QUALITY CONTROL HYDRO CHECKLIST FOR BRIDGE AND BRIDGE-SIZED CULVERT

****Tidal follows riverine criteria except when specifically noted****

QC Item	Check Box			Reference
Computer Models				
Acceptable numerical models used for Hydrology and Hydraulics	□Yes	□ No	□N/A	RHDS p. 74
List computer models used: _____				
Qualitative and Geomorphic Analysis				
Stream Characteristics analyzed	□Yes	□ No	□N/A	RHDS 1.2.1.1
Land Use Changes analyzed	□Yes	□ No	□N/A	RHDS 1.2.1.2
Overall Stability analyzed	□Yes	□ No	□N/A	RHDS 1.2.1.3
Lateral Stability analyzed	□Yes	□ No	□N/A	RHDS 1.2.1.4
Vertical Stability analyzed	□Yes	□ No	□N/A	RHDS 1.2.1.5
Debris Potential analyzed	□Yes	□ No	□N/A	RHDS 1.2.1.6
Stream Response analyzed	□Yes	□ No	□N/A	RHDS 1.2.1.7
Hydrologic Analysis				
Discharges calculated for the 50,10,4,2,1, and 0.2 % AEP (2, 10, 25, 50, 100, and 500-year storm events)	□Yes	□ No	□N/A	RHDS 1.3.1.1 C
Discharges determined using USGS regression equations (most common)	□Yes	□ No	□N/A	RHDS 1.3.1.1 C
Discharges determined using Log-Pearson Type III frequency distribution for gaged streams	□Yes	□ No	□N/A	RHDS 1.3.1.1 C
Hydrograph routing for drainage areas with significant storage volume	□Yes	□ No	□N/A	RHDS 1.3.1.1 C
Other method for determining discharges (explanation required)	□Yes	□ No	□N/A	RHDS 1.3.1.1 C
□Explanation_____				
Flood History and Stream Analysis				
Flood history studied	□Yes	□ No	□N/A	RHDS 1.3.1 Step 1 A
Field evaluation conducted for proposed bridge site to determine natural hydraulic controls or dams within the reach, determine existing bridge performance, document "n" values, and sketch the existing site and structure.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 A
Field evaluation conducted for comparative bridge sites ranging in size from half to twice the drainage area of the study site to evaluate the hydraulic performance of crossings used as comparative data	□Yes	□ No	□N/A	RHDS 1.3.1.Step 2 A; RHDS 1.3.1 Step 1 D; Comparative Data Sheet in Section 1.6.2
Documentation of possible violations of drainage regulations to Department legal staff	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 B
Watershed sediment yield evaluated. Level 3 Analysis conducted for sites with large rates of change in sediment yield	□Yes	□ No	□N/A	RHDS 1.3.1 Step 4
Incipient Motion analysis completed	□Yes	□ No	□N/A	RHDS 1.3.1 Step 5
Potential for armoring evaluated	□Yes	□ No	□N/A	RHDS 1.3.1 Step 6
Historical rating curve data has been evaluated for streams with USGS gages to give indication of long-term stability	□Yes	□ No	□N/A	RHDS 1.3.1 Step 7
Level 3 Analysis performed for studies requiring 2D hydraulic modeling	□Yes	□ No	□N/A	RHDS 1.4
Hydraulic Modeling				
Hydraulic analysis performed using appropriate 1D or 2D method for modeling	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 B

Hydraulic model contains existing, natural, and proposed conditions runs	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 B
50,10,4,2,1, and 0.2 % AEP (2, 10, 25, 50, 100, and 500-year storm event) discharges are modeled for each condition	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 B
Hydraulic model geometry developed from survey data, LiDAR, and/or USGS topo maps	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 B
Hydraulic model contains sensitivity analysis to ensure study is modeled downstream far enough to where a +- 3 ft starting water surface elevation does not affect water surface elevation at proposed bridge site	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 B
Hydraulic model extends upstream far enough to where no backwater is caused by the proposed bridge	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 B
Compliance to FEMA and SCDOT guidelines have been met when modeling bridges and culverts within limits of Flood Insurance Studies	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
1-D model follow HEC-RAS *Hydraulic Reference Manual* guidelines	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
2-D models follow *Two Dimensional Hydraulic Modeling for Highways in the River Environment* guidance and others mentioned in RHDS section	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
Appropriate Mannings "n" values used in model	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 A 2
Bridge Geometric Layout				
Low chord of replacement bridge not below existing bridge	□Yes	□ No	□N/A	HDB 2019-4 1.1.9;**Design Variance**
Bridge ends of replacement bridge not within limits of existing bridge	□Yes	□ No	□N/A	HDB 2019-4 1.1.9;**Design Variance**
Abutment toes of replacement bridge do not extend past abutment toe of existing bridge	□Yes	□ No	□N/A	HDB 2019-4 1.1.9;**Design Variance**
Orientation of bridge substructure determined by high flow angle	□Yes	□ No	□N/A	RHDS 1.3.1 Step 8
Spacing of overflow bridges does not exceed 1/2 mile in wide floodplains	□Yes	□ No	□N/A	RHDS 1.3.1 Step 8
Min low chord set based on hydraulic design criteria. Check freeboard requirements. Roadway and structural requirements may dictate higher grade than hydraulic requirements.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 8
Channels 100 ft and less are completely spanned	□Yes	□ No	□N/A	HDB 2019-4 1.1.11
Min distance from top of channel bank for abutment setback met. Abutment toe placed 10 ft from top of bank, or at a point where the projection of the spill through slope provides a minimum 10 ft distance from any point on the channel bank or bed, whichever distance is greater	□Yes	□ No	□N/A	HDB 2019-4 1.1.10 - Figure 1.3; **Design Variance**
Min distance from top of channel bank for substructure setback met. Minimum set back for piles = 5 ft setback; Pier widths <= 5ft = 10 ft setback; Pier width > 5 ft = 10 ft setback plus half the pier width beyond 5 ft	□Yes	□ No	□N/A	HDB 2019-4 1.1.11 - Figure 1.4, 1.5 and Table 1.2
Bents and piers aligned to existing structure for parallel bridges	□Yes	□ No	□N/A	RHDS 1.3.1.8 Step 8 C
Piers are located away from bank toes	□Yes	□ No	□N/A	HEC 9 and HEC 18
Piers are not located near the thalweg	□Yes	□ No	□N/A	HEC 9 and HEC 18
Hydraulic Model Design Criteria				
1 % AEP (100-yr event) flood does not overtop roadway	□Yes	□ No	□N/A	HDB 2019-4 1.1.1; **Design Variance**
Backwater < 1.0 ft for 1 % AEP (100-yr event) compared to natural conditions	□Yes	□ No	□N/A	HDB 2019-4 1.1.1; **Design Variance**

Proposed bridge backwater <= existing bridge backwater	□Yes	□ No	□N/A	HDB 2019-4 1.1.1; **Design Variance**
Design flood frequency correct for road type □4 % AEP (25-year event) for secondary routes □2 % AEP (50-year event) for Interstate, Primary, and Evacuation Routes	□Yes	□ No	□N/A	HDB 2019-4 1.1.1
Min freeboard requirements met for design flood □Rivers - min 2.0 ft □Large rivers - min 7.0 ft □Lakes - min 8.0 ft	□Yes	□ No	□N/A	HDB 2019-4 1.1.5; **Design Variance**
Free surface flow maintained through bridge for frequencies up to and including the 1 % AEP (100-year event)	□Yes	□ No	□N/A	HDB 2019-4 1.1.5.1; **Design Variance**
Bench elevation is above design high water elevation	□Yes	□ No	□N/A	HDB 2019-4 1.1.6; Standard Drawing 804-105-00; **Design Variance**
Abandoned road embankments and temporary construction fill is removed and the area graded to the approximate natural ground conditions.	□Yes	□ No	□N/A	HDB 2019-4 1.1.9; **Design Variance**
Lifelines and Interstate are operational during the 1 % AEP (100-year event) and 0.2 % AEP (500-year event)	□Yes	□ No	□N/A	HDB 2019-4 1.1.1
*Tidal - Freeboard is 2 ft above the 10-year design storm plus wave height	□Yes	□ No	□N/A	RHDS 1.1.5.2
Plan Sheet Requirements				
Scour plots for 1 % AEP (100-year event) and 0.2 % AEP (500-year event) shown on plan and profile sheet	□Yes	□ No	□N/A	RHDS 1.5.1
Flow direction shown on plans	□Yes	□ No	□N/A	RHDS 1.5.1
Historical high water data shown on plans	□Yes	□ No	□N/A	RHDS 1.5.1
Hydro data shown on plans	□Yes	□ No	□N/A	RHDS 1.5.1
Note on plans showing location of USGS equipment and referencing the special provision	□Yes	□ No	□N/A	PCDM 21
Bridge Hydraulic Report				
Latest edition of the Requirements for Hydraulic Design Studies used on title sheet of plans and cover page of report	□Yes	□ No	□N/A	RHDS 1.5
Title sheet and an index page signed and sealed by a Registered Professional Engineer of the State of South Carolina	□Yes	□ No	□N/A	RHDS 1.5
Narrative, modifications being made, specifics on existing and proposed structures, floodplain zone type and explanation, justification for a finding of "No Impact" or CLOMR/LOMR route, conclusions, and project location provided. If applicable, a signed and sealed copy of the "No impact" statement included in report.	□Yes	□ No	□N/A	RHDS 1.5
Hydraulic analysis narrative with background information, scope of work, overview of the models used and the difference between each one, vertical datum used for the modeling and project, and analysis for SCDOT and FEMA compliance provided	□Yes	□ No	□N/A	RHDS 1.5
Scour analysis with table showing the applicability of the SC envelope curves, an explanation of HEC-18 equations used, a table showing the results of the study, a copy of the SC envelope equations spreadsheet, and determination of scour type provided	□Yes	□ No	□N/A	RHDS 1.5

Comparison table in the report for the water surface elevations for the design event, 1 % AEP (100-year event), 0.2 % AEP (500-year event), and any other flood events for the natural, existing, and proposed models provided	□Yes	□ No	□N/A	RHDS 1.5
Figure showing the location of cross sections, control structure in and outside survey limits, ineffective flow pattern lines, and other applicable information for the existing and proposed models provided	□Yes	□ No	□N/A	RHDS 1.5
Hydrology Data Sheet for Riverine Bridge completed	□Yes	□ No	□N/A	RHDS 1.5.4
Comparative Data Sheet complete	□Yes	□ No	□N/A	RHDS 1.6.2
Site Inspection Form	□Yes	□ No	□N/A	RHDS 1.6.3
Site Characteristics Form complete	□Yes	□ No	□N/A	RHDS 1.6.3.1
Comparative Bridge Site Inspection Form complete	□Yes	□ No	□N/A	RHDS 1.6.2
Manning's "n" Values for Channels form complete	□Yes	□ No	□N/A	RHDS 1.6.3.2
Manning's "n" Values for Overbanks form complete	□Yes	□ No	□N/A	RHDS 1.6.3.4
Risk Assessment Form complete	□Yes	□ No	□N/A	RHDS 1.6.4
Scour				
Historical data and scour history reviewed to gain insights on scour potential	□Yes	□ No	□N/A	RHDS 1.3.1 Step 1 B; HDB 2019-3
Soil borings considered for location bridge foundation and scour analysis	□Yes	□ No	□N/A	RHDS 1.3.1 Step 3
D_{50} from surface bed in channel and floodplain used	□Yes	□ No	□N/A	HDB 2019-3
Sediment supply and land use changes considered for bridge foundation design	□Yes	□ No	□N/A	RHDS 1.3.1 Step 4
Scour analysis performed for the 1 % AEP (100-year event) and 0.2 % AEP (500-year event) storms	□Yes	□ No	□N/A	HDB 2019-3
Scour analysis performed using USGS bridge-scour envelope curves, where possible. Preferred alternative when site characteristics are within the limits of the data.	□Yes	□ No	□N/A	HDB 2019-3
Scour analysis performed using HEC-18 when USGS bridge-scour curves are not applicable and for comparison purposes. Used with unusual site conditions (pressure flow, overtopping, hydraulically wide piers, and complex piers).	□Yes	□ No	□N/A	HDB 2019-3
Min Class B rip-rap for abutment protection is used	□Yes	□ No	□N/A	HDB 2019-4 1.1.6; Standard Drawing 804-105-00
Rip-rap thickness 2 x D_{50} on end fills	□Yes	□ No	□N/A	HDB 2019-4 1.1.6; Standard Drawing 804-105-00
Rip-rap entrenched 2.0 ft below ground line and 2.0 ft above design year storm (or top of bench)	□Yes	□ No	□N/A	HDB 2019-4 1.1.6; Standard Drawing 804-105-00
Rip-rap protection provided on all abutment end fills	□Yes	□ No	□N/A	HDB 2019-3
Bridge foundations designed to withstand scour without aid of bridge-scour countermeasures	□Yes	□ No	□N/A	HDB 2019-4 1.1.4
Hydraulic Scour Depth estimated from <u>one</u> method of analysis based on engineering judgement	□Yes	□ No	□N/A	HDB 2019-3
Scour analysis made for bottomless culverts based on HEC-18 guidance	□Yes	□ No	□N/A	HDB 2019-3
Design avoids severe flow contractions	□Yes	□ No	□N/A	HDB 2019-3
Bridge sized to minimize velocities and scour potential	□Yes	□ No	□N/A	HDB 2019-4 1.1.3
Channel stabilization considered for site in or near a channel bend. Channel stabilization discussed in HEC-11 and HEC-20	□Yes	□ No	□N/A	HDB 2019-3
Channel degradation added to other scour components for streams with gravel and sand mining	□Yes	□ No	□N/A	HDB 2019-3
Worst case for scour potential used for sites with backwater from lakes or larger streams.	□Yes	□ No	□N/A	HDB 2019-3

HEC-18 guidance followed for evaluating scour at bridges with overtopping/pressure flow	□Yes	□ No	□N/A	HDB 2019-3
Geotechnically Adjusted Scour Depth (GASD) used for final scour profiles	□Yes	□ No	□N/A	HDB 2019-3
Scour study and determination for Item 113 (Scour Critical Bridges) sent to Hydraulic Design Support Office for inclusion in Bridge Maintenance's Bridge Files	□Yes	□ No	□N/A	HDB 2019-4 1.1.4
*Tidal - HEC-18 guidance used for scour analysis of tidal bridges	□Yes	□ No	□N/A	RHDS 1.3.2.4
*Tidal - Scour protection for tidal culverts designed for both ends of the culvert under maximum velocity conditions	□Yes	□ No	□N/A	RHDS 1.3.2.5
Bridges in Floodplains				
There is no increase in the post water surface profiles compared to pre conditions. Non-compliance requires FEMA involvement.	□Yes	□ No	□N/A	HDB 2019-4 1.1.2
Proper model designations used in model with floodplain. The model designations are current effective, converted, corrected effective, existing conditions, revised conditions, unrestricted (or natural) conditions, as-build revised conditions.	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.1
Finding of "No Impact" met for for SFHAs with floodways. SCDOT considers a project to meet the requirements for a finding of “No Impact” if there is no increase in the 1% AEP flood and floodway profiles and there is no increase in floodway width at published and unpublished cross sections.	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.2
Finding of "No Impact" met for for SFHAs without floodways set with limited detail models. SCDOT considers a project to meet the requirements for a finding of “No Impact” if there is no increase in the 1% AEP flood profile for published and unpublished cross sections.	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.2
Finding of "No Impact" met for an approximate Zone A and areas outside of a SFHA. SCDOT considers a project to meet the requirements for a finding of “No Impact” when the hydraulic design demonstrates 1.0 foot or less of backwater above the unrestricted or natural 1% AEP flood profile and there is no increase in backwater compared to the existing conditions profile.	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.2
CLOMR or LOMR prepared for crossing where "No Impact" is not achievable	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.3
Procedures followed for Projects in Special Flood Hazard Areas with Floodways	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.4
Procedures followed for Projects in Special Flood Hazard Areas without Floodways based on Limited Detailed Studies	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.5
Procedures followed for Projects in Approximate Zone A	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.6
Procedures followed for Projects outside of Special Flood Hazard Areas	□Yes	□ No	□N/A	HDB 2019-4 1.1.2.7
FEMA/SCDOT Compliance Report				
An electronic copy of the model files and output files for the effective model from FEMA with 10-, 2-, 1-, and 0.2 % AEP (10, 50, 100, and 500-year event) flood profiles or the 1% AEP (100-year event) where only a Limited Detail Study is available	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C

An electronic copy of the model files and output files for the existing, proposed, and natural conditions with the 10-, 2-, 1-, and 0.2 % AEP (10, 50, 100, and 500-year event) flood profiles and any additional cross-section data from the project survey and LiDAR, any change in roughness values, and comments should be included in the report to identify and justify changes to the model.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
If HEC-RAS is used, provide copies of the cross sections, Standard Table 1, Standard Table 2, Six XS Bridge, Bridge Only, Bridge Comparison, and Encroachment 1 for the effective, natural, existing, and proposed profiles as applicable.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
If models other than HEC-RAS are used, the same data should be provided in a form generated by the model or other means.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
For 1D models, provide a figure showing the location of cross sections, control structure in and outside of the survey limits, ineffective flow pattern lines, and other applicable information for the existing and proposed models.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
For 2D models, provide figure showing the crossing, materials, flow vectors, the Lidar and survey topography/bathymetry and additional items recommended by the FHWA.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
Provide model files and output files of the floodway analysis and profiles for the current effective, existing conditions, and revised models.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
Provide a comparison table in the report for the water surface elevations for the 1% AEP (100-year event) with and without the floodway for the unrestricted conditions, existing conditions, and proposed models.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
Provide a comparison table in the report for the floodway widths related to 1% AEP (100-year event) for the existing and revised conditions models.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
Provide supporting narrative on the project, the modifications being made, specifics on the existing and proposed structures, floodplain zone type and explanation, justification for a finding of "No Impact" or CLOMR/LOMR route, conclusions, and information related to the project's location.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C
Provide a hydraulic analysis narrative with background information, scope of work, overview of the models used and the difference between each one, vertical datum used for the modeling and project, floodway analysis, and floodplain analysis.	□Yes	□ No	□N/A	RHDS 1.3.1 Step 2 C

Bridge Sized Culvert (20 ft or greater) Additional Items to Review				
Culvert sized to minimize velocities and scour potential	□Yes	□ No	□N/A	HDB 2019-4 1.1.3
Used in areas with low debris potential	□Yes	□ No	□N/A	HDB 2019-4 1.1.8
Outlet protection design using HEC-14	□Yes	□ No	□N/A	HDB 2019-4 1.1.8
Box culvert invert elevations set 1.0 ft below stream bottom	□Yes	□ No	□N/A	HDB 2019-4 1.1.8
Hydrology Data Sheet for Riverine Bridge-Sized Culverts (>= 20 feet wide) completed	□Yes	□ No	□N/A	RHDS 1.5.5