REFERENCES

NATIONAL DOCUMENTS

HEC–23

SCDOT DOCUMENTS

RHDS

RELATED DRAWINGS & KEYWORDS

THIS DRAWING IS ONLY VALID FOR CONSTRUCTION WHEN SEALED AND SIGNED BY A PROFESSIONAL ENGINEER REGISTERED IN THE STATE OF SOUTH CAROLINA. CHECK WWW.SCDOT.ORG FOR LATEST UPDATE.

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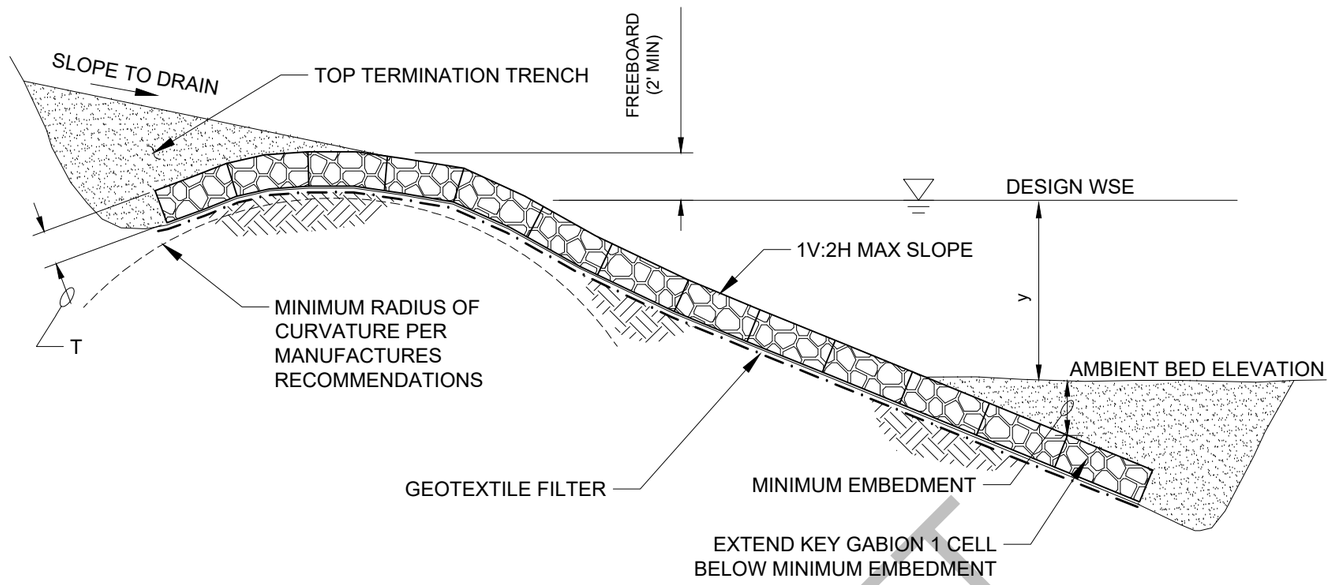
STANDARD DRAWING

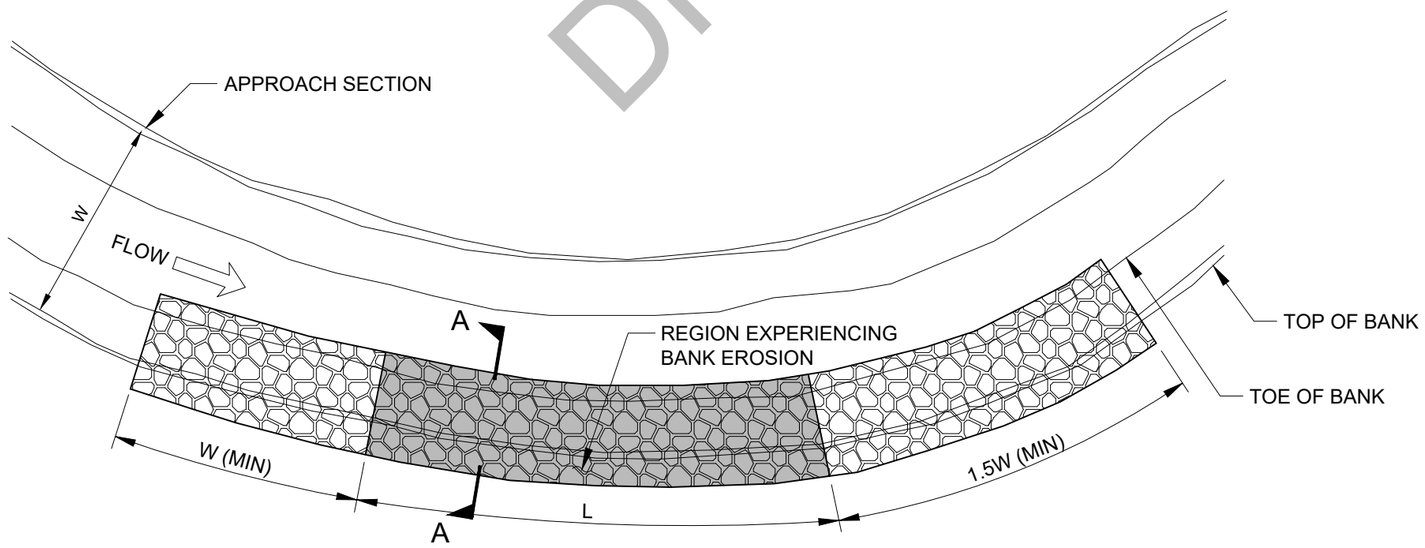
GABION REVETMENT FOR EXISTING SCOUR CRITICAL BRIDGES

XXX–XXX–XX

EFFECTIVE LETTING DATE



SECTION A-A



PLAN

CHART XXX-XXX		
SCDOT RIPRAP CLASSES		
CLASS	D_{50} (FT.)	MINIMUM THICKNESS (T) (FT)
C	1.30	2.60
D	1.80	3.60
E	2.25	4.50
F	2.85	5.70

NOTE:

1. DESIGN SCOUR COUNTERMEASURES IN ACCORDANCE WITH RHDS AND APPLICABLE
2. TERMINATION TRENCHES ARE RIPRAP STRUCTURES USED TO PROTECT BANKS FROM CAVING CAUSED BY EROSION
3. SEE PLANS FOR DIMENSIONS
4. MINIMUM EMBEDMENT = MAX(CS + LTD, BWS + LTD) + 0.2y (IF APPLICABLE)
5. THE REVETMENT SYSTEM SHOULD EITHER EXTEND BELOW THE DESIGN SCOUR DEPTH FOR THIS TYPE OF COUNTERMEASURE OR COVER THE ENTIRE CHANNEL BOTTOM. SEE HEC-23 FOR ALTERNATIVES WHEN THE DESIGN SCOUR DEPTH CANNOT BE REACHED. CONTACT HDSO BEFORE CONSIDERING ALTERNATIVES.
6. CLASS 2 NON-WOVEN GEOTEXTILE FABRIC UNDER RIPRAP PER SCOOT 2007 STANDARD SPECIFICATION FOR HIGHWAY CONSTRUCTION SECTION 804.2.11.
7. RIPRAP PER SCDOT STANDARD SPECIFICATION FOR HIGHWAY CONSTRUCTION SECTION 804.2 AND 804.3.
8. THE PAY ITEMS MAY INCLUDE:
   - 2031000 UNCLASSIFIED EXCAVATION CY
   - 8041020 RIPRAP (CLASS B) TON
   - 8041030 RIPRAP (CLASS C) TON
   - 8041040 RIPRAP (CLASS D) TON
   - 8041050 RIPRAP (CLASS E) TON
   - 8041060 RIPRAP (CLASS F) TON
   - 8042800 GEOTEXTILE FABRIC FOR EROSION CONTROL UNDER RIPRAP (CLASS 2) SY

VARIABLES:

CS = CONTRACTION SCOUR
LTD = LONG TERM DEGRADATION
BWS = BENDWAY SCOUR (MIN)
T = MINIMUM THICKNESS = $2D_{50}$ (SEE CHART XXX-XXX), INCREASE BY 50% FOR UNDERWATER INSTALLATIONS
L = LENGTH OF BANK EROSION
y = DESIGN FLOW DEPTH OF APPROACH SECTION
0.2y = BEDFORM TRENCH DEPTH
D_{50} = MEDIAN GRAIN SIZE
D_{100} = MAX GRAIN SIZE/ACTIVE LAYER THICKNESS

THIS DRAWING IS NOT TO SCALE

REFERENCES

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STANDARD DRAWING

GABION REVETMENT FOR EXISTING SCOUR CRITICAL BRIDGES

XXX–XXX–XX

EFFECTIVE LETTING DATE

GENERAL NOTES

1. GABION MATTRESSES CONSIST OF WIRE MESH FILLED WITH ROCKS. THE LENGTH OF A GABION MATTRESS IS GREATER THAN THE WIDTH, AND THE WIDTH IS GREATER THAN THE THICKNESS. THE WIRE MESH ALLOWS THE GABIONS TO DEFORM AND ADAPT TO CHANGES IN THE SUBGRADE WHILE MAINTAINING STABILITY. GABION MATTRESSES PROVIDE THE BENEFIT OF ALLOWING THE USE OF SMALLER ROCKS FOR PROTECTION THAN WOULD BE REQUIRED WITH ROCK RIPRAP.

2. GABION RIPRAP IS SUBJECT TO THE SAME RECOMMENDED STANDARD TESTS AS RIPRAP REVETMENT. THESE TESTS ARE INTENDED TO ENSURE THAT THE ROCK IS DENSE, DURABLE, AND WILL NOT DEGRADE SIGNIFICANTLY OVER TIME. ROCKS USED FOR GABION MATTRESSES SHOULD ONLY BREAK WITH DIFFICULTY, HAVE NO EARTHY ODOR, NO CLOSELY SPACED DISCONTINUITIES, AND SHOULD NOT ABSORB WATER EASILY. THE RECOMMENDED TESTS AND ALLOWABLE VALUES ARE SUMMARIZED IN HEC-23 VOLUME 2.

3. WIRE SHOULD BE SINGLE STRAND GALVANIZED STEEL. THE WIRE MESH MAY BE FORMED WITH A DOUBLE TWIST HEXAGONAL PATTERN OR CAN BE MADE OF WELDED WIRE FABRIC. FASTENERS, SUCH AS RING BINDERS OR SPIRAL BINDERS, MUST BE OF THE SAME QUALITY AND STRENGTH AS THAT SPECIFIED FOR THE GABION MATTRESSES. REFERENCE HEC-23 VOLUME 2 FOR ASTM STANDARDS RELEVANT TO THE WIRE.

4. DUE TO THE POTENTIAL FOR ABRASION BY COARSE BED LOAD, GABION MATTRESSES ARE NOT APPROPRIATE FOR GRAVEL BED STREAMS AND SHOULD ONLY BE USED IN SAND- OR FINE-BED STREAMS. ADDITIONALLY, WATER QUALITY OF THE STREAM MUST BE NONCORROSIVE (I.E., NON-SALINE AND NON-ACIDIC). A POLYVINYL CHLORIDE (PVC) COATING SHOULD BE USED FOR APPLICATIONS WHERE THE POTENTIAL FOR CORROSION EXISTS.

5. FLEXIBILITY OF THE GABION MATTRESS UNITS IS A MAJOR FACTOR IN THE SUCCESSFUL PERFORMANCE OF THESE SYSTEMS. THE ABILITY TO ADJUST TO DIFFERENTIAL SETTLEMENT, FROST HEAVE, OR OTHER CHANGES IN THE SUBGRADE IS DESIRABLE.

7. PLANS, AS-BUILTS, AND DESIGN DOCUMENTATION ARE REQUIRED. HDSO REVIEW AND APPROVAL ARE REQUIRED FOR ALL ITEMS.

8. FOLLOW SPECIFICATIONS IN 804.2.1, 804.2.7, 804.2.11 FOR MATERIALS. FOLLOW SPECIFICATIONS 804.4.7 FOR CONSTRUCTION.

LIMITATIONS:

1. MUST HAVE ADEQUATE TURN DOWNS AT PERIPHERY.

2. WIRES ARE EASILY ABRADED WHEN EXPOSED TO COARSE BEDLOAD (GRAVEL AND COARSER).

3. WIRES MUST BE GALVANIZED OR PVC COATED TO RESIST CORROSION IN BRACKISH, SALTY, OR CORROSIVE WATER.

4. MORE DIFFICULT TO PLACE UNDERWATER THAN IN THE DRY.

DESIGN GUIDELINES

PRIOR TO DESIGNING ANY COUNTERMEASURE, FOLLOW DIRECTIONS IN POAGM SECTION 5 AND RHDS. PERFORM A FULL STREAM STABILITY AND SCOUR EVALUATION FOLLOWING HEC 20 AND RHDS.

ESTIMATE LATERAL INSTABILITY, LONG-TERM DEGRADATION, CONTRACTION SCOUR (IF APPLICABLE), MAXIMUM BEDFORM TROUGH DEPTH BELOW THE BED (FOR SAND-BED CHANNELS), AND ACTIVE LAYER DEPTH (FOR COARSE-BED CHANNELS). SCOUR EVALUATION FOR COUNTERMEASURE DESIGN AT SCOUR CRITICAL BRIDGES MUST BE CONSISTENT WITH RHDS, AT A MINIMUM.

2D MODELS ARE REQUIRED FOR HYDRAULIC COUNTERMEASURE DESIGN. SEE RDHS FOR MORE REQUIRMENTS AND GUIDANCE.

RIPRAP SIZING:

THE MINIMUM TARGET FACTOR OF SAFETY (SF_T) FOR REVETMENT IS 1.2. LARGER VALUES SHOULD BE USED BASED ON CONSEQUENCE OF FAILURE (X_C) AND UNCERTAINTY (X_M) IN HYDROLOGIC AND/OR HYDRAULIC MODELING. ONCE A DESIRED TARGET FACTOR OF SAFETY IS ESTABLISHED, THE ACTUAL FACTOR OF SAFETY IS CALCULATED FOR A PARTICULAR GABION MATTRESS SYSTEM. THE ACTUAL FACTOR OF SAFETY FOR THE DESIGN CONDITIONS SHOULD BE EQUAL TO OR GREATER THAN THE TARGET VALUE. PROCEDURES FOR DETERMINING THE TARGET FACTOR OF SAFETY ARE ILLUSTRATED IN HEC-23 VOLUME 2.

$$SF_T = (SF_B)(X_C)(X_M)$$

WHERE:

- SF_B = BASE FACTOR OF SAFETY (1.2-1.4 FOR CHANNEL BED OR BANKS)
- X_C = MULTIPLIER FOR CONSEQUENCE OF FAILURE (1.0-2.0)
- X_M = MULTIPLIER FOR DEGREE OF UNCERTAINTY (1.0-2.0)

THE LOCAL SHEAR STRESS AT THE OUTSIDE OF THE BEND THAT ACCOUNTS FOR SUPERELEVATION AND FLOW ACCELERATION SHOULD BE USED IN DESIGN EQUATIONS. A 2D HYDRAULIC MODEL DIRECTLY ACCOUNTS FOR THESE EFFECTS, AND SO THE DESIGNER CAN USE THE REGIONAL MAXIMUM SHEAR STRESS ALONG THE BEND. BECAUSE A 1D MODEL DOES NOT ACCOUNT FOR THESE EFFECTS, THE DESIGN SHEAR STRESS SHOULD BE ADJUSTED USING THE FOLLOWING EQUATION:

$$\tau_{des} = K_b \gamma_W y SF_T$$

WHERE:

- τ_{des} = DESIGN SHEAR STRESS AT PIER
- K_b = BEND COEFFICIENT
  - = 2.0 FOR $RC/T \le 2.0$
  - = $2.38 - 0.206(R_C/T) + 0.0073(R_C/T)^2$ FOR $2.0 < R_C/T < 10.0$
  - = 1.05 FOR $R_C/T \ge 10.0$
- γ_W = UNIT WEIGHT OF WATER, 62.4 LB/FT^3 FOR FRESH WATER
- y = DEPTH OF FLOW AT PIER
- SF_T = FACTOR OF SAFETY
- R_C = RADIUS OF CURVATURE OF BEND
- T = TOP WIDTH OF CHANNEL

PERMISSIBLE SHEAR STRESS CAN THEN BE CALCULATED:

$$\tau_p = (SF_T)(\tau_{des})$$

FOR GABION MATTRESSES PLACED ON CHANNEL BEDS OR BANKS, THE SHEAR STRESS ON THE MATTRESS IS CALCULATED AS FOLLOWING METHODS IN HEC-23. THE PROCEDURE FOR DETERMINING THE PERMISSIBLE SHEAR STRESS FOR A GABION MATTRESS IS DETERMINED USING THE RELATIONSHIP PROVIDED IN HEC-15. THE FACTOR OF SAFETY PROCEDURES IN HEC-23 IS TO BE USED AS PART OF THE PROCESS.

THE ROCK RIPRAP PARTICLE SIZE FOR WHICH 50% IS FINER BY WEIGHT IS DETERMINED USING THE FOLLOWING EQUATION:

$$d_{50} = \tau_p/(C_s(\gamma_S - \gamma_W))$$

WHERE:

- d_{50} = MEDIAN ROCK RIPRAP PARTICLE SIZE
- C_s = 0.10, STABILITY COEFFICIENT FOR ROCK-FILLED GABION MATTRESS
- γ_S = UNIT WEIGHT OF ROCK
- γ_W = UNIT WEIGHT OF WATER, 62.4 LB/FT^3 FOR FRESH WATER

THE MINIMUM ROCK SIZE SHOULD BE AT LEAST 1.25 TIMES LARGER THAN THE MESH APERTURE SIZE, AND ROCK SIZE SHOULD BE WELL-DISTRIBUTED TO MINIMIZE VOIDS.

IF THE DESIGN SIZE OF THE RIPRAP DOES NOT MATCH A STANDARD RIPRAP SIZE CLASS, SELECT THE NEXT LARGEST SIZE CLASS FOR DESIGN.

GABION LAYOUT EXTENTS, EMBEDMENT, AND THICKNESS:

THE THICKNESS OF THE MATTRESS SHOULD BE AT LEAST TWICE THE MEDIAN ROCK DIAMETER. AT A MINIMUM, THE THICKNESS OF THE GABION MATTRESS SHOULD BE GREATER THAN 12 INCHES. IF THE COMPUTED THICKNESS DOES NOT MATCH A STANDARD GABION THICKNESS, THE NEXT LARGER THICKNESS SHOULD BE USED.

THE REVETMENT ARMOR SHOULD CONTINUOUSLY COVER A LONGITUDINAL DISTANCE THAT EXTENDS BOTH UPSTREAM AND DOWNSTREAM OF THE REGION WHICH EXPERIENCES HYDRAULIC FORCES SEVERE ENOUGH TO CAUSE DISLODGING AND /OR TRANSPORT OF BED OR BANK MATERIAL. THE MINIMUM UPSTREAM DISTANCE IS 1.0 CHANNEL WIDTH AND MINIMUM DOWNSTREAM DISTANCE IS 1.5 CHANNEL WIDTHS. EACH UPSTREAM AND DOWNSTREAM TERMINATION POINT OF THE GABION MATTRESS REVETMENT SHOULD INCLUDE A KEY TRENCH TO LIMIT FLOW TRANSITION SCOUR.

THE CHANNEL REACH WHICH EXPERIENCES SEVERE HYDRAULIC FORCES IS USUALLY IDENTIFIED BY SITE INSPECTION, EXAMINATION OF AERIAL PHOTOGRAPHY, HYDRAULIC MODELING, OR A COMBINATION OF THESE METHODS. IN MEANDERING REACHES, SINCE THE NATURAL PROGRESSION OF BANK EROSION IS IN THE DOWNSTREAM DIRECTION, THE PRESENT LIMIT OF EROSION MAY NOT NECESSARILY DEFINE THE ULTIMATE DOWNSTREAM LIMIT. HEC-20 PROVIDES GUIDANCE FOR THE ASSESSMENT OF LATERAL MIGRATION. THE DESIGN ENGINEER IS ENCOURAGED TO REVIEW THIS REFERENCE FOR PROPER IMPLEMENTATION.

THE VERTICAL EXTENT OF THE REVETMENT SHOULD PROVIDE A MINIMUM OF 2 FEET OF FREEBOARD ABOVE THE DESIGN WATER SURFACE. FREEBOARD IS AT LEAST 3 FT FOR CONTRACTED REACHES. IF THE FLOW IS SUPERCRITICAL, THE FREEBOARD SHOULD BE BASED ON HEIGHT ABOVE THE ENERGY GRADE LINE RATHER THAN THE WATER SURFACE.

THE REVETMENT SYSTEM SHOULD EXTEND BELOW THE BED TO A DEPTH AT LEAST AS DEEP AS BENDWAY SCOUR PLUS LONG-TERM DEGRADATION OR CONTRACTION SCOUR PLUS LONG-TERM DEGRADATION, PLUS BEDFORM TRENCH DEPTH (0.2y).

WHERE SUCH TOE DOWN DEPTH CANNOT BE ACHIEVED, SUCH AS IF BEDROCK IS ENCOUNTERED, ANCHORS ALONG THE UPSTREAM FACE AND SIDES OF THE MATTRESSES ARE RECOMMENDED. SPACING BETWEEN ANCHORS OF NO MORE THAN 4 FT IS RECOMMENDED. SEE HEC-23 VOLUME 2 FOR MORE INFORMATION ON ANCHOR SPACING.

A GABION COUNTERMEASURE MUST INCLUDE A GEOTEXTILE FILTER TO RETAIN UNDERLYING FOUNDATION SOILS AND ALLOW FREE PASSAGE OF PORE WATER. GEOTEXTILE FILTERS SHOULD EXTEND BENEATH THE ENTIRE GABION MATTRESS LAYER. FOR GABION MATTRESSES PLACED ON CHANNEL BEDS OR BANKS, THE SHEAR STRESS ON THE MATTRESS IS CALCULATED AS FOLLOWING METHODS IN HEC-23.

INSTALLATION

GUIDELINES

MANUFACTURER'S ASSEMBLY INSTRUCTIONS SHOULD BE FOLLOWED. MATTRESSES SHOULD BE PLACED ON THE FILTER LAYER AND ASSEMBLED SO THAT THE WIRE DOES NOT KINK OR BEND. MATTRESSES SHOULD BE ORIENTED SO THAT THE LONG DIMENSION IS PARALLEL TO THE FLOW AND INTERNAL DIAPHRAGMS ARE PERPENDICULAR TO THE FLOW. PRIOR TO FILLING, ADJACENT MATTRESSES SHOULD BE CONNECTED ALONG THE VERTICAL EDGES AND THE TOP SELVEDGES BY LACING, FASTENERS, OR SPIRAL BINDING. CUSTOM FITTING OF MATTRESSES AROUND CORNERS OR CURVES SHOULD BE DONE ACCORDING TO THE MANUFACTURER'S RECOMMENDATIONS.

AVOID DAMAGE TO THE GEOTEXTILE OR SUBGRADE. MATTRESSES SHOULD NOT BE PUSHED OR PULLED LATERALLY ONCE THEY ARE ON THE GEOTEXTILE. PLACE AND FILL MATTRESSES STARTING AT THE UPSTREAM SECTION AND PROCEED DOWNSTREAM. ON SLOPED SECTIONS, BEGIN PLACEMENT AND FILLING AT THE TOE OF THE SLOPE AND PROCEED UPSLOPE. DO NOT INSTALL GABION MATTRESSES ON A SLOPE STEEPER THAN 2H:1V (50%).

EXCAVATION, GRADING, AND PLACEMENT OF GABION MATTRESSES AND FILTER UNDER WATER REQUIRE ADDITIONAL MEASURES. FOR INSTALLATIONS OF A RELATIVELY SMALL SCALE, DIVERSION OF THE STREAM AROUND THE WORK AREA CAN BE ACCOMPLISHED DURING THE LOW FLOW SEASON. FOR INSTALLATIONS ON LARGER RIVERS OR IN DEEPER WATER, THE AREA CAN BE TEMPORARILY ENCLOSED BY A COFFERDAM WHICH ALLOWS FOR CONSTRUCTION DEWATERING IF NECESSARY. ALTERNATIVELY, A SILT CURTAIN MADE OF PLASTIC SHEETING MAY BE SUSPENDED BY BUOYS AROUND THE WORK AREA TO MINIMIZE ENVIRONMENTAL DEGRADATION DURING CONSTRUCTION.

INSPECTION & MAINTENANCE

THE INSPECTION OF COUNTERMEASURES AT EACH BRIDGE SHOULD BE PERFORMED AND RECORDED DURING ROUTINE, SCOUR, AND THE UNDERWATER INSPECTION AT A MINIMUM. ENSURING FUNCTIONING CONDITION OF THE COUNTERMEASURE IS ESSENTIAL FOR LONG-TERM FOUNDATION PROTECTION AGAINST SCOUR. ANY DAMAGE OR REMOVAL OF THE COUNTERMEASURE ELEMENTS SHOULD BE RECORDED IN THE INSPECTION REPORT AND REPORTED TO THE HYDRAULIC DESIGN SUPPORT OFFICE AND TO THE DISTRICT BRIDGE ENGINEER . MAINTENANCE REPAIRS SHOULD BE CONDUCTED AT THE EARLIEST OPPORTUNITY IF DISTRESS IS OBSERVED.