Supersaturated Dissolved Oxygen (SDOX™) Delivery Technology at Norfork Dam

Scott Osborn, Chief Technology Officer

Clay Thompson, Senior Engineer

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BlueInGreen, LLC
535 W. Research Blvd.
Fayetteville, AR 72701
(479) 527-6378

Background

- Thanks to Marshall Boyken, Southwestern Power Administration, Tulsa for inviting us and setting this up.
- The original presentation is from a meeting concerning low DO at Norfork Dam in Arkansas and how BlueInGreen's technology can address this problem.
- Norfork River (tailrace) is 303(d) listed for low DO, feeds Norfork National Fish Hatchery, and the river is a valuable trout habitat.
- A grant from National Science Foundation is funding a demonstration of the SDOX™ at Norfork Dam for tailrace (low flow) and hatchery oxygenation.

Presentation Outline

- SDOX™ technology overview;
- Comparison of SDOX™ to LOX injection and paddlewheel;
- Specific advantages for Norfork Dam;
- NSF project overview;
- Demonstration data;
- Operating cost comparisons to existing technology;
- Norfork cost estimates for specific flows;
- Questions/ discussion.

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What is the SDOX?

The SDOX™ system uses a patented and patents pending process that removes a side-stream of water and dissolves oxygen into this side-stream under the most efficient conditions to increase the concentration of DO to very high levels (310 mg/L). The high DO side-stream is then injected back into and mixed to saturation or below with the water being treated.

Key Features of the SDOX

- Real-time automated control of dissolved oxygen delivery rate
- Greatly reduced operating costs (up to 80%)
- Negligible loss of oxygen by prevention of off-gassing
- Targeted delivery of dissolved oxygen to any depth in a water column
- Portability option allows for deployment in remote locations or to meet seasonal needs

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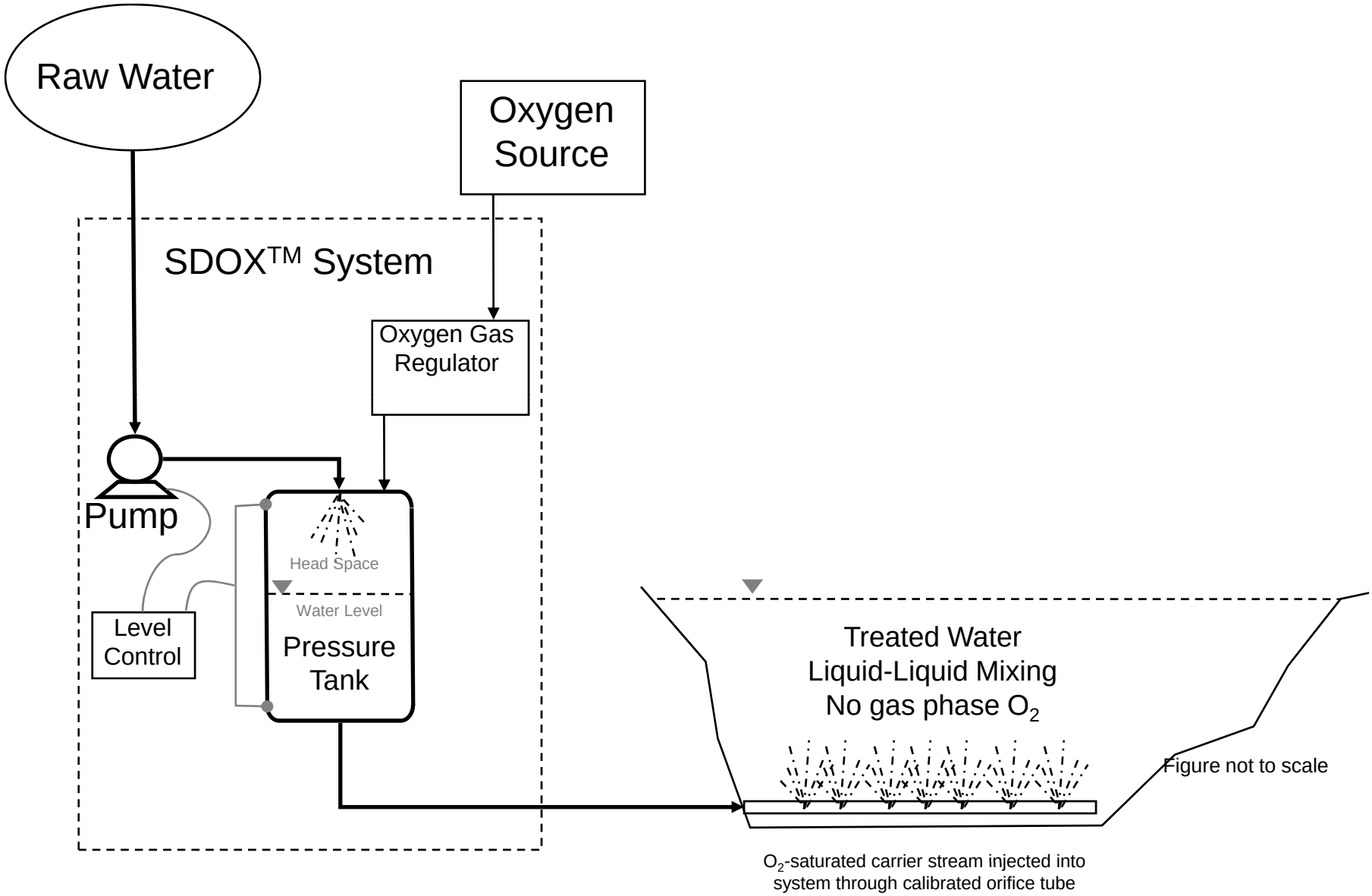
Raw Water
Oxygen Source
SDOX™ System
Oxygen Gas Regulator
Pump
Head Space
Water Level
Level Control
Pressure Tank
Treated Water
Liquid-Liquid Mixing
No gas phase O_2
Figure not to scale
O_2-saturated carrier stream injected into system through calibrated orifice tube

Installation at Noland (Fayetteville) WWTP

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How Does the Technology Provide Advantages?

- Pre-dissolves oxygen in carrier stream so a very high concentration of DO is produced in the exiting water;
- Delivers stream with all gas dissolved to liquid form from a pipe to water being treated;
- High DO allows a small amount of liquid to provide a large increase of DO (310 mg/L vs. 12 mg/L);
- Liquid-liquid mixing allows more cost effective delivery;
- High concentration allows smaller relative footprint and lower capital cost;
- Continually control DO rate by controlling water flow rate and can be automated to respond to DO requirements.

Competing Technology: Bubble Aeration (LOX Injection)

- Must dissolve gas bubbles into water while distributing. Bubbles rise causing currents and making targeted oxygenation difficult especially at great depth.
- Bad for shallow systems (tailrace) as bubble leave water before dissolving.
- Oxygenates more water than required - wasting cost.
- Difficult to control DO delivery rate, hard to create small area for fish DO refuge or to travel with internal flow.
- System must run continuously to prevent clogging from biogrowth.

Competing Technology: Paddlewheel

- May require modification to dam.
- Limited effectiveness at DO exceeding 3 mg/L.
- Surface aeration only (not at depth).
- Require specific flow through dam to provide minimum stream depth.
- Must maintain contact with stream surface requiring adjustability with water depth.

Advantages for Use at Norfork Dam

- No structural modification to the dam will be required
- No minimum (few feet) or maximum water depth is required for operation
- Delivery rate of dissolved oxygen can be automatically increased or decreased to respond to changes in upstream DO concentration or flow rate
- System can be turned off and on as-needed without clogging underwater delivery pipe
- Delivery of dissolved oxygen can be targeted to precise locations (fish kill zones)
- Any target DO up to saturation (12 mg/L) can be maintained

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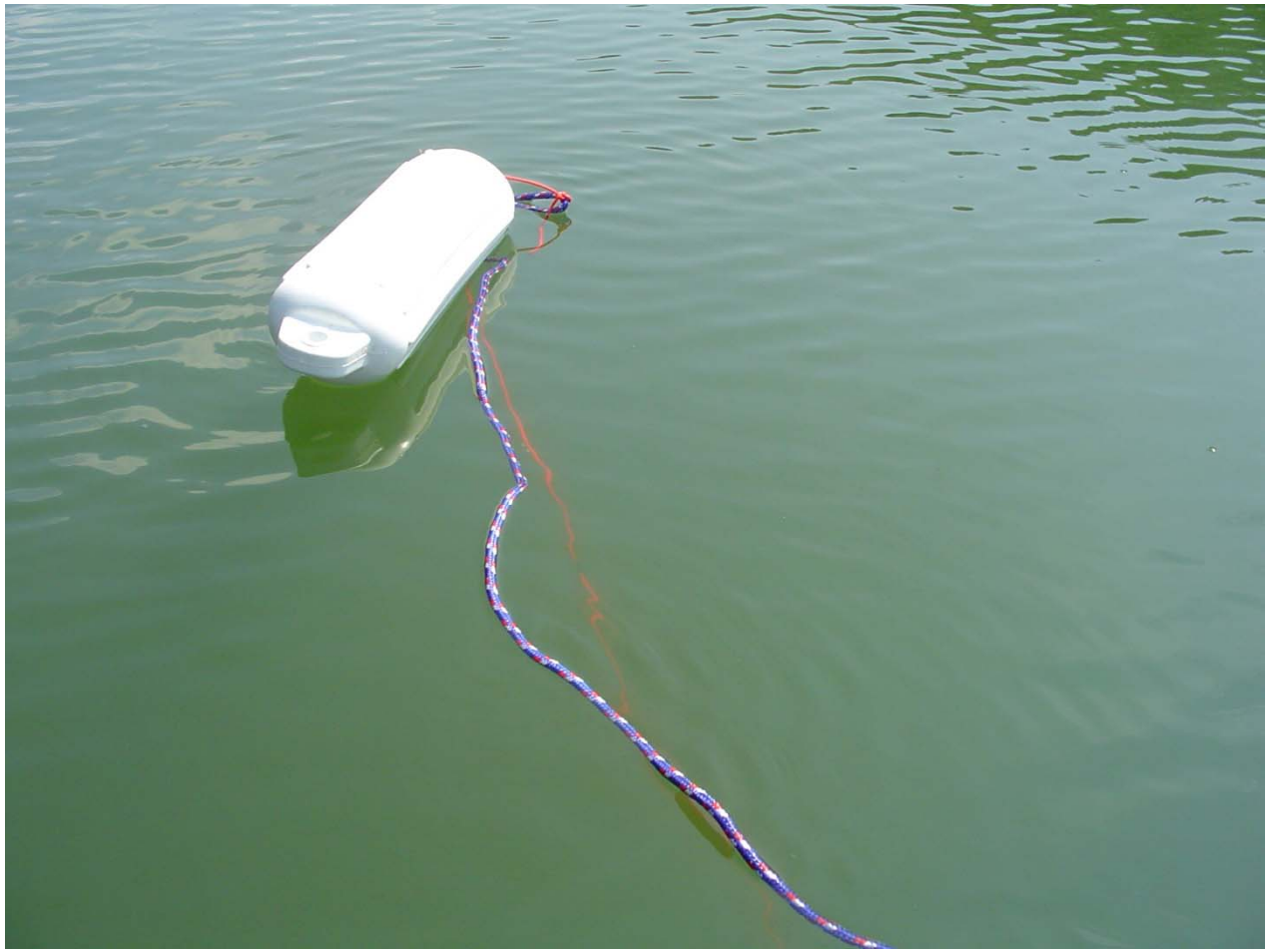
Overview of the NSF project

The deployments to be conducted in the Fall of 2008 will provide the information necessary to tailor a full-scale system for Norfork Dam, AR.

- Determination of optimal locations for oxygen addition to hatchery: tailrace, inlet pipe into the hatchery and/or forebay
- Required DO delivery rates to meet oxygen demand and maintain target DO of 6 mg/L in tailrace at low flow
- Rate of precipitation of dissolved metals (Fe and Mn)
- Overall benefit to the health of fish in Norfork National Fish Hatchery

Example in Lake Atalanta, Rogers

(1/700 th scale of Norfork system)



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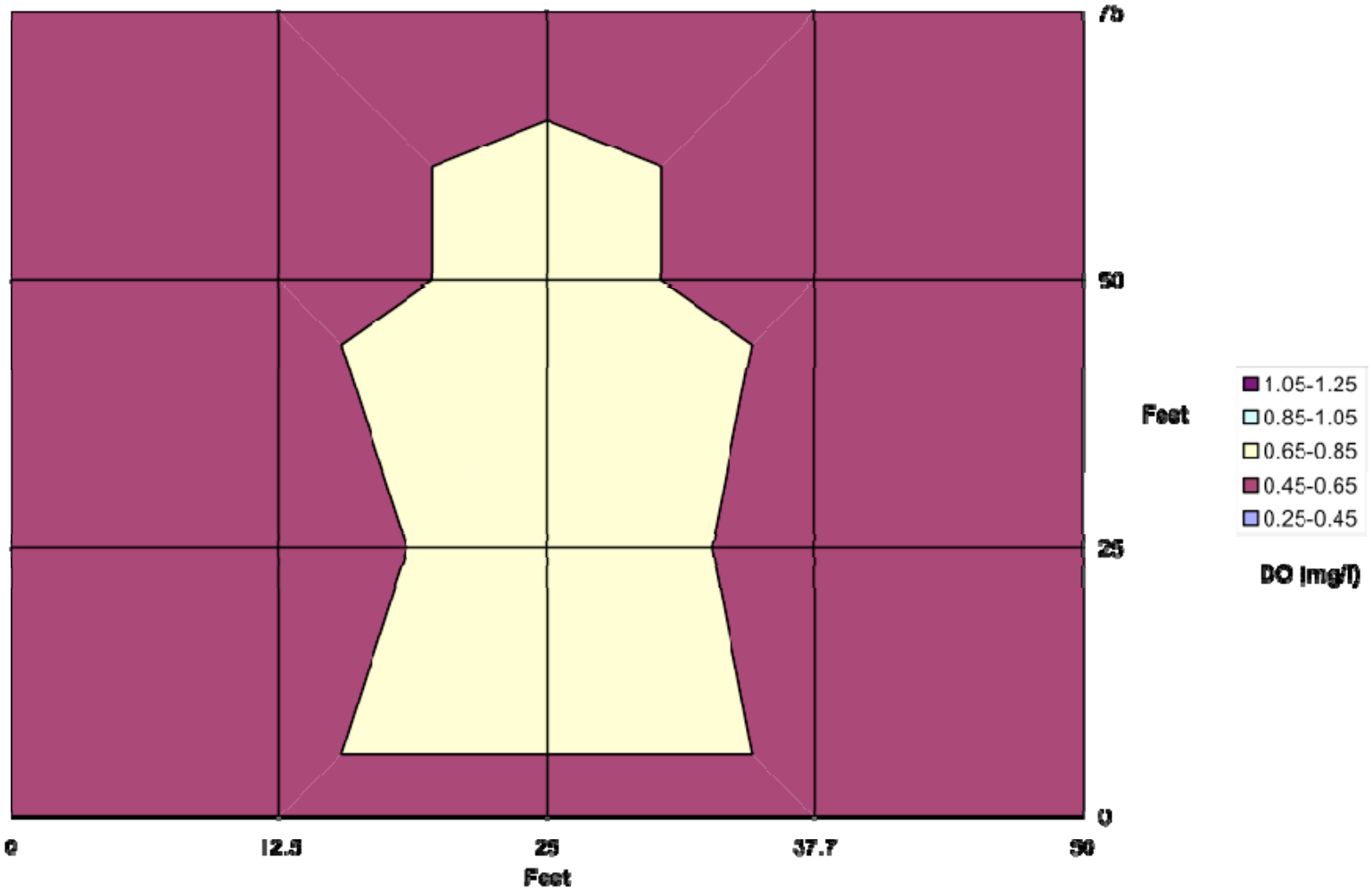
1:00pm 20 Feet depth



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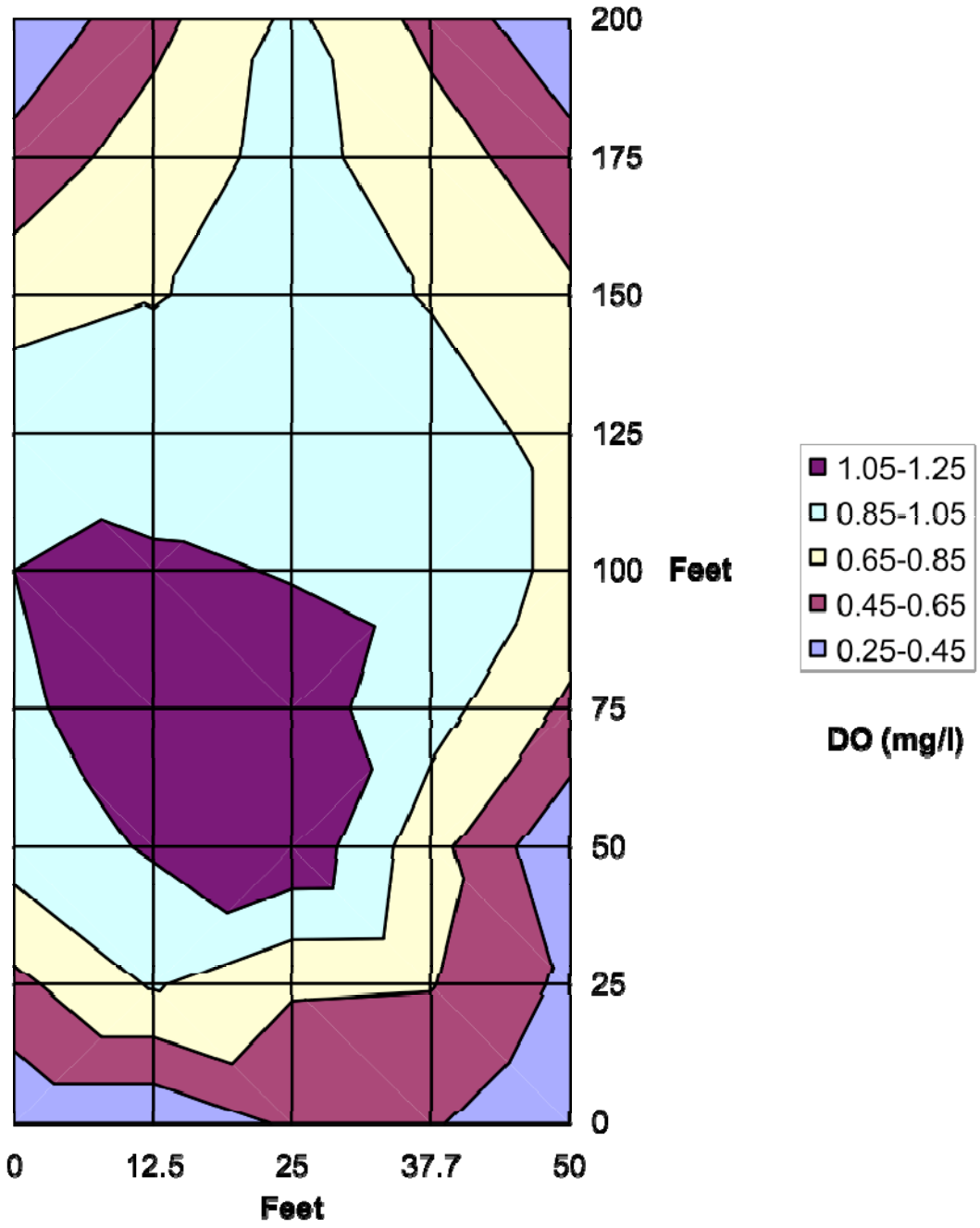
Data from Lake Atalanta

- Two hours of deployment
- One bottle of oxygen
- The thermocline was undisturbed
- A larger mass of less oxygenated lake water radiated outward



Lake Brittany – Bella Vista, AR

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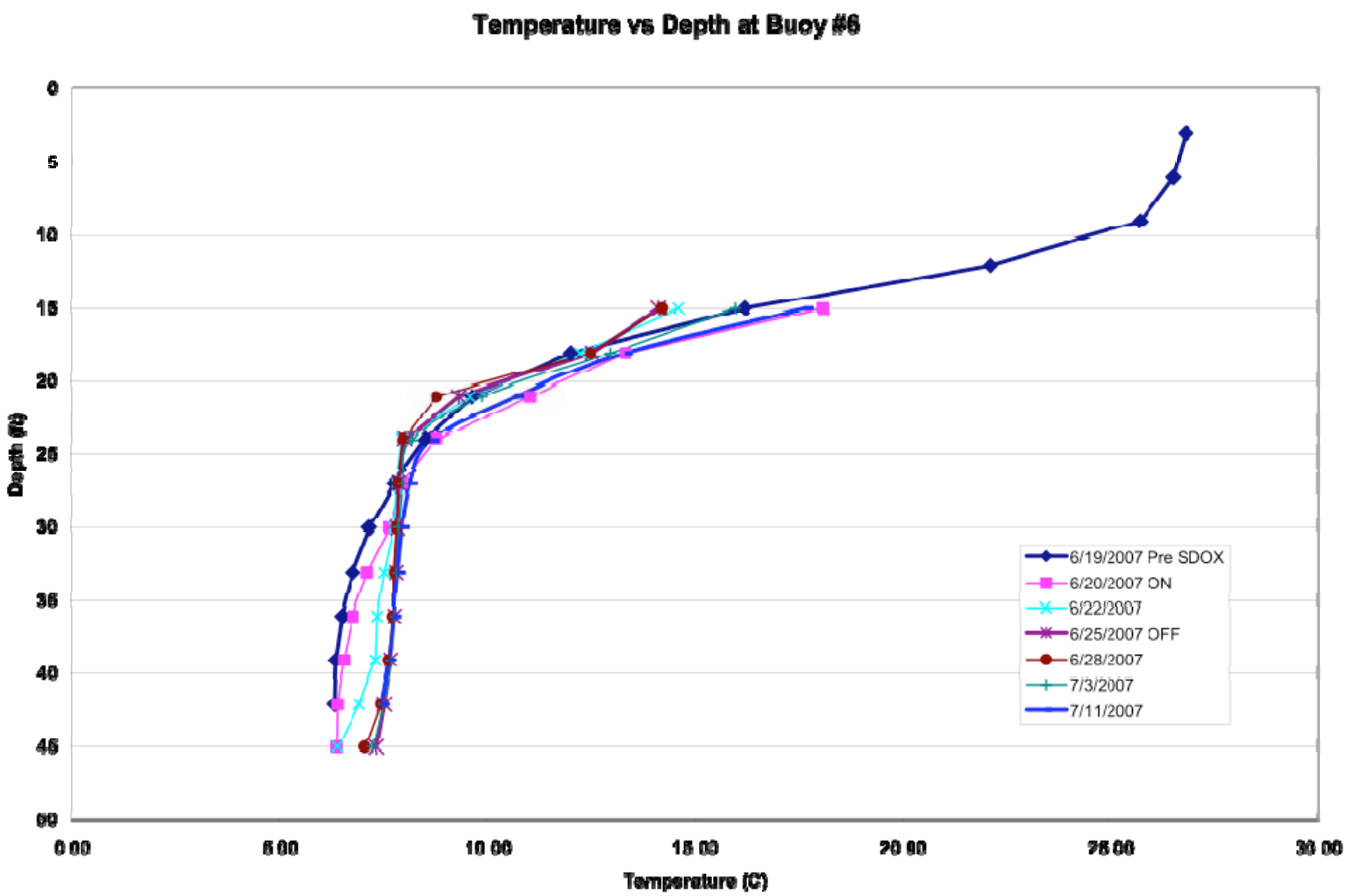
Lake Brittany – Bella Vista, AR



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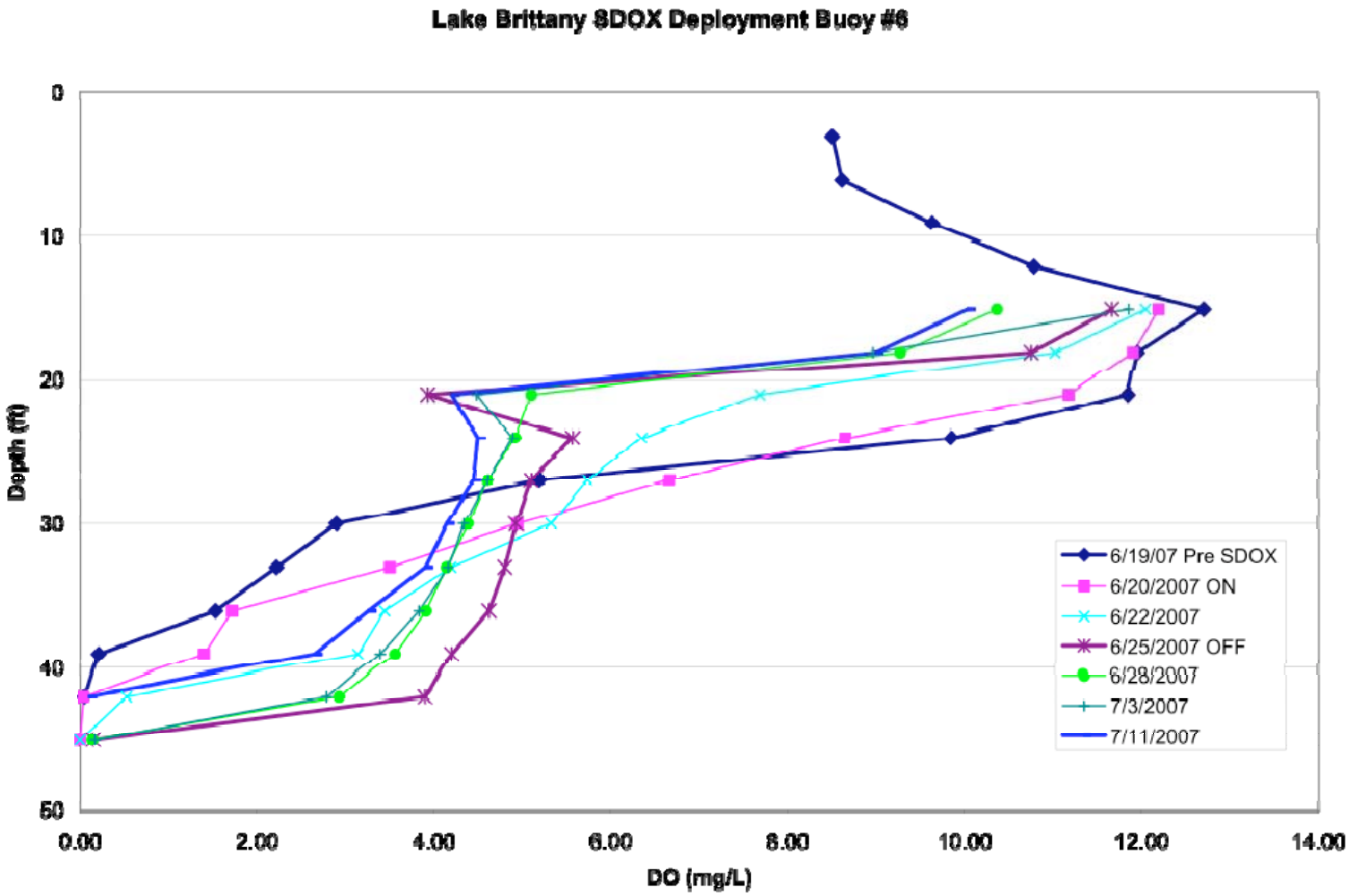
Lake Brittany – Bella Vista, AR



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Noland Wastewater Treatment Facility

Operating Cost Savings $35,000 per year.

	DO Increase	Oxygen Consumed	Power Consumed	Cost Efficiency*
	(mg/L)	(lb O2/day)	(HP)	($/lb DO)
Existing System	3.9	4040	30	$0.81
SDOX	3.2	505	13.6	$0.15

* Based on 2007 costs for electricity and liquid oxygen

Table 1: Comparisons between SDOX and Existing oxygenation system at Noland Wastewater Treatment Plant in Fayetteville, AR.

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Rogers Wastewater Treatment Facility

	DO Increase	Oxygen Consumed	Power Consumed	Aeration Efficiency
	(mg/L)	(lb O_2 / day)	(HP)	(lb DO / HP-hr)
Existing System	4.5	182	32	0.25
SDOX	6.7	268	6.7	1.5

Table 2: Comparisons between SDOX and Existing oxygenation system at Rogers Pollution Control Facility, Rogers, AR.

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SDOX Cost Estimates for Treating Norfork Dam

Flow Rate	DO Rise	Estimated SDOX Cost	Monthly Operating Cost- Oxygen Supply ($0.50 /100scf)		Monthly Operating Cost- Electricity ($0.068 /kW-hr)		
(cfs)	(mg/L)	($)	LOX ($)	PSA ($)	LOX ($)	PSA* ($)	SDOX ($)
40	12	290,000	7,500	-	-	4,250	3,250
75	6	290,000	7,500	-	-	4,250	3,250
115	6	450,000	9,000	-	-	5,000	4,000
260	6	850,000	22,500	-	-	12,250	9,750
300	6	850,000	22,500	-	-	12,250	9,750
1000	3	1,700,000	37,500	-	-	19,750	16,000
1000	6	3,400,000	72,500	-	-	40,000	32,500
3000	6	7,400,000	207,500	-	-	127,500	102,500

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Oxygen Equipment Cost Estimates for Treating Norfork Dam

Flow Rate	DO Rise	Oxygen Supply Equipment Monthly Lease Cost	Oxygen Supply Equipment Capital Cost	
(cfs)	(mg/L)	LOX ($)	LOX ($)	PSA ($)
40	12	1,500	190,000	190,000
75	6	1,500	190,000	190,000
115	6	1,500	200,000	250,000
260	6	2,250	270,000	470,000
300	6	2,250	270,000	470,000
1000	3	2,250	270,000	660,000
1000	6	3,000	540,000	1,200,00
3000	6	6,000	1,100,000	3,000,000

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Benefits to the State of Arkansas

- Provide sufficient DO to meet regulatory requirements
- Increased tourism dollars from the fishing industry
- Improved efficiency of production of hydroelectric power (green energy)
- Improve production efficiency of fish at Norfork National Fish Hatchery
- Substantial cost savings over traditional oxygenation systems

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Questions and Discussion

Contact Information:

Scott Osborn
scott.osborn@blueingreen.biz

Clay Thompson
clay.thompson@blueingreen.biz

Anna McCain
anna.mccain@blueingreen.biz

(479) 527-6378

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