Modified Level II Streambed-Scour Analysis for Structure I-64-11-5202 Crossing Flat Run Ditch in Posey County, Indiana

By JOHN T. WILSON, BRET A. ROBINSON, DAVID C. VOELKER, 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	U. S. Geological Survey
WSPRO	Water Surface PROfile model

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By John T. Wilson, 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-64-11-5202 on Interstate 64 crossing Flat Run Ditch in Posey County, Indiana, are presented. The site is near the town of Poseyville in the northeastern part of Posey 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 7.3 feet for the modeled discharge of 1,630 cubic feet per second and approximately 13.5 feet for the modeled discharge of 2,780 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-64-11-5202.

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 Poseyville in the northeastern part of Posey County. The drainage area for the site is approximately 2.59 mi^2 (Merril Dougherty, Indiana Department of Transportation, written commun., 1997). The predominant land use in the basin is agricultural; in the immediate vicinity of the bridge, the land is predominantly row crop with some pasture land nearby.

Within the immediate vicinity of the bridge, Flat Run Ditch has a channel-bed slope of approximately 0.0028 ft/ft. The channel-bed material is silt-clay, and the channel banks consist of silt-clay. At the time of the Level I site visit on June 17, 1992, the banks were observed to have no woody vegetative cover; the field report noted that the banks were stable.

The Interstate 64 crossing of Flat Run Ditch is a 70-ft-long, multi-lane bridge consisting of three spans supported by concrete and steel piers and sloping concrete 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 USGS 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-64-11-5202 crossing Flat Run Ditch in Posey County, Indiana

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 1,630 cubic feet per second							
1	634+17	406	1.9	5.4	7.3	398	393.4
2	634+45	406	1.9	5.4	7.3	398	393.4
Modeled discharge is 2,780 cubic feet per second							
1	634+17	406	7.2	6.3	13.5	398	387.2
2	634+45	406	7.2	6.3	13.5	398	387.2

[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, 634+17, represents a point 63,417 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 (400.7 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.

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 64: Bridge File I-64-11-5202.

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-64 OVER FLAT RUN DITCH      I64-11-5202
T2          COUNTY: POSEY                 QUAD: POSEYVILLE 192B
T3          8-01-97                       JOHN T. WILSON
Q           1630    2780
SK          .0028  .0028
XS   EXIT  0   11
GR         62880 420    63418 411  63433 411  63454 400.7  63458 400.7
GR         63478 410.5  63515 411  63550 412  63575 413    63596 414
GR         63611 415    63630 416  63648 417  63694 422
N          .035       .035       .035
SA               63433      63478
XS   FULLV  68   11
BR   BRDGE  68   414.9   11
*          ***BRIDGE DECK SKEWED 11 DEGREES (FROM BRIDGE PLANS)***
GR         63396 414.9  63396 414.8  63399 414.8  63417 406.4  63422 404.1
GR         63429 400.7  63434 400.7  63443 405.4  63461 414.6  63464 414.6
GR         63464 414.8  63396 414.9
N          .035
PD         406.4   2.0   1
PD         406.4   4.0   2
CD         3    122    2    417
DC 0 BRDGE  63407  63454  63378  63420  *  4
*           ***DC LIMITS AT BRIDGE ARE LEW AND REW FOR Q1***
*           BXL     BXR     PW   *  *  K1  K2   K3
DP          63396   63464   2.0  *  *  1   1    1.1
DP          63396   63464   2.0  *  *  1   1    1.1
*           ***DP CARDS USE WHOLE BRIDGE OPENING FOR BXL/BXR***
*           ***NO PIERS IN MAIN CHANNEL***
XS   APPR  258
*          ***SECTION IS ADJUSTED FOR 11 DEGREES OF SKEW***
GR         62887 420    63221 410    63311 410  63367 411  63378 410.5
GR         63397 400.9  63402 400.9  63420 410  63461 413  63487 414
GR         63511 415    63532 416    63690 430
N          .045       .035       .045
SA               63378      63420
HP 2 BRDGE  411.4  *  411.4   1630
HP 2 BRDGE  412.7  *  412.7   2780
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  1:00 pm     Version V050196
          Input File: flatrun.dat    Output File: flatrun.LST
   *-------------------------------------------------------------*
T1          I-64 OVER FLAT RUN DITCH      I64-11-5202
T2          COUNTY: POSEY                 QUAD: POSEYVILLE 192B
T3          8-01-97                       JOHN T. WILSON
Q           1630    2780

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

SK          .0028  .0028

   ************************  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-64 OVER FLAT RUN DITCH      I64-11-5202
          COUNTY: POSEY                 QUAD: POSEYVILLE 192B
             8-01-97                       JOHN T. WILSON

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

XS   EXIT  0   11
GR         62880 420    63418 411  63433 411  63454 400.7  63458 400.7
GR         63478 410.5  63515 411  63550 412  63575 413    63596 414
GR         63611 415    63630 416  63648 417  63694 422
N          .035       .035       .035
SA               63433      63478

 ***   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:  11.0   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
----------  ----------   ----------  ----------   ----------  ----------
 62880.000     420.000    63418.000     411.000    63433.000     411.000
 63454.000     400.700    63458.000     400.700    63478.000     410.500
 63515.000     411.000    63550.000     412.000    63575.000     413.000
 63596.000     414.000    63611.000     415.000    63630.000     416.000
 63648.000     417.000    63694.000     422.000
----------  ----------   ----------  ----------   ----------  ----------
```

WSPRO OUTPUT

Minimum and Maximum X,Y-coordinates

Minimum X-Station:	62880.000	(associated Y-Elevation:	420.000)
Maximum X-Station:	63694.000	(associated Y-Elevation:	422.000)
Minimum Y-Elevation:	400.700	(associated X-Station:	63458.000)
Maximum Y-Elevation:	422.000	(associated X-Station:	63694.000)

X-coordinates & Horizontal Breakpoints Translated by Skew Angle

X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
62880.000	62890.620	63418.000	63418.730	63433.000	63433.460
63454.000	63454.070	63458.000	63458.000	63478.000	63477.630
63515.000	63513.950	63550.000	63548.310	63575.000	63572.850
63596.000	63593.460	63611.000	63608.190	63630.000	63626.840
63648.000	63644.510	63694.000	63689.660		

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.035	---
	---	********
2	.035	---
	---	********
3	.035	---

```
        *-----------------------------------------------------*
        *      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-64 OVER FLAT RUN DITCH      I64-11-5202
          COUNTY: POSEY                 QUAD: POSEYVILLE 192B
             8-01-97                       JOHN T. WILSON

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

XS   FULLV  68   11

 ***   Completed Reading Data Associated With Header Record FULLV   ***
 ***   No Roughness Data Input, Propagating From Previous Section   ***
 ***  Storing X-Section Data In Temporary File As Record Number  2  ***
```

WSPRO OUTPUT

```
***              Data Summary For Header Record FULLV                ***
SRD Location:       68.   Cross-Section Skew:  11.0   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
---------  ---------   ---------  ---------   ---------  ---------
62880.000     420.000   63418.000     411.000   63433.000     411.000
63454.000     400.700   63458.000     400.700   63478.000     410.500
63515.000     411.000   63550.000     412.000   63575.000     413.000
63596.000     414.000   63611.000     415.000   63630.000     416.000
63648.000     417.000   63694.000     422.000
---------  ---------   ---------  ---------   ---------  ---------

                Minimum and Maximum X,Y-coordinates
 Minimum X-Station:   62880.000  ( associated Y-Elevation:  420.000 )
 Maximum X-Station:   63694.000  ( associated Y-Elevation:  422.000 )
 Minimum Y-Elevation:   400.700  ( associated X-Station:  63458.000 )
 Maximum Y-Elevation:   422.000  ( associated X-Station:  63694.000 )

    X-coordinates & Horizontal Breakpoints Translated by Skew Angle
 X Input    X Skewed      X Input    X Skewed      X Input    X Skewed
---------  ---------   ---------  ---------   ---------  ---------
62880.000  62890.620   63418.000  63418.730   63433.000  63433.460
63454.000  63454.070   63458.000  63458.000   63478.000  63477.630
63515.000  63513.950   63550.000  63548.310   63575.000  63572.850
63596.000  63593.460   63611.000  63608.190   63630.000  63626.840
63648.000  63644.510   63694.000  63689.660
---------  ---------   ---------  ---------   ---------  ---------

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

      *-------------------------------------------------*
      *      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-64 OVER FLAT RUN DITCH     I64-11-5202
      COUNTY: POSEY                QUAD: POSEYVILLE 192B
         8-01-97                      JOHN T. WILSON
```

WSPRO OUTPUT

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

 BR   BRDGE  68   414.9   11
 GR        63396 414.9  63396 414.8  63399 414.8  63417 406.4  63422 404.1
 GR        63429 400.7  63434 400.7  63443 405.4  63461 414.6  63464 414.6
 GR        63464 414.8  63396 414.9
 N         .035
 PD        406.4   2.0   1
 PD        406.4   4.0   2
 CD        3    122    2    417

  ***   Completed Reading Data Associated With Header Record BRDGE   ***
+++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #11 increased to eliminate vertical segment.
  ***   Storing Bridge Data In Temporary File As Record Number  3    ***

  ***              Data Summary For Bridge Record BRDGE              ***
  SRD Location:       68.   Cross-Section Skew:  11.0   Error Code   0
  Valley Slope:  *******    Averaging Conveyance By Geometric Mean.
  Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                      X,Y-coordinates (12 pairs)
     X          Y          X          Y          X          Y
----------  ----------  ----------  ----------  ----------  ----------
 63396.000     414.900    63396.100     414.800    63399.000     414.800
 63417.000     406.400    63422.000     404.100    63429.000     400.700
 63434.000     400.700    63443.000     405.400    63461.000     414.600
 63464.000     414.600    63464.100     414.800    63396.000     414.900
----------  ----------  ----------  ----------  ----------  ----------

                  Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   63396.000  ( associated Y-Elevation:  414.900 )
  Maximum X-Station:   63464.100  ( associated Y-Elevation:  414.800 )
  Minimum Y-Elevation:   400.700  ( associated X-Station:  63434.000 )
  Maximum Y-Elevation:   414.900  ( associated X-Station:  63396.000 )

      X-coordinates & Horizontal Breakpoints Translated by Skew Angle
  X Input    X Skewed      X Input    X Skewed      X Input    X Skewed
----------  ----------  ----------  ----------  ----------  ----------
 63396.000   63396.700    63396.100   63396.800    63399.000   63399.640
 63417.000   63417.310    63422.000   63422.220    63429.000   63429.090
 63434.000   63434.000    63443.000   63442.840    63461.000   63460.500
 63464.000   63463.450    63464.100   63463.550    63396.000   63396.700
----------  ----------  ----------  ----------  ----------  ----------

                    Roughness Data (  1 SubAreas )
                           Roughness   Horizontal
                  SubArea  Coefficient  Breakpoint
                  -------  -----------  ----------
                     1         .035        ---
                  -------  -----------  ----------
```

WSPRO OUTPUT

```
                Discharge coefficient parameters
              BRType    BRWdth    EMBSS    EMBElv     UserCD
                3       122.000    2.00    417.000 **********

                     Pressure flow elevations
                        AVBCEL      PFElev
                      *********     414.900

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


                  Pier/Pile Data (  2 Group(s) )
                 Code Indicates Bridge Uses Piers
                 Group  Elevation  Gross Width  Number
                ------  ---------  -----------  ------
                   1      406.400      2.000       1
                   2      406.400      4.000       2
                ------  ---------  -----------  ------

          *-------------------------------------------------*
          *      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-64 OVER FLAT RUN DITCH     I64-11-5202
          COUNTY: POSEY                QUAD: POSEYVILLE 192B
             8-01-97                      JOHN T. WILSON
DC 0 BRDGE  63407  63454  63378  63420  *  4
DP         63396   63464   2.0  *  *  1   1    1.1
DP         63396   63464   2.0  *  *  1   1    1.1

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

XS   APPR  258
GR         62887 420    63221 410    63311 410  63367 411  63378 410.5
GR         63397 400.9  63402 400.9  63420 410  63461 413  63487 414
GR         63511 415    63532 416    63690 430
N          .045       .035       .045
SA               63378      63420

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

WSPRO OUTPUT

```
***              Data Summary For Header Record APPR                ***
SRD Location:      258.   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 (13 pairs)
    X          Y             X          Y             X          Y
---------  ---------    ---------  ---------    ---------  ---------
62887.000     420.000    63221.000     410.000    63311.000     410.000
63367.000     411.000    63378.000     410.500    63397.000     400.900
63402.000     400.900    63420.000     410.000    63461.000     413.000
63487.000     414.000    63511.000     415.000    63532.000     416.000
63690.000     430.000
---------  ---------    ---------  ---------    ---------  ---------

                Minimum and Maximum X,Y-coordinates
 Minimum X-Station:   62887.000  ( associated Y-Elevation:  420.000 )
 Maximum X-Station:   63690.000  ( associated Y-Elevation:  430.000 )
 Minimum Y-Elevation:   400.900  ( associated X-Station:  63402.000 )
 Maximum Y-Elevation:   430.000  ( associated X-Station:  63690.000 )

                  Roughness Data (  3 SubAreas )
                         Roughness   Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .045        ---
                             ---       ********
                   2         .035        ---
                             ---       ********
                   3         .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-64 OVER FLAT RUN DITCH     I64-11-5202
           COUNTY: POSEY                 QUAD: POSEYVILLE 192B
              8-01-97                       JOHN T. WILSON
  HP 2 BRDGE  411.4  *  411.4   1630
  HP 2 BRDGE  412.7  *  412.7   2780
  EX

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

WSPRO OUTPUT

```
      Reach      Water Surface   Friction
 #   Discharge      Elevation      Slope         Flow Regime
--   ---------    ------------   --------   --------------------
 1     1630.00       ********        .0028        Sub-Critical
 2     2780.00       ********        .0028        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-64 OVER FLAT RUN DITCH     I64-11-5202
       COUNTY: POSEY                 QUAD: POSEYVILLE 192B
          8-01-97                       JOHN T. WILSON

                  WSEL     VHD       Q         AREA      SRDL      LEW
                  EGEL      HF       V          K        FLEN      REW
                  CRWS      HO     FR #         SF       ALPHA     ERR
                --------- ------ ---------- ---------- --------- ---------
Section: EXIT      410.767   .676   1630.000    249.542 ********* 63433.480
Header Type: XS    411.443 ******      6.532   30785.70 ********* 63497.750
SRD:       .000    408.116 ******       .590     ******     1.019    ******

Section: FULLV     411.018   .610   1630.000    268.354    68.000 63416.930
Header Type: FV    411.628   .177      6.074   33064.78    68.000 63515.630
SRD:     68.000    408.116   .000       .670      .0026     1.064       .008

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

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
      KRATIO:  1.53

Section: APPR      411.676   .254   1630.000    572.535   190.000 63165.020
Header Type: AS    411.930   .302      2.847   50507.66   190.000 63442.910
SRD:    258.000    408.152   .000       .496      .0016     2.013     -.001

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

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

WSPRO OUTPUT

```
                      WSEL     VHD        Q          AREA       SRDL       LEW
                      EGEL      HF        V            K         FLEN       REW
                      CRWS      HO       FR #         SF        ALPHA      ERR
                    --------- ------ ---------- ---------- --------- ---------
 Section: BRDGE      411.053   .578   1630.000    267.838    68.000 63407.030
 Header Type: BR     411.631   .186      6.086   33975.45    68.000 63454.060
 SRD:     68.000     407.964   .002       .450     ******     1.003      .000

 Specific Bridge Information   C      P/A    PFELEV     BLEN      XLAB      XRAB
 Bridge Type 3   Flow Type 1 ------ ----- -------- -------- -------- --------
 Pier/Pile Code  0             .9985  .069  414.900 ******** ******** ********
 --------------------------- ------ ----- -------- -------- -------- --------

                      WSEL     VHD        Q          AREA       SRDL       LEW
                      EGEL      HF        V            K         FLEN       REW
                      CRWS      HO       FR #         SF        ALPHA      ERR
                    --------- ------ ---------- ---------- --------- ---------
 Section: APPR       411.908   .206   1630.000    638.082    68.000 63157.290
 Header Type: AS     412.114   .132      2.555   56167.14    88.070 63446.070
 SRD:    258.000     408.152   .351       .432      .0016     2.031      .001

            Approach Section APPR  Flow Contraction Information
           M( G )   M( K )     KQ       XLKQ      XRKQ      OTEL
          -------- -------- --------- -------- -------- --------
              .831     .255   41819.1 ******** ********  411.908
          -------- -------- --------- -------- -------- --------

              <<< 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-64 OVER FLAT RUN DITCH      I64-11-5202
          COUNTY: POSEY                  QUAD: POSEYVILLE 192B
             8-01-97                        JOHN T. WILSON
===150 WARNING: SLOPE-CONVEYANCE CONVERGENCE FAILURE.
       Used final trial values.
       QCOMP, WSTRY:    2767.     412.30


                      WSEL     VHD        Q          AREA       SRDL       LEW
                      EGEL      HF        V            K         FLEN       REW
                      CRWS      HO       FR #         SF        ALPHA      ERR
                    --------- ------ ---------- ---------- --------- ---------
 Section: EXIT       412.296   .830   2780.000    471.367 ********* 63340.550
 Header Type: XS     413.125 ******      5.898   52289.23 ********* 63557.390
 SRD:        .000    410.057 ******       .873     ******     1.533    ******

 Section: FULLV      412.649   .639   2780.000    553.281    68.000 63319.430
 Header Type: FV     413.288   .167      5.025   60094.78    68.000 63566.220
 SRD:     68.000     410.057   .000       .755      .0025     1.627     -.005
```

WSPRO OUTPUT

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

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
      KRATIO:  1.68

 Section: APPR      413.334   .193   2780.000   1098.741   190.000 63109.630
 Header Type: AS    413.528   .241      2.530  101257.90   190.000 63469.700
 SRD:    258.000    411.275   .000       .356      .0013     1.940     -.001

        <<< 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     412.122  1.374   2780.000    320.456    68.000 63404.740
 Header Type: BR    413.496   .250      8.675   43149.08    68.000 63456.150
 SRD:     68.000    410.117   .117       .664     ******     1.174     -.010

 Specific Bridge Information   C      P/A    PFELEV    BLEN      XLAB      XRAB
 Bridge Type 3   Flow Type 1 ------ ----- -------- -------- -------- --------
 Pier/Pile Code  0            .9229  .071  414.900 ******** ******** ********
 --------------------------- ------ ----- -------- -------- -------- --------

                     WSEL     VHD       Q          AREA       SRDL       LEW
                     EGEL      HF       V            K        FLEN       REW
                     CRWS      HO      FR #         SF       ALPHA      ERR
                   --------- ------ ---------- ---------- --------- ---------
 Section: APPR      414.120   .114   2780.000   1399.927    68.000 63083.390
 Header Type: AS    414.234   .131      1.986  133960.30    90.769 63489.880
 SRD:    258.000    411.275   .613       .258      .0013     1.866      .018

            Approach Section APPR  Flow Contraction Information
             M( G )   M( K )     KQ        XLKQ      XRKQ      OTEL
            -------- -------- --------- -------- -------- --------
                .851     .493   67526.6 ******** ********  414.120
            -------- -------- --------- -------- -------- --------

              <<< 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-64 OVER FLAT RUN DITCH      I64-11-5202
          COUNTY: POSEY                  QUAD: POSEYVILLE 192B
             8-01-97                        JOHN T. WILSON
```

WSPRO OUTPUT

```
   ***     Beginning Velocity Distribution For Header Record BRDGE     ***
           SRD Location:     68.000       Header Record Number  3

        Water Surface Elevation:    411.400              Element # 1
        Flow:    1630.000   Velocity:  5.73  Hydraulic Depth:   5.870
        Cross-Section Area:    284.40         Conveyance:    36804.18
           Bank Stations ->  Left:  63406.290   Right:  63454.740

X STA.     63406.3    63417.0    63420.1    63422.3    63424.1    63425.6
  A( I )              26.6       17.7       15.6       14.1       12.9
  V( I )              3.07       4.62       5.23       5.78       6.33
  D( I )              2.49       5.69       6.92       7.88       8.68

X STA.     63425.6    63426.9    63428.1    63429.1    63430.1    63431.1
  A( I )              12.1       11.7       11.3       10.7       10.7
  V( I )              6.72       6.94       7.20       7.65       7.65
  D( I )              9.35       9.95      10.50      10.70      10.70

X STA.     63431.1    63432.1    63433.1    63434.1    63435.3    63436.5
  A( I )              10.7       10.7       10.8       11.7       12.0
  V( I )              7.62       7.62       7.56       6.98       6.77
  D( I )             10.70      10.70      10.70      10.34       9.72

X STA.     63436.5    63437.9    63439.6    63441.6    63444.6    63454.7
  A( I )              12.7       13.8       14.9       17.5       26.3
  V( I )              6.42       5.89       5.47       4.66       3.10
  D( I )              9.03       8.22       7.24       5.94       2.59

      ************************* 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-64 OVER FLAT RUN DITCH      I64-11-5202
            COUNTY: POSEY                  QUAD: POSEYVILLE 192B
               8-01-97                        JOHN T. WILSON

   ***     Beginning Velocity Distribution For Header Record BRDGE     ***
           SRD Location:     68.000       Header Record Number  3

        Water Surface Elevation:    412.700              Element # 1
        Flow:    2780.000   Velocity:  7.92  Hydraulic Depth:   6.524
        Cross-Section Area:    350.85         Conveyance:    48688.02
           Bank Stations ->  Left:  63403.500   Right:  63457.280

X STA.     63403.5    63415.4    63418.8    63421.3    63423.3    63424.9
  A( I )              32.8       21.8       19.2       17.4       15.8
  V( I )              4.24       6.39       7.23       8.00       8.81
  D( I )              2.77       6.33       7.70       8.74       9.62

X STA.     63424.9    63426.4    63427.7    63428.9    63430.0    63431.1
  A( I )              15.0       14.7       13.9       13.1       13.2
  V( I )              9.28       9.48       9.98      10.59      10.55
  D( I )             10.37      11.04      11.65      12.00      12.00
```

WSPRO OUTPUT

X STA.	63431.1	63432.2	63433.3	63434.4	63435.6	63437.0
A(I)		13.2	13.2	13.4	14.3	14.7
V(I)		10.52	10.52	10.40	9.73	9.43
D(I)		12.00	12.00	11.96	11.47	10.79

X STA.	63437.0	63438.6	63440.5	63442.8	63446.0	63457.3
A(I)		15.6	17.4	18.3	21.6	32.4
V(I)		8.92	8.00	7.59	6.44	4.29
D(I)		10.02	9.12	8.03	6.59	2.88

********** 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-64 OVER FLAT RUN DITCH I64-11-5202
COUNTY: POSEY QUAD: POSEYVILLE 192B
8-01-97 JOHN T. WILSON

*** 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	1.880	1630.000	1205.958	43.000	42.000	Left:	********	********
	..... Approach Channel Depth:	6.886				Right:	********	********
2	7.249	2780.000	1372.024	43.000	42.000	Left:	********	********
	..... Approach Channel Depth:	9.099				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-64 OVER FLAT RUN DITCH I64-11-5202
COUNTY: POSEY QUAD: POSEYVILLE 192B
8-01-97 JOHN T. WILSON

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

WSPRO OUTPUT

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 Depth	Localized Hydraulic Properties Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	Right
1	5.40	1630.000	411.404	10.704	7.644	.412	63396.000	63464.000
2	6.30	2780.000	412.735	12.035	10.522	.535	63396.000	63464.000

********** 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-64 OVER FLAT RUN DITCH I64-11-5202
COUNTY: POSEY QUAD: POSEYVILLE 192B
8-01-97 JOHN T. WILSON

*** 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 Depth	Localized Hydraulic Properties Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	Right
1	5.40	1630.000	411.404	10.704	7.644	.412	63396.000	63464.000
2	6.30	2780.000	412.735	12.035	10.522	.535	63396.000	63464.000

ER

********** Normal end of WSPRO execution. **********
********** Elapsed Time: 0 Minutes 46 Seconds **********