moffatt & nichol

4700 Falls of Neuse Road, Suite 300
Raleigh, NC 27609

(919) 781-4626 Fax: (919) 781-4626
www.moffattnichol.com

**DRAFT**

# MEMORANDUM

| | |
|---|---|
| **To:** | **Roy Bruce - Lochner** |
| **Cc:** | **John Dorney – M&N** |
| **From:** | **Jeff Shelden – M&N** |
| **Date:** | **August 19, 2019** |
| **Subject:** | **Mid-Currituck Bridge – Sea Level Rise** |
| **M&N Job No:** | **10555** |

Moffatt & Nichol's *Mid-Currituck Bridge Coastal Engineering Design Criteria Report* dated July 31, 2009 made the following recommendation regarding sea level rise and the low-chord elevation for the bridge.

*"The recommended low-chord elevation for the proposed Mid-Currituck Bridge is +16 feet-NAVD. This is based on a maximum modeled wave crest elevation of +12.4 feet-NAVD; plus 1.6 feet of projected sea-level rise during the lifespan of the bridge; plus 1.0 feet of clearance as recommended by the AASHTO specifications; plus another 1.0 feet to account for uncertainties of regional land subsidence, additional contributions from polar ice melt, and potential increased storminess."*

This recommendation assumed that the bridge would be constructed by 2013 and have a 75-year lifespan. Hence, these sea level rise projections were to the year 2088. Since the bridge is now assumed to be completed by 2026 and having a 75-year lifespan, sea level rise projections for the year 2101 are necessary.

Upon review by others of M&N's memo dated July 26, 2019 addressing this issue, a question arose regarding NOAA's recent sea level rise projections. These are presented in "NOAA Technical Report NOS CO-OPS 083, Global and Regional Sea Level Rise Scenarios for the United States, January 2017." In this report, NOAA presents six different global sea level rise scenarios; Low, Intermediate-Low, Intermediate, Intermediate-High, High, and Extreme which assume global sea level rises between the Year 2000 and the Year 2100 of 0.3m (0.98 ft), 0.5m (1.64 ft), 1.0m (3.28 ft), 1.5m (4.92 ft), 2.0m (6.56 ft), and 2.5m (8.20 ft), respectively. These global sea level rises were then modified by NOAA for local factors (both climate-related processes and non-climate background changes) to develop region specific relative sea level rise (RSL) values. For the project location, based on the Duck Pier tidal gage, NOAA presents the relative sea level rise values shown in Table 1a (and Table 1b) for these different scenarios.

Additionally, NOAA presents the Probability of Exceedance for the various scenarios for three different RCP's (Representative Concentration Pathways), representing different greenhouse gas emissions scenarios, which are provided in Table 2.

**Table 1a: Relative Sea Level Rise based on Duck Pier (metric units)**

| Scenario | RSL in 2000 (cm) | RSL in 2010 (cm) | RSL in 2020 (cm) | RSL in 2030 (cm) | RSL in 2040 (cm) | RSL in 2050 (cm) | RSL in 2060 (cm) | RSL in 2070 (cm) | RSL in 2080 (cm) | RSL in 2090 (cm) | RSL in 2100 (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Low (0.3m) | 0 | 5 | 11 | 17 | 23 | 29 | 34 | 40 | 45 | 50 | 52 |
| Intermediate-Low (0.5m) | 0 | 6 | 13 | 20 | 28 | 35 | 42 | 49 | 55 | 62 | 68 |
| Intermediate (1.0m) | 0 | 9 | 18 | 29 | 40 | 53 | 67 | 82 | 99 | 116 | 134 |
| Intermediate-High (1.5m) | 0 | 11 | 23 | 37 | 53 | 72 | 93 | 117 | 144 | 173 | 206 |
| High (2.0m) | 0 | 14 | 27 | 46 | 67 | 94 | 124 | 158 | 195 | 237 | 286 |
| Extreme (2.5m) | 0 | 14 | 29 | 50 | 75 | 107 | 146 | 188 | 234 | 288 | 348 |

**Table 1b: Relative Sea Level Rise based on Duck Pier (imperial units)**

| Scenario | RSL in 2000 (ft) | RSL in 2010 (ft) | RSL in 2020 (ft) | RSL in 2030 (ft) | RSL in 2040 (ft) | RSL in 2050 (ft) | RSL in 2060 (ft) | RSL in 2070 (ft) | RSL in 2080 (ft) | RSL in 2090 (ft) | RSL in 2100 (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Low (0.98 ft) | 0 | 0.16 | 0.36 | 0.56 | 0.75 | 0.95 | 1.12 | 1.31 | 1.48 | 1.64 | 1.71 |
| Intermediate-Low (1.64 ft) | 0 | 0.20 | 0.43 | 0.66 | 0.92 | 1.15 | 1.38 | 1.61 | 1.80 | 2.03 | 2.23 |
| Intermediate (3.28 ft) | 0 | 0.30 | 0.59 | 0.95 | 1.31 | 1.74 | 2.20 | 2.69 | 3.25 | 3.81 | 4.40 |
| Intermediate-High (4.92 ft) | 0 | 0.36 | 0.75 | 1.21 | 1.74 | 2.36 | 3.05 | 3.84 | 4.72 | 5.68 | 6.76 |
| High (6.56 ft) | 0 | 0.46 | 0.89 | 1.51 | 2.20 | 3.08 | 4.07 | 5.18 | 6.40 | 7.78 | 9.38 |
| Extreme (8.20 ft) | 0 | 0.46 | 0.95 | 1.64 | 2.46 | 3.54 | 4.79 | 6.17 | 7.68 | 9.45 | 11.42 |

**Table 2: Probability of Exceeding Scenarios in 2100**

| Scenario | RCP 2.6 | RCP4.5 | RCP8.5 |
|---|---|---|---|
| Low | 94% | 98% | 100% |
| Intermediate-Low | 49% | 73% | 96% |
| Intermediate | 2% | 3% | 17% |
| Intermediate-High | 0.4% | 0.5% | 1.3% |
| High | 0.1% | 0.1% | 0.3% |
| Extreme | 0.05% | 0.05% | 0.1% |

Based on the values in Tables 1a / 1b and Table 2, in the Year 2100, the Intermediate Scenario could result in a relative sea level rise that, when combined with the maximum wave crest height, might impact the originally proposed bridge low chord elevation. (134 cm or 4.40 ft plus +12.4 ft-NAVD maximum wave crest = 16.8 ft-NAVD which is higher than proposed low chord of +16 ft-NAVD).

However, interpolating the values in Tables 1a / 1b shows that the bridge would only be impacted by the maximum wave crest around the Year 2086, or during the last 15 years of its projected life. The probability that one or more 100-year storm events (the basis of the design maximum wave crest elevation) will occur during this 15-year period is only 14%. Combining this with the sea level rise probability of occurrences presented in Table 2 for the Intermediate Scenarios results in a total probability of occurrence of the 100-year maximum wave crest impacting the bridge of 0.3% (14% x 2%), 0.4% (14% x 3%) and 2.4% (14% x 17%) for the RCP2.6, RCP4.5 and RCP8.5 scenarios, respectively. These are acceptable risks given that the impact from a very small portion of the maximum wave crest will not damage the bridge. Thus, the originally recommended low chord elevation of +16 ft-NAVD remains valid.