Modified Level II Streambed-Scour Analysis for Structure I-70-60-5180 Crossing Branch of McCracken Creek in Hendricks County, Indiana

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Tables

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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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-70-60-5180 on Interstate 70 crossing Branch of McCracken Creek in Hendricks County, Indiana, are presented. The site is near the town of Center Valley in the south-central part of Hendricks County. Scour depths were computed with the Water Surface PROfile model, version V050196, which incorporates the scour-calculation procedures outlined in Hydraulic Engineering Circular No. 18. Total scour depths at the piers were approximately 12.4 feet for the modeled discharge of 1,200 cubic feet per second and approximately 24.8 feet for the modeled discharge of 2,040 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-70-60-5180.

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 Center Valley in the south-central part of Hendricks County. The drainage area for the site is approximately 2.25 mi^2 (estimated using Hoggatt, 1975, and USGS 7.5-minute topographic data). The predominant land use in the basin is agricultural; in the immediate vicinity of the bridge, the land is predominantly wooded.

Within the immediate vicinity of the bridge, Branch of McCracken Creek has a channel-bed slope of approximately 0.0029 ft/ft. The channel-bed material is sand, and the channel banks consist of silt-clay. At the time of the Level I site visit on June 3, 1991, the banks were observed to have 0 to 10 percent woody vegetative cover; the field report noted that the banks were experiencing some fluvial erosion.

The Interstate 70 crossing of Branch of McCracken Creek is a 72-ft-long, multi-lane bridge consisting of three spans supported by concrete and steel piers and sloping riprap-covered spill-through abutments. Additional details describing conditions at the site are included in the Level I data base (Hopkins and Robinson, unpub. data, 1997). Photographs of the site, taken at the time of the Level I site visit, are archived at the USGS office in Indianapolis.

EVALUATION METHODS

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

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

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

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

Most of the cross-section and bridge-opening geometry data were taken from the bridge plans (Indiana State Highway Commission, 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-70-60-5180 crossing Branch of McCracken Creek in Hendricks County, Indiana

[--, no value]

Pier number[1]	Stationing from bridge plans[2]	Initial bed-elevation at pier (feet)	Main-channel contrac-tion scour depth (feet)	Local scour depth (feet)	Worst-case total-scour depth[3] (feet)	Bottom elevation of pier (feet)	Worst-case bed elevation after scour[4] (feet)
Modeled discharge[5] is 1,200 cubic feet per second							
1	591+98	750	7.8	4.6	12.4	740.0	733.6
2	592+25	750	7.8	4.6	12.4	740.0	733.6
Modeled discharge is 2,040 cubic feet per second							
1	591+98	750	19.5	5.3	24.8	740.0	721.2
2	592+25	750	19.5	5.3	24.8	740.0	721.2

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

[2]Stationing is the center line of the pier as determined from the bridge plans. Stationing from bridge plan, 591+98, represents a point 59,198 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 (746.0 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-70-60-5180.

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 Br. McCracken Creek      I70-60-5180
T2        County: Hendricks                  Quad: Mooresville West
T3        02-20-97                           Bret A. Robinson
SI        0
Q         1200 2040
SK        .0029 .0029
XS    EXIT 0 0
GR        58847 760   58918 762   58935 759   58961 758   58978 757
GR        59003 756   59009 755   59020 753   59051 752   59101 751
GR        59141 751   59186 751   59201 746   59219 746   59228 750
GR        59231 751   59241 752   59286 755   59299 756   59323 757
GR        59474 765   59495 770   59742 770   59814 770   60020 780
GR        60269 780   60363 780
N         .100      .034      .100
SA        59190     59225
XS    FULLV77 0
GR        58847 760   58918 762   58935 759   58961 758   58978 757
GR        59003 756   59009 755   59020 753   59051 752   59101 751
GR        59141 751   59186 751   59201 746   59219 746   59228 750
GR        59231 751   59241 752   59286 755   59299 756   59323 757
GR        59474 765   59495 770   59742 770   59814 770   60020 780
GR        60269 780   60363 780
N         .100      .034      .100
SA        59190     59225
BR    BRDGE77 759 0
GR        59175 0759.2   59175 0758.6   59178 0758.6   59205 0745.9
GR        59218 0745.9   59241 0758.6   59244 0758.6   59244 0759.3
GR        59208 0759.2   59175 0759.2
N         .045      .034      .045
SA        59205     59218
PD        750 3 1
CD        3 135 2 758.5
*         LXBr RXBr * * * TPierW
DC 0 BRDGE 59194 59228 59197 59256 * 3
*         LPierEdge RPierEdge PierWdth * * K1 K2 K3(1.1)
DP        59175 59244 1.5 * * 1 1 1.1
DP        59175 59244 1.5 * * 1 1 1.1
XS    APPR 289 0
GR        58261 770   58503 770   58951 762   58958 761   59008 756
GR        59044 753   59197 752   59205 751   59210 747   59216 747
GR        59232 748   59246 749   59256 751   59272 752   59297 752
GR        59307 752   59316 752   59318 752   59324 752   59339 752
GR        59426 758   59447 760   59504 770   59884 770   60107 780
N         .100      .034      .100
SA        59175     59200
EX
ER
```

WSPRO OUTPUT

```
************************  W S P R O  ***************************
        Federal Highway Administration  -  U. S. Geological Survey
                Model for Water-Surface Profile Computations.
            Run Date & Time:  8/ 6/97  6:59 am     Version V050196
            Input File: 5180.dat        Output File: 5180.LST
        *-------------------------------------------------------------*
T1        I-70 OVER BR. MCCRACKEN CREEK     I70-60-5180
T2        COUNTY: HENDRICKS                 QUAD: MOORESVILLE WEST
T3        02-20-97                          BRET A. ROBINSON
SI        0
Q         1200 2040

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


SK        .0029 .0029


        ************************  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 BR. MCCRACKEN CREEK     I70-60-5180
         COUNTY: HENDRICKS                 QUAD: MOORESVILLE WEST
            02-20-97                         BRET A. ROBINSON


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


XS   EXIT 0 0
GR        58847 760   58918 762   58935 759   58961 758   58978 757
GR        59003 756   59009 755   59020 753   59051 752   59101 751
GR        59141 751   59186 751   59201 746   59219 746   59228 750
GR        59231 751   59241 752   59286 755   59299 756   59323 757
GR        59474 765   59495 770   59742 770   59814 770   60020 780
GR        60269 780   60363 780
N         .100      .034      .100
SA          59190      59225

   ***    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 (27 pairs)

X	Y	X	Y	X	Y
58847.000	760.000	58918.000	762.000	58935.000	759.000
58961.000	758.000	58978.000	757.000	59003.000	756.000
59009.000	755.000	59020.000	753.000	59051.000	752.000
59101.000	751.000	59141.000	751.000	59186.000	751.000

WSPRO OUTPUT

59201.000	746.000	59219.000	746.000	59228.000	750.000
59231.000	751.000	59241.000	752.000	59286.000	755.000
59299.000	756.000	59323.000	757.000	59474.000	765.000
59495.000	770.000	59742.000	770.000	59814.000	770.000
60020.000	780.000	60269.000	780.000	60363.000	780.000

```
                  Minimum and Maximum X,Y-coordinates
   Minimum X-Station:   58847.000  ( associated Y-Elevation:  760.000 )
   Maximum X-Station:   60363.000  ( associated Y-Elevation:  780.000 )
   Minimum Y-Elevation:   746.000  ( associated X-Station:  59219.000 )
   Maximum Y-Elevation:   780.000  ( associated X-Station:  60020.000 )
```

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

```
    *------------------------------------------------------*
    *       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 BR. MCCRACKEN CREEK      I70-60-5180
    COUNTY: HENDRICKS                  QUAD: MOORESVILLE WEST
       02-20-97                           BRET A. ROBINSON
```

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

```
XS   FULLV77 0
GR       58847 760   58918 762   58935 759   58961 758   58978 757
GR       59003 756   59009 755   59020 753   59051 752   59101 751
GR       59141 751   59186 751   59201 746   59219 746   59228 750
GR       59231 751   59241 752   59286 755   59299 756   59323 757
GR       59474 765   59495 770   59742 770   59814 770   60020 780
GR       60269 780   60363 780
N        .100       .034       .100
SA         59190     59225
```

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

WSPRO OUTPUT

```
***                    Data Summary For Header Record FULLV                ***
SRD Location:        77.     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 (27 pairs)

X	Y	X	Y	X	Y
58847.000	760.000	58918.000	762.000	58935.000	759.000
58961.000	758.000	58978.000	757.000	59003.000	756.000
59009.000	755.000	59020.000	753.000	59051.000	752.000
59101.000	751.000	59141.000	751.000	59186.000	751.000
59201.000	746.000	59219.000	746.000	59228.000	750.000
59231.000	751.000	59241.000	752.000	59286.000	755.000
59299.000	756.000	59323.000	757.000	59474.000	765.000
59495.000	770.000	59742.000	770.000	59814.000	770.000
60020.000	780.000	60269.000	780.000	60363.000	780.000

Minimum and Maximum X,Y-coordinates

```
Minimum X-Station:    58847.000  ( associated Y-Elevation:    760.000 )
Maximum X-Station:    60363.000  ( associated Y-Elevation:    780.000 )
Minimum Y-Elevation:    746.000  ( associated X-Station:  59219.000 )
Maximum Y-Elevation:    780.000  ( associated X-Station:  60020.000 )
```

Roughness Data (3 SubAreas)

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

```
         *-----------------------------------------------------*
         *       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 BR. MCCRACKEN CREEK       I70-60-5180
      COUNTY: HENDRICKS                 QUAD: MOORESVILLE WEST
         02-20-97                          BRET A. ROBINSON


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


BR    BRDGE77 759 0
```

WSPRO OUTPUT

```
GR        59175 0759.2   59175 0758.6   59178 0758.6   59205 0745.9
GR        59218 0745.9   59241 0758.6   59244 0758.6   59244 0759.3
GR        59208 0759.2   59175 0759.2
N         .045      .034       .045
SA          59205     59218
PD        750 3 1
CD        3 135 2 758.5
```

```
    ***   Completed Reading Data Associated With Header Record BRDGE   ***
+++072 NOTICE:  X-coordinate # 2 increased to eliminate vertical segment.
+++072 NOTICE:  X-coordinate # 8 increased to eliminate vertical segment.
    ***   Storing Bridge Data In Temporary File As Record Number  3    ***
```

```
    ***            Data Summary For Bridge Record BRDGE            ***
SRD Location:      77.   Cross-Section Skew:     .0   Error Code   0
Valley Slope: ******    Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients -> Expansion:  .50   Contraction:   .00
```

X,Y-coordinates (10 pairs)

X	Y	X	Y	X	Y
59175.000	759.200	59175.100	758.600	59178.000	758.600
59205.000	745.900	59218.000	745.900	59241.000	758.600
59244.000	758.600	59244.100	759.300	59208.000	759.200
59175.000	759.200				

Minimum and Maximum X,Y-coordinates

```
Minimum X-Station:   59175.000  ( associated Y-Elevation:  759.200 )
Maximum X-Station:   59244.100  ( associated Y-Elevation:  759.300 )
Minimum Y-Elevation:   745.900  ( associated X-Station: 59218.000 )
Maximum Y-Elevation:   759.300  ( associated X-Station: 59244.100 )
```

Roughness Data (3 SubAreas)

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

Discharge coefficient parameters

BRType	BRWdth	EMBSS	EMBElv	UserCD
3	135.000	2.00	758.500	*********

Pressure flow elevations

AVBCEL	PFElev
********	759.000

Abutment Parameters

ABSLPL	ABSLPR	XTOELT	YTOELT	XTOERT	YTOERT

WSPRO OUTPUT

```
******  ******  ********  ********  ********  ********
```

```
              Pier/Pile Data (  1 Group(s) )
              Code Indicates Bridge Uses Piers
           Group  Elevation  Gross Width  Number
           ------  ---------  -----------  ------
             1      750.000      3.000       1
           ------  ---------  -----------  ------


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


     ************************  W S P R O  ****************************
        Federal Highway Administration  -  U. S. Geological Survey
                Model for Water-Surface Profile Computations.
             Input Units: English  /  Output Units: English
        *----------------------------------------------------------*
             I-70 OVER BR. MCCRACKEN CREEK      I70-60-5180
        COUNTY: HENDRICKS                  QUAD: MOORESVILLE WEST    _
             02-20-97                           BRET A. ROBINSON
DC 0 BRDGE 59194 59228 59197 59256 * 3
DP        59175 59244 1.5 * * 1 1 1.1
DP        59175 59244 1.5 * * 1 1 1.1


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


XS   APPR 289 0
GR        58261 770  58503 770  58951 762  58958 761  59008 756
GR        59044 753  59197 752  59205 751  59210 747  59216 747
GR        59232 748  59246 749  59256 751  59272 752  59297 752
GR        59307 752  59316 752  59318 752  59324 752  59339 752
GR        59426 758  59447 760  59504 770  59884 770  60107 780
N         .100     .034     .100
SA        59175    59200

   ***  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:      289.  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 (25 pairs)

X	Y	X	Y	X	Y
58261.000	770.000	58503.000	770.000	58951.000	762.000
58958.000	761.000	59008.000	756.000	59044.000	753.000
59197.000	752.000	59205.000	751.000	59210.000	747.000
59216.000	747.000	59232.000	748.000	59246.000	749.000

WSPRO OUTPUT

59256.000	751.000	59272.000	752.000	59297.000	752.000
59307.000	752.000	59316.000	752.000	59318.000	752.000
59324.000	752.000	59339.000	752.000	59426.000	758.000
59447.000	760.000	59504.000	770.000	59884.000	770.000
60107.000	780.000				

```
              Minimum and Maximum X,Y-coordinates
  Minimum X-Station:   58261.000  ( associated Y-Elevation:  770.000 )
  Maximum X-Station:   60107.000  ( associated Y-Elevation:  780.000 )
  Minimum Y-Elevation:   747.000  ( associated X-Station:  59216.000 )
  Maximum Y-Elevation:   780.000  ( associated X-Station:  60107.000 )
```

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

```
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 BR. MCCRACKEN CREEK      I70-60-5180
     COUNTY: HENDRICKS                   QUAD: MOORESVILLE WEST
        02-20-97                           BRET A. ROBINSON
EX
```

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

| | Reach | Water Surface | Friction | |
#	Discharge	Elevation	Slope	Flow Regime
1	1200.00	*******	.0029	Sub-Critical
2	2040.00	*******	.0029	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-70 OVER BR. MCCRACKEN CREEK      I70-60-5180
      COUNTY: HENDRICKS                 QUAD: MOORESVILLE WEST
         02-20-97                          BRET A. ROBINSON
```

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: EXIT	751.712	.656	1200.000	263.807	********	59065.390
Header Type: XS	752.369	******	4.549	22267.84	********	59238.120
SRD: .000	750.134	******	.927	******	2.040	******
Section: FULLV	752.043	.526	1200.000	324.136	77.000	59049.680
Header Type: FV	752.569	.195	3.702	25590.38	77.000	59241.640
SRD: 77.000	750.134	.000	.789	.0025	2.469	.005

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

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ".
        KRATIO:    .53
```

	WSEL EGEL CRWS	VHD HF HO	Q V FR #	AREA K SF	SRDL FLEN ALPHA	LEW REW ERR
Section: APPR	753.337	.111	1200.000	529.590	212.000	59039.950
Header Type: AS	753.448	.871	2.266	13689.00	212.000	59358.390
SRD: 289.000	750.934	.000	.365	.0041	1.387	.008

```
         <<< 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	751.858	1.122	1200.000	147.342	77.000	59192.330
Header Type: BR	752.980	.444	8.144	15551.75	77.000	59228.790
SRD: 77.000	751.261	.163	.745	******	1.087	-.009

Specific Bridge	Information	C	P/A	PFELEV	BLEN	XLAB	XRAB
Bridge Type 3	Flow Type 1	------	-----	--------	--------	--------	--------
Pier/Pile Code	0	.9590	.038	759.000	********	********	********

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

WSPRO OUTPUT

	CRWS	HO	FR #	SF	ALPHA	ERR
Section: APPR	754.263	.052	1200.000	835.850	77.000	59028.840
Header Type: AS	754.315	.423	1.436	26376.76	86.575	59371.820
SRD: 289.000	750.934	.918	.207	.0041	1.629	.005

Approach Section APPR Flow Contraction Information

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
.883	.573	11217.0	*******	*******	754.263

<<< 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 BR. MCCRACKEN CREEK   I70-60-5180
COUNTY: HENDRICKS   QUAD: MOORESVILLE WEST
02-20-97   BRET A. ROBINSON

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: EXIT	753.025	.788	2040.000	534.971	********	59019.860
Header Type: XS	753.813	*****	3.813	37874.43	********	59256.380
SRD: .000	752.094	*****	.834	******	3.485	******
Section: FULLV	753.387	.619	2040.000	621.753	77.000	59017.880
Header Type: FV	754.005	.195	3.281	43469.11	77.000	59261.800
SRD: 77.000	752.094	.000	.696	.0025	3.695	-.003

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

Section: APPR	754.528	.127	2040.000	927.754	212.000	59025.660
Header Type: AS	754.655	.660	2.199	30769.78	212.000	59375.660
SRD: 289.000	752.528	.000	.309	.0031	1.682	-.010

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

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

===210 QUESTIONABLE CRITICAL-FLOW SOLUTION AT SECID "BRDGE".
Q, CRWS: 2040.00   753.23

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

WSPRO OUTPUT

```
        --------- ------ ----------- ----------- --------- ---------
Section: BRDGE      753.235  1.921   2040.000     201.262   77.000 59189.410
Header Type: BR     755.156 ******     10.136    23435.70   77.000 59231.290
SRD:     77.000     753.235 ******       .894    ******      1.202  ******


Specific Bridge Information  C     P/A   PFELEV    BLEN      XLAB      XRAB
Bridge Type 3   Flow Type 1 ------ ----- -------- -------- -------- --------
Pier/Pile Code  0            .9120  .048  759.000 ******** ******** ********
------------------------------- ------ ----- -------- -------- -------- --------


                 WSEL    VHD        Q        AREA      SRDL      LEW
                 EGEL    HF         V        K         FLEN      REW
                 CRWS    HO         FR #     SF        ALPHA     ERR
                 --------- ------ ----------- ----------- --------- ---------
Section: APPR    756.518  .045   2040.000    1676.461   77.000 59002.820
Header Type: AS  756.563  .245      1.217   73940.25    90.445 59404.520
SRD:    289.000  752.528 1.162       .147       .0031    1.953     .009


       Approach Section APPR  Flow Contraction Information
       M( G )    M( K )    KQ        XLKQ      XRKQ      OTEL
       --------- -------- --------- -------- -------- --------
           .879     .717   20833.6 ******** ********  756.518
       --------- -------- --------- -------- -------- --------


           <<< 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 BR. MCCRACKEN CREEK      I70-60-5180
       COUNTY: HENDRICKS               QUAD: MOORESVILLE WEST
         02-20-97                        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):  3.000
         *------------------------------------------------*


      Scour      -- Flow --           -- Width --        --- X-Limits ---
   #  Depth   Contract  Approach   Contract Approach  Side  Contract Approach
   -- ------- --------- --------- -------- --------- ------ -------- --------
   1  7.762   1200.000   690.754   31.000   59.000  Left:  ******** ********
      ..... Approach Channel Depth:    5.484 .....   Right: ******** ********
   2  19.549  2040.000   752.940   31.000   59.000  Left:  ******** ********
      ..... Approach Channel Depth:    7.739 .....   Right: ******** ********
   -- ------- --------- --------- -------- --------- ------ -------- --------
```

WSPRO OUTPUT

```
      Scour   ---- Localized Hydraulic Properties ----      -- X-Stations --
  #   Depth     Flow        WSE     Depth  Velocity Froude #    Left       Right
  --  -----  ----------  --------  ------  --------  --------  ----------  ---------
  1   4.61   1200.000    752.776   6.876    9.386       .631   59175.000  59244.000
  2   5.28   2040.000    754.397   8.497   12.004       .726   59175.000  59244.000
  --  -----  ----------  --------  ------  --------  --------  ----------  ---------
```

WSPRO OUTPUT

	Scour	---- Localized	Hydraulic	Properties	----		-- X-Stations	--
#	Depth	Flow	WSE	Depth	Velocity	Froude #	Left	Right
1	4.61	1200.000	752.776	6.876	9.386	.631	59175.000	59244.000
2	5.28	2040.000	754.397	8.497	12.004	.726	59175.000	59244.000

ER

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