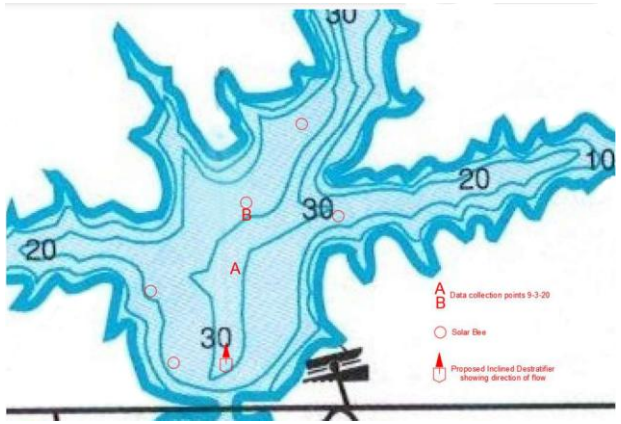
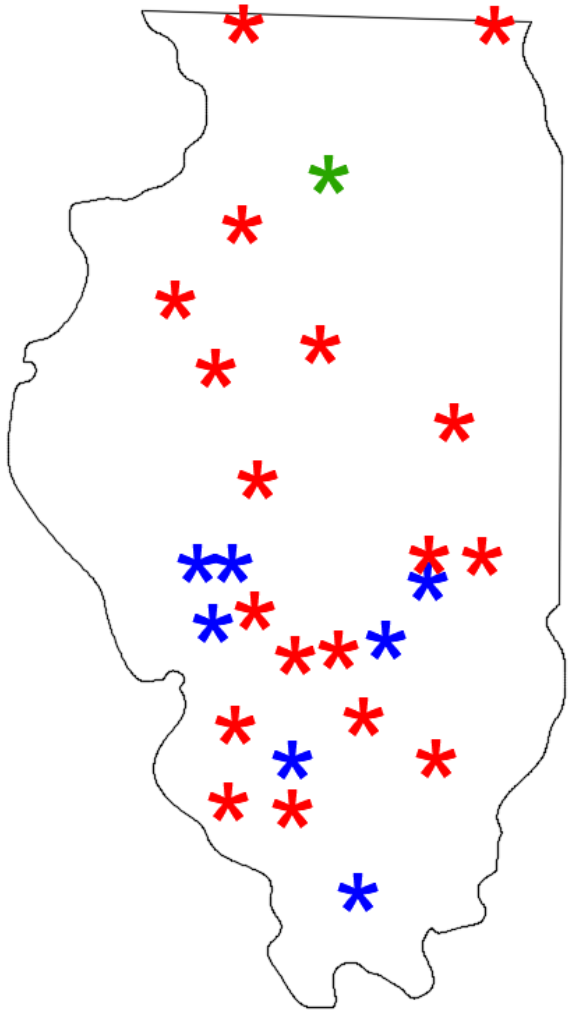
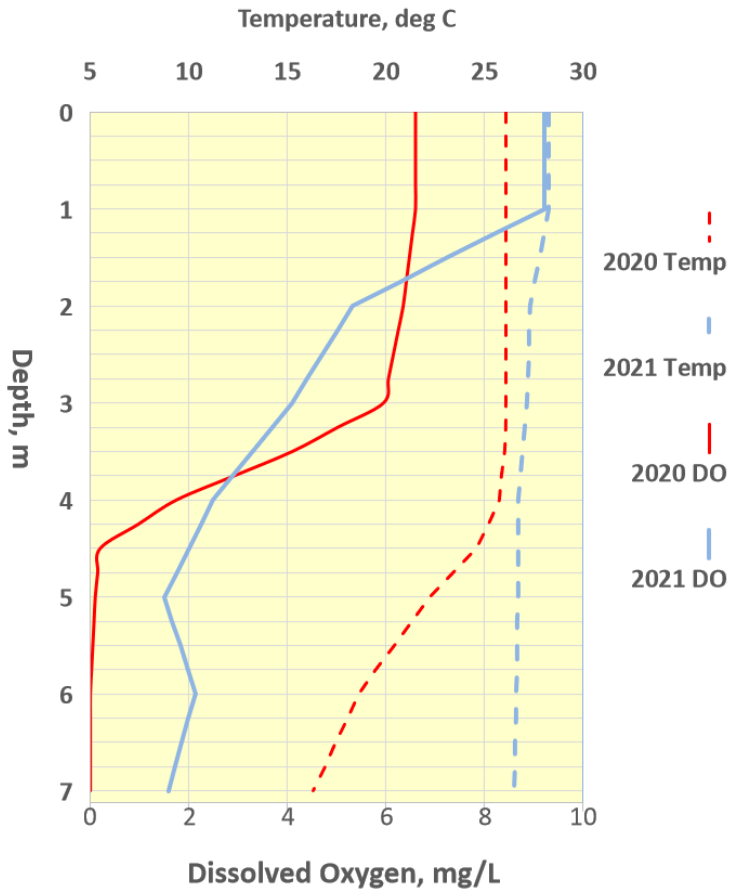
Mechanical Destratification:

An Illinois Legacy in Improving Water Quality in Lakes and Reservoirs

Limnetics







DESTRATIFIERS

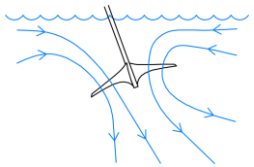
Limnetics

TYPICAL SPECS:

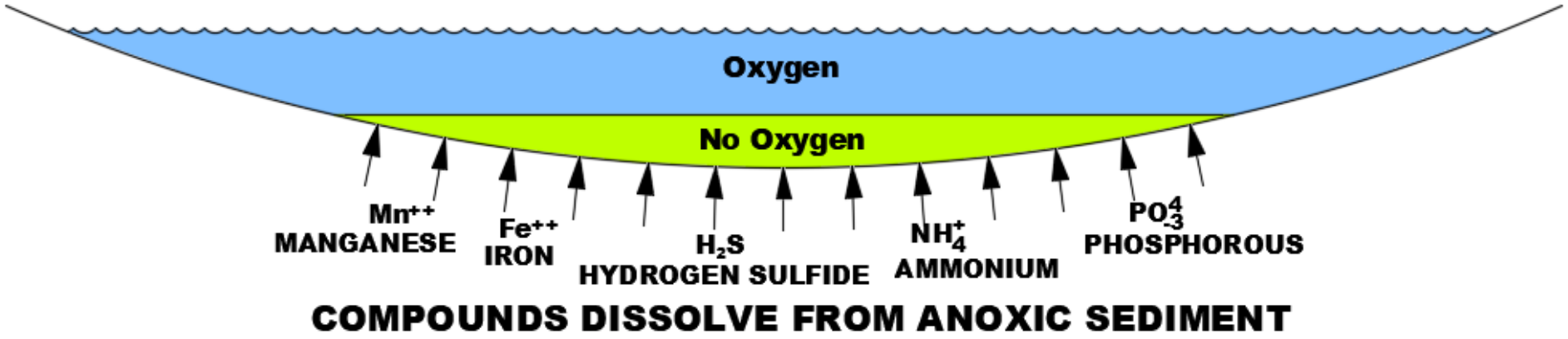
- Prop Diameter: 6 ft
- Power: 3 HP
- Flow: 25,000 GPM
  = 110 acre-ft/day

Mechanical Destratification

Limnetics

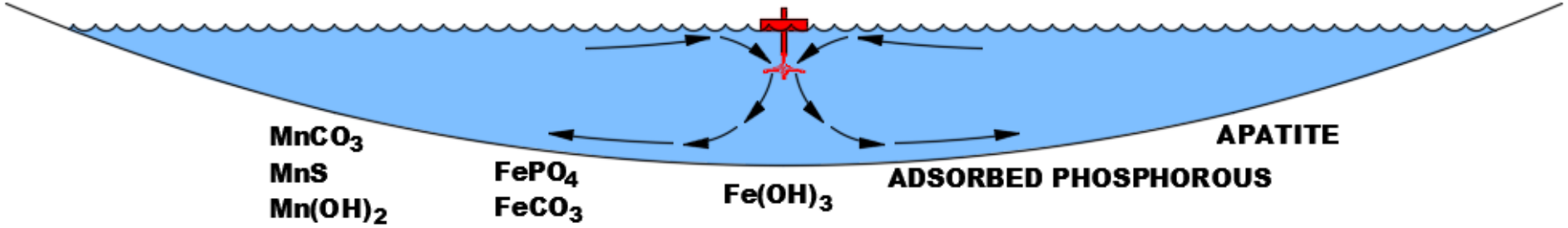


THE PROBLEM

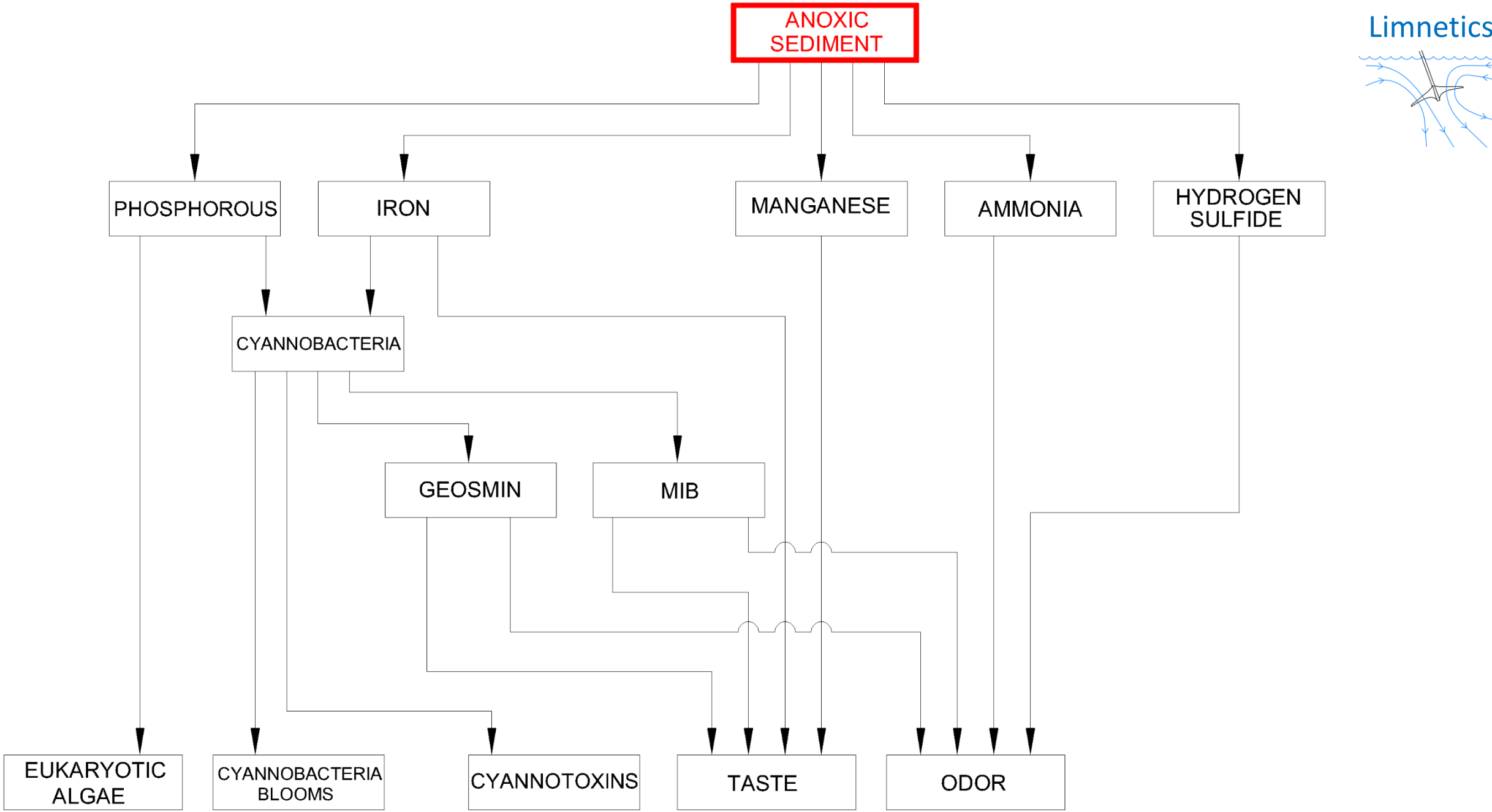


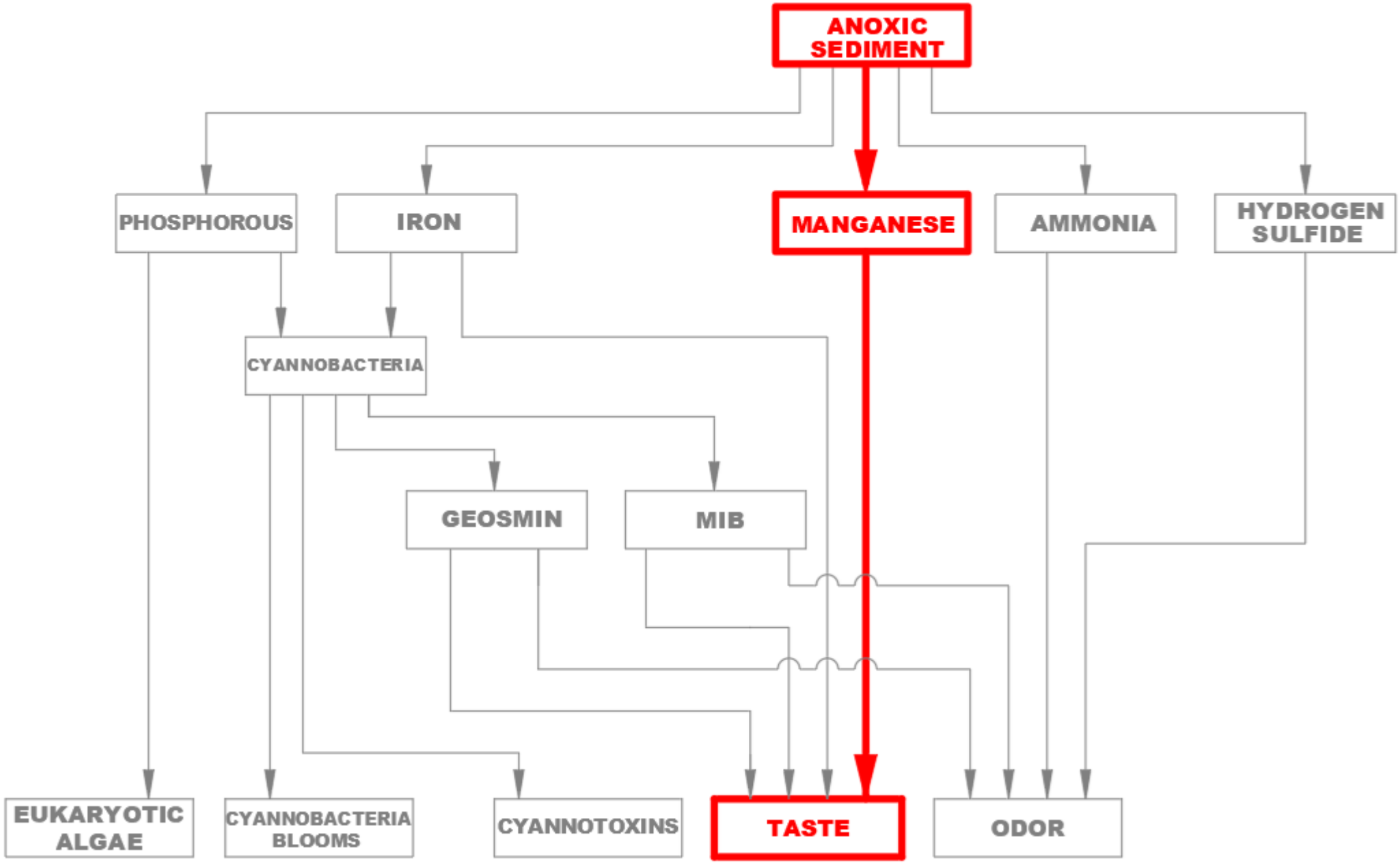
COMPOUNDS DISSOLVE FROM ANOXIC SEDIMENT

THE SOLUTION



OXIDIZED COMPOUNDS REMAIN SOLID ON BOTTOM


ANOXIC SEDIMENT
Limnetics
PHOSPHOROUS
IRON
MANGANESE
AMMONIA
HYDROGEN SULFIDE
CYANNOBACTERIA
GEOSMIN
MIB
EUKARYOTIC ALGAE
CYANNOBACTERIA BLOOMS
CYANNOTOXINS
TASTE
ODOR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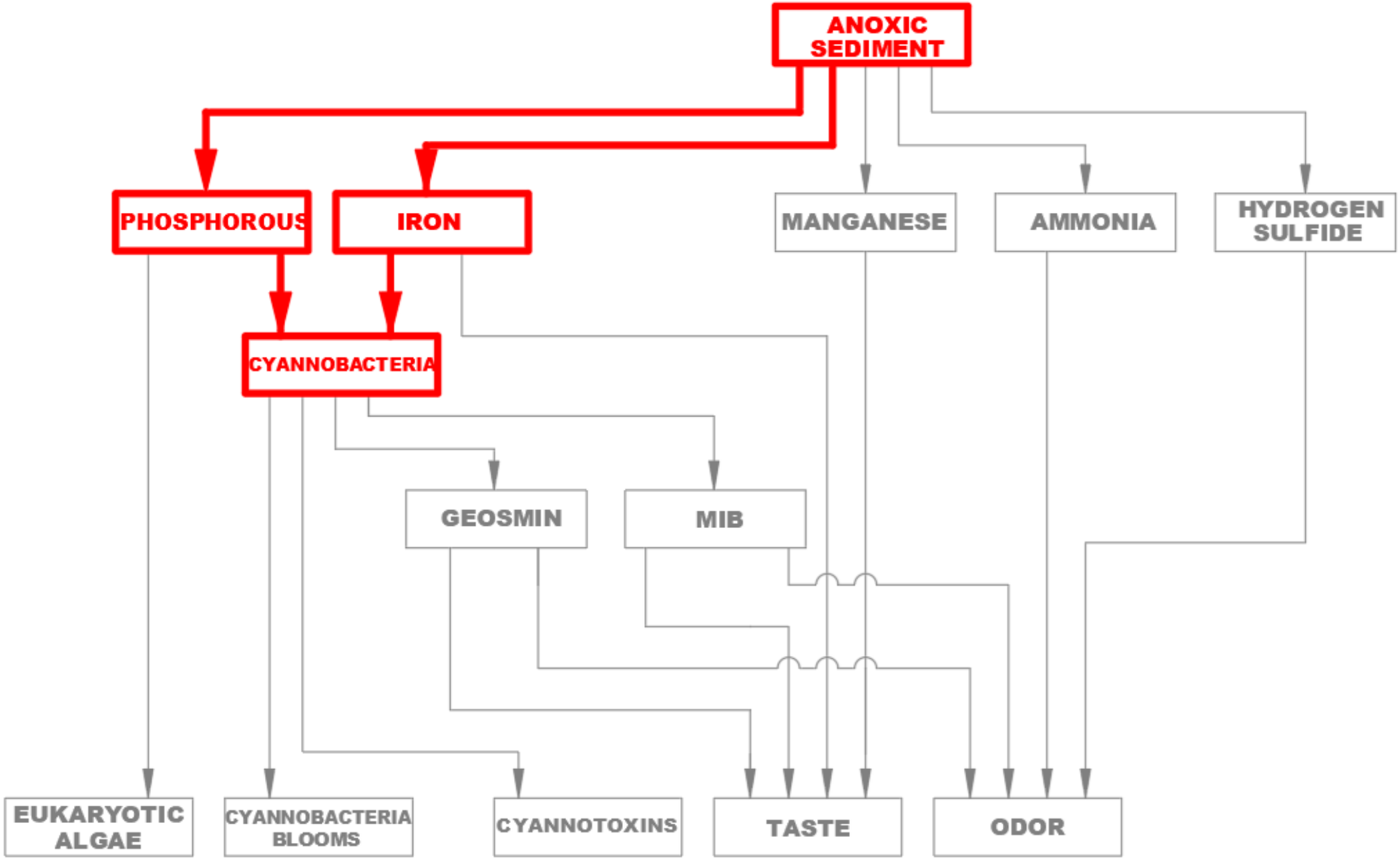
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HYDROGEN SULFIDE
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EUKARYOTIC ALGAE
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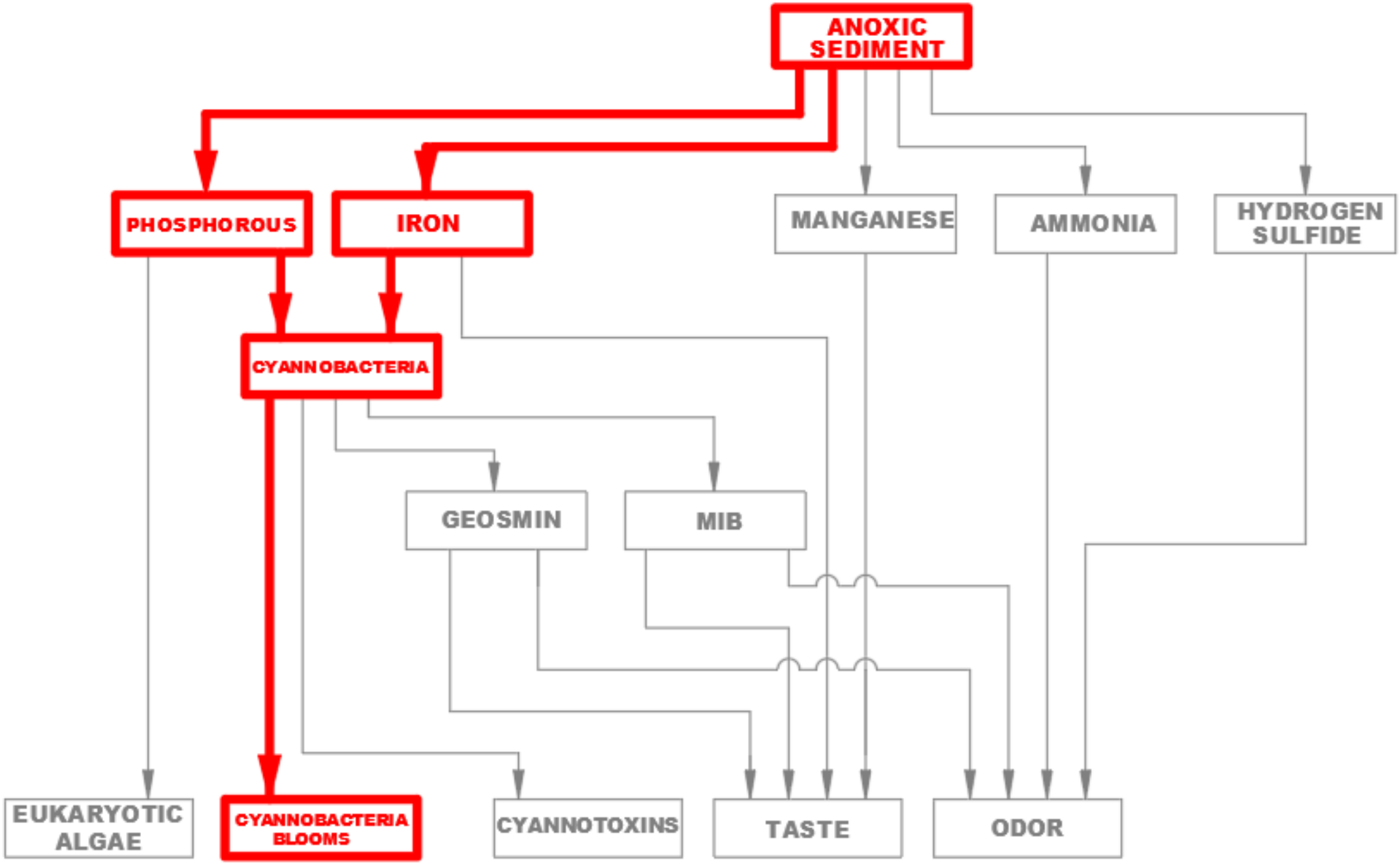
Limnetics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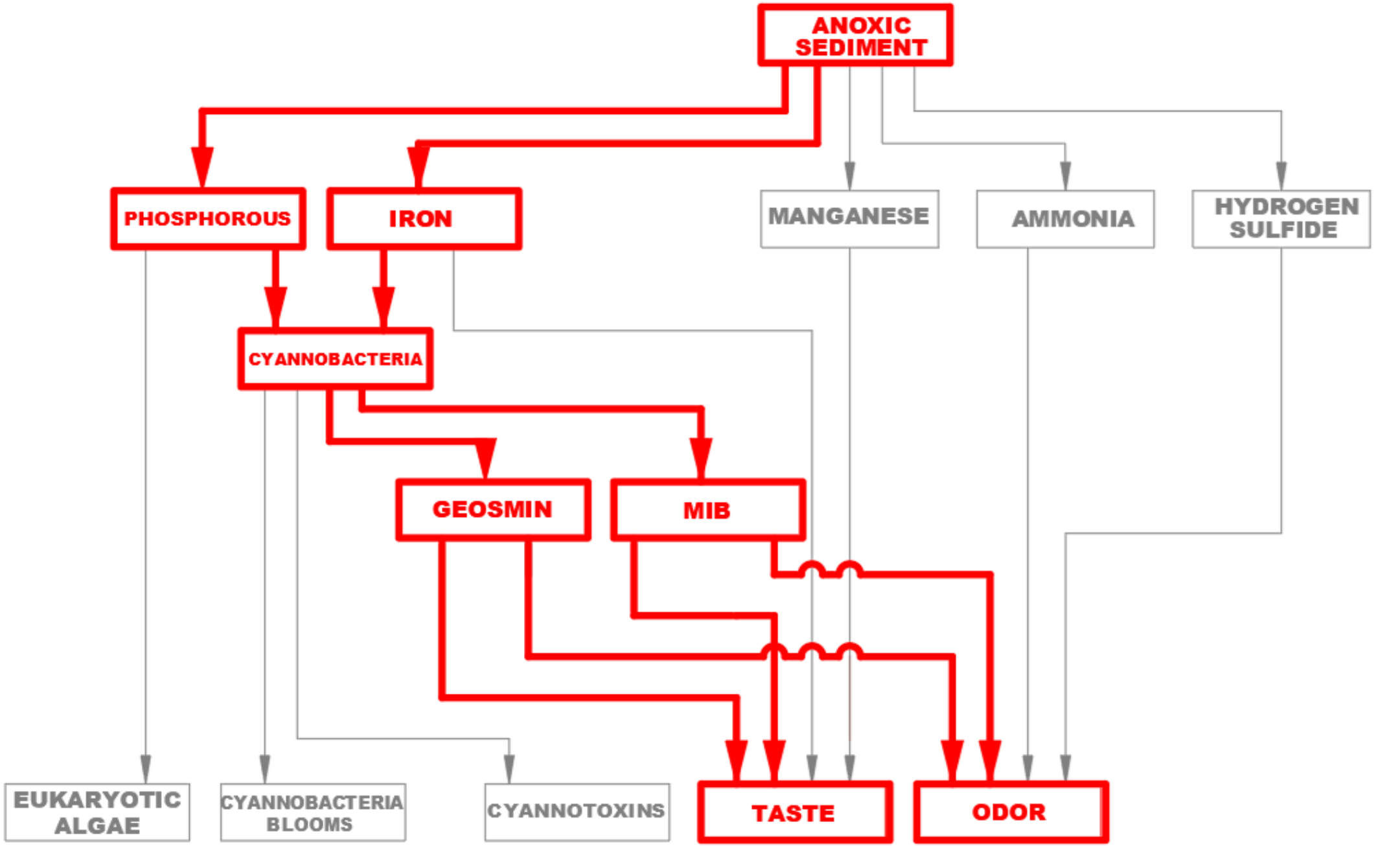
Limnetics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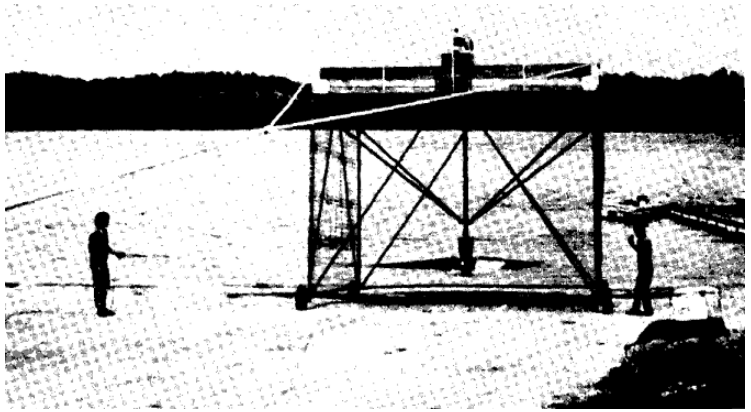
ODOR

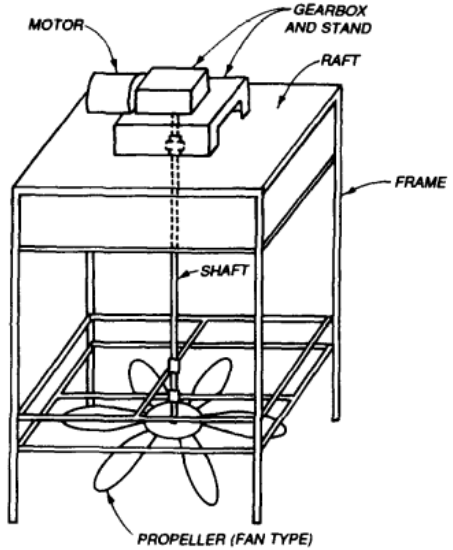
Limnetics

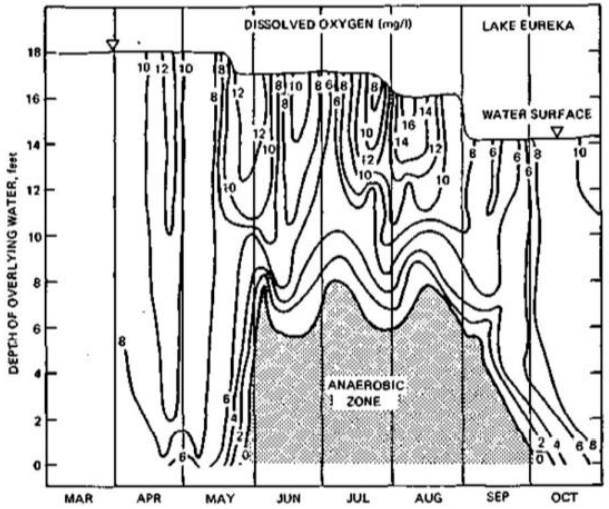
DESTRATIFIER HISTORICAL MILESTONES

RESEARCH:

1970-78	Prof. James Garton of **Oklahoma State U** destratifies two reservoirs with fan blade **"Garton Pump"**
1980-85	Richard Punnett, **Army Corps of Engineers**, develops performance equations
1981-95	Raman Raman, **Illinois State Water Survey** demonstrates benefits in drinking water reservoirs





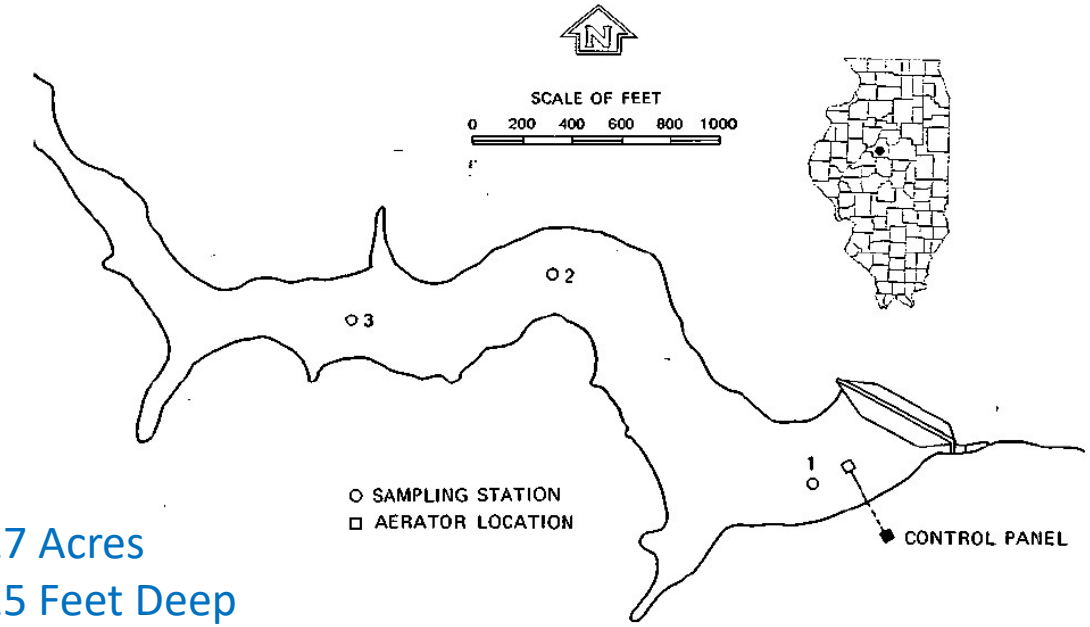


Limnetics

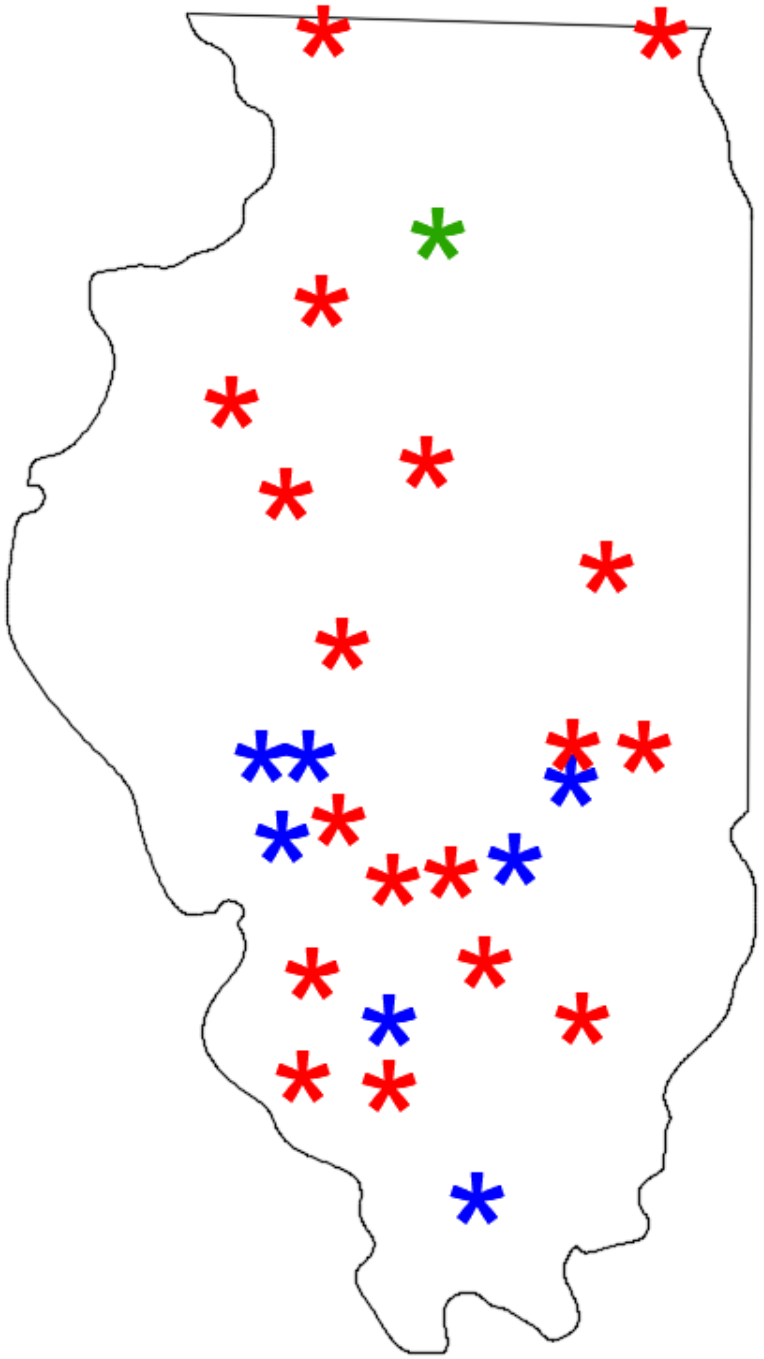
Lake Eureka

1981 Results

- 97% reduction in manganese & iron
- 50%+ reduction in chlorine demand
- Algal species shift away from blue-green



27 Acres
15 Feet Deep



Limnetics

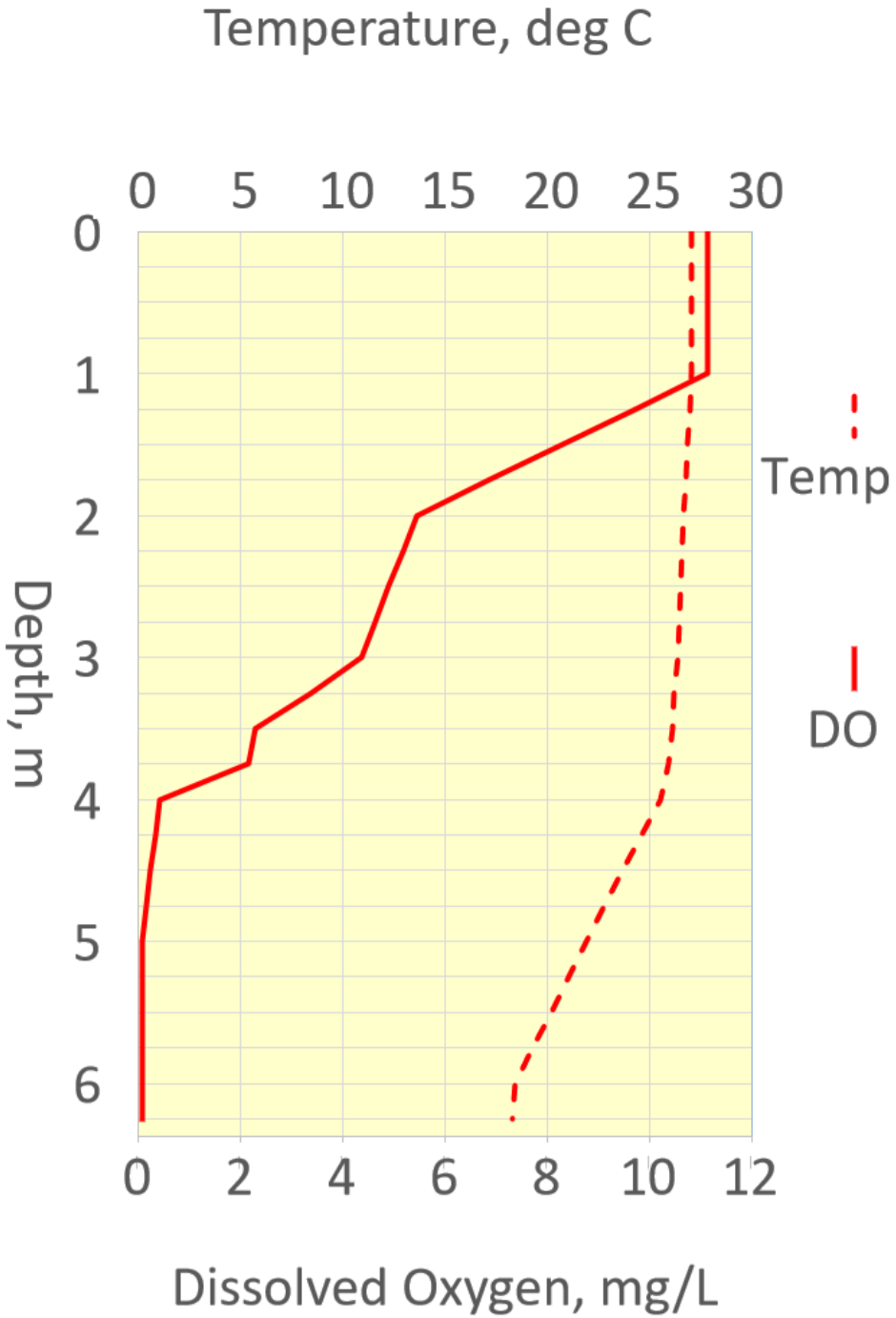
DESTRATIFIERS IN ILLINOIS

Past & Present

* Baker
* Limnetics
* WEARS

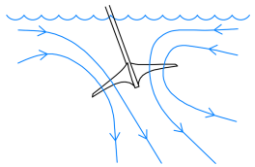
Typical Summer Dissolved Oxygen Profile

Lake Centralia, IL
Aug. 5, 2021



Limnetics

Limnetics

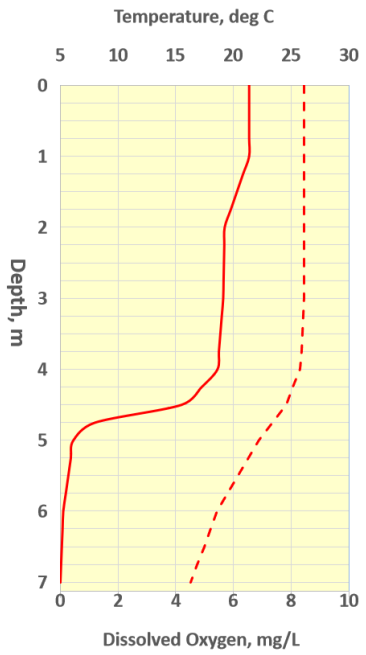


Typical Dissolved Oxygen Profiles

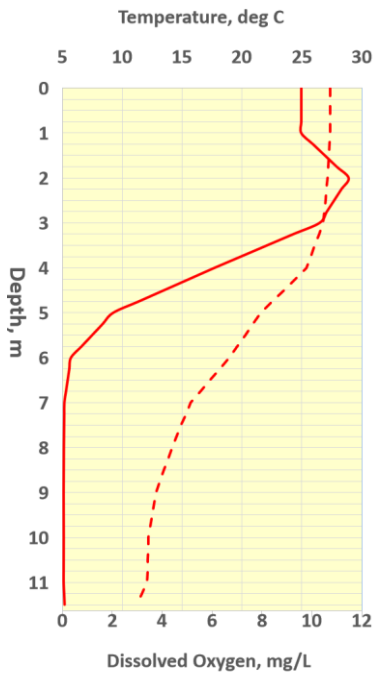
Dissolved Oxygen(DO) ——— Temperature - - - - - -

STRATIFIED LAKES

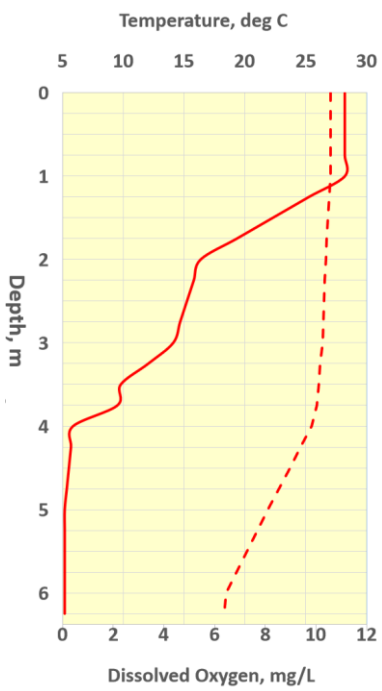
Glen Shoals Lake, Illinois



Juno Lake, Michigan

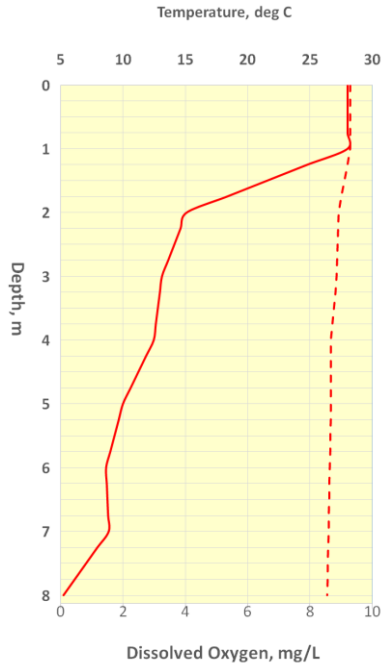


Lake Centralia, Illinois

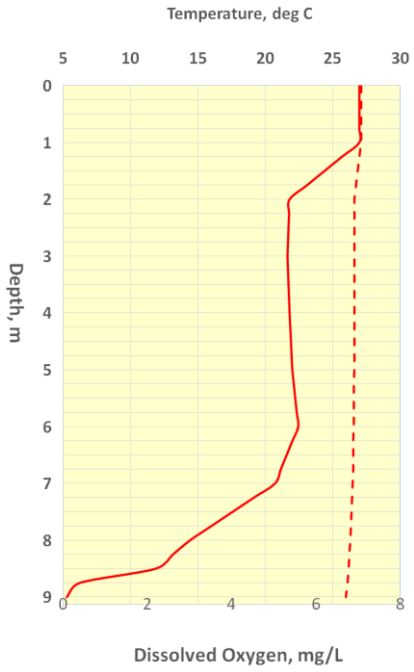


DESTRATIFIED LAKES

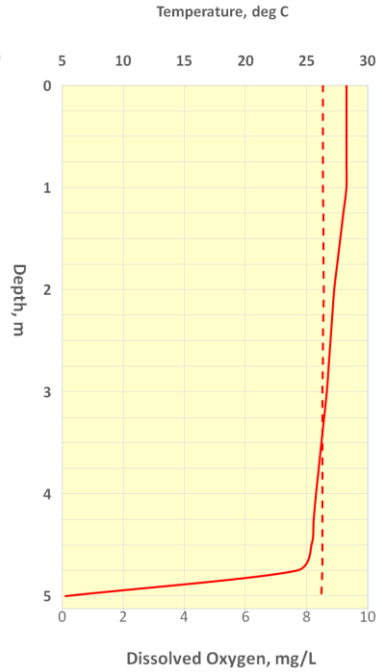
Upper Otter Lake, Illinois



Altamont Reservoir, Illinois



Lake Paradise, Illinois



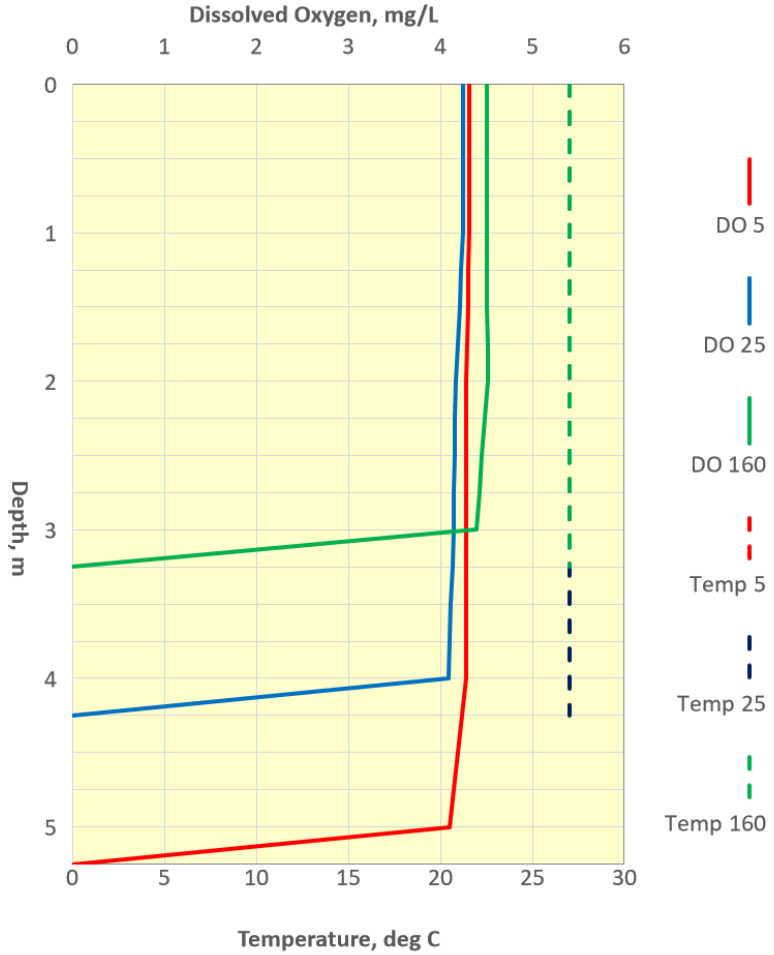
DESTRATIFIED RESERVOIRS:

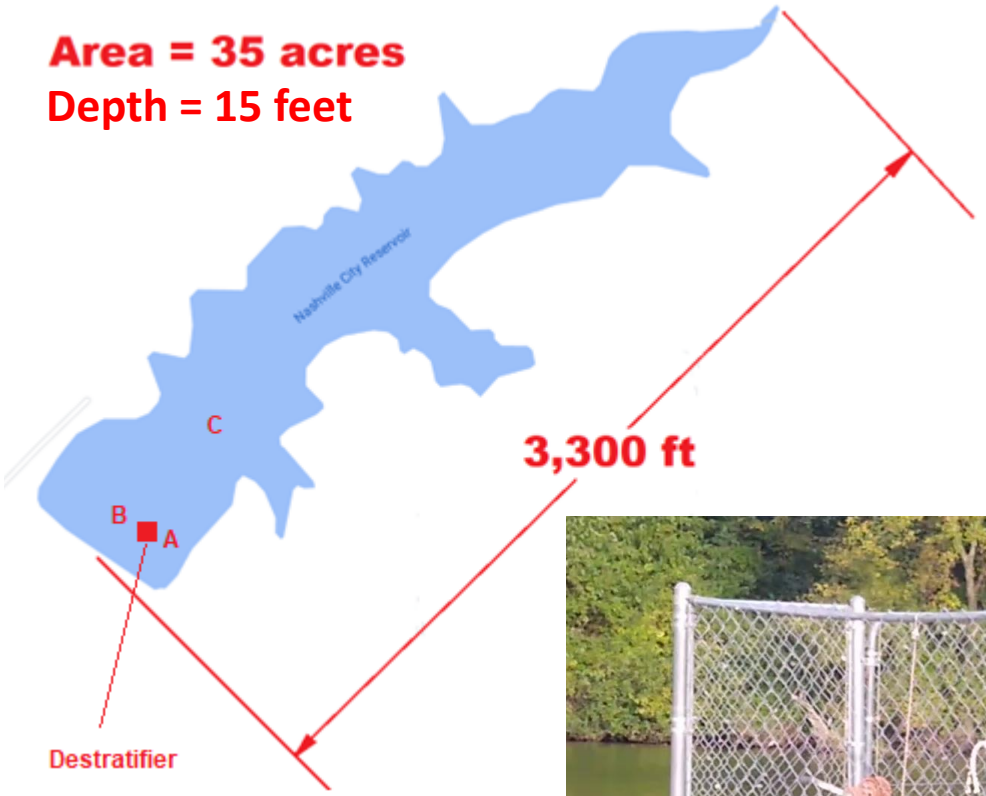
Nashville City Reservoir

Nashville, Illinois

Limnetics

8-4-21 2/3 Speed

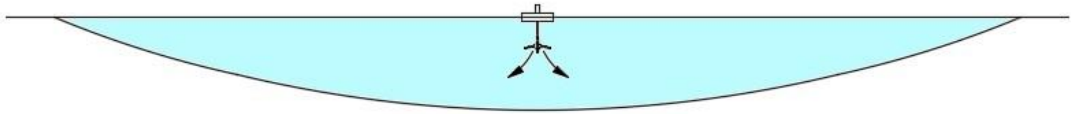




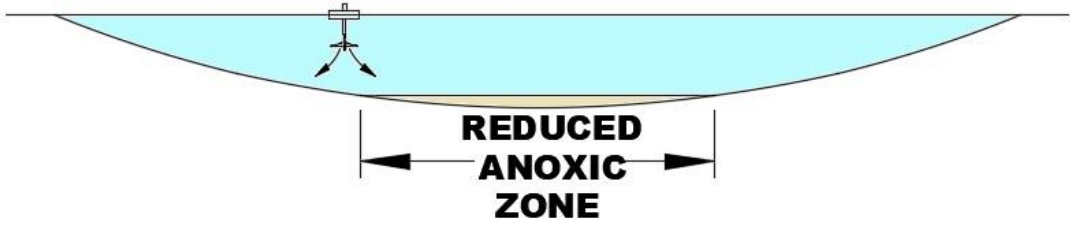
Limnetics

DESTRATIFIER PLACEMENT

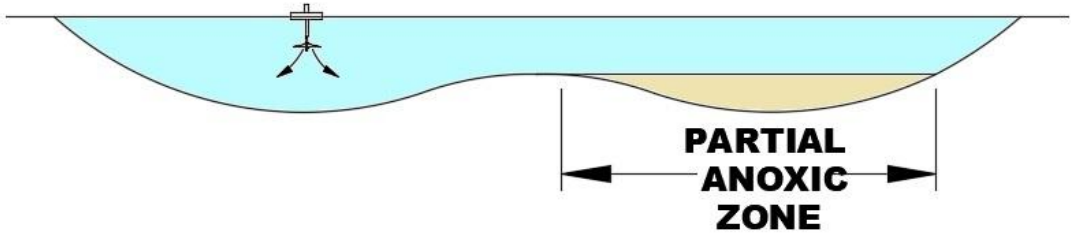
SINGLE BASIN , DESTRATIFIER AT DEEPEST POINT



SINGLE BASIN , DESTRATIFIER NOT AT DEEPEST POINT



SPLIT BASIN , ONE DESTRATIFIER

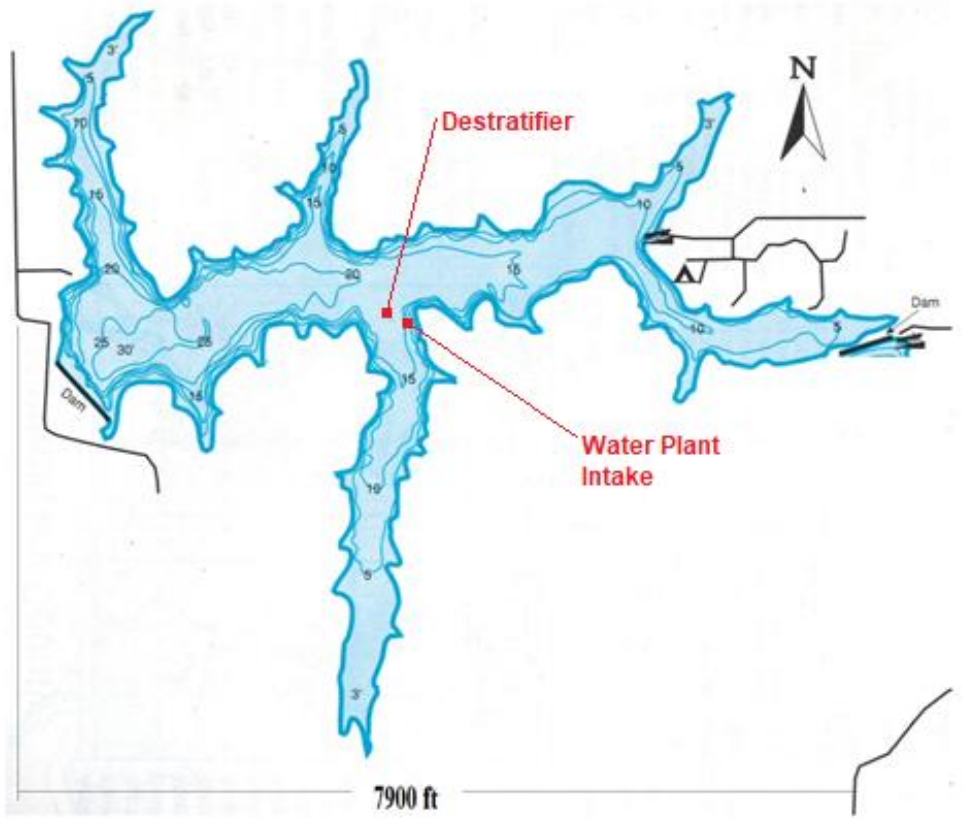


DRINKING WATER RESERVOIRS

Limnetics

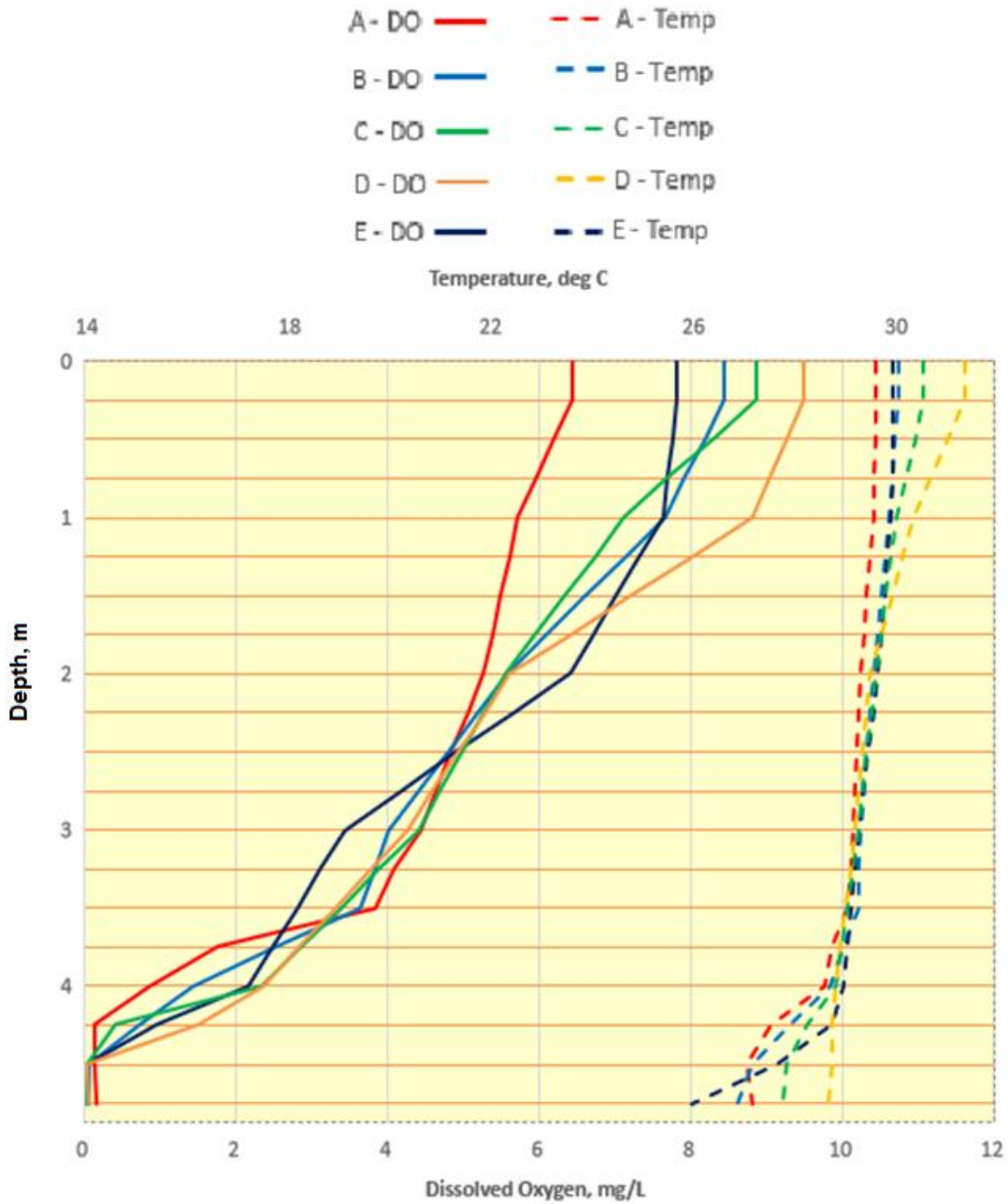
Gillespie New Lake, Illinois

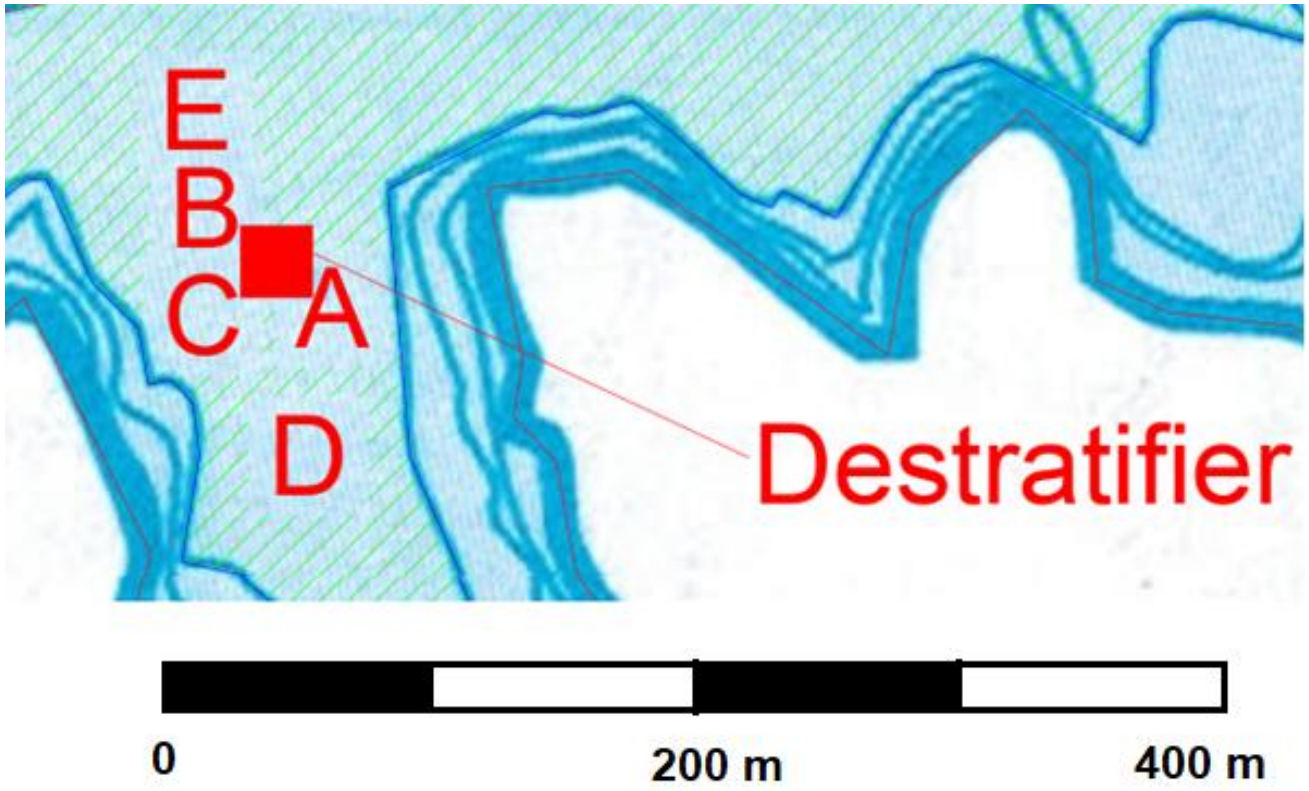
Surface Area	334 Acres	(135 ha)
Depth	31.5 ft	(9.6 m)



Lake Gillespie

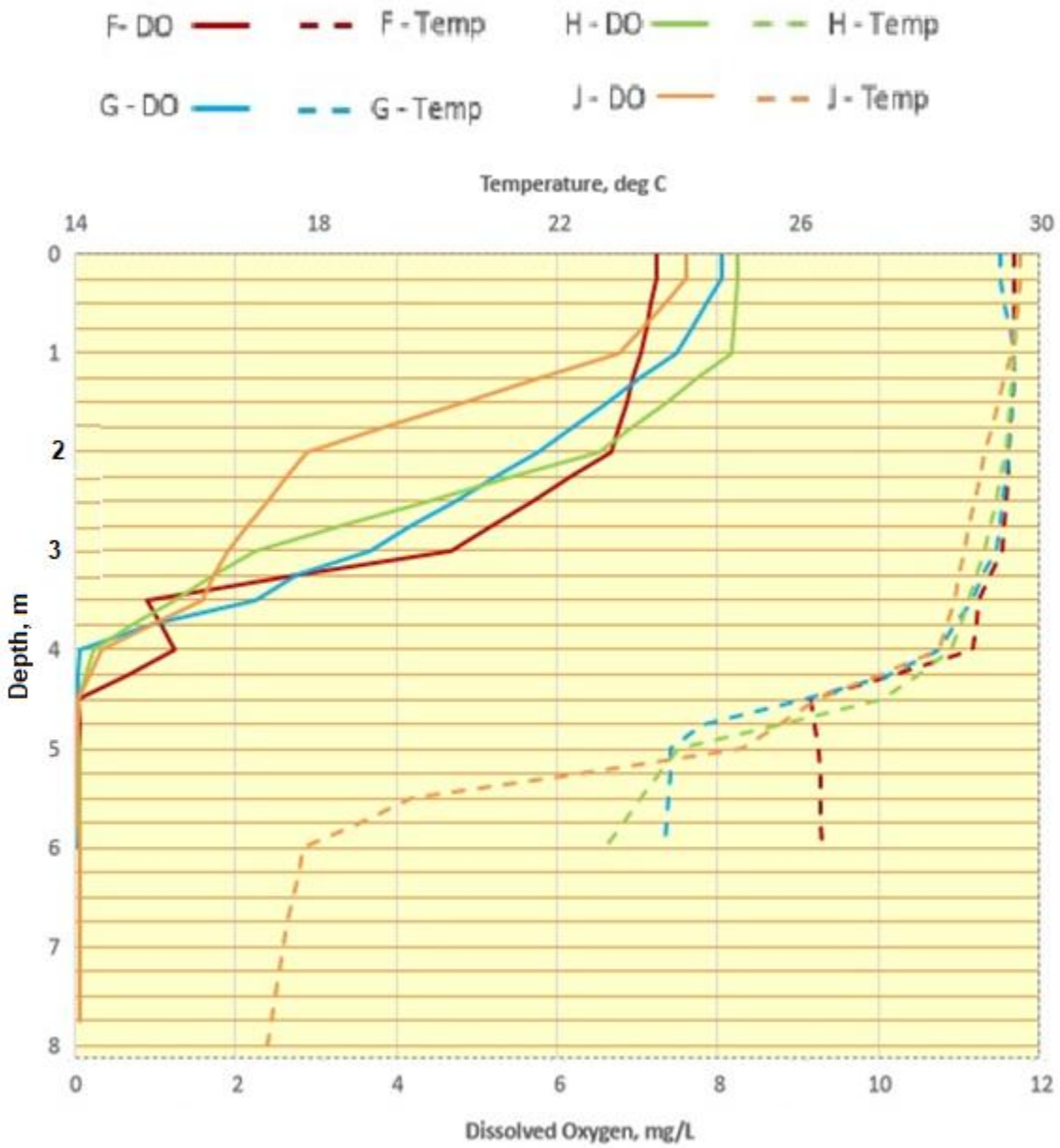
Limnetics

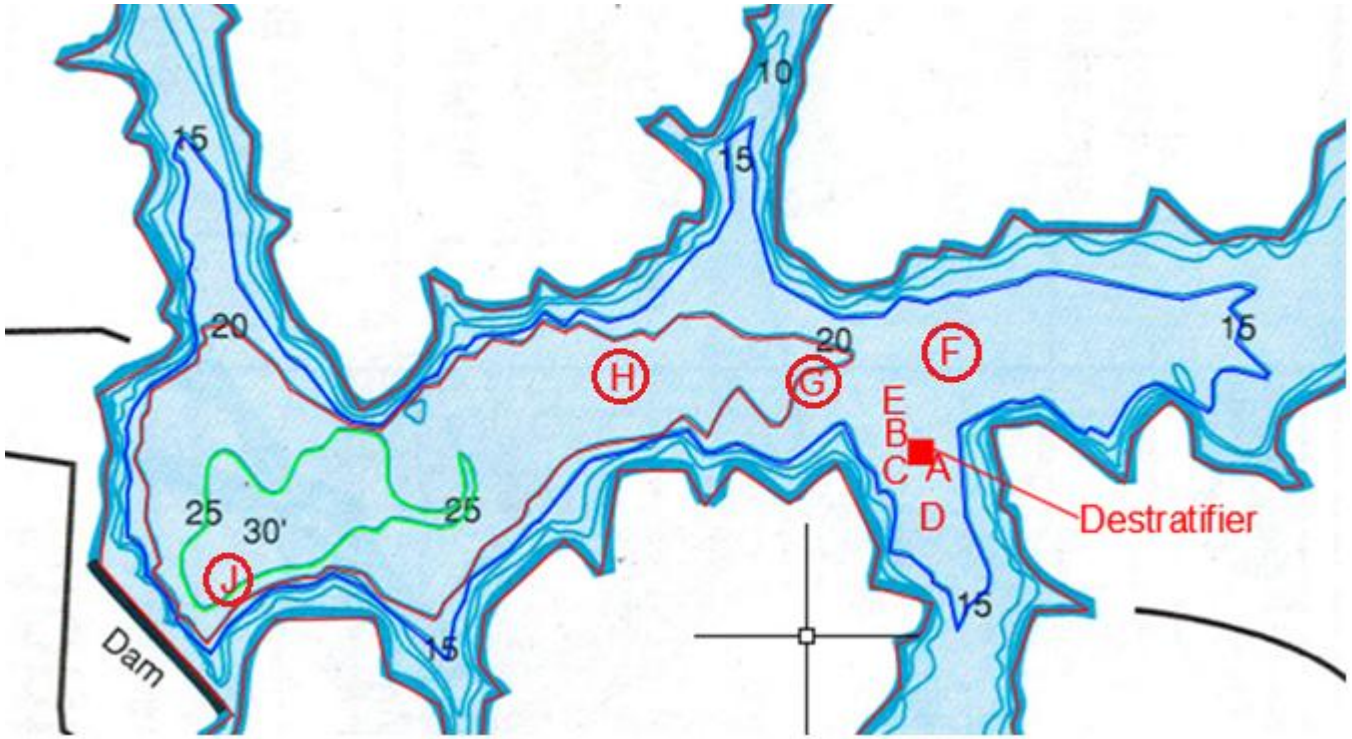




Gillespie New Lake

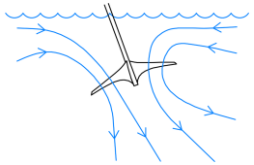
Limnetics



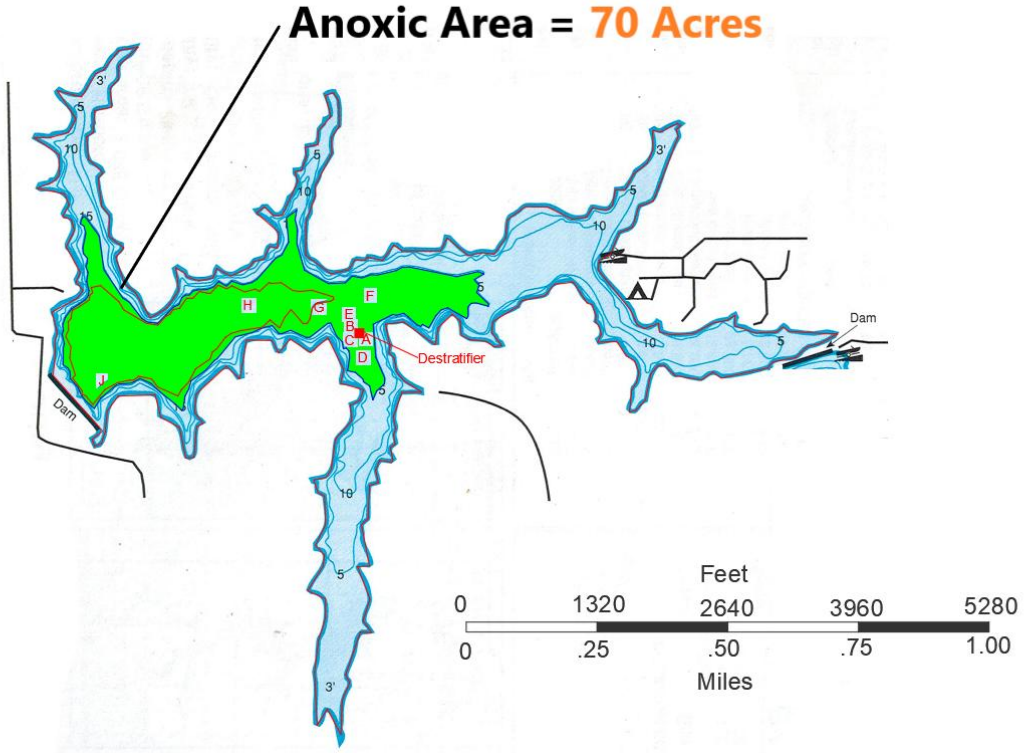


Lake Gillespie, Illinois

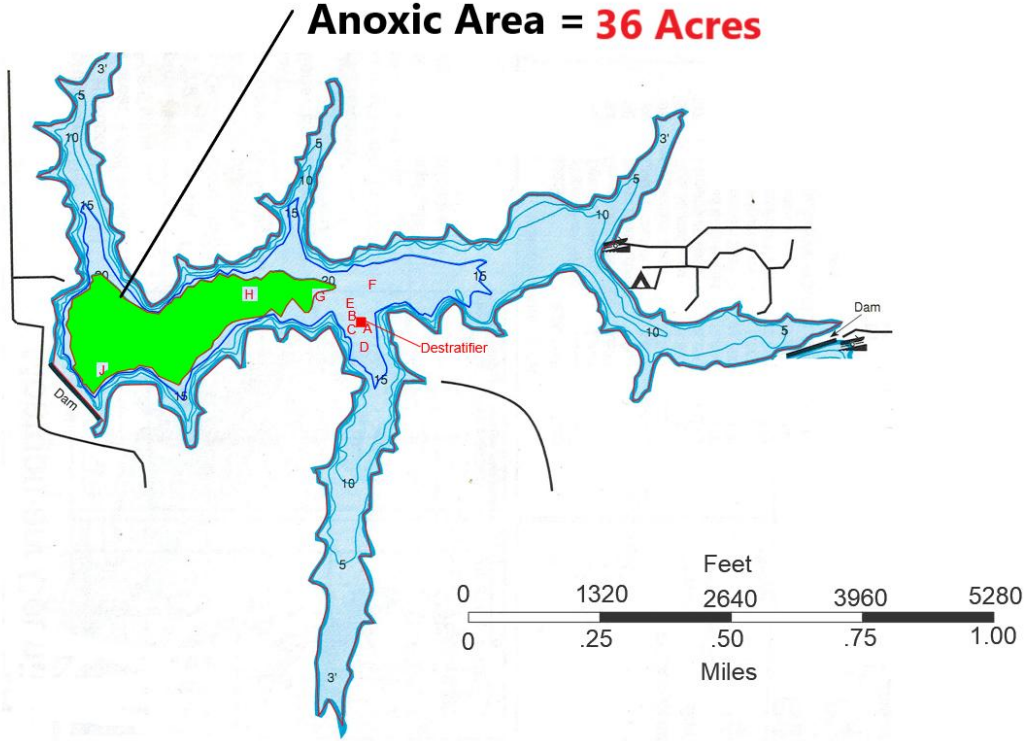
Limnetics

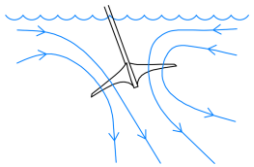


No Destratifier (estimated)

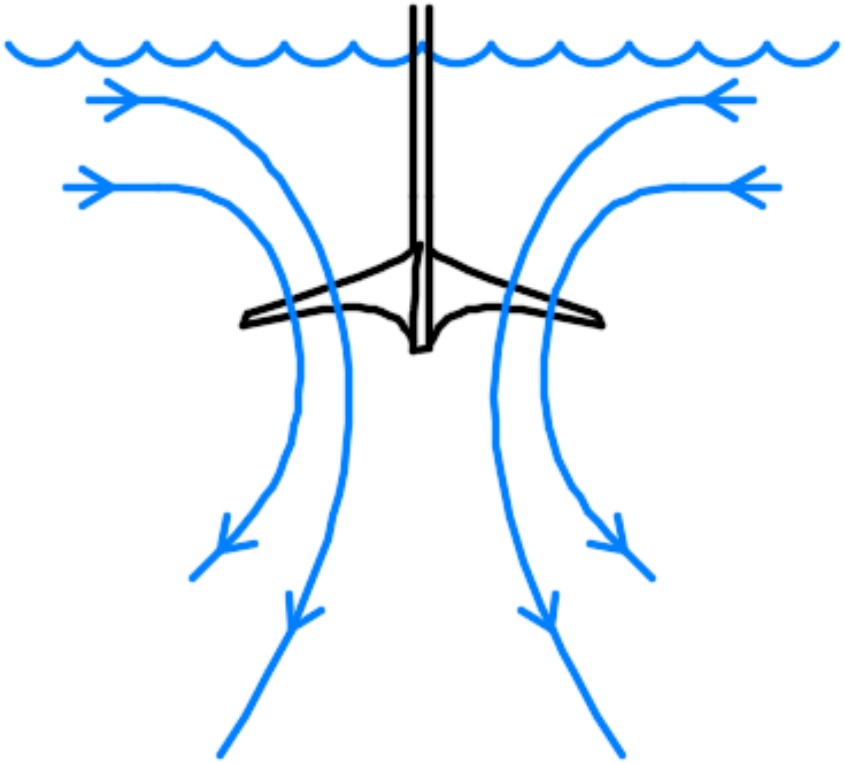


With Destratifier

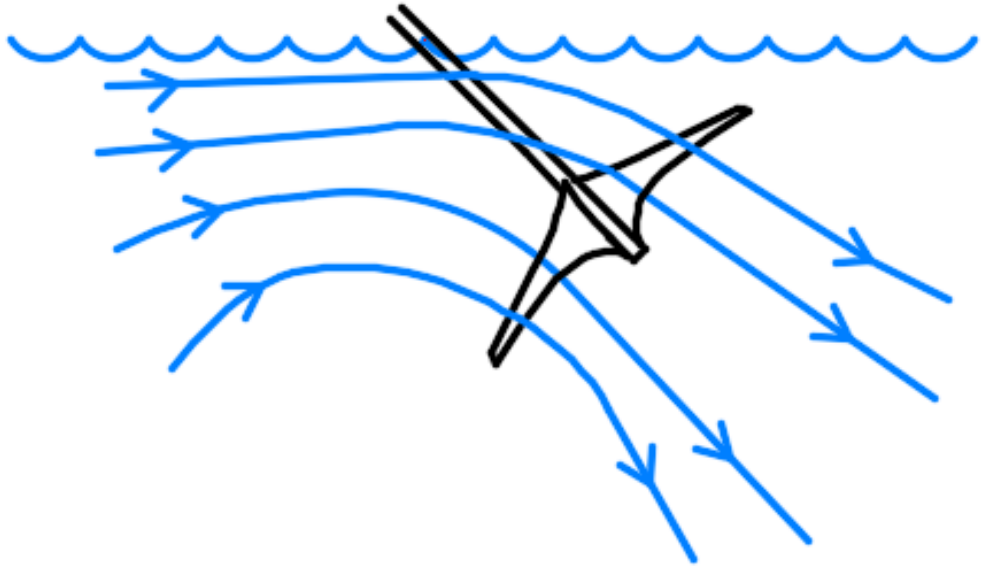




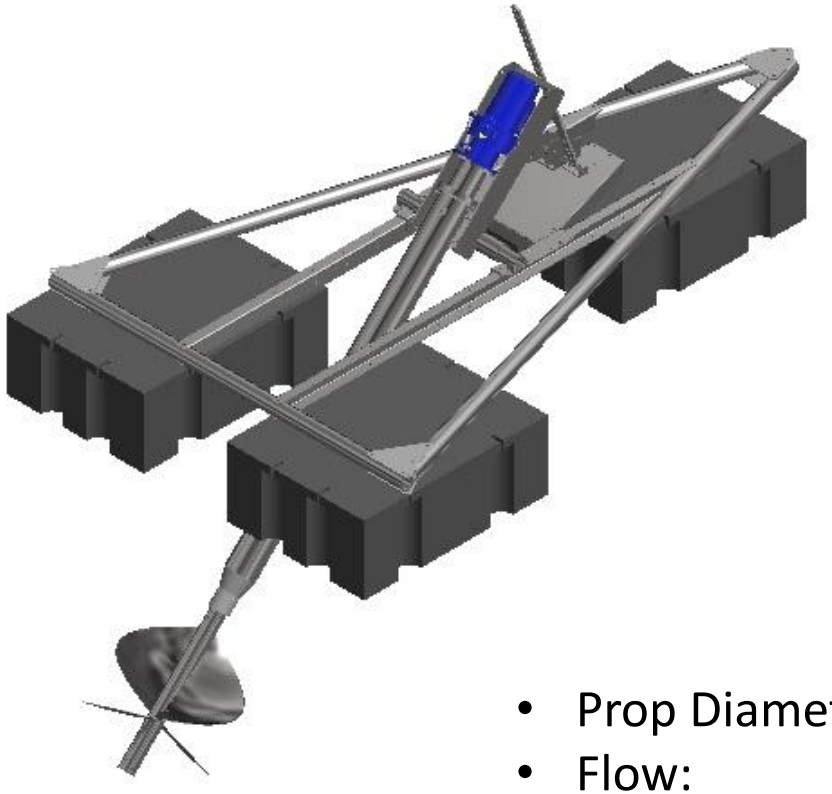
CONVENTIONAL



INCLINED



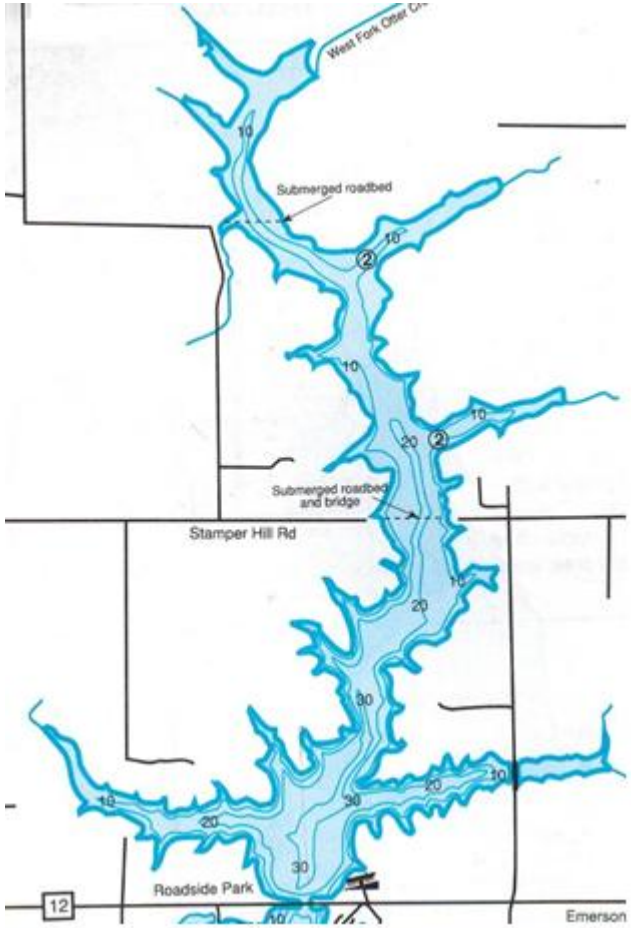
LIMNETICS INCLINED DESTRATIFIER

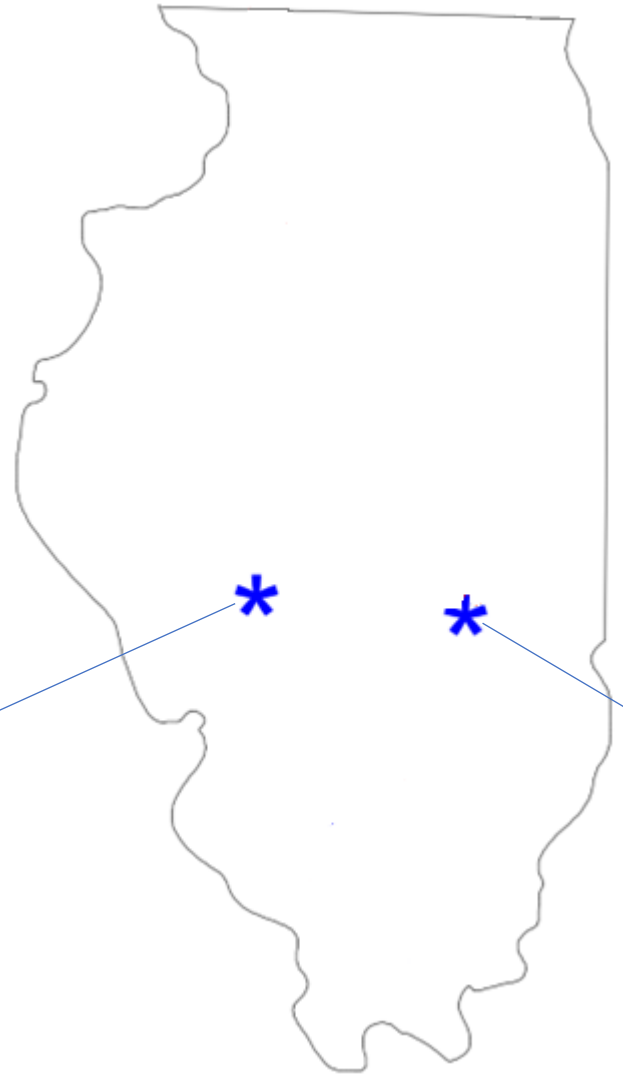


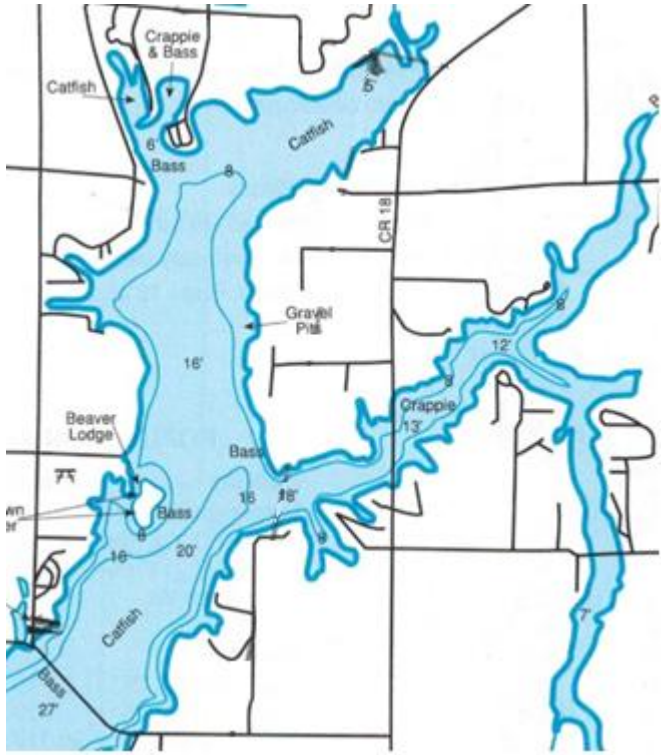
- Prop Diameter: 6’-3”
- Flow: 25,000 GPM = 110 acre-ft/day
- Power: 3 HP
- Tilt Angle: Vertical –to-30 degrees from Horizontal

EXPERIMENT LOCATIONS

Limnetics







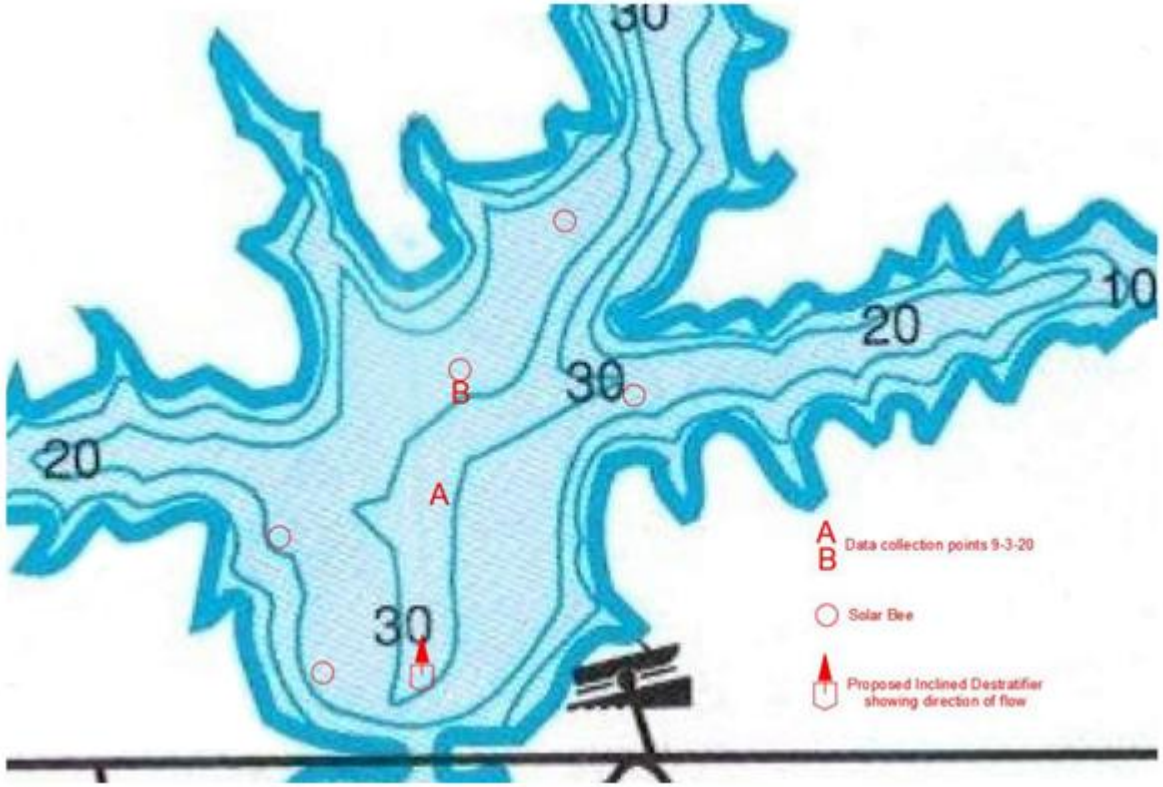
UPPER OTTER LAKE
312 acres
Max Depth = 25 ft

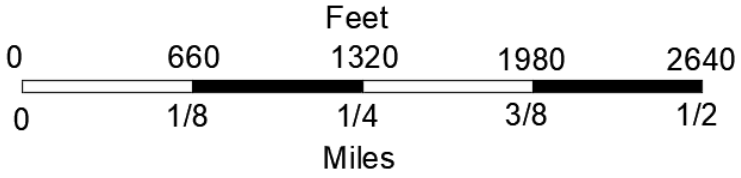
UPPER LAKE MATTOON
470 acres
Max Depth = 17 ft

DESTRATIFIED RESERVOIRS:
Upper Otter Lake, Illinois

Limnetics

325 Acres
25 Feet Deep



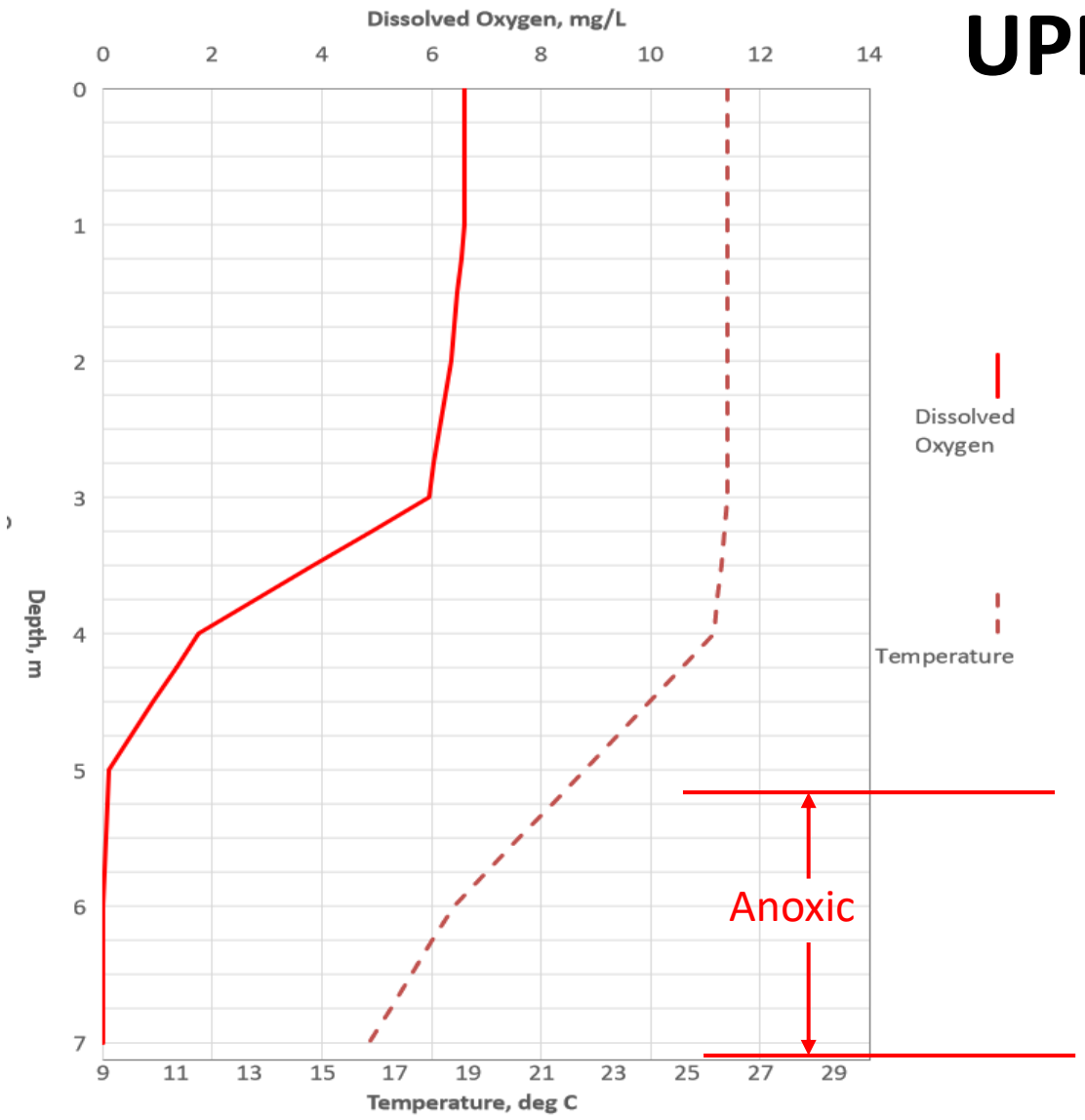


UPPER OTTER LAKE – 2020

BEFORE Destratifier

9-3-2020

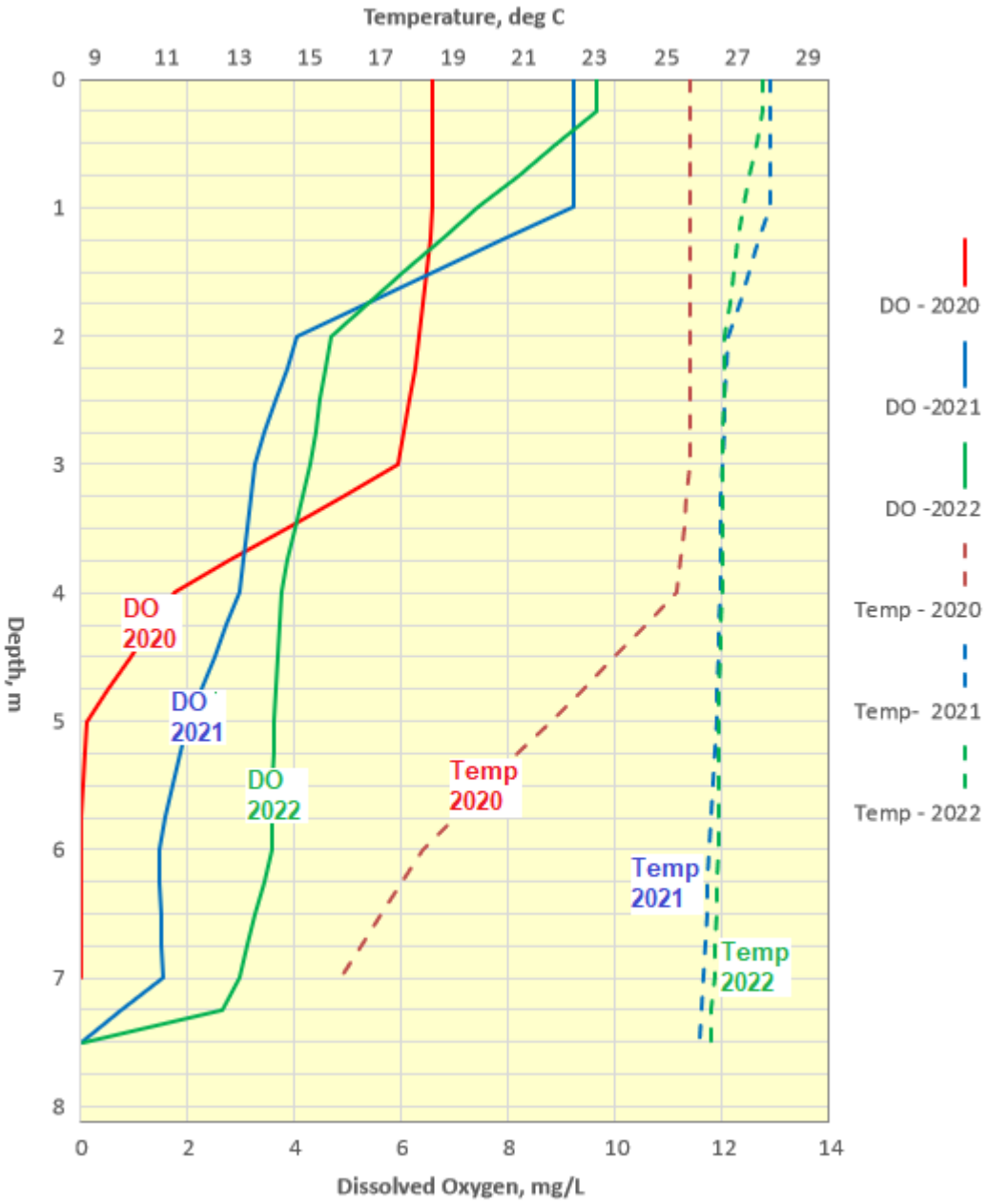
Limnetics



UPPER OTTER LAKE

Late Summer Comparison

Limnetics



Middle of Main Basin

Sept 3, 2020 – No Destratifier

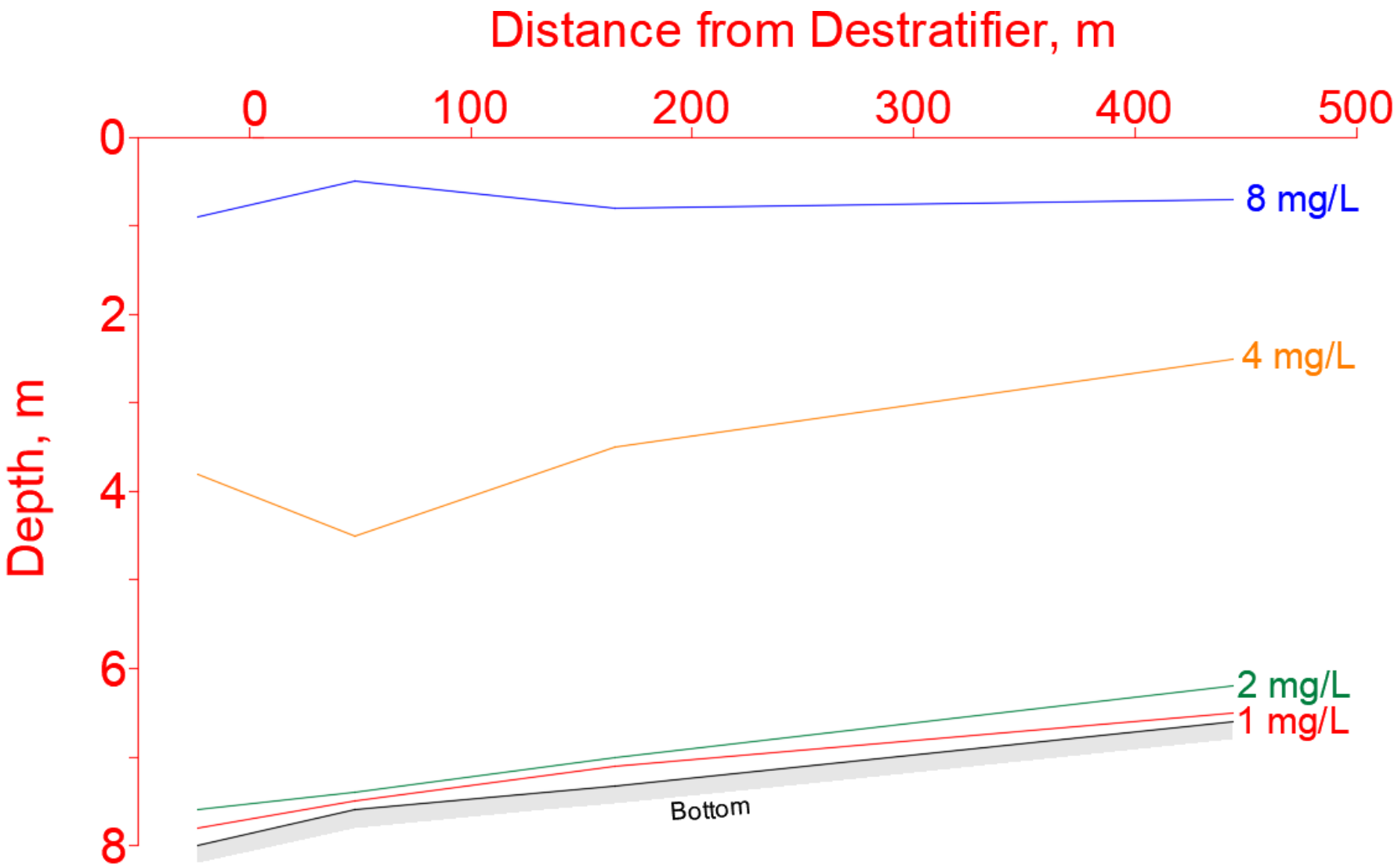
Aug 3, 2021 – Destratifier

Aug 16, 2022 - Destratifier

UPPER OTTER LAKE

August 16, 2022

Limnetics

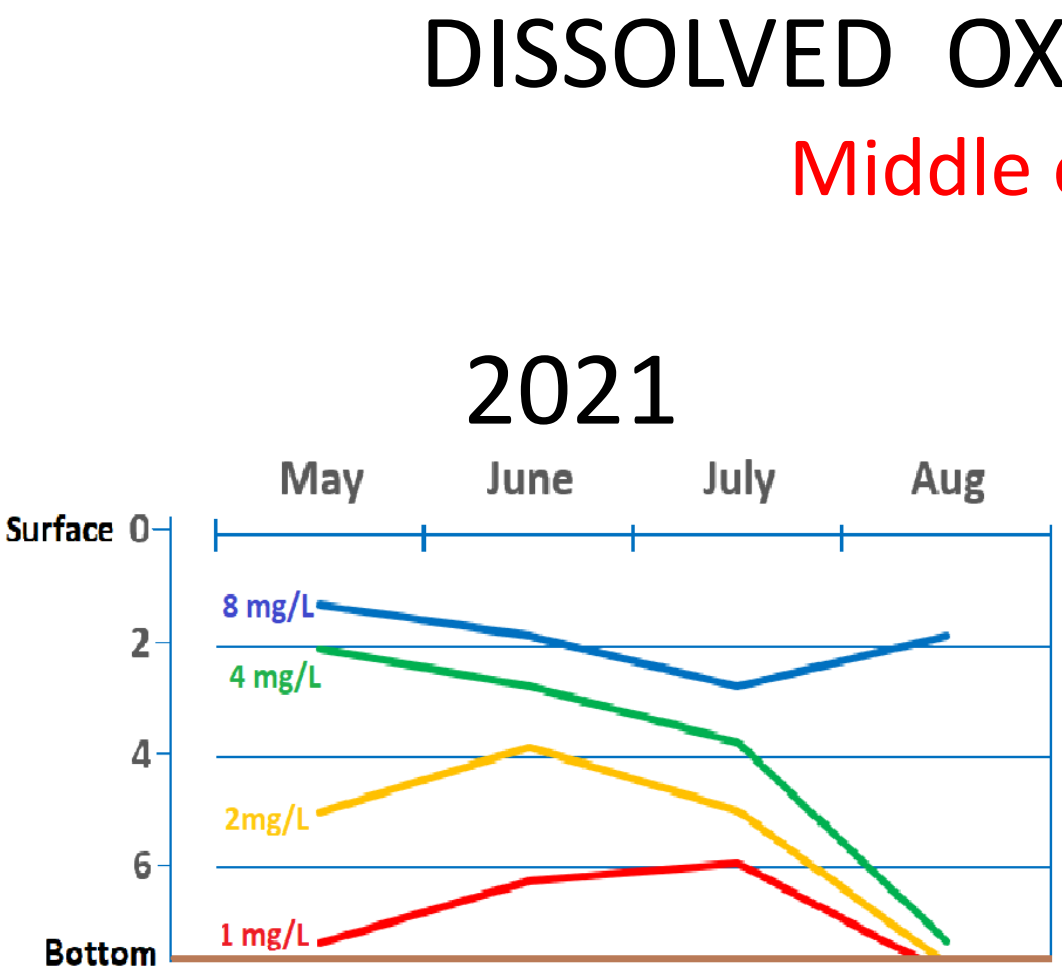


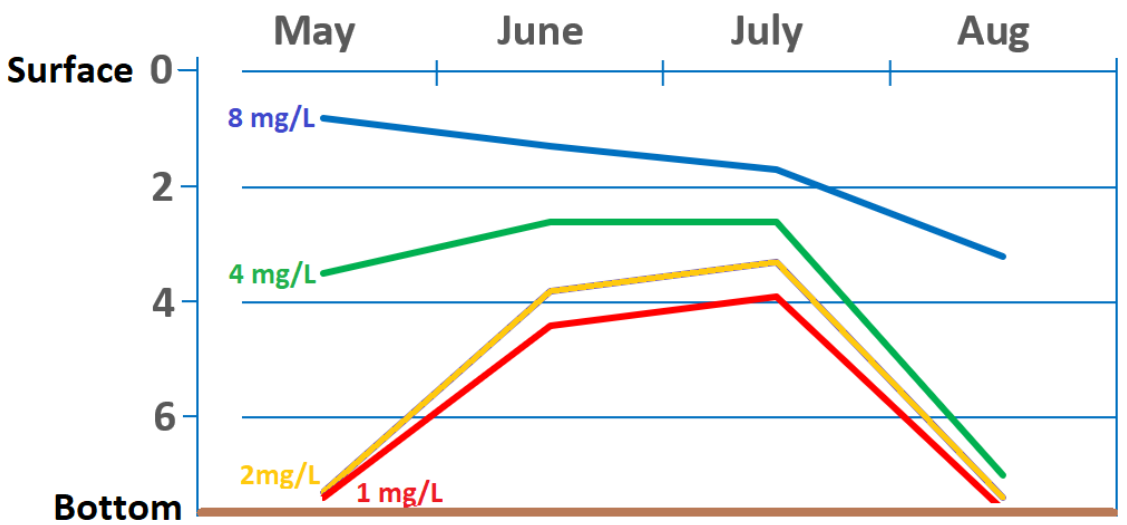
Upper Otter Lake

DISSOLVED OXYGEN OVER TIME

Middle of Main Pool

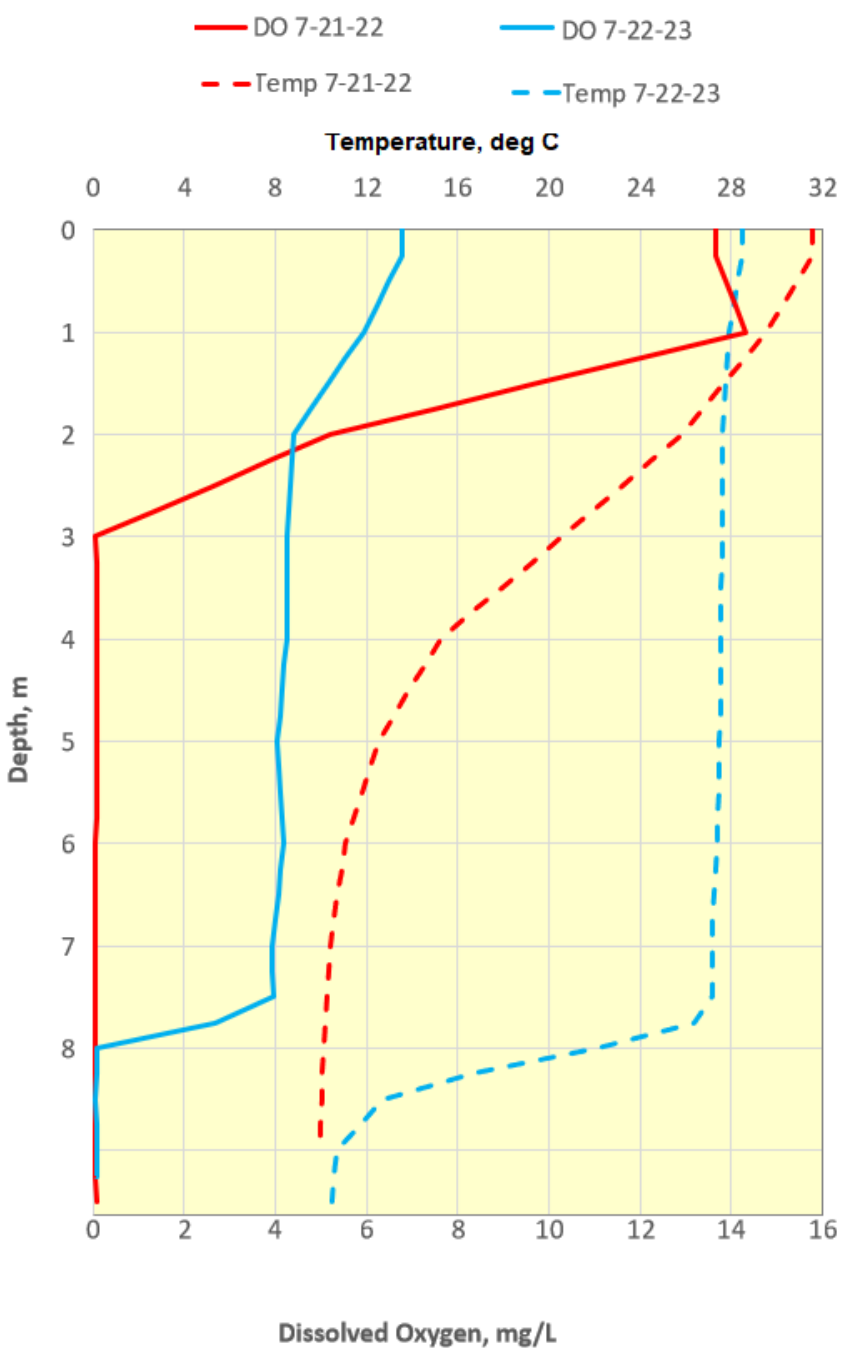
Limnetics



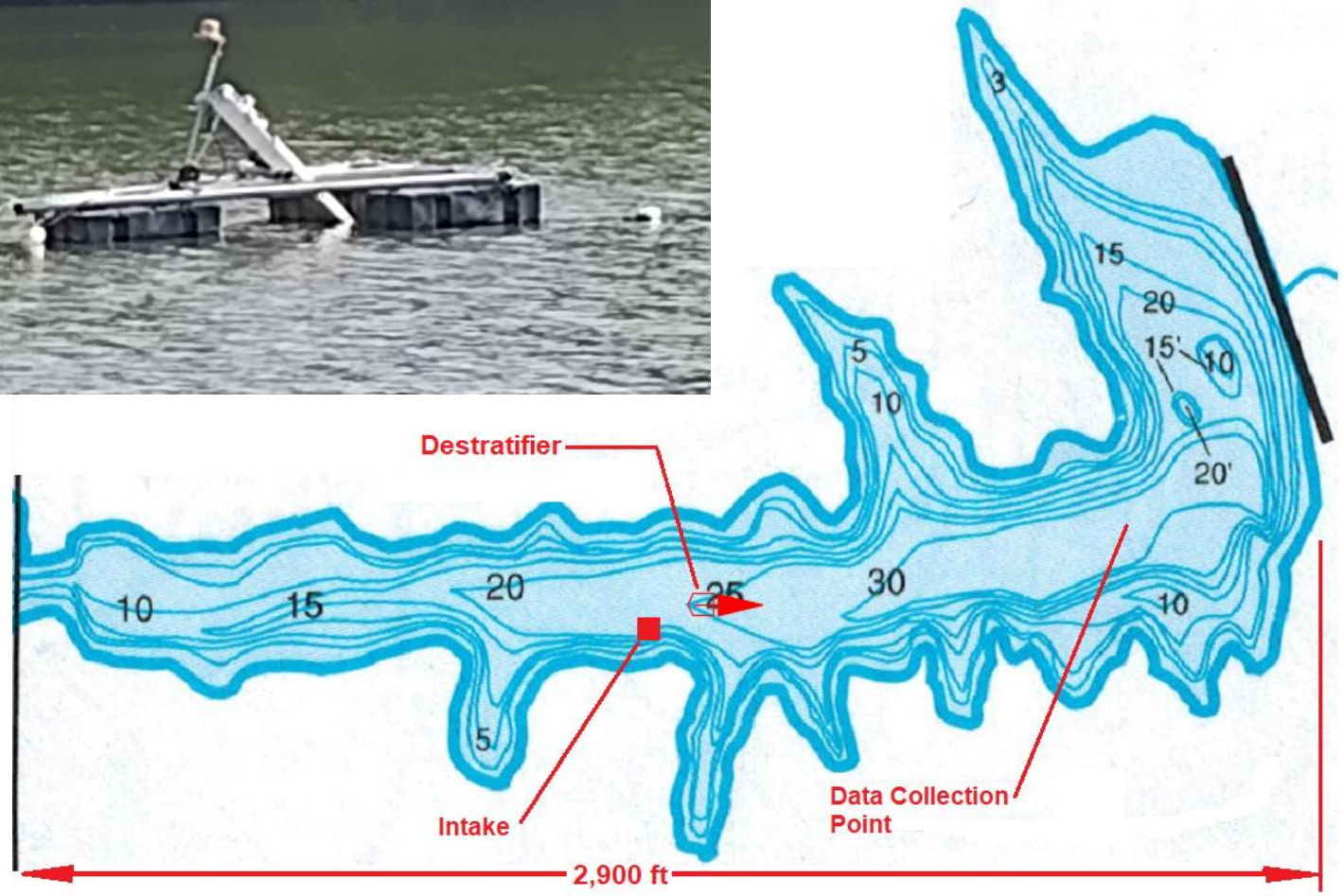


DESTRATIFIED RESERVOIRS:
Palmyra Modesto Lake, Illinois

Limnetics



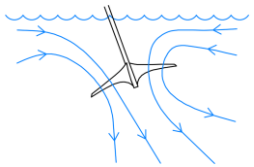
30 Acres



Anoxic Zone Reduction

Palmyra Modesto Lake

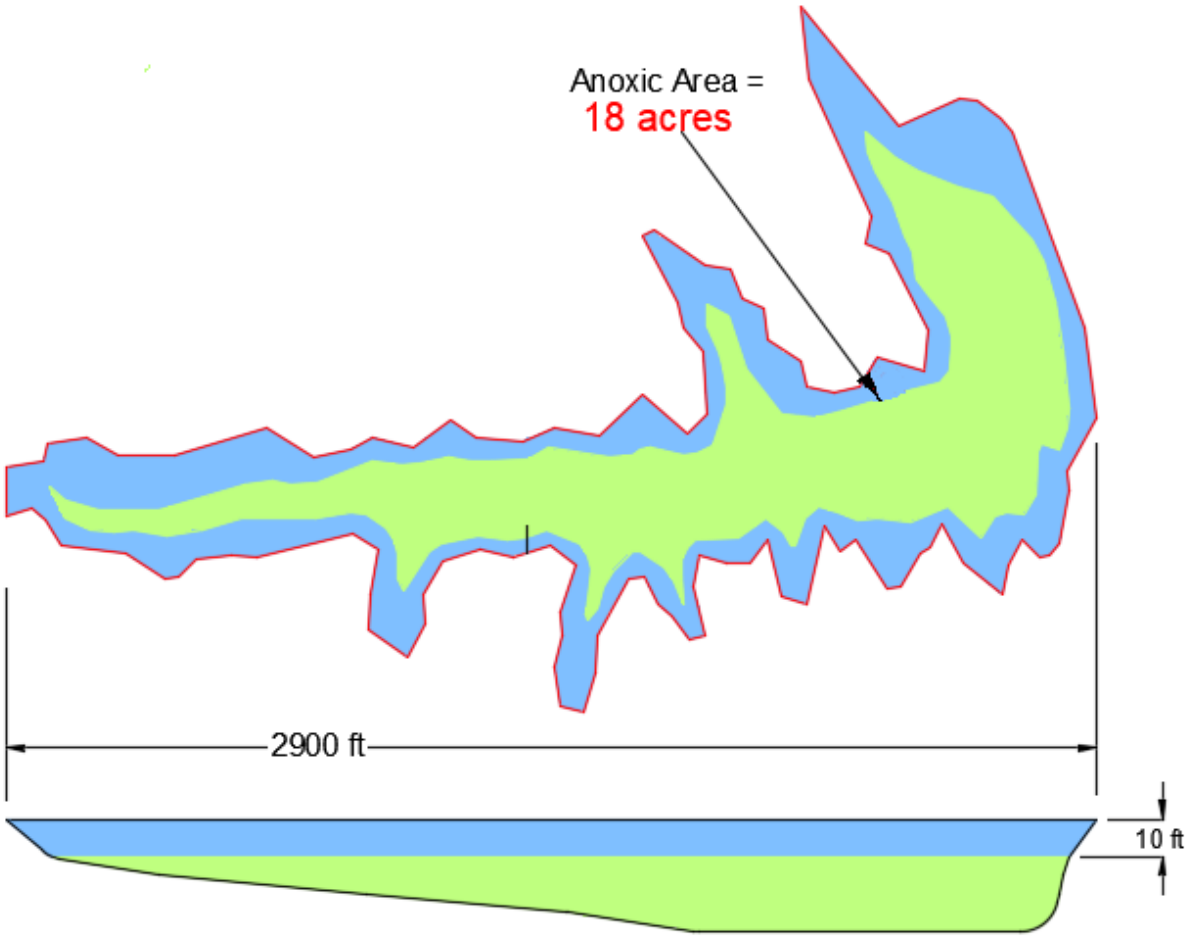
Limnetics



2022

No Destratifier

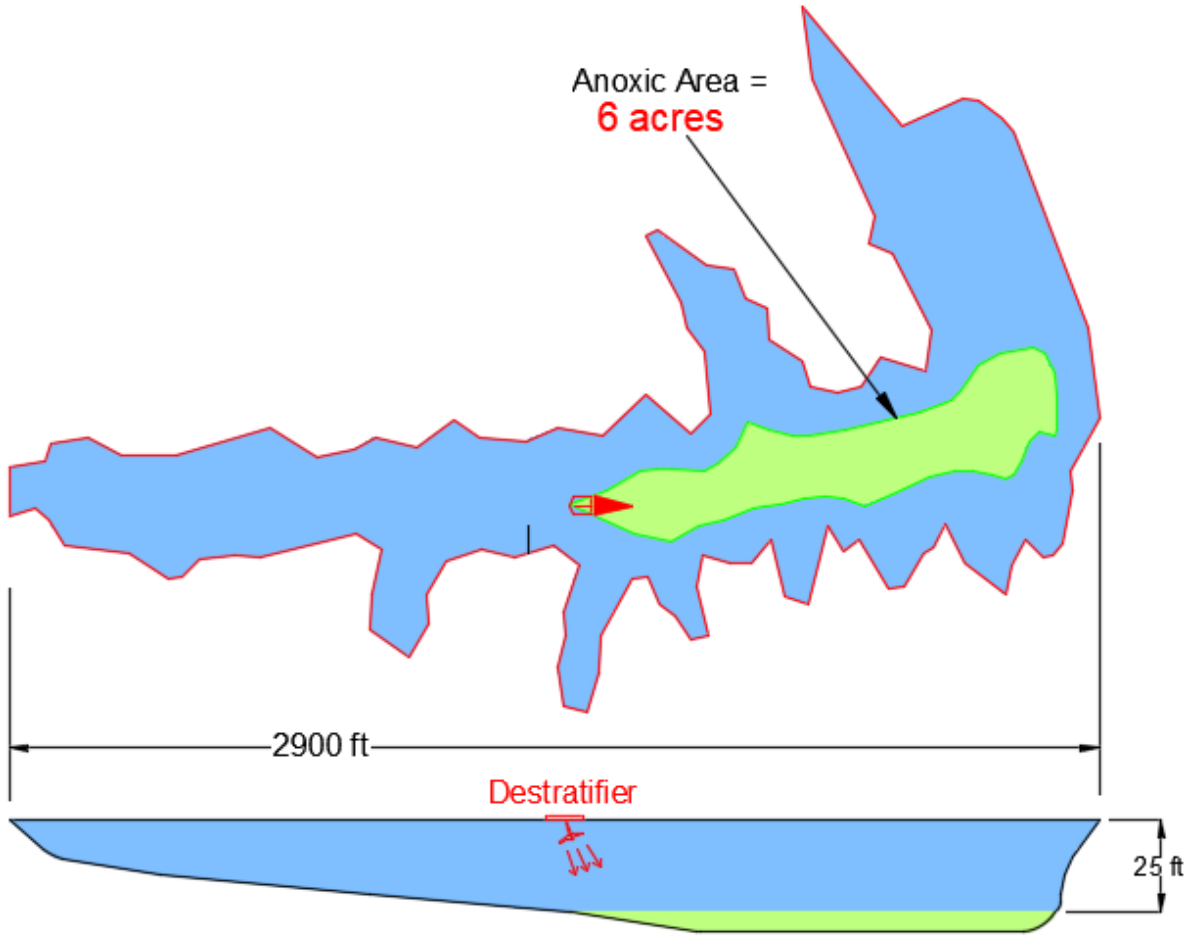
Thermocline Depth = 10 ft



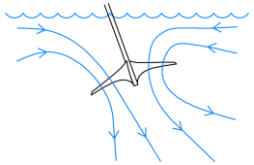
2023

Destratifier

Thermocline Depth = 25 ft



Limnetics



SIZING: FLOW VOLUME REQUIRED

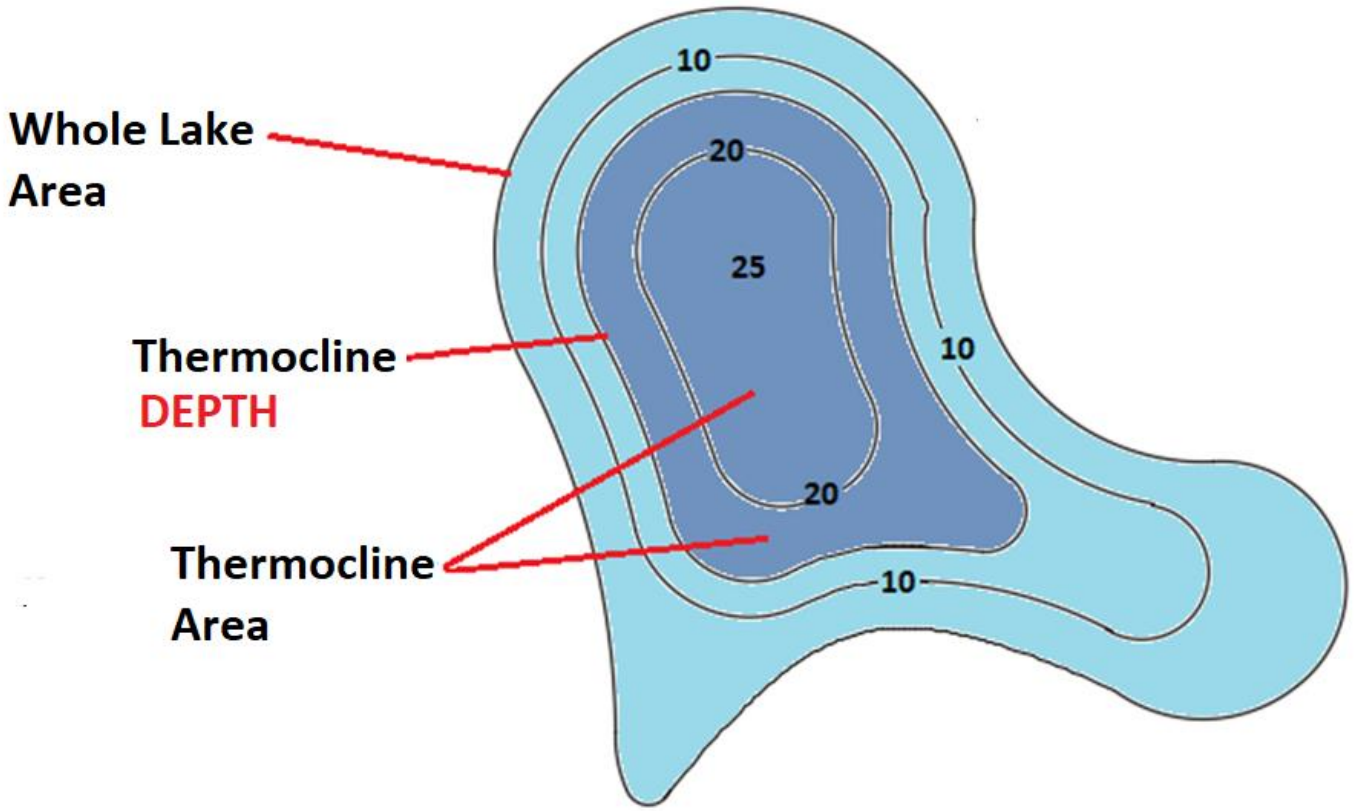
1. Manufacturer: Whole Lake volume every 25 days
2. Army Corp of Engineers: Hypolimnion volume every 8 days
3. Limnetics: Hypolimnion volume every 5 days

DAILY FLOW VOLUME

Limnetics

Minimum = 1/5 of Hypolimneon Volume =

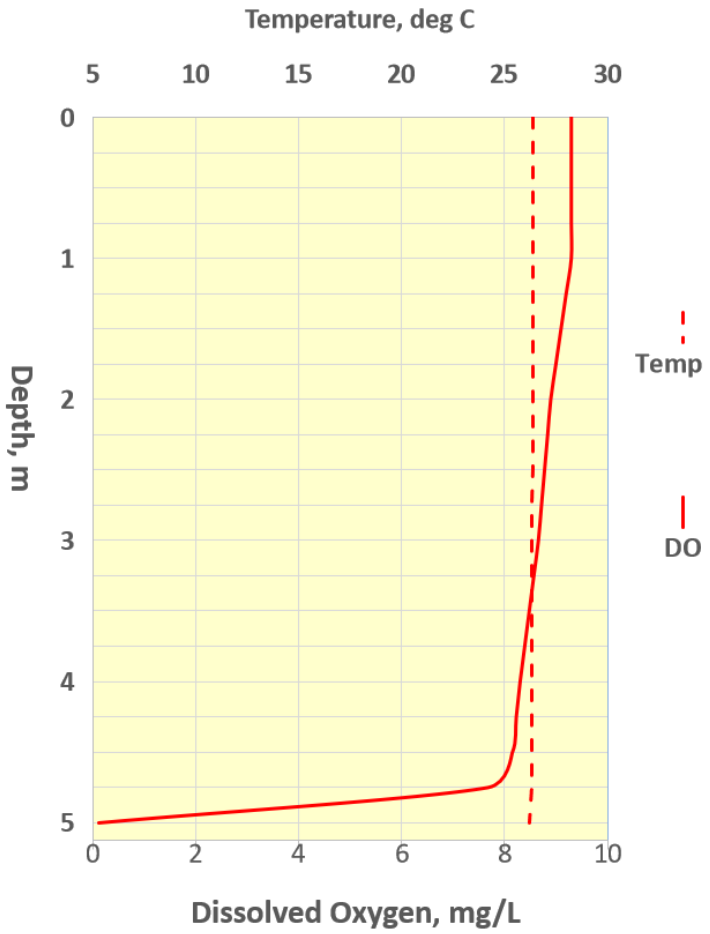
5 Day Turnover



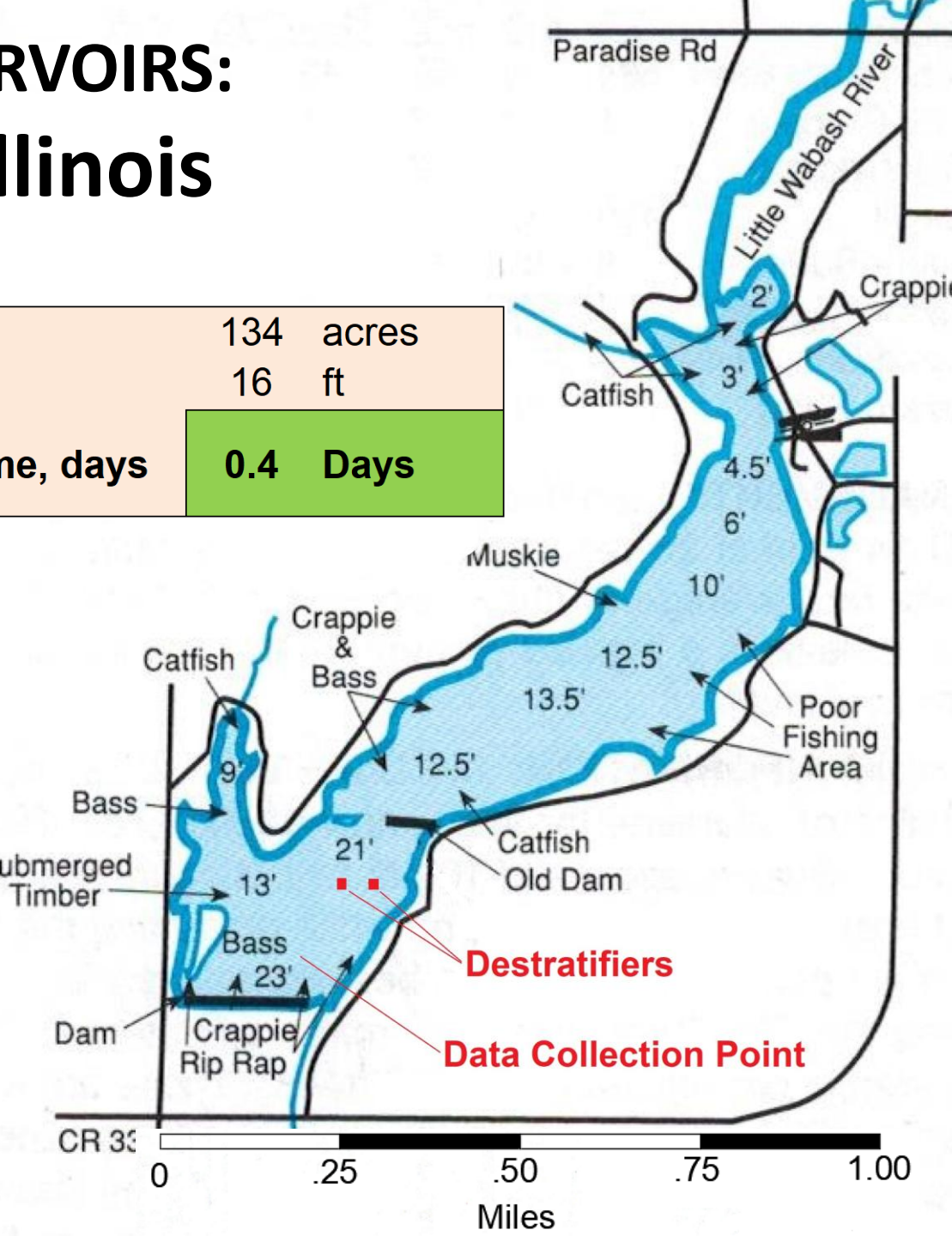
DESTRATIFIED RESERVOIRS:

Lake Paradise, Illinois

August 6, 2021

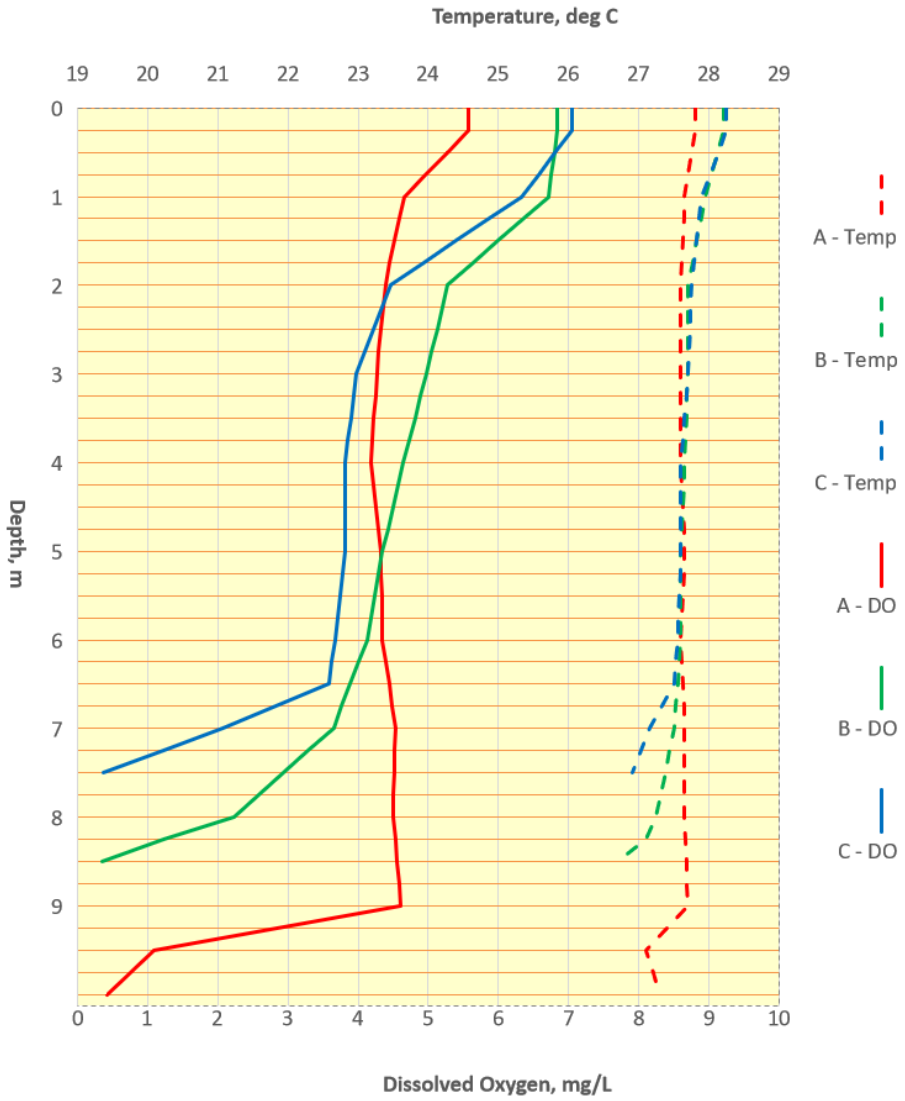


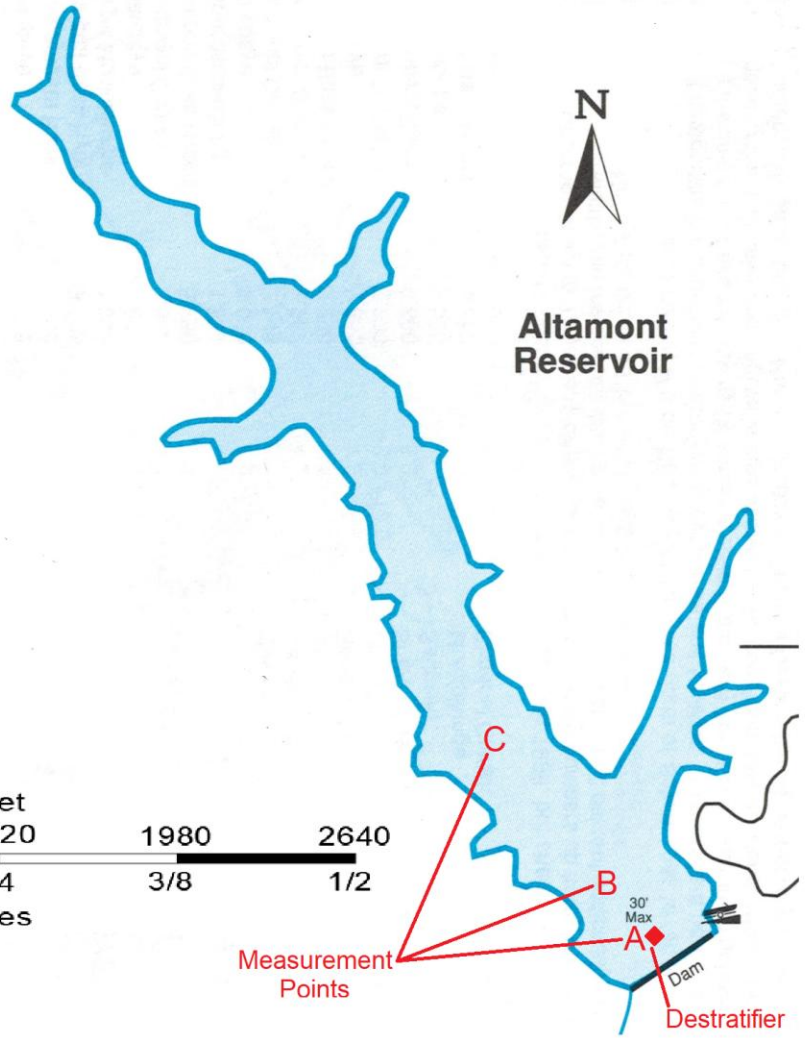
Surface Area	134	acres
Depth	16	ft
Hypolimneon Turnover Time, days	**0.4**	**Days**

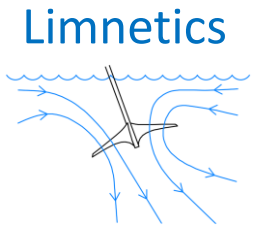


DESTRATIFIED RESERVOIRS:

Altamont Reservoir, Illinois







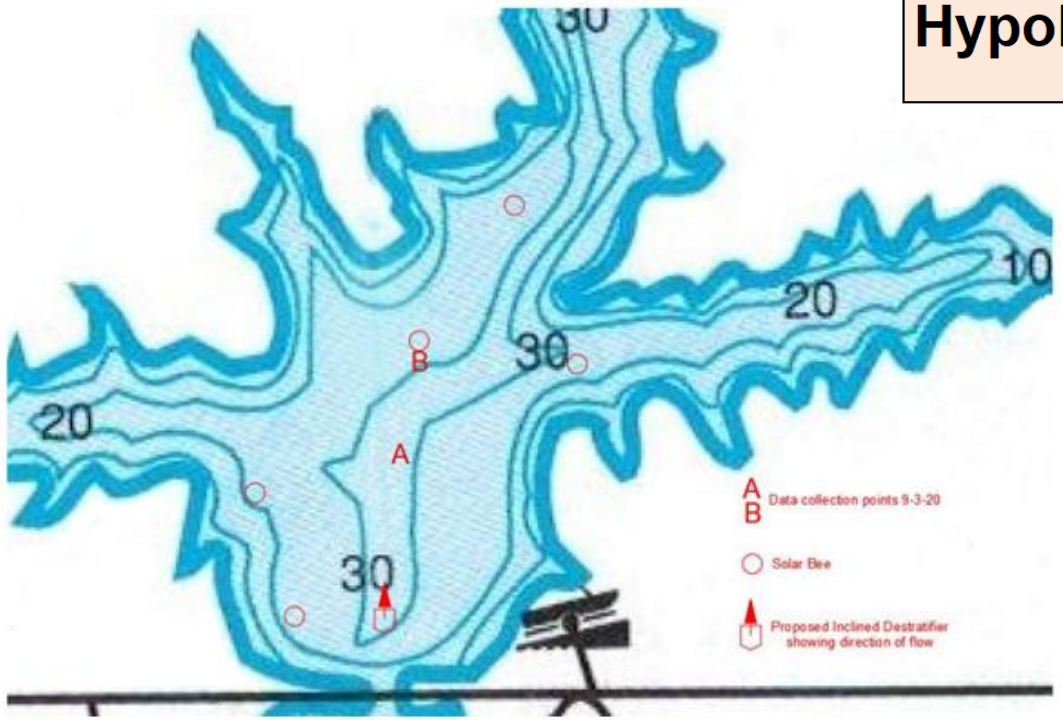
Surface Area	58	acres
Depth	30	ft
Hypolimneon Turnover Time, days	**1.2**	**Days**

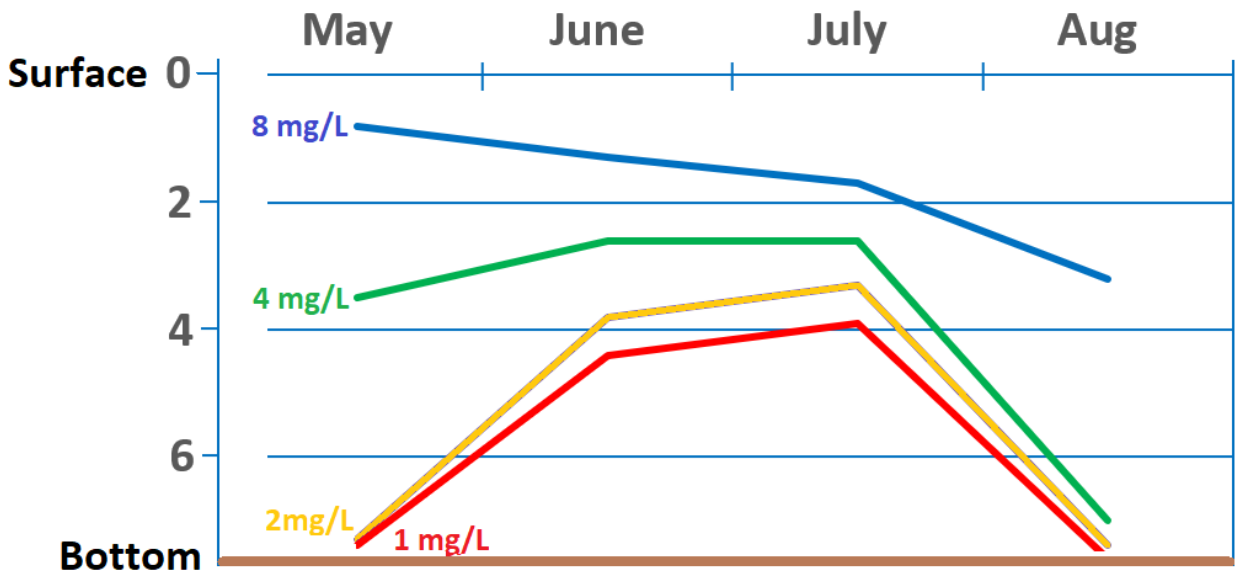
6-24-24

DESTRATIFIED RESERVOIRS:
Upper Otter Lake, Illinois

Limnetics

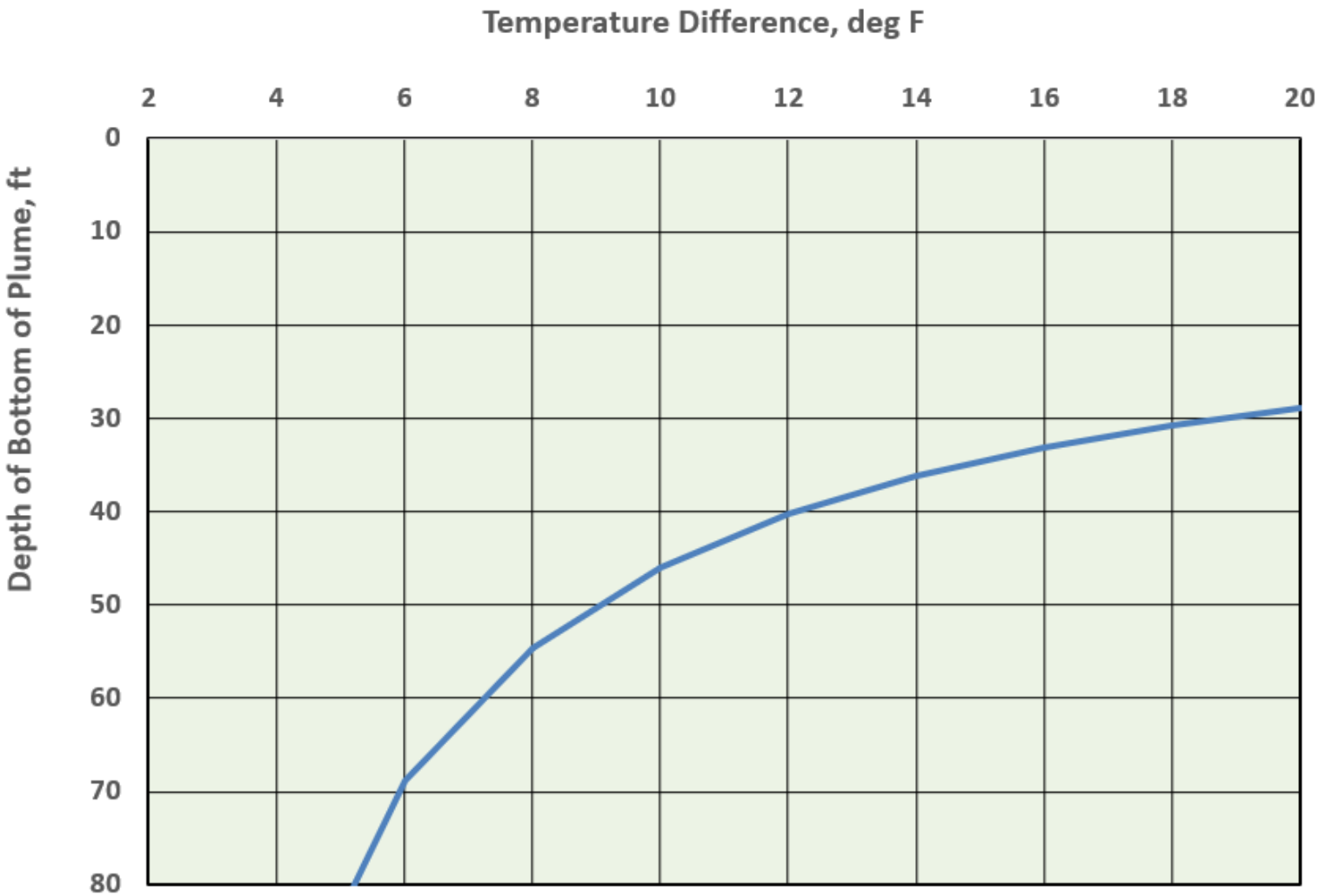
Surface Area	312	acres
Depth	25	ft
Hypolimneon Turnover Time, days	**10.5**	**Days**





SIZING: PLUME DEPTH OF PENETRATION

Limnetics



$$\frac{H_p}{D} = 0.176 \frac{V^2}{g(\Delta\rho/\rho_o)} + 0.756 \frac{H_e}{D}$$

From Richard E. Punnett, DESIGN AND OPERATION OF AXIAL FLOW PUMPS FOR RESERVOIR DESTRATIFICATION, US Army Corps of Engineers, 1991

DESTRATIFIER SAFETY WARNINGS

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Cage and Fence

Marker Buoys

Warning Signs

Beacon Lights

ELECTRICAL SEFETY

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National Electrical Code

ARTICLE 862 Naturally and Artificially Made Bodies of Water

- Extra-hard usage cable
- Plug connection on cord
- Connections 12” above deck
- Disconnect in sight of shore
- Controls 5 ft. from shore & 36” over high water mark

ELECTRIC SHOCK HAZARD

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Adjustable Protection Panels
10 – 500 mA

Destratifiers

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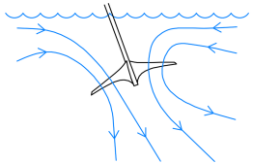

SUMMARY

- Proven to reduce manganese
- Potential to reduce cyanobacteria
- Best at 15-35 ft depths

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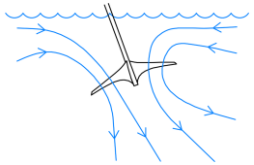
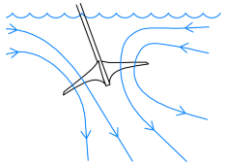


ACKNOWLEGEMENTS

Nashville Public Works Dept. – Jim Leonard, Blaine Middleton
Otter Lake Water Commission - Denzel Jines, Stan Crawford, Joe Hogan
Mattoon Water Dept. - Dave Basham, AJ Kobble
Palmyra Modesto Water Commission - Brian Durbin
Altamont City Water Department – Vaughn Voelker
Gillespie Water Works – Dave Pickett
Marion City Water Dept - Bill Johnson
Curry & Associates – Mike Curry, Roger Mensing

Limnetics



Tom C. Hausenbauer, P.E.
Limnetics Corporation
507-351-6371
tom@limnetics.net

www.limnetics.com

Limnetics

COST OF MECHANICAL DESTRATIFICATION

Example: 3 HP , 1.9m Diameter Prop

Destratifier	$35,000
Controls	$1,200
Anchor Materials	$1,500
Freight	$1,500
Marker Buoys, Lights	$1,000
Installation	$3,000
TOTAL	**$43,200**

Annual Energy Cost =

8,766 hrs. 2.7 kW x $.144 / kW-hr = **$3,408**

DEPLOYMENT

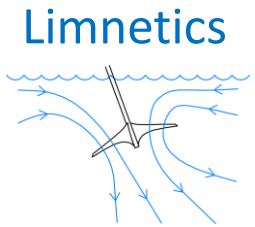
Limnetics

Delivery

Crane

Launch

Mechanical Destratification of Large Water Bodies



ADVANTAGES:

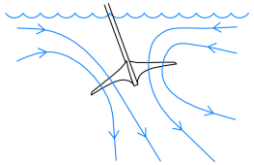
- Equipment cost
- Energy & operating costs
- Ease of deployment / removal
- Downflow or upflow

DISADVANTAGES:

- Sediment disturbance at startup
- Increased aerobic decomposition
- Cold water fish environment
- Public safety concerns

ELECTRIC SHOCK HAZARD

Limnetics

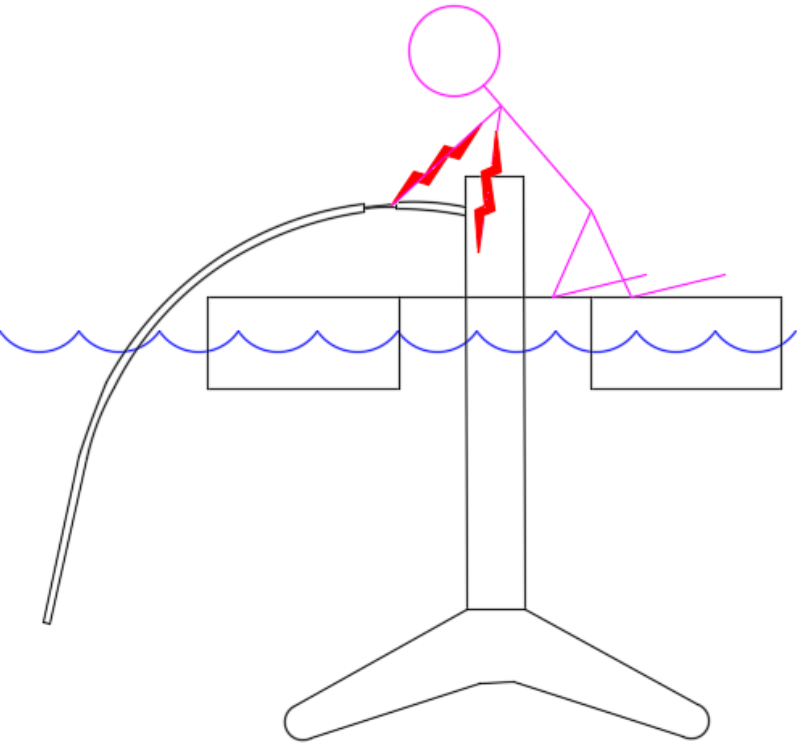


National Electrical Code (NEC) sections

Section	Description	GFI Requirement
• 553	Floating Buildings	100 mA
• 555	Marinas, boatyards, and Docking Facilities	30 mA
• 680	Swimming Pools, Spas, Hot Tubs, Fountains	5 mA
• **682**	**Natural and Artificial Water Bodies**	**No**

ELECTRIC SHOCK HAZARD

Limnetics



Current through Human Body:

1 mA	Slight tingling
5-10 mA	Muscle contractions
10-20 mA	Severe pain and muscle spasms
20-50 mA	Respiratory paralysis
50-100 mA	Ventricular fibrillation

Source: ChatGPT

Electric Shock Hazard

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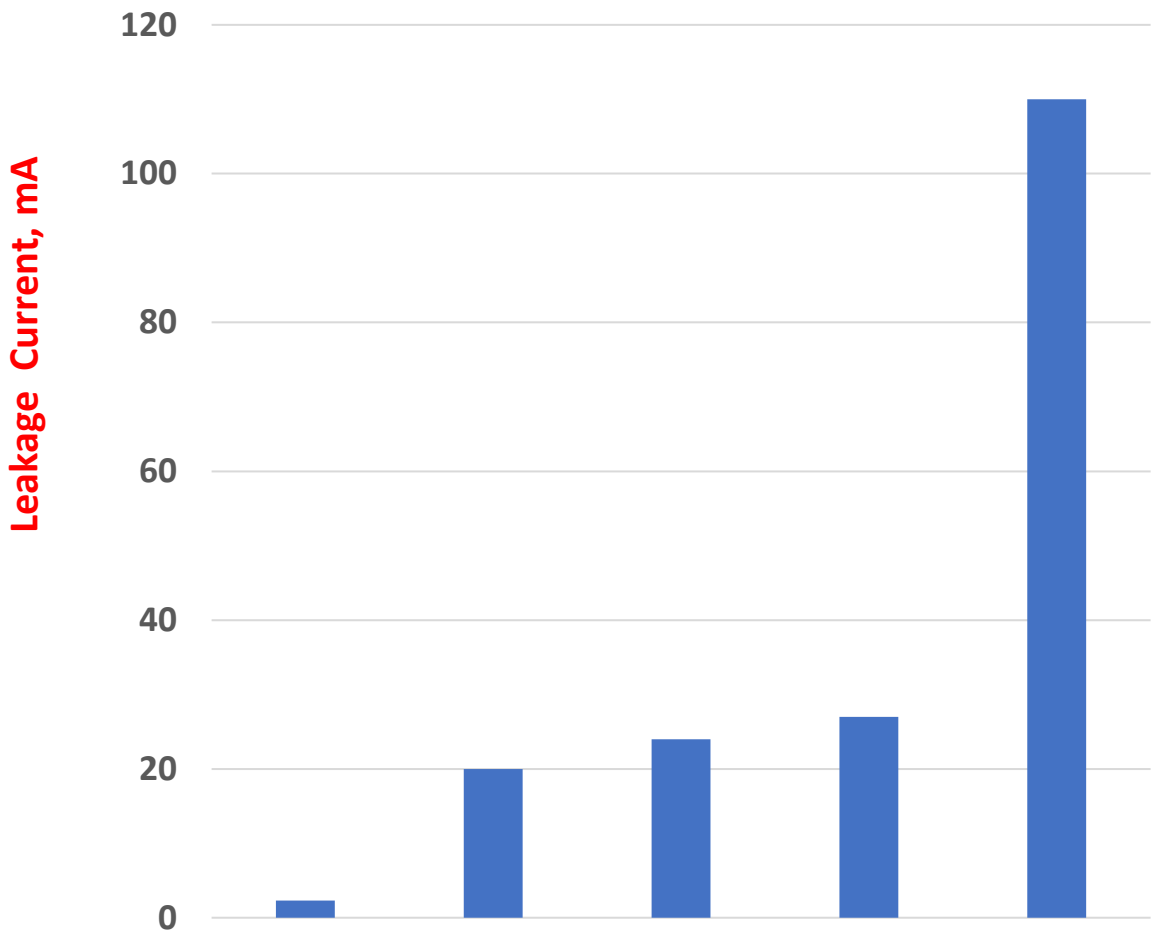
BACKGROUND LEAKAGE

Typical Destratifiers



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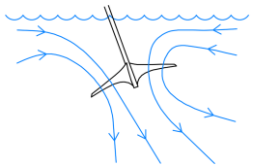

COSTS OF AERATION / OXIDATION OPTIONS

METHOD	Typical Costs per 100 ha	
	Installed	Annual O&M
Large Mechanical Destratifiers	$40,000	$5,000
Large Mechanical Destratifiers with Flow Tubes	$50,000	$6,000
Hypolimnetic Oxygenation*	$100,0000 - $500,000	$5,000 - $25,000
Small Mechanical / Solar Circulators	$200,000	-

* Based on : 1. Moore ET. AL., Lake Line, Vol. 35 #1 Spring 2015, p. 28
2. Mobley ET.AL., Lake & Reservoir Management, Vol. 35 Issue 3, Sept. 2019, p. 262