



New York City's Experience with Cyanobacterial Blooms

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Watershed Water Quality Science and Research



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Outline

- Intro to NYC water supply system
- Methods used for monitoring and addressing blooms
- Case studies for reservoirs in the three systems
- Future plans

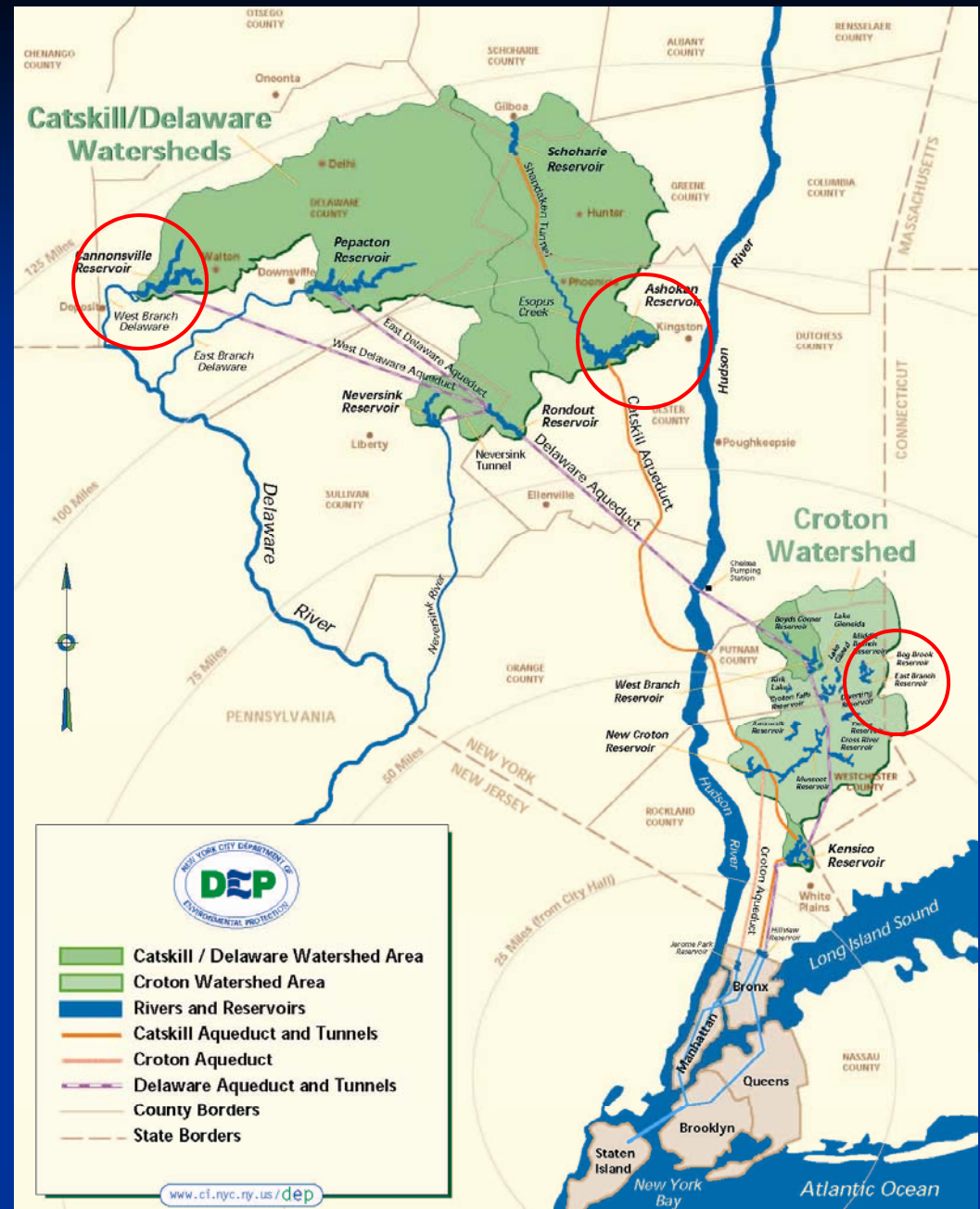


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- Three systems:
 - Croton – 1842, supplies ca. 10%, eutrophic
 - Catskill – 1926, supplies ca. 40%, meso-trophic
 - Delaware – 1964, largest supply (ca 50%) and a mixture of oligo-, meso- and eutrophic.



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Methods employed by NYCDEP

■ Monitoring

- Keypoint (entry point) sampling varies from once to three times a week for phytoplankton
- Reservoir sampling once or twice / month
- Analytes relevant to algae include dissolved oxygen, pH, total phosphorus, chlorophyll *a* and phytoplankton counts.
 - Phytoplankton analysis currently performed using areal standard units (ASU ml⁻¹)
 - Chlorophyll *a* analysis via HPLC



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Treatment methods

■ Chemical

- Previously treated with CuSO_4 , but currently a restricted use pesticide in NYS.
- Treated via saturated solution fed into connecting tunnels.
- Trigger levels of $>2000 \text{ ASU ml}^{-1}$ for total phytoplankton or $> 1000 \text{ ASU ml}^{-1}$ for one genus

■ Operations

- Discontinue diversions during blue-green blooms
- Selective withdrawal depth to minimize blooms



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Cyanobacteria commonly found

- *Anabaena* – Croton System, Cannonsville Reservoir
- *Aphanizomenon* – Croton System, Cannonsville Reservoir
- *Microcystis* – Croton System, Cannonsville Reservoir
- *Lyngbya* – Croton System
- Others – *Oscillatoria*, *Synechococcus*, *Coelesphaerium*



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Case studies

- Events and the actions taken
 - East Branch Reservoir – *Lyngbya*
 - Ashokan Reservoir – *Synechococcus*
 - Cannonsville Reservoir –
 - *Anabaena, Microcystis &*
 - *Coelesphaerium*



Case studies

■ East Branch Reservoir (Croton System)

- *Lyngbya* bloom in July, 2004
- Detected via surveillance
- Samples collected showed:
 - Dominance of *Lyngbya*
 - Some diatoms & many bacteria
- Selective withdrawal (bottom) and minimal release kept the bloom localized
- East Branch is a headwater reservoir, removed from the source water for the Croton System. Allow natural die-off.



Case studies (East Branch continued)

- Typical formation of mats by *Lyngbya*
- Decomposition and foul odor associated with sulfur bacteria (e.g. *Chromatium*)
- Potential toxin producer
 - Neurotoxins and dermatotoxins



Case studies (continued)

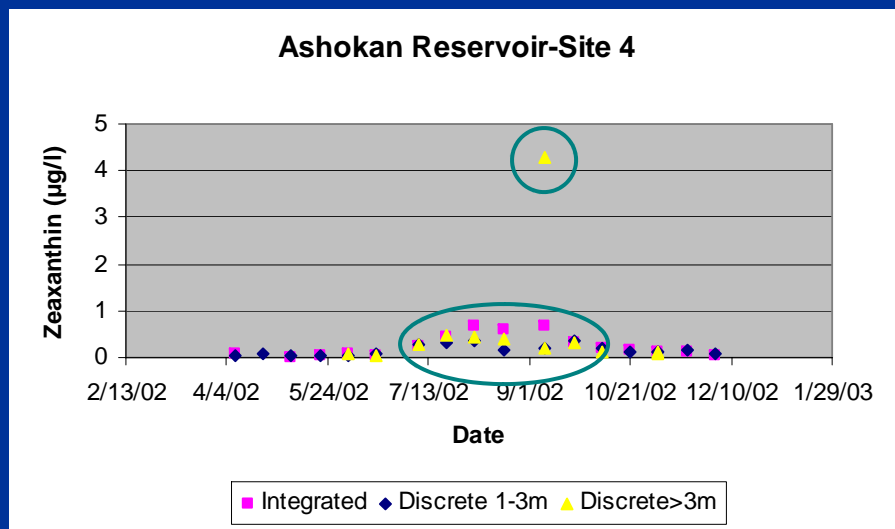
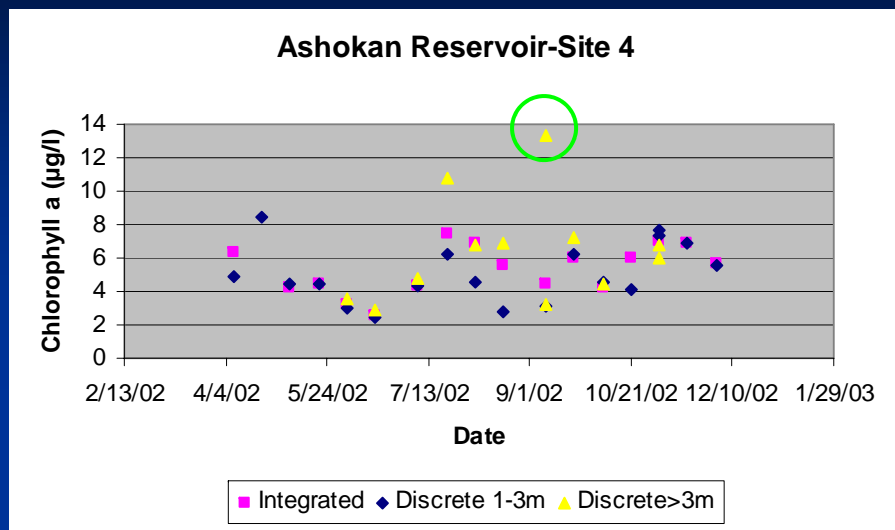
- Ashokan Reservoir (Catskill System)
 - Bloom of *Synechococcus*
 - Small blue-greens that typically go unnoticed (picoplankton), chromatoplasm barely visible
 - Occurred at the depth of the metalimnion in September (2002).
 - Detected by the use of HPLC
 - Auxiliary pigments identified and tracked over time.
 - Evidence of presence starting in early summer
 - Confirmation by detailed microscopy



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Case studies (Ashokan continued)



- $13.3 \mu\text{g L}^{-1}$ of chl a in 10 m sample
- Microscopy showed only 200 ASU mL^{-1} of the diatoms *Synedra* & *Rhizosolenia*
- HPLC showed high level of zeaxanthin (only in blue-greens)
- Detailed microscopy found *Synechococcus*
- Evidence of cyanobacteria increase starting in July

Case studies (Ashokan continued)



- *Synechococcus* produces geosmin (T&O)
 - suspected toxin producer
- Selective withdrawal used to avoid bloom

Case Studies (Continued...)

- Cannonsville Reservoir
 - Previous problems with cyanobacterial blooms
 - Have used tunnel treatment with CuSO_4 in the past
 - Typically use avoidance
 - Watershed management
 - Decreased TP → Reduced cyanobacterial blooms
 - Restoration Success Story
 - Early work (Wood 1979) indicated eutrophic conditions
 - In 1992, Watershed Protection Programs were implemented
 - By 2002 no longer considered phosphorus restricted
 - In 2004 taken off State impaired waters 303 (d) list



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Cannonsville Reservoir WQ characteristics

- Eutrophic-mesotrophic
 - Phosphorus
 - Mean=19.1 $\mu\text{g L}^{-1}$
 - P-limited but can be N-limited for short periods (N:P ratio)
 - Chlorophyll
 - Mean=10.1 $\mu\text{g L}^{-1}$
 - Diatoms in spring and fall
 - Blue-greens in summer
- Dimictic stratification pattern
 - Anoxic hypolimnion in late summer but minimal P-release



Cannonsville Basin Characteristics

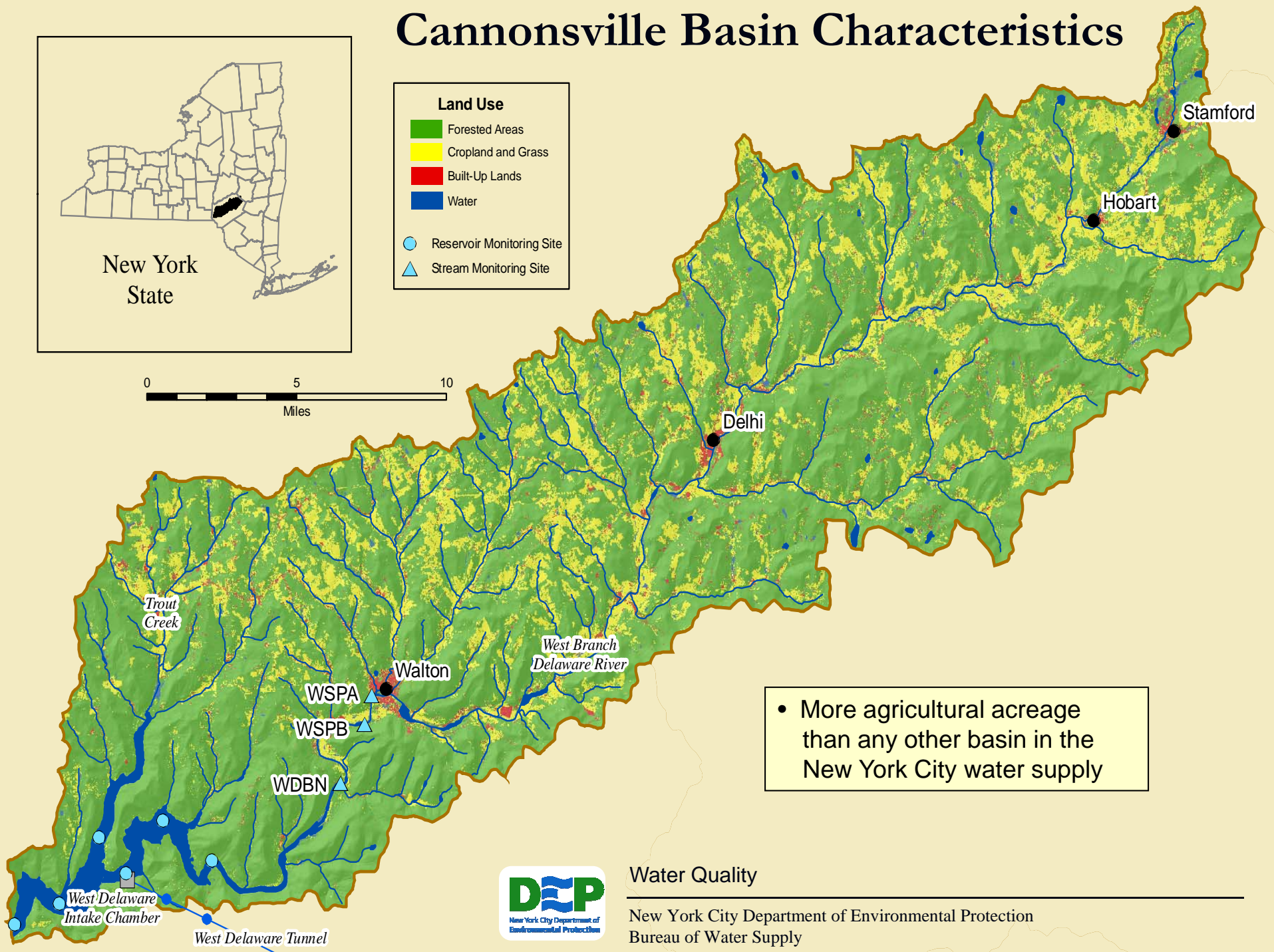
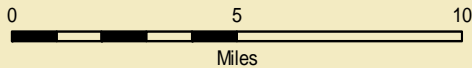


Land Use

- Forested Areas
- Cropland and Grass
- Built-Up Lands
- Water

Reservoir Monitoring Site

Stream Monitoring Site



• More agricultural acreage than any other basin in the New York City water supply



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Cannonsville Basin Watershed Partnership Programs

Program	As of Dec 31, 2008
Whole farm plan participants (95% participation)	204
• Ag BMP's implemented	2674
WWTP upgrades	5
Remediated septic failures	535
Stream management projects	6
Storm water retrofits	10
Sand/Salt storage	10
Acquired land + easements	24,305 acres

Net effect : Nutrient and sediment reductions

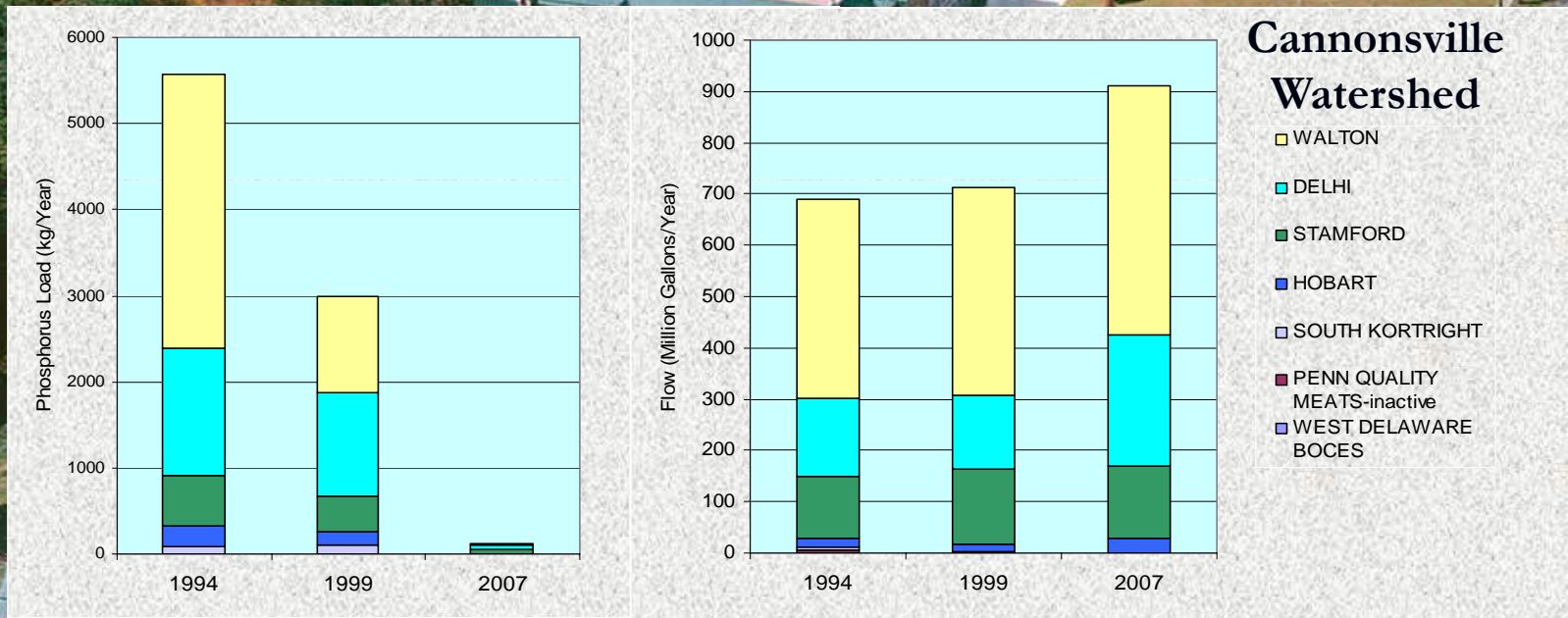
- verified by paired watershed experiment, model results and by past trend analysis



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Wastewater treatment upgrade example

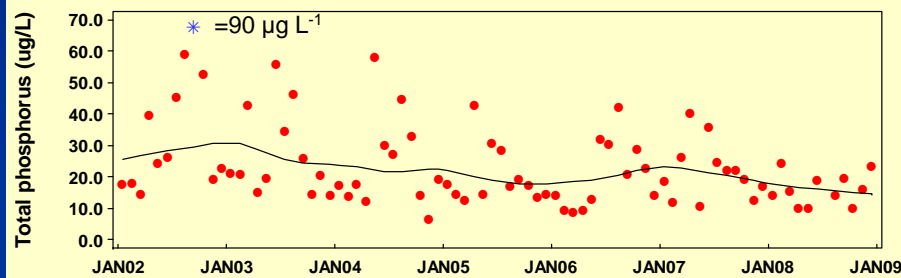


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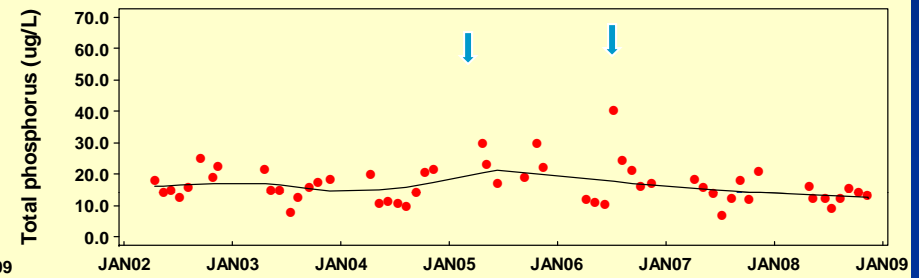
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Case studies (Cannonsville trends)

West Branch Delaware River



Cannonsville Reservoir



River

- Decrease of 8.5% per yr. overall ($2.1 \mu\text{g L}^{-1}$)
- Elevated 2002 TP related to Walton WWTP (final upgrades implemented by 2003)
 - Decrease post 2002 from cumulative effects of Watershed Protection Program

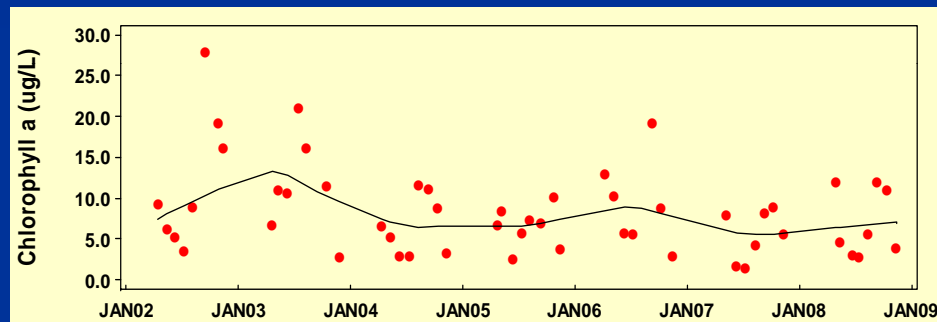
Reservoir

- Decrease of 3% per yr. overall ($0.6 \mu\text{g L}^{-1}$)
- Down trend influenced by:
 - Mar 05 snowmelt & Jun 06 flood



Case studies (Cannonsville trends)

Cannonsville Reservoir



- Overall downward trend of 7% per yr ($0.5 \mu\text{g L}^{-1}$)
 - Chlorophyll *a* has now stabilized at a lower level as a result of the watershed management program

Case studies (Cannonville 7/90)



- *Anabaena* 5150 ASU mL⁻¹
- *Coelesphaerium* 1450 ASU mL⁻¹
- Chlorophyll *a* 32.2 μg L⁻¹

Case studies (Cannonville 8/90)



- *Microcystis* 13,000 ASU mL⁻¹
- *Coelesphaerium* 9250 ASU mL⁻¹
- Chlorophyll *a* 71.9 μg L⁻¹

Case studies (Cannonsville 2008)

- Summer maximum *Aphanizomenon* of 740 ASU mL⁻¹
- Summer maximum *Microcystis* of 260 ASU mL⁻¹
- Summer maximum chlorophyll *a* of 12.4 μg L⁻¹ during *Aphanizomenon* “bloom”



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Future work

- Flow cytometer
 - DEP is investigating flow cytometers for algal enumeration
 - Microscopic validation will be necessary
- HPLC
 - DEP already performs chl a analysis w/HPLC
 - Can use pigments, established ratios or CHEMTAX to determine occurrence of cyanobacterial blooms and for early warning
- In-situ monitoring (presently at early investigation stage)
 - Reservoir based monitoring buoys with cytometer and fluorescence capability (e.g. Cytobuoy)
 - UV-Vis spectrometers (e.g. S::CAN)



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Future work (continued)

- Early warning in distribution system
 - S::CAN presently used at multiple locations
 - Working with mfg on detection of cyanobacteria & other T&O algae
 - Fish – flow through systems to detect toxins and other adverse conditions
 - 311 calls – monitor customer complaints
- Modeling
 - PROTECH - Phytoplankton assemblage response to climate change
 - OASIS – implementation of operational model for the system



Summary

- NYCDEP has had notable experience with cyanobacteria blooms
 - Able to minimize effects via:
 - Watershed protection
 - Surveillance & detection
 - Selective withdrawal
- Present and future monitoring
 - Requires utilization of multiple techniques to detect and avoid cyanobacterial blooms



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Questions ?



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