Neuse River Nutrient Management Strategy, North Carolina

ACWA 2021 Nutrients Permitting Workshop
Online October 26-28, 2021

Rich Gannon
Nonpoint Source Planning Branch
NC Division of Water Resources

Talk Coverage

- Strategy drivers, overview
- Strategy elements, rule by rule, w/ limitations
- Progress metrics & diagnostics
- Current status, potential directions

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OHIO
Ohio
Ohio
CHARLESTON
Summerville Lake
WEST VIRGINIA
New
Blue Stone Lake
R.D. Bailey Lake
RICHMOND
Chesapeake Bay
VIRGINIA
Hampton
Newport News
Virginia Beach
Norfolk
KENTUCKY
Smith Mtn Lake
Lake Gaston
J.H. Kerr Res.
Roanoke Rapids Lake
New
New
Durham
Winston-Salem
Greensboro
RALEIGH
Norris Lake
TENNESSEE
Douglas Lake
Rhodhiss Lake
Lake Hickory
High Rock Lake
NORTH CAROLINA
Outer Banks
Lake James
Lake Norman
Knoxville
Asheville
Charlotte
Fayetteville
Jacsonville
Lake Wylie
Wilmington
Lake Wateree
ATLANTIC OCEAN
Lake Keowee
Hartwell Lake
Carters Lake
Lake Murray
COLUMBIA
Russel Lake
Long Bay
N. Oconee
SOUTH CAROLINA
Lake Sidney Lanier
J. Strom Thurmond Res.
Lake Marion
Lake Moultrie
ezilon.com
ATLANTA
Oconee Lake
Savannah
Lake Sinclair
GEORGIA
0 km
40
80
120 km
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Neuse River Estuary, Summer 1995

Common Features of 'Modern' NC Nutrient Strategies

- Collaborative development w/ stakeholders
- Major watershed sources
  - Model-based reduction goals, wasteload allocations*
- Chl *a* standard as basis (no numeric N, P criteria to date)
- Minimize inequities
  - Point and nonpoint sources, "fair, reasonable and proportionate" reductions, incremental schedule*
  - All sources same relative reductions vs. baseline
  - Options, offsets/trading
- Compliance horizons – 5 yrs* -> expanding with experience
- Challenges
  - Reactive to impairment, water-by-water
  - Resource-intensive
  - Multi-year development, Commission/legislative interventions

* Statutory directive

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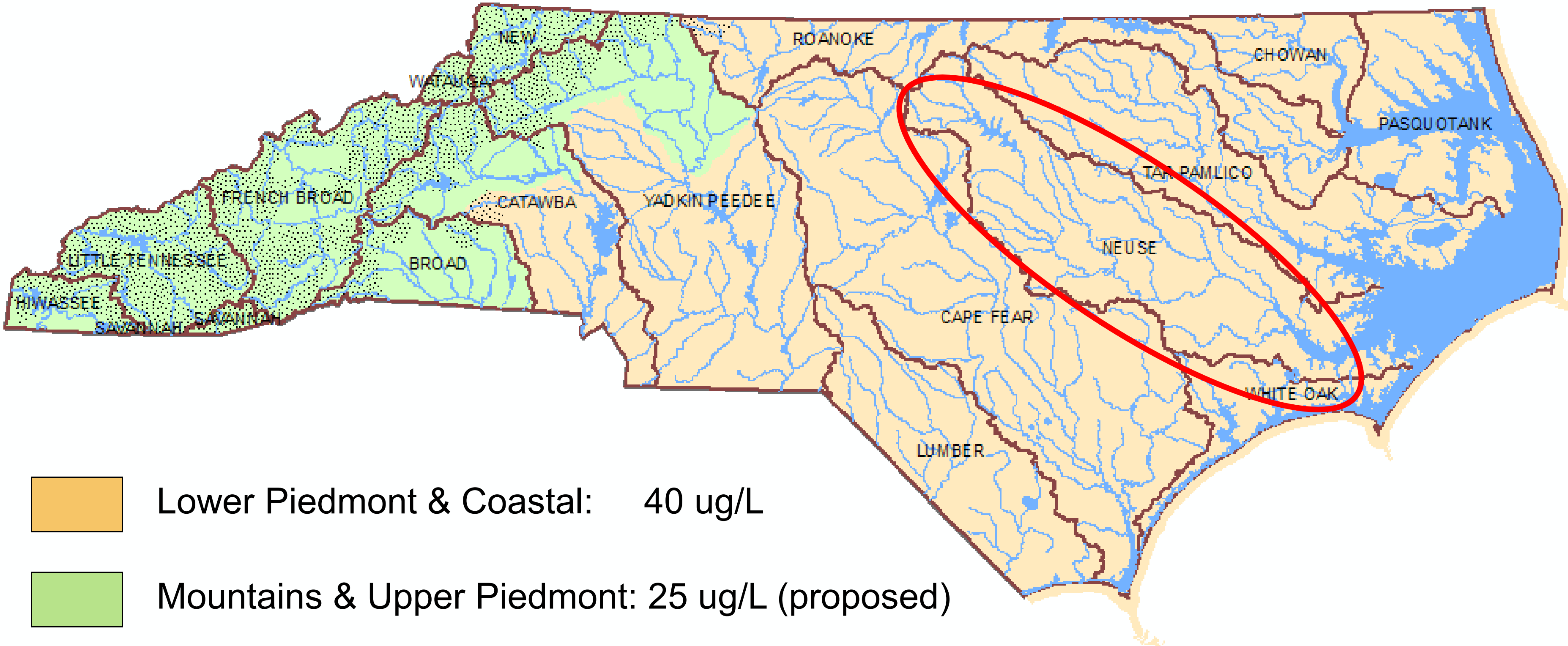
NC Chlorophyll a Standards



Lower Piedmont & Coastal: 40 ug/L

Mountains & Upper Piedmont: 25 ug/L (proposed)

Areas with Trout (Tr) Waters : 15 ug/L

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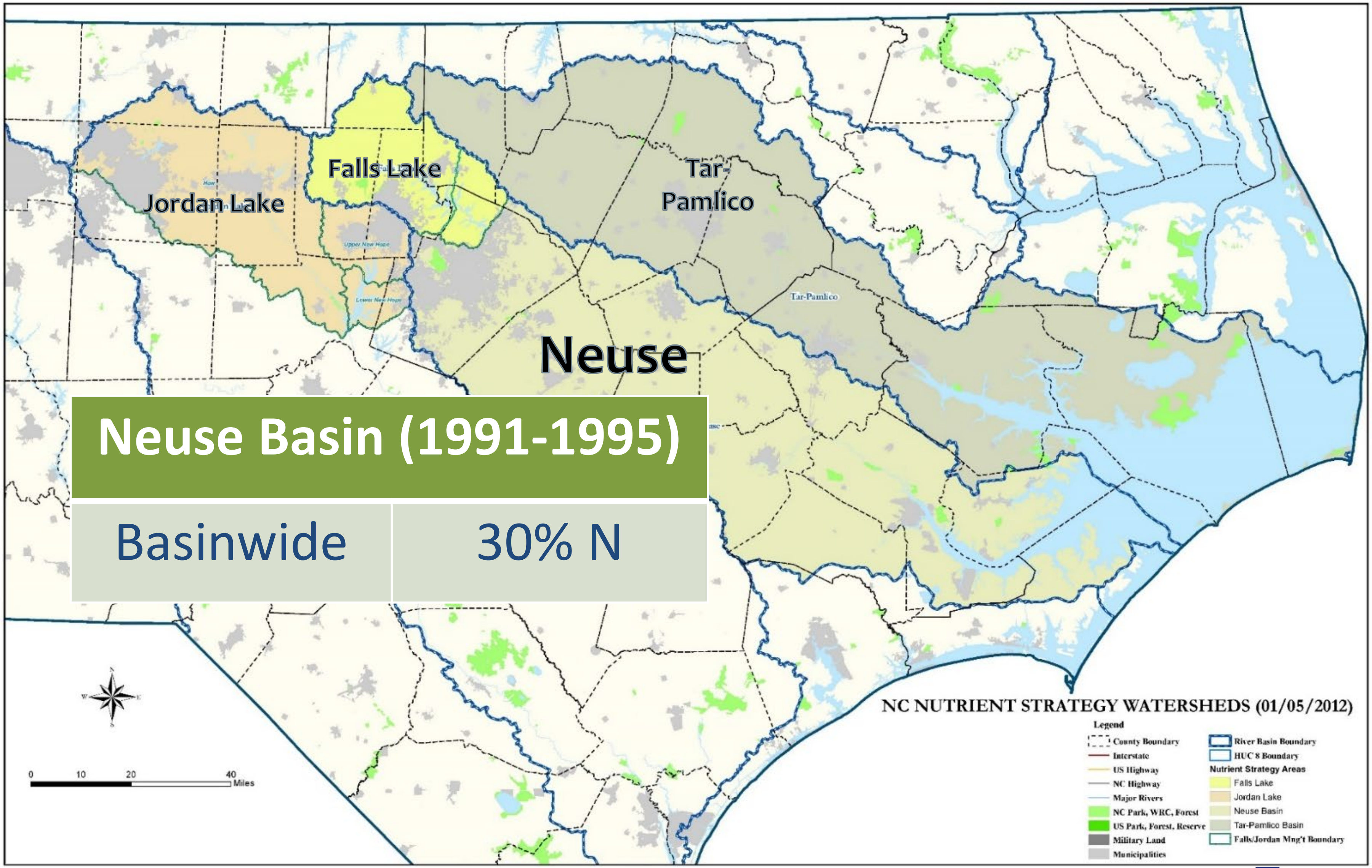
“Modern” NC Nutrient Strategy Watersheds



Neuse Basin (1991-1995)	
Basinwide	30% N

Rules of the Neuse Nutrient Strategy

Effective 1998, 5-yr compliance window

Rules:

- Wastewater
- Agriculture
- New Development Stormwater
- Riparian Buffer Protection
- Nutrient trading

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Neuse Wastewater Rule

- Existing > 0.5 MGD - TN mass limits based on:
  - WLA = ∑ equivalent [TN] * permitted flow * delivery factor
  - Option: purchase allocation; ~9 to date, permanent; $275 - $500/lb
  - Option: Watershed group permit (trading alternative)
    - Combined limits, overlay on individual permits
    - Meet limit? No problema. Exceed? Offset + enforcement on both group and individual exceeders
    - Non-profit compliance association
    - Bi-laws govern contractual trades, address ‘free rider’ problem.
    - Over individual limits – purchase credit from others. Ranges $4-$9/lb
- New & expanding – obtain allocation or NPS offset for all new load
  - NPS Offsets: 1 to date, recent. More in works.
    - 1.5:1 uncertainty ratio
    - Private banks, NC Division of Mitigation Services
- Trades - delivered loads, no hot spots, major mod w/public comment

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Neuse TN, TP Discharge Requirements

Facilities Affected	Mass TN Limits Equivalent To:	Mass TP Limits Equivalent To:	Group TN WL Allocation, Estuary (million lb/yr) (%)
≥ 0.5 MGD POTW (31)	3.75 or 5.5 mg/L	2.0 mg/L	1.234 (75%)
≥ 0.5 MGD Industrial (3)	3.2 mg/L	2.0 mg/L	.355 (22%)
< 0.5 MGD (42)	6.6 mg/L (no limit)	2.0 mg/L (no limit)	.050 (3%)
Total Estuary Wasteload Allocation			1.64

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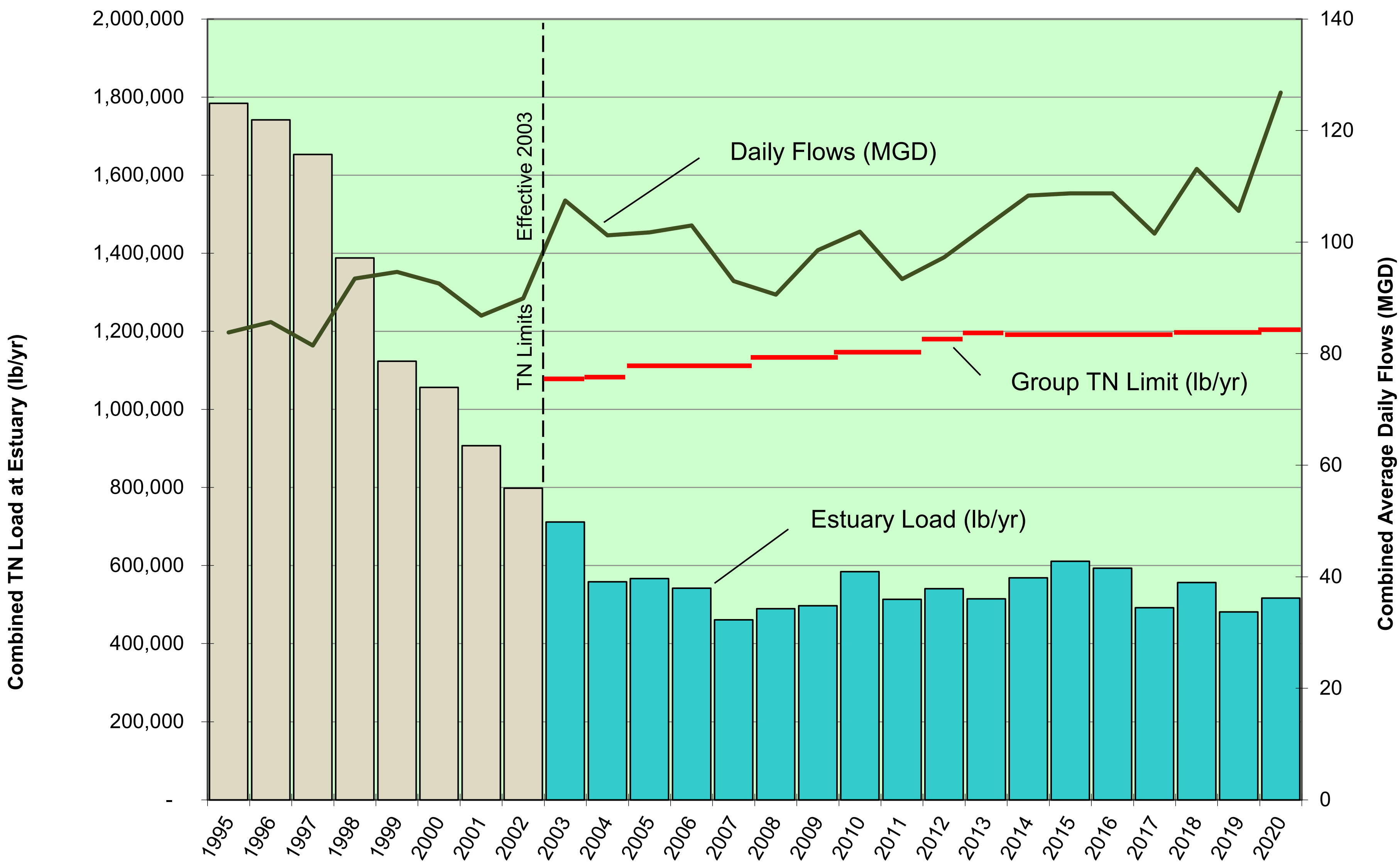
Aggregate Annual Estuary TN Loads, Neuse Basin Dischargers' Association



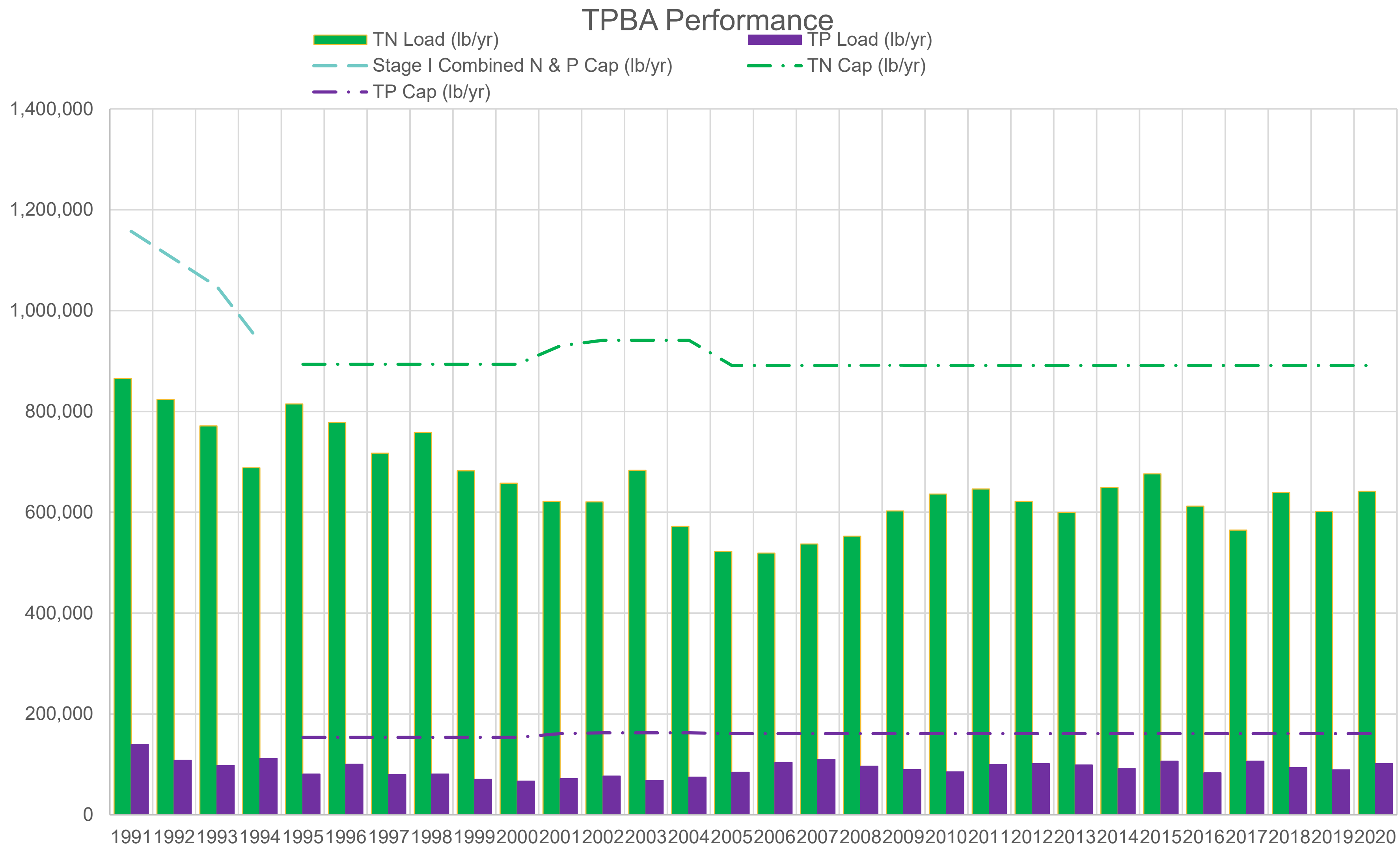
Best NC Nitrogen Performers, 2016 (all in Neuse Basin)

POTWs with 2016 Effluent TN < 3.0 mg/L

Permit	Owner Name	Facility Name	Ann. Avg. Nitrogen (mg/L)	Permitted Flow (MGD)	Ann. Avg. Flow (MGD)	% Capacity
NC0029572	Town of Farmville	Farmville WWTP	1.22	3.50	2.003	57%
NC0026433	Town of Hillsborough	Hillsborough WWTP	1.45	3.00	1.060	35%
NC0032077	Contentnea MSD	Contentnea MSD WWTP	1.59	2.85	2.137	75%
NC0079316	City of Raleigh	Little Creek WWTP	1.79	2.20	0.805	37%
NC0065102	Town of Cary	South Cary WRF	2.10	16.00	5.369	34%
NC0048879	Town of Cary	North Cary WRF	2.26	12.00	5.659	47%
NC0023906	City of Wilson	Wilson WWTP	2.26	14.00	9.497	68%
NC0026824	South Granville W&SA	SGWASA WWTP	2.29	5.50	2.019	37%
NC0023949	City of Goldsboro	Goldsboro WRF	2.34	17.60	9.096	52%
NC0024236	City of Kinston	Kinston Regional WRF	2.43	11.85	6.278	53%
NC0064891	Town of Kenly	Kenly Regional WWTP	2.49	0.63	0.401	64%
NC0023841	City of Durham	North Durham WRF	2.49	20.00	9.779	49%

Note: All dischargers are in the Neuse River basin.

Tar-Pamlico Basin Association Annual Nutrient Performance



Neuse Stormwater Rule

- Locally implemented (10 muni's, 5 co's)
- Project requirements:
  - 3.6 lb N/ac/yr performance target
  - Offsite in-lieu fee option –
    - threshold 6/10 lb/ac/yr residential/commercial
  - ILF options –
    - Private banks
    - NC Division of Mitigation Services
    - Exclusive practice to date –
      rural riparian buffer restoration @ 76 lb N/ac
  - Overlay on Phase II, WSW requirements
- Establish 50' riparian buffers

[also separate buffer protection rule across all land uses]

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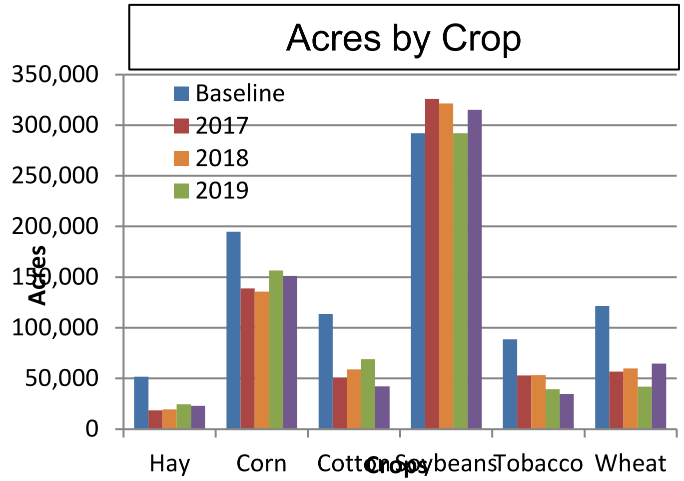
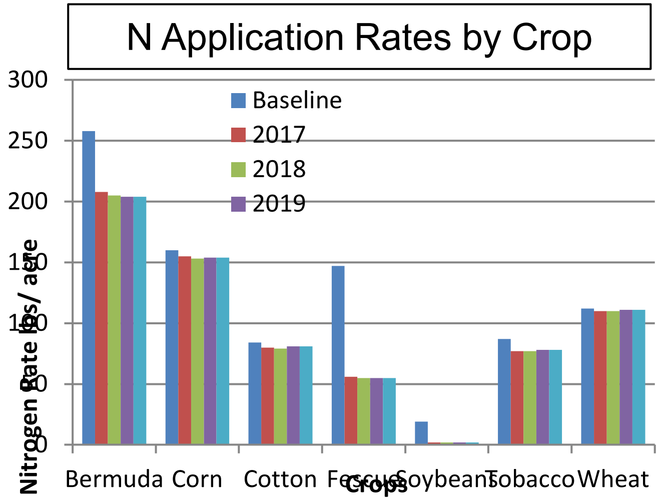
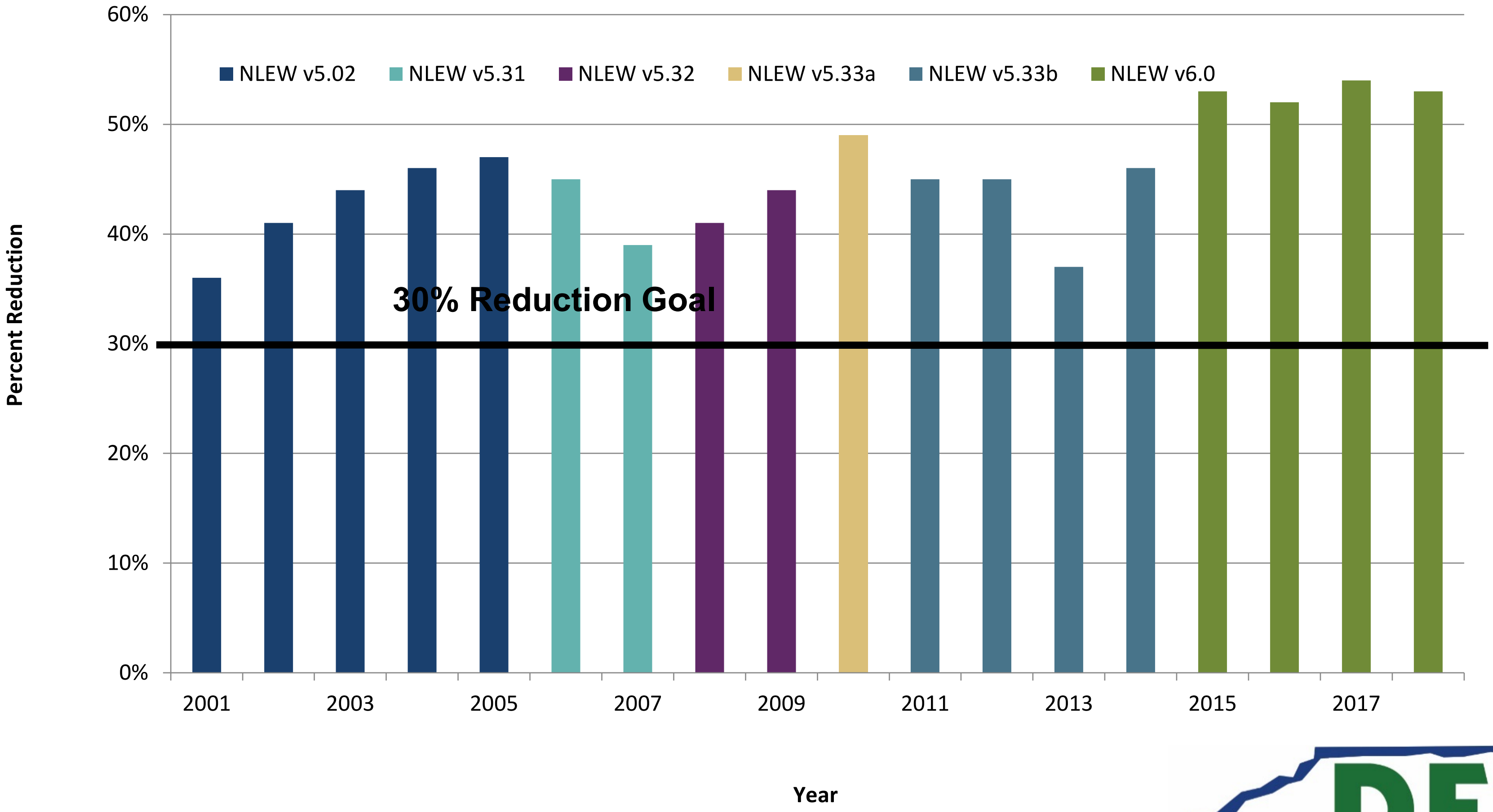
Neuse Agriculture Rule

- Collective compliance approach
  - Basinwide, agriculture to meet strategy 30%
- Based on cropland TN loss accounting
  - County-scale, edge-of-field N loss reduction estimates, aggregated for basin
  - Reductions: BMPs, fertilizer decreases, crop shifts, ag land lost
- Qualifiers:
  - Not calibrated modeling
  - Loss does not equal loading
  - County average N rates by crop per BPJ
  - Does not include:
    - Small acreage crops
    - AFO houses
    - Horticulture
    - BMPs w/insufficient research





Annual Cropland TN Loss Reductions, Neuse River Basin



Ongoing Trading Challenges

- Realities of relative cost-effectiveness, NPS vs PS
- PS:NPS
  - Scale: availability and time required for NPS implementation
  - Comparative uncertainties in setting nominal reductions
  - Comparative uncertainties in actual reductions from installations
  - Comparative long-term performance, stewardship challenges
- Transport factors
- Potential cultural/political challenges:
  - PS:PS allocation “guarding”
  - PS:NPS
    - NPS sector protectiveness – agriculture
    - Commoditization, external pressure to alter trading markets

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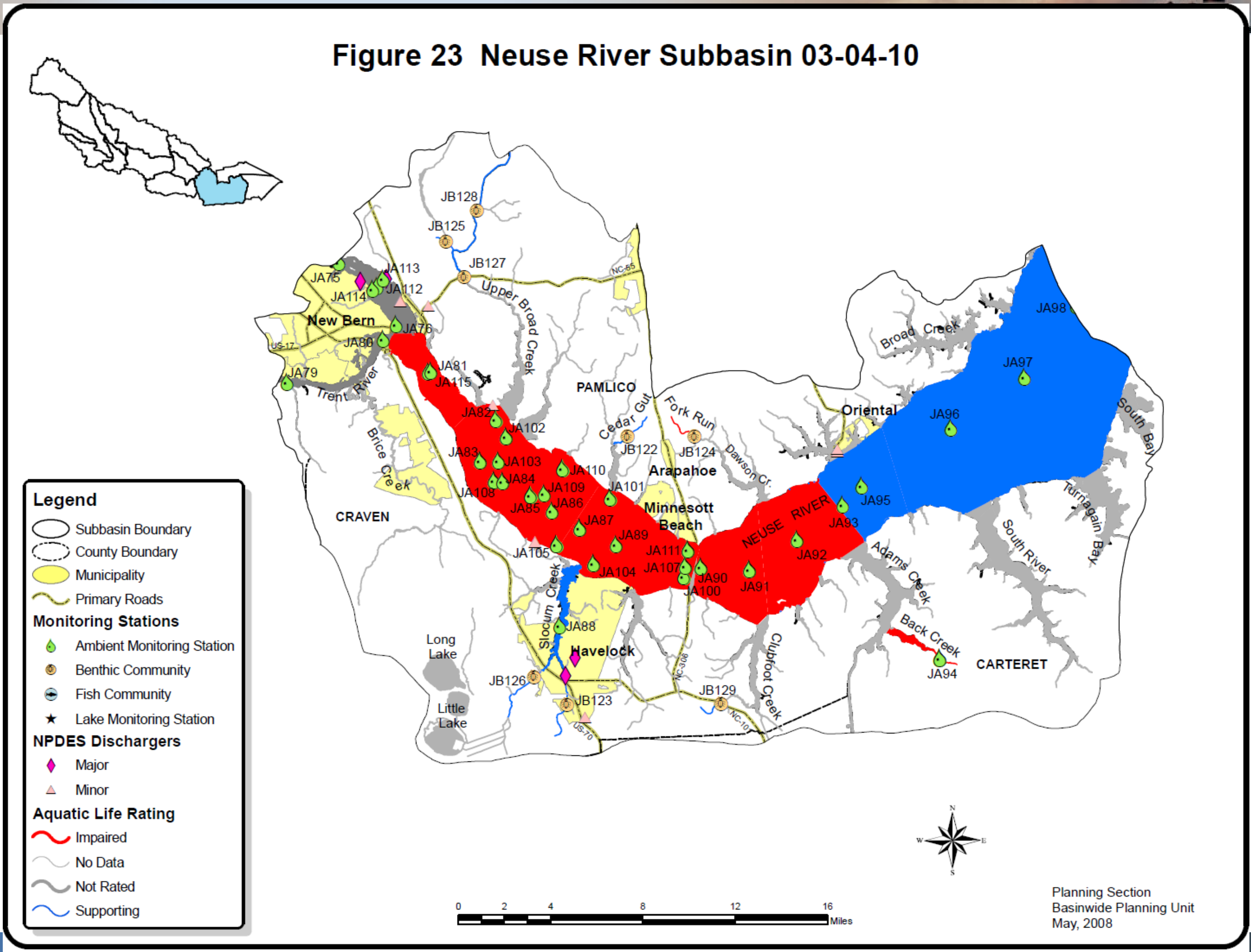
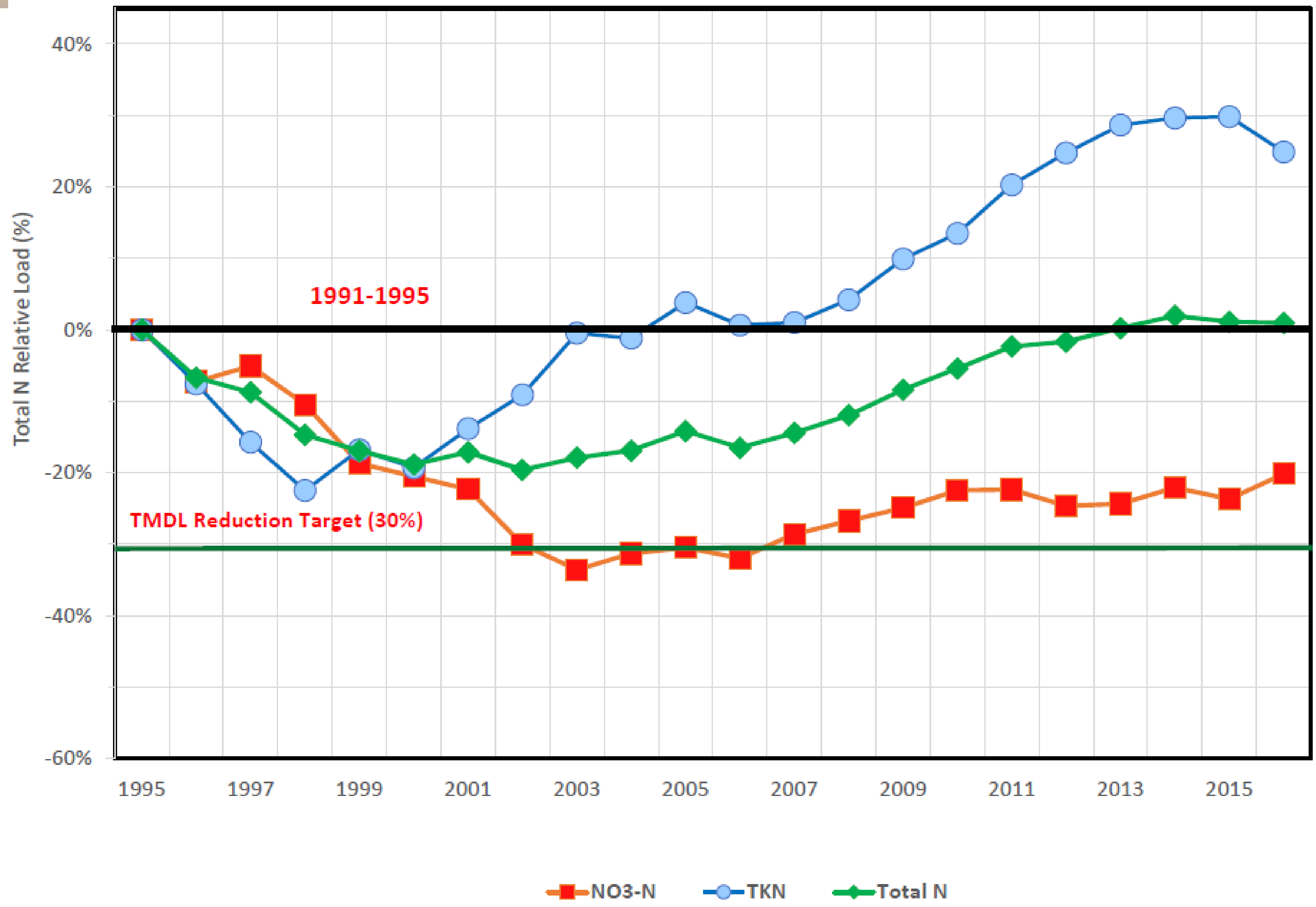
Neuse Estuary Impairment



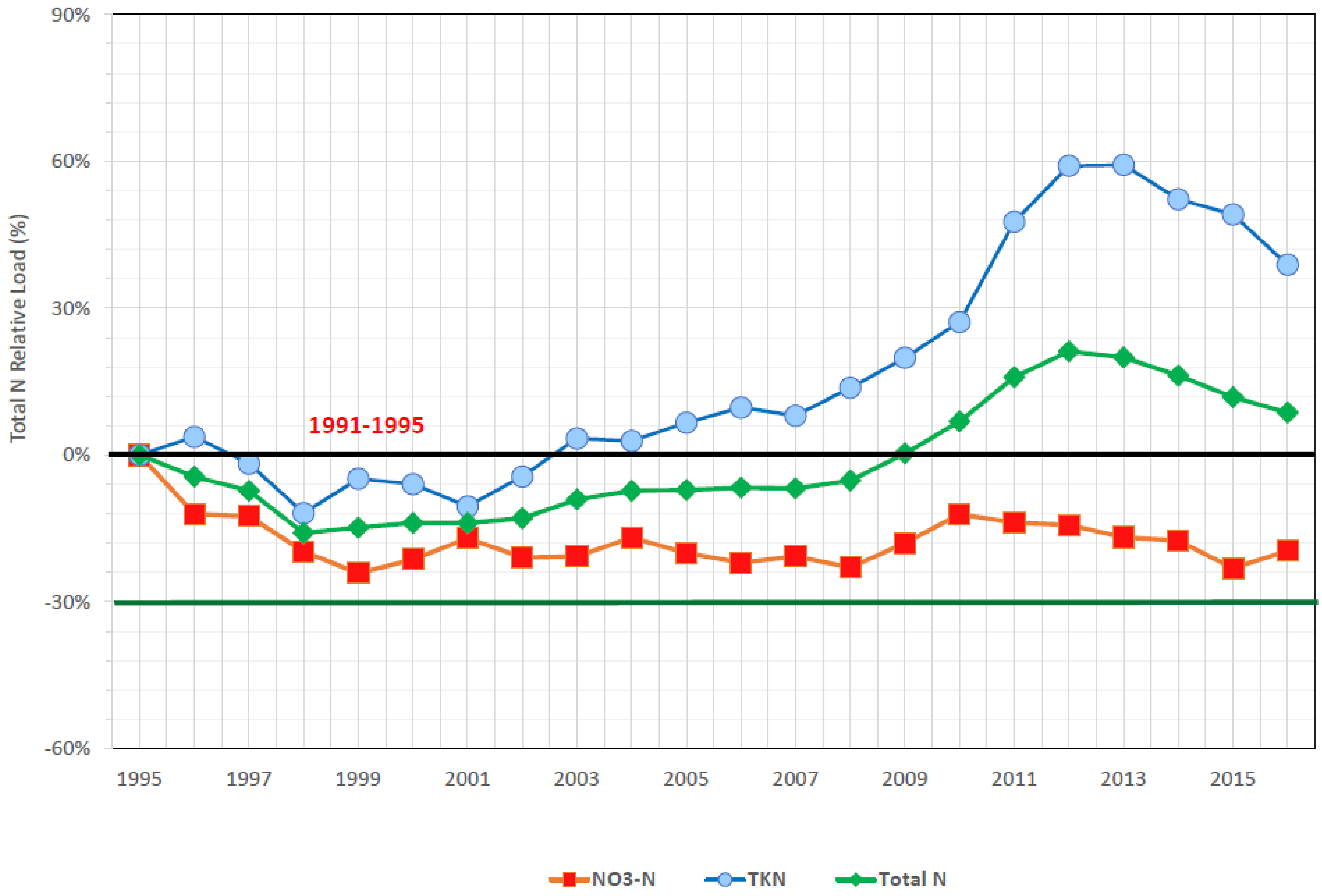
Flow-Normalized Nitrogen Loads (% vs. 1991-1995)

Neuse River at Fort Barnwell

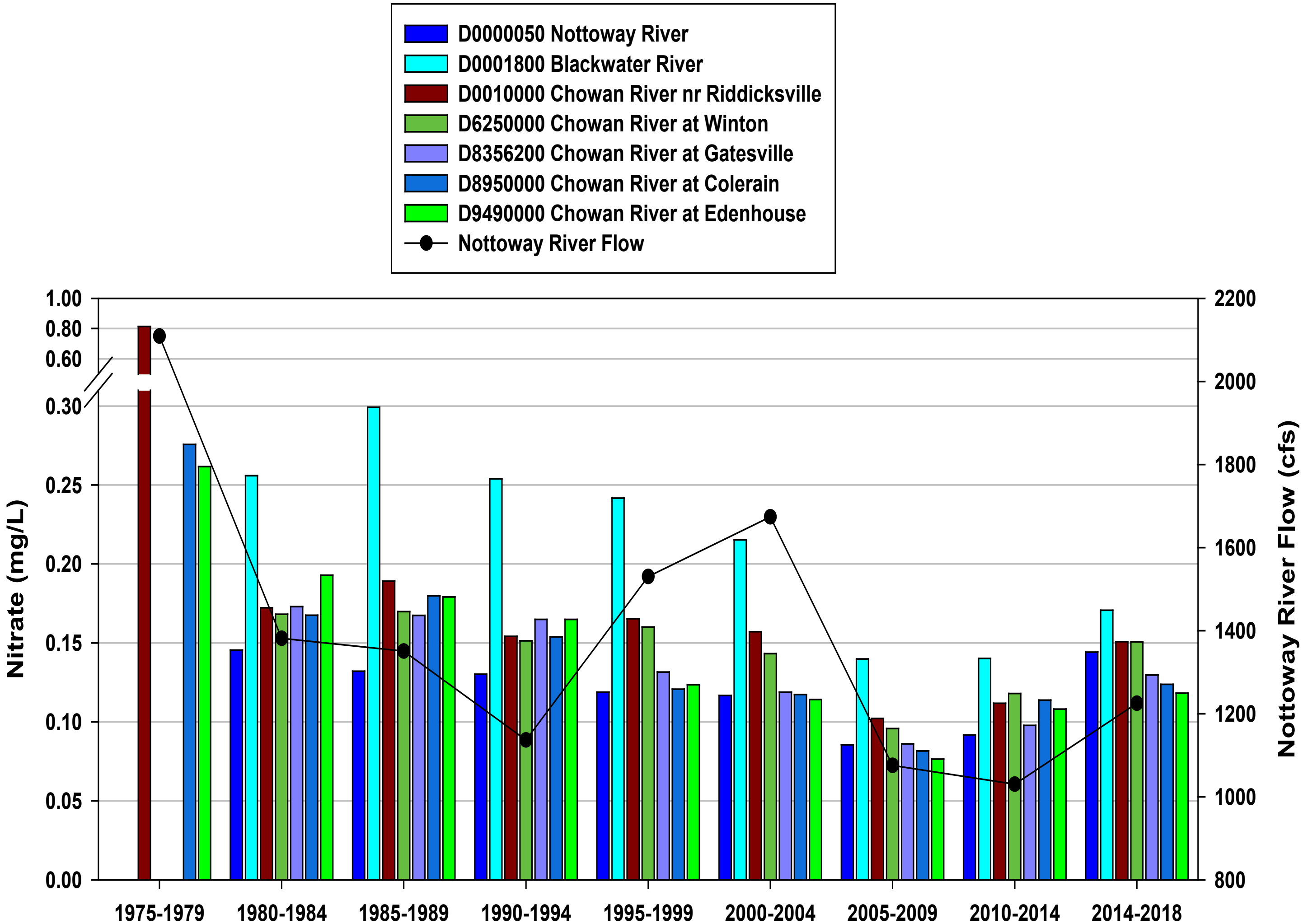


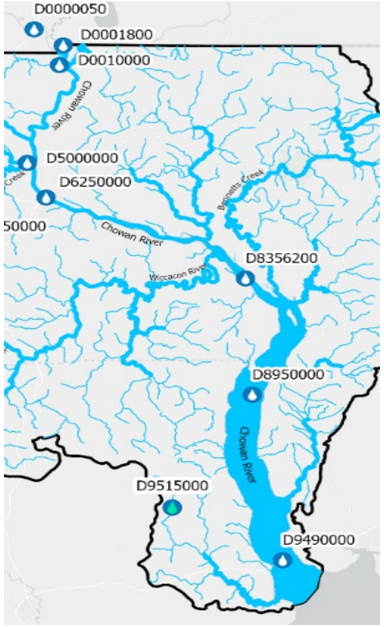
Flow-Normalized Nitrogen Loads (% vs. 1991-1995)

Tar River near Grimesland



Chowan River Basin Water Resources Plan
Nutrient Sensitive Water Summary





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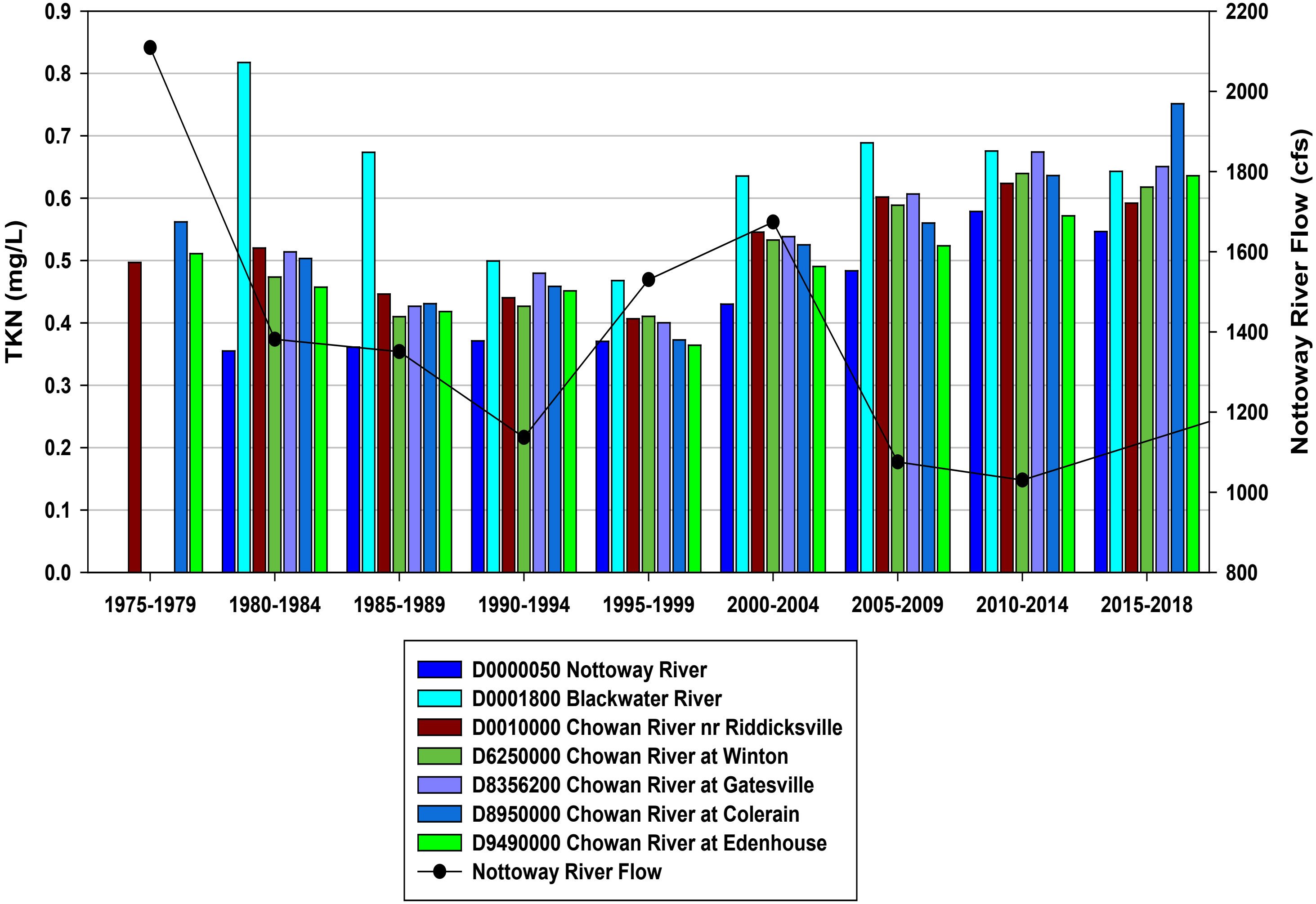
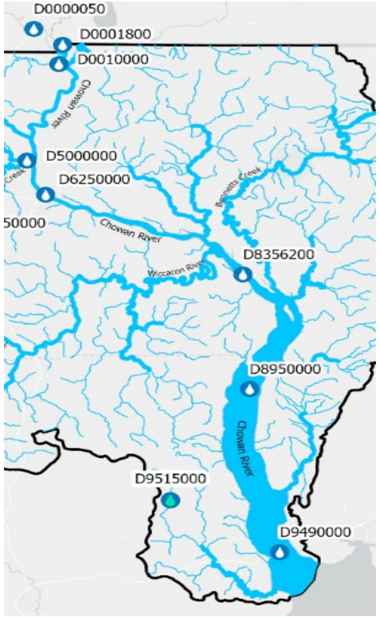
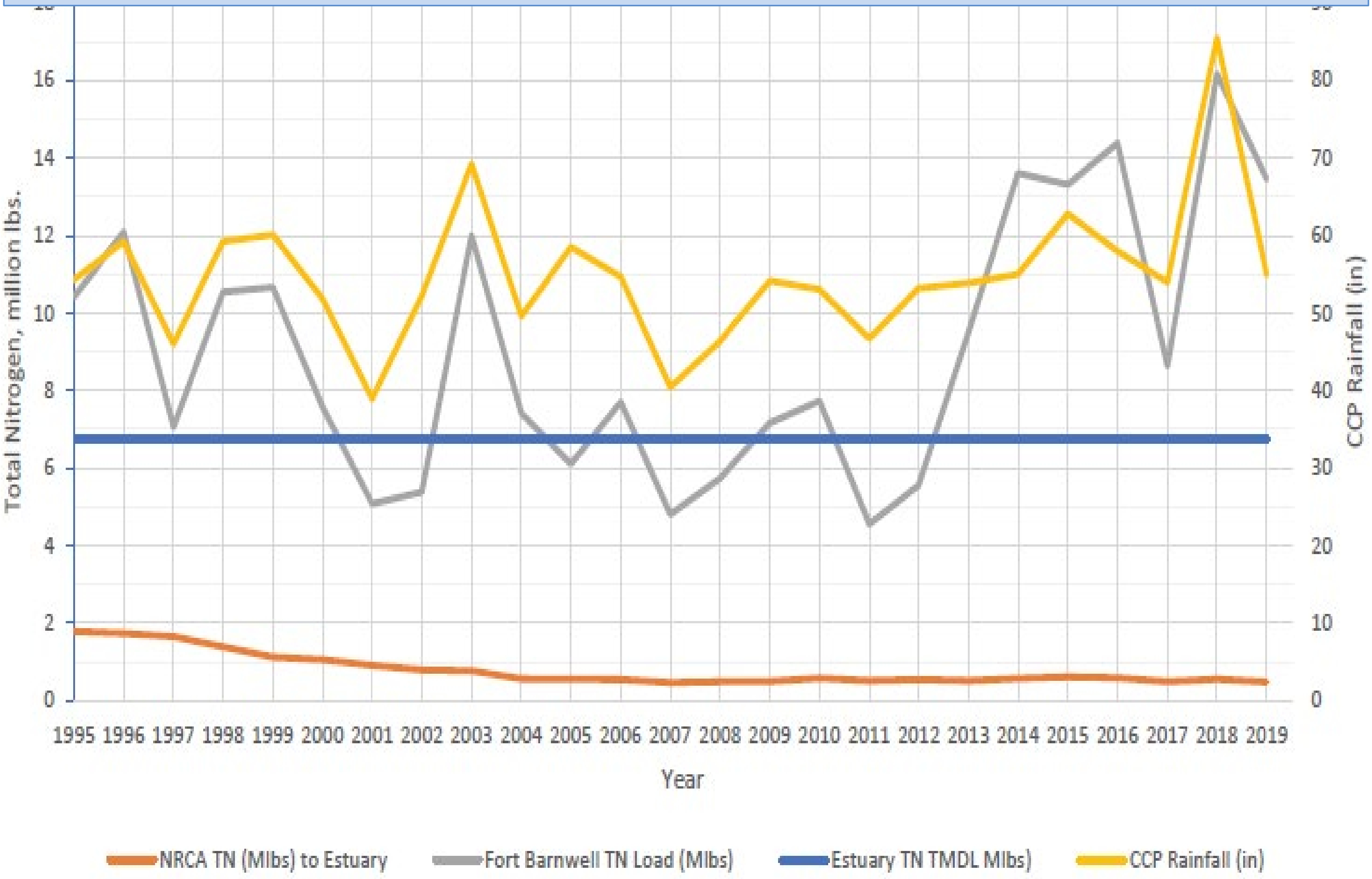
Chowan River Basin Water Resources Plan
Nutrient Sensitive Water Summary



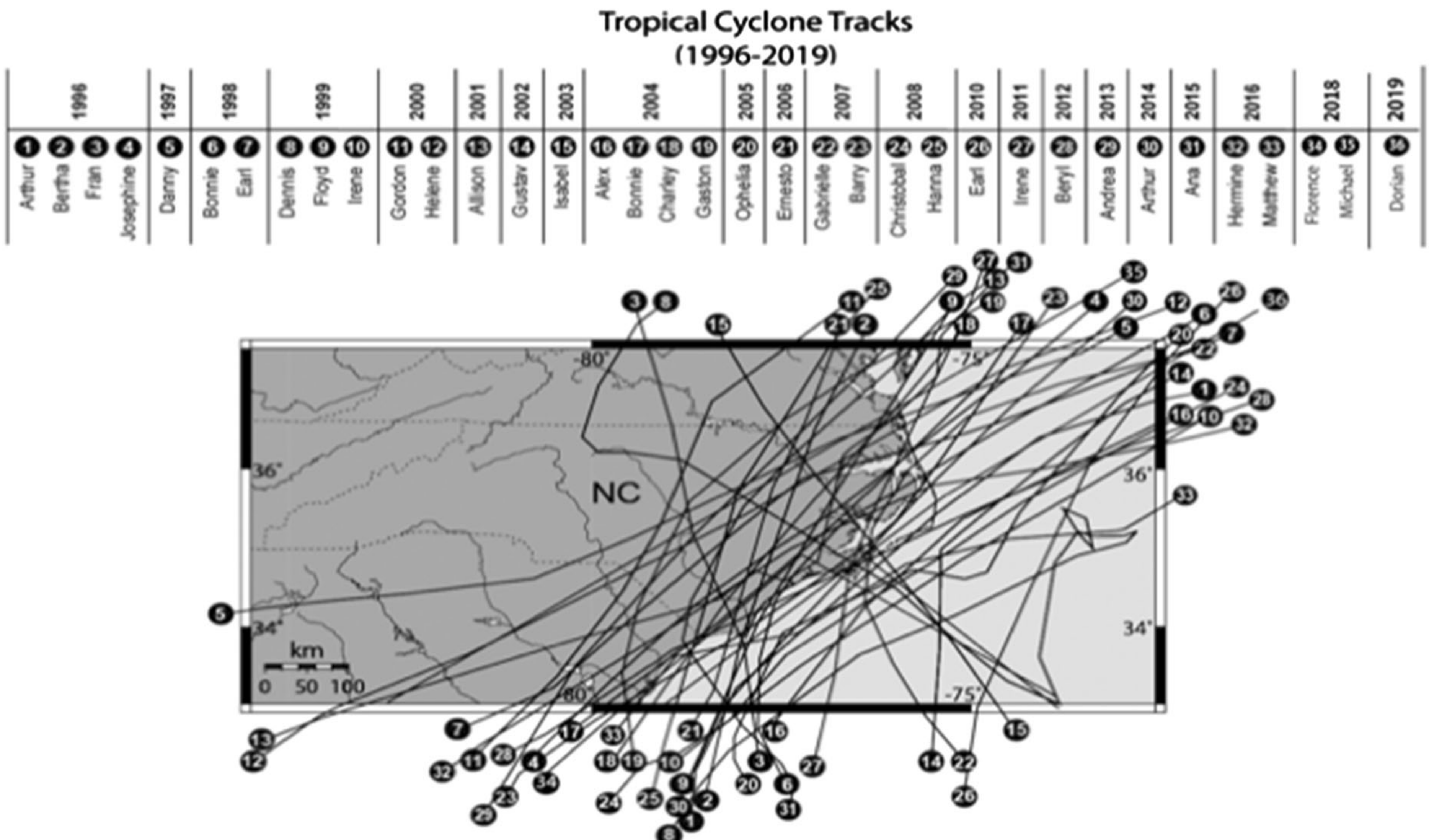


Total Nitrogen Load at Fort Barnwell, Lower Neuse River



Tropical Cyclone Paths through NC for Elevated Period, Mid-1990's - 2019

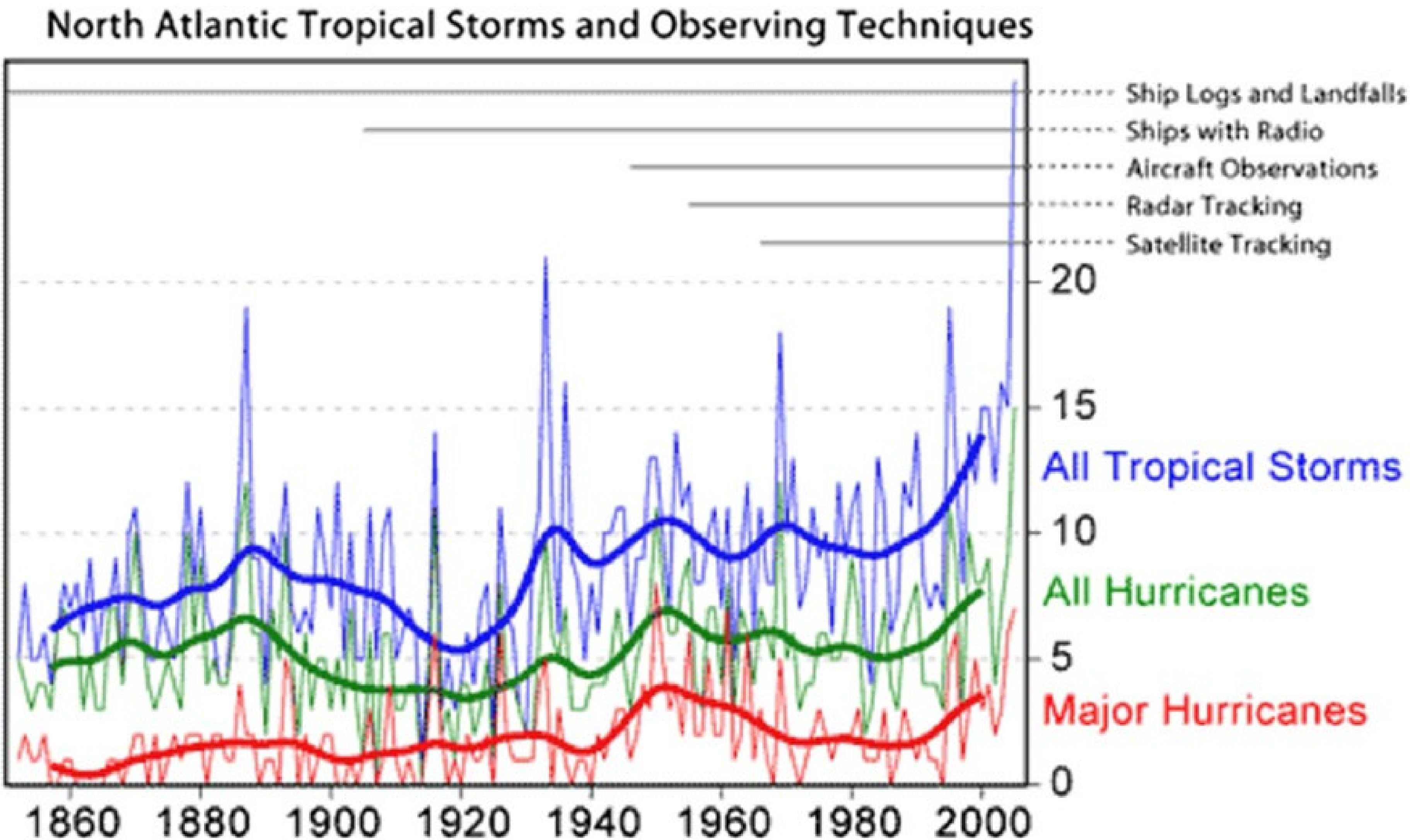
(from Paerl et al, Biogeochemistry, 2020)



History of Tropical Cyclones in North Atlantic Ocean

derived from National Hurricane Center, Miami FL

(from Paerl et al, 2020, Biogeochemistry)



Highlights from Paerl et al, 2020, Biogeochemistry

Recent increases of rainfall and flooding from tropical cyclones (TCs) in North Carolina (USA): implications for organic matter and nutrient cycling in coastal watersheds

- NC - 36 tropical cyclones last 2 decades
  - 6 of 7 wettest storms in last 120 years
  - Unprecedented high precipitation events
  - 3 floods of historical significance

- Account for > 50% annual loads of C, N and P
  - Estuary either "processor" or "pipeline", depending on conditions
  - During storms, C sources enhanced by wetlands release
  - Event-scale discharge plays important or predominant role in loadings

- Appears we've "entered new climatic regime characterized by more frequent extreme precipitation events, with major ramifications for hydrology, cycling of C, N and P, water quality and habitat conditions in estuarine and coastal waters".

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Recent Strategy-Related Activity (2017-2020) - Mandatory Neuse Rules Readoption

Drivers

- Legislatively mandated for all state rules
- Political pressure to avoid strengthening

Outcomes

- Wastewater –
    - Proposed limits for small dischargers (< 500k gpd) - scuttled
    - PS:NPS trading uncertainty ratio batted around, landed at 1.5:1
- New Development Stormwater –
    - Added 14 local governments
    - Comm/industrial/m-f disturbance threshold lowered to ½ ac
    - Strengthened onsite treatment requirements

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Strategy Adaptations Going Forward?

Current Activities

- Revising Albermarle Sound nutrient criteria – pilot estuary
- Contracting Neuse watershed nutrient delivery modeling
- Revising riparian buffer restoration offset credit

Sources Meriting Closer Consideration

- ‘Intermediate’ (.1 - .5 MGD) discharger limits
- New Development – stem stream degradation
  - lower density threshold for treatment
  - greater runoff volume control onsite
- Existing developed lands (long-term proposition)
  - Runoff, sanitary infrastructure
- Agriculture
  - Dry litter poultry (statute revision required)
  - Cropland - shift to tracking only

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Questions?

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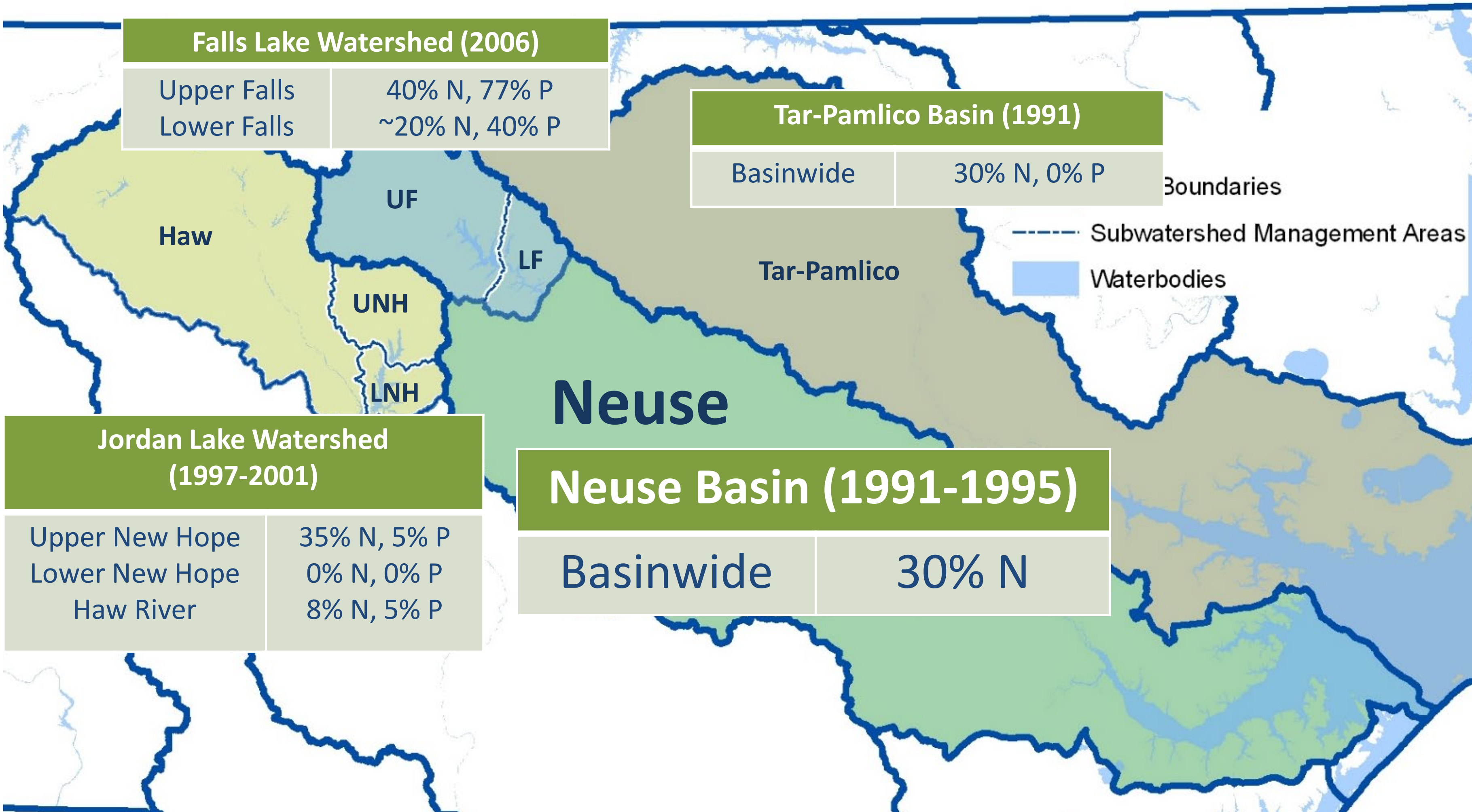
Nutrient Strategy Reduction Goals



Falls Lake Watershed (2006)	
Upper Falls	40% N, 77% P
Lower Falls	~20% N, 40% P

Tar-Pamlico Basin (1991)	
Basinwide	30% N, 0% P

Jordan Lake Watershed (1997-2001)	
Upper New Hope	35% N, 5% P
Lower New Hope	0% N, 0% P
Haw River	8% N, 5% P

Neuse Basin (1991-1995)	
Basinwide	30% N

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"Other" Agricultural Nutrient BMPs Installed

Neuse River Basin

*Table 4. Nutrient-Reducing Best Management Practices Not Accounted for in NLEW, CY1996 to CY2020, Neuse River Basin**

BMP	Units	1996-2018	2019	2020
Diversion	Feet	180,717	183,017	185,317
Fencing (USDA programs)	Feet	234,827	239,587	239,587
Field Border	Acres	5,949	5,955	5,959
Grassed Waterway	Acres	2,501	2,517	2,531
Livestock Exclusion	Feet	149,501	151,648	153,795
Precision Agriculture	Acres	4,672	4,672	5,326
Sod Based Rotation	Acres	109,314	111,304	122,619
Tillage Management	Acres	61,384	62,478	63,634
Terraces	Feet	77,633	77,633	77,633

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Joint Compliance and Allocation Trades: Neuse Basin

NRCA NitrogenTransactions (Sales/Leases)

Date: 2/14/18

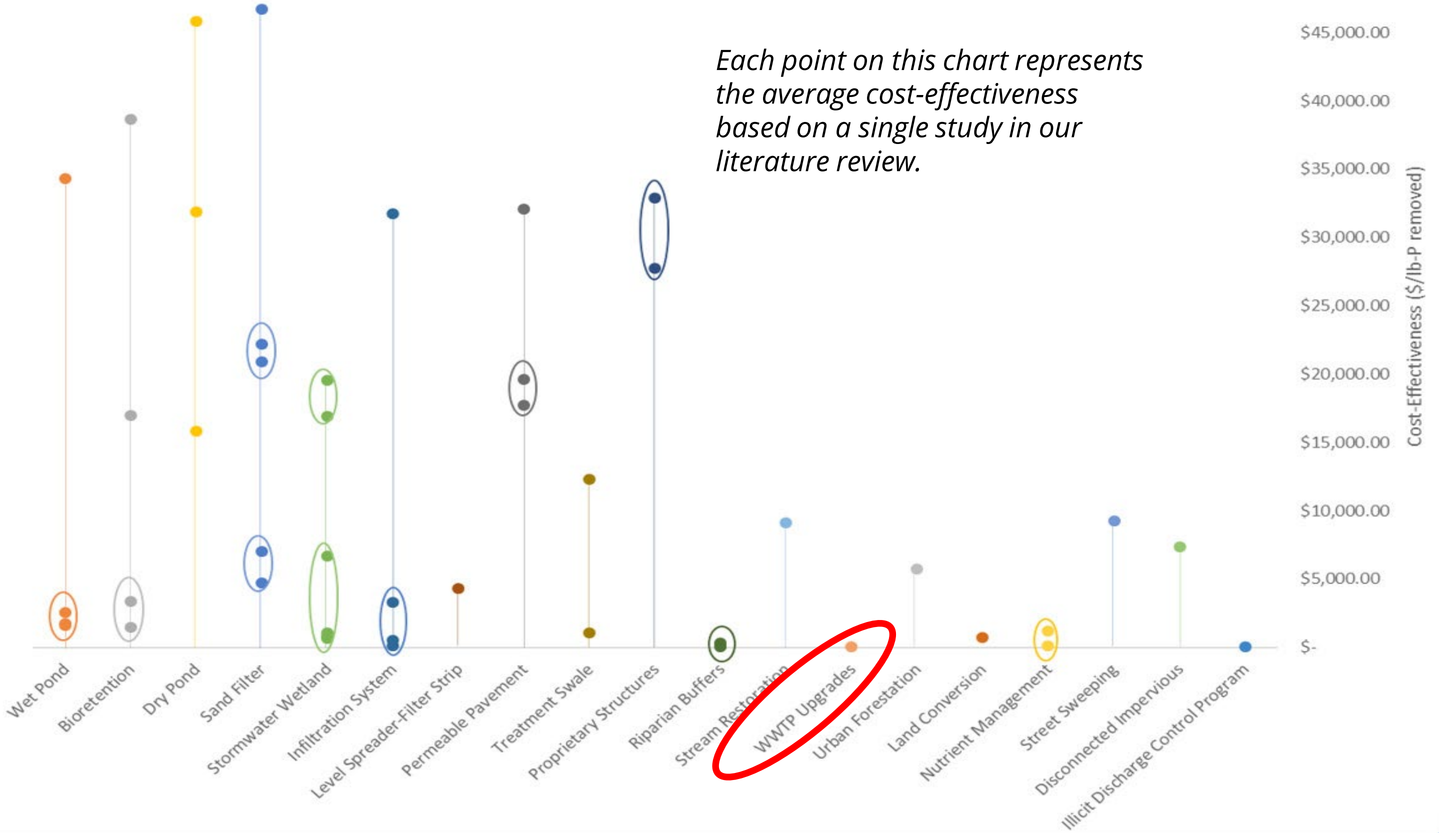
Year	Type of Nitrogen Transaction	Seller/Leasor	Buyer/Leasee	Estuary Lbs. of Nitrogen *		Cost per Pound
2017	Lease	Contentnea MSD	CWS, Inc.	7,000	$	5.00
	Lease	NRCA	Craven County	50		9.00
	Lease	Dow-Dupont	Craven County	307		4.00
2016	Lease	Contentnea MSD	Town of LaGrange	1,000	$	4.00
	Lease	NRCA	Craven County	50		9.00
2015	Lease	Contentnea MSD	Aqua, N.C., Inc.	750	$	4.00
	Lease	Contentnea MSD	Town of LaGrange	1,300		4.00
	Lease	NRCA	Craven County	50		9.00
2014	Lease	Contentnea MSD	Aqua, N.C., Inc.	4,000	$	4.00
	Lease	Contentnea MSD	Town of LaGrange	1,300		4.00
	Lease	NRCA	Craven County	50		9.00

Cost-Effectiveness of Nitrogen Removal BMPs and Programs

(2019, McManus, Kirk and Rosenfeld, UNC Environmental Finance Center)

Cost-Effectiveness of Phosphorus Removal BMPs and Programs

(2019, McManus, Kirk and Rosenfeld, UNC Environmental Finance Center)



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Cost Effectiveness of BMPs

UNC Environmental Finance Center - McManus, Kirk, et al - 2019

Strategy	Type	Avg. of TP Reduction [$/lb]	Avg. of TN Reduction [$/lb]	Avg. of TP Reduction [%]	Avg. of TN Reduction [%]	Count TP	Count TN
Bioretention	Physical	$ 10,637.79	$ 754.05	0.59	0.52	8	8
Dry Pond	Physical	$ 30,083.66	$ 659.10	0.16	0.08	10	16
Infiltration System	Physical	$ 10,183.49	$ 230.46	0.66	0.5	7	5
Land Conversion	Physical	$ 710.25	$ 226.13	0.56	0.64	4	4
Level Spreader-Filter Strip	Physical	$ 4,292.00	$ 199.44	0.38	0.35	2	3
Permeable Pavement	Physical	$ 34,956.95	$ 2,905.07	0.61	0.48	7	4
Proprietary Structure	Physical	$ 28,249.59	$ 7,146.10	0.46	0.08	10	1
Riparian Buffer	Physical	$ 164.50	$ 454.51	0.48	0.58	3	4
Sand filter	Physical	$ 16,195.37	$ 2,205.45	0.53	0.33	7	4
Stormwater Wetland	Physical	$ 4,348.10	$ 461.67	0.48	0.52	7	8
Stream Restoration	Physical	$ 9,095.00	$ 1,522.58	No Data	No Data	2	4
Treatment Swale	Physical	$ 3,134.12	$ 230.29	0.44	0.38	7	6
WWTP Upgrade	Physical	$ 50.84	$ 13.97	No Data	No Data	9	15
Wet Pond	Physical	$ 7,440.22	$ 438.67	0.44	0.28	6	15
Disconnected Impervious Surfaces	Policy	$ 7,354.09	$ 2,439.05	No Data	No Data	1	1
Illicit Discharge Control Program	Policy	$ 53.11	$ 13.28	1	1	2	2
Nutrient Management Programs	Policy	$ 626.60	$ 120.78	0.05	0.09	5	5
Street Sweeping	Policy	$ 9,595.35	$ 1,824.64	0.09	0.03	2	2
Urban Forestation	Policy	$ 5,736.24	$ 404.22	0.5	0.25	2	2

Buffers →

WWTP Upgrades →

Illicit Discharge Control Program →

Sources of Uncertainty in NPS Practice Crediting

PS:NPS Uncertainty

- Daily flow, nutrient monitoring vs. not monitored, research-based inferred performance
- Daily performance oversight vs. annual o&m inspection
- Operational control vs. passive design
- Relatively low susceptibility to environmental variation vs. wholly subject to environmental variability

Individual NPS Practice Credit Uncertainty

- Available research data pool often limited; more so with ecosystem and ag practices
- Applicability of research studies specifics often varies vs. credit-seeking installations
  - Practice designs, physiographic setting specifics, catchment land management, credit method elements addressed
- Inter-study design variability; many design facets, often dissimilar across studies
- Intra/Inter-study performance results often highly variable
  - Often stakeholder pressure to assign generous credit; e.g. to incentivize implementation
- Performance often evolves vs. new practice bias in research

Comparative differences by NPS practice type:

- Engineered stormwater practices – more research, more control -> less uncertainty
- Ecosystem restoration and agricultural practices – less research, less control, more variable land management, more susceptibility to environmental factors -> ***significantly greater*** uncertainty

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Factors in Wastewater vs. NPS Load Estimation Uncertainty

Source of Uncertainty	Wastewater	Nonpoint Sources
Measurement Uncertainty		
Calibration drift of monitoring equipment	✔	✔
Laboratory errors	✔	✔
Omission of sampling data	✔	
Differing or novel data collection		✔
Small sample sizes		✔
Surrogate measurements		✔
Inherent NPS monitoring limitations		✔
Delivery Uncertainty		
Delivery or Transport factors (stream to lake/estuary)	✔	✔
Landscape factors (landscape to stream)		✔
Measurement vs. Estimation		
Generalized estimates from literature		✔
Credit Establishment Uncertainty		
Weather-driven: episodic, seasonal, increasingly variable loading		✔
Large number of site variables		✔
Limited studies, inclusion of poor applicability studies		✔
Untested assumptions underpinning credit or research		✔
Simplified credit methods		✔
Differences in design of studies		✔
New practice bias		✔
Practice Implementation Uncertainty		
Environmental variability • Slope • Soil type • Landscape position • Seasonal variation • Extreme events (flooding, droughts) • Floodplain connectivity		✔ ✔ ✔ ✔ ✔ ✔
Limited inputs for load reduction estimation tools		✔
Unforeseen variations in practice design		✔
Compliance with maintenance requirements		✔
Project failure rate		✔
Long term change in surrounding land uses		✔
Decreased practice performance over time		✔
Time lag between implementation and reductions		✔
Prior Crediting Inaccuracies		
Documented crediting inaccuracies		✔

New Development Stormwater Nutrient SCMs

(As Retrofits, Candidate PS:NPS Offset Practices)

Previously Available:

- Bioretention w/ or w/o IWS
- Infiltration
- Permeable Pavement – 3
- Wet Pond
- Stormwater Wetland
- Sand Filter – 2
- Rainwater Harvesting
- Green Roof
- Disconnected Impervious
- Level Spreader-Filter Strip
- Grass Swale
- Dry Pond

Added with SNAP Tool:

- Bioretention Variants
- Permeable Pavement Variants
- Floating Treatment Wetlands
- LS-FS w/Virophos
- Dry or Wet Grass Swale
- StormFilter ®
- Silva Cell ® w/ or w/o IWS
- Over/undersizing: all SCMs except green roof, grass swale, StormFilter

Existing Development Practices Completed or Under Development

(Candidate PS:NPS Offset Practices)

Available

- Soil amendment (ED)
- Illicit Discharge Elimination (ww)
- Cattle Exclusion (agriculture)
- Streetsweeping / Stormdrain Cleanout (ED)
- Remedy discharging sand filter (ww)

In Progress

- Developed land buffer restoration (ED)
- Built land reforestation (ED)
- WW Regionalization / Overtreatment
- Programmatic Septic Malfunction Reduction

2021 or Later

- *Revise* Rural Buffer Restoration
- Stream Restoration:
  - Stem Sediment Loss
  - Floodplain Reconnect
- Bioswale
- Cropland Conversion to Trees
- Algal Turf Scrubber
- RSC

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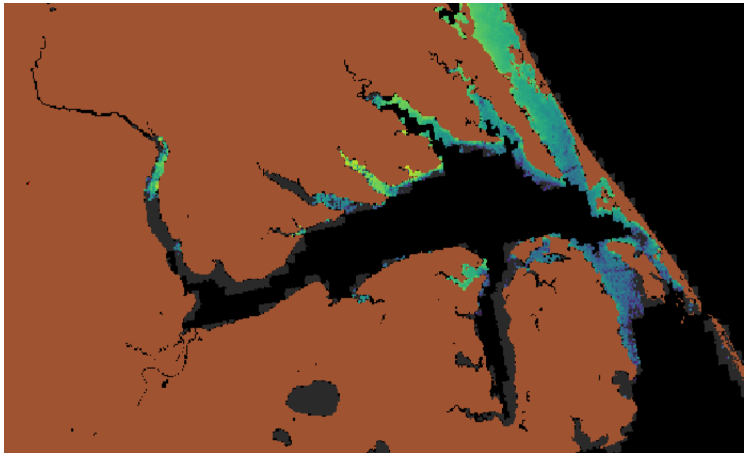
Nutrient Criteria Development

- Criteria = water quality protection standards
  - Protect water body's designated uses via sensitive endpoints
- "NCDP" Process – pilots 1st: reservoir, estuary, flowing stream
  - Guided by Scientific Advisory Committee (researchers)
  - Draft criteria -> Criteria Implementation Committee (management implications)
  - Rulemaking
- Estuary pilot: Albemarle Sound/ Chowan River
  - Phase I i.d.'d research, now occurring
  - Reevaluating response criteria
  - Potential for N, P numeric criteria
  - Timeline
    - SAC recommendations mid-2022
    - Rulemaking complete 2024



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Flow-Normalized Total Phosphorus Load (% vs. 1991-95)

Tar River near Grimesland