BNSF Railway Company

Phoenix Subdivision
Line Segment 7208
Maricopa County, Arizona

Bridge 149.9
Morristown, Arizona

Final Floodplain Use Permit Report
BNSF Project Number: BF46766
Flood Control District of Maricopa County
Review Number: FCP2012072

May 28, 2013

BNSF RAILWAY

Prepared for:

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Floodplain Use Permit Comment Resolution Matrix

No.	Comment	Response	FCDMC Secondary Comments	Biogeo Response
1	As referenced in my email to you on 3/21/13, the Wickenburg Phase 3 hydrology update is complete. For the Little San Domingo Wash the resulting discharge has been lowered from what I previously reported to you. It is 3314 cfs at US 60. As this is numerically insignificant to the FEMA effective discharge of 3299, the second run with a higher discharge is no longer warranted.	Updated HEC-RAS Model utilizes 3299 cfs. See Tables 4-9 of the FUP Report.	Comment Resolved	
2	Review and trim the model as discussed in the CLOMR comments and ensure that the model correctly reflects the proposed conditions downstream of the bridge as discussed in our River Mechanics Branch's comments.	CLOMR model was clipped to section 19 (DS) and 30 (US) to limit the model to the area of interest. The same model is now being utilized for both the FUP and CLOMR because the additional discharge is no longer required as discussed in comment No. 1. See River Mechanics Branch Comment Resolution Matrix for changes to proposed conditions model.	Comment Resolved	
3	In addition to the subcritical run done to show the adequacy of the proposed structure opening, the second run provided for the erosion and scour design (done as subcritical) may be done as mixed flow, as this still models supercritical flow where it occurs.	Mixed flow results were imported into DDMSW to perform scour analysis. Scour results updated in Tables 10,11, and 12 in section 6.6 of the FUP Report.	Comment Resolved	
4	Please provide specific discussion regarding the planned refurbishment of the existing riprap apron.	Repair of the downstream riprap apron is discussed in section 6.1 of the FUP Report.	Comment Resolved	
5	Comments from FCD Engineering Application Development and River Mechanics Branch, attached to this document, are to be addressed for the next submittal of the revised report.	See River Mechanics Branch Comment Resolution Matrix	Comment Resolved	
			Please revise references to MCFCD to FCDMC and likewise Maricopa County Flood Control District to Flood Control District of Maricopa County	Performed Find and Replace on document to revise all references to MCFCD or Maricopa County Flood Control District accordingly.

River Mechanics Branch Comment Resolution Matrix

No.	Comment	Response	FCDMC Secondary Comments	Biogeo Response
1	The proposed riprap expansion at the downstream of the gabion structure needs to extend to the total scour depth. Another alternative approach would be to construct launchable riprap which is a thickened riprap toe protection that will launch as erosion takes place. The procedure for launchable riprap or toe protection can be found in the end of this review comments document. For either approach, the total scour depth at the downstream of the drop structure needs to be determined. The total scour depth consists of several scour components which are long term scour, general scour, local scour, bend scour, bed form scour, and low flow scour. All scour components should be computed by using the Flood Control District of Maricopa County's DDMSW software (version 4.6.0). The long term scour can be based on AZ State Standard option in DDMSW. The local scour should be the scour downstream of a drop structure (Schoklitsch option in DDMSW). Bend scour is part of general scour Lacey's Method with a bend factor. Bed form can be computed by DDMSW. The low flow incisement scour can be assumed to be 1-2 ft. The DDMSW software (version 4.6.0) is available from www.fcd.maricopa.gov. Our preliminary calculations indicate the total scour at the immediate downstream of the riprap apron is about 35'.	The proposed riprap will be installed to a depth of 9' (2 times D50) and a program of regular inspection and maintenance will be utilized by the BNSF Railroad to ensure the integrity of the revetment is maintained. Scour was calculated at HEC-RAS section 23 using DDMSW software. The HEC-RAS model results were imported into DDMSW and scour was calculated using Long Term (State Standard Level I), General (Lacey), Local (Grade Control or Drop Structure - Schoklitsch), Bedform, and Low Flow (Estimated to be 2 ft.). Results of the Scour Calculations are included in Table 11 Section 6.6 of the FUP Report.	Comment Resolved	No Response
2	Table 2 of the report (page 32) indicates the pier's total scour depth (17.25 ft) includes three components: long-term bed degradation (10'), contraction scour (0.93'), and pier's local scour (6.32'). It is stated (line 10 from top of page 32) that abutment scour is not included because the existing concrete paving below the bridge will be maintained. When the bridge local scour is computed, the pier width needs to be increased to account for debris. For detailed requirements, please see Standard 6.7.15 of the Drainage Policies and Standards for Maricopa County, Arizona, which is available at http://www.fcd.maricopa.gov/Pub/Manuals/downloads/DPSM_Draft_011113.pdf In addition, general scour should be computed. It is the larger value between the general scour by the Neill method and the contraction scour by HEC-18. Please use the Flood Control District of Maricopa County's DDMSW software (Version 4.6.0) which is available from www.fcd.maricopa.gov Our preliminary calculations indicate the pier total scour is about 26'. It consists of local pier scour and general scour. The local pier scour is larger than the submitted value because the pier width is increased due to debris. Since the riprap serves as a grade control structure, the long term scour may be assumed to be zero.	Scour at the bridge was calculated using the DDMSW software at section 28. The scour calculation included General (Neill), and Local (piers). The pier width was entered as 5.15 ft. (2 ft either side of the pier) according to the guidelines in Standard 6.7.15 of the Drainage Policies and Standards for Maricopa County, Arizona. The results of the scour calculations are included in Table 10 of Section 6.6 of the FUP Report.	Comment Resolved	No Response
3	In the pier's local scour calculation, the Consultant used an angle of attack of the flow of 0°, which does not appear to be truly valid. The aerial photo below seems to show the wash is not perpendicular to the railroad.	An angle of attack of 30° was used for the pier local scour calculation.	Comment Resolved	No Response
4	The proposed D50 for the riprap expansion is 2.5' as shown in a plan sheet sealed and signed by William Yord. The riprap sizing was based on a chart claimed by the Consultant to be form HEC-11 (USBR). However, HEC-11 is from Federal Highway Administration (publication No. FHWA-IP-89-016, March 1986) and it does not contain the chart shown in the report. In addition, the velocity based on the submitted HEC-RAS is 27.88 ft/s at cross section 23. The velocity is beyond the velocity range of the chart. It is also beyond the velocity range for the USBR D50 sizing method for riprap downstream of a stilling basin. Based on our preliminary analysis using DDMSW with "Channel Bed on a Straight Reach", the D50 is also too large to be applicable. This suggests that riprap approach may not be applicable to such high velocity. An energy dissipation structure should be installed to reduce the velocity significantly.	Riprap was sized using the DDMSW software at section 23 using the "Channel Bed on Straight Reach" method. The result of the calculation is a D50 of 4.48 ft., and is shown in Table 12 of Section 6.6 of the FUP Report.	Please Make sure that filter below the riprap will be installed. Please show it on the plans. Please also show gradation for the riprap (D100, D85, D50, and D15) on the plans.	Riprap gradation and filter notes were added to Proposed Bridge Plan.
5	The sheet for Structure Cross Section (cut at channel flow line) shows the proposed riprap expansion downstream of the existing gabion structure. But the HEC-RAS models do not correspond to this proposed channel bed profile. The HEC-RAS models show a channel invert drop. The velocity in HEC-RAS model is about 27.88 ft/s at cross-section 23. We suggest modifying the HEC-RAS model channel invert to match the proposed channel bed profile and hopefully the velocity will be less. If velocity cannot get reduced significantly, we suggest using an energy dissipation structure like a vertical concrete drop structure or the one downstream of US-60. Riprap is still required at the downstream of the energy dissipation structure. But since the velocity will be significantly reduced by the drop structure or the energy dissipation structure, smaller riprap can be used with DDMSW software (Channel Bed on Straight Reach option).	Cross section 23,24, and 26 were modified in the proposed model to reflect the proposed construction.	Although cross section 23,24, and 26 have been modified to represent the proposed construction (gabion-loose-riprap apron), the flow velocity at cross section 23 is still high (19.64 ft/s), which resulted in quite a large riprap D50 (4.48 ft). If the consultants decide to use the large riprap, we are okay. Please make sure that filter below the riprap will be installed. Please show it on the plans. Please also show gradation for the riprap (D100, D85, D50, and D15) on the plans.	Riprap gradation and filter notes were added to Proposed Bridge Plan.

River Mechanics Branch Comment Resolution Matrix				
No.	**Comment**	**Response**	**FCDMC Secondary Comments**	**Biogeo Response**
6	What is the D50 of the existing riprap apron contained in wire mesh? The D50 value should be adequate in case the wire mesh is broken. If not adequate, inspections after floods should be performed as part of Operation and Maintenance Plans.	Inspections after floods are regularly performed by the BNSF Railroad following floods for all of their structures. See Section 6.6.1 Page 19 of the FUP Report.	Since it is not known whether the rock size in the existing gabion mattress is adequate without the wires, an Operation and Maintenance Plan should be prepared and attached to the Floodplain Use Permit report. A single evaluation suggestion (page 19) in the report may not be able to bring sufficient BNSF attention to the issue.	See section 1.1 Operation and Maintenance Page 5 of the Floodplain Use Permit Report.
7	The sediment D50 value of 2.5 mm puts the sediment into the category of fine gravel or coarser, which does not seem to be consistent with the boring logs' sediment descriptions (most are in the category of sand). Use of this larger (than actual) D50 may result in underestimate of scour depths.	The D50 value was revised to 2.1 mm which is consistent with the sieve analysis. See Appendix F of the report.	Comment Resolved	No Response
8	According to the report, two soil borings were drilled in the area where additional loose riprap apron is proposed for, and sediment samples were collected from the two borings and were tested. Sample testing results are not found in the Appendix F as the report claimed (except the D50 and D95 values). Please provide sieve analysis report.	The soil boring report and sieve analysis has been included in Appendix F of the FUP Report.	Comment Resolved	No Response
9	The submitted HEC-RAS output of Plan 140NGVD shows flow velocity at cross section 28 is higher than for Plan ExCond1929. Is it possible for the proposed bridge project not to increase the flow velocity? Otherwise, the erosion protection upstream of the bridge needs to be re-evaluated.	As a result of the removal of existing bridge footings and the repair of the existing concrete apron, Manning's n values through the bridge opening will be reduced from 0.035 to 0.020. The velocity through the bridge opening will increase from 22.19 to 24.47 ft/s. The concrete apron and downstream control structure will remain in place to mitigate adverse effects of this slight increase in velocity. Velocities outside of the bridge structure and riprap apron remain the same. Section 23, which is on the existing riprap apron indicates a velocity drop from 21.74 to 19.64 ft/s using supercritical velocities. In addition, regular maintenance and inspection following flood events will be performed. This maintenance and inspection program will include areas upstream and downstream of the bridge.	In general, there should be some erosion protection upstream of a control structure such as culverts or concrete apron. This becomes an issue especially when the velocity increases. We recommend adding some erosion protection measure such as gabion basket (10 ft wide and 5 ft deep) across the channel cross-section immediately upstream of the concrete apron. 5 feet deep is based on the calculated general scour depth.	Additional proposed riprap was added upstream of the proposed structure on the Proposed Bridge Plan.
10	Please send us a hard copy of the final report after all comments are resolved and the report is updated. The final report will be put into our library.	Hard copy of the final report will be provided.	We look forward to receiving the final report. Please attach a CD/DVD to the final report that includes all the digital files that have been used to produce the final report. The files should include, but not limited to, HEC-RAS files, DDMSW files, Excel files, Word or PDF file for the report, etc.	The requested files are included in the submitted report package.

Flood Control District of Maricopa County

Received Stamp

For District use only

FLOODPLAIN USE PERMIT APPLICATION

(Completed by Applicant or Agent)

Applicant Information

Name: John Larson

Mailing Address: 9330 LBJ Freeway, Suite 900 City: Dallas State: TX ZIP: 75243

Phone Number: 816-401-0071 Business Phone Number (if applicable): 214-438-3894

E-Mail: larson.biogeo@gmail.com

Consultant/Agent: ________ Phone Number: ________

Property Information

Address: N/A City: Unincorporated State: AZ ZIP: 85342

Assessor Parcel Number: N/A Section: 13 Township: 6 N Range: 4 W ¼ Section: SW

Purpose of application:

Reconstruct an existing BNSF railroad bridge located in an unincorporated section of Maricopa County near Morristown, AZ.

APPLICANT SIGNATURE ________ DATE ________

For Flood Control District use only

Tracking Number: ________ Supervisory District: ________ Fee: ________

Floodplain: ________ Flood Map: ________ FIRM: ________

Zone: ________ Map Date: ________ BFE: ________ RFE: ________

Additional Documentation:

- ☐ Surety
- ADEQ
- ☐ Recorded Notice
- ☐ Notification of Variance
- ☐ Elevation/Floodproofing Certificate
- ☐ Flood Damage Statement
- ☐ 404
- ☐ Warning and Disclaimer of Liability
- ☐ Coordination ________ (Agency)

For Floodplain Administrator's use only

Approved subject to attached stipulations ________ Floodplain Administrator ________ Date

FCDMC Rev. 9/23/2010

Flood Control District
of Maricopa County

WARNING AND DISCLAIMER OF LIABILITY

A Floodplain Regulation for Maricopa County has been in force since February 25, 1974. The current version of the Floodplain Regulation for Maricopa County, Arizona was adopted on August 4, 1986, and amended March 23, 1987, April 6, 1988, September 18, 1989, September 3, 1991, December 15, 1993, November 1, 2000, December 20, 2006, and November 30, 2011. The intent of the Regulations is to prevent the dangerous and expensive misuse of floodplains in Maricopa County.

A Floodplain as defined in the Regulations is the areas adjoining the channel of a watercourse susceptible to inundation by a base flood including areas where drainage is or may be restricted by man-made structures that have been or may be covered partially or wholly by flood water from the 100-year flood.

Depending on the location of your property it could possibly be inundated by greater frequency flood events (those occurring more often). A flood greater in magnitude than the 100-year flood could also occur.

The review your development has undergone is solely for the purpose of determining if your application conforms with the written requirements of the Floodplain Regulation for Maricopa County. It is not to be taken as a warranty. Compliance with this Regulation does not insure complete protection from flooding. The Floodplain Regulation meets established standards for floodplain management, but neither this review nor the Regulation take into account such flood related problems as natural erosion, streambed meander or man-made obstructions and diversions all of which may have an adverse affect in the event of a flood. You are advised to consult your own engineer or other expert regarding these considerations.

In consideration for the issuance of the requested permit the applicant, owner, agent, engineer and their successors agree to hold the District harmless from any onsite or offsite damages of any kind arising from the development of the subject property in accordance with their submittals as outlined in the attached permit.

I have read and understand the above WARNING AND DISCLAIMER OF LIABILITY.

FP ____________ ______________________________ ____________

Permit Number Owner or Agent Date

FCDMC Rev. 12/13/2011

2801 West Durango Street Phoenix, Arizona 85009 Phone: 602-506-2419 Fax: 602-506-4601

Flood Control District
of Maricopa County

FLOODPLAIN USE PERMIT APPLICATION – PROPERTY OWNER AUTHORIZATION FORM

FORM MUST BE COMPLETED IF THE APPLICANT IS NOT THE PROPERTY OWNER

I hereby authorize: (name) John Larson
(address) 9330 LBJ Freeway, Suite 900
(city, state, zip) Dallas, TX 75243
(e-mail address) larson.biogeo@gmail.com

to file this application for a floodplain use permit for development, as described in the application and supporting materials, for my property at BNSF MP 149.9, and to take all action required related to the requested development on my property including documentation and submittal of technical information required by the Flood Control District of Maricopa County ("District").

Property Owner Signature: ____________________

Property Owner Printed Name: Stephanie Swanson

Property Owner Address: 4515 Kansas Ave.

City, State, Zip Kansas City, KS 66106

Date: ____________________

STATE OF ____________)
)ss.
COUNTY OF ____________)

SUBSCRIBED AND SWORN TO before me this ________ day of ____________________

____
Notary Public

My Commission Expires: ____________________

NOTE: This form is for all Floodplain Use Permits except for extraction of sand and gravel or other materials.

DISTRICT USE ONLY

Tracking Number: ____________________

Project Name: ____________________

BNSF Railway Company

Phoenix Subdivision
Line Segment 7208
Maricopa County, Arizona

Bridge 149.9
Morristown, Arizona

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May 28, 2013

BNSF RAILWAY

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Section 1: Introduction

This report summarizes a Floodplain Use Permit request prepared by the project team, BioGeo, LLC (BioGeo) and The Louis Berger Group (LBG), on behalf of The Burlington Northern Santa Fe Railway (BNSF). The BNSF bridge number 149.9 is located over the Little San Domingo Wash in Section 13-T6N-R4W near the City of Morristown, within Maricopa County, Arizona and is scheduled to be replaced in the 2013 calendar year. Figures 1 and 2 are location and vicinity maps for the bridge. Immediately downstream of Bridge 149.9 is an existing riprap apron which is in need of repair. As part of the bridge reconstruction, this riprap apron will be repaired and additional riprap countermeasures will be installed to stabilize the Little San Domingo Wash downstream of the bridge opening. Bridge 149.9 is located approximately 800 feet downstream of four 10' x 8' RCBs that has a drop structure and energy dissipator on the downstream side of US Highway 60 and is approximately 1.9 miles upstream of the Hassayampa River confluence.

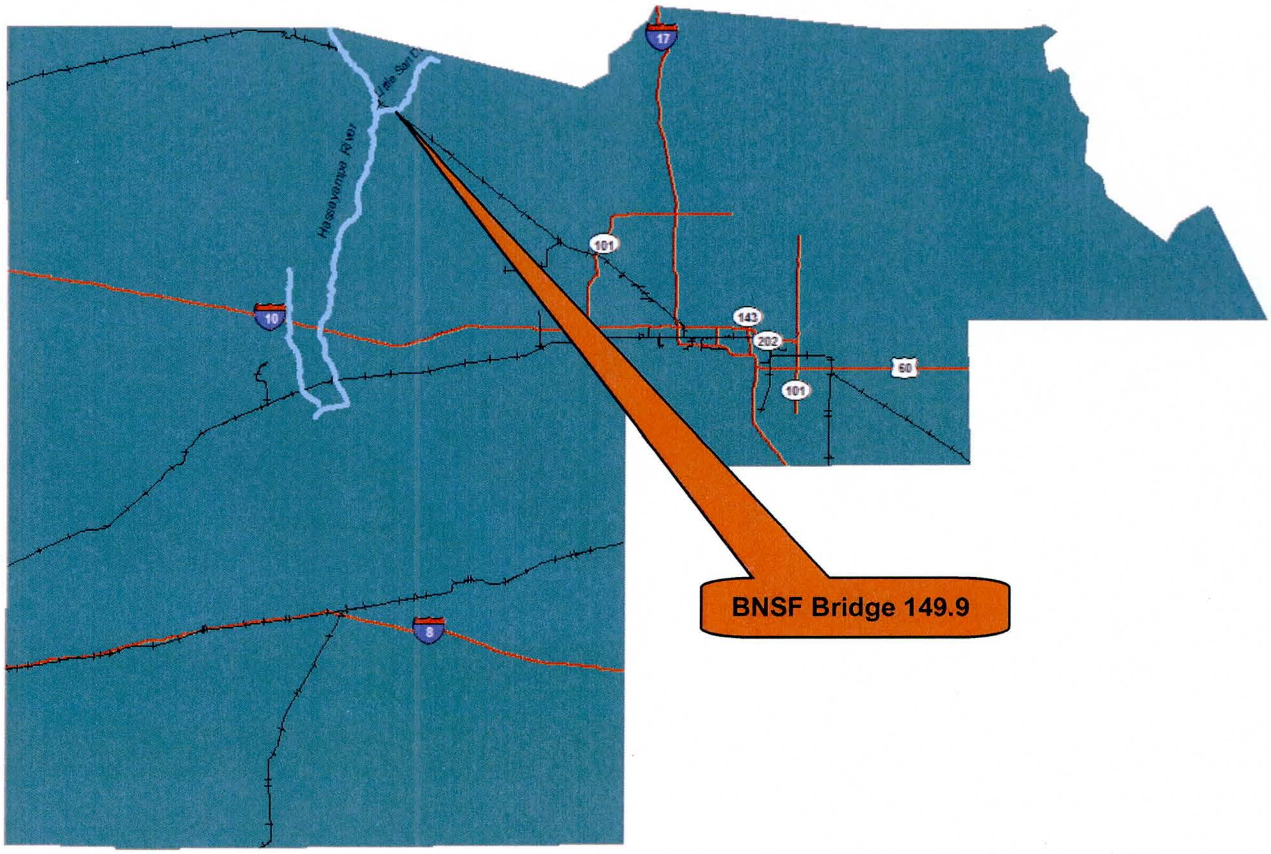


Figure 1. Bridge 149.9 Location Map

Bridge 149.9 is located in a designated FEMA Floodway area as shown on the Flood Insurance Rate Map (FIRM) Number 04013C0660G, Panel 660 of 4350 with an effective date of September 30, 2005. Bridge 149.9 is at section H, between section I and G of the published detailed study of The Little San Domingo Wash. The Floodplain Use Permit (FUP) is required by the Flood Control District of Maricopa County (FCDMC) in order to perform construction activities within the floodway.

Figure 2. Bridge 149.9 Vicinity Map

Bridge 149.9 (Shown in Picture 1) consists of a 127 foot long timber pile trestle bridge with nine fourteen foot spans. The area upstream of the structure that drains to the bridge is predominantly rural arid range land. The area directly upstream of the bridge is composed of sandy bed and bank material with sparse vegetation. The girder depth is approximately 5.9' from top of tie to low chord on both the upstream and downstream sides of the structure. The current bridge is founded on a concrete apron and concrete footings. The bottoms of the concrete footings for this structure are not known. BNSF indicated that they speculate that these footings are at shallow depths and are a cause of concern for the overall stability of the existing bridge.

Picture 1. South (downstream) fascia of Bridge 149.9

The proposed bridge will be a 140 foot long precast concrete girder bridge with five twenty-eight foot spans. The bridge will be placed on Steel H-Piles with spill slopes through the bridge opening. The concrete apron will remain in place under the existing structure, with repair taking place due to the removal of the existing footings and also due to the construction of the new bridge. The piles of the proposed bridge will penetrate into hard material to a depth exceeding 33 feet. The new bridge structure's foundation will be designed to withstand this maximum potential scour depth of 20.5 ft. Undermining of the bridge foundations will also be minimized because of the existing concrete apron that will remain under the structure and will serve as a hard point in the Little San Domingo Wash under Bridge 149.9. In addition, the downstream riprap apron (Shown in Picture 2) will be repaired cleaned and additional riprap that is capable of withstanding shear forces of supercritical flow velocities will be installed to keep the existing riprap in place and to mitigate further downstream degradation. The wire enclosing the existing riprap apron will also be retied in order to ensure the integrity of the apron. Grading and work downstream of the proposed structure including the repair of the riprap countermeasures have been computed as under one tenth of an acre.

Picture 2. Riprap apron downstream of Bridge 149.9

Included within this report are survey and mapping information, as well as hydraulic analysis of the existing and proposed bridge using HEC-RAS 4.1.0. This hydraulic analysis was performed using the existing published discharge of 3299 cfs. Because this discharge was provided, no hydrologic analysis was performed by LBG as part of this report. Based on the results of this analysis, the water surface elevation below the bridge and immediately upstream and downstream of the bridge will be lowered due to the larger bridge opening. No adverse impacts will occur from this improvement as a result of the design storms.

1.1 Operation and Maintenance

The BNSF Railway owns and operates Bridge 149.9. The structural integrity of BNSF bridge operations and maintenance is subject to The Federal Railroad Administration's (FRA) 49 CFR Parts 213 and 237, Bridge Safety Standards. Inspections are required by law subject to FRA requirements. In Arizona, after significant rainfall events, each bridge is routinely inspected by a designated field supervisor. Therefore, the BNSF will adhere to their internal operations and maintenance schedules for bridge inspections compliant with federal rules and their bridge-specific maintenance practices.

Section 2: Local Government Abstract

Study Documentation Abstract for Local Government Submittals		
Section 1: Project Contact Information		
1.1	Owner Contact Information - Mailing Address - Phone Number - E -Mail	BNSF Railway - Stephanie Swanson 4515 Kansas Ave. Kansas City, KS 66106 (913) 551-4192 Stephanie.Swanson@bnsf.com
1.2	Study Contractor Contact Information - Mailing Address - Phone Number - E -Mail	BioGeo, LLC - John Larson 9330 LBJ Freeway, Suite 900 Dallas TX, 75243 (816) 401-0071 larson.biogeo@gmail.com
1.3	Local Technical Reviewer - Mailing Address - Phone Number - E -Mail	
1.4	Date Study Submitted	
1.5	Date Review Comments Returned (if applicable)	
1.6	Date Study Approved by Local Reviewing Agency	
Section 2: General Information		
Section 2.1: Project Location		
2.1.1	Community	Maricopa County
2.1.2	County	Maricopa County, AZ
2.1.3	River or Stream Name	Little San Domingo Wash
2.1.4	Reach Description	Sparsely vegetated sand riverbed
2.1.5	Study type (Riverine, Alluvial Fan, etc.)	Wash
Section 2.2: Project Purposes and Summary of Findings		
2.2.1	Purpose of the Study	Reconstruction of Bridge 149.9
2.2.2	Summary of Hydrology and Hydraulic Methodologies Utilized	No Hydrology was performed as part of this submittal. HEC-RAS 4.1.0 was utilized for Hydraulic Analysis
2.2.3	Brief Summary Description of the Study Results	Water surface elevations below and immediately adjacent to Bridge 149.9 will be lowered
2.2.4	Acknowledgements	

Section 3: Survey and Mapping Information		
3.1	Digital Projection Information Type/Source Coordinate System Date	Survey shot December 14, 2011. Established by GPS Surveys with GEOID09, at NGS Station 4LH2 NAD 83 (2007) US State Plane, Arizona Central (0202) 95% Confidence Level in Centimeters North 0.96, East 0.84, Ellipsoid 1.31
3.2	USGS Quad Sheet(s) with original photo date & latest photo revision date. Current data may be substituted if available.	Wickenburg SW Quad (1962)
3.3	Mapping for Hydrologic Study Type/Source Scale Date	None
3.4	Mapping for Hydraulic Study Type/Source Scale Date Subcontractor (Aerial) Date of Aerial Mapping	None

Section 4: Hydrology		
4.1	Model or Method Used (including vendor and version description)	N/A
4.2	Storm Duration	100 Year
4.3	Hydrograph Type	N/A
4.4	Frequencies Determined	N/A
4.5	List of Gages Used in Frequency Analysis or Calibration (Location, Years of Record, Gage Ownership)	N/A
4.6	Rainfall Amounts and Reference	N/A
4.7	Unique Conditions and Issues	N/A
4.8	Coordination of Discharges (Agency, Date, Comments)	N/A

Section 5: Hydraulics		
5.1	Model or Method Used (including vendor and version description)	U.S. Army Corps of Engineers' Hydrologic Engineering Center's River Analysis System (HEC-RAS) 4.1.0
5.2	Regime	Subcritical and Supercritical runs performed
5.3	Frequencies for Which Profiles Were Computed	100 year
5.4	Method of Floodway Calculation	No Floodway encroachments used for this report
5.5	Unique Conditions and Issues	None

Section 6: Erosion, Sediment Transport, and Geomorphic Analysis		
6.1	Summary of Method	Flood Control District of Maricopa County DDMSW software (version 4.6.0)
6.2	Issues Encountered During Study	None
6.3	Summary of Findings	Maximum Potential Scour = 20.48' Riprap D50 = 4.5' buried a depth = 2xD50

Section 7: Additional Study Information

Item	Description / Discussion

Section 3: Survey and Mapping Information

3.1 Digital Projection Information

On December 14, 2011 survey was performed by CVL Consultants for Bridge 149.9 and the surrounding area. A Microstation file containing this original survey data is provided in Appendix C. This survey was established by GPS Survey with GEOID09 at NGS Station 4LH2 (Height Modernization Survey Station) PID (AJ3888). The coordinate system for this survey data is NAD83 (2007), US State Plane, Arizona Central (0202). Vertical control was based on NAVD88. The survey has a 95% confidence level in Centimeters North 0.96, East 0.84, Ellipsoid 1.31.

3.2 Field Survey Information

The survey shot by CVL Consultants for Bridge 149.9 was performed using GPS and no field notes were provided. The survey was provided by Matt Barr, PLS of CVL Consultants. The survey shot on December 14, 2011 is included in a Microstation file in Appendix C. This information was used to update the effective hydraulic model at Bridge 149.9. This information was adjusted -2.07 ft to convert to NGVD29 in order to be consistent with the effective hydraulic model provided by the FCDMC. This conversion factor was verified using both the US Army Corps of Engineers Corpscon v6.0.1 and the National Geodetic Survey's VERTCON. No other survey data was utilized for this analysis

3.3 Mapping

See sections 3.1 and 3.2 for survey information. All survey provided by CVL consultants was used to update the effective hydraulic model provided by the FCDMC. Changes to the model were made at Bridge 149.9 and immediately upstream and downstream of the bridge to reflect surveyed data. No other cross section changes were made to the model beyond the surveyed data area. No hydrology was performed as part of this study and therefore all mapping information was used for hydraulic modeling purposes.

Section 4: Hydrology

A field visit was completed by BioGeo, CVL and LBG personnel on December 6, 2011, to determine site-specific information with regards to valley setting, drainage, sediment transport and scour issues. This visit was also used to discuss survey data acquisition, and to take field notes and pictures (Included in Appendix D) upstream and downstream of the bridge.

The drainage area tributary to Bridge 149.9 mostly exists as rural range land. The basin discharge from the published flood insurance study and provided to LBG as part of the effective HEC-2 analysis was originally adopted for use in the floodplain use permit model. Because this discharge was provided by the FCDMC as the effective discharge no additional hydrologic calculations were performed for this project and are not included in this report.

Section 5: Hydraulics

5.1 Method Description

The Little San Domingo Wash is a small, well-defined wash near the unincorporated area of Morristown in northern Maricopa County, AZ. According to the published Flood Insurance Study (FIS), the Little San Domingo drains approximately 6.2 square miles of desert highlands. The effective model provided by the FCDMC starts approximately 3.8 miles upstream of the confluence with the Hassayampa River. The model continues to the confluence with the Hassayampa River at the Hassayampa River FIS Cross Section 41.290.

The HEC-2 model that was provided by Maricopa County was imported into HEC-RAS 4.1.0 and debugged to run in the updated program. The changes that were incorporated for the model to run in HEC-RAS included the addition of distances between the upstream and downstream fasciae of each structure in the model. HEC-RAS 4.1.0 was utilized to perform the hydraulic modeling of BNSF Bridge 149.9. This is the latest version of the U.S. Army Corps of Engineers one dimensional flow model developed for standard step backwater procedures for open channel and bridge hydraulic design. The discharges and cross-sections included in the HEC-RAS model were imported from the Flood Control District of Maricopa County HEC-2 analysis.

Data from the field survey of the bridge and project site was utilized in the HEC-RAS model to more accurately reflect the existing conditions between cross sections 21 to 28. Conversion of the survey from NAVD88 to NGVD29 was necessary to stay consistent with the HEC 2 hydraulic model. The difference in elevation from NAVD88 to NGVD29 is -2.07 feet for this area of the United States. The low chord elevations and pier locations for Bridge 149.9 were input using NGVD29 elevations to simulate the existing conditions. The low chord elevation for Bridge 149.9 is 1949.81 ft., which is approximately 5.9' from the top of the tie to the low chord elevation. This elevation was utilized in the HEC-RAS model for the existing bridge condition. Additional cross sections were also included (sections 25.4, 25.2, 21.6, 21.4, and 21.2) downstream of Bridge 149.9 in order to more accurately reflect the riprap apron downstream of the structure. This updated model was titled the "Corrected Base" HEC-RAS Plan.

This Existing Conditions model was then saved out as the "140' Bridge" plan. The existing bridge information was removed and the proposed bridge information was input. Low chord for the proposed bridge was set 3'-10" below the surveyed top of tie based on the standard height of precast concrete girders utilized by the BNSF Railway. The cross sections below the bridge and upstream and downstream were also modified to reflect the proposed changes to the area around and through the bridge opening. Once an area of influence was determined the plans were trimmed one cross section upstream and downstream of the area of influence. The starting water surface elevations were set as known water surface elevations. This known water surface elevation was determined based on the results of the model prior to being trimmed to an area of influence.

5.2 Work Study Maps

The Hydraulic Work Map provided in the Exhibit Maps Section of this report is for HEC-RAS cross sections 19 through 30, which covers the entire area of interest for Bridge 149.9 as well as upstream and downstream sections for reference. The Hydraulic Work Map shows all of the cross sections within the project area, the effective base flood elevation, and the effective FEMA floodway boundary.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

Mannings n values directly upstream and downstream of Bridge 149.9 were estimated based on aerial mapping, site reconnaissance, survey and photographs. All other Manning's n values which imported from the HEC-2 analysis were maintained. Picture 3 shows the typical riverbed conditions used to determine manning's n values for the added cross sections.

Table 1. Manning's n Values

River	Reach	River Station	Manning's n #1		Manning's n #2		Manning's n #3	
			Existing	Proposed	Existing	Proposed	Existing	Proposed
River-1	Reach-1	30	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	29	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	28	0.065	0.065	0.035	0.02	0.065	0.065
River-1	Reach-1	27.5	Bridge					
River-1	Reach-1	27	0.065	0.065	0.035	0.02	0.065	0.065
River-1	Reach-1	26	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	25.4	0.065	0.065	0.035	0.013	0.065	0.065
River-1	Reach-1	25.2	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	25	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	24	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	23	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	22	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	21.6	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	21.4	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	21.2	0.065	0.065	0.035	0.035	0.065	0.065
River-1	Reach-1	21	0.06	0.06	0.035	0.035	0.06	0.06
River-1	Reach-1	20	0.06	0.06	0.035	0.035	0.06	0.06
River-1	Reach-1	19	0.06	0.06	0.035	0.035	0.06	0.06

Picture 3. Typical River Bed Near Bridge 149.9

5.3.2 Expansion and Contraction Coefficients

Expansion and contraction coefficients are used to account for energy losses that occur due to changes in the cross section geometry. This most often occurs when entering or exiting a structure such as a bridge or culvert. Expansion and contraction coefficients for the existing structure were maintained from the imported HEC-2 expansion and contraction coefficients. Expansion and contraction coefficients were input for the proposed bridge according to the guidance provided in Chapter 3 of the HEC-RAS reference manual.

5.4 Cross Section Description

The majority of cross sections for this project were imported from the HEC-2 analysis provided by the FCDMC. Additional cross sections were added around Bridge 149.9 in order to provide more detail to the model. These additional cross sections were determined using the ground survey provided by CVL Consultants. Cross Sections 21 through 28 were also updated for these two models with the new survey data. The ground survey at each cross section was extracted and imported into the HEC-RAS model. Each of the cross sections was then lowered by the NAVD88 to NGVD29 conversion rate of -2.07 ft. The updated cross sections were then compared with cross sections in the imported model in order to verify that the cross sections were successfully imported and the information in the model was consistent and accurate. Once the cross section geometries were imported and verified the downstream reach lengths, Manning's n values, expansion and contraction coefficients, and Main Channel Bank Stations were entered to accurately reflect the conditions in the field. The following table reflects the cross sections that were added to the hydraulic model and cross sections that were changed in the hydraulic model.

Table 2. Summary of Changes Between Hydraulic Models

Modified Sections	Changes by Model	
	Existing	Proposed
30	No Change from HEC-2 model.	No Change from HEC-2 model or Existing Plan.
29	No Change from HEC-2 model.	No Change from HEC-2 model or Existing Plan.
28	Updated cross section geometry and reach lengths according to CVL survey information.	Modified to reflect changes made during construction of proposed bridge.
27.5	Updated High and Low Chord, and pier shape and location	Modified to reflect changes made during construction of proposed bridge.
27	Updated cross section geometry and reach lengths according to CVL survey information.	Modified to reflect changes made during construction of proposed bridge.
26	Updated cross section geometry and reach lengths according to CVL survey information.	Modified to reflect changes made during construction of proposed bridge.
25	Updated cross section geometry and reach lengths according to CVL survey information.	Modified to reflect changes made during construction of proposed bridge.
24	Updated cross section geometry and reach lengths according to CVL survey information.	Modified to reflect changes made during construction of proposed bridge.
23	Updated cross section geometry and reach lengths according to CVL survey information.	Modified to reflect changes made during construction of proposed bridge.
22	Updated cross section geometry and reach lengths according to CVL survey information.	Maintained changes from existing to proposed.
21	Updated cross section geometry according to CVL survey information.	Maintained changes from existing to proposed.
20	No Change from HEC-2 model.	No Change from HEC-2 model or Existing Plan.
19	No Change from HEC-2 model.	No Change from HEC-2 model or Existing Plan.
Additional Cross Sections	Existing Model	Proposed Model
25.4	Additional cross section included to reflect step down in riprap apron	Modified to reflect changes made during construction of proposed bridge.
25.2	Additional cross section included to reflect step down in riprap apron	Modified to reflect changes made during construction of proposed bridge.
21.6	Additional cross section included to provide more detailed transition downstream of Bridge 149.9	Maintained changes from existing to proposed.
21.4	Additional cross section included to provide more detailed transition downstream of Bridge 149.9	Maintained changes from existing to proposed.
21.2	Additional cross section included to provide more detailed transition downstream of Bridge 149.9	Maintained changes from existing to proposed.

5.5 Modeling Considerations

5.5.1 Hydraulic Jump and Drop Analysis

There is a drop of approximately 8 feet in approximately 53 feet downstream of Bridge 149.9. Potential hydraulic turbulence and high velocities in this area will be mitigated with the repair of the existing riprap apron and the addition of proposed riprap that will be sized to resist shear stresses and to help keep the existing riprap apron intact (see Section 6).

5.5.2 Bridges and Culverts

BNSF Bridge 149.9, which is located at section 27.5, was updated according to the survey provided by CVL Consultants.

The existing and proposed Bridge 149.9 was modeled using the CVL Consultants survey information on location of piers, width of the structure, and low chord elevation. Table 3 below summarizes the structures included in the model.

Table 3. Structure Summary Table

Structure	River Station	Type of Structure	Modeling Method
Bridge 149.9	27.5	Bridge	Momentum

5.5.3 Levees and Dikes

No Levees or Dikes were modeled as part of this analysis

5.5.4 Non-Levee Embankments

No Non-Levee Embankments were modeled as part of this analysis

5.5.5 Islands and Flow Splits

No Islands or Flow Splits were modeled as part of this analysis

5.5.6 Ineffective Flow Areas

The models do not have ineffective flow for Bridge 149.9 because the bridge setting does not currently prevent flow from progressing through the structure. Because the proposed bridge does not make any changes to the bridge setting, this will remain the case. No other areas of ineffective flow were modeled for this project. Ineffective flow areas were also added in all models at section 20 and 21. This was done because ineffective flow areas were set in the HEC-2 model using the ET data. When the HEC-2 model was imported this information was not brought in and had to be added manually.

5.5.7 Supercritical Flow

Supercritical flow is present through Bridge 149.9 and the downstream apron.

5.6 Floodway Modeling

No Floodway was modeled for the Floodplain Use Permit Analysis.

5.7 Issues Encountered During the Study

5.7.1 Special Issues and Solutions

There were no special modeling issues encountered with this project.

5.7.2 Modeling Warning and Error Messages

There were no error messages in the model output. There were several warning messages where the model defaulted to critical depth or warned that additional cross sections may be needed. The warnings within the project area were reviewed and do not significantly impact the accuracy of the results.

5.8 Calibration

Model calibration took place with a comparison of available evidence when conducting the field investigation, such as available water stains that were present on the bridge piers, any debris that was discovered at the bridge site, and vegetation that showed evidence of high flows. There is no gauging information available in the project area. Additional information obtained from BNSF track personnel was considered during the hydraulic modeling for the Bridge.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

The water surface profile for the proposed model is lower than the existing model between cross sections 21 through 28. The following tables provide a summary of the HEC-RAS results for the existing and proposed models.

Table 4. Supercritical HEC-RAS Output

River Station	Profile	Plan	Total Discharge (cfs)	Water Surface Elevation (ft)	Critical Water Surface Elevation (ft)	Avg. Vel. (ft/s)	Top Width (ft)	Depth of Flow (ft)	Froude Number	Left station where water surface meets existing ground	Right station where water surface meets existing ground
30	100 Year	140' BR	3299.00	1947.28	1947.28	14.24	53.92	6.30	1.00	976.13	1030.05
30	100 Year	CorrBase1929	3299.00	1947.28	1947.28	14.24	53.92	6.30	1.00	976.13	1030.05
29	100 Year	140' BR	3299.00	1947.37	1947.37	13.83	40.71	5.86	1.01	979.06	1019.77
29	100 Year	CorrBase1929	3299.00	1947.37	1947.37	13.83	40.71	5.86	1.01	979.06	1019.77
28	100 Year	140' BR	3299.00	1935.94	1938.08	24.47	76.48	1.76	3.25	965.11	1041.59
28	100 Year	CorrBase1929	3299.00	1937.01	1939.00	22.19	69.53	2.22	2.63	971.83	1041.36
27.5			Bridge								
27	100 Year	140' BR	3299.00	1936.06	1937.89	21.19	76.82	2.03	2.62	964.77	1041.59
27	100 Year	CorrBase1929	3299.00	1937.50	1938.36	14.51	77.07	3.13	1.45	964.32	1041.39
26	100 Year	140' BR	3299.00	1936.02	1937.72	20.06	80.41	2.05	2.47	955.26	1035.67
26	100 Year	CorrBase1929	3299.00	1938.35	1938.35	11.14	79.15	3.89	1.00	954.64	1033.78
25.4	100 Year	140' BR	3299.00	1935.35	1937.07	20.52	84.77	1.90	2.63	961.25	1046.02
25.4	100 Year	CorrBase1929	3299.00	1936.10	1937.15	15.25	81.20	2.66	1.65	964.06	1045.27
25.2	100 Year	140' BR	3299.00	1935.07	1936.79	20.47	83.37	1.93	2.60	962.30	1045.67
25.2	100 Year	CorrBase1929	3299.00	1935.85	1936.96	15.50	83.83	2.54	1.71	961.80	1045.63
25	100 Year	140' BR	3299.00	1933.97	1935.78	21.56	83.30	1.84	2.80	962.34	1045.65
25	100 Year	CorrBase1929	3299.00	1934.69	1936.08	17.32	82.30	2.31	2.01	962.59	1044.89
24	100 Year	140' BR	3299.00	1932.65	1934.22	19.21	91.96	1.87	2.48	961.63	1053.59
24	100 Year	CorrBase1929	3299.00	1933.12	1934.54	17.82	90.10	2.08	2.18	964.62	1054.73
23	100 Year	140' BR	3299.00	1931.42	1933.06	19.64	86.85	1.93	2.49	972.58	1059.43
23	100 Year	CorrBase1929	3299.00	1929.19	1931.12	21.74	76.13	2.07	2.66	979.59	1055.72
22	100 Year	140' BR	3299.00	1932.00	1932.00	13.06	65.16	5.81	0.95	971.32	1036.48
22	100 Year	CorrBase1929	3299.00	1932.00	1932.00	13.06	65.16	5.81	0.95	971.32	1036.48
21.4	100 Year	140' BR	3299.00	1927.12	1927.44	11.41	103.46	2.97	1.17	104.75	208.21
21.4	100 Year	CorrBase1929	3299.00	1927.12	1927.44	11.41	103.46	2.97	1.17	104.75	208.21
21.2	100 Year	140' BR	3299.00	1926.39	1926.39	10.41	102.38	3.40	0.99	37.44	139.82
21.2	100 Year	CorrBase1929	3299.00	1926.39	1926.39	10.41	102.38	3.40	0.99	37.44	139.82
21	100 Year	140' BR	3299.00	1928.93	1928.93	10.62	358.12	3.83	0.96	657.68	1059.44
21	100 Year	CorrBase1929	3299.00	1929.60	1929.60	12.37	398.53	6.53	0.85	656.00	1077.97
20	100 Year	140' BR	3299.00	1920.92	1921.16	13.03	440.18	2.58	1.43	910.55	1484.50
20	100 Year	CorrBase1929	3299.00	1920.45	1921.16	18.13	386.01	2.10	2.20	911.36	1480.17
19	100 Year	140' BR	3299.00	1914.80	1914.80	11.49	127.14	4.40	0.97	876.52	1361.24
19	100 Year	CorrBase1929	3299.00	1914.80	1914.80	11.49	127.14	4.40	0.97	876.52	1361.24

Table 5. Existing Conditions Bridge 149.9 Supercritical Summary Table RS: 27.5 Profile: 100 Year

E.G. US. (ft)	1944.58	Element	Inside BR US (Sta. 28)	Inside BR DS (Sta. 27)
W.S. US. (ft)	1937.01	E.G. Elev (ft)	1943.13	1941.15
Q Total (cfs)	3299.00	W.S. Elev (ft)	1938.13	1939.12
Q Bridge (cfs)	3299.00	Crit W.S. (ft)	1939.66	1939.12
Q Weir (cfs)		Max Chl Dpth (ft)	4.16	5.46
Weir Sta Lft (ft)		Vel Total (ft/s)	17.44	11.14
Weir Sta Rgt (ft)		Flow Area (sq ft)	189.16	296.11
Weir Submerg		Froude # Chl	1.92	0.98
Weir Max Depth (ft)		Specif Force (cu ft)	2144.31	1834.49
Min El Weir Flow (ft)	1955.71	Hydr Depth (ft)	2.61	3.95
Min El Prs (ft)	1955.70	W.P. Total (ft)	115.06	142.00
Delta EG (ft)	3.84	Conv. Total (cfs)	11245.5	20815.6
Delta WS (ft)	-0.49	Top Width (ft)	72.56	74.97
BR Open Area (sq ft)	1294.80	Frctn Loss (ft)	0.17	
BR Open Vel (ft/s)	17.44	C & E Loss (ft)	1.29	
Coef of Q		Shear Total (lb/sq ft)	8.83	3.27
Br Sel Method	Energy only	Power Total (lb/ft s)	912.00	912.00

Table 6. Proposed Bridge 149.9 Supercritical Summary Table RS: 27.5 Profile: 100 Year

E.G. US. (ft)	1945.24	Element	Inside BR US (Sta. 28)	Inside BR DS (Sta. 27)
W.S. US. (ft)	1935.94	E.G. Elev (ft)	1944.93	1943.09
Q Total (cfs)	3299.00	W.S. Elev (ft)	1936.05	1936.15
Q Bridge (cfs)	3299.00	Crit W.S. (ft)	1938.15	1938.01
Q Weir (cfs)		Max Chl Dpth (ft)	1.90	2.15
Weir Sta Lft (ft)		Vel Total (ft/s)	23.92	21.14
Weir Sta Rgt (ft)		Flow Area (sq ft)	137.94	156.04
Weir Submerg		Froude # Chl	3.08	2.57
Weir Max Depth (ft)		Specif Force (cu ft)	2580.67	2332.45
Min El Weir Flow (ft)	1956.14	Hydr Depth (ft)	1.87	2.10
Min El Prs (ft)	1952.80	W.P. Total (ft)	83.96	85.57
Delta EG (ft)	2.20	Conv. Total (cfs)	14269.8	17304.7
Delta WS (ft)	-0.12	Top Width (ft)	73.83	74.13
BR Open Area (sq ft)	1727.15	Frctn Loss (ft)	0.10	0.87
BR Open Vel (ft/s)	23.92	C & E Loss (ft)	0.21	0.97
Coef of Q		Shear Total (lb/sq ft)	5.48	4.14
Br Sel Method	Energy only	Power Total (lb/ft s)	912.00	912.00

Supercritical Flow Regime Hydraulic Summary Table

River Station	Profile	Total Discharge (cfs)	Existing Conditions							
			Water Surface Elevation (ft)	Crit Water Surface Elevation (ft)	Average Velocity (ft/s)	Depth of Flow (ft)	Water Surface Elevation (ft)	Crit Water Surface Elevation (ft)	Average Velocity (ft/s)	Depth of Flow (ft)
30	100 Year	3299	1947.28	1947.28	14.24	6.30	1947.28	1947.28	14.24	6.30
29	100 Year	3299	1947.37	1947.37	13.83	5.86	1947.37	1947.37	13.83	5.86
28	100 Year	3299	1937.01	1939.00	22.19	2.22	1935.94	1938.08	24.47	1.76
27.5			Bridge				Bridge			
27	100 Year	3299	1937.50	1938.36	14.51	3.13	1936.06	1937.89	21.19	2.03
26	100 Year	3299	1938.35	1938.35	11.14	3.89	1936.02	1937.72	20.06	2.05
25.4	100 Year	3299	1936.10	1937.15	15.25	2.66	1935.35	1937.07	20.52	1.90
25.2	100 Year	3299	1935.85	1936.96	15.50	2.54	1935.07	1936.79	20.47	1.93
25	100 Year	3299	1934.69	1936.08	17.32	2.31	1933.97	1935.78	21.56	1.84
24	100 Year	3299	1933.12	1934.54	17.82	2.08	1932.65	1934.22	19.21	1.87
23	100 Year	3299	1929.19	1931.12	21.74	2.07	1931.42	1933.06	19.64	1.93
22	100 Year	3299	1932.00	1932.00	13.06	5.81	1932.00	1932.00	13.06	5.81
21.6	100 Year	3299	1927.56	1928.93	17.29	2.47	1927.56	1928.93	17.29	2.47
21.4	100 Year	3299	1927.12	1927.44	11.41	2.97	1927.12	1927.44	11.41	2.97
21.2	100 Year	3299	1926.39	1926.39	10.41	3.40	1926.39	1926.39	10.41	3.40
21	100 Year	3299	1929.60	1929.60	12.37	6.53	1928.93	1928.93	10.62	3.83
20	100 Year	3299	1920.45	1921.16	18.13	2.10	1920.92	1921.16	13.03	2.58
19	100 Year	3299	1914.80	1914.80	11.49	4.40	1914.80	1914.80	11.49	4.40

Table 7. Subcritical HEC-RAS Output

River Station	Profile	Plan	Total Discharge (cfs)	Water Surface Elevation (ft)	Crit Water Surface Elevation (ft)	Average Velocity (ft/s)	Top Width (ft)	Depth of Flow (ft)	Froude Number	Left station where water surface meets existing ground	Right station where water surface meets existing ground
30	100 Year	140' BR	3299.00	1951.38	1947.30	8.20	61.70	10.40	0.45	968.38	1030.08
30	100 Year	CorrBase1929	3299.00	1951.38	1947.30	8.20	61.70	10.40	0.45	968.38	1030.08
29	100 Year	140' BR	3299.00	1947.40	1947.40	13.76	40.79	5.88	1.00	979.02	1019.81
29	100 Year	CorrBase1929	3299.00	1947.40	1947.40	13.76	40.79	5.88	1.00	979.02	1019.81
28	100 Year	140' BR	3299.00	1939.18	1938.08	8.31	87.83	4.52	0.69	960.61	1048.44
28	100 Year	CorrBase1929	3299.00	1941.21	1939.00	7.17	93.03	6.23	0.51	960.10	1053.14
27.5			Bridge								
27	100 Year	140' BR	3299.00	1937.89	1937.89	11.05	79.54	3.75	1.01	962.27	1041.81
27	100 Year	CorrBase1929	3299.00	1939.08	1938.36	9.58	82.01	4.71	0.78	961.34	1043.35
26	100 Year	140' BR	3299.00	1937.72	1937.72	10.82	84.75	3.60	1.01	953.07	1037.82
26	100 Year	CorrBase1929	3299.00	1938.35	1938.35	11.14	79.15	3.89	1.00	954.64	1033.78
25.4	100 Year	140' BR	3299.00	1937.07	1937.07	10.64	88.98	3.49	1.00	959.35	1048.32
25.4	100 Year	CorrBase1929	3299.00	1937.15	1937.15	10.88	83.95	3.64	1.01	962.65	1046.60
25.2	100 Year	140' BR	3299.00	1936.79	1936.79	10.75	86.30	3.55	1.01	961.17	1047.47
25.2	100 Year	CorrBase1929	3299.00	1936.96	1936.96	10.74	86.50	3.55	1.00	961.06	1047.56
25	100 Year	140' BR	3299.00	1935.78	1935.78	10.77	86.12	3.56	1.01	961.12	1047.24
25	100 Year	CorrBase1929	3299.00	1936.08	1936.08	10.72	86.18	3.57	1.00	961.13	1047.31
24	100 Year	140' BR	3299.00	1934.68	1934.22	9.02	104.21	3.70	0.83	955.02	1059.24
24	100 Year	CorrBase1929	3299.00	1934.54	1934.54	10.51	98.15	3.50	0.99	960.70	1058.85
23	100 Year	140' BR	3299.00	1934.94	1933.06	6.41	111.06	4.82	0.51	960.20	1071.26
23	100 Year	CorrBase1929	3299.00	1934.97	1931.12	5.42	111.65	7.85	0.34	960.09	1071.74
22	100 Year	140' BR	3299.00	1932.00	1932.00	13.06	65.16	5.81	0.95	971.32	1036.48
22	100 Year	CorrBase1929	3299.00	1932.00	1932.00	13.06	65.16	5.81	0.95	971.32	1036.48
21.6	100 Year	140' BR	3299.00	1930.40	1928.93	7.95	104.28	5.31	0.61	79.96	184.24
21.6	100 Year	CorrBase1929	3299.00	1931.34	1928.93	6.67	122.58	6.25	0.47	78.16	200.74
21.4	100 Year	140' BR	3299.00	1930.68	1927.44	4.83	215.05	6.53	0.33	25.13	240.18
21.4	100 Year	CorrBase1929	3299.00	1931.55	1927.44	4.12	234.64	7.40	0.27	20.96	255.60
21.2	100 Year	140' BR	3299.00	1930.67	1926.39	4.24	195.82	7.68	0.27	9.77	205.59
21.2	100 Year	CorrBase1929	3299.00	1931.54	1926.39	3.72	211.20	8.55	0.22	3.41	214.61
21	100 Year	140' BR	3299.00	1928.93	1928.93	10.62	358.12	3.83	0.96	657.68	1059.44
21	100 Year	CorrBase1929	3299.00	1929.60	1929.60	12.37	398.53	6.53	0.85	656.00	1077.97
20	100 Year	140' BR	3299.00	1921.57	1921.16	9.00	479.04	3.22	0.88	909.85	1491.05
20	100 Year	CorrBase1929	3299.00	1921.57	1921.16	9.00	479.04	3.22	0.88	909.85	1491.05
19	100 Year	140' BR	3299.00	1914.77	1914.77	11.56	125.30	4.37	0.97	876.64	1360.66
19	100 Year	CorrBase1929	3299.00	1914.77	1914.77	11.56	125.30	4.37	0.97	876.64	1360.66

Table 8. Existing Conditions Bridge 149.9 Subcritical Summary Table RS: 27.5 Profile: 100 Year

E.G. US. (ft)	1941.98	Element	Inside BR US (Sta. 28)	Inside BR DS (Sta. 27)
W.S. US. (ft)	1941.21	E.G. Elev (ft)	1941.92	1941.15
Q Total (cfs)	3299.00	W.S. Elev (ft)	1940.69	1939.12
Q Bridge (cfs)	3299.00	Crit W.S. (ft)	1939.66	1939.12
Q Weir (cfs)		Max Chl Dpth (ft)	6.72	5.46
Weir Sta Lft (ft)		Vel Total (ft/s)	8.46	11.14
Weir Sta Rgt (ft)		Flow Area (sq ft)	389.80	296.11
Weir Submerg		Froude # Chl	0.69	0.98
Weir Max Depth (ft)		Specif Force (cu ft)	1952.31	1834.49
Min El Weir Flow (ft)	1955.71	Hydr Depth (ft)	4.71	3.95
Min El Prs (ft)	1955.70	W.P. Total (ft)	157.89	142.00
Delta EG (ft)	1.49	Conv. Total (cfs)	29524.3	20815.6
Delta WS (ft)	2.13	Top Width (ft)	82.69	74.97
BR Open Area (sq ft)	1294.80	Frctn Loss (ft)		
BR Open Vel (ft/s)	11.14	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	1.92	3.27
Br Sel Method	Momentum	Power Total (lb/ft s)	912.00	912.00

Table 9. Proposed Bridge 149.9 Subcritical Summary Table RS: 27.5 Profile: 100 Year

E.G. US. (ft)	1940.25	Element	Inside BR US (Sta. 28)	Inside BR DS (Sta. 27)
W.S. US. (ft)	1939.18	E.G. Elev (ft)	1940.16	1939.93
Q Total (cfs)	3299.00	W.S. Elev (ft)	1938.73	1938.01
Q Bridge (cfs)	3299.00	Crit W.S. (ft)	1938.15	1938.01
Q Weir (cfs)		Max Chl Dpth (ft)	4.58	4.01
Weir Sta Lft (ft)		Vel Total (ft/s)	9.58	11.11
Weir Sta Rgt (ft)		Flow Area (sq ft)	344.23	296.81
Weir Submerg		Froude # Chl	0.82	0.99
Weir Max Depth (ft)		Specif Force (cu ft)	1753.57	1726.97
Min El Weir Flow (ft)	1956.14	Hydr Depth (ft)	4.26	3.88
Min El Prs (ft)	1952.80	W.P. Total (ft)	105.39	97.90
Delta EG (ft)	0.46	Conv. Total (cfs)	56299.9	46193.0
Delta WS (ft)	1.28	Top Width (ft)	80.71	76.55
BR Open Area (sq ft)	1727.15	Frctn Loss (ft)		
BR Open Vel (ft/s)	11.11	C & E Loss (ft)		
Coef of Q		Shear Total (lb/sq ft)	0.70	0.97
Br Sel Method	Momentum	Power Total (lb/ft s)	912.00	912.00

Subcritical Flow Regime Hydraulic Summary Table										
River Station	Profile	Total Discharge (cfs)	Existing Conditions				Proposed Conditions			
			Water Surface Elevation (ft)	Crit Water Surface Elevation (ft)	Average Velocity (ft/s)	Depth of Flow (ft)	Water Surface Elevation (ft)	Crit Water Surface Elevation (ft)	Average Velocity (ft/s)	Depth of Flow (ft)
30	100 Year	3299	1951.38	1947.30	8.20	10.40	1951.38	1947.3	8.2	10.4
29	100 Year	3299	1947.40	1947.40	13.76	5.88	1947.4	1947.4	13.76	5.88
28	100 Year	3299	1941.21	1939.00	7.17	6.23	1939.18	1938.08	8.31	4.52
27.5			Bridge				Bridge			
27	100 Year	3299	1939.08	1938.36	9.58	4.71	1937.89	1937.89	11.05	3.75
26	100 Year	3299	1938.35	1938.35	11.14	3.89	1937.72	1937.72	10.82	3.6
25.4	100 Year	3299	1937.15	1937.15	10.88	3.64	1937.07	1937.07	10.64	3.49
25.2	100 Year	3299	1936.96	1936.96	10.74	3.55	1936.79	1936.79	10.75	3.55
25	100 Year	3299	1936.08	1936.08	10.72	3.57	1935.78	1935.78	10.77	3.56
24	100 Year	3299	1934.54	1934.54	10.51	3.50	1934.68	1934.22	9.02	3.7
23	100 Year	3299	1934.97	1931.12	5.42	7.85	1934.94	1933.06	6.41	4.82
22	100 Year	3299	1932.00	1932.00	13.06	5.81	1932	1932	13.06	5.81
21.6	100 Year	3299	1931.34	1928.93	6.67	6.25	1930.4	1928.93	7.95	5.31
21.4	100 Year	3299	1931.55	1927.44	4.12	7.40	1930.68	1927.44	4.83	6.53
21.2	100 Year	3299	1931.54	1926.39	3.72	8.55	1930.67	1926.39	4.24	7.68
21	100 Year	3299	1929.60	1929.60	12.37	6.53	1928.93	1928.93	10.62	3.83
20	100 Year	3299	1921.57	1921.16	9.00	3.22	1921.57	1921.16	9	3.22
19	100 Year	3299	1914.77	1914.77	11.56	4.37	1914.77	1914.77	11.56	4.37

5.9.2 Verification or Comparison of Results

The results of the proposed model are consistent with what was expected. The only change from existing to proposed was the installation of the new bridge. Because the new bridge is longer and obstructs less flow, because of fewer piers being in the water, it is expected that the water surface elevations in cross sections adjacent to the bridge would be lower than existing.

Section 6: Erosion, Sediment Transport, and Geomorphic Analysis

6.1 Method Description

The drainage system and channel upstream of Bridge 149.9 consists of a well-defined channel. The channel upstream of Bridge 149.9 is part of the existing railroad right of way. The beds and banks of the area are sparsely vegetated and may be susceptible to erosion and sedimentation. As indicated previously, there is a history of scour issues downstream of this bridge. This history necessitated the installation of the existing downstream riprap apron that is contained by wire mesh to prevent head cutting and undermining of the existing bridge foundations. The following picture was provided by the BNSF Railway. This picture was taken approximately 11 years ago prior to the installation of the riprap apron.

Picture 4. Historical Erosion Downstream of Bridge 149.9

Scour analysis was performed for the proposed Bridge 149.9 structure using the Flood Control District of Maricopa County Drainage Design Management System (DDMSW) software. The area downstream of the bridge is currently made up of a riprap mat enclosed with wire fabric, sand, and alluvial material. The existing structure currently has a concrete apron that will remain in place for the new structure. Bridge 149.9 is constructed on shallow spread footings of unknown depth. Because of the potential bed degradation shown in Picture 5, the existing BNSF Bridge structure is considered scour critical and in need of replacement. In an attempt to remedy this issue and prevent further erosion from undermining their structure, BNSF installed the riprap apron shown previously. Although it is in need of repair, this structure has prevented the further degradation of the area downstream of the bridge and has served the purpose of its installation fairly well. The reason for this historical bed degradation may be the result of several contributing factors.

1. The stream is primarily composed of sand and alluvial material which is more easily eroded than cohesive soil streambeds.
2. The increased discharge and velocities that this structure has seen over time may have resulted in the damage seen in the picture above.

Several options were investigated as alternatives to the gabion structure to help protect the proposed bridge from similar scour problems. These options included a baffled apron and a USBR Stilling Basin. After careful consideration and discussion with the railroad, it was determined that in order to minimize disturbance within the floodway the existing gabion structure would be cleaned and retied and additional riprap capable of withstanding supercritical velocities would be added to help hold the structure in place and help slow down the high velocities in this area. Repair of the existing structure will consist of the addition of rock within the structure where voids currently exist, and repair of the wire mesh in places where it has been damaged. The new rock will be installed to a minimum depth equal to twice the calculated D_{50} around the perimeter of the existing riprap apron. The proposed perimeter riprap was sized using DDMSW and will be carefully placed and compacted on non-woven filter fabric so as to make a well graded mat that is keyed together to form a mass according to HEC-23 guidelines. The gabion structure and added riprap, in addition to the concrete lined bottom below the bridge and regular inspection following flood events and regular maintenance by the railroad will provide the most protection with the least amount of disturbance and cost.

6.2 Parameter Estimation

As part of this project a geotechnical investigation was performed by BioGeo, LLC in order to determine depth to bedrock and/or hard impenetrable rock surface, and to identify field evidence of subsurface maximum scour potential for the structure. In addition, the information provided by this investigation was then utilized to perform a detailed scour analysis as a comparison for the bridge.

On August 20, 2012, a truck-mounted drill rig was mobilized to the site. D&S Drilling, Inc. performed the drilling via hollow-stem auger methods. Investigation of strata followed ASTM protocol for geotechnical analysis via standard penetration testing (SPT) of non-cohesive soils with subsequent split-spoon sample recovery at 1.5-foot intervals. Two distinct boring locations were installed near the rip-rap apron downstream of the bridge within the Wash. Each boring, identified as B-1 and B-2, were drilled approximately 43 feet lateral distance apart.

BioGeo logged the borings and samples recovered using the Unified Soil Classification System (USCS). Upon conclusion of the drilling activities, samples were bagged and labeled and submitted to Ricker, Atkinson, McBee, Mormon & Associates, Inc. (RAMM) for geotechnical laboratory testing. Upon reaching total depth (i.e., refusal) each boring location was abandoned with cuttings to the original ground surface level. Refusal was noted upon auger and SPT refusal. Results of this investigation can be found in Appendix F as well as the corresponding sub-appendices.

The results of this investigation were then provided to the Louis Berger Group for use in scour analysis. This information was used in conjunction with the historical information and hydraulic analysis in order to determine long term bed degradation, general contraction scour, and local pier scour using the DDMSW software. Abutment scour was not included in the analysis because the existing concrete paving below Bridge 149.9 will be maintained and repaired during the construction of the new bridge. These values were then combined by superposition to determine the maximum potential scour depth. Based on this analysis, the maximum potential scour depth is estimated to be 19.50' at the bridge. Note that this depth did not consider the concrete apron underneath the bridge structure that will be maintained.

6.3 Modeling Considerations

Scour analysis was not performed using HEC-RAS, but was performed using the DDMSW and verified with field data from the borings.

6.4 Issues Encountered During the Study

6.4.1 Special Issues and Solutions

No special issues were encountered in this study.

6.4.2 Modeling Warning and Error Messages

Scour analysis was not performed using HEC-RAS, but was performed using DDMSW and verified with field data from the borings.

6.5 Calibration

All variable values used as part of the Calculations were chosen based on information collected during the geotechnical investigation and site visit. As noted above, verification utilizing the borings and field data were compared to the maximum scour calculations as shown in the tables below.

6.6 Final Results

6.6.1 Erosion, Sediment Transport, and Geomorphic Analysis Results

A summary of the computed scour depths and riprap sizing are included in the tables below. The approximate maximum scour depth is drawn on the elevation drawing of Bridge 149.9 in Appendix F. It should be noted that these computations do not take into consideration the existing concrete apron below the structure, which serves as a hard point in the stream, the downstream gabion structure or the armor layer determined to be between 19 and 20 feet below grade during the geotechnical investigation.

Table 10. Scour Results – Calculated at Bridge 149.9

Total Scour					
Scour Parameter	**Method**	**Calculated Value**	**Factor of Safety**	**Estimated Scour Value**	**Comment**
Long-Term Bed Degradation	Not Included	--	--	0.00	Assume to be 0 due to riprap control structure.
General Scour	Neill	3.66	1.3	4.76	Includes a 30° Bend Angle
Local Scour	Piers	11.15	1.3	14.50	Pier Width Taken as 5.16 ft. (2 ft either side of pier) according to Standard 6.7.15.
Bedform Scour	Not Included	--	--	0.00	Assume to be 0 due to concrete pavement below bridge.
Low Flow Scour	Not Included	--	--	0.00	Assume to be 0 due to concrete pavement below bridge.
Total Scour				**19.26**	

Table 11. Scour Results – Calculated Downstream of Riprap Apron

Total Scour					
Scour Parameter	**Method**	**Calculated Value**	**Factor of Safety**	**Estimated Scour Value**	**Comment**
Long-Term Bed Degradation	State Standard Level I	2.58	1.3	3.35	
General Scour	Lacey	2.56	1.3	3.33	
Local Scour	Grade Control or Drop Structure - Schoklitsch	3.41	1.3	4.43	
Bedform Scour		5.21	1.3	6.77	
Low Flow Scour		2.00	1.3	2.60	Assume to be 2 ft
Total Scour				**20.48**	

Table 12 Riprap Sizing Results - Calculated Downstream of Riprap Apron

Riprap Sizing	
Parameter	**Value**
Method	Channel Bed on Straight Reach
Average Velocity (ft/s)	19.64
Specific Weight of Stone (lb/cu ft)	165.00
Specific Weight of Water (lb/cu ft)	62.43
Calculated D_{50}	**4.48**

Based on the results of the geotechnical report and scour analysis the following evaluation was provided to the BNSF Railway:

1. Foundations for Bridge 149.9 should be established below the scour critical elevation for support (19-21 ft); therefore piles will be founded below this depth into the hard rock surface at >33 ft to support dead and live loads for the structure while keeping in mind slenderness ratios at the maximum potential scour profile.
2. Pile footings may require rock coring for lateral stability for a pile foundation.
3. Based on the general expense of coring into rock, a spread footing or footing on micropiles may provide an economical alternative.
4. A shallow pile supported footing may also be a consideration, which would provide a table top footing anchored below the scour critical elevation and allow a multitude of substructure supports for the bridge.
5. Regular inspection and maintenance of the bridge and areas upstream and downstream of the bridge will be performed following flood events in accordance with FRA requirements as discussed in Section 1.1 Operation and Maintenance.

6.6.2 Verification of Results

The results of the scour analysis are within reasonable limits. There are no previous studies to which comparison of these results can be made. Based on historical information these results are consistent with what was expected and with the field data collected from borings.

Section 7: N/A

Appendix A: References

A.1 Data Collection Summary

FEMA Flood Insurance Study: Maricopa County, Arizona and Incorporated Areas – Flood Insurance Study Number 04013C

A.2 Referenced Documents

Federal Emergency Management Agency (FEMA). "FEMA: Flood Insurance Rate Maps" *Flood Hazard Assessments and Mapping Requirements*. 3 May 2011. FEMA. April 2011 http://www.fema.gov/hazard/map/firm.shtm.

US Army Corps of Engineers Hydrologic Engineering Center, Jan 2010. *HEC-RAS River Analysis System*, Version 4.1.0. US Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center, Davis CA. http://www.hec.usace.army.mil.

Davis, S.R., and E.V. Richarson. United States. *HEC-18: Evaluating Scour at Bridges, Fourth Edition*. Arlington, VA: , 2001.

Lagasse, P.F., J.D. Schall, and E.V. Richarson. United States. *HEC-20: Stream Stability at Highway Structures, Third Edition*. Arlington, VA: , 2001.

Lagasse, P.F., J.D. Schall, L.W. Zevenbergen, and P.E. Clopper. United States. *HEC-23: Bridge Scour and Stream Instability Countermeasures, Second Edition*. Arlington, VA: , 2001.

Arizona Department of Transportation, Hydrologic and Hydraulic Manual

Appendix B: General Documentation and Correspondence

B.1 General Project Documentation and Correspondence

N/A

B.2 Contract Documents

BioGeo

November 11, 2011

Mr. Howard R. Perry, PE
Manager Structures Design
BNSF Railway Co.
4515 Kansas Ave.
Kansas City, KS 66106

ACCT 2010 CST 367
RSN 130 CNTR 14901
LOC 473080
AUTHORITY A11-9670
CONTRACT NO. BF46766
APPROVED H. R. PERRY
TITLE MGR. STRUCT. DESIGN
TASK ORDER 10970

Re: Proposal for Consulting Services
Surveying, Drainage Studies, and Permitting
<u>BNSF Bridge #149.9</u>
<u>Maricopa County, Arizona</u>

Dear Mr. Perry:

BioGeo, Solutions Corp. (BioGeo) is pleased to present this proposal to the Burlington Northern Santa Fe Railway Co. (BNSF) for consulting services at the above referenced bridge (#149.9) located northwest of Phoenix near Morristown, in Maricopa County, Arizona. BioGeo will team with the Louis Berger Group, Inc. (LBG) and Coe & Van Loo (CVL) Consultants of Colorado, Inc. to provide the comprehensive services described below. This scope of services is in response to your October 20, 2011 request to representatives of BioGeo (Mr. Larson) and LBG (Mr. Bill Yord) during a face-to-face meeting. This letter proposal lists the services the Team (BioGeo, LBG, and CVL) will provide, the deliverables, schedule, and fee.

PROJECT UNDERSTANDING AND BACKGROUND

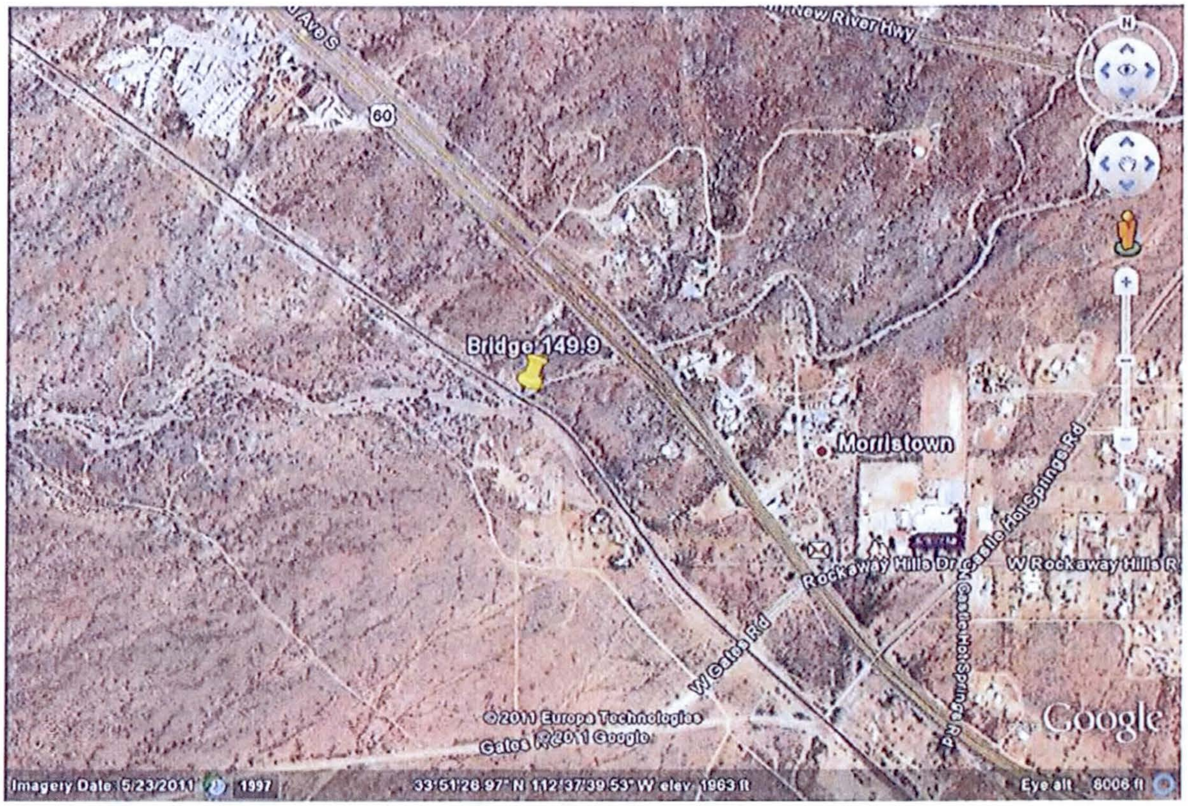
BNSF has indicated that they would like to have a recommendation for Bridge #149.9 within 6 months from notice to proceed so that this structure may be placed on the 2012 or 2013 Bridge Program. The Team understands that BNSF requires the following:

- Bridge Survey
- Bridge Survey Sheets in MicroStation Format
- Hydrologic & Hydraulic (H&H) review and studies
- Permitting and associated Agency Approvals
- Reporting

CVL will perform the surveying of Bridge #149.9 and provide survey data to LBG for their H&H studies. LBG will provide the H&H reviews and report, and Survey Sheets. BioGeo will coordinate the permitting requirements for the Bridge project and perform associated agency correspondences for concurrence and will provide overall project management.

Bridge 149.9 of Line Segment 7208 Phoenix Subdivision, is located on the Little San Domingo Wash and drains southwest into the Hassayampa River. The structure lies downstream of US Highway 60. BNSF Bridge 149.9 is located on the northwest side of Morristown, Maricopa County, Arizona. A location map of this structure is shown below.

9330 LBJ Freeway; Ste 900 • Dallas, TX 75243
Telephone 214-438-3894; Cell 816-401-0071



Scope of Services

Task 1: Bridge #149.9 Surveying

Coe & Van Loo (CVL) of Denver Colorado, a licensed surveyor in Arizona will perform the bridge survey. CVL will meet with Mr. Yord of LBG onsite and establish a minimum of two (2) control points at the existing bridge. Surveying will comprise, but not be limited to, two control points, one at each end of the bridge, structure centerline with upstream/downstream drainage centerline at 300 feet from bridge identified, applicable utilities, top of rail, bridge abutments and pier type, size, and locations. The survey points will be used for the engineering studies and will be suitable for future construction staking activities. The control surveys will be conducted using the NAD 83, Arizona State Plane coordinate System. Elevations will based upon NAVD 88. CVL will adhere to BNSF Railroad Flag coordination and On-site Safety procedures, including a BNSF Safety Action Plan (SAP), Fall Protection, PPE, and relevant training and certifications.

Deliverable

CVL will provide the data in Microstation format to LBG for points surveyed. Copies of field notes/sketches and photographs will be provided in pdf format. CVL will provide a stamped licensed Surveyor Report.

Task 2: Bridge Survey Sheets. CVL will coordinate with Mr. Yord of LBG to execute the above surveying services. Upon receipt of CVL's surveying data, LBG will incorporate their hydraulic and hydrology study data.

Deliverable

LBG will be responsible for the Final Survey Sheets for Bridge Design application and submittal to BNSF.

Task 3: Hydrology and Hydraulic Studies and Reporting

Bridge #149.9 LBG will lead the hydraulic and hydrology studies. Mr. Yord of LBG will provide onsite reconnaissance data collection.

LBG will gather the data necessary to perform a hydrologic analysis for the bridge listed above. LBG will utilize the appropriate methods for determining the design discharge through the structure. LBG personnel will visit the site to provide a hydrologic assessment for the bridge as part of this work.

At this time, no direction from BNSF has been given regarding the replacement structures. LBG will work directly with BNSF regarding possible replacement structures after the field visit and discharges through the structures have been determined and include this assessment in our report.

Bridge 149.9 is in FEMA Zone AE according to Panel 660 of 4350 of the Flood Insurance Rate Map (FIRM) Number 04013C660G with an effective date of September 30, 2005. There has been a detailed study and a base flood elevation, which is defined as the 100 year water surface elevation (WSE) established. A hydrologic and hydraulic study modeling the existing and proposed conditions will need to be performed to make sure the proposed structure will not increase the 100 year WSE which has been established by FEMA.

LBG will utilize the bridge and stream survey data and USGS DTM data to construct a hydraulic model using the latest version of Hec-RAS. We will provide a hydraulic report of our findings and make a recommendation for the proposed structures so they may be placed on a future bridge program list.

LBG will work with BioGeo to provide information for permitting purposes to the U.S. Army Corps of Engineers (ACE). Additional analysis outside of providing a recommendation to BNSF for a replacement structure is not included in this scope, but may be added with a task order increase.

Deliverable

LBG will compose a complete hydrologic and hydraulic report for Bridge 128.7. The sections in the reports will include the following:

- Introduction and Background
- Existing Conditions
- Hydrologic Investigation
- Hydraulic Investigation
- Sedimentation, Scour and Monitoring
- Conclusions and Recommendations
- Appendices

Task 4: Cultural and Historical Resource Reviews

Historic, Archaeological and Architectural Resources: In accordance with Section 106 regulations (36 CFR 800) and compliance guidelines established by the State Historic Preservation Office (SHPO) of Arizona, consultation with the SHPO will be performed. BioGeo will issue a letter of inquiry to the SHPO to assess whether the potential project will have an adverse effect on significant historic properties including potential unreported archeological sites that may exist within the project area subject to future ground disturbance(s). Historic and archaeological resources included in or nominated for inclusion in the National Register of Historic Places (NHRP) will be identified through consultation within the State Historic Preservation Officer (SHPO). Background research and field windshield/pedestrian survey will be conducted for documentation.

Deliverable
It is anticipated that a letter of concurrence will be obtained from the Arizona SHPO. If significant cultural and/or historical resources are determined, an additional scope of services associated with Cultural and Historical Resource investigation will be developed and submitted to BNSF prior to performing onsite field determinations of the potential impacts. No intrusive archaeological field surveys are anticipated to be conducted as part of this study.

Task 5: Environmental Reviews and Permitting

Water Resources and Wetlands: In addition to conducting a field review of the area, water resources (i.e., reservoirs, lakes, ponds, streams) and wetlands will be identified using USGS maps and National Wetland Inventory (NWI) maps for the site. Field review will verify the mapped information as well as identify potentially jurisdictional areas that may have been omitted from the mapping. The presence of hydric soils will be documented. Public/private wells and water towers will also be identified. Significant water resources that may require protection under state or local statutes will also be identified through review of the State Water Quality Regulations and coordination with the federal and local agencies. Water resources and wetlands will be indicated on a site base map and identified. If potential impacts to wetlands may result due to the site re-developments, wetland delineations may be required for jurisdictional determination. [Note: this scope of services does not include performance of a Preliminary Jurisdictional Determination (PJD); however will identify if such is needed.] Jurisdictional waters on the site may include ephemeral tributaries, wetlands, and (potentially) open waters. Non-jurisdictional isolated waters will also be identified. Wetlands will be identified via methods used by the U.S. Army Corps of Engineers (ACE) of inundated or saturated surface and/or ground water at duration and frequency to support hydrophytic vegetation. Prevalence of hydrophytic vegetation, hydric soils, and hydrology to support the wetlands environment will be documented.

Floodplains: The 100-year floodplain limits within the study area will be identified using National Floodplain Insurance Maps (FIRM) and shown on a site map.

Other Resource Issues--Threatened and Endangered Species: Threatened and endangered species known locations and habitats will be identified through coordination with the State Department of Conservation and/or the US Fish and Wildlife Service. If areas of potential habitat are identified, field review of these areas will be conducted to determine if suitable habitat does exist.

Permits: Determination of necessary permits/approvals to allow the project to be re-constructed. It is anticipated that clearances/approvals/permits may be required under the following regulations:

- Section 401 (water quality) of the Clean Water Act
- Section 402 (NPDES) of the Clean Water Act and associated Construction General Permit (CGP) authorized via EPA. The Construction Permit may be acquired at a later date upon implementation of a construction schedule (e.g., 2013).
- Section 404 (wetlands and waters of the U.S.) of the Clean Water Act [determination and obtaining of Individual or Nationwide permits will require coordination and approval with the ACE]
- Indian Lands Permit requirements –to be determined
- Interface with Flood Control District of Maricopa County (Note: a pre-application meeting may be necessary either with the Flood Control district and/or with the U.S. ACE –Los Angeles District to streamline the permitting process).

Impact to Corps jurisdictional waters may require submittal of a Section 404 Permit Application. There are various 404 permit mechanisms based on impact thresholds that will be determined in the event a PJD is conducted. For example, a Nationwide 14 may be pursued with no ACE notification if the project causes the loss of less than 0.10 acre of waters; no loss of intermittent and/or perennial tributaries below the high water mark; or, if greater 0.10 -0.5 acres and less than 300 linear feet are impacted, then a Nationwide Permit is required with notification to the ACE and the Arizona Department of Environmental Quality (ADEQ) for Section 401 Certification.

Another option is a Waiver Permit might be pursued whereupon the ACE is notified with a Mitigation Plan, and no net loss of wetlands can be demonstrated. A Waiver might be initiated if greater than 0.5 acres are to be impacted and/or greater than 300 linear feet of tributaries are impacted, but are considered minor impacts with a "no net loss" plan developed. Alternatively, a Section 404 Individual Permit Application would be needed if significant threshold (>0.5 ac; >300 feet) impacts are expected. An Individual Permit would require about 6 months of ACE and public stakeholder reviews. It is anticipated that a Section 404 Nationwide Permit, subject to NWP 14 conditions, for linear transportation projects, will occur for the given project(s) criteria.

<u>Task 6: Final Reporting</u>

Upon conclusion of the environmental reviews and potential receipt of permit(s), a Report will document the recommended clearances and statements for approval(s) to be required from regulatory agencies at the local, state, and federal level in order to allow construction of the selected bridge replacement/improvements. Preliminary interface with several agencies will include, but not be limited to, the U.S. Army Corps of Engineers-Los Angeles District; Arizona Agencies such as the ADEQ, as well as local Indian tribes, as appropriate. Regulatory requirements and the likely environmental permits needed to proceed with bridge construction will be submitted in the Environmental Review Summary of the Final Report to the BNSF. The Final Report will include a summary of the permitting requirements, and, the evaluated structure's Existing Conditions, Stream Classification, and the associated results of the Hydrologic and Hydraulic model and studies performed with recommended replacement/improvement structure.

Estimated Date	***Milestone***
Nov 15	Notice to Proceed
Dec 6-8	Team Field Visit
Dec 6-9	Field Surveying
December-April	Correspondence with Agencies for Permitting
February 15	Surveying Deliverables
March 19-23	Hydrologic analysis Bridge 149.9
March 26-30	Produce Bridge Survey Sheets (including QA/QC)
April 2-6	Hydraulic analysis Bridge 149.9
April 6	Meet with BNSF to discuss bridge replacements
April 9-12	Finalize hydraulic model
April 16-20	Draft H&H Report
April 18	Environmental Permitting Deliverables
May 28	Deliver Final Report and Bridge Survey Sheets to BNSF

Therefore, we anticipate that submittal of the aforementioned tasks' deliverables to occur approximately 6 months from notice to proceed. However, it is possible some delays may be encountered, including, but not limited to agency concurrence/correspondence. We assume that 45-90 day agency correspondence periods are possible for this project. The schedule for agency correspondences and reviews are not the responsibility of BioGeo.

Estimated Fee

A summary of estimated costs for Bridge Project #149.9 is provided below. The Team offers these services with the following labor categories and rates.

- Project Engineer PE - $150.00/hr (LBG)
- Engineer Technician - $55.00/hr (LBG)
- QA/QC Senior Engineer PE - $180.00/hr (LBG)
- Senior Scientist PG - $95.00/hr (BioGeo)
- GIS Technician - $60.00/hr (BioGeo and/or LBG)
- Surveying – Lump sum (CVL, see below)

General Task Item for Scope of Services	Estimated Cost: Bridge #149.9
Task 1: Surveying [a]	$3,245.00
Task 2: Bridge Survey Sheets [a]	$1,540.00
Task 3: Hydraulic & Hydrology Investigation [a]	$13,270.00
Task 4: Cultural and Historic Resource Reviews	$650.00
Task 5: Environmental & Permitting Reviews	$2,650.00
Task 6: Reporting	$600.00
TOTAL	**$21,955**

[a] includes 10% Subcontractor mark-up and associated expenses for Contractor field visits

Qualifications of Terms and Conditions

This proposal is subject to the terms and conditions of Contract Number #BF46766 between BNSF and BioGeo, dated August 30, 2007. This proposal includes a flat 10% mark-up on the anticipated subcontracted activities.

The projects will be billed in accordance with BioGeo's Contract with BNSF; Contract #BF46766 for a total not-to-exceed amount of **$21,955.00 for the Bridge #149.9 Project**. Invoices will be billed on a time and materials basis not to exceed the amount shown here unless previously authorized by BNSF.

All field personnel will be certified to complete BNSF's Contractor Orientation Course prior to field mobilization. A BNSF flagman is required present during our Team's personnel field visits.

The services outlined above will be provided in accordance with generally accepted engineering practices at the time the work is performed. It is important to recognize that even the most comprehensive scope of services may fail to detect environmental, archaeological, engineering structural liabilities on a particular site. Therefore, BioGeo cannot act as insurers and cannot "certify" that a site is free of such liabilities. No expressed or implied representation or warranty is included or intended in our reports, except that our services were performed, within the limits prescribed by our client, with the customary thoroughness and competence of our profession.

Thank you for the opportunity to provide these services on this important project. BioGeo looks forward to working with you and LBG personnel and continuing our long-term business relationship and commitment to providing BNSF expert consulting services. Please sign and date the acceptance below, and send back to me so that we can proceed. Please feel free to contact me at (816) 401-0071 if you have any questions.

Sincerely,
BIOGEO SOLUTIONS, CORP.

John R. Larson

John R. Larson, PG, MPH
President

ACCEPTANCE:

BNSF hereby accepts the proposal outlined above and does hereby engage BioGeo Solutions Corp to perform the Scope of Services described, and the terms and conditions set forth in the Contract #BF46766. BioGeo will invoice BNSF upon services rendered on a monthly schedule. BNSF accepts and agrees to the terms and conditions of the Contract Services Agreement.

Howard R Perez	BNSF
Name	Company
MANAGER STRUCTURES DESIGN	11-17-11
Title	Date

7

ACCT 2010 CST 367
RSN 130 CNTR 14901
LOC ARIZONA
AUTHORITY A12-0499
CONTRACT NO. BF46766
APPROVED H.R. PERRY
TITLE MGR. STRUCT. DESIGN
10970-1 SUPPLEMENT 1

BioGeo

August 9, 2012

Mr. Howard R. Perry, PE
Manager Structures Design
BNSF Railway Co.
4515 Kansas Ave.
Kansas City, KS 66106

Re: **Proposal for Conditional Letter of Map Revision (CLOMR) Documentation**
CLOMR Permit Submittal
BNSF Bridge #149.9
Maricopa County, Arizona

Dear Mr. Perry:

BioGeo, LLC (BioGeo) is pleased to present this proposal to the Burlington Northern Santa Fe Railway Co. (BNSF) for additional consulting services at the above referenced bridge (#149.9) located northwest of Phoenix near Morristown, in Maricopa County, Arizona. The bridge 149.9 is located in the Little San Domingo Wash on Line Segment 7208 of the Phoenix Subdivision. This proposal is an ADDENDUM to the existing TASK ORDER #10970 issued by BNSF, dated November 17, 2011. BioGeo will team with the Louis Berger Group, Inc. (LBG) to provide the necessary services to meet regulatory requirements associated with the scheduled bridge replacement to occur in 2013.

PROJECT UNDERSTANDING AND BACKGROUND

To date, the Team has conducted surveying of the bridge, performed hydrology studies, and has had several correspondences with agencies such as the Maricopa County Flood Control District (MCFCD) representatives regarding permitting requirements. Earlier this year we learned that an independent drainage study was being conducted by MCFCD and we have requested results of those data but have yet to receive those data. Based on the drainage studies performed by LBG, the new structure proposed condition is not anticipated to raise the base flood elevation (100-year rainfall event); therefore, a "No Rise Certificate" may be issued. However, in proceeding with our studies and in dialogue with the MCFCD, the District indicates that a CLOMR is now required within their jurisdiction because the bridge is within a floodway. Therefore, this task order request ADDENDUM is necessary to address the CLOMR requirement.

In discussions with MCFCD representative, Ms. Stacy Lapp, we understand that it is...." not a legal requirement"... by MCFCD nor the Federal Emergency Management Agency (FEMA) to obtain CLOMR approval in advance of construction. However, the MCFCD does require a separate Floodplain Use Permit approval prior to construction (see example provided in Final Report: Bridge 139.1, Wickenburg, Arizona, dated June 2012). Because the CLOMR application process and approvals (via 2 agencies, the MCFCD and FEMA) takes a longer period of time than a Floodplain Use Permit the CLOMR should be submitted soon. Later, upon final design of the new structure (to be approved- and submitted as 'final' design- by BNSF) the Floodplain Use Permit will be submitted to MCFCD. It is important to note, that the Floodplain Use Permit, required by Maricopa County, requires an $800.00 application fee and is included herein as a separate line item fee (not covered in the scope/fee of task order #10970). A detailed scour analysis is required for documentation in the Floodplain Use Permit. The scour analysis will be provided for the Floodplain Use Permit in conjunction with ongoing investigation activities subject to task order #11084.

9330 LBJ Freeway; Ste 900 • Dallas, TX 75243
Telephone 214-438-3894; Cell 816-401-0071

During a telephone conference call meeting attended by the Team and Ms. Lapp of MCFCD, the date of September 15, 2012 was agreed upon as a 'deadline' for issuance of the CLOMR application upon which use of "existing published data" will be provided in lieu of the MCFCD drainage (independent study) data. LBG will utilize the existing published flow data for the CLOMR—there is no requirement to use the new MCFCD data for CLOMR permitting. If we receive the new flow data (via MCFCD) by September 15th; we will utilize those data for the scour analyses; however, if it is not received by September 15th, then existing published data will be used as representative of drainage flow/maximum scour depth for documentation of discharge in the Little San Domingo Wash.

CLOMR Scope of Services

Bridge #149.9 There are two (2) separate permit fees associated with the CLOMR application process: 1) $3,000 fee to the MCFCD; and 2) $4,600 fee to the FEMA.

LBG will gather the data necessary to submit the CLOMR permit application to include as follows:

- FEMA Forms MT-1 and MT-2
- Effective and Proposed Hydrology
- Effective and Proposed Hydraulics
- Current FEMA map
- FEMA Map with Annotated and Proposed Changes
- Hydraulic Work Map
- Written Report

BioGeo will include a compilation of the listed Threatened and Endangered Species and an official letter from the Arizona Ecological Fish & Wildlife Services (FWS) of potential habitat "adverse affect" or "no effect" statement in compliance with FEMA's Endangered Species Act (ESA) requirements for the CLOMR submittal. Additionally, documentation of the State Historic Preservation Office (SHPO) research of potential historic/archaeological and correspondence with the U.S. Army Corps of Engineers in attainment of Nationwide Permit 14 (for linear transportation projects) will be provided, as needed.

Estimated Schedule	***Milestone***
August 13	Notice to Proceed
August 13-Sept.15	Compilation of data for CLOMR and interface with FWS & MCFCD
Sept. 30	Submittal of CLOMR to MCFCD
October 1-Jan.1	MCFCD Review of CLOMR (maximum 90 days)
Jan. 2	Submittal to FEMA upon MCFCD approval
Jan.3-April 3	FEMA Review of CLOMR (maximum 90 days)
April 2013	CLOMR Approvals in-place

We anticipate completion of the detailed scour analysis by October 15, 2012 with submittal of the Floodplain Use Permit contingent upon BNSF's final bridge design. Therefore, the Floodplain Use Permit is expected to be submitted in November, 2012 with a 90-day approval process by MCFCD in February 2013. Agency review schedules and approvals are not the responsibility of BioGeo.

Estimated Fee

General Task Item for Scope of Services	ADDENDUM Estimated Cost: Bridge #149.9
Task 1: CLOMR Documentation [a]	$8,500.00
Task 2: CLOMR Submittal Fee to MCFCD	$3,000.00
Task 3: CLOMR Submittal Fee to FEMA	$4,600.00

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Task 4: Floodplain Use Permit Submittal Fee to MCFCD	$800.00
Task 5: Project Management, CLOMR & Floodplain Use Permits-- Processing & Handling	$950.00
TOTAL—ADDENDUM COSTS	**$17,850**
TOTAL—Task Order #10970	**$21,955**
GRAND TOTAL (Task Order #10970 + ADDENDUM)	**$39,805**

[a] includes 10% Subcontractor mark-up and associated expenses

Qualifications of Terms and Conditions

This proposal is subject to the terms and conditions of Contract Number #BF46766 between BNSF and BioGeo, dated August 30, 2007. This proposal includes a flat 10% mark-up on the anticipated subcontracted activities.

The projects will be billed in accordance with BioGeo's Contract with BNSF; Contract #BF46766 for a total not-to-exceed amount of **$39,805 for the Bridge #149.9 Project subject to ADDNEDUM Task Order #10970.** Invoices will be billed on a time and materials basis not to exceed the amount shown here unless previously authorized by BNSF.

The services outlined above will be provided in accordance with generally accepted engineering practices at the time the work is performed. It is important to recognize that even the most comprehensive scope of services may fail to detect environmental, archaeological, engineering structural liabilities on a particular site. Therefore, BioGeo cannot act as insurers and cannot "certify" that a site is free of such liabilities. No expressed or implied representation or warranty is included or intended in our reports, except that our services were performed, within the limits prescribed by our client, with the customary thoroughness and competence of our profession.

Thank you for the opportunity to provide these services. Please sign and date the acceptance below, and send back to me so that we can proceed. Please feel free to contact me at (816) 401-0071 if you have any questions.

Sincerely,
BIOGEO, LLC

John R. Larson

John R. Larson, PG, MPH
President

ACCEPTANCE:

BNSF hereby accepts the proposal outlined above and does hereby engage BioGeo, LLC to perform the Scope of Services described, and the terms and conditions set forth in the Contract #BF46766. BioGeo will invoice BNSF upon services rendered on a monthly schedule. BNSF accepts and agrees to the terms and conditions of the Contract Services Agreement.

Howard R Perry
Name

BNSF
Company

HOWARD R. PERRY

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B.3 Public Notification
N/A

B.4 FEMA Correspondence
N/A

Appendix C: Survey Field Notes

C.1 Digital Projection Information
The coordinate system for this survey data is NAD83 (2007), US State Plane, Arizona Central (0202). Vertical control was based on NAVD88.

The survey data used for this project is included on the attached CD

C.2 Survey Field Notes for Aerial Mapping Control
N/A

C.3 Survey Field Notes for Hydrologic Modeling
N/A

C.4 Survey Field Notes for Hydraulic Modeling
No Survey Field notes were provided for this project. All information provided is included in CADD file in Appendix C.1

Appendix D: Hydrologic Analysis Supporting Documentation

D.1 Precipitation Data
N/A

D.2 Physical Parameter Calculations
N/A

D.3 Hydrograph Routing Data
N/A

D.4 Reservoir Routing Data
N/A

D.5 Flow Splits and Diversions Data
N/A

D.6 Hydrologic Calculations
N/A

Appendix E: Hydraulic Analysis Supporting Documentation

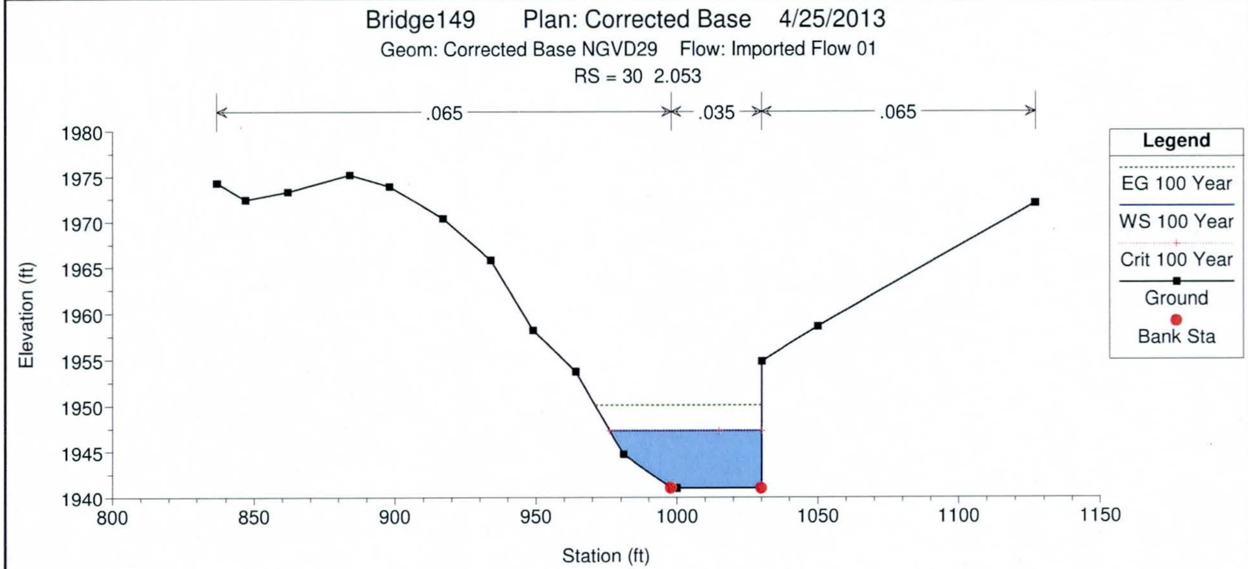
E.1 Roughness Coefficient Estimation

Channel upstream of Bridge 149.9

Channel Downstream of Bridge 149.9

E.2 Cross Section Plots

Existing Conditions Supercritical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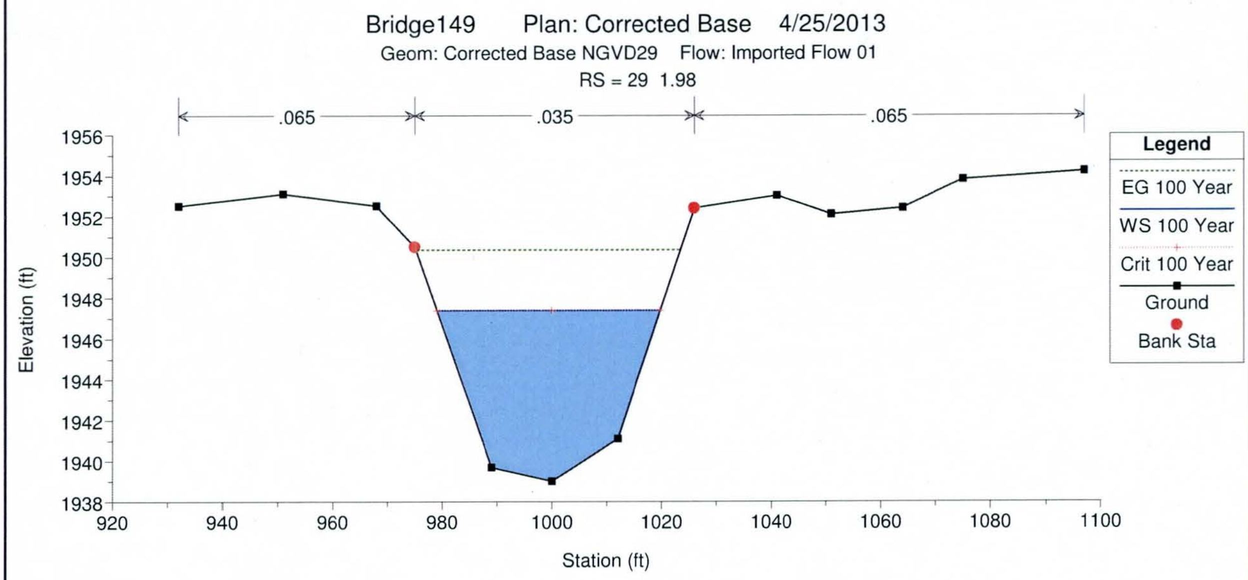
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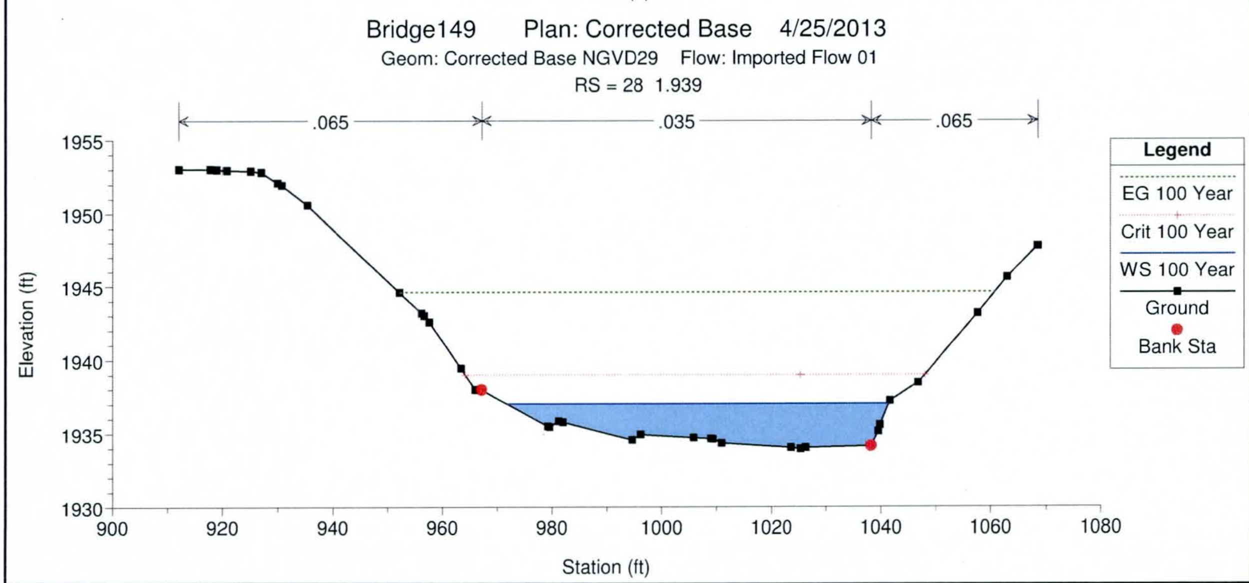
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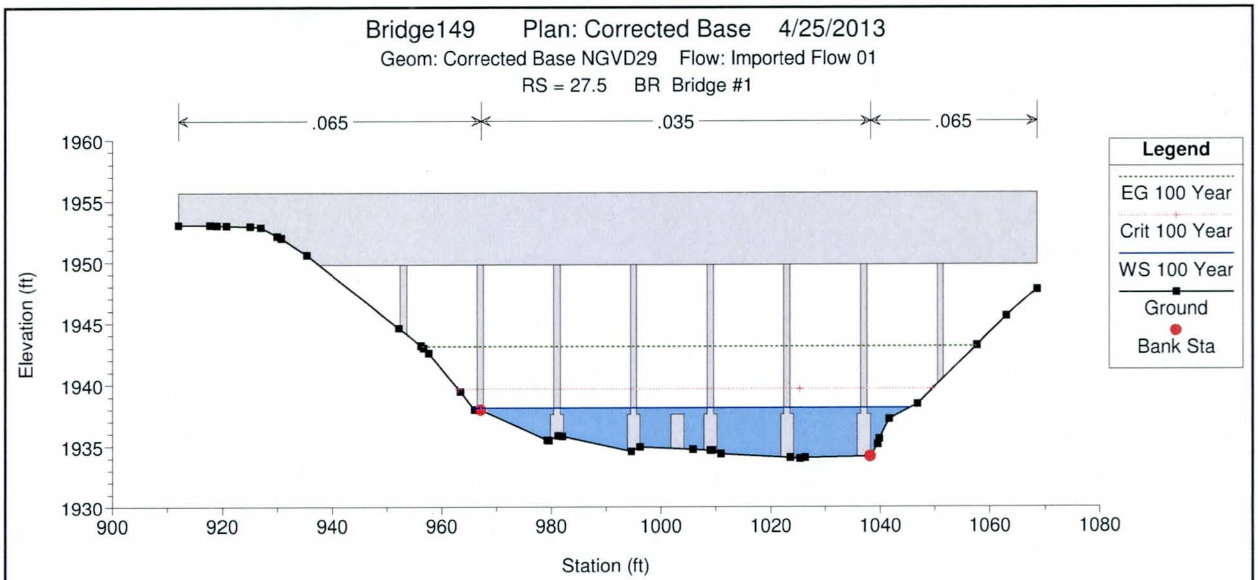

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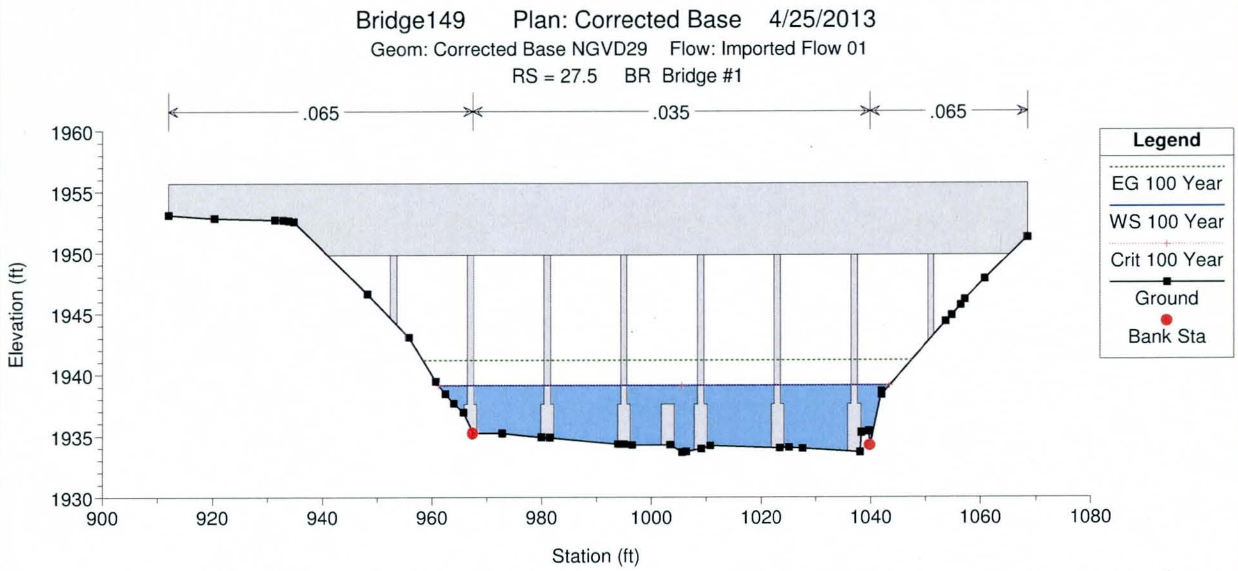

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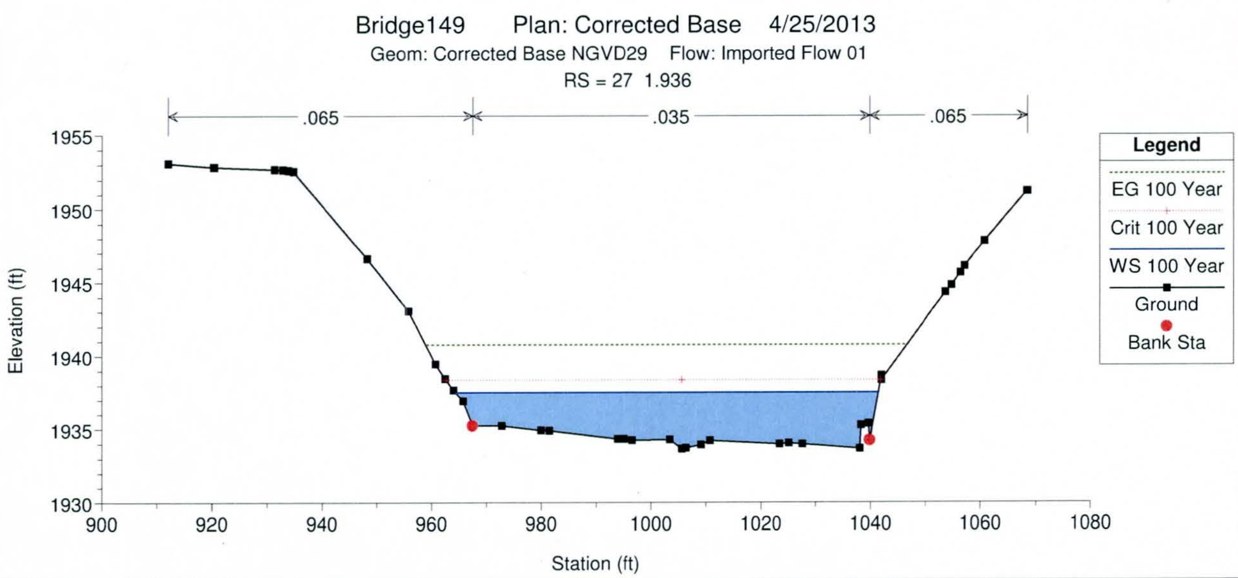

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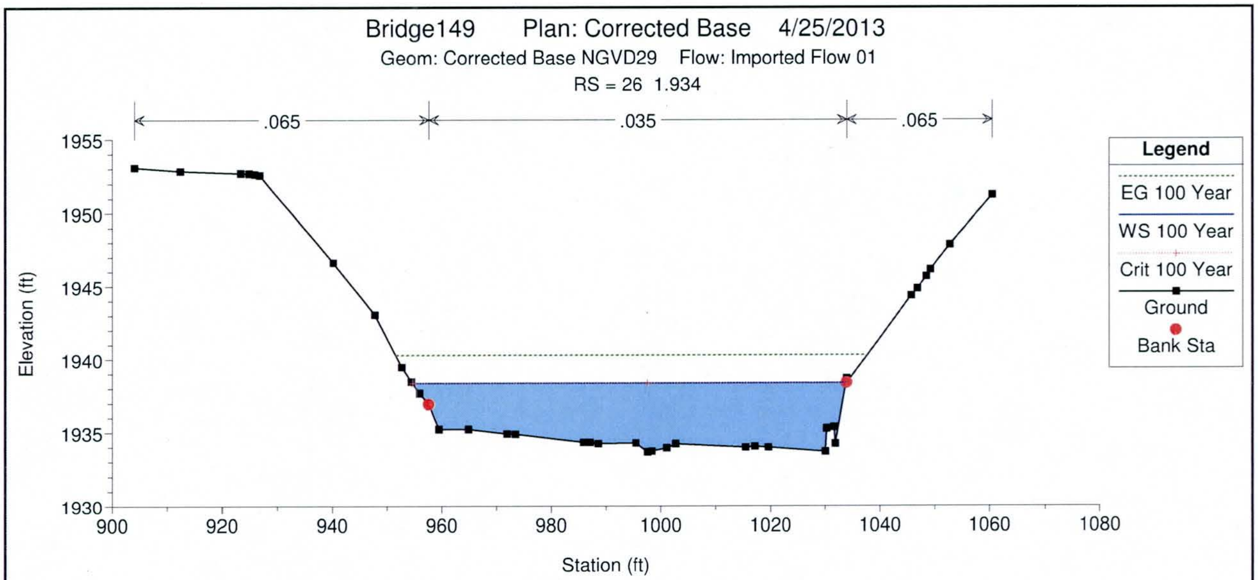
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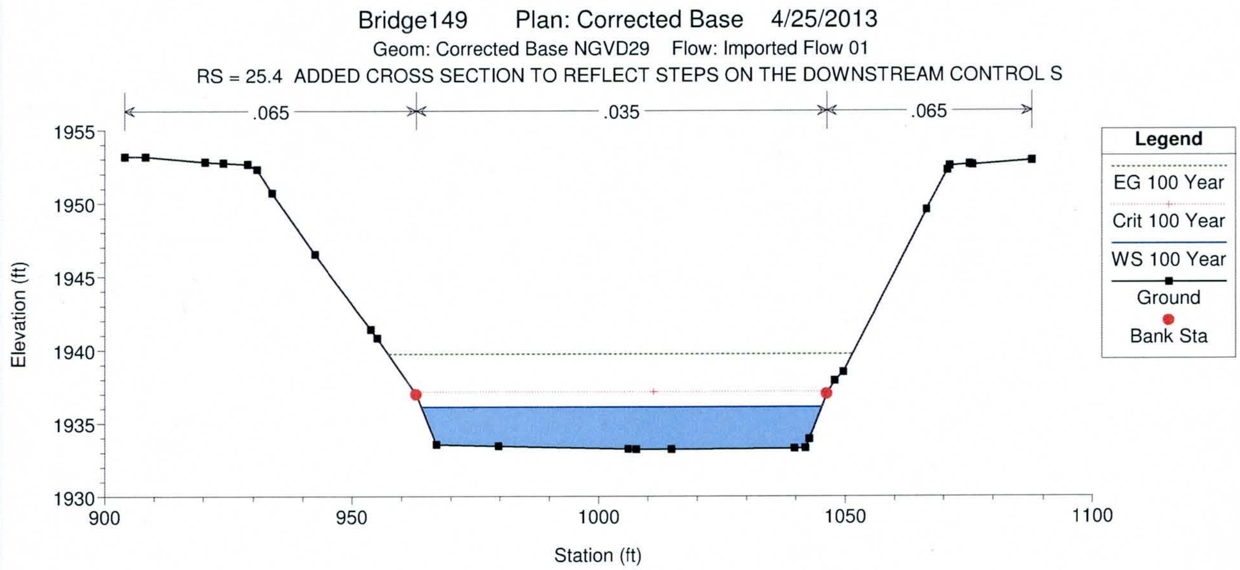
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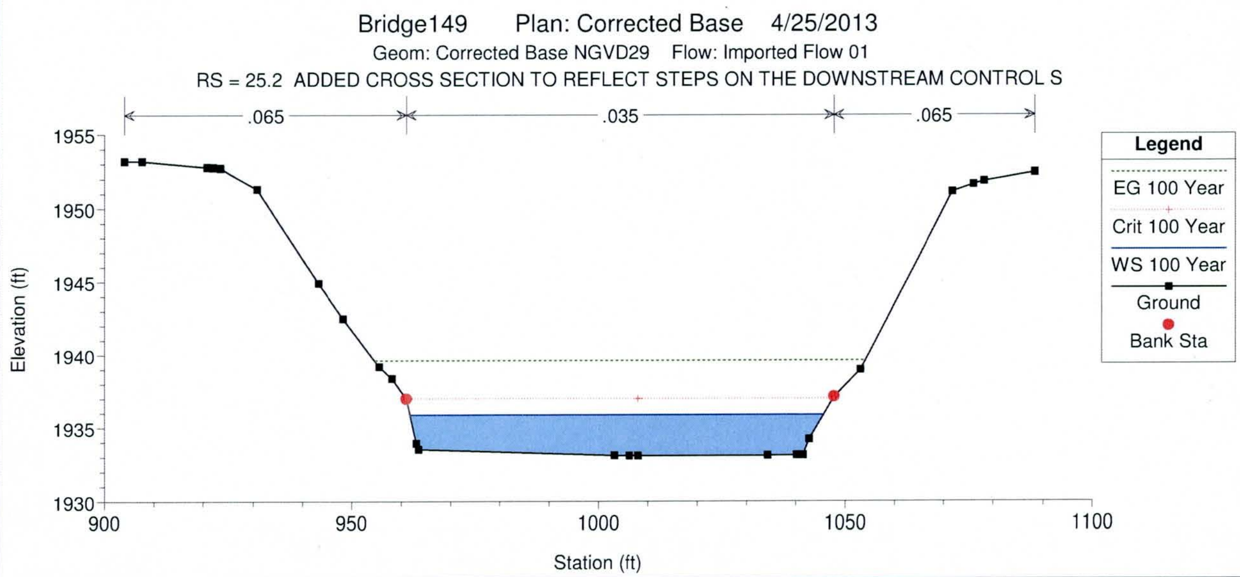
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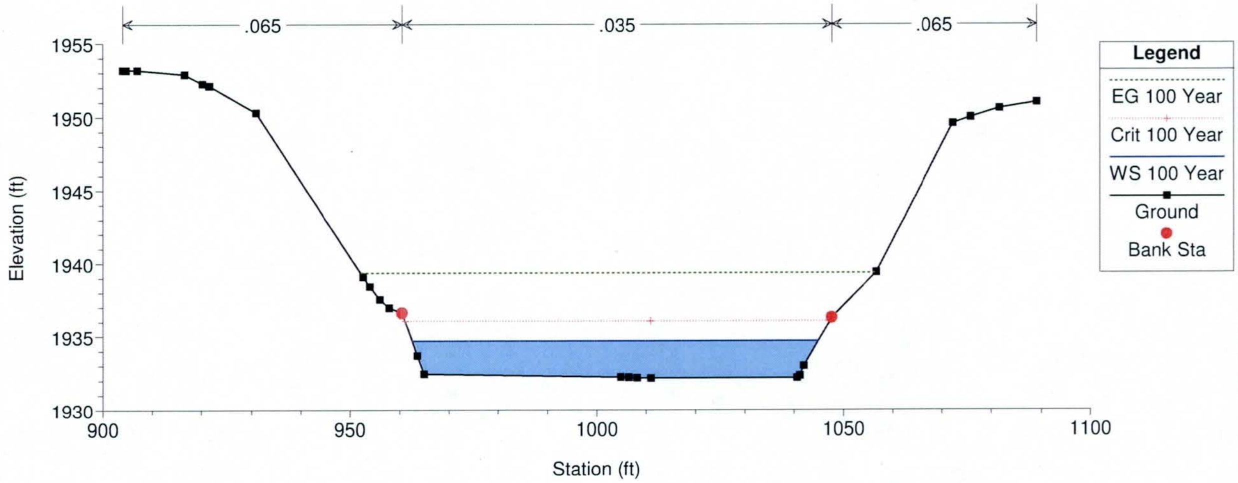

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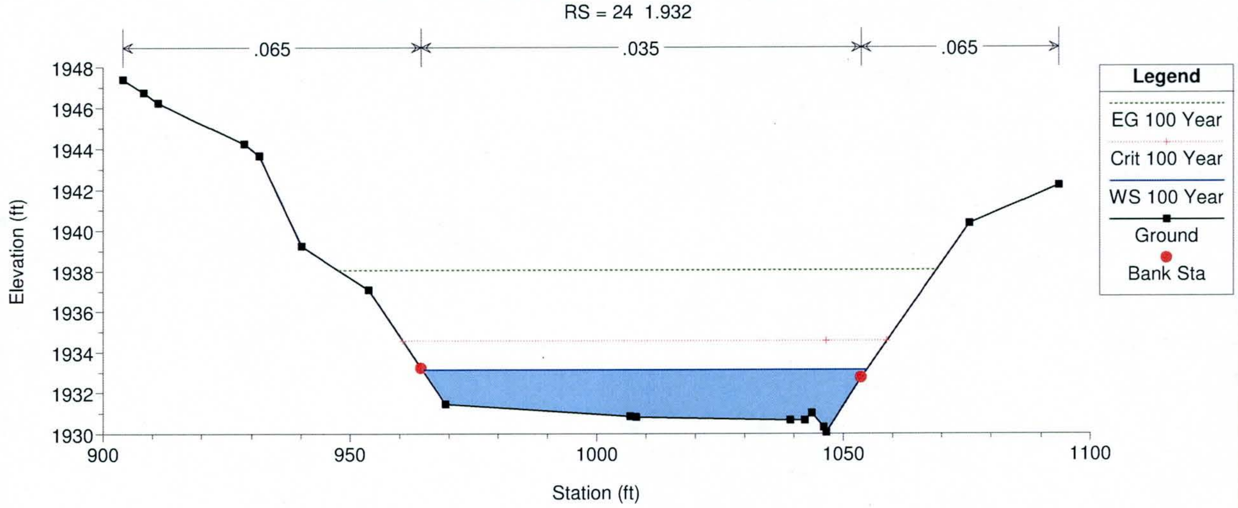

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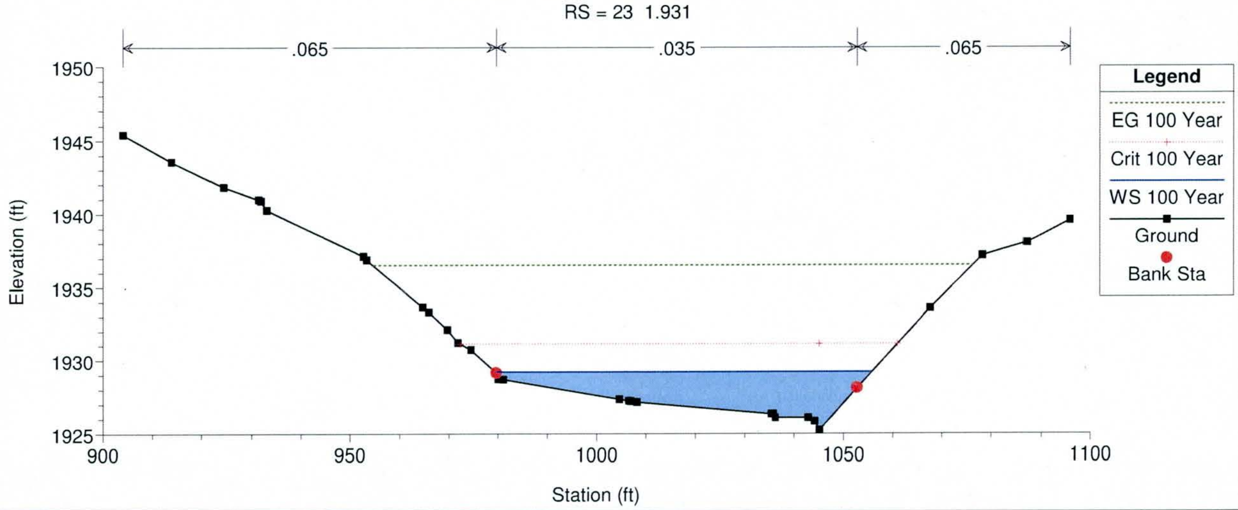

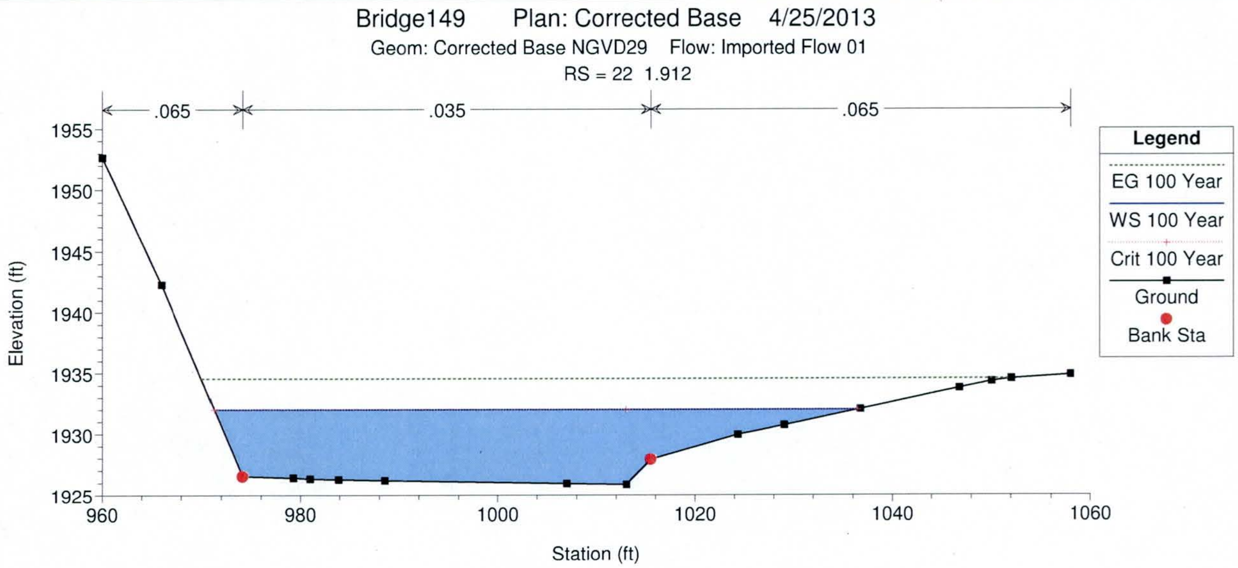
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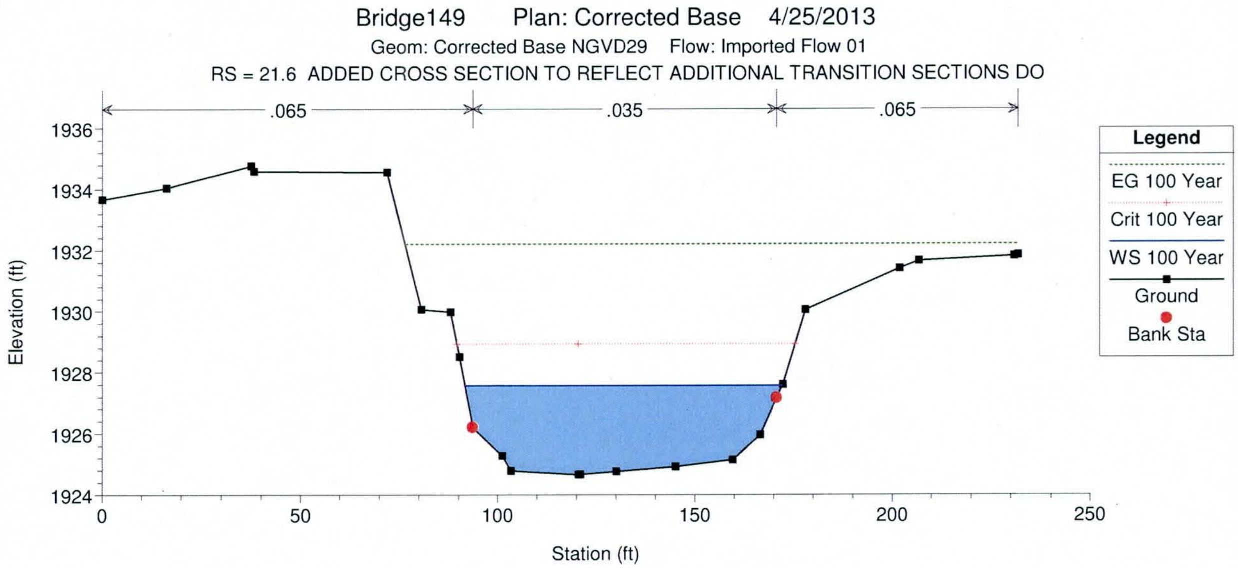
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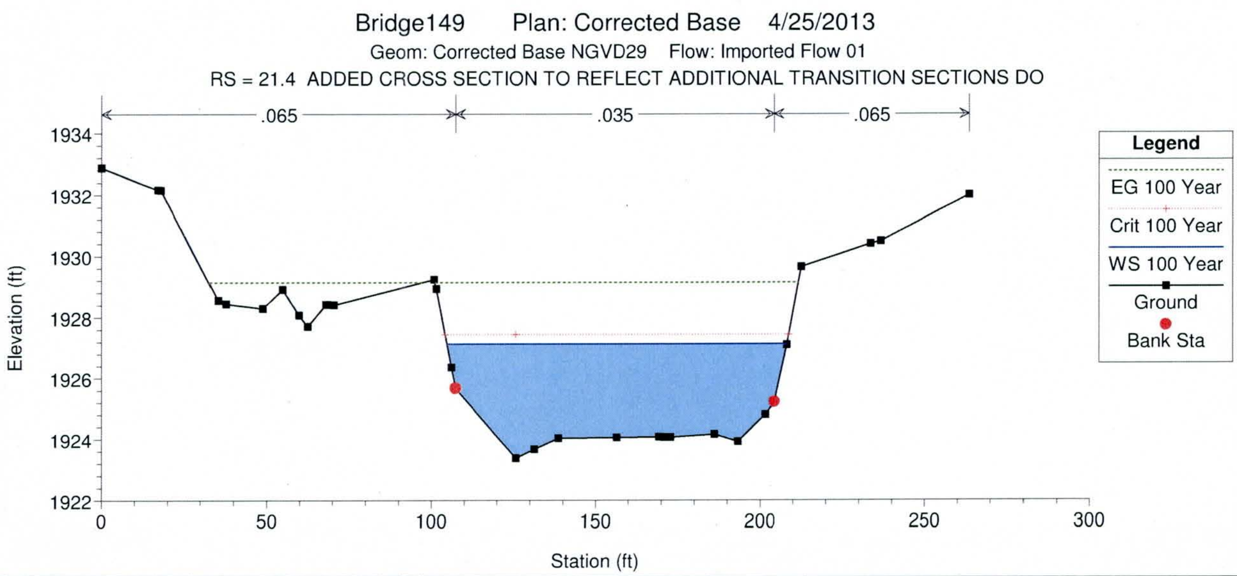
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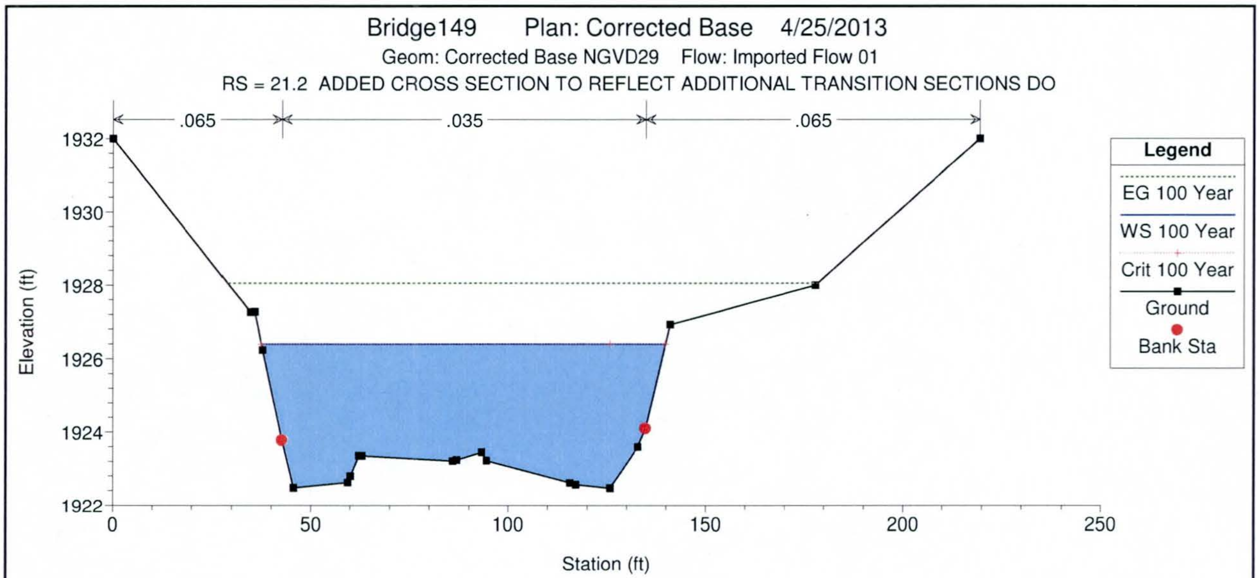
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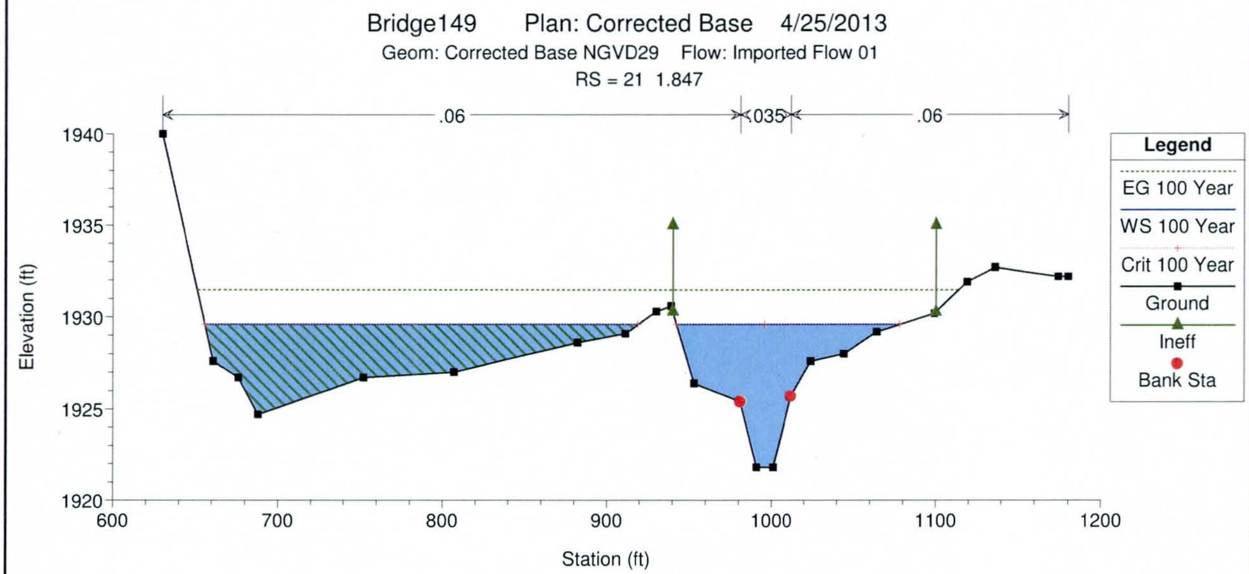
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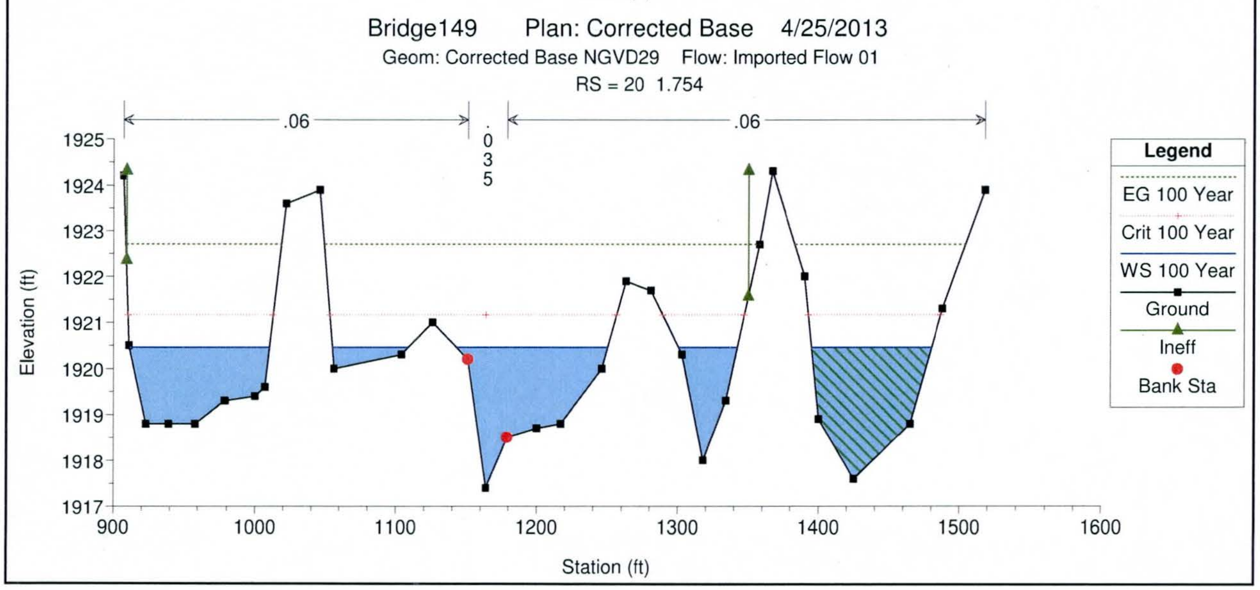
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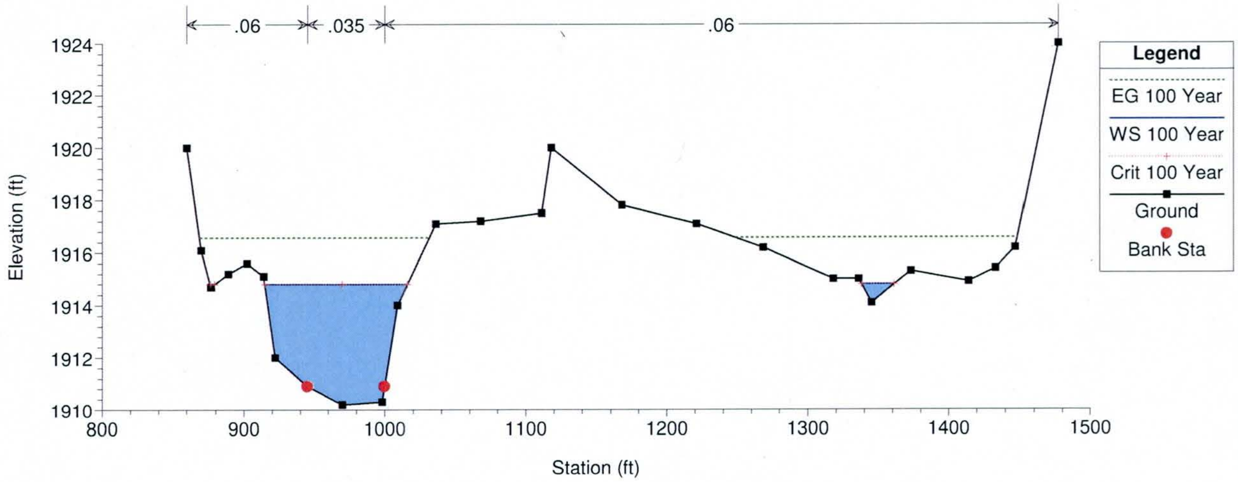
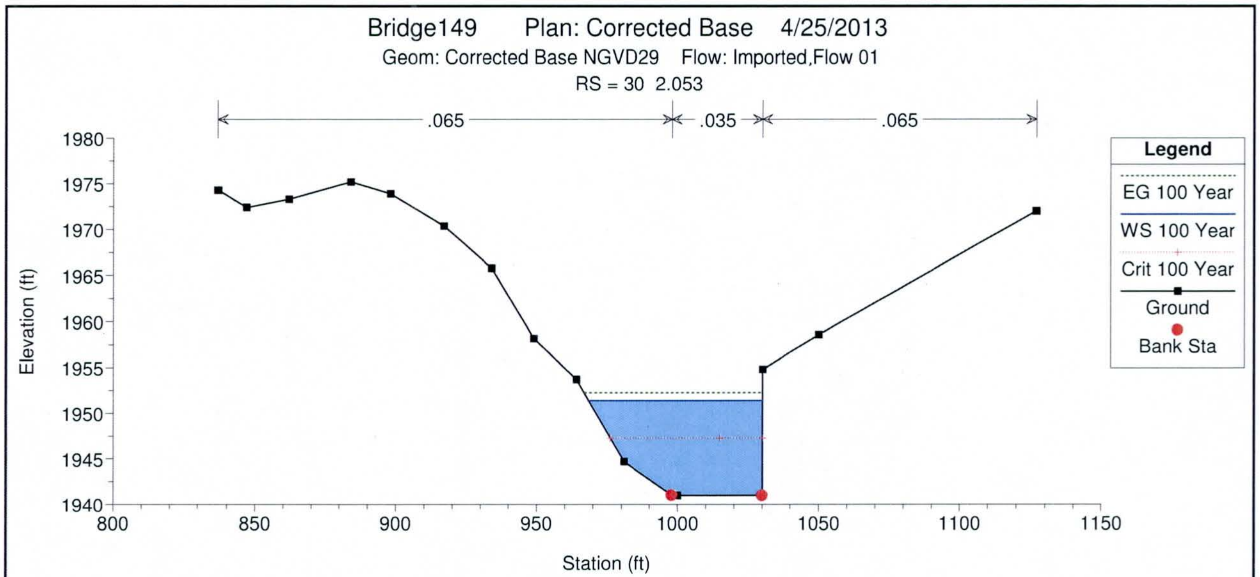


Existing Conditions Subcritical



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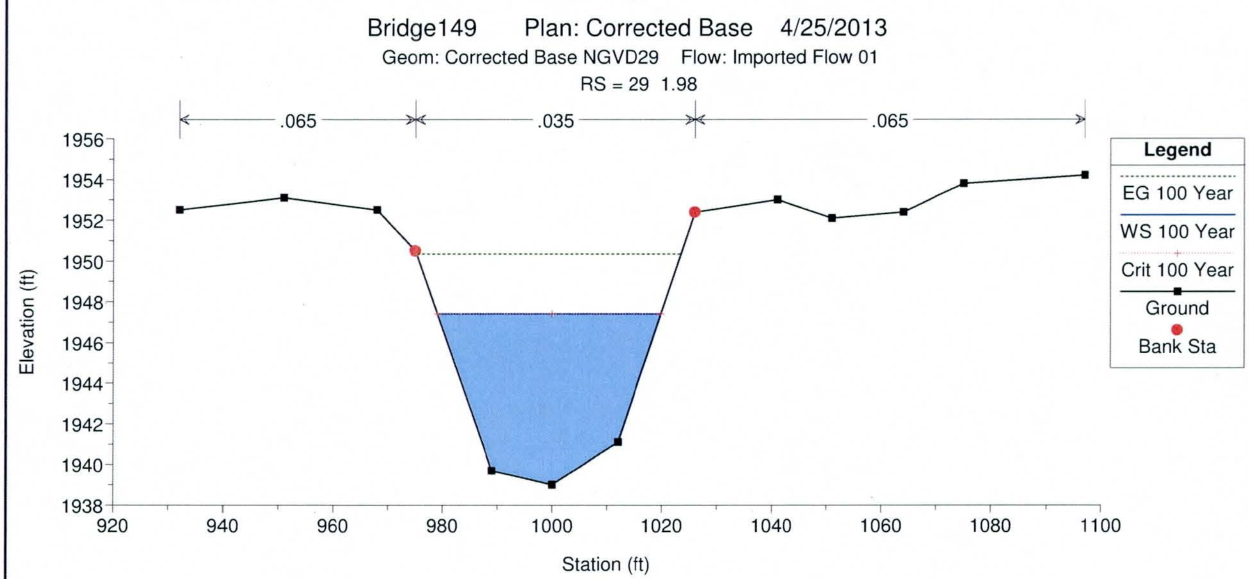

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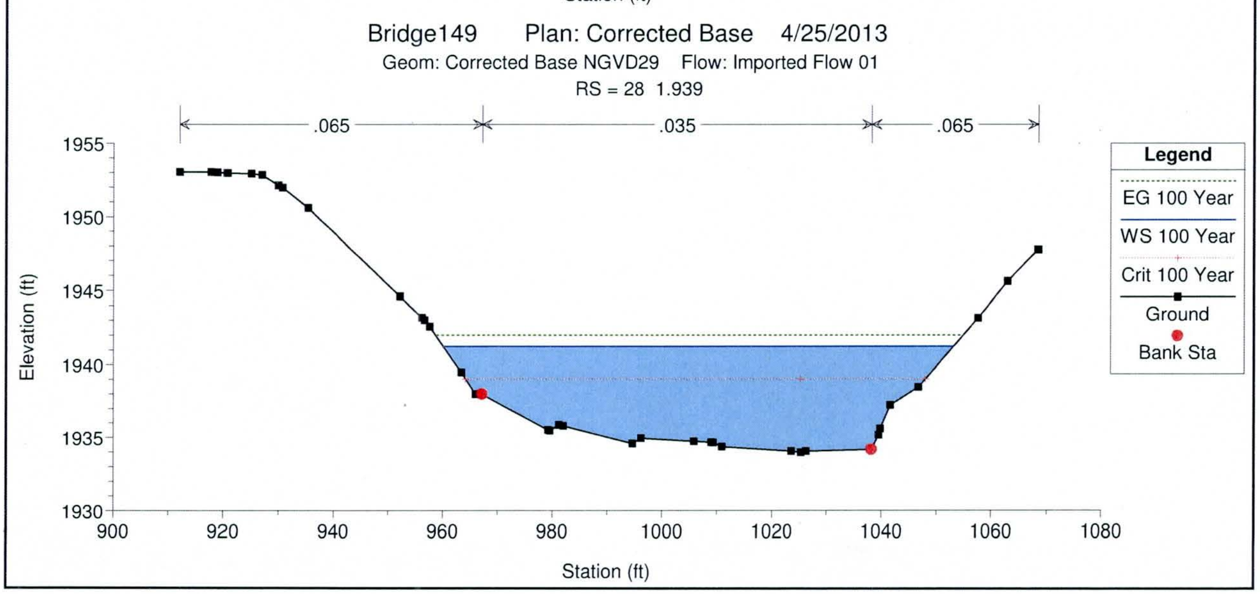
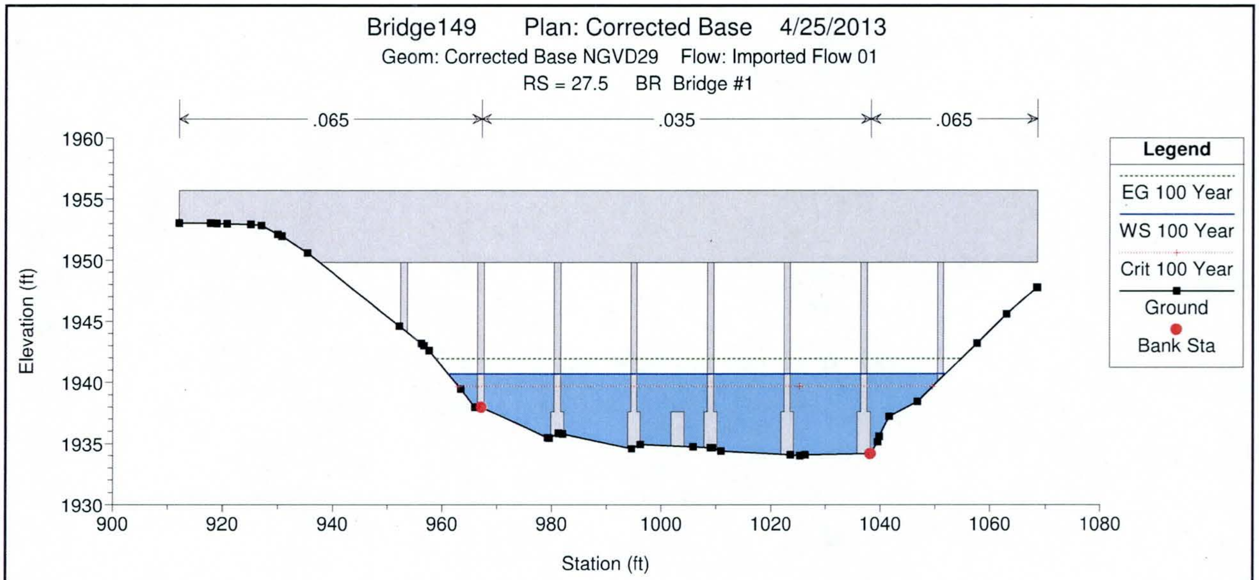
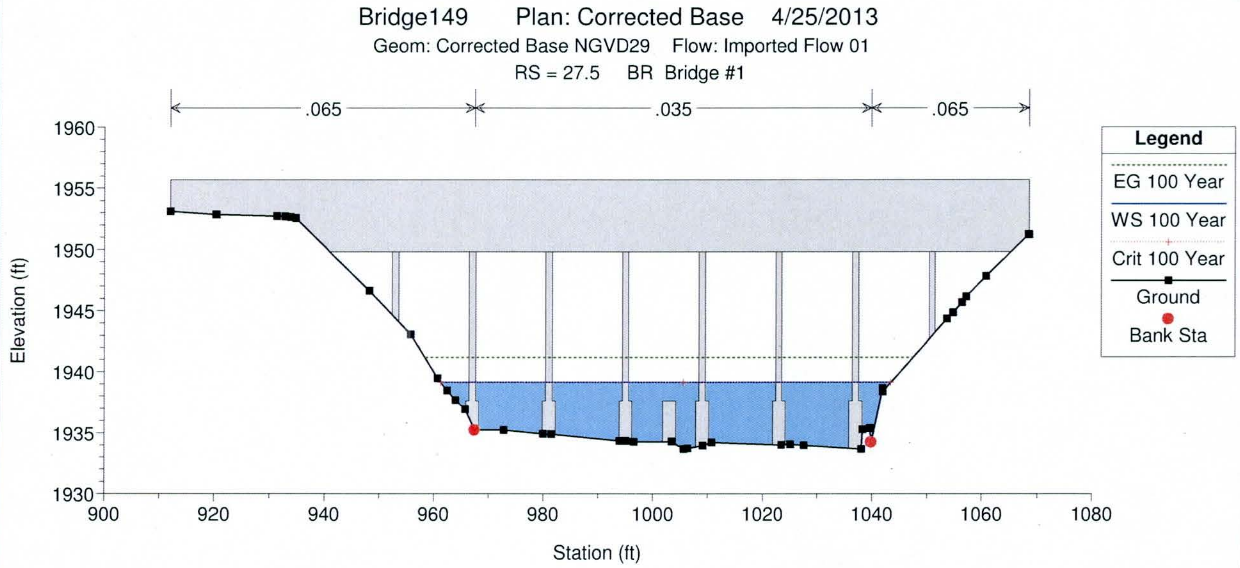
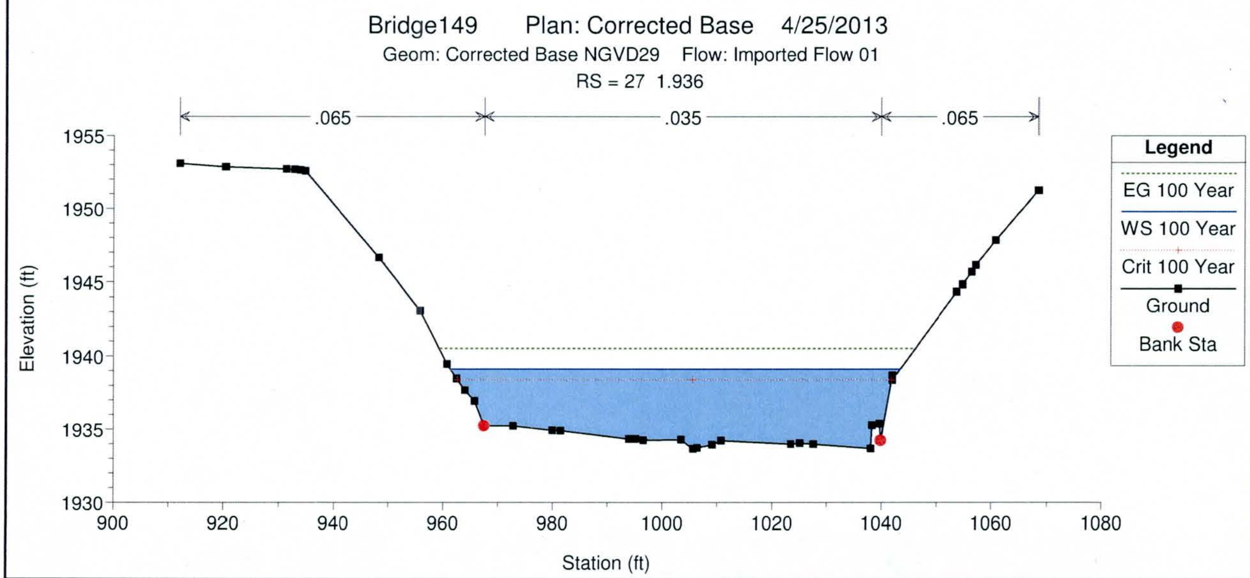
Ground
Bank Sta



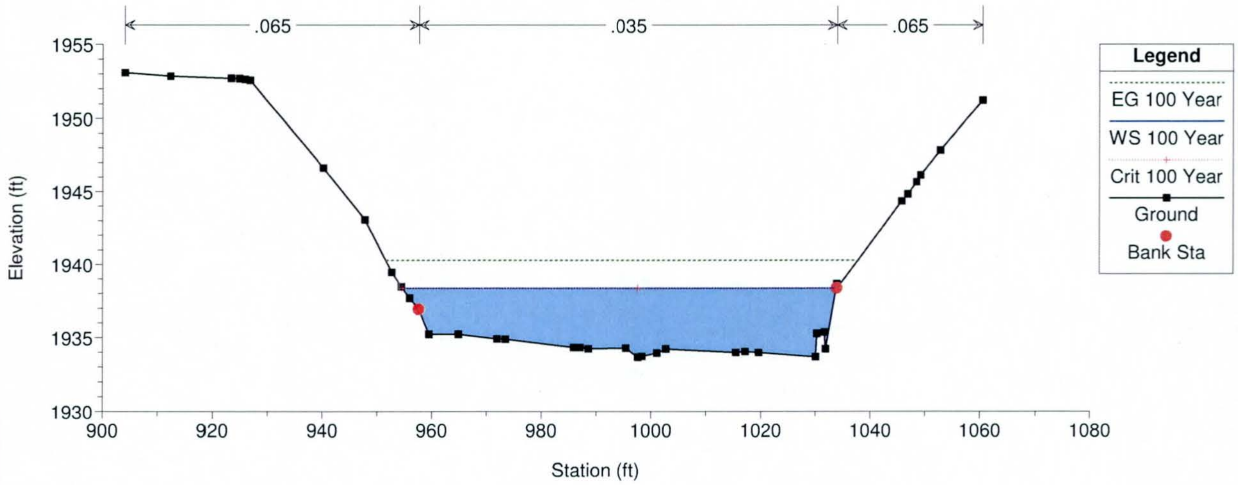
Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 28 1.939
.065
.035
.065
Elevation (ft)
Station (ft)
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta


Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 27.5 BR Bridge #1
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1930
1935
1940
1945
1950
1955
1960
900
920
940
960
980
1000
1020
1040
1060
1080

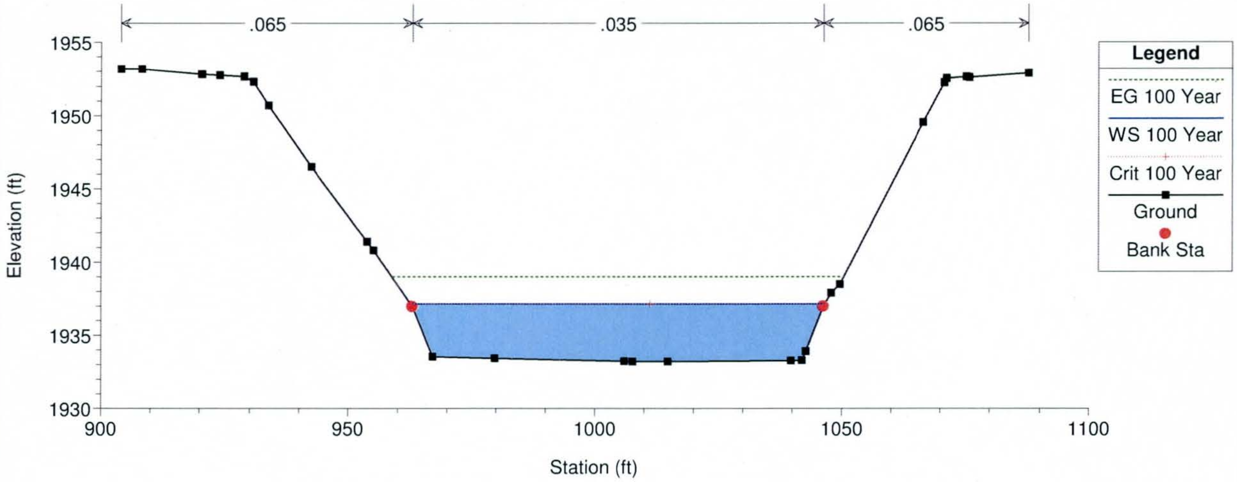

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 27.5 BR Bridge #1
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1930
1935
1940
1945
1950
1955
1960
900
920
940
960
980
1000
1020
1040
1060
1080


Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 27 1.936
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1930
1935
1940
1945
1950
1955
900
920
940
960
980
1000
1020
1040
1060
1080

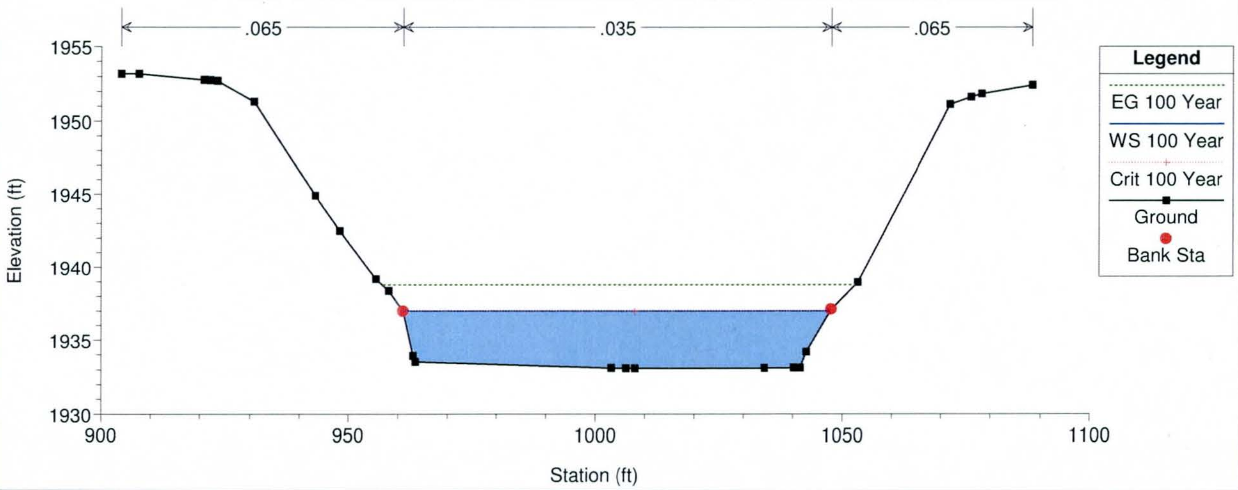
Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 26 1.934

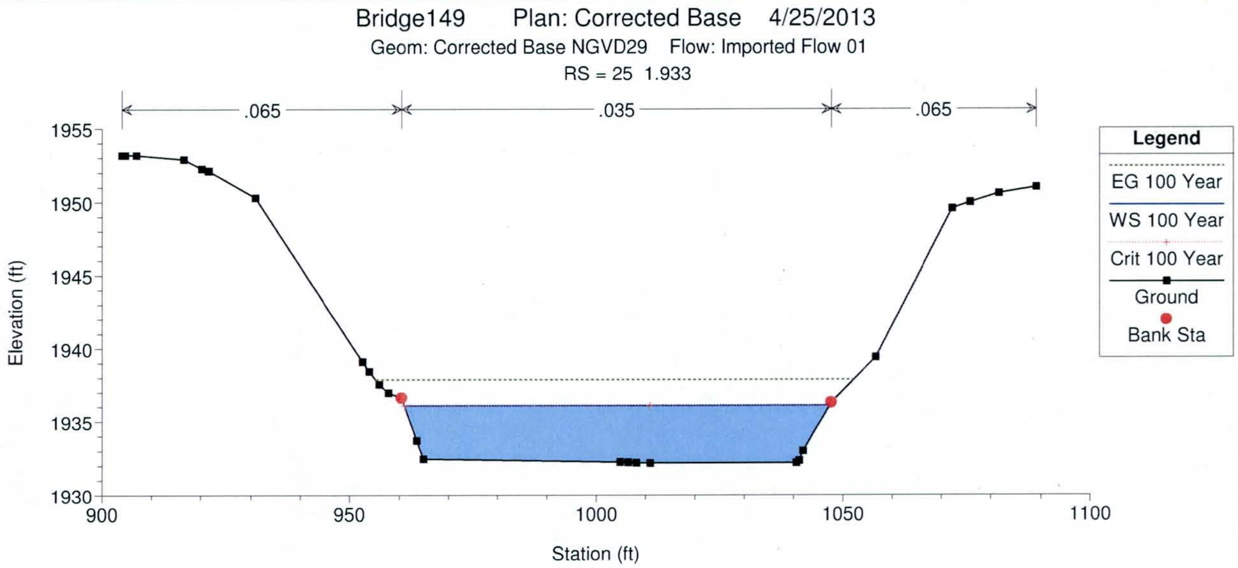


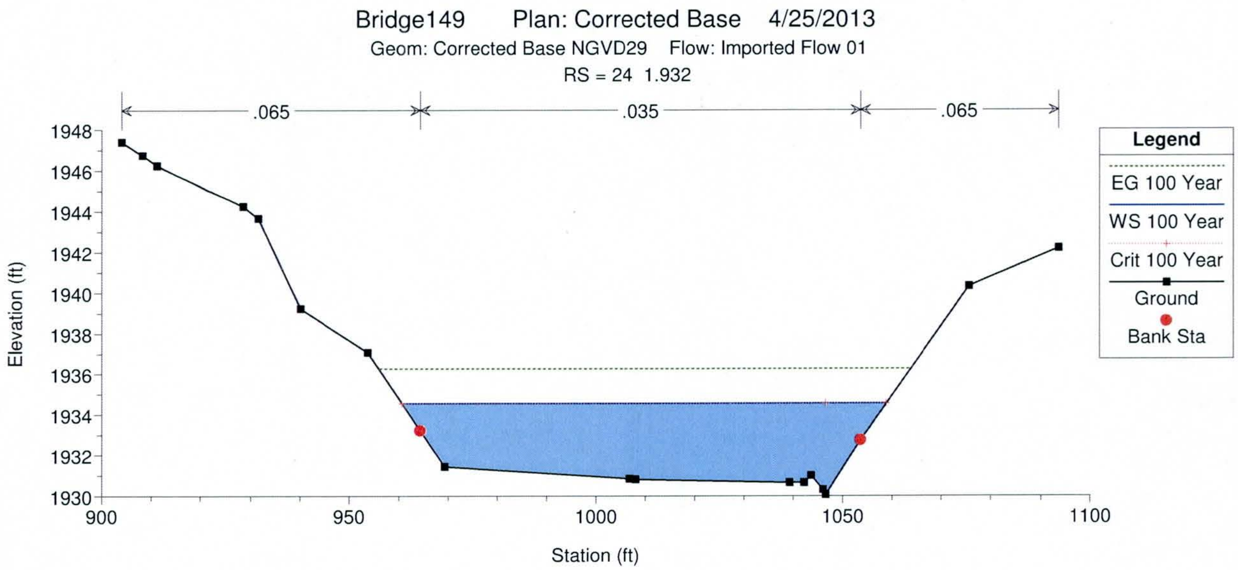
Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 25.4 ADDED CROSS SECTION TO REFLECT STEPS ON THE DOWNSTREAM CONTROL S

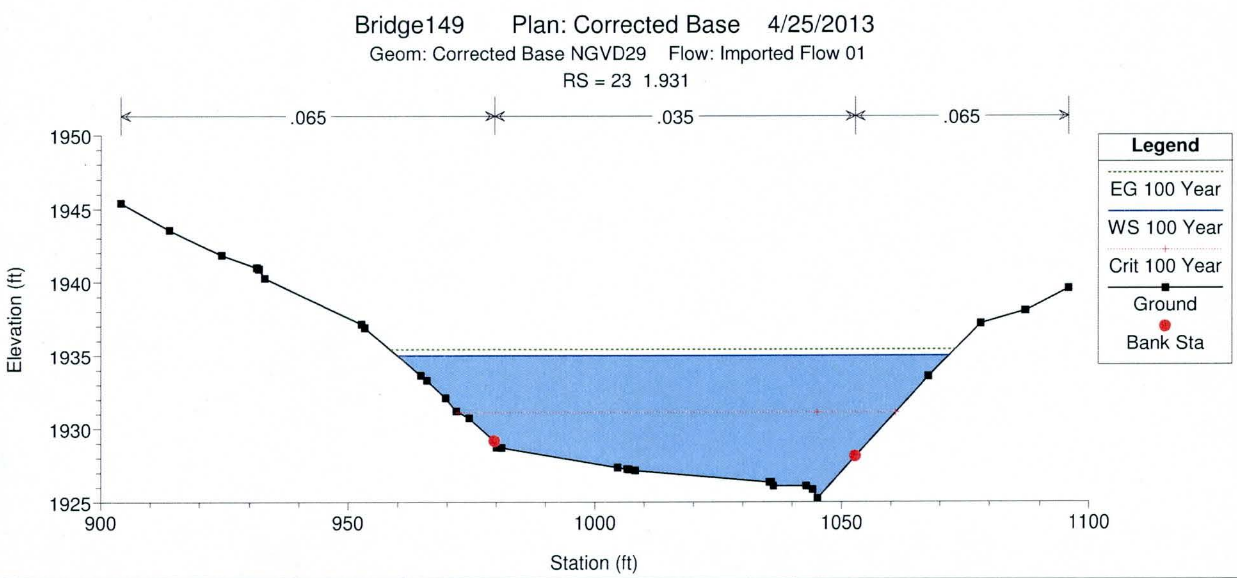


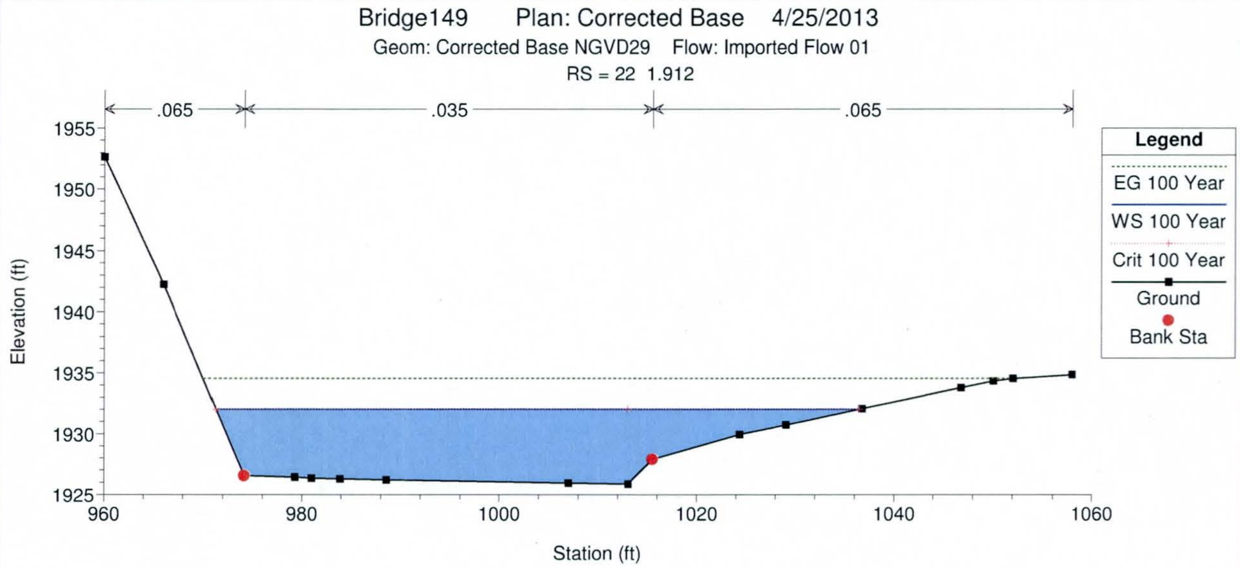
Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 25.2 ADDED CROSS SECTION TO REFLECT STEPS ON THE DOWNSTREAM CONTROL S

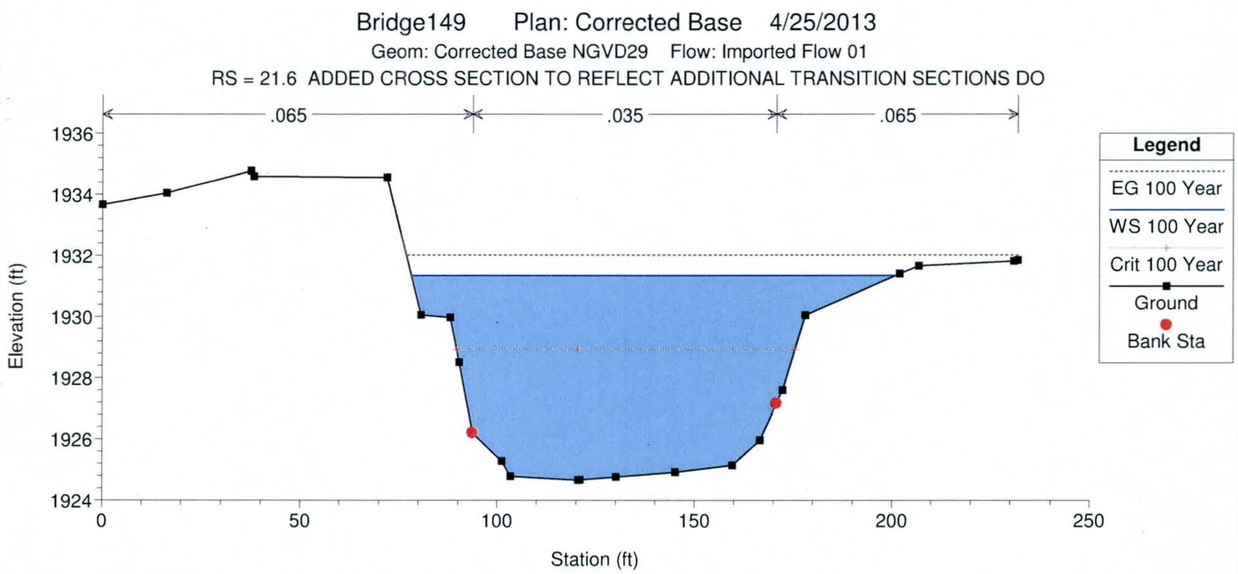


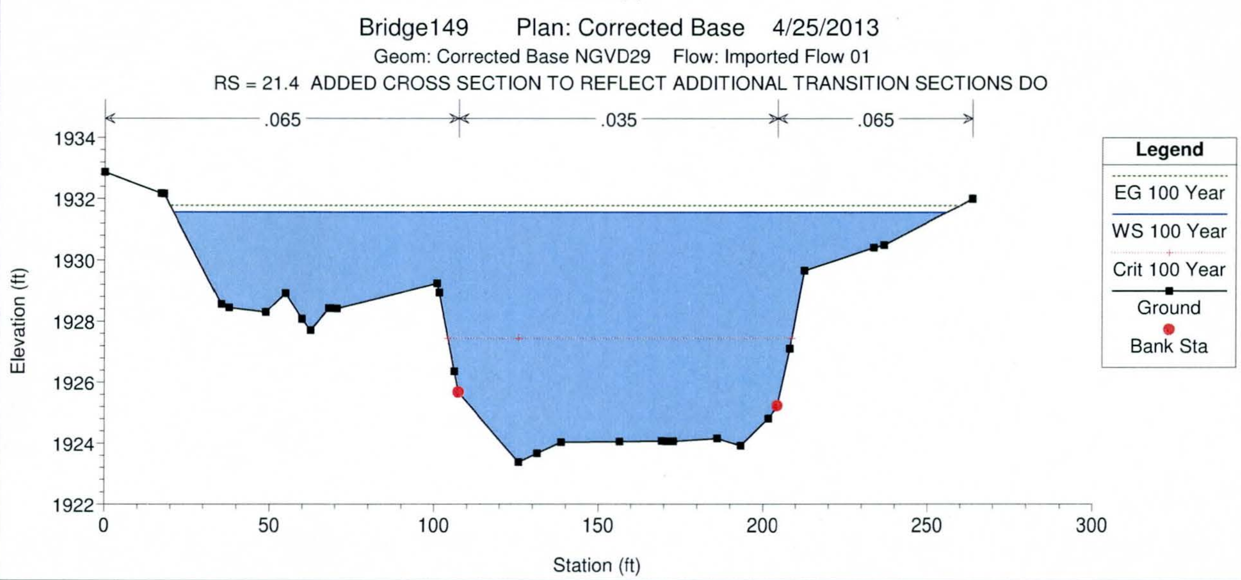

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 25 1.933
.065
.035
.065
Elevation (ft)
1955
1950
1945
1940
1935
1930
900
950
1000
1050
1100
Station (ft)
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta

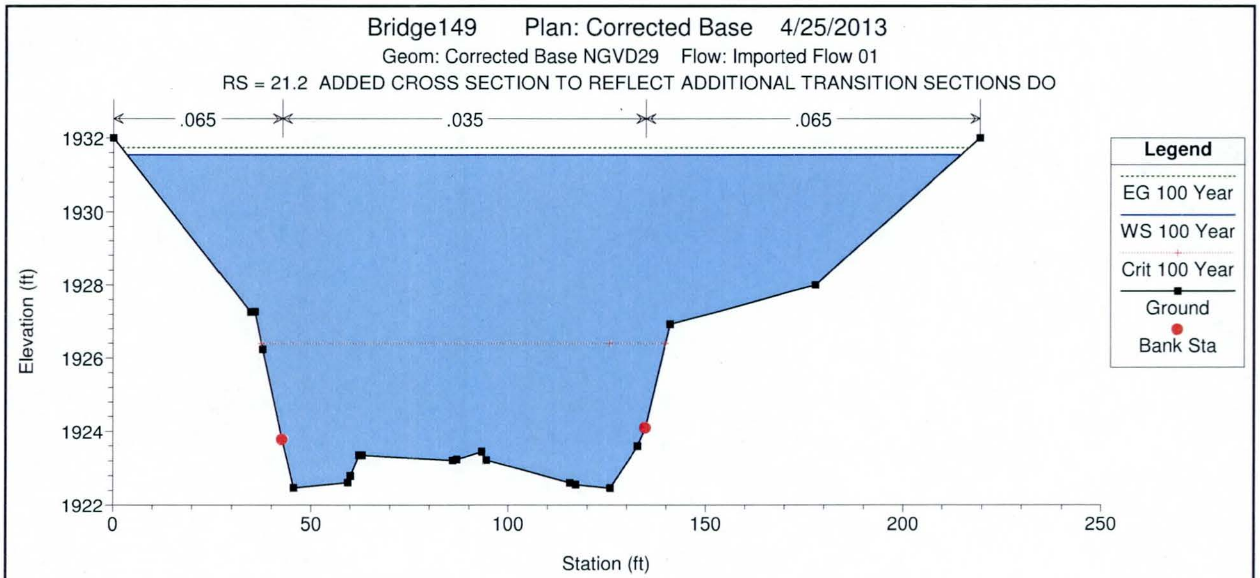

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 24 1.932
.065
.035
.065
Elevation (ft)
1948
1946
1944
1942
1940
1938
1936
1934
1932
1930
900
950
1000
1050
1100
Station (ft)
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta

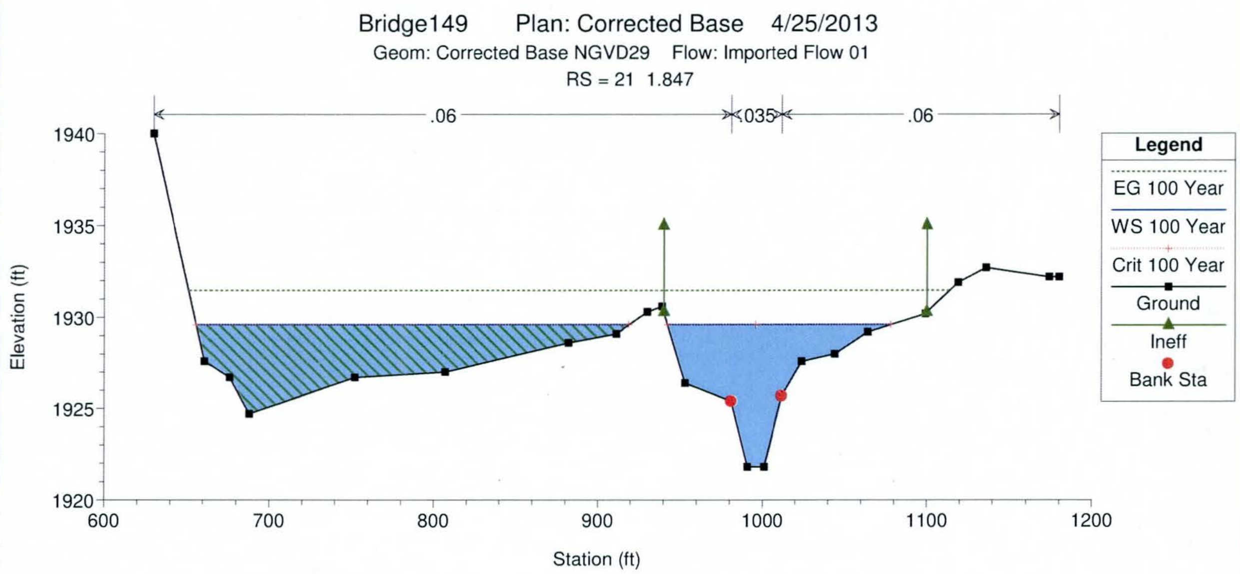

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 23 1.931
.065
.035
.065
Elevation (ft)
1950
1945
1940
1935
1930
1925
900
950
1000
1050
1100
Station (ft)
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta

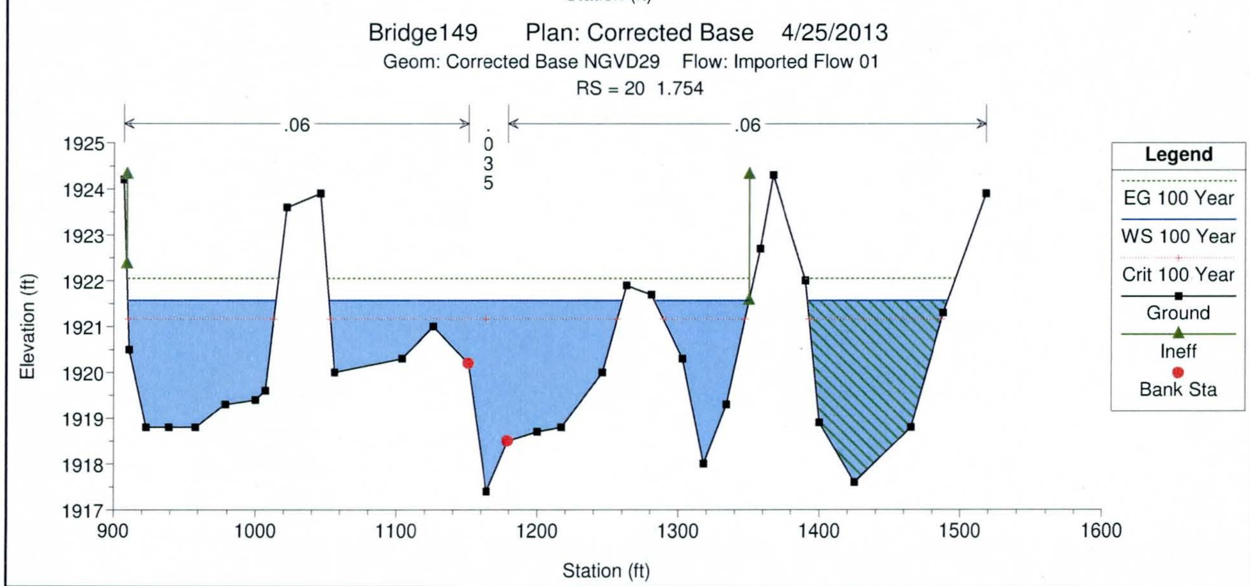

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 22 1.912
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1955
1950
1945
1940
1935
1930
1925
960
980
1000
1020
1040
1060

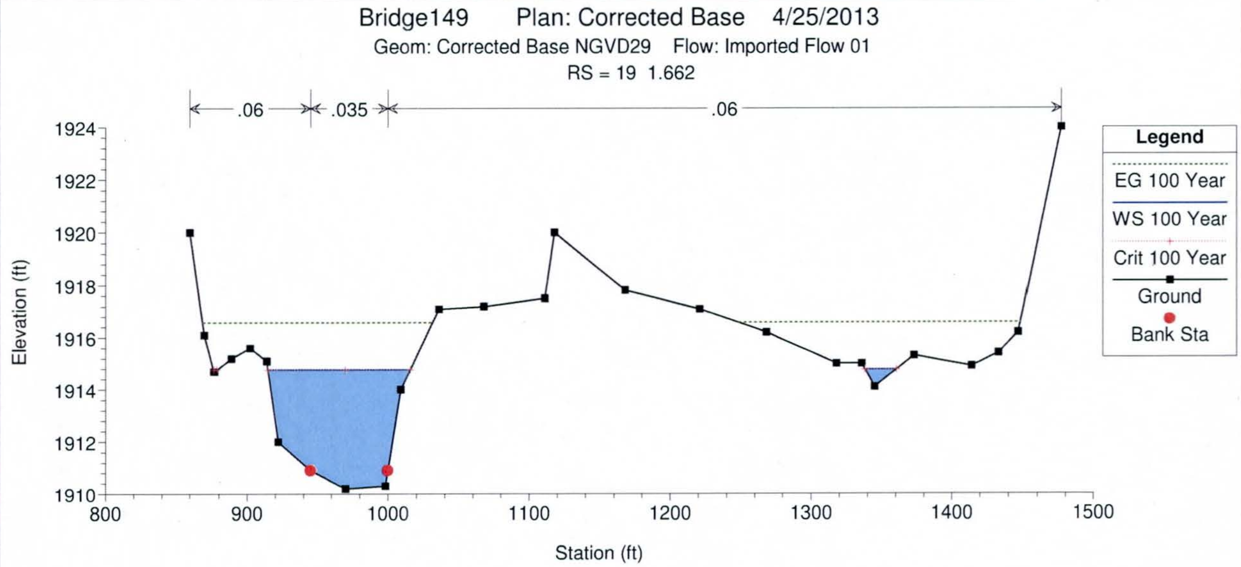

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 21.6 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1936
1934
1932
1930
1928
1926
1924
0
50
100
150
200
250


Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 21.4 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1934
1932
1930
1928
1926
1924
1922
0
50
100
150
200
250
300

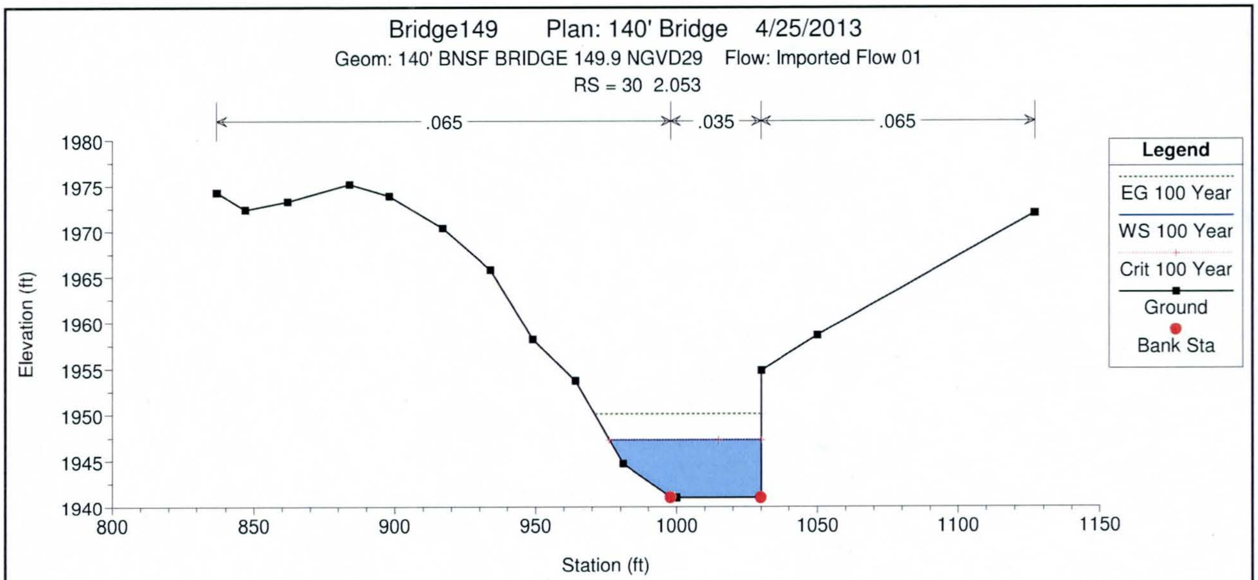

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 21.2 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO
.065
.035
.065
Elevation (ft)
1922
1924
1926
1928
1930
1932
Station (ft)
0
50
100
150
200
250
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta

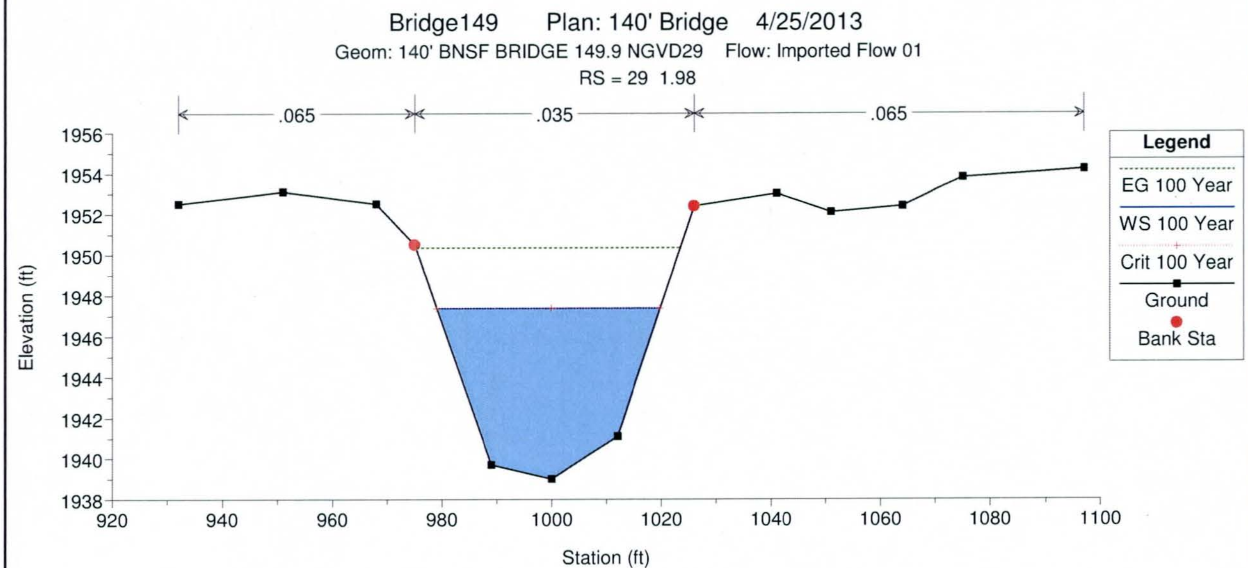

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 21 1.847
.06
.035
.06
Elevation (ft)
1920
1925
1930
1935
1940
Station (ft)
600
700
800
900
1000
1100
1200
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Ineff
Bank Sta

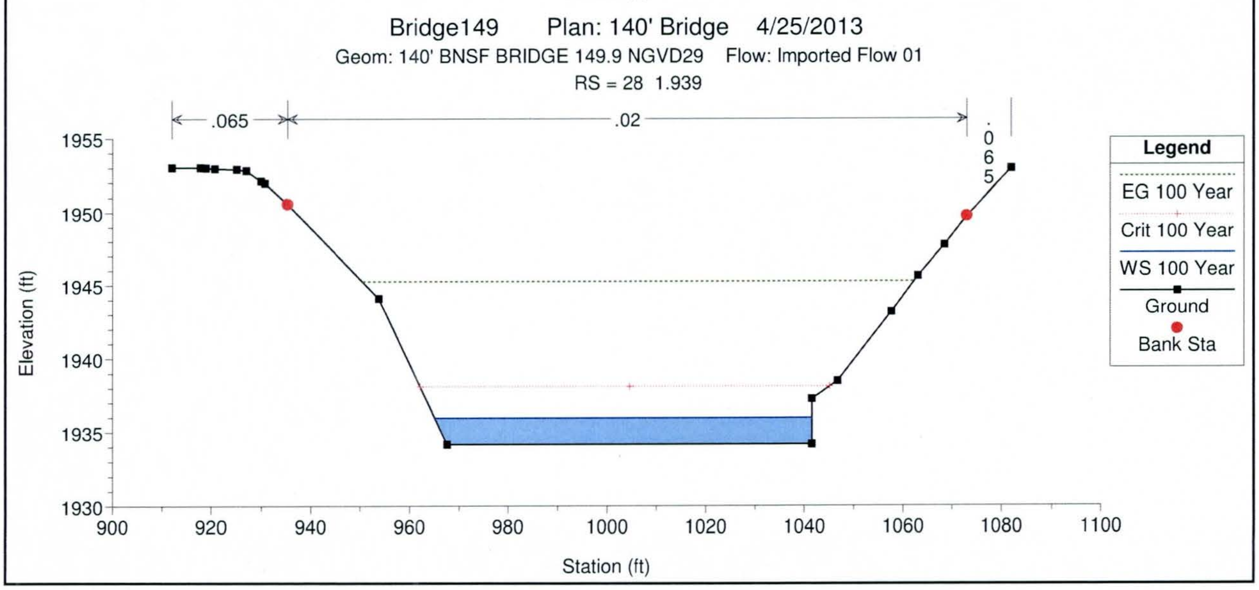

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 20 1.754
.06
.035
.06
Elevation (ft)
1917
1918
1919
1920
1921
1922
1923
1924
1925
Station (ft)
900
1000
1100
1200
1300
1400
1500
1600
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Ineff
Bank Sta

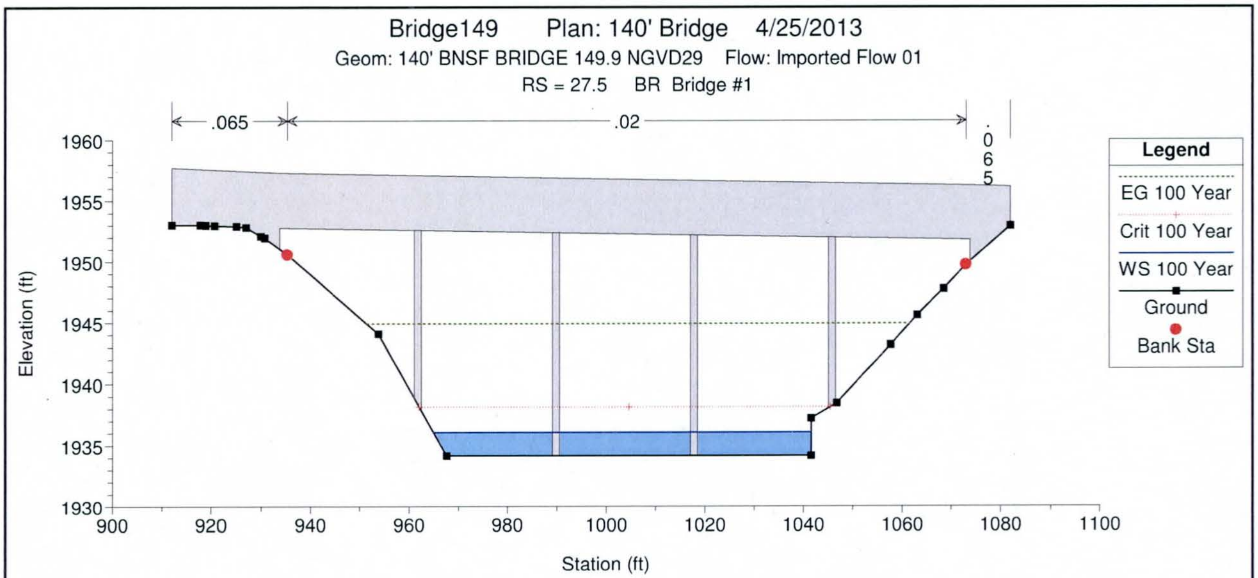

Bridge149 Plan: Corrected Base 4/25/2013
Geom: Corrected Base NGVD29 Flow: Imported Flow 01
RS = 19 1.662
.06
.035
.06
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1924
1922
1920
1918
1916
1914
1912
1910
800
900
1000
1100
1200
1300
1400
1500

Proposed Supercritical

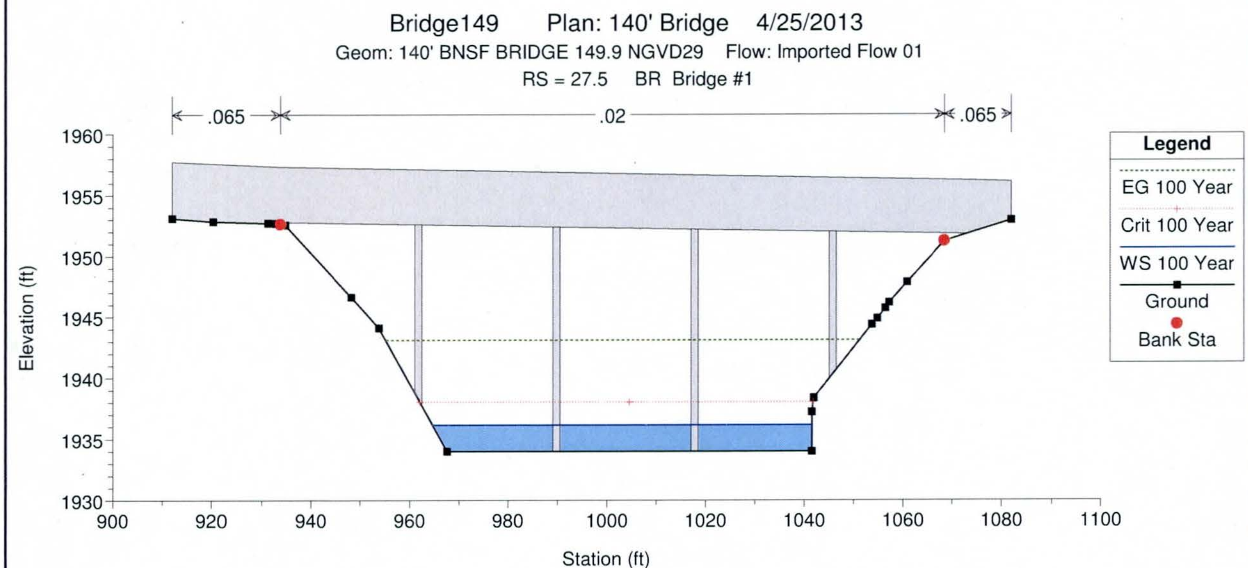

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 30 2.053
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 29 1.98
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

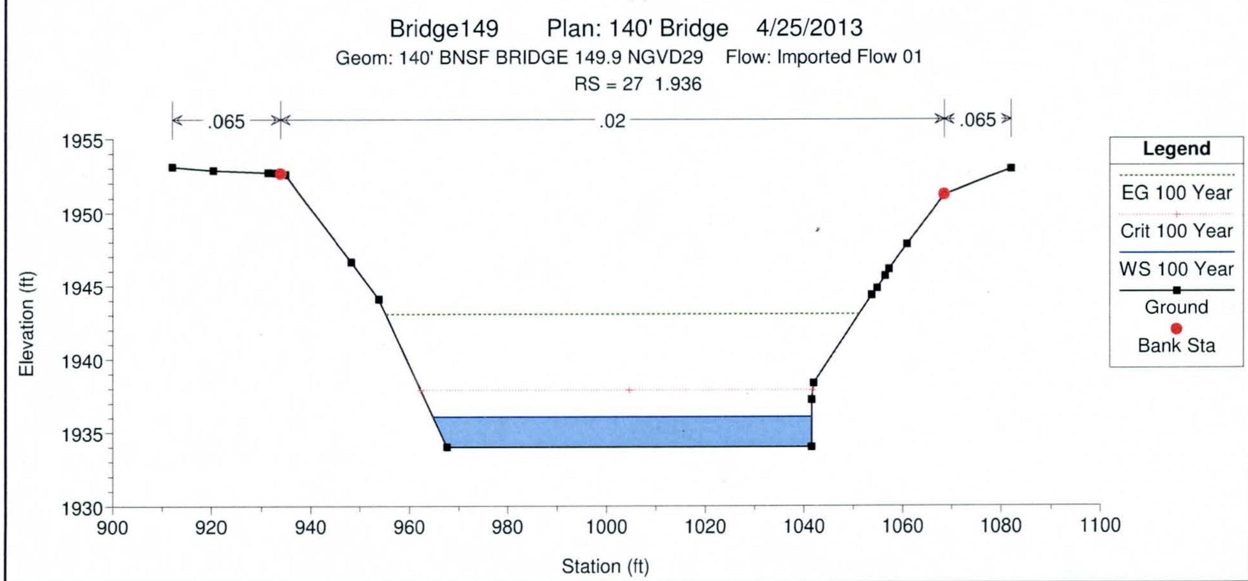

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 28 1.939
.065
.02
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



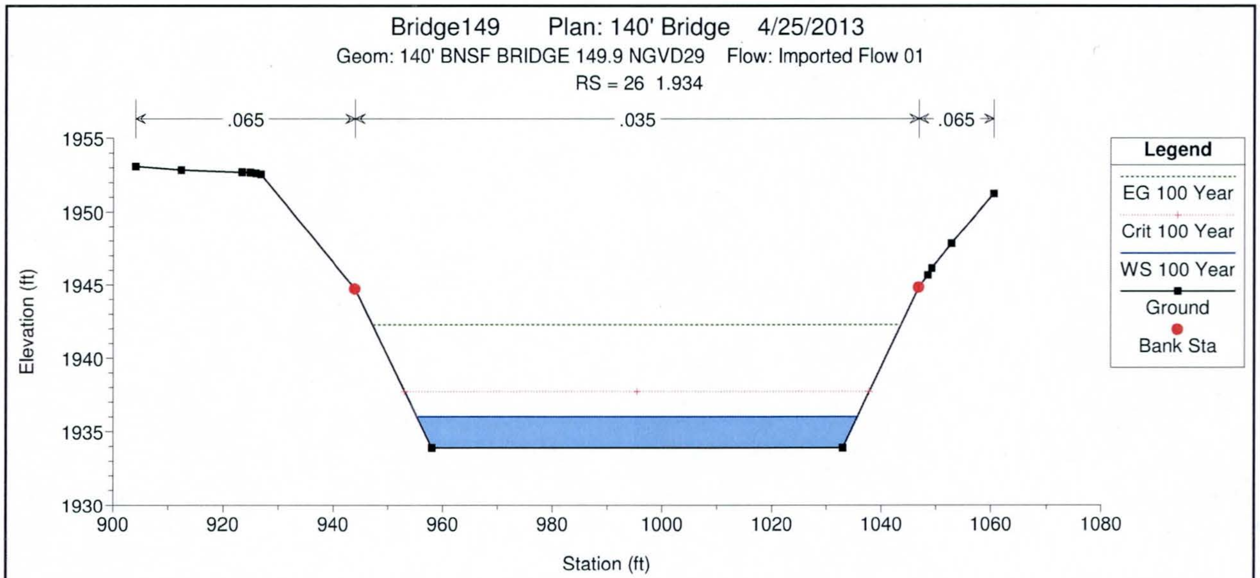
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 27.5 BR Bridge #1
.065
.02
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



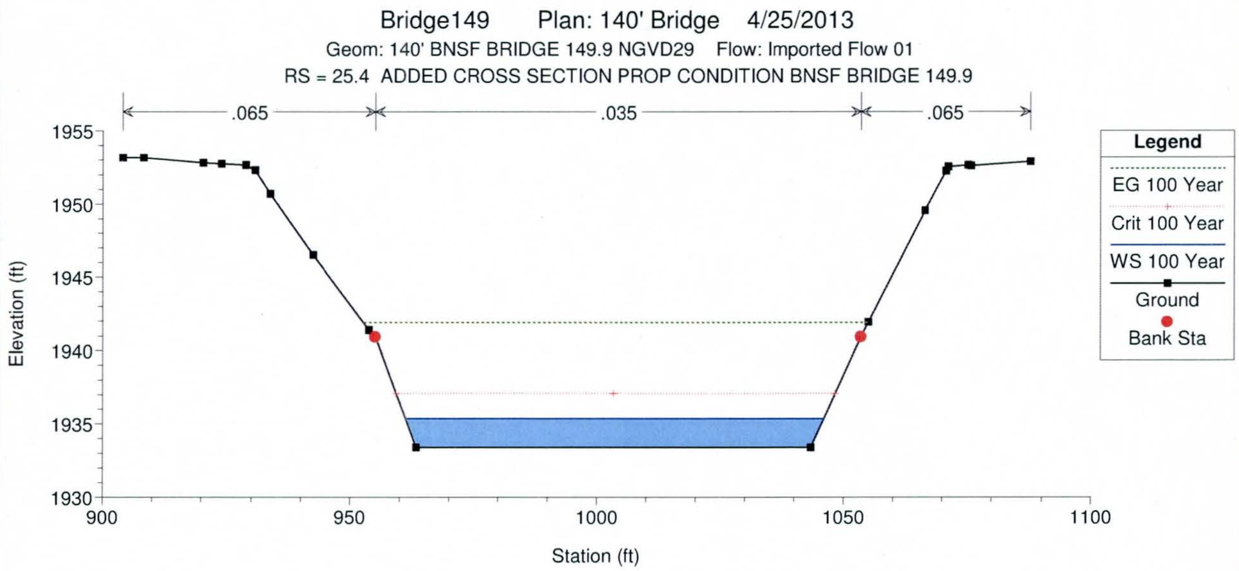
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 27.5 BR Bridge #1
.065
.02
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



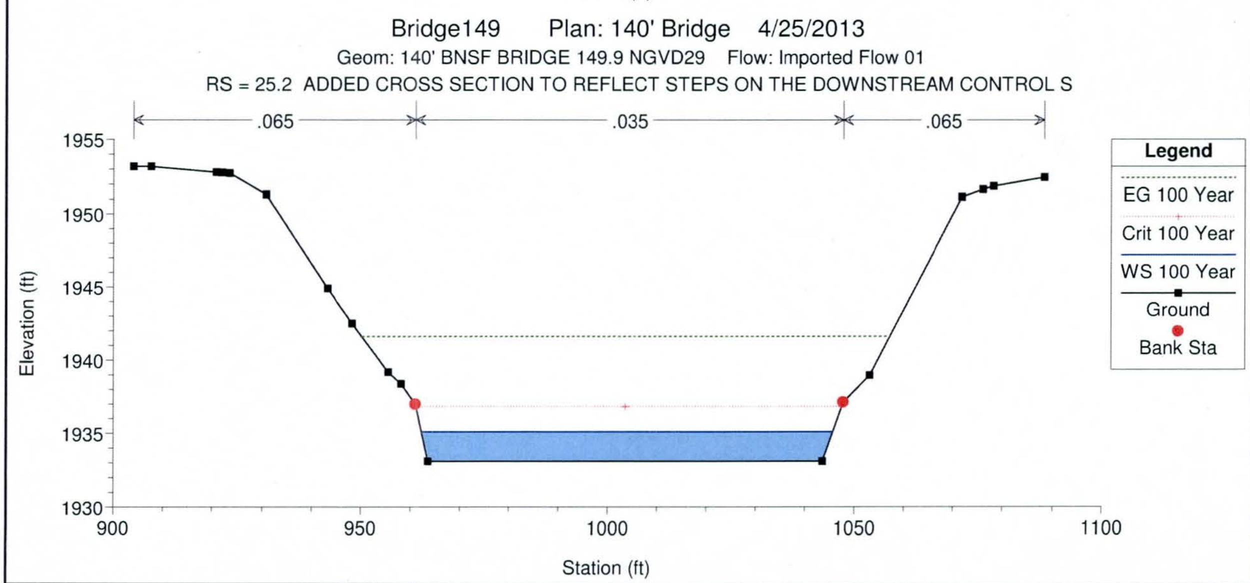
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 27 1.936
.065
.02
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



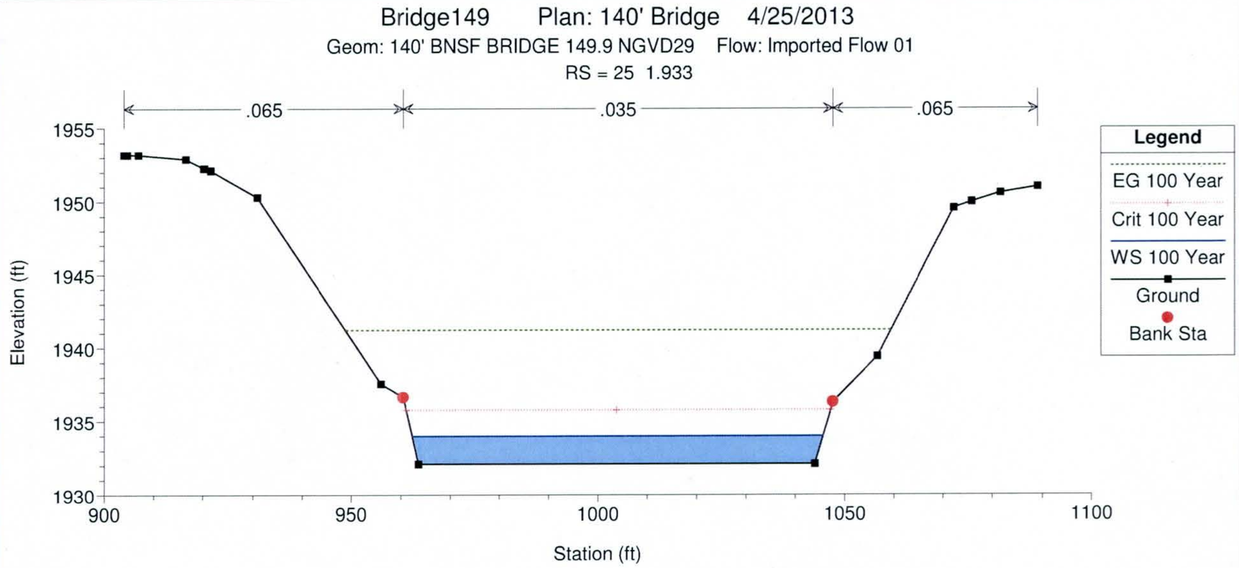
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 26 1.934
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

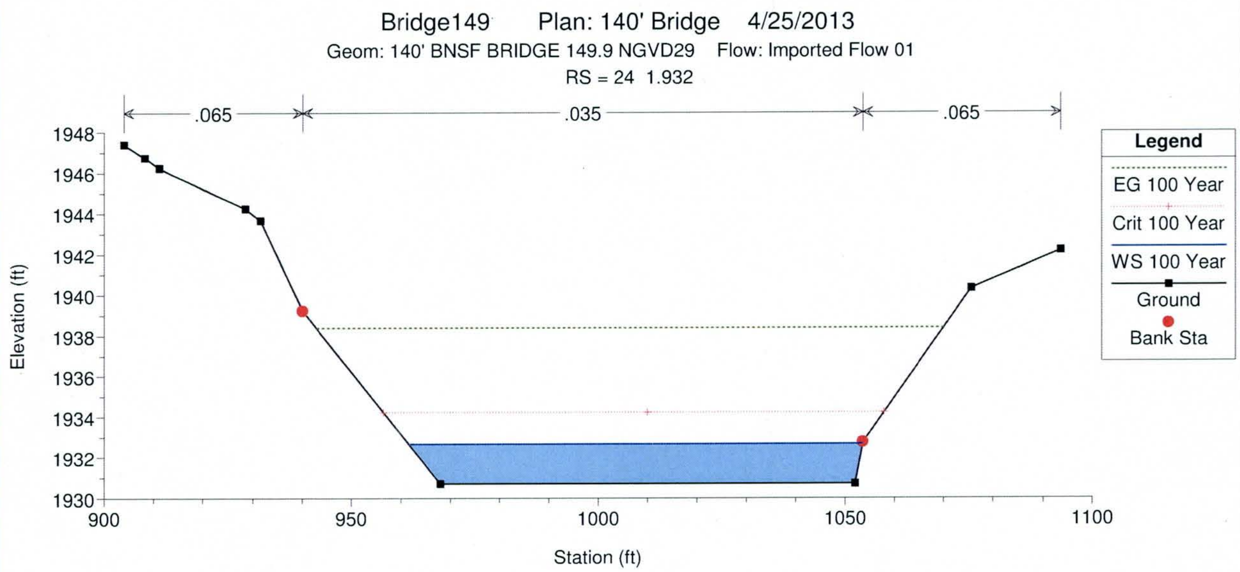


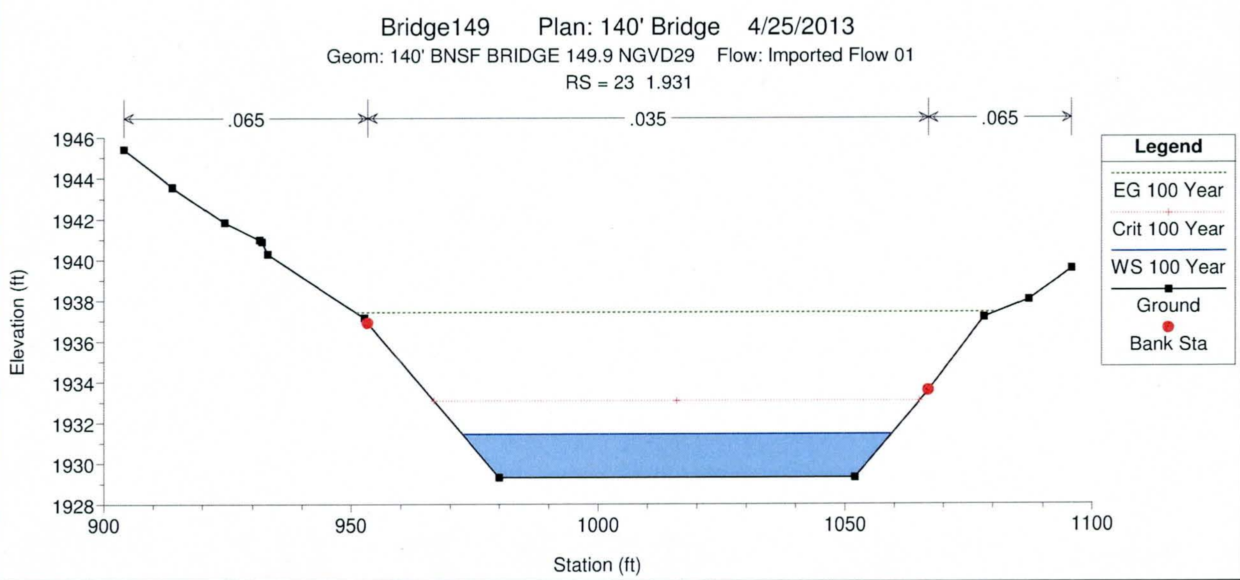
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 25.4 ADDED CROSS SECTION PROP CONDITION BNSF BRIDGE 149.9
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

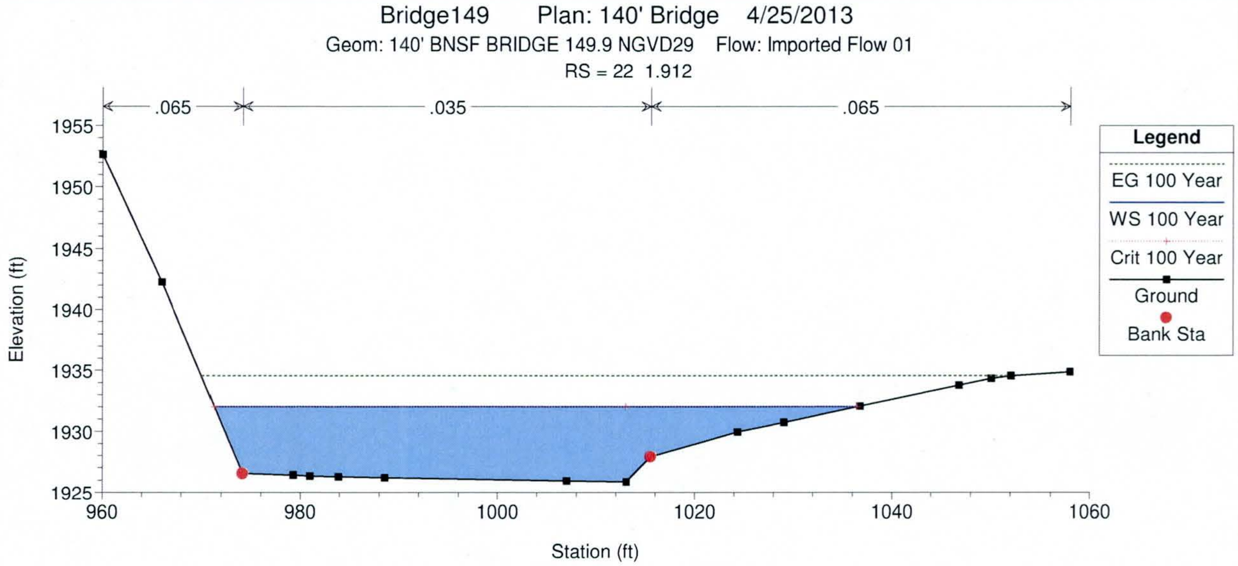


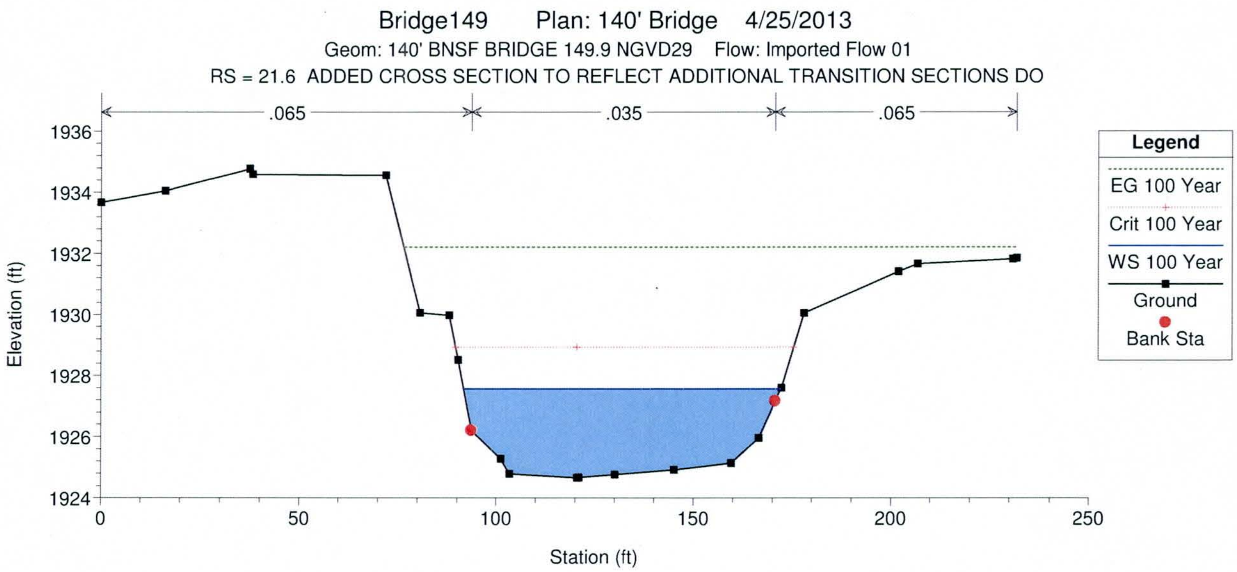
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 25.2 ADDED CROSS SECTION TO REFLECT STEPS ON THE DOWNSTREAM CONTROL S
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

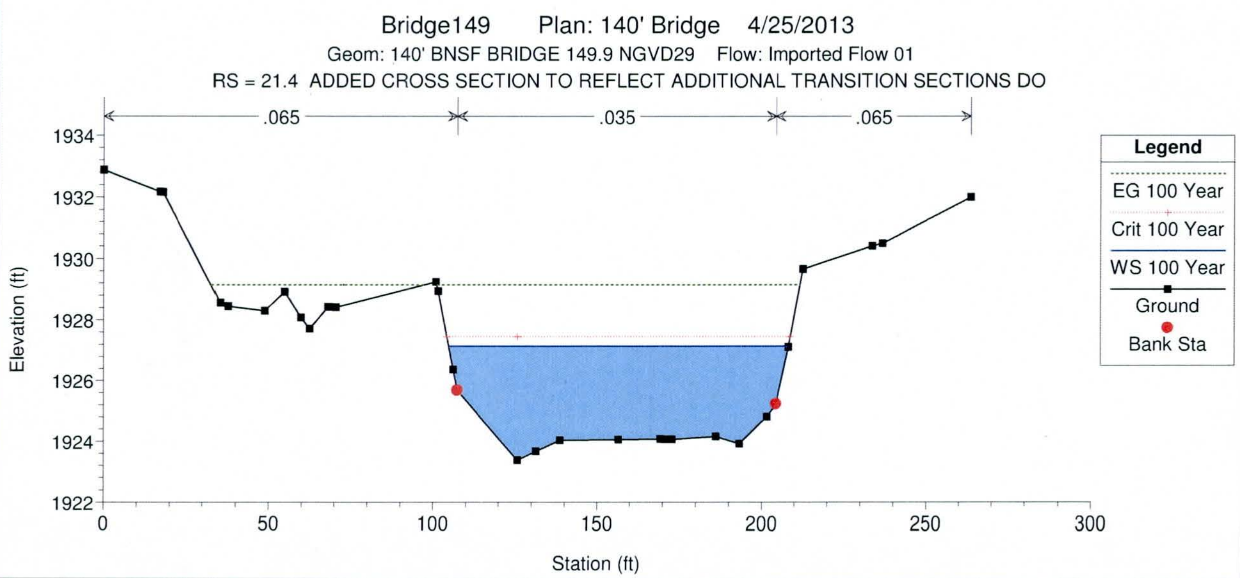

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 25 1.933
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1930
1935
1940
1945
1950
1955
900
950
1000
1050
1100


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 24 1.932
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
900
950
1000
1050
1100

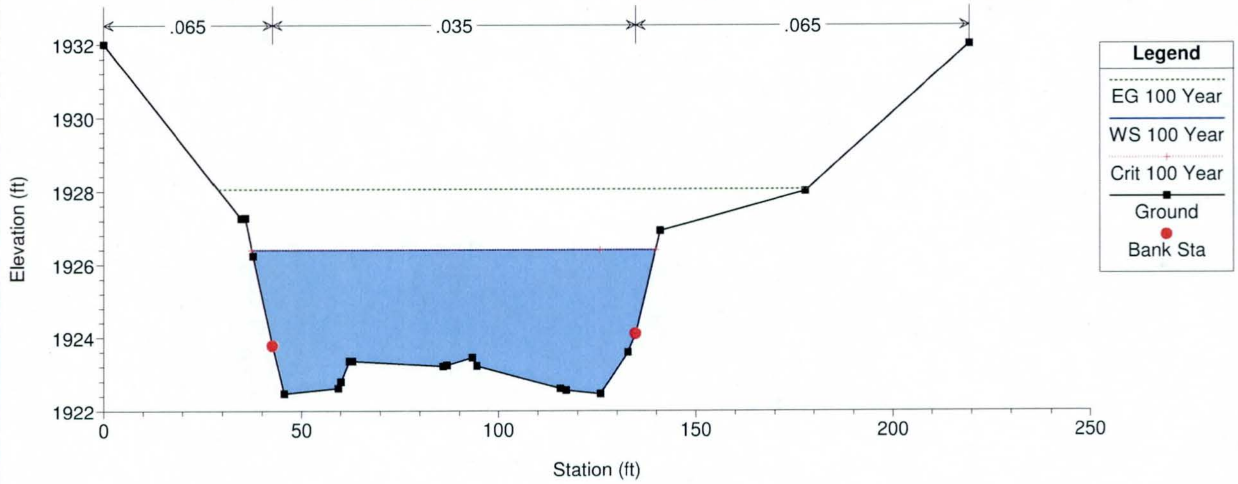

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 23 1.931
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)
1928
1930
1932
1934
1936
1938
1940
1942
1944
1946
900
950
1000
1050
1100


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 22 1.912
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

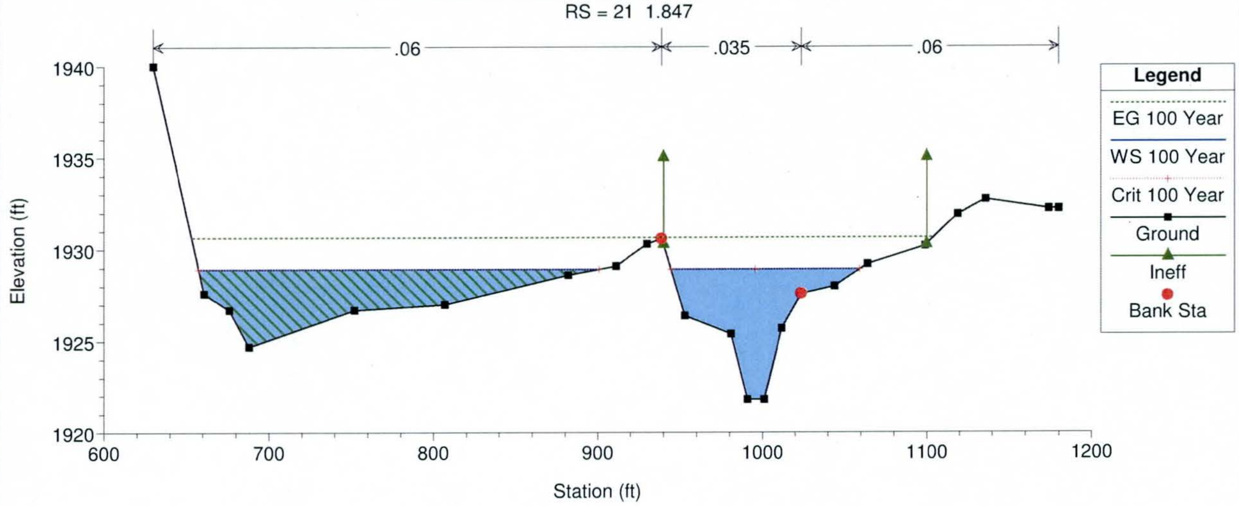

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21.6 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21.4 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO
.065
.035
.065
Legend
EG 100 Year
Crit 100 Year
WS 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

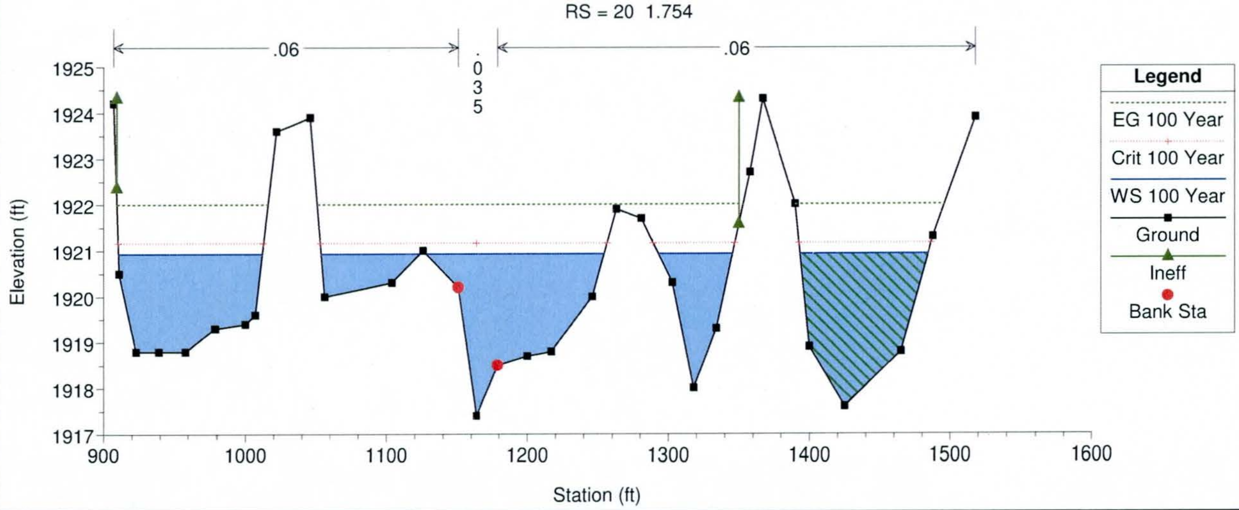
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21.2 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO

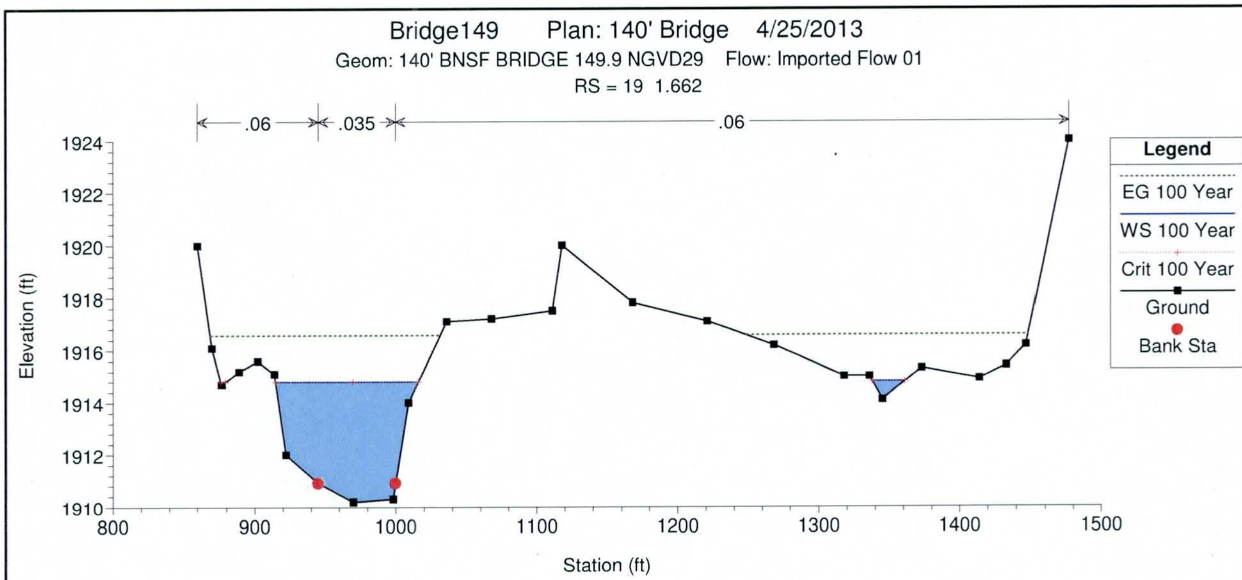


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21 1.847



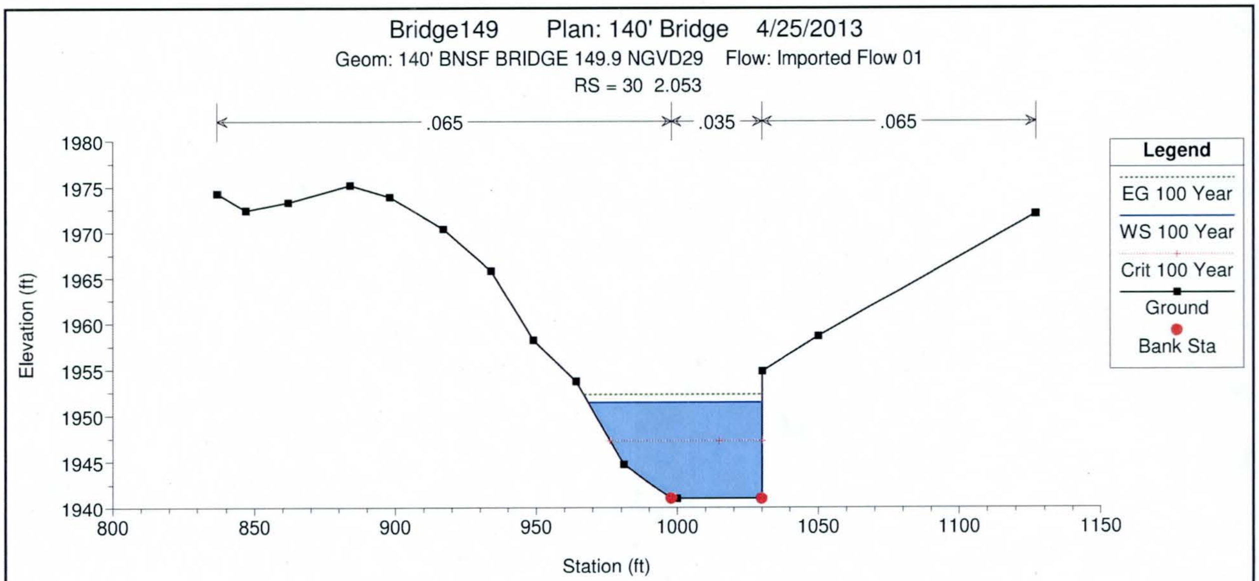
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 20 1.754

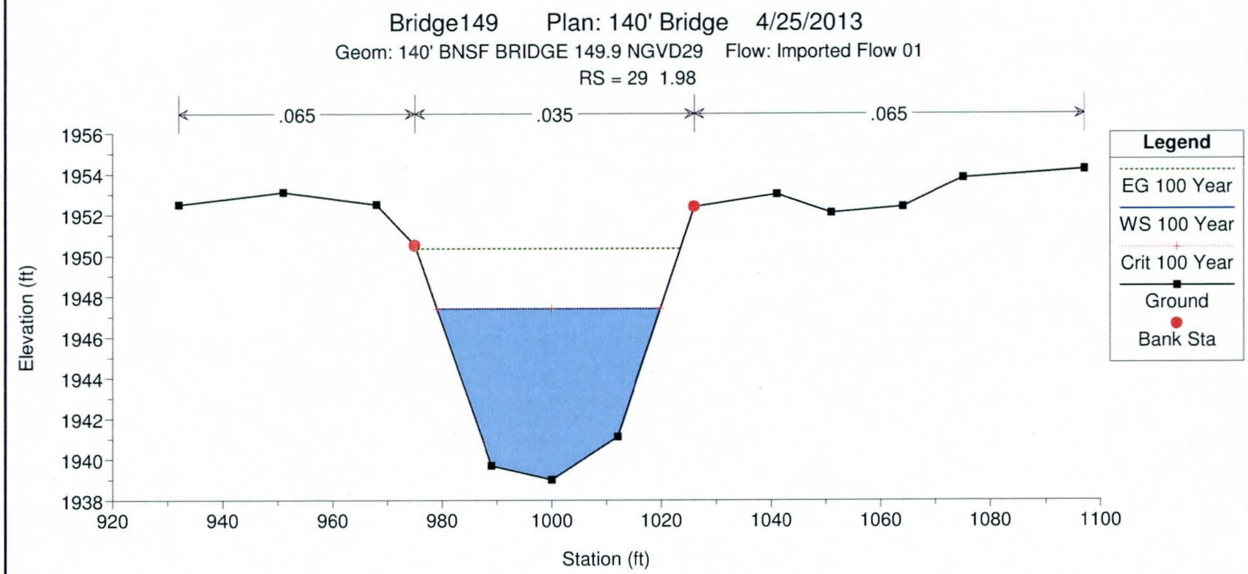


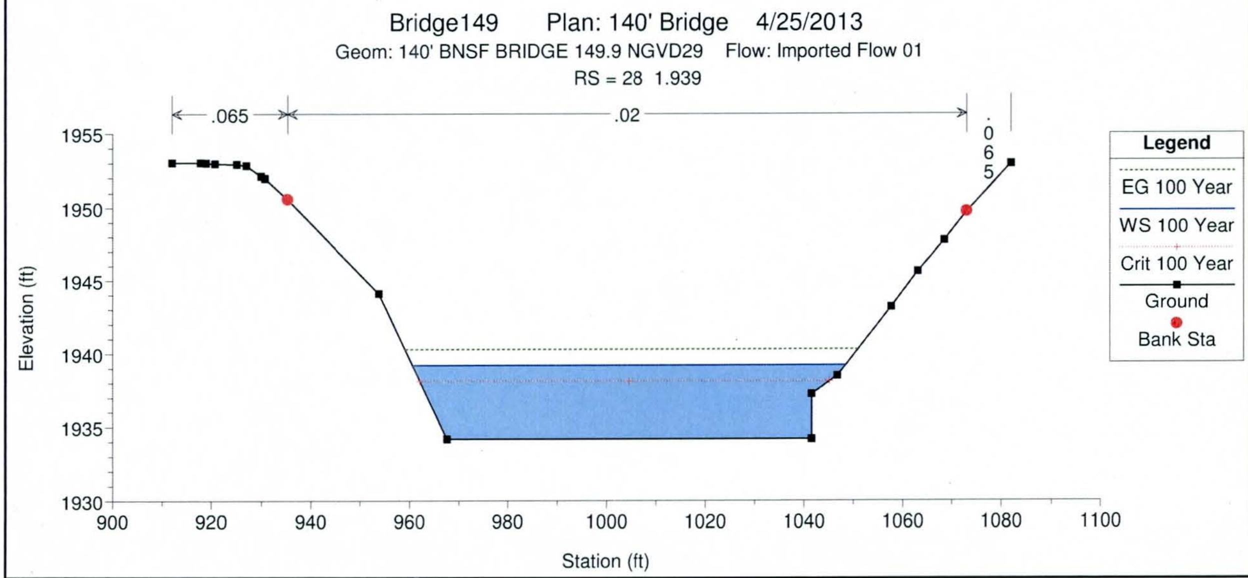


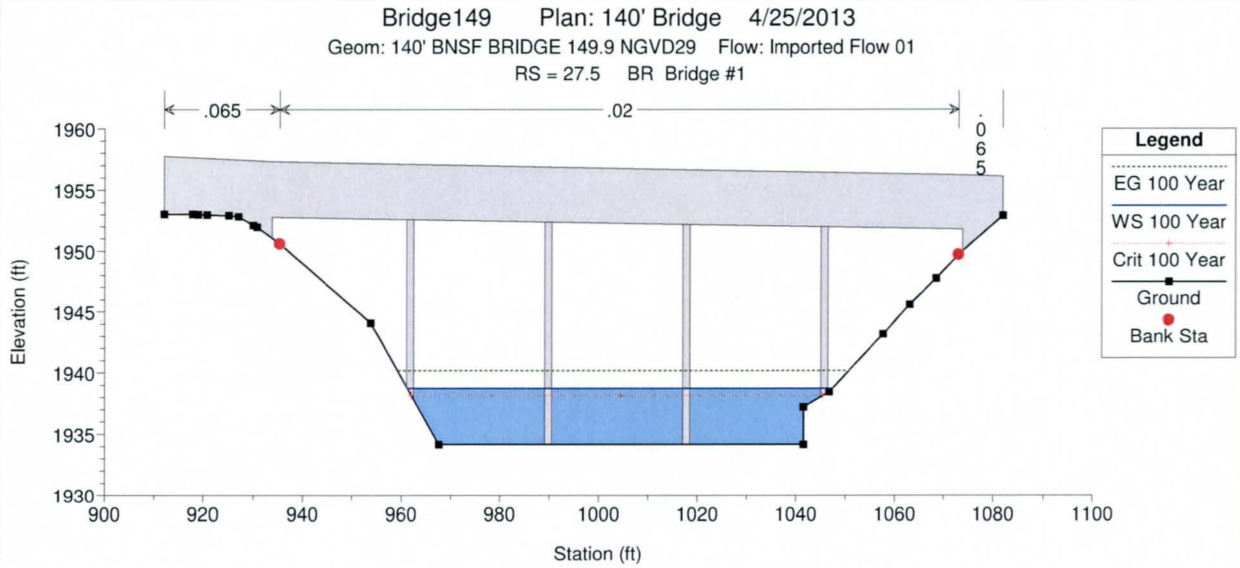
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 19 1.662
.06
.035
.06
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
1924
1922
1920
1918
1916
1914
1912
1910
800
900
1000
1100
1200
1300
1400
1500
Station (ft)

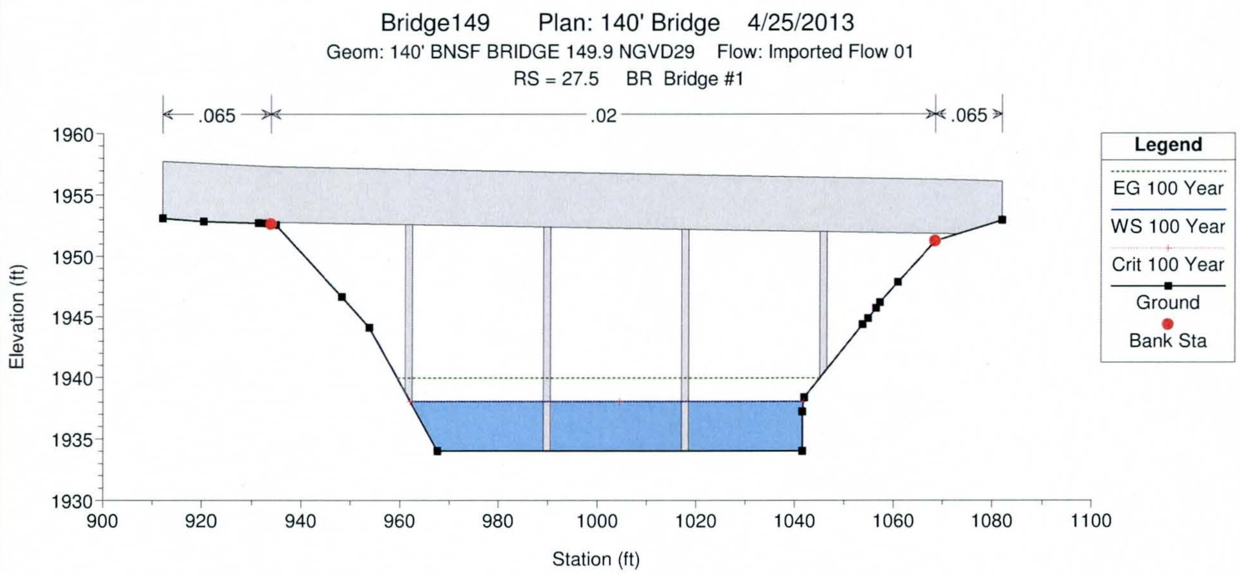
Proposed Subcritical

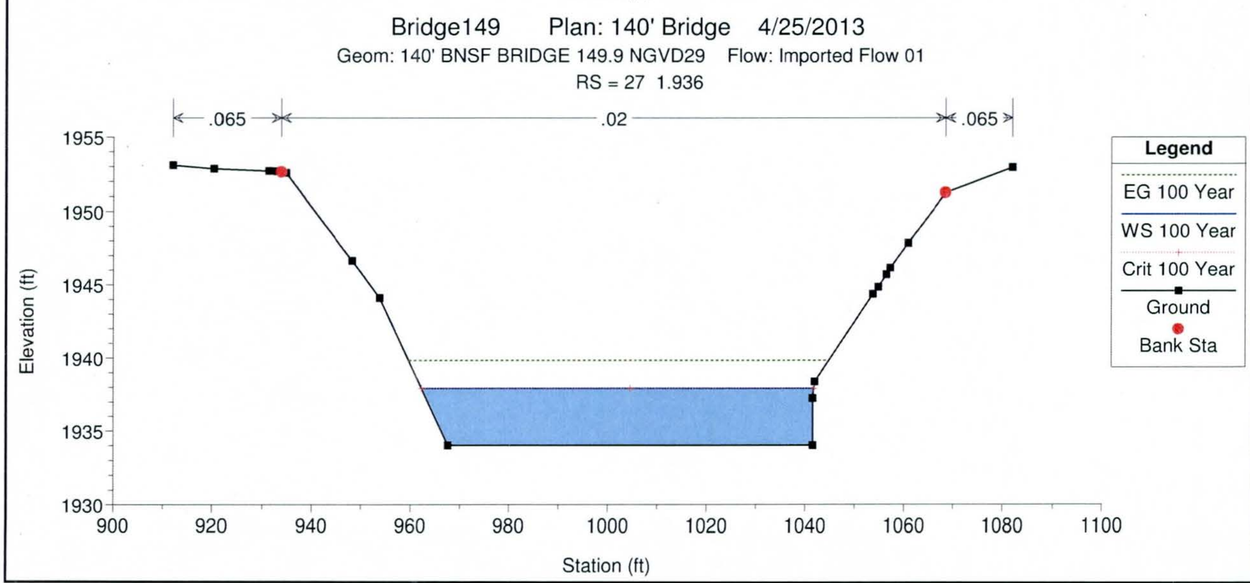

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 30 2.053
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 29 1.98
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

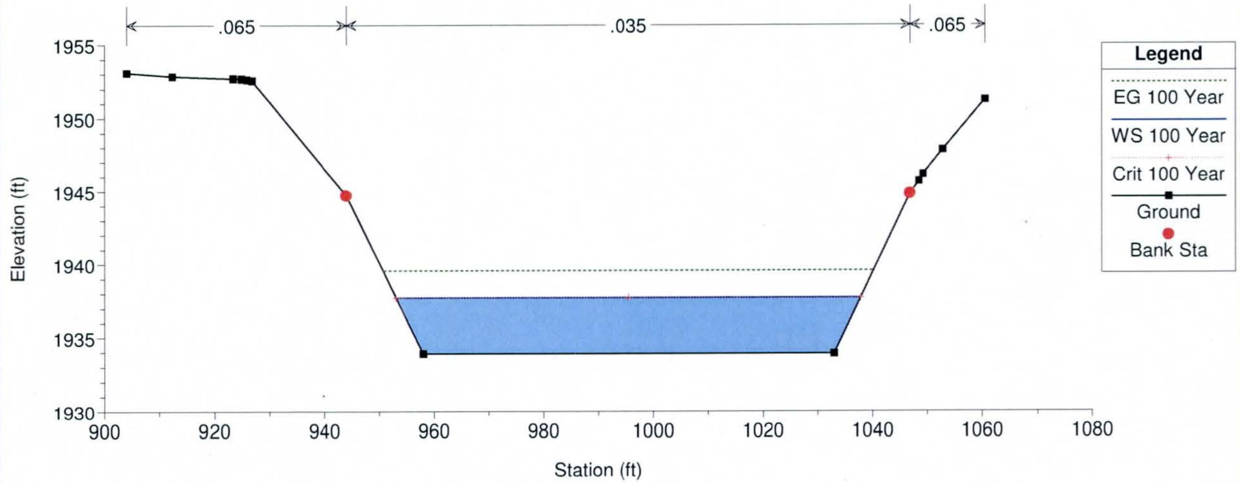

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 28 1.939
.065
.02
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 27.5 BR Bridge #1
.065
.02
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

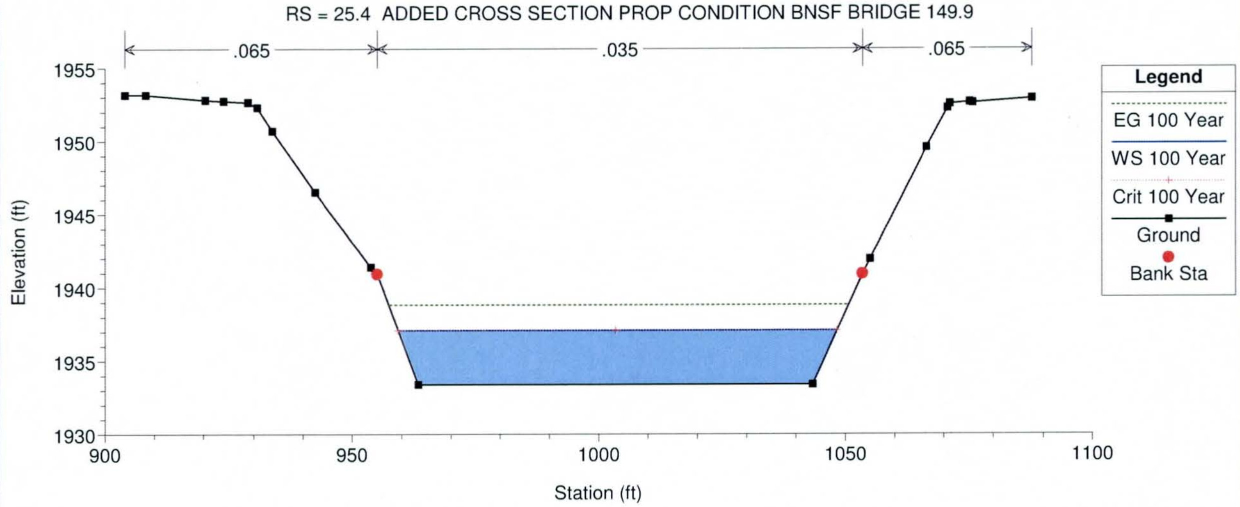

Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 27.5 BR Bridge #1
.065
.02
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 27 1.936
.065
.02
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)

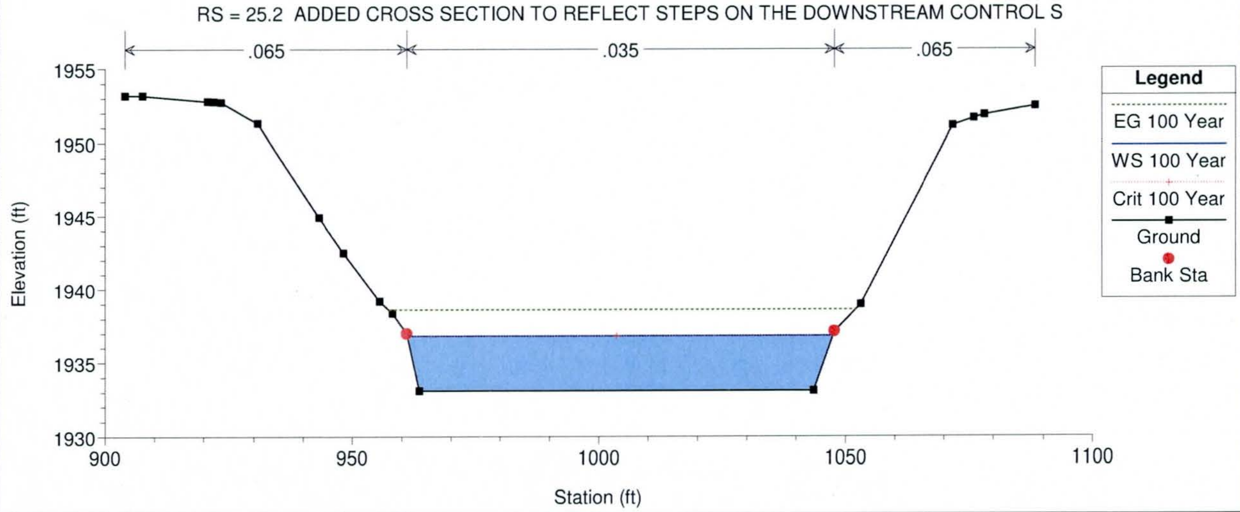
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 26 1.934

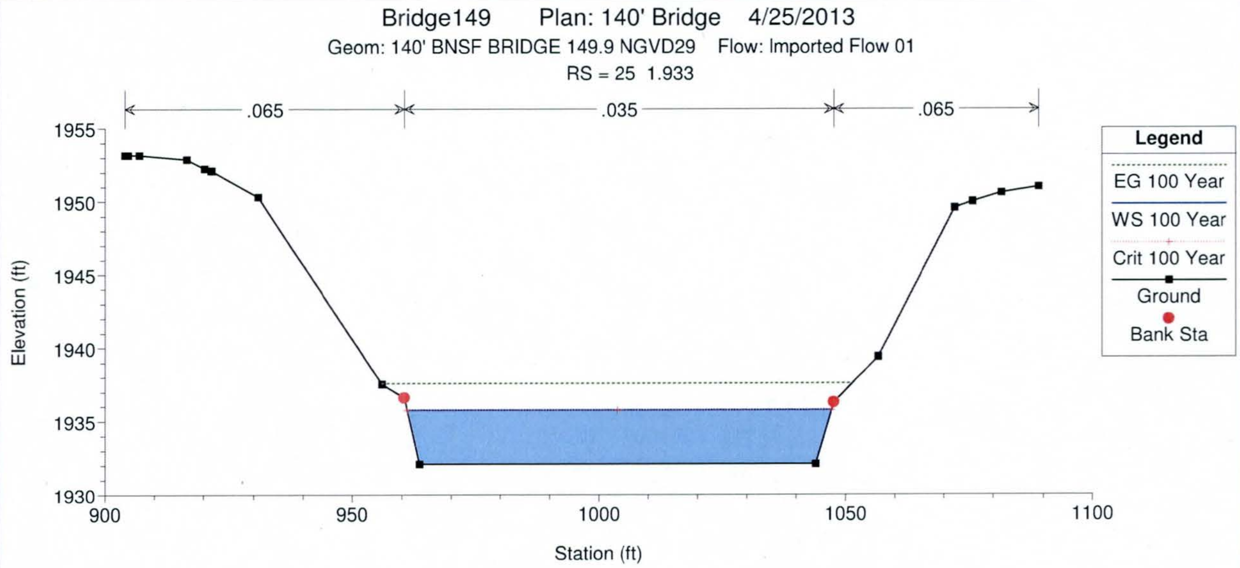


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 25.4 ADDED CROSS SECTION PROP CONDITION BNSF BRIDGE 149.9

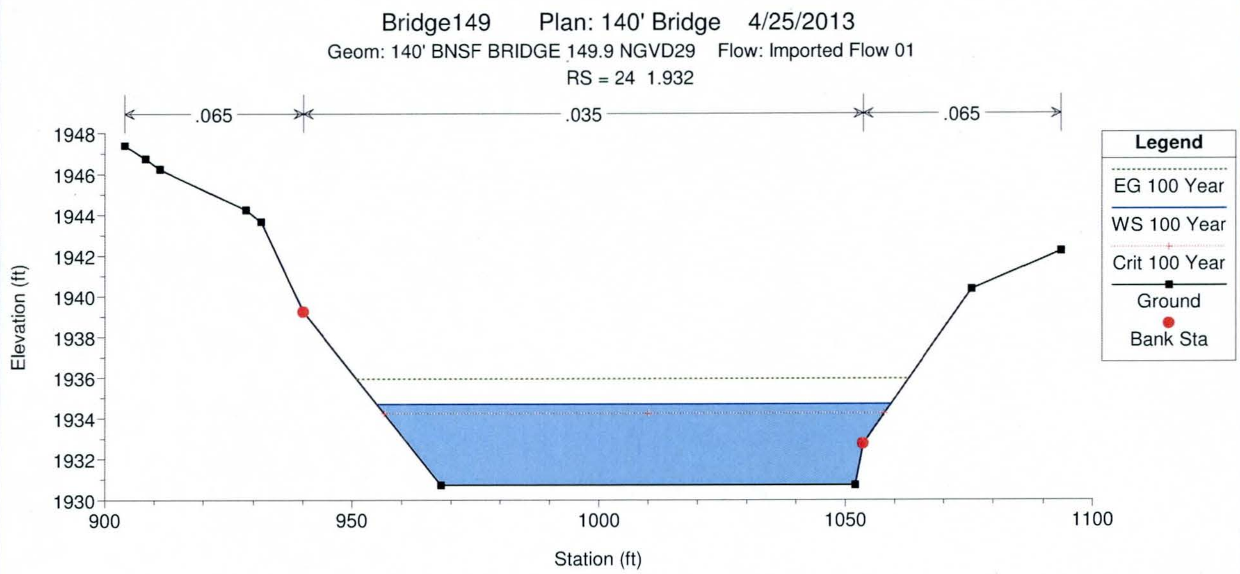


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 25.2 ADDED CROSS SECTION TO REFLECT STEPS ON THE DOWNSTREAM CONTROL S

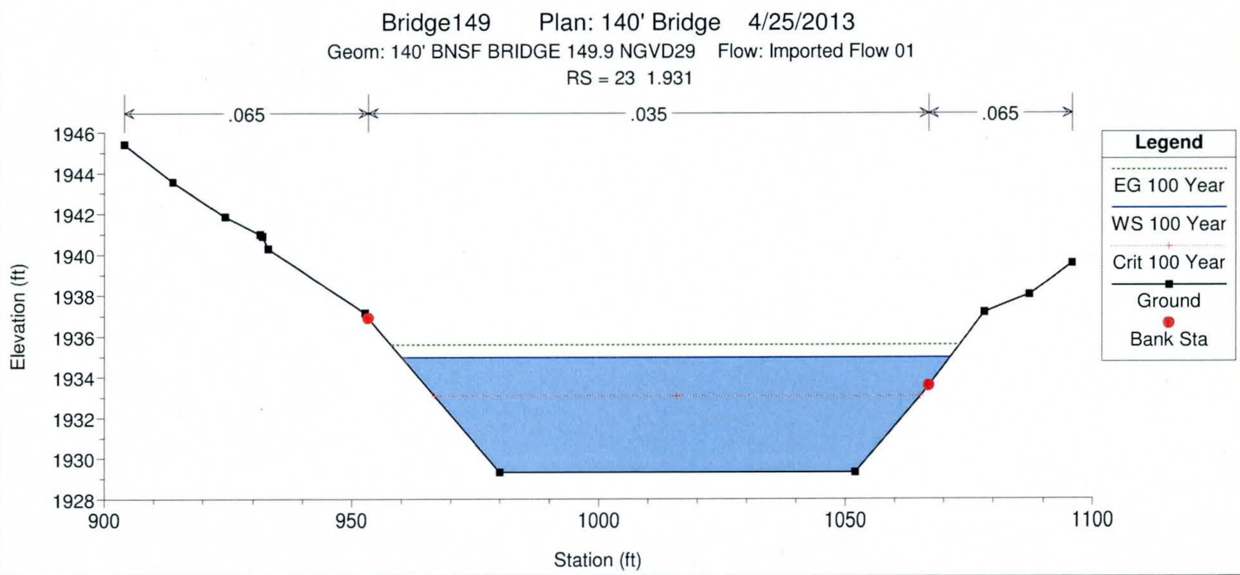




Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 25 1.933
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
1930
1935
1940
1945
1950
1955
900
950
1000
1050
1100
Station (ft)

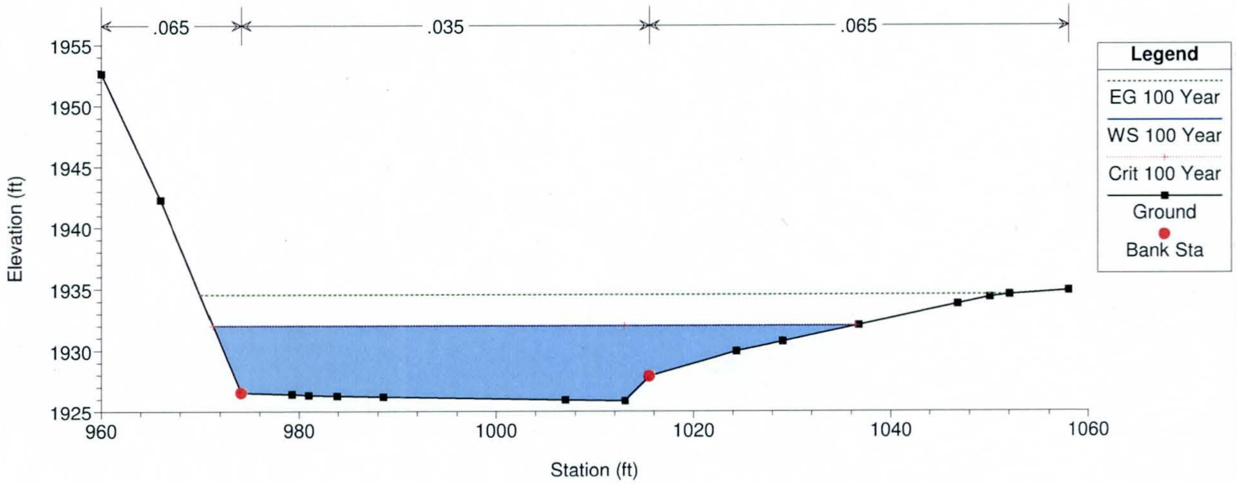


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 24 1.932
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
900
950
1000
1050
1100
Station (ft)

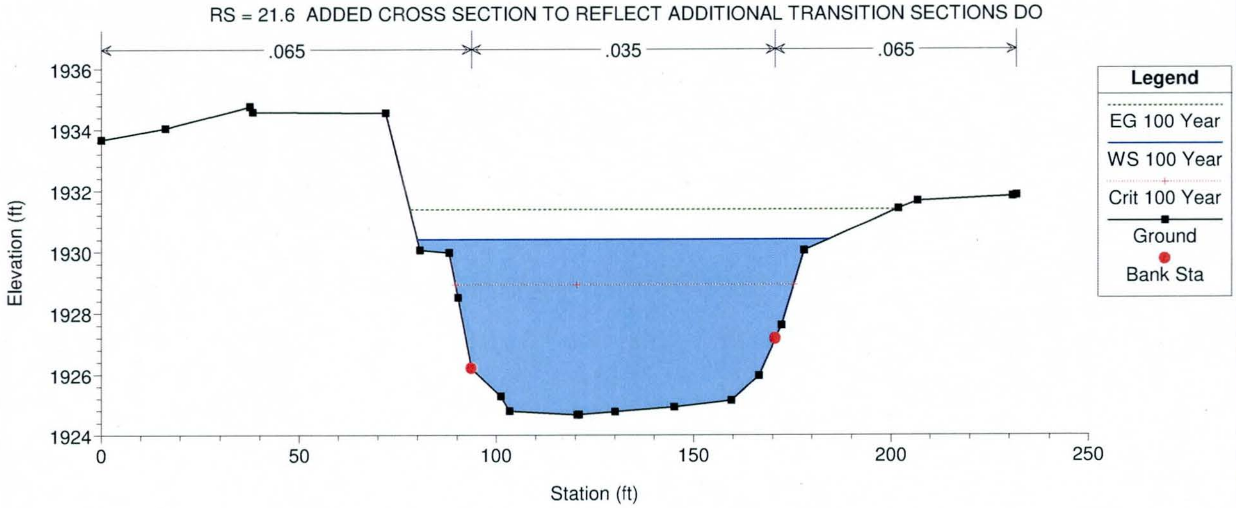


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 23 1.931
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
1928
1930
1932
1934
1936
1938
1940
1942
1944
1946
900
950
1000
1050
1100
Station (ft)

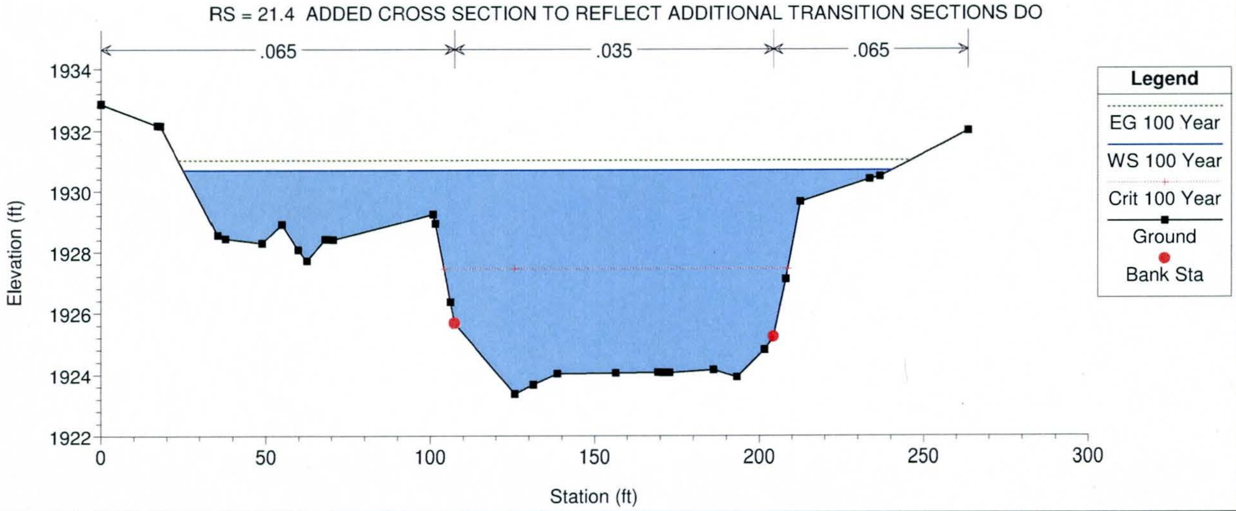
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 22 1.912

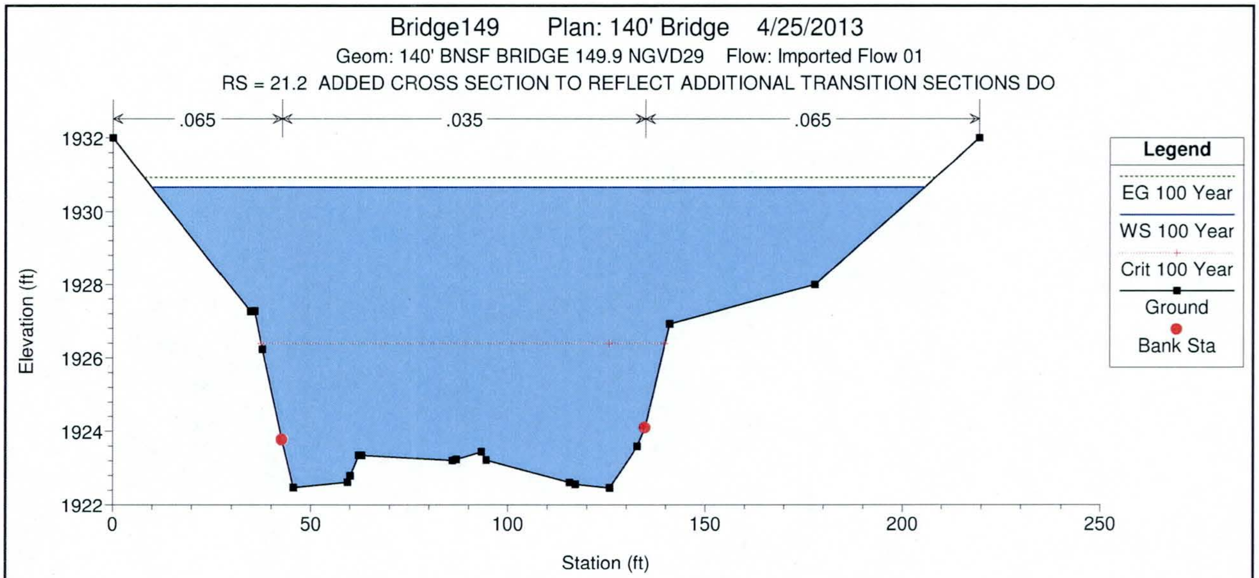


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21.6 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO

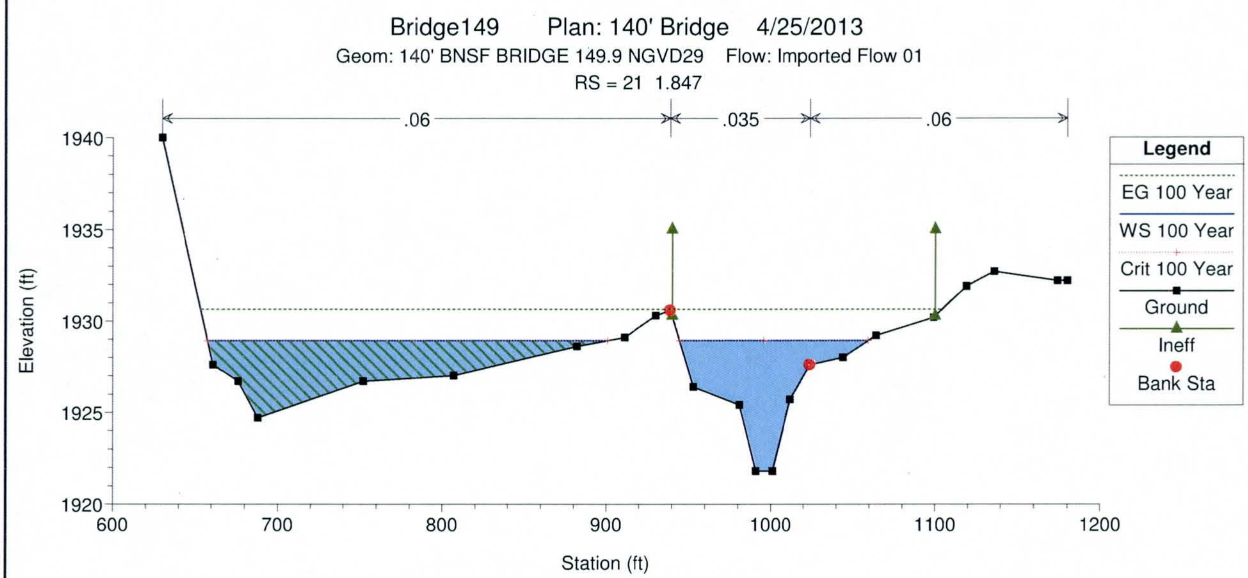


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21.4 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO

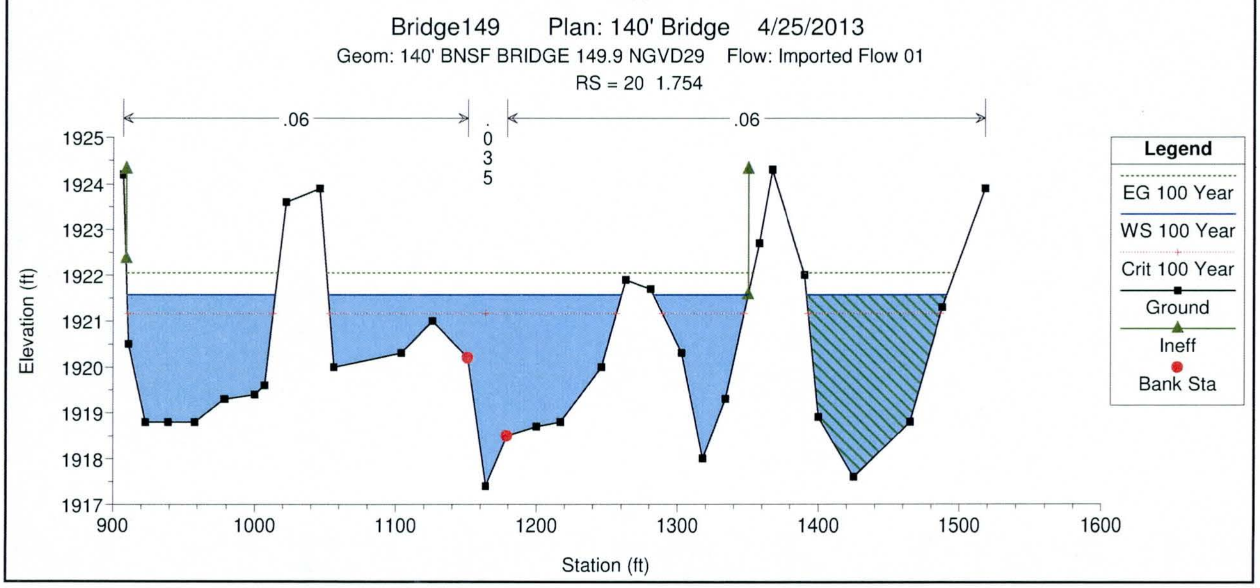




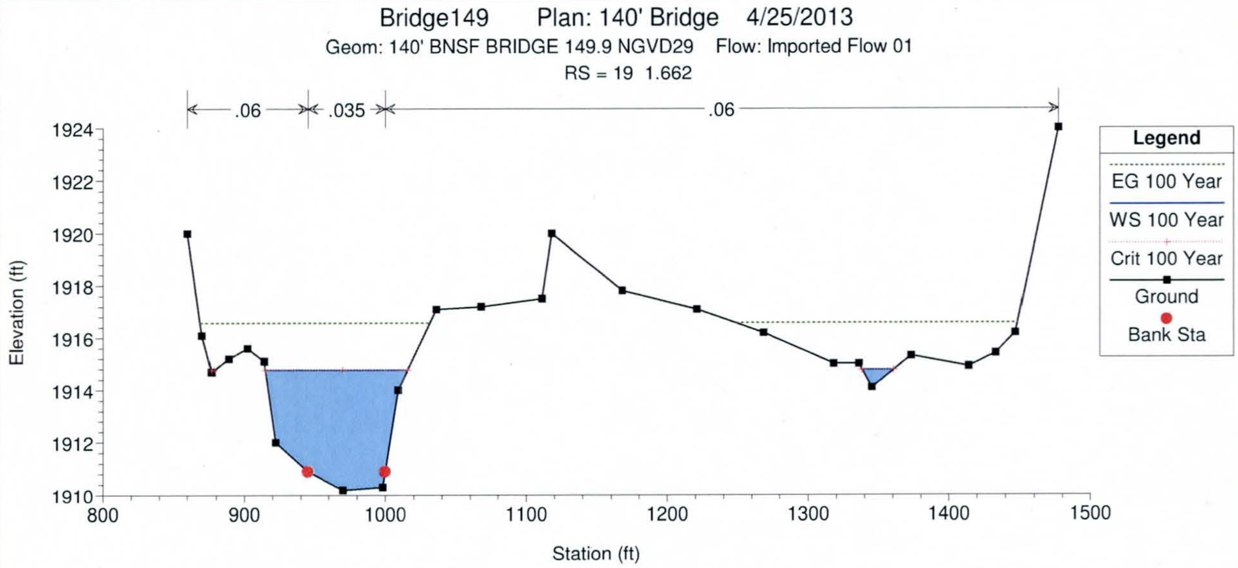
Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21.2 ADDED CROSS SECTION TO REFLECT ADDITIONAL TRANSITION SECTIONS DO
.065
.035
.065
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
Station (ft)



Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 21 1.847
.06
.035
.06
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 20 1.754
.06
.035
.06
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)


Bridge149 Plan: 140' Bridge 4/25/2013
Geom: 140' BNSF BRIDGE 149.9 NGVD29 Flow: Imported Flow 01
RS = 19 1.662
.06
.035
.06
Legend
EG 100 Year
WS 100 Year
Crit 100 Year
Ground
Bank Sta
Elevation (ft)
1924
1922
1920
1918
1916
1914
1912
1910
800
900
1000
1100
1200
1300
1400
1500
Station (ft)

E.3 Expansion and Contraction Coefficients

River Station	Contraction		Expansion	
	Existing	Proposed	Existing	Proposed
30	0.3	0.3	0.5	0.5
29	0.1	0.1	0.3	0.3
28	0.3	0.3	0.5	0.5
27.5	Bridge			
27	0.3	0.3	0.5	0.5
26	0.3	0.3	0.5	0.5
25.4	0.1	0.1	0.3	0.3
25.2	0.1	0.1	0.3	0.3
25	0.3	0.3	0.5	0.5
24	0.3	0.3	0.5	0.5
23	0.3	0.3	0.5	0.5
22	0.3	0.3	0.5	0.5
21.6	0.1	0.1	0.3	0.3
21.4	0.1	0.1	0.3	0.3
21.2	0.1	0.1	0.3	0.3
21	0.3	0.3	0.5	0.5
20	0.3	0.3	0.5	0.5
19	0.3	0.3	0.5	0.5

E.4 Analysis of Structures
N/A

E.5 Hydraulic Calculations
Summary Tables included in Section 5.9.1

Appendix F: Erosion, Sediment Transport, and Geomorphic Analysis Supporting Documentation

BioGeo

September 5, 2012

Mr. Howard R. Perry, PE
Manager Structures Design
BNSF Railway Co.
4515 Kansas Ave.
Kansas City, KS 66106

Re: Geotechnical Investigation Results
<u>BNSF Bridge #149.9</u>
<u>Maricopa County, Arizona</u>

Dear Mr. Perry:

BioGeo, LLC (BioGeo) is pleased to present this report to the Burlington Northern Santa Fe Railway Co. (BNSF) associated with the geotechnical investigation at the above referenced bridge (#149.9) located northwest of Morristown, in Maricopa County, Arizona. BioGeo and its subcontractors, D&S Drilling, Inc. of Chandler AZ; and Ricker, Atkinson, McBee, Morman & Associates, Inc (RAMM) company, a certified geotechnical and materials testing laboratory, of Phoenix AZ, completed the field and laboratory investigative portion of the scope of work in August, 2012. Results of this investigation will be provided to the Louis Berger Group, Inc. (LBG) for detailed computational scour analysis.

Purpose and Method

This study was conducted to evaluate strata beneath the Little San Domingo Wash, an arroyo that drains southwest into the Hassayampa River. The structure lies downstream of US Highway 60. The BNSF Bridge 149.9 is located northwest of Morristown, Arizona as shown on the map below:

9330 LBJ Freeway; Ste 900 • Dallas, TX 75243
Telephone 214-438-3894; Cell 816-401-0071

The Little San Domingo Wash traverses beneath the rail bridge 149.9 and has created erosional effects beneath the bridge and along its abutments over time. The Bridge 149.9 is an 8-span timber trestle bridge. The bridge structure is scheduled to be replaced in 2013. The bridge is timbers are situated into and on a floating slab of concrete with no apparent structural footing into competent rock. Downstream of the bridge, a rip-rap fence-tied apron, presumably installed about eight years ago, provides some scour countermeasure during peak rainfall and flood events in the Wash. The toe of rip-rap apron shows evidence of recent scour erosional effects.

The primary purpose of this study was conducted to:

- Determine the depth of scour; and,
- Determine depth to bedrock; and/or a hard impenetrable rock surface.

The findings of this investigation provide important information for future bridge design recommendations associated with potential scour countermeasures and potential H-pile depth to rock for the bridge replacement structure.

On August 20, 2012, a truck-mounted rig (see attached Appendix A--Field Notes; and Appendix B--Photographic Log) was mobilized to the site. D&S Drilling, Inc. performed the drilling via hollow-stem auger methods. Investigation of strata followed ASTM protocol for geotechnical analysis via standard penetration testing (SPT) of non-cohesive soils with subsequent split-spoon sample recovery at 1.5-foot intervals. Two, distinct boring locations were installed near the rip-rap apron downstream of the bridge within the Wash. Each boring, identified as B-1 and B-2, were drilled approximately 43 feet lateral distance apart (see Photo 2 of Appendix B).

BioGeo logged the borings and samples recovered using the United Soil Classification System (USCS, see Appendix C). A copy of the field boring logs is included as Appendix C. Upon conclusion of the drilling activities, samples were bagged and labeled and submitted to the Ricker, Atkinson, McBee, Mormon & Associates, Inc. (RAMM) for geotechnical laboratory testing. The laboratory test results are included as Appendix D.

Upon reaching total depth (i.e., refusal) each boring location was abandoned with cuttings to the original ground surface level. Refusal was noted upon auger and SPT refusal.

Findings and Conclusions

Scour Conditions

A hard, calcareous (CaCO3) layer was encountered in each boring at approximately 19 and 20 feet bgs for B-1 and B-2, respectively. This layer had SPT n values of 81 for B-1 and 77 for B-2; or very dense/hard (based on blow counts) material. The layer appeared to be pinkish white in color and moderately fizzed with HCL acid solution. The layer was likely an ancestral exposed stratum that formed similar to a caliche, or locally referred to as a lime cemented pan. The alluvium above and below this layer was significantly different in color, density, weathering, and lithology characteristics.

In both borings the alluvium material above this CaCO3-lime layer consists of weathered, discolored (often greenish due to water oxidation/reduction) sands and gravels. This shallow alluvium, of Quaternary geologic age, is characterized as moderately coarse-textured and formed from parent material of mixed alluvium derived from upslope materials of volcanic rocks (e.g., San Domingo Peak located about 7.5 miles upslope of the bridge site), schist, and limestone origin (USDA, Natural Resources Conservation Service, Web Soil Survey of Maricopa County, 2012 Online Database). The mixed alluvium is dominated by unconsolidated sand and gravel beneath the Little San Domingo Wash channel. According to the literature, upper Quaternary age mixed alluvium in the area can be up to 20 feet thick (Arizona Geological Survey, Open File Report, 87-9, 1987). The upper alluvium in both borings had significantly more gravel content (see Appendix D) than the lower, older Quaternary-age alluvium beneath the CaCO3 layer. The SPT n values indicated the upper alluvium of 'loose to medium dense' densities.

Shallow saturated conditions were observed at about 16.2 feet bgs in B-1. The boring B-2 had 'damp' semi-saturated conditions at 16.5 feet bgs. Moisture contents were low for both borings.

Below the CaCO3 layer, the strata in both borings were characterized as mostly sand and silt. Uniform grain sizes of poorly graded sands (SP) were observed for both borings in samples below the CaCO3-lime layer (i.e., below 20 feet). This interval beneath the lime pan layer, thus, is older alluvium Quaternary age deposit which consists of unconsolidated to semi-consolidated sediments. The brownish yellow sands were slightly- to, non-weathered. The SPT n values indicated this lower alluvium of medium dense, dense to hard densities throughout the lower alluvium sequence from 20 to 33 feet.

Therefore, the CaCO3 layer observed at about 19-20 feet beneath the Little San Domingo Wash is a natural break or 'ledge' that demarks the scour surface. The maximum depth of the scour surface is estimated to be approximately 17-18 feet below the Little San Domingo Wash. The laboratory results of grain size analyses (see Appendix D) confirm the field observations.

Bedrock, or Hard Rock/Refusal Conditions

Refusal was encountered in both borings at 33 feet bgs. Augers were advanced to about 33 feet and could not 'turn' due to hard rock encountered. In boring B-2, the drilling rig lifted due to the hard subsurface conditions. SPT samples were attempted below the auger refusal depth, but none were obtained due to refusal of the SPT hammer (or 50 blows with minimal penetration of about 1 to 2inches). The high friction conditions and lack of penetration indicates that hard rock is present beginning at 33 to 33.5 feet below Little San Domingo Wash. Although this hard bed may not be granitic bedrock, it is a very hard geologic substrate that may be conducive for driving H-piles for bridge replacement.

The geology of the area (AGS, 1987) indicates regional grabens, or downfaulted basins, with thick in-filled sequences of alluvium and colluvium of up to 500' to 1,000' thick are common in the Central Arizona region. The literature indicates that within these grabens the top of the bedrock-granite surface typically ranges from 300- to 1,000- feet in depth. Because refusal was encountered in hard rock at 33 feet in borings B-1 and B-2, there was no reason to rig up NX coring tools to test the depth of bedrock.

BioGeo appreciates the opportunity to provide these consulting services on this important project. Please feel free to contact me at (816) 401-0071 if you have any questions.

Sincerely,
BIOGEO, LLC.

John R. Larson

John R. Larson, PG, MPH
President

RICKER-ATKINSON-MCBEE-MORMAN & ASSOCIATES, INC.
2105 South Hardy Drive, Suite 13
Tempe, Arizona 85282-1921
Phone: (480) 921-8100 • Fax: (480) 921-4081

R·A·M·M

LETTER OF TRANSMITTAL

TO: John R. Larson

COMPANY: BIO GEO, LLC
9330 LBJ Freeway, Suite 900
Dallas, Texas 75243

SUBJECT:
1. Test Boring Logs
2. Results of Laboratory Tests

DATE: 8-28-12

_____ Geotechnical Engineering Report
X Materials Testing Reports
_____ Fee Schedule
_____ Other:

For your:

X Information
_____ Correction
_____ Review and Comment
_____ Signature and Return

Comments:

Respectfully submitted,

RICKER-ATKINSON-MCBEE-MORMAN & ASSOCIATES, INC.

By: Kenneth L. Ricker, P.E., President

/dh

Copies to: Addressee (1)

TEST BORING LOG

BORING NO. B-1
PROJECT NAME: BNSF Bridge 149.9
LOCATION: Morristown, AZ, Little San Domingo Wash
DRILL EQUIPMENT: Dietrich 120

DATE: 8-20-2012 **BY:** JL (BIOGEO)
SHEET NO. 1 **OF** 2
GROUND ELEV. TBD
W.T. ELEV. N/A
DRILLER: D & S Drilling

Depth, feet	Sample Number	Blows/Foot	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
	S-1	19	N		4.2	SM	Silty Gravelly Sand; yellowish brown, slightly damp, medium dense, no to low plasticity fines.
	S-2	36	N		2.8	GP/ GM	Sandy Gravel, Trace to Some Silt; brown, slightly damp, medium dense, non-plastic fines, some greenish staining.
5	S-3	16	N		3.8		
	S-4	24	N		NR		
	S-5	20	N		6.9	SM/ GP	Sand and Gravel, Some Silt; light brown, slightly damp, medium dense, non-plastic fines.
10							
	S-6	23	N		4.6		
	S-7	18	N		4.4		
15	S-8	26	N		4.2		
	S-9	18	N		4.7		∇ Seepage at 16.2 feet, dark brown
20	S-10	81	N		4.9	SM	Silty Gravelly Sand; brown/pink/white, slightly damp, very dense, heavy cementation, ($CaCO_3$), non-plastic fines.
	S-11	22	N		5.0	SP/ SM	Sand, Some Silt, Some to With Gravel; brown to yellowish brown, slightly damp, medium dense, non-plastic fines.
25							
	S-12	71	N		4.4		- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. B-1
PROJECT NAME: BNSF Bridge 149.9
LOCATION: Morristown, AZ, Little San Domingo Wash
DRILL EQUIPMENT: Dietrich 120

DATE: 8-20-2012 **BY:** JL (BIOGEO)
SHEET NO. 2 **OF** 2
GROUND ELEV. TBD
W.T. ELEV. N/A
DRILLER: D & S Drilling

Depth, feet	Sample Number	Blows/Foot	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
	S-12	71	N		4.4	SP/ SM	Sand, Some Silt, Some to With Gravel; - continued
30							
	S-13	26	N		5.1		
	S-14	50/2"	N		NR	GP	Sand, Gravel, Cobbles; brown, nearly dry, very dense.
35							Refusal to auger penetration at 33.2 feet. NR=No Recovery.
							*Note: B-1 location at foot of Bridge 149.9 apron at 43.0 from B-2
40							
45							
50							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. B-2
PROJECT NAME: BNSF Bridge 149.9
LOCATION: Morristown, AZ, Little San Domingo Wash
DRILL EQUIPMENT: Dietrich 120

DATE: 8-20-2012 **BY:** JL (BIOGEO)
SHEET NO. 1 **OF** 2
GROUND ELEV. TBD
W.T. ELEV. N/A
DRILLER: D & S Drilling

Depth, feet	Sample Number	Blows/Foot	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
	S-1	7	N		4.9	SP/ GP	Sand and Gravel, Trace to Some Silt; yellowish brown, slightly damp, loose to medium dense, non-plastic fines.
	S-2	10	N		4.0		
5	S-3	29	N		2.6		
	S-4	15	N		4.6		
	S-5	14	N		2.9	SM	Silty Gravelly Sand; greenish gray to brown, slightly damp, medium dense to dense, non-plastic fines.
10	S-6	18	N		NR		
	S-7	40	N		4.7		
15	S-8	60	N		4.7		
	S-9	53	N		4.6		∇ Seepage at 16.5 feet.
20	S-10	37	N		4.2		
	S-11	77	N		5.0	SM	Silty Sand, Trace Gravel; light brown to white, slightly damp, very dense, heavy cementation, ($CaCO_3$), non-plastic fines.
						SP/ SM	Sand, Some Silt, Some to With Gravel; brown to yellowish brown, slightly damp, medium dense, non-plastic fines.
25	S-12	45	N		5.7		

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. B-2
PROJECT NAME: BNSF Bridge 149.9
LOCATION: Morristown, AZ, Little San Domingo Wash
DRILL EQUIPMENT: Dietrich 120

DATE: 8-20-2012 **BY:** JL (BIOGEO)
SHEET NO. 2 **OF** 2
GROUND ELEV. TBD
W.T. ELEV. N/A
DRILLER: D & S Drilling

Depth, feet	Sample Number	Blows/Foot	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
	S-12	45	N		5.7	SP/ SM	Sand, Some Silt, Some to With Gravel; - continued
30							
	S-13	61	N		5.5		
	S-14	50/1"	N		NR		
35							Refusal to auger penetration at 33.5 feet. NR=No Recovery. *Note: B-2 location at foot of Bridge 149.9 apron at 43.0 from B-1
40							
45							
50							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

LABORATORY TEST RESULTS

Date: 28-Aug-12

SAMPLE SOURCE: As noted below

TESTING PERFORMED: Sieve Analysis, Percent Passing No. 200 Sieve, Atterberg Limits (ASTM C136, D1140, D4318)

SAMPLED BY: Client

RESULTS:

Sample	Atterberg Limits		Sieve Size - Accumulative Percent Passing											Soil
Source	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.*
B-1 @ S-1			14	17	22	25	36	48	64	96	100			SM
B-1 @ S-2			4.2	6	9	12	16	22	31	64	100			GP/GM
B-1 @ S-3			6.3	8	11	15	21	29	40	70	82	100		GP/GM
B-1 @ S-5	N/A	NP	9.8	14	18	23	29	38	49	88	88	100		GP/GM
B-1 @ S-6			10	14	18	23	29	37	47	72	72	100		SM/GP
B-1 @ S-7			12	16	21	26	33	43	56	91	100			SM/GP
B-1 @ S-8	N/A	NP	10	13	17	21	27	34	43	74	85	100		SM/GP
B-1 @ S-9			9.4	13	16	22	28	37	48	80	91	100		SM/GP
B-1 @ S-10 **	N/A	NP	19	27	42	53	61	67	72	86	95	100		SM
B-1 @ S-11			7.5	12	26	61	78	87	93	100				SP/SM
B-1 @ S-12			8.6	13	21	37	55	69	77	87	91	100		SP/SM
B-1 @ S-13	N/A	NP	15	20	32	50	68	79	86	98	100			SP/SM
B-2 @ S-1			5.6	9	14	18	36	53	71	97	100			SP/GP
B-2 @ S-2			6.2	9	13	20	30	42	56	89	100			SP/GP
B-2 @ S-3			7.1	11	16	21	28	39	53	79	100			SP/GP
B-2 @ S-4	N/A	NP	8.6	12	17	23	32	43	57	85	100			SP/GP
B-2 @ S-5			12	16	22	29	38	50	62	85	100			SM
B-2 @ S-7			16	23	32	43	54	66	76	91	91	100		SM
B-2 @ S-8	N/A	NP	12	17	26	44	62	75	84	100				SM
B-2 @ S-9			15	21	30	46	60	71	81	96	100			SM
B-2 @ S-10			8.4	13	24	41	56	66	73	86	92	100		SM
B-2 @ S-11 **	N/A	NP	17	25	41	61	78	88	93	100				SM
B-2 @ S-12	N/A	NP	8.6	14	33	60	70	79	86	98	100			SP/SM
B-2 @ S-13			12	17	34	58	75	86	91	100				SP/SM

NP = Non-Plastic

* Unified Soil Classification System

** ACID TEST - Moderate to Heavy Bubbles.

LABORATORY TEST RESULTS

Date: 30-Aug-12

SAMPLE SOURCE: As noted below

TESTING PERFORMED: Sieve Analysis, Percent Passing No. 200 Sieve, Atterberg Limits (ASTM C136, D1140, D4318)

SAMPLED BY: Client

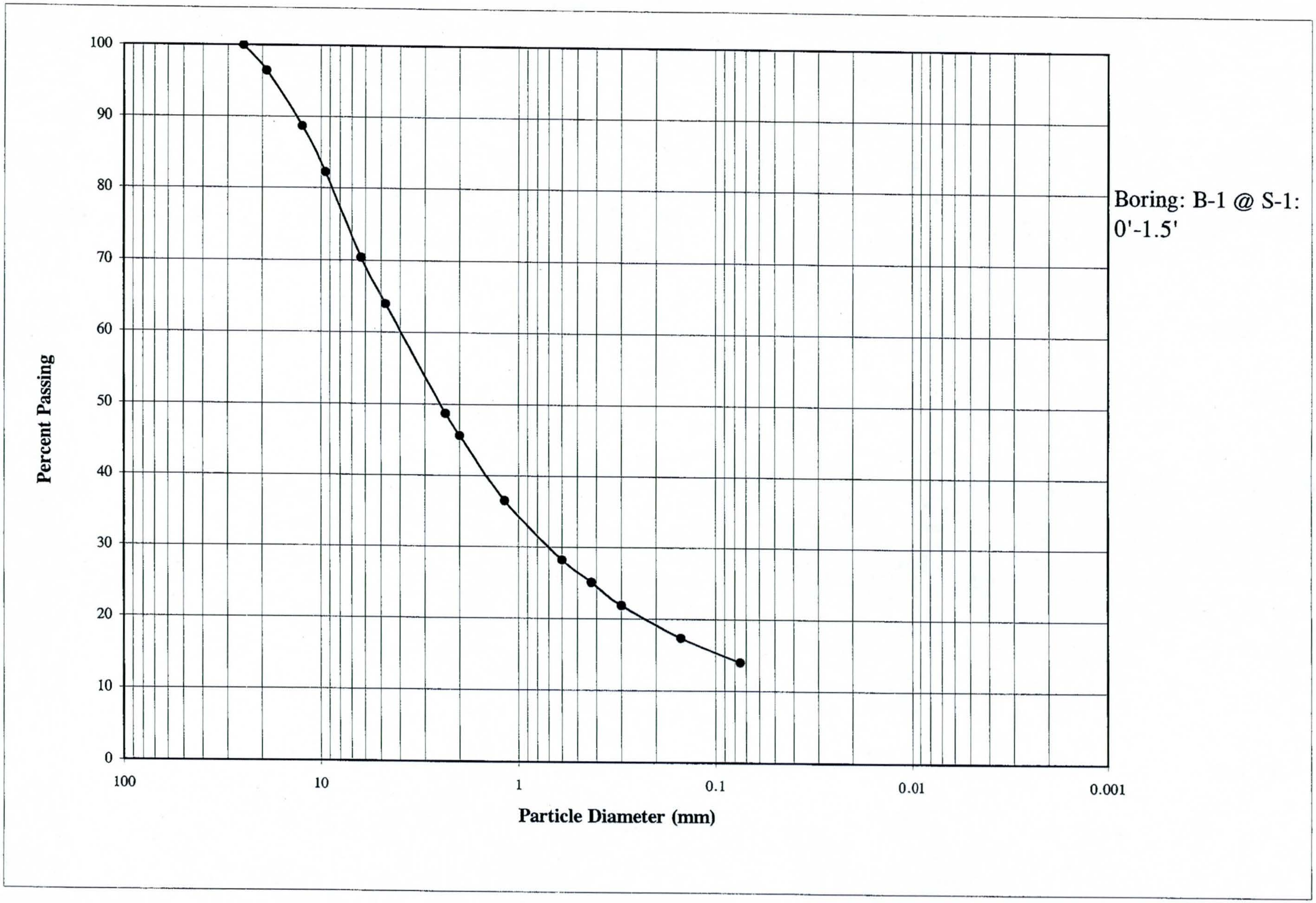
RESULTS:

Sample	Atterberg Limits		Sieve Size - Accumulative Percent Passing											Soil
Source	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.*
B-1 @ S-1: 0'-1.5'			14	17	22	25	36	48	64	96	100			SM
B-1 @ S-2: 2'-3.5'			4.2	6	9	12	16	22	31	64	100			GP/GM
B-1 @ S-3: 4'-5.5'			6.3	8	11	15	21	29	40	70	82	100		GP/GM
B-1 @ S-5: 8'-9.5'	N/A	NP	9.8	14	18	23	29	38	49	88	88	100		GP/GM
B-1 @ S-6: 10'-11.5'			10	14	18	23	29	37	47	72	72	100		SM/GP
B-1 @ S-7: 12'-13.5'			12	16	21	26	33	43	56	91	100			SM/GP
B-1 @ S-8: 14'-15.5'	N/A	NP	10	13	17	21	27	34	43	74	85	100		SM/GP
B-1 @ S-9: 16'-17.5'			9.4	13	16	22	28	37	48	80	91	100		SM/GP
B-1 @ S-10: 18'-19.5'	N/A	NP	19	27	42	53	61	67	72	86	95	100		SM**
B-1 @ S-11: 20'-21.5'			7.5	12	26	61	78	87	93	100				SP/SM
B-1 @ S-12: 25'-26.5'			8.6	13	21	37	55	69	77	87	91	100		SP/SM
B-1 @ S-13: 30'-31.5'	N/A	NP	15	20	32	50	68	79	86	98	100			SM
B-2 @ S-1: 0'-1.5'			5.6	9	14	18	36	53	71	97	100			SP/GP
B-2 @ S-2: 2'-3.5'			6.2	9	13	20	30	42	56	89	100			SP/GP
B-2 @ S-3: 4'-5.5'			7.1	11	16	21	28	39	53	79	100			SP/GP
B-2 @ S-4: 6'-7.5'	N/A	NP	8.6	12	17	23	32	43	57	85	100			SP/GP
B-2 @ S-5: 8'-9.5'			12	16	22	29	38	50	62	85	100			SM
B-2 @ S-7: 12'-13.5'			16	23	32	43	54	66	76	91	91	100		SM
B-2 @ S-8: 14'-15.5'	N/A	NP	12	17	26	44	62	75	84	100				SM
B-2 @ S-9: 16'-17.5'			15	21	30	46	60	71	81	96	100			SM
B-2 @ S-10: 18'-19.5'			8.4	13	24	41	56	66	73	86	92	100		SM
B-2 @ S-11: 20'-21.5'	N/A	NP	17	25	41	61	78	88	93	100				SM**
B-2 @ S-12: 25'-26.5'	N/A	NP	8.6	14	33	60	70	79	86	98	100			SP/SM
B-2 @ S-13: 30'-31.5'			12	17	34	58	75	86	91	100				SP/SM

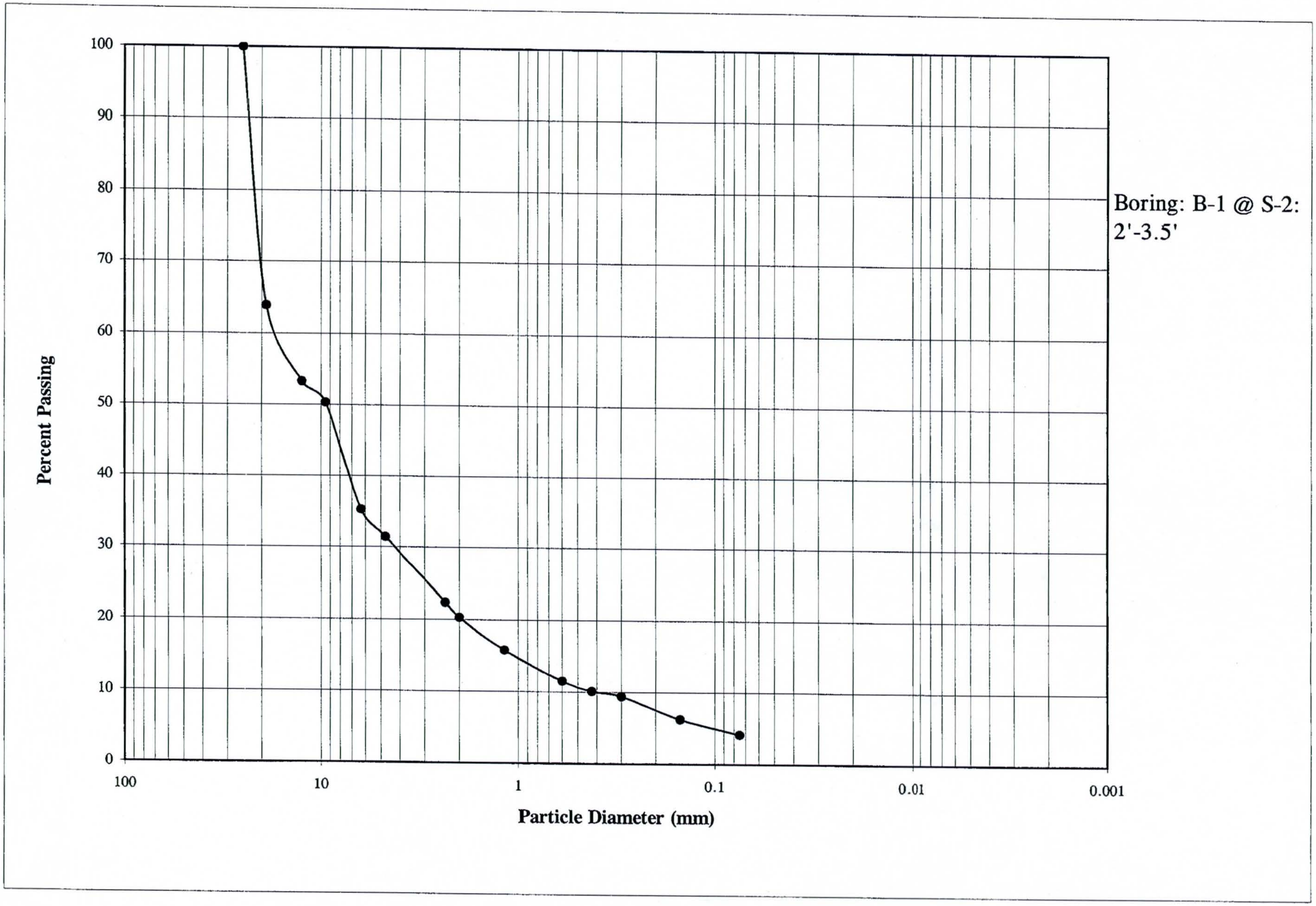
NP = Non-Plastic

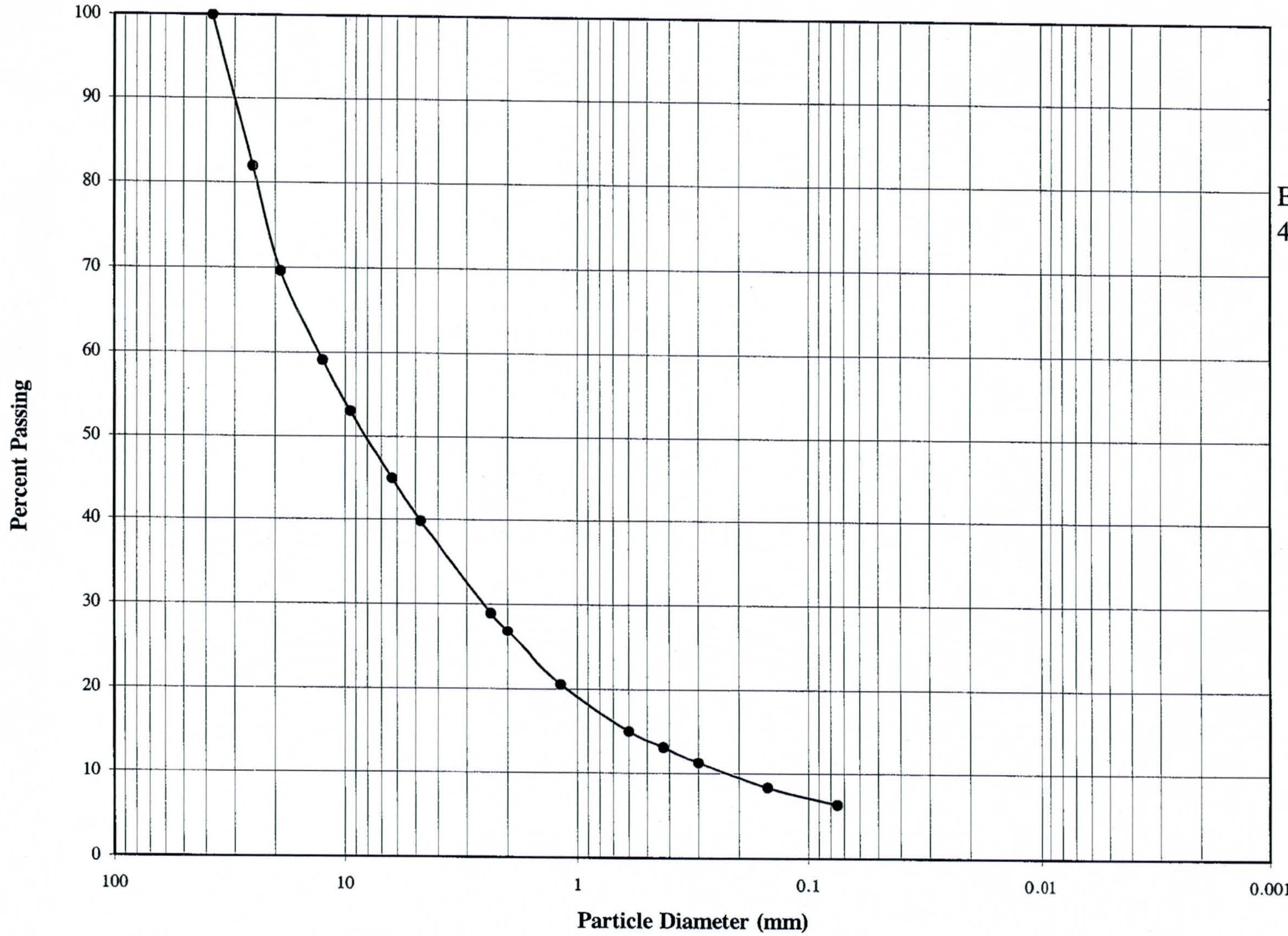
* Unified Soil Classification System

** ACID TEST - Moderate to Heavy Bubbles.

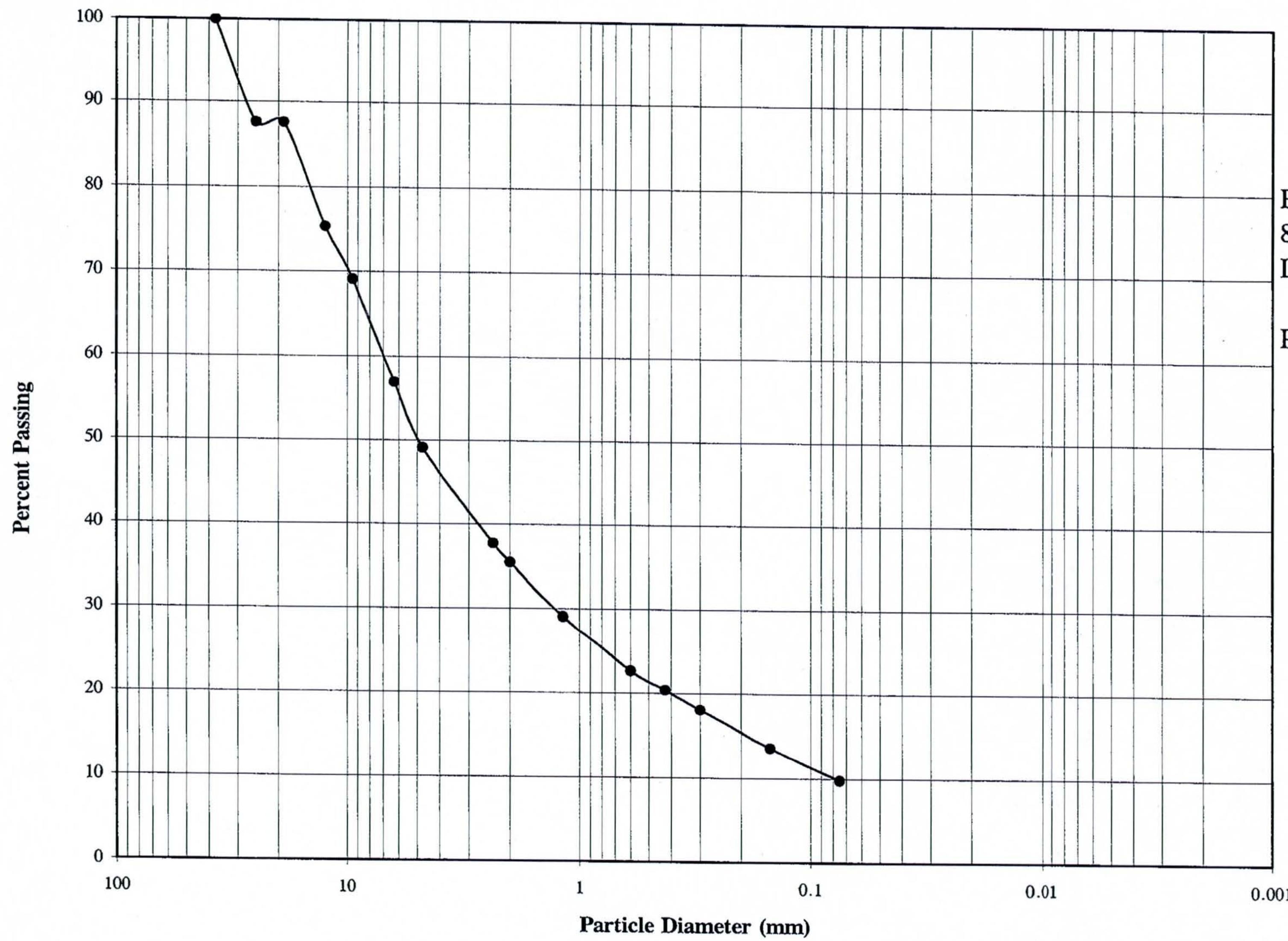


Percent Passing
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-1 @ S-1: 0'-1.5'


Percent Passing
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-1 @ S-2: 2'-3.5'



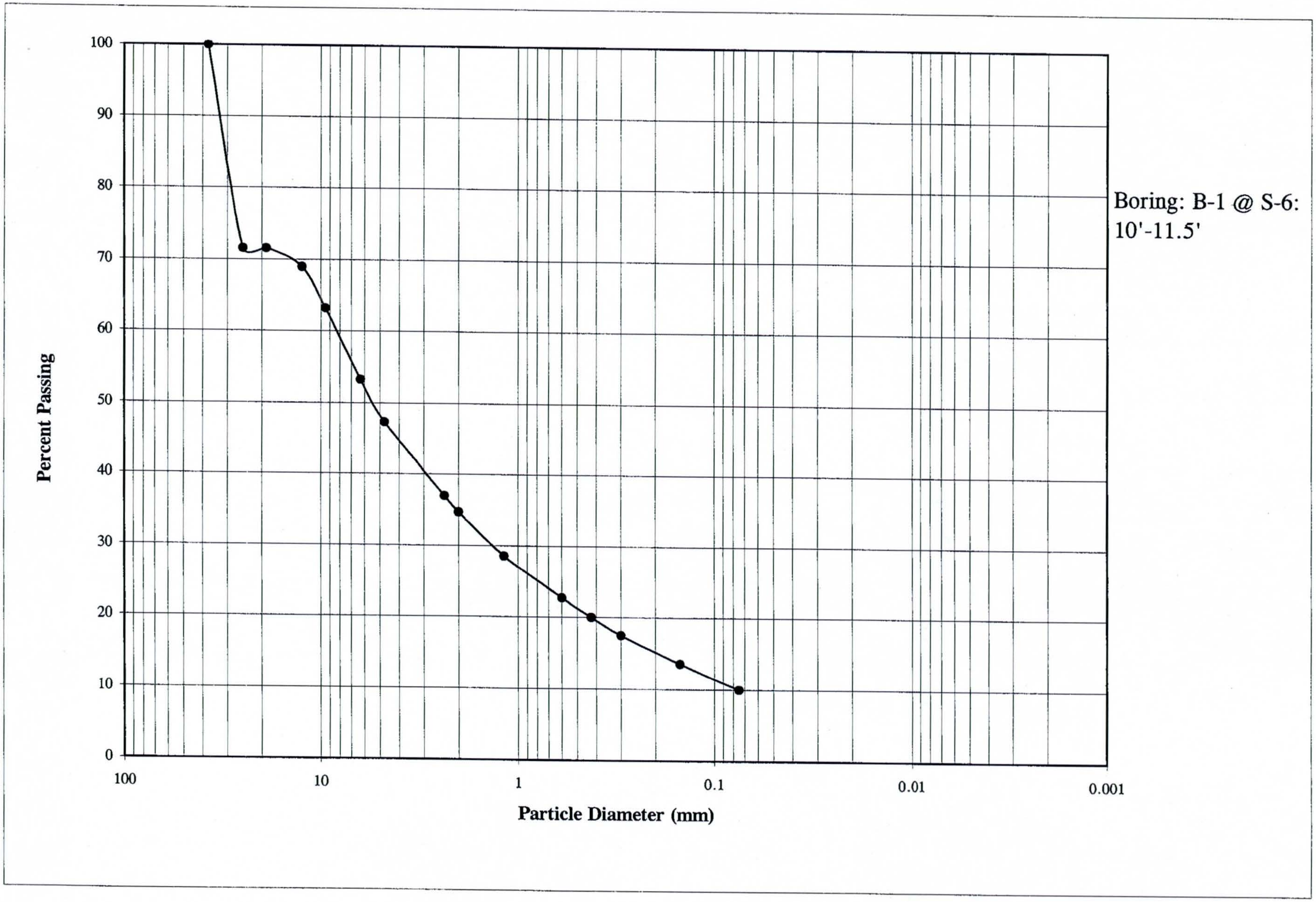
Boring: B-1 @ S-3: 4'-5.5'

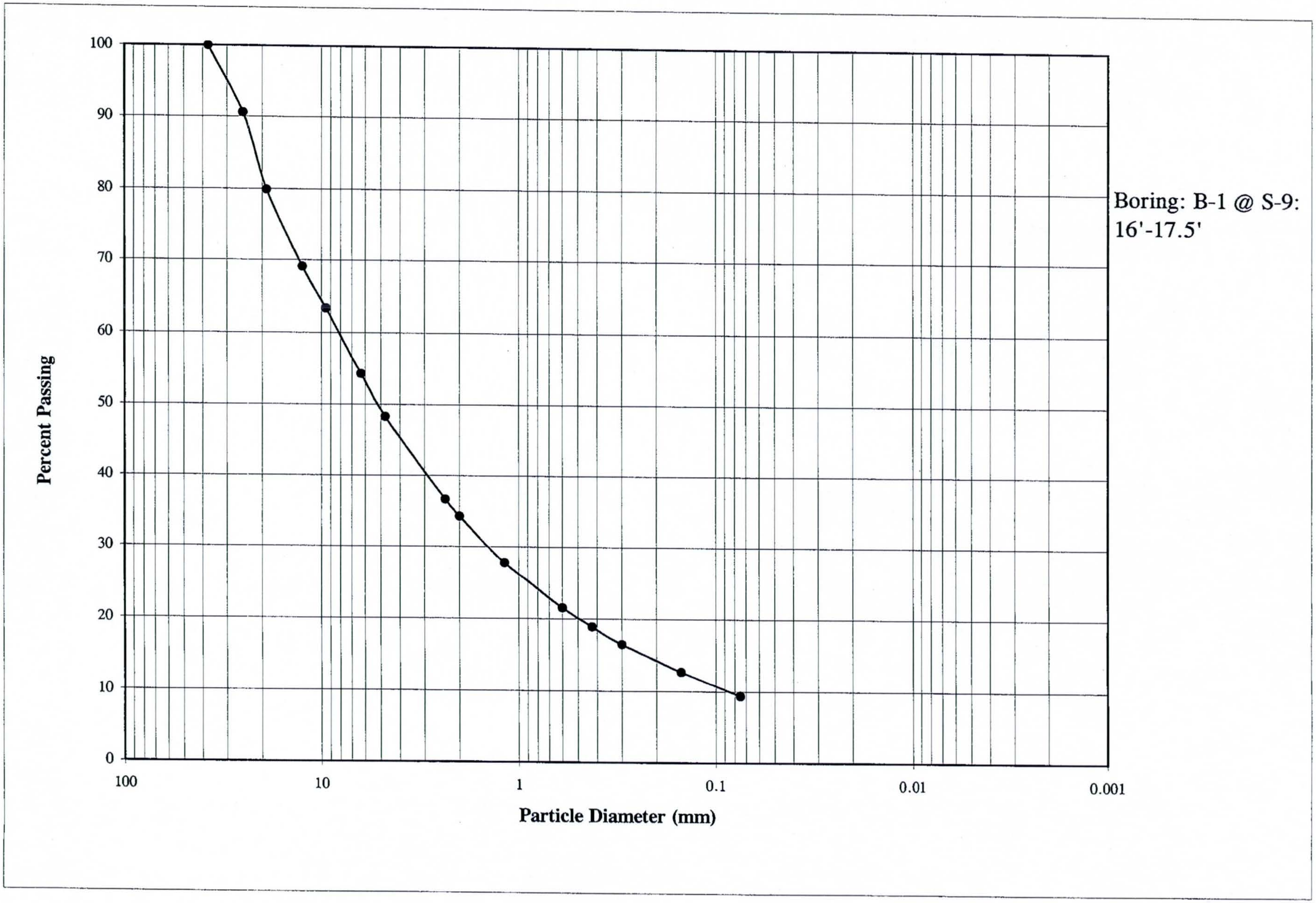


Boring: B-1 @ S-5: 8'-9.5'
Liquid Limit: N/A

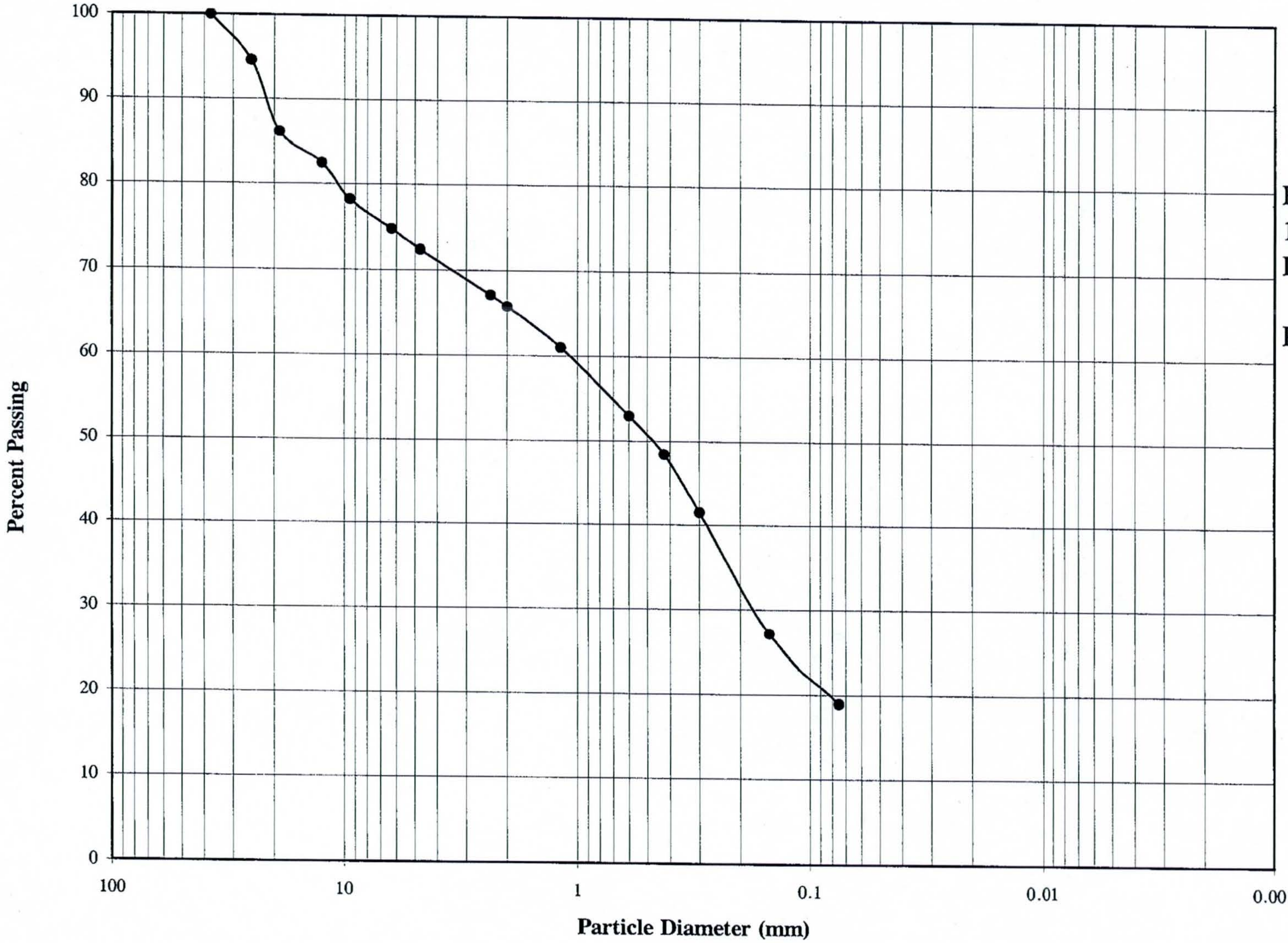
Plasticity Index: NP

RAMM Project No. G19737


100
90
80
70
60
50
40
30
20
10
0
Percent Passing
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-1 @ S-6:
10'-11.5'

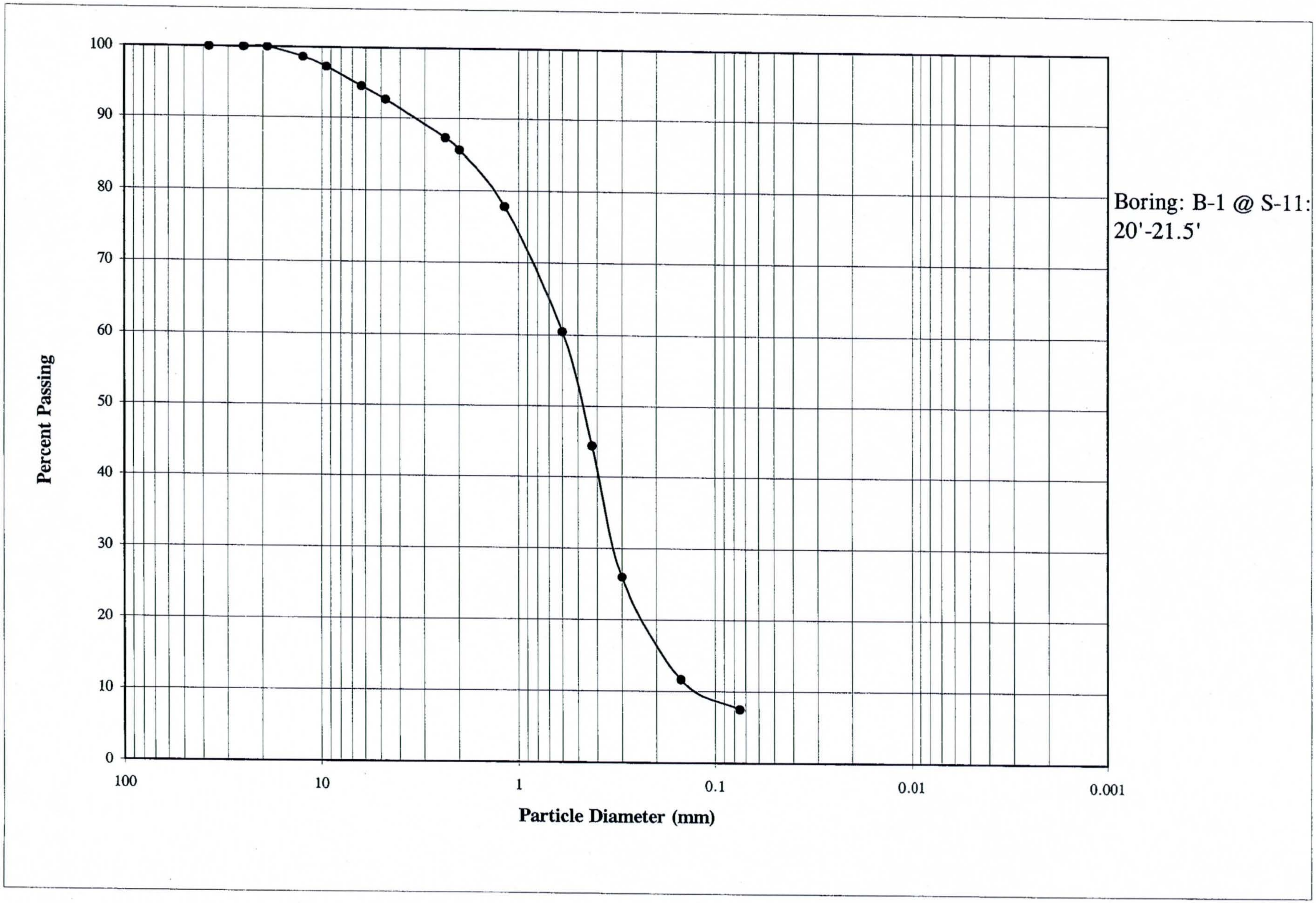


RAMM Project No. G19737



Boring: B-1 @ S-10: 18'-19.5'
Liquid Limit: N/A

Plasticity Index: NP



100
90
80
70
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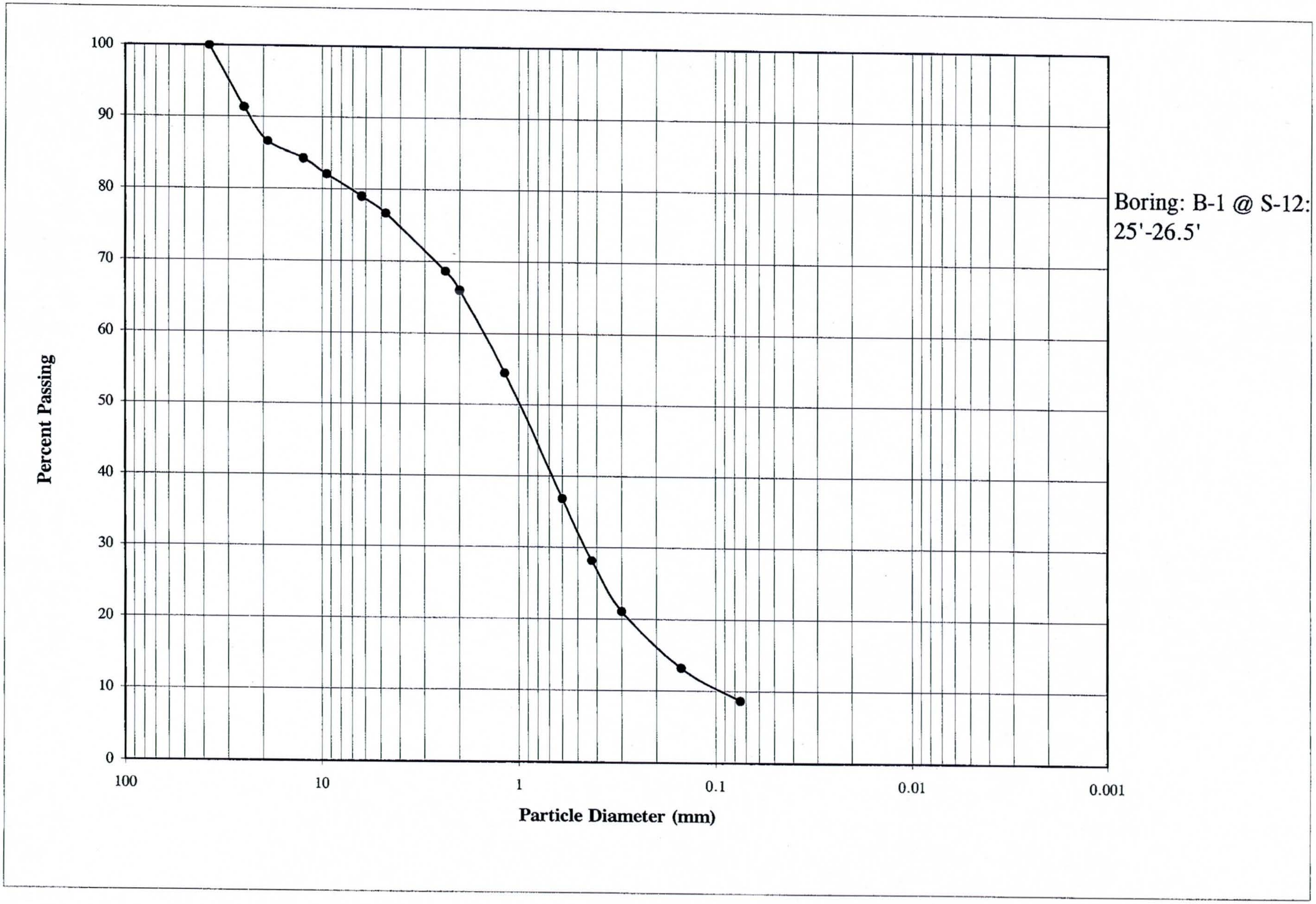
50
40
30
20
10
0
Percent Passing
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-1 @ S-11: 20'-21.5'


100
90
80
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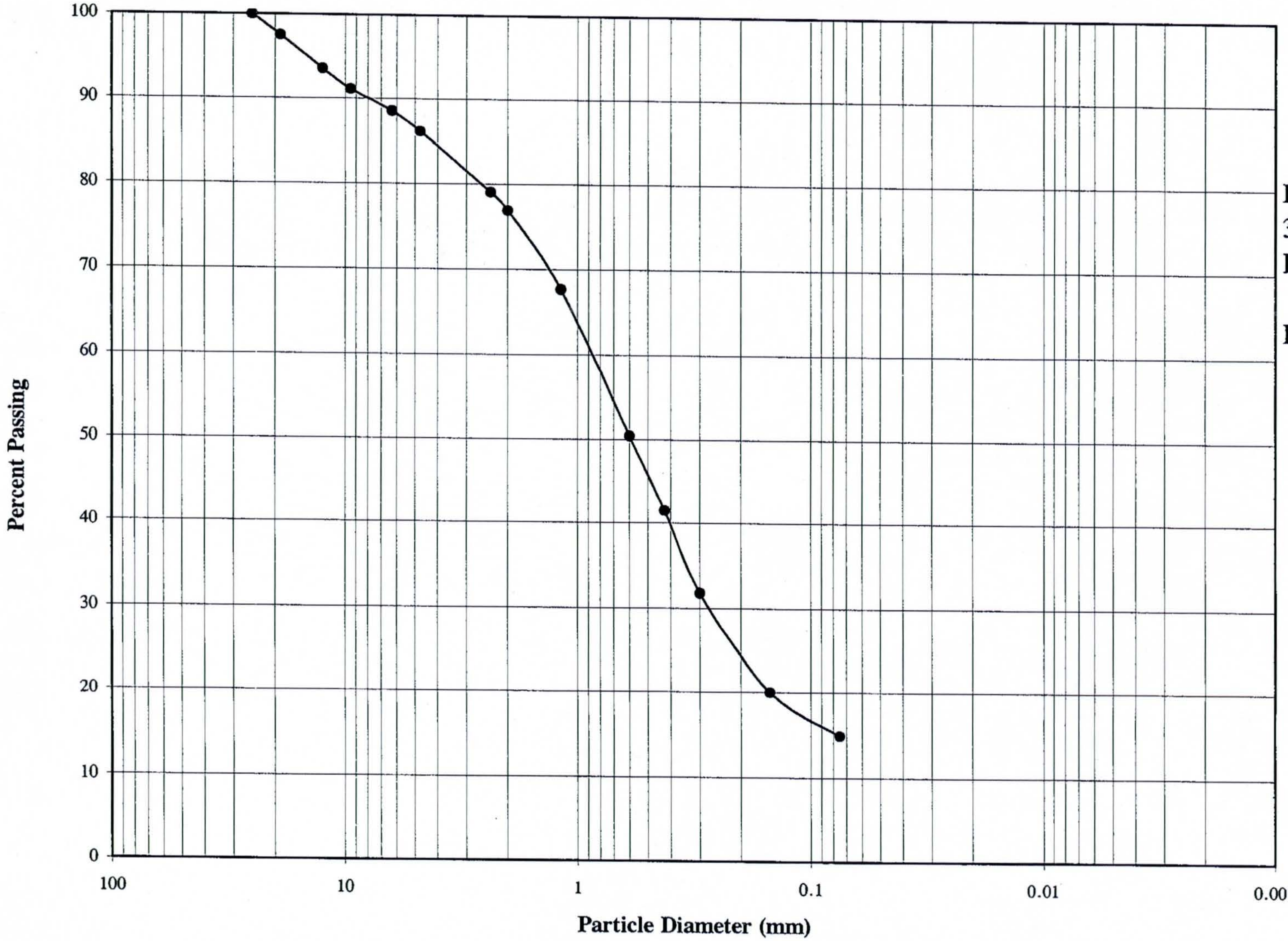
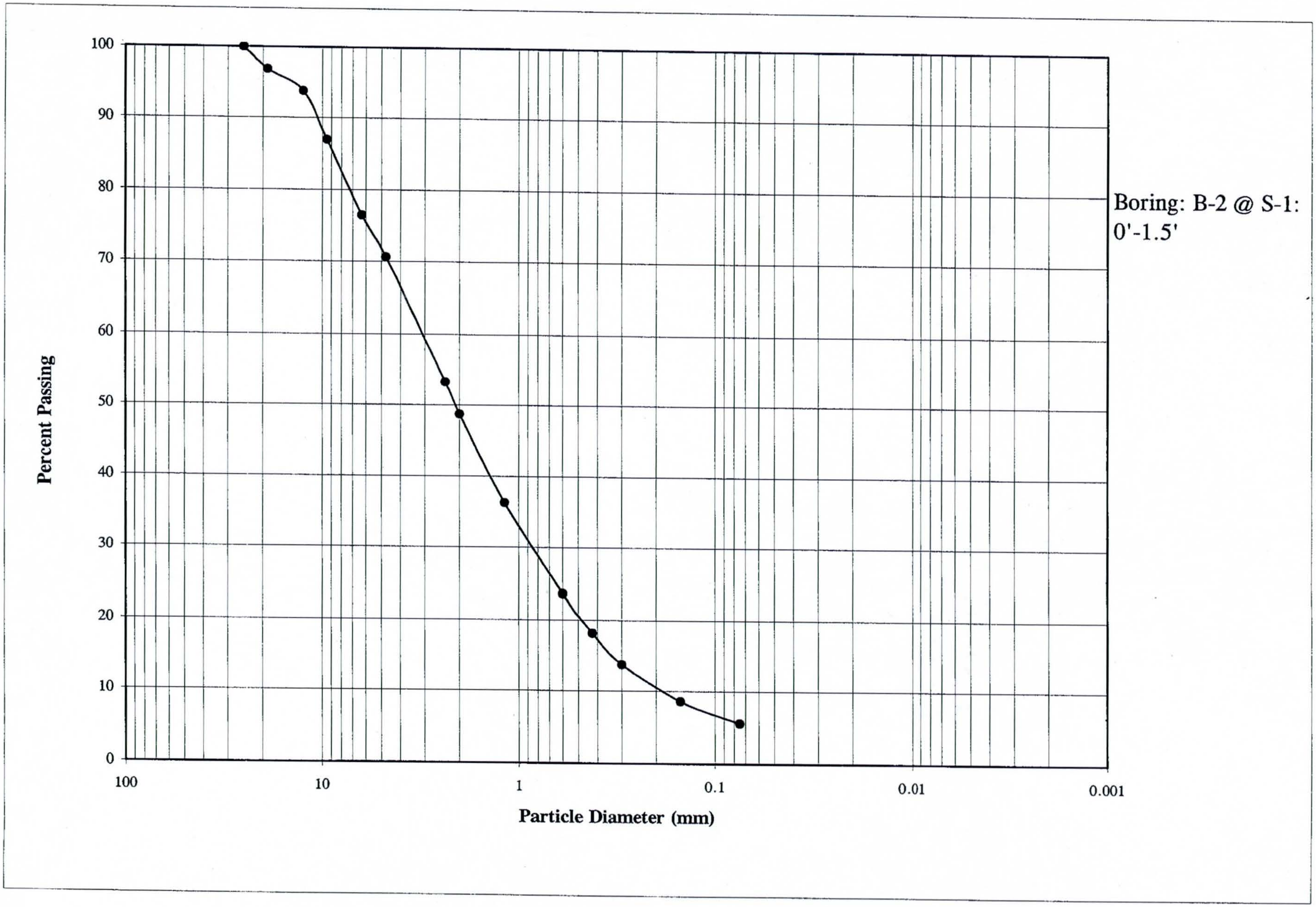
60
50
40
30
20
10
0
Percent Passing
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-1 @ S-12:
25'-26.5'

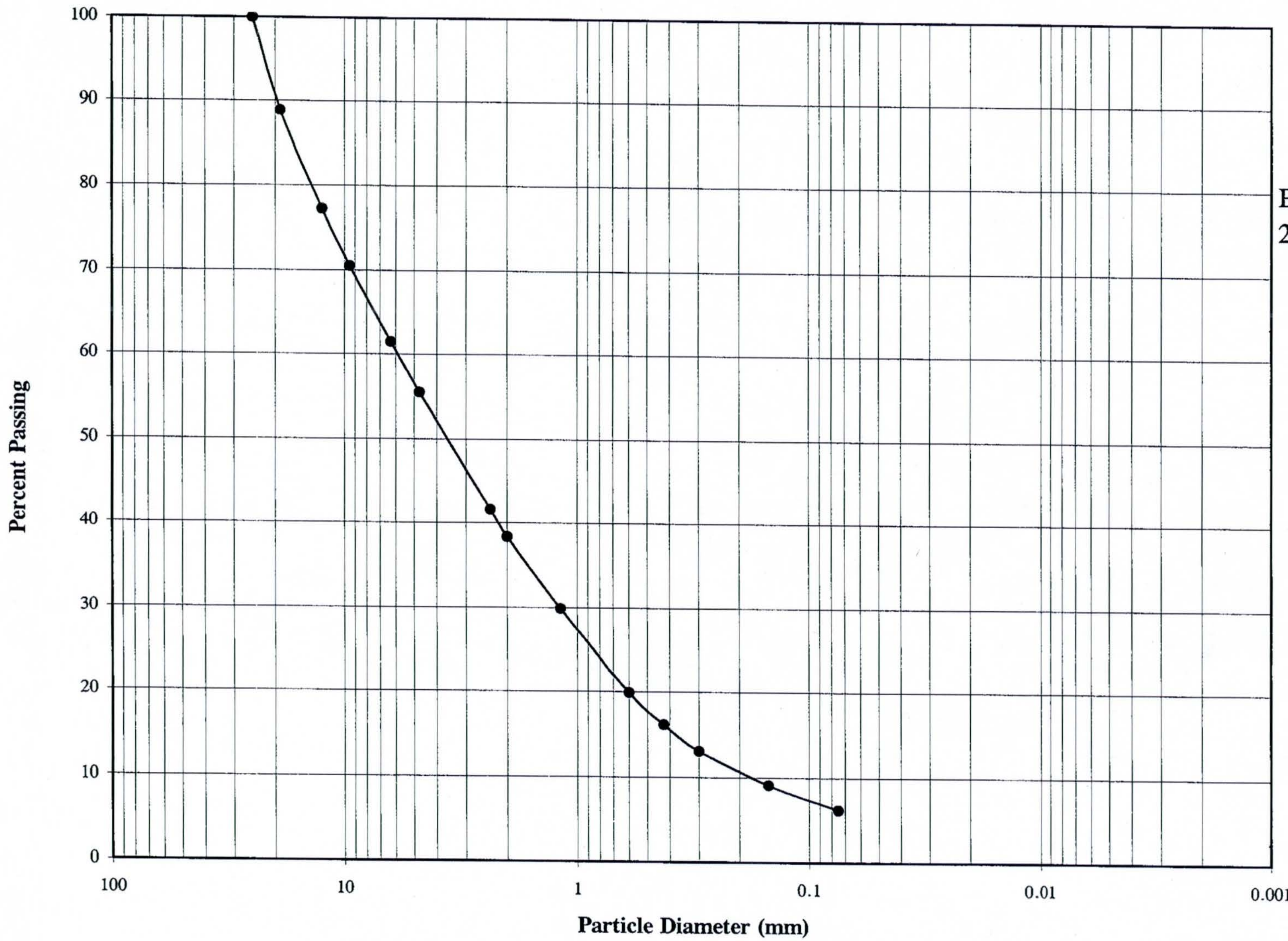


Boring: B-1 @ S-13: 30'-31.5'
Liquid Limit: N/A

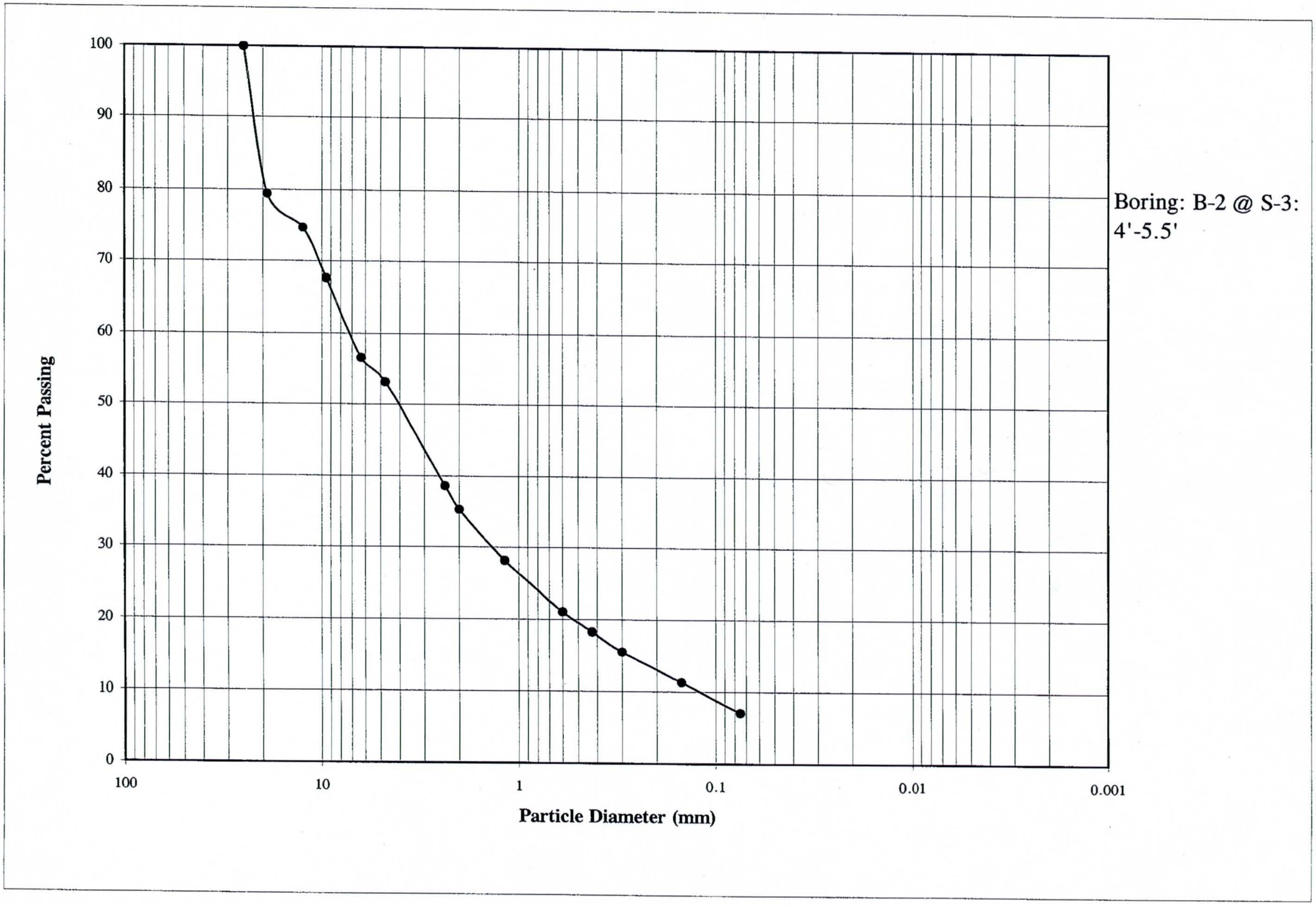
Plasticity Index: NP

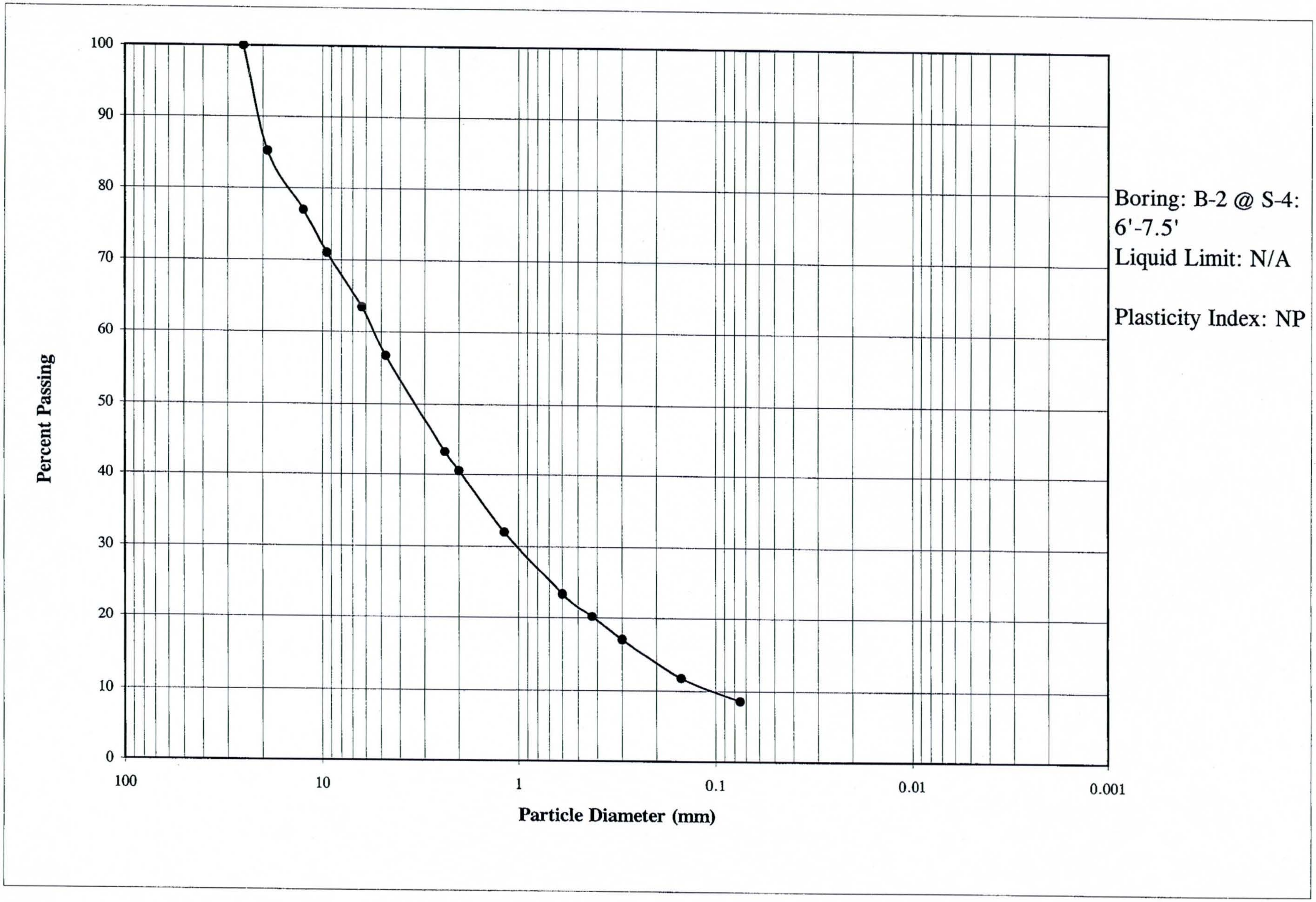


100
90
80
70
60
50
40
30
20
10
0
Percent Passing
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-2 @ S-1: 0'-1.5'

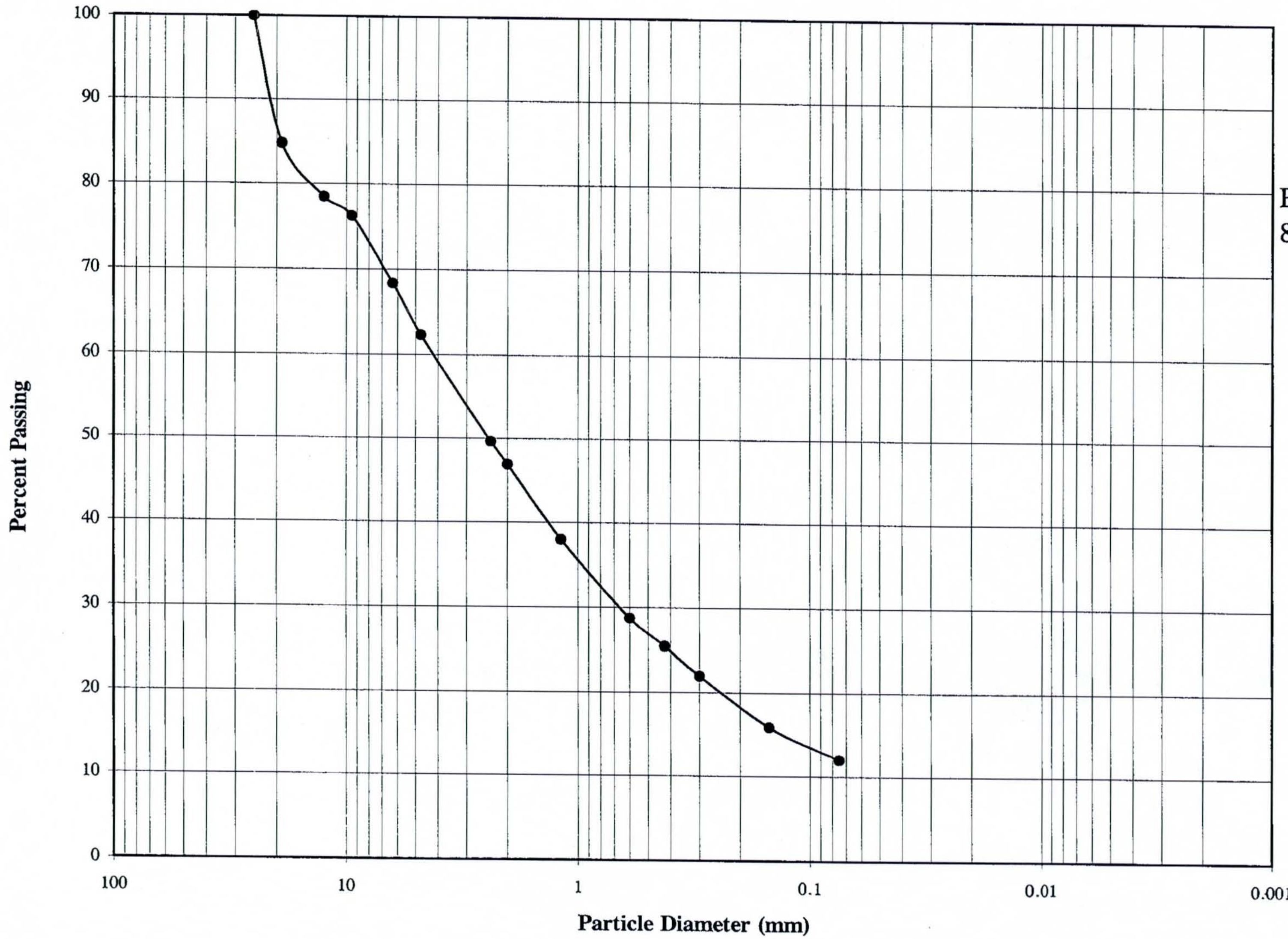


Boring: B-2 @ S-2: 2'-3.5'


Percent Passing
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-2 @ S-3: 4'-5.5'

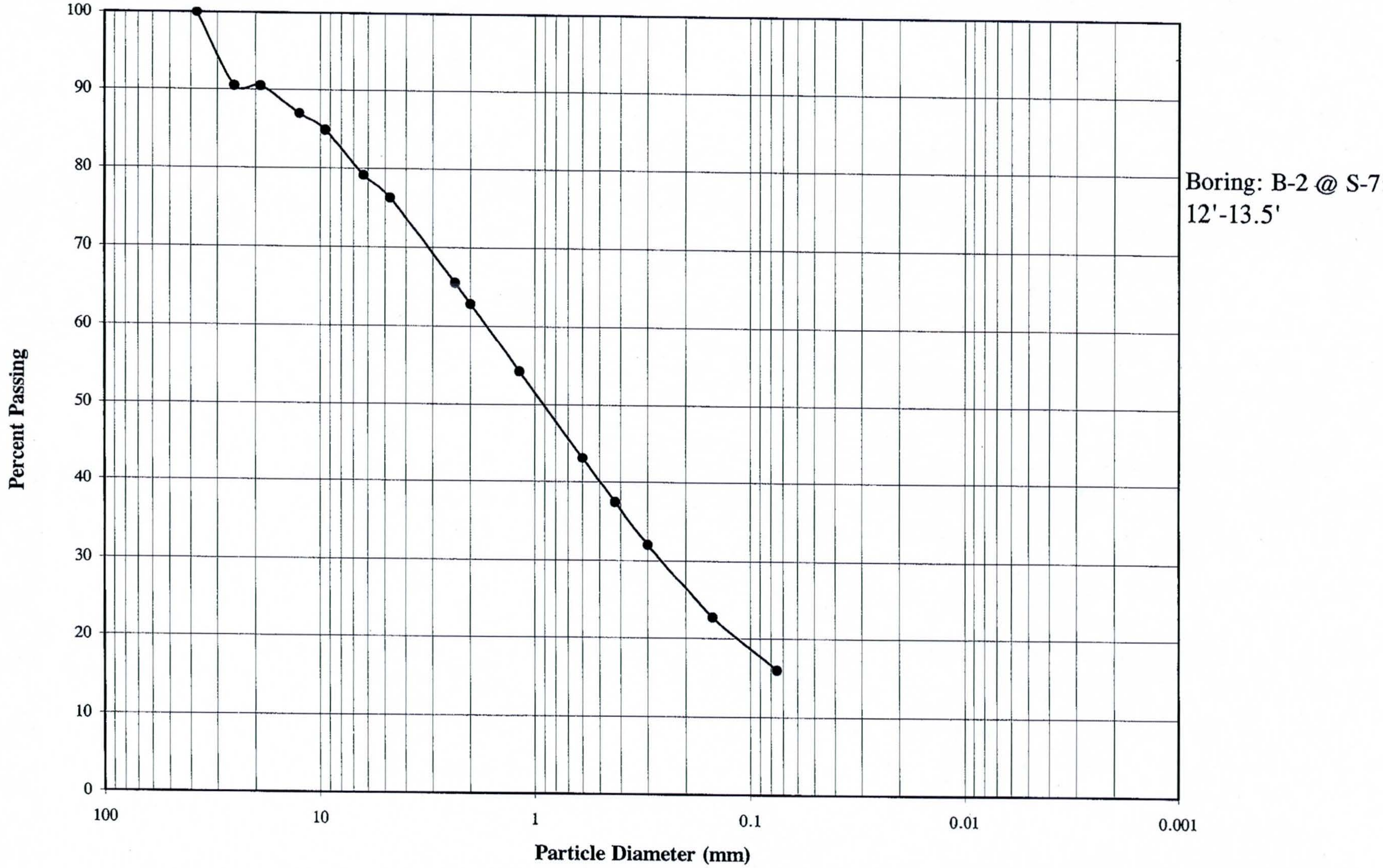


RAMM Project No. G19737

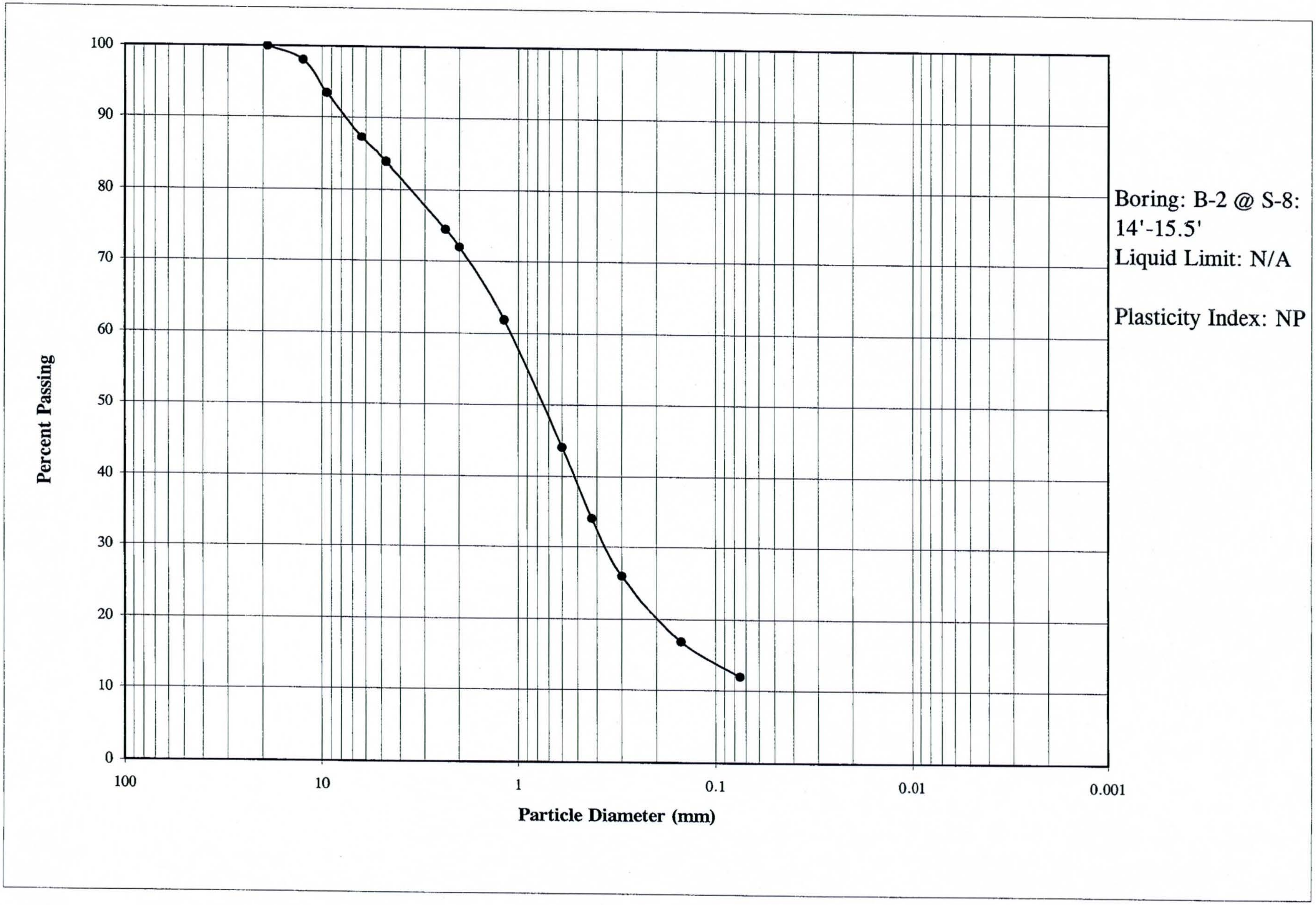


Boring: B-2 @ S-5: 8'-9.5'

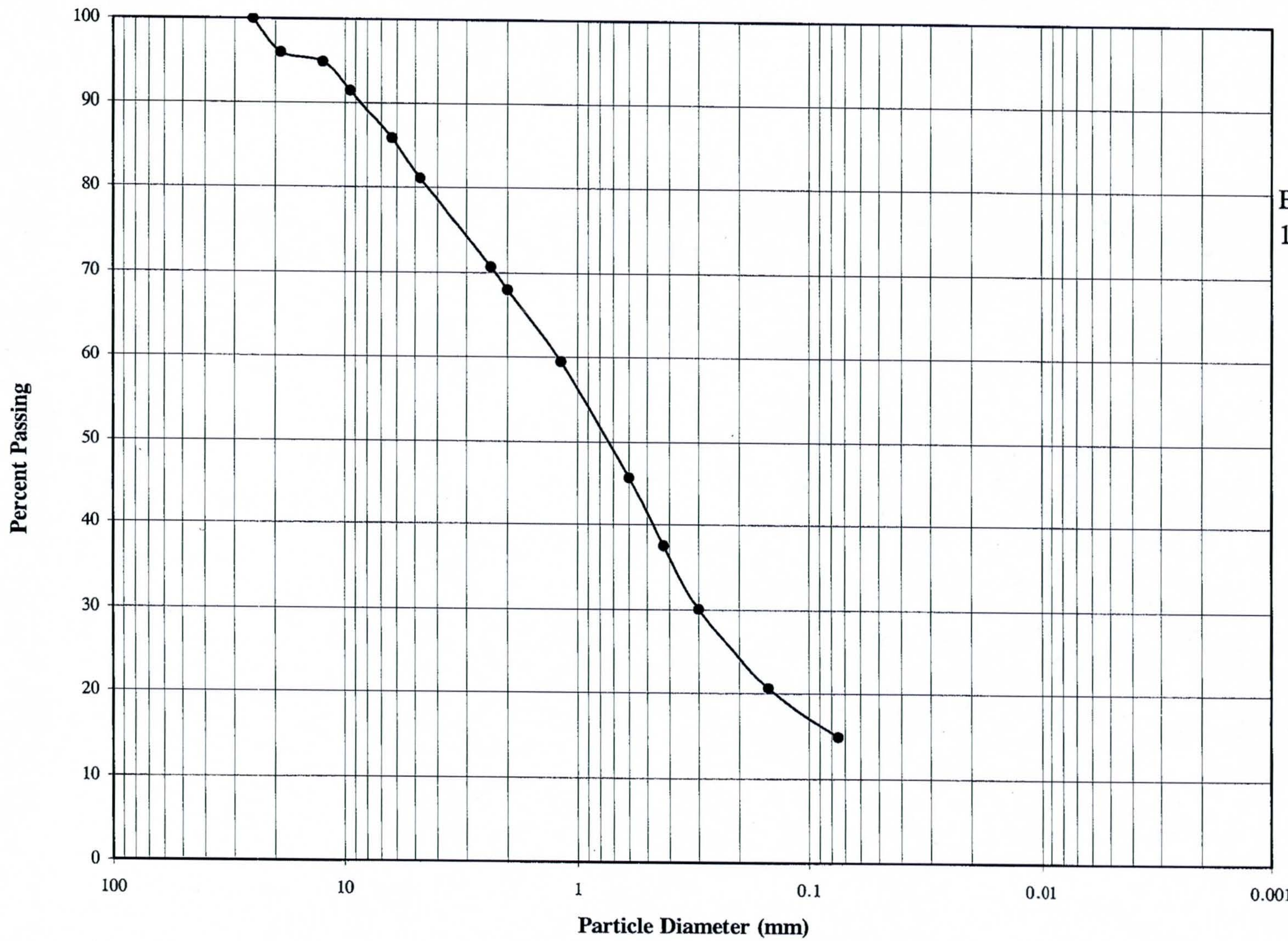
RAMM Project No. G19737



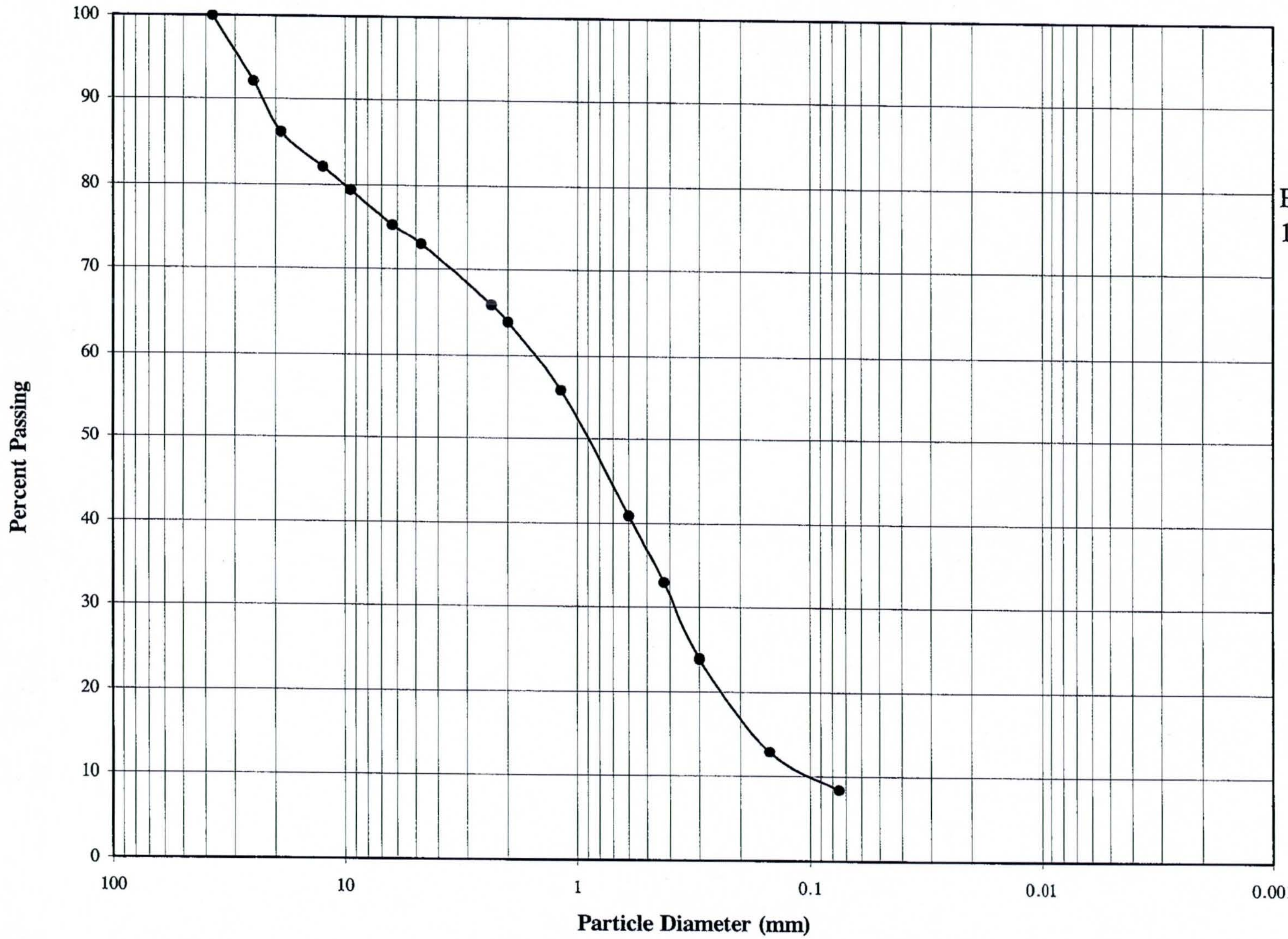
100
90
80
70
60
50
40
30
20
10
0
Percent Passing
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-2 @ S-7:
12'-13.5'



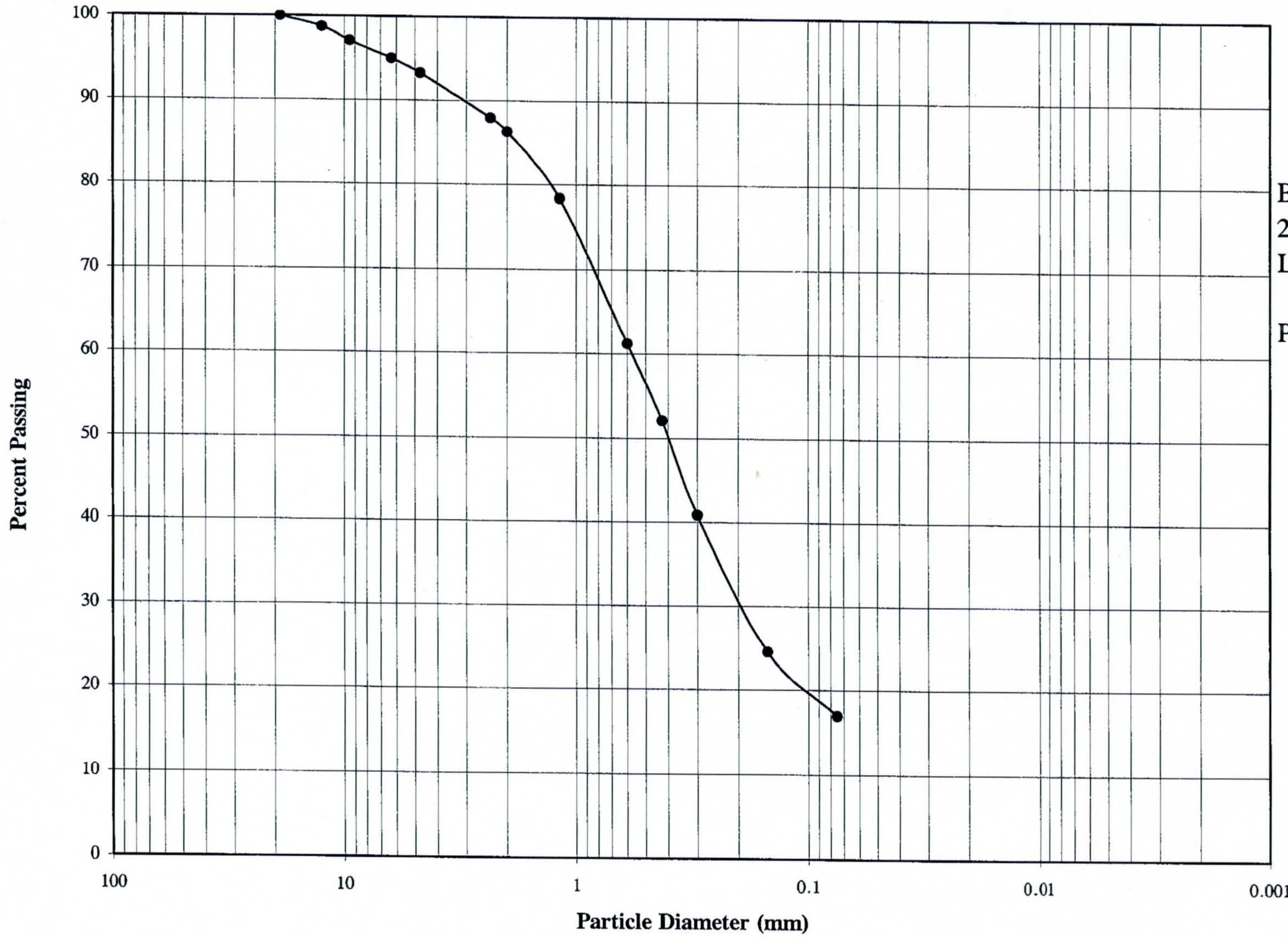
RAMM Project No. G19737



Boring: B-2 @ S-9:
16'-17.5'



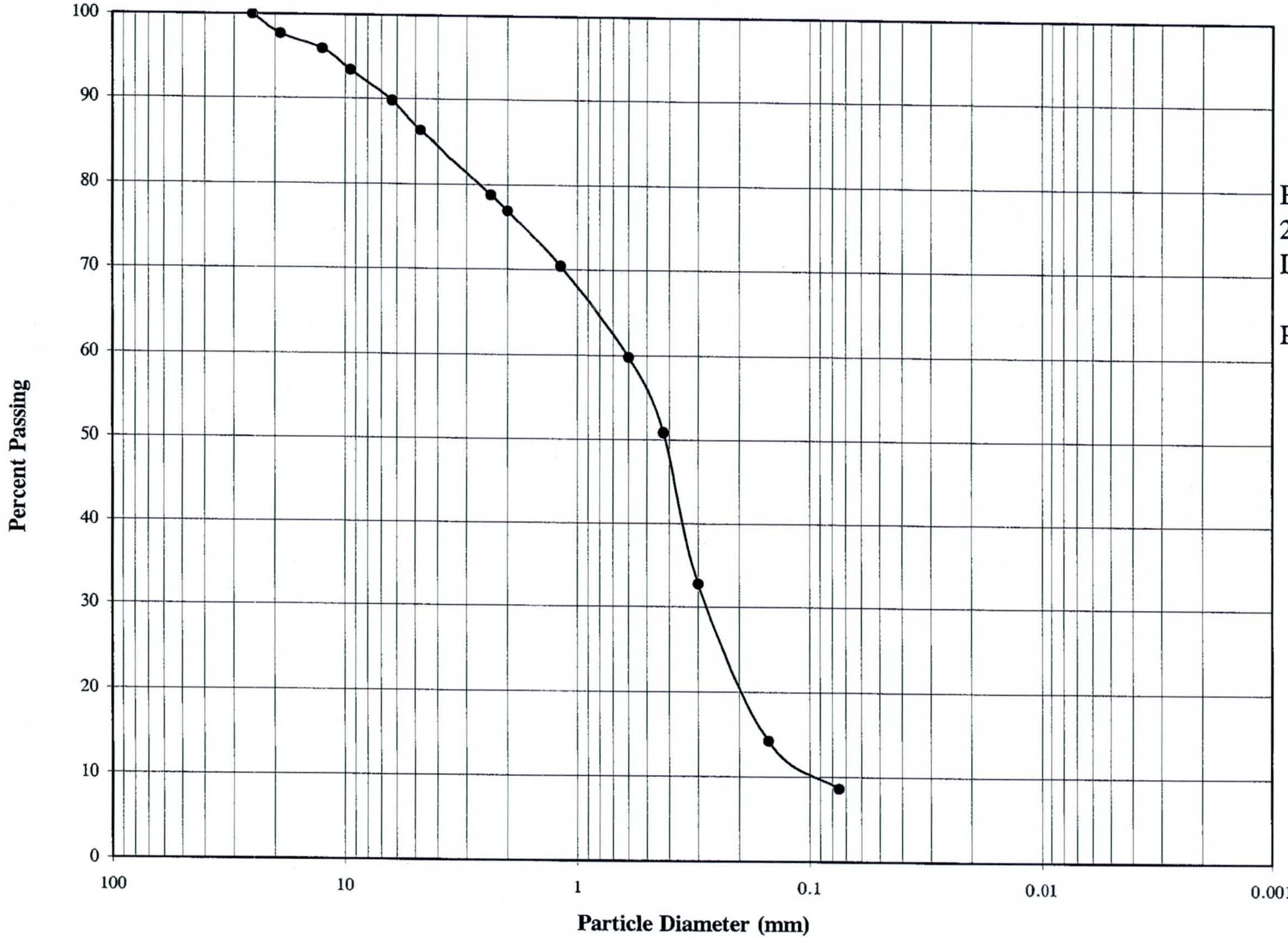
Boring: B-2 @ S-10: 18'-19.5'



Boring: B-2 @ S-11: 20'-21.5'
Liquid Limit: N/A

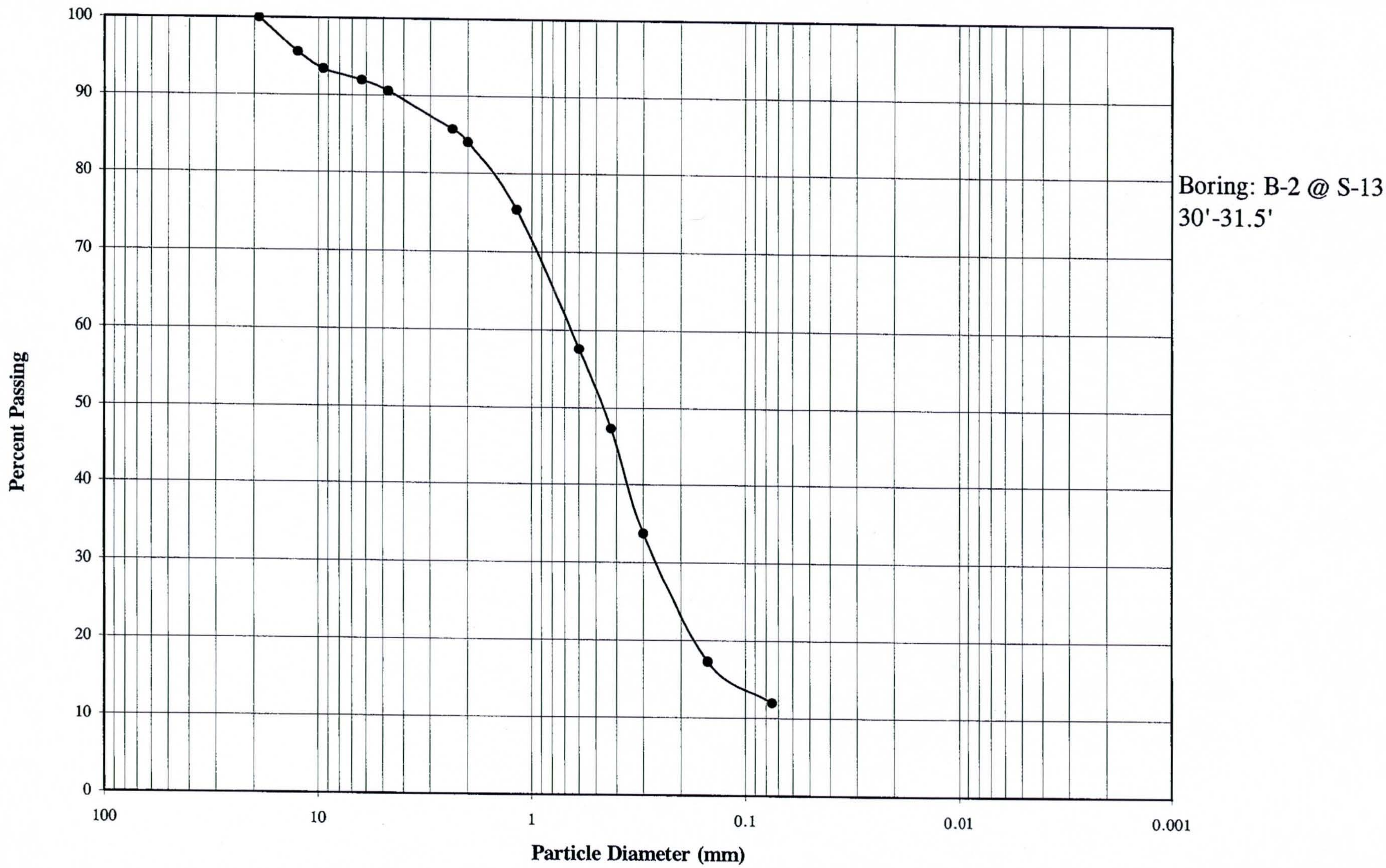
Plasticity Index: NP

RAMM Project No. G19737



Boring: B-2 @ S-12: 25'-26.5'
Liquid Limit: N/A

Plasticity Index: NP



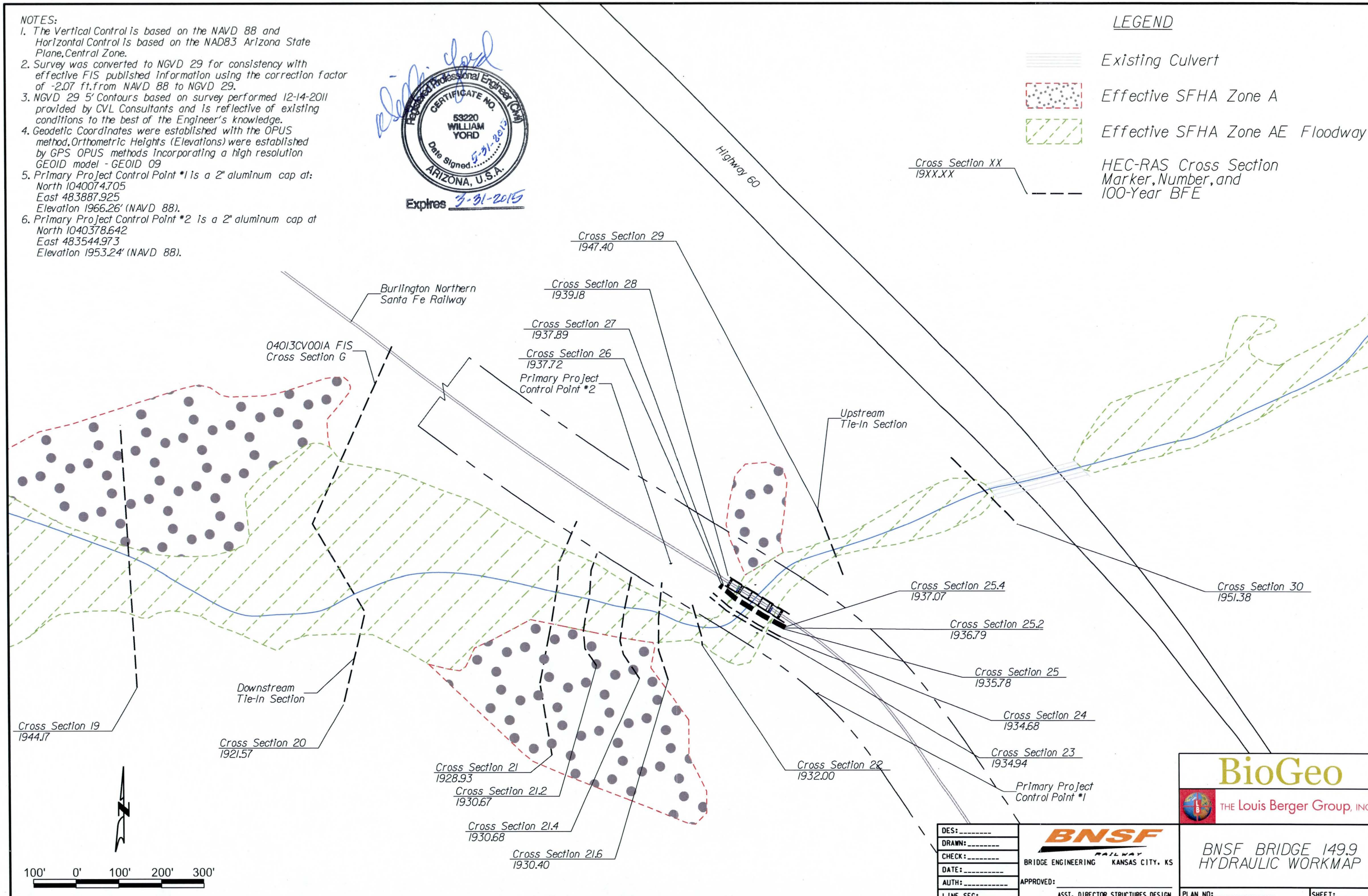
100
90
80
70
60
50
40
30
20
10
0
Percent Passing
100
10
1
0.1
0.01
0.001
Particle Diameter (mm)
Boring: B-2 @ S-13: 30'-31.5'

Exhibit Maps

NOTES:

1. The Vertical Control is based on the NAVD 88 and Horizontal Control is based on the NAD83 Arizona State Plane, Central Zone.
2. Survey was converted to NGVD 29 for consistency with effective FIS published information using the correction factor of -2.07 ft. from NAVD 88 to NGVD 29.
3. NGVD 29 5' Contours based on survey performed 12-14-2011 provided by CVL Consultants and is reflective of existing conditions to the best of the Engineer's knowledge.
4. Geodetic Coordinates were established with the OPUS method, Orthometric Heights (Elevations) were established by GPS OPUS methods incorporating a high resolution GEOID model - GEOID 09
5. Primary Project Control Point #1 is a 2" aluminum cap at:
   North 1040074.705
   East 483887.925
   Elevation 1966.26' (NAVD 88).
6. Primary Project Control Point #2 is a 2" aluminum cap at
   North 1040378.642
   East 483544.973
   Elevation 1953.24' (NAVD 88).

Registered Professional Engineer (Civil)
CERTIFICATE NO. 53220
WILLIAM YORD
Date Signed 5-31-2013
ARIZONA, U.S.A.
Expires 3-31-2015



DES:_______
DRAWN:_______
CHECK:_______
DATE:_______
AUTH:_______
LINE SEG:____

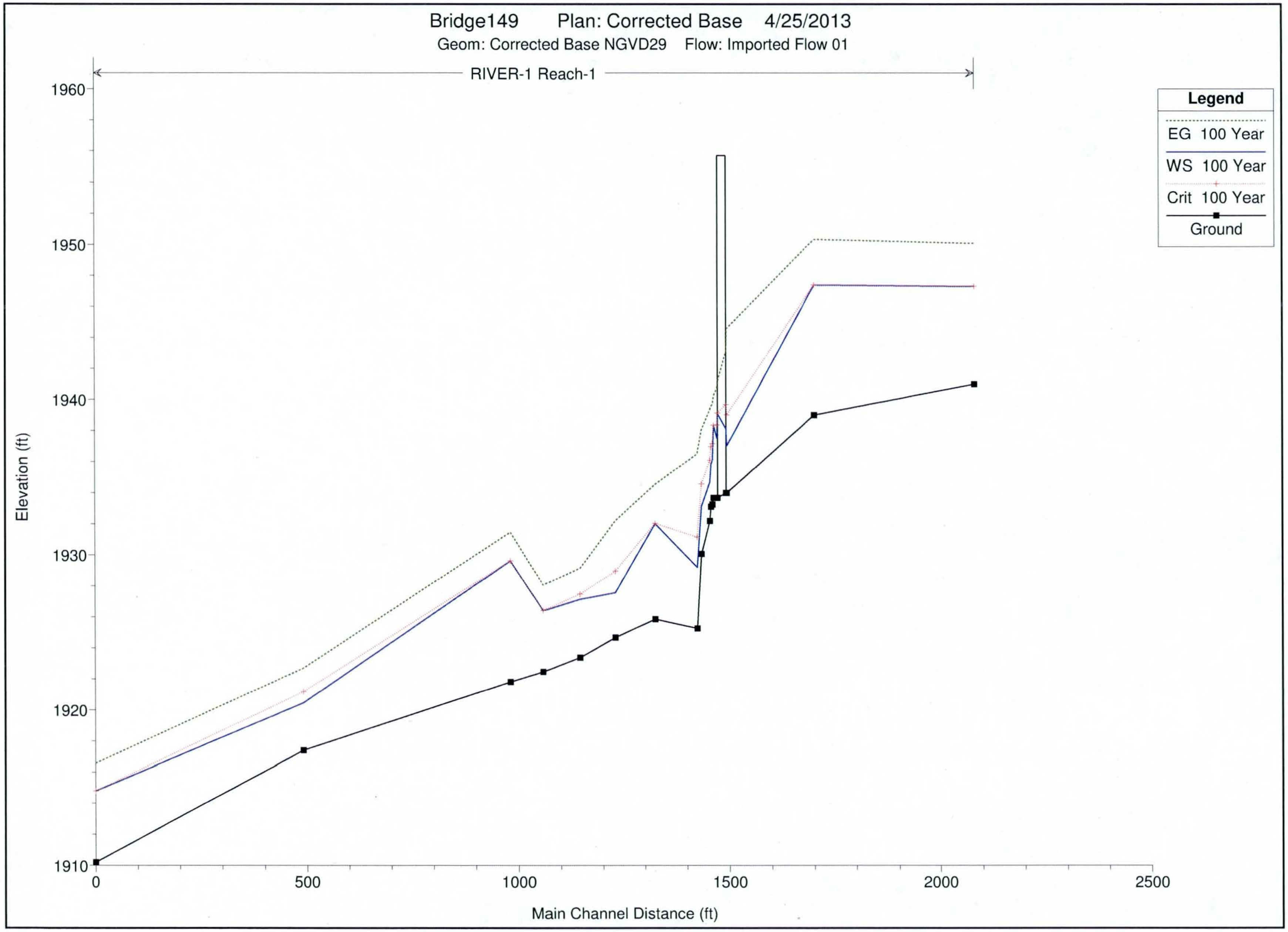
BNSF RAILWAY
BRIDGE ENGINEERING KANSAS CITY, KS
APPROVED:
ASST. DIRECTOR STRUCTURES DESIGN

BioGeo
The Louis Berger Group, INC.

BNSF BRIDGE 149.9 HYDRAULIC WORKMAP

PLAN NO:_____________ SHEET:_______

Existing Conditions Supercritical Flow Regime Profile



cHECk-RAS Report
Existing Conditions Supercritical Flow Regime

HEC-RAS Project: *bridge149clomr.prj*
Plan File: *bridge149clomr.p02*
Geometry File: *bridge149clomr.g10*
Flow File: *bridge149clomr.f01*
Report Date: *4/25/2013*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	27.5(Bridge-UP)	
BR LF 03	This is the upstream internal Bridge Section ($secno3$). The selected profile is $profilename$. Type of flow is low flow. Critical depth occurs at the BRU section. However, input BrSelMthd is not Momentum. Select Momentum as the Low Flow Method and rerun the plan.	27.5(Bridge-UP)	
FW FW 01L	The Left encroachment station is within the channel. The Left encroachment station $encrstal$ is more than left channel bank station $stalob$. The left encroachment station should be the same as the left channel bank station.	29	
FW FW 01R	The Right encroachment station is within the channel. The Right encroachment station $encrstar$ is less than right channel bank station $starob$. The right encroachment station should be the same as the right channel bank station.	29	
FW FW 03L	The left channel bank elevation of $lobelev$ is higher than the 1-percent-annual-chance WSEL of $wsel$. Relocate the left channel bank station at or below the 1-percent-annual-chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	24; 25; 25.2; 25.4; 29	

FW FW 03R	The right channel bank elevation of $robelev$ is higher than the 1-percent annual chance WSEL of $wsel$. Relocate the right channel bank station at or below the 1-percent annual chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	25; 25.2; 25.4; 26; 29	
FW FW 04L	The 1-percent-annual-chance floodplain is outside of the channel. The left station effective of $ineffstal$ for the 1-percent-annual-chance floodplain is less than the left channel bank station $stalob$. However, the left encroachment station $encstal$ is outside of the 1-percent-annual-chance floodplain. Adjust the left encroachment station so that it will be within the floodplain.	19; 20; 21; 21.6; 22; 23; 26; 30	
FW FW 04R	The 1-percent-annual-chance floodplain is outside of the channel. The right station effective of $ineffstar$ for the 1-percent-annual-chance floodplain is greater than the right channel bank station $starob$. However, the right encroachment station $encstar$ is outside of the 1-percent-annual-chance floodplain. Adjust the right encroachment station so that it will be within the floodplain.	20; 21; 21.2; 21.4; 21.6; 23; 24; 30	
FW FW 05L	The 1-percent annual chance flood is contained within the channel. The Left encroachment station $encstal$ is outside the channel. The Left channel bank station is $stalob$. Adjust the left encroachment station so that it is the same as the left channel bank station.	24; 25; 25.2; 25.4	
FW FW 05R	The 1-percent annual chance flood is contained within the channel. The Right encroachment station $encstar$ is outside the channel. Right channel bank station is $starob$. Adjust the right encroachment station so that it is the same as the right channel bank station..	25; 25.2; 25.4; 26	
FW FW 06L	The left side of the floodway boundary is within the channel. The left station effective of $ineffstal$ for the floodway profile is more than the left channel bank station of $stalob$. The left encroachment station of $encstal$ is less than the left channel bank station. Adjust the left encroachment station so that it is the same as the left channel bank station.	24; 25; 25.2; 25.4	

FW FW 06R	The right side of the floodway boundary is within the channel. The right station effective of $ineffstar$ for the floodway profile is less than the right channel bank station of $starob$. The right encroachment station of $encstar$ is more than the right channel bank station. Adjust the right encroachment station so that it is the same as the right channel bank station.	25; 25.2; 25.4; 26	
FW ST 06S3	This is Section 3 of a hydraulic structure. Negative surcharge value of $negsurchrg$ occurs at this section. Use the suggestions from the Help section such that negative surcharge value will not be less than (-0.09) foot.	28	
FW ST 08S2L	This is Section 2 of a hydraulic structure. The left encroachment station is outside the 1%-annual-chance floodplain. The left station effective of $ineffstal$ for the 1%-annual-chance profile is less than the left channel bank station of $stalob$. The 1%-annual-chance floodplain is outside the channel. The left encroachment station of $encstal$ is less than the left station effective of $ineffstal$ for the 1%-annual-chance profile. The Enc_Sta_L must be within the 1%-annual-chance floodplain.	27	
FW ST 08S2R	This is Section 2 of a hydraulic structure. The right encroachment station is outside the 1%-annual-chance floodplain. The right station effective of $ineffstar$ for the 1%-annual-chance profile is greater than the right channel bank station of $starob$. The 1%-annual-chance floodplain is outside the channel. The right encroachment station of $encstar$ is greater than the right station effective of $ineffstar$ for the 1%-annual-chance profile. The Enc_Sta_R must be within the 1%-annual-chance floodplain.	27	
FW ST 08S3R	This is Section 3 of a hydraulic structure. The right encroachment station is outside the 1%-annual-chance floodplain. The right station effective of $ineffstar$ for the 1%-annual-chance profile is greater than the right channel bank station of $starob$. The 1%-annual-chance floodplain is outside the channel. The right encroachment station of $encstar$ is greater than the right station effective of $ineffstar$ for the 1%-annual-chance profile. The Enc_Sta_R must be within the 1%-annual-chance floodplain.	28	

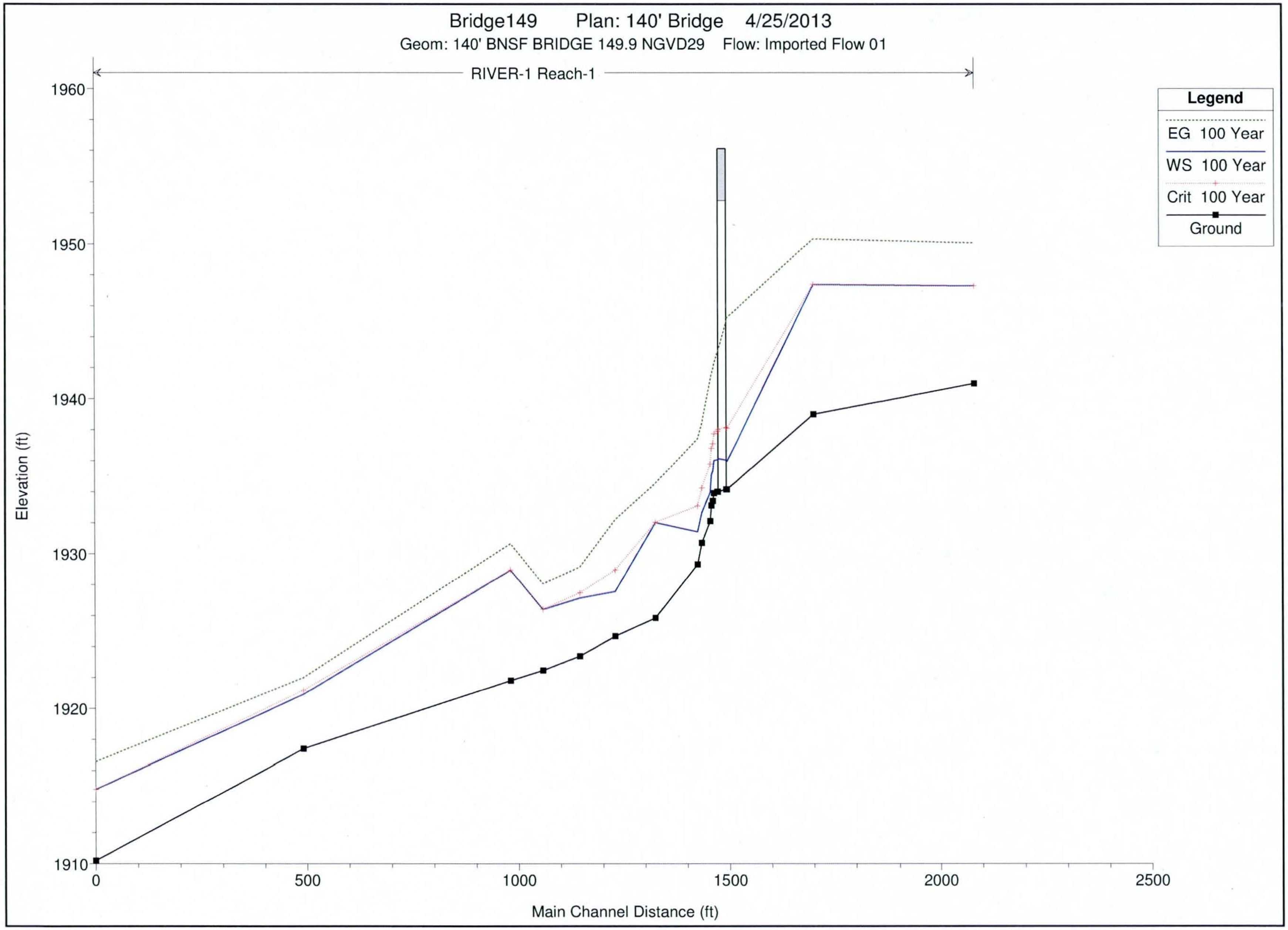
FW SW 01M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. Known WS option is used for both the 1%-annual-chance flood and floodway profiles. The floodway profile starting WSEL of $knownwsfw$ is not equal to the 1%-annual-chance flood starting WSEL of $knownws100yr$ plus the allowable surcharge value of $allowsurchrg$. The Normal Depth option with the energy slope of the 1%-annual-chance flood should be used for both profiles and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	19	
MP SW 01DD	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. The downstream starting water-surface elevation, SWSEL, is computed from different methods. SWSEL of the 50 %-annual-chance flood is computed from SW_Method. SWSEL of the 10 %-annual-chance flood is computed from SW_Method. SWSEL of the 4 %-annual-chance flood is computed from SW_Method. SWSEL of the 2 %-annual-chance flood is computed from SW_Method. SWSEL of the 1%-annual-chance flood is computed from SW_Method. SWSEL of the 0.2%-annual-chance flood is computed from SW_Method. The same method should be used for all the profiles.		
MP SW 01UD	The name of the stream is ($streamname$). The flow regime is mixed flow or supercritical. The upstream starting water-surface elevation, SWSEL, is computed from different methods.		
NT RS 02BDC	This is the Downstream Bridge Section (BRD). The channel n value of $chldn$ for the downstream internal bridge opening section is equal to or larger than the channel n value of $chl2$ at Section 2. Usually, the channel "n" value of the bridge opening section represents the area below the bridge deck and is less than the channel "n" value of Section 2. The "n" value for Section 2 represents the natural valley channel section roughness for the reach between Section 3 and Section 4. Please change the "n" value of the internal bridge opening section or provide supporting information for the use of the higher "n" value.	27.5(Bridge-DN)	

NT RS 02BUC	This is the Upstream Bridge Section (BRU). The channel n value of $chlup$ for the upstream internal bridge opening section is equal to or larger than the channel n value of $chl3$ at Section 3. Usually, the channel "n" value of the bridge opening section represents the area below the bridge deck and is less than the channel "n" value of Section 3. The "n" value for Section 3 represents the natural valley channel section roughness for the reach between Section 3 and Section 4. Please change the "n" value of the internal bridge opening section or provide supporting information for the use of a higher "n" value.	27.5(Bridge-UP)	
NT TL 01S4	This is Section 4 of a hydraulic structure. The contraction and expansion loss coefficients are cc and ce. They should be equal to 0.3 and 0.5, respectively according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010)..	29	
NT TL 02	Contraction and expansion loss coefficients are cc and ce, respectively. However, this cross section is not at a hydraulic structure. They should be equal to 0.1 and 0.3 according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010).	19; 20; 21; 22; 23; 24; 25; 30	
ST DT 01B	This is ($strucname$). 'Upstream Dist' of $distup$ in "Bridge Width Table" is less than the height of the bridge opening of $height$. This indicates that Section 3 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 3 should be relocated or provide a statement that it represents the natural valley cross section. The HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 4, 3 and 2 and 'Upstream Dist' should be adjusted.	27.5(Bridge-UP)	
ST DT 02B	This is ($strucname$). 'Downstream Dist' of $distdn$ in 'Bridge Width Table' is less than the height of the bridge opening of $height$. This indicates that Section 2 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 2 should be relocated or provide a statement that it represents the natural valley cross section. A HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 3 and 2 should be adjusted.	27.5(Bridge-DN)	

ST DT 03	This is ($Structure$) section. The Contraction Length is longer than the Expansion Length. Section 4 channel distance of $Length_Chnl4$ is longer than Section 2 channel distance of $Length_Chnl2$. Section 4 and Section 1 should be relocated. The HEC-RAS geometry file may need to be recreated using a GIS program.	27.5(Bridge-UP)	
ST IF 01S2L	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S2R	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow Station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3L	This is Section 3. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to lmntprdu of $lmntprdu$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3R	This is Section 3 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to rmntprdu of $rmntprdu$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	

XS CD 01	Critical Depth occurs at $assignedname$ flood. Flow Code will be "C". The Ineffective flow option is used. The Ineffective Flow elevation is equal to or higher than the Critical WSEL. Please investigate whether this selection is appropriate.	21	
XS DC 02	Constant discharge used for the entire profile for $assignedname$ flood. At least two discharges should be selected; one at the mouth and the other at the middle of the watershed or above the confluence of a tributary. Or provide explanation why only one discharge should be used. Other flood frequencies should also be checked.		
XS DT 01	Both the right overbank distance of rob and the left overbank distance of lob are longer than the channel distance of chl . Please review the creation of left overbank, channel and right overbank distances. The HEC-RAS geometry file may need to be recreated using a GIS program. Please resolve the differences among the distances.	20	
XS FR 01	The profile is computed as supercritical flow regime. It is acceptable if the entire stream is an engineered channel. For Flood Insurance Studies a subcritical flow regime should be selected, for natural streams. Mixed flow regime should be selected if part of the stream is an engineered channel. The flow regime should be changed appropriately or justify the selection of supercritical flow regime.		

Proposed Condition Supercritical Flow Regime Profile



cHECk-RAS Report
Proposed Conditions Supercritical Flow Regime

HEC-RAS Project: *bridge149clomr.prj*
Plan File: *bridge149clomr.p01*
Geometry File: *bridge149clomr.g11*
Flow File: *bridge149clomr.f01*
Report Date: *4/25/2013*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	27.5(Bridge-UP)	
FW FW 01L	The Left encroachment station is within the channel. The Left encroachment station $encrstal$ is more than left channel bank station $stalob$. The left encroachment station should be the same as the left channel bank station.	21; 23; 24; 25.4; 26; 29	
FW FW 01R	The Right encroachment station is within the channel. The Right encroachment station $encrstar$ is less than right channel bank station $starob$. The right encroachment station should be the same as the right channel bank station.	23; 25.4; 29	
FW FW 03L	The left channel bank elevation of $lobelev$ is higher than the 1-percent-annual-chance WSEL of $wsel$. Relocate the left channel bank station at or below the 1-percent-annual-chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	21; 23; 24; 25; 25.2; 25.4; 26; 29	
FW FW 03R	The right channel bank elevation of $robelev$ is higher than the 1-percent annual chance WSEL of $wsel$. Relocate the right channel bank station at or below the 1-percent annual chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	23; 24; 25; 25.2; 25.4; 26; 29	

FW FW 04L	The 1-percent-annual-chance floodplain is outside of the channel. The left station effective of $ineffstal$ for the 1-percent-annual-chance floodplain is less than the left channel bank station $stalob$. However, the left encroachment station $encstal$ is outside of the 1-percent-annual-chance floodplain. Adjust the left encroachment station so that it will be within the floodplain.	19; 20; 21.6; 22; 30	
FW FW 04R	The 1-percent-annual-chance floodplain is outside of the channel. The right station effective of $ineffstar$ for the 1-percent-annual-chance floodplain is greater than the right channel bank station $starob$. However, the right encroachment station $encstar$ is outside of the 1-percent-annual-chance floodplain. Adjust the right encroachment station so that it will be within the floodplain.	20; 21; 21.2; 21.4; 21.6; 30	
FW FW 05L	The 1-percent annual chance flood is contained within the channel. The Left encroachment station $encstal$ is outside the channel. The Left channel bank station is $stalob$. Adjust the left encroachment station so that it is the same as the left channel bank station.	25; 25.2	
FW FW 05R	The 1-percent annual chance flood is contained within the channel. The Right encroachment station $encstar$ is outside the channel. Right channel bank station is $starob$. Adjust the right encroachment station so that it is the same as the right channel bank station..	24; 25; 25.2; 26	
FW FW 06L	The left side of the floodway boundary is within the channel. The left station effective of $ineffstal$ for the floodway profile is more than the left channel bank station of $stalob$. The left encroachment station of $encstal$ is less than the left channel bank station. Adjust the left encroachment station so that it is the same as the left channel bank station.	25; 25.2	
FW FW 06R	The right side of the floodway boundary is within the channel. The right station effective of $ineffstar$ for the floodway profile is less than the right channel bank station of $starob$. The right encroachment station of $encstar$ is more than the right channel bank station. Adjust the right encroachment station so that it is the same as the right channel bank station.	24; 25; 25.2; 26	
FW ST 04BDR	This is ($strucname$) downstream internal section. The right encroachment station is within the channel. The right encroachment station of $encstar$ is less than the right bank station of $starob$. The right encroachment station should be the same as the right channel bank station.	27.5(Bridge-DN)	

FW ST 04S2L	This is Section 2 of a hydraulic structure. The left encroachment station is within the channel. The left encroachment station of $encstal$ is greater than the left bank station of $stalob$. The left encroachment station should be the same as the left channel bank station.	27	
FW ST 04S2R	This is Section 2 of a hydraulic structure. The right encroachment station is within the channel. The right encroachment station of $encstar$ is less than the right bank station of $starob$. The right encroachment station should be the same as right channel bank station.	27	
FW ST 04S3L	This is Section 3 of a hydraulic structure. The Left Channel Bank station is outside the Left Abutment station. The left encroachment station is within the channel. The left encroachment station of $encstal$ is greater than the left bank station of $stalob$. The left encroachment station should be the same as the left channel bank station.	28	
FW ST 04S3R	This is Section 3 of a hydraulic structure. The right encroachment station is within the channel. The right encroachment station of $encstar$ is less than the right bank station of $starob$. The right encroachment station should be the same as the right channel bank station.	28	
FW ST 06S3	This is Section 3 of a hydraulic structure. Negative surcharge value of $negsurchrg$ occurs at this section. Use the suggestions from the Help section such that negative surcharge value will not be less than (-0.09) foot.	28	
FW SW 01M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. Known WS option is used for both the 1%-annual-chance flood and floodway profiles. The floodway profile starting WSEL of $knownwsfw$ is not equal to the 1%-annual-chance flood starting WSEL of $knownws100yr$ plus the allowable surcharge value of $allowsurchrg$. The Normal Depth option with the energy slope of the 1%-annual-chance flood should be used for both profiles and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	19	

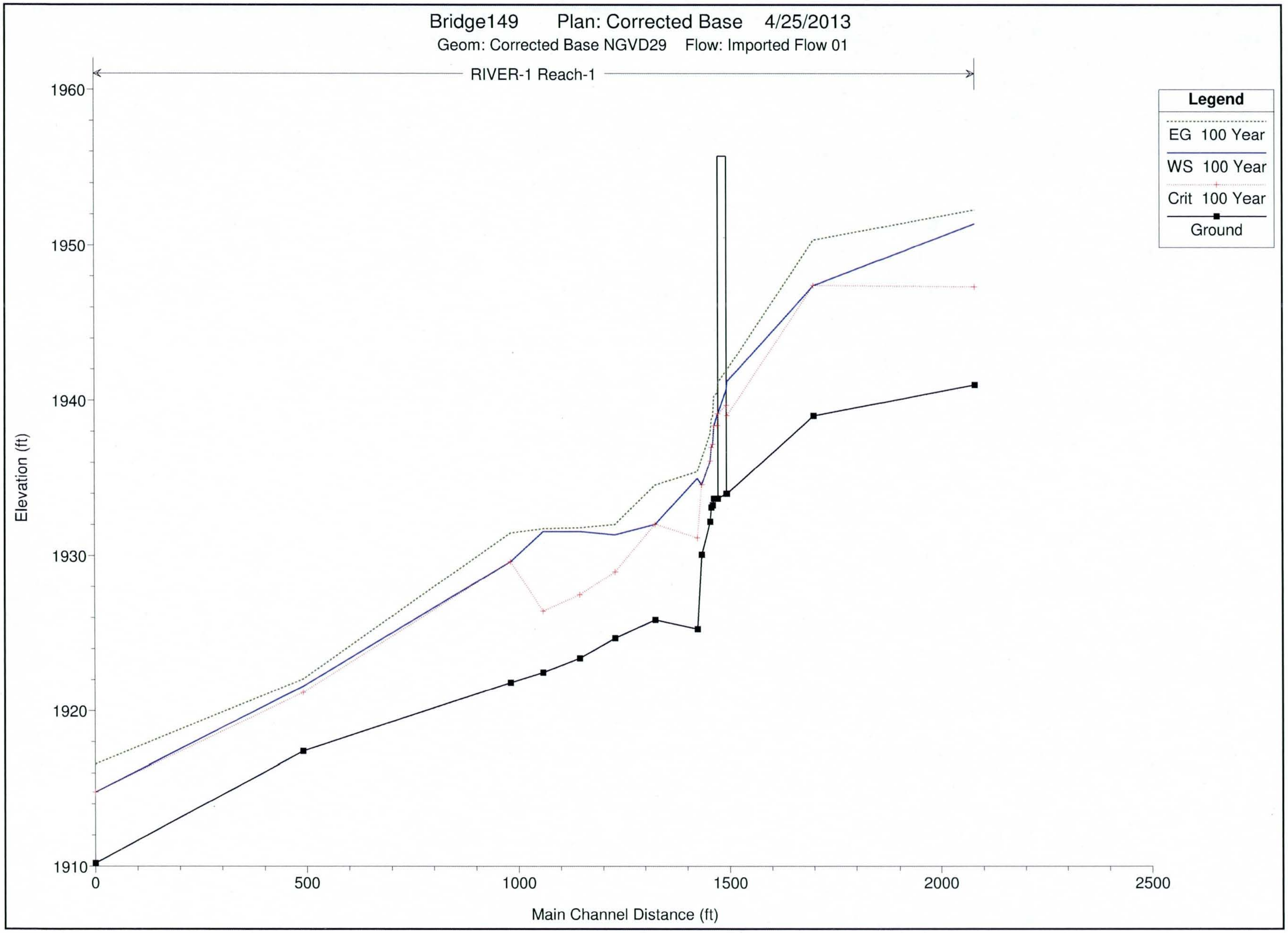
MP SW 01DD	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. The downstream starting water-surface elevation, SWSEL, is computed from different methods. SWSEL of the 50 %-annual-chance flood is computed from SW_Method. SWSEL of the 10 %-annual-chance flood is computed from SW_Method. SWSEL of the 4 %-annual-chance flood is computed from SW_Method. SWSEL of the 2 %-annual-chance flood is computed from SW_Method. SWSEL of the 1%-annual-chance flood is computed from SW_Method. SWSEL of the 0.2%-annual-chance flood is computed from SW_Method. The same method should be used for all the profiles.		
MP SW 01UD	The name of the stream is ($streamname$). The flow regime is mixed flow or supercritical. The upstream starting water-surface elevation, SWSEL, is computed from different methods.		
NT RS 01S2C	This is Section 2 of a hydraulic structure. Channel n value of $chl2$ is less than the channel n value of $chl1$ at Section 1. Normally the channel "n" value at Section 2 represents the reach between Section 2 and Section 1, and is higher than the "n" value within the hydraulic structure. Please change the "n" value or provide supporting information for the use of the lower "n" value.	27	
NT RS 01S3C	This is Section 3 of a hydraulic structure. Channel n value of $chl3$ is less than the channel n value of $chl4$ at Section 4. Normally the channel "n" value at Section 3 represents the reach between Section 3 and Section 4, and is higher than the "n" value within the hydraulic structure. Please change the "n" value or provide supporting information for the use of the lower "n" value.	28	
NT RS 02BUC	This is the Upstream Bridge Section (BRU). The channel n value of $chlup$ for the upstream internal bridge opening section is equal to or larger than the channel n value of $chl3$ at Section 3. Usually, the channel "n" value of the bridge opening section represents the area below the bridge deck and is less than the channel "n" value of Section 3. The "n" value for Section 3 represents the natural valley channel section roughness for the reach between Section 3 and Section 4. Please change the "n" value of the internal bridge opening section or provide supporting information for the use of a higher "n" value.	27.5(Bridge-UP)	

NT TL 01S4	This is Section 4 of a hydraulic structure. The contraction and expansion loss coefficients are \$cc\$ and \$ce\$. They should be equal to 0.3 and 0.5, respectively according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010)..	29	
NT TL 02	Contraction and expansion loss coefficients are \$cc\$ and \$ce\$, respectively. However, this cross section is not at a hydraulic structure. They should be equal to 0.1 and 0.3 according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010).	19; 20; 21; 22; 23; 24; 25; 30	
ST DT 01B	This is (\$strucname\$). 'Upstream Dist' of \$distup\$ in "Bridge Width Table" is less than the height of the bridge opening of \$height\$. This indicates that Section 3 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 3 should be relocated or provide a statement that it represents the natural valley cross section. The HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 4, 3 and 2 and 'Upstream Dist' should be adjusted.	27.5(Bridge-UP)	
ST DT 02B	This is (\$strucname\$). 'Downstream Dist' of \$distdn\$ in 'Bridge Width Table' is less than the height of the bridge opening of \$height\$. This indicates that Section 2 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 2 should be relocated or provide a statement that it represents the natural valley cross section. A HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 3 and 2 should be adjusted.	27.5(Bridge-DN)	
ST DT 03	This is (\$Structure\$) section. The Contraction Length is longer than the Expansion Length. Section 4 channel distance of \$Length_Chnl4\$ is longer than Section 2 channel distance of \$Length_Chnl2\$. Section 4 and Section 1 should be relocated. The HEC-RAS geometry file may need to be recreated using a GIS program.	27.5(Bridge-UP)	
ST GD 06	Left and/or right abutment station computed by the cHECk-RAS program is equal to zero. cHECk-RAS cannot evaluate this structure.	27.5(Bridge)	

ST IF 01S2L	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S2R	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow Station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3L	This is Section 3. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to lmntprdu of $lmntprdu$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3R	This is Section 3 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to rmntprdu of $rmntprdu$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
XS CD 01	Critical Depth occurs at $assignedname$ flood. Flow Code will be "C". The Ineffective flow option is used. The Ineffective Flow elevation is equal to or higher than the Critical WSEL. Please investigate whether this selection is appropriate.	21	

XS DC 02	Constant discharge used for the entire profile for $assignedname$ flood. At least two discharges should be selected; one at the mouth and the other at the middle of the watershed or above the confluence of a tributary. Or provide explanation why only one discharge should be used. Other flood frequencies should also be checked.		
XS DT 01	Both the right overbank distance of rob and the left overbank distance of lob are longer than the channel distance of chl . Please review the creation of left overbank, channel and right overbank distances. The HEC-RAS geometry file may need to be recreated using a GIS program. Please resolve the differences among the distances.	20	
XS FR 01	The profile is computed as supercritical flow regime. It is acceptable if the entire stream is an engineered channel. For Flood Insurance Studies a subcritical flow regime should be selected, for natural streams. Mixed flow regime should be selected if part of the stream is an engineered channel. The flow regime should be changed appropriately or justify the selection of supercritical flow regime.		
XS IF 03L	The Left Ineffective Flow Station is within the channel. The Left Ineffective Flow Station of $ineffstal$ is greater than the LeftBankSta of $bankstal$. The Left Ineffective Flow Station or the LeftBankSta should be adjusted.	21	

Existing Conditions Subcritical Flow Regime Profile



cHECk-RAS Report
Existing Conditions Subcritical Flow Regime

HEC-RAS Project: *bridge149clomr.prj*
Plan File: *bridge149clomr.p02*
Geometry File: *bridge149clomr.g10*
Flow File: *bridge149clomr.f01*
Report Date: *4/25/2013*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	27.5(Bridge-UP)	
FW FW 01L	The Left encroachment station is within the channel. The Left encroachment station $encrstal$ is more than left channel bank station $stalob$. The left encroachment station should be the same as the left channel bank station.	29	
FW FW 01R	The Right encroachment station is within the channel. The Right encroachment station $encrstar$ is less than right channel bank station $starob$. The right encroachment station should be the same as the right channel bank station.	29	
FW FW 03L	The left channel bank elevation of $lobelev$ is higher than the 1-percent-annual-chance WSEL of $wsel$. Relocate the left channel bank station at or below the 1-percent-annual-chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	25; 25.2; 29	
FW FW 03R	The right channel bank elevation of $robelev$ is higher than the 1-percent annual chance WSEL of $wsel$. Relocate the right channel bank station at or below the 1-percent annual chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	25; 25.2; 26; 29	

FW FW 04L	The 1-percent-annual-chance floodplain is outside of the channel. The left station effective of $ineffstal$ for the 1-percent-annual-chance floodplain is less than the left channel bank station $stalob$. However, the left encroachment station $encstal$ is outside of the 1-percent-annual-chance floodplain. Adjust the left encroachment station so that it will be within the floodplain.	19; 20; 21; 22; 24; 25.4; 26; 30	
FW FW 04R	The 1-percent-annual-chance floodplain is outside of the channel. The right station effective of $ineffstar$ for the 1-percent-annual-chance floodplain is greater than the right channel bank station $starob$. However, the right encroachment station $encstar$ is outside of the 1-percent-annual-chance floodplain. Adjust the right encroachment station so that it will be within the floodplain.	20; 21; 24; 25.4; 30	
FW FW 05L	The 1-percent annual chance flood is contained within the channel. The Left encroachment station $encstal$ is outside the channel. The Left channel bank station is $stalob$. Adjust the left encroachment station so that it is the same as the left channel bank station.	25; 25.2	
FW FW 05R	The 1-percent annual chance flood is contained within the channel. The Right encroachment station $encstar$ is outside the channel. Right channel bank station is $starob$. Adjust the right encroachment station so that it is the same as the right channel bank station..	25; 25.2; 26	
FW FW 06L	The left side of the floodway boundary is within the channel. The left station effective of $ineffstal$ for the floodway profile is more than the left channel bank station of $stalob$. The left encroachment station of $encstal$ is less than the left channel bank station. Adjust the left encroachment station so that it is the same as the left channel bank station.	25; 25.2	
FW FW 06R	The right side of the floodway boundary is within the channel. The right station effective of $ineffstar$ for the floodway profile is less than the right channel bank station of $starob$. The right encroachment station of $encstar$ is more than the right channel bank station. Adjust the right encroachment station so that it is the same as the right channel bank station.	25; 25.2; 26	

FW ST 08S2L	This is Section 2 of a hydraulic structure. The left encroachment station is outside the 1%-annual-chance floodplain. The left station effective of $ineffstal$ for the 1%-annual-chance profile is less than the left channel bank station of $stalob$. The 1%-annual-chance floodplain is outside the channel. The left encroachment station of $encstal$ is less than the left station effective of $ineffstal$ for the 1%-annual-chance profile. The Enc_Sta_L must be within the 1%-annual-chance floodplain.	27	
FW ST 08S2R	This is Section 2 of a hydraulic structure. The right encroachment station is outside the 1%-annual-chance floodplain. The right station effective of $ineffstar$ for the 1%-annual-chance profile is greater than the right channel bank station of $starob$. The 1%-annual-chance floodplain is outside the channel. The right encroachment station of $encstar$ is greater than the right station effective of $ineffstar$ for the 1%-annual-chance profile. The Enc_Sta_R must be within the 1%-annual-chance floodplain.	27	
FW ST 08S3L	This is Section 3 of a hydraulic structure. The left encroachment station is outside the 1%-annual-chance floodplain. The left station effective of $ineffstal$ for the 1%-annual-chance profile is less than the left channel bank station of $stalob$. The 1%-annual-chance floodplain is outside the channel. The left encroachment station of $encstal$ is less than the left station effective of $ineffstal$ for the 1%-annual-chance profile. The Enc_Sta_L must be within the 1%-annual-chance floodplain.	28	
FW SW 01M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. Known WS option is used for both the 1%-annual-chance flood and floodway profiles. The floodway profile starting WSEL of $knownwsfw$ is not equal to the 1%-annual-chance flood starting WSEL of $knownws100yr$ plus the allowable surcharge value of $allowsurchrg$. The Normal Depth option with the energy slope of the 1%-annual-chance flood should be used for both profiles and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	19	

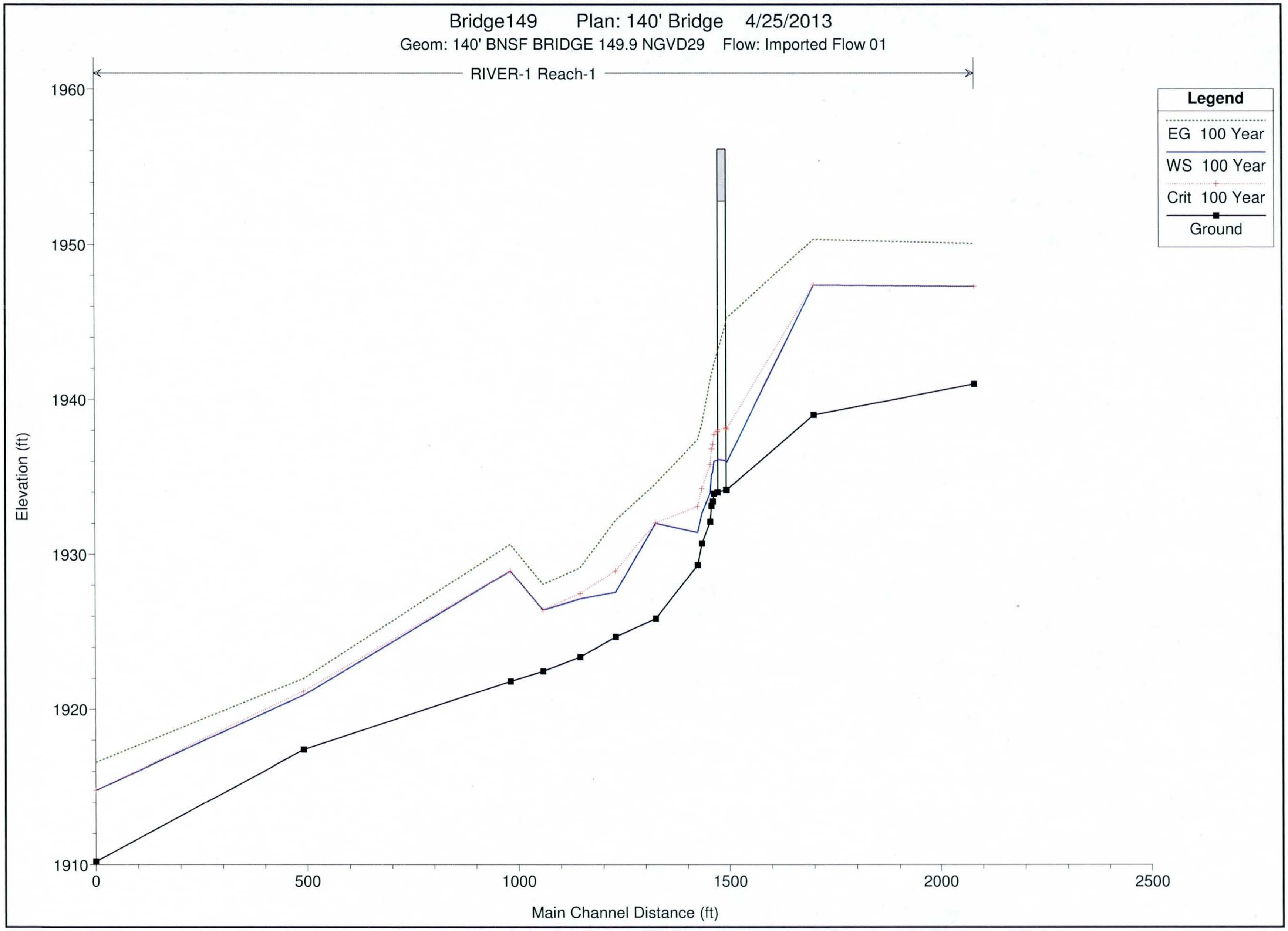
MP SW 01DD	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. The downstream starting water-surface elevation, SWSEL, is computed from different methods. SWSEL of the 50 %-annual-chance flood is computed from SW_Method. SWSEL of the 10 %-annual-chance flood is computed from SW_Method. SWSEL of the 4 %-annual-chance flood is computed from SW_Method. SWSEL of the 2 %-annual-chance flood is computed from SW_Method. SWSEL of the 1%-annual-chance flood is computed from SW_Method. SWSEL of the 0.2%-annual-chance flood is computed from SW_Method. The same method should be used for all the profiles.		
MP SW 01UD	The name of the stream is ($streamname$). The flow regime is mixed flow or supercritical. The upstream starting water-surface elevation, SWSEL, is computed from different methods.		
NT RS 02BDC	This is the Downstream Bridge Section (BRD). The channel n value of $chldn$ for the downstream internal bridge opening section is equal to or larger than the channel n value of $chl2$ at Section 2. Usually, the channel "n" value of the bridge opening section represents the area below the bridge deck and is less than the channel "n" value of Section 2. The "n" value for Section 2 represents the natural valley channel section roughness for the reach between Section 3 and Section 4. Please change the "n" value of the internal bridge opening section or provide supporting information for the use of the higher "n" value.	27.5(Bridge-DN)	
NT RS 02BUC	This is the Upstream Bridge Section (BRU). The channel n value of $chlup$ for the upstream internal bridge opening section is equal to or larger than the channel n value of $chl3$ at Section 3. Usually, the channel "n" value of the bridge opening section represents the area below the bridge deck and is less than the channel "n" value of Section 3. The "n" value for Section 3 represents the natural valley channel section roughness for the reach between Section 3 and Section 4. Please change the "n" value of the internal bridge opening section or provide supporting information for the use of a higher "n" value.	27.5(Bridge-UP)	
NT TL 01S4	This is Section 4 of a hydraulic structure. The contraction and expansion loss coefficients are cc and ce. They should be equal to 0.3 and 0.5, respectively according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010)..	29	

NT TL 02	Contraction and expansion loss coefficients are cc and ce, respectively. However, this cross section is not at a hydraulic structure. They should be equal to 0.1 and 0.3 according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010).	19; 20; 21; 22; 23; 24; 25; 30	
ST DT 01B	This is ($strucname$). 'Upstream Dist' of $distup$ in "Bridge Width Table" is less than the height of the bridge opening of $height$. This indicates that Section 3 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 3 should be relocated or provide a statement that it represents the natural valley cross section. The HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 4, 3 and 2 and 'Upstream Dist' should be adjusted.	27.5(Bridge-UP)	
ST DT 02B	This is ($strucname$). 'Downstream Dist' of $distdn$ in 'Bridge Width Table' is less than the height of the bridge opening of $height$. This indicates that Section 2 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 2 should be relocated or provide a statement that it represents the natural valley cross section. A HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 3 and 2 should be adjusted.	27.5(Bridge-DN)	
ST DT 03	This is ($Structure$) section. The Contraction Length is longer than the Expansion Length. Section 4 channel distance of $Length_Chnl4$ is longer than Section 2 channel distance of $Length_Chnl2$. Section 4 and Section 1 should be relocated. The HEC-RAS geometry file may need to be recreated using a GIS program.	27.5(Bridge-UP)	
ST IF 01S2L	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	

ST IF 01S2R	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow Station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3L	This is Section 3. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to lmntprdu of $lmntprdu$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3R	This is Section 3 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to rmntprdu of $rmntprdu$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
XS CD 01	Critical Depth occurs at $assignedname$ flood. Flow Code will be "C". The Ineffective flow option is used. The Ineffective Flow elevation is equal to or higher than the Critical WSEL. Please investigate whether this selection is appropriate.	21	
XS DC 02	Constant discharge used for the entire profile for $assignedname$ flood. At least two discharges should be selected; one at the mouth and the other at the middle of the watershed or above the confluence of a tributary. Or provide explanation why only one discharge should be used. Other flood frequencies should also be checked.		

XS DT 01	Both the right overbank distance of rob and the left overbank distance of lob are longer than the channel distance of chl . Please review the creation of left overbank, channel and right overbank distances. The HEC-RAS geometry file may need to be recreated using a GIS program. Please resolve the differences among the distances.	20	

Proposed Condition Subcritical Flow Regime Profile



cHECk-RAS Report
Proposed Conditions Subcritical Flow Regime

HEC-RAS Project: *bridge149clomr.prj*
Plan File: *bridge149clomr.p01*
Geometry File: *bridge149clomr.g11*
Flow File: *bridge149clomr.f01*
Report Date: *4/25/2013*

Message ID	Message	Cross sections affected	Comments
BR LF 01	This is ($strucname$). The selected profile is $profilename$. Type of flow is low flow because, 1. EGEL 3 of $egel3$ is less than or equal to MinTopRd of $minelweirflow$. 2. EGEL 3 of $egel3$ is less than MxLoCdU of $mxlocdu$.	27.5(Bridge-UP)	
FW FW 01L	The Left encroachment station is within the channel. The Left encroachment station $encrstal$ is more than left channel bank station $stalob$. The left encroachment station should be the same as the left channel bank station.	21; 23; 24; 25.4; 26; 29	
FW FW 01R	The Right encroachment station is within the channel. The Right encroachment station $encrstar$ is less than right channel bank station $starob$. The right encroachment station should be the same as the right channel bank station.	23; 25.4; 29	
FW FW 03L	The left channel bank elevation of $lobelev$ is higher than the 1-percent-annual-chance WSEL of $wsel$. Relocate the left channel bank station at or below the 1-percent-annual-chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	21; 23; 24; 25; 25.2; 25.4; 26; 29	
FW FW 03R	The right channel bank elevation of $robelev$ is higher than the 1-percent annual chance WSEL of $wsel$. Relocate the right channel bank station at or below the 1-percent annual chance WSEL. Do not place the bank stations at the bottom of the channel. Do not place the bank stations at the low flow channel. Use the Horizontal Variation in "n" Values option in HEC-RAS to assign different "n" values to the left bank slope, low flow channel, and the right bank slope. Let HEC-RAS compute the composite "n" value based on the depth of flow.	25; 25.2; 25.4; 26; 29	

FW FW 04L	The 1-percent-annual-chance floodplain is outside of the channel. The left station effective of $ineffstal$ for the 1-percent-annual-chance floodplain is less than the left channel bank station $stalob$. However, the left encroachment station $encstal$ is outside of the 1-percent-annual-chance floodplain. Adjust the left encroachment station so that it will be within the floodplain.	19; 20; 22; 30	
FW FW 04R	The 1-percent-annual-chance floodplain is outside of the channel. The right station effective of $ineffstar$ for the 1-percent-annual-chance floodplain is greater than the right channel bank station $starob$. However, the right encroachment station $encstar$ is outside of the 1-percent-annual-chance floodplain. Adjust the right encroachment station so that it will be within the floodplain.	20; 21; 30	
FW FW 05L	The 1-percent annual chance flood is contained within the channel. The Left encroachment station $encstal$ is outside the channel. The Left channel bank station is $stalob$. Adjust the left encroachment station so that it is the same as the left channel bank station.	25; 25.2	
FW FW 05R	The 1-percent annual chance flood is contained within the channel. The Right encroachment station $encstar$ is outside the channel. Right channel bank station is $starob$. Adjust the right encroachment station so that it is the same as the right channel bank station..	25; 25.2; 26	
FW FW 06L	The left side of the floodway boundary is within the channel. The left station effective of $ineffstal$ for the floodway profile is more than the left channel bank station of $stalob$. The left encroachment station of $encstal$ is less than the left channel bank station. Adjust the left encroachment station so that it is the same as the left channel bank station.	25; 25.2	
FW FW 06R	The right side of the floodway boundary is within the channel. The right station effective of $ineffstar$ for the floodway profile is less than the right channel bank station of $starob$. The right encroachment station of $encstar$ is more than the right channel bank station. Adjust the right encroachment station so that it is the same as the right channel bank station.	25; 25.2; 26	
FW SC 01	The surcharge value is negative. Use the suggestions from the Help section such that the negative surcharge value will not be less than (-0.09) foot.	23; 24	

FW ST 04BDR	This is ($strucname$) downstream internal section. The right encroachment station is within the channel. The right encroachment station of $encstar$ is less than the right bank station of $starob$. The right encroachment station should be the same as the right channel bank station.	27.5(Bridge-DN)	
FW ST 04S2L	This is Section 2 of a hydraulic structure. The left encroachment station is within the channel. The left encroachment station of $encstal$ is greater than the left bank station of $stalob$. The left encroachment station should be the same as the left channel bank station.	27	
FW ST 04S2R	This is Section 2 of a hydraulic structure. The right encroachment station is within the channel. The right encroachment station of $encstar$ is less than the right bank station of $starob$. The right encroachment station should be the same as right channel bank station.	27	
FW ST 04S3L	This is Section 3 of a hydraulic structure. The Left Channel Bank station is outside the Left Abutment station. The left encroachment station is within the channel. The left encroachment station of $encstal$ is greater than the left bank station of $stalob$. The left encroachment station should be the same as the left channel bank station.	28	
FW ST 04S3R	This is Section 3 of a hydraulic structure. The right encroachment station is within the channel. The right encroachment station of $encstar$ is less than the right bank station of $starob$. The right encroachment station should be the same as the right channel bank station.	28	
FW SW 01M1	The name of the stream is ($streamname$). Encroachment Method 1 is used. Known WS option is used for both the 1%-annual-chance flood and floodway profiles. The floodway profile starting WSEL of $knownwsfw$ is not equal to the 1%-annual-chance flood starting WSEL of $knownws100yr$ plus the allowable surcharge value of $allowsurchrg$. The Normal Depth option with the energy slope of the 1%-annual-chance flood should be used for both profiles and the plan should be rerun. This message may not be applicable when revising only a portion of a hydraulic model.	19	

MP SW 01DD	The name of the stream is ($streamname$). The flow regime is subcritical or mixed flow. The downstream starting water-surface elevation, SWSEL, is computed from different methods. SWSEL of the 50 %-annual-chance flood is computed from SW_Method. SWSEL of the 10 %-annual-chance flood is computed from SW_Method. SWSEL of the 4 %-annual-chance flood is computed from SW_Method. SWSEL of the 2 %-annual-chance flood is computed from SW_Method. SWSEL of the 1%-annual-chance flood is computed from SW_Method. SWSEL of the 0.2%-annual-chance flood is computed from SW_Method. The same method should be used for all the profiles.		
MP SW 01UD	The name of the stream is ($streamname$). The flow regime is mixed flow or supercritical. The upstream starting water-surface elevation, SWSEL, is computed from different methods.		
NT RS 01S2C	This is Section 2 of a hydraulic structure. Channel n value of $chl2$ is less than the channel n value of $chl1$ at Section 1. Normally the channel "n" value at Section 2 represents the reach between Section 2 and Section 1, and is higher than the "n" value within the hydraulic structure. Please change the "n" value or provide supporting information for the use of the lower "n" value.	27	
NT RS 01S3C	This is Section 3 of a hydraulic structure. Channel n value of $chl3$ is less than the channel n value of $chl4$ at Section 4. Normally the channel "n" value at Section 3 represents the reach between Section 3 and Section 4, and is higher than the "n" value within the hydraulic structure. Please change the "n" value or provide supporting information for the use of the lower "n" value.	28	
NT RS 02BUC	This is the Upstream Bridge Section (BRU). The channel n value of $chlup$ for the upstream internal bridge opening section is equal to or larger than the channel n value of $chl3$ at Section 3. Usually, the channel "n" value of the bridge opening section represents the area below the bridge deck and is less than the channel "n" value of Section 3. The "n" value for Section 3 represents the natural valley channel section roughness for the reach between Section 3 and Section 4. Please change the "n" value of the internal bridge opening section or provide supporting information for the use of a higher "n" value.	27.5(Bridge-UP)	

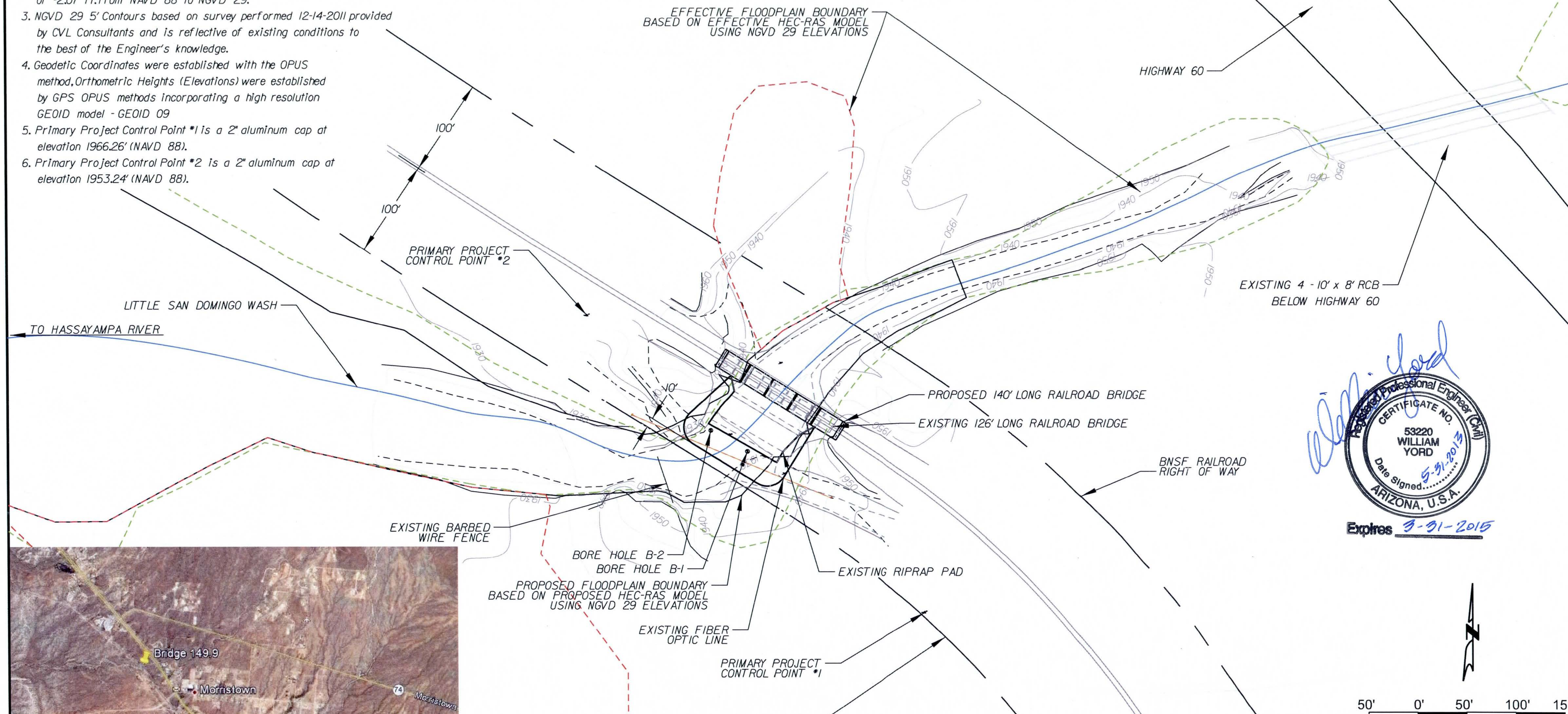
NT TL 01S4	This is Section 4 of a hydraulic structure. The contraction and expansion loss coefficients are cc and ce. They should be equal to 0.3 and 0.5, respectively according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010)..	29	
NT TL 02	Contraction and expansion loss coefficients are cc and ce, respectively. However, this cross section is not at a hydraulic structure. They should be equal to 0.1 and 0.3 according to page 5-8 of the HEC-RAS Hydraulic Reference Manual (HEC, 2010).	19; 20; 21; 22; 23; 24; 25; 30	
ST DT 01B	This is ($strucname$). 'Upstream Dist' of $distup$ in "Bridge Width Table" is less than the height of the bridge opening of $height$. This indicates that Section 3 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 3 should be relocated or provide a statement that it represents the natural valley cross section. The HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 4, 3 and 2 and 'Upstream Dist' should be adjusted.	27.5(Bridge-UP)	
ST DT 02B	This is ($strucname$). 'Downstream Dist' of $distdn$ in 'Bridge Width Table' is less than the height of the bridge opening of $height$. This indicates that Section 2 may not be placed at the foot of the road embankment or wing walls and may not represent the natural valley cross section. Section 2 should be relocated or provide a statement that it represents the natural valley cross section. A HEC-RAS geometry file may need to be recreated using a GIS program. Lengths at Sections 3 and 2 should be adjusted.	27.5(Bridge-DN)	
ST DT 03	This is ($Structure$) section. The Contraction Length is longer than the Expansion Length. Section 4 channel distance of $Length_Chnl4$ is longer than Section 2 channel distance of $Length_Chnl2$. Section 4 and Section 1 should be relocated. The HEC-RAS geometry file may need to be recreated using a GIS program.	27.5(Bridge-UP)	
ST GD 06	Left and/or right abutment station computed by the cHECk-RAS program is equal to zero. cHECk-RAS cannot evaluate this structure.	27.5(Bridge)	

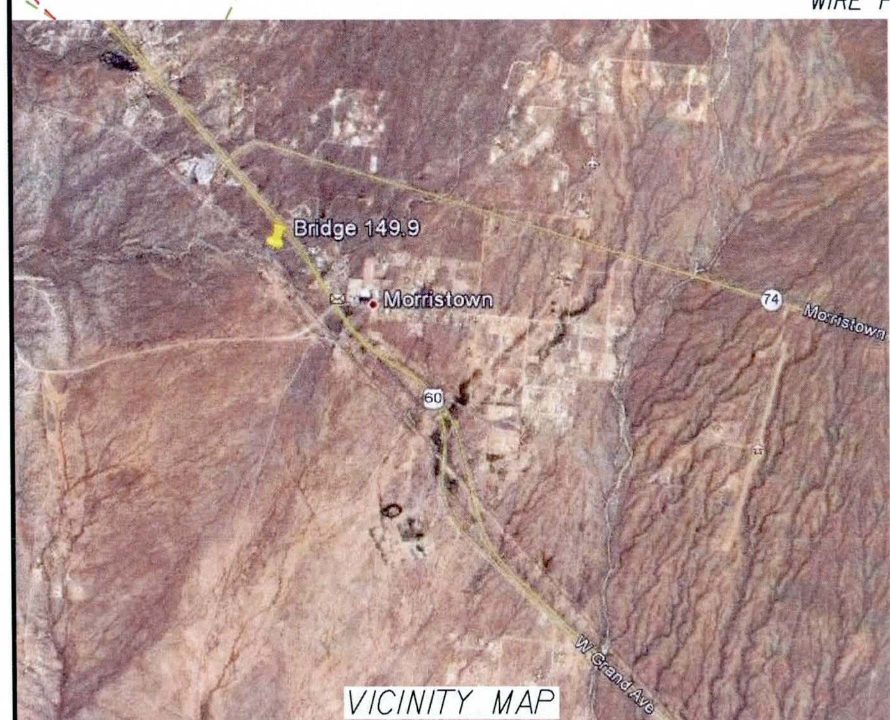
ST IF 01S2L	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S2R	This is Section 2 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow Station was not considered at Section 2. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to wsel2 of $wsel$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3L	This is Section 3. The highest flood frequency that has low or pressure flow is $profilename$. However, the Left Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The left ineffective flow elevation should be equal to lmntprdu of $lmntprdu$. The placement of the left ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
ST IF 01S3R	This is Section 3 of a hydraulic structure. The highest flood frequency that has low or pressure flow is $profilename$. However, the Right Ineffective Flow station was not considered at Section 3. The ineffective flow station and elevation should be inserted. The right ineffective flow elevation should be equal to rmntprdu of $rmntprdu$. The placement of the right ineffective flow station is explained on page 5-7 of Hydraulic Reference Manual (HEC, 2010).	27.5(Bridge)	
XS CD 01	Critical Depth occurs at $assignedname$ flood. Flow Code will be "C". The Ineffective flow option is used. The Ineffective Flow elevation is equal to or higher than the Critical WSEL. Please investigate whether this selection is appropriate.	21	

XS DC 02	Constant discharge used for the entire profile for $assignedname$ flood. At least two discharges should be selected; one at the mouth and the other at the middle of the watershed or above the confluence of a tributary. Or provide explanation why only one discharge should be used. Other flood frequencies should also be checked.		
XS DT 01	Both the right overbank distance of rob and the left overbank distance of lob are longer than the channel distance of chl . Please review the creation of left overbank, channel and right overbank distances. The HEC-RAS geometry file may need to be recreated using a GIS program. Please resolve the differences among the distances.	20	
XS IF 03L	The Left Ineffective Flow Station is within the channel. The Left Ineffective Flow Station of $ineffstal$ is greater than the LeftBankSta of $bankstal$. The Left Ineffective Flow Station or the LeftBankSta should be adjusted.	21	

NOTES:

1. The Vertical Control is based on the NAVD 88 and Horizontal Control is based on the NAD83 Arizona State Plane, Central Zone.
2. Survey was converted to NGVD 29 for consistency with effective FIS published information using the correction factor of -2.07 ft. from NAVD 88 to NGVD 29.
3. NGVD 29 5' Contours based on survey performed 12-14-2011 provided by CVL Consultants and is reflective of existing conditions to the best of the Engineer's knowledge.
4. Geodetic Coordinates were established with the OPUS method, Orthometric Heights (Elevations) were established by GPS OPUS methods incorporating a high resolution GEOID model - GEOID 09
5. Primary Project Control Point #1 is a 2" aluminum cap at elevation 1966.26' (NAVD 88).
6. Primary Project Control Point #2 is a 2" aluminum cap at elevation 1953.24' (NAVD 88).





VICINITY MAP

Registered Professional Engineer (Civil)
CERTIFICATE NO. 53220
WILLIAM YORD
Date Signed 5-31-2013
ARIZONA, U.S.A.
Expires 3-31-2015

BioGeo

THE Louis Berger Group, INC.

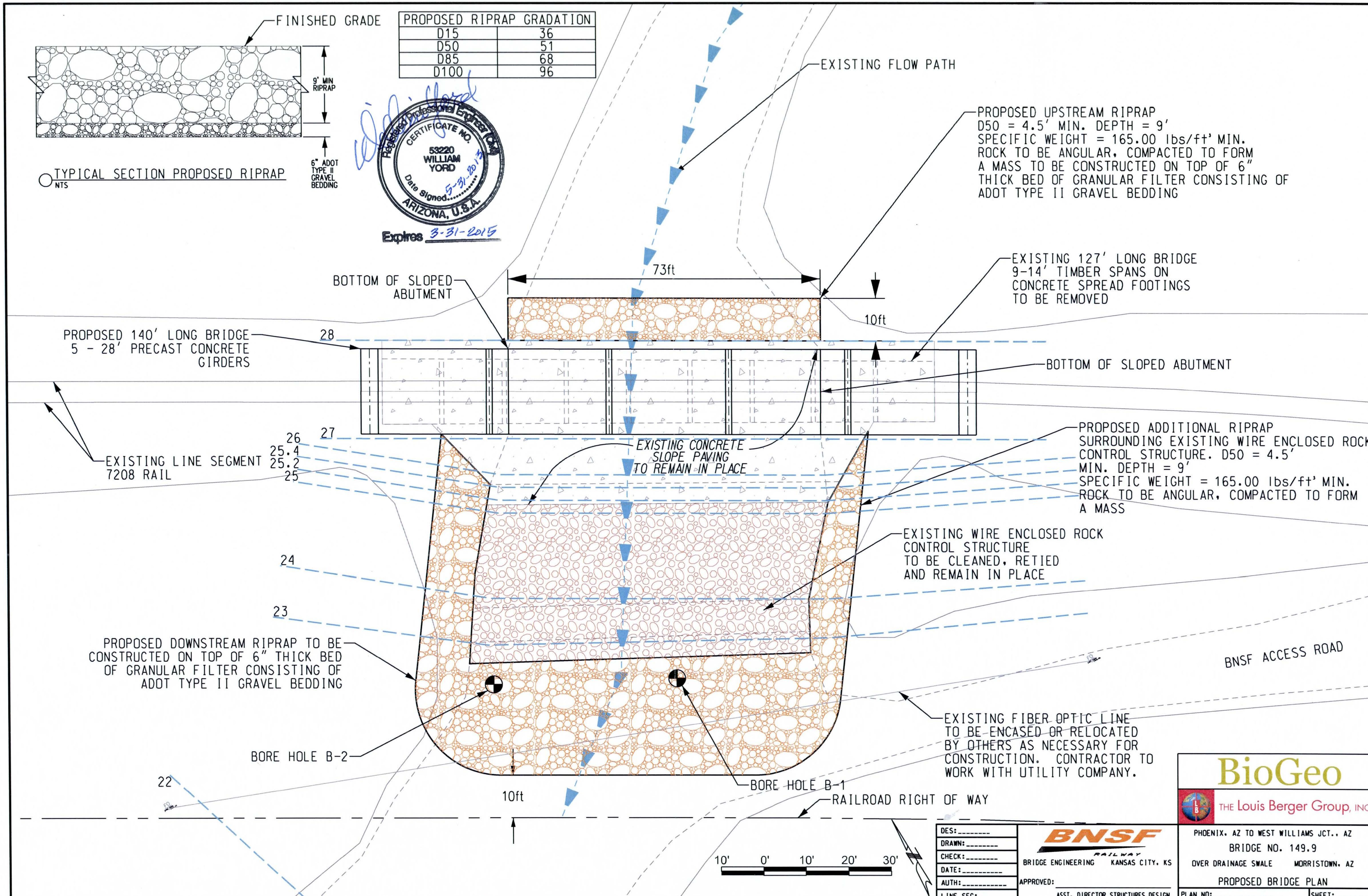
DES:________
DRAWN:________
CHECK:________
DATE:__________
AUTH:__________
LINE SEG:____

BNSF RAILWAY

BRIDGE ENGINEERING KANSAS CITY, KS
4515 KANSAS AVENUE
KANSAS CITY, KS 66106
913-551-4192
Howard.Perry@bnsf.com

BNSF BRIDGE 149.9
FLOODPLAIN USE PERMIT
PLAN VIEW

PLAN NO:______________ SHEET:_______



PROPOSED RIPRAP GRADATION	
D15	36
D50	51
D85	68
D100	96

BioGeo

THE Louis Berger Group, INC.

DES:_______
DRAWN:_______
CHECK:_______
DATE:_______
AUTH:_______
LINE SEG:____

BNSF RAILWAY

BRIDGE ENGINEERING KANSAS CITY, KS

APPROVED:

ASST. DIRECTOR STRUCTURES DESIGN

PHOENIX, AZ TO WEST WILLIAMS JCT., AZ

BRIDGE NO. 149.9

OVER DRAINAGE SWALE MORRISTOWN, AZ

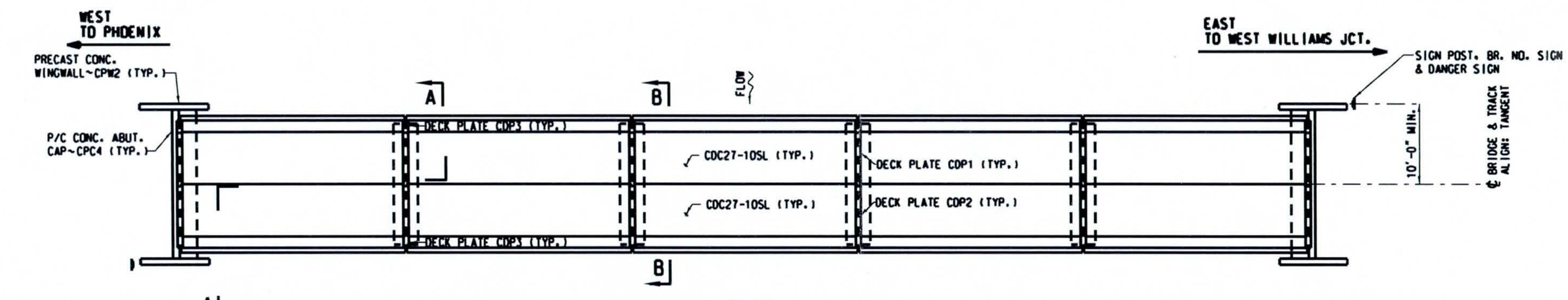
PROPOSED BRIDGE PLAN

PLAN NO:_______ SHEET:_______

ATTENTION !
INFORMATION SHOWN ON THESE PLANS CONCERNING TYPE AND LOCATION OF UNDERGROUND OR ABOVE GROUND UTILITIES IS NOT GUARANTEED TO BE ACCURATE OR ALL INCLUSIVE.
THE SUPERVISOR OF STRUCTURES OR THE FOREMAN IN CHARGE WILL VERIFY THE LOCATION OF UNDERGROUND AND OVERHEAD UTILITIES BEFORE BEGINNING CONSTRUCTION AND PER THE BNSF ENGINEERING INSTRUCTIONS CHAPTER 26.

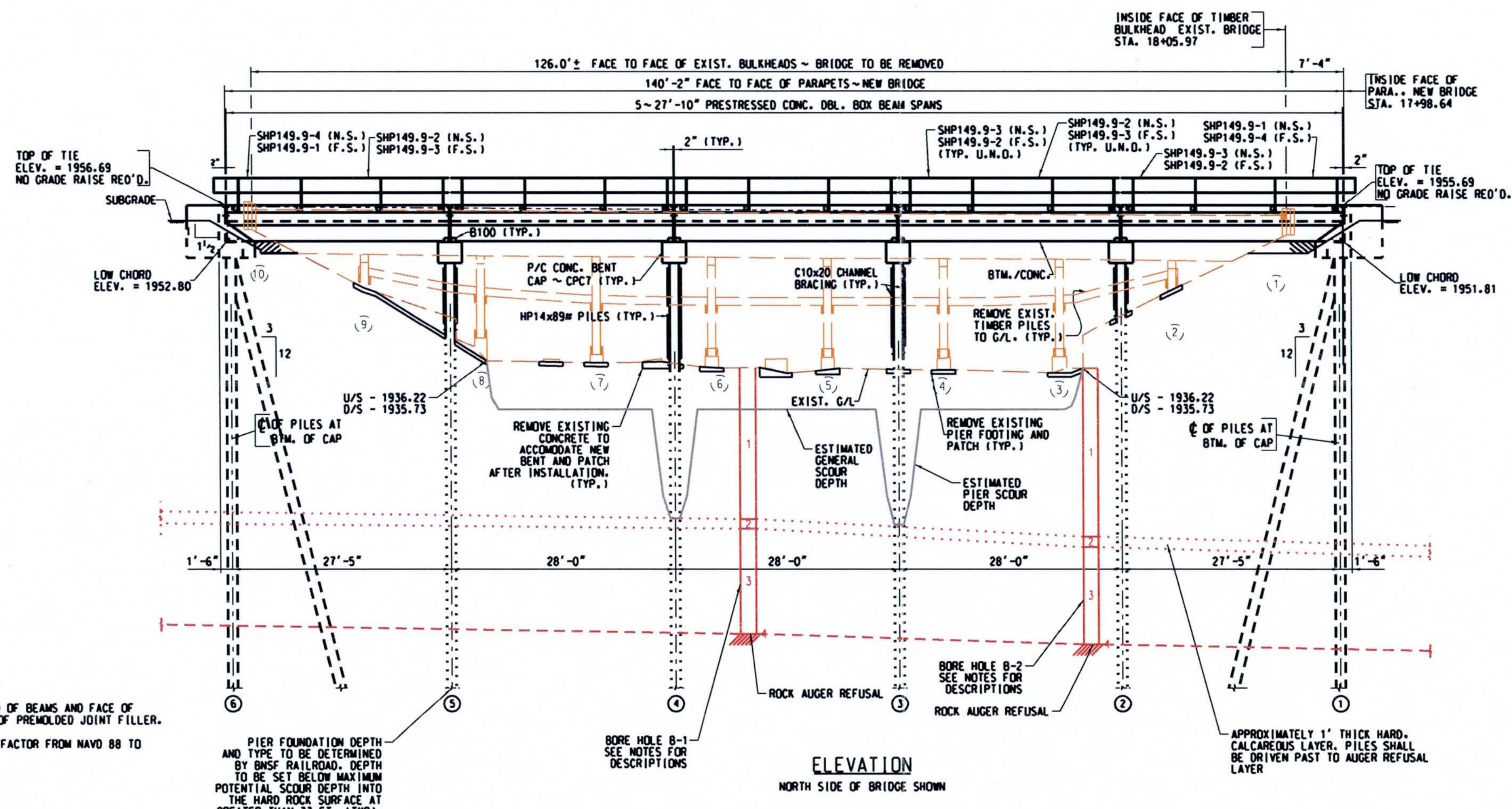
ESTIMATED LIFTING WEIGHTS:

PRECAST MATERIAL	
CDC27-10SL	46,200 LBS.
CPC4	25,300 LBS.
CPW2	5,100 LBS.
CPC7	20,300 LBS.



PLAN

SEE SHEET 2 FOR SECTIONS A-A & B-B



ELEVATION

NORTH SIDE OF BRIDGE SHOWN

NOTES:

FILL GAP BETWEEN END OF BEAMS AND BETWEEN END OF BEAMS AND FACE OF PARAPET WALL WITH 8 ½" x 28" x 6'-4" PLIES OF PREMOLDED JOINT FILLER.

ALL ELEVATIONS SHOWN IN NAVD 88. CORRECTION FACTOR FROM NAVD 88 TO NGVD 29 IS NAVD 88 ELEVATION - 2.07 FT.

N.S. DENOTES NEAR SIDE
F.S. DENOTES FAR SIDE
U.N.O. DENOTES UNLESS NOTED OTHERWISE

STRATA DESCRIPTION:

1)	0.0'-18.8'	RECENT ALLUVIUM
2)	18.8'-20.0'	HARD CARBONATE LEDGE
5)	20.0'-33'	FINE TO MEDIUM GRAINED CLEAN SAND
7)	33'	ROCK AUGER REFUSAL

Registered Professional Engineer (Civil)
CERTIFICATE NO. 53220
WILLIAM YORD
Date Signed 5-31-2013
ARIZONA, U.S.A.
Expires 3-31-2015

BioGeo
THE Louis Berger Group, INC.

DES:	BNSF RAILWAY	WEST WILLIAMS JCT. TO PHOENIX
DRAWN:		BRIDGE NUMBER 149.9
CHECK:	BRIDGE ENGINEERING KANSAS CITY, KS	OVER DRAINAGE SWALE NEAR MORRISTOWN, AZ
DATE:		PROPOSED BRIDGE ELEVATION
AUTH:	APPROVED:	
LINE SEG:	ASST. DIRECTOR STRUCTURES DESIGN	PLAN NO: 7208-149.9-001 SHEET: