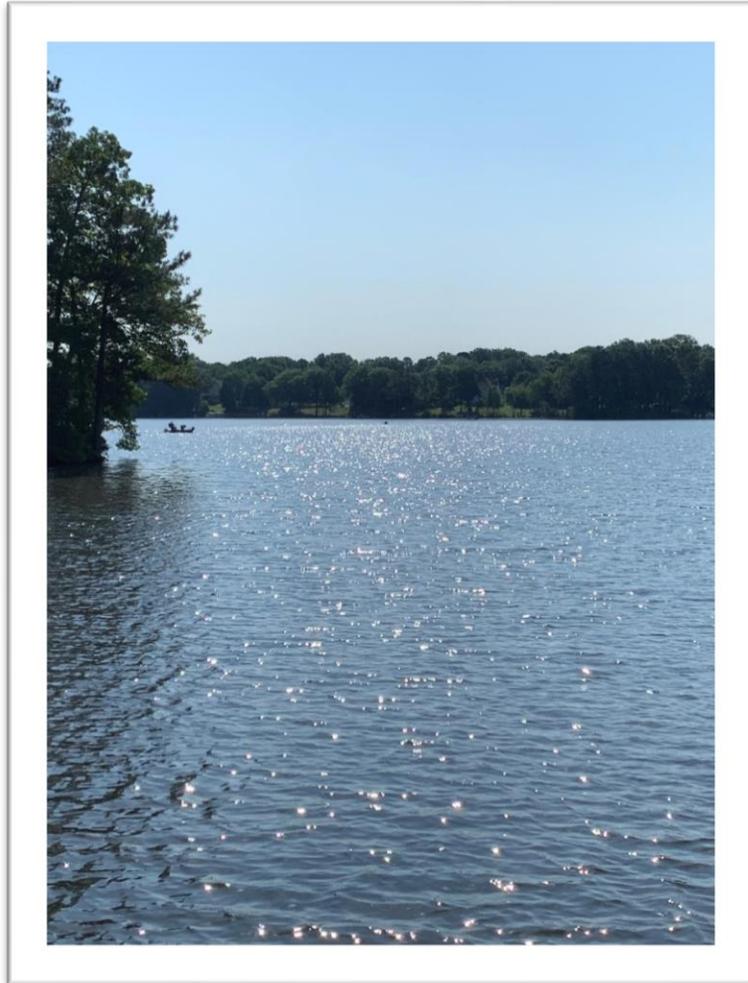




# **Swift Creek Reservoir Water Quality Data Report 2018**



**Chesterfield County  
Department of Environmental Engineering  
Water Quality Section  
&  
Department of Utilities  
Addison-Evans Water Production/Laboratory Facility**

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## **Executive Summary**

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory Staff for the period of January through December 2018 and represents the twenty sixth consecutive year of monitoring of the Swift Creek Reservoir. During 2018, pool elevations measured at the dam ranged from 176.0 to 179.3 feet above mean sea level, corresponding to an approximate reservoir volume between 4.0 to 5.8 billion gallons. Reservoir sampling occurred once a month at eight stations with additional samples obtained every other week at the lacustrine zone. Rainfall over the reservoir and its watershed totaled 62.91 inches, approximately twenty inches above the 33-year long-term average. During 2018, approximately 400 pounds of sodium carbonate peroxyhydrate were applied during March and May to treat algae growth in the reservoir. The applications of sodium carbonate peroxyhydrate assist to improve source water quality for the optimization of the water treatment process. Two MPC – Buoys were installed in the intake bay in December of 2017. These buoys are floating, solar-powered systems that use real-time monitoring and ultrasonic sound waves to effectively control algae in lakes and reservoirs.

An increased concentration of chlorophyll *a* was observed in 2018 as compared to the previous year indicating an increased presence of algae in the reservoir. The growing season 90<sup>th</sup> percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 49.1 µg/L, a slight increase from the 41.9 µg/L observed in 2017. Four stations (Stations 5, 6, 7 and 8) exceeded the 35 µg/L criteria value for the growing season 90<sup>th</sup> percentile indicating higher than acceptable levels of algal growth.

Throughout the reservoir, total phosphorus concentrations decreased in 2018 but were still the highest second observed concentrations in the reservoir to date. The growing season median total phosphorus concentration for the surface water of the main body stations (Stations 4, 5, 6 and 8) was 0.048 mg/L as P; above the Virginia Department of Environmental Quality (VADEQ) nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for the surface water at all eight sites in Swift Creek Reservoir was 0.047 mg/L as P, near the county goal of 0.05 mg/L as P.

During 2018, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in early May and lasting through the first week of November. During the stratification period, dissolved oxygen concentrations within the epilimnion were above the VADEQ minimum criterion of 4.0 mg/L for all stations.

Median growing season Secchi disk readings ranged from 2.0 to 3.0 feet. The growing season

turbidity median (6.2 NTUs) was slightly higher than the median observed in 2017 (5.5 NTUs). The observed increases in Secchi disk depth and relative consistency in turbidity readings indicate an overall high degree of water clarity throughout the reservoir system over time. The 2018 growing season median total suspended solids concentration for all stations (5.2 mg/L) was slightly increased compared to the concentration observed in 2017 (4.4 mg/L). Total nitrogen levels remained consistent with 2017 concentrations throughout the reservoir with growing season median concentrations ranging from 0.46 to 0.56 mg/L as N. *E. coli* median densities remained acceptable with one individual value greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season.

Water temperature in Swift Creek Reservoir varied normally according to season during 2018. Surface pH values ranged from 5.5 to 8.8 units with an annual in-lake median of 6.9 units. Conductivity measurements within the reservoir ranged from 39 to 302  $\mu\text{S}/\text{cm}$  with an annual median of 80  $\mu\text{S}/\text{cm}$ . All lead concentrations were below the reporting limit ( $<0.0025$  mg/L) during 2018. There were also no measurable zinc concentrations observed in 2018 as each were below the laboratory's detection limit ( $<0.05$  mg/L).

A total of 56 individual genera of algae representing ten phyla were documented during 2018. Analysis of the general types of algae by phyla in the reservoir indicated that the community structure continued to be comprised largely of diatoms (Bacillariophyta) and blue-green algae (Cyanoprokaryota). The frequency of occurrence for the taste and odor producing blue-green algae concentration remained consistent with 2017 concentrations potentially accounting for any continued taste and odor complaints reported to the Department of Utilities.

In 2014, the *Hydrilla* biomass reestablished itself in the reservoir. In April of 2015, additional triploid grass carp were stocked into the reservoir with the goal of maintaining the *Hydrilla* biomass at a manageable level and the grass carp remained very effective in controlling *Hydrilla* in 2016. The *Hydrilla* coverage in the reservoir increased but remained manageable in 2017 and 2018. More detailed information about the Department of Utilities strategies and current updates on the ongoing control efforts of *Hydrilla* can be found on the department's webpage under the Swift Creek Reservoir page: <https://www.chesterfield.gov/428/Swift-Creek-Reservoir>

## Introduction

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory staff between January and December 2018 and is the 26<sup>th</sup> consecutive year of monitoring of the Swift Creek Reservoir. The Swift Creek Reservoir is a public water supply for Chesterfield County located approximately 20 miles southwest of Richmond, Virginia. The reservoir is a 1,700-acre impoundment containing approximately 5.0 billion gallons of water at full pool elevation (177.0 feet above mean sea level). The portion of the Swift Creek Reservoir watershed located within the northwest corner of the county encompasses approximately 55.9 square miles. Current data on land use characteristics of the Swift Creek Reservoir Watershed and the entirety of Chesterfield County is available through the Chesterfield County Planning Department.

Rainfall was measured at three automated tipping bucket rain gages within the watershed. The average rainfall over the watershed totaled 62.91 inches during 2018 (Figure 1). Rainfall was approximately 20 inches above the long-term average (43.50 inches) and the second highest amount observed since 1986. During 2018, pool elevations measured at the dam ranged from 176.0 to 179.3 feet above mean sea level, corresponding to an approximate reservoir volume between 4.0 to 5.8 billion gallons. Reservoir sampling occurred once a month at eight stations with additional samples obtained every other week at the lacustrine zone Stations 5 and 8 (Figure 2). At these deeper water sites, discrete epilimnion, metalimnion, and hypolimnion samples were taken for nutrient analysis. All other stations in the reservoir (sites 1, 2, 3, 4, 6 and 7) were sampled at the surface only.

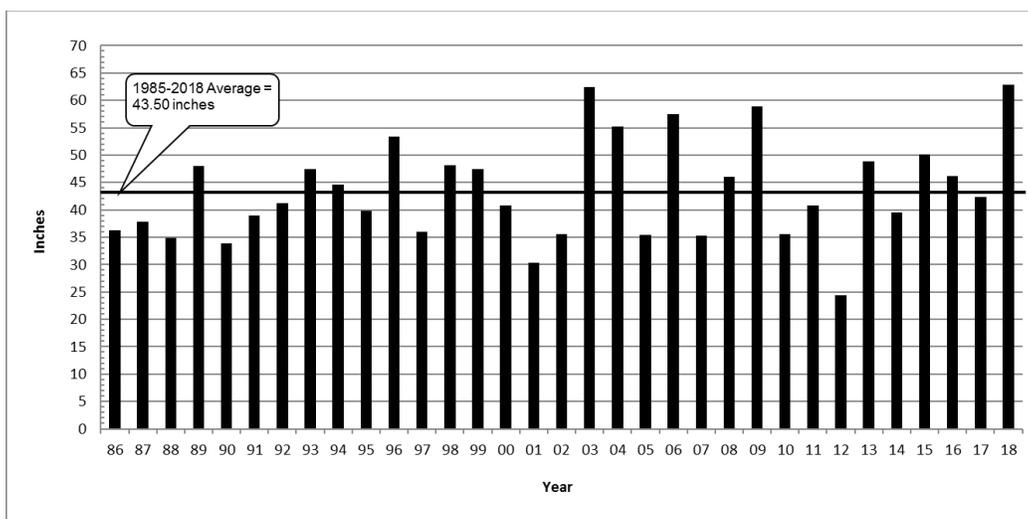


Figure 1. Total Annual Estimated Rainfall Recorded for Swift Creek Reservoir Watershed from 1986-2018 (Source data: Department of Utilities).

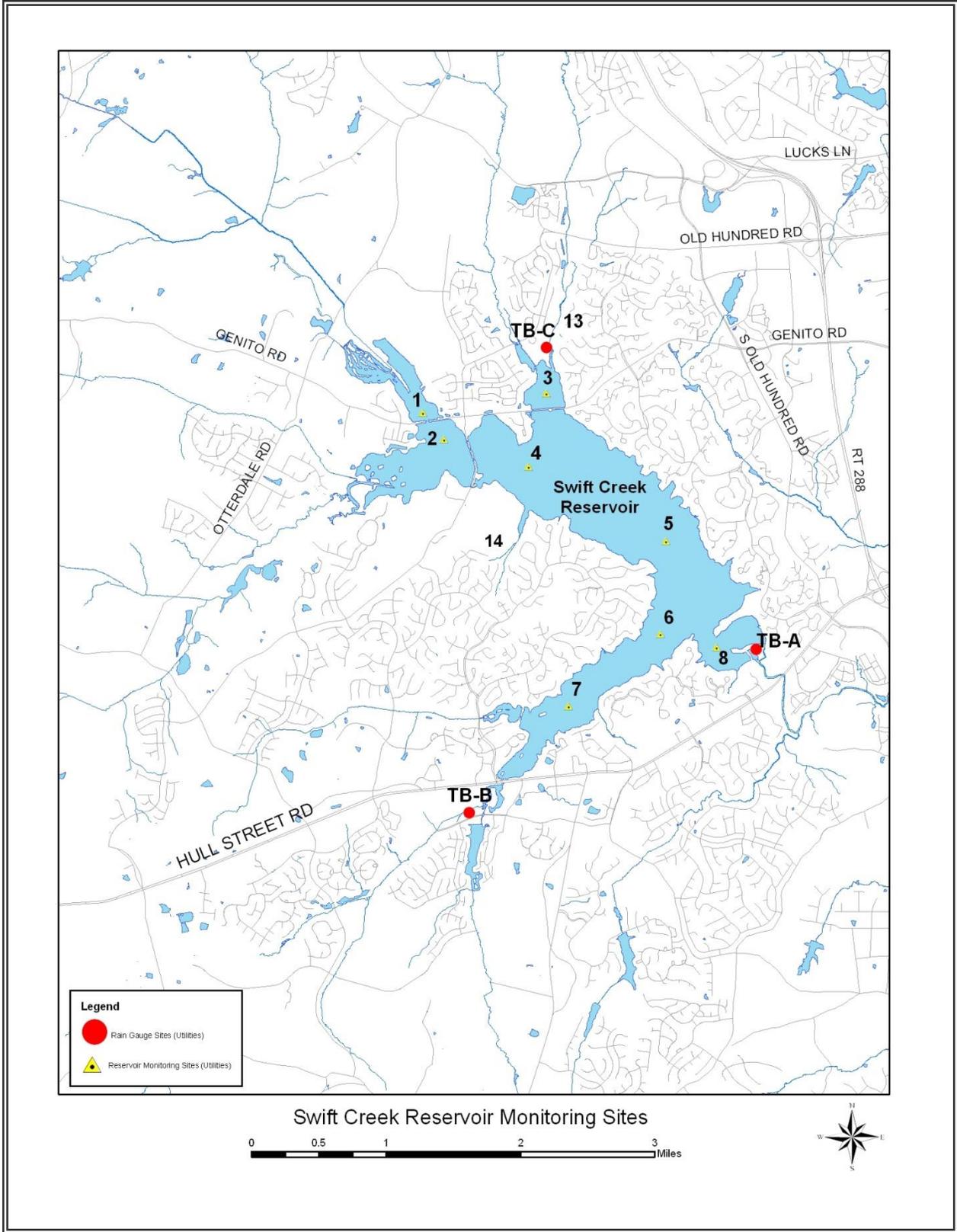


Figure 2. Map of Swift Creek Reservoir monitoring stations.

Water quality parameters (Table 1) were chosen to provide information on basic water quality and the ecological health of the reservoir. Details concerning specific analytical procedures are listed in Table 2.

Table 1. Sampling Regime for Swift Creek Reservoir 2018.

PARAMETER	RESERVOIR STATIONS 1,2,3,4,7	RESERVOIR STATIONS 5,6,8
DEPTH	X1	X1A
SECCHI DISC	X	X
WATER TEMPERATURE	X1	X1A
DISSOLVED OXYGEN (Given as mg/L & % saturation)	X1	X1A
CONDUCTIVITY	X1	X1A
pH	X1	X1A
OXIDATION REDUCTION POTENTIAL	X1	X1A
TOTAL PHOSPHORUS	X2	X3
ORTHO PHOSPHATE PHOSPHORUS	X2	X3
TOTAL KJELDAHL NITROGEN	X2	X3
OXIDIZED NITROGEN	X2	X3
AMMONIA NITROGEN	X2	X3
TOTAL ORGANIC CARBON	X2, 1/QTR	X2, 1/QTR
LEAD	X2, 1/QTR	X2, 1/QTR
ZINC	X2, 1/QTR	X2, 1/QTR
SUSPENDED SOLIDS/TURBIDITY	X2	X2
CHLOROPHYLL <i>a</i>	X4	X4
PHEOPHYTIN <i>a</i>	X4	X4
ALGAE COUNTS	X4	X4
<i>ESCHERICHIA coli</i> ( <i>E. coli</i> )	X2	X2

X1 – ONE METER INTERVALS

X1A – ONE FOOT INTERVALS

X2 – SURFACE SAMPLING ONLY

X3 – DISCRETE SAMPLES OF EPILIMNION, METALIMNION AND HYPOLIMNION WHEN STRATIFICATION EXISTS **OR** SURFACE, MID-DEPTH AND NEAR BOTTOM WHEN NO STRATIFICATION IS PRESENT

X4 – A COMPOSITE OF BENEATH SURFACE, 1/2/ SECCHI DEPTH, SECCHI DEPTH AND 1-1/2 SECCHI DEPTH SAMPLES

Table 2. Parameters and Analytical Methods 2018. When Reporting Limit based upon detection is not an applicable measurement for a parameter, it has been replaced by an estimation of accuracy (e.g. pH measurement has an estimated accuracy of 0.2 units) as indicated by (\*).

Parameter	Analytical Method	Detection Limit
Depth	Probe: Hydrolab MiniSonde	± 0.08 m*
Dissolved Oxygen	Probe: Hydrolab MiniSonde	± 0.2 mg/L*
Oxidation Reduction Potential	Probe: Hydrolab MiniSonde	± 20mV*
Water Temperature	Probe: Hydrolab MiniSonde	± 0.1 °C*
Conductivity	Probe: Hydrolab MiniSonde	± 0.1 µmhos/cm*
pH	Probe: Hydrolab MiniSonde	± 0.2 units
Secchi Depth	20 cm Standard Secchi Disk	± 0.1 ft*
Total Phosphorus	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Orthophosphate	Skalar:EPA Approved, Autom.	0.005 mg/L as P
Total Kjeldahl Nitrogen	Skalar:EPA Approved, Autom.	0.05 mg/L as N
Oxidized Nitrogen	Skalar:EPA Approved, Autom.	0.01 mg/L as N
Ammonia-N	Hach, Method 10205	0.015 mg/L as N
Total Organic Carbon	Standard Methods, 5310C	0.5 mg/L
Lead	EPA 200.9, Platform Furnace	2.5 µg/L
Zinc	EPA 289.1, Flame	50 µg/L
Total Suspended Solids	Standard Methods, 2540D	1.0 mg/L
Chlorophyll <i>a</i>	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Pheophytin <i>a</i>	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Algae Counts	Standard Methods, 10200F	1 cell/mL
<i>ESCHERICHIA coli</i> ( <i>E. coli</i> ) Density	Standard Methods, 9222B (Quanti-Tray)	1.0 MPN/100mL

**NOTE:** Standard Methods for the Examination of Water and Wastewater, 22th Edition.

### **Quality Assurance and Quality Control**

All analytical methods used were EPA approved, in accordance with *Standard Methods for the Examination of Water and Wastewater* (Standard Methods) with the exception of free ammonia analyses which were made following the Hach Chemical Company's test kit procedure. For each parameter analyzed, Method Detection Limits (MDL) were calculated following the EPA procedure as detailed in the *Code of Federal Regulations (CFR), Volume 46, Part 136 Appendix B (EPA, 1984)*. Stock and standard solutions were prepared from American Chemical Society reagent grade materials for preparation of calibration standards. Correlation coefficients were evaluated for each calibration curve and had to be greater than or equal to 0.995 to be used for analysis. To ensure calibration validity throughout an analysis, Continuing Calibration Verifications (CCV) standards were tested after every 10 samples analyzed. Similarly, Continuing

Calibration Blanks (CCB) were evaluated after every 10 samples to detect any baseline drift errors. With each analysis, field blanks and digestion/analytical blanks were evaluated to ensure detection of contamination during sampling or sample preparation. Independent source Standard Reference Materials (SRM) were purchased and used to verify the accuracy of each analysis calibration. When any standard (or SRM) was not within 10 percent (per EPA guidelines) of the true value, or CCB showed baseline drift, corrective actions were implemented. An ERA performance evaluation of blind nutrient samples in a split sampling study is performed annually. Reported concentrations for orthophosphate and total phosphorus, ammonia, oxidized nitrogen, and total Kjeldahl nitrogen continue to be within the limits of the ERA's acceptable analytical values. Manufacturers recommended preventive maintenance procedures were followed for all instruments.

## **Results and Discussion**

Eight stations in the reservoir were sampled monthly during 2018. Stations 5 and 8 were sampled twice per month throughout the year to obtain additional data for the deep-water areas. Sampling at all stations included surface grab samples and water column profiles of physical parameters. Supplemental bottom water quality samples were obtained at the mainbody Stations 5 and 8. Specific reports concerning reservoir data are available upon request from the Departments of Environmental Engineering or Utilities.

The county's water quality goal for the annual median concentration of total phosphorus in surface waters is 0.05 mg/L as P or less and was originally based on a Nutrient Controls Standards Workshop held in 1987 by the Virginia Department of Environmental Quality (VADEQ). In June 2006, VADEQ adopted freshwater nutrient standards for 116 lakes and reservoirs in Virginia, including the Swift Creek Reservoir. The EPA approved regulations in July of 2007 and the amended water quality standards [9 VAC 25 - 260] became effective August 14, 2007. These regulations set growing season (April through October) chlorophyll *a* and total phosphorus criteria for Swift Creek Reservoir at 35 µg/L (0.035 mg/L) and 40 µg/L (0.040 mg/L as P) respectively. These growing season measurements are intended not to be exceeded for two consecutive years as measured by the State in their Lake Monitoring Program. Specifically, VADEQ considers the reservoir nutrient enriched if the 90<sup>th</sup> percentile of the chlorophyll *a* data in surface waters of the main body of the reservoir (Stations 4, 5, 6, and 8) during the growing season exceeds the criteria for two consecutive years. However, algaecides use can make the chlorophyll *a* measurements unreliable. If algaecides are used, then both chlorophyll *a* and total phosphorus criteria are applicable. In the Swift Creek Reservoir, the algaecide sodium carbonate peroxyhydrate is used occasionally to spot treat algal blooms. The algaecide use is variable over the reservoir between

months and between years. Because of the algaecide treatments, analysis of the reservoir data has always included both the total phosphorus and chlorophyll *a* criteria. Additionally, VADEQ would consider the reservoir nutrient enriched if the growing season median concentration of total phosphorus in surface waters of the main body of the reservoir exceeded the criterion for two consecutive years. During 2018, approximately 400 pounds of sodium carbonate peroxyhydrate were applied during the months of March and May to the intake bay to treat algae growth in the reservoir. All applications of sodium carbonate peroxyhydrate were performed to improve source water quality for the optimization of the water treatment process within the plant. Algal blooms are known causes of taste and odor issues in drinking water and can clog filters, decreasing available potable water production and supply.

Two LG Sonic system buoy platforms were installed in the intake bay in December of 2017. These buoy platforms are floating, solar-powered systems that use real-time monitoring and ultrasonic sound waves to effectively control algae in lakes and reservoirs. The system has significantly decreased the need to apply algaecide treatments to the intake bay and allow for a more environmentally friendly manner to control the algae. These buoy platforms, the first deployed in the Commonwealth of Virginia, are a significant advancement for the water treatment plant and will assist in producing excellent quality drinking water.

### **Chlorophyll *a***

VADEQ has identified chlorophyll *a* as the most important parameter that can be measured to determine the nutrient enrichment status of a reservoir. Chlorophyll *a*, a green photosynthetic pigment found in algae, is an indirect measure of biological response to nutrient loadings. VADEQ considers the threshold value for nutrient enrichment in Swift Creek Reservoir to be the 90<sup>th</sup> percentile concentration that exceeds 35 µg/L, measured between April and October (*i.e.* the growing season) within the main body for two consecutive years. Sixty-nine (69) chlorophyll *a* samples from the eight sites were collected and analyzed during the growing season.

An increased concentration of chlorophyll *a* was observed in 2018 as compared to the previous year indicating an increased presence of algae in the reservoir. The growing season 90<sup>th</sup> percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 49.1 µg/L (Table 3), an increase from the 41.9 µg/L observed in 2017. In 2018, all eight of the stations combined had a 90<sup>th</sup> percentile concentration during the growing season of 46.2 µg/L, an increase from the 40.5 µg/L observed in 2017. The greatest individual measurement observed (97.9 µg/L) occurred at lacustrine Station 8 on June 13, 2018. The highest growing season 90<sup>th</sup> percentile concentration (58.4 µg/L) was observed at Station 5. Four stations (Stations 5, 6, 7 and 8) exceeded the 35 µg/L

criteria value for the growing season 90<sup>th</sup> percentile indicating higher than acceptable levels of algal growth at those sites.

*Table 3. Growing Season Chlorophyll a Concentrations (Surface) 2018.*

Station	Growing Season 90th Percentile Chlorophyll a (µg/L)
1	19.0
2	34.5
3	27.9
4	30.7
5	58.4
6	56.1
7	50.0
8	40.1
<b>Mainbody Stations (4, 5, 6, 8)</b>	<b>49.1</b>

### Total Phosphorus

Total phosphorus is measured as an indicator of nutrient enrichment. The VADEQ has adopted a freshwater nutrient criterion of 40 µg/L (0.040 mg/L as P), measured as the median value, for the surface waters of the reservoir’s main body for the growing season. Sixty-six (66) total phosphorus samples from the eight sites were collected and analyzed during the growing season. The growing season (April – October) median total phosphorus concentrations for each reservoir station are provided in Table 4.

*Table 4. Growing Season Median Total Phosphorus Concentrations (Surface) for 2018.*

Station	Growing Season Median Total Phosphorus (mg/L as P)
1	0.054
2	0.057
3	0.056
4	0.054
5	0.046
6	0.053
7	0.049
8	0.048
<b>Mainbody Stations (4, 5, 6, 8)</b>	<b>0.048</b>

In 2018, the growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.048 mg/L as P, decreased from the 0.067 mg/L

as P concentration noted in 2017. The growing season median value observed in the mainbody was above the VADEQ freshwater nutrient criterion threshold of 0.04 mg/L as P (Figure 3) for the second time since monitoring began and was the second highest observed in the reservoir to date. Each of the reservoir's stations had median phosphorus concentrations above the 0.04 mg/L as P threshold during the growing season indicating nutrient enrichment in both the lacustrine and shallow areas of the reservoir (Table 4). It should be noted that the state phosphorus criterion is only applicable for the lacustrine zone (Stations 4, 5, 6 and 8) and is not intended as a regulatory value for the shallow, backwater areas of the reservoir. During 2018, for all sites monitored in the reservoir, 78 individual measurements (69.0%) were at or exceeded 0.04 mg/L as P, a decrease from the 2018 observations (n=105; 87.5%). The annual median phosphorus concentration for all eight sites was 0.047 mg/L as P and was near the county's goal of 0.05 mg/L as P. The total phosphorus levels present in Swift Creek Reservoir indicated a consistent level of nutrient enrichment during 2018.

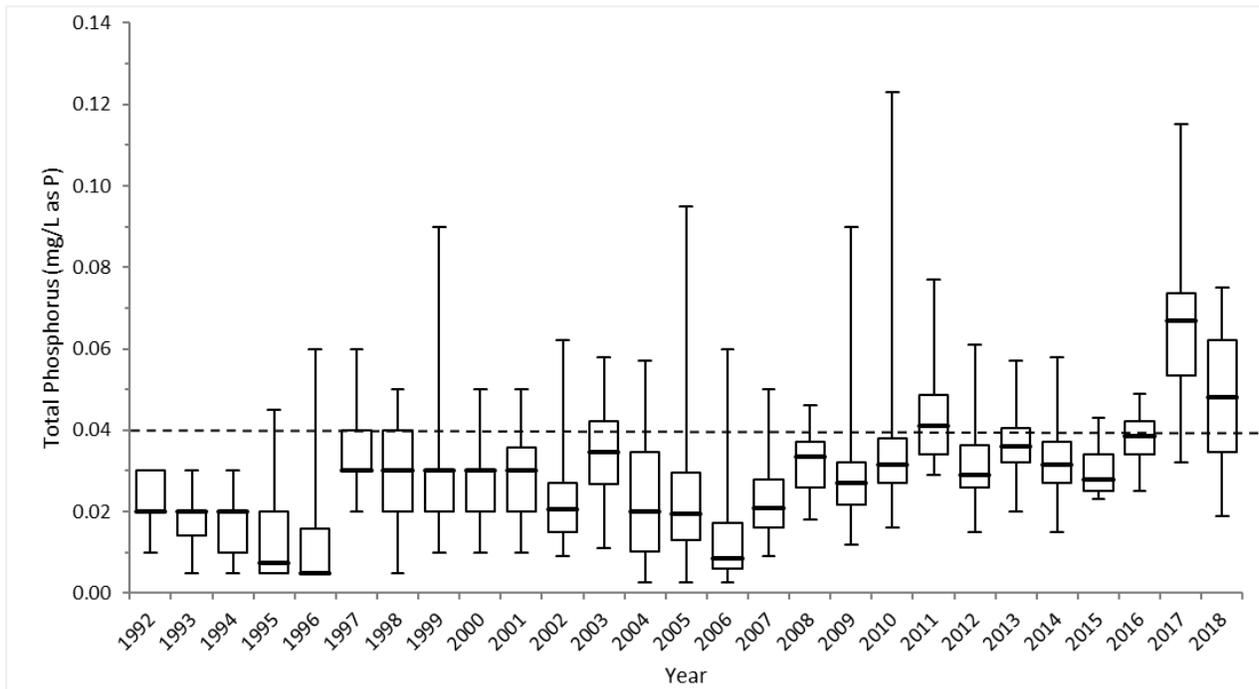


Figure 3. Box plot demonstrating the growing season median total phosphorus concentrations and ranges of observations for the surface waters of main body sites within Swift Creek Reservoir 1992 – 2018. The dashed line denotes VADEQ maximum threshold of 0.04 mg/L as P for acceptable water quality.

Higher concentrations of total phosphorus in anoxic (oxygen depleted) bottom waters as compared with surface water concentrations indicate active phosphorus release from sediments. The release of phosphorus from the sediments results in additional nutrient loading to the reservoir, as this

phosphorus is then mixed with the upper water layers during de-stratification. At Stations 5 and 8 during 2018, there were 29 instances where the concentrations of total phosphorus in the benthic sample were greater than the values obtained at the surface; an increase from the 22 instances observed in 2017. Of these 2018 instances, five were considered substantial (*i.e.*  $\geq 50\%$  difference), a decrease from the six observed substantial differences in 2017. The bottom phosphorus concentrations at Stations 5 and 8 ranged from 0.024 to 0.218 mg/L as P. This represented a median bottom concentration of 0.046 mg/L as P; similar to the annual median surface concentration (0.047 mg/L as P). The 2018 bottom concentration was decreased from the 2017 bottom concentration of 0.061 mg/L. All other differences noted were minor ( $\leq 50\%$  difference).

## **Dissolved Oxygen**

Adequately oxygenated water is critical for a healthy aquatic environment and as good quality source water for municipal treatment facilities. Hypoxic conditions occur when dissolved oxygen drops below 5.0 mg/L, resulting in stress on fish and other aquatic life. An anoxic condition occurs when dissolved oxygen drops below 1.0 mg/L, which can result in fish kills and the release of phosphorus, iron, manganese and other elements from the sediments. The release of these elements can result in increased algal blooms and treatment problems (undesirable tastes and odors) in the production of drinking water.

In July 2007, EPA approved the VADEQ's proposed dissolved oxygen standard (5.0 mg/L daily average, 4.0 mg/L minimum), which had been modified to account for naturally occurring decreases in dissolved oxygen due to thermal stratification in reservoirs. These new standards apply to the entire water column when the reservoir is well mixed and only to the surface waters (epilimnion) when the water column is vertically stratified. The most recent 2018 draft of VADEQ's 303(d) listing of impaired water bodies lists the Swift Creek Reservoir as fully supporting in all categories: aquatic life, fish consumption, recreational contact and wildlife.

Thermal stratification is a natural process in many lakes and reservoirs that occurs when summer conditions warm the upper water column while the lower water column remains cooler. The warmer surface waters become lighter than the colder and denser bottom waters, resulting in layers of water separated by a zone of sharply changing temperature, known as a thermocline, which inhibits vertical mixing. The thermal stratification continues until falling temperatures in the autumn cool the surface water sufficiently and disrupt the thermocline. Often a large fall storm event will result in rapid destratification of the lake.

During 2018, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in early April at Station 8 and early May at Station 5 lasting through the first week of November at both stations. Thermal stratification of Swift Creek Reservoir was first observed on May 3, 2018 at both Station 5 and 8, corresponding with the first substantial drop in dissolved oxygen levels at and near the bottom at Station 5. Stratification continued at both Station 5 and Station 8 until November 6, 2018, when the lake completed the seasonal turn over and became thoroughly mixed. During the stratification period, dissolved oxygen concentrations within the epilimnion were at or above the VADEQ standard of 4.0 mg/L minimum for all stations. The time period and degree of thermal and dissolved oxygen stratification within Swift Creek Reservoir were consistent with past observations.

### **Secchi Depth, Total Suspended Solids, Turbidity, Total Nitrogen and *E. coli***

During the 2018 growing season, 69 secchi depth readings, turbidity, total suspended solids, total nitrogen and *E. coli* samples from the eight sites were collected and analyzed. Secchi depth is a measurement of water transparency using a weighted black and white disk that is lowered into the water until the distinction between the black and white portions are no longer visible. The depth at which the distinction is no longer visible is then recorded as “Secchi disk transparency.” Secchi disk transparency is a function of the reflection of light from the surface of the disk. Secchi disk transparency is affected by the light absorption characteristics of the water as well as by dissolved and suspended particulate matter. It provides an estimate of water clarity and is closely related to turbidity.

*Table 5. Growing Season Median Values for Select Parameters (Surface) 2018*

<b>STATION</b>	<b>SECCHI DEPTH (Feet)</b>	<b><i>E. coli</i> DENSITY (MPN/100 mL)</b>	<b>TOTAL NITROGEN (mg/L as N)</b>	<b>TOTAL SUSPENDED SOLIDS (mg/L)</b>	<b>TURBIDITY (NTUs)</b>
1	2.5	8.6	0.48	7.2	8.0
2	2.0	2.6	0.56	7.6	10.1
3	2.0	16.0	0.55	5.6	9.5
4	2.5	7.5	0.53	5.6	5.7
5	2.5	6.3	0.53	4.8	5.1
6	2.3	3.1	0.48	4.4	5.4
7	2.0	8.6	0.46	5.2	6.4
8	3.0	16.8	0.56	4.2	4.6
<b>Mainbody Stations (4, 5, 6, 8)</b>	<b>2.8</b>	<b>8.0</b>	<b>0.53</b>	<b>4.4</b>	<b>5.3</b>

All stations had median growing season Secchi disk readings ranging from 2.0 to 3.0 feet (Table 5); these results are an increase in clarity when compared with the previous year. The 2018 growing season median value for all sites (2.8 feet) was similar to the median observed in 2017

(2.5 feet) with a slight increase in clarity observed throughout the reservoir. Individual site growing season medians for turbidity ranged from 4.6 to 10.1 NTUs with the greatest turbidity observed in the shallow backwater stations. The growing season turbidity median (6.2 NTUs) for all stations was similar to the median observed in 2017 (5.5 NTUs). The increases in Secchi disk depth and consistency of turbidity indicate an overall high degree of water clarity in 2018 and continue to reflect a high degree of water clarity throughout the reservoir system over time.

The 2018 growing season median total suspended solids concentration for all stations (5.2 mg/L) was slightly increased compared to the concentration observed in 2017 (4.4 mg/L). Overall, the growing season total suspended solids concentrations in the reservoir have continued to be consistently low supporting the observation of good water clarity. As in previous years, total nitrogen levels remained consistent throughout the reservoir with growing season median concentrations ranging from 0.46 to 0.56 mg/L as N (Table 5). The 2018 growing season median for all stations (0.52 mg/L as N) was consistent with the 2017 observation (0.48 mg/L as N) and indicated an unchanged degree in nitrogen enrichment throughout the reservoir. The mainbody stations' growing season medians were again consistent with the shallow backwater stations.

*E. coli* densities, as expressed as the Most Probable Number (MPN) of *E. coli* per 100mL, ranged from a growing season median of 2.6 MPN/100mL at Station 2 to 16.8 MPN/100mL at Station 8. The growing season median for all stations in 2018 was 9.6 MPN/100mL. There was one individual value greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season at Station 5 in October (275.5 MPN/100mL). During the non-growing season months, there were eight (8) instances in the reservoir when *E. coli* densities were greater than the VADEQ maximum threshold (6.9% of total observations). In these eight (8) instances, *E. coli* densities ranged from 240.0 to >2416.6 MPN/100mL.

### **Temperature, pH, Conductivity, Lead and Zinc**

Water temperature in Swift Creek Reservoir varied normally according to season during 2018. Surface temperatures throughout the reservoir ranged from 2.0°C to 30.2°C during the year with a median value of 16.0°C. No individual surface temperatures exceeded the VADEQ maximum standard of 32.0°C during 2018. Surface pH values ranged from 5.5 to 8.8 units with an annual in-lake median of 6.9 units, consistent with the annual pH concentrations previously observed. One of the individual surface values measured in 2018 fell outside of the 6.0 to 9.0 unit VADEQ acceptable range for pH. The observation occurred during the June 13, 2018 sample at Station 8 (5.5 units). Conductivity measurements within the reservoir ranged from 39 to 302 µS/cm with an annual median of 80 µS/cm; an observation consistent with previously recorded values. Thirty-one lead and zinc samples were collected and analyzed from all eight stations during the year. All

lead concentrations were below the reporting limit (<0.0025 mg/L) during 2018. There were also no measurable zinc concentrations observed in 2018 as each were below the laboratory’s detection limit (<0.05 mg/L).

### Algal Community Structure of Swift Creek Reservoir

In 2018, the Department of Utilities updated and refined the counting and identification of algae resulting in an increase in the number of descriptive phyla categories. A total of 56 individual genera of algae representing ten phyla were documented in Swift Creek Reservoir during 2018. The 2018 median algal density per month (3302 cells/mL) decreased by one fifth when compared with the 2017 (4080 cells/mL) density. Analysis of the general types of algae by phyla in Swift Creek Reservoir (Figure 4) indicated that the community structure to be comprised largely of diatoms (Bacillariophyta, 43.6%) and blue-green algae (Cyanoprokaryota, 31.0%). These two phyla combined represented 73.6% of the algal community observed. The frequency of occurrence for the taste and odor producing blue-green algae (Cyanoprokaryota, 31.0%) remained consistent with the 2017 frequency (36.5%) potentially accounting for any continued taste and odor complaints reported to the Department of Utilities.

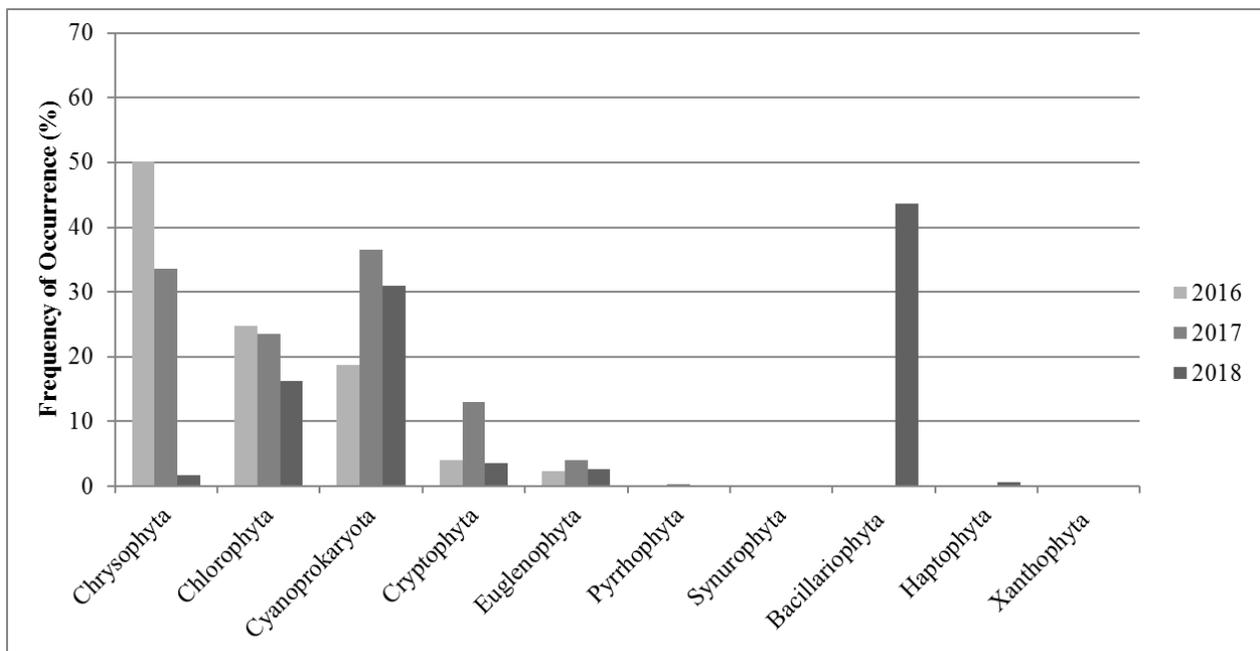


Figure 4. A comparison of the frequency of occurrence of six algae phyla observed in Swift Creek Reservoir 2016 - 2018.

The ten most common algal genera were identified (Table 6). These ten genera combined represented approximately 81% of all algae observed in 2018.

Table 6. Ten most common taxa of algae observed in Swift Creek Reservoir 2018.

Number	Phyla	Genus	% of Total Observed
1	Bacillariophyta	<i>Asterionella</i>	31.6
2	Cyanoprokaryota	<i>Cylindrospermopsis</i>	18.0
3	Cyanoprokaryota	<i>Planktolyngbya</i>	6.4
4	Chlorophyta	<i>Ankistrodesmus</i>	5.9
5	Bacillariophyta	<i>Melosira</i>	5.4
6	Cyanoprokaryota	<i>Pseudoanabaena</i>	3.5
7	Bacillariophyta	<i>Nitzschia</i>	2.9
8	Cyanoprokaryota	<i>Anabaena</i>	2.7
9	Chlorophyta	<i>Scenedesmus</i>	2.4
10	Chrysophyta	<i>Cryptomonas</i>	2.1

### Status of *Hydrilla* and its Control in the Swift Creek Reservoir

The rapid growing invasive aquatic weed, *Hydrilla verticillata*, was first identified in the Swift Creek Reservoir in August 2009. Action for the long-term management of *Hydrilla* was initiated by the introduction of triploid grass carp (*Ctenopharyngodon idella*) to the reservoir in April 2010. In September 2011 the grass carp population was observed as healthy and the fish growing in size, correlating with the observed density reduction in the *Hydrilla*. Surveys conducted during 2012 and again in 2013 confirmed the grass carp were effective in controlling the *Hydrilla* growth.

While the more vegetative structures of the *Hydrilla* plant had been minimized in 2012 and 2013, in 2014 the *Hydrilla* biomass reestablished itself in the reservoir. Because reestablishment of some *Hydrilla* was anticipated as a function of the plant's reproductive strategies, additional triploid grass carp were stocked into the reservoir in April 2015 to maintain the *Hydrilla* biomass at a manageable level and the grass carp remained very effective in controlling *Hydrilla* in 2016. The majority of the reservoir remained clear of *Hydrilla* coverage through the 2016 growing season. The *Hydrilla* coverage in the reservoir increased but remained manageable in 2017 and 2018. More detailed information about the Department of Utilities strategies and current updates on the ongoing control efforts of *Hydrilla* can be found on the department's webpage under the Swift Creek Reservoir page: <https://www.chesterfield.gov/428/Swift-Creek-Reservoir>

## Conclusion

Indicators of water quality continue to suggest acceptable conditions in the Swift Creek Reservoir. An increased concentration of chlorophyll *a* was observed in 2018 as compared to the previous year indicating an increased presence of algae in the reservoir. Throughout the reservoir, total phosphorus concentrations decreased as compared with observations from 2017. The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.048 mg/L as P and, for the second time, exceeded the VADEQ nutrient threshold of 0.04 mg/L as P. The annual median phosphorus concentration for the surface water at all eight sites in Swift Creek Reservoir was 0.047 mg/L as P, near the county threshold goal of 0.05 mg/L as P.

As in prior years, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in early May and lasting through the first week of November. During this stratification period, dissolved oxygen concentrations within the epilimnion remained above the VADEQ standard of 4.0 mg/L for all stations.

The median Secchi disk readings during the growing season ranged from 2.0 to 3.0 feet and were increased from the medians noted in prior reports. Individual site growing season medians for turbidity ranged from 4.6 to 10.1 NTUs with the greatest measurements observed in the shallow backwater stations. The growing season total nitrogen concentrations continued to be similar to those observed in past years with site medians ranging from 0.46 to 0.56 mg/L as N and indicated an unchanged degree in nitrogen enrichment. There was one observation of individual *E. coli* density values greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season. Water temperature in Swift Creek Reservoir varied normally throughout the year. Surface pH values ranged from 5.5 to 8.8 units. Conductivity values within the reservoir were acceptable with an annual median of 80  $\mu$ S/cm. All lead concentrations were below the reporting limit (<0.0025 mg/L) during 2017. There was no measurable zinc concentration observed in 2017 as each were below the laboratory's detection limit (<0.05 mg/L).

A total of 56 individual genera of algae representing ten distinct phyla were documented in Swift Creek Reservoir during 2018 and analysis of the general types of algae indicated that the community structure continued to be dominated by diatoms and blue-green algae. The continued presence of blue-green algae potentially accounted for a portion of any taste and odor complaints reported in 2018. The 2018 *Hydrilla* coverage in the reservoir was comparable to 2017 coverage levels and remained manageable.