VAHydro-GW

2014-2015 Withdrawals Simulations

September 1, 2015
Office of Water Supply
Water Withdrawal Permitting and Compliance
Water Planning Division

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Table of Contents

1. The VAHydro-GW Model Background

The Virginia Coastal Plain Model[1] (VCPM) is a SEAWAT[2] groundwater model which encompasses all of the Coastal Plain within Virginia and parts of the Coastal Plain in northern North Carolina and southern Maryland. The original groundwater model was created by the USGS and simulates water levels within the aquifers and confining units of the coastal plan from 1890 through 2003 based upon historic pumping records. The VCPM incorporated an updated conceptualization of the Virginia Coastal Plain hydrogeologic framework – including the Chesapeake Bay impact crater and consolidation of the Upper, Middle, and Lower Potomac aquifers and confining units into a single Potomac aquifer and confining unit.

For aquifers near coastal areas the increase in density across a transition zone from fresh groundwater to seawater significantly affects the direction of groundwater flow. The capacity of SEAWAT to simulate the variable-density form of the groundwater flow equation increases the accuracy of simulated water levels in the Coastal Plain aquifers. The groundwater density distribution was established for the VCPM by a separate 108,000-year solute transport simulation of Pleistocene freshwater flushing around the Chesapeake Bay impact crater during transient sea-level changes. The resulting water density distribution is used for the duration of the VCPM simulation. The water density distribution remains unchanged during the simulation since the VCPM does not simulate solute transport.

The original VCPM was updated and adapted for use in the VA-DEQ well permitting process in 2013 and is referred to as VAHydro-GW. The updating process included adding historic pumping records from 2003 to 2012. As a result the VAHydro-GW then simulated water levels from 1890 to 2012 – this portion of the model is referred to as the historic portion of the model. The updating process also included modifying the VCPM to simulate water levels for 50 years beyond the end of the historic portion of the model (2012) – this portion of the model is referred to as the predictive portion of the model. The predictive portion of the model was based upon two scenarios: the total permitted scenario and the reported use scenario. The total permitted scenario simulated water levels for 50 years beyond 2012 by using the then current total permitted withdrawal rates established for withdrawal permits issued by the VA-DEQ together with the estimates for non-permitted withdrawals (domestic wells, wells in Maryland and North Carolina, wells within unregulated portions of Virginia) based upon estimated use for the year 2003. The total permitted scenario represents the estimated water levels 50 years into the future if all permittees within the Coastal Plain were to pump at their authorized maximum withdrawal rates for the duration of the 50 year period. The reported use scenario simulated water levels for 50 years using the 2012 reported pumping rates for wells permitted by the DEQ and

[1] Heywood and Pope, Simulation of Groundwater Flow in the Coastal Plain Aquifer System of Virginia, Scientific Investigation Report 2009-5039.
[2] Langevin, C.D., Thorne, D.T., Jr., Dausman, A.M., Sukop, M.C., and Guo, Weixing, 2008, SEAWAT Version 4: A Computer Program for Simulation of Multi-Species Solute and Heat Transport: U.S. Geological Survey Techniques and Methods Book 6, Chapter A22, 39 p.

estimates for non-permitted withdrawals based upon 2003 estimated use. The reported use simulation represents the best available estimate of water levels within the Coastal Plain aquifers over the next 50 years if pumping were to continue at the currently reported pumping rates for the permitted wells within the Coastal Plain. The remainder of this report outlines the process of updating the VAHydro-GW with reported use pumping data from 2013-2014 and total permitted pumping values from 2015.

2. 2014 Reported Use Simulation

2.1 Model Preparation

The VAHydro-GW 2014 Reported Use Simulation was performed representing the groundwater withdrawals reported to the DEQ. Reports were obtained in electronic format from the Virginia Water Use Data System ("VWUDS"), and the permit compliance reports. The Virginia Water Use Data System houses water use reported under the Water Withdrawal Reporting Regulation. This regulation requires annual reporting of monthly surface and groundwater withdrawals exceeding an average of 10,000 gallons per day. DEQ Office of Water Supply receives water use data from Groundwater Withdrawal Permit holders as a condition of their permits.

The VAHydro-GW encompasses all of the Coastal Plain within Virginia and parts of the Coastal Plain in northern North Carolina and southern Maryland. Row and column assignments for withdrawals reported within Virginia were made using well locations (latitude and longitude) to plot the position on a GIS coverage of the VAHydro-GW finite-difference grid. Model layers for withdrawals within the Eastern Virginia Groundwater Management Area (GWMA) were assigned based upon the top and bottom elevation of the withdrawal screens - using a land surface Digital Elevation Model (DEM) and the depths of the withdrawal screens. Layer assignments for withdrawals within the newly expanded portion of the GWMA were made based upon existing layer assignments for wells in the original VCPM; and, wells not currently in the VAHydro-GW were assigned to model layers based upon the assignments of nearby wells and the USGS report, *Private Domestic-Well Characteristics and the Distribution of Domestic Withdrawals among Aquifers in the Virginia Coastal Plain*[3]. Adjustments to model layer assignments were made based upon the documentation - *Regulatory Implementation of the Virginia Coastal Plain Model* on file with the Virginia DEQ. These adjustments were made to ensure that withdrawals were assigned to layers containing an adequate portion of the withdrawal aquifer(s).

The historic portion of the VAHydro-GW was updated by adding reported use pumping records from 2013 and 2014. For each year, the reported withdrawals were simulated at a constant rate (cfd) equivalent to the annual average for that year. The predictive portion of the VAHydro-GW was then executed for a 50 year simulation period. For this Reported Use simulation, withdrawals from Virginia

[3] Pope, McFarland, and Banks, Private Domestic-Well Characteristics and the Distribution of Domestic Withdrawals among Aquifers in the Virginia Coastal Plain, U.S. Geological Survey Scientific Investigations Report 2007-5250.

were simulated for the duration of the 50 year simulation using the average reported pumping for the 5 years from 2010 through 2014. Withdrawals from Maryland and North Carolina were simulated at the 2003 rates (the most recent year available at the time of the model execution). Boundary conditions representing underflow to Maryland and underflow from the Piedmont Province were simulated at the 2003 rates specified by the USGS in the original VCPM for the duration of the simulation. Domestic withdrawals were also repeated at the 2003 rates for each year of the simulation.

A total use of 84.3 million gallons per day (MGD) was assigned to all withdrawals in the 2014 Reported Use simulation. A total use of 65.6 MGD was assigned withdrawals within the Virginia Coastal Plain. Total use assigned to Maryland and North Carolina withdrawals was 9.4 and 9.3 MGD, respectively. A breakdown of the Virginia reported water use data by county appears in the Table 1.

Table 1. 2014 Water Use Report -Withdrawals Modeled by City/County

City/County (* = estimated)	**Use Allocated to Model (MGD)**	**Use Allocated to Model (%)**
*Caroline	1.10	1.7%
Charles City	0.06	0.1%
City of Chesapeake	3.16	4.8%
Chesterfield	0.20	0.3%
*Essex	0.34	0.5%
Franklin City	0.98	1.5%
*Gloucester	0.32	0.5%
City of Hampton	0.0	0.0%
Hanover	0.37	0.6%
Henrico	0.0	0.0%
Isle of Wight	15.77	24.0%
James City	5.38	8.2%
*King and Queen	0.03	0.0%
*King George	1.07	1.6%
King William	19.03	29.0%
*Lancaster	0.43	0.7%
*Mathews	0.02	0.0%
*Middlesex	0.15	0.2%
New Kent	0.65	1.0%
City of Newport News	1.16	1.8%
City of Norfolk	0.08	0.1%
*Northumberland	0.36	0.6%
City of Portsmouth	0.50	0.8%
Prince George	0.21	0.3%
*Richmond County	0.27	0.4%
Southampton	3.59	5.5%

City of Suffolk	6.95	10.6%
Surry	0.30	0.5%
Sussex	0.37	0.6%
City of Virginia Beach	0.16	0.2%
*Westmoreland	1.24	1.9%
City of Williamsburg	0.99	1.5%
York	0.36	0.5%
TOTAL	**65.61**	**100.0%**

The reported use amount allocated to each aquifer is shown in Table 2.

Table 2. Reported Use - Total Simulated By Aquifer

Aquifer	Use Allocated to Model (MGD)	Use Allocated to Model (%)
Surficial	0.57	0.9%
Yorktown-Eastover	0.61	0.9%
St. Mary's	0.30	0.5%
Piney Point	2.21	3.4%
Aquia	0.64	1.0%
Virginia Beach	0.10	0.2%
Potomac	61.17	93.2%
TOTAL	**65.61**	**100.0%**

The model outputs (potentiometric water levels) are generated by the MODFLOW Hydrogeologic-Unit Flow Package (HUF) for each hydrogeologic unit. For each confined, regulated aquifer the water levels were assigned to corresponding one mile square Geographic Information System (GIS) grid cells then converted to an ArcView shapefile. The head values were then contoured using ESRI's Spatial Analyst Spline tool. Smoothest contours were generated using the spline method (20 neighbors). Contour intervals were selected consistent with the graphics produced for previous annual simulations (see Attachment A).

2.2 VAHydro-GW Cells Violating the 80% Drawdown Criterion

The 2014 Reported Use Simulation shows areas of the Coastal Plain for the Potomac, Virginia Beach, Aquia, Piney Point, and Yorktown-Eastover aquifers where the predicted water levels (at the end of the 50 year simulation) are below the critical surface for those aquifers. In a number of the cells with water levels predicted to be below the critical surface, the predicted water levels are also below the aquifer top represented in the model framework. Maps of all areas violating the 80% drawdown criterion are presented in Attachment B. Areas with water levels also predicted to be below aquifer tops are noted on these maps.

3. 2015 Total Permitted Simulation

3.1 Withdrawals Simulated

9VAC25-610-110(D) ("Evaluation Criteria for permit applications") of the GWMA Regulations requires the evaluation of proposed withdrawals in combination with all existing lawful withdrawals. This simulation was created by replacing the reported use amounts of the predictive portion of the 2014 Reported Use simulation for all GWMA permit holders with the maximum annual withdrawal limit allowed under the terms of active permits. All other withdrawals from the 2014 Reported Use simulation were not changed. For the GWMA permit holders the individual permit amount was evenly divided between the active and proposed wells of the permit. For permits with special conditions requiring limits on groups of wells, the maximum amount per well grouping was divided evenly between all wells in the group. Pending permits (those awaiting VDH approval) were also modeled at their maximum annual limit.

Model layers for withdrawals within the GWMA were assigned based upon the top and bottom elevation of the withdrawal screens - using a land surface DEM and the depths of the withdrawal screens. Adjustments to model layer assignments were made based upon the documentation - *Regulatory Implementation of the Virginia Coastal Plain Model* on file with the Virginia DEQ. These adjustments were made to ensure that withdrawals were assigned to layers containing an adequate portion of the withdrawal aquifer(s). The VAHydro-GW utilizes the MODFLOW Multi-Node Well (MNW) package. The MNW package allows withdrawals so be assigned to multiple, consecutive (single aquifer withdrawals) or non-consecutive (multi-aquifer withdrawals) model layers. Modeled water extraction is allocated by the MNW package among assigned model layers based upon the layer hydrogeologic properties.

All of the permitted withdrawals simulated in the "2015 Total Permitted Simulation" are listed in Attachment E. Table 3 outlines the withdrawal amounts in the 2015 Total Permitted Simulation. The total simulated withdrawal of 169.5 MGD is 85.2 MGD greater than the total amount reported as actual use.

Table 3. Total Permitted - Withdrawals Simulated

Withdrawal Source	Use Allocated to Model (MGD)	Use Allocated to Model (%)
GWMA Maximum Permitted	145.4	85.8%
Non-GWMA Reported Use	5.4	3.2%
Maryland Reported Use	9.4	5.5%
North Carolina Reported Use	9.3	5.5%
TOTAL	**169.5**	**100.0%**

Contour maps of the Total Permitted simulation appear as Attachment C in this document. These maps depict the water level elevations for each confined aquifer predicted to occur if all permitted users were

to withdrawal at their maximum lawful limit for the duration of the 50 year simulation. These maps were contoured consistent with the process for the 2005 Reported Use Simulation and other previous water use reports.

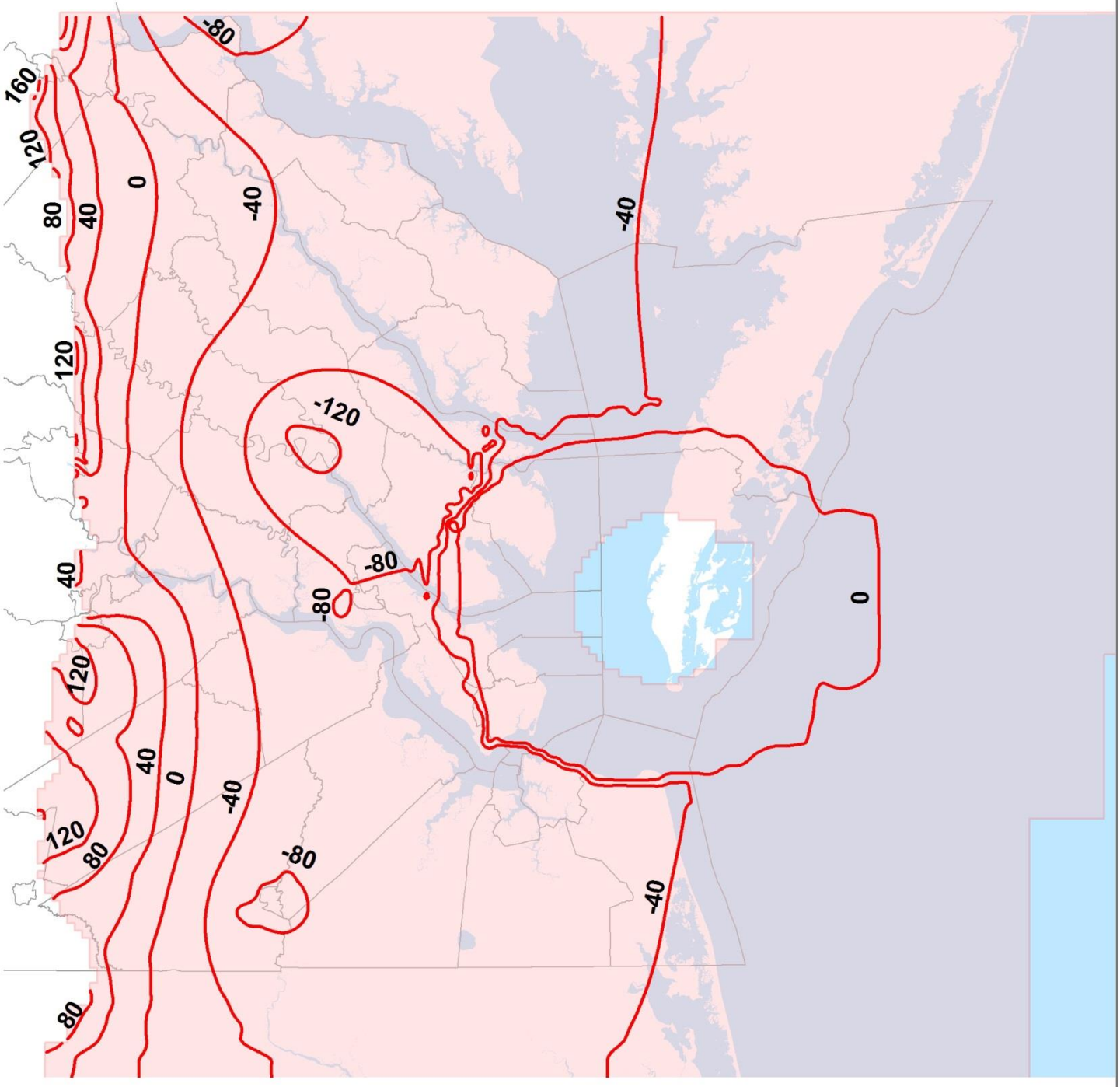
3.2 VAHydro-GW Cells Violating the 80% Drawdown Criterion

The 2015 Total Permitted Simulation shows areas of the Coastal Plain for the Potomac, Virginia Beach, Aquia, Piney Point, and Yorktown-Eastover aquifers where the predicted water levels (at the end of the 50 year simulation) are below the critical surface for those aquifers. In a number of the cells with water levels predicted to be below the critical surface, the predicted water levels are also below the aquifer top represented in the model framework. Maps of all areas violating the 80% drawdown criterion are presented in Attachment D. Areas with water levels also predicted to be below aquifer tops are noted on these maps.

Attachment A

Simulated Potentiometric Contours
2014 Reported Use Simulation

Simulated Potentiometric Contours
Potomac Aquifer
2014 Reported Use Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 40 ft intervals.

Prepared by Aquaveo, LLC for the Virginia DEQ, Office of Water Supply
September 1, 2015

Potentiometric Water Level Contours

Potomac Aquifer Model Boundary

0 15 30 60 Miles

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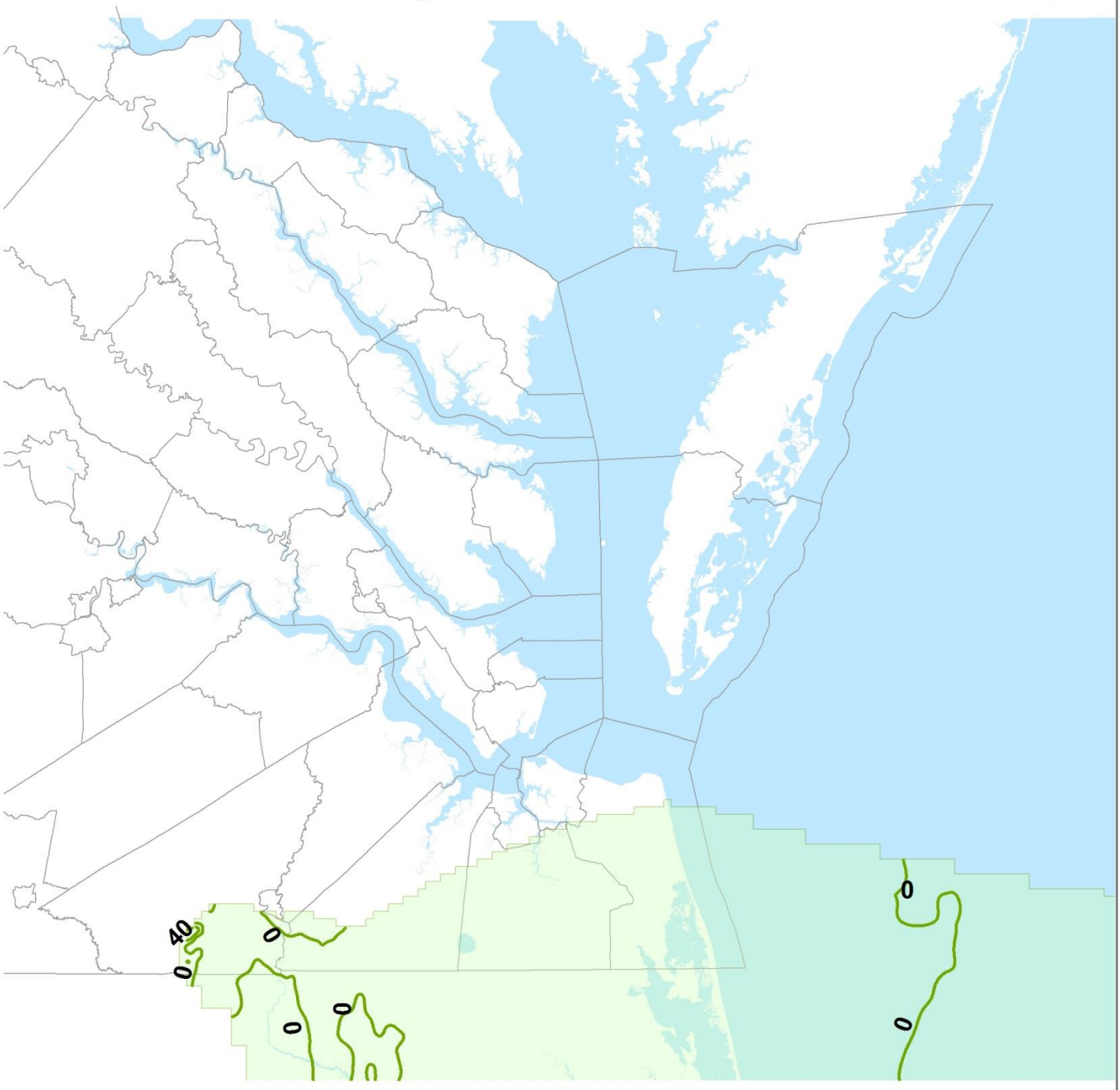
Simulated Potentiometric Contours
Virginia Beach Aquifer
2014 Reported Use Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 40 ft intervals.

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September 1, 2015

Potentiometric Water Level Contours

Virginia Beach Model Boundary

0 15 30 60 Miles

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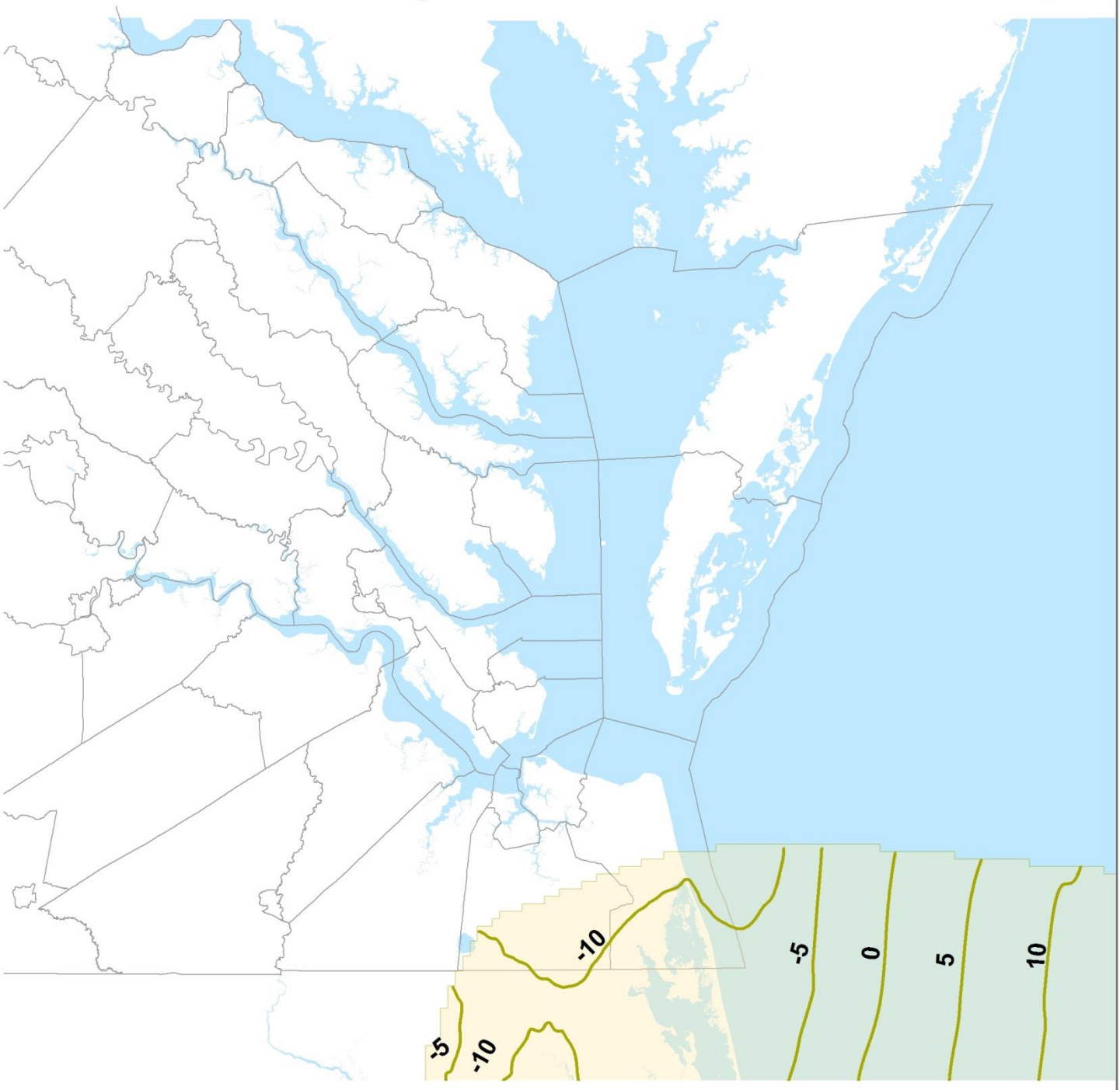
Simulated Potentiometric Contours
Pee Dee Aquifer
2014 Reported Use Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 5 ft intervals.

Prepared by Aquaveo, LLC for the Virginia DEQ, Office of Water Supply
September 1, 2015

Potentiometric Water Level Contours

Pee Dee Model Boundary

0 15 30 60 Miles

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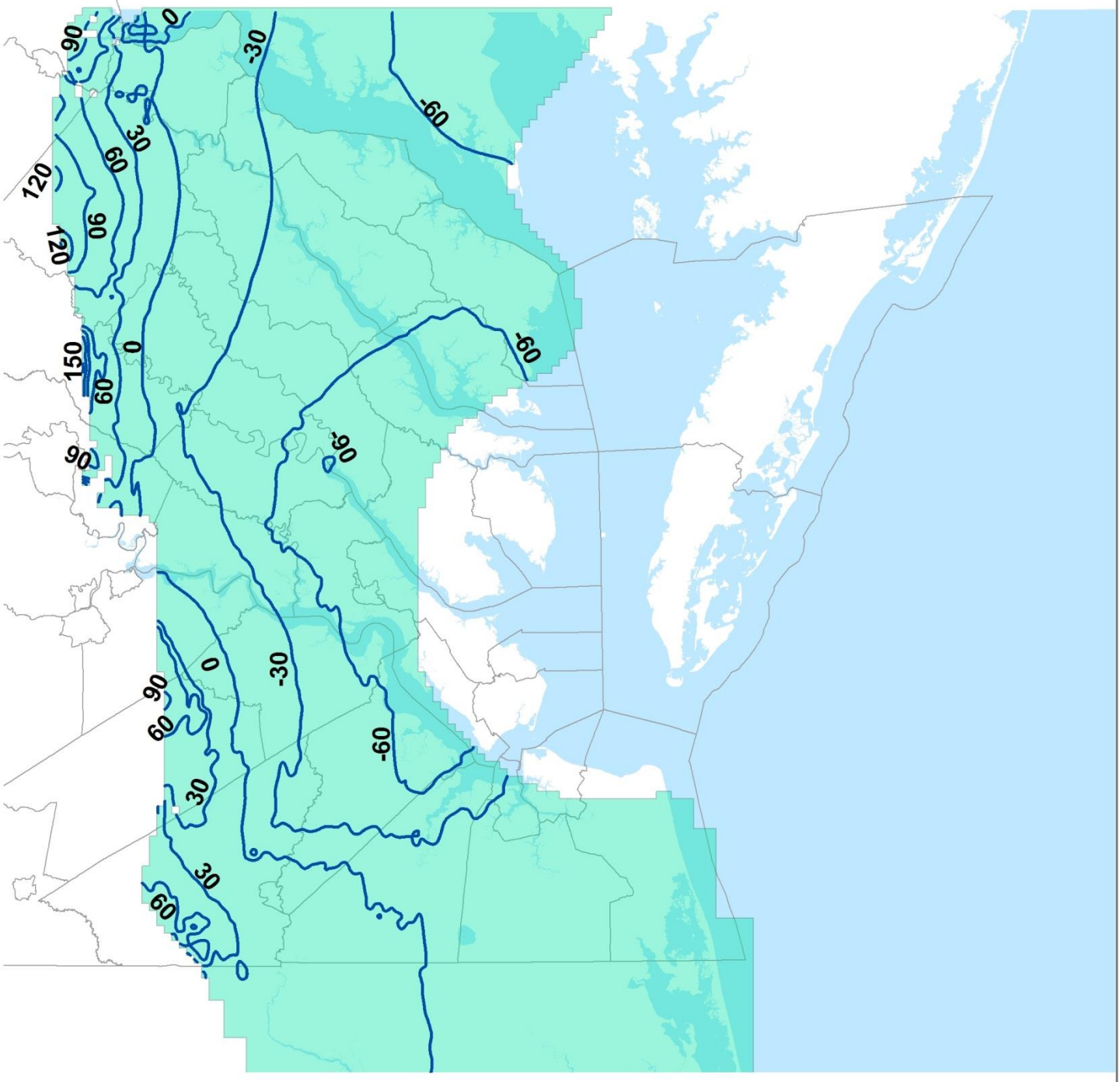
Simulated Potentiometric Contours
Aquia Aquifer
2014 Reported Use Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

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September 1, 2015

Potentiometric Water Level Contours

Aquia Aquifer Model Boundary

0 15 30 60 Miles

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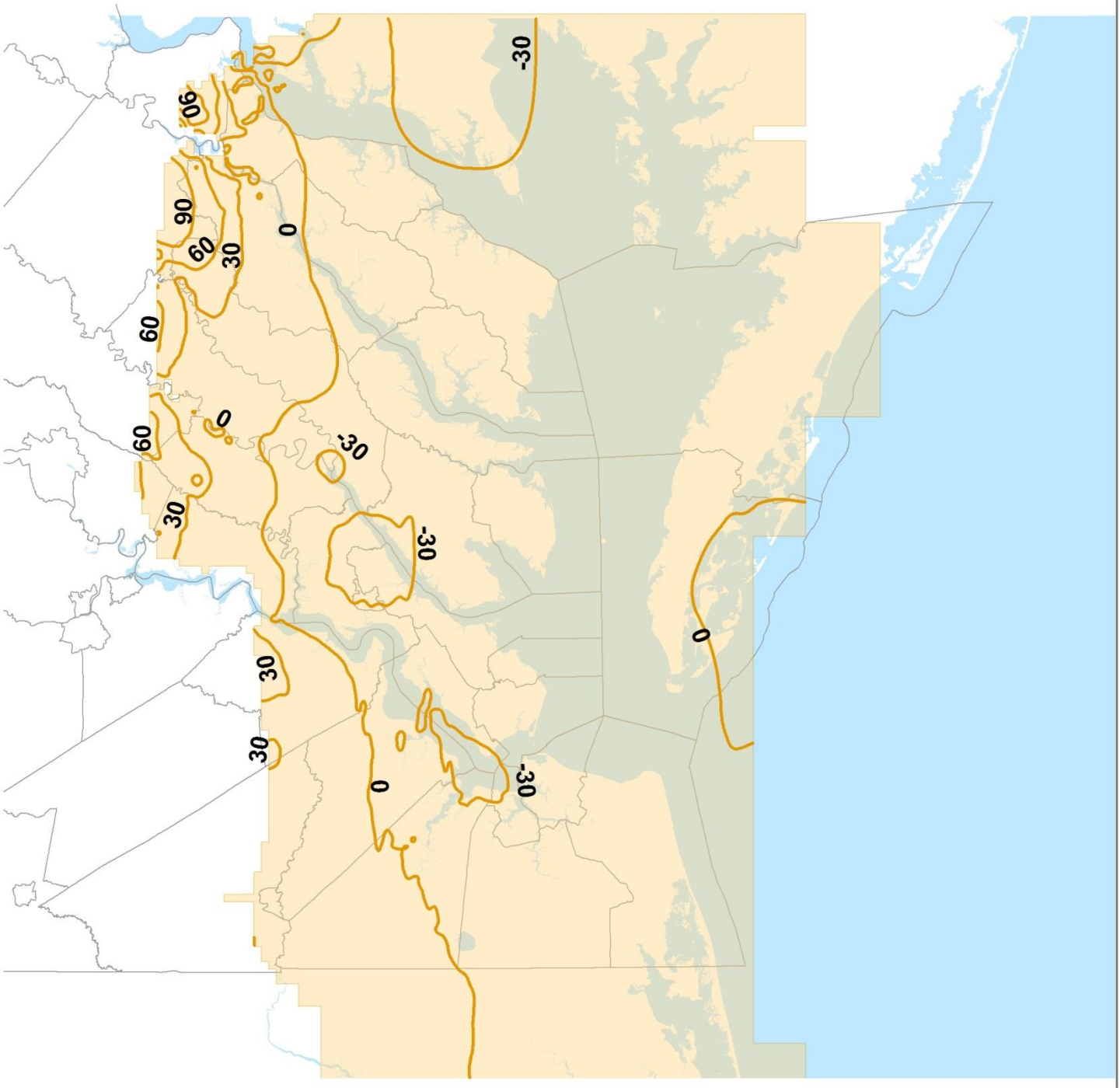
Simulated Potentiometric Contours
Piney Point Aquifer
2014 Reported Use Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

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Potentiometric Water Level Contours

Piney Point Aquifer Model Boundary

0 15 30 60 Miles

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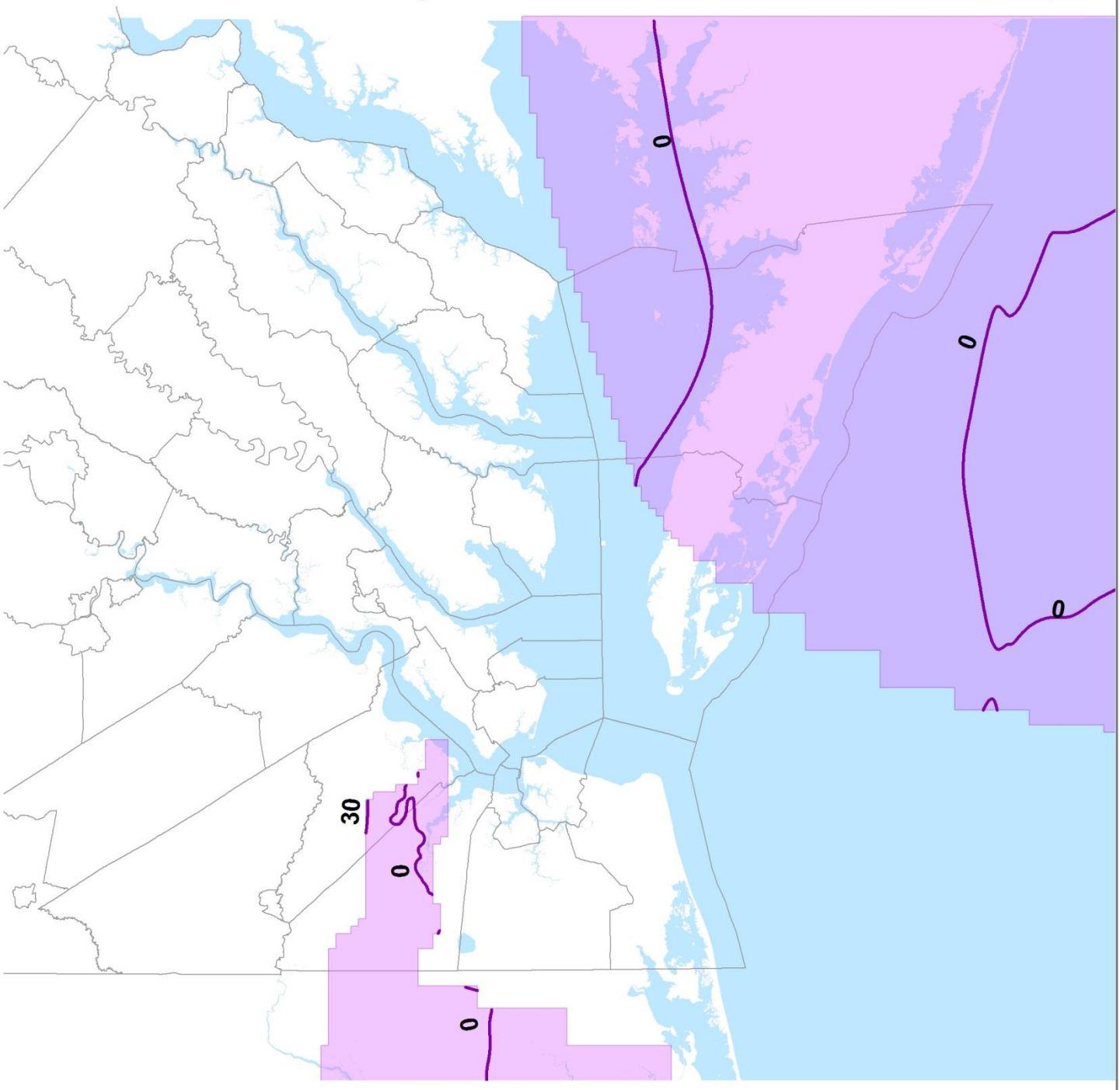
Simulated Potentiometric Contours
St. Mary's Aquifer
2014 Reported Use Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

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Potentiometric Water Level Contours

St. Mary's Aquifer Model Boundary

0 15 30 60 Miles

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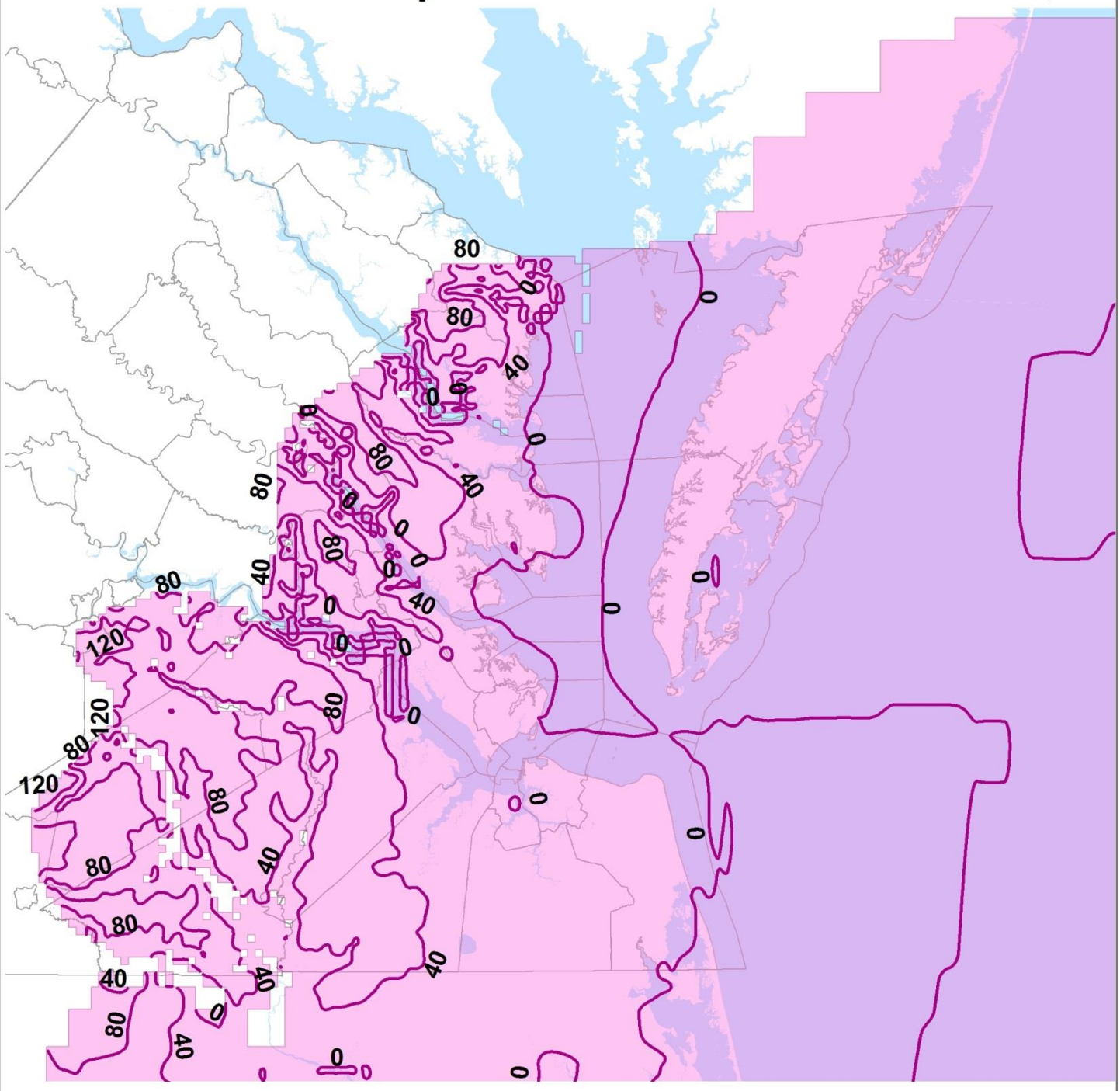
Simulated Potentiometric Contours
Yorktown-Eastover Aquifer
2014 Reported Use Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 40 ft intervals.

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September 1, 2015

Potentiometric Water Level Contours

Yorktown-Eastover Aquifer Model Boundary

0 15 30 60 Miles

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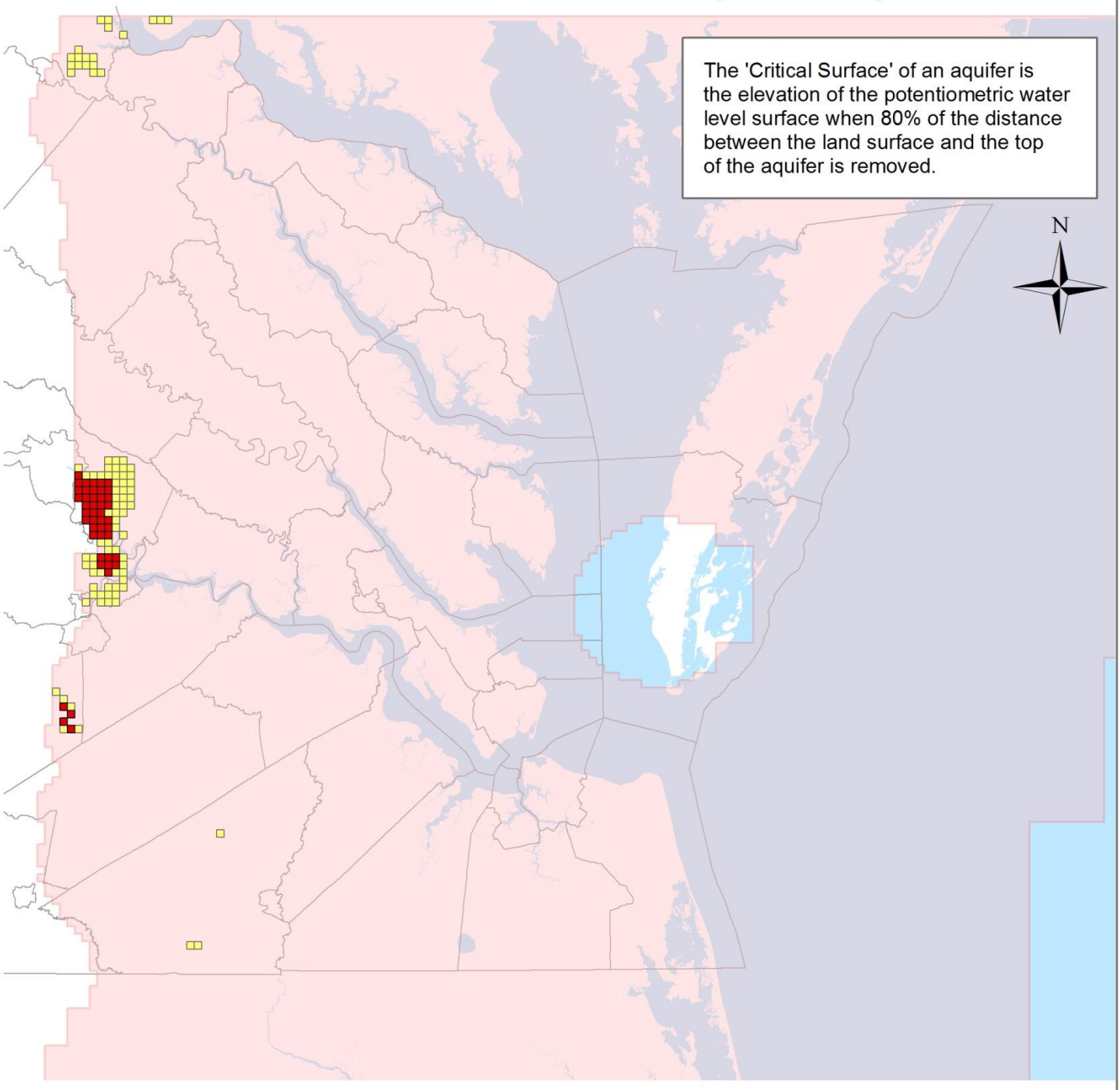
Attachment B

Simulated Water Levels
Below the Critical Surface and Below the Aquifer Top
2014 Reported Use Simulation

2014 Reported Use Simulation - Potomac Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



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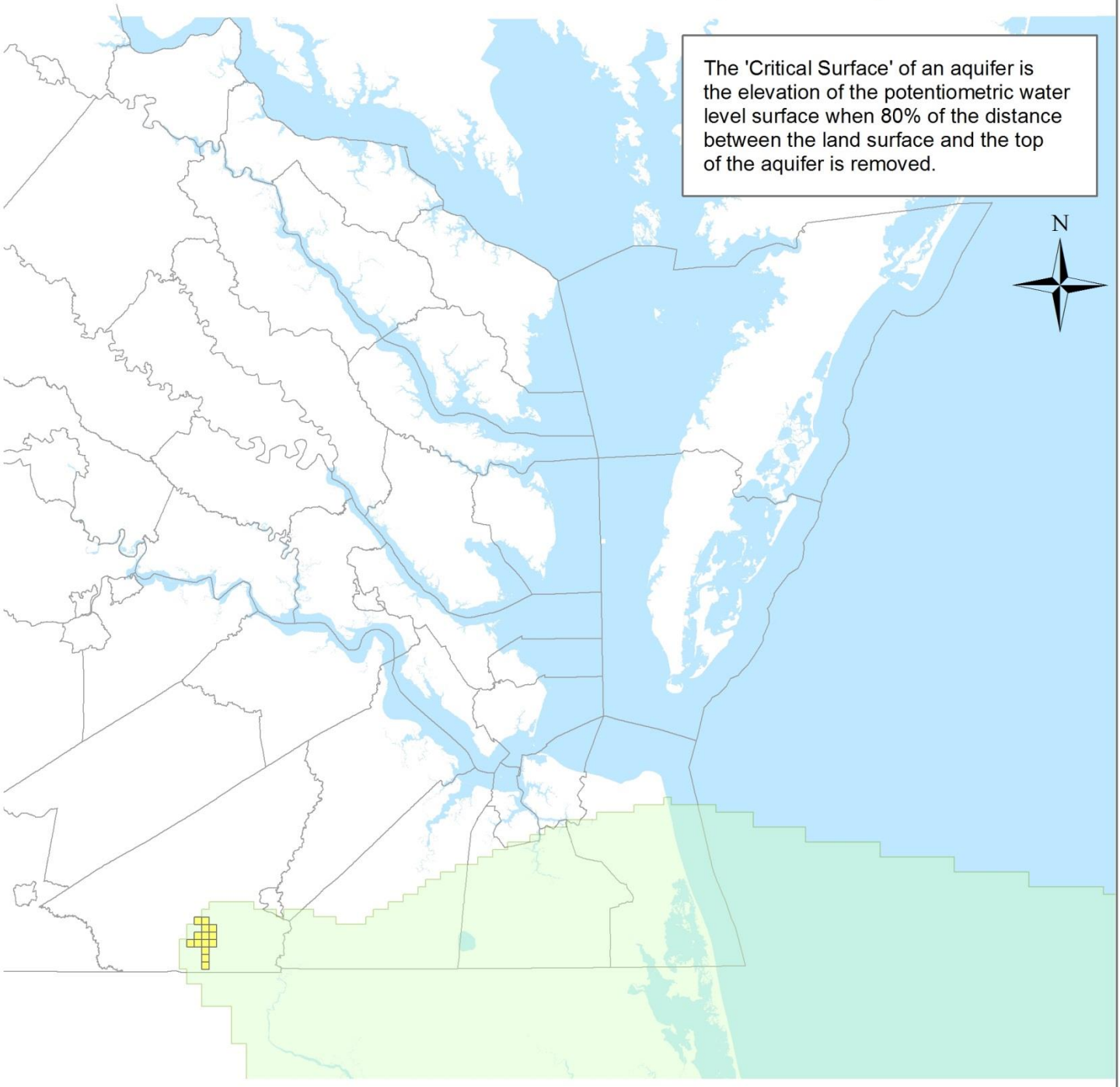
2014 Reported Use Simulation - Virginia Beach Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



Prepared by Aquaveo, LLC for the Virginia DEQ,Office of Water Supply
September 1, 2015

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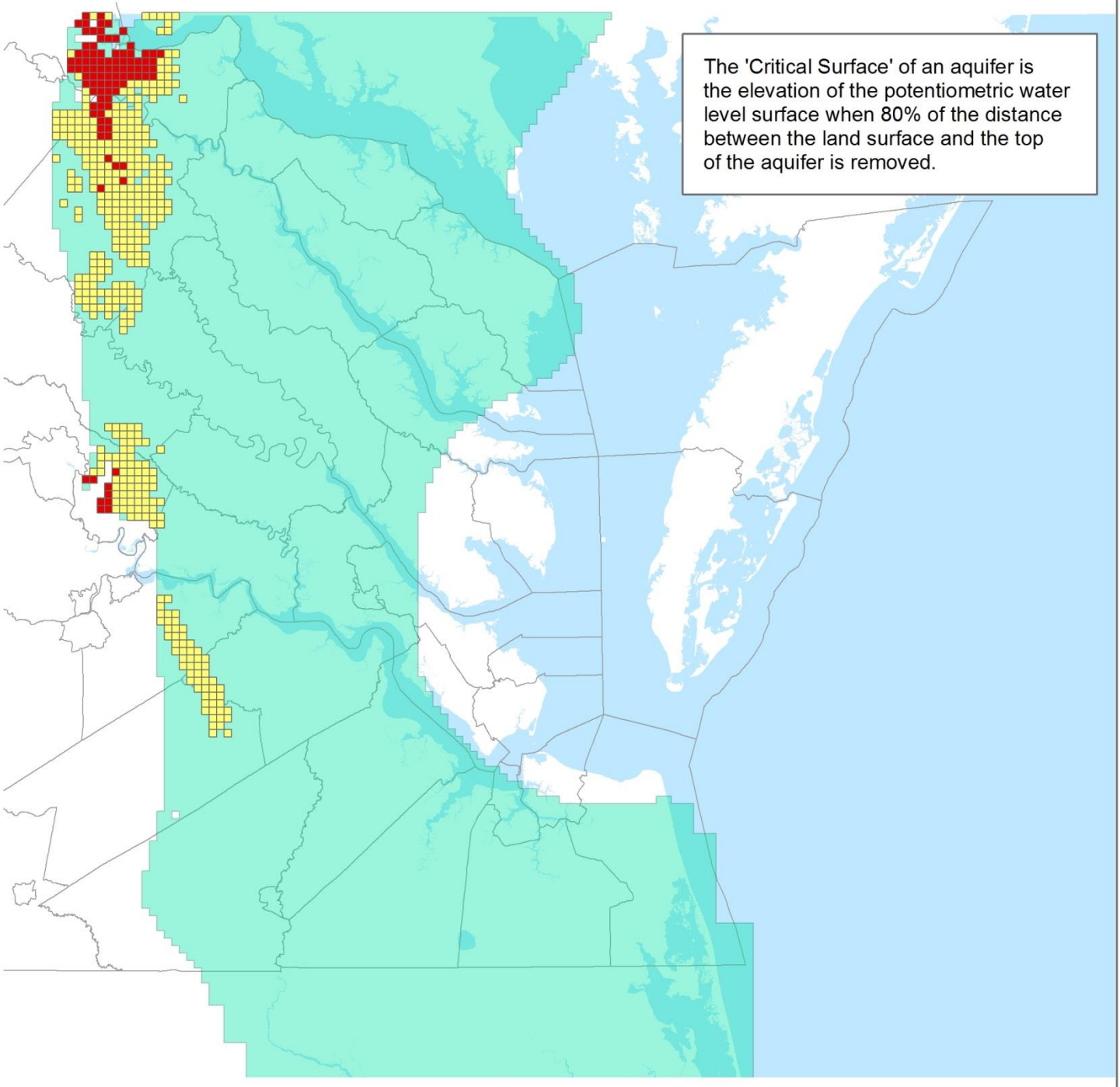
2014 Reported Use Simulation - Aquia Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



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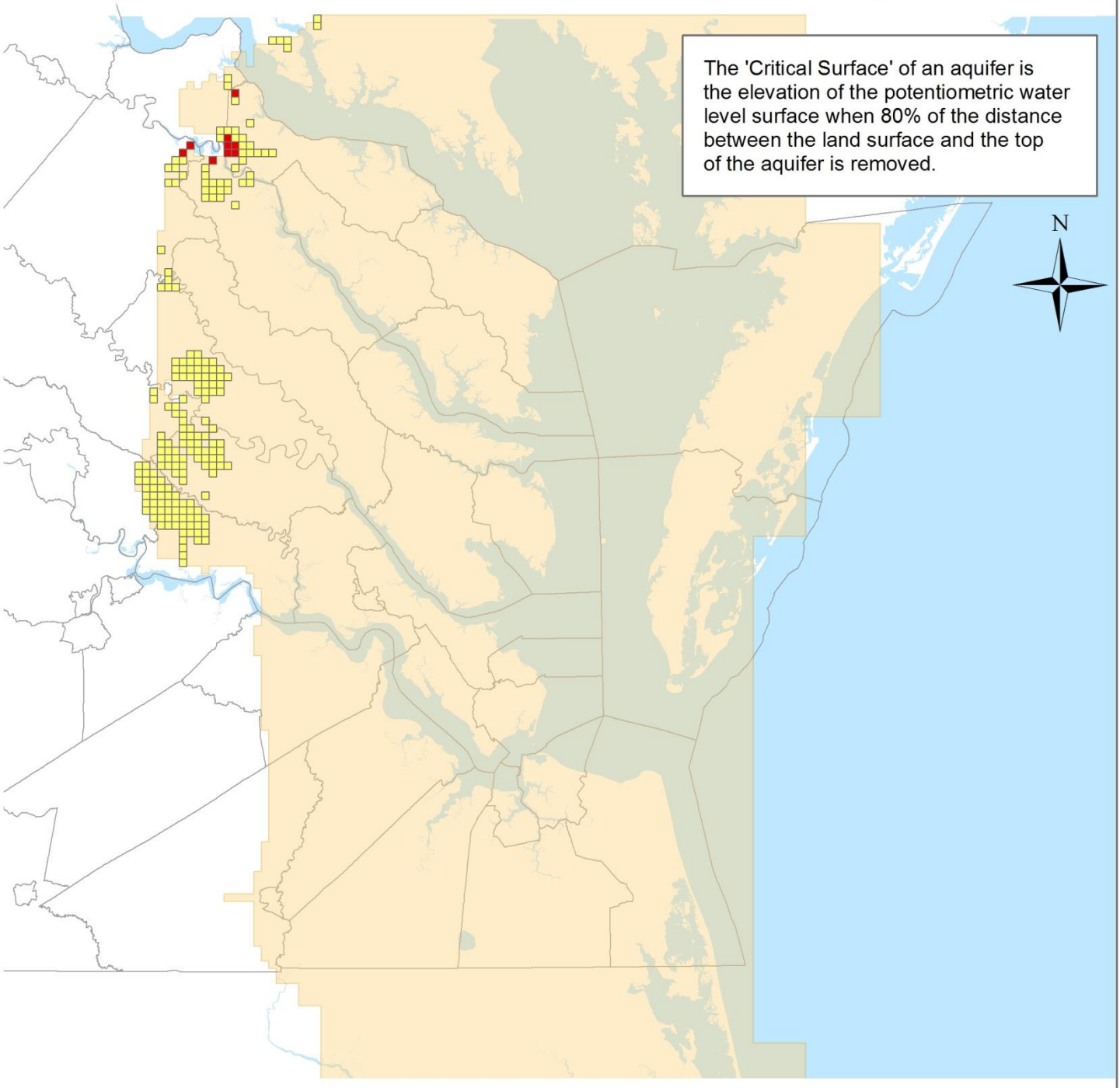
2014 Reported Use Simulation - Piney Point Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



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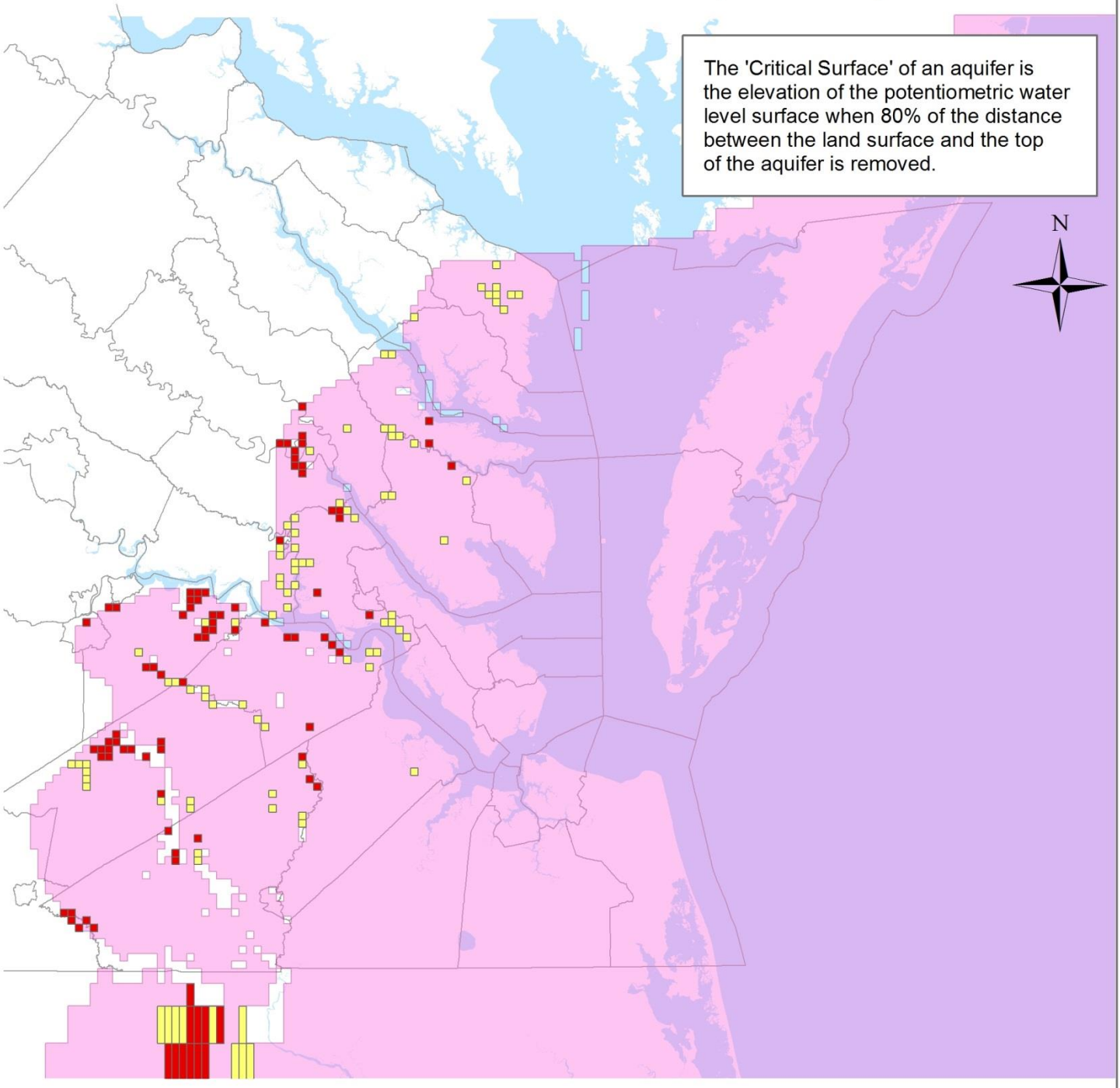
2014 Reported Use Simulation - Yorktown-Eastover Aquifer
Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



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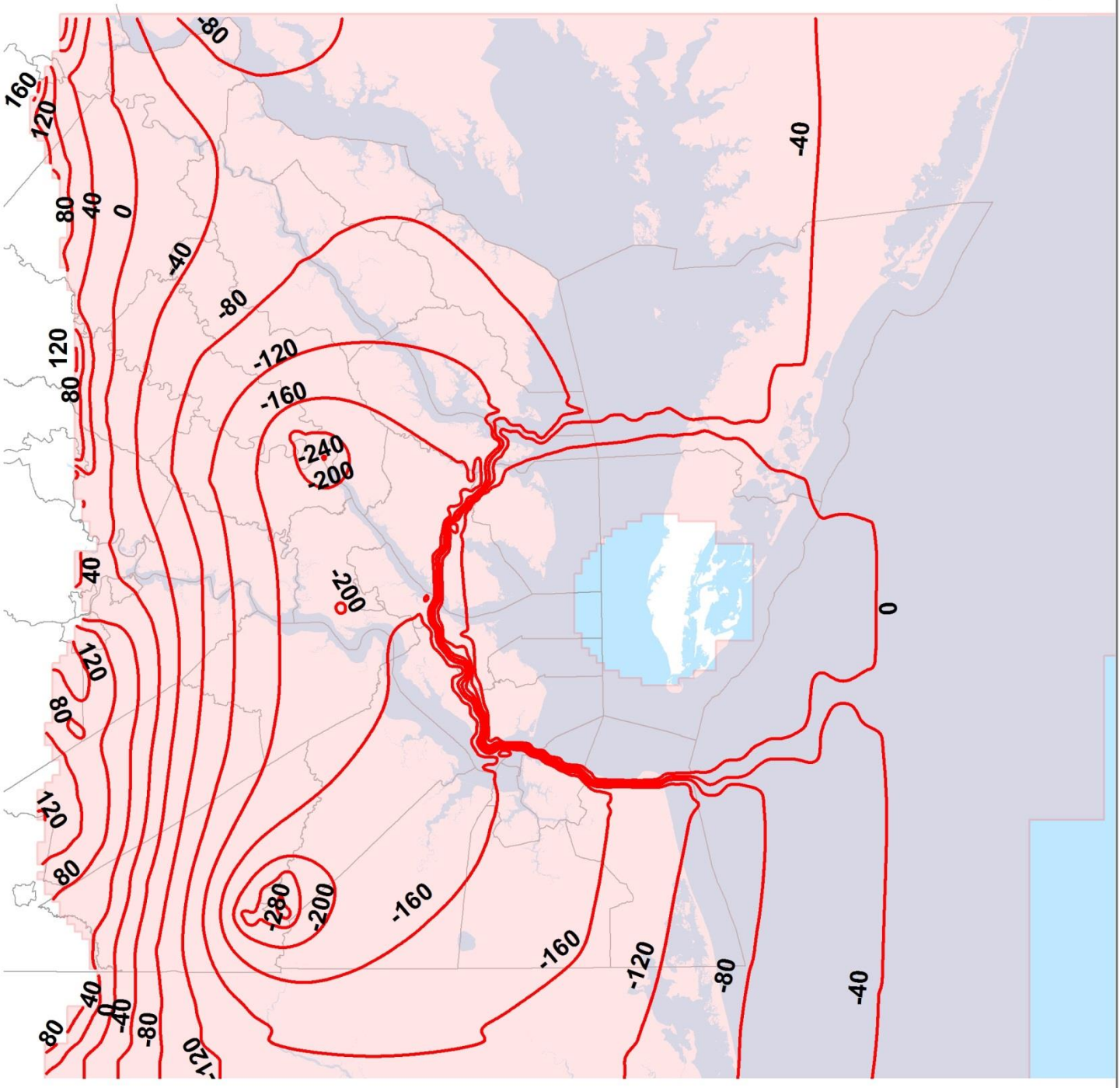
Attachment C

Simulated Potentiometric Contours
2015 Total Permitted Simulation

Simulated Potentiometric Contours
Potomac Aquifer
2015 Total Permitted Simulation



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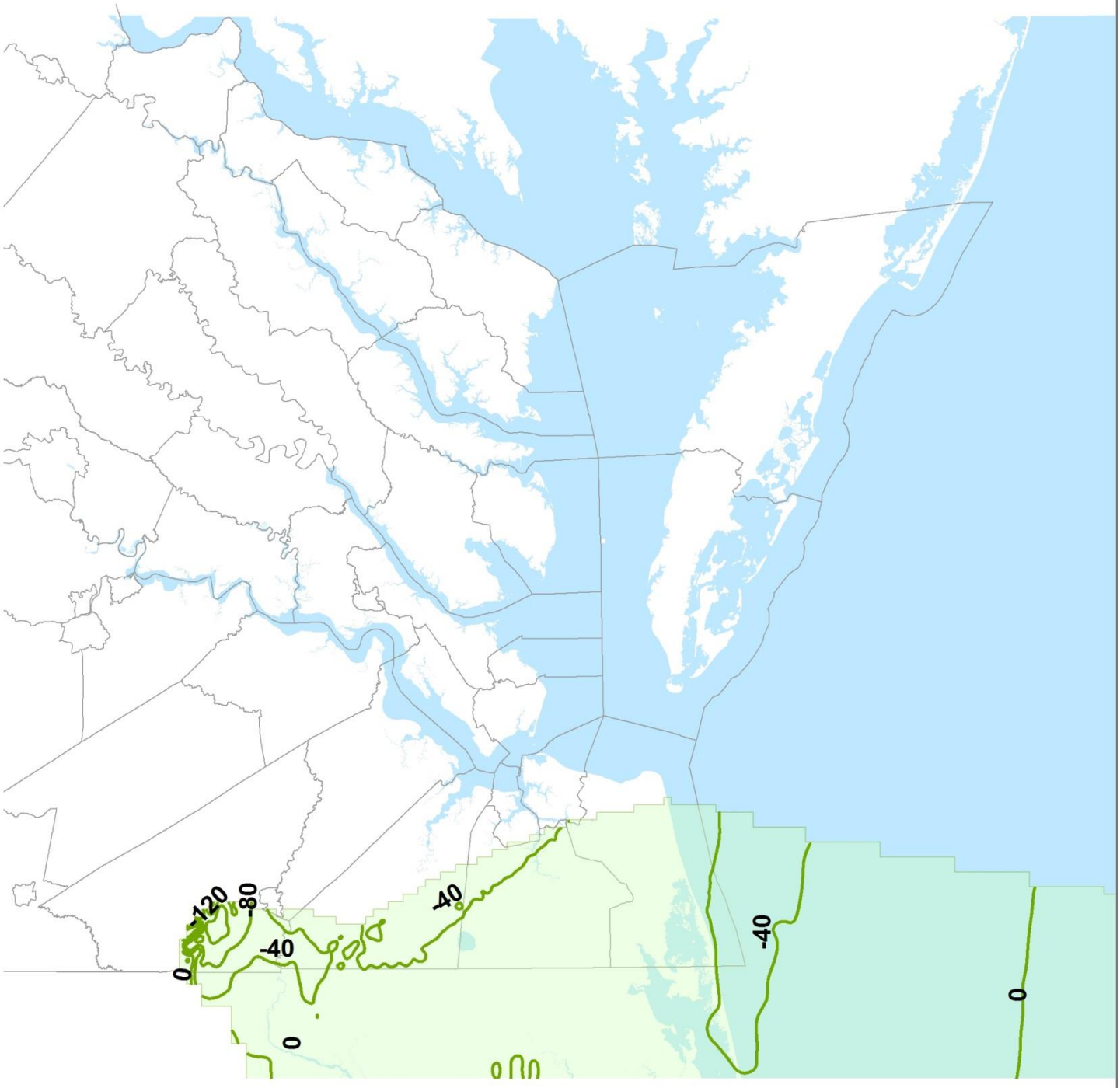
Simulated Potentiometric Contours
Virginia Beach Aquifer
2015 Total Permitted Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 40 ft intervals.

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September 1, 2015

Potentiometric Water Level Contours

Virginia Beach Model Boundary

0 15 30 60 Miles

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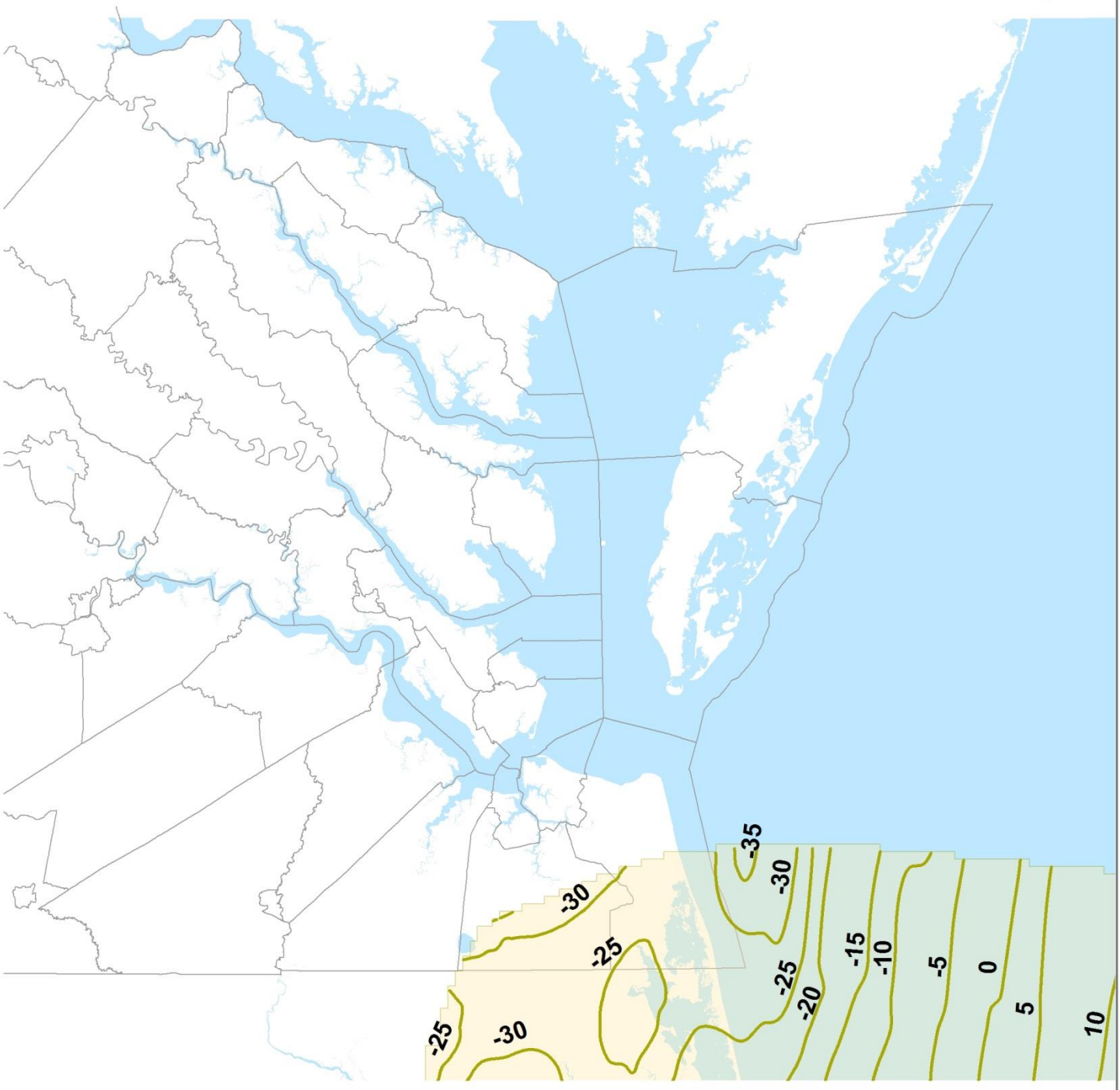
Simulated Potentiometric Contours
Pee Dee Aquifer
2015 Total Permitted Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 5 ft intervals.

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Potentiometric Water Level Contours

Pee Dee Model Boundary

0 15 30 60 Miles

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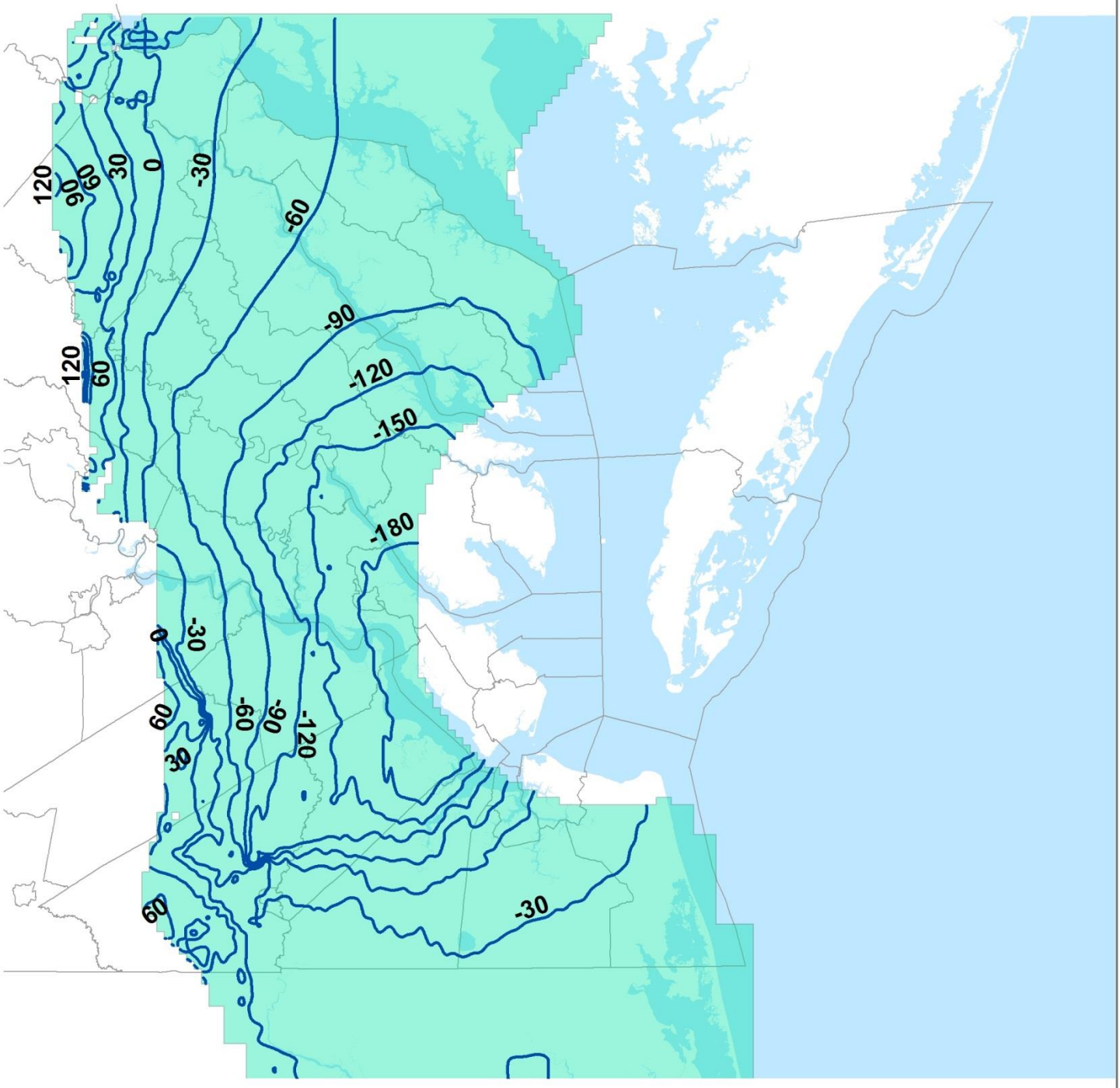
Simulated Potentiometric Contours
Aquia Aquifer
2015 Total Permitted Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

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Potentiometric Water Level Contours

Aquia Aquifer Model Boundary

0 15 30 60 Miles

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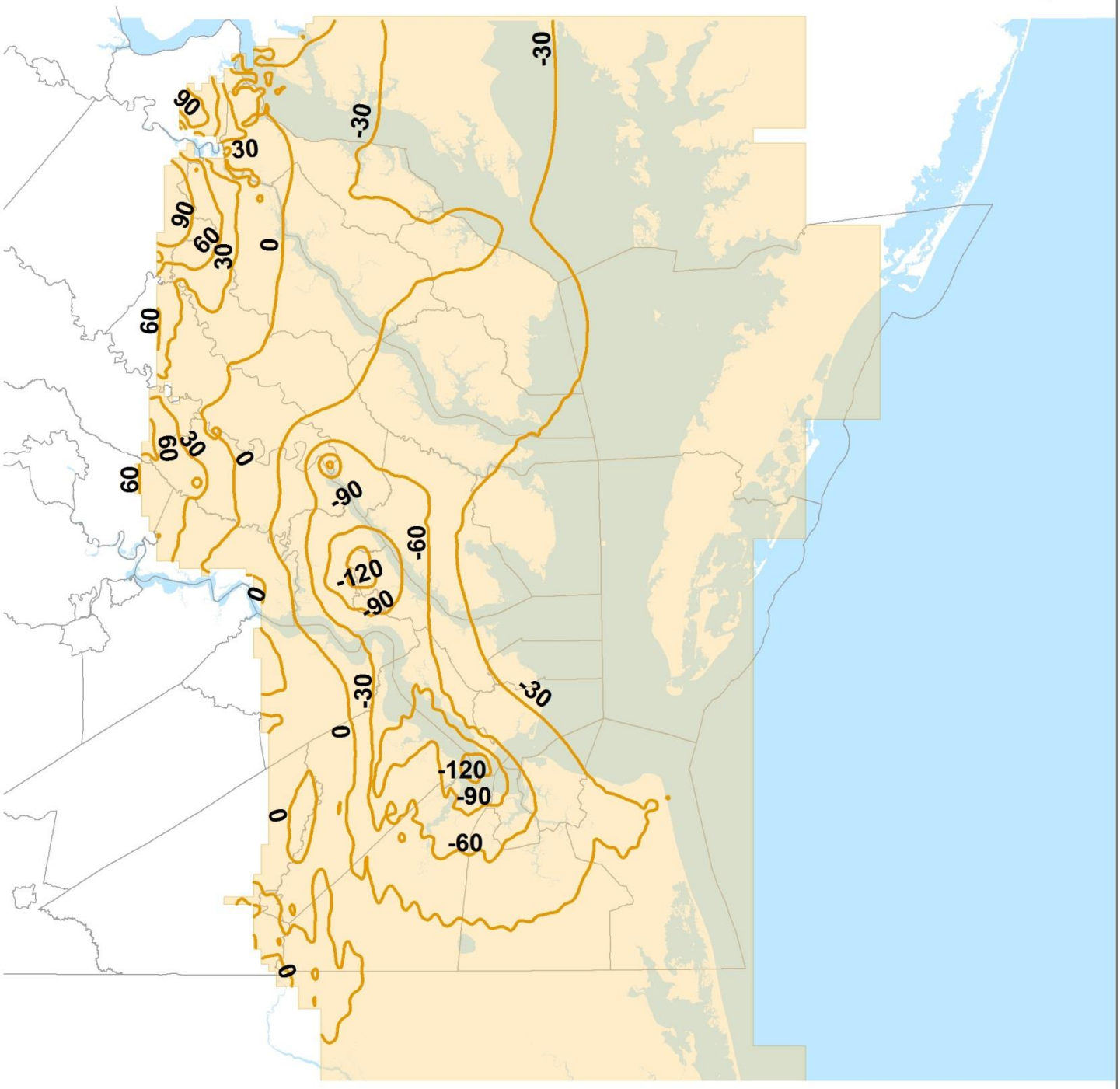
Simulated Potentiometric Contours
Piney Point Aquifer
2015 Total Permitted Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

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September 1, 2015

Potentiometric Water Level Contours

Piney Point Aquifer Model Boundary

0 15 30 60 Miles

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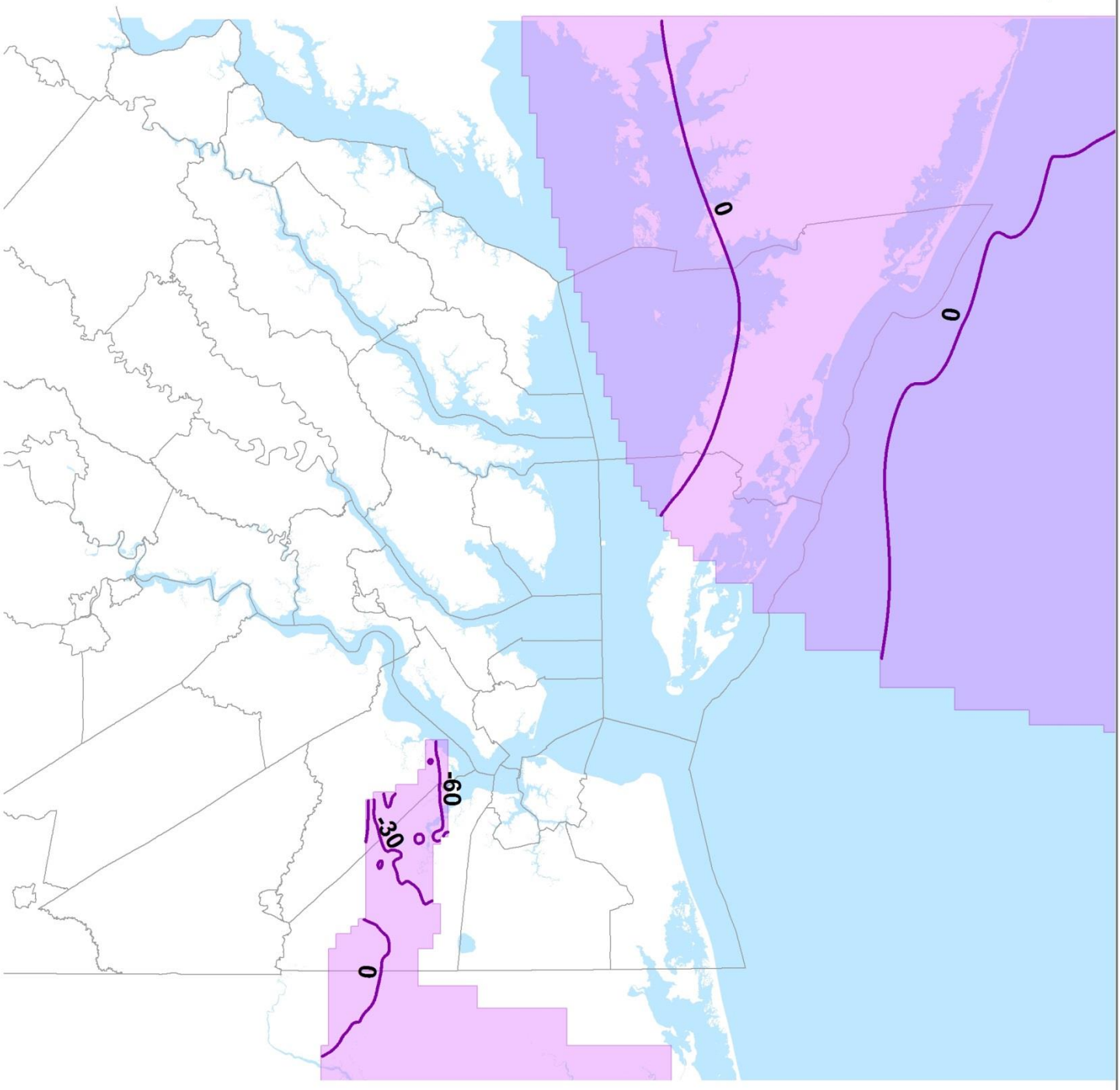
Simulated Potentiometric Contours
St. Mary's Aquifer
2015 Total Permitted Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

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September 1, 2015

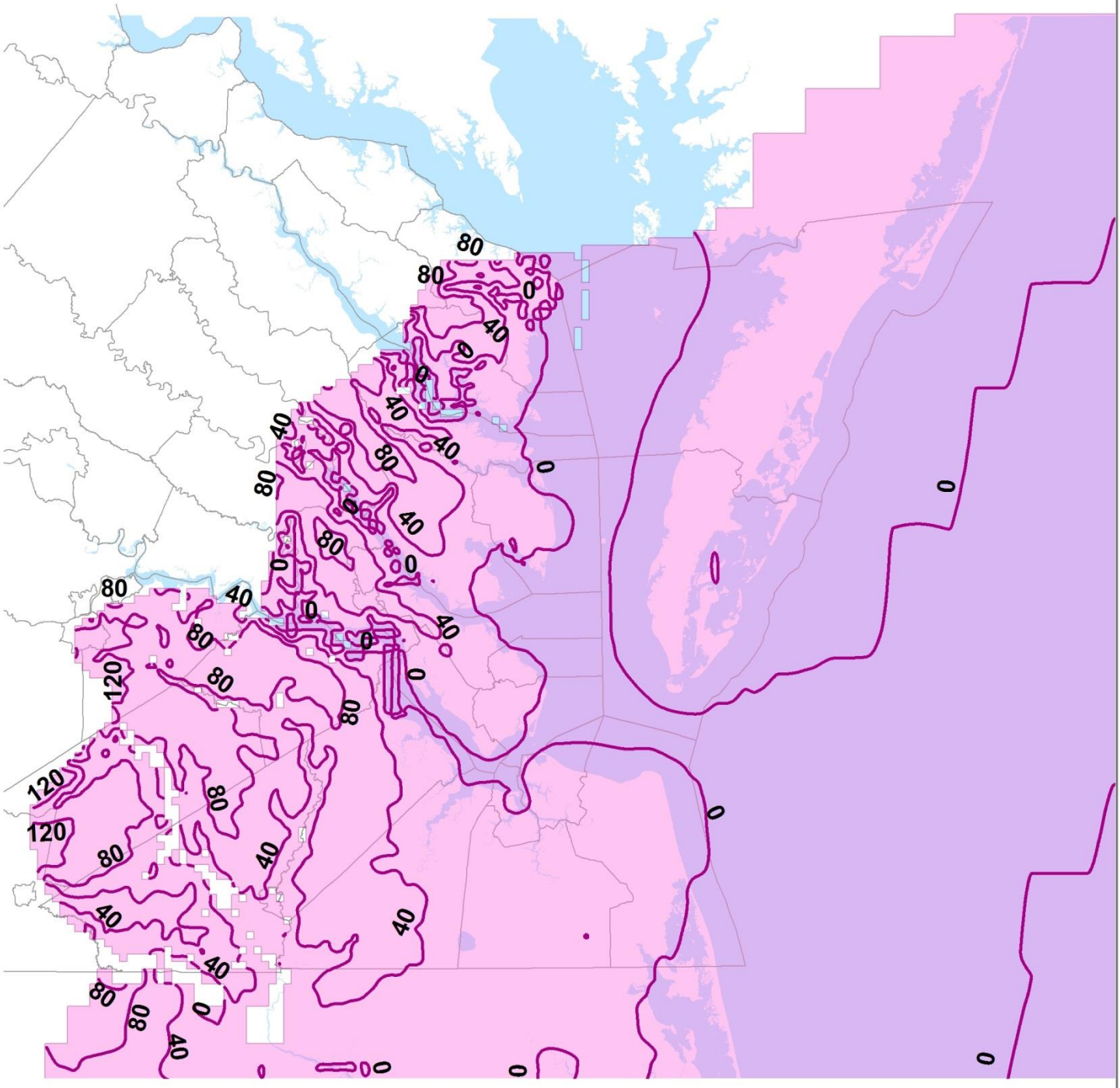
Potentiometric Water Level Contours

St. Mary's Aquifer Model Boundary

0 15 30 60 Miles

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
Yorktown-Eastover Aquifer
2015 Total Permitted Simulation



Contour elevations are in feet relative to mean sea level (msl) and at 40 ft intervals.

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September 1, 2015

Potentiometric Water Level Contours

Yorktown-Eastover Aquifer Model Boundary

0 15 30 60 Miles

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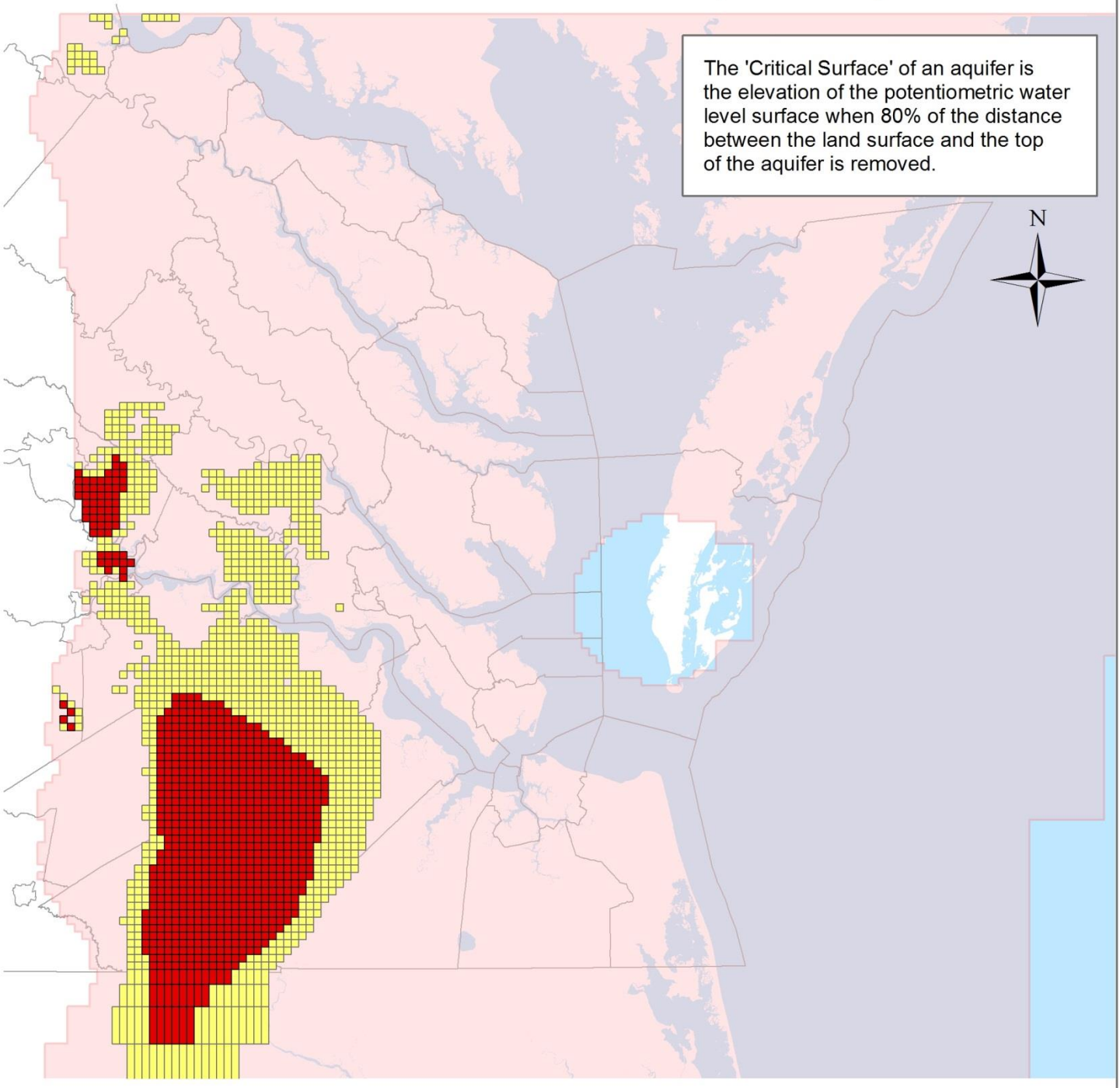
Attachment D

Simulated Water Levels
Below the Critical Surface and Below the Aquifer Top
2015 Total Permitted Simulation

2015 Total Permitted Simulation - Potomac Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



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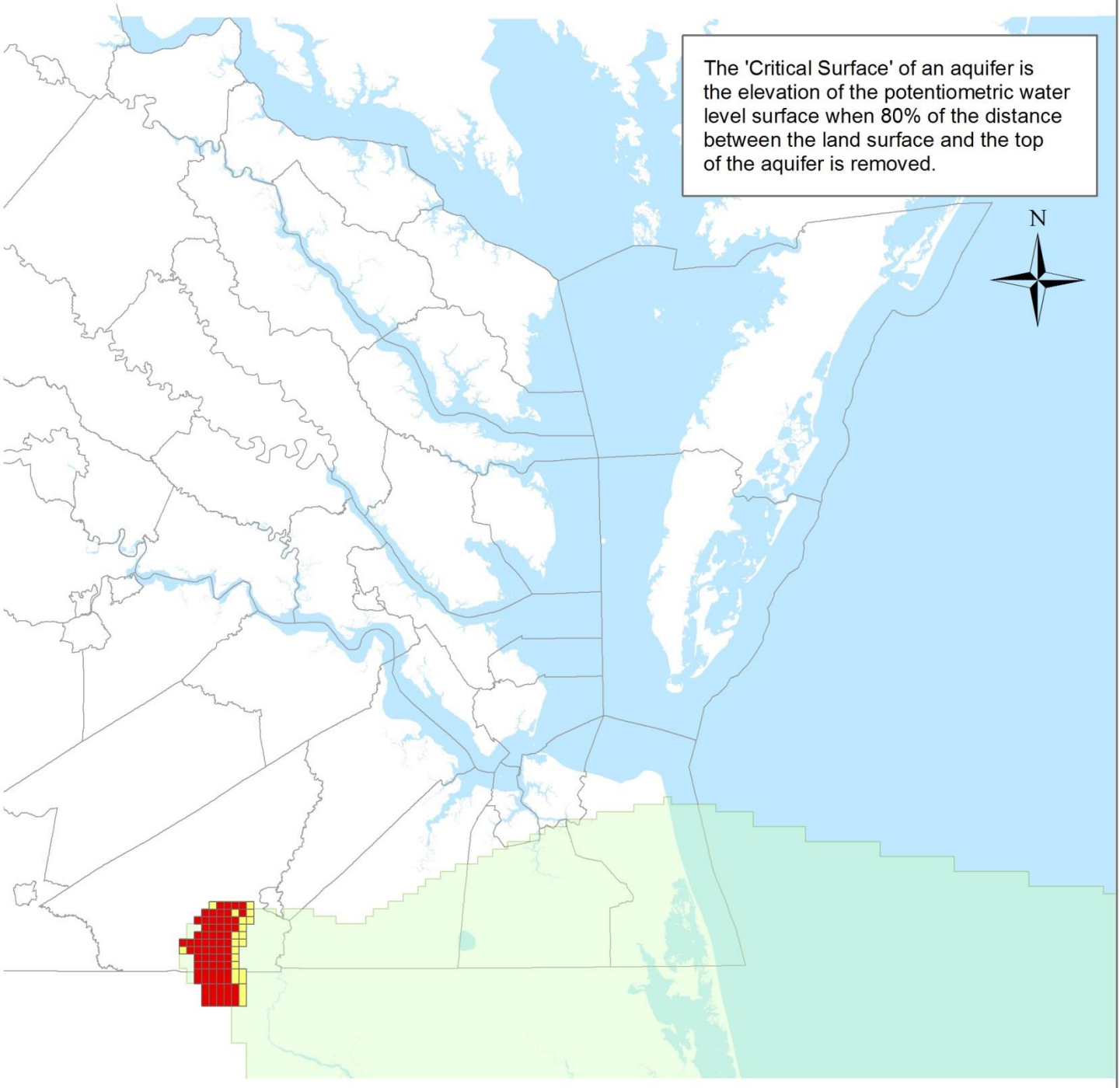
September 1, 2015

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

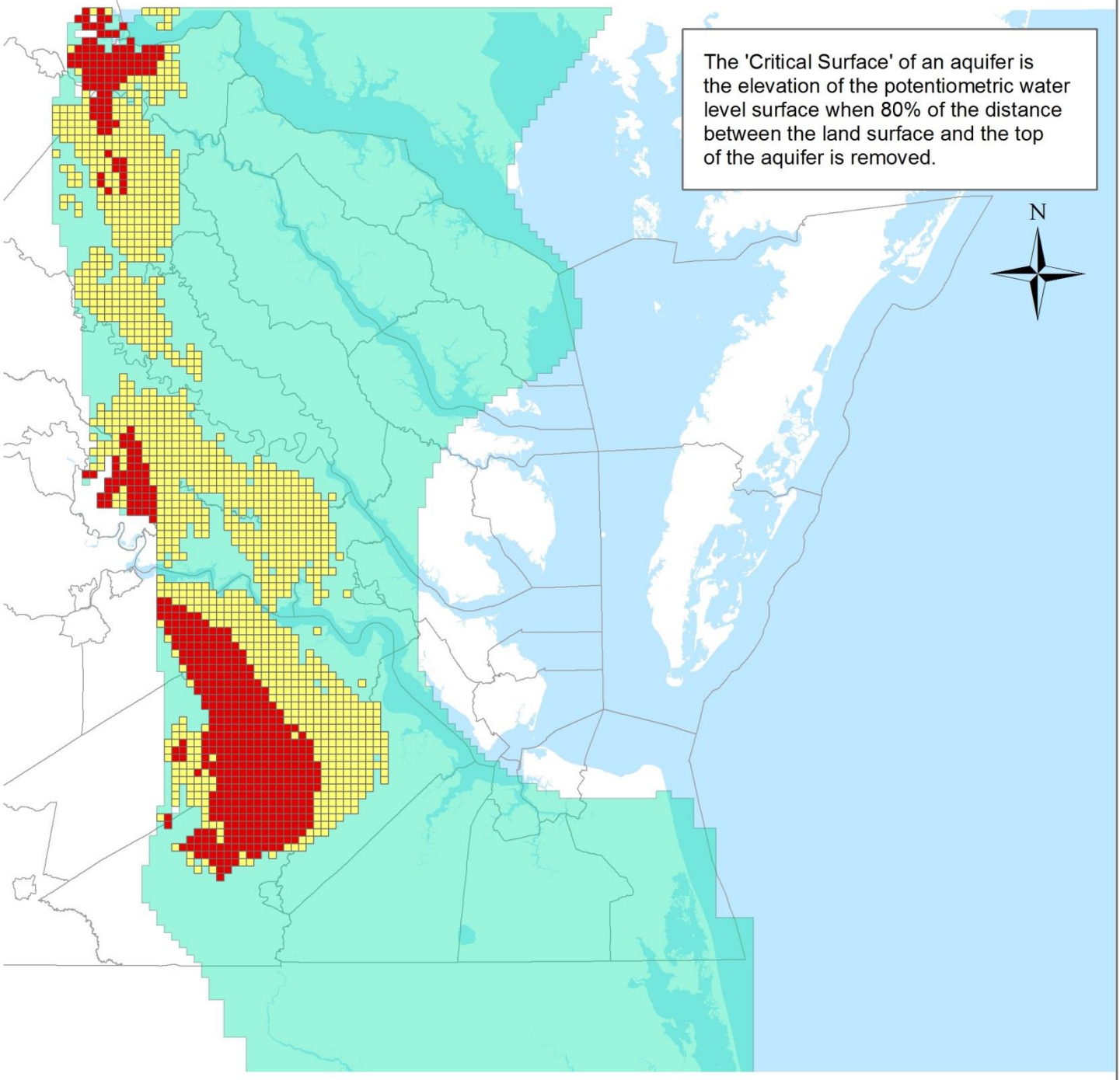
2015 Total Permitted Simulation - Virginia Beach Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



Prepared by Aquaveo, LLC for the Virginia DEQ, Office of Water Supply
September 1, 2015

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

2015 Total Permitted Simulation - Aquia Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



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September 1, 2015

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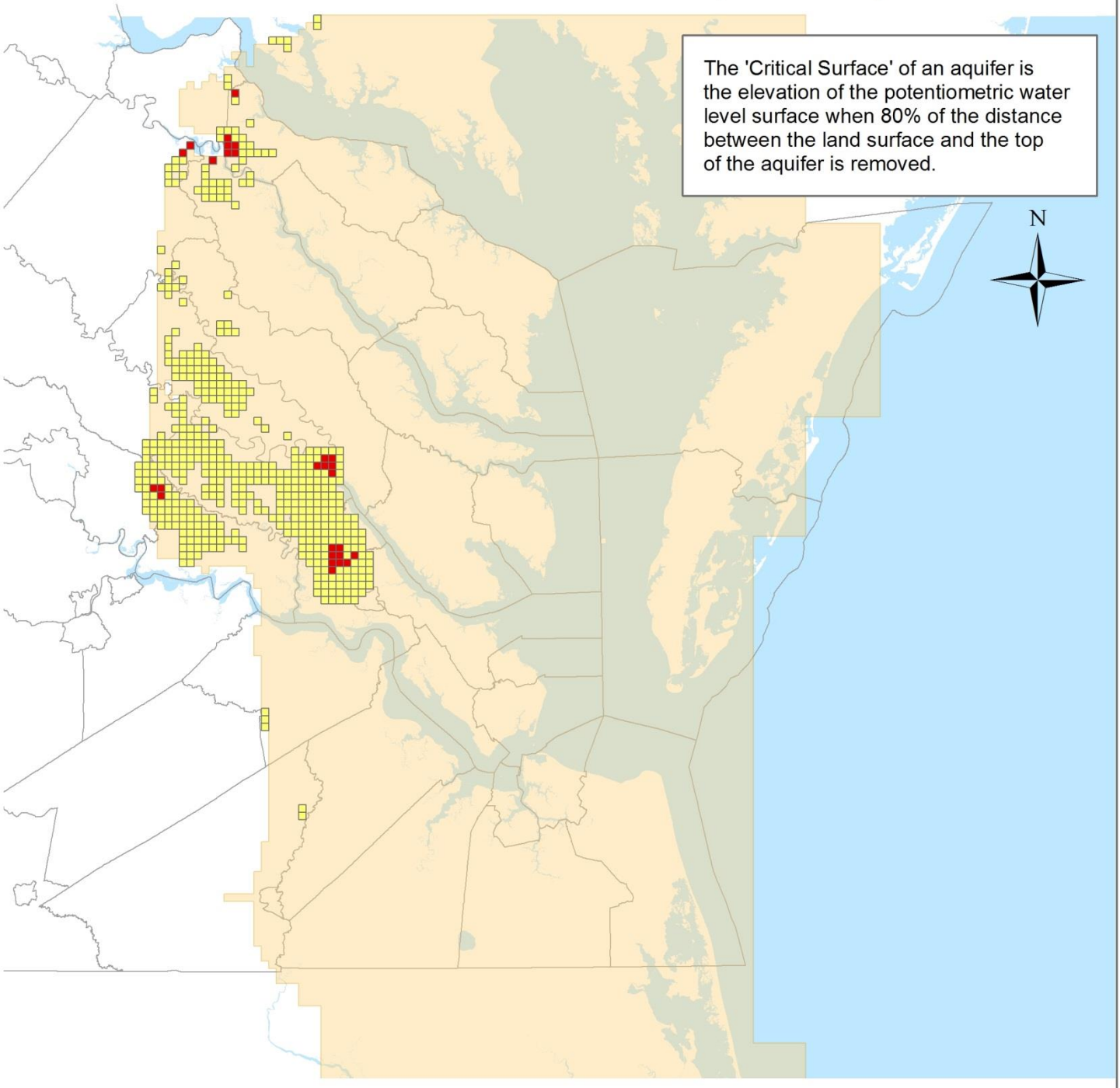
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

2015 Total Permitted Simulation - Piney Point Aquifer Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



Prepared by Aquaveo, LLC for the Virginia DEQ, Office of Water Supply
September 1, 2015

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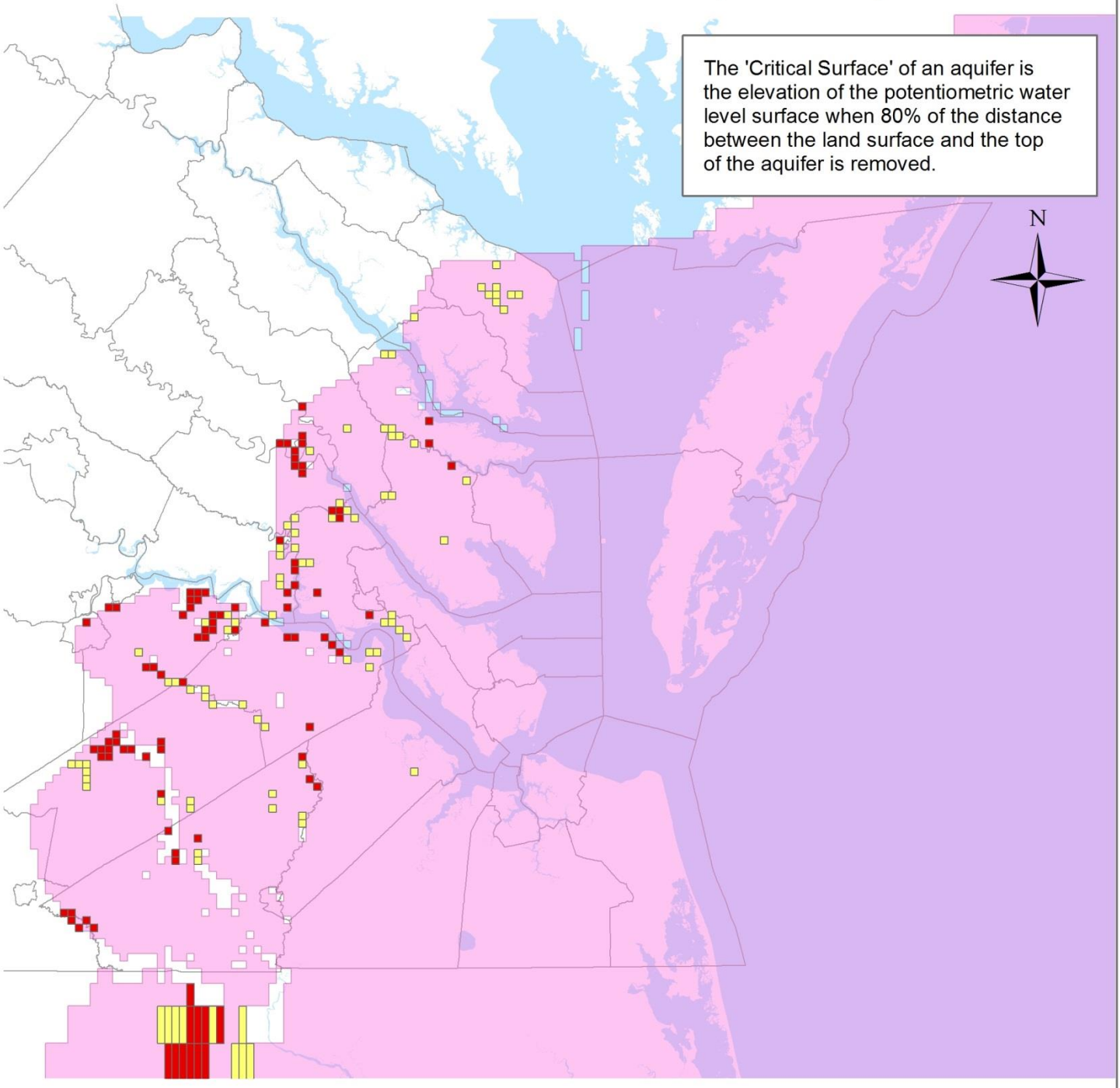
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

2015 Total Permitted Simulation - Yorktown-Eastover Aquifer
Simulated Water Levels Below the Critical Surface and Below the Aquifer Top



Prepared by Aquaveo, LLC for the Virginia DEQ, Office of Water Supply
September 1, 2015

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VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Attachment E

Permits Simulated
2015 Total Permitted Simulation

PERMIT	OWNER	FACILITY	PERMITTED Q (MGD)	PERMITTED Q (%)
GW0000401	DuPont Teijin Films	DuPont Teijin Films	0.25	0.22%
GW0000601	New Kent County of	Route 33 Corridor Water System	0.23	0.20%
GW0000801	Claremont Town of	Claremont Town of Water System	0.05	0.03%
GW0001001	Woodhaven Water Company Incorporated	Woodhaven Water Company Incorporated	0.09	0.06%
GW0001201	Cedarwood Properties (Prince George County)	Cedarwood Subdivision Water System	0.02	0.01%
GW0001301	New Kent County of	Colonial Downs Public Water System	0.62	0.43%
GW0001401	Hanover County of	Georgetown	0.02	0.01%
GW0001701	Hanover County of	Sinclair Manor	0.01	0.01%
GW0001901	Hanover County of	Strawhorne	0.02	0.01%
GW0002001	Sydnor Hydrodynamics Incorporated	Woodruff Public Water System	0.01	0.01%
GW0002200	New Kent County of	Woods Edge Dispatch Station Water System	0.03	0.02%
GW0002301	Hanover County of	Hanover Courthouse	0.07	0.05%
GW0002401	Aqua Virginia, Inc.	Avondale Robin Ridge	0.09	0.06%
GW0002601	Aqua Virginia, Inc.	Walnut Grove	0.02	0.02%
GW0002801	Aqua Virginia, Inc.	Cherrydale	0.06	0.04%
GW0002901	Aqua Virginia, Inc.	Hanover Farms	0.03	0.02%
GW0003001	Sydnor Hydrodynamics Incorporated	Rural Point	0.06	0.04%
GW0003101	Aqua Virginia, Inc.	Burnside Farms Mayfield Ellerson	0.06	0.04%
GW0003201	Aqua Virginia, Inc.	Colonial Forest	0.02	0.01%
GW0003301	Aqua Virginia, Inc.	High Point Farms	0.02	0.02%
GW0003401	Aqua Virginia, Inc.	Spring Meadows and Meadowgate Water System	0.13	0.09%
GW0003501	Golden Cat Division of Ralston Purina	Golden Cat Division of Ralston Purina	0.09	0.06%
GW0003601	Prince George County of	Rivers Edge	0.03	0.02%
GW0003901	Virginia Electric & Power Company	Surry Power Station	0.42	0.29%
GW0004301	Wakefield Town of	Wakefield Town of Municipal Water Supply Syste	0.12	0.08%
GW0004600	Charles City County of	Wayside Well System	0.02	0.01%
GW0004700	Prince George County of	Food Lion Industrial Water Supply	0.07	0.05%
GW0004800	Whispering Winds LLC	Whispering Winds Mobile Home Park	0.01	0.01%
GW0004900	Charles City County of	Mt Zion Rustic Public Water System	0.04	0.03%
GW0005001	West Point Town of	West Point Public Water System	0.51	0.35%
GW0005100	Smurfit-Stone Container Enterprises, Inc	West Point Mill Water System	23.03	15.83%
GW0005201	US Army CASCOM and Fort Lee	Cardinal Golf Course at Fort Lee	0.12	0.08%
GW0005600	West Point Veneer, LLC	West Point Veneer Mill Water Supply	0.06	0.04%
GW0005700	New Kent County of	Quinton Park Water System	0.01	0.01%
GW0005800	New Kent County of	Quinton Estates	0.02	0.01%
GW0006000	Surry County of Public Schools School Board	Surry County of Public Schools	0.01	0.01%
GW0006100	Sun Pool 1 LLC	Pine Ridge Community	0.05	0.04%
GW0006400	Southeast 4H Educational Center	Southeast 4 H Educational Center	0.01	0.01%
GW0006700	New Kent County of	Farms of New Kent Water System	0.66	0.45%
GW0007100	Sydnor Hydro, Inc.	Scot's Landing Subdivision	0.04	0.03%
GW0007300	New Kent County of	Bottoms Bridge	0.49	0.34%
GW0007400	King William County	King William County - Central Garage Water Sys	0.47	0.32%
GW0007500	Industrial Power Generating Company, LLC	INGENCO Charles City Peaking Facility	0.02	0.01%
GW0007600	New Kent County of	New Kent Courthouse	0.16	0.11%
GW0007800	Sydnor Hydrodynamics Incorporated	Oak Springs Subdivision	0.07	0.05%
GW0007900	Surry Town of	Surry Town of	0.06	0.04%
GW0008400	Virginia Commonwealth of DCR	Chippokes Plantation State Park	0.02	0.01%

GW0008500	Charles City County School Board	Charles City County School Complex	0.01	0.01%
GW0008600	Aqua Virginia, Inc.	Five Lakes #1 Water System	0.02	0.01%
GW0008700	Prince George County of	Route 301 Water System	0.12	0.09%
GW0008800	Sussex Service Authority	Stony Creek Town of Municipal Water Supply Sys	0.13	0.09%
GW0008900	New Kent County of	Whitehouse Farms	0.01	0.01%
GW0009000	Prince George County of	Beechwood Manor	0.14	0.09%
GW0009100	King William County of Public Schools	Acquinton Elementary School and Hmltn Holmes	0.01	0.01%
GW0009800	Brookwood Manor Water System	Brookwood Manor Subdivision	0.01	0.01%
GW0030200	Newport News City of Public Utilities	Newport News City of Waterworks Lee Hall	3.44	4.81%
GW0031001	James City Service Authority	JCSA -Racefield Subdivision W 29	0.01	0.01%
GW0031500	US Navy Commander Naval Base Norfolk	Naval Security Activity Northwest	0.03	0.02%
GW0031801	Smithfield Town of	Smithfield Town of	1.28	0.88%
GW0032501	Isle of Wight Department of Public Util	Rushmere	0.02	0.01%
GW0032900	Higgerson-Buchanan, Inc.	Higgerson-Buchanan	0.04	0.03%
GW0033801	Southampton County of	Agri-Business Industrial Park	0.08	0.05%
GW0034300	BASF Corporation	BASF - Portsmouth Plant	0.42	0.29%
GW0035101	BASF Corporation	BASF Corporation	0.03	0.02%
GW0036101	Colonial Williamsburg Foundation	Colonial Williamsburg -New Golf Course	0.09	0.06%
GW0036200	Courtland Town of	Courtland Town of	0.16	0.11%
GW0036300	Cogentrix Virginia Leasing Corporation	Cogentrix Virginia Wells A thru F	2.60	1.79%
GW0036501	Bayshore Concrete Products/Chesapeake, Inc.	Bayshore Concrete Products/Chesapeake, Inc.	0.02	0.01%
GW0037001	James River Country Club	James River Country Club	0.03	0.02%
GW0037401	Cintas Corporation No. 2	Cintas, Portsmouth #391	0.06	0.04%
GW0037600	Solenis, LLC	Solenis LLC	6.67	4.58%
GW0037700	Williamsburg City of	Williamsburg City of -number 1	0.71	0.49%
GW0038100	BASF Corporation	BASF Corporation	0.09	0.06%
GW0039001	Richmond Cold Storage Incorporated	Richmond Cold Storage - Smithfield Plant	0.01	0.01%
GW0039501	Southampton County of	Branchville Boykins	0.15	0.10%
GW0039601	Southampton County of	Drewryville	0.02	0.01%
GW0039701	Southampton County of	Edgehill	0.02	0.02%
GW0040101	Virginia Department of Corrections	VDOC -Saint Brides / Indian Creek Correctional	0.33	0.23%
GW0040401	US Navy Commander Naval Base Norfolk	Sewells Point Golf Course	0.01	0.00%
GW0040501	US Navy Commander Naval Base Norfolk	Oceana Golf Club	0.00	0.00%
GW0040801	Aqua Virginia, Inc.	Indian River Water Company	0.12	0.08%
GW0041300	Colonial Williamsburg Foundation	Colonial Williamsburg	1.84	1.27%
GW0041401	Virginia Beach Development Authority	Virginia Beach National Golf Course	0.13	0.09%
GW0042000	International Paper Company	Franklin Virginia Mill	20.61	25.21%
GW0042201	Smithfield Packing Company, Incorporated	Smithfield Farmland	2.60	1.79%
GW0042301	C & P Isle of Wight Water Company	Scottswood Subdivision Water System	0.04	0.03%
GW0042801	Continental Automotive Systems US, Inc.	Continental Automotive Systems US, Inc.	0.04	0.03%
GW0042900	Franklin City of	Franklin Water System	2.88	1.98%
GW0043201	Southampton County of	Newsoms Town of	0.06	0.04%
GW0043400	James City Service Authority	JCSA -Central System	8.83	6.07%
GW0043501	Narricot Industries, LLC	Narricot Industries, LLC	0.14	0.10%
GW0043900	Chesapeake City of Public Utilities Dept	Northwest River/Western Branch Systems	11.00	7.56%
GW0044001	Virginia Beach City of	Kempsville Greens Golf Course	0.03	0.02%
GW0044400	Southampton Group	Southampton Mobile Home Park	0.09	0.06%
GW0044700	Kinder Morgan Bulk Terminals	Pier IX/X Terminals	0.12	0.08%
GW0045001	James City Service Authority	JCSA -Kings Village Subdivision W 31	0.01	0.01%
GW0045200	Bracey Enterprises Clydes Dale Mobile Home	Clydes Dale Mobile Home Park	0.04	0.03%
GW0045500	Dominion Terminal Associates	Dominion Terminal Associates	0.15	0.10%

GW0045800	Western Tidewater Water Authority	Western Tidewater Water Authority	8.34	5.73%
GW0046400	Isle of Wight Department of PublicUtilities	Days Point	0.02	0.01%
GW0046600	Cavalier Golf and Yacht Club	Cavalier Golf and Yacht Club	0.06	0.04%
GW0046701	Princess Anne Country Club	Princess Anne Country Club	0.07	0.05%
GW0046800	Virginia Department of Veterans Services	Albert G. Horton, Jr. Memorial Veterans Cemetery	0.02	0.01%
GW0047000	Isle of Wight Department of Public Util	Lawnes Point	0.04	0.03%
GW0047100	Norfolk City of Department of Utilities	Norfolk City of Utilities Four Suffolk Wells	3.74	2.57%
GW0047500	Valley Proteins Incorporated	Valley Proteins Incorporated Emporia Plant	0.03	0.02%
GW0047700	Alsco Incorporated	Servitex Division of Alsco	0.05	0.04%
GW0047800	SeaWorld Parks & Entertainment, LLC	Busch Gardens Williamsburg Operations Dept	0.13	0.09%
GW0048100	Bayville Golf Club	Bayville Golf Club	0.04	0.03%
GW0048200	Suffolk City of Department of Public Util	Village of Whaleyville	0.10	0.07%
GW0048300	Capital Concrete Incorporated	Capital Concrete Inc Stapleton Street Plant	0.04	0.03%
GW0048400	Tidewater Area Central Hospital Laundry Inc	Shared Hospital Services	0.12	0.08%
GW0049000	CF Broad Bay Arcis LLC	The Tradition Golf Club at Broad Bay	0.07	0.05%
GW0049100	Virginia Department of Corrections	VDOC -Southampton Correctional Complex	0.33	0.23%
GW0049400	James City Service Authority	JCSA -Wexford Hills Subdivision	0.04	0.03%
GW0049800	Titan Virginia Ready-Mix LLC	Rip Rap Road Ready Mix Plant Well 1 2 and 3	0.03	0.02%
GW0050500	Titan Virginia Ready-Mix LLC	Campostella Ready Mix Plant	0.04	0.03%
GW0050700	SHODON	Mobile Estates	0.01	0.01%
GW0051300	Williamsburg Country Club	Williamsburg Country Club	0.02	0.01%
GW0051700	James City Service Authority	Liberty Ridge Subdivision	0.04	0.02%
GW0051800	Isle of Wight Department of Public Util	Carrsville Water System	0.02	0.01%
GW0051900	Isle of Wight Department of Public Util	Smithfield Heights Sandy Mount Manor	0.04	0.03%
GW0052100	Town of Ivor	Town of Ivor	0.05	0.04%
GW0052200	Newport News Waterworks	Combined Skimino Banbury and Lightfoot Systems	0.70	0.48%
GW0052300	Titan Virginia Ready-Mix LLC	Oceana Plant	0.02	0.01%
GW0053000	Robert Finch	Sedley Water Company	0.04	0.02%
GW0053100	Elizabeth Manor Golf and Country Club	Elizabeth Manor Golf and Country Club	0.06	0.04%
GW0053600	J H Miles and Company, Inc.	J H Miles and Company, Inc.	0.22	0.15%
GW0053700	Rescue Water Works	Rescue Water Works	0.01	0.01%
GW0054100	Governors Land Associates	Two Rivers Country Club	0.20	0.14%
GW0054600	Virginia Beach City of	Bow Creek Golf Course	0.01	0.01%
GW0054800	Capron Town of	Capron Town of	0.03	0.02%
GW0055000	James City Service Authority	JCSA -The Retreat	0.02	0.02%
GW0055100	US Army -Army Transport Center	Fort Eustis	0.12	0.08%
GW0055600	Virginia Beach City of	Princess Anne Athletic Complex	0.09	0.06%
GW0055900	James City Service Authority	Summerplace Subdivision	0.04	0.03%
GW0056300	Southampton County of	Turner Tract	0.08	0.05%
GW0057000	White Tail Park	White Tail Park	0.02	0.01%
GW0060001	Norfolk City of Nursery	Norfolk City of Nursery	0.01	0.00%
GW0066100	Murphy Brown LLC	Smithfield Carroll's Farms 1 thru 5	0.15	0.10%
GW0066200	Murphy Brown LLC	Smithfield Carroll's Farm 6-8	0.08	0.06%
GW0066300	Murphy Brown LLC	Smithfield Carroll's Farms - 9,10 & 21	0.10	0.07%
GW0066400	Murphy Brown LLC	Smithfield Carroll's Farm 12	0.03	0.02%
GW0066500	Murphy Brown LLC	Smithfield Carroll's Farms - 13 & 14	0.05	0.04%
GW0066600	Murphy Brown LLC	Smithfield Carroll's Farm - 15	0.03	0.02%
GW0066700	Murphy Brown LLC	Smithfield Carroll's Farms - 16 & 17	0.06	0.04%
GW0066800	Murphy Brown LLC	Smithfield Carroll's Farm 18	0.03	0.02%
GW0066900	Murphy Brown LLC	Smithfield Carroll's Farms -19 & 20	0.06	0.04%
GW0067000	Murphy Brown LLC	Smithfield Carroll's Farms - Feedmill	0.02	0.01%

GW0068200	Garth H Wiemer	Pampatike Hill	0.02	0.02%
GW0068500	Claude W Reeson	CW Reeson Boxwood Nursery	0.01	0.01%
GW1005900	New Kent County of	Kenwood Farms	0.07	0.05%
GW1042700	Windsor Town of	Windsor Public Water System	0.54	0.37%
PA020	Portsmouth City of	Portsmouth City of Department of Public Utility	3.17	10.58%