State of the Lake: An Overview of Water Quality in the Cayuga Lake Watershed

Canoga, New York

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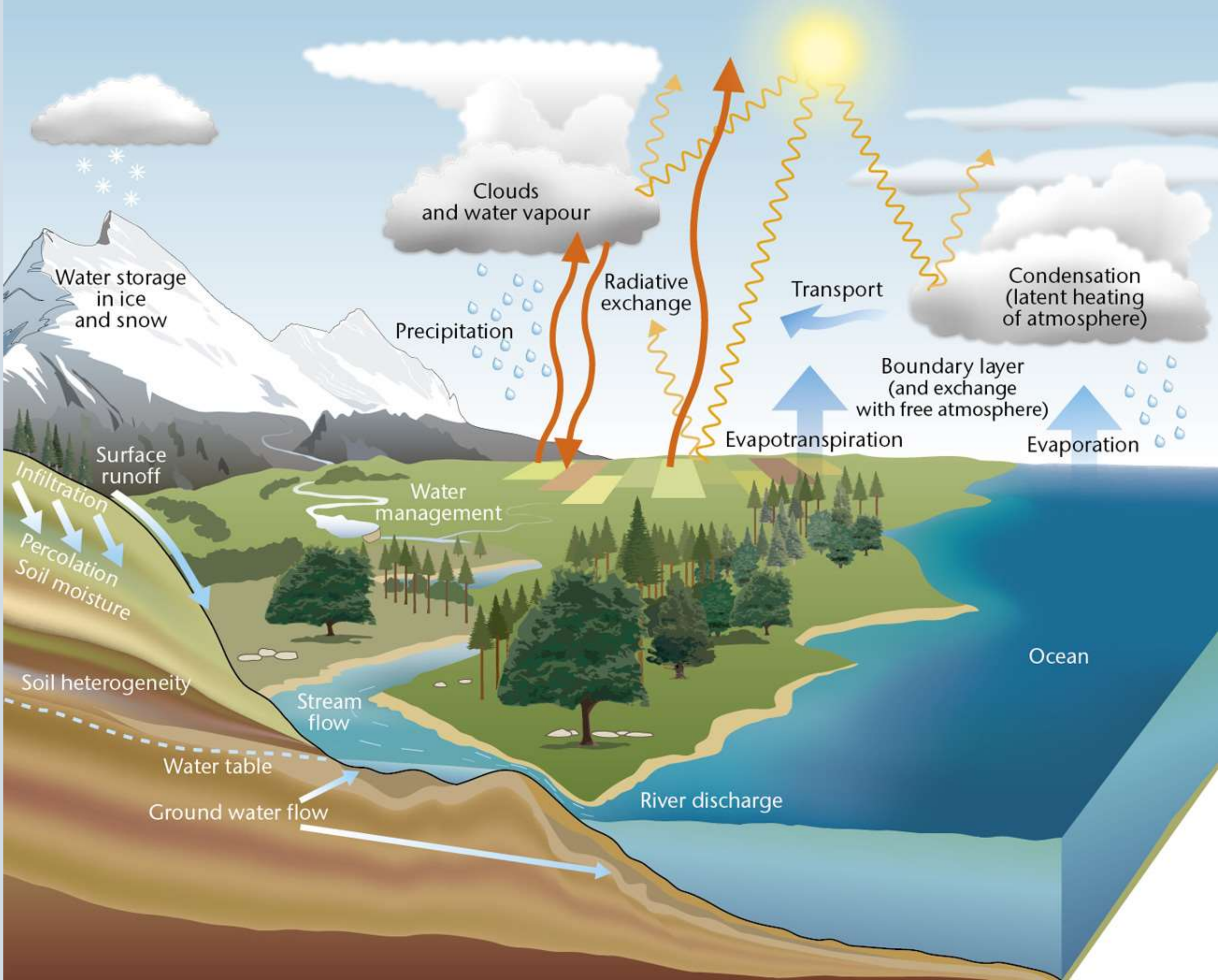
Freshwater streams and lakes are part of the hydrologic cycle and are fed by:

a) Groundwater

b) Runoff



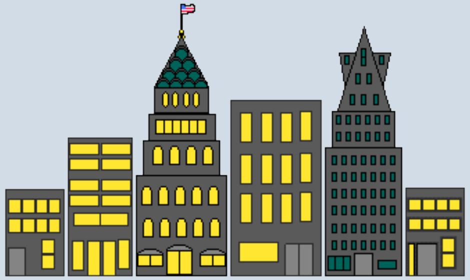
Freshwater quantity and quality are both important

Quantity is affected by the amount of precipitation, which depends on the weather

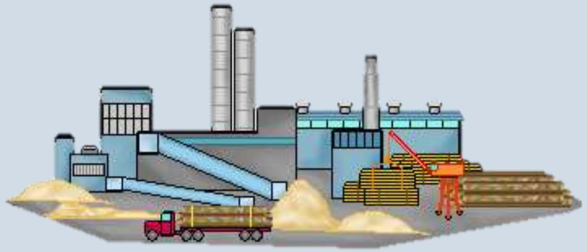
Quality can be impacted by human uses of the land as well as by the natural geology of a watershed

Agriculture

Urban Development



Industry



Stream Erosion

Common Surface Water Pollutants: Sources and Impacts

Suspended Sediments and Solids

Sources: Runoff from agricultural fields and urban surfaces; natural erosion of stream beds and banks

Impacts: Smother aquatic life in streams; fill in lakes

Common Surface Water Pollutants: Sources and Impacts

Pathogenic Bacteria

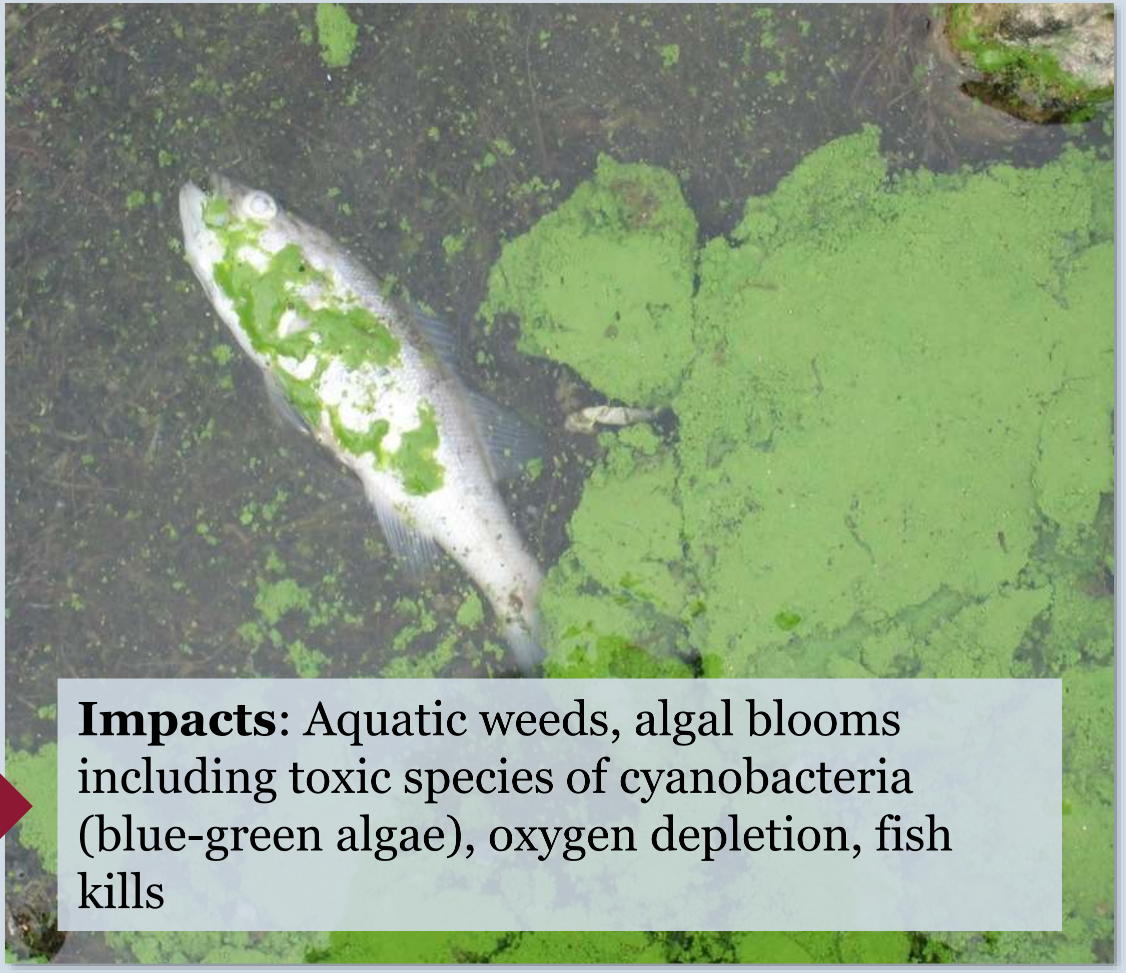
Sources: Manure on agricultural fields; sewage treatment plants; wildlife

Impacts: Public health risk from contact recreation such as swimming and boating

Common Surface Water Pollutants: Sources and Impacts

Phosphorus and Nitrogen Nutrients

Sources: Fertilizers used in agriculture; on lawns, gardens, golf courses, etc.



Impacts: Aquatic weeds, algal blooms including toxic species of cyanobacteria (blue-green algae), oxygen depletion, fish kills

Common Surface Water Pollutants: Sources and Impacts

Salt

Sources: Road salt that infiltrates groundwater; rarely, leaking brine ponds and storage caverns for liquefied gas products

Impacts: Reduction in diversity and abundance of aquatic life; increased cost of producing drinking water

Less Common and Emerging Surface Water Pollutants

Pesticides
From agriculture, gardens, lawns

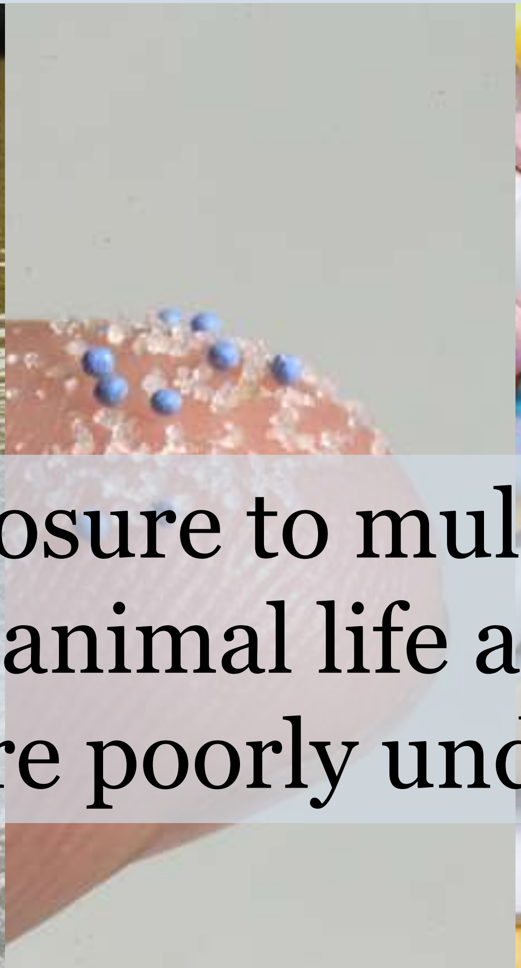
Endocrine Disrupters
From industrial waste, personal care

Microplastics
From plastic bags, personal care products

Pharmaceuticals
From drugs and their breakdown products in urine and feces

Metals, Organic Solvents
From superfund sites, local geology





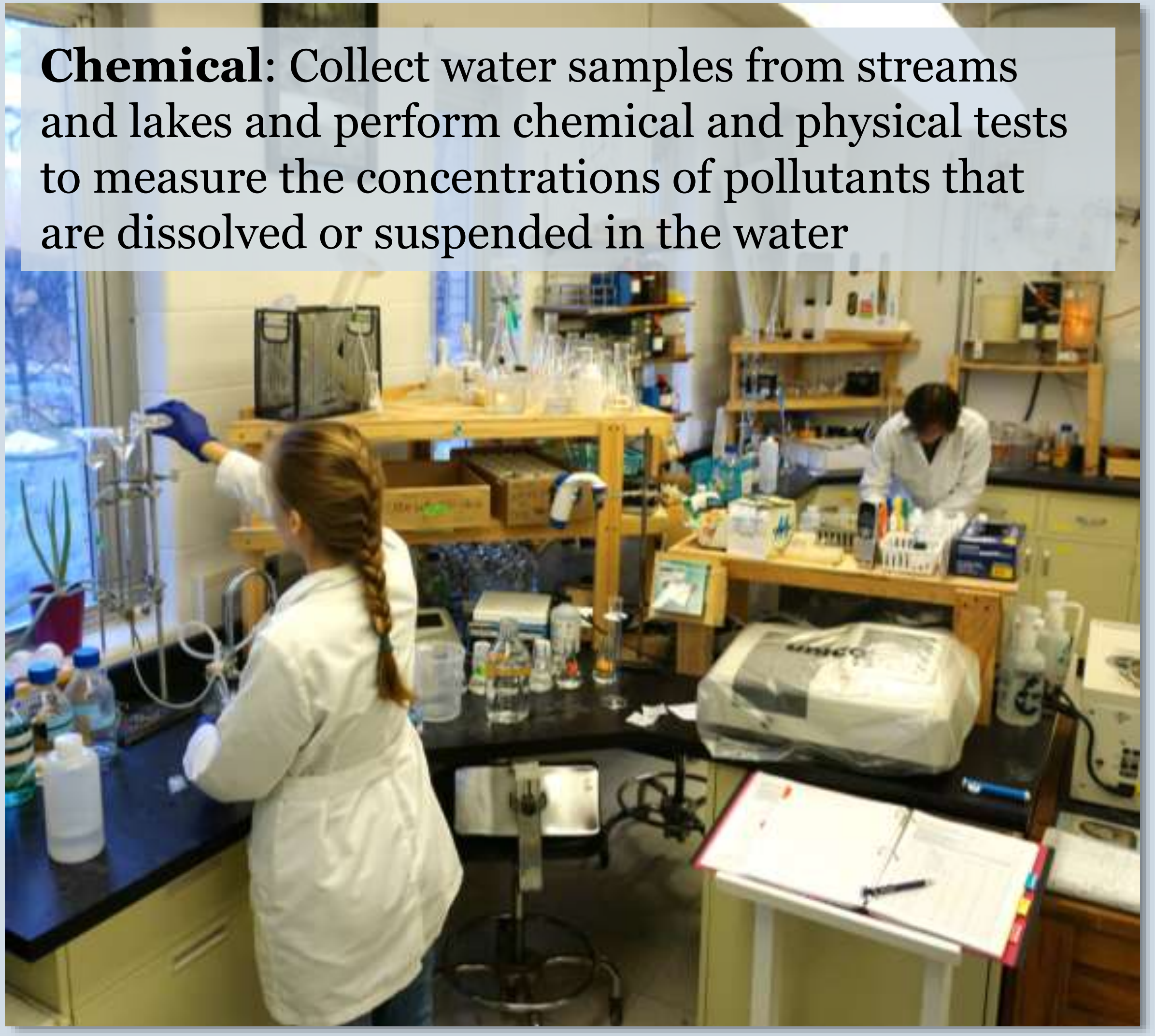
Impacts of exposure to multiple pollutants on plant and animal life and on human health are poorly understood.

Community Science Institute (CSI) Tracks Common Surface Water Pollutants

- **Not-for-profit 501(c)3** tax-exempt organization, founded 2000
- **Water Quality Testing Lab Certified by NYSDOH-ELAP**: Streams and lakes; also drinking water; total of 35 certified tests
- **Mission**: Empower communities to become stewards of their local streams by partnering with CSI to collect scientifically credible data
- **Funding Sources**: Local governments in Tompkins County, fee-for-service testing, donations, foundation grants
- **Budget**: $249,000 in 2016

Two Basic, Complementary Approaches to Tracking Surface Water Quality

Chemical: Collect water samples from streams and lakes and perform chemical and physical tests to measure the concentrations of pollutants that are dissolved or suspended in the water



Biological: Collect samples of aquatic life and assess the diversity and abundance of the community of living organisms

CSI Uses Both Chemical and Biological Approaches to Track Water Quality

CSI

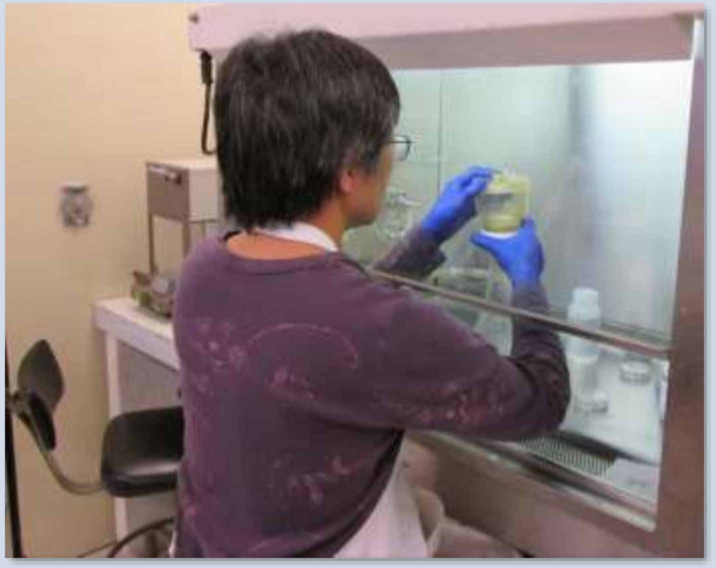
- Certified Water Testing Lab ELAP# 11790
- Chemical and Biological Monitoring Partnerships with Volunteer Groups
- Public Dissemination of Results in Online Database

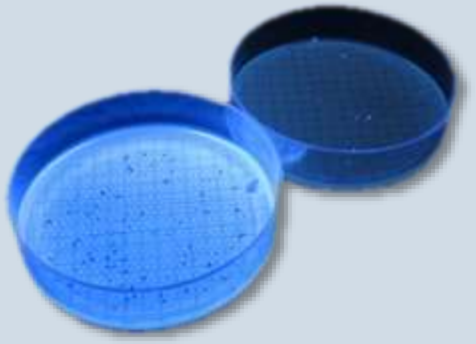
Certified Lab

- Regulated by NYS Department of Health
  - Regulatory & Legal purposes
- Potable and Non-potable water
- Chemistry & Microbiology
- Full list of tests and fees online

Learn more about testing your drinking water at www.communityscience.org/certified-lab/

Michi tests for total coliform and E. coli bacteria





After the assay is complete bacteria colonies grow and are counted on plates

Volunteer Monitoring Partnerships

Synoptic Chemical Sampling – Cayuga and Seneca Lake Watersheds

- Impacts from agriculture, urban development, point sources

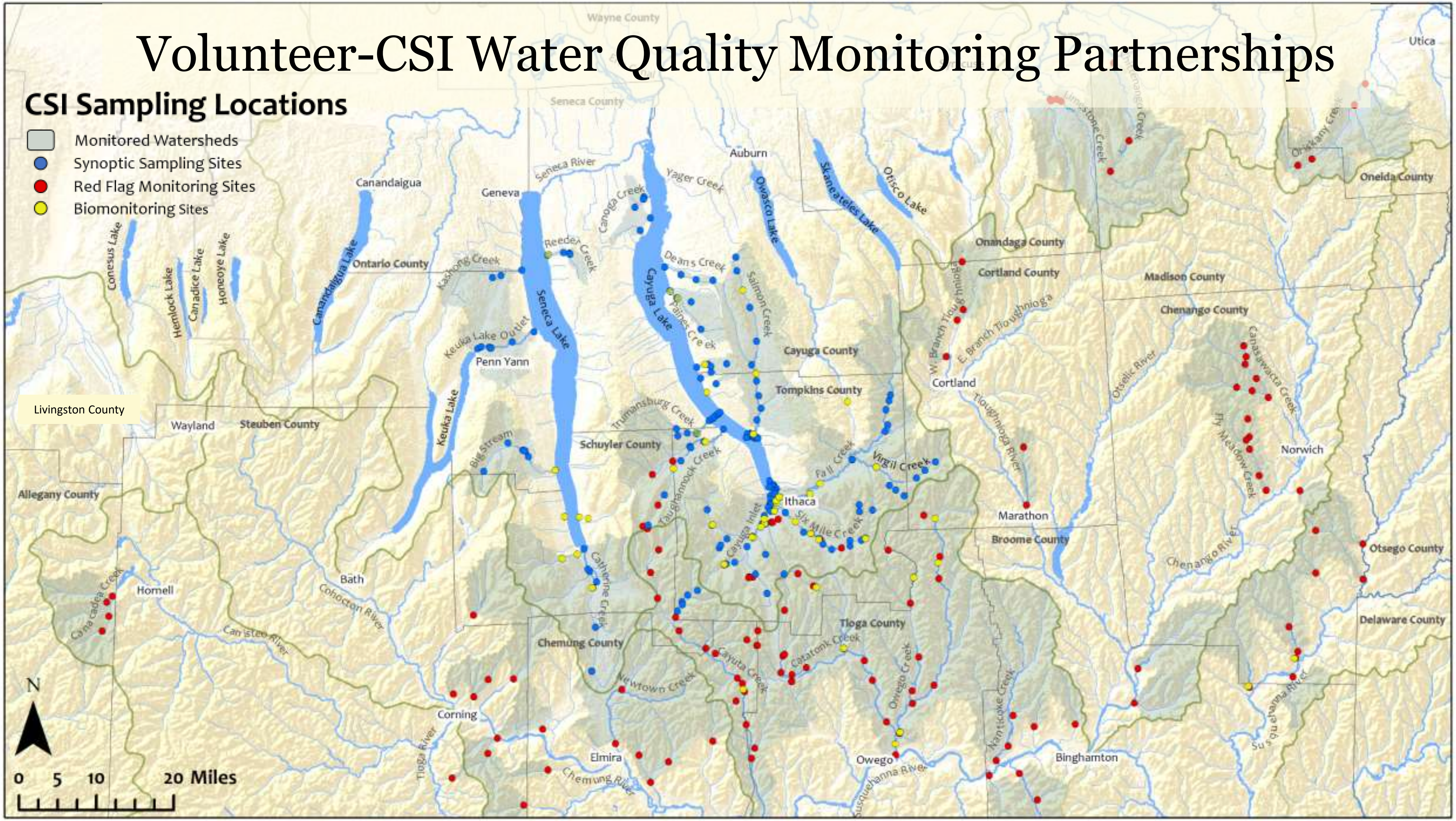
Red Flag Chemical Monitoring – Upper Susquehanna Watershed

- Baseline and nutrient data collection on small streams

Biological Monitoring (BMI) – Any stream of local interest

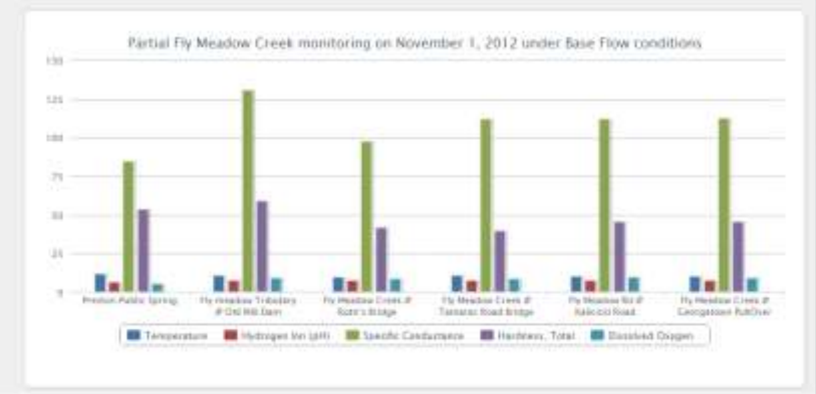
- Aquatic insect communities show long-term water quality

Volunteer-CSI Water Quality Monitoring Partnerships



Online Databases for Surface Water, Groundwater and (coming in 2017) BMI

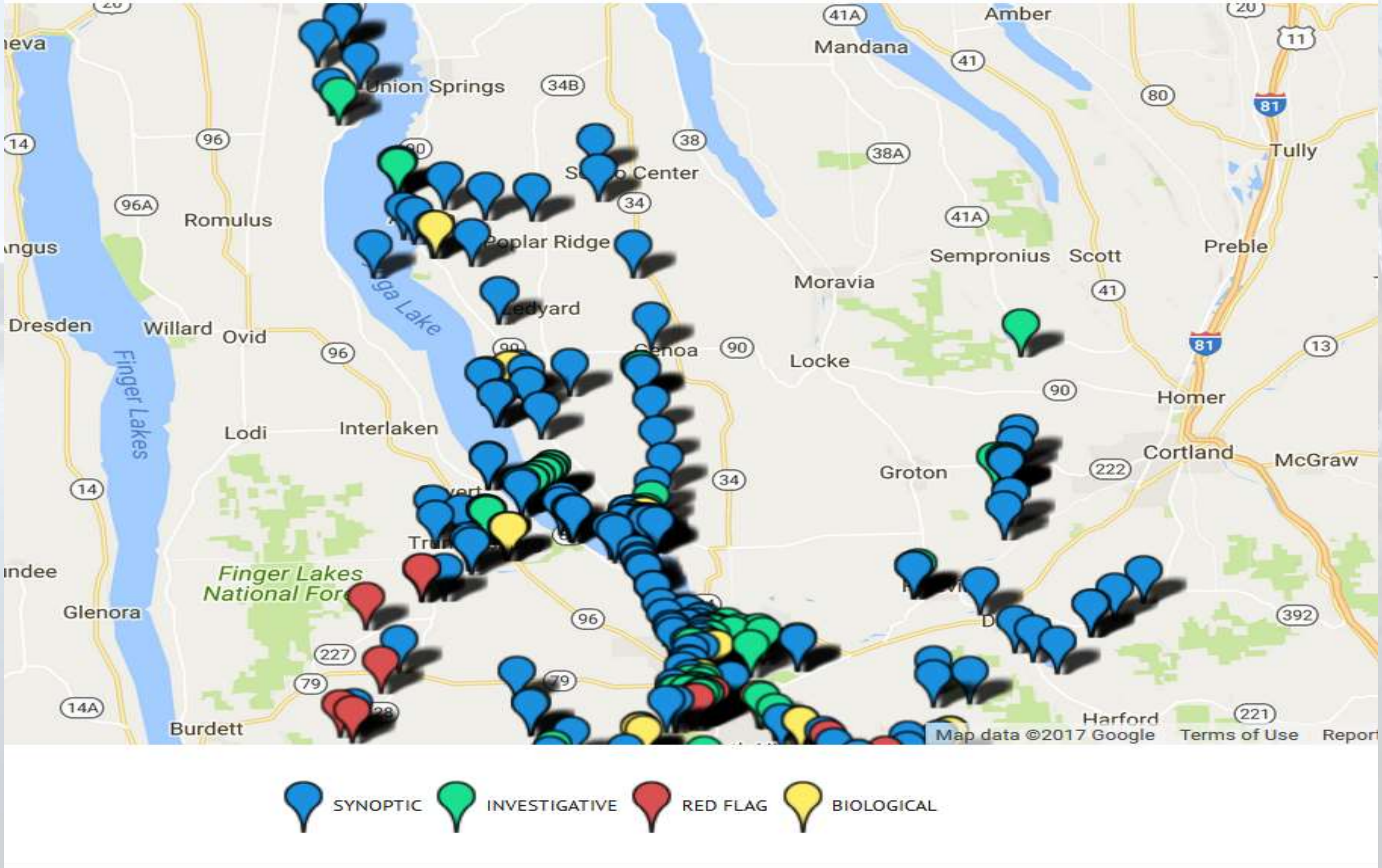
- Raw stream monitoring data are archived in **public** online databases that may be searched and downloaded **free** of charge
- Goal is to disseminate scientifically credible results to the public, to local and regional stakeholders, and to government agencies at all levels in order to improve water resource understanding and management
- Streams and lakes database launched in 2006
- Groundwater database launched in 2014
- BMI database by end of 2017



Overview of Common Pollutants in Cayuga Lake and its Tributary Streams, 2002-2016

- Common pollutants addressed in this overview are based on certified lab tests that serve as markers: Pathogenic bacteria based on E. coli test; bioavailable phosphorus, the limiting nutrient for plant growth and algae blooms, based on soluble reactive phosphorus test (method EPA 365.3); soil and sediment erosion, based on total suspended solids test; and salt, based on chloride test
- Levels of common pollutants are depicted in graphs as multi-year averages
- Overview is based entirely on data collected by volunteer-CSI monitoring partnerships from 2002 to the present and archived in CSI's public database
  - Cayuga Lake has been monitored at 7 sites for 10 years
  - Tributaries have been monitored from 1.5 to 14 years, depending on the stream; ~80 tributary monitoring sites in Cayuga Lake watershed

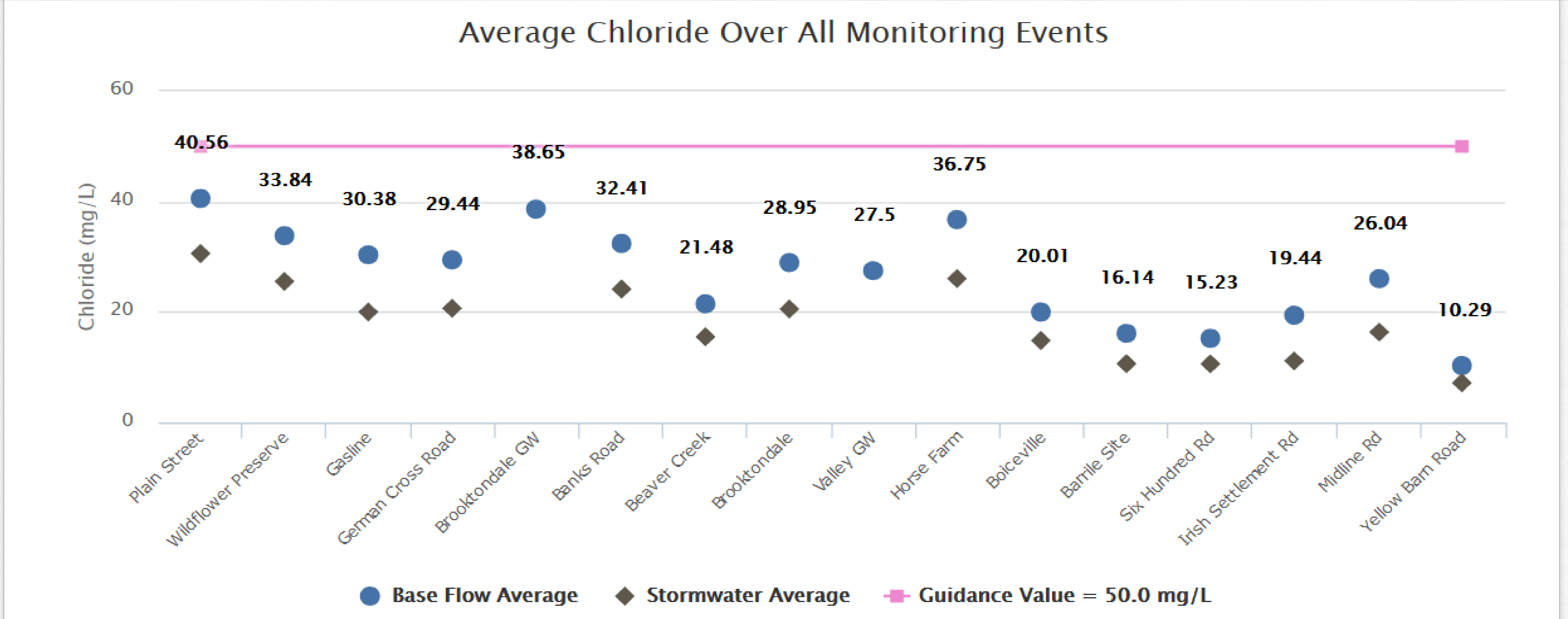
Chemical and Biological Sampling Locations in the Cayuga Lake Watershed



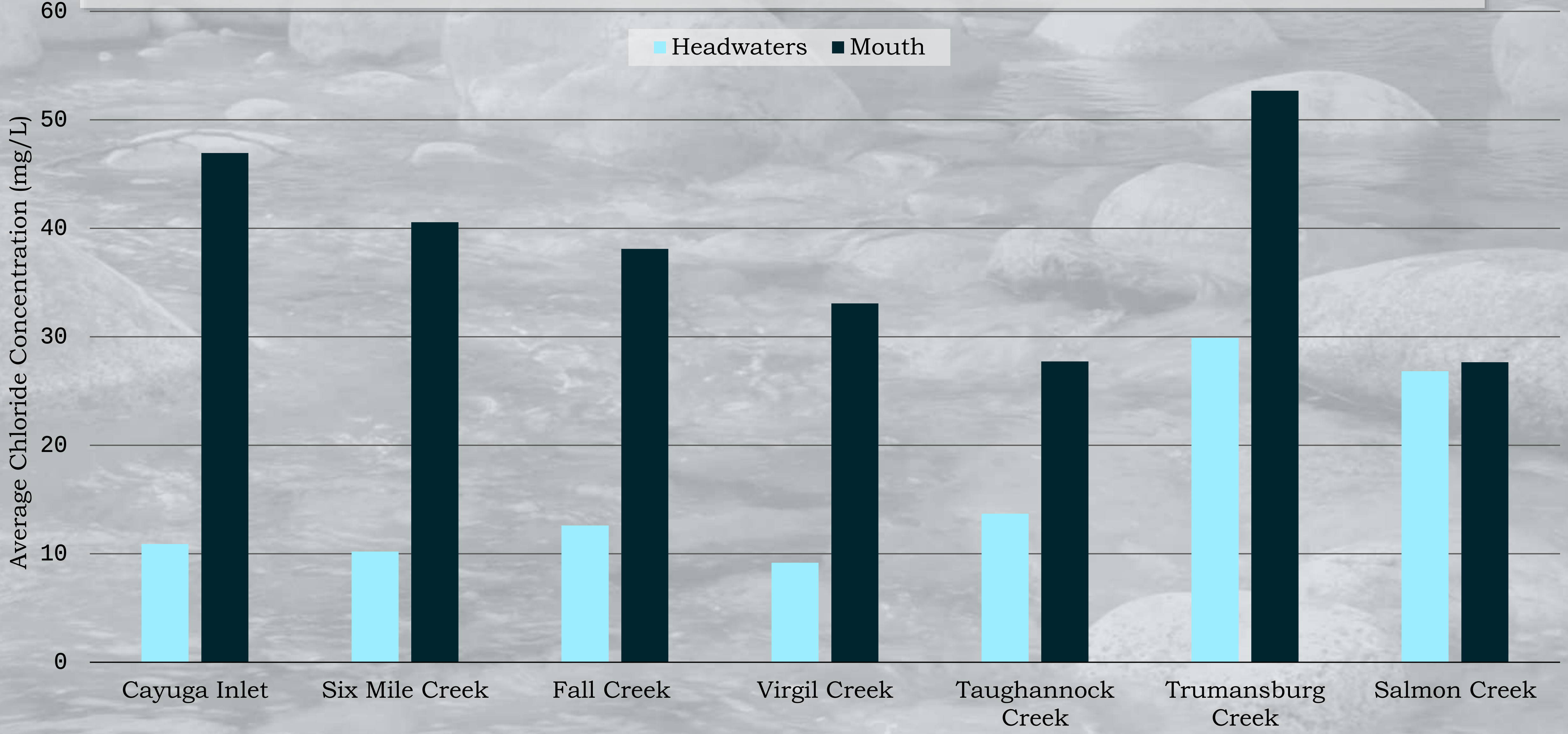
Salt in Our Streams

Chloride is a marker for salt. Multi-year southern streams data indicate:

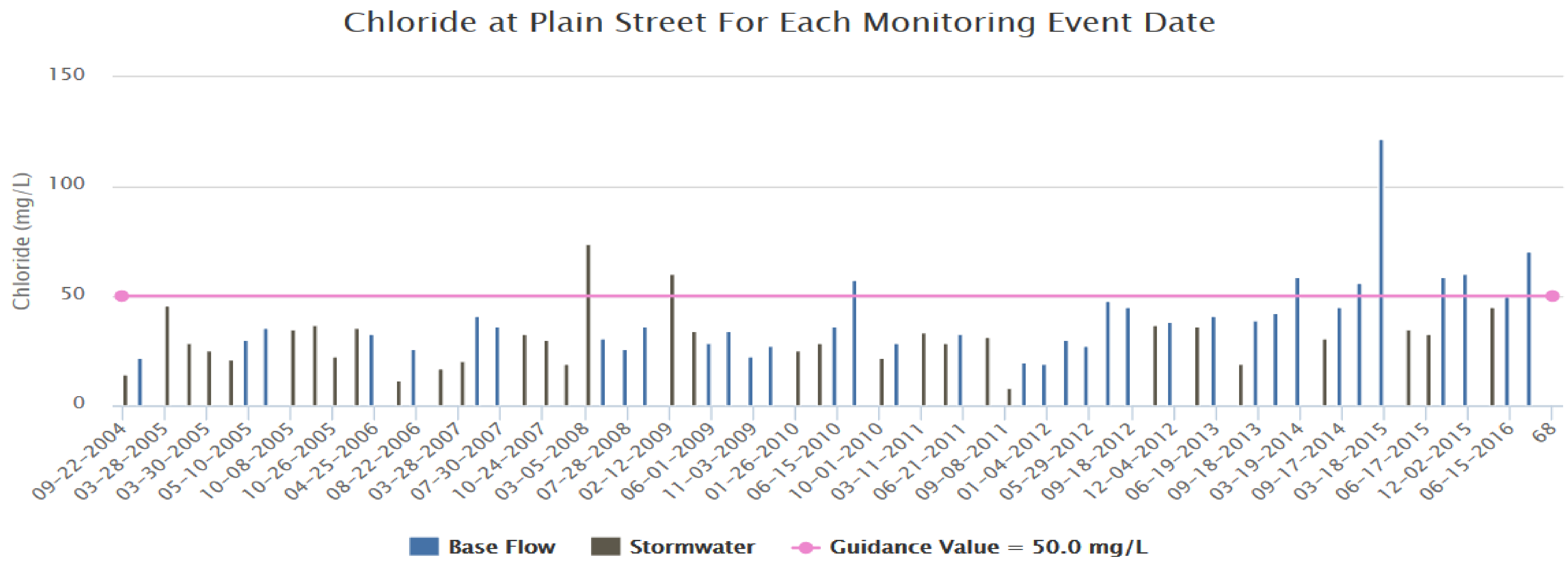
1) Road salt (chloride) enters streams indirectly via groundwater, as shown by decreased stormwater concentrations of chloride in streams
2) In most streams, salt (chloride) increases from headwaters (lower road density) to mouth (higher road density)

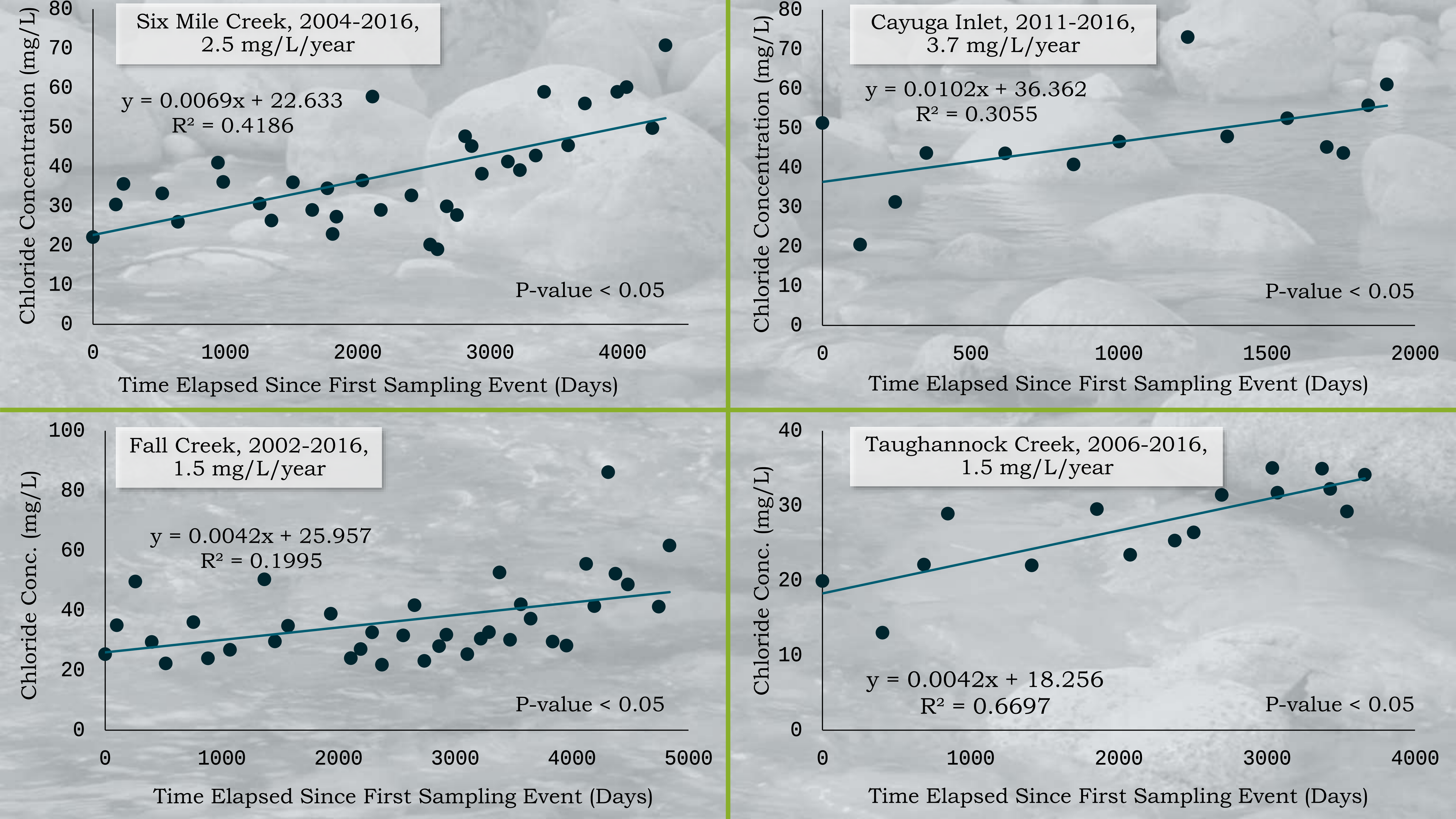


Salt Concentrations Increase from the Headwaters to the Mouths of Most Southern Cayuga Lake Streams



Inspection of multi-year chloride concentrations in the CSI database suggests that salt levels are trending up in streams and, therefore, in groundwater. A statistically significant rise is confirmed by regression analysis.



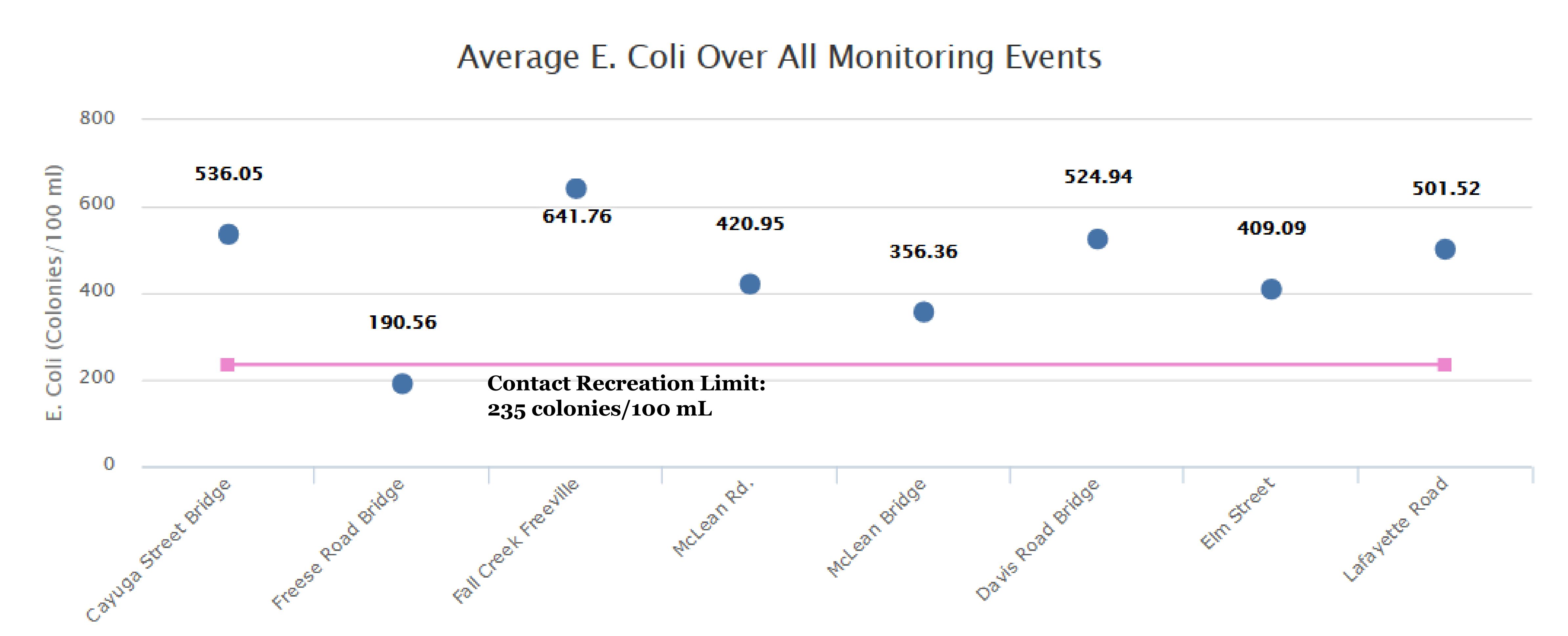


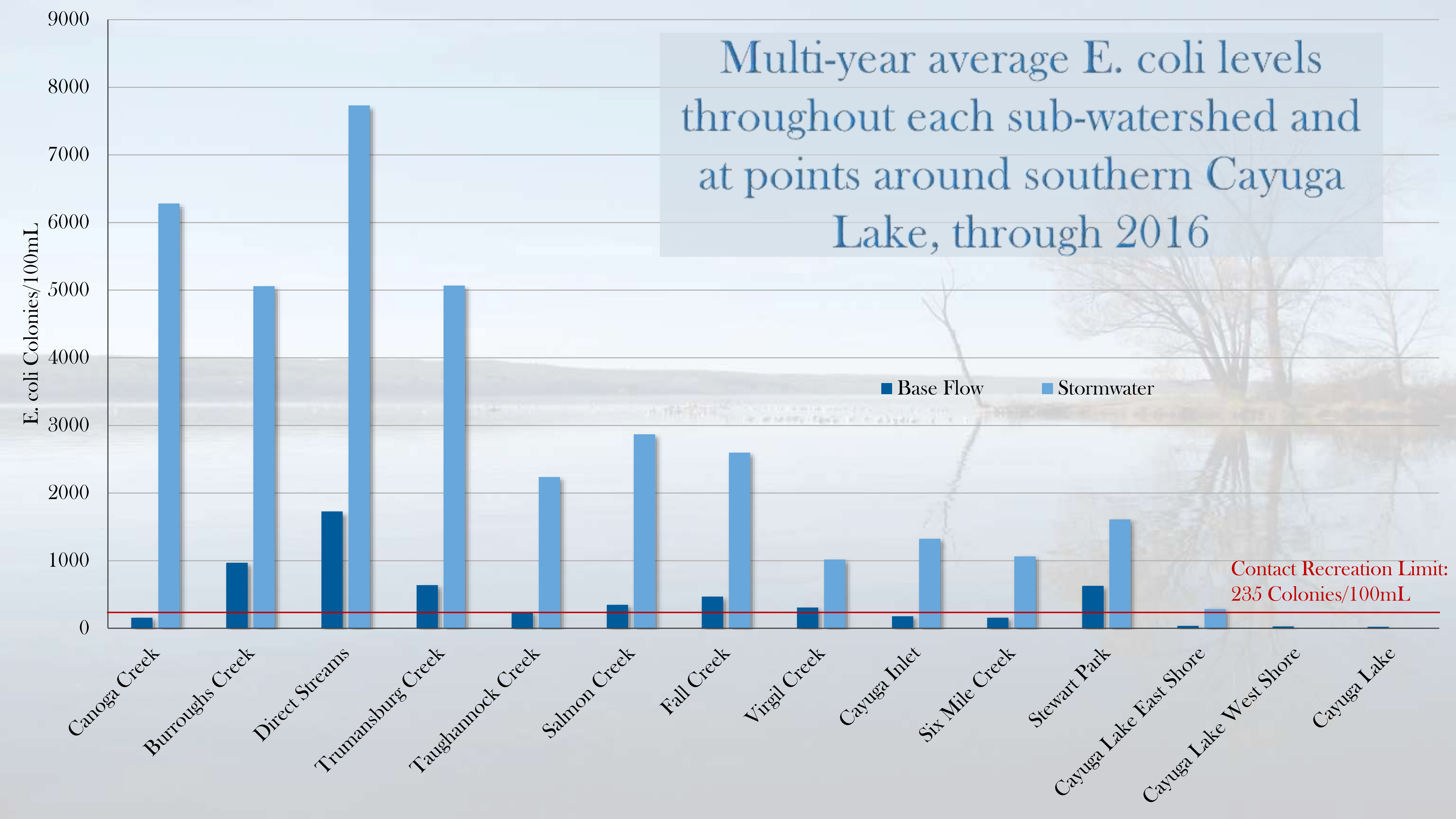
Six Mile Creek, 2004-2016,
2.5 mg/L/year
y = 0.0069x + 22.633
R² = 0.4186
P-value < 0.05
Chloride Concentration (mg/L)
Time Elapsed Since First Sampling Event (Days)
Cayuga Inlet, 2011-2016,
3.7 mg/L/year
y = 0.0102x + 36.362
R² = 0.3055
P-value < 0.05
Chloride Concentration (mg/L)
Time Elapsed Since First Sampling Event (Days)
Fall Creek, 2002-2016,
1.5 mg/L/year
y = 0.0042x + 25.957
R² = 0.1995
P-value < 0.05
Chloride Conc. (mg/L)
Time Elapsed Since First Sampling Event (Days)
Taughannock Creek, 2006-2016,
1.5 mg/L/year
y = 0.0042x + 18.256
R² = 0.6697
P-value < 0.05
Chloride Conc. (mg/L)
Time Elapsed Since First Sampling Event (Days)

Pathogenic Bacteria: A Common Pollutant and a Public Health Issue

- Pathogenic bacteria pose an immediate risk to public health
- E. coli bacteria are used as a “red flag” indicator of the potential contamination of fresh water by pathogenic bacteria
- In areas regulated by New York State Parks, swimming is closed to the public on any day that the E. coli concentration exceeds 235 colonies/100 ml
- Volunteer-CSI monitoring partnerships routinely measure E. coli levels in tributary streams and Cayuga Lake
- In streams, average E. coli levels exceed 235 colonies/100 ml at most, but not all, monitoring locations
- At monitoring sites in southern Cayuga Lake and along the east and west shores, E. coli levels are far lower, on the order of 25 colonies/100 ml

Multi-Year Average E. coli Concentrations Across Fall Creek Watershed at Base Flow

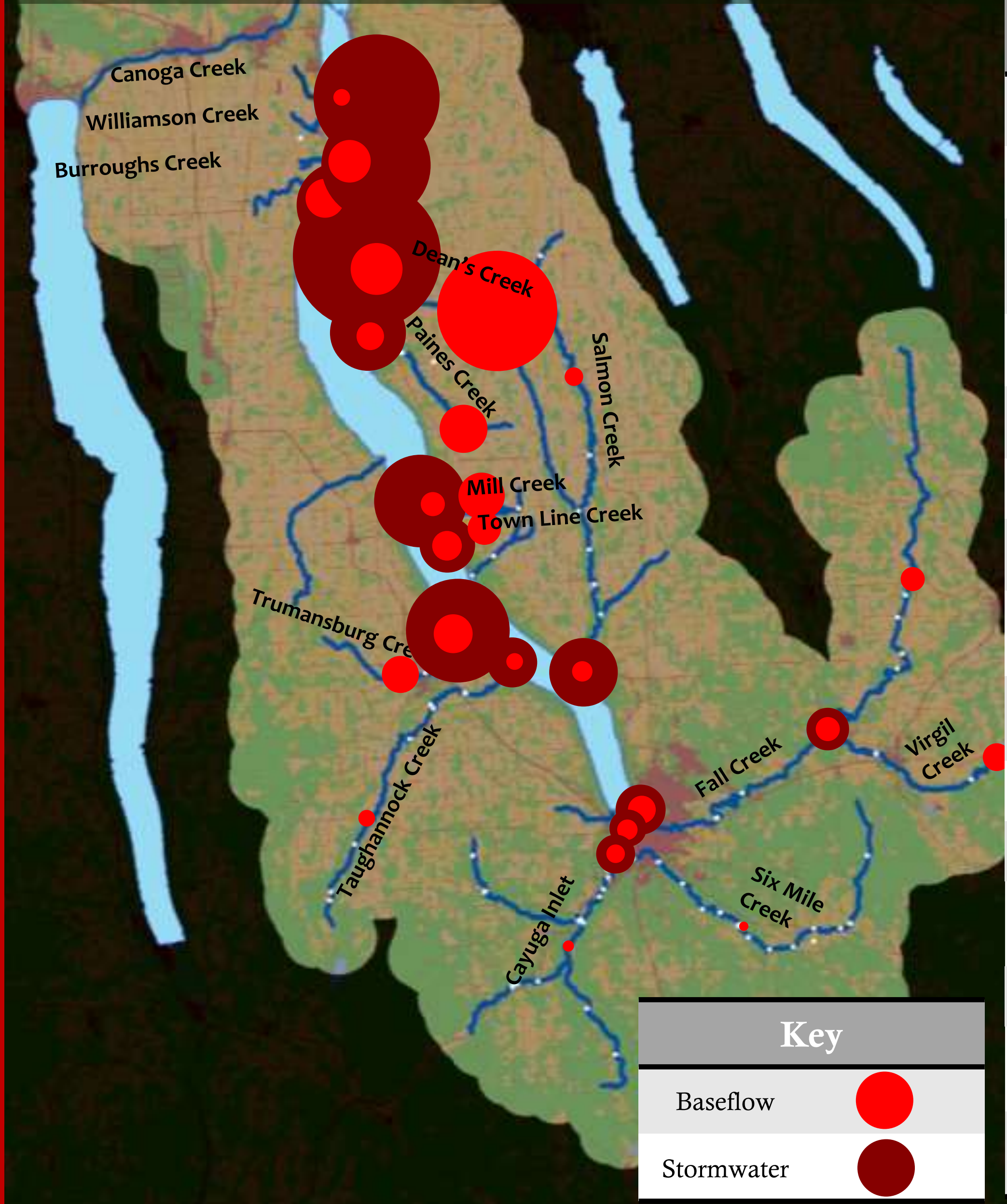



Multi-year average E. coli levels throughout each sub-watershed and at points around southern Cayuga Lake, through 2016
E. coli Colonies/100mL
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Base Flow
Stormwater
Contact Recreation Limit:
235 Colonies/100mL
Canoga Creek
Burroughs Creek
Direct Streams
Trumansburg Creek
Taughannock Creek
Salmon Creek
Fall Creek
Virgil Creek
Cayuga Inlet
Six Mile Creek
Stewart Park
Cayuga Lake East Shore
Cayuga Lake West Shore
Cayuga Lake

E. coli concentrations in southern Cayuga Lake and along east and west shores (colonies/100 ml)

Selected E. coli Concentrations

Contact recreation limit = 235 colonies/100 ml



Stream (North to South)	Base Flow E. coli at mouth (colonies/100 ml)	Base Flow E. coli at Other Location (colonies/100 ml)	Stormwater E. coli at mouth (colonies/100 ml)
Canoga Creek	235	2.5	12135
Williamson Creek	1350	ND	9170
Burroughs Creek	1140	ND	5435
Dean's Creek	2046	11051	16746
Paine's Creek	620	1799	4306
Mill Creek	432	1581	6475
Town line creek	637	862	2362
Trumansburg Creek	1114	1078	8247
Taughannock Creek	231	210	1887
Salmon Creek	326	287	3560
Fall Creek	549	409	1959
Virgil Creek	439	606	1376
Cayuga Inlet	251	84	1200
Six Mile Creek	311	65	1076
Cascadilla Creek*	424	ND	2659

Brief Detour: E. coli Data Collected by Volunteer-CSI Monitoring Partnerships Have Triggered the Resolution of Two Public Health Issues

- The southern shelf portion of Cayuga Lake was placed on the EPA's **303(d) list of impaired waterbodies** for phosphorus and sediment in 2002 and for **pathogenic bacteria** in 2008.

  - In 2014, CSI and IAWWTP data persuaded NYSDEC and EPA to delist the southern shelf for pathogenic bacteria

  - DEC admitted that the 6 years of 303(d) listing was a mistake.

  - Delisting greatly benefits residents' recreational uses of Cayuga Lake as well as the regional tourism industry.

Upgrade of Aging Infrastructure

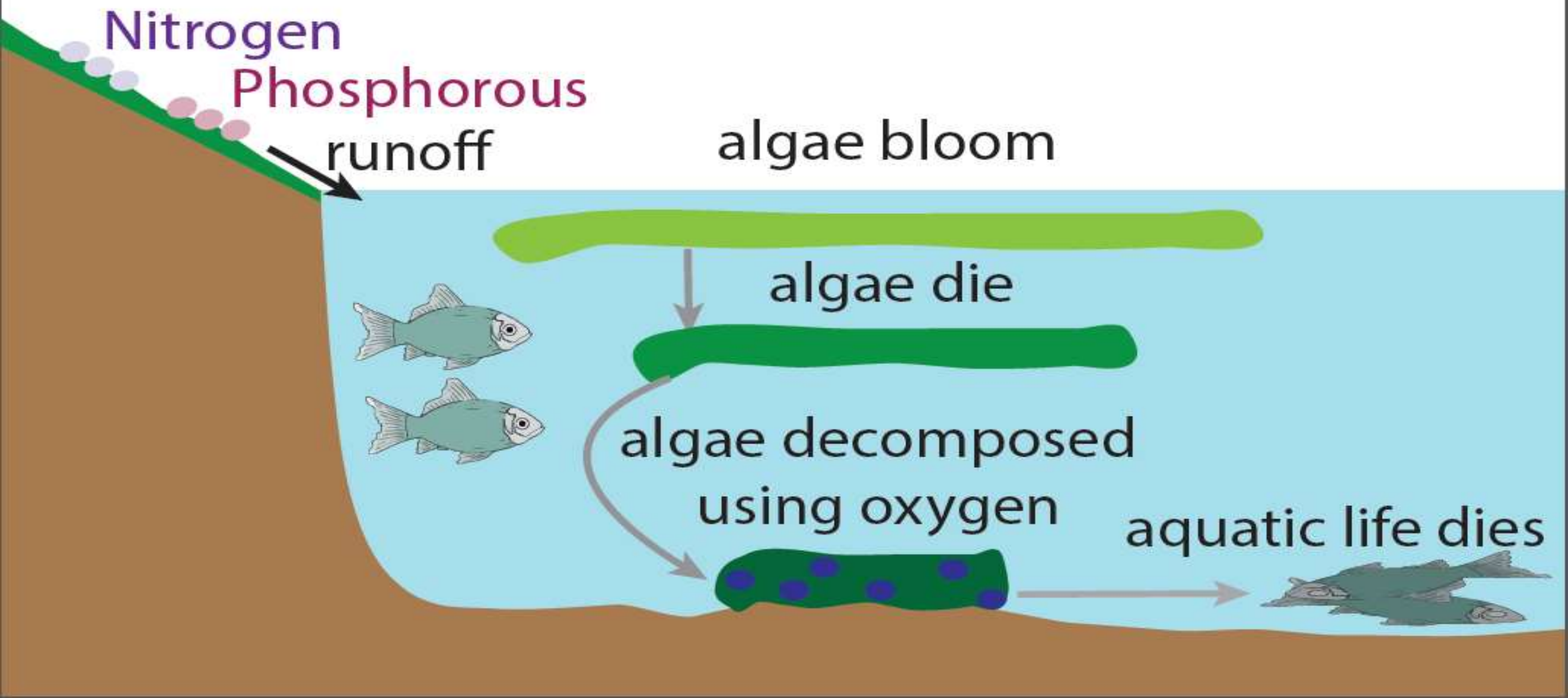
- CSI met with Village of Trumansburg officials several times from 2007 to 2012 to discuss the very high E. coli levels in the effluent of the wastewater treatment plant under base flow conditions, in clear violation of their SPDES permit. When levels did not go down, the CSI Board wrote to the DEC. The DEC investigated, and the press got involved. Eventually, the Village borrowed $6.2 for an upgrade of the plant, which was completed at the end of 2016. An effluent sample collected in February 2017 had no E. coli.

    - This is an example of aging infrastructure. It is very likely that other plants, if monitored, would also be found to exceed the health-based level of 200 colonies/100 of fecal coliform.
    - It is also an example of a regulatory system that relies on regulated entities to monitor themselves. Small plants are only required to test for bacteria once a month, whenever they choose. Monitoring by volunteers is effectively random.

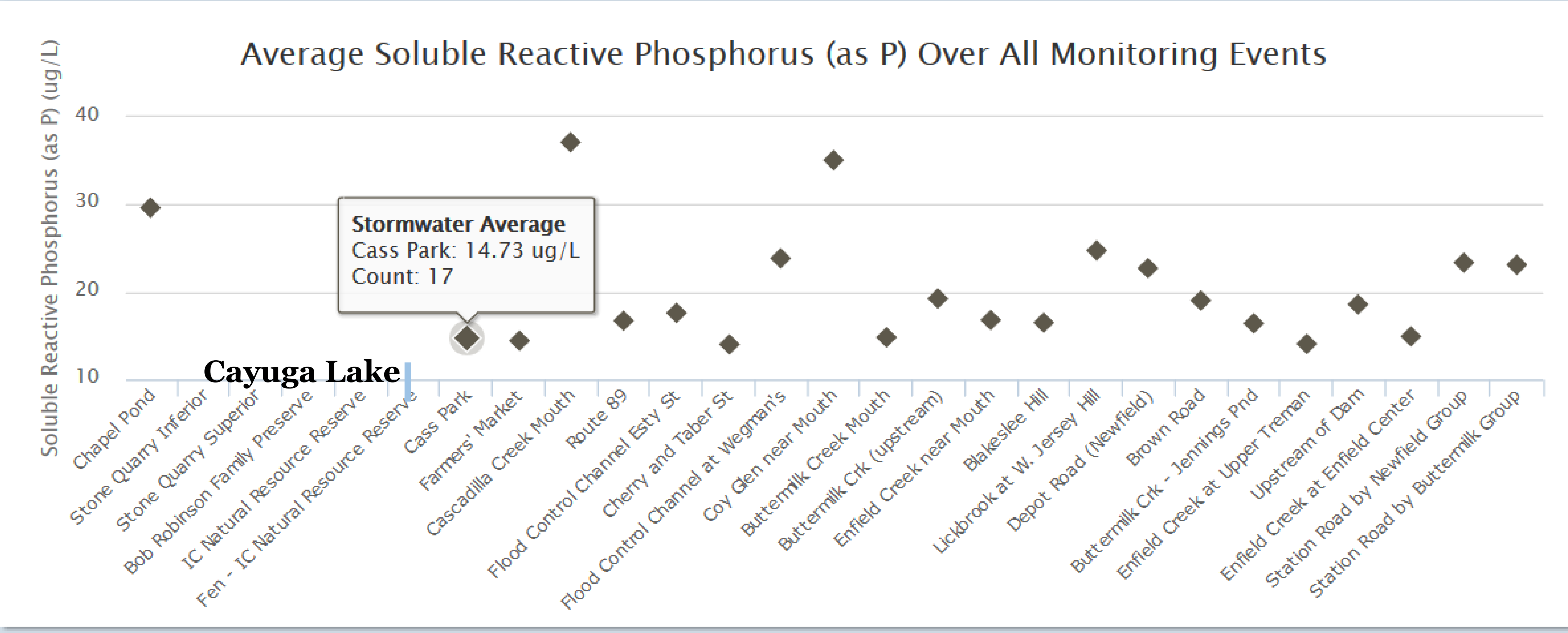
Bioavailable Phosphorus in the Cayuga Lake Watershed

- Dissolved phosphorus is considered mostly bioavailable, meaning it is taken up by algae and other plants and promotes their growth
- The Cayuga Lake Modeling Project (CLMP) determined that **particulate**, or soil-bound, phosphorus is mostly **not** bioavailable while confirming that **dissolved** phosphorus mostly **is** bioavailable
- Concentrations of dissolved phosphorus determined in the CSI lab produce load estimates that align fairly well with loads of bioavailable phosphorus determined by the CLMP, even though different methods were used to measure dissolved phosphorus
- CSI's results for dissolved, or "soluble reactive," phosphorus provide affordable and useful, albeit imperfect, estimates of bioavailable phosphorus for characterizing phosphorus loading to lakes

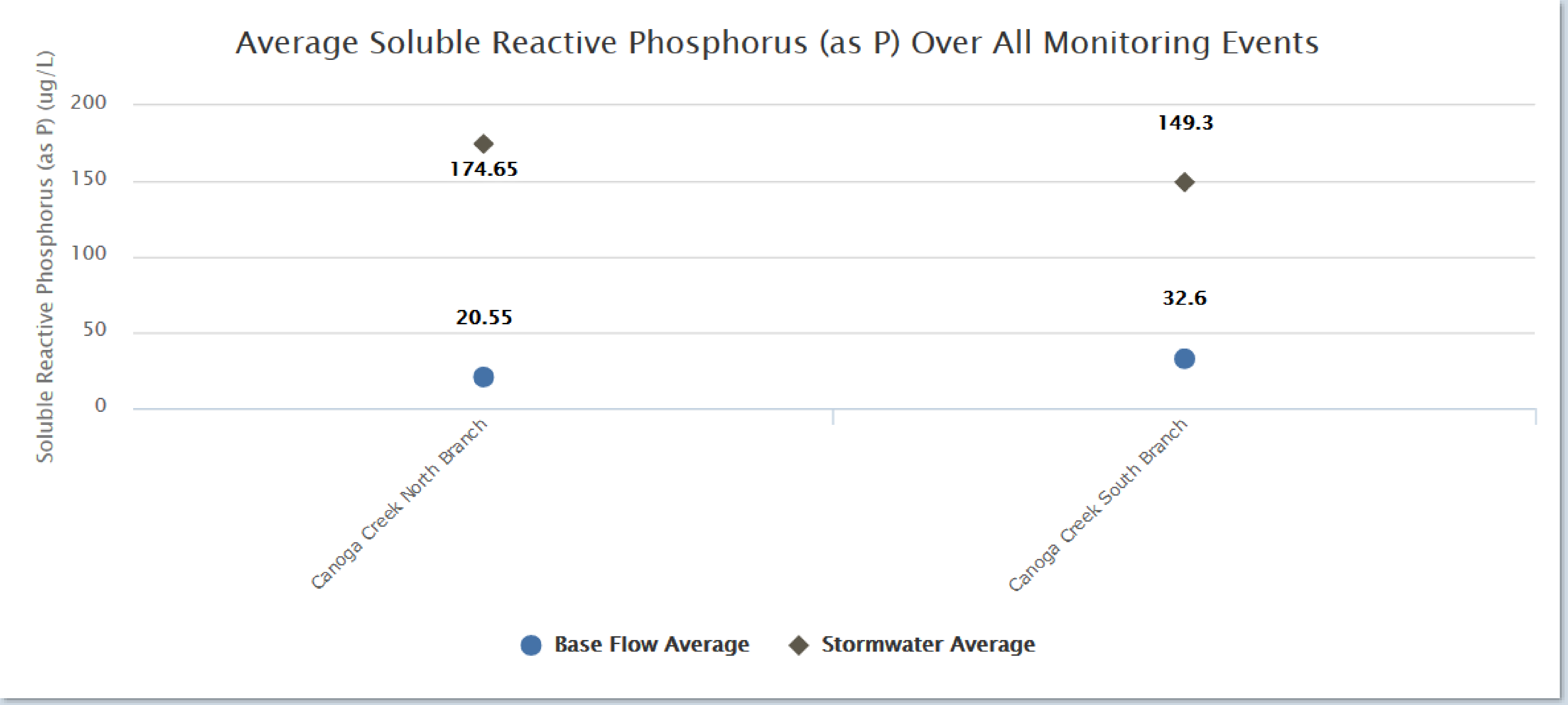
Eutrophication

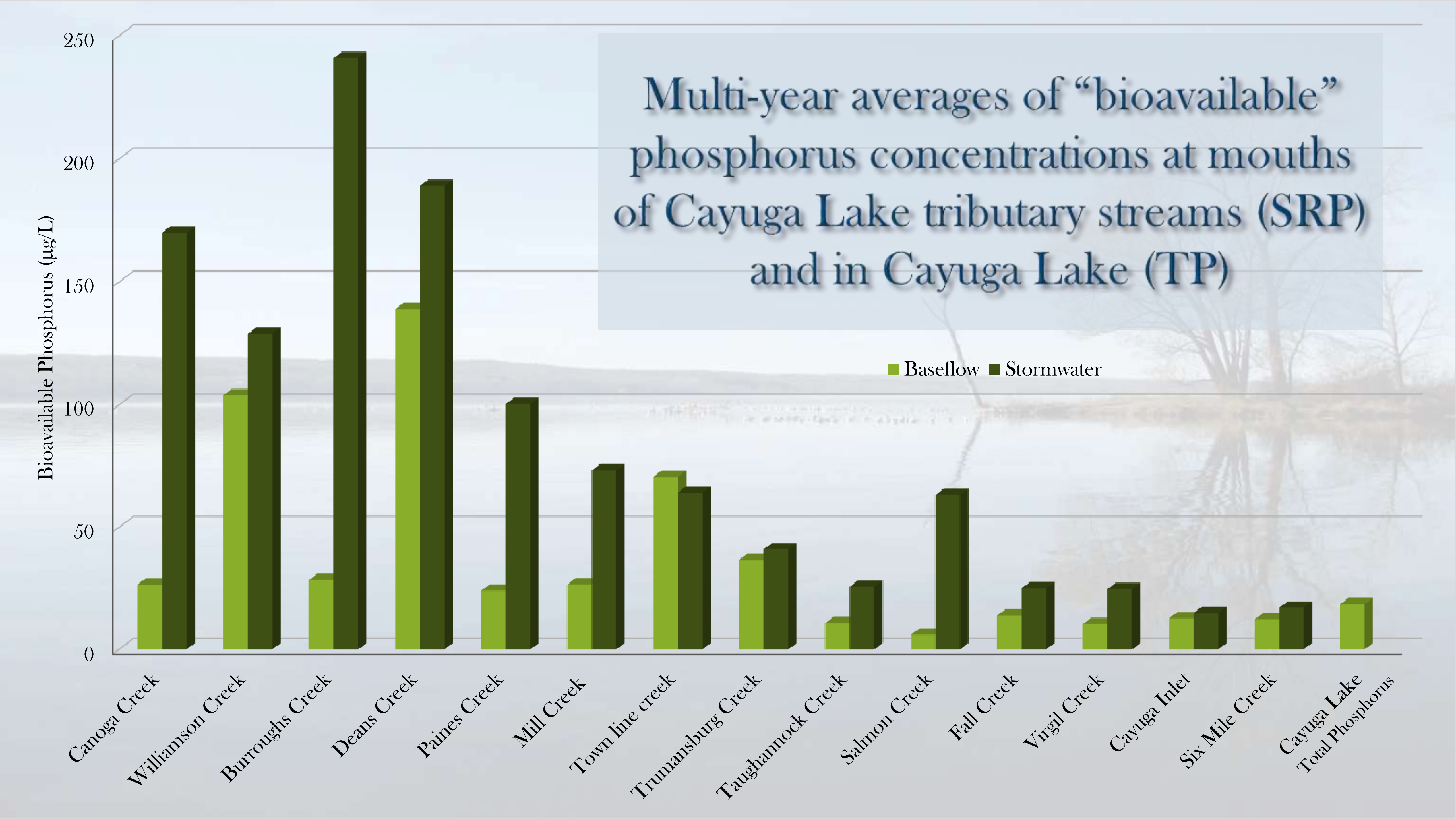


8-Year Average Dissolved, “Bioavailable” Phosphorus in the Cayuga Inlet, Stormwater Flows



1.5-Year Average Dissolved "Bioavailable" Phosphorus in Canoga Creek, Base Flow and Stormwater





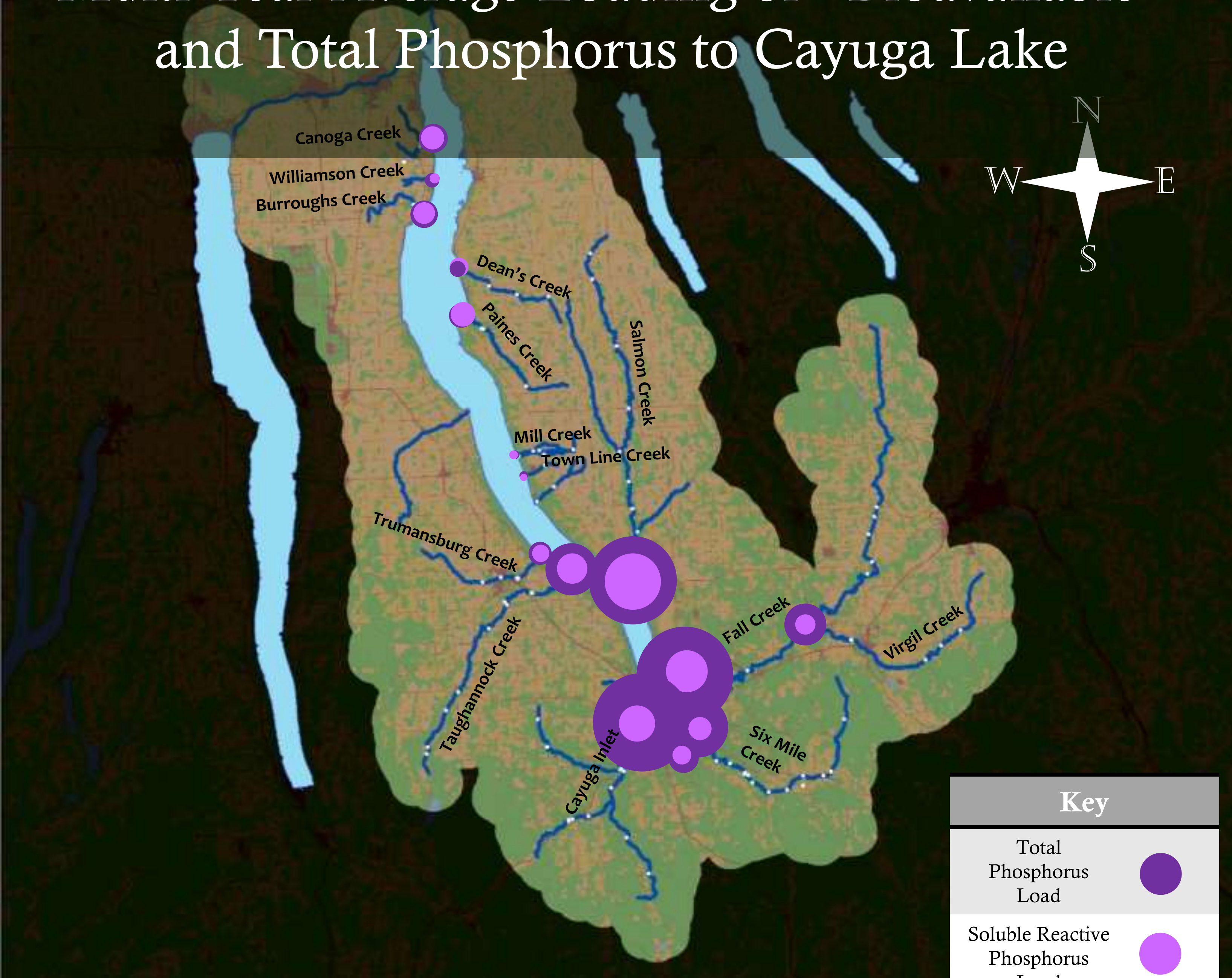
Multi-year averages of "bioavailable" phosphorus concentrations at mouths of Cayuga Lake tributary streams (SRP) and in Cayuga Lake (TP)
Bioavailable Phosphorus (µg/L)
250
200
150
100
50
0
Baseflow
Stormwater
Canoga Creek
Williamson Creek
Burroughs Creek
Deans Creek
Paines Creek
Mill Creek
Town line creek
Trumansburg Creek
Taughannock Creek
Salmon Creek
Fall Creek
Virgil Creek
Cayuga Inlet
Six Mile Creek
Cayuga Lake Total Phosphorus

Multi-Year Average Soluble Reactive ("Bioavailable") Phosphorus Concentrations at Stream Mouths

Key	
Baseflow	
Stormwater	

Stream (North to South)	Baseflow Soluble Reactive Phosphorus (µgP/L)	Stormwater Soluble Reactive Phosphorus (µgP/L)
Canoga Creek	26.58	169.98
Williamson Creek	104.00	129.00
Burroughs Creek	28.50	241.00
Deans Creek	138.95	189.00
Paines Creek	24.10	100.40
Mill Creek	26.66	73.37
Town line creek	70.66	64.23
Trumansburg Creek	36.70	41.06
Taughannock Creek	10.70	25.74
Salmon Creek	6.01	63.34
Fall Creek	13.78	25.06
Virgil Creek	10.37	24.77
Stewart Park Visitor's Center	59.92	62.20
Cayuga Inlet	12.70	14.80
Six Mile Creek	12.35	17.07
Cascadilla Creek*	18.81	37.59

Multi-Year Average Loading of “Bioavailable” and Total Phosphorus to Cayuga Lake



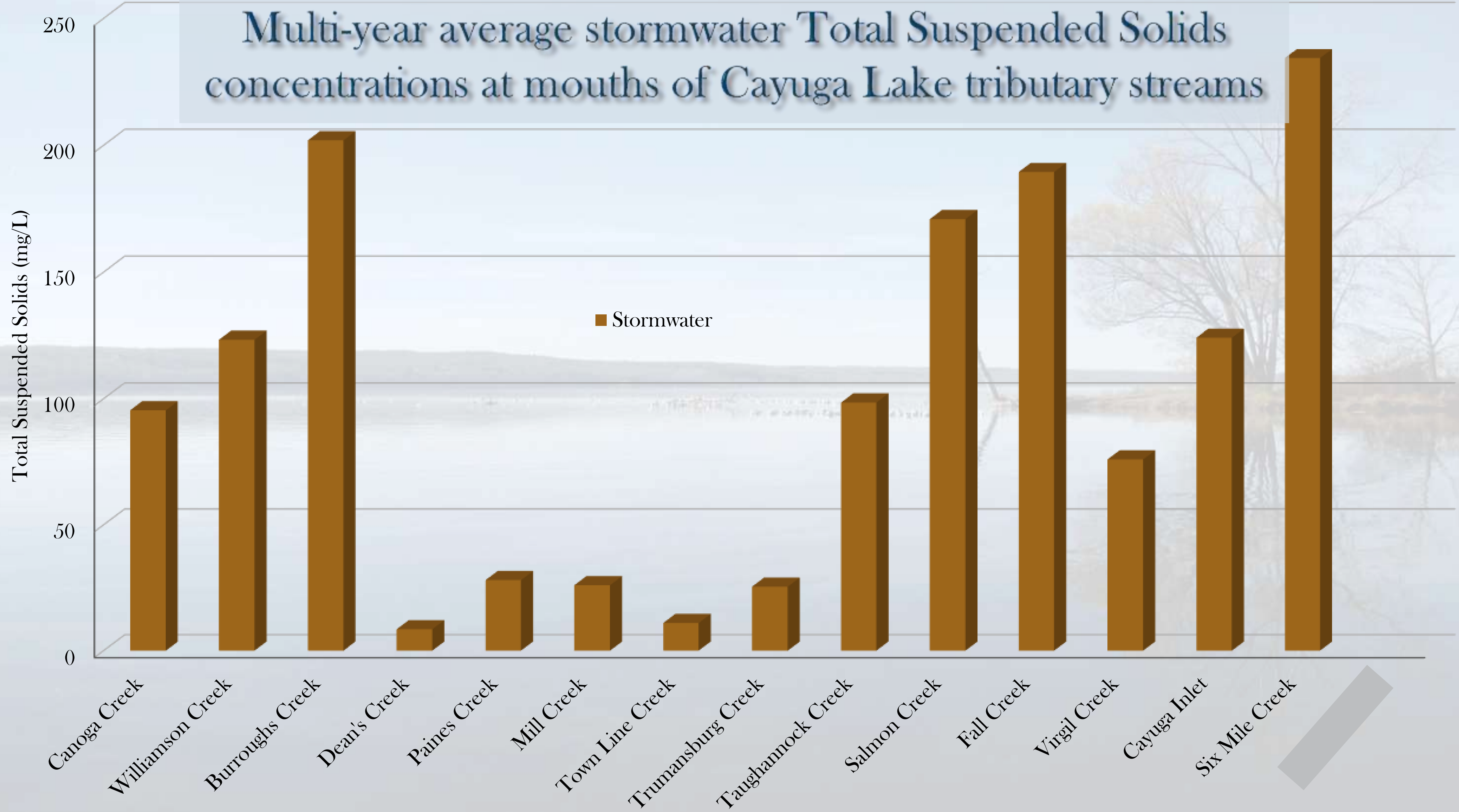
Key	
Total Phosphorus Load	(dark purple circle)
Soluble Reactive Phosphorus Load	(light purple circle)

Watershed (North to South)	Drainage Area (mi²)	Loading of Total Phosphorus (tons/yr)	Loading of Soluble Reactive Phosphorus (tons/yr)
Canoga Creek*	5.83	2.05	1.32
Williamson Creek*	1.40	0.51	0.24
Burroughs Creek*	3.7	1.84	1.20
Deans Creek*	3.2	0.71	0.81
Paines Creek*	15.3	1.51	1.51
Mill Creek*	1.4	0.18	0.19
Town Line Creek*	1.7	0.19	0.15
Trumansburg Creek*	13.07	1.30	0.76
Taughannock Creek*	66.8	6.51	2.31
Salmon Creek*	89.2	19.14	7.59
Fall Creek^	**129.0**	**23.11**	**4.34**
Virgil Creek^	**40.6**	**4.35**	**1.08**
Cayuga Inlet^	**158.0**	**23.76**	**3.14**
Six Mile Creek^	**51.5**	**8.89**	**1.33**
Cascadilla Creek^	**13.7**	**2.39**	**0.80**

^Calculated load, average 2011-2013
*Extrapolated from Fall Creek load

Soil and Sediment Runoff and Transport to Cayuga Lake

Multi-year average stormwater Total Suspended Solids concentrations at mouths of Cayuga Lake tributary streams



Total Suspended Solids (TSS) in Tributary Streams of Cayuga Lake

- Highest stormwater concentrations of suspended solids so far have been observed in north and south end tributaries; however, Cayuga and Seneca County stream data is sparse
- CSI has calculated annual TSS load estimates for southern tributaries (available on request)
- Multi-year comparison of CSI load estimates with USGS load estimates at Bethel Grove on Six Mile Creek indicates that CSI underestimates suspended solids by about 40%, on average
- Underestimate is probably due largely to stormwater sample collection methods: CSI volunteers collect grab samples by hand near the surface and the shore (so they won’t drown); USGS uses automated equipment to collect depth-integrated samples from the stream’s Thalweg

Conclusions

- **Salt, pathogenic bacteria**, **phosphorus** and **sediment** are common pollutants that have direct and indirect impacts on the environment and on human health.
- The major sources of pollutants have changed **from point** sources 40 years ago -- such as factories and sewage treatment plants -- **to non-point sources** today -- such as agriculture, suburban landscapes, and impervious urban surfaces.
- Managing non-point source pollutants requires a collective effort, beginning at the local and regional level:
  1) To understand the scope and sources of non-point source pollution
  2) To design management strategies for each watershed
  3) To secure financial support to implement consensus management decisions

Wastewater treatment plants remain a concern due to a combination of aging infrastructure and regulatory loopholes

Thank you!

- **Cayuga Lake Watershed Network**
- **Canoga Fire District**
- **CSI staff**
  - **Michi Schulenberg, Laura Dwyer, Noah Mark** -- Lab analyses
  - **Claire Weston** – Outreach, website, Power Point slides
  - **Adrianna Hirtler** – Biomonitoring through BMI
  - **Abner Figueroa** – Database development and maintenance


Questions?