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Evaluation of Scour and Stream Stability by Using CAESAR

Introduction

An important aspect of bridge maintenance is a periodic assessment of the soundness of the structure. The evaluation of the potential for pier scour and stream instability is a significant aspect in this assessment. One of the objectives of this project was “examination of mathematical models that could be used for problems relating to bridge scour”. Numerical models were used first to examine the pier scour. These models have not yet reached the stage where they can be used with confidence. Hence these studies were not pursued further.

An alternative approach to evaluate problems related to bridge scour is based on expert systems. These may be formal methodologies such as CAESAR (Catalog and Expert Evaluation of Scour Risk and

River Stability) or they may be informal indices such as INDOT potential streambed scour index. Three of the prominent indices are the INDOT potential streambed scour index, observed streambed scour index and the Simon potential streambed scour index. These indices have been developed by using different sets of empirical data, and different methodologies. There is no information about the consistency of results obtained by these indices. Likewise, these results have not been compared to those recently developed models such as CAESAR. Because CAESAR may be a potentially useful tool that is more consistent than the other available indices, it was decided to compare the results of CAESAR with those obtained by the other indices.

Findings

Data from ten bridges in Indiana were selected for the evaluation of CAESAR and the other three scour indices, namely, the observed streambed scour index, the INDOT potential streambed scour index and the Simon potential streambed scour index.

Of these, CAESAR is the most data intensive. The earlier version of CAESAR had quite a few problems, but the most current version is considerably improved. Data items required by CAESAR were often

not available. Others were retrieved from the USGS database.

The results from CAESAR and observed streambed scour index were similar in the sense that both of them identified similar scour risks for a bridge. This leads to the possibility of using the simpler observed streambed scour index rather than the data-intensive CAESAR. This conclusion must be tested further by using a larger database.

CAESAR identified more bridges as scour critical than INDOT potential streambed scour index and the Simon potential streambed scour index. This may be due to the fact that these two indices do

not consider many variables that are used by CAESAR. The results from CAESAR are thus more conservative than the results from these two indices.

Implementation

The following conclusions are offered as a result of this study.

- (1) CAESAR may be used for evaluation of bridge scour. The results from CAESAR are conservative.

- (2) If a quicker alternative is needed, the observed streambed scour index may be used.

- (3) A larger study involving data from more bridges may be developed to compare the performances of CAESAR and observed streambed scour indices.

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Using CAESAR**

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EVALUATION OF SCOUR AND STREAM STABILITY BY USING CAESAR

FHWA/IN/JTRP-2000/11

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16. Abstract The performance of an expert system (CAESAR for Catalog and Expert Evaluation of Scour Risk and River Stability) for an initial evaluation of scour and stream stability was assessed. Three alternative scour indices are used to compare with the evaluation results of CAESAR. These scour indices include the Observed Streambed Scour index, the INDOT Potential Streambed Scour Index, and the Simon Potential Streambed Scour Index. Ten bridges in Indiana are selected for evaluation in this study. The scour indices and the field inspection information required by CAESAR are retrieved from the USGS data base. In general, the results show that CAESAR is able to reflect current scour risks as well as the Observed Streambed Scour Index, and the results from CAESAR identifies more bridges as scour critical than the INDOT Potential Streambed Scour Index and the Simon Potential Streambed Scour Index. Because the INDOT Potential Streambed Scour Index and the Simon Potential Streambed Scour Index do not take into account the overall stream geometry, bank materials, channel and floodplain widths, and other considerations required by CAESAR, the results of these two indices are not as conservative as that given by CAESAR. It is concluded that the results from CAESAR may be used to estimate the scour risk of bridge piers.					
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Introduction

A scour screening inspection method (Simon et al., 1989) was developed by the U.S. Geological Survey (USGS) in Tennessee for assessing streambed scour and stream instability near bridges. The method of Simon et al. (1989) was designed originally for bridge inspection in Tennessee. In order to adjust this method to geographical characteristics in Indiana, an alternative method, which is called INDOT Potential Streambed Scour Index (Hopkins and Robinson, 1997), was developed by the USGS through consultation with Indiana Department of Transportation (INDOT) in 1995. However, the INDOT Potential Streambed Scour Index is limited by the fact that it does not take into consideration overall stream geometry, bank material, streamflow velocity, flood-channel width, and propensity for debris to accumulate (Hopkins and Robinson, 1997).

An expert system called CAESAR (Catalog and Expert Evaluation of Scour Risk And River Stability at Bridge Site) was recently developed for the evaluation of scour and stream stability by Richard N. Palmer and George P. Turkiyyah under a project of National Cooperative Highway Research Program (NCHRP) (Palmer, Turkiyyah and Harmsen, 1999). By an evaluation of case studies, the ability of CAESAR was demonstrated to provide conclusions similar to those provided by human bridge-scour experts (Palmer, Turkiyyah and Harmsen, 1999). It was concluded by the developers that CAESAR can be readily implemented into state scour inspection processes and will perform its designed function to assist in the bridge scour inspection process and provide an assessment of scour risks at bridge sites (Palmer, Turkiyyah and Harmsen, 1999).

The objective of this study is to assess the performance of CAESAR by comparing the evaluation results of CAESAR with three scour indices available in the USGS data base for assessment of streambed scour and channel instability at selected bridges in Indiana, 1991-95 (Hopkins and Robinson, 1997). Ten bridges in Indiana are selected for this study. In order to perform the comparisons, the field inspection information required by CAESAR is retrieved from the USGS data base. These three scour indices are the Observed Streambed Scour Index, the INDOT Potential Streambed Scour Index, and the Simon Potential Streambed Scour Index. The version 2.2.2 of CAESAR was used in this study.

The report is organized as follows. The methods used in the study are discussed in Chapter 2. The data used in the study are discussed in Chapter 3. The outputs from CAESAR and the comparisons of scour evaluations are given in Chapters 4 and 5. The conclusions of the present study and suggestions for future study are found in Chapter 6.

II. Evaluation Methods

2.1 CAESAR

CAESAR is an expert system for Cataloging And Evaluation of Scour Risk and River stability at bridge sites (Palmer et al., 1997). The system was developed in Microsoft Visual Basic and runs in a Windows 95 environment. It is written for field inspectors with little formal training in scour processes. The system provides a screening tool for bridge sites, and assists in developing bridge code ratings for items 60 (substructure), 61 (channel and channel protection), 71 (waterway adequacy) and 113 (scour critical bridges) of the FHWA Inventory Manual.

CAESAR includes two parts: (1) the user interface for information collection, storage and retrieval; and (2) an evaluation model presenting recommendations with confidence values and suggestions for appropriate actions. CAESAR aids bridge inspectors by developing a catalog of important features of a bridge site, storing photographs and cross-section profiles, and reviewing past inspections. CAESAR also helps with the assessment of scour risk at a bridge, increases the accuracy of the bridge scour screening process, and facilitates the training of new inspectors.

The heart of CAESAR is a Bayesian network. A Bayesian network is a decision support logic mechanism which encodes the knowledge of numerous scour experts and bridge scour literature in a probabilistic representation of the bridge scour. The determination of scour risk is accomplished by analyzing three components of scour and stream stability. The three components of scour at highway crossings include: long-term aggradation and degradation, contraction and local scour. The evidence of stream instability

is mainly observed in four processes: lateral channel and thalweg migration, vertical channel and thalweg degradation. In order to make accurate and reasonable conclusions about the scour risks, and recommend proper actions to mitigate the risks, the Bayesian network incorporates the knowledge of experts from the fields of hydraulic engineering, geotechnical engineering, geomorphology, and structural engineering.

Two types of information related to the bridge and scour are required to evaluate CAESAR: (a) ‘static’ information; and (b) ‘dynamic’ information.

1. **Static information** about a bridge is that which does not change over time, including data such as the number of piers, the type of abutments, foundation type, deck elevation, pier locations, as-built channel elevation, and pier shape. Table 1 is a list of static information needed to run CAESAR. This information is obtained by reviewing bridge plans and profiles, aerial photographs, and historical inspection reports.

Table 1. Static information required by CAESAR (Palmer, Turkiyyah and Harmsen, 1999).

Static information	Primary use
Pier locations. Foundation types. Foundation elevations. Pier shapes. As-built channel elevations.	Inspectors use them to determine critical foundation embedment level and to become familiar with the site. The system uses the information to determine severity of scour risk by analyzing embedment, foundation location, and changes of embedment with time.
Surface bed material. Subsurface bed material.	The system uses them as part of evidence for foundation stability, contraction scour, and long-term degradation.
Notes about maintenance work. Hydraulic problems. Scour problems.	Inspectors use them to determine if there are specific concerns noted by the maintenance or hydraulics staff.
Historical inspection records.	Inspectors use them to identify changes at the bridge site by inspecting historical cross-section profiles, photographs, and site observation.

2. **Dynamic information** may change from inspection to inspection, including information such as the cross-section profile, photographs, and visual observations of the site. Table 2 is a summary of the dynamic information requested by CAESAR. An inspection evaluation form (given in Appendix 1) is designed for field inspectors to record the dynamic information required by CAESAR.

**Table 2. Dynamic information required by CAESAR
(Palmer, Turkiyyah and Harmsen, 1999).**

Dynamic information	Primary use
Presence of 'scour screamers'.	The program warns users that "scour screamers" are serious problems and experts should investigate the bridge.
Cross-section profile.	Inspectors use it to determine magnitude of lateral and vertical thalweg stability. The system uses it to determine severity of total scour, lateral stream migration, thalweg migration, and vertical stream degradation.
Site photographs.	Inspectors use them to visually record site conditions and compare the results with visual observations of previous inspection.
Erosion severity and location.	The system uses them to assess lateral stream migration and vertical stream instability.
Point bar location, size, and vegetation.	The system uses them to assess potential for lateral stream migration.
Instream bar location, size, and vegetation.	The system uses them as part of evidence for contraction scour and lateral stream instability.
Abutment specific data: countermeasure presence, serious observable scour, historical scour problems.	The system uses them to assess scour risk and potential for scour at abutments.
Pier specific data: countermeasure presence, serious observable scour, historical scour problems.	The system uses them to assess scour risk and potential for scour at piers.

2.2 Scour Indices

Three scour indices are available in the USGS data base, including the Observed Streambed Scour Index, the INDOT Potential Streambed Scour Index, and the Simon Potential Streambed Scour Index (Simon et al., 1989). The method of Simon et al. (1989) originally was used by the USGS in Tennessee. The Observed Streambed Scour Index and the INDOT Scour Potential Streambed Scour Index were adjusted to geographical characteristics in Indiana by USGS, from the method of Simon et al. (1989).

The Observed Streambed Scour Index in the USGS data base is generated by using the information contained in the data base. The methodology of using the Observed Streambed Scour Index is given by Robinson and Thompson (1995). The Observed Streambed Scour Index (from 0 to 10) and the corresponding observed scour conditions are shown in Table 3. The more severe the scour condition, lower is the value of the Observed Streambed Scour Index.

Table 3. Observed-streambed-scour index for the streambed-scour and channel-instability data base for selected bridges in Indiana, 1991-95 (Hopkins and Robinson, 1997).

Observed-streambed-scour conditions	Ranking values
No observed streambed scour	10
Scour hole(s) only	9
Local scour at abutment(s) only	8
Local scour at pier(s) only	7
Local scour at pier(s) and scour hole(s)	6
Blowhole	5
Vertical abutment(s) with footing(s) exposed	4
Sloping abutment(s) with pile(s) exposed	3
Vertical abutment(s) with pile(s) exposed	2
Pier(s) with footing(s) exposed	1
Pier(s) with pile(s) exposed	0

The **INDOT Potential Streambed Scour Index** was developed by the USGS in consultation with INDOT. The values of the INDOT Potential Streambed Scour Index (from 0 to 100) are calculated by summing the weights from each of the four categories in Table 4. These four categories are bed material, attack angle, debris, and contraction ratio. The higher the value of the INDOT Potential Streambed Scour Index, the greater is the potential for scour.

Table 4. Potential-streambed-scour categories and assigned weighting points for the Indiana scour-assessment data base of selected bridges, 1991-95 (Hopkins and Robinson, 1997).

Potential-scour categories	Sub-categories	Weighting points
Bed material	Sand	30
	Silt/Clay	18
	Gravel	0
	Cobble/Boulder	-12
Attack angle	> 45°	30
	26° - 45°	24
	10° - 25°	18
	< 10°	0
Sites with high debris potential (percent of opening blocked by debris)	> 20%	20
	16 - 20%	16
	11 - 15%	12
	6 - 10%	8
	0 - 5%	4
	All other sites	0
Contraction ratio [(channel width at bridge / upstream channel width) - 1] × 100	> 75%	20
	51 - 75%	16
	26 - 50%	12
	6 - 25%	8
	< 6%	0

III. Data Sources

Ten bridges in Indiana are selected for this study. These are listed in Table 5.

Table 5. Ten bridges in Indiana selected for this study.

Bridge	Structure No.	Stream and County
1	I-164-7-6973	Bluegrass Creek in Vanderburgh County
2	I-465-139-5260	Fishback Creek in Boone County
3	I-465-158-4458	State Ditch in Marion County
4	I-65-124-4285	Bush's Run in Marion County
5	I-65-34-4240	Muscatatuck River overflow in Scott County
6	I-65-81-5523	Big Blue River in Shelby County
7	I-65-85-5527	State Ditch in Marion County
8	I-70-104-5128	Brandywine Creek in Hancock County
9	I-70-35-5245	Big Walnut Creek in Putnam County
10	I-74-32-4946	Sugar Creek in Montgomery County

The inspection data sources of this study include the following:

1. Bridge plans and profiles provided by INDOT.
2. Archived photographs provided by INDOT: four photographs were taken at each bridge — one each from the bridge looking upstream, looking downstream, upstream looking downstream at the bridge, and downstream looking upstream.
3. Data Base for Assessment of Streambed Scour and Channel Instability at Selected Bridges in Indiana, 1991-95, U.S. Geological Survey (Robinson and Thompson, 1995): this data base is composed of five groups — (a) general site characteristics, (b) observed and calculated scour characteristics, (c) bridge characteristics, (d) stream characteristics, and (e) debris characteristics. General limitations of the USGS data base are: (1) some scouring which might have occurred during higher stages might

have been obscured by deposition of sediment; (2) some of the impacts attributed to scour during site visits may have resulted from processes other than stream-bridge interactions; and (3) site conditions described in the data base may not reflect current site conditions (Hopkins and Robinson, 1997).

No additional field data were collected for this study. A few of the required input data were not available in the USGS data base or the bridge profiles and plans. These unavailable data are entered as 'unknown' or reasonable values were assumed. The unavailable items include:

1. General Site: bridge experienced 100-year flood, and floodplain width.
2. Bridge Site: stream braidedness, valley setting, and frequency of roadway overtopping.
3. Abutment: roadway embankment encroachment into floodplain.

IV. Outputs from CAESAR

The outputs from CAESAR include pier/abutment evaluations, general site evaluations, and conclusions. The percentages in the outputs (Appendix 2) represent the confidence values corresponding to each state of conclusion. The conclusion with the highest confidence value represents the most probable state. The outputs from CAESAR for these ten bridges are given in the Appendix 2.

The pier/abutment evaluations are provided in three categories:

1. Overall pier/abutment rating: the confidence in the stability of the pier/abutment during future floods.
2. Evidence/likelihood of scour at pier/abutment: the confidence that the abutment or pier will experience severe scour during the next flood and that it has experienced scour in the past.
3. Apparent ability for pier/abutment to resist scour: a measure of the structural stability of the sub-structure foundation.

The general site evaluations are provided in three categories:

1. Potential or evidence of lateral migration: the likelihood of the channel migrating to the left or right.
2. Potential or evidence of vertical stream instability: a measure of the vertical channel or thalweg stability.
3. Qualitative contraction scour: a qualitative estimate of contraction scour, which is based on expert system evaluation.

Conclusions are given as a textual list of specific scour risks, potential threats to substructure elements, and suggestions for mitigation methods.

V. Comparisons of Scour Evaluations

Each bridge pair investigated in this research is modeled as one bridge for CAESAR evaluation. These bridge pairs have a continuous abutment or fill between the bridges.

Because the qualitative estimates of contraction and local scour depth provided by CAESAR are not results of hydraulic engineering calculations, the values of scour depth in Table 6 are not intended for quantitative comparisons with those obtained by following the standard HEC-18 procedures, involving the use of software such as WSPRO to determine hydraulic parameters. The scour depth calculated using WSPRO results are given in the open-file reports of modified level II streambed-scour analysis for these ten bridges, which are published by U.S. Geological Survey in Indianapolis, Indiana. The modeled discharge for WSPRO is the coordinated 100-year discharge.

According to the results of evaluation by CAESAR, four bridges (Bridges 6, 8, 9, and 10 in Table 6) have sub-structures which are at risk from scour, seven bridges (Bridges 1, 2, 3, 6, 8, 9, and 10) have sub-structures which have high potential for scour risk during future floods, four bridges (Bridges 2, 5, 9, and 10) have high values of contraction scour, and seven bridges (Bridges 1, 2, 3, 5, 8, 9, and 10) have critical calculated scour (local scour plus contraction scour). Two bridges are not scour critical (Bridges 4, and 7).

Because each bridge pair consists of two bridges in different directions, USGA data base gives two index values for each bridge pair. For example, Structure I70-104-5128N(S) has index values 1(6), which means Bridges I70-104-5128N and I70-104-5128S have index values 1 and 6, respectively. According to the Observed Streambed Scour Index from 10 to 0 (most serious), four bridges (Bridges 6, 8, 9, and 10) have more serious scour index

values: 1(1), 1(6), 6(6), and 6(1), respectively (Table 6). The outputs for these four bridges from CAESAR show that all of them have substructures at risk from scour. Therefore, results from CAESAR reflect current scour risks in a similar manner as the Observed Streambed Scour Index.

According to the INDOT Potential Streambed Scour Index (from 0 to 100 (most serious)), five bridges (Bridges 3, 5, 6, 7, and 9) have values greater than 30, which are 48(48), 42(18), 42(42), 46(46), and 34(34), respectively (Table 6). The outputs from CAESAR show that three of them (Bridges 3, 6, and 9) have high potential for scour risk, one of them (Bridge 5) has a critical value of calculated scour, but one of them (Bridge 7) is not scour critical. On the other hand, four bridges (Bridges 1, 2, 8, and 10) which have high potential for scour risk according to CAESAR have values less than 30 in the INDOT Potential Streambed Scour Index. These results show that there are discrepancies between CAESAR and the INDOT Potential Streambed Scour Index for more than half the bridges investigated.

According to the Simon Potential Streambed Scour Index (from 0 to 40 (most serious)), six bridges (Bridges 3, 4, 5, 6, 7, and 8) have values greater than 10, which are 12(12), 12(13), 12(7), 18(18), 12(15), and 11(12), respectively (Table 6). The outputs from CAESAR show that three of them (Bridges 3, 6, and 8) have high potential for scour risk, one of them (Bridge 5) has a critical value of calculated scour, but two of them (Bridges 4, and 7) are not scour critical. On the other hand, three bridges (Bridges 1, 2, and 10) which yield high potential for scour risk by using CAESAR have values less than 10 in the Simon Potential Streambed Scour Index. These results, similar to those of INDOT Potential

Streambed Scour Index, show that there are discrepancies between CAESAR and the Simon Potential Streambed Scour Index for about half the bridges investigated.

In the evaluation results given by INDOT scour committee (Table 6), it is shown that two bridges (Bridges 1 and 10) are not scour critical, four bridges have high potential for scour risk (Bridges 2, 4, 7 and 8), and four bridges need more information and re-evaluation (Bridges 3, 5, 6 and 9). The outputs from CAESAR (Table 6) show that Bridges 1 and 10 have high potential for scour risk, Bridges 4 and 7 are not scour critical. Due to the limitation of USGS data base that site conditions described in the data base may not reflect current site conditions, there are discrepancies between results from CAESAR and INDOT scour committee.

In general, these results show that CAESAR is able to reflect current scour risks as the Observed Streambed Scour Index, and identifies more bridges as scour critical than the INDOT Potential Streambed Scour Index and the Simon Potential Streambed Scour Index. Because the INDOT Potential Streambed Scour Index and the Simon Potential Streambed Scour Index do not take into account the overall stream geometry, bank materials, channel and floodplain widths, and other considerations required by CAESAR, the results of these two indices are not as conservative as that given by CAESAR.

Table 6. Comparison of scour indices and calculated scour.

Bridge No.	1	2	3
Structure No.	I164-7-6973N (I164-7-6973S)	I465-139-5260N (I465-139-5260S)	I465-158-4458E (I465-158-4458W)
Observed Streambed Scour Index	10(10)	10(10)	10(7)
INDOT Potential Streambed Scour Index	22(22)	8(8)	48(48)
Simon Potential Streambed Scour Index	10(10)	5(9)	12(12)
Contraction scour: ft (WSPRO)	3.3	5.7	15.3
Contraction scour: ft (CAESAR)	3.7	4.7	2.5
Local scour: ft (WSPRO)	9.8	7.8	13.6
Local scour: ft (CAESAR)	4.8	4.8	4.8
Conclusions stated by CAESAR	1. High potential for scour risk (piers 2 and 3). 2. Calculated scour is critical (piers 2 and 3). 3. Shallow pile embedment (piers 2 and 3).	1. High potential for scour risk (piers 2 and 3). 2. High value of contraction scour. 3. Calculated scour is critical (piers 2 and 3).	1. High potential for scour risk (left abutment, piers 2 and 3). 2. Calculated scour is critical (piers 2 and 3).
INDOT scour committee	1. Adjusted local scour (WSPRO) is 4.9 ft. 2. The plan indicates piles are driven to rock. 3. Determined to be low risk because of pile depth and minimal calculated scour depth. (6/28/99)	1. Install improved countermeasures. 2. Bridge should remain high risk. (9/16/99).	1. Continue to monitor existing countermeasures. (6/28/99)

Table 6. (Continued)

Bridge No.	4	5	6
Structure No.	I65-124-4285N (I65-124-4285S)	I65-34-4240N (I65-34-4240S)	I65-81-5523N (I65-81-5523S)
Observed Streambed Scour Index	10(10)	9(10)	1(1)
INDOT Potential Streambed Scour Index	18(18)	42(18)	42(42)
Simon Potential Streambed Scour Index	13(12)	12(7)	18(18)
Contraction scour: ft (WSPRO)	3.2	41.3	8.5
Contraction scour: ft (CAESAR)	0.6	4.1	0.8
Local scour: ft (WSPRO)	4.0	25.2	22.3
Local scour: ft (CAESAR)		6.0	8.4
Conclusions stated by CAESAR		<ol style="list-style-type: none"> 1. High value of contraction scour. 2. Calculated scour is critical (pier 3). 3. Debris in channel. 4. Evidence and/or potential to migrate to left. 	<ol style="list-style-type: none"> 1. At risk from scour (piers 2 and 3). 2. High potential for scour risk (piers 4 and 5). 3. Footings exposed (piers 2 and 3).
INDOT scour committee	<ol style="list-style-type: none"> 1. Install countermeasures. 2. Identified as high risk. (9/16/99) 	<ol style="list-style-type: none"> 1. The bents have piles driven to slate or keyed into slate according to plans. 2. Reevaluate. Need more information on existing scour countermeasures and piles stability. (6/28/99) 	<ol style="list-style-type: none"> 1. Adjusted local scour (WSPRO) is 9.2 ft. 2. Obtain pile tip elevations and review later.

Table 6. (Continued)

Bridge No.	7	8	9
Structure No.	I65-85-5527N (I65-85-5527S)	I70-104-5128E (I70-104-5128W)	I70-35-5245E (I70-35-5245W)
Observed Streambed Scour Index	7(7)	1(6)	6(6)
INDOT Potential Streambed Scour Index	46(46)	18(18)	34(34)
Simon Potential Streambed Scour Index	12(15)	11(12)	10(10)
Contraction scour: ft (WSPRO)	9.8	5.4	4.3
Contraction scour: ft (CAESAR)	1.5	3.8	4.5
Local scour: ft (WSPRO)	17.0	6.5	12.7
Local scour: ft (CAESAR)		4.8	4.8
Actions/ conclusions stated by CAESAR	1. Debris in channel. 2. Potential to move left.	1. At risk from scour (pier 3). 2. High potential for scour risk (pier 2). 3. Calculated scour is critical (pier 2). 4. Potential to move left. 5. Footings exposed (pier 3).	1. At risk from scour (piers 3 and 4). 2. High potential for scour risk (piers 2, 5 and 6). 3. High value of contraction scour. 4. Calculated scour is critical (piers 3, 4, 5 and 6). 5. Shallow pile embedment (piers 3 and 4).
INDOT scour committee	1. Countermeasures required. 2. High risk. Should be monitored until countermeasures are in place.	1. Needs riprap countermeasures. 2. Structure should remain high risk. (6/28/99)	1. During the 100-year storm, nearly half of the soil supporting the piles will be scoured away. 2. Reevaluate after more data is obtained. (6/28/99)

Table 6. (Continued)

Bridge No.	10
Structure No.	I74-32-4946E (I74-32-4946W)
Observed Streambed Scour Index	6(1)
INDOT Potential Streambed Scour Index	8(8)
Simon Potential Streambed Scour Index	8(10)
Contraction scour: (WSPRO)	0 ft
Contraction scour: (CAESAR)	5.3 ft
Local scour: ft (WSPRO)	13.0
Local scour: ft (CAESAR)	7.2
Actions/ conclusions stated by CAESAR	<ol style="list-style-type: none"> 1. At risk from scour (pier 3). 2. High potential for scour risk (piers 2 and 4). 3. High value of contraction scour. 4. Calculated scour is critical (piers 2, 3, 4 and 5). 5. Debris in channel. 6. Footings exposed (pier 3).
INDOT scour committee	<ol style="list-style-type: none"> 1. The piers are keyed into rocks according to the plans. 2. No action required. 3. Assumes footers are in Albany shale therefore low risk.

Conclusions and Suggestions

1. CAESAR considers more inspection information, and performs an evaluation based on expert systems methodology. Consequently, the evaluation results are more conservative than the scour indices available in the USGS data base. As an initial scour screening method, CAESAR helps in identifying scour-susceptible bridges.
2. Some of the requested inspection data by CAESAR are not available in the current USGS data base, or require adjusting to the inspection form of CAESAR. Therefore, the incorporation of the current USGS data base and the needed inspection data by CAESAR should be provided, if CAESAR is used for scour evaluation by INDOT.
3. A great number of mistakes and errors were found in the previous versions of CAESAR during this research. These mistakes and errors were corrected through personal communications with the developers of CAESAR. However, mistakes and errors not found previously might still be found in the outputs. A thorough examination on the interfaces of the system is suggested to the users of CAESAR.

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Appendix 1: Inspection evaluation form.

Appendix 2: Outputs from CAESAR for ten bridges in Indiana.

Appendix 1: Inspection evaluation form.

Bridge No.	Owner:	Roadway:	Waterway:
		Data Constructed:	Local Name:

Site Review

Piers rotating/ tilting:	☐ Yes	☐ No
Abutments tilting/ moving in:	☐ Yes	☐ No
Bridge Rail or deck sagging:	☐ Yes	☐ No
Blow hole at the site:	☐ Yes	☐ No

General Site:

Bridge experienced 100 year flood:	☐ Yes	☐ No	☐ Unknown	
High flow angle of attack:	☐ 0 - 5°	☐ 5 to 10°	☐ > 10°	
Alignment of Flow w.r.t. opening	☐ aligned	☐ left embnk	☐ right embnk	
Floodplain Width	☐ flpl = channel	☐ 2X chan	☐ 3-4X chan	☐ 5-6X chan
	☐ 7-8X chan	☐ 9-10X chan	☐ >10X chan	
Width of Bridge Opening	☐ flpl = channel	☐ 2X chan	☐ 3-4X chan	☐ 5-6X chan
	☐ 7-8X chan	☐ 9-10X chan	☐ >10X chan	
Relief Bridge:	☐ Yes	☐ No		
Channel constriction by piers	☐ Yes	☐ No		
Extent of Floodplain Vegetation	☐ none/ minor	☐ moderate	☐ mature	
Age of Bridge	☐ < 10 years	☐ 10-30 years	☐ 30-50 years	
	☐ 50-80 years	☐ > 80 years	☐ unknown	
Up/ downstream activities (check all that apply):				
☐ logging ☐ gravel mining ☐ storage reservoir				
☐ urbanization ☐ dredging ☐ other				
☐ check dam ☐ channel straightening ☐ Unknown				

Bridge No.	Owner:	Roadway:	Waterway:
		Data Constructed:	Local Name:

Upstream			
Point bars present upstream:	☐ Yes	☐ No	
Side of channel:	☐ left	☐ right	
Point bar size:	☐ average	☐ Larger than average	
Point bar vegetation:	☐ New	☐ Mature	☐ None
Instream bar upstream of bridge:	☐ Yes	☐ No	
Bar size:	☐ average	☐ Larger than average	
Bar vegetation:	☐ New	☐ Mature	☐ None
Bank Erosion and Bank Countermeasures upstream			
Left Bank			
Left bank erosion	☐ None	☐ Minor	☐ Moderate ☐ Major
Left bank countermeasures	☐ Yes	☐ No	
Left bank c.m. damage	☐ none/ minor	☐ Moderate	☐ Major
Left bank opposite a bend	☐ Yes	☐ No	
Right Bank			
Right bank erosion	☐ None	☐ Minor	☐ Moderate ☐ Major
Right bank countermeasures	☐ Yes	☐ No	
Right bank c.m. damage	☐ none/ minor	☐ Moderate	☐ Major
Right bank opposite a bend	☐ Yes	☐ No	

NOTE: The downstream information is not used in the analysis, this downstream information is just for cataloging purposes.

Bridge No.	Owner:	Roadway:	Waterway:
		Data Constructed:	Local Name:

Downstream			
Point bars present downstream:	☐ Yes	☐ No	
Side of channel:	☐ left	☐ right	
Point bar size:	☐ average	☐ Larger than average	
Point bar vegetation:	☐ New	☐ Mature	☐ None
Instream bar downstream of bridge:	☐ Yes	☐ No	
Bar size:	☐ average	☐ Larger than average	
Bar vegetation:	☐ New	☐ Mature	☐ None
Bank Erosion and Bank Countermeasures downstream:			
Left Bank			
Left bank erosion	☐ None	☐ Minor	☐ Moderate ☐ Major
Left bank countermeasures	☐ Yes	☐ No	
Left bank c.m. damage	☐ none/minor	☐ Moderate	☐ Major
Left bank opposite a bend	☐ Yes	☐ No	
Right Bank			
Right bank erosion	☐ None	☐ Minor	☐ Moderate ☐ Major
Right bank countermeasures	☐ Yes	☐ No	
Right bank c.m. damage	☐ none/minor	☐ Moderate	☐ Major
Right bank opposite a bend	☐ Yes	☐ No	

Bridge No.	Owner:	Roadway:	Waterway:
		Data Constructed:	Local Name:

Bridge:

Point bars present at Bridge:	☐ Yes	☐ No
Side of channel:	☐ left	☐ right
Point bar size:	☐ average	☐ Larger than average
Point bar vegetation:	☐ New	☐ Mature ☐ None
Instream bar at bridge:	☐ Yes	☐ No
Bar size:	☐ average	☐ Larger than average
Bar vegetation:	☐ New	☐ Mature ☐ None

Bank Erosion and Bank Countermeasures at bridge**Left Bank**

Left bank erosion	☐ None	☐ Minor	☐ Moderate	☐ Major
Left bank countermeasures	☐ Yes	☐ No		
Left bank c.m. damage	☐ none/ minor	☐ Moderate	☐ Major	
Left Bank Opposite a bend	☐ Yes	☐ No		

Right Bank

Right bank erosion	☐ None	☐ Minor	☐ Moderate	☐ Major
Right bank countermeasures	☐ Yes	☐ No		
Right bank c.m. damage	☐ none/ minor	☐ Moderate	☐ Major	
Right Bank Opposite a bend	☐ Yes	☐ No		

Bridge Site

Debris at Bridge Site:	☐ Yes	☐ No
Instream:	☐ None	☐ Minor ☐ Moderate ☐ Major
Banks:	☐ None	☐ Minor ☐ Moderate ☐ Major
Floodplain:	☐ None	☐ Minor ☐ Moderate ☐ Major
Instream bar downstream:	☐ Yes	☐ No
Bar size:	☐ average	☐ Larger than average
Bar vegetation:	☐ New	☐ Mature ☐ None
Stream Constant Width:	☐ Yes	☐ No
Stream braidedness:	☐ < 5%	☐ 5 - 35% ☐ > 35%
Valley setting:	☐ mountainous	☐ hilly ☐ flat
Frequency of Roadway overtopping	☐ 2 -10 year flood ☐ 10-50 year flood ☐ 50-100 year flood ☐ does not overtop by 100 year flood	

Bridge No.	Owner:	Roadway:	Waterway:
Data Constructed:		Local Name:	
Right Abutment			
Bank erosion at right abutment:	☐ none/minor ☐ moderate ☐ major		
Erosion at right spill slope:	☐ none/minor ☐ moderate ☐ major		
Right roadway embankment encroachment into floodplain (% of floodplain):	☐ < 10% ☐ 10% to 30% ☐ > 30%		
Right abutment encroachment into channel (% of channel width):	☐ < 10% ☐ 10% to 30% ☐ > 30%		
Height of approach fill near right abutment:	☐ < 6' ☐ 6' - 10' ☐ > 10'		
Flood high water:	☐ above/ at bridge deck ☐ below bridge deck ☐ unknown		
Annual high water:	☐ above/at bridge deck ☐ below bridge deck ☐ unknown		
Obstruction Diverting Flow to Abutment	☐ Yes ☐ No		
Severity of diverted flow	☐ none/minor ☐ moderate ☐ major		
Left Abutment			
Bank erosion at left abutment:	☐ none/minor ☐ moderate ☐ major		
Erosion at left spill slope:	☐ none/minor ☐ moderate ☐ major		
Left roadway embankment encroachment into floodplain (% of floodplain):	☐ < 10% ☐ 10% to 30% ☐ > 30%		
Left abutment encroachment into channel (% of channel width):	☐ < 10% ☐ 10% to 30% ☐ > 30%		
Height of approach fill near left abutment:	☐ < 6' ☐ 6' - 10' ☐ > 10'		
Obstruction Diverting Flow to Abutment	☐ Yes ☐ No		
Severity of diverted flow	☐ none/minor ☐ moderate ☐ major		

Bridge No.	Owner:	Roadway:	Waterway:
		Data Constructed:	Local Name:

Bank Stability

Left Bank Stability	☐ Yes	☐ No
Left bank profile:	☐ gentle (< 30°)	☐ steep (> 30°) ☐ abrupt
Left bank natural resistance to erosion:	☐ low	☐ moderate ☐ high
Left bank vegetation:	☐ sparse	☐ moderate ☐ heavy
Right Bank Stability		
Right bank profile:	☐ gentle (< 30°)	☐ steep (> 30°) ☐ abrupt
Right bank natural resistance to erosion:	☐ low	☐ moderate ☐ high
Right bank vegetation:	☐ sparse	☐ moderate ☐ heavy
River training works at site:	☐ Yes	☐ No
Type of river training works:	☐ spurs	☐ guide banks ☐ dikes
Damage to river training works:	☐ none/minor	☐ moderate ☐ major
Cross Section: (To be answered after channel cross section has been entered into program)		
Bed level RIGHT since last inspection:	☐ aggraded	☐ degraded ☐ unchanged
Bed level LEFT since last inspection:	☐ aggraded	☐ degraded ☐ unchanged
Local scour hole in cross section:	☐ Yes	☐ No
Lateral shifting cross section:	☐ Yes	☐ No
Thalweg Stability:	☐ unstable	☐ mod. stable ☐ stable ☐ unknown
Historical vertical thalweg degradation	☐ low	☐ moderate ☐ high ☐ none

Pier Data

	Left Abutment	Pier 2	Pier 3
Calculated Local Scour			
Calculated Contraction Scour			
Footing Exposed	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Foundation Location	☐ channel ☐ at bank ☐ set back ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill
Countermeasures Present	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Countermeasure Damage	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
C.M. Performance History	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown
Historical Scour	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major
Abutment Orientation	☐ Skew upstream ☐ Skew downstream ☐ No skew		
Flow Location	☐ at abutment ☐ away from abutment		

	Pier 4	Pier 5	Pier 6
Calculated Local Scour			
Calculated Contraction Scour			
Footing Exposed	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Foundation Location	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill
Countermeasures Present	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Countermeasure Damage	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
C.M. Performance History	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown
Historical Scour	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major

	Pier 10	Pier 11	Pier 12
Calculated Local Scour			
Calculated Contraction Scour			
Footing Exposed	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Foundation Location	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill
Countermeasures Present	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Countermeasure Damage	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
C.M. Performance History	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown
Historical Scour	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major

	Pier 13	Pier 14	Pier 15
Calculated Local Scour			
Calculated Contraction Scour			
Footing Exposed	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Foundation Location	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill
Countermeasures Present	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Countermeasure Damage	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
C.M. Performance History	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown
Historical Scour	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major

	Pier 16	Pier 17	Pier 18
Calculated Local Scour			
Calculated Contraction Scour			
Footing Exposed	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Foundation Location	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill
Countermeasures Present	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
Countermeasure Damage	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
C.M. Performance History	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown
Historical Scour	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major

	Pier 19	Right Abutment
Calculated Local Scour		
Calculated Contraction Scour		
Footing Exposed	☐ yes ☐ no	☐ yes ☐ no
Foundation Location	☐ channel ☐ floodplain ☐ pt. buried apprch fill ☐ buried apprch fill	☐ channel ☐ at bank ☐ set back ☐ buried apprch fill
Countermeasures Present	☐ yes ☐ no	☐ yes ☐ no
Countermeasure Damage	☐ yes ☐ no	☐ yes ☐ no
C.M. Performance History	☐ survived flood ☐ not survived flood ☐ unknown	☐ survived flood ☐ not survived flood ☐ unknown
Historical Scour	☐ minor ☐ moderate ☐ major	☐ minor ☐ moderate ☐ major
Abutment Orientation		☐ Skew upstream ☐ Skew downstream ☐ No skew
Flow Location		☐ at abutment ☐ away from abutment

Appendix 2: Outputs from CAESAR for ten bridges in Indiana.

CAESAR Inspection Output Summary

Bridge No: I-164-7-6973

Waterway: BLUEGRASS C

Inspection Date: 030492

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	2 %,29 %,68 %	32 %,61 %,6 %	41 %,54 %,6 %
Evidence / Likelihood of Scour (low,moderate,high)	27 %,63 %,11 %	0 %,15 %,85 %	0 %,28 %,72 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,12 %,88 %	10 %,62 %,28 %	15 %,77 %,8 %

	Right Abutment
Overall Rating (poor,good,excellent)	2 %,32 %,66 %
Evidence / Likelihood of Scour (low,moderate,high)	18 %,65 %,17 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,12 %,88 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(7%), no(93%)	low (unstable): 71 %	3.70 feet (1.13 m)
To the right	yes(7%), no(93%)	high (stable): 29 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that none of the substructure elements seem to be at severe risk from scour.

	<p>*CAESAR has determined that the following substructure elements may have a potential for scour risk and might require monitoring: Pier 2 & Pier 3</p> <p>*CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent.</p> <p>Pier 2; Percent Embedment Lost: 54.2%; Local Scour: 4.8 ft.</p> <p>Pier 3; Percent Embedment Lost: 48.3%; Local Scour: 4.8 ft.</p>
Monitor Pier	<p>The foundation of Pier 3 has a low Overall Rating, but countermeasures may not be warranted. Perhaps this pier should be monitored.</p>
These risks are not apparent	<p>Based on the entered information none of the following risks are apparent: Lateral channel migration, vertical thalweg degradation, contraction scour, or lateral thalweg migration.</p>
Shallow Pile Embedment	<p>The piles of Pier 2 & Pier 3 are embedded less than 15 ft (4.5 m). Subsurface bed material was entered as scour susceptible, thus these foundations may be scour critical.</p>

INSPECTION DATA

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Bridge Number: I-164-7-6973
Waterway: BLUEGRASS C
Inspection Date: 030492
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 5-10
Alignment flow with respect to opening: aligned
Floodplain width: floodplain = 5-6x channel width
Width of bridge opening: floodplain = 3-4x channel width
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: moderate
Bridge constructed in: 1988
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: minor
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? no

BRIDGE SITE

Debris at bridge site? no
Instream bar present downstream? no
Does stream have a constant width? yes
Stream abraidedness: <5%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: aggraded
State of left bed level since last inspection: aggraded
Local scour hole in cross section? no
Lateral shifting shown in cross sectional comparison? no
Thalweg stability: unknown
Historical vertical thalweg degradation: none

RIGHT ABUTMENT

Bank erosion at right abutment: none or minor

Erosion at right spill slope: none or minor
 Right abutment encroachment into channel: 10-30%
 Right roadway embankment encroachment into channel: >30%
 Height of approach fill near right abutment: >10'
 Flood high water: below bridge deck
 Annual high water: unknown
 Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: none or minor
 Erosion at left spill slope: none or minor
 Left abutment encroachment into channel: 10-30%
 Left roadway embankment encroachment into channel: >30%
 Height of approach fill near left abutment: >10'
 Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep
 Left bank natural resistance to erosion: moderate
 Left bank vegetation: moderate
 Right bank profile: steep
 Right bank natural resistance to erosion: moderate
 Right bank vegetation: moderate
 River training works at site? no

UPSTREAM

Point bars present upstream? no
 Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: minor
 Left bank countermeasures? no
 Left bank countermeasure damage: no
 Erosion or countermeasure opposite bend? no
 Right bank erosion: minor
 Right bank countermeasures? no
 Right bank countermeasure damage: no
 Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: buried approach fill
 Countermeasures present? yes
 Countermeasure damage? yes
 Countermeasure performance history: unknown
 Historical scour: not critical
 Abutment orientation: skew downstream
 Flow impact location: away from abutment
 Pier 2
 Local scour: No data
 Calculated contraction scour: No data

Footing exposed? no
Foundation location: floodplain
Countermeasures present? no
Historical scour: not critical
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: not critical
Right abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: not critical
Abutment orientation: skew upstream
Flow impact location: at abutment

CAESAR Inspection Output Summary

Bridge No: I-465-139-5260

Waterway: Fishback Creek

Inspection Date: 062091

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	5 %,37 %,58 %	27 %,63 %,10 %	30 %,61 %,9 %
Evidence / Likelihood of Scour (low,moderate,high)	1 %,47 %,52 %	0 %,38 %,62 %	0 %,38 %,62 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,14 %,86 %	17 %,62 %,21 %	19 %,68 %,13 %

	Right Abutment
Overall Rating (poor,good,excellent)	7 %,30 %,63 %
Evidence / Likelihood of Scour (low,moderate,high)	9 %,64 %,27 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,14 %,86 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(22%), no(78%)	low (unstable): 16 %	4.74 feet (1.44 m)
To the right	yes(17%), no(83%)	high (stable): 84 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that none of the substructure elements seem to be at severe risk from scour.

	<p>*CAESAR has determined that the following substructure elements may have a potential for scour risk and might require monitoring: Pier 2 & Pier 3</p> <p>*CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Contraction Scour	Contraction scour was determined by the expert system to be 4.7ft, this is a high value of contraction scour and should be investigated more thoroughly.
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent.</p> <p>Pier 2; Percent Footing Exposed: 70.8%; Local Scour: 4.8 ft.</p> <p>Pier 3; Percent Footing Exposed: 70.8%; Local Scour: 4.8 ft.</p>

INSPECTION DATA

Bridge Number: I-465-139-5260
Waterway: Fishback Creek
Inspection Date: 062091
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 0-5
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = >10x channel width
Width of bridge opening: floodplain = channel
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: none or minor
Bridge constructed in:
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: none
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? no

BRIDGE SITE

Debris at bridge site? no
Instream bar present downstream? no
Does stream have a constant width? no
Stream abraidedness: 5-35%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: unchanged
State of left bed level since last inspection: unchanged
Local scour hole in cross section? no
Lateral shifting shown in cross sectional comparison? no
Thalweg stability: unknown
Historical vertical thalweg degradation: none

RIGHT ABUTMENT

Bank erosion at right abutment: none or minor

Erosion at right spill slope: none or minor
Right abutment encroachment into channel: 10-30%
Right roadway embankment encroachment into channel: >30%
Height of approach fill near right abutment: >10'
Flood high water: below bridge deck
Annual high water: below bridge deck
Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: none or minor
Erosion at left spill slope: none or minor
Left abutment encroachment into channel: 10-30%
Left roadway embankment encroachment into channel: >30%
Height of approach fill near left abutment: >10'
Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: gentle
Left bank natural resistance to erosion: moderate
Left bank vegetation: moderate
Right bank profile: gentle
Right bank natural resistance to erosion: moderate
Right bank vegetation: moderate
River training works at site? no

UPSTREAM

Point bars present upstream? yes
Side of channel: left
Point bar size: average
Point bar vegetation: new
Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: minor
Left bank countermeasures? yes
Left bank countermeasure damage: none or minor
Erosion or countermeasure opposite bend? no
Right bank erosion: minor
Right bank countermeasures? yes
Right bank countermeasure damage: none or minor
Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: unknown
Abutment orientation: skew downstream
Flow impact location: at abutment

Pier 2
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: unknown
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: unknown
Right abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: unknown
Abutment orientation: skew upstream
Flow impact location: away from abutment

CAESAR Inspection Output Summary

Bridge No: I465-158-4458

Waterway: State ditch

Inspection Date: 052395

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	8 %,40 %,52 %	31 %,50 %,19 %	30 %,49 %,21 %
Evidence / Likelihood of Scour (low,moderate,high)	5 %,51 %,44 %	3 %,40 %,57 %	3 %,40 %,57 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,26 %,74 %	29 %,68 %,4 %	29 %,68 %,4 %

	Right Abutment
Overall Rating (poor,good,excellent)	6 %,24 %,71 %
Evidence / Likelihood of Scour (low,moderate,high)	53 %,37 %,10 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,26 %,74 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(15%), no(85%)	low (unstable): 14 %	2.53 feet (0.77 m)
To the right	yes(15%), no(85%)	high (stable): 86 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that none of the substructure elements seem to be at severe risk from scour.

	<p>*CAESAR has determined that the following substructure elements may have a potential for scour risk and might require monitoring: Pier 2 & Pier 3</p> <p>*CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent.</p> <p>Pier 2; Percent Footing Exposed: 85.4%; Local Scour: 4.8 ft.</p> <p>Pier 3; Percent Footing Exposed: 85.4%; Local Scour: 4.8 ft.</p>
These risks are not apparent	<p>Based on the entered information none of the following risks are apparent: Lateral channel migration, vertical thalweg degradation, contraction scour, or lateral thalweg migration.</p>

INSPECTION DATA

Bridge Number: I465-158-4458
Waterway: State ditch
Inspection Date: 052395
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 0-5
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = >10x channel width
Width of bridge opening: floodplain = 1-2x channel width
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: none or minor
Bridge constructed in: 1962
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? yes
Side of channel: left
Point bar size: average
Point bar vegetation: mature
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: minor
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? no

BRIDGE SITE

Debris at bridge site? no
Instream bar present downstream? no
Does stream have a constant width? no
Stream abraidedness: <5%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: unchanged
State of left bed level since last inspection: unchanged
Local scour hole in cross section? no
Lateral shifting shown in cross sectional comparison? yes
Thalweg stability: unknown
Historical vertical thalweg degradation: none

RIGHT ABUTMENT

Bank erosion at right abutment: none or minor
 Erosion at right spill slope: none or minor
 Right abutment encroachment into channel: <10%
 Right roadway embankment encroachment into channel: <10%
 Height of approach fill near right abutment: <6'
 Flood high water: below bridge deck
 Annual high water: unknown
 Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: none or minor
 Erosion at left spill slope: none or minor
 Left abutment encroachment into channel: <10%
 Left roadway embankment encroachment into channel: <10%
 Height of approach fill near left abutment: <6'
 Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep
 Left bank natural resistance to erosion: moderate
 Left bank vegetation: moderate
 Right bank profile: steep
 Right bank natural resistance to erosion: moderate
 Right bank vegetation: moderate
 River training works at site? no

UPSTREAM

Point bars present upstream? yes
 Side of channel: right
 Point bar size: average
 Point bar vegetation: mature
 Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: minor
 Left bank countermeasures? no
 Left bank countermeasure damage: no
 Erosion or countermeasure opposite bend? no
 Right bank erosion: minor
 Right bank countermeasures? no
 Right bank countermeasure damage: no
 Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: buried approach fill
 Countermeasures present? yes
 Countermeasure damage? yes
 Countermeasure performance history: unknown

Historical scour: not critical
Abutment orientation: skew upstream
Flow impact location: at abutment
Pier 2
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: moderate
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: not critical
Right abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: not critical
Abutment orientation: skew downstream
Flow impact location: away from abutment

CAESAR Inspection Output Summary

Bridge No: I-65-124-4285

Waterway: Bush Run

Inspection Date: 031495

Inspector: USGS

Cross Section Profile

- Inspection Data
- Calculated Local Scour
- Calculated Total Scour
- Countermeasure Present
- Water Surface Elevation

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	3 %,38 %,59 %	2 %,55 %,42 %	3 %,56 %,41 %
Evidence / Likelihood of Scour (low,moderate,high)	9 %,52 %,39 %	26 %,59 %,15 %	26 %,59 %,15 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,12 %,88 %	2 %,27 %,71 %	4 %,33 %,63 %

	Pier 4	Right Abutment
Overall Rating (poor,good,excellent)	3 %,55 %,42 %	0 %,19 %,81 %
Evidence / Likelihood of Scour (low,moderate,high)	26 %,59 %,15 %	75 %,25 %,0 %
Apparent Ability to Resist Scour (low,moderate,high)	4 %,33 %,63 %	0 %,12 %,88 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(31%), no(69%)	low (unstable): 60 %	0.63 feet (0.19 m)
To the right	yes(33%), no(67%)	high (stable): 40 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that none of the substructure elements seem to be at severe risk from scour.

	<p>*CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment, Pier 2, Pier 3, Pier 4, & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
These risks are not apparent	Based on the entered information none of the following risks are apparent: Lateral channel migration, vertical thalweg degradation, contraction scour, or lateral thalweg migration.

INSPECTION DATA

Bridge Number: I-65-124-4285
Waterway: Bush Run
Inspection Date: 031495
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 10+
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = 3-4x channel width
Width of bridge opening: floodplain = 1-2x channel width
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: mature
Bridge constructed in:
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: minor
Left bank countermeasures? yes
Left bank countermeasure damage: moderate
Erosion or countermeasure opposite bend? no
Right bank erosion: minor
Right bank countermeasures? yes
Right bank countermeasure damage: moderate
Erosion or countermeasure opposite bend? no

BRIDGE SITE

Debris at bridge site? no
Instream bar present downstream? no
Does stream have a constant width? yes
Stream abradedness: 5-35%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: degraded
State of left bed level since last inspection: degraded
Local scour hole in cross section? yes
Lateral shifting shown in cross sectional comparison? no
Thalweg stability: unknown

Historical vertical thalweg degradation: none

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RIGHT ABUTMENT

Bank erosion at right abutment: none or minor

Erosion at right spill slope: none or minor

Right abutment encroachment into channel: <10%

Right roadway embankment encroachment into channel: <10%

Height of approach fill near right abutment: >10'

Flood high water: below bridge deck

Annual high water: below bridge deck

Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: none or minor

Erosion at left spill slope: none or minor

Left abutment encroachment into channel: <10%

Left roadway embankment encroachment into channel: <10%

Height of approach fill near left abutment: >10'

Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep

Left bank natural resistance to erosion: moderate

Left bank vegetation: moderate

Right bank profile: steep

Right bank natural resistance to erosion: moderate

Right bank vegetation: moderate

River training works at site? no

UPSTREAM

Point bars present upstream? yes

Side of channel: right

Point bar size: average

Point bar vegetation: new

Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: minor

Left bank countermeasures? no

Left bank countermeasure damage: no

Erosion or countermeasure opposite bend? no

Right bank erosion: minor

Right bank countermeasures? yes

Right bank countermeasure damage: moderate

Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: buried approach fill

Countermeasures present? yes

Countermeasure damage? yes

Countermeasure performance history: unknown
Historical scour: not critical
Abutment orientation: skew downstream
Flow impact location: at abutment
Pier 2
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: floodplain
Countermeasures present? no
Historical scour: moderate
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: major

CAESAR Inspection Output Summary

Bridge No: I65-34-4240

Waterway: MUSCATATUCK R. OVERFLOW

Inspection Date: 062292

Inspector: USGS

Cross Section Profile

- Inspection Data
- Calculated Local Scour
- Calculated Total Scour
- Countermeasure Present
- Water Surface Elevation

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	9 %,39 %,52 %	10 %,49 %,41 %	10 %,64 %,25 %
Evidence / Likelihood of Scour (low,moderate,high)	19 %,59 %,22 %	19 %,60 %,21 %	1 %,32 %,68 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,16 %,84 %	2 %,27 %,71 %	4 %,33 %,63 %

	Right Abutment
Overall Rating (poor,good,excellent)	11 %,54 %,35 %
Evidence / Likelihood of Scour (low,moderate,high)	1 %,45 %,54 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,16 %,84 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(29%), no(71%)	low (unstable): 6 %	4.12 feet (1.26 m)
To the right	yes(50%), no(50%)	high (stable): 94 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that none of the substructure elements seem to be at severe risk from scour.

	<p>*CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment, Pier 2, Pier 3, & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Contraction Scour	Contraction scour was determined by the expert system to be 4.1 ft, this is a high value of contraction scour and should be investigated more thoroughly.
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent.</p> <p>Pier 3; Percent Footing Exposed: 85.4%; Local Scour: 6.0 ft.</p>
Debris In Channel	The debris hung up on the piers or in the channel is an indication of the susceptibility of this bridge to debris build up. Debris should be monitored at this site.
Moving Left	<p>There is evidence and/or potential for the channel to migrate to the left. The following item(s) are the evidence and potential for the channel to move left (E is evidence, P is Potential):</p> <p>P: Planform Effects (stream constant width, valley setting, instream bars, abradedness), unstable.</p> <p>P: Left bank upstream opposite a bend</p>
Left Bank C.M.	Left bank countermeasure installation upstream of the bridge might help slow lateral channel migration to the left.

INSPECTION DATA

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Bridge Number: I65-34-4240
Waterway: MUSCATATUCK R. OVERFLOW
Inspection Date: 062292
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 5-10
Alignment flow with respect to opening: right embankment
Floodplain width: floodplain = >10x channel width
Width of bridge opening: floodplain = 3-4x channel width
Relief Bridge present? yes
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: moderate
Bridge constructed in: 1959
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: none
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? yes
Right bank countermeasure damage: moderate
Erosion or countermeasure opposite bend? no

BRIDGE SITE

Debris at bridge site? yes
In channel: minor
On banks: minor
On floodplain: minor
Instream bar present downstream? no
Does stream have a constant width? no
Stream abraidedness: 5-35%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: unchanged
State of left bed level since last inspection: unchanged
Local scour hole in cross section? no
Lateral shifting shown in cross sectional comparison? no

Thalweg stability: unknown
Historical vertical thalweg degradation: none

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RIGHT ABUTMENT

Bank erosion at right abutment: none or minor
Erosion at right spill slope: none or minor
Right abutment encroachment into channel: 10-30%
Right roadway embankment encroachment into channel: 10-30%
Height of approach fill near right abutment: <6'
Flood high water: unknown
Annual high water: unknown
Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: none or minor
Erosion at left spill slope: none or minor
Left abutment encroachment into channel: 10-30%
Left roadway embankment encroachment into channel: 10-30%
Height of approach fill near left abutment: <6'
Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep
Left bank natural resistance to erosion: moderate
Left bank vegetation: moderate
Right bank profile: steep
Right bank natural resistance to erosion: moderate
Right bank vegetation: moderate
River training works at site? no

UPSTREAM

Point bars present upstream? no
Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: no
Left bank countermeasures? no
Left bank countermeasure damage: no
Erosion or countermeasure opposite bend? yes
Right bank erosion: yes
Right bank countermeasures? no
Right bank countermeasure damage: no
Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? no
Historical scour: not critical
Abutment orientation: skew downstream
Flow impact location: away from abutment

Pier 2

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: partially buried in approach fill

Countermeasures present? no

Historical scour: moderate

Pier 3

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: channel

Countermeasures present? no

Historical scour: not critical

Right abutment

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: buried approach fill

Countermeasures present? no

Historical scour: no

Abutment orientation: skew upstream

Flow impact location: at abutment

Pier 2

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: partially buried in approach fill

Countermeasures present? no

Historical scour: moderate

Pier 3

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: channel

Countermeasures present? no

Historical scour: not critical

Right abutment

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: buried approach fill

Countermeasures present? no

Historical scour: no

Abutment orientation: skew upstream

Flow impact location: at abutment

CAESAR Inspection Output Summary

Bridge No: I-65-81-5523

Waterway: BIG BLUE RIVER

Inspection Date: 092595

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	21 %,57 %,22 %	100 %,0 %,0 %	100 %,0 %,0 %
Evidence / Likelihood of Scour (low,moderate,high)	7 %,57 %,36 %	5 %,48 %,48 %	2 %,39 %,59 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,12 %,88 %	100 %,0 %,0 %	100 %,0 %,0 %

	Pier 4	Pier 5	Right Abutment
Overall Rating (poor,good,excellent)	39 %,49 %,12 %	23 %,56 %,21 %	18 %,45 %,38 %
Evidence / Likelihood of Scour (low,moderate,high)	2 %,36 %,63 %	5 %,44 %,52 %	78 %,12 %,10 %
Apparent Ability to Resist Scour (low,moderate,high)	21 %,75 %,4 %	6 %,47 %,47 %	0 %,12 %,88 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(40%), no(60%)	low (unstable): 77 %	0.77 feet (0.23 m)
To the right	yes(27%), no(73%)	high (stable): 23 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that the following substructure elements may be at risk from scour and could require corrective action:

	<p>Pier 2 & Pier 3 *CAESAR has determined that the following substructure elements may have a potential for scour risk and might require monitoring: Pier 4 & Pier 5 *CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with with the site evaluation; these are listed below.</p>
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent.</p> <p>Pier 2; Percent Embedment Lost: 43.2%; Local Scour: 8.4 ft. Pier 3; Percent Embedment Lost: 50.9%; Local Scour: 8.4 ft. Pier 4; Percent Embedment Lost: 50.9%; Local Scour: 8.4 ft. Pier 5; Percent Embedment Lost: 44.9%; Local Scour: 8.4 ft.</p>
Perhaps install CM's	<p>The Overall Ratings of Pier 2 & Pier 3 are low and/or scour risks are present. Perhaps cm's should be installed at these piers to decrease the risk of foundation undermining.</p>
Monitor Pier	<p>The foundation of Pier 4 has a low Overall Rating, but countermeasures may not be warranted. Perhaps this pier should be monitored.</p>
These risks are not apparent	<p>Based on the entered information none of the following risks are apparent: Lateral channel migration, vertical thalweg degradation, contraction scour, or lateral thalweg migration.</p>
Footings Exposed	<p>The footings of Pier 2, & Pier 3 are exposed or</p>

	almost exposed. Subsurface bed material was entered as scour susceptible, and thus these footings may be scour critical.
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INSPECTION DATA

Bridge Number: I-65-81-5523
Waterway: BIG BLUE RIVER
Inspection Date: 092595
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 10+
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = 3-4x channel width
Width of bridge opening: floodplain = 1-2x channel width
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: moderate
Bridge constructed in: 1968
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: minor
Left bank countermeasures? yes
Left bank countermeasure damage: moderate
Erosion or countermeasure opposite bend? no
Right bank erosion: minor
Right bank countermeasures? yes
Right bank countermeasure damage: moderate
Erosion or countermeasure opposite bend? no

BRIDGE SITE

Debris at bridge site? no
Instream bar present downstream? no
Does stream have a constant width? no
Stream abraidedness: 5-35%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: aggraded
State of left bed level since last inspection: aggraded
Local scour hole in cross section? yes
Lateral shifting shown in cross sectional comparison? no
Thalweg stability: unknown

Historical vertical thalweg degradation: none

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RIGHT ABUTMENT

Bank erosion at right abutment: moderate

Erosion at right spill slope: moderate

Right abutment encroachment into channel: <10%

Right roadway embankment encroachment into channel: <10%

Height of approach fill near right abutment: <6'

Flood high water: below bridge deck

Annual high water: below bridge deck

Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: moderate

Erosion at left spill slope: moderate

Left abutment encroachment into channel: <10%

Left roadway embankment encroachment into channel: <10%

Height of approach fill near left abutment: <6'

Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep

Left bank natural resistance to erosion: moderate

Left bank vegetation: moderate

Right bank profile: steep

Right bank natural resistance to erosion: moderate

Right bank vegetation: moderate

River training works at site? no

UPSTREAM

Point bars present upstream? no

Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: minor

Left bank countermeasures? no

Left bank countermeasure damage: no

Erosion or countermeasure opposite bend? no

Right bank erosion: minor

Right bank countermeasures? no

Right bank countermeasure damage: no

Erosion or countermeasure opposite bend? yes

PIER DATA

Left abutment

Local scour: No data

Calculated contraction scour: No data

Footing exposed? no

Foundation location: buried approach fill

Countermeasures present? yes

Countermeasure damage? yes

Countermeasure performance history: unknown

Historical scour: not critical

Abutment orientation: skew upstream

Flow impact location: at abutment
Pier 2
Local scour: No data
Calculated contraction scour: No data
Footing exposed? yes
Foundation location: floodplain
Countermeasures present? no
Historical scour: moderate
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? yes
Foundation location: channel
Countermeasures present? no
Historical scour: moderate
Pier 4
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: moderate
Pier 5
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: floodplain
Countermeasures present? no
Historical scour: not critical
Right abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: not critical
Abutment orientation: skew downstream
Flow impact location: away from abutment

CAESAR Inspection Output Summary

Bridge No: I-65-85-5527

Waterway: Sugar Creek

Inspection Date: 062294

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	12 %,35 %,53 %	1 %,35 %,64 %	1 %,35 %,64 %
Evidence / Likelihood of Scour (low,moderate,high)	5 %,48 %,47 %	48 %,43 %,9 %	48 %,43 %,9 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,12 %,88 %	2 %,27 %,71 %	2 %,27 %,71 %

	Pier 4	Pier 5	Right Abutment
Overall Rating (poor,good,excellent)	1 %,34 %,65 %	1 %,34 %,65 %	3 %,14 %,83 %
Evidence / Likelihood of Scour (low,moderate,high)	48 %,43 %,9 %	48 %,43 %,9 %	71 %,23 %,6 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,17 %,83 %	0 %,17 %,83 %	0 %,12 %,88 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(28%), no(72%)	low (unstable): 37 %	1.50 feet (0.46 m)
To the right	yes(66%), no(34%)	high (stable): 63 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that none of the substructure elements seem to be at severe risk from scour.

	<p>*CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment, Pier 2, Pier 3, Pier 4, Pier 5, & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Debris In Channel	The debris hung up on the piers or in the channel is an indication of the susceptibility of this bridge to debris build up. Debris should be monitored at this site.
Moving Left	<p>There is evidence and/or potential for the channel to migrate to the left. The following item(s) are the evidence and potential for the channel to move left (E is evidence, P is Potential):</p> <p>E: Left Bank Erosion upstream, opposite a bend P: Point bar right side of channel upstream of bridge P: Left bank upstream opposite a bend</p>
Left Bank C.M.	Left bank countermeasure installation upstream of the bridge might help slow lateral channel migration to the left.

INSPECTION DATA

Bridge Number: I-65-85-5527
Waterway: Sugar Creek
Inspection Date: 062294
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 0-5
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = >10x channel width
Width of bridge opening: floodplain = 5-6x channel width
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: mature
Bridge constructed in: 1970
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: major
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? no

BRIDGE SITE

Debris at bridge site? yes
In channel: minor
On banks: minor
On floodplain: minor
Instream bar present downstream? no
Does stream have a constant width? yes
Stream abradedness: 5-35%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: unchanged
State of left bed level since last inspection: unchanged
Local scour hole in cross section? no
Lateral shifting shown in cross sectional comparison? yes
Thalweg stability: unknown
Historical vertical thalweg degradation: none

RIGHT ABUTMENT

Bank erosion at right abutment: none or minor
Erosion at right spill slope: none or minor
Right abutment encroachment into channel: <10%
Right roadway embankment encroachment into channel: <10%
Height of approach fill near right abutment: 6-10'
Flood high water: unknown
Annual high water: unknown
Obstruction diverting flow to right abutment? no

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LEFT ABUTMENT

Bank erosion at left abutment: none or minor
Erosion at left spill slope: none or minor
Left abutment encroachment into channel: <10%
Left roadway embankment encroachment into channel: <10%
Height of approach fill near left abutment: 6-10'
Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep
Left bank natural resistance to erosion: moderate
Left bank vegetation: moderate
Right bank profile: steep
Right bank natural resistance to erosion: moderate
Right bank vegetation: moderate
River training works at site? no

UPSTREAM

Point bars present upstream? yes
Side of channel: right
Point bar size: average
Point bar vegetation: none
Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: major
Left bank countermeasures? no
Left bank countermeasure damage: no
Erosion or countermeasure opposite bend? yes
Right bank erosion: major
Right bank countermeasures? no
Right bank countermeasure damage: no
Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown

Historical scour: unknown
Abutment orientation: skew upstream
Flow impact location: at abutment
Pier 2
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: floodplain
Countermeasures present? no
Historical scour: unknown
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: floodplain
Countermeasures present? no
Historical scour: unknown
Pier 4
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried in approach fill
Countermeasures present? no
Historical scour: unknown
Pier 5
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried in approach fill
Countermeasures present? no
Historical scour: unknown
Right abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: unknown
Abutment orientation: skew downstream
Flow impact location: away from abutment

CAESAR Inspection Output Summary

Bridge No: I-70-104-5128

Waterway: Brandy Wine

Inspection Date: 080494

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	1 %,44 %,55 %	19 %,68 %,13 %	100 %,0 %,0 %
Evidence / Likelihood of Scour (low,moderate,high)	3 %,54 %,44 %	3 %,34 %,62 %	13 %,77 %,10 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,21 %,79 %	12 %,45 %,43 %	100 %,0 %,0 %

	Right Abutment
Overall Rating (poor,good,excellent)	0 %,33 %,66 %
Evidence / Likelihood of Scour (low,moderate,high)	22 %,67 %,11 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,21 %,79 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(34%), no(66%)	low (unstable): 22 %	3.84 feet (1.17 m)
To the right	yes(38%), no(62%)	high (stable): 78 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that the following substructure elements may be at risk from scour and could require corrective action:

	<p>Pier 3 *CAESAR has determined that the following substructure elements may have a potential for scour risk and might require monitoring: Pier 2 *CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent. Pier 2; Percent Footing Exposed: 73.6%; Local Scour: 4.8 ft.</p>
Perhaps Install CM's	<p>The Overall Rating of Pier 3 is low and/or scour risks are present. Perhaps cm's should be installed at Pier 3 to decrease the risk of foundation undermining.</p>
Potential to move left	<p>There are signs of potential for the channel to migrate to the left. The following item(s) represent the sign(s) of potential for the channel to move left: P: Planform Effects (stream constant width, valley setting, instream bars, abraidedness), unstable. P: Left bank upstream opposite a bend</p>
These risks are not apparent	<p>Based on the entered information none of the following risks are apparent: Lateral channel migration, vertical thalweg degradation, contraction scour, or lateral thalweg migration.</p>
Footing Exposed	<p>The footing of Pier 3 is exposed or almost exposed. Subsurface bed material was entered as scour susceptible, and thus the footing may be</p>

	scour critical.
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INSPECTION DATA

Bridge Number: I-70-104-5128
Waterway: Brandy Wine
Inspection Date: 080494
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 0-5
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = 3-4x channel width
Width of bridge opening: floodplain = 1-2x channel width
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: moderate
Bridge constructed in:
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: minor
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? no

BRIDGE SITE

Debris at bridge site? no
Instream bar present downstream? no
Does stream have a constant width? no
Stream abraidedness: 5-35%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: unchanged
State of left bed level since last inspection: unchanged
Local scour hole in cross section? yes
Lateral shifting shown in cross sectional comparison? yes
Thalweg stability: unknown
Historical vertical thalweg degradation: none

RIGHT ABUTMENT

Bank erosion at right abutment: none or minor

Erosion at right spill slope: none or minor
Right abutment encroachment into channel: 10-30%
Right roadway embankment encroachment into channel: 10-30%
Height of approach fill near right abutment: 6-10'
Flood high water: below bridge deck
Annual high water: below bridge deck
Obstruction diverting flow to right abutment? no

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LEFT ABUTMENT

Bank erosion at left abutment: none or minor
Erosion at left spill slope: none or minor
Left abutment encroachment into channel: 10-30%
Left roadway embankment encroachment into channel: 10-30%
Height of approach fill near left abutment: 6-10'
Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep
Left bank natural resistance to erosion: moderate
Left bank vegetation: moderate
Right bank profile: steep
Right bank natural resistance to erosion: moderate
Right bank vegetation: moderate
River training works at site? no

UPSTREAM

Point bars present upstream? no
Instream bar upstream of bridge? yes
Bar size: larger than average
Bar vegetation: larger than average

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: minor
Left bank countermeasures? no
Left bank countermeasure damage: no
Erosion or countermeasure opposite bend? yes
Right bank erosion: minor
Right bank countermeasures? yes
Right bank countermeasure damage: major
Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: not critical
Abutment orientation: skew downstream
Flow impact location: at abutment
Pier 2

Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: moderate
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? yes
Foundation location: floodplain
Countermeasures present? no
Historical scour: major
Right abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: not critical
Abutment orientation: skew upstream
Flow impact location: away from abutment

CAESAR Inspection Output Summary

Bridge No: I-70-35-5245

Waterway: Big Walnut Creek

Inspection Date: 060491

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	10 %,42 %,47 %	35 %,40 %,25 %	53 %,47 %,0 %
Evidence / Likelihood of Scour (low,moderate,high)	1 %,45 %,54 %	16 %,53 %,31 %	0 %,0 %,100 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,14 %,86 %	0 %,20 %,80 %	28 %,72 %,0 %

	Pier 4	Pier 5	Pier 6
Overall Rating (poor,good,excellent)	69 %,31 %,0 %	44 %,54 %,2 %	32 %,63 %,5 %
Evidence / Likelihood of Scour (low,moderate,high)	0 %,0 %,100 %	0 %,0 %,100 %	0 %,7 %,93 %
Apparent Ability to Resist Scour (low,moderate,high)	28 %,72 %,0 %	14 %,62 %,24 %	10 %,50 %,40 %

	Right Abutment
Overall Rating (poor,good,excellent)	8 %,33 %,59 %
Evidence / Likelihood of Scour (low,moderate,high)	18 %,62 %,20 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,14 %,86 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(19%), no(81%)	low (unstable): 73 %	4.48 feet (1.37 m)
To the right	yes(19%), no(81%)	high (stable): 27 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	<p>*CAESAR has determined that the following substructure elements may be at risk from scour and could require corrective action: Pier 3 & Pier 4</p> <p>*CAESAR has determined that the following substructure elements may have a potential for scour risk and might require monitoring: Pier 2, Pier 5, & Pier 6</p> <p>*CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Contraction Scour	Contraction scour was determined by the expert system to be 4.5ft, this is a high value of contraction scour and should be investigated more thoroughly.
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent.</p> <p>Pier 3; Percent Embedment Lost: >60.0%; Local Scour: 4.8 ft.</p> <p>Pier 4; Percent Embedment Lost: >60.0%; Local</p>

	<p>Scour: 4.8 ft. Pier 5; Percent Embedment Lost: >60.0%; Local Scour: 4.8 ft. Pier 6; Percent Embedment Lost: 57.7%; Local Scour: 4.8 ft.</p>
Perhaps install CM's	<p>The Overall Ratings of Pier 3 & Pier 4 are low and/or scour risks are present. Perhaps cm's should be installed at these piers to decrease the risk of foundation undermining.</p>
Shallow Pile Embedment	<p>The piles of Pier 3 & Pier 4 are embedded less than 15 ft (4.5 m). Subsurface bed material was entered as scour susceptible, thus these foundations may may be scour critical.</p>

INSPECTION DATA

Bridge Number: I-70-35-5245
Waterway: Big Walnut Creek
Inspection Date: 060491
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 0-5
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = >10x channel width
Width of bridge opening: floodplain = 1-2x channel width
Relief Bridge present? no
Channel constriction by piers? yes
Channel constriction by countermeasures? no
Extent of floodplain vegetation: moderate
Bridge constructed in:
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: none
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? no

BRIDGE SITE

Debris at bridge site? no
Instream bar present downstream? no
Does stream have a constant width? no
Stream abraidedness: >35%
Valley setting: flat
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: aggraded
State of left bed level since last inspection: aggraded
Local scour hole in cross section? yes
Lateral shifting shown in cross sectional comparison? no
Thalweg stability: unknown
Historical vertical thalweg degradation: none

RIGHT ABUTMENT

Bank erosion at right abutment: none or minor

Erosion at right spill slope: none or minor
Right abutment encroachment into channel: 10-30%
Right roadway embankment encroachment into channel: 10-30%
Height of approach fill near right abutment: >10'
Flood high water: below bridge deck
Annual high water: below bridge deck
Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: none or minor
Erosion at left spill slope: none or minor
Left abutment encroachment into channel: 10-30%
Left roadway embankment encroachment into channel: >30%
Height of approach fill near left abutment: >10'
Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep
Left bank natural resistance to erosion: moderate
Left bank vegetation: moderate
Right bank profile: steep
Right bank natural resistance to erosion: moderate
Right bank vegetation: moderate
River training works at site? no

UPSTREAM

Point bars present upstream? no
Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: none
Left bank countermeasures? no
Left bank countermeasure damage: no
Erosion or countermeasure opposite bend? no
Right bank erosion: none
Right bank countermeasures? no
Right bank countermeasure damage: no
Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? yes
Countermeasure damage? yes
Countermeasure performance history: unknown
Historical scour: not critical
Abutment orientation: no skew
Flow impact location: at abutment
Pier 2
Local scour: No data
Calculated contraction scour: No data

Footing exposed? no
 Foundation location: partially buried in approach fill
 Countermeasures present? no
 Historical scour: not critical
 Pier 3
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: channel
 Countermeasures present? no
 Historical scour: moderate
 Pier 4
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: channel
 Countermeasures present? no
 Historical scour: moderate
 Pier 5
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: floodplain
 Countermeasures present? no
 Historical scour: moderate
 Pier 6
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: partially buried in approach fill
 Countermeasures present? no
 Historical scour: not critical
 Right abutment
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: buried approach fill
 Countermeasures present? yes
 Countermeasure damage? yes
 Countermeasure performance history: unknown
 Historical scour: not critical
 Abutment orientation: no skew
 Flow impact location: away from abutment

CAESAR Inspection Output Summary

Bridge No: I-74-32-4946

Waterway: SUGAR CREEK

Inspection Date: 062591

Inspector: USGS

Cross Section Profile

Pier / Abutment Evaluations

	Left Abutment	Pier 2	Pier 3
Overall Rating (poor,good,excellent)	16 %,60 %,24 %	22 %,62 %,17 %	100 %,0 %,0 %
Evidence / Likelihood of Scour (low,moderate,high)	1 %,46 %,54 %	1 %,34 %,65 %	1 %,34 %,65 %
Apparent Ability to Resist Scour (low,moderate,high)	0 %,41 %,59 %	10 %,62 %,28 %	100 %,0 %,0 %

	Pier 4	Pier 5	Right Abutment
Overall Rating (poor,good,excellent)	35 %,52 %,13 %	17 %,63 %,20 %	7 %,49 %,44 %
Evidence / Likelihood of Scour (low,moderate,high)	1 %,34 %,65 %	1 %,34 %,65 %	8 %,71 %,22 %
Apparent Ability to Resist Scour (low,moderate,high)	29 %,68 %,4 %	7 %,50 %,42 %	0 %,24 %,76 %

General Site Evaluations

Potential/Evidence of Lateral Migration		Potential/Evidence of Vertical Stream Stability	Qualitative Contraction Scour
To the left	yes(12%), no(88%)	low (unstable): 65 %	5.31 feet (1.62 m)
To the right	yes(34%), no(66%)	high (stable): 35 %	

Conclusions

Subject	Associated Conclusion
CAESAR's evaluation summary	*CAESAR has determined that the following substructure elements may be at risk from scour and could require corrective action:

	<p>Pier 3 *CAESAR has determined that the following substructure elements may have a potential for scour risk and might require monitoring: Pier 2 & Pier 4 *CAESAR has determined that the following substructure elements are probably not at risk from scour: Left Abutment, Pier 5, & Right Abutment</p> <p>CAESAR also arrived at several intermediate conclusions that may help with the site evaluation; these are listed below.</p>
Contraction Scour	Contraction scour was determined by the expert system to be 5.3ft, this is a high value of contraction scour and should be investigated more thoroughly.
Calculated scour is critical	<p>The calculated total scour on the following piers was determined to be moderately serious to very serious. This is only a scour calculation, not the true estimated stability of the pier(s). The severity of total scour is based on percent of footing exposed of a spreadfooting, and based on percent of embedment lost if the foundation is a pile, caisson, shaft or pile bent.</p> <p>Pier 2; Percent Footing Exposed: 85.4%; Local Scour: 7.2 ft. Pier 3; Percent Footing Exposed: 85.4%; Local Scour: 7.2 ft. Pier 4; Percent Footing Exposed: 85.4%; Local Scour: 7.2 ft. Pier 5; Percent Footing Exposed: 85.4%; Local Scour: 7.2 ft.</p>
Perhaps Install CM's	The Overall Rating of Pier 3 is low and/or scour risks are present. Perhaps cm's should be installed at Pier 3 to decrease the risk of foundation undermining.
Monitor Pier	The foundation of Pier 4 has a low Overall Rating, but countermeasures may not be warranted. Perhaps this pier should be monitored.
Debris In Channel	The debris hung up on the piers or in the channel is an indication of the susceptibility of this

	bridge to debris build up. Debris should be monitored at this site.
Footing Exposed	The footing of Pier 3 is exposed or almost exposed. Subsurface bed material was entered as scour susceptible, and thus the footing may be scour critical.

INSPECTION DATA

95

Bridge Number: I-74-32-4946
Waterway: SUGAR CREEK
Inspection Date: 062591
Inspector: USGS

SITE REVIEW

Piers rotating/tilting? no
Abutments rotating/tilting? no
Bridge rail or deck sagging? no
Blow hole at this site? no

GENERAL SITE

Bridge experienced major flood? unknown
High flow angle of attack: 10+
Alignment flow with respect to opening: left embankment
Floodplain width: floodplain = 3-4x channel width
Width of bridge opening: floodplain = 1-2x channel width
Relief Bridge present? no
Channel constriction by piers? no
Channel constriction by countermeasures? no
Extent of floodplain vegetation: mature
Bridge constructed in: 1964
Upstream/Downstream activities:

BRIDGE

Point bars present at bridge? no
Instream bar at bridge? no
Bar erosion and bank countermeasures at bridge
Left bank erosion: none
Left bank countermeasures? no
Right bank erosion: no
Right bank countermeasures? no

BRIDGE SITE

Debris at bridge site? yes
In channel: minor
On banks: none
On floodplain: none
Instream bar present downstream? no
Does stream have a constant width? yes
Stream abraidedness: 5-35%
Valley setting: hilly
Roadway overtop flood interval: doesn't overtop by 100 year flood

CROSS SECTION

State of right bed level since last inspection: aggraded
State of left bed level since last inspection: aggraded
Local scour hole in cross section? yes
Lateral shifting shown in cross sectional comparison? no
Thalweg stability: unknown
Historical vertical thalweg degradation: none

RIGHT ABUTMENT

Bank erosion at right abutment: none or minor
 Erosion at right spill slope: none or minor
 Right abutment encroachment into channel: 10-30%
 Right roadway embankment encroachment into channel: 10-30%
 Height of approach fill near right abutment: >10'
 Flood high water: below bridge deck
 Annual high water: below bridge deck
 Obstruction diverting flow to right abutment? no

LEFT ABUTMENT

Bank erosion at left abutment: none or minor
 Erosion at left spill slope: none or minor
 Left abutment encroachment into channel: 10-30%
 Left roadway embankment encroachment into channel: 10-30%
 Height of approach fill near left abutment: >10'
 Obstruction diverting flow to left abutment? no

BANK STABILITY

Left bank profile: steep
 Left bank natural resistance to erosion: moderate
 Left bank vegetation: heavy
 Right bank profile: steep
 Right bank natural resistance to erosion: moderate
 Right bank vegetation: heavy
 River training works at site? no

UPSTREAM

Point bars present upstream? yes
 Side of channel: right
 Point bar size: average
 Point bar vegetation: new
 Instream bar upstream of bridge? no

BANK EROSION AND BANK COUNTERMEASURES UPSTREAM

Left bank erosion: moderate
 Left bank countermeasures? no
 Left bank countermeasure damage: no
 Erosion or countermeasure opposite bend? no
 Right bank erosion: none
 Right bank countermeasures? no
 Right bank countermeasure damage: no
 Erosion or countermeasure opposite bend? no

PIER DATA

Left abutment
 Local scour: No data
 Calculated contraction scour: No data
 Footing exposed? no
 Foundation location: buried approach fill
 Countermeasures present? no
 Historical scour: not critical
 Abutment orientation: skew downstream

Flow impact location: at abutment
Pier 2
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: floodplain
Countermeasures present? no
Historical scour: moderate
Pier 3
Local scour: No data
Calculated contraction scour: No data
Footing exposed? yes
Foundation location: channel
Countermeasures present? no
Historical scour: major
Pier 4
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: channel
Countermeasures present? no
Historical scour: moderate
Pier 5
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: floodplain
Countermeasures present? no
Historical scour: not critical
Right abutment
Local scour: No data
Calculated contraction scour: No data
Footing exposed? no
Foundation location: buried approach fill
Countermeasures present? no
Historical scour: no
Abutment orientation: skew upstream
Flow impact location: away from abutment