North Carolina Department of Transportation

Coordination and Compliance Plan for Department of Transportation and Emergency Management

Hydraulics Unit

October 2023

Abstract

This document provides guidance for the interagency coordination and technical NFIP compliance aspects for actions related to the 12-14-2020 Memorandum of Agreement (MOA) between the Department of Transportation, an agency of the State of North Carolina, and North Carolina Emergency Management, an office within the Department of Public Safety of the State of North Carolina.

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Acronyms

NCEM (or EM)	North Carolina Emergency Management
FEMA	Federal Emergency Management Agency
NFIP	National Flood Insurance Program
CTP	Cooperating Technical Partners
CFR	Code of Federal Regulations
BFE	Base Flood Elevation
SFHA	Special Flood Hazard Area
NCFMP	North Carolina Floodplain Mapping Program
NCEM-RM	North Carolina Emergency Management, Risk Management Section
FIRM	Flood Insurance Rate Map
DFIRM	Digital Flood Insurance Rate Map
FIS	Flood Insurance Study
FRIS	Flood Risk Information System
FIMAN	Flood Inundation Mapping and Alert Network
PE	Professional Engineer
PLS	Professional Land Surveyor
CFM	Certified Floodplain Manager
CFS	Certified Floodplain Surveyor
CFS (discharge)	Cubic Feet per Second
NCDOT	North Carolina Department of Transportation
NCDPS	North Carolina Department of Public Safety
State EOC	State Emergency Operations Center
MOA	Memorandum of Agreement

LOMR	Letter of Map Revision
CLOMR	Conditional Letter of Map Revision
GIS	Geographic Information System
SFC	State Floodplain Compliance
H&H	Hydrologic and Hydraulic
FHWA	Federal Highway Administration
LiDAR	Light Detection and Ranging

1. Introduction

The North Carolina Department of Transportation (NCDOT) and Emergency Management (NCEM) first entered into a Memorandum of Agreement (MOA) on June 8, 2008, to facilitate cooperation and collaboration to effectively deliver the Department's multi-modal transportation programs, including road, bridge, and culvert construction or repair, maintenance facilities, ferry facilities, greenways, railroads, etc. This MOA also satisfied Federal Emergency Management Agency's (FEMA's) National Flood Insurance Program (NFIP) requirements to help ensure that the State's Flood Insurance Rate Maps (FIRMs) included current NCDOT's projects. The agreement enables the efficient use of both agencies' resources and intends to streamline project reviews to cost effectively meet construction schedules. The agreement has been tremendously successful and has been modified and renewed several times.

The most recently approved version was signed by both agencies on December 14, 2020, which was agreed to be a more general document that could be sustainable for many years without the need for frequent official renewal from the two agencies. As such, the agreement states:

"Regarding programmatic, reporting, and technical aspects, NCDOT and EM shall coordinate in sharing information and resources pertaining to FEMA-related design data and map updates for projects that meet the qualifications for this Agreement as outlined in separate documentation which shall be maintained by NCDOT. Such documentation may be updated as needed with mutual consultation and approval by both agencies to facilitate ongoing changes in operational protocols, technological advances, and NFIP regulations."

This Coordination and Compliance Plan (CCP) document intends to serve the above stated purpose. The latest mutually approved version will be maintained and posted publicly on the Department's Hydraulics Unit website.

2. Coordination

2.1 Monthly Coordination Meetings

The NCEM representatives shall meet with the Hydraulics Unit at least monthly to review candidate projects' eligibility and schedule that require NFIP compliance. NCDOT's contract consultants may not ever directly contact the NCFMP staff for meetings or consultation; all requests must go through the Hydraulics Unit staff. The review may include the following:

- hydrologic and hydraulic modeling issues
- training needs
- emergency drainage structure repairs
- consultation on CLOMRs

It is NCDOT's responsibility to make submittals to the NCFMP in a timely manner to avoid delay of project construction.

These monthly meetings will also serve as a regular opportunity for updates on various program initiatives and activities of both agencies to address the status of ongoing efforts, to work through any challenges or issues that may arise, and to plan and strategize on next steps and future for implementation of mutual program objectives.

2.2 Final As-Builts and LOMR Processing Coordination

Within six months of completion of construction of NCDOT hydraulic structures on FEMA-regulated streams, requisite as-built surveys are required to be provided to Hydraulics Unit by the NCDOT Division Construction staff (NCDOT 2016). These must be subsequently verified and certified, with corrected hydraulic models where warranted, then submitted to NCFMP (of NCEM) (NCDOT 2016). Any projects associated with State Floodplain Compliance (SFC) approvals under the terms of the current or previous versions of the MOA that require submittal of a LOMR, NCDOT (or its designated contractor(s)) will prepare the LOMR submittal and will coordinate with NCFMP (a CTP for FEMA) in accordance with established legal protocols to obtain final determination from FEMA on LOMR approvals. DOT shall provide notification to NCFMP of any projects for which the six-month timeframe has elapsed and provide regular updates on status.

2.3 Coordination on Mapping

NCEM will establish a web-based GIS layer as part of the Flood Risk Information System (FRIS) interface or a similar platform in which to store State Floodplain Compliance approval data and mapping associated with NCDOT projects. With this

layer, users can download the final as-built survey hydraulic structure data and associated hydraulic model with accompanying revisions to the flood maps. NCDOT will coordinate this effort with the NCDOT-funded engineer and GIS specialist staff positions at NCEM dedicated to supporting NCDOT projects and program advancement.

2.4 Coordination Before, During, After Storm Events

2.4.1 Preparation Before Events (Preparedness)

NCDOT and NCEM are working together to develop two important tools which will provide greater awareness and preparedness prior to major storm events. These tools are FIMAN-T and BridgeWatch. Details about these two applications can be found on each application's user interface, including their benefits and specific functions and services they provide. The Hydraulics Unit website also maintains additional information about these tools. The success of both tools is the ongoing improvement and enhancement of North Carolina's stream gage network. NCDOT and NCEM are committed to collaborating in this effort, which includes installation of many new stream gages, ongoing maintenance of the gage network, and associated hydraulic and hydrologic analyses needed to develop flood inundation mapping, with ground-truthing and calibration to ensure the highest degree of accuracy and reliability possible.

2.4.2 Coordination During Storm Events (Response)

NCDOT will monitor and track a storm event as it is approaching or underway. With FIMAN-T and BridgeWatch functionality, NCDOT staff can notify internal response staff and external stakeholders, including NCEM, of alerts and notifications of transportation vulnerabilities, and provide updates on actions to mobilize NCDOT resources to close roads and redirect traffic from potential or actual hazardous travel locations. In major events, such as hurricanes, NCDOT will provide ongoing reporting and consultation to the State EOC as warranted.

2.4.3 Coordination Following Storm Events (Recovery)

For emergency repairs, NCDOT will follow the procedures outlined in the current *Guidelines for Drainage Studies and Hydraulic Design* Chapter 15, Section 15.7 (NCDOT 2022).

2.5 Coordination on Training and Program Improvement

NCDOT will provide annual NFIP awareness training with the assistance of NCFMP staff. This training will be delivered to all NCDOT personnel and contractors involved in the design, construction, and maintenance activities and will cover general flooding-related issues, appropriate coordination with FEMA and/or NCFMP on issues of compliance, mitigation, etc.

3. State Floodplain Compliance (SFC) – Technical Guidance

NCDOT has established several MOAs with a variety of partners, and the MOA with NCFMP is often confused with other MOA. To avoid confusion in the future, all projects review under the MOA with NCFMP will be referred to as State Floodplain Compliance (SFC). Projects must obtain SFC or CLOMR approval to meet NFIP requirements. All project submittals made following January 1, 2022, must be reviewed in accordance with this technical guidance. Any submittals prior to that date will follow the previously effective guidance associated with the August 12, 2016, MOA.

3.1 Criteria Required for SFC and NFIP Approval

A project must meet the criteria as outlined in Section 3.2 below to achieve NFIP approval. If the project cannot meet these criteria, it must be processed as a CLOMR through the FEMA MT-2 process (Type C in Section 3.2 below).

A BFE increase (measured to the hundredths of a foot) that impacts an existing structure located outside of the right-of-way is not allowed under any circumstance (both CLOMR and SFC Approval Process).

3.2 State Floodplain Compliance (SFC) Protocols

The following are the NFIP-qualified State Floodplain Compliance (SFC) types that are created based on potential impacts to the Base Flood Elevation (BFE) due to the proposed NCDOT project. NCDOT will coordinate with NCFMP to provide the following information:

Type A Type A classifications applies to a project that meets any of the following criteria:

- no change in BFE at any location (measured to hundredth of a foot)
- any BFE changes (increase or decrease) that are contained solely within NCDOT's rights-of-way
- A BFE increase of up to one foot on a Limited Detailed Study reach, as allowed under 44 CFR 60.3 (c) (FEMA 2020), provided no structures outside NCDOT's rights-of-way are impacted by any BFE increase (when measured to the hundredth of a foot)

For Type A projects, NCDOT shall review the Hydrologic and Hydraulic (H&H) designs and issue approval certification. NCDOT shall notify the NCFMP of the certification and provide the SFC submittal packet.

NCDOT will notify the NCFMP after the project is completed, and the NCFMP shall incorporate the data into its future flood map studies and Digital Flood Insurance Rate Map (DFIRM) updates.

Type B — Type B classification applies to a project that results in a BFE decrease outside of NCDOT rights-of-way.

For Type B projects, NCDOT will review the Hydrologic and Hydraulic (H&H) designs and issue approval certification. NCDOT will notify the NCFMP of the certification and provide the SFC submittal packet.

After the project is completed, NCDOT will notify the NCFMP and coordinate with the NCFMP to prepare and process a Letter of Map Revision (LOMR) when applicable.

Type C — Type C classification applies to a project that cannot be classified as Type A or B.

NCDOT will coordinate with the NCFMP to submit a request through the FEMA MT-2 Process as a CLOMR.

After project completion, NCDOT will notify the NCFMP and coordinate with the NCFMP in preparing and processing a Letter of Map Revision (LOMR).

If the project can be classified as Type A and B, then the project will be submitted as a Type B and all conditions for both Types must be met.

1. For maintenance culvert replacements on a FEMA Regulatory Stream, NCDOT supply NCFMP with hydrologic and hydraulic calculations/analysis of both existing and proposed structures, a copy of the hydraulics recommendation letter and a copy of the area FEMA mapping. The hydrologic and hydraulic analysis information should include but not be limited to:
   - project location information including LAT/LONG location and facility involved
   - existing structure information
   - bed-to-crown height
   - hydrologic and hydraulic methodologies used.
2. For emergency repairs, NCDOT will follow the procedures outlined in the current Guidelines for Drainage Studies and Hydraulic Design Chapter 2, Section 2.4.13
3. In the event a project that was previously approved as a qualifying SFC type or CLOMR, and its as-built surveys deviate from the design plans and flood models, NCDOT shall submit revised design reports and flood models to the NCFMP for acceptance and submit a LOMR request, if required.

4. NCDOT and the NCFMP shall share design and survey data, including hydrologic and hydraulic designs and engineering models. NCDOT will give the NCFMP the H&H design reports for the bridges and culverts across the state through the ongoing programmatic project submittals or upon request as needed. The NCFMP will provide NCDOT the FIS flood data and hydraulic models.
5. NCFMP will provide technical expertise and consultation as needed for projects involving FEMA-regulated streams in the FIS for which major errors were encountered with respect to the original effective hydraulic models, resulting in considerable hydraulic modeling difficulty. Examples include:
   - FIS model output not matching the published effective data
   - missing or incorrect structures/cross-sections
   - major discrepancies/errors in topographic data
   - erroneous hydrologic analysis, etc.

   With the prior consultation and concurrence of the NCFMP, NCDOT may opt to develop H&H design reports using its field survey data and a minimum of six section analyses and develop the BFE comparison table for the existing and proposed conditions. The proposed upstream BFE is not required to match within one-half foot of the published BFE, and modeling of floodway encroachments is not required. NCDOT shall submit the H&H design data to the NCFMP for review and approval. The NCFMP shall incorporate this data and the associated as-built plans into its future map studies and DFIRM updates.
6. Upon request, the NCFMP may assist NCDOT with internal review and approvals for the SFC projects. This is delegated to NCDOT's State Hydraulics Engineer.
7. The NCFMP shall provide NFIP compliance requirements training to NCDOT as needed. Topics include checklists, H&H modeling, Certified Floodplain Manager Certification, training for NCDOT's Operations forces, etc. NCDOT will reimburse the NCFMP for training and other associated costs.
8. With the assistance of NCFMP staff, NCDOT shall provide annual NFIP awareness training for NCDOT's personnel and contractors involved in the design, construction, and maintenance activities. This training shall cover general flooding-related issues, appropriate coordination with FEMA and/or NCFMP on issues of compliance, mitigation, etc.
9. NCDOT and the NCFMP understand and agree that proper administration of the SFC ensures that NCDOT is consistent with FEMA's NFIP Regulations as well as FHWA's guidance of NS 23 CFR Part 650A.
10. All design and modeling work shall be performed in accordance with Federal regulations, policies, and guidelines, as well as NCDOT's current Guidelines for Drainage Studies and Hydraulic Design (NCDOT 2022). All reviews and approvals of the hydraulic design reports and engineering flood models shall be performed by Professional Engineers registered in the State of North Carolina.

3.3 Floodplain Modeling Guidelines

1. **Initial SFC submittal:** The initial SFC submittal requires a minimum of 90 days lead time prior to the scheduled commencement of project construction. Final As-Built Plans must be submitted to NCFMP within 180 days of completion of construction.
2. **SFC and Model Nomenclature:** Rules in Section 3.8.1 of this document should be followed to maintain file organization and provide efficient model descriptions.
3. **Plan Types:**
   - Duplicate Effective: The Duplicate Effective Model is a copy of the hydraulic analysis used in the effective FIS, (referred to as the Current Effective Model) which is reproduced on the requestor's equipment.
   - Corrected Effective: The Corrected Effective Model is the model that corrects any errors that occur in the Duplicate Effective Model, adds any additional cross-sections to the Duplicate Effective Model or incorporates more detailed topographic information than that used in the Current Effective Model. The Corrective Effective model must not reflect any manmade physical changes since the date of the effective model.
   - Existing Conditions: The Existing Conditions Model incorporates any manmade topographical changes that have occurred within the floodplain since the date of the Effective model but prior to the construction of the project for which the revision is being requested. In most cases, an Existing Conditions Model will not be applicable.

     Note: Such changes may be included in the Corrected Effective model without the need for an Existing Conditions model. However, some situations may warrant the inclusion of an Existing Conditions model for clarity.
   - Revised: The Revised Model reflects the revised or post-project conditions. This model must incorporate any physical changes to the floodplain since the Current Effective Model was produced, as well as the effects of the project.
4. **Rounding Base Flood Elevations to the Hundredth of a Foot:** The implementation of the December 14, 2020, version of the MOA now dictates that all flood elevations must be rounded to the nearest one-hundredth of a foot. This is a change from the previous versions of the MOA, which specified to round BFEs to the tenth of a foot. This rounding is more consistent with FEMA requirements, and has been updated in the current Guidelines for Drainage Studies and Hydraulic Design Chapter 15, Section 15.4 (NCDOT 2022) as promulgated by the current Guidelines for Drainage Studies and Hydraulic Design Section 15.4 (NCDOT 2022).
5. **HEC-RAS Model Version:** Typically, the latest version of HEC-RAS accepted by FEMA* should be used for NFIP studies. A previous version of HEC-RAS may be used, provided it is accepted by FEMA, is not older than the effective model version, and is documented in the narrative.

* - Currently accepted HEC-RAS versions can be found in Software for Flood Mapping section of the FEMA website (USACE 2021). Additionally, the older versions of HEC-RAS software can be downloaded from US Army Corps of Engineers' Hydrologic Engineering Center - River Analysis System (HEC-RAS) website (USACE 2021).

6. **FIS Data Request:** FIS models and data not available on the Flood Risk Information System (FRIS) website can be requested from NCDOT via the Flood Insurance Study Data Request Form (NCDOT 2021).
7. **Hydrology:** The hydrology in the effective model should match the FIS. If it does not, discuss with NCDOT and NCFMP prior to submittal and note it in the project narrative. The flows which produce the effective water surface elevations should be used and flows should not change in any of the submitted models.
8. **Area of Influence (Upstream and Downstream Tie-In):** This covers the limits of the stream reach that must be shown on the Comparison Table and Work Map. Both of the following conditions must be met to determine the Area of Influence:

   Effective Model tie-in to Revised Model

   - For streams with a **detailed study,** an effective tie-in is obtained when the revised base flood and floodway elevations are within 0.5 feet of the effective elevations, and the revised floodway encroachment stations match the effective floodway stations at both the upstream and downstream limits.
   - For streams without a **regulated floodway**, an effective tie-in is obtained when the revised base flood elevations are within 0.5 feet of the effective elevations at both the upstream and downstream limits.

   Corrected Model tie-in to Revised Model

   - The upstream and downstream limits of the corrected and revised models must extend until the water surface elevations and stream velocities match exactly between them. The mapped top widths should also match within one foot.
9. **The Structure Data (deck width, low chord, roadway grade, culvert inverts, etc.)** in the hydraulic model should match the data contained in the Hydraulics Structure Reports (BSR & CSR). Account for and note all data adjustments between the structure reports and hydraulic model in the narrative. The narrative must include the following information:
   - Height of the bridge rail modeled in both the Corrected Effective and Revised models
   - Road profile shown in both the Corrected Effective and Revise models reflects the highest roadway elevations
   - Low chord elevation of the bridge shown in the Corrected Effective and Revised models reflects the lowest low chord elevation of the bridge and has been adjusted for super elevation drop and asphalt/concrete overlay on the bridge

- If the bridge length and/or opening has been adjusted for skew in both the Corrected Effective and Revised models. Describe the skew adjustment mathematically and/or graphically.
- If the bridge opening has been adjusted due to the abutment and or/cap width in both the Corrected Effective and Revised model
- Pier width and shape used in both the Corrected Effective and Revised models

10. **No Impacts to Structures**: The SFC narrative must confirm that there are no structures impacted by an increase greater than 0.00 feet and specify that the analysis is consistent with guidance provided in the 1982 Federal Highway Administration Memorandum of Understanding with FEMA, entitled *Procedures for Coordinating Highway Encroachments on Floodplains within the Federal Emergency Management Agency (FEMA)* (FHWA 1982), and the September 1992 FHWA NS 23 CFR Part 650A, Transmittal 5.
11. **BFE Comparison Table:** The table must be placed in Excel spreadsheet format and should include the following information at minimum:
    - Duplicate Effective, Corrected, and Revised model outputs
    - Water surface elevations, reported to the one-hundredth of a foot, for the 1% and the floodway (encroachment) models and the difference between water surface elevations from the Corrected model to the Revised model
    - Encroachment stations and any changes in encroachment stations from the Effective model to the Revised model
    - Highlight maximum increase or decrease in base flood elevation.
12. **Effective Model Unavailable:** If an effective model for a FEMA-studied stream is not available, include documentation to verify that an **external data request (EDR)** was submitted through NCFMP to FEMA NFIP Library with the result that no copy of the effective model could be found. This action verifies that “due diligence” has been exercised in attempting to obtain the effective model.
13. **HEC-2 Conversion:** Conversion to HEC-RAS is recommended but not required when the effective model is HEC-2. Take care when converting HEC-2 data to HEC-RAS, since the HEC-RAS duplicate effective model will likely require adjustments and corrections to match the effective results. Any differences in WSEL between the effective model (HEC-2) and duplicate effective model (HEC-RAS) must be fully documented and thoroughly explained. Once the duplicate effective model has been established in HEC-RAS, the Corrected Effective, Existing Conditions, and Revised models can be created in HEC-RAS using the Duplicate Effective model as the basis. The HEC-RAS models must tie into the effective water surface profile within 0.5 foot at the upstream and downstream ends of the revised reach. If a printout is the only model available, follow the procedure outlined in FEMA’s Guidance for Flood Risk Analysis and Mapping: MT-2 Requests section 2.5.2 (FEMA 2020).

14. **Levees** should not be used without prior approval unless it is a certified levee, as other techniques exist to block effective flow in the HEC-RAS environment.
15. **2D Models:** 2D modeling shall be used on a case-by-case basis based on the needs and complexity of the project. The 2D model will be used to inform a 1D model until such time when 2D models are accepted as the regulatory model. Generate a 2D analysis to thoroughly understand the hydraulics in a particular area, and then calibrate a 1D model to that 2D analysis to serve as the regulatory model. Consultation with NCDOT and NCFMP is required.
16. **Small Pipe Replacement:** It is NCDOT policy to develop and make reasonable use of its lands and rights-of-way through sound, reasonable, and acceptable engineering practices and to deny responsibility for effects of augmented or accelerated flow caused by its improvements unless determined to cause unreasonable and substantial damages. It is NCDOT policy to expect the same practice and acceptance of responsibility of owners and developers of properties adjacent to state highways. Replacement of existing drainage structures is in-kind relative to roadway facility especially following extreme events such as hurricanes. The replacement of these existing structures results in a negligible additional impervious area in the overall watershed. Additionally, most culvert replacements increase in size which reduces or improves outlet velocities. Follow the procedure outlined in the current *Guidelines for Drainage Studies and Hydraulic Design* Chapter 15, Section 15.3.1 (NCDOT 2022) for State Floodplain Compliance for these replacements.

3.4 Floodplain Modeling Standards

1. Follow the guidance promulgated in the Riverine Hydrologic & Hydraulic Engineering Guidelines and Standards (NCFMP 2014 (rev 2020)).

2. **Bridge Modeling Methods:** Select low flow methods to compute both Energy and Momentum using the highest energy answer. High flow methods should be set to pressure and/or weir. Further guidance can be found in the Riverine Hydrologic & Hydraulic Engineering Guidelines and Standards (NCFMP 2014 (rev 2020)). Where appropriate, also check Yarnell for low flow, though it is generally not required. If the effective model does not include these modeling methods, they should be included in the Corrected Effective, Existing Conditions, and Revised Conditions models. For all other crossings in the model, do not change the modeling methodology unless the engineer determines it to be appropriate. All changes in modeling should be described in the project narrative.

3. **Momentum Equation:** The "Add friction component" for momentum should be checked, but the "Add weight component" should not.

4. **Bridge Rail Modeling**: Engineers should use their engineering judgment when coding in bridge railings and guardrails. There may be situations where coding in different heights and lengths of bridge rails and/or guardrails may be warranted. Additional guidance can be found in the Riverine Hydrologic & Hydraulic Engineering Guidelines and Standards (NCFMP 2014 (rev 2020)).. The engineer should document his/her decisions on modeling bridge rails if they are different than noted below.

    - Model existing bridge rail based on height and length and show as blocked
    - Model proposed bridge rail based on height and bridge length and show as blocked. Model the first 12 feet of guardrail anchor unit at each end of bridge and show as blocked (see Roadway Standard Drawings 862.03)

5. **Manning's "n" (roughness coefficient) changes** should be justifiable and stated in the project narrative and supported with photographs. Manning's "n" changes without documentation will not be accepted under the SFC.

6. **Boundary Conditions:** The boundary conditions should not vary from the effective model. There should be overwhelming evidence that the boundary condition is incorrect before it is revised from the effective model and should only be completed in the corrected effective and subsequent models. Use a known starting water surface elevation most of the time if using a truncated model.

7. **Fixed WSEL:** Do not use fixed water surface elevation points at any locations in the models. The only exception is the use of "fixed" starting water surface elevation as a boundary condition at the most downstream section of a truncated duplicate effective model. NCFMP typically requests the inclusion of a copy of the unedited full effective model for reference.

8. **New Cross-Sections:** Geo-reference all new cross-sections added to the model for any effective model which is geo-referenced. Interpolating cross-sections are not allowed. If new cross-sections are added, they should be field surveyed. LiDAR data may be used in areas beyond the reach of the normal surveyed area. For cross-sections generated from LiDAR, the channel geometry may be interpolated or estimated. The cut line length in the geometric data must match the cross-section length.

9. **Contraction and expansion coefficients:** should typically be 0.3 and 0.5, respectively for sections four, three and two in the flow contraction and expansion reach associated with bridge and culvert structures. If the contracted width of flow is greater than 25% of the total width of flow (100-yr flood fringe), do not use the typical bridge sections' subcritical flow contraction coefficient of 0.3 (per Table 3-3 of the HEC-RAS Hydraulic Reference Manual (USACE 2021)). Instead, use the guidance in Table B-4 of the HEC-RAS Hydraulic Reference Manual (USACE 2021) to determine the appropriate contraction coefficient for subcritical flow.

   Contraction and expansion coefficients should be 0.1 and 0.3 in all other locations. If the effective model has other contraction and expansion coefficients and is older than 1998, the coefficients should be changed in the Corrected and Revised models to 0.1 and 0.3 unless the engineer can justify otherwise.

   Discuss contraction and expansion coefficients in the model narrative and justify any changes from the effective model or use of non-typical values. Justification should include reference source, for example Table B-4 of the HEC-RAS Hydraulic Reference Manual, if applicable.

   Additional guidance can be found in the Riverine Hydrologic & Hydraulic Engineering Guidelines and Standards (NCFMP 2014 (rev 2020)).

10. **Encroachment station placement** should tie in with the effective model stations at the upstream and downstream cross-section in any truncated model. They should be contained by the 100-yr floodplain boundary, be outside of bank stations, and not be placed in the ineffective flow areas, etc. Additional guidance can be found in the Riverine Hydrologic & Hydraulic Engineering Guidelines and Standards (NCFMP 2014 (rev 2020)). Always use Method 1 to set encroachment stations in the Duplicate Effective, Corrected Effective, Existing Conditions, and Revised models. If other methods are used in the effective model, change to Method 1, and insert the exact encroachment stations from the Effective model output into the Duplicate Effective model. See below

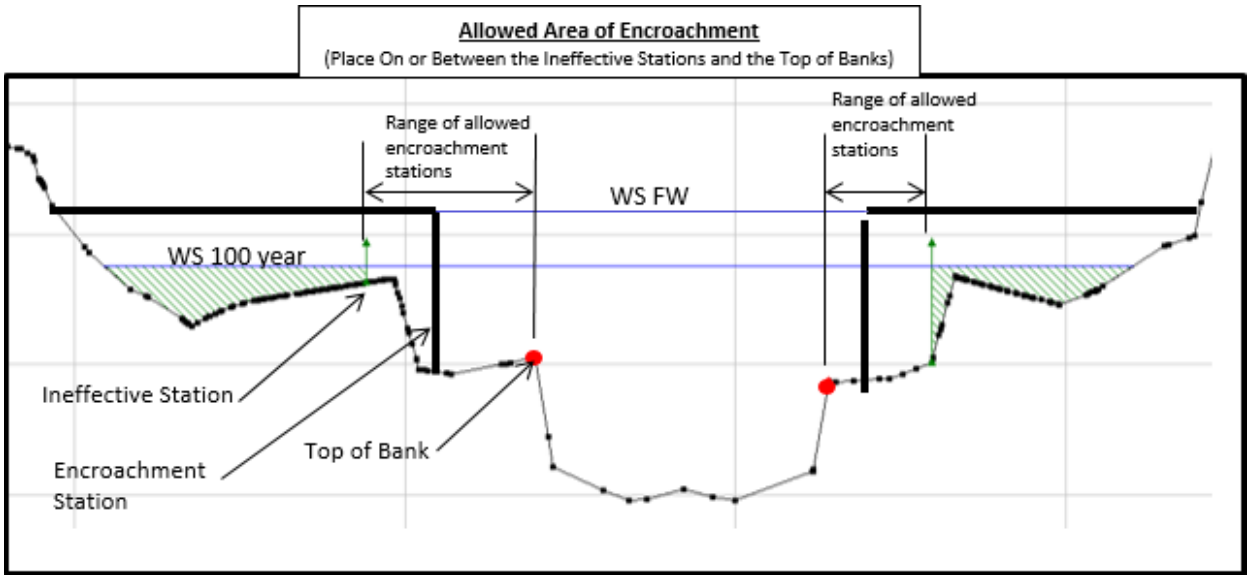


Figure 1. Allowable Encroachment Stations

11. **Ineffective Flow Areas**: Describe the placement and/or adjustment of ineffective flow areas in the project narrative. It may be helpful to submit supporting information such as contraction/expansion lines on the work map. The general accepted contraction ratio (CR: 1) is 1:1 and the expansion ratio (ER: 1) generally ranges from 1:1 to 4:1. Be consistent when revising ineffective flow elevations and ensure that the ineffective flow areas act together on the upstream and downstream cross-sections of a structure (sections 2 and 3). Do not adjust ineffective flow areas anywhere else in the model unless justified. If so, adjust in the Corrected Effective, Existing Conditions, and Revised models. Additional guidance can be found in the Riverine Hydrologic & Hydraulic Engineering Guidelines and Standards (NCFMP 2014 (rev 2020)).

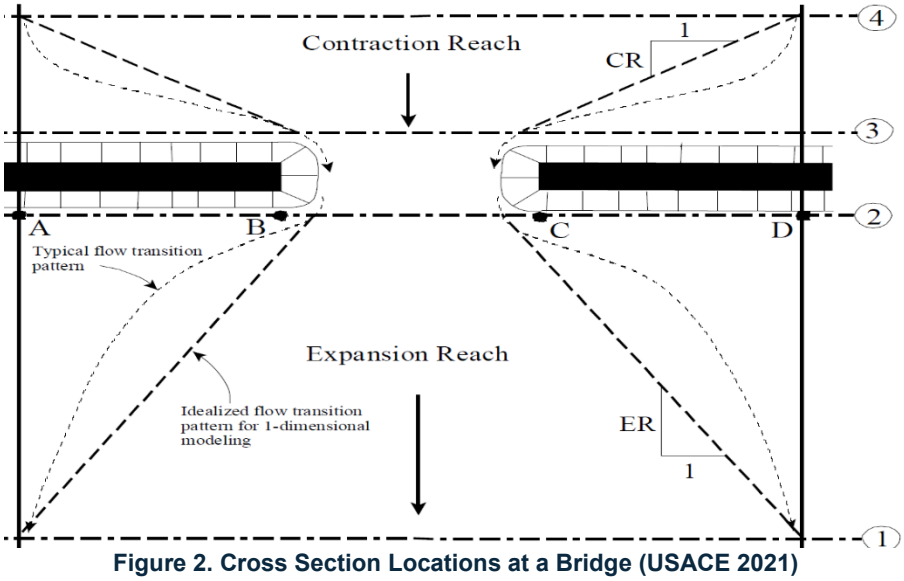


Figure 2. Cross Section Locations at a Bridge (USACE 2021)

12. **Six-Section Analysis:** Approval from NCDOT and NCFMP is required to perform a six-section analysis. The six sections do not include the two internal structure cross-sections. In addition to the four cross-sections required to correctly model a bridge or culvert (as defined in Figure 5-1 (see also Figure 2) of the HEC-RAS Hydraulic Reference Manual (USACE 2021)) there must be a minimum of two additional cross-sections, at least one upstream of the approach cross-section and one downstream of the exit cross-section. If starting with Manning's Normal Depth as the downstream boundary condition of a subcritical hydraulic water surface profile computation model, the location of the downstream boundary cross-section should be far enough downstream of the study reach to allow the computed water surface profile to converge to a consistent answer by the time the computations reach the exit cross-section, to prevent errors within the study reach from being introduced. Additional sections may be needed depending on site-specific hydraulic controls and constraints upstream and downstream of the study reach. Only the BFE natural profile will be reviewed. No floodway profile is required.

3.5 Common Modeling Issues

1. Watch for datum adjustments. For models with a different datum, make sure that boundary conditions are adjusted along with geometry. Adjust all plans (Corrected Effective, Existing Conditions, and Revised).

2. Center reach lengths should be the upstream station minus the downstream station. It is noticed when these do not line up, but is not always commented upon, depending on the effective model. Pay attention to reach lengths during the model build, especially when adding in new cross-sections, adjusting effective cross-section locations, or modifying the reach due to stream relocation.

3. Make sure the bank stations contain the stream centerline in the geometric window from HEC-RAS.

4. Make sure Floodway or Encroachment Surcharges are no greater than one foot nor negative in the Corrected Effective, Existing Conditions, or Revised Models. Negative surcharges are usually due to modeling error or over-encroachment around bridges and culverts. Surcharges greater than one foot or negative must be corrected inside the area of influence and, unless truncated, throughout the entire model.

5. Only include the required runs in the submitted **SFC** Model, e.g., Duplicate Effective, Corrected Effective, Existing Conditions, and Revised.

6. Only include the same flow profiles as used in the Effective model (including future conditions, if effective for study reach) in the submitted **SFC** Model. Create a separate design model if additional design frequencies are needed, but do not include it in **SFC** Model.

7. Make sure all runs have an output file saved in the submitted **SFC** Model

8. Make certain the warning “Geometry is newer than output” does not appear on any of the plans in the submitted **SFC** Model.

9. Center coordinates on the FEMA Coordination Form on the location of the crossing and report in decimal degrees to at least five decimal places. Use the Measure Location Tool on FRIS to determine the latitude and longitude.

10. Examine the Output Table and the Profile Plot when comparing the corrected and revised WSELs.

3.6 Deliverables

The following SFC deliverables to NCFMP are required, in addition to the submittal package structure and deliverable descriptions.

Exhibit A: Submittal Package Structure and SFC Deliverables to NCFMP

SFC Project.zip (name following the SFC and HEC-RAS Nomenclature guidance)

Effective Model
Copy of the Effective Model

SFC Model
Model Files

SFC Files (Forms found on the Hydraulics/FEMA Coordination site)

- **FEMA Coordination Form** (submit as Excel form)
- **Title Sheet or Vicinity Map** (Make sure R/W and Let dates are current)
- **CADD File** (name file: "yyyymmdd_TIP_SFC.dgn") Include: existing and proposed roadway alignment, existing and proposed bridge, slope stakes, TOPO (w/any buildings, etc.), contours, stream alignment, and HEC RAS cross-section locations (with sections labeled)
- **TIN File**
- **NCDOT Bridge / Culvert Survey Report** (signed, sealed and NCDOT-approved)
- **Hydraulic Model Narrative** (describe model changes as progression takes place from Duplicate Effective Model to Corrected Effective Model (to Existing Conditions Model if needed) to the Revised Model.)
- **Output Comparison Table** (Excel format) - Spreadsheet should cover the area from downstream tie to upstream tie. Highlight the maximum WSEL increase or decrease.

- **Parcel / Property Owner Information** (CADD file) - Parcel boundary electronic file with deed book & page numbers, Not required for Type A submittals
- **Documentation of FMP concurrence, if applicable**
- **Other Files, if applicable**

3.7 Submittal Procedures

Initial SFC/CLOMR Submittal

1. Prepare SFC Submittal Package. Place all required data in a properly structured and labeled folder. It will be the submitting engineer's responsibility to make sure all required data is provided.
2. Submit the SFC submittal package via the NCDOT Hydraulics / FEMA Coordination team website. (See Section 3.7.1)
3. The coordination team will process the submittal and assign for review.
4. Once the review is complete, the coordination team will send review comments or the approval to the assigned staff.

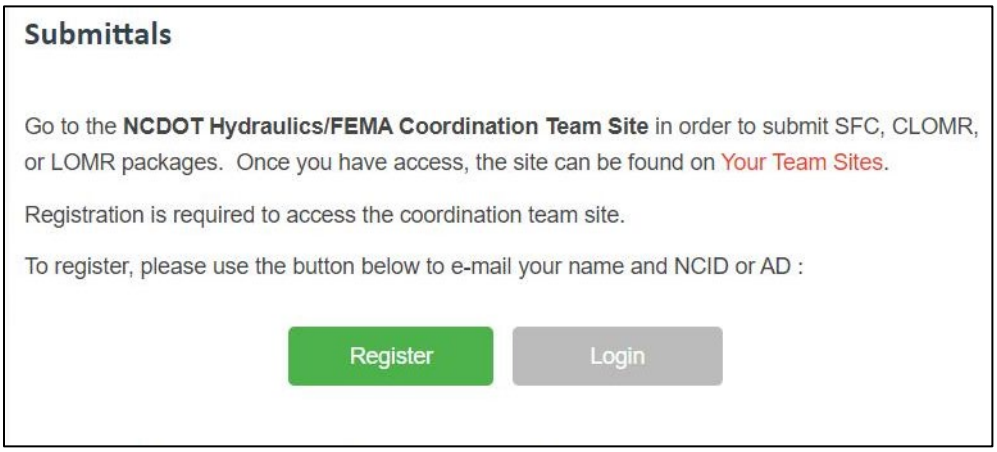
Response SFC/CLOMR Submittal:

1. The procedure lists the initial submittal.
2. Prepare the response package folder and label it with the word "RESPONSE" in the title.
5. Submit the SFC submittal package via NCDOT Hydraulics / FEMA Coordination team website. (See Section 3.7.1)
3. The coordination team will process the response submittal.
4. Once the review is complete, the coordination team will send additional review comments or approval to the assigned staff.

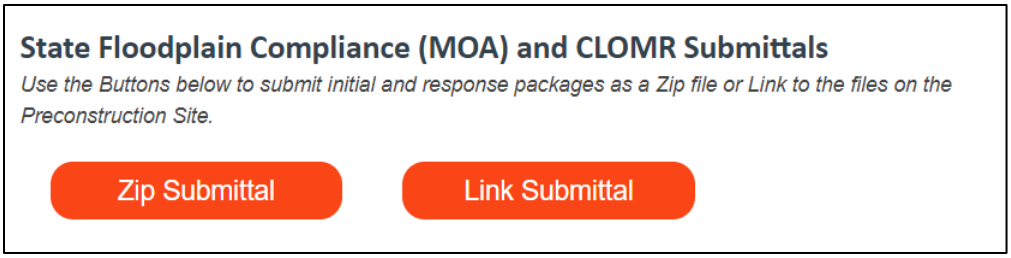
3.7.1 Steps to Submit SFC or CLOMR Submittal Package

1. From the Hydraulics Connect site go to the Highway Floodplain Program (HFP) site.

a. Select **Login**. Consultant firms and others will need to select **Register** to request access to the site. All Division, SMU and PMU personnel should have access.

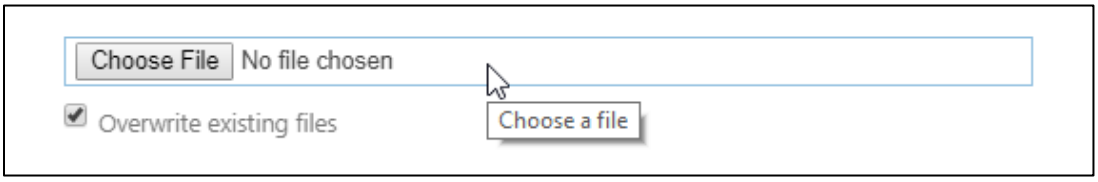


2. Once on the Highway Floodplain Program Coordination Site, SFC packages can be submitted as a zip file or a link to the file on the Preconstruction site.

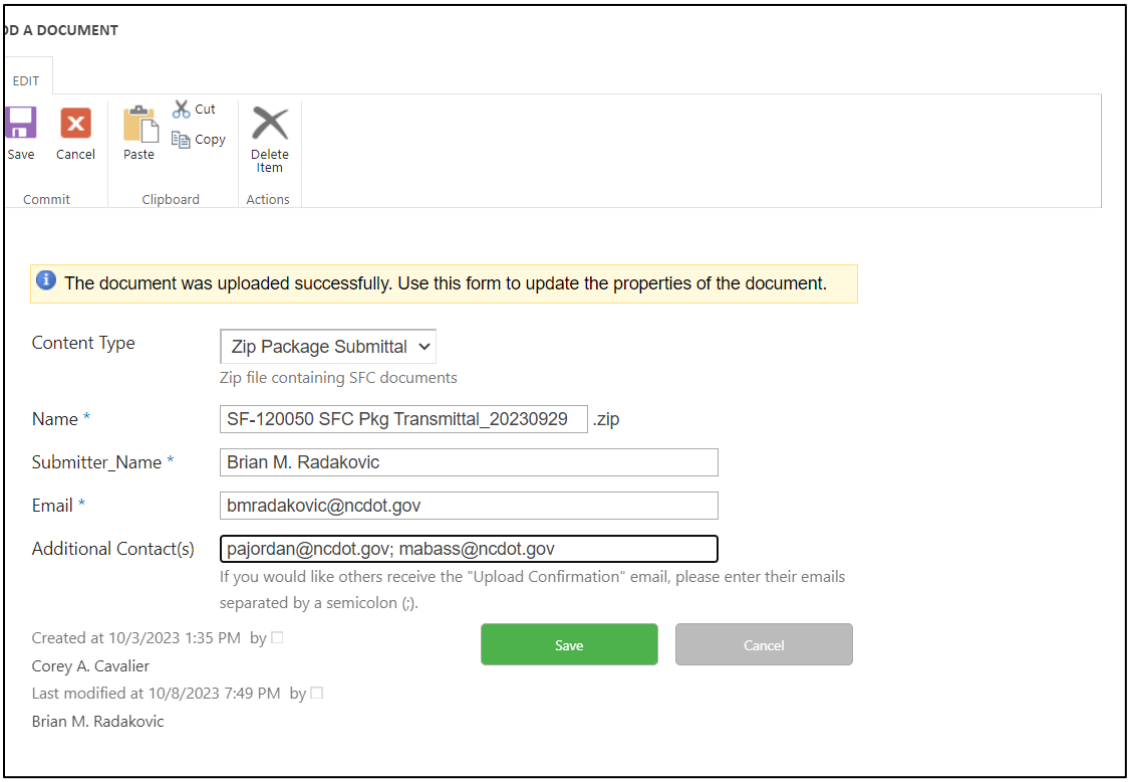


a. Zip Submittal

- Choose the zip file to upload and select OK

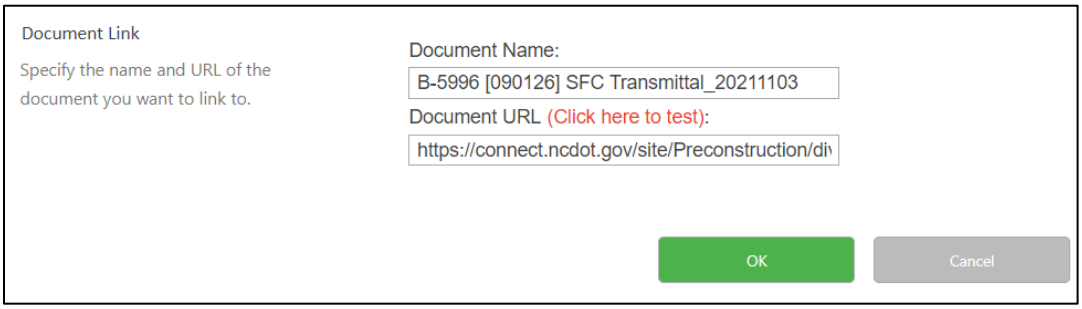


- Complete the form that pops up and select “Check In”

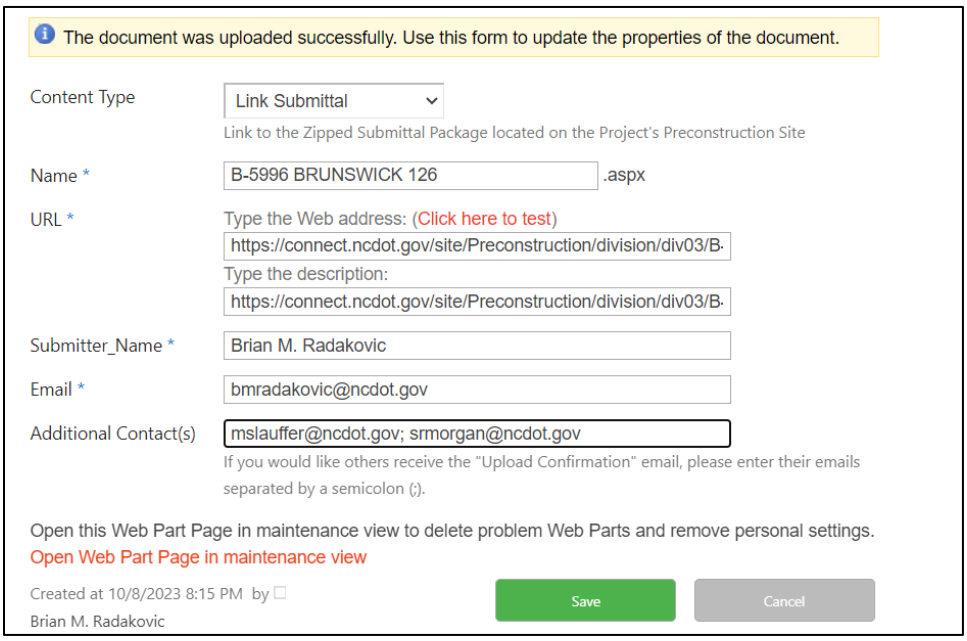


b. Link Submittal

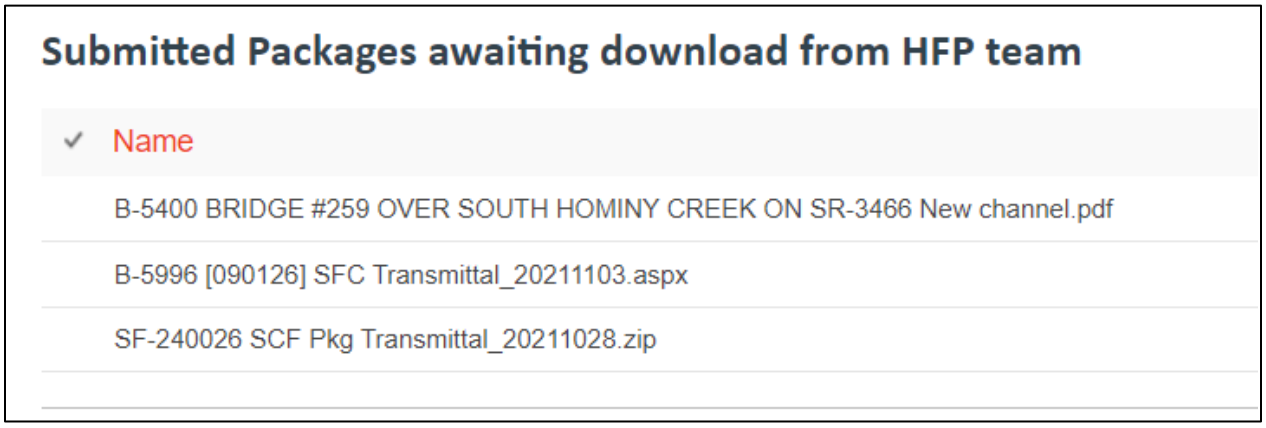
- Fill in the document name provide the URL to the package and select OK



- Complete the form that pops up and select “Save”



3. Returned to the Highway Floodplain Program Coordination Site, and view the list below the Submittal Buttons to confirm that the submittal is waiting to be downloaded from the HFP team.



A confirmation email will be sent once the HFP team receives the package. The Coordination Team will contact you if any questions or additional information is required.

3.8 Additional Technical Guidelines

3.8.1 Nomenclature

HEC-RAS Model Files

- The Project title should contain the respective Project ID Number, the name of the stream or creek, and the Route Number.
- The Project Description should remain the same as reflected in the Effective Model.
- Flow profile names should mimic the profile names from the effective model. If additional profiles are included, the follow the guidance promulgated in the Riverine Hydrologic & Hydraulic Engineering Guidelines and Standards (NCFMP 2014 (rev 2020))
- The Plan and Geometry Files should be named according to the data reflected in the files; Duplicate Effective, Corrected Effective, Existing, or Revised.

SFC Documents

- Projects should be labeled using the following convention:

  SFC Label= ProjectID_ StructureID (The Structure ID is not required for projects with the structure number as part of the Project ID.)
  where,

  ProjectID = Assigned project TIP, SF, BD, etc. DO NOT use a WBS Number.

  StructureID = Existing structure number. If the number is not assigned then assign identifiers to the structures such as B01, B02, C01, C02, etc. The Structure ID is not required for projects with the structure number as part of the Project ID. *Additional Considerations: If more than one bridge corresponding to a single Project ID, (such as overflow structures or dual parallel bridges) just choose ONE of the bridges for the 6-digit bridge number designation in the Project ID, and note the other(s) included in remarks (in the notes field in tracking database, in SFC narrative, and on Coordination form).*

- All SFC forms should have the **SFC Label** included as the beginning part of the file name.

  Examples:

  - The narrative for a State-Funded project in Ashe County at bridge 300 would be labeled: SF-040300_Narrative
  - The coordination form for Project B-3868 in Martin County at Bridge 117 would be labeled: B-3868_570117_ Coordination Form
  - A comparison table for Project R-2536 in Yancy County with an unnumbered culvert would be labeled R-2536_990C01_Comparison Table
  - The narrative for Project R-4814 which has two parallel bridges, 810102 and 810103 would be labeled: R-4814_810102_Narrative

Submittal Folder

- The Submitted SFC Folder shall be labeled with the **SFC Label** and the submittal type, Initial, Response#, etc.

4. References

FEMA. 2020. "Guidance for Flood Risk Analysis and Mapping - MT-2 Requests (Guidance Document 106)." *Federal Emergency Management Agency.* December. Accessed December 2021. https://www.fema.gov/sites/default/files/documents/mt-2_requests_guidance_dec_2020.pdf.

—. 2021. *Software for Flood Mapping.* Accessed December 2021. https://www.fema.gov/flood-maps/software.

FHWA. 1982. "Procedures for Coordinating Highway Encroachments on Floodplains with the Federl Emergency Management Agency (FEMA)." *Federal Highway Administration.* June 25. Accessed December 2021. https://www.fhwa.dot.gov/engineering/hydraulics/policymemo/820625.pdf.

FRIS. 2021. *North Carolina Flood Risk Information System.* Accessed December 2021. https://fris.nc.gov/fris/Home.aspx?ST=NC.

NCDOT. 2016. "As-Built Certification Review Form Guide." *NCDOT Hydraulics Unit.* July 12. Accessed December 2021. https://connect.ncdot.gov/resources/hydro/FEMA%20and%20Interagency%20Design/As-Built%20Certification%20Checklist%20and%20Review%20Form_20160716.pdf .

—. 2021. *Flood Insurance Study Data Request Form.* Accessed December 2021. https://forms.office.com/pages/responsepage.aspx?id=3IF2etC5mkSFw-zCbNftGaO5JgetmzdCk8E1oHHYtBtUODZSN0pQMjVFRFg2WVpSTktaOElZMlBKOCQlQCN0PWcu&web=1&wdLOR=c212F214F-E8AA-42F0-87DF-1FEE02BE19C4.

—. 2016. "Guide for Preparing As-Built Plans for FEMA Compliance." *NCDOT Hydraulics Unit.* July 12. Accessed December 2021. https://connect.ncdot.gov/resources/hydro/FEMA%20and%20Interagency%20Design/Guide%20for%20Preparing%20As-Built%20Plans%20for%20FEMA%20Compliance_20170716.pdf.

—. 2022. "Guidelines for Drainage Studies and Hydraulic Design." *NCDOT Hydraulics Unit.* Accessed December 2021. https://connect.ncdot.gov/resources/hydro/Pages/Guidelines-Drainage-Studies.aspx .

NCFMP. 2014 (rev 2020). "Riverine Hydrologic & Hydraulic Modeling Guidelines and Standards." *NC Cooperating Technical State Mapping Program.* September 4. Accessed December 2021. ~~https://flood.nc.gov/NCFLOOD_BUCKET/NFIP/Riverine%20HandH%20Engineering%20Guidelines%20and%20Standards-05212020.pdf.~~ https://flood.nc.gov/NCFLOOD_BUCKET/ISSUE/Riverine%20HandH%20Engineering%20Guidelines%20and%20Standards-FINAL%20-08262024.pdf

USACE. 2021. "HEC-RAS River Analysis System: Hydraulic Reference Manual version 6.0." *US Army Corps of Engineers - Hydrologic Engineering Center.* May. Accessed December 2021. https://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS_6.0_Reference_Manual.pdf.

—. 2021. *Hydrologic Engineering Center's River Analysis System (HEC-RAS).* Accessed December 2021. https://www.hec.usace.army.mil/software/hec-ras/.