Lake and Pond Solutions LLC

Oxygenation Saturation Technology (OST) 2-Year Case Study Review

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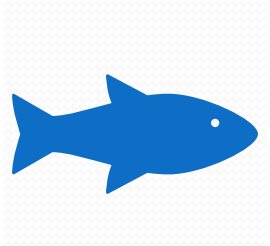
Lake and Pond Solutions LLC

Overview

What is Oxygenation Saturation Technology?



Case Study 1: New Trout Pond

Case Study 2: Aged Stormwater Pond

These are two of the first three underwater OST systems installed worldwide

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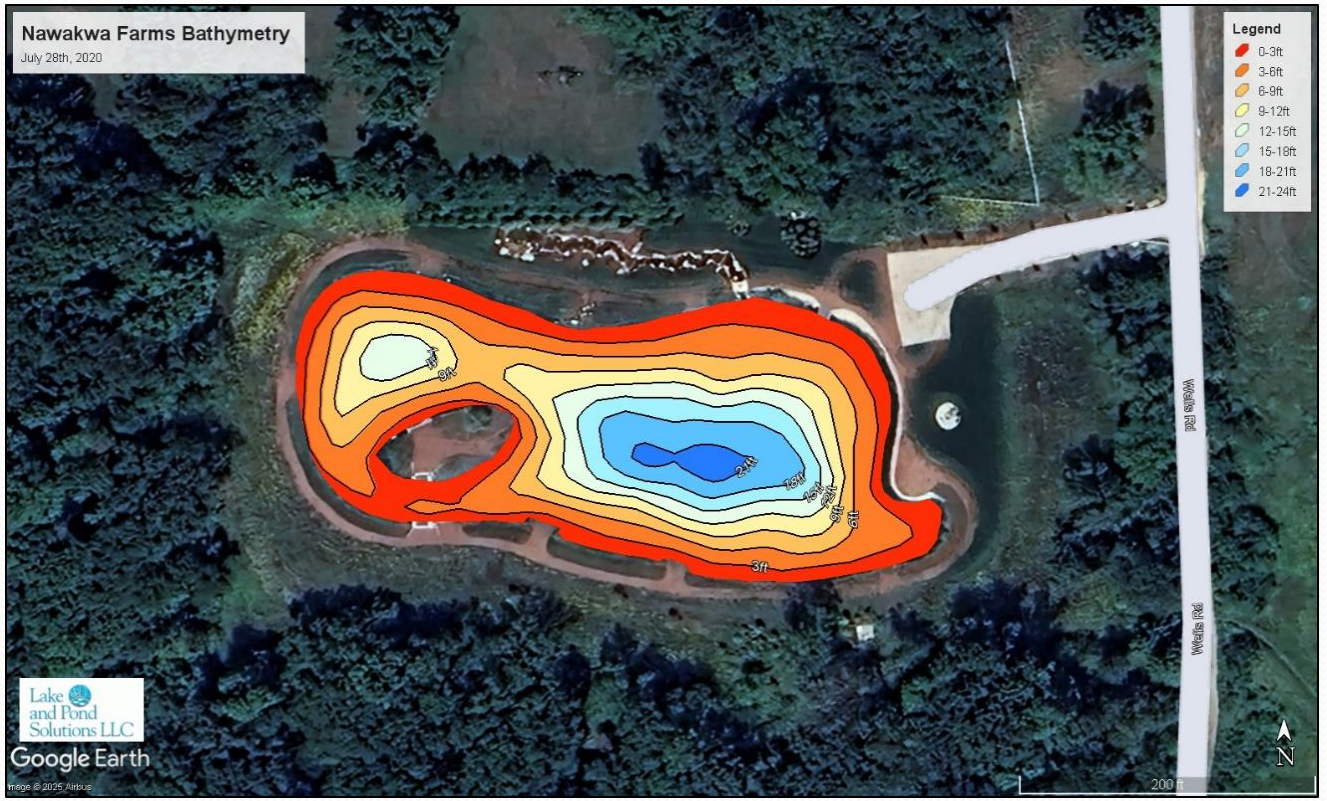
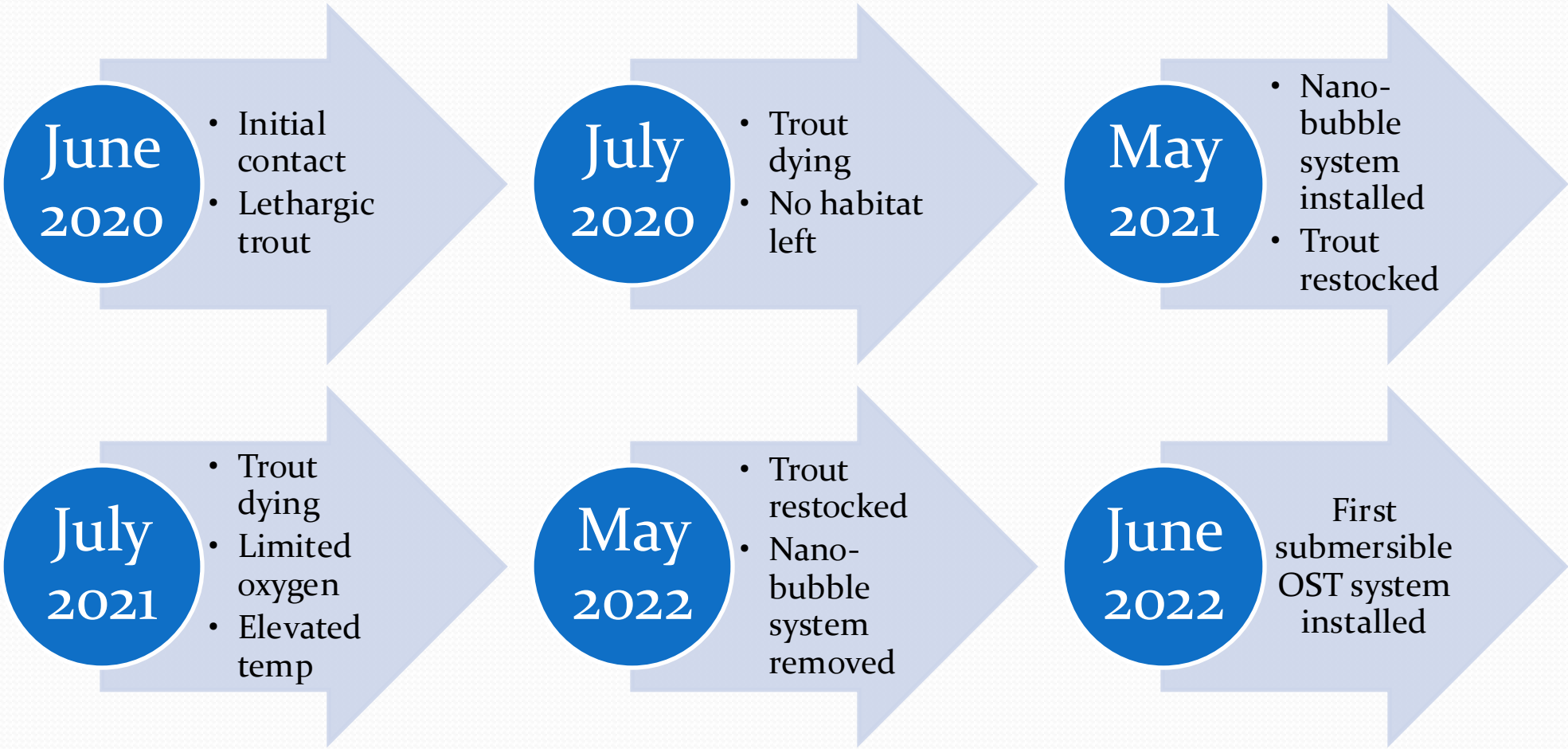
CASE STUDY 1: Trout Pond

Background

- Pond located in Walworth County, Wisconsin
- Clay-lined and built in 2019
- 1.47 acres with 23.2’ max depth, 8.2’ avg. depth
- 10 gpm well replaced by recirc stream and 65 gpm well in 2022



Project Timeline

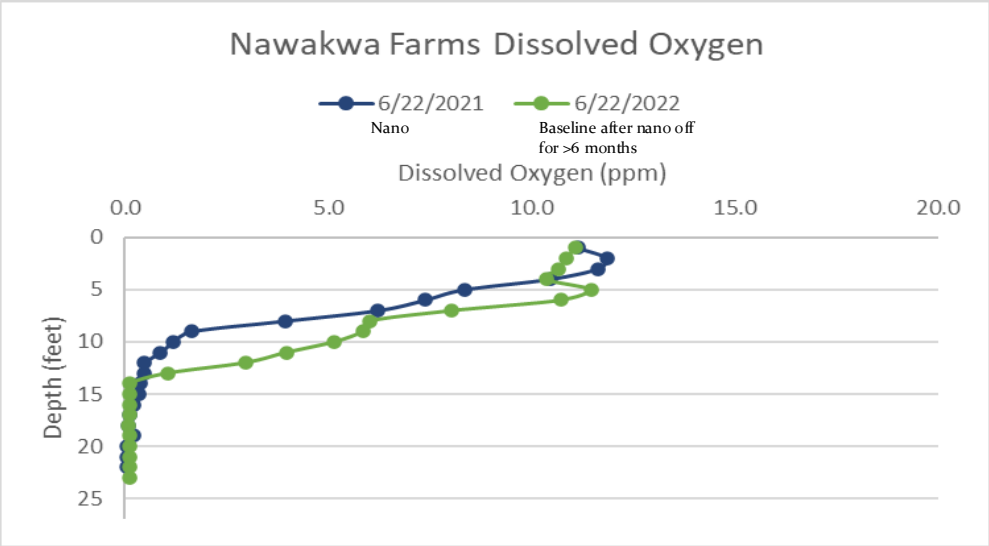


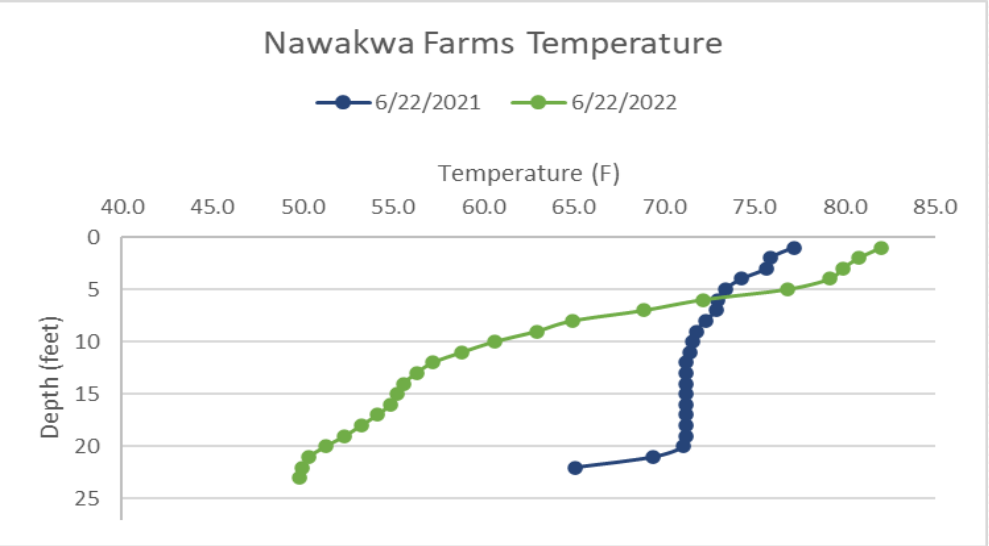
Project Details

- OST system installed in deep hole of east basin
- Suitable Trout Habitat
  - Temperature ≤ 70° F
  - Dissolved oxygen (DO) ≥ 7 ppm
- Full profiles taken with YSI 550A meter or YSI DO200 meter
- Automated readings taken with series of probes at 23' 20', 17', and 14'
  - Measurements every 15 – 60 minutes
  - Connects to online dashboard

Pre-OST

- 6 weeks post nanobubble install (BLUE) vs pre-OST (GREEN)

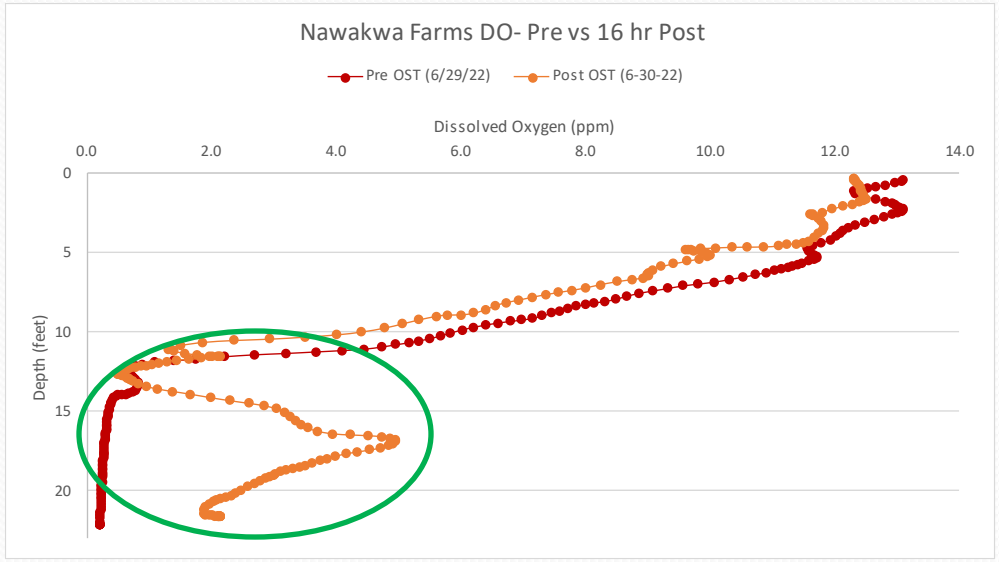


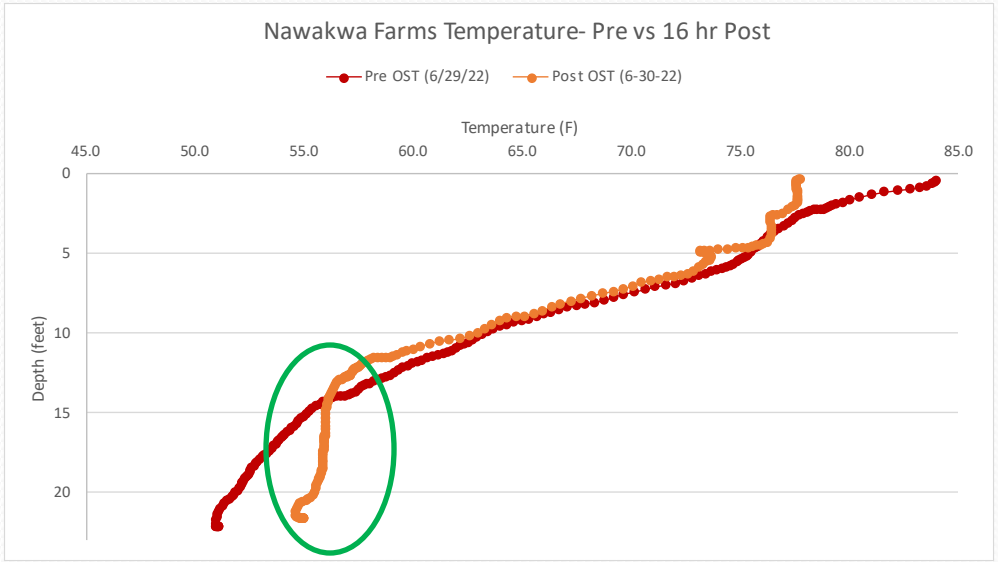


- Higher avg DO pre-OST (5.18 ppm) vs nanobubble (3.51 ppm)
- 32° F temperature difference pre-OST (stratified) vs 12° F post nanobubble (mostly mixed)

Initial OST Startup

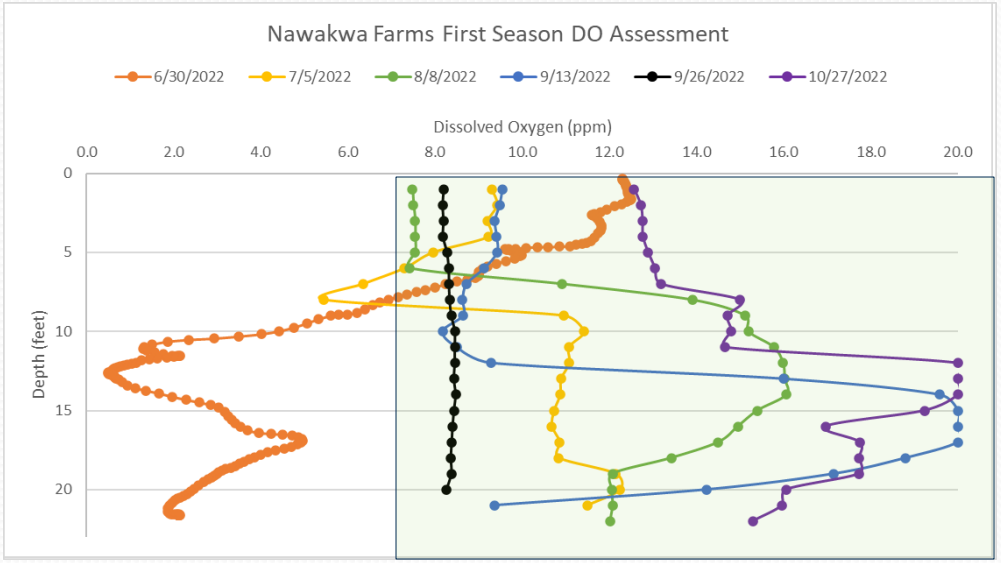
- Pre-OST (RED) vs 16 hrs. post installation (ORANGE)

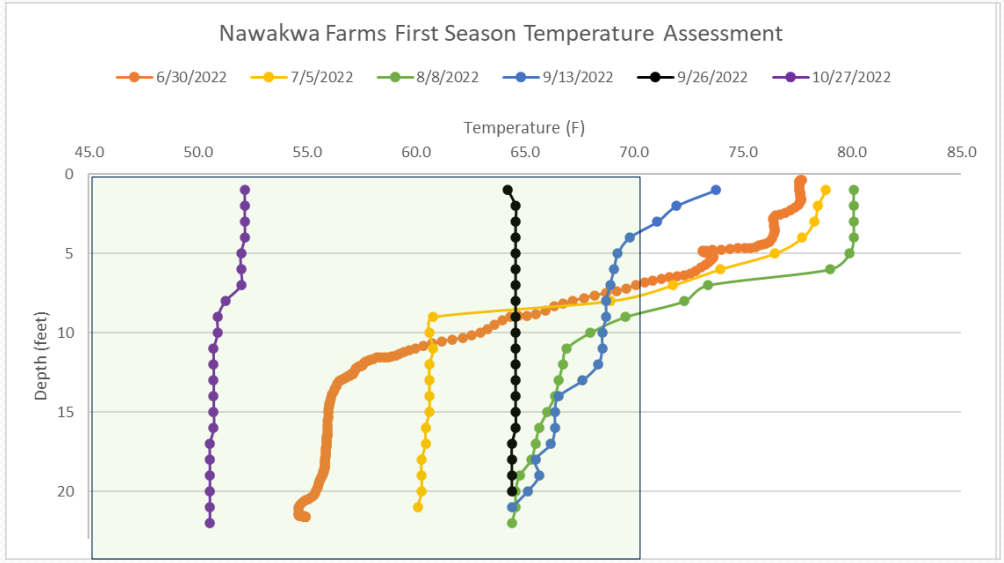




- 2.6 ppm avg DO increase in bottom 13' and 4.7 ppm increase at 17'
- Intentional mixing of bottom water but not entire water column

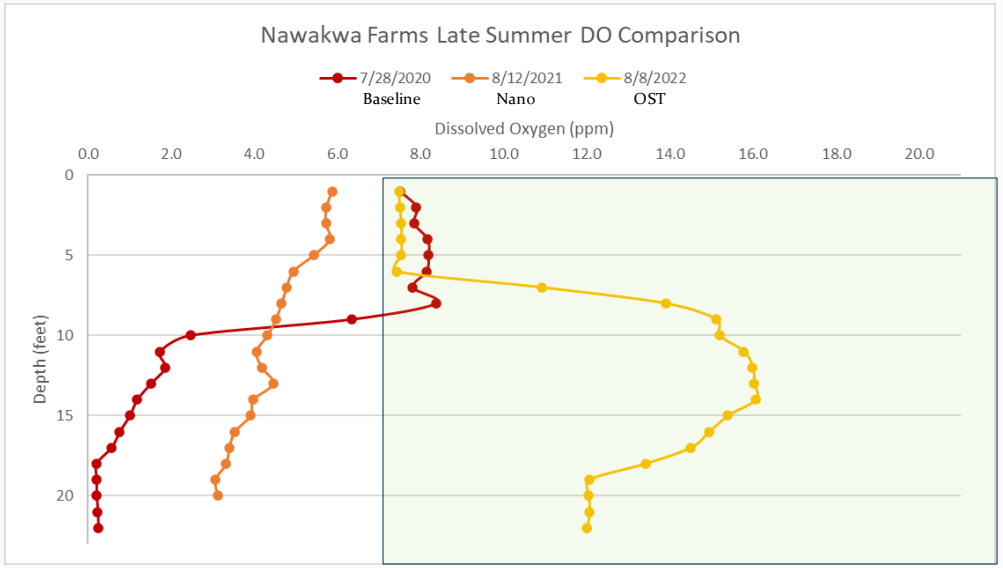
First Season Assessment (2022)

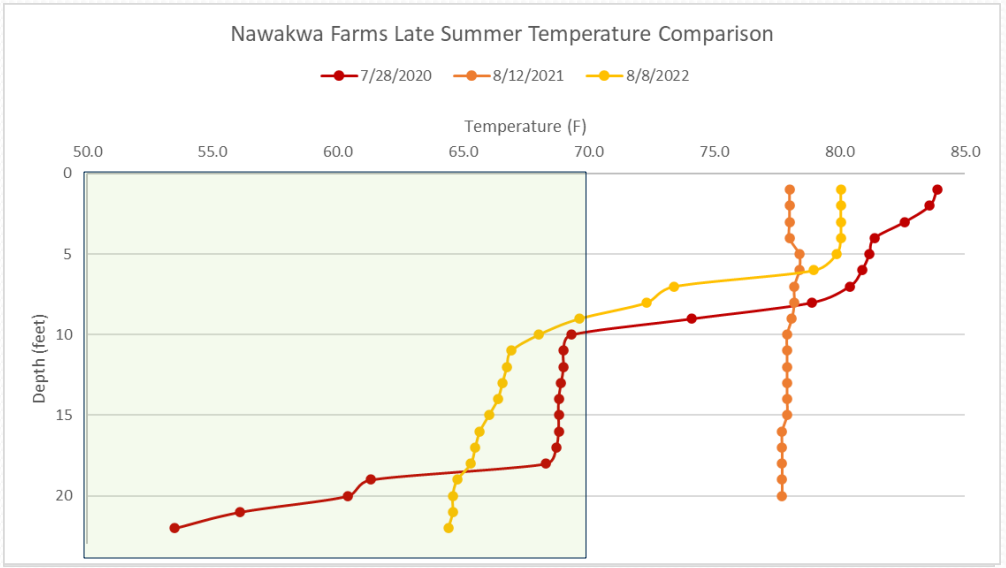




- DO > 10 ppm in bottom 13' after 6 days (YELLOW - still stratified)
- Intended bottom mixing June - August
- Natural turnover in late September with quick DO recovery
- DO ≥ 8 ppm and temp ≤ 70° F in bottom 13' entire season

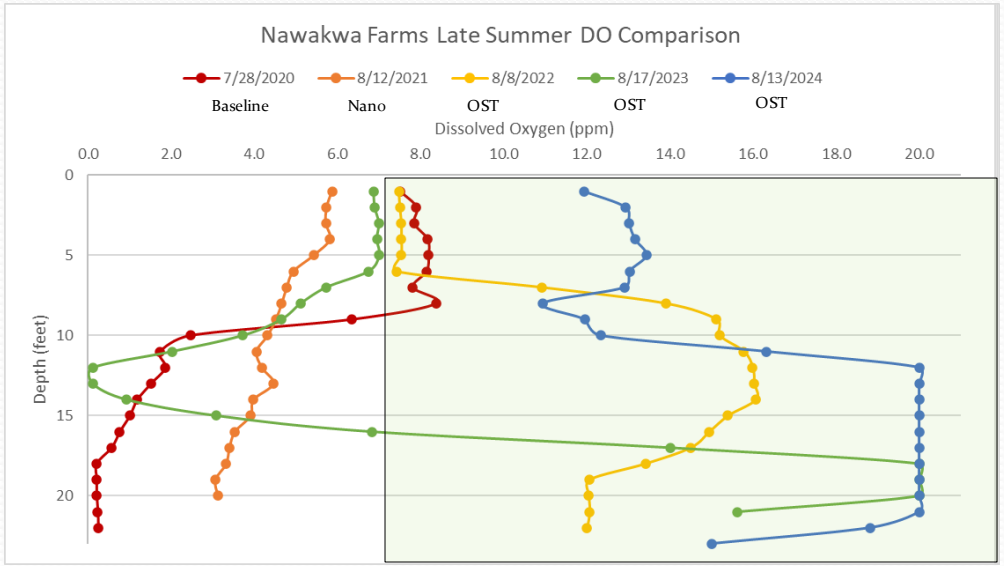
Full Project Late Summer Comparison

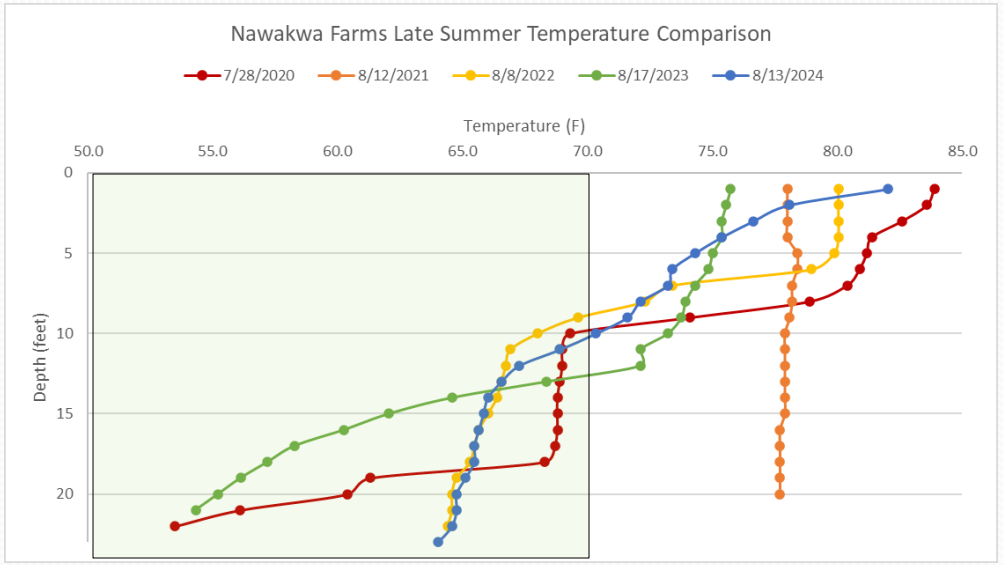




- DO and temp were unsuitable for trout in 2020 (RED) and 2021 (ORANGE)
  - Near complete fish loss observed both seasons
- 1st season OST (YELLOW) – substantial increase in bottom DO and 15.4° F stratification
  - Intentional mixing in bottom portions

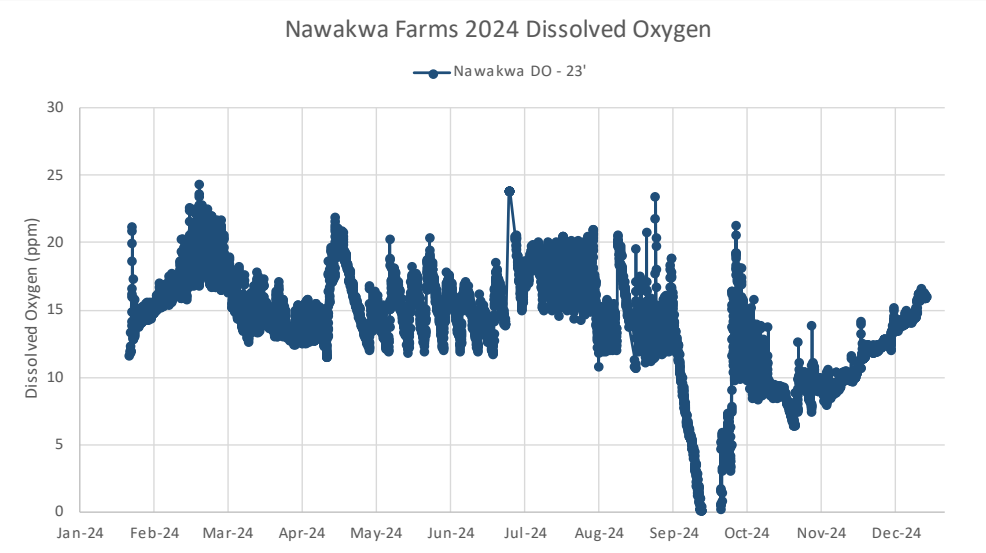
Full Project Late Summer Comparison

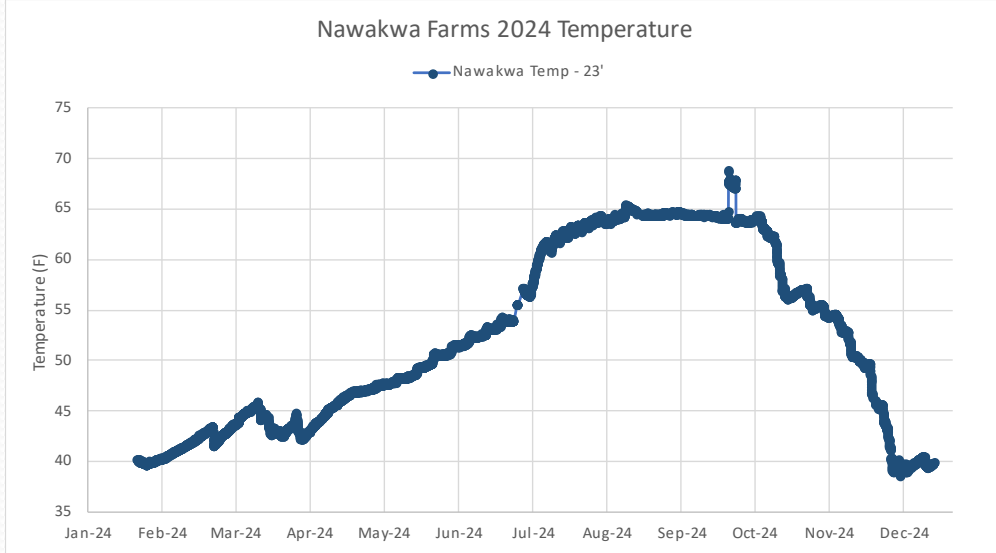




- 2nd season OST (GREEN) – good bottom DO and 21.4° F stratification
  - No intentional mixing thus more localized DO (well water inputs too)
- 3rd season OST (BLUE) – substantial bottom DO and 18.0° F stratification
  - Unintended mixing in bottom portions due to clogged headers

Complete 2024 Sensor Dataset





- DO remained in 10 – 20 ppm target range
  - System shutdown in September (header replacement)
  - 9 days for DO to drop to zero when system isn't running but only 5 days to increase to 10 ppm
- Temperature at 23' remained under 65.3° F all summer

Trout Habitat (DO ≥ 7ppm and Temp ≤ 70° F)

	MID-JUNE					
	Year	Avg DO (15-23')	Avg Temp (15-23')	Depths w/ DO >7	Depths w/ Temp <70	Depths w/ Both
Baseline	2020	0.16	54.8	6	17	1
Nano	2021	0.14	70.2	6	2	0
OST	2022	0.18*	52.3*	6*	22*	5*
OST	2023	13.96	51.2	20	12	12
OST	2024	13.54	55.0	15	12	7

Avg June bottom DO 84x – 100x better than previous

Avg June bottom temp closely matched unmixed conditions

Depths with suitable oxygen increased 2.5x – 3.3x and suitable trout habitat increased

Trout Habitat (DO ≥ 7ppm and Temp ≤ 70° F)

	MID-AUGUST					
	Year	Avg DO (15-23')	Avg Temp (15-23')	Depths w/ DO >7	Depths w/ Temp <70	Depths w/ Both
Baseline	2020	0.40	63.2	8	13	0
Nano	2021	3.39	77.7	0	0	0
OST	2022	13.31	65.1	22	14	14
OST	2023	14.22	57.6	9	11	7
OST	2024	19.31	65.1	23	13	13

Avg Aug bottom DO 4x – 48x better than previous

Avg Aug bottom temp closely matched unmixed conditions

No suitable habitat prior to OST but 7 – 14' after install

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Project Conclusions

- DO increases of nearly 5 ppm in first 16 hrs and 10 ppm in 6 days
- Resistance to full pond mixing – thermal stratification of 15 – 21° F in August
- DO levels ≥ 7 ppm and temp ≤ 66° F in bottom 7' throughout project duration
- 84x – 100x more DO in June and 4x – 48x more DO in August
- Ability to maintain 7' - 14' of suitable trout habitat
- Able to maintain suitable DO in winter without impacting ice conditions
- No trout loss throughout duration of project

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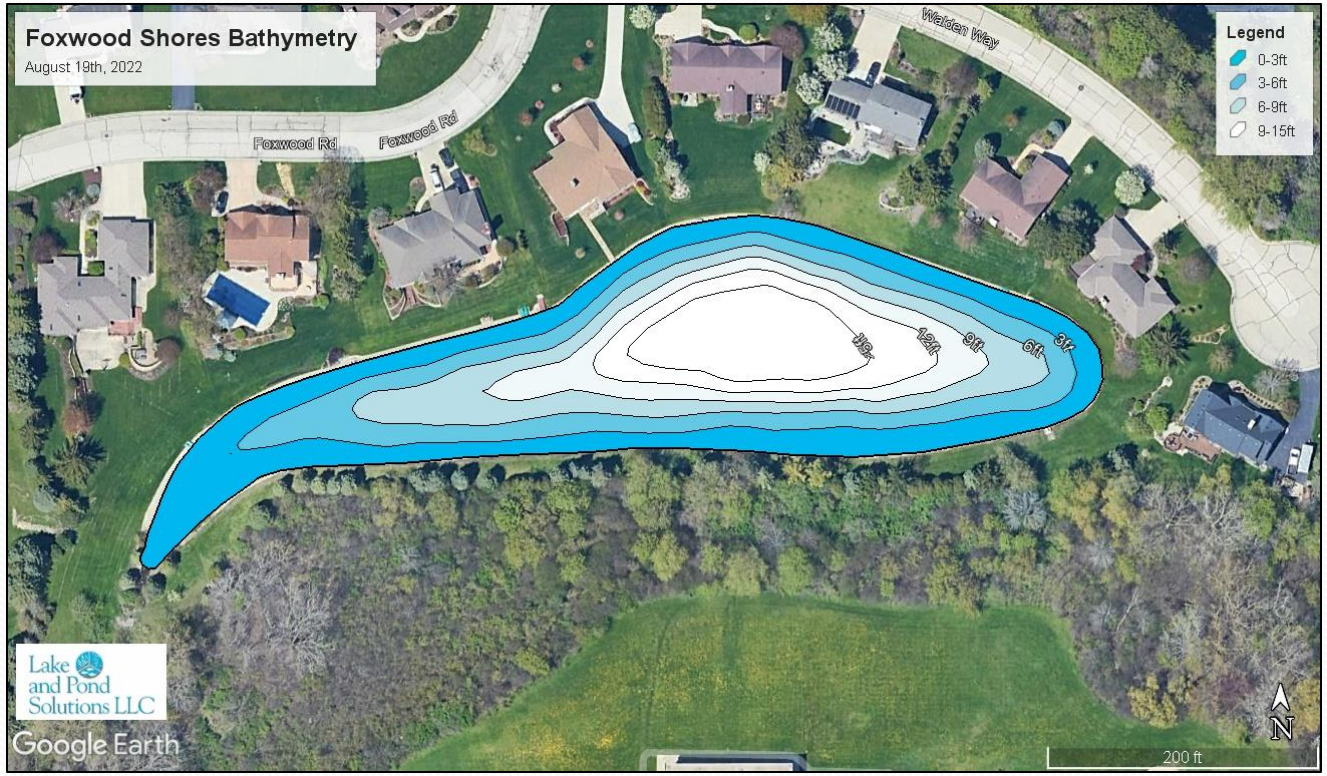
CASE STUDY 2:
Aged Stormwater Pond

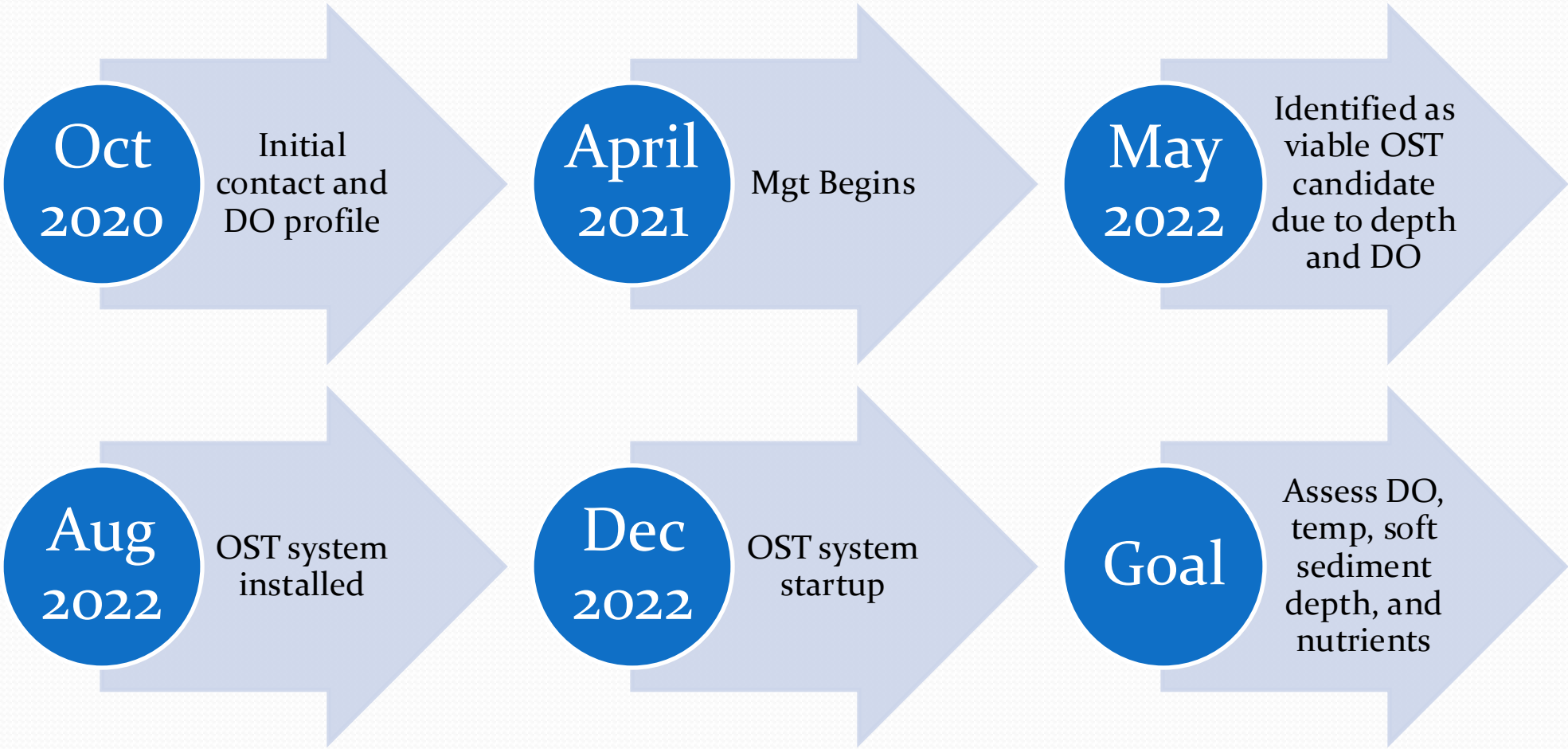
Background

- Pond located in Racine County, Wisconsin
- Earthen stormwater pond built in the 1990's
- 1.75 acres with 17.4' max depth, 6.7' avg. depth



- Constant inflow on SW corner that brings in constant 5-15 gpm plus stormwater runoff

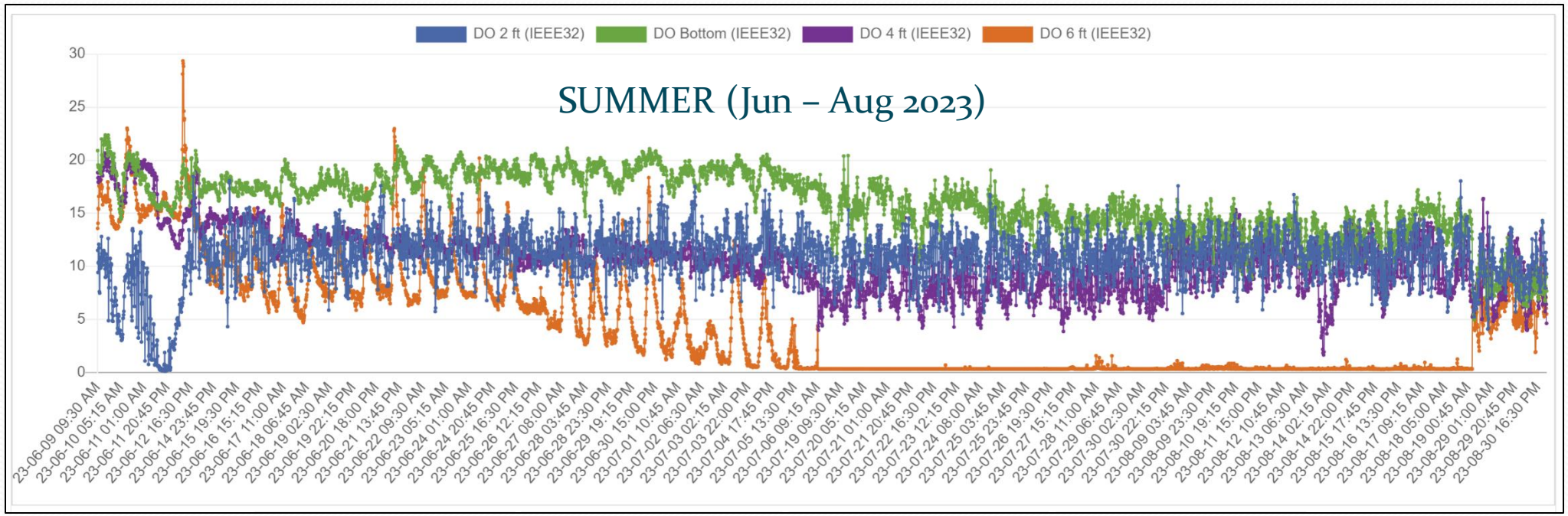
Project Timeline



Project Details

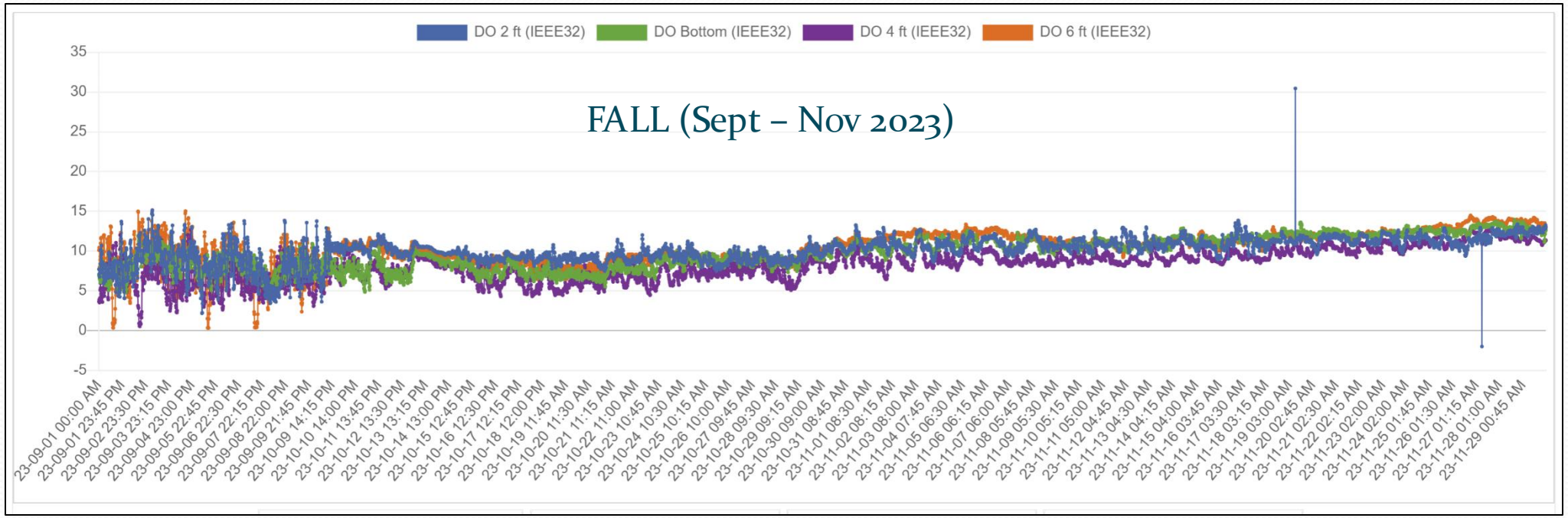
- OST system installed in deep basin
- Full DO/Temp profiles taken with YSI 550A meter or YSI DO200 meter
- Automated readings taken with series of probes at 17’ 15’, 13’, and 11’
  - Measurements every 15 – 60 minutes
  - Connects to online dashboard
- Soft sediment measurements taken and water samples collected pre and post install

Dissolved Oxygen – Summer 2023



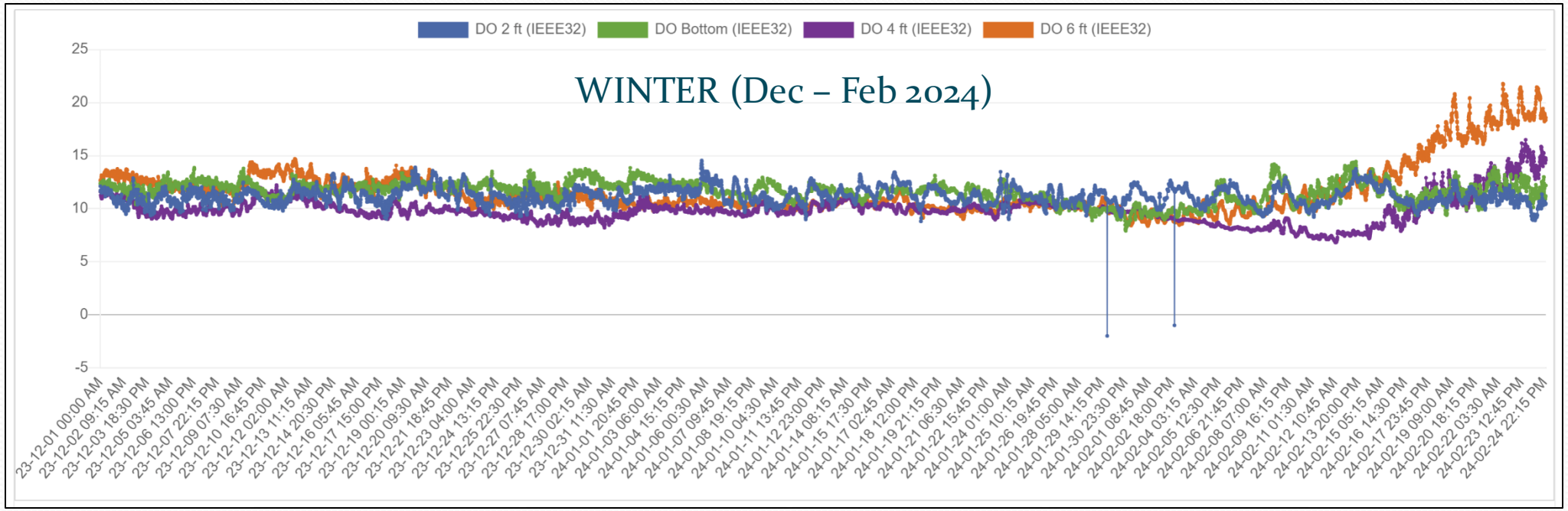
- Avg DO at 17' – **15.97 ppm**
- Avg DO at 13' – **10.73 ppm**
- Avg DO at 15' – **10.93 ppm**
- Avg DO at 11' – **4.53 ppm**

Dissolved Oxygen – Fall 2023



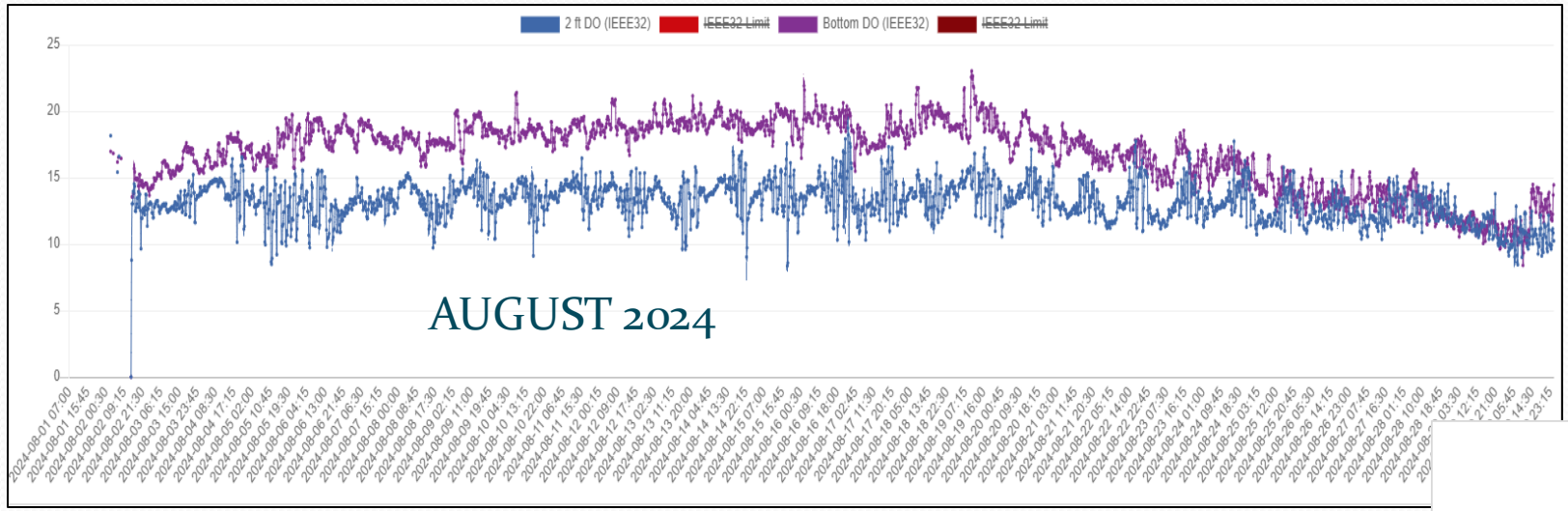
- Avg DO at 17' – **9.83 ppm**
- Avg DO at 13' – **8.43 ppm**
- Avg DO at 15' – **10.15 ppm**
- Avg DO at 11' – **10.41 ppm**

Dissolved Oxygen – Winter 2023/2024



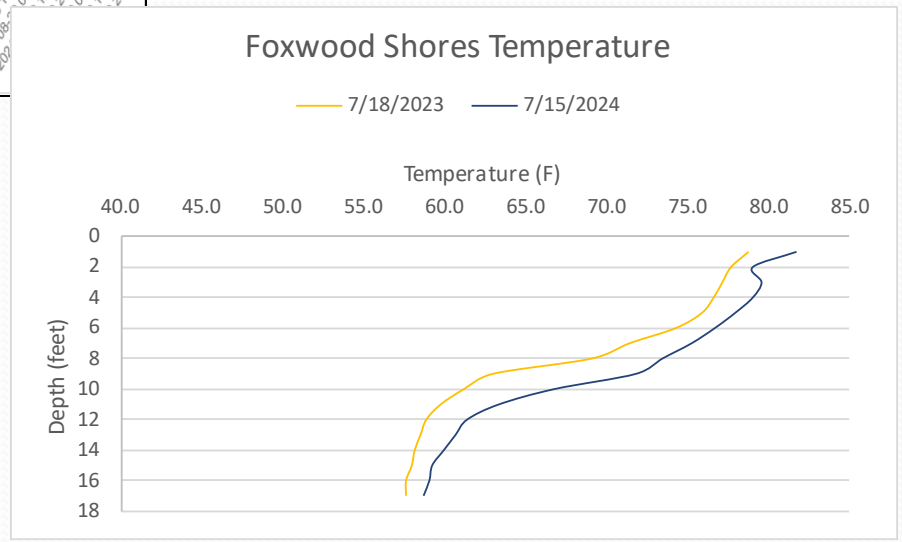
- Avg DO at 17' – **11.62 ppm**
- Avg DO at 13' – **9.87 ppm**
- Avg DO at 15' – **11.19 ppm**
- Avg DO at 11' – **11.70 ppm**

Dissolved Oxygen – August 2024



- Avg DO at 17' – **16.86 ppm**
- Avg DO at 15' – **13.16 ppm**

- No mixing occurring mid-summer of 2023 or 2024
  - 21.2° – 23.1° F difference
  - Avg DO in bottom 6' was 13.88 – 14.25 ppm



Soft Sediment

- 22-point grid established
- Graduated pole used to measure water and soft sediment depths
- Readings taken Aug 2022 (pre), Oct 2023, and Oct 2024

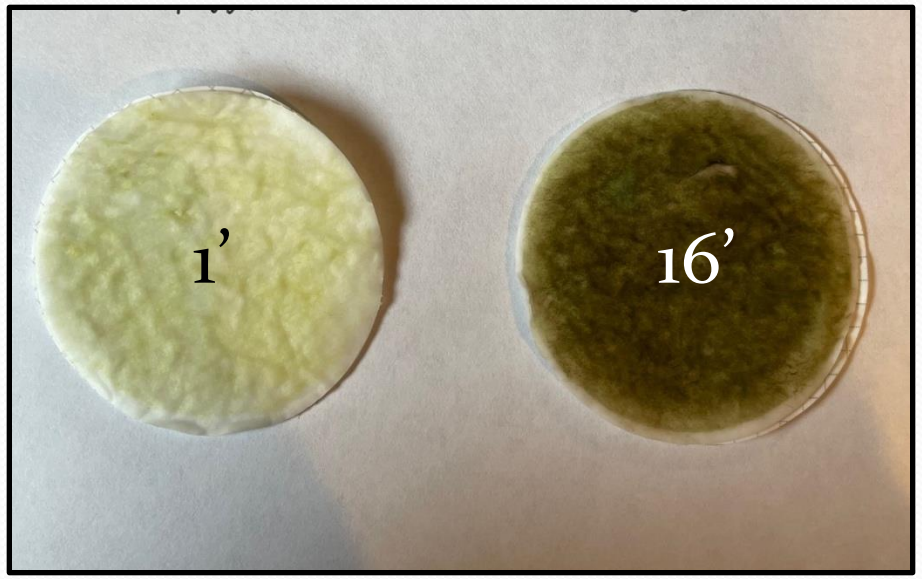
Soft Sediment

	TOTAL		INLET		REST OF POND	
Date	Avg Accumulation	Points w/ 1+' Accumulation	Avg Accumulation	Points w/ 1+' Accumulation	Avg Accumulation	Points w/ 1+' Accumulation
8/19/2022	1.01	15	1.31	4	0.94	11
10/16/2023	0.69	6	1.25	3	0.57	3
10/1/2024	0.64	3	1.05	3	0.55	0
REDUCTION	36.6%	80.0%	19.8%	25.0%	41.5%	100.0%

- Separated inlet from rest of pond due to depth and constant inflow
- 36.6% reduction in total soft sediment accumulation (41.5% excl inlet)
  - 18/22 points (82%) had reductions while only 1/22 had an increase (inlet)
- 15 points with 1+' of accumulation pre-OST and only 3 points 2 years later (all in inlet)

Water Quality

- Samples collected over deep hole at 1’ and 16’ utilizing Van Dorn bottle
- Pre-OST samples taken late Aug of 2022
  - Filters show deep algal bloom – nutrient release
- Post-OST samples taken in April and October of 2023 and 2024
- State certified lab analyzed RP, TP, NH_3, NO_2+NO_3, TKN, and TN



Water Quality

AVERAGES (in PPM)	React P	Total P	NH3	NO2 + NO3 (N)	TKN	Total N
PRE - August 2022	0.0700	0.1100	1.150	0.00	2.30	2.30
POST - April 2023	0.0000	0.0120	0.000	1.50	0.44	1.94
POST - October 2023	0.0000	0.0420	0.635	0.16	1.70	1.86
POST - April 2024	0.0000	0.0270	0.033	0.85	0.68	1.52
POST - October 2024	0.0059	0.0264	0.504	0.22	1.56	1.78

BOTTOM (in PPM)	React P	Total P	NH3	NO2 + NO3 (N)	TKN	Total N
PRE - August 2022	0.1400	0.2200	2.300	0.00	4.10	4.10
POST - October 2024	0.0066	0.0302	0.756	0.24	2.10	2.34
% REDUCTION (Pre to Oct 2024)	**95.29%**	**86.27%**	**67.13%**	**n/a - increase**	**48.78%**	**42.93%**

Project Conclusions

- DO averaging 9.53 – 15.88 ppm in bottom 6' throughout 22-month project
- Resistance to full pond mixing – thermal stratification of 21° – 23° F in July
- 41% reduction in soft sediment with 95% of points decreasing or constant
- Decreases of 92% in RP and 76% in TP – more pronounced at bottom
- Decreases of 56% in NH_3, 32% in TKN, and 23% in TN – more pronounced at bottom

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Questions?