

Blue Water Satellite

Using Satellite Imaging to Monitor the World's Land
and Water Resources™

What we do

- We use satellite images and patented image processing algorithms to monitor the world's land and water resources
- We provide you with images and data that allow you to
 - Determine land and water body quality
 - Spot problems areas
 - Develop cost effective remediation strategies (cost savings offset image costs)

Some of our Customers

Environmental Engineering



US Army Corps of Engineers

Oil Companies



Federal, State, Local Agencies, HOA's



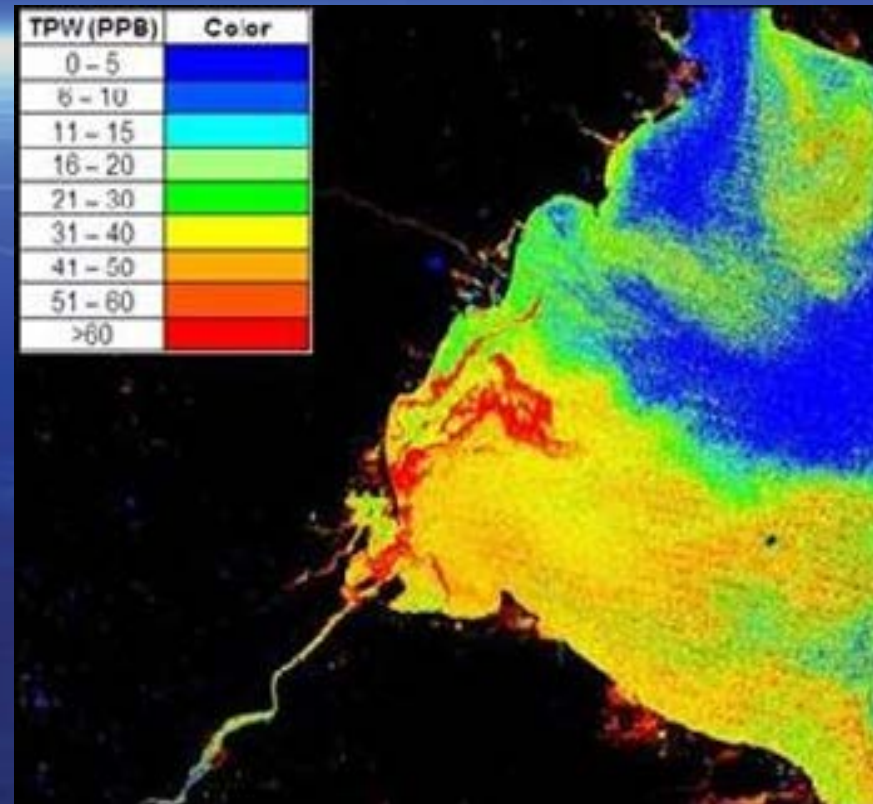
Power Companies



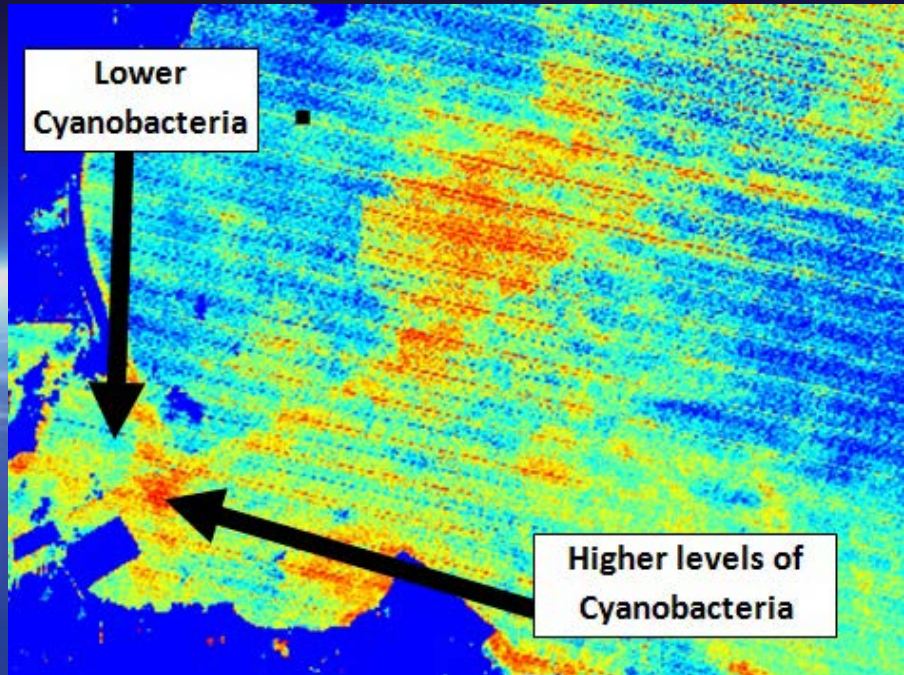
Blue Water Satellite

Using Landsat and other satellites...

...to see where the problems are.



You CAN'T tell this.....



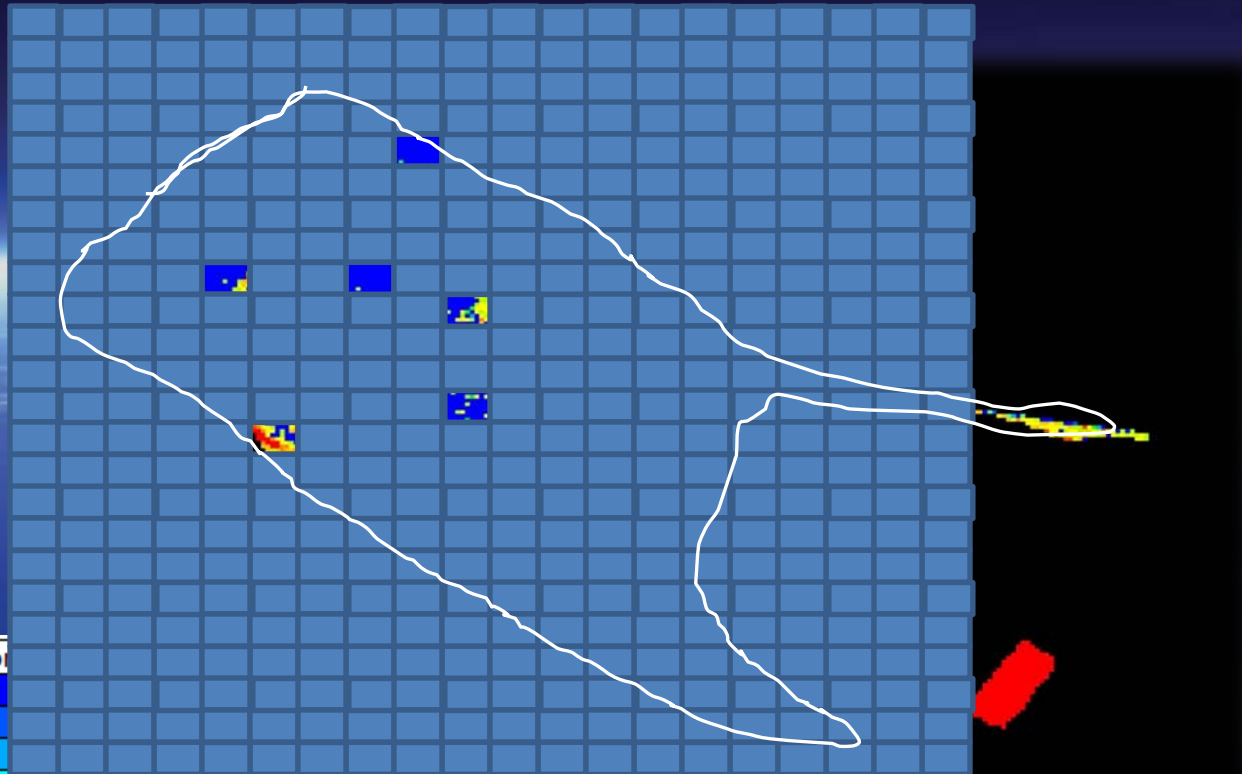
From this.



To make intelligent decisions,

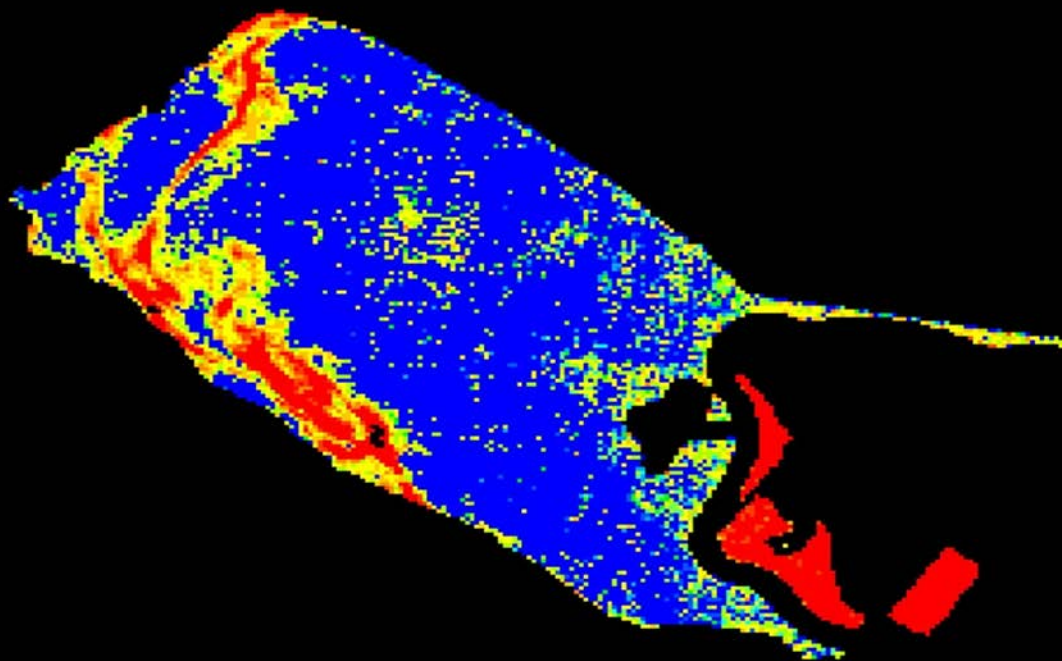
you need more data. BWS=5 samples/acre

Lake Elsinore 10/01/1997 Chl-a Scan



Chl-a (PPB)	Color
0 - 5	Dark Blue
6 - 10	Blue
11 - 15	Light Blue
16 - 20	Cyan
21 - 30	Light Green
31 - 40	Green
41 - 50	Yellow-Green
51 - 75	Yellow
76 - 100	Orange
101 - 125	Dark Orange
126 - 150	Red-Orange
>150	Red

Lake Elsinore 10/01/1997 Chl-a Scan



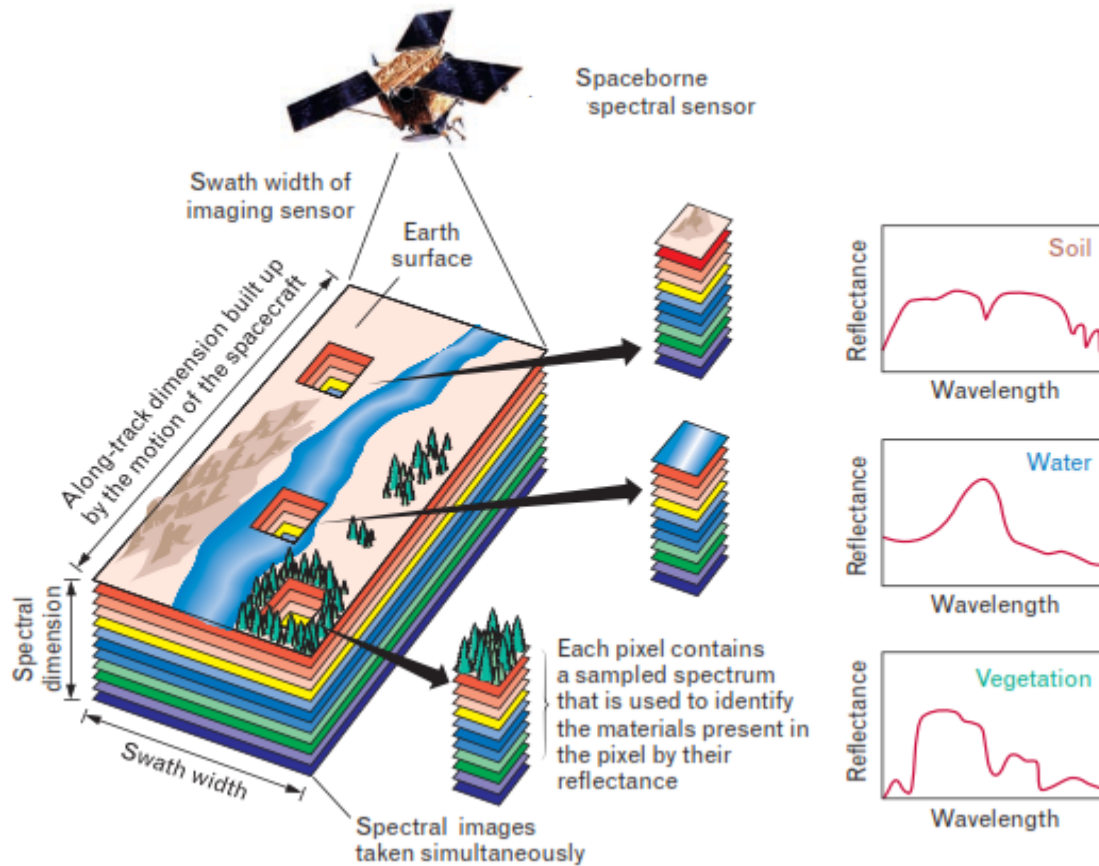
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31 - 40	Yellow-Green
41 - 50	Yellow
51 - 75	Orange
76 - 100	Dark Orange
101 - 125	Red-Orange
126 - 150	Red
>150	Dark Red

Most Water Bodies are not Homogeneous!

Station	Station	Mean	Mean
		Chl a	PC
ST 196	1	187.825	143.5
ST 197	2	371.225	309.225
ST 198	3	122.675	137.625
ST 199	4	616.775	568.525
ST 200	5	106.075	108.975
ST 201	6	65.775	60.625
ST 202	7	42.375	33.2
ST 203	8	51.65	39.7
ST 204	9	52.725	44.225
ST 205	10	32.675	23.1
ST 206	11	53.975	57.05
ST 207	12	52.375	45.05
ST 208	13	35.175	30.45
ST 209	14	30.175	23.6
ST 210	15	28.425	20.675
ST 606	16	26.75	23.55
ST 607	17	31.975	33.7
ST 608	18	33.2	37.275
ST 609	19	71.575	49.175
ST 610	20	143.125	69.55

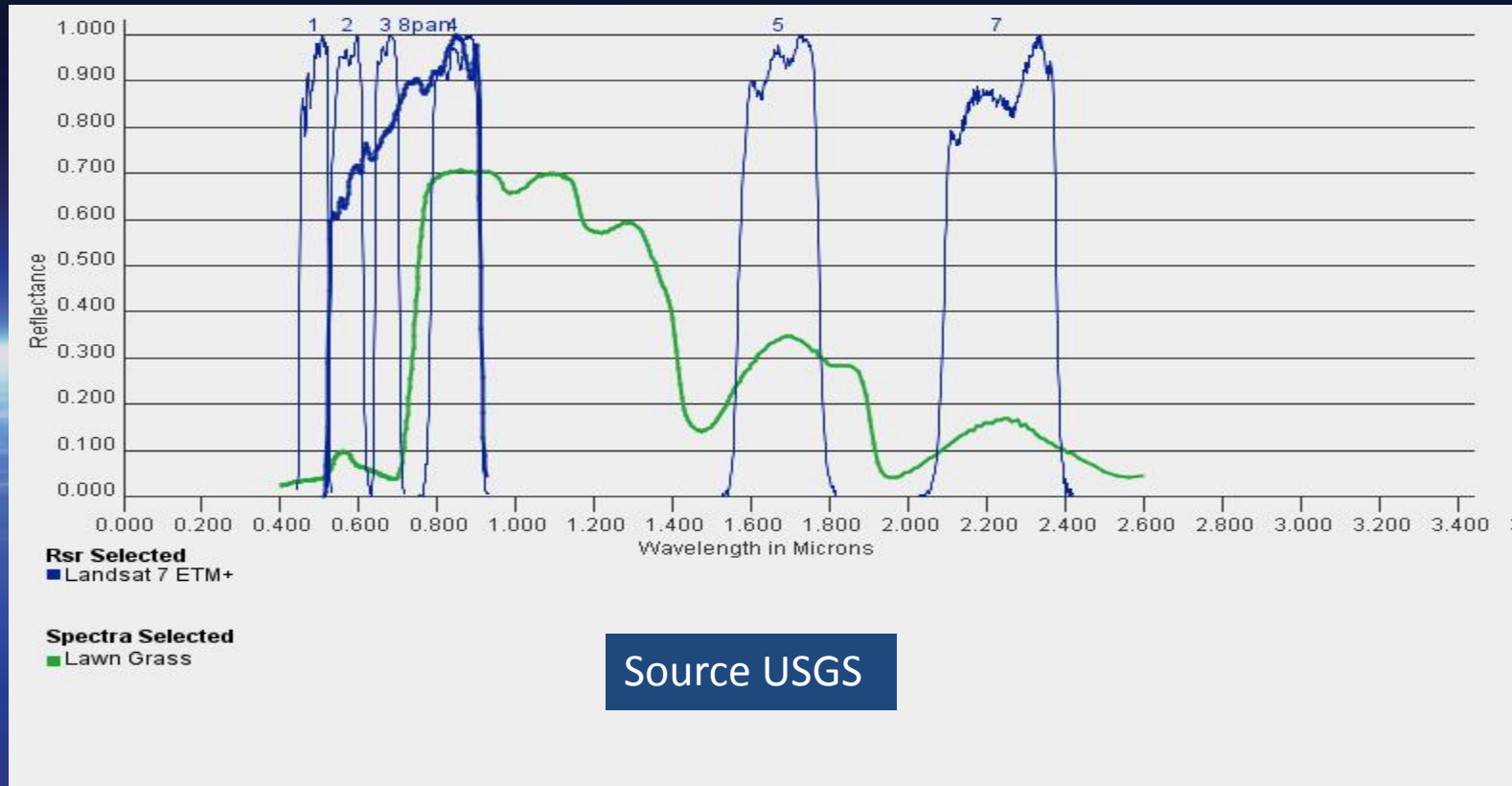
All data from EPA method certified labs in ppb

How it works



Many chemical and biological constituents produce a unique spectral reflectance signature
(Courtesy MIT Lincoln Labs)

How Blue Water Satellite Works

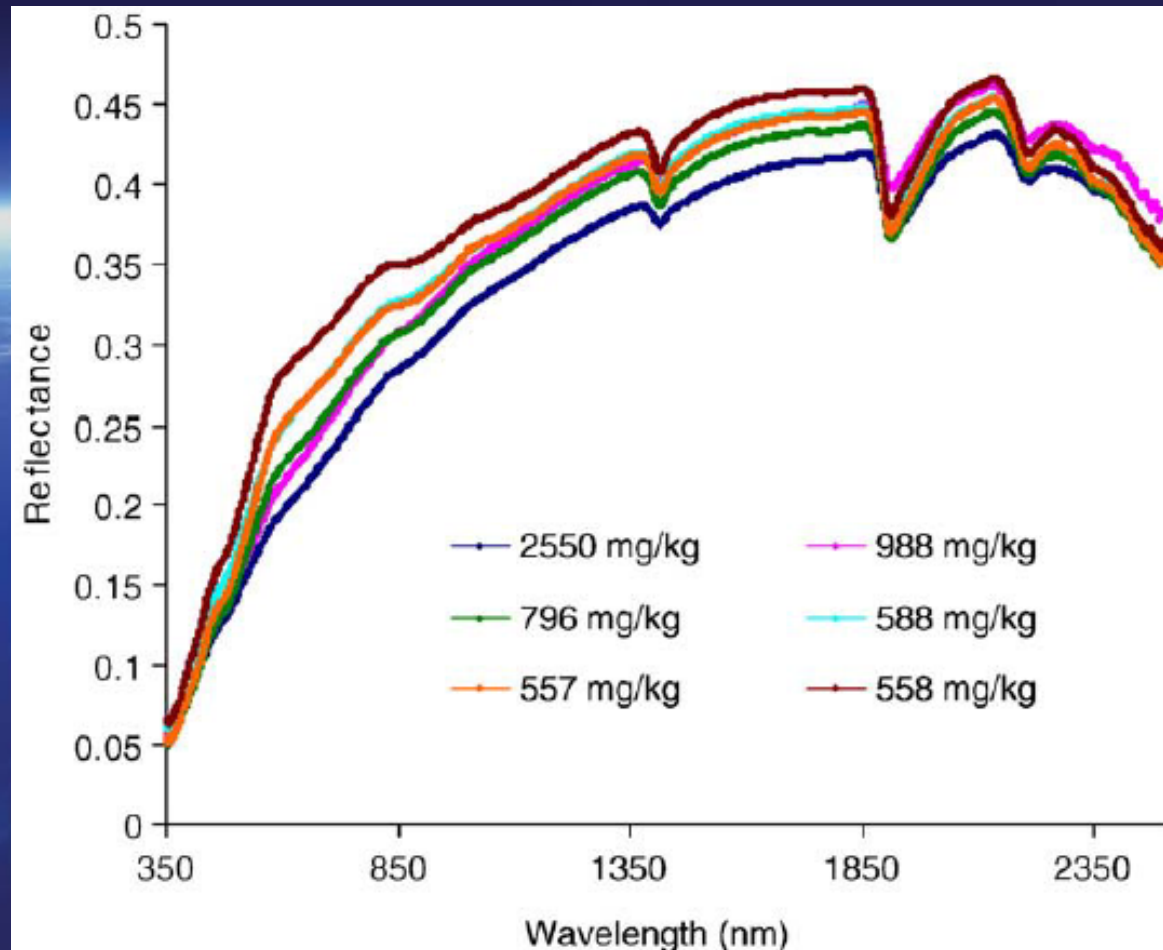


The ratios between the 7 bands of reflected light is a “fingerprint “ for each constituent

Spectral Reflectance Curve Phosphorus on Land

Phosphorus in Soils

Spectra of Soil at Various Phosphorus Levels used in BWSI Algorithm





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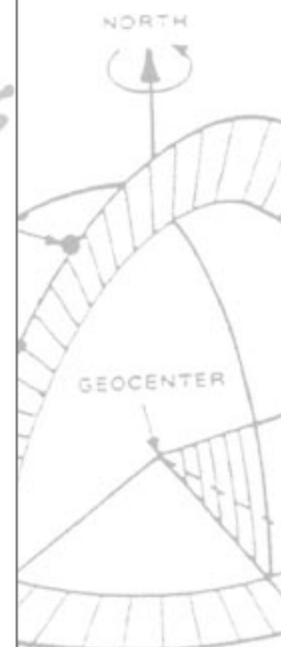
landsat news

Landsat Enables Remote Detection of Dangerous Water Pollutants

Nov. 12 • A young Ohio business, Blue Water Satellite, Inc., is using Landsat 5 and 7 data to detect potentially harmful pollutants in water bodies across the U.S. used for recreation and for drinking water supplies. Using Landsat and algorithms developed at Ohio's Bowling Green State University, Blue Water can detect E. Coli, cyanobacteria, phosphorus, and Red Tide. Dr. Robert K. Vincent, a geology professor at BGSU, used NASA and NOAA grant money to help develop the pollutant-detection algorithms.

More information:

+ [Bowling Green business goes global \[external link\]](#)



Years of Research & Peer Review



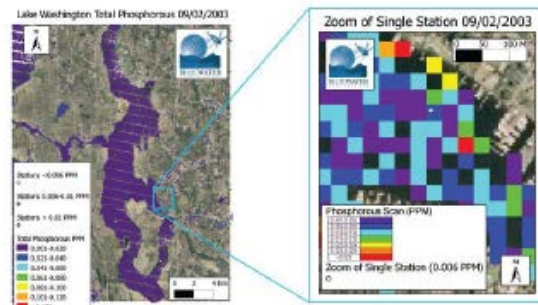
Science of the Total Environment

An International Journal for Scientific Research into the Environment and its Relationship with Humankind



Total Phosphorus Water Monitoring Using Satellite Imagery

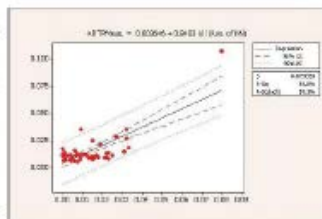
Figure 1: BWSI Total Phosphorus Processed Image Example, Lake Washington



Remote Sensing of Environment 99 (2004) 311–312

Remote Sensing of Environment

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show that using the BWSI processed images for Phosphorus scanning will become a realistic and future monitoring efforts. The next evaluation shows how the data line of field sample collection and satellite overpass are closer together.

Phycocyanin detection from LANDSAT TM data for mapping cyanobacterial blooms in Lake Erie

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US007132254B2

(12) United States Patent Vincent

(10) Patent No.: US 7,132,254 B2
(45) Date of Patent: Nov. 7, 2006

(54) METHOD AND APPARATUS FOR DETECTING PHYCOCYANIN-PIGMENTED ALGAL AND BACTERIA FROM REFLECTED LIGHT

(75) Inventor: Robert Vincent, Bowling Green, OH (US)

(73) Assignee: Bowling Green State University, Bowling Green, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 10/763,118

(22) Filed: Jan. 22, 2004

OTHER PUBLICATIONS

Richardson, Laurie, Remote sensing of algal bloom dynamics, *J. Great Lakes Res.*, vol. 46, No. 7, pp. 492-501.
Gitelson, A., et al., Optical properties of dense algal cultures outdoors and their application to remote estimation of biomass and pigment concentration in *Spirulina platensis* (Cyanobacteria), 1995, *J. Appl. Phycol.*, vol. 31, No. 5, pp. 828-834, abstract.
Green, S., 2003, <http://www.usadl.com/phys/strat/MODEL.HTM>, The effect of chlorophyll concentration on airborne hyperspectral reflectance.
Landfast "Science Data Users Handbook, <http://ftp.wv.gov/gsc/naas/gov/LAS/handbook...html#chapter6.html>, last updated Aug. 7, 2001; accessed Dec. 16, 2004.
Gitelson, A. et al., Optical properties of dense algal cultures outdoors and their application to remote estimation of biomass and pigment concentration in *Spirulina platensis* (cyanobacteria), 1995, *J. Phycol.*, 31: 828-834.*



Science of the Total Environment

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Mapping the total phosphorus concentration of biosolid amended surface soils using LANDSAT TM data

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ABSTRACT

Conventional methods for soil sampling and analysis for soil variability in chemical characteristics are too



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ABSTRACT

Conventional methods for soil sampling and analysis for soil variability in chemical characteristics are too time-consuming and expensive for routine monitoring over large-scale areas. Hence, the objective of this study was to determine if LANDSAT TM data can be used to map surface chemical characteristics of such amended soils. For this study, we selected 100 soils in Ohio, developed a TM data set that had been applied with 24 and 11 ton/ha² of biosolids, respectively. Soil samples from a total of 170 sampling locations across the two fields were collected one day prior to LANDSAT TM overpass and were analyzed for several chemical concentrations. The concentrations of N, O, Ca, S, and P were found to be significantly higher in the four soils (TAN/TA, compared to BWSI). Regression equations were established for each of the elements considered, and the model equations employed only spectral ratios. The model was successfully tested for validation by applying it to another LANDSAT TM image obtained on 15 June 2003. The results indicate that LANDSAT TM mapping of total phosphorus can be used to quantify and map the spatial variation of total phosphorus concentration in surface soils. This research has significant implications for identification and mapping of areas with high P levels to increase the engineering and monitoring the total phosphorus management practices across the region.

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1. Introduction

Application of treated sewage sludge (biosolids) to agricultural land has become a prevalent and acceptable method of waste disposal in recent years. Biosolids are known to improve soil physical characteristics (Cassner et al., 1975; Wu et al., 1983), increase the organic matter and cation exchange capacity, and supply the nutrients required for crop growth (Sommers, 1971; Singh and Agarwal, 2000). However, the potential for excess application of biosolids, resulting in a build up of nitrogen, phosphorus (Mann et al., 2001), and copper (de la Motte et al., 2003; Udén et al., 2004; Nyman and Mörner, 1999) and cadmium (Bergholm et al., 2003) in the surface soil of agricultural fields continues to be an area of concern. Accumulation of phosphorus at high concentration is a major environmental concern, as it affects the water quality of lakes and rivers in the event of runoff (Shaner and Sims, 2002). Hence, there is an increasing need to continuously monitor the extent of

soil contamination in biosolid applied fields. Even though conventional methods of soil sampling and testing are being used for this purpose, they are often expensive, time-consuming and unsuitable for mapping soil contamination over large areas. Remote sensing, has been used as an alternative method for detecting and mapping the physical and chemical characteristics of the soil. High resolution aerial imagery was used to monitor the organic carbon (Chang et al., 2001; Clark and Robinson, 1999; Srinivasan, 1999; Singh and Ramesh, 1995), organic carbon (Singh and Ramesh, 1995; Singh and Ramesh, 1995), organic carbon (Singh and Ramesh, 1995; Singh and Ramesh, 1995), and soil phosphorus (Singh and Ramesh, 1995). The addition of soil contaminants as a result of biosolid application needs to be considered in surface soil samples (Mann et al., 2003; Bergholm et al., 2003; Udén et al., 2004; Nyman and Mörner,

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BWS to Laboratory Data Comparison

Data comparison Blue Water Satellite, Heidelberg National Center for Water Quality, UNH						
Phosphorus in water ppb data from samples taken at Moultonborough NH						
#	Date	Lat	Long	Landsat TP (Averaged) ppb	Heidelberg Data ppb	UNH Data ppb
1	7/16/2011	43 40' 29.9"	71 20' 45.3"	4.7	9.8	5.6
2	7/16/2011	43 42' 23.0"	71 21' 16.1"	11.3	11.6	6.9
3	7/16/2011	43 43' 07.8"	71 24' 33.7"	9.3	11.6	8.5
4	7/16/2011	43 43' 34.2"	71 22' 32.6"	6.5	12.5	8.6
5	7/16/2011	43 42' 57.4"	71 22' 08.7"	2.6	14.8	9
6	7/16/2011	43 43' 03.2"	71 24' 37.3"	13.4	12.4	11
7	7/16/2011	43 43' 26.0"	71 24' 37.3"	*	16	8.4
8	7/16/2011	43 43' 14.7"	71 22' 58.7"	8.8	11.6	8.5
*In an area where satellite measurement could not be made						
				Δ Landsat to Heidleberg (ppb)	Δ Landsat to UNH (ppb)	Δ Heidleberg to UNH (ppb)
				5.1	0.9	4.2
				0.3	4.4	4.7
				2.3	0.8	3.1
				6.0	2.1	3.9
				12.2	6.4	5.8
				1.0	2.4	1.4
						7.6
				2.8	0.3	3.1
Average of Absolute Value delta (ppb)				4.3	2.5	4.2

Technology

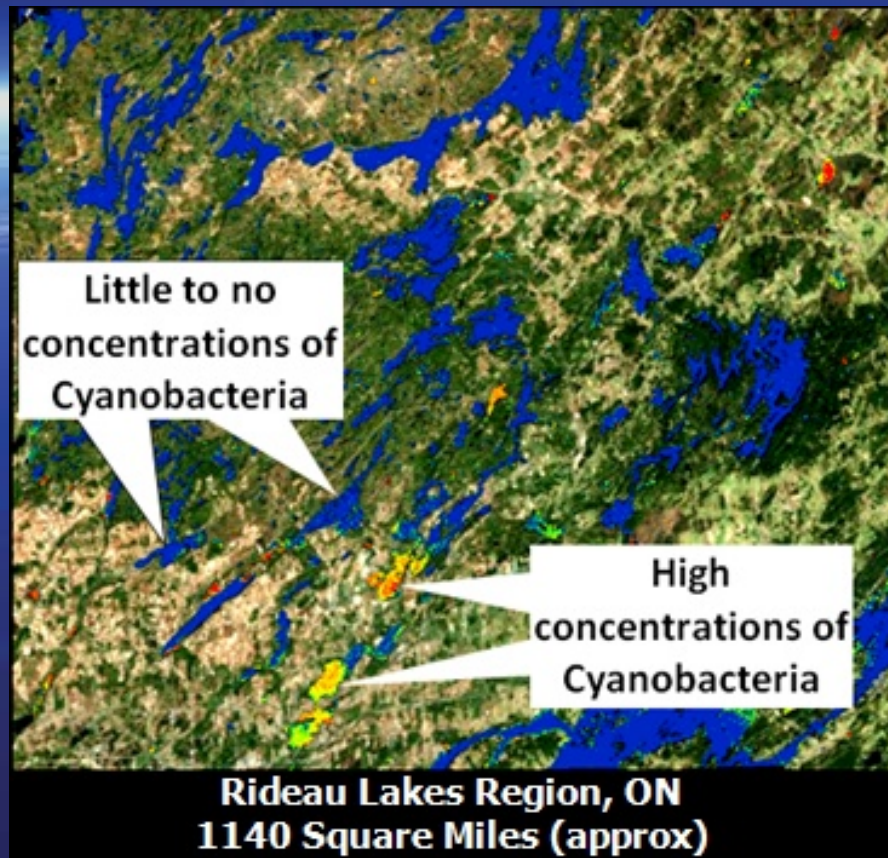
- Uses Landsat and commercial satellites
- Technology Bowling Green State University (BGSU).
- \$1 million in funding from NASA and NOAA over 2 ½ years for validation.
- 3 issued patents and 8 pending patents
- Peer reviewed science
- Ability to go back in time to 1984
- 5 samples/acre
- Worldwide China, Australia, Canada, US, Etc.



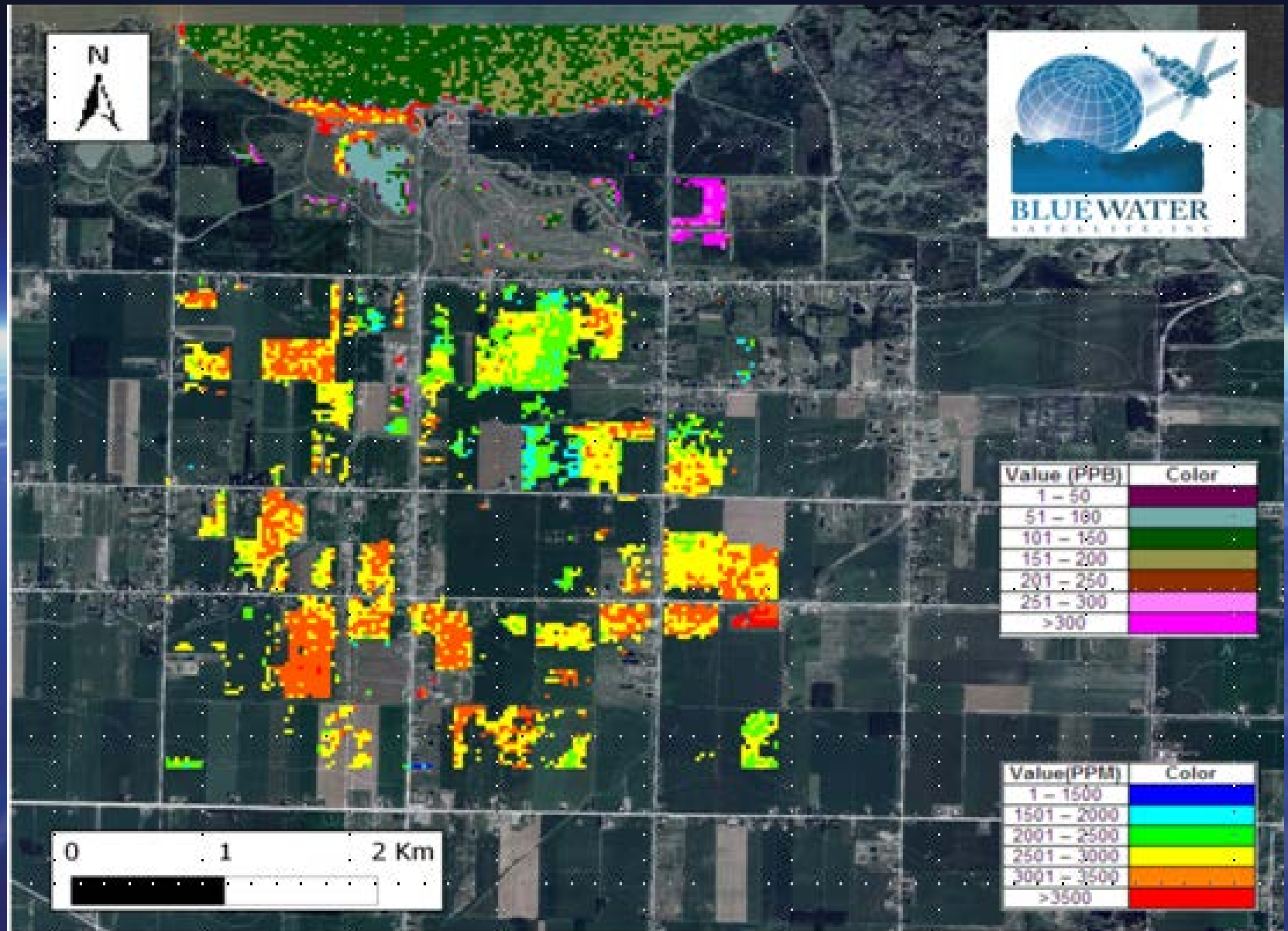
Case Study #1

Identifying where the problems are

Area with 106 Lakes



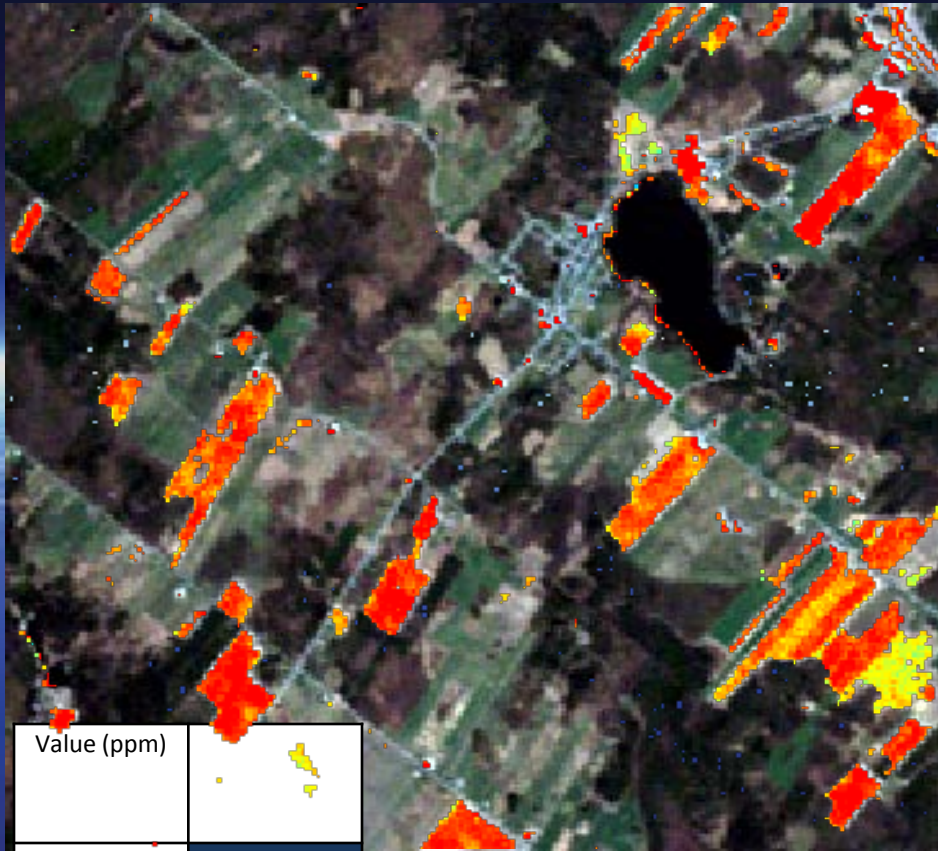
Case Study #2 Sources Phosphorus Land



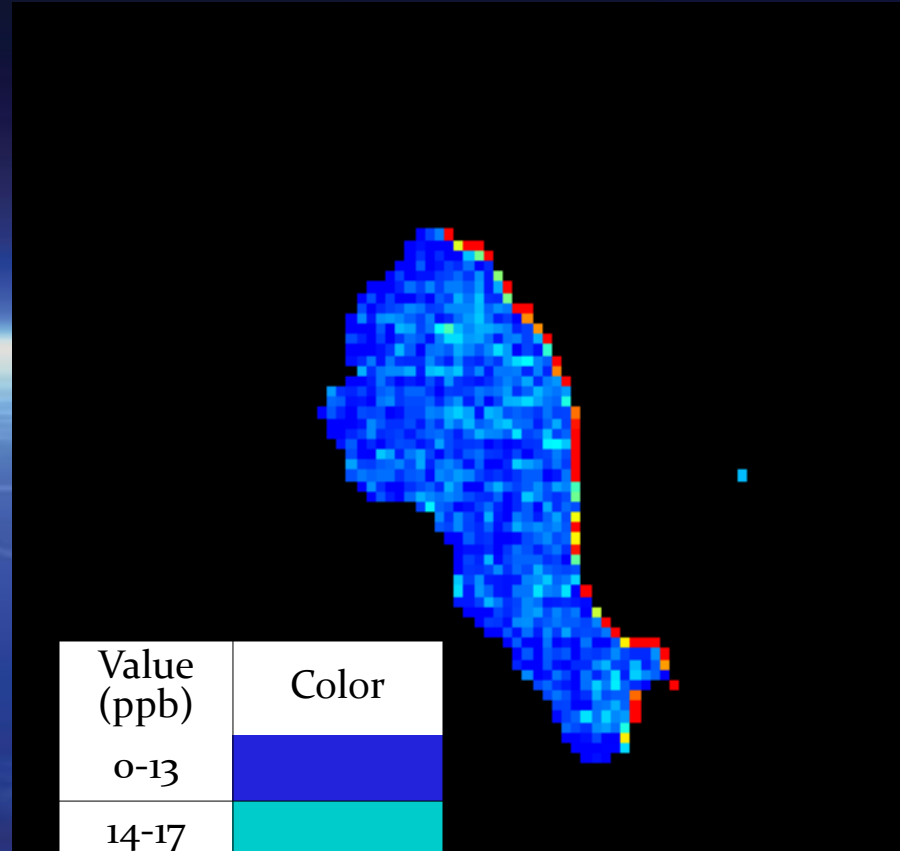
Case Study #3

Identifying Point Source Problems on Land

The image below details Total Phosphorus on Land (TPL) in an agricultural area



Value (ppm)	Color
0	Blue
1900	Green
2400	Yellow
2700	Orange
3800	Red

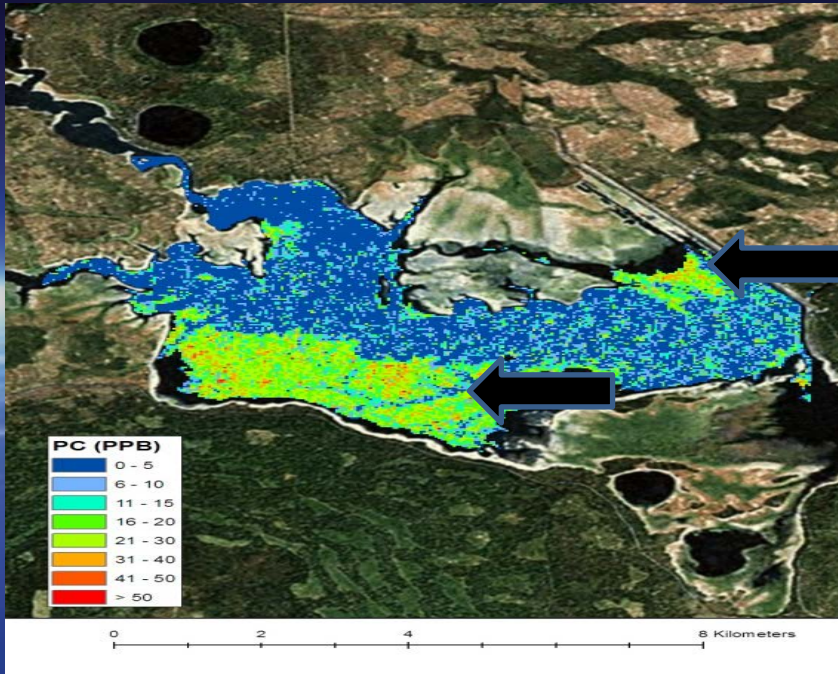


Value (ppb)	Color
0-13	Blue
14-17	Cyan
18-21	Green
22-26	Yellow
27-49	Orange
>50	Red

Case Study #4

Reducing Treatment Cost

BWSI is the only technology that enables significant savings in treatment costs!



Planned Treatment :

Apply Alum in entire lake	\$2,200,000
---------------------------	-------------

BWSI Solution:

Target Alum to affected areas	\$1,300,000
Cost of Satellite Images	\$ 40,000
Total	\$1,340,000

Customer Savings:

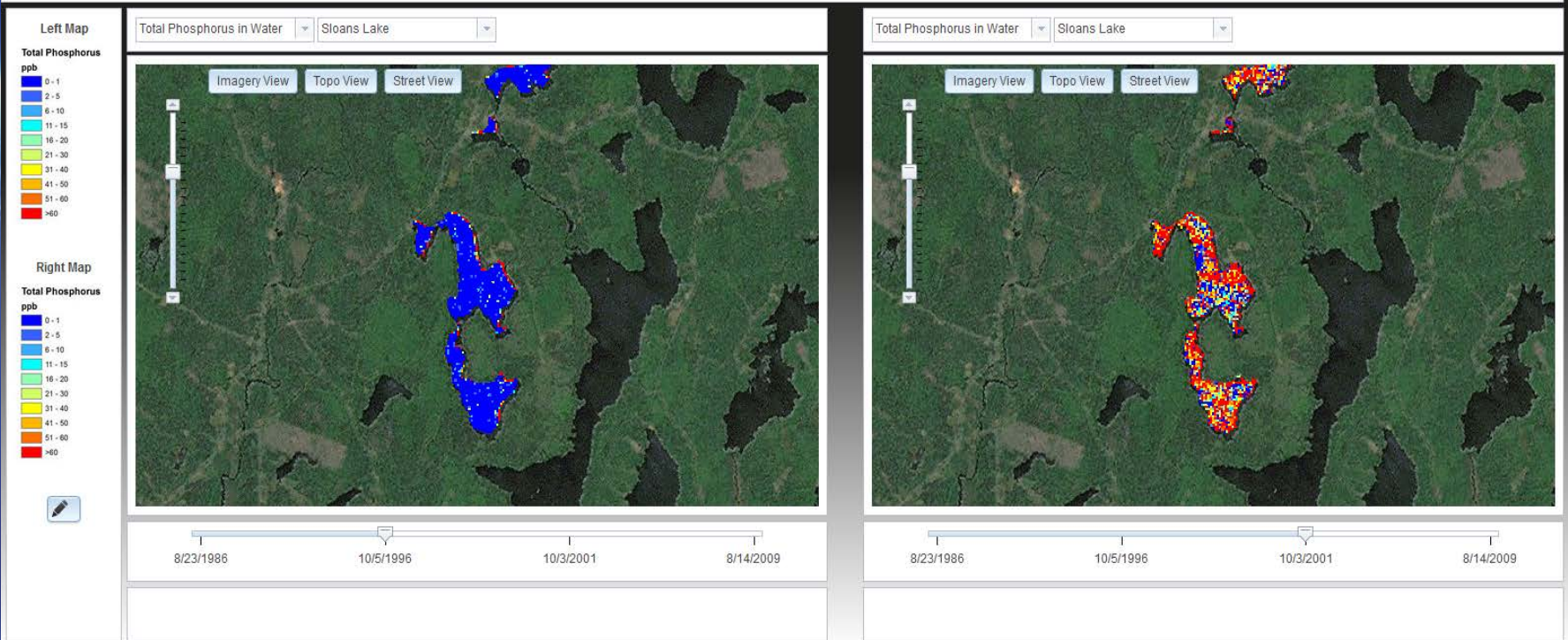
\$860,000!

"You really can't get this information in a cost-effective manner any other way. It's a real bargain if you're trying to do comprehensive sampling of the lake. It's the only way to get the information we want in a cost effective manner because it's lake wide and it's a big lake. – Frank Pickett PPL Montana

Case study #5 Risk Mitigation

The Blue Water Satellite Viewer (BWS Viewer™) enables clients to:

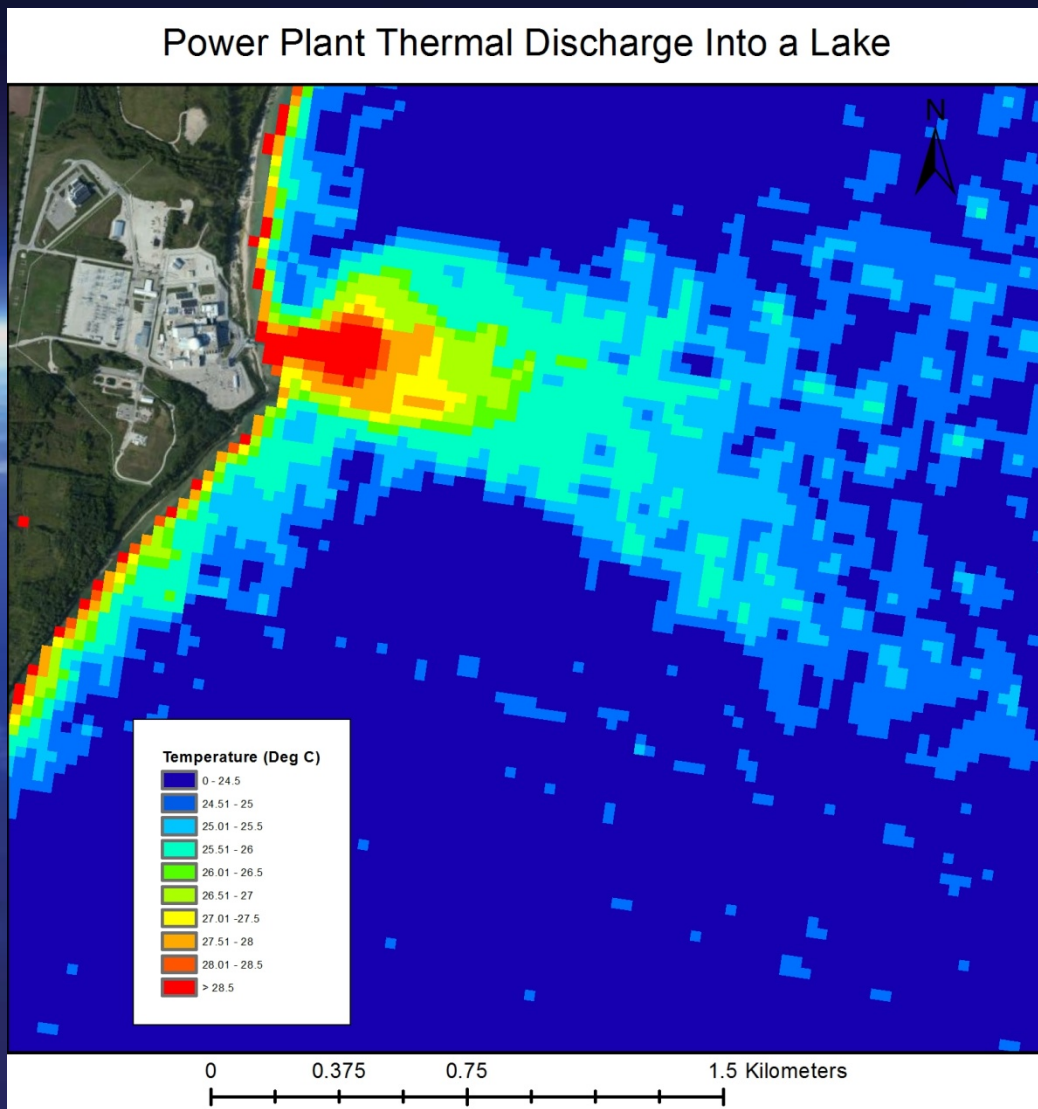
Compare water bodies and constituents
Quickly evaluate current and historic trends





Case Study #6 Temperature Plumes

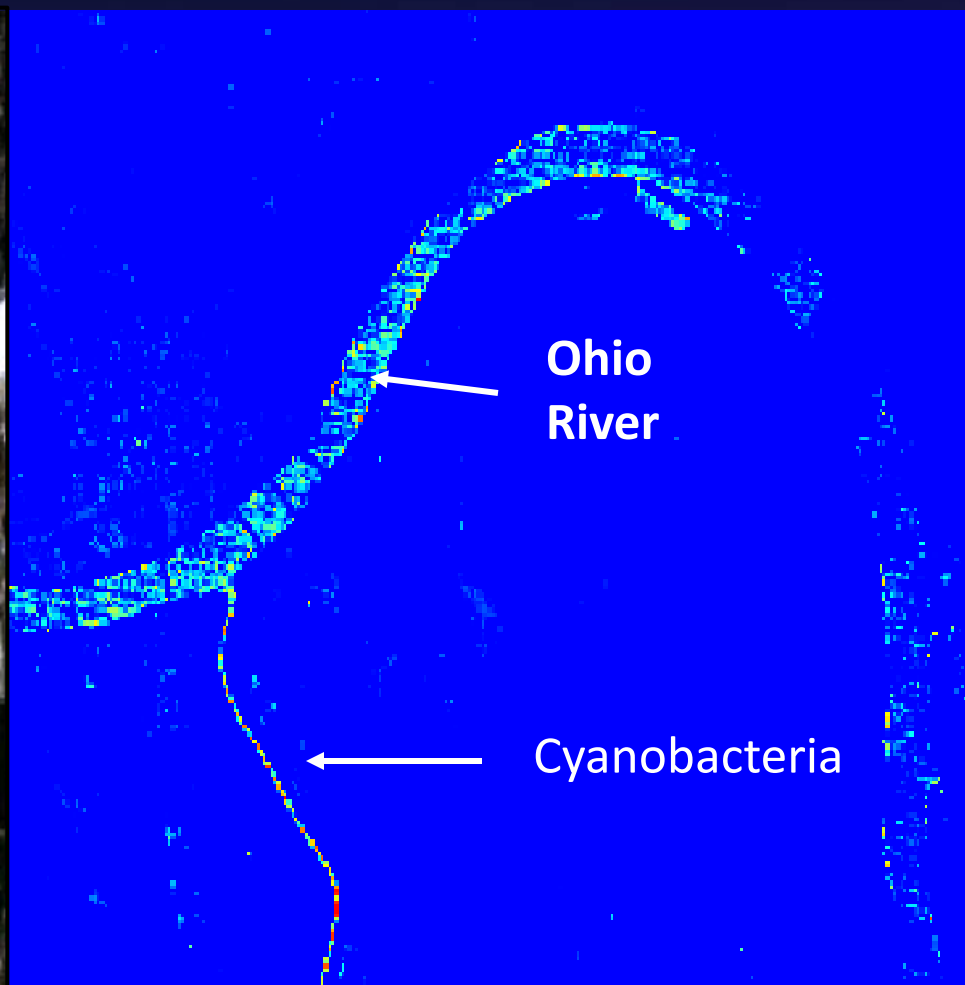
The image below details temperature in water (Deg C)



Case Study #7 Aid in Determining Problem Sources Ohio River 2008



Landsat Natural Color Image

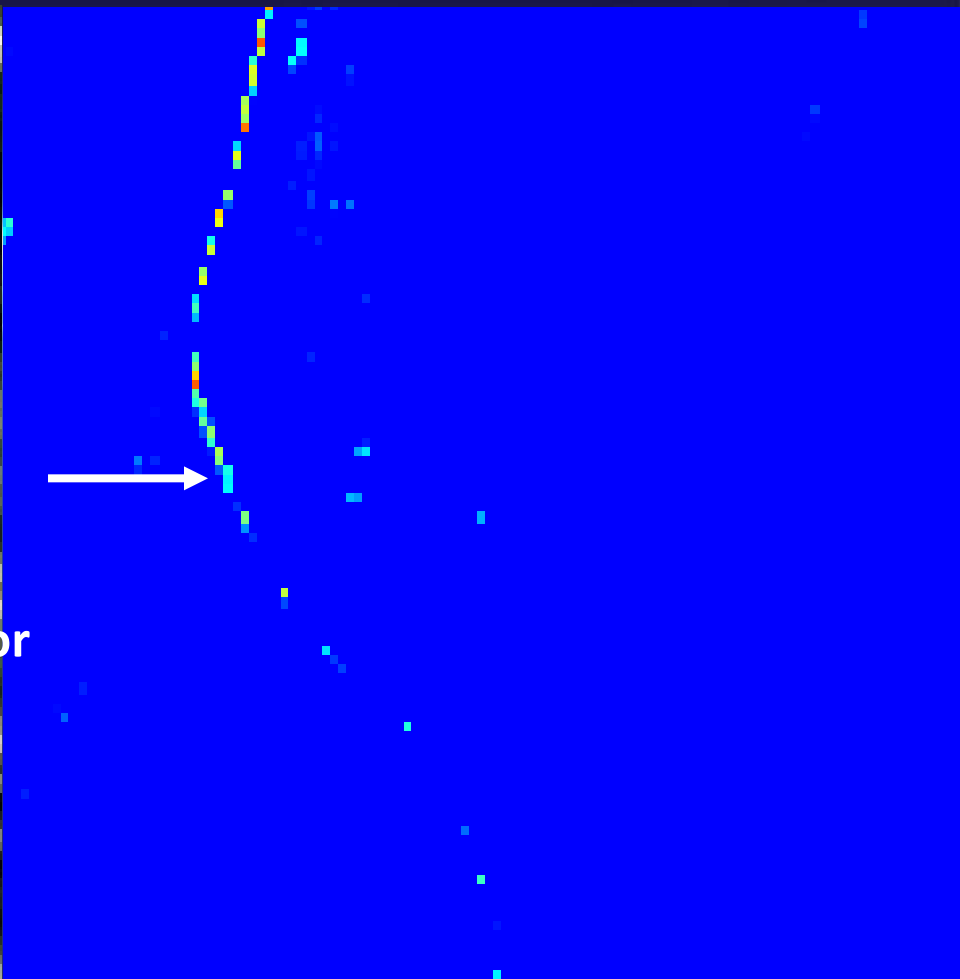


Landsat processed Image

Case Study #7 Aid in Determining Problem Sources Licking River 2008



Landsat Natural Color Image



Landsat Processed image



BWS Range and Accuracy

Blue Water Satellite Constituent Accuracy and Range Data

Constituent	Range	Accuracy
Cyanobacteria (Phycocyanin)	0-17 ppb	±2 ppb
Cyanobacteria (Phycocyanin)	17-60 ppb ^A	±17 ppb
Total Phosphorus Water (TPW)	0-20 ppb	±6 ppb
Total Phosphorus Water (TPW)	20-100 ppb	±11 ppb
Total Phosphorus Land (TPL)	0-4000 ppm	±530 ppm
Chlorophyll-a	1-155 ppb	±22 ppb
Temperature	1.9 - 27.6°C	± 1.52°C
Aquatic Vegetation	Relative	Presence/ Absence

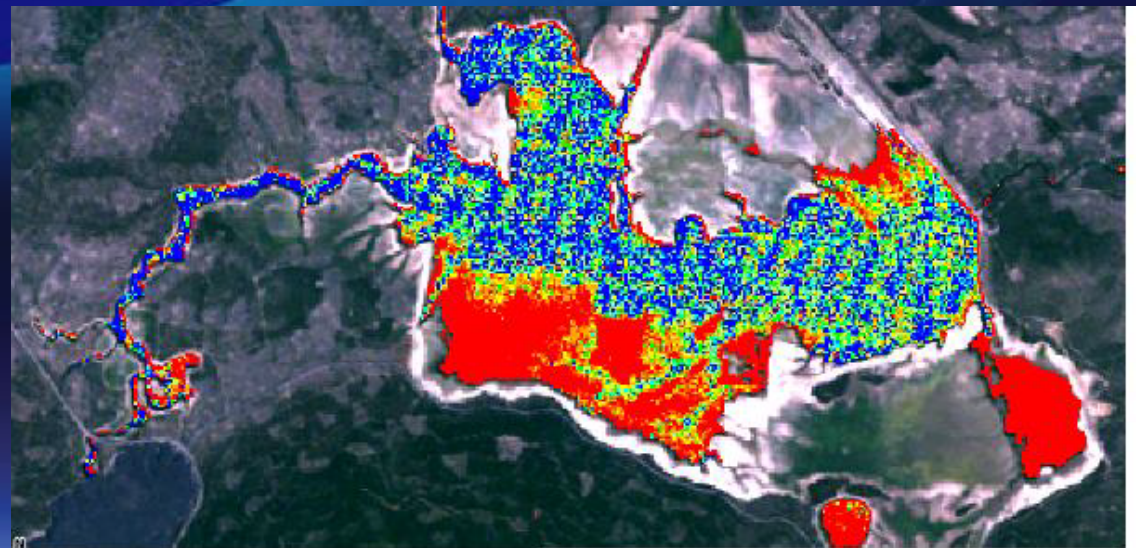
Note: ppb = parts per billion

Note: ppm = parts per million

^A Above 60 ppb will measure 60 ppb

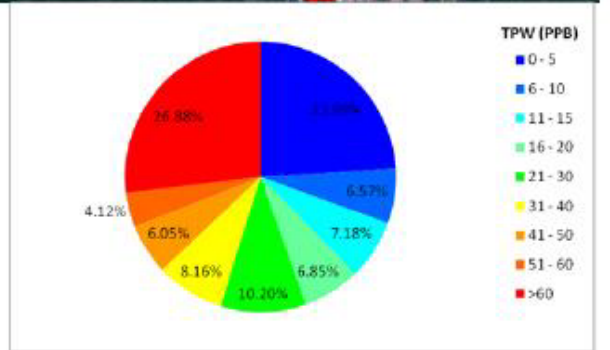
Blue Water Satellite Deliverables

- Geo TIFF file for each image (for ArcGIS)
- Processed images (pdf, tiff, or jpeg)
- Custom report (sample page as shown)
- Accuracy data
- BWS Viewer™ (optional)



TPW (PPB)	Color
0 - 5	Blue
6 - 10	Light Blue
11 - 15	Cyan
16 - 20	Light Green
21 - 30	Green
31 - 40	Yellow-Green
41 - 50	Yellow
51 - 60	Orange
>60	Red

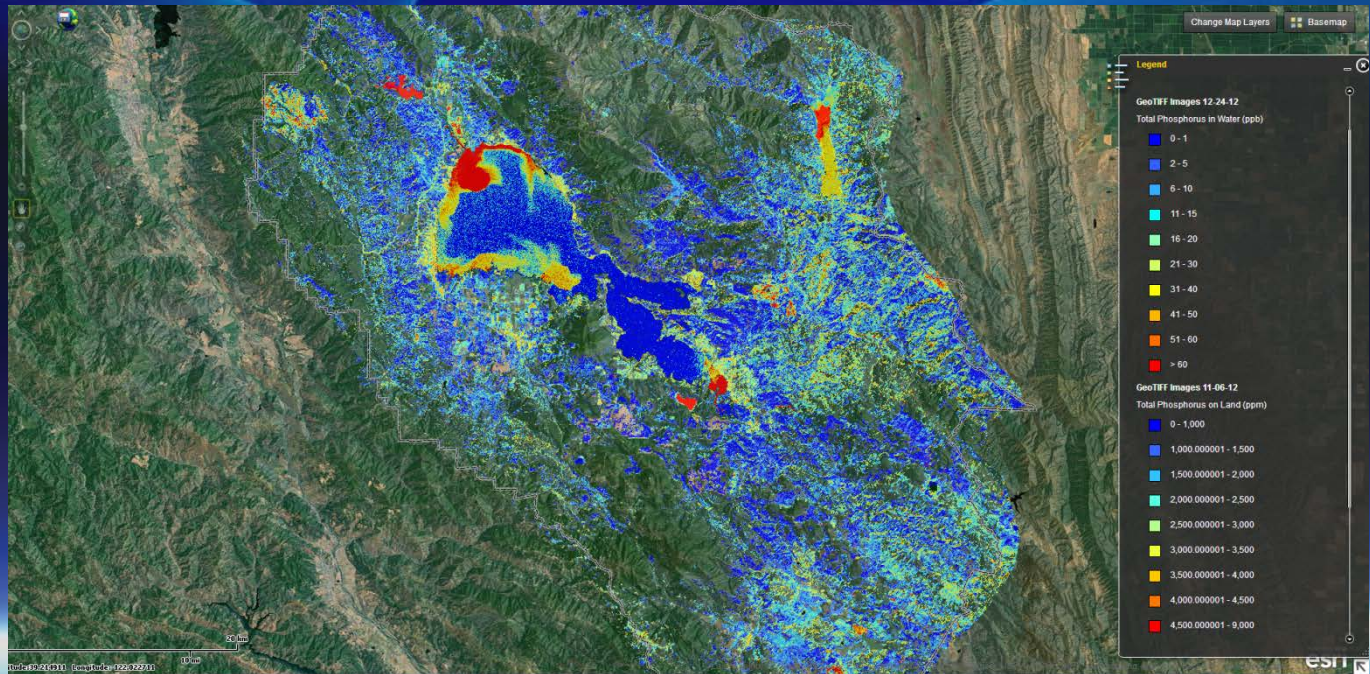
TPW (PPB)	Area (Acres)	Percent of Lake
0 - 5	1174.24	23.99
6 - 10	321.81	6.57
11 - 15	351.38	7.18
16 - 20	335.15	6.85
21 - 30	499.78	10.20
31 - 40	399.64	8.16
41 - 50	296.23	6.05
51 - 60	201.93	4.12
>60	1315.91	26.88



Color scale (above left) indicates ranges of concentration of phosphorus in parts per billion as represented in scan image (top).

Pie chart histogram (above) indicates percentage of water within view delineated by concentration ranges.

Table (left) indicates actual acreage falling within each range of concentration of phosphorus.

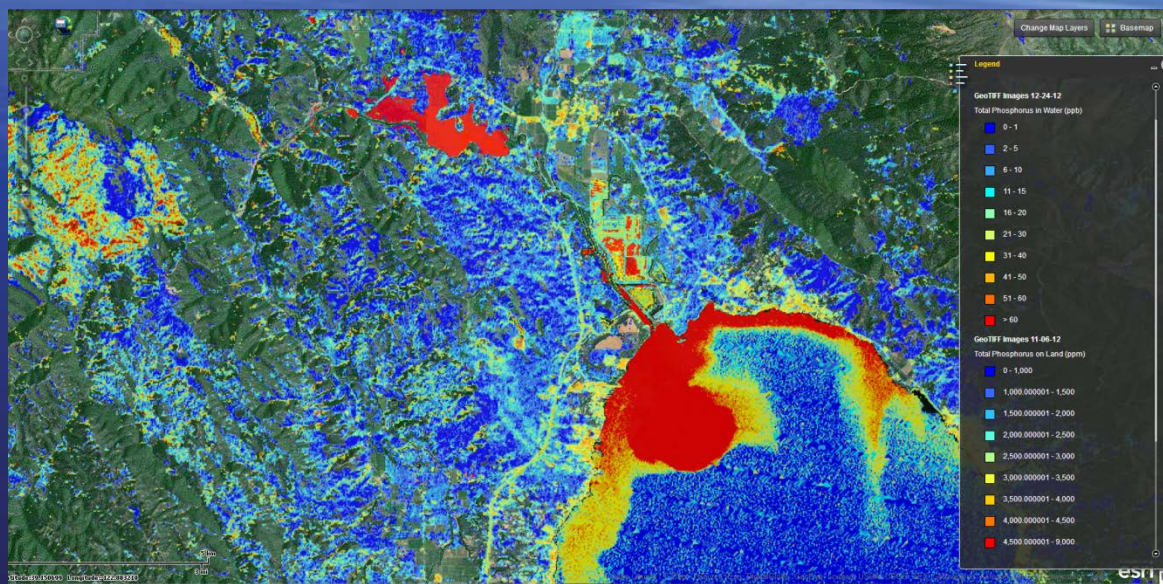


Phosphorus on land
and in water analysis

<http://gispublic.co.lake.ca.us/BWS/>

Blue Water Satellite
Customer Example:
Clear Lake, California

Lake County makes
BWS data available
online for public
outreach



zoom

Blue Water Satellite



**No one sees it like Blue Water Satellite.
No one.**

For additional information 855-885-5648 ext 1