Illinois Department of Transportation
2300 South Dirksen Parkway / Springfield, Illinois 62764

April 22, 1996

National Bridge Inspection Program
Scour Critical Evaluation

#96-7

COUNTY ENGINEERS/SUPERINTENDENT OF HIGHWAYS
MUNICIPAL ENGINEERS/ DIRECTORS OF PUBLIC WORKS
CONSULTING ENGINEERS

According to the National Bridge Inspection Standards (NBIS) each bridge over a waterway must be evaluated for susceptibility to substructure failure due to streambed scour. The FHWA Technical Advisory, "Scour at Bridges" (T5140.20) established the evaluation requirements in 1988. The target date for completion of all scour critical evaluations is December 31, 1996 as previously communicated by Bureau of Local Roads and Streets Letter #92-11 dated June 26, 1992. Any local agency which does not anticipate completion by the target date must submit an action plan to the district explaining why this date cannot be met and when the scour critical analysis will be completed. The scour evaluation action plan should be submitted no later than October 1, 1996.

To reduce the effort needed to do the scour critical evaluation, the Department is providing two new simplified methods that may be used to meet the scour critical evaluation requirements. These methods are in addition to the analysis method described in Hydraulic Engineering Circular #18 (HEC 18) that has been in use since 1991. They are:

- Bridge Scour Assessment Procedure (BSAP)
- Simplified Scour Analysis Method (SSAM)

These two new scour evaluation methods may be used in lieu of or as a pre-screening for the HEC 18 analysis method. In many instances the new evaluation methods may tend to give more conservative results. In order to avoid costly scour countermeasures or monitoring that may be indicated for certain bridges because of the conservatism of the BSAP or SSAM, it may be prudent to perform an analysis using the procedure from HEC 18. In any case, the guidelines and general discussion of streambed scour at bridges in HEC 18 will remain very useful in any bridge scour assessment.

Two one-day training courses for the BSAP and SSAM have been scheduled to be held in Peoria and at Rend Lake Community College. The Peoria class will be held at the IDOT District 4 office beginning at 8:30 a.m. on June 11, 1996. The Rend Lake class will begin at 8:30 a.m., June 13, 1996. An enrollment form is attached. This course will be essentially the same as was offered in October and November, 1995. Counties which have had no personnel attend one of the previous classes will be contacted by separate letter in the near future. Local agencies will be given priority for registration, however consulting engineers are encouraged to register and will be allowed to attend depending on available space.

As an alternative, when neither the BSAP, SSAM or HEC 18 are believed to yield reasonable results, an assessment based on sound engineering judgment may be performed. Such modification must be accompanied by written documentation and included in the bridge inspection file for the bridge.

The suggested scour critical evaluation methods are briefly described as follows:

Bridge Scour Assessment Procedure (BSAP)

The Bridge Scour Assessment Procedure (BSAP) is a simplified, non-analytical evaluation which results in the conservative assignment of the Scour Critical Evaluation Rating (Item 113) for the Illinois Structure Information System (ISIS). A hydraulic analysis is not required to perform this procedure. BSAP uses information which should be readily available from field and historical observation, bridge plans, construction records, soil borings and maps. The parameters considered include historical scour performance, flood history, scour countermeasures, debris and blockage, geomorphic conditions, hydraulic conditions, structural conditions, special low risk conditions, unknown foundations and foundation scour resistance.

The detailed documentation for the BSAP is in the attached, "Bridge Scour Assessment Procedure for Local Roads and Streets" and the accompanying "Instructions". An MS-DOS based computer program to aid in the use of the BSAP is also available for download from the "Bridge Program" file section of the Bureau of Local Roads and Streets' computer bulletin board system at 217/524-5330. A diskette with the program is also being sent to each district Bureau of Local Roads with this letter. The appropriate district Bureau of Local Roads may be contacted for further information on obtaining the BSAP program.

Simplified Scour Analysis Method (SSAM)

The Simplified Scour Analysis Method (SSAM) was developed for Illinois local agency bridges by the Water Resources Division of the U.S. Geological Survey (USGS). This method consists of applying total scour-envelope curves to estimate the 500-year flood scour. These curves were developed as empirical relationships between the total scour calculated using the scour depth estimations and bridge-site characteristics for 202 State Highway bridges

previously analyzed using HEC 18. The SSAM uses measurable bridge site characteristics and an approximated 100-year flood discharge to arrive at an estimated total scour depth. Table 1 (attached) describes the data required to perform this analysis. An MS-Windows / MS-DOS computer program has been developed to aid in calculating the estimated scour depth.

The USGS Water-Resources Investigations Report 95-4298, *Development, Verification, and Application of a Simplified Method to Estimate Total-Streambed Scour at Bridge Sites in Illinois* describes this simplified analysis method in detail. This publication can be obtained from: USGS, Information Services, Box 25268, Federal Center, Denver, CO 80225 and additional information is available by writing to: District Chief, USGS, 102 E. Main St., 4th Floor, Urbana, IL 61801. A limited number of copies are being distributed with this letter to County Engineers and selected Municipal Engineers with responsibility for bridges over waterways. A diskette containing the SSAM computer program is included with this publication. The SSAM program is also available for download from the "Bridge Program" file section of the Bureau of Local Roads and Streets' computer bulletin board system at 217/524-5330.

"HEC 18" Scour Analysis

A hydraulic analysis, preferably using WSPRO, is required to utilize the HEC 18 scour analysis procedure. The hydraulics can be determined with a lesser degree of precision than would normally be needed for the design of a new structure. The HEC 18 Scour Analysis gives reasonable scour depth estimates for contraction scour and local pier scour with non-cohesive granular type soils. Localized scour at abutments should not be estimated using the HEC 18 analysis method. Evaluation of potential for local scour at abutments will largely depend on prudent engineering judgment.

Hydraulic Engineering Circular #18 (FHWA-IP-90-017, HEC 18), *Evaluating Scour at Bridges* is available through the National Technical Information Service, Springfield, VA 22161, 703/487-4650. A MS-DOS computer program, "HY9", that utilizes the HEC 18 analysis can be obtained from the "Bridge Program" file section of the Bureau of Local Roads and Streets' computer bulletin board system at 217/524-5330 (SCOUREV.EXE) and McTrans, Voice - 904/392-0378, BBS - 904/392-3225 ("Scour at Bridges").

The use of any of the recommended scour critical evaluation methods requires first-hand knowledge of the bridge site conditions and a degree of engineering expertise with regard to hydraulics, soils and foundations. The aim of the scour critical evaluation program is to provide additional safety for the users of public roads from the potential sudden collapse of structures due to streambed scour at bridge foundations. The scour critical evaluation is not intended to result in the installation of countermeasures or the institution of time-consuming scour monitoring that are unnecessary and unreasonable. Any inappropriate results produced by the suggested evaluation methods may be overruled by well documented and sound engineering judgment.

Local agency bridge construction and reconstruction projects are to have scour critical evaluation incorporated in their designs. Bridges should also have a scour critical evaluation performed prior to any jurisdictional transfer.

Beginning with this letter and until all evaluations are completed, the Bureau of Bridges and Structures will be sending bi-monthly scour evaluation status reports to the district offices. With the BSAP, the SSAM and the HEC 18 methods, the tools are available to quickly complete the scour critical evaluations. The affected local agencies are strongly encouraged to direct attention to completion by the December 31, 1996 target date.

Questions regarding the scour critical evaluation procedures may be addressed to Tim Souther of the Local Bridge Unit at 217/785-8748.

Very truly yours,

Ralph E. Anderson

Ralph E. Anderson
Engineer of Bridges and Structures

TES/cw20733
cc- District Engineers
Illinois Department of Natural Resources
Metropolitan Water Reclamation District of Greater Chicago
FHWA, Illinois Division/Attn: Dan Brydl

Illinois Department of Transportation

BRIDGE SCOUR ASSESSMENT PROCEDURE

FOR LOCAL ROADS AND STREETS

I. HISTORICAL SCOUR PERFORMANCE:

Has the bridge ever experienced "significant scour" (deeper than 4 feet, spread footing exposed, or a footing on piles or pile encasement undermined) that has not been adequately corrected by scour countermeasures? yes, no, unknown.

If the answer is "yes" or "unknown" go to *VIII*. If the answer is "no" go to *II*.

II. FLOOD HISTORY:

a. Has the bridge experienced a flood with a documented 100 yr. return interval which did not result in significant scour? *yes, no, unknown*.

b. Has the bridge experienced a significant flood (≥ 25 yr. return interval) according to local flood records or as implied from the attached Q50/100 USGS stream guaging station map? *yes, no, unknown*.

If the answer to *a.* is "yes" assign a rating of "***8***" to Scour Critical Evaluation Rating (ISIS Item 113). If the answer to *a.* is "no" or "unknown" and *b.* is "yes" go to *III*. If the answer to *b.* is "no" or "unknown" go to *VIII*.

III. SCOUR COUNTERMEASURES:

a. Are scour countermeasures in place and functioning properly? *yes, no, unknown*.

b. If they *are* present, were the scour countermeasures installed to correct a previously existing problem with scour? *yes, no, unknown*

c. Do other substructure units that are not protected by scour countermeasures warrant an ISIS Item 113 rating of at least "8"? *yes, no, unknown*

If the answer to all three questions is "yes", ISIS Item 113 should be coded "***7***". If the answer to *a.*is "yes", and *b.* is "no" or "unknown", and *c.* is "yes", ISIS Item 113 should be coded "***8***". If the answer to *a.* is "no" or "unknown", or *c.* is "no", go to *IV*. If the answer to *a.* is "yes" and *c.* is "unknown" continue with *IV*. and return to this section if it is determined that substructure units not protected by scour countermeasures warrant an ISIS Item 113 rating of at least "8".

IV. DEBRIS AND BLOCKAGE:

a. Does debris collect or build up at the bridge and block at least 10% of the flow cross section? *yes, no, unknown*.

b. Do ice jams build up at the bridge and block at least 10% of the flow cross section? *yes, no, unknown*.

If the answer to either question is "yes" or "unknown", go to *VIII*. If the answer to both questions is "no", go to *V*.

V. GEOMORPHIC CONDITIONS AFFECTING SCOUR RESISTANCE:

a. Is the stream bed degrading? *yes, no, unknown*.

b. For natural streams, are there channel bends of greater than 30 degrees within a distance of 4 times the channel width upstream of the bridge? *yes, no, unknown*.

c. Are the stream banks unstable? *yes, no, unknown*.

d. Are bridge abutments or piers skewed from the direction of flow? *yes, no, unknown*.

e. Is the effective flow width (width of flow during the 100 year flood) greater than 5 times the total bridge span or 5 times the bank full channel width? *yes, no, unknown*.

If the answer to any of the above five questions is "yes" or "unknown", go to *VIII*. If the answer to all the above questions is "no", go to *VI*.

VI. HYDRAULIC CONDITIONS AFFECTING SCOUR RESISTANCE:

Based upon known topographic information and water surface profile calculations or historical records or professional judgment, answer the following questions:

a. Is the 100 year flood depth less than 3 feet and stream slope, within a mile of the bridge, less than 5 feet per mile? *yes, no, unknown*.

b. Is the 100 year flood depth less than 10 feet and stream slope, within a mile of the bridge, less than 1 foot per mile? *yes, no, unknown*.

c. Is the 100 year flood depth less than 20 feet and stream slope, within a mile of the bridge, less than 0.5 feet per mile? *yes, no, unknown*.

d. For floods of magnitude greater than 50 years, is the average velocity through the bridge less than 3 fps in sand bed water courses or less than 5 fps in clay bed water courses? *yes, no, unknown*.

If the answer to any of the above four questions is "yes", rate the bridge as "***8***" and proceed no further. If the answer to all of the above questions is "no" or "unknown", go to *VII*.

VII. SINGLE SPAN BRIDGE CONSIDERATIONS:

If the bridge is multiple span, go to *VIII*. If the bridge is a single span and the effective flood plain width for the 100 year flood is less than 5 times the span length, answer the following three questions. Otherwise, go to *VIII*.

a. Is the bridge supported by concrete abutments on piles? *yes, no, unknown*.

b. Is the bridge supported by timber or steel abutments less than 6 feet high on piles? *yes, no, unknown*.

c. Is the bridge on concrete abutments and over a man made ditch with slope of less than 5 feet per mile or average ditch velocity less than 3 fps for a flood of magnitude 50 years or greater? *yes, no, unknown*.

If the answer to any of the above three questions is "yes", rate the bridge as "***8***". If the answer to *a.* or *b.* is unknown, code ISIS Item 113B as "***C***" (Unknown Foundation). If the answer to all three questions is "no" or "unknown", go to *VIII*.

VIII. MONITORED REDUCED RISK BRIDGES:

a. Is the bridge scheduled for replacement or installation of constructed scour countermeasures within 5 years? *yes, no, unknown*.

b. Is the road classified as a "Local Road" (ISIS Item 26 - Functional Class code "60") or is the estimated average daily traffic (ADT) over the bridge less than 25? *yes, no*.

c. Does the bridge or adjacent roadway overtop more often than on average every 5 years, requiring closure and therefore inspection before reopening? *yes, no, unknown*.

d. Did this assessment process for this bridge require consideration of each of the previous sections (I. through VII.) prior to reaching this section (Section VIII.)? *yes, no*.

If the answer to all three (3) questions *a.*, *b.* and *c.* is "no" or unknown, go to *IX*. If the answer to any of *a.*, *b.*, or *c.* is "yes" and *d.* is "no", rate the bridge as "***5***". The local professional engineer having jurisdiction over the bridge inspection shall direct the scour monitoring program for the bridge. If *a.*, *b.* or *c.* is "yes" and *d.* is "yes" and the evaluator wishes to investigate the possibility of ISIS Item 113 being "***8***", go to *X*., or else rate the bridge as "***5***" and monitor.

IX. KNOWLEDGE OF FOUNDATION:

a. Can the foundation type and depth be determined or reasonably estimated from plans or other construction records? *yes*, *no*.

b. Can the foundation soil types be reasonably ascertained from existing records or field conditions? *yes*, *no*.

If the answer to *a.* is "no" and there is no evidence of significant scour having occurred, code ISIS Item 113 as "*5*" and code Item 113B as "*C*". In this circumstance but where significant scour is in evidence, code ISIS Item 113 as "*3*" and code Item 113B as "*C*". If the answer to *a.* is "yes" and *b.* is "no", assume scourable granular soils and go to X or perform a scour analysis. If the answer to both *a.* and *b.* is "yes", go to X or perform a scour analysis.

X. FOUNDATION SCOUR RESISTANCE ASSESSMENT:

This section may be utilized for any structure with a known foundation and less than 700 square mile drainage area. Use the first applicable foundation / soil case moving sequentially through the following procedure. Alternatively, at the discretion of the scour evaluation engineer(s), a scour critical analysis may be performed. If it is the opinion of the engineer(s) that the rating for a bridge derived from this procedure *or* from a scour critical analysis would not yield reasonable results, he may assign an alternate scour critical evaluation rating using sound engineering judgment. Such a rating must be clearly documented in the NBIS bridge files.

Spread Footings

On Rock

Footing not exposed ⇒ "*8*"

Top of footing is exposed ⇒ "*5*"

Footing undermined ⇒ "*2*"

On Soil

Stiff clays / clay till ($Q_u \geq 1.5$tsf):

No scour ⇒ "*5*" (inspect for scour @ max. 4 yr. interval)

Scour present, footing not exposed ⇒ "*5*" (inspect for scour @ max. 2 yr. interval)

Scour present, footing is exposed ⇒ "*3*"

Footing undermined ⇒ "*2*"

Granular or soft soils ($Q_u < 1.5$tsf): ⇒ "*2*"

Pile Foundations

Any soil type:

Pile tips ≥ 40' below ground surface and piles not exposed by "significant" scour ⇒ "*8*"

Socketed or driven into rock:

Piles not exposed by "significant" scour ⇒ "*8*"

Piles exposed by "significant" scour ⇒ "*4*"

Pile tips on rock but not socketed or driven into the rock:

Little or no existing scour is present or has occurred previously:

A 3-foot minimum thickness of cohesive soil in upper ½ of embedded pile length ⇒ "***8***"

No layers of cohesive soil in upper ½ of embedded pile length ⇒ "***5***"

History of "significant" scour or erosion:

A 3-foot minimum thickness of cohesive soil in upper ½ of embedded pile length ⇒ "***4***"

No layers of cohesive soil in upper ½ of embedded pile length ⇒ "***3***"

Friction piles in cohesive soils:

Little or no existing scour is present or has occurred previously:

Pile tips ≥ 15' deep, min. 3-ft layer w/Q_u ≥ 1.5tsf in upper ½ of embedded pile length ⇒ "***8***"

Pile tips < 15' deep, min. 3-ft layer w/Q_u ≥ 1.5tsf in upper ½ of embedded pile length ⇒ "***5***"

History of "significant" scour or erosion:

Pile tips ≥ 35' deep, min. 3-ft layer w/Q_u ≥ 1.5tsf in upper ½ of embedded pile length ⇒ "***8***"

Pile tips ≥ 25' deep, min. 3-ft layer w/Q_u ≥ 1.5tsf in upper ½ of embedded pile length ⇒ "***5***"

Pile tips ≥ 15' deep, min. 3-ft layer w/Q_u ≥ 1.5tsf in upper ½ of embedded pile length ⇒ "***3***"

Pile tips < 15' deep ⇒ "***2***"

Friction piles in granular or soft soils:

Pile tips ≥ 40' below ground surface with significant scour present ⇒ "***4***"

Pile tips ≥ 30' below ground surface ⇒ "***3***"

Pile tips < 30' below ground surface ⇒ "***2***"

Scour Critical Evaluation Coding Report

Report Action: *New Evaluation, Re-evaluation, Error Revision*

Structure Number: _____ - _____

Item 113A Scour Critical Evaluation Date: ___/ ___/ ___ (mm/dd/yr)

Item 113 Scour Critical Rating: ___ (Valid Codes: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9)

Item 113B Scour Critical Evaluation Method: ___ (Valid Codes: A, B, C, D)

Item 113C Scour Critical Evaluation By: _____ (20 characters max.)

Item 113D Scour Critical Remarks: (3 lines, 79 characters max. each line.)

_____

_____

_____

IDOT Bridge Scour Assessment Procedure Worksheet

Scour Assessment: Structure Number : _____ - _____

I. y, n, u :⇒ _____

II. a. - y, n, u ; b.- y, n, u :⇒ _____

III. a. - y, n, u ; b.- y, n, u ; c. - y, n, u :⇒_____

IV. a. - y, n, u ; b.- y, n, u :⇒ _____

V. a. - y, n, u ; b.- y, n, u ; c. - y, n, u ; d.- y, n, u ; e. - y, n, u :⇒_____

VI. a. - y, n, u ; b.- y, n, u ; c. - y, n, u ; d. - y, n, u :⇒ _____

VII. a. - y, n, u ; b.- y, n, u ; c. - y, n, u :⇒ _____

VIII. a. - y, n, u ; b.- y, n, u ; c. - y, n, u ; d, - y, n :⇒_____

IX. a. - y, n ; b.- y, n : ⇒_____

X. _____

Item 113 - __ ; Item 113A - __/__/__ ; Item 113B - __ ; Item 113C - _____
Item 113D - _____

_____

_____

Scour Assessment: Structure Number : _____ - _____

I. y, n, u :⇒ _____

II. a. - y, n, u ; b.- y, n, u :⇒ _____

III. a. - y, n, u ; b.- y, n, u ; c. - y, n, u :⇒_____

IV. a. - y, n, u ; b.- y, n, u :⇒ _____

V. a. - y, n, u ; b.- y, n, u ; c. - y, n, u ; d.- y, n, u ; e. - y, n, u :⇒_____

VI. a. - y, n, u ; b.- y, n, u ; c. - y, n, u ; d. - y, n, u :⇒ _____

VII. a. - y, n, u ; b.- y, n, u ; c. - y, n, u :⇒ _____

VIII. a. - y, n, u ; b.- y, n, u ; c. - y, n, u ; d, - y, n :⇒_____

IX. a. - y, n ; b.- y, n : ⇒_____

X. _____

Item 113 - __ ; Item 113A - __/__/__ ; Item 113B - __ ; Item 113C - _____
Item 113D - _____

_____

INSTRUCTIONS FOR THE BRIDGE SCOUR ASSESSMENT PROCEDURE FOR LOCAL ROADS AND STREETS

The Illinois Department of Transportation has developed a scour assessment procedure to reduce the time and cost of evaluating bridges for foundation scour. This procedure is meant to provide guidance in evaluating existing bridges for vulnerability to scour and not as an exact analysis. The variableness of river geometry, scourability of bed materials, and magnitude and duration of floods may make an accurate analysis extremely costly or virtually impossible with the tools currently available. To streamline this complex process into a scour assessment procedure is difficult; however, with the use of engineering judgment and common sense, we believe a scour assessment can be helpful in reducing the number of bridges requiring a detailed analysis. Periodic observation and recording of the changes due to the dynamic nature of river geomorphics is essential. This should be a part of the routine NBIS inspections so they can be utilized as a comparison during future inspections.

Scour assessment eliminates the need for a calculated scour analysis by examining parameters related to the performance of the bridge under scour conditions. The parameters considered are:

- historical scour performance
- flood history
- scour countermeasures
- debris and blockage
- geomorphic conditions
- hydraulic conditions
- structural conditions
- special reduced risk conditions
- knowledge of foundation
- foundation scour resistance,.

It is intended that a bridge will be assessed for scour vulnerability under the direction of a professional engineer familiar with the bridge or expert in the subject of bridge scour, by answering the questions on a preprinted questionnaire entitled "Scour Assessment of Illinois Bridges". Information required to perform a scour assessment includes: structure inventory sheet, USGS quadrangle map showing the water course at least one mile upstream and one mile downstream of the bridge, plan and elevation drawings of the bridge, bridge photographs, and bridge inspection reports. Additional information that is recommended when available are soil information/boring logs and hydraulic design data. Although a field review may not be necessary if the engineer doing the screening is familiar with the bridge, in many cases a field review is recommended because it allows the engineer to see and document the conditions as they exist currently.

When the engineer(s) performing the evaluation believes that this scour assessment is not appropriate for a bridge, a scour critical analysis or an assessment based on engineering judgment may be performed instead. The scour analysis is to be performed using the USGS Simplified Scour Analysis Method (SSAM) or the equations from HEC 18. In cases where neither this assessment procedure or an analysis would yield an appropriate result, the engineer(s) may recommend an alternate value to be assigned for ISIS Item 113, Scour Critical Evaluation Rating. Such a scour critical assessment will be applied on a case-by-case basis using sound engineering judgment and the basis for the conclusions reached must be clearly documented in the bridge inspection file for the bridge to which it applies. When the BSAP or other engineering judgment procedure forms the primary basis for the rating and the bridge has a known foundation, then ISIS Item 113B, Scour Critical Evaluation Method should be coded "B" - "Rational Analysis".

Instructions: BSAP (cont'd)

Complete the questionnaire consisting of ten (10) sections in consecutive order (one for each parameter) by answering "yes", "no", or "unknown" to each question. Responses to questions in the various sections may result in rating the bridge without completing the questionnaire in total. Fill out the Scour Critical Analysis Coding Report with the appropriate coding values and comments for submittal to the IDOT District office.

The engineer(s) performing the assessment should fill out the assessment form according to the following instructions:

I. HISTORICAL SCOUR PERFORMANCE: This section accounts for any scour which has affected the bridge. The reviewer will consider foundation or substructure undermining which is specifically attributed to pier scour, abutment scour, contraction scour, channel vertical degradation, or channel lateral migration, which has not been corrected by properly designed and constructed scour countermeasures. Minor changes to the bridge's "designed and constructed condition", such as minor channel cross section changes or the need for riprap replenishment, which should be addressed by normal maintenance, are not at issue. If the bridge has continuing scour problems, a more detailed evaluation or monitoring program will be required.

II. FLOOD HISTORY: The intent of this section is to determine whether the bridge has experienced a flood which could have been a cause for scour damage. This may be determined from local records or from the attached USGS map. A bridge which has been documented to have experienced a 100-year flood with insignificant scour is considered to be stable for scour with no need for further monitoring. The fact that a bridge has withstood a 25-year flood without incurring significant scour indicates a degree of scour resistance.

III. SCOUR COUNTERMEASURES: This section considers the presence of properly designed and/or working scour countermeasures as a basis for scour critical evaluation. The Illinois Structure Information System (ISIS) indicates this by a Scour Critical Evaluation Rating (ISIS Item 113) of "**7**" when the countermeasures have corrected a previous scour problem. If scour countermeasures are in place, but no problem previously existed, e.g.- rip-rapped slopes, then Item 113 would be "**8**" for the affected substructure unit. To be considered as adequate the installation of the scour countermeasures must have been based on a design or they must have demonstrated the ability to withstand a 25-year flood as referred to in Section II. In order for the bridge's overall scour evaluation rating to be "7" or "8" *all* substructure units must warrant a scour rating of *at least* "7" or "8" respectively; i.e. - scour countermeasures at one substructure unit does not *necessarily* imply an ISIS Item 113 rating of "7" or "8".

IV. DEBRIS AND BLOCKAGE: The obstruction of a bridge opening by debris and ice is a serious problem which can have grave consequences for the bridge by partially damming the water course and raising the head differential from one side of the bridge to the other and therefore raising the water velocity through the bridge. These conditions are difficult to predict quantitatively and therefore any possibility of blockage must be treated as a potential scour problem and the bridge will require a more detailed evaluation or monitoring program.

V. GEOMORPHIC CONDITIONS AFFECTING SCOUR RESISTANCE: The reviewer must consider geomorphic conditions which may indicate a potential scour problem at the

Instructions: BSAP (cont'd)

bridge. Comparing current channel bottom elevations with the bottom elevations shown on the bridge plan can reveal that degradation of the channel or contraction scour has occurred under the bridge. Observed bank erosion; channel and bridge geometry which might aggravate scour conditions such as significant channel bends upstream of the bridge; piers or abutments which are skewed to the direction of flow; and significant constriction of flood flows can all be indicative of potential scour problems. If such conditions exist at the bridge site, a more detailed evaluation or monitoring program will be required.

VI. HYDRAULIC CONDITIONS AFFECTING SCOUR RESISTANCE: Water courses with small hydraulic gradients (and without the scour aggravating conditions discussed in Sections I., II., III., & IV. above) should not develop velocities sufficient to cause serious scour problems. The reviewer should consider the channel slope in the vicinity of the bridge and observed flood velocities which indicate non-scouring conditions. In general, if the average cross sectional velocity through the bridge during significant flood events is less than 3 fps (*5 fps* in clay bed streams) the bridge can be considered low risk for scour and no additional evaluation or monitoring is required. The questions in this section are designed to identify low velocity conditions.

VII. SINGLE SPAN BRIDGE CONSIDERATIONS: Certain structural features of single span bridges provide a demonstrated toughness against scour problems. These features include concrete abutments on piles and timber abutments less than 6 feet high on piles. In addition, man made drainage ditches designed to allow low velocities, have also been demonstrated to be non-threatening to single span bridges. If the reviewer can identify these conditions without the aggravating scour conditions discussed in Sections I. through VI. above, the bridge can be considered low risk for scour and further evaluation or monitoring is not required.

VIII. MONITORED REDUCED RISK BRIDGES: The bridge must meet one of the following criteria: Scheduled for replacement or installation of constructed scour countermeasures within 5 years; road classified as a Local Road or with an estimated ADT of less than 25; or overtopping the bridge or adjacent roadway on the average of every 5 years or less. This section is designed to identify bridges for which a monitoring program is a logical economic choice instead of continued scour evaluation studies. Bridges that are being monitored for scour can be considered to have a reduced risk to the general public. If a monitoring program is not in existence or will not be implemented, more detailed scour evaluation or countermeasures will be required.

Reduced risk bridges which have been evaluated as not having potential scour related problems in Sections I. through VII. could potentially warrant an ISIS Item 113 rating of "8". For these bridges, that possibility may be investigated by continuing with Section X. This step is to be considered as strictly optional. If the rating of "5" is considered to be acceptable the evaluation may stop here.

IX. KNOWLEDGE OF FOUNDATION: This section addresses situations when there is not enough information about foundation type or depth, or subsurface soil conditions to judge a structure's susceptibility to damage from streambed scour. For the purposes of this section a foundation is considered to be "unknown" only when there is no way to reasonably approximate its type and depth. Suggested sources of information are: pile driving logs, soil borings, construction billing records and estimated pile lengths on bridge

Instructions: BSAP (cont'd)

plans. When the depth is known but the soil types are unknown it shall be conservatively assumed that scourable soils predominate. Existing or historical scour problems will be accounted for when assigning the ISIS Item 113 rating for bridges with unknown foundations.

X. FOUNDATION SCOUR RESISTANCE: The intent of this section is to give the reviewer a chance to rate bridges for scour vulnerability with regard to the scour resistance of their foundations. This section may be applied to bridges with drainage areas of 700 square miles or less. A bridge with greater than a 700 square mile drainage area which have been referred to this section of the assessment procedure, must undergo a scour critical analysis.

The conditions considered under this section for spread footings and pile foundations include: founding bed materials (rock, cohesive and granular soils); depth of foundation; presence of scour; foundation exposure. The ISIS Item 113 rating is recommended in this section for each of the indicated foundation conditions. It is necessary that the "cohesive soil" classification be determined from soil boring data as recorded on the bridge plan or other soil boring logs and located in the approximate location and elevation of the foundation elements. A Standard Penetration Test in cohesive soils of approximately 12 blows per foot has been published in the literature as being correlated with an unconfined compressive strength of approximately 3000 lbs/ft'. Caution should be exercised when interpreting blow counts because wide variations in unconfined compression strength may exist for the same blow count. Sounding rod tests with a 50 lb. hammer are not appropriate for determining the existence of "cohesive" soils.

It is recognized that a scour analysis for bridges founded on erodible or semi-erodible bedrock or stiff clay is useless or of very limited value because the tools are not available at this time. It is expected that such materials will erode at a much slower rate than non-cohesive material, so that a close scrutiny during the routine inspection should be adequate to insure foundation integrity. Probing to determine the top of rock or stiff clay may be necessary to determine if there has been any change due to potential scour. Documenting the cross section taken at the bridge is recommended.

If the values derived from the assessment chart seem unreasonable to the evaluation team for a bridge they may choose to perform a scour critical analysis or to provide an alternative rationale for the rating based on sound engineering judgment.

Table 1. -- Bridge-site characteristics and associated abbreviations used in the simplified total streambed scour estimation method in Illinois

Characteristic	*Abbreviation*	*Explanation*
Drainage area	DA	That area, in square miles, in a drainage basin that is enclosed by the drainage divide.
100-year flood discharge	Q	The discharge for a particular drainage area of a particular stream that statistically has a 1 percent chance to occur in any given year. For Illinois streams, this value can be determined by the USGS regression equations (Curtis, 1987, Allen and Bejcek, 1979). The units are cubic feet per second.
Effecfive floodplain width	FPW	The width of the flood plain, one bridge length upstream from the bridge, that would have water of some velocity overtopping it during the 1 00-year flood discharge. Without detailed hydraulic information, this value is difficult to determine. For purposes of this study, when the value is unknown, the effective flood plain is estimated to be three times the bridge length. The units are feet.
Base flow channel width one bridge length upstream	CWU	The width of the base flow channel, in feet, from right descending bank to left descending bank one bridge length upstream from the bridge.
Base flow channel width at the bridge	CWB	The width of the base flow channel, in feet, from right descending bank to left descending bank at the bridge.
Bridge length	BW	The bridge length, in feet, from abutment to abutment.
Abutment type	AT	The type of abutment that is present at the bridge: vertical abutments with wingwalls, vertical abutments without wingwalls, and spill through abutments (Matthai, 1968).
Cutbank presence	CB	From a visual inspection of the bridge site, the amount of cutting present in the streambanks.
Low steel to bed distance	LSTB	The distance, in feet, between the lowest member of the bridge (that part of the bridge to contact the rising water surface first) and the approximate mean streambed elevation near mid-channel.
Bed material type	BM	The predominant type of bed material present in the streambed determined from a visual inspection.
Channel slope	S	The local channel slope, in feet per feet, near the bridge-site.
Pier type	PT	The type of pier present at the bridge (see fig. 8D). For bridges with multiple types of piers, by trial and error, pier type that results in the most conservative scour estimate should be used.

[USGS, U.S. Geological Survey]

Table 1.(Cont'd) -- Bridge-site characteristics and associated abbreviations used in the simplified total streambed scour estimation method in Illinois

Flow angle of attack	A	The predominant angle that the flow during floods will impact with the bridge pier (see fig. 8B).
Number of spans	SP	The number of spans present at the bridge-site.
Maximum pier width	PW	The maximum pier width for the bridge. For a multi-pier structure with piers of differing widths, the maximum of all the pier widths should be used. For those piers with varying vertical pier width, the maximum value should be used.
Existing scour presence	ES	From a visual site inspection, the degree, if any, of noticeable scour at the piers, abutments or wingwalls.