A Statistical Analysis of the Effects of River Flow on Downstream Water Quality in the Lower Roanoke River, North Carolina

Presenter: Christopher Wu, ENSR, cswu@ensr.aecom.com
Co-Authors: Steve Cibik, ENSR, scibik@ensr.aecom.com, Mark Gerath, ENSR, mgerath@ensr.aecom.com, Jennifer Cassada, ENSR, jcassada@ensr.aecom.com, Michelle Woolfolk, City of Durham, Michelle.Woolfolk@durhamnc.gov, Martin Lebo, Weyerhaeuser, martin.lebo@weyerhaeuser.com

The lower portion of the Roanoke River is a dynamic system that is highly susceptible to seasonal dissolved oxygen deficits (DO) and salt wedge incursions. Historic data show that ambient DO concentrations often fall below 5 mg/L, and in some cases, low DO levels have been associated with fish kills in the middle and lower portions of the Roanoke River. Additionally, the river is vulnerable to salt wedge incursions originating from both the Pamlico and Albemarle Sounds. Previous ambient sampling has shown that the salt wedge, with conductivity levels in excess of 10,000 μs/cm, has moved as far upstream as 10 miles into the river. ENSR performed two statistical studies to identify environmental variables that significantly contribute to such adverse conditions in the Roanoke River. Using a combination of multivariate analyses, ENSR identified flow, controlled by upstream dam releases, and prevailing wind direction as the primary determinants of river dynamics. Using frequency analysis, multiple regression, and recursive partitioning, ENSR identified river flows exceeding 7,000 cfs as a threshold at which the Roanoke River would be likely to experience DO deficits, the severity of which grows with increased dam discharges. Large releases from upstream hydropower dams have the potential to flood riparian wetlands, contributing Biochemical Oxygen Demand (BOD) to the river and decreasing in-stream DO concentrations. Flows in excess of 7,000 cfs are not uncommon in the Roanoke River; the median flow from 1964 to 2007 was 6,080 cfs while the upper quartile was 11,100 cfs. Conversely, low flow and drought conditions leave the lower portion of the Roanoke River susceptible to salt wedge incursions. Using wind roses and recursive partitioning, ENSR identified both an approximate flow threshold (< 3,000 cfs) and a persistent wind direction (southwest) for significant salt wedge incursions. Southwest wind events of two or more days drive salinity migration in Pamlico and Albemarle Sounds and are necessary for salt wedge migration upstream under conditions of low flow. An evaluation of data indicates that flows in excess of approximately 3,000 cfs tend to push the salt wedge downstream regardless of wind conditions.