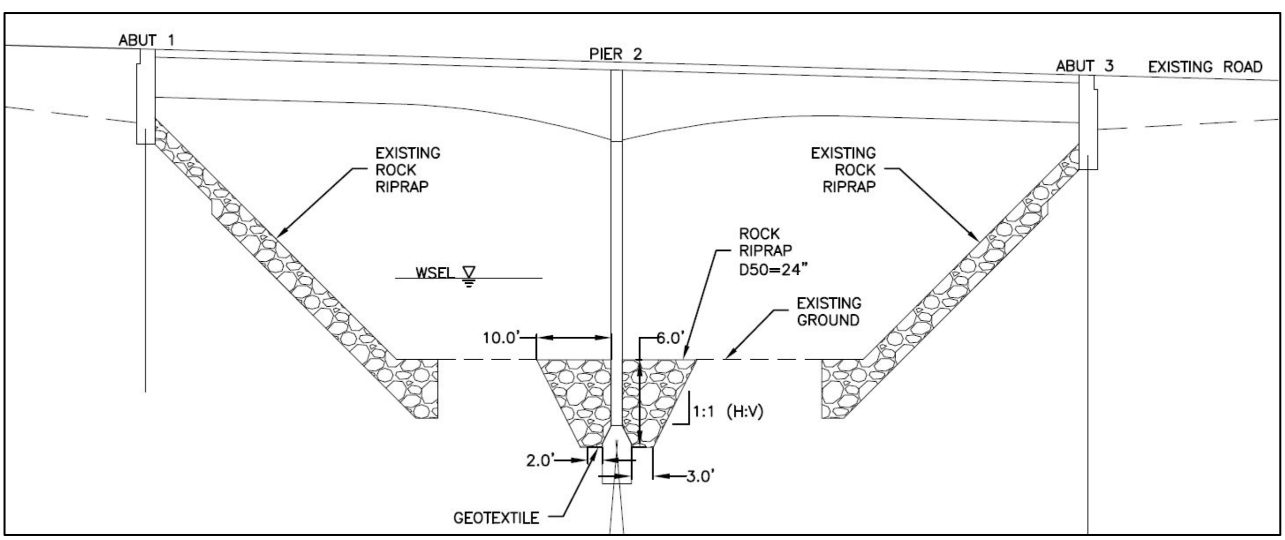


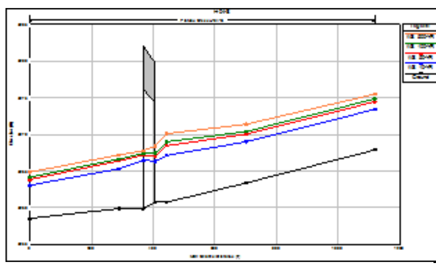
Figure 6. Cross-sectional view of Bridge H-04-Z with recommended hydraulic scour countermeasures

STATE HIGHWAY 330 BRIDGE H-04-S OVER PLATEAU CREEK, COLORADO

Bridge H-04-S is located in Mesa County on State Highway 330 ML where the highway crosses Plateau Creek. Figure 1 shows Bridge H-04-S over Plateau Creek.

Figure 1. Bridge H-04-S over Plateau Creek

Hydrau-Tech, Inc. began the POA study of Bridge H-04-S by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 6,169 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



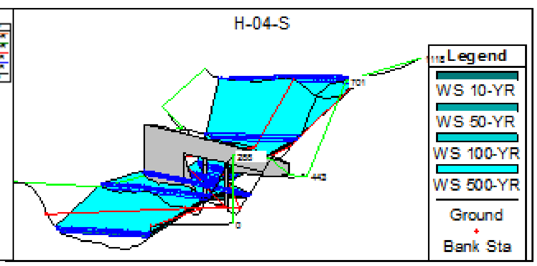


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure H-04-S

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

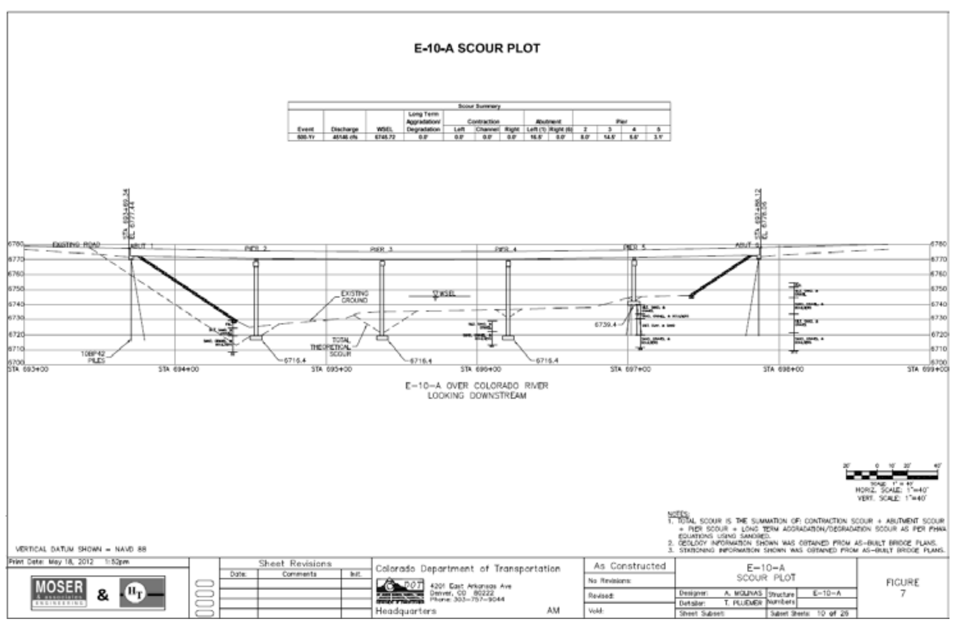


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, and pier 4). Figure 5 shows an aerial image of structure E-10-A with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

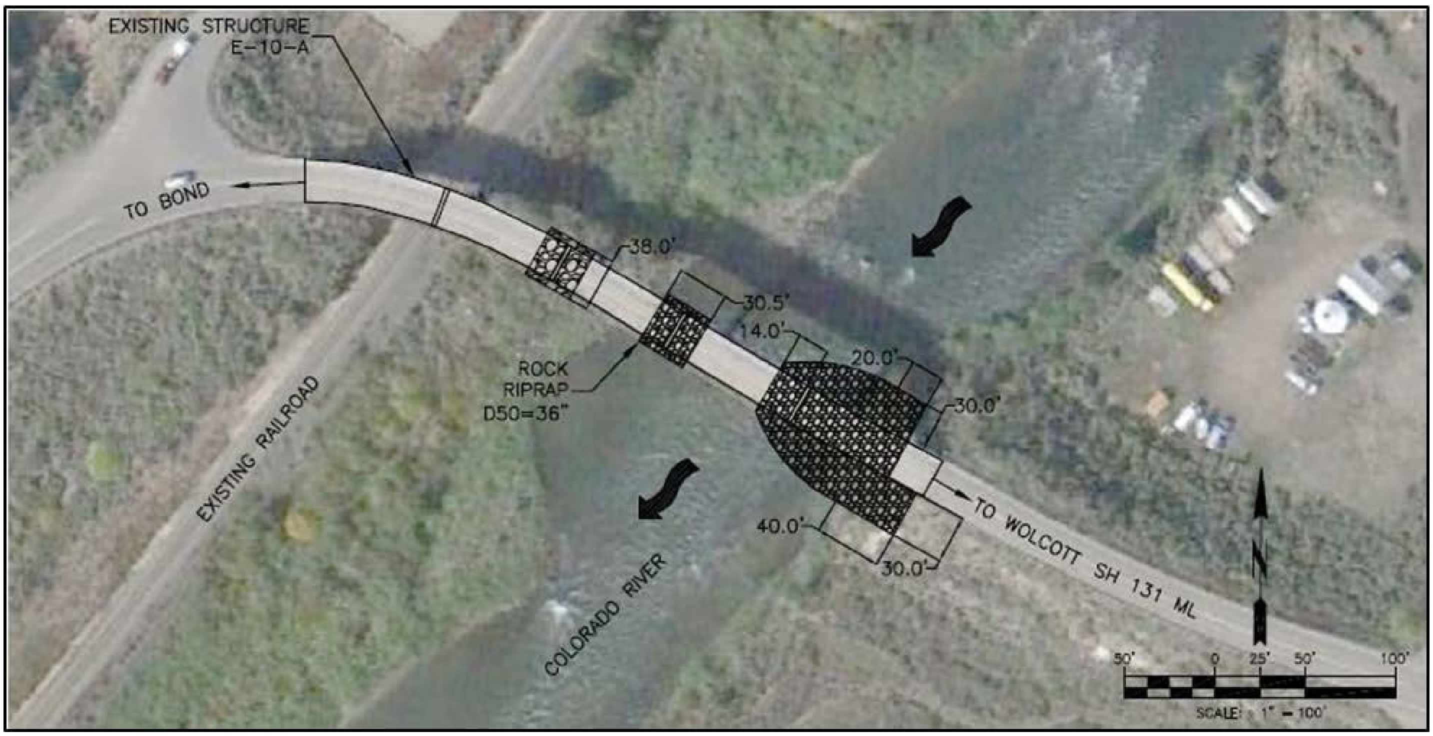


Figure 5. Plan view of Bridge E-10-A with recommended hydraulic scour countermeasure locations

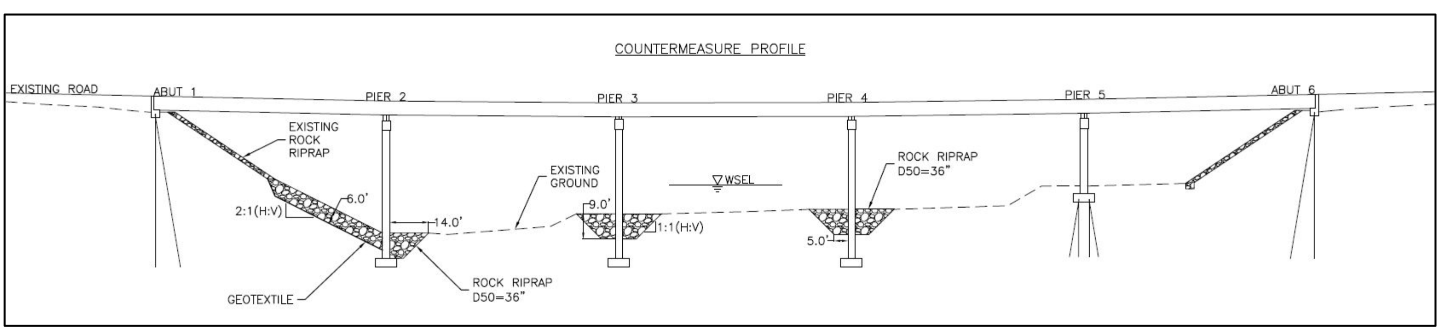


Figure 6. Cross-sectional view of Bridge E-10-A with recommended hydraulic scour countermeasures

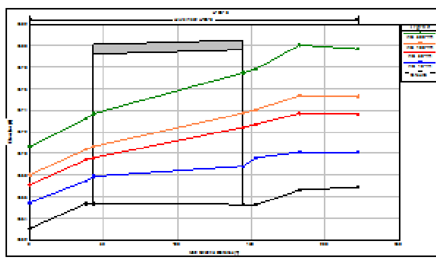
Interstate 70 Business Route Bridge H-03-Z over Lewis Wash, Colorado

Bridge H-03-Z is located in Mesa County on Interstate 70 Business Route where the highway crosses Lewis Wash. Figure 1 shows Bridge H-03-Z over Lewis Wash.

Hydrau-Tech, Inc. began the POA study of Bridge H-03-Z by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 2,830 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge H-03-Z over Lewis Wash



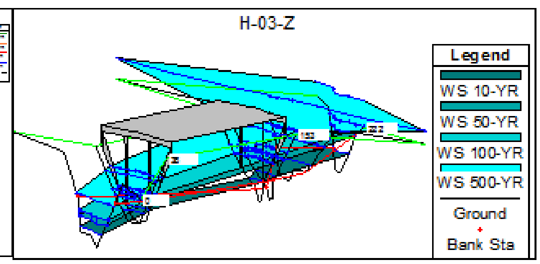


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure H-03-Z

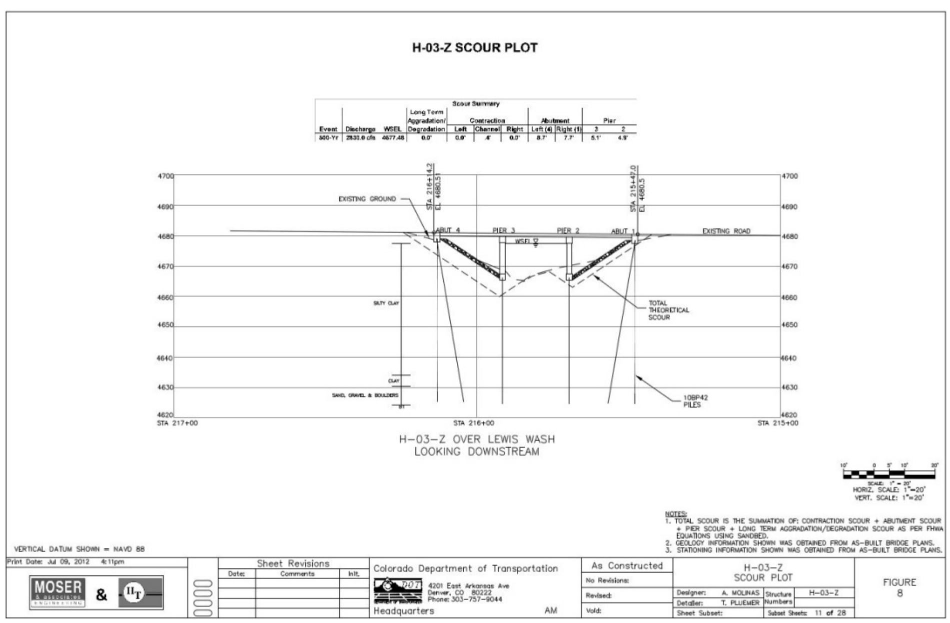


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier, abutment and channel riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment, channel and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (abutments, piers, channel and upstream and downstream of bridge). Figure 5 shows an aerial image of structure H-03-Z with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

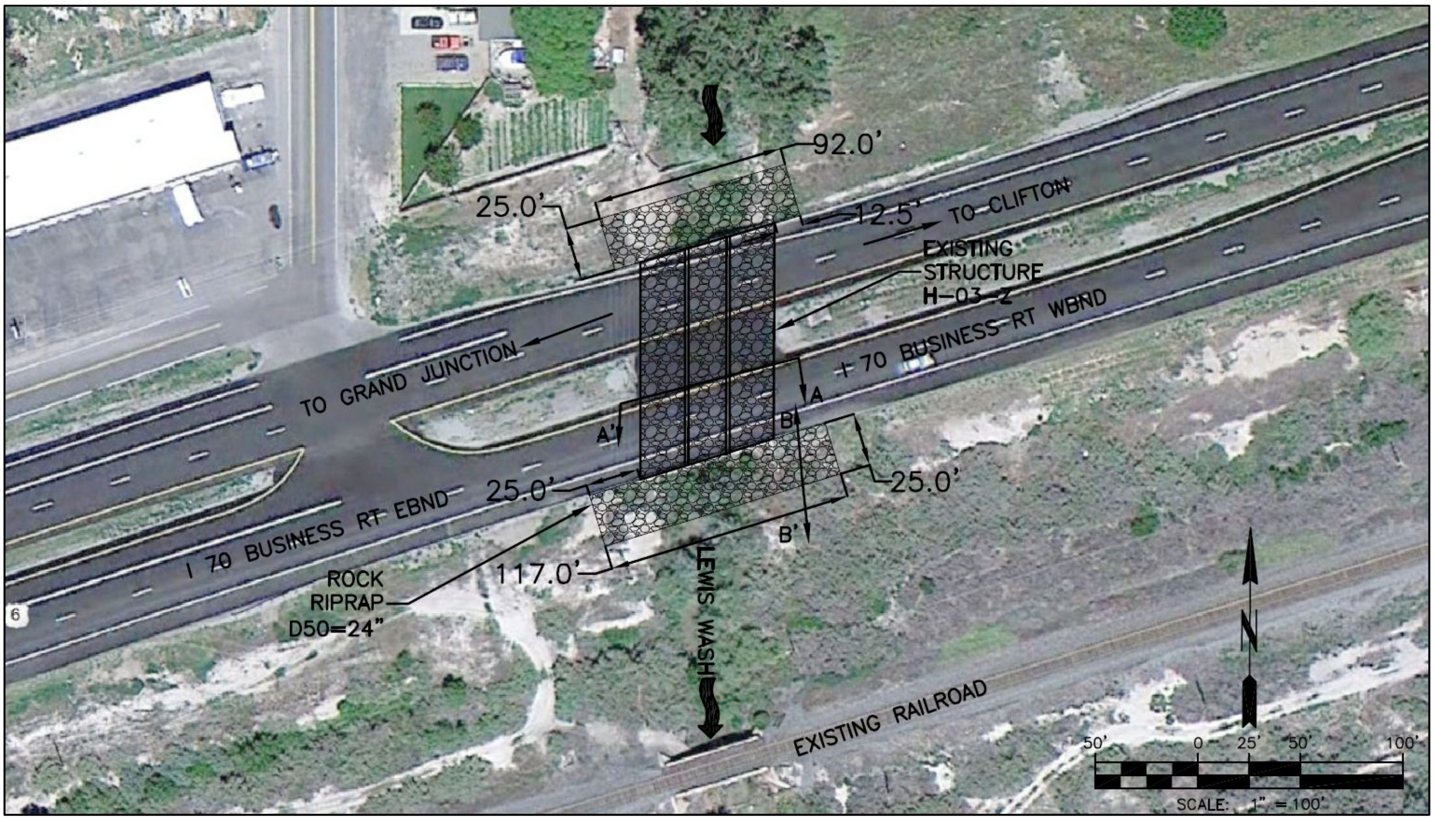


Figure 5. Plan view of Bridge H-03-Z with recommended hydraulic scour countermeasure locations

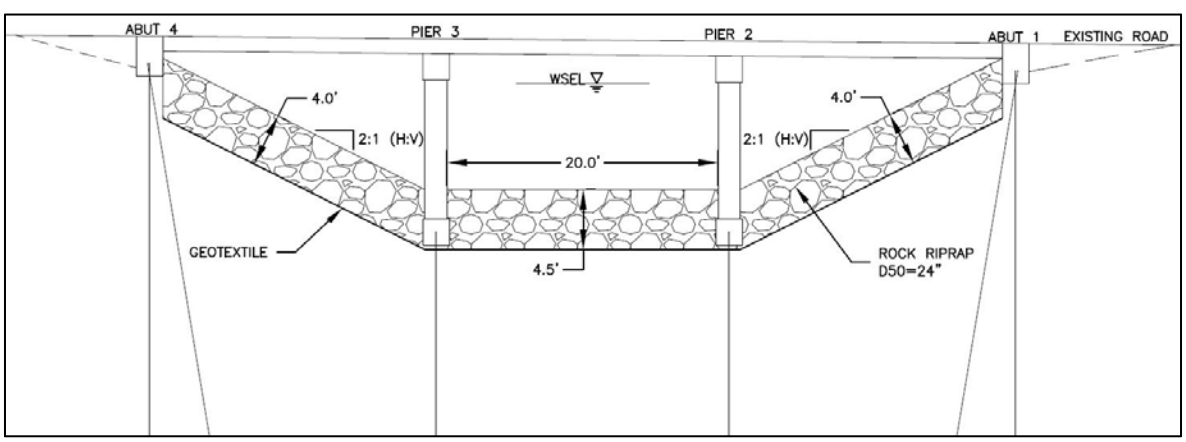


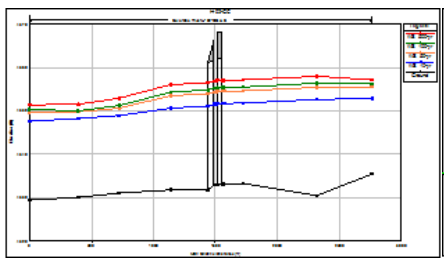
Figure 6. Cross-sectional view of Bridge H-03-Z with recommended hydraulic scour countermeasures

State Highway 340 Bridges H-02-GC and H-02-S Over the Colorado River, Colorado

Bridges H-02-GC and H-02-S are located in Mesa County on State Highway 340 ML where the highway crosses the Colorado River. Figure 1 shows Bridges H-02-GC and H-02-S over the Colorado River.

Figure 1. Bridge H-02-GC and H-02-S over the Colorado River

Hydrau-Tech, Inc. began the POA study of Bridges H-02-GC and H-02-S by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 83,321 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



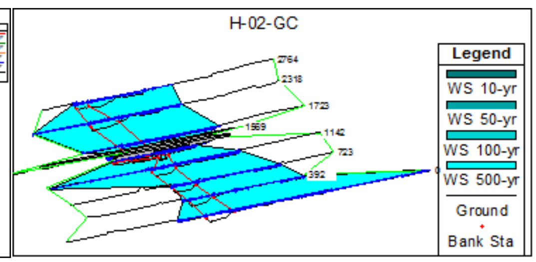


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structures H-02-GC and H-02-S

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

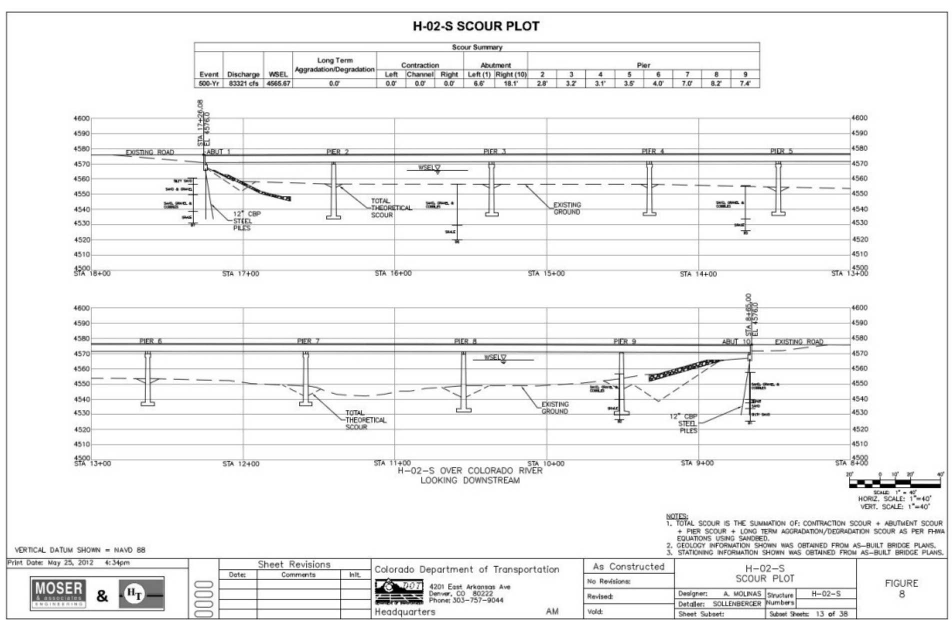


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the pier protection and riprap with a median grain size diameter of 1.0 feet was used to design the abutment protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridges (abutment 10 of both bridges, piers 6, 7, 8 and 9 on H-02-GC and piers 7, 8 and 9 on H-02-S). Figure 5 shows an aerial image of structures H-02-GC and H-02-S with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of structure H-02-GC with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

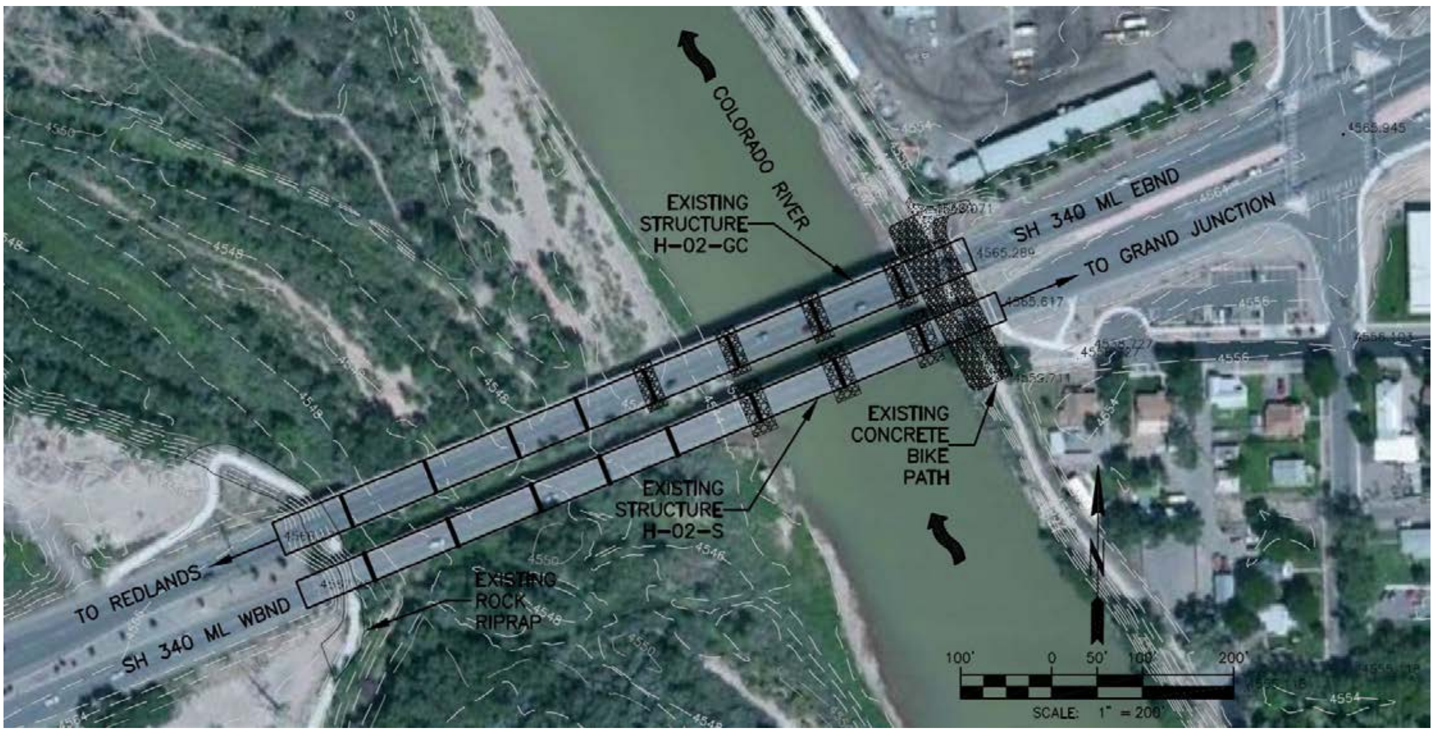


Figure 5. Plan view of Bridges H-02-GC and H-02-S with recommended hydraulic scour countermeasure locations

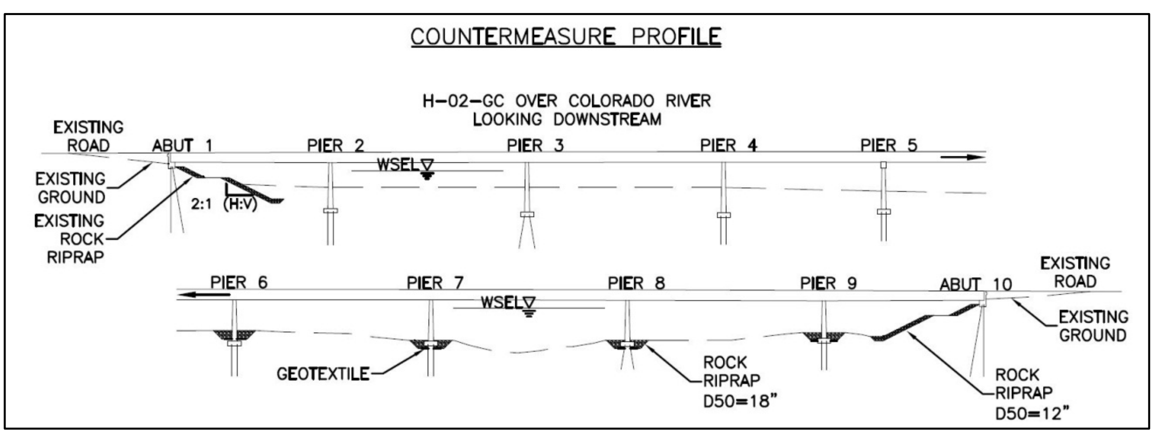


Figure 6. Cross-sectional view of Bridge H-02-GC with recommended hydraulic scour countermeasures

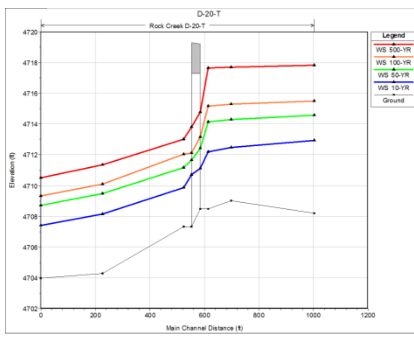
STATE HIGHWAY 52 BRIDGE D-20-T OVER ROCK CREEK, COLORADO

Bridge D-20-T is located in Morgan County on State Highway 52 ML where the highway crosses the upper Rock Creek. Figure 1 shows Bridge D-20-T over Rock Creek.

Hydrau-Tech, Inc. began the POA study of Bridge D-20-T by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 3,570 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge D-20-T over the Colorado River



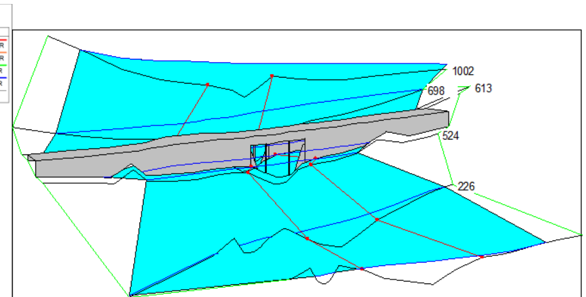


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure D-20-T

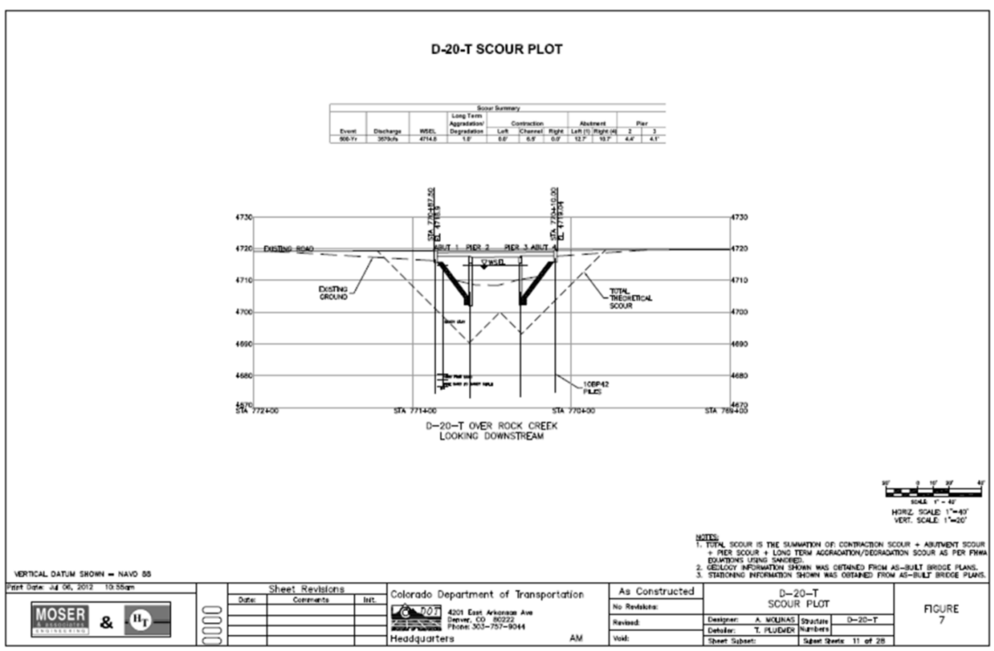


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, and right abutment). Figure 5 shows an aerial image of structure D-20-T with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

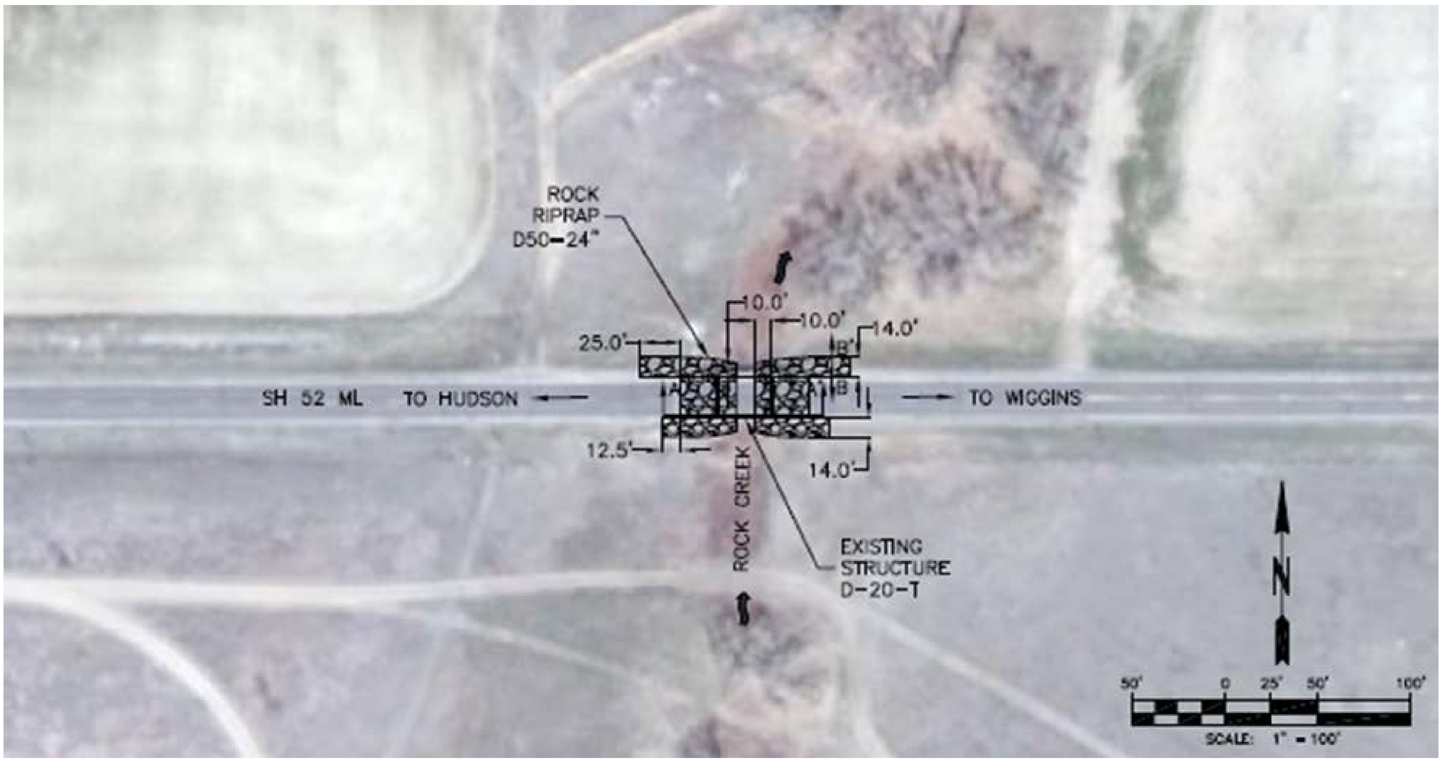


Figure 5. Plan view of Bridge D-20-T with recommended hydraulic scour countermeasure locations

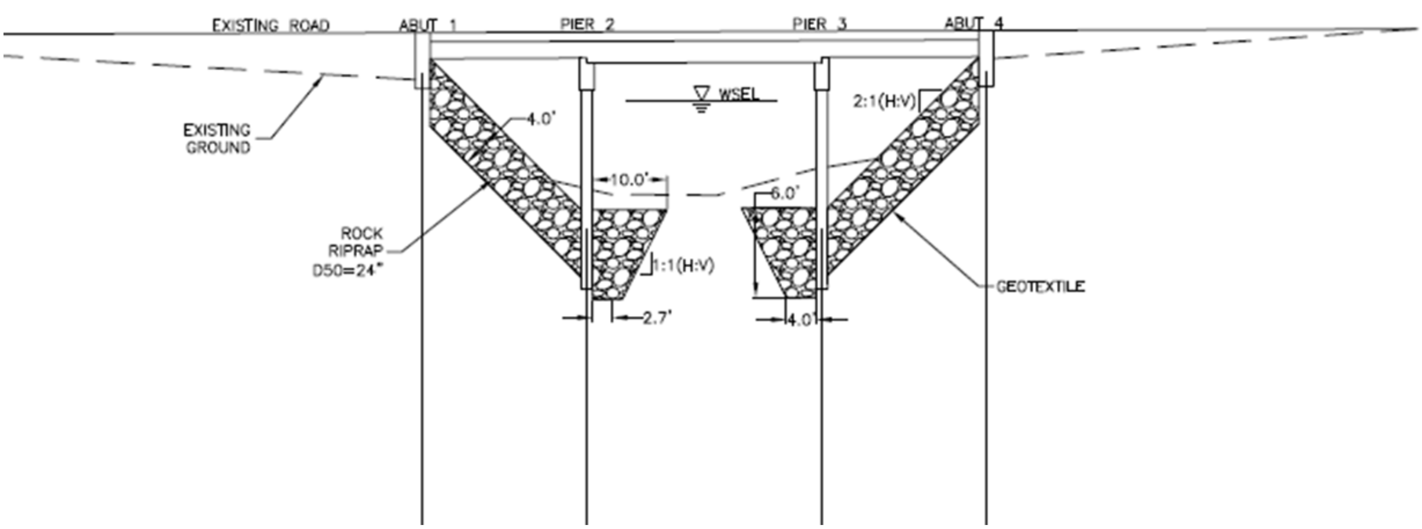


Figure 6. Cross-sectional view of Bridge D-20-T with recommended hydraulic scour countermeasures

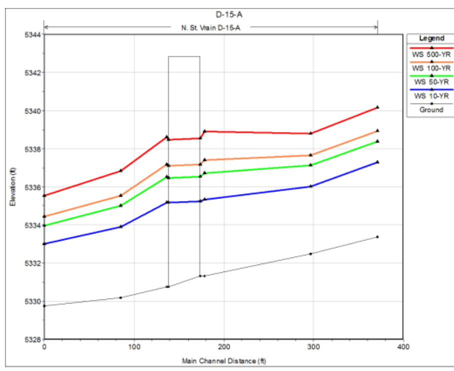
State Highway 7 Bridge D-15-A Over North St. Vrain Creek, Colorado

Bridge D-15-A is located in Boulder County on State Highway 7 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge D-15-A over the North St. Vrain Creek River.

Hydrau-Tech, Inc. began the POA study of Bridge D-15-A by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 3,690 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge D-15-A over the North St. Vrain Creek



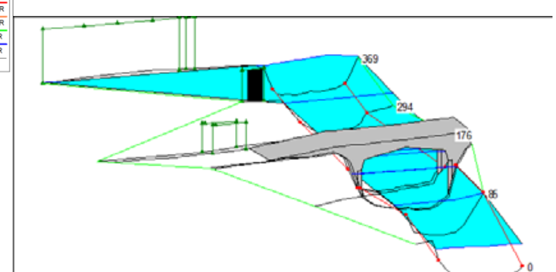


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure D-15-A

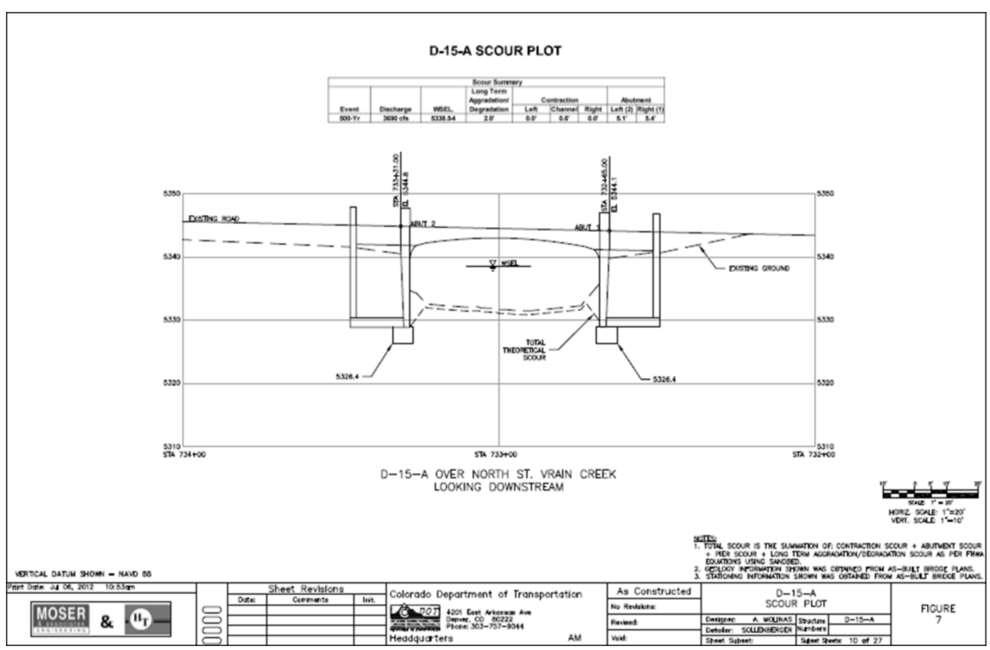


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 15 inches was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, and right abutment). Figure 5 shows an aerial image of structure D-15-A with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge D-15-A with recommended hydraulic scour countermeasure locations

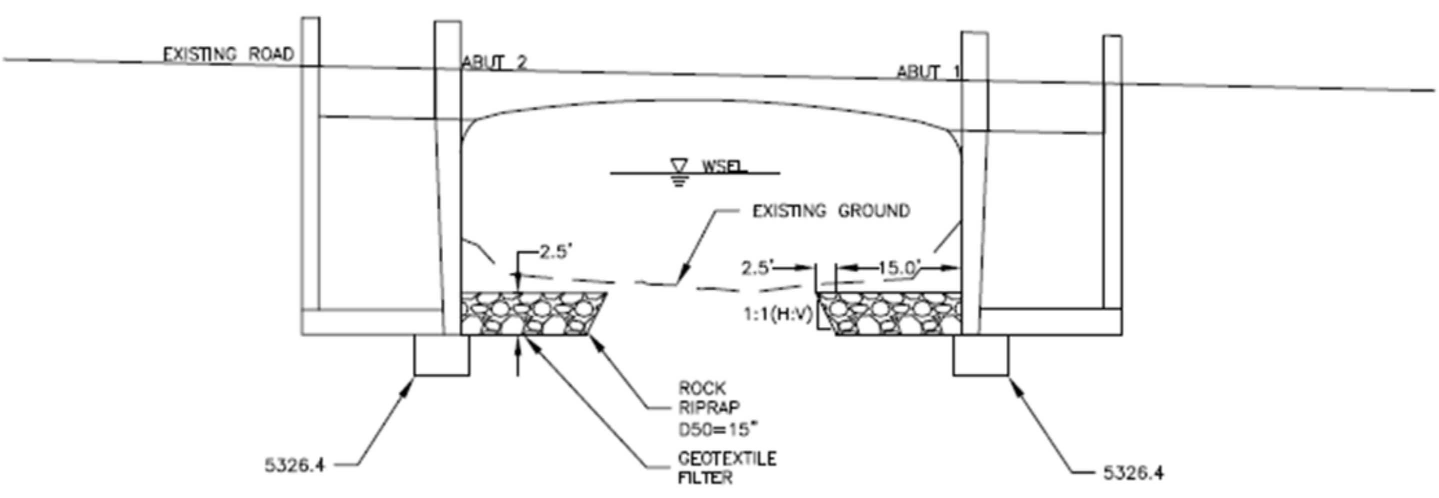


Figure 6. Cross-sectional view of Bridge D-15-A with recommended hydraulic scour countermeasures

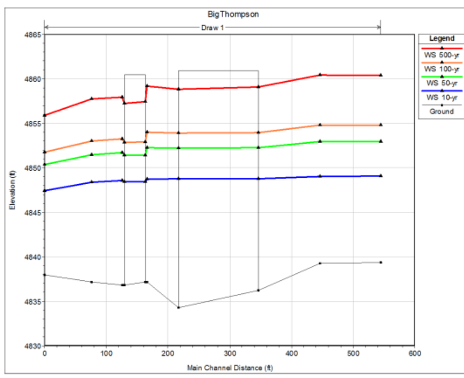
US I-25 Service Rd Bridge C-17-F Over Big Thompson River, Colorado

Bridge C-17-F is located in Larimer County on US I-25 Service Road where the highway crosses the upper Colorado River. Figure 1 shows Bridge C-17-F over the Big Thompson River.

Hydrau-Tech, Inc. began the POA study of Bridge C-17-F by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 21,000 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge C-17-F over the Big Thompson River



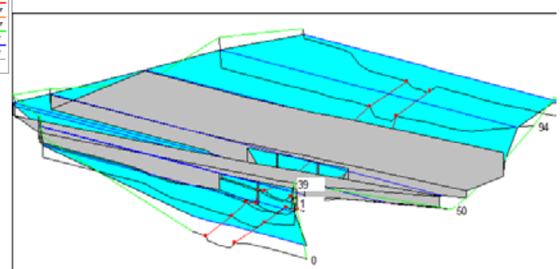


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure C-17-F

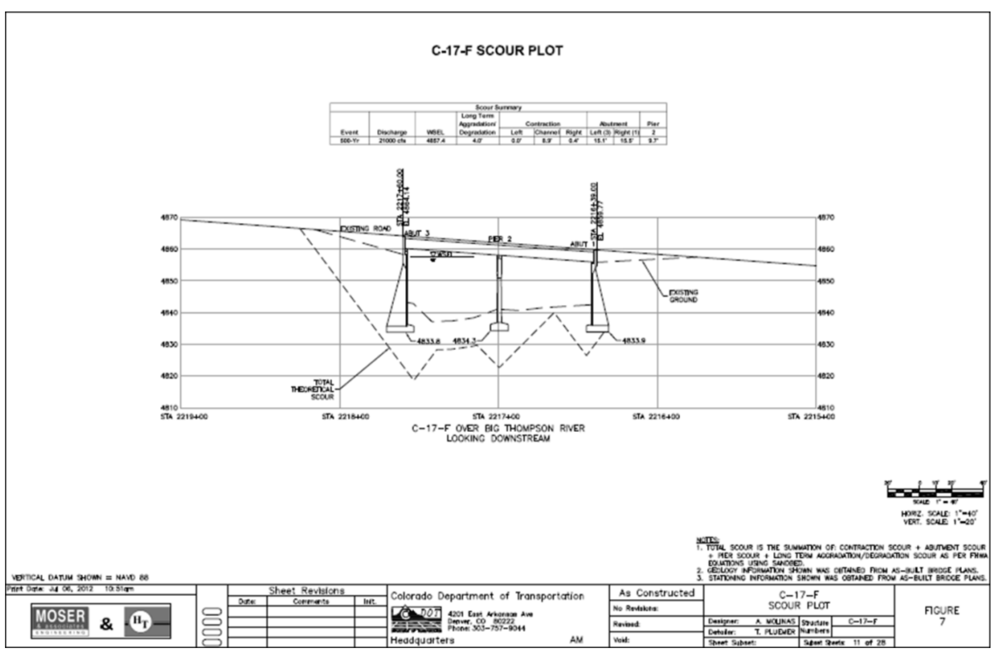


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, and right abutment). Figure 5 shows an aerial image of structure C-17-F with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

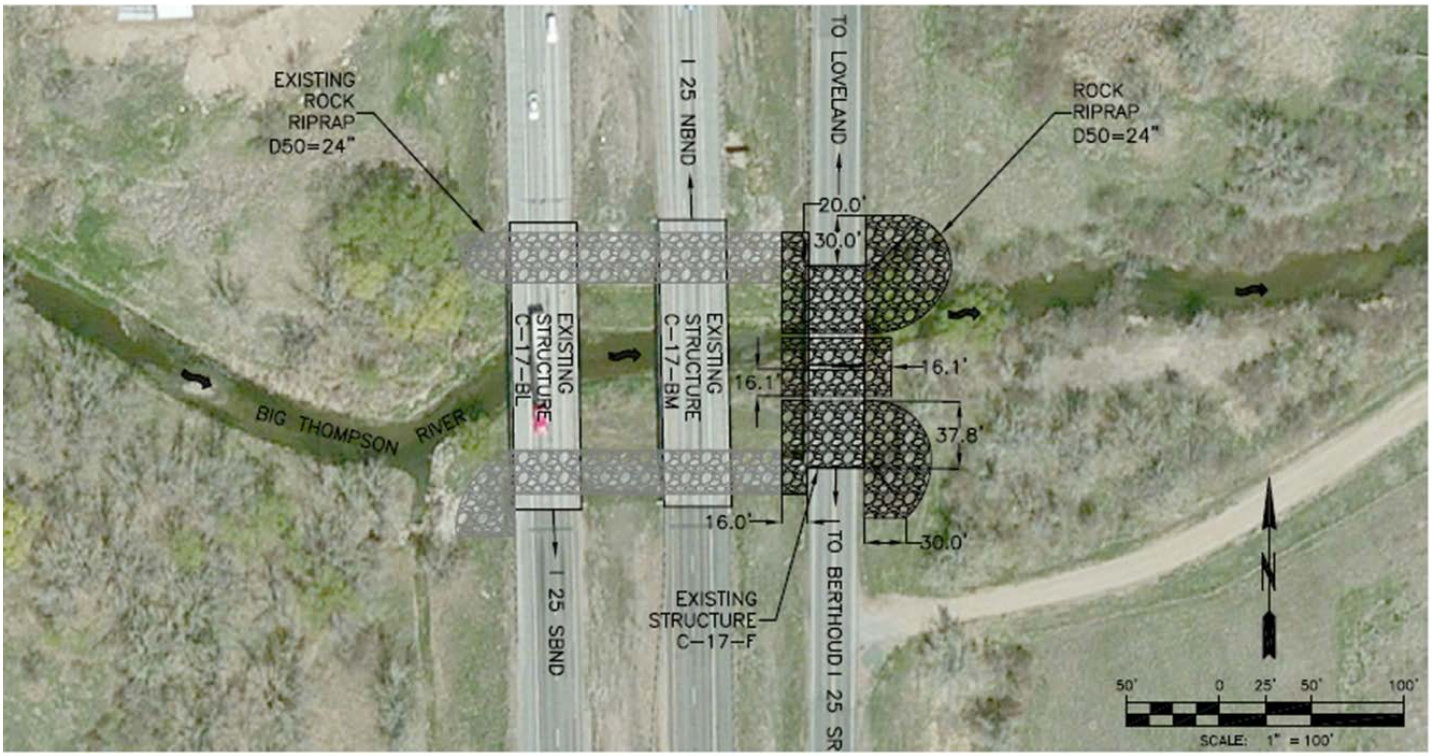


Figure 5. Plan view of Bridge C-17-F with recommended hydraulic scour countermeasure locations

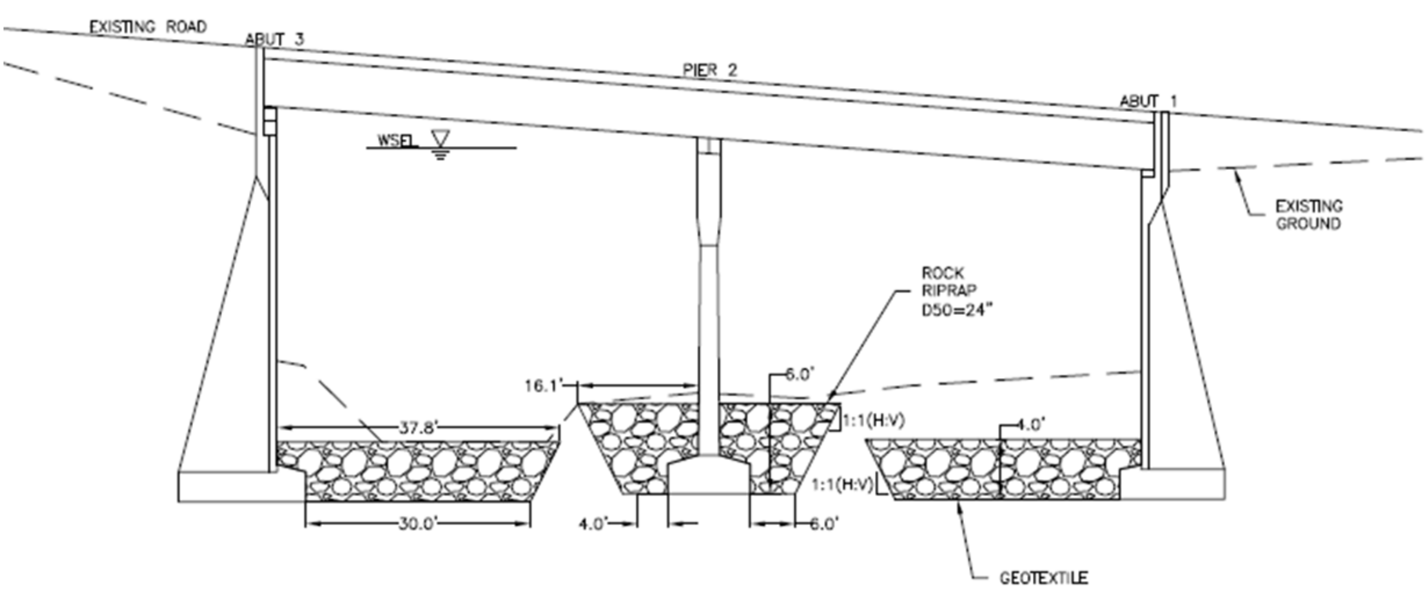


Figure 6. Cross-sectional view of Bridge C-17-F with recommended hydraulic scour countermeasures

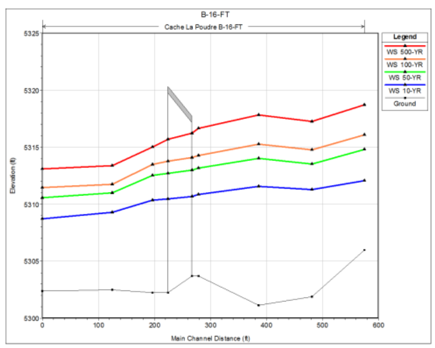
State Highway 14 Bridge B-16-FT Over Cache La Poudre River, Colorado

Bridge B-16-FT is located in Logan County on State Highway 14 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge B-16-FT over the Cache La Poudre.

Hydrau-Tech, Inc. began the POA study of Bridge B-16-FT by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 11,700 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge B-16-FT over the Cache La Poudre



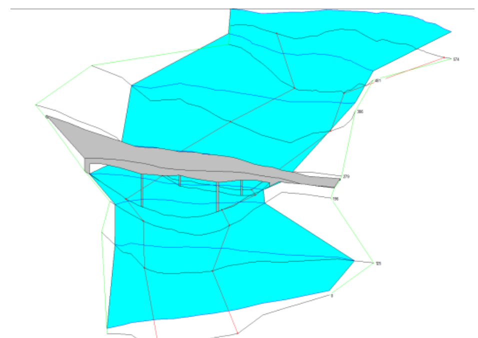


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure B-16-FT

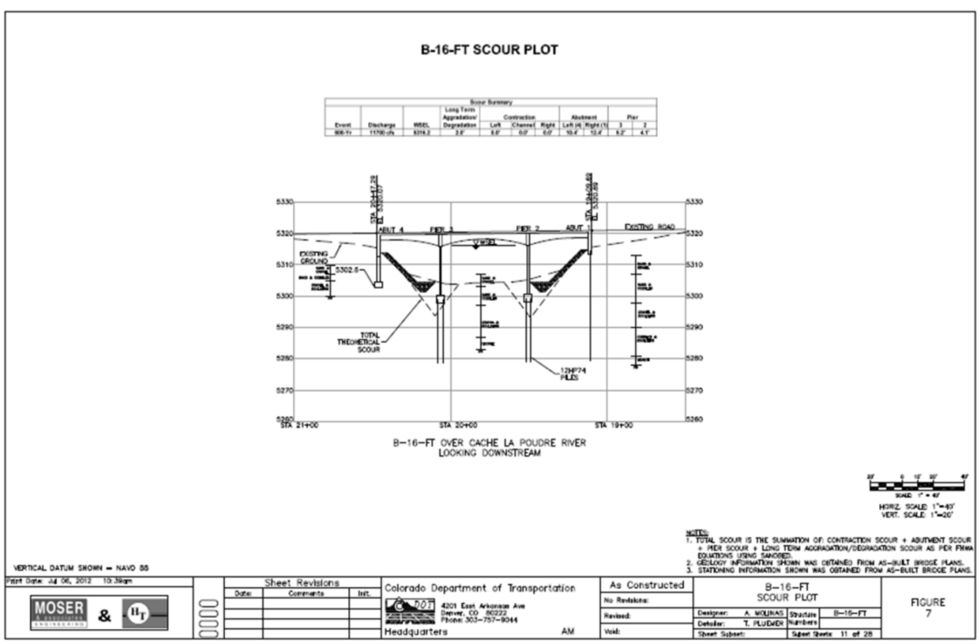


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, and right abutment). Figure 5 shows an aerial image of structure B-16-FT with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

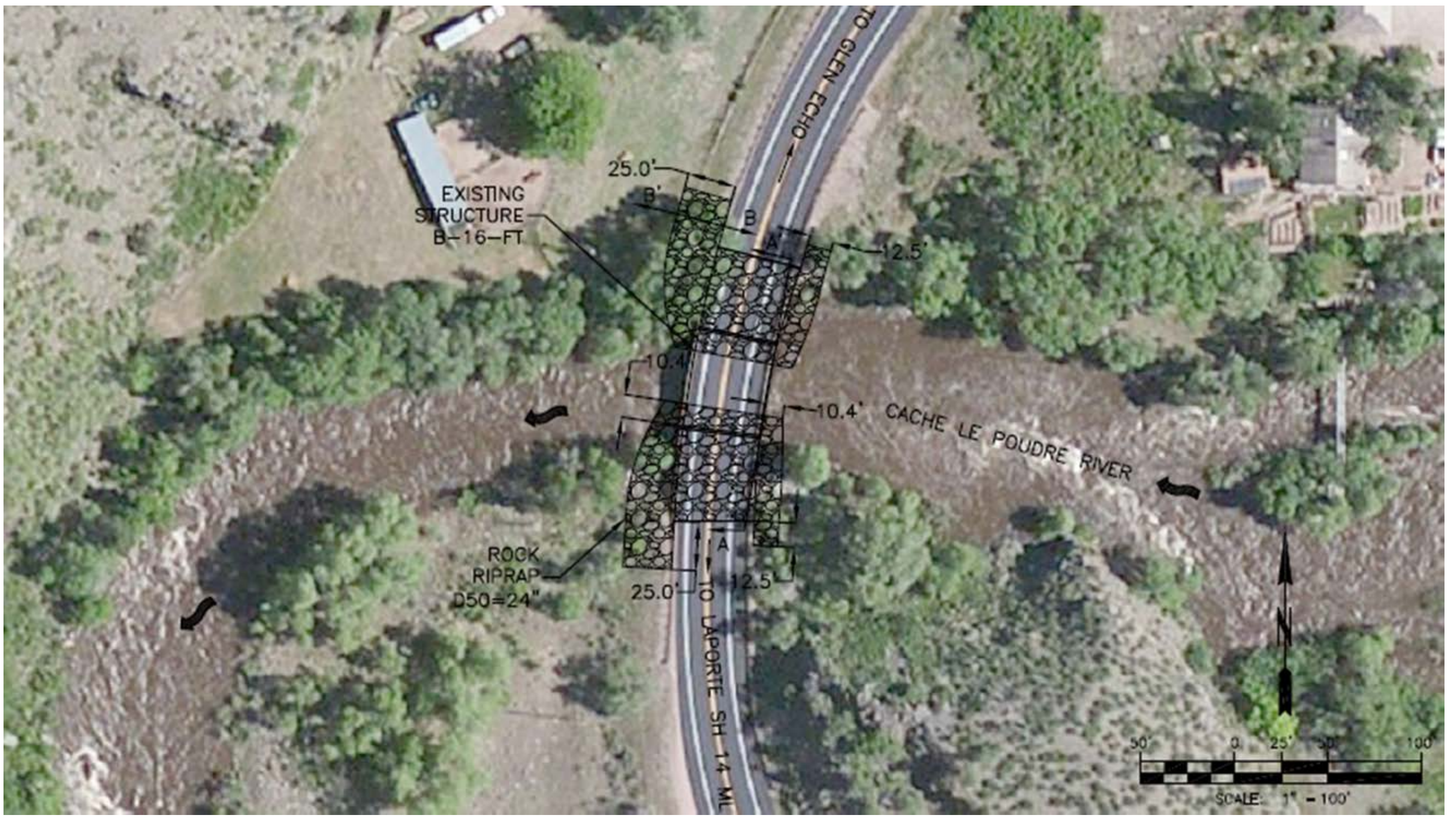


Figure 5. Plan view of Bridge B-16-FT with recommended hydraulic scour countermeasure locations

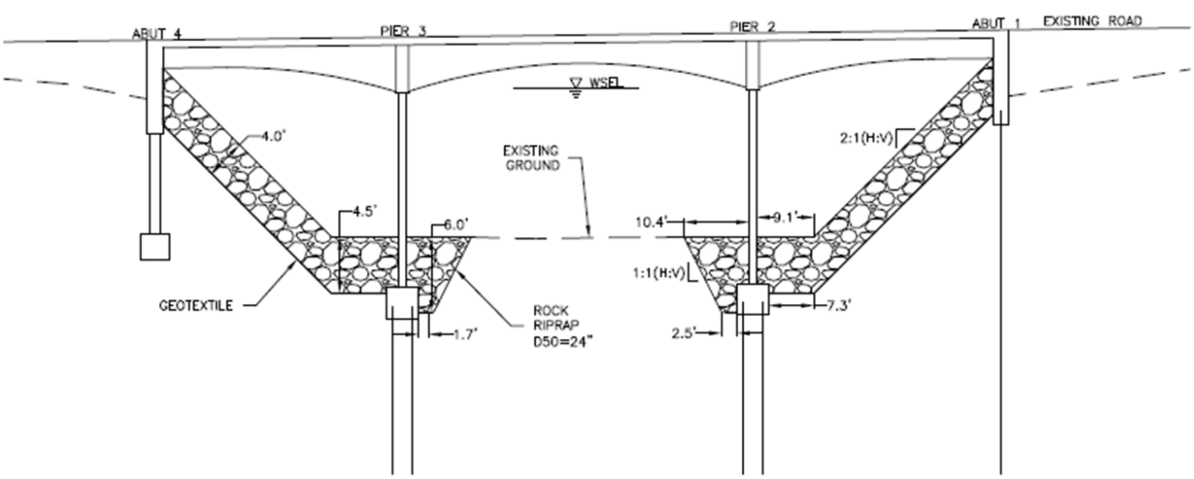


Figure 6. Cross-sectional view of Bridge B-16-FT with recommended hydraulic scour countermeasures

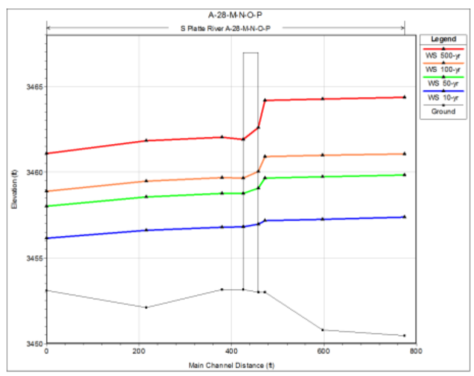
US HIGHWAY 385 BRIDGE A-28-P OVER SOUTH PLATTE RIVER, COLORADO

Bridge A-28-P is located in Sedgwick County on US Highway 385 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge A-28-P over the Colorado River.

Hydrau-Tech, Inc. began the POA study of Bridge A-28-P by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 88,718 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge A-28-P over the South Platte River



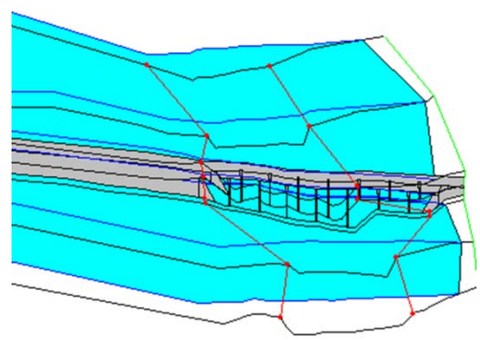


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-28-P

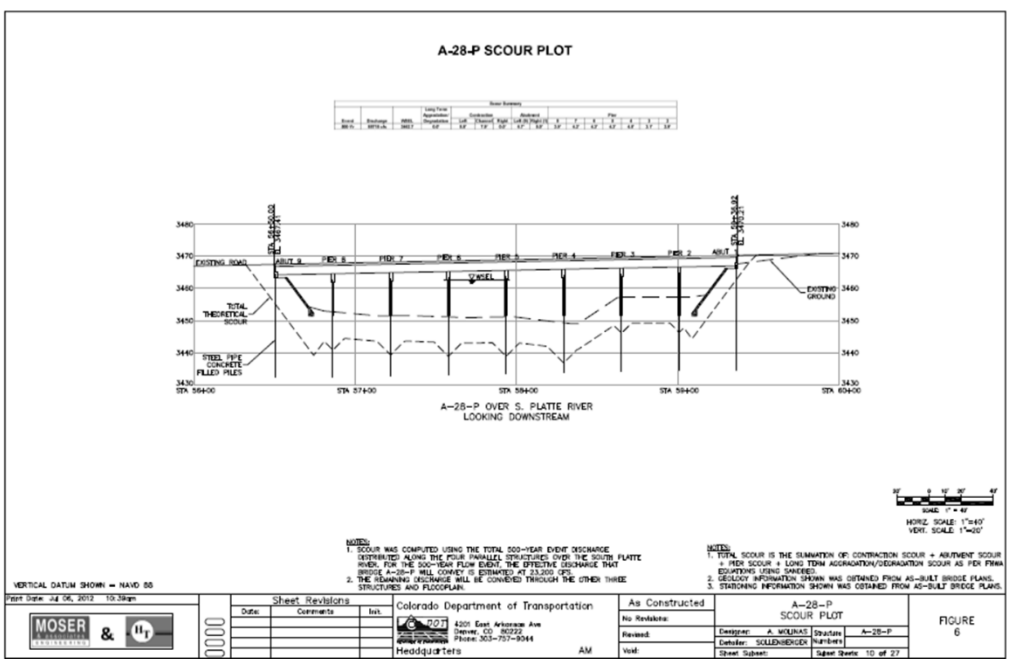


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, pier 4, pier 5, pier 6, pier 7, pier 8, and right abutment). Figure 5 shows an aerial image of structure A-28-P with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge A-28-P with recommended hydraulic scour countermeasure locations

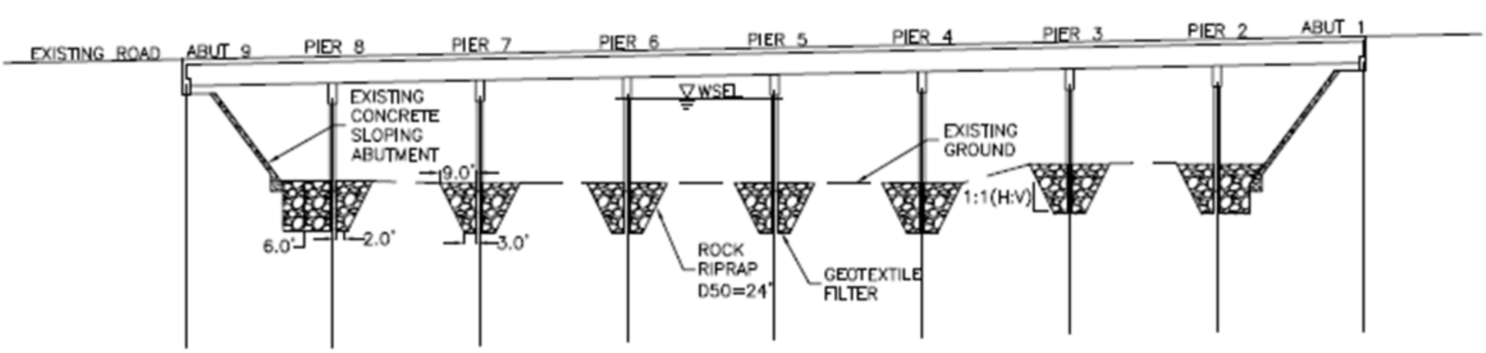


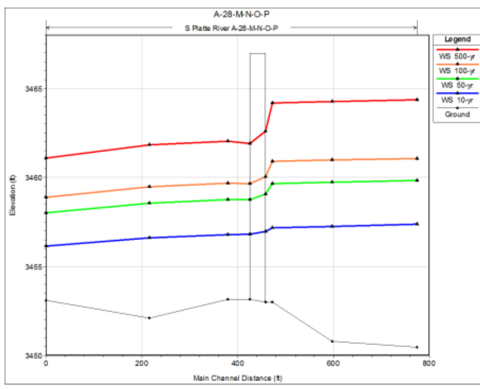
Figure 6. Cross-sectional view of Bridge A-28-P with recommended hydraulic scour countermeasures

US Highway 385 Bridge A-28-O Over South Platte River, Colorado

Bridge A-28-O is located in Sedgwick County on US Highway 385 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge A-28-O over the Colorado River.

Figure 1. Bridge A-28-O over the South Platte River

Hydrau-Tech, Inc. began the POA study of Bridge A-28-O by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 88,718 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



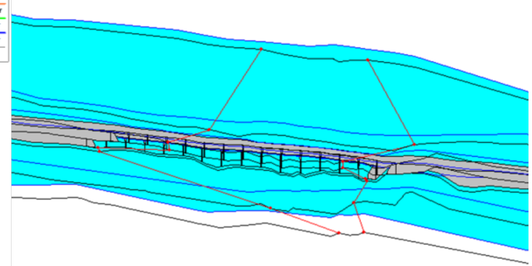


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-28-O

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

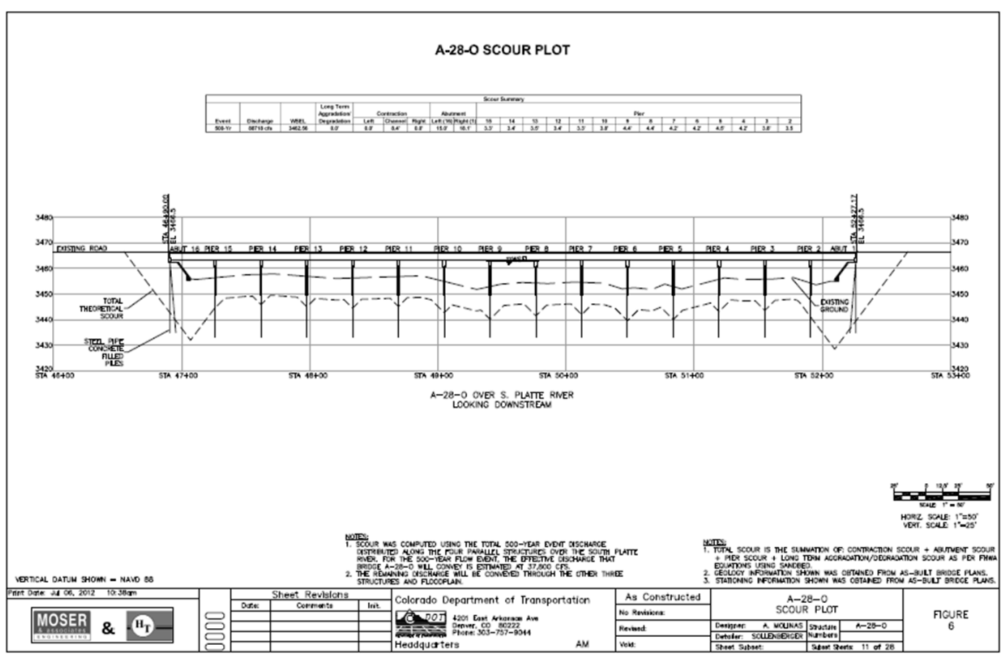


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, all piers, and right abutment). Figure 5 shows an aerial image of structure A-28-O with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge A-28-O with recommended hydraulic scour countermeasure locations

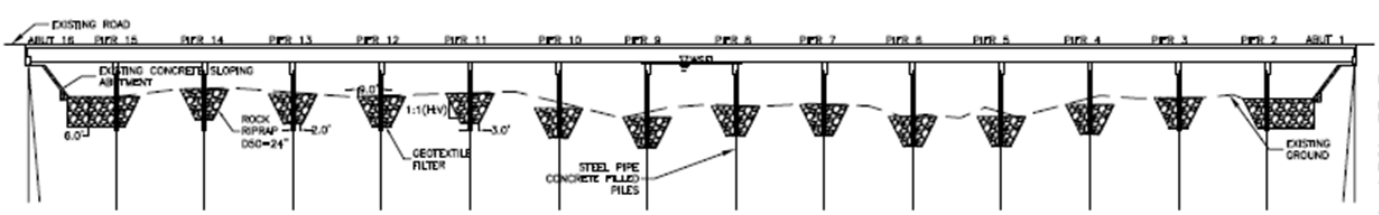


Figure 6. Cross-sectional view of Bridge A-28-O with recommended hydraulic scour countermeasures

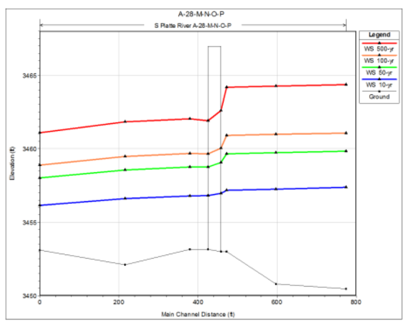
US HIGHWAY 385 BRIDGE A-28-N OVER SOUTH PLATTE RIVER, COLORADO

Bridge A-28-N is located in Sedgwick County on US Highway 385 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge A-28-N over the Colorado River.

Hydrau-Tech, Inc. began the POA study of Bridge A-28-N by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 88,718 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge A-28-N over the South Platte River



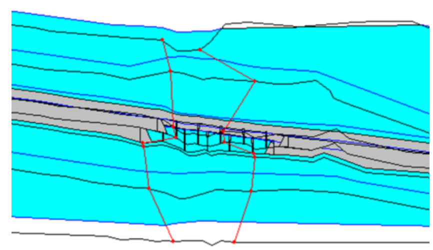


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-28-N

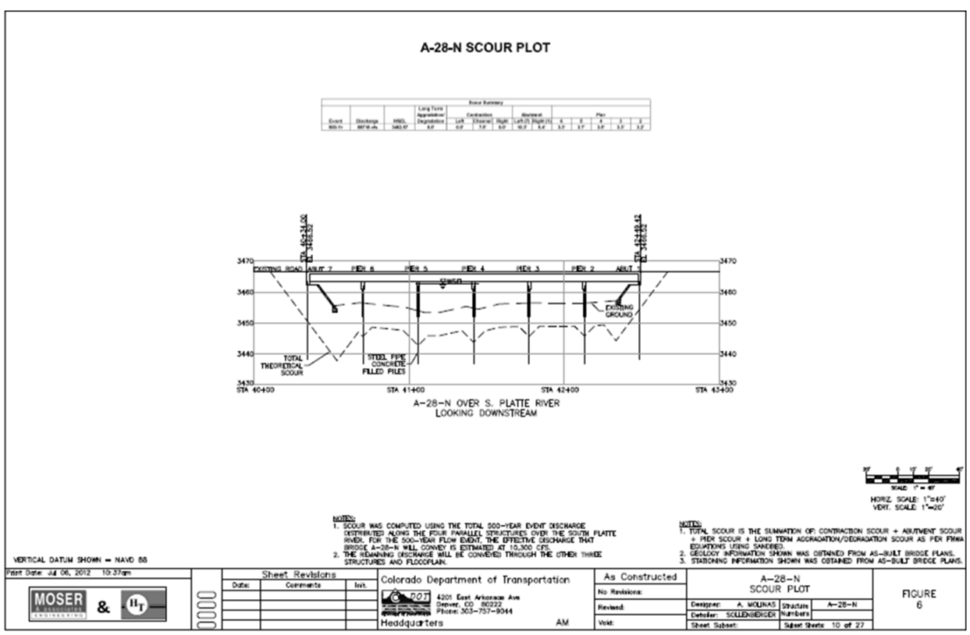


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, pier 4, pier 5, pier 6, and right abutment). Figure 5 shows an aerial image of structure A-28-N with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge A-28-N with recommended hydraulic scour countermeasure locations

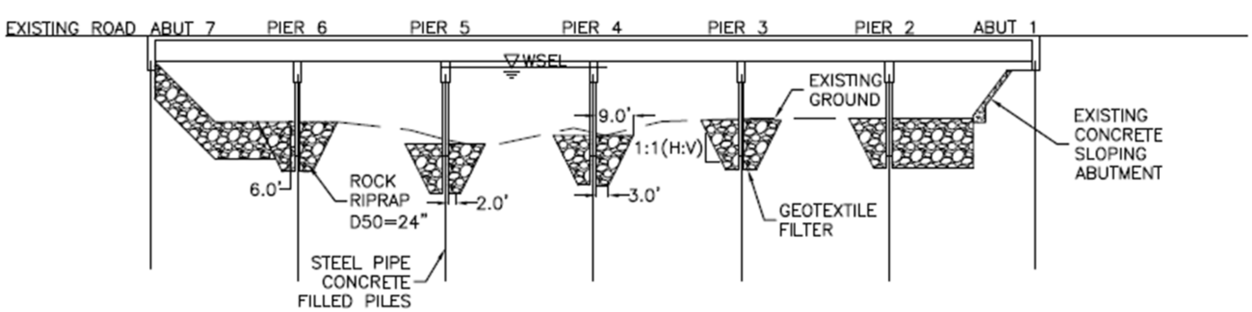


Figure 6. Cross-sectional view of Bridge A-28-N with recommended hydraulic scour countermeasures

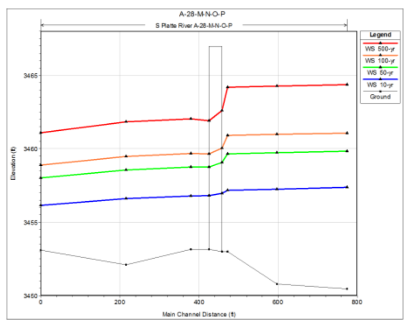
US Highway 385 Bridge A-28-M Over South Platte River, Colorado

Bridge A-28-M is located in Sedgwick County on US Highway 385 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge A-28-M over the Colorado River.

Hydrau-Tech, Inc. began the POA study of Bridge A-28-M by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 88,718 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge A-28-M over the South Platte River



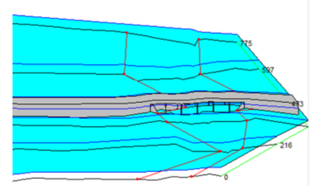


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-28-M

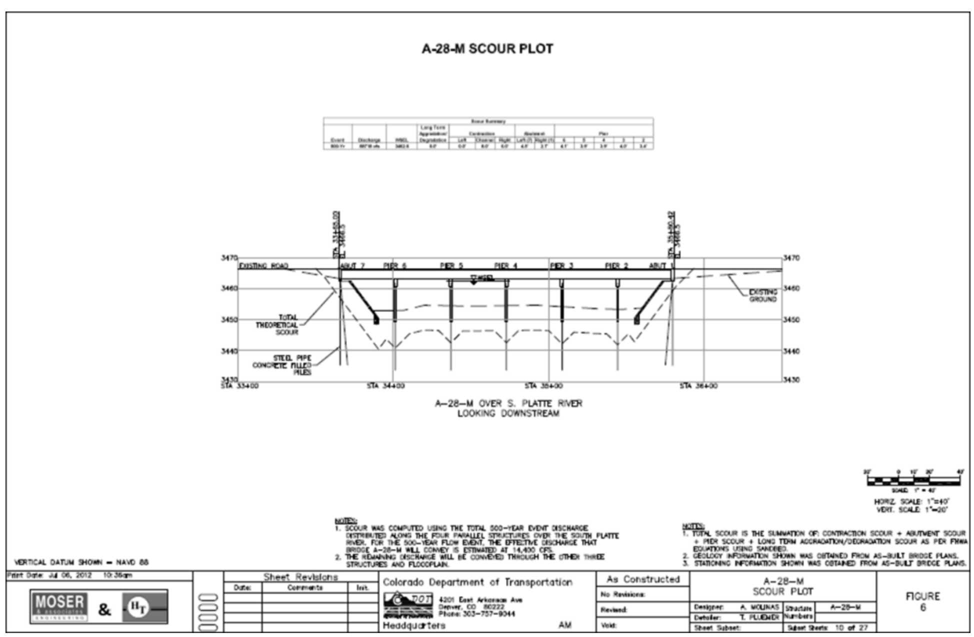


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, pier 4, pier 5, pier 6, and right abutment). Figure 5 shows an aerial image of structure A-28-M with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge A-28-M with recommended hydraulic scour countermeasure locations

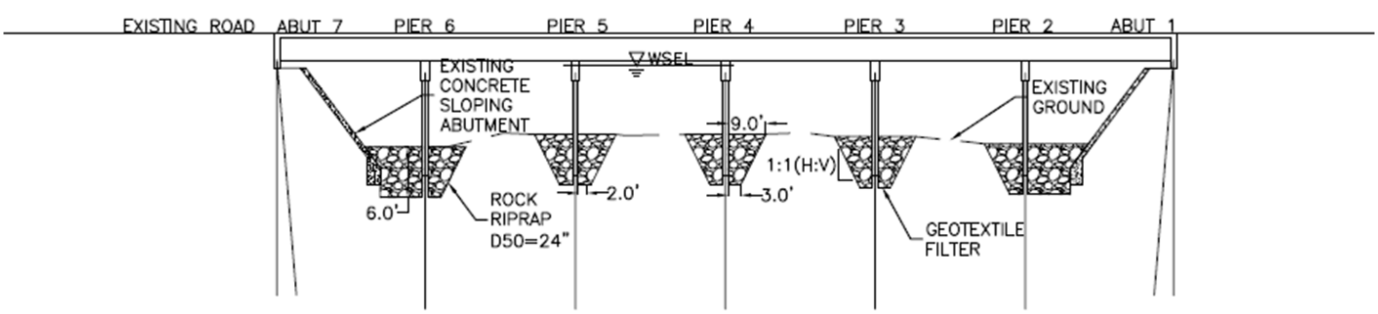


Figure 6. Cross-sectional view of Bridge A-28-M with recommended hydraulic scour countermeasures

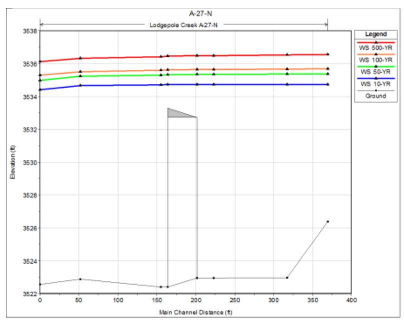
State Highway 138 Bridge A-27-N Over Lodgepole Creek, Colorado

Bridge A-27-N is located in Sedgwick County on State Highway 138 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge A-27-N over the Colorado River.

Hydrau-Tech, Inc. began the POA study of Bridge A-27-N by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 44,567 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge A-27-N over the Lodgepole Creek



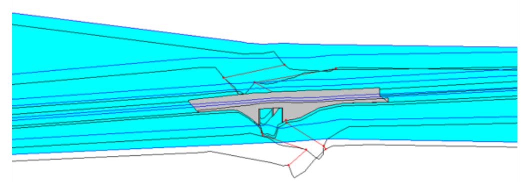


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-27-N

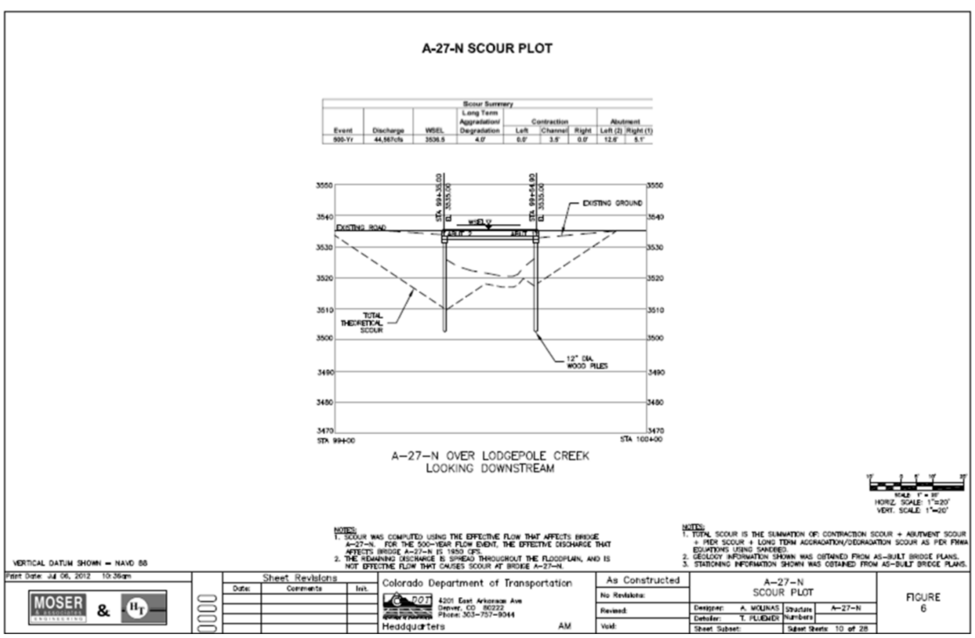


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap and a drop structure was chosen as the preferred hydraulic scour countermeasures. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection and drop structure designs, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment and right abutment), as well as a downstream drop sturcture. Figure 5 shows an aerial image of structure A-27-N with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

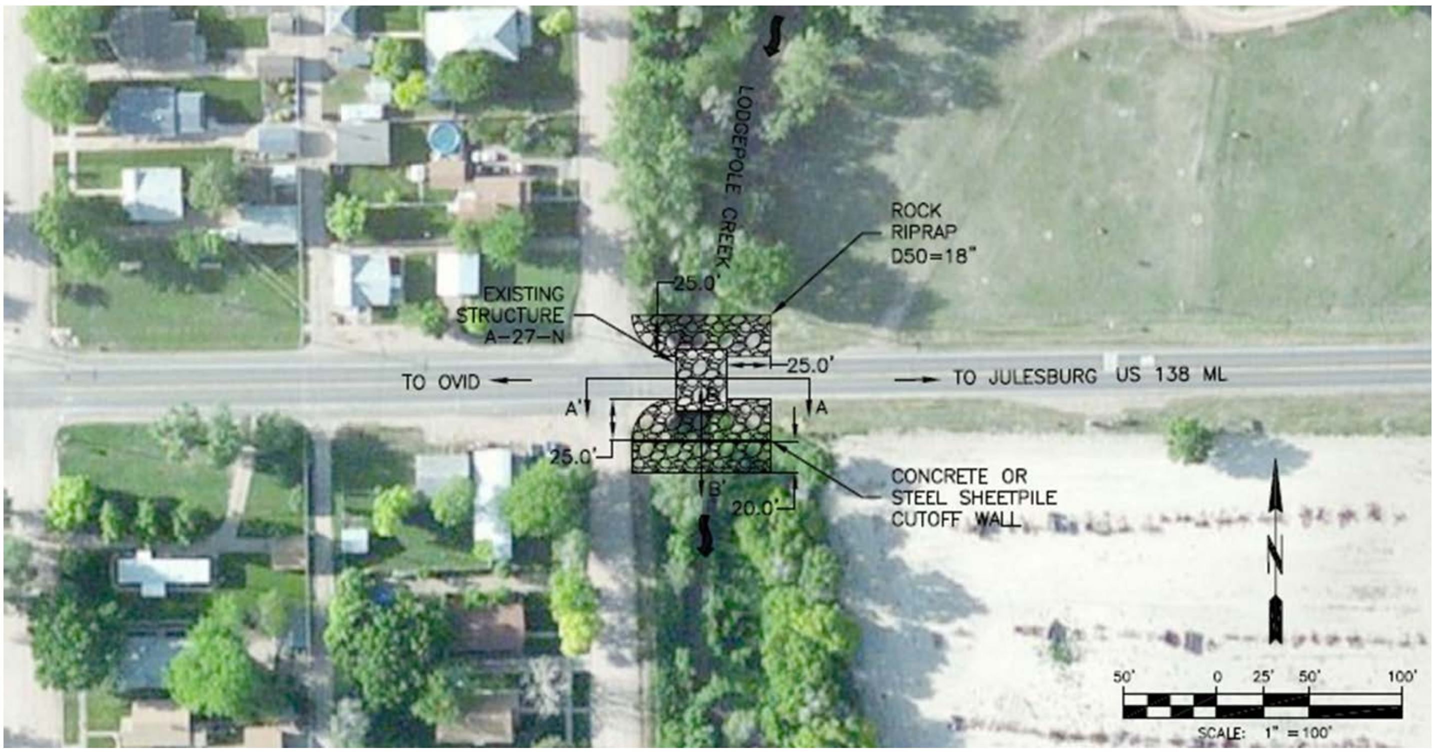


Figure 5. Plan view of Bridge A-27-N with recommended hydraulic scour countermeasure locations

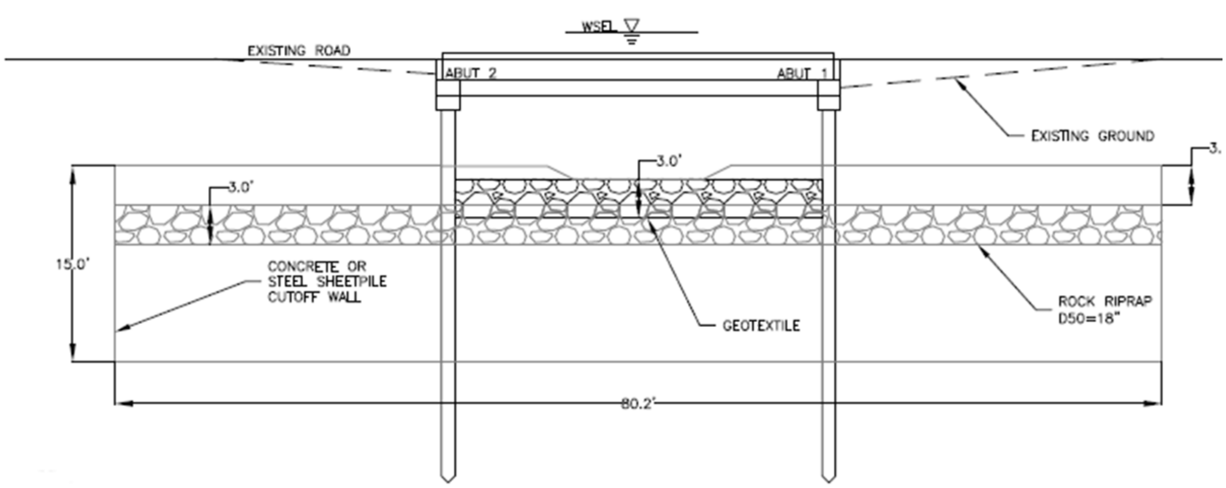


Figure 6. Cross-sectional view of Bridge A-27-N with recommended hydraulic scour countermeasures

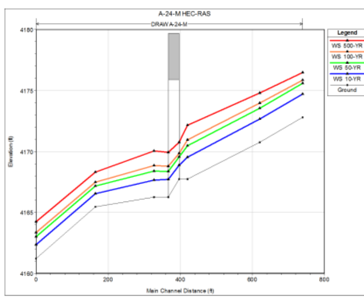
STATE HIGHWAY 113 BRIDGE A-24-M OVER DRAW, COLORADO

Bridge A-24-M is located in Eagle County on State Highway 131 ML where the highway crosses the upper Colorado River. Figure 1 shows Bridge A-24-M over the Colorado River.

Hydrau-Tech, Inc. began the POA study of Bridge A-24-M by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 518 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge A-24-M over Draw



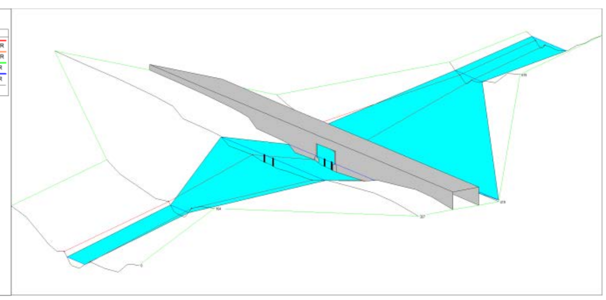


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-24-M

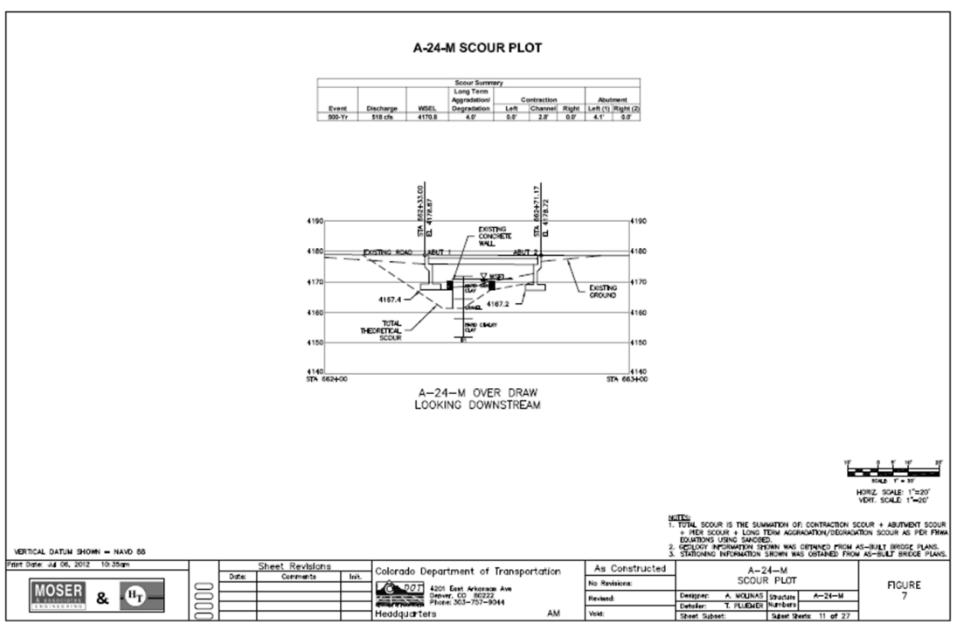


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment and right abutment). Figure 5 shows an aerial image of structure A-24-M with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge A-24-M with recommended hydraulic scour countermeasure locations

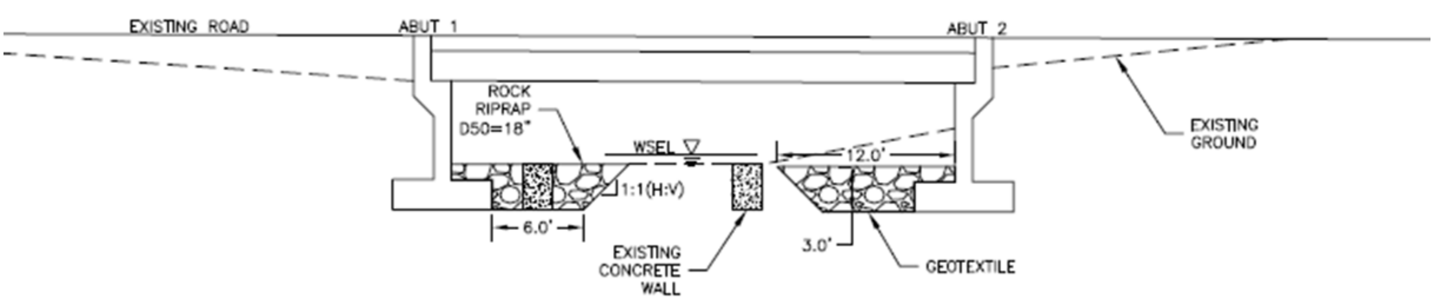


Figure 6. Cross-sectional view of Bridge A-24-M with recommended hydraulic scour countermeasures

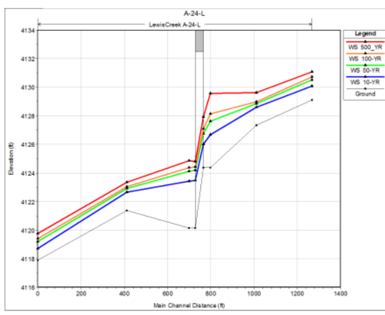
State Highway 113 Bridge A-24-L Over Draw, Colorado

Bridge A-24-L is located in Logan County on State Highway 113 ML where the highway crosses the upper Draw. Figure 1 shows Bridge A-24-L over the Draw.

Hydrau-Tech, Inc. began the POA study of Bridge A-24-L by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 820 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge A-24-L over the Draw



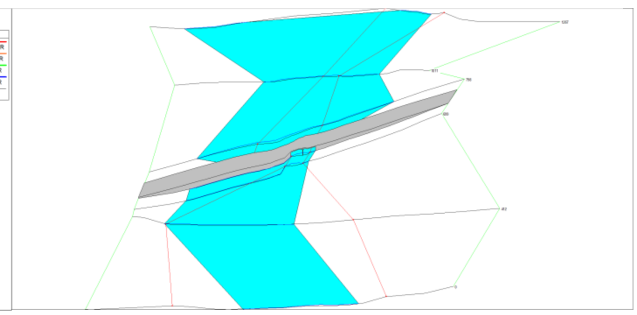


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-24-L

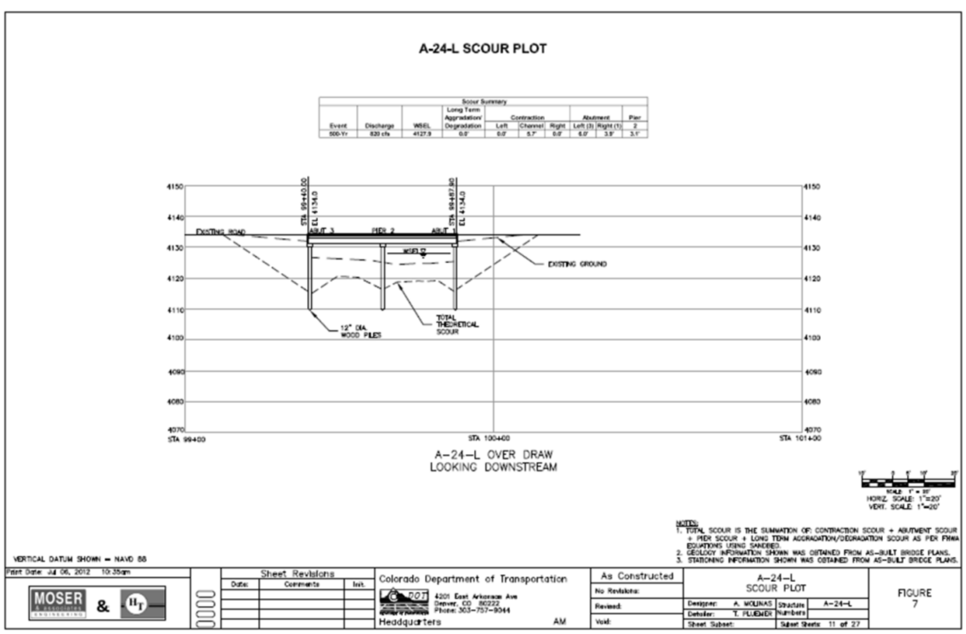


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, and right abutment). Figure 5 shows an aerial image of structure A-24-L with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge A-24-L with recommended hydraulic scour countermeasure locations

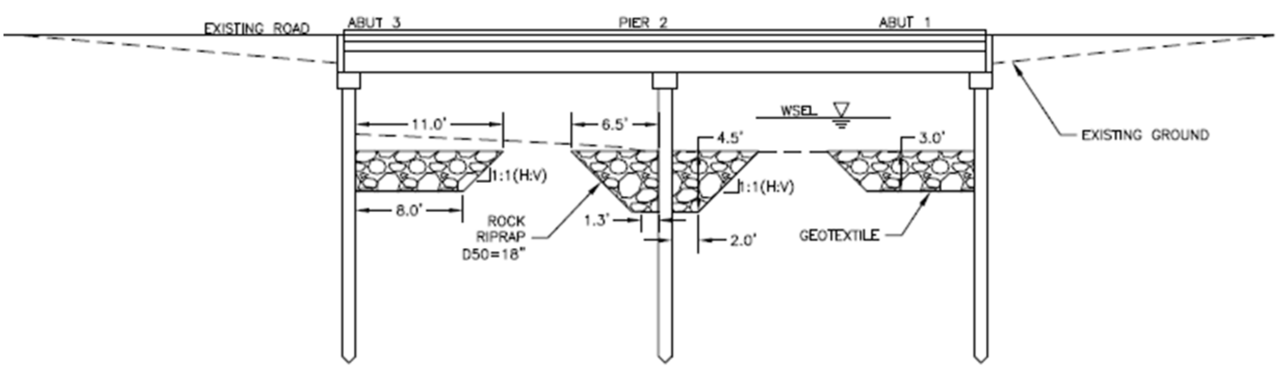


Figure 6. Cross-sectional view of Bridge A-24-L with recommended hydraulic scour countermeasures

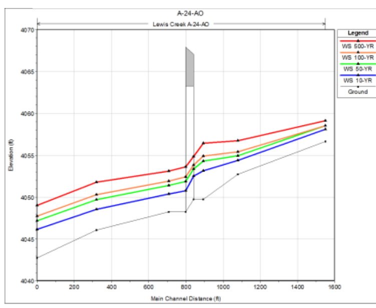
State Highway 113 Bridge A-24-AO Over Lewis Creek, Colorado

Bridge A-24-AO is located in Eagle County on State Highway 113 ML where the highway crosses the upper Lewis Creek. Figure 1 shows Bridge A-24-AO over Lewis Creek.

Hydrau-Tech, Inc. began the POA study of Bridge A-24-AO by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 4,260 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge A-24-AO over Lewis Creek



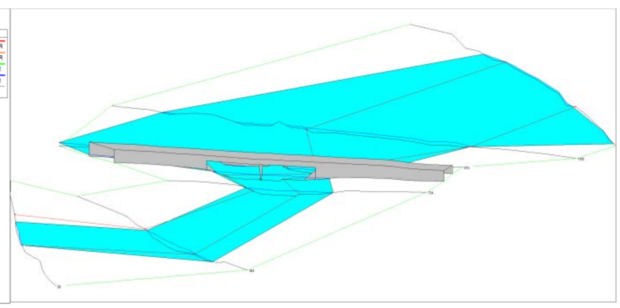


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-24-AO

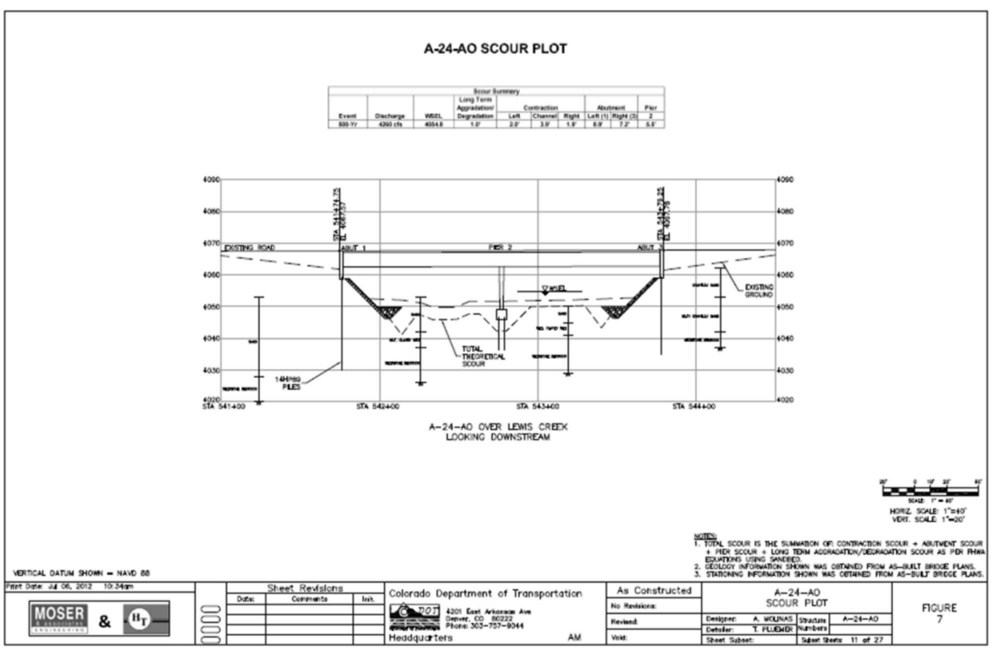


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, and right abutment). Figure 5 shows an aerial image of structure A-24-AO with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

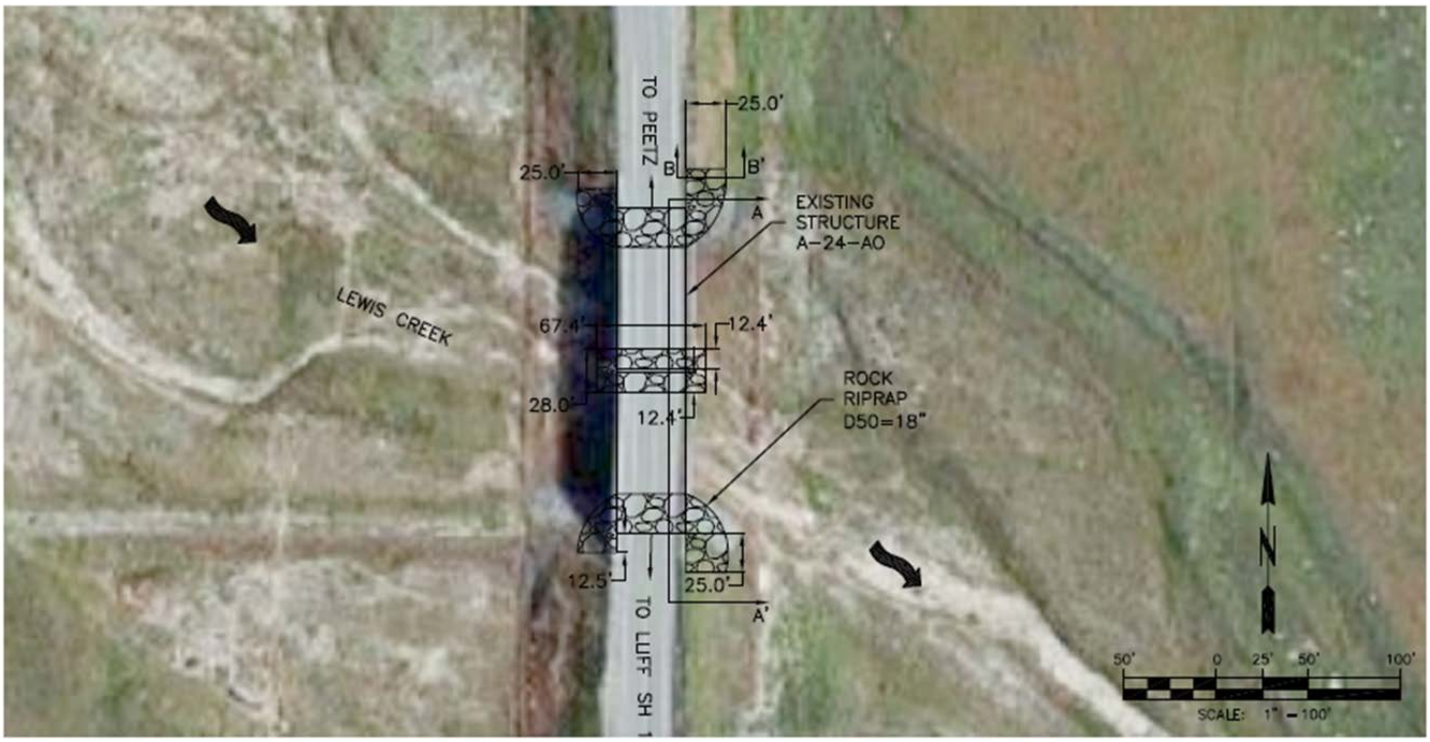


Figure 5. Plan view of Bridge A-24-AO with recommended hydraulic scour countermeasure locations

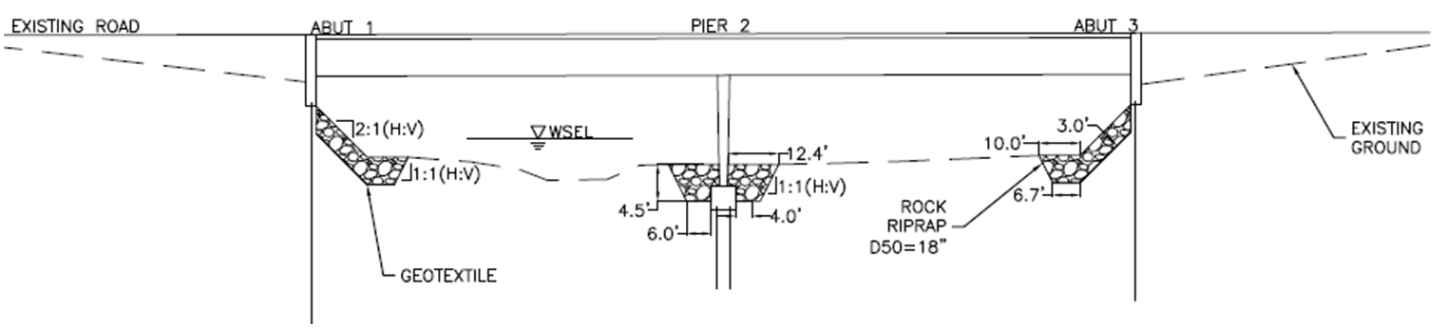


Figure 6. Cross-sectional view of Bridge A-24-AO with recommended hydraulic scour countermeasures

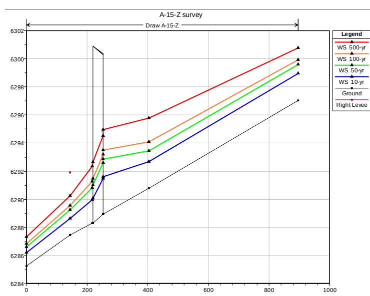
State Highway 287 Bridge A-15-Z Over Draw, Colorado

Bridge A-15-Z is located in Larimer Country on State Highway 287 where the highway crosses the upper Draw. Figure 1 shows Bridge A-15-Z over the Draw.

Hydrau-Tech, Inc. began the POA study of Bridge A-15-Z by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 1,220 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge A-15-Z over the Draw



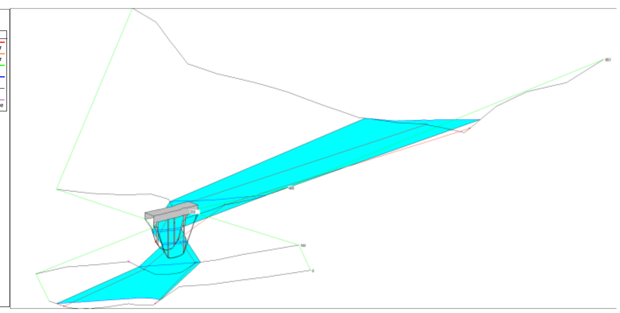


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure A-15-Z

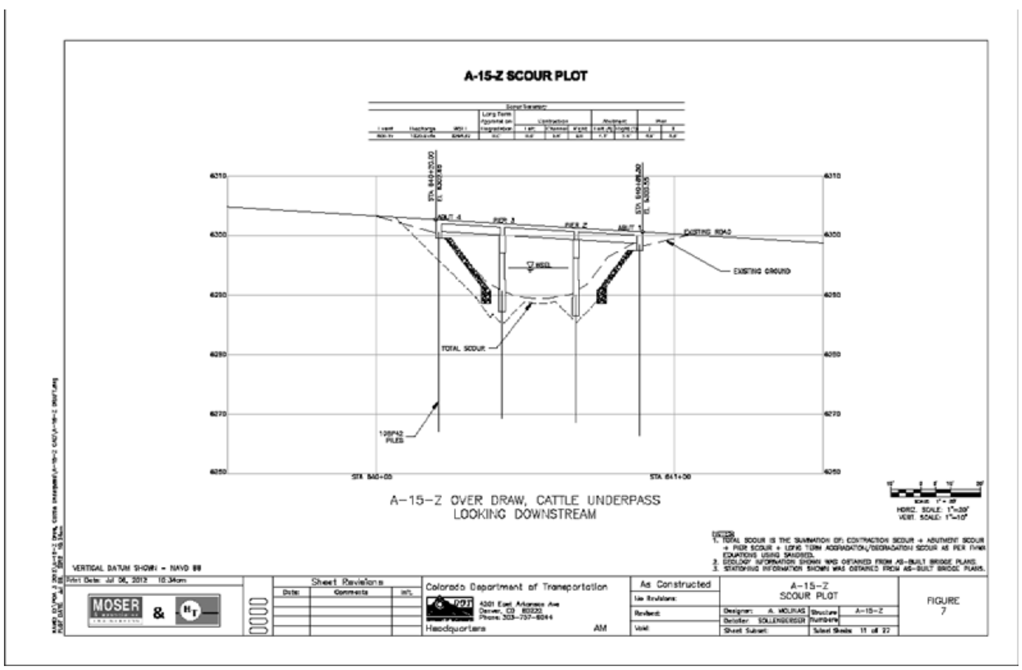


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment, pier 2, pier 3, and right abutment). Figure 5 shows an aerial image of structure A-15-Z with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

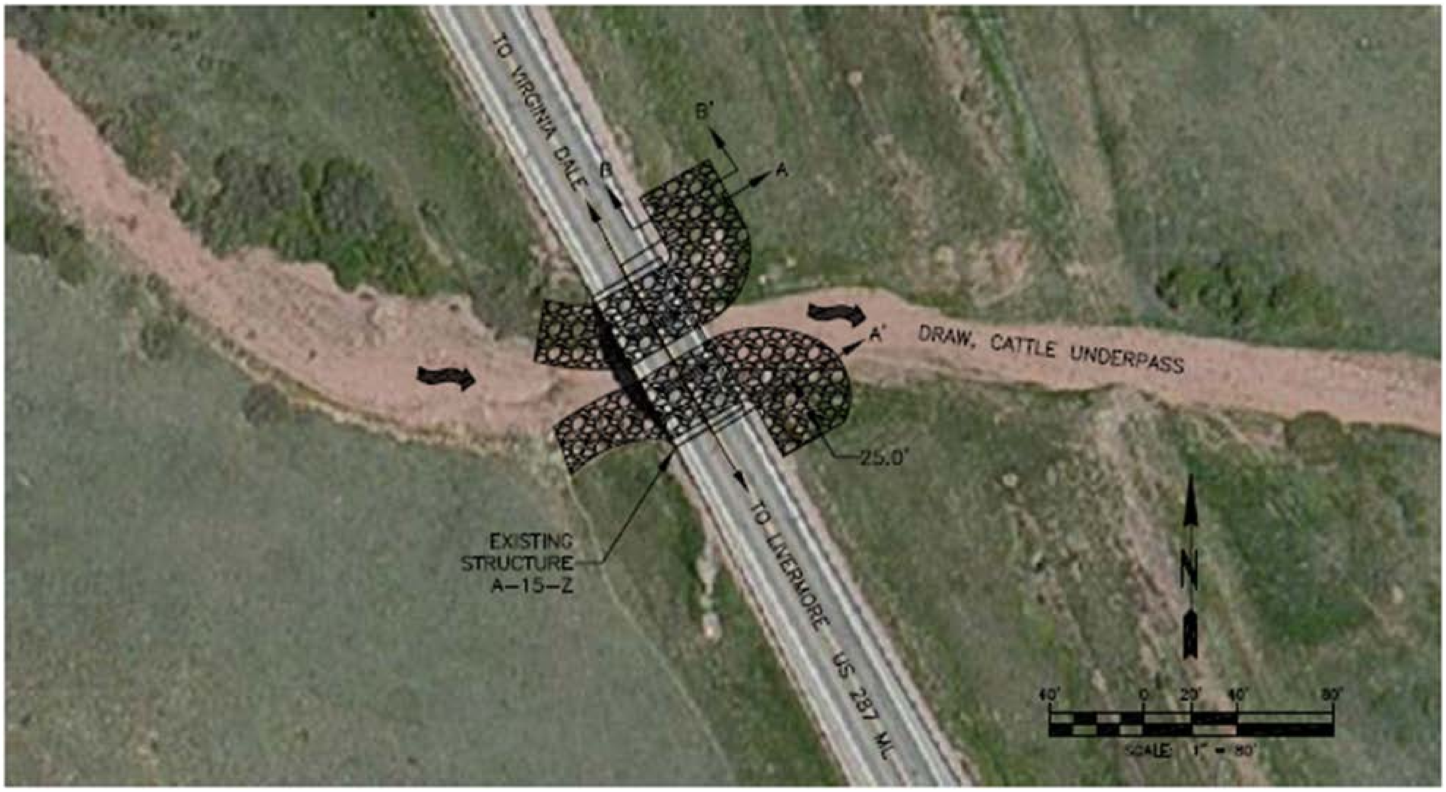


Figure 5. Plan view of Bridge A-15-Z with recommended hydraulic scour countermeasure locations

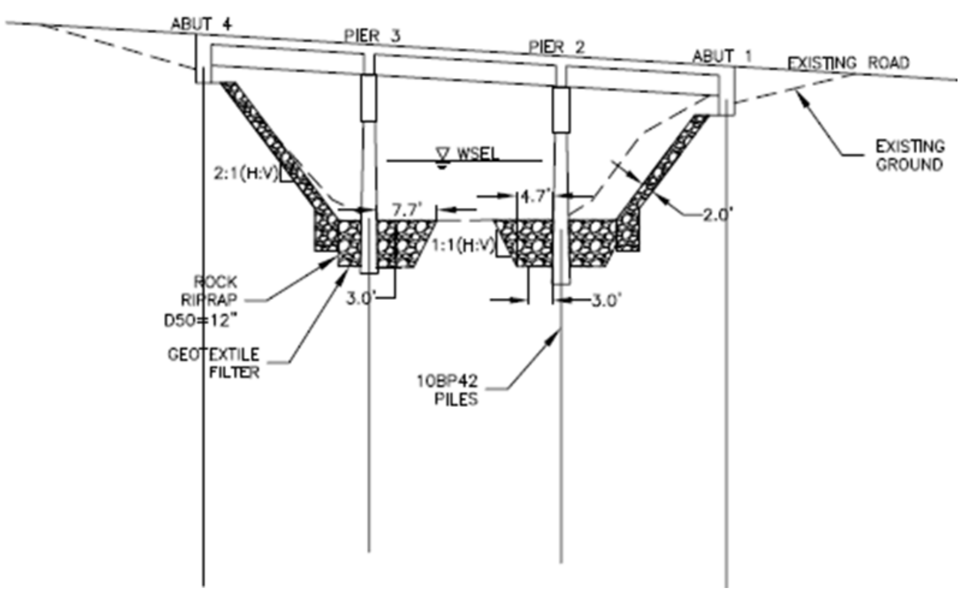


Figure 6. Cross-sectional view of Bridge A-15-Z with recommended hydraulic scour countermeasures

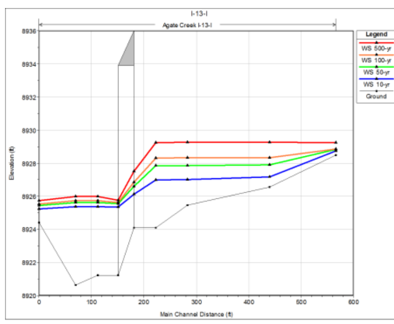
US HIGHWAY 24 BRIDGE I-13-I OVER AGATE CREEK, COLORADO

Bridge I-13-I is located in Park County on US Highway 24 ML where the highway crosses Agate Creek. Figure 1 shows Bridge I-13-I over Agate Creek.

Hydrau-Tech, Inc. began the POA study of Bridge I-13-I by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 651cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge I-13-I over Agate Creek



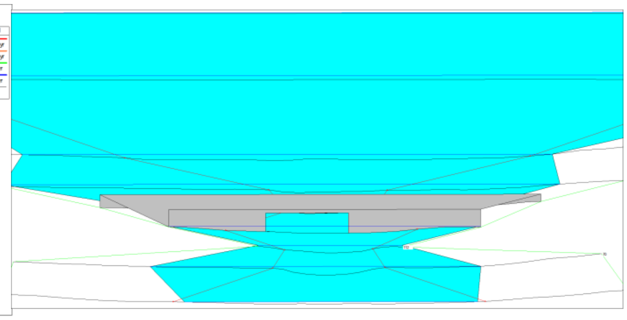


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure E-10-A

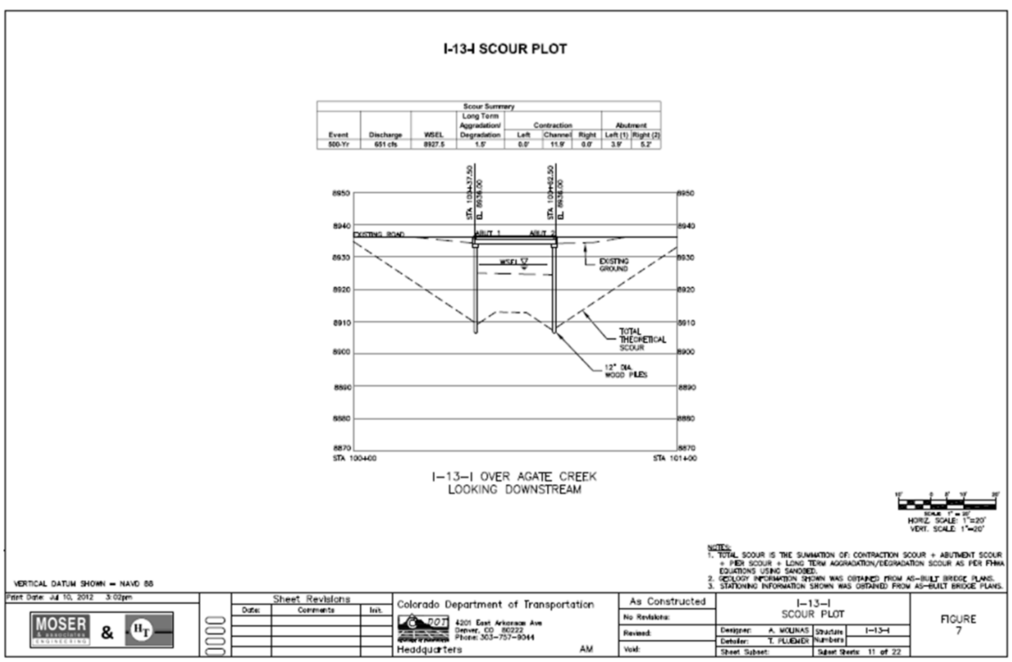


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Abutment riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left and right abutments). Figure 5 shows an aerial image of structure I-13-I with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

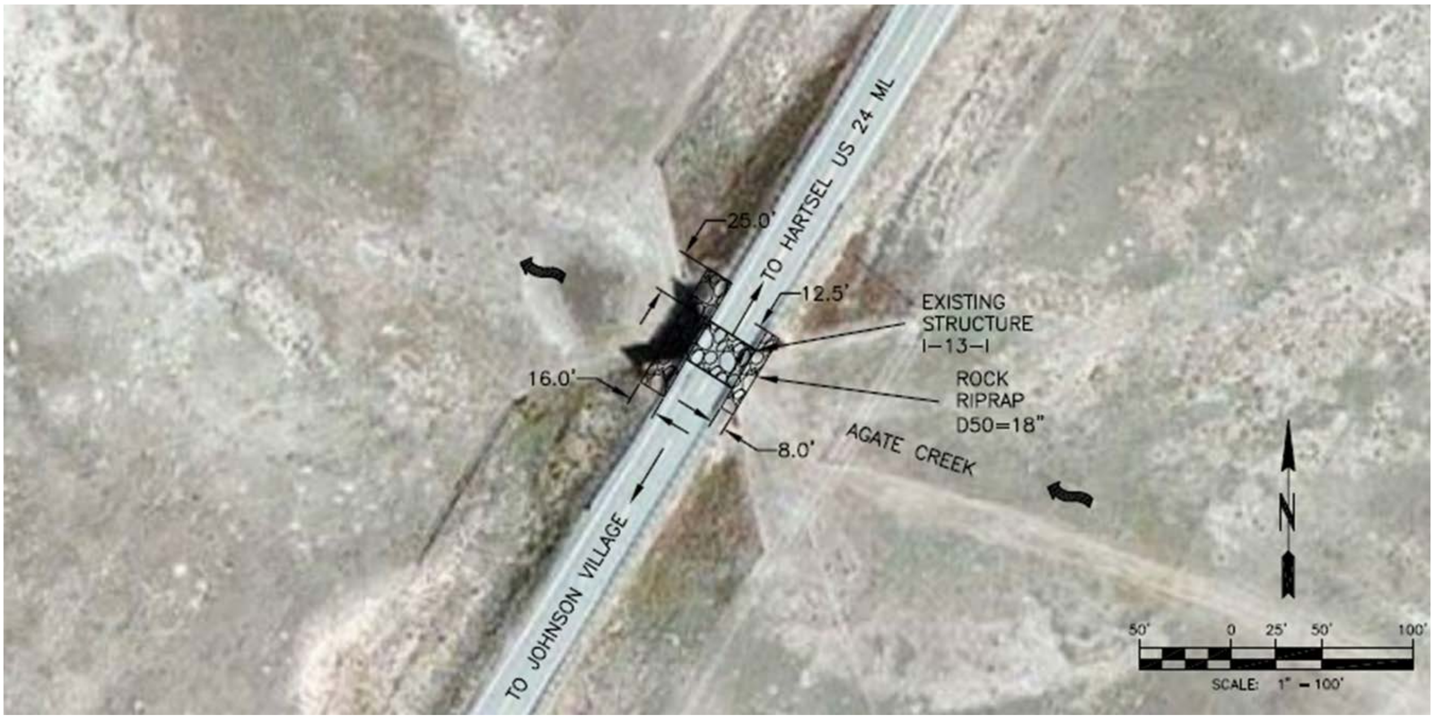


Figure 5. Plan view of Bridge I-13-I with recommended hydraulic scour countermeasure locations

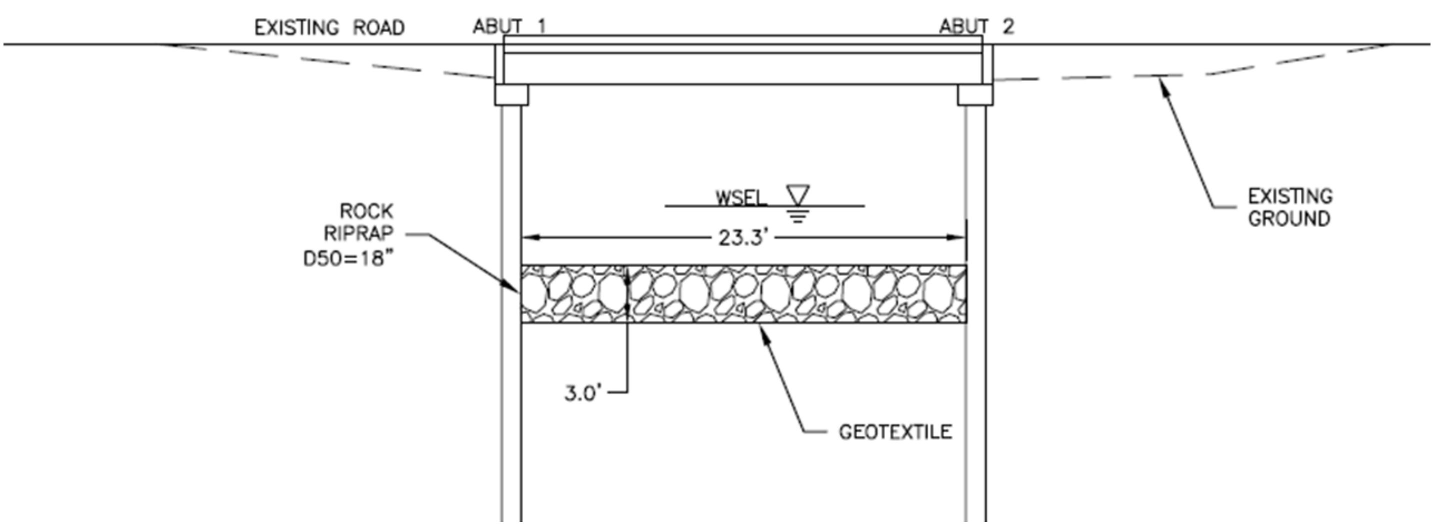


Figure 6. Cross-sectional view of Bridge I-13-I with recommended hydraulic scour countermeasures

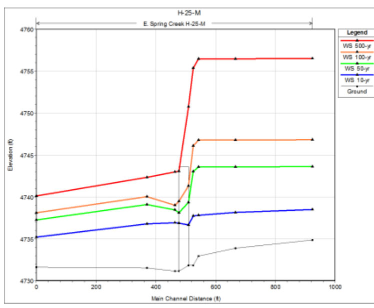
State Highway 59 Bridge H-25-M over East Spring Creek Tributary, Colorado

Bridge H-25-M is located in Kit Carson County on State Highway 59 ML where the highway crosses East Spring Creek Tributary. Figure 1 shows Bridge H-25-M over East Spring Creek Tributary.

Hydrau-Tech, Inc. began the POA study of Bridge H-25-M by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 100-year flood discharge of 4,380cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 100-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge H-25-M over East Spring Creek Tributary



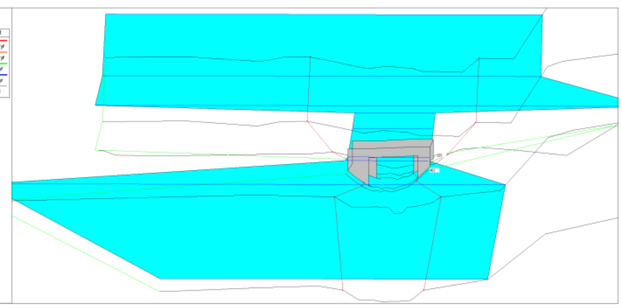


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure H-25-M

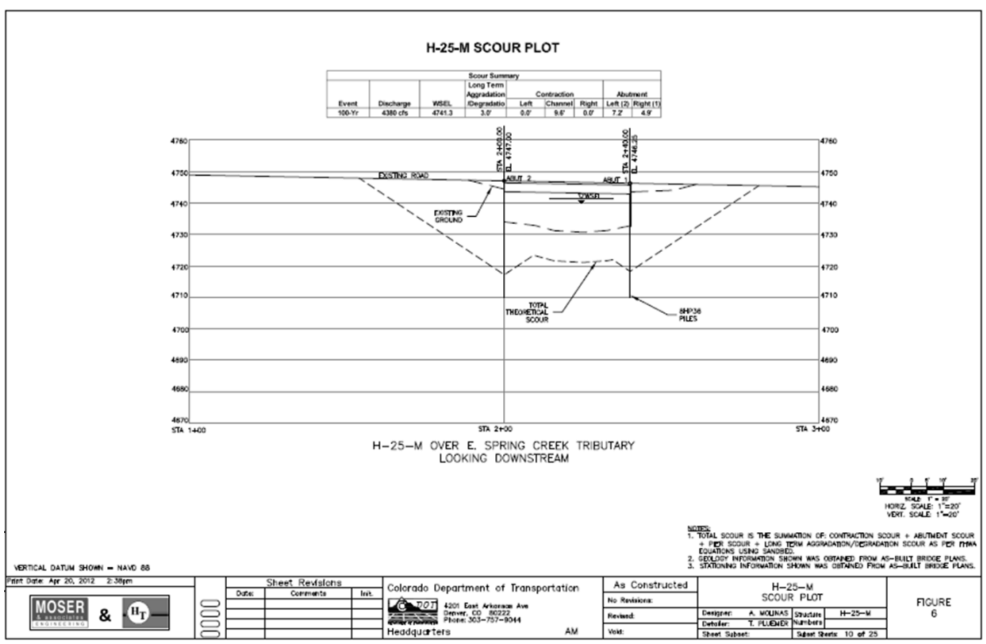


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Partially grouted riprap was chosen as the preferred hydraulic scour countermeasure. Abutment riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.25 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left abutment and right abutments). Figure 5 shows an aerial image of structure H-25-M with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

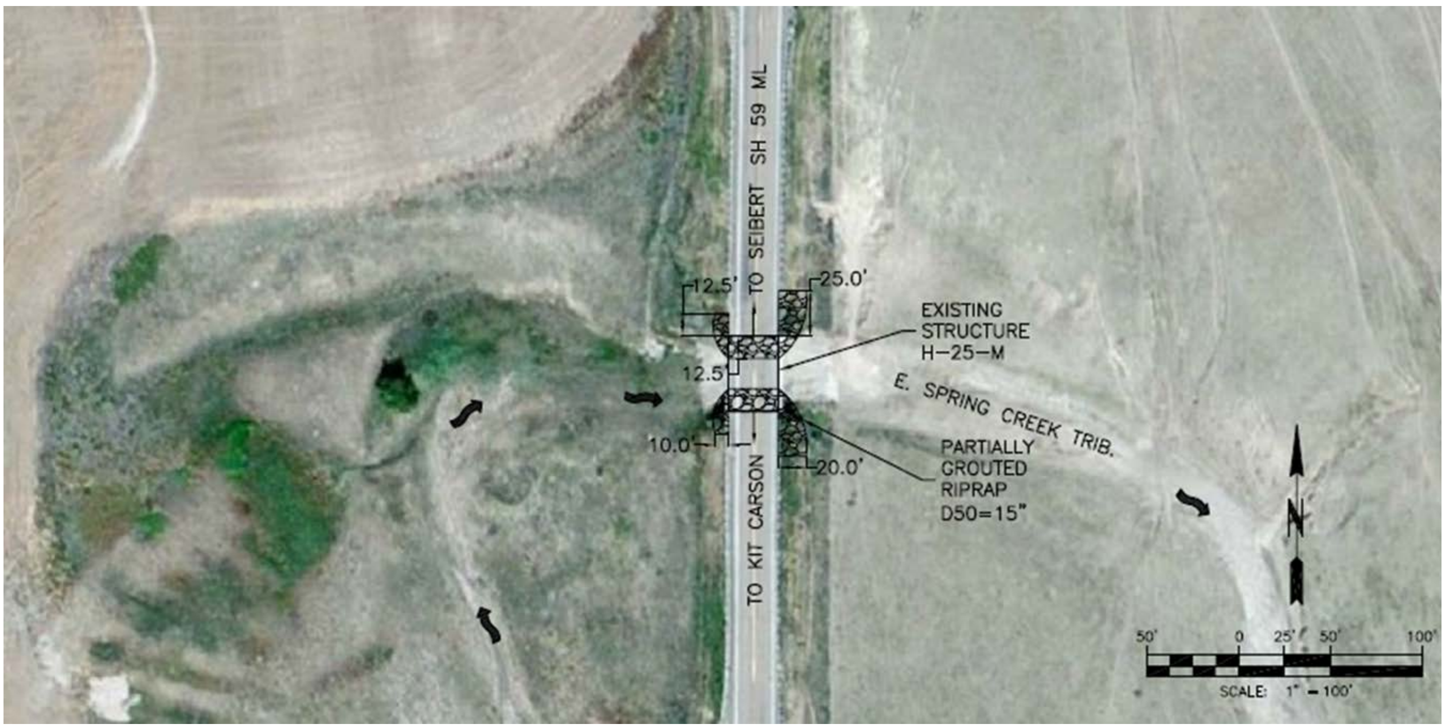


Figure 5. Plan view of Bridge H-25-M with recommended hydraulic scour countermeasure locations

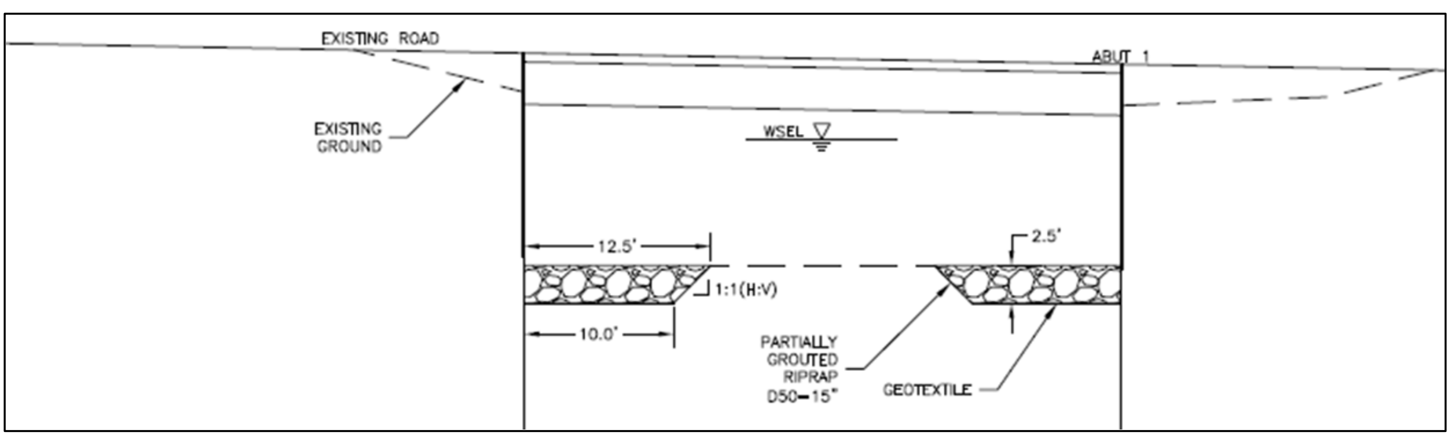


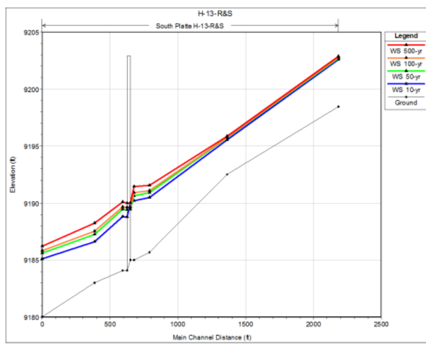
Figure 6. Cross-sectional view of Bridge H-25-M with recommended hydraulic scour countermeasures

STATE HIGHWAY 9 BRIDGE H-13-R OVER THE MIDDLE FORK SOUTH PLATTE RIVER, COLORADO

Bridge H-13-R is located in Park County on State Highway 9 ML where the highway crosses the Middle Fork South Platte River. Figure 1 shows Bridge H-13-R over the Middle Fork South Platte River.

Figure 1. Bridge H-13-R over the Middle Fork South Platte River

Hydrau-Tech, Inc. began the POA study of Bridge H-13-R by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, a modeled flow distribution of the regional regression equations resulted in a 500-year flood discharge of 2,050 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot



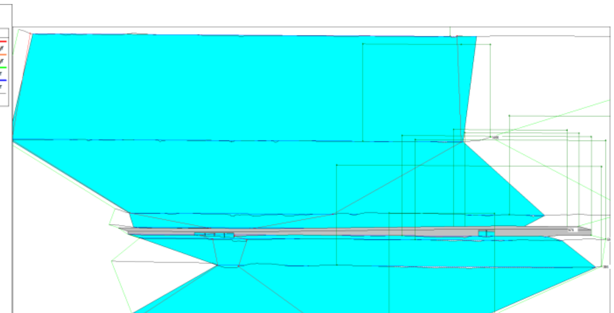


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure H-13-R

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

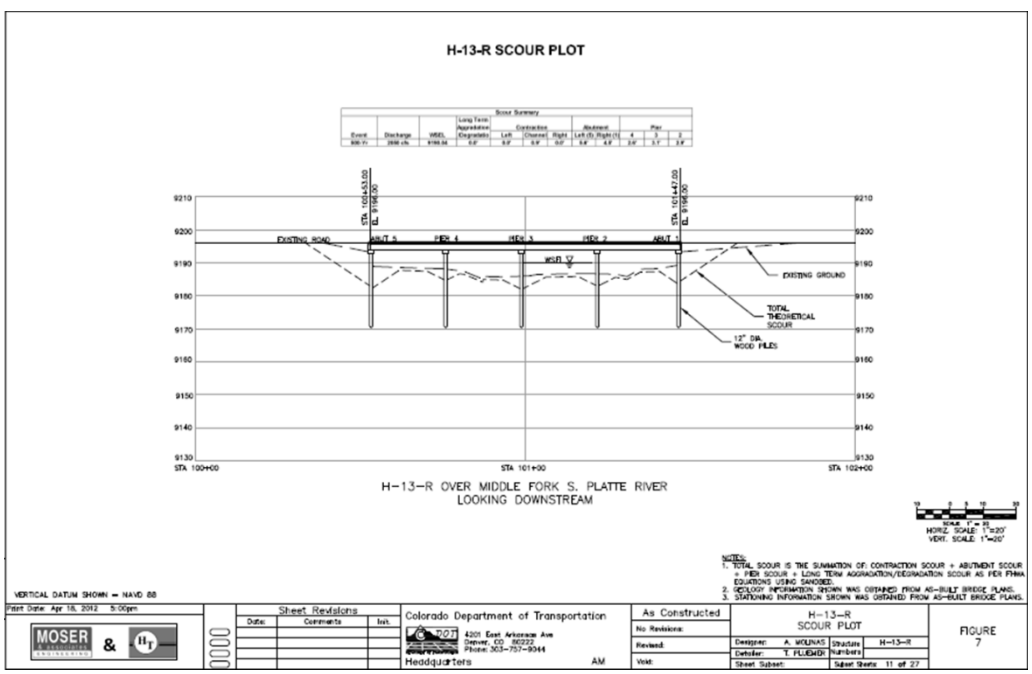


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (both abutments and both piers). Figure 5 shows an aerial image of structure H-13-R with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge H-13-R with recommended hydraulic scour countermeasure locations

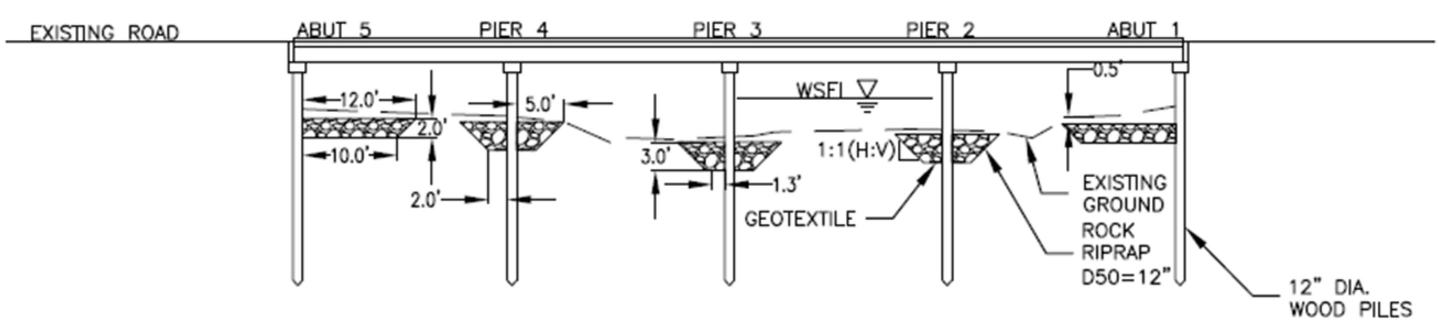


Figure 6. Cross-sectional view of Bridge H-13-R with recommended hydraulic scour countermeasures

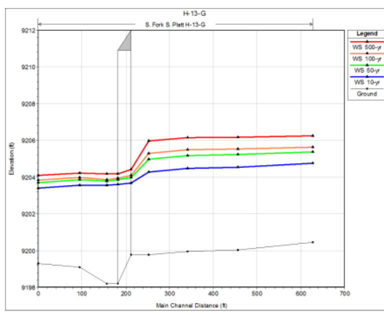
US HIGHWAY 285 BRIDGE H-13-G OVER SOUTH FORK SOUTH PLATTE RIVER, COLORADO

Bridge H-13-G is located in Park County on US 285 ML where the highway crosses the South Fork South Platte River. Figure 1 shows Bridge H-13-G over the South Fork South Platte River.

Hydrau-Tech, Inc. began the POA study of BridgeH-13-G by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 1,530 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge H-13-G over the South Fork South Platte River



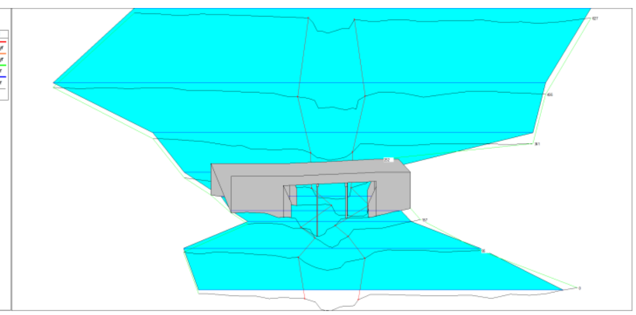


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure H-13-G

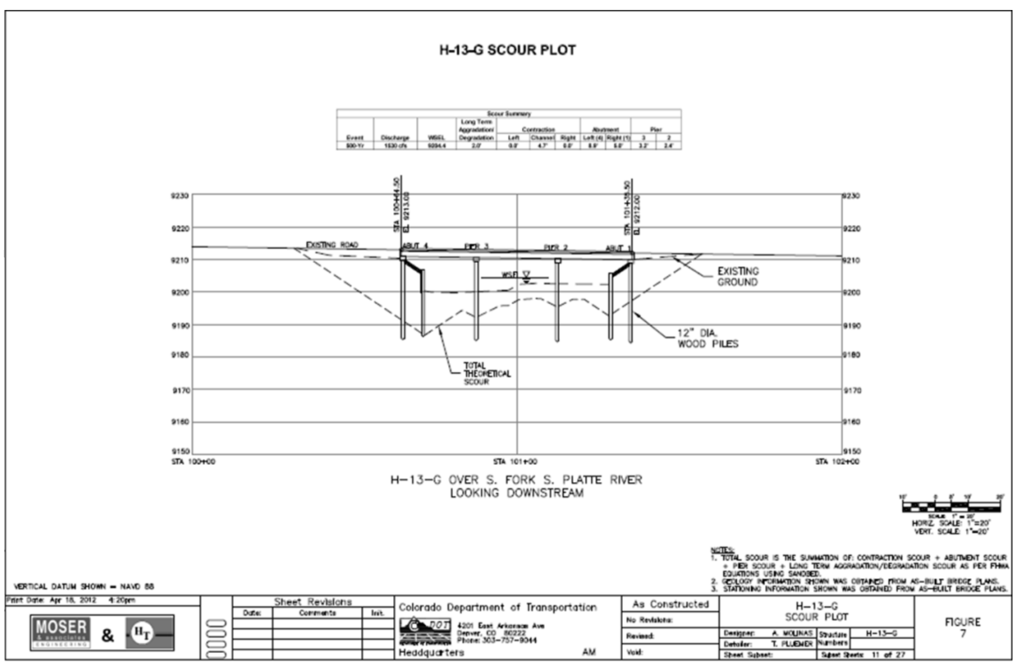


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (both abutments and both piers). Figure 5 shows an aerial image of structure H-13-G with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were completed for comparison.

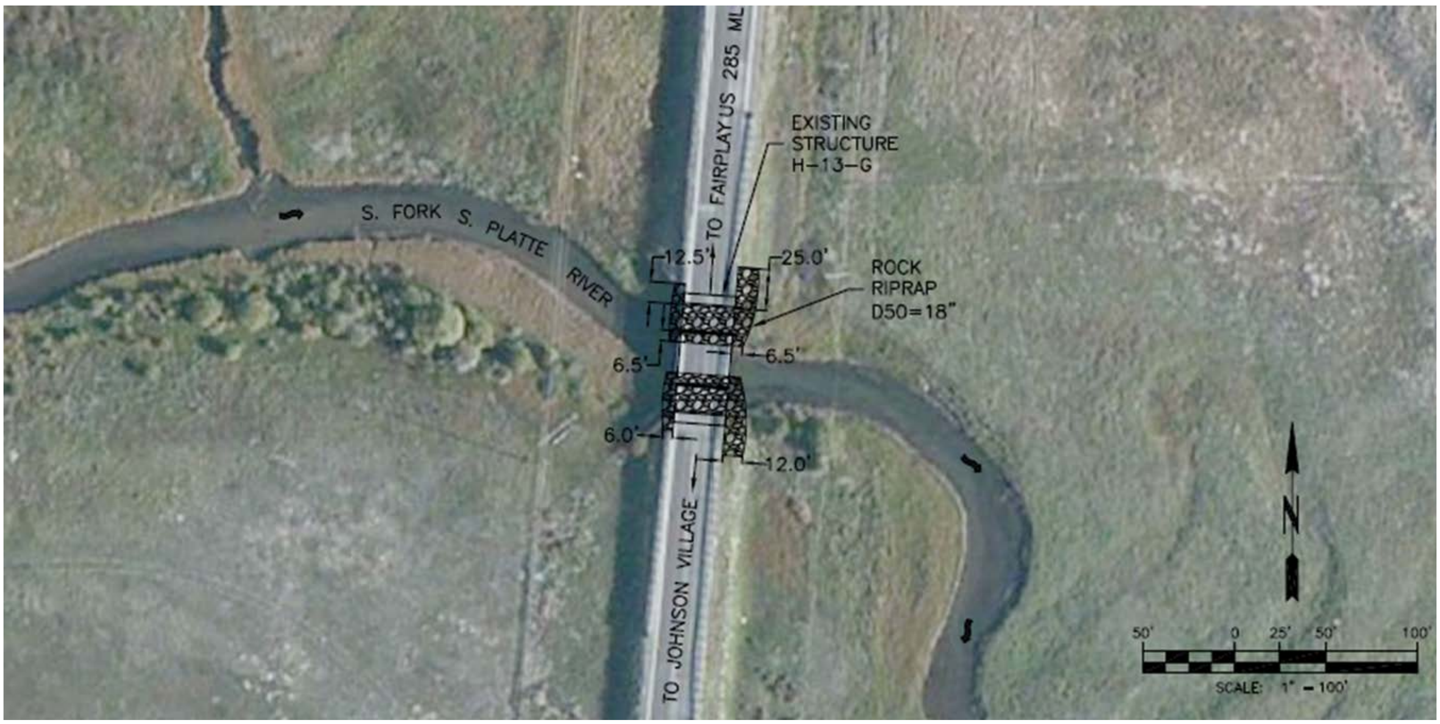


Figure 5. Plan view of Bridge H-13-G with recommended hydraulic scour countermeasure locations

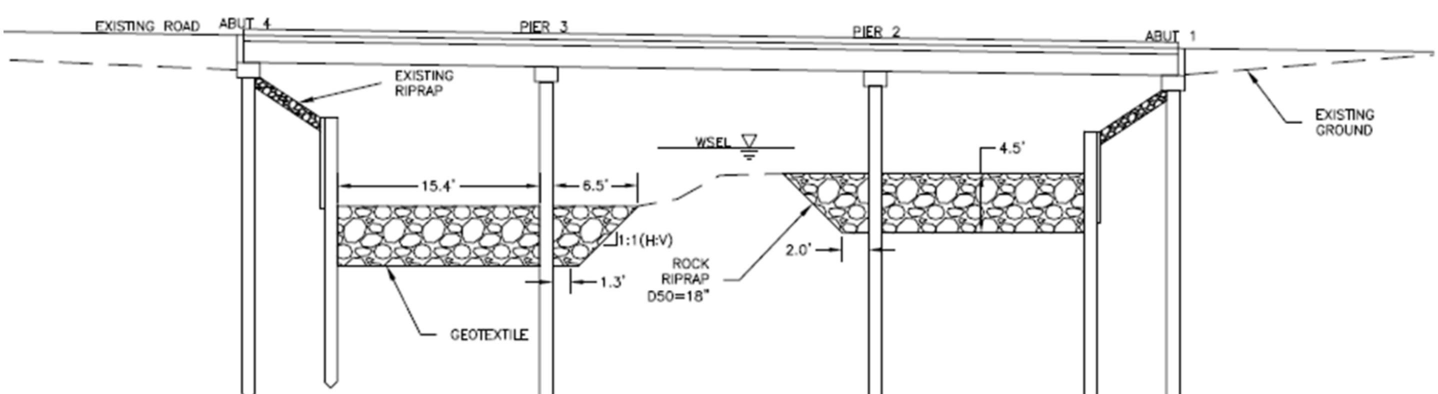


Figure 6. Cross-sectional view of Bridge H-13-G with recommended hydraulic scour countermeasures

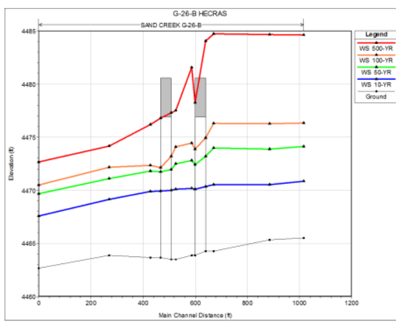
INTERSTATE 70
BRIDGE G-26-B OVER
SPRING CREEK,
COLORADO

Bridge G-26-B is located in Kit Carson County on Interstate Highway 70 where the highway crosses Spring Creek. Figure 1 shows Bridge G-26-B over Spring Creek.

Hydrau-Tech, Inc. began the POA study of Bridge G-26-B by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 18,400cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge G-26-B over Spring Creek



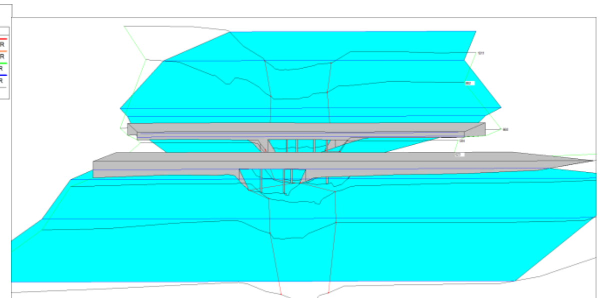


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-26-B

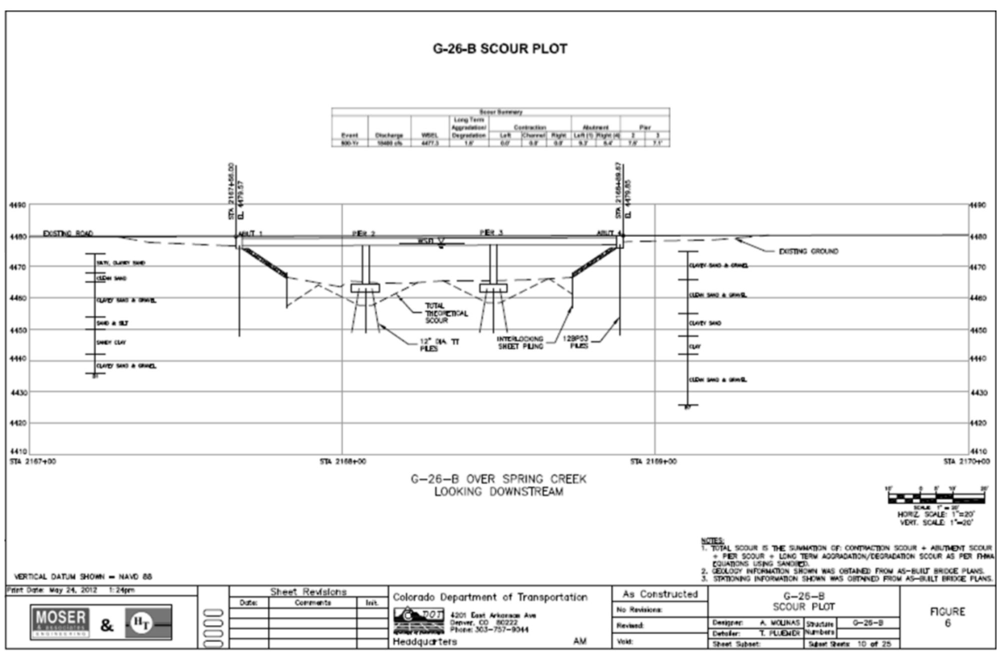


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Partially grouted riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.25 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (both abutments and both piers). Figure 5 shows an aerial image of structure G-26-B with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

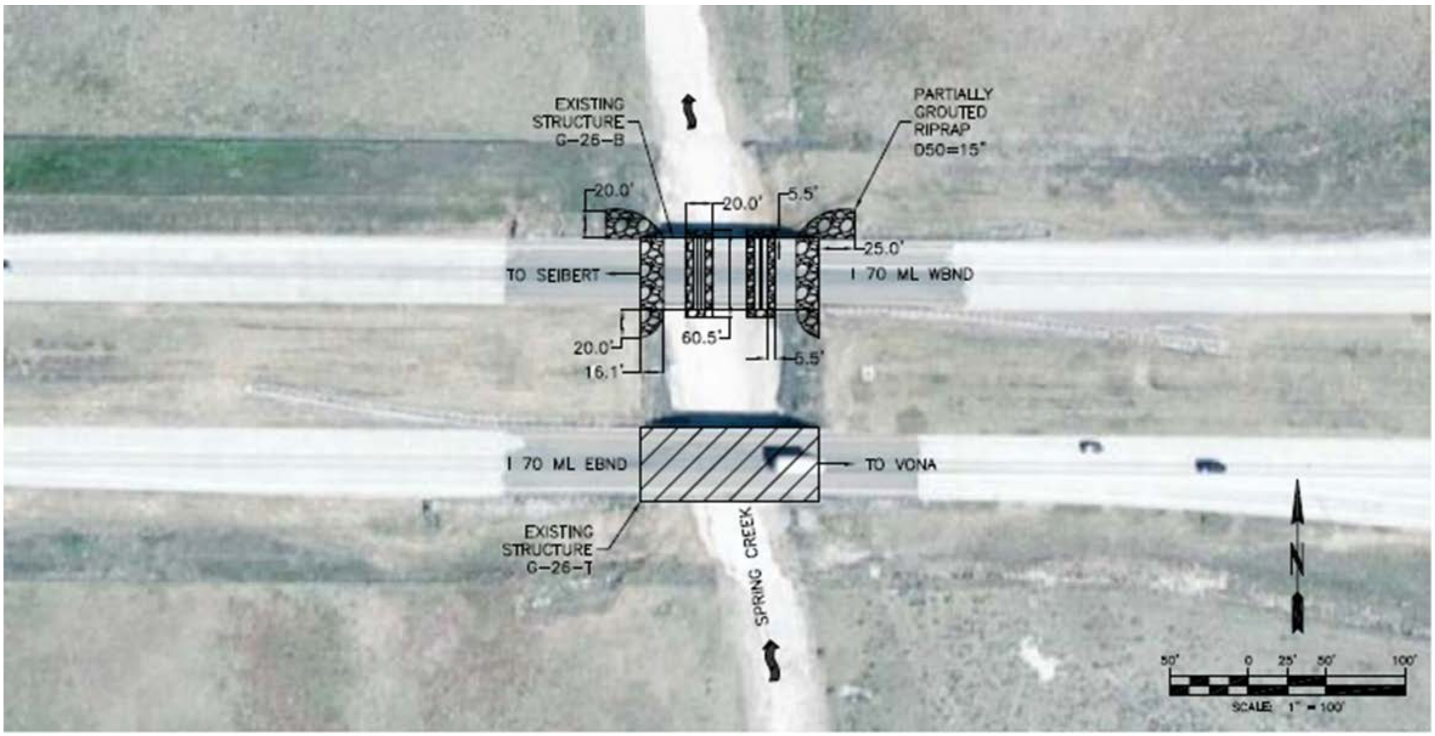


Figure 5. Plan view of Bridge G-26-B with recommended hydraulic scour countermeasure locations

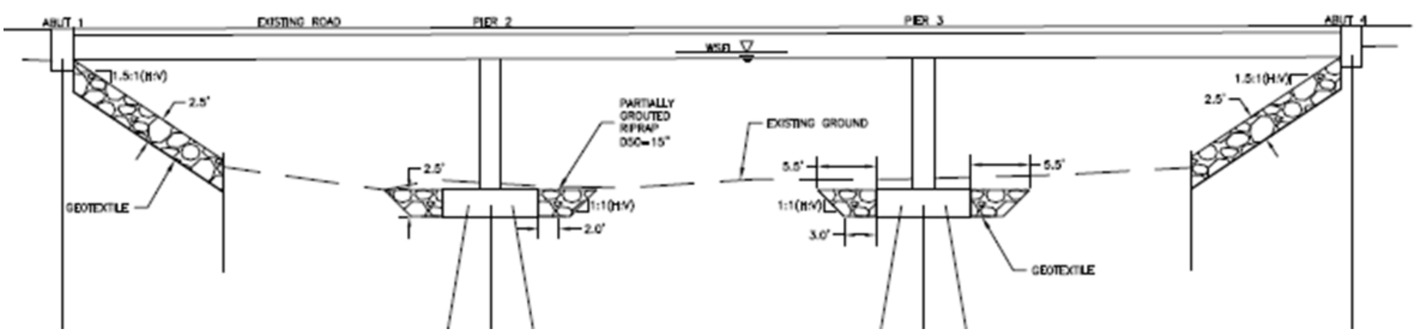


Figure 6. Cross-sectional view of Bridge G-26-B with recommended hydraulic scour countermeasures

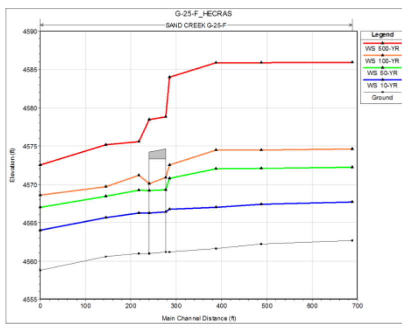
STATE HIGHWAY 59 BRIDGE G-25-F OVER SAND CREEK, COLORADO

Bridge G-25-F is located in Kit Carson County on State Highway 59 ML where the highway crosses Sand Creek. Figure 1 shows Bridge G-25-F over Sand Creek.

Hydrau-Tech, Inc. began the POA study of Bridge G-25-F by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 100-year flood discharge of 11,700 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 100-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge G-25-F over Sand Creek



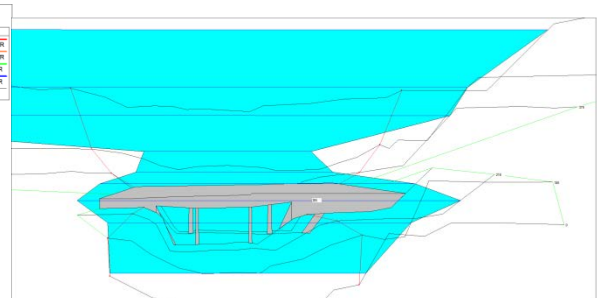


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-25-F

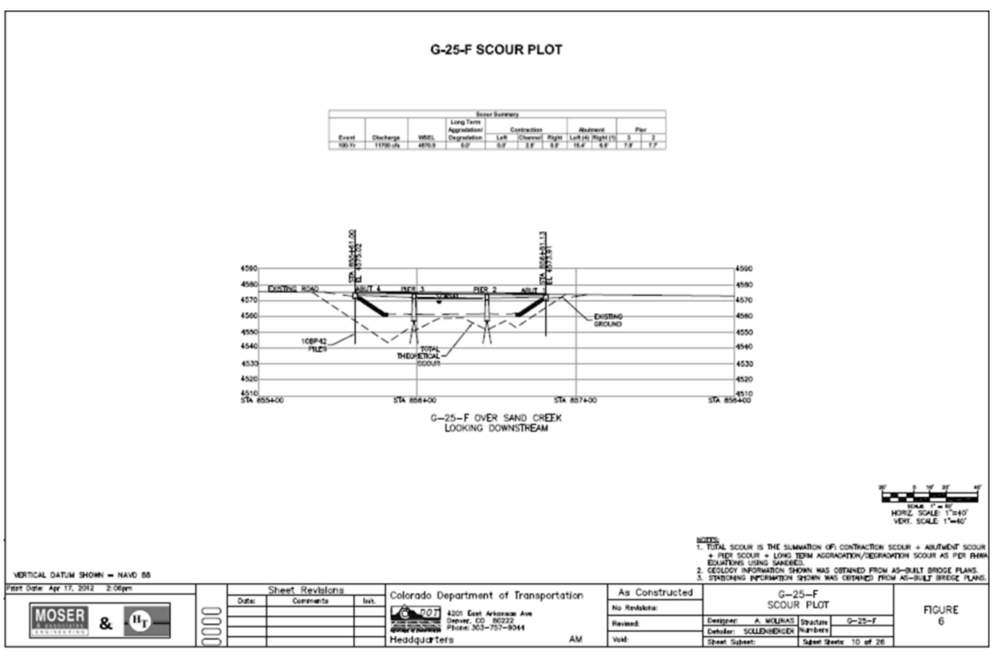


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Partially grouted riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.25 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (both abutments and both piers). Figure 5 shows an aerial image of structure G-25-F with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

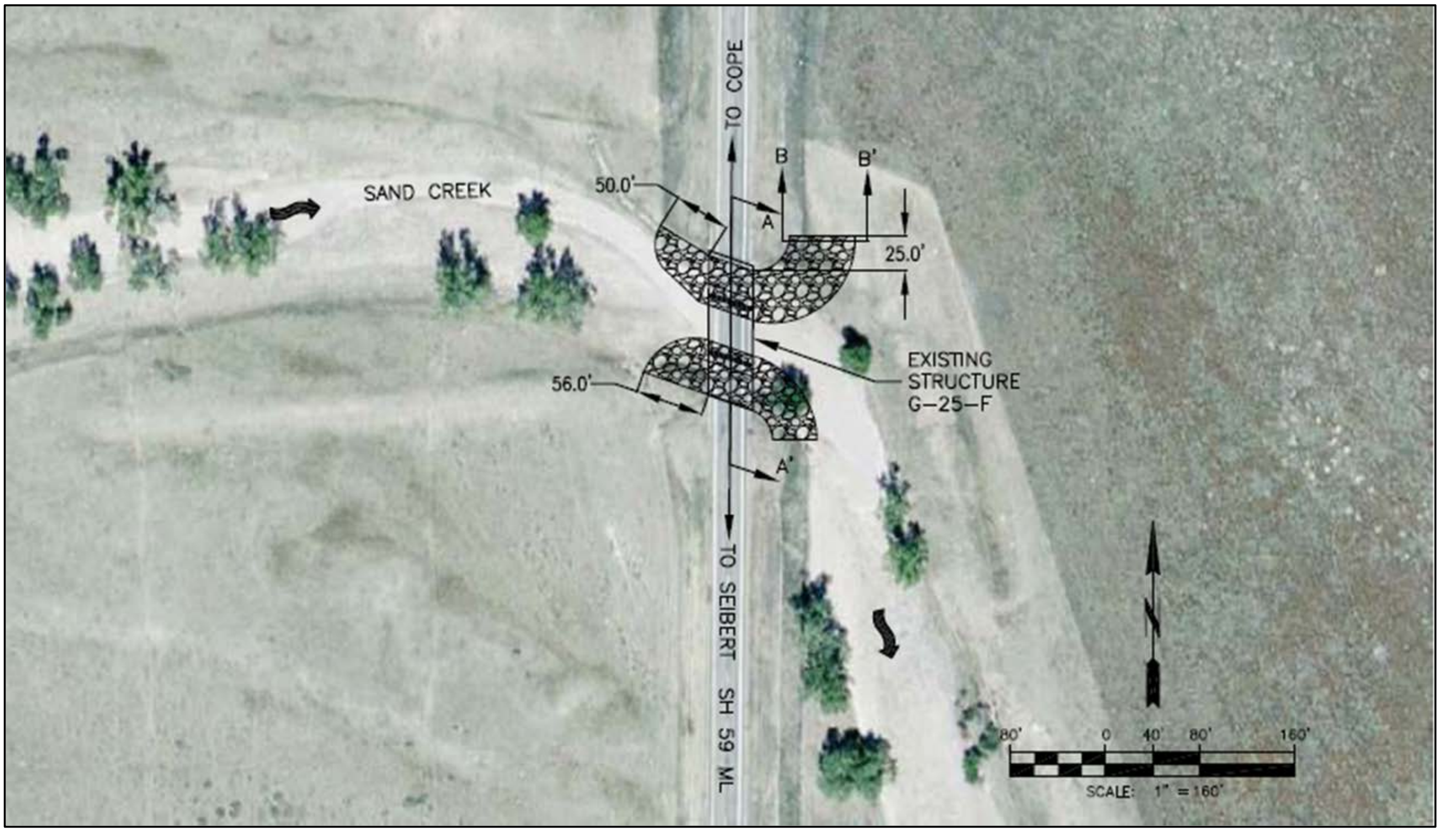


Figure 5. Plan view of Bridge G-25-F with recommended hydraulic scour countermeasure locations

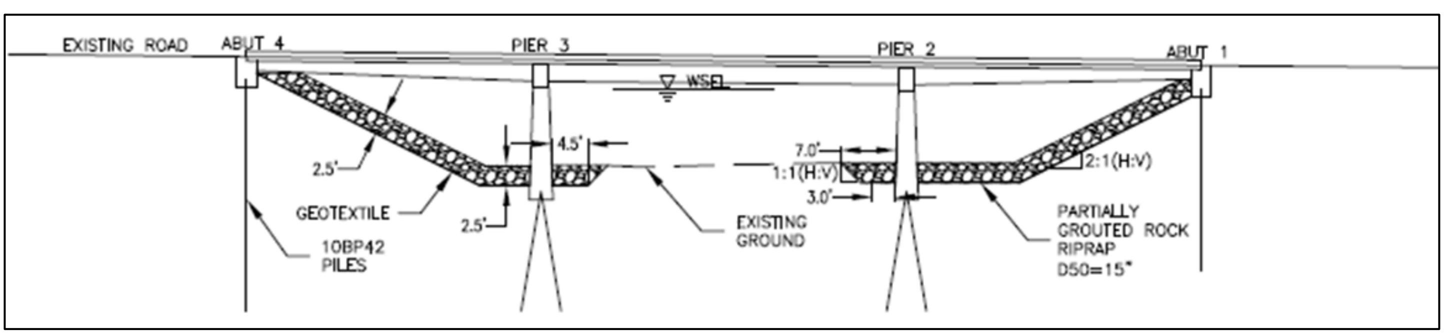


Figure 6. Cross-sectional view of Bridge G-25-F with recommended hydraulic scour countermeasures

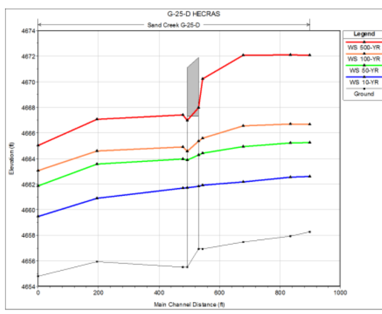
US 24 HIGHWAY
BRIDGE G-25-D OVER
SAND CREEK,
COLORADO

Bridge G-25-D is located in Kit Carson County on US 24 where the highway crosses the Sand Creek. Figure 1 shows Bridge G-25-D over Sand Creek.

Hydrau-Tech, Inc. began the POA study of Bridge G-25-D by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 23,100 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge G-25-D over Sand Creek



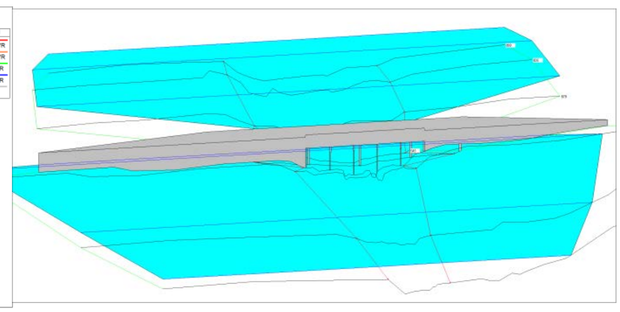


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-25-D

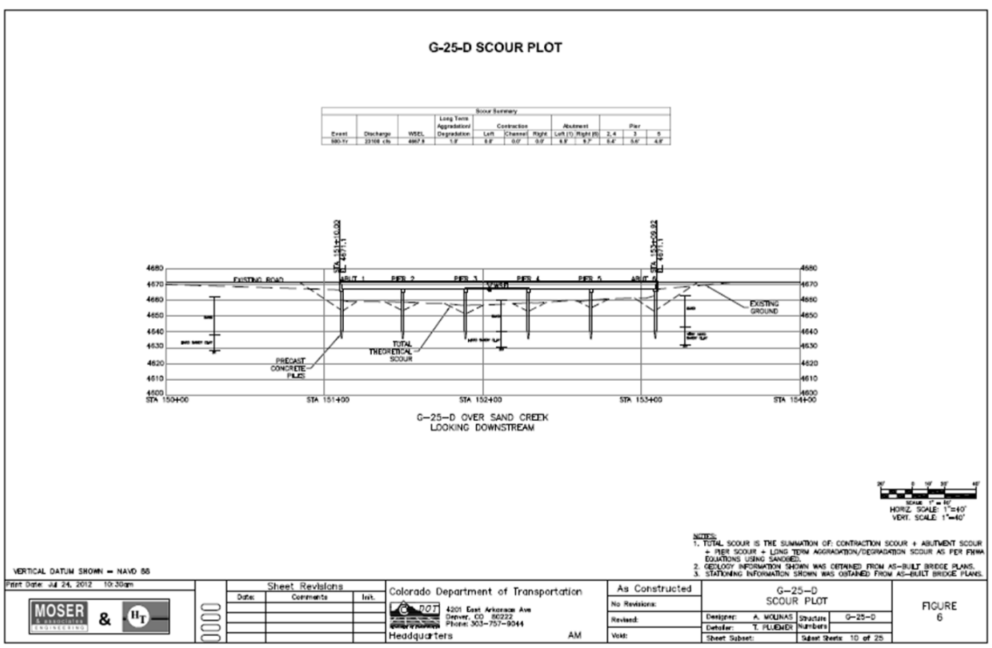


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Abutment riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 3.0 feet was used to design the abutment protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left and right abutments). Figure 5 shows an aerial image of structure G-25-D with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

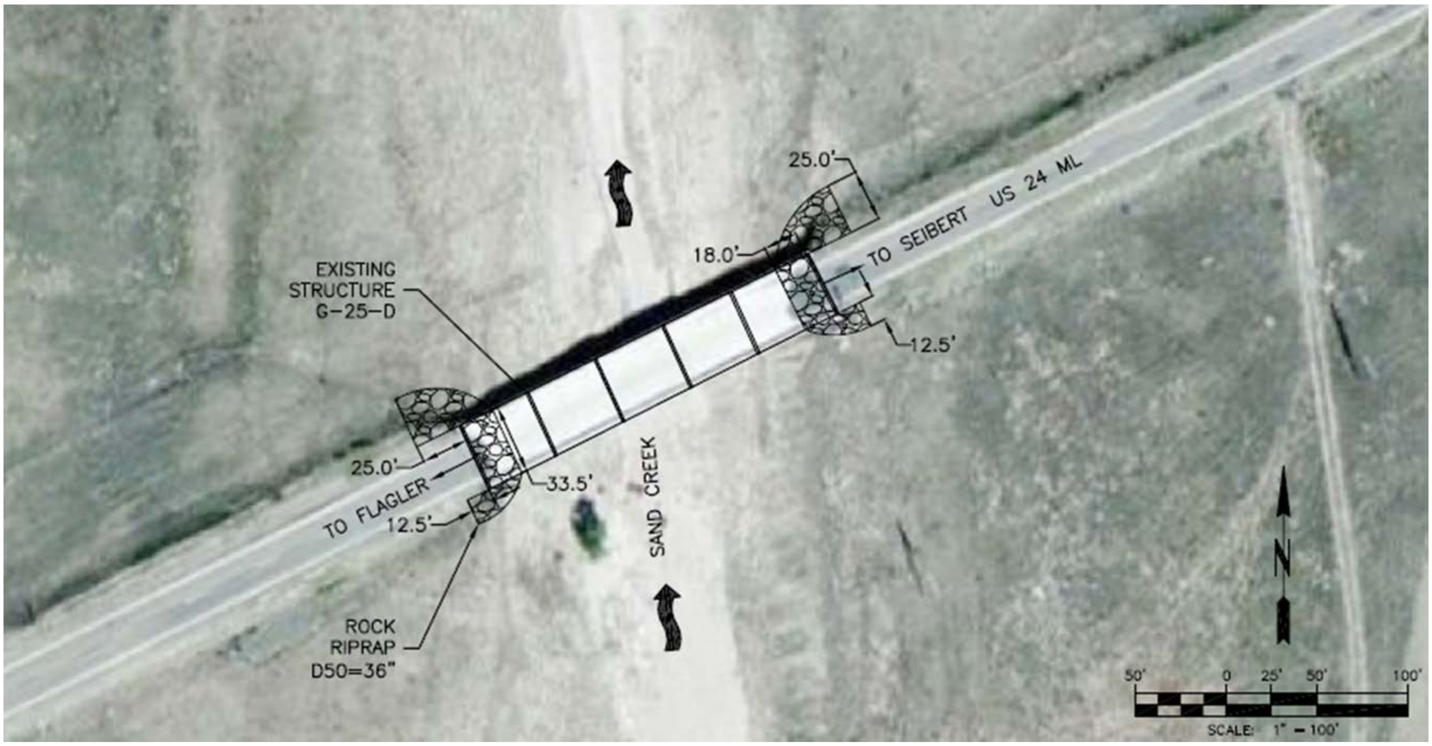


Figure 5. Plan view of Bridge G-25-D with recommended hydraulic scour countermeasure locations

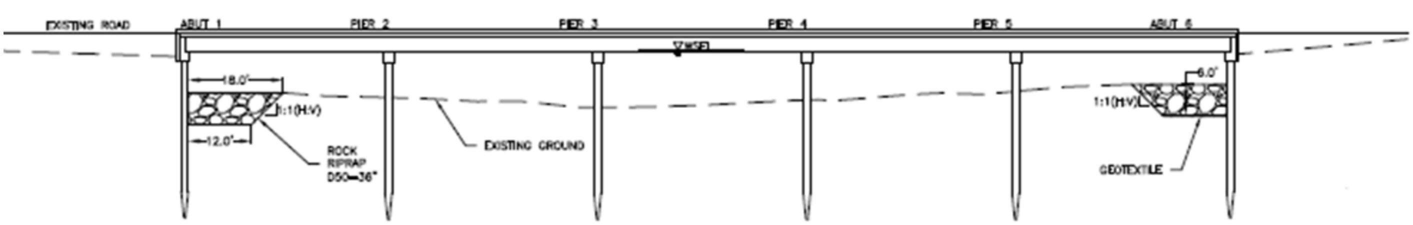


Figure 6. Cross-sectional view of Bridge G-25-D with recommended hydraulic scour countermeasures

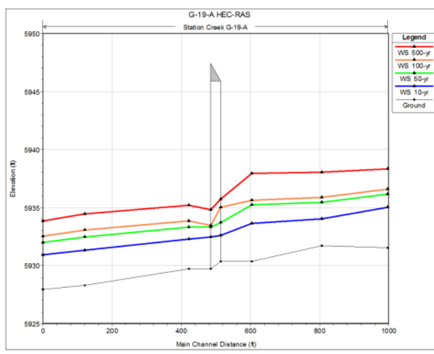
STATE HIGHWAY 86 BRIDGE G-19-A OVER STATION CREEK, COLORADO

Bridge G-19-A is located in Elbert County on State Highway 86 ML where the highway crosses Station Creek. Figure 1 shows Bridge G-19-A over Station Creek.

Hydrau-Tech, Inc. began the POA study of Bridge G-19-A by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 2,370 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge G-19-A over Station Creek



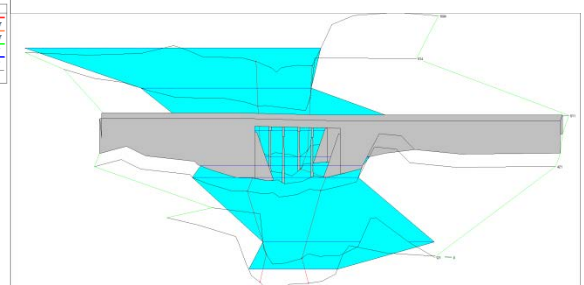


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-19-A

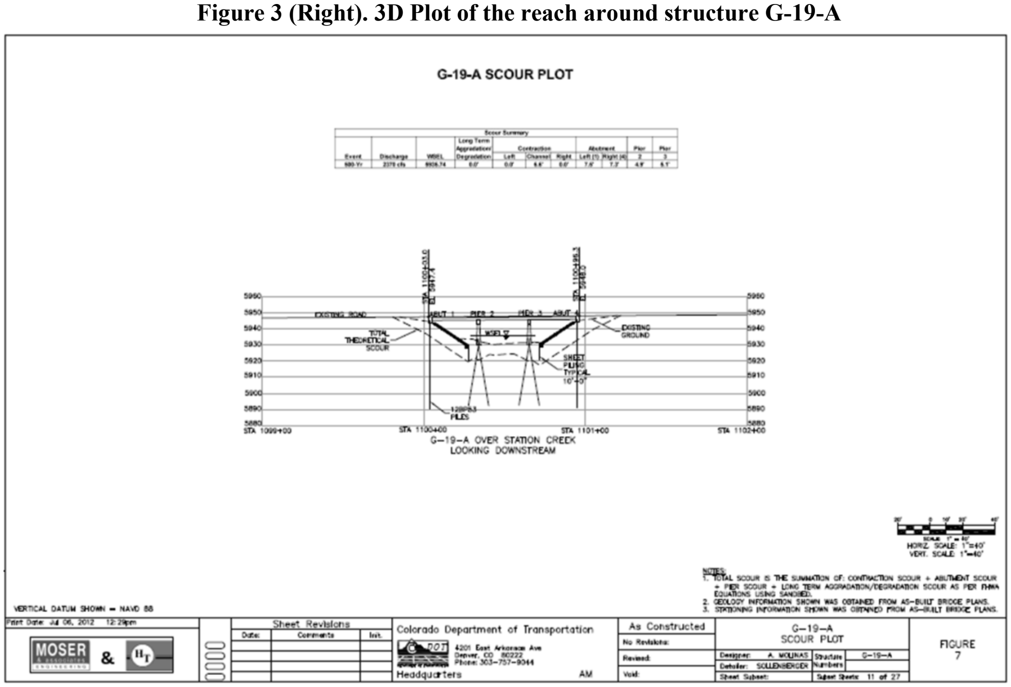


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left and right abutments, piers 2 and 3). Figure 5 shows an aerial image of structure G-19-A with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge G-19-A with recommended hydraulic scour countermeasure locations

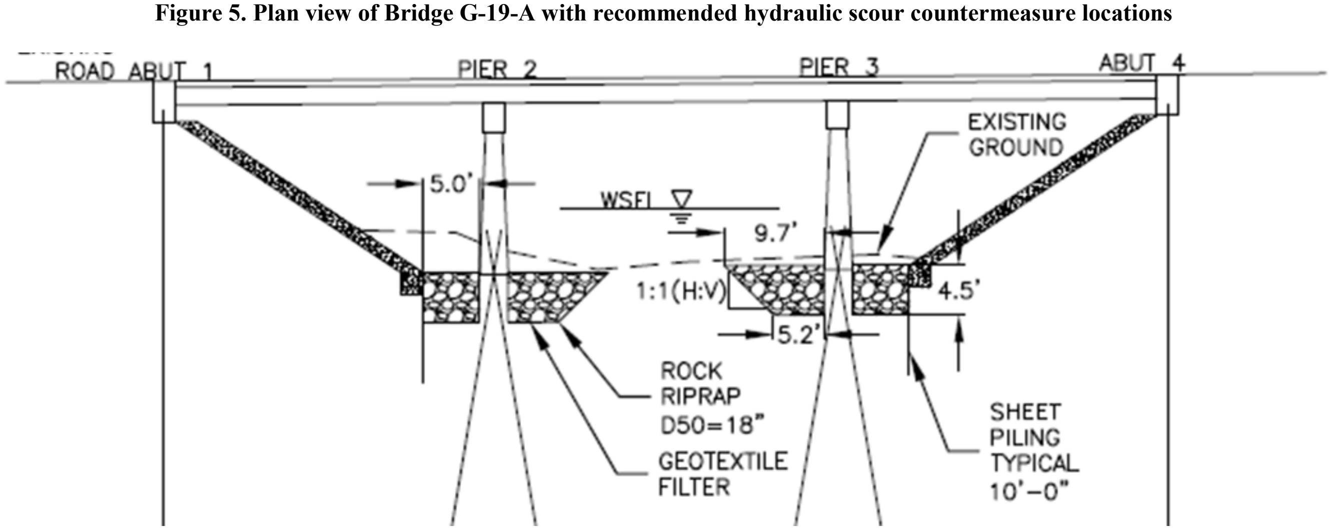


Figure 6. Cross-sectional view of Bridge G-19-A with recommended hydraulic scour countermeasures

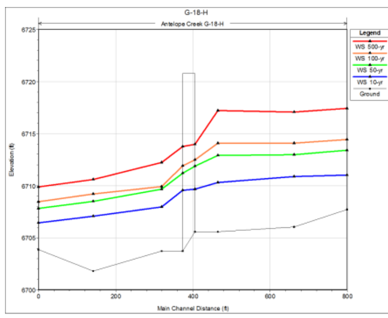
State Highway 83 Bridge G-18-H over Antelope Creek, Colorado

Bridge G-18-H is located in Douglas County on State Highway 83 ML where the highway crosses Antelope Creek. Figure 1 shows Bridge G-18-H over Antelope Creek.

Hydrau-Tech, Inc. began the POA study of Bridge G-18-H by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 4,580 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge G-18-H over Antelope Creek



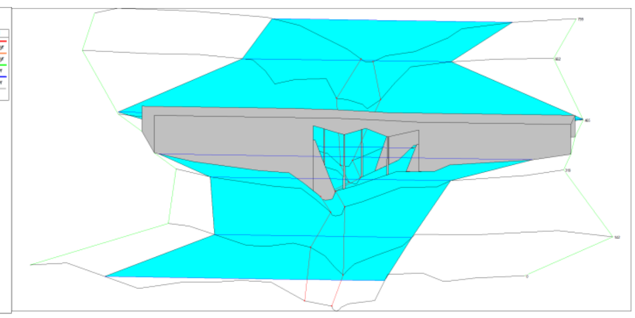


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-18-H

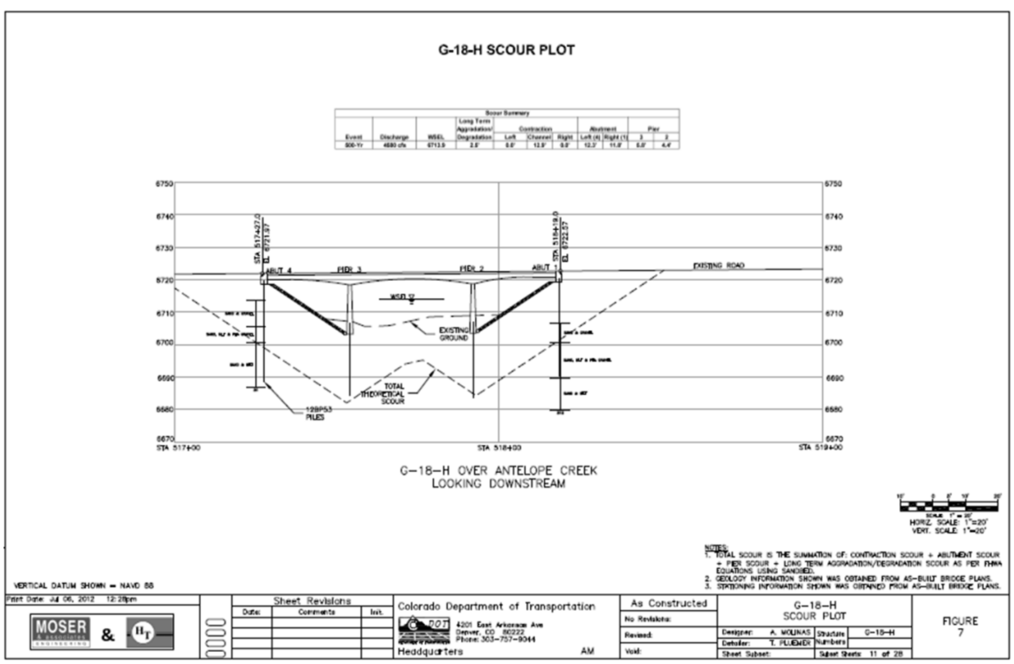


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left and right abutments, and pier 2 and 3). Figure 5 shows an aerial image of structure G-18-H with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge G-18-H with recommended hydraulic scour countermeasure locations

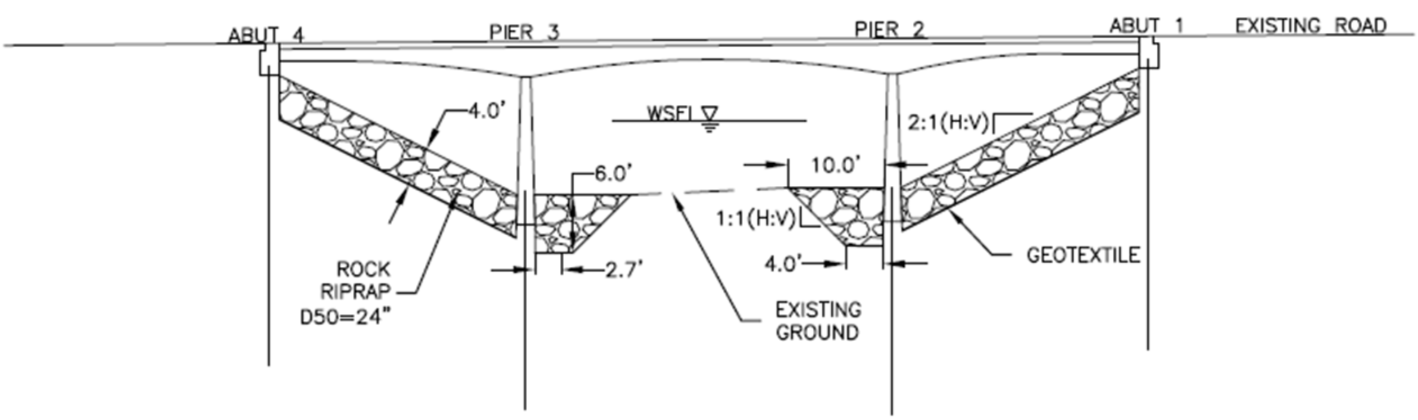


Figure 6. Cross-sectional view of Bridge G-18-H with recommended hydraulic scour countermeasures

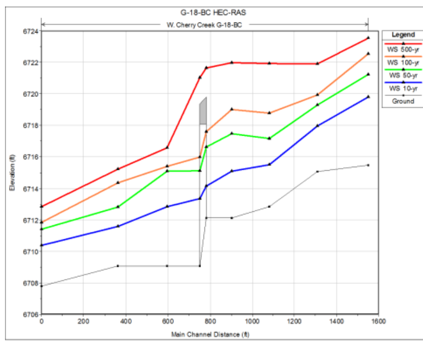
STATE HIGHWAY 83 BRIDGE G-18-BC OVER WEST CHERRY CREEK, COLORADO

Bridge G-18-BC is located in Douglas County on State Highway 83 ML where the highway crosses West Cherry Creek. Figure 1 shows Bridge G-18-BC over West Cherry Creek.

Hydrau-Tech, Inc. began the POA study of Bridge G-18-BC by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 100-year flood discharge of 3,750 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 100-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge G-18-BC over West Cherry Creek



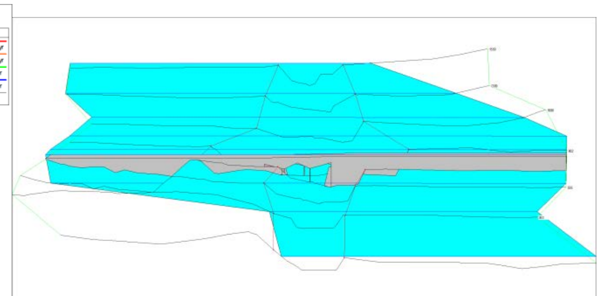


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-18-BC

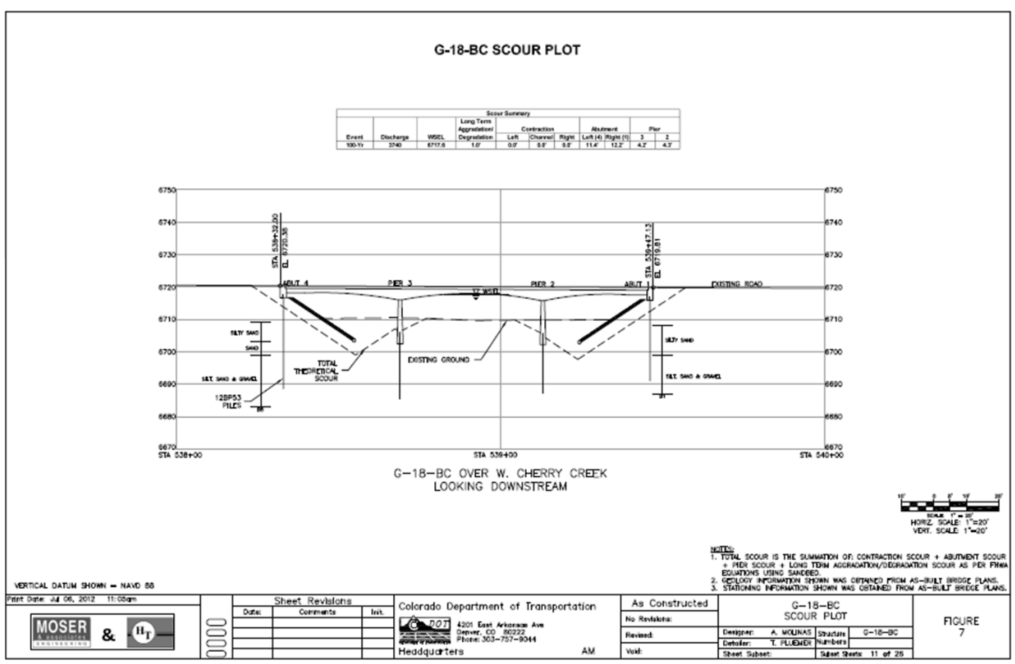


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Abutment riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left and right abutment). Figure 5 shows an aerial image of structure G-18-BC with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge G-18-BC with recommended hydraulic scour countermeasure locations

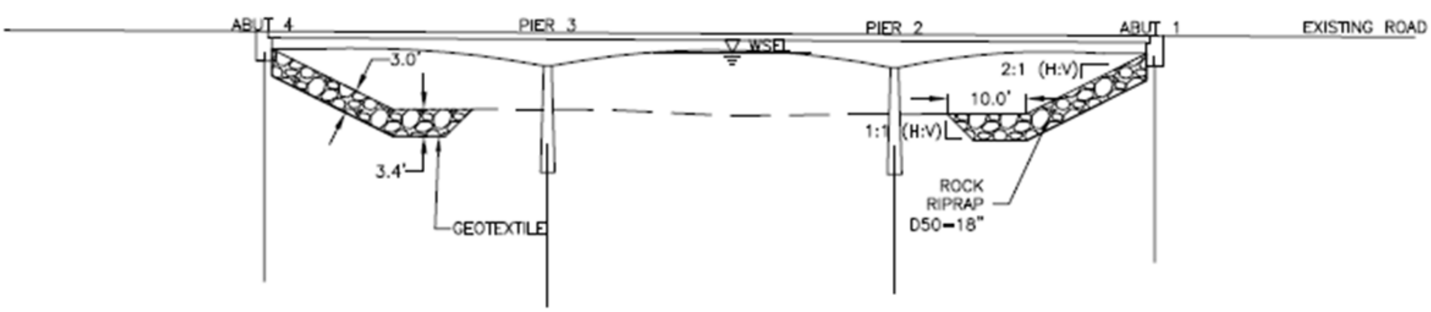


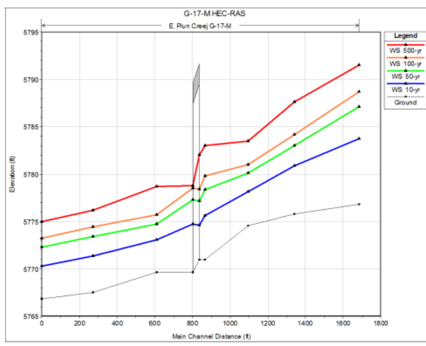
Figure 6. Cross-sectional view of Bridge G-18-BC with recommended hydraulic scour countermeasures

STATE HIGHWAY 67 BRIDGE G-17-M OVER EAST PLUM CREEK, COLORADO

Bridge G-17-M is located in Douglas County on State Highway 67 ML where the highway crosses East Plum Creek. Figure 1 shows Bridge G-17-M over East Plum Creek.

Figure 1. Bridge G-17-M over East Plum Creek

Hydrau-Tech, Inc. began the POA study of Bridge G-17-M by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 11,700 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.



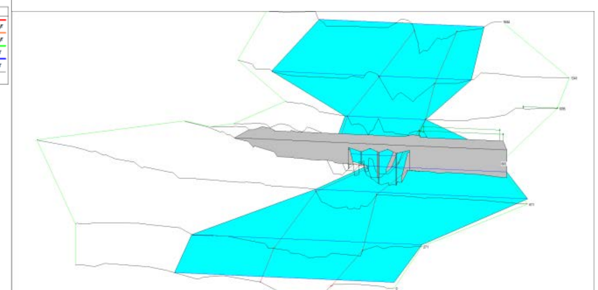


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-17-M

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

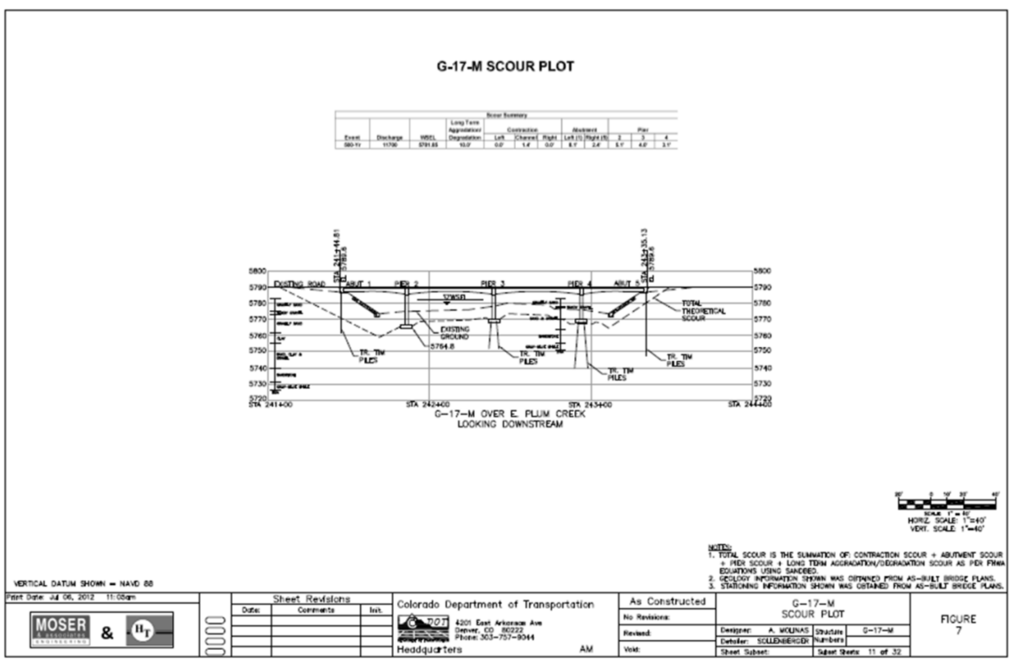


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap and a drop structure was chosen as the preferred hydraulic scour countermeasures. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection and drop structure designs, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (abutments 1 and 5, and piers 2,3, and 4) as well as a downstream drop structure. Figure 5 shows an aerial image of structure G-17-M with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

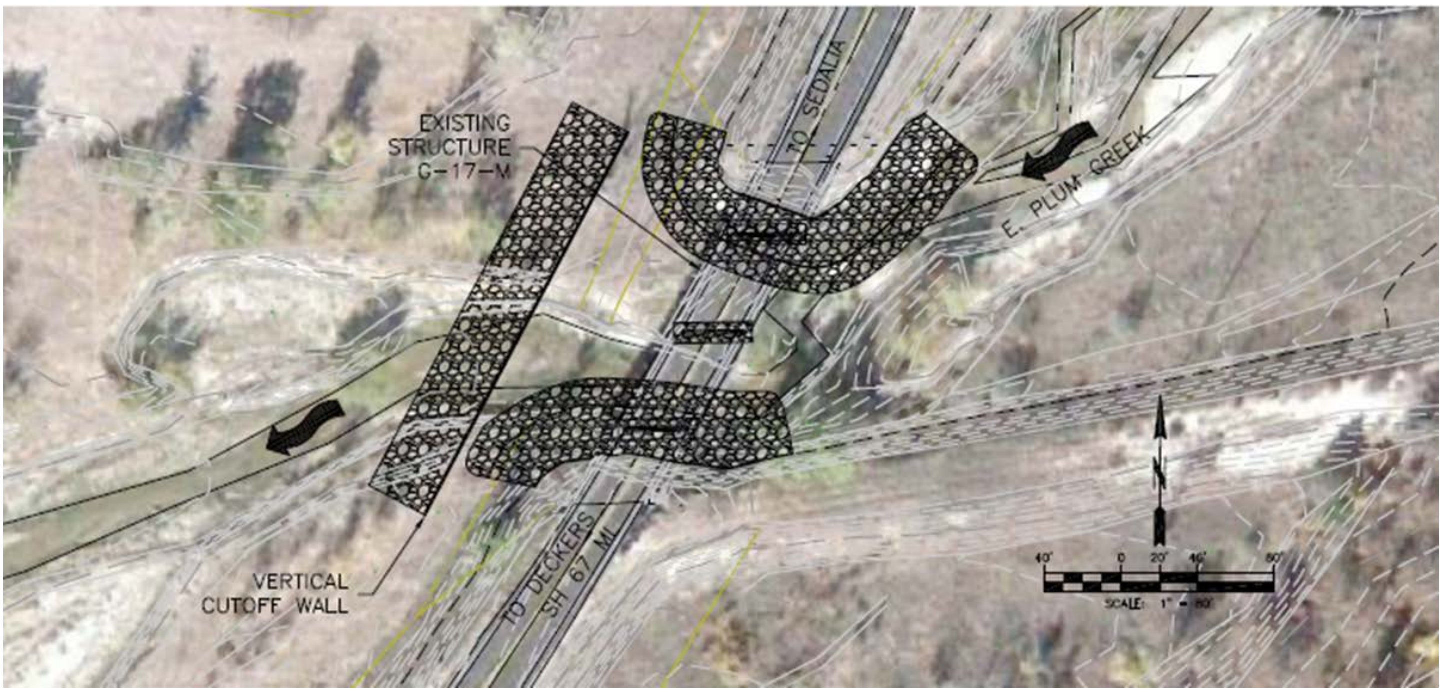


Figure 5. Plan view of Bridge G-17-M with recommended hydraulic scour countermeasure locations

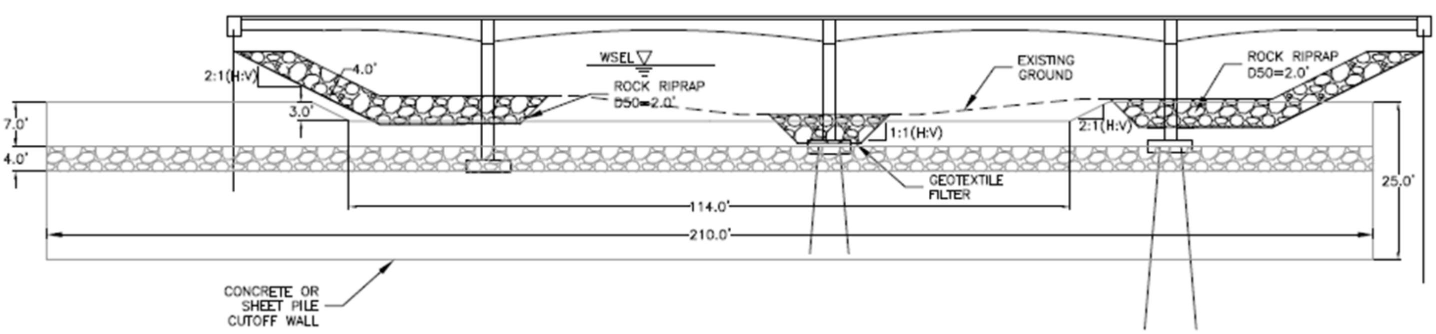


Figure 6. Cross-sectional view of Bridge G-17-M with recommended hydraulic scour countermeasures

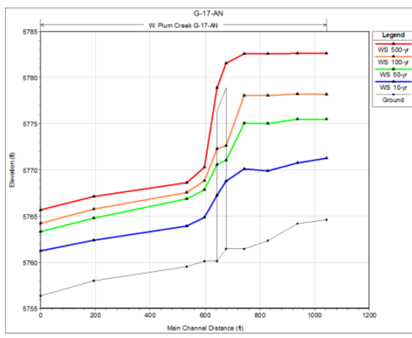
STATE HIGHWAY 65 BRIDGE G-17-AN OVER WEST PLUM CREEK, COLORADO

Bridge G-17-AN is located in Douglas County on State Highway 67 ML where the highway crosses West Plum Creek. Figure 1 shows Bridge G-17-AN over West Plum Creek.

Hydrau-Tech, Inc. began the POA study of Bridge G-17-AN by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 100-year flood discharge of 4,710 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 100-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge G-17-AN over West Plum Creek



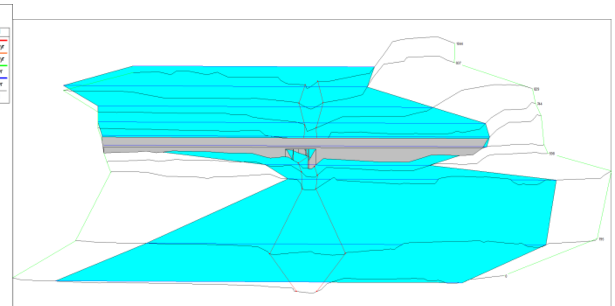


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-17-AN

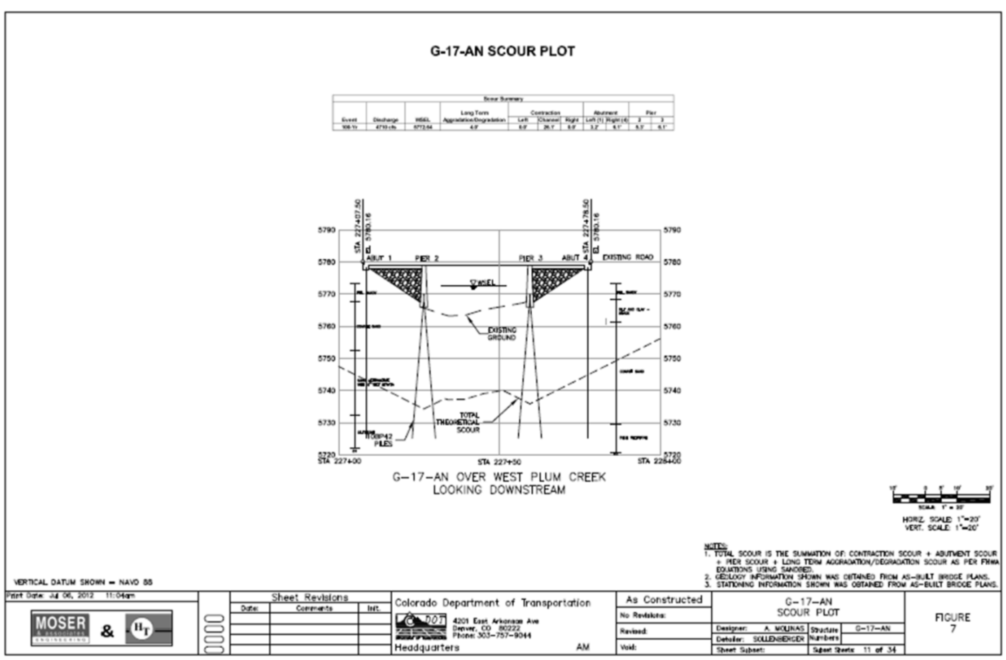


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap and a drop structure was chosen as the preferred hydraulic scour countermeasures. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection and drop structure designs, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (abutments 1 and 4, and piers 2 and 3), as well as a downstream drop structure. Figure 5 shows an aerial image of structure G-17-AN with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge G-17-AN with recommended hydraulic scour countermeasure locations

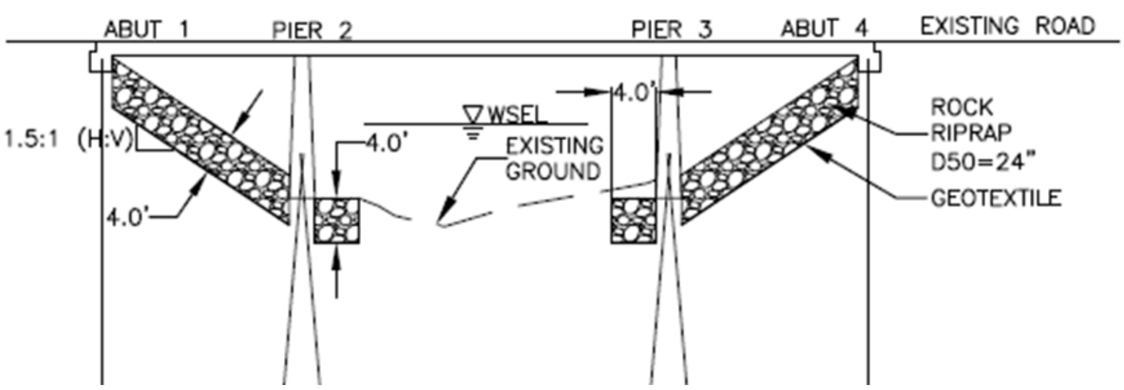


Figure 6. Cross-sectional view of Bridge G-17-AN with recommended hydraulic scour countermeasures

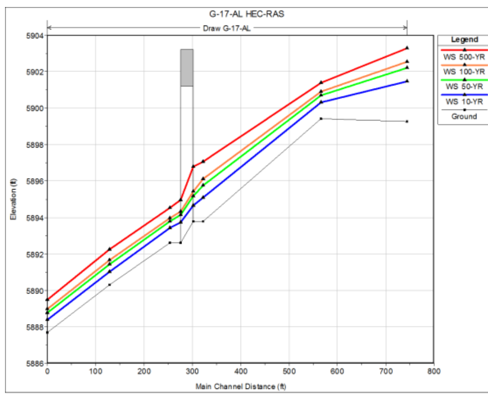
State Highway 105 Bridge G-17-AL Over Draw, Colorado

Bridge G-17-AL is located in Douglas County on State Highway 105 ML where the highway crosses Douglas Creek. Figure 1 shows Bridge G-17-AL over Draw.

Hydrau-Tech, Inc. began the POA study of Bridge G-17-AL by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 1,250 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 1. Bridge G-17-AL over Draw



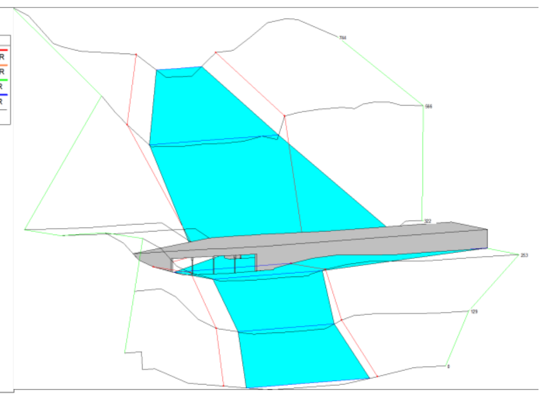


Figure 2 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure G-17-AL

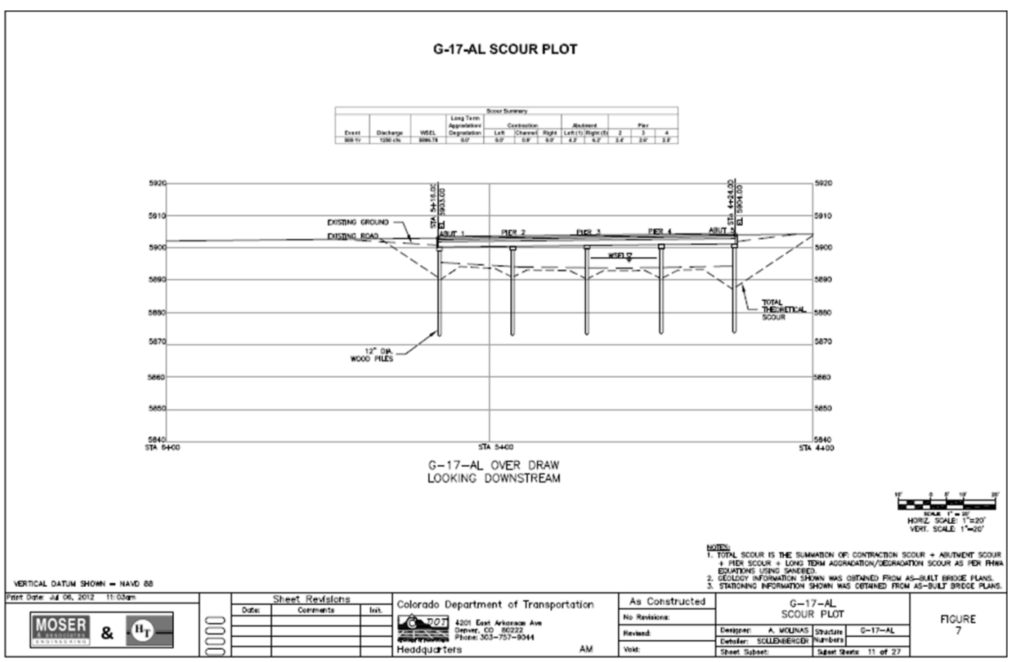


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Abutment riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.0 foot was used to design the abutment protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (left and right abutments). Figure 5 shows an aerial image of structure G-17-ALwith the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

Figure 5. Plan view of Bridge G-17-AL with recommended hydraulic scour countermeasure locations

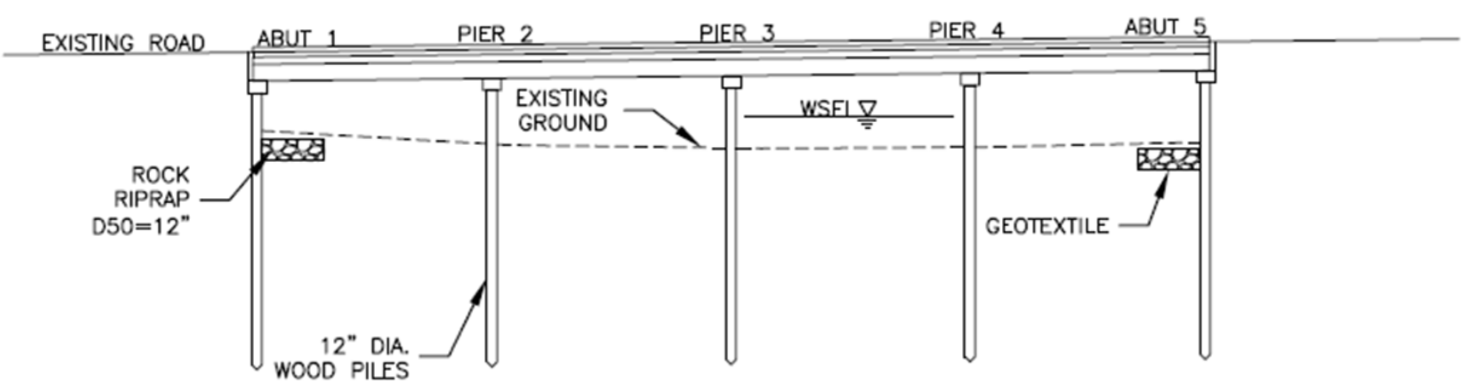


Figure 6. Cross-sectional view of Bridge G-17-AL with recommended hydraulic scour countermeasures

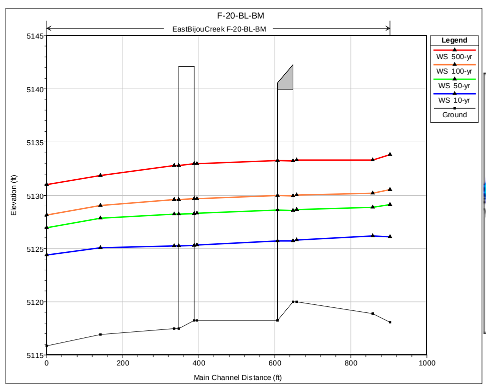
INTERSTATE 70 BRIDGES F-20-BL AND F-20-BM OVER EAST BIJOU CREEK, COLORADO

Bridges F-20-BL and F-20-BM are located in Arapahoe County on Interstate 70 where the highway crosses East Bijou Creek. Figure 1 shows Bridges F-20-BL and F-20-BM over East Bijou Creek.

Hydrau-Tech, Inc. began the POA study of Bridges F-20-BL and F-20-BM by collecting information on the site and structures in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 20,500 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structures and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structures under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridges F-20-BL and F-20-BM over East Bijou Creek



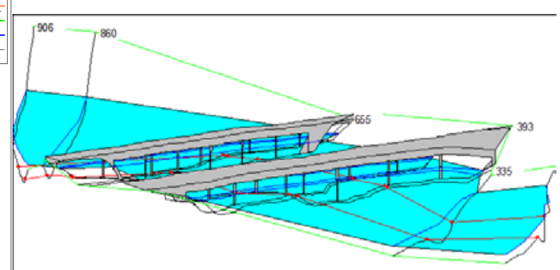


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure F-20-BL AND F-20-BM

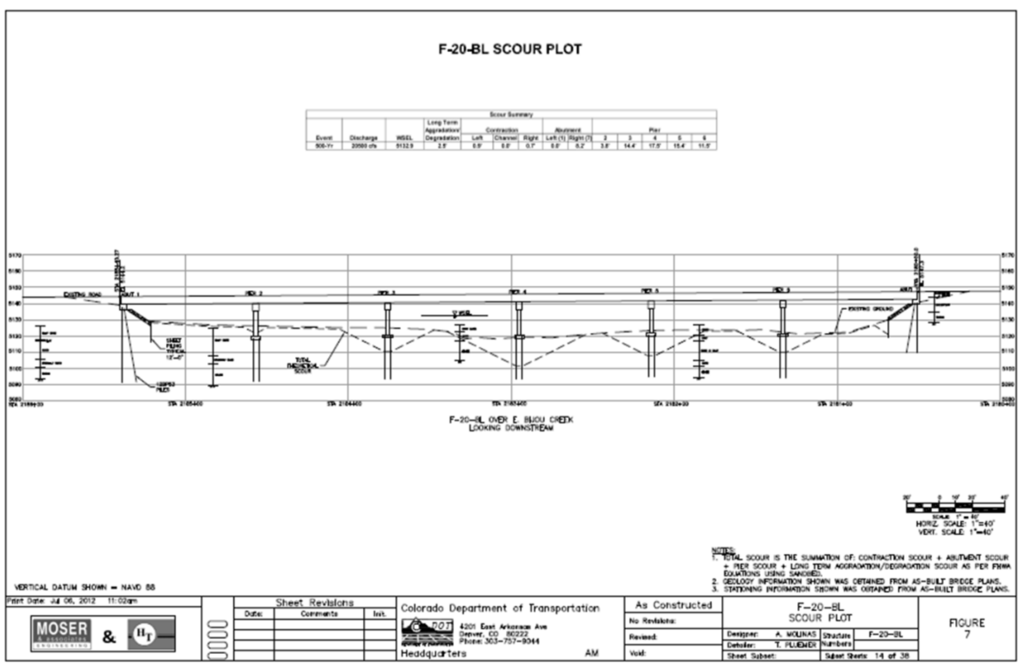


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Pier riprap and abutment riprap sizing were selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 1.5 feet was used to design the abutment and pier protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridges (abutments and piers). Figure 5 shows an aerial image of structures F-20-BL and F-20-BM with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of structure F-20-BL with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

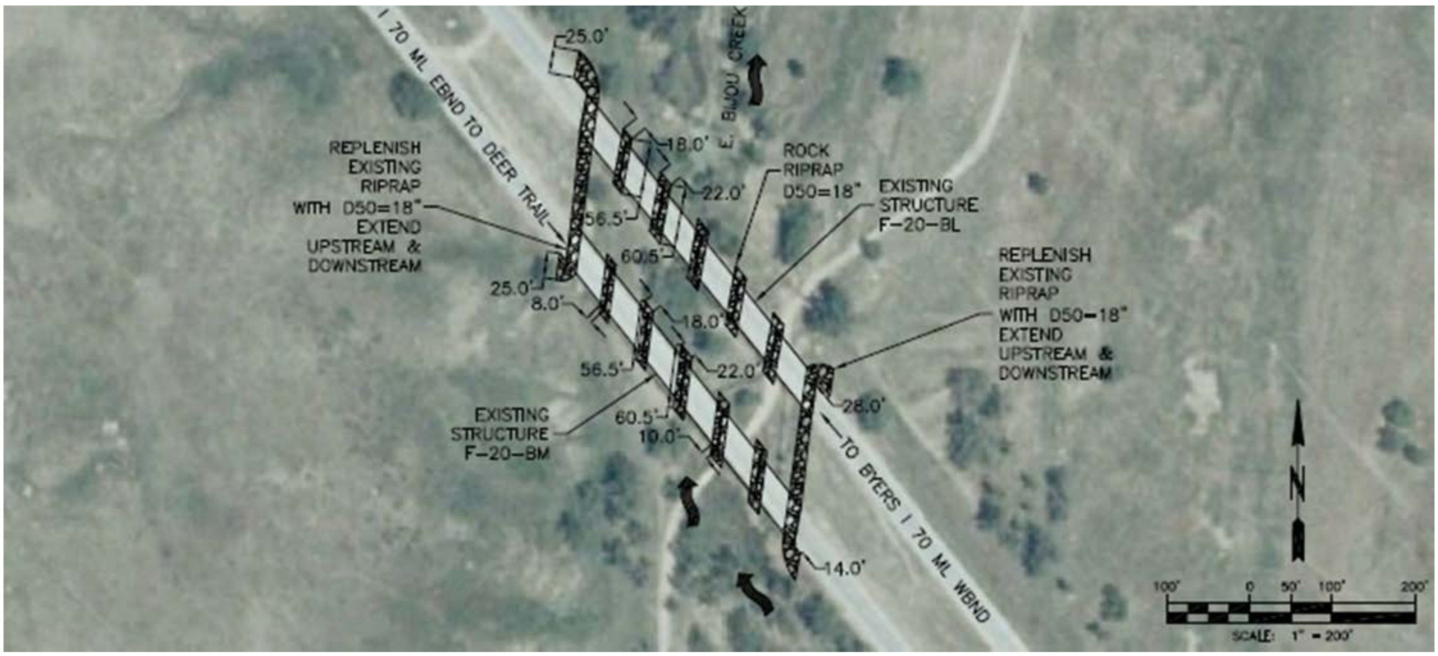


Figure 5. Plan view of Bridges F-20-BL and F-20-BM with recommended hydraulic scour countermeasure locations

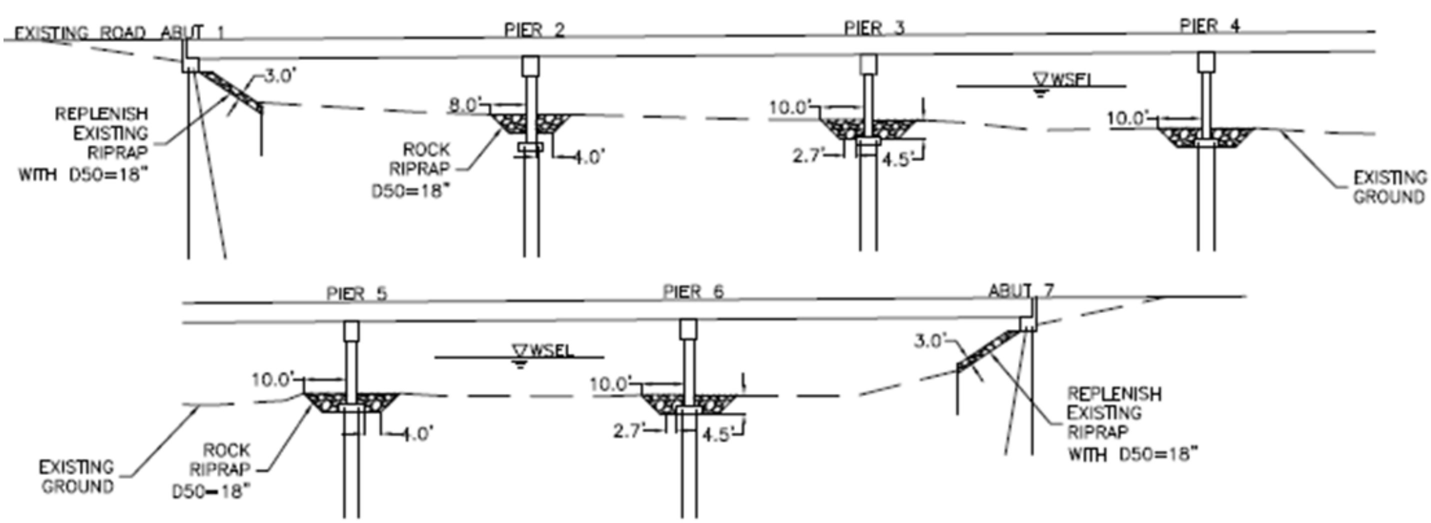


Figure 6. Cross-sectional view of Bridge F-20-BL with recommended hydraulic scour countermeasures

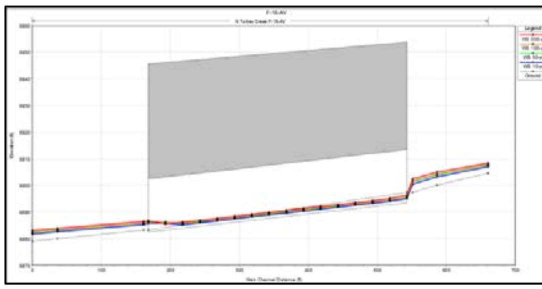
US HIGHWAY 285 BRIDGE F-16-AV OVER NORTH TURKEY CREEK, COLORADO

Bridge F-16-AV is located in Jefferson County on US Highway 285 ML where the highway crosses the North Turkey Creek. Figure 1 shows Bridge F-16-AV over North Turkey Creek.

Hydrau-Tech, Inc. began the POA study of Bridge F-16-AV by collecting information on the site and structure in question, including hydrologic characteristics of the site, GIS information and original bridge construction plans. Using these parameters, regional regression equations result in a 500-year flood discharge of 690 cfs (cubic feet per second). After completing a survey of the reach upstream and downstream of the structure and sediment size analysis, a HEC-RAS hydraulic model was developed. This model was used to estimate the hydraulic conditions during the 500-year flow including: discharge distributions, velocity distributions, and water surface profiles. Figure 2 shows the water surface profile produced by the HEC-RAS hydraulic model. Figure 3 shows the reach geometry plot produced by HEC-RAS.

Using the results from hydraulic modeling, theoretical scour estimates were calculated with FHWA's HEC-18 scour equations. Updated Auto-CAD drawings were produced with adjusted datum elevations and theoretical scour lines in order to determine the stability of the structure under the scour conditions created by flooding. Figure 4 shows a completed theoretical scour plot using AutoCAD showing foundation elevations and potential scour.

Figure 2. Bridge F-16-AV over North Turkey Creek



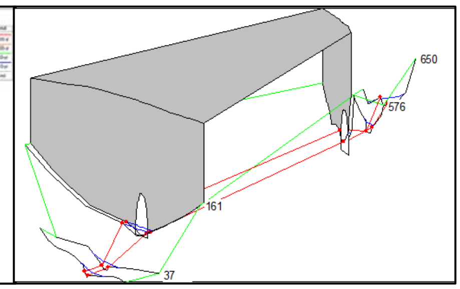


Figure 1 (Left). Water surface profile showing the 10, 50, 100 and 500-year flows
Figure 3 (Right). 3D Plot of the reach around structure F-16-AV

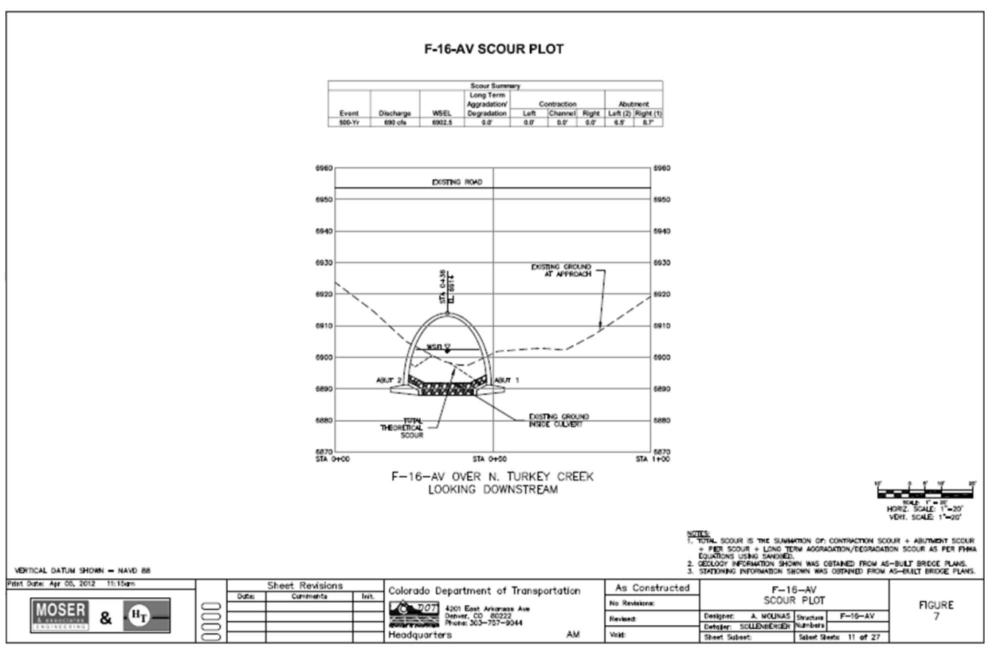


Figure 4. Scour plot generated in AutoCAD showing bridge geometry, foundation elevations, sediment boring hole results and theoretical scour

Based on the theoretical scour and the current site conditions such as foundation depths and existing structure protection, countermeasures were designed by Hydrau-Tech, Inc. Riprap was chosen as the preferred hydraulic scour countermeasure. Abutment and bottomless culvert riprap sizing was selected by using FHWA's equations. Based on the theoretical velocities, riprap with a median grain size diameter of 2.0 feet was used to design the abutment and channel protection. Using the guidelines in HEC-23 for riprap protection design, Hydrau-Tech, Inc. developed preliminary riprap countermeasures at each of the critical locations on the bridge (culvert channel and downstream abutment). Figure 5 shows an aerial image of structure F-16-AV with the recommended scour countermeasure. Figure 6 shows a cross-sectional view of the structure with the recommended scour countermeasures and appropriate geometry. As a part of analysis, various cost estimates for alternative countermeasures were complete for comparison.

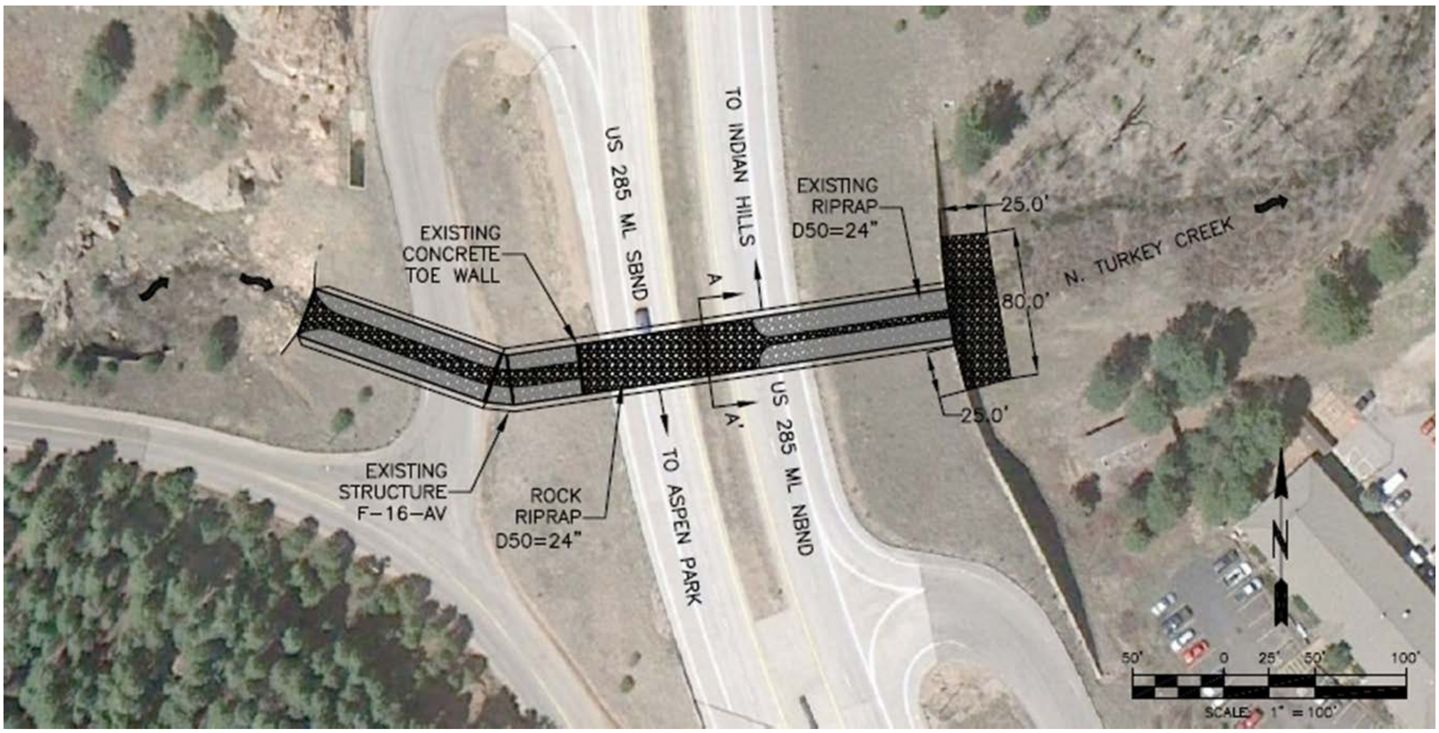


Figure 5. Plan view of Bridge F-16-AV with recommended hydraulic scour countermeasure locations

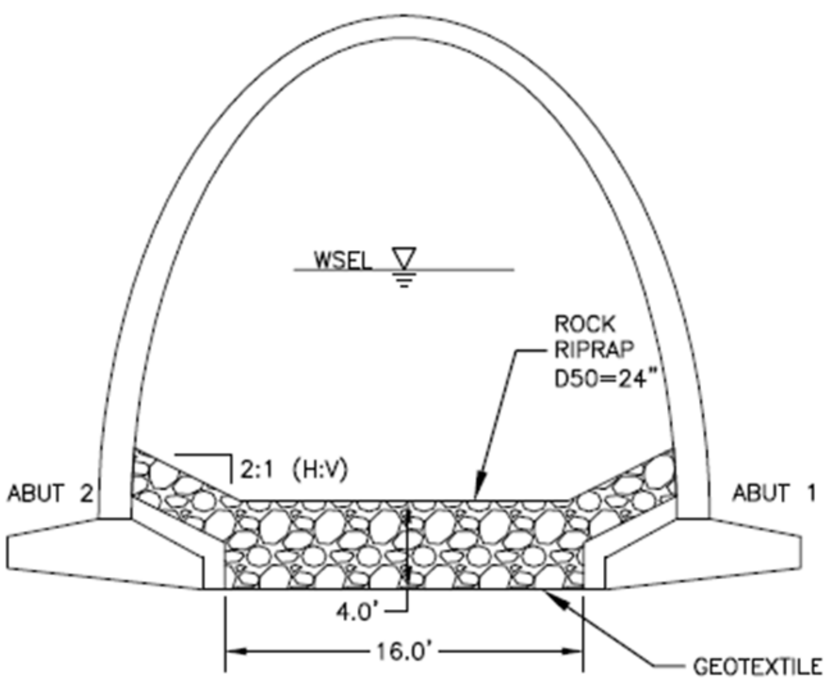


Figure 6. Cross-sectional view of Bridge F-16-AV with recommended hydraulic scour countermeasures

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