Water Quality Assessment of Drinking Water from Local Public Water Systems (Community/ Utilities) in Lee County Florida.

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Introduction

Water is one of the most vital resources to humans' survival, its availability is important and its potability is even more critical. A common question among Lee County residents has been whether the tap water is "safe". Without proper access to safe and consumable drinking water, serious health problems emerge (Ritchie, Fiona and Roser 2024). Water deemed for human consumption means water that is ingested, or absorbed into the body by dermal contact, or through inhalation, except for water that is used solely for fire or chemical emergencies (Florida Department of State 2015). The United States Environmental Protection Agency (EPA) regulations set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water (Environmental Protection Agency 2024). Regulations under the US Safe Drinking Water Act (SDWA) specify chemical and bacteriological levels allowable in drinking water at the point of delivery, with the intent to protect consumers from negative health effects (Environmental Protection Agency 2024). To ensure compliance with the SDWA, the Maximum Contaminant Level (MCL) for each contaminant is set by EPA to indicate the maximum permissible level of a contaminant delivered to any user of a public water system (Florida Department of State 2015). Public health and safety are maintained when the chemicals and bacteriological contaminants are maintained below the MCL.

Utilities are required to conduct analysis for at least 104 individual contaminants. These contaminants are grouped as Turbidity, Inorganics, Disinfection Byproducts (DBP), Volatile Organics, Synthetic Organics, Microorganisms, Secondary, Radionuclides, Lead and Copper. All contaminants are considered *chronic* contaminants, except for Turbidity, Microorganisms, Nitrate and Nitrite, which are *acute* contaminants (Florida Department of State 2015). *Chronic* contaminants have the potential to cause harm to human health after long-term exposures while *acute* contaminants pose health risks after short-term exposures (United States Environmental Protection Agency (EPA) 2003). The health effects for each contaminant and length of exposure associated with the effects are outlined in Appendix B of the Code of Federal Regulation title 40 Part 141 (United States Environmental Protection Agency (EPA) 2003).

Table 1 below shows the MCL for regulated chemical and bacteriological contaminants. The list and MCLs for Inorganics, Disinfection byproduct (DBP), Volatile Organics, Synthetic Organic, Secondary, Turbidity and Radionuclides groups can also be found in Florida Administrative Code (F.A.C.) 62-550 (Florida Department of State 2015). The MCLs for microorganism contaminants can be found in the Revised Total Coliform Rule (United States

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Environmental Protection Agency 2020). Lead and copper MCLs can be found in the 40 CFR federal rule (United States Environmental Protection Agency (EPA) 2007).

Table 1
Chemicals and microorganisms Maximum Contaminant Level (MCL)

Contaminants	**Maximum Contaminant Level**	**Units** **mg/L (milligrams per liter)** **pCi/L (picoCuries per liter)** **ug/L (micrograms per liter)** **CU (color units)** **TON (threshold odor number)** **TU (turbidity unit)**
Inorganic		
Nitrate (as N)	10	mg/L
Nitrite (as N)	1	mg/L
Arsenic	0.010	mg/L
Barium	2	mg/L
Cadmium	0.005	mg/L
Chromium	0.1	mg/L
Cyanide	0.2	mg/L
Fluoride	4.0	mg/L
Lead	0.015	mg/L
Mercury	0.002	mg/L
Nickel	0.1	mg/L
Selenium	0.05	mg/L
Sodium	160	mg/L
Antimony	0.006	mg/L
Beryllium	0.004	mg/L
Thallium	0.002	mg/L
Asbestos	7	MFL
Radionuclides		
Combined radium226 and radium228	5	pCi/L
Gross alpha particle activity including radium226 but excluding radon and uranium	15	pCi/L
Uranium	30	ug/L
Disinfection Byproducts		
Chlorite	1000	µg/L
Bromate	10	µg/L
Monochloroacetic Acid	N/A	µg/L

Contaminants	**Maximum Contaminant Level**	**Units** **mg/L (milligrams per liter)** **pCi/L (picoCuries per liter)** **ug/L (micrograms per liter)** **CU (color units)** **TON (threshold odor number)** **TU (turbidity unit)**
Dichloroacetic Acid	N/A	µg/L
Trichloroacetic Acid	N/A	µg/L
Monobromoacetic Acid	N/A	µg/L
Dibromoacetic Acid	N/A	µg/L
Total Haloacetic Acids (HAA5)	60	µg/L
Chloroform	N/A	µg/L
Bromoform	N/A	µg/L
Bromodichloromethane	N/A	µg/L
Dibromochloromethane	N/A	µg/L
Total Trihalomethanes (TTHM)	80	µg/L
Volatile Organics		
1,2,4-Trichlorobenzene	70	µg/L
cis-1,2-Dichloroethylene	70	µg/L
Xylenes (total)	10,000	µg/L
Dichloromethane	5	µg/L
o-Dichlorobenzene	600	µg/L
para-Dichlorobenzene	75	µg/L
Vinyl Chloride	1	µg/L
1,1-Dichloroethylene	7	µg/L
trans-1,2-Dichloroethylene	100	µg/L
1,2-Dichloroethane	3	µg/L
1,1,1-Trichloroethane	200	µg/L
Carbon tetrachloride	3	µg/L
1,2-Dichloropropane	5	µg/L
Trichloroethylene	3	µg/L
1,1,2-Trichloroethane	5	µg/L
Tetrachloroethylene	3	µg/L
Monochlorobenzene	100	µg/L
Benzene	1	µg/L
Toluene	1,000	µg/L
Ethylbenzene	700	µg/L
Styrene	100	µg/L
Synthetic Organics		

Contaminants	**Maximum Contaminant Level**	**Units** **mg/L (milligrams per liter)** **pCi/L (picoCuries per liter)** **ug/L (micrograms per liter)** **CU (color units)** **TON (threshold odor number)** **TU (turbidity unit)**
Endrin	2	µg/L
Lindane	0.2	µg/L
Methoxychlor	40	µg/L
Toxaphene	3	µg/L
Dalapon	200	µg/L
Diquat	20	µg/L
Endothall	100	µg/L
Glyphosate	700	µg/L
Di(2-ethylhexyl)adipate	400	µg/L
Oxamyl (Vydate)	200	µg/L
Simazine	4	µg/L
Di(2-ethylhexyl)phthalate	6	µg/L
Picloram	500	µg/L
Dinoseb	7	µg/L
Hexachlorocyclopentadinene	50	µg/L
Carbofuran	40	µg/L
Atrazine	3	µg/L
Alachlor	2	µg/L
2,3,7,8-TCDD (Dioxin)	0.03	ng/L
Heptachlor	0.4	µg/L
Heptachlor Epoxide	0.2	µg/L
2,4-D	70	µg/L
2,4,5-TP (Silvex)	50	µg/L
Hexachlorobenzene	1	µg/L
Benzo(a)pyrene	0.2	µg/L
Pentachlorophenol	1	µg/L
Polychlorinated biphenyls (PCBs)	0.5	µg/L
Dibromochloropropane	0.2	µg/L
Ethylene Dibromide (EDB)	0.02	µg/L
Chlordane	2	µg/L
Secondary		
Aluminum	0.2	mg/L
Chloride	250	mg/L
Copper	1	mg/L

Contaminants	**Maximum Contaminant Level**	**Units** **mg/L (milligrams per liter)** **pCi/L (picoCuries per liter)** **ug/L (micrograms per liter)** **CU (color units)** **TON (threshold odor number)** **TU (turbidity unit)**
Fluoride	2.0	mg/L
Iron	0.3	mg/L
Manganese	0.05	mg/L
Silver	0.1	mg/L
Sulfate	250	mg/L
Zinc	5	mg/L
Color	15	CU
Odor	3	TON
pH (field pH from page 1)	6.5 - 8.5	
Total Dissolved Solids	500	mg/L
Foaming Agents	0.5	mg/L
Lead and Copper		
Lead	0.015	mg/L
Copper	1.3	mg/L
Microbial acute MCL violation: (*Escherichia coli*) *E*. coli MCL violation occurs with the Following Sample Result Combination E.Coli positive (EC+) Total coliform positive (TC+)		
Routine sample EC+ and Repeat sample TC+		N/A
Routine sample EC+ and Any missing Repeat sample		N/A
Routine sample EC+ and Repeat sample EC+		N/A
Routine sample TC+ and Repeat sample EC+		N/A
Routine sample TC+ and Repeat sample TC+ (but no E. coli analysis)		N/A

Contaminants	**Maximum Contaminant Level**	**Units** **mg/L (milligrams per liter)** **pCi/L (picoCuries per liter)** **ug/L (micrograms per liter)** **CU (color units)** **TON (threshold odor number)** **TU (turbidity unit)**
Microbial non-acute MCL violation: treatment technique (TT) violation		
A PWS collecting fewer than 40 samples per month has 2 or more TC+ routine and/or repeat samples in the same month.		N/A
A PWS collecting at least 40 samples per month has greater than 5.0 percent of than 5.0 percent of the routine and/or repeat samples in the same month that are TC+.		N/A
Turbidity		
	One TU as determined by a monthly average or Five turbidity units based on an average for two consecutive days	TU

It is important to note that an exceedance of an MCL does not necessarily result in a violation. Utilities have guidelines on corrective actions they must take after an MCL is exceeded for a particular contaminant. When corrective actions required are not met, the utility would be out of compliance or in violation. Corrective actions vary between contaminants. They include but are not limited to, increased monitoring/ frequent sampling for the contaminant, system assessment and/or completion of an Operation Evaluation Report (OER) (Florida Department of State 2015). Systems that do not successfully meet the corrective action requirements within a year are required to assess the system to determine the source of contamination and apply techniques to reduce the contamination, such as installing a treatment system. Utilities have a responsibility to inform the public about their water quality and comply with the Safe Drinking Water Act (SDWA) outlined by the Federal Environmental Protection Agency (EPA) in a timely and effective manner to prevent catastrophic outcomes.

The purpose of this study is to evaluate the water quality compliance of the Lee County water systems and analyze further the relationship between Disinfection Byproducts (DBPs) contaminants, and disinfection. Specifically, these research questions are:

- Did the selected ten (10) local public water systems in Lee County maintain contaminant levels below the MCL defined by EPA between 2018 and 2022?

- Were the reported contaminant mean values significantly different among local public water systems in Lee County (community systems/utilities)?
- Was there a correlation between disinfection, meaning free or total chlorine residual ppm, and DBPs chronic contaminants, specifically Total Trihalomethanes (TTHM) parts per billion (ppb) and Total Haloacetic Acids (HAA5s) ppb?
- Was there a change in the disinfection, and chronic contaminants TTHMs and HAA5s over time?

Regulated Contaminants Overview

Each contaminant group source, sampling requirements, and corrective actions required after an MCL exceedance, as stated in F.A.C., are described below with details shown in the Appendix (Florida Department of State 2015).

Acute Contaminants

These contaminants pose health risks after short-term exposures (United States Environmental Protection Agency (EPA) 2003).

*Turbidity***.** The turbidity characteristic of water must be measured continuously at a system's entry point to distribution (POE) for systems using surface water and groundwater under the direct influence of surface water (GWUDI) (United States Environmental Protection Agency (EPA) 2003), see definition of GWUDI in the Appendix. High turbidity in finished/treated water is indicative of a failure of filtration of large-diameter pathogens such as *Giardia lamblia* or *Cryptosporidium*. See the Appendix for turbidity measurement criteria and maximum contaminant level requirements. Olga plant is part of Lee County Utilities that uses surface water as a source from the Caloosahatchee River (Lee County Utilities 2023). Therefore, the Lee County Utilities system is considered a Subpart H system. Mobile Manor Mobile Home Park (MHP) and FM Beach Water are consecutive systems that buy their water from Lee County Utilities; hence they are considered subpart H systems too.

Microorganisms. Total Coliform (TC) is a ubiquitous group of related bacteria. Detection of TC in water does not necessarily mean that the water is non-potable, the reason being most TC microorganisms are not harmful to humans. However, they are used as an indicator that other potentially harmful bacteria may be present in water when the amount detected exceeds EPA MCL levels (United States Environmental Protection Agency (EPA) 2003); (United States Environmental Protection Agency, 2020). *Escherichia coli* (*E. coli*) are common types of fecal bacteria found in the intestines of animals and humans (Leishear 2021). See the Appendix for *E. coli* sources and potential ways that these microbes can be introduced into drinking water. Microbial detection is not a violation until a utility exceeds a certain threshold for microorganisms detected in the raw water (well water) or the distribution system.

Groundwater sources (wells/raw water) microbial testing is conducted monthly for community water systems unless a system is considered a 4-log, see the definition in the Appendix. Uncompromised wells are free of detectable levels of pathogenic microbiological contaminants. Microbial testing is not conducted on surface water or GWUDI samples, testing is only done at the distribution system, which is finished or treated water. The sampling frequency and number of distribution samples required are outlined in the Revised Total Coliform Rule (RTCR) (United States Environmental Protection Agency 2020) referenced in rule 62-550.830 F.A.C (Florida Department of State 2015). Information about what constitutes a violation and the corrective actions required after a system detects TC and/or *E. coli* in the distribution and/or raw water sample are outlined in the Appendix.

Inorganics Nitrate and Nitrite. Routine monitoring for nitrate and nitrite is conducted annually from each entry point to the distribution (POE) (Florida Department of State 2015). Systems that report nitrite levels equal to/greater than 50% of the MCL must start quarterly sampling. Systems that report nitrite and nitrate levels that exceed the MCL must complete corrective actions outlined in Rule 62-550, F.A.C. (Florida Department of State 2015).

Chronic Contaminants

The contaminants have the potential to cause harm to human health after long-term exposure (United States Environmental Protection Agency (EPA) 2003).

*Inorganics, Synthetic Organic Contaminants (SOC), Volatile Organic Contaminants (VOC), Radionuclides contaminants or DBP contaminants***.** Routine monitoring requires one sample from each POE for Inorganics, Synthetic Organic Contaminants (SOC), Volatile Organic Contaminants (VOC), and Radionuclides contaminants (Florida Department of State 2015). The routine sampling requirements, reduced monitoring qualifications, contaminant sources, and corrective actions required to post an MCL exceedance or MCL violation are outlined in the Appendix. Waiver application and requirements for monitoring of SOCs and VOCs are listed in form 62-560.545_2 F.A.C. (Florida Department of Environmental Protection (DEP) 2022). Rule 62-550.500(7)(b), F.A.C. states that a system monitoring annually or less frequently is only in violation if the MCL is exceeded after one year of quarterly sampling for the inorganic contaminants (excluding nitrate or nitrite), VOC, SOC, or the radiological (radionuclides) contaminants (Florida Department of State 2015).

The DBP contaminants, which include Total Trihalomethanes (TTHMs) in ppb and Total Haloacetic Acids (HAA5s) in ppb and the emphasis of this paper, are collected within the distribution system. Number of DBP samples required are described in the Appendix and **Table 3**. Sampling for DBP is conducted quarterly, systems can qualify for routine sampling if DBPs detected are less than MCL or qualify for reduced monitoring if results are equal to or less than 50% of the MCL (United States Environmental Protection Agency (EPA) 2003). Increased monitoring for DBP means quarterly sampling is required, this occurs when systems exceed the

DBP MCL levels (Florida Department of State 2015). Systems are also required to submit an Operation Evaluation Report (OER) whenever there is a DBP MCL exceedance after calculating the operational evaluation level (OEL) following 3 quarterly sampling events or if the initial exceedance is so high that after 3 quarterly sampling events the MCL will be exceeded (United States Environmental Protection Agency (EPA) 2003). A description of how OEL is calculated can be found in the Code of Federal Regulations CFR title 40 (United States Environmental Protection Agency (EPA) 2003). When the DBP running annual average of any sampling point is greater than the MCL, the system is out of compliance (Florida Department of State 2015). Contaminant sources for DBP contaminants can be found in Appendix A of the Code of Federal Regulations CFR title 40 (United States Environmental Protection Agency (EPA) 2003). See techniques used to reduce DBP contaminants in the Appendix of this paper.

*Lead and Copper***.** Standard sampling for lead and copper is biannual unless systems qualify for reduced monitoring and samples must be collected in the distribution (United States Environmental Protection Agency (EPA) 2007). The procedure for collecting samples, the number of samples required based on population, reduced monitoring criteria, and contaminant sources are outlined in the Appendix. Systems are required to notify all customers of the lead sampling results (United States Environmental Protection Agency (EPA) 2007). Before 2023, a system incurred an Action Level (AL) exceedance when the 90^{th} percentile level of the tap water sample exceeded 0.015 mg/L for lead (Pb) and 1.3 mg/L for Copper (Cu). Corrective actions required following the AL exceedance are listed in the Appendix.

Secondary Contaminants. Community water systems test for secondary contaminants every three years, at the POE (Florida Department of State 2015). Contaminant sources for secondary contaminants and corrective action required after an MCL exceedance can be found in the Appendix.

Methodology

Data Acquisition and Analysis

As outlined in the Florida Administrative Code (F.A.C.) 62-550.824, all utilities are required to inform their customers of the quality of their drinking water (Florida Department of State 2010). The utilities meet this requirement by issuing a Consumer Confidence Report (CCR) on an annual basis. The report is due to customers by July 1 and contains information about the previous year's water quality results. Systems have the option to issue the CCR documents to each billed customer via mail, hand delivery, or electronic delivery. Most utilities opt to place their CCRs on their websites and list the direct Uniform Resource Locator (URL) link to the website on the customers' bill. By rule, the statement must remain on the water bill for at least three months. Customers can also view chemical and bacteriological reports submitted to their regulatory agency in the Florida Department of Environmental Protection (DEP) Document Management System, OCULUS. In the case of non-compliance, utilities have a responsibility to

take corrective actions to remedy the non-compliance and maintain potable water distribution (Florida Department of State 2015).

In Lee County Florida, there are 20 community water systems (community systems/utilities). At the time of this study, CCRs for 2018 to 2022 could be located for ten (10) of those 20 utilities, and their water quality was assessed. The other 10 utilities were excluded because, at the time of this study, 2018 data was not available. Table 2 below shows the list of 10 community systems in Lee County, the CCR, and OCULUS sources used for this study.

Table 2

Lee County potable water Public Water Systems (community systems/utilities) used in the study

System Name	**Public Water System ID**	**CCR Reference***
Bonita Springs Utilities	5360025	(Bonita Springs Utilities, Inc 2018) (Bonita Springs Utilities Inc 2019-2021), (Bonita Springs Utilities Inc 2022).
City Of Fort Myers Water Treatment Plant (WTP)	5360102	(City of Fort Myers Public Works 2022).
Island Water Association, Inc. (IWA)	5360146	(The Island Water Association, Inc 2022).
Florida Governmental Utility Authority (FGUA) Lehigh Acres Water Treatment Plant (WTP)	5360172	(Florida Governmental Utility Authority 2019-2021) (Florida Governmental Utility Authority 2022).
Greater Pine Island Water Association (GPIWA)	5360322	(Pine Island Water Association, Inc 2022).
City Of Cape Coral	5360325	(Cape Coral Florida 2022).
Lake Fairways Mobile Home Park (MHP)	5364040	(Lake Fairways FGUA 2019), (Lake Fairways FGUA 2020), (FGUA 2021), (Lake Fairways FGUA 2022).
Lee County Utilities	5364048	(Lee County Utilities 2018), (Lee County Utilities 2019), (Lee County Utilities 2020), (Lee County Utilities 2021), (Lee County Utilities 2022).
Town Of Fort Myers Beach (FM Beach Water)	5364145	(Fort Myers Beach 2019-2021), (Fort Myers Beach 2022).
Mobile Manor Mobile Home Park (MHP)	5364152	(Mobile Manor MHP 2019), (Mobile Manor MHP 2020), (Mobile Manor MHP 2021), (Mobile Manor MHP 2022).

*CCRs can also be found in OCULUS (OCULUS 2024)

The CCR documents in Table 2 show the chemical, Radionuclides, and bacteriological results for each community system. The chemical, Radionuclides, and bacteriological

contaminants were analyzed using methods approved by the Code of Federal Regulations (Code of Federal Regulations Title 40 (40 CFR) 2024), by laboratories certified by the National Environmental Laboratories Accreditation Program (NELAP). The laboratories' certification and methods listed in the chemical, Radionuclides, and bacteriological reports can be verified on the Florida Department of Environmental Protection NELAP Certified Laboratory Search website (Florida Department of Environmental Protection 2024).

All analyses were completed, and graphs were developed using Excel software (Microsoft Corporation 2013). Sample sizes (numbers) for each contaminant vary between utilities because of the sampling requirements outlined in the introduction section above. The sampling frequency is dependent on whether the system is on routine, increased, or reduced monitoring. Each utility was only required to sample VOC, SOC, Radionuclides, and lead and copper contaminants once every 3 years due to undetected or low contaminants results (below MCL). The VOC, SOC, Radionuclides, and Secondary contaminants samples were collected at the POE. Lead and copper samples were collected at distribution, number of samples required was based on population size and whether a system is on standard or reduced monitoring (United States Environmental Protection Agency (EPA) 2007), see Table 3 below. Secondary contaminants, for all utilities, including Lake Fairways MHP, were sampled once every 3 years at the POE. There was no record of odor complaints after MCL exceedance. Therefore, Lake Fairways MHP continued triennial sampling for odor. Each utility sampled acute inorganic contaminants (nitrate and nitrite) once a year at POE and all other inorganic contaminants only had to be sampled at POE once every 3 years due to undetected or low results (below MCL). None of the facilities were required to sample for turbidity and asbestos.

The number of samples collected within a year for DBP chronic contaminants (TTHMs ppb and HAA5s ppb) varied between utilities due to sampling frequency (increased, routine, or reduced) and because some systems had more than one sampling location due to their population size, see Table 3 below. For example, Bonita Springs Utilities sampled each DBP contaminant once a year from two sampling locations, a total of 2 samples per year. The City of Cape Coral sampled each DBP contaminant at two locations on a quarterly basis, a total of eight (8) samples per year. Microorganisms sample sizes also varied between utilities due to each system's population size, sampling frequency was monthly for all systems. Table 3 below indicates sampling frequency and sample sizes for Disinfection Byproducts, microorganisms, lead, and copper.

Table 3

The sample size and sampling frequency for Disinfection Byproducts, Microorganisms (Microbial), Lead, and Copper at each utility from 2018 to 2022

System Name	Disinfection Byproducts number of dual or individual samples * (Sample size) required and collected	Disinfection Byproducts sampling frequency	Microbial the sample size required and the number collected	Microbial sampling frequency	Lead and Copper sample size required and collected	Lead and Copper sampling frequency***
Bonita Springs Utilities	2 duals are required; the system collected 2 duals	Annually 2018 through 2022	80 distribution samples and No source/ raw water sample required (4-Log removal) **	Monthly***	30	Every 3 years (triennial, reduced monitoring)
City Of Fort Myers Water Treatment Plant (WTP)	2 duals are required; the system collected 1 dual from 2018 through 2021. 2 dual samples collected in 2022	Annually 2018 through 2022	90 distribution samples and No source/ raw water sample required (4-Log removal) **	Monthly***	30	Triennial
Island Water Association, Inc. (IWA)	2 duals are required; the system collected 2 duals	Annually 2018 through 2022	15 distribution samples and No source/ raw water sample required (4-Log removal) **	Monthly***	30	Triennial
Florida Governmental Utility Authority (Fgua) Lehigh Acres Water Treatment	2 duals were required but the system collected 4 duals from 2018 to 2022	4 quarters in 2018 and 2019 3 quarters in 2020 Annually in 2021 and 2022	30 distribution samples and 13 source/ raw water samples.	Monthly***	30	Triennial

System Name	Disinfection Byproducts number of dual or individual samples * (Sample size) required and collected	Disinfection Byproducts sampling frequency	Microbial the sample size required and the number collected	Microbial sampling frequency	Lead and Copper sample size required and collected	Lead and Copper sampling frequency***
Plant (WTP)						
Greater Pine Island Water Association (GPIWA)	2 duals are required. The system collected 2 duals in 2018, 2020, 2021 and 2022. Four (4) duals collected in 2019.	Annually 2018 through 2022	15 distribution samples and No source/ raw water sample required (4-Log removal) **	Monthly***	30	Triennial
City Of Cape Coral	2 duals are required; the system collected 2 duals	4 quarters every year 2018 through 2022	120 distribution samples and No source/ raw water sample required (4-Log removal) **	monthly****	50	Triennial
Lake Fairways Mobile Home Park (MHP)	1 dual required, system collected 2 duals	Annually in 2018 and 2019 2 quarters in 2020 4 quarters in 2021 2 quarters in 2022	2 distribution samples and One source/ raw water sample.	Monthly***	10	Triennial

System Name	Disinfection Byproducts number of dual or individual samples * (Sample size) required and collected	Disinfection Byproducts sampling frequency	Microbial the sample size required and the number collected	Microbial sampling frequency	Lead and Copper sample size required and collected	Lead and Copper sampling frequency***
Lee County Utilities	2 duals are required; the system collected 8 duals	4 quarters in 2018 through 2022	150 distribution samples and No source/ raw water sample required (4-Log removal) **	Monthly***	50	Triennial
Town Of Fort Myers Beach (FM Beach Water)	1 dual required, system collected 2 duals	4 quarters in 2018 through 2021 3 quarters in 2022	7 distribution samples and No source/ raw water sample is required (consecutive system).	Monthly***	20	Triennial
Mobile Manor Mobile Home Park (MHP)	1 dual required, system collected 1 dual	Annually 2018 through 2022	1 distribution sample and No source/ raw water sample required (consecutive system)	Monthly***	10	Triennial

*A dual sample refers to a sample collected from one tap, analyzed for both Total Trihalomethanes (TTHM) parts per billion (ppb) and Total Haloacetic Acids (HAA5s) (Environmental Protection Agency (EPA) 2024).

** A system with 4-log removal capability means the system is providing treatment that reliably achieves at least 4-log treatment of viruses (United States Environmental Protection Agency (EPA) 2008).

*** Monthly sampling means that samples are collected daily or weekly until all required number of samples have been collected within a month, these are called compliance samples. Compliance samples must be collected by the end of each month. Selected distribution sampling locations are representative of the distribution system per Rule 62-550.518 (1), F.A.C. (Florida Department of State 2015). Number of samples shown in Table 3 are compliance samples. They

do not include repeat (confirmation) samples collected whenever TC or *E. Coli* was detected in the distribution or in the well.

****Each sample was analyzed for both lead and copper contaminant.

Analysis, Results And Discussion

Descriptive Statistical Analysis

Descriptive statistical analysis was conducted for discrete and continuous numerical data for specific contaminants recorded in CCR and OCULUS documents, for 10 Public Water Systems (community systems/utilities). Descriptive statistics, also known as summary statistics, characterize, summarize, and organize data to help answer the research questions of what happened or what is happening (Richardson and Watson 2024). Summary statistics are a measure of location, variability, and shape. Measure of location includes mean, median, mode, Confidence Interval (CI) limits of the population mean, and quartiles calculations used to determine outliers. Standard deviation, variance, coefficient of variation (CV), and IQR are measures of variability/ dispersion, they show how much values deviate from the mean (Richardson and Watson 2024). Skewness and Kurtosis are a measure of shape and distribution, they show whether the data distribution is centered or skewed, flat or peaked.

Descriptive statistical analysis was conducted for contaminants tested annually or more frequently from 2018 through 2022. Tables 4 through 6 show the summary statistics for Inorganic (nitrate and nitrite), DBP, and Microorganisms (bacteriological) contaminant groups. Results shown in Tables 4 and 6 indicate that nitrate, nitrite, and bacteriological contaminants were skewed right and peaked for all utilities (skew>1, positive and kurtosis was greater than 3). The positive skew and peak indicate that from 2018 to 2022 nitrate, nitrite, and bacteriological contaminants were higher earlier on but were detected less over time. With respect to DBP contaminants, as shown in Table 5, HAA5 in GPIWA and TTHMs in Lee County Utilities and FGUA Lehigh Acres WTP have almost 0 skewness, centered data and negative Kurtosis, so more flat. An indication that there was little variation in levels of DBP detected 2018 through 2022.

Table 4

Descriptive analysis and confidence interval (CI) results for inorganic contaminants of nitrate and nitrite ppm.

	Nitrite ppm				
Analysis	**Lee County Utilities**	**Lake Fairways MHP**	**Bonita Springs Utilities**	**Lee County Utilities**	**Lake Fairways MHP**
Mean	0.147	0.006	0.046	0.018	0.005
Standard Error	0.062	0.006	0.034	0.005	0.005
Median	0.017	0	0.01	0.009	0
Mode	0	0	0.01	0.009	0

Standard Deviation	0.342	0.015	0.075	0.025	0.014
Sample Variance	0.117	0.0002	0.006	0.0006	0.0002
Kurtosis	7.044	7	4.932	4.387	8
Skewness	2.723	2.646	2.218	2.26	2.828
Range	1.428	0.04	0.17	0.097	0.04
Minimum	0	0	0.01	0	0
Maximum	1.428	0.04	0.18	0.097	0.04
Sum	4.4	0.04	0.23	0.531	0.04
Count	30	7	5	30	8
Lower CI	0.019	-0.008	-0.047	0.0083	-0.0068
Upper CI	0.274	0.02	0.1391	0.027	0.0168

Confidence level is determined by the analyst, such as 90% or 95% reflects the probability that the true value of a population mean/parameter falls within a certain range (Richardson and Watson 2024). We can state with 95% confidence level that the true population means falls within the calculated confidence interval (CI). The CI for nitrate and nitrite contaminant ppm at Lee County Utilities, Lake Fairways MHP, and Bonita Springs Utilities are below the MCL levels outlined by EPA. Therefore, it is concluded that these systems complied with EPA requirements. Similar conclusions can be made for Table 5 CI results for DBP contaminants, TTHMs ppb and HAA5s ppb. The true population parameter for all systems listed in Table 5 are below MCL levels set by EPA.

Table 5

Descriptive analysis and confidence interval (CI) results for chronic Disinfection byproduct (DBP) contaminants.

	Haloacetic Acids (HAA5s) ppb				**Total Trihalomethanes (TTHMs) ppb**						
Analysis	**Bonita Springs Utilities**	**IWA**	**GPIWA**	**Lee County Utilities**	**Bonita Springs Utilities**	**IWA**	**GPIWA**	**Mobile Manor MHP**	**Lee County Utilities**	**FGUA Lehigh Acres WTP**	**Lake Fairways MHP**
Mean	22.7	8.797	15.133	13.017	36.79	3.816	22.43	2.426	13.789	40.142	26.12
Standard Error	2.809	3.516	2.302	0.706	3.689	0.619	4.336	1.211	0.697	2.6	4.651
Median	20	5.43	14.2	11.928	35	3.185	20	1.6	14	43	21
Mode	20	11.7	#N/A	16	35	#N/A	#N/A	#N/A	0	51	21
Standard Deviation	8.883	11.119	7.976	9.369	11.667	1.956	15.022	2.709	9.245	16.442	22.787
Sample Variance	78.9	123.63	63.611	87.785	136.11	3.832	225.654	7.338	85.477	270.33	519.23
Kurtosis	1.079	6.916	-0.283	1.987	1.300	0.424	6.089	4.446	-0.539	-0.926	1.4
Skewness	1.491	2.511	0.672	1.104	1.242	1.185	2.2	2.069	0.302	-0.044	1.329
Range	27	37.3	26.6	52.45	37	5.81	58.04	6.67	38	60	81.7
Minimum	13	1.2	4.4	0	25	2.03	6.56	0.53	0	10	2.3
Maximum	40	38.5	31	52.45	62	7.84	64.6	7.2	38	70	84
Sum	227	87.97	181.6	2290.95	367.9	38.16	269.16	12.13	2426.79	1605.66	626.88
Count	10	10	12	176	10	10	12	5	176	40	24
Lower CI	16.346	0.843	10.066	11.623	28.444	2.41	12.886	-0.938	12.413	34.883	16.498
Upper CI	29.054	16.751	20.200	14.411	45.136	5.22	31.974	5.7896	15.164	45.3999	35.742

Table 6 CI results indicate that TC detection is likely at the facilities listed in the table as results shows that both lower and upper CI are above zero. The negative values of the lower confidence interval under the *Escherichia coli* (*E. coli*) section indicate that there is potential for *E. coli* to be undetected at City of Fort Myers WTP, FGUA Lehigh Acres WTP, City of Cape Coral, and Lee County Utilities. Descriptive statistics for City of Fort Myers WTP, GPIWA and IWA indicated that the facilities had undetectable levels of nitrate and nitrite contaminants. *E. coli* was undetected at GPIWA, IWA, Lake Fairways MHP, FM Beach Water and Mobile Manor MHP. Descriptive statistics also showed that TC was undetected at Mobile Manor MHP.

Table 6.
Descriptive analysis and confidence interval (CI) results for microbiological reports.

	Total Coliform (Present/Absent)					**Escherichia Coli (Present/Absent)**			
Analysis	**City of Fort Myers WTP**	**FM Beach Water**	**FGUA Lehigh Acres WTP**	**City of Cape Coral**	**Lee County Utilities**	**City of Fort Myers WTP**	**FGUA Lehigh Acres WTP**	**City of Cape Coral**	**Lee County Utilities**
Mean	0.088	0.043	0.067	0.038	0.062	0.004	0.003	0.004	0.002
Standard Error	0.012	0.0159	0.013	0.007	0.006	0.003	0.003	0.002	0.001
Median	0	0	0	0	0	0	0	0	0
Mode	0	0	0	0	0	0	0	0	0
Standard Deviation	0.284	0.203	0.250	0.191	0.241	0.064	0.052	0.065	0.046
Sample Variance	0.081	0.041	0.063	0.037	0.058	0.004	0.003	0.004	0.002
Kurtosis	6.509	18.943	10.179	21.550	11.233	241.48	364	234.32	476.65
Skewness	2.913	4.551	3.482	4.847	3.636	15.57	19.079	15.35	21.863
Range	1	1	1	1	1	1	1	1	1
Minimum	0	0	0	0	0	0	0	0	0
Maximum	1	1	1	1	1	1	1		1
Sum	47	7	26	28	95	2	1	3	3
Count	533	163	389	738	1532	488	364	713	1440
Lower CI	0.064	0.0115	0.042	0.024	0.05	-0.002	-0.0027	-0.001	-0.0003
Upper CI	0.112	0.074	0.092	0.052	0.074	0.0098	0.008	0.009	0.004

Notes: TTHMs stands for Total Trihalomethanes and HAA5s stands for Total Haloacetic Acids

Maximum Contaminant Value Compared to Maximum Contaminant Level

The maximum values for each contaminant were compared to the MCL defined by the federal Environmental Protection Agency (EPA). The contaminants groups are Lead and Copper, Microorganisms, Inorganic, Secondary, DBP, Radionuclides, Volatile Organics, and Synthetic

Organic contaminants. All groups are chronic contaminants except for Turbidity, Microorganisms and Nitrite & Nitrate (within inorganic groups) which are acute contaminants (Florida Department of State 2015). The comparison between the maximum values to MCL levels was done to determine whether water treatment utilities in Lee County meet the MCL requirements of EPA. Turbidity comparisons could not be conducted because only a few systems (Lee County Utilities and its consecutive systems) are subpart H systems. Most utilities had contaminant levels that were undetected or below MCL except for Lake Fairways MHP and Bonita Springs Utilities, see Figure 1 below. Lake Fairways MHP had TTHMs readings above the MCL one time in 2020, location 5 reading was 84 ppb and location 3 reading was 81 ppb (OCULUS 2024). Bonita Springs Utilities reported odor readings that exceeded the MCL only one time in 2017 (OCULUS 2024).

Figure 1

Total Trihalomethanes (TTHMs) Disinfection byproduct, Sodium inorganic contaminant, and Odor secondary and maximum values detected, 2018 through 2022, compared to the maximum contaminant level (MCL) set by the Federal Environmental Protection Agency.

Figure 1 shows the maximum recorded sodium level for each utility between 2018 and 2020. City of Fort Myers WTP had higher sodium relative to other systems, but not exceeding the MCL. The sodium levels ranged between 151 ppm and 155 ppm from 2018 through 2022 (City of Fort Myers Public Works 2022). A permit was issued in 2023 to City of Fort Myers WTP to install additional temporary reverse osmosis (RO) treatment units that was later replaced with permanent RO treatment units (OCULUS 2024). The new RO systems could facilitate the reduction in sodium levels.

Bonita Springs Utilities reported odor (secondary contaminant) levels that exceeded MCL, see Figure 1. The exceedance only happened once in 2017, a reading of 10 threshold odor number (TON) was reported 2017 (OCULUS 2024). One incident of contamination MCL exceedance is not a violation. The exceedance in 2017 was reported in 2018 and 2019 CCR (Bonita Springs Utilities, Inc 2018). Odor is an aesthetic characteristic, and most of the time it does not pose a public health threat (Washington State Department of Health 2018). However, a sudden change in the color, taste, or odor of the tap water could indicate a public health concern (Washington State Department of Health 2018). The most common source of odor are algae blooms in surface water sources, organics, and volatile organic contaminants (VOCs) that occur naturally in the well water (Minnesota Rural Water Association 2024). Examples of VOCs are Hydrogen sulfide (H_2S) and methane gas from the decomposition of organic matter (Minnesota Rural Water Association 2024). Other sources of odor are microbial growth within water supply lines, such as water mains and service lines. The problem can occur when bacteria is introduced in the system after a water main break, where there is an inadequate amount of disinfection in the system. Microbial growth could also become prevalent in a system using chloramines with low free chlorine. Nitrifying bacteria and inorganic compounds form in the water main and cause odor issues. Both bacteria and inorganic compounds can be eliminated or reduced by adjusting the amount of disinfection in the system or temporarily converting chloramines to free chlorine. The latter is also known as a chlorine burn, which eliminates excess ammonia, oxidizes nitrite and nitrifying bacteria, and controls biofilm in water mains (Florida Department of State 2014).

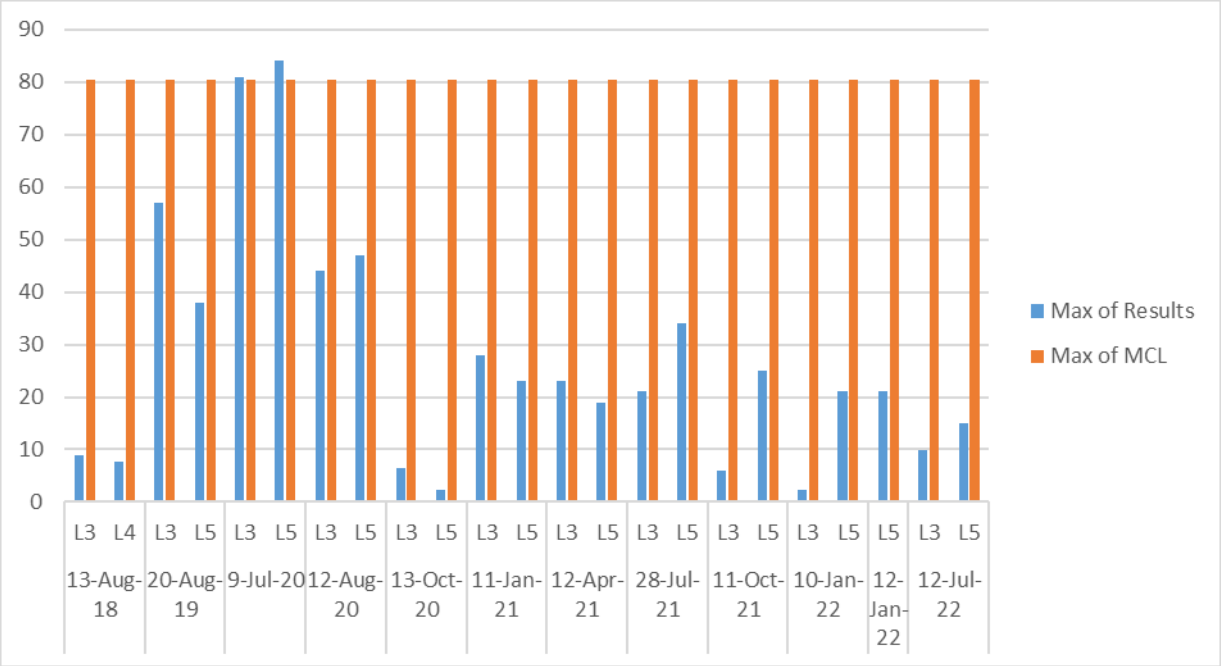
Oxidation, aeration, adsorption, and improved coagulation filtration can be effective in reducing taste and odor at the water treatment plant (Minnesota Rural Water Association 2024). Aeration, granular activated carbon (GAC), and powdered activated carbon (PAC) are examples of treatment techniques that can be employed to reduce odor (Minnesota Rural Water Association 2024). Oxidizing agents can also be introduced to raw water (untreated water from a source) to remove microbial growth and organics. An example is hydrogen peroxide, a more powerful oxidant than chlorine (Cl_2), chlorine dioxide (ClO_2), and potassium permanganate ($KMnO_4$), that oxidizes organic nitrogen and humic acids compounds while also acting as a disinfectant (Popescu, et al. 2019). Hydrogen peroxide is often added prior to chlorine treatment due to its dechlorination effect. Bonita Springs Utilities complied with odor levels requirements 2020 through 2022.

It is important to note that one incident of a chronic contaminant MCL exceedance is not a violation. Lake Fairways MHP exceeded the MCL level for TTHMs only one time in 2020,

location 5 reading was 84 ppb and location 3 reading was 81 ppb, see Figure 1 and Figure 2. The TTHMs are by-product formed when disinfection reacts with organic matter present in the water (United States Environmental Protection Agency (EPA) 2003). The precursor is Natural Organic Matter (NOM) which is frequently evaluated as Total Organic Carbon or dissolved organic carbon (DOC) (Ghernaout 2018). As a corrective action for the TTHMs exceedance, Lake Fairways MHP monitored DBP quarterly from 2020 through 2021. The system was back in compliance after the DBP results were below 50% of the MCL, see Figure 2 below. The MCL for TTHMs was 80 ppb and HAA5 is 60 ppb, the 2021 DBP running annual average readings were below 40 ppb for TTHMs and less than 60 ppb for HAA5. The system began routine (annual) monitoring in 2022.

Figure 2

Total Trihalomethanes (TTHMs) contaminant results for Lake Fairways Mobile Home Park.



Total coliform was detected in all systems except for Mobile Home Park utility, 2018 through 2022. *E. coli* was detected in five out of the ten systems assessed in this study. However, only 3 systems had *E. coli* MCL violations. Table 7 below indicates the systems that incurred microbial MCL violations in the distribution systems. Three (3) out of ten (10) local public water systems in Lee County incurred *E. coli* MCL violations while four (4) out of 10 systems recorded non-acute MCL violations, as defined by EPA. Results submitted after corrective action indicate that systems met EPA requirements for Total Coliform and *E. coli* contaminant levels. Corrective actions required after a system detects TC and/or *E. coli* in the distribution and/or raw water sample are outlined in the Appendix. Total coliform and *E. coli* were not detected at City of Cape Coral in December 2022. At FGUA Lehigh Acres WTP, TC was detected once in April 2021 and two times in April 2022 (in the distribution and repeat sample). No MCL violations

were recorded at Lee County Utilities after September 2021. The City of Fort Myers WTP had no MCL violations after July 2022, and no microorganisms detected in December 2022. At FM Beach Water, total coliform was only detected once after 2019.

Table 7
Distribution systems MCL violations.

System Name	**City of Cape Coral**	**FGUA Lehigh Acres WTP**	**Lee County Utilities**	**City of Fort Myers WTP**	**FM Beach Water**
Number of Samples Required per month	120	30	150	90	8
E. Coli MCL Violation dates	9/1/2022 (OCULUS 2024)	6/1/2018 (OCULUS 2024)	9/1/2021 (OCULUS 2024)	N/A	N/A
non-acute MCL violation dates (Number of Total Coliform positive samples in a month that trigger treatment technique (TT) violation)	N/A	4/1/2022 (2 samples) (OCULUS 2024) and 7/1/2018 (2 samples) (OCULUS 2024)	5/1/2021 (11 samples) (OCULUS 2024) and 9/1/2019 (9 samples) (OCULUS 2024)	7/1/2022 (7 samples) (OCULUS 2024), 3/1/2020 (6 samples) (OCULUS 2024) , and 5/1/2018 (7 samples) (OCULUS 2024)	8/1/2019 (2 samples) and 11/1/2018 (2 samples) (OCULUS 2024)

Total coliform was detected in ground water source water (wells) at FGUA Lehigh Acres WTP four (4) times in 2018, three (3) times in 2019, and one (1) time in 2022. However, no violations were noted. Violations would have occurred if the system failed to collect confirmation samples after each TC detection, or if routine samples and confirmation samples tested positive and the system failed to follow correct procedure of well disinfection and/or failed to carry out corrective actions outlined in the Appendix.

Each utility sampled at least 104 contaminants from 2018 through 2022 and only four contaminants were above MCL; TTHMs, Odor, Total Coliform and E.Coli. The systems resolved the MCL exceedance by conducting corrective action described in the Appendix, which included multiple sampling events. The results show that overtime the contaminants detected decreased to levels below the MCL, which brought the systems discussed above back to compliance. The results indicate that from 2018 to 2022 all10 systems analyzed in this study

complied with EPA maximum contaminant levels requirements and therefore in compliance with F.A.C Rule and EPA requirements.

Contaminant Mean Differences Among Utilities

The ANOVA test was conducted for contaminants analyzed annually, from 2018 through 2022, to determine whether the contaminants mean values were significantly different among utilities. The P-value is compared to a predetermined 0.05 alpha significance level, to determine statistical significance. The alpha value (0.05) was calculated based on a 95% confidence level that is, 1-0.95 = 0.05. Results of the analysis, as seen in Table 8, indicate that F statistics were greater than F critical and P-value less than (<) 0.05 for nitrite inorganic, DBP (HAA5 and TTHMs) and Total Coliform microorganism contaminants. Therefore, means values for nitrite inorganic, DBP, and Total Coliform microorganism contaminants are significantly different among utilities. However, mean values for nitrate and E. Coli detected are not statistically different among utilities. As previously stated, contaminants listed in Table 8 were below the MCL levels for most systems except for lake Fairways MHP TTHMs and systems listed under Table 7. Therefore, most systems were complying with EPA regulations.

Table 8

ANOVA test results for 2018 to 2022 mean differences among Local Public Water Systems in Lee County.

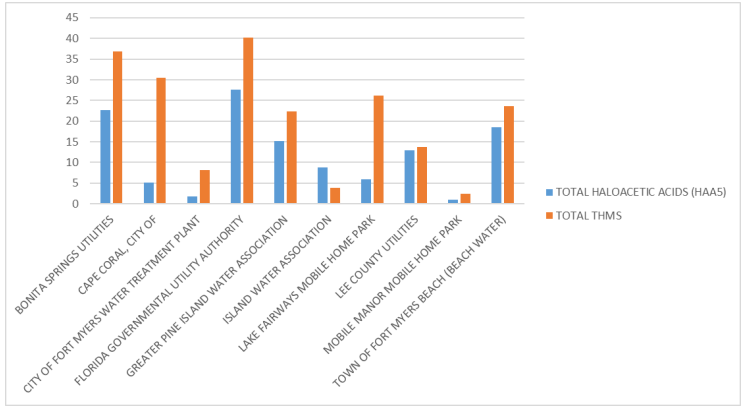
Contaminant	**Source of Variance**					
	SS between Groups	**Df between Groups**	**MS between Groups**	**F**	**P-value**	**F crit**
Nitrate (Inorganic)	0.33222	7	0.04746	0.90279	0.50992	2.1541
Nitrite (Inorganic)	0.01018	7	0.00145	2.22221	*0.04325*	2.15184
Haloacetic Acids (HAA5) (DBP)	15774.12	9	1752.68	28.07006	*0.0*	1.90659
Total Trihalomethanes (TTHMs) (DBP)	36492.1	9	4054.7	31.78	*0.0*	1.90659
Total Coliform (microorganisms)	1.95622	9	0.21736	4.30185	*0.00001*	1.88198
E. Coli (microorganisms)	0.00813	9	0.00090	0.37512	0.94742	1.88239

Figure 3 shows the mean values for the 10 utilities, for contaminants tested annually 2018 through 2022, which include nitrate, nitrite, DBPs, and microbial contaminants. Results show that FGUA Lehigh Acres WTP had a significantly higher DBP (HAA5 and TTHMS) mean value relative to other utilities. City of Fort Myers WTP, Island Water Association and Mobile manor MHP had lower detected DBP relative to other utilities in this study. The significant mean differences for DBP, among utilities, may indicate that some utilities either have fewer organic

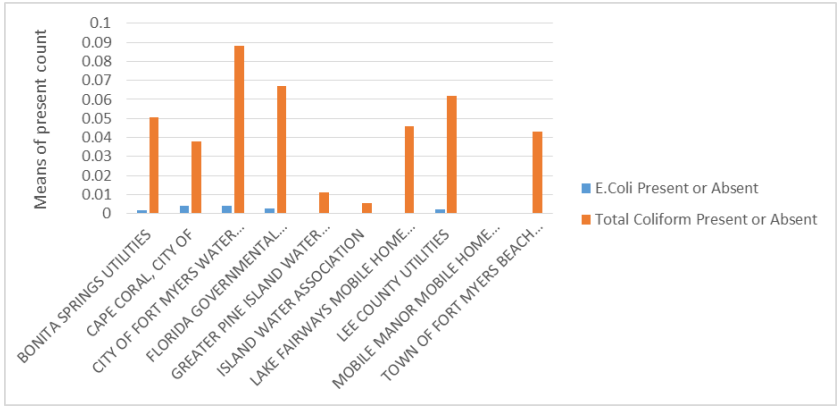
contaminants in the source water; or the treatment processes and/or management practices (such as equipment maintenance, storage tank aeration and turnover) are efficient at removing organic contaminants in source water and in the distribution system, thus preventing the formation of DBP. The DBP mean values were below MCL for all systems, an indication that on average all utilities remain in compliance with EPA requirements.

Figure 3

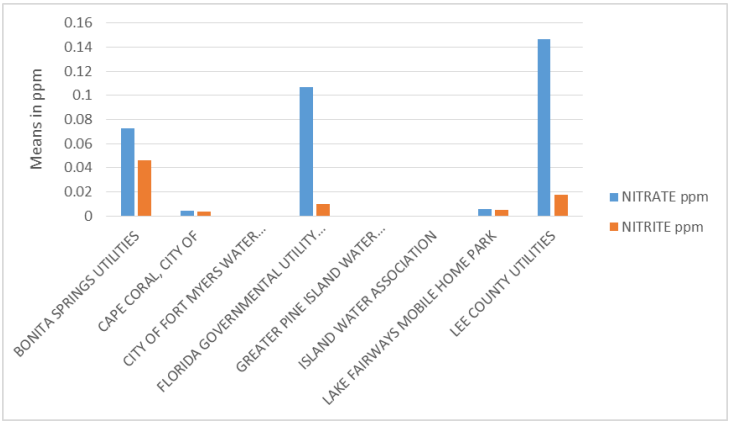
Contaminant mean values among local Public Water Systems in Lee County (community systems/utilities) for contaminant that require frequent sampling.



Total Haloacetic Acids (HAA5) and Total Trihalomethanes (TTHMs) Disinfection byproduct (DBP)



E. Coli and Total Coliform microbial contaminant mean



Nitrate and nitrite inorganic contaminants. Mobile Manor MHP and FM Beach Water are consecutive systems that buy water from other utilities therefore have no Point of Entry (POE) sampling locations for nitrite nitrate

Lee County Utilities recorded the highest nitrate mean value compared to other utilities, see Figure 3. However, the difference was not statistically significant based on the ANOVA test in Table 8 above. The conclusion is that the difference in nitrate mean values among utilities was due to chance. Bonita Springs Utilities had significantly the highest nitrite mean value compared to other utilities. Higher nitrite mean values at Bonita springs utility, FGUA and Lee County utilities may indicate higher concentration of inorganic contaminants in the source water. However, not enough to cause negative health effects as the contaminant detected was below MCL. City of Fort Myers WTP, GPIWA, and IWA did not detect nitrate and nitrite inorganic contaminants in 2018 through 2022. An indication that the source water may be low in inorganic contaminants and /or the treatment processes and management practices are effective at removing inorganic contaminants. The nitrite mean values for all utilizes were below the MCL.

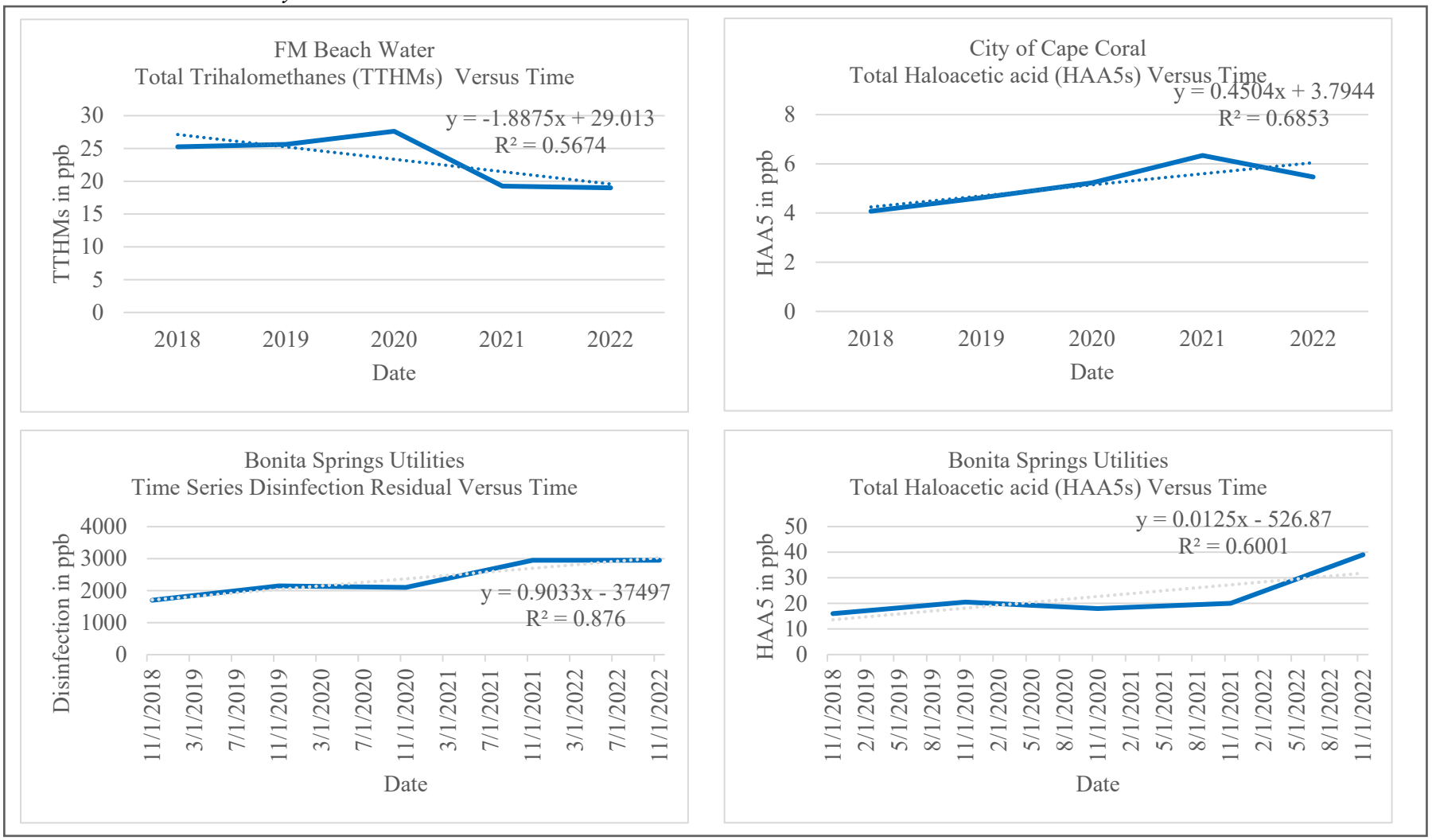
The City of Fort Myers WTP recorded a significantly higher Total Coliform (TC) mean value compared to other utilities, see Figure 3 and Table 8. All utilities reported TC detection except for Mobile Manor MHP. *E. coli* was undetected at GPIWA, IWA, Lake Fairways MHP and FM Beach Water 2018 through 2022. Microorganisms (TC and *E. coli)* were undetected at Mobile Manor MHP, 2018 through 2022. The mean values indicate that TC detection in water is more common than E.Coli detection, with some utilities detecting TC more frequently than others. However, water quality is not a concern until non-acute or E.Coli MCL violation occurs. Table 7 showed systems that incurred non-acute and E.Coli MCL violations. Description of non-acute and E.Coli MCL violations can be found in the Appendix. It is important to note that although the DBP and acute inorganics (nitrite and nitrate) were detected by the systems, the results were below the MCL, except for Lake Fairways MHP, which exceeded the TTHMs MCL requirements. Four (4) systems had microbial non-acute MCL violations, and three (3) systems had *E. coli* violations (see Table 7). However, the utilities were able to resolve the noncompliance issues after completing corrective actions outlined in the Appendix. In summary, the mean value differences among utilities show that on average, the 10 systems provided water that that meet SDWA standards as the mean values are below MCL; also, differences in contaminants detected among utilities could be indicative of variation in source water quality, treatment efficiency and/or management practices.

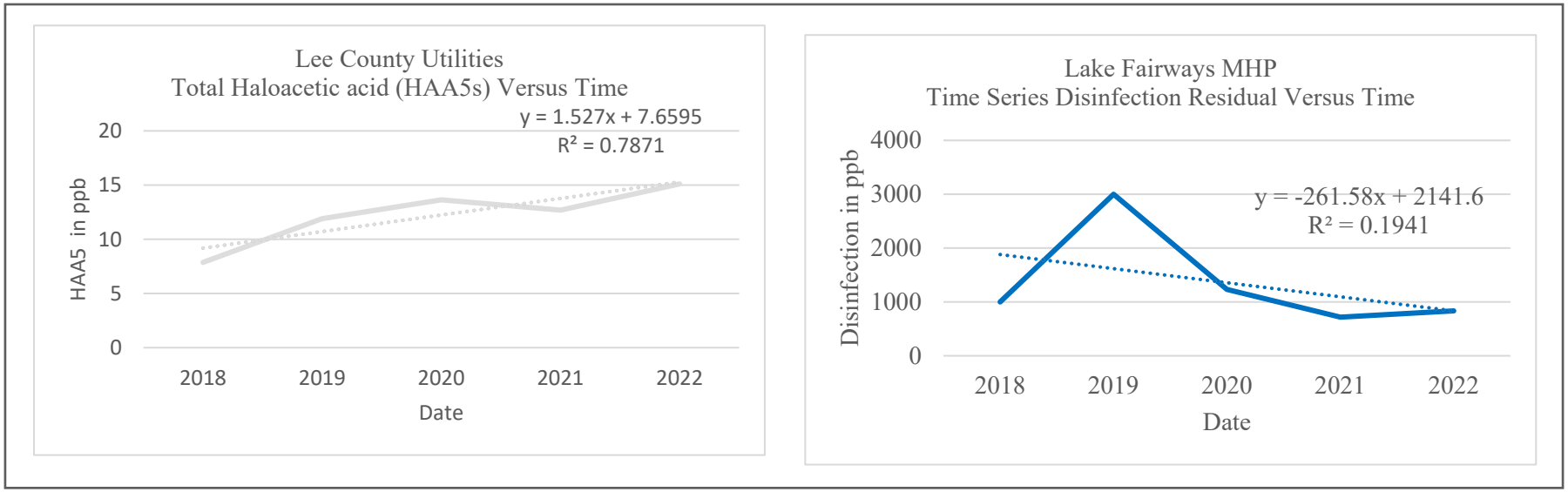
Regression Analysis

The association between disinfection (X variable) and DBP (Y variable) for each potable water system (utility) was determined by a regression analysis. The DBP analyzed in this case were HAA5s and TTHMs. Disinfection is measured as total or free chlorine residual. Systems that disinfect water with chloramines (ammonia and chlorine) measure the total chlorine residual, while systems that only use chlorine measure free chlorine residual to ensure compliance with Florida administrative code requirements (Florida Department of State 2015).

Figure 3.

Time series line plot for contaminants versus time for FM Beach Water, City of Cape Coral, Bonita Springs Utilities, Lee County Utilities and Lake Fairways MHP.





As discussed above, consumers are not exposed to DBP contaminants in potentially harmful amounts. Only one incident of exceedance was reported at Lake Fairways MHP and after the subsequent quarterly sampling, system was back in compliance. Therefore, there was no violation. As stated before, one incident of an MCL exceedance is not a violation because DBP chronic contaminants require long term exposure to cause health effects.

The purpose of the regression analysis was to identify the relationship between HAA5s and TTHMs and disinfection measured as chlorine (total or free) residual. Disinfection byproducts form when disinfectants used to control microbial pathogens combine with naturally occurring organic material present in water (United States Environmental Protection Agency (EPA), 2023). Utilities are not required to report levels of Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC), the organic precursors for DBP formation (Ghernaout, 2018). However, utilities measure and report disinfection residual at the time of DBP sampling event. Therefore, relationship analysis was conducted to determine whether changes in disinfection are associated with changes in HAA5s or TTHMs. An outlier test was completed prior to analysis. Only one utility, Lee County Utilities, had outliers based on the Z score. Outliers for HAA5s and for nitrate and nitrite were detected in Lee County Utilities for samples collected October 7, 2019, and samples collected October 13, 2022. The outliers were removed prior to regression analysis.

Times Series Regressions. First, a trend analysis/time series for disinfection and each DBP contaminant change over time was conducted. The ideal DBP trend is no increase in the contaminants level over time. Disinfection may fluctuate over time as long as the following conditions are met: the source water does not contain organic material that would lead to formation of DBPs; the disinfection level fluctuation is not drastic; and the changes in disinfection remain within acceptable regulatory limits (0.6 ppm to 4ppm for total chlorine and 0.2ppm to 4ppm for free chlorine residuals). Data was used to perform a time series regression analysis for the DBP contaminants of TTHMs and HAA5s, and disinfection measurements of free or total chlorine residual. Time series charts were developed for systems that had significant results based on the time series regression model p value with alpha set at 0.05 (based on 95% confidence level). The charts were developed based on the annual average reading for TTHMs, HAA5s and disinfection. Figure 3 shows annual trends for DBP contaminants of TTHMs and HAA5s, and disinfection measurements of free or total chlorine residual for selected utilities between 2018 and 2022.

As shown in Figure 3, a negative trend in TTHMs overtime was observed at FM Beach Water. The TTHMs decreased at a rate of 1.887 ppb per year with an R squared (R^2) of 56.7%. However, an increase in HAA5s over time at City of Cape Coral was observed, at a rate of 0.45 ppb per year with 68.53% R^2. Similarly, an increase in disinfection over time at Bonita Springs Utilities was observed, at a rate of 0.9 ppb per year with 87% R^2. The system maintained disinfection residual levels within acceptable regulatory limits as described above. Moreover, an increase in HAA5s for the same period was also observed at Bonita Springs Utilities, at a rate of 0.012 ppb with 60% R^2. There was no statistically significant correlation found between disinfection and HAA5s at Bonita Springs. Lee County Utilities had an increase in HAA5s overtime as well, observed at a rate of 1.53 ppb with 78.71% R^2. A downward trend of disinfection was observed over the years (2018 through 2022) at Lake Fairways MHP at a rate of 261.58 ppb per year with 19.4% R^2.

Overall increase in HAA5s was observed at City of Cape Coral, Bonita Springs Utilities and Lee County Utilities. The increases were small, and the systems remained in compliance as the MCL for HAA5s was not exceeded. TTHMs decreased over time at FM Beach Water. There was a variation in disinfection trend, as an upward trend was observed at Bonita Springs Utilities while a downward trend observed at Lake Fairways MHP. All other trends were not statistically significant based on raw data time series regression model p value.

*Regression Analysis Between Disinfection Byproducts And Disinfection***.** The regression analysis showed a significant, but weak, negative correlation (-0.175) between HAA5s and disinfection for Lee County Utilities. Time series assessment showed that there was an overall decrease (-0.00437 ppb) in disinfection over time, but the decrease was not statistically significant based on time series regression model p value, with alpha set at 0.05 (based on 95% confidence level). However, HAA5s significantly increased overtime (Figure 3). The regression analysis showed

that for every 1 increase in disinfection, measured by Chlorine residual ppb, HAA5s decreases by -0.00239 ppb, with 95% confidence that the decrease is between -0.0044 and 0.00036 ppb. The reverse is also true, 0.00239 increase in HAA5s with every 1 decrease in disinfection. The regression analysis output in Table 9 shows that the inverse correlation was very weak (-0.1746), and the R squared results show that only 3.1% of variation in HAA5s can be attributed to changes in disinfection. So, this indicates that the changes in HAA5s are influenced less by the amount of disinfection in water and likely affected by other factors, such as the amount of DBP precursors in source water/water mains and treatment efficiency in removing the precursors.

Similarly, with respect to City of Fort Myers WTP, a significant inverse correlation between HAA5s and disinfection (chlorine residual), was found (P value 0.0267 < 0.05). For every increase in disinfection, HAA5s decreases by -0.0016 ppb, with 95% confidence that the decrease is between -0.0029 and -0.0003. The vice versa is also true, 0.0016 increase in HAA5s with every 1 decrease in disinfection. Time series assessment showed an overall increase of 0.1227ppb in disinfection chlorine residual and no change in HAA5s over time. However, these results were not statistically significant. Much like Lee County Utilities results, City of Fort Myers WTP results are inconsistent with a study that found a positive correlation between HAA5s and disinfection (Xue, et al. 2017). The regression analysis in Table 9 and Figure 4 show strong inverse correlation (-0.863) and the R squared results show that 74.6% of variation in disinfection chlorine residual can be attributed to changes in HAA5 ppm. These results indicate that for City of Fort Myers WTP, the changes in HAA5s observed over time is affected by the amount of disinfection present in the water, contrary to Lee County Utilities samples.

Table 9

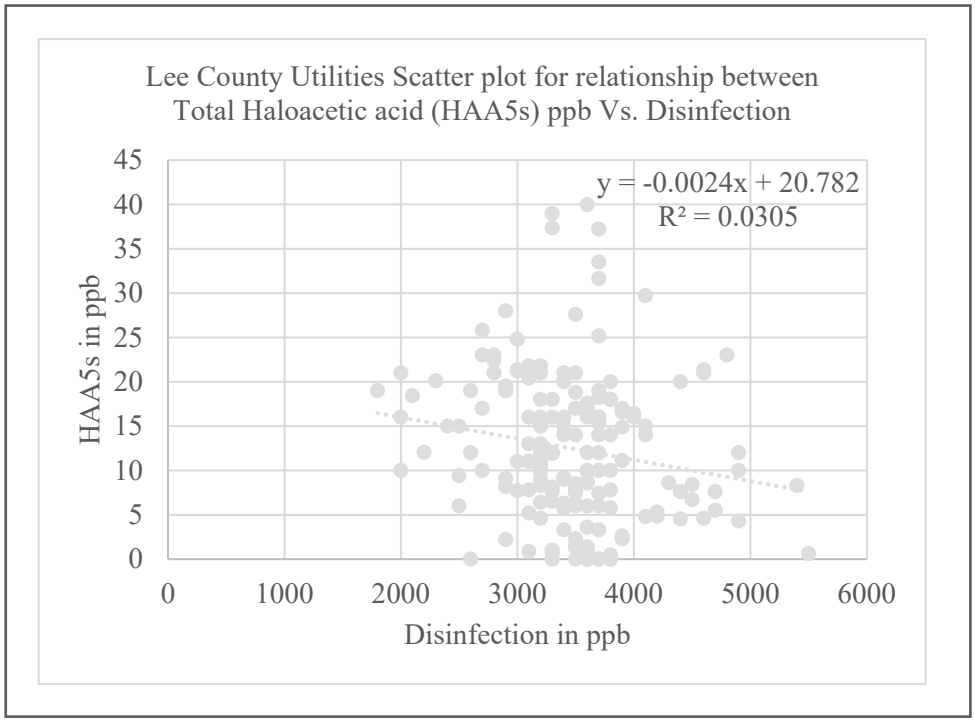
Regression statistics ANOVA test results for disinfection total or free chlorine residual and Disinfection byproduct (Total Haloacetic acid (HAA5s).

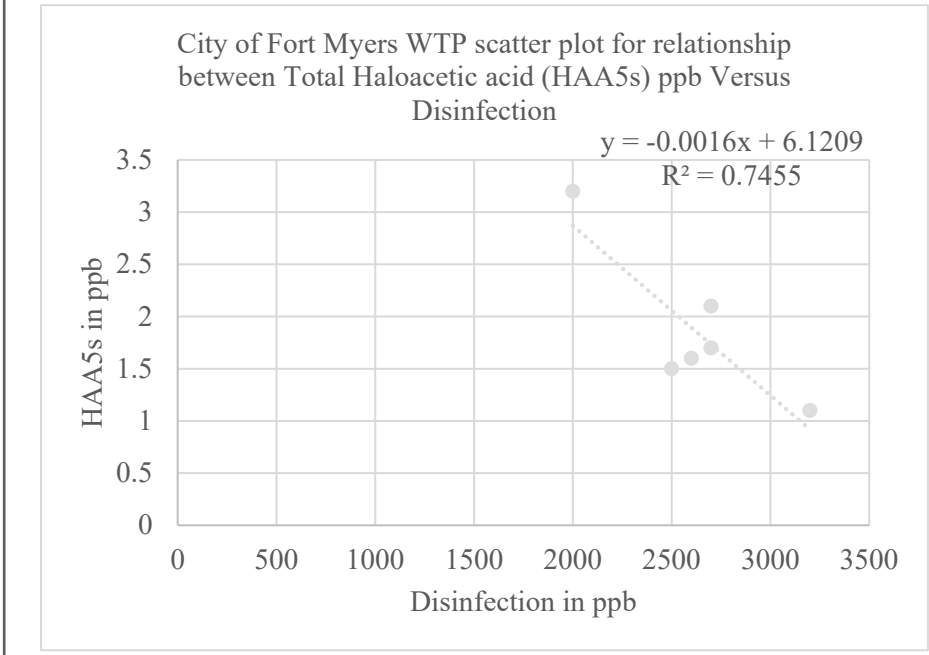
		Regression analysis output	
Utility	**Lee County Utilities**	**City of Fort Myers WTP**	**Lake Fairways MHP**
Correlation	-0.1746	- 0.863	0.664
R Squared (R^2)	0.0305	0.7455	0.4409
Statistical Significance	P = 0.0216	P = 0.0267	P = 0.0004
X- Coefficient (slope/ b1)	-0.00239	-0.0016	0.0037
Lower bound and Upper bound 95% confidence interval of b1	-0.0044 -0.00036	-0.0029 -0.0003	0.0019 0.0055

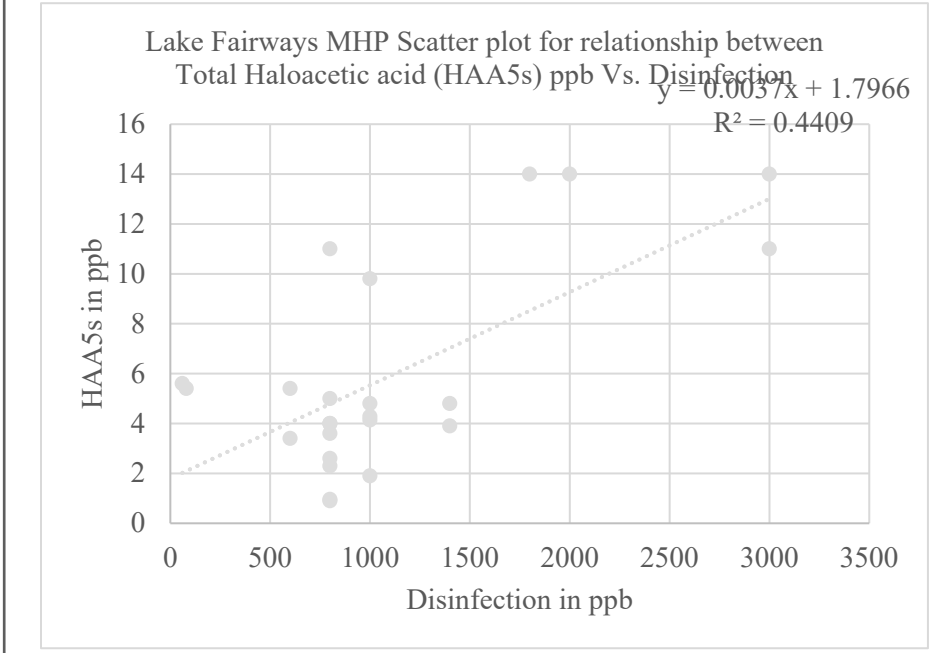
A significant moderate positive correlation (0.664) between HAA5s (DBP) and disinfection chlorine residual at Lake Fairways MHP was observed. The R^2 in Figure 4 and Table 9 was 44.09%, indicating that 44.09% of changes in HAA5s can be attributed to changes in chlorine disinfection residual. For each one (1) increase in disinfection, HAA5s increases by 0.0037 ppb (or vice versa) and with 95% confidence that increase is between 0.0019 ppb and 0.0055 ppb. The time series/trend analysis assessment showed an overall decrease of 0.0042 ppb in HAA5s over time. However, these results were not statistically significant. So, Lake Fairways MHP disinfection and DBP patterns are different than Lee County Utilities and City of Fort Myers WTP. Figure 4 shows the scatters plots visualizing the association between disinfection and HAA5 for these utilities.

Figure 4.

Scatter plot for relationship between Total Haloacetic acid (HAA5s) and disinfection at Lee County Utilities, City of Fort Myers WTP and Lake Fairways MHP







Conclusion

The main objective of this study was to analyze existing data from 2018 through 2022 to determine whether water from community water systems (utilities) in Lee County provided water that was potable. This is achieved by ensuring compliance with the EPA SDWA requirements. Ten utilities out of twenty were assessed because at the time of this study, a record of 2018 CCR reports could not be found for the other ten utilities.

Were maximum levels of contaminants detected below the MCL set by EPA? Most utilities met the MCL requirements defined by EPA. Detected contaminants were below the MCL, except for Lake Fairways MHP, which had TTHMs reading above the MCL, 84 ppb and 81 ppb in 2020; Bonita Springs Utilities that recorded odor reading of 10 threshold odor number (TON) in 2017; City of Cape Coral, FGUA Lehigh Acres WTP, and Lee County Utilities with *Escherichia coli* (*E. coli*) MCL violations; FGUA Lehigh Acres WTP, Lee County Utilities, City of Fort Myers WTP, and FM Beach Water with non-acute MCL violations. Results submitted after corrective actions completion indicate that systems were able to reduce contaminants to levels below MCL requirements and therefore able to meet EPA requirements. GPIWA and IWA indicated that the facilities had undetectable levels of nitrate and nitrite contaminants. *E. coli* was undetected at GPIWA, IWA, Lake Fairways MHP, FM Beach Water, and Mobile Manor MHP from 2018 through 2022. Total Coliform was undetected in Mobile Manor MHP during the same period.

Each utility sampled at least 104 contaminants from 2018 through 2022 and only four contaminants were above MCL; TTHMs, Odor, Total Coliform and E.Coli. The systems resolved the MCL exceedance by conducting corrective action described in the Appendix, which included multiple sampling events. The results show that overtime the contaminants detected decreased to levels below the MCL, which brought the systems back to compliance. The results indicate that from 2018 to 2022 all 10 systems analyzed in this study complied with EPA maximum contaminant levels requirements and therefore in compliance with F.A.C Rule, EPA and SDWA requirements.

Were contaminant mean values among utilities different? Means values for nitrite inorganic, DBP, and TC contaminants were significantly different among utilities. The mean values for nitrate and *E. coli* were not significantly different. FGUA Lehigh Acres WTP had a significantly higher DBP (HAA5 and TTHMS) mean values relative to other utilities, based on the ANOVA test. Bonita Springs Utilities had significantly the highest nitrite mean value compared to other utilities. City of Fort Myers WTP, GPIWA, and IWA did not detect nitrate and nitrite inorganic contaminants 2018 through 2022. The City of Fort Myers WTP recorded significantly higher TC mean values compared to other utilities. *E. coli* was undetected at GPIWA, IWA, Lake Fairways MHP, and FM Beach Water 2018 through 2022. Total Coliform and *E. coli* microorganisms were undetected at Mobile Manor MHP, 2018 through 2022.

To reiterate, contaminant detection does not necessarily indicate that the water poses a health risk. Public health and safety are likely to be threatened when corrective actions are not carried out after MCL exceedance of acute and chronic contaminants. There is minimal risk to human health for non-vulnerable population at FGUA Lehigh Acres WTP and Bonita Springs Utilities because levels detected for DBP and nitrite, respectively, were below MCL levels. An indication that although, on average, FGUA Lehigh Acres WTP DBP levels and Bonita Springs Utilities nitrite levels were higher compared to other utilities, these systems continued to provide water that met EPA and SDWA standards. More research is required to determine the causes of higher DBP at FGUA Lehigh Acres WTP and nitrate levels at Bonita Springs Utilities relative to

other utilities for example, whether the source water may be contributing to higher contaminants levels; whether the treatment process does not efficiently remove these contaminants at FGUA Lehigh Acres WTP and Bonita Springs Utilities compared to treatments used at other utilities; whether introducing management practices such as equipment maintenance, managing water age to reduce DBP formation, conducting more frequent free chlorine flushing (also called chlorine burn) to reduce nitrite contaminants, et cetera can help reduce DBP and nitrite contaminants.

Higher TC levels in the City of Fort Myers WTP, relative to other facilities, could possibly be attributed to water main repairs and breaks. An in-depth review of the system's data may be needed to accurately pinpoint the sources of the TC contaminants. Higher TC detection at City of Fort Myers, relative to other utilities is not indicative of poor water quality. As indicated in the analysis completed in this study, the utility complied with EPA requirements by completing corrective action required after TC detection and after non-acute TC positive MCL violation. There were no reports of any MCL violation after July 2022.

Is there a correlation between disinfection and Disinfection byproducts? For Lee County Utilities, a significant negative association between HAA5s and disinfection was found, but with low R^2. Thus, changes in HAA5s at Lee County Utilities are less influenced by amount of disinfection in water and likely affected by other factors, such as the amount of DBP precursors in source water/water mains and treatment efficiency in removing the precursors. At City of Fort Myers WTP, a strong inverse association was observed between disinfection chlorine residual and HAA5s. Much like Lee County Utilities results, City of Fort Myers WTP results do not agree with an early study which found a positive correlation between HAA5s and disinfection (Xue, et al. 2017). However, for Lake Fairways MHP a significant positive association was found. The results at Lake Fairways MHP indicate that increase in disinfection added contributes to increased formation of DBP contaminants and vice versa. The correlation analysis indicated a significant positive correlation between disinfection chlorine residual and HAA5s at Lake Fairways MHP. Time series/trend analysis assessment showed an overall decrease in HAA5s and disinfection over the years at Lake Fairways MHP. The reduction in disinfection residual after 2020 may have contributed to the reduction in DBPs to levels below the MCL. This corrective action allowed the system to achieve compliance with EPA requirements. As this study showed, the corrective actions needed were completed by Lake Fairways MHP. Based on the results of this study, disinfection influences the formation of DBPs at Lake Fairways MHP hence maintaining lower disinfection residual (within EPA limits) could be considered as a more proactive approach to maintaining DBP levels below the MCL requirement.

Lee County Utilities and City of Fort Myers WTP DBP levels were less than the MCL 2018 through 2022 therefore systems were compliant with EPA and SDWA requirements. Lake Fairways MHP only exceeded the MCL one time, and they completed corrective actions to bring system back to compliance with the SDWA. Despite the exceedance, the public health was not threatened as DBP are chronic contaminants, long term exposure of levels exceeding the MCL are required for any health effects to take place in nonvulnerable communities.

Is there an upward or downward trend detected for disinfection ppm, TTHMs and HAA5s over time, between 2018 and 2020? Discrepancies were found among utilities. Disinfection and DBP may increase over time at one utility but decrease at another. For instance, a decrease in TTHMs over time was observed at FM Beach Water. Upward trend in HAA5s over time were recorded at City of Cape Coral, Bonita Springs Utilities, and Lee County Utilities. The increases were small, and public heath was not at risk as utilities maintained HAA5s levels below the MCL. Disinfection increased over time at Bonita Springs Utilities and decreased over time at Lake Fairways MHP. Time series/trend analysis assessment showed an overall decrease in HAA5s and disinfection over the years at Lake Fairways MHP.

In general, it can be concluded that data analysis in this study demonstrated that water was safe for the non-vulnerable population during the 2018 through 2022 period. The 10 community water systems assessed in this study demonstrated compliance with SDWA implemented by the Federal EPA by: having undetectable levels of contaminants; maintaining contaminants levels below MCL for those contaminants that were detected; or by implementing corrective actions to reduce contaminants to levels below MCL. Some people may be more vulnerable to contaminants in drinking water than the general population (Code of Federal Regulations Title 40 (40 CFR) 2024). Immuno-compromised persons, such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants should seek advice from their health care providers about consuming tap water (Code of Federal Regulations Title 40 (40 CFR) 2024).

In addition, it is important to note that not all contaminants are regulated under the SDWA. Utilities are not required to report non-regulated contaminants. Timely resolution of MCL exceedances is critical in ensuring public health and safety. Corrective action for acute contaminants (Turbidity, Microorganisms, Nitrate and Nitrite) must begin immediately after the initial compliance sample and confirmation samples exceed the MCL, to quickly identify the source of the contaminant and correct the issue. For non-acute contaminants, systems have a year to identify and fix the problem because for such contaminants, as exposure would need to be more than a year to cause health effects for non-vulnerable population. During that year, the public must be notified of the issues so that people with compromised immune systems can find alternative water to use. Future direction is to evaluate other regulated aspects of public water systems, such as facility inspections and expand the study to other counties in the Department of Environmental Protection’s South District area.

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Appendix

Turbidity

Source water includes ground water (well water), surface water, and ground water under the direct influence of surface water (GWUDI). The latter is any water beneath the surface of the ground with significant occurrence of insects or other microorganisms, algae, or large diameter

pathogens, such as *Giardia lamblia* or *Cryptosporidium* (United States Environmental Protection Agency (EPA) 2003). Due to surface water and GWUDI inevitable microbial contamination, in addition to disinfection treatments, the turbidity characteristic of water must be measured continuously at the entry point to distribution system (United States Environmental Protection Agency (EPA) 2003). High turbidity in finished/treated water is indicative of failure of filtration of large diameter pathogens, such as *Giardia lamblia* or *Cryptosporidium*. The Federal Rule 40 CFR part 141, sections 141.13(a) and 141.13(a) outline turbidity maximum contaminant level requirements (United States Environmental Protection Agency (EPA) 2003). Rules 62-550.550, and 62-550.817(15), F.A.C. (Florida Department of State 2015), and Federal Rule 40 CFR part 141.173 outline measurement requirements (United States Environmental Protection Agency (EPA) 2003). Rule 62-550.518(5), F.A.C., outlines actions to be taken when turbidity exceeds one NTU (Nephelometric Turbidity Unit) (Florida Department of State 2015).

Microorganisms

Sources of *E. coli* contamination include animal or human fecal waste (United States Environmental Protection Agency (EPA) 2003). The waste can be introduced to a well through a crack in the sanitary seal, via a compromised well head, through the distribution system of a community water facility during water main repairs, or after water mains breaks. Microbial detection is not a violation until a system exceeds a certain threshold for microorganisms detected in the raw water (source water) or in the distribution system.

Ground water source (wells/raw water) microbial testing is conducted monthly for community water systems, unless a system is considered a 4-log. The latter means that a system has treatment that can achieve at least 99.9 percent inactivation and/or removal of viruses (United States Environmental Protection Agency (EPA) 2003). Whenever a system detects Total coliform (TC) in raw water, a confirmation sample must be collected. If the confirmation sample tests positive for TC, the well must be disinfected to inactivate any microbiological contaminant that may have been introduced into the well, then the true microbiological character of well water is determined by a bacteriological survey (Florida Department of State 2014). Bacteriological survey instructions are outlined in Rule 62-555.315(6)(b), F.A.C. (Florida Department of State 2014). When *E. coli* (a fecal indicator) is detected in the raw water, a system must issue a tier 1 public notice, a boil water notice, notify the regulatory agency within 24 hours, and collect five additional source water samples within 24 hours of being notified of the positive sample (United States Environmental Protection Agency (EPA) 2008). If any one of the five additional samples test positive for *E. coli*, the system must complete corrective actions (United States Environmental Protection Agency (EPA) 2008). Corrective actions include: identifying and correcting all the well deficiencies; providing an alternate source of water; eliminating the source of contamination; or providing treatment that reliably achieves at least 4-log treatment of viruses (United States Environmental Protection Agency (EPA) 2008).

Whenever Total Coliform (TC) or *Escherichia coli* (*E. coli*) is detected in the distribution system, a well sample must be collected from each source that was active at the time the TC

positive sample was collected, and confirmation (repeat) samples must be collected from the point of origin, upstream and downstream (Florida Department of State 2015); (United States Environmental Protection Agency (EPA) 2008). Systems incur a microbial non-acute MCL violation (Treatment Technique (TT) violation) when the following instances occur: systems taking 40 or more distribution samples (including routine and repeat samples) per month exceed 5.0 percent TC positive (+) samples in the same month; systems taking fewer than 40 distribution samples (including routine and repeat samples) per month get two or more TC+ samples in the same month; or when the system fails to take every required repeat sample after any single routine TC+ distribution sample (United States Environmental Protection Agency 2020). Microbial non-acute MCL violations is a TT violation that triggers a level one (Level 1) assessment (United States Environmental Protection Agency 2020). A Public Water System (PWS) that exceeds a specified frequency of total coliform occurrence must conduct an assessment to determine if any sanitary defects exist in the distribution system, and if found, correct them (United States Environmental Protection Agency 2020).

A PWS is considered to have an *Escherichia coli* (*E. coli*) MCL violation when the following happens: a confirmation (repeat) sample tests *E. coli* positive (EC+) after a TC+ routine distribution sample; a repeat sample test TC+ after an EC+ routine distribution sample; a PWS fails to take all required repeat distribution samples after an EC+ routine sample; or a system fails to test for E. coli when any compliance distribution sample tests TC+ (United States Environmental Protection Agency 2020). An *E. coli* MCL violation is a TT violation that triggers a level two (Level 2) assessment. A PWS that incurs an E. coli MCL violation must conduct an assessment and correct any sanitary defects found (United States Environmental Protection Agency 2020). The Level 1 and Level 2 assessments are the degree and depth to which a PWS must examine its system, including monitoring and operational practices, depending on the TT trigger's potential impact to public health (United States Environmental Protection Agency 2020). A Level 2 assessment requires a more in-depth and comprehensive review of the PWS compared to a Level 1 assessment (United States Environmental Protection Agency 2020).

Inorganics, Synthetic Organic Contaminants (SOC), Volatile Organic Contaminants (VOC), Radionuclides contaminants or Disinfection byproduct (DBP) contaminants

Routine monitoring consists of taking one sample from each entry point to the distribution system (POE) for Inorganics, Synthetic Organic Contaminants (SOC), Volatile Organic Contaminants (VOC), and Radionuclides contaminants (Florida Department of State 2015). Disinfection byproduct (DBP) contaminants are collected within the distribution system. The number of samples required, and sampling requirements are outlined in the Federal Rule 40 CFR Chapter 1 Part 141 under Subpart L for Stage 1 DBP and under Subpart V for Stage 2 DBP (United States Environmental Protection Agency (EPA) 2003). The systems reviewed in this study fall under Stage 2 DBP rule. Routine sampling frequency for inorganic contaminants is once every three (3) years for systems using wells and annually for subpart H systems (systems using surface water or ground water under the direct influence of surface water (GWUDI)

(Florida Department of State 2015). The exceptions are asbestos, nitrate and nitrites contaminants. Nitrates and nitrites are sampled annually (Florida Department of State 2015).

Asbestos is found in decaying asbestos cement water mains and erosion of natural deposits (United States Environmental Protection Agency (EPA) 2003). There are no known geologic deposits in Florida which contain asbestos bearing minerals (Florida Administrative Code and Florida Administrative Register 2010). Therefore, utilities in Florida are not required to test for asbestos unless a source of the contaminant is identified that could pollute the drinking water supply. The Florida Administrative Code (F.A.C.) 62-550.546 states that unless the regulatory agency finds that there is a source of asbestos which could potentially contaminate a water supply and notifies the system in accordance with Rule 62-550.511, F.A.C., public water systems shall not be required to analyze raw water or treated water at the entry point to the distribution system for asbestos (Florida Administrative Code and Florida Administrative Register 2010). Community water systems that are susceptible to asbestos contamination are required to routinely test for asbestos once every nine (9) years (Florida Department of State 2015). Asbestos sampling requirements and number of locations required are as follows: systems susceptible to asbestos contamination due solely to corrosion of asbestos-cement pipe must sample at a tap served by asbestos-cement pipe and under conditions where asbestos contamination is most likely to occur (Florida Department of State 2015); systems susceptible to asbestos contamination due solely to source water must monitor at every entry point to the distribution system during normal operating conditions (Florida Department of State 2015); and systems susceptible to asbestos contamination due to both source water and corrosion of asbestos-cement pipe must sample at a tap served by asbestos-cement pipe and under conditions where asbestos contamination is most likely to occur (Florida Department of State 2015). When a community water system exceeds the MCL level for Asbestos, the initial corrective action required is to sample quarterly. Four (4) consecutive quarterly samples must be below MCL for the issue to be considered resolved (Florida Department of State 2015).

The SOC and VOC contaminants are sampled every 3 years for 4 consecutive quarters in one year. If the contaminants are undetected, a system can qualify for reduced monitoring, which would require one triennial VOC sample and 2 quarterly SOC samples in the same year, for a triennial period (Florida Department of State 2015). A utility can qualify for additional SOC sampling reduction to 2 quarterly SOC samples in the same year, in a given 9 years cycle, if they submit a waiver request and meet all requirements listed in form 62-560.545_2 F.A.C. (Florida Department of Environmental Protection (DEP) 2022). Disinfection byproduct (DBP) routine sampling is quarterly, and systems can qualify for routine sampling if DBPs detected are below MCL and qualify for reduced sampling when levels detected are equal to or less than 50 % of the MCL (United States Environmental Protection Agency (EPA) 2003). Routine sampling for Radionuclides contaminants are once every 3 years and reduced monitoring can be applied to every 9 years, if contaminants level are below the detection limit.

The MCL values are listed in Rule 62-550.310, F.A.C., and Tables 1 through 5 of Rule 62-550, F.A.C. (Florida Department of State 2015). Whenever an MCL is exceeded for inorganic

(other than nitrate or nitrite), volatile organic (VOC), synthetic organic (SOC), Radionuclides or Disinfection byproduct (DBP) contaminants, systems are placed on increased monitoring (Florida Department of State 2015). The DBP increased monitoring means quarterly sampling, if the running annual average exceeds MCL system is in violation (Florida Department of State 2015). Systems are also required to submit an Operation Evaluation Report (OER) whenever there is a DBP MCL exceedance after calculating the operational evaluation level (OEL) following 3 quarterly sampling events or if the initial exceedance is so high that after 3 quarterly sampling events the MCL will be exceeded (United States Environmental Protection Agency (EPA) 2003). A description of how OEL is calculated can be found in Code of Federal Regulations CFR title 40 (United States Environmental Protection Agency (EPA) 2003). Increased monitoring for Inorganic, volatile organic (VOC), synthetic organic (SOC), and Radionuclides is quarterly. Results from four (4) consecutive quarters must be below the MCL or the utility/system will be out of compliance (Florida Department of State 2015). Rule 62-550.500(7)(b), F.A.C., states that a system monitoring annually or less frequently for the inorganic contaminants, other than nitrate or nitrite, listed in subsection 62 550.310(1), F.A.C., the volatile organic contaminants (VOC) listed in paragraph 62 550.310(4)(a), F.A.C., the synthetic organic contaminants (SOC) listed in paragraph 62-550.310(4)(b), F.A.C., or the radiological (radionuclides) contaminants listed in subsection 62-550.310(6), F.A.C., whose sample result exceeds the MCL will not be considered in violation of the MCL until it has completed one year of quarterly sampling (Florida Department of State 2015). If the running annual average of any sampling point is greater than the maximum contaminant level, then the system is out of compliance (Florida Department of State 2015). Contaminant sources for inorganics, SOC, VOC, DBPs, and Radionuclides contaminants can be found in Appendix A of Code of Federal Regulations CFR title 40 (United States Environmental Protection Agency (EPA) 2003).

Disinfection byproducts can be reduced by doing the following: adjusting disinfection levels; reducing the amount of Natural Organic Matter (NOM) in source water or in water mains using coagulation and settling, filtering, and oxidation techniques; or adding disinfection after organic and inorganic matter have been removed from the water (Ghernaout 2018). Best available technologies (BAT) for reducing organic are: granulated activated carbon (GAC) that uses sorption to remove Dissolved Organic Carbon (DOC), aeration, oxidation (OX), ion exchange, Reverse Osmosis, and Electrodialysis (United States Environmental Protection Agency (EPA) 2003).

Lead and Copper

Routine sampling for lead and copper is biannual and samples must be collected in the distribution system (United States Environmental Protection Agency (EPA) 2007). First-draw samples must be collected from water taps in homes or buildings (United States Environmental Protection Agency (EPA) 2007). Taps that are at an elevated risk of lead/copper contamination must be prioritized (United States Environmental Protection Agency (EPA) 2007). The number

of samples required is based on population size (United States Environmental Protection Agency (EPA) 2007). Before 2023, systems could qualify for less frequent monitoring to annually when the 90th percentile level of tap water sample is below 0.015 mg/L for lead (Pb) and 1.3 mg/L for Copper (Cu**).** In addition, reduction in sampling events (triennial) and sampling locations could be approved for systems with 90th percentile Pb and Cu levels less than or equal to 0.005 mg/L and 0.65 mg/L, respectively (United States Environmental Protection Agency (EPA) 2007). Systems are required to notify all customers of the lead sampling results through the consumer notice and a certification of the notice must be submitted to the regulatory agency (United States Environmental Protection Agency (EPA) 2007). Potential contaminant sources are corrosion of household plumbing systems and erosion of natural deposits (United States Environmental Protection Agency (EPA) 2003). Action level (AL) exceedance would result to corrective actions requirements. Before 2023, a system incurred an AL exceedance when the 90th percentile level of tap water sample exceeded 0.015 mg/L for lead (Pb) and 1.3 mg/L for Copper (Cu). Corrective actions required following an exceedance include: Increased sampling to biannually; source water sampling; water quality parameter (WQP) analysis of distribution samples; public education for Pb exceedances; lead service line replacement; source water treatment; corrosion control treatment installation (United States Environmental Protection Agency (EPA) 2007); and/or setting and completing the Optimal Water Quality Parameter (OWQP) (Florida Department of Environmental Protection (FDEP) 2024). All Lead and copper requirements explained above are described in the Federal rule 40 CFR referenced in Rule 62-550.800, F.A.C. (Florida Department of State 2015).

Secondary contaminants

Community water systems test for secondary contaminants every three years, at the entry point to the distribution system, per Table 7 in Rule 62-550, F.A.C. (Florida Department of State 2015). Contaminant sources for secondary contaminants can also be found in Appendix A of Code of Federal Regulations CFR title 40 (United States Environmental Protection Agency (EPA) 2003). The maximum Contaminant Levels (MCL) can be found in Table 6 of Rule 62-550, F.A.C. (Florida Department of State 2015). Failure to meet the fluoride secondary standard requires public notification pursuant to Rule 62-560.430, F.A.C., and corrective action to reduce the contaminant to levels below the MCL are outlined in Rule 62-550 (Florida Department of State 2015). When customer complaints are received following an MCL violation for all other secondary contaminants, systems are required to implement management techniques or install treatment to eliminate or reduce the contaminant to levels below the MCL.