San Lorenzo Valley Water District
Bear Creek Estates Wastewater Treatment System, Boulder Creek

Technical Memorandum No. 2

Date:	July 29, 2016
Subject:	**Wastewater Treatment Plant Process Assessment**
Prepared By:	Abraham Philip, PE
Reviewed By:	Jane Costello, PE, Rob Weber, PE

Introduction

The Bear Creek Estates wastewater system is operated by the San Lorenzo Valley Water District, Boulder Creek, California. The system treats domestic wastewater flow from 56 residential units located in Bear Creek Estates subdivision 3, 4 and 5, Boulder Creek, California. It consists of 1.2 miles of gravity collection sewers, two (2) pump/lift stations, and a septic tank-trickling filter treatment system discharging treated effluent to subsurface leach fields. The wastewater system is regulated by the California Central Coast Regional Water Quality Board (CCRWQB) under Waste Discharge Order No. 00-43 (WDR).

Purpose

On April 1, 2016, the CCRWQB issued a Notice of Violation of Wastewater Discharge Permit to the District citing ongoing violations with insufficient total nitrogen reduction since 2007, excess flow (over permit) violations from inflow and infiltration into the District collection system during rain events, and unsatisfactory operator response for occasional sewer/wastewater treatment plant spills and runoffs from the system into Bear Creek.

This Technical Memorandum is intended to identify the possible causes for insufficient total nitrogen reduction and suggest corrective action. The troubleshooting methodology used herein is a combination of the biology behind the treatment process, a study of the process modifications, desktop review of available documents, discussions with plant personnel and site visits.

The inflow and infiltration issues and an emergency spill response plan is addressed separately in Technical Memorandum No. 1 and No. 3 respectively.

Background

The Bear Creek Wastewater Treatment plant is located at 15900 Bear Creek Road, Boulder Creek, California. It was initially constructed in 1985 as a septic tank treatment system. It was designed to treat a design daily average flow of 12,000 gallons per day (GPD) and a peak wet weather flow of 32,500 gallons per day (GPD). In its original form, it consisted of two (2) cast-in-place, underground concrete tanks, an influent pump station, an effluent pump station, and a 2.3-acre leach field.

In 2005, the CCRWQB issued new regulations requiring 50% reduction in total nitrogen (TN) in the wastewater discharge from the treatment plant. This caused the District to embark on a series of plant process modifications aimed at regulatory compliance commencing in 2005, when the existing treatment septic system was basically modified to a 2-stage trickling filter plant. Due to a continued inability to consistently meet the total nitrogen reduction requirements, the District implemented further process modifications during the period 2009 to 2013. This consisted of installing a 3rd - stage tricking filter tank in 2009, pumping modifications and new internal recirculation/splitter/ball valves in 2011, and new air blowers with high-capacity disc diffusers in the clarifier tanks in 2013. Unfortunately, these modifications were not successful and did not achieve the desired outcome of consistently meeting the CCRWQB TN reduction requirements.

Process Description

Based on site visits, desktop reviews of available documents and interviews with Plant Operations, a process schematic was developed for the plant. This schematic is shown in Figure 1.

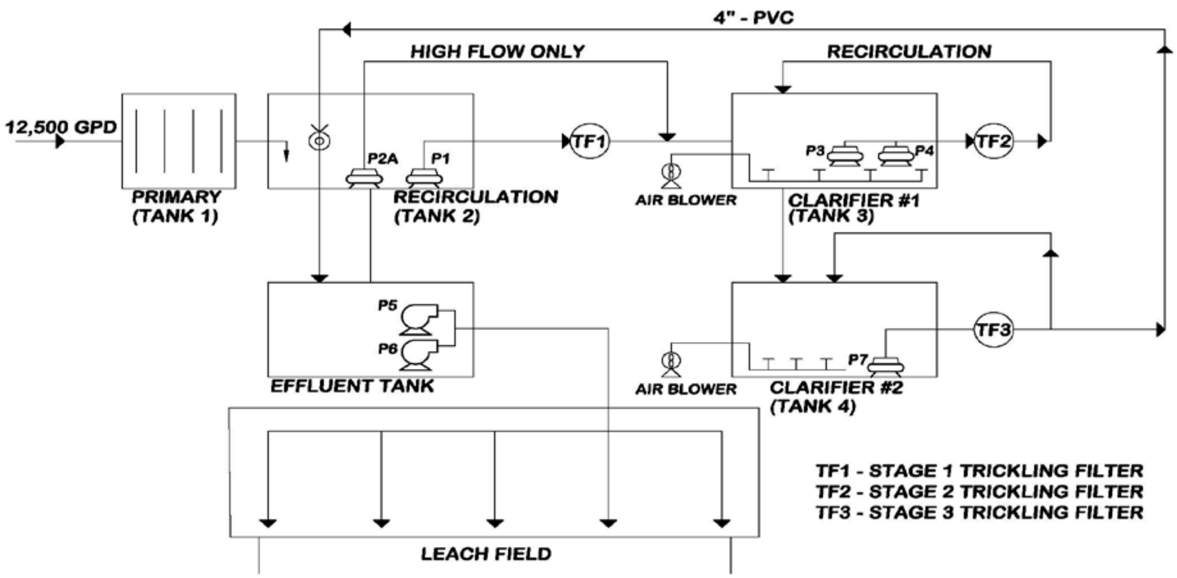


Figure 1: Existing Plant Process Schematic

The first of two original septic tanks (Tank 1) provide primary settling of solids. The second tank (Tank 2) serves both settling and recirculation. On top of each tank is two sets of poly tanks which contain randomly packed media (Bio Pac SF-30 manufactured by Jaeger USA) for the wastewater to flow over and down through to the bottom. These are trickling filters stages 1 and 2. The plastic media facilitates biological growth which converts ammonia to nitrites/nitrate and subsequently to nitrogen gas.

Wastewater from Tank 2 is pumped to the trickling filter stage 1 where the bacterial growth serves to remove a significant amount of organic carbon. It then flows to Clarifier Tank 1. Since it appeared that the nitrification process was incomplete in the first stage, air blowers were added to Clarifier 1 as part of the process modification to improve and complete the nitrification process. It is then pumped to trickling filter stage 2 for further treatment and the effluent from Stage 2 recirculated back to Clarifier 1.

During one of the later process modifications a third stage trickling filter was added and a second recirculation loop with the treated effluent being recirculated to Clarifier 2. Clarifier 1 and 2 are connected via a gravity outlet. Treated wastewater effluent from Clarifier 2 flows out of the tank through a 4-inch PVC line into a float operated recirculation device (float is based on waste levels in the recirculation tank) located in the influent manhole of the recirculation tank which discharges effluent to the effluent tank for distribution to the leach field.

Figure 2: Tank 2 and Trickling Filter Stage One (Left); Random Pack Media Bio-Pac SF 30 (Right)

Nitrification/Denitrification Theory

Bacteria remove nitrogen from wastewater by a two- step biological process: nitrification followed by denitrification.

Nitrification is a two-step biological process, involving biological conversion of ammonium nitrogen (NH4) to nitrate nitrogen (NO3). Bacteria known as *Nitrosomonas* convert ammonia and ammonium to nitrite. Next, bacteria called *Nitrobacter* finish the conversion of Nitrite to Nitrate. Nitrifying bacteria or “autotrophic bacteria” are strict “aerobes” meaning they must have free dissolved oxygen (4 mg/l of oxygen per 1 mg/l of ammonia). The process is heavily influenced by alkalinity concentrations (7.14 mg/l as calcium carbonate per 1 mg/l of Ammonia). Automatic chemical feed systems are often required to break down ammonia and maintain a minimum effluent alkalinity concentration of in excess of 100mg/l. pH levels are extremely important – a pH of 7.5 – 8.5 is ideal for nitrification. Nitrification effectively ceases at a pH of 5.

Denitrification is the process of biological reduction of nitrate (NO3) to nitrogen (N2) gas by facultative bacteria. The process is accomplished by facultative bacteria or “heterotrophs”. Denitrification occurs when the oxygen levels are depleted and nitrate becomes the primary oxygen source for microorganisms. Needless to say, denitrification occurs under anoxic conditions, it require oxygen levels to be depleted (<0.5 mg/l) and sufficient residual alkalinity (>100 mg+). It occurs partially in the trickling filter and partially in the tank.

Temperature in the liquid stream and the treatment media have a pronounced effect on both nitrification and denitrification and maintaining temperatures above 60 degrees F.

Data Analysis

Plant Data from the last three years (2014, 2015 and 2016) was reviewed. An average value was computed for key parameters, BOD, TSS, TDS, TN, Organic Nitrogen, Nitrites, Nitrates, Kjeldahl Nitrogen and Ammonia Nitrogen. Peak values of total influent nitrogen for each year was also extracted and analyzed separately. An objective in this data analysis effort was to determine the effectiveness of the trickling filter in achieving the desired total nitrogen reduction and the presence of nitrates in the effluent.

Table 1A: Annual Average and Peak Values of Key Influent and Effluent Characteristics

SAN LORENZO WATER DISTRICT WASTEWATER SYTEM CHARACTERISTICS															
SUMMARY TABLE (ANNUAL AVERAGE)															
Year	Location	B.O.D. (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (mg/L)	Sodium (mg/L)	Chloride (mg/L)	Total Nitrogen (mg/L)	Total Nitrogen Reduction (%)	Organic Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Kjeldahl Nitrogen (mg/L)	Ammonia Nitrogen (mg/L)	pH	Average Daily (gal/day)
4/2013 -4/2014	BC Inlet Pump Station	180.59	168.83	424.00	42.00	38.78	58.17	30.90	24.94	n/a	0.43	55.72	32.50	7.9	10,000
	Bear Creek Effluent	11.60	14.40	396.90	46.60	39.40	39.10		6.60	0.50	3.60	35.20	29.40	7.4	
4/2014 - 4/2015	BC Inlet Pump Station	195.83	161.00	472.50	44.77	44.00	63.38	46.00	27.50	n/a	0.47	63.17	35.50	7.8	9,400
	Bear Creek Effluent	9.00	14.50	380.00	45.60	37.30	33.20		7.50	0.50	5.00	27.90	21.10	7.4	
4/2015 - 4/2016	BC Inlet Pump Station	180.75	187.35	399.50	43.40	37.81	58.06	26.51	22.72	n/a	n/a	58.03	35.27	7.7	9,500
	Bear Creek Effluent	7.93	12.71	393.13	42.81	39.76	41.28		5.95	0.32	4.20	37.00	31.70	7.5	
Note: Data represents average numbers over a 12-month period.															

Table 1B: Annual Peak Values of Key Influent and Effluent Characteristics

SAN LORENZO WATER DISTRICT WASTEWATER SYTEM CHARACTERISTICS															
SUMMARY TABLE (PEAK VALUES OF TOTAL NITROGEN)															
Year	Location	B.O.D. (mg/L)	Total Suspended Solids (mg/L)	Total Dissolved Solids (mg/L)	Sodium (mg/L)	Chloride (mg/L)	Total Nitrogen (mg/L)	Total Nitrogen Reduction (%)	Organic Nitrogen (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Kjeldahl Nitrogen	Ammonia Nitrogen	pH	Average Daily (gal/day)
8/1/2013	BC Inlet Pump Station	220.00	110.00	470.00	43.00	39.00	80.00	46.25	38.00	ND	0.55	80.00	42.00	8.4	9,000
	Bear Creek Effluent	13.00	9.00	420.00	45.00	39.00	43.00		6.30	ND	1.10	42.00	36.00	7.4	
12/1/2014	BC Inlet Pump Station	200.00	140.00	500.00	42.00	43.00	85.00	43.53	36.00	ND	ND	85.00	49.00	8.4	8,500
	Bear Creek Effluent	16.00	12.00	400.00	42.00	37.00	48.00		8.60	ND	1.80	46.00	38.00	7.5	
12/1/2015	BC Inlet Pump Station	220.00	220.00	580.00	60.00	45.00	87.00	39.08	46.00	ND	ND	87.00	41.00	8.0	7,000
	Bear Creek Effluent	6.30	13.00	470.00	51.00	46.00	53.00		4.20	ND	3.00	50.00	46.00	7.6	

Sampling

Preliminary sampling was conducted on June 22 and 23, 2016 Grab samples were collected at the location indicated on Table 2. Given that the nitrification/denitrification process is greatly influenced by alkalinity and dissolved oxygen, the intent of the sampling was to obtain a general idea of these parameters. The samples were analyzed by Alpha Analytical Laboratories, Ukiah, CA and the results are presented in Table 2. It is recommended that detailed sampling be conducted at key locations to conclusively determine the performance of the trickling filters.

Table 2: Grab Sampling Results

Parameter	Clarifier 1	Clarifier 2	Tank 2
Dissolved Oxygen (mg/)	0.9 and 4.8 mg/l	ND and 1.3 mg/l	2.4 mg/l and 1.2 mg/l
Total Alkalinity as CcCo3 (mg/l)	150 mg/l	140 mg/l	160 mg/l

Key Parameters Important to this evaluation

The following design parameters were considered in troubleshooting possible causes for the inconsistency in TN reduction requirements:

- Tank Size (Primary & Recirculation)
- Trickling Filter Sizing
- Media Condition (Bio-Pac SF30)
- Pumping Rates
- Alkalinity Required (based on average TKN of 60 mg/l)
- Dissolved Oxygen level in Clarifier tanks and Recirculation Tank

Conclusions drawn from the preliminary observations are summarized in Table 3:

Table 3: Assessment of Key Parameters

Design Parameter	Actual	Recommended
Tank, Primary (@2 days HRT, 12,500 GPD DADF)	16,000 gallons	25,000 gallons
Tank, Pre-anoxic (@2 days HRT, 12,500 GPD DADF)	18,000 gallons	25,000 gallons
Media Assessment (Bio-Pac SF 30)	Appears clean with less than typical biological growth	Increased biological growth
Total Alkalinity as (calculated based on 60 mg/l daily average TN)	140 -150 mg/l	240 mg/l
Dissolved Oxygen level, Clarifier 1	0.9 mg/l & 4.8 mg/l	3 mg/l preferred
Dissolved Oxygen level, Clarifier 2	ND and 1.3	3 mg/l
Dissolved Oxygen Level, pre-anoxic tank	1.2 mg/l	< 1 mg/l for denitrification

Recommendations

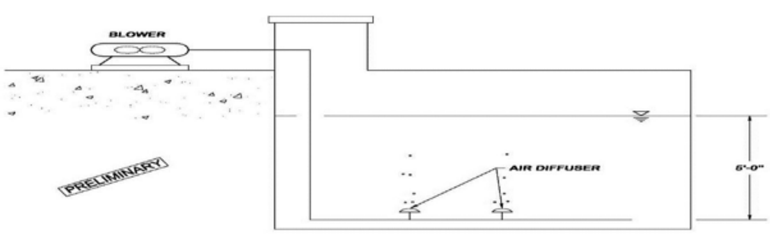
The following overall recommendations are offered to meet the desired TN reduction requirements.

***Recommendation No. 1* – Testing:** Conduct rigorous sampling to determine trickling filter performance. Obtain grab samples at several points in the process for key constituents

Location	Test Constituent
Influent Manhole	BOD, TSS, TN, Alkalinity, DO*, pH*, temperature*
Primary Settling Tank (Tank 1)	BOD, TSS, TN, Alkalinity, DO*, pH*, temperature, ammonia nitrogen
Recirculation Tank (Tank 2)	BOD, TSS, TN, alkalinity, DO, pH, temperature*, nitrites, nitrate, ammonia nitrogen, organic, kjeldahl nitrogen
Trickling Filter Stage 1, 2, 3 Inlet	BOD, TSS, TN, alkalinity, DO*, pH*, temperature*, nitrites, nitrate, ammonia nitrogen, organic, kjeldahl nitrogen
Trickling Filter Stage 1, 2, 3 Exit	BOD, TSS, TN, alkalinity, DO*, pH*, temperature*, nitrites, nitrates, ammonia nitrogen, organic, kjeldahl nitrogen
Clarifier 1, 2 (Tank 3, 4)	BOD, TSS, TN, alkalinity, DO*, pH*, temperature*, nitrites, nitrates, ammonia nitrogen, organic, kjeldahl nitrogen
Effluent Tank	BOD, TSS, TN, alkalinity, DO*, pH*, temperature*, nitrites, nitrates, ammonia nitrogen, organic, kjeldahl nitrogen

** Dissolved oxygen, pH and temperature must be analyzed in the field to meet specified EPA 15 minute hold time.*

Recommendation No. 2 – Improve Process Control: Verify blowers are adequately sized for height of water/sludge level above the diffusers. Maintain consistent DO levels. (It is suggested that the plant obtain a new dissolved oxygen meter).



Blower Pressure $P_W = \frac{WRT}{550\mu e}\left[\left(\frac{p_2}{p_1}\right)^{0.283} - 1\right]$
Clarifier Volume= 3000 gallons
Service Volume @ 80% = 2400 gallons
Assume $\frac{10\ cfm}{1000\ ft^3}$
Say 192 cfm w/ 2hp motor

Figure 4: Preliminary sizing of Aeration Blowers

***Recommendation No. 3* – Alkalinity Addition:** Procure and install an alkalinity feed system is recommended if influent alkalinity is below 260 mg/L. Preliminary sizing details are provided in Table 5. Prior to implementing these requirements it is imperative that the performance of each trickling filter stage be independently verified and a treatment baseline be established through sampling and testing.

Table 5: Alkalinity Feed System

Feed System:	Alkalinity Feed System

Chemical Used:	Soda Ash
Feed Rate:	1.2 lbs/hour*
30 Day Storage:	14.5 cu. ft.

* Feed rate is based on an assumed incoming alkalinity of 150 mg/L. Typical cost of Soda Ash is $0.09/lb.
Two installation options – install directly in feed line to TF1 or to recirculation tank.

Figure 3: Alkalinity Feed System (typical)

Recommendation No. 3: This is a lower priority recommendation than 1 and 2. To address need for the recommended storage consider rehabilitating/re-using tank at the site of the old activated sludge facility.

Budgetary Costs

A summary of order-of-magnitude costs is provided in the table below. Note all costs are approximate and based on conversation with vendors. It assumes that the District will complete the installation of the chemical feed system including power and base construction, if any.

Table 6: Budget Cost Estimate

Recommendation	Planning Level Cost
Improve process control. Verify blowers are adequately sized for height of water/sludge level above the diffusers.	$ 10,000
Install alkalinity feed system to provide additional alkalinity – two installation options – install directly in feed line to TF1 or to recirculation tank. Monitor results - 30 days.	$ 25,000
Clean and inspect tank for cracks, repair as required	$ 25,000
Total	$ 60,000

Next Steps

- Step 1: Obtain baseline influent wastewater characteristics at key locations
- Step 2 1: Isolate and test performance of each trickling filter stage
- Step 3: Improve process control, maintain DO level with new blowers
- Step 4: Add alkalinity as required
- Step 5: Bring Trickling Filters 2 and 3 online, if required.

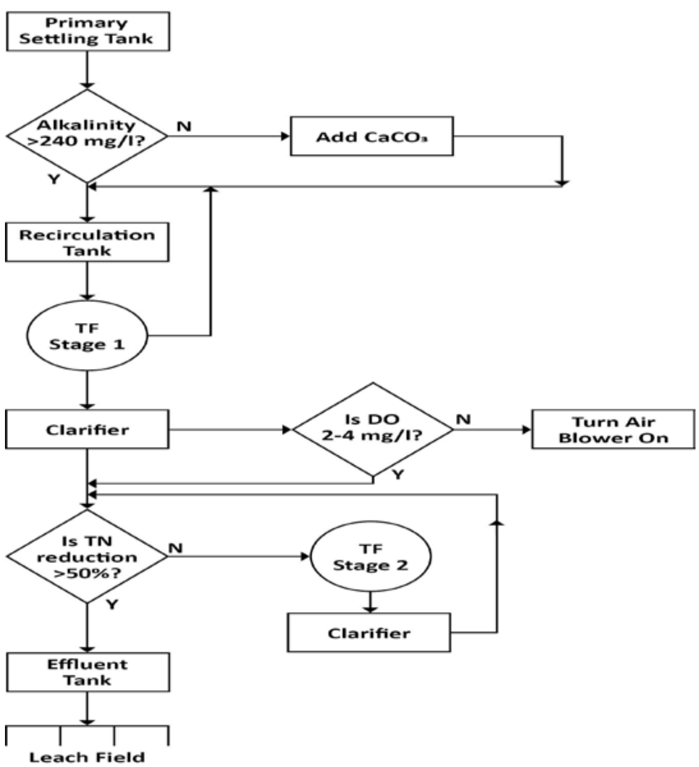


Figure 8 – Troubleshooting Chart

Appendix A

Wastewater Analysis

Appendix B

Test Results