Modified Level II Streambed-Scour Analysis for Structure I-70-35-5245 Crossing Big Walnut Creek in Putnam County, Indiana

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

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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-70-35-5245 on Interstate 70 crossing Big Walnut Creek in Putnam County, Indiana, are presented. The site is near the town of Manhattan in the southwestern part of Putnam 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 17.0 feet for the modeled discharge of 29,200 cubic feet per second and approximately 30.9 feet for the modeled discharge of 49,600 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-70-35-5245.

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 Manhattan in the southwestern part of Putnam County. The drainage area for the site is approximately 331 mi^2 (estimated using Hoggatt, 1975, and USGS 7.5-minute topographic data). The predominant land use in the basin is forest; in the immediate vicinity of the bridge, the land is predominantly agricultural.

Within the immediate vicinity of the bridge, Big Walnut Creek has a channel-bed slope of approximately 0.00104 ft/ft. The channel-bed material is sand, and the channel banks consist of sand. At the time of the Level I site visit on June 4, 1991, the banks were observed to have 30 to 60 percent woody vegetative cover; the field report noted that the banks were experiencing some fluvial erosion and mass wasting.

The Interstate 70 crossing of Big Walnut Creek is a 453-ft-long, multi-lane bridge consisting of six spans supported by concrete and steel piers and sloping riprap-covered spill-through abutments. Additional details describing conditions at the site are included in the Level I data base (Hopkins and Robinson, unpub. data, 1997). Photographs of the site, taken at the time of the Level I site visit, are archived at the USGS office in Indianapolis.

EVALUATION METHODS

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

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

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

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

Most of the cross-section and bridge-opening geometry data were taken from the bridge plans (Indiana State Highway Commission, 1964) 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-70-35-5245 crossing Big Walnut Creek in Putnam 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 29,200 cubic feet per second							
1	1773+71	586	4.3	12.7	17.0	571.9	559.3
2	1774+58	585	4.3	12.7	17.0	571.2	559.3
3	1775+43	577	4.3	12.7	17.0	570.8	559.3
4	1776+28	576	4.3	12.7	17.0	569.7	559.3
5	1777+13	594	4.3	12.7	17.0	568.9	559.3
Modeled discharge is 49,600 cubic feet per second							
1	1773+71	586	15.7	15.2	30.9	571.9	545.4
2	1774+58	585	15.7	15.2	30.9	571.2	545.4
3	1775+43	577	15.7	15.2	30.9	570.8	545.4
4	1776+28	576	15.7	15.2	30.9	569.7	545.4
5	1777+13	594	15.7	15.2	30.9	568.9	545.4

[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, 1773+71, represents a point 177,371 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 (576.3 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, 1964, Bridge plans Interstate Route 70: Bridge File I-70-35-5245.

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 Big Walnut Creek     I70-35-5245
T2        County: Putnam                 Quad: Reelsville 121C
T3        10-25-96                       Bret A. Robinson
SI        0
Q         29200 49600
SK        .00104 .00104
XS   EXIT 0 10
GR        75702 630 75794 620 75956 610 76146 600
GR        77313 593 77338 593 77347 592 77353 591
GR        77359 590 77368 589 77410 588 77446 588
GR        77470 589 77491 590 77502 590 77511 589
GR        77518 588 77537 587 77545 587 77548 588
GR        77551 589 77565 589 77569 588 77573 587
GR        77578 585 77593 581 77606 580 77639 575
GR        77648 575 77671 580 77692 585 77695 590
GR        77702 591 77735 592 77787 591 77821 590
GR        77870 589 78932 590 80657 600 80953 620
N         .045     .036     .045
SA            77573    77695
XS   FULLV 450 10
GR        75702 630 75794 620 75956 610 76146 600
GR        77313 593 77338 593 77347 592 77353 591
GR        77359 590 77368 589 77410 588 77446 588
GR        77470 589 77491 590 77502 590 77511 589
GR        77518 588 77537 587 77545 587 77548 588
GR        77551 589 77565 589 77569 588 77573 587
GR        77578 585 77593 581 77606 580 77639 575
GR        77648 575 77671 580 77692 585 77695 590
GR        77702 591 77735 592 77787 591 77821 590
GR        77870 589 78932 590 80657 600 80953 620
N         .045     .036     .045
SA            77573    77695
BR   BRDGE 450 601.43 10
GR        77320 604.6 77320 603.0 77322 603.0 77336 596.2
GR        77347 590.4 77355 586.1 77373 585.9 77396 585.6
GR        77415 585.3 77435 585.1 77452 584.8 77470 584.6
GR        77487 584.4 77499 578.0 77524 577.3 77562 576.6
GR        77626 576.3 77662 575.4 77681 577.2 77684 578.1
GR        77704 593.2 77733 594.7 77748 593.9 77765 603.2
GR        77768 602.9 77768 604.0 77770 604.2 77770 605.0
GR        77753 605.2 77730 603.8 77715 601.6 77712 601.3
GR        77703 602.7 77681 604.4 77658 604.2 77638 602.6
GR        77629 601.0 77627 601.1 77627 601.8 77610 603.6
GR        77590 604.3 77567 603.8 77545 601.5 77545 600.7
GR        77542 600.4 77542 601.6 77525 603.6 77496 604.4
GR        77479 603.8 77460 601.6 77460 600.9 77457 600.8
GR        77457 601.8 77427 604.3 77388 602.9 77375 601.5
GR        77375 600.8 77373 600.9 77373 601.4 77345 604.2
GR        77330 604.5 77321 604.4 77320 604.6 77320 604.6
N         .032
PD        576.3 3 4
PD        577.0 3 4
PD        577.0 6 3
PD        584.7 6 3
```

WSPRO INPUT FILE

```
PD        584.7 9 2
PD        585.9 9 2
PD        585.9 12 1
PD        593.2 12 1
PD        593.2 15 5
CD        3 120 2 603
DC 0 BRDGE 77605 77705 77585 77670 * 15
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
XS   APPR 1020 10
GR        75948 650 76385 600 77269 594 77376 594
GR        77414 593 77425 592 77562 591 77576 590
GR        77591 580 77599 579 77612 578 77638 577
GR        77648 576 77656 576 77663 577 77670 580
GR        77675 590 77687 593 77742 591 77832 590
GR        78118 590 78669 590 78809 590 80255 600
GR        80573 620
N         .045   .036   .045
SA            77576   77675
EX
ER
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WSPRO OUTPUT

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      Federal Highway Administration  -  U. S. Geological Survey
            Model for Water-Surface Profile Computations.
        Run Date & Time:  8/ 4/97  1:23 pm     Version V050196
         Input File: 5245.dat       Output File: 5245.LST
   *-------------------------------------------------------------*
T1         I-70 OVER BIG WALNUT CREEK     I70-35-5245
T2         COUNTY: PUTNAM                 QUAD: REELSVILLE 121C
T3         10-25-96                       BRET A. ROBINSON
SI         0
Q          29200 49600

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

SK         .00104 .00104

   ************************  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 BIG WALNUT CREEK     I70-35-5245
        COUNTY: PUTNAM                 QUAD: REELSVILLE 121C
           10-25-96                       BRET A. ROBINSON

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

XS   EXIT 0 10
GR         75702 630 75794 620 75956 610 76146 600
GR         77313 593 77338 593 77347 592 77353 591
GR         77359 590 77368 589 77410 588 77446 588
GR         77470 589 77491 590 77502 590 77511 589
GR         77518 588 77537 587 77545 587 77548 588
GR         77551 589 77565 589 77569 588 77573 587
GR         77578 585 77593 581 77606 580 77639 575
GR         77648 575 77671 580 77692 585 77695 590
GR         77702 591 77735 592 77787 591 77821 590
GR         77870 589 78932 590 80657 600 80953 620
N          .045     .036     .045
SA             77573    77695

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

                     X,Y-coordinates (40 pairs)
     X          Y             X          Y             X          Y
```

WSPRO OUTPUT

75702.000	630.000	75794.000	620.000	75956.000	610.000
76146.000	600.000	77313.000	593.000	77338.000	593.000
77347.000	592.000	77353.000	591.000	77359.000	590.000
77368.000	589.000	77410.000	588.000	77446.000	588.000
77470.000	589.000	77491.000	590.000	77502.000	590.000
77511.000	589.000	77518.000	588.000	77537.000	587.000
77545.000	587.000	77548.000	588.000	77551.000	589.000
77565.000	589.000	77569.000	588.000	77573.000	587.000
77578.000	585.000	77593.000	581.000	77606.000	580.000
77639.000	575.000	77648.000	575.000	77671.000	580.000
77692.000	585.000	77695.000	590.000	77702.000	591.000
77735.000	592.000	77787.000	591.000	77821.000	590.000
77870.000	589.000	78932.000	590.000	80657.000	600.000
80953.000	620.000				

Minimum and Maximum X,Y-coordinates

Minimum X-Station: 75702.000 (associated Y-Elevation: 630.000)
Maximum X-Station: 80953.000 (associated Y-Elevation: 620.000)
Minimum Y-Elevation: 575.000 (associated X-Station: 77648.000)
Maximum Y-Elevation: 630.000 (associated X-Station: 75702.000)

X-coordinates & Horizontal Breakpoints Translated by Skew Angle

X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
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76146.000	76168.820	77313.000	77318.090	77338.000	77342.710
77347.000	77351.570	77353.000	77357.480	77359.000	77363.390
77368.000	77372.250	77410.000	77413.620	77446.000	77449.070
77470.000	77472.700	77491.000	77493.380	77502.000	77504.220
77511.000	77513.080	77518.000	77519.980	77537.000	77538.690
77545.000	77546.560	77548.000	77549.520	77551.000	77552.480
77565.000	77566.260	77569.000	77570.200	77573.000	77574.140
77578.000	77579.060	77593.000	77593.840	77606.000	77606.640
77639.000	77639.140	77648.000	77648.000	77671.000	77670.650
77692.000	77691.330	77695.000	77694.290	77702.000	77701.180
77735.000	77733.680	77787.000	77784.890	77821.000	77818.380
77870.000	77866.630	78932.000	78912.490	80657.000	80611.290
80953.000	80902.790				

Roughness Data (3 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.045	---
	---	********
2	.036	---
	---	********
3	.045	---

--

WSPRO OUTPUT

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        *      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 BIG WALNUT CREEK    I70-35-5245
        COUNTY: PUTNAM                QUAD: REELSVILLE 121C
           10-25-96                      BRET A. ROBINSON

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

XS   FULLV 450 10
GR        75702 630 75794 620 75956 610 76146 600
GR        77313 593 77338 593 77347 592 77353 591
GR        77359 590 77368 589 77410 588 77446 588
GR        77470 589 77491 590 77502 590 77511 589
GR        77518 588 77537 587 77545 587 77548 588
GR        77551 589 77565 589 77569 588 77573 587
GR        77578 585 77593 581 77606 580 77639 575
GR        77648 575 77671 580 77692 585 77695 590
GR        77702 591 77735 592 77787 591 77821 590
GR        77870 589 78932 590 80657 600 80953 620
N         .045     .036     .045
SA            77573    77695

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 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                    X,Y-coordinates (40 pairs)
    X          Y             X          Y             X          Y
---------  ---------   ---------  ---------   ---------  ---------
 75702.000     630.000    75794.000     620.000    75956.000     610.000
 76146.000     600.000    77313.000     593.000    77338.000     593.000
 77347.000     592.000    77353.000     591.000    77359.000     590.000
 77368.000     589.000    77410.000     588.000    77446.000     588.000
 77470.000     589.000    77491.000     590.000    77502.000     590.000
 77511.000     589.000    77518.000     588.000    77537.000     587.000
 77545.000     587.000    77548.000     588.000    77551.000     589.000
 77565.000     589.000    77569.000     588.000    77573.000     587.000
 77578.000     585.000    77593.000     581.000    77606.000     580.000
 77639.000     575.000    77648.000     575.000    77671.000     580.000
 77692.000     585.000    77695.000     590.000    77702.000     591.000
 77735.000     592.000    77787.000     591.000    77821.000     590.000
 77870.000     589.000    78932.000     590.000    80657.000     600.000
```

WSPRO OUTPUT

```
 80953.000     620.000
---------- ---------- ---------- ---------- ---------- ----------

                Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   75702.000  ( associated Y-Elevation:  630.000 )
  Maximum X-Station:   80953.000  ( associated Y-Elevation:  620.000 )
  Minimum Y-Elevation:   575.000  ( associated X-Station:  77648.000 )
  Maximum Y-Elevation:   630.000  ( associated X-Station:  75702.000 )

     X-coordinates & Horizontal Breakpoints Translated by Skew Angle
  X Input    X Skewed      X Input    X Skewed      X Input    X Skewed
---------- ----------   ---------- ----------   ---------- ----------
 75702.000   75731.560    75794.000   75822.160    75956.000   75981.700
 76146.000   76168.820    77313.000   77318.090    77338.000   77342.710
 77347.000   77351.570    77353.000   77357.480    77359.000   77363.390
 77368.000   77372.250    77410.000   77413.620    77446.000   77449.070
 77470.000   77472.700    77491.000   77493.380    77502.000   77504.220
 77511.000   77513.080    77518.000   77519.980    77537.000   77538.690
 77545.000   77546.560    77548.000   77549.520    77551.000   77552.480
 77565.000   77566.260    77569.000   77570.200    77573.000   77574.140
 77578.000   77579.060    77593.000   77593.840    77606.000   77606.640
 77639.000   77639.140    77648.000   77648.000    77671.000   77670.650
 77692.000   77691.330    77695.000   77694.290    77702.000   77701.180
 77735.000   77733.680    77787.000   77784.890    77821.000   77818.380
 77870.000   77866.630    78932.000   78912.490    80657.000   80611.290
 80953.000   80902.790
---------- ----------   ---------- ----------   ---------- ----------

                  Roughness Data (  3 SubAreas )
                         Roughness   Horizontal
                SubArea  Coefficient  Breakpoint
                -------  -----------  ----------
                   1         .045        ---
                             ---        ********
                   2         .036        ---
                             ---        ********
                   3         .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 BIG WALNUT CREEK    I70-35-5245
      COUNTY: PUTNAM                 QUAD: REELSVILLE 121C
         10-25-96                      BRET A. ROBINSON

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

WSPRO OUTPUT

```
          *-------------------------------------------------*

  BR   BRDGE 450 601.43 10
  GR         77320 604.6 77320 603.0 77322 603.0 77336 596.2
  GR         77347 590.4 77355 586.1 77373 585.9 77396 585.6
  GR         77415 585.3 77435 585.1 77452 584.8 77470 584.6
  GR         77487 584.4 77499 578.0 77524 577.3 77562 576.6
  GR         77626 576.3 77662 575.4 77681 577.2 77684 578.1
  GR         77704 593.2 77733 594.7 77748 593.9 77765 603.2
  GR         77768 602.9 77768 604.0 77770 604.2 77770 605.0
  GR         77753 605.2 77730 603.8 77715 601.6 77712 601.3
  GR         77703 602.7 77681 604.4 77658 604.2 77638 602.6
  GR         77629 601.0 77627 601.1 77627 601.8 77610 603.6
  GR         77590 604.3 77567 603.8 77545 601.5 77545 600.7
  GR         77542 600.4 77542 601.6 77525 603.6 77496 604.4
  GR         77479 603.8 77460 601.6 77460 600.9 77457 600.8
  GR         77457 601.8 77427 604.3 77388 602.9 77375 601.5
  GR         77375 600.8 77373 600.9 77373 601.4 77345 604.2
  GR         77330 604.5 77321 604.4 77320 604.6 77320 604.6
  N          .032
  PD         576.3 3 4
  PD         577.0 3 4
  PD         577.0 6 3
  PD         584.7 6 3
  PD         584.7 9 2
  PD         585.9 9 2
  PD         585.9 12 1
  PD         593.2 12 1
  PD         593.2 15 5
  CD         3 120 2 603

    ***   Completed Reading Data Associated With Header Record BRDGE   ***
+++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #26 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #28 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #39 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #44 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #46 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #51 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #53 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #57 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate #59 increased to eliminate vertical segment.
    ***   Storing Bridge Data In Temporary File As Record Number  3    ***

    ***              Data Summary For Bridge Record BRDGE              ***
    SRD Location:      450.   Cross-Section Skew:  10.0   Error Code   0
    Valley Slope:  *******    Averaging Conveyance By Geometric Mean.
    Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00

                        X,Y-coordinates (64 pairs)
        X          Y             X          Y             X          Y
  ----------  ----------   ----------  ----------   ----------  ----------
   77320.000     604.600    77320.100     603.000    77322.000     603.000
   77336.000     596.200    77347.000     590.400    77355.000     586.100
```

WSPRO OUTPUT

77373.000	585.900	77396.000	585.600	77415.000	585.300
77435.000	585.100	77452.000	584.800	77470.000	584.600
77487.000	584.400	77499.000	578.000	77524.000	577.300
77562.000	576.600	77626.000	576.300	77662.000	575.400
77681.000	577.200	77684.000	578.100	77704.000	593.200
77733.000	594.700	77748.000	593.900	77765.000	603.200
77768.000	602.900	77768.100	604.000	77770.000	604.200
77770.100	605.000	77753.000	605.200	77730.000	603.800
77715.000	601.600	77712.000	601.300	77703.000	602.700
77681.000	604.400	77658.000	604.200	77638.000	602.600
77629.000	601.000	77627.000	601.100	77627.100	601.800
77610.000	603.600	77590.000	604.300	77567.000	603.800
77545.000	601.500	77545.100	600.700	77542.000	600.400
77542.100	601.600	77525.000	603.600	77496.000	604.400
77479.000	603.800	77460.000	601.600	77460.100	600.900
77457.000	600.800	77457.100	601.800	77427.000	604.300
77388.000	602.900	77375.000	601.500	77375.100	600.800
77373.000	600.900	77373.100	601.400	77345.000	604.200
77330.000	604.500	77321.000	604.400	77320.000	604.600
77320.000	604.600				

Minimum and Maximum X,Y-coordinates

Minimum X-Station: 77320.000 (associated Y-Elevation: 604.600)
Maximum X-Station: 77770.100 (associated Y-Elevation: 605.000)
Minimum Y-Elevation: 575.400 (associated X-Station: 77662.000)
Maximum Y-Elevation: 605.200 (associated X-Station: 77753.000)

X-coordinates & Horizontal Breakpoints Translated by Skew Angle

X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
77320.000	77325.200	77320.100	77325.300	77322.000	77327.160
77336.000	77340.950	77347.000	77351.790	77355.000	77359.660
77373.000	77377.390	77396.000	77400.040	77415.000	77418.750
77435.000	77438.450	77452.000	77455.190	77470.000	77472.910
77487.000	77489.660	77499.000	77501.480	77524.000	77526.090
77562.000	77563.520	77626.000	77626.550	77662.000	77662.000
77681.000	77680.710	77684.000	77683.660	77704.000	77703.360
77733.000	77731.920	77748.000	77746.700	77765.000	77763.440
77768.000	77766.390	77768.100	77766.490	77770.000	77768.360
77770.100	77768.460	77753.000	77751.620	77730.000	77728.970
77715.000	77714.200	77712.000	77711.240	77703.000	77702.380
77681.000	77680.710	77658.000	77658.060	77638.000	77638.370
77629.000	77629.500	77627.000	77627.530	77627.100	77627.630
77610.000	77610.790	77590.000	77591.090	77567.000	77568.450
77545.000	77546.780	77545.100	77546.880	77542.000	77543.820
77542.100	77543.920	77525.000	77527.080	77496.000	77498.520
77479.000	77481.780	77460.000	77463.070	77460.100	77463.170
77457.000	77460.120	77457.100	77460.210	77427.000	77430.570
77388.000	77392.160	77375.000	77379.360	77375.100	77379.460
77373.000	77377.390	77373.100	77377.490	77345.000	77349.810
77330.000	77335.050	77321.000	77326.180	77320.000	77325.200
77320.000	77325.200				

WSPRO OUTPUT

Roughness Data (1 SubAreas)

SubArea	Roughness Coefficient	Horizontal Breakpoint
1	.032	---

Discharge coefficient parameters

BRType	BRWdth	EMBSS	EMBElv	UserCD
3	120.000	2.00	603.000	**********

Pressure flow elevations

AVBCEL	PFElev
*********	601.430

Abutment Parameters

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

Pier/Pile Data (9 Group(s))
Code Indicates Bridge Uses Piers

Group	Elevation	Gross Width	Number
1	576.300	3.000	4
2	577.000	3.000	4
3	577.000	6.000	3
4	584.700	6.000	3
5	584.700	9.000	2
6	585.900	9.000	2
7	585.900	12.000	1
8	593.200	12.000	1
9	593.200	15.000	5

```
*-------------------------------------------------*
*      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 BIG WALNUT CREEK    I70-35-5245
      COUNTY: PUTNAM                QUAD: REELSVILLE 121C
         10-25-96                      BRET A. ROBINSON
DC 0 BRDGE 77605 77705 77585 77670 * 15
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
DP        77320  77770  3  *  *  1  1.7 1.1
```

WSPRO OUTPUT

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

XS    APPR 1020 10
GR         75948 650 76385 600 77269 594 77376 594
GR         77414 593 77425 592 77562 591 77576 590
GR         77591 580 77599 579 77612 578 77638 577
GR         77648 576 77656 576 77663 577 77670 580
GR         77675 590 77687 593 77742 591 77832 590
GR         78118 590 78669 590 78809 590 80255 600
GR         80573 620
N          .045   .036   .045
SA             77576   77675

 ***   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:      1020.   Cross-Section Skew:  10.0   Error Code   0
 Valley Slope:    .00000    Averaging Conveyance By Geometric Mean.
 Energy Loss Coefficients ->   Expansion:   .50   Contraction:   .00
```

X,Y-coordinates (25 pairs)

X	Y	X	Y	X	Y
75948.000	650.000	76385.000	600.000	77269.000	594.000
77376.000	594.000	77414.000	593.000	77425.000	592.000
77562.000	591.000	77576.000	590.000	77591.000	580.000
77599.000	579.000	77612.000	578.000	77638.000	577.000
77648.000	576.000	77656.000	576.000	77663.000	577.000
77670.000	580.000	77675.000	590.000	77687.000	593.000
77742.000	591.000	77832.000	590.000	78118.000	590.000
78669.000	590.000	78809.000	590.000	80255.000	600.000
80573.000	620.000				

```
                 Minimum and Maximum X,Y-coordinates
  Minimum X-Station:    75948.000  ( associated Y-Elevation:   650.000 )
  Maximum X-Station:    80573.000  ( associated Y-Elevation:   620.000 )
  Minimum Y-Elevation:    576.000  ( associated X-Station:   77656.000 )
  Maximum Y-Elevation:    650.000  ( associated X-Station:   75948.000 )
```

X-coordinates & Horizontal Breakpoints Translated by Skew Angle

X Input	X Skewed	X Input	X Skewed	X Input	X Skewed
75948.000	75973.950	76385.000	76404.310	77269.000	77274.880
77376.000	77380.250	77414.000	77417.680	77425.000	77428.510
77562.000	77563.430	77576.000	77577.220	77591.000	77591.980
77599.000	77599.870	77612.000	77612.670	77638.000	77638.270
77648.000	77648.130	77656.000	77656.000	77663.000	77662.890
77670.000	77669.790	77675.000	77674.710	77687.000	77686.530
77742.000	77740.700	77832.000	77829.330	78118.000	78110.980

WSPRO OUTPUT

```
 78669.000   78653.610    78809.000   78791.480    80255.000   80215.520
 80573.000   80528.690
----------  ----------   ----------  ----------   ----------  ----------

                    Roughness Data (  3 SubAreas )
                             Roughness   Horizontal
                  SubArea  Coefficient  Breakpoint
                  -------  -----------  ----------
                     1         .045        ---
                               ---        ********
                     2         .036        ---
                               ---        ********
                     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-70 OVER BIG WALNUT CREEK    I70-35-5245
          COUNTY: PUTNAM                QUAD: REELSVILLE 121C
            10-25-96                      BRET A. ROBINSON
  EX

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

            Reach       Water Surface   Friction
     #    Discharge       Elevation       Slope          Flow Regime
    --    ---------     -------------   --------   --------------------
     1     29200.00       ********         .0010        Sub-Critical
     2     49600.00       ********         .0010        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-70 OVER BIG WALNUT CREEK    I70-35-5245
```

WSPRO OUTPUT

COUNTY: PUTNAM QUAD: REELSVILLE 121C
10-25-96 BRET A. ROBINSON

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: EXIT	593.652	.420	29200.000	8823.979	*********	77210.980
Header Type: XS	594.072	******	3.309	904738.80	*********	79532.950
SRD: .000	592.020	******	.470	******	2.466	******
Section: FULLV	594.163	.311	29200.000	10053.060	450.000	77127.160
Header Type: FV	594.474	.405	2.905	1046108.00	450.000	79619.690
SRD: 450.000	592.020	.000	.392	.0009	2.369	-.004

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

Section: APPR	594.608	.439	29200.000	8632.828	570.000	77186.620
Header Type: AS	595.047	.515	3.382	901277.30	570.000	79447.730
SRD: 1020.000	593.026	.064	.479	.0009	2.466	-.006

<<< 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	594.449	1.012	29200.000	4859.298	450.000	77344.230
Header Type: BR	595.462	1.161	6.009	1185856.00	450.000	77747.690
SRD: 450.000	586.612	.229	.405	******	1.802	.005

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1						
Pier/Pile Code 0	.7449	.034	601.430	********	********	********

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: APPR	596.321	.166	29200.000	12927.790	450.000	76938.080
Header Type: AS	596.487	.939	2.259	1439850.00	576.969	79691.660
SRD: 1020.000	593.026	.087	.265	.0009	2.086	.014

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.822	.745	365224.7	********	********	596.321

WSPRO OUTPUT

<<< 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 BIG WALNUT CREEK    I70-35-5245
      COUNTY: PUTNAM                QUAD: REELSVILLE 121C
         10-25-96                      BRET A. ROBINSON
```

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: EXIT	595.604	.411	49600.000	13992.090	*********	76890.550
Header Type: XS	596.015	******	3.545	1537151.00	*********	79864.510
SRD: .000	592.988	******	.418	******	2.102	******
Section: FULLV	596.105	.321	49600.000	15524.190	450.000	76808.280
Header Type: FV	596.426	.414	3.195	1740603.00	450.000	79949.630
SRD: 450.000	592.988	.000	.360	.0009	2.022	-.002

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

Section: APPR	596.582	.419	49600.000	13656.220	570.000	76900.210
Header Type: AS	597.001	.524	3.632	1537125.00	570.000	79728.820
SRD: 1020.000	594.304	.049	.416	.0009	2.040	.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	596.037	2.351	49600.000	5503.379	450.000	77341.260
Header Type: BR	598.388	1.292	9.013	1421765.00	450.000	77750.540
SRD: 450.000	589.335	1.082	.591	******	1.861	.005

Specific Bridge Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3 Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code 0	.7331	.034	601.430	********	********	********

	WSEL / EGEL / CRWS	VHD / HF / HO	Q / V / FR #	AREA / K / SF	SRDL / FLEN / ALPHA	LEW / REW / ERR
Section: APPR	599.351	.126	49600.000	22590.970	450.000	76498.430

WSPRO OUTPUT

```
Header Type: AS    599.478    .923      2.196 2842892.00   592.431 80123.140
SRD:   1020.000    594.304    .166       .201      .0009     1.687      .014

            Approach Section APPR  Flow Contraction Information
           M( G )   M( K )     KQ       XLKQ     XRKQ     OTEL
          -------- -------- --------- -------- -------- --------
              .855     .803  557230.4 ******** ********  599.351
          -------- -------- --------- -------- -------- --------

              <<< 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 BIG WALNUT CREEK    I70-35-5245
         COUNTY: PUTNAM                QUAD: REELSVILLE 121C
            10-25-96                      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): 15.000
              *-----------------------------------------------*

     Scour      -- Flow --          -- Width --         --- X-Limits ---
 #   Depth  Contract Approach  Contract Approach  Side   Contract Approach
--   ------ --------- --------- -------- --------  ------ -------- --------
 1   4.290 11382.020  8890.629   85.000   85.000  Left:  ******** ********
    ..... Approach Channel Depth:   18.333 .....  Right: ******** ********
 2  15.701 18855.990  9869.666   85.000   85.000  Left:  ******** ********
    ..... Approach Channel Depth:   21.363 .....  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-70 OVER BIG WALNUT CREEK    I70-35-5245
         COUNTY: PUTNAM                QUAD: REELSVILLE 121C
            10-25-96                      BRET A. ROBINSON

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

                    Constants and Input Variables

                          Pier Width:   3.000
              *-----------------------------------------*
```

WSPRO OUTPUT

```
                Pier Shape Factor            (K1):   1.00
                Flow Angle of Attack Factor  (K2):   1.70
                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	12.74	29200.000	594.536	19.136	7.383	.297	77320.000	77770.000
2	15.24	49600.000	596.204	20.804	10.911	.422	77320.000	77770.000

```
      ************************  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 BIG WALNUT CREEK    I70-35-5245
           COUNTY: PUTNAM                QUAD: REELSVILLE 121C
              10-25-96                      BRET A. ROBINSON

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

                       Constants and Input Variables

                           Pier Width:   3.000
              *-----------------------------------------*
                Pier Shape Factor            (K1):   1.00
                Flow Angle of Attack Factor  (K2):   1.70
                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	12.74	29200.000	594.536	19.136	7.383	.297	77320.000	77770.000
2	15.24	49600.000	596.204	20.804	10.911	.422	77320.000	77770.000

```
      ************************  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 BIG WALNUT CREEK    I70-35-5245
           COUNTY: PUTNAM                QUAD: REELSVILLE 121C
```

WSPRO OUTPUT

10-25-96 BRET A. ROBINSON

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

Constants and Input Variables

Pier Width: 3.000

Pier Shape Factor	(K1):	1.00
Flow Angle of Attack Factor	(K2):	1.70
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	12.74	29200.000	594.536	19.136	7.383	.297	77320.000	77770.000
2	15.24	49600.000	596.204	20.804	10.911	.422	77320.000	77770.000

********** 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 BIG WALNUT CREEK I70-35-5245

COUNTY: PUTNAM QUAD: REELSVILLE 121C

10-25-96 BRET A. ROBINSON

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

Constants and Input Variables

Pier Width: 3.000

Pier Shape Factor	(K1):	1.00
Flow Angle of Attack Factor	(K2):	1.70
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	12.74	29200.000	594.536	19.136	7.383	.297	77320.000	77770.000
2	15.24	49600.000	596.204	20.804	10.911	.422	77320.000	77770.000

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-70 OVER BIG WALNUT CREEK    I70-35-5245
     COUNTY: PUTNAM                QUAD: REELSVILLE 121C
        10-25-96                      BRET A. ROBINSON

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

                  Constants and Input Variables

                       Pier Width:   3.000
              *-----------------------------------------*
                Pier Shape Factor            (K1):   1.00
                Flow Angle of Attack Factor  (K2):   1.70
                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	12.74	29200.000	594.536	19.136	7.383	.297	77320.000	77770.000
2	15.24	49600.000	596.204	20.804	10.911	.422	77320.000	77770.000

```
  ER

   ******************  Normal end of WSPRO execution.  *****************
   ***************  Elapsed Time:   0 Minutes 13 Seconds  **************
```