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ENGINEERING AND CONSTRUCTION BULLETIN

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Subject: Scour Upstream of Navigation Projects

Applicability: Guidance

1. Purpose: This Engineering and Construction Bulletin addresses findings from upstream Multi-beam Side Scan Sonar scour surveys for three of the Upper Mississippi River Locks and Dams, as well as findings of the ERDC Technical Report HL-87-4, *Scour Protection for Locks and Dams 2-10, Upper Mississippi River*,

<http://libweb.wes.army.mil/uhtbin/hyperion/TR-HL-87-4.pdf> and offers suggested guidance for taking and analyzing surveys, as well as design considerations for future scour protection upstream of our Locks and Dams.

2. Background: In April 2007 a survey of Mel Price Lock and Dam was performed using a 240 KHz multi-beam side scan sonar system. Evaluation of the graphical survey data indicated large areas of scour immediately upstream of Pier 2 and Piers 5-11, at the interface of the scour protection and concrete portion of the upstream sill. Scour depths below design grade varied from 7 to 23 feet with the deepest scour immediately upstream of Pier 2 exposing 7 feet of the upstream sheet pile cutoff wall. Surveys were conducted at Locks and Dams 24 and 25 using the same system to determine if similar scour situations had also occurred upstream of these navigation dams. Evaluation of the graphical survey data indicated larger areas of scour upstream of Locks and Dams 24 and 25 than at Mel Price. The deepest scour found at Dam No. 25 was 11 feet beneath the bottom of the concrete at gate bay 15 which exposed 11 feet of the sheet-pile cutoff wall. The scour adjacent to Pier 16 exposed 7 feet of the timber friction piles supporting the pier bull nose. The deepest scour at Dam No. 24 was 4 feet below the bottom of the concrete upstream of Pier 4. This exposed 4 feet of the upstream sheet pile cutoff wall and timber friction piles.

3. Discussion: USACE is concerned that upstream scour is potentially a systemic dam safety problem for all the navigation dams. Exposed unprotected upstream sheet pile cutoff walls can lead to serious under-seepage conditions developing that may lead to a piping condition. Exposure of the timber friction piles reduce the ability of the pile foundation to carry the loading on the dam piers which could result in excess pier movement and settlement. When piles are exposed over time, they can be damaged when passing ice or debris through the dam. Any of these conditions could cause the dam to become inoperable or lead to dam failure. A multi-disciplined team of engineers reviewed and analyzed surveys using conventional and Multi-beam Side Scan Sonar at other Mississippi River Locks and Dams and discovered similar but not as severe scour situations at several navigation structures. Surveys indicated that scour

started around the upstream piers or bull noses and progressed in front of the dam gates. Consensus of the team was that the scour holes developed over a long period of time and are consistent with scour around bridge piers. The team also concluded that the bedding material did not meet the current filter design criteria, allowing the underlying material to be piped out from beneath the protection causing the scour hole to develop, and there did not appear to be horizontal movement of the riprap or derrick stone through the gates.

WES Technical Report HL-87-1, *Scour Protection for Locks and Dams 2-10, Upper Mississippi River* dated April 1987 provides valuable information on scour upstream of locks and dams. For that report, scale model tests of lock and dam 2-10 were investigated for probable causes of scour on the Upper Mississippi River. Possible causes considered for the study included uncontrolled spillway flows, controlled spillway flows with low tailwater, non-uniform gate operation, the effect of frazil ice formation and stratified flow. Of the causes considered, it was found that single gate operation with large gate openings was the most critical, with scour occurring both upstream and downstream, with the deepest scour occurring downstream of the gate piers. The consensus of the team (described above) is consistent with findings stated in this report. HL-87-1 states that full-open and half-open gate operations for a single gate with normal pool and minimum tail water are critical hydraulic conditions for riprap design. Consideration should be given to potential impact to riprap design of non-uniform operations of multi-gate structures. Also, in the design of scour protection that is subject to highly turbulent flow the report stated it is imperative that an adequate filter be provided to prevent leaching of material from underneath the riprap.

4. Guidance:

a. Existing navigation projects should be given an initial survey within one year of the issue date of this bulletin, unless a comparable survey taken within the last 2 years shows no problems. Surveys should include the foundation contact areas upstream and downstream of the dam. Surveys should be taken using multi-beam side scan sonar systems or similar technology, which allow surveys to be taken closer to the dam gates without the boat being in close proximity to the gates.

b. A follow up survey should be taken within 2 years of the initial survey for dams having an alluvial foundation contact, and within 5 years for dams having a sound rock foundation contact. In either case, additional surveys should be taken after major high water events or as deemed necessary based on the initial surveys.

c. When analyzing scour surveys, the reviewer should compare the scour contours with the original design grades, as-built sections through the dam and foundation, and previous surveys.

d. Review the original or rehabilitation filter and riprap design in accordance with current engineering manuals and regulations to assure they include an analysis of the increased potential for piping of bedding material around gate piers and bull noses during ice and debris passage and hinge

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point operation. This would not be necessary in those instances where design of filter material is not an issue.

e. Review all lock and dam water control manuals for procedures on ice and debris passage and hinge point operation. Query lock and dam operators to determine if gate operating practices used in the past produced critical hydraulic conditions for lock and dam scour protection and update manuals if necessary. Single gate operations with large gate openings should be avoided since this is a major cause of scour adjacent to the structure.

f. The guidance provided in this ECB is relatively low cost and should be funded as routine O&M. Due to the relative low cost of inspection and the high consequence of instability due to scour, accomplishing sonar inspections should be considered urgent. Corrective action, if needed, may require special funding beyond what would be expected to come out of the routine O&M operating budget.

g. While this ECB addresses scour at navigation projects, consideration should be given to weirs, drainage control structures, or other pertinent structures also.

5. Point of contact for this bulletin is Duane Stagg, CEMVD-RB-T, 601-634-5644.

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JAMES C. DALTON, P.E.
Chief, Engineering and Construction
Directorate of Civil Works