Lyons Avenue/Dockweiler Road Extension Project
Draft Environmental Impact Report

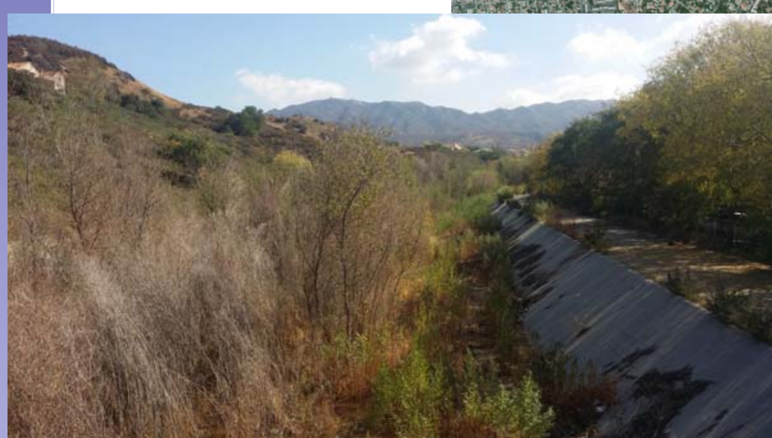
Appendix G
Hydraulic and Scour Analysis

HYDRAULIC REPORT

HYDRAULIC AND SCOUR ANALYSIS

NEWHALL CREEK AT PROPOSED DOCKWEILER ROAD BRIDGE

NEWHALL, CALIFORNIA



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APPENDIX

Rivertech is pleased to submit this report that documents the analysis of the hydraulics, sedimentation, scour potential and bend shear stress for the proposed Dockweiler Road crossing of Newhall Creek located in the City of Santa Clarita, Los Angeles County, California. It is our hope that the contents of this application are sufficient for an expedient review and approval process.

This drainage concept study evaluates the hydraulic and scour impacts of the proposed box culvert in Newhall Creek and documents on-site and off-site hydrology and drainage patterns. This report summarizes findings and proposed channel improvements and modifications including recommended scour countermeasures.

Rivertech performed a scour analysis at the future Dockweiler Road Bridge to determine the scour potential per the methodology accepted by the County of Los Angeles. Provided in this study are the hydraulic conceptual design to evaluate the need for potential countermeasures for scour protection. The Location of the site is shown on Figure 1.

Figure 1. Site Location Map.

INTRODUCTION/PURPOSE OF STUDY

The purpose of this study is to evaluate the future extension of Dockweiler Road and conceptually the planned Dockweiler Road Bridge, which will connect to Lyons Avenue, over Newhall Creek. This hydraulic and scour study associated with the proposed Dockweiler Road and Lyons Avenue extension is focusing on following tasks:

- To determine the scour and channel stability characteristics, perform hydraulic analysis applying the Capital Flood and Flood Insurance Study (FIS) flows of the Newhall Creek Channel between Master College and existing 15th Street bridge.
- To determinate the existing and post-project scour potential with implementation the proposed bridge over Newhall Creek Channel
- To recommend Newhall Channel countermeasure that will provide more channel stability and mitigate the scour potential.

LITERATURE REVIEW

Rivertech reviewed and implemented all the relevant information and data, specifically but not limited to the site plans, design plans and prior reports and studies.

TECHNICAL APPROACH

The basis for this hydraulic and scour study is the existing technical data and field reconnaissance. Existing technical data such as record plans, available hydrology data and flood studies, floodplain maps and topographic data were reviewed for relevance and applicability for this study of the proposed site. Data sources included the LACFCD, FEMA and the US Army Corps of Engineers.

Hydrology Data

The hydraulic, sedimentation and scour analyses require both steady-state and unsteady flow. For the one-dimensional hydraulic and scour analyses, peak flows are needed as input data.

Peak Flow

One of the sources of hydrologic data is the Los Angeles County Flood Control District (LACFCD) Design Division who provided hydrologic data for Newhall Creek Channel, which was part of 2001 to 2005 LACFCD comprehensive study for the South Fork of the Santa Clara River watershed. Peak flows for Newhall Creek sub-areas are provided for 50-year clear-flow, 50-year burned-flow and 50-year burned/bulked (Capital Flood).

The second source of hydrologic data is the Federal Emergency Management Agency, as part of the Flood Insurance Study, which provides 100-year peak flows.

Table1. Summary of Flood Flows

Source	Event	Peak Discharge (ft^3/s)
Capital Flood[1]	50-year Burn/Bulk	9,200
LACDPW[2]	50-year Burn	7,321
LACDPW[2]	50-year Clear	7,021
Flood Insurance Study[3]	100-year	4,640

[1] *South Fork Santa Clara River / Newhall Creek Capital Flood Flow Rates*, Los Angeles County, Department of Public Works, Flood Control District.

[2] *Santa Clara River Hydrology Study*, Los Angeles County, Department of Public Works, Water Resources, Division Hydrology Section, 2003

[3] *Flood Insurance Study*, Los Angeles County, Federal Emergency Management Agency, Volume 060337CV002A, September 26, 2008.

Reviewing the drainage information associated with Newhall Creek Channel as provided in these studies, the LACFCD public works policy of flood protection, and the drainage policy for Santa Clara River per Section 2.2 of the LACFCD Sedimentation Manual it can be concluded that the Newhall creek channel shall be designed based on the Capital flood rates (50-year rainfall, burned and bulked) and channel section of soft bottom with protective levee. These design requirements are consistent with the existing flood control improvements per LACFCD as-built plans "Newhall Creek unit 1A" and Storm Drain Plans in Tract No.32365.

Unsteady Flow

The sediment transport modeling requires time-varied flow as the upstream boundary condition. The hydrologic data, which was furnished by the aforementioned sources, is for steady-state conditions.

Although there are no streamflow gages along Newhall Creek and one abandoned short-term gage along the South Fork of the Santa Clara River, there are a few gages in the Santa Clara River watershed that exhibit similar hydrologic characteristics to Newhall Creek. The USGS streamflow gages that are meet the minimum record length (10 years) criterion and are located in the same hydrologically region, are: Santa Clara River Near Saugus, CA (11108000), Santa Clara River Ab Rr Station Near Lang, CA (107745) and Bouquet Canyon Near Saugus, CA (11107860). The annual peak flows were determined from each of the gage records and used as input to a Log Pearson Type III streamflow gage analysis.[4] The peak flows from this flood frequency analysis was plotted as a function of the drainage area of the respective gage, as shown in Figure 2. From these points, least-squares best-fit lines were fit to the data and the equation of each line is shown in Figure 2.

The drainage area of Newhall Creek at the proposed is 7.7 mi^2, which would extrapolate all of the flows of the frequencies in Figure 2 well below 100 ft^3/s. Therefore, using these curves to establish historical flows by relating to other gage sites is not feasible. Alternatively, the records for all three gages were reviewed for flow magnitudes that are comparable to the peak flows estimated in Table 1. From these records, “wet’ and “average” water years, corresponding to 2003 and 1962, respectively, were selected. There are several dry years but these do not yield significant aggradation and degradation.

[4] *Guidelines for Determining Flood Flow Frequency, Bulletin 17B*, Interagency Advisory Committee on Water Data, USGS, March 1982.

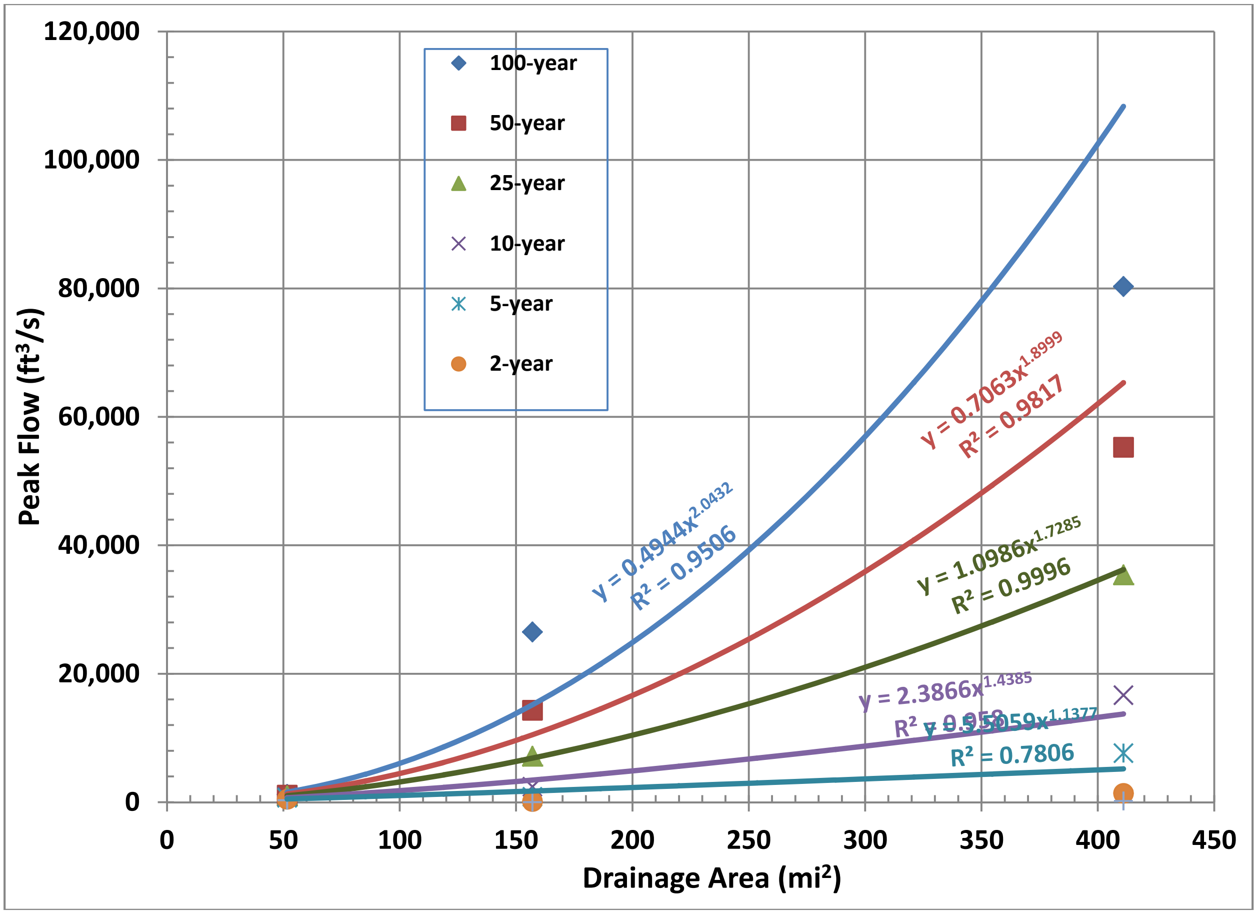

Figure 2. Flow-Drainage Area Relationship of Regional Gages

Existing Topographic Conditions

The digital terrain model of existing conditions was based on the 2 feet interval aerial topography provided from the City of Santa Clarita.

Hydraulic Modeling

Rivertech will develop an existing and post-project HEC-RAS[5] hydraulic model of the Newhall Creek Channel at the proposed Dockweiler Road bridge crossing to determine the hydraulics parameters to be used in the scour analysis.

The river tools of the Watershed Modeling System (WMS)[6] software was used to develop a terrain model from the CAD drawings, from which a flow line was delineated and cross sections were cut. This georeferenced data was exported to HEC–RAS, which served as the existing hydraulic model geometric base. Modifications were made to reflect the existing bridges, roughness and other input parameters.

One bridge/culvert structure was included in HEC-RAS model. The Newhall Creek Channel Bridge consists of four box culverts with 24' span and 8’ rise at the crossing with Lyons Avenue extension. Using the HEC-RAS tool, the proposed Newhall Creek Channel floodplain limits

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[5] *HEC-RAS River Analysis System*, Version 4.1, US Army Corp of Engineers, Hydrologic Engineering Center, 2010.
[6] *Watershed Modeling System (WMS)*, Version 9.1. Aquaveo, www.aquaveo.com, May 2014.

were established. Water surface profiles and their associated hydraulic parameters were derived for Newhall Creek Channel Capital Flood scenario.

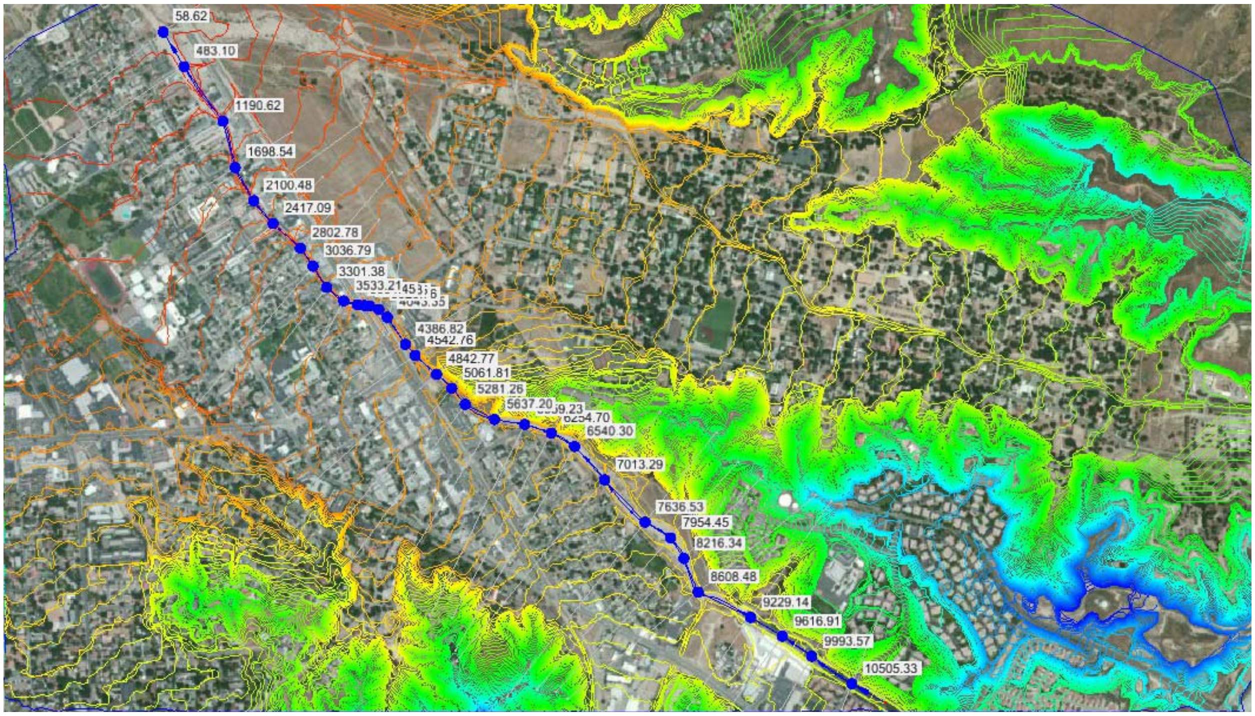

Figure 3. Topography and River Stationing

Study Boundary Conditions

The Newhall Creek study reach boundaries are Placerita Creek and the survey limits (approximately 3,000 feet downstream of the SR14 crossing) at the downstream and upstream limits, respectively. Based on the available topographic survey, the average channel slope of 0.4% was applied to determine the downstream normal depth, which is added to the channel invert to arrive at the starting water-surface elevation.

HYDRAULIC ANALYSIS AND RESULTS

The proposed bridge, an extension of Dockweiler Road and Lyons Avenue over Newhall Creek Channel crossing was modeled using the culvert hydraulics computer program HY-8.[7] The proposed four 24-feet wide and 8-feet deep opening reinforced concrete bridge will accommodate the Capital Flood.

[7] *Culvert Hydraulics, HY8*, Version 7.3, Federal Highway Administration developed in cooperation with Aquaveo LLC and Environmental Modeling Research Laboratory. April 30, 2014.

Figure 4. Hydraulic Sections, Plan View

Based on the LACFCD Sedimentation Manual recommendation for the Santa Clara River watershed, it is proscribed that the Newhall Creek be improved as a soft bottom channel with protected levees. To convey the Capital Flood, a discharge of 9,200 ft^3/, the proposed channel section will require a trapezoidal section with an 80-foot wide base and 2:1 lined side slopes. This section is similar to the existing upstream improvements at Del Oro Street crossing with Newhall Creek.

HEC-RAS model input and output data, including cross sections and detailed tables are provided in the Appendix for reference. The floodplain map for Capital peak flow is provided in the Appendix.

Existing Condition

The cut sections using the WMS river tools were imported into HECRAS as georeferenced geometry. This geometric data was then modified and amended to accurately reflect the hydraulic characteristics, e.g., bridges, channel banks, roughness, etc. The model includes the Railroad Avenue and Southern Pacific Railway bridges. Boundary conditions, i.e., flows and starting water-surface elevations, were added to complete the model.

Figure 5 illustrates the resulting water-surface profiles for the existing condition.

The detailed input and output of the existing condition hydraulic model is exhibited in the appendix.

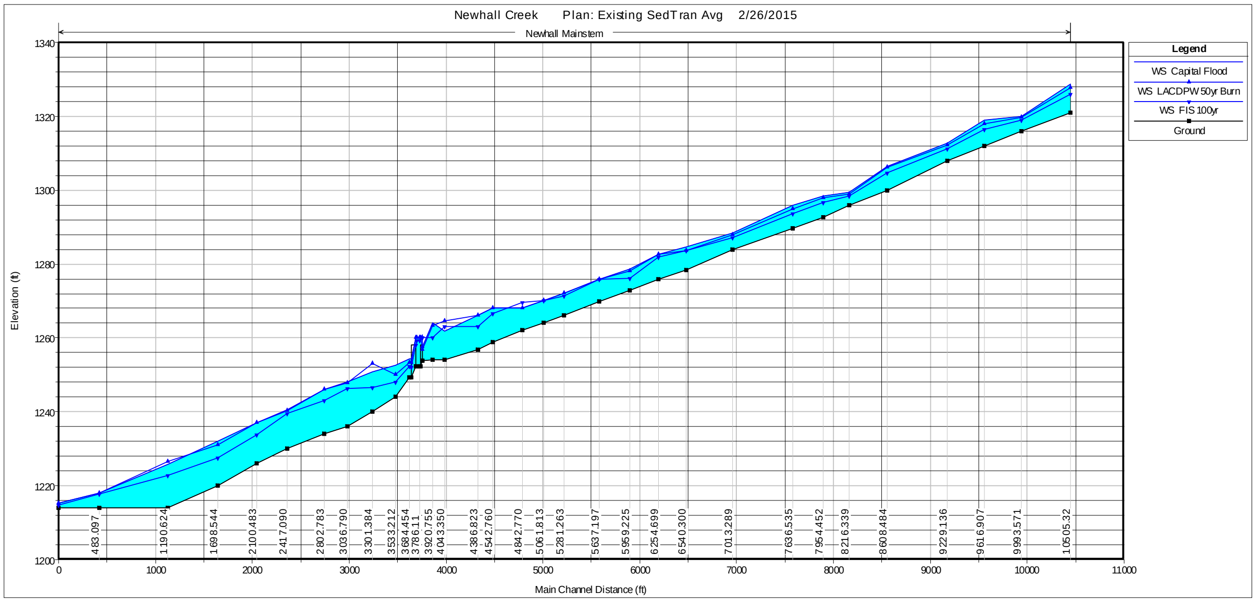

Figure 5. Water-Surface Profile, Existing Condition

Post-Project Condition

The implementation of the proposed bridge and channel widening are two significant components of the post-project hydraulic model. The bridge has four 25-foot wide and 8-foot deep openings. The approach to the bridge is an improved channel that is trapezoidal in shape with na 80-foot bottom width and 2:1 aide slopes.

The hydraulic sections and input from the existing condition model was the basis for the post-project with the implementation of the proposed bridge and channel widening.

The results of the HEC-RAS hydraulic model output indicate that the proposed bridge and channel improvement will accommodate the Capital Flood, i.e., no overtopping of the road, and will not create any flood hazard for the adjacent railroad and proposed street improvements. The bridge conveys both the 50-year burn/bulk and FIS 100-year flood flows with more than 2 feet of freeboard. Figure 6 illustrates the resulting water-surface profiles for the post-project scenario.

The detailed input and output of the post-project scenario hydraulic model is exhibited in the appendix.

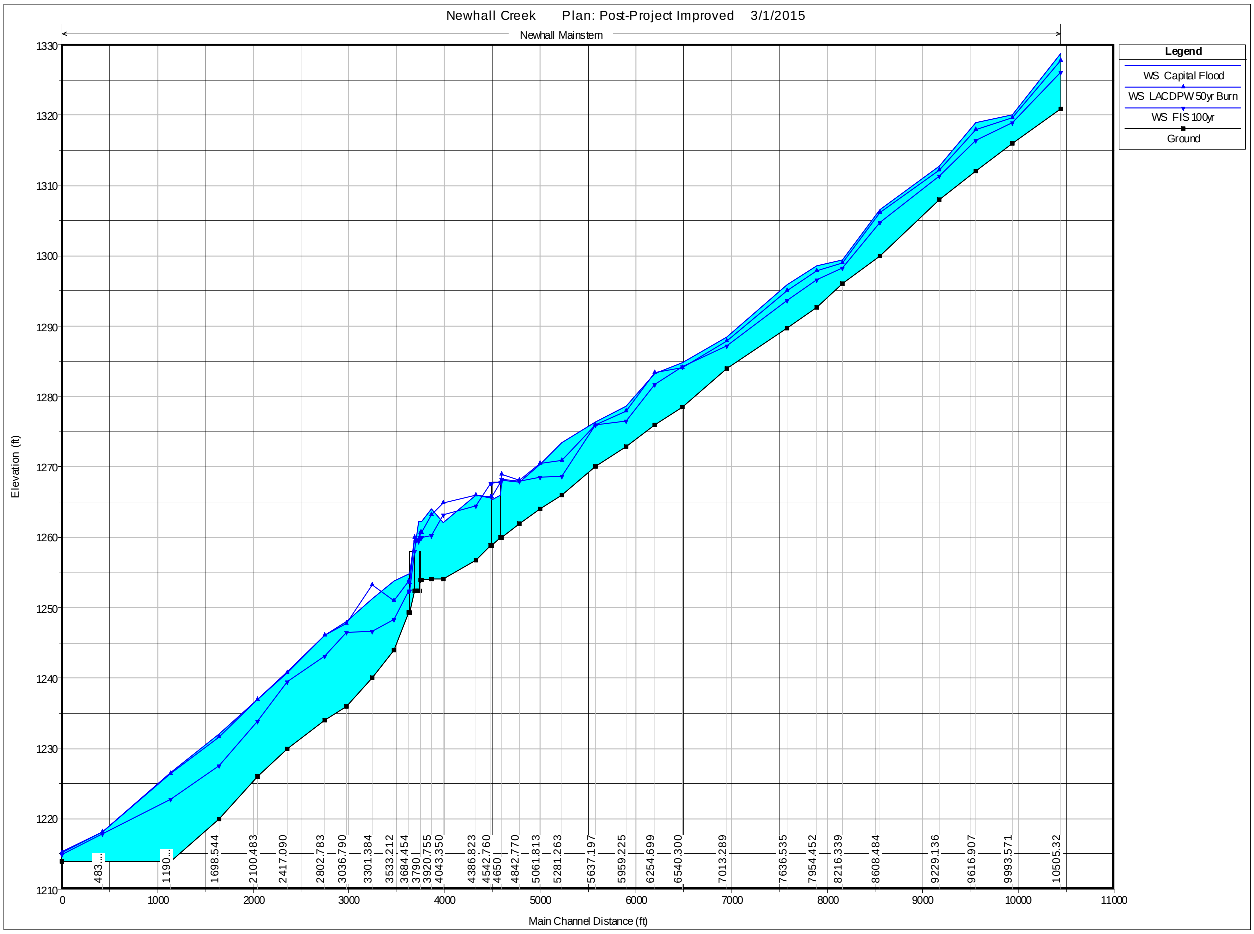

Figure 6. Water-Surface Profile, Post-Project Scenario

SCOUR ANALYSIS

The results of the post-project hydraulic model were used to determine the long-term aggradation/degradation process. We will determine total maximum scour, which would include bank and bed erosion, bend (if measurable) and contraction/expansion influences.

Scour Analysis

The first part of the study is to determine the potential scour due to the implementation of the project. The three scour processes that occur are long-term, contraction and bend scour – the latter due to the natural bend in the exit segment of the study reach. The results of the HEC-RAS model were used to define the hydraulic characteristics required as input for the scour and shear stress analyses.

Long-Term Scour, Sediment Transport

The bed-material load models available in the HEC-RAS program are, as follows: Yang (1973), Laursen (1958), Ackers and White (1973), Engelund and Hansen (1967), Meyer-Peter and

Muller (1948) and Einstein (1950).[8] The Meyer-Peter and Muller equation is recommended for bed material coarser than 5 mm, which does not apply for this stream system in this model, so it was not used. Ackers and White or Engelund and Hansen's equation is recommended for subcritical flow in the lower flow regime. However, there is a mixed flow where some reaches are subcritical and supercritical flow, so this system may not be the most appropriate application of these methods. The Laursen equation is best suited for laboratory flumes and shallow rivers with fine sand or coarse silt. The Yang equation is recommended for sand transport in laboratory flumes and natural rivers, which is an appropriate application for this stream system.

Fall velocity is computed using the Toffaletti equation, the recommended method for sand-bed rivers, which is the case for this application. The default extent of erodible lining is set to the cross section bank limits. The maximum depth of erodibility is a user-defined input and limits the lower limit to which degradation is set.

Boundary Conditions: Sediment Load

The input options in the HEC-RAS sediment transport module for sediment load are equilibrium load, rating table and user-defined sediment load series. Lacking any historical sediment load data, the equilibrium load was applied.

Sensitivity analysis, Sediment Transport

The various applicable transport functions, including Yang, Ackers and White, Engelund and Hansen, Copeland and Laursen were considered and evaluated for this model. The results of these bed-material load models yielded similar results but the Yang method was most consistent and stable, so it is the recommended method. The modeling results in this study reflect the Yang method.

Using the nationwide guidelines for long-term aggradation/degradation, and the *HEC-RAS* hydraulic model implementation of *HEC-6*, we developed a sediment transport model, using the Yang (sand) methodology. This type of scour is not a result of a specific single event but rather a series of events over time. Observed (gage) data is not available in Newhall Creek or the South Fork of the Santa Clara River so an approximation of the flood flow is made to estimate the potential long-term scour. The sediment transport model simulated a series of time-varied flows with varying durations for a poorly graded sandy channel to determine the maximum scour depth for peak flows of 4,620 and 7,290 ft^3/s, corresponding to water years 1962 and 2003.

Soil samples were taken along the bed and bank and used in the laboratory sieve analyses, which yielded particle size distribution curves, shown in Figure 7, that were input in the sediment transport models. As can be seen in Figure 7, the median grain size for the two samples are 1.0 and 2.0 mm, respectively.

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[8] *Sedimentation Engineering, Processes, Measurements, Modeling and Practice, ASCE Manual No. 110,* American Society of Civil Engineers, Reston, VA, 2007.

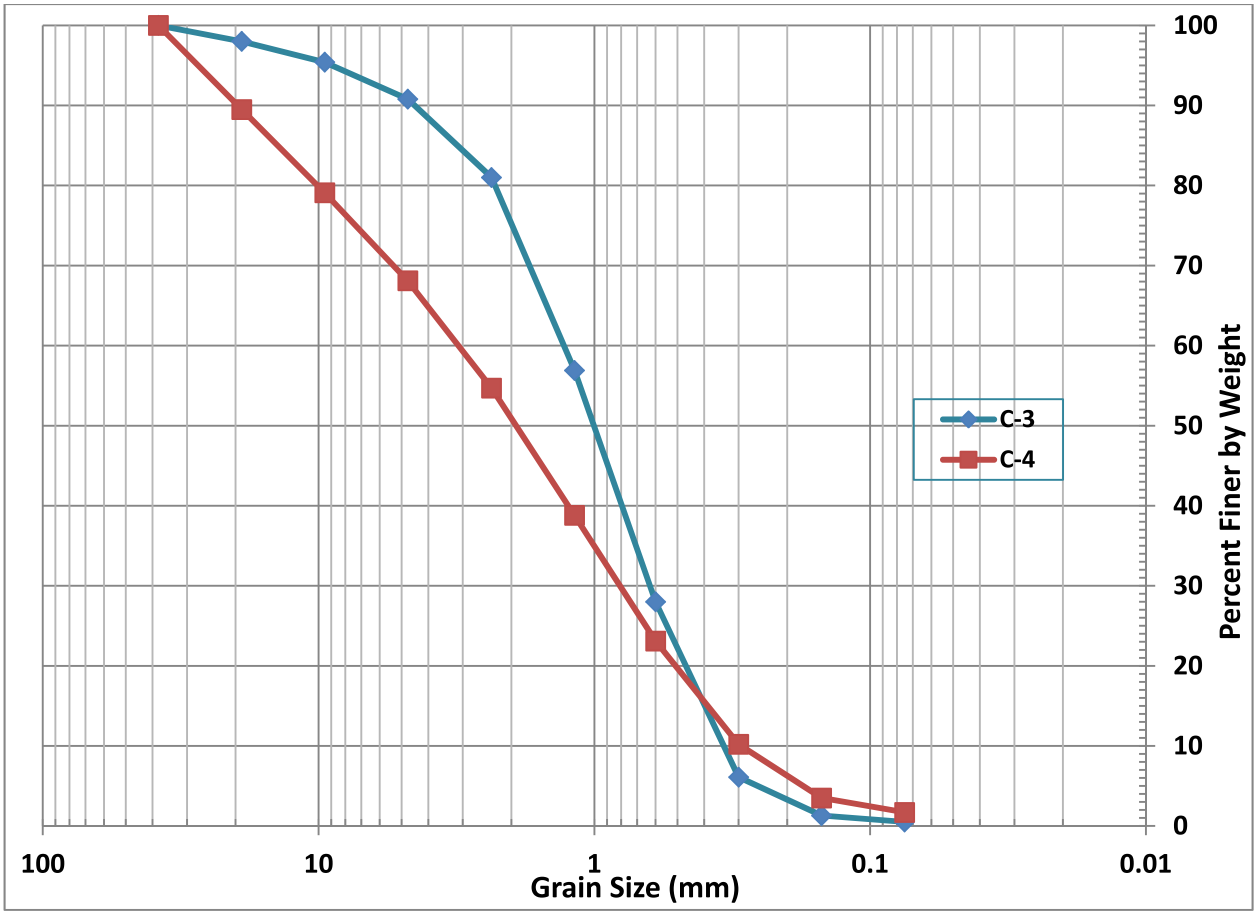

Figure 7. Particle Size Distribution Curves

Figure 8 illustrates the maximum aggradation and degradation event, which corresponds to water year 1962. The system is in balance with the upper reaches deposit zones and the lower reaches erosion zones. As can be seen, the proposed bridge causes aggradation in the approach sections and a minor scour depth in the exit sections adjacent to the bridge. Hence, the computed maximum scour depth, set to **0.3 feet**, corresponds to a simulation time of one year. The results of this analysis are presented in the appendix.

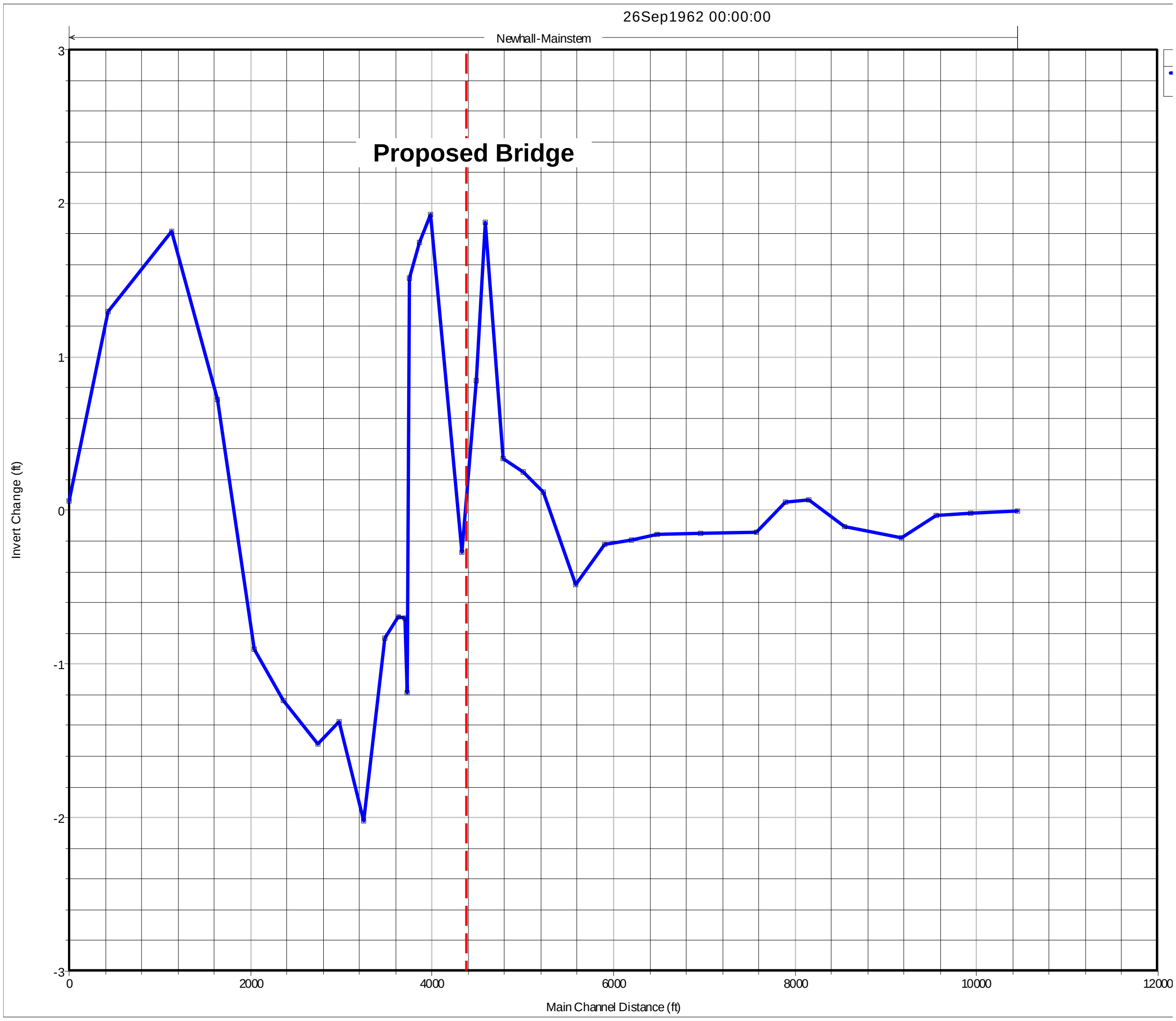

Figure 8. Particle Size Distribution Curves

Contraction Scour

Using the nationwide guidelines for contraction scour[9] and the *HEC-RAS* hydraulic model developed for the site, we estimated the potential scour due to contraction caused by the transition in the exit section back to the existing channel. Since the channel is in *live bed* condition, the live-bed contraction scour equation governs:

$$\frac{y_2}{y_1} = \left(\frac{Q_2}{Q_1}\right)^{6/7} \left(\frac{W_1}{W_2}\right)^{k_1}$$

$$y_s = y_2 - y_o$$

9 *Evaluating Scour at Bridges, Hydraulic Engineering Circular No. 18*, Publication No. FHWA NHI 01-001, Federal Highway Administration, May 2001.

Where: y_s is the average contraction scour depth; y_1 and y_2 are average depth in upstream main channel and contracted section, respectively; y_o is existing depth in contracted section before scour; Q_1 and Q_2 are flows in upstream and contracted sections, respectively; and W_1 and W_2 are bottom widths in upstream main channel and contracted section, respectively.

For this analysis, the relevant grain sizes were obtained from a sieve analysis of a soil sample in the scour zone.[10] The input and output for this analysis are exhibited in the appendix. The HEC-RAS results yield a contraction scour depth of **0.0 feet** for the proposed bridge.

The pier scour, using the CSU equation, is negligible but the abutment scour is estimated to be 22.2 feet and 27.3 feet, for the Capital Flood and FIS 100-year, respectively. The ***total maximum potential scour*** is the sum of the long-term, contraction, pier and abutment scour which is conservative estimate of **27.6 feet**.

Bend Scour

We estimated the potential scour at the bend using Maynord's equation, as documented in *HEC-23*:[11]

$$\frac{D_{mxb}}{D_{mnc}} = 1.8 - 0.051\left(\frac{R_c}{W}\right) + 0.0084\left(\frac{W}{D_{mnc}}\right)$$

Where: D_{mxb} is the maximum water depth in the bend; D_{mnc} is the average water depth in the crossing upstream of the bend; W is the width of the bend; and R_c is the centerline radius of the bend.

For this stream bend, we determined that R_c, W and length of curvature, L_c, are 265, 137 and 500 feet, respectively. The computations for this analysis are exhibited in the appendix. The results for the Capital Flood and FIS 100-year yield bend scour depths of **2.4** and **2.3 feet**, respectively.

Streambank Mechanics

There is a bend that is located approximately 500 downstream of the proposed bridge and is therefore within the hydraulic zone of influence. Associated with this bend is a concentration of shear stress directed to the right (east) bank of the Newhall Creek channel.

Erodibility Index Method

Erosion potential within the channel can be assessed using the Erodibility Index Method (EIM)[12] and Shields Parameter. These approaches have been used in this study to assess the stability of the study reach. EIM determines that power of the stream flow and compares it to the power to resist by the channel lining, which in this case is sand.

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[10] Laboratory Soil Test Results, performed by Kling Consulting Group, Inc., February 2014

[11] *Bridge Scour and Stream Instability Countermeasures, Experience, Selection and Design Guidance, Third Edition, Hydraulic Engineering Circular No. 23,* Publication No. FHWA NHI-09-111, p. 4.10, Federal Highway Administration, September 2009.

[12] *Scour Technology*, Annandale, G.W. New York. McGraw-Hill. (pp. 122-259), 2006

As can be seen in Figure 7, the stream power varies along the study reach. Within the segment of proposed improvements, the maximum power is 605 W/m^2, which corresponds to a minimum bulb size of 250 mm, if vegetation was implemented as the natural mitigation for channel stabilization. Details of this analysis is exhibited in the appendix.

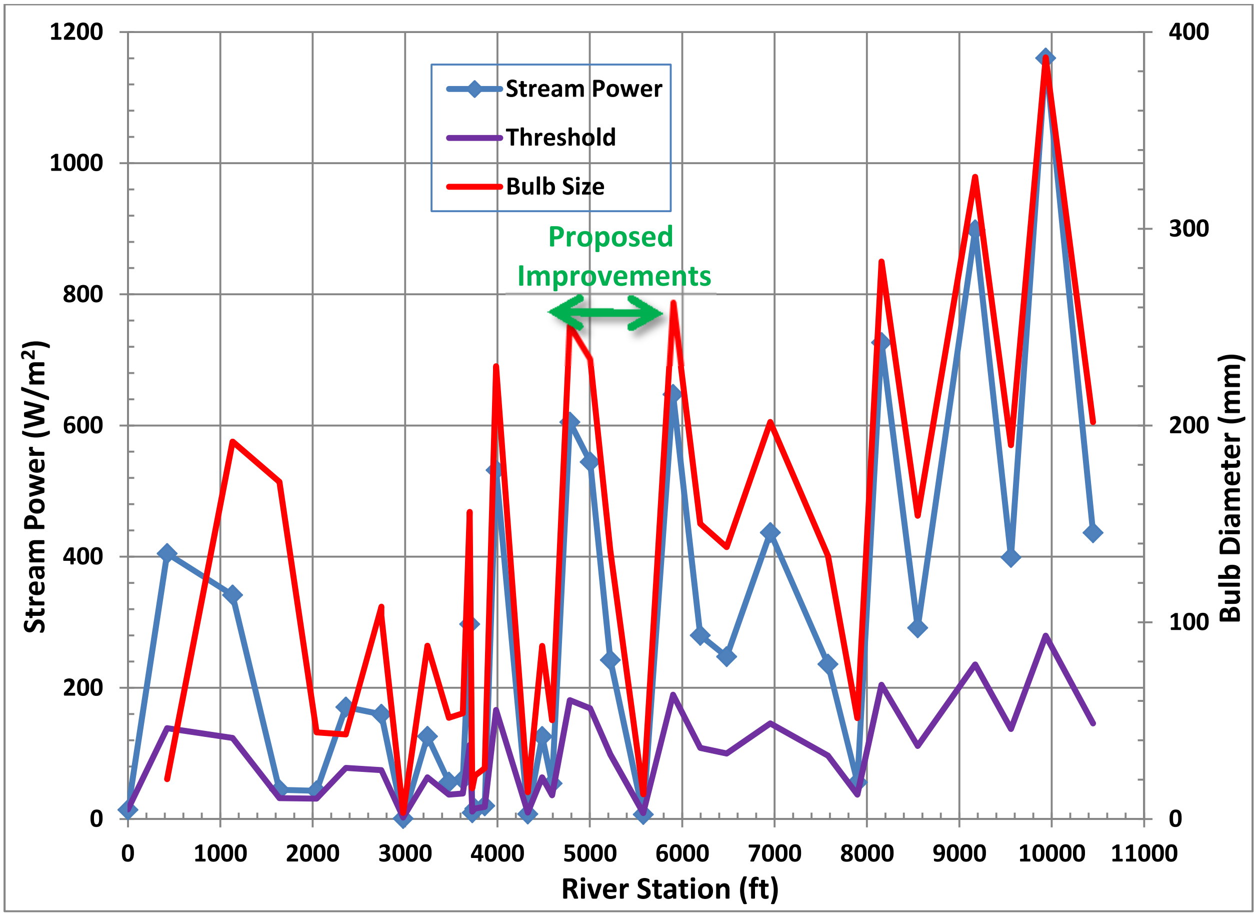

Figure 9. Stream Power

Radial Stress

We estimated the shear stress at the bend using Begin's approach, as documented in *HEC-23*: [13]The radial stress, i.e., the shear stress on the outer bank in a bend is defined as:

$$\phi_r = \frac{F}{A_b} = \frac{\rho Q V}{Y\left(R_c + \frac{W}{2}\right)}$$

Where: A_b is area of the outer bend; φ_r is radial stress; F is centripetal force; ρ is fluid density; Q is discharge; V is velocity; and Y is mean flow depth.

The computations for this analysis are exhibited in the appendix. The results of the Capital Flood and FIS 100-year yield bend shear stresses of **60.4** and **47.2 lb/ft^2**, respectively. From the HEC-

[13] *Bridge Scour and Stream Instability Countermeasures, Experience, Selection and Design Guidance, Third Edition, Hydraulic Engineering Circular No. 23*, Publication No. FHWA NHI-09-111, p. 4.11, Federal Highway Administration, September 2009.

RAS hydraulic model, the average shear stresses on the bed in the bend reach are **1.3** and **0.9 lb/ft²**. Therefore, the ***total shear stress*** is the sum of the average shear stress on the bed and radial shear stress which is **61.7** and **48.1 lb/ft²**, respectively. These estimates are extremely conservative, so verification with another methodology would be advisable.

Chang's Stream Power

As an alternative approach, we applied the more robust Chang Transverse Stream Power methodology with the aid of the *Mathcad*[14] computer program. This application is too complex to summarize in the body of this letter so the input and output for this analysis are exhibited in the appendix. The results yield a *total calculated shear stress,* τ_c, on the outer streambank of **7.7 lb/ft²**, which is the design shear stress that is recommended. So any lining of the channel along the bend would have to greater than or equal to **7.7 lb/ft²** to be stable.

SCOUR COUNTERMEASURES

In addition to the vegetative treatment proscribed in the prior section, there are high shear zones in the exit section of the proposed bridge where more robust countermeasures may be required.

Based on the results of the hydraulic and scour analyses, we are prescribing lining and energy dissipators to resist the computed erosive forces and recommend mitigation measures. With the aid of HY8 and the methodology of HEC-14[15], countermeasures to mitigate the highly-erosive exit velocities of the proposed bridge were evaluated. The feasible alternatives, whose criteria were met by the proposed bridge and hydraulic characteristics, are limited to the following streambed level structures: riprap basin, CSU Basin and Contra Cost Basin, the latter two being rigid structures. The riprap basin, illustrated in typical plan and sections in Figure 10, is recommended but comes with a relatively large footprint, with a total length of 400 feet and width of 366 feet, both of which will need to be reduced to fit the channel physical constraints.

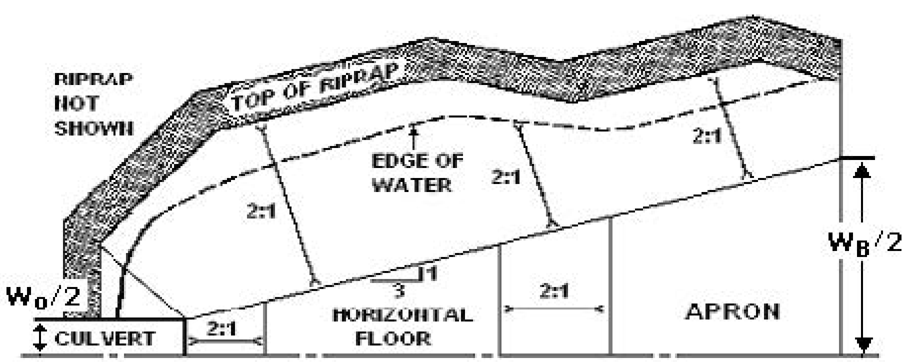

Figure 10a. Riprap Basin, Plan View

[14] *Mathcad*, version 15, Parametric Technology Corporation (PTC), www.ptc.com, 2010.
[15] *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Hydraulic Engineering Circular No. 14, (HEC-14), Third Edition, Federal Highway Administration, Publication No. FHWA-NHI-06-086, July 2006.

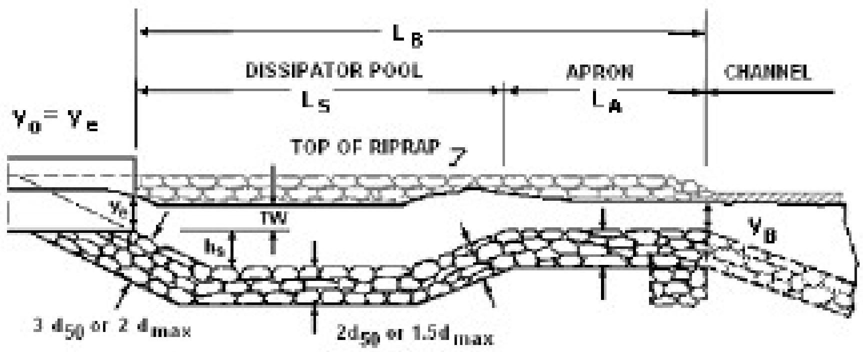

Figure 10b. Riprap Basin, Profile View

RECOMMENDATIONS AND CONCLUSION

In summary, the existing Newhall Creek Channel does not have the capacity to convey the FIS 100-year and the Capital Flood flow rates. As a result, the 100-year model results show that a significant percentage of the flow spill out the main channel and flood the railroad, entering the Railroad Avenue.

As part of the proposed Dockweiler Road / Lyons Avenue extension, there are four 25-foot wide and 8-foot deep openings in a concrete box bridge at the crossing of the Newhall Creek channel and the channel improvement to trapezoidal sections with 80-foot wide soft base and 2:1 protected side slopes. The proposed improvements accommodate Capital Flood, with no overtopping, and will not create any flood hazard for the adjacent railroad and proposed street improvements.

The results of this study provide the calculated shear stress on the streambank. In order to protect the streambank from erosion, a lining with a *permissible shear stress,* τ_p, greater than τ_c must be installed. Riprap and vegetation linings are recommended for the high and moderate shear zones, respectively.

The two methodologies that we applied yield similar results, albeit, the *HEC-23* radial stress approach is more conservative. In the respective documentations for the two approaches, it is stated that the *HEC-23* has limited field verification, whereas, the Chang method has been more thoroughly verified with field data. Therefore, despite the conservatism of the *HEC-23* approach, we recommend implementing a countermeasure that has a *permissible shear stress,* τ_p greater than the *calculated shear stress,* τ_c as determined using the *Chang Stream Power* methodology.

Sensitivity analysis, Sediment Transport

The various applicable transport functions, including Yang, Ackers and White, Engelund and Hansen, Copeland and Laursen were considered and evaluated for this model. The results of these bed-material load models yielded similar results but the Yang method was most consistent and stable, so it is the recommended method. The modeling results in this study reflect the Yang method.

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