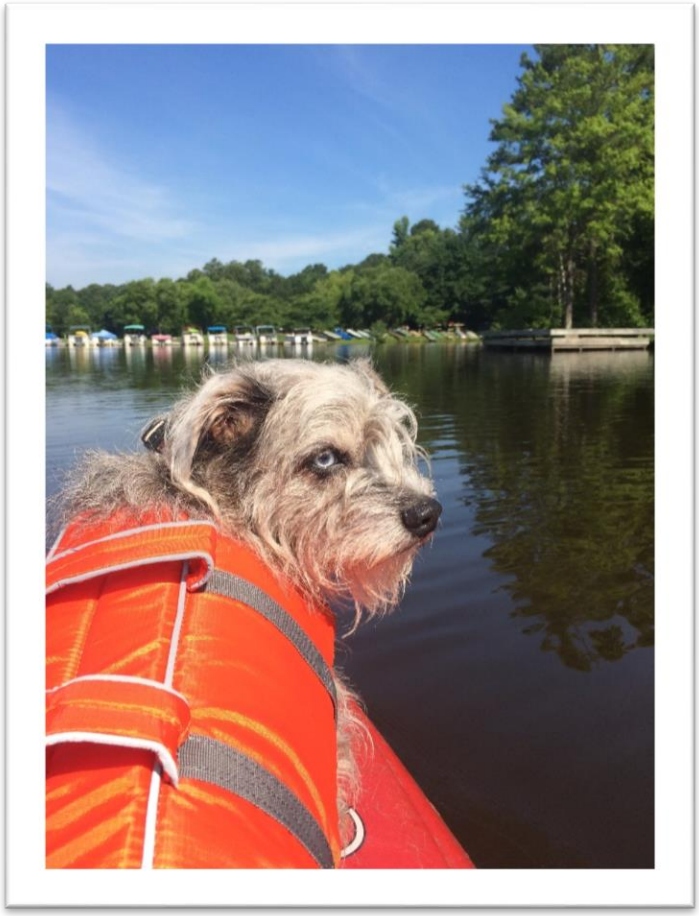
Swift Creek Reservoir
Water Quality Data Report 2017



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

September 2018

Table of Contents

List of Figures and Tables

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 2017 and represents the twenty fifth consecutive year of monitoring of the Swift Creek Reservoir. During 2017, pool elevations measured at the dam ranged from 176.2 to 178.0 feet above mean sea level. Full pool elevation is controlled by a concrete spillway at 177.0 feet, this corresponds to an approximate reservoir volume of 5.0 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 42.37 inches, approximately equal to the 32-year long-term average. During 2017, approximately 2800 pounds of copper sulfate were applied during May, June and July to treat algae growth in the reservoir. The applications of copper sulfate 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 control blue-green algae in lakes and reservoirs.

A decreased concentration of chlorophyll *a* was observed in 2017 as compared to the previous year indicating a decreased presence of algae in the reservoir. The growing season 90^{th} percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 41.9 µg/L (Table 4), approximately a 27% percent decrease from the 57.1 µg/L observed in 2016.

Throughout the reservoir, total phosphorus concentrations increased in 2017 and were the highest 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 0.067 mg/L as P. An increase in the concentration of total phosphorus released from the sediments during the summer stratification period at Stations 5 & 8 was noted during 2017.

During 2017, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late April and lasting through the first week of October. 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 1.5 to 3.0 feet, an increase in clarity when compared with prior reports. The growing season turbidity median for the mainbody stations (4.8 NTUs) was approximately 23% lower than the median observed in 2016 (6.2 NTUs). The observed increases in Secchi disk depth and decreases in turbidity indicate an overall improvement

in water clarity in 2017 and continue to reflect a high degree of water clarity throughout the reservoir system over time. The 2017 growing season median total suspended solids concentration for mainbody stations (4.0 mg/L) was slightly decreased compared to the concentration observed in 2016 (4.8 mg/L). Total nitrogen levels remained consistent with 2016 concentrations throughout the reservoir with growing season median concentrations ranging from 0.42 to 0.52 mg/L as N. *E. coli* median densities remained acceptable with no individual value greater than the VADEQ single sample maximum of 235 E. coli colonies/100mL observed during the growing season.

Water temperature in Swift Creek Reservoir varied normally according to season during 2017. Surface pH values ranged from 6.2 to 9.4 units with an annual in-lake median of 7.1 units. Conductivity measurements within the reservoir ranged from 44 to 150 µS/cm with an annual median of 81 µS/cm. All lead concentrations were below the reporting limit (<0.0025 mg/L) during 2017. There were no measurable zinc concentrations observed in 2017 as each were below the laboratory's detection limit (<0.05 mg/L).

A total of 52 individual genera of algae representing six phyla were documented during 2017. Analysis of the general types of algae by phyla in the reservoir indicated that the community structure continued to be comprised largely of blue-green algae (Cyanoprokaryota), golden algae/diatoms (Chrysophyta) and green algae (Chlorophyta). The frequency of occurrence for blue-green algae concentration approximately doubled when compared to 2016, golden algae/diatoms decreased by approximately 20% and green algae remained approximately the same.

In 2014, the *Hydrilla* biomass reestablished itself in the reservoir. In April 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. The management goal for *Hydrilla* in Swift Creek Reservoir is to establish 10 to 25 percent bottom coverage by aquatic vegetation during the growing season. 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: http://www.chesterfield.gov/Utilities.aspx?id=8590144713

Introduction

This report presents the water quality data collected by the Addison-Evans Water Production and Laboratory staff between January and December 2017 and is the twenty fifth 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 42.37 inches during 2017 (Figure 1). Rainfall was equivalent to the long-term average observed over the last 32 years (42.89 inches). During 2017, pool elevations measured at the dam ranged from 176.2 to 178.0 feet above mean sea level, full pool elevation is controlled by a concrete spillway at 177.0 feet corresponding to an approximate reservoir volume of 5.0 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.

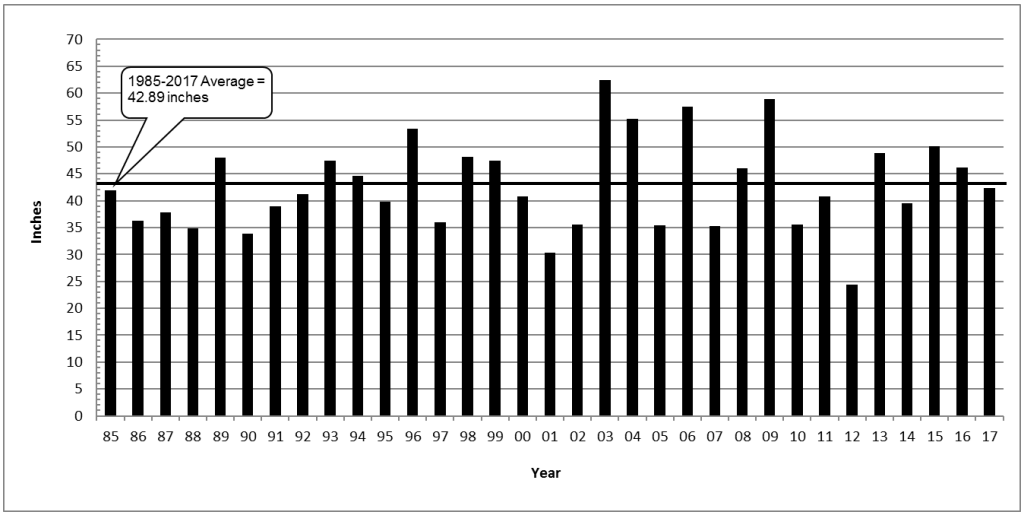


Figure 1. Total Annual Estimated Rainfall Recorded for Swift Creek Reservoir Watershed from 1985-2017 (Source data: Department of Utilities).

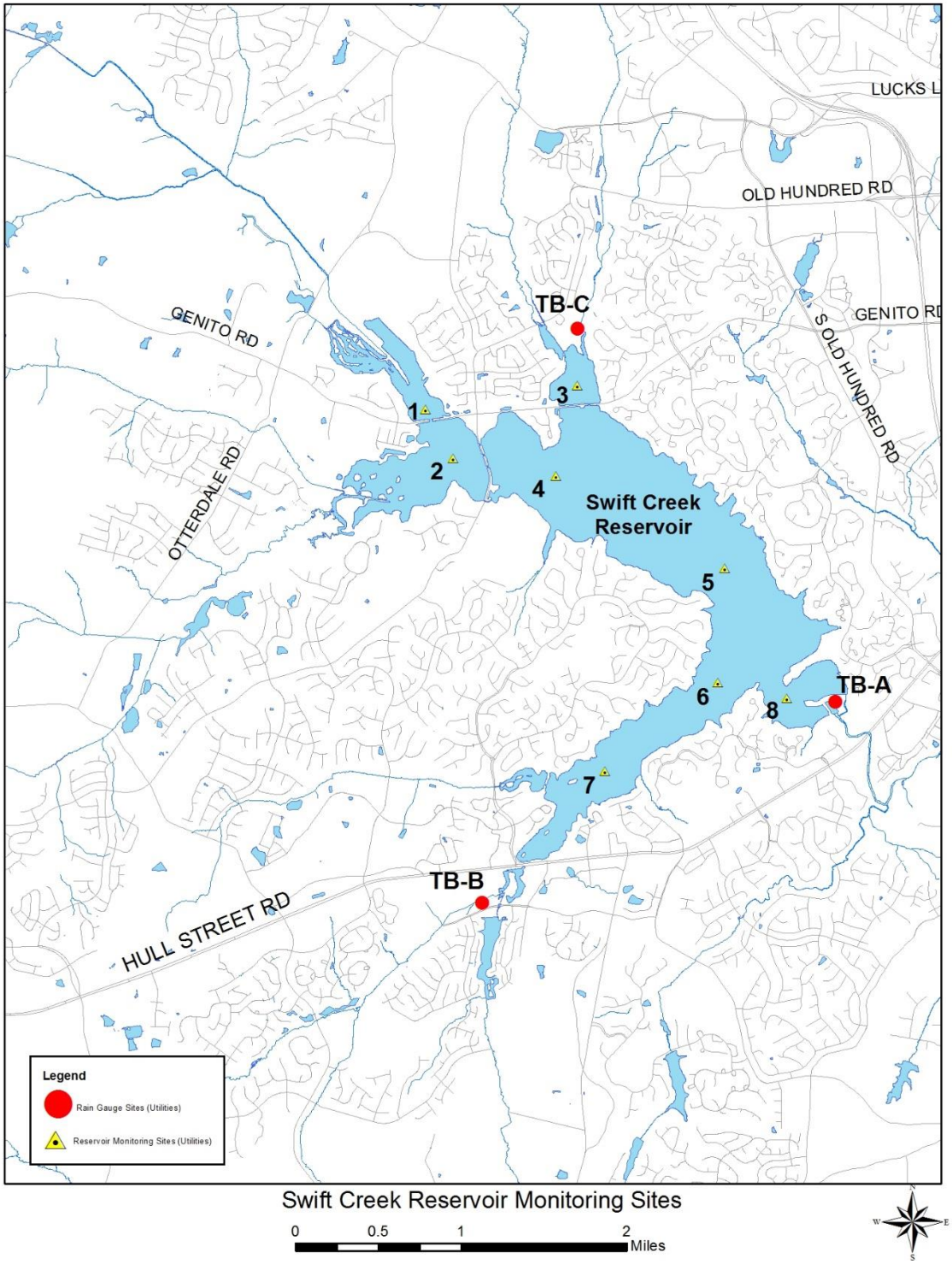


Figure 2. Map of Swift Creek Reservoir monitoring stations.

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 2017.

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 *a*	X4	X4
PHEOPHYTIN *a*	X4	X4
ALGAE COUNTS	X4	X4
ESCHERICHIA coli (E. coli)	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
QTR - Quarter

Table 2. Parameters and Analytical Methods 2017. 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 ^{o}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 *a*	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Pheophytin *a*	Standard Methods, 10200H-3, Fluorom.	1.0 µg/L
Algae Counts	Standard Methods, 10200F	1 cell/mL
ESCHERICHIA coli (E. coli) 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 2017. 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 main body Stations 5 and 8. Specific reports concerning reservoir data are available upon request from the Departments of Environmental Engineering or Utilities.

In the Swift Creek Reservoir, the algaecide copper sulfate is used occasionally to spot treat algal blooms and its use is variable over the reservoir between months and between years. During 2017, approximately 2800 pounds of copper sulfate were applied during the months of May, June and July to treat algae growth in the reservoir. Twenty-two hundred (2200) pounds were applied throughout the month of May to the reservoir covering areas in the mainbody and intake bays. In June, 400 total pounds were applied to the intake bay - split between two application events. One application occurred in late July of 200 pounds to the intake bay. All applications of copper sulfate 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 control blue-green algae in lakes and reservoirs. These buoy platforms, the first deployed in the Commonwealth of Virginia, are an additional algae control measure and will assist in maintaining source water quality in the reservoir intake bay.

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. Seventy (70) chlorophyll *a* samples from the eight sites were collected and analyzed by Utilities staff during the growing season.

A decreased concentration of chlorophyll *a* was observed in 2017 as compared to the previous year indicating a reduced presence of algae in the reservoir. The growing season 90th percentile concentration for the mainstem reservoir stations (Stations 4, 5, 6 and 8) was 41.9 µg/L (Table 3), approximately a 27% percent decrease from the 57.1 µg/L observed in 2016. The greatest individual measurement of chlorophyll *a* observed (75.8 µg/L) occurred at lacustrine Station 8 on July 31, 2018.

Table 3. Growing Season Chlorophyll a *Concentrations (Surface) 2017.*

Station	Growing Season 90th Percentile Chlorophyll *a* (µg/L)
1	16.1
2	22.7
3	21.0
4	34.2
5	35.3
6	39.0
7	50.7
8	48.1
Mainbody Stations (4, 5, 6, 8)	**41.9**

Total Phosphorus

Total phosphorus is measured as an indicator of nutrient enrichment. Seventy (70) total phosphorus samples from the eight sites were collected and analyzed by Utilities staff during the growing season. The growing season (April – October) median total phosphorus concentrations for each reservoir station are provided in Table 4.

In 2017, the growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.067 mg/L as P; increased from the 0.039 mg/L as P concentration in 2016. The 2017 sampling year was the first time since monitoring began that the growing season total phosphorus exceeded 0.04 mg/L and was the highest observed in the

reservoir to date. The total phosphorus levels present in Swift Creek Reservoir indicate a consistent level of nutrient enrichment during 2017.

Table 4. Growing Season Median Total Phosphorus Concentrations (Surface) for 2017.

Station	Growing Season Median Total Phosphorus (mg/L as P)
1	0.077
2	0.095
3	0.066
4	0.070
5	0.065
6	0.067
7	0.073
8	0.067
Mainbody Stations (4, 5, 6, 8)	**0.067**

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 2017, there were 22 instances where the concentrations of total phosphorus in the benthic sample were greater than the values obtained at the surface; the same number as observed in 2016. Of these 2017 instances, six were considered substantial (*i.e.* ≥ 50% difference), a doubling of the three observed substantial differences in 2016. The bottom phosphorus concentrations at Stations 5 and 8 ranged from 0.028 to 0.213 mg/L as P. This represented a median bottom concentration of 0.061 mg/L as P; slightly below the growing season median surface concentration (0.067 mg/L as P). The 2017 bottom concentration was increased from the 2016 bottom concentration of 0.042 mg/L. All other differences noted were minor (≤ 50% difference).

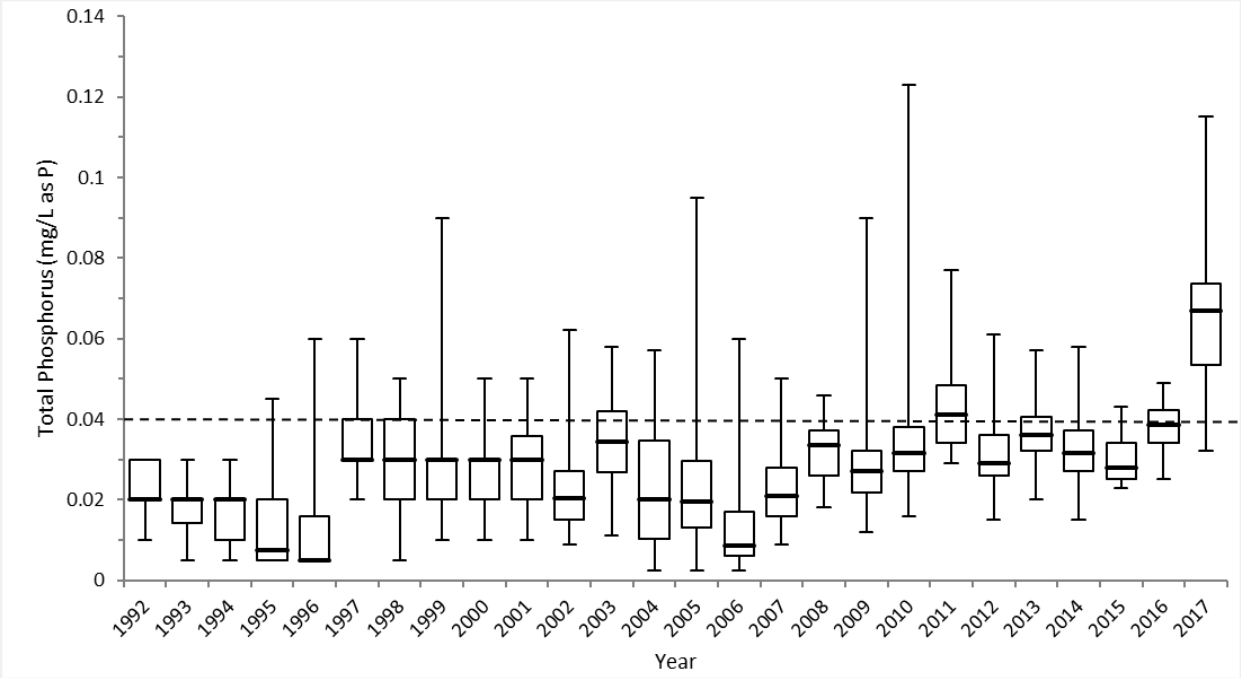


Figure 3. Box plot demonstrating the growing season median total phosphorus concentrations and ranges of observations for the surface waters of main body sites within Swift Creek Reservoir 1992 – 2017. The dashed line denotes 0.04 mg/L as P.

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 2016 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.

During 2017, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late April and lasting through the first week of October at both Station 5 and Station 8. Thermal stratification of Swift Creek Reservoir was first observed on April 17, 2017 at both Station 5 and 8, corresponding with the first substantial drop in dissolved oxygen levels at and near the bottom. Stratification continued at both Station 5 and Station 8 until October 3, 2017, when the lake completed the seasonal turn over and became thoroughly mixed. During the stratification period, dissolved oxygen concentrations within the epilimnion were 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 2017 growing season, 77 secchi depth readings and 70 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.

All stations had median growing season Secchi disk readings ranging from 1.5 to 3.0 feet (Table 5); these results are an increase in clarity when compared with the previous year. The 2017 growing season median value for all the mainbody stations (2.5 feet) was a half foot deeper than the median observed in 2016 (2.0 feet) with the increase in clarity correlated to the decreased algae density observed throughout the reservoir. Individual site growing season medians for turbidity ranged from 4.5 to 13.1 NTUs with the greatest turbidity observed in the shallow backwater stations. The growing season mainbody station turbidity median (4.8 NTUs) was approximately

23% lower than the median observed in 2016 (6.2 NTUs). The observed increases in Secchi disk depth and decreases in turbidity indicate an overall improvement in water clarity in 2017 and continue to reflect a high degree of water clarity throughout the reservoir system over time.

Table 5. Growing Season Median Values for Select Parameters (Surface) 2017.

STATION	SECCHI DEPTH (Feet)	E. coli DENSITY (MPN/100 mL)	TOTAL NITROGEN (mg/L as N)	TOTAL SUSPENDED SOLIDS (mg/L)	TURBIDITY (NTUs)
1	2.0	4.1	0.48	11.2	9.3
2	1.5	1.0	0.47	6.0	13.1
3	2.0	4.1	0.42	3.2	10.8
4	2.5	1.0	0.45	3.6	5.5
5	2.5	2.0	0.50	4.2	4.8
6	2.5	1.0	0.50	4.8	5.2
7	2.5	5.2	0.46	4.8	5.2
8	3.0	10.9	0.52	3.6	4.5
Mainbody Stations (4, 5, 6, 8)	**2.5**	**3.1**	**0.50**	**4.0**	**4.8**

The 2017 growing season median total suspended solids concentration for mainbody stations (4.0 mg/L) was decreased compared to the concentration observed in 2016 (4.8 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 0.42 to 0.52 mg/L as N (Table 5). The 2017 growing season median for mainbody stations (0.50 mg/L as N) was consistent with the 2016 observation (0.49 mg/L as N) and indicated an unchanged degree in nitrogen enrichment throughout the reservoir.

E. coli densities, as expressed as the Most Probable Number (MPN) of *E. coli* per 100mL, ranged from a growing season median of 1.0 MPN/100mL at Stations 2, 4 and 6 to 10.9 MPN/100mL at Station 8. The growing season median for the mainbody stations in 2017 was 3.1 MPN/100mL. There were no individual values greater than the VADEQ single sample maximum of 235 *E. coli* colonies/100mL during the growing season. During the non-growing season months, there were five (5) instances in the reservoir when *E. coli* densities were greater than the VADEQ maximum threshold (4.2% of total observations) and the frequency was decreased from the 13 observed in 2016. In these five (5) instances, *E. coli* densities ranged from 307.6 to 816.4 MPN/100mL. Three (3) observations exceeding the state standard were observed at Station 5, which had the most frequent occurrence of exceedances, and the remaining occurred at Station 4 (n=2).

Temperature, pH, Conductivity, Lead and Zinc

Water temperature in Swift Creek Reservoir varied normally according to season during 2017. Surface temperatures throughout the reservoir ranged from 4.4^{o}C to 31.4^{o}C during the year with a median value of 19.3^{o}C. Eight (8) individual surface temperatures exceeded the VADEQ maximum standard of 32.0^{o}C during 2017. All temperature exceedances occurred on July 17, 2017 at each station. Surface pH values ranged from 6.2 to 9.4 units with an annual in-lake median of 7.1 units, consistent with the annual pH concentrations previously observed. Two of the individual surface values measured in 2017 fell outside of the 6.0 to 9.0 unit VADEQ acceptable range for pH. They both occurred during the September 11, 2017 sample at Station 1 (9.4 units) and Station 3 (9.4 units). Conductivity measurements within the reservoir ranged from 44 to 150 µS/cm with an annual median of 81 µS/cm; an observation consistent with previously recorded values. Thirty-two 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 2017. There were also no measurable zinc concentrations observed in 2017 as each were below the laboratory's detection limit (<0.05 mg/L).

Algal Community Structure of Swift Creek Reservoir

A total of 52 individual genera of algae representing six phyla were documented in Swift Creek Reservoir during 2017. The 2017 median algal density per month (4080 cells/mL) decreased by one third when compared with the 2016 (6219 cells/mL) density. Analysis of the general types of algae by phyla in Swift Creek Reservoir (Figure 4) indicated that the community structure continued to be comprised largely of blue-green algae (Cyanoprokaryota, 36.5%), golden algae/diatoms (Chrysophyta, 33.6%), green algae (Chlorophyta, 22%). These three phyla combined represented 92.1% of the algal community observed in 2017; this was approximately consistent with the 97.9% dominance composition observed in 2016. The frequency of occurrence for blue-green algae (Cyanoprokaryota, 36.5%) approximately double as compared to 2016 (18.7%) and was also increased from the 2015 quantity observed (28.3%). Since 2015, green algae Chlorophyta has decreased from 31.7% to 24.7% in 2017, similar to 23.5% of 2016.

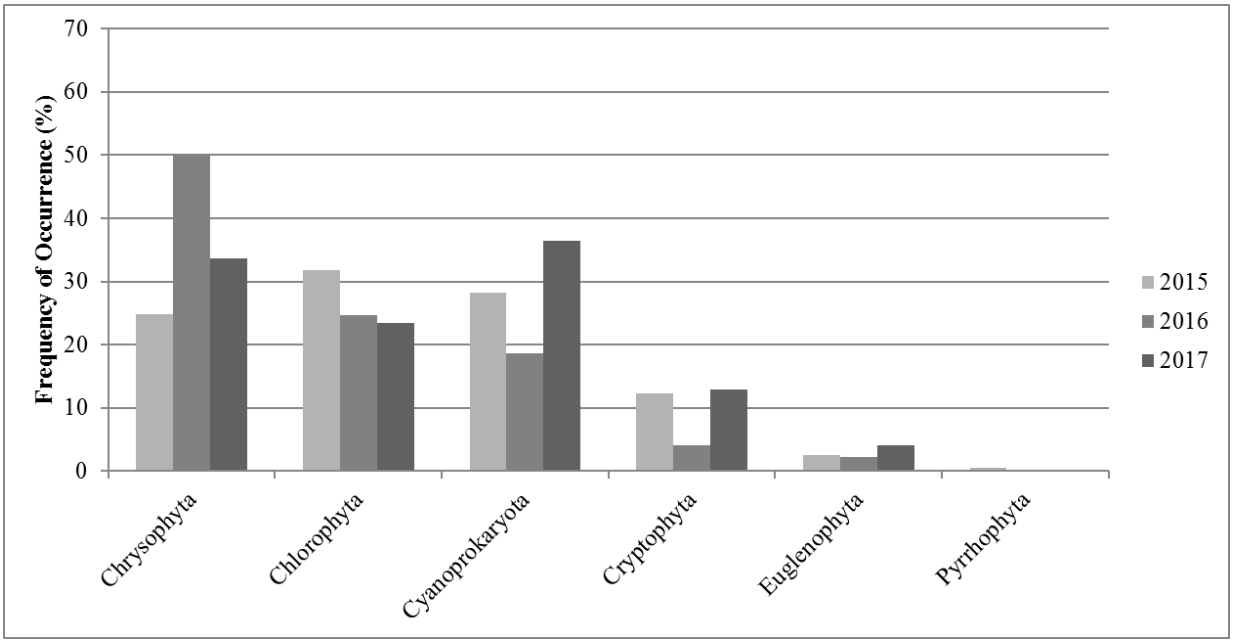


Figure 4. A comparison of the frequency of occurrence of six algae phyla observed in Swift Creek Reservoir 2015 - 2017.

The ten most common algal genera were identified (Table 6). These ten genera combined represented approximately 79% of all algae observed in 2017. Seven of these genera are known to potentially affect the taste and odor of production water.

Table 6. Ten most common taxa of algae observed in Swift Creek Reservoir 2017.

Number	Phyla	Genus	% of Total Observed
1	Cyanoprokayota	*Anabaena*	30.1
2	Chrysophyta	*Melosira*	12.6
3	Chrysophyta	*Tabellaria*	10.8
4	Chlorophyta	*Ankistrodesmus*	4.7
5	Chlorophyta	*Dictyosphaerium*	4.4
6	Chlorophyta	*Raciborskiella*	3.8
7	Chrysophyta	*Asterionella*	3.7
8	Chlorophyta	*Scenedesmus*	3.3
9	Chlorophyta	*Crucigenia*	3.1
10	Cryptophyta	*Chroomonas*	2.9

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 growth correlated with the observed density reduction in the *Hydrilla*. Surveys conducted during 2012 and again in 2013 confirmed the grass carp to be effective in controlling the *Hydrilla* growth.

While the more vegetative structures of the *Hydrilla* plant had been minimalized 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. The grass carp remained 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. The management goal for *Hydrilla* in Swift Creek Reservoir is to establish 10 to 25 percent bottom coverage by aquatic vegetation during the growing season. 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: http://www.chesterfield.gov/Utilities.aspx?id=8590144713

Conclusions

Indicators of water quality continue to suggest acceptable conditions in the Swift Creek Reservoir. Except for total phosphorus, all other water quality indicators were improved when compared with the 2016 observations. The Department of Utilities worked to control algal blooms with the use of copper sulfate during the year and a decreased concentration of chlorophyll *a* was observed in 2017 as compared to the previous year. This practice follows historical control methods used in previous years. Throughout the reservoir, total phosphorus concentrations increased as compared with observations from previous years. The growing season median total phosphorus concentration for the surface waters of the main body stations (Stations 4, 5, 6 and 8) was 0.067 mg/L as P. An increase in the concentration of total phosphorus released from the sediments during the summer stratification period at Stations 5 & 8 was noted during 2017.

As in prior years, the reservoir exhibited consistent thermal and dissolved oxygen stratification in its deeper sections beginning in late April and lasting through the first week of October. 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 1.5 to 3.0 feet and were increased from the medians noted in prior reports. Individual site growing season medians for turbidity ranged from 4.5 to 13.1 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 0.42 to 0.52 mg/L as N and indicated an unchanged degree in nitrogen enrichment. There were no observations 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 6.0 to 9.6 units. Conductivity values within the reservoir were acceptable with an annual median of 81 µS/cm. All lead concentrations were below the reporting limit (<0.0025 mg/L) during 2017. There were no measurable zinc concentrations observed in 2017 as each were below the laboratory's detection limit (<0.05 mg/L).

A total of 52 individual genera of algae representing six distinct phyla were documented in Swift Creek Reservoir during 2017 and analysis of the general types of algae indicated that the community structure continued to be dominated by blue-green algae, golden algae/diatoms, and green algae. The 2017 *Hydrilla* coverage in the reservoir increased when compared with 2016 coverage levels but remained manageable.