HRSD SWIFT Research Center (SRC) Quarterly Report on SWIFT Water Quality Targets

This report documents SWIFT Water Quality results for recharge operations from January 1 – March 31, 2020. The compliance requirements are documented in HRSD's SWIFT Underground Injection Control Inventory Information Package (UIC-IIP) submitted to EPA Region III in January 2018. These requirements are noted in Tables 1-4. While table 2-4 are identical to those originally submitted with the UIC-IIP, Table 1 is being revised effective with this quarterly report. The total coliform limit has been revised following discussion with Virginia Department of Health (VDH) and EPA Region III UIC staff. Total coliform monitoring and compliance is discussed in greater detail on page 2 of this report.

Figures 1 and 2 and Table 6 provide a summary of the data from the referenced quarter of operations relative to the SWIFT Water Quality Targets. Table 6 represents a summary of all analytes that were present above the laboratory reporting limit. A detailed table identifying the parameters monitored for the purpose of evaluating compliance with the SWIFT Water Quality Targets can be found as an Appendix to this report.

Parameter	Proposed Regulatory Limit	Non-Regulatory Action/Goal
EPA Drinking Water Primary Maximum Contaminant Levels (MCLs)	Meet all primary MCLs	N/A
Total Nitrogen	5 mg/L Monthly Average; 8 mg/L Max Daily	Secondary Effluent Critical Control Point (CCP) Action Limit for Total Inorganic Nitrogen (TIN) = 5 mg/L-N; CCP Action Limit for SWIFT Water Total Nitrogen (TN) = 5 mg/L-N
Turbidity	Individual Filter Effluent (IFE) < 0.15 NTU 95% of time and never >0.3 NTU in two consecutive 15 min measurements	CCP Action Limit IFE of 0.10 NTU to initiate backwash or place a filter in standby
Total Organic Carbon (TOC)[1]	4 mg/L Monthly Average 6 mg/L Maximum	Critical Operating Point (COP) Action Limit to Initiate GAC Regeneration
Total Coliform[2]	<2 CFU/100 mL for 95% of calendar month observations, applied as the 95th percentile	N/A
E.coli	Non-detect	N/A
TDS[3]	N/A	Monitor PAS Compatibility

Table 1: SRC Regulatory and Monitoring Limits for SWIFT Water

[1] Regulatory limit applies to the TOC laboratory analysis which is collected at a frequency of 3 times per week.

[2] The TC monitoring requirement for the SRC originally included compliance with a geometric mean of 3 CFU/100 mL for a running 20 daily samples. The Virginia Department of Health (VDH) determined that the requirement to meet TC < 2 CFU/100 mL 95% of the time within a given month was protective of this geometric mean requirement, and the application of both regulatory limits was not necessary. Following consultation with EPA Region III UIC staff, the geometric mean requirement has been removed as an additional TC compliance requirement.

[3] No limit for TDS proposed as the primary driver is aquifer compatibility. The concentration of SWIFT Water at the SRC generally ranges from 500-850 mg/L.

Total Coliform Investigation

Since the start-up of the SRC through Quarter 4 of 2019, there were a total of 4 total coliform detections in SWIFT Water (once in October 2018 and August 2019 and twice in December 2019). The detection on December 31, 2019 was followed by two additional detections on January 1 and January 4 (2 CFU/100 mL, 3 CFU/100 mL and 1 CFU/100mL, respectively). At no time in SRC operation has E. coli been detected in SWIFT Water samples. Process monitoring near the outlet of UV reactors as part of this investigation indicated that total coliform was not present immediately following disinfection (numerous special samples were collected; all data will be shared in the upcoming research report for this period).

With each of the initial total coliform detections in 2018 and 2019, HRSD worked with staff to ensure they were fully trained and following proper aseptic sampling protocols. With the December 2019 and January 2020 detections, it was clear that another factor was influencing the sample results. HRSD suspended recharge operations for the remainder of the month of January to conduct multiple investigations into the source of the contamination. Repeated cycles of free chlorine flushes combined with process monitoring to isolate varying potential sources failed to conclusively identify the source of the total coliform contamination.

Following a continuous free chlorine flush (24 hours, ~ 25 mg/L as Cl_2) at the end of January, HRSD confirmed non-detect total coliform results, returned to the use of monochloramine post-UV and initiated recharge on February 5. On February 7, there was a total coliform detection of 1 CFU/100 mL followed by 2 days of non-detect results. The samples collected on February 10 and 11 both returned results of 2 CFU/100 mL. The results for February 10 were available for staff review on February 11 and recharge operations were suspended on that date to develop a plan for additional investigation and total coliform management. Beginning on February 14, HRSD switched to the use of free chlorine following UV disinfection. Free chlorination continued through March 1. During this period, additional SWIFT Water samples were analyzed for disinfection by-products to confirm that these concentrations remained well below the PMCLs (see Table 6).

Beginning March 2, HRSD resumed the use of monochloramine post-UV. Samples collected March 2 and March 3 had elevated concentrations of total coliforms (21 CFU/100 mL and 4 CFU/100 mL, respectively). Upon receiving the results from March 2, operations were immediately suspended. Recharge resumed on March 5 with the use of free chlorine post-UV. Replacing chloramine with free chlorine post-UV has been found to effectively prevent total coliform detections in the SWIFT Water samples. However, additional work is planned in May to test an array of hypotheses as to the likely cause of these total coliform detections. These include molecular PCR-based speciation studies to identify the species of coliform present when monochloramine is in use compared to free chlorine and also an evaluation of total coliform analytical methods (membrane filtration vs colilert) to confirm that the detections of total coliform are not an artifact of method.

Several conclusions can be made from the various special studies and sampling events and normal operation over the last few months. It is important to recognize for this discussion that free chlorine is well known to be a more potent disinfectant than monochloramine. A more detailed summary of the data will be provided in an upcoming research report.

- There have been no detections of total coliform or E coli in the UV effluent, suggesting that the upstream disinfection processes are operating effectively.
- The source of total coliform contamination must between the UV disinfection step and the SWIFT Water sampling point. Between those two sampling points there are chemical feeds (sodium hydroxide for pH adjustment and free chlorine or preformed monochloramine addition), and the currently unused 5-minute chlorine contact pipeline (CCPL).
- Free chlorination of SWIFT Water prevents total coliform detections in SWIFT Water
- Returning to monochloramine addition after a period of free chlorination results in total coliform detections in SWIFT Water within a few days. Those detections are eliminated immediately after returning to free chlorination.
- The possible sources of contamination include sample port piping and the CCPL. The CCPL was investigated by closed-circuit television (CCTV) in April 2020. There is some accumulation of sediment in the CCPL that could be contributing to total coliform detections when preformed monochloramine is in use. Discussion is ongoing now about potential future cleaning of the CCPL. All sample lines have been well flushed with free chlorine, so this seems an unlikely source of contamination.
- For the time being, however, the SRC will continue to use free chlorine for recharge well biofouling control. he molecular investigation of preformed monochloramine addition will be performed as a special study with the SRC is in operation but not recharging (off-spec condition).

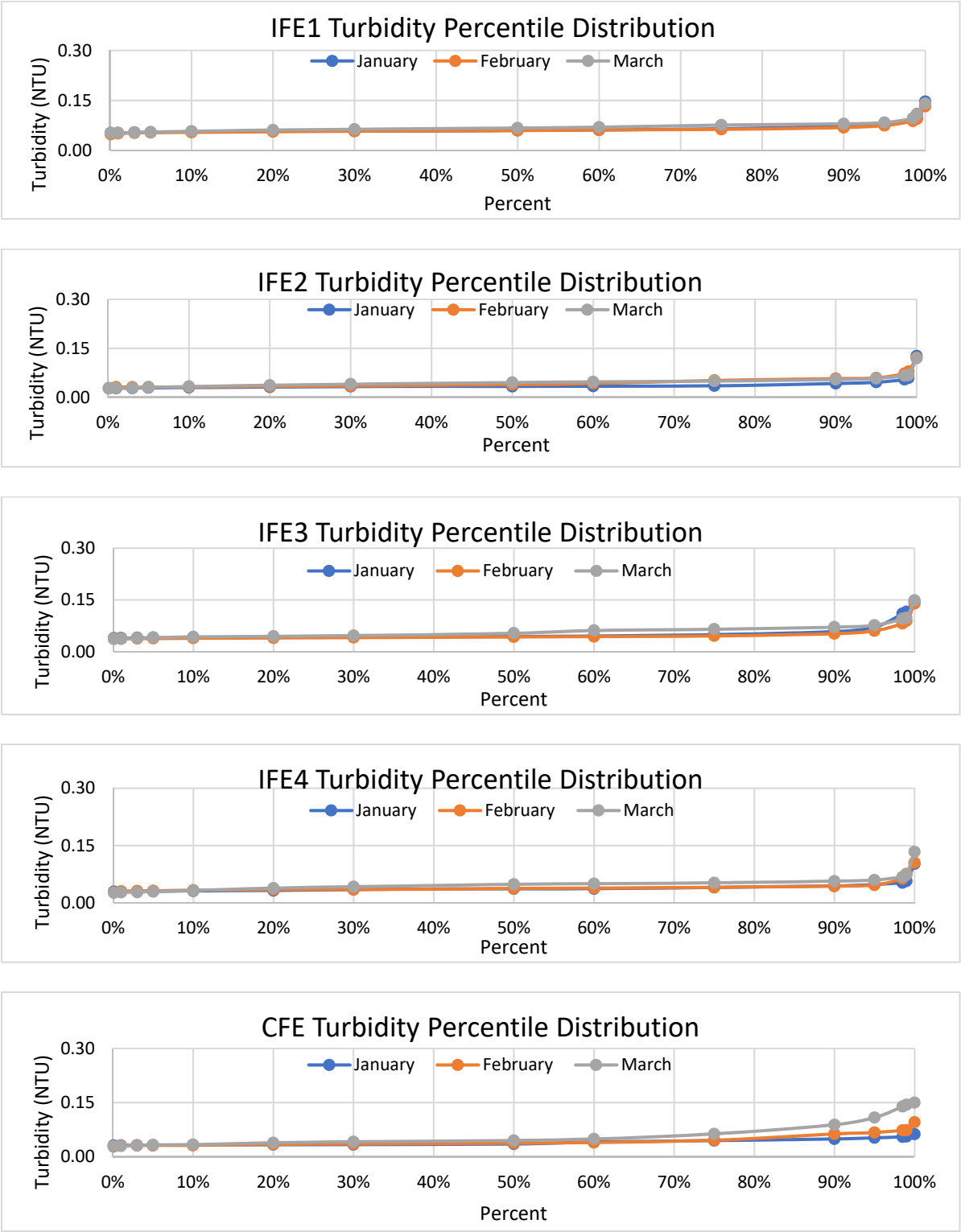

Figure 1: Percentile distribution of 15-minute average Individual Filter Effluent (IFE) Turbidities for Biofilters 1-4 (IFE1-4) and Biofilter Combined Filter Effluent (CFE). There were no 15-minute periods in this quarter with biofilter effluent turbidity values greater than 0.3 NTU. The 95% measured value for each biofilter IFE and the CFE was less than 0.15 NTU for each month in this quarter.

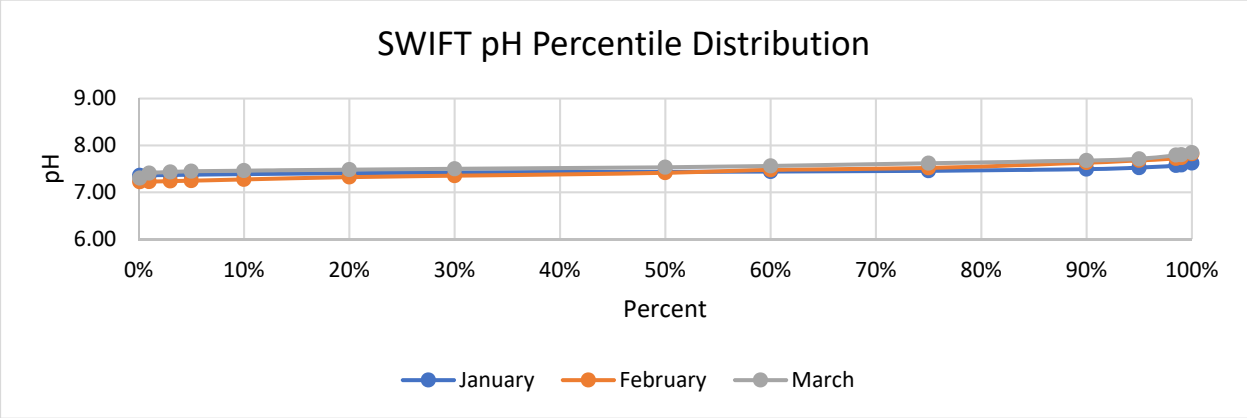

Figure 2: Distribution of Monthly SWIFT Water pH values.

Monitoring at the SRC also includes monitoring for performance indicators as documented in Table 2, extracted from Attachment B of the UIC-IIP.

Constituent	Category	Trigger Value	Unit	Notes
1,4-Dioxane	Public Health	1	µg/L	CCL4; CA Notification Limit
17-β-Estradiol	Public Health	TBD	ng/L range	CCL4
DEET	Public Health	200	µg/L	MN Health Guidance Value
Ethinyl Estradiol	Public Health	TBD	ng/L range	CCL4
NDMA	Public Health	10	ng/L	CCL4; CA Notification Limit
Perchlorate	Public Health	6	µg/L	CA Notification Limit
PFOA+PFOS	Public Health	70	ng/L	CCL4; EPA Health Advisory
TCEP	Public Health	5	µg/L	MN Health Guidance Value
Cotinine	Treatment Effectiveness	1	µg/L	Surrogate for low molecular weight, partially charged cyclics
Primidone	Treatment Effectiveness	10	µg/L	
Phenytoin	Treatment Effectiveness	2	µg/L	
Meprobamate	Treatment Effectiveness	200	µg/L	High occurrence in wastewater treatment plant effluent
Atenolol	Treatment Effectiveness	4	µg/L	
Carbamazepine	Treatment Effectiveness	10	µg/L	Unique structure
Estrone	Treatment Effectiveness	320	ng/L	Surrogate for steroids
Sucralose	Treatment Effectiveness	150	mg/L	Surrogate for water soluble, uncharged chemicals with moderate molecular weight
Triclosan	Treatment Effectiveness	2,100	µg/L	Chemical of interest

TBD = to be determined

Table 2: SRC Non-Regulatory Performance Indicators

Pathogen Log Removal Value (LRV) is not strictly regulated but the SRC has been designed and is operated to achieve at least 12 LRV for viruses and 10 LRV for *Cryptosporidium* and *Giardia* through a combination of advanced treatment processes and soil aquifer treatment. Table 3 provides a treatment process pathogen LRV summary for recharge conditions. Table 4 provides additional monitoring that is being completed to document compliance with the LRVs for ozone and UV.

Parameter	Floc/Sed (+BAC)	Ozone	BAC+GAC	UV	Cl2	SAT	Total
Enteric Viruses	2	0-3 (TBD)	0	4	0-4	6	12-19
Cryptosporidium	4	0	0	6	0	6	16
Giardia	2.5	0-1.5 (TBD)	0	6	0	6	14.5-16

Table 3: SRC Pathogen LRV for Potomac Aquifer System (PAS) Recharge.

Ozone LRV
Ozone Influent Temperature
Ozone Influent Flow
Liquid Phase Ozone Concentration[1]
Contact Time
CT
UV LRV
UV Intensity, each reactor
UVT, GAC Combined Effluent
Reactor Flow, each
Calculated Dose, each Lamp
Status, each

[1] The ozone liquid phase probe is verified with lab grab samples performed at least once per week.

Table 4: Additional Monitoring to Support Ozone and UV LRV. All data are collected as continuous measurements. The 15-minute LRV data is submitted in Table 6.

Critical Control Points

The SRC incorporates Critical Control Points (CCP) throughout the treatment process, per Attachment G of UIC-IIP to verify that treatment goals are being met at each of the individual processes. A violation of any CCP means that the SRC may not be producing water that meets the treatment goals and will trigger a diversion of the SWIFT Water so that it is not directed to the recharge well. In most instances, the SRC will continue to operate through the CCP violation, but the SWIFT Water will be diverted back to the Nansemond Plant chlorine contact tanks (CCT).

CCPs have alert values at which point the operator is expected to take action to correct the performance as well as the alarm values at which point an automated response will trigger action and prevent flow from going to the recharge well. Both

the alert and alarm values will be measured consistently for a specified duration before action is taken so that blips in online analyzers do not trigger action. The specific values for the alert and alarm levels will be configured as adjustable set points in the Distributed Control System (DCS) and optimized as needed to meet the water quality requirements.

Table 5 shows the current CCPs in effect at the SRC. Modifications have been made to the CCPs since startup as compared to the original design documents in order to optimize their performance. Each of the modifications from previous quarters was discussed in the relevant quarterly report for the period. No modifications were made during this quarter.

Parameter	Alert Value	Alarm Value	Unit	Action
Critical Control Points (CCPs)				
Influent Pump Station Conductivity	1,400	1,600	microSiemens per centimeter	Place Biofilters in Filter To Waste
Influent Pump Station Total Inorganic Nitrogen	4.0	5.0	mg/L-N	Place Biofilters in Filter To Waste
Influent Pump Station Turbidity	3.5	5.0	NTU	Place Biofilters in Filter To Waste
Preformed Chloramine Failure on Injection	N/A	Failure	mg/L	Divert SWIFT Water
Total Chlorine Post Injection upstream of ozone	2.0	1.0	mg/L	Divert SWIFT Water
Chloramine injection upstream of ozone	2.0	1.0	mg/L	Divert SWIFT Water
Ozone Feed	N/A	Failure	N/A	Open Biofilter Backwash Waste Valve
Ozone Contactor Calculated LRV – Virus	<120% LRV Goal	≤110% LRV Goal	%	Open Biofilter Backwash Waste Valve
Biofilter Individual Effluent Turbidity	0.1	0.15	NTU	Place That Biofilter in Filter To Waste
Biofilter Combined Filter Effluent Turbidity	0.1	0.15	NTU	Place Biofilters in Filter To Waste
GAC Combined Effluent TOC, instantaneous online analyzer	4.0	5.0	mg/L	Divert SWIFT Water
UV Reactor Dose	<120% of Dose Setpoint	<105% of Dose Setpoint	%	Divert SWIFT Water
Free Chlorine CT ***(This CCP is not being used since free chlorination of the SWIFT Water is not currently being practiced)***	<120% of CT Target	<105% of CT Target	%	Divert SWIFT Water
GAC Combined Effluent Nitrite	0.25	0.50	mg/L-N	Divert SWIFT Water
SWIFT Water TN	4.5	5.0	mg/L-N	Divert SWIFT Water
Ozone dose	70	80	lbs/day	Place Biofilters in Filter To Waste
Tasting System Free Chlorine CT	<110% of Required CT	<100% of Required CT	mg-min/L	Shut Down Tasting System
Tasting System Total Ammonia	0.1	0.3	mg/L-N	Shut Down Tasting System

Table 5. Critical Control Points for the SRC

Table 6: Summary of regulatory monitoring for SWIFT Water

Parameter	Units	Maximum Contaminant Level (MCL) or MCL Goal (MCLG) where numerical MCL not expressed. Values noted for indicator compounds are non-regulatory screening values	Minimum Report Level[1]	Required Monitoring Frequency	January 2020			February 2020			March 2020		
					Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples
Regulatory Parameters													
Total Nitrogen (TN)	mg/L	NA	0.50	Daily[3]	**4.01**	**4.11**	**3**	**3.43**	**4.66**	**20**	**3.05**	**4.25**	**21**
NO_3	mg/L	10	0.01	Daily[3]	**3.15**	**3.21**	**3**	**2.73**	**3.81**	**20**	**2.52**	**3.53**	**21**
NO_2	mg/L	1	0.01	Daily[3]	**0.01**	**0.01**	**3**	**<0.01**	**0.01**	**20**	**<0.01**	**<0.01**	**21**
Turbidity	NTU	NA	0.01	Continuous	**Figure 1**								
Total Organic Carbon (TOC)	mg/L	NA	1.00	3x/Wk[3]		**3.66**	**1**	**3.53**	**3.74**	**15**	**3.73**	**4.23**	**15**
pH		NA	NA	Continuous	**Figure 2**								
TDS[4]	mg/L	Potomac Aquifer System Range: 694-8,720	2.5	Monthly					**554**	**1**		**691**	**1**
Microorganisms													
Total Coliform[5]	MPN/100 mL	MCLG = 0	1	Daily[3]	**1**	**3**	**3**	**<1**	**2**	**20**	**1**	**21**	**21**
E. coli	MPN/100 mL	NA	1	Weekly	**<1**	**<1**	**3**	**<1**	**<1**	**20**	**<1**	**<1**	**21**
Disinfection Byproducts													
Bromate	µg/L	10	0.15	Monthly				**1.74**	**2.25**	**9**		**1.93**	**1**
Trihalomethanes[6]													
Bromodichloromethane	µg/L		1.00	Monthly				**<1.00**	**1.15**	**10**		**<1**	**1**
Bromoform	µg/L		1.00	Monthly				**3.92**	**5.06**	**10**		**<1**	**1**
Chloroform	µg/L		1.00	Monthly				**<1.00**	**1.02**	**10**		**<1**	**1**
Dibromochloromethane	µg/L		1.00	Monthly				**2.40**	**3.40**	**10**		**<1**	**1**
Total Trihalomethanes	µg/L	80						**6.33**	**10.6**				
HAAs[6]													
Dichloroacetic acid	µg/L		0.60	Monthly				**1.26**	**2.59**	**10**		**2.23**	**1**
Trichloroacetic acid	µg/L		0.20	Monthly				**0.55**	**0.70**	**10**		**0.81**	**1**
Monochloroacetic acid	µg/L		0.60	Monthly				**<0.6**	**<0.6**	**10**		**<0.6**	**1**
Bromoacetic acid	µg/L		0.40	Monthly				**0.73**	**1.12**	**10**		**<0.4**	**1**
Dibromoacetic acid	µg/L		0.20	Monthly				**6.76**	**9.69**	**10**		**0.33**	**1**
Total Haloacetic Acids	µg/L	60						**9.31**	**14.1**			**3.37**	
Disinfectants[6, 7]													
Monochloramine (as Cl_2)	mg/L	4		Continuous	**0.29**	**0.41**		**0.31**	**1.17**		**0.10**	**0.82**	
Chlorine (as Cl_2)	mg/L	4		Continuous	**0.28**	**0.37**		**0.70**	**1.43**		**0.51**	**0.88**	
Inorganic Chemical													
Arsenic	µg/L	10	0.2	Monthly					**0.5**	**1**		**0.4**	**1**
Barium	mg/L	2	0.005	Monthly					**0.008**	**1**		**0.009**	**1**
Fluoride	mg/L	4.0	0.100	Monthly	**0.947**	**0.965**	**3**	**0.829**	**0.907**	**20**	**0.935**	**1.04**	**21**
Radionuclides													
Beta particles and photon emitters	pCi/L	4 mrem/yr[8]	3	Monthly					**14**	**1**		**17**	**1**

Table 6: Summary of regulatory monitoring for SWIFT Water

Parameter	Units	Maximum Contaminant Level (MCL) or MCL Goal (MCLG) where numerical MCL not expressed. Values noted for indicator compounds are non-regulatory screening values	Minimum Report Level[1]	Required Monitoring Frequency	January 2020			February 2020			March 2020		
					Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples
Non-regulatory Performance Indicators													
Public Health Indicators		**Trigger Limits**											
1,4-dioxane	µg/L	1	0.06	Quarterly				**0.40**	**0.41**	**3**	**0.45**	**0.48**	**4**
Perfluorooctanoic Acid (PFOA)	ng/L	70 (PFOA+PFOS)	2.0	Quarterly					**5.3**	**1**			
Treatment Efficacy Indicators		**Trigger Limits**											
Primidone	ng/L	10,000	5.0	Quarterly					**9.7**	**1**			
Sucralose	ng/L	150,000,000	1000	Quarterly					**12000**	**1**			
Additional Monitoring (Ozone & UV LRV)					**Average**	**Minimum**		**Average**	**Minimum**		**Average**	**Minimum**	
Ozone Virus LRV				Continuous	**4.51**	**3.66**		**4.51**	**3.93**		**4.63**	**3.57**	
Ozone Giardia LRV				Continuous	**2.24**	**1.80**		**2.22**	**1.95**		**2.33**	**1.77**	
UV Dose Reactor 1	mJ/cm^2			Continuous	**>186**	**>186**		**>186**	**>186**		**>186**	**>186**	
UV Virus LRV Reactor 1				Continuous	**>4**	**>4**		**>4**	**>4**		**>4**	**>4**	
UV Dose Reactor 2	mJ/cm^2			Continuous	**>186**	**>186**		**>186**	**>186**		**>186**	**>186**	
UV Virus LRV Reactor 2				Continuous	**>4**	**>4**		**>4**	**>4**		**>4**	**>4**	

Note: Monthly monitoring was not completed for the month of January. Recharge was halted on January 5 to address troubleshooting for total coliform detections.

[1] When minimum reporting limits varied during the quarter, the highest minumum reporting limit used is identified.

[2] Analytical results less than the reporting limit were treated as zero for the purposes of the averaging calculation.

[3] Daily samples are typically not collected on days in which there is no or limited recharge. TOC sample collection occurs routinely on Monday through Friday when recharging. Limited or inconsistent recharge impacts the collection of daily samples, particularly for the microbiological samples collected for total coliform and e coli which have limited holding time requirements. In January, recharge occurred on 4 days; limited recharge impacted one day of sampling. In February, recharge occurred on 21 days; limited recharge impacted one day of sampling. In March, recharge occurred on 24 days; limited recharge impacted 3 days of sampling.

[4] TDS of the Potomac Aquifer System is based on the averages within the upper, middle and lower Potomac Aquifer as determined during baseline montioring.

[5] A positive TC result was documented on December 5 with a result of 1 CFU/100 mL and again on December 31 with a result of 2 CFU/100 mL. In both samples E coli was absent.

[6] Free chlorine was used as an alternative to monochloramine to prevent biofouling of the well post-UV disinfection for a portion of the operational period.

[7] The maximum residual disinfectant level (or MRDL) MCL for monochloramine and chlorine are based on annual averages.

[8] The measurement unit for beta particles and photon emitters is pCi/L while the MCL is expressed as mrem/yr. Per EPA's Implementation Guidance for Radionuclides (EPA 816-F-00-002, March 2002), the screening threshold for beta particles and photon emitters is 50 pCi/L. If sample concentrations exceed 50 pCi/L, each individual beta particle and photon emitter is converted from pCi/L to mrem using the EPA designated conversation tables, currently available in the referenced document.

Recharge Statistics

The total volume recharged during this operational period was 30.5 million gallons. 4.4 million gallons was backflushed for a net recharge of 26.1 million gallons (Figure 3). Brief backflushing periods occur as part of routine well maintenance on an approximate daily basis. During its entire period of operation, the SRC has recharged a total volume of 288.5 million gallons.

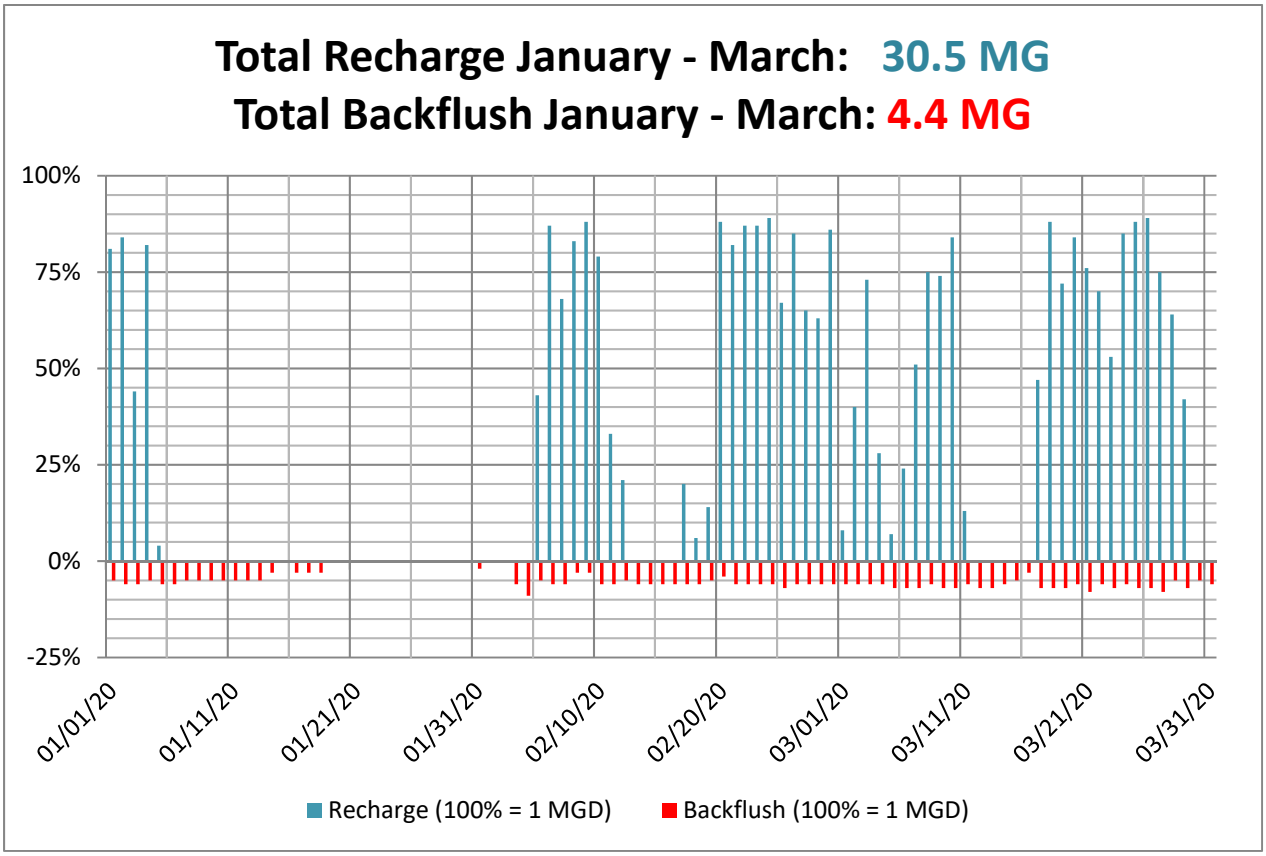

Figure 3: Recharge and Backflush Volumes, January 1 – March 31, 2020

HRSD has developed an internal target to recharge 75% of a SWIFT facility's operational capacity. This is a particularly relevant planning target for full-scale operations and HRSD is striving to meet this target at the SRC. Operational redundancies will exist at full-scale facilities (e.g., multiple recharge wells) which will likely result in a higher rate of recharge at full-scale. For this operational period, the recharge capture was 33%. For much of the period, recharge operations were halted in order to investigate the cause of total coliform detections. Figure 4 depicts the operational activity for this monitoring period identifying the percentage of operational time spent in recharge as well as the general factors precluding recharge.

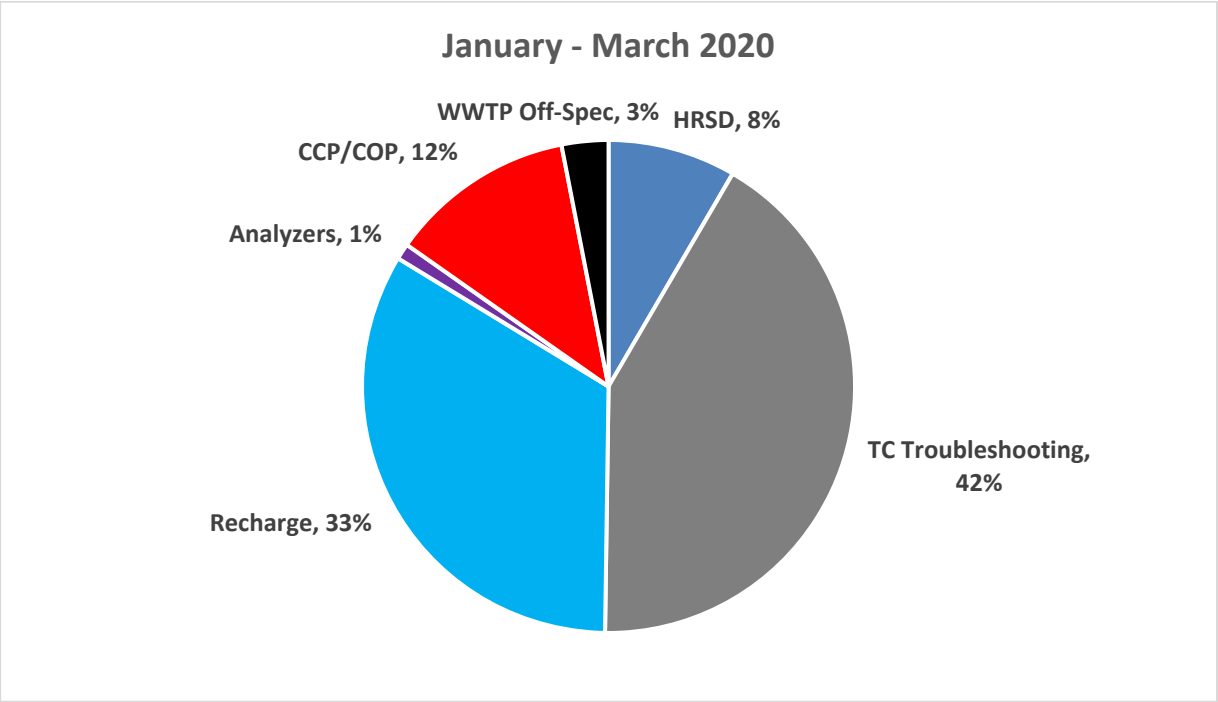

Figure 4: Operational activity for monitoring period. Notes: *Recharge*: Recharge of SWIFT Water; *TC Troubleshooting*: Period of special investigation to determine cause of TC detections (discussed elsewhere in document); *CCP/COP*: Critical Control Point/Critical Operating Parameter threshold triggered, diverting SWIFT Water from recharge well (e.g. elevated conductivity on SRC influent, elevated TOC/TN in SWIFT Water, low LRV, etc.); *WWTP Off-Spec*: Influent to the SWIFT facility (wastewater facility secondary clarifier effluent) does not meet influent quality requirements (e.g. elevated TOC or TN, or WWTP repairs; *HRSD*: Broad category covering activity within SWIFT facility that may lead to shut-down (e.g. maintenance and repairs, operational problems); *Analyzers*: On-line analyzer maintenance and repair.

Conventional Monitoring Wells

The conventional monitoring well for the upper zone of the Potomac Aquifer (MW-UPA), located approximately 400 ft from the recharge well, has been monitored daily for fluoride to evaluate the migration of recharge water. It was assumed that fluoride would serve as a suitable tracer given the low concentration of fluoride in SWIFT Water (average of 0.96 mg/L in the 2019 operational period) relative to the background concentration of fluoride in MW-UPA (> 4 mg/L). However, the daily monitoring of fluoride concentration in MW-UPA has failed to correlate to the presence of the recharge front as observed by the trend in total organic carbon (TOC) in MW-UPA as presented in the last quarterly report and updated in Figure 5. Similar increases in TOC have not been observed in the monitoring wells located in the middle and lower zones of the Potomac Aquifer (MW-MPA, MW-LPA). Based on the observed increase in TOC in MW-UPA, samples for all PMCLs and the indicator compounds were collected in November and sampling has continued monthly in this operational period. Results for all regulatory parameters are less than the PMCL and all regulated organics were non-detect. Nitrite and arsenic observations are described in further detail in the sections below.

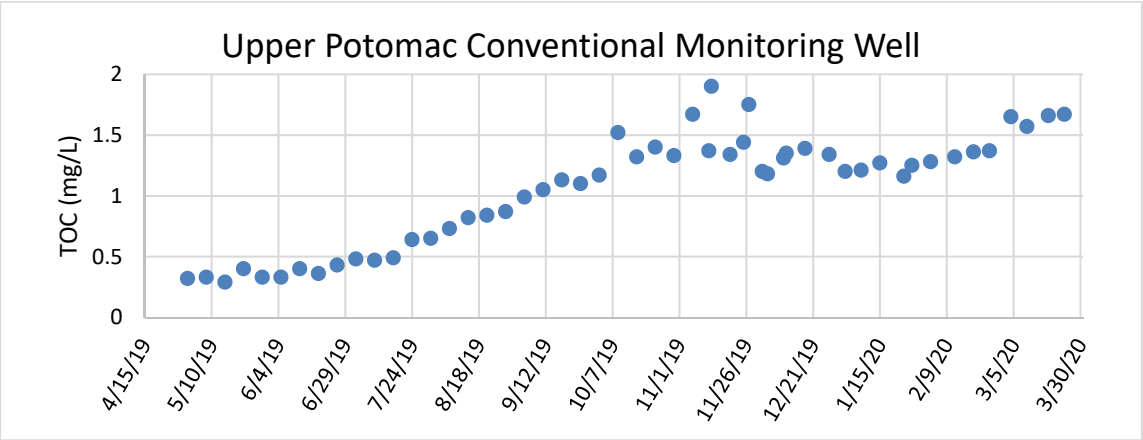

Figure 5: TOC concentration in the Upper Potomac conventional monitoring well, MW-UPA. TOC concentration in the January – March 2020 monitoring period in MW-UPA averaged 1.4 mg/L. The monthly average of SWIFT Water TOC since the start of operations is 2.4 mg/L. The monthly average for the 2018 and 2019 operational periods was 1.5 and 2.6 mg/L, respectively.

Monitoring identified quantifiable concentrations of the indicator compounds, 1,4 dioxane, NDMA, and sucralose (Table 7). NDMA concentration is also plotted separately in Figure 6. All reported values were less than the action thresholds ("trigger values") identified in Table 2 of this report.

NDMA is most commonly < 2.00 ng/L in SWIFT Water, though higher concentrations ranging up to 8.3 ng/L (July 2019) were observed in SWIFT Water after the 2019 restart of operations. With reported MW-UPA sample concentrations of NDMA as high as 8.08 ng/L, HRSD is working to better understand NDMA formation potential within the aquifer. Another consideration under review is the possibility that the detectable concentrations of NDMA in the MW-UPA reflect the higher concentrations observed in SWIFT Water in mid-2019. A full analysis will be provided in an upcoming research report along with a discussion of other inorganic SWIFT Water constituents that could serve as semi-conservative tracers. It should be noted that the soil column studies conducted by HRSD indicated that NDMA was well removed through soil aquifer treatment. As additional data is generated from MW-UPA, correlations between SWIFT Water concentration and MW-UPA observations will be invaluable in quantifying the realized availability of soil aquifer treatment.

Due to the shut-down of the SWIFT Research Center for warranty repairs, it is difficult to quantify a travel time associated with this movement of recharge water to MW-UPA. At the beginning of October 2019 when TOC concentration appeared to begin to stabilize, the net volume of recharge water was approximately 148 million gallons. A bromide tracer study designed to resolve some of the existing uncertainty associated with travel time estimations was scheduled for the end of March but has now been delayed due to travel constraints associated with the COVID-19 pandemic.

Table 7: Indicator compounds quantified in MW-UPA. Average values are not calculated when the maximum value reported represents a single sample.

Indicator	MW-UPA										SWIFT Water	
	November 2019		December 2019		January 2020		February 2020		March 2020		2018-2019 Operations	
	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg
1,4 Dioxane, µg/L	0.38	-	0.39	0.38	0.40	0.37	0.39	0.37	0.52	0.46	0.61	0.40
NDMA, ng/L	4.45	-	4.15	2.80	8.08	4.84	3.81	2.69	2.26	<2.00	8.34	1.07
Sucralose, ng/L	340	-	300	-	<100	-	150	-	160	-	780	175

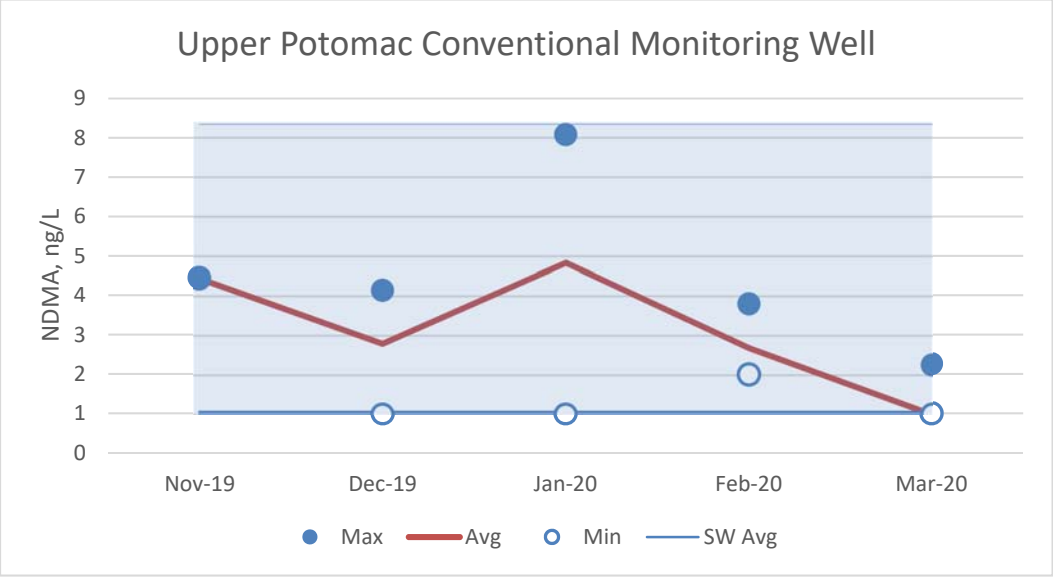

Figure 6: NDMA concentration in the upper Potomac conventional monitoring well, MW-UPA. The shaded area reflects the range of maximum and minimum concentrations of NDMA in SWIFT Water (SW) over the 2018 and 2019 operational period. The reporting limit for NDMA analysis is 2.00 ng/L. Values less than the reporting limit were plotted at ½ the reporting limit.

Nitrite in MW-SAT Update

HRSD continues to monitor nitrite levels within the monitoring well located 50 ft from the recharge well, MW-SAT, and the conventional wells to better understand the occurrence

of in situ partial denitrification and the potential for nitrite migration with the recharge front. The maximum nitrite concentration was quantified in screen interval 9 in January at 0.67 mg/L. The remaining samples collected for screen interval 9 during this monitoring period were all < 0.40 mg/L. Nitrite concentration in the remaining screen intervals for this monitoring period was < 0.1 mg/L. Nitrite concentration in SWIFT Water during this operational period was ≤ 0.01 mg/L (Table 6).

As described above, recharge water is being detected in the upper zone of the Potomac in the conventional monitoring well, MW-UPA. Nitrite concentrations in MW-UPA during this monitoring period remain <0.01 mg/L.

Arsenic in MW-SAT Update

As described in a brief report issued on May 16, 2019, the concentration of arsenic in MW-SAT screen interval 9 increased above the MCL of 10 µg/L in a sample collected on May 6, eight days after resuming recharge. Since that time, groundwater monitoring and soil column studies have been on-going to better understand the potential for arsenic mobilization within the aquifer. The concentration of arsenic in MW-SAT in all screen intervals has remained < 3 µg/L since November 2019 with a maximum concentration of 2.69 µg/L in the January sample for screen interval 2. (Table 8).

As described above, recharge water is being detected in the upper zone of the Potomac in the conventional monitoring well, MW-UPA. The concentration of arsenic in MW-UPA during this monitoring period remained <1.00 µg/L.

Table 8: Total arsenic concentration in selected screen intervals of MW-SAT. Total arsenic concentration in the remaining screen intervals was < 1.50 µg/L in each month of the monitoring period. Total arsenic concentration in the conventional monitoring wells, MW-UPA, MW-MPA and MW-LPA as well as SWIFT Water remained <1.00 µg/L during the monitoring period.

MW-Sat Screen	Total Arsenic, µg/L					
	January		November		December	
	Max	Avg	Max	Avg	Max	Avg
2	2.69	-	2.34	1.37	1.79	1.11
3	1.42	-	1.62	1.29	1.72	1.47
5	1.63	-	2.12	1.89	1.82	1.63
8	0.72	-	0.98	0.84	1.82	0.86
9	1.39	-	2.27	1.75	1.33	1.22

Appendix
Monitoring Data for SWIFT Water Quality Regulatory Targets

Parameter	Units	Maximum Contaminant Level (MCL) or MCL Goal (MCLG) where numerical MCL not expressed. Values noted for indicator compounds are non-regulatory screening values	Minimum Report Level[1]	Required Monitoring Frequency	January 2020			February 2020			March 2020		
					Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples
Regulatory Parameters													
Total Nitrogen (TN)	mg/L	NA	0.50	Daily[3]	**4.01**	**4.11**	**3**	**3.43**	**4.66**	**20**	**3.05**	**4.25**	**21**
NO_3	mg/L	10	0.01	Daily[3]	**3.15**	**3.21**	**3**	**2.73**	**3.81**	**20**	**2.52**	**3.53**	**21**
NO_2	mg/L	1	0.01	Daily[3]	**0.01**	**0.01**	**3**	**<0.01**	**0.01**	**20**	**<0.01**	**<0.01**	**21**
Turbidity	NTU	NA	0.01	Continuous	**Figure 1**								
Total Organic Carbon (TOC)	mg/L	NA	1.00	3x/Wk[3]		**3.66**	**1**	**3.53**	**3.74**	**15**	**3.73**	**4.23**	**15**
pH		NA	NA	Continuous	**Figure 2**								
TDS[4]	mg/L	Potomac Aquifer System Range: 694-8,720	2.5	Monthly					**554**	**1**		**691**	**1**
Microorganisms													
Total Coliform[5]	MPN/100 mL	MCLG = 0	1	Daily[3]	**1**	**3**	**3**	**<1**	**2**	**20**	**1**	**21**	**21**
E. coli	MPN/100 mL	NA	1	Weekly	**<1**	**<1**	**3**	**<1**	**<1**	**20**	**<1**	**<1**	**21**
Cryptosporidium	oocysts/L	Treatment Technique, MCLG = 0	0.089	Quarterly					**<0.089**	**1**			
Giardia lamblia	oocysts/L	Treatment Technique, MCLG = 0	0.089	Quarterly					**<0.089**	**1**			
Legionella	MPN/100 mL	Treatment Technique, MCLG = 0	10	Quarterly					**<10**	**1**			
Disinfection Byproducts													
Bromate	µg/L	10	0.15	Monthly				**1.74**	**2.25**	**9**		**1.93**	**1**
Chlorite	mg/L	1.0	0.1	Monthly				**<0.1**	**<0.1**	**9**		**<0.1**	**1**
Trihalomethanes[6]													
Bromodichloromethane	µg/L		1.00	Monthly				**<1.00**	**1.15**	**10**		**<1**	**1**
Bromoform	µg/L		1.00	Monthly				**3.92**	**5.06**	**10**		**<1**	**1**
Chloroform	µg/L		1.00	Monthly				**<1.00**	**1.02**	**10**		**<1**	**1**
Dibromochloromethane	µg/L		1.00	Monthly				**2.40**	**3.40**	**10**		**<1**	**1**
Total Trihalomethanes	µg/L	80						**6.33**	**10.6**				
HAAs[6]													
Dichloroacetic acid	µg/L		0.60	Monthly				**1.26**	**2.59**	**10**		**2.23**	**1**
Trichloroacetic acid	µg/L		0.20	Monthly				**0.55**	**0.70**	**10**		**0.81**	**1**
Monochloroacetic acid	µg/L		0.60	Monthly				**<0.6**	**<0.6**	**10**		**<0.6**	**1**
Bromoacetic acid	µg/L		0.40	Monthly				**0.73**	**1.12**	**10**		**<0.4**	**1**
Dibromoacetic acid	µg/L		0.20	Monthly				**6.76**	**9.69**	**10**		**0.33**	**1**
Total Haloacetic Acids	µg/L	60						**9.31**	**14.1**			**3.37**	

Parameter	Units	Maximum Contaminant Level (MCL) or MCL Goal (MCLG) where numerical MCL not expressed. Values noted for indicator compounds are non-regulatory screening values	Minimum Report Level[1]	Required Monitoring Frequency	January 2020			February 2020			March 2020		
					Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples
Disinfectants[6, 7]													
Monochloramine (as Cl_2)	mg/L	4		Continuous	**0.29**	**0.41**		**0.31**	**1.17**		**0.10**	**0.82**	
Chlorine (as Cl_2)	mg/L	4		Continuous	**0.28**	**0.37**		**0.70**	**1.43**		**0.51**	**0.88**	
Inorganic Chemical													
Antimony	µg/L	6	0.5	Monthly					**<0.5**	**1**		**<0.5**	**1**
Arsenic	µg/L	10	0.2	Monthly					**0.5**	**1**		**0.4**	**1**
Asbestos	MFL	7	0.2	Monthly					**<0.2**	**1**		**<0.2**	**1**
Barium	mg/L	2	0.005	Monthly					**0.008**	**1**		**0.009**	**1**
Beryllium	µg/L	4	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Cadmium	µg/L	5	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Chromium (total)	µg/L	100	2.5	Monthly					**<2.5**	**1**		**<2.5**	**1**
Copper	mg/L	1.3 (action level)	0.005	Monthly					**<0.005**	**1**		**<0.005**	**1**
Cyanide (total)	µg/L	200	10	Monthly					**<10**	**1**		**<10**	**1**
Fluoride	mg/L	4.0	0.100	Monthly	**0.947**	**0.965**	**3**	**0.829**	**0.907**	**20**	**0.935**	**1.04**	**21**
Lead	µg/L	15 (action level)	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Mercury	µg/L	2	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Selenium	µg/L	50	5	Monthly					**<5**	**1**		**<5**	**1**
Thallium	µg/L	2	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Organic Chemicals													
Acrylamide	µg/L	Treatment Technique, MCLG =	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Alachlor	µg/L	2	0.05	Monthly					**<0.05**	**1**		**<0.05**	**1**
Atrazine	µg/L	3	0.05	Monthly					**<0.05, R7**	**1**		**<0.05**	**1**
Benzo(a)pyrene (PAHs)	µg/L	0.2	0.02	Monthly					**<0.02**	**1**		**<0.02**	**1**
Di(2-ethylhexyl) adipate	µg/L	400	0.6	Monthly					**<0.6**	**1**		**<0.6**	**1**
Di(2-ethylhexyl) phthalate	µg/L	6	0.6	Monthly					**<0.6**	**1**		**<0.6**	**1**
Hexachlorocyclopentadiene	µg/L	50	0.05	Monthly					**<0.05, R7**	**1**		**<0.05**	**1**
Hexachlorobenzene	µg/L	1	0.05	Monthly					**<0.05, R7**	**1**		**<0.05**	**1**
Simazine	µg/L	4	0.05	Monthly					**<0.05, R7**	**1**		**<0.05**	**1**
Carbofuran	µg/L	40	0.5	Monthly					**<0.5**	**1**		**<0.5**	**1**
Oxamyl (Vydate)	µg/L	200	0.5	Monthly					**<0.5**	**1**		**<0.5**	**1**
Chlordane	µg/L	2	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Endrin	µg/L	2	0.01	Monthly					**<0.01**	**1**		**<0.01**	**1**
Heptachlor	µg/L	0.4	0.01	Monthly					**<0.01**	**1**		**<0.01**	**1**
Heptachlor Epoxide	µg/L	0.2	0.01	Monthly					**<0.01**	**1**		**<0.01**	**1**

Parameter	Units	Maximum Contaminant Level (MCL) or MCL Goal (MCLG) where numerical MCL not expressed. Values noted for indicator compounds are non-regulatory screening values	Minimum Report Level[1]	Required Monitoring Frequency	January 2020			February 2020			March 2020		
					Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples
Lindane	µg/L	0.2	0.01	Monthly					**<0.01**	**1**		**<0.01**	**1**
Methoxychlor	µg/L	40	0.05	Monthly					**<0.05**	**1**		**<0.05**	**1**
Toxaphene	µg/L	3	0.5	Monthly					**<0.5**	**1**		**<0.5**	**1**
PCB Arochlor1016	µg/L		0.08	Monthly					**<0.08**	**1**		**<0.08**	**1**
PCB Arochlor1221	µg/L		0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
PCB Arochlor1232	µg/L		0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
PCB Arochlor1242	µg/L		0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
PCB Arochlor1248	µg/L		0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
PCB Arochlor1254	µg/L		0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
PCB Arochlor1260	µg/L		0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Total Polychlorinated Biphenyls (PCBs)	µg/L	0.5											
2,4-D	µg/L	70	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
Dalapon	µg/L	200	1	Monthly					**<1**	**1**		**<1**	**1**
Picloram	µg/L	500	0.1	Monthly					**<0.1**	**1**		**<0.1**	**1**
2,4,5-TP (Silvex)	µg/L	50	0.2	Monthly					**<0.2**	**1**		**<0.2**	**1**
Dinoseb	µg/L	7	0.2	Monthly					**<0.2**	**1**		**<0.2**	**1**
Pentachlorophenol	µg/L	1	0.04	Monthly					**<0.04**	**1**		**<0.04**	**1**
Dioxin (2,3,7,8-TCDD)	pg/L	30	5	Monthly					**<5**	**1**		**<5**	**1**
Diquat	µg/L	20	0.4	Monthly					**<0.4**	**1**		**<0.4**	**1**
Endothall	µg/L	100	5	Monthly					**<5**	**1**		**<5**	**1**
Epichlorohydrin	µg/L	Treatment Technique, MCLG =	0.4	Monthly					**<0.4**	**1**		**<0.4**	**1**
Glycophosphate	µg/L	700	6	Monthly					**<6**	**1**		**<6**	**1**
Benzene	µg/L	5	1	Monthly					**<1**	**1**		**<1**	**1**
Carbon Tetrachloride	µg/L	5	1	Monthly					**<1**	**1**		**<1**	**1**
Chlorobenzene	µg/L	100	1	Monthly					**<1**	**1**		**<1**	**1**
1,2-dibromo-3-chloropropane (DBCP)	µg/L	0.2	0.02	Monthly					**<0.02**	**1**		**<0.02**	**1**
o-Dichlororbenzene	µg/L	600	1	Monthly					**<1**	**1**		**<1**	**1**
p-Dichlorobenzene	µg/L	75	1	Monthly					**<1**	**1**		**<1**	**1**
1,2-Dichloroethane	µg/L	5	1	Monthly					**<1**	**1**		**<1**	**1**
1,1-Dichlororethylene	µg/L	7	1	Monthly					**<1**	**1**		**<1**	**1**
cis-1,2-Dichloroehtylene	µg/L	70	1	Monthly					**<1**	**1**		**<1**	**1**
trans-1,2-Dichloroethylene	µg/L	100	1	Monthly					**<1**	**1**		**<1**	**1**
Dichloromethane	µg/L	5	1	Monthly					**<1**	**1**		**<1**	**1**
1,2-Dichloropropane	µg/L	5	1	Monthly					**<1**	**1**		**<1**	**1**

Appendix
Monitoring Data for SWIFT Water Quality Regulatory Targets

Parameter	Units	Maximum Contaminant Level (MCL) or MCL Goal (MCLG) where numerical MCL not expressed. Values noted for indicator compounds are non-regulatory screening values	Minimum Report Level[1]	Required Monitoring Frequency	January 2020			February 2020			March 2020		
					Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples
Ethylbenzene	µg/L	700	1	Monthly					<1	1		<1	1
Ethylene Dibromide (EDB)	µg/L	0.05	0.02	Monthly					<0.02	1		<0.02	1
Styrene	µg/L	100	1	Monthly					<1	1		<1	1
Tetrachloroethylene	µg/L	5	1	Monthly					<1	1		<1	1
Toluene	µg/L	1,000	1	Monthly					<1	1		<1	1
1,2,4-Trichlorobenzene	µg/L	70	1	Monthly					<1	1		<1	1
1,1,1-Trichloroethane	µg/L	200	1	Monthly					<1	1		<1	1
1,1,2-Trichloroethane	µg/L	5	1	Monthly					<1	1		<1	1
Trichloroethylene	µg/L	5	1	Monthly					<1	1		<1	1
Vinyl Chloride	µg/L	2	1	Monthly					<1	1		<1	1
Total Xylene	µg/L	10,000	3	Monthly					<3	1		<3	1
Radionuclides													
Alpha particles	pCi/L	15	3	Monthly					<3	1		<3	1
Beta particles and photon emitters	pCi/L	4 mrem/yr[8]	3	Monthly					14	1		17	1
Radium 226	pCi/L	5 (226+228)	1	Monthly					<1	1		<1	1
Radium 228	pCi/L	5 (226+228)	1	Monthly					<1	1		<1	1
Uranium	µg/L	30	0.1	Monthly					<0.1	1		<0.1	1
Strontium-90	pCi/L	NA	1.04	Monthly					<1.04	1		<1.04	1
Tritium	pCi/L	NA	361	Monthly					<361	1		<361	1
Non-regulatory Performance Indicators													
Public Health Indicators		**Trigger Limits**											
1,4-dioxane	µg/L	1	0.06	Quarterly				0.40	0.41	3	0.45	0.48	4
17-β-estradiol	ng/L	TBD	0.43	Quarterly					<0.43	1			
DEET	ng/L	200,000	10	Quarterly					<10	1			
Ethinyl estradiol	ng/L	TBD	0.972	Quarterly					<0.972	1			
Tris(2-carboxyethyl)phosphine (TCEP)	ng/L	5,000	10	Quarterly					<10	1			
NDMA	ng/L	10	2	Quarterly				<2	<2	3	<2	<2	4
Perchlorate	µg/L	6	0.5	Quarterly					<0.5	1			
Perfluorooctanoic Acid (PFOA)	ng/L	70 (PFOA+PFOS)	2.0	Quarterly					5.3	1			
Perfluorooctanesulfonic Acid (PFOS)	ng/L	70 (PFOA+PFOS)	2.0	Quarterly					<2.0	1			
Treatment Efficacy Indicators		**Trigger Limits**											
Cotinine	ng/L	1,000	10	Quarterly					<10	1			
Primidone	ng/L	10,000	5.0	Quarterly					9.7	1			
Phenytoin (Dilantin)	ng/L	2,000	20	Quarterly					<20	1			
Meprobamate	ng/L	200,000	5	Quarterly					<5	1			
Atenolol	ng/L	4,000	5	Quarterly					<5	1			
Carbamazepine	ng/L	10,000	5	Quarterly					<5	1			
Estrone	ng/L	320,000	2.2	Quarterly					<2.2	1			
Sucralose	ng/L	150,000,000	1000	Quarterly					12000	1			
Triclosan	ng/L	210,000	200	Quarterly					<200	1			

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Parameter	Units	Maximum Contaminant Level (MCL) or MCL Goal (MCLG) where numerical MCL not expressed. Values noted for indicator compounds are non-regulatory screening values	Minimum Report Level[1]	Required Monitoring Frequency	January 2020			February 2020			March 2020		
					Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples	Average[2]	Maximum	Numer of Samples
Additional Monitoring (Ozone & UV LRV)					**Average**	**Minimum**		**Average**	**Minimum**		**Average**	**Minimum**	
Ozone Virus LRV				Continuous	**4.51**	**3.66**		**4.51**	**3.93**		**4.63**	**3.57**	
Ozone Giardia LRV				Continuous	**2.24**	**1.80**		**2.22**	**1.95**		**2.33**	**1.77**	
UV Dose Reactor 1	mJ/cm^2			Continuous	**>186**	**>186**		**>186**	**>186**		**>186**	**>186**	
UV Virus LRV Reactor 1				Continuous	**>4**	**>4**		**>4**	**>4**		**>4**	**>4**	
UV Dose Reactor 2	mJ/cm^2			Continuous	**>186**	**>186**		**>186**	**>186**		**>186**	**>186**	
UV Virus LRV Reactor 2				Continuous	**>4**	**>4**		**>4**	**>4**		**>4**	**>4**	

Note: Monthly monitoring was not completed for the month of January. Recharge was halted on January 5 to address troubleshooting for total coliform detections.

[1] When minimum reporting limits varied during the quarter, the highest minumum reporting limit used is identified.

[2] Analytical results less than the reporting limit were treated as zero for the purposes of the averaging calculation.

[3] Daily samples are typically not collected on days in which there is no or limited recharge. TOC sample collection occurs routinely on Monday through Friday when recharging. Limited or inconsistent recharge impacts the collection of daily samples, particularly for the microbiological samples collected for total coliform and e coli which have limited holding time requirements. In January, recharge occurred on 4 days; limited recharge impacted one day of sampling. In February, recharge occurred on 21 days; limited recharge impacted one day of sampling. In March, recharge occurred on 24 days; limited recharge impacted 3 days of sampling.

[4] TDS of the Potomac Aquifer System is based on the averages within the upper, middle and lower Potomac Aquifer as determined during baseline montioring.

[5] A positive TC result was documented on December 5 with a result of 1 CFU/100 mL and again on December 31 with a result of 2 CFU/100 mL. In both samples E coli was absent.

[6] Free chlorine was used as an alternative to monochloramine to prevent biofouling of the well post-UV disinfection for a portion of the operational period.

[7] The maximum residual disinfectant level (or MRDL) MCL for monochloramine and chlorine are based on annual averages.

[8] The measurement unit for beta particles and photon emitters is pCi/L while the MCL is expressed as mrem/yr. Per EPA's Implementation Guidance for Radionuclides (EPA 816-F-00-002, March 2002), the screening threshold for beta particles and photon emitters is 50 pCi/L. If sample concentrations exceed 50 pCi/L, each individual beta particle and photon emitter is converted from pCi/L to mrem using the EPA designated conversation tables, currently available in the referenced document.

Contract Laboratory Flags

R7 - LFB/LFBD RPD exceeded the laboratory acceptance limit. Recovery met acceptance criteria.