EUTROPHICATION AND OLIGOTROPHICATION OF AN URBAN WATER SUPPLY RESERVOIR

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State of Oklahoma
OWRB
WATER RESOURCES BOARD
the water agency

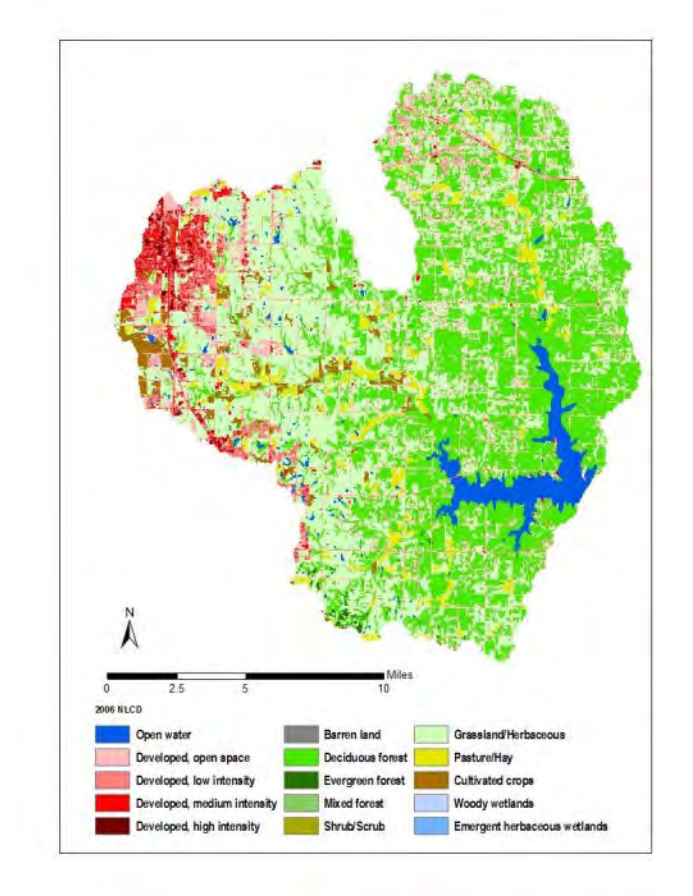
Outline

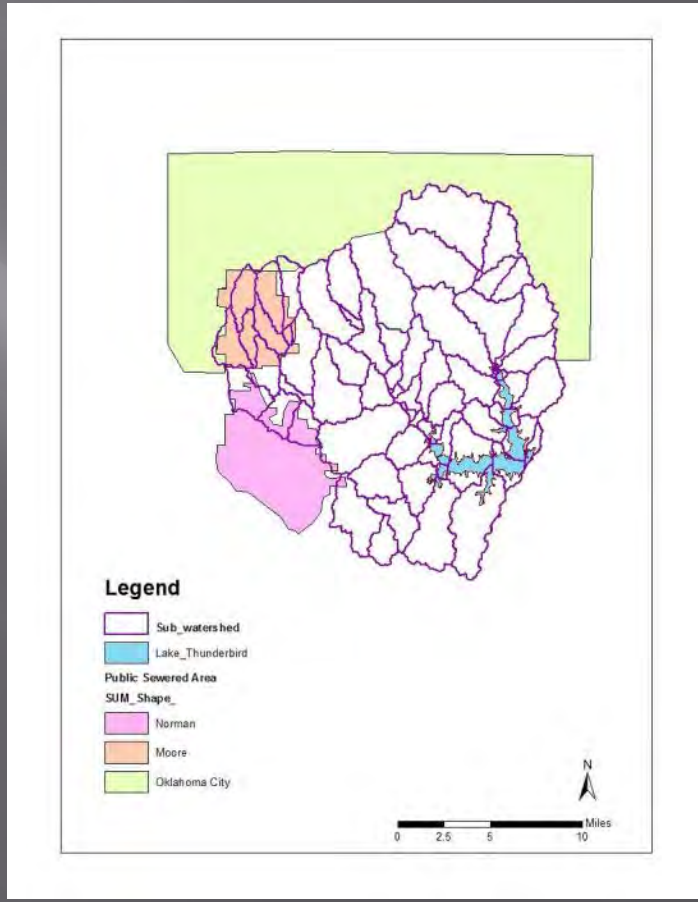
- Background
- Raw Water Quality
- Eutrophication
- Oligotrophication

Lake Thunderbird

- Operational 1966 by Bureau of Reclamation
- Flood control, municipal water supply, recreation, and fish and wildlife propagation
- Central Oklahoma Master Conservancy District (COMCD) manager
- Raw water for Del City, Midwest City, and the City of Norman
- Sensitive Water Supply & Nutrient Limited Waterbody

Watershed 256 sq. mi.





OWQS

Dissolved Oxygen: not to exceed 50% of volume <2 mg/L

- 2007 & 2015 volumetric violations

Turbidity: No more than 10% of samples >25

- 10 year average: 24.7 NTU; 27% out of compliance

Chl-a (SWS): Ten year average not to exceed 10 ug/L

- 10 year average: 26.9 ug/L; 82.7% over 10 ug/L

TMDL dictates 35% reduction of N, P & Solids

Figure 13: City of Norman treatment costs vs raw TOC. Dataset 2002-2009.

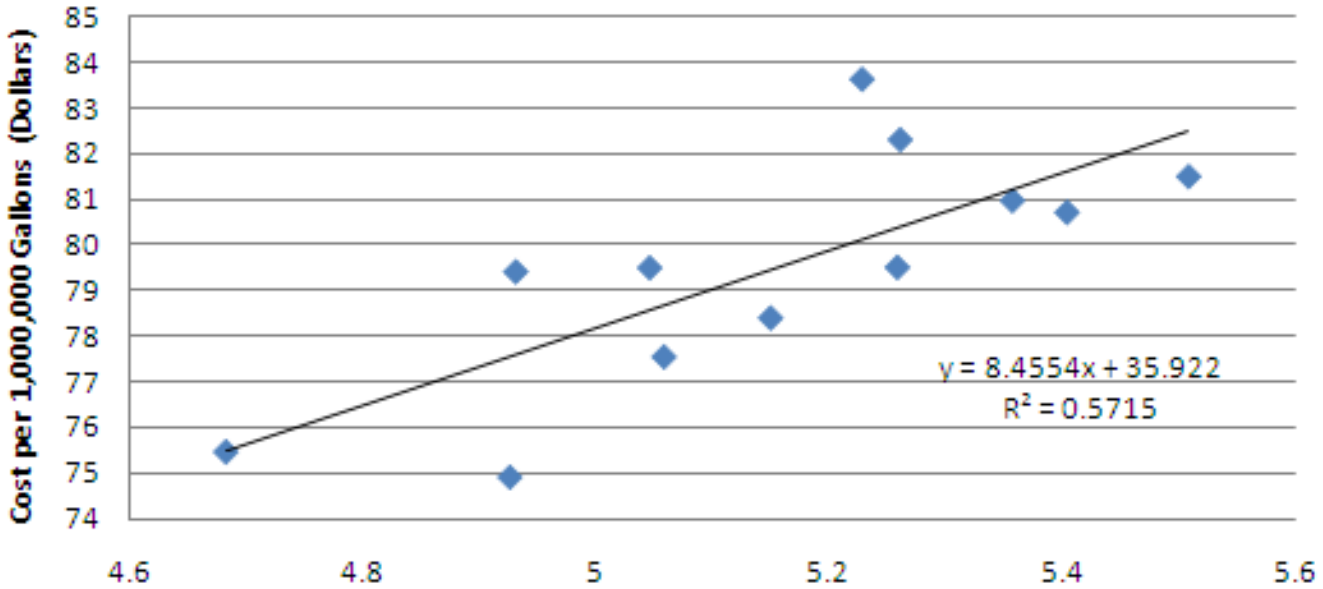
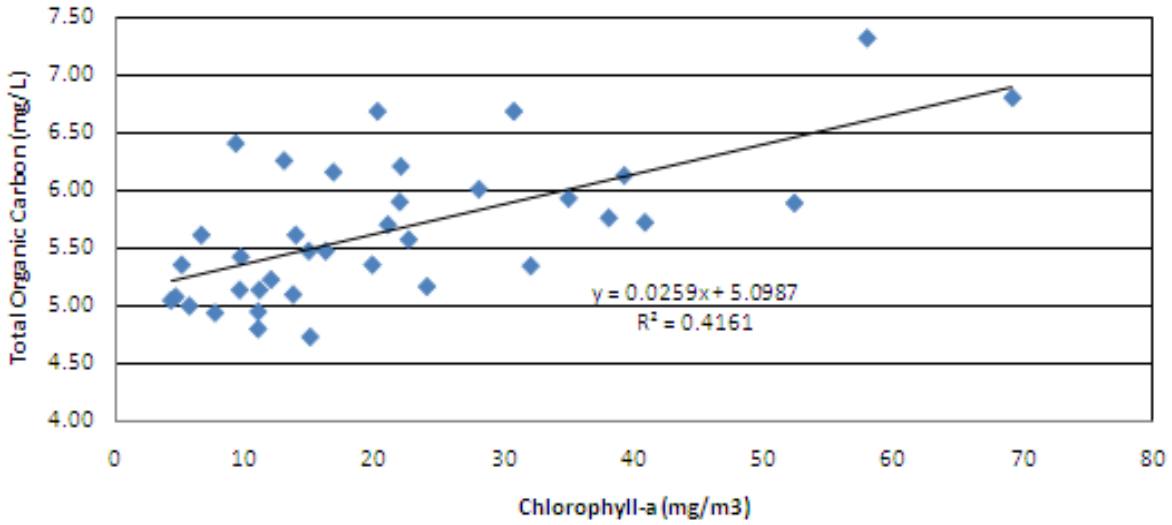
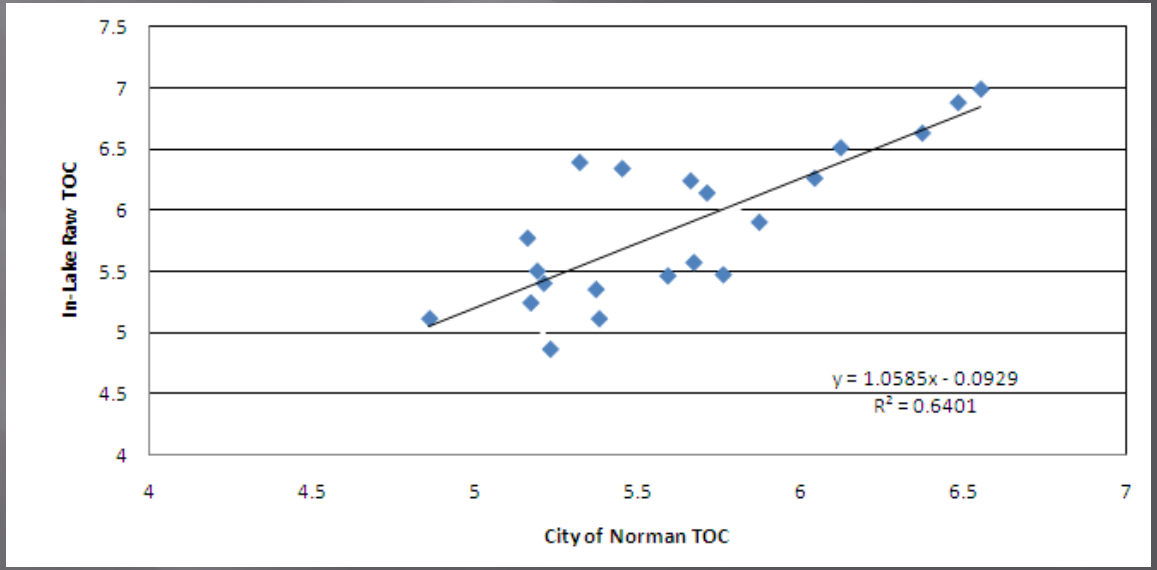
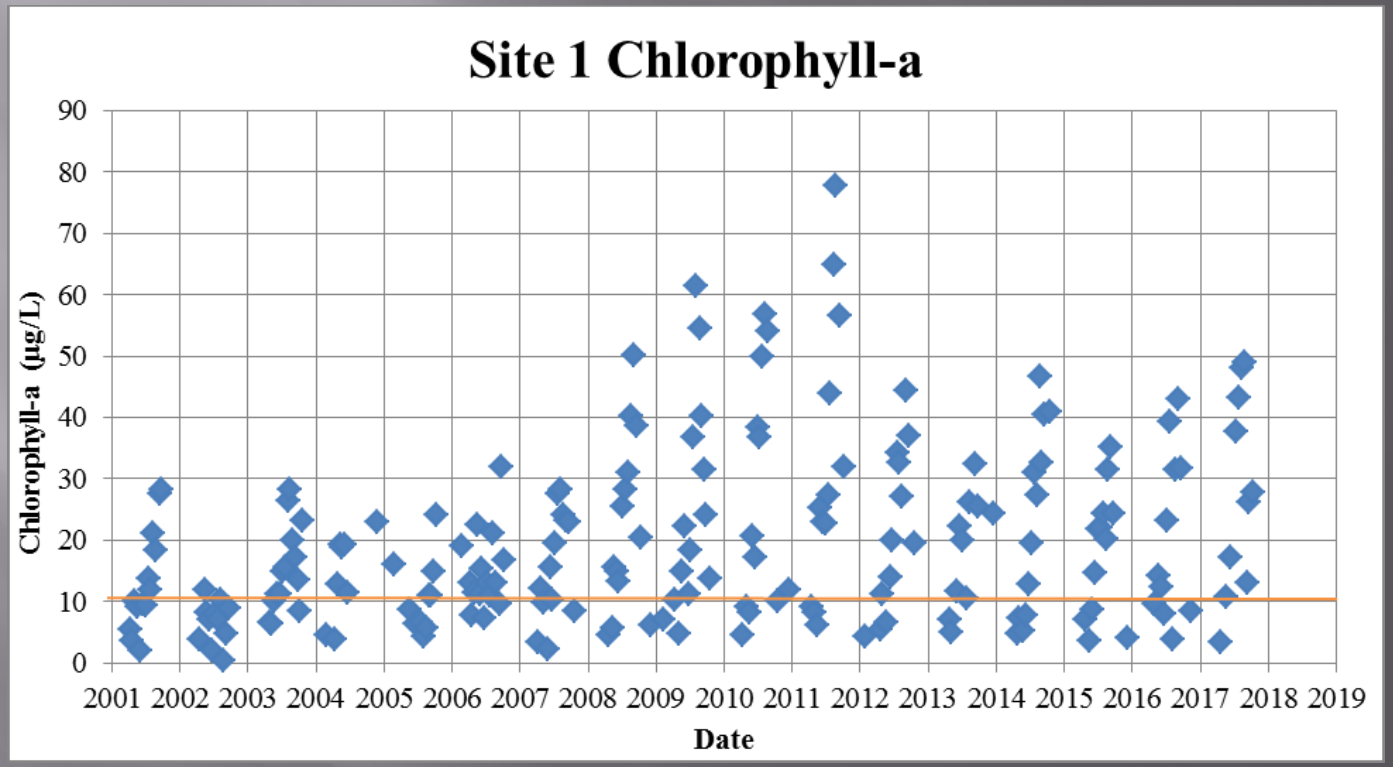


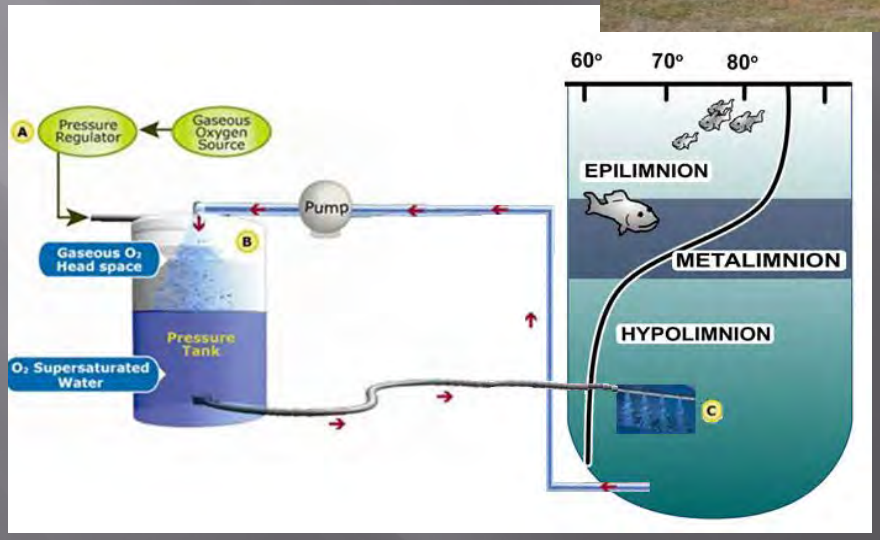
Figure 7: Lake Thunderbird TOC vs Chlorophyll-a for raw water samples.






Site 1 Chlorophyll-a
Chlorophyll-a (µg/L)
90
80
70
60
50
40
30
20
10
0
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Date

Hypolimnetic Oxidation



SDOX Performance: Sediment Release

Nutrient Release (Nurnberg 1994)

$$\text{Load} = RR_{sed} * AF$$

$$Log(RR)_{sed} = 0.8 + 0.76 \log(TP_{sed})$$

$$AF = \sum_{i=1}^{n} (t_i * a_i) / A_o$$

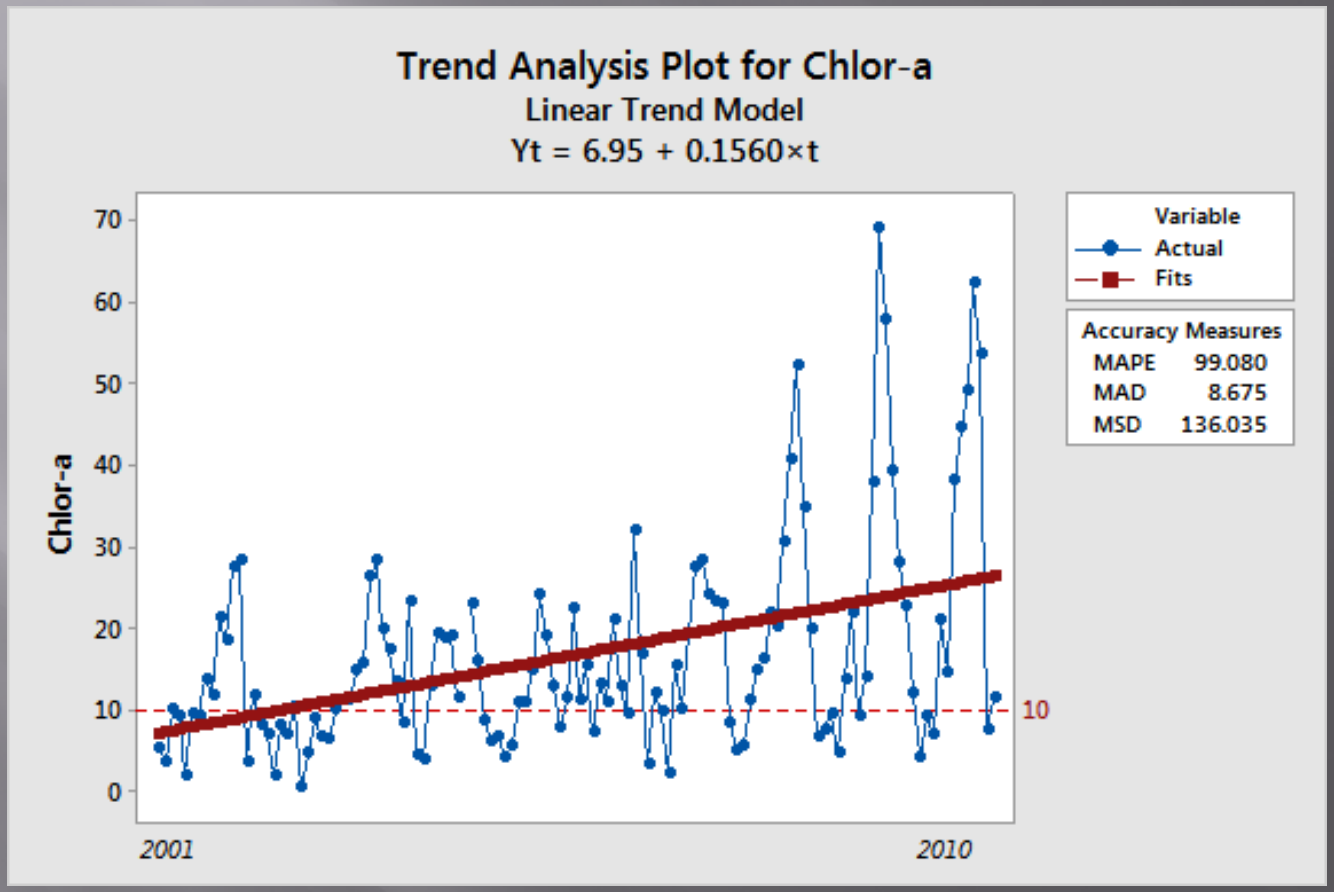
Where
- n = number of time intervals
- t = time interval
- a = area of anoxic sediment within time
- A_o = area of lake

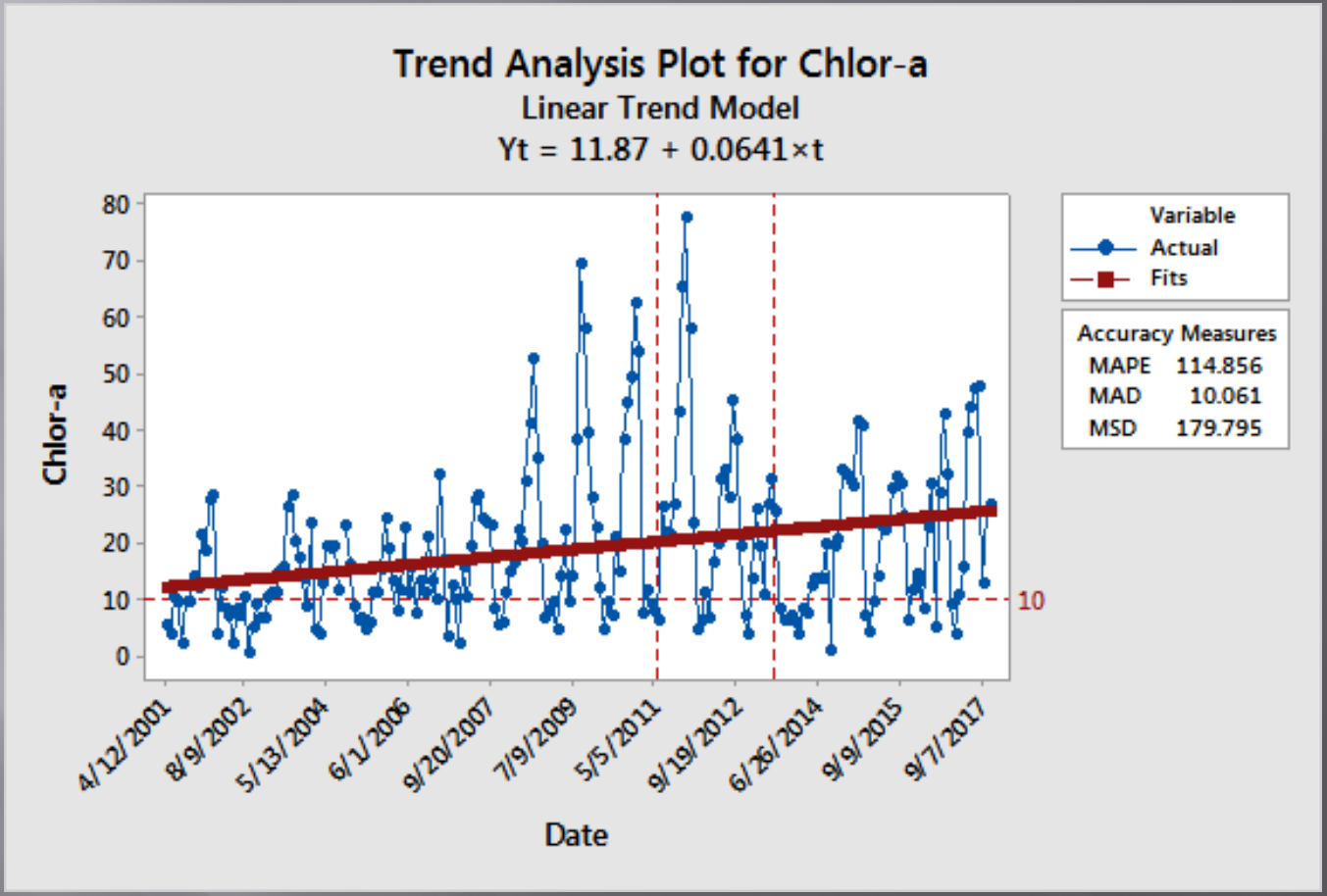
Anoxic Factor (AF) and Sediment Phosphorus Load (P-load) by Year (2011 – 2017) with Relative Percent Difference (RPD)*

Year	AF (day^{-1})	RPD	P-load (kg)	RPD
05 –– 09 Average	33.03	0%	3,548	0%
2011	21.47	35%	2,307	35%
2012	25.5	23%	2,739	23%
2013	13.07	60%	1,404	60%
2014	38.26	-16%	2,257	36%
2015	56.28	-70%	5,884	-66%
2016	47.06	-42%	4,552	-28%
2017	47.13	-43%	4,440	-25%

* Nurnberg, Gertrud. "Phosphorous Release from Anoxic Sediments: What We Know and How We Can Deal With It." Limnetica . 10.1 (1994): 1-4. Print.

Pre-Implementation



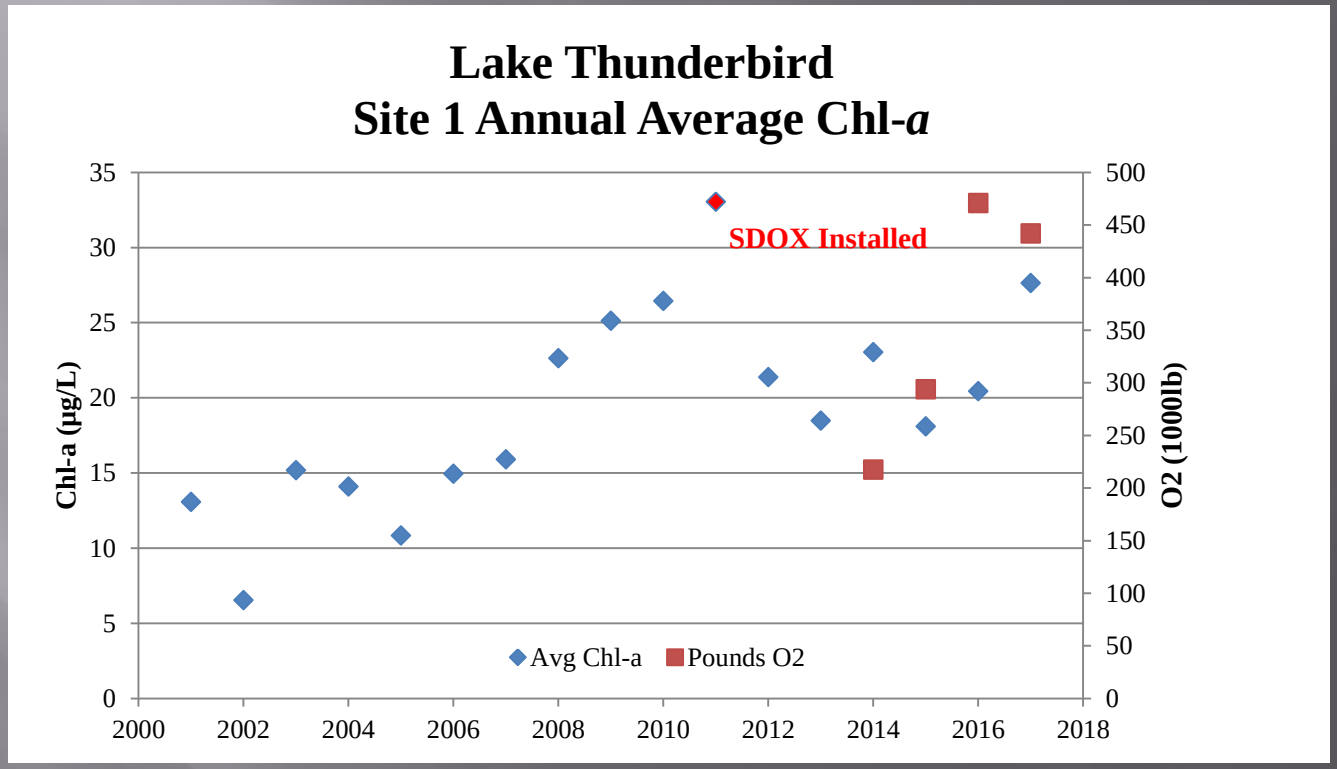


Time Span: 2001 – 2017

Yt = 11.87 + 0.0641×t

Time Span: 2001 – 2010

Yt = 6.95 + 0.1560×t


Lake Thunderbird
Site 1 Annual Average Chl-a
Chl-a (µg/L)
O2 (1000lb)
SDOX Installed
Avg Chl-a
Pounds O2
0
5
10
15
20
25
30
35
0
50
100
150
200
250
300
350
400
450
500
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018

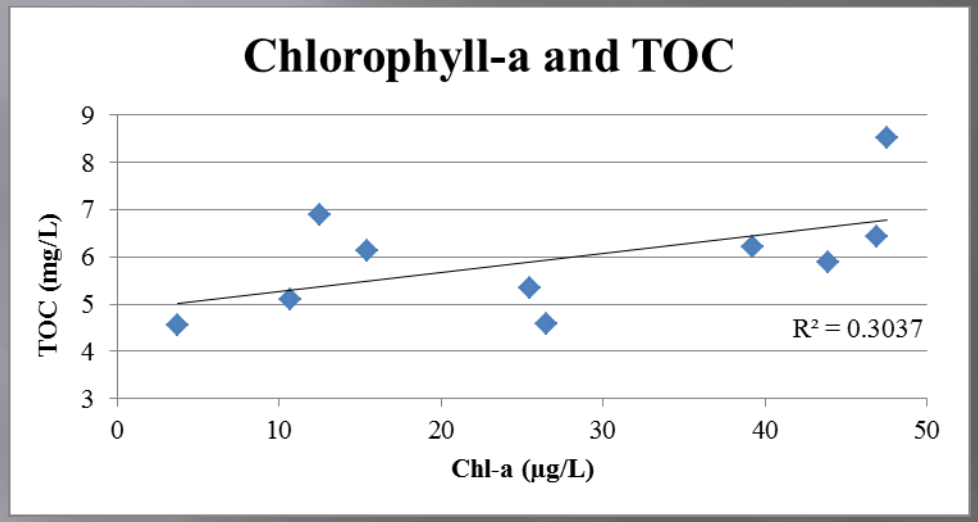
Eutrophication ongoing

In-lake BMP induced oligotrophication

Evidence of increased watershed impact

SWS Designation - Appropriate

Questions



For every 4.5 µg/L change in chlorophyll-a (algae content) the cost of chemicals to treat the water for drinking increases one dollar.