2017 City of Kelowna Annual Water and Filtration Exclusion Report

Prepared for: Interior Health and City of Kelowna
Prepared by: Ed Hoppe, Water Quality and Customer Care Supervisor
City of Kelowna
951 Raymer Ave, Kelowna, BC
www.kelowna.ca
Report Date Covered: January through December 2017
Report Submitted: June 29, 2018

Table of Contents

Introduction

As required by the *British Columbia Drinking Water Protection Act*, the City of Kelowna (COK) provides the following annual report in accordance with our conditions on permit and conditions on filtration treatment exclusion.

This report provides an overview of our service area, staff certification program, water source protection assessments, water sustainability initiatives, distribution system overview, capital works projects, cross connection program, water quality monitoring program, emergency response plan, and water services provided.

The City of Kelowna's primary focus is to provide sustainable, quality drinking water from source to tap and to ensure it is safe to drink for the customers of the Kelowna Water Utility. For further details on the content of this report or to request additional information, please contact the City of Kelowna at 250-469-8475 or email ask@kelowna.ca.

Water System Overview

The City of Kelowna water utility is one of five water providers operating within the municipal boundary and services approximately 70,000 residents as well as a diverse and robust commercial and business sector. Within the water boundary, there is one main distribution system that services over 99% of the population. This includes the Poplar Point, Eldorado and Cedar Creek pump stations and one small water system that services approximately 300 residents via the Swick Road pump station.

COK also operates and maintains the Kelowna International Airport Water System which receives treated water from the Glenmore Ellison Improvement District (GEID).

Service Area

The defined geographical service area for City of Kelowna Water Utility customers is bordered by Lake Okanagan to the West and four water districts to the East as presented in Figure 1. There are several areas that are identified as "Future City" which currently does not have water supplied by the utility, but is slated for servicing pending future water demand and land development.

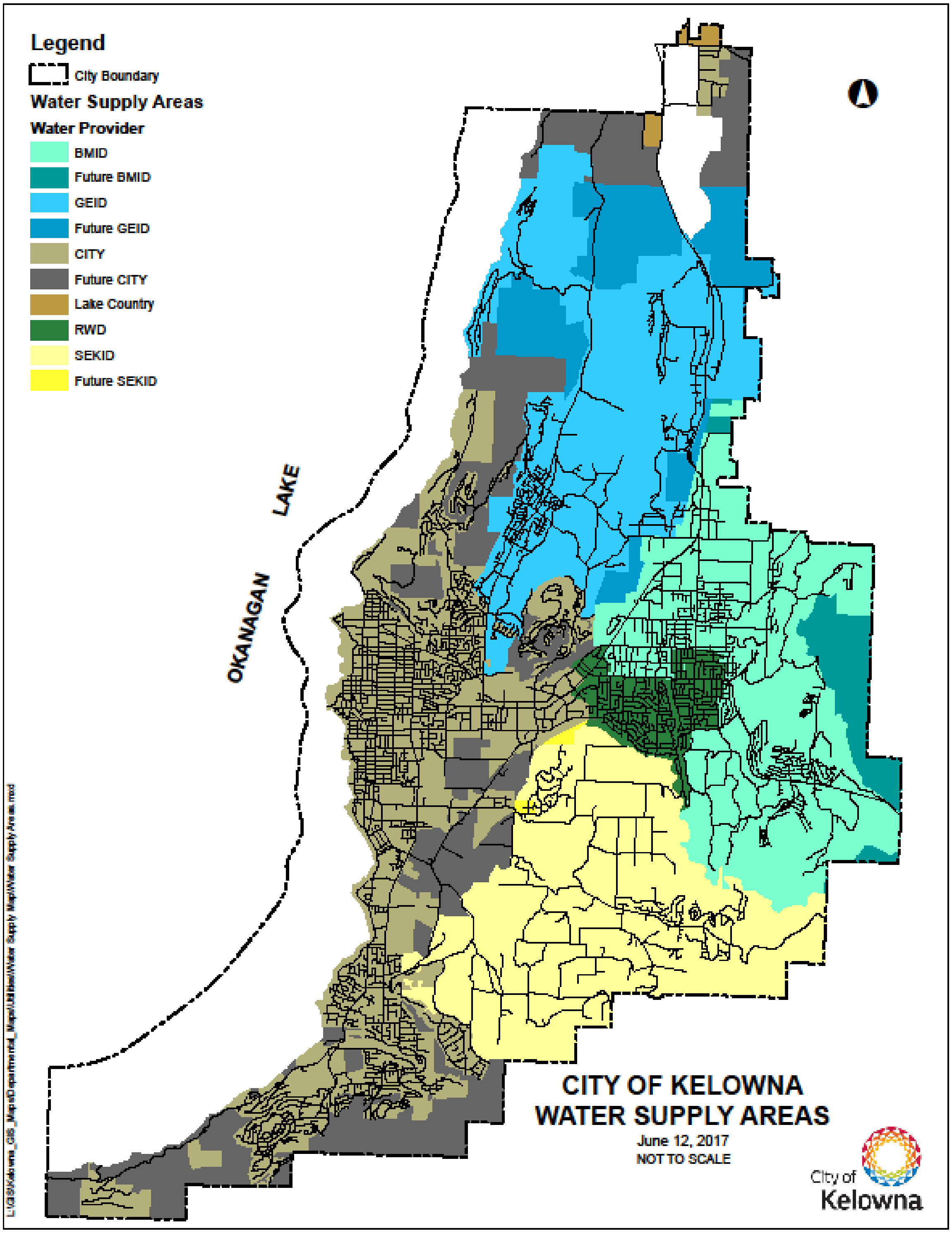


Figure 1. Water Supply area for City of Kelowna Water Utility and surrounding water districts

Water Source and Treatment

Okanagan Lake is considered a fjord lake of glacial origin and is used as a water source by several communities in the North, Central, and South Okanagan. The lake is 135 km long, between 4-5 km in width, surface area of 348 km^2 and has a maximum depth of 232 meters. Major inflows primarily consist of Mission, Vernon, Trout, Penticton, Equesis, Kelowna, Peachland, and Powers Creeks and is drained at the south end by the Okanagan River and continues through to a series of lake chains until it reaches its confluence with the Columbia River in the Unites States.

COK is licensed to draw water from Okanagan Lake through 3 primary intakes (Poplar Point, Cedar Creek, and Swick) and 1 seasonal intake (Eldorado) that is typically only utilized during peak water demand periods. Intake locations have been designed and constructed to draw water at designated lake depths to minimize impact of suspended material, microorganisms, and chemical influences.

Figure 2. City of Kelowna Water Utility Intake locations

Utilizing multiple intakes insures that there is water source redundancy in the event that an intake needs to be taken off-line due to water quality issues in localized areas, such as contaminated spills, and provides some flexibility to redirect water volume to meet demand. This applies to Poplar, Eldorado, and Cedar Creek only as the Swick system is not currently interconnected due to geographic location. Summary of intake locations, treatment employed, and depths are located in Table 1.

Intake	On-site Treatment	Depth (m)	Pump Capacity (ML/day)	Date Commissioned	Modifications
Poplar Point	UV, Chlorine	26	75	1985	UV Treatment added (2005)
Eldorado	UV, Chlorine	14	25	1972	UV Treatment added (2005)
Cedar Creek	UV, Chlorine	20	15	1997	UV Treatment added (2015)
Swick	UV, Chlorine	16	1.2	1984	UV treatment added (2005)

Table 1. City of Kelowna Water Utility intake specifications

The city water system is classified as a Level 2 water treatment system and employs a multi-barrier treatment approach that consists of UV dosing and chlorination disinfection prior to the water entering the distribution system. This aligns and complies with the "Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in BC" as established and adopted by the Ministry of Health – Health Protection Branch.

The source water supplied to the Airport water system source comes from Okanagan Lake via GEID has an additional stand-alone water filtration system in place to reduce the amount of suspended material, color, odor, and naturally occurring Total Organic Compounds (TOC). Maintenance of the filtration system is conducted by COK water operators.

Distribution System

The Poplar Point and Cedar Creek water distribution systems are classified as EOCP level IV based on population served, water storage capacity, flow and pumping ability, whereas the Swick system distribution is classified as a Small Water System.

The delivery system infrastructure consists of 423 km of pipe and has approximately 16,000 service connections of which 14,600 connections are residential, 1,400 commercials, and 18 farm or agricultural. Currently, all of the water supplied through the distribution system is considered potable.

A summary description of the pipe length and material in our system is summarized in Table 2.

Pipe Material	Length in Service	Comments
Asbestos Cement	147 km	Majority installed prior to 1978
Cast Iron	12 km	Majority installed prior to 1978
Concrete	14 km	Majority installed prior to 1978, used in larger diameter applications
Copper	1.4 km	Used in smaller applications
Ductile Iron	24 km	Ductile Iron still used in some applications
Galvanized	0.08 km	Galvanized still used is some applications
High Density Poly Ethylene	1.2 km	Used for specialized applications
PVC	220 km	Used in most applications since 1979
PVCO	1.5 km	Used for specialized applications
Steel	0.25 km	Used for specialized or larger applications
Thermal Lined Ductile Iron	0.69 km	Used for specialized applications
Total	**423 km**	

Table 2. Water distribution system pipe material in use for the City of Kelowna Water through 2017

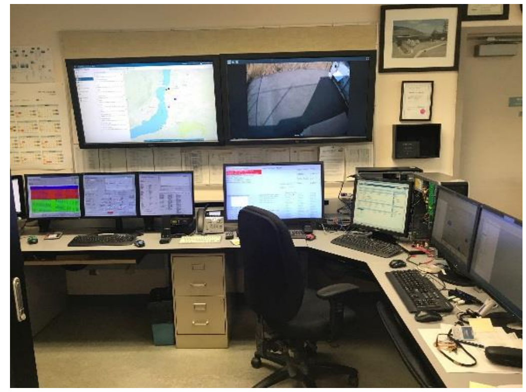
The COK distribution system connections are serviced by 4 pump stations, 21 booster stations, 21 pressure reduction stations, 22 balancing reservoirs, and delivered over 15.5 million cubic meters of water to customers in 2017. Associated costs for treatment and delivery are recovered through water meter billing whereby water users are charged by a flat rate, a tiered volume consumption calculation, and a water quality enhancement fee to cover future improvements.

The distribution system infrastructure is maintained by the COK Utility Network Maintenance division that included 390 km of pipe flushing and 2206 hydrant checks in 2017. A summary of asset values of the COK water system are detailed in Table 3.

Asset Category	Dimension	Replacement Value (millions)
Watermain	422 km	$312
Booster Stations and PRV's	42	$18
Meters	17588	$12
Reservoirs	22	$46
Source Water Pump Stations	4	$17
UV Treatment Facilities	4	$19
Total		**$424**

Table 3. City of Kelowna Water System Asset inventory and value in 2017

System Control



The operation and maintenance monitoring of the water quality, operating pumps, reservoir water levels, distribution system water pressures are all conducted through the use of a Supervisory Control and Data Acquisition Software (SCADA) program. Connected by wireless links, the SCADA software remotely collects information from sensors at all of the pump stations and reservoirs. The software interprets the receiving data and automatically adjusts pumps and system settings to maintain pre-defined operating requirements. When an issue is detected within the system, the SCADA system issues alerts and alarms to water system operators who then respond to the concerns. This software platform also allows the COK to collect and track historical performance of our system for auditing and future optimization of our water system.

Staffing

Section 12 of the *Drinking Water Protection Regulations* (DWPR) refers to the qualification standards for water system operators. In this section, the "Environmental Operators Certification Program" (EOCP) is required for certification of operators to maintain, operate, or repair a water system. The qualification levels required for operators are determined by the class of the system under the EOCP. Current list of water system operators and certification levels are listed in Table 4.

Name	Water Treatment		Water Distribution				Wastewater Collection			Wastewater Treatment		Chlorine Handling
	I	II	I	II	III	IV	I	II	III	I	II	
B. Stuart	■	■	■	■	■	■	■	■	■	■		■
S. Saran	■		■	■	■		■	■				■
B. Mandryk	■		■	■			■					■
J. Hilstob	■		■	■			■					■
D. Sharpe	■		■	■			■					■
D. Enns	■		■	■	■	■	■			■	■	■
M. Lange	■		■	■								■
R. Hogan										■		■
T. Hall			■									■
C. Jensen			■									■

Table 4. City of Kelowna Water System Operators certification levels

COK employs a diverse and talented team of engineers, managers, supervisors, technical and support staff that are responsible for the planning, design, analytical testing, budgeting, inspection, public communications, staffing and management aspects of the Water Utility operations (Table 5).

Staff	Role
K. Van Vliet, P.Eng., M.Eng.	Utility Services Manager
B. Stuart, WQT	Water Supply and Pump Stations Supervisor
M. Murrell	Utilities Network Maintenance Supervisor
J. Shaw, P.Eng.	Infrastructure Engineering Manager
J. Foster, MA	Community Communications Manager
M. Lee	Communications Advisor
G. Davidson, CPA, CMA	Divisional Director, Financial Services
P. Sourisseau	Human Resource Manager
R. MacLean, P.Eng.	Utilities Planning Manager
E. Hoppe, B.Sc., P.Chem.	Water Quality and Customer Care Supervisor
C. Moody	Cross Connection Control Program Coordinator
L. Jablonski, WQT	Water and Wastewater Quality Technician
D. Bachmann, WQT	Water and Wastewater Quality Technician

Table 5. City of Kelowna Water System Managers and Support Staff for 2017

Capital Works Projects

A number of capital projects were scheduled in 2017 that involved upgrades and improvements to existing water infrastructure and drainage systems that totaled over $4.0 million - an increase of $700,000 above 2016. Projects were completed by priority, contractor pricing, conjunction with other road construction projects, and long term development planning. Summary of budgeted water projects descriptions and values are presented in Table 6.

Water Capital Projects 2017	Description	Value	Level of Completion
Infrastructure Upgrade	Watermain Construction - Alta Vista Road	$ 110,000	Carried over to 2018
Infrastructure Replacement	Replace 225m of aging 200mm Cast Iron water main on Doyle to 250mm PVC from Water Street to Ellis Street	$ 275,000	Complete
Infrastructure Replacement	Replacement of 325m of aging infrastructure on Ethel from Harvey to Sutherland as part of the Active Transportation Corridor	$ 350,000	Complete
Infrastructure Upgrade	Re-construction of access road to Knox Mountain Reservoir	$ 100,000	Complete
Sediment Separator	Construction of Knox, Dilworth Sediment Separators	$ 121,900	Complete

Water Capital Projects Cont.	Description	Value	Level of Completion
Infrastructure Replacement	Construction of 200m of aging infrastructure on Martin from Richter to Ethel in conjunction with phase 2 of Ethel Corridor	$ 75,000	Carried over to 2018
Infrastructure Replacement	Replacement budget for the installation of new water meters within the Kelowna water distribution system for new development	$ 150,000	Complete
Infrastructure Upgrade	Construction of Watermain on Morrison Ave between Richter and Ethel	$ 500,000	Carried over to 2018
Infrastructure Upgrade	Oversize water Utility services beyond developer requirements to meet future demand.	$ 60,000	Complete
Infrastructure Replacement	Replacement of 600m of aging Cast Iron water main to 200mm PVC main from Bernard to Cawston	$ 700,000	Carried over to 2018
Infrastructure Replacement	Replacement of aging infrastructure along Saucier in conjunction with phase 3 of Ethel Active Transportation Corridor	$ 256,550	Complete
Infrastructure Replacement	Replace and relocate key electrical equipment from underground chamber to above ground pads at Skyline Booster Station. Upgrade in response to flooding experienced in 2016	$ 235,000	Carried over to 2018
Infrastructure Upgrade	Construction of new pressure reducing station on Vintage Terrace Road to improve fire flow in Mission area	$ 200,000	Carried over to 2018
Provisional Upgrades	Budget to design upcoming capital project replacements in 2018	$ 20,000	Misc. work completed
	Total	**$ 3,153,450**	

Table 6. Drinking Water capital projects through 2017

Water drainage improvement projects are similarly budgeted, scheduled and implemented by the Infrastructure Division. Due to the prolonged flooding events in 2017 and contractor availability, a number of these projects were carried over to 2018. A summary of the 2017 water drainage capital projects obtaining budget and approval are listed in Table 7.

Drainage Capital Projects 2017	Description	Value	Level of Completion
Stormwater Attenuation	Construction of dual culvert detention pond to attenuate large storm and run-off events of Brandt's Creek next to Clement Ave.	$ 84,350	Complete
Sediment Capture	Construction of sediment catchment structure for drainage water into Chichester Pond	$ 150,000	Carried over to 2018
Stormwater Separator	Construction of Oil/Water separator at Dilworth Drive outfall	$ 88,650	Carried over to 2018

Drainage Capital Projects Cont.	Description	Value	Level of Completion
Stormwater Attenuation	Pre-design for stormwater detention area along Gopher Creek to mitigate flooding events	$ 325,000	Carried over to 2018
Drainage Upgrade	Design of drainage works on Lakeshore from Barnaby to Vintage Terrace road	$ 204,910	Carried over to 2018
Stormwater Separator	Construction of Oil/Water separator on Sutherland Ave.	$ 48,550	Carried over to 2018
Stormwater Separator	Construction of Oil/Grit separator at Sutherland outfall	$ 90,000	Carried over to 2018
	Total	**$ 991,460**	

Table 7. Water Drainage capital projects through 2017

Cross Connection Program

The City of Kelowna Water Utility implemented a comprehensive Cross Connection Control (CCC) program in 1998. The CCC program is designed to protect water quality in the distribution system from backflow and any subsequent contaminants that could be carried from point of use sources. Our program has been strategically implemented to include the 5 distinct water district purveyors in Kelowna and tracks 4800 testable backflow prevention assemblies in 2080 facilities throughout the city. The total inventory of backflow preventers continues to grow at a rate of 5-7% annually.

Program Scope

The Cross Connection Control program applies to all water customers within the city regardless of their water purveyor. The City of Kelowna manages the program on behalf of all Kelowna water providers through the Kelowna Joint Water Committee. Although the program applies to all customers, it is focused on Industrial, Commercial, Institutional, and Agricultural customers. There are standard backflow prevention requirements that apply to single family dwellings but these requirements don't usually involve testable Back Flow Preventers (BFP) assemblies. Occasionally single family home owners will install a commercial type system or appliance in their home and in these instances appropriate backflow prevention assemblies may be installed. The program utilizes field inspections and review of construction plans and building permit applications to identify cross-connection hazards and risk of backflow. When a cross-connection hazard is identified, a backflow prevention assembly (BFP) is required to be installed to isolate and contain the hazard and to prevent backflow into the public water system.

Annual Testing

Consumers connected to the public water supply in the City share the responsibility of protecting the water system from the backflow of contaminants. The assembly owners are required to contact the services of a qualified tester and submit a passing test report for the assembly(s) annually.

The City of Kelowna strives to achieve total compliance with the annual testing component of our program and is successful within 2% year after year. For summary of backflow devices in use and testing completed in 2017, refer to Table 8.

Premise Protection	In-Service	New Installs	Failures	Cleaned	Repairs	Tests Completed
Double Check Detector Assembly	11	0	0	0	0	11
Double Check Valve Assembly	2444	128	56	3	17	2503
Pressure Vacuum Breaker Assembly	3	0	0	0	0	2
Reduced Pressure Backflow Assembly	1463	92	58	6	8	1531
Total	**3921**	**220**	**114**	**9**	**25**	**4047**
Premise Isolation						
Double Check Detector Assembly	1	0	0	0	0	1
Double Check Valve Assembly	613	47	18	1	2	658
Reduced Pressure Backflow Assembly	210	9	11	0	1	241
Total	**824**	**56**	**29**	**1**	**3**	**900**
Grand Total	**4745**	**276**	**143**	**10**	**28**	**4947**

Table 8. Summary of 2017 Cross Connection Backflow Devices and compliance tested within City of Kelowna

2017 Progress

The temporary construction water backflow device installation requirement, first stipulated by Bylaw in 2016, is now widely adopted by developers and contractors. This designation is put in place during construction until such a time that an appropriate water meter (and backflow device if required) is installed on-site and registered at the Utility office.

The anticipated operational takeover of both the South East Kelowna Irrigation District (SEKID) and the South Okanagan Mission Irrigation District (SOMID) in 2018/2019 will position the program to apply standard backflow prevention requirements to agricultural users. Practice and enforcement is not currently standardized in these areas.

Water Quality Monitoring

The COK Water Quality Program references the following regulations and guidelines to develop a formal reporting and monitoring program:

- *Guidelines for Canadian Drinking Water Quality (GCDWQ)*
- *British Columbia Approved Water Quality Guidelines*
- *British Columbia Drinking Water Protection Act and Regulation (DWPA)*
- *Drinking Water Treatment Objectives for Surface Water in BC*
- *IHA Decision Tree for Responding to Turbidity Events in Unfiltered Water*

The *Guidelines for Canadian Drinking Water Quality* are based on the current, published scientific research related to the health effects, aesthetic effects, and operational considerations. Health based guidelines are established on the basis of comprehensive review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical techniques. The highest priority guidelines are those dealing with microbiological contaminants such as bacteria, protozoa, and viruses.

Sample Collection and Frequency

A source to tap drinking water quality monitoring program is a function of source water quality, water treatment, and water quality through the distribution system. As a result, the monitoring of the COK drinking water quality consists of 4 main sample and information collection components:

- Source Water Monitoring
- Monitoring at the outflow of Treatment Plant
- Monitoring in the Distribution System
- Customer Concerns and Service Requests

The sampling location, frequency, and water quality parameters required at each of the source to tap sites are reviewed yearly, approved by IHA, and samples collected as per frequency referenced in the COK Water Utility Water Quality Sampling Guidelines (Appendix A). Qualified field and lab technicians perform more than 500 monthly tests on source and distribution water at over 80 sites throughout the system. Sampling sites include various locations from Okanagan Lake, tributary creeks, pump stations, reservoirs, booster stations, valve chambers, and final tap source points.

Data collection consists of SCADA monitoring, field measurements, in-lab testing and submission of samples to a third party, external, accredited laboratory as part of the quality assurance program. Analytical results are entered into a WaterTrax software database, which has the ability to alert water operation staff and utility management in the event that specific parameters exceed operational or water quality guidelines as outlined in the CDWQG.

Source Water Quality Monitoring

Over 2,300 combined source water samples were tested from Okanagan Lake drawn from each of the four intake locations. The samples were taken prior to both UV and Chlorine treatment and analyzed for a variety of water quality parameters either on-site at the COK laboratory or at the certified lab as per monthly sampling schedule.

Detailed chemical and biological parameter descriptions, graphical trends, and related WQ objectives are listed in Appendix B and include the following:

- Turbidity (Table 13, Figures 10-11)
- Total Coliform (Table 14, Figures 12-13)
- Escherichia coli (E. Coli.) (Table 15, Figures 14-15)
- pH (Table 16, Figures 16-17)
- Color (Table 17, Figures 18-19)
- Temperature (Table 18, Figures 20-21)
- UV Transmittance (Table 19, Figures 22-23)

There was a period of elevated Turbidity in the Source Water from May to the beginning of July resulting in the issuing of a Water Quality Advisory for a period of 55 days. This was primarily attributed to the historic flooding event and resulting debris that was deposited into Okanagan lake. This also contributed to elevated Total Coliform counts as associated soil bacteria were introduced into the lake and mixed through stratification turnover. Alternately, the E. coli. counts decreased substantially at most intakes potentially due to dilution effects of increased inflow. pH dropped by 0.2 pH units below 2015-2016 levels, color rose marginally, yearly average temperature dropped by 1-2 degrees, and UVT yearly average remained fairly stable relative to the previous 4 years.

Overall Lake Okanagan Water Quality Health

In addition to internal testing, the COK is part of an annual *Collaborative Okanagan Lake Water Quality Study*, conducted annually since 2011 by Larratt Aquatic Consultants in conjunction with the Ministry of Environment, West Kelowna, Penticton, Vernon, and Okanagan Native Alliance (ONA). The report captures water quality data at various representative points and depths along Okanagan Lake and comments on the general physical, chemical, and biological health relative to the Water Quality objectives published in the 2005 Nordin Water Quality objective reference document (available upon request) .

Tested parameters generally all fell within water quality objectives with the exception of several Water Quality trends in the shallower northern end of the lake including lower water clarity, increasing concentrations of Nitrogen and Phosphorus, and Algae blooms. The high degree of flooding and subsequent drought conditions contributed to lower water quality than is typical for Okanagan Lake. Current recommendations include continual, annual monitoring to determine on-going water quality trends of concerns. A copy of this document can be requested from the City of Kelowna through our on-line service request link at www.kelowna.ca.

Treated Water Quality Monitoring

Similar to the source water sampling program, over 2,800 combined treated water samples were tested from each of the four intake location immediately post UV and Chlorine treatment. The purpose of this monitoring program is to establish that the treatment is effectively removing or neutralizing any microbiological threat, improving, or at least not deteriorating the chemical and physical quality of the drinking water, and complying with the established *GCDWQ* health and aesthetic guidelines.

Detailed chemical and biological parameter descriptions, graphical trends, and related water quality objectives are listed in Appendix C and include:

- Turbidity (Table 20, Figures 24-25)
- Free Chlorine (Table 21, Figures 26-27)
- Total Coliform (Table 22)
- Escherichia coli (E. Coli.) (Table 23)
- pH (Table 24, Figures 28-29)
- Color (Table 25, Figures 30-31)
- Temperature (Table 26, Figures 32-33)
- UV Transmittance (Table 27, Figures 34-35)

The Treated Water Turbidity trend was proportional to the Source Water Turbidity concentrations, but approximately 0.1-0.2 NTU lower primarily as a result of reservoir settling. Free Chlorine residuals and UVT met operational objectives and all bacterial results were negative, indicating that treatment was effective at all times. pH levels met the CDWQG at all times throughout the year and there were only minor Color and Temperature exceedances of the 15 ACU aesthetic objective and 15^{o}C operational objective respectively.

Annual Physical, Chemical and Biological Analysis

In addition to the on-site and in-lab analytical testing program, the COK submits treated water samples to an external accredited laboratory for full comprehensive physical, chemical, and microbiological analysis from each of the Intake sites. The purpose of utilizing an external lab is to verify internal test results as a quality control check and evaluate a broader range of compounds and highlight any water quality health concerns.

The 2017 analytical results validated the data generated by internal lab testing and did not indicate any significant year over year trend. There were no exceedances of aesthetic or health maximum guideline of any parameters listed and no significant trends relative to previous years of historical comprehensive analysis (Table 28).

Pesticides and Herbicides

The Okanagan valley is renowned for its long standing agricultural industry and continues to be a hallmark of the BC interior region. Farming practices have commonly included the application of a variety of pesticides and herbicides over the past 80 years. Although much of the hazardous compounds have been phased or legislated out, there are still some legacy chemical compounds that are monitored due to its lifespan in the environment. Due to the proximity of the agricultural land to Okanagan Lake, Herbicides and Pesticides are tested on a four-year cycle. Since the beginning of this screening practice, none of the fifty-five scanned Pesticides or Herbicides has been detected in any of the samples (Table 29). Testing was completed in 2017 and is scheduled every 4 years.

Radiological

Radionuclides are naturally present in the environment and have been surveyed in various regions throughout British Columbia of which Uranium is the most common isotope identified in the Okanagan. Leaching of these radionuclides into ground water is of concern and therefore are measured against health standards. Maximum acceptable concentrations in drinking water have been established for three natural isotopes (210-Pb, 226-Ra, and 236-U) and four artificial isotopes (90-Sr, 131-I, 137-Cs, and H3-Tritium). The COK has been testing these parameters since 2011 on a four-year cycle and to date has not shown any significant Gross Alpha or Gross Beta radionuclides in the drinking water (Table 28 and 30). Testing was last conducted in 2014 and is slated for testing again in 2018.

Distribution System Testing Program

The COK has over 400km of in-ground water pipes that services residential, commercial and agricultural properties which in turn has over 17,000 point of use sources that requires consist clean drinking water quality. In order to maintain this service, bacteria, chlorine residual, and chlorination byproducts are routinely monitored and reported to Interior Health to ensure that it strictly meets all *BC Drinking Water Regulations* and *Guidelines for Canadian Drinking Water Quality*. Representative sampling sites are determined by COK and approved by IHA and are designed to capture changes in water quality as it flows throughout the distribution system. As part of this program, samples are taken at the outer regions of the water system to ensure that there is free chlorine residual maintained throughout and to monitor chlorination byproducts. Specific parameters that are monitored are listed in Appendix D and include:

- Free Chlorine (Table 31, Figures 36-37)
- Total Coliform (Table 32)
- Escherichia coli (E. Coli) (Table 33)
- Trihalomethanes (THM) (Table 34, Figures 38-39)
- Haloacetic Acids (HAA) (Table 35, Figures 40-41)

As per established GCDWQ guidelines, the following microbiological criteria for drinking water distribution systems are referenced:

- No sample should contain more than one Escherichia Coli organisms per 100mL
- No two consecutive samples from the same site should show the positive presence of Total Coliform organisms per 100mL
- At least 90% of the samples must have zero Total Coliform per 100mL

As per Table 9, COK demonstrated that the bacterial water quality in the distribution system met the guideline criteria for both Total Coliform and E. Coli. throughout 2017.

Criteria – Total Coliform	**City System**	**Swick System**	**Airport System**
Number of In-house microbiological tests - Total Coliform	879	124	181
Number of ALS microbiological tests - Total Coliform	220	46	12
Total number of Total Coliform samples tested	1099	170	193
Number of samples containing positive Total Coliform/100mL	0	0	0
Samples with >10 Total Coliform / 100mL	0	0	0
Occasions with consecutive positive Total Coliform / 100mL	0	0	0
Criteria – Escherichia coli			
Number of In-house microbiological tests - E. Coli.	879	124	181
Number of ALS microbiological tests - E. Coli.	220	46	12
Total number of E. Coli. samples tested	1099	170	193
Number of samples containing positive E. Coli. /100mL	0	0	0

Table 9: Summary of Bacterial tests in COK distribution systems

Free Chlorine residuals have an operational objective of 0.20 mg/L at end of pipe and this level was maintained without exception in 2017 (Table 31). The free chlorine continued to measure significantly higher in the Airport system relative to the other COK water systems due to the proximity to the GEID chlorination station, but were all within operational targets.

Quarterly THM results only indicated one exceedance of the 0.1 mg/L concentration threshold, but on a yearly average basis, all water system met the CDWQG objectives (Figure 38-39). Overall, there seems to be an overall increasing trend in THM's in the Swick system, but stable or decreasing for the City and Airport system. Quarterly HAA results were all within the <0.08 mg/L objective and yearly averages were all within the CDWQ guidelines. A marginal increasing trend in HAA concentrations was noted over the past 5 years (Figure 41).

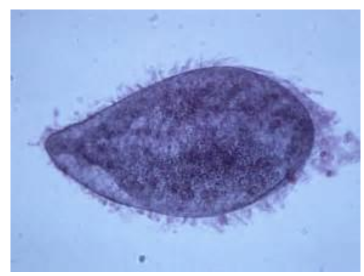
Filtration Exclusion Requirements

The City of Kelowna applied for filtration treatment exclusion in 2010 and was approved in 2011 based on the proviso that several treatment and water quality objectives be adopted, monitored, and reported to Interior Health on an annual basis. Since obtaining filtration exclusion, COK has continually met or exceeded the seven requirements outlined by Interior Health and approved by the provincial Medical Health Officer.

Dual Disinfection

In accordance with the IHA dual barrier approach for drinking water, all of the Kelowna intake systems are equipped and utilize both Ultra Violet(UV) and chlorine disinfection prior to the water entering the distribution system. UV disinfection is applied at a minimal dose of 40 mj/cm through the reactor cells and chlorine is applied to provide to maintain a minimum free chlorine residual of 0.2 mg/L in the distribution system.

Protozoa Sampling



Protozoa was analyzed extensively between 1996 and 2013 on raw and treated water samples throughout the COK water system. After consultation and review of the data with IHA, this requirement was removed from the scope as it was demonstrated that the UV treatment adequately accounted for the deactivation and neutralization of all protozoa entering the water system.

Watershed Protection Assessment and Response Plan

As a condition on Permit to Operate, COK contracted an external Environmental consultant with the purpose of conducting and documenting a Water Source Protection Plan (WSPP) assessment. This was formally completed in 2011 with the intent that the resulting recommendations would trigger an assessment action response plan that would be annually reviewed and updated in accordance with the risks identified. Six main risk categories were identified as influential to the water quality for the COK and include:

1) Creek Flow
2) In-Lake Algal Production
3) Wastewater Treatment Plant Discharge
4) Transportation Corridor Spills
5) Boating Activities
6) Impact of Lake Physics

The findings of the Source Water Assessment have been initially addressed in the COK *Source Water Protection Assessment Response* document published in 2017 and further developed in 2018 with a new *Source Water Protection Plan* action plan to be developed by an external Environmental consultant. This will be a working document that will be continually evaluated and updated as progress is made. Results will be documented reported in subsequent IHA and COK Annual Water reports.

It is important to note that the COK is not a regulator in water source protection and does not have authority related to land use practices on Crown land or land outside of its boundaries, which is where the majority of the water quality impacts originate from. The COK relies on Federal and Provincial Acts, Regulations, Stewardship Plans, Best Management Practices and Local Government bylaws and policies to protect water resources from the impacts of land use in the watershed. As such, COK has been participating in a source water protection stakeholder Technical Advisory Committee (TAC) that began in 2017. The TAC groups consists of representatives from Ministry of Environment, Interior Health, Environmental consultants, Municipalities, Regional Districts, and Academic institutes that meet regularly to review progress and make recommendations on common risk mitigations and promotion of best practices for source water on a broader scale.

Drainage Water Quality Program

As part of the COK *Source Water Protection Assessment Plan*, there are number of chemical and biological parameters that are tested and monitored at storm water outfalls and local tributaries that enter Okanagan Lake. Contaminants carried through the drainage system have the potential to impact the water quality at the intakes and therefore have been categorically assessed, recommendations made, and actions taken to mitigate and monitor the risks. Yearly assessments include correlating elevated Turbidity and E. Coli. levels in tributaries to the same parameters at intakes, recording water quality changes during rain and flushing events through the storm water system, summer beach sampling for E. Coli., and testing of routine water quality parameters in creeks at a minimum of 5 times a month to determine the level of nutrient and pathogen contribution to the lake water quality. Details of each category are listed with commentary in Appendix E

Raw Water Bacteria

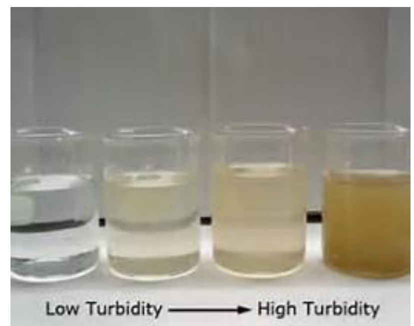
As per the annual COK water quality sampling program, the source water was monitored for Total and E. Coli. Bacteria throughout the year at each intake. Results are collected and reviewed through the WaterTrax software system that allows for alert levels to flag and notify the Utility of elevated levels. Corresponding monthly summary reports were issued to Interior Health as part of the Condition on Permit to operate and to assess if the water treatment is sufficiently neutralizing the raw water bacterial counts at the intake. For the 2017 calendar year, all samples from poplar Point, Cedar Creek, Eldorado or Swick Road intakes met the Filtration Exclusion criteria of:

- No more than 10% of the source water E. Coli. samples exceed 20/100ml in any 6-month period (Table 15 in Appendix B)

The levels of Total Coliform in the source water increased in July at all intakes and remained high through early September, during which time the Lake experienced thermal stratification (Table 14 in Appendix B).

The elevated levels may have been attributed to an influx of organic matter, and related coliform bacterial commonly found, in the hypolimnion layer during the flooding event. Operational adjustments were made at each treatment site by elevating chlorine doses and increasing UV energy dosage accordingly in response to the corresponding elevation in Turbidity. Bacterial results of the treated water at each of the intake systems indicate that the Chlorine and UV treatment was effective at neutralizing all bacteria despite the elevated levels and met all drinking water objectives throughout the year.

Raw Water Physical Parameters



In 2006, Interior Health introduced the Turbidity Education and Notification Campaign for unfiltered water systems to inform customers that health risks increase as Turbidity rises and to notify customers (particularly for at-risk populations with weakened immune systems) for levels higher than one (1) Nephelometric Turbidity Units (NTU). None of the four COK intakes currently are equipped with filtration and therefore routine testing and reporting of Turbidity levels to Interior Health is required to demonstrate that source water levels are meeting the 1 NTU target.

Turbidity is continuously measured at all water supply sources via on-line Turbidity meters and monitored by SCADA and is primarily used as a screening or trend indicator. Turbidity results that are officially reported are generated by water quality staff with an in-lab calibrated Nephelometer to ensure accuracy. 2017 SCADA Turbidity values for each of the monitored intakes are plotted in Figures 3-6 with weekly average granularity and associated guideline.

As with past annual Turbidity reports, there was a noteable increase in late April / early May at most intakes which coincided with spring freshet season. Several larger tributary creeks drain into Okanagan lake along the Kelowna bondary foreshore and have a direct impact on the water qaulity at the intakes. In order to better understand the relationship and impact of these tributaries, the COK has implemented a sampling program that cross references the freshet as well as timely weather events with water quality tested at the intakes. Summary and commentary on these relationships can be found in the drainage report (Appendix E).

A detailed list of additional raw water physical parameters monitored for filtration exclusion are listed in the Appendix B of this report. The *Okanagan Lake Collaborative Monitoring Agreement 2017 Summary Report* supplements the findings in this report, but on a larger, lake wide overview to determine if watershed trends exist and what collaborative action needs to be taken by valley wide stakeholders.

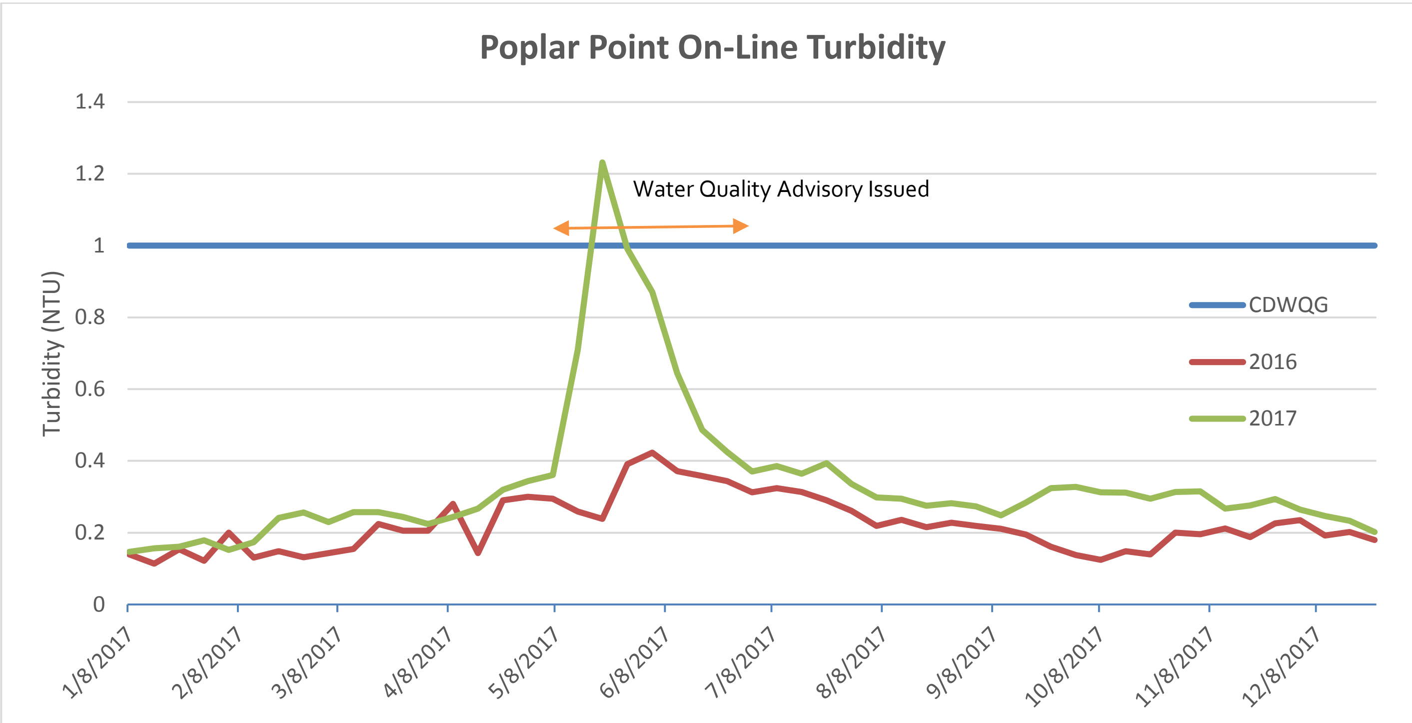


Figure 3. On-line Turbidity values at Poplar Point intake

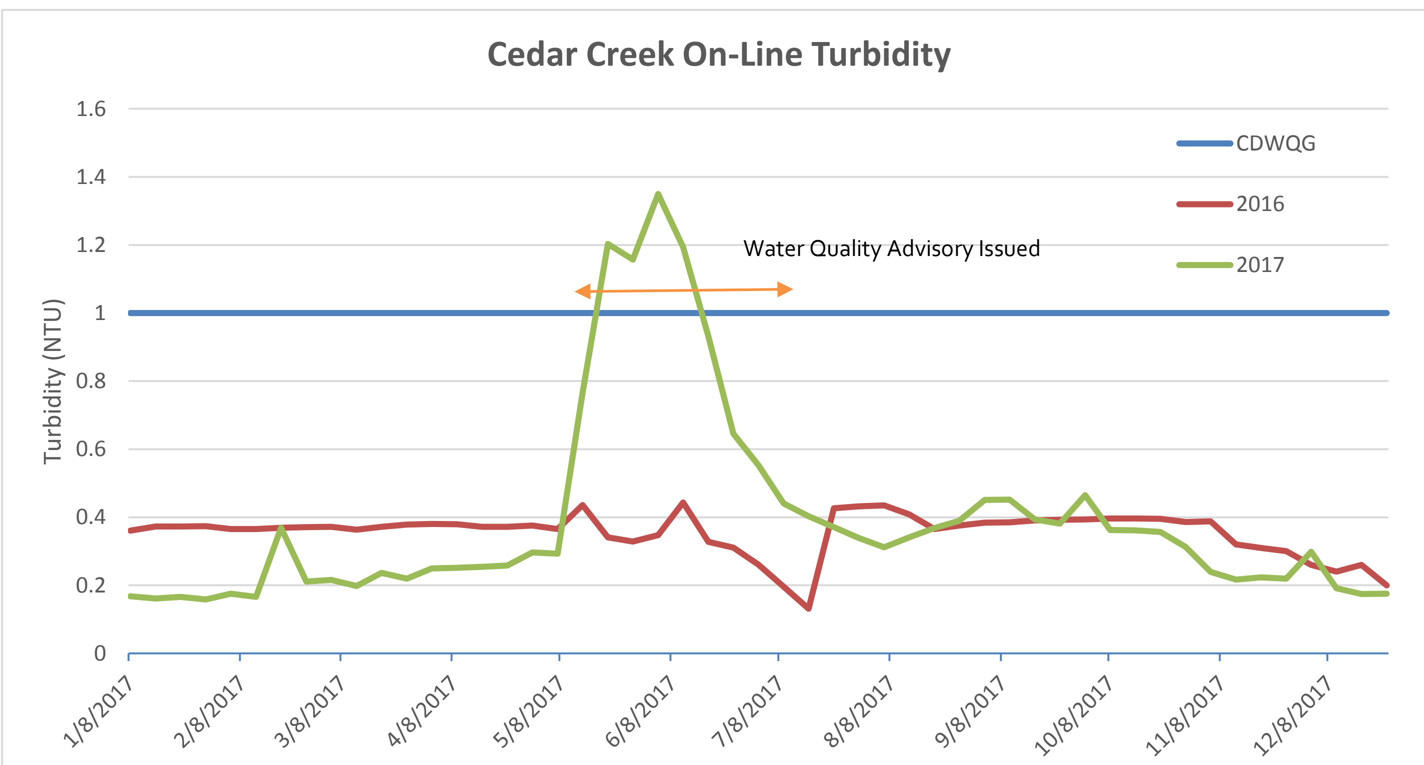


Figure 4. On-line Turbidity values at Cedar Creek intake

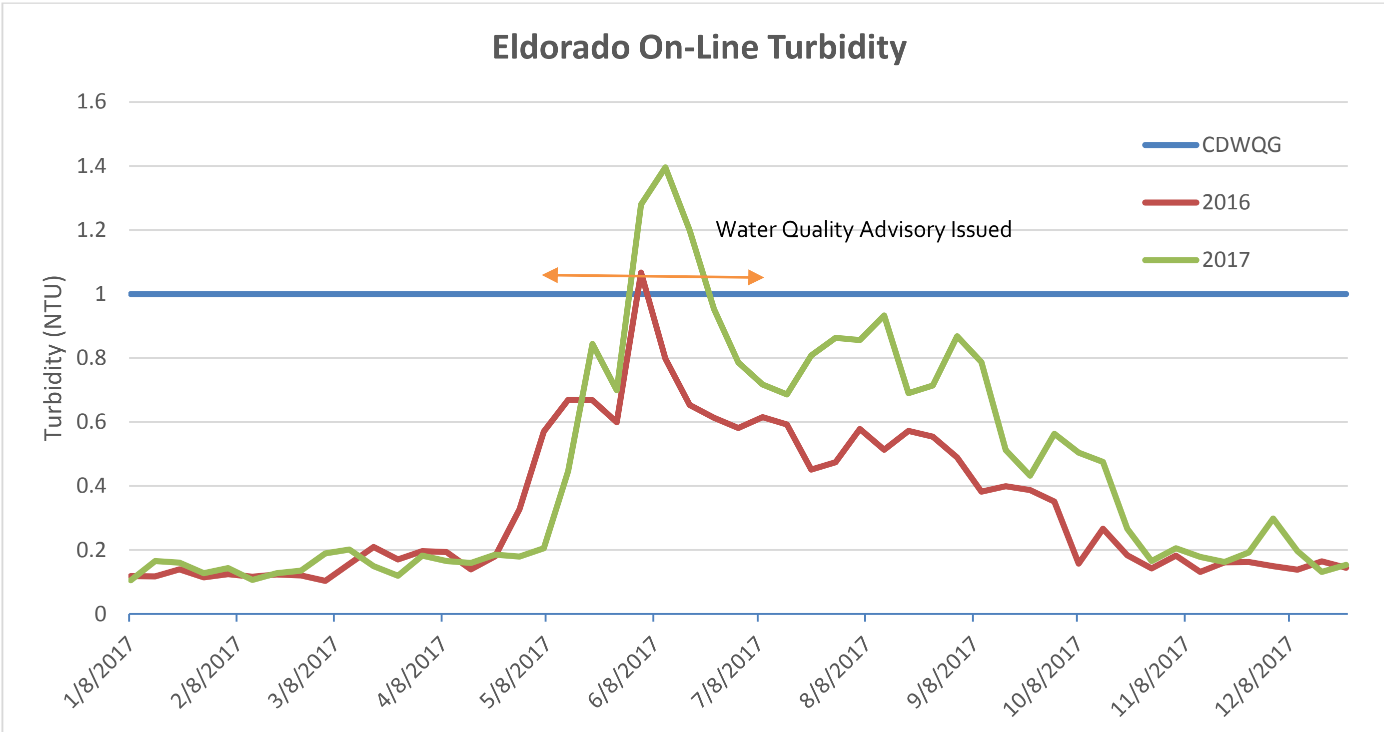


Figure 5. On-line Turbidity values at Eldorado intake

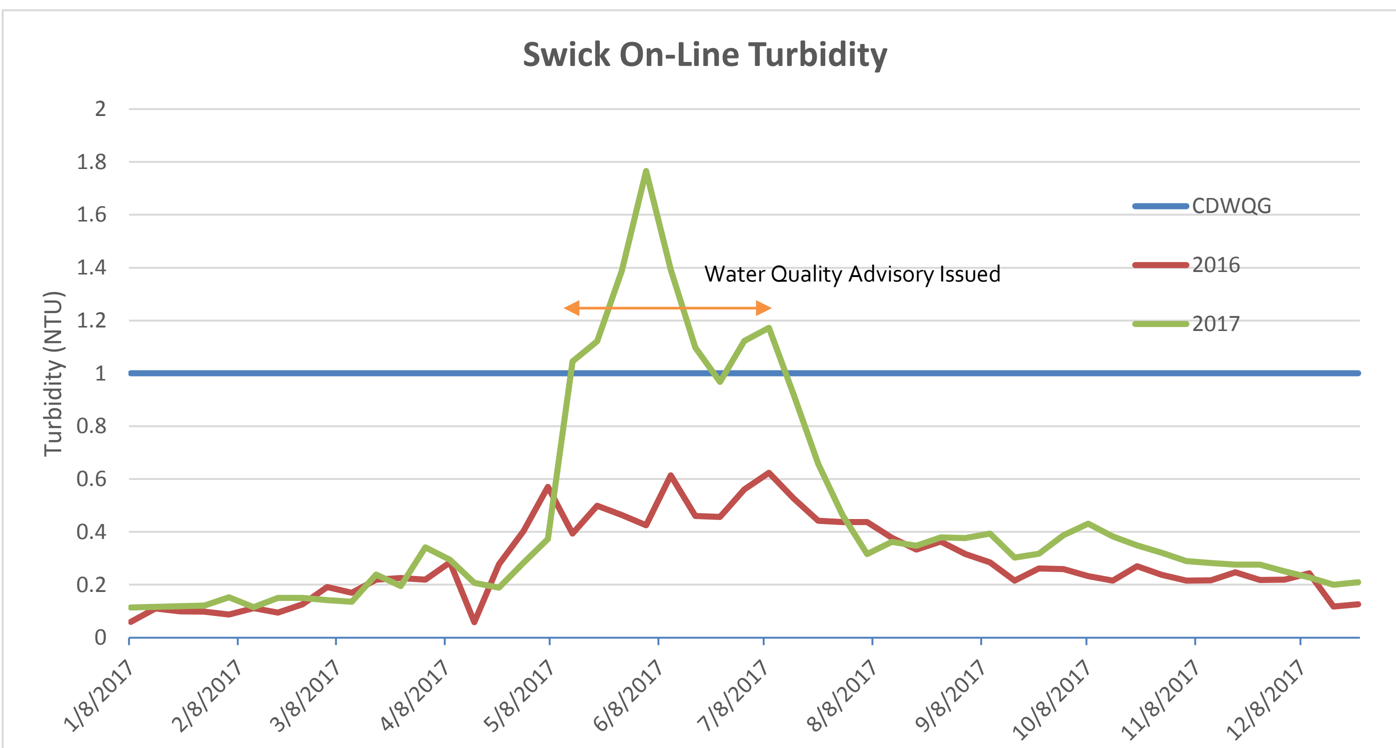


Figure 6. On-line Turbidity values at Swick intake

Raw Water Chemical Parameters

As referenced in the Water Distribution Testing Program section, the THM yearly average for all sites were at or below the 0.100 mg/L objective. There was a number of seasonal, quarterly samples that were higher than the objective are likely a result of elevated Total Organic Carbon (TOC) in the raw water source. Overall, there is an upward trend in the Airport THM concentrations over the past 5 years (Appendix D, Figure 39).

Water Production

Water production within the COK service area are monitored at each pump station prior to treatment. The Poplar Point system consistently accounts for 84% of the total annual water production with the remaining 16% spread between Cedar Creek, Eldorado and Swick. Production demand typically picks up in April, peaks in late July / early August due to agriculture and irrigation demand and drops through October (Figure 7).
Due to the extended drought conditions between June and September, water demand and peak demand was notably higher in the summer months of 2017 (Figure 7, 8). However, there continues to be a comparatively long term decreasing trend in overall and peak demand (Figure 8, 9).

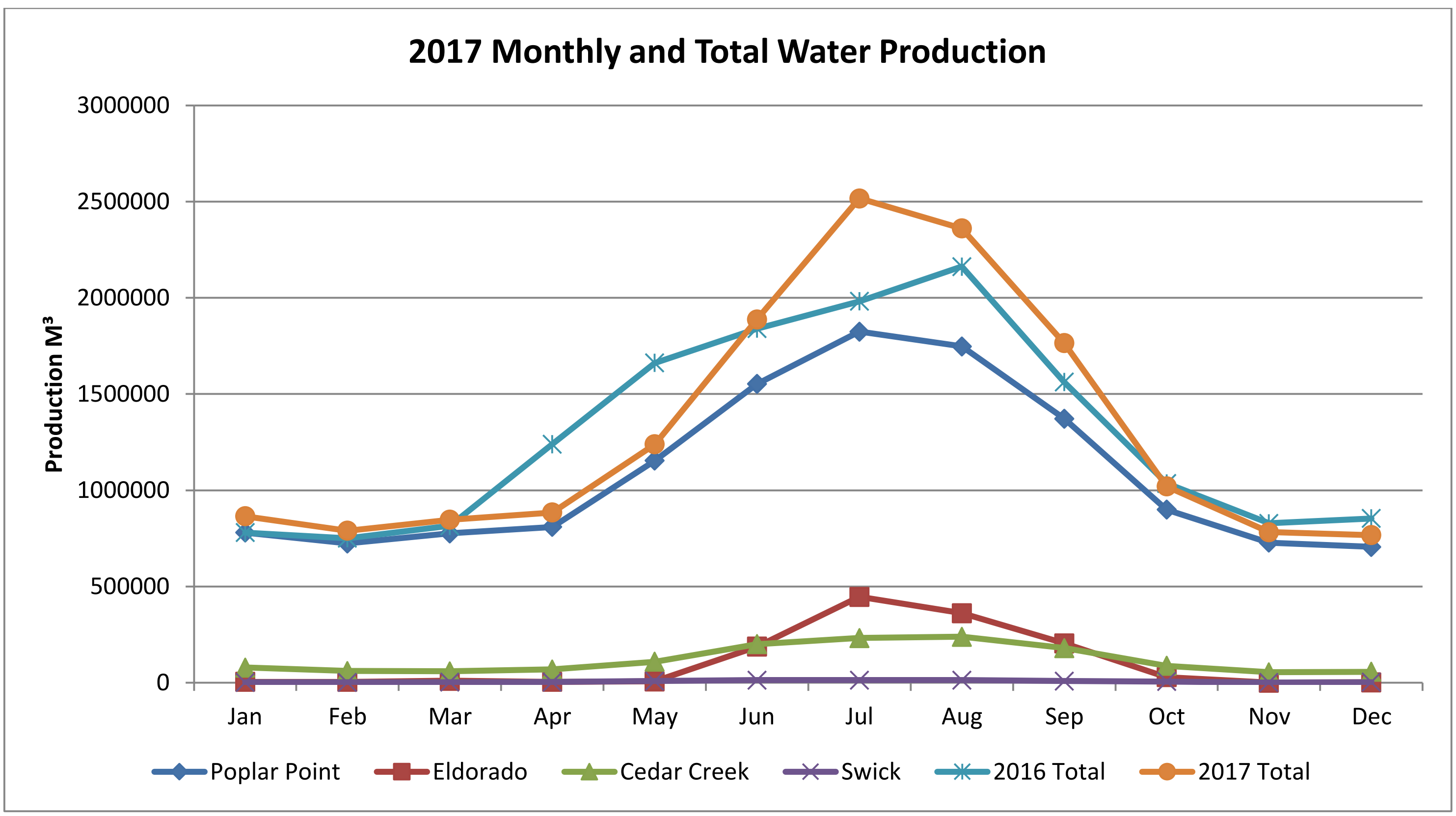


Figure 7. Monthly water production at each COK pump station

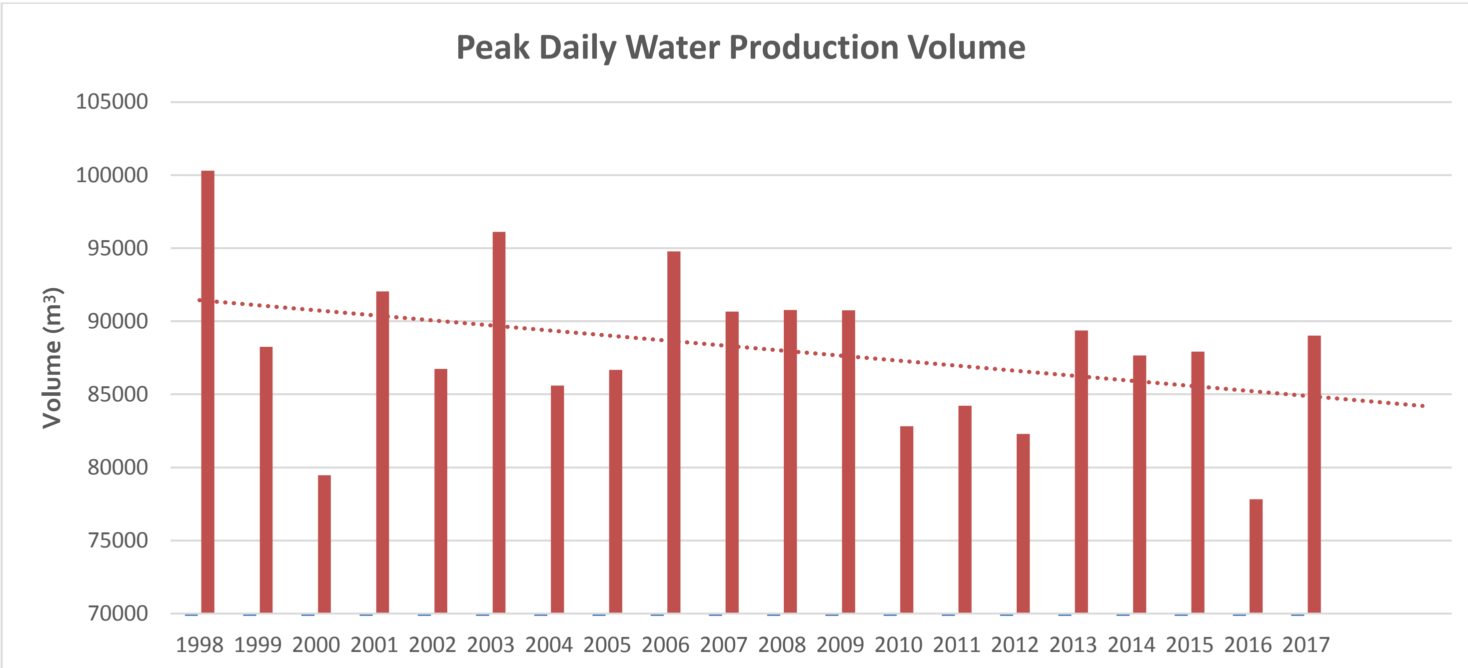


Figure 8. Peak daily water production volume trending

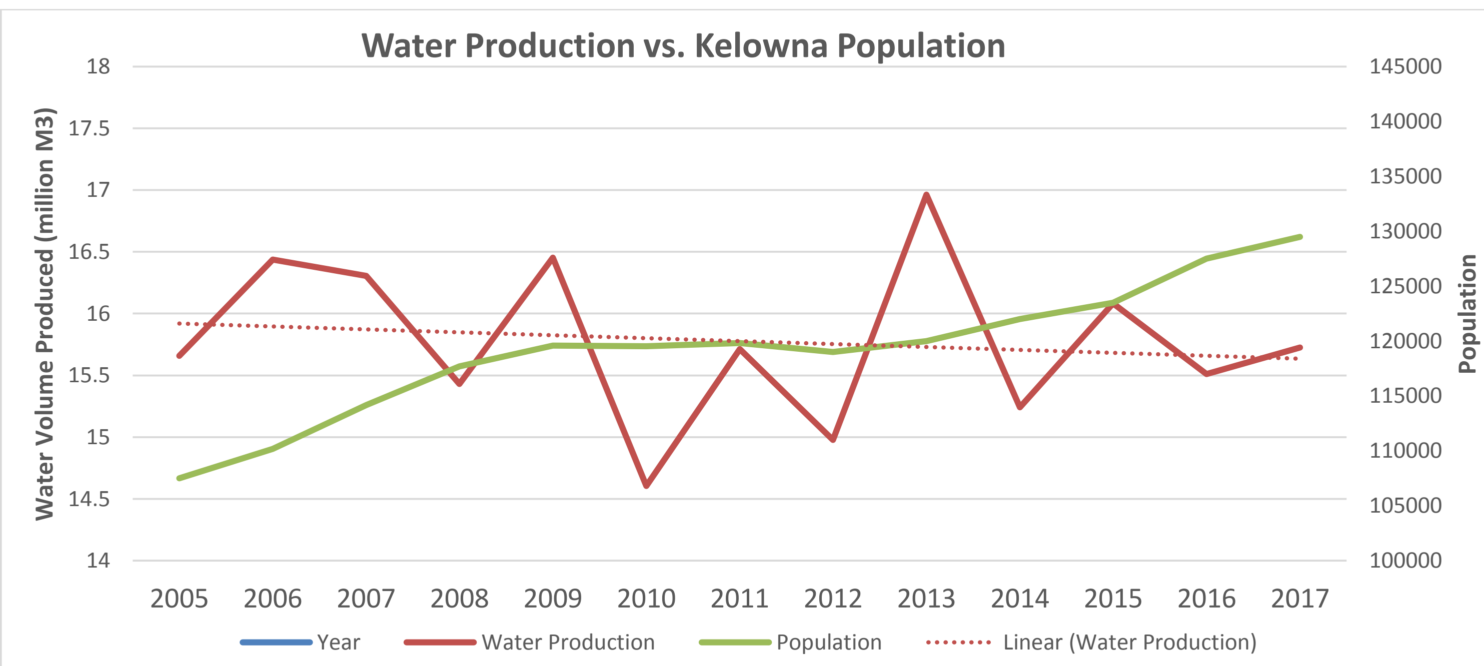


Figure 9. Total water production relative to COK population growth

Similarly, the total water production has been tracked relative to the population of the Utility service area over the past 12 years (Figure 9). Of note, there is an overall downward water volume production demand trend relative to increasing population due to a combination of factors including level of precipitation, conservation and water restriction efforts, amount of land developed for agricultural purposes, and population densification.

Consumption is also tracked by service type and metered accounts and provides a correlation between what is produced and what is consumed. Discrepancies between the two values indicate potential water loss due to leakage or line flushing or as a result of unmetered accounts. Based on benchmarking data from other jurisdictions, Kelowna has a relatively low water leakage rate and through diligent monitoring, the rate of unmetered accounts is considered insignificant. The standardized consumption rates have been relatively consistent for the past five years as the population trends have increased (Table 10).

	2012	***2013***	***2014***	***2015***	***2016***	***Unit***
Production						
Total Pumped	14,983.2	16,962	15,243.2	16,083.6	15,512.8	1000 m^3
Population within COK Water Utility Boundary						
2.7 per Single Family Dwelling, 1.9 per multifamily unit	67,311	68,523	68,077	69,679	70,694	people
Climate						
Precipitation (April-September) (Normal: 209 mm)	181	288	214	153	148	mm
Number of Services (active and inactive)						
Residential	14,087	14,408	14,425	14,084	14,365	services
Multifamily	396	409	387	342	351	services
Strata	658	660	651	648	657	services
Commercial	1,104	1,120	1,074	1,361	1,367	services
Parks	191	187	194	167	167	services
Total	16,436	16,784	16,980	16,910	16,907	services
Consumption (Metered)						
Residential	5,649.8	5,369.3	5,481.4	6,052.0	5,647.6	1000 m^3
Multifamily	2,164.4	2,251.1	2,168.8	2,542.7	2,443.0	1000 m^3
Strata	683.4	656.0	673.4	735.5	717.0	1000 m^3
Commercial	3,058.8	3,250.9	3,304.9	3,666.0	3,867.8	1000 m^3
Parks	479.5	402.2	495.6	585.3	498.0	1000 m^3
Total	12,035.9	11,929.5	12,124.0	13,599.5	13,173.4	1000 m^3
Indicator						
Other Use*	2,446.9	2,728.0	829.9	2,421.5	2,201.1	1000 m^3
Max Day Demand	82.3	89.4	87.7	87.9	77.8	1000 m^3
Average Day Demand	41.1	41.0	41.7	44.1	42.4	1000 m^3
Utility wide Peak Day Demand	1,223	1,304	1,392	1,261	989	L/capita/day
Utility wide Average Day Demand	611	598	662	633	539	L/capita/day
Single Family Dwelling Demand	392	371	420	436	403	L/capita/day
Average Monthly Residential Consumption per Service	36	34	35	36	33	m^3/month
Peaking Factor (April-September)	1.5	1.6	1.6	1.5	1.4	
Peaking Factor (October-March)	1.9	1.3	1.5	1.7	1.7	

* Includes water sold through fill stations and portable hydrant carts, Utility use, and Fire Department use.

Table 10. Summary of water production and consumption trends

Water Sustainability Management

The COK demand management programs are focused on reducing water demand both internally (within the treatment system and COK sponsored services such as the Parks department) and the customer point of use in order to achieve sustainable use. Since the implementation of several water demand management initiatives since 2005, which includes mandatory installment of water meters for residential, commercial and agriculture, tiered consumption-based water rates, and water conservation education programs, COK has seen an overall reduction in yearly water demand relative to population (Figure 9).

Water Conservation

A number of Water Smart initiatives were undertaken in 2017 in conjunction with both Waterkind consulting and Okanagan Basin Water Board (OBWB) to support the goal of educating the public and reducing water usage across the city.

Landscape Water Conservation Reports

Submission of Landscape Conservation reports are a bylaw requirement within Utility boundary for any irrigation installation or retrofit that covers an area greater than 100m^2 in order to confirm that acceptable watering systems and landscape materials are utilized. 94% of all reports in Kelowna were submitted by contractors in 2017, which relative to 2013 reports, translates into a calculated savings of 45,000m^3 of water per year. However, submission rates of reports in general continue to be low (18%) relative to new metered sites approved. Workshops will be sponsored in 2018 with the intent of improving education both for commercial and residential users.

Water Restrictions

Year round watering restrictions remain in place since first introduction in 2016. Intent is to make residents cognoscente of their water usage and to level the water production demand on the water system throughout the week. Allowable irrigation times are limited to 3 days per week and specific times during the allowable day. In order to assist residents to comply with these requirements, the City continues to sponsor a controller rebate program that provides a financial credit towards the purchase of a compliant water system controller that can be programmed accordingly. 75 rebates were issued in 2017 and received considerable support from the public.

Irrigation Inquiries / Service Requests / Community Events

The COK offers a number of free services to assist residents with inspection, operation, and scheduling of their irrigation systems. Service Requests are submitted to Waterkind Services who responds with an on-site visit to assess the condition and operation of the irrigation system and make recommendations as to action required. 42 such requests were submitted in 2017 and effectively helped reduce water usage and subsequent water bills. Water Smart also participated in 6 community events through the summer and provided public education in a variety of formats. This engagement venue will be expanded in 2018 with the addition of a summer student.

Water Disruption Events

As with all water utilities, there are certain events throughout the year that interrupt water services – either planned or unplanned. These include pipe breaks, seized valves, leaking hydrants, and power outage occur. Regardless of cause, the COK strives to quickly correct the deficiencies with minimal disruption to water service. Summary of 2017 infrastructure replacement and repairs are captured in Table 12 relative to previous year.

	2015	2016	2017
Water Main break repairs	11	12	8
Water service leak repairs	91	100	121
Fire Hydrant replacements	4	4	3
Water Main Blow off replacements	7	8	3
Water Disruption Events	38	66	104

Table 12. 2015-2017 Water disruption events

The city strives to be as proactive as possible with planned infrastructure replacements, whereas repairs tend to be reactive and have dedicated water utility staff on standby at all times to address concerns – both in terms of repair as well as water quality assessments in order to comply with AWWA standard C651-14.

Emergency Response and Notifications

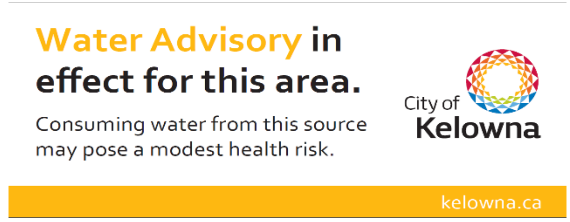
The COK Water Utility and Communications department has developed a series of emergency protocol documents that addresses action that needs to be taken in the event of water quality deviations or emergencies:

- Water Utility Emergency Preparedness and Response Plan
- Public Notification Protocol
- Turbidity Response Plan – within the Water Quality Sampling Protocol

These documents contain information on course of actions, list of appropriate contacts, and procedure necessary to assist operators and staff to make timely and informed decisions.

The COK is responsible for notifying IHA as well as the public in the event that the treated water quality does not meet drinking water standards. Notifications are issued in the form of media releases, electronic sign boards, social media outlets, radio messages, automated email notifications for those registered on a sensitive customer list (hospitals, care homes, daycare and nurseries), website updates and links with specific instructions for food establishments, signage at public water fountains, washrooms and facilities, and in some cases door to door hangers distributed by staff.
Residents and businesses are reminded to sign up on the City of Kelowna e-subscribe system, found on the City website at www.kelowna.ca, that allows the selection and automatic notification delivery of a number of service updates, including water quality changes and advisories.

Water Quality Advisory



A Water Quality Advisory (WQA) was issued in the Kelowna Water Utility for the first time since 1996 as a result of elevated levels of Turbidity from spring freshet. An unusually cold winter and wet spring resulted in higher than anticipated tributary flows and subsequent flooding conditions throughout Lake Okanagan. Turbidity concentrations first exceeded the 1 NTU advisory threshold at the Swick intake on May 3 and as a result of current flows, wind direction, and temperature fluctuations, elevated Turbidity was experienced at the other 3 intake locations shortly after (Figures 3-6).

A water quality advisory was issued on May 5 and the public notification process was carried out as per notification protocol. Chlorine dosing and UV treatment was adjusted at all intakes to accommodate the conditions of the advisory and through continual monitoring, it was demonstrated that no bacterial counts were detected in the water distribution system and chlorine residual and demand remained consistent. The advisory was lifted in stages in various service areas as Turbidity values fell and consistently stayed below 1 NTU. A full advisory rescind was discussed with IHA and formally issued on July 6. There were no reports of elevated health related illnesses to the City as a result of the Water Advisory event.

Service Requests and Responses

The COK provides residents a number of open and transparent options to report water and water quality related issues to the utility. These include a phone-in number as well as on-line service request form to submit electronically through the COK website. These are all documented and responded to in a timely fashion by related utility staff that are equipped to address the public concerns or comments.

In 2017, there were a total of 91 service requests submitted and responded to by staff:

- Cross Connection Control: 1
- Water Restrictions: 31
- Dirty/cloudy water: 7
- Other Districts: 1
- Taste and Odor: 1
- Drinking Water information: 22
- Pool discharge 1
- Miscellaneous: 7
- Catch Basin discharge: 1
- Source water protection: 2
- Water Smart – Water Conservation: 17

Long Term Improvements

The COK has a dedicated Utility Planning department that works in conjunction with Utility Operations in determining the design, implementation, and funding requirements for long term water service improvements. This requires reliable development forecasts, environmental considerations, government grant funding opportunities, and strategies that chart the path for future growth while balancing the sustainability of existing capital assets. The COK continues to charge an annual Water Quality Enhancement (WQE) fee to residents and businesses that is set aside to fund future water quality capital improvement initiatives such as water filtration. The reserve grew by $1.07 million in 2017 for a total balance of $13.2 million.

Future initiatives include:

- Integration with surrounding water districts to improve water quality and water supply resiliency for all COK residents
- Drought Management Plan to be created in conjunction with OBWB developed mainstem lake drought triggers
- Upgrade of the Cedar Creek pump station to increase capacity and allow for the decommissioning of the Eldorado pump station
- Capital water infrastructure upgrade projects totaling over $100 million by 2020
- Separation of domestic and agriculture water supply infrastructure in South East Kelowna area
- Transfer public notification system for water quality alerts from the Kelowna Joint Water Committee to internal COK e-subscribe public.gov. delivery network
- Creation of long term water conservation plan through 2025
- Microbiology laboratory accreditation to EWQA and Public Health standard to allow reporting of internal water testing results to Interior Health
- Upgrade and replacement of all water meters to advanced technology data collection and reporting system
- Development of Master Integrated Water strategy for COK, which includes long term filtration plans

Conclusion

The COK is committed to continually improving water quality and services to its residents, commercial users, and agriculture stakeholders. Protecting our water source is not an option – it is a requirement, for our current generation and those to come. To that end, the City has created a list of priorities of which providing safe and reliable drinking water is at the heart of leadership decisions. This requires extensive planning, funding, collaboration, vision and leadership from City Council all the way through to the water utility staff and operators working diligently to support the Kelowna vision statement:

"To be the best mid-sized city in North America"

City of Kelowna is pleased to present the 2016 Annual Water Quality Report, detailing the health and direction of our water system. If you have any questions about this report or wish to have additional information provided, please contact the COK Water Utility at 250-469-8475 or email at ask@kelowna.ca/.

Appendix A

2017 Water Quality Sampling and Reporting Guidelines

Kelowna Water Utility Water Quality Sampling Program 2017

KWU operates under a single permit for three water systems; City of Kelowna Water System, Swick Road Water System and Kelowna International Airport

1. City of Kelowna Water System – fed by Poplar Point intake and Cedar Creek intake supplemented by Eldorado intake when operationally required. System includes the R&E system, City center, the Mission system, Okaview system, Kettle Valley, Southridge, and Quarry neighborhoods. The Poplar Point System is interconnected to the Cedar Creek System via a booster pump at Steele Road Reservoir.
2. Swick System – small water system with less than 500 populations during a 24-hour period fed by Swick Road intake, completely separate from the other system.
3. Airport Water System – small water system that serves the three terminal buildings operated by the City of Kelowna. Glenmore Ellison Irrigation District supplies bulk water to the location and it is then treated using point of use treatment technology.

KWU Current Sampling Program

City of Kelowna Water System:
Treated Water Samples:

20 certified lab micro sample per month (MPN Total Coliform and E. Coli)
133 in-house micro samples per month (MPN Total Coliform and E. Coli)
85 free & total chlorine residuals per month
133 Turbidity, color, temperature, UV transmittance and taste & odour samples per month
32 THM/HAA samples per year (performed by a certified lab)
3 Drinking Water Certificate of Analysis per year (performed by a certified lab)
3 Radiological Scan per 4 years (performed by a certified lab, SRC)
3 Herbicide & Pesticides Scan per 4 years (performed by a certified lab)
\+ Online data monitoring 24 hrs./day 7 days/week (Turbidity, pH, temperature, UV transmittance)

Raw Water Samples:

18 in-house micro samples per month (MPN Total Coliform and E. Coli)
18 Turbidity, color, temperature, UV transmittance

Swick Road Water System:
Treated Water Samples:

4 certified lab micro samples per month (MPN Total Coliform and E. Coli)
29 in-house micro samples per month (MPN Total Coliform and E. Coli)
20 free & total chlorine residuals per month
29 Turbidity, color, temperature, UV transmittance and taste & odour samples per month
4 THM/HAA samples per year (performed by a certified lab)
1 Drinking Water Certificate of Analysis per year (performed by a certified lab)
1 Radiological Scan per 4 years (performed by a certified lab, SRC)
1 Herbicide & Pesticides Scan per 4 years (performed by a certified lab)
\+ Online data (Turbidity, pH, temperature)

Raw Water Samples:

8 in-house micro samples per month (MPN Total Coliform and E. Coli)
8 Turbidity, color, temperature, UV absorbance

Airport System:
1 certified lab micro sample per month (MPN Total Coliform and E. Coli)
8 in-house micro samples per month (MPN Total Coliform and E. Coli)
8 free & total chlorine residuals per month
8 Turbidity, color, temperature, UV absorbance and taste & odour samples per month
4 THM/HAA samples per year (performed by a certified lab)
\+ online data (Turbidity, pH, temperature)

Raw Water Samples:
8 In-house micro samples per month (MPN Total Coliform and E. Coli)
8 Turbidity, colour, temperature, UV absorbance

<u>Reporting</u>

-All Drinking Water Quality and Drainage Water Quality data will be reported to the Watertrax data base.
***Note**-During the winter months (November – March) there is a decrease in the number of sites sampled due to some sample stations not being compatible with the colder weather and freezing. The Poplar Point System decreases from 58 to 53 locations, Swick System from 5 to 3 locations and the Airport System from 9 to 8 locations.
-Month end summary reports include:

Drinking Water Quality

- free & total chlorine - max, min, mean, number of tests
- certified lab coliform results - total, fecal from no less than 15 sites. Only positives will be location specific.
- in-house micro results - total coliform, E coli, number of sites. Only positives will be location specific.
- Color, Turbidity, UV transmittance, temperature, odour – max, min, mean, number of tests
- report of any irregular events

Drainage Water Quality

- **Regular Sampling**- the standard drainage water quality scan (SDWQS) includes ammonia, chloride, true and apparent color, conductivity, dissolved oxygen, *E. Coli*, pH, suspended solids, temperature, and Turbidity will be analyzed in-house and reported for ~65 creek and storm system sites per month (site number may increase/decrease due to seasonal variations)
- **5/30 (A- Creek Water)**- for filtration exclusion, the mouths of Mission Creek, Mill Creek, and Brandt's Creek are sampled 5 times in 30 days from April 15th to September 15th, analyzed for the SDWQS, and included in the regular sampling monthly report
- **Water Quality at Intakes (B- Creek Water)**- for filtration exclusion, the mouths of Mission Creek, Mill Creek, and Brandt's Creek are sampled when decreased water quality of raw water at the intakes occurs, analyzed for the SDWQS, and included in the regular sampling monthly report
- **Storm Water-** for filtration exclusion, the first flush samples are collected at selected outfalls on Mill Creek and Brandt's Creek, analyzed for the SDWQS, and included in the monthly report
- **Cross Connection-** for filtration exclusion, Fascieux Creek is sampled 3 times per year at 3 locations during rain events, analyzed for the SDWQS, and included in the monthly report
- **Irregular events**- analyzed for the SDWQS, nitrate, phosphate, and chemical oxygen demand (samples may be sent to a private lab for further analysis if the situation dictates)

Appendix B

Source Water Quality Monitoring Parameters

Source Water Quality Parameters

Turbidity

Turbidity measurements are related to the optical properties of water. Suspended materials such as clay, silt, organic and inorganic particles, plankton, and other microscopic organisms all contribute to Turbidity and can have a negative effect on disinfection techniques.

There was an extended period of time during freshet that Turbidity exceeded the 1 NTU threshold at the intakes and was marked by a Water Quality Advisory between May 12 through July 6 (Figure 10). This was primarily attributed to the very high tributary flows that ran an average of double the Turbidity concentrations (Figure 51) relative to previous years. The previous 4-year trend had indicated an overall decrease in average Turbidity for source water at all intakes (Figure 11).

Intake	Average (NTU)	Minimum (NTU)	Maximum (NTU)	Guideline (NTU)	Number of Exceedances	Number of Tests in 2017
Poplar Point	0.437	0.18	1.55	<1.0	5	189
Eldorado	1.015	0.321	2.77	<1.0	12	27
Cedar Creek	0.766	0.2	1.77	<1.0	15	64
Swick	0.567	0.16	1.87	<1.0	14	109

Table 13. Source Water Turbidity annual summary

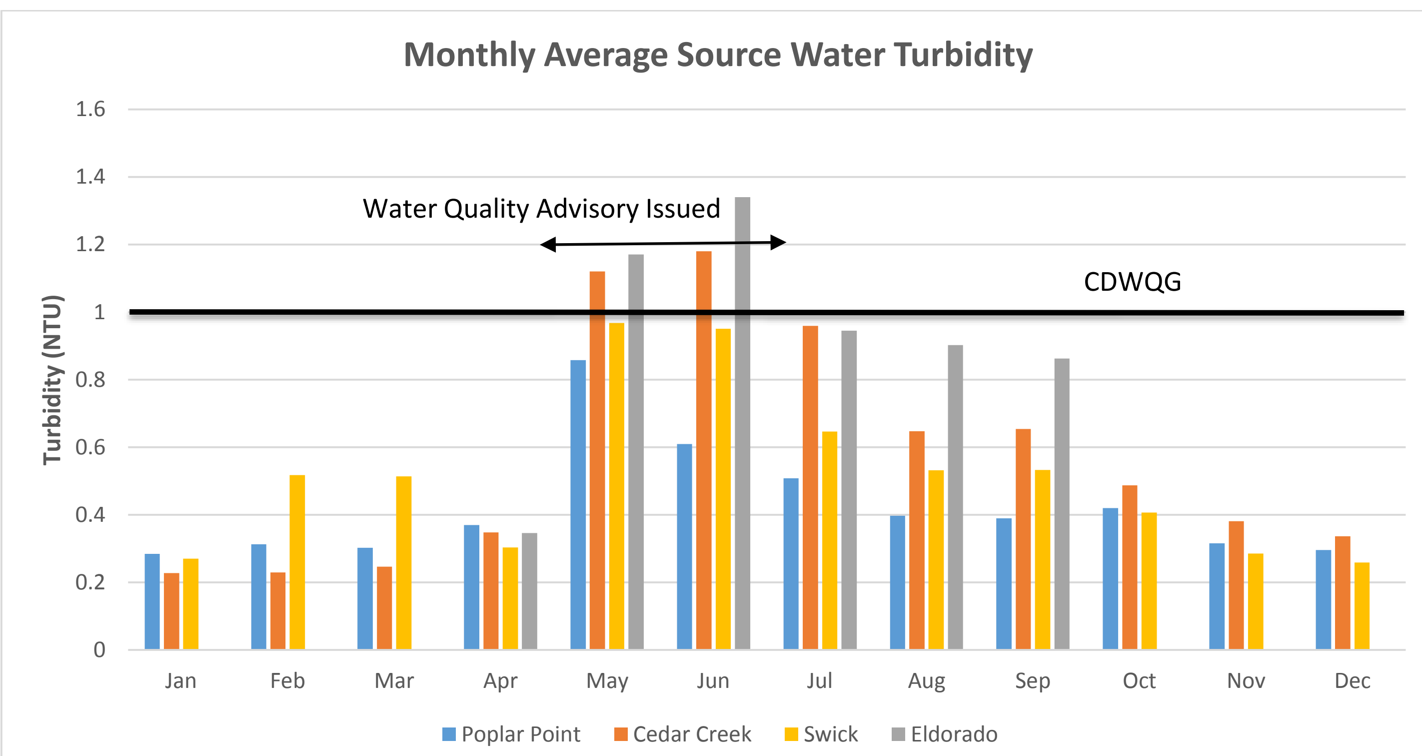


Figure 10. Monthly Turbidity average at Intake source

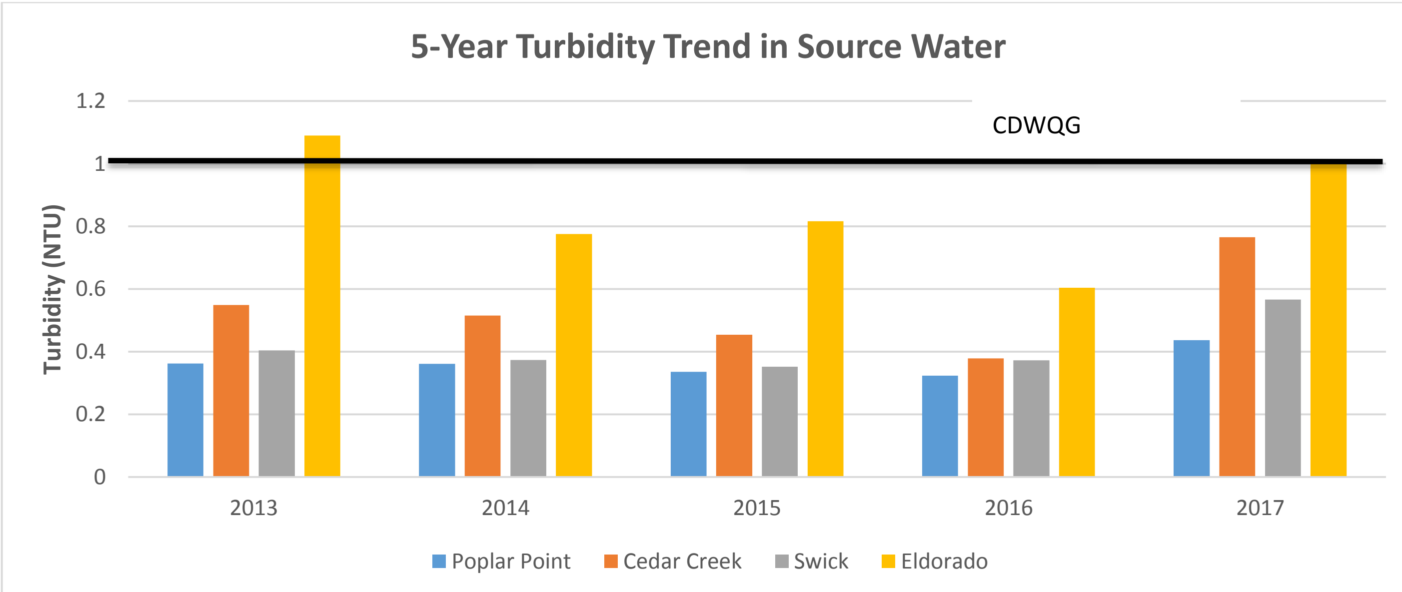


Figure 11. 5-Year Turbidity trend in Source Water

Total Coliform

The coliform group consists of several genera of bacteria belonging to the Enterobacteriaceae family. The detection of these bacteria can be determined with a variety of analytical techniques including membrane filtration and lactose fermentation. The COK utilizes the Quanti-tray method which is based on the fermentation technique which involves a reaction with an enzymatic substrate. The water sample reacts with the enzymes in multiple wells or tubes over 18-24 hours and generates a detectable yellow color for positive Total Coliform. The replicate wells are reported in terms of the Most Probable Number (MPN) which is statistically derived number to determine the presence of the coliform.

. Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Number of Tests in 2017	# of Tests >100 MPN	2017 % of Tests >100MPN	2016 % of Tests >100MPN
Poplar Point	67	0	1300	189	44	23	27
Eldorado	129	0	1986	26	9	35	54
Cedar Creek	44	0	2909	64	11	17	29
Swick	44	0	1414	109	18	17	24

Table 14. Source Water Total Coliform annual summary

There was an elevated level of Total Coliform bacteria in the source water at all intakes during July and September (Figure 12). Chlorine and UV treatment was adjusted during this time to ensure that contact time and full inactivation of coliform bacteria was complete. There was an overall decrease in the Total Coliform counts at Eldorado over 2016 and increase at the other intakes as shown in the 5-year trend data (Figure 13). This is most likely attributed to the Coliform associated with soil that was transported by the spring flooding events. However, there was a decreasing trend in the number of Coliform counts that exceeded 100 MPN counts (Table 14).

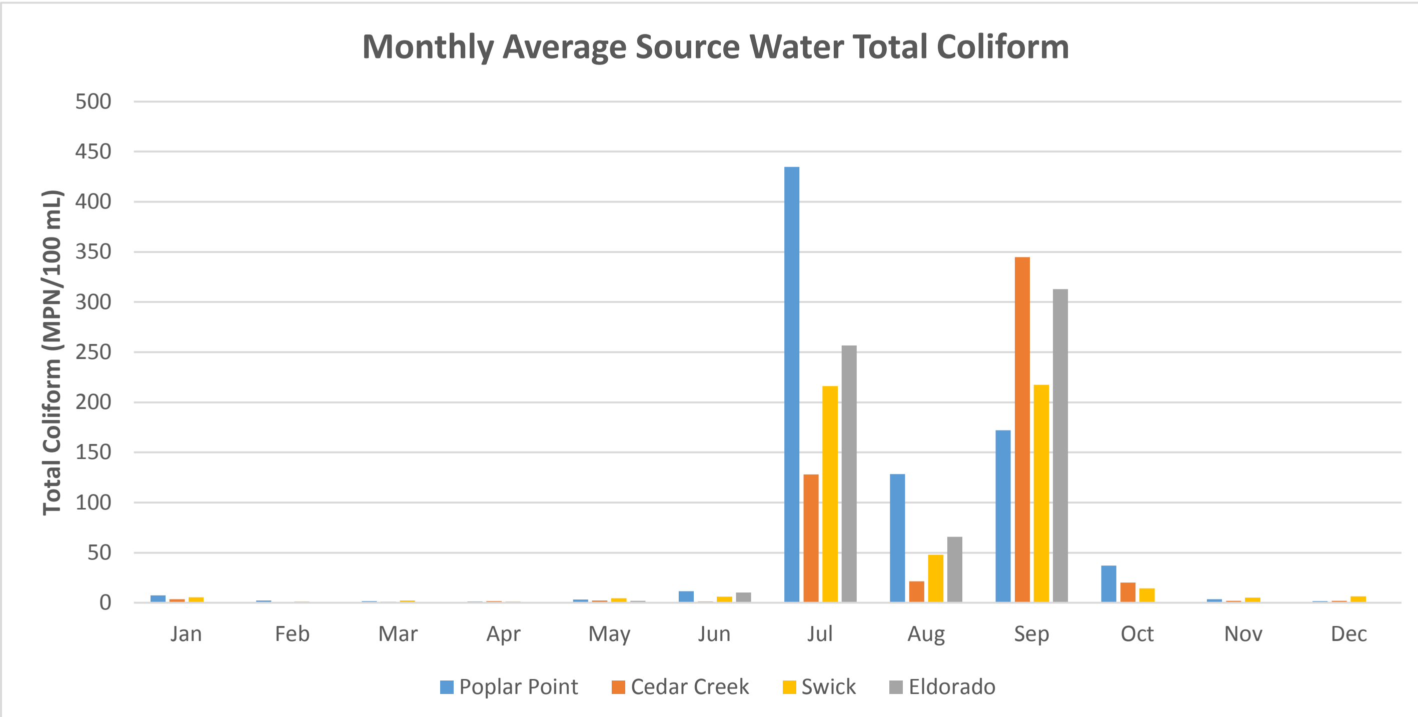


Figure 12. Monthly Total Coliform average at Intake source

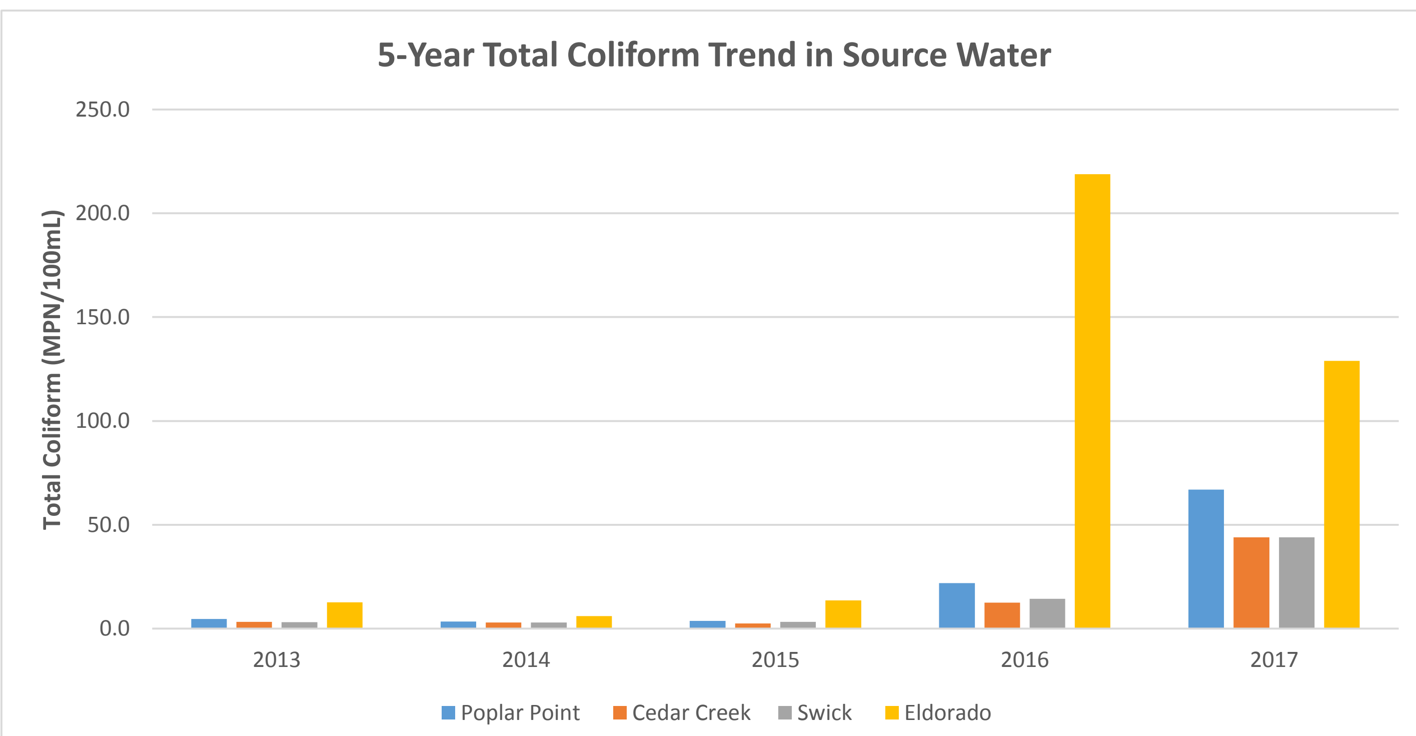


Figure 13. 5-Year Total Coliform trend in Source Water

E. Coli.

Escherichia coli (E. Coli.) is a sub-category within the coliform family and is used as a high risk indicator of harmful pathogens derived from human or animal fecal matter. The principle behind the methodology to detect E. Coli. is identical to the Total Coliform method in that an enzymatic reaction and subsequent fermentation is used to produce a detectable presence of the pathogen. The unique characteristic of E. Coli. using this technique is that in the presence of a long wave UV lamp (365nm), the resulting sample wells fluoresce. The number of wells that fluoresce are counted and calculated and reported as MPN values.

Although elevated levels of Total Coliform were observed, with the exception of the Swick intake, the levels of E. Coli. dropped substantially relative to previous years and were all within the filtration exclusion target of no more than 10% of E. coli. counts to exceed 20 MPN/100mL (Table 15, Figure 14-15). This is most likely attributed to dilution effects of increased water flows into Okanagan lake during freshet.

Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Number of Tests in 2017	# of Tests >20 MPN	% of Tests >20MPN
Poplar Point	0.3	0	8.7	189	0	0
Eldorado	0.2	0	2	26	0	0
Cedar Creek	0.3	0	2	64	0	0
Swick	1.3	0	25.4	109	2	2

Table 15. Source Water E. Coli. annual summary

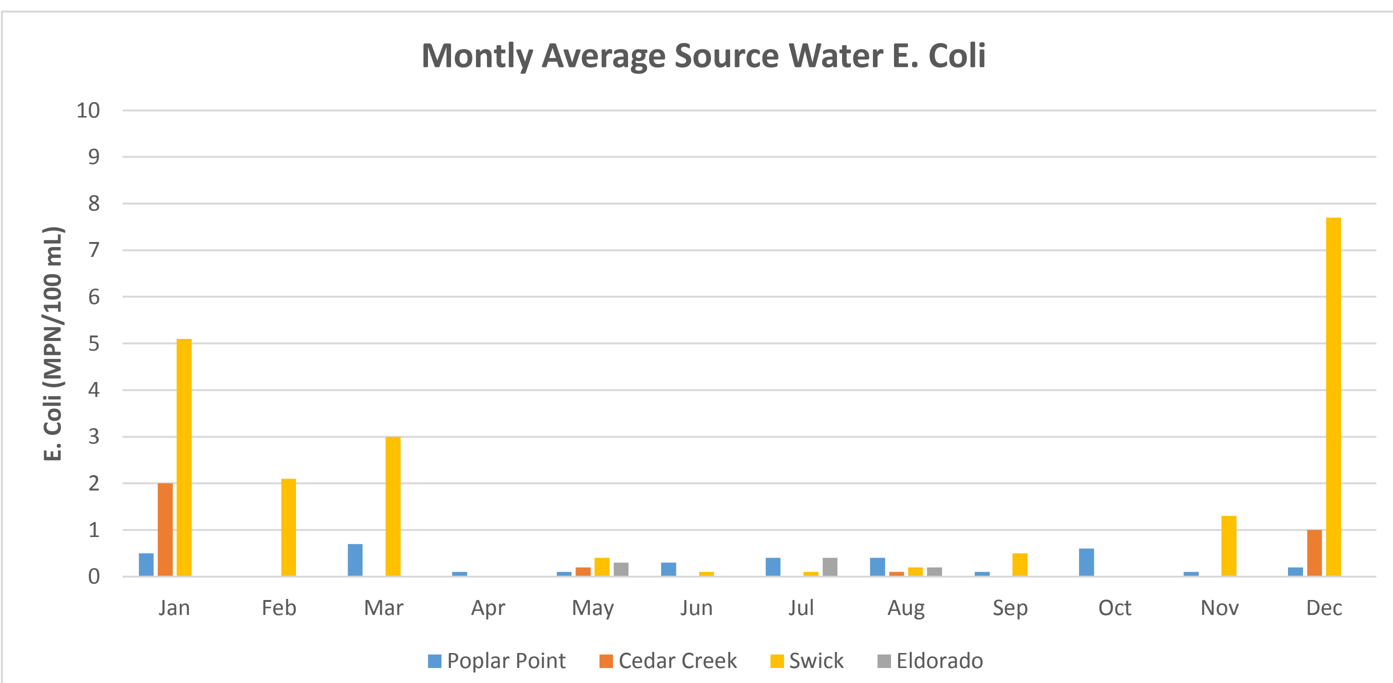


Figure 14. Monthly E. Coli. average at Intake source

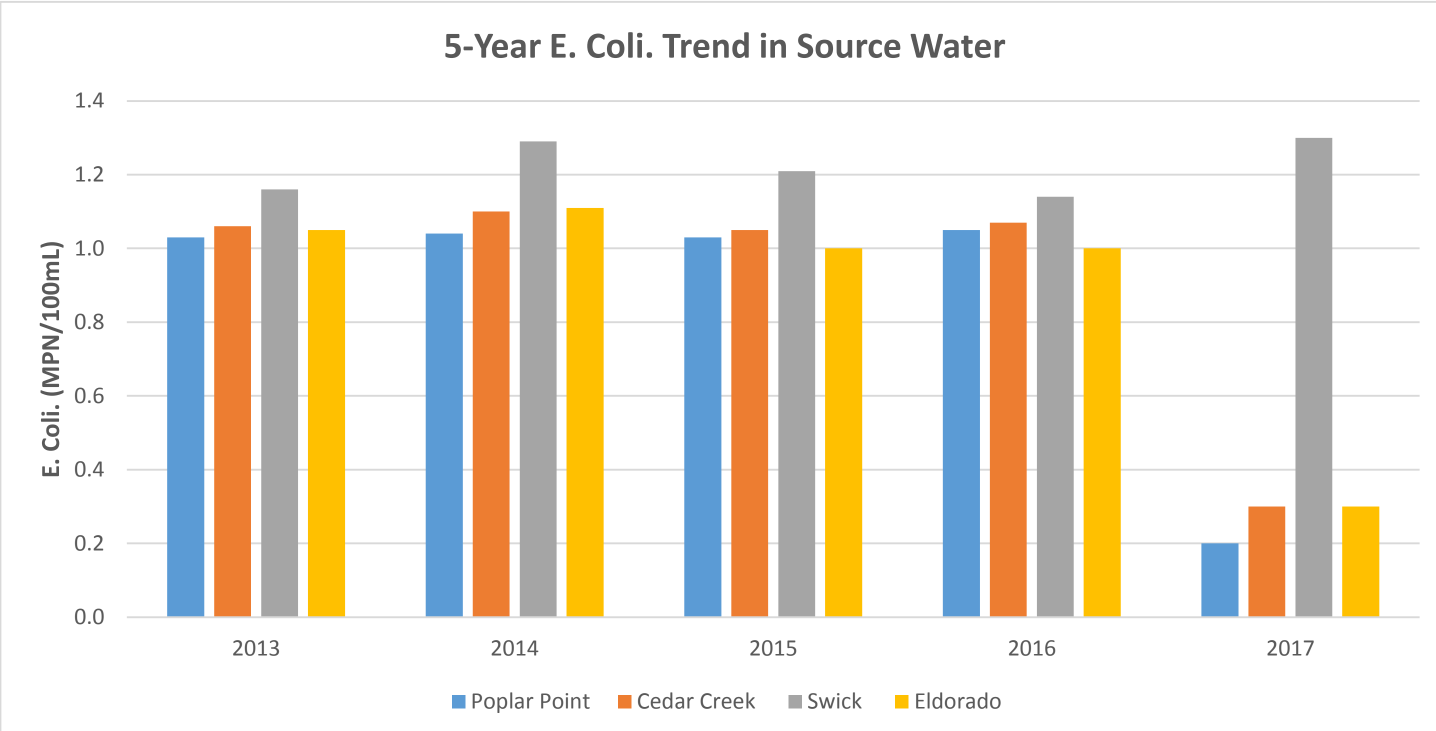


Figure 15. 5-Year E. Coli. trend in Source Water

pH

Measurement of pH is one of the most import and frequently used tests in water chemistry. Practically every aspect of water supply and treatment is pH dependent such as acid-base neutralization, water softening, precipitation, coagulation, disinfection, and corrosion control. At a given temperature, the intensity of the acidic or basic character of a solution is indicated by pH or hydrogen ion activity. Natural waters tend to have a pH value in the range of 4-9, and most are slightly basic (7.5-9) due to the presence of bicarbonates and carbonates of the alkali and alkaline earth metals in the environment.

The pH values for each of the intakes were within the objective range of 7.5-10 with no instances of exceedance (Table 16). The overall 5-year trend in pH indicates an approximate decrease of 0.2 pH units below the past 2-year average and in-line with 2013-2014 historical averages (Figure 17).

Intake	Average	Minimum	Maximum	Guideline	Number of Exceedances	Number of Tests in 2017
Poplar Point	7.84	7.39	8.38	7.0 - 10.5	0	181
Eldorado	7.93	7.61	8.35	7.0 - 10.5	0	23
Cedar Creek	7.87	7.68	8.09	7.0 - 10.5	0	57
Swick	7.80	7.23	8.24	7.0 - 10.5	0	100

Table 16. Source Water pH annual summary

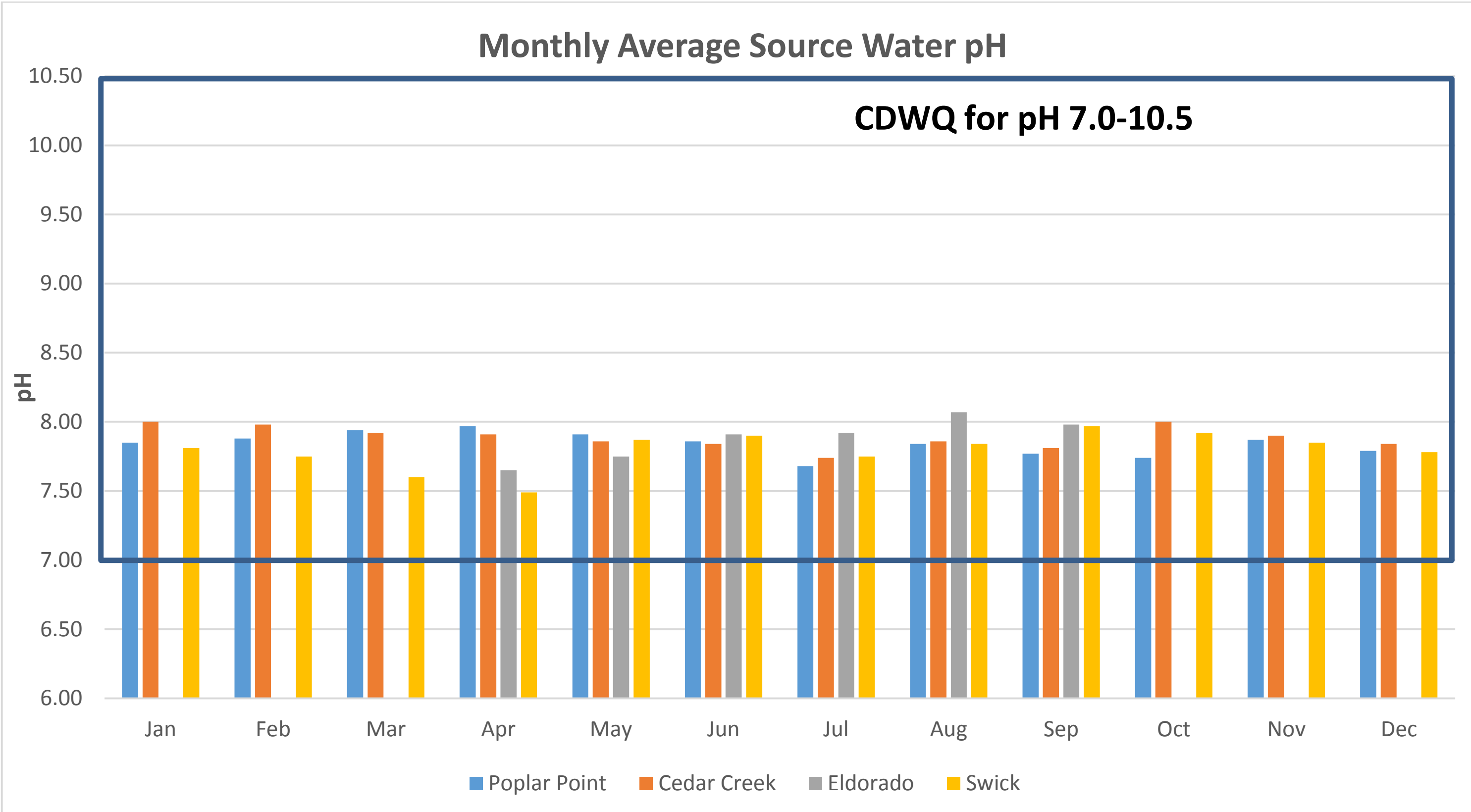


Figure 16. Monthly pH average at Intake source

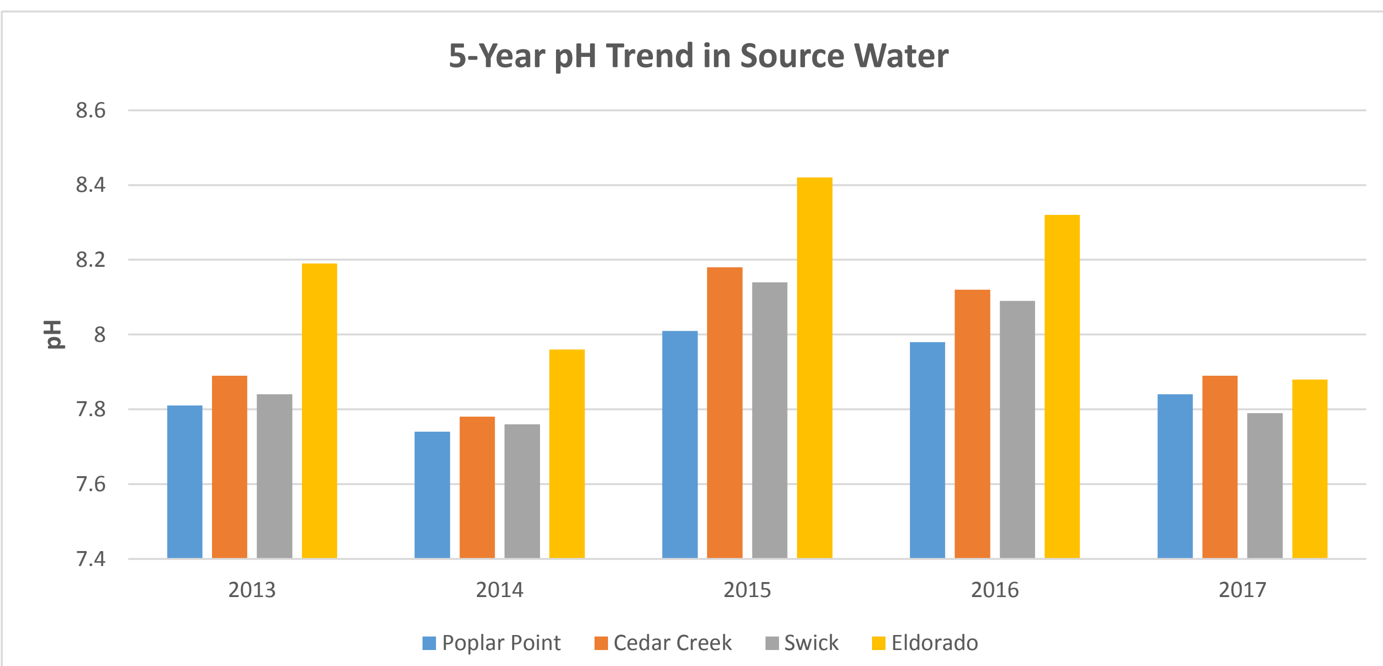


Figure 17. 5-Year pH trend in Source Water

Color

Color in surface waters result primarily from the presence of natural organic humic matter. Humic matter consists of humic and fulvic acids; both of which cause a yellow-brown color that can be measured by spectrophotometer wavelength. Color is preferred to be kept to a minimum as those compounds are considered precursors in the formation of chlorine disinfection byproducts such as chloroform. Assessment of color data is primarily gauged against an aesthetic objective of 15 color units.

With the influx of significant amount of organic debris from the tributaries during freshet, it was not surprising to see a general increase in the concentration and aesthetic exceedances of the apparent color in the source water beginning in May and continuing through July (Figure 18). However, this only marginally increased the annual average apparent color at the intakes by 1-2 color units above previous years (Figure 19).

Intake	Average (ACU)	Minimum (ACU)	Maximum (ACU)	Guideline (ACU)	Number of Exceedances	Number of Tests in 2017
Poplar Point	8	4	21	AO:≤15	9	189
Eldorado	15	4	31	AO: ≤15	12	27
Cedar Creek	10	5	26	AO:≤15	15	64
Swick	10	3	26	AO:<15	20	109

Table 17. Source Water Color annual summary

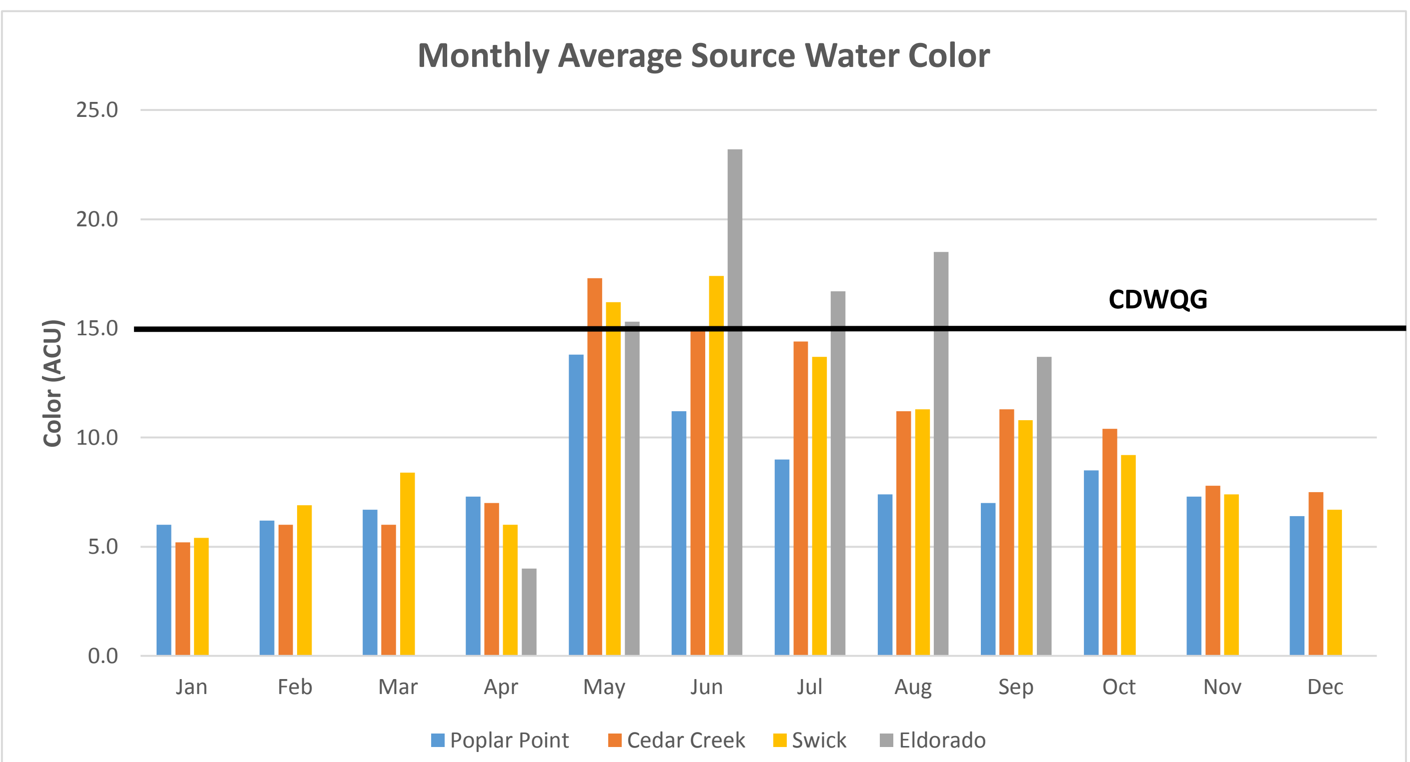


Figure 18. Monthly Apparent Color average at Intake source

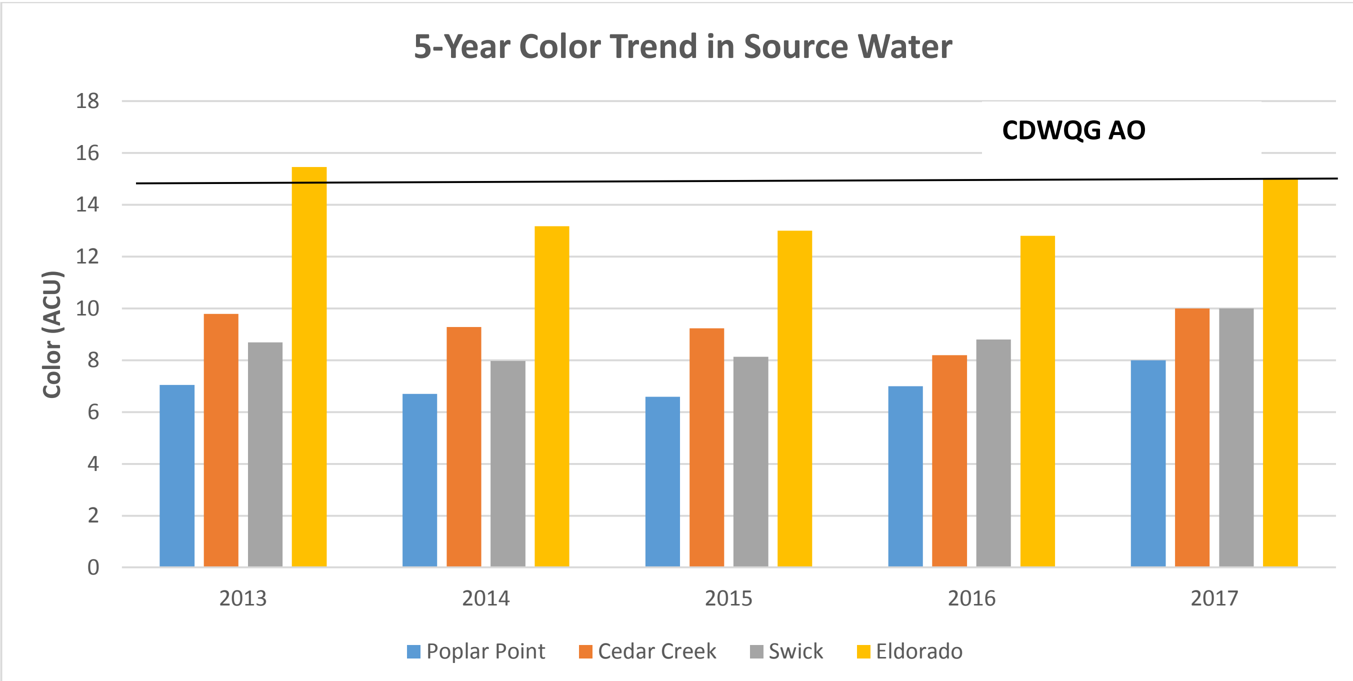


Figure 19. 5-Year Apparent Color trend in Source Water

Temperature

Temperature is an important factor to consider in water quality as it has influences on several other parameters and can alter the physical and chemical properties of water. Water temperature is considered when determining:

- Metabolic rates of aquatic life
- Dissolved Oxygen
- Conductivity and Salinity
- pH
- Water Density

Temperature fluctuations also plays an important role in the lake limnology which can transport nutrients and potential contaminants to the water intake sources. The COK operational objective is to consistently draw from water source at <15°C, which was maintained 98% of the time at the intake sites (Table 18). Despite a dry, hot summer season, temperatures were below the previous 3 years average and had a profile that was proportional to intake depth (Figure 21). This trend may have been impacted by the rapid and high volume of inflow during freshet.

Intake	Average (°C)	Minimum (°C)	Maximum (°C)	Guideline (°C)	Number of Exceedances	Number of Tests in 2017
Poplar Point	5.4	3	10	AO:≤15	0	189
Eldorado	11.7	5.5	17.5	AO:≤15	6	27
Cedar Creek	7.4	3	12.5	AO:≤15	0	64
Swick	8.5	2.5	17.5	AO:≤15	3	109

Table 18. Source Water Temperature annual summary

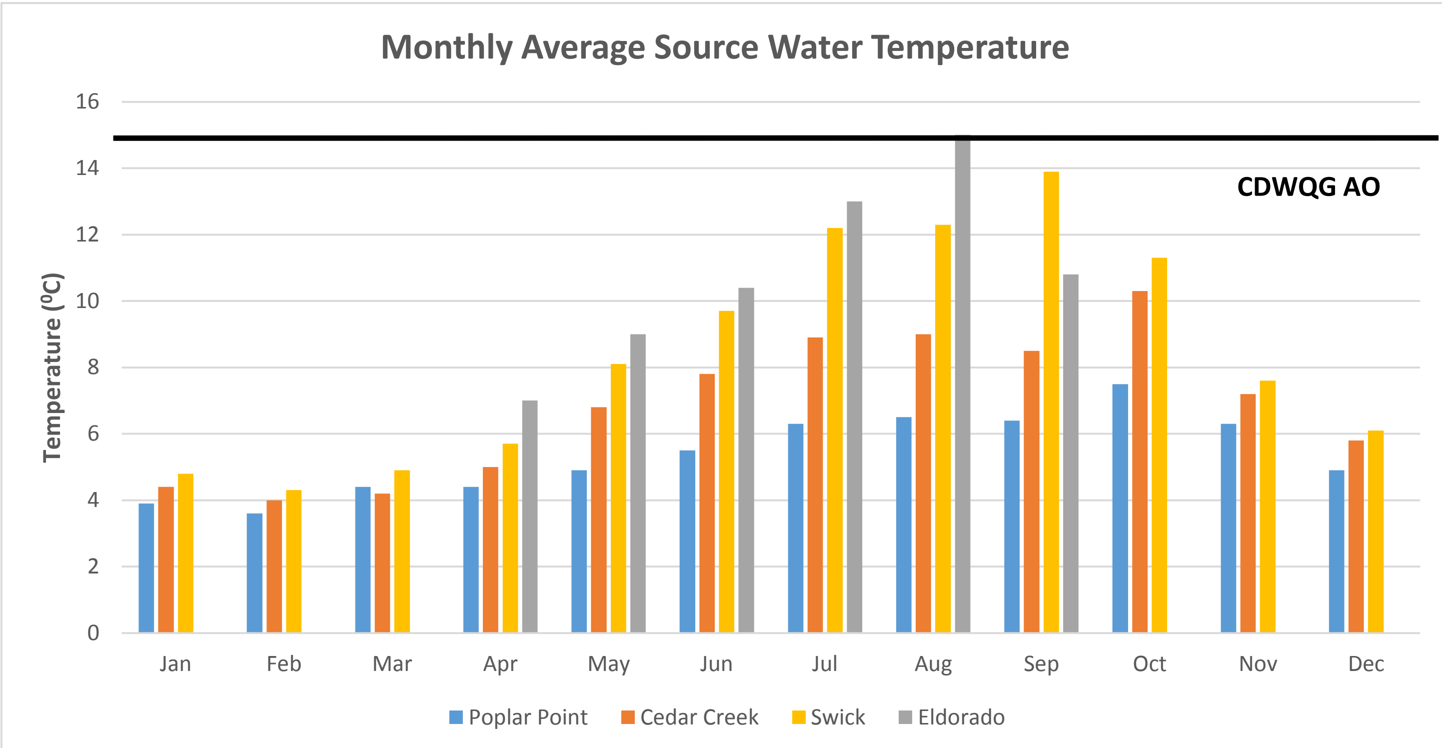


Figure 20. Monthly Water Temperature average at Intake source

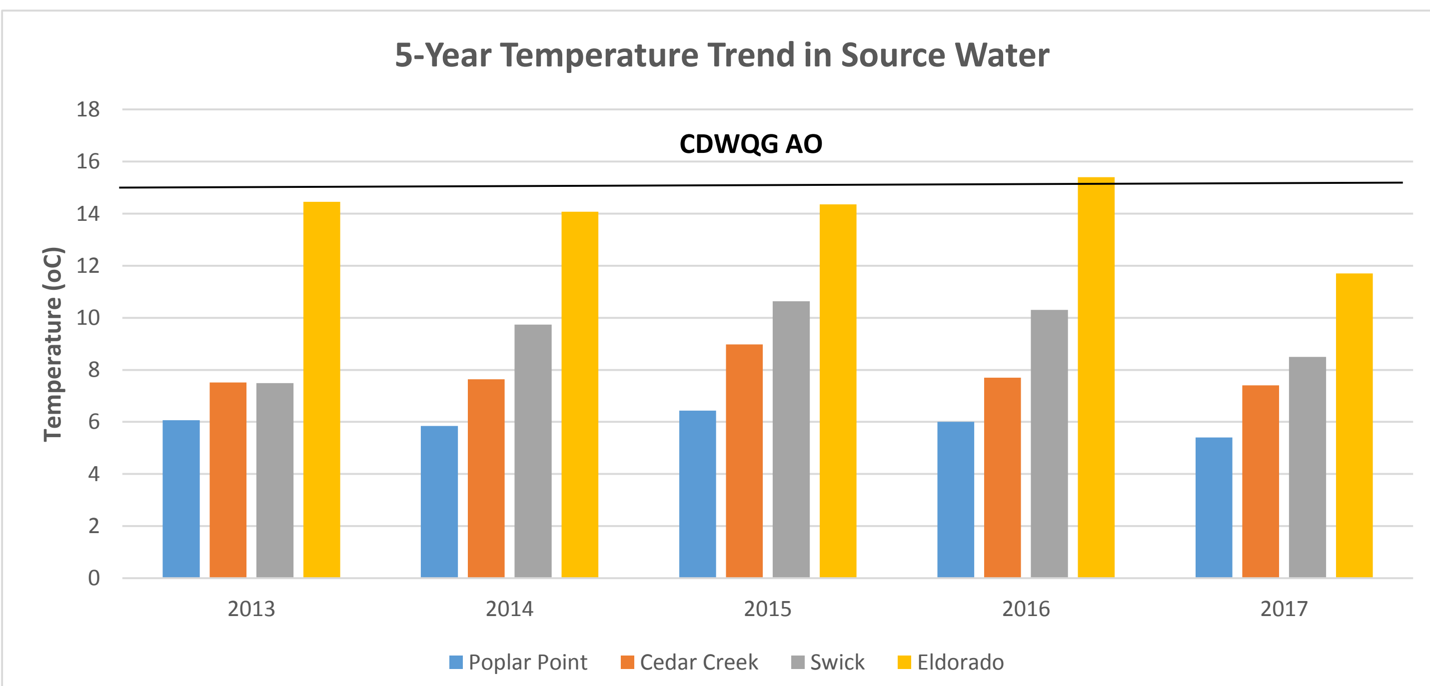


Figure 21. 5-Year Temperature trend in Source Water

UV Transmittance

Ultra Violet transmittance (UVT) represents the amount of light transmitted through water and is used to gauge the effectiveness of the UV light will be on the disinfection of the drinking water. The higher the Transmittance, the less UV dosing, in theory, is required to treat the sample. It is important to note that both solid and dissolved compounds have the ability to absorb UV light, which in turn has a negative impact on UVT.

COK measures UVT of unfiltered samples (representative of treatment type) at a wavelength of 254nm and reported as a percentage. For the 2017 calendar year, all source water samples remained above the UVT operational >80% objective despite notable higher Turbidity (Table 19). Overall decrease in UVT was experienced starting in May and contributed to the overall reduction of the yearly UVT average (Figures 22-23).

Intake	Average (%T)	Minimum (%T)	Maximum (%T)	Objective (%T)	Number of Exceedances	Number of Tests in 2017
Poplar Point	86.1	82.2	90.8	>80	0	189
Eldorado	82.6	80.0	93.3	>80	0	27
Cedar Creek	85.7	89.7	81.5	>80	0	64
Swick	85.3	80.5	91.2	>80	0	109

Table 19. Source Water UV Transmittance annual summary

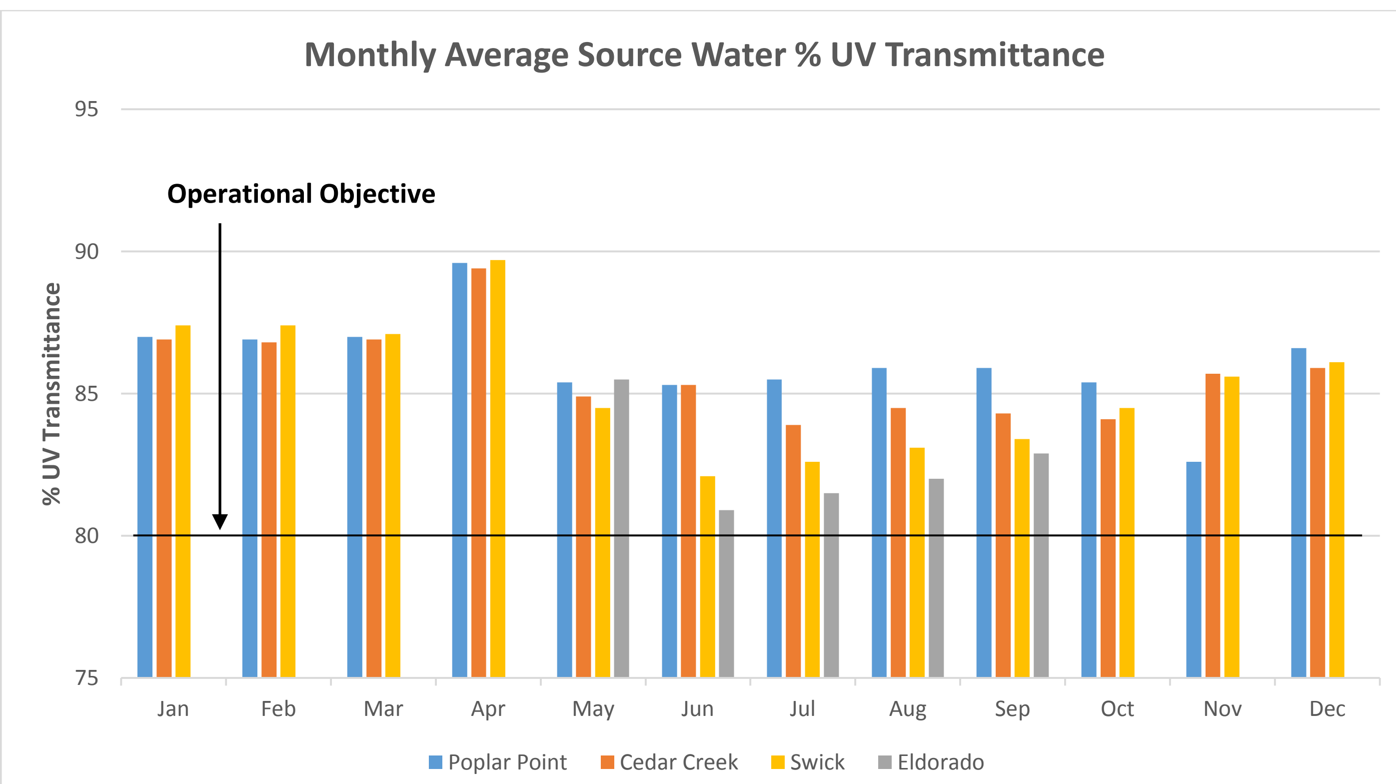


Figure 22. Monthly UV Transmittance average at Intake source

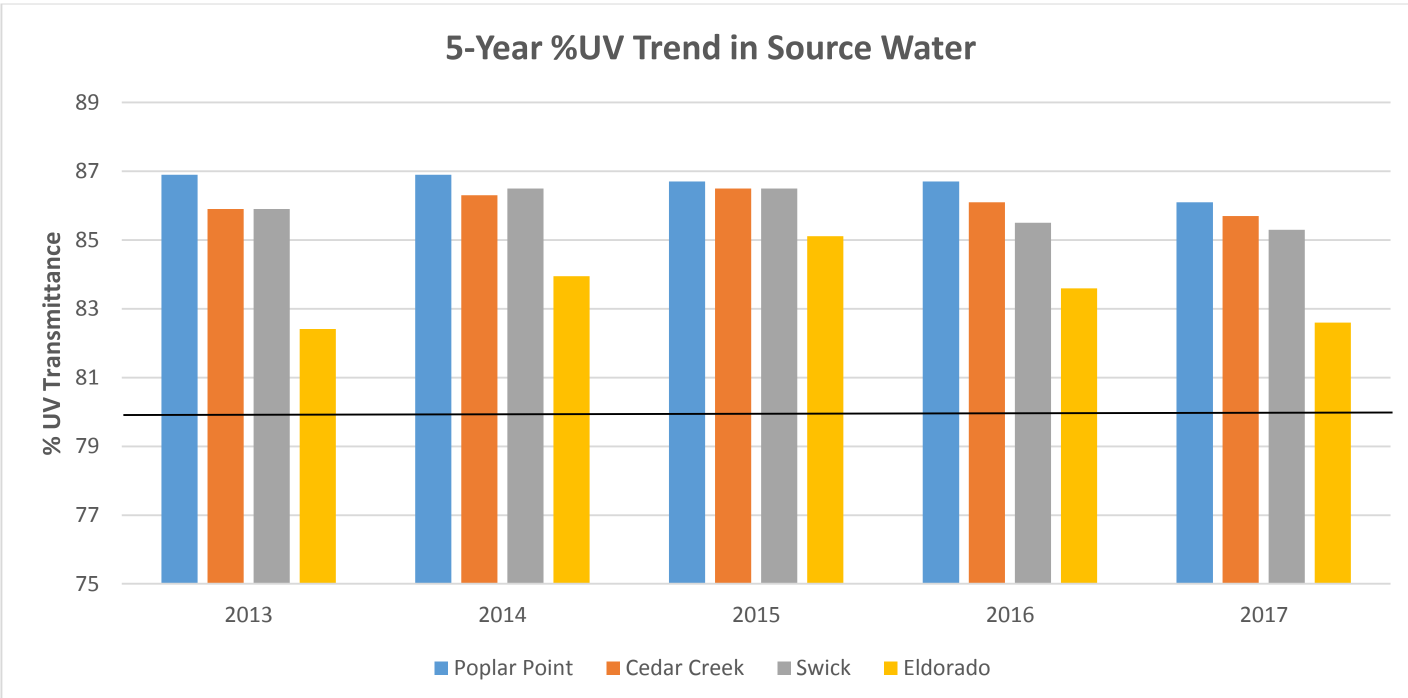


Figure 23. 5-Year % UV trend in Source Water

Algae

The number and types of algae present in Okanagan Lake provide excellent water quality for most of the year. In the surface water, peak algae growth follows the spring overturn, followed by a lull during late July and August as key nutrients and vitamins are exhausted, and finally a smaller peak in cyanobacteria (blue-green algae) near the fall overturn. Cyanobacteria counts in intake samples often include species that inhabit deep water or grow along the substrate. Cyanobacteria are a problematic group of organisms in which some types can generate toxins, and all types contain BMAA, and they readily form THM's (Trihalomethanes) after disinfection with chlorine. Okanagan Lake has been dominated by cyanobacteria for at least 70 years. Since 2006, the COK has contracted Larratt Aquatic Environmental consultants to conduct quarterly Microcystin sampling and analysis to determine concentrations of Cyanobacteria and general Algal biomass that would have an impact on water quality at the intake systems.

The final 2017 Algae report was still outstanding at the issue date of this document, but an update will be referenced in the subsequent annual report.

For further information regarding detailed Algae test results, please contact the City of Kelowna at ask@kelowna.ca and request a copy of the "*2017 Microflora at City of Kelowna Okanagan Lake Intake*" report.

Appendix C

Treated Water Quality Monitoring Parameters

Treated Water Quality Parameters

Turbidity

The primary function of monitoring the Turbidity post treatment is to ensure that the chlorination and UV dosing has not detrimentally affected the water quality and remains at operational objective levels. Relative to the source water Turbidity, the level of treated water concentrations and exceedances remained relatively consistent (Table 20). The 2017 data reverses the 5-year downward Turbidity concentration trend (Figure 25).

Intake	Average (NTU)	Minimum (NTU)	Maximum (NTU)	Guideline (NTU)	Number of Exceedances	Number of Tests in 2017
Poplar Point	0.457	0.194	1.65	<1.0	8	191
Eldorado	0.861	0.333	3.32	<1.0	10	49
Cedar Creek	0.531	0.214	1.43	<1.0	6	106
Swick	0.531	0.176	2.07	<1.0	10	110

Table 20. Annual Treated Water Turbidity summary

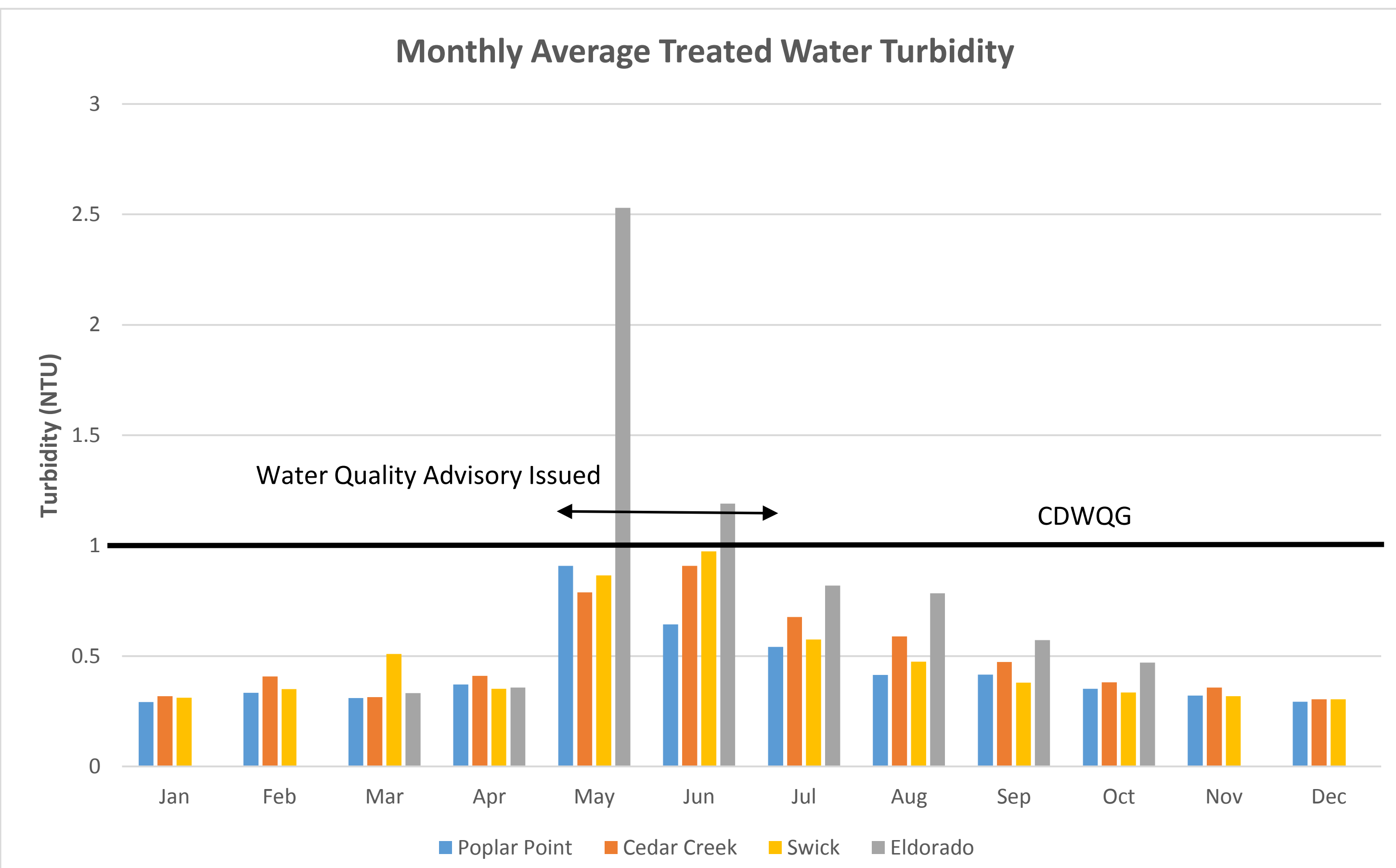


Figure 24. Monthly average Turbidity of Treated Water

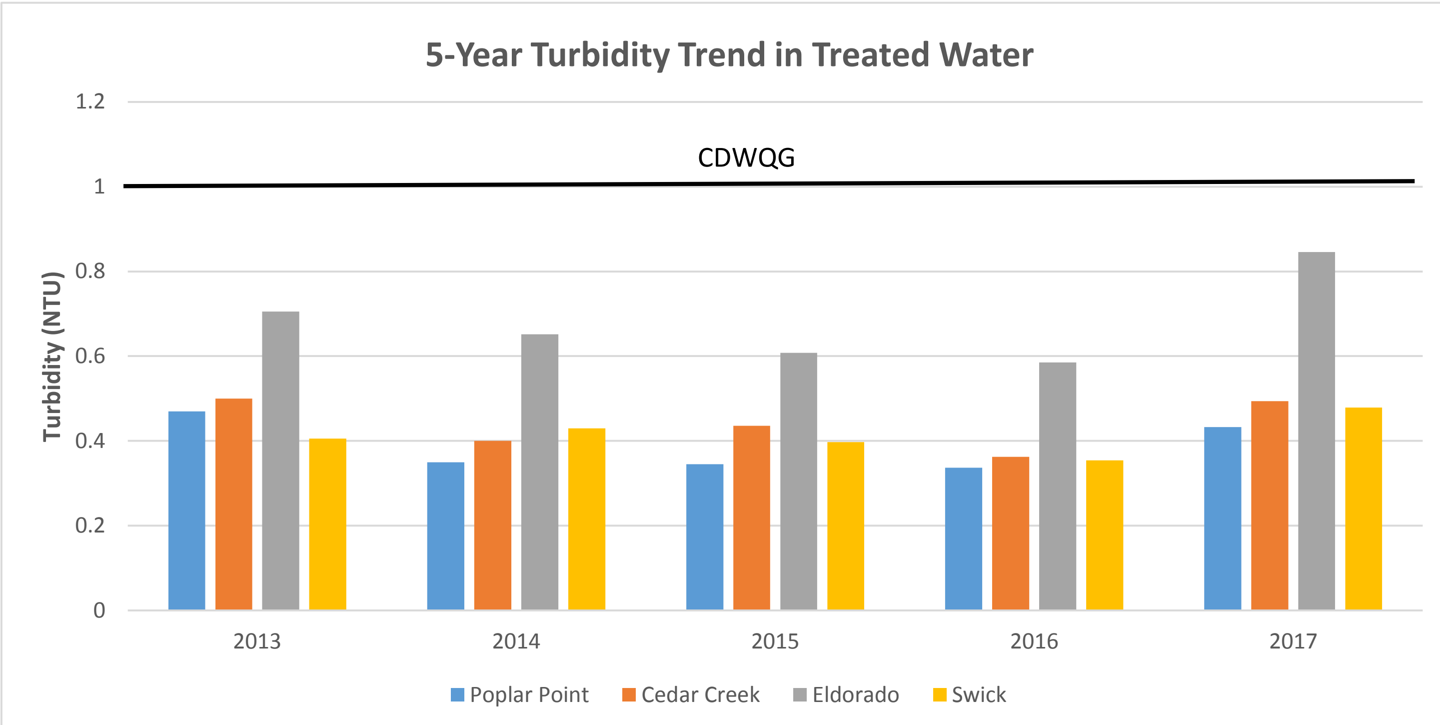


Figure 25. 5-Year Turbidity trend in Treated Water

Chlorine – Free

Chlorine is introduced to source water at each pump house through exposure and mixing with either chlorine gas or commercial hypochlorite at set time levels and concentrations that meet the criteria of 3 and 4-log reduction of bacteria and pathogens. Both Total and Free Chlorine are measured to ensure that the initial chlorine demand does not exceed the dosing applied and is at appropriate levels to maintain a residual throughout the entire length of the distribution system. Free Chlorine is primarily monitored as that is the form of chlorine available to neutralize pathogens beyond the initial dosing point.

The average Free Chlorine value at each intake immediately post treatment met the operational objectives in 2017 (Table 21). Due to adjusted chlorine dosing during elevated Turbidity, there was notable increase in the overall yearly average Free Chlorine above the previous 2 years (Figure 27).

Intake	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Objective (mg/L)	Number of Tests in 2017
Poplar Point	1.51	0.78	2.13	0.20	190
Eldorado	1.30	0.30	2.02	0.20	47
Cedar Creek	0.92	0.47	1.33	0.20	105
Swick	1.25	0.52	2.20	0.20	109

Table 21. Treated Water Free Chlorine annual summary

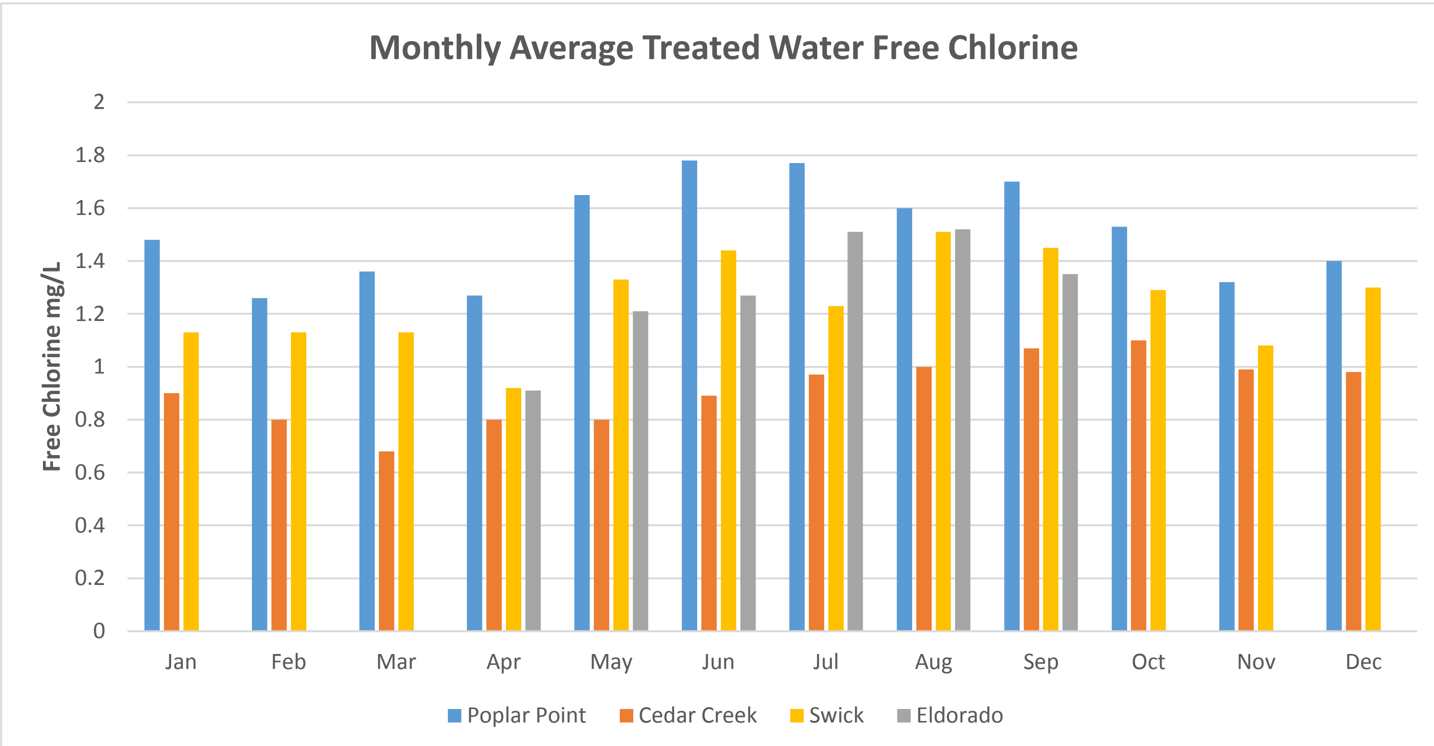


Figure 26. Monthly average Free Chlorine of Treated Water

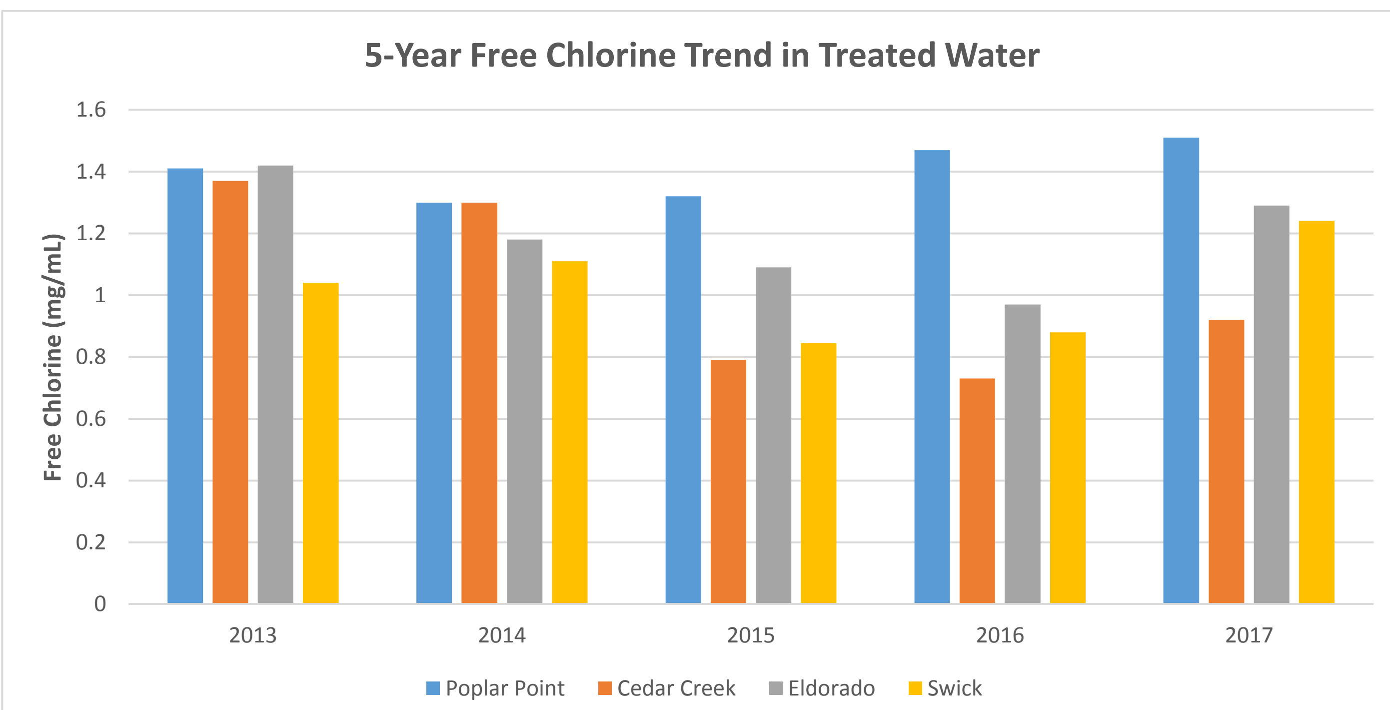


Figure 27. 5-Year Free Chlorine trend in Treated Water

Total Coliform

Effectiveness of water treatment is measured by the viable presence of both Total Coliform and E. Coli. bacteria. At no point throughout 2017 was there any positive Total Coliform detected immediately post treatment. This is in line with the 5-year trend and the CDWQ guideline requirement of <1 MPN/100mL. (Table 22). Important to note that the reporting requirement of the MPN Quanti-tray method produces a minimum value of <1 MPN/100mL, which is essentially equivalent to the CDWQ guideline of 0 CFU/100mL.

Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2017
Poplar Point	<1.0	<1.0	<1.0	<1.0	0	191
Eldorado	<1.0	<1.0	<1.0	<1.0	0	47
Cedar Creek	<1.0	<1.0	<1.0	<1.0	0	106
Swick	<1.0	<1.0	<1.0	<1.0	0	110

Table 22. Total Coliform in Treated Water annual summary

E. Coli.

The guideline objective for E. Coli. are identical to that of Total Coliform in that all viable bacteria related to Fecal matter requires complete and full inactivation (<1 MPN/100mL). The objective was achieved at all treatment points throughout 2017 (Table 23).

Intake	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2017
Poplar Point	<1.0	<1.0	<1.0	<1.0	0	191
Eldorado	<1.0	<1.0	<1.0	<1.0	0	47
Cedar Creek	<1.0	<1.0	<1.0	<1.0	0	106
Swick	<1.0	<1.0	<1.0	<1.0	0	110

Table 23. Treated Water E. Coli. annual summary

pH

The pH level of the water has a direct influence on the effectiveness and efficiency of the chlorine treatment applied as well as impact on the rate of infrastructure corrosion. Ideal range of pH for maximum chlorine disinfection (Hypochlorous acid) is between 6-7, but corrosion is a concern at levels <7.5. The pH of treated water is similar to the source water and is not significantly altered in any fashion. Levels are consistently within the target guideline range at all treatment points (Table 24). Much like the Source water pH, there was a notable drop in the pH value of the treated water by an average of 0.2 pH units (Figure 29).

Intake	Average	Minimum	Maximum	Guideline (AO)	Number of Exceedances	Number of Tests in 2017
Poplar Point	7.52	7.29	8.02	7.0 - 10.5	0	179
Eldorado	7.72	7.44	8.10	7.0 - 10.5	0	44
Cedar Creek	7.91	7.73	8.17	7.0 - 10.5	0	99
Swick	7.92	7.55	8.16	7.0 - 10.5	0	100

Table 24. Treated Water pH annual summary

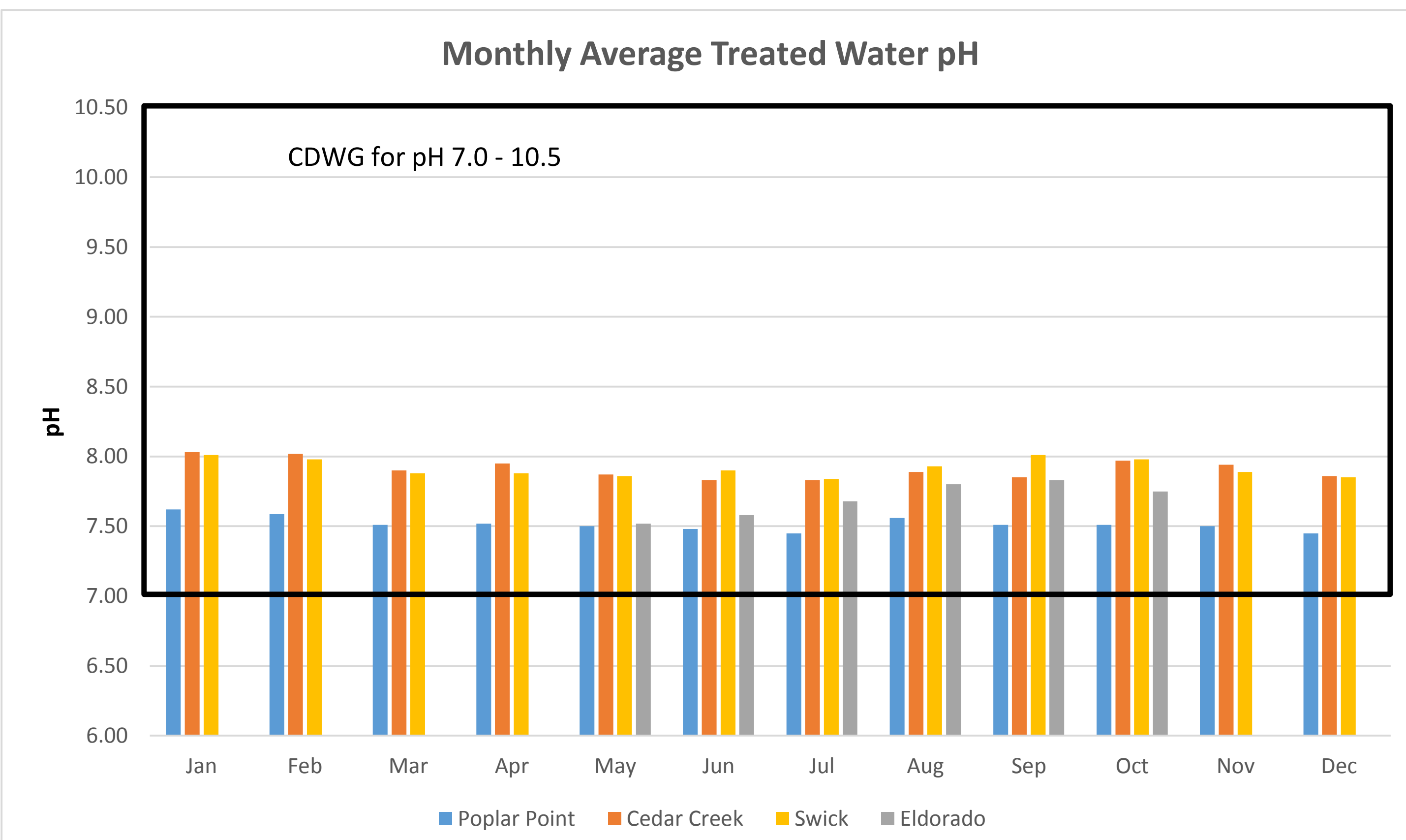


Figure 28. Monthly average pH of Treated Water

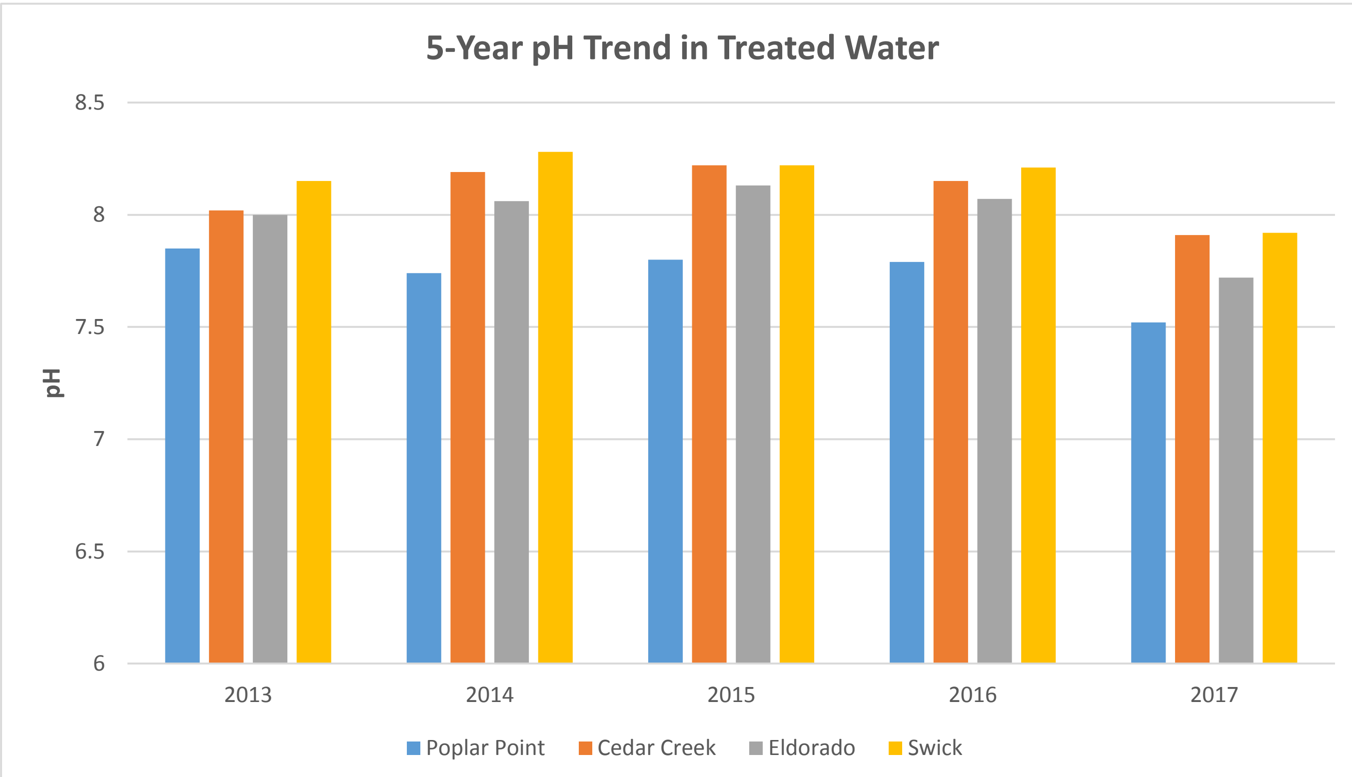


Figure 29. 5-Year pH trend in Treated Water

Color

Elevated levels of color post treatment can have a direct connection to the concentration levels of chlorination byproducts such as THM's and HAA's. As with previous year data, chlorination and UVT treatment resulted in a 2-3 color unit drop in the finished water and only a 6% exceedances above the Aesthetic objective of 15 ACU at all sites (Table 25). As expected, there was an increase in the overall Color average for the year (Figure 31).

Intake	Average (ACU)	Minimum (ACU)	Maximum (ACU)	Objective (ACU)	Number of Exceedances	Number of Tests in 2017
Poplar Point	6	3	20	AO:≤15	6	190
Eldorado	11	3	27	AO:≤15	8	47
Cedar Creek	7	3	19	AO:≤15	4	105
Swick	8	3	29	AO:≤15	7	109

Table 25. Treated Water Color annual summary

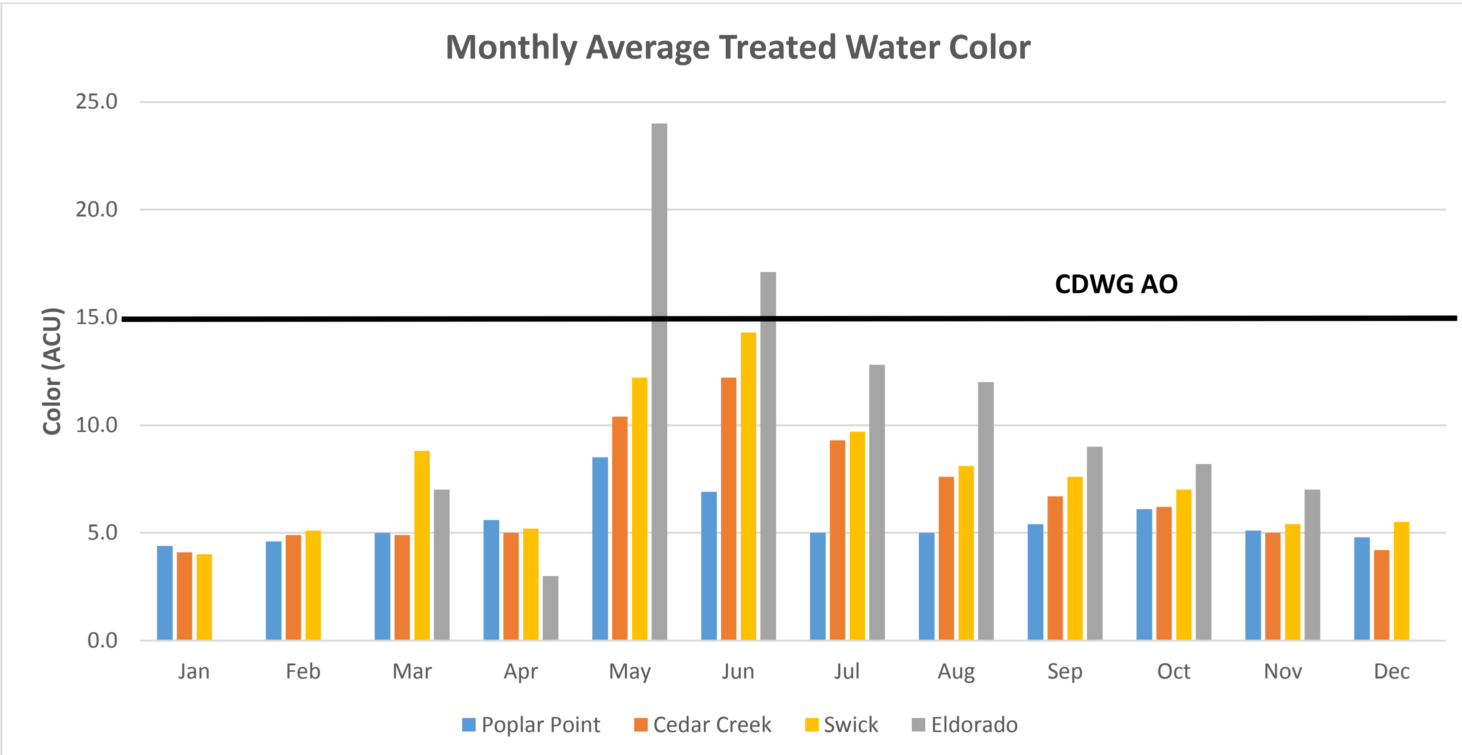


Figure 30. Monthly average Color for Treated Water

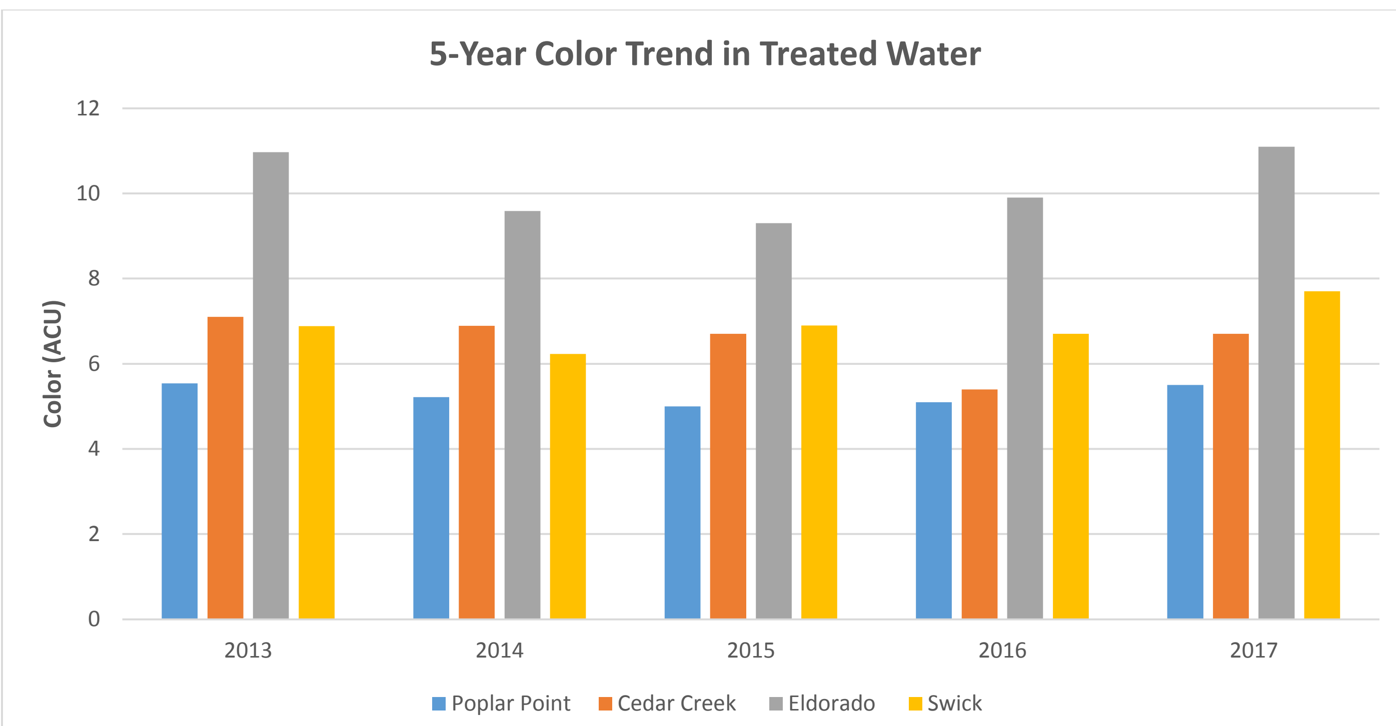


Figure 31. 5-Year Color trend in Treated Water

Temperature

The water temperature levels post treatment is not significantly different that the source water temperature as there is little heating or chilling applied during the treatment process. Elevated temperatures in treated water have been proven to enhance THM byproduct formation and therefore are preferred to be within objective limits. Minor objective exceedances were observed for both source and treated water during summer season (Table 26). There is a general downward trend in the yearly average temperature readings relative to the previous 3 years (Figure 33).

Intake	Average (°C)	Minimum (°C)	Maximum (°C)	Objective (°C)	Number of Exceedances	Number of Tests in 2017
Poplar Point	6.0	2.0	11.0	AO:≤15	0	190
Eldorado	14.0	5.0	19.5	AO:≤15	18	47
Cedar Creek	8.3	3.5	12.5	AO:≤15	0	105
Swick	9.6	3.5	18.0	AO:≤15	9	108

Table 26. Treated Water Temperature annual summary

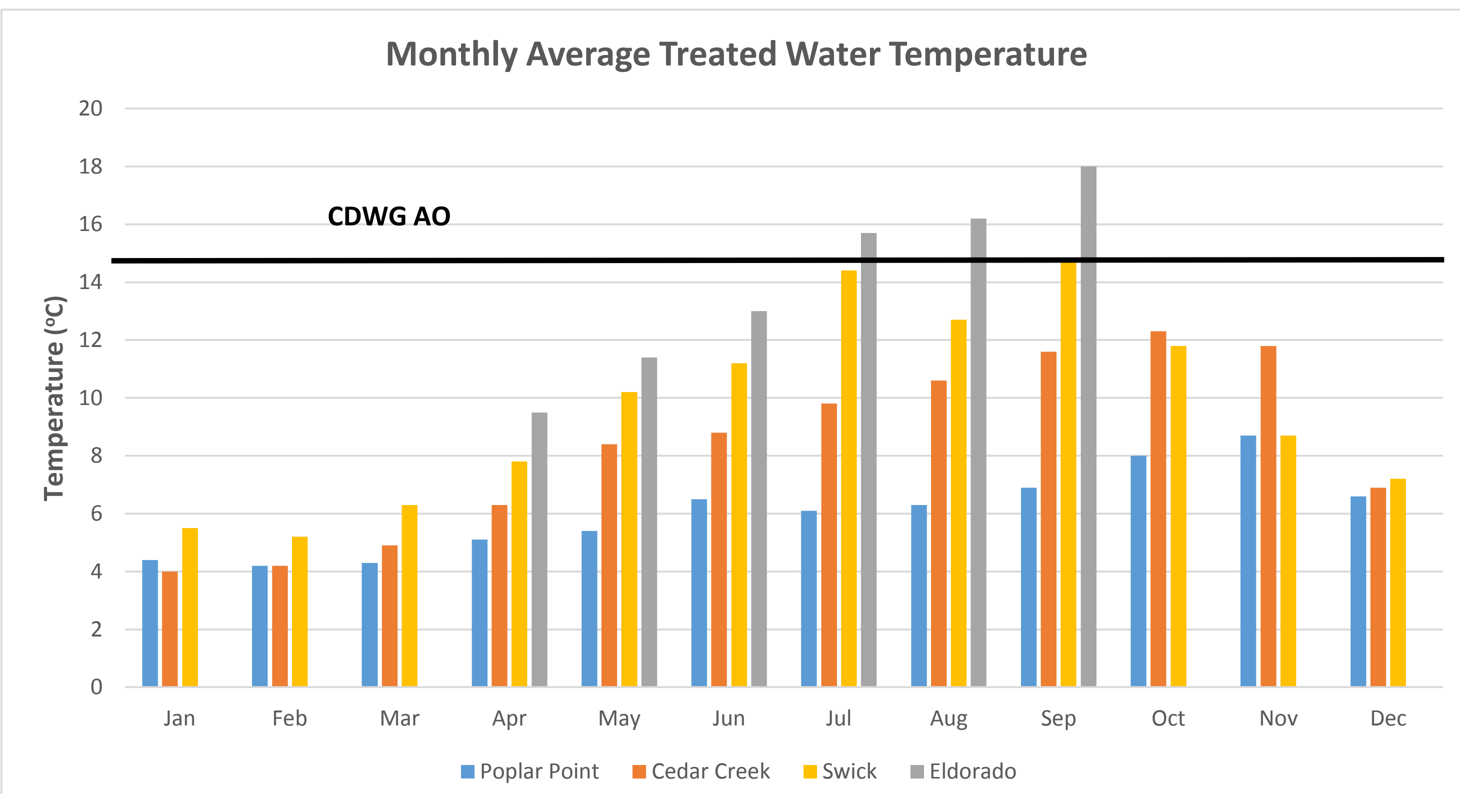


Figure 32. Monthly average Temperature of Treated Water

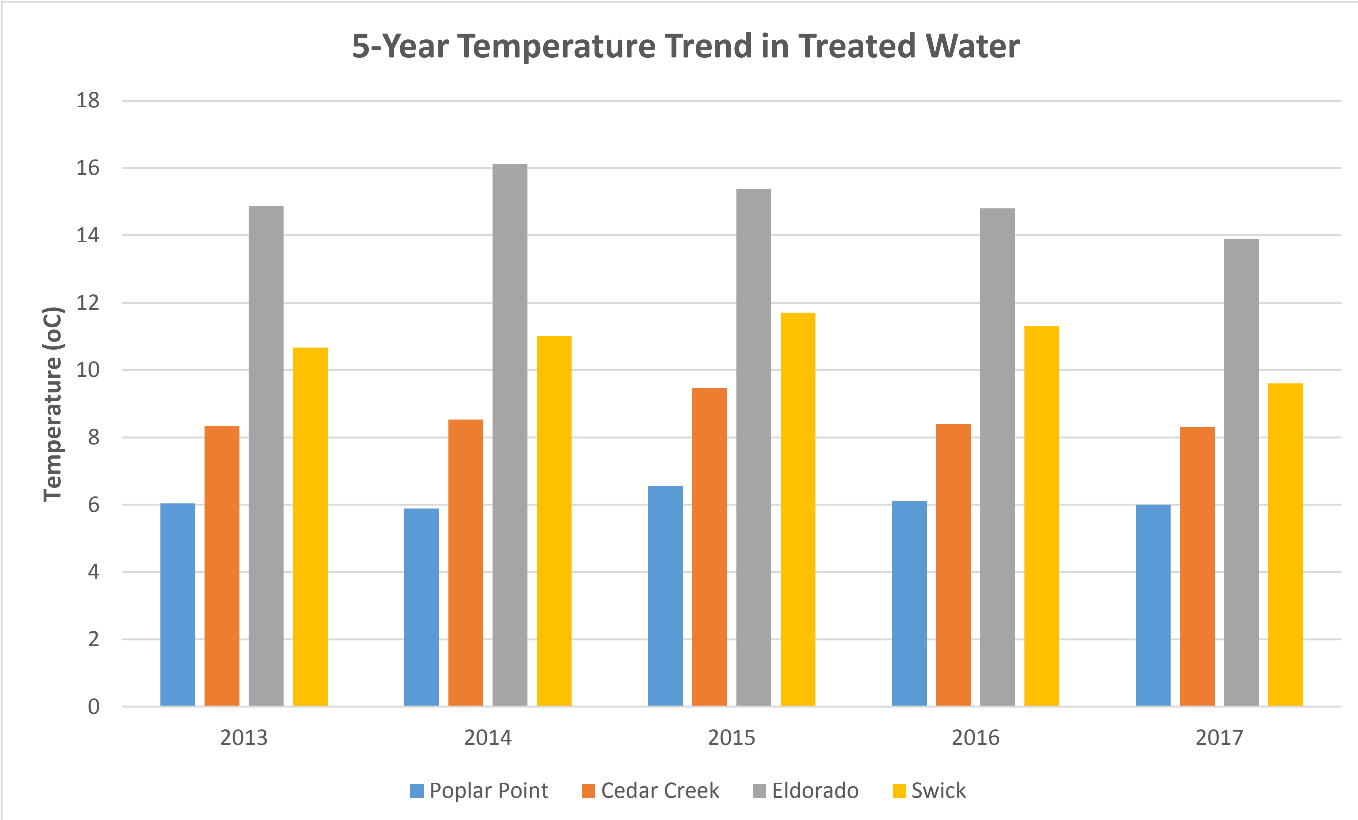


Figure 33. 5-Year Temperature trend in Treated Water

UV Transmittance

After dosing thought the UV reactor cells, the transmittance of the treated water is increased by an average of 2% over the UV transmittance of the source water for all sites. All test results met the objective of >80% transmittance throughout 2017 (Table 27). There was no significant trend observed over the past 5 years (Figure 35).

Intake	Average (%T)	Minimum (%T)	Maximum (%T)	Objective (%T)	Number of Exceedances	Number of Tests in 2017
Poplar Point	88.9	84.9	92.9	>80	0	190
Eldorado	85.6	83.2	93.3	>80	0	47
Cedar Creek	88.9	84.9	92.9	>80	0	105
Swick	87.5	83.6	92.3	>80	0	109

Table 27. Treated Water UV Transmittance annual summary

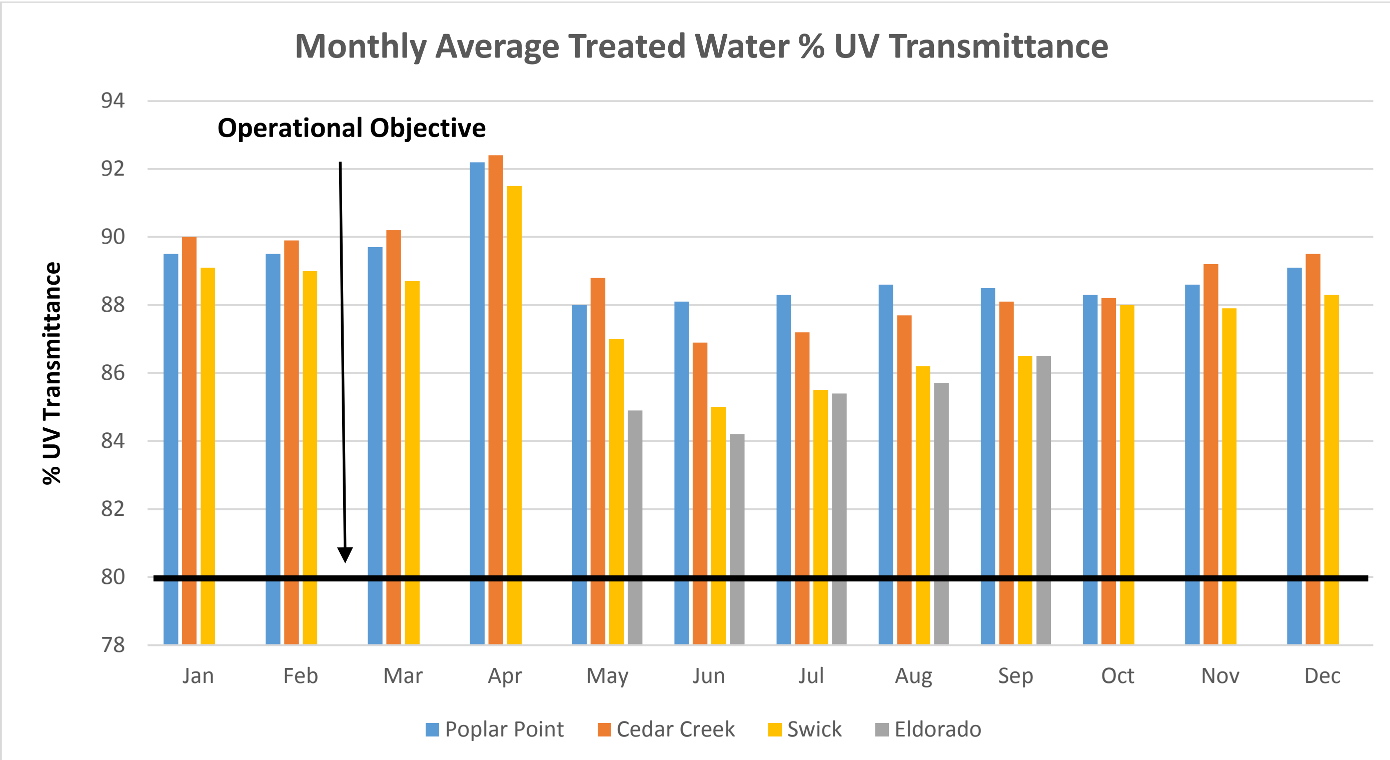


Figure 34. Monthly average % UV for Treated Water

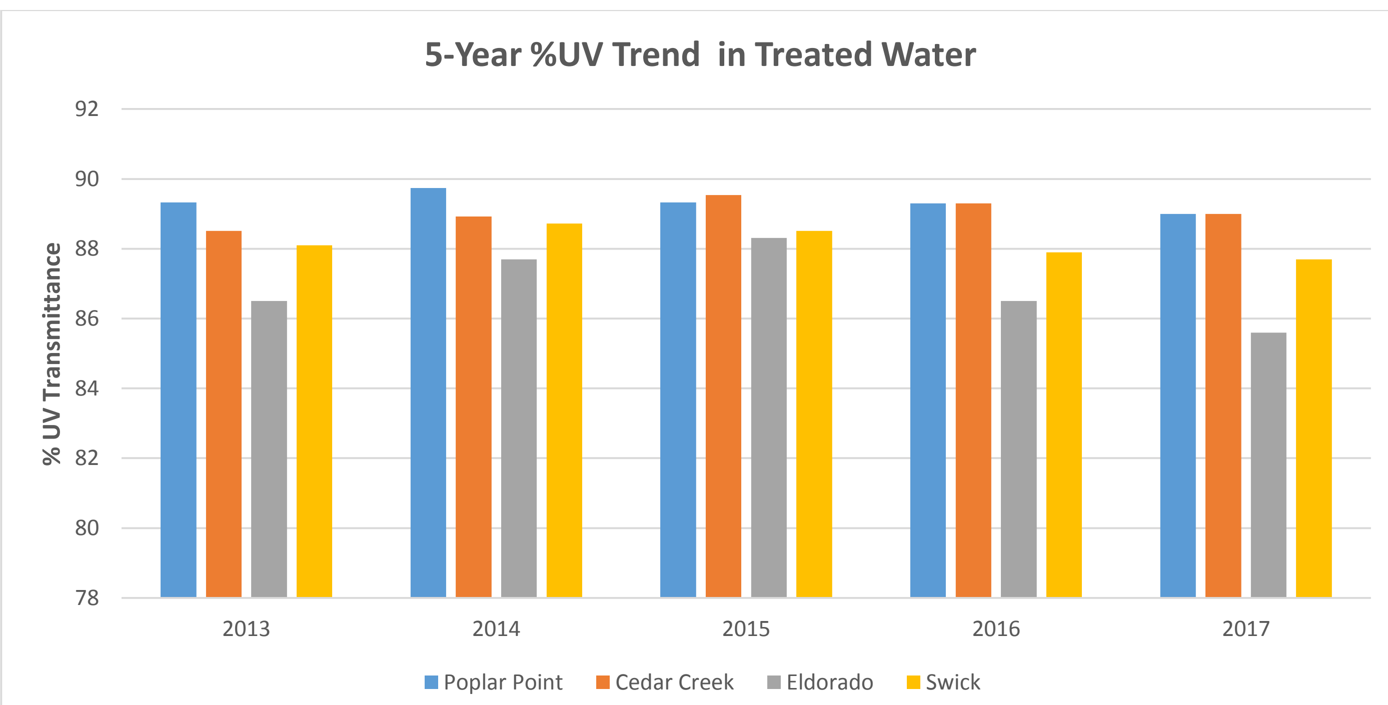


Figure 35. 5-Year %UV trend in Treated Water

Annual Physical, Chemical and Biological Analysis

Comprehensive water analysis is conducted annually at each intake and compared to a variety of health and aesthetic objectives. There were no guideline exceedances for any of the parameters as per CDWQ guidelines (Table 28).

ALS Environmental Services			POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Date Sampled			27-Jul-2017	27-Jul-2017	27-Jul-2017	27-Jul-2017
Physical Tests (Water)	Units	Guideline	Water	Water	Water	Water
Color, True	CU	AO=15	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm		279	267	285	278
Hardness (as CaCO3)	mg/L		133	130	129	131
pH	pH	7.5-10	8.02	8.10	8.11	8.14
Total Dissolved Solids	mg/L	AO=500	179	164	185	184
Turbidity	NTU	MAC=1	0.32	0.52	0.43	0.33
Anions and Nutrients (Water)						
Alkalinity, Total (as CaCO3)	mg/L		107	104	109	107
Ammonia, Total (as N)	mg/L		0.0062	<0.0050	0.0052	<0.0050
Chloride (Cl)	mg/L	AO=250	6.91	6.90	11.10	7.56
Fluoride (F)	mg/L	MAC=1.5	0.179	0.175	0.176	0.175
Nitrate (as N)	mg/L	MAC=10	0.0952	<0.0050	0.0480	0.0278
Nitrite (as N)	mg/L	MAC=1	<0.0010	<0.0010	<0.0010	<0.0010
Sulfate (SO4)	mg/L	AO=500	29.7	28.2	28.5	28.3
Sulphide as S	mg/L		0.022	0.021	<0.018	0.02

ALS Environmental Services			POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Date Sampled			27-Jul-2017	27-Jul-2017	27-Jul-2017	27-Jul-2017
Organic / Inorganic Carbon (Water)						
Total Organic Carbon	mg/L		4.09	4.90	4.38	4.62
Bacteriological Tests (Water)						
E. coli	MPN/100mL	MAC=<1	<1	<1	<1	<1
Coliform Bacteria - Total	MPN/100mL	MAC=<1	<1	<1	<1	<1
Total Metals (Water)						
Aluminum (Al)-Total	mg/L	AO=0.1	0.014	0.022	0.017	0.012
Antimony (Sb)-Total	mg/L	MAC=0.006	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)-Total	mg/L	MAC=0.01	0.00053	0.00050	0.00049	0.00047
Barium (Ba)-Total	mg/L	MAC=1	0.022	0.022	0.022	0.022
Boron (B)-Total	mg/L	MAC=5	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)-Total	mg/L	MAC=0.005	<0.00020	<0.00020	<0.00020	<0.00020
Calcium (Ca)-Total	mg/L		36.7	35.7	36.0	36.2
Chromium (Cr)-Total	mg/L	MAC=0.05	<0.0020	<0.0020	<0.0020	<0.0020
Copper (Cu)-Total	mg/L	AO=15	0.0011	0.0276	0.0012	0.0083
Iron (Fe)-Total	mg/L	AO=0.3	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Total	mg/L	MAC=0.01	<0.00050	<0.00050	<0.00050	<0.00050
Magnesium (Mg)-Total	mg/L		9.92	9.80	9.59	9.74
Manganese (Mn)-Total	mg/L	AO=0.05	<0.0020	<0.0020	<0.0020	<0.0020
Mercury (Hg)-Total	mg/L	MAC=0.001	<0.00020	<0.00020	<0.00020	<0.00020
Potassium (K)-Total	mg/L		2.35	2.36	2.28	2.33
Selenium (Se)-Total	mg/L	MAC=0.05	<0.0010	<0.0010	<0.0010	<0.0010
Sodium (Na)-Total	mg/L	AO=200	10.7	10.7	14.5	12.5
Uranium (U)-Total	mg/L	MAC=0.02	0.00252	0.00245	0.00251	0.00248
Zinc (Zn)-Total	mg/L	AO=5	<0.050	<0.050	<0.050	<0.050
Dissolved Metals (Water)						
Mercury (Hg)-Dissolved (mg/L)	mg/L	AO=5	<0.050	<0.050	<0.050	<0.050

MAC= Maximum Acceptable Concerntration related to Health Concerns

AO = Aesthetic Objective related to Taste, Odor, Appearance

Table 28. Treated Water comprehensive analysis summary

Pesticides and Herbicides

The scan presented here includes historically applied compounds as well as newly formulated spray compounds. To date, none of the listed Pesticides or Herbicides have been identified in the Kelowna water distribution system at appreciable levels (Table 29).

ALS Environmental Services		POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Date Sampled		27-Jul-2017	27-Jul-2017	27-Jul-2017	27-Jul-2017
Parameter	Units	Water	Water	Water	Water
Organochlorine Pesticides					
alpha-Chlordane	ug/L	<0.10	<0.10	<0.10	<0.10
gamma-Chlordane	ug/L	<0.10	<0.10	<0.10	<0.10
p,p-DDD	ug/L	<0.10	<0.10	<0.10	<0.10
p,p-DDE	ug/L	<0.10	<0.10	<0.10	<0.10
o,p-DDT	ug/L	<0.10	<0.10	<0.10	<0.10
p,p-DDT	ug/L	<0.10	<0.10	<0.10	<0.10
Oxychlordane	ug/L	<0.10	<0.10	<0.10	<0.10
d14-Terphenyl	%	82.5	85.1	87.6	89.4
Herbicides					
Bromoxynil	ug/L	<0.20	<0.20	<0.20	<0.20
2,4-D	ug/L	<0.20	<0.20	<0.20	<0.20
Dicamba	ug/L	<0.20	<0.20	<0.20	<0.20
Glyphosate	ug/L	<50.0	<50.0	<50.0	<5.0
MCPA	ug/L	<0.20	<0.20	<0.20	<0.20
Picloram	ug/L	<0.20	<0.20	<0.20	<0.20
2,4-Dichlorophenylacetic Acid	%	96.3	95.1	97.1	98.1

Pesticides Cont.		POPLAR POINT TREATED	ELDORADO TREATED	KVR TREATED	SWICK ROAD TREATED
Date Sampled		27-Jul-2017	27-Jul-2017	27-Jul-2017	27-Jul-2017
Pesticides					
Alachlor	ug/L	<0.10	<0.10	<0.10	<0.10
Atrazine	ug/L	<0.10	<0.10	<0.10	<0.10
Atrazine & Metabolites	ug/L	<0.20	<0.20	<0.20	<0.20
Azinphos-methyl	ug/L	<0.10	<0.10	<0.10	<0.10
Benzo(a)pyrene	ug/L	<0.010	<0.010	<0.010	<0.010
Carbaryl	ug/L	<0.20	<0.20	<0.20	<0.20
Carbofuran	ug/L	<0.20	<0.20	<0.20	<0.20
Chlorpyrifos	ug/L	<0.10	<0.10	<0.10	<0.10
Diazinon	ug/L	<0.10	<0.10	<0.10	<0.10
Dimethoate	ug/L	<0.10	<0.10	<0.10	<0.10
Diquat	ug/L	<1.0	<1.0	<1.0	<1.0
Atrazine Desethyl	ug/L	<0.10	<0.10	<0.10	<0.10
Malathion	ug/L	<0.10	<0.10	<0.10	<0.10
Diclofop-methyl	ug/L	<0.20	<0.20	<0.20	<0.20
Metolachlor	ug/L	<0.10	<0.10	<0.10	<0.10
Metribuzin	ug/L	<0.10	<0.10	<0.10	<0.10
Paraquat	ug/L	<1.0	<1.0	<1.0	<1.0
Phorate	ug/L	<0.10	<0.10	<0.10	<0.10
Prometryne	ug/L	<0.10	<0.10	<0.10	<0.10
Simazine	ug/L	<0.10	<0.10	<0.10	<0.10
Terbufos	ug/L	<0.20	<0.20	<0.20	<0.20
Triallate	ug/L	<0.10	<0.10	<0.10	<0.10
Trifluralin	ug/L	<0.10	<0.10	<0.10	<0.10
2-Fluorobiphenyl	%	78.7	76.6	79.6	79.4

Table 29. Pesticide and Herbicide scans of treated water

Radiological Parameters

There were no detectable levels of Gross Alpha compounds (naturally occurring) and minor concentrations of

Gross Beta compounds (artificially occurring) well below CDWQ guidelines (Table 30).

SRC Analytical Services			POPLAR POINT TREATED	ELDORADO TREATED	CEDAR CREEK TREATED	SWICK ROAD TREATED
Date Sampled			28-Jul-2014	28-Jul-2014	28-Jul-2014	28-Jul-2014
Parameter	Guideline*	Units	Water	Water	Water	Water
Radiological						
Gross Alpha	<0.5	Bq/L	<0.14	<0.14	<0.14	<0.14
Gross Beta	<1	Bq/L	0.20	0.19	0.22	0.17

Based on Canadian Drinking Water Quality Guidelines

Table 30. Radiological scans of treated water

Appendix D

Water Distribution Water Quality Monitoring Parameters

Distribution Water Quality Parameters

Chlorine – Free

In order to maintain free chlorine residual throughout the distribution system, booster stations are equipped to inject additional sodium hypochlorite at strategic intervals and are sampled from point of source through to end of pipe in order to maintain an operational target of 0.2 mg/mL free chlorine residual throughout. These sites are monitored weekly and reported to IHA on a monthly basis. All minimal operating Chlorine residual concentrations were maintained in the distribution system in 2017 (Figure 36). Of note is that the Free Chlorine in the Airport water system is supplied by GEID and not under direct control of COK water utility. The 5-year trend indicates fairly consistent Chlorine residuals throughout the distribution and within Canadian Drinking Water guidelines (Figure 37).

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of Tests in 2017
City System	0.76	0.22	2.2	888
Swick	0.51	0.21	1.36	126
Airport	1.26	0.30	1.83	181

Table 31. Free Chlorine in distribution water system summary

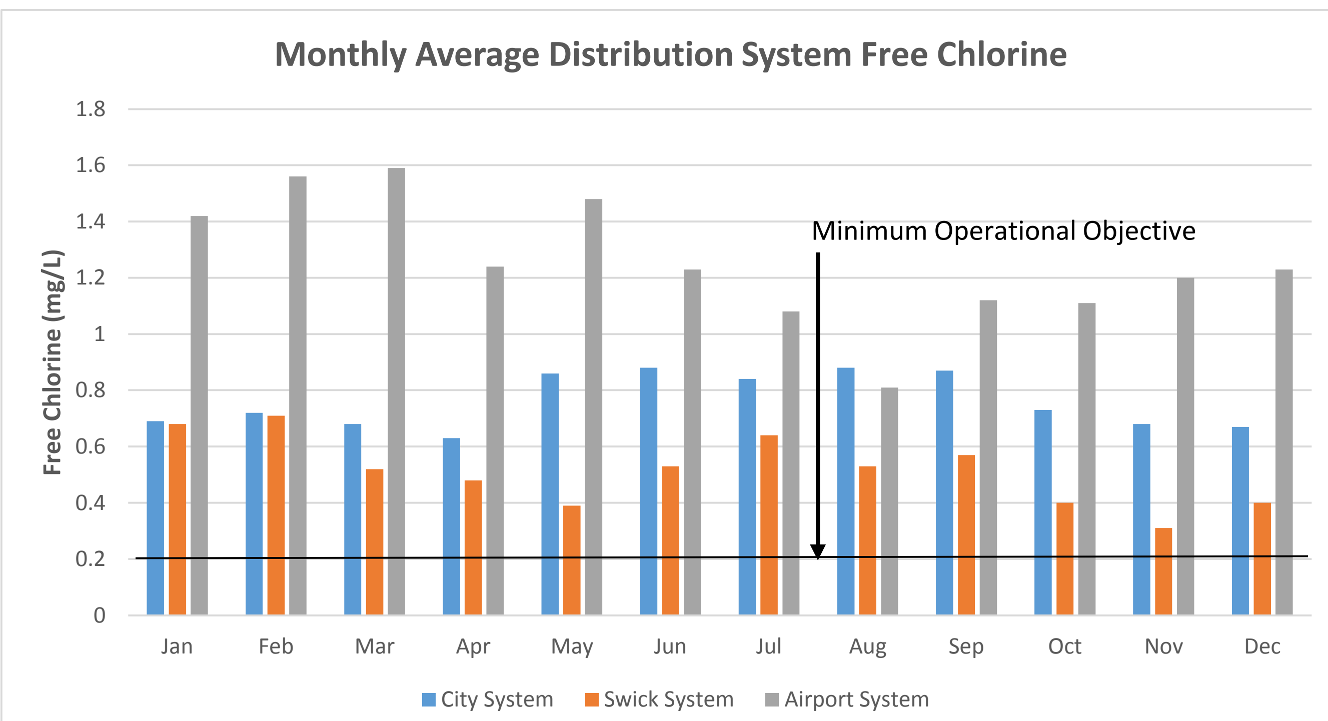


Figure 36. Monthly average Free Chlorine in Distribution System

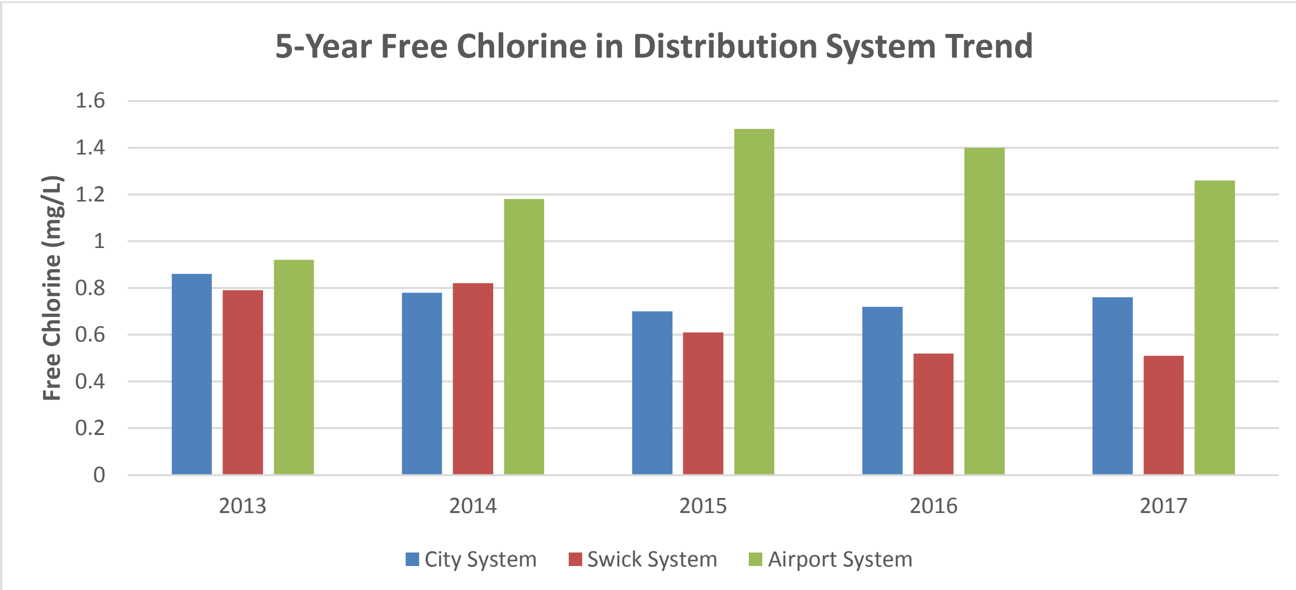


Figure 37. 5-Year Average Free Chlorine in Distribution System

Total Coliform

Total Coliform and E. Coli. bacteria are monitored routinely at various points along the distribution system to ensure that no bacterial re-growth has occurred and that new bacteria has not been introduced through leaks or line breaks. To date, there has been no indication that there were detectable levels of Total Coliform or E. Coli. at any of the sampling sites (Table 32 and 33). This is in line with the distribution system bacterial results in previous years and has not resulted in any boil water notifications in the past 20 years.

	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2017
City System	0	0	0	0	0	1099
Swick	0	0	0	0	0	170
Airport	0	0	0	0	0	193

Table 32. Total Coliform in distribution water system summary

E. Coli.

	Average (MPN/100ml)	Minimum (MPN/100ml)	Maximum (MPN/100ml)	Guideline (MPN/100ml)	Number of Exceedances	Number of Tests in 2017
City System	0	0	0	0	0	1099
Swick	0	0	0	0	0	170
Airport	0	0	0	0	0	193

Table 33. E. Coli. in distribution water system summary

Trihalomethanes

Trihalomethanes (THM) and Haloacetic acids (HAA) are produced during the relatively slow organic reaction that occur between free chlorine and naturally occurring organic precursors such as humic and fulvic acids. Samples are tested quarterly (Figure 38) and also reported as an annual average (Figure 39) to demonstrate compliance with the 0.10 mg/L Canadian Drinking Water guideline requirements. While the City system has remained consistent in THM concentration over the past 5 years, the Swick system has shown an increase. The airport system, as a result of receiving higher organic water from GEID, has been found to produce the highest level of THM of the 3 water systems (Table 34), although this is improving as a result of the water source changing to Okanagan lake for the past several years.

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Guideline (mg/L)	Number of Exceedances	Number of Tests in 2016
City System	0.0624	0.0550	0.0682	<0.1	0	28
Swick	0.0843	0.0748	0.1007	<0.1	1	9
Airport	0.0999	0.0814	0.1200	<0.1	1	4

Table 34. Summary of THM concentrations in the distribution water system

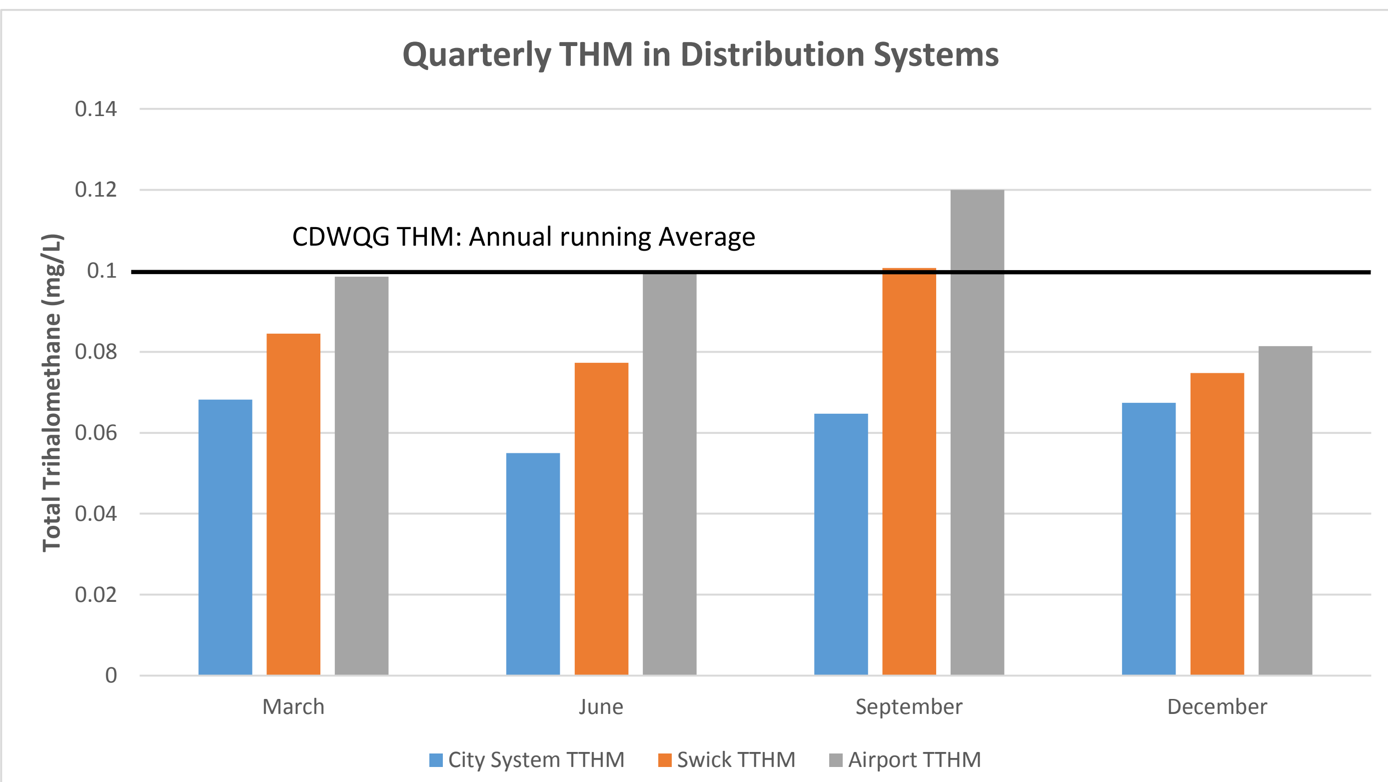


Figure 38. Quarterly average THM in Distribution system

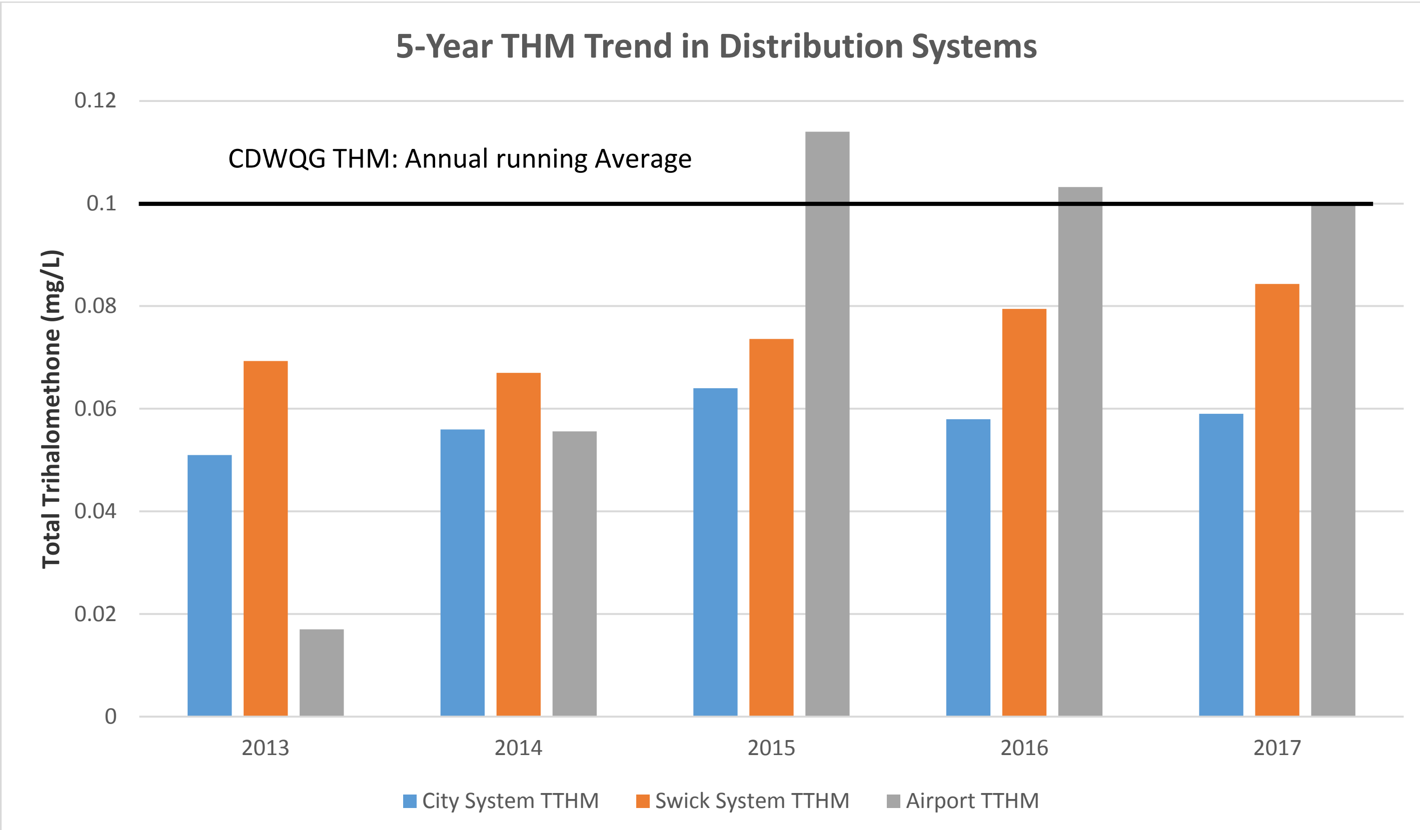


Figure 39. 5-year THM trend in Distribution Systems

Haloacetic Acids

Similar to the THM concentrations, HAA's have been found to be highest at the Airport water system relative to the organic precursor concentrations. There were no guideline exceedances of any of the concentrations throughout 2017 (Table 35). 2017 HAA's overall trended higher in all systems above 2015-2016, but have been fairly consistent in concentrations over the past 5 years (Figure 41).

	Average (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Guideline (mg/L)	Number of Exceedances	Number of Tests in 2016
City System	0.0436	0.0161	0.0961	<0.08	0	28
Swick	0.0357	<0.005	0.0571	<0.08	0	9
Airport	0.0737	0.0672	0.081	<0.08	0	4

Table 35. Summary of HAA concentrations in the distribution water system

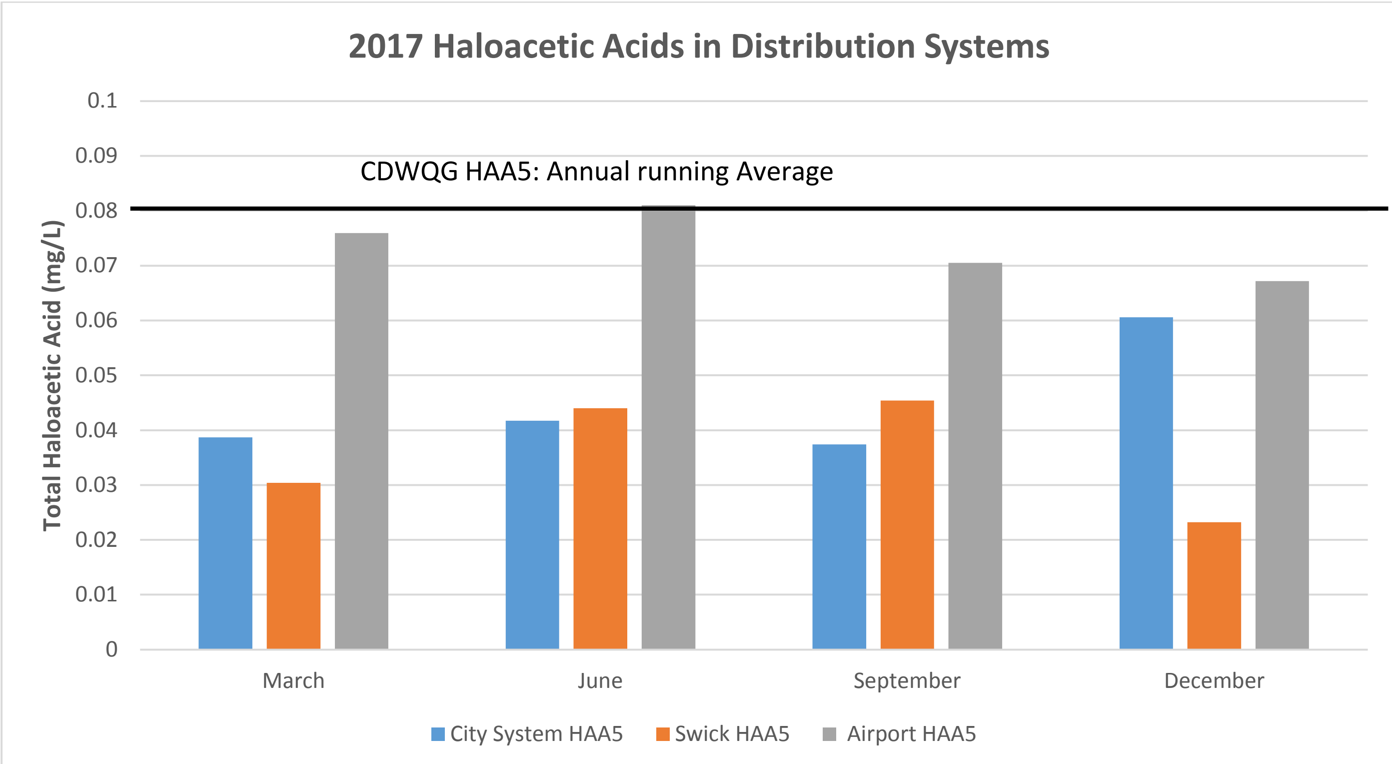


Figure 40. Quarterly Haloacetic Acids in Distribution Systems

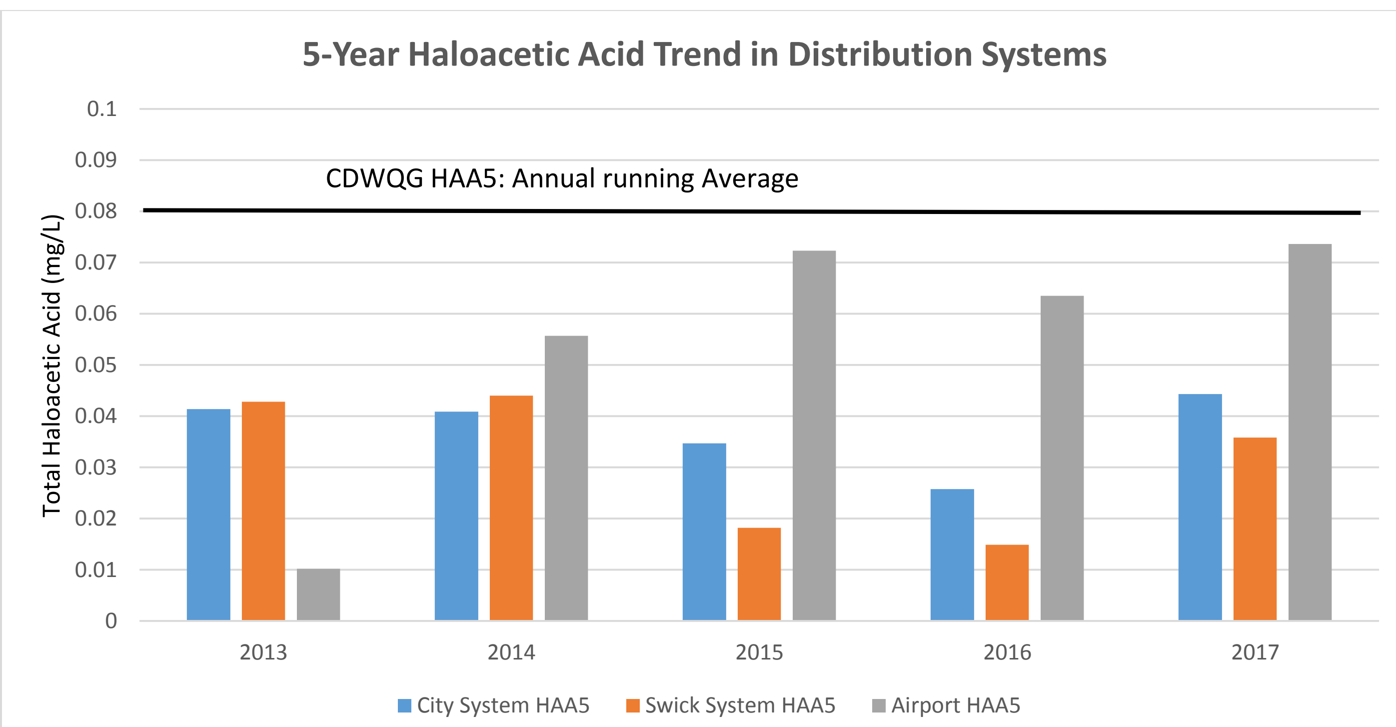


Figure 41. 5-year Haloacetic Acid trends in Distribution Systems

Appendix E

Drainage and Beaches

Drainage and Beaches

Introduction

This section of the report addresses a number of source water protection recommendations that have been identified in the Kelowna Source Water Protection Assessment (EBA, 2011). Monitoring water quality parameters of tributaries flowing into Lake Okanagan and along the foreshore allows a correlation to the potential impact on Kelowna's drinking water. These insights helps shape environmental planning and action in the event that trends or threats are identified. The monitoring consists of routine creek sampling, supplemental creek monitoring in the event of elevated Turbidity at intakes to determine if a connection in events exist, increased creek monitoring during rain and flush events, and beach sampling for E. Coli.

Monthly Monitoring

The mouths of Brandt's, Mill, and Mission Creek are sampled a minimum of 5 times in one month (5/30) in order to determine water quality trends and events how they correspond to water quality values tested at the intake sites. The correlation is taken into consideration for increased water treatment vigilance and source water protection planning. Parameters that the creek sites were sampled for include ammonia, chloride, true color, conductivity, dissolved oxygen, *E. coli*, pH, total suspended solids, temperature, and Turbidity and are graphically presented relative to the CDWQ. Specific sampling sites are listed in the Sampling Site section of this Appendix.

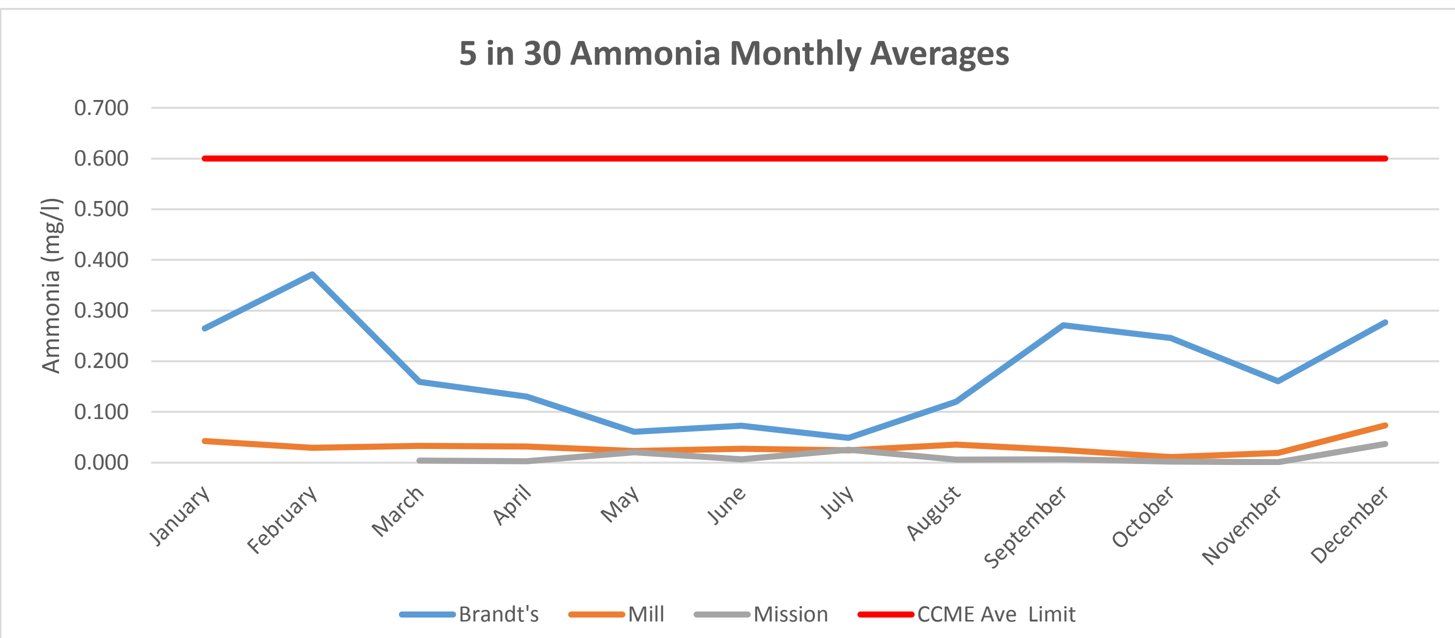


Figure 42. Monthly Ammonia average for creek samples

There was an increased ammonia concentration trend in Brandt's creek from July through to December in 2017 while Mill and Mission remained consistent throughout the year. In all cases, the Ammonia concentrations were below calculated CCME guidelines for freshwater.

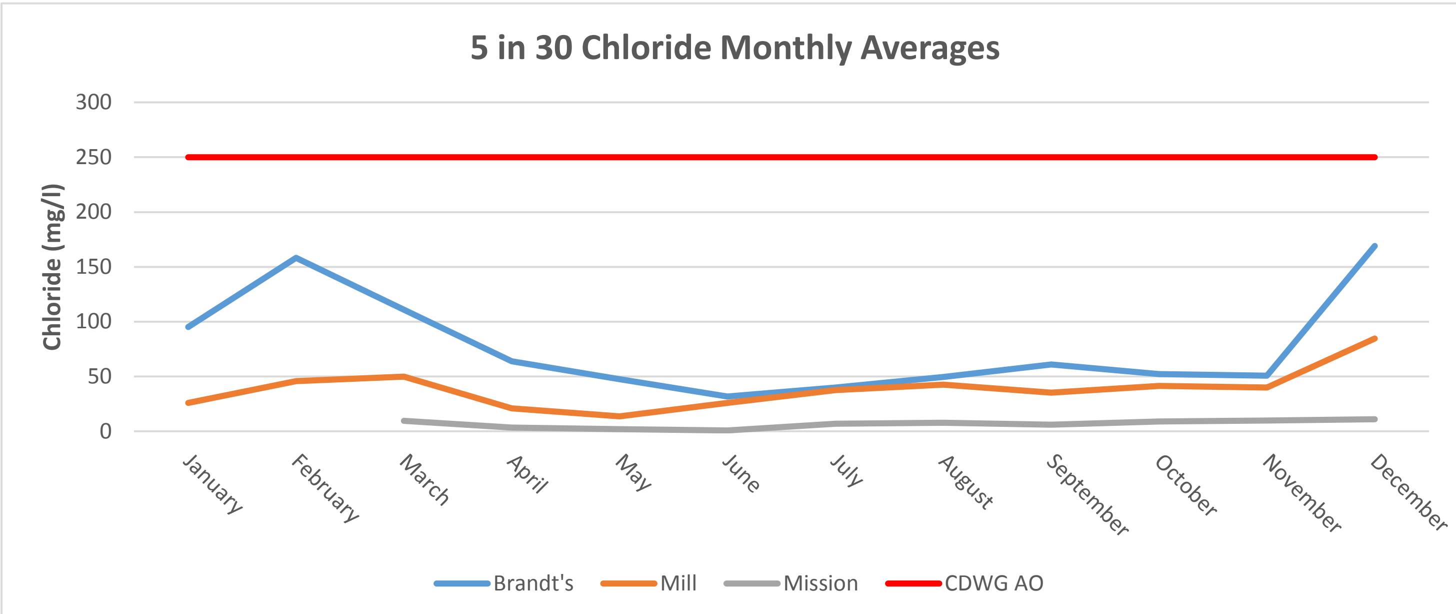


Figure 43. Monthly Chloride average for creek samples

Chloride concentrations were consistent with 2016 results and well within Aesthetic objectives for all creeks.

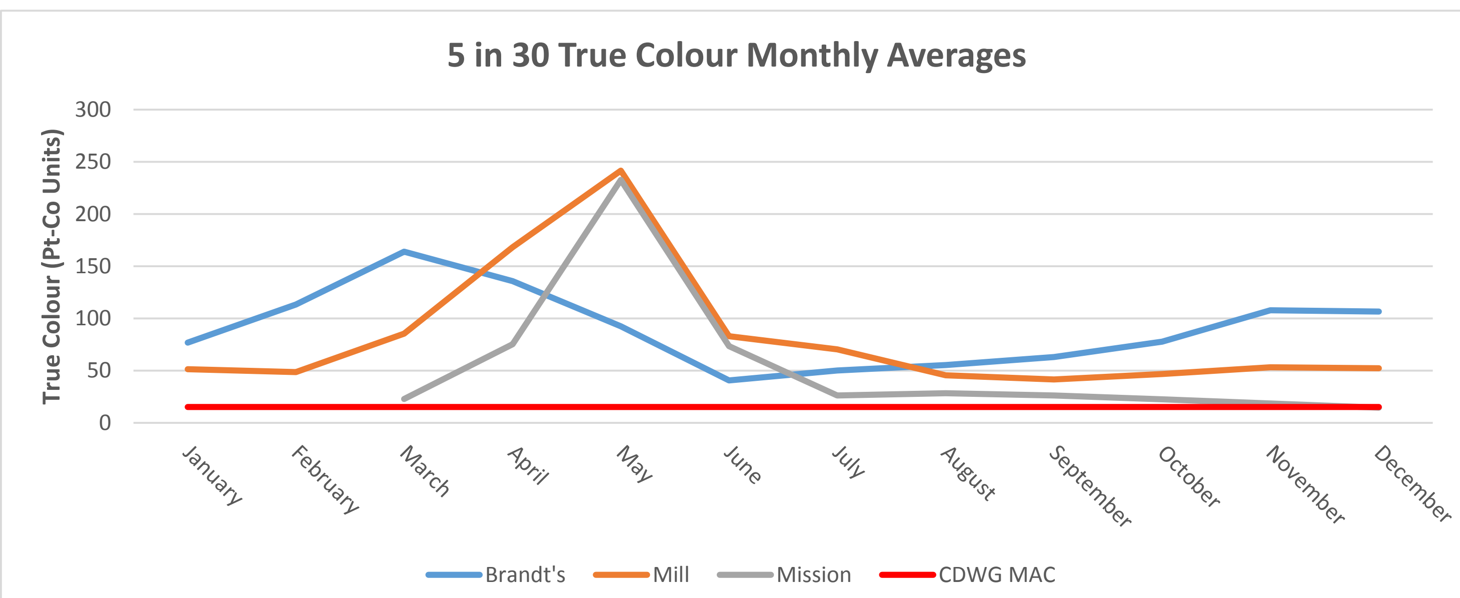


Figure 44. Monthly Color averages for creek samples

Color levels elevated during freshet and during periods of higher rainfall in the spring and fall of 2017. This is in line with annual trends observed in previous years. Due to high organic content, color remained above CDWQ at all times of the year.

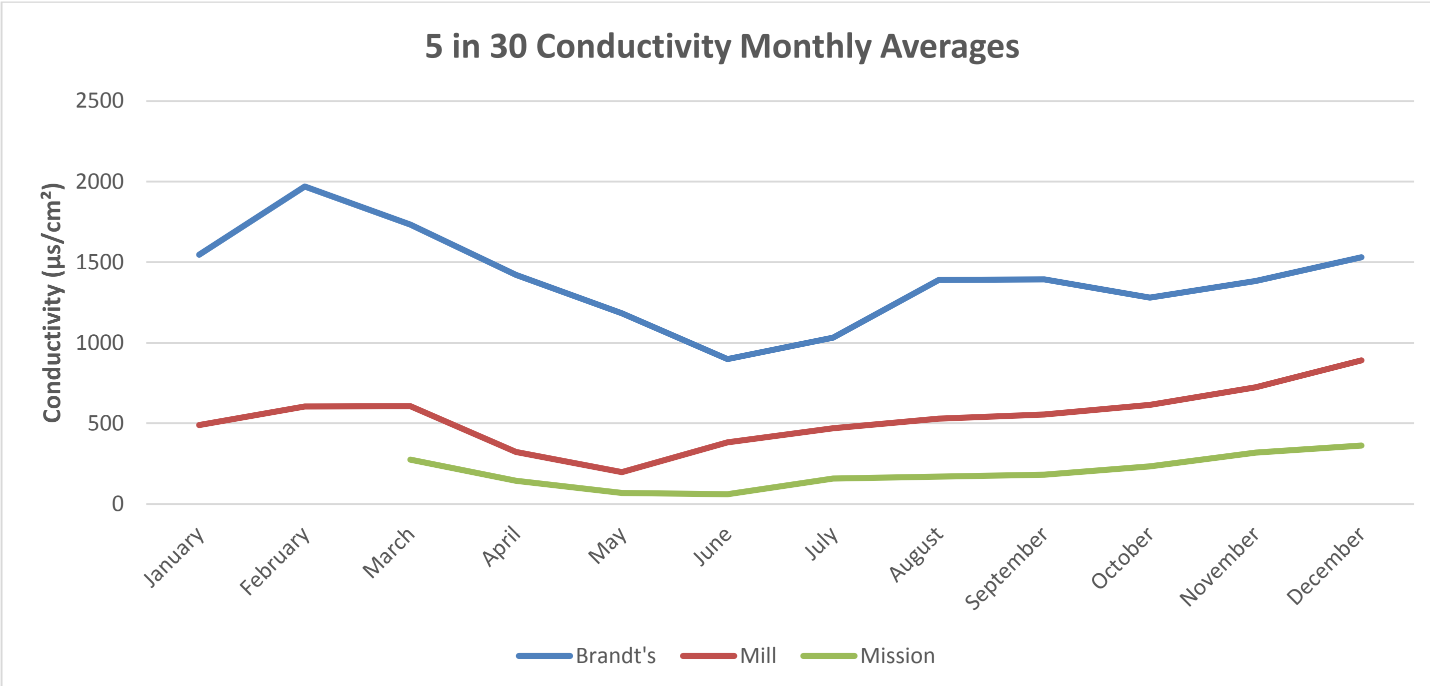


Figure 45. Monthly Conductivity averages for creek samples

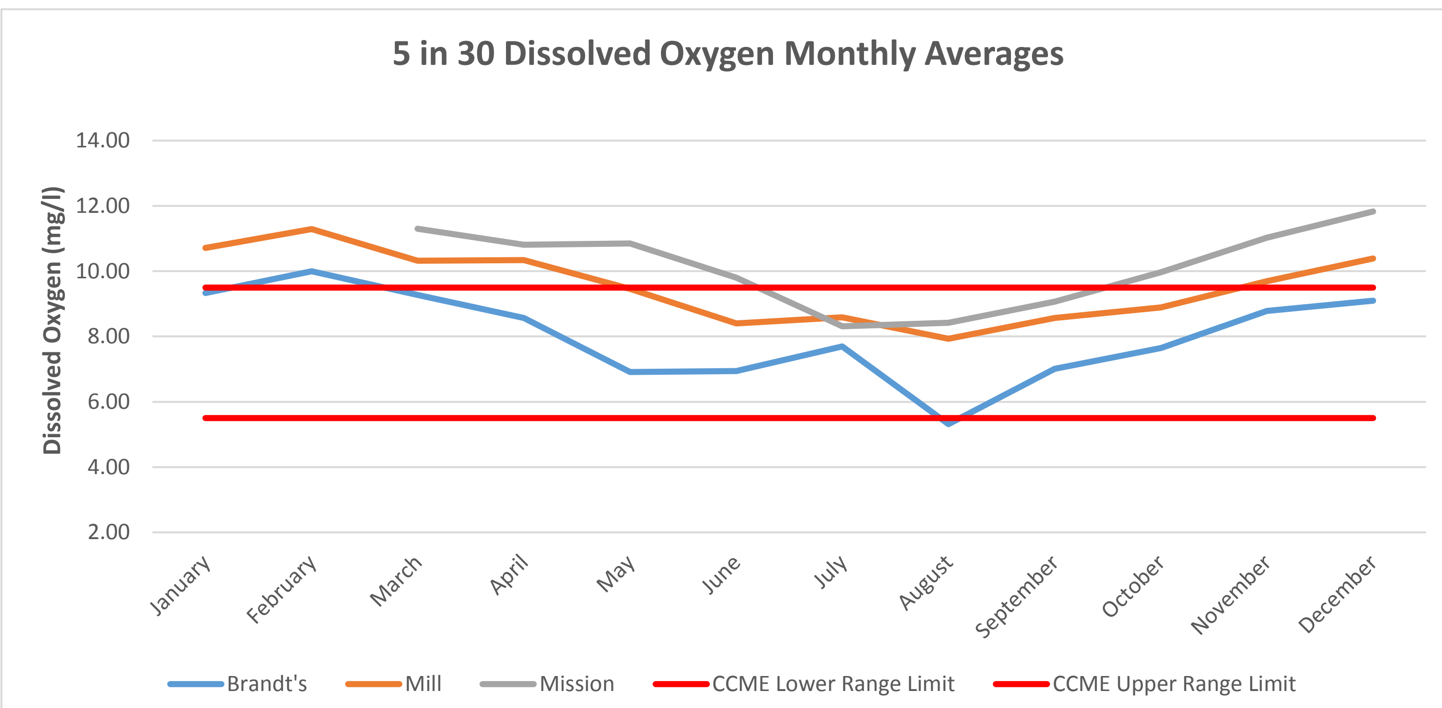


Figure 46. Monthly Dissolved Oxygen average for creek samples

Dissolved Oxygen concentrations are relative to temperature and therefore a higher trend is observed in winter months.

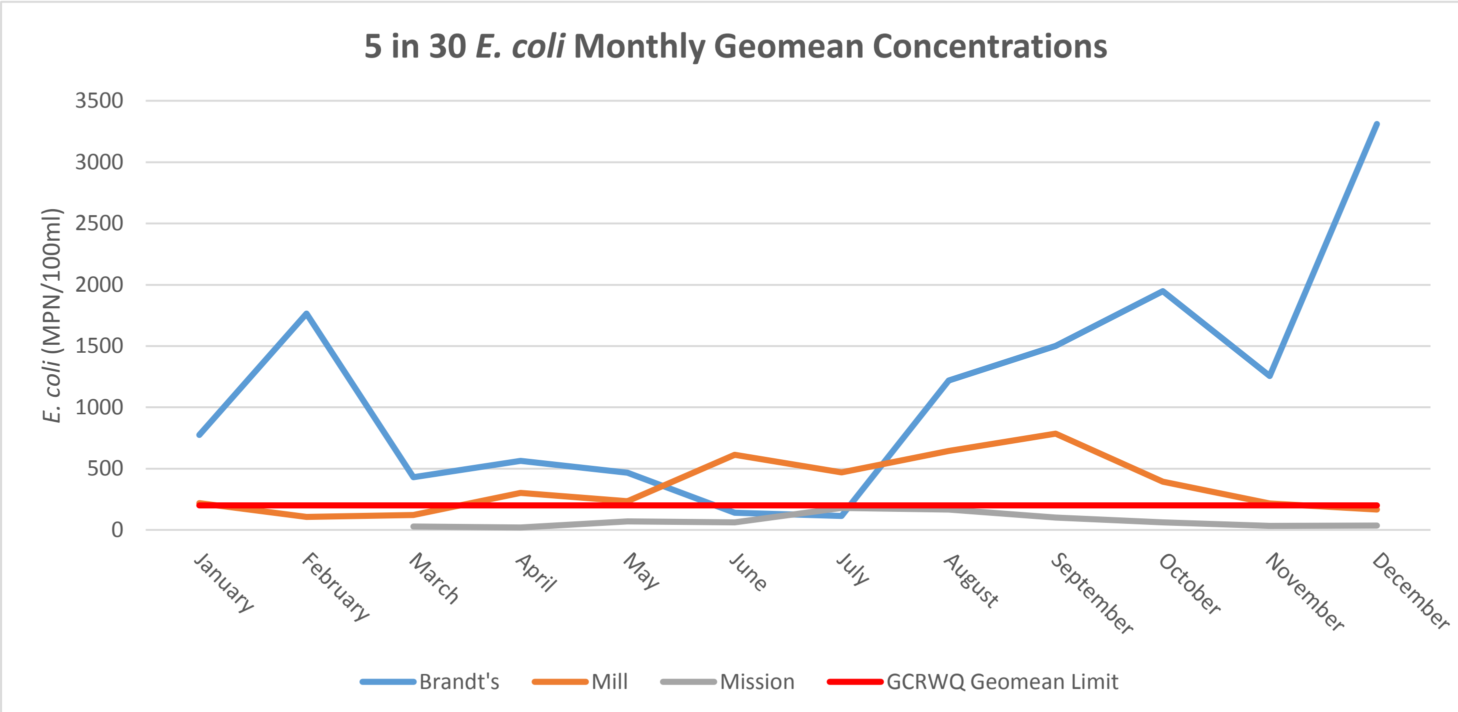


Figure 47. Monthly E. Coli averages in creek samples

E. coli. counts for Brandt's Creek fluctuated during winter months potentially due to waterfowl activity in area.

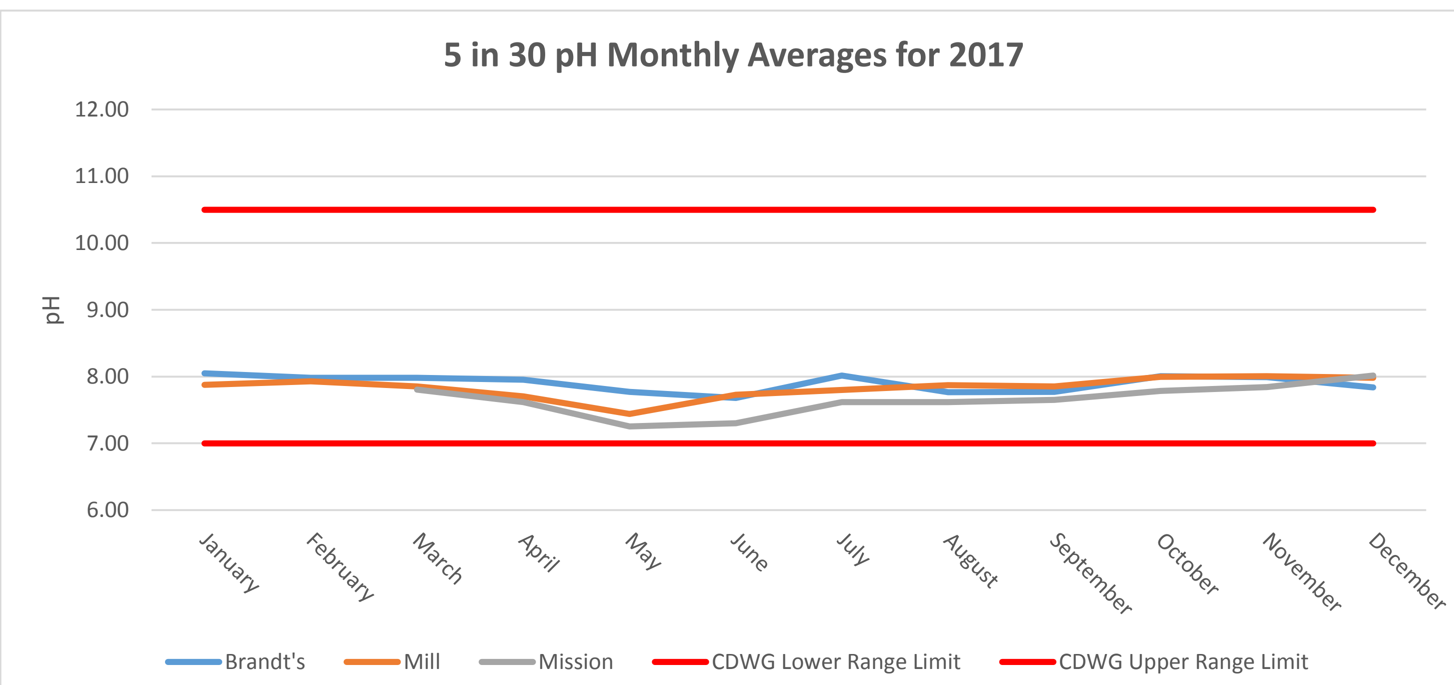


Figure 48. Monthly pH averages for creek samples

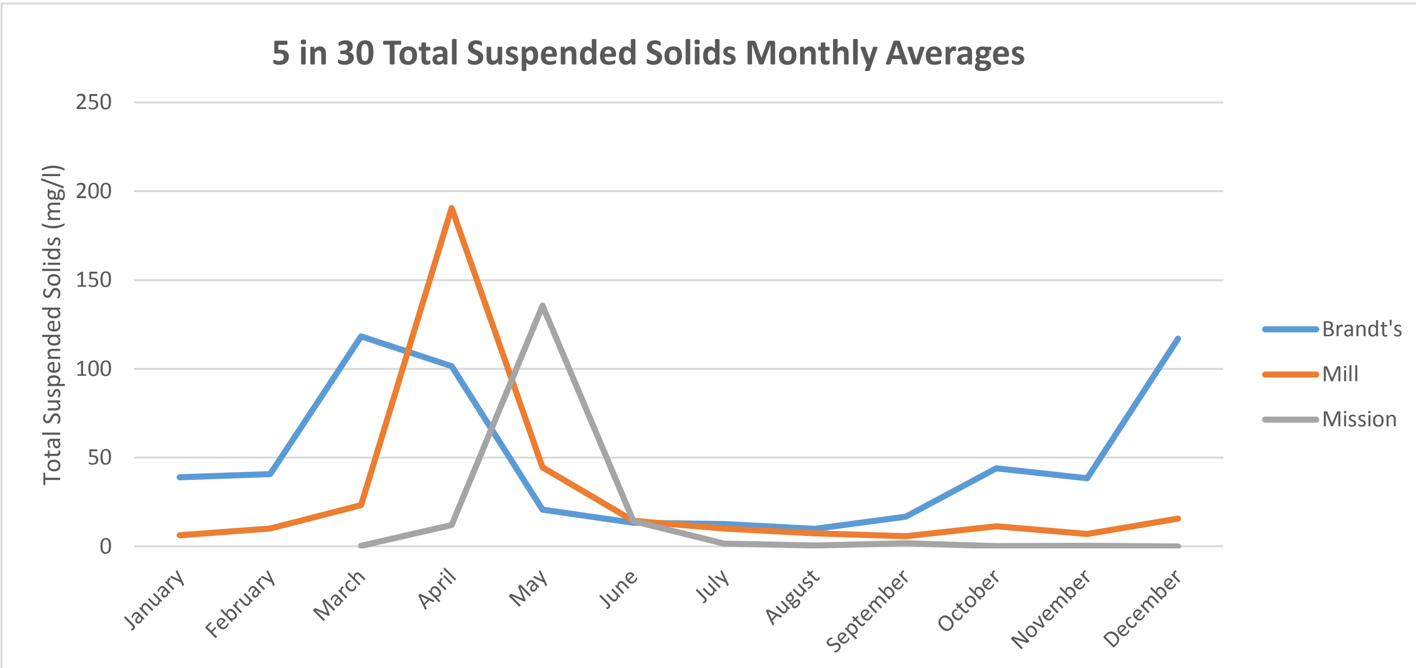


Figure 49. Monthly TSS averages for creek samples

As with Color and Turbidity, Total Suspended Material increased during the intense freshet and rain events that flushed sediment through the creek systems. Values during freshet was noticeably higher over 2016.

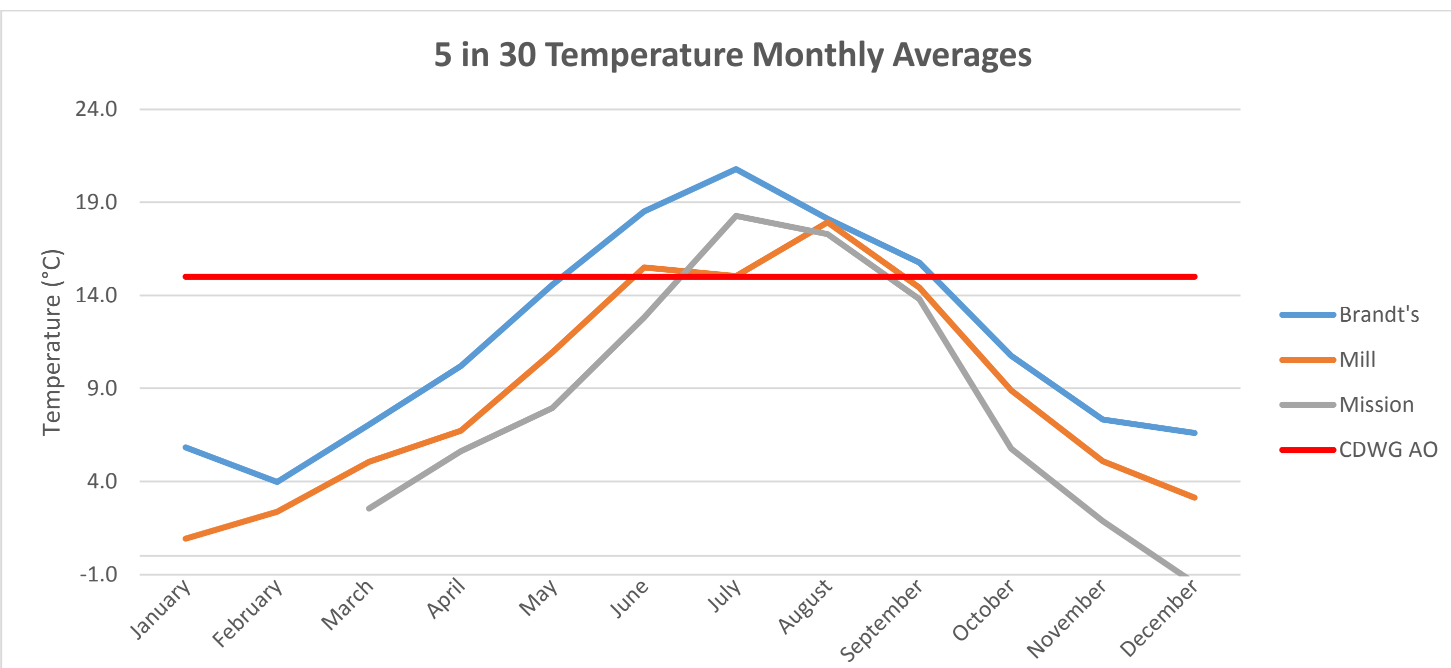


Figure 50. Monthly Temperature average for creek samples

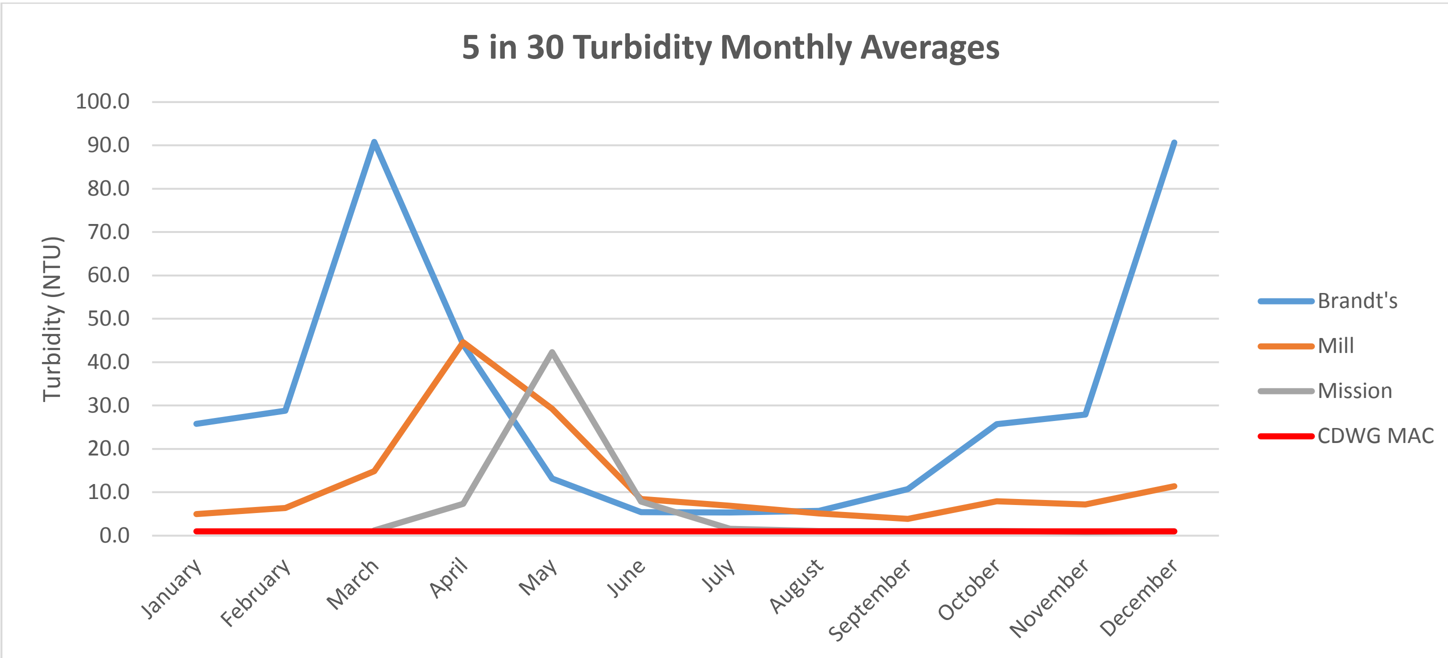


Figure 51. Monthly Turbidity average for creek samples

Creek Turbidities were 20-30 NTU higher during 2017 freshet relative to 2016 and contributed to the Water Quality Advisory issued in early May due to elevated Turbidity concentrations.

Creek Testing during elevated Turbidity at Intakes

The mouths of Brandt's Creek, Mill Creek, and Mission Creek (Appendix A) are sampled when there is increased Turbidity in raw water quality at the drinking water intakes. When the Turbidity is above 0.800NTU the mouths of the creeks are sampled. Turbidity close to 1NTU usually happens in the spring when freshet occurs and when the lake is mixing. The Turbidity at the drinking water intakes is typically 0.500NTU or below. Below the graph shows when the Turbidity was close to 1 NTU at one or more of the drinking water intakes and what the Turbidity is at the mouths of tributaries closest or most influential to the Intake during that time period. Additional set of graphs compares *E. coli* at the mouths of the closest or most influential creeks in the area of the Intakes when the Turbidity at the Intake is close to 1 NTU. The intent of the graphs is to correlate the contribution of creek Turbidity and *E. coli* concentrations to Turbidity at the Intakes.

Similar to historical Turbidity tracking, there is an approximate 1-week lag time between elevated Creek Turbidity and elevated Turbidity at the Intakes during the onset of freshet (Figures 52-54). However, once creek Turbidities decrease, the Turbidities at the Intakes take a much longer time to return to historical levels below the CDWQG - presumably due to mixing and current effects at the Intake depths.

Based on proximity, there appeared to be somewhat of an influential correlation related to E. coli counts for the following pairs: Cedar Creek Intake and Mission Creek (Figure 56), Eldorado Intake and Mission Creek (Figure 57), Poplar Point Intake and Brandt's Creek (Figure 58), and Swick Intake and Varty Creek (Figure 59).

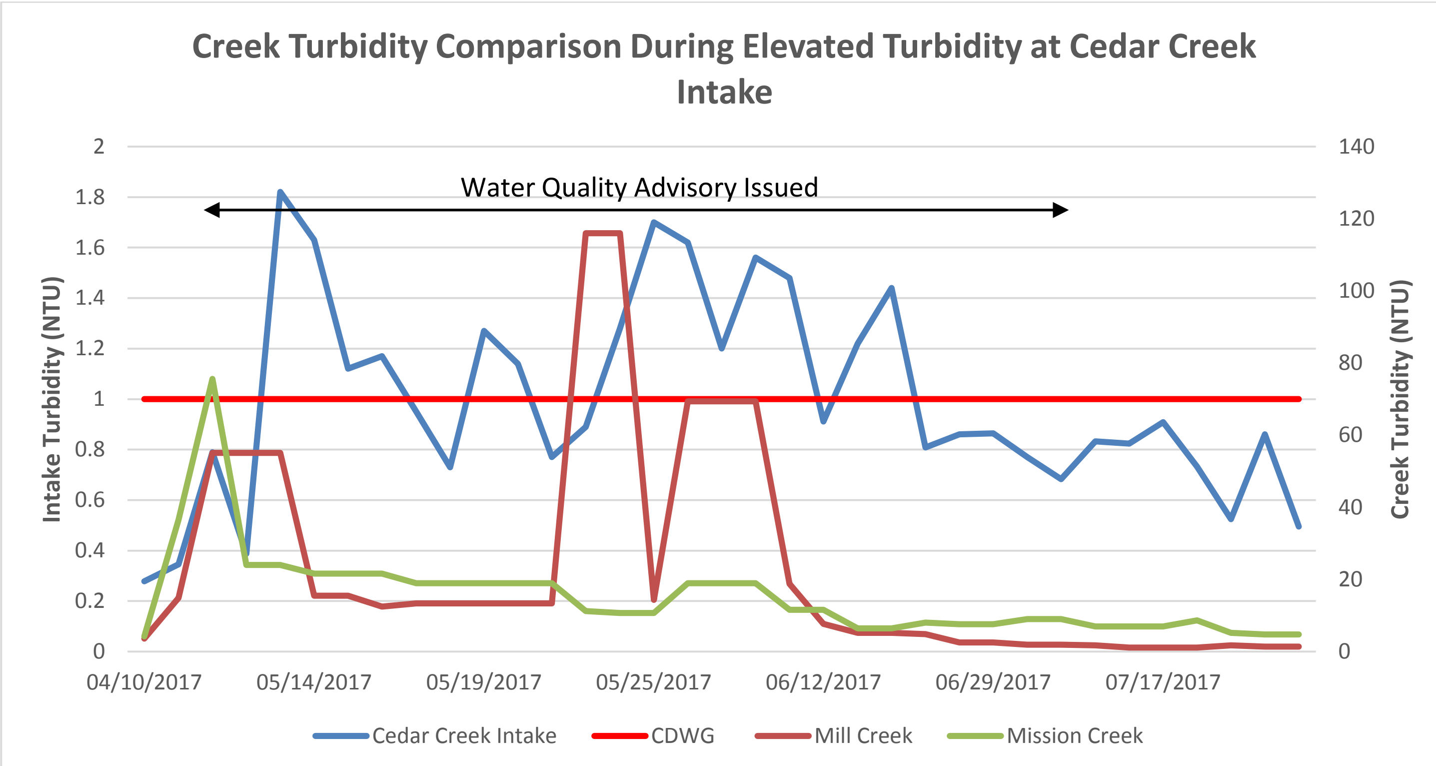


Figure 52. Creek Turbidities when elevated Turbidity at Cedar Creek was observed

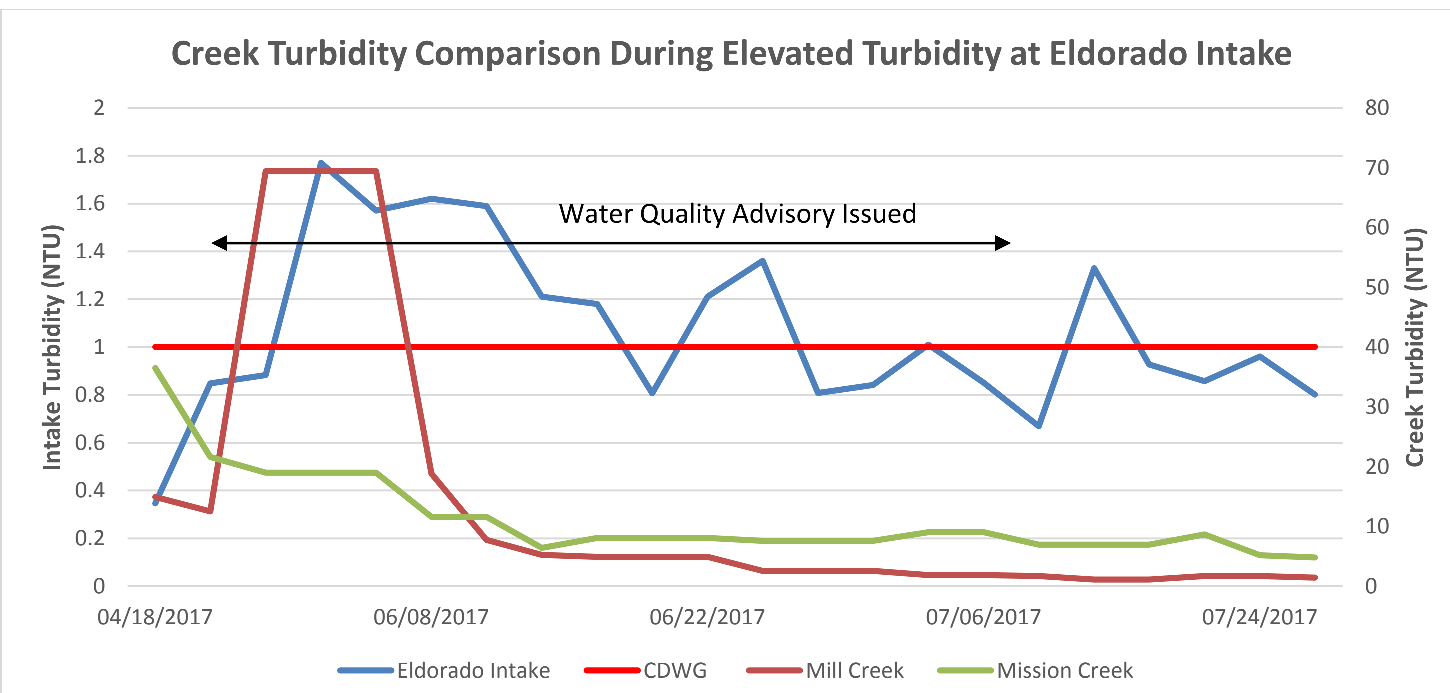


Figure 53. Creek Turbidities when elevated turbidities at Eldorado was observed

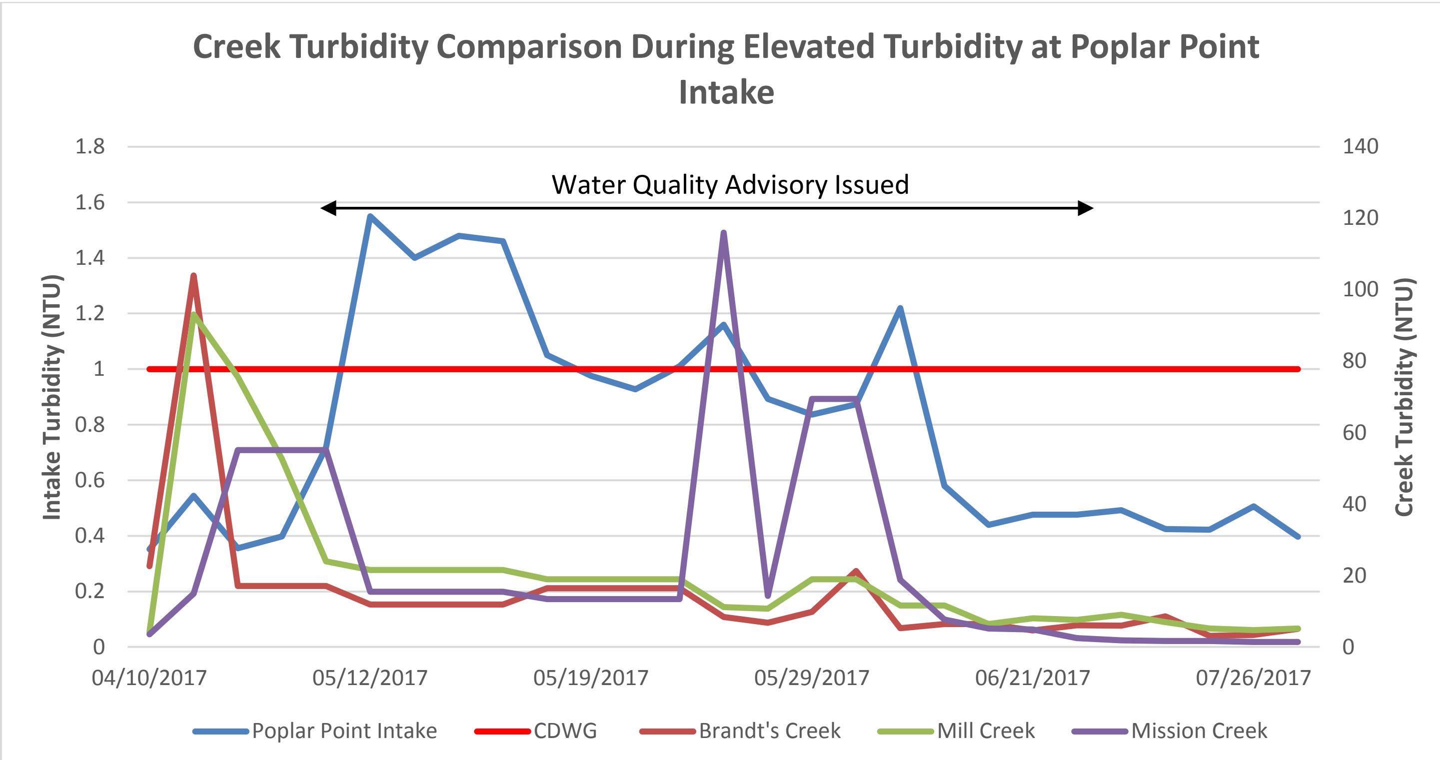


Figure 54. Creek Turbidities when elevated Turbidity levels at Poplar point was observed

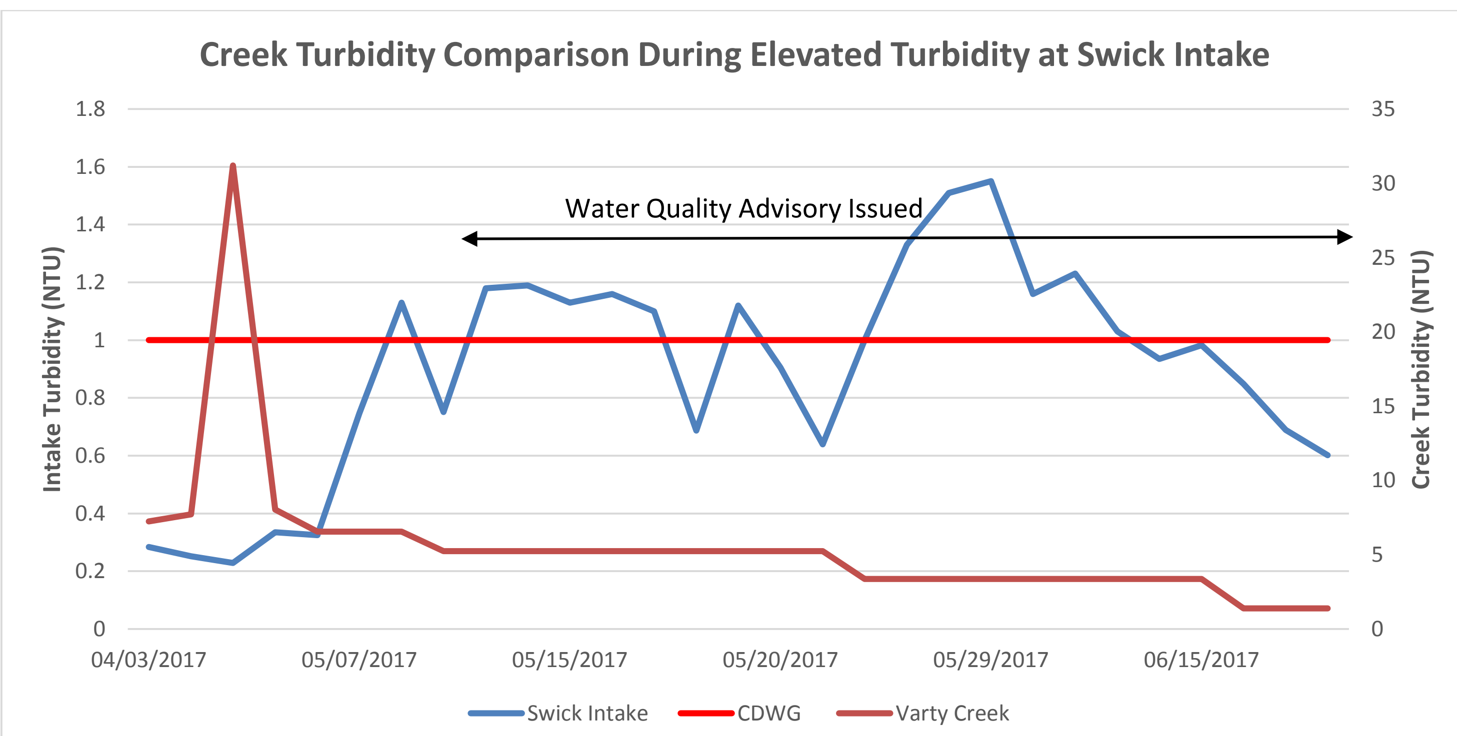


Figure 55. Varty Creek Turbidity when elevated Turbidity levels at Swick was observed

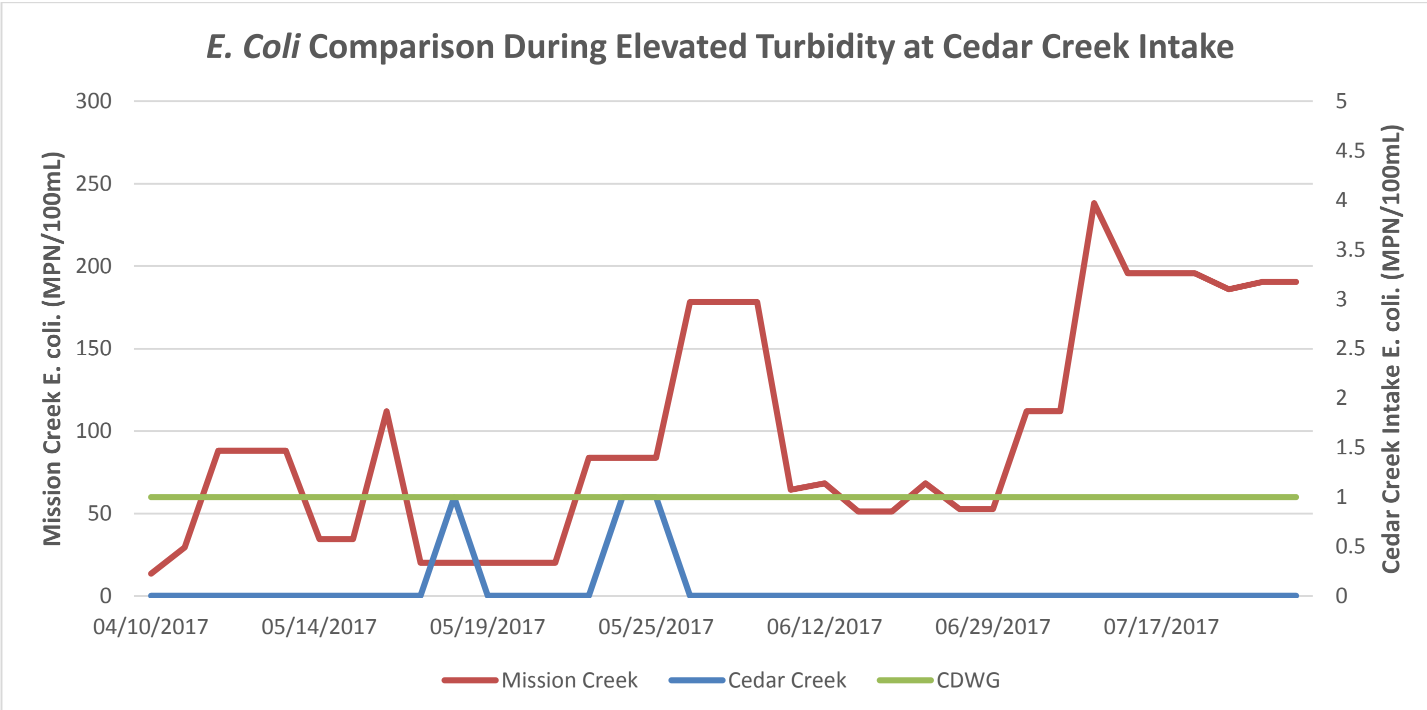


Figure 56. Mission Creek E. Coli when elevated Turbidity levels at Cedar Creek was observed

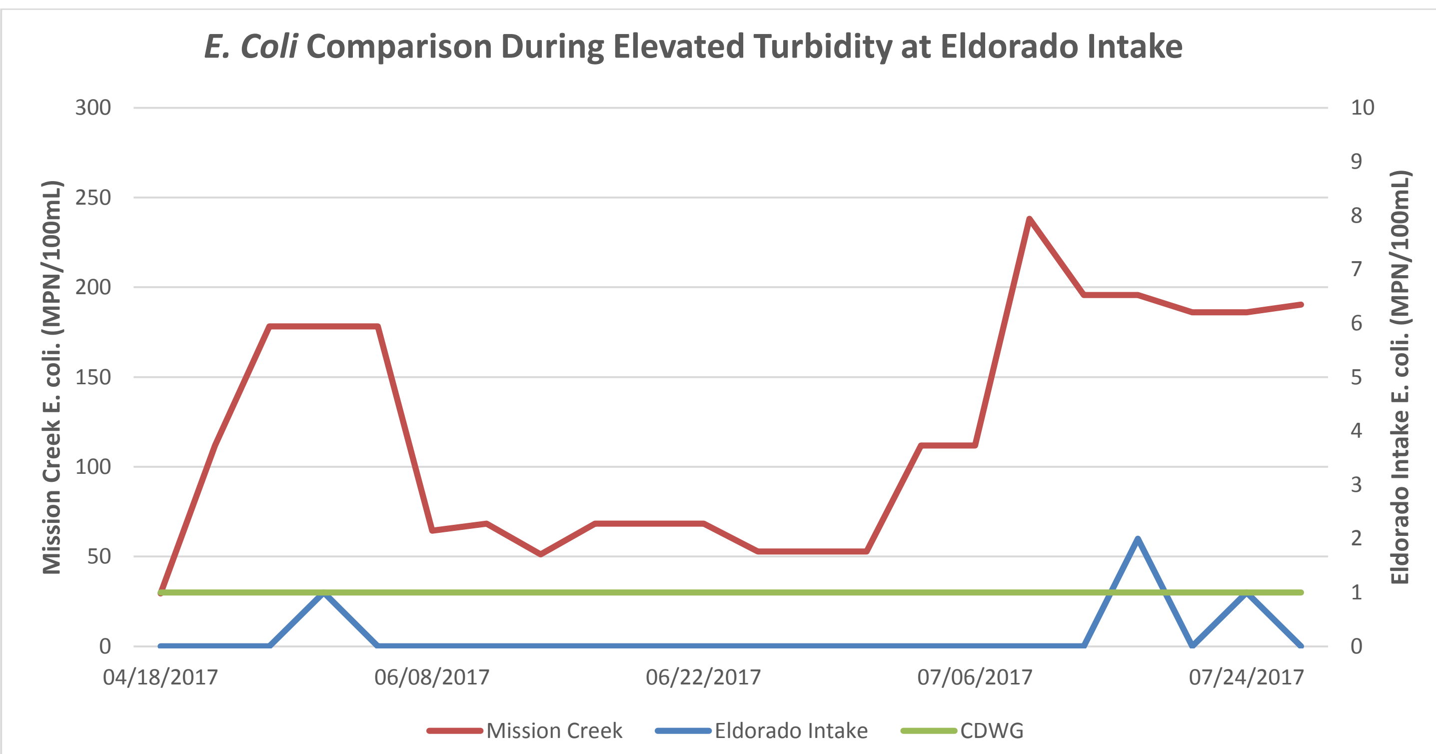


Figure 57. Mission Creek and Eldorado E. coli during elevated Turbidity levels at Intake

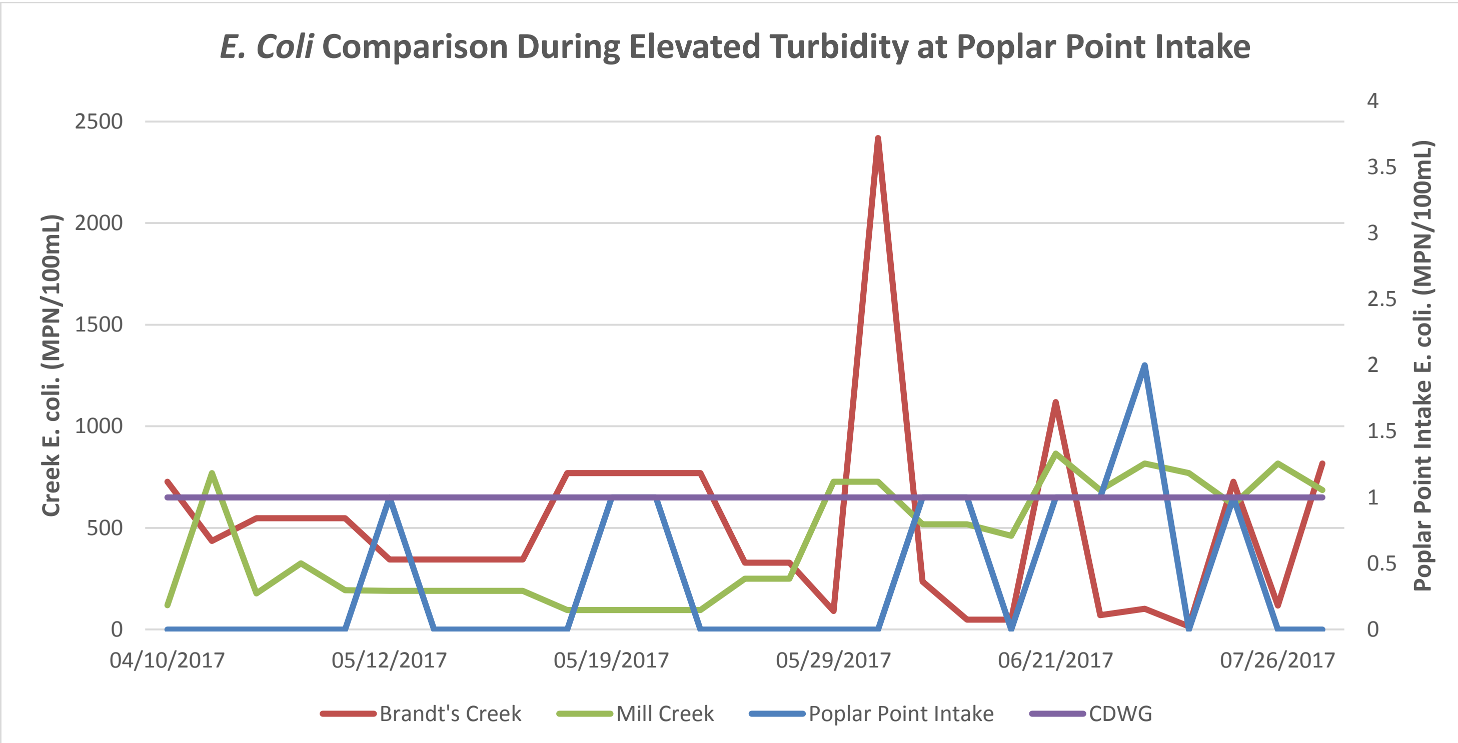


Figure 58. Comparison of creek E. coli. when elevated Turbidity levels at Poplar Point Intake was observed

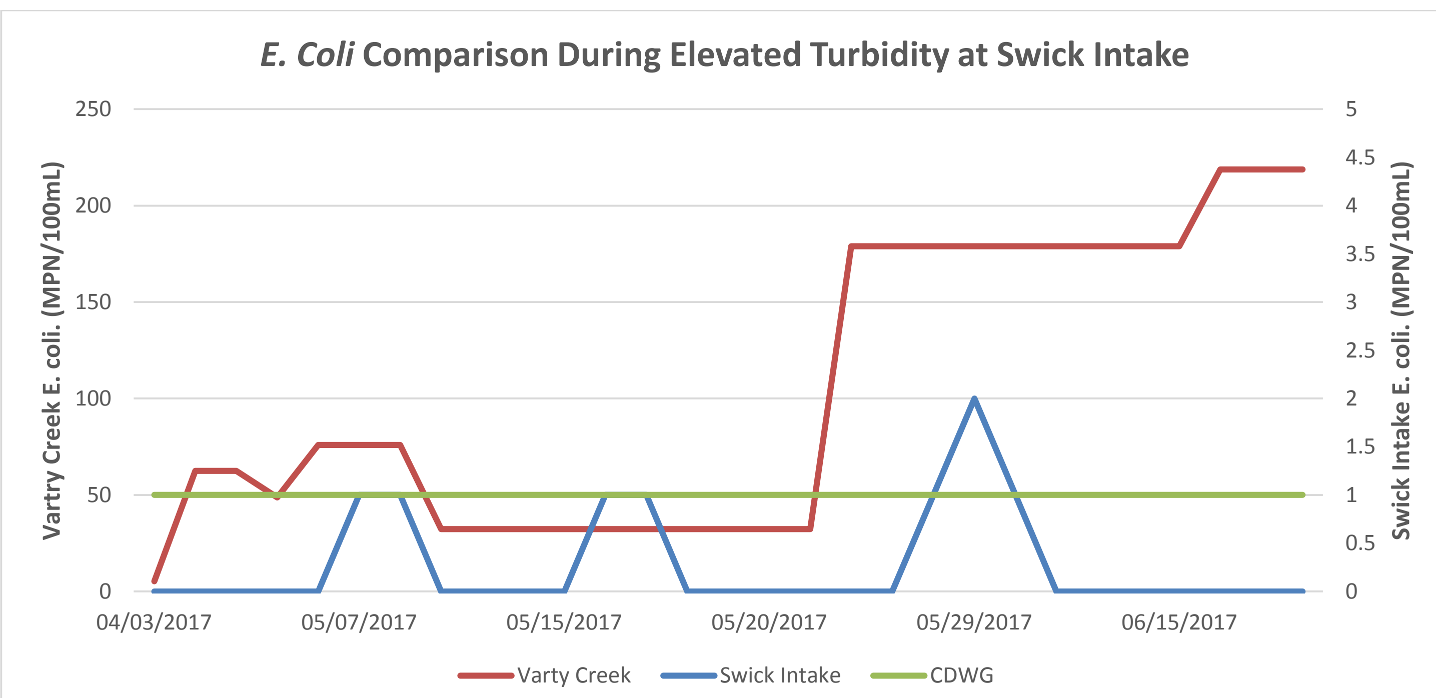


Figure 59. Varty Creek E. Coli. when elevated Turbidity levels at Swick Intake was observed

First Flush and Rain Event Monitoring at Outfalls

First flush is defined as the first major rain or snow melt that would push significant material through the storm water system and eventually into Okanagan lake. Brandt's Creek and Mill Creek outfalls were monitored during the first flush and rain events of more than 5mm during March-April (Table 36-37). As expected, there was consistent trend of First Flush depositing the highest amount of Suspended Solids, Color, and Turbidity into the creeks relative to subsequent rain events. Conductivity, E. coli., Chloride, and pH all tended to drop as a result of a dilution and buffering effect of the snow / rain water.

Brandt's Creek Outfall						
Parameter	**Brandt's Creek at Brant Ave February 27, 2017 Pre-Rainfall**	**First Flush ~5mm, March 14, 2017**	**Brandt's Creek at Brant Ave March 27, 2017 Pre-Rainfall**	**Rain Event ~9mm, March 29, 2017**	**Brandt's Creek at Brant Ave April 18, 2017 Pre-Rainfall**	**Rain Event ~7mm, April 20, 2017**
Ammonia (mg/l)	0.146	0.241	0.026	0.153	0.096	0.247
Chloride (mg/l)	159	80	100	22	68	14
True Colour (Pt-Co Units)	130	959	75	987	95	501
Conductivity (µs/cm²)	2553	428.2	2120	172.8	1699	119.4
Dissolved Oxygen (mg/l)	11.20	9.24	10.41	9.97	9.22	9.56
E. coli (MPN/100ml)	9208	172	687	517	816	201
pH	8.09	7.82	8.23	7.50	8.19	7.38
Total Suspended Solids (mg/l)	30	259	11	216	30	91
Temperature (°C)	2.7	5.4	7.3	8.2	11.1	10.9
Turbidity (NTU)	20.3	636.0	9.1	235.0	20.2	79.4

Table 36. Water Quality at Brandt's creek during rainfall events

Mill Creek Outfall						
Parameter	**Mill Creek at Hardy St February 23, 2017 Pre-Rainfall**	**First Flush ~5mm, March 14, 2017**	**Mill Creek March at Hardy St 28, 2017 Pre-Rainfall**	**Rain Event ~9mm, March 29, 2017**	**Mill Creek at Hardy St April 19, 2017 Pre-Rainfall**	**Rain Event ~7mm, April 20, 2017**
Ammonia (mg/l)	0.012	0.147	0.012	0.113	0.012	0.114
Chloride (mg/l)	31	90	31	27	14	14
True Color (Pt-Co Units)	52	377	63	730	203	382
Conductivity (µs/cm²)	583.7	691.3	507.8	285.8	237.7	175.7
Dissolved Oxygen (mg/l)	11.69	10.53	10.42	9.95	10.96	9.97
E. coli (MPN/100ml)	102	96	62	135	112	261
pH	7.94	7.85	7.91	7.26	7.81	7.19
Total Suspended Solids (mg/l)	10	589	4	129	97	202
Temperature (°C)	2.4	5.4	7.4	8.3	6.1	8.2
Turbidity (NTU)	5.79	287.0	3.8	148.0	43.1	90.7

Table 37. Water quality at Mill creek during rainfall events

Fascieux Creek Rain Event Sampling

Fascieux Creek was sampled at multiple locations and during various rain events to monitor and identify potential contamination through interconnection with Sanitary flow. Along with various chemical parameters, E. coli. is the primary indicator for storm / sanitary interconnection as it is not naturally occurring and carries a significant health risk. Further investigation is required in the event that E. Coli. counts are in excess of 25,000 MPN/100mL. Chemical and Biological profiles and trends recorded were similar to that noted at the Brandt's and Mill Creek outfalls (Tables 36-37). None of the collected samples indicated any significant increase in E. coli. concentrations which support the notion that there are no current interconnection issues with sanitary for this outfall system.

Fascieux Creek at Gordon Drive				
Parameter	**First Flush ~5mm, March 14, 2017**	**Rain Event ~9mm, March 29, 2017**	**Rain Event ~7mm, April 20, 2017**	**2017 Average**
Ammonia (mg/l)	0.410	0.169	0.351	0.235
Chloride (mg/l)	80	38	31	36
True Color (Pt-Co Units)	303	335	474	124
Conductivity (µs/cm²)	622.2	418.8	393.8	477.9
Dissolved Oxygen (mg/l)	8.56	8.16	8.18	7.53
E. coli (MPN/100ml)	361	291	488	789
pH	7.47	7.17	7.18	7.36
Total Suspended Solids (mg/l)	194	89	146	40
Temperature (°C)	6.0	7.7	9.6	9.3
Turbidity (NTU)	240.0	62.8	152.0	43.5

Table 38. Water quality test results of Fascieux Creek at Gordon during rain events

Fascieux Creek at Gosnell Road				
Parameter	**First Flush ~5mm, March 14, 2017**	**Rain Event ~9mm, March 29, 2017**	**Rain Event ~7mm, April 20, 2017**	**2017 Average**
Ammonia (mg/l)	0.196	0.182	0.223	0.199
Chloride (mg/l)	46	31	23	28
True Color (Pt-Co Units)	202	113	116	63
Conductivity (µs/cm²)	616.2	586.1	461.0	551.0
Dissolved Oxygen (mg/l)	8.72	7.59	7.75	7.20
E. coli (MPN/100ml)	144	109	291	343
pH	7.65	7.43	7.32	7.48
Total Suspended Solids (mg/l)	54	12	17	15
Temperature (°C)	6.3	7.9	9.8	9.3
Turbidity (NTU)	61.2	14.4	16.4	12.5

Table 39. Water quality test results of Fascieux Creek at Gosnell during rain events

Fascieux Creek at Watt Road				
Parameter	**First Flush ~5mm, March 14, 2017**	**Rain Event ~9mm, March 29, 2017**	**Rain Event ~7mm, April 20, 2017**	**2017 Average**
Ammonia (mg/l)	0.303	0.125	0.250	0.270
Chloride (mg/l)	100	38	31	49
True Color (Pt-Co Units)	132	292	270	83
Conductivity (µs/cm²)	744.9	449.7	408.5	641.8
Dissolved Oxygen (mg/l)	7.92	8.62	8.39	6.80
E. coli (MPN/100ml)	326	727	192	234
pH	7.46	7.25	7.25	7.36
Total Suspended Solids (mg/l)	330	105	69	39
Temperature (°C)	6.8	8.6	10.3	16.4
Turbidity (NTU)	320.0	92.0	57.3	37.9

Table 40. Water quality test results of Fascieux Creek at Watt during rain events

Beach Sampling for *E. coli*

City of Kelowna beaches were sampled at eleven sites once a week from June to September of 2017. The beaches sampled were City Park (2 sites), Gyro Beach Park (2 sites), Rotary Beach Park (2 sites), Sarson's Beach Park (2 sites), Strathcona Park (1 site), and Waterfront Park (2 sites). The graphs indicate the geometric mean for each site relative to the geometric mean guideline, which is the primary determining factor when beaches need further testing of require closure by IHA. The purpose of these graphs is to be able to determine the overall E. coli. count trends at the beaches throughout the summer season and determine if any beach water quality notifications or closures are required.

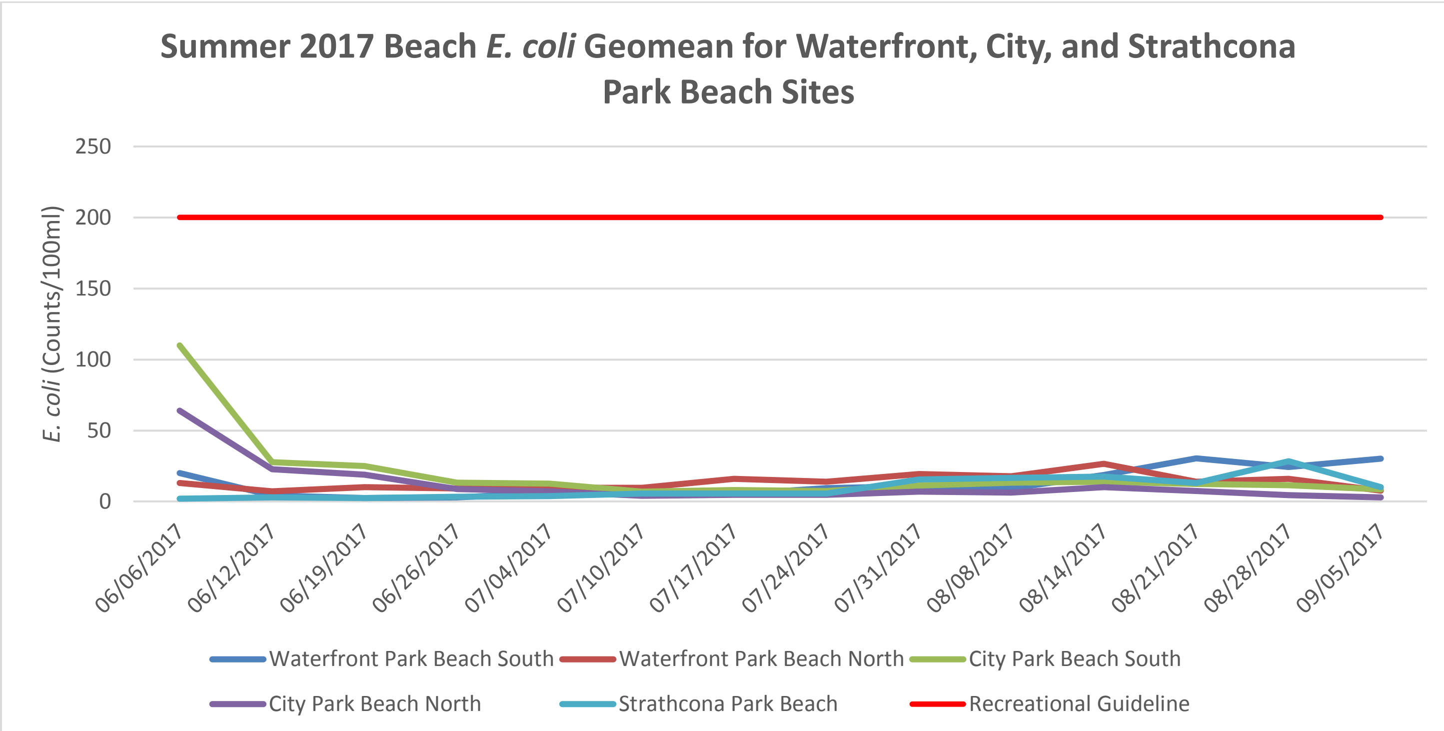


Figure 60. E. Coli. test results at north Kelowna beaches

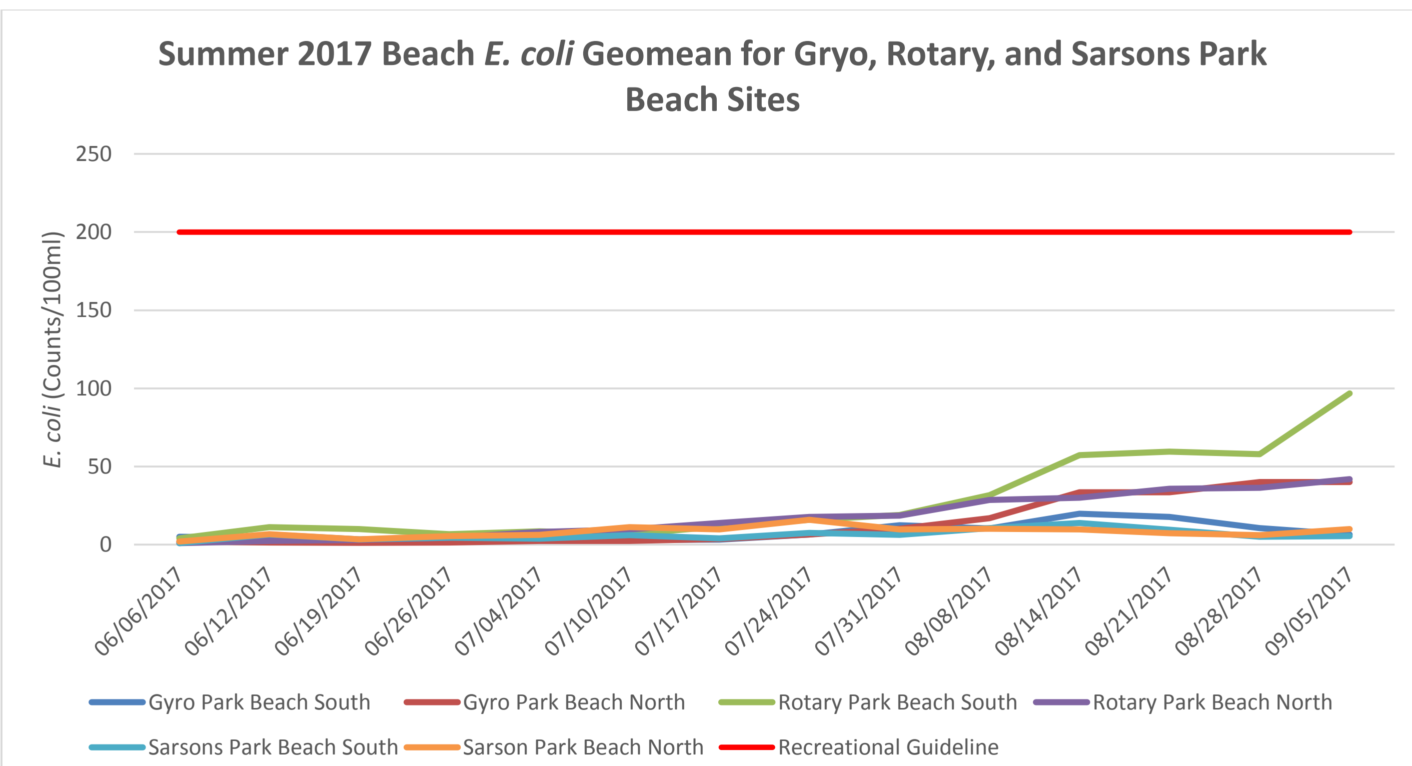


Figure 61. E. Coli. test results at south Kelowna beaches

Sampling Sites

The creeks sampled are Brandt's Creek, Mill Creek, Mission Creek, and Fascieux Creek. The main sample site on Brandt's Creek is near the mouth of Brandt's Creek located in Rotary Marsh Wetland on Sunset Drive (Figure 62). The other sample site on Brandt's Creek is a 750mm outfall pipe located on Gordon Drive and Weddell Place which is sampled for first flush as well as during rain events of 7mm or more. The main sample site on Mill Creek is located near the mouth at the end of Lake Avenue (Figure 62). The other sample site on Mill Creek is a 1075mm outfall pipe located on Enterprise Way and Hardy Street which is sampled for first flush as well as during rain events of 7mm or more. The main sample site located on Mission Creek is near the mouth and is accessed by Bluebird Road (Figure 62). Fascieux Creek has three sampling site locations: Gordon Drive between KLO Road and Bothe Road, Gosnell Road and Quesnel Road, and at the end of Watt Road. Beach sites are located between lower Mission and Knox mountain foreshore.

Figure 62. Kelowna Beach and Creek sample sites