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# Quantifying the Role of Groundwater in Delaying Chesapeake Bay Restoration

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# Objectives:

- To develop a groundwater flow model that can simulate return-times to streams (base-flow ages) on the Delmarva Peninsula
- To explain the spatial and temporal trends in nitrate on the Delmarva Peninsula using a mass-balance regression equation that includes the base-flow age distributions obtained from the flow model
- To use the calibrated equation to forecast total nitrogen loading to the Bay from the Eastern Shore
- To forecast changes in future loadings to the bay given different loading application rates at the land surface
- To develop maps that will help resource managers target areas that will respond most efficiently to better management practices

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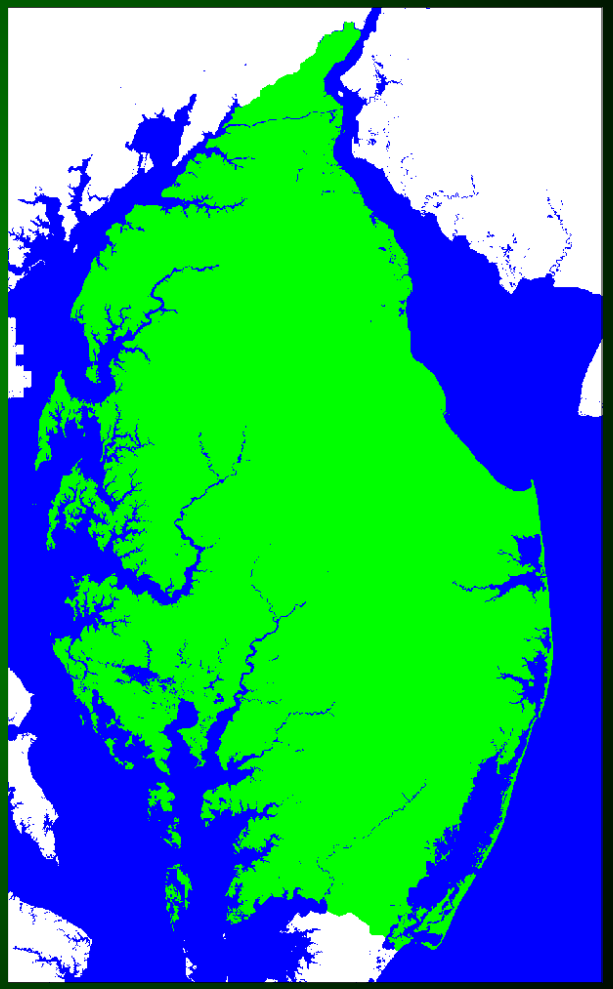
# Groundwater Model—Delmarva Peninsula

- MODFLOW 2005
- 500 ft cell resolution
- 7 Model Layers
- 4+ million active cells
- 30-m DEM, LIDAR
- 300 ft deep
- Steady State Flow
- MODPATH travel times
- USGS Open File Report 2012-1140.



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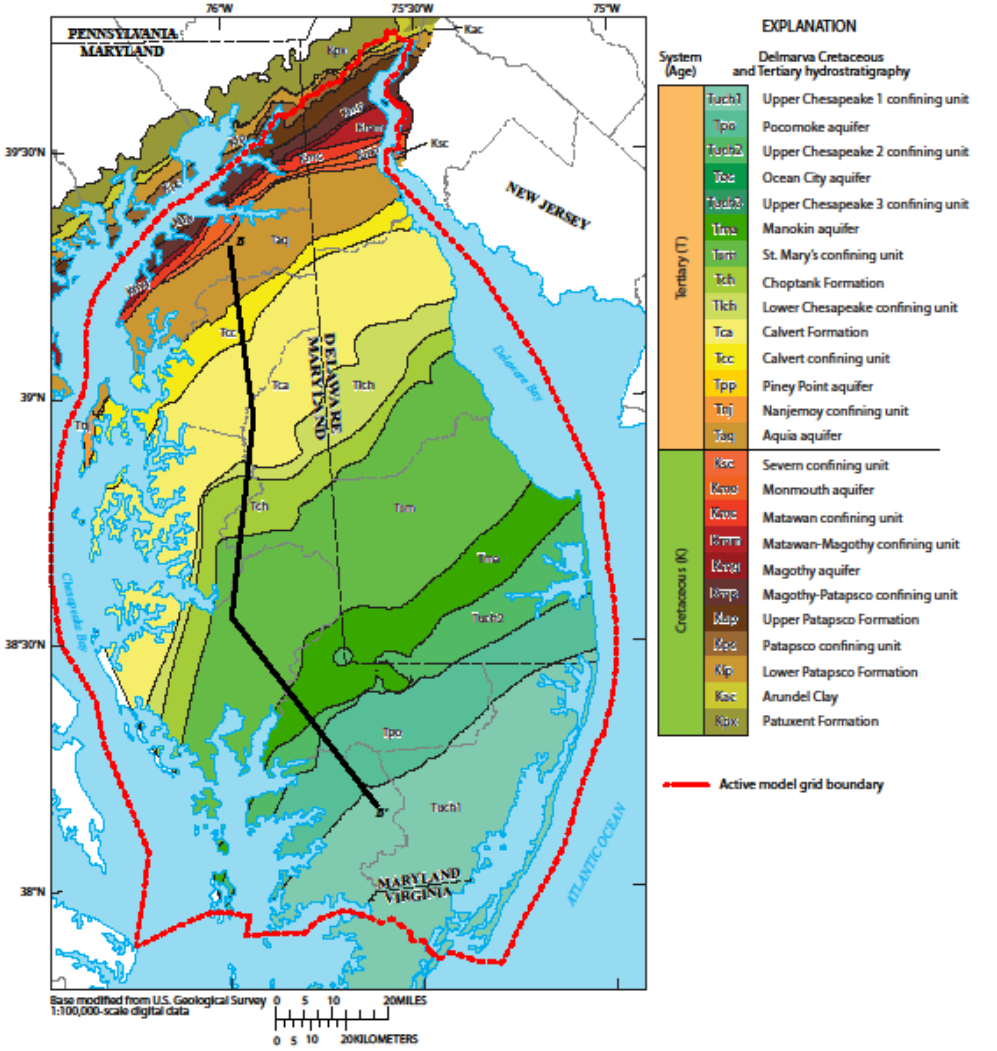



Figure 20. Locations where various Cretaceous (K) and Tertiary (T) deposits outcrop at the land surface or subcrop beneath Quaternary deposits on the Delmarva Peninsula. Section along line B-B' is shown in figure 23. Data files from Andreasen and others (2007).

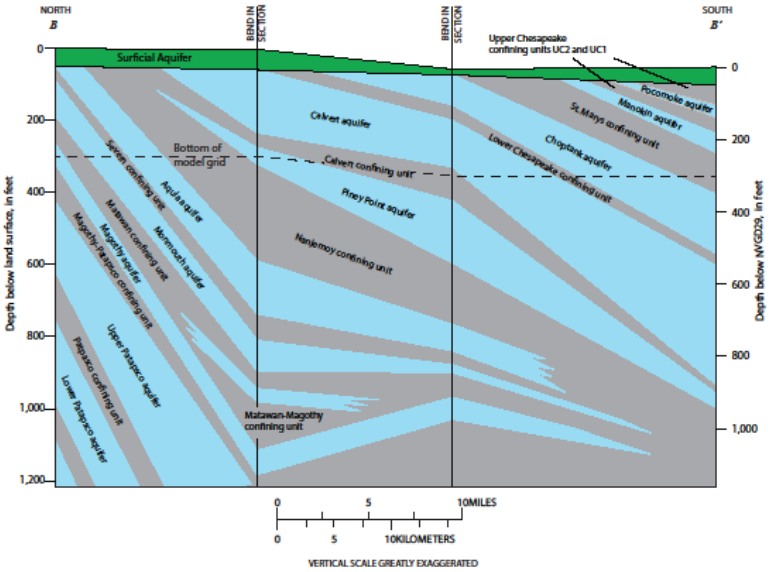
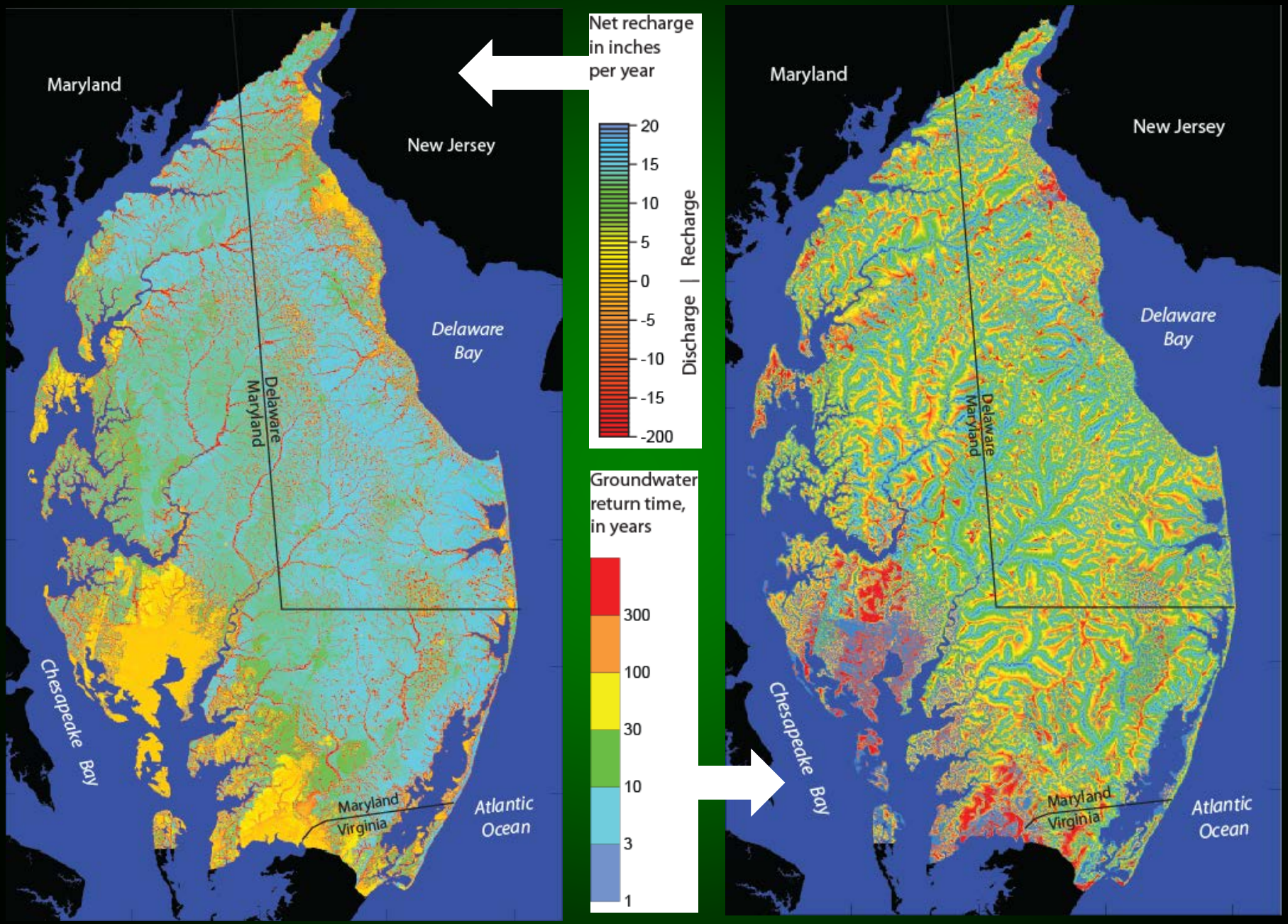
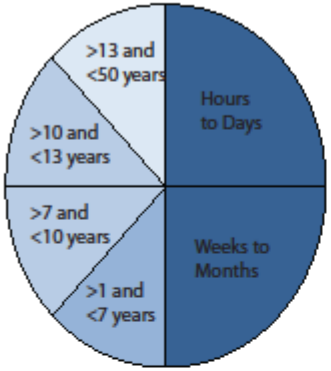


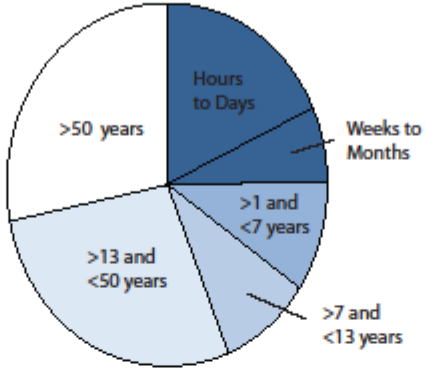

Figure 21. Cross-sectional view showing dipping of confined hydrogeologic units beneath the surficial aquifer along the line B-B'. See figure 22 for location of section line. Modified from Andreasen and others (2007).


Net recharge in inches per year
20
15
10
5
0
-5
-10
-15
-200
Discharge | Recharge
Groundwater return time, in years
300
100
30
10
3
1
Maryland
New Jersey
Delaware Bay
Delaware
Maryland
Chesapeake Bay
Maryland
Virginia
Atlantic Ocean
Maryland
New Jersey
Delaware Bay
Delaware
Maryland
Chesapeake Bay
Maryland
Virginia
Atlantic Ocean

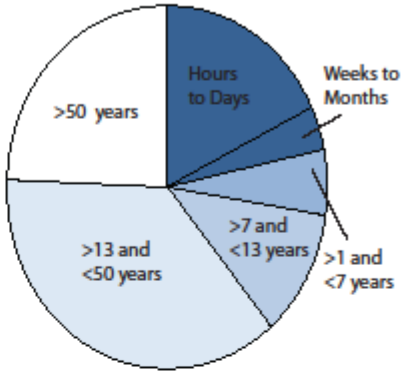
Chesapeake Bay Watershed
USGS Fact Sheet FS-091-03



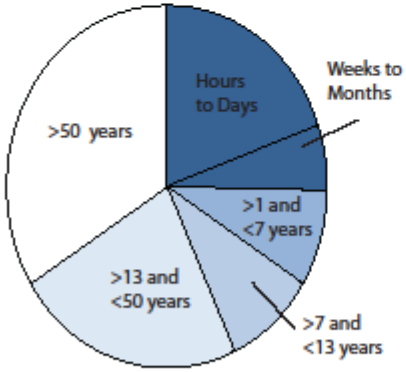

0206002 Chester/Sassafras



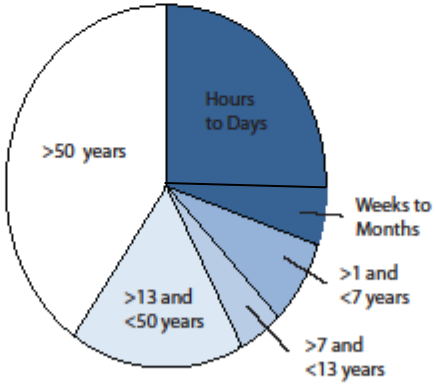

0206008 Nanticoke/Marshyhope



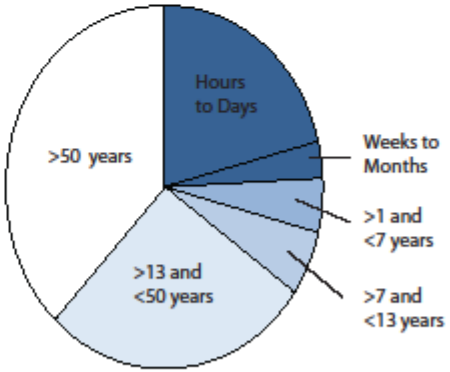

0206005 Choptank/Tuckahoe




0206007 Blackwater/Wicomico




0206008 Pocomoke/Annemessex

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Seven watersheds had substantial stream nitrate Data and were used:

1. Morgan Creek
2. Chesterville Branch
3. Choptank River
4. Marshyhope Creek
5. Nanticoke River
6. Pocomoke River
7. Nassawango Creek

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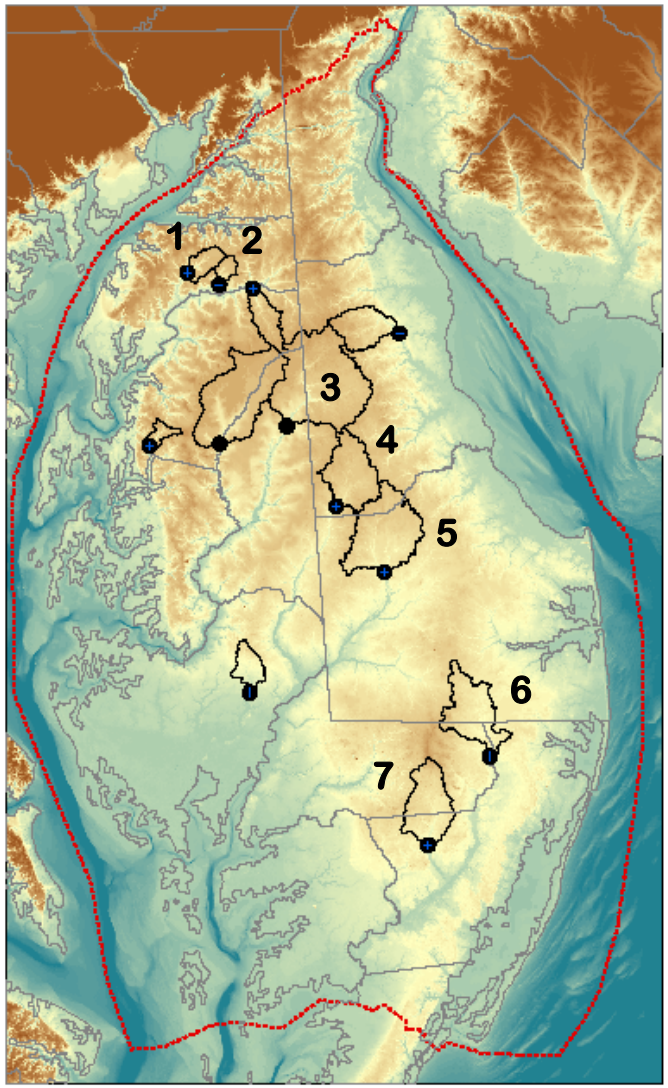
Watersheds for Delmarva Real-Time Gages



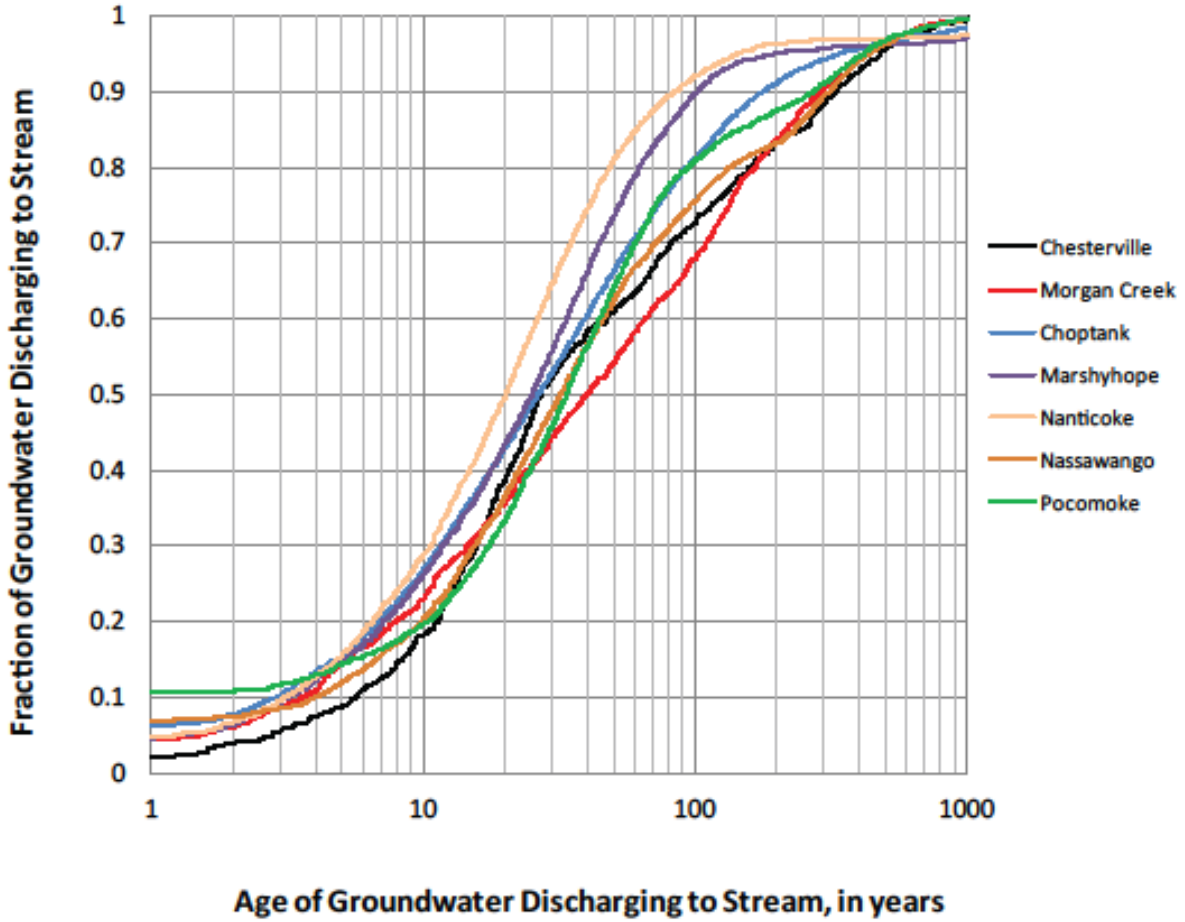
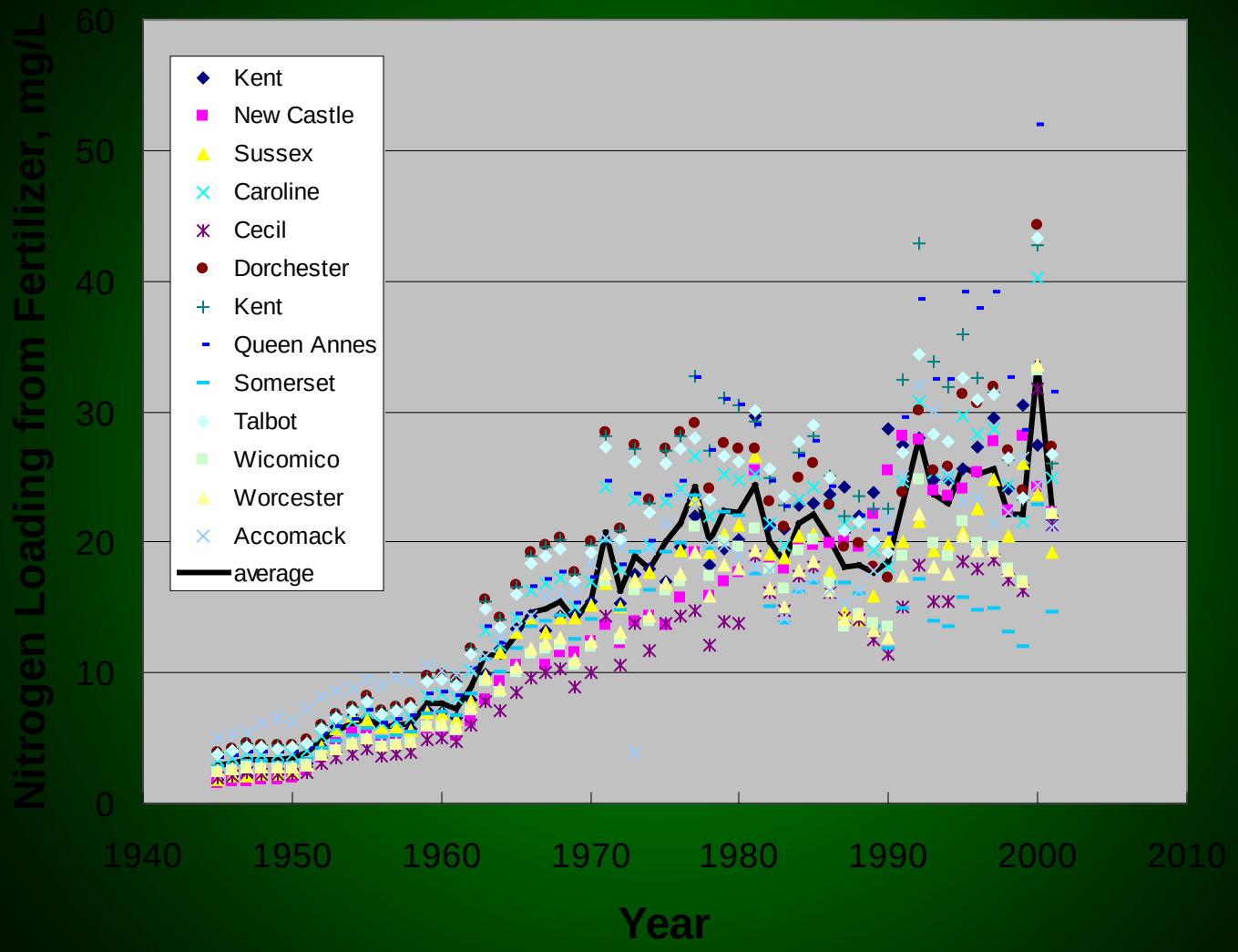



Figure 17. Cumulative distribution of simulated base-flow age at the real-time stream gages used in this study.


Nitrogen Loading from Fertilizer, mg/L
60
50
40
30
20
10
0
1940
1950
1960
1970
1980
1990
2000
2010
Year
Kent
New Castle
Sussex
Caroline
Cecil
Dorchester
Kent
Queen Annes
Somerset
Talbot
Wicomico
Worcester
Accomack
average

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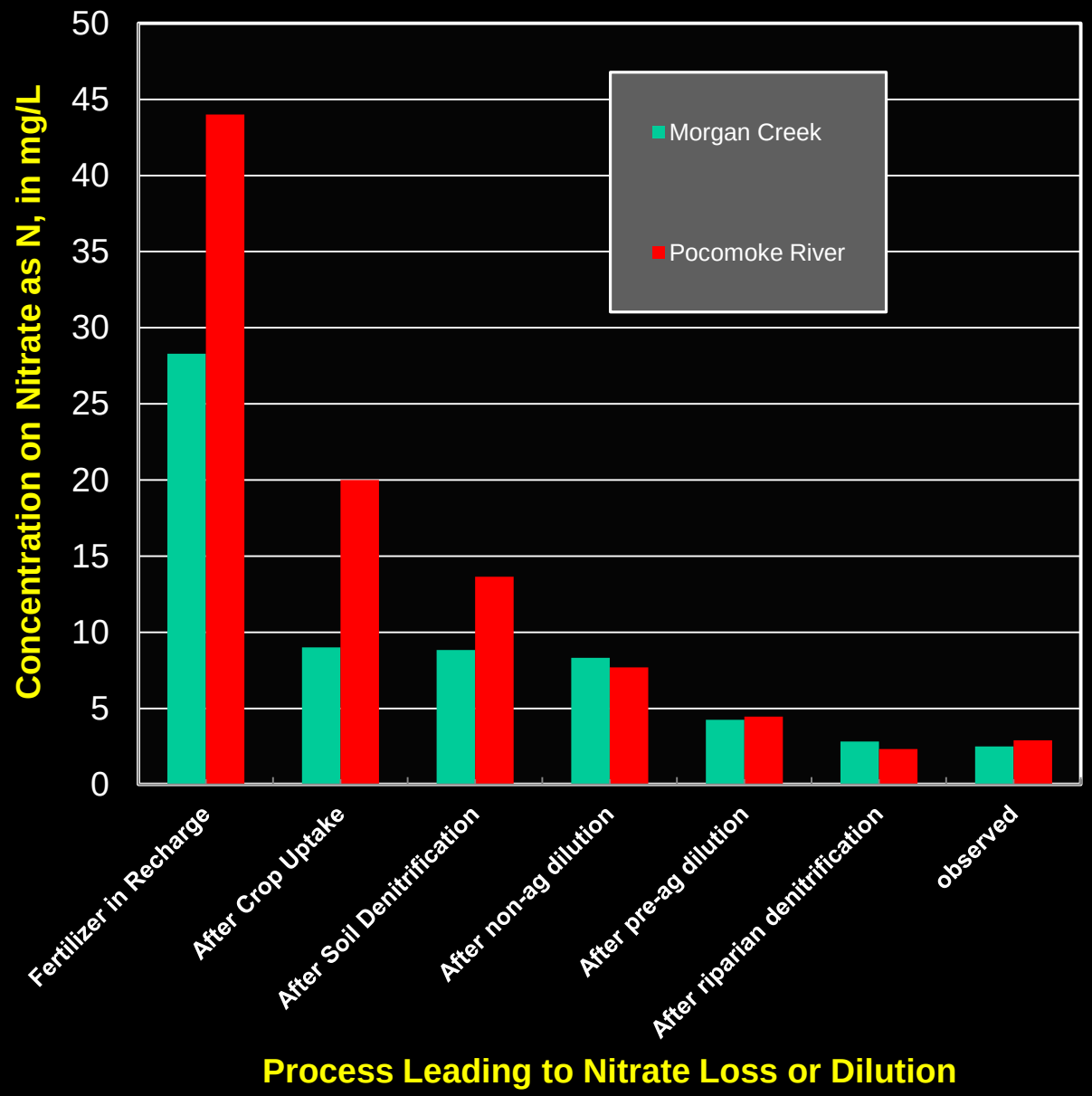
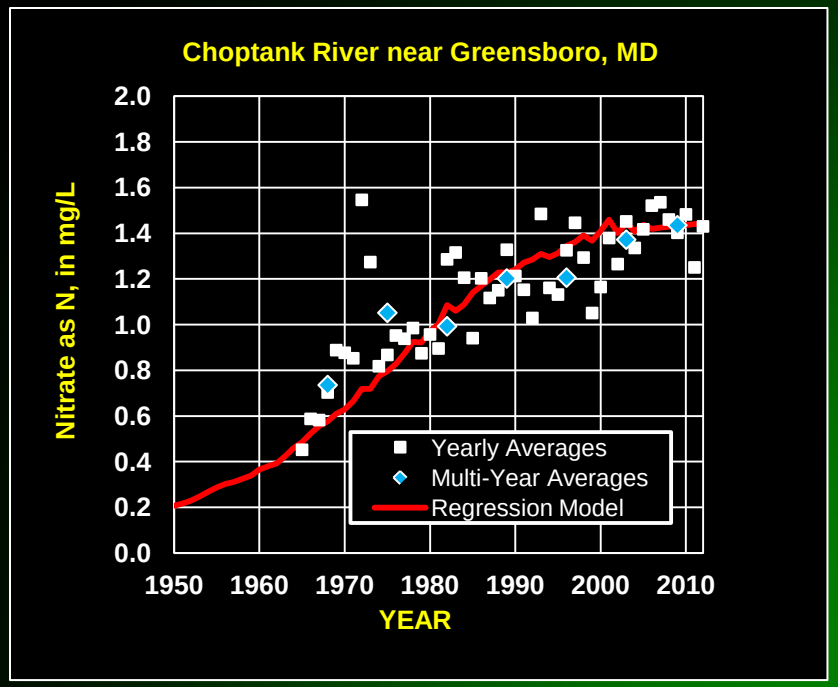
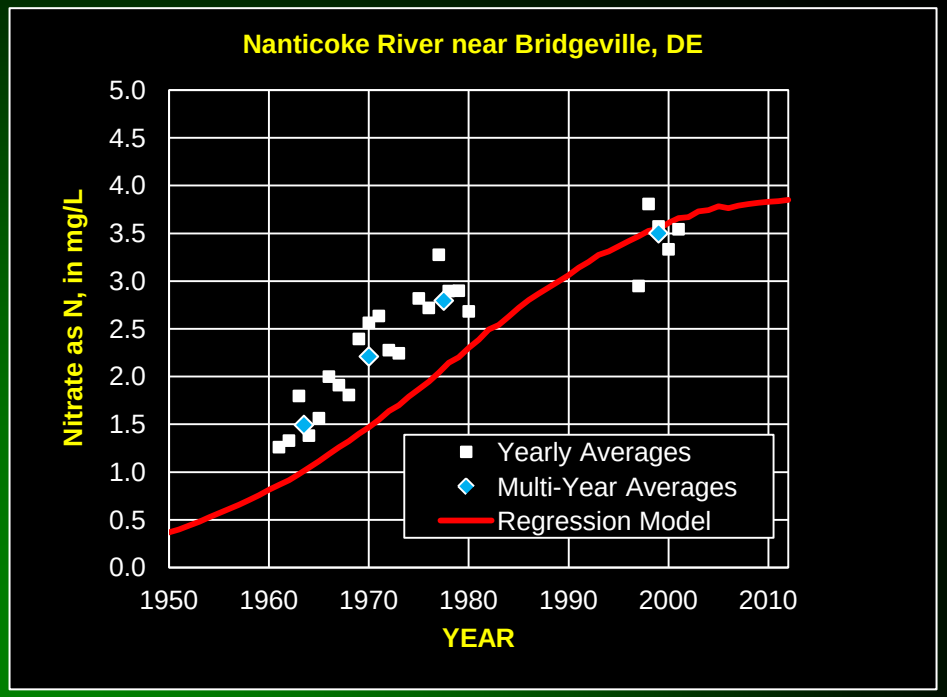
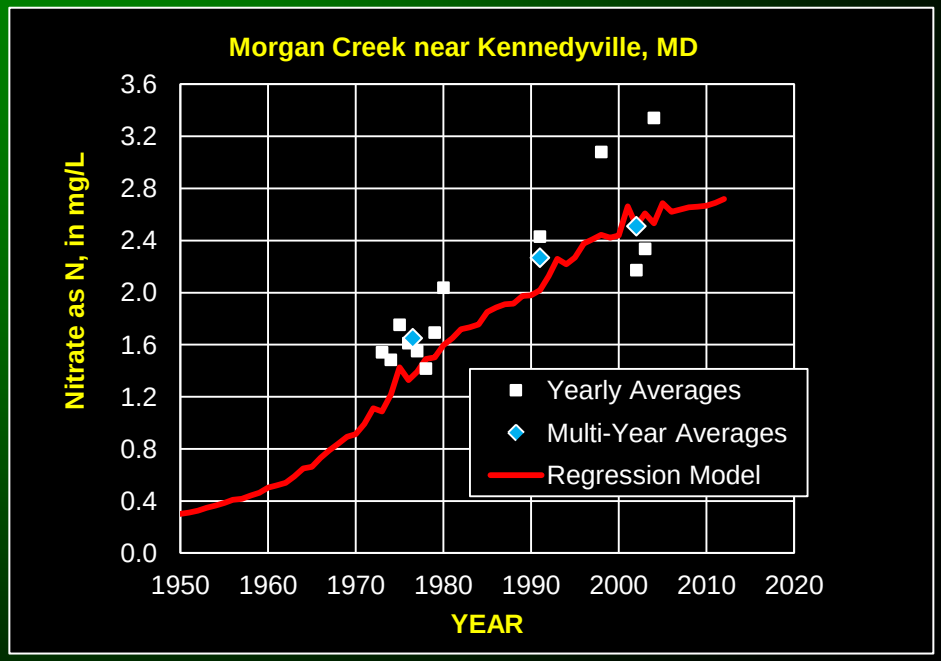

Concentration on Nitrate as N, in mg/L
50
45
40
35
30
25
20
15
10
5
0
Morgan Creek
Pocomoke River
Fertilizer in Recharge
After Crop Uptake
After Soil Denitrification
After non-ag dilution
After pre-ag dilution
After riparian denitrification
observed
Process Leading to Nitrate Loss or Dilution




Best Fit for Four Parameters with constant Fertilizer and Manure Uptake Efficiences through Time

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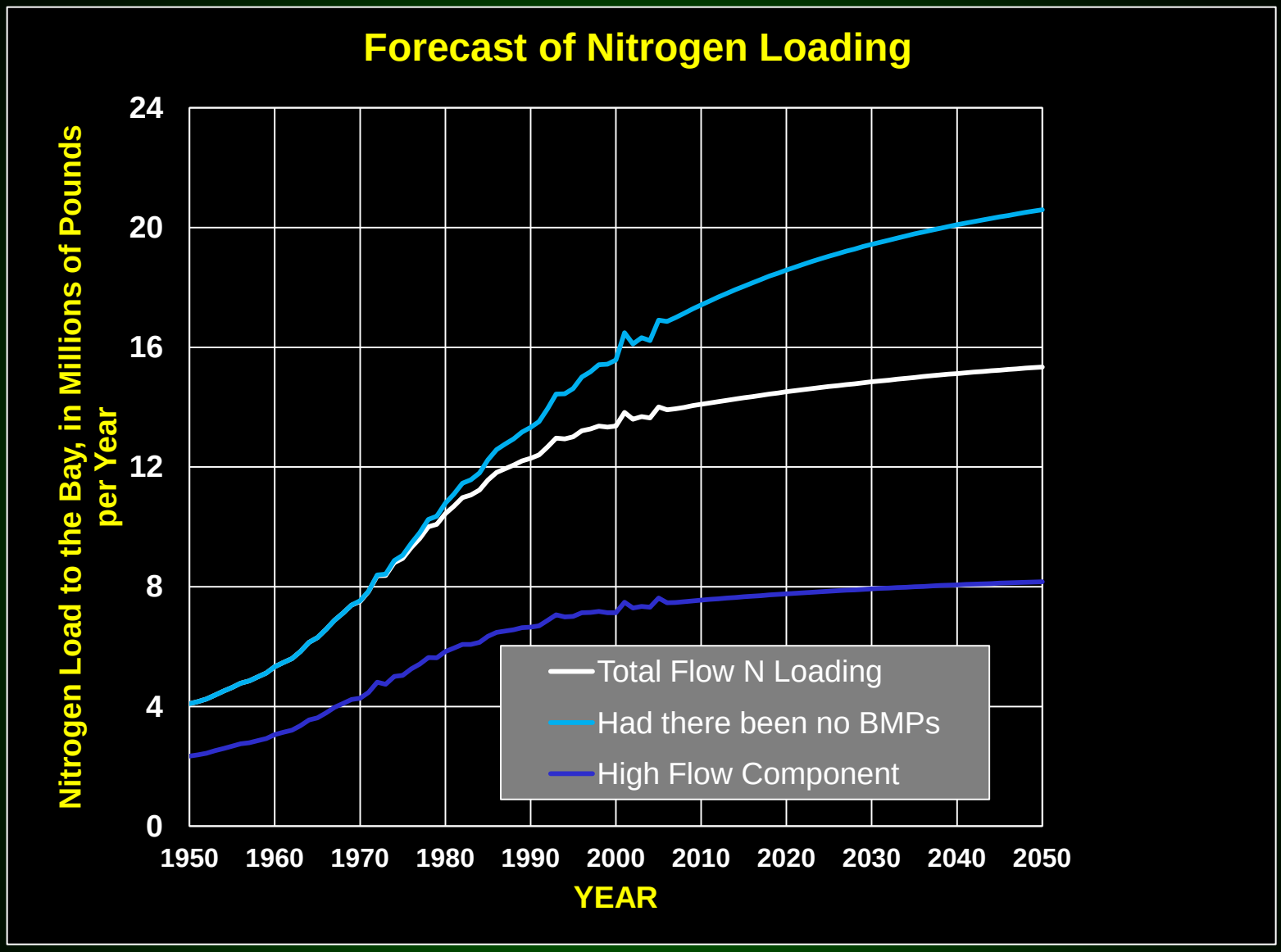
Forecast of Nitrogen Loading
Nitrogen Load to the Bay, in Millions of Pounds per Year
24
20
16
12
8
4
0
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
YEAR
Total Flow N Loading
Had there been no BMPs
High Flow Component

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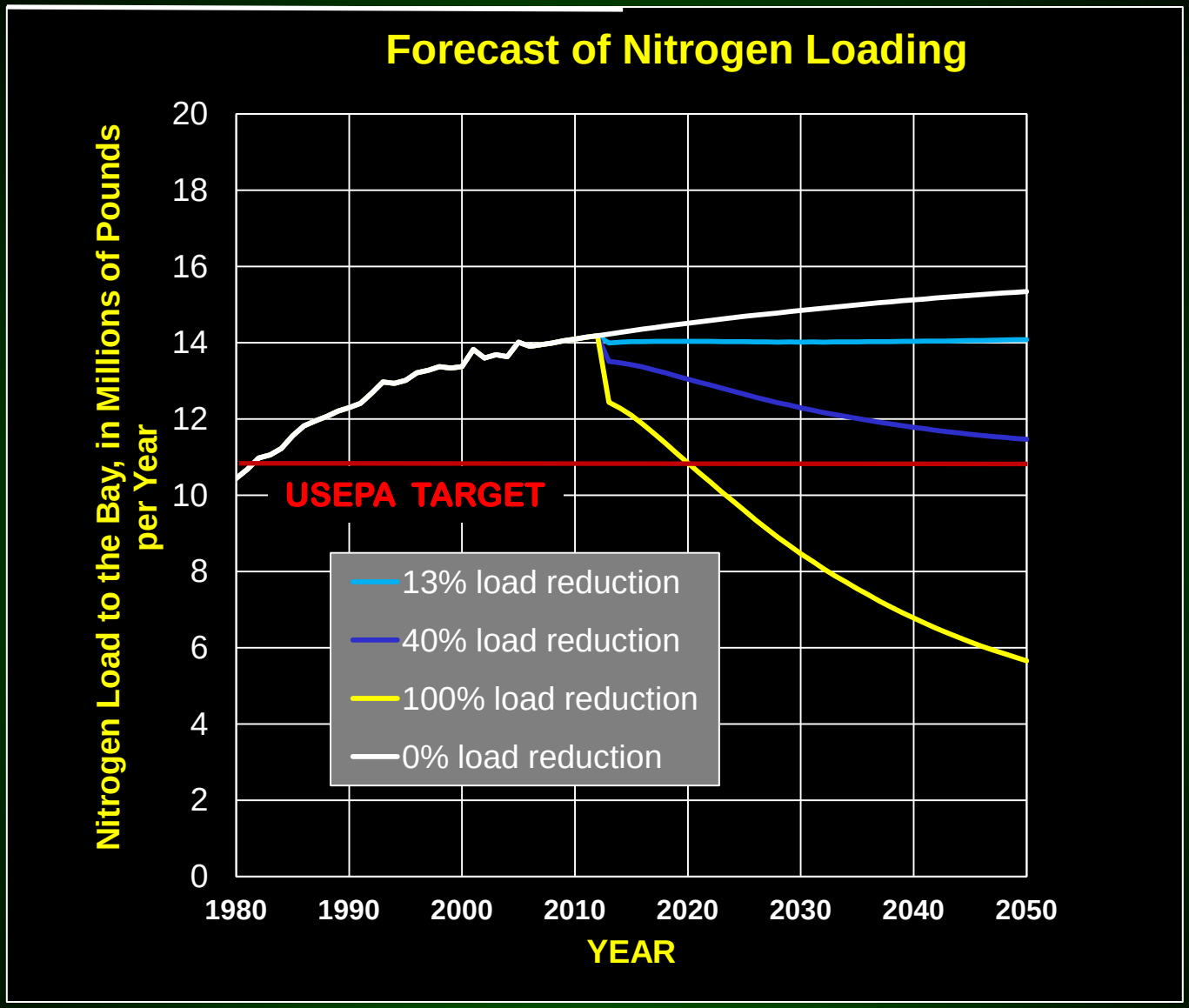
Forecast of Nitrogen Loading
Nitrogen Load to the Bay, in Millions of Pounds per Year
20
18
16
14
12
10
8
6
4
2
0
USEPA TARGET
13% load reduction
40% load reduction
100% load reduction
0% load reduction
1980
1990
2000
2010
2020
2030
2040
2050
YEAR

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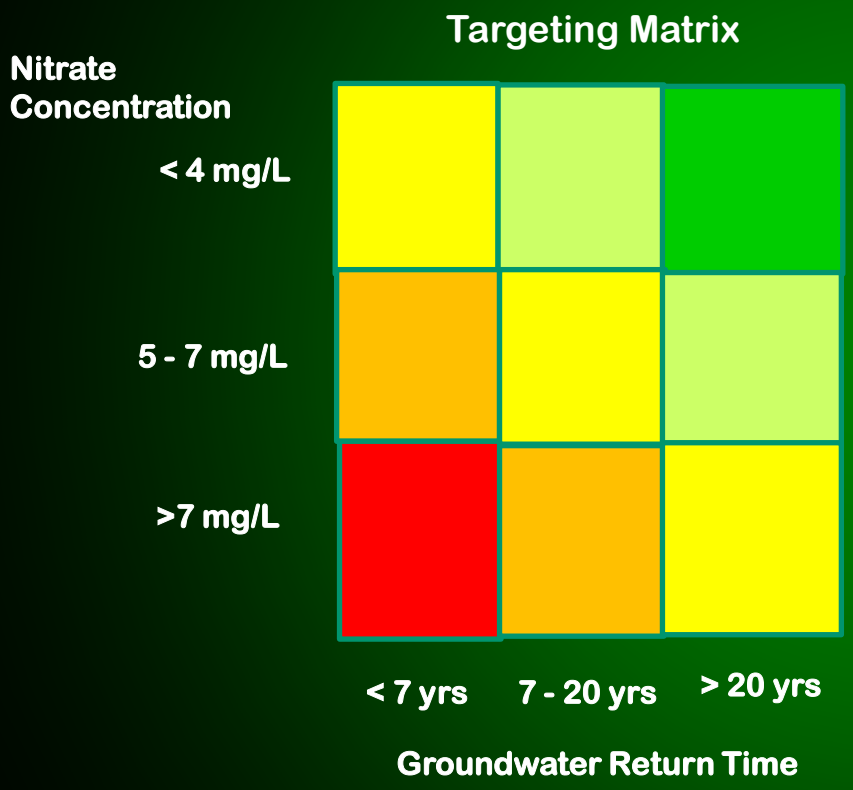
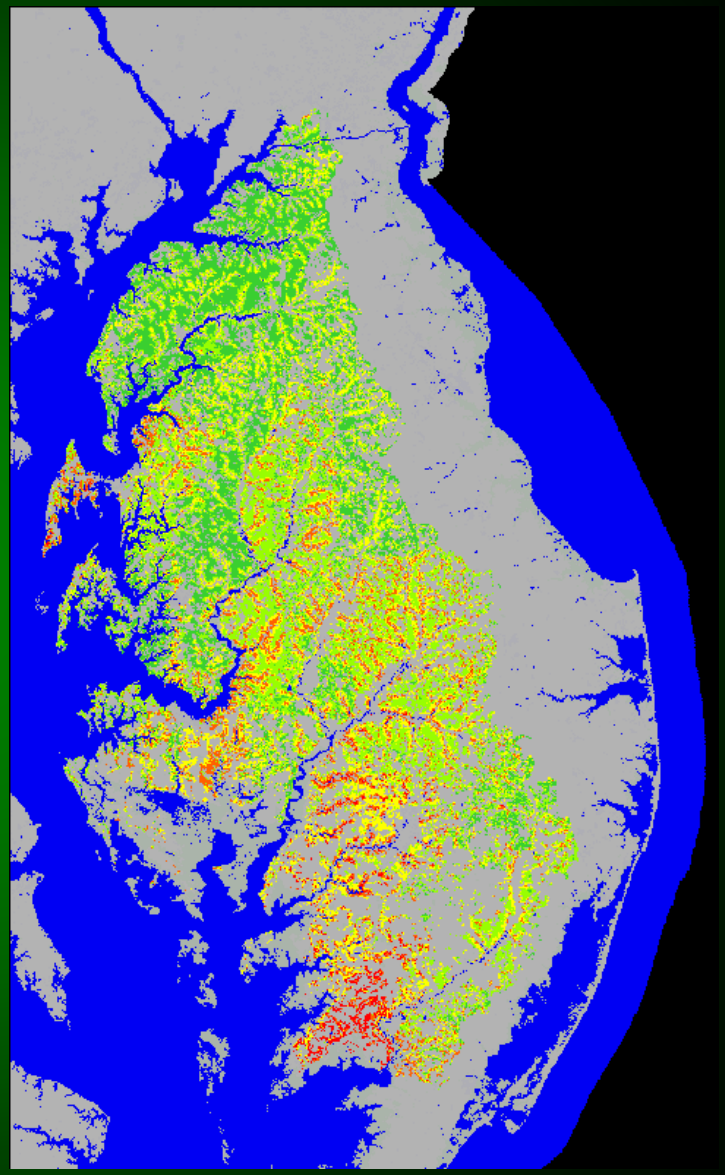
# Targeting that Includes Response Time and Nitrogen Delivered to the Bay



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# Summary and Conclusions

Results from a groundwater flow model were coupled to a nitrate-mass-balance regression model and calibrated against stream nitrate data.

The calibrated model suggests that nitrogen uptake efficiencies on the Eastern Shore may be improving over time.

Response time of nitrogen delivery to the Bay on the Eastern Shore is on the order of several decades

EPA targets are for reduced loading of ~20% (3 million lbs/yr) on the Eastern Shore. This cannot be accomplished by reducing land surface applications by 20%, as loads will continue to rise 13%.

The new model can help target areas where reduced nitrogen loadings would be the most beneficial at reducing total loadings to the Bay.

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