STAFFORD LAKE
2021 WATERSHED SANITARY SURVEY

North Marin Water District

Prepared by:

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LIST OF APPENDICES

Introduction

This document was developed to meet the requirements of the California State Water Resources Control Board (SWRCB) Division of Drinking Water (Division or DDW) regulations for surface water treatment of Stafford Lake, a surface water source serving the North Marin Water District (NMWD). DDW regulations require domestic water suppliers that use a surface water source to conduct a sanitary survey and to update the survey every five (5) years.[1]

This document serves as an update of the 2002 Stafford Lake Watershed Sanitary Survey (WSS), and provides information used to develop watershed management goals and encourage effective management practices. The survey was conducted by SRT Consultants utilizing data developed from the past years of watershed surveillance and monitoring, as well as in-person site visits conducted in 2020. The survey was performed using a combination of literature reviews and interviews of stakeholders, including representatives of local agencies and landowners.

Section 1 - Stafford Lake Watershed

Stafford Lake is part of the drinking water supply for NMWD, which provides water for 61,000 people in Novato, California. Stafford Lake is located approximately five (5) miles west of Novato (Figure 1). The Stafford Lake watershed is 8.4 square miles in size. The lake was created in 1951 for the purpose of water supply by constructing a dam on Novato Creek, which flows from the highlands between Red Hill and Mount Burdell to San Pablo Bay. Stafford Lake Watershed is part of the larger Novato Creek Watershed; the North Bay Watersheds and the NMWD service areas are shown in Figure 2. The Point Reyes drinking water system and the Oceana Marin wastewater systems operated by North Marin Water District are separate and distinct, and are not served by Stafford Lake. Kennedy Engineers designed both the dam and the Stafford Treatment Plant (STP) that was originally constructed in 1952. The Stafford watershed above the lake consists of hilly grasslands and is, for the most part, undeveloped. The Watershed Management Plan from 2003 is included in Appendix A and the NMWD Urban Water Management Plan from 2015 is included in Appendix B.

[1] The California Surface Water Treatment Rule (SWTR), Title 22, Article 7, 64665 of the California Code of Regulations (CCR) required every public water system using surface water to complete a watershed sanitary survey and update it with any significant changes every five (5) years.

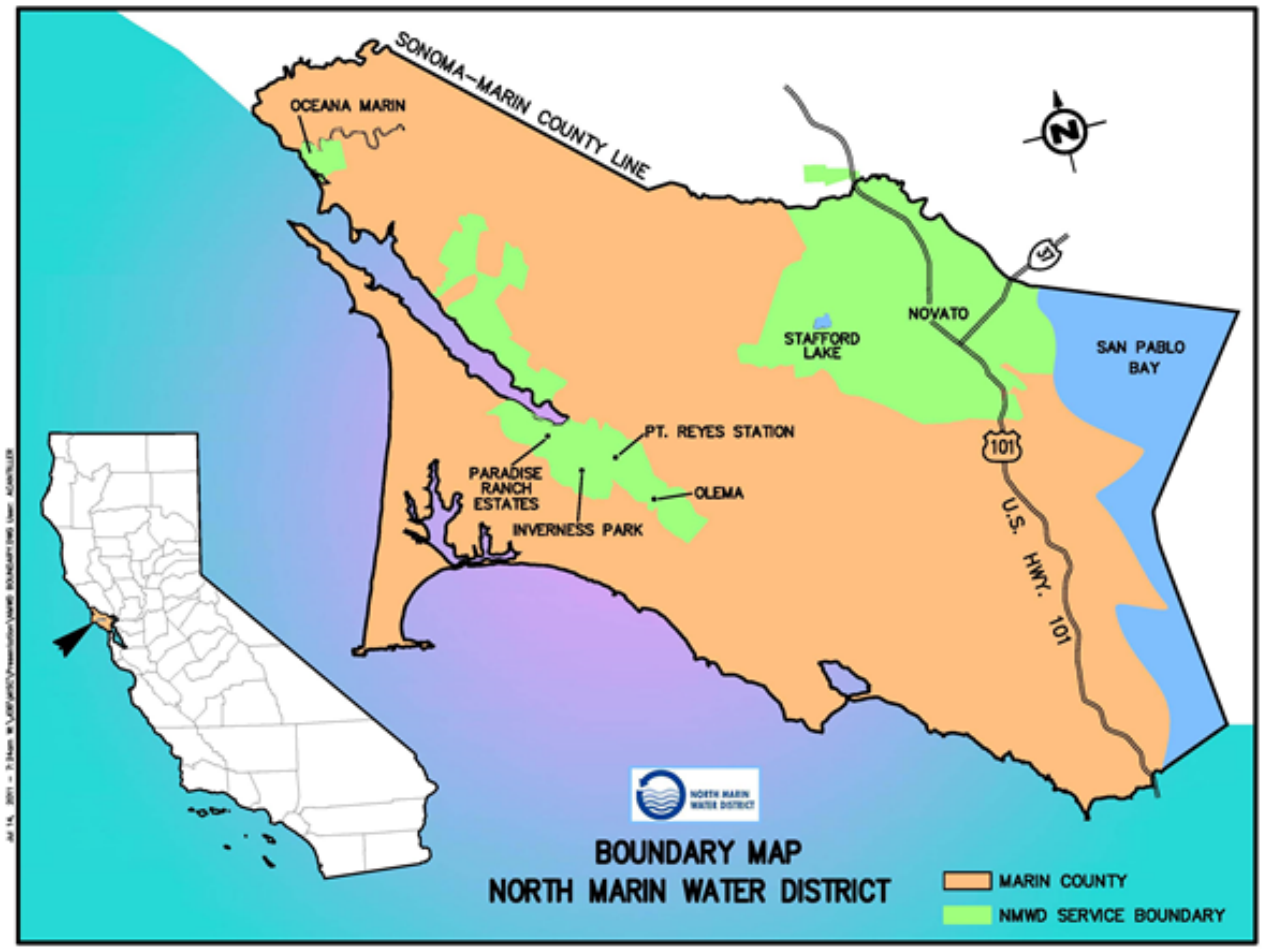

Figure 1. Stafford Lake Location and Service Area

Figure 2. North Bay Watershed Association Map

1.1 Regional Geology

Stafford Lake is located in a small valley within the central portion of the Coastal Mountain range of California. The coastal ranges consist of Franciscan formation rock overlain by Cretaceous and Tertiary sedimentary rocks. The Franciscan formation consists of sedimentary, volcanic and metamorphic rocks that in some areas form a melange due to intense shearing and crushing. During the Mesozoic era, the Franciscan rocks were deposited in a submarine trench off the coast of California. During the late Jurassic and early Cretaceous era, the coastal ranges were formed by uplifting of these sediments. The initial point of deposition of the rocks currently in the Marin County area may have been as far south as Baja California.The varying resistance of the different rock types to shearing and crushing, as they were uplifted and moved laterally, has resulted in the development of the Franciscan Melange. The existing topography is largely the result of the differential erosion rates of these rocks. The metamorphism of most of the original sediments in the area has mixed with volcanics during the same period of geologic time.

The entire area beneath Stafford Lake is underlain by Franciscan formation rocks of a number of types, all of which are variably sheared. The principal rock type is slightly to moderately metamorphosed graywacke sandstone. Other rock types include green stone, metachert, and minor amounts of metaconglomerate. The floor of Stafford Lake is composed of a 45-foot layer of alluvium overlaying Franciscan bedrock in the form of metamorphosed sandstone shale and chert with some inclusions of serpentine (asbestos). The bedrock varies from relatively large, intact, distinguishable blocks of individual rock types to a highly sheered and jumbled melange.[2]

1.2 Seismology

There is historical seismic activity In the vicinity of Stafford Lake, and the region generally is subject to three (3) broad categories of seismic risk:

1) Rupture of the ground surface along an active fault;
2) Shaking of the ground caused by the passage of seismic waves through the earth; and
3) Permanent ground surface displacements, such as landslides and subsidence.

Any of these events could potentially be triggered by an earthquake along one of the several faults located in the area (see Figure 3). The closest major faults are:

[2] Regional Geology is provided by the NMWD 2002 WSS.

Faults	Distance from Stafford
San Andreas	10 miles southwest
Hayward	15 miles southeast
Concord	18 miles east
Calaveras	41 miles southeast
Healdsburg - Rodgers Creek	10 miles northwest

Other faults in the area include the Burdell Mountain fault zone as well as various small inactive faults and sheer zones. One of these inactive faults is believed to pass through Stafford Lake in a northwest- southeast direction, approximately 500 feet from the dam embankment. No faults or sheer zones are known to underlie the embankment itself.

The dam embankment has been subjected to several relatively large earthquakes with epicenters within about 80 miles of the site. These earthquakes ranged in Richter magnitude from 5.2 to 7.1. There are no records indicating damage or adverse effects to the dam due to any of these earthquakes. Accelerographs located at the dam and the bedrock above have only triggered during the Loma Prieta quake.

In addition to the larger earthquakes, several smaller shocks on the order of magnitude 3 to 4 on the Richter scale have been felt in the area. Various studies conducted for the District have concluded that the Stafford Lake dam is not subject to failure if subjected to an earthquake of magnitude 8.25 on the San Andreas Fault (epicenter 10 miles from the dam site). A study performed in 2015 by Michael Baker International analyzed the risk of inundation for downstream areas in the case of both a breach or an overtopping.[3] No study has been made to determine the stability of the several smaller earthen dams on various ranch properties.

[3] Michael Baker International. (2015). Preparing for the Worst: Stafford Dam Emergency Action Planning and Risk Awareness. https://cdn.ymaws.com/membersfloodplain.site-ym.com/resource/resmgr/2015Conference/Thursday/Preparing-for-the-Worst---Mi.pdf

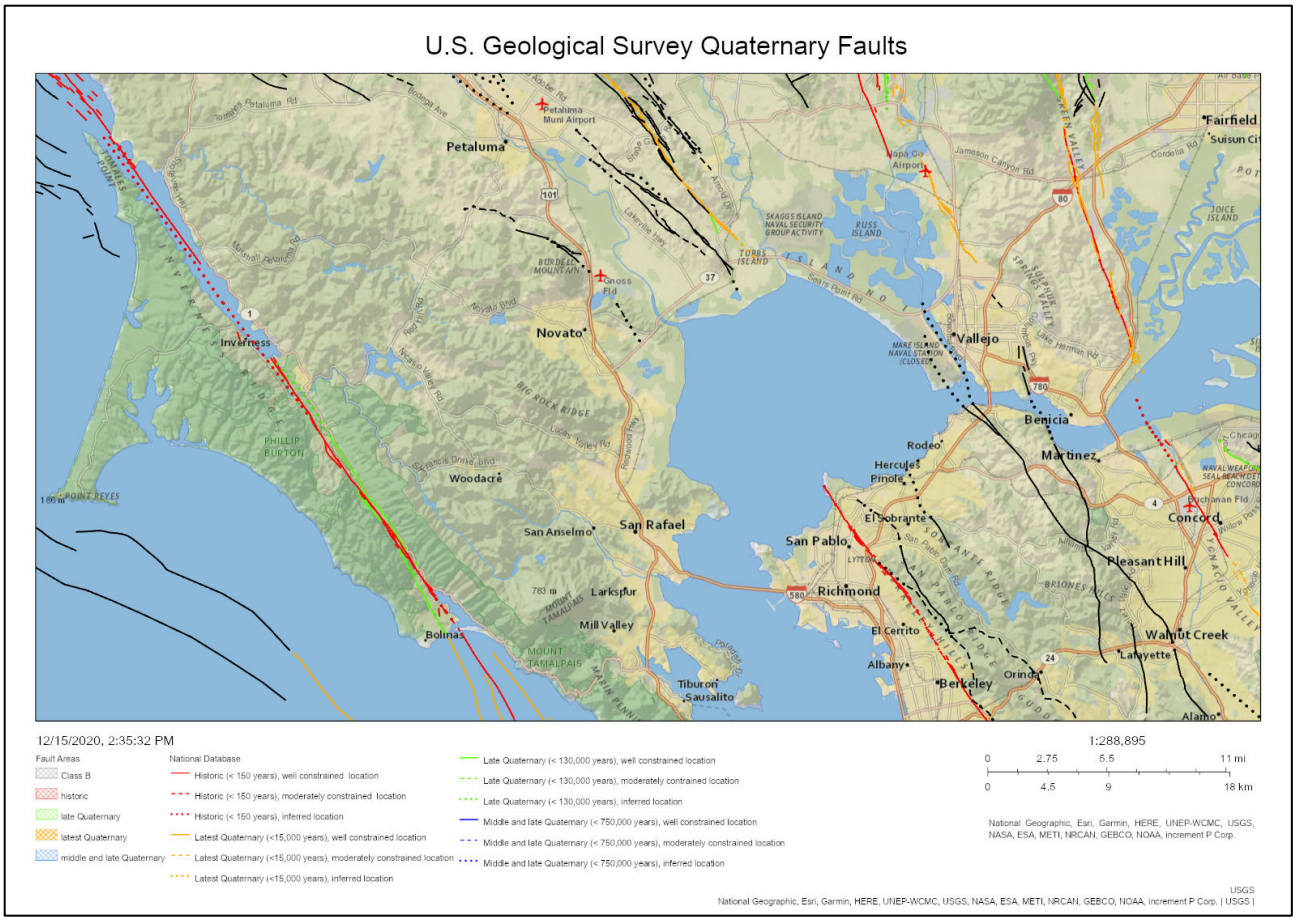

Figure 3. Novato area regional faultlines. Source: USGS

1.3 Soil Survey

In 1985 the Soil Conservation Service published the Marin County Soil Survey, which describes all soil types and provides data on various properties, limitations, and potential uses of the various soils.[4] Appendix C maps the soil types surrounding Stafford Lake and describes the soil properties of each type. A high percentage of the watershed has slopes in excess of 30%. In addition, the erosion potential is high for a significant portion of the watershed. Soil slippage has occurred in several sites leading to a high potential for colloidal clay to be a constituent of water flowing into Stafford Lake.

[4] United States Department of Agriculture Soil Conservation Service. (1985). Soil Survey of Marin County California.
https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/california/marinCA1985/marinCA1985.pdf

1.4 Land Use

The Stafford Lake watershed includes a mixture of public, agricultural, and residential land use. Approximately 18 percent of the watershed is under public ownership, while approximately 81% is designated agricultural, and below 1% is considered private residential (see Table 1).

Table 1. Stafford Lake Watershed Land Use

	Approximate Size (Acres)	Percentage (%)
PUBLIC LANDS		
North Marin Water District (incl. lake 213 acres)	880	16
Marin County Parks & Open Space	130	2.4
PRIVATE LANDS		
Residential (lots less than 10 acres)	30	0.6
Ranching (dairy, cattle, stables, grazing)	4420	81
Total Acres	**5460**	

The private, agricultural land is predominantly used for ranching. All private agricultural parcels in the Stafford Lake watershed are currently zoned as A-2 under County of Marin zoning ordinances. This zoning classification permits limited agricultural uses, as follows:

1) Processing of agricultural products grown entirely on property;
2) Stables;
3) Kennels having less than six dogs; and
4) Accessory uses

In addition, uses designated as R-1 are permitted, both in A-2 zones and in the private residential areas. These uses include:

1) One family dwellings;
2) Public parks and playgrounds;
3) Crop and tree farming and gardening;
4) Nurseries and greenhouses;
5) Home occupations; and
6) Accessory building uses.

Table 2 lists the parcels within the Stafford Lake watershed, with the associated owner, estimated acreage, and land use. Parcel maps and information related to Marin County planning are included in Appendix D.

Table 2. Stafford Watershed Parcels

Parcel No.	Total Acres	Est. Acres on Watershed	Usage	Owner
121-060-02	118	60	G	Douglas and Catherine Lelmorini
121-060-03	100	100	G	Cleoni Gause and Georgina Kretz
121-100-11	3.5	3.5	R	Cleoni Gause
121-100-12	2.79	3.5	R	Cleoni Gause
121-100-13	5.2	5.2	R	Georgina Kretz
121-100-14	474.3	474.3	G	Cleoni Gause and Georgina Kretz
121-110-15	4.95	4.95	R	Warren Glass & Trust
121-110-18	5.3	5.3	R	Dennis Cash
121-110-19	3.3	3.3	R	Ronald & Theresa Cook
121-110-20	1	1	R,S	Heritage Park, LLC
121-110-21	15.1	15.1	S	Heritage Park, LLC
121-110-23	2.4	2.4	R	Robert and Margaret Morrison
121-110-24	4.9	1.9	R	Robert and Marguerite Cratty
121-110-34	262.79	262.79	Rec, G	NMWD
121-110-35	242	100	Rec	Marin Co Open Space
125-050-06	343	200	G	Calvin Dolcini (Trust)
125-050-10	125	25	G	Calvin Dolcini
125-050-12	172	100	G	Calvin Dolcini
125-050-13	353	353	G, R	Calvin Dolcini
125-060-07	100	40	G	Ann Corda (Trust)
125-060-12	855	855	G,R	Ann Corda
125-090-06	47	46	G	NMWD
125-090-07	583	500	Rec, G	NMWD
125-090-08	66.5	66.5	(lake)	NMWD
R = Residence, Rec = Recreation, G = Grazing, S = Stables				

Table 2. Stafford Watershed Parcels (cont.)

125-060-09	221	20	G	Edward Grossi (Trust)
125-090-19	129	129	Rec	Marin County Parks
125-090-20	649	640	G, R	Edward Grossi (Trust)
125-090-21	439.9	439.9	G, R	Dominic Grossi
125-100-11	1214	900	G, R	Alfred Corda (Trust)
125-100-12	1136	200	G	Raymond & Patricia Ronsheimer
R = Residence, Rec = Recreation, G = Grazing, S = Stables				

1.4.1 Historical and Existing Agricultural Use

Historically the ranch land was predominantly (80%) dairy ranch property. Over the past 50 years, as a result of tougher water protection requirements and federal financial incentives, only one dairy ranch remained in 2019, representing only 8% of the acreage. In 2019, this ranch also ceased dairy operations due to a loss of profitability. Beef cattle and dairy dry stock have replaced the dairy operations on the other ranch acreage. A horse stable located on 15 acres on the southwest side of the watershed is the only other significant agricultural business.

Most of the large land parcels are currently under Williamson Act contracts, which allow lower property taxes in exchange for restricting properties to agricultural use for 10 years. Some acreage is under the Marin Agricultural Land Trust (MALT); the MALT agreements protect the property from development indefinitely. The 1994 Marin Countywide Plan contains detailed information on these agricultural policies.

1.4.2 Regulatory Jurisdiction

In addition to the landowners in the watershed, various other State and County agencies have authorities within the watershed. Table 3 includes the main regulatory agencies that have relevant roles in protecting the watershed.

Table 3. Key Watershed Regulatory Agencies

Agency	Relevant Role in Watershed Protection
Marin County Planning Department	Land use
Marin County Agricultural Commissioner / Director of Weights and Measures	Pesticide use
Marin County Office of Waste Management	Hazardous material inventories
Marin County Environmental Health Dept.	Septic tanks
Regional Water Quality Control Board	Water pollution control systems
California Dept. of Transportation	Transportation and road maintenance
Marin County Fire Department	Fire roads

1.5 Hydrology

Novato Creek is the major tributary to Stafford Lake. Novato Creek originates in the northwest portion of the watershed and flows (seasonally) for six miles into Stafford Lake. The average annual inflow (rainfall, runoff, creek flows) to Stafford Lake from the watershed is 4800 acre-feet with a 50% probability of greater than 3800 acre-feet in any year. The capacity of Stafford Lake is 4430 acre-feet. Table 4 describes some of the general hydrologic data. Stafford Lake rain data is included in Appendix E.

Table 4. General Hydrologic Data for Stafford Lake

Characteristics	Precipitation	Outflows
Drainage Area: 8.4 square miles Lake Capacity: 4,450 acre-feet Maximum Depth: 63 feet Maximum Surface Area: 231 acres Other inflow can occur by "backfeeding" of treated Sonoma County Water Agency (SCWA) supply to the lake through the intake structure. This has occurred only on a limited basis during drought periods. It is not cost effective to backfeed and is not considered a standard practice., but may occur more frequently in the future during periods of drought. At the time of this report (Summer 2021), the lake was being backfed and the stored water will be used later in the year.	Precipitation falls in the form of rain from November through April. The water year is considered to be October-September. Seasonal Rainfall Year Amount (inches)[5] 00-01 22.76 01-02 26.99 02-03 32.01 03-04 24.86 04-05 38.58 05-06 35.83 06-07 15.32 07-08 24.02 08-09 20.37 09-10 26.62 10-11 29.16 11-12 16.32 12-13 20.37 13-14 13.87 14-15 25.74 15-16 22.08 16-17 40.15 17-18 19.27 18-19 40.67 19-20 18.46 The rain-year is from October 1 to September 30 of the following year The monthly and yearly totals for rainfall in the Stafford area from 1916 to 2020 are included in the Appendix E.	Estimated Stafford Lake Evaporation/Seepage Losses (Inches) Month Mean October 2.9 November 1.2 December 0.7 January 0.6 February 1.1 March 2.2 April 3.5 May 5.3 June 6.2 July 4.7 August 6.2 September 4.7 Total 43 Fish and Game Releases: 154 ac ft Golf course and Park irrigation average annual requirements (2011-2020): Co. Park 38 ac ft IVGC 198 ac ft

[5] Annual Rainfall data were provided by NMWD's Stafford Rain Gage Record.

1.6 NMWD Facilities

NMWD facilities on the watershed ensure delivery of water from Stafford Lake to NMWD customers, and include the Stafford Lake Dam, intake structures, the STP, and water storage tanks. These facilities are discussed in the following sections.

1.6.1 Dam

Stafford Lake Dam was initially constructed in 1951. In 1954, the spillway was raised such that the capacity of the lake increased from 1,720 ac ft to 4,450 ac-ft with a safe annual yield of 2,000 ac-ft, based on the hydrologic conditions at the time.[6] The dam was reconstructed in 1985 for flood control improvements and now has a concrete spillway at an elevation of 196 ft. Cyclone fencing has also been installed across the dam face since the previous WSS was conducted.

Maintenance at the dam consists of removing weeds, monitoring piezometers, and replacing signs. District treatment operations staff check the spillway area once a day for trespassers, warn trespassers if sighted, and report significant problems to the District. Park personnel will also warn trespassers and report problems to the District, as necessary. The District acts on notification as appropriate.

1.6.2 Lake Intake Tower

The lake intake tower is located on the east side of the lake, near the dam. In 2010, the intake tower was rehabilitated, including a seismic retrofit; tower updates; and replacement of the ladder, gates, lake level gauges, gate operators and controls, electrical facilities, and an equipment building. It is now equipped with two (2) hydraulically operated intake gates – located at 174 and 158 ft. in elevation – and a scourer gate, which is located at the very bottom of the lake (el. 150 ft). All three (3) intake gates are exercised regularly, and the scour gate is typically opened at least once a year as required by the California Division of Dam Safety. The scourer gate was most recently operated in February 2021 to remove silt. A lake level chart recorder is located on the tower and is activated in the rainy season. Maintenance at the tower consists primarily of removing algae film from the elevation staff gauge and checking hydraulic fittings.

1.6.3 Lake Aeration System

The lake aeration system is intended to mitigate lake stratification as well as treatment inefficiencies at STP due to the presence of dissolved minerals, which will oxidize and precipitate given sufficient aeration. It is also intended to mitigate taste and odor (T&O) issues and filter clogging by minimizing algae blooms.

In 1968, a compression-driven aeration system was installed to maintain de-stratified conditions in order to improve water quality, which had been degrading over the years due to algae blooms and eutrophication. In 2008, two (2) hypolimnetic mixers were added to the lake to assist in lake

[6] North Marin Water District. (2021). History. https://nmwd.com/about/history/

turnover and destratification - the objective of these mixers was to maintain or assist destratification by allowing oxygenated water from the epilimnion to circulate to the anoxic hypolimnion. However, the hypolimnetic mixers were found to be ineffective by NMWD operations staff and were converted to epilimnetic mixers. In late 2013, NMWD replaced the existing aeration system with a different compression-driven aeration system over twelve (12) acres near the intake tower. The new system consisted of 16 emitters and four (4) compressors. DO is measured by NMWD weekly from late June through early November at 5-foot depths from the surface at three (3) locations in the lake, including a location near the intake tower and aeration system. Data from 2015 through 2020 at the intake tower location was reviewed and indicated that DO is not continuously maintained at depths from 15 to 30 feet during the T&O season. NMWD staff has also observed that although the aeration system was successful in destratification to some extent, it failed to maintain DO levels in the hypolimnion throughout the T&O season. In May 2021, 16 additional emitters were added, bringing the total number of emitters to 32. DO will continue to be monitored and reviewed to evaluate the effectiveness of the aeraton system.

1.6.4 Treatment Plant

NMWD treats water from Stafford Lake primarily in the late spring through fall to augment its purchased, Sonoma County Water Agency (SCWA) supply. Production goals have been developed that promote operation of the STP to maximize the use of Stafford Lake water. STP production is maximized for cost savings and is limited to the quantity that was stored over the previous winter. In times of drought, a supply evaluation can be made in late winter to determine the value of diverting surplus treated SCWA water to Stafford Lake. Such a diversion has occurred on four separate occasions, most recently in 2021, however it is not cost effective and is not considered a standard practice.

The STP was designed by Kennedy Engineers and constructed in 1952. It was expanded in 1972 to 6.2 MGD (4,200 gpm) by Culp, Wesner, Culp. In 2006, The District completed major upgrades to the plant, including the addition of chlorine dioxide oxidation, three (3) Actifloc™ filter units, and granular activated carbon (GAC) filters. The current design includes chlorine dioxide pre-treatment; coagulation; sand garnet/anthracite high-rate filtration combined with coagulation and sedimentation; GAC filtration; chlorine disinfection; and sodium hydroxide for corrosion control. The process train is shown below in Figure 4. NMWD Operations Staff and their Treatment and Distribution Certification Levels are included in Appendix F.

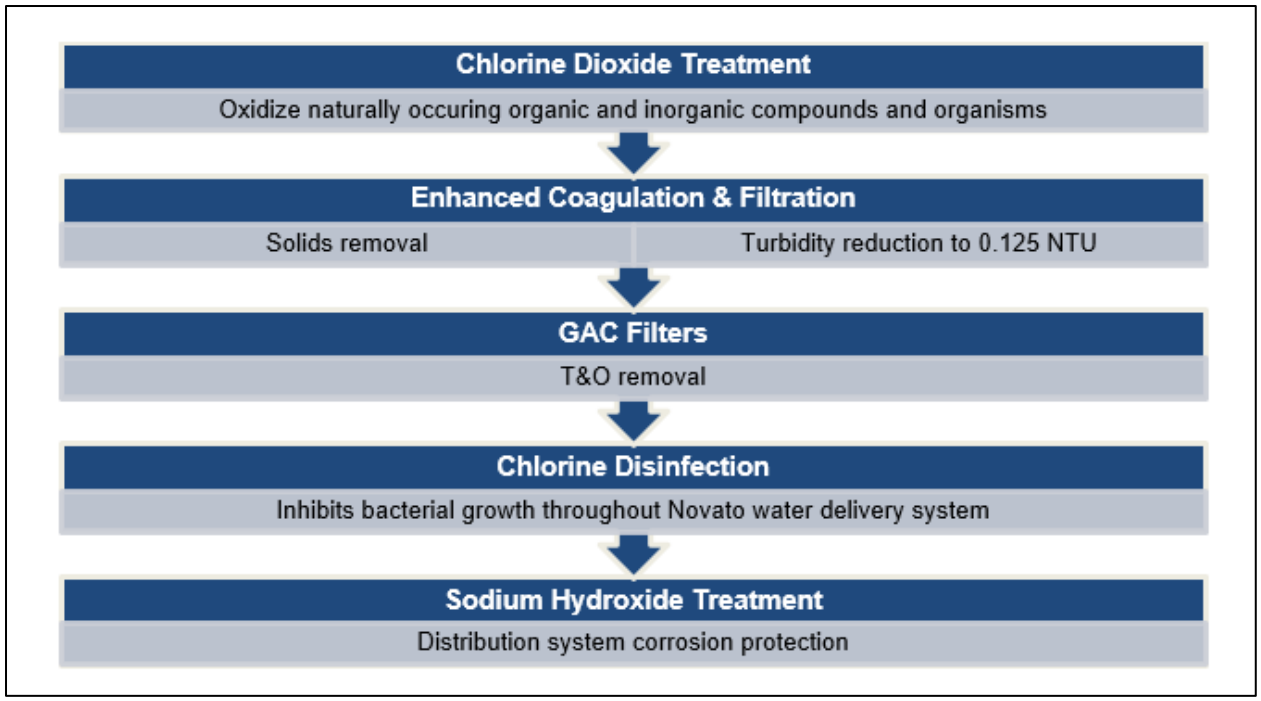

Figure 4. STP Process Diagram

1.6.5 Sludge Disposal

Disposal of settled sludge is by hauling offsite to be used as a soil amendment, while the supernatant is delivered to Novato Sanitary District (NSD) through the sewer collection system. An NSD Industrial Discharge permit is maintained; this permit is located in Appendix G.

1.6.6 Finished Water Storage

NMWD has over 33 MG of finished water storage in 30 tanks, serving four zones. This finished water storage is equivalent to approximately 2 days at maximum demand rates.

1.6.7 Other Supplies

Approximately eighty percent of Novato's water is purchased through a water supply delivery agreement with SCWA. In 2006, a Restructured Agreement for Water Supply with SCWA was executed, authorizing SCWA to construct facilities to increase NMWD's water delivery entitlement to meet Novato's expected future needs. North Marin's aqueduct capacity entitlement in the Restructured Agreement is now 19.9 MGD.

1.6.8 Emergency Plans

NMWD is an active participant in the City of Novato Emergency Operations Center. A California Standardized Emergency Management System-compliant Emergency Operations Plan (last updated 2019) has been developed and is on file with OHS. Additionally, an Emergency Action Plan for Stafford Lake Dam, which addresses the risk of breaching or overtopping, was

developed in 2015. Emergency power to operate STP is supplied by a 300kW diesel powered generator, which was installed in 2020.

1.6.9 Operation Plans

Operations Plans (Distribution Operations and Treatment Operations) have been developed to meet Division requirements. An updated combined Distribution and Treatment Plan for the operation of the Novato system was submitted to the Division in 2016.

THIS DOCUMENT IS OVER 1,000 PAGES IN LENGTH WITH ALL APPENDICES. THE ENTIRE DOCUMENT, INCLUDING THE REMIANING SECTIONS 2, 3 AND 4, ARE AVAILABLE AT THE DISTRICT OFFICE OR ELECTRONICALLY BY REQUEST.