Review of Wastewater Nutrient Concentrations and Trends in Virginia's Chesapeake Bay TMDL Phase III Watershed Implementation Plan

Virginia Department of Environmental Quality
COMMONWEALTH OF VIRGINIA

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Executive Summary

The Department of Environmental Quality convened a stakeholders workgroup and completed a review of "*the assumptions used in estimating the effluent nutrient concentrations and trends of wastewater facilities and to identify cost-effective options to achieve wastewater nutrient load levels with reasonable assurance consistent with the needs of the Chesapeake Bay TMDL Phase III Watershed Implementation Plan*" in accordance with 2020 Va. Acts Ch. 1289 Item #377 F.2. The results of that review found that although the assumptions used in estimating nutrient concentrations and loads for the wastewater sector were conservative, the assumptions did not impact the decision to include proposed municipal floating wasteload allocations (WLAs) in Initiative #52 of the Chesapeake Bay Phase III Watershed Implementation Plan. Furthermore, as explained in this report, the proposed municipal floating WLAs included in Initiative #52 represent the Commonwealth's best opportunity to achieve the additional significant, reliable and timely nutrient reductions necessary under the TMDL.

Development of the Phase III Watershed Implementation Plan

In developing Virginia's Phase III Watershed Implementation Plan (WIP) under the Chesapeake Bay Total Maximum Daily Load (TMDL), it became clear that the Commonwealth had significant reductions to make in order to meet the United States Environmental Protection Agency's (EPA) 2025 deadline for the TMDL. Based on progress through 2018, Virginia needed to achieve an additional 15% reduction in Total Nitrogen (TN) loads (approximately 9,047,673 lbs/yr) and an additional 14% reduction in Total Phosphorus TP loads (approximately 873,569 lbs/yr) by 2025.

Table 1 – Nitrogen Loads by Basin

	2010 Nitrogen	2018 Nitrogen	WIP3 Nitrogen	2018 to WIP3 Nitrogen Δ
VA Eastern Shore	**2,500,611**	**2,268,380**	**1,523,901**	**-744,480**
Natural	360,728	339,269	301,473	
Agriculture	1,599,445	1,582,063	937,370	
Developed	241,143	252,357	206,151	
Septic	59,364	58,378	46,363	
Wastewater	239,930	36,313	32,544	
VA James River Basin	**31,942,026**	**23,993,085**	**21,022,130**	**-2,970,954**
Natural	5,687,640	5,472,850	5,127,445	
Agriculture	4,506,579	4,398,566	2,843,671	
Developed	4,376,911	4,619,043	4,201,735	
Septic	640,433	673,416	569,283	
Wastewater	16,730,463	8,829,210	8,279,997	
VA Potomac River Basin	**18,555,667**	**17,892,513**	**15,508,893**	**-2,383,620**
Natural	3,154,519	3,143,793	3,006,768	
Agriculture	7,389,514	7,710,018	5,168,494	
Developed	3,393,529	3,658,563	3,302,186	
Septic	751,899	818,562	740,103	
Wastewater	3,866,206	2,561,577	3,291,342	
VA Rappahannock River Basin	**8,414,391**	**8,388,742**	**6,518,744**	**-1,869,998**
Natural	2,072,726	2,042,594	1,902,211	
Agriculture	4,423,918	4,403,045	2,816,075	
Developed	1,112,217	1,169,346	1,066,018	
Septic	308,477	332,998	310,097	
Wastewater	497,053	440,758	424,343	
VA York River Basin	**6,905,086**	**6,414,427**	**5,335,807**	**-1,078,620**
Natural	1,827,349	1,813,233	1,633,436	
Agriculture	2,464,385	2,487,050	1,741,187	
Developed	1,075,341	1,139,059	1,020,879	
Septic	238,502	253,469	214,813	
Wastewater	1,299,509	721,616	725,492	
Grand Total	**68,317,781**	**58,957,147**	**49,909,474**	**-9,047,673**

Table 2 – Phosphorus Loads by Basin

	2010 Phosphorus	2018 Phosphorus	WIP3 Phosphorus	2018 to WIP3 Phosphorus Δ
VA Eastern Shore	184,538	175,177	139,777	-35,399
Natural	59,132	55,193	32,077	
Agriculture	17,970	18,454	14,869	
Developed	100,218	97,869	90,988	
Septic	3	3	3	
Wastewater	7,213	3,658	1,840	
VA James River Basin	2,793,402	2,471,666	2,096,938	-374,728
Natural	412,713	359,353	236,058	
Agriculture	494,358	519,671	469,943	
Developed	919,307	881,859	790,610	
Septic	553	553	553	
Wastewater	966,470	710,230	599,775	
VA Potomac River Basin	2,283,197	1,994,233	1,691,951	-302,282
Natural	815,707	813,506	549,288	
Agriculture	467,426	498,021	446,090	
Developed	563,416	541,077	495,835	
Septic	378	378	378	
Wastewater	436,270	141,250	200,360	
VA Rappahannock River Basin	963,337	876,102	745,490	-130,613
Natural	298,955	252,556	164,017	
Agriculture	157,881	159,593	147,983	
Developed	443,022	420,293	390,229	
Septic	309	309	309	
Wastewater	63,170	43,352	42,951	
VA York River Basin	590,342	553,283	522,735	-30,548
Natural	54,651	44,255	33,542	
Agriculture	100,499	104,724	94,307	
Developed	320,628	316,850	293,827	
Septic	0	0	0	
Wastewater	114,565	87,455	101,059	
Grand Total	6,814,815	6,070,461	5,196,891	-873,569

Based on progress to date, the most dependable reductions achieved have occurred from the wastewater sector. These reductions were only possible due to significant investments in capital upgrades by publicly and privately owned sewage treatment facilities and industrial wastewater treatment facilities. Since 1998, the Commonwealth has awarded 94 grants totaling approximately $894 million for the installation of nutrient removal technology at publicly owned treatment works (POTWs). When evaluated by sector, the success of the wastewater industry is clear. Since 2010, the wastewater sector is responsible for 97% of all TN reductions and 75% of all TP reductions made in Virginia's Chesapeake Bay watershed.

Table 3 – Nutrient Loads by Sector

	2010 Nitrogen	2018 Nitrogen	2010 to 2018 Nitrogen Δ	2010 Phosphorus	2018 Phosphorus	2010 to 2018 Phosphorus Δ
Natural	13,102,963	12,811,739	-291,224	1,641,158	1,524,863	-116,296
Agriculture [1]	20,383,841	20,580,742	196,900	1,238,134	1,300,463	62,329
Developed	10,199,142	10,838,369	639,227	2,346,591	2,257,948	-88,643
Septic	1,998,674	2,136,823	138,149	1,243	1,243	0
Wastewater	22,633,161	12,589,475	-10,043,686	1,587,689	985,944	-601,745
Grand Total	68,317,781	58,957,147	-9,360,634	6,814,815	6,070,461	-744,354

[1] Agricultural loads have decreased slightly over the past decade with minor year-to-year fluctuations attributable to BMP reporting issues and EPA's restrictions on BMP credit duration.

Despite significant investments in agricultural best management practices and urban stormwater controls, it is clear that the wastewater sector has provided the greatest opportunity for significant nutrient reductions. In developing the Phase III WIP it was clear that additional opportunities for significant nutrient reductions within the wastewater sector represented Virginia's best chance of meeting the goals of the Chesapeake Bay TMDL.

The draft Phase III WIP released in April 2019 included a provision that would have required significant municipal wastewater treatment plants to meet annual average nutrient concentrations of 4 mg/l TN and 0.3 mg/l TP. Based on 2018 discharge reporting, this provision would have required upgrades at 45 of the 96 significant municipal wastewater treatment plants in Virginia and generated approximately 3,000,000 pounds of delivered TN reductions and 260,000 pounds of delivered TP reductions per year. The municipal wastewater sector raised significant concerns with this proposal. Representatives of the municipal wastewater sector commented that the existing load-based nutrient trading program has been tremendously successful and that a "one-size-fits-all" technology regulation would represent a costly, inefficient approach with negative ramifications on rate payers and Virginia Water Quality Improvement Fund (WQIF) appropriations.

In response to comments received on the draft Phase III WIP, the strategy for the wastewater sector was modified to include floating WLAs to be calculated based on the discharged flow in any given year and 4 mg/l TN and 0.3 mg/l TP. In any given year, the applicable WLA would be the more stringent of the existing WLA included in Virginia's Water Quality Management Planning Regulation (9VAC25-720) or the proposed floating WLA. This approach encourages additional point source nutrient reductions in the near term while preserving existing WLAs to accommodate long-term growth. This strategy was included in Initiative #52 in Virginia's final Phase III WIP.

The modified strategy (Initiative #52) responded to comments received during the public comment period by incorporating the reductions into Virginia's well-established and successful nutrient

trading program. This allows the facilities participating in the nutrient trading program to achieve the necessary reductions in the most cost effective manner available, including any combination of optimizing operations at existing treatment facilities, upgrading facilities, or purchasing nutrient credits generated by other treatment facilities.

Scope of this Report

The Commonwealth's 2020-2022 biennium budget directed DEQ to work with stakeholders through a workgroup "*to review the assumptions used in estimating the effluent nutrient concentrations and trends of wastewater facilities and to identify cost-effective options to achieve wastewater nutrient load levels with reasonable assurance consistent with the needs of the Chesapeake Bay TMDL Phase III Watershed Implementation Plan*". 2020 Va. Acts Ch. 1289 Item #377 F.2. DEQ formed a stakeholders group (see Appendix 1) and held five meetings to advise the agency on the WIP III alternatives addressed by this report as well as to aid the regulatory advisory panel in evaluating alternatives to the floating WLA approach in the proposed amendment to the Water Quality Management Planning Regulation (9VAC25-720). The stakeholders on the workgroup helped identify the alternatives addressed in this report and the capital costs associated with those alternatives. DEQ staff completed the evaluation of alternatives

Assumptions Used in Developing the Phase III Watershed Implementation Plan's Nutrient Loads for the Wastewater Sector

The following assumptions form the basis for the Phase III WIP nutrient loads for the wastewater sector:

Table 4 – WIP III Wastewater Assumptions

Wastewater Category	Total Nitrogen	Total Phosphorus
Significant Municipal Facilities	2018 flows x the lesser of 4.0 mg/l or the concentration that serves as the basis for the Existing WLA	2018 flows x the lesser of 0.3 mg/l or the concentration that serves as the basis for the Existing WLA
Significant Industrial Facilities	Existing WLA	Existing WLA
Non-significant Facilities	Estimated existing load	Estimated existing load

These assumptions were considered conservative at the time they were developed and actual performance with the implementation of Initiative #52 was expected to produce loads less than those included in WIP III. The conservatism was due to the assumption that the significant wastewater facilities would not out-perform their existing or proposed WLAs. Regulated sectors are risk adverse and almost always perform better than required in order to stay in compliance;

however, the Commonwealth chose not to commit the wastewater sector to continued over performance. On a statewide basis, these WIP III wastewater assumptions resulted in projected loads nearly identical to actual 2018 loads, although on a basin-by-basin basis the results varied. In the Potomac, Rappahannock, York and Eastern Shore Basins, these assumptions resulted in an increase over existing nutrient loads for the wastewater sector. In the James Basin, where wastewater nutrient loads are significantly higher than the other four basins combined, the combination of assumptions resulted in a significant decrease in nutrient loads. A comparison of these loads can be found in Appendix 3.

In developing nutrient reduction strategies for each basin, Virginia came up short on the nutrient reductions necessary to meet EPA's planning targets in the Potomac Basin and on the Eastern Shore. The WIP III wastewater assumptions partially contributed to this shortfall. Not achieving the overall target loads in the Potomac Basin and on the Eastern Shore resulted in some basin-to-basin nutrient exchanges to meet the individual basin goals. Under this procedure established by EPA, excess nutrient reductions in one basin are exchanged (using an equivalency ratio accounting for location) to make up for shortfalls in another basin. Likewise, shortfalls in reducing one nutrient can be made up (again using equivalency factors) by exceeding reduction goals for the other nutrient. EPA's distribution of nutrient targets between the Virginia basins also contributed to the reduction shortfalls in the Potomac Basin and on the Eastern Shore and the resulting nutrient exchanges. EPA recognized this in allowing nutrient exchanges to make up for these imbalances. EPA could have rebalanced the nutrient targets among Virginia's river basins to match the reduction strategies identified in Virginia's WIP and thereby eliminated the need for any nutrient exchanges.

It is also important to note that the need for additional nutrient reductions from the wastewater sector was anticipated from the very beginning of the Phase III WIP development process in recognition of the significant overall nutrient reduction challenges identified in Tables 1 and 2 above and the historical achievements of the wastewater sector identified in Table 3. The floating WLA concept is essential to achieving Virginia's overall nutrient reduction goals and it was developed completely independent of the individual basin shortfalls and resulting nutrient exchanges in the Phase III WIP.

Implementation of the Phase III Watershed Implementation Plan

The Department of Environmental Quality (DEQ) began the rulemaking process to implement the floating WLA process with the publication of a Notice of Intended Regulatory Action on November 25, 2019. A regulatory advisory panel (RAP) was formed and nine meetings have been held to date.

In response to stakeholder input, DEQ has made significant changes to the original proposal to reduce the impact on the wastewater sector while still achieving the majority of the reductions anticipated from the original proposal. Limiting the application of floating WLAs to facilities with design flows of 5 million gallons/day (MGD) or greater west of the fall line and 3 MGD or greater east of the fall line significantly reduces the number of facilities impacted. Additional accommodations are also proposed to address unique circumstances at several facilities. The Upper Occoquan Sewage Authority water reclamation plant in Centreville is not included in the current proposal because of potential adverse impacts on the downstream water supply. Over 80% of the Hopewell Water Renewal Treatment Facility's wastestream is difficult to treat industrial waste and DEQ proposes to include higher nutrient concentration bases for the floating WLAs. The Cities of Richmond and Lynchburg are currently financing highly expensive combined sewer overflow (CSO) control projects and DEQ proposes to include relaxed floating WLA requirements for TN so that scarce funds are not diverted from funding can be prioritized for the important CSO control projects. Alexandria Renew Enterprises is also facing highly expensive CSO projects but has already upgraded its facility to meet an annual average TN concentration of 3 mg/l.

The changes outlined above reduce the number of significant municipal treatment facilities subject to the floating WLAs from 96 to 37 facilities while still capturing greater than 90% of the nutrient reductions identified in the original proposal. Of the 37 facilities subject to the current proposal, all but 16 have either already upgraded to meet the level of treatment required by the proposal or were otherwise able to meet the reductions in 2018. Of the 16 facilities that did not meet the proposed level of treatment in 2018, 11 have previously planned upgrades or consolidation projects leaving a balance of 5 wastewater treatment plants directly impacted by the floating WLA proposal that were not otherwise already in the process of planning upgrades.

Identification of Alternatives

The workgroup identified five alternatives to the assumptions used to develop the Phase III WIP, four of which are quantified and evaluated further in the following sections. In addition to the four alternatives quantified below, the analysis includes three scenarios that serve as points of reference for evaluation of the new alternatives. These include:

Scenario A - 2018 Actual Loads
Scenario B – 2018 Actual Loads plus Floating WLA Reductions
Scenario C – Scenario B plus 75% Injection of HRSD SWIFT Project Flows

Scenario C – Scenario B plus 75% Injection of HRSD SWIFT Project Flows

This alternative includes all of the elements of Scenario B plus reductions associated with the HRSD's Sustainable Water Initiative for Tomorrow (SWIFT) project. HRSD is in the process of upgrading treatment capabilities at five wastewater treatment facilities in the York and James basins to allow flows to be injected into the ground as part of the SWIFT project. These facilities include the HRSD York River, Nansemond, James River, Virginia Initiative and Williamsburg wastewater treatment plants. The Boat Harbor and Army Base WWTPs will be closed and their flows diverted to the Nansemond and James River WWTPs. HRSD plans to inject 75% of the effluent flow at the five remaining facilities into the Potomac aquifer thereby reducing the discharge to the Chesapeake Bay watershed.

The five alternatives identified by the stakeholders workgroup are outlined in the following sections.

Scenario D - Continuation of 2018 Performance plus Expected Projects

A basic assumption in all of the identified alternatives was that existing performance for the wastewater sector would remain relatively constant in the absence of any changes to the program. Although some variability occurs from year-to-year (nutrient loads from facilities registered under the watershed general permit loads increased by 3% (TN) and 5% (TP) from 2018 to 2019), long-term trends tend to be relatively level in the absence of additional facility upgrades or significant population growth. Most variability from year-to-year is attributable to the impacts of weather and operational variability. Previously planned wastewater treatment plant upgrades that are expected to proceed on approximately the same timeline as the floating WLAs (completion by 2026) include:

Upgrade and Expansion of the Massaponax WWTP

Spotsylvania County is currently in the preliminary engineering stage of a planned upgrade and expansion of the Massaponax WWTP. This project will allow the county to shut down the FMC WWTP and divert those flows to the expanded Massaponax facility. The FMC WWTP also treats some flows from the City of Fredericksburg and this alternative assumes that the City of Fredericksburg will close the Fredericksburg WWTP and divert all wastewater flows to the Massaponax WWTP. WLAs for the Fredericksburg and FMC WWTPs would be transferred to the Massaponax WWTP. As of the date of this report, no agreement has been reached between the City of Fredericksburg and Spotsylvania for the consolidation of the wastewater systems and recent discussions indicate that that the City may choose to upgrade the Fredericksburg WWTP rather than consolidate with the Spotsylvania system due to cost concerns.

Upgrade of the South Central WWTP

The South Central Wastewater Authority owns and operates the South Central WWTP serving the Cities of Petersburg and Colonial Heights as well as portions of Chesterfield, Dinwiddie and Prince George Counties. The South Central Wastewater Authority has voted to proceed to the design stage for a facility upgrade to a TN concentration of 4 mg/l and a TP concentration of 0.3 mgl.

Diversion of Wastewater Flows from the HRSD Chesapeake-Elizabeth WWTP Outside of the Chesapeake Bay Watershed

In order to meet its current WLAs, the Hampton Roads Sanitation District (HRSD) plans to begin diverting flows from the Chesapeake-Elizabeth WWTP to other facilities beginning in late 2021 or early 2022. HRSD will permanently close the Chesapeake-Elizabeth WWTP once all flows are diverted. HRSD will divert the vast majority flows from the facility to the Atlantic WWTP that discharges outside of the Chesapeake Bay watershed.

Scenario E – Scenario D Plus Lower Total Nitrogen Wasteload Allocations in the Tidal York and Lower Tidal James Basins

This alternative includes completion of all of the expected projects listed in the Scenario D alternative plus new TN WLAs for municipal wastewater treatment plants with design flows greater than 5 MGD in the tidal York River and the lower tidal James River. The new TN WLAs would be based on a concentration of 5 mg/l at full design flow. These WLAs are currently based on 6 mg/l of TN in the tidal York and the equivalent of 6.2 mg/l of TN in the lower tidal James.

Scenario F – Scenario E Plus HRSD SWIFT Treatment Plant Upgrades

This alternative includes all of the elements of Scenario E plus reductions associated with the HRSD's SWIFT treatment plant upgrades. The SWIFT treatment plant upgrades are necessary in order to be able to inject the reclaimed wastewater into the Potomac aquifer and are essentially equivalent to the technology required by the proposed floating WLAs.

Scenario G – Scenario E Plus Injection of 75% of HRSD SWIFT Project Flows

This alternative includes all of the elements of the previous alternative plus groundwater injection of 75% of the flows treated at the five HRSD SWIFT treatment plants.

Performance Optimization Incentive Grants

This alternative consists of the creation of a new incentive grant program that would pay dischargers under the watershed general permit for performing better than the concentration that serves as the basis for their TN or TP WLA. Facilities that have installed nutrient treatment technology are already subject to annual average concentration limits established in accordance with 9VAC25-40-70. This alternative would require the Commonwealth to enact legislation to

create an incentive based grant program that would encourage treatment to concentrations below those currently included in Virginia Pollutant Discharge Elimination System (VPDES) permits.

A program similar to this alternative exists in the State of Maryland where 10% of the revenues from the Bay Restoration Fund can be used to provide performance incentive grants to wastewater treatment facilities. Approximately $111 million is contributed to the fund every year through fees paid by each household ($5/month in the Chesapeake Bay watershed and $2.5/month outside of the watershed) generating $11million/year that could be used to incentivize treatment. The 65 municipal facilities eligible for the program in Maryland discharged an average of 2.8 mg/l TN and 0.12 mg/l of TP in Fiscal Year (FY) 2019. DEQ does not know what additional reductions could be achieved with such a program or how big the financial incentive would have to be to generate the reductions. Additionally, sources of revenue would have to be identified to finance this alternative.

Evaluation of Alternatives

Nutrient Load Reductions

Nutrient load reductions from each of the identified alternatives other than performance optimization incentive grants are identified in Appendix 3 and summarized below:

Table 5 – Nutrient Reduction Alternatives

Delivered Total Nitrogen (lbs/yr)							
	A	B	C	D	E	F	G
	2018 Actual Loads	2018 Actual Loads plus Floating WLA reductions	2018 Actual Loads plus Floating WLA and 75% SWIFT Injection	2018 Actual Loads plus Expected Projects	2018 Actual Loads plus Expected Projects and TN WLA reductions in Tidal York and Lower Tidal James	Scenario E plus HRSD SWIFT Upgrades	Scenario E plus HRSD SWIFT Upgrades and 75% SWIFT Injection
Potomac	2,126,946	2,126,946	2,126,946	2,126,946	2,126,946	2,126,946	2,126,946
Rappahannock	284,827	245,649	245,649	245,649	245,649	245,649	245,649
York	560,411	525,788	409,346	560,411	560,411	548,820	429,028
James	7,873,696	5,204,935	4,179,704	6,035,313	5,651,857	5,095,486	4,284,537
Eastern Shore	9,085	9,085	9,085	9,085	9,085	9,085	9,085
Virginia Total	10,854,965	8,112,403	6,970,730	8,977,404	8,593,947	8,025,985	7,095,245

Delivered Total Phosphorus (lbs/yr)							
	A	B	C	D	E	F	G
	2018 Actual Loads	2018 Actual Loads plus Floating WLA reductions	2018 Actual Loads plus Floating WLA and 75% SWIFT Injection	2018 Actual Loads plus Expected Projects	2018 Actual Loads plus Expected Projects and TN WLA reductions in Tidal York and Lower Tidal James	Scenario E plus HRSD SWIFT Upgrades	Scenario E plus HRSD SWIFT Upgrades and 75% SWIFT Injection
Potomac	75,324	75,324	75,324	75,324	75,324	75,324	75,324
Rappahannock	14,628	14,628	14,628	14,628	14,628	14,628	14,628
York	65,750	65,498	57,767	65,750	65,750	65,750	58,019
James	583,150	342,750	264,860	520,955	520,955	419,658	342,014
Eastern Shore	568	568	568	568	568	568	568
Virginia Total	739,419	498,768	413,147	677,224	677,224	575,928	490,553

Any of the alternatives discussed by the workgroup that include the installation of nutrient treatment technology (B, D, E and F) will likely result in loads below those listed above due to the conservative nature of engineering design and operating for permit compliance. There are also two proposed modifications to the Water Quality Management Planning Regulation (9VAC25-720) that could result in additional reductions in the York and James River Basins.

In the York River Basin, DEQ is proposing to move WLA associated with the former Plains Marketing Refinery in Yorktown to the Nutrient Offset Fund in accordance with § 62.1-44.19:14.D to provide opportunity for future economic development projects. This change removes a significant supply of nutrient credits from the market that dischargers would otherwise have access to in order to comply with new floating WLAs. This change also creates a potential credit shortfall for TN under the watershed general permit (see York Basin TN graph on page 4 of Appendix 3). DEQ proposes to address the potential shortfall by allowing York Basin dischargers not subject to a floating WLA to acquire TN credits from the Nutrient Offset Fund during the next permit cycle. The Nutrient Offset Fund serves as backstop to the nutrient trading market, providing a last resort supply of credits to ensure permit compliance.

In the James River Basin, new TP WLAs are proposed to meet water quality criteria for chlorophyll-a. Although the proposed chlorophyll-a based WLAs will require reductions at full design flow, most WWTPs currently operate at flows that are considerably below design flow so it is unclear if the chlorophyll-a based WLAs alone would drive significant additional reductions in the near term. Note that the James Basin and Statewide TP graphs in Appendix 3 indicate the aggregate WLAs from the chlorophyll-a based WLAs (in purple) and the floating WLAs (in red). For any given municipal facility subject to both WLAs, either of the two WLAs may be more limiting. Municipal facilities operating at flows less than 67% of their design flow will be limited by the floating WLA and facilities operating at flows greater than 67% of their design flow will be limited by their chlorophyll-a based WLA (the break point for Hopewell WWTP is 40% of design flow due to the 0.5 mg/l TP basis for the floating WLA). When the chlorophyll-a and floating WLAs are both applied on a facility-by-facility basis, the more limiting of the two WLAs applies and the resulting aggregate WLA (in green) is less than the aggregate WLAs generated by either of the two proposals individually.

Timing of Reductions

Scenario B

Nutrient reductions generated from floating WLAs would be achieved by January 1, 2026 under Initiative #52 in Virginia's Phase III WIP. Under proposed amendments to the Water Quality Management Planning Regulation (9VAC25-720) currently under development, the TN and TP reductions would be required by 2026. If completion of construction projects for the 5

incremental facilities directly impacted by the floating WLA proposal and the acceleration of any HRSD James River upgrades necessary to meet floating WLAs for TP presents a challenge, DEQ expects an adequate supply of credits to be available (from other dischargers and/or the Nutrient Offset Fund) to ensure permit compliance in each basin with the possible exception of TP in the lower James estuary.

Scenario C

HRSD intends to inject up to 75% of the wastewater flows into the aquifer, thereby eliminating that load from the Chesapeake Bay watershed. If successful, the aquifer injection element of the SWIFT project will greatly exceed the goals of the floating WLA proposal but on a longer timeframe. Current SWIFT project schedules plan for groundwater injection beginning in 2026 at the James River WWTP, 2028 at the York River WWTP, 2030 at the Virginia Initiative and Nansemond WWTPs, and 2032 at the Williamsburg WWTP.

Scenario D

From a timing standpoint, the reductions achieved from the implementation of floating WLAs (Scenario B) and the completion of expected projects (Scenario D) are on approximately the same schedule and provide the best comparison for the regulatory versus non-regulatory approaches under consideration. The current regulatory proposal (Scenario B) would implement floating WLAs on January 1, 2026. Without the regulatory driver provided by the proposed floating WLA, there is no certainty that the Massaponax and South Central WWTP upgrades will be completed by January 1, 2026. The Massaponax upgrade is likely to proceed although at the time of this report no agreement has been reached between the City of Fredericksburg and Spotsylvania County for the consolidation of the wastewater systems. Recent discussions indicate that that the City may choose to upgrade the Fredericksburg WWTP rather than consolidate with the Spotsylvania system. It is unknown how such a decision would impact the timing of Scenario D. Likewise, the South Central Wastewater Authority has voted to proceed to design an upgraded facility but this decision was influenced by the proposal to develop floating WLAs. Without the regulatory driver provided by the proposed floating WLA, it is unclear if the Authority will also vote to take on the additional financial commitment to construct the facility. HRSD plans to complete the final expected project in Scenario D, diversion of the Chesapeake-Elizabeth WWTP flows outside of the Chesapeake Bay watershed, by 2022, well ahead of the proposed 2026 deadline for the floating WLAs.

Scenario E

Scenario E reduces the basis for current TN WLAs in the tidal York River from 6 mg/l to 5 mg/l (-17%) and in the lower tidal James River from an effective concentration of 6.2 mg/l to 5 mg/l (-19%). Because these WLAs apply at full design flow, facilities operating at less than 80% of design flow would not necessarily have a regulatory driver to trigger an upgrade until nutrient

loads approach the revised WLA. In the York Basin, Scenario E limits future increases in TN loads rather than driving reductions from current discharge levels. In the James Basin, TN load reductions from Scenario E (380,000 lbs/yr TN) could be achieved by January 1, 2026 if the WLAs are incorporated into the current Water Quality Management Planning Regulation rulemaking.

Scenario F

The HRSD SWIFT project will eliminate discharges from the Boat Harbor and Army Base WWTPs by diverting those flows to the James River and Nansemond WWTPs respectively. The remaining four James Basin facilities (James River, Nansemond, Virginia Initiative and Williamsburg WWTPs) and the York River WWTP will be upgraded in order to be able to inject a portion of their flows into the Potomac aquifer. The upgraded facilities are expected to reduce nutrient concentrations to 4 mg/l TN and 0.3 mg/l TP. All of the upgrades necessary to produce 4 mg/l TN are scheduled to be completed by 2026. The majority of the TP reductions for the HRSD James River facilities will occur with the construction of effluent filters at each facility – currently scheduled for completion by 2026 at the James River WWTP, 2031 at the Virginia Initiative and Nansemond WWTPs, and 2033 at the Williamsburg WWTP.

Scenario G

The timing of Scenario G is identical to that of Scenario C. Current SWIFT project schedules plan for groundwater injection beginning in 2026 at the James River WWTP, 2028 at the York River WWTP, 2030 at the Virginia Initiative and Nansemond WWTPs, and 2032 at the Williamsburg WWTP.

Costs of Reductions

The scope and cost associated with the floating WLA concept included in Initiative #52 in Virginia's Phase III WIP has been reduced significantly with modifications included in the proposed Water Quality Management Planning Regulation amendments. The number of significant municipal facilities to which the floating WLA would apply has been reduced from 96 to 37 facilities. Of the 37 facilities potentially subject to the rule, 21 have either already upgraded to 4 mg/l TN and 0.3 mg/l TP or were otherwise able to meet the proposed requirements in 2018. Of the 16 remaining facilities that did not provide the proposed level of treatment in 2018, 11 have already planned upgrade or consolidation projects leaving a balance of 5 facilities impacted by this rulemaking that were not already planning facility upgrades.

In evaluating the cost of the proposal, DEQ only considered the incremental capital improvement costs for facilities that would be upgrading under Scenario B that were not otherwise planning upgrades. Those facilities and the associated capital improvement costs include:

Table 6 – Incremental Capital Upgrade Costs

Permit Number	Facility Name	Basin	Design Flow (MGD)	Estimated Total Project Cost	Estimated WQIF Grant Amount
VA0089915	Hanover County Totopotomoy WWTP	York	10	$9,532,000	$1,080,000
VA0024996	Chesterfield County Falling Creek WWTP	James	12	$13,950,000	$1,708,875
VA0060194	Chesterfield County Proctors Creek WWTP	James	27	$40,550,000	$4,967,375
VA0063690	Henrico County Water Reclamation Facility	James	75	$51,300,000	17,955,000
VA0066630	Hopewell Water Renewal	James	50	$1,000,000	$600,000
			Total	$116,332,000	$26,311,250

The costs noted above are estimated incremental capital improvement costs associated with the floating WLA proposal. The Henrico County Water Reclamation Facility cost represents the incremental cost between a previously planned $45.4 million project to replace existing filters with deep bed filters that could be converted to denitrification filters and a $96.7 million project that includes denitrifying deep bed filters and other improvements necessary to meet a TN of 4 mg/l and a TP of 0.20 – 0.25 mg/l (anticipated chlorophyll-a based TP limits). Henrico County would expect to apply to the Water Quality Improvement Fund for the full $96.7 million cost if floating WLAs are adopted.

The project cost for the Hopewell Water Renewal facility covers the addition of TP instrumentation and feed control equipment. This minor upgrade is expected to enable the facility to operate close to the 0.5 mg/l basis for its proposed floating WLA but is not guaranteed to meet the goal consistently. Some TP credit purchases may still be required but the number of credits required would be significantly reduced from recent history. Reductions in the chlorophyll-a based TP WLA for the Hopewell facility are expected to be considerably more stringent than the floating WLA and could require a substantial upgrade to reduce effluent total suspended solids concentrations or the purchase of up to approximately 12,000 lbs of additional TP credits per year.

The incremental capital upgrade costs presented in Table 6 were taken from the DEQ's Water Quality Improvement Fund FY2021 to FY2025 Needs Assessment Survey as well as additional input from individual treatment facilities. The incremental capital upgrade cost of $116,332,000 compares with a total capital cost of all projects of approximately $1,220,400,000 or approximately 10% of the financing needs for POTWs in Virginia's Chesapeake Bay watershed. The total capital cost includes $740,400,000 for expected projects included in Scenario D and HRSD SWIFT projects included in Scenarios C and F. The remaining $319,300,000 in costs includes routine asset replacement and upgrade projects, conveyance and consolidation projects, facility expansions and nutrient upgrades not required by the current floating WLA proposal.

The incremental capital costs above do not include the additional operating costs that facilities would incur such as additional chemical feed, sludge processing and disposal, and energy costs. Nor does it include any additional costs for the purchase of credits by facilities that currently comply with their WLAs by operating under an aggregate general permit registration. Many smaller facilities comply with their WLAs by relying on the over performance of other larger facilities under common ownership and co-registered under the same general permit "bubble". If the over performing facility generates fewer credits in the future due to the floating WLA then the smaller facility may have to purchase credits from outside of the "bubble" for the first time. This is likely to occur within the Hanover County bubble and possibly the HRSD York River bubble. The impacted facilities (Ashland and HRSD-West Point) would have to decide whether to acquire credits or to upgrade. Hanover County has estimated a cost of $12,188,000 to upgrade the Ashland WWTP to achieve 4 mg/l TN and 0.3 mg/l TP. As currently proposed, the floating WLA is not applied to the Ashland WWTP and the facility would only have to upgrade to meet the concentration bases of its current WLAs (6 mg/l TN and 0.4 mg/l). Alternatively, Hanover County could purchase any credits necessary on a year-to-year basis at a cost estimated at less than $10,000/year. No upgrade costs are available for the HRSD West Point facility but once the HRSD York River facility has completed its upgrade for the SWIFT project the need for credits for the West Point facility is greatly diminished.

Certainty of Reductions

Scenario B

Scenario B is the only alternative that includes regulatory certainty provided by incorporation of the requirement in the Water Quality Management Planning Regulation (9VAC25-720) and the General VPDES Watershed Permit Regulation for Total Nitrogen and Total Phosphorus Discharges and Nutrient Trading in the Chesapeake Bay Watershed in Virginia (9VAC25-820). Achievement of the reductions would be required by January 1, 2026.

Scenarios C and G

The injection of 75% of the HRSD wastewater flows into the Potomac aquifer is an ambitious goal that will produce nutrient reductions significantly beyond the reductions required to meet floating WLAs. Although this promising technology has been implemented in other areas of the country, it has yet to be demonstrated on a full scale basis in Virginia. Implementation will require a significant amount of research and testing in each location. HRSD is well on the way to solving these issues through work being performed at the SWIFT Research Center in Suffolk but it is not known whether HRSD will be able to achieve its goal of injecting approximately 75% of the wastewater flows by 2033.

Scenario D

There is reasonable certainty that 2018 loads will not change significantly between now and 2026. This same assumption is included in all of the alternatives evaluated in this report. There is considerable uncertainty however as to whether the reductions from the three expected projects will all materialize by 2026. Reductions from the closure of the HRSD Chesapeake-Elizabeth WWTP are reasonably certain as the facility is scheduled to be completed by 2022 and these reductions are necessary to meet dissolved oxygen-based TN WLAs that become effective on January 1, 2022. Likewise, Spotsylvania has been in the planning process for the Massaponax project for several years and will likely proceed with the project. At this time however, it is unknown whether Fredericksburg will join in the regional facility, choose to upgrade the City's own WWTP or continue to rely on the purchase of nutrient credits on an as needed basis. This uncertainty could also impact the timing of the Massaponax project. Finally, although the South Central Wastewater Authority has voted to begin design of the WWTP upgrade, it is unclear if the Authority will proceed to construction without the incentive provided by the floating WLA proposal. Additional certainty for these projects could be provided by WQIF grant agreements for construction or schedules of compliance added to individual VPDES permits.

Scenario E

The incremental TN load reduction between Scenarios D and E (approximately 380,000 lbs in the James Basin) would be relatively certain provided that the 5 mg/l TN WLAs are incorporated in the current Water Quality Management Planning Regulation rulemaking. The Scenario D reductions included in Scenario E are subject to the same considerations outlined in the above discussion.

Scenario F

HRSD has been planning and aggressively pursuing the SWIFT project for a number of years and is expected to stay on the basic schedule included in this report for the installation of the additional treatment technology included in Scenario F. The Scenario D reductions included in Scenario F are subject to the same considerations outlined in the above discussion.

Conclusions

The assumptions used in estimating nutrient concentrations and trends for wastewater facilities in Virginia's Chesapeake Bay TMDL Phase III WIP were conservative. However, the assumptions used did not impact the decision to develop the municipal floating WLAs included in Initiative #52 of the

Phase III WIP. The floating WLAs were developed in response to significant objections from the wastewater sector to technology-based limitations included in the April 2019 draft Phase III WIP. The wastewater industry has been by far the most successful sector in providing nutrient reductions achieved to date and it also represents the greatest opportunity for additional significant, timely and dependable nutrient reductions moving forward. The stakeholders' workgroup assisting DEQ identified four alternatives (Alternatives D thru G) to the floating WLAs however none of the alternatives achieve the reductions provided by the floating WLAs (Alternative B) with the same degree of timeliness and certainty. Significant modifications to the original floating WLA proposal have also been made in response to stakeholder input during the Regulatory Advisory Panel process. These proposed modifications greatly reduce the number of facilities subject to floating WLAs and the overall fiscal impact without substantially impacting the nutrient reductions achieved.

Appendix 1 – Workgroup Members

George Hayes	Chesterfield County Department of Public Utilities
Ted Henifin	Hampton Roads Sanitation District
Adrienne Kotula	Chesapeake Bay Commission
Chris McDonald	Virginia Association of Counties
Chris Pomeroy	Virginia Association of Municipal Wastewater Agencies
Peggy Sanner	Chesapeake Bay Foundation
William Street	James River Association

DEQ Staff

Allan Brockenbrough	Facilitator
Melanie Davenport	Facilitator
Gary Graham	Recorder/Agency Contact

Appendix 2 – Significant Municipal Facilities

	Facility Names	Basin	Subject to Currently Proposed Floating WLA?	Meeting Floating WLA in 2018?	Upgrade or Consolidation Previously Planned?
1	Falling Creek WWTP	James	Yes	No	No
2	Proctors Creek WWTP	James	Yes	No	No
3	Henrico County Water Reclamation Facility	James	Yes	No	No
4	Hopewell Water Renewal	James	Yes	No	No
5	Hanover County Totopotomoy WWTP	York	Yes	No	No
6	HRSD – York River Sewage Treatment Plant	York	Yes	No	Yes
7	South Central Wastewater Authority WWTF	James	Yes	No	Yes
8	HRSD - Army Base WWTP	James	Yes	No	Yes
9	HRSD - Boat Harbor Sewage Treatment Plant	James	Yes	No	Yes
10	HRSD - Chesapeake-Elizabeth Sewage Treatment Plant	James	Yes	No	Yes
11	HRSD - James River Sewage Treatment Plant	James	Yes	No	Yes
12	HRSD - Virginia Initiative WWTP	James	Yes	No	Yes
13	HRSD - Nansemond Sewage Treatment Plant	James	Yes	No	Yes
14	HRSD - Williamsburg Sewage Treatment Plant	James	Yes	No	Yes
15	Fredericksburg Wastewater Treatment Facility	Rappahannock	Yes	No	Yes
16	FMC Wastewater Treatment Facility	Rappahannock	Yes	No	Yes
17	Lynchburg Regional Wastewater Treatment Plant	James	Yes	Yes	
18	Moores Creek Advanced Water Resource Recovery Fac	James	Yes	Yes	
19	Richmond WWTP	James	Yes	Yes	
20	Massaponax Wastewater Treatment Facility	Rappahannock	Yes	Yes	
21	Culpeper Wastewater Treatment Plant	Rappahannock	Yes	Yes	
22	Little Falls Run Wastewater Treatment Facility	Rappahannock	Yes	Yes	
23	Virginia American Water Prince William - Section 8	Shenandoah/Potomac	Yes	Yes	
24	Virginia American Water Prince William - Section 1	Shenandoah/Potomac	Yes	Yes	
25	PWCSA - H L Mooney Wastewater Treatment Works	Shenandoah/Potomac	Yes	Yes	
26	Arlington County Water Pollution Control Facility	Shenandoah/Potomac	Yes	Yes	
27	Waynesboro WWTP	Shenandoah/Potomac	Yes	Yes	
28	Alexandria Renew Enterprises WWTP	Shenandoah/Potomac	Yes	Yes	
29	Noman M Cole Jr Pollution Control Plant	Shenandoah/Potomac	Yes	Yes	
30	North River WWTF	Shenandoah/Potomac	Yes	Yes	
31	Aquia Wastewater Treatment Plant	Shenandoah/Potomac	Yes	Yes	
32	Front Royal WWTP	Shenandoah/Potomac	Yes	Yes	
33	Middle River Regional WWTP	Shenandoah/Potomac	Yes	Yes	
34	Opequon Water Reclamation Facility	Shenandoah/Potomac	Yes	Yes	
35	Parkins Mill WWTF	Shenandoah/Potomac	Yes	Yes	
36	Broad Run Water Reclamation	Shenandoah/Potomac	Yes	Yes	
37	Leesburg Town - Water Pollution Control Division	Shenandoah/Potomac	Yes	Yes	
38	Onancock Town - Waste Water Treatment Plant	Eastern Shore	No		
39	Cape Charles Town - Wastewater Treatment Plant	Eastern Shore	No		
40	Riverside Shore Memorial Hospital	Eastern Shore	No		
41	Tangier Town	Eastern Shore	No		
42	Crewe WWTP	James	No		

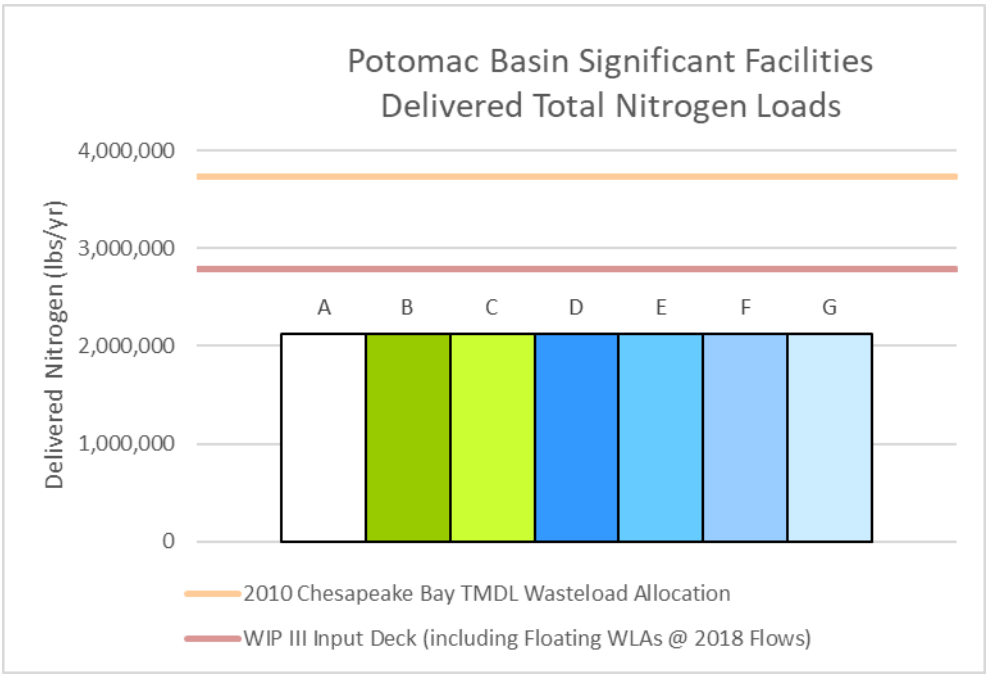
	Facility Names	Basin	Subject to Currently Proposed Floating WLA?	Meeting Floating WLA in 2018?	Upgrade or Consolidation Previously Planned?
43	DOC Powhatan Correctional Center	James	No		
44	Buena Vista STP	James	No		
45	Lake Monticello WWTP	James	No		
46	Covington City - Wastewater Treatment Plant	James	No		
47	Alleghany County - Low Moor WWTP	James	No		
48	Rutledge Creek WWTP	James	No		
49	Farmville Advanced WWTP	James	No		
50	Lexington-Rockbridge Regional WQCF	James	No		
51	Alleghany Co - Lower Jackson River Regional WWTP	James	No		
52	Kilmarnock Wastewater Treatment Plant	Rappahannock	No		
53	Warrenton Town Sewage Treatment Plant	Rappahannock	No		
54	Orange Town Sewage Treatment Plant	Rappahannock	No		
55	Haynesville Correctional Center	Rappahannock	No		
56	HRSD Urbanna Sewage Treatment Plant	Rappahannock	No		
57	Warsaw Wastewater Treatment Plant	Rappahannock	No		
58	Marshall Wastewater Treatment Plant	Rappahannock	No		
59	US Army - Fort A P Hill - Wilcox Camp	Rappahannock	No		
60	Reedville Sanitary District	Rappahannock	No		
61	Tappahannock Town of WWTP	Rappahannock	No		
62	Montross Westmoreland WWTP	Rappahannock	No		
63	Remington Wastewater Treatment Plant	Rappahannock	No		
64	Clevengers Village WWTP	Rappahannock	No		
65	Wilderness Wastewater Treatment Plant	Rappahannock	No		
66	Oakland Park Sewage Treatment Plant	Rappahannock	No		
67	Haymount Wastewater Treatment Facility	Rappahannock	No		
68	Hopyard Farm Wastewater Treatment Facility	Rappahannock	No		
69	Rapidan WWTP	Rappahannock	No		
70	Strasburg STP	Shenandoah/Potomac	No		
71	Vint Hill Farms Station WWTP	Shenandoah/Potomac	No		
72	Berryville WWTP	Shenandoah/Potomac	No		
73	Naval Support Facility Dahlgren	Shenandoah/Potomac	No		
74	Weyers Cave WWTP	Shenandoah/Potomac	No		
75	Basham Simms Wastewater Facility	Shenandoah/Potomac	No		
76	Massanutten Public Service Corporation STP	Shenandoah/Potomac	No		
77	UOSA - Centreville	Shenandoah/Potomac	No		
78	Fishersville Regional WWTP	Shenandoah/Potomac	No		
79	Round Hill Town Wastewater Treatment Plant	Shenandoah/Potomac	No		
80	Town of Colonial Beach Wastewater Treatment Plant	Shenandoah/Potomac	No		
81	Mt Jackson STP	Shenandoah/Potomac	No		
82	Woodstock STP	Shenandoah/Potomac	No		
83	Dahlgren District Wastewater Treatment Plant	Shenandoah/Potomac	No		
84	US Marine Corps - MCB Quantico - Mainside STP	Shenandoah/Potomac	No		
85	Stoney Creek Sanitary District STP	Shenandoah/Potomac	No		
86	Luray WWTP	Shenandoah/Potomac	No		
87	Stuarts Draft WWTP	Shenandoah/Potomac	No		
88	Purkins Corner Wastewater Treatment Plant	Shenandoah/Potomac	No		

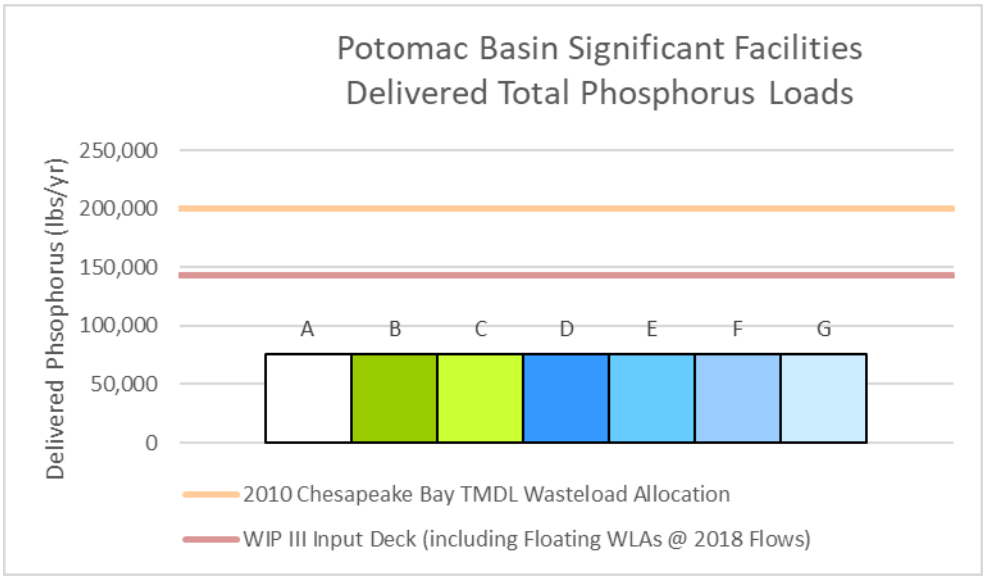
	Facility Names	Basin	Subject to Currently Proposed Floating WLA?	Meeting Floating WLA in 2018?	Upgrade or Consolidation Previously Planned?
89	Town of Broadway Regional WWTF	Shenandoah/Potomac	No		
90	Fairview Beach Wastewater Treatment Plant	Shenandoah/Potomac	No		
91	Gordonsville Sewage Treatment Plant	York	No		
92	Ashland WWTP	York	No		
93	Hanover County Doswell WWTP	York	No		
94	Caroline County Regional WWTP	York	No		
95	HRSD West Point Sewage Treatment Plant	York	No		
96	Parham Landing WWTP	York	No		

Appendix 3 – Scenario Delivered Loads

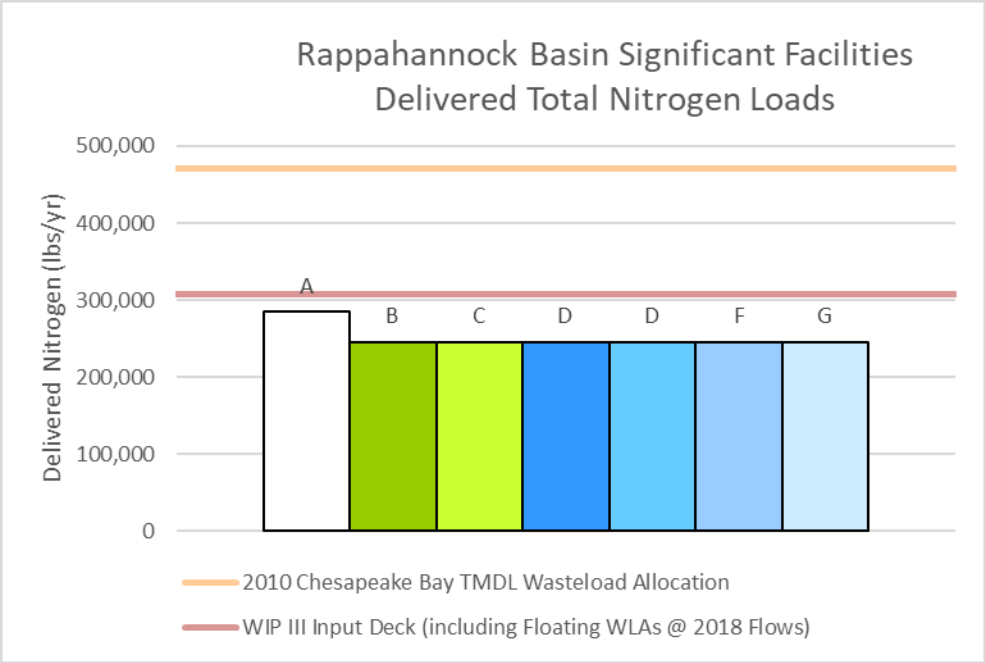
Delivered Total Nitrogen (lbs/yr)							
	A	B	C	D	E	F	G
	2018 Actual Loads	2018 Actual Loads plus Floating WLA reductions	2018 Actual Loads plus Floating WLA and 75% SWIFT Injection	2018 Actual Loads plus Expected Projects	2018 Actual Loads plus Expected Projects and TN WLA reductions in Tidal York and Lower Tidal James	Scenario E plus HRSD SWIFT Upgrades	Scenario E plus HRSD SWIFT Upgrades and 75% SWIFT Injection
Potomac	2,126,946	2,126,946	2,126,946	2,126,946	2,126,946	2,126,946	2,126,946
Rappahannock	284,827	245,649	245,649	245,649	245,649	245,649	245,649
York	560,411	525,788	409,346	560,411	560,411	548,820	429,028
James	7,873,696	5,204,935	4,179,704	6,035,313	5,651,857	5,095,486	4,284,537
Eastern Shore	9,085	9,085	9,085	9,085	9,085	9,085	9,085
Virginia Total	10,854,965	8,112,403	6,970,730	8,977,404	8,593,947	8,025,985	7,095,245

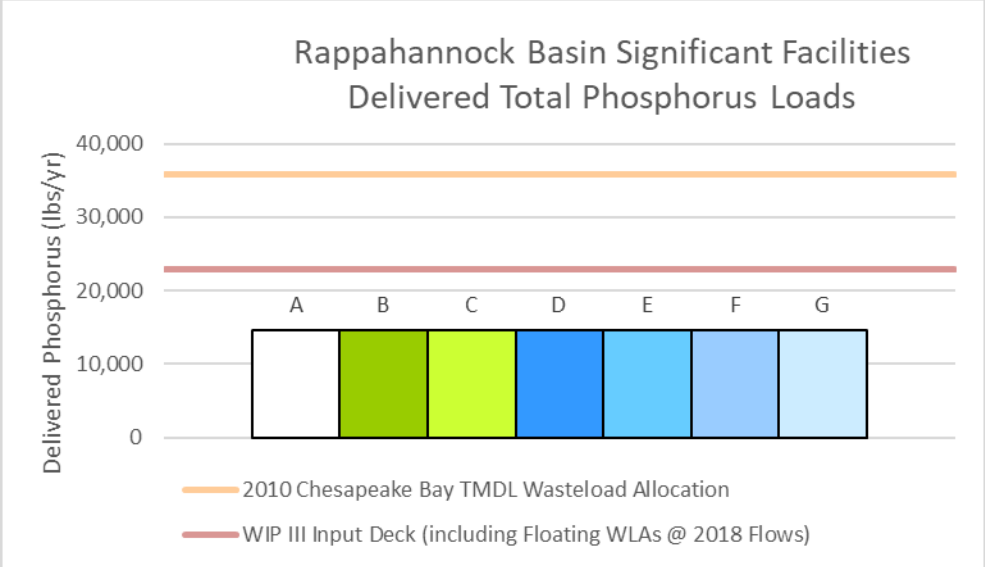
Delivered Total Phosphorus (lbs/yr)							
	A	B	C	D	E	F	G
	2018 Actual Loads	2018 Actual Loads plus Floating WLA reductions	2018 Actual Loads plus Floating WLA and 75% SWIFT Injection	2018 Actual Loads plus Expected Projects	2018 Actual Loads plus Expected Projects and TN WLA reductions in Tidal York and Lower Tidal James	Scenario E plus HRSD SWIFT Upgrades	Scenario E plus HRSD SWIFT Upgrades and 75% SWIFT Injection
Potomac	75,324	75,324	75,324	75,324	75,324	75,324	75,324
Rappahannock	14,628	14,628	14,628	14,628	14,628	14,628	14,628
York	65,750	65,498	57,767	65,750	65,750	65,750	58,019
James	583,150	342,750	264,860	520,955	520,955	419,658	342,014
Eastern Shore	568	568	568	568	568	568	568
Virginia Total	739,419	498,768	413,147	677,224	677,224	575,928	490,553





Scenario	
A	2018 Actual Loads
B	2018 Actual Loads plus Floating WLA reductions
C	2018 Actual Loads plus Floating WLA and 75% SWIFT injection reductions
D	2018 Actual Loads plus Expected Projects (Massaponax/FMC/Fredericksburg, South Central and HRSD Ches/Liz)
E	2018 Actual Loads plus Expected Projects and TN WLA reductions on Tidal York and Lower Tidal James
F	Scenario G plus HRSD SWIFT upgrades
G	Scenario G plus HRSD SWIFT upgrades and 75% HRSD SWIFT injection





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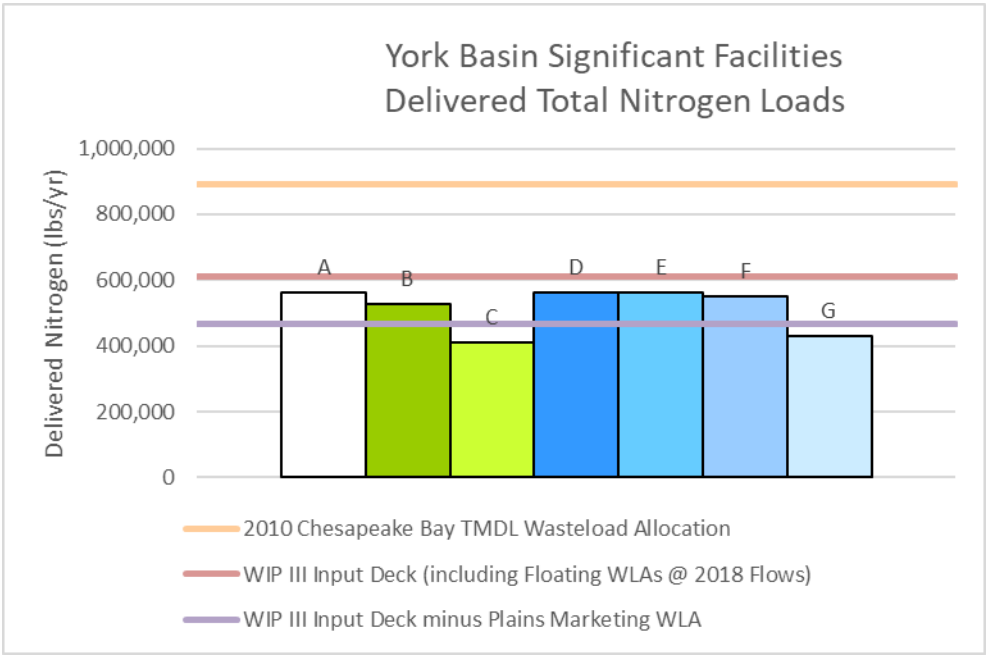
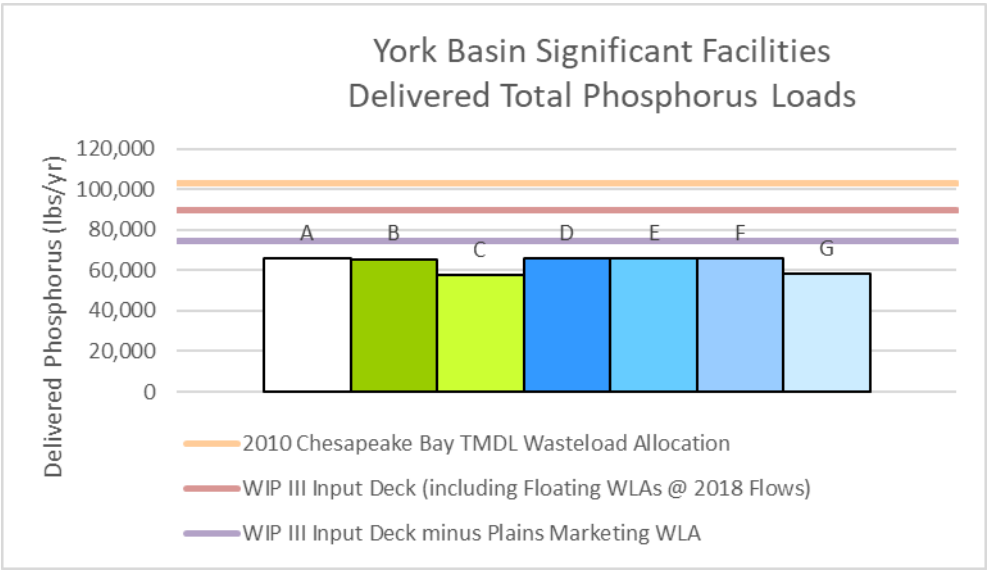
G	Scenario G plus HRSD SWIFT upgrades and 75% HRSD SWIFT injection





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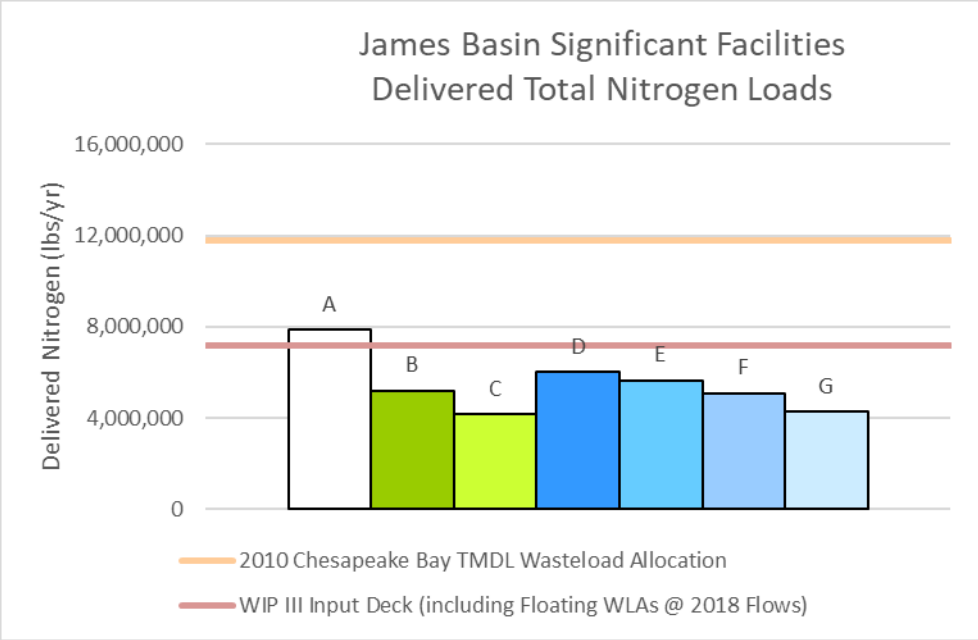

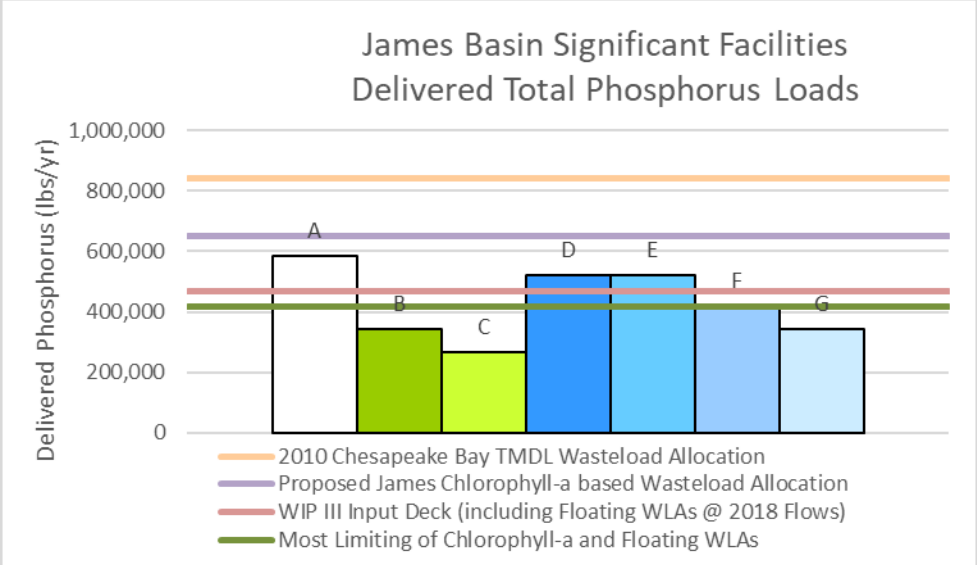

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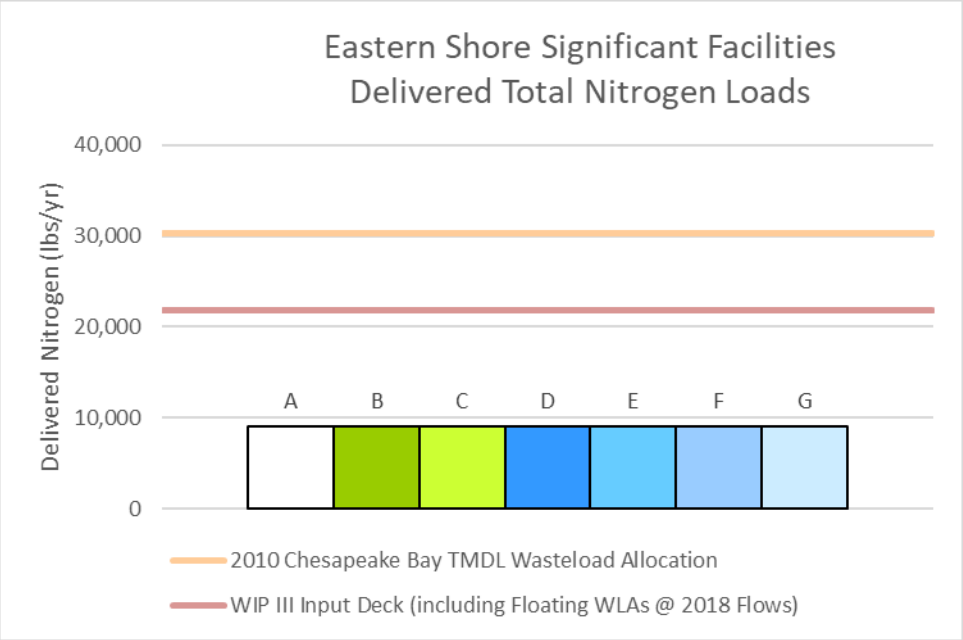
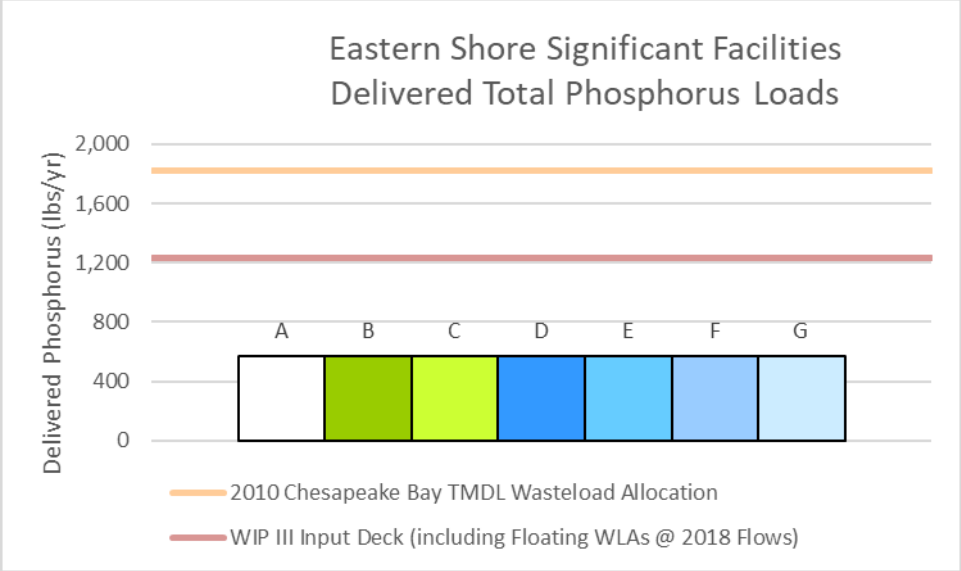
G	Scenario G plus HRSD SWIFT upgrades and 75% HRSD SWIFT injection





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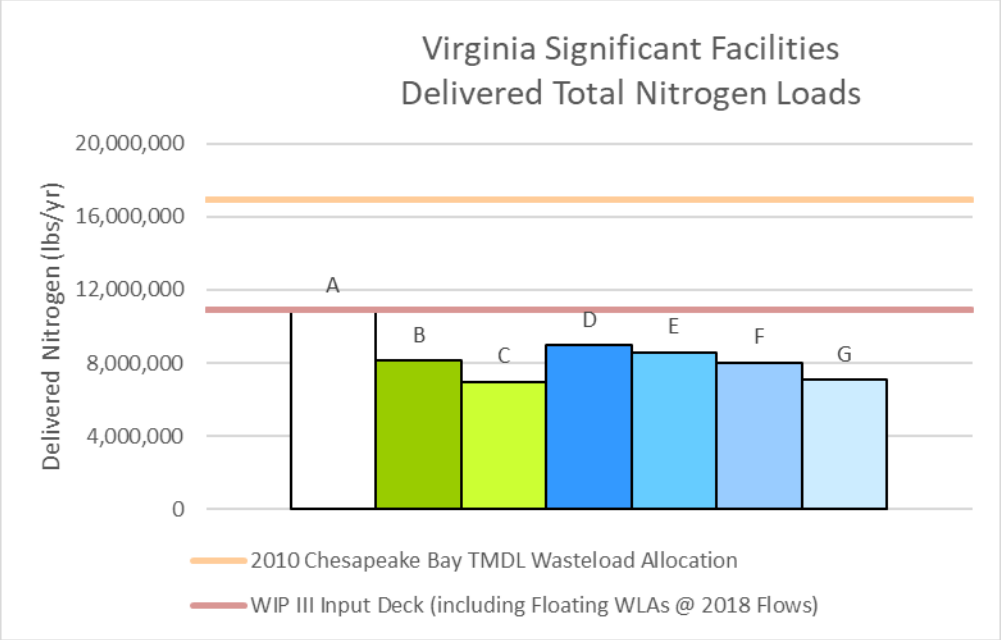
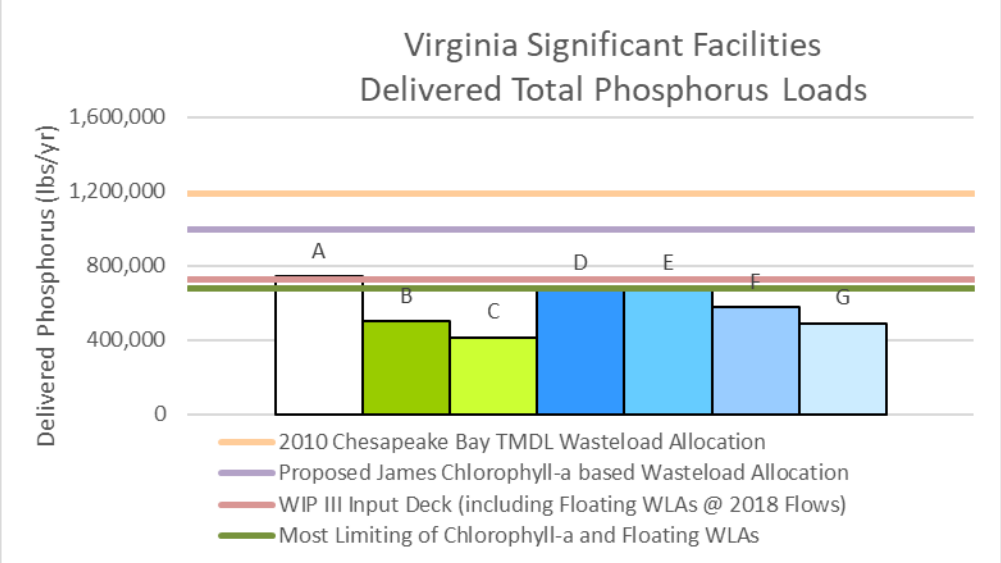
E	2018 Actual Loads plus Expected Projects and TN WLA reductions on Tidal York and Low er Tidal James
F	Scenario G plus HRSD SWIFT upgrades
G	Scenario G plus HRSD SWIFT upgrades and 75% HRSD SWIFT injection





Scenario	
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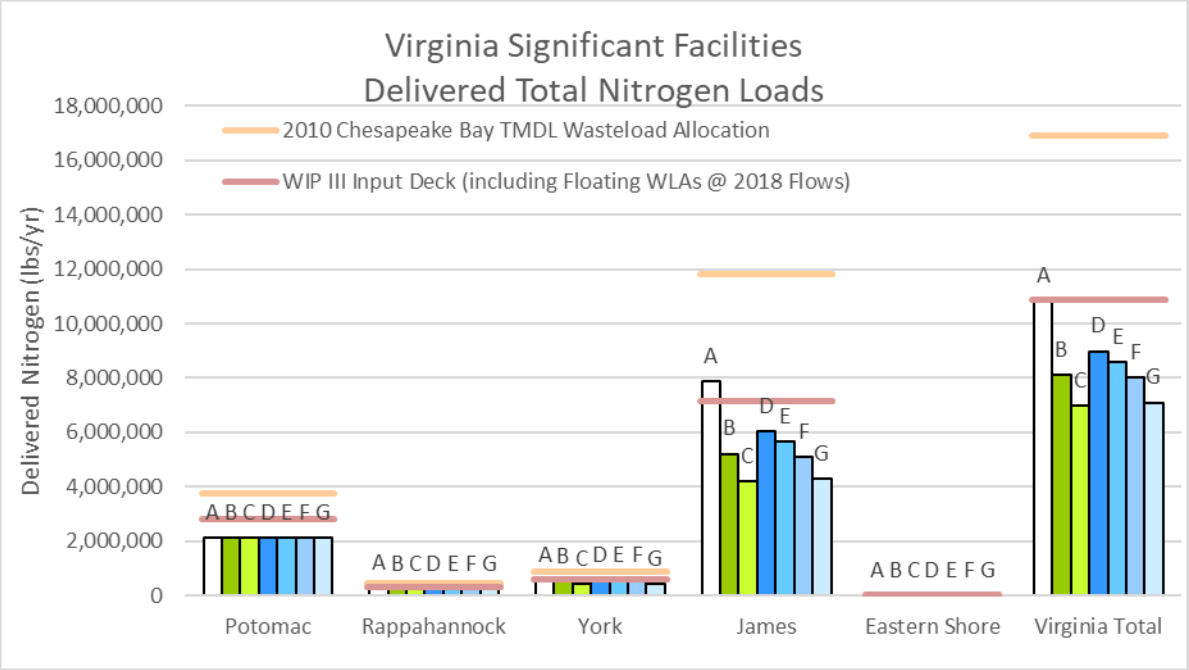

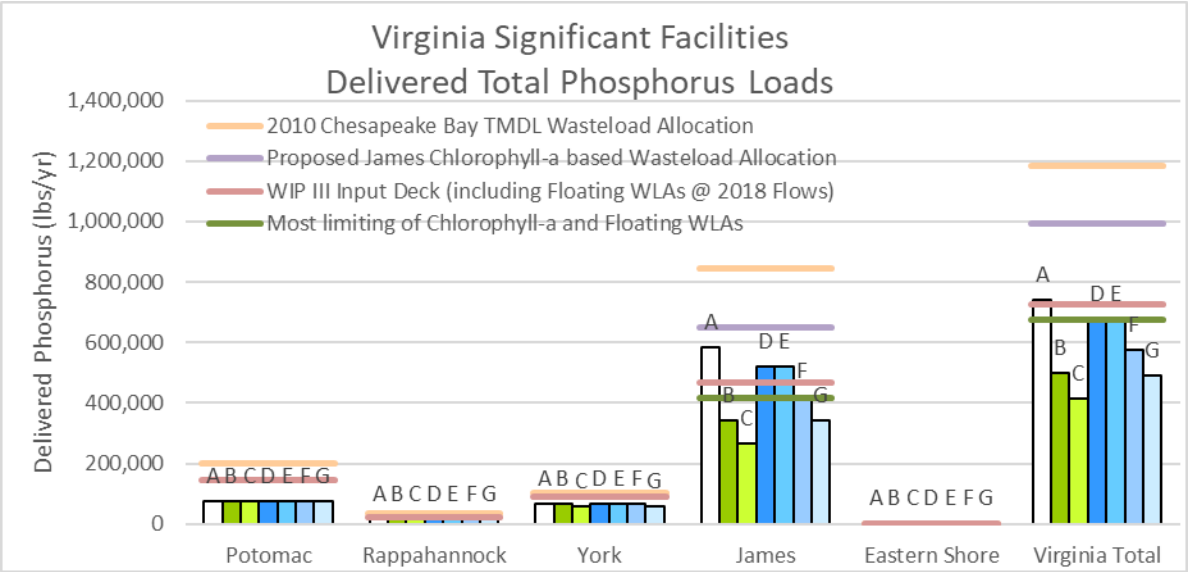

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F	Scenario G plus HRSD SWIFT upgrades
G	Scenario G plus HRSD SWIFT upgrades and 75% HRSD SWIFT injection