

Technical Memorandum – Accotink Creek Chloride Study



April 27, 2016

Background:

On September 29, 2015 the Virginia Department of Environmental Quality (DEQ) finalized the [stressor identification analysis report](#) for the Accotink Creek biological water quality impairment. Chloride was identified as one of four most probable stressors contributing to the biological impairment. However, because the bulk of the data (172 of 195 observations) were in the upper Accotink Creek watershed, comments submitted during the 30-day public comment period for the stressor identification analysis report expressed concern that chloride was not sufficiently documented to be a stressor to the biological community in the Long Branch (Central) and lower Accotink Creek watersheds. While there were no paired chloride and specific conductivity observations in Long Branch (Central), continuous monitoring of specific conductivity by USGS indicates that chloride criteria were likely exceeded because of the strong correlation established between specific conductivity measurements and chloride concentration. In the lower Accotink Creek watershed, there were limited (n=23) paired chloride and specific conductivity observations and no continuous monitoring of specific conductance during winter months when exceedances of chloride criteria are expected. Accordingly, DEQ conducted a chloride study that gathered additional paired chloride and specific conductivity observations in all three Total Maximum Daily Load (TMDL) watersheds in addition to continuous monitoring of specific conductivity in the lower Accotink Creek watershed over a 2 month period (1/11/16 through 2/29/16). The data gathered during this period was combined with historical chloride and specific conductivity data to determine if chloride relationships observed in the stressor identification analysis report were corroborated in all three TMDL watersheds.

Methods:

On January 11, 2016 DEQ deployed a sonde and data logger that measured specific conductivity at 15 minute intervals in the lower Accotink Creek TMDL watershed at sampling station 1AACO004.84 located near the Telegraph Road bridge crossing of Accotink Creek (**Figure 1**). That data logger recorded specific conductivity measurements through February 29, 2016. During this period, paired chloride and specific conductivity measurements were collected at 5 monitoring stations (**Table 1**) under all winter conditions including snow melt. There were two snow events captured during this sampling period. On January 22nd and 23rd around 29 inches of snow fell in the Accotink Creek watershed, and on February 15th approximately 2 inches of snow fell followed by about an inch of rain. The paired chloride and specific conductivity data collected in 2016 was combined with historical chloride and specific conductivity data (1/6/04 through 12/29/15) to conduct a regression analysis for each of the three TMDL watersheds. The regression equations were then used to predict chloride concentrations based on continuous monitoring of specific conductivity during 1/11/16 through 2/29/16 in order to evaluate estimated trends in chloride concentrations following snow melt events.

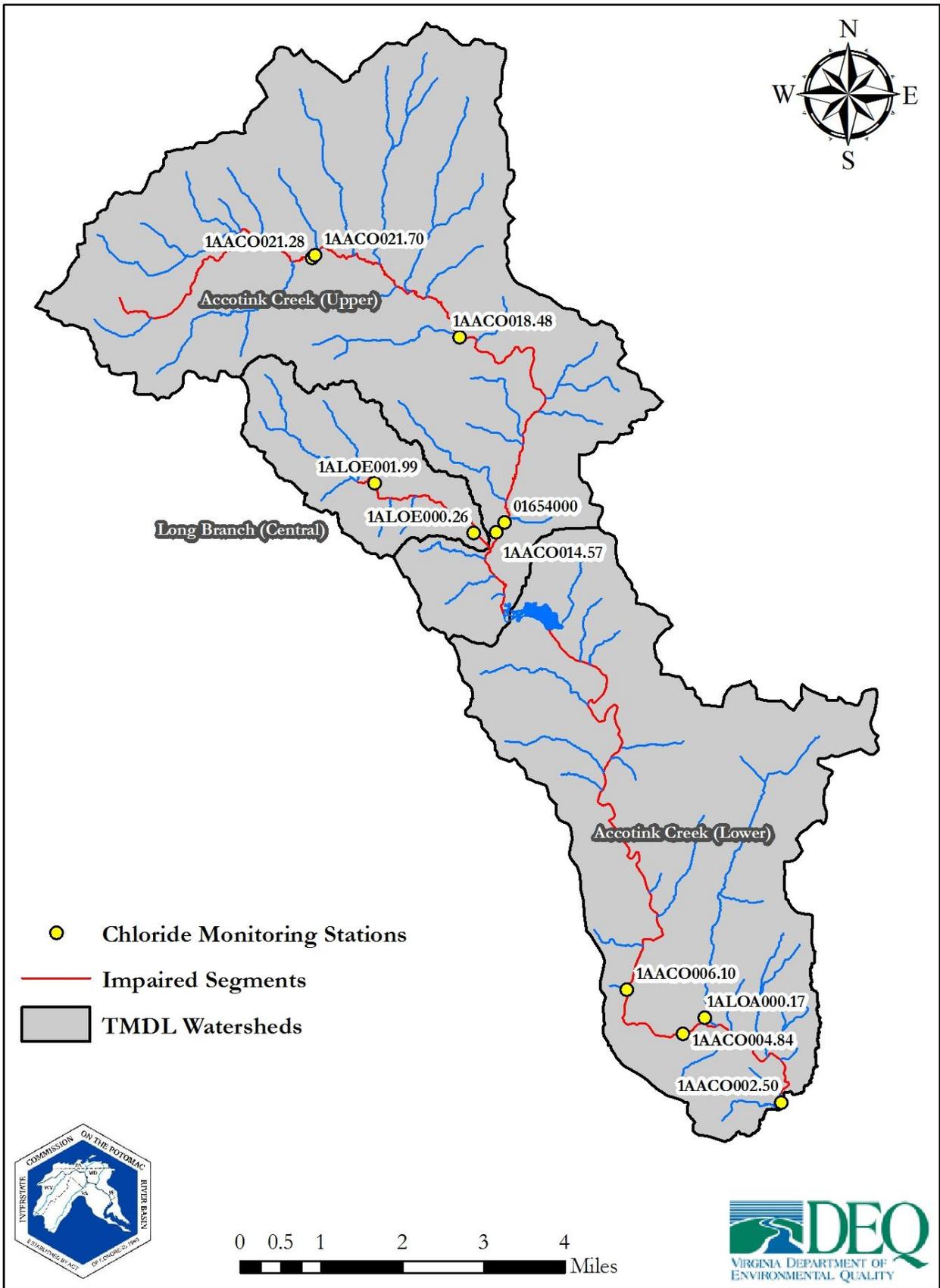


Figure 1. Map of Accotink Creek TMDL watersheds and chloride monitoring stations.

Table 1. Summary of data record for monitoring stations in each TMDL watershed.

Watershed	Station Name	Number of Paired Chloride and Specific Conductivity Samples	Date Range	Collection Agency
	01654000	146	1/6/04 - 7/15/14	USGS
Upper	1AACO014.57*	37	3/9/05 - 2/18/16	DEQ
Accotink	1AACO018.48*	1	2/16/16	DEQ
Creek	1AACO021.28*	1	2/16/16	DEQ
	1AACO021.70	1	2/15/06	DEQ
Long Branch	1ALOE000.26*	7	3/4/15 - 2/18/16	DEQ
(Central)	1ALOE001.99	1	6/1/06	DEQ
	1AACO002.50	1	6/1/06	DEQ
Lower	1AACO004.84*	18	3/8/07 - 2/29/16	DEQ
Accotink	1AACO006.10	6	6/1/06 - 3/4/15	DEQ
Creek	1ALOA000.17	9	9/28/06 - 6/4/07	DEQ

*Includes data collected as part of the winter 2016 chloride and specific conductivity monitoring effort

Results:

Chloride Criteria Exceedances: **Table 2** summarizes all chloride criteria exceedances observed during the past 7 years. Based on the period of record, each of the three TMDL watersheds had at least three measured exceedances of chloride criteria during the past 3 years. The acute chloride criterion for Virginia states that the one hour average concentration of chloride is not to exceed 860 mg/L more than once every 3 years on average. The chronic chloride criterion for Virginia states that the four-day average concentration of chloride is not to exceed 230 mg/L more than once every 3 years on average (9VAC25-260-140). Acute criterion exceedances were evaluated using a single sample, whereas chronic criterion exceedances were evaluated using the average of data collected in a 4-day period. In the upper Accotink Creek TMDL watershed there were 6 acute criterion exceedances and 2 chronic criterion exceedances observed in the last 3 years in addition to 1 acute criterion exceedance in 2010. In the Long Branch (central) TMDL watershed there was 1 acute criterion exceedance and 2 chronic criterion exceedances during the last 3 years. In the lower Accotink Creek TMDL watershed there were 2 acute criterion exceedances and 2 chronic criterion exceedances throughout the last 3 years.

Table 2. Summary of chloride criteria exceedances.

Observed Exceedances							
Watershed	Collection Agency	Station	Date	SpC ($\mu\text{S}/\text{cm}$)	Chloride (mg/L)	Exceedance Type	Comment
Upper Accotink Creek Watershed	USGS	01654000 (LAWQA)	02/02/10	4150	1320	Acute	Not in 3 yr data window
	USGS	01654000 (LAWQA)	02/19/14	3090	925	Acute	
	USGS	01654000 (LAWQA)	03/05/14	4660	1410	Acute	
	USGS	01654000 (LAWQA)	03/19/14	3230	977	Acute	
	DEQ	1AACO014.57	1/27/2016	3612	1210	Acute	Also Chronic (avg = 1049 mg/L)
	DEQ	1AACO014.57	1/28/2016	2929	888	Acute	
	DEQ	1AACO014.57	2/16/2016	7986	2570	Acute	Time frame overlaps previous acute exceedance
	DEQ	1AACO014.57	2/16/2016	7986	2570	Chronic (avg = 1537 mg/L)	
Long Branch (Central) Watershed	DEQ	1ALOEO00.26	1/27/2016	2586	847	Chronic (avg = 687 mg/L)	
	DEQ	1ALOEO00.26	1/28/2016	1774	526		
	DEQ	1ALOEO00.26	2/16/2016	3229	1010	Acute	Time frame overlaps previous acute exceedance
	DEQ	1ALOEO00.26	2/16/2016	3229	1010	Chronic (avg = 619 mg/L)	
	DEQ	1AACO014.57	2/18/2016	1682	504		
Lower Accotink Creek Watershed	DEQ	1AACO004.84	01/26/16	1367	367	Chronic (avg = 605 mg/L)	
	DEQ	1AACO004.84	01/27/16	2346	681		
	DEQ	1AACO004.84	01/28/16	2489	767		
	DEQ	1AACO004.84	02/16/16	4781	1580	Acute	Time frame overlaps previous acute exceedance
	DEQ	1AACO004.84	02/16/16	4781	1580	Chronic (avg = 1014 mg/L)	
	DEQ	1AACO004.84	02/18/16	1435	448		
	DEQ	1AACO006.10	03/04/15	3817	1160	Acute	

Regression Analysis: Using the entire data record of paired chloride and specific conductivity observations (**Table 1**), scatter plots were prepared to analyze the relationship between the specific conductivity and the chloride (**Figure 2**). The relationship between measured chloride and measured specific conductivity in each of the 3 TMDL watersheds was very similar and strong as indicated by the R^2 values and the regression equations (**Table 3**). The similarities in the equations suggest that the specific conductivity and chloride relationship in all three watersheds functions the same. Furthermore, the high R^2 values for each TMDL watershed indicates that specific conductivity can accurately predict chloride concentrations for model calibration. However, at the time of writing this technical memorandum, the actual predictive equation that would be used for model calibration has not been established. Nevertheless, it is likely that the predictive equation to be used in model calibration will be similar to those shown in **Figure 2** and **Table 3**.

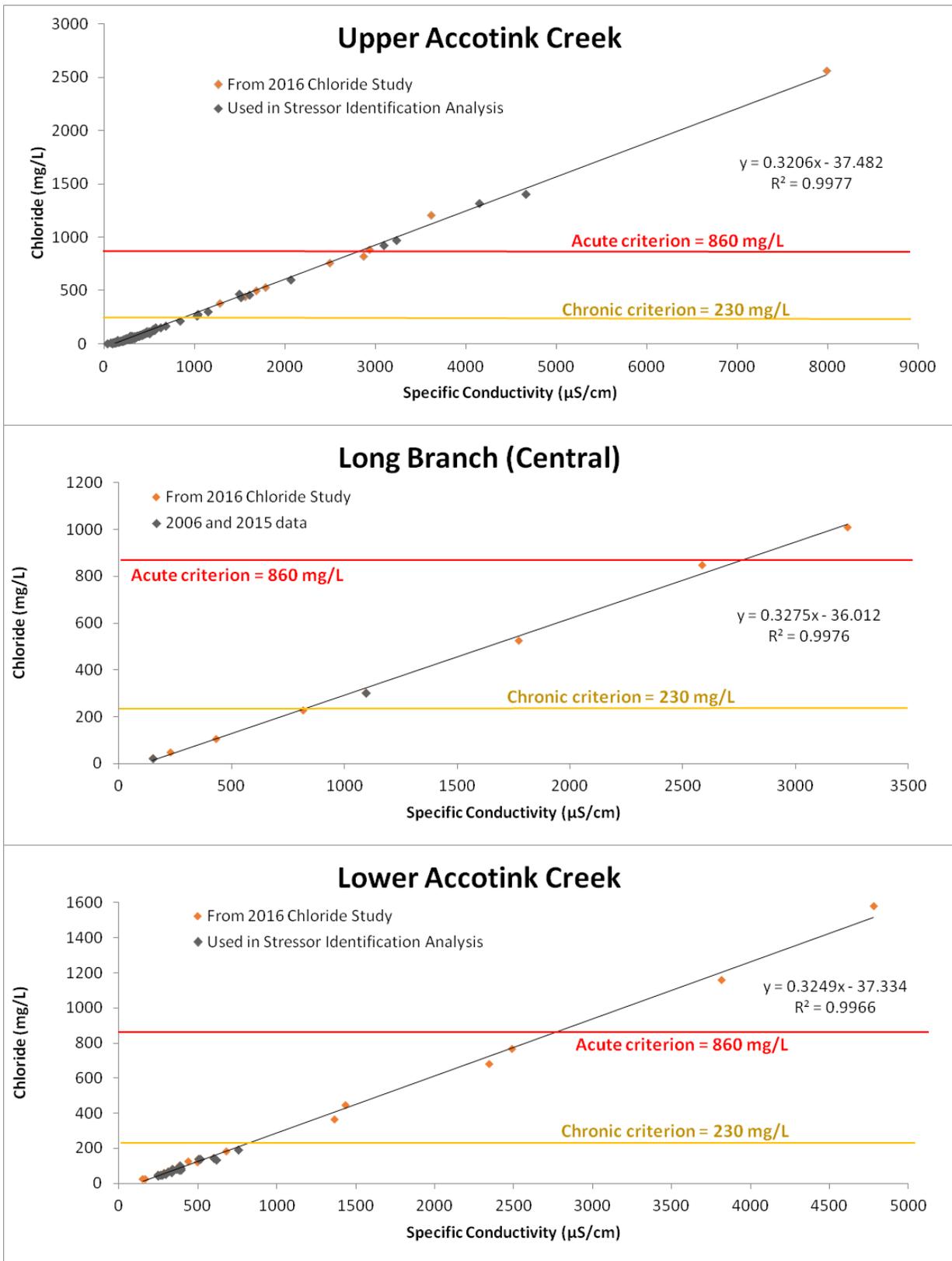


Figure 2. Regression analysis of chloride concentration as a function of specific conductivity in each TMDL watershed.

Table 3. Results of the regression analysis between specific conductivity and chloride concentrations for each watershed.

Watershed	Regression Equation*	R ²	Number of Samples
Lower Accotink	$y = 0.3249x - 37.334$	0.9966	186
Long Branch (Central)	$y = 0.3275x - 36.012$	0.9976	8
Upper Accotink	$y = 0.3206x - 37.482$	0.9977	34

*Specific conductivity ($\mu\text{S}/\text{cm}$) was the independent variable and chloride concentration (mg/L) was the dependent variable

Predicted Chloride Concentrations: Specific conductivity is measured by the USGS at 15 minute intervals in the upper Accotink Creek TMDL watershed ([Station 01654000](#)) and the Long Branch (Central) TMDL watershed ([Station 01654500](#)). These stations are proximal to DEQ sampling stations 1AACO014.57 and 1ALOE000.26, respectively. The continuous monitoring record in the lower Accotink Creek TMDL watershed (DEQ station 1AACO004.84) represented the shortest period of record among all 3 TMDL watersheds. Therefore, that period of record (1/11/16 through 2/29/16) was used to predict chloride concentrations using measured specific conductivity and each TMDL watershed’s regression equation (**Table 3**). **Figure 3** shows the predicted chloride concentrations over that period of record. Following each of the two snow events, estimated chloride concentrations spiked over chloride water quality standards and remained elevated for extended periods of time. Additionally, the benefit of estimating chloride concentrations using the continuous records of specific conductivity is that maximum values can be seen even when sampling efforts miss them. For example, based on a specific conductivity measurement of 12,600 $\mu\text{S}/\text{cm}$ at 4:00 am on February 16th, 2016 in the upper Accotink Creek watershed, the corresponding predicted chloride concentration was 4002 mg/L . Later that day at 11:42 am, DEQ monitoring staff measured a specific conductivity of 7986 $\mu\text{S}/\text{cm}$ and a chloride concentration of 2149 mg/L .

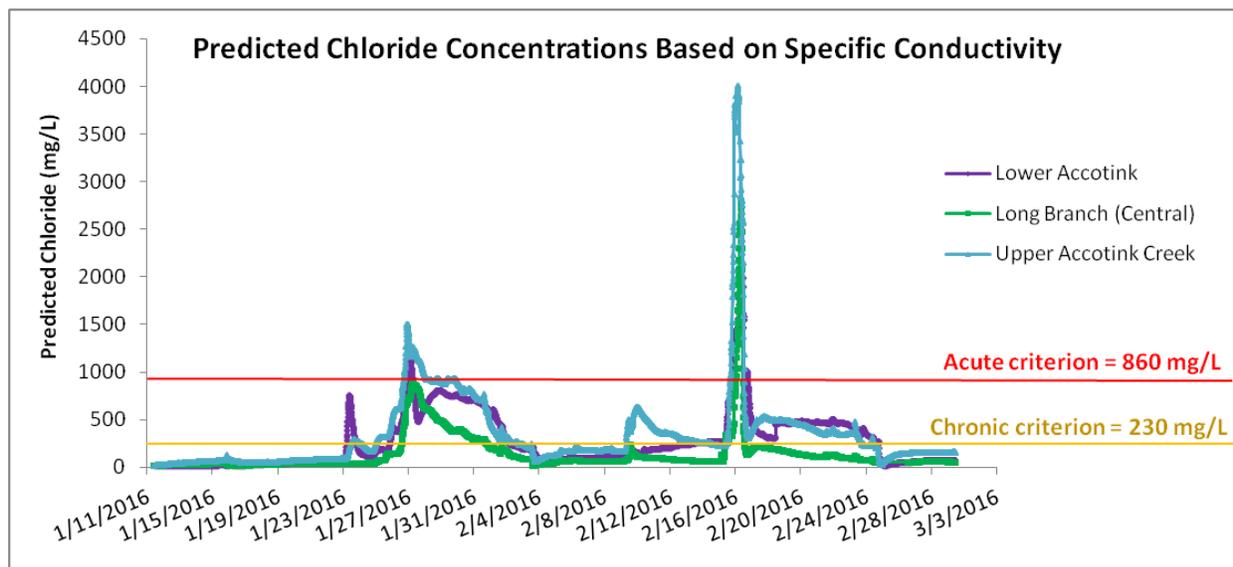


Figure 3. Chloride concentrations predicted using each TMDL watershed’s regression equation and continuous monitoring of specific conductivity. Specific conductivity was measured in 15 minute intervals from 1/11/2016 through 2/29/2016 at USGS station 01654000 for Upper Accotink Creek, USGS station 01654500 for Long Branch (Central), and DEQ station 1AACO004.84 for Lower Accotink Creek.

Conclusion:

In the recommendations section of the [final stressor identification analysis report](#), it states that “A TMDL for chloride should be developed for Long Branch if the predictive relationship between specific conductance and chloride can be corroborated by additional monitoring,” and that “A chloride TMDL should be developed for lower Accotink Creek if additional monitoring corroborates the chloride conductance relationship and continuous monitoring of specific conductance in lower Accotink Creek confirms that it is likely that chloride concentrations are exceeding Virginia’s criteria to protect aquatic life.” Based on the measured exceedances of the chloride aquatic life criteria established in the Virginia Water Quality Standards (9VAC25-260-140), the corroborated relationships between specific conductivity and chloride concentrations as indicated by similar regression equations and strong R^2 s, and the estimated chloride concentrations following snow events, DEQ is confident that chlorides are a stressor to the biological community in each of the 3 TMDL watersheds. Therefore, the Accotink Creek TMDL study will develop a chloride TMDL for each watershed.