Modified Level II Streambed-Scour Analysis for Structure I-65-120-4841 Crossing Little Eagle Creek in Marion County, Indiana

By DAVID C. VOELKER, BRET A. ROBINSON, and ROBERT L. MILLER

Prepared in cooperation with the
INDIANA DEPARTMENT OF TRANSPORTATION

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For additional information, write to:
District Chief
U.S. Geological Survey
Water Resources Division
5957 Lakeside Boulevard
Indianapolis, IN 46278-1996

Copies of this report can be purchased from:
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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
square foot (ft^2)	929.0	square centimeter
feet per second (ft/s)	0.3048	meters per second
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

ABBREVIATIONS used in this report:

D_{50}	median diameter of bed material
Q100	100-year discharge
FEMA	Federal Emergency Management Agency
HEC	Hydraulic Engineering Circular
IDNR	Indiana Department of Natural Resources
INDOT	Indiana Department of Transportation
USGS	United States Geological Survey
WSPRO	Water Surface PROfile model

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By David C. Voelker, Bret A. Robinson, *and* Robert L. Miller

ABSTRACT

Level II scour evaluations follow a process in which hydrologic, hydraulic, and sediment-transport data are evaluated to calculate the depth of scour that may result when a given discharge is routed through a bridge opening. The results of the modified Level II analysis for structure I-65-120-4841 on Interstate 65 crossing Little Eagle Creek in Marion County, Indiana, are presented. The site is in the city of Indianapolis in the west-central part of Marion County. Scour depths were computed with the Water Surface PROfile model, version V050196, which incorporates the scour-calculation procedures outlined in Hydraulic Engineering Circular No. 18. Total scour depths at the piers were approximately 6.2 feet for the modeled discharge of 5,400 cubic feet per second and approximately 7.1 feet for the modeled discharge of 8,080 cubic feet per second.

INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the Indiana Department of Transportation (INDOT), is conducting Level II scour analyses at a number of bridges throughout Indiana. This report describes the methods applied and the modeling results for bridge I-65-120-4841.

Background and Scope

Level I scour assessment is a process where a large number of bridges are studied as a group. Assessments usually are made by evaluating a combination of geomorphic, hydrologic, and bridge-characteristic data. The results help investigators determine which bridges appear to be most likely to experience streambed-scour problems and which bridges appear to be relatively immune to problems brought on by streambed scour (for example, bridges built on bedrock).

When applied correctly, Level I scour assessments provide an investigator with information to identify those bridges that appear to be relatively safe and those bridges that fall into higher risk categories.

Level II scour evaluations describe the process for an investigator to apply a model to a bridge site and calculate the potential depth of scour that may result from a given flood event. Level II analyses involve the application of basic hydrologic, hydraulic, and sediment-transport engineering concepts and may include an evaluation of flood history, channel hydraulic conditions (for example, water-surface profile analysis), and basic sediment-transport analyses such as scour calculations (Lagasse and others, 1995).

The methods and model outlined in Hydraulic Engineering Circular (HEC) No. 18 (Richardson and Davis, 1995) formulate the basis for Level II scour evaluations. Methods used in this study for Level II scour evaluations are a modification of the HEC-18 standards. These modifications were made to comply with the methodology requested by INDOT (Merril Dougherty, Indiana Department of Transportation, oral commun., 1996). Descriptions of the specific modifications are given in the "Evaluation Methods" section of this report.

This report presents the methods followed for modeling, special considerations for this study site, and the input for and the output from the Water Surface PROfile (WSPRO) model.

Site Description

The study site is located in the city of Indianapolis in the west-central part of Marion County. The drainage area for the site is approximately 12.9 mi^2 (estimated using Hoggatt, 1975, and USGS 7.5-minute topographic data). The predominant land use in the basin is suburban; in the immediate vicinity of the bridge, the land is predominantly pasture and grassy areas with suburban area nearby.

Within the immediate vicinity of the bridge, Little Eagle Creek has a channel-bed slope of approximately 0.002 ft/ft. The channel-bed material is silt-clay, and the channel banks consist of gravelly silt-clay. At the time of the Level I site visit on June 16, 1994, the banks were observed to have 50 to 75 percent woody vegetative cover; the field report noted that the banks were experiencing fluvial erosion.

The Interstate 65 crossing of Little Eagle Creek is a 202-ft-long, multi-lane bridge consisting of three spans supported by concrete and steel piers and sloping riprap covered spill-through abutments. Additional details describing conditions at the site are included in the Level I data base (Hopkins and Robinson, unpub. data, 1997). Photographs of the site, taken at the time of the Level I site visit, are archived at the USGS office in Indianapolis.

EVALUATION METHODS

The methods described in this section apply to a number of bridge sites in Indiana being evaluated for scour and outline the procedures requested by INDOT for these modified Level II scour analyses. The principal modification requested by INDOT was that the input data to the model come from or be estimated from existing data sources; no additional field data were collected. Actual methods used in the scour evaluation at this particular bridge site use the most applicable method possible, given the data available.

To determine drainage area, either published values found in Hoggatt (1975) or 7.5-minute topographic maps with Hoggatt's original drainage-area delineations were used. Where there are no published data, drainage-area segments measured from the maps produced by Hoggatt were either subtracted from downstream sites or added to upstream sites published by Hoggatt (1975).

In Indiana, flood discharges are coordinated by agreement among State and Federal agencies. At sites where flood discharges officially are coordinated among State and Federal agencies in Indiana, the coordinated 100-year discharge (Q100) was modeled. INDOT also provided an additional flood discharge for these coordinated sites in excess of the Q100 to be modeled.

If a flood discharge was not coordinated, the USGS examined Federal Emergency Management Agency (FEMA) studies for Q100 determinations. Where FEMA studies did not produce a Q100, the USGS contacted IDNR for an estimated Q100 in the vicinity of the site being studied. If IDNR did not have a Q100, data from nearby USGS streamflow-gaging stations were analyzed with nearby and similar drainage basins that have been coordinated. At sites having no coordinated discharge data, the two discharges used in the model were 1) the approximated Q100 and 2) a discharge equal to 1.7 times the approximated Q100.

Most of the cross-section and bridge-opening geometry data were taken from the bridge plans (Indiana State Highway Commission, 1962) provided by INDOT. Bridge plans are presumed to be representative of current conditions at the site. To determine the cross-section geometry, a line was drawn on the bridge plans parallel to the bridge stationing and approximately one bridge width from the bridge. For sites where the bridge plans did not extend far enough laterally for collection of all cross-section data required for WSPRO model analysis, additional data were collected from 7.5-minute topographic maps.

The roadway and embankment profile was taken from the bridge and highway plans for those sites where roadway overtopping was expected. The INDOT bridge plans and 7.5-minute topographic maps were used as a guide, based on the water-surface elevations calculated by the WSPRO model, to determine if roadway overtopping might occur.

Roughness values (n-values) for the main channel were estimated by viewing photographs archived from the Level I scour assessments. The n-values for the overbanks were assigned on the basis of the surface-cover data summarized in the Level I data base (Hopkins and Robinson, unpub. data, 1997). From those data, the following roughness values were assigned to the surface-cover categories: urban—0.050, suburban—0.035, row crop—0.045, pasture—0.035, brush—0.120, forest—0.100, and wetland (any area covered by standing water)—0.100. The n-values for the overbanks were adjusted if the Level I photographs provided sufficient detail to warrant an adjustment.

WSPRO version V050196 was used to model flow through the study site. Starting water-surface elevation was obtained with a slope-conveyance computation. The channel-bed slope in the immediate vicinity of the bridge was estimated from the 7.5-minute topographic map and was used as the slope of the energy grade line for this computation.

WSPRO version V050196 includes a field that allows the input of up to four scour-adjustment factors (K1 to K4). For this modeling, the default value for K4 (bed armoring) was chosen. For scour-adjustment factors K1 and K2 (pier-nose shape and angle of attack, respectively), input values were determined by evaluating the data archived in the Level I data base (Hopkins and Robinson, unpub. data, 1997). For the K3 factor (bed forms), a value of 1.1 was applied in all cases.

In some cases, piers set on the overbanks are constructed with footings that are higher in elevation than pier footings in the main channel. In these situations, if the channel position changes, the piers that were initially constructed on the overbank may become part of the main channel. Therefore, to evaluate total potential scour, the model results obtained for contraction scour and deepest local scour in the main channel were added and applied to all piers in the bridge opening. This methodology allowed for an evaluation of potential undermining of pier supports in the event that future channel movement placed overbank piers in the main channel.

Where bridge pairs have a continuous abutment or fill between the bridges that does not allow expansion of flow, the bridge pair was modeled as one bridge. Sites with discontinuous abutments, allowing expansion between the bridges, were modeled as two separate bridges. In those cases, a valley cross section was measured between the bridges and used as the approach section for the downstream bridge and as the exit section for the upstream bridge.

At sites with no embankment to function as a weir or at sites where the tailwater drowns out the embankment, a composite bridge and road section was used to compute flow. Those sites were computed with friction-loss equations rather than with a bridge routine.

Total scour is taken as the sum of local scour plus contraction scour. If the model predicted negative contraction scour (aggradation), the contraction-scour value was assumed to be zero in determining the total scour depth (table 1). This assumption was made so that a negative contraction scour would not mask the potentially detrimental effects of local scour at a pier. No abutment scour evaluations were made in this study.

Table 1. Cumulative scour depths for the modeled discharges at structure I-65-120-4841 crossing Little Eagle Creek in Marion County, Indiana

[--, no value]

Pier number[1]	Stationing from bridge plans[2]	Initial bed-elevation at pier (feet)	Main-channel contraction scour depth (feet)	Local scour depth (feet)	Worst-case total-scour depth[3] (feet)	Bottom elevation of pier (feet)	Worst-case bed elevation after scour[4] (feet)
Modeled discharge[5] is 5,400 cubic feet per second							
1	168+63	743	0.6	5.6	6.2	736.3	734.5
2	169+39	743	.6	5.6	6.2	736.6	734.5
Modeled discharge is 8,080 cubic feet per second							
1	168+63	743	0.8	6.3	7.1	736.3	733.6
2	169+39	743	.8	6.3	7.1	736.6	733.6

[1]Pier numbers were assigned from left to right as shown on the bridge plans.

[2]Stationing is the center line of the pier as determined from the bridge plans. Stationing from bridge plan, 168+63, represents a point 16,863 feet from an arbitrary starting location referenced on the bridge plans.

[3]Worst-case total-scour depths are generated by summing the calculated contraction-scour depth with the worst case of local scour.

[4]Worst-case bed elevation is computed by subtracting the worst-case total-scour depth from the lowest initial bed elevation in the bridge opening (740.7 feet).

[5]Coordinated discharge.

SPECIAL CONSIDERATIONS

The bridge plans showed that the Little Eagle Creek channel underwent major realignment at the time the interstate and bridge were constructed. Little Eagle Creek became a manmade channel, and the natural contour data from the bridge plans were unusable for creating cross-section data. To run the model, the proposed bridge-opening cross-section data for the constructed channel were used. The assumption also had to be made that the constructed cross-section geometry was extended in the upstream and downstream directions. Channel slope was used to adjust the bed elevations, and the same cross-section geometry was translated into the approach and exit cross sections for the model. Overbank contours and channel slope were taken from the 7.5-minute topographic map.

Model runs indicate the water-surface elevation at the bridge is lower than the low-steel elevation for the modeled discharges. Therefore, there should be no pressure flow through the bridge opening for the discharges modeled.

RESULTS

Scour depths were computed with a version of WSPRO (Larry Arneson, Federal Highway Administration, written commun., 1996) modified from Shearman (1990). This version of WSPRO includes scour calculations in the model output. Scour depths were calculated assuming an infinite depth of material that could erode and a homogeneous particle-size distribution. The results of the scour analysis are presented in table 1; a complete input file and output results are presented in the appendix.

REFERENCES

Hoggatt, R.E., 1975, Drainage areas of Indiana streams: U.S. Geological Survey, Water Resources Division, 231 p.

Indiana State Highway Commission, 1962, Bridge plans Interstate Route 65: Bridge File I-65-120-4841.

Lagasse, P.F.; Schall, J.D.; Johnson, F.; Richardson, E.V.; and Chang, F., 1995, Stream stability at highway structures (2d ed.): Federal Highway Administration, Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.

Richardson, E.V., and Davis, S.R., 1995, Evaluating scour at bridges (3d ed.): Federal Highway Administration, Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.

Shearman, J.O., 1990, User's manual for WSPRO, a computer model for water-surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 177 p.

APPENDIX

WSPRO INPUT FILE

```
T1          I-65 over Little Eagle Creek      I-65-120-4841
T2          County: Marion                    Quad: Indianapolis West, IND 111C
T3          11-21-96                          David C Voelker
SI          0
Q           5400       8080
SK           .002      .002
XS   EXIT  0    30
GR         16276 755  16460 750  16964 745  17026 742.2  17029 741.2
GR         17048 740.4  17059 741.2  17062 742.2  17138 745  17193 750
GR         17471 755
N          .050         .032         .10         .050
SA              16964        17138        17193
XS   FULL  200   30
GR         16276 755  16460 750  16964 745  17026 742.2  17029 741.2
GR         17048 740.4  17059 741.2  17062 742.2  17138 745  17193 750
GR         17471 755
N          .050         .032         .10         .050
SA              16964        17138        17193
BR   BRDGE  200   753.7     35
GR        16799 0756.9  16799 0751.6  16804 0751.6  16824 0742.8  16886 0742.5
GR        16889 0741.5  16901 0740.7  16911 0741.5  16914 0742.5  16976 0742.9
GR         16998 0752.8  17001 0752.8  17003 0757.8  16799 0756.9
N             0.035        0.032         0.035
SA                  16824         16976
PD 0       742.6   5.0   1
CD         3     130     2.0        752.7
DC 0 BRDGE  16804 17003  16701  16944   *    5.0
DP         16799 17003 2.5  *   *   1.0   1.0   1.1
DP         16799 17003 2.5  *   *   1.0   1.0   1.1
XS   APPR   530    0
GR         16296 755  16701 750  16751 745  16813 742.8  16816 741.8
GR         16828 741.0  16839 741.8  16842 742.8  16904 745  16944 750
GR         17136 752.5
N              .035       0.10        .032        .10         .035
SA                  16701      16751       16904       16944
EX
ER
```

WSPRO OUTPUT

```
************************  W S P R O  ***************************
        Federal Highway Administration  -  U. S. Geological Survey
              Model for Water-Surface Profile Computations.
          Run Date & Time:  8/ 6/97  8:34 am     Version V050196
           Input File: 4841.dat       Output File: 4841.LST
     *-------------------------------------------------------------*
   T1         I-65 OVER LITTLE EAGLE CREEK     I-65-120-4841
   T2         COUNTY: MARION                   QUAD: INDIANAPOLIS WEST, IND
111C
   T3         11-21-96                         DAVID C VOELKER
   SI         0
   Q          5400      8080

    ***   Processing Flow Data; Placing Information into Sequence  1   ***

   SK          .002      .002

      ************************  W S P R O  ***************************
         Federal Highway Administration  -  U. S. Geological Survey
               Model for Water-Surface Profile Computations.
              Input Units: English  /  Output Units: English
      *-------------------------------------------------------------*
             I-65 OVER LITTLE EAGLE CREEK     I-65-120-4841
    COUNTY: MARION                    QUAD: INDIANAPOLIS WEST, IND 111C
            11-21-96                          DAVID C VOELKER

            *-----------------------------------------------*
            *      Starting To Process Header Record EXIT   *
            *-----------------------------------------------*

   XS   EXIT  0    30
   GR         16276 755  16460 750  16964 745  17026 742.2  17029 741.2
   GR         17048 740.4  17059 741.2  17062 742.2  17138 745  17193 750
   GR         17471 755
   N          .050        .032        .10        .050
   SA              16964       17138       17193

    ***   Completed Reading Data Associated With Header Record EXIT    ***
    ***  Storing X-Section Data In Temporary File As Record Number  1  ***

    ***              Data Summary For Header Record EXIT              ***
    SRD Location:        0.   Cross-Section Skew:  30.0   Error Code   0
    Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
    Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                        X,Y-coordinates (11 pairs)
        X          Y            X          Y            X          Y
   ----------  ----------   ----------  ----------   ----------  ----------
    16276.000     755.000    16460.000     750.000    16964.000     745.000
    17026.000     742.200    17029.000     741.200    17048.000     740.400
    17059.000     741.200    17062.000     742.200    17138.000     745.000
    17193.000     750.000    17471.000     755.000
   ----------  ----------   ----------  ----------   ----------  ----------
```

WSPRO OUTPUT

```
                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   16276.000  ( associated Y-Elevation:  755.000 )
  Maximum X-Station:   17471.000  ( associated Y-Elevation:  755.000 )
  Minimum Y-Elevation:   740.400  ( associated X-Station:  17048.000 )
  Maximum Y-Elevation:   755.000  ( associated X-Station:  16276.000 )

     X-coordinates & Horizontal Breakpoints Translated by Skew Angle
  X Input    X Skewed      X Input    X Skewed      X Input    X Skewed
----------  ----------   ----------  ----------   ----------  ----------
 16276.000   16379.430    16460.000   16538.780    16964.000   16975.250
 17026.000   17028.950    17029.000   17031.540    17048.000   17048.000
 17059.000   17057.530    17062.000   17060.130    17138.000   17125.940
 17193.000   17173.570    17471.000   17414.330
----------  ----------   ----------  ----------   ----------  ----------

                    Roughness Data (  4 SubAreas )
                             Roughness   Horizontal
                   SubArea  Coefficient  Breakpoint
                   -------  -----------  ----------
                      1         .050        ---
                                ---       ********
                      2         .032        ---
                                ---       ********
                      3         .100        ---
                                ---       ********
                      4         .050        ---
                   -------  -----------  ----------

         *-----------------------------------------------------*
         *      Finished Processing Header Record EXIT         *
         *-----------------------------------------------------*

   ************************* W S P R O ****************************
      Federal Highway Administration  -  U. S. Geological Survey
            Model for Water-Surface Profile Computations.
           Input Units: English  /  Output Units: English
   *-------------------------------------------------------------*
          I-65 OVER LITTLE EAGLE CREEK     I-65-120-4841
 COUNTY: MARION                    QUAD: INDIANAPOLIS WEST, IND 111C
          11-21-96                          DAVID C VOELKER

         *-----------------------------------------------------*
         *      Starting To Process Header Record FULL         *
         *-----------------------------------------------------*

XS   FULL  200   30
GR        16276 755  16460 750  16964 745  17026 742.2  17029 741.2
GR        17048 740.4  17059 741.2  17062 742.2  17138 745  17193 750
GR        17471 755
N         .050        .032        .10        .050
SA             16964       17138       17193

 ***   Completed Reading Data Associated With Header Record FULL    ***
 ***  Storing X-Section Data In Temporary File As Record Number  2  ***
```

WSPRO OUTPUT

```
***                Data Summary For Header Record FULL                  ***
SRD Location:      200.   Cross-Section Skew:  30.0   Error Code    0
Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                    X,Y-coordinates (11 pairs)
    X          Y            X          Y            X          Y
----------  ----------   ----------  ----------   ----------  ----------
16276.000     755.000    16460.000     750.000    16964.000     745.000
17026.000     742.200    17029.000     741.200    17048.000     740.400
17059.000     741.200    17062.000     742.200    17138.000     745.000
17193.000     750.000    17471.000     755.000
----------  ----------   ----------  ----------   ----------  ----------

                Minimum and Maximum X,Y-coordinates
 Minimum X-Station:   16276.000  ( associated Y-Elevation:  755.000 )
 Maximum X-Station:   17471.000  ( associated Y-Elevation:  755.000 )
 Minimum Y-Elevation:   740.400  ( associated X-Station:  17048.000 )
 Maximum Y-Elevation:   755.000  ( associated X-Station:  16276.000 )

     X-coordinates & Horizontal Breakpoints Translated by Skew Angle
 X Input    X Skewed      X Input    X Skewed      X Input    X Skewed
----------  ----------   ----------  ----------   ----------  ----------
16276.000   16379.430    16460.000   16538.780    16964.000   16975.250
17026.000   17028.950    17029.000   17031.540    17048.000   17048.000
17059.000   17057.530    17062.000   17060.130    17138.000   17125.940
17193.000   17173.570    17471.000   17414.330
----------  ----------   ----------  ----------   ----------  ----------

                  Roughness Data (  4 SubAreas )
                          Roughness   Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .050        ---
                             ---       ********
                   2         .032        ---
                             ---       ********
                   3         .100        ---
                             ---       ********
                   4         .050        ---
                -------  -----------  ----------

        *-------------------------------------------------*
        *      Finished Processing Header Record FULL     *
        *-------------------------------------------------*

  ************************  W S P R O  ***************************
     Federal Highway Administration  -  U. S. Geological Survey
           Model for Water-Surface Profile Computations.
          Input Units: English  /  Output Units: English
  *-------------------------------------------------------------*
        I-65 OVER LITTLE EAGLE CREEK     I-65-120-4841
COUNTY: MARION                    QUAD: INDIANAPOLIS WEST, IND 111C
```

WSPRO OUTPUT

11-21-96 DAVID C VOELKER

```
*-------------------------------------------------*
*      Starting To Process Header Record BRDGE    *
*-------------------------------------------------*

  BR   BRDGE  200   753.7     35
  GR        16799 0756.9  16799 0751.6  16804 0751.6  16824 0742.8  16886
0742.5
  GR        16889 0741.5  16901 0740.7  16911 0741.5  16914 0742.5  16976
0742.9
  GR        16998 0752.8  17001 0752.8  17003 0757.8  16799 0756.9
  N             0.035         0.032         0.035
  SA                  16824         16976
  PD 0      742.6   5.0   1
  CD        3     130     2.0       752.7

   ***   Completed Reading Data Associated With Header Record BRDGE   ***
 +++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
   ***   Storing Bridge Data In Temporary File As Record Number  3    ***

   ***              Data Summary For Bridge Record BRDGE              ***
   SRD Location:      200.   Cross-Section Skew:  35.0   Error Code   0
   Valley Slope:  *******    Averaging Conveyance By Geometric Mean.
   Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (14 pairs)

X	Y	X	Y	X	Y
16799.000	756.900	16799.100	751.600	16804.000	751.600
16824.000	742.800	16886.000	742.500	16889.000	741.500
16901.000	740.700	16911.000	741.500	16914.000	742.500
16976.000	742.900	16998.000	752.800	17001.000	752.800
17003.000	757.800	16799.000	756.900		

Minimum and Maximum X,Y-coordinates

Minimum X-Station:	16799.000	(associated Y-Elevation:	756.900)
Maximum X-Station:	17003.000	(associated Y-Elevation:	757.800)
Minimum Y-Elevation:	740.700	(associated X-Station:	16901.000)
Maximum Y-Elevation:	757.800	(associated X-Station:	17003.000)

X-coordinates & Horizontal Breakpoints Translated by Skew Angle

X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
16799.000	16817.450	16799.100	16817.530	16804.000	16821.540
16824.000	16837.930	16886.000	16888.710	16889.000	16891.170
16901.000	16901.000	16911.000	16909.190	16914.000	16911.650
16976.000	16962.440	16998.000	16980.460	17001.000	16982.920
17003.000	16984.550	16799.000	16817.450		

Roughness Data (3 SubAreas)

	Roughness	Horizontal

WSPRO OUTPUT

```
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .035        ---
                             ---        ********
                   2         .032        ---
                             ---        ********
                   3         .035        ---
                -------  -----------  ----------

                  Discharge coefficient parameters
              BRType   BRWdth   EMBSS   EMBElv    UserCD
                3      130.000   2.00   752.700 **********

                    Pressure flow elevations
                       AVBCEL     PFElev
                    *********    753.700

                      Abutment Parameters
        ABSLPL  ABSLPR   XTOELT    YTOELT    XTOERT    YTOERT
      ******* ******* ********* ********* ********* *********

                                                                -

                  Pier/Pile Data (  1 Group(s) )
                 Code Indicates Bridge Uses Piers
                Group  Elevation  Gross Width  Number
               ------  ---------  -----------  ------
                  1      742.600      5.000       1
               ------  ---------  -----------  ------

          *-------------------------------------------------*
          *      Finished Processing Header Record BRDGE    *
          *-------------------------------------------------*

   ************************  W S P R O  ***************************
      Federal Highway Administration  -  U. S. Geological Survey
            Model for Water-Surface Profile Computations.
           Input Units: English  /  Output Units: English
   *-------------------------------------------------------------*
          I-65 OVER LITTLE EAGLE CREEK     I-65-120-4841
 COUNTY: MARION                    QUAD: INDIANAPOLIS WEST, IND 111C
          11-21-96                           DAVID C VOELKER
DC 0 BRDGE  16804 17003  16701  16944   *    5.0
DP          16799 17003 2.5  *    *   1.0   1.0   1.1
DP          16799 17003 2.5  *    *   1.0   1.0   1.1

          *-------------------------------------------------*
          *      Starting To Process Header Record APPR     *
          *-------------------------------------------------*

XS   APPR   530    0
GR          16296 755  16701 750  16751 745  16813 742.8  16816 741.8
GR          16828 741.0  16839 741.8  16842 742.8  16904 745  16944 750
GR          17136 752.5
N                .035       0.10        .032        .10         .035
```

WSPRO OUTPUT

```
SA                  16701      16751       16904       16944

 ***   Completed Reading Data Associated With Header Record APPR     ***
 ***  Storing X-Section Data In Temporary File As Record Number  4   ***

 ***              Data Summary For Header Record APPR                ***
 SRD Location:      530.   Cross-Section Skew:    .0   Error Code   0
 Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                     X,Y-coordinates (11 pairs)
    X          Y            X          Y            X          Y
----------  ----------   ----------  ----------   ----------  ----------
16296.000     755.000    16701.000     750.000    16751.000     745.000
16813.000     742.800    16816.000     741.800    16828.000     741.000
16839.000     741.800    16842.000     742.800    16904.000     745.000
16944.000     750.000    17136.000     752.500
----------  ----------   ----------  ----------   ----------  ----------

                  Minimum and Maximum X,Y-coordinates
 Minimum X-Station:   16296.000  ( associated Y-Elevation:  755.000 )
 Maximum X-Station:   17136.000  ( associated Y-Elevation:  752.500 )
 Minimum Y-Elevation:   741.000  ( associated X-Station:  16828.000 )
 Maximum Y-Elevation:   755.000  ( associated X-Station:  16296.000 )

                    Roughness Data (  5 SubAreas )
                            Roughness   Horizontal
                  SubArea  Coefficient  Breakpoint
                  -------  -----------  ----------
                     1         .035        ---
                               ---       ********
                     2         .100        ---
                               ---       ********
                     3         .032        ---
                               ---       ********
                     4         .100        ---
                               ---       ********
                     5         .035        ---
                  -------  -----------  ----------

Bridge datum projection(s):  XREFLT  XREFRT  FDSTLT  FDSTRT
                            ******* ******* ******* *******

          *-------------------------------------------------*
          *      Finished Processing Header Record APPR     *
          *-------------------------------------------------*

    ************************  W S P R O  ***************************
       Federal Highway Administration  -  U. S. Geological Survey
             Model for Water-Surface Profile Computations.
           Input Units: English  /  Output Units: English
    *-----------------------------------------------------------*
          I-65 OVER LITTLE EAGLE CREEK     I-65-120-4841
  COUNTY: MARION                    QUAD: INDIANAPOLIS WEST, IND 111C
```

WSPRO OUTPUT

```
          11-21-96                              DAVID C VOELKER
EX

         *=================================================*
         *     Summary of Boundary Condition Information    *
         *=================================================*

           Reach       Water Surface   Friction
     #   Discharge       Elevation      Slope          Flow Regime
    --   ---------     ------------    --------   --------------------
     1     5400.00       ********         .0020        Sub-Critical
     2     8080.00       ********         .0020        Sub-Critical
    --   ---------     ------------    --------   --------------------

         *=================================================*
         *         Beginning  2 Profile Calculation(s)     *
         *=================================================*


   ************************  W S P R O  ***************************
      Federal Highway Administration  -  U. S. Geological Survey
             Model for Water-Surface Profile Computations.
            Input Units: English  /  Output Units: English
   *-------------------------------------------------------------*
          I-65 OVER LITTLE EAGLE CREEK     I-65-120-4841
  COUNTY: MARION                    QUAD: INDIANAPOLIS WEST, IND 111C
          11-21-96                          DAVID C VOELKER

                     WSEL     VHD       Q          AREA       SRDL       LEW
                     EGEL      HF       V           K         FLEN       REW
                     CRWS      HO     FR #         SF        ALPHA      ERR
                   --------- ------ ---------- ---------- --------- ---------
Section: EXIT       747.742   .466   5400.000   1236.643 ********* 16687.560
Header Type: XS     748.209 ******      4.367  120674.70 ********* 17168.170
SRD:       .000     746.282 ******       .602     ******     1.573    ******

Section: FULL       748.192   .352   5400.000   1464.108   200.000 16642.220
Header Type: FV     748.544   .332      3.688  145471.20   200.000 17173.120
SRD:    200.000     746.282   .000       .505      .0017     1.663      .003

       <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

Section: APPR       748.622   .678   5400.000    907.662   330.000 16714.780
Header Type: AS     749.300   .591      5.949  111876.90   330.000 16932.980
SRD:    530.000     746.866   .163       .571      .0018     1.232      .002

       <<< The Preceding Data Reflect The "Unconstricted" Profile >>>

        <<< The Following Data Reflect The "Constricted" Profile >>>
          <<< Beginning Bridge/Culvert Hydraulic Computations >>>

                     WSEL     VHD       Q          AREA       SRDL       LEW
                     EGEL      HF       V           K         FLEN       REW
```

WSPRO OUTPUT

	CRWS	HO	FR #	SF	ALPHA	ERR
Section: BRDGE	748.097	.531	5400.000	924.807	200.000	16811.960
Header Type: BR	748.628	.419	5.839	132014.50	200.000	16987.550
SRD: 200.000	745.869	.000	.449	******	1.001	-.003

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1						
Pier/Pile Code 0	.9994	.030	753.700	********	********	********

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: APPR	748.742	.646	5400.000	933.879	200.000	16713.580
Header Type: AS	749.387	.517	5.782	116363.10	237.680	16933.930
SRD: 530.000	746.866	.245	.552	.0018	1.242	.009

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.193	.005	115428.8	********	********	748.742

<<< End of Bridge Hydraulics Computations >>>

********** W S P R O **********

Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English

I-65 OVER LITTLE EAGLE CREEK I-65-120-4841
COUNTY: MARION QUAD: INDIANAPOLIS WEST, IND 111C
11-21-96 DAVID C VOELKER

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	748.753	.565	8080.000	1779.306	*********	16585.710
Header Type: XS	749.318	******	4.541	180582.20	*********	17179.280
SRD: .000	747.233	******	.614	******	1.762	******
Section: FULL	749.233	.432	8080.000	2076.931	200.000	16537.350
Header Type: FV	749.664	.337	3.890	214533.60	200.000	17184.560
SRD: 200.000	747.233	.000	.519	.0017	1.835	.009

<<< The Preceding Data Reflect The "Unconstricted" Profile >>>

Section: APPR	749.591	1.046	8080.000	1127.576	330.000	16705.090
Header Type: AS	750.638	.667	7.166	150467.70	330.000	16940.730
SRD: 530.000	747.910	.307	.661	.0020	1.310	-.001

WSPRO OUTPUT

<<< The Preceding Data Reflect The "Unconstricted" Profile >>>

<<< The Following Data Reflect The "Constricted" Profile >>>
<<< Beginning Bridge/Culvert Hydraulic Computations >>>

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: BRDGE	748.962	.883	8080.000	1078.254	200.000	16810.000
Header Type: BR	749.844	.459	7.494	168292.80	200.000	16989.470
SRD: 200.000	746.917	.064	.542	******	1.011	-.014

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.9948	.029	753.700	********	********	********

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: APPR	749.805	.971	8080.000	1178.370	200.000	16702.950
Header Type: AS	750.776	.610	6.857	159659.00	234.372	16942.440
SRD: 530.000	747.910	.330	.628	.0020	1.328	.013

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.233	.009	157669.2	********	********	749.805

<<< End of Bridge Hydraulics Computations >>>

********** W S P R O **********
Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English

I-65 OVER LITTLE EAGLE CREEK I-65-120-4841
COUNTY: MARION QUAD: INDIANAPOLIS WEST, IND 111C
11-21-96 DAVID C VOELKER

*** Live-Bed Contraction Scour Calculations for Header Record BRDGE ***

Constants and Input Variables

Bed Material Transport Mode Factor (k1):	.64
Total Pier Width Value (Pw):	5.000

WSPRO OUTPUT

#	Scour Depth	-- Flow -- Contract	Approach	-- Width -- Contract	Approach	--- X-Limits --- Side	Contract	Approach
1	.596	5400.000	5400.000	194.000	243.000	Left:	********	********
	..... Approach Channel Depth:	3.843				Right:	********	********
2	.752	8080.000	8080.000	194.000	243.000	Left:	********	********
	..... Approach Channel Depth:	4.849				Right:	********	********

********** W S P R O **********
Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English

I-65 OVER LITTLE EAGLE CREEK I-65-120-4841
COUNTY: MARION QUAD: INDIANAPOLIS WEST, IND 111C
11-21-96 DAVID C VOELKER

*** Pier Scour Calculations for Header Record BRDGE ***

Constants and Input Variables

Pier Width: 2.500

Pier Shape Factor	(K1):	1.00
Flow Angle of Attack Factor	(K2):	1.00
Bed Condition Factor	(K3):	1.10
Bed Material Factor	(K4):	1.00
Velocity Multiplier	(VM):	1.00
Depth Multiplier	(YM):	1.00

#	Scour Depth	---- Localized Hydraulic Properties ---- Flow	WSE	Depth	Velocity	Froude #	-- X-Stations -- Left	Right
1	5.60	5400.000	748.342	7.642	6.581	.420	16799.000	17003.000
2	6.29	8080.000	749.292	8.592	8.335	.501	16799.000	17003.000

********** W S P R O **********
Federal Highway Administration - U. S. Geological Survey
Model for Water-Surface Profile Computations.
Input Units: English / Output Units: English

I-65 OVER LITTLE EAGLE CREEK I-65-120-4841
COUNTY: MARION QUAD: INDIANAPOLIS WEST, IND 111C
11-21-96 DAVID C VOELKER

*** Pier Scour Calculations for Header Record BRDGE ***

Constants and Input Variables

WSPRO OUTPUT

Pier Width: 2.500

Pier Shape Factor	(K1):	1.00
Flow Angle of Attack Factor	(K2):	1.00
Bed Condition Factor	(K3):	1.10
Bed Material Factor	(K4):	1.00
Velocity Multiplier	(VM):	1.00
Depth Multiplier	(YM):	1.00

#	Scour Depth	Localized Hydraulic Properties: Flow	WSE	Depth	Velocity	Froude #	X-Stations: Left	Right
1	5.60	5400.000	748.342	7.642	6.581	.420	16799.000	17003.000
2	6.29	8080.000	749.292	8.592	8.335	.501	16799.000	17003.000

ER

********** Normal end of WSPRO execution. **********
********** Elapsed Time: 0 Minutes 4 Seconds **********