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Water Quality in Southern Accomack County Watersheds

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The Issue. Expansion of poultry grow out houses in Accomack County VA has raised concerns for water quality impacts both seaside and bayside where harvesting marine resources and aquaculture operations may be affected. The dust and litter from the poultry houses are potential sources of nitrogen, phosphorous, and fecal contamination to watersheds and receiving waters. Siting regulations, storm water controls, and management of litter storage and handling are designed to limit these impacts, yet no analysis has been implemented to verify the efficacy of these protective measures. This investigation sampled watersheds after a 2 week dry period prior to a storm event and immediately after the rain event in July 2018, and later in November 2018 after a month of continuous light rainy wet weather resulting in water saturated soils but no major rainfall. Samples were processed for Total *Enterococcus* fecal indicators, dissolved ammonia, total nitrogen and total phosphorous.

Methodology. Watersheds segments in southern Accomack County were chosen on bayside and seaside where poultry operations have recently been built (Figures 1 and 2), and adjacent watershed segments where no poultry operations currently exist. Stream and ditch crossings at roadside right of ways were targeted. For the 20 July 2018 dry sampling event, some of the streams were not flowing and the samples consisted of stagnant pools of water at the culverts. For the rain and wet period sampling on 25 July and 9 November 2018, all samples were taken from flowing water.

Standard water quality sampling procedures were followed. Field technicians used latex gloves to prevent contamination of samples. For each sampling event, an acid rinsed and sterilized 500 ml Nalgene polypropylene bottle was filled and rinsed three times with site water before final filling, capping, and placing on ice for transport to the laboratory. Field blanks consisted of newly opened commercial spring water. Field data sheets recorded the number of the sample, date and time of collection, coordinates for each sample location recorded from GPS. Temperature and salinity (where appropriate) of the water was recorded from a handheld YSI meter. Samples were processed in a VIMS ESL laboratory within 6 hours of collection.

EPA Method 1600 was followed for determining total *Enterococcus* counts. Water samples were filtered onto Micron Separations Inc. (MSI) 0.45 µm 47mm cellulose filters as a 10 ml aliquot and a 1 ml aliquot diluted with 9 ml autoclaved spring water. Filter apparati were rinsed with ethanol and sterile spring water between samples. Filters were placed onto commercially prepared *Entercoccus* growth media with blue indicator dye in 50 mm plates (Aquaplates Inc. mEI plates). Samples were incubated at 41 degrees C and all colonies colored blue from the indicator dye counted after 24 hours.

Additional sample water was passed through 13 mm Whatman GF/F filters and collected in acid washed 60 ml polypropylene bottles for dissolved ammonia determination and frozen at -20 degrees C until analysis. The filters were frozen at -20 degrees C, dried at 50 degrees C, and held under vacuum for later stable isotope analysis. Additional sample water was placed into acid washed 125 ml polypropylene bottles without filtration and frozen -20 degrees C until analysis for total nitrogen and total phosphorous determination. Details of the nutrient analyses are presented in Appendix I. The raw data are presented in Appendix II. Data were plotted using ESRI ArcView GIS mapping software.

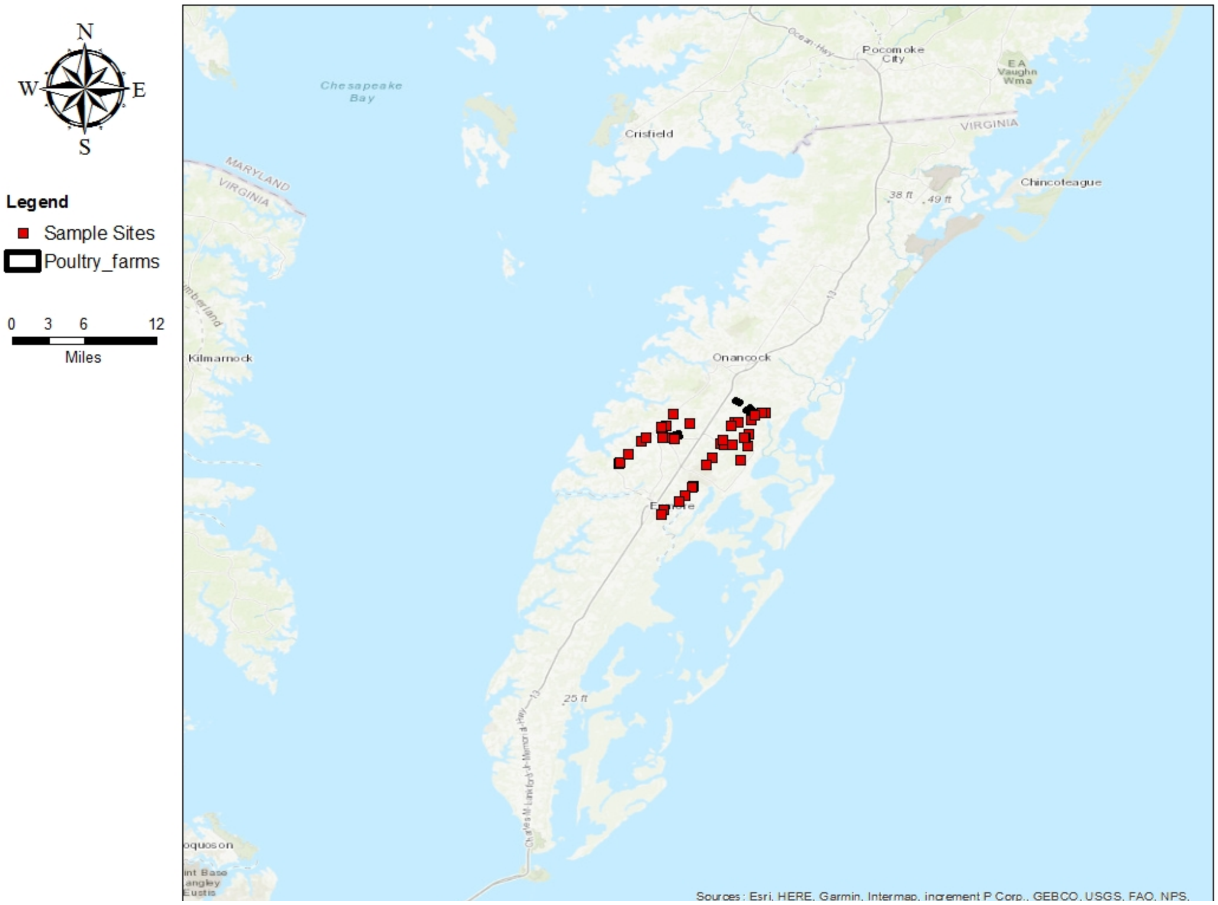

Figure 1. Sample locations on the Eastern Shore of Virginia.

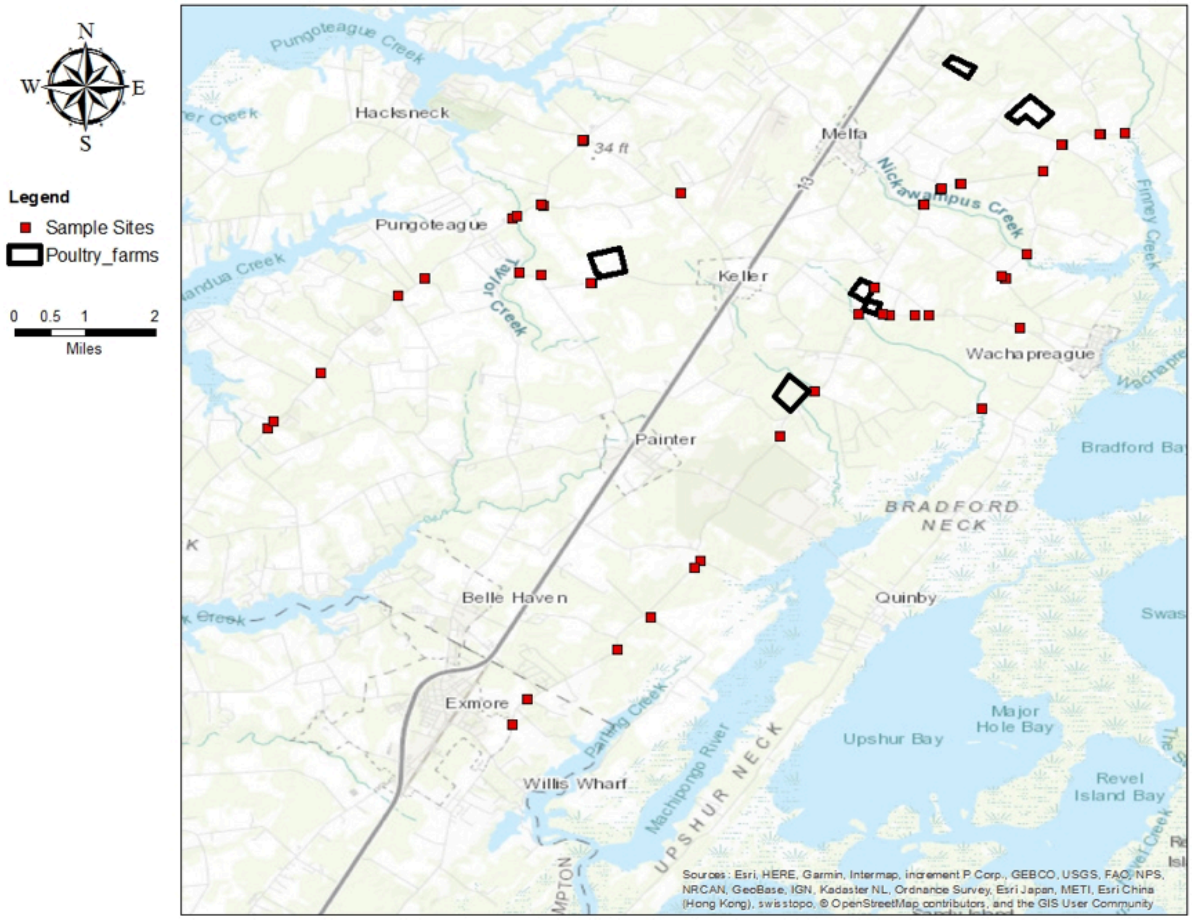

Figure 2. Sample locations for drainages at road crossings (red squares) and the locations of poultry operations (black polygons).

Results and Discussion

Rainfall records were obtained from the National Weather Service archived records for Melfa Airport: https://weatherspark.com/h/m/147126/2018/7/Historical-Weather-in-July-2018-at-Melfa-Accomack-Airport-Virginia-United-States#Figures-Rainfall. Prior to the dry sampling conducted 20 July 2018, no rainfall was recorded for 14 days. Between 21 July and 25 July, 3.22 inches of rain were recorded with 1.45 inches recorded for the 24 hours prior to sampling on the 25th of July, and 0.15 inches recorded for the 24 hours encompassing the sampling event. For the 9 November sampling, rainfall was recorded every day Nov 3-9 for the week prior with the exception of 7 Nov, ranging from .01 to .48 inches, with 0.04 inches falling in the 24hours prior to sampling, and 0.77 inches recorded for the 24 hours post sampling. Drizzling rain was occurring at the time of sampling. Soil conditions across the peninsula were wet at the time.

High nitrogen values were recovered during all three sampling events at the stream crossing Bobtown Road near the intersection of Hollies Church Road. No poultry operations are in this watershed, and these data were removed from any comparisons to samples taken in watershed segments where poultry operations existed, as listed in Table 1.

Enterococcus data was not available for the 20 July dry sampling period. *Enterococcus* counts for the 25 July 2019 sample date (Table 1) were overall higher (geomean 1027 vs 411) but also more variable than the data from the 9 November sampling date. The minimum counts were 45 vs 110 per 100 ml and maximum counts were 2850 vs 1190 per 100 ml respectively. All samples taken except for 1 (45 per 100 ml), exceed the VA DEQ one sample threshold for *Enterococcus* counts (9VAC25-260-170). For all samples taken in watershed segments containing poultry operations with any chance of receiving runoff or groundwater, no differences were found when compared to watershed segments with no poultry operations (Table 1), although the data are highly variable. Visual presentation of the data by GIS is shown in Figures 3 and 4.

The Enterococcus counts, indicative of warm blooded animal or human fecal contamination were generally elevated in all samples, with the highest concentrations occurring in areas not containing poultry operations or litter applications. (Figures 3 and 4). High Fecal indicator counts are common on the ESVA, and the wooded stream basins and wooded swamps characteristic of ESVA watersheds provide habitat for wildlife that contribute to these data. Scattered small scale livestock operations are known for the area, but not identified per watershed segment. In addition, many of the homes located within the watersheds and close to the waterways are on septic systems with drain fields that have the potential to add to fecal loadings in the stream flow. Open pit disposal (outhouses, cesspools) are known to exist but were not located or surveyed in this investigation.

Ammonia concentrations are indicative of recent heterotrophic metabolic activity, largely the deamination of proteins and amino acids in organic matter by microbes and animals. This compound is bioreactive, picked up by plants, microbes, and algae to build proteins, or oxidized to nitrate by microbes. The seaside bays and marshes of the ESVA tend to be nitrogen limited (Giordano et al., 2011), so excess ammonia and other nitrogen sources are of concern. VA DEQ Acute Criteria thresholds for ammonia are pH dependent (9VAC25-260-155), but only two stations had values that exceed this threshold for any pH. The flowing stream at the corner of Bobtown Road and Hollies Church Road exceed the threshold values in all samples taken. One other sample exceeded the threshold for a sample taken under dry conditions in a stagnant pool from a drainage ditch receiving water from an agricultural field with no poultry associated. Generally, the ammonia levels obtained for the samples reported here were well below established thresholds for ecological effects, and no association with poultry operations was evident (Table 1; Figures 5-7).

An Observed Effects Concentration (OEC) for Total Nitrogen (TN) in Virginia streams was proposed for between 2.60 and 3.66 mg/L and for a Total Phosphorous (TP), an OEC threshold was proposed at 0.25-0.284 mg/L (Zipper et al., 2012). The lower end of these proposed limits was used for this evaluation.

TN values found in the ESVA stream samples presented in this report exceeded the threshold for several locations. Overall, 16 of the 58 samples taken were higher than 2.60 mg/L. For the separate sampling events, this represented 46% of the dry period samples (20 July), 20% of the rain event samples (25 July), and 26% of the extended wet period samples (9 November). No association of TN values and poultry operations was observed (Table 1; Figures 8-10).

Only two TP samples exceeded the lower limit of the proposed OEC threshold and at different locations. The first was a sample taken from a stagnant pool in a ditch draining an agricultural field with no associated poultry during the dry period samples of 20 July. One other sample from this period was close to the OEC threshold, also from a stagnant pool in a drainage immediately downstream from a poultry operation. The second sample over the OEC was from a stream associated with a flooded woodland swamp during the rain event sampling on 25 July. This site was downstream of a poultry operation that was not yet raising birds. None of the samples from the extended wet period sampling on 9 November came close to the limit, with a maximum recorded value of 0.156 mg/L (Table 1). No association of phosphorous concentrations with poultry operations was apparent from these data (Table 1; Figures 11-13).

In general, the spatial variability in the data for all parameters and the lack of correlation of any high values to poultry sites does not suggest storm water runoff impacts from poultry operations. Further sampling at these locations will monitor any changes in these water quality parameters as the poultry operations mature, and will help to assess the adequacy of siting regulations to ensure they are protective of the marine resources downstream of these operations.

References

Giordano, JCP, MJ Brush, and IC Anderson. 2011. Quantifying annual nitrogen loads to Virginia's coastal lagoons: sources and water quality response. *Estuaries and Coasts* 34:297-309.

Zipper, CE, K Stephenson, L Shabman, G Yagow, and J Walker. 2012. *Technical and policy considerations and options in assessing nutrient stresses on freshwater streams in Virginia. Report of the Academic Advisory Committee for the Virginia Department of Environmental Quality*. Virginia Water Resources Research Center, Virginia Tech, Blacksburg, VA.

Table 1. Summary data for the three sampling dates.

		Entercoccus 100 ml-1	NH3 Units: mg/L MDL: 0.0062	TDN Units: mg/L MDL: 0.0285	TDP Units: mg/L MDL: 0.0095
20-Jul-18	geomean		0.149	2.765	0.064
	max		16.45	21.932	0.283
	min		0.006	0.825	0.019
25-Jul-18	geomean	1027	0.069	1.184	0.049
	max	2850	8.68	9.56	0.382
	min	45	0.013	0.179	0.014
9-Nov-18	geomean	411	0.044	1.354	0.031
	max	1190	17.5	18.26	0.156
	min	110	0.01	0.173	0.01
overall	geomean	623	0.064	1.473	0.042
	max	2850	17.5	21.932	0.382
	min	45	0.006	0.173	0.01
poultry	geomean	685	0.030	1.437	0.035
	max	2800	0.0947	6.8799	0.3822
	min	210	0.0064	0.1725	0.01
non-poultry	geomean	580	0.058	1.220	0.043
	max	2850	4.765	6.1372	0.2833
	min	45	0.0125	0.204	0.01

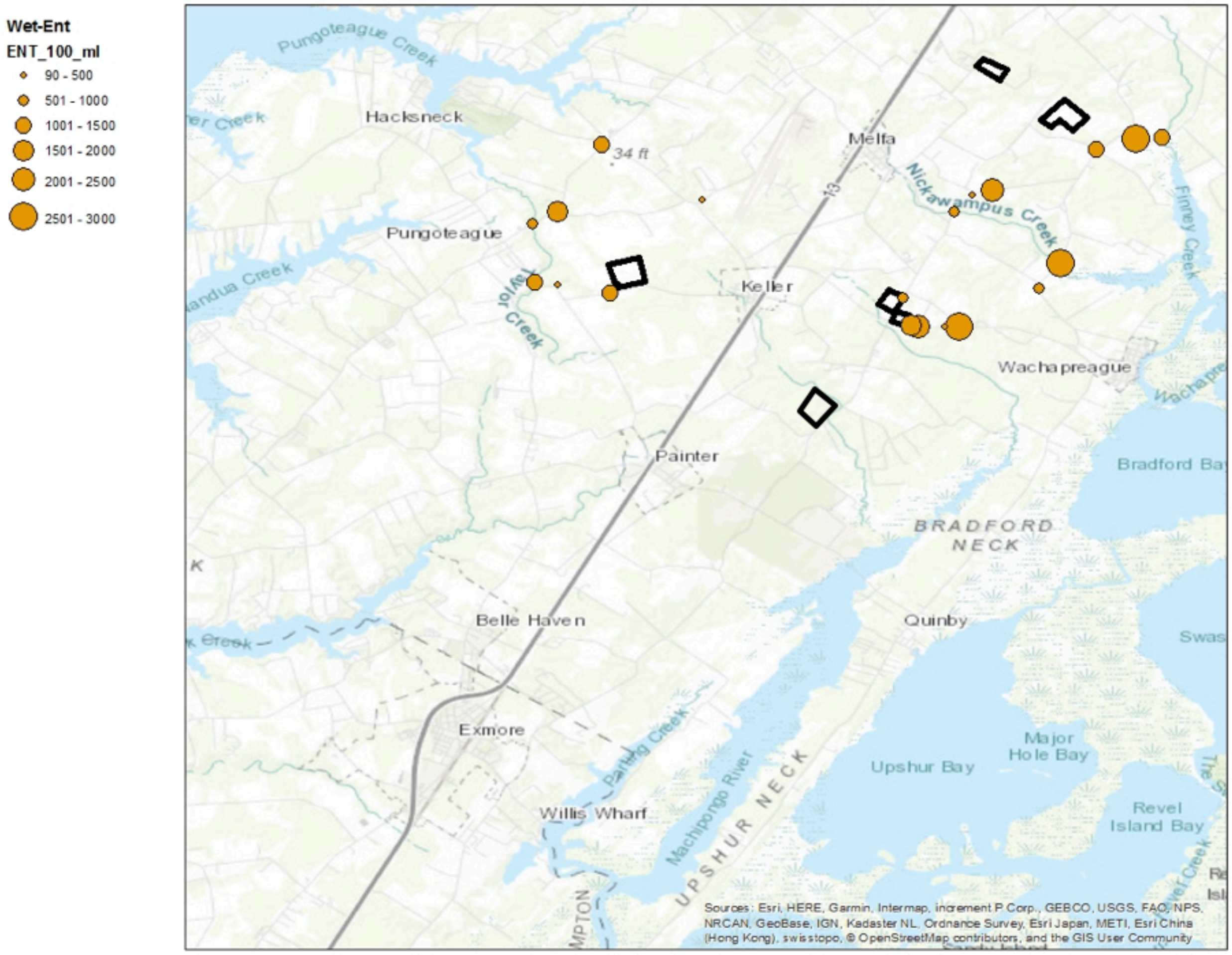

Figure 3. *Enterococcus* counts per 100 ml, during the end of a rain event. Sampling date was 25 July 2018.

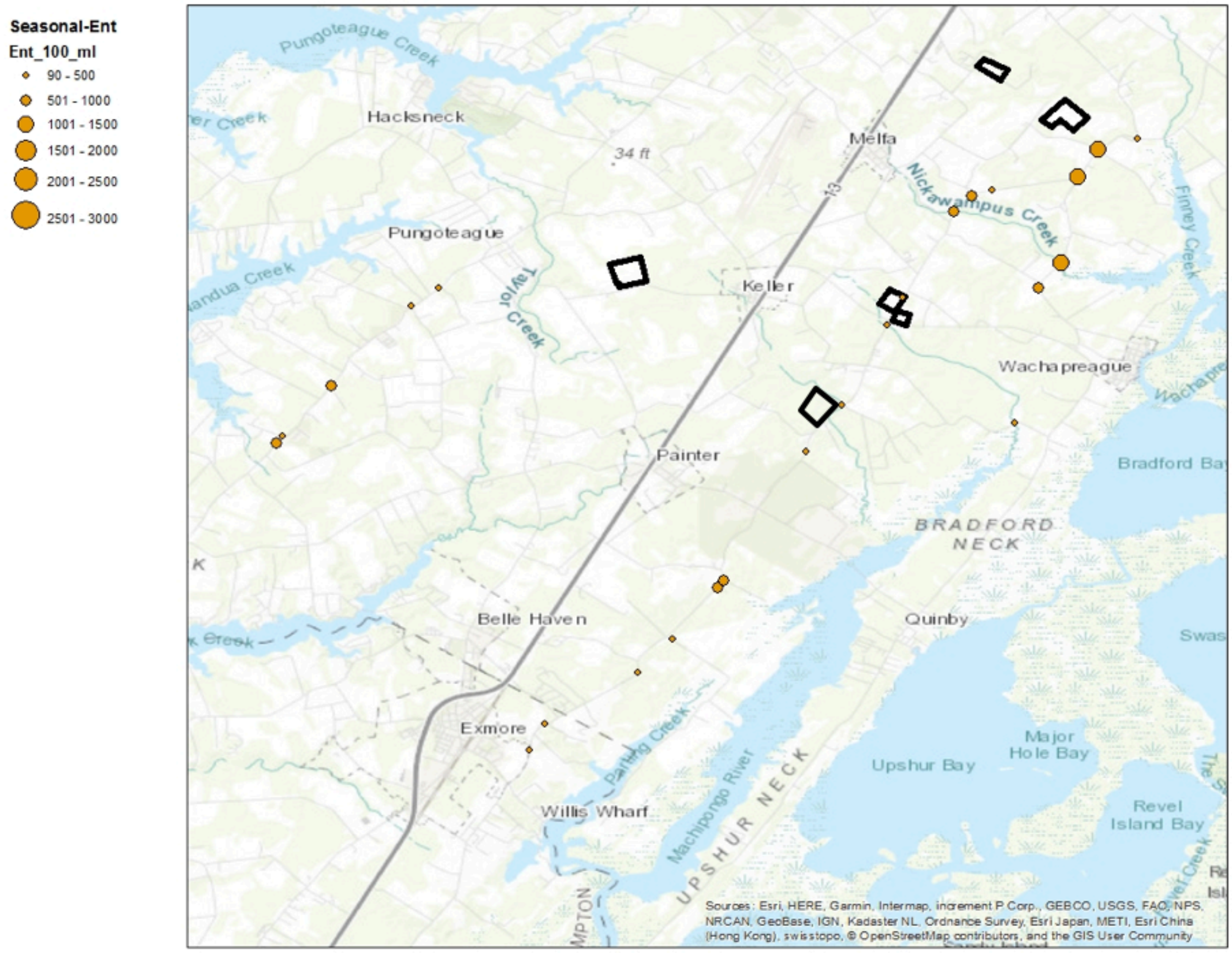

Figure 4. *Enterococcus* counts per 100 ml, not associated with rainfall but extended wet weather resulting in saturated soil conditions. Sampling date was 9 November 2018.

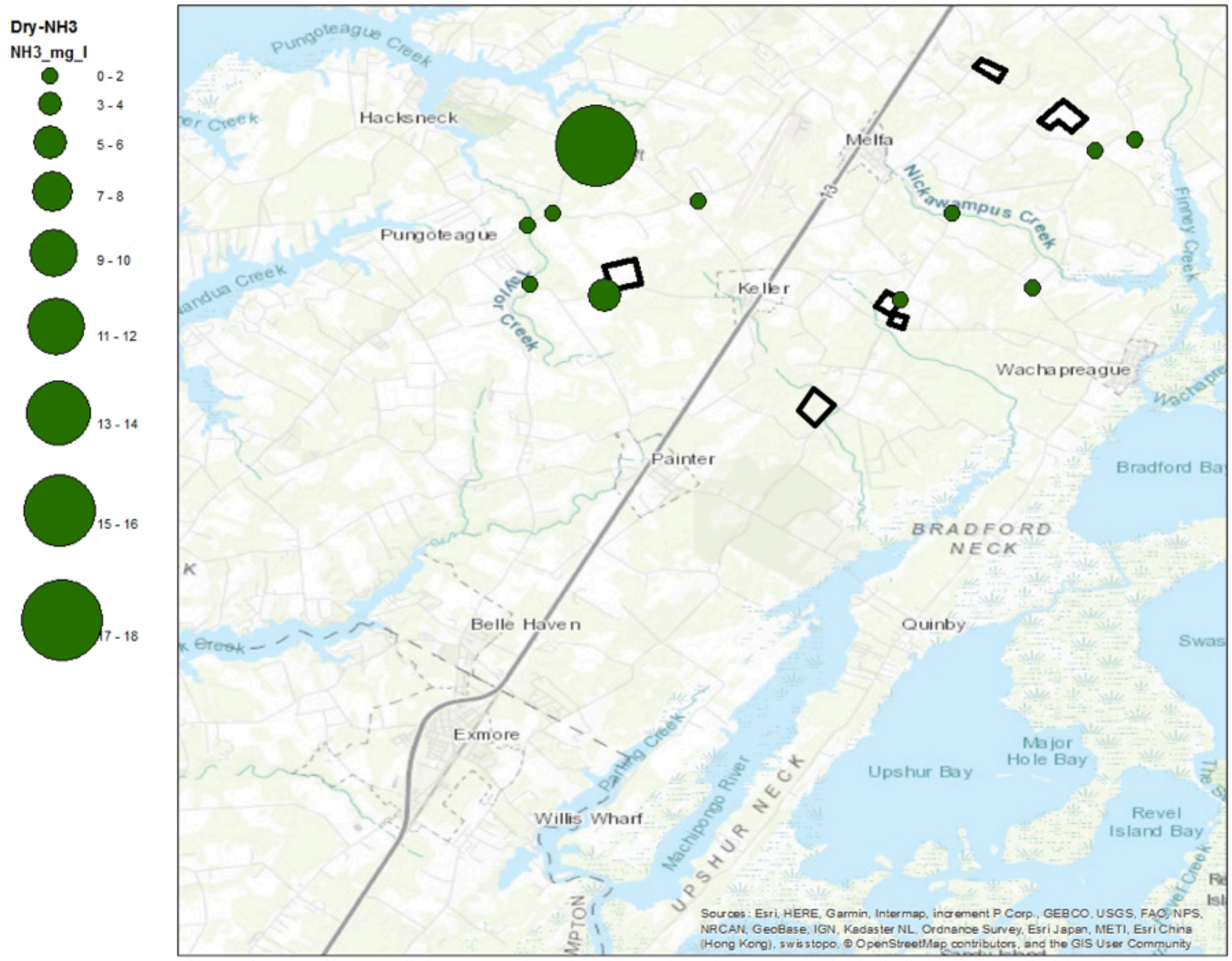

Figure 5. Ammonia concentrations during a dry period immediately prior to a rain fall event. Sampling date was 20 July 2018.

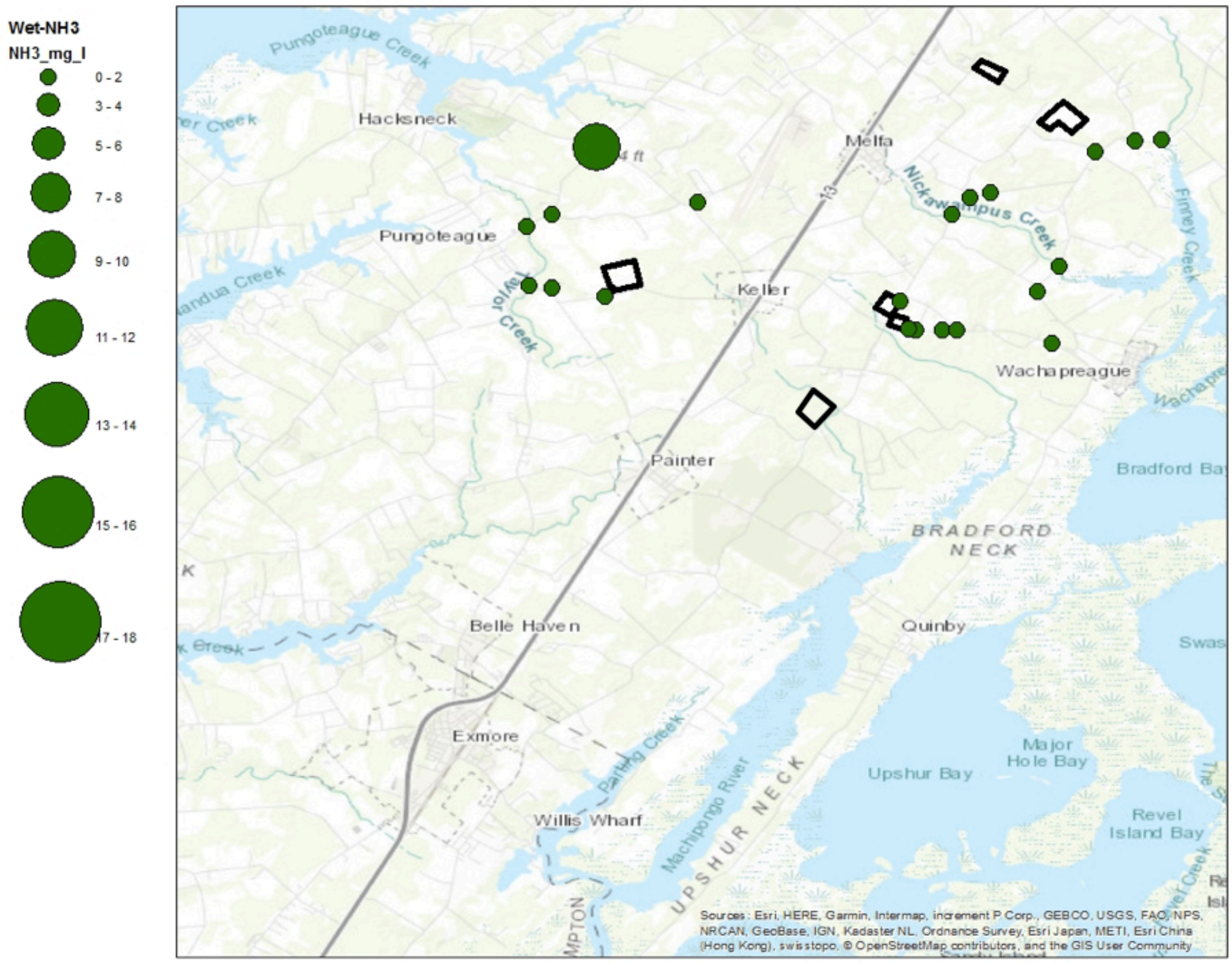

Figure 6. Ammonia concentrations during the end of a rain event. Sampling date was 25 July 2018.

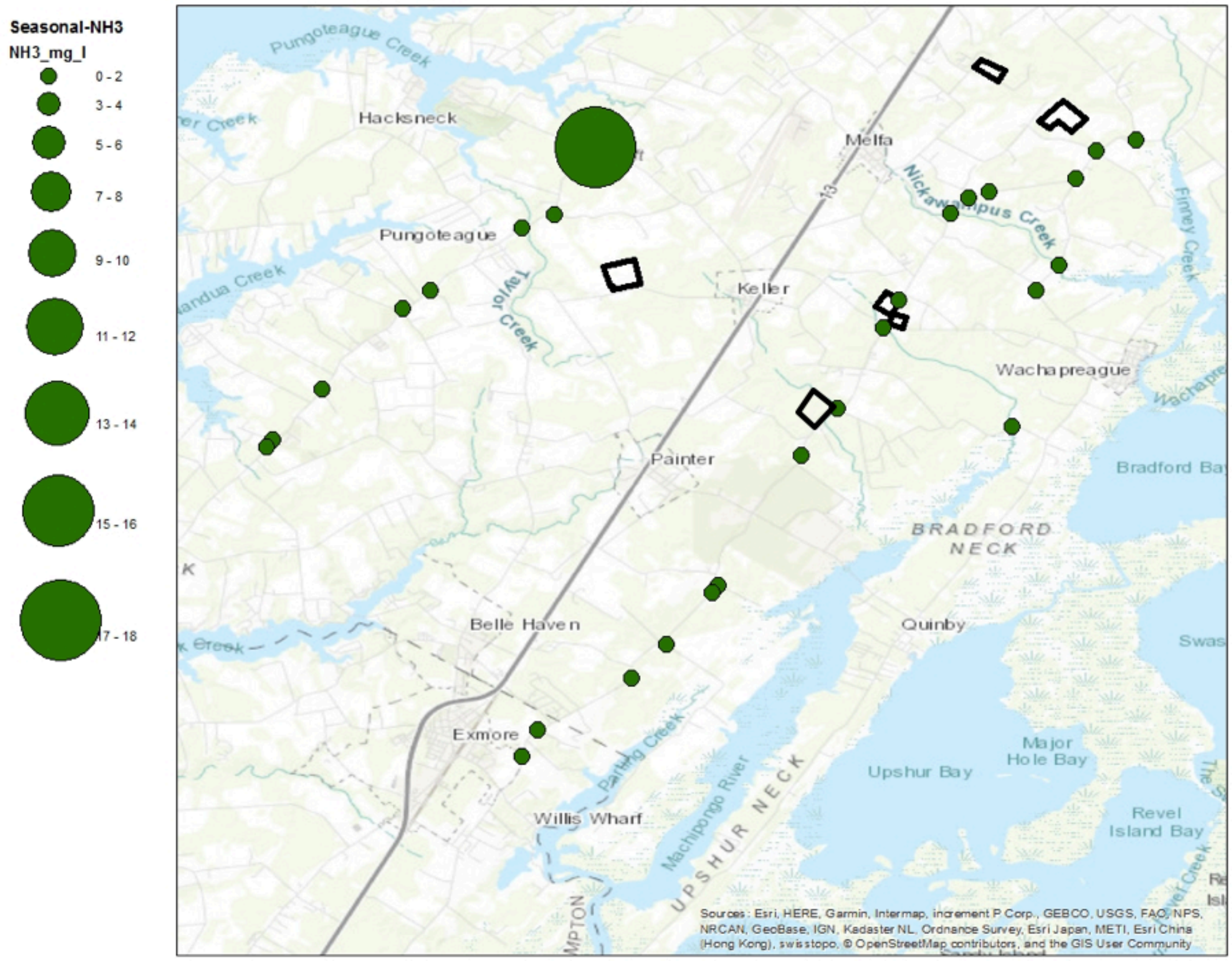

Figure 7. Ammonia concentrations not associated with rainfall but extended wet weather resulting in saturated soil conditions. Sampling date was 9 November 2018.

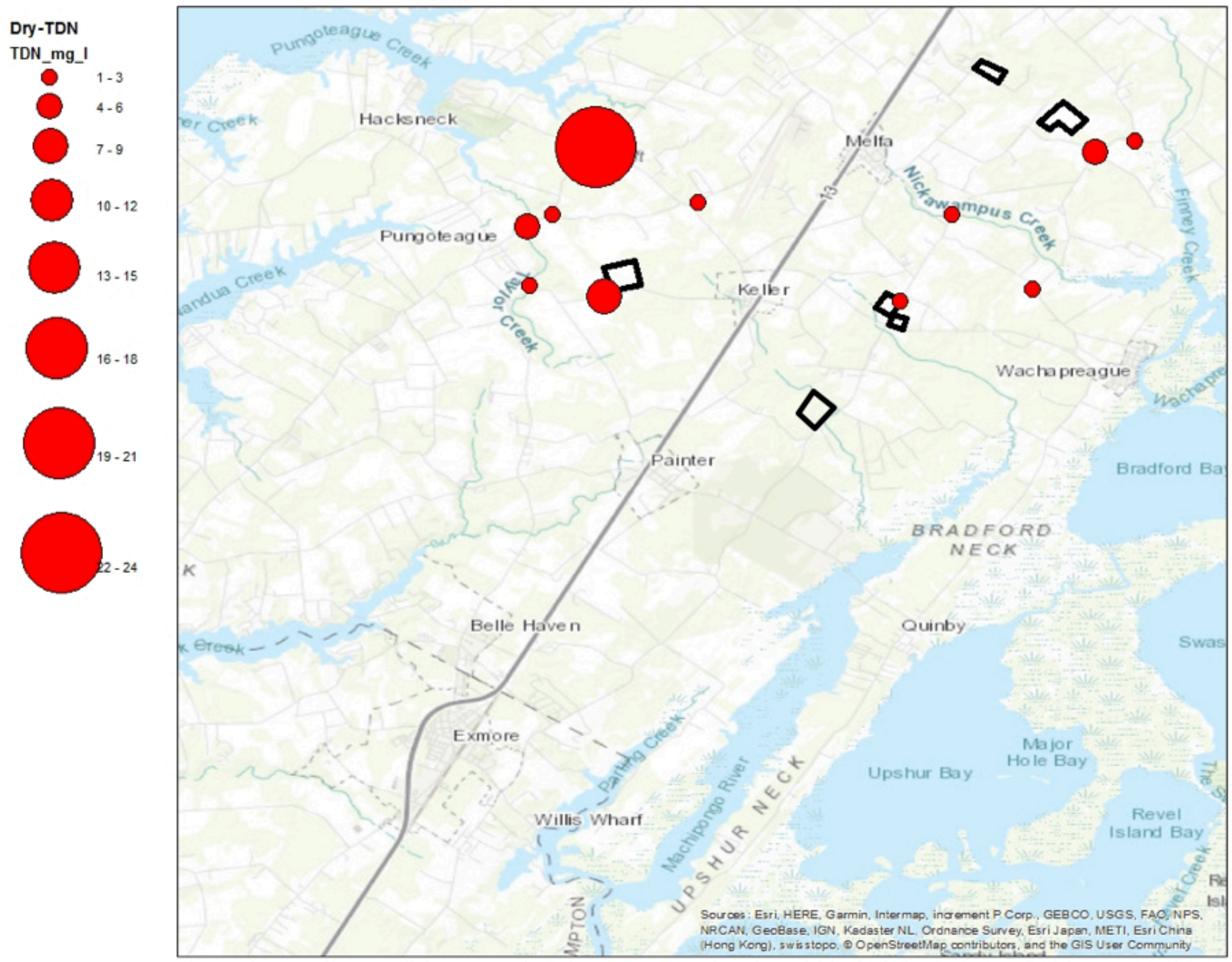

Figure 8. Total Nitrogen (TN) content during a dry period immediately prior to a rain fall event. Sampling date was 20 July 2018.

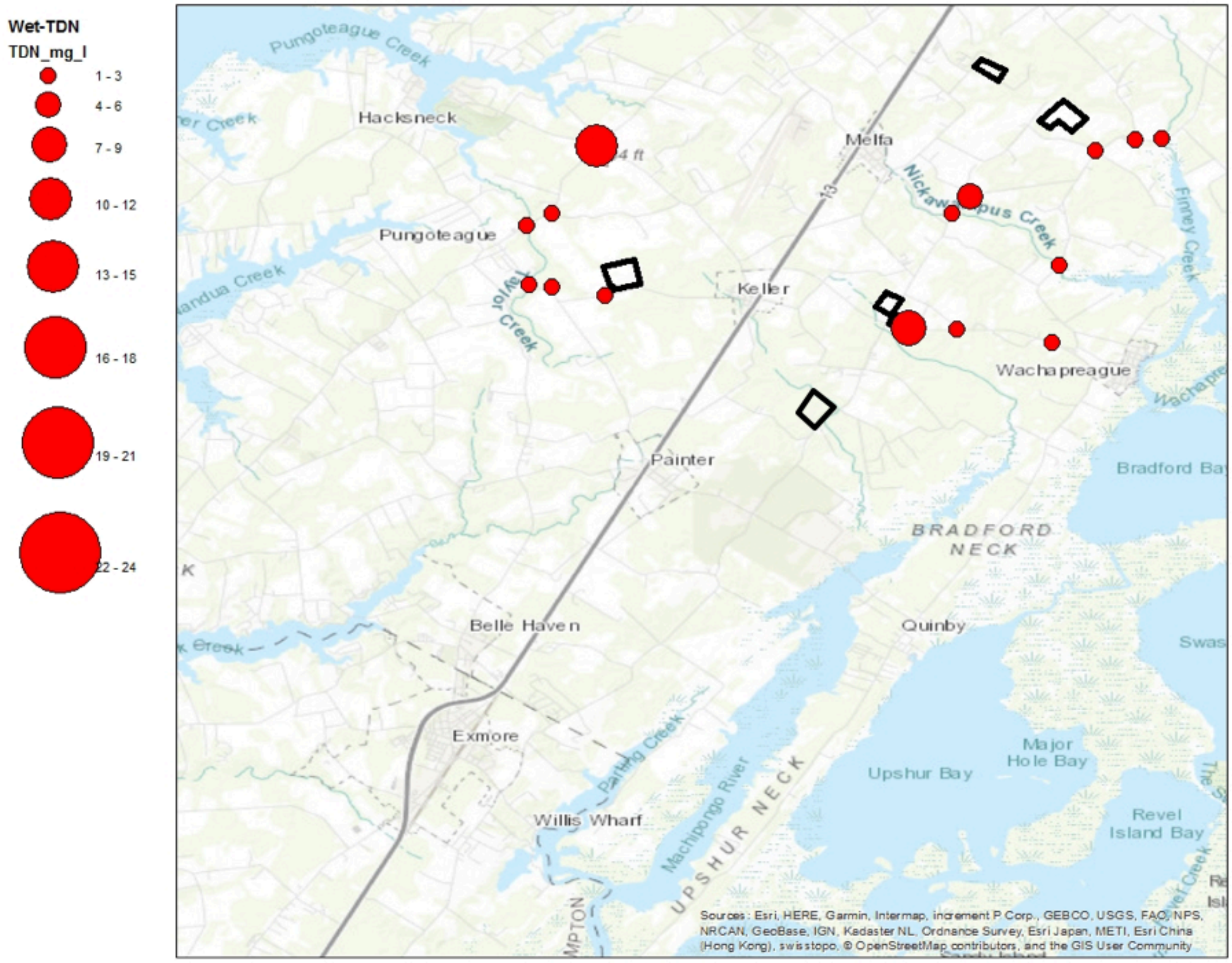

Figure 9. Total Nitrogen (TN) content during the end of a rain event. Sampling date was 25 July 2018.

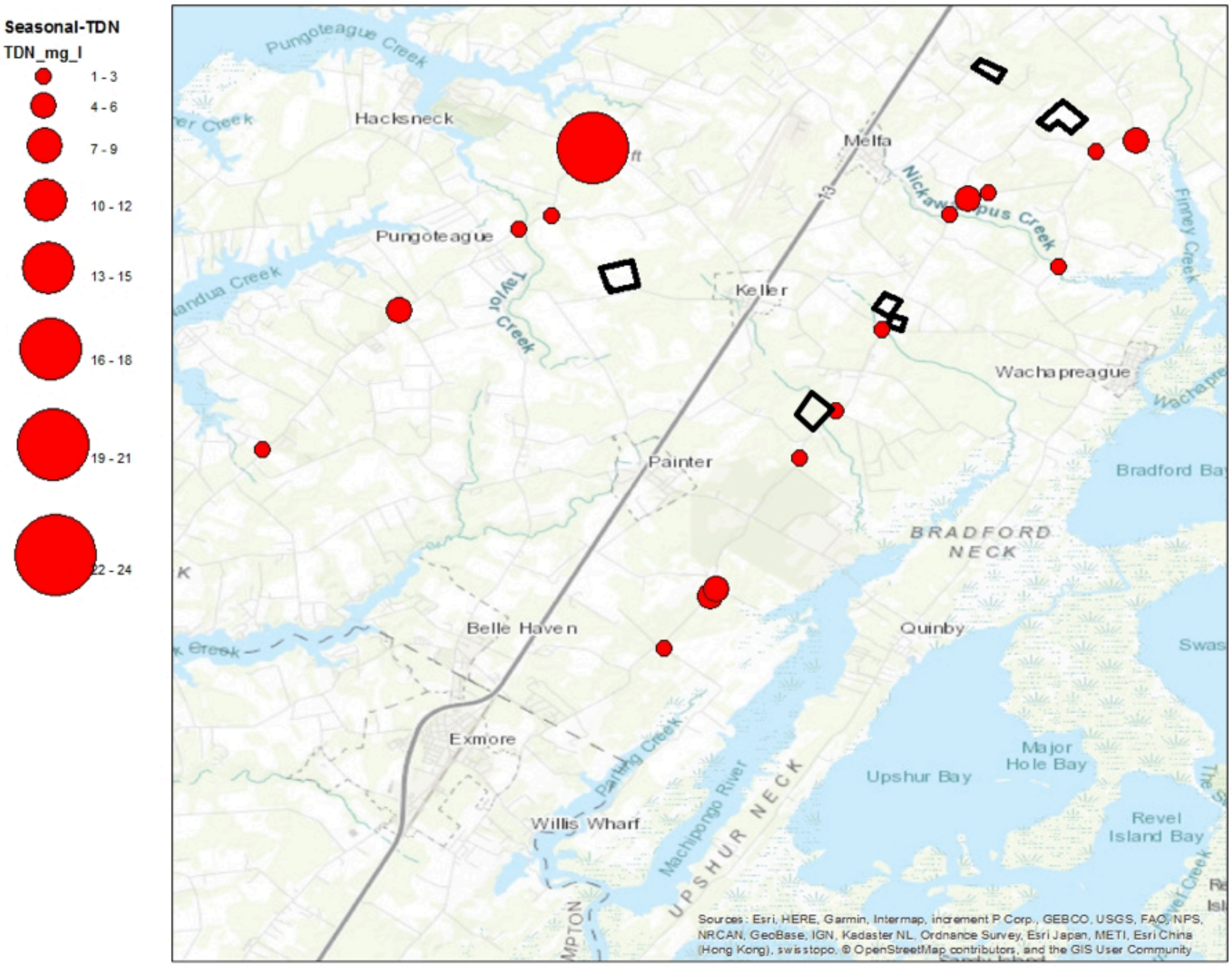

Figure 10. Total Nitrogen (TN) content not associated with rainfall but extended wet weather resulting in saturated soil conditions. Sampling date was 9 November 2018.

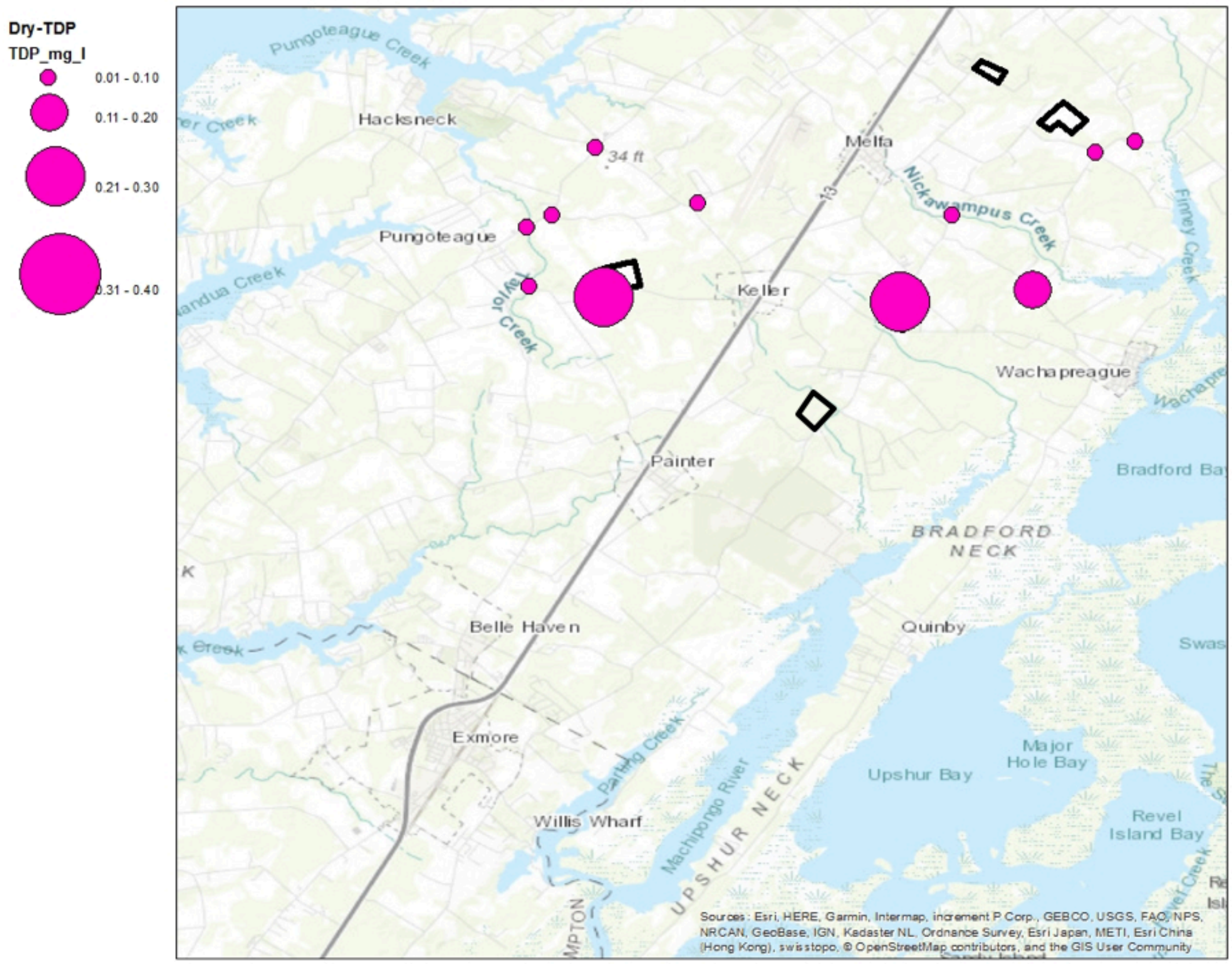

Figure 11. Total Phosphate (TP) content during a dry period immediately prior to a rain fall event. Sampling date was 20 July 2018.

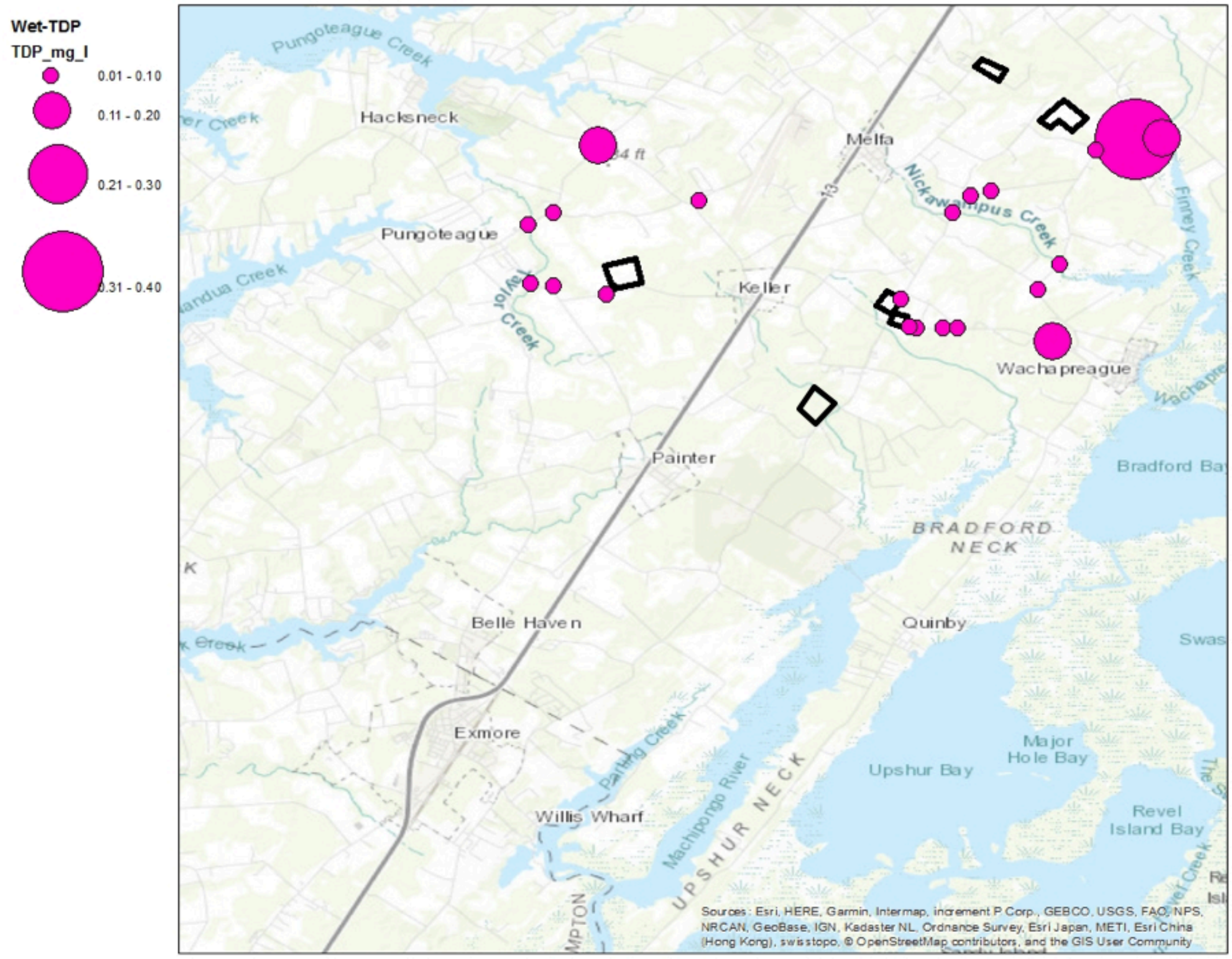

Figure 12. Total Phosphate (TP) content during the end of a rain event. Sampling date was 25 July 2018.

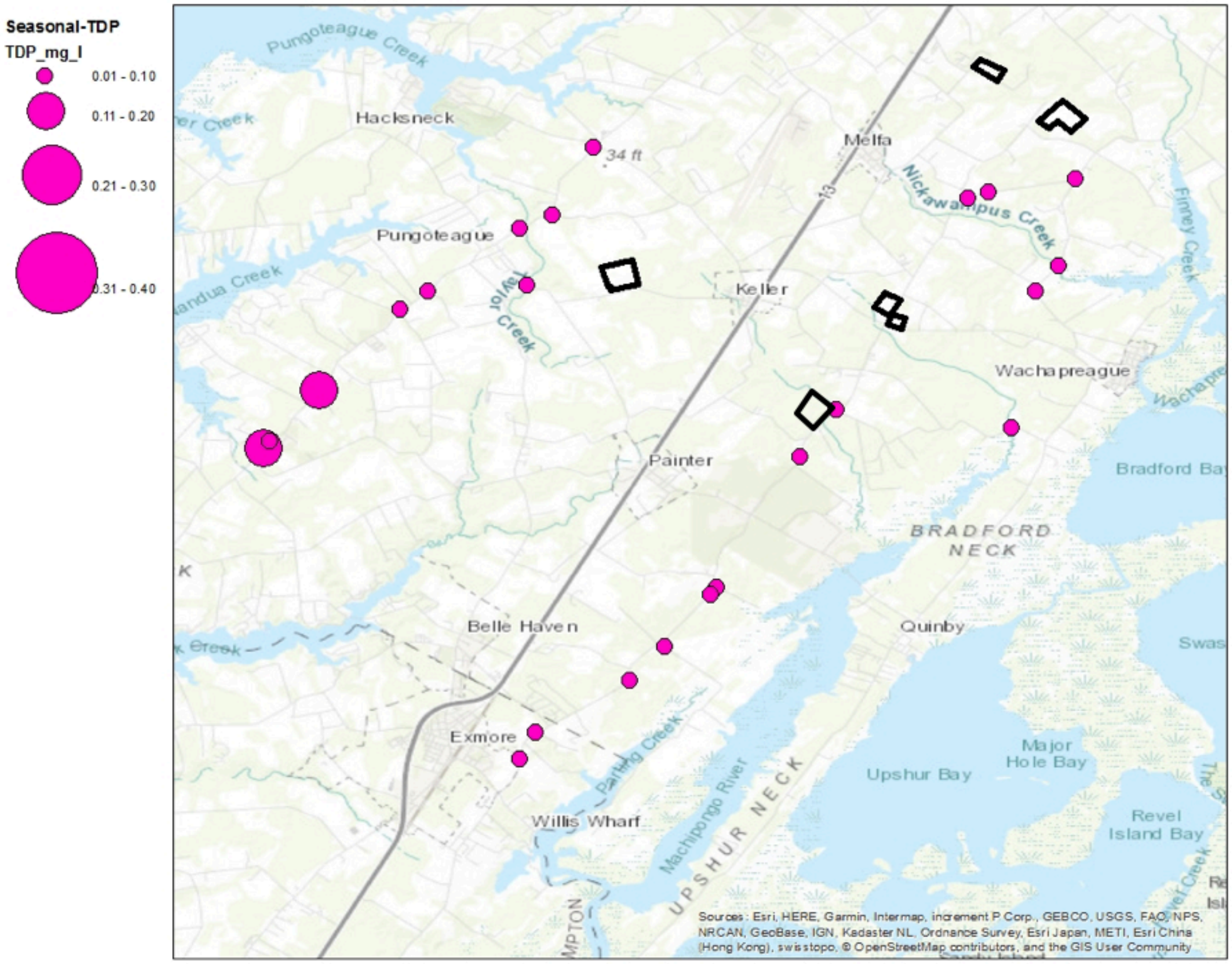

Figure 13. Total Phosphate (TP) content not associated with rainfall but extended wet weather resulting in saturated soil conditions. Sampling date was 9 November 2018.

Appendix I. Analytical methods for nutrient analyses.

Determination of Ammonia by Skalar Auto Analyzer

ASC METHOD: 3000

Document Control Number: 00072

1.0 SCOPE AND APPLICATION:

1.1 This method is for the determination of Ammonia by Skalar Autoanalyzer. The applicable range is 0.005-2.0 mg/l.

2.0 SUMMARY OF METHOD:

2.1 Automated Continuous flow, segmented stream, no bubble gating.

2.2 Dual wavelength detection and matrix correction.

2.3 Alkaline phenol and hypochlorite react with ammonia to form indophenol blue that is proportional to the ammonia concentration. The blue color formed is intensified with sodium nitroprusside. Reaction is heat catalyzed at 37°C.

Determination of Total Dissolved Nitrogen and Total Dissolved Phosphorous by Skalar Auto Analyzer

ASC METHOD: 3005

Document Control Number: 00076

1.0 SCOPE AND APPLICATION:

1.1 This method describes the digestion procedure for total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) in fresh and estuarine surface waters by the alkaline persulfate oxidation technique. The dissolved fraction are aliquots of sample which have passed through a filter to remove particulates. The method is suitable for the determination of total nitrogen (TN) and total phosphorus (TP) with necessary precautions to ensure that particulates are fully digested. The applicable range for TDN and TN is 0.09-0.90 mg/L. The applicable range TDP and TP is 0.01-0.40 mg/L.

2.0 SUMMARY OF METHOD:

2.1 The persulfate oxidation technique for nitrogen in water is performed under heated alkaline conditions, where all organic and inorganic forms of nitrogen are oxidized to nitrate. As the reaction proceeds, NaOH is consumed and the pH drops to < 2.2, which allows the oxidation of all phosphorus compounds to orthophosphate.

2.2 An aliquot of digested sample is analyzed for nitrate and orthophosphate using automated colorimetric methods (Method 3001 and Method 3003, respectively) to produce total nitrogen and total phosphorus concentrations.

Appendix II. Data

Sample locations in watershed segments downstream or inclusive of poultry operations are highlighted in yellow.

Date	Time	Lat	Long	*Entercoccus* 100 ml-1	NH3 Units: mg/L MDL: 0.0062	TN Units: mg/L MDL: 0.0285	TP Units: mg/L MDL: 0.0095
20-Jul-18	13:45	37.6217	75.7082		0.4936	0.8252	0.1397
20-Jul-18	14:00	37.6194	75.7344		0.0064	1.5566	0.2052
20-Jul-18	14:10	37.6366	75.7240		0.0271	2.5216	0.0299
20-Jul-18	14:35	37.6511	75.6879		0.0870	1.5800	0.0436
20-Jul-18	14:45	37.6488	75.6957		0.0316	4.2052	0.0191
20-Jul-18	15:30	37.6499	75.7945		16.4500	21.9323	0.0638
20-Jul-18	15:45	37.6365	75.8030		0.0947	1.9832	0.0351
20-Jul-18	15:55	37.6342	75.8081		0.0670	5.6542	0.0511
20-Jul-18	16:10	37.6224	75.8076		0.0712	1.9262	0.0792
20-Jul-18	16:20	37.6205	75.7928		4.7650	6.1372	0.2833
20-Jul-18	16:47	37.6389	75.7744		0.0989	1.1530	0.0397
25-Jul-18	13:00	37.6137	75.7259	230	0.1035	0.6418	0.0360
25-Jul-18	13:02	37.6137	75.7313	2005	0.0471	0.7243	0.0329
25-Jul-18	13:12	37.6138	75.7327	2800	0.0237	6.8799	0.0138
25-Jul-18	13:15	37.6195	75.7344	1600	0.0126	0.1791	0.0187
25-Jul-18	13:21	37.6137	75.7232	870	0.0125	0.9802	0.0212
25-Jul-18	13:40	37.6366	75.7241	1440	0.0506	2.3122	0.022
25-Jul-18	13:41	37.6398	75.7205	720	0.1095	3.9595	0.0439
25-Jul-18	13:42	37.6409	75.7164	45	0.0576	0.6195	0.0625
25-Jul-18	13:46	37.6488	75.6959	2020	0.0199	0.9393	0.0207
25-Jul-18	13:58	37.6511	75.6879	2785	0.0258	2.1089	0.3822
25-Jul-18	14:02	37.6512	75.6827	960	0.0739	2.7199	0.1177
25-Jul-18	14:08	37.6262	75.7030	1620	0.0717	1.1624	0.0968
25-Jul-18	14:10	37.6213	75.7072	1790	0.0351	0.2040	0.0228
25-Jul-18	14:32	37.6388	75.7744	360	0.0976	0.2411	0.0318
25-Jul-18	14:40	37.6364	75.8030	225	0.0373	1.0565	0.0309
25-Jul-18	14:47	37.6499	75.7943	2230	8.6800	9.5600	0.1001
25-Jul-18	14:50	37.6343	75.8080	720	0.0799	1.9534	0.0630
25-Jul-18	15:00	37.6225	75.8076	1240	0.0341	1.2601	0.0443
25-Jul-18	15:05	37.6204	75.7927	2805	0.8076	1.2232	0.0752
25-Jul-18	15:20	37.6219	75.8030	2850	0.1458	0.8440	0.0935
9-Nov-18	8:41	37.6212	75.7073	520	0.0583	0.6328	0.0361
9-Nov-18	8:48	37.6263	75.7030	1190	0.0500	2.3880	0.03
9-Nov-18	8:52	37.6433	75.6996	1160	0.02	0.7348	0.03
9-Nov-18	8:56	37.6488	75.6955	1010	0.02	1.6490	0.01
9-Nov-18	9:00	37.6511	75.6877	210	0.0273	3.4750	0.01
9-Nov-18	9:12	37.6409	75.7166	110	0.0229	0.8970	0.0317
9-Nov-18	9:15	37.6397	75.7207	510	0.0378	4.0040	0.03
9-Nov-18	9:17	37.6364	75.7243	590	0.0407	2.8970	0.01
9-Nov-18	9:22	37.6193	75.7345	380	0.02	0.1725	0.01
9-Nov-18	9:26	37.6139	75.7378	330	0.0462	1.1150	0.01
9-Nov-18	9:34	37.5944	75.7123	280	0.0423	0.7194	0.0675
9-Nov-18	9:58	37.5980	75.7468	400	0.0251	1.0010	0.01
9-Nov-18	10:03	37.5886	75.7538	320	0.0432	2.2410	0.0309
9-Nov-18	10:08	37.5631	75.7703	560	0.0647	3.7060	0.02
9-Nov-18	10:11	37.5617	75.7715	830	0.0405	4.3770	0.02

9-Nov-18	10:18	37.5513	75.7806	310	0.1139	1.5500	0.0668
9-Nov-18	10:22	37.5448	75.7874	340	0.0254	0.5874	0.0396
9-Nov-18	10:27	37.5345	75.8058	340	0.0272	0.7823	0.02
9-Nov-18	10:29	37.5293	75.8090	160	0.1281	0.7575	0.0533
9-Nov-18	10:48	37.5905	75.8595	520	0.0436	0.8470	0.1560
9-Nov-18	10:45	37.5919	75.8584	410	0.0460	0.5865	0.0611
9-Nov-18	10:53	37.6017	75.8486	660	0.0252	0.7060	0.1228
9-Nov-18	11:03	37.6176	75.8326	200	0.0245	4.1910	0.0474
9-Nov-18	11:09	37.6213	75.8271	320	0.0349	0.4709	0.0479
9-Nov-18	11:11	37.6338	75.8091		0.0296	2.1430	0.0390
9-Nov-18	11:17	37.6363	75.8026		0.0291	1.2430	0.03
9-Nov-18	11:22	37.6496	75.7945		17.5000	18.26	0.0439