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IDENTIFICATION AND ANALYSIS OF THE CONTRIBUTION OF VARIOUS SOURCES OF TOTAL DISSOLVED SOLIDS (TDS) IN LAKE ELSINORE POTABLE WATER AND WASTEWATER

Lenai Hunter

IDENTIFICATION AND ANALYSIS OF THE CONTRIBUTION OF VARIOUS SOURCES OF TOTAL DISSOLVED SOLIDS (TDS) IN LAKE ELSINORE POTABLE WATER AND WASTEWATER

A Thesis

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in

Environmental Sciences

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by

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ABSTRACT

Total Dissolved Solids (TDS) are primarily inorganic salts that can pass through a 2-micron (or smaller) filter and, when found in high concentrations, can cause adverse effects on aquatic organisms and the surrounding environment. The agency servicing Lake Elsinore and surrounding areas is the Elsinore Valley Municipal Water District (EVMWD). EVMWD's wastewater treatment facilities are not equipped to remove TDS from the wastewater. Therefore, the influent TDS values are often similar to the final treated effluent recycled water TDS values. EVMWD has permit limits at the wastewater treatment plants relating to TDS, and due to the higher influent TDS concentrations noted at the wastewater treatment facilities, the effluent TDS values regular exceed these permit limitations. This analysis investigated whether the cause of the increased TDS values is from the following: the source water itself; the chemical treatment of potable source water for disinfection; regular use of water at homes, businesses, and industries and associated conservation measures; or chemical addition at wastewater sewage lift stations for odor control.

Approximately 600 samples were collected at various locations from Lake Elsinore and the surrounding region for this analysis. The raw source water TDS was not identified as being a key contributor to the variation of the influent TDS values; however, it was identified as comprising the majority of the increased TDS mass loadings for the three facilities measured. The linear regression

analyses yielded coefficients of determination which indicated that consumer uses, including industrial, commercial, and domestic users, along with associated conservation practices and lift station chemical additions, were strongly correlated with influent values at two Water Reclamation Facilities (WRF): the Railroad WRF and Horsethief WRF. The analysis showed minor impact regarding the addition of chemicals to potable water for disinfection purposes as a contributor to all three facilities. Therefore, the analysis suggests that the TDS increase as a result of addition of chemicals is secondary to the increase caused by source water TDS, consumer usage, and conservation measures. However, more analyses and studies should be done to refine the quantification of TDS contribution from various sources to recommend appropriate control measures and assist in compliance with the permit limitations.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

BBGWTP	Back Basin Groundwater Treatment Plant
CFR	Code of Federal Regulations
DBP	Disinfection By-Products
EPA	Environmental Protection Agency
EVMWD	Elsinore Valley Municipal Water District
FOG	Fats, Oils, & Grease
GPM	Gallons per Minute
MBR	Membrane Bioreactor
MCL	Maximum Contaminant Level
MG	Million Gallons
MGD	Million Gallons a Day
NPDES	National Pollutant Discharge Elimination System
POTW	Publicly Owned Treatment Works
SCADA	Supervisory Control and Data Acquisition
SIC	Standard Industrial Classification
SIU	Significant Industrial User
SGWS	Self-Generating Water Softeners
SWP	State Water Project
TDS	Total Dissolved Solids
TTHM	Total Trihalomethanes
WDR	Waste Discharge Requirement
WRF	Water Reclamation Facility
WWTP	Wastewater Treatment Plant

CHAPTER ONE:

INTRODUCTION

Water reclamation facilities (more commonly known as wastewater treatment plants; both terms are used interchangeably throughout this analysis) are governed by the federal Environmental Protection Agency and are issued permits for treated wastewater discharge by state or regional water resources control boards. Permits are issued either in the form of National Pollutant Discharge Elimination System (NPDES) permits or Waste Discharge Requirement (WDR) permits; both impose limitations on various pollutants and nutrients based on the ambient surrounding environment, the US Environmental Protection Agency (EPA), and state and local limits.

One of the constituents that is limited is Total Dissolved Solids (TDS). TDS are portions of solids, typically inorganic salts, that can pass through a filter of two (2) microns or less. TDS can lead to multiple environmental issues and concerns, including causing harm to aquatic organisms, excess salt loading, or degradation of the receiving environment. Though TDS is found occurring in the natural environment in the form of dissolved inorganic and organic salts and minerals, these inorganics also can be added to the environment in higher concentrations through certain industrial, household, and commercial activities.

Total dissolved solids are not always removed during the wastewater treatment process. One example is the Lake Elsinore region where the incoming TDS values at the treatment plants usually indicate the expected effluent TDS values of the produced recycled water. Figure 1 below depicts the Lake Elsinore and surrounding area used for this analysis.

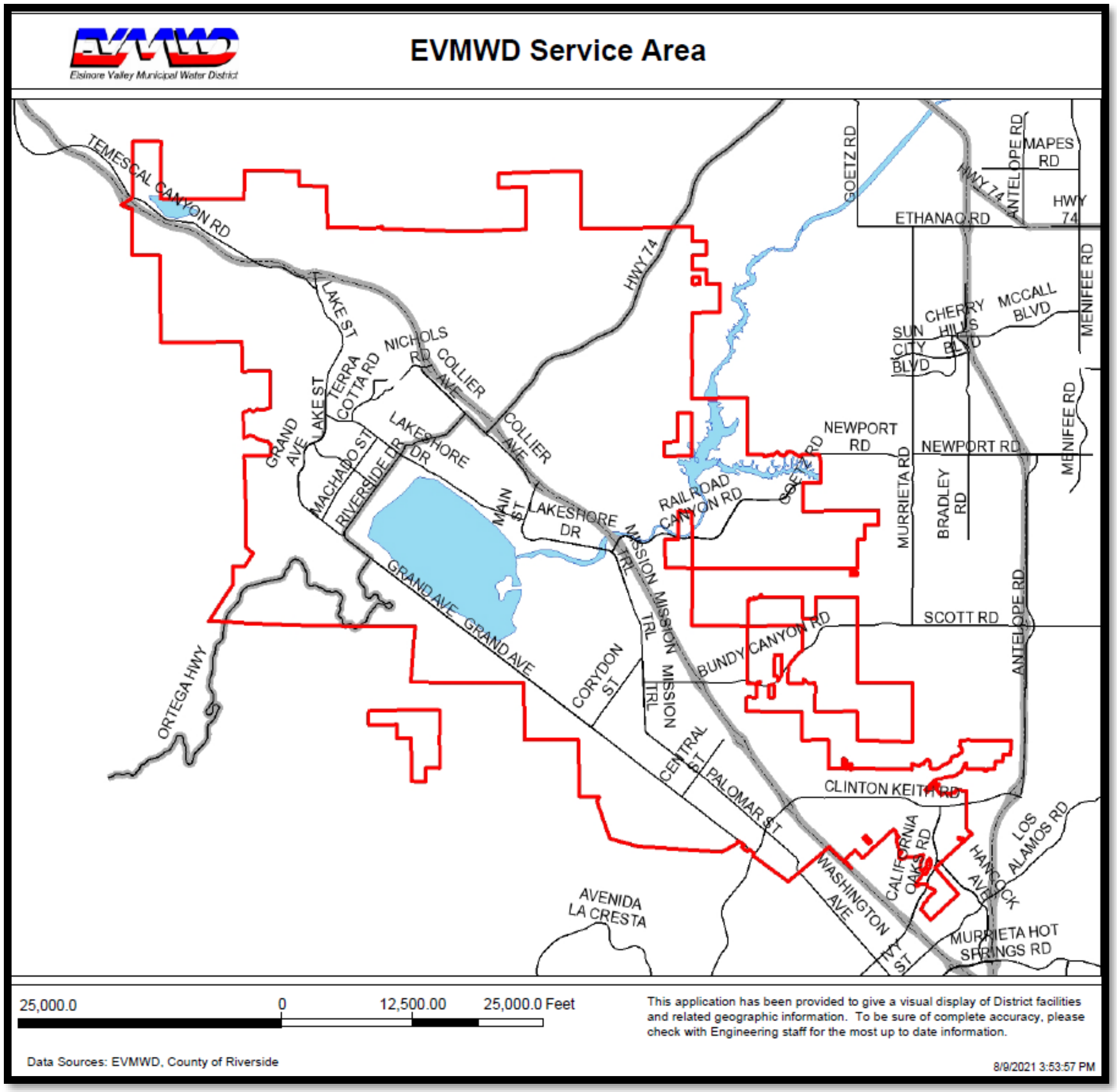


Figure 1. EVMWD service area

California allows two possible options for the wastewater discharger's permit: either the specified numerical concentration limit listed in the permit or the TDS concentration of the source water plus a buffer amount of 250 mg/L. Whichever is the lower limit between the two options becomes the controlling limit, and thus is the required monthly limit to meet. It should be noted that while the calculation of the potable source water TDS is completed on a monthly basis, this monthly average value is not used to determine the water reclamation facility's monthly TDS compliance limit. Instead, the monthly average value is input into a 12-month running average calculation and this 12-month running average becomes the monthly limit; if it is the lower of the two values, it becomes the controlling permit limit. More information about this calculation is included in Tables 13 and 14 in Appendix A.

The amount of TDS measured in Lake Elsinore's (and other inland dischargers) recycled water regularly exceeds the permit effluent limits (Tables 1-3). Lake Elsinore receives potable imported water from both the Colorado River and the State Water Project. The Colorado River water TDS is approximately 350-500 mg/L, while the State Water Project water TDS is typically closer to 200-300 mg/L. The 12-month running average wastewater permit limits for recycled water are 700 mg/L for Regional WRF & Railroad WRF and 850 mg/L for Horsethief WRF. This is a fixed value. However, the permit limit can also be based off the 250 mg/L above the potable water supply TDS concentration (variable based on the monthly potable TDS value). Between the point of receiving the imported potable water or raw groundwater for distribution and discharging recycled water from the wastewater treatment plants, the TDS levels rise approximately 350-400 mg/L, exceeding the allowable addition of 250 mg/L.

Table 1. Horsethief Canyon WRF TDS permit exceedance

2020 TDS Concentrations (mg/L)	Horsethief Effluent	Permit Limit	250+ Source (12-month avg)	Exceeded Permit Limit?	Exceeded 250+ Source Limit?
January	736.4	850	659	No	Yes
February	762.4	850	646	No	Yes
March	734.3	850	638	No	Yes
April	649.2	850	649	No	Yes
May	636.0	850	657	No	No
June	629.0	850	662	No	No
July	726.4	850	674	No	Yes
August	737.2	850	693	No	Yes
September	736.7	850	705	No	Yes
October	833.6	850	716	No	Yes
November	736.8	850	730	No	Yes
December	696.3	850	736	No	No

Table 2. Railroad Canyon WRF TDS permit exceedance

2020 TDS Concentrations (mg/L)	Railroad Effluent	Permit Limit	250+ Source (12-month avg)	Exceeded Permit Limit?	Exceeded 250+ Source Limit?
January	931.6	700	634	Yes	Yes
February	805.6	700	632	Yes	Yes
March	790.3	700	626	Yes	Yes
April	842.8	700	604	Yes	Yes
May	827.6	700	607	Yes	Yes
June	750.4	700	592	Yes	Yes
July	772.7	700	597	Yes	Yes
August	768.8	700	588	Yes	Yes
September	716.7	700	595	Yes	Yes
October	758.8	700	598	Yes	Yes
November	702.8	700	612	Yes	Yes
December	730.0	700	581	Yes	Yes

Table 3. Regional WRF TDS permit exceedance

2020 TDS Concentrations (mg/L)	Regional Effluent	Permit Limit	250+ Source (12-month avg)	Exceeded Permit Limit?	Exceeded 250+ Source Limit?
January	753.6	700	627	Yes	Yes
February	715.6	700	496	Yes	Yes
March	722.7	700	554	Yes	Yes
April	725.2	700	454	Yes	Yes
May	748.4	700	564	Yes	Yes
June	669.7	700	574	No	Yes
July	698.0	700	586	No	Yes
August	728.4	700	590	Yes	Yes
September	696.3	700	600	No	Yes
October	750.0	700	676	Yes	Yes
November	679.6	700	706	No	No
December	677.3	700	540	No	Yes

This analysis aims to determine if the source of the increase in TDS, occurring between the source water received for use and the wastewater influent received at the water reclamation facilities, can be identified and if so, what alternative methods may be proposed to effectively and economically mitigate the source(s).

Four possible TDS sources are considered:

1) Raw source water
2) Chemically-treated potable source water
3) Domestic, industrial, and commercial uses
4) Chemical addition to sewer lift stations, for odor control purposes

CHAPTER TWO:

WHAT ARE TOTAL DISSOLVED SOLIDS?

The total solids measured in water are a combination of dissolved solids, suspended solids, and settleable solids. Total dissolved solids generally consist of inorganic salts and minerals, such as calcium, chlorides, nitrate, phosphates, iron, sulfates, and other ions that can pass through a 2-micron filter. Suspended solids include silt, clay, algae, plankton, and other fine organic matter, which cannot pass through a 2-micron filter (EPA, n.d.). TDS are naturally occurring within the environment and surrounding geological features can contribute to dissolved solid concentrations. For example, clay soils increase the ionic concentration in the water, while granite bedrock will not (Fondriest Environmental Learning Center , n.d.). Groundwater zones can also affect TDS values due to the varying geology that the water flows through.

TDS share a relationship with two other water quality indicators, salinity and conductivity. Salinity is the total concentration of all dissolved salts in water (EPA, n.d.) and conductivity is a measure of the water's ability to conduct electrical flow, which is directly related to the concentration of ions in the water. Typically, salinity is not measured directly for water quality; rather it is measured as a derivation from the measurement of conductivity. TDS, like salinity, also consist of inorganic salts and ions, but the difference is that salinity and conductivity are measures of dissolved ions in the water, while TDS also includes non-ionic species (EPA, n.d.). TDS usually are considered the equivalent of salinity in clean water, but in wastewaters, TDS can include organic solutes, such as hydrocarbons or urea, as well as the salt ions (EPA, n.d.). Most states issue a maximum limit for TDS as a measurement of water quality; discharges of recycled water to freshwater lakes or streams can have a limit of 2,000 mg/L of TDS, though many times the receiving streams or lakes existing TDS concentrations may already exceed that limit (EPA, n.d.). Concentrations above 2,200 mg/L have shown evidence of toxic effects on the ability of fish eggs to both hatch and survive (Fondriest Environmental Learning Center , n.d.). The maximum TDS limit for drinking water, however, is set at 500 mg/L (EPA, n.d.). For irrigation purposes, which is one of the primary beneficial reuse options for local water districts, the maximum TDS limit is suggested to be 700 mg/L (Water Quality Control Plan for Santa Ana River Basin, 2016).

The concentration of TDS in natural waterways is important, because of its ability to affect the balance of an aquatic organism's cellular structure. When the surrounding environment is higher in dissolved solids, the flow of water will move to the environment, away and out from the organism's cells, causing them to shrink. Conversely, when the amounts of dissolved solids are lower in the surrounding aquatic system, the flow of water will move into the organism's cells, causing them to swell. If the aquatic organisms are not able to adapt to the changes in salinity, they may struggle to thrive or even survive. Additionally, solids in the water affect the clarity of water, which hinders light's ability to reach aquatic plants for photosynthesis and the higher concentrations of solids in the water can cause water to heat up at a higher rate than it would under normal conditions, which could lead to the warmer temperature having an adverse effect on the aquatic life (EPA, n.d.). For humans, the effects of TDS in water tend to be more aesthetic issues – color and taste. A high concentration of solids leads to water that is unpalatable in taste and may leave deposits on glassware.

Beyond the effects to public health and the environment, certain constituents of TDS, such as chlorides, magnesium, and calcium, can cause unfavorable effects to water-distribution systems, in the form of corrosion or scaling (WHO Guidelines for Drinking-water Quality, 2003). Additionally, TDS levels in excess of 500 mg/L can cause economic damages to households, with increased scaling in water pipes, household appliances, and water heaters (WHO Guidelines for Drinking-water Quality, 2003).

Almost every user or producer who utilizes water adds salt into the associated wastewater and in California's Central Valley alone, more than 7 million tons of salt are added annually to the water and wastewater systems from users (Central Valley Salinity Coalition, 2021). This results in a substantial cost, with up to 250,000 acres of land annually rendered unusable due to the excessive salt loadings impairing the ability of agricultural growth. This causes the land to be taken out of production and 1.5 million acres deemed as salinity impaired, which can yield an annual cost of up to $1.5 billion dollars by the year 2030 (Central Valley Salinity Coalition, 2021). The salt issue compounds, as surface water and groundwater sources are inter-connected and the TDS deposits accumulate in the soil and water, creating a long-term chronic problem.

TDS is measured in milligrams per liter and can be determined by either a gravimetric measurement or as a calculated value, specifically by multiplying conductivity with an empirical factor. The empirical factor can be obtained when the source of water is known to be freshwater or freshwater mixed with saline water. The Standard Methods for the Examination of Water and Wastewater accepts an empirical conductivity factor of 0.55-0.7, where the conversion equation is: $TDS\ (mg/L) = k * EC(\frac{\mu S}{cm})$, where K is the empirical conductivity factor and EC is electrical conductivity (Fondriest Environmental Learning Center , n.d.). For purposes of obtaining field measurements or performing continuous monitoring, the calculation method is preferable, as it is a quicker option (Fondriest Environmental Learning Center , n.d.). The gravimetry method requires more time but is beneficial if the source water is not known. In the case of wastewater, the source cannot be identified from any one specific water body, so the gravimetric method is used - specifically the EPA-approved Standard Methods 2540C (Standard Methods for the Examination of Water and Wastewater 18th Ed, 1992).

CHAPTER THREE:

HISTORY OF REGULATIONS

One of the main impetuses for water quality regulation stems from the Clean Water Act. The Clean Water Act of 1972 was adopted in response to the public concern for environmental issues relating to the nation's water bodies. Some of the notable events that spurred the formation of this act include the Cuyahoga River fires and pollution in the Nashua River. The Nashua River is located in Massachusetts and New Hampshire, and in the mid-1900's was so heavily polluted by local industries and municipal wastes that the river was considered essentially an open sewer and the only life forms that could survive in the river were sludge worms (McGraw Hill Companies). The Nashua River experienced periods of changing into various colors, based on the industrial discharge from the textile mills located along the river. The Cuyahoga River was also one of the most polluted rivers in the United States during the early to mid-1900's, due to the increased industrialization and lack of waste disposal regulations (Ohio History Central). Raw sewage and other pollutants such as gasoline, oils, paints, and metals were being discharged directly into the river, causing the river to be referred to by some as 'a rainbow of many different colors' (History of the Cuyahoga River) and a 'flowing dump' (History of the Cuyahoga River). Multiple fires broke out on the river from 1868 to 1952, resulting in significant damage to local structures, but the river fire which occurred in 1969 was the most documented, due to the increasing scrutiny on environmental concerns and the safety of the waterways. It was after this 1969 Cuyahoga River fire event that the National Environmental Policy Act was signed into law and this act assisted in establishing the EPA, where one of the first legislations put into action was the Clean Water Act.

The Clean Water Act of 1972 was essentially an amendment to a previous federal law known as the Federal Water Pollution Control Act of 1948**.** While the Federal Water Pollution Control Act had the right intentions, it wasn’t very effective; it didn’t truly prevent pollution, as it gave only limited oversight to government bodies, and included a complex enforcement scheme (Powers). The Clean Water Act amended those regulations to provide the basic structure for regulating pollutants and wastewater discharges into surface water bodies and gave enforcement rights to the EPA to ensure compliance. Funding was allotted for construction of sewage plants and permits were issued for rights to discharge, upon meeting given limits. The Clean Water Act established regulations that altered the landscape of the current disposal practices of sewage and industrial waste facilities.

The EPA or individual states now issue permits to industrial and municipal dischargers and the responsibility falls upon local agencies to ensure compliance is being met and permit conditions are reasonable. Under the Porter-Cologne Water Quality Control Act**,** the State Water Resources Control Board is given the authority for water rights and water quality policy within California (Sunding &

Zilberman, 2005). The Porter-Cologne Act also established nine local satellite offices of the State Water Quality Control Board, known as regional boards. The Porter-Cologne Water Quality Control Act tasked the regional boards with creating local basin plans to identify beneficial uses of water bodies, water quality objectives, and enforcement plans to regulate point and non-point sources of pollution to local water bodies (Sunding & Zilberman, 2005). Many discharge permits refer to these basin plans to help set local limits and objectives.

In the Inland Empire (the region east of Los Angeles, California consisting of the metropolitan area surrounding the cities of San Bernardino and Riverside), prior to settlement, it is opined that the Santa Ana River primarily flowed from the San Bernardino mountains to the Pacific Ocean for a majority of the year (Water Quality Control Plan for Santa Ana River Basin, 2016). The San Jacinto River also provided a substantial flow of water to the region, but is suggested to have ended in Lake Elsinore, which is essentially like a sink, as the lake has inlet points but no outflow locations. When heavy rainfall events occurred, the flows from San Jacinto River may have overflowed the lake, which would have caused the water to be diverted to Temescal Creek, which in turn flows to the Santa Ana River. Both rivers historically provided plenty of water to groundwater basins and kept them relatively full. Over time, the flows from both the San Jacinto River and Santa Ana River have been diverted to agricultural and domestic uses, and now typically only carry waters from intermittent stormwater events, agricultural run-off, and treated wastewater (Water Quality Control Plan for Santa Ana River

Basin, 2016). Periods of drought and dry weather conditions have also impacted the regions surface water bodies and groundwater zones.

While many agencies began to look to imported water sources for aiding in supply, locally available water is generally more affordable, and therefore, more desirable. However, with the excessive use and reuse of the water, downstream users of the San Jacinto River and Santa Ana River were receiving reduced flows with a noticeable ‘salty’ taste (Water Quality Control Plan for Santa Ana River Basin, 2016). In the late-1960’s, the recently enacted Federal Clean Water Act and Porter-Cologne Act resulted in the regional boards actively constructing plans to meet the newly established water quality objectives. While establishing these plans and objectives, the Santa Ana Regional Water Quality Control Board identified the salt balance and TDS issue in the region’s water supplies, which was occurring due to the continuous cycle of use (Water Quality Control Plan for Santa Ana River Basin, 2016). Each cycle was typically adding additional salts into the water, either from evaporation (which decreases the dilution factor) or by direct addition, at a rate of approximately 200-300 mg/L increase per cycle (Water Quality Control Plan for Santa Ana River Basin, 2016). For reference, drinking water TDS regulations are set at 500 mg/L and above this point, the TDS levels start to affect the usability of water. At 2000 mg/L, water is brackish and not suggested for use.

Some of the initial plans to address the brackish, overused water included importing large volumes of low TDS water, via the State Water Project;

constructing a large well field to remove the poor-quality water from the basin; or initiating use of a brine line, which collects the high TDS water and transports it directly to the ocean (It is important to note that ocean salt water is typically greater than 15,000 mg/L TDS, while brine is greater than 35,000 mg/L TDS).

CHAPTER FOUR:

LITERATURE REVIEW

The EPA issues National Pollutant Discharge Elimination System (NPDES) permits for any facility which discharges recognized pollutants from a point source into a surface water body, such as a river, lake, or even out to 200 miles into the ocean (NPDES Permit Basics, n.d.). A point source is identified as containing a specific conveyance feature, such as a pipe, channel, or tunnel, which transfers potential pollutants from the facility into a water body (NPDES Permit Basics, n.d.). The EPA issues either a general NPDES permit, which can cover all dischargers within a specific region who exhibit similar operations and discharge waste to the waters of the United States, or an individual NPDES permit, which identifies the allowable site-specific potential pollutants load discharge from the facility, the current ambient status of the receiving water body, and treatment capabilities (NPDES Permit Basics, n.d.).

For facilities that generate waste but discharge to land as opposed to surface water bodies, California state issues Waste Discharge Requirement (WDR) permits. WDR permits are issued by the regional water quality control board under the provisions of the California Water Code, Division 7 “Water Quality,” Article 4 “Waste Discharge Requirements.” (Water Quality Control Plan for Santa Ana River Basin, 2016) . ‘The requirements regulate the discharge of wastes which are not made to surface waters, but which may impact the region’s water quality by affecting underlying groundwater basins. Such WDRs are issued for municipal wastewater reclamation operations and discharge of wastes from industrial facilities or other activities such as septic systems, sanitary landfills, dairies, or other activities which can significantly affect water quality. (Water Quality Control Plan for Santa Ana River Basin, 2016)

Both types of permits have specific sets of nutrient and pollutants limitations, and any facilities caught discharging without an appropriate permit or discharging outside of permitted limits are subject to fines, penalties, or imprisonment for environmental negligence. Additional policies, such as the Recycled Water Policy (State Water Resources Control Board - Cal EPA, 2019), further researches and analyzes groundwater basins to assist in developing sustainable solutions for local water supplies. Information from these types of policies affect both the regional basin plans and the existing Waste Discharge Requirements, and influence future permit renewals and revisions.

One important feature to note between the federal and state guidelines is that while the EPA grants authority to the State Water Resources Control Board, there are certain caveats to this authority: while the state can choose to be more stringent with limitations and guidelines than the federal government, it cannot be more relaxed. For example, the EPA for the NPDES general permit requires a minimum of secondary-treated wastewater; however, for most dischargers within the Inland Empire, and for Elsinore Valley Municipal Water District (EVMWD), the NPDES discharge requirement is at least disinfected tertiary-treated wastewater.

Many of the California State requirements for recycled water criteria can be found within California Title 22 Code of Regulations, Division 4, Chapter 3 (Cornell Law School: Legal Information Institute).

California has also adopted a state-wide Recycled Water Policy to address recycled water criteria for dischargers. As noted above, §6 (6.1) (6.11) of the Recycled Water Policy identifies groundwater basins within various regions of the state already containing salt and nutrients that exceed water quality objectives. Some of these salt and nutrients exist naturally in the environment, while others may have been added as a result of industrial, domestic, or municipal wastewater discharges or agricultural fertilizers (State Water Resources Control Board - Cal EPA, 2019). Additionally, recycled water also contributes to the TDS loading within the local area, due to inability of the general wastewater processes to reduce TDS concentrations. However, the Recycled Water Policy identifies that there is not a realistic, nor feasible, one-size-fits all solution for the various regions. Combined with the information gleaned from the basin plans, Section § 6 (6.1) (6.1.3) of the Recycled Water Policy necessitates that if a discharger is contributing to a groundwater basin or sub-basin that is determined to have salt or nutrient contents which pose a threat to water quality, the discharger has to procure a Salt & Nutrient Management Plan (State Water Resources Control Board - Cal EPA, 2019) to monitor, analyze, and address any possible degradation concerns to maintain compliance with the State Water Resources Control Board Resolution 68-16 Statement of Policy with Respect to

Maintaining High Quality of Waters in California (Antidegradation Policy) (State Water Resources Control Board - Cal EPA, 2019).

The Inland Empire (including Lake Elsinore) is considered to be part of the 8th California water quality control region and is regulated by the Santa Ana Regional Water Quality Control Board. Within this region, the Santa Ana River Basin plan provides the majority of the water quality objectives and identifies constituents of concern for the area, and many of the subsequent water quality reports and limits that EVMWD complies with are based upon the Water Quality Control Plan, including the Salt and Nutrient Management Plan (SNMP), Total Maximum Daily Loads (TMDLs), Total Nitrogen/Total Phosphorus Offset Plan, etc.

The Water Quality Control Plan, commonly referred to as the Basin Plan, is a document that recognizes regional water quality differences, the varying beneficial uses of the region's water bodies, and local water quality concerns and issues (Water Quality Control Plan for Santa Ana River Basin, 2016). Each of California's nine Regional Boards must adopt a Basin Plan specific to their region. The Basin Plan also establishes water quality objectives for both groundwater and surface waters. Cited in the Santa Ana Regional Water Quality Control Basin Plan is CCR, Division 4, Chapter 15, Article 16, §64449, which states that the concentration of TDS in drinking water should be limited to 500 mg/L and that water used for irrigation purposes should maintain a TDS concentration below 700 mg/L (Water Quality Control Plan for Santa Ana River Basin, 2016).

The Water Quality Control Plan for the Santa Ana Basin (Basin Plan) includes a TDS and Nitrogen Management Plan (SNMP). The revised SNMP addresses TDS and nitrogen in both surface waters and groundwaters throughout the Santa Ana River basin in order to control the excess salt buildup in the region’s waters. The average TDS and nitrate-nitrogen concentrations are reassessed every 3 years and the plan is reviewed and amended as needed. An SNMP is required for regions which are impaired for salinity and nitrogen. EVMWD has an SNMP with the following key elements:

1. Compute antidegradation objectives for nitrogen and TDS;
2. Calculate current ambient water quality for the applicable groundwater management zone;
3. Estimate the impact of recycled water use and recycled water discharge plans on the water quality of the groundwater management zone; and
4. Describe the regulatory considerations for alternative plans relating to recycled water and challenges surrounding TDS and nitrogen. (Inc., 2017).

Additional literature reviewed includes 40 Code of Federal Register (CFR) Chapter I, Sub-Chapter N – Part 400-471 (Categorical Dischargers and their

Effluent Guidelines), to assist this analysis with identifying certain industrial dischargers that may be contributing excess TDS loads to the wastewater stream. Industrial dischargers are analyzed by Standard Industrial Classification (SIC) codes, which specify industrial waste dischargers by industry types, and the associated concentrations of expected pollutants based on that industry. Certain SIC codes and categories of industries are suspected or known to generate high TDS wastewater.

CHAPTER FIVE:

WATER AND WASTEWATER TREATMENT OVERVIEW

The EVMWD water and wastewater systems are located in western Riverside County and serve the cities of Lake Elsinore and Canyon Lake, portions of Murrieta and Corona, and other unincorporated cities within its 96-square mile service area. In 2020, EVMWD provided approximately 7.4 billion gallons of potable water to its customers. To meet this demand, EVMWD operated eleven groundwater production wells and purchases treated imported water from Metropolitan Water District via the Auld Valley Pipeline and the Temescal Valley Pipeline. In 2020, imported water accounted for approximately 63% of EVMWD’s water supply, with groundwater contributing 37%. The Canyon Lake Water Treatment Plant typically also provides potable water via a surface water source (Canyon Lake) approximately 6 months per year. During the year 2020, however, the treatment plant was placed offline to address issues with meeting new treatment requirements for per- and polyfluoroalkyl substances (PFAS), a constituent of emerging concern. At this time, the plant is scheduled to remain offline until further notice and the design to upgrade the plant is in progress. No data from the Canyon Lake Water Treatment Plant is included in this analysis.

There are currently eleven groundwater-producing wells for potable use in EVMWD's service area, though not all are online and pumping water at the same time; only nine operated during the year 2020. The groundwater produced from the well sites tends to have higher TDS than imported sources: approximately 500 – 1000 mg/L. It should be noted that while some of the well sites are located near the lake in Lake Elsinore, the lake bottom has a non-permeable clay layer, which restricts the primarily recycled lake water from flowing down to the groundwater table. The Canyon Lake Reservoir also tends to be higher in TDS, approximately 800 mg/L because it is a surface water body, which tend to contain more contaminants and require more treatment than groundwater. Imported sources in Southern California are usually obtained from the State Water Project or the Colorado River. The State Water Project includes 22 dams and reservoirs and a 700+-mile long delivery system that transports water from Northern California to Southern California (Public Works Los Angeles, n.d.). The Colorado River passes through seven states and allots 4.4 million acre-feet of water annually to California. The imported source water for EVMWD is in the form of potable water purchased from Metropolitan Water District, which gets their water through both the Colorado River and the State Water Project (Public Works Los Angeles, n.d.). Approximate TDS values for the State Water Project water are generally 200-300 mg/L, while the approximate TDS values for the Colorado River water is 350-500 mg/L

Groundwater is produced from the local groundwater wells. After extraction, the raw, untreated groundwater is sampled for several parameters, including TDS. Certain well sites dose sodium hypochlorite or chloramine for disinfection prior to pumping water into the distribution system, so chemicals are typically added at these wells. Chloramines consist of a mixture of 12.5% chlorine and 19% aqueous ammonia, at a 5:1 ratio, and are an alternative for chlorine bleach. Since chloramines are less volatile, they remain in the water longer and do not produce as many disinfection-by-products as chlorine (CDC Center for Disease Control and Prevention, n.d.). It is important to note that both chlorine and chloramine dosing for disinfection do contribute to the overall TDS in the water. The chemical dosage and TDS contribution may vary, based on ambient groundwater parameters and chlorine demand. It is also important to note that two well sites (Cereal 3 and Cereal 4) experience high arsenic issues and require blending of flows with other well sites to meet the maximum contaminant level (MCL) for arsenic set out by the EPA. Due to this, additional sampling occurs at the blending stations, including samples collected to measure TDS after disinfection occurs in the individual flows. Of the nine active well sites which produced water during 2020, seven utilized chloramines and two utilized sodium hypochlorite.

For the facilities which dose chlorine-only, aqueous chlorine in the form of hypochlorous acid (HOCl), is used as the disinfectant product and acts as a weak acid which ionizes to form a positively charged hydronium ion and the negatively charged hypochlorite ion. (National Research Council (US) Safe Drinking Water Committee, 1980):

$$HOCl \Leftrightarrow H^+ + OCl^-$$

Chlorine uses three basic mechanisms to react in organic solutions: addition, oxidation, and substitution. In all three mechanisms, the hypochlorous acid serves as the electrophile. However, only in the addition and substitution reactions will chlorinated products be formed (National Research Council (US) Safe Drinking Water Committee, 1980) and the chlorinated products can result in in trihalomethanes. There are four primary trihalomethane species: chloroform ($CHCl_3$), bromodichloromethane ($CHBrCl_2$), dibromochloromethane ($CHBr_2Cl$), and bromoform ($CHBr_3$) (Nuckols, et al., 2005). The sum of the trihalomethanes is measured as the total trihalomethanes (TTHMs). TTHMs are associated with adverse health effects such as cancer and reproductive harm (Nuckols, et al., 2005).

For facilities which utilize chloramines, the chloramines are created using a combination of chlorine (Cl_2) with ammonia (NH_3), at an approximate 5:1 ratio. The chemical equation for the formation of monochloramine (NH_2Cl) as follows:

$$NH_3 + HOCl \longrightarrow NH_2Cl + H_2O$$

Dichloramine ($NHCl_2$) and trichloramine (NCl_3) can also be formed. The hypochlorous acid reacts rapidly (the reaction rate is usually 90% complete in approximately 1 minute (National Research Council (US) Safe Drinking Water Committee, 1980)) with the ammonia to form a mixture of monochloramine, dichloramine, and trichloramine. The formation of the various chloramines depends upon several factors, including pH, the concentrations of the hypochlorous acid and ammonia, reaction times, and temperature (National Research Council (US) Safe Drinking Water Committee, 1980). However, monochloramine is typically the primary chloramine compound observed based on the conditions associated with water treatment. Monochloramine is assumed to contribute less to disinfection-by-products (DBPs) such as TTHMs, but limited studies exist which focus on what products may form after reaction of chloramines with organic or inorganic constituents of the water supply. Based on current studies, reaction mechanisms for chloramines include addition, substitution, oxidation, amination, and free radical reactions (National Research Council (US) Safe Drinking Water Committee, 1980). However, many of these reactions require either very high or very low pH values, which are typically not seen in drinking water treatment (pH is maintained between 6.5 – 8.5). As such, it is opined that interpretation of the chemical studies relating to these reactions are more speculative in nature.

The water from the blending stations and six of the nine operating wells enters directly into the distribution system. Figure 2 shows a map which includes the well sites and blending stations. However, water produced from both the Cereal 3 Well and Cereal 4 Well is directed to the Back Basin Groundwater Treatment Plant (BBGWTP) for additional treatment and removal of arsenic. The BBGWTP's primary function is to remove arsenic, which is achieved by using ferric chloride addition. Chloramines are also dosed at this facility, for additional disinfection. Terra Cotta Well water also does not enter the distribution system directly, but instead is routed to Lucerne Reservoir. No additional chemical dosing is performed at the Lucerne Reservoir.

The well sites and treatment plant are not the only locations where chemical disinfection is added. Along the distribution system, there are water pump stations which capture water at low pressure zones and utilize pumps to increase pressure and allow the potable water to either overcome the head pressure for higher elevations or maintain proper pressure levels for consumption. There are nine pump stations located within the EVMWD boundary that dose chemicals: three stations dose sodium hypochlorite and six stations dose chloramines.

The imported potable water is also sampled for certain parameters, including TDS, then directed to nearby booster systems, which automatically monitor the chlorine residual values and dose additional sodium hypochlorite or chloramines if residuals are low. The booster systems pump the potable water into the distribution system, allowing adequate pressure for consumer use. Once the water demand in the distribution lines is fulfilled, the water begins to fill the nearest reservoirs, for storage purposes and later use during peak demands. The maximum dosage rate for chlorination of drinking water is 4 mg/L (EPA, n.d.).

Once the potable water is available in the distribution system, industrial, commercial, and private consumers then utilize the potable drinking water, converting a percentage of the water to a waste product to be discharged into the sewers and transported to the wastewater treatment plants. For purposes of determining potential sources of increased TDS concentrations, industrial and commercial users were identified within EVMWD service area. There are approximately 278 permitted industrial users within the EVMWD service area, none of which are considered as Significant Industrial Users (SIU). A Significant Industrial User is a discharger that is either subject to categorical pretreatment standards (40 CFR 403.6 and 40 CFR Chapter I, Sub-Chapter N) or meets the following:

1. discharges an average of at least 25,000 gallons per day of process wastewater,

2. contributes process wastewater discharges that constitute 5% or more of average dry-weather flow conditions, and

3. is designated by the Public Owned Treatment Works (POTW) as having a reasonable potential for adversely affecting the POTW operations (Environmental Protection Agency, n.d.).

Approximately 80% of the permitted industrial dischargers are ‘Food Service Facilities’, such as restaurants. The primary concern from restaurants is the discharge of Fats, Oils, & Grease (FOG) to the sewer. FOG can lead to blockages in sewer pipes resulting in sewer overflow and failure of equipment, such as pumps.

Other industry types consist of car washes, auto repair shops, and liquid waste haulers. However, there are no significant industrial activities or manufacturing plants which could significantly affect the TDS concentration. The automobile repair shops, and car washes have oil/sand gravity separators to prevent excessive grit and oily discharges entering the sewer. Petroleum based oil discharges into sewers are discouraged because of adverse impact on processes in the water reclamation facilities and to avoid a condition called ‘pass through’, where the pollutants pass directly through the entire treatment processes and enter via the effluent into the environment. Pass through of specific pollutants is prohibited in the discharge permits and could lead to serious fines or penalties, however oil discharges are not expected to contribute significantly to TDS concentrations. EVMWD also has septic haulers occasionally dumping domestic septage from septic tanks or portable toilet waste at the Regional Water Reclamation Facility, but those are limited, about one every month received, on average. Additionally, domestic households and other buildings discharge domestic wastewater to the sewer.

EVMWD has over 400 miles of sewer system, including force mains, gravity lines, and lift stations. Once the used waters have been discharged into the sewer system, the wastewater can follow a variety of pathways to make its way to the nearest water reclamation facility. One possible method of transport is a gravity line to the nearest lift station where flow is achieved by a difference in elevation. To move waste to higher elevations, a sewage lift station is used. This consists of a wet well, where the raw wastewater is received and when it reaches a designated level, the pumps are turned on. The pumps typically used are known as submersible pumps and can pump up to 7500 gallons per minute (GPM). The pumps discharge the raw sewage into a force main, which is a pressurized pipe that transports the flow from a lower elevation to a higher elevation. Once the pipe reaches the desired high elevation, it will slope downward again, and the raw wastewater will flow by gravity down to the next lift station or the treatment plant. During the interim periods that the wastewater collects at the lift stations, odors from the hydrogen sulfide can sometimes be noticed by nearby neighbors, especially if the lift station is located in a residential neighborhood or next to a heavily foot-trafficked area. To combat this issue of public nuisance, sodium hypochlorite is dosed into the wet well to reduce the odors by oxidizing hydrogen sulfide and organic odors. Of the 36 lift stations in operations, 15 utilize sodium hypochlorite as an odor control solution.

The cycle of gravity, lift, and pump continues until the sewage reaches the nearest water reclamation facility. Once received at the reclamation facility, the raw wastewater enters into the wet well of the plant influent pump station, where it is pumped into the headworks of the water reclamation facility. It is during this initial pumping period, prior to the headworks, that both composite samples and grab samples are collected. Influent samples are for monitoring purposes only and have no limitations; however, if the influent is too high in certain parameters, it could affect the plant's ability to treat the wastewater or lead to an exceedance in permit limits for effluent discharge or sludge disposal.

EVMWD has three water reclamation facilities: Regional Water Reclamation Facility (Regional WRF), which discharges to surface water bodies (both Lake Elsinore and Temescal Creek) and holds an NPDES permit; and Horsethief Canyon WRF and Railroad Canyon WRF, which both discharge to land and have Waste Discharge Requirement (WDR) permits. All three permits reference specific requirements relating to salt concentrations; specifically, the current TDS limits are 700 mg/L for Regional WRF and Railroad Canyon WRF and 850 mg/L for the Horsethief WRF. However, per the permits, the effluent limit is identified in two-parts; either by the specified limit listed in the permits or by calculating the amount of potable TDS (from source water, prior to distribution into the community for use) plus an additional 250 mg/L. Whichever is the lower value becomes the controlling limit, and therefore the facility may be within the limit listed in the permit, but still exceed effluent concentrations due to the inability to meet the source water-plus 250 mg/L objective (or vice versa). While the wastewater treatment plants do not have processes or equipment to specifically remove TDS, the removal of soluble organic matter and ammonia nitrogen throughout the treatment process results in a net removal of approximately 2 to 6 % of influent TDS (MWH - prepared for EVMWD, 2012).

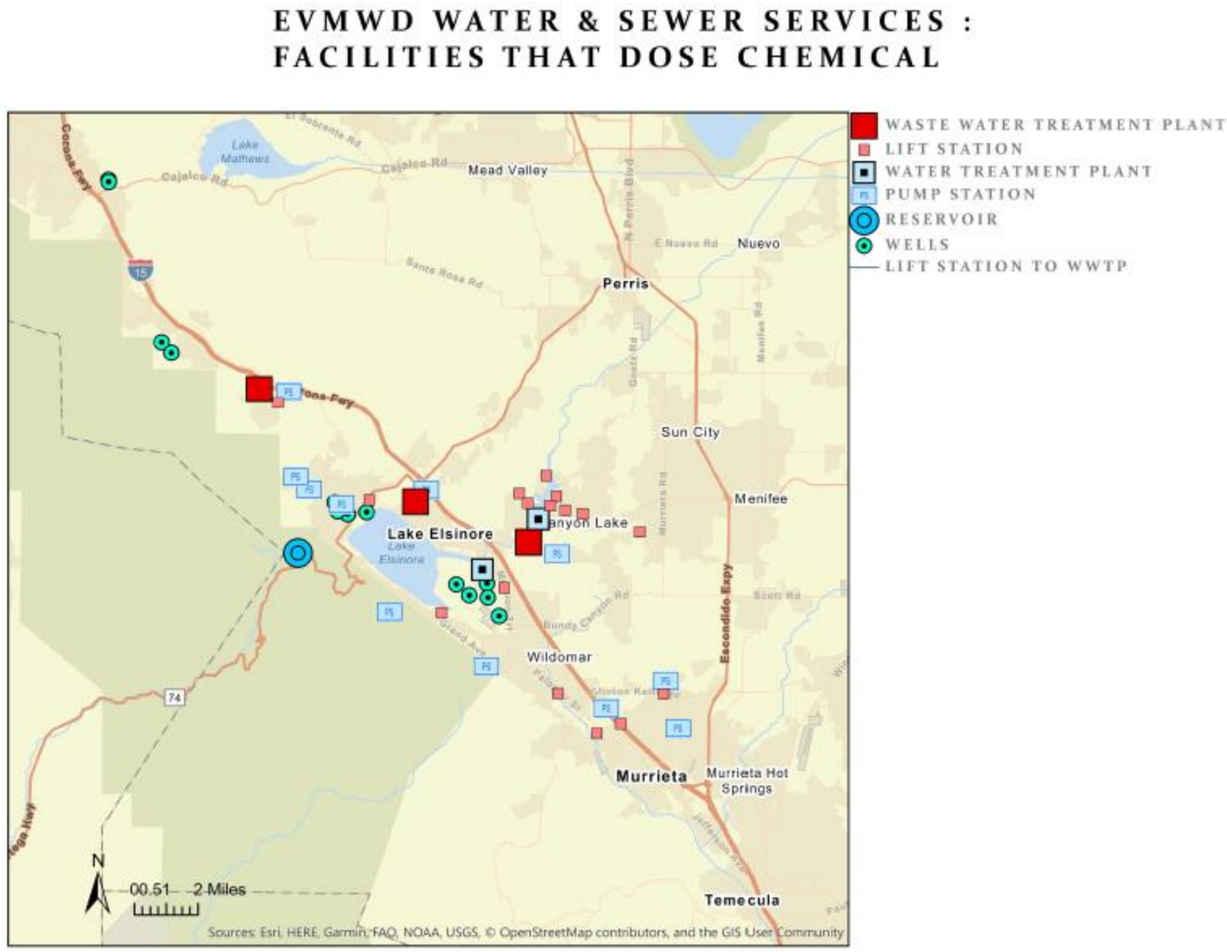


Figure 2. Water/wastewater facilities located within EVMWD boundary that dose chemicals & potentially add to the TDS load in the system

Figure 2 above shows a map of EVMWD's service area and focuses on the main locations that utilize chemicals for various purposes throughout the system. The sewer lift stations typically contribute TDS via sodium hypochlorite addition for odor control, while the water treatment plants, pump/booster stations, reservoirs, and wells dose chloramines or sodium hypochlorite for disinfection.

As mentioned above, the initial hypothesis focuses on the likelihood of the sewer lift stations as the primary source of increased TDS to the wastewater treatment facilities, as these lift stations serve as direct arteries to the influent of the wastewater plants which show high influent TDS values. The lift stations currently have no existing flow meters nor chemical dosing meters, so there is no historical data to analyze and/or compare to. Samples were initially intended to be collected at the sewer lift stations which apply chemicals for odor control, at locations directly upstream and downstream of the stations to capture data for this analysis. However, EVMWD underwent management modifications in the sewer Collections Systems department during the 2020 calendar year, and the most recent Collections System manager began an odor control study at the beginning of 2021. In this odor control study, different chemicals or methods are used to control odors instead of the usual sodium hypochlorite addition. At this time, the odor control study is still ongoing. These alternative odor control methods include various proprietary nitrate-based products from different chemical vendors, ferrous chloride, and odor control scrubber methods (which may not contribute chemical).

CHAPTER SIX:

METHODOLOGY

Sample collection occurred at multiple locations for this analysis. TDS samples sites include the influent of the water reclamation facilities for monitoring purposes, and groundwater well sites, blending stations, and potable water pump stations for compliance purposes. TDS samples were analyzed using the gravimetric method to yield the most accurate solids values.

The analysis for total dissolved solids using Standard Methods 2540C is based on the weight increase of a pre-weighed dish before and after application of sample. The difference in weight is calculated to then yield the value of TDS. To begin the sample collection, resistant glass or plastic bottles should be used to assist in preventing the adherence of particles to the sample bottle walls (Standard Methods for the Examination of Water and Wastewater 18th Ed, 1992). Samples are not preserved and need to be analyzed as soon as possible, though if some time was needed, refrigeration of the sample up to 4°C helps to minimize any possible decomposition. Seven days is the maximum hold time allowed for a solids sample.

The analysis first involves mixing the sample thoroughly and then filtering through a standard glass fiber filter (Standard Methods for the Examination of Water and Wastewater 18th Ed, 1992). The glass fiber filter is prepared prior to analysis and washed with three successive 20-mL amounts of reagent grade water, then suctioned dry until all traces of water are removed (Standard Methods for the Examination of Water and Wastewater 18th Ed, 1992). An evaporating dish is also prepared by heating a clean dish in an oven at approximately 180°C for one hour. The prepared dishes are stored in a desiccator and weighed immediately before use.

When ready, the sample is stirred with a magnetic stir bar and a volume intended to yield between 2.5 to 200 milligrams of dried residue is pipetted to the prepared 2 micron-or-less glass fiber filter and vacuum apparatus (Standard Methods for the Examination of Water and Wastewater 18th Ed, 1992). For wastewater and recycled water samples, the volume collected is 50 mL. The glass fiber filter is washed three times with 10 mL of reagent grade water and allowed to completely dry between each wash. Once washing is complete, the vacuum apparatus continues to suction for another three minutes, then the total filtrate and washings are transferred to the prepared and pre-weighed evaporating disk. The sample is dried in a drying oven for at least one hour at approximately 180 °C, then cooled in the desiccator to balance temperature, and weighed. The samples continue to be dried, cooled, desiccated, and weighed until the weight change stabilizes. The amount of total dissolved solids can be calculated by using the following calculation: $\frac{(A-B)\times 1000}{sample\ volume, mL}$, where A is the weight of dried residue and the dish (in mg) and B is the weight of the dish (in mg).

Statistical analysis was used to develop a greater understanding of the potential influence of the various hypotheses on the influent TDS concentrations at the wastewater treatment plants. The WRF influent TDS concentrations are identified as the response variables, while the various TDS concentrations sampled and estimated throughout the system serve as the explanatory variables. The response variable is analyzed to determine the level of dependency, if any, on the explanatory variables. Linear regression models were completed using Excel and R software (The R Project for Statistical Computing, 2021) to assist in this determination of potential cause and effect scenarios.

Typically, a multiple linear regression model is:

$$\hat{Y} = b_0 + b_1X_1 + b_2X_2 + \cdots + b_pX_p$$

Where:

$\hat{Y}$ = the TDS value for the WRF influent

X_1 through X_p = X_1 (TDS addition from consumer use)
X_2 (Raw TDS)
X_3 (Treated Source Water TDS)

b_0 = value of Y when all independent variables are zero

b_1 through b_p = relative TDS contributions from each sample location

Maps were generated using Esri ArcGIS Pro software. Monitoring data was collected from Supervisory Control and Data Acquisition (SCADA) software systems (Inductive Automation, 2018) and EVMWD operator log sheets.

Laboratory sampling and analyses were completed by the EVMWD Regional Lab.

Calculations

Source water TDS calculations are weighted values using the water production volume and TDS concentrations to determine the monthly source water TDS results. This monthly source water TDS will be allowed an additional 250 mg/L buffer. If the total TDS value (source + 250 mg/L) is *lower* than the wastewater treatment plant's numerical permit effluent limit, this TDS values (source water TDS + 250 mg/L) becomes the controlling effluent limit.

Weighted Average of Source Water TDS:

1. $Production\ Volume\ \left(\frac{ac}{ft}\right) * TDS\ \left(\frac{mg}{L}\right) = Individual\ Weighted\ TDS\ \left(\frac{mg}{L}\right)$

2. $\frac{\Sigma Individual\ Weight\ TDS\ \left(\frac{mg}{L}\right)}{\Sigma Volume\ \left(\frac{ac}{ft}\right)} = Weighted\ Avg.of\ Source\ Water\ TDS\ \left(\frac{mg}{L}\right)$

The addition of sodium hypochlorite (NaOCl) was also calculated to determine the estimated TDS impact for the water and wastewater system. The flows and concentration were converted to pounds of TDS per day added to the system and recalculated to yield the concentration per day:

$$NaOCl\ Mass\ Added\ (Weight) = Flow * 24\frac{hr}{day} * 8.34\frac{lb}{gal} * chemical\ concentration$$

Where: the NAOCl mass added is lbs/day

flow is in gallons per hour

the chemical composition is a percentage

$$NaOCl\ Masses\ Added = \left(\frac{Chemical\ Weight}{Flow} * 8.34\frac{lbs}{gal}\right) * (Days\ in\ operation)$$

Where: the NaOCL mass added is in mg/L

Flow is in million gallons per day

Per EPA regulations, the maximum dosing concentration for both chlorine and chloramines is 4 mg/L (EPA, n.d.). When chlorine is added to water, certain chemical reactions occur which can yield different compounds and reduce the availability of free chlorine necessary to maintain disinfection. A chlorine residual of at least 0.2 mg/L is required in a drinking water system, so additional system dosing may be needed to maintain this residual requirement.

Sample data for this analysis includes approximately 600 TDS samples taken between January 1 and December 31, 2020. Samples were collected at both the influent and effluent locations of the three water reclamation facilities, to first determine if the treatment plants were contributing a significant source of

TDS to the final effluent values (Table 4). Samples were also collected at various locations throughout the water and wastewater system, specifically at sites which are known to contribute TDS additions into the system. As these sites are known to contribute to TDS, these various location samples are used to assist in determining the significance of the TDS additions at the influent of the water reclamation facilities. The locations sampled throughout the system include the raw, untreated groundwater wells; the groundwater wells and water pump stations that dose chemicals for disinfection purposes; and the imported water sources that have already been disinfected. Samples were intended to be collected at lift stations and throughout the wastewater system but were unable to be collected at the time of this study due to staff turnover and the initiation of lift station odor control studies. During these odor control studies, the existing sodium hypochlorite systems were placed offline and various other chemicals were temporarily used to determine their effectiveness for odor control. Due to this, no representative samples specifically focused on the TDS contributions from sodium hypochlorite dosing at the lift stations could be collected. Further sampling and studies are recommended for lift station sites which dose sodium hypochlorite for odor control purposes.

Table 4. TDS Sample Sites

	Site	Samples	Flow	TDS	Flow	TDS	Flow	TDS
Water Reclamation Facility (WWTP)	Regional WRF	365	X	X	X	X	X	X
	Railroad Canyon WRF	52	X	X	X	X	X	X
	Horsethief Canyon WRF	52	X	X	X	X	X	X
Wells (Raw Water)	Cereal 1 Well	6			X	X		
	Cereal 3 Well	4			X	X		
	Cereal 4 Well	8			X	X		
	Corydon Well	6			X	X		
	Diamond Well	10			X	X		
	Joy St. Well	11			X	X		
	Machado Well	12			X	X		
	Terra Cotta Well	11			X	X		
	Flagler 2A & 3A Well (combined effluent flow)	13			X	X	X	X
Blend Stations (Potable, disinfected combined flows of specific well sites)	Machado Blend - includes water from Joy St. Well & Machado Well	7					X	X
	Back Basin Groundwater Treatment Plant (BBGWTP) - includes water from Cereal 2 Well & Cereal 3 Well	9					X	X
	Corydon Blend - includes water from Cereal 1 Well, Corydon Well, Diamond Well, Summerly Well, & BBGWTP effluent	6					X	X
	Flagler Well Blend - includes water from Flagler Well 2A, 3A, and imported Temescal Valley Pipeline (TVP) connection	5					X	X
Imported Sources	Temescal Valley Pipeline (TVP) - water received from Metropolitan Water District via the State Water Project	12			X	X	X	X
	Auld Valley Pipeline (AVP) - water received from a combination of the State Water Project and Colorado River	12			X	X	X	X

The samples taken during this time were collected and analyzed using EPA Method 2540 C (Standard Methods for the Examination of Water and Wastewater 18th Ed, 1992). Additionally, the sample results are weighted with the amount of water production that occurred from each source. Sites with high

TDS values but low production may have less of an effect on the system compared with low TDS and high production sites (Figure 3.)

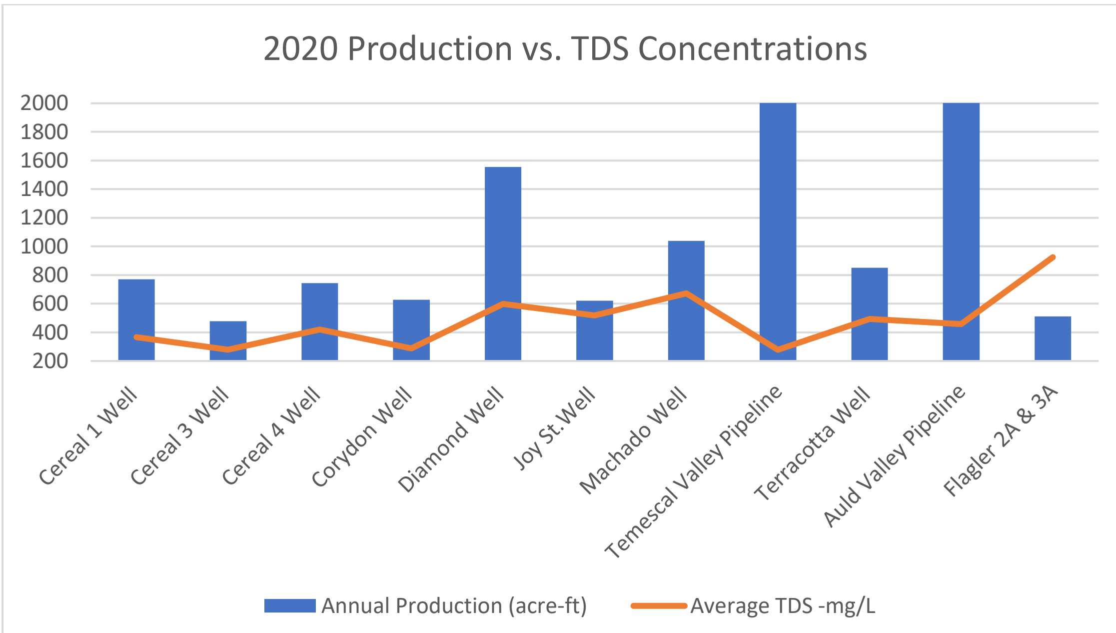


Figure 3. 2020 Production volumes and associated TDS concentration

The initial hypothesis was that much of the increased TDS concentrations seen at the influent of the wastewater treatment plants are the result of the chemical addition used for odor control at upstream sewer lift stations. However, as these samples were unable to be collected, alternate analyses were conducted which compared the influent TDS samples from 2020 and 2021 (sodium hypochlorite dosing at lift stations occurred in 2020 but did not in 2021 – Table 5).

Linear regression analyses were completed on each source to analyze the influence on the variables on the appropriate influent TDS values. The coefficients of determination were assessed on the ability of each source to indicate the proportion of variation on the influent TDS values. Descriptive statistics were also employed to quantitatively assess the data and identify trends.

CHAPTER SEVEN:

RESULTS AND DISCUSSIONS

The three WRFs in the Elsinore Valley Municipal Water District (Regional WRF, Horsethief Canyon WRF, and Railroad Canyon WRF) are required to meet the lower of the specified TDS permit limit or the 250-plus-potable water TDS requirement on recycled water. However, the controlling effluent TDS limit at the wastewater treatment plants is exceeded on a regular basis. While EVMWD participates in various water quality objective programs, including the ongoing Salt Nutrient Management Plan, Maximum Benefit Analysis, and the Basin Plan, these programs primarily set the water quality objectives for the groundwater basin and limits in the effluent discharge. Due to the wastewater treatment plant's current absence of processes to remove TDS, determining the TDS in the plant's influent and upstream sources is important, as these values assist in accurately distinguishing the predominant sources of increased TDS contributions. Thus, ways to effectively reduce the inorganic salts and ions present in the final recycled water may be identified and addressed upstream of the treatment plants.

Identifying Relationship between WRF Influent and Effluent TDS

Preliminary analysis of the Regional WRF which discharges to surface water was conducted for both the influent TDS (prior to the headworks of the treatment plant) and the recycled water final discharge location and yielded no significant variation in TDS values (Table 5). This facility utilizes a tertiary treatment with filtration and disinfection by UV process rather than chlorine or sodium hypochlorite solution. The UV process does not increase TDS, whereas sodium hypochlorite being completely soluble adds to TDS.

Influent and effluent TDS sampling was also completed at the two other wastewater treatment facilities, both of which discharge recycled water for landscape irrigation, and in these facilities, an increase in TDS may be observed, as the facilities follow 40 CCR Title 22 requirements of chlorination for disinfection. In some instances, however, the Railroad WRF experienced a decrease in effluent TDS compared to the influent TDS. It can also be noted that for Railroad WRF and Regional WRF, the influent TDS values are typically above the 700 mg/L permit limits. Figures 4-6 show the graphical correlation between influent and effluent TDS values at the treatment facilities, which indicate that the influent values are very similar to the effluent values and the wastewater treatment facilities are not likely the primary contributor of TDS to the effluent. Figures 7-9 compare the influent TDS values versus the monthly source water TDS and the 250+ source TDS, to show the correlations between the influent TDS and the source water.

Table 5. Comparison of influent and effluent TDS concentration at the WRFs

Horsethief			Railroad			Regional		
	Influent	**Effluent**		**Influent**	**Effluent**		**Influent**	**Effluent**
January	666	736	**January**	878	932	**January**	772	754
February	626	762	**February**	883	806	**February**	720	716
March	597	734	**March**	869	790	**March**	712	723
April	584	649	**April**	964	843	**April**	760	725
May	614	636	**May**	919	828	**May**	746	748
June	554	629	**June**	749	750	**June**	652	670
July	662	726	**July**	816	773	**July**	726	698
August	674	737	**August**	797	769	**August**	754	728
September	655	737	**September**	739	717	**September**	704	696
October	756	834	**October**	930	759	**October**	777	750
November	701	737	**November**	756	703	**November**	739	680
December	637	696	**December**	765	730	**December**	683	677
Permit Limit		**850**	**Permit Limit**		**700**	**Permit Limit**		**700**

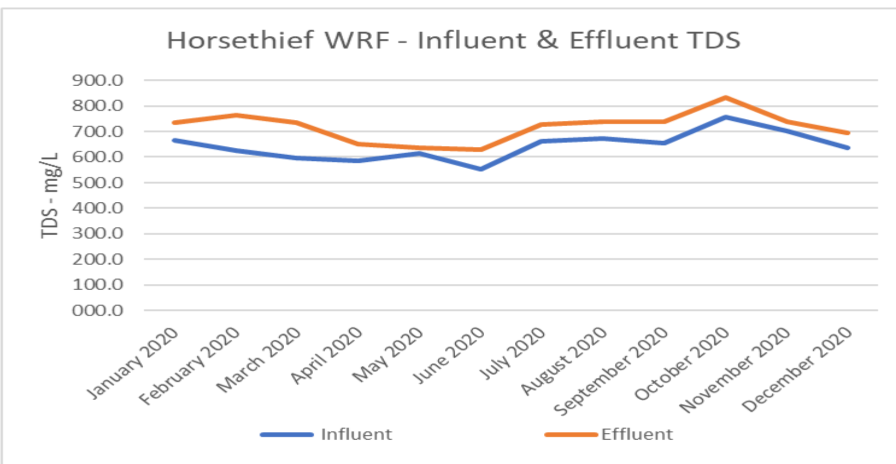


Figure 4. Influent v. effluent TDS values at the Horsethief WRF, mg/L.

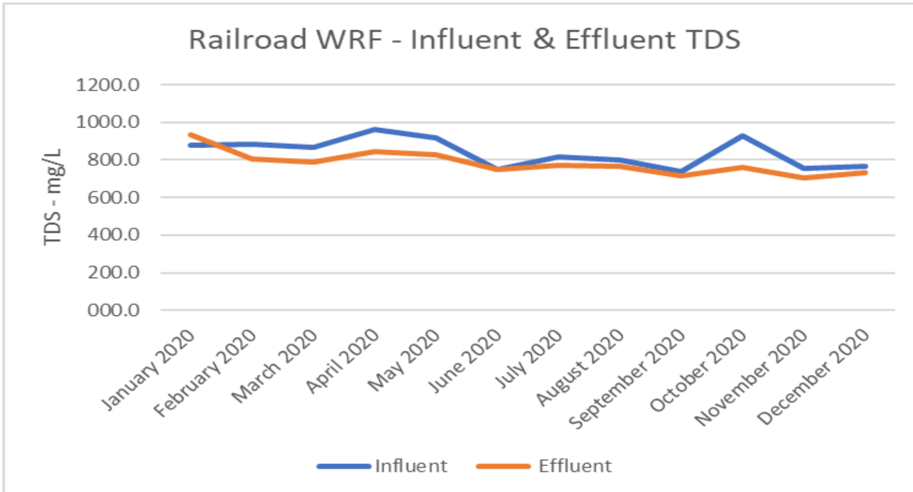


Figure 5. Influent v. effluent TDS values at the Railroad WRF, mg/L.

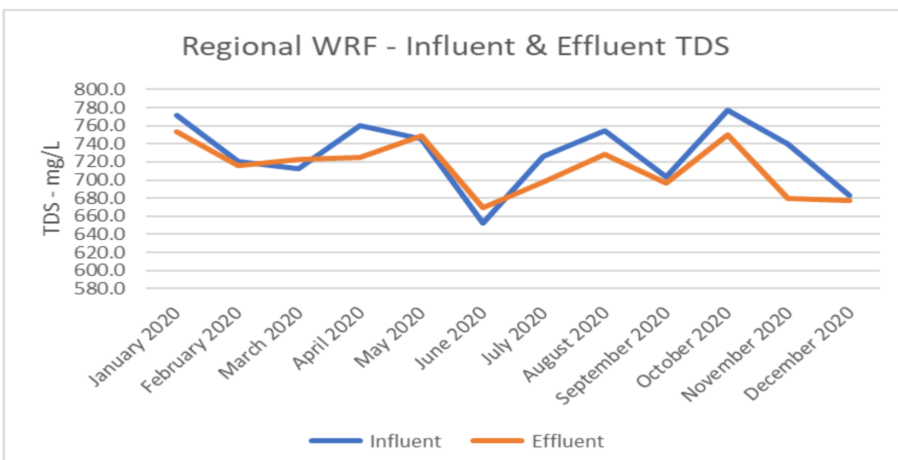


Figure 6. Influent v. Effluent TDS values at the Regional WRF, mg/L.

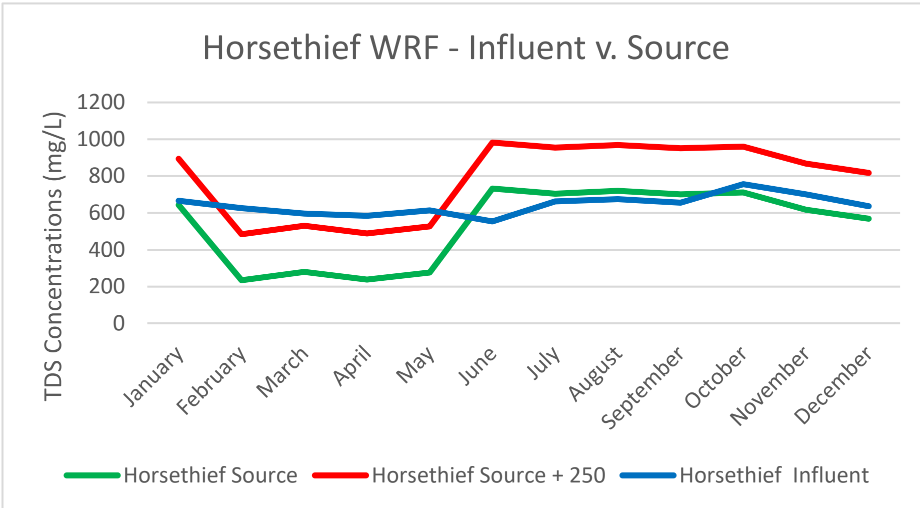


Figure 7. Horsethief WRF Influent TDS v. Source TDS & Source +250 TDS, mg/L

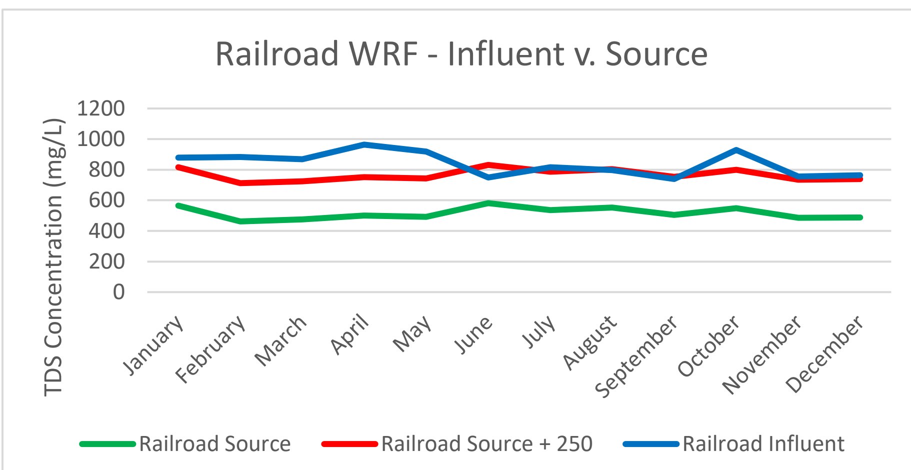


Figure 8. Railroad WRF Influent TDS v. Source TDS & Source +250 TDS, ml/L

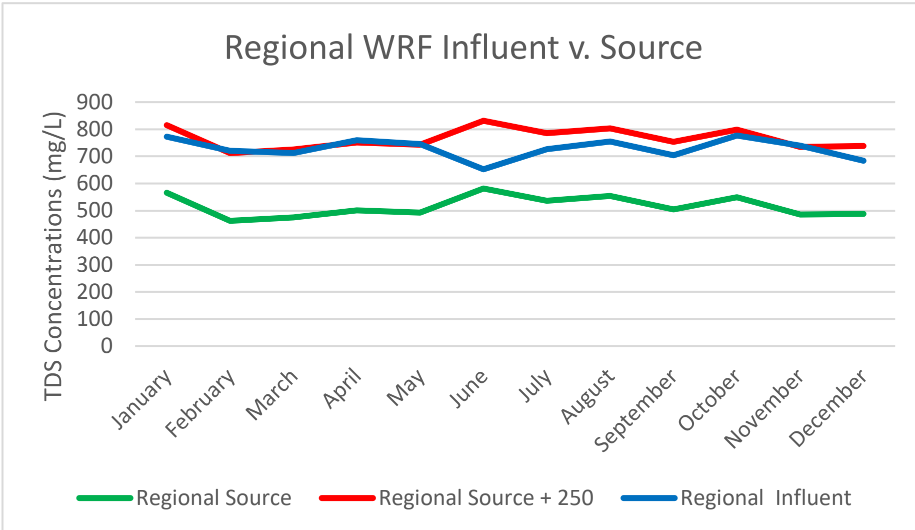


Figure 9. Regional WRF Influent TDS v. Source TDS & Source +250 TDS, mg/L

Additionally, linear regression models were completed to establish an initial relationship between the influent and effluent TDS of each individual wastewater treatment facility. The results of the linear regression also indicate that the influent TDS values correlate significantly to the effluent TDS values. The correlating p-values for the significance of influence from the influent TDS on the effluent TDS values are listed in Table 6:

Table 6. Linear regression analyses for influent and effluent TDS values at the WRF's

Facility	Multiple R^2	Intercept	Slope	P-Value
Regional WRF	0.67	242.88	0.65	.0012
Railroad WRF	0.46	325.06	0.55	.016
Horsethief WRF	0.67	157.69	0.87	.0011

As the p-values are less than 0.05, they indicate a strong influence of the influent TDS on the effluent TDS at all three wastewater treatment facilities (Appendix C). This further helps to confirm the determination that the wastewater treatment process does not affect the TDS concentrations.

<u>Chemical Dosing at Lift Stations Source Analysis</u>

Due to the lack of historical data for analysis and the inability to effectively sample lift stations for TDS increases due to sodium hypochlorite addition, as chemicals other than sodium hypochlorite are being introduced into the system for odor control, alternate analytical methods were employed. Influent TDS samples had previously been collected in 2020 at the wastewater treatment plants, prior to the lift station odor control study which took place in 2021 during this analysis. Therefore, the influent TDS data was compared between the period of sodium hypochlorite chemical addition at the lift stations and from the period of odor control studies (Table 7). Based on this comparative analysis, the two periods of influent TDS sample collection were found to be unlikely in influencing the influent TDS concentrations for the Regional and Horsethief WRF's. The comparison data does indicate, however, that the chemical addition from the lift stations may have been influencing the Railroad Canyon WRF influent TDS values, with the Railroad TDS concentrations showing decreased influent values in all months in 2021 (with no sodium hypochlorite dosing due to odor control studies) versus the year 2020, where sodium hypochlorite addition at the lift stations was still occurring regularly. This indicates that the initial hypothesis which postulates that the chemical-dosing sewer lift stations are contributing to the TDS concentrations at the influent of the wastewater treatment plants may be likely only for the Railroad Canyon WRF.

Table 7. Comparison of 2020 v. 2021 TDS (mg/L) influent data at all 3 facilities

Comparison of 2020 v. 2021 TDS Influent Data

	2020			2021			2020/2021 Difference		
	Horsethief Influent	Railroad Influent	Regional Influent	Horsethief Influent	Railroad Influent	Regional Influent	Horsethief Influent	Railroad Influent	Regional Influent
January	666.0	878.0	772.0	815.2	672.0	815.2	149.2	-206.0	43.2
February	626.0	883.0	720.0	788.0	673.0	788.0	162.0	-210.0	68.0
March	596.8	868.8	712.0	736.0	619.2	736.0	139.2	-249.6	24.0
April	584.0	964.0	760.0	787.2	689.0	787.2	203.2	-275.0	27.2
May	614.0	919.0	745.6	822.4	660.0	822.4	208.4	-259.0	76.8
June	553.6	749.0	652.2	766.0	613.6	766.0	212.4	-135.4	113.8
July	662.0	816.0	726.4	812.8	688.0	812.8	150.8	-128.0	86.4
August	674.0	797.0	754.4	765.6	680.0	765.6	91.6	-117.0	11.2
September	655.2	739.2	704.0	*At current time, data not yet available					
October	756.0	930.0	776.8	*At current time, data not yet available					
November	701.0	756.0	739.2	*At current time, data not yet available					
December	636.8	764.8	683.3	*At current time, data not yet available					

Difference is calculated as '2021-2020 = difference', with positive values showing increases in TDS concentrations in 2021 from the 2020 values; and negative values showing decreases in TDS influent concentrations between the two years.

Raw Water and Chemically-Treated Water Source Analysis

Increased TDS addition occur from the raw potable water and the chemical addition for disinfection purposes. Analyses were performed to determine the degree of influent the TDS values for these sources have on the influent TDS at the wastewater treatment facilities. The two main chemical solutions used for disinfection, sodium hypochlorite or chloramines, are added into the water system at certain well sites and pump stations. Chloramines consist of a mixture of 12.5% chlorine bleach and 19% aqueous ammonia, at a 5:1 ratio, and are an alternative for chlorine bleach. The sodium hypochlorite chemical concentrations range from 0.08% to 12.5%. The maximum dosage amount for chlorination of drinking water is 4 mg/L, with a targeted chlorine residual of 0.2 mg/L (the minimum required residual value) to 1.0 mg/L (EPA, n.d.).

The well sites extract groundwater from various locations around EVMWD's service area. The raw, untreated groundwater is sampled for TDS, then chloramines or sodium hypochlorite for disinfection purposes are added. The chemical dosage varies, based on ambient groundwater parameters and chlorine demand. Some of the disinfected groundwater is blended with other well sites in order to meet the MCL for arsenic. TDS samples are collected at these blend stations, for the combined flows which consist of disinfected well water from specifically designated well sites. Table 8 details the well sites assigned to each blending station.

Table 8. *Blend station information: Well sites assigned to each blending station*

Facility	Treated Effluent Flow Rate	Comments
Machado Blend Facility	**3,600 gpm**	**Joy Well Lincoln Well Machado Well**
Corydon Blend Facility	**9,000 gpm (if all potential sources operating)**	**Cereal Well #1 Corydon Well Diamond Welll Summerly Well BBGWTP Effluent**
Flagler Well Chlorine Contact Reservoir	**1,025 - 1,550 gpm**	**Flagler Well 2A Flagler Well 3A**
Northern Well Blending Plan	**3,625 (final blend)**	**Flagler Well 2A Flagler Well 3A Mayhew Well Station 71 Well TVP**

**Note: if only one well site is producing from a blend station, sampling is only completed for the single well's raw water and additional sampling is not collected for the blend.*

The specific addition value of TDS from chemical-addition disinfection can vary, based on factors such as temperature, evaporation, or flow rates. The data included in this analysis are the raw groundwater well TDS values, prior to chloramination or sodium hypochlorite addition for disinfection; well site TDS values after chemical dosing for disinfection; booster stations, which dose chemical for disinfection; and the blending stations, which combine flows from several well sites and includes post-chloraminated/post-chlorinated flows.

Based on the chemical concentration calculation:

$$([X]\frac{mg}{L} = \frac{(\frac{lbs}{day})}{(Flow * 8.34)})$$

Where: Flow is million gallons per day

described in the ‘Calculations’ section in Methodology, every gallon of the 12.5% sodium hypochlorite in both types of disinfection dosing contributes approximately 2.2 mg/L of TDS from the sodium and chlorine to every 20,000 gallons of water (Skinner). This calculation is also used in Appendix B, which lists the production flows and the related chemical dosing to calculate the expected TDS increase to the water system.

Source water TDS values were also taken into consideration, as the value of TDS from source water can significantly influence the ability to stay within the fixed numerical permit limit (700 mg/L for Regional WRF and Railroad Canyon WRF; 800 mg/L for Horsethief Canyon WRF). This is due to the need for disinfection as required for potable water treatment; this addition of disinfection-related TDS to source water that is already high in TDS may influence the higher influent TDS values seen at the wastewater treatment plants. The main water sources for EVMWD are typically groundwater, surface water (Canyon Lake), State Water Project water, and Colorado River water (Figure 10). Figure 10 includes the 2016 year, which was within a notable drought period in Southern California. TDS levels begin to decline once precipitation increased and the state experienced temporary alleviation on drought conditions. However, drought in

Southern California may become more frequent and it can be expected that TDS in source waters subsequently increase.

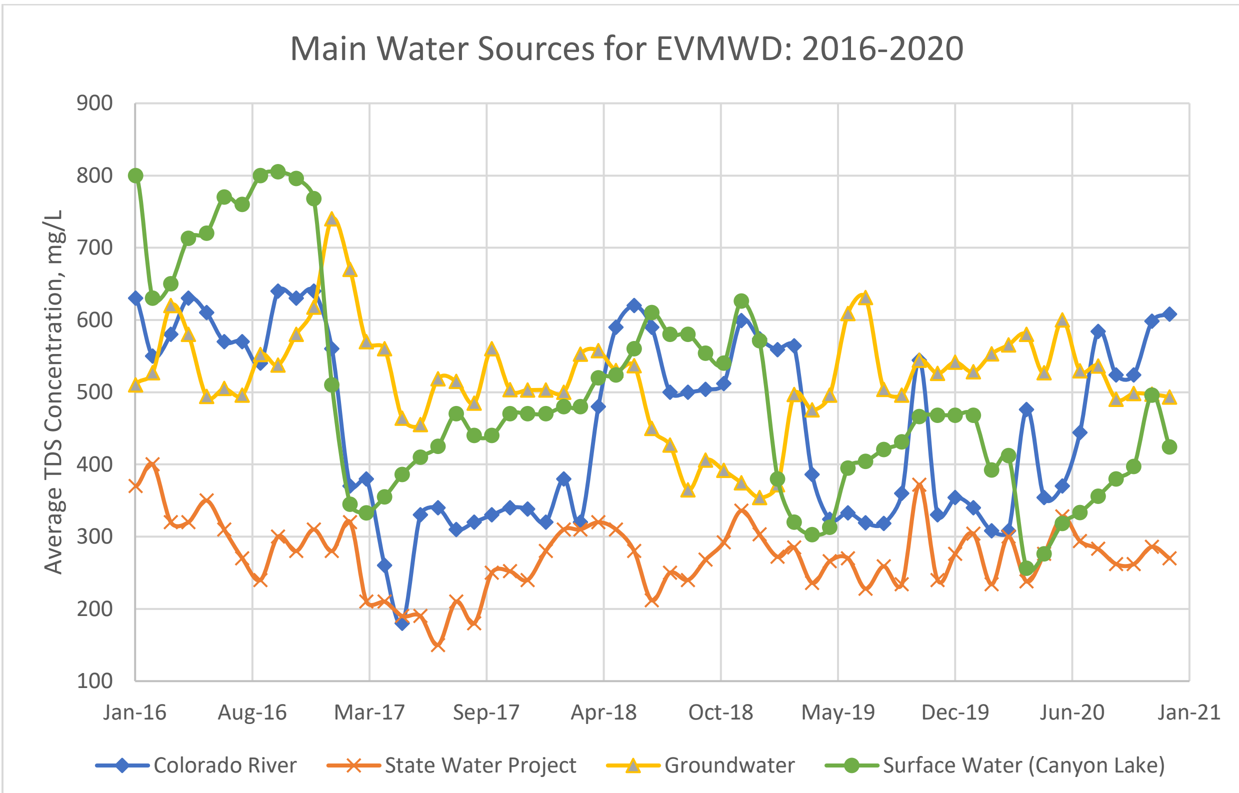


Figure 10. TDS values for the main water sources for EVMWD between 2016 to 2020, mg/L.

Figure 11 depicts the groundwater wells within the service area and the correlating TDS concentrations for the raw water. The cells in yellow are for TDS between 251 and 500 mg/L; orange are TDS concentrations between 501 and 700 mg/L; and red are TDS above 701 mg/L.

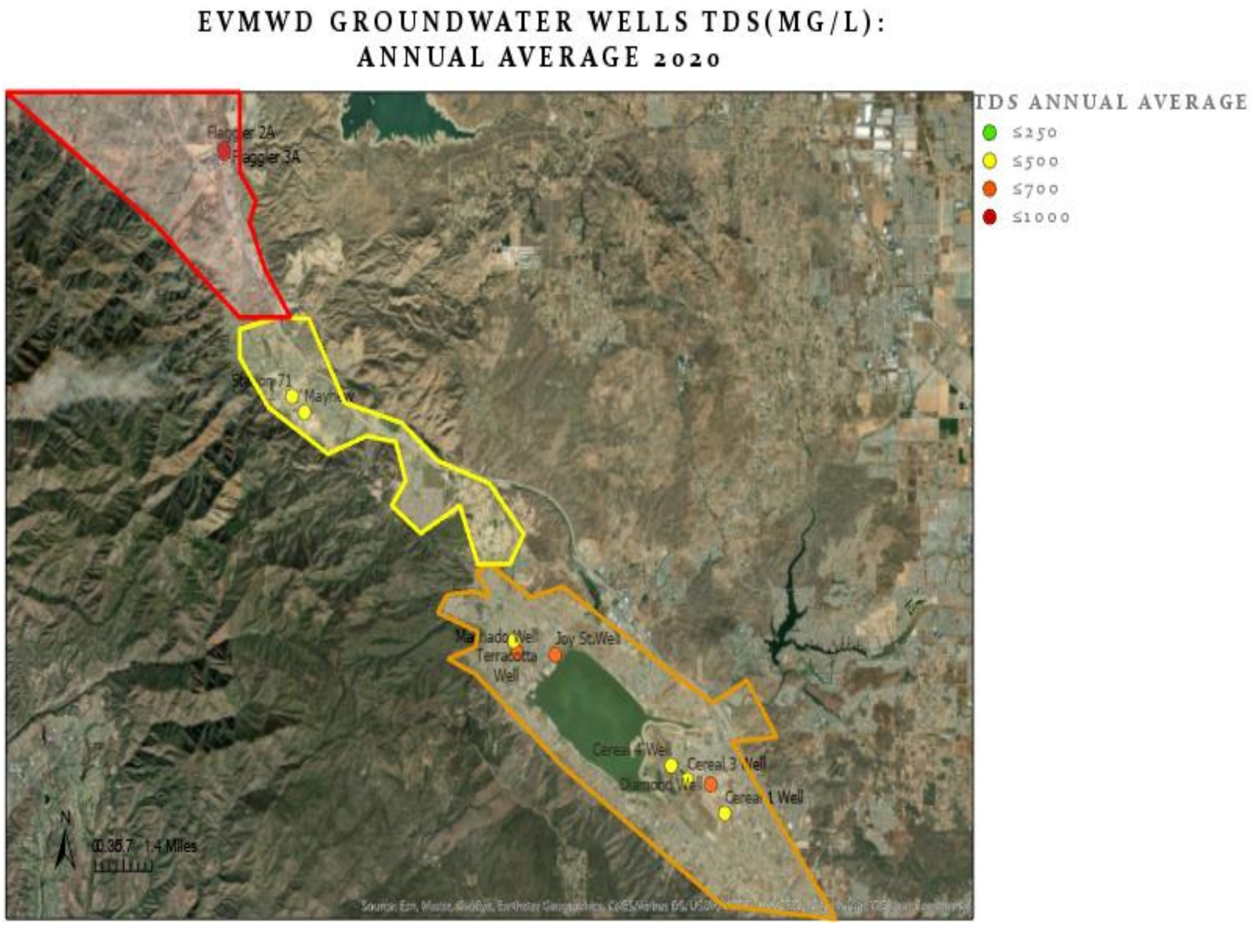


Figure 11. Annual TDS Averages (2020)

Shows the areas where TDS values from the groundwater wells are noted to be very high (>700), high (>500), and average (>250). The information on this Figure was collected during the 2020 calendar year and reflects the annual average TDS values.

Table 9. Raw water TDS concentrations prior to chemical addition, mg/L. *Note: only sources which produced potable flow volumes are included in this table*

	Cereal 1 Well Total Dissolved Solids / TDS (mg/L)	Cereal 3 Well Total Dissolved Solids / TDS (mg/L)	Cereal 4 Well Total Dissolved Solids / TDS (mg/L)	Corydon Well Total Dissolved Solids / TDS (mg/L)	Diamond Well Total Dissolved Solids / TDS (mg/L)	Joy St.Well Total Dissolved Solids / TDS (mg/L)	Machado Well Total Dissolved Solids / TDS (mg/L)	Temescal Valley Pipeline Total Dissolved Solids / TDS (mg/L)	Terracotta Well Total Dissolved Solids / TDS (mg/L)	Auld Valley Pipeline Total Dissolved Solids / TDS (mg/L)	Flagler 2A Total Dissolved Solids / TDS (mg/L)	Flagler 3A Total Dissolved Solids / TDS (mg/L)
January 2020	*offline*	*offline*	514.0	*offline*	582.0	572.0	664.0	304.0	*offline*	340.0	983.0	*offline*
February 2020	*offline*	*offline*	*offline*	*offline*	586.0	514.0	648.0	234.0	482.0	308.0	*offline*	*offline*
March 2020	*offline*	*offline*	*offline*	*offline*	606.0	504.0	642.0	280.0	510.0	308.0	*offline*	*offline*
April 2020	*offline*	*offline*	476.0	*offline*	626.0	522.0	660.0	238.0	508.0	476.0	*offline*	*offline*
May 2020	*offline*	*offline*	518.0	*offline*	614.0	516.0	664.0	276.0	506.0	354.0	*offline*	*offline*
June 2020	*offline*	*offline*	388.0	*offline*	600.0	514.0	670.0	328.0	494.0	370.0	982.0	886.0
July 2020	418.0	*offline*	360.0	322.0	598.0	480.0	660.0	278.8	502.0	444.0	953	880
August 2020	488.0	*offline*	324.0	296.0	572.0	498.0	670.0	283.3	500.0	584.0	982.0	892.7
September 2020	348.0	288.0	310.0	244.0	616.0	480.0	638.0	262.0	492.0	524.0	980.0	862.0
October 2020	326.0	274.0	*offline*	300.0	*offline*	584.0	818.0	257.0	482.0	574.0	991.0	884.0
November 2020	318.0	274.0	*offline*	284.0	*offline*	506.0	682.0	286.0	468.0	598.0	948.0	*offline*
December 2020	302.0	278.0	476.0	284.0	584.0	*offline*	652.0	270.0	488.0	608.0	866.0	*offline*

For Table 9 above, the cells in orange are TDS concentrations greater than 500 mg/L (The drinking water secondary standard). Cells in red are TDS concentrations greater than 700 mg/L, which is one of the effluent permit limits for the wastewater facilities.

Data was also compiled and analyzed for the source water TDS values (Table 9). These analyses were completed using month-to-month data, as the calculated permit limits are based on a 12-month average while the influent to the treatment plants are on a month-by-month basis (no statistical calculation to affect the concentration amount). This raw source water versus WRF influent water analysis aimed to determine if the TDS concentrations of the raw source water, prior to any treatment, were contributing to the monthly influent concentrations. Source water TDS was analyzed using linear regression, to determine the significance of the raw water, prior to any chemical treatment, on the influent TDS values seen at the wastewater treatment plants.

Commercial and Industrial Source Analysis

Commercial and industrial sources were also analyzed, to determine if any specific industries were expected to contribute significant TDS concentrations. This analysis included comparison of industry SIC codes to EPA data (Environmental Protection Agency, n.d.) to identify any potential dischargers of concern. EVMWD has 278 industrial dischargers, none of which are considered to meet the qualifications of a Significant Industrial User (SIU). As such, no industrial pretreatment dischargers were successfully identified as being significant contributors to the TDS concentration increase seen at the influent to the wastewater treatment plants.

Table 10. Pretreatment dischargers and associated SIC codes

Pretreatment Dischargers & SIC Codes					
Type	**Class**	**No. of Dischargers**	**SIC Code**	**Potential Pollutants**	**Description**
Categorical/SIU	Class I	0	Varies	Varies based on industry	Dischargers classified as Categorical or SIU
Non-Domestic Wastewater	Class II	2	Varies	BOD, TS, metals, toxic organics	Dischargers which discharge non-domestic wastewater and have potential to discharge incompatible pollutants
Food service	Class III	218	5812	BOD/TSS/pH/Grease&Oil /Minerals	Food Service
Oil/Sand Separator	Class IV	30	7699	Oils	Required to install & maintain oil/sand separator or clarification system
Liquid Waste Haulers	Class V	5	4952	BOD, TSS, metals, toxic organics	Service and repair domestic septic tank systems
Domestic Wastewater	Class VI	23	3599	BOD, TSS, pH	Discharge only domestic wastewater, but have potential to discharge hazardous materials or incompatible pollutants

Domestic Usage and Conservation Effects Source Analysis

The addition of TDS concentrations from residential households was analyzed and based on household uses - including laundry and bathing - a single person excretes an approximate salt load of 50 grams per day (Daniel B. Stephens & Associates, Inc., 2018). Senate Bill 7, Section 1 Part 2.55, Chapter 3 10608.20 (A) mandates that indoor water use be provisionally set as 55 gallons per capita daily, to become officially required by California residences in 2025. However, the relationship between TDS concentrations and indoor household water use is inverse, with the WWTP influent TDS concentrations estimated to increase by 1.2 to 1.7 mg/L for every 1 gallon/day per capita of indoor water use decrease (Daniel B. Stephens & Associates, Inc., 2018). As water use per capita is restricted or conservation activities are in effect, the TDS concentrations are expected to rise.

A high contributor of TDS from domestic households are the use of Self-Generating Water Softeners (SGWS). A typical SGSW contributes a salt load of approximately 1.65 pounds (Daniel B. Stephens & Associates, Inc., 2018) of salt, per day (or approximately 750 grams/day), to the wastewater system. The total average influent flow for the three wastewater treatment facilities in 2020 was 7 million gallons per day. TDS concentrations from SGWS into the system can be calculated by using the following equation (if the number of SGWS are known):

$$TDS\ Added = \frac{No.of\ SGWS\ Units * 1.65\ lbs\ of\ salt/day}{Influent\ WWTP\ Flow}$$

While EVMWD does not currently regulate customer use of self-generating water softeners in households, AB-1366 does grant local agencies that own or operate a public-owned treatment works or water recycling plant the authority to enact regulations for SGWS (Daniel B. Stephens & Associates, Inc., 2018).

Linear regression analyses were completed for all three wastewater treatment facilities using well site raw groundwater TDS concentrations combined with chemical dosing calculations and estimated TDS addition from water pump stations to yield approximate loading concentrations to the water system. The variables included in these analyses are the TDS addition values from consumer input (X_1) the raw potable TDS values (X_2) and treated source water TDS values (X_3). The TDS additions from consumer inputs include industrial users, domestic uses, and lift stations, as lift station analyses could not be conducted separately.

The TDS addition from the consumer use variable was calculated by subtracting the potable treated water TDS values from the treatment plant's influent TDS values. This new value is the additional TDS concentrations observed between the point of the treated potable water being delivered to consumers and the influent locations of the wastewater treatment facilities. As such, it is important to note that this variable (X_1) does experience variation from the Y variable (influent locations of wastewater treatment facilities) and does not represent a true regression. However, this variable yields a fairly accurate estimate of the consumer TDS inputs. The results of these analyses are discussed as follows:

Source Contribution Analysis – Regional WRF

Correlation plots of the WRF influent versus the three variables are shown in Figures 12-14. Some correlation of changes in TDS is seen with consumer contributions (Figure 12) and raw source water TDS (Figure 13), but no correlation with chemical dosing (Figure 14). However, as all three variables have an effect on the final TDS, multivariable regression is needed.

The Regional WRF yielded higher R^2 value for both the raw TDS (X_2) and consumer input TDS additions (X_1) ($R^2 > 0.35$), but a much smaller R^2 value for the chemical dosing in potable water's influence on TDS ($R^2 > 0.02$). As the R_2 values are intended to suggest correlations for the X variables to explain the Y value (WRF influent TDS), this analysis weakly suggests that raw source water TDS and consumer-added TDS explain the influent TDS concentrations, while it does not indicate that chemical dosing for potable water sources contributes a significant influence to the WRF influent TDS. When running the multivariable regression on the X_1 and X_2 variables, the R^2 value is 0.887 and the slopes for X_1 and X_2 are and .081 and 1.12, respectively; however, as mentioned above, the X_1 values includes the variance from the Y values, which explains why the R^2 value is higher using multivariable regression over the individual regression analyses. Note that X_3 (chemical dosing for potable source water) was omitted from the multivariable regression analysis due to this value already being included within the X_1 variable (X_1 calculated by subtracting the potable treated source water TDS from the WWTP influent TDS values). Based on the calculations, the influent TDS for Regional during this time is comprised of approximately 66.3% raw TDS, 21.9% user contributions to TDS, and only 11.8% TDS addition from chemical dosing (Table 13).

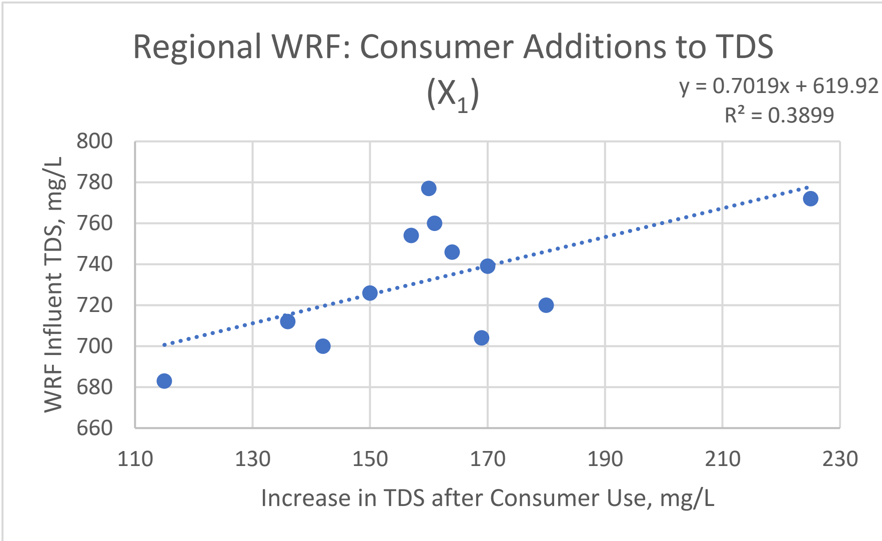


Figure 12. Regional WRF: Analysis of TDS (mg/L) increase due to consumer use

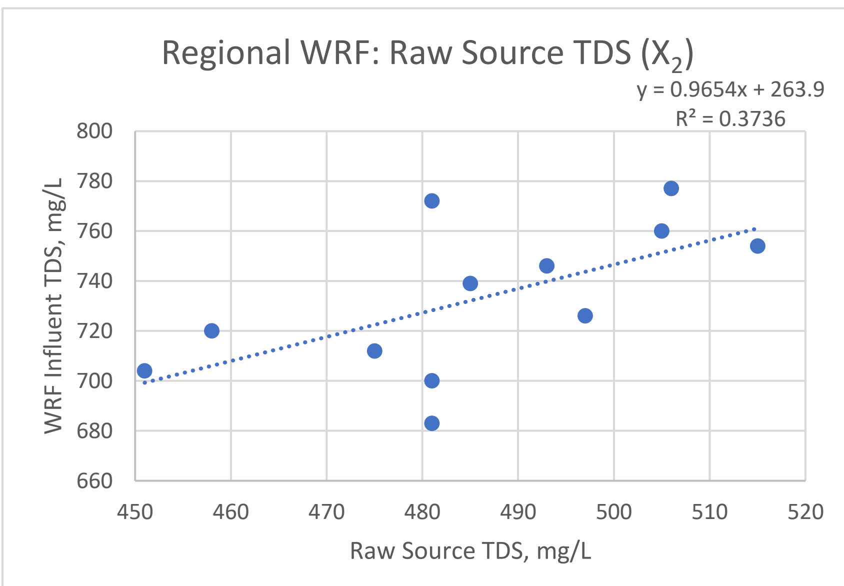


Figure 13. Regional WRF: Analysis of TDS (mg/L) increase due to raw source water TDS

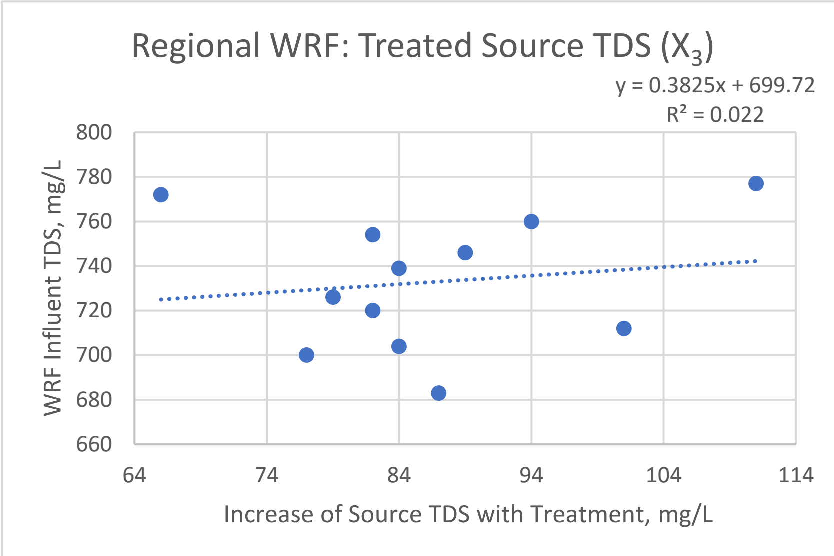


Figure 14. Regional WRF: Analysis of TDS (mg/L) increase due to treated source water

Source Contribution Analysis – Railroad WRF

Correlation plots at Railroad WRF suggest a high level of contribution from consumers (Figure 15), with less contribution from raw source water TDS (Figure 16) and chemical dosing (Figure 17). Using multivariable regression, the Railroad WRF yielded a much more significant R^2 value, of 0.903, for consumer-influenced TDS values. An R^2 value of 0.903 strongly indicates that a source, or sources, within this variable are significantly influencing the influent TDS values. Additional discussions on these possible sources are continued below. The R^2 values for the raw TDS and treated source water TDS are much less significant, at 0.131 (X_2) and 0.196 (X_3), respectively, indicating lower explanatory potential in these areas. The multivariable regression analyses on variables X_1 and X_2 yield an R^2 value of 0.981, with slopes of 1.04 (X_1) and 1.15 (X_2). Based on the calculations, the influent TDS for Railroad WRF during this time is comprised of approximately 57.9% raw TDS, 31.8% user contributions to TDS, and only 10.3% TDS addition from chemical dosing (Table 14).

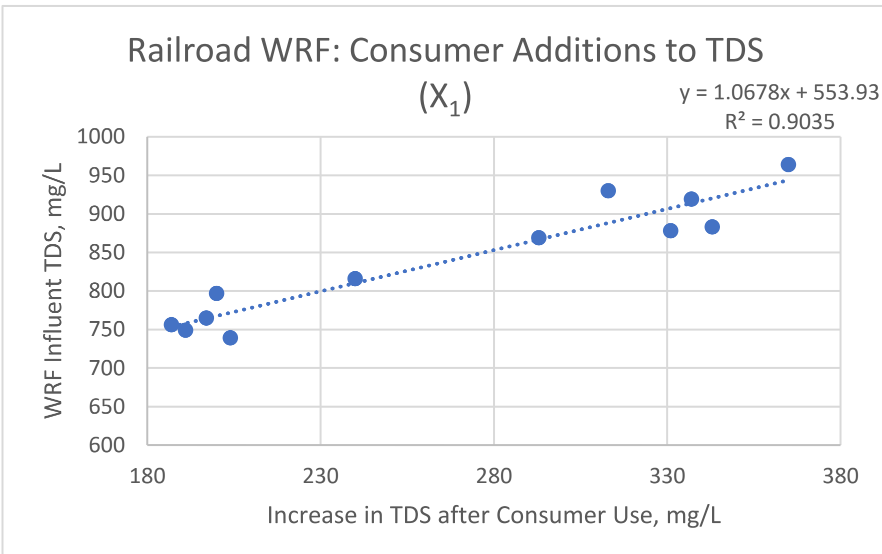


Figure 15. Railroad WRF: Analysis of TDS (mg/L) increase due to consumer use

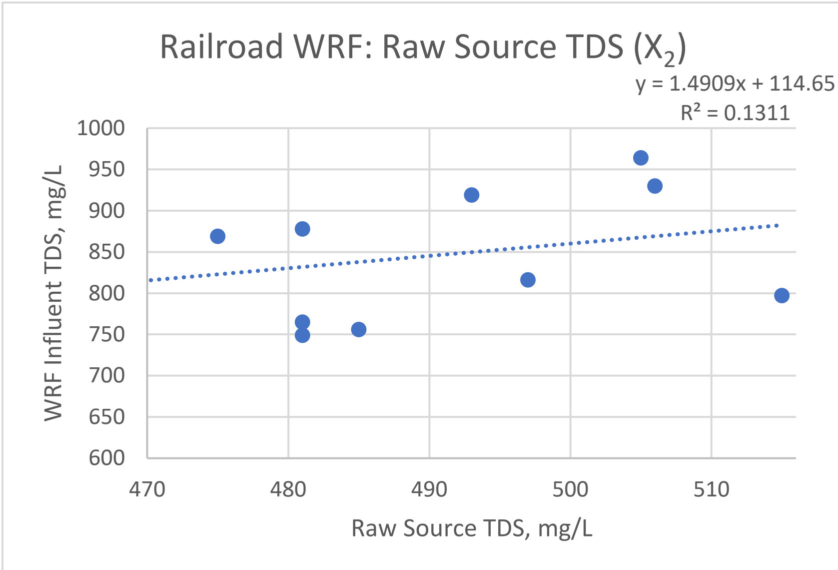


Figure 16. Railroad WRF: Analysis of TDS (mg/L) increase due to raw source water

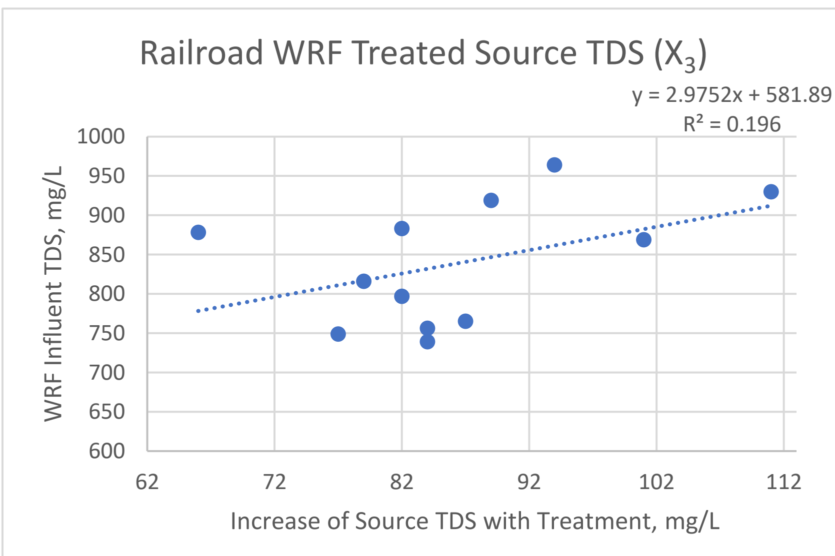


Figure 17. Railroad WRF: Analysis of TDS (mg/L) increase due to treated source water

Source Contribution Analysis - Horsethief WRF

The Horsethief WRF yielded similar results to Railroad WRF, in that the analysis results indicated a higher R^2 value (0.742) for the consumer addition of TDS as a potential significant influence on the influent TDS of the facility (Figure 18). The R^2 values relating to the raw TDS (0.071, Figure 19) and treated source water TDS (0.042, Figure 20) were much smaller, suggesting that these factors may be close to negligible when it comes to providing an explanation for the influent TDS values. The multivariable regression for the raw TDS (X_2) and consumer addition of TDS (X_1) generated an R^2 value 0.945, strongly indicating that these factors influence the Horsethief influent TDS values. The slopes for these variables are 0.975 (X_1) and 1.149 (X_2). Based on the calculations, the influent TDS for Horsethief WRF during this time is comprised of approximately 74.7% raw TDS, 12.0% user contributions to TDS, and 13.3% TDS addition from chemical dosing (Table 15).

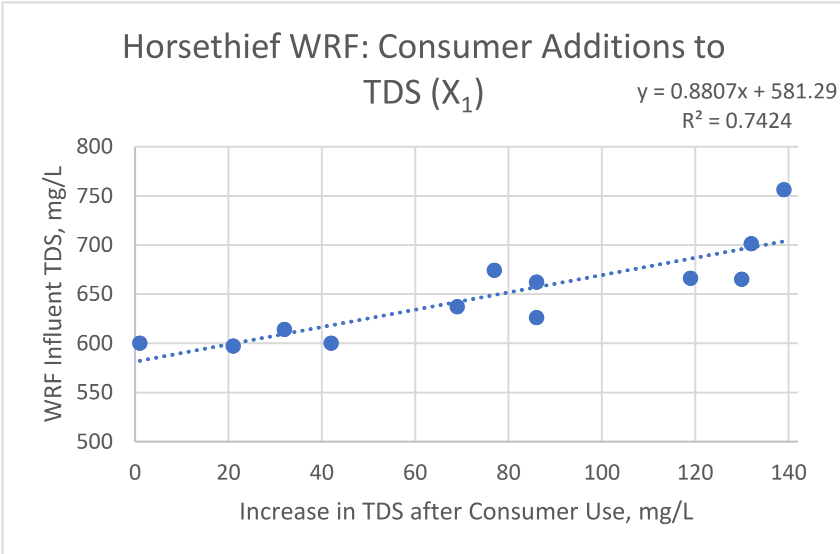


Figure 18. Horsethief WRF: Analysis of TDS (mg/L) increase due to consumer use

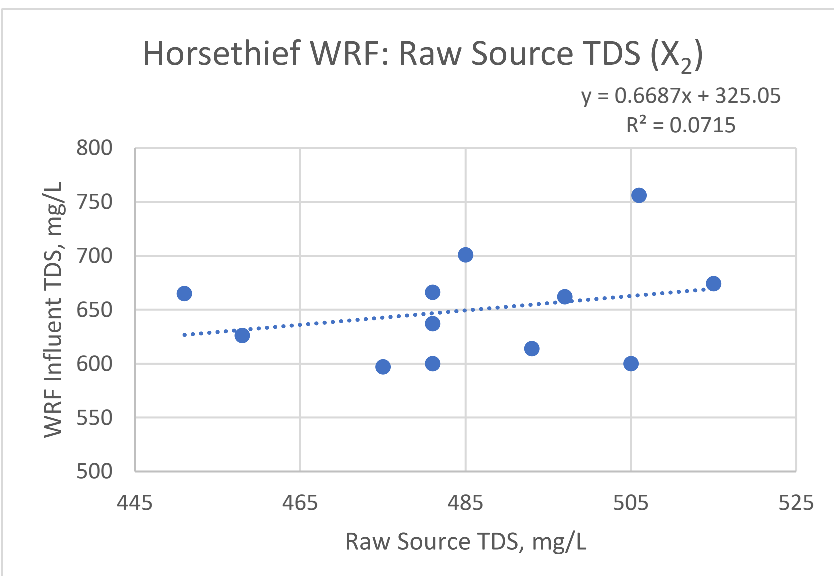


Figure 19. Horsethief WRF: Analysis of TDS (mg/L) increase due to raw source water

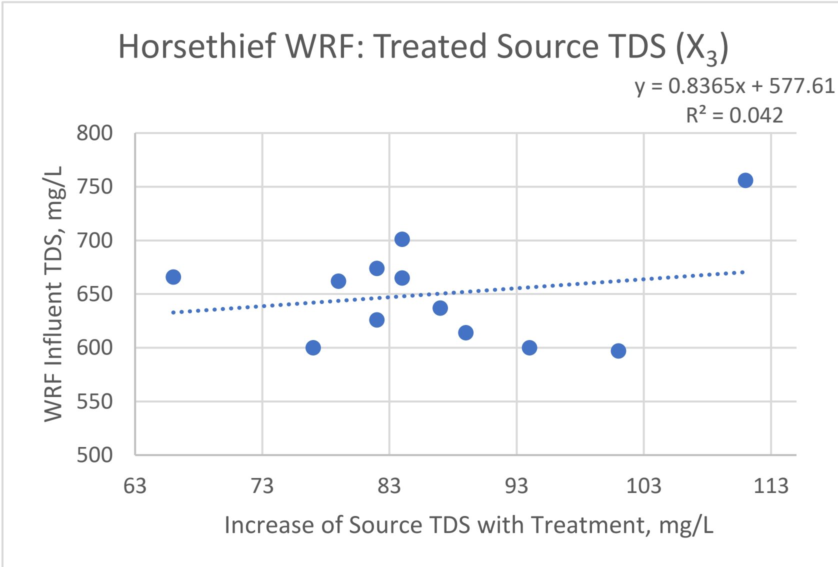


Figure 20. Horsethief WRF: Analysis of TDS (mg/L) increase due to treated source water

Source Contribution Analysis Overview

Of the three facilities, Railroad WRF yielded the strongest correlation between the consumer use addition of TDS and the influent TDS concentrations seen at the treatment facility. This facility is located in a pass between two local hills and is situated at a higher elevation that the Regional WRF and Horsethief WRF. As such, the flow that is received at this facility is primarily from the nearby Canyon Lake suburban community and small local restaurants, car washes, and automotive repair shops. An analysis of the businesses and industries that contribute to this sewer shed area resulted in no significant industries which could be identified as contributors to this increase. The Canyon Lake Golf Course is also within this zone of influence, as well as local parks irrigated with recycled water. It can be noted that Canyon Lake and its surrounding neighborhoods have multiple lift stations which typically dose chemical for odor control. Additionally, the Canyon Lake Water Treatment Plant was also inoperable during the period of this study, so this potential influence is omitted from this analysis. It is not confirmed at this time what possible source, or sources, are leading to this significant influence at the influent of Railroad WRF. However, data strongly suggests that chemical dosing from nearby lift stations influenced this increase in influent TDS (Table 7). It is recommended that samples are collected once chemical dosing resumes at the lift stations, to confirm this hypothesis.

Horsethief WRF yielded similar, yet not as significant, results suggesting that TDS from consumer uses provides the largest variation to the influent TDS concentrations for the water reclamation facility, yet the TDS concentrations from this source only make up 12.0% of the total influent TDS. The raw TDS sources account for almost 75% of the total influent TDS. The Horsethief WRF is located in the Horsethief Canyon suburban community and is the smallest of the three facilities, at 0.5 MGD capacity. This facility was constructed to accommodate the surrounding houses, elementary school, and parks located in the community. This facility is the closest to the Temescal Valley Pipeline, which receives imported water from Metropolitan Municipal Water District. The recently constructed Flagler Wells, which have very high TDS (>900 mg/L, on average), are also located closer to this area. The close proximity to these sources may explain why a majority of the TDS concentrations at the facility are from raw water sources. However, the facility receives no wastewater from industry, as there are none in the sewer shed area, and there are also no lift stations which dose chemical for odor control in this area, so it is surprising that the consumer-added TDS concentrations provides the largest variation to the influent TDS at this facility. There may be an excess of household water softener devices in this area; however, this hypothesis is out of the scope of this analysis.

The Regional WRF did not yield especially strong correlations for any of the variables. The results of the analyses were slightly stronger with the consumer uses TDS and raw water TDS concentrations as being key influences to the variation of influent TDS concentrations, but there is almost no correlation with the treated source water TDS addition values. The Regional WRF is the largest of the three facilities, at 8.0 MGD capacity, and it is located at the lowest elevation. Additionally, any flows that the Railroad WRF is unable to treat, and all solids produced from Railroad WRF, are sent to the Regional WRF for treatment. No flows from Horsethief WRF's sewer shed area are able to be diverted to the Regional WRF, as there are no sewer lines that connect the two sewer areas. The Regional WRF receives the most industrial and commercial flow of the three facilities, due to its location and size. The raw TDS concentrations seen in this sewer shed area are primarily from both the imported water and the groundwater basin. It is not known at this time what sources may be contributing the most significant effect on the influent TDS of the Regional WRF. Additional studies may be recommended for this facility.

The linear regression models and R^2 data did not seem to indicate strong correlation effects for raw water TDS or treated source water TDS for all three wastewater treatment plant influents, though scatter plots of the influent TDS data compared with the source water TDS (both raw and treated) show graphical trends of correlating increases and decreases in TDS:

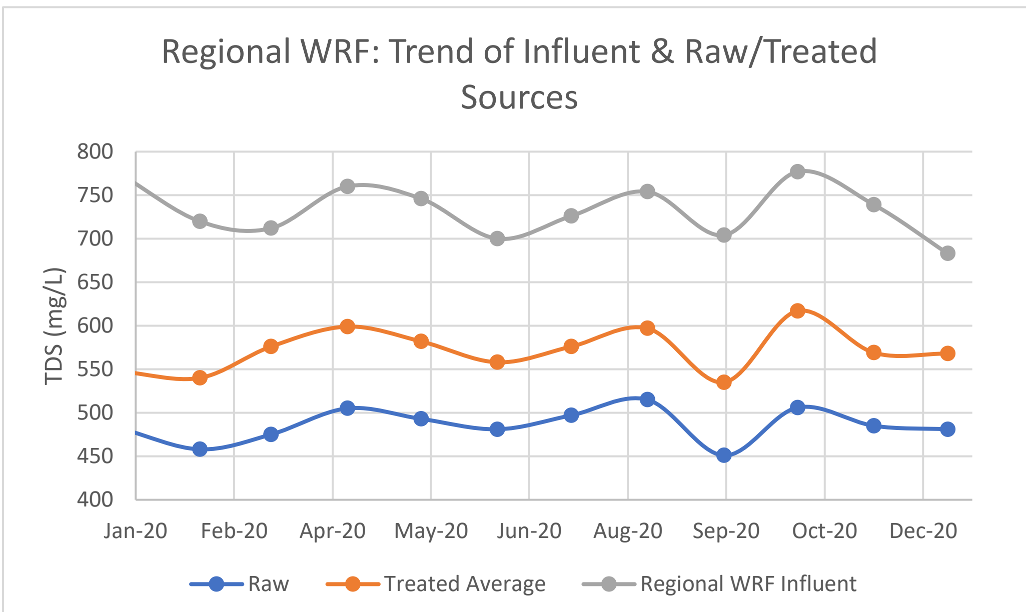


Figure 21. Regional WRF: Trend of Influent & Raw/Treated Sources

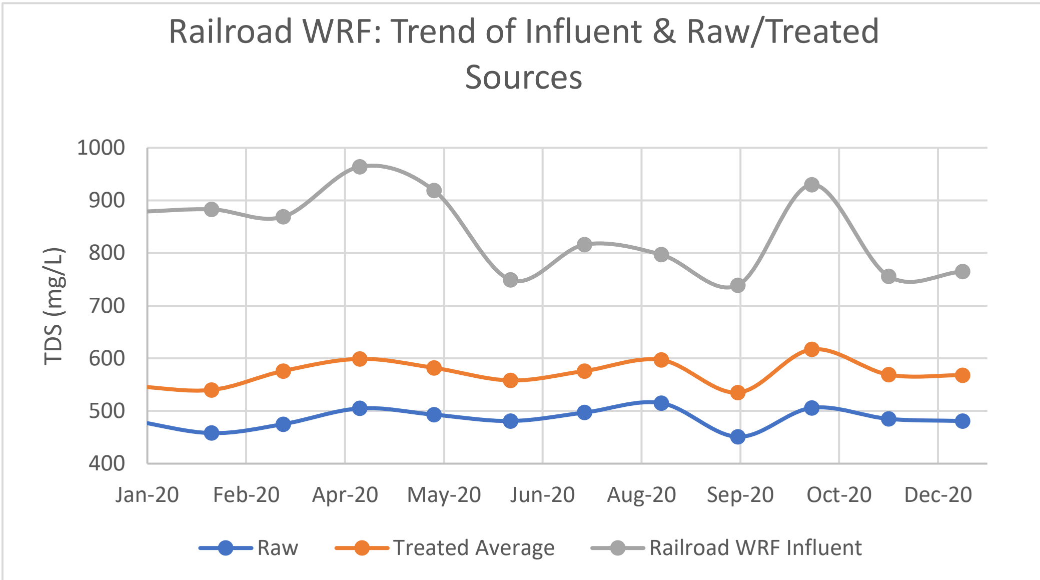


Figure 22. Railroad WRF: Trend of Influent & Raw/Treated Sources

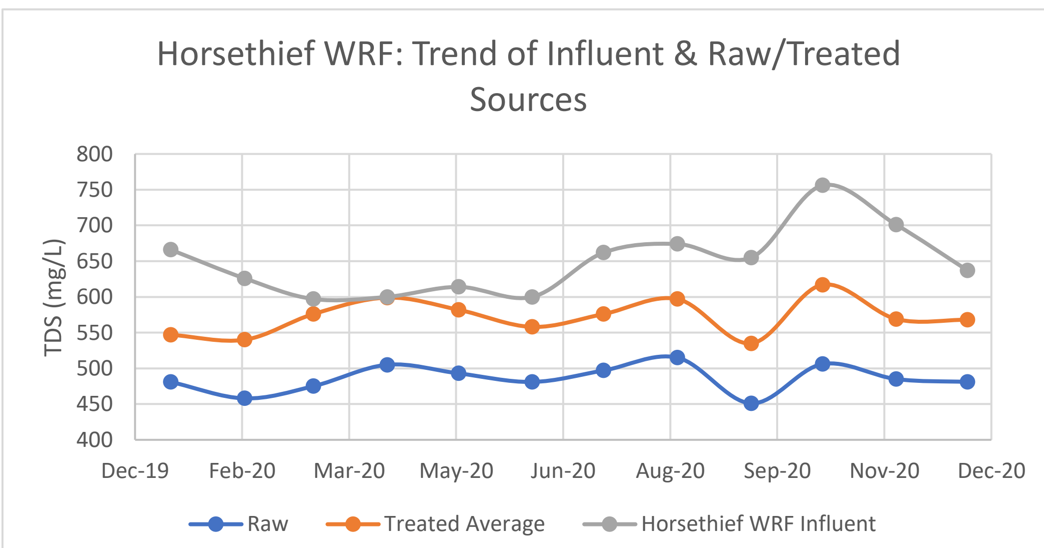


Figure 23. Horsethief WRF: Trend of Influent & Raw/Treated Sources

CHAPTER EIGHT:

CONCLUSIONS

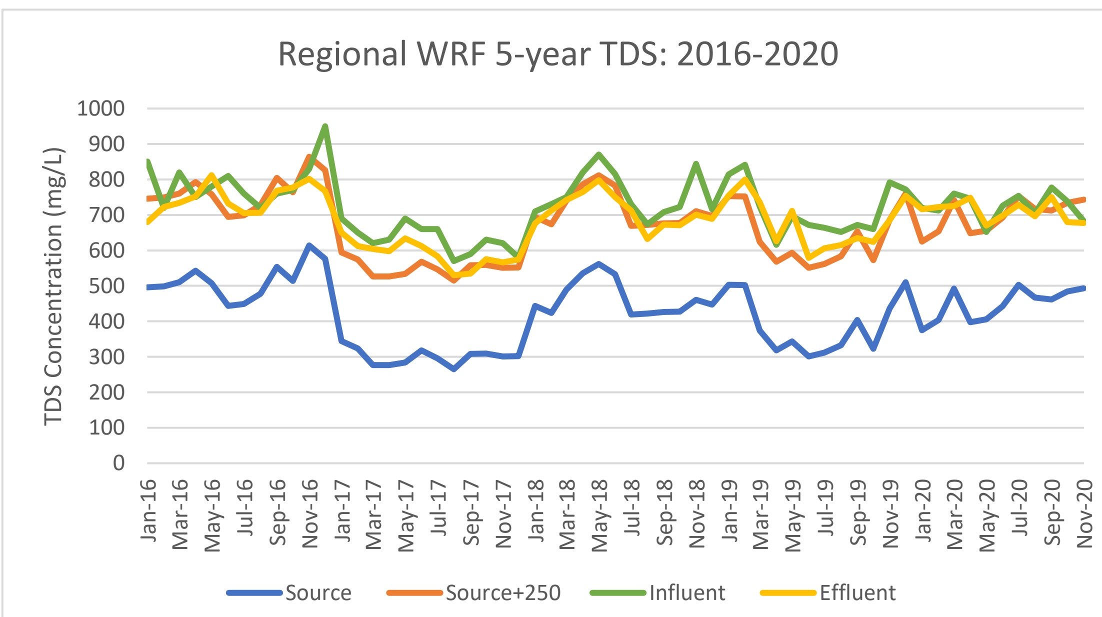
The possible sources for the increase in TDS values were initially hypothesized to be either from the sewer lift stations, which apply sodium hypochlorite as odor control; industrial facilities, commercial users, domestic household discharges and the associated water conservation measures; raw source water; or potable water, treated with chemical for disinfection purposes.

Upon analysis of the TDS sample data taken during the 2020 calendar year compared with data from the 2021 calendar year, it appears as though this initial hypothesis of TDS contributions from sewer lift stations may explain some of the influent TDS concentrations seen at the Railroad WRF. However, additional sampling and studies should be completed to confirm this hypothesis. This hypothesis is less supportive for the Regional WRF and Horsethief WRF, as the Regional WRF showed a weaker correlation for consumer use-related TDS influencing the influent TDS concentrations, and Horsethief WRF does not have any lift stations within its sewer shed area that dose chemical for odor control purposes. Due to the inability to collect upstream and downstream samples for the lift stations which dose chemical, this contributing source was included in the consumer usage variable for this analysis.

The next hypothesis analyzes consumer uses of water, including domestic, industrial, and commercial dischargers coupled with the associated impacts of water conservation practices, and chemical dosing at lift stations for odor control. Railroad WRF and Horsethief WRF showed strong correlations to this variable as being a key influence on the influent TDS values, while Regional showed a weaker correlation. Additional studies and samples may be conducted for the sources within this variable to further differentiate between the possible key contributors.

The final hypothesis looks to the water system as a possible main contributor, either in the raw, untreated source water, or the chemically-treated disinfected water. The groundwater wells dose a monthly average of 61.32 mg/L TDS, while the water booster stations dose a monthly average of 123.90 mg/L of TDS addition to the water system from sodium hypochlorite/chloramines for disinfection (Table 19). It is important to note, however, that the booster stations typically only dose flows that are going to reservoirs for water storage and as sodium hypochlorite continues to react in the water, over time it will eventually fall out of solution. All facilities showed the raw, untreated water TDS as providing the largest mass loadings of TDS to the facilities. However, none of the three facilities showed a very strong correlation between the raw water TDS as influencing the influent of the wastewater treatment facilities, with Regional showing a weak correlation and Railroad and Horsethief yielding weak-to-no correlation. The chemical addition to source water for disinfection purposes was found to hold weak-to-no correlation for all facilities.

It has recently been proposed via the currently pending Basin Plan amendment to adjust the TDS permit effluent limits to 5-year rolling averages, instead of 1-year rolling averages. Based on this alternative method, Regional WRF would be with permit limit requirements for TDS (5-year rolling average from 2016-2020: 686 mg/L, Figure 24); however, Railroad would still be unable to meet permit limits, as the 5-year rolling average from 2016-2020 is 787 mg/L (Figure 25). Horsethief WRF's TDS concentrations would not be affected by this rolling average, as Horsethief has a higher permit effluent limit and typically exceeds only on the source water TDS + 250 permit limit:



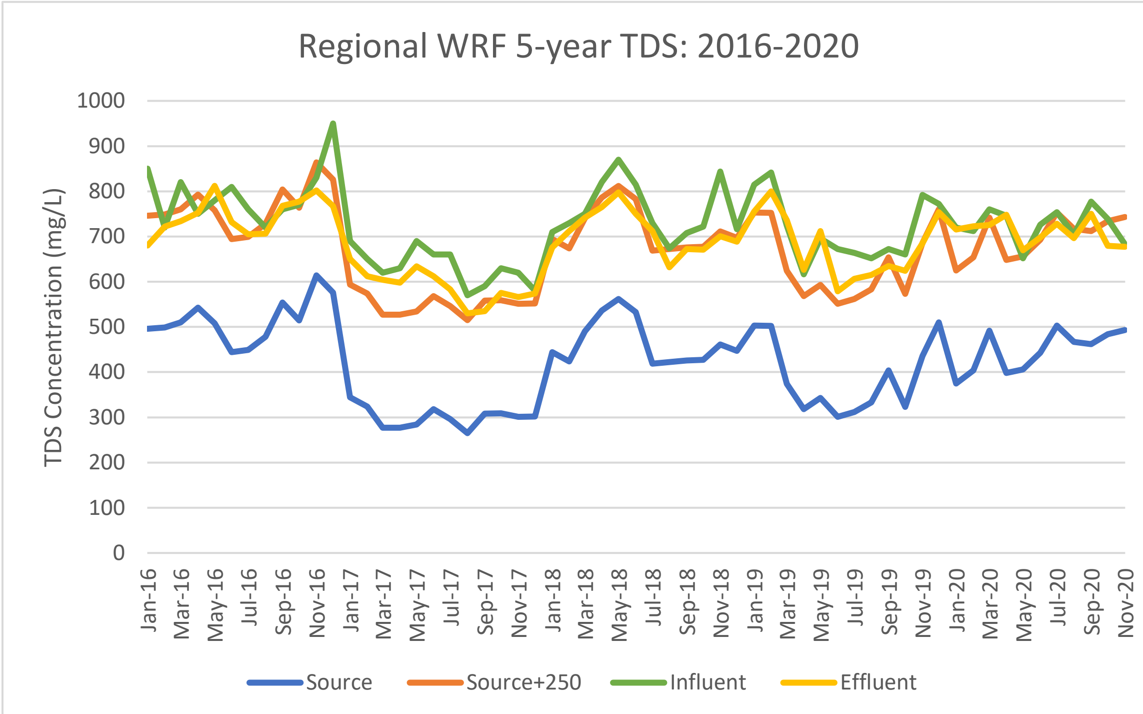


Figure 24. Regional WRF 5-year TDS Average

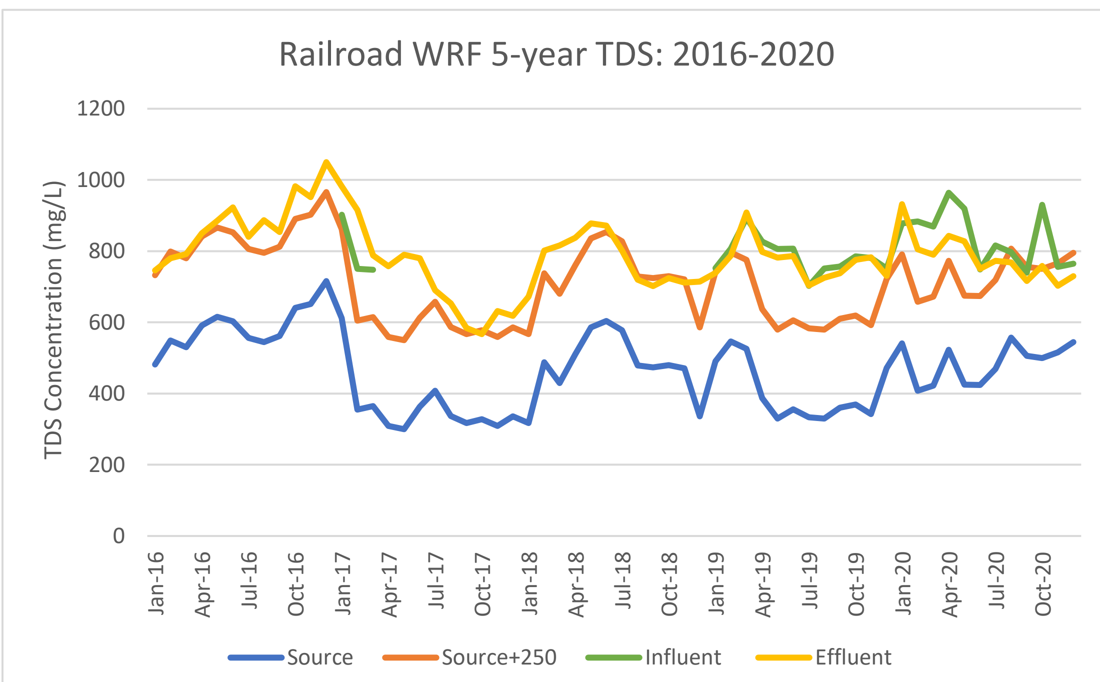


Figure 25. Railroad WRF 5-year TDS Average

More data and studies are needed to determine the significance of raw source water, and by association, the water stations which dose chemical for disinfection, as contributors of increased TDS to the water and wastewater system. Once odor control studies are completed at the sewer lift stations, samples may be collected to determine actual contribution of TDS values to the wastewater system, though these may not be comparable to the 2020 year, as an alternative chemical solution is likely to be chosen in place of the existing sodium hypochlorite. Samples can also be collected along the sewer collection system to determine areas of high TDS and potentially pinpoint if any specific domestic, commercial, or industrial processes may be contributing to TDS.

Additionally, options such as adjusting the permit limits from a 12-month rolling average to a 60-month (5-year) rolling average may alleviate some of the concerns regarding drought, water conservation activities, and inconsistencies with TDS concentrations. However, only one of the three wastewater treatment facilities would be affected as a result of this modification, while the remaining two facilities would still struggle to meet TDS effluent limits. Another option would be to assess the State-allowed ‘250 mg/L’ addition after receiving source water, to determine if this is still a realistic scenario for southern California wastewater treatment facilities. This allowance of ‘250’ may no longer be enough of a buffer, as conservation and drought are leading to an increase in TDS concentrations, without the typically accompanying increased flows to dilute these values.

Projected data from the TDS Offset Plan (MWH - prepared for EVMWD, 2012) assumes an estimate of approximately 465 to 759 tons of TDS offset will be required between the years of 2005 – 2022 (Table 12). This estimate takes into account only the excess TDS amounts above the 700 mg/L permitted final effluent discharge value. Other estimated offset totals includes either a scenario where the incoming potable water TDS concentration is taken into consideration and the incoming TDS values above 400 mg/L from the Colorado River and State Water Project are deducted from the offset amount required (water supply credit); or a calculation of only the actual water volumes estimated to reach the Santa Ana River or impact the Temescal groundwater. Despite the various options for offset requirements, all three scenarios will still require the need for TDS offset.

Table 11. Summary of historical and projected offset requirements for Regional WRF

Summary of Historical and Projected Offset Requirements for RWRF (2005 – 2022)

Year	Exceedances above permit requirements for Regional WRF (Tons)
2005 - 2011 Historical – without credit when in compliance	446
2005-2011 Historical Offset with credit for elevated Metropolitan water supply TDS	303
2005 – 2011 Historical – with acceptance of no impact in Reaches 2 and 3 and Temescal Valley Groundwater	0
Projected Offset (Median Hydrology) (2012 – 2022)	19
Projected Offset (Wet Hydrology – Reduced Lake Elsinore Discharge)	313
Projected Offset (Dry Hydrology – Maximum Lake Elsinore Discharge)	19
Total Offset Required (2005 – 2022) without credits	465 – 759
Total Offset Required (2005 – 2022) with water supply credit	322-616
Total Offset Required (2005-2022) with acceptance of no impacts	19-313

Systems such as reverse osmosis are proven to be effective for removing inorganic salts and other ions, but the economic considerations have to be considered, since the costs that cannot be subsidized from government programs often fall onto the consumers. A reverse osmosis system is extremely effective at treating wastewater and providing higher quality water, but it needs a suitable pretreatment system to prevent fouling (Manufacturing.Net, 2009). A common pretreatment option is a Membrane Bioreactor system (MBR), which utilizes ultrafiltration or microfiltration methods (Manufacturing.Net, 2009). MBR systems also require cleaning to reduce fouling, which includes chemical addition of sodium hypochlorite and citric acid, and increased maintenance to ensure proper operation.

Reverse Osmosis systems also produce concentrated brine material, which will need to be disposed of. The current planned design for brine disposal is through the Inland Empire Brine Line, which will transport the heavily concentrated water to the ocean. The additional equipment, chemicals, and labor associated with advanced wastewater treatment technologies can prove to be quite expensive and not always economically feasible. Therefore, if the TDS sources can be identified and mitigated prior to this point, the economic disadvantages of installing advanced treatment equipment can be forestalled while the TDS issue is addressed.

APPENDIX A. – TDS CALCULATION DATA

Regional WRF - December 2020	Raw TDS mg/L	MG	ACRE FT
Back Basin GWTP	516	0.00	0.00
Corydon Well	284	20.91	64.18
Cereal #1 Well	302	8.29	25.43
Cereal #3 Well	278	40.90	125.53
Cereal #4 Well	476	0.00	0.00
Lincoln Well	466	0.00	0.00
Machado Well Forward	652	26.20	80.41
Joy St Well	506	0.00	0.00
Diamond Well	584	14.21	43.62
Summerly Well	560	0.00	0.00
CLWTP CE	324	0.00	0.00
Auld Valley/CalOaks Connection	608	237.22	727.99
Flagler	866	13.98	42.90
Terra Cotta	488	26.50	81.34
Temescal Valley Connection	270	104.15	319.61
WEIGHTED AVERAGE			492.69
TOTAL PRODUCTION ACRE FEET			1,511.01

12 Month Flow Weighted TDS Averages + 250 mg/L

	12 MO AVG	20-Jan	20-Feb	20-Mar	20-Apr	20-May	20-Jun	20-Jul	20-Aug	20-Sep	20-Oct	20-Nov	20-Dec
TDS	**453**	510	375	404	492	398	406	443	503	467	462	484	493
+250	**703**												

Railroad WRF - December 2020	Raw TDS mg/L	MG	ACRE FT
Back Basin GWTP	516	0.00	0.00
Corydon Well	284	20.91	64.18
Cereal #1 Well	302	8.29	25.43
Cereal #3 Well	278	40.90	125.53
Cereal #4 Well	476	0.00	0.00
Lincoln Well	466	0.00	0.00
Machado Well Forward	652	26.20	80.41
Joy St Well	506	0.00	0.00
Diamond Well	584	14.21	43.62
Summerly Well	560	0.00	0.00
CLWTP CE	324	0.00	0.00
Auld Valley/CalOaks Connection	608	237.22	727.99
Flagler	866	13.98	42.90
Terra Cotta	488	26.50	81.34
EMWD Carla Jean PSS 15	314	1.88	5.75
EMWD Desalter 85	304	10.63	32.61
WEIGHTED AVERAGE			544.74
TOTAL PRODUCTION ACRE FEET			1,229.76

12 Month Flow Weighted TDS Averages + 250 mg/L

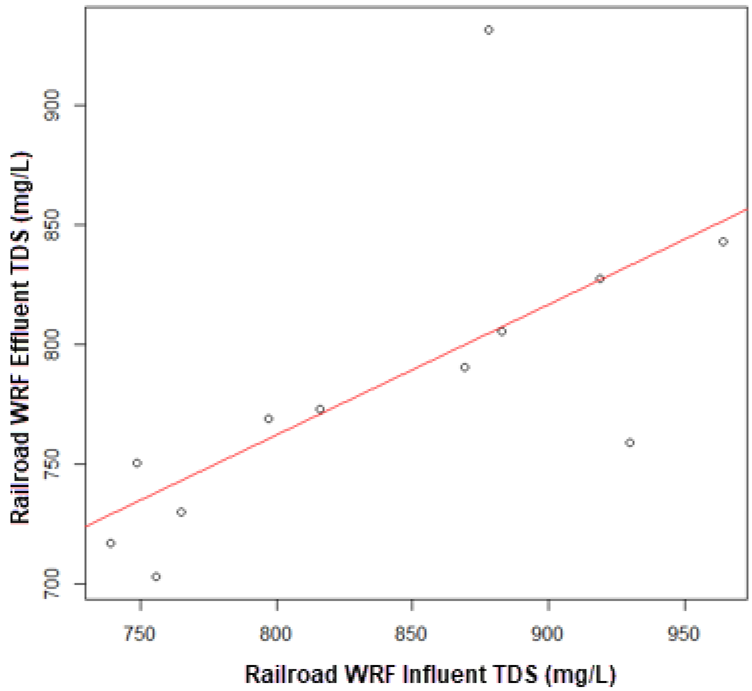
	12 MO AVG	20-Jan	20-Feb	20-Mar	20-Apr	20-May	20-Jun	20-Jul	20-Aug	20-Sep	20-Oct	20-Nov	20-Dec
TDS	**486**	541	408	422	523	425	424	469	557	506	500	516	545
+250	**736**												

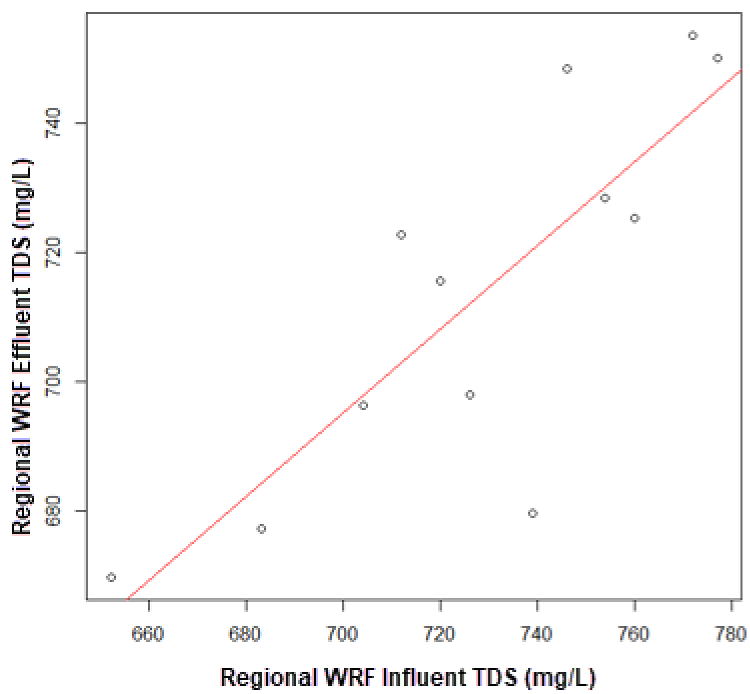
APPENDIX B. RAILROAD WRF AND REGIONAL WRF TDS VALUES (5-YEAR)

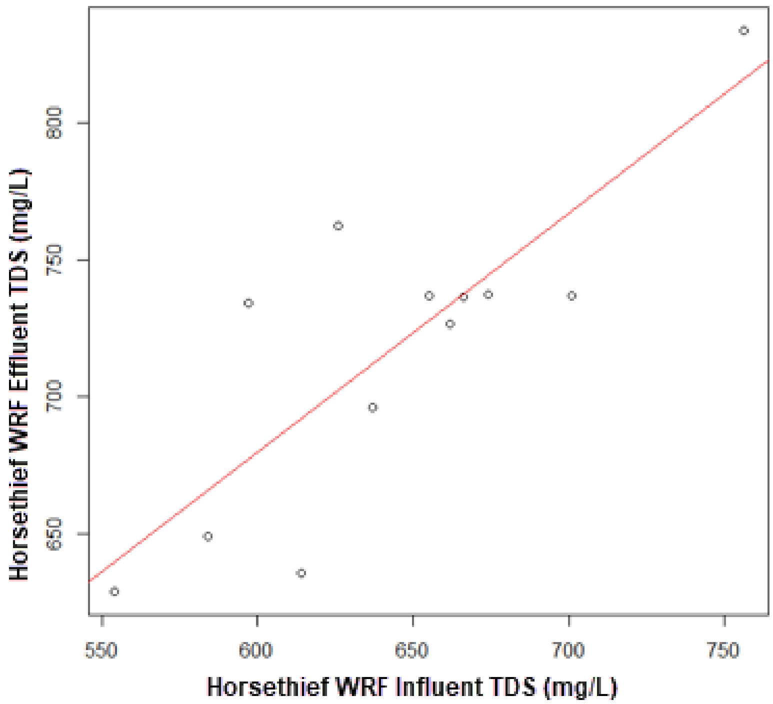
	Regional WRF				Railroad WRF			
Date	Source	Source+250	Influent	Effluent	Source	Source+250	Influent	Effluent
Jan-16	457	707		665	482	732	NA	746
Feb-16	496	746	850	680	549	799	NA	780
Mar-16	499	749	720	722	530	780	NA	792
Apr-16	510	760	820	734	591	841	NA	850
May-16	543	793	750	752	616	866	NA	885
Jun-16	508	758	780	812	603	853	NA	923
Jul-16	444	694	810	732	556	806	NA	840
Aug-16	449	699	760	705	545	795	NA	887
Sep-16	478	728	720	706	562	812	NA	854
Oct-16	554	804	760	768	641	891	NA	982
Nov-16	514	764	770	777	652	902	NA	952
Dec-16	614	864	830	802	716	966	NA	1050
Jan-17	576	826	950	767	612	862	902	982
Feb-17	344	594	690	650	355	605	750	916
Mar-17	324	574	650	612	365	615	748	788
Apr-17	277	527	620	604	309	559	NA	758
May-17	277	527	630	598	300	550	NA	790
Jun-17	284	534	690	634	363	613	NA	780
Jul-17	318	568	660	612	408	658	NA	690
Aug-17	296	546	660	583	337	587	NA	653
Sep-17	265	515	570	530	317	567	NA	584
Oct-17	308	558	590	535	328	578	NA	567
Nov-17	309	559	630	575	309	559	NA	632
Dec-17	301	551	620	566	336	586	NA	618
Jan-18	302	552	580	574	317	567	NA	672
Feb-18	444	694	710	676	488	738	NA	802
Mar-18	424	674	730	712	430	680	NA	816
Apr-18	490	740	750	742	510	760	NA	838
May-18	536	786	820	765	586	836	NA	878
Jun-18	562	812	870	798	604	854	NA	872
Jul-18	533	783	815	750	578	828	NA	802
Aug-18	419	669	730	712	479	729	NA	720
Sep-18	422	672	674	632	474	724	NA	702
Oct-18	426	676	708	672	480	730	NA	725
Nov-18	427	677	722	671	471	721	NA	712
Dec-18	461	711	844	700	336	586	NA	715
Jan-19	447	697	716	689	491	741	752	738
Feb-19	503	753	814	755	546	796	807	788
Mar-19	502	752	842	800	526	776	893	909
Date	Regional WRF (Cont.)				Railroad WRF (Cont.)			

	Source	Source+250	Influent	Effluent	Source	Source+250	Influent	Effluent
Apr-19	374	624	724	736	387	637	827	798
May-19	318	568	616	626	330	580	806	782
Jun-19	343	593	696	712	356	606	807	786
Jul-19	301	551	672	579	333	583	702	704
Aug-19	312	562	664	606	330	580	751	726
Sep-19	333	583	652	615	360	610	757	738
Oct-19	404	654	672	635	369	619	785	775
Nov-19	323	573	660	624	342	592	781	783
Dec-19	436	686	792	685	472	722	752	730
Jan-20	510	760	772	754	541	791	878	932
Feb-20	375	625	720	716	408	658	883	806
Mar-20	404	654	712	723	422	672	869	790
Apr-20	492	742	760	725	523	773	964	843
May-20	398	648	746	748	425	675	919	828
Jun-20	406	656	652	670	424	674	749	750
Jul-20	443	693	726	698	469	719	816	773
Aug-20	503	753	754	728	557	807	797	769
Sep-20	467	717	704	696	506	756	739	717
Oct-20	462	712	777	750	500	750	930	759
Nov-20	484	734	739	680	516	766	756	703
Dec-20	493	743	683	677	545	795	765	730
AVERAGE				**686**				**787**

APPENDIX C. LINEAR REGRESSION GRAPHS AND DATA


Railroad WRF Effluent TDS (mg/L)
700
750
800
850
900
750
800
850
900
950
Railroad WRF Influent TDS (mg/L)


Regional WRF Effluent TDS (mg/L)
680
700
720
740
660
680
700
720
740
760
780
Regional WRF Influent TDS (mg/L)



Horsethief WRF Effluent TDS (mg/L)
650
700
750
800
550
600
650
700
750
Horsethief WRF Influent TDS (mg/L)

Regional WRF						
Variables ->	Y				X_1	X_2
Date	Influent	Blended source (disinfected)	Blended source (raw)	Increase from Treatment	Increase after Treatment	Blended source (raw)
1/15/2020	772	547	481	66	225	481
2/15/2020	720	540	458	82	180	458
3/15/2020	712	576	475	101	136	475
4/15/2020	760	599	505	94	161	505
5/15/2020	746	582	493	89	164	493
6/15/2020	700	558	481	77	142	481
7/15/2020	726	576	497	79	150	497
8/15/2020	754	597	515	82	157	515
9/15/2020	704	535	451	84	169	451
10/15/2020	777	617	506	111	160	506
11/15/2020	739	569	485	84	170	485
12/15/2020	683	568	481	87	115	481
Average	***732.8***	***572.0***	***485.7***	***86.3***	***160.8***	
Percent	***100***		***66.3***	***11.8***	***21.9***	
Correlation Coefficient with Influent, R			**0.611219511**	**0.148386155**	**0.624407701**	
Coefficient of Determination, R^2			**0.373589291**	**0.022018451**	**0.389884978**	

Railroad WRF						
Variables ->	Y				X_1	X_2
Date	Influent	Blended source (disinfected)	Blended source (raw)	Increase from Treatment	Increase after Treatment	Blended source (raw)
1/15/2020	878	547	481	66	331	481
2/15/2020	883	540	458	82	343	458
3/15/2020	869	576	475	101	293	475
4/15/2020	964	599	505	94	365	505
5/15/2020	919	582	493	89	337	493
6/15/2020	749	558	481	77	191	481
7/15/2020	816	576	497	79	240	497
8/15/2020	797	597	515	82	200	515
9/15/2020	739	535	451	84	204	451
10/15/2020	930	617	506	111	313	506
11/15/2020	756	569	485	84	187	485
12/15/2020	765	568	481	87	197	481
Average	***838.8***	***572.0***	***485.7***	***86.3***	***266.8***	
Percent	***100***		***57.9***	***10.3***	***31.8***	
Correlation Coefficient with Influent, R			**0.362098459**	**0.442694551**	**0.950536437**	
Coefficient of Determination, R^2			**0.131115294**	**0.195978466**	**0.903519518**	

	<u>Horsethief WRF</u>					
Variables ->	**Y**				**X_1**	**X_2**
Date	**Influent**	**Blended source (disinfected)**	**Blended source (raw)**	**Increase from Treatment**	**Increase after Treatment**	**Blended source (raw)**
1/15/2020	666	547	481	66	119	481
2/15/2020	626	540	458	82	86	458
3/15/2020	597	576	475	101	21	475
4/15/2020	600	599	505	94	1	505
5/15/2020	614	582	493	89	32	493
6/15/2020	600	558	481	77	42	481
7/15/2020	662	576	497	79	86	497
8/15/2020	674	597	515	82	77	515
9/15/2020	665	535	451	84	130	451
10/15/2020	756	617	506	111	139	506
11/15/2020	701	569	485	84	132	485
12/15/2020	637	568	481	87	69	481
Average	***649.8***	***572.0***	***485.7***	***86.3***	***77.8***	
Percent	***100***		***74.7***	***13.3***	***12.0***	
Correlation Coefficient with Influent, R			**0.267313623**	**0.204867473**	**0.861629225**	
Coefficient of Determination, R^2			**0.071456573**	**0.041970681**	**0.742404922**	

Multivariable Regression			
	X_2	**X_1**	**b (intercept)**
	1.124509	0.813365	55.86499213
std. dev.	0.178753	0.127225	91.9774625
R^2	**0.886957**	11.16251	#N/A
F	35.30784	9	#N/A
	8798.835	1121.415	#N/A

Regional WRF

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.941784
R Square	0.886957
Adjusted R Squ	0.861836
Standard Error	11.16251
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	2	8798.835	4399.41732	35.30784	5.49E-05
Residual	9	1121.415	124.6017066		
Total	11	9920.25			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	55.86499	91.97746	0.607376966	0.558612	-152.202	263.9325	-152.202	263.9324677
X Variable 1	0.813365	0.127225	6.39313042	0.000126	0.525562	1.101167	0.525562	1.101167499
X Variable 2	1.124509	0.178753	6.290844485	0.000143	0.720141	1.528877	0.720141	1.528877141

Railroad WRF

Multivariable Regression

	X_2	X_1	b (intercept)
	1.14797	1.039563	3.915885365
std. dev.	0.191848	0.052339	93.02844046
R^2	**0.98062**	12.049	#N/A
F	227.698	9	#N/A
	66113.64	1306.605	#N/A

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.990263
R Square	0.98062
Adjusted R Squ	0.976313
Standard Error	12.049
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	2	66113.64	33056.82243	227.698	1.96E-08
Residual	9	1306.605	145.1783497		
Total	11	67420.25			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	3.915885	93.02844	0.042093422	0.967343	-206.529	214.3608	-206.529	214.3608383
X Variable 1	1.039563	0.052339	19.86219053	9.65E-09	0.921164	1.157962	0.921164	1.157961621
X Variable 2	1.14797	0.191848	5.983740729	0.000207	0.713979	1.581961	0.713979	1.581960561

APPENDIX D. CHEMICAL DOSING AND PRODUCTION DATA

Cereal 1 Well							
Month	**Avg Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Well Production (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	1.33	0.125	33.3	2.0	0.3	29.1	66.6
February	0.00	0.125	0.0	0.0	0.0	0.0	0.0
March	0.00	0.125	0.0	0.0	0.0	0.0	0.0
April	0.00	0.125	0.0	0.0	0.0	0.0	0.0
May	0.00	0.125	0.0	0.0	0.0	0.0	0.0
June	0.00	0.125	0.0	0.0	0.0	0.0	0.0
July	1.70	0.125	42.4	20.0	0.9	110.6	848.7
August	1.67	0.125	41.8	27.0	1.7	78.9	1128.2
September	1.67	0.125	41.8	27.0	1.8	75.3	1128.2
October	2.05	0.125	51.3	26.0	1.3	127.0	1333.6
November	1.87	0.125	46.8	30.0	2.0	84.9	1403.6
December	1.84	0.125	46.0	3.0	0.3	60.0	138.1

Cereal 3 Well							
Month	**Avg Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Well Production (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	0.00	0.080	0.0	0.0	0.0	0.0	0.0
February	0.00	0.080	0.0	0.0	0.0	0.0	0.0
March	0.00	0.080	0.0	0.0	0.0	0.0	0.0
April	0.00	0.080	0.0	0.0	0.0	0.0	0.0
May	0.00	0.080	0.0	0.0	0.0	0.0	0.0
June	0.00	0.080	0.0	0.0	0.0	0.0	0.0
July	0.00	0.080	0.0	0.0	0.0	0.0	0.0
August	0.00	0.080	0.0	0.0	0.0	0.0	0.0
September	0.99	0.080	15.8	13.0	0.7	34.4	205.3
October	0.97	0.080	15.5	31.0	1.3	43.8	480.5
November	0.97	0.080	15.5	30.0	1.7	32.0	466.5
December	1.07	0.080	17.2	28.0	1.4	42.3	481.5

Corydon Blend							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	Lbs/day of chemical addition	# of days online	Avg. Well Production (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	1.40	0.125	35.0	4.0	0.2	81.4	140.1
February	0.00	0.125	0.0	0.0	0.0	0.0	0.0
March	0.00	0.125	0.0	0.0	0.0	0.0	0.0
April	0.00	0.125	0.0	0.0	0.0	0.0	0.0
May	0.00	0.125	0.0	0.0	0.0	0.0	0.0
June	0.00	0.125	0.0	0.0	0.0	0.0	0.0
July	1.58	0.125	39.5	16.0	0.7	104.8	632.5
August	1.68	0.125	42.1	26.0	1.4	93.4	1094.2
September	1.83	0.125	45.7	24.0	1.2	112.8	1095.9
October	1.77	0.125	44.2	25.0	1.2	107.0	1104.0
November	1.60	0.125	40.1	28.0	1.4	96.6	1122.3
December	1.50	0.125	37.5	13.0	0.7	83.9	487.9

Cereal 4 Well							
Month	Avg Cl Dose (GPH)	Cl2 Conc.	Lbs/day of chemical addition	# of days online	Avg. Well Production (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	1.53	0.080	24.5	8.0	0.7	34.9	196.0
February	0.00	0.080	0.0	0.0	0.0	0.0	0.0
March	0.00	0.080	0.0	0.0	0.0	0.0	0.0
April	0.00	0.080	0.0	0.0	0.0	0.0	0.0
May	1.76	0.080	28.2	24.0	1.2	67.0	676.4
June	1.66	0.080	26.6	30.0	2.7	35.1	799.4
July	1.59	0.080	25.4	30.0	2.0	45.4	761.4
August	1.60	0.080	25.6	11.0	1.1	30.9	281.8
September	1.80	0.080	28.8	4.0	0.4	38.3	115.3
October	0.00	0.080	0.0	0.0	0.0	0.0	0.0
November	0.00	0.080	0.0	0.0	0.0	0.0	0.0
December	0.00	0.080	0.0	0.0	0.0	0.0	0.0

Diamond Well							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	lbs/day of chemical addition	# of days online	Avg. Well Production (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	2.57	0.125	64.3	29.0	2.3	98.4	1864.7
February	2.35	0.125	58.7	25.0	1.8	99.5	1468.0
March	2.47	0.125	61.7	24.0	2.0	90.9	1480.2
April	2.51	0.125	62.7	27.0	1.9	109.0	1693.6
May	2.49	0.125	62.4	31.0	1.9	121.3	1933.6
June	2.62	0.125	65.4	30.0	2.4	97.9	1962.8
July	2.60	0.125	65.2	31.0	2.1	118.0	2019.7
August	2.41	0.125	60.3	23.0	1.7	99.9	1385.9
September	0.00	0.125	0.0	0.0	0.0	0.0	0.0
October	0.00	0.125	0.0	0.0	0.0	0.0	0.0
November	0.00	0.125	0.0	0.0	0.0	0.0	0.0
December	2.82	0.125	70.5	10.0	0.5	178.3	704.7

Joy St Well							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	lbs/day of chemical addition	# of days online	Avg. Well Production (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	0.00	0.080	0.0	0.0	0.0	0.0	0.0
February	1.71	0.080	27.4	14.0	0.4	123.8	383.3
March	1.56	0.080	24.9	21.0	0.7	86.2	523.3
April	1.51	0.080	24.1	19.0	0.7	79.3	458.5
May	1.47	0.080	23.5	26.0	0.8	95.0	610.6
June	1.46	0.080	23.3	20.0	0.6	98.8	466.6
July	1.46	0.080	23.4	31.0	1.0	90.0	724.7
August	1.80	0.080	28.8	27.0	0.9	108.9	778.2
September	2.16	0.080	34.5	27.0	0.8	143.7	931.9
October	1.97	0.080	31.5	24.0	0.7	138.8	755.8
November	1.76	0.080	28.2	12.0	0.4	111.2	338.7
December	0.00	0.080	0.0	0.0	0.0	0.0	0.0

Machado Well							
Month	**Avg. Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Well Production (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	1.73	0.080	27.8	31.0	0.9	113.1	860.4
February	1.92	0.080	30.7	28.0	0.9	108.9	860.3
March	2.00	0.080	32.0	28.0	1.1	94.9	896.7
April	2.06	0.080	33.0	28.0	0.9	125.2	924.7
May	1.93	0.080	30.8	30.0	0.9	123.9	924.7
June	1.99	0.080	31.8	28.0	1.0	103.6	890.0
July	2.24	0.080	35.9	31.0	1.0	128.2	1114.1
August	2.09	0.080	33.4	29.0	1.0	111.7	969.4
September	1.98	0.080	31.6	28.0	0.9	115.7	885.5
October	2.14	0.080	34.3	25.0	0.8	136.7	856.7
November	2.17	0.080	34.7	29.0	0.9	140.0	1006.1
December	1.90	0.080	30.4	29.0	0.9	121.1	882.3

Flagler 2A & 3A Well							
Month	**Avg. Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Well Production (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	0.00	0.125	0.0	0.0	0.0	0.0	0.0
February	0.00	0.125	0.0	0.0	0.0	0.0	0.0
March	0.00	0.125	0.0	0.0	0.0	0.0	0.0
April	0.12	0.125	3.0	30.0	0.0	0.0	89.2
May	0.42	0.125	10.6	31.0	0.0	0.0	328.1
June	0.79	0.125	19.9	30.0	0.0	0.0	596.0
July	1.22	0.125	30.4	16.0	0.7	83.8	487.0
August	1.47	0.125	36.7	26.0	1.2	92.1	953.6
September	1.16	0.125	28.9	26.0	1.2	77.0	751.4
October	1.26	0.125	31.5	23.0	1.1	80.2	725.3
November	0.60	0.125	15.1	17.0	0.5	56.7	257.2
December	0.57	0.125	14.2	22.0	0.5	80.4	312.4

Terra Cotta Well							
Month	**Avg. Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Well Production (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	2.01	0.080	32.2	29.0	0.8	149.1	934.9
February	0.00	0.080	0.0	29.0	0.2	0.0	0.0
March	2.00	0.080	32.0	28.0	0.5	222.0	896.7
April	2.02	0.080	32.3	25.0	0.9	102.5	807.4
May	2.09	0.080	33.5	31.0	1.1	118.4	1038.7
June	2.02	0.080	32.3	25.0	1.0	101.5	807.6
July	0.00	0.080	0.0	0.0	0.0	0.0	0.0
August	2.10	0.080	33.6	26.0	1.0	103.5	874.3
September	2.32	0.080	37.1	25.0	0.9	120.8	927.4
October	2.18	0.080	34.8	31.0	1.0	127.9	1079.7
November	1.89	0.080	30.2	29.0	1.1	100.0	876.5
December	1.94	0.080	31.0	29.0	0.9	122.1	899.3

Auld Valley Pipeline (@ Cal Oaks/Auld Valley Pump Station)							
Month	**Avg. Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Flow (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	2.78	0.080	44.6	26.0	5.8	24.2	1158.8
February	2.83	0.080	45.3	29.0	6.0	26.1	1314.2
March	2.14	0.080	34.3	31.0	4.5	28.6	1062.3
April	2.65	0.080	42.4	30.0	5.4	28.1	1271.6
May	3.75	0.080	60.0	31.0	8.1	27.6	1861.5
June	3.28	0.080	52.6	30.0	8.8	21.4	1577.3
July	3.44	0.080	55.0	31.0	8.5	24.0	1706.4
August	1.98	0.080	31.7	30.0	7.8	14.6	950.4
September	3.61	0.080	57.9	30.0	9.4	22.2	1736.2
October	2.59	0.080	41.5	31.0	8.5	18.2	1285.7
November	2.73	0.080	43.7	30.0	4.6	34.5	1311.4
December	2.36	0.080	37.7	30.0	6.6	20.5	1131.9

La Laguna I Pump Station							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	Lbs/day of chemical addition	# of days online	Avg. Flow (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	0.53	0.125	13.2	13.0	0.5	38.8	171.3
February	0.48	0.125	12.0	11.0	0.9	17.2	132.1
March	0.49	0.125	12.1	5.0	1.2	6.1	60.7
April	0.50	0.125	12.5	6.0	1.1	8.5	75.1
May	0.51	0.125	12.7	3.0	1.4	3.3	38.1
June	0.44	0.125	11.0	6.0	1.4	5.5	66.1
July	0.47	0.125	11.8	9.0	1.3	9.6	106.6
August	0.48	0.125	12.0	15.0	0.9	22.9	180.1
September	0.53	0.125	13.3	28.0	0.7	64.5	373.6
October	0.54	0.125	13.5	31.0	0.5	102.1	418.8
November	0.51	0.125	12.7	29.0	0.6	75.2	367.6
December	0.43	0.125	10.8	26.0	0.4	77.4	281.9

Cottonwood 2 Pump Station							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	lbs/day of chemical addition	# of days online	Avg. Flow (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	0.93	0.080	14.8	24.0	0.1	360.4	356.1
February	1.03	0.080	16.4	26.0	0.4	130.8	427.4
March	0.86	0.080	13.7	28.0	0.2	263.6	384.3
April	1.10	0.080	17.5	29.0	0.3	209.5	508.8
May	0.77	0.080	12.3	30.0	0.4	110.2	368.3
June	1.22	0.080	19.5	29.0	0.4	190.3	566.5
July	0.90	0.080	14.5	29.0	0.4	118.1	419.1
August	1.11	0.080	17.7	30.0	0.4	178.2	530.8
September	1.32	0.080	21.1	28.0	0.6	125.3	591.8
October	1.30	0.080	20.8	31.0	0.4	191.4	644.1
November	0.94	0.080	15.1	30.0	0.3	166.8	453.5
December	0.69	0.080	11.0	27.0	0.1	320.2	296.2

Rosetta 2 Pump Station							
Month	**Avg. Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Flow (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	0.44	0.080	7.0	29.0	0.4	67.7	204.3
February	0.66	0.080	10.6	28.0	0.3	130.9	295.9
March	1.32	0.080	21.1	30.0	0.2	485.8	634.1
April	1.93	0.080	31.0	30.0	0.5	204.0	929.1
May	1.04	0.080	16.7	31.0	0.4	170.9	516.3
June	1.01	0.080	16.1	30.0	0.5	113.1	483.1
July	0.95	0.080	15.2	30.0	0.4	124.8	456.4
August	1.65	0.080	26.4	31.0	0.3	391.3	817.1
September	0.64	0.080	10.2	30.0	0.2	215.7	307.4
October	0.93	0.080	14.9	31.0	0.2	266.2	461.6
November	0.70	0.080	11.2	28.0	0.5	74.7	313.9
December	0.50	0.080	8.0	29.0	0.2	148.2	232.2

Temescal Valley Pipeline (@ Horsethief Pump Station)							
Month	**Avg. Cl Dose (GPH)**	**Cl2 Conc.**	**lbs/day of chemical addition**	**# of days online**	**Avg. Flow (MGD)**	**Total Monthly TDS Addition (mg/L or ppm)**	**Total Monthly TDS Addition (lbs/month)**
January	1.25	0.125	31.3	21.0	2.0	38.8	656.8
February	1.80	0.125	45.0	29.0	3.5	44.7	1306.0
March	1.78	0.125	44.4	31.0	2.4	69.8	1376.7
April	2.85	0.125	71.3	30.0	2.3	110.1	2139.2
May	3.53	0.125	88.3	31.0	5.1	63.8	2736.4
June	5.03	0.125	125.7	30.0	6.2	72.8	3771.8
July	6.81	0.125	170.3	31.0	8.2	77.1	5279.1
August	6.94	0.125	173.5	31.0	9.6	67.3	5379.9
September	7.39	0.125	184.8	30.0	6.8	97.4	5543.7
October	6.80	0.125	170.1	31.0	6.7	93.7	5274.2
November	5.91	0.125	147.9	31.0	6.6	83.2	4583.9
December	5.10	0.125	127.6	29.0	6.0	73.9	3700.5

Cal Oaks Pump Station							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	lbs/day of chemical addition	# of days online	Avg. Flow (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	1.32	0.080	21.1	31.0	1.1	69.5	652.8
February	1.15	0.080	18.4	29.0	1.3	50.4	534.0
March	1.32	0.080	21.2	31.0	1.1	70.4	656.9
April	1.46	0.080	23.4	30.0	0.9	92.7	702.6
May	1.66	0.080	26.6	31.0	1.9	52.6	825.4
June	2.40	0.080	38.5	30.0	2.2	62.4	1154.5
July	1.65	0.080	26.3	31.0	2.1	45.8	816.6
August	1.22	0.080	19.5	30.0	2.2	32.1	585.3
September	2.35	0.080	37.6	30.0	2.3	58.4	1128.9
October	0.98	0.080	15.7	31.0	1.8	32.5	488.1
November	1.93	0.080	30.8	30.0	0.9	117.5	924.7
December	2.30	0.080	36.8	28.0	1.2	106.0	1031.2

Lucerne Pump Station							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	lbs/day of chemical addition	# of days online	Avg. Flow (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	1.46	0.125	36.5	26.0	4.5	25.4	949.8
February	0.52	0.125	13.1	26.0	1.9	21.0	340.4
March	1.31	0.125	32.8	29.0	1.3	85.9	950.5
April	1.10	0.125	27.5	30.0	1.4	70.1	825.7
May	0.97	0.125	24.2	30.0	2.5	34.7	726.6
June	0.72	0.125	18.0	26.0	3.0	18.5	468.4
July	1.45	0.125	36.2	29.0	2.9	42.8	1049.7
August	1.41	0.125	35.3	30.0	3.6	35.2	1059.8
September	0.94	0.125	23.6	30.0	3.4	24.8	708.1
October	1.37	0.125	34.4	31.0	2.5	50.6	1065.2
November	0.65	0.125	16.3	29.0	1.5	38.5	471.6
December	0.36	0.125	9.0	28.0	1.7	17.5	252.2

Woodmoor Pump Station							
Month	Avg. Cl Dose (GPH)	Cl2 Conc.	lbs/day of chemical addition	# of days online	Avg. Flow (MGD)	Total Monthly TDS Addition (mg/L or ppm)	Total Monthly TDS Addition (lbs/month)
January	0.47	0.125	11.8	27.0	0.1	364.3	318.9
February	0.42	0.125	10.5	29.0	0.2	228.4	304.7
March	1.02	0.125	25.6	28.0	0.2	391.0	717.4
April	0.39	0.125	9.8	29.0	0.5	63.8	284.2
May	0.36	0.125	9.1	30.0	0.7	50.2	272.1
June	0.34	0.125	8.4	29.0	0.1	418.4	244.3
July	0.36	0.125	9.0	30.0	0.1	279.9	270.2
August	0.39	0.125	9.8	28.0	0.1	283.5	274.6
September	0.39	0.125	9.7	29.0	0.1	293.2	280.6
October	0.40	0.125	9.9	28.0	0.1	384.4	278.5
November	0.45	0.125	11.3	27.0	0.1	301.0	304.0
December	0.43	0.125	10.8	27.0	0.2	153.8	290.5

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