Modified Level II Streambed-Scour Analysis for Structure I-70-69-5185 Crossing East Fork White Lick Creek in Hendricks County, Indiana

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

Prepared in cooperation with the
INDIANA DEPARTMENT OF TRANSPORTATION

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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 Bret A. Robinson, David C. Voelker, *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-70-69-5185 on Interstate 70 crossing East Fork White Lick Creek in Hendricks County, Indiana, are presented. The site is near the town of Camby and is in the southeastern part of Hendricks 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 12.0 feet for the modeled discharge of 5,720 cubic feet per second and approximately 13.8 feet for the modeled discharge of 7,360 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-70-69-5185.

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 near the town of Camby and is in the southeastern part of Hendricks County. The drainage area for the site is approximately 34.5 mi^2 (estimated using Hoggatt, 1975, and USGS 7.5-minute topographic data). The predominant land use in the basin is agricultural and suburban; in the immediate vicinity of the bridge, the land is predominantly pasture with some forested land nearby.

Within the immediate vicinity of the bridge, East Fork White Lick Creek has a channel-bed slope of approximately 0.0008 ft/ft. The channel-bed material is silty sand, and the channel banks consist of silty clay. At the time of the Level I site visit on June 3, 1991, the banks were observed to have 0 to 30 percent woody vegetative cover; the field report noted that the banks were fairly stable with some small areas experiencing mass wasting.

The Interstate 70 crossing of East Fork White Lick Creek is a 111-ft-long, multi-lane bridge consisting of three spans supported by concrete and steel piers and 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, 1965) 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-70-69-5185 crossing East Fork White Lick Creek in Hendricks 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 5,720 cubic feet per second							
1	295+02	702	5.9	6.1	12.0	697	688.4
2	295+45	703	5.9	6.1	12.0	697	688.4
Modeled discharge is 7,360 cubic feet per second							
1	295+02	702	7.2	6.6	13.8	697	686.6
2	295+45	703	7.2	6.6	13.8	697	686.6

[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, 295+02, represents a point 29,502 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 (700.4 feet).

[5]Not a coordinated discharge.

SPECIAL CONSIDERATIONS

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. Information gained by viewing the archived photographs caused the authors to slightly adjust the channel-bed material and bank stability values used for this modeling.

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, 1965, Bridge plans Interstate Route 70: Bridge File I-70-69-5185.

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-70 Over East Fork White Lick Creek  I70-69-5185
T2        County: Hendricks                     Quad: Bridgeport 123B
T3        11-19-96                              Bret A. Robinson
SI        0
Q         5720 7360
SK        .0008 .0008
XS   EXIT 0 0
GR        27677 720  28280 715  29348 710  29419 708  29466 708  29483 700
GR        29521 700  29540 708  29596 708  29647 710  29890 715  29968 720
GR        30049 725  30551 725
N         .045 .100 .034 .100 .045
SA        29400 29450 29540 29595
XS   FULLV 112 0
GR        27677 720  28280 715  29348 710  29419 708  29466 708  29483 700
GR        29521 700  29540 708  29596 708  29647 710  29890 715  29968 720
GR        30049 725  30551 725
N         .045 .100 .034 .100 .045
SA        29400 29450 29540 29595
BR   BRDGE 112 716.8 0
GR       29470 0717.1  29470 0716.6  29473 0716.6  29508 0700.3  29543 0700.4
GR       29577 0717.0  29580 0717.1  29581 0717.7  29581 0717.8  29576 0717.8
GR       29569 0717.6  29560 0717.2  29552 0716.5  29549 0716.2  29548 0716.2
GR       29544 0716.7  29538 0717.1  29530 0717.3  29522 0717.3  29513 0716.9
GR       29506 0716.3  29504 0716.0  29502 0716.0  29497 0716.3  29491 0716.7
GR        29483 0717.1  29476 0717.1  29472 0717.2  29470 0717.1
N         .034
PD        702.5 4 1
CD        3 130 2 716.7
DC 0 BRDGE  29486 29565 29430 29680 * 4
*         LPierEdge RPierEdge PierWdth * * K1 K2 K3(1.1)
DP        29470 29581 2 * * 1 1 1.1
DP        29470 29581 2 * * 1 1 1.1
XS   APPR 354 0
GR        27643 725  28695 725  28944 720  29420 715  29460 710  29493 709
GR        29499 708  29502 708  29512 708  29529 701  29565 701  29600 708
GR        29667 715  29778 715  29854 720  30476 725
N         .045 .100 .034 .100 .045
SA        29400 29450 29620 29675
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/ 4/97  2:40 pm     Version V050196
          Input File: 5185.dat       Output File: 5185.LST
   *-------------------------------------------------------------*
T1         I-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
T2         COUNTY: HENDRICKS                     QUAD: BRIDGEPORT 123B
T3         11-19-96                              BRET A. ROBINSON
SI         0
Q          5720 7360

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

SK         .0008 .0008

   ************************  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-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
    COUNTY: HENDRICKS                      QUAD: BRIDGEPORT 123B
       11-19-96                               BRET A. ROBINSON

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

XS   EXIT 0 0
GR         27677 720  28280 715  29348 710  29419 708  29466 708  29483 700
GR         29521 700  29540 708  29596 708  29647 710  29890 715  29968 720
GR         30049 725  30551 725
N          .045 .100 .034 .100 .045
SA         29400 29450 29540 29595

 ***   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:    .0   Error Code   0
 Valley Slope:   .00000    Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                    X,Y-coordinates (14 pairs)
     X          Y            X          Y            X          Y
----------  ----------   ----------  ----------   ----------  ----------
 27677.000     720.000    28280.000     715.000    29348.000     710.000
 29419.000     708.000    29466.000     708.000    29483.000     700.000
 29521.000     700.000    29540.000     708.000    29596.000     708.000
 29647.000     710.000    29890.000     715.000    29968.000     720.000
 30049.000     725.000    30551.000     725.000
----------  ----------   ----------  ----------   ----------  ----------
```

WSPRO OUTPUT

```
                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   27677.000  ( associated Y-Elevation:  720.000 )
  Maximum X-Station:   30551.000  ( associated Y-Elevation:  725.000 )
  Minimum Y-Elevation:   700.000  ( associated X-Station:  29521.000 )
  Maximum Y-Elevation:   725.000  ( associated X-Station:  30049.000 )

                    Roughness Data (  5 SubAreas )
                             Roughness   Horizontal
                  SubArea  Coefficient  Breakpoint
                  -------  -----------  ----------
                     1         .045        ---
                               ---        ********
                     2         .100        ---
                               ---        ********
                     3         .034        ---
                               ---        ********
                     4         .100        ---
                               ---        ********
                     5         .045        ---
                  -------  -----------  ----------

         *-----------------------------------------------------*
         *      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-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
    COUNTY: HENDRICKS                    QUAD: BRIDGEPORT 123B
       11-19-96                             BRET A. ROBINSON

         *-----------------------------------------------------*
         *      Starting To Process Header Record FULLV        *
         *-----------------------------------------------------*

XS   FULLV 112 0
GR        27677 720  28280 715  29348 710  29419 708  29466 708  29483 700
GR        29521 700  29540 708  29596 708  29647 710  29890 715  29968 720
GR        30049 725  30551 725
N         .045 .100 .034 .100 .045
SA        29400 29450 29540 29595

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

 ***              Data Summary For Header Record FULLV               ***
 SRD Location:      112.   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 (14 pairs)
```

WSPRO OUTPUT

X	Y	X	Y	X	Y
27677.000	720.000	28280.000	715.000	29348.000	710.000
29419.000	708.000	29466.000	708.000	29483.000	700.000
29521.000	700.000	29540.000	708.000	29596.000	708.000
29647.000	710.000	29890.000	715.000	29968.000	720.000
30049.000	725.000	30551.000	725.000		

Minimum and Maximum X,Y-coordinates

Minimum X-Station: 27677.000 (associated Y-Elevation: 720.000)
Maximum X-Station: 30551.000 (associated Y-Elevation: 725.000)
Minimum Y-Elevation: 700.000 (associated X-Station: 29521.000)
Maximum Y-Elevation: 725.000 (associated X-Station: 30049.000)

Roughness Data (5 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.045	---
	---	********
2	.100	---
	---	********
3	.034	---
	---	********
4	.100	---
	---	********
5	.045	---

---
* Finished Processing Header Record FULLV *

********** 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-70 OVER EAST FORK WHITE LICK CREEK I70-69-5185
COUNTY: HENDRICKS QUAD: BRIDGEPORT 123B
11-19-96 BRET A. ROBINSON

---
* Starting To Process Header Record BRDGE *

```
BR   BRDGE 112 716.8 0
GR        29470 0717.1  29470 0716.6  29473 0716.6  29508 0700.3  29543
0700.4
GR        29577 0717.0  29580 0717.1  29581 0717.7  29581 0717.8  29576
0717.8
GR        29569 0717.6  29560 0717.2  29552 0716.5  29549 0716.2  29548
0716.2
```

WSPRO OUTPUT

```
   GR         29544 0716.7  29538 0717.1  29530 0717.3  29522 0717.3  29513
0716.9
   GR         29506 0716.3  29504 0716.0  29502 0716.0  29497 0716.3  29491
0716.7
   GR         29483 0717.1  29476 0717.1  29472 0717.2  29470 0717.1
   N          .034
   PD         702.5 4 1
   CD         3 130 2 716.7

    ***   Completed Reading Data Associated With Header Record BRDGE   ***
 +++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
 +++072 NOTICE:  X-coordinate # 9 increased to eliminate vertical segment.
    ***   Storing Bridge Data In Temporary File As Record Number  3    ***

    ***              Data Summary For Bridge Record BRDGE              ***
    SRD Location:      112.   Cross-Section Skew:    .0   Error Code   0
    Valley Slope:  *******    Averaging Conveyance By Geometric Mean.
    Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                      X,Y-coordinates (29 pairs)
        X          Y              X          Y              X          Y
  ----------  ----------    ----------  ----------    ----------  ----------
   29470.000     717.100     29470.100     716.600     29473.000     716.600
   29508.000     700.300     29543.000     700.400     29577.000     717.000
   29580.000     717.100     29581.000     717.700     29581.100     717.800
   29576.000     717.800     29569.000     717.600     29560.000     717.200
   29552.000     716.500     29549.000     716.200     29548.000     716.200
   29544.000     716.700     29538.000     717.100     29530.000     717.300
   29522.000     717.300     29513.000     716.900     29506.000     716.300
   29504.000     716.000     29502.000     716.000     29497.000     716.300
   29491.000     716.700     29483.000     717.100     29476.000     717.100
   29472.000     717.200     29470.000     717.100
  ----------  ----------    ----------  ----------    ----------  ----------

                  Minimum and Maximum X,Y-coordinates
    Minimum X-Station:    29470.000  ( associated Y-Elevation:  717.100 )
    Maximum X-Station:    29581.100  ( associated Y-Elevation:  717.800 )
    Minimum Y-Elevation:    700.300  ( associated X-Station:  29508.000 )
    Maximum Y-Elevation:    717.800  ( associated X-Station:  29581.100 )

                    Roughness Data (  1 SubAreas )
                             Roughness   Horizontal
                    SubArea  Coefficient  Breakpoint
                    -------  -----------  ----------
                       1         .034        ---
                    -------  -----------  ----------

                  Discharge coefficient parameters
                BRType   BRWdth   EMBSS   EMBElv    UserCD
                  3      130.000   2.00   716.700 **********

                    Pressure flow elevations
                       AVBCEL     PFElev
                    *********     716.800
```

WSPRO OUTPUT

```
                    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      702.500      4.000       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-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
    COUNTY: HENDRICKS                      QUAD: BRIDGEPORT 123B
       11-19-96                               BRET A. ROBINSON
DC 0 BRDGE  29486 29565 29430 29680 * 4
DP        29470 29581 2 * * 1 1 1.1
DP        29470 29581 2 * * 1 1 1.1

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

XS   APPR 354 0
GR        27643 725  28695 725  28944 720  29420 715  29460 710  29493 709
GR        29499 708  29502 708  29512 708  29529 701  29565 701  29600 708
GR        29667 715  29778 715  29854 720  30476 725
N         .045 .100 .034 .100 .045
SA        29400 29450 29620 29675

 ***   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:      354.   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 (16 pairs)
    X          Y            X          Y            X          Y
----------  ----------   ----------  ----------   ----------  ----------
 27643.000     725.000    28695.000     725.000    28944.000     720.000
 29420.000     715.000    29460.000     710.000    29493.000     709.000
 29499.000     708.000    29502.000     708.000    29512.000     708.000
```

WSPRO OUTPUT

```
 29529.000      701.000     29565.000      701.000     29600.000      708.000
 29667.000      715.000     29778.000      715.000     29854.000      720.000
 30476.000      725.000
----------  ----------  ----------  ----------  ----------  ----------

                  Minimum and Maximum X,Y-coordinates
   Minimum X-Station:   27643.000  ( associated Y-Elevation:  725.000 )
   Maximum X-Station:   30476.000  ( associated Y-Elevation:  725.000 )
   Minimum Y-Elevation:   701.000  ( associated X-Station:  29565.000 )
   Maximum Y-Elevation:   725.000  ( associated X-Station:  27643.000 )

                     Roughness Data (  5 SubAreas )
                             Roughness   Horizontal
                   SubArea  Coefficient  Breakpoint
                   -------  -----------  ----------
                      1         .045        ---
                                ---       ********
                      2         .100        ---
                                ---       ********
                      3         .034        ---
                                ---       ********
                      4         .100        ---
                                ---       ********
                      5         .045        ---
                   -------  -----------  ----------

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-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
     COUNTY: HENDRICKS                      QUAD: BRIDGEPORT 123B
        11-19-96                               BRET A. ROBINSON
  EX

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

            Reach       Water Surface   Friction
     #    Discharge       Elevation       Slope          Flow Regime
    --    ---------     -------------   --------   --------------------
     1      5720.00       ********         .0008        Sub-Critical
     2      7360.00       ********         .0008        Sub-Critical
    --    ---------     -------------   --------   --------------------
```

WSPRO OUTPUT

```
*=================================================*
*        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-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
 COUNTY: HENDRICKS                      QUAD: BRIDGEPORT 123B
   11-19-96                               BRET A. ROBINSON
```

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: EXIT	712.072	.324	5720.000	2106.215	*********	28905.460
Header Type: XS	712.396	******	2.716	202130.00	*********	29747.690
SRD: .000	707.610	******	.509	******	2.822	******
Section: FULLV	712.193	.298	5720.000	2210.461	112.000	28879.510
Header Type: FV	712.492	.086	2.588	210620.10	112.000	29753.590
SRD: 112.000	707.610	.000	.486	.0008	2.865	.010

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

Section: APPR	712.359	.436	5720.000	1105.015	242.000	29441.130
Header Type: AS	712.796	.235	5.176	159748.80	242.000	29641.720
SRD: 354.000	708.435	.069	.398	.0010	1.047	.000

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

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

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: BRDGE	711.883	1.093	5720.000	682.740	112.000	29483.130
Header Type: BR	712.976	.165	8.378	116407.90	112.000	29566.520
SRD: 112.000	708.585	.416	.517	******	1.001	-.001

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.9993	.055	716.800	********	********	********

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR

WSPRO OUTPUT

Section: APPR	713.190	.338	5720.000	1277.805	112.000	29434.480
Header Type: AS	713.528	.184	4.476	196821.20	121.108	29649.680
SRD: 354.000	708.435	.370	.337	.0010	1.084	.015

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.578	.105	175575.8	********	********	713.190

<<< 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-70 OVER EAST FORK WHITE LICK CREEK I70-69-5185
COUNTY: HENDRICKS QUAD: BRIDGEPORT 123B
11-19-96 BRET A. ROBINSON

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	712.812	.323	7360.000	2801.197	*********	28747.410
Header Type: XS	713.135	******	2.627	259973.90	*********	29783.650
SRD: .000	709.495	******	.489	******	3.008	******
Section: FULLV	712.930	.297	7360.000	2925.539	112.000	28722.150
Header Type: FV	713.227	.086	2.516	270644.40	112.000	29789.400
SRD: 112.000	709.495	.000	.466	.0008	3.022	.007

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

Section: APPR	713.040	.585	7360.000	1245.594	242.000	29435.680
Header Type: AS	713.625	.255	5.909	189851.00	242.000	29648.240
SRD: 354.000	709.598	.144	.447	.0011	1.077	-.002

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

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

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: BRDGE	712.498	1.642	7360.000	734.841	112.000	29481.810
Header Type: BR	714.141	.192	10.016	128829.10	112.000	29567.780
SRD: 112.000	709.842	.814	.620	******	1.053	-.001

WSPRO OUTPUT

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.9746	.054	716.800	********	********	********

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: APPR	714.440	.398	7360.000	1560.492	112.000	29424.480
Header Type: AS	714.838	.207	4.716	258971.60	120.716	29661.640
SRD: 354.000	709.598	.491	.348	.0011	1.150	.005

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.587	.169	214839.3	********	********	714.440

<<< 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-70 OVER EAST FORK WHITE LICK CREEK I70-69-5185

COUNTY: HENDRICKS QUAD: BRIDGEPORT 123B

11-19-96 BRET A. ROBINSON

*** 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): 4.000

#	Scour Depth	-- Flow -- Contract	Approach	-- Width -- Contract	Approach	--- X-Limits --- Side	Contract	Approach
1	5.934	5720.000	5720.000	75.000	250.000	Left:	********	********
	..... Approach Channel Depth:	5.111				Right:	********	********
2	7.238	7360.000	7360.000	75.000	250.000	Left:	********	********
	..... Approach Channel Depth:	6.234				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

WSPRO OUTPUT

```
*-------------------------------------------------------------*
     I-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
 COUNTY: HENDRICKS                      QUAD: BRIDGEPORT 123B
    11-19-96                               BRET A. ROBINSON

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

                Constants and Input Variables

                     Pier Width:   2.000
              *-----------------------------------------*
                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   ---- Localized Hydraulic Properties ----      -- X-Stations --
 #  Depth    Flow      WSE    Depth  Velocity Froude #   Left      Right
--  ----- ---------- -------- ------ -------- -------- --------- ---------
 1   6.11   5720.000  712.253 11.953   9.806     .500  29470.000 29581.000
 2   6.63   7360.000  712.989 12.689  11.646     .576  29470.000 29581.000
--  ----- ---------- -------- ------ -------- -------- --------- ---------


************************  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-70 OVER EAST FORK WHITE LICK CREEK  I70-69-5185
 COUNTY: HENDRICKS                      QUAD: BRIDGEPORT 123B
    11-19-96                               BRET A. ROBINSON

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

                Constants and Input Variables

                     Pier Width:   2.000
              *-----------------------------------------*
                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   ---- Localized Hydraulic Properties ----      -- X-Stations --
 #  Depth    Flow      WSE    Depth  Velocity Froude #   Left      Right
--  ----- ---------- -------- ------ -------- -------- --------- ---------
 1   6.11   5720.000  712.253 11.953   9.806     .500  29470.000 29581.000
```

WSPRO OUTPUT

```
 2     6.63    7360.000  712.989 12.689  11.646      .576  29470.000 29581.000
--    ----- ---------- -------- ------ -------- -------- --------- ---------

  ER

   ****************** Normal end of WSPRO execution. ******************
   *************** Elapsed Time:   0 Minutes  5 Seconds  **************
```