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Project Name:
Wilmington Rail Realignment

Project ref:
WBS - 3.5

From:
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Date:
January 22, 2021

Subject: Preliminary Hydraulic Analysis for Conceptual Engineering

Memorandum

Objective of Memorandum

The purpose of this memorandum is to begin identifying the impacts of hydraulic considerations on the further development of minimum design criteria for the conceptual engineering of the Wilmington Rail Realignment project. Hydraulic considerations should be addressed in the development of conceptual designs primarily by identifying their impact on the minimum design for top of rail elevations. As noted in this memorandum, more stringent navigational and other regulatory requirements may supersede any identified minimum elevation requirements identified through hydraulic grade control analysis. However, a preliminary hydraulic analysis is required in order to confirm that the base flood elevation (BFE) of the Cape Fear River is an appropriate design criteria for minimum elevation of minor structures.

Description of Project and Site Analysis

The City of Wilmington (“City”), in coordination with the Federal Railroad Administration (FRA) (Lead Federal Agency) and North Carolina Department of Transportation (NCDOT), is undertaking a study to evaluate realigning an existing CSX Transportation (CSXT) freight rail line that traverses through City limits as well as unincorporated areas of Brunswick and New Hanover counties. The study, referred to as the Wilmington Rail Realignment (Project), proposes a route to bypass the existing freight rail route between Navassa (Davis Yard) and the Port of Wilmington. The result would create a new freight rail alignment that would improve freight rail operations, public mobility, and public safety in the region.

Site Conditions and Assumptions

As part of this project, several corridors are currently being studied through Pre-NEPA environmental documentation and conceptual design development processes. To support conceptual design development, a preliminary hydraulic analysis was undertaken in order to identify hydraulic considerations that impact minimum design criteria for each of the corridors under consideration.

Several of these corridors cross hydraulic features to include the Cape Fear River, Alligator Creek and tributaries to each. The corridors that cross hydraulic features (or that would impact drainage to these hydraulic features) are analyzed in this memorandum (see *Figure 1* for further details), primarily through an analysis of the grade control at locations where hydraulic conveyance must be accommodated. While more detailed hydraulic analysis

will be forthcoming to support more advanced preliminary engineering activities, the preliminary hydraulic analysis appropriate for this level of conceptual design is governed by what is required for the most hydraulically restrictive situation, i.e. an earthen embankment requiring culvert design. This type of hydraulic analysis differs from what is required for a facility that would be on elevated structures, which would be the least hydraulically impactful design. Elevated structures will be required for the crossing of major waterbodies, the minimum design criteria of which are controlled by the US Coast Guard.

Hydraulic analysis for conceptual engineering is appropriately grounded in basic hydraulic design standards used by the railroad industry and by the Federal Emergency Management Agency (FEMA). The railroad industry uses the 100 Year Storm as a design standard for railroad projects. FEMA produces Digital Flood Insurance Rate Maps (DFIRM) to depict the same 100 Year Storm event. The base flood elevation (BFE) used in this memorandum corresponds to both the regulatory event used by FEMA (in their DFIRM maps) and the 100 Year Storm used by the railroad industry. In addition to minimum design considerations revealed through the analysis of these datasets, future design of a railroad along one of these corridors (if identified as the locally preferred alternative through the environmental review process) will include additional height to address sea level rise concerns.

For the purposes of this memorandum and in order to calculate the minimum top of rail elevation, 1.0 ft of cover over the structure was added plus 2.25 ft of rail structure (which includes the depth of the rail, rail ties and ballast) was assumed. Additionally, in situations where the required pipe size would be submerged below the normal water surface elevation, the size was increased to allow for 1.0 ft of free board to the crown of the structure.

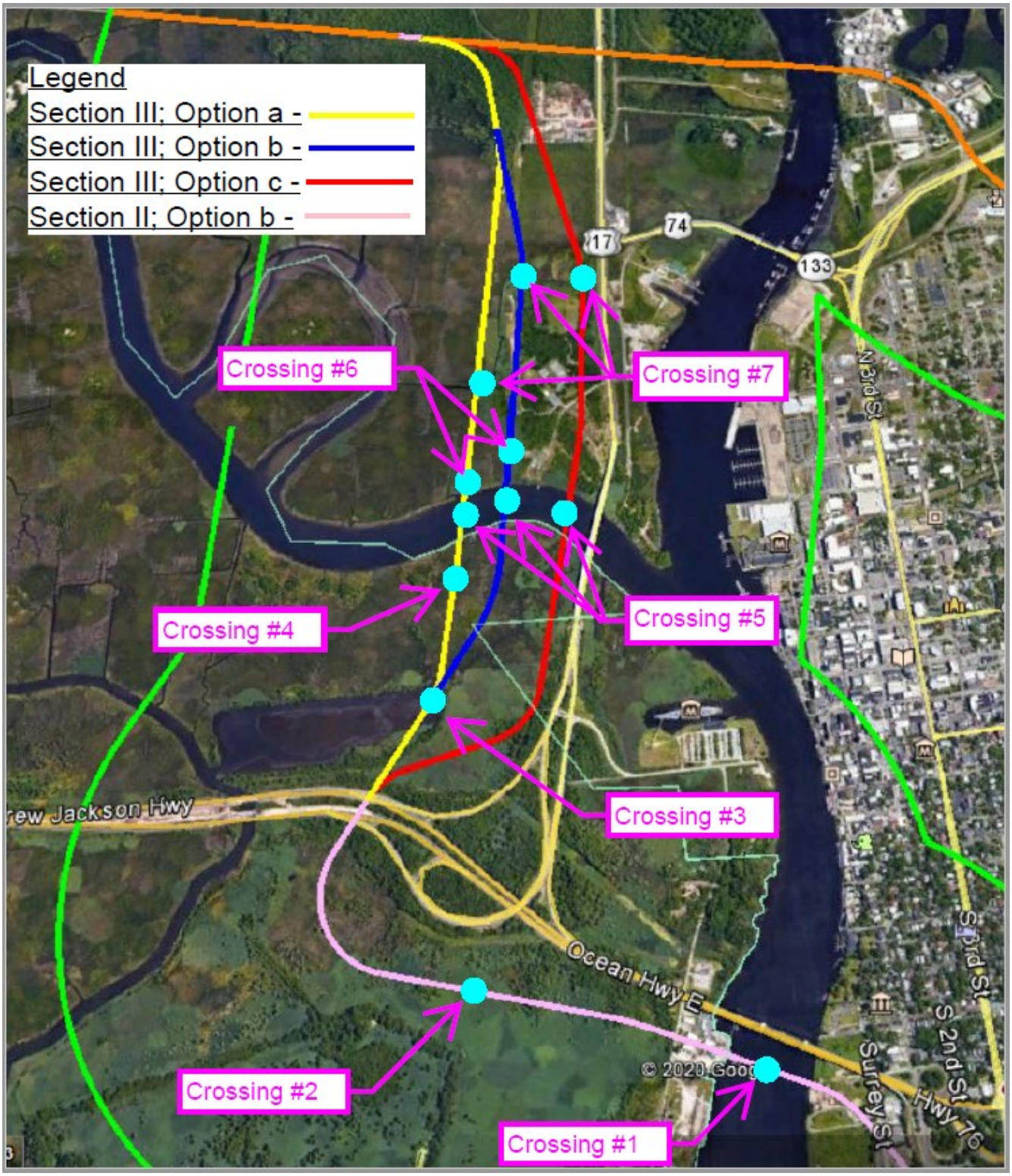
It is important to further note that while hydraulic considerations help to establish the minimum design criteria, additional criteria and requirements may be more stringent in governing minimum design criteria. Such criteria are briefly discussed under the “Analysis” section that follows.

Identification of Crossings Analyzed for Hydraulic Considerations

The locations along the proposed screening sections described below (and depicted in Figure 1) were used for the analysis documented in this memorandum:

- Crossing #1 – Along the Cape Fear River at station 55+00, this crossing would be required for any corridors using Section II Option b
- Crossing #2 – Along the Alligator Creek drainage basin at station 87+50, this crossing would be required for any corridors using Section II Option b
- Crossing #3 – Along a tributary of Alligator Creek at station 132+00, this crossing would be required for any corridors using Section III Option a or Section III Option b
- Crossing #4 – Which drains to the Cape Fear River at station 143+50, this crossing would be required for any corridors using Section III Option a
- Crossing #5 – Along the Cape Fear River at station 150+00, this crossing would be required for any corridors using Section III Option a, Section III Option b, or Section III Option c
- Crossing #6 – Which drains to the Cape Fear River at stations 153+00 and 160+00, this crossing would be required for any corridors using Section III Option a or Section III Option b
- Crossing #7 – Which drains to the Cape Fear River at stations 166+00, 181+00, and 188+00, this crossing would be required for any corridors using Section III Option a, Section III Option b, or Section III Option c

Figure 1 – Identification of Crossings Analyzed for Hydraulic Considerations



Analysis

The identified crossing locations (#1 - #7) along the proposed screening sections have been analyzed based on preliminary data for the required hydraulic conveyance of the 100-Year Storm event for both the individual basins as well as the 100-Year Storm event for the Cape Fear River.

Establishing Minimum Top of Rail Elevations: Hydraulic Analysis

Discharges for the individual crossings were calculated using the rational method for areas under 60 acres and the regional rural regression equation (SIR2009-5158) was used for crossing #7 Opt. A & B per standard hydrologic practices. Due to the location of the corridor within the flood plain of the Cape Fear River, the basins were also analyzed in a fully inundated state resulting from the 9.0' Base Flood Elevation (BFE) as shown on the Effective FEMA DFIRM Maps. In all cases the Cape Fear River BFE was the governing event, meaning that the discharge that resulted from draining the basin filled by the Cape Fear River at flood stage exiting the basin was larger than the discharges calculated due the 100-Year Storm event within those individual basins. The volume of the individual basin was calculated between the lowest basin overtopping elevation and the mean water elevation. That volume was released over a 6-hour tide cycle to determine a 100-Year discharge. That discharge was input into HY-8 to determine the appropriate crossing size given typical pipe burial depths (1.0' in CAMA Counties regardless of jurisdictional determination), assumed water depth in the channel, and mean water elevation to obtain a HW/D of 1.5 or less per AREMA design specifications. Finally, the minimum cover over the pipe plus the track structure depth (rail, tie plates, ties, ballast, etc.) was added to obtain the minimum top of rail grade at a given crossing. The table on the following page (Figure 2) shows the recommended hydraulic grade control elevations.

Figure 2 – Recommended Hydraulic Grade Control Elevations

Crossing	Alignment	Station	Governing Feature	Drainage Area (Ac)	Rainfall Discharge (cfs)	DA Storage <9' (ft^3)	Storm Surge Discharge (cfs)	Channel Geometry (Top Width) (ft)	Culvert Size Recommendation	Top of Culvert Elevation (ft)	Minimum Top of Rail Elevation (1' cover + 2.25' Track Structure)
1	Sec. II; Opt. b	55+00	Cape Fear River	Navigational Requirements will Govern				875	-	-	-
2	Sec. II; Opt. b	87+50	Cape Fear River	33.6	33.6	2,927,232	135.5	N/A	72" Pipe	9	12.25
3	Sec. III; Opt. a, b	132+00	Cape Fear River	31.3	30.6	1,946,588	90.1	30	72" Pipe [1]	6.2	9.45
	Sec. III; Opt. a, b	132+00	Cape Fear River	31.3	30.6	1,946,588	90.1	30	72" Pipe [1]	6.7	9.95
4	Sec. III; Opt. a	143+50	Cape Fear River	6.3	4.0	548,856	25.4	5	48" Pipe	4.6	7.85
5	Sec. III; Opt. a	150+00	Cape Fear River	Navigational Requirements will Govern				480	-	-	-
	Sec. III; Opt. b	150+00	Cape Fear River	Navigational Requirements will Govern				480	-	-	-
	Sec. III; Opt. c	150+00	Cape Fear River	Navigational Requirements will Govern				480	-	-	-
6	Sec. III; Opt. a	153+00	Cape Fear River	9.6	10.7	627,264	29.0	15	78" Pipe [1]	4.4	7.65
	Sec. III; Opt. b	160+00	Cape Fear River	4.5	8.1	294,030	13.6	N/A	42" Pipe	5.5	8.75
7	Sec. III; Opt. a	166+00	Cape Fear River	116.9	138.4	15,277,851	707.3	30	2, 7' x 7' RCBC	4	7.25
	Sec. III; Opt. b	181+00	Cape Fear River	68.0	100.3	14,809,877	685.6	15	2, 7' x 7' RCBC	5	8.25
	Sec. III; Opt. c	188+00	Cape Fear River	22.0	76.4	4,796,566	222.1	15	1, 6' x 6' RCBC	4	7.25

Pipe size was increased to allow for freeboard from assumed WSEL to Top of Culvert and to avoid a fully submerged structure [1]

All crossings are inundated by the Effective BFE of 9.0' and therefore this elevation governs for the entire corridor

All elevations are based off QL2 data and are subject to change upon physical survey of crossing locations

All reinforced concrete box culverts are assumed to have a 1.0' thick top slab

Further Consideration on the Establishment of Minimum Top of Rail Elevations: Other Qualitative Considerations

Crossings #1 and #5 are the only crossings currently under study which are over major waterbodies and therefore subject to navigational requirements from the US Coast Guard. As noted in Figure 2, these crossings will be controlled by navigational requirements and therefore were not analyzed for hydraulic conveyance. It is further noted that, while preliminary hydraulic analysis (as appropriate for this stage of conceptual design) impacts the minimum design criteria and top of rail elevations, more stringent design criteria regarding minimum elevations are likely to govern the design of this project to include regulations from the US Coast Guard and US Army Corps of Engineers. These additional regulatory considerations will be forthcoming through continuous coordination with the agencies as the project progresses.

Conclusion

As shown in Figure 2, hydraulic crossings of the proposed alignments have been sized based on the 100-Year Event at the local scale within the individual crossings' drainage basins. However, the maximum water surface elevation and subsequent discharges that will be experienced by these crossings will likely result from the FEMA 100-Year Base Flood Event on the Cape Fear River which is 9.0 feet. Given this, the minimum top of rail elevation for all crossings except the Cape Fear River crossings should be 12.25'. This includes 1.0' of cover plus 2.25' of rail structure thickness as required by CSX (CSX Standard Drawing 2532, CSX Standard Drawing 2601 and CSX Standard Drawing 2602).

All analysis and conclusions represented in this memorandum rely on the data and assumptions made at this early stage of the conceptual engineering design process. More refined base data and additional regulatory agency coordination may require revisions to the design criteria elevation minimums at a later date.