US EPA Office of Compliance Technical Assistance Webinar Series

Introduction: Seth Heminway, US EPA Office of Compliance (heminway.seth@epa.gov)

- Webinar series supports the national EPA and state initiative to reduce noncompliance among CWA -NPDES permited facilities. Focus is on helping wastewater system operators return their facilities to compliance, and those interested in fine-tuning their systems.
- The webinar will be recorded and posted.
- Certificates of attendance will be sent to those who have registered.
- You will be in “listen only mode.”
- Use the chat box to ask questions and to suggest other training
- Speakers do not necessarily reflect EPA positions or policy.
- Be sure to download the Chart from Downloads Tab to follow along.
- We strive for continuous improvement. Please complete the post webinar survey.

Facultative Wastewater Lagoon Troubleshooting

Steven M Harris
President
H&S Environmental, LLC
www.lagoonops.com

What we will do today:

- Make introductions
- Describe the general principals behind facultative lagoon troubleshooting
- Go through case studies


WINNEBAGO TRIBAL
FACILITIES
DEPARTMENT


HQ40d
multi


Objectives

Introduce you to our protocol for optimizing and troubleshooting wastewater lagoon systems

This Protocol Starts with Understanding the Following:

- There is a where, a when, and a why to solving problems and optimizing wastewater lagoon systems
- Algae cause BOD problems because they respire for five (5) days in the BOD_5 test bottle
- Intra-Pond Testing is CRITICAL to solving lagoon problems
- Cell # 1 should remove at least 80% of the influent $BOD_{5.}$ Cell # 2 Should be for removing nutrients and the other cells are for killing pathogens and settling (clarifying) effluent water
- You can do little to solve problems without data!

- Wastewater lagoons fail for about six (6) main reasons, but they fail largely fail because of two (2) main reasons;

1) Sort-circuiting, and
2) Sludge accumulation

- When and how you test is very important. Composite sampling is the best
- The collection system should be considered as part of your pond system

The Protocol

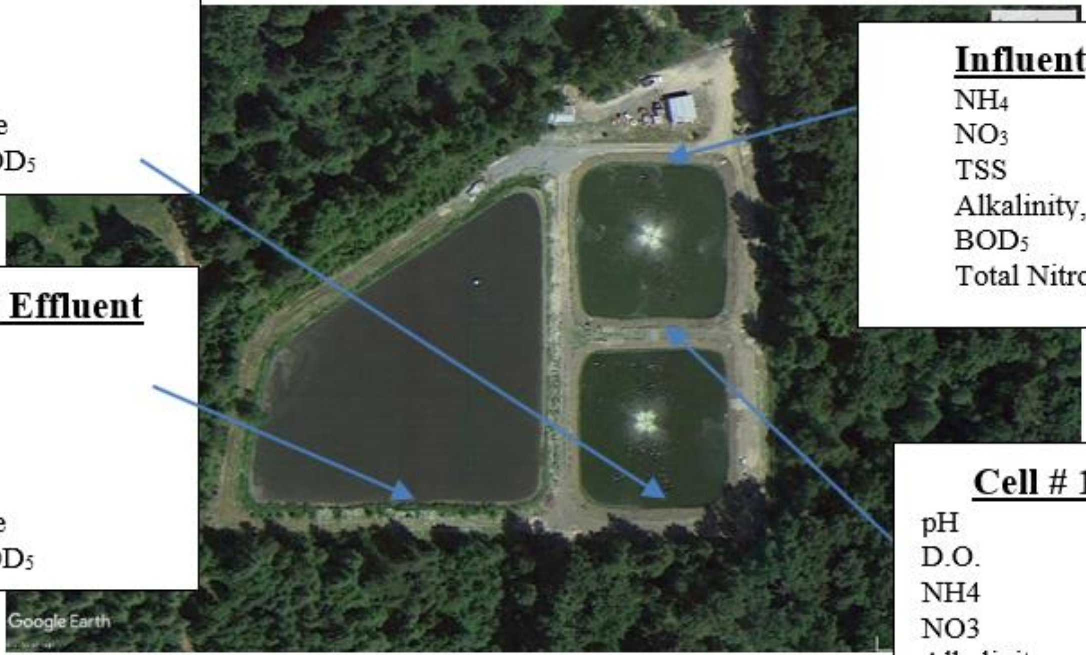
Your Town WWTP

Cell # 2 Effluent

pH
D.O.
NH_4
NO_3
Alkalinity
Temperature
BOD_5, $CBOD_5$

Influent

NH_4
NO_3
TSS
Alkalinity, pH
BOD_5
Total Nitrogen



Cell # 3 Effluent

pH
D.O.
NH_4
NO_3
Alkalinity
Temperature
BOD_5, $CBOD_5$

Cell # 1 Effluent

pH
D.O.
NH4
NO3
Alkalinity
Temperature
BOD_5, $CBOD_5$

Within Each Cell:

Sludge depth profile
DO & pH profile at 1 ft. increments from the surface of the cell to bottom

Final Plant Effluent Post Disinfection

pH, D.O. , NH_4, NO_3, Alkalinity
Temperature
Total Nitrogen,
BOD_5, $CBOD_5$, $SCBOD_5$,
TSS

1) This testing protocol is the basis for understanding what is happening biologically and biochemically in your lagoon, so you can make decisions to optimize a system to meet permit limits.

2) Pinpointing the source ***and location*** of a lagoon system's inefficiencies saves time and money by selecting the right troubleshooting or optimization course of action. It also provides a greater understanding of how and **where** lagoon systems work and why a system performs the way it does.

3) We combine at least five (5) years of historical data with field grab sample data taken onsite and perform statistical analysis on DMR and system data sets to find correlations leading to the direction optimization and or troubleshooting should take.
4) Field data and historical data are then combined to understand why things are happening in the system, where things are happening, and when it is happening. In this way, we can pinpoint the source of the problem or find the place to focus optimization efforts to meet treatment objectives.

Here is how the optimization/troubleshooting process works; the primary treatment cell is responsible for removing up to eighty percent (80%) of a system's influent BOD. If the Primary treatment cell is not accomplishing this goal, it tells us that there is:

- Short-circuiting
- Too much sludge accumulation
- Too little air for the load
- A need for pre-treatment (toxicity / loading control)
- A need for headworks modification or maintenance
- Too great of a load (septage waste, portable toilet waste, vault waste, illegal drug waste or industrial waste)

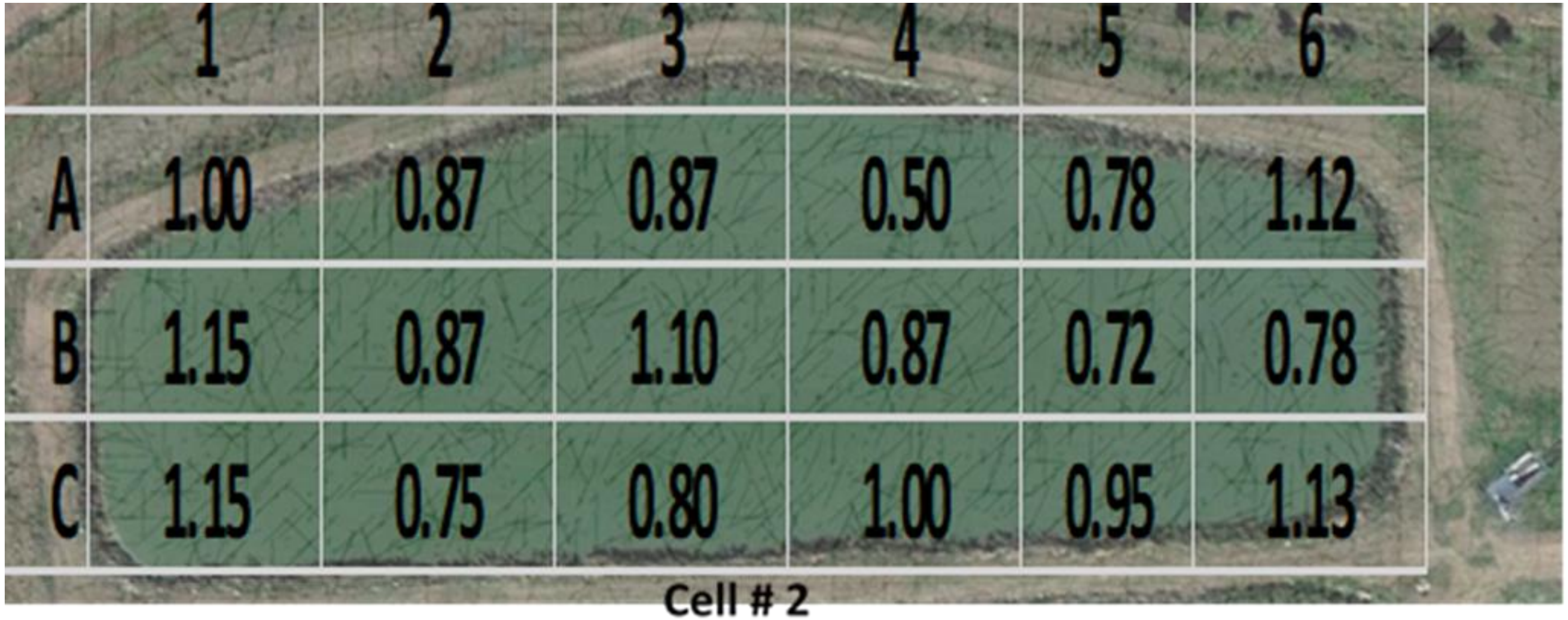
If the primary treatment cell can remove 80% of the influent BOD_5, then other cells are free to effectively remove **nitrogen**, settle solids, and kill pathogens.

Not removing 80% of the influent BOD “pushes” the job of BOD removal to subsequent treatment cells. Getting the primary treatment cell to do its job, for example, is critical to successful ammonia removal in wastewater lagoon systems.

This allows the lagoon system to accomplish what the engineer designed the system to do

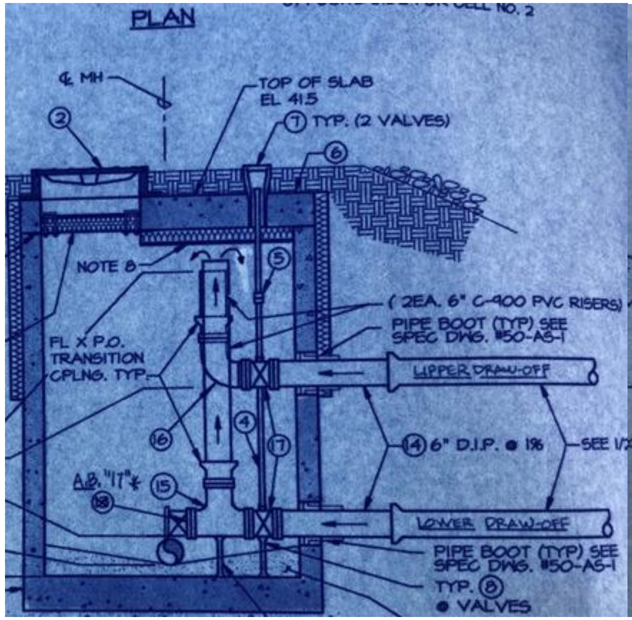
Cases

Case # 1, The Problem with Sludge

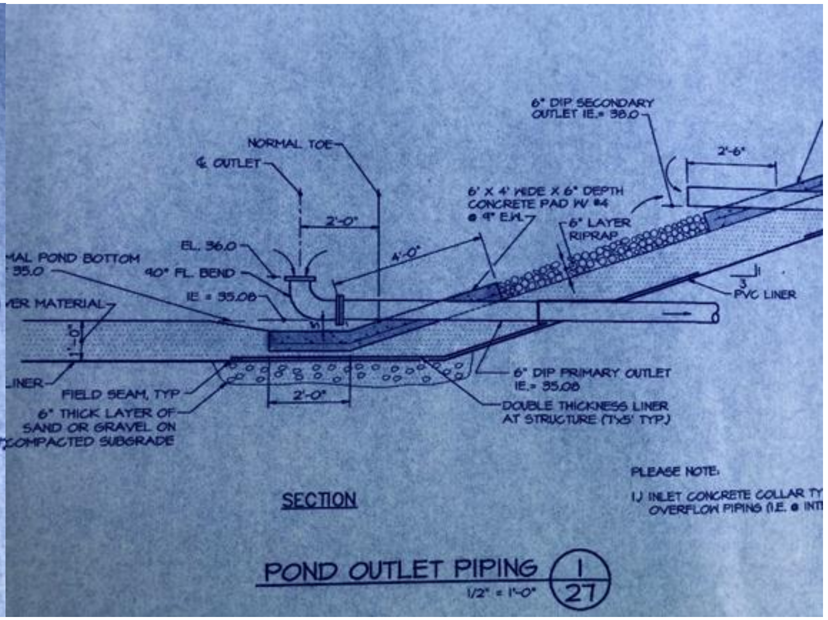


1 2 3 4 5 6
A 1.00 0.87 0.87 0.50 0.78 1.12
B 1.15 0.87 1.10 0.87 0.72 0.78
C 1.15 0.75 0.80 1.00 0.95 1.13

Cell # 2



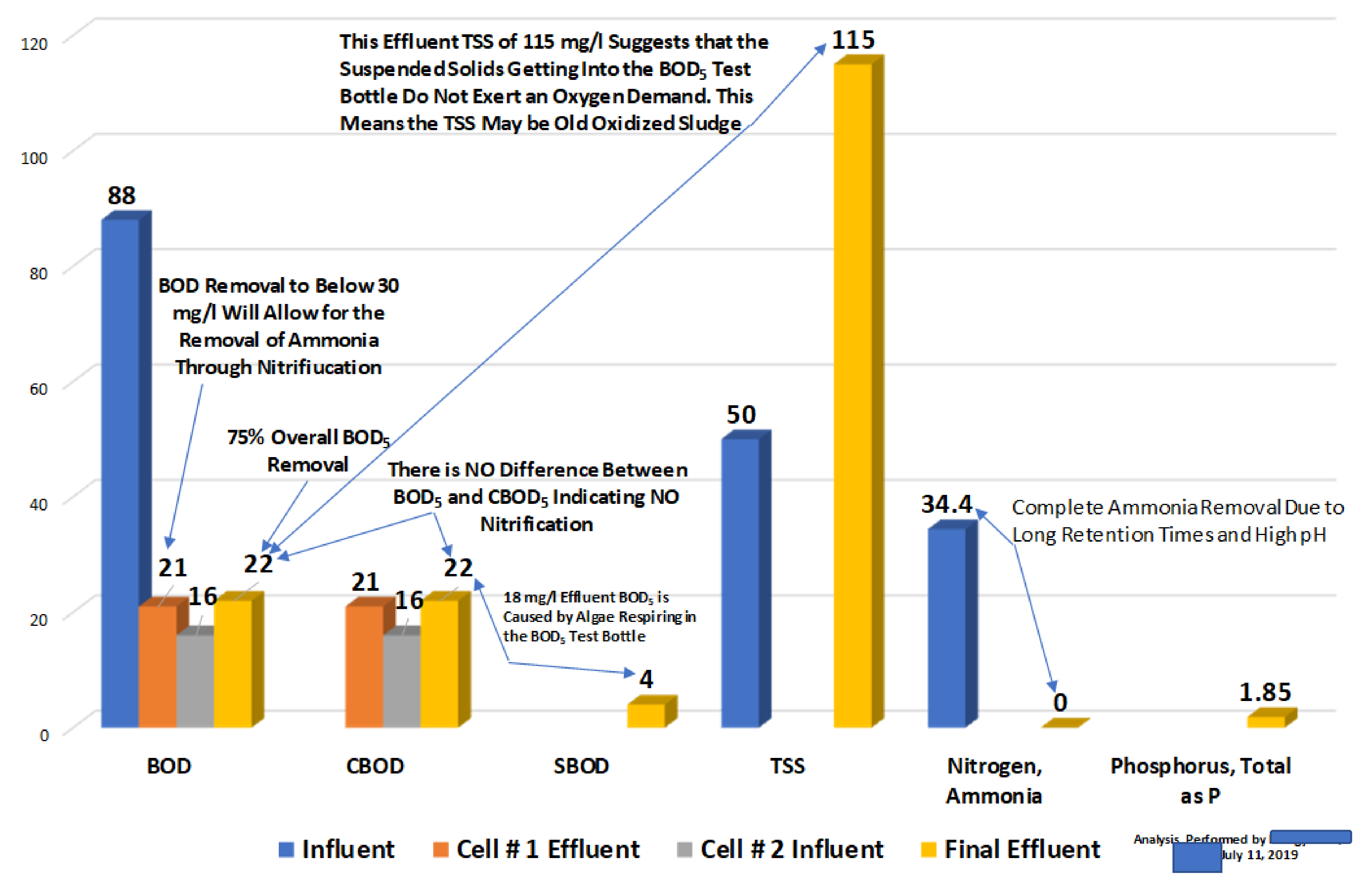
PLAN
℄ MH
TOP OF SLAB EL 41.5
TYP. (2 VALVES)
NOTE 8
(2EA. 6" C-900 PVC RISERS)
PIPE BOOT (TYP) SEE SPEC DWG. #50-AS-1
FL X P.O. TRANSITION CPLNG. TYP.
UPPER DRAW-OFF
6" D.I.P. @ 1%
LOWER DRAW-OFF
PIPE BOOT (TYP) SEE SPEC DWG. #50-AS-1
TYP. @ VALVES

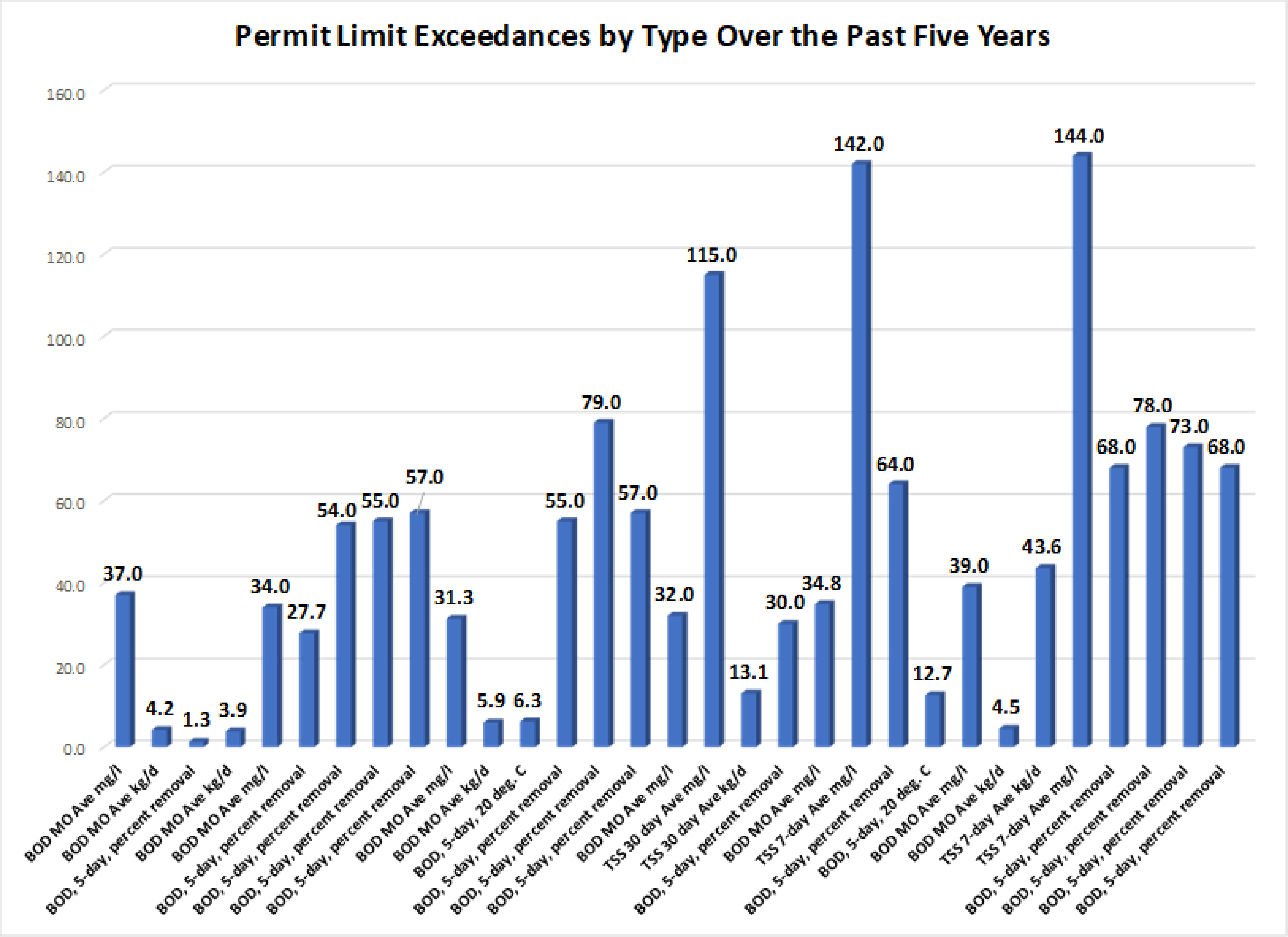


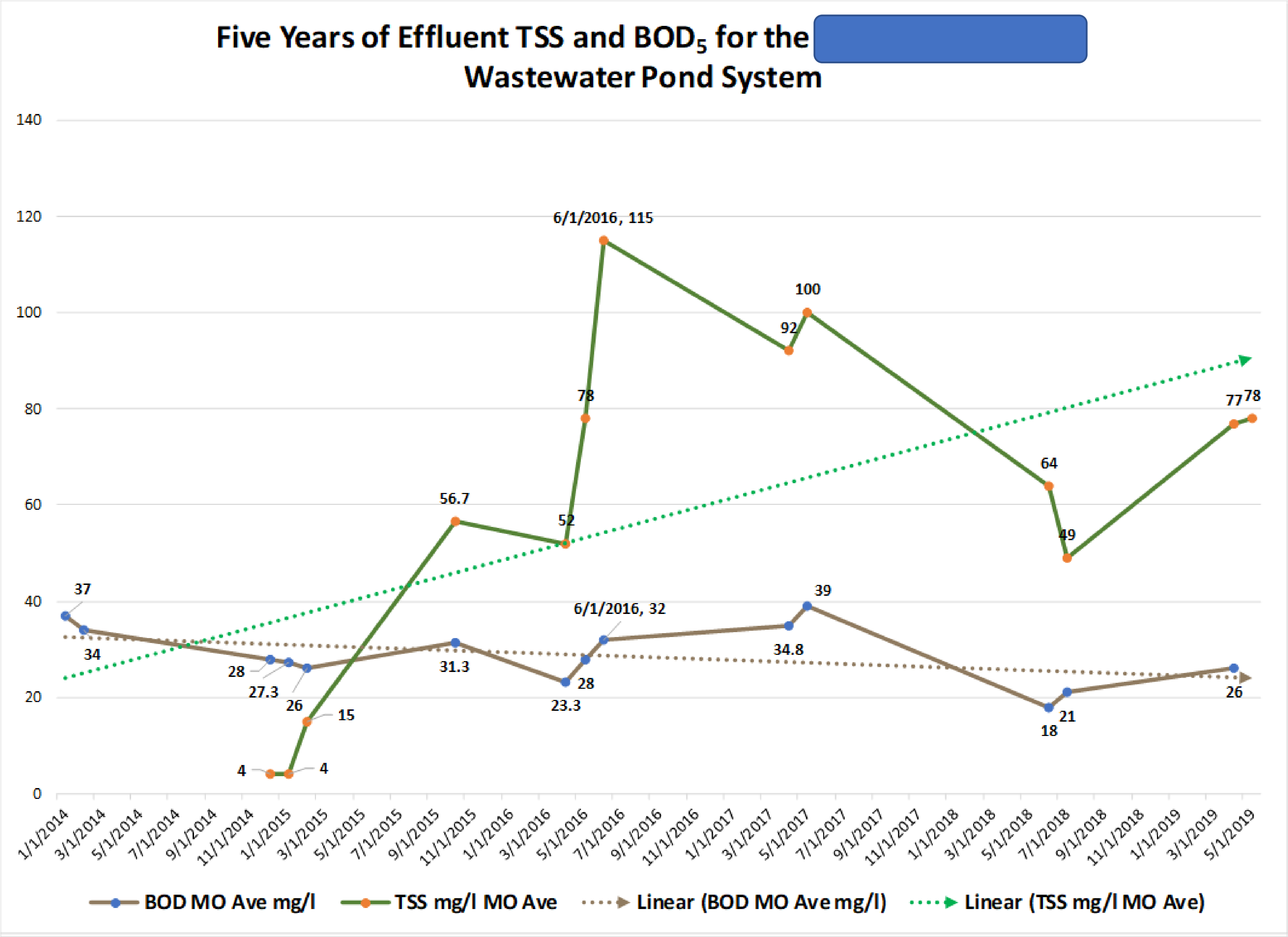
6" DIP SECONDARY OUTLET IE.= 38.0
NORMAL TOE
℄ OUTLET
2'-0"
2'-6"
6' X 4' WIDE X 6" DEPTH CONCRETE PAD W/ #4 @ 4" E.W.
6" LAYER RIPRAP
4'-0"
EL. 36.0
90° FL. BEND
IE = 35.08
PVC LINER
FIELD SEAM, TYP
6" THICK LAYER OF SAND OR GRAVEL ON COMPACTED SUBGRADE
6" DIP PRIMARY OUTLET IE.= 35.08
DOUBLE THICKNESS LINER AT STRUCTURE (7'X5' TYP.)
PLEASE NOTE:
SECTION
POND OUTLET PIPING
1/2" = 1'-0"

Samples are taken right from the effluent weir

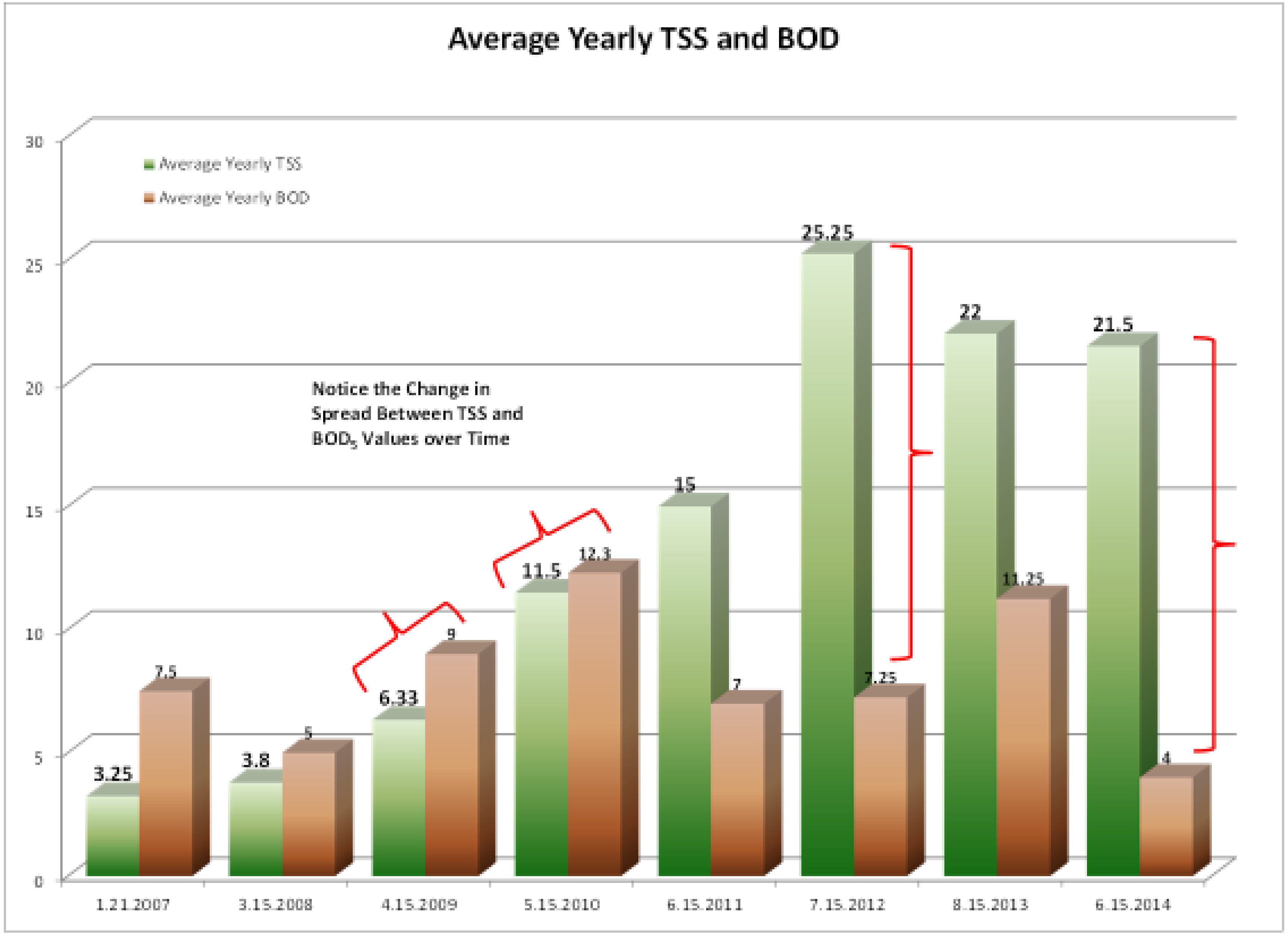
Intra-Pond BOD Analysis for the [redacted] Wastewater Pond System




Permit Limit Exceedances by Type Over the Past Five Years
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
37.0
4.2
1.3
3.9
34.0
27.7
54.0
55.0
57.0
31.3
5.9
6.3
55.0
79.0
57.0
32.0
115.0
13.1
30.0
34.8
142.0
64.0
12.7
39.0
4.5
43.6
144.0
68.0
78.0
73.0
68.0
BOD MO Ave mg/l
BOD MO Ave kg/d
BOD, 5-day, percent removal
BOD MO Ave kg/d
BOD MO Ave mg/l
BOD, 5-day, percent removal
BOD, 5-day, percent removal
BOD, 5-day, percent removal
BOD, 5-day, percent removal
BOD MO Ave mg/l
BOD MO Ave kg/d
BOD, 5-day, 20 deg. C
BOD, 5-day, percent removal
BOD, 5-day, percent removal
BOD, 5-day, percent removal
BOD MO Ave mg/l
TSS 30 day Ave mg/l
TSS 30 day Ave kg/d
BOD, 5-day, percent removal
BOD MO Ave mg/l
TSS 7-day Ave mg/l
BOD, 5-day, percent removal
BOD, 5-day, 20 deg. C
BOD MO Ave mg/l
BOD MO Ave kg/d
TSS 7-day Ave kg/d
TSS 7-day Ave mg/l
BOD, 5-day, percent removal
BOD, 5-day, percent removal
BOD, 5-day, percent removal
BOD, 5-day, percent removal


Five Years of Effluent TSS and BOD_5 for the [redacted] Wastewater Pond System
140
120
100
80
60
40
20
0
6/1/2016, 115
100
92
78
77
78
64
56.7
52
49
37
34
28
27.3
26
15
4
4
31.3
28
23.3
6/1/2016, 32
39
34.8
26
21
18
1/1/2014 3/1/2014 5/1/2014 7/1/2014 9/1/2014 11/1/2014 1/1/2015 3/1/2015 5/1/2015 7/1/2015 9/1/2015 11/1/2015 1/1/2016 3/1/2016 5/1/2016 7/1/2016 9/1/2016 11/1/2016 1/1/2017 3/1/2017 5/1/2017 7/1/2017 9/1/2017 11/1/2017 1/1/2018 3/1/2018 5/1/2018 7/1/2018 9/1/2018 11/1/2018 1/1/2019 3/1/2019 5/1/2019
BOD MO Ave mg/l
TSS mg/l MO Ave
Linear (BOD MO Ave mg/l)
Linear (TSS mg/l MO Ave)

This is what 30-year-old sludge looks like



Sludge at the Effluent Structure

Sludge Accumulation in the chlorine contact chamber at a Small Plant in Indiana

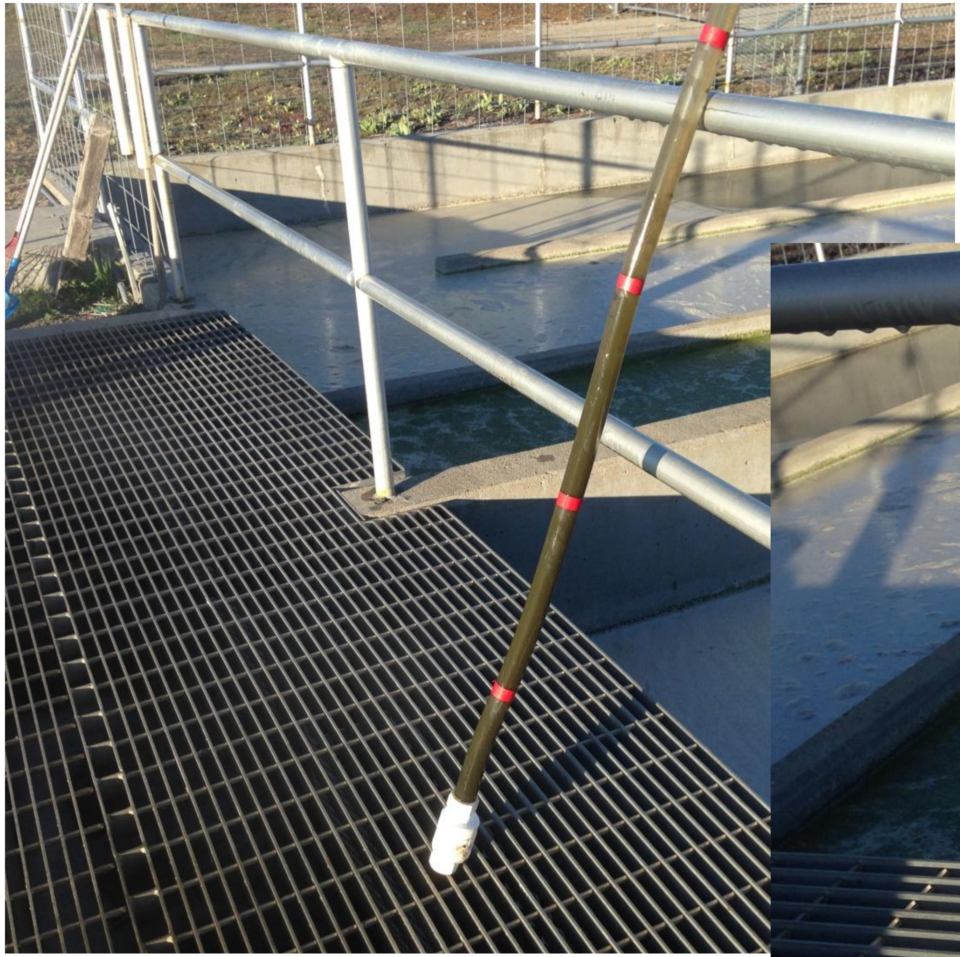
The Jar to the left is from the final treatment cell. The jar to the right is from the chlorine contact chamber after the chamber was mixed

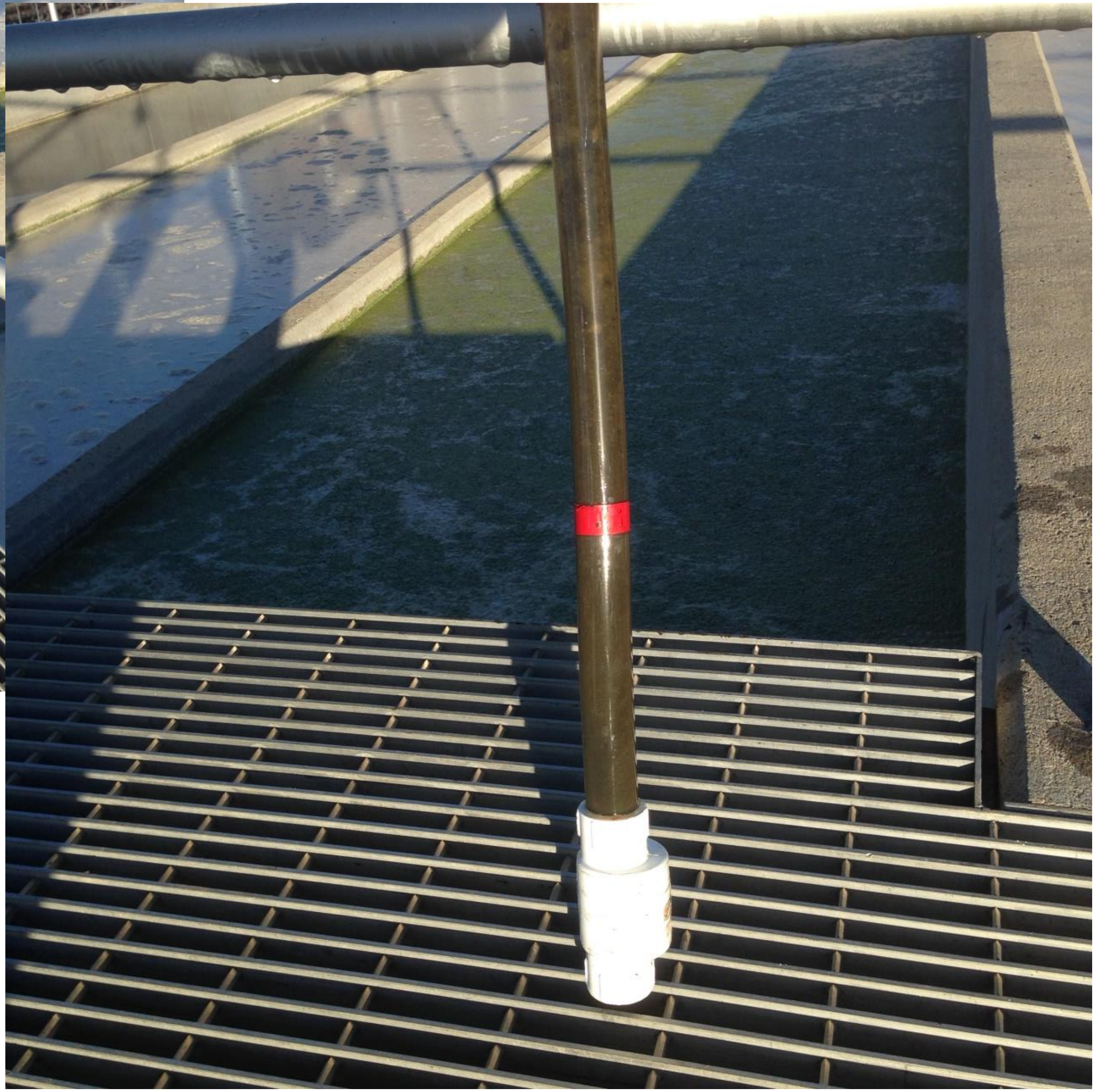
Three Feet of Sludge at the Effluent Structure

sludge accumulation at the effluent structure


03/23/2017

These accumulated Solids Can Affect Permit Results





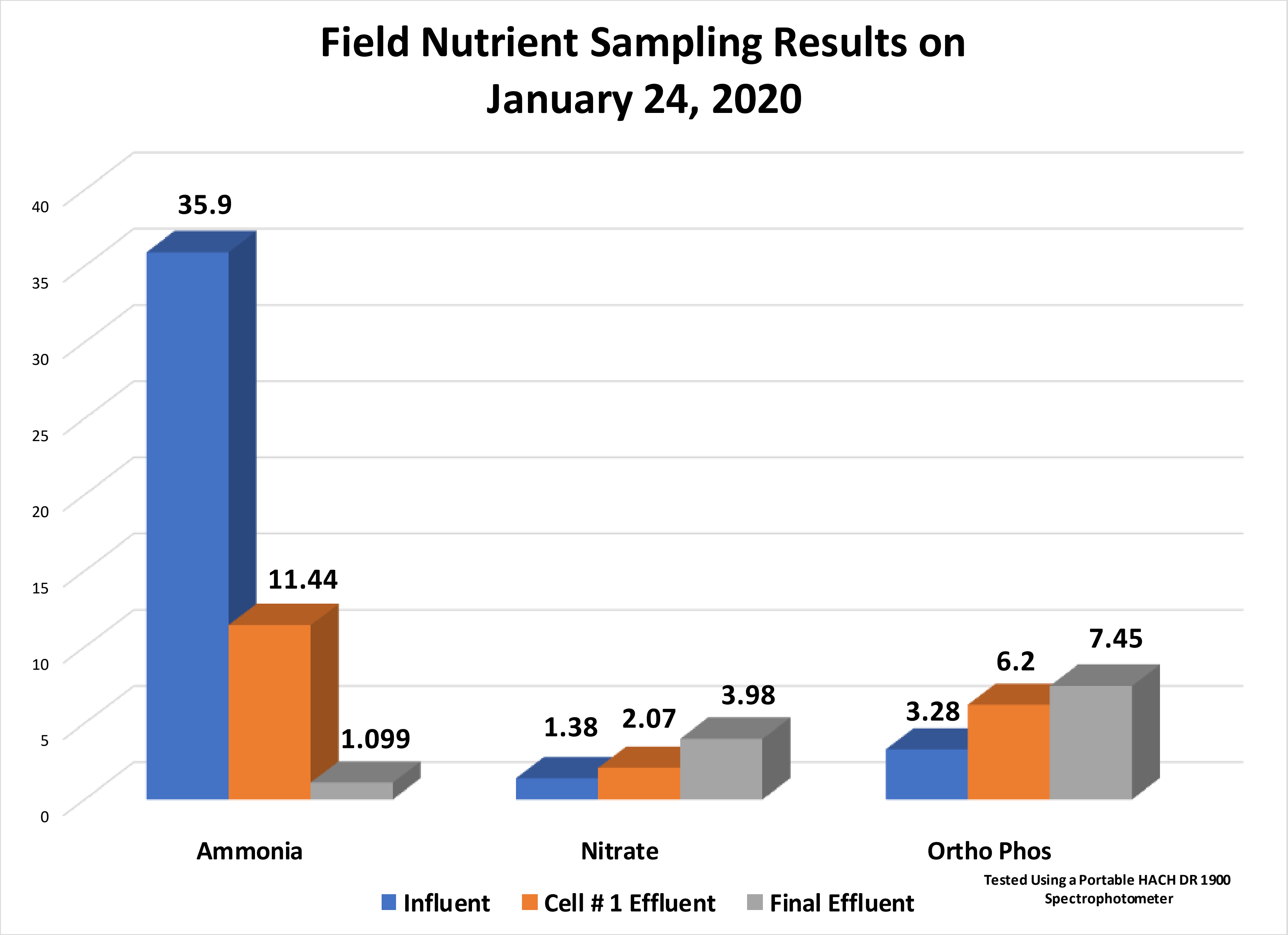
Solids at the effluent can cause sporadic test results as sludge “burps” up whenever

Discharge Cell

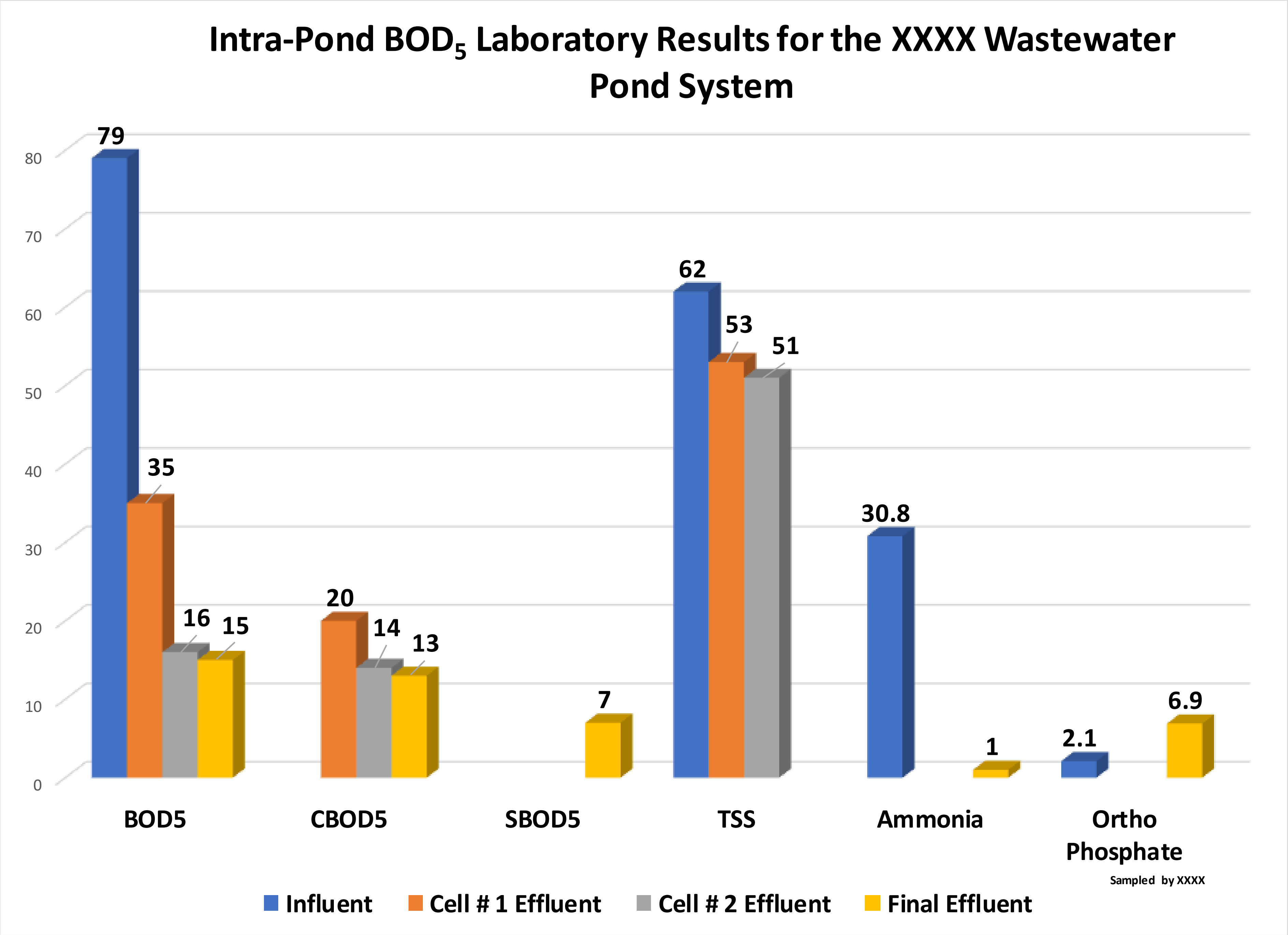
			NORTH			
	1	2	3	4	5	6
A	0.00					
B	1.42	1.75	1.08	0.00	0.00	0.00
C	1.17	1.42	1.00	1.00	0.00	0.00
D	2.17	1.50	0.17	0.25	0.00	
E			0.00	0.00	0.00	

Sludge in the Discharge Well

Sludge in the UV Tank



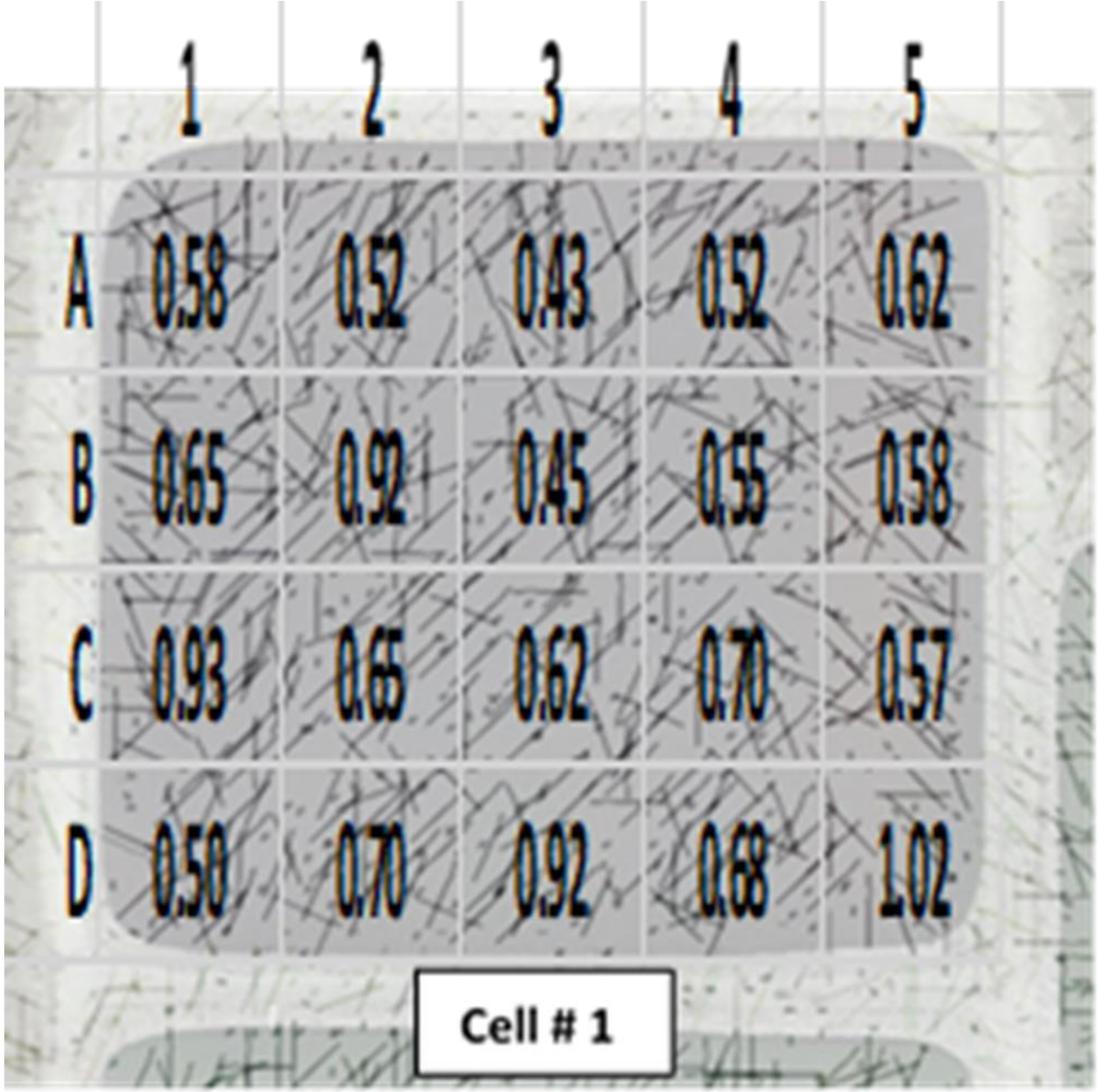
This is what benthal feedback looks like


Intra-Pond BOD_5 Laboratory Results for the XXXX Wastewater Pond System
79
35
16
15
20
14
13
7
62
53
51
30.8
1
2.1
6.9
80
70
60
50
40
30
20
10
0
BOD5
CBOD5
SBOD5
TSS
Ammonia
Ortho Phosphate
Sampled by XXXX
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Final Effluent

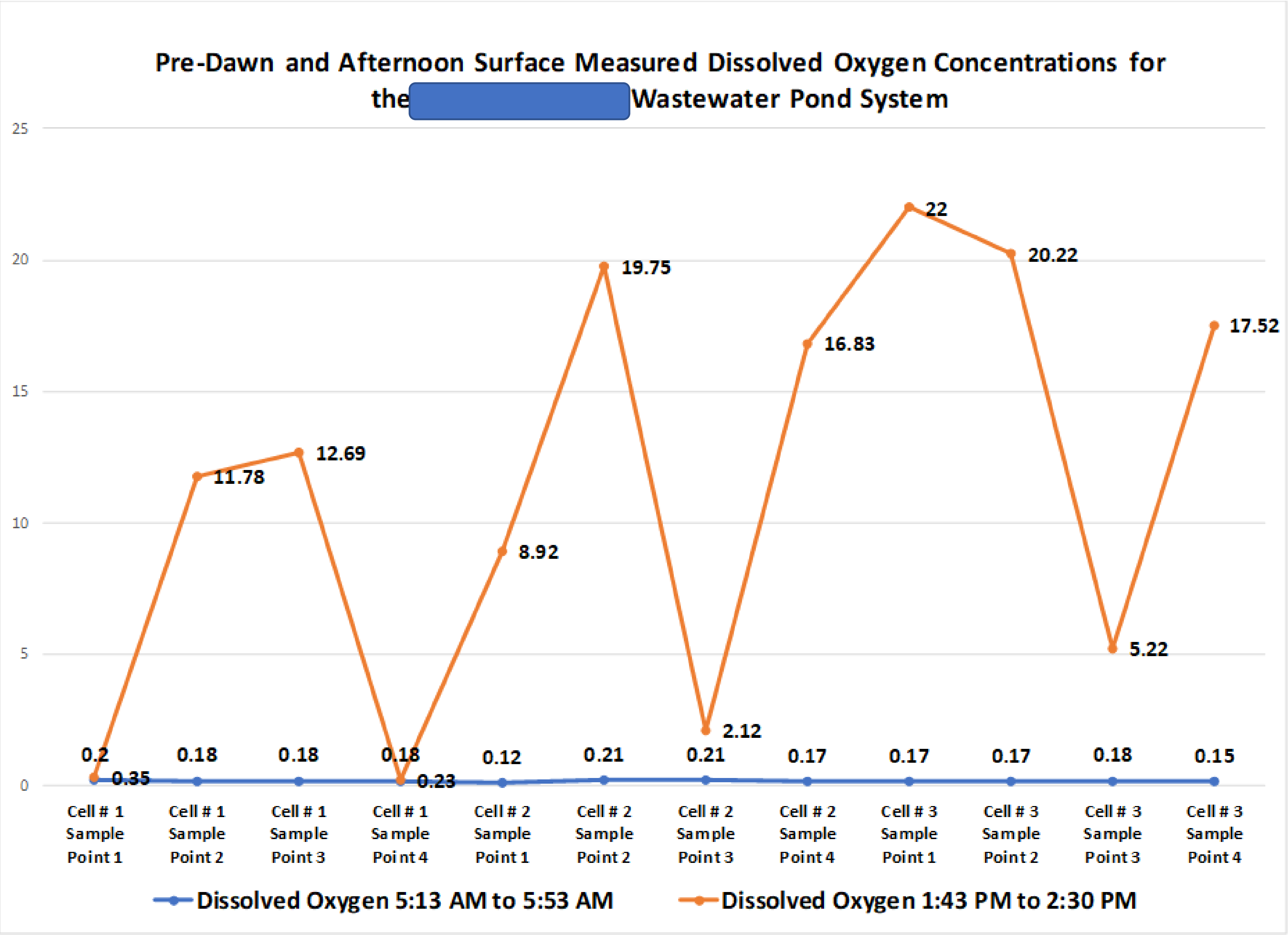
Overloading Case

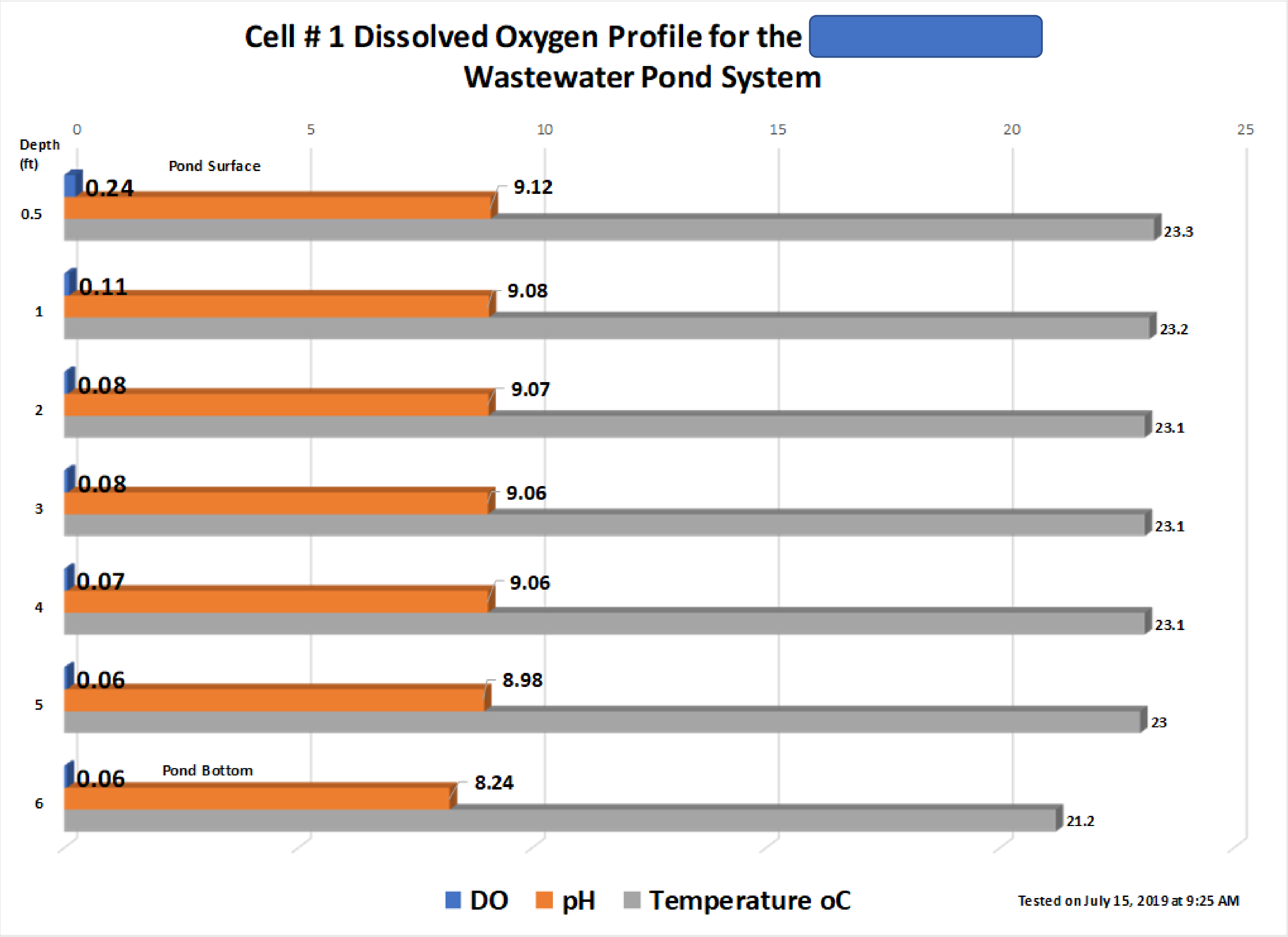
Overloading Case

There was very little sludge accumulation in any of the three treatment cells



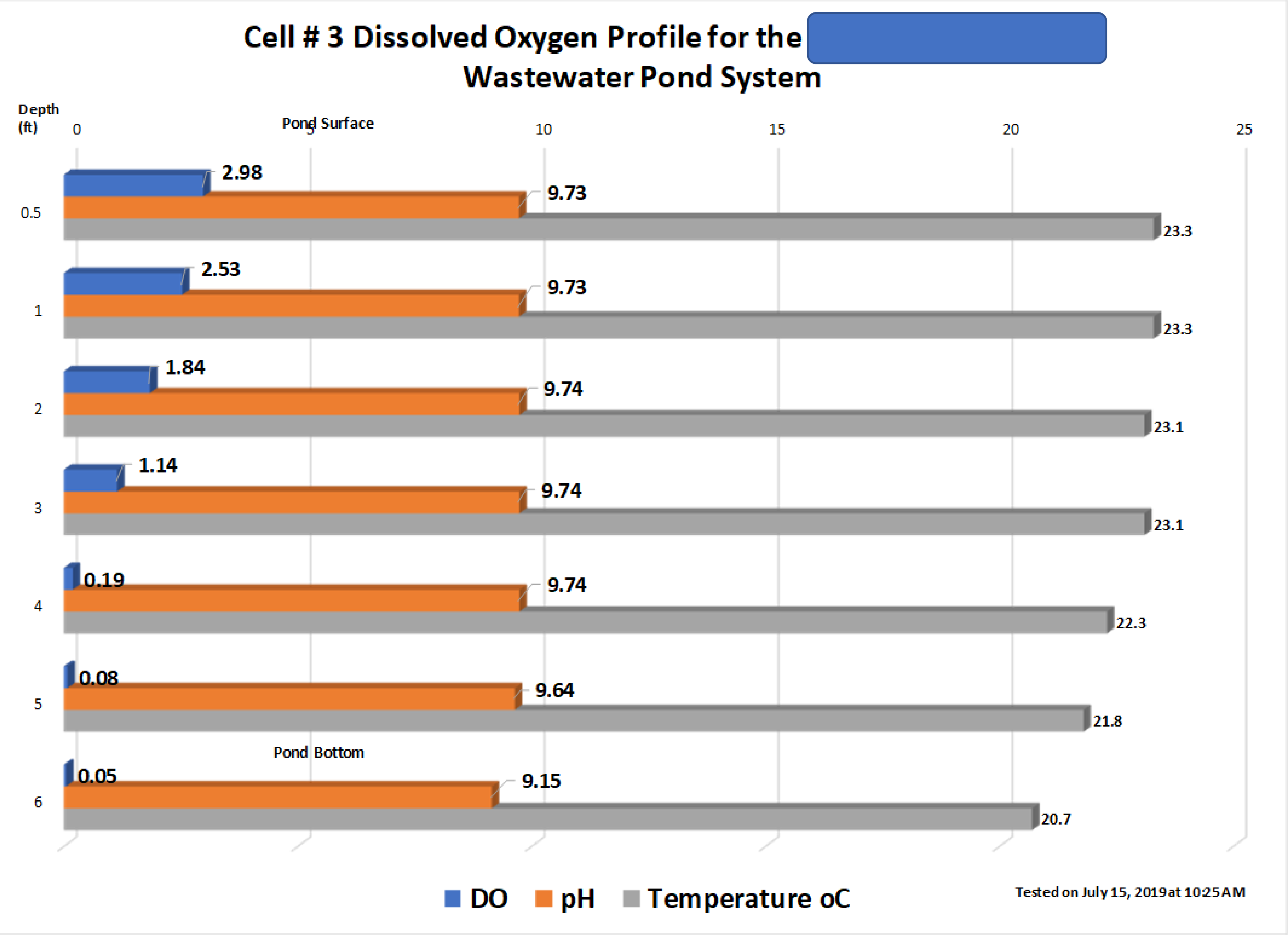
Dissolved Oxygen was completely absent in the early morning hours before sunrise



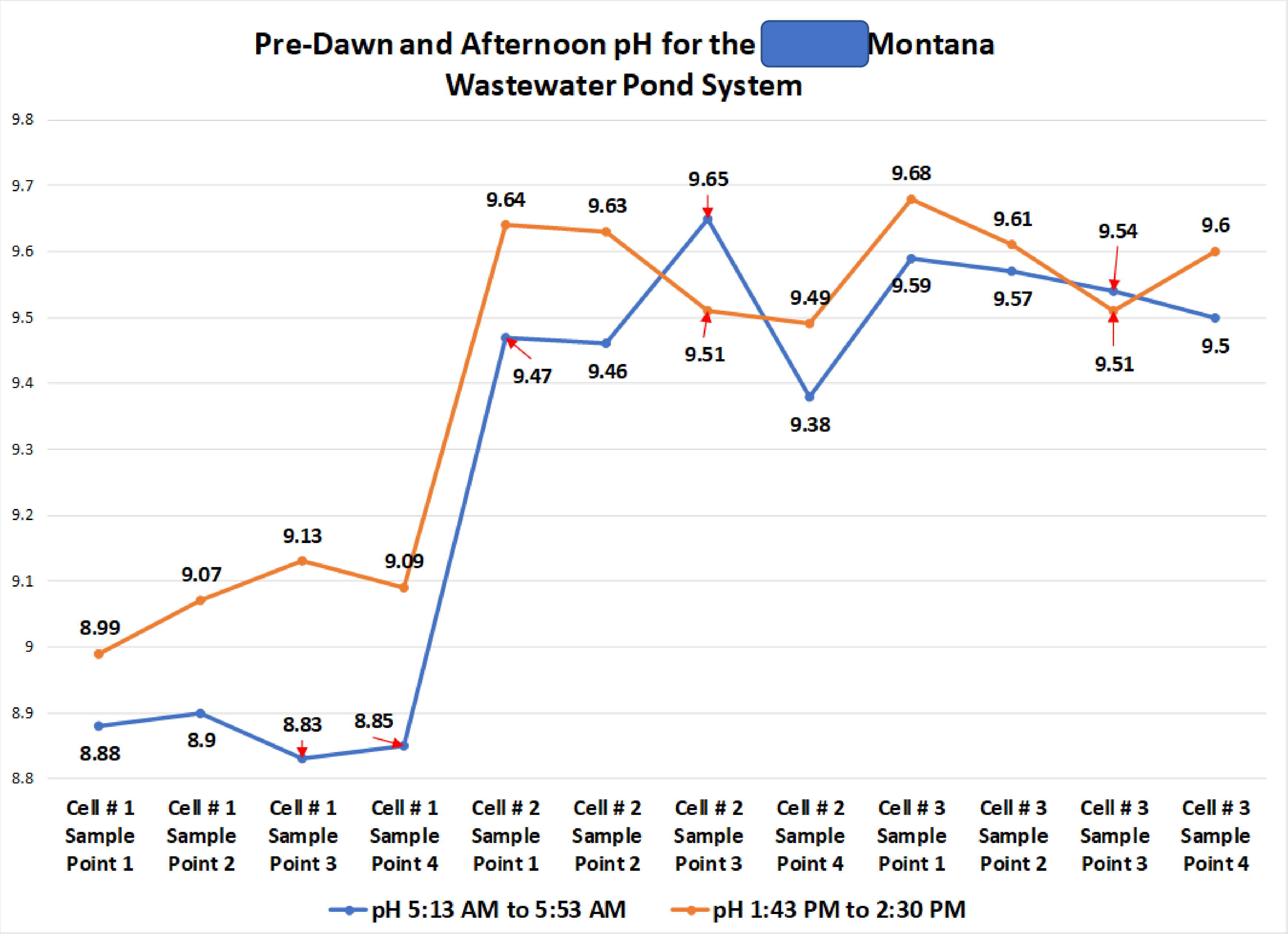


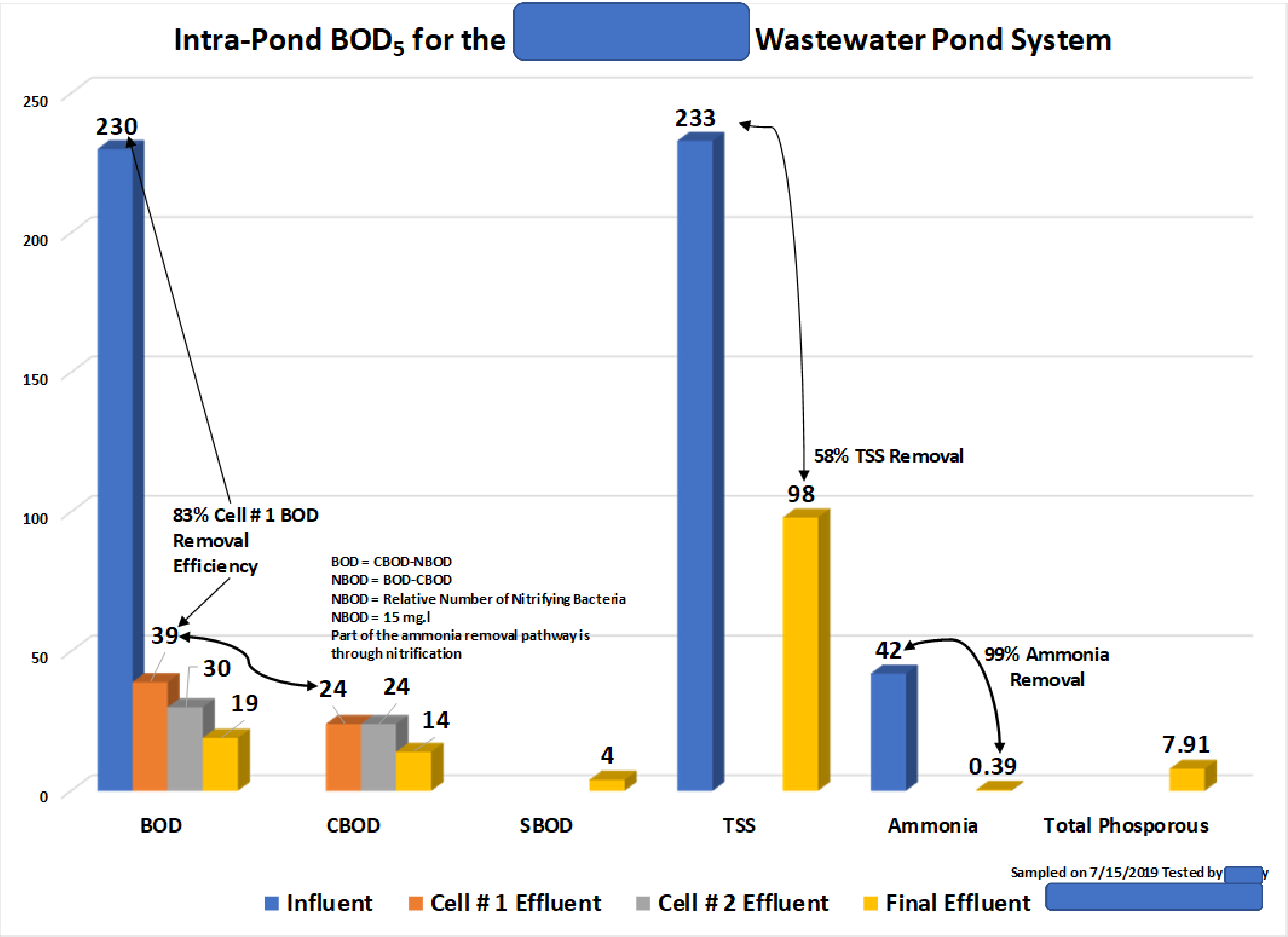
Cell # 1 Dissolved Oxygen Profile for the [redacted] Wastewater Pond System
Depth (ft)
0
5
10
15
20
25
Pond Surface
Pond Bottom
0.5
1
2
3
4
5
6
0.24
9.12
23.3
0.11
9.08
23.2
0.08
9.07
23.1
0.08
9.06
23.1
0.07
9.06
23.1
0.06
8.98
23
0.06
8.24
21.2
DO
pH
Temperature oC
Tested on July 15, 2019 at 9:25 AM

Notice how the dissolved oxygens concentrations drops off rapidly after the first three feet

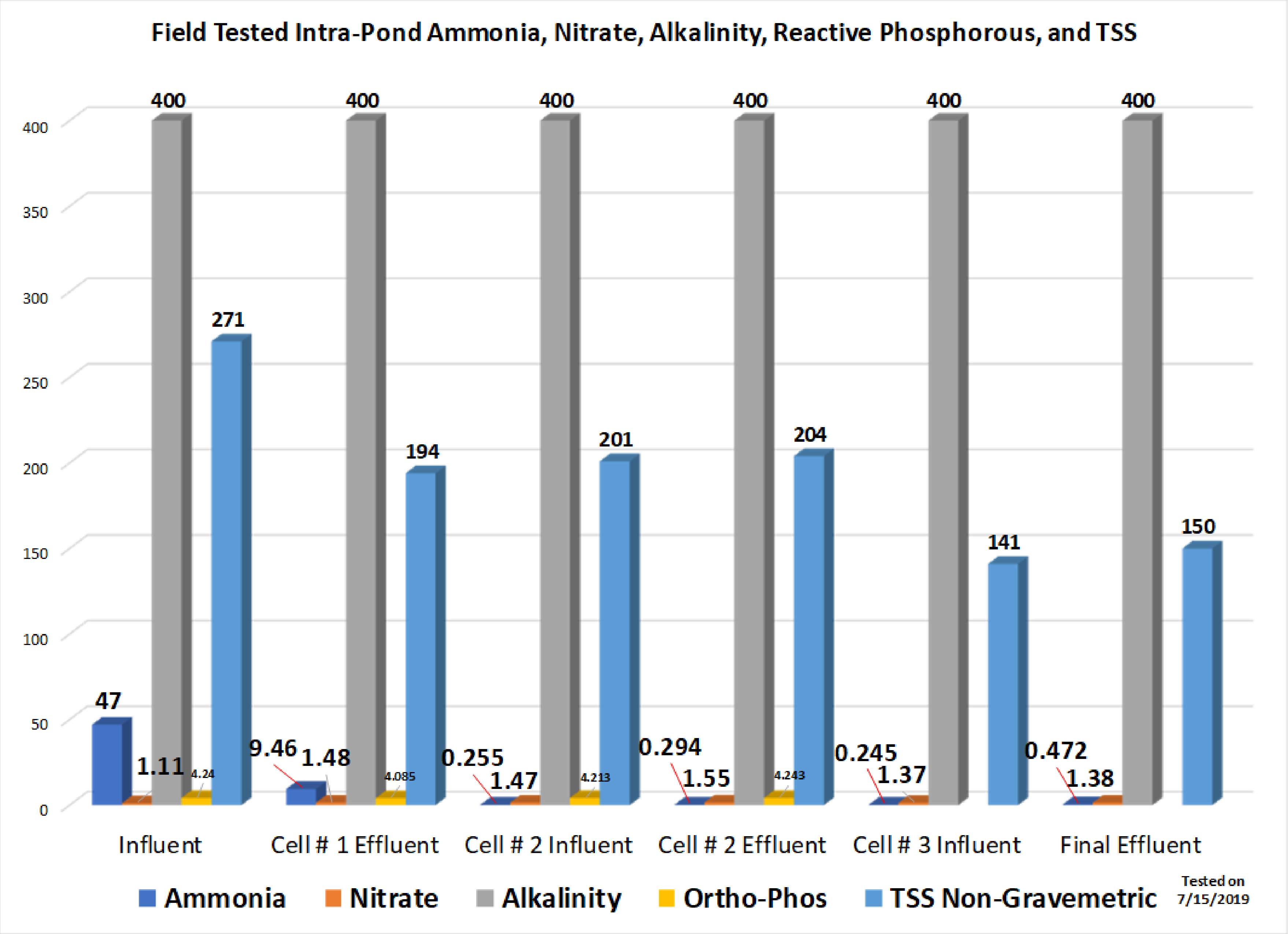


pH is useful for removing ammonia in pond systems

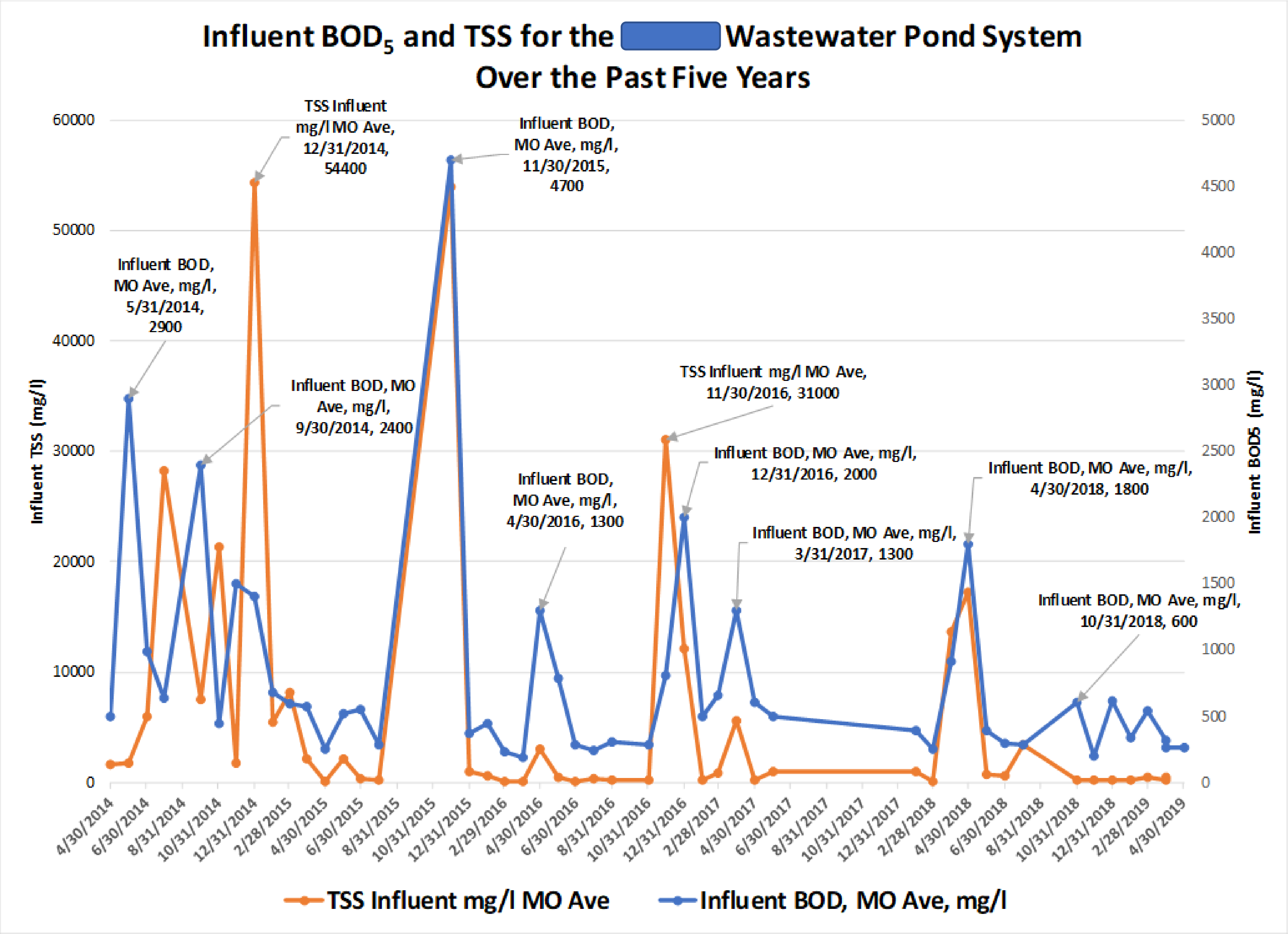


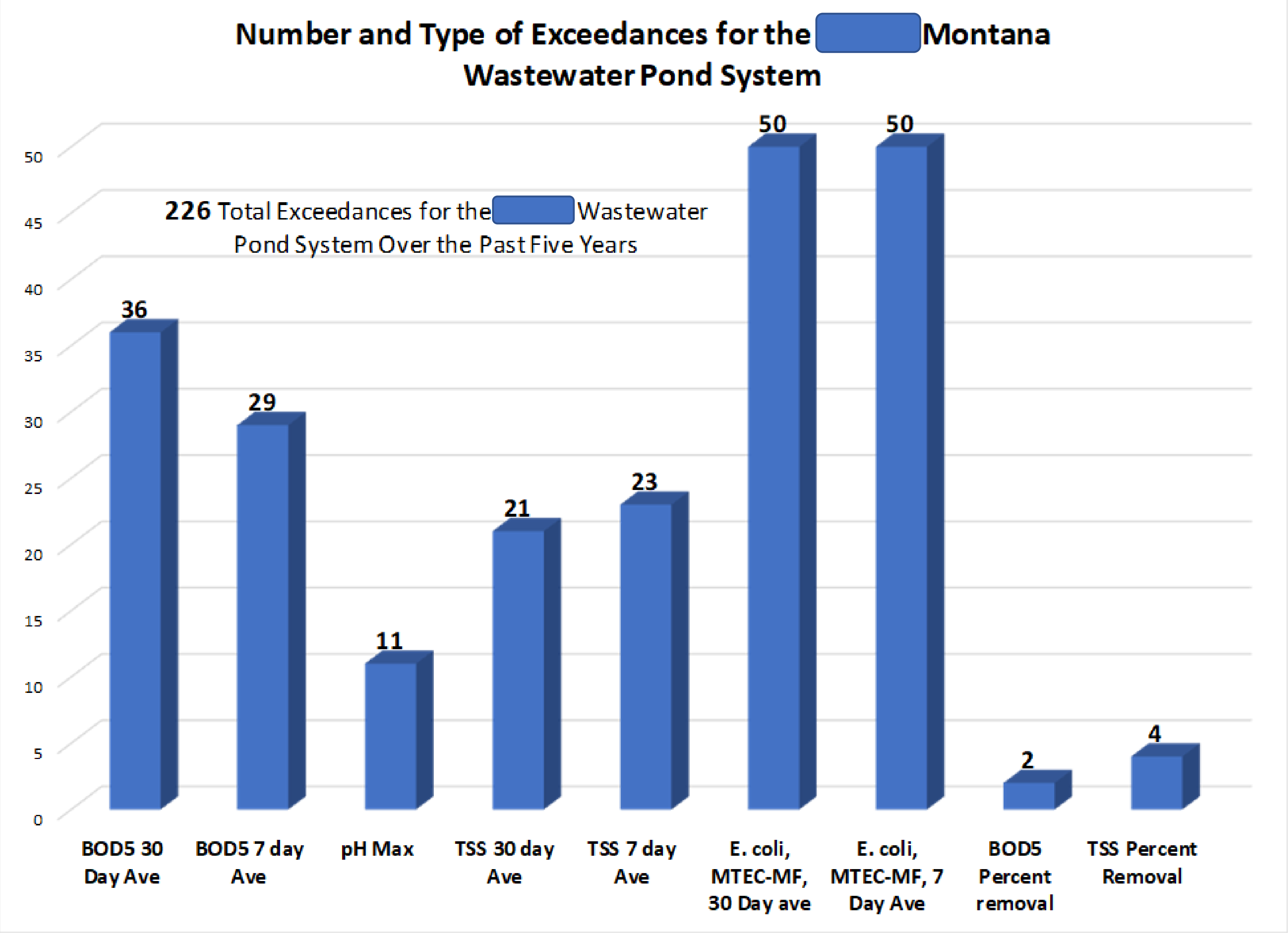


Intra-Pond BOD_5 for the [redacted] Wastewater Pond System
250
200
150
100
50
0
230
83% Cell # 1 BOD Removal Efficiency
39
30
19
24
24
14
BOD = CBOD-NBOD
NBOD = BOD-CBOD
NBOD = Relative Number of Nitrifying Bacteria
NBOD = 15 mg.l
Part of the ammonia removal pathway is through nitrification
4
233
58% TSS Removal
98
42
99% Ammonia Removal
0.39
7.91
BOD
CBOD
SBOD
TSS
Ammonia
Total Phosporous
Sampled on 7/15/2019 Tested by [redacted]
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Final Effluent



Field Tested Intra-Pond Ammonia, Nitrate, Alkalinity, Reactive Phosphorous, and TSS
400
350
300
250
200
150
100
50
0
400
400
400
400
400
400
271
194
201
204
141
150
47
1.11
4.24
9.46
1.48
4.085
0.255
1.47
4.213
0.294
1.55
4.243
0.245
1.37
0.472
1.38
Influent
Cell # 1 Effluent
Cell # 2 Influent
Cell # 2 Effluent
Cell # 3 Influent
Final Effluent
Ammonia
Nitrate
Alkalinity
Ortho-Phos
TSS Non-Gravemetric
Tested on 7/15/2019

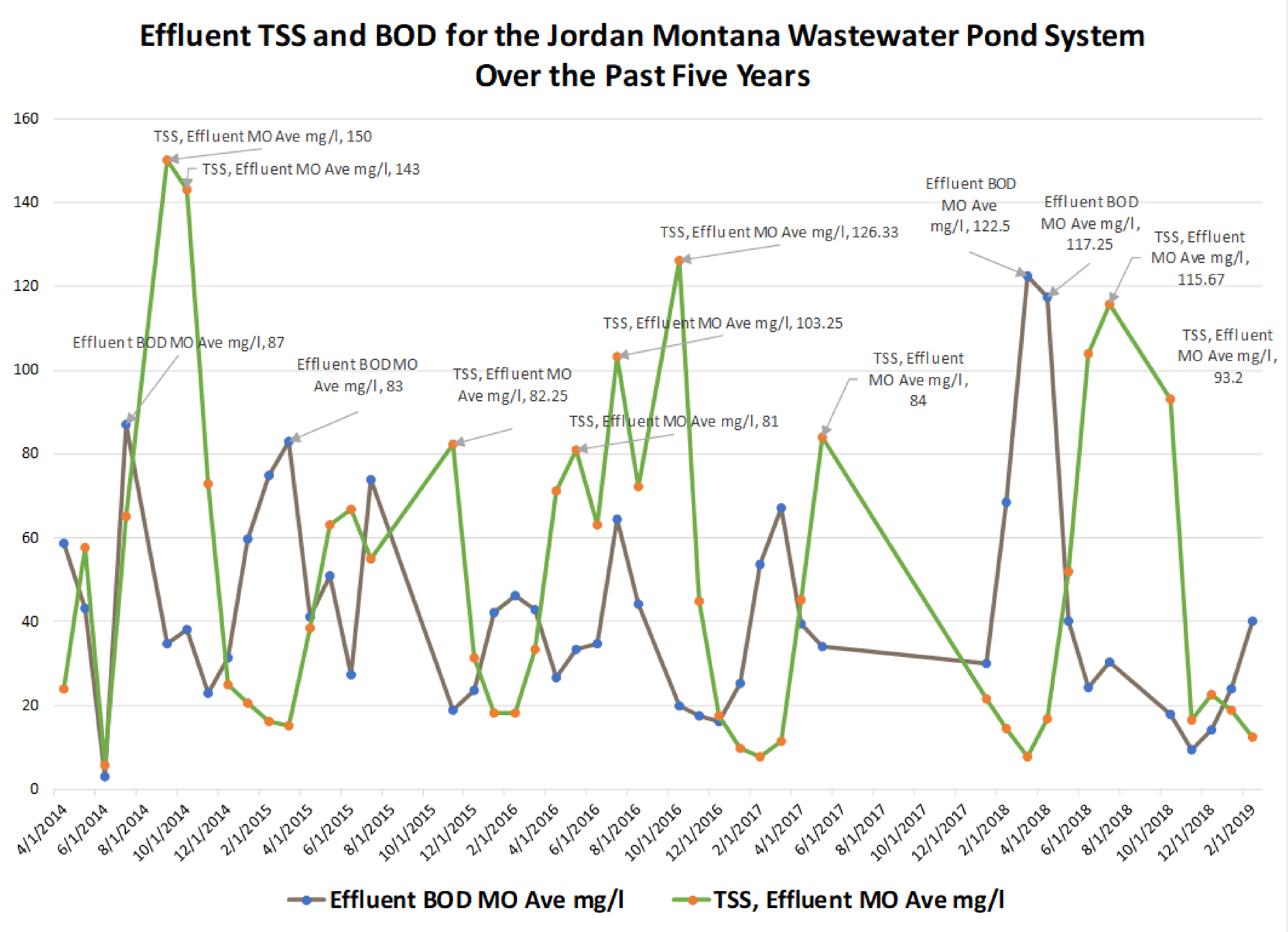

Influent BOD5 and TSS for the [redacted] Wastewater Pond System
Over the Past Five Years
Influent TSS (mg/l)
Influent BOD5 (mg/l)
TSS Influent mg/l MO Ave, 12/31/2014, 54400
Influent BOD, MO Ave, mg/l, 11/30/2015, 4700
Influent BOD, MO Ave, mg/l, 5/31/2014, 2900
Influent BOD, MO Ave, mg/l, 9/30/2014, 2400
TSS Influent mg/l MO Ave, 11/30/2016, 31000
Influent BOD, MO Ave, mg/l, 12/31/2016, 2000
Influent BOD, MO Ave, mg/l, 4/30/2018, 1800
Influent BOD, MO Ave, mg/l, 4/30/2016, 1300
Influent BOD, MO Ave, mg/l, 3/31/2017, 1300
Influent BOD, MO Ave, mg/l, 10/31/2018, 600
TSS Influent mg/l MO Ave
Influent BOD, MO Ave, mg/l

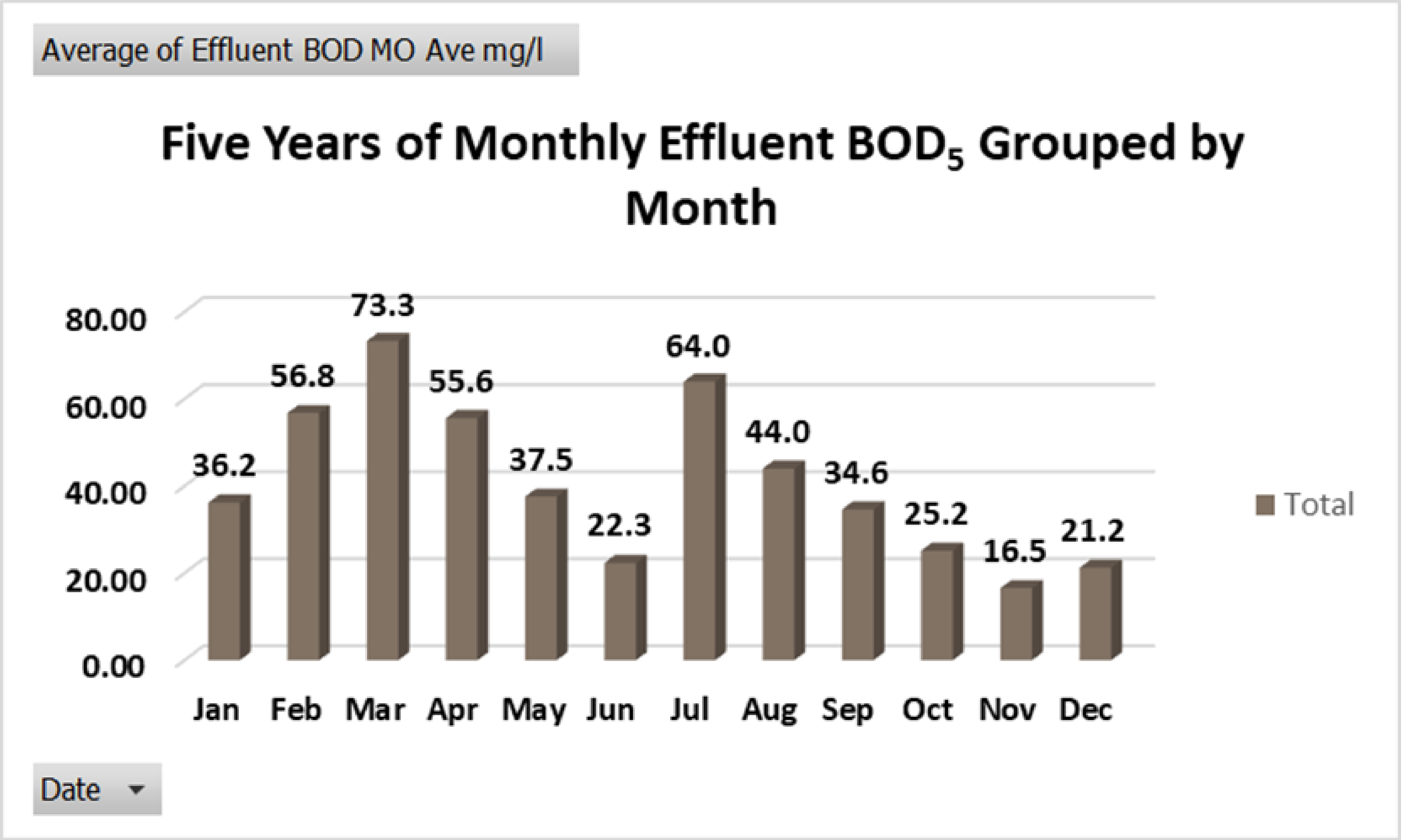

Number and Type of Exceedances for the [redacted] Montana Wastewater Pond System
226 Total Exceedances for the [redacted] Wastewater Pond System Over the Past Five Years
50
45
40
35
30
25
20
15
10
5
0
36
29
11
21
23
50
50
2
4
BOD5 30 Day Ave
BOD5 7 day Ave
pH Max
TSS 30 day Ave
TSS 7 day Ave
E. coli, MTEC-MF, 30 Day ave
E. coli, MTEC-MF, 7 Day Ave
BOD5 Percent removal
TSS Percent Removal

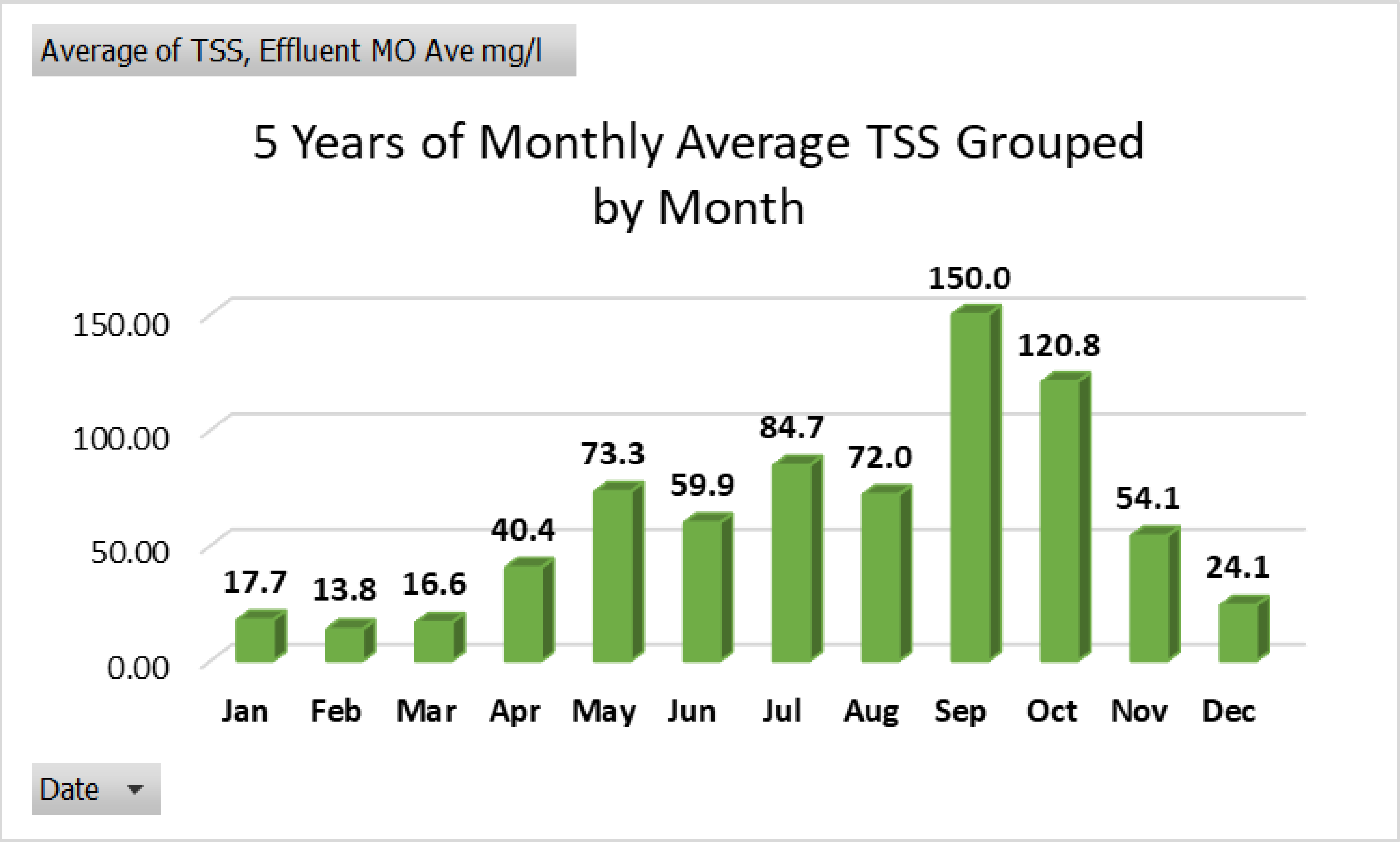
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1		Effluent BOD MO Ave lbs/d	Influent BOD, MO Ave, mg/l	Effluent BOD MO Ave mg/l	Effluent BOD Wkly Ave mg/l	Effluent BOD Wkly Ave lbs/d	TSS, Effluent MO Ave lbs/d (17.5)	TSS, Effluent Wkly Ave lbs/d (25.2)	TSS, Effluent MO Ave mg/l	TSS, Effluent Wkly Ave mg/l	TSS Influent mg/l MO Ave	TSS Pct Removal	BOD Pct Removal	TSS:BOD Ratio	NH4 MO Ave	NH4 Wkly Ave	TKN MO Ave mg/l	On	NO2 NO3	TN MO Ave lbs/d	TN MO Ave mg/l	E.coli, MO Ave	Flow MO Ave	Flow Daily Max	Oil & Grease	pH Max	pH Min
8	11/30/2014	2.87	1500	22.75	26	6.56	9.21	23.96	73	95	1770	96	98	3.2	3.3	3.98	16.6	13.3	0.4	2.14	17	61000	0.0151	0.0302	3	8.92	[illegible]
9	12/31/2014	7.87	1400	31.2	40	10.09	6.31	9.84	25	39	54400	99	99	0.8	8.8	9.6	16.4	7.6	0.18	4.19	16.6	130000	0.0302	0.0302	5	9.19	[illegible]
10	1/31/2015	11.06	680	59.75	67	16.88	4.11	6.3	20.5	25	5430	99	91	0.3	13.2	15.6	21.4	8.2	0.08	4	21.5	41000	0.0223	0.0302	3	9.19	[illegible]
11	2/28/2015	16.82	590	75	84	21.17	3.6	4.28	16.25	17	8180	99	87	0.2	14.65	15.6	20.2	5.55	0.02	4.42	20.2	7700	0.0263	0.0302	3	9.16	[illegible]
12	3/31/2015	20.66	570	83	88	21.92	3.78	4.28	15	17	2090	99	86	0.2	17.1	17.4	25.3	8.2	0.04	6.38	25.3	130000	0.0302	0.0302	3	9.09	[illegible]
13	4/30/2015	0.197	250	41	52	6.24	2.45	5.22	38.4	75	56	31	84	0.9	16.97	19.7	24.6	7.63	0.03	1.71	24.6	44000	0.0084	0.0144	4	9.17	7
14	5/31/2015	0.816	520	50.75	68	0.0151	5.67	9.36	63	78	2150	99.74	100	1.2	15.2	20.3	34.2	19	0.01	1.03	34.2	77000	0.0036	0.0058	2	9.59	
15	6/30/2015	4.25	550	27.4	38	9.94	12.01	33.7	66.8	103	324	79	95	2.4	3.13	4.5	14.8	11.67		2.93	14.8	6500	0.0233	0.0518		9.59	
16	7/31/2015	0.888	290	74	74	0.888	0.66	0.66	55	55	258	79	74	0.7	7.8	7.8	20.2	12.4		0.24	20.2	39000	0.0014	0.0014	5	8.99	[illegible]
17	11/30/2015	0.819	4700	18.75	3.74	3.6	18.01	16.8	82.25	140	53900	99.85	99.6	4.4	3.05	3.19	19	15.95	0.03	4.16	19	46000	0.0263	0.0302		10.22	[illegible]
18	12/31/2015	1.49	370	23.4	34	8.57	7.86	11.59	31.2	46	958	96.74	93.68	1.3	5.76	6.5	14.8	9.04	0.05	3.75	14.9	69000	0.0302	0.0302		9.96	[illegible]
19	1/31/2016	10.58	450	42	53	13.36	4.6	5.04	18.25	20	647	97.18	90.67	0.4	9.5	9.9	17.8	8.3	0.02	4.49	17.8	28000	0.0302	0.0302	1	8.83	[illegible]
20	2/29/2016	11.66	230	46.25	51	12.85	4.6	5.04	18.25	20	130	86	80	0.4	12.65	12.9	22.8	10.15		5.75	22.8	41000	0.0302	0.0302	4	9.2	
21	3/31/2016	8.2	190	42.8	65	16.38	5.01	6.36	33.4	53	113	70	77	0.8	13.8	14.1	20.4	6.6		3.53	20.4	6900	0.0207	0.0302	3	9	
22	4/30/2016	5	1300	26.5	28	7.06	14.23	24.19	71	96	3080	98	98	2.7	11.55	12.6	24.2	12.65		24.2	4.5	10000	0.0223	0.0302	1	9	
23	5/31/2016	7.34	790	33.5	10.85	11.63	18.05	27.5	81	123	505	84	96	2.4	6.15	7.4	22	15.85	0.29	22.3	4.85	16000	0.0261	0.0321	1	9.3	
24	6/30/2016	3.75	290	34.8	45	7.01	8.11	17.71	63	91	128	51	88	1.8	3.58	5.1	19.8	16.22	0.04	2.2	19.8	3700	0.0134	0.0234		9.3	
25	7/31/2016	2.82	240	64.5	78	8.14	6.64	23.39	103.25	224	320	68	73	1.6	4.79	5.4	17.8	13.01	0.05	0.68	17.8	5500	0.0046	0.0026		9.2	
26	8/31/2016	1.61	310	44	46	3.15	2.12	3.15	72	98	199	64	86	1.6	1.9	1.9	17.8	15.9		0.6	15	3700	0.0048	0.0082	1	9.3	
27	10/31/2016	6.7	280	19.67	27	9.72	42.65	58.68	126.33	163	209	40	93	6.4	1.29	1.29	21.2	19.91		7.14	21.2	870	0.0404	0.0432		9.1	
28	11/30/2016	4.39	810	17.6	23	6.89	12.09	33.49	44.8	107	31000	99.9	97.8	2.5	2.41	2.78	17.2	14.79		3.42	17.2	14000	0.0239	0.0376	5	9.1	
29	12/31/2016	3.23	2000	16	17	3.5	3.57	6.26	17.5	30	12100	99.9	99.2	1.1	4.2	4.89	10.5	6.3	0.1	2.14	10.6	12000	0.0242	0.025	3	9.2	
30	1/31/2017	5.89	500	25.2	39	10.4	2.11	2.86	9.8	14	272	96	95	0.4	7.45	8.8	13	5.55	0.04	2.94	13	11000	0.0272	0.032	2	9.3	
31	2/28/2017	14.78	660	53.75	67	19.69	2.06	2.99	7.75	11	830	99	92	0.1	8.71	15	19.7	10.99		5.38	19.7	120000	0.0328	0.0353	3	9.3	
32	3/31/2017	18.47	1300	67.25	78	21.93	3.11	3.42	11.25	12	5560	99	95	0.2	16.95	17.1	23.2	6.25		6.43	23.2	49000	0.0332	0.0393	4	9.3	
33	4/30/2017	5.94	610	39.25	44	8.86	6.44	10.39	45.25	70	158	71	94	1.2	14.75	15.2	20.9	6.15	0.02	3.12	20.9	14000	0.0179	0.0242		9.3	
34	5/31/2017	1.98	500	34	38	3.34	5.09	9.6	84	95	1020	92	93	2.5	14.05	15	26.6	12.55		1.61	26.6	6100	0.0073	0.0125		9.3	
35	1/31/2018	7.85	390	30	38	10.94	2.13	5.18	21.39	18	934	99.44	92.31	0.7	8.9	9.7	16.8	7.9		16.8	4.31	17000	0.0308	0.0346	8.1	9.01	
36	2/28/2018	18.25	250	68.5	87	23.43	3.86	4.68	14.5	18	114	87	73	0.2	14.7	15.5	23.7	9		6.31	23.7	6500	0.032	0.0325	4	9.1	
37	3/31/2018	35.65	910	122.5	130	45.05	2.48	6.24	7.75	18	13600	99	87	0.1	21.7	23.5	31.6	9.9	0.01	9.15	31.6	11000	0.0347	0.0416	2	9.1	
38	4/30/2018	41.48	1800	117.25	150	56.52	5.89	8.08	16.75	23	17300	99	93	0.1	26.4	27.5	35.4	9	0.01	12.23	35.4	6000	0.0414	0.0452	3	9.1	
39	5/31/2018	4.26	390	40	30.4	5.77	7.52	15.83	52	125	724	93	92	1.3	11.95	14.4	21.8	9.85	0.07	3.33	21.9	3200	0.0182	0.0305	2	9.5	
40	6/30/2018	3.82	300	24.25	30	5.4	16.42	28.25	104	169	552	81	92	4.3	2.12	4	15.9	13.78	0.02	2.49	15.9	2700	0.0188	0.027		9.5	
41	7/31/2018	1.76	280	30.33	40	3.27	8.68	17.28	115.67	132	3380	97	89	3.8	2.05	3.97	17.4	15.35	0.02	1.18	17.4	120	0.0082	0.0157		9.5	
42	10/31/2018	1.546	600	17.8	31	2.77	7.512	15.08	93.2	178	273	66	97	5.2	0.86	0.87	22	21.14	0.01	2.13	22	1100	0.116	0.0166		9	
43	11/30/2018	1.122	200	9.25	12	1.29	2.275	5.376	16.5	50	252	93	95	1.8	0.9	1.18	9.9	9		1.23	9.9	390	0.0149	0.0199		9.4	
44	12/31/2018	3.182	620	14.25	24	7.58	5.112	12.318	22.5	39	215	90	98	1.6	2.55	3.24	8.2	5.65	0.03	1.576	8.2	8300	0.023	0.0379		9.6	[illegible]
45	1/31/2019	7.018	340	24	42	13.033	5.321	5.718	18.8	22	195	90	93	0.8	3.61	3.81	11.3	7.69	0.03	3.22	11.3	4900	0.0342	0.0372		9.41	[illegible]
46	2/28/2019	13.426	540	40.25	68	21.281	4.21	5.25	12.25	14	511	98	93	0.3	9.7	11.5	15.3	5.6		5.243	15.3	8400	0.0411	0.0455		9.2	[illegible]
47	3/31/2019	17.31	320.00	50.75	66.00	25.44	5.66	10.56	15.75	22.00	268.00	94.00	84.00		17.15	18.30	7.30		0.01	7.82	23.00	8400.00	0.04	0.06	2.00	9.00	[illegible]
48	4/1/2019	14.35	260	51.2	87	34.45	10.772	19.062	47.2	90	502	91	80		16.6	19.1	27.3			6.939	27.5	28000	0.0303	0.0475	2	9	[illegible]
49	5/2/2019	5.44	260	23.75	28	7.52	24.85	43.56	102.25	122		80	91		7.4	9.1	23.4			5.56	23.4	2700	0.0285	0.0475		9.378	[illegible]
50	Average	9.04	775.42	42.55	52.03	13.81	10.00	16.61	49.97	71.66	6191.21	88.34	90.90	1.66	9.29	10.49	20.04	11.10	0.08	5.17	19.05	25562.08	0.02	0.03	3.03	9.17	8

- design loading of 22 lbs./acre/day
- 226 permit exceedances in 5 years
- loading to the primary treatment cell is 63.89 lbs./ac/day.

About Seventy-Five (75) Percent of the Time the XXXX Pond System will Violate its Monthly Average Effluent BOD Limits and about Fifty-Six (56) Percent of the Time it will Violate its TSS Limits




Average of Effluent BOD MO Ave mg/l
Five Years of Monthly Effluent BOD5 Grouped by Month
80.00
60.00
40.00
20.00
0.00
36.2
56.8
73.3
55.6
37.5
22.3
64.0
44.0
34.6
25.2
16.5
21.2
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Total
Date



Average of TSS, Effluent MO Ave mg/l
5 Years of Monthly Average TSS Grouped by Month
150.00
100.00
50.00
0.00
17.7
13.8
16.6
40.4
73.3
59.9
84.7
72.0
150.0
120.8
54.1
24.1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date

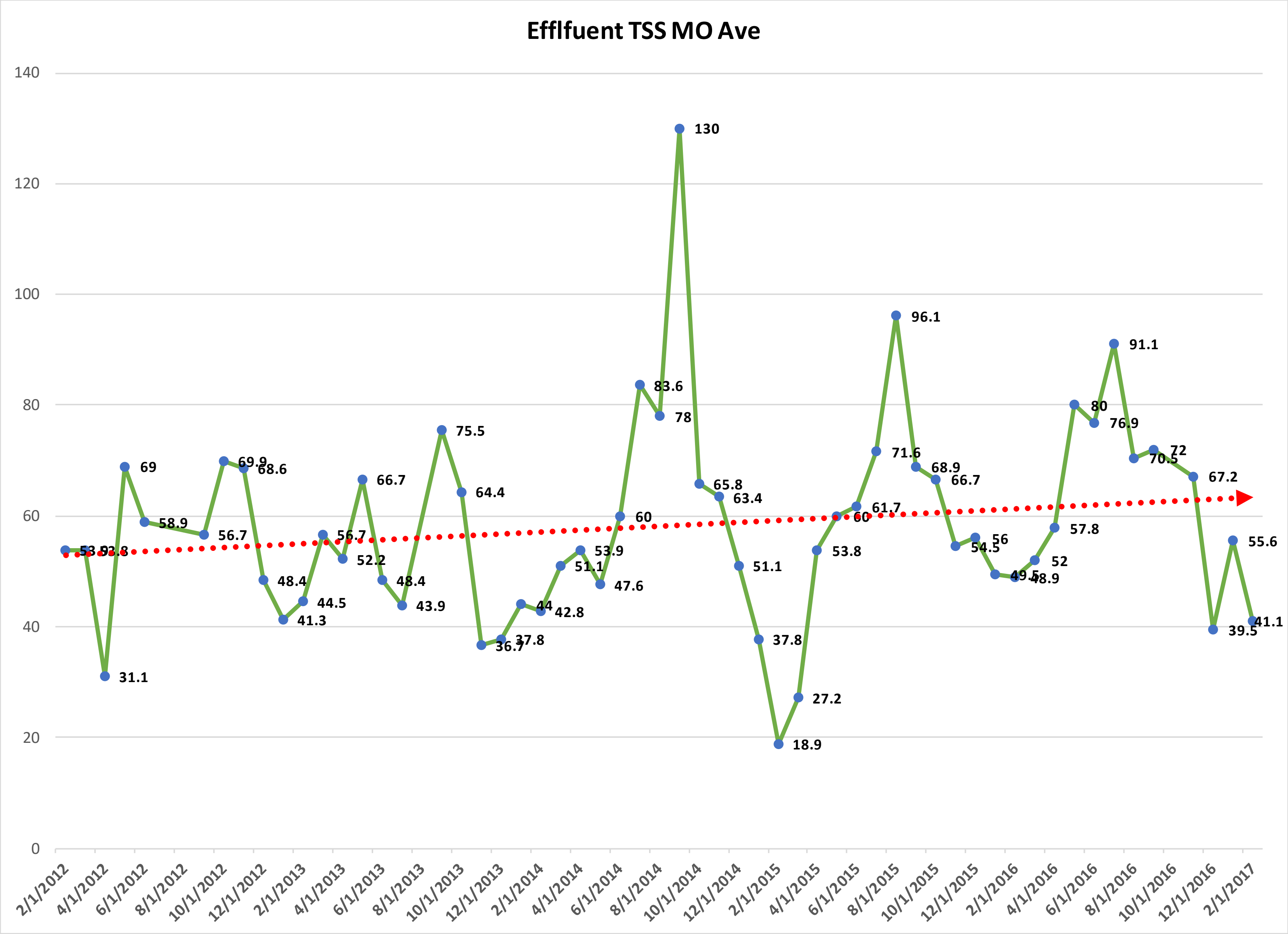
The pond system's intended purpose was to treat domestic waste from its citizens and a few small businesses. The engineers fully expected the pond system to meet treatment objectives based on certain assumptions. Based on the existing design, the engineers anticipated the pond would successfully meet treatment goals with a loading no greater than 300 mg/l BOD_5 or about 27 lbs. BOD5/acre/day.

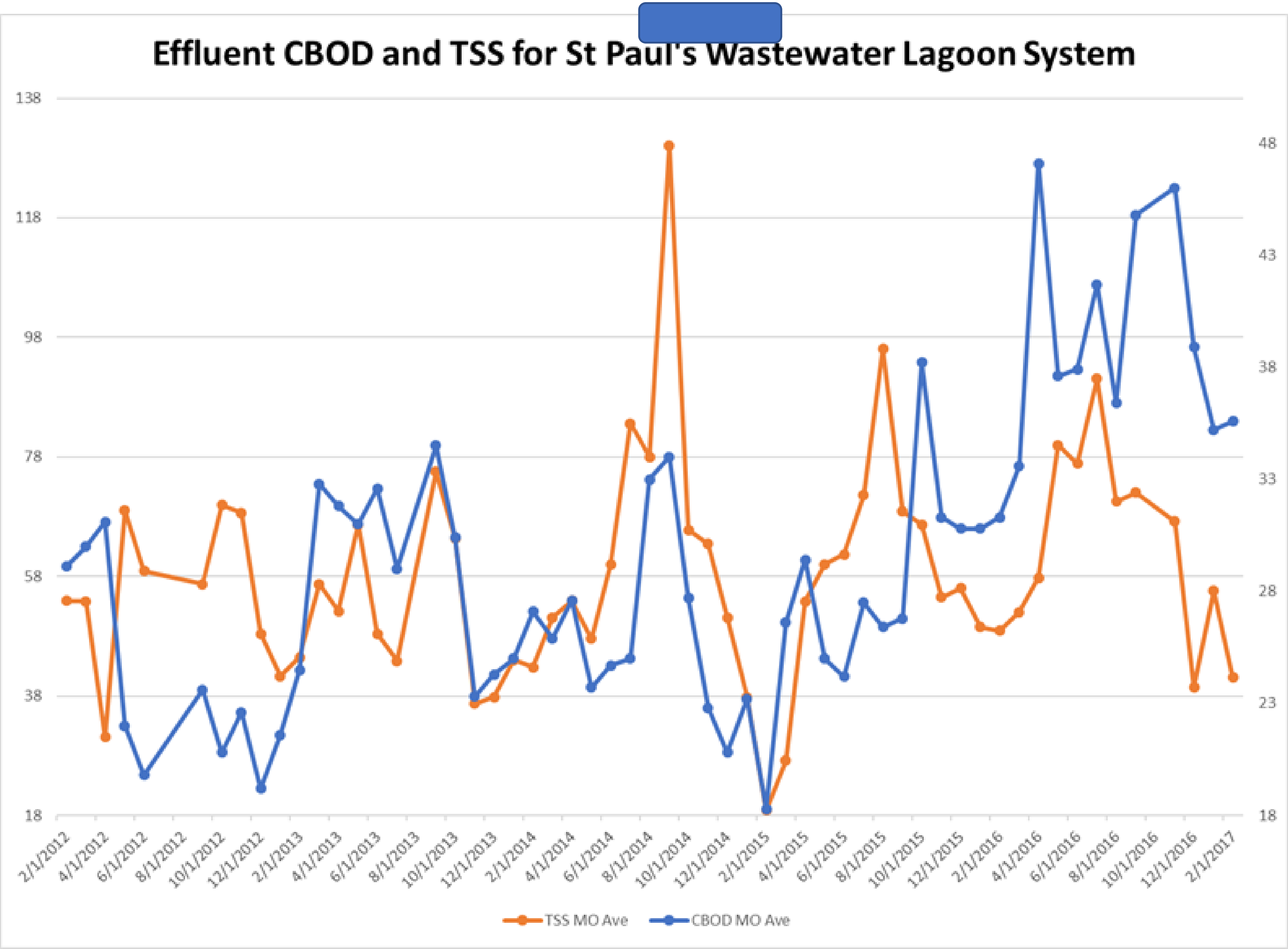
With the existing loadings, the XXX Wastewater Pond System is being asked to do something it was never intended or designed to do. The pond system is not meeting design expectations because it is too heavily loaded. As can be seen from the DMR data, the XXX pond system has consistently failed to meet its treatment objectives.

Solutions to this situation are clear…lighten the weekly load to the pond system by removing as much organic (and inorganic) material from the industrial discharge as possible. The pretreatment objective for the industrial discharger should be to send the Town of XXX a waste stream of no more than 300 mg/l BOD_5. No manure should ever reach the XXX pond system.

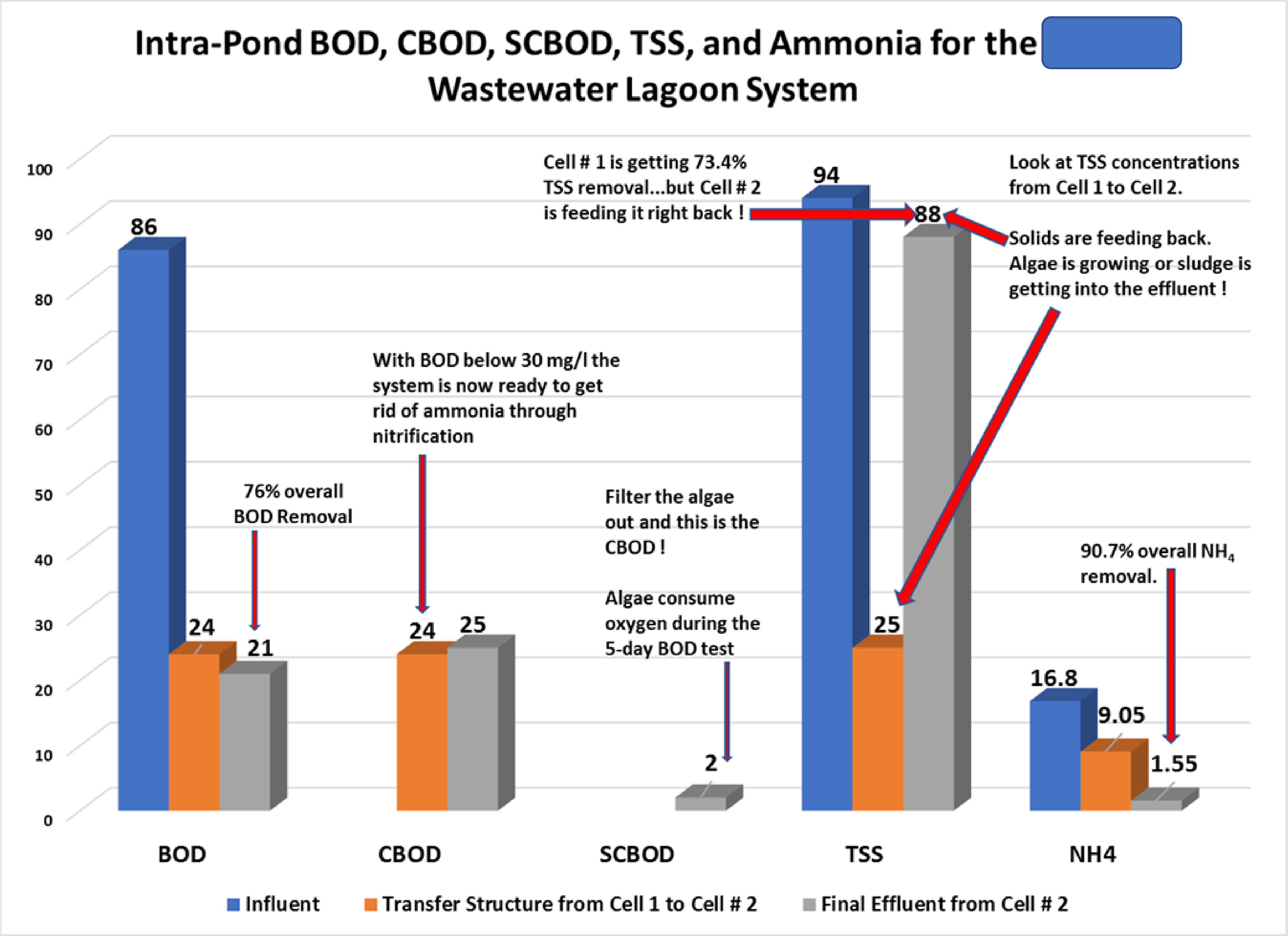
A Word About Sludge

Here is what accumulated sludge looks like over time:

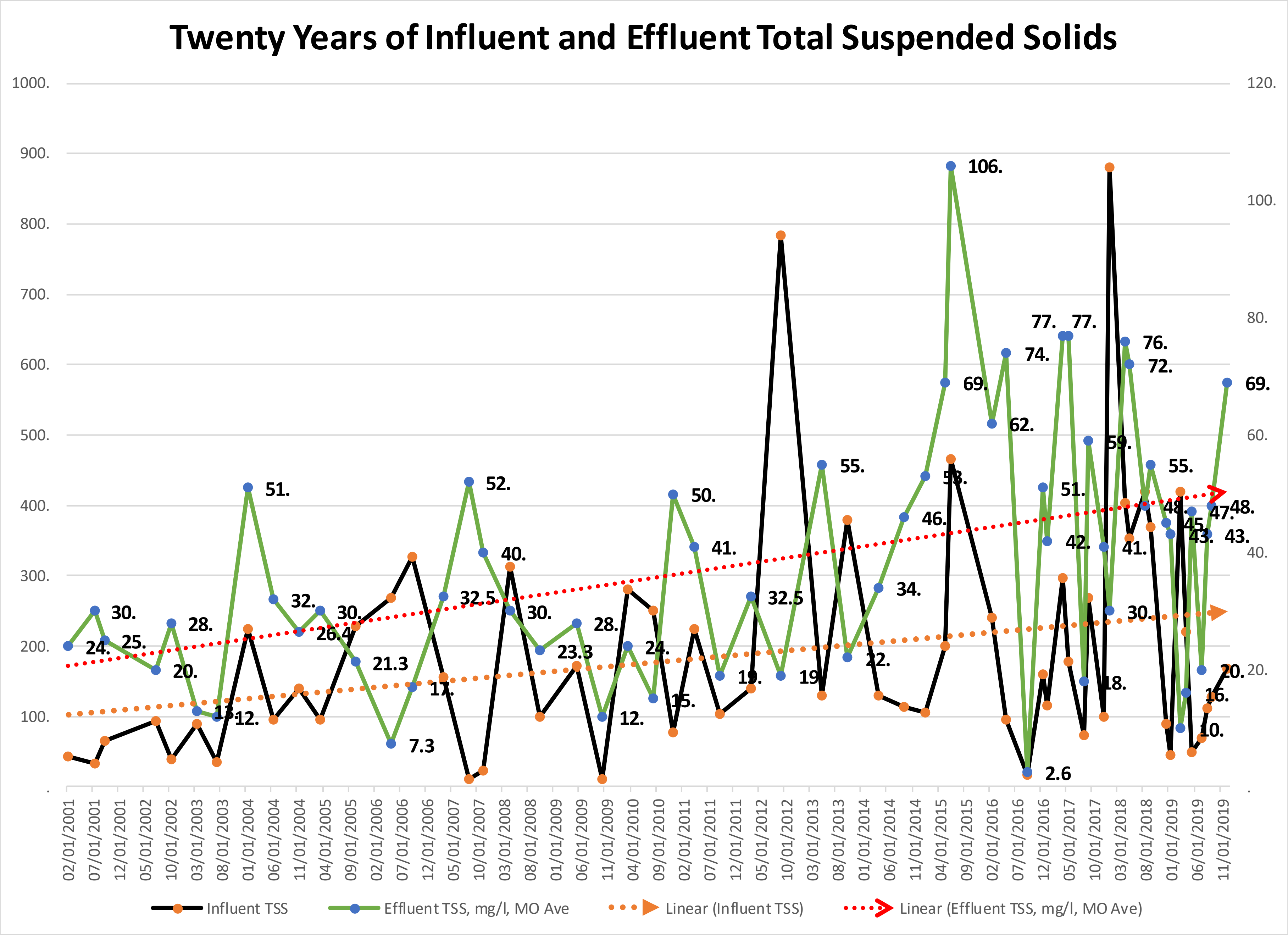




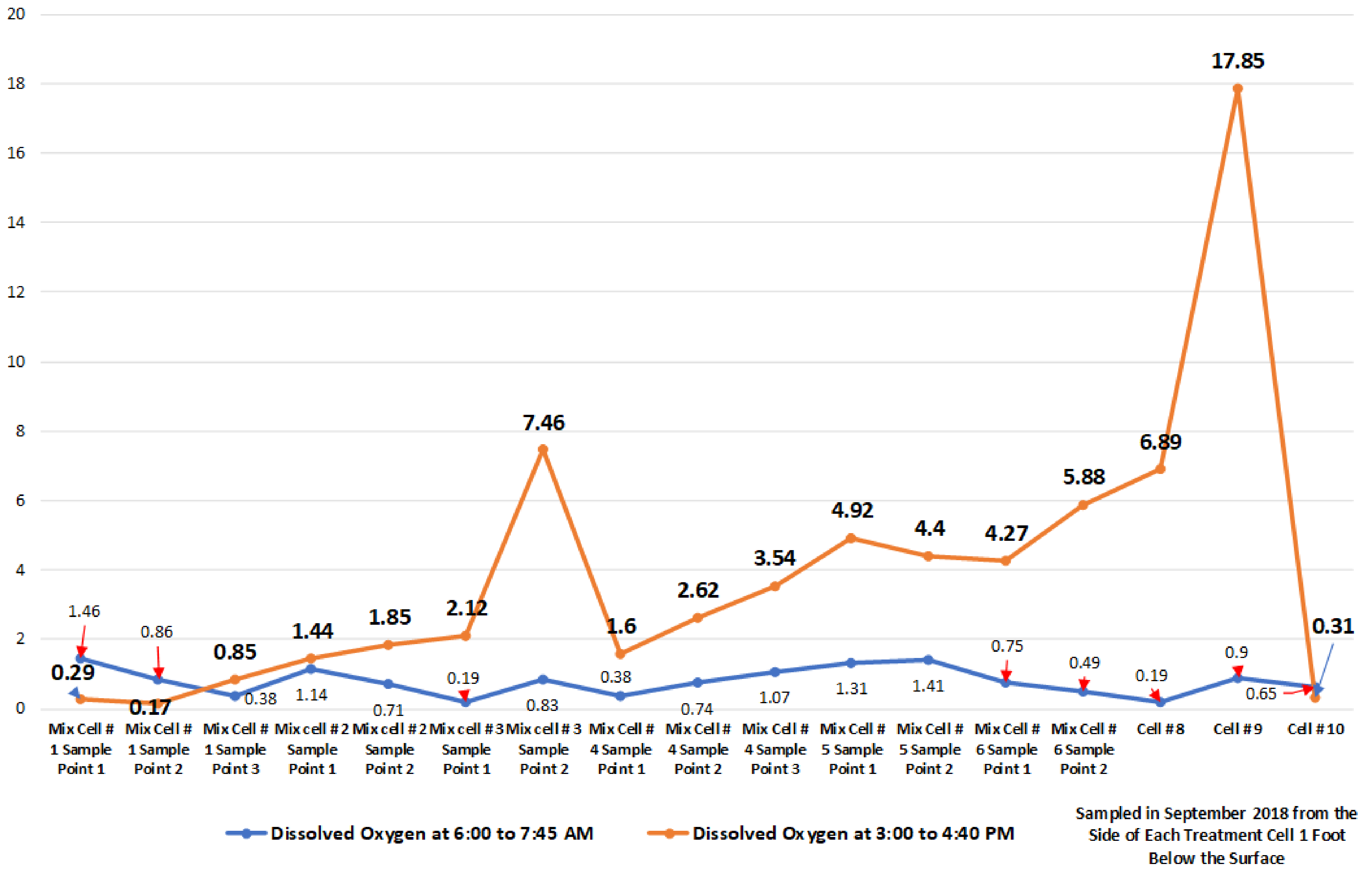
TSS and BOD_5 Typically Move Together if Algae are the sole source of TSS in the effluent

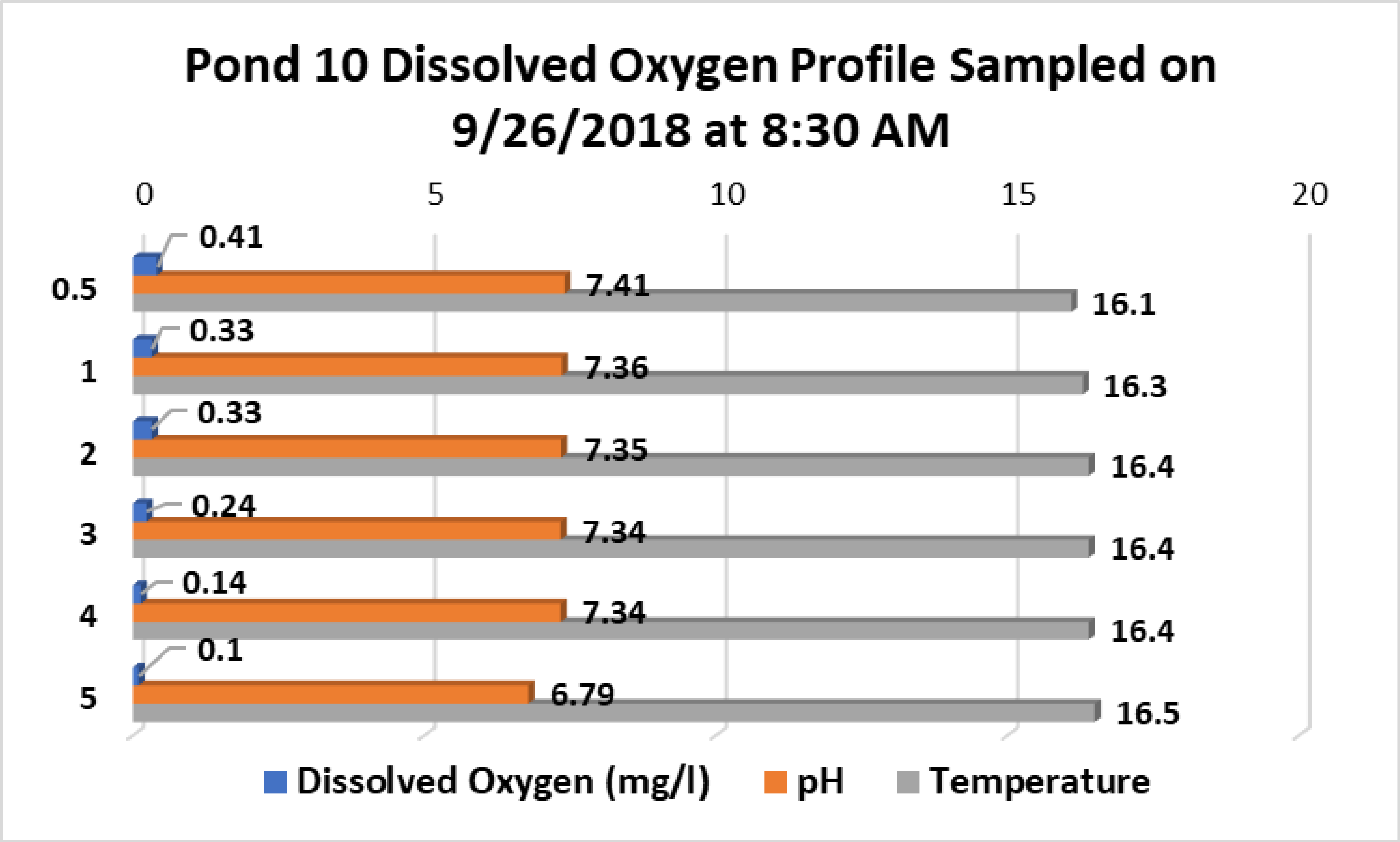


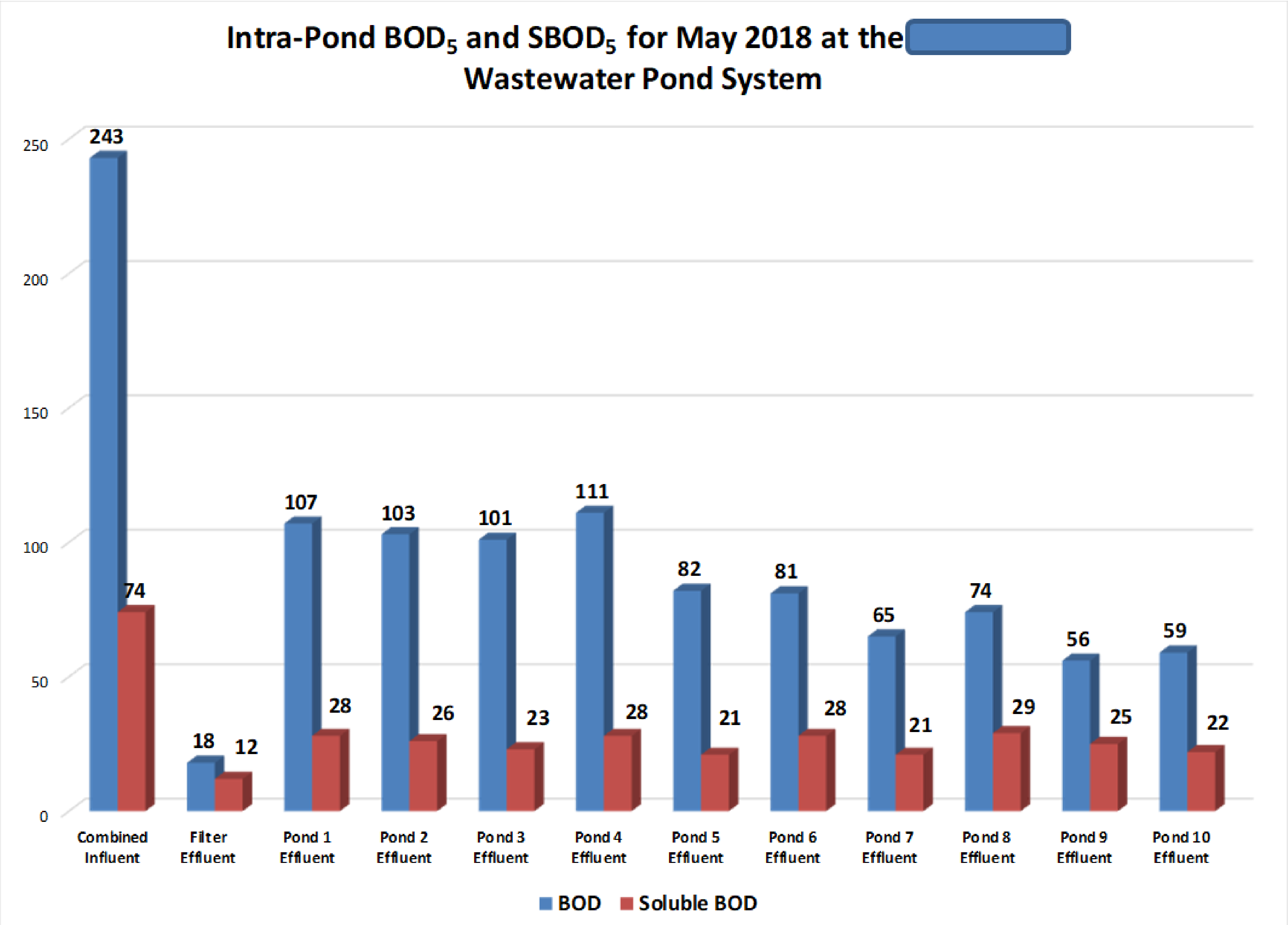
Intra-Pond BOD, CBOD, SCBOD, TSS, and Ammonia for the [redacted] Wastewater Lagoon System
100
90
80
70
60
50
40
30
20
10
0
86
24
21
76% overall BOD Removal
With BOD below 30 mg/l the system is now ready to get rid of ammonia through nitrification
24
25
Filter the algae out and this is the CBOD !
Algae consume oxygen during the 5-day BOD test
2
Cell # 1 is getting 73.4% TSS removal...but Cell # 2 is feeding it right back !
94
88
25
Look at TSS concentrations from Cell 1 to Cell 2.
Solids are feeding back. Algae is growing or sludge is getting into the effluent !
90.7% overall NH_4 removal.
16.8
9.05
1.55
BOD
CBOD
SCBOD
TSS
NH4
Influent
Transfer Structure from Cell 1 to Cell # 2
Final Effluent from Cell # 2

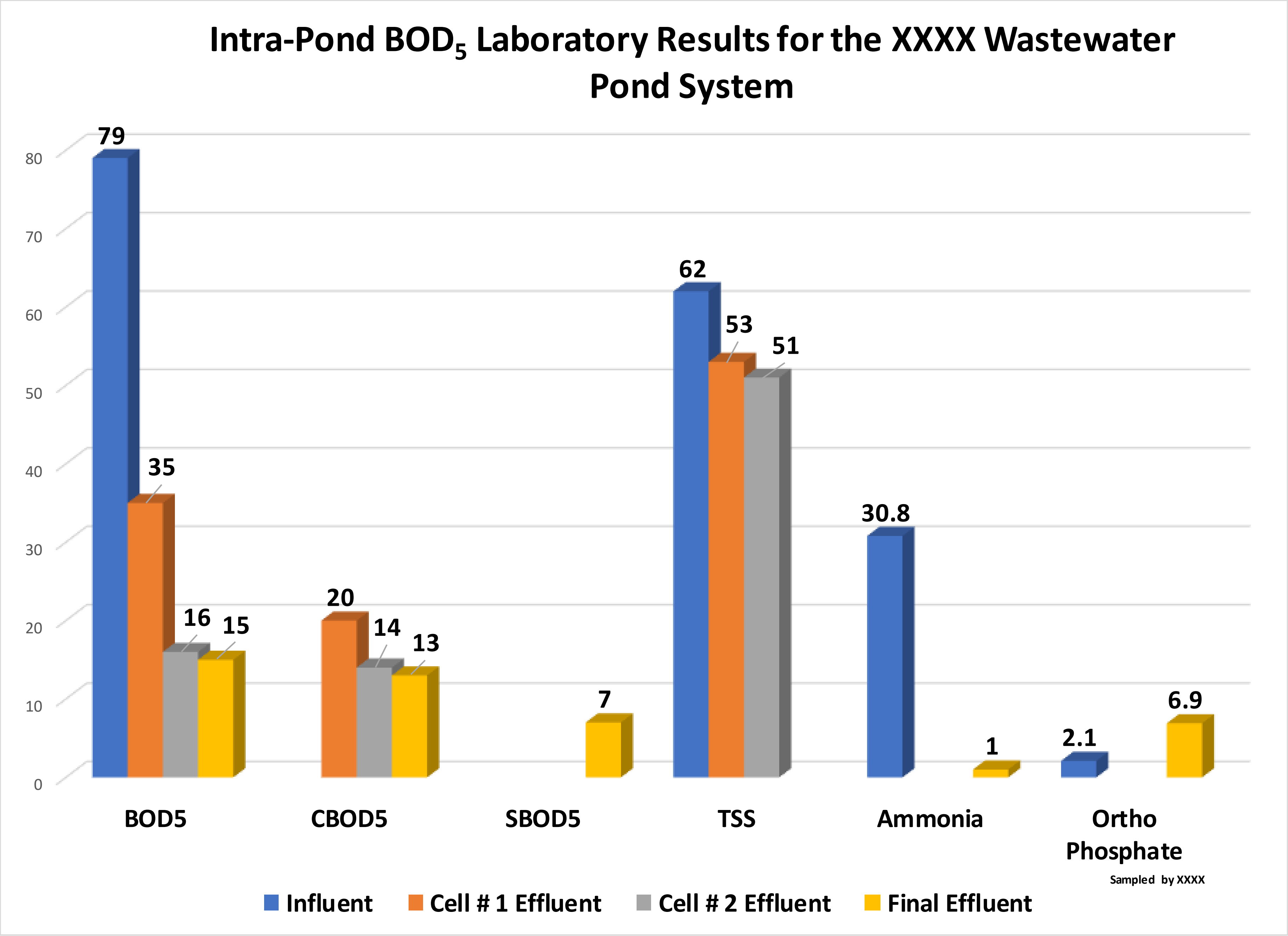

Twenty Years of Influent and Effluent Total Suspended Solids
Influent TSS
Effluent TSS, mg/l, MO Ave
Linear (Influent TSS)
Linear (Effluent TSS, mg/l, MO Ave)

Pre-Dawn and Afternoon Surface Dissolved Oxygen Concentrations for the [redacted] Wastewater Pond System




Pond 10 Dissolved Oxygen Profile Sampled on 9/26/2018 at 8:30 AM
0
5
10
15
20
0.5
1
2
3
4
5
0.41
7.41
16.1
0.33
7.36
16.3
0.33
7.35
16.4
0.24
7.34
16.4
0.14
7.34
16.4
0.1
6.79
16.5
Dissolved Oxygen (mg/l)
pH
Temperature


Intra-Pond BOD_5 and $SBOD_5$ for May 2018 at the [redacted] Wastewater Pond System
250
200
150
100
50
0
243
74
18
12
107
28
103
26
101
23
111
28
82
21
81
28
65
21
74
29
56
25
59
22
Combined Influent
Filter Effluent
Pond 1 Effluent
Pond 2 Effluent
Pond 3 Effluent
Pond 4 Effluent
Pond 5 Effluent
Pond 6 Effluent
Pond 7 Effluent
Pond 8 Effluent
Pond 9 Effluent
Pond 10 Effluent
BOD
Soluble BOD



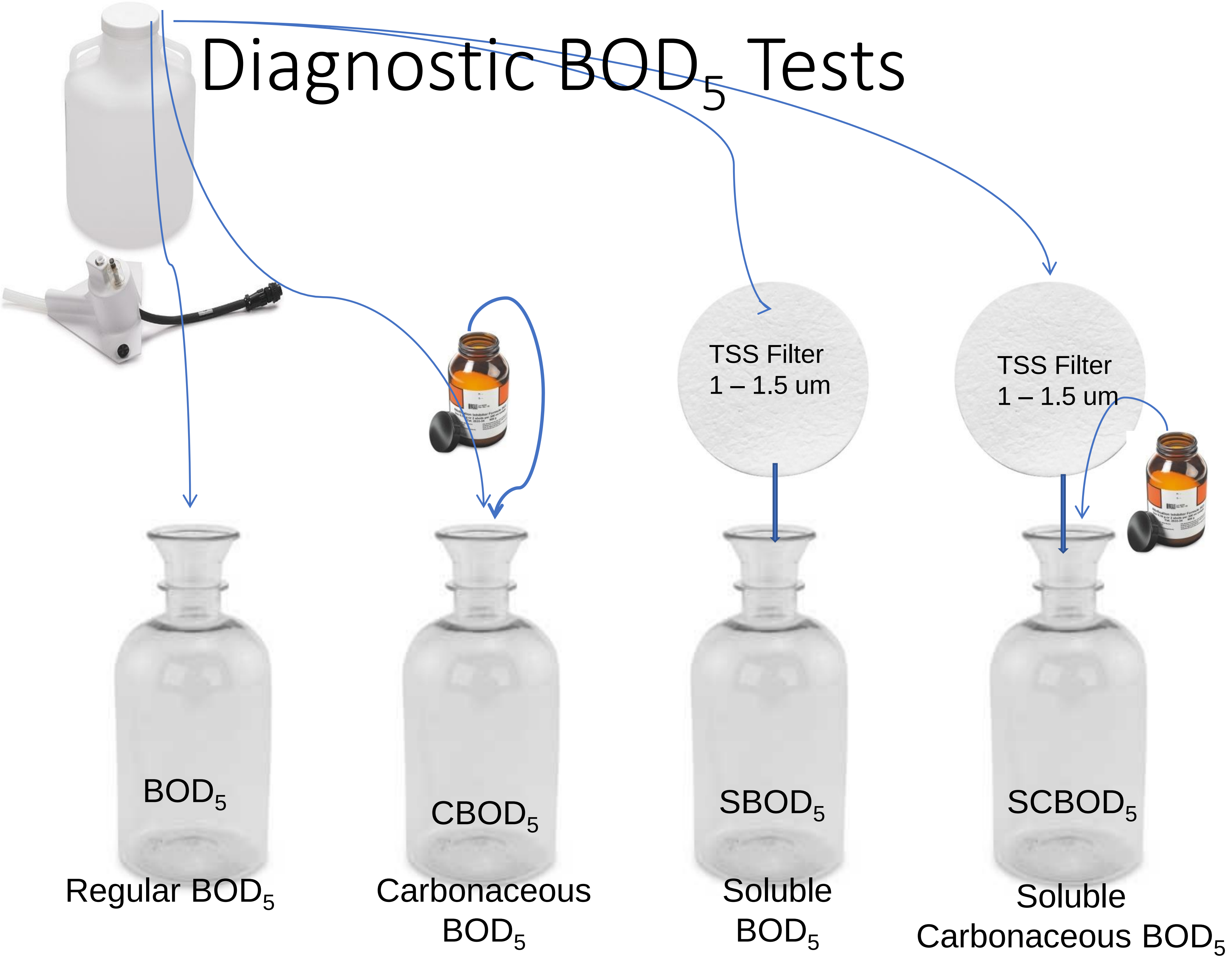
Here is an example of benthal feedback…nutrient release from the sludge blanket.

This system has a severe effluent TSS problem.

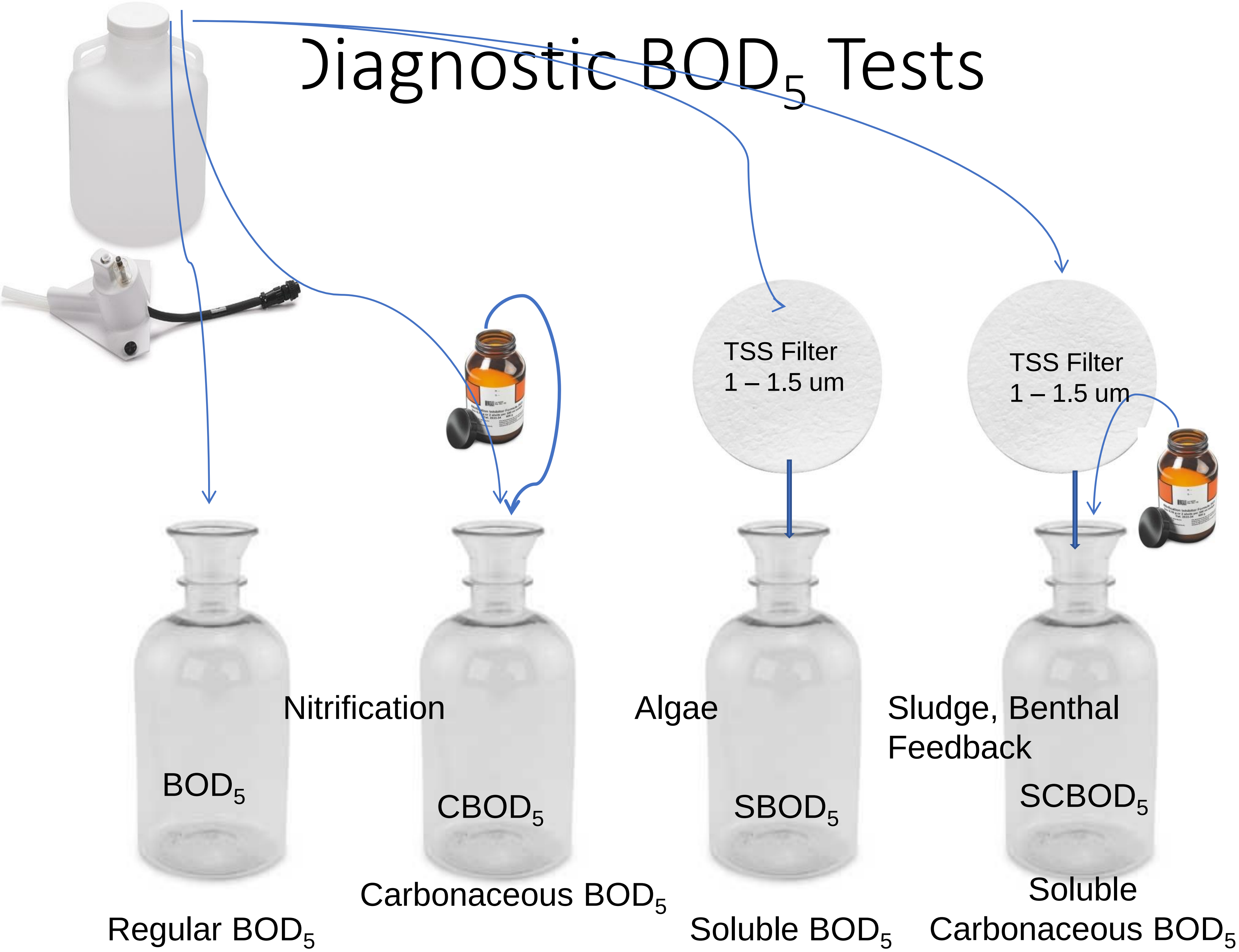
Sampled last month.
Temperatures 5.5 degrees C

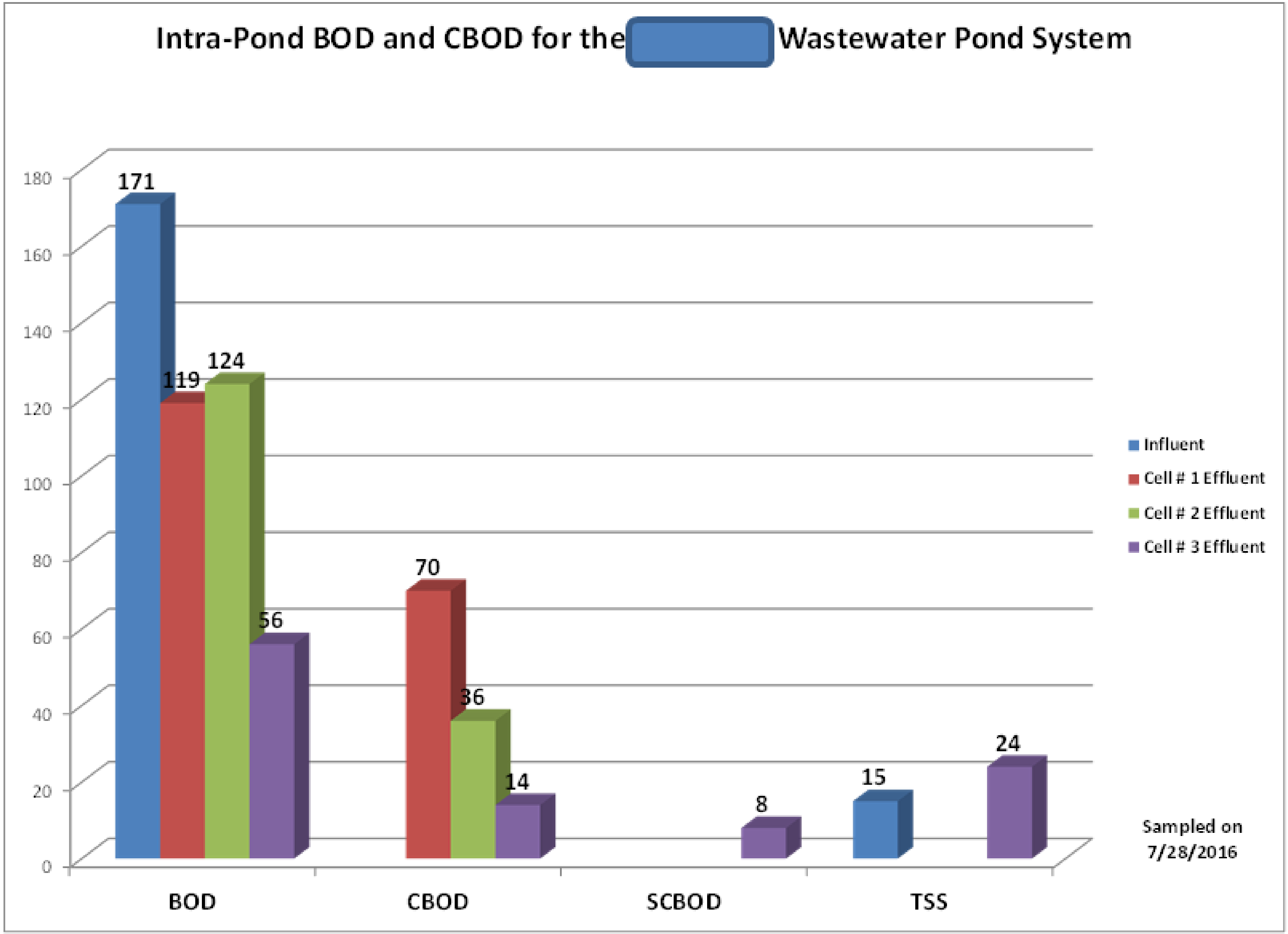
Diagnostic BODs

Diagnostic BOD_5 Tests

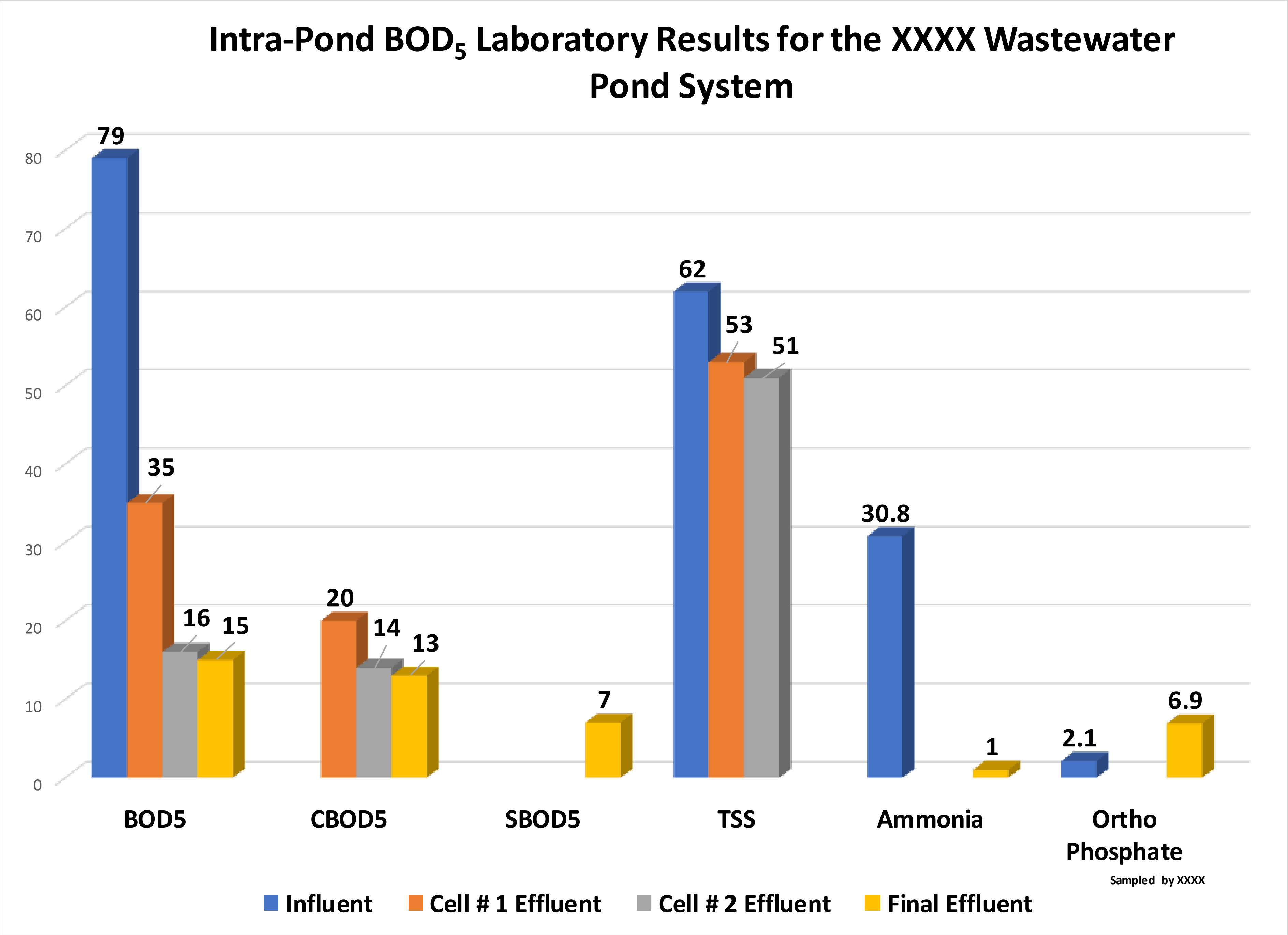


Diagnostic BOD$_5$ Tests



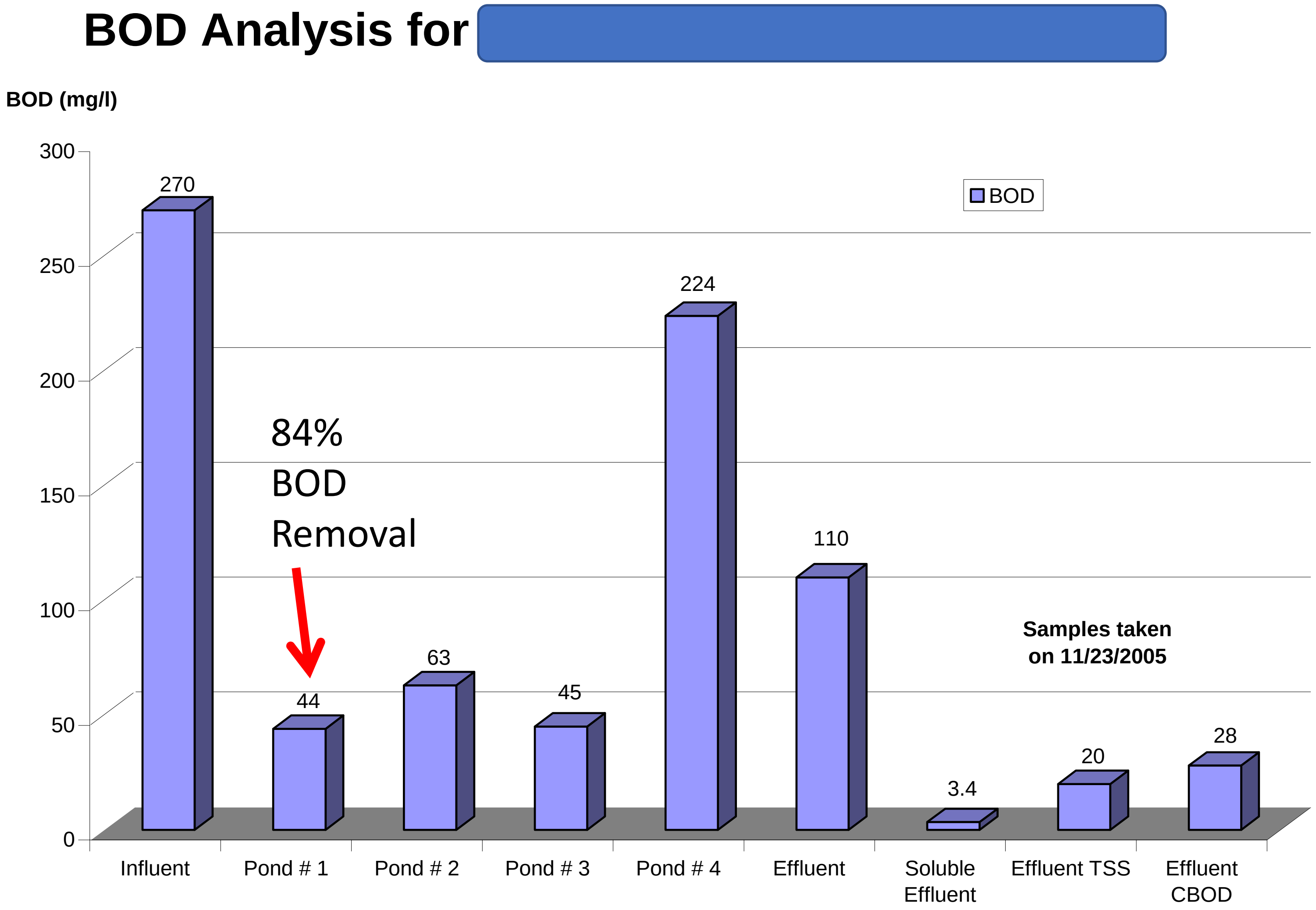


Intra-Pond BOD and CBOD for the [redacted] Wastewater Pond System
180
160
140
120
100
80
60
40
20
0
171
119
124
56
70
36
14
8
15
24
BOD
CBOD
SCBOD
TSS
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Cell # 3 Effluent
Sampled on 7/28/2016



Intra-Pond BOD$_5$ Laboratory Results for the XXXX Wastewater Pond System
80
70
60
50
40
30
20
10
0
79
35
16
15
20
14
13
7
62
53
51
30.8
1
2.1
6.9
BOD5
CBOD5
SBOD5
TSS
Ammonia
Ortho Phosphate
Sampled by XXXX
Influent
Cell # 1 Effluent
Cell # 2 Effluent
Final Effluent

It is Important to know Where the Problem is Occurring



What do you suppose the difference in pH would be? BOD_5? TSS?

Picture Courtesy of **Mark Court**, Wyoming Rural Water Association

Biochemical Oxygen Demand	SM 5210B	54	10	mg/L	10	A613004	09/23/16 16:37	09/28/16		

Sample ID: A6I2745-04
Sampled By: [redacted]
Sample Description: Pond 2 out

Sample Date - Time: 09/22/16 - 13:10
Matrix: Waste Water
Sample Type: Grab

BSK Associates Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Biochemical Oxygen Demand	SM 5210B	130	30	mg/L	30	A613004	09/23/16 16:39	09/28/16	

Both Pond # 3 Discharges!!!

Sample ID: A6I2745-05
Sampled By: [redacted]
Sample Description: Pond 3 Discharge

Sample Date - Time: 09/22/16 - 13:15
Matrix: Waste Water
Sample Type: Grab

BSK Associates Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Biochemical Oxygen Demand	SM 5210B	100	15	mg/L	15	A613004	09/23/16 16:41	09/28/16	

100 mg/l

Sample ID: A6I2745-06
Sampled By: [redacted]
Sample Description: Pond 3 Discharge

Sample Date - Time: 09/22/16 - 13:15
Matrix: Waste Water
Sample Type: Grab

BSK Associates Fresno

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
Biochemical Oxygen Demand - Dissolved (1)	SM 5210B	6.0	4.0	mg/L	4	A613004	09/23/16 16:43	09/28/16	

Figure 3. Final Filtered BOD, BOD without Algae Cells, is 6 mg/l. 94 mg/l of BOD is caused by Algae Respiring in the BOD test bottle

6 mg/l

94 mg/l caused by algae consuming oxygen in the BOD_5 test bottle for 5 days

ıssenvironmental@earthlink.net

Diagnostic TSS

Diagnostic TSS

- TSS = BTSS + ATSS + MTSS
  - BTSS is suspended bacterial solids
  - ATSS is the algal component of TSS
  - MTSS is silt, clay, cell debris, bottom solids

Solids Types Lost to the Effluent

- Raw Wastewater Solids - Short Circuiting or

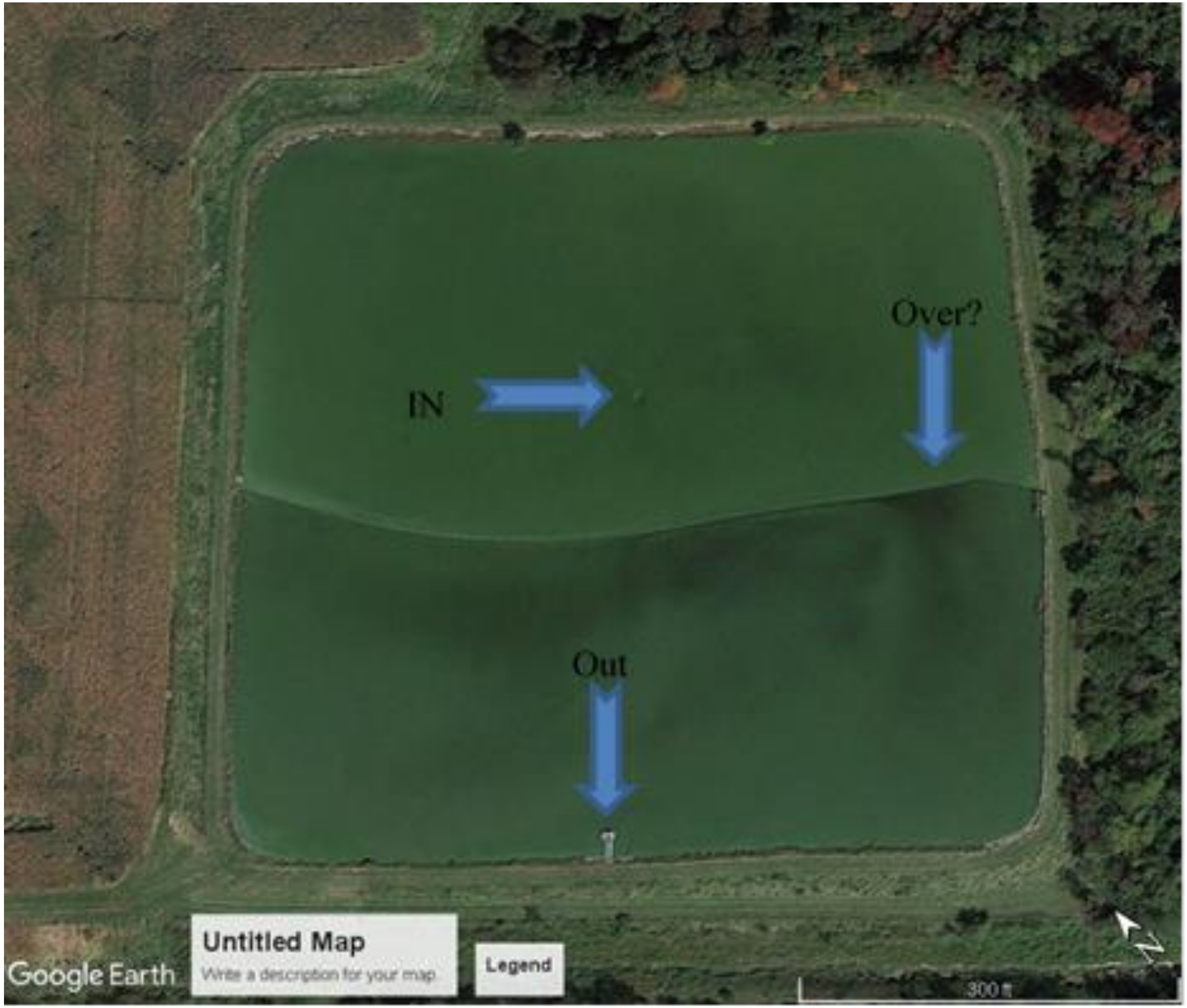
  Poor aeration
- Old Sludge Particles - Sludge buildup
- Treatment Solids (bacterial flocs)

  organic overload or sludge accumulation
- Filamentous Bacteria - indicates low D.O. or septicity
- Sulfur Bacteria - anoxic conditions and sulfides forming
- Algae or Protozoa

This is an effluent structure

What would Sludge Look Like on a TSS Filter Under the Microscope?

Hydraulics

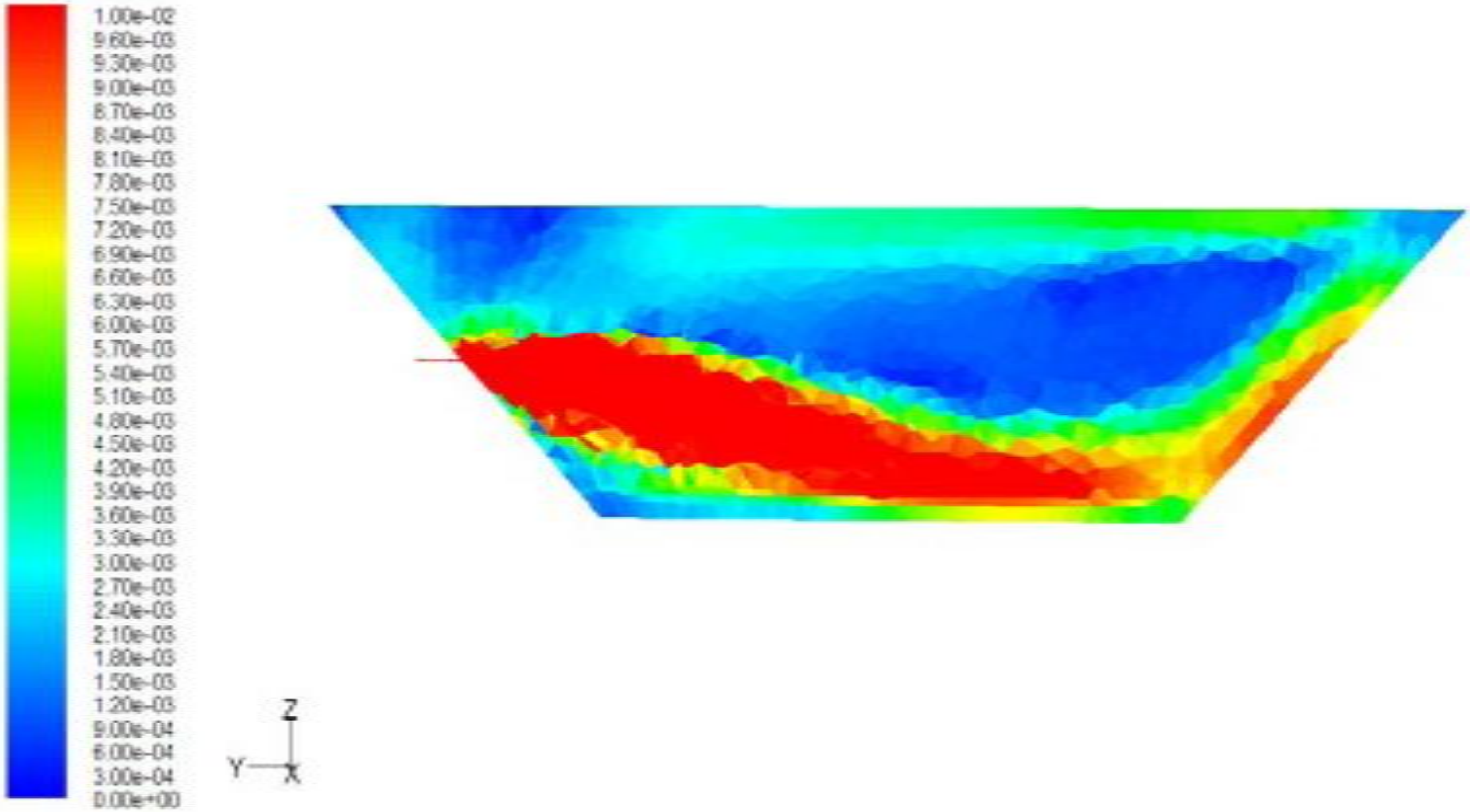


Short Circuiting

"Short-circuiting is the greatest deterrent to successful pond performance, barring any toxic effects. The importance of the hydraulic design of a pond system cannot be overemphasized"

- Middlebrooks

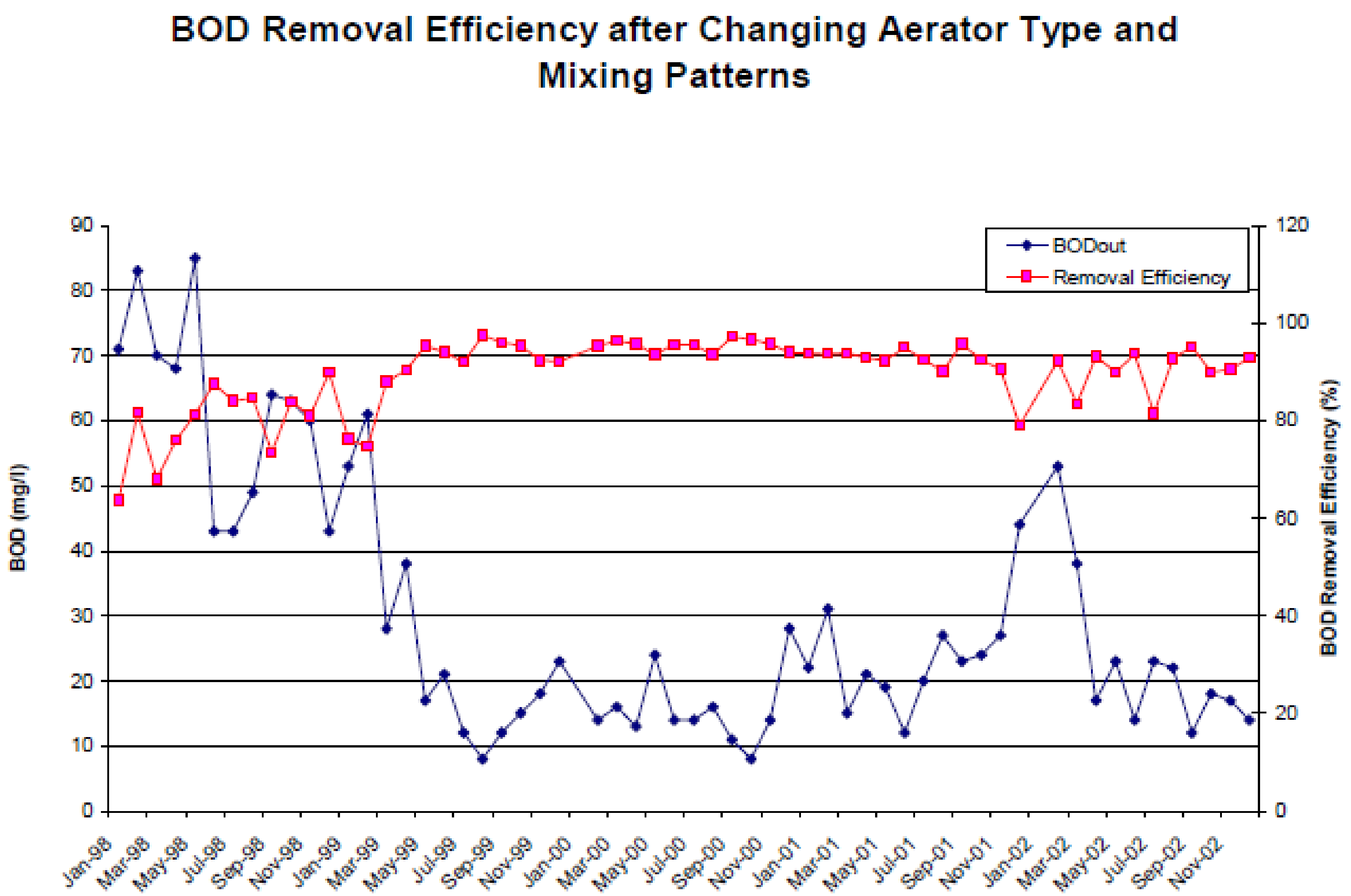

Nezperce lagoons
© 2009 Tele Atlas
©2008 Google
46°14'27.13" N 116°14'28.50" W
elev 978 m
Jun 16, 2004
Eye alt 1.30 km

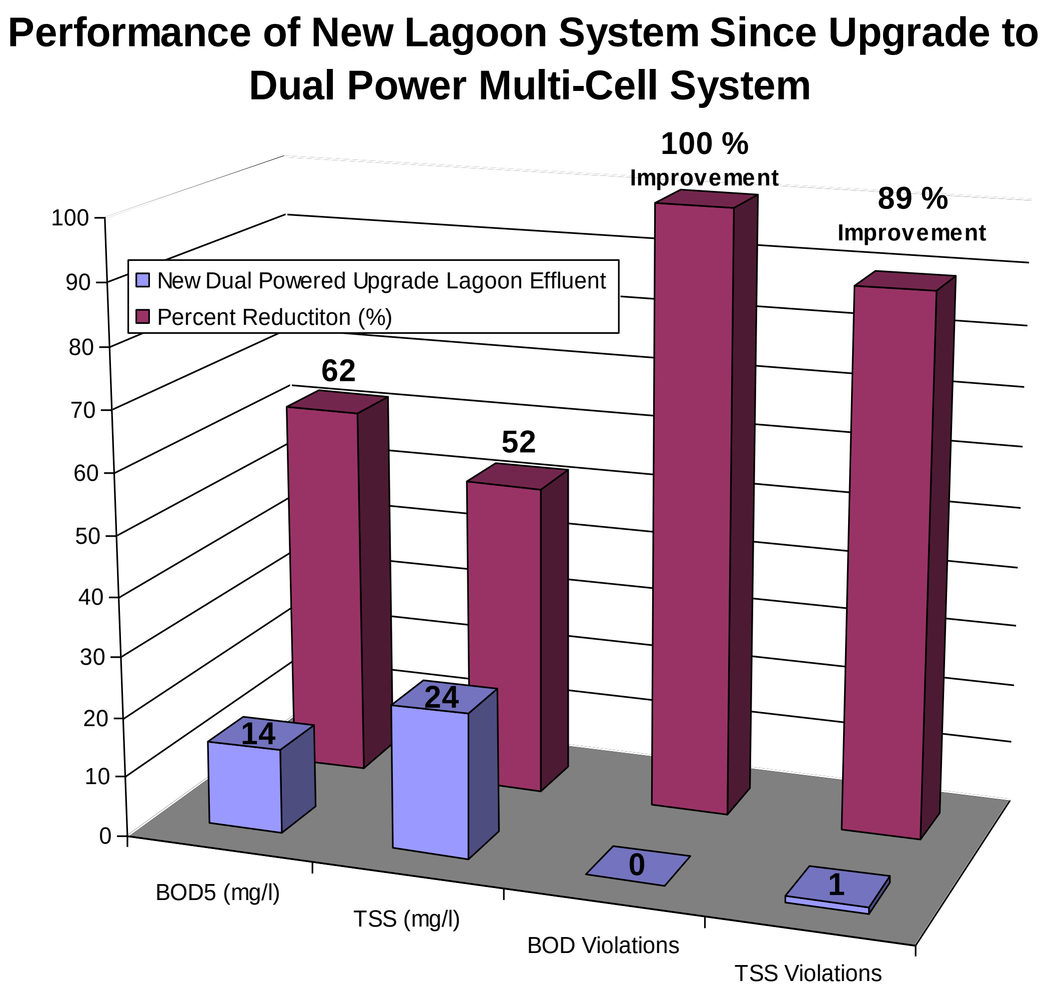


1.00e-02
9.60e-03
9.30e-03
9.00e-03
8.70e-03
8.40e-03
8.10e-03
7.80e-03
7.50e-03
7.20e-03
6.90e-03
6.60e-03
6.30e-03
6.00e-03
5.70e-03
5.40e-03
5.10e-03
4.80e-03
4.50e-03
4.20e-03
3.90e-03
3.60e-03
3.30e-03
3.00e-03
2.70e-03
2.40e-03
2.10e-03
1.80e-03
1.50e-03
1.20e-03
9.00e-04
6.00e-04
3.00e-04
0.00e+00
Z
Y
X

The Hydraulic Difference Between Types of Aeration

The Effect of Switching Aerator Types at the Wasco State Pr[redacted]



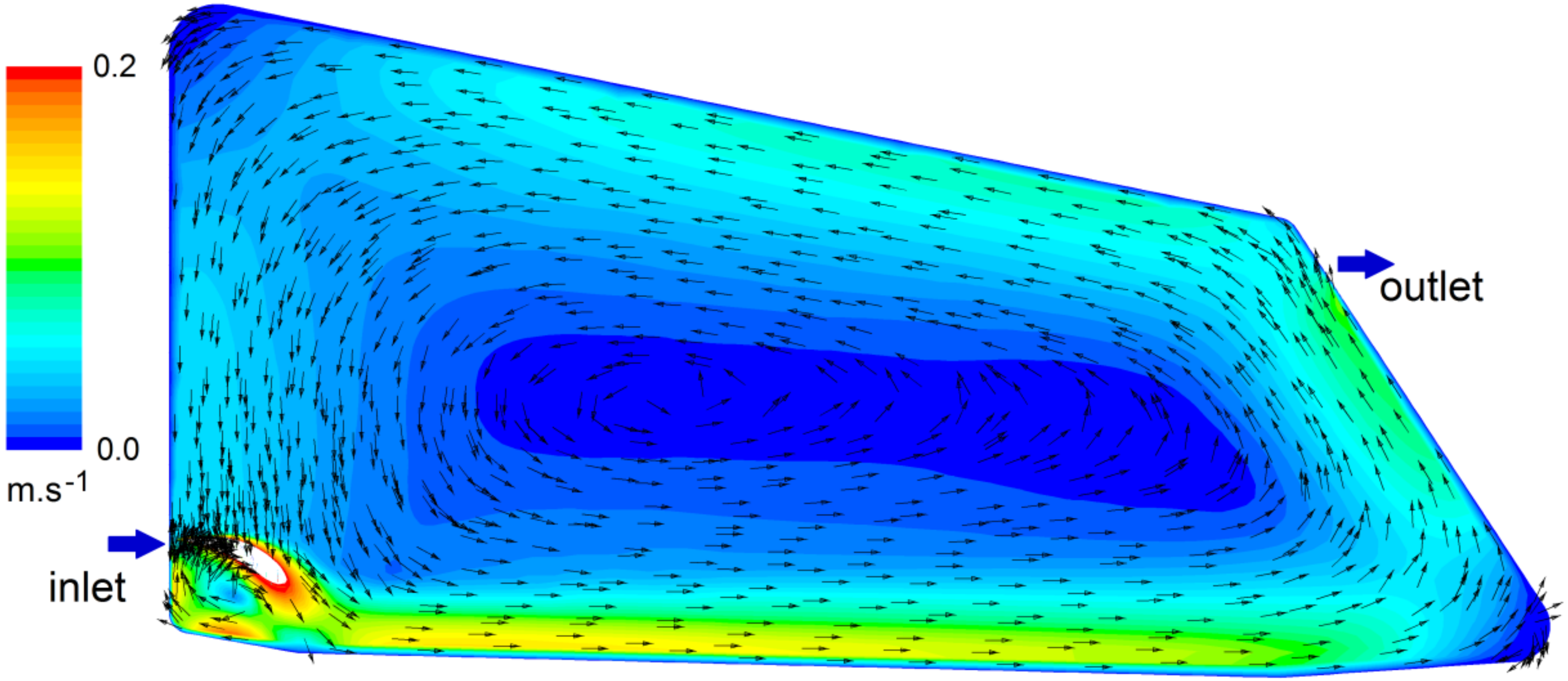


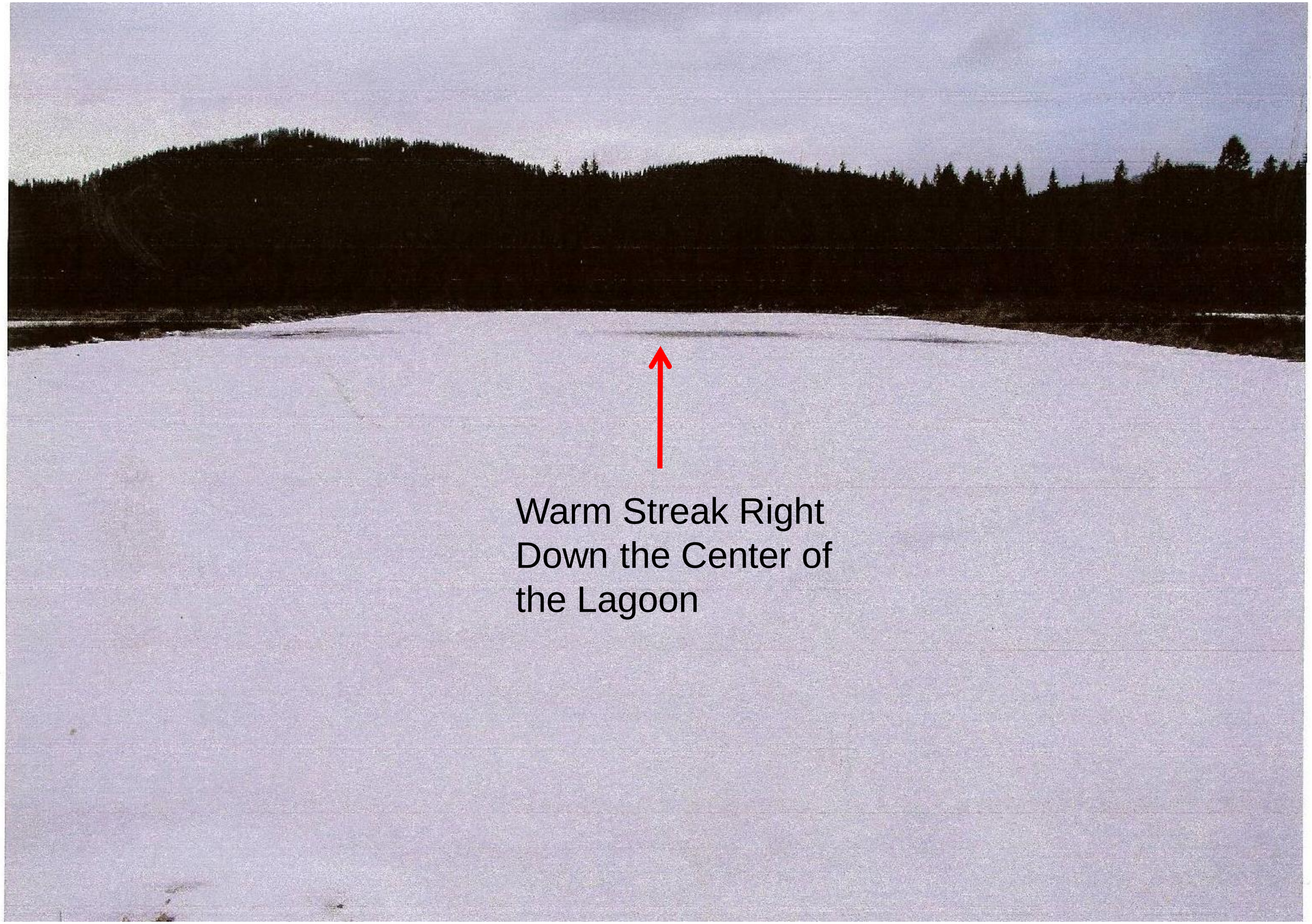
Saves $110,000/year in energy costs using 8 less aerators

Total Construction Cost Including stabilizing lagoon embankments: **<u>$650,000</u>**


JOHN DEERE

Notice the Dead Zones




Warm Streak Right
Down the Center of
the Lagoon

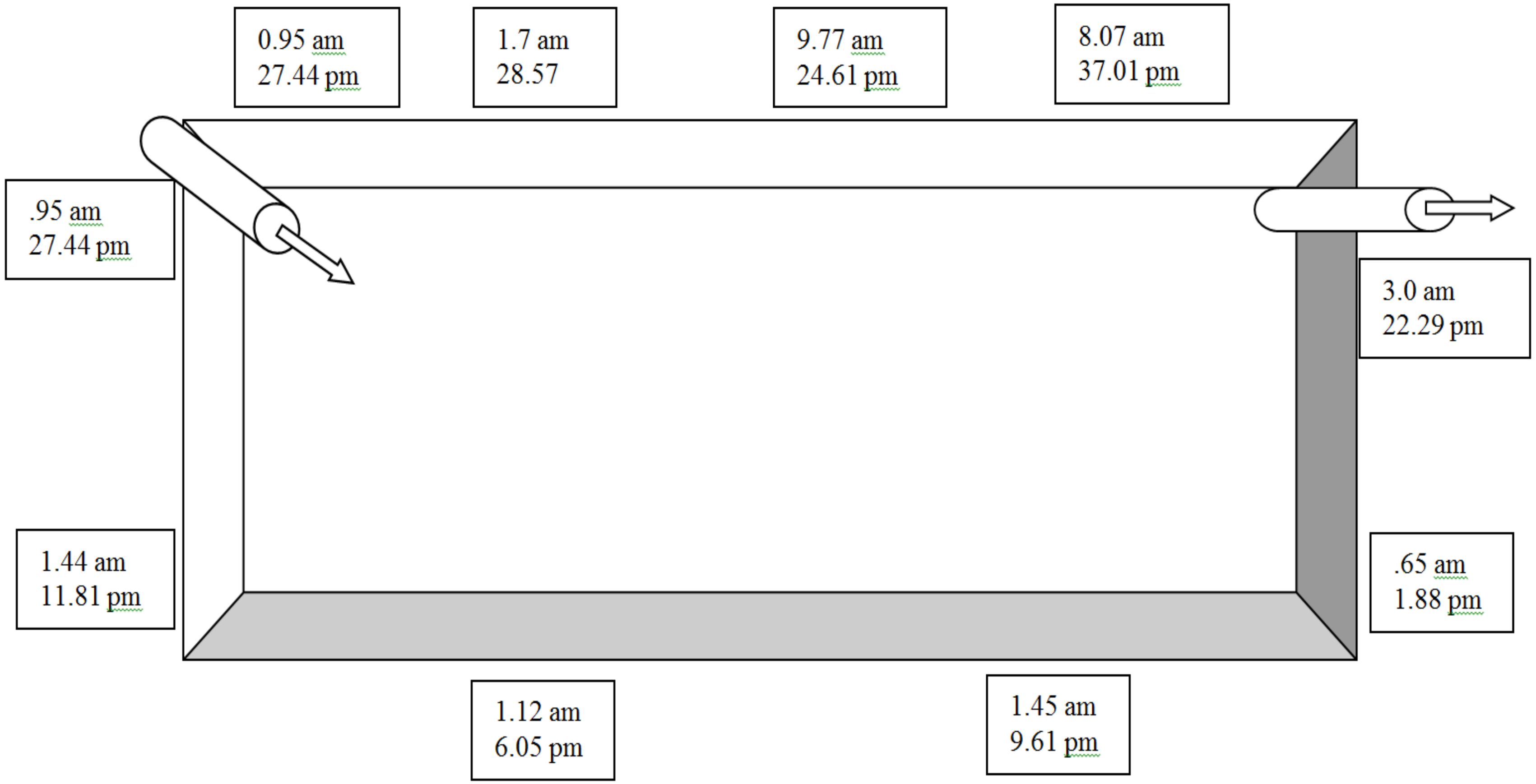

SANITARY
SEWER


0923 016846

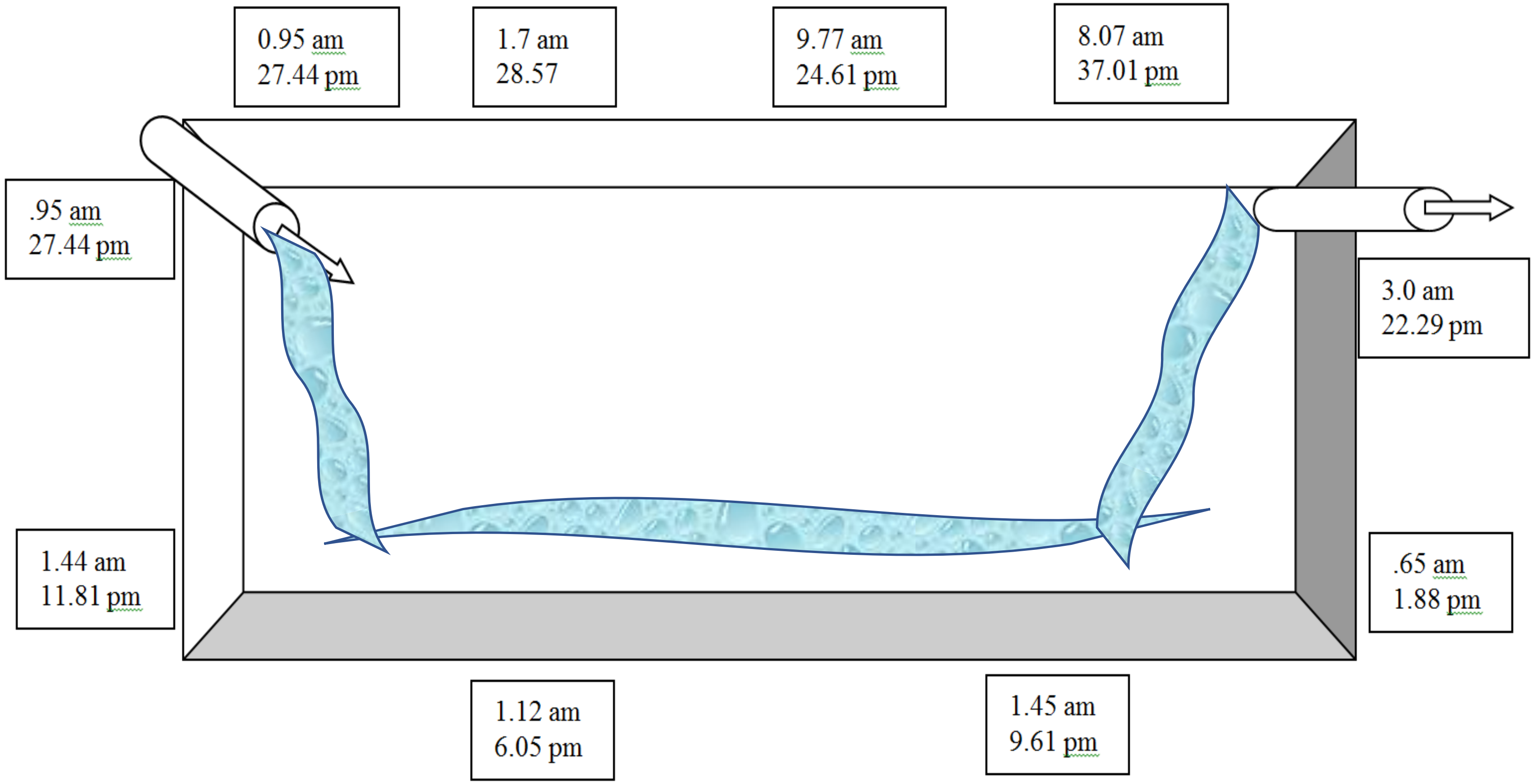

CLOSED
CLOSED
PARADE
PARADE

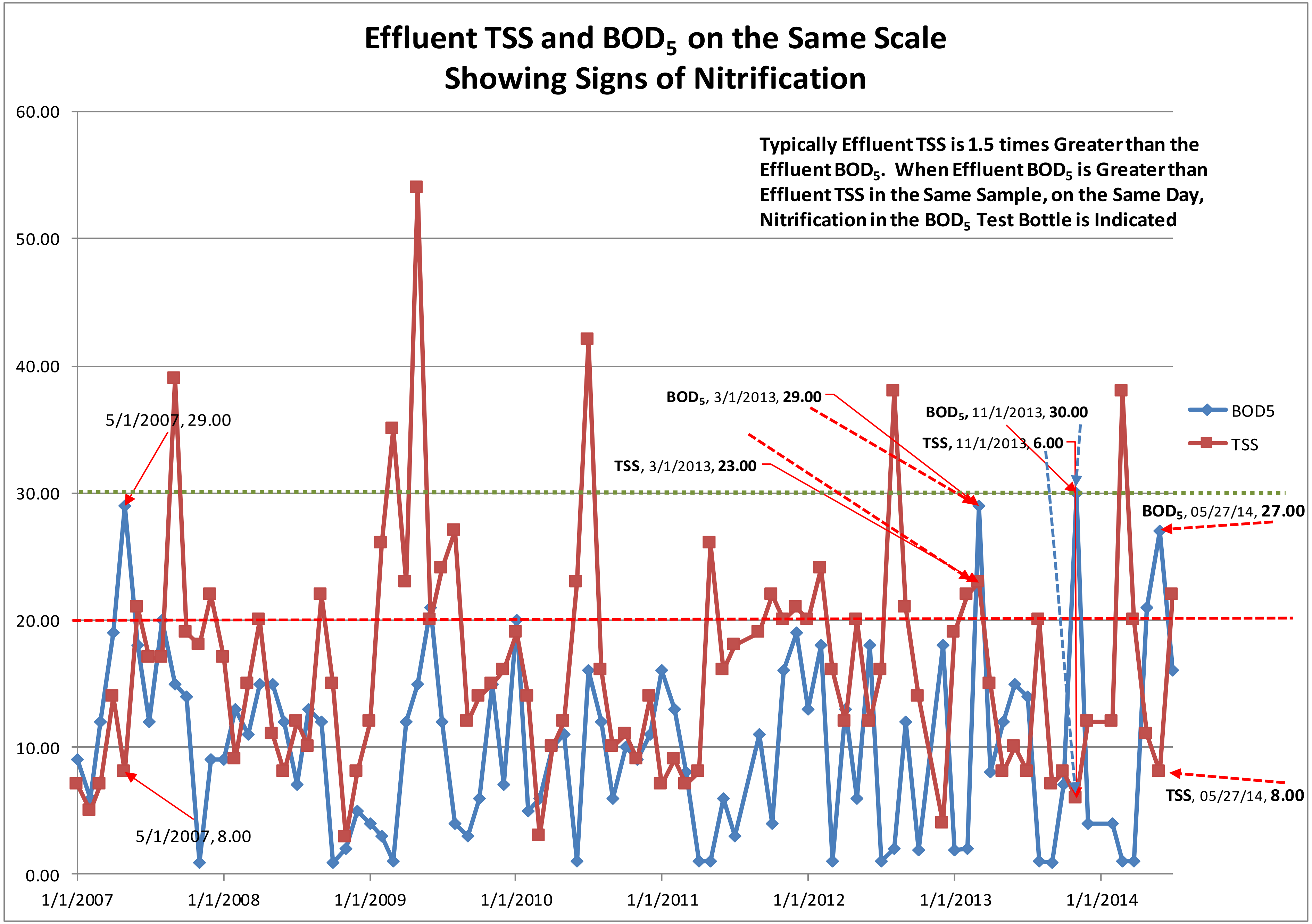
Center of Pond Influent Structure

Spatial Changes in D.O. Measurements at



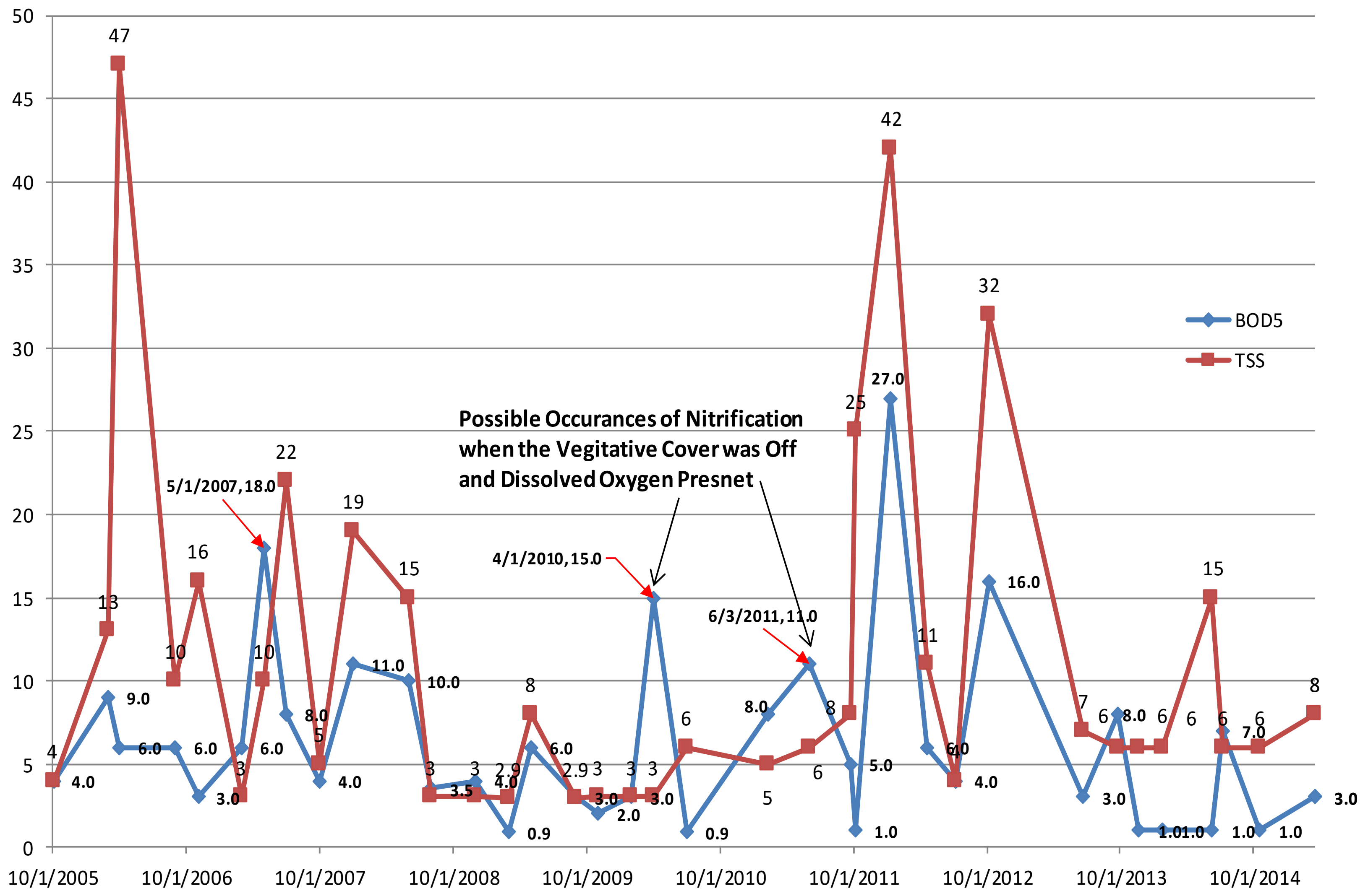
Spatial Changes in D.O. Measurements at



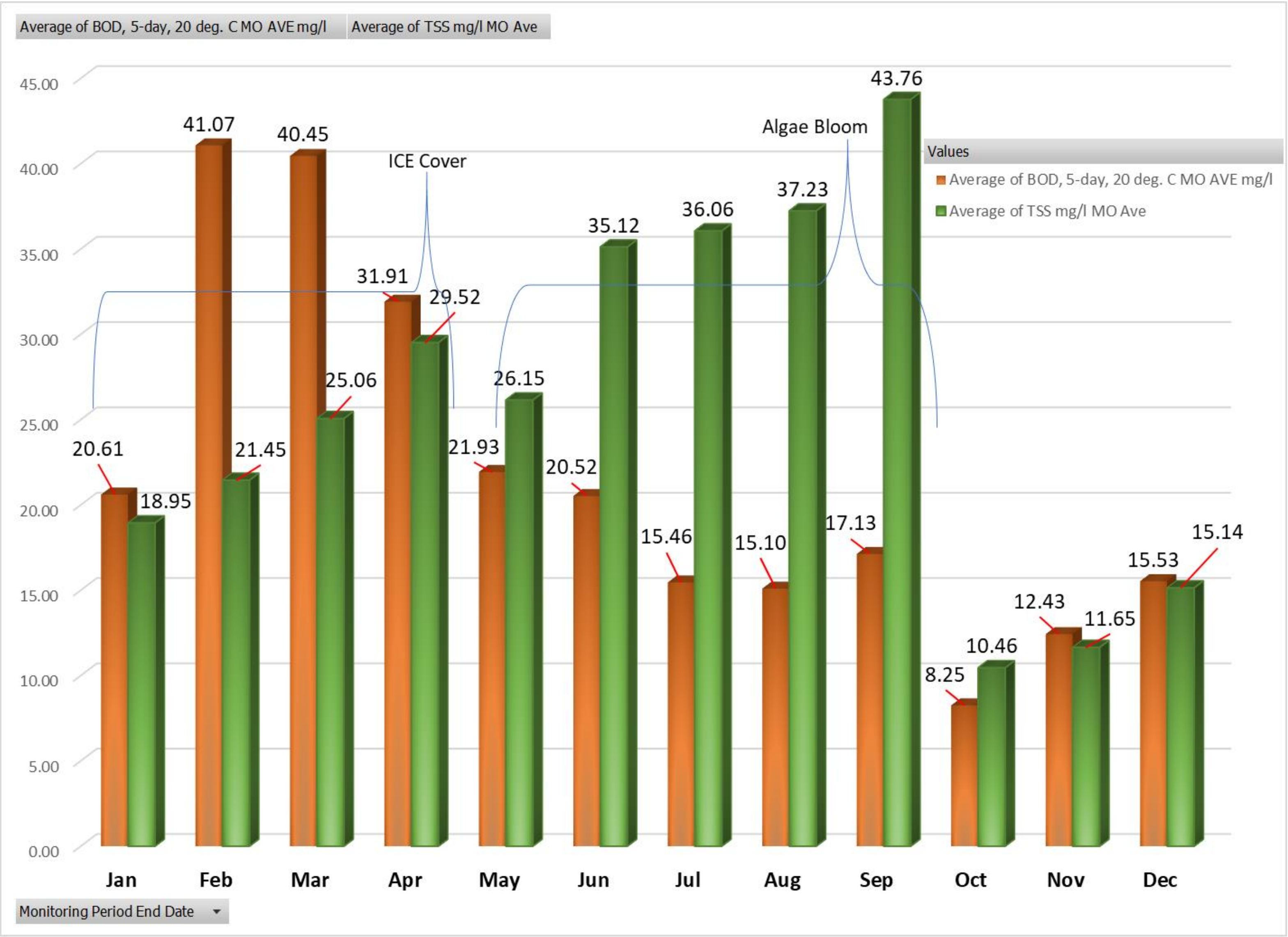


Effluent TSS and BOD_5 on the Same Scale
Showing Signs of Nitrification
Typically Effluent TSS is 1.5 times Greater than the Effluent BOD_5. When Effluent BOD_5 is Greater than Effluent TSS in the Same Sample, on the Same Day, Nitrification in the BOD_5 Test Bottle is Indicated
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
5/1/2007, 29.00
5/1/2007, 8.00
BOD_5, 3/1/2013, 29.00
TSS, 3/1/2013, 23.00
BOD_5, 11/1/2013, 30.00
TSS, 11/1/2013, 6.00
BOD_5, 05/27/14, 27.00
TSS, 05/27/14, 8.00
BOD5
TSS

Effluent TSS and BOD Charted on the Same Scale



BOD can Also Be Greater Than TSS During the Winter



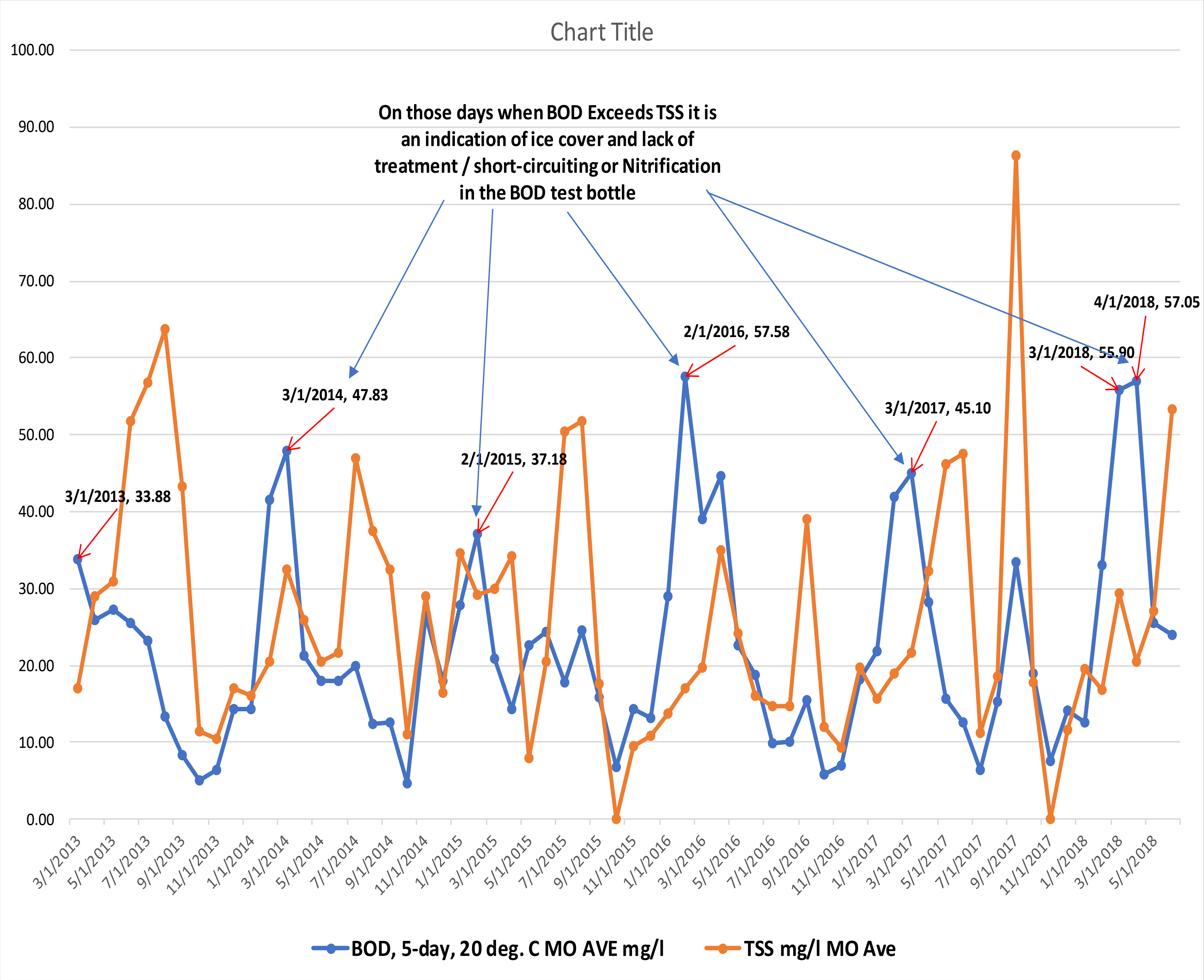
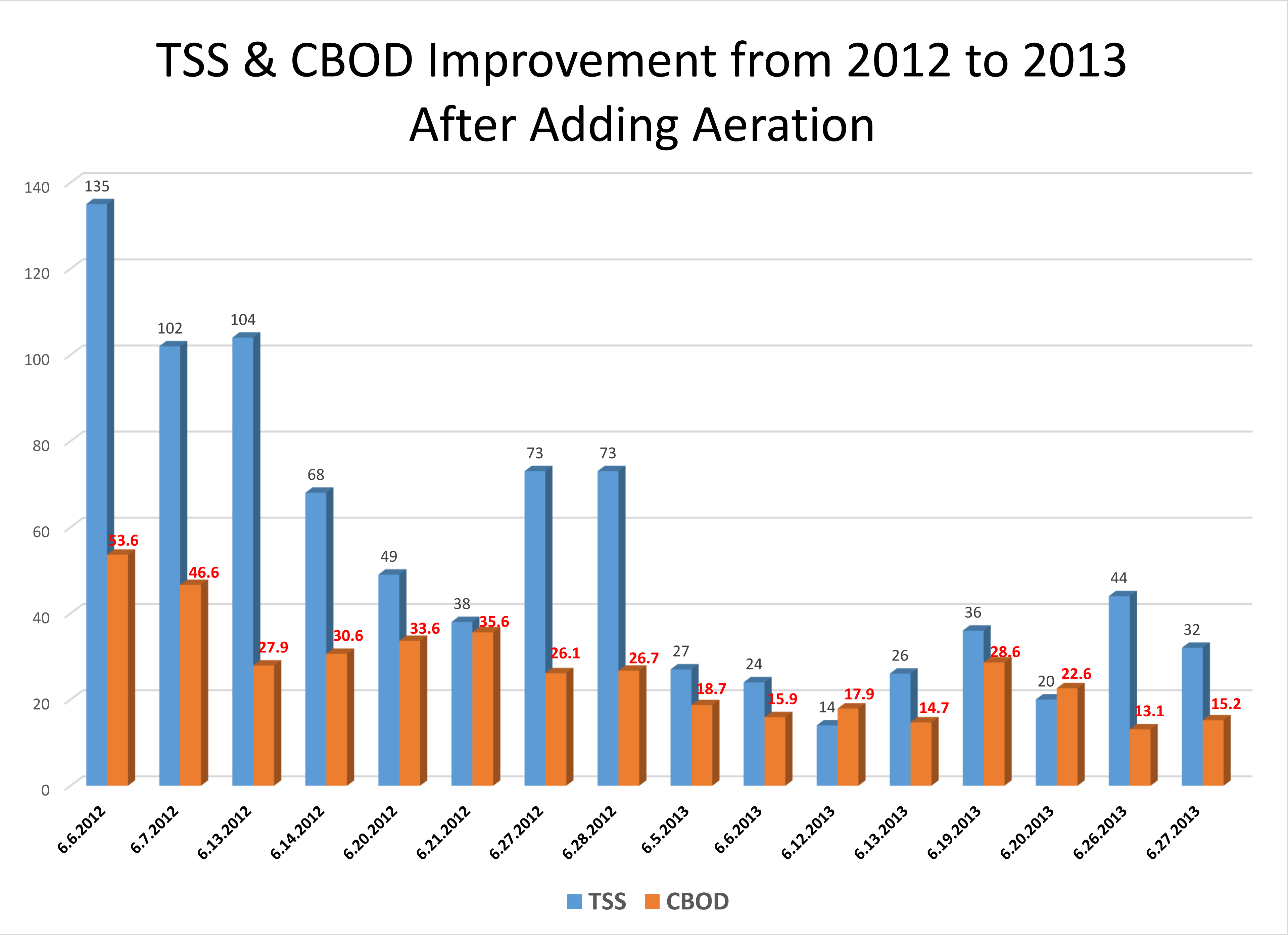
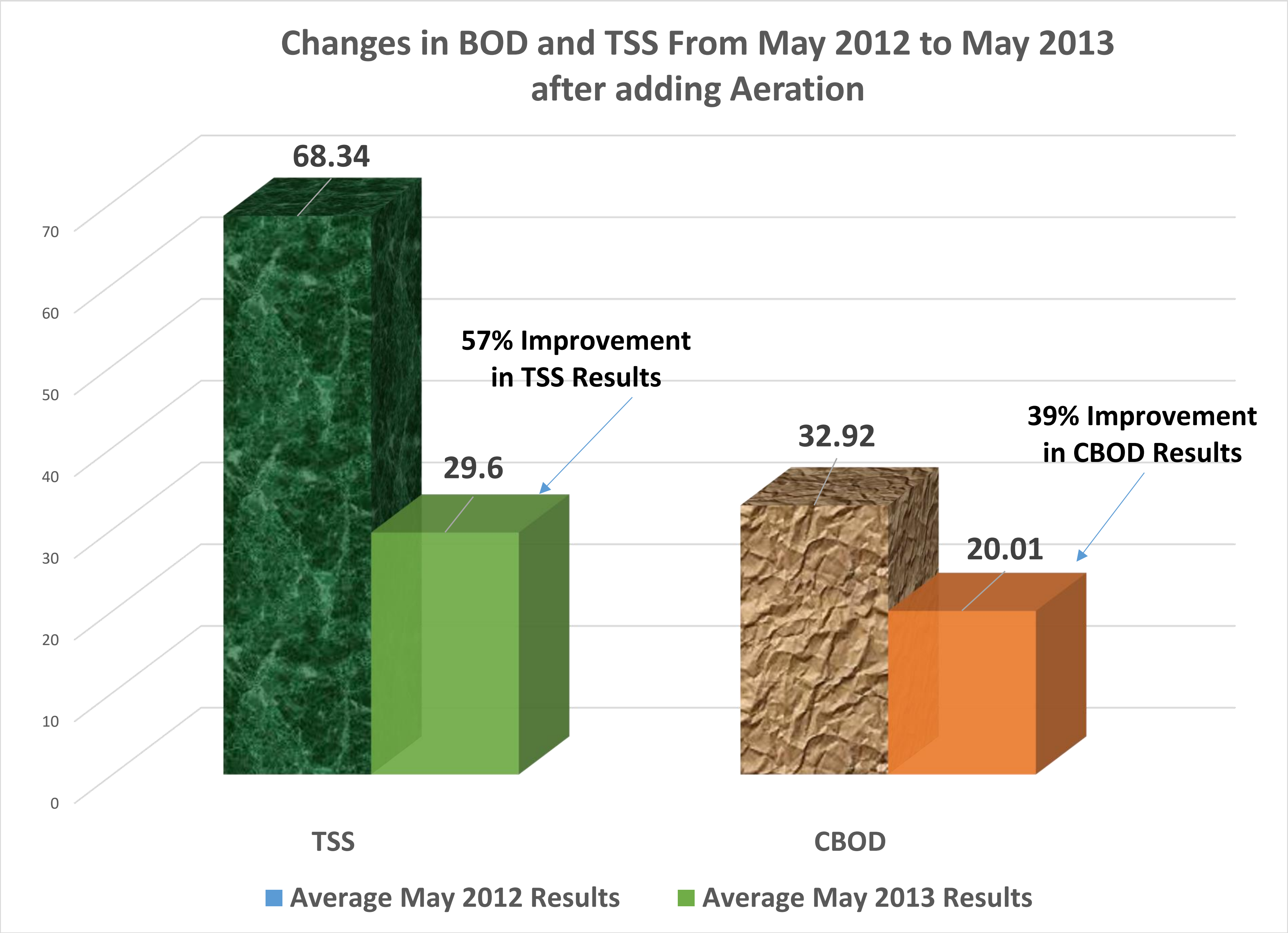


Chart Title
On those days when BOD Exceeds TSS it is an indication of ice cover and lack of treatment / short-circuiting or Nitrification in the BOD test bottle
3/1/2013, 33.88
3/1/2014, 47.83
2/1/2015, 37.18
2/1/2016, 57.58
3/1/2017, 45.10
3/1/2018, 55.90
4/1/2018, 57.05
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
3/1/2013
5/1/2013
7/1/2013
9/1/2013
11/1/2013
1/1/2014
3/1/2014
5/1/2014
7/1/2014
9/1/2014
11/1/2014
1/1/2015
3/1/2015
5/1/2015
7/1/2015
9/1/2015
11/1/2015
1/1/2016
3/1/2016
5/1/2016
7/1/2016
9/1/2016
11/1/2016
1/1/2017
3/1/2017
5/1/2017
7/1/2017
9/1/2017
11/1/2017
1/1/2018
3/1/2018
5/1/2018
BOD, 5-day, 20 deg. C MO AVE mg/l
TSS mg/l MO Ave

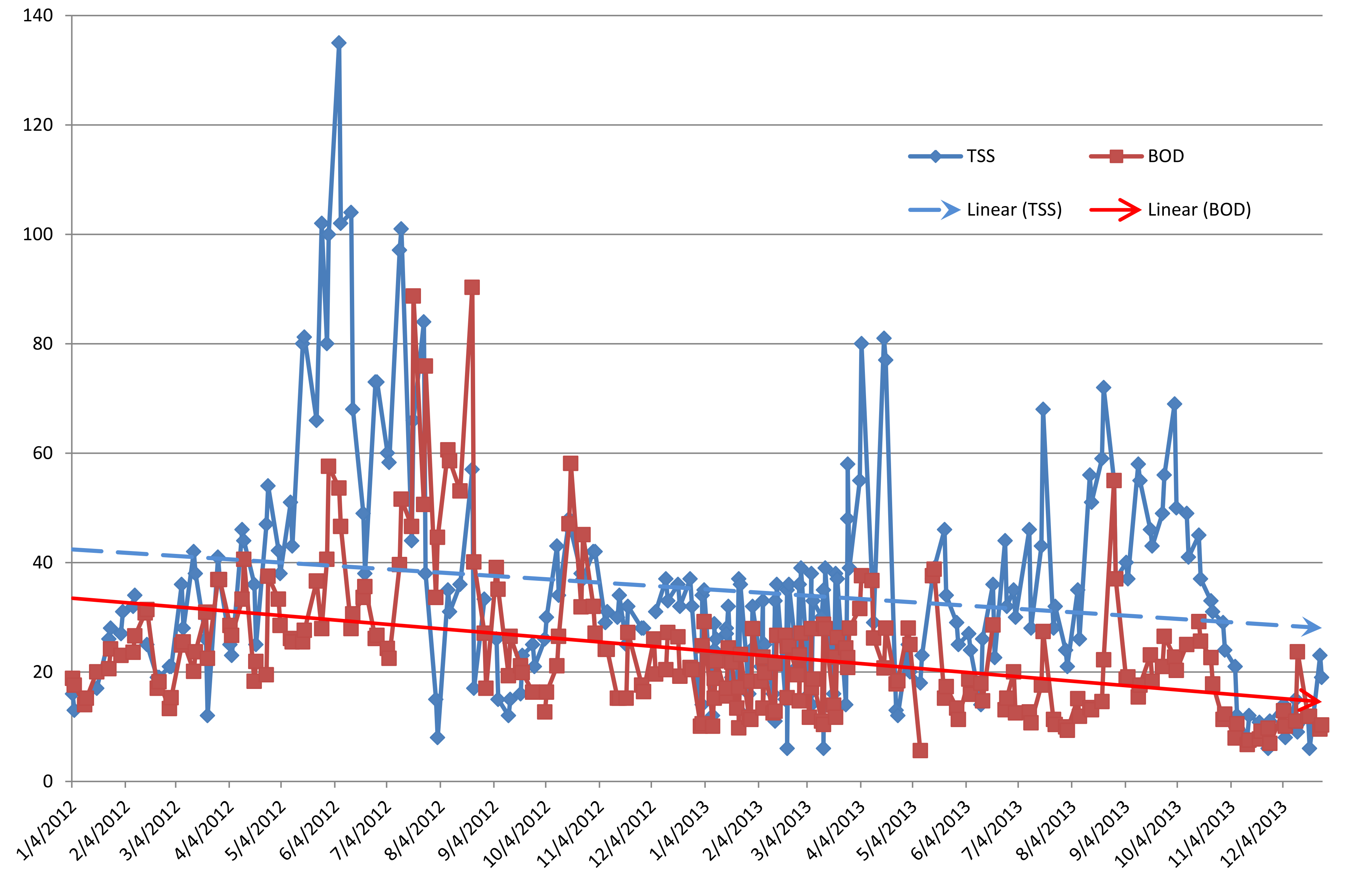
Case for Solving an Overloading Problem


TSS & CBOD Improvement from 2012 to 2013
After Adding Aeration
140
120
100
80
60
40
20
0
135
53.6
102
46.6
104
27.9
68
30.6
49
33.6
38
35.6
73
26.1
73
26.7
27
18.7
24
15.9
14
17.9
26
14.7
36
28.6
20
22.6
44
13.1
32
15.2
6.6.2012
6.7.2012
6.13.2012
6.14.2012
6.20.2012
6.21.2012
6.27.2012
6.28.2012
6.5.2013
6.6.2013
6.12.2013
6.13.2013
6.19.2013
6.20.2013
6.26.2013
6.27.2013
TSS
CBOD

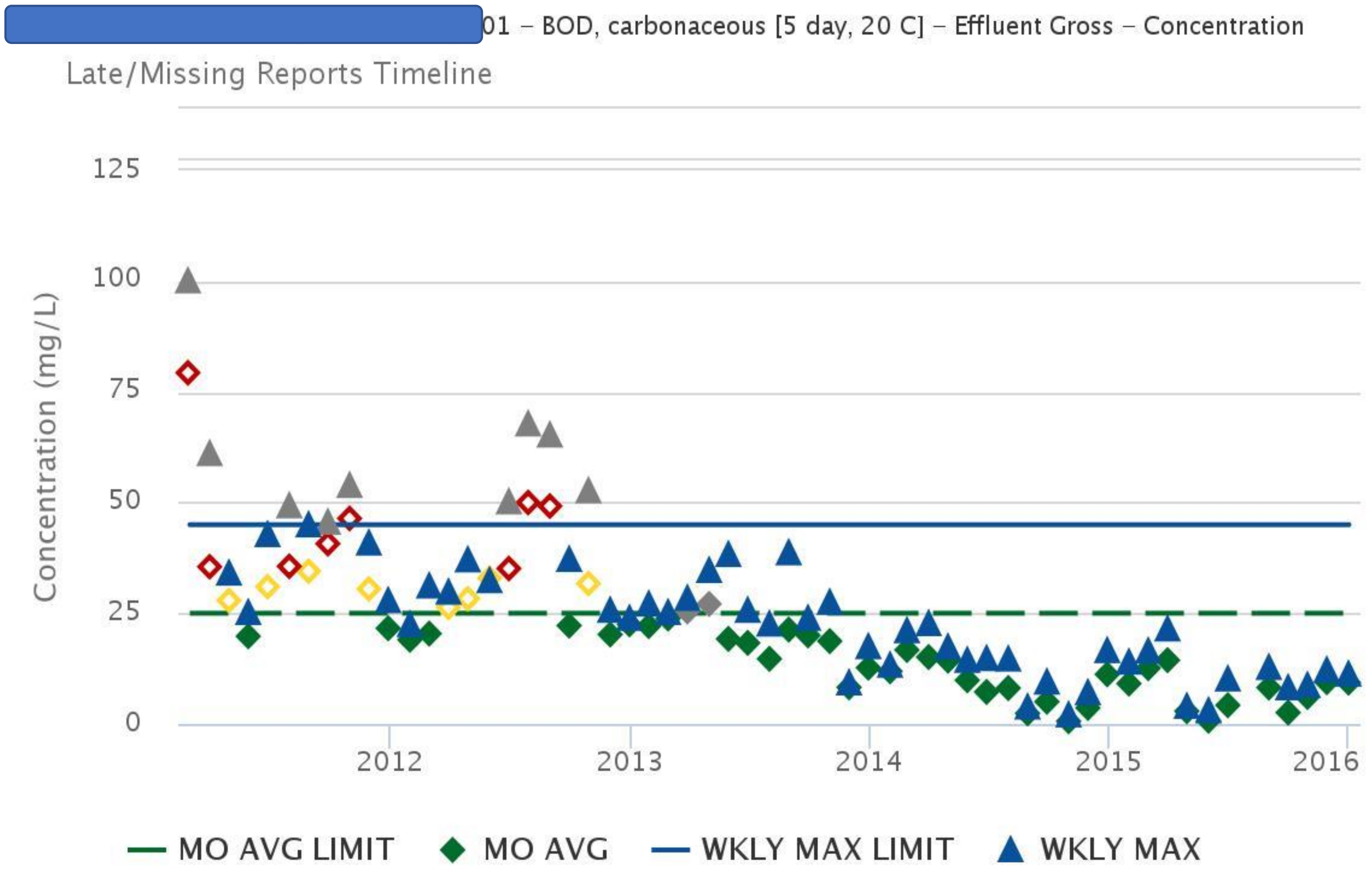


Changes in BOD and TSS From May 2012 to May 2013
after adding Aeration
68.34
29.6
57% Improvement
in TSS Results
32.92
20.01
39% Improvement
in CBOD Results
70
60
50
40
30
20
10
0
TSS
CBOD
Average May 2012 Results
Average May 2013 Results

Effluent CBOD for [redacted] after Adding Aeration and the Cessation of Added Industrial Food Processing Waste

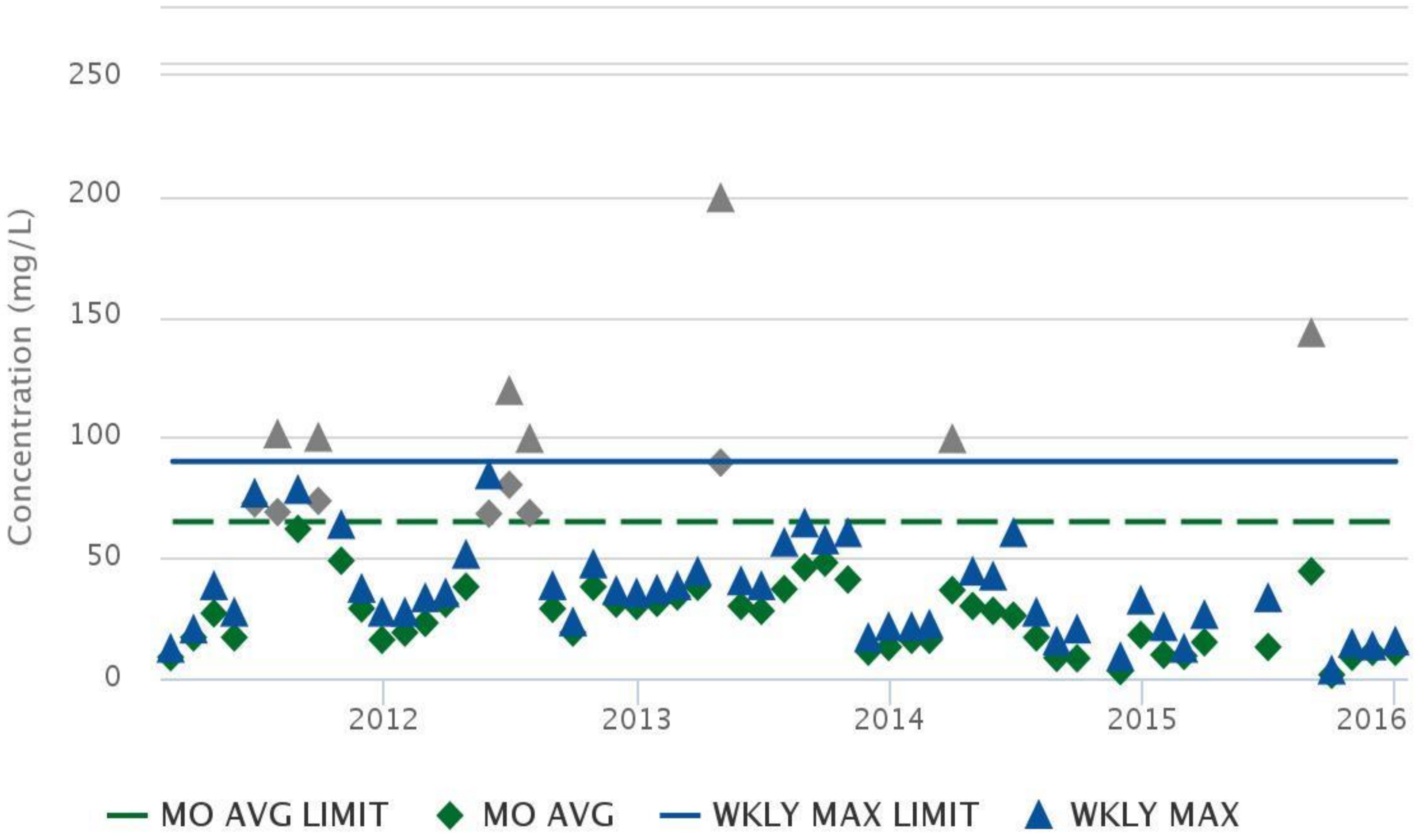


USEPA ECHO Charts

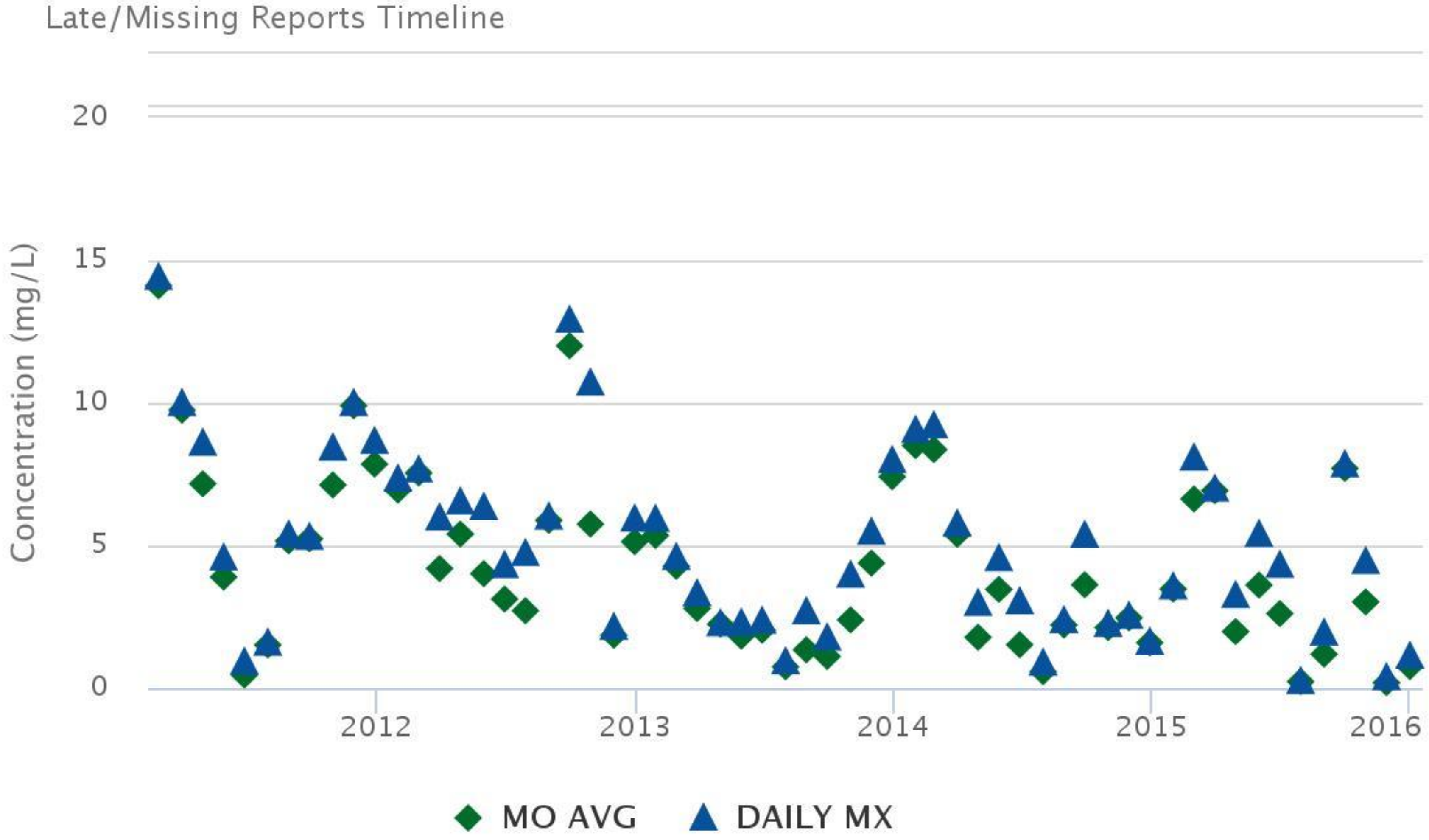


[redacted] – Solids, total suspended – Effluent Gross – Concentration

Late/Missing Reports Timeline



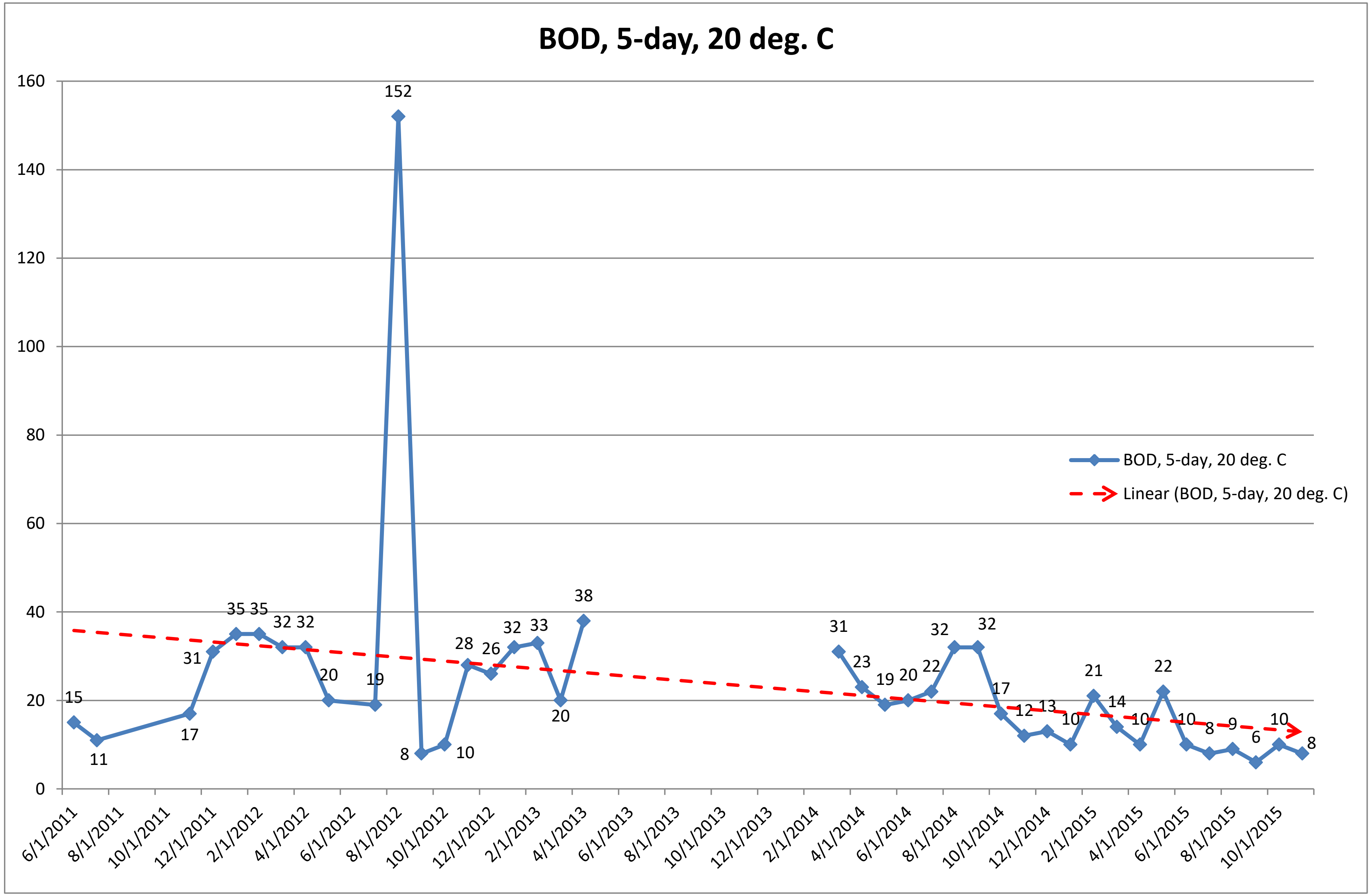
[redacted] – Nitrogen, ammonia total [as N] – Effluent Gross – Concentration



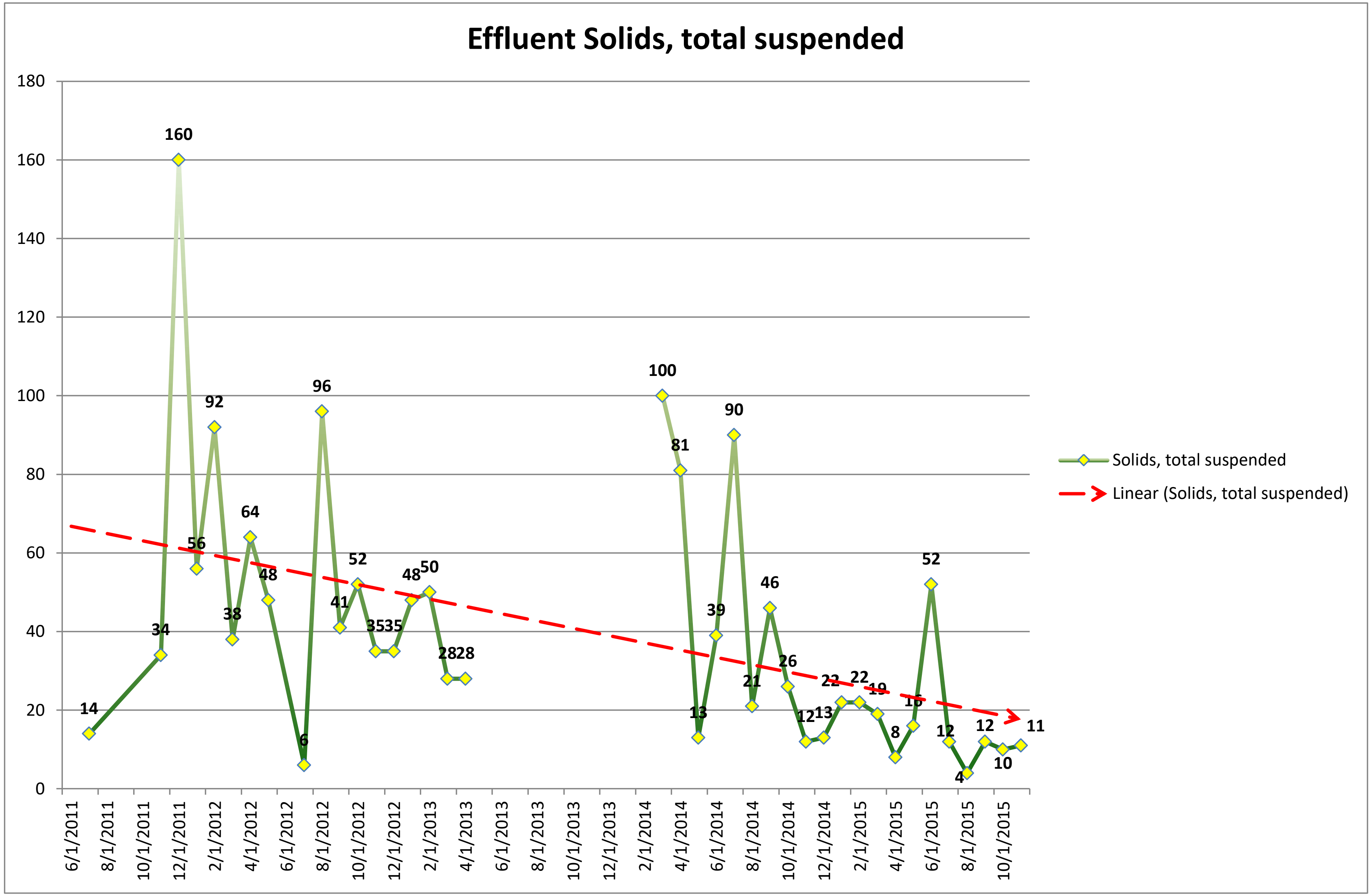
XXX, Missouri

Response to Improved Operations and Maintenance

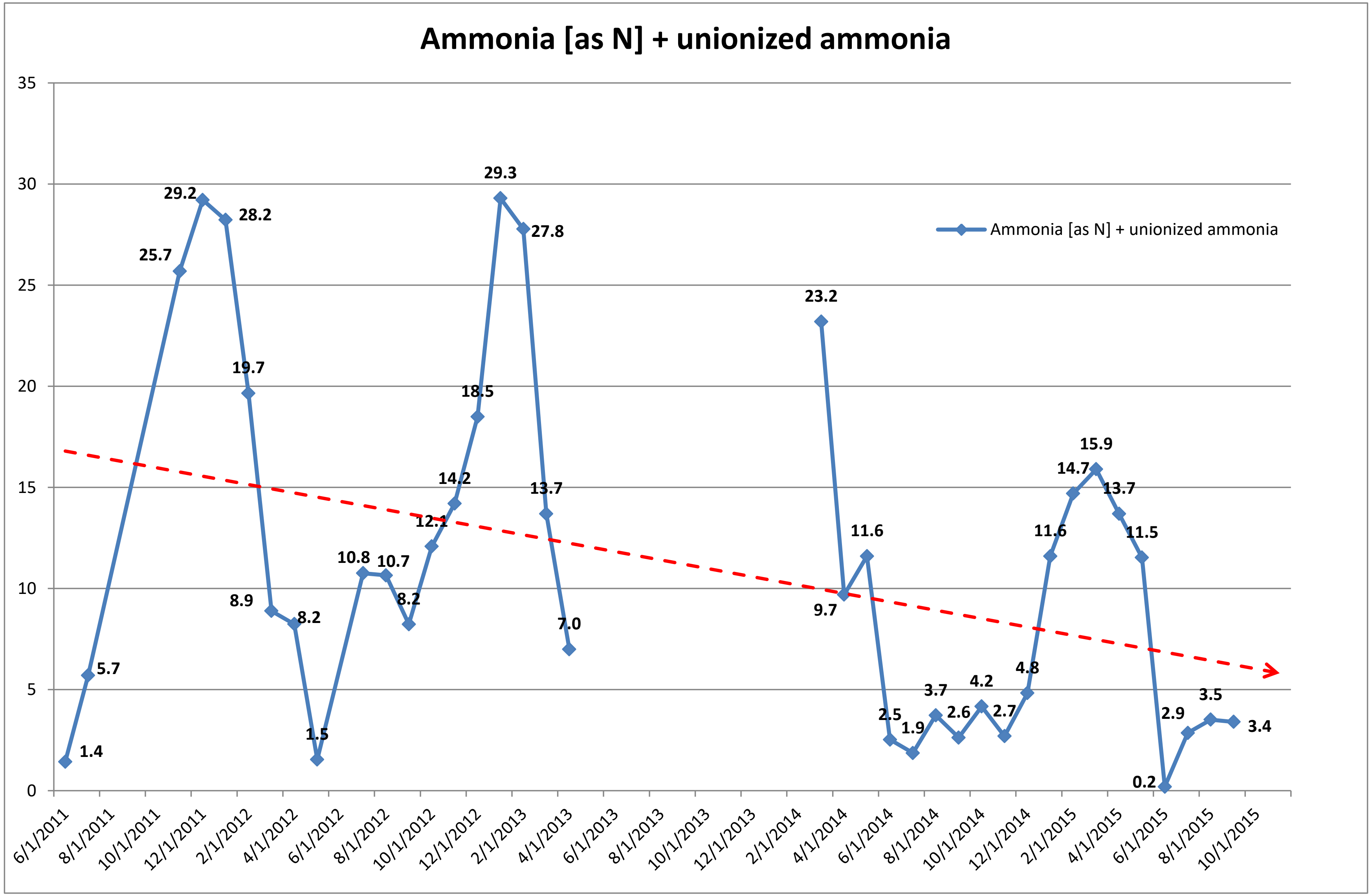

7/2015
Image © 2016 DigitalGlobe
Google earth
Imagery Date: 7/16/2015 39°26'35.74" N 94°20'56.80" W elev 844 ft eye alt 2074 ft



BOD, 5-day, 20 deg. C
160
140
120
100
80
60
40
20
0
152
15
11
17
31
35 35
32 32
20
19
8
10
28
26
32
33
38
20
31
23
19
20
22
32
32
17
12
13
10
21
14
10
22
10
8
9
6
10
8
BOD, 5-day, 20 deg. C
Linear (BOD, 5-day, 20 deg. C)
6/1/2011
8/1/2011
10/1/2011
12/1/2011
2/1/2012
4/1/2012
6/1/2012
8/1/2012
10/1/2012
12/1/2012
2/1/2013
4/1/2013
6/1/2013
8/1/2013
10/1/2013
12/1/2013
2/1/2014
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
2/1/2015
4/1/2015
6/1/2015
8/1/2015
10/1/2015



Effluent Solids, total suspended
180
160
140
120
100
80
60
40
20
0
160
92
56
64
38
48
96
52
41
35
35
48
50
28
28
14
34
6
100
81
90
39
13
46
21
26
22
22
19
12
13
8
16
52
12
4
12
10
11
6/1/2011
8/1/2011
10/1/2011
12/1/2011
2/1/2012
4/1/2012
6/1/2012
8/1/2012
10/1/2012
12/1/2012
2/1/2013
4/1/2013
6/1/2013
8/1/2013
10/1/2013
12/1/2013
2/1/2014
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
2/1/2015
4/1/2015
6/1/2015
8/1/2015
10/1/2015
Solids, total suspended
Linear (Solids, total suspended)


Ammonia [as N] + unionized ammonia
Ammonia [as N] + unionized ammonia
35
30
25
20
15
10
5
0
6/1/2011
8/1/2011
10/1/2011
12/1/2011
2/1/2012
4/1/2012
6/1/2012
8/1/2012
10/1/2012
12/1/2012
2/1/2013
4/1/2013
6/1/2013
8/1/2013
10/1/2013
12/1/2013
2/1/2014
4/1/2014
6/1/2014
8/1/2014
10/1/2014
12/1/2014
2/1/2015
4/1/2015
6/1/2015
8/1/2015
10/1/2015
1.4
5.7
25.7
29.2
28.2
19.7
8.9
8.2
1.5
10.8
10.7
8.2
12.1
14.2
18.5
29.3
27.8
13.7
7.0
23.2
9.7
11.6
2.5
1.9
3.7
2.6
4.2
2.7
4.8
11.6
14.7
15.9
13.7
11.5
0.2
2.9
3.5
3.4

Operators Notes

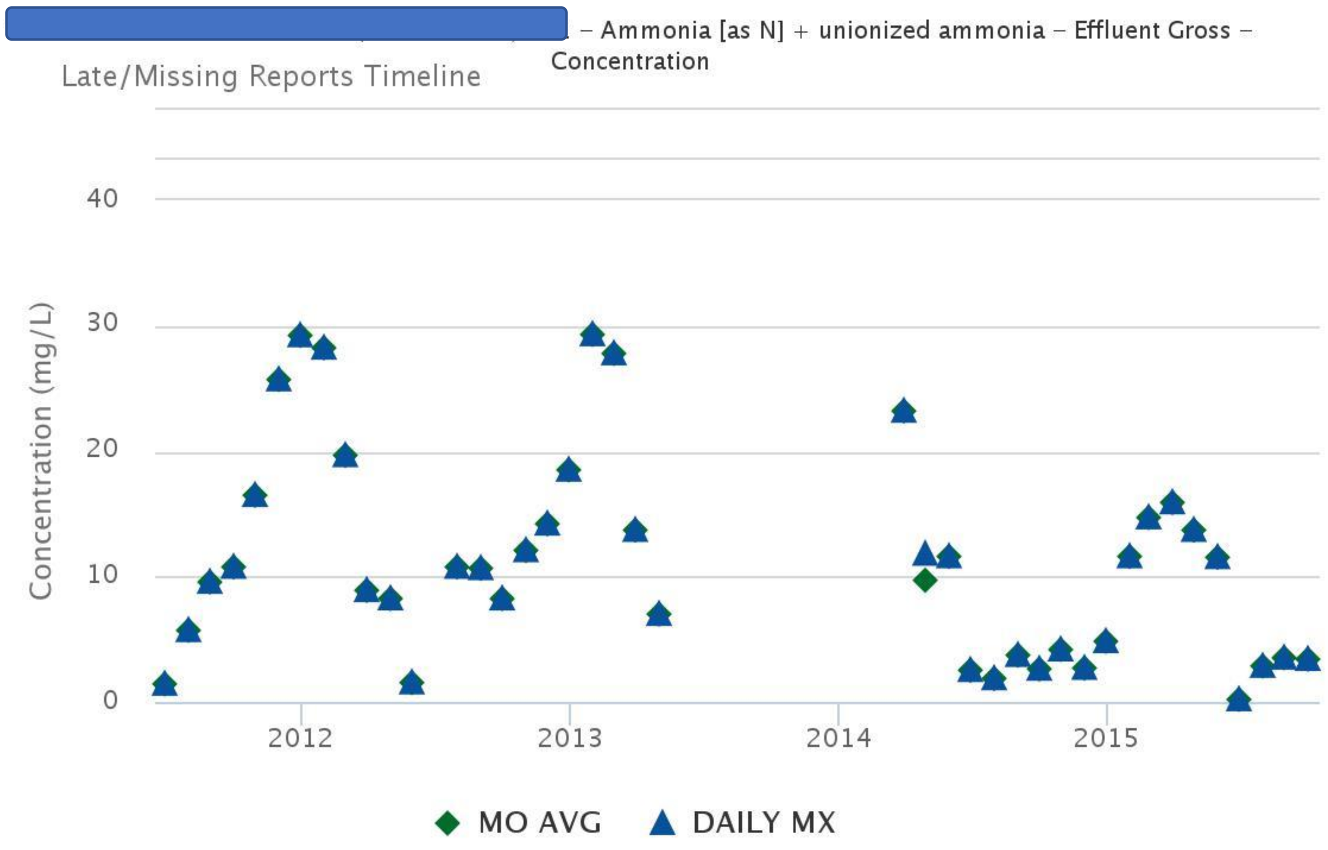
- 1) “The valves were all set on the lowest setting pulling water from too close to the sludge blanket.”
- 2) “The first to cells were completely covered with duck weed which I removed with my custom set up and moved the duck weed to the final tertiary the old fashion Lemna process to knock the TSS down.”
- 3) “Since taking over the lagoons I have dropped the BOD and TSS to almost always single digits. Last month the BOD was 8 mg/l and TSS was 10 mg/l, ammonia was 16.”
- 4) “The grass around [the cells] was taller than my car so now it gets mowed regularly and burned off as well to help keep the D.O. up. Other than that we had no ammonia limit so this is new territory.”
- …Jonathan Shaw, Operator, 3/14/2016

What to do next?

- In May we are going to sludge profile each treatment cell
- We will perform nutrient removal and formation testing throughout each cell
- DO and pH profile each cell spatially and diurnally
- Perform intra-pond TSS and BOD sampling through the system

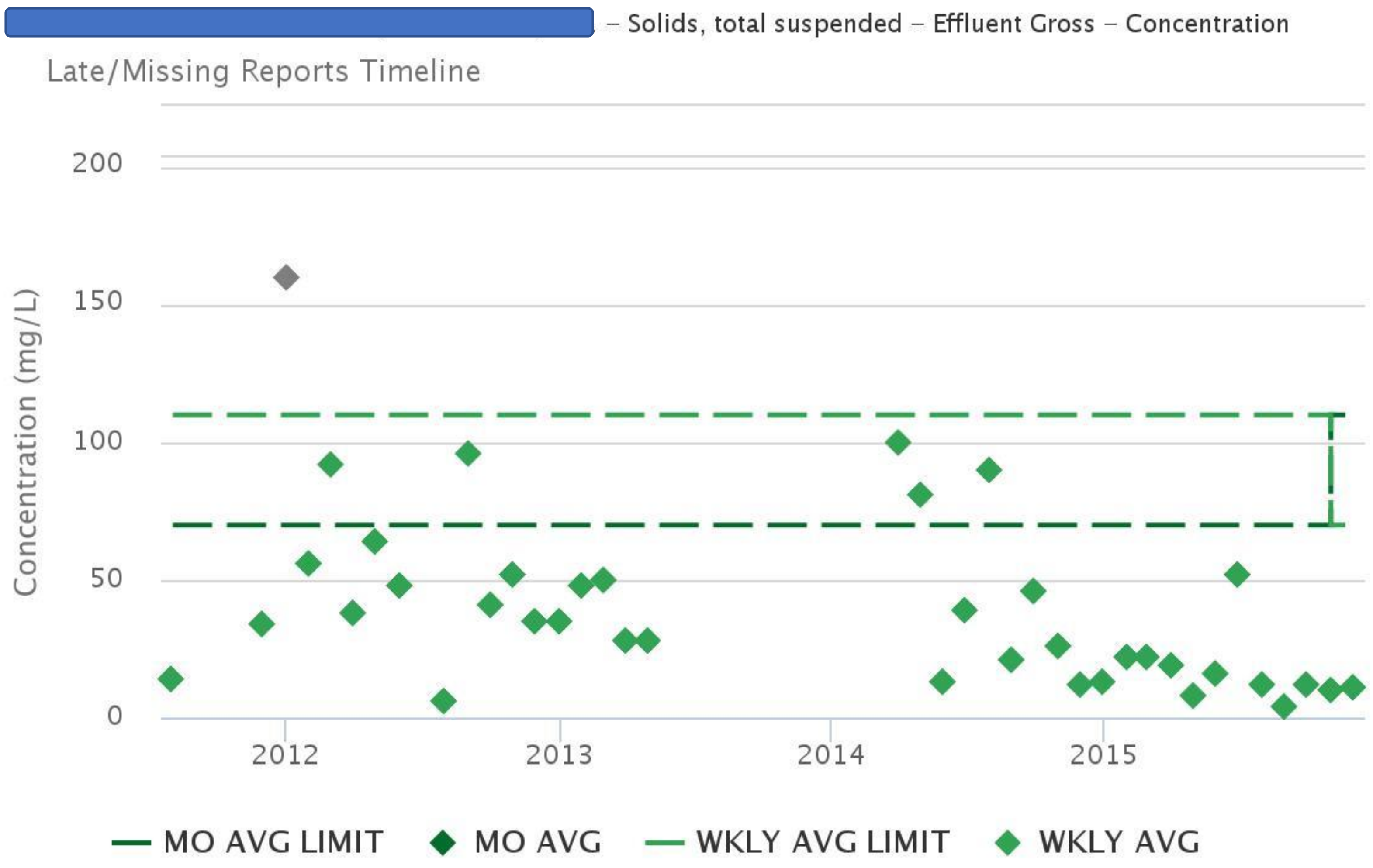
As the XXX Operator Continues to Make Changes to His System, Water Quality will Continue to Improve

ECHO Chart for XXXX Effluent Ammonia



ECHO Chart for XXX Effluent BOD_5

ECHO TSS Chart for XXX



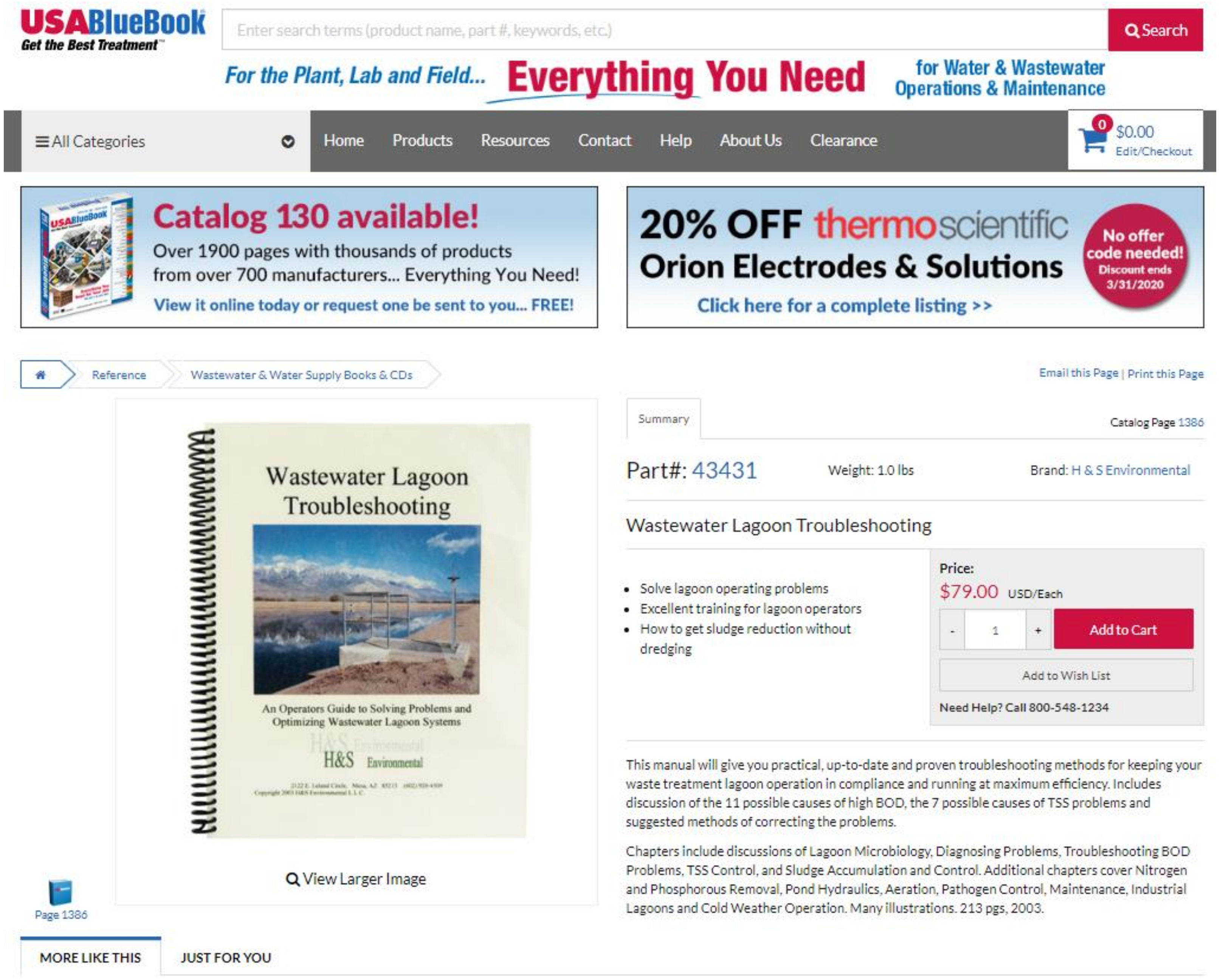
Headworks

- Will reduce influent BOD
- Extend the time between desludging
- Control vectors


DANGER
THIS EQUIPMENT
STARTS AUTOMATICALLY

References:

- Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers https://www.epa.gov/nutrient-policy-data/principles-design-and-operations-wastewater-treatment-pond-systems-plant (see Appendix E for Troubleshooting)
- https://www.rcap.org/resource/wastewater-lagoon-basics/ (56 minutes webinar)
- https://www.rcap.org/resource/wastewater-lagoon-troubleshooting/ (61 minutes webinar)
- EPA - Wastewater Technology Fact Sheet Facultative Lagoons (4 pages)
- EPA - Wastewater Technology Fact Sheet Aerated, Partial Mix Lagoons (https://www3.epa.gov/npdes/pubs/apartlag.pdf) (5 pages)



A Good Wastewater Lagoon Book

Steven M. Harris
H&S Environmental, LLC
www.lagoonops@gmail.com
www.lagoonops.com
1 (480) 274-8410

Lagoon Troubleshooting book available at usabluebook.com Part # 43431, Page 1386 in Catalog

Online at: https://www.usabluebook.com/p-286936-wastewater-lagoon-troubleshooting.aspx