Modified Level II Streambed-Scour Analysis for Structure I-275-0-5639 Crossing the Ohio River in Dearborn County, Indiana

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

Prepared in cooperation with the
INDIANA DEPARTMENT OF TRANSPORTATION

U.S. GEOLOGICAL SURVEY
Open-File Report 97-330

Indianapolis, Indiana
1997

U.S. DEPARTMENT OF THE INTERIOR
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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 Robert L. Miller, Bret A. Robinson, *and* David C. Voelker

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-275-0-5639 on Interstate 275 crossing the Ohio River in Dearborn County, Indiana, are presented. The site is near the town of Lawrenceburg in the southeastern part of Dearborn 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 35.6 feet for the modeled discharge of 760,000 cubic feet per second and approximately 35.7 feet for the modeled discharge of 890,000 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-275-0-5639.

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 Lawrenceburg in the southeastern part of Dearborn County. The drainage area for the site is approximately 82,000 mi^2. Land use in the immediate vicinity of the bridge includes row crop and some wooded areas.

At the time of the Level I site visit on November 16, 1994, the banks were observed to have 0 to 75 percent woody vegetative cover; the field report noted that the banks were experiencing fluvial erosion.

The Interstate 275 crossing of the Ohio River is a 3,268-ft-long, multi-lane bridge consisting of numerous spans supported by concrete and steel piers and sloping 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, 1967 and 1968) 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-275-0-5639 crossing the Ohio River in Dearborn 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 760,000 cubic feet per second							
1	50+78	474	8.9	16.3	25.2	457.6	379.8
2	51+90	466	8.9	16.3	25.2	455.6	379.8
3	53+01	468	8.9	16.3	25.2	456.6	379.8
4	54+12	470	8.9	16.3	25.2	459.5	379.8
5	55+24	470	8.9	16.3	25.2	460.0	379.8
6	56+36	470	8.9	16.3	25.2	458.9	379.8
7	57+47	467	8.9	16.3	25.2	459.0	379.8
8	58+58	463	8.9	16.3	25.2	460.0	379.8
9	59+71	459	8.9	26.7	35.6	430.0	379.8
10	64+76	450	8.9	26.7	35.6	405.0	379.8
11	72+26	418	8.9	26.7	35.6	371.0	379.8
12	77+30	434	8.9	26.7	35.6	423.0	379.8
13	78+86	474	8.9	19.2	28.1	442.5	379.8
14	80+39	507	8.9	19.2	28.1	475.0	379.8

Table 1. Cumulative scour depths for the modeled discharges at structure I-275-0-5639 crossing the Ohio River in Dearborn County, Indiana—Continued

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 is 890,000 cubic feet per second							
1	50+78	474	8.3	16.7	25.0	457.6	379.7
2	51+90	466	8.3	16.7	25.0	455.6	379.7
3	53+01	468	8.3	16.7	25.0	456.6	379.7
4	54+12	470	8.3	16.7	25.0	459.5	379.7
5	55+24	470	8.3	16.7	25.0	460.0	379.7
6	56+36	470	8.3	16.7	25.0	458.9	379.7
7	57+47	467	8.3	16.7	25.0	459.0	379.7
8	58+58	463	8.3	16.7	25.0	460.0	379.7
9	59+71	459	8.3	27.4	35.7	430.0	379.7
10	64+76	450	8.3	27.4	35.7	405.0	379.7
11	72+26	418	8.3	27.4	35.7	371.0	379.7
12	77+30	434	8.3	27.4	35.7	423.0	379.7
13	78+86	474	8.3	19.6	27.9	442.5	379.7
14	80+39	507	8.3	19.6	27.9	475.0	379.7

[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, 50+78, represents a point 5,078 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 (415.4 feet).

[5]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.

Cross section data, roughness values, discharges and starting water-surface elevations were provided by the Army Corps of Engineers. The stationing of the cross sections were adjusted to match the stationing values of the bridge plans. It was assumed that the railroad embankment to the north of the Ohio River would act to contain the main-channel flow. Therefore, the cross sections also were artificially walled up at the railroad embankment.

The bridge plans indicate that all piers are protected by riprap and that the piles below the piers are driven to bedrock (gray shale). The scour calculations outlined in this report, however, have been made without regard for how these two conditions may provide added stability to this bridge.

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, 1967, Bridge plans Interstate Route 275: Bridge File I-275-0-5639.

Indiana State Highway Commission, 1968, Bridge plans Interstate Route 275: Bridge File I-275-0-5639.

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-275 OVER OHIO RIVER                    I-275-0-5639
T2        COUNTY: DEARBORN                         QUAD: LAWRENCEBURG 155D
T3        7-22-97                                  R L MILLER
SI        0
Q         760000  890000
WS         490.77  497.16
XS   EXIT  0
GR        5000 480  5070 470  5750 470  5930 460  6080 460  6190 450
GR        6230 445  6280 435.2  6330 431  6430 428.5 6480 428.7
GR        6530 421.1  6560 425.4  6650 419  6700 418.6  6740 417.5
GR        6800 418  7050 418.4  7180 420.5  7255 423  7300 420.9
GR        7350 422.2  7400 431.3  7430 430.8  7650 442  7820 444
GR        7850 450  8030 460  8100 465  8335 470  8380 475  8910 475
GR        9100 515
N            .110   .0287   .110
SA               6080     8030
XS   FULLV  3000
GR        5000 480  5070 470  5750 470  5930 460  6080 460  6190 450
GR        6230 445  6280 435.2  6330 431  6430 428.5 6480 428.7
GR        6530 421.1  6560 425.4  6650 419  6700 418.6  6740 417.5
GR        6800 418  7050 418.4  7180 420.5  7255 423  7300 420.9
GR        7350 422.2  7400 431.3  7430 430.8  7650 442  7820 444
GR        7850 450  8030 460  8100 465  8335 470  8380 475  8910 475
GR        9100 515
N            .110   .0287   .110
SA               6080     8030
BR   BRDGE   3000  515
GR        5000 515  5000 490  5095 470 5155 465 5375 470  5665 470
GR        5928 460  6413 454  6483 450  6578 435.9  6648 426.3  6688 426.1
GR        6738 424.6  6788 425  6883 419.9  6968 417.3  7023 417  7078 415.4
GR        7138 417.3  7378 417.9  7538 421  7628 423.4  7738 434.9
GR        7818 460  8078 515  5000 515
N            .050  .0287  .050
SA              6483    7818
PD        418 15  1
PD        434 15  2
PD        434 30  3
PD        450 30  4
PD        450 45  5
PD        459 45  6
PD        459 60  7
PD        463 60  8
PD        463 67  9
PD        467 67  10
PD        467 81  11
PD        470 81  12
PD        470 109 13
PD        473 109 14
PD        473 125 15
PD        507 125 16
PD        507 134 17
PD        570 134 18
CD         3  83  3  515
DC 0 BRDGE 6483  7818  6310  8040  *   134
```

WSPRO INPUT FILE

```
DP        5000 8078 7 * * 1 1 1.1
DP        5000 8078 15 * * 1 1 1.1
DP        5000 8078 9 * * 1 1 1.1
XS   APPR    6100
GR        5000 500 5000 490
GR        6310 475  6395 460  6490 450  6540 441.1  6580 439.8
GR        6650 429.9 6700 426.9 6740 426.2 6780 422  6830 425.4  6880 423.7
GR        7080 417.1  7210 417.6  7330 415.8  7400 413.4  7480 413.9
GR        7580 410.9  7625 412.1  7695 409.1  7735 410.9  7780 407.5
GR        7870 412.4  7920 414.9  8040 460  8130 470  8280 515
N          .110   .0287   .110
SA             6310     8040
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:  8/11/97  3:45 pm     Version V050196
          Input File: 5639.dat       Output File: 5639.LST
   *-------------------------------------------------------------*
T1         I-275 OVER OHIO RIVER                    I-275-0-5639
T2         COUNTY: DEARBORN                         QUAD: LAWRENCEBURG 155D
T3         7-22-97                                  R L MILLER
SI         0
Q          760000  890000

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

WS          490.77  497.16

   ************************  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-275 OVER OHIO RIVER                    I-275-0-5639
   COUNTY: DEARBORN                         QUAD: LAWRENCEBURG 155D
        7-22-97                                  R L MILLER

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

XS   EXIT  0
GR         5000 480  5070 470  5750 470  5930 460  6080 460  6190 450
GR         6230 445  6280 435.2  6330 431  6430 428.5 6480 428.7
GR         6530 421.1  6560 425.4  6650 419  6700 418.6  6740 417.5
GR         6800 418  7050 418.4  7180 420.5  7255 423  7300 420.9
GR         7350 422.2  7400 431.3  7430 430.8  7650 442  7820 444
GR         7850 450  8030 460  8100 465  8335 470  8380 475  8910 475
GR         9100 515
N             .110   .0287   .110
SA                6080     8030

 ***   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 (33 pairs)
     X          Y          X          Y          X          Y
----------  ----------  ----------  ----------  ----------  ----------
  5000.000    480.000     5070.000    470.000     5750.000    470.000
  5930.000    460.000     6080.000    460.000     6190.000    450.000
  6230.000    445.000     6280.000    435.200     6330.000    431.000
```

WSPRO OUTPUT

```
  6430.000     428.500     6480.000     428.700     6530.000     421.100
  6560.000     425.400     6650.000     419.000     6700.000     418.600
  6740.000     417.500     6800.000     418.000     7050.000     418.400
  7180.000     420.500     7255.000     423.000     7300.000     420.900
  7350.000     422.200     7400.000     431.300     7430.000     430.800
  7650.000     442.000     7820.000     444.000     7850.000     450.000
  8030.000     460.000     8100.000     465.000     8335.000     470.000
  8380.000     475.000     8910.000     475.000     9100.000     515.000
----------   ----------   ----------  ----------   ----------  ----------

                 Minimum and Maximum X,Y-coordinates
  Minimum X-Station:    5000.000  ( associated Y-Elevation:  480.000 )
  Maximum X-Station:    9100.000  ( associated Y-Elevation:  515.000 )
  Minimum Y-Elevation:   417.500  ( associated X-Station:   6740.000 )
  Maximum Y-Elevation:   515.000  ( associated X-Station:   9100.000 )

                    Roughness Data (  3 SubAreas )
                             Roughness   Horizontal
                  SubArea  Coefficient  Breakpoint
                  -------  -----------  ----------
                     1         .110        ---
                               ---       6080.000
                     2         .029        ---
                               ---       8030.000
                     3         .110        ---
                  -------  -----------  ----------

        *-----------------------------------------------------*
        *      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-275 OVER OHIO RIVER                  I-275-0-5639
   COUNTY: DEARBORN                       QUAD: LAWRENCEBURG 155D
         7-22-97                                R L MILLER

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

XS   FULLV  3000
GR        5000 480  5070 470  5750 470  5930 460  6080 460  6190 450
GR        6230 445  6280 435.2  6330 431  6430 428.5 6480 428.7
GR        6530 421.1  6560 425.4  6650 419  6700 418.6  6740 417.5
GR        6800 418  7050 418.4  7180 420.5  7255 423  7300 420.9
GR        7350 422.2  7400 431.3  7430 430.8  7650 442  7820 444
GR        7850 450  8030 460  8100 465  8335 470  8380 475  8910 475
GR        9100 515
N            .110   .0287   .110
SA               6080     8030
```

WSPRO OUTPUT

```
***   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:     3000.   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 (33 pairs)

X	Y	X	Y	X	Y
5000.000	480.000	5070.000	470.000	5750.000	470.000
5930.000	460.000	6080.000	460.000	6190.000	450.000
6230.000	445.000	6280.000	435.200	6330.000	431.000
6430.000	428.500	6480.000	428.700	6530.000	421.100
6560.000	425.400	6650.000	419.000	6700.000	418.600
6740.000	417.500	6800.000	418.000	7050.000	418.400
7180.000	420.500	7255.000	423.000	7300.000	420.900
7350.000	422.200	7400.000	431.300	7430.000	430.800
7650.000	442.000	7820.000	444.000	7850.000	450.000
8030.000	460.000	8100.000	465.000	8335.000	470.000
8380.000	475.000	8910.000	475.000	9100.000	515.000

Minimum and Maximum X,Y-coordinates

```
Minimum X-Station:    5000.000  ( associated Y-Elevation:  480.000 )
Maximum X-Station:    9100.000  ( associated Y-Elevation:  515.000 )
Minimum Y-Elevation:   417.500  ( associated X-Station:   6740.000 )
Maximum Y-Elevation:   515.000  ( associated X-Station:   9100.000 )
```

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.110	---
	---	6080.000
2	.029	---
	---	8030.000
3	.110	---

```
      *-----------------------------------------------------*
      *      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-275 OVER OHIO RIVER                    I-275-0-5639
 COUNTY: DEARBORN                         QUAD: LAWRENCEBURG 155D
       7-22-97                                  R L MILLER
```

WSPRO OUTPUT

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

   BR   BRDGE   3000  515
   GR        5000 515  5000 490  5095 470 5155 465 5375 470  5665 470
   GR        5928 460  6413 454  6483 450  6578 435.9  6648 426.3  6688 426.1
   GR        6738 424.6  6788 425  6883 419.9  6968 417.3  7023 417  7078
415.4
   GR        7138 417.3  7378 417.9  7538 421  7628 423.4  7738 434.9
   GR        7818 460  8078 515  5000 515
   N            .050  .0287  .050
   SA             6483    7818
   PD        418 15  1
   PD        434 15  2
   PD        434 30  3
   PD        450 30  4
   PD        450 45  5
   PD        459 45  6
   PD        459 60  7
   PD        463 60  8
   PD        463 67  9
   PD        467 67  10
   PD        467 81  11
   PD        470 81  12
   PD        470 109 13
   PD        473 109 14
   PD        473 125 15
   PD        507 125 16
   PD        507 134 17
   PD        570 134 18
   CD         3  83  3  515

    ***   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:     3000.   Cross-Section Skew:    .0   Error Code   0
    Valley Slope:  *******    Averaging Conveyance By Geometric Mean.
    Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                        X,Y-coordinates (26 pairs)
        X          Y          X          Y          X          Y
   ----------  ----------  ----------  ----------  ----------  ----------
     5000.000    515.000     5000.100    490.000     5095.000    470.000
     5155.000    465.000     5375.000    470.000     5665.000    470.000
     5928.000    460.000     6413.000    454.000     6483.000    450.000
     6578.000    435.900     6648.000    426.300     6688.000    426.100
     6738.000    424.600     6788.000    425.000     6883.000    419.900
     6968.000    417.300     7023.000    417.000     7078.000    415.400
     7138.000    417.300     7378.000    417.900     7538.000    421.000
     7628.000    423.400     7738.000    434.900     7818.000    460.000
```

WSPRO OUTPUT

8078.000	515.000	5000.000	515.000		

Minimum and Maximum X,Y-coordinates

Minimum X-Station:	5000.000	(associated Y-Elevation:	515.000)
Maximum X-Station:	8078.000	(associated Y-Elevation:	515.000)
Minimum Y-Elevation:	415.400	(associated X-Station:	7078.000)
Maximum Y-Elevation:	515.000	(associated X-Station:	5000.000)

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.050	---
	---	6483.000
2	.029	---
	---	7818.000
3	.050	---

Discharge coefficient parameters

BRType	BRWdth	EMBSS	EMBElv	UserCD
3	83.000	3.00	515.000	**********

Pressure flow elevations

AVBCEL	PFElev
*********	515.000

Abutment Parameters

ABSLPL	ABSLPR	XTOELT	YTOELT	XTOERT	YTOERT
*******	*******	*********	*********	*********	*********

Pier/Pile Data (18 Group(s))

Code Indicates Bridge Uses Piers

Group	Elevation	Gross Width	Number
1	418.000	15.000	1
2	434.000	15.000	2
3	434.000	30.000	3
4	450.000	30.000	4
5	450.000	45.000	5
6	459.000	45.000	6
7	459.000	60.000	7
8	463.000	60.000	8
9	463.000	67.000	9
10	467.000	67.000	10
11	467.000	81.000	11
12	470.000	81.000	12
13	470.000	109.000	13
14	473.000	109.000	14
15	473.000	125.000	15
16	507.000	125.000	16
17	507.000	134.000	17

WSPRO OUTPUT

```
                18      570.000    134.000      18
              ------  ---------  -----------  ------

          *-------------------------------------------------*
          *      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-275 OVER OHIO RIVER                    I-275-0-5639
    COUNTY: DEARBORN                        QUAD: LAWRENCEBURG 155D
         7-22-97                                 R L MILLER
  DC 0 BRDGE 6483  7818  6310  8040  *   134
  DP         5000 8078 7 * * 1 1 1.1
  DP         5000 8078 15 * * 1 1 1.1
  DP         5000 8078 9 * * 1 1 1.1

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

  XS   APPR    6100
  GR         5000 500 5000 490
  GR         6310 475  6395 460  6490 450  6540 441.1  6580 439.8
  GR         6650 429.9 6700 426.9 6740 426.2 6780 422  6830 425.4  6880 423.7
  GR         7080 417.1  7210 417.6  7330 415.8  7400 413.4  7480 413.9
  GR         7580 410.9  7625 412.1  7695 409.1  7735 410.9  7780 407.5
  GR         7870 412.4  7920 414.9  8040 460  8130 470  8280 515
  N            .110   .0287   .110
  SA               6310     8040

   ***   Completed Reading Data Associated With Header Record APPR    ***
+++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
   ***  Storing X-Section Data In Temporary File As Record Number  4  ***

   ***              Data Summary For Header Record APPR               ***
   SRD Location:     6100.   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 (28 pairs)
      X          Y          X          Y          X          Y
  ---------  ---------  ---------  ---------  ---------  ---------
    5000.000   500.000    5000.100   490.000    6310.000   475.000
    6395.000   460.000    6490.000   450.000    6540.000   441.100
    6580.000   439.800    6650.000   429.900    6700.000   426.900
    6740.000   426.200    6780.000   422.000    6830.000   425.400
    6880.000   423.700    7080.000   417.100    7210.000   417.600
    7330.000   415.800    7400.000   413.400    7480.000   413.900
    7580.000   410.900    7625.000   412.100    7695.000   409.100
    7735.000   410.900    7780.000   407.500    7870.000   412.400
```

WSPRO OUTPUT

```
   7920.000     414.900     8040.000     460.000     8130.000     470.000
   8280.000     515.000
---------- ---------- ---------- ---------- ---------- ----------

                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:    5000.000  ( associated Y-Elevation:  500.000 )
  Maximum X-Station:    8280.000  ( associated Y-Elevation:  515.000 )
  Minimum Y-Elevation:   407.500  ( associated X-Station:   7780.000 )
  Maximum Y-Elevation:   515.000  ( associated X-Station:   8280.000 )

                  Roughness Data (  3 SubAreas )
                          Roughness   Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .110        ---
                             ---        6310.000
                   2         .029        ---
                             ---        8040.000
                   3         .110        ---
                -------  -----------  ----------

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-275 OVER OHIO RIVER                  I-275-0-5639
    COUNTY: DEARBORN                       QUAD: LAWRENCEBURG 155D
         7-22-97                                R L MILLER
  EX

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

           Reach      Water Surface   Friction
     #   Discharge      Elevation      Slope         Flow Regime
    --   ---------    -------------   --------   --------------------
     1   760000.00       490.770      ******        Sub-Critical
     2   890000.00       497.160      ******        Sub-Critical
    --   ---------    -------------   --------   --------------------

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

WSPRO OUTPUT

```
************************* 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-275 OVER OHIO RIVER                  I-275-0-5639
  COUNTY: DEARBORN                     QUAD: LAWRENCEBURG 155D
       7-22-97                              R L MILLER
```

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: EXIT	490.770	.595	760000.000	156346.900	*********	5000.000
Header Type: XS	491.365	******	4.861	**********	*********	8984.907
SRD: .000	446.420	******	.174	******	1.620	******
Section: FULLV	490.972	.590	760000.000	157152.900	3000.000	5000.000
Header Type: FV	491.563	.196	4.836	**********	3000.000	8985.868
SRD: 3000.000	446.420	.000	.173	.0001	1.623	.002

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

Section: APPR	491.130	.664	760000.000	129059.000	3100.000	5000.089
Header Type: AS	491.793	.194	5.889	**********	3100.000	8200.432
SRD: 6100.000	438.925	.037	.181	.0001	1.231	.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	491.055	.532	760000.000	131013.000	3000.000	5000.096
Header Type: BR	491.587	.221	5.801	**********	3000.000	7964.805
SRD: 3000.000	445.638	.000	.155	******	1.016	.001

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.9922	.034	515.000	********	********	********

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: APPR	491.154	.663	760000.000	129138.400	3017.000	5000.088
Header Type: AS	491.818	.218	5.885	**********	3081.434	8200.515
SRD: 6100.000	438.925	.013	.181	.0001	1.231	-.001

WSPRO OUTPUT

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.074	.000	*********	5245.394	8210.096	491.154

<<< 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-275 OVER OHIO RIVER — I-275-0-5639
COUNTY: DEARBORN — QUAD: LAWRENCEBURG 155D
7-22-97 — R L MILLER

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: EXIT	497.160	.637	890000.000	181907.400	*********	5000.000
Header Type: XS	497.797	******	4.893	**********	*********	9015.260
SRD: .000	448.640	******	.168	******	1.711	******
Section: FULLV	497.351	.633	890000.000	182675.200	3000.000	5000.000
Header Type: FV	497.984	.185	4.872	**********	3000.000	9016.168
SRD: 3000.000	448.640	.000	.167	.0001	1.714	.002

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

Section: APPR	497.501	.739	890000.000	149516.400	3100.000	5000.025
Header Type: AS	498.239	.188	5.953	**********	3100.000	8221.669
SRD: 6100.000	441.501	.053	.178	.0001	1.341	.014

<<< 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	497.448	.559	890000.000	150063.900	3000.000	5000.070
Header Type: BR	498.007	.210	5.931	**********	3000.000	7995.028
SRD: 3000.000	448.322	.000	.149	******	1.022	.002

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.9890	.035	515.000	********	********	********

WSPRO OUTPUT

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: APPR	497.493	.739	890000.000	149491.600	3017.000	5000.025
Header Type: AS	498.232	.214	5.954	**********	3094.892	8221.644
SRD: 6100.000	441.501	.011	.178	.0001	1.341	-.001

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.071	.001	*********	5247.646	8242.596	497.493

<<< 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-275 OVER OHIO RIVER I-275-0-5639
COUNTY: DEARBORN QUAD: LAWRENCEBURG 155D
7-22-97 R L MILLER

*** 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): ******

#	Scour Depth	-- Flow -- Contract	Approach	-- Width -- Contract	Approach	Side	--- X-Limits --- Contract	Approach
1	8.873	*********	*********	1201.000	1730.000	Left:	6483.000	6310.000
	..... Approach Channel Depth:	66.302	.....			Right:	7818.000	8040.000
2	8.306	*********	*********	1201.000	1730.000	Left:	6483.000	6310.000
	..... Approach Channel Depth:	72.640	.....			Right:	7818.000	8040.000

********** 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-275 OVER OHIO RIVER I-275-0-5639
COUNTY: DEARBORN QUAD: LAWRENCEBURG 155D
7-22-97 R L MILLER

WSPRO OUTPUT

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

Constants and Input Variables

Pier Width: 7.000

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	Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	X-Stations Right
1	16.27	760000.000	491.068	75.668	8.076	.164	5000.000	8078.000
2	16.66	890000.000	497.459	82.059	8.326	.162	5000.000	8078.000

********** 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-275 OVER OHIO RIVER I-275-0-5639

COUNTY: DEARBORN QUAD: LAWRENCEBURG 155D

7-22-97 R L MILLER

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

Constants and Input Variables

Pier Width: 15.000

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	Flow	WSE	Depth	Velocity	Froude #	X-Stations Left	X-Stations Right
1	26.70	760000.000	491.068	75.668	8.076	.164	5000.000	8078.000
2	27.35	890000.000	497.459	82.059	8.326	.162	5000.000	8078.000

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

WSPRO OUTPUT

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

I-275 OVER OHIO RIVER I-275-0-5639
COUNTY: DEARBORN QUAD: LAWRENCEBURG 155D
7-22-97 R L MILLER

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

Constants and Input Variables

Pier Width: 9.000

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	19.15	760000.000	491.068	75.668	8.076	.164	5000.000	8078.000
2	19.62	890000.000	497.459	82.059	8.326	.162	5000.000	8078.000

ER

********** Normal end of WSPRO execution. **********
********** Elapsed Time: 0 Minutes 10 Seconds **********