

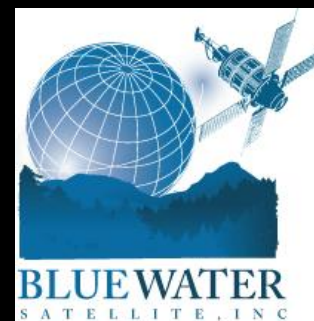
Satellite Imagery for Monitoring Select Water Quality Parameters

Presented By Dave Allan

Real-Time Water Quality
Monitoring Workshop, St. John's, NL
June 7 & 8, 2011

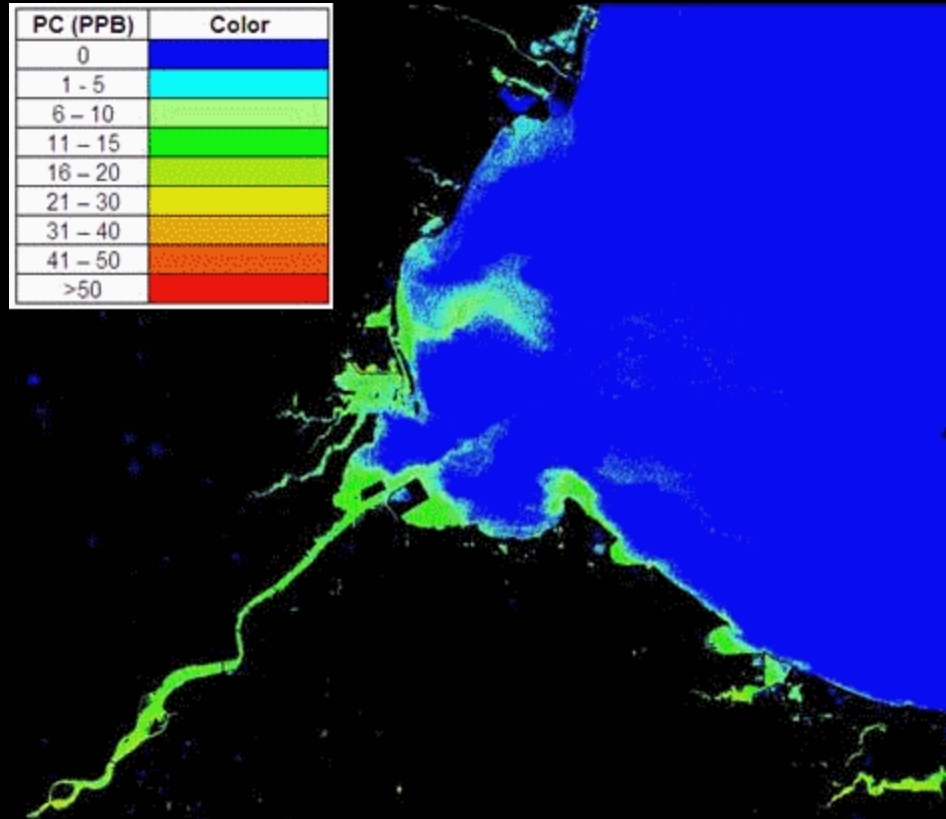


Unrivaled
Environmental Monitoring



Blue Water Satellite

PC (PPB)	Color
0	Blue
1 - 5	Cyan
6 - 10	Light Green
11 - 15	Green
16 - 20	Yellow-Green
21 - 30	Yellow
31 - 40	Orange
41 - 50	Red-Orange
>50	Red



September 1994



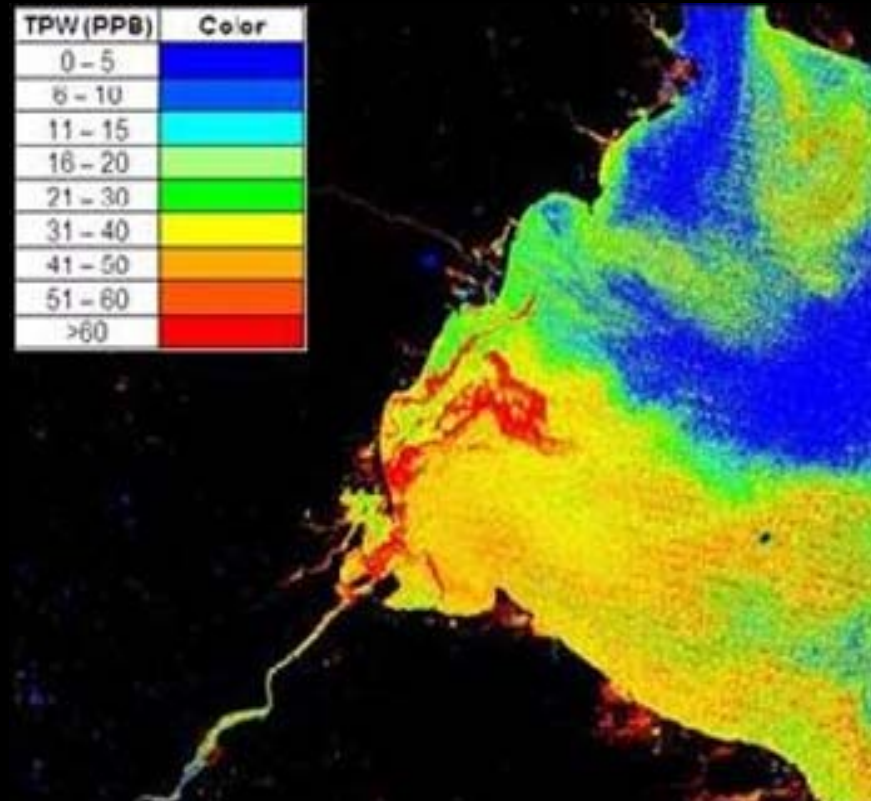
Blue Water Satellite

Using Landsat...

...to see where
the problems are.

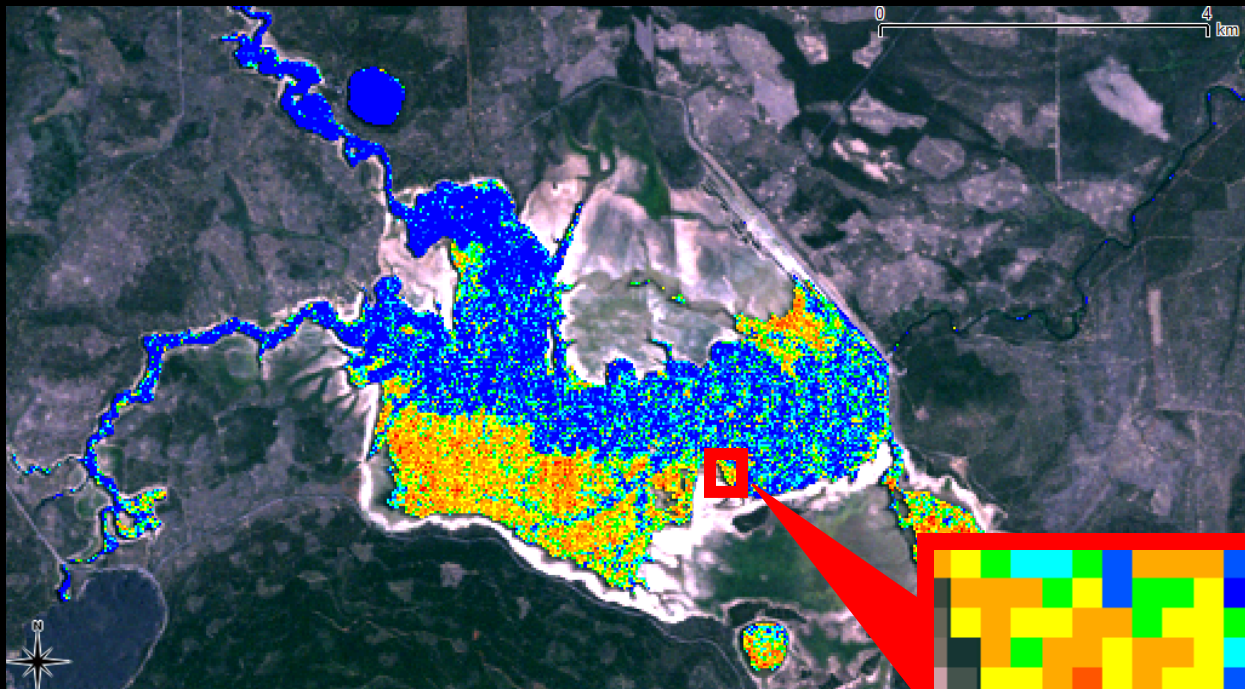


TPW (PPB)	Color
0 - 5	Dark Blue
6 - 10	Blue
11 - 15	Cyan
16 - 20	Light Green
21 - 30	Green
31 - 40	Yellow
41 - 50	Orange
51 - 60	Red-Orange
>60	Red

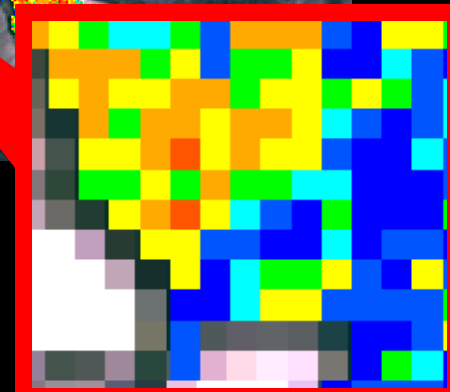


Blue Water Satellite

Showing you the big picture...

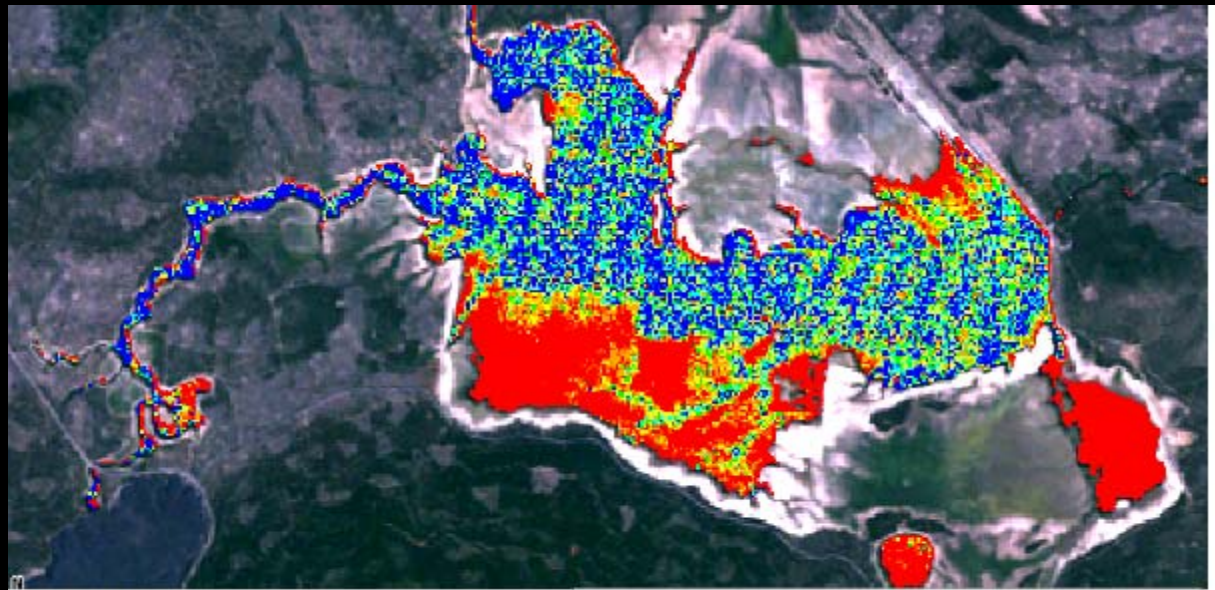


...and the finest detail
(each sample 30m x 30m)



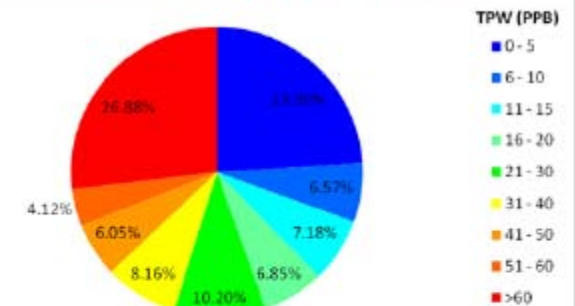
Blue Water Satellite

Report



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



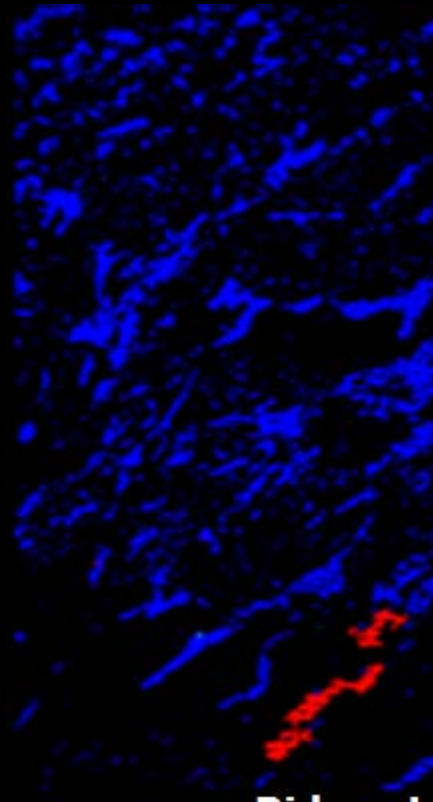
Color scale (above left) indicates ranges of concentration of phosphorus in parts per billion as represented in scan image (top).

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

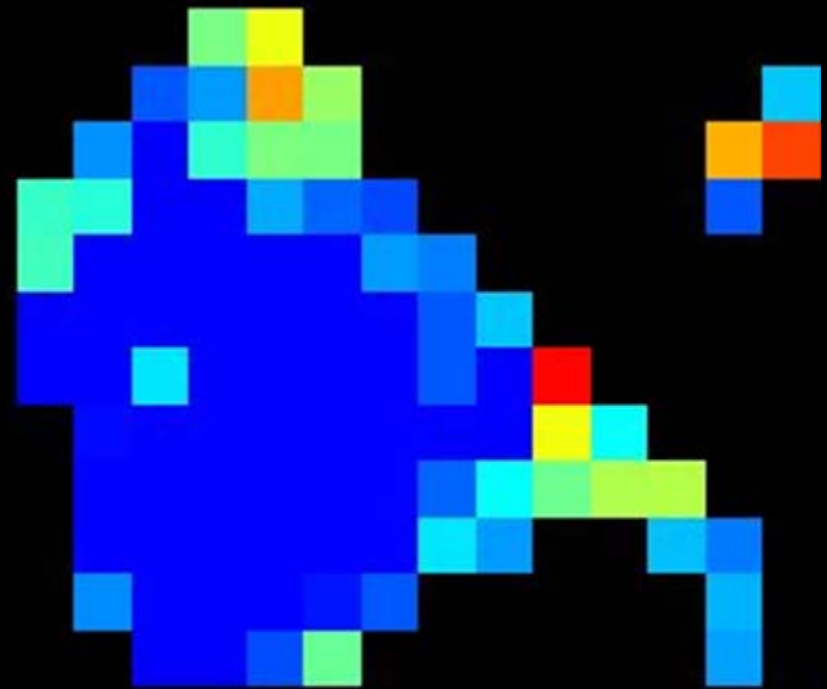
Table (left) indicates actual acreage falling within each range of concentration of phosphorus.

Blue Water Satellite

Scanning from your smallest
widest watershedbody of water.



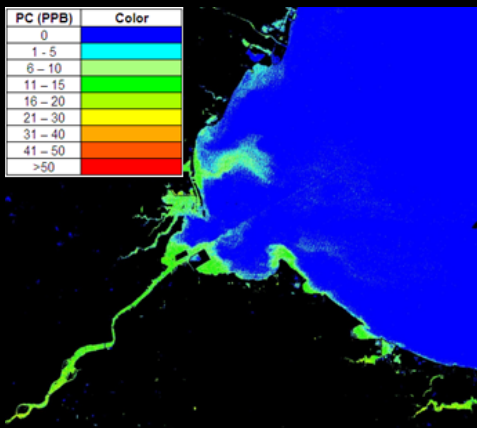
Rideau Lake
1140 Square Miles



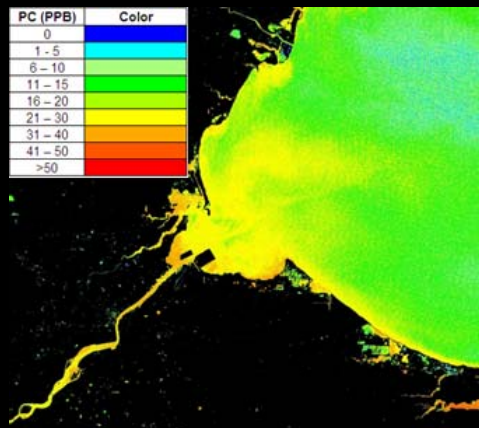
20 Acre Lake

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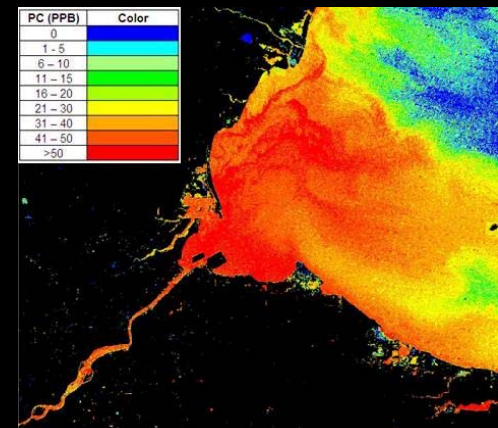
An unparalleled ability to look back
in time.



September 1994
Moderate Cyanobacteria
in Western Lake Erie



September 2002
Higher concentrations
are appearing in some
tributaries and the
Maumee Bay
(center of image)

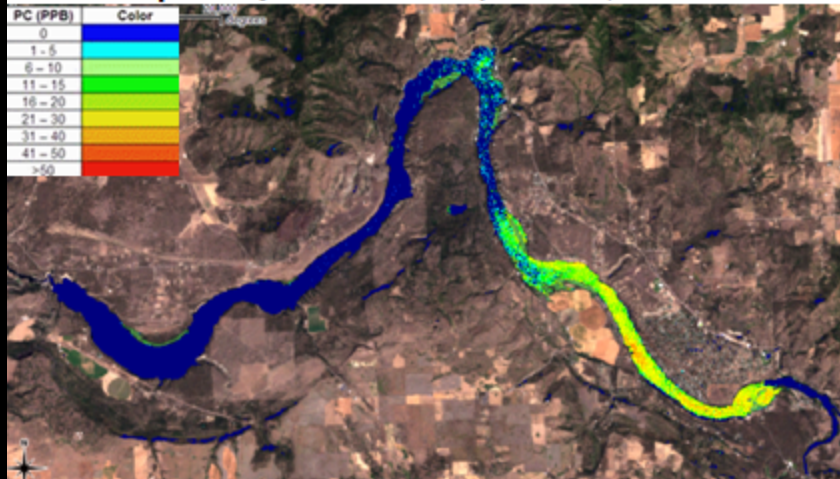


September 2008
Cyanobacteria has
overwhelmed the
western basin of
Lake Erie.

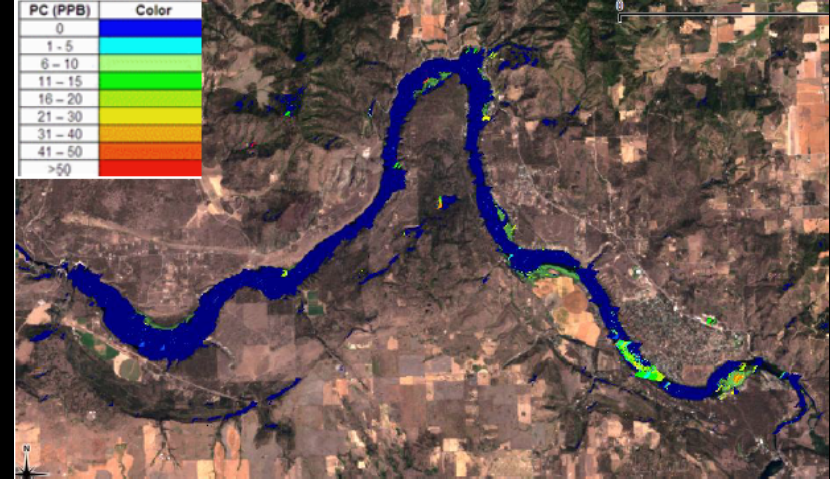
Blue Water Satellite

Graphically Demonstrating Your Results

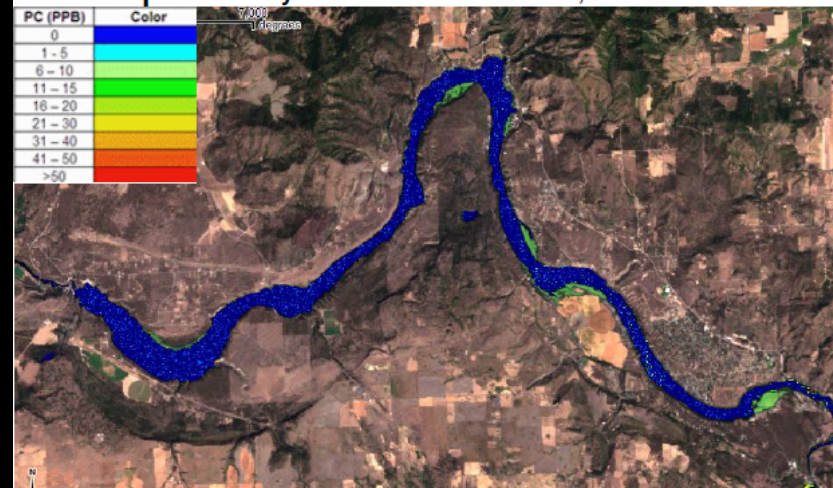
Trouble Spots: Cyanobacteria on September 23, 2001



Improving: Cyanobacteria on September 22, 2006

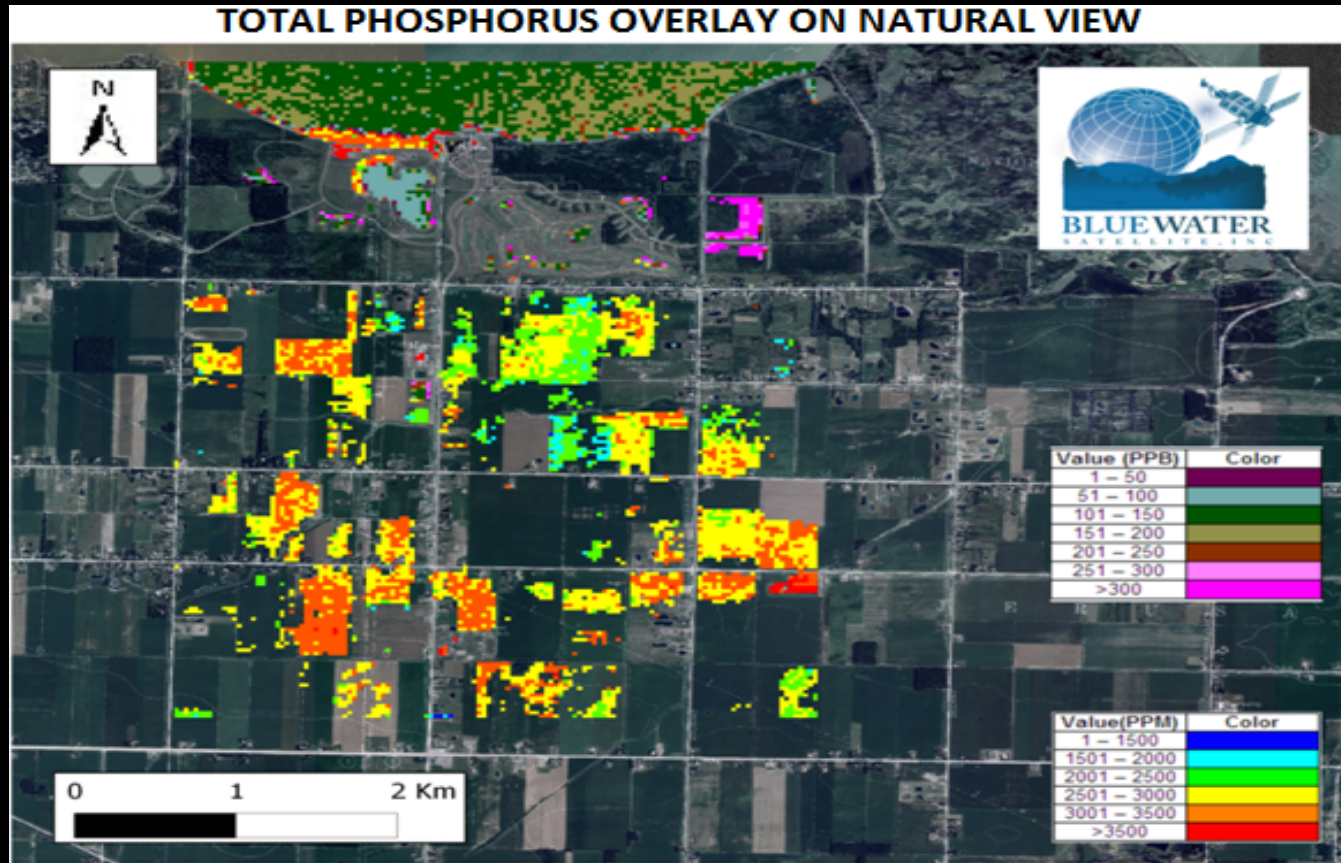


Much Improved: cyanobacteria on October 1, 2010



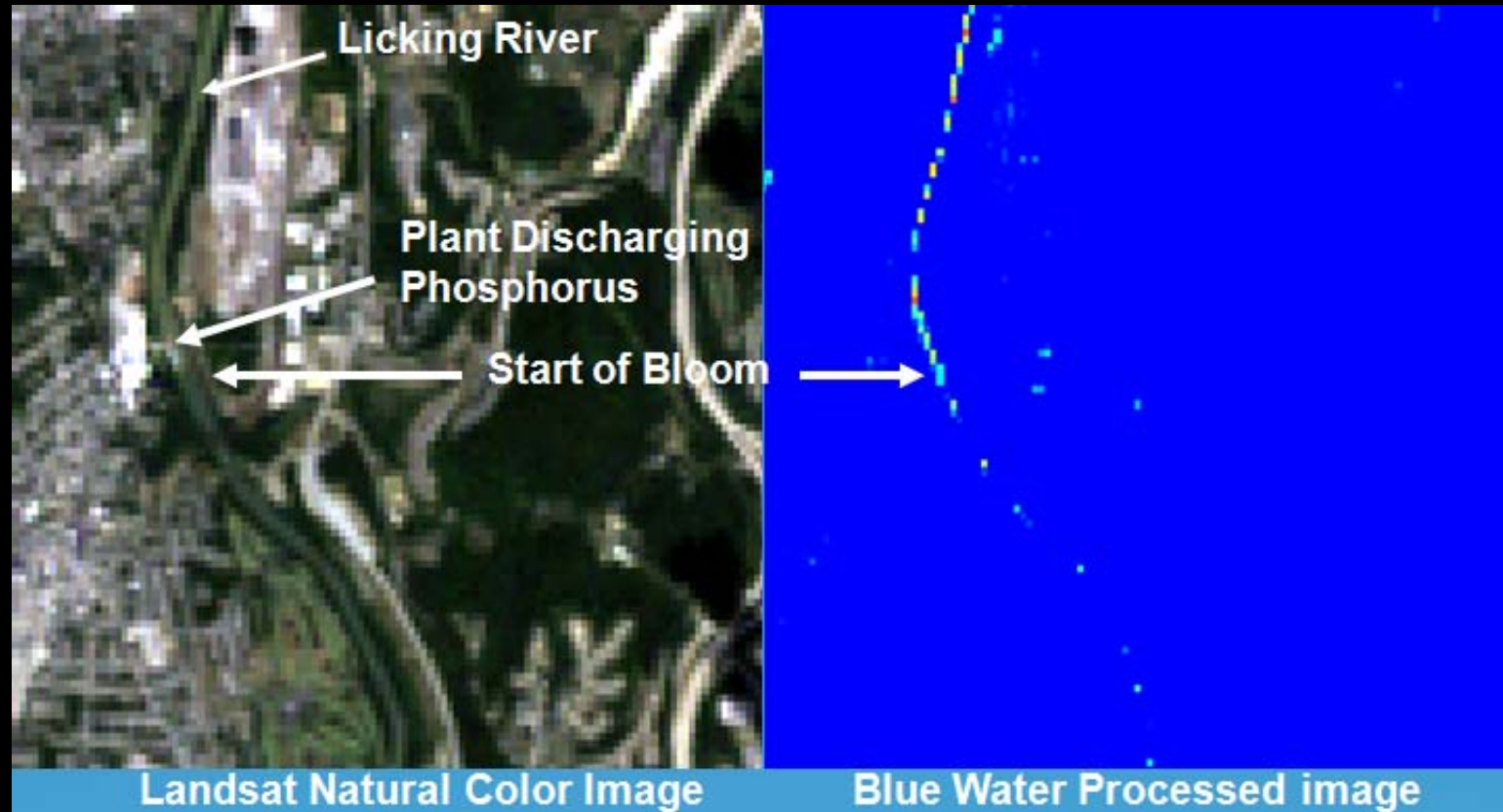
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Tracking non-point
sources...



Blue Water Satellite

...to precise point
sources.



Blue Water Satellite



We detect the precise locations and concentrations of...

Cyanobacteria (Blue-Green Algae)

(± 5 ppb)



Blue Water Satellite



We detect the precise locations and concentrations of...

Phosphorus (± 5 ppb)

Lake Champlain Land Trust



The Lake Champlain Land Trust considers the Lake's increased phosphorous levels as a major threat to our environment.

Blue Water Satellite

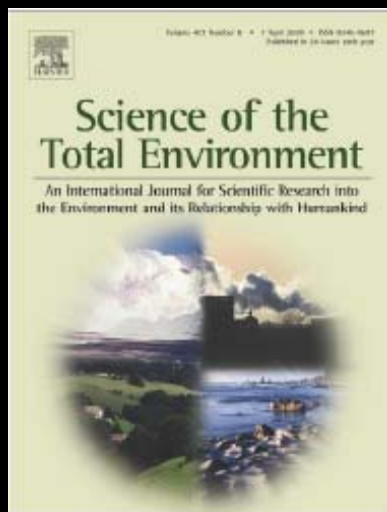


We detect the precise locations and concentrations of...

Chlorophyll-a (± 5 ppb)



Years of Research & Peer Review



Total Phosphorus Water Monitoring Using Satellite Imagery

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

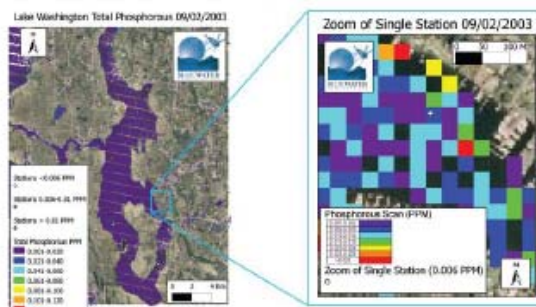
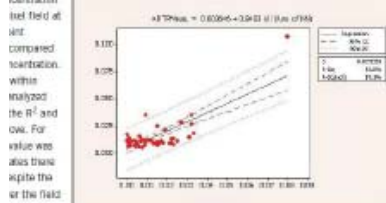


Figure 1: BWSI Total Phosphorus Processed Image Example, Lake Washington



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

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(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 ALGAE 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.: **10/763,138**
- (22) Filed: **Jan. 22, 2004**

OTHER PUBLICATIONS

Richardson, Laurie, Remote sensing of algal bloom dynamics, *Jul/Aug. 1996, Bioscience*, 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, *Jrnl of Phycology*, vol. 31, No. 5, pp. 828-834, abstract.*

Green, S., 2003, <http://www.usd.edu/~app/phys/stuart/MODEL.HTM>, The effect of chlorophyll concentration on airborne hyperspectral reflectance.*

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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.*

Patent Classification



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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: (1) to determine changes in chemical concentrations of soils that are amended with treated sewage sludge and (2) to determine if LANDSAT TM data can be used to map surface chemical characteristics of such amended soils. For this study, we selected two soils in NW Ohio, designated as T1 and T2, that had been applied with 14 and 11 t ha⁻¹ of biosolids, respectively, soil samples from a total of 70 sampling locations across the two fields were collected one day prior to LANDSAT TM images and were analyzed for several chemical concentrations. The concentrations of Ca, Cu, Co, S and P were found to be significantly higher in the surface soils of T1 and T2 compared to T0. Regression equations were established to search for algorithms that could map these chemical concentrations in the surface soils using six dual-date Landsat TM images. LANDSAT TM bands and the 15 waveband spectral ratios derived from these six bands for the May 26, 2003, LANDSAT TM image. Phosphorus T1 had the highest P_{total} adjusted value (0.017) among all the chemical considered, and the mapping algorithm employed the spectral ratio. The model was successfully tested by substituting by applying it to another LANDSAT TM image obtained on June 5, 2003. The results enabled us to consider that LANDSAT TM images of farm soils can be used to quantify and map the spatial variations of soil phosphorus concentration in surface soils. This research has significant implications for identification and mapping of areas with high P_{total} which is important for implementing and monitoring the best phosphorus management practices across the region.

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1. Introduction

Application of treated sewage sludge (biosolids) to agricultural and non-agricultural lands has become a prominent and acceptable method of waste disposal in recent years. Biosolids are known to improve soil physical characteristics (Lambert et al., 1975; Van et al., 1985), increase the organic matter and cation exchange capacity and supply the nutrients required for crop growth (Sorensen, 1971; Singh and Agarwal, 2000). However, the potential for excess application of biosolids, resulting in a build up of nutrients, phosphorus (Meyer et al., 2003), zinc, copper, lead (Meyer et al., 2003; Soren et al., 2004; Panagopoulos and Mermides, 2005) and cadmium (Bergqvist et al., 2001) in the surface soils of agricultural lands continues to be a source of concern. Accumulation of phosphorus at high concentrations is a major environmental concern as it affects the water quality of lakes and rivers in the event of runoff (Chapra and Barri, 2003). 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. Remote sensing has been used as an alternative method for determining the soil color (Chen et al., 2003), texture and particle size distribution (Chang et al., 2001) and moisture (Lal and Anon, 2002; van den Berg et al., 2002), sedimentation (Ben-Zur and Ben-Zur, 1999; Ben-Zur and Ben-Zur, 1999), organic carbon (Lal and Henry, 1986; Henry et al., 1995; Ben-Zur, 2002) and particle size (Ben-Zur et al., 1992) and soil phosphorus (Ben-Zur and Ben-Zur, 2002).

The addition of soil contaminants as a result of biosolid applications needs to be monitored in surface soil samples (Meyer et al., 2003; Bergqvist et al., 2001; Soren et al., 2004; Panagopoulos and Mermides,

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No one sees it like Blue Water Satellite.

No one.