Meeting of the WQAC

Evaluation of SPW Chloride Data

Delaware River Basin Commission

July 28, 2020

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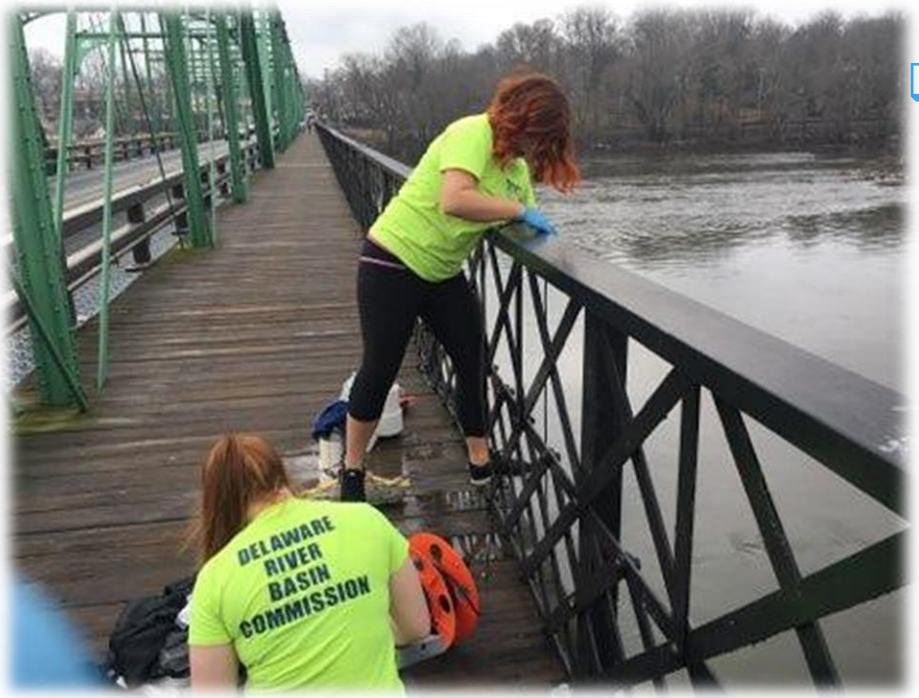
Freshwater Salinization and Increasing Chloride



- Why did DRBC assess SPW chloride data?
  - Freshwater salinization as a global concern
  - Readily available long-term dataset of conventional parameters and nutrients available through Water Quality Portal
    - Trends in non-tidal Delaware River (SPW watershed) corroborate other assessments
    - Delaware River at Calhoun Street Bridge captures freshwater inflows to the Delaware Estuary and reflects upstream water quality
      - Long-term monitoring site of DRBC and USGS

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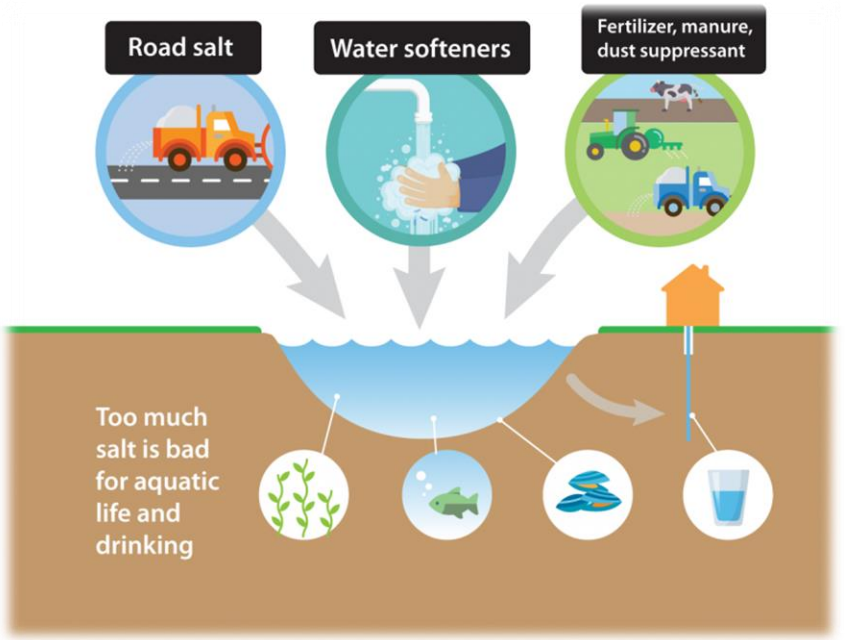
Chloride Culprits

- Human activity combined with high reactivity and mobilization of chlorides
  - Increased impervious surfaces and deforestation
  - Road deicing salt with inconsistent regulation of application
  - Fertilizers (agriculture, private land)
  - Wastewater (industrial, municipal)
  - Water softeners
  - High-salt diets
  - Other
- Compounding effect



https://www.pca.state.mn.us/water/chloride-101

Increasing Chloride as a Concern

- Ecological effects
  - Toxic to aquatic life at certain thresholds
  - Increasing salinity, concurrent with increasing chloride concern, may alter water quality dynamics (stratification and nutrient cycling)
- Mobilization of toxic metals
- Human health risks – increased salt and heart health
- Changes to infrastructure
- Other known, unknown and/or combined effects

https://www.worldhighways.com/wh6/products/concrete-protection-chloride-attack

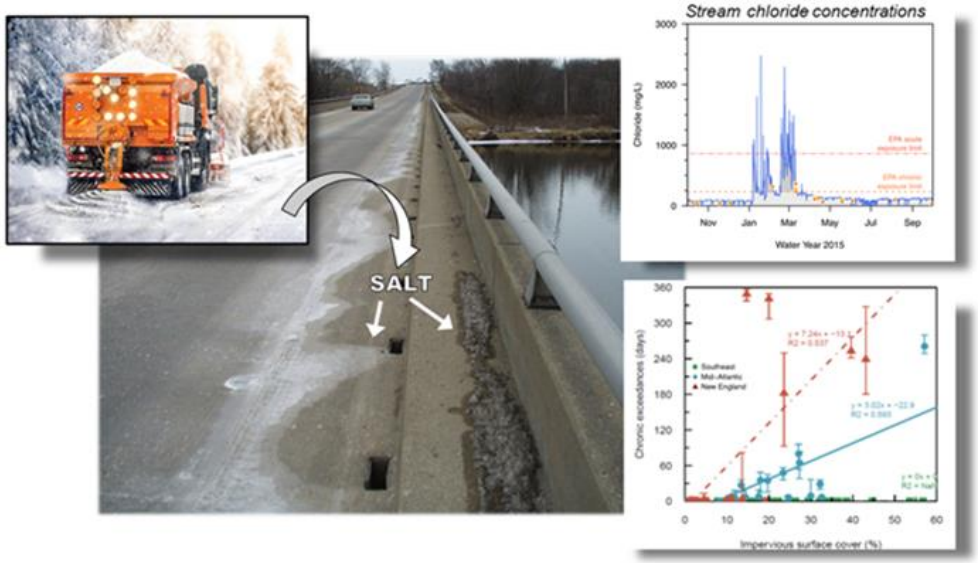
Trends of Increasing Freshwater Chloride

- Webinar hosted at USGS Lawrenceville, NJ office

How salty are our streams? Using high-frequency data to characterize chloride exceedance events above ecologically-relevant thresholds

Wednesday, January 8, 2020 at 12:00 pm ET

Presented by:
Rosemary Fanelli (USGS South Atlantic Water Science Center)
and
Joel Moore (Towson University/USGS MD-DE-DC Water Science Center)



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Growing Public Awareness

Where will all that road salt go? Into the Delaware River - and that's a concern

The Philadelphia Inquirer

by Frank Kummer, Posted: January 12, 2018

https://www.inquirer.com/philly/health/environment/where-will-all-that-philadelphia-road-salt-go-in-the-delaware-river-and-thats-not-good-20180111.html

https://twitter.com/RiderUniversity/status/1093538422042574848

Local example:

- Dr. Hongbing Sun with Rider University has been featured in the news over the past couple of years by multiple stations regarding his research about road deicing salt impacts

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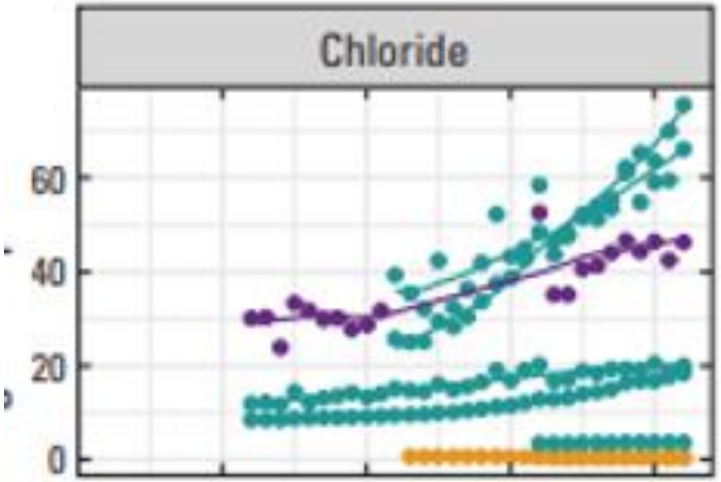
Trends of increasing freshwater chloride

- USGS 2019 pilot regional Integrated Water Availability Assessment (IWAA) covering data from 1972-2012, increases in specific conductance and chloride

USGS
science for a changing world

Integrated Water Availability Assessments Program

A Historical Look at Changing Water Quality in the Delaware River Basin



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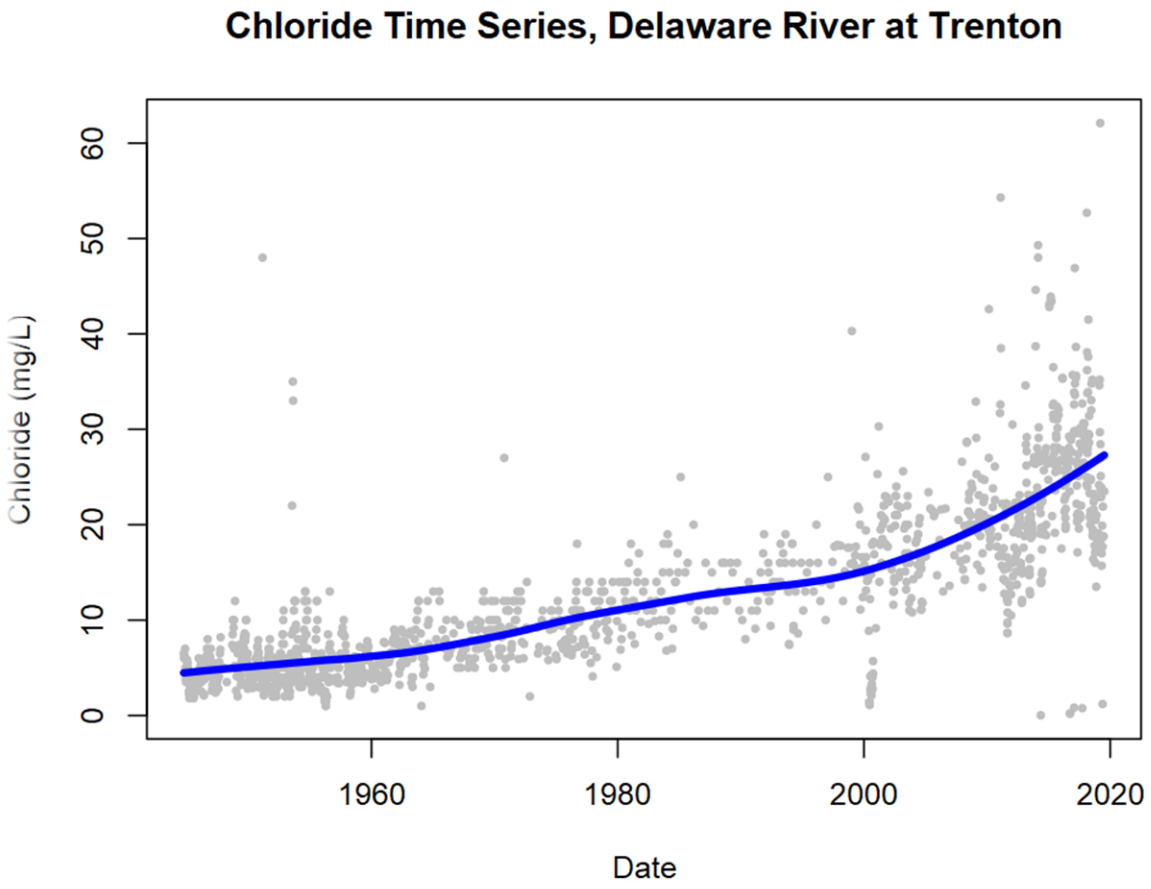
Delaware River at Trenton (Calhoun Street Bridge)



- Chloride concentrations in non-tidal DR generally not at levels toxic to aquatic life, but the increasing trend is of concern

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Special Protection Waters Program

Special Protection Waters:

Keeping the Clean Water Clean

- Adopted in 1992, and designed as an antidegradation program for streams and rivers where existing water quality is better than established standards
- New and expanding dischargers in SPW area must demonstrate no measurable change to existing water quality to obtain DRBC approval
  - What is ***Existing Water Quality***?

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Existing Water Quality

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Existing Water Quality Atlas of the Delaware River Special Protection Waters

DRBC Special Protection Waters Program

September 2016 – Edition 1.0

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- Baseline conditions established for 57 non-tidal tributary (BCP sites) for 2000-2004 (28 mainstem non-tidal – ICP sites)
- Assess measurable change over time
- Dataset covers 2004-2017

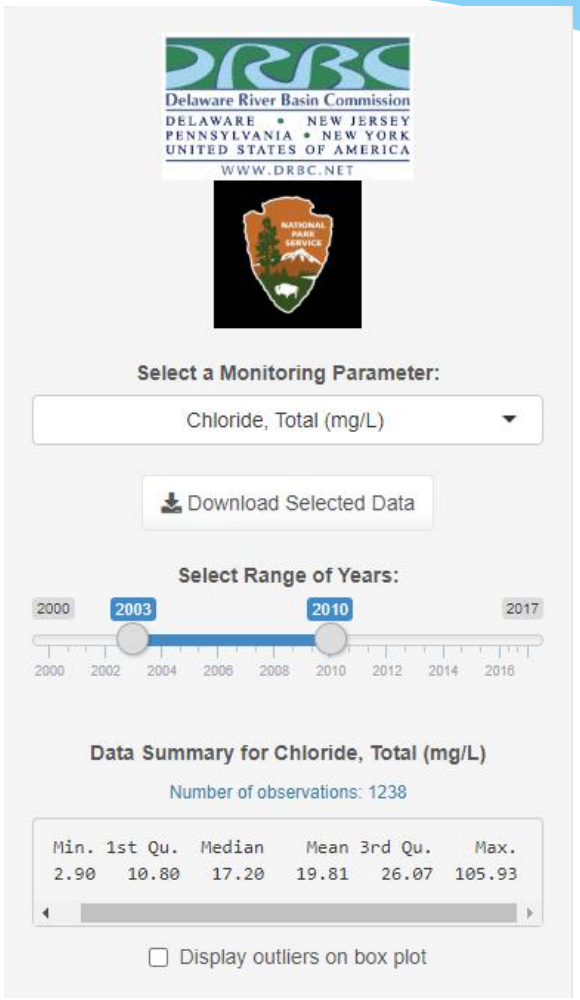
Results from Lower Delaware Measurable Change Assessment 2009-2011

Site Color Key: Dark Blue = Interstate Control Point (ICP); Dark Red = Pennsylvania Tributary Boundary Control Point (BCP); Dark Green = New Jersey Tributary Boundary Control Point (BCP)

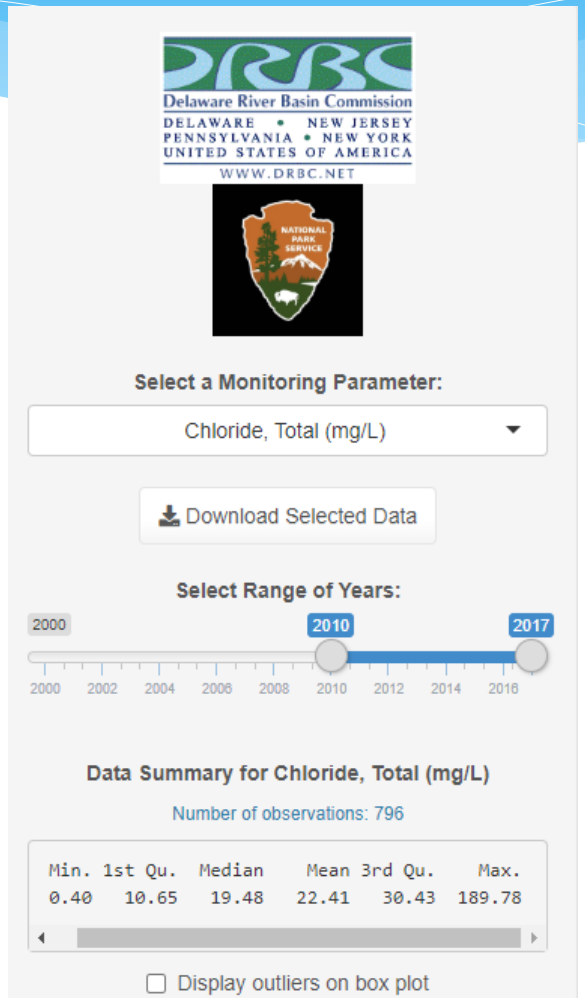
	Parameter / Site Number	Del. River at Trenton 1343 ICP	Del. River at Washngtn Crossing 1418 ICP	Pidcock Creek, PA 1463 BCP	Delaware River at Lambrtvlle 1487 ICP	Wicke-cheoke Creek, NJ 1525 BCP	Lockatong Creek, NJ 1540 BCP	Delaware River at Bulls Island 1554 ICP	Pauna-cussing Creek, PA 1556 BCP	Tohickon Creek, PA 1570 BCP	Tinicum Creek, PA 1616 BCP	Nishi-sakawick Creek, NJ 1641 BCP	Del. River at Milford 1677 ICP	Cooks Creek, PA 1737 BCP	Musco-netcong River, NJ 1746 BCP	Del. River at Rieglsvll 1748 ICP	Pohat-cong Creek, NJ 1774 BCP	Lehigh River, PA 1837 BCP	Del. River at Easton 1838 ICP	Bushkill Creek, PA 1841 BCP	Martins Creek, PA 1907 BCP	Pequest River, NJ 1978 BCP	Del. River at Belvidere 1978 ICP	Paulins Kill River, NJ 2070 BCP	Del. River at Portland 2074 ICP
Field	Dissolved Oxygen (DO) mg/l											~													
	Dissolved Oxygen Saturation %											~													
	pH, units																								
	Water Temperature, degrees C																								
Nutrients	Ammonia Nitrogen as N, Total mg/l																								
	Nitrate + Nitrite as N, Total mg/l																**								
	Nitrogen as N, Total (TN) mg/l																**								
	Nitrogen, Kjeldahl, Total (TKN) mg/l																								
	Orthophosphate as P, Total mg/l																								
	Phosphorus as P, Total (TP) mg/l																								
Bacteria	Enterococcus colonies/100 ml	~			~																				
	Escherichia coli colonies/100 ml	**	**	**	**	**	**			**	**	**													
	Fecal coliform colonies/100 ml																								
Conventionals	Alkalinity as CaCO3, Total mg/l																								
	Hardness as CaCO3, Total mg/l											~													
	Chloride, Total mg/l			**		**	**	**	**	**		**	**	**	**	**	**	**	~	**	**	**	**		**
	Specific Conductance µmho/cm			**		**	**	~	**	**	**	**	**	**	**	~	**	**	~	~	~	**	~		
	Total Dissolved Solids (TDS) mg/l																								
	Total Suspended Solids (TSS) mg/l																								
	Turbidity NTU																								

KEY: = No indication of measurable change to EWQ; ** = Indication of measurable water quality change toward more degraded status; ~ = Weak indication of measurable water quality change toward more degraded status

DRBC Special Protection Waters Monitoring Program Explorer

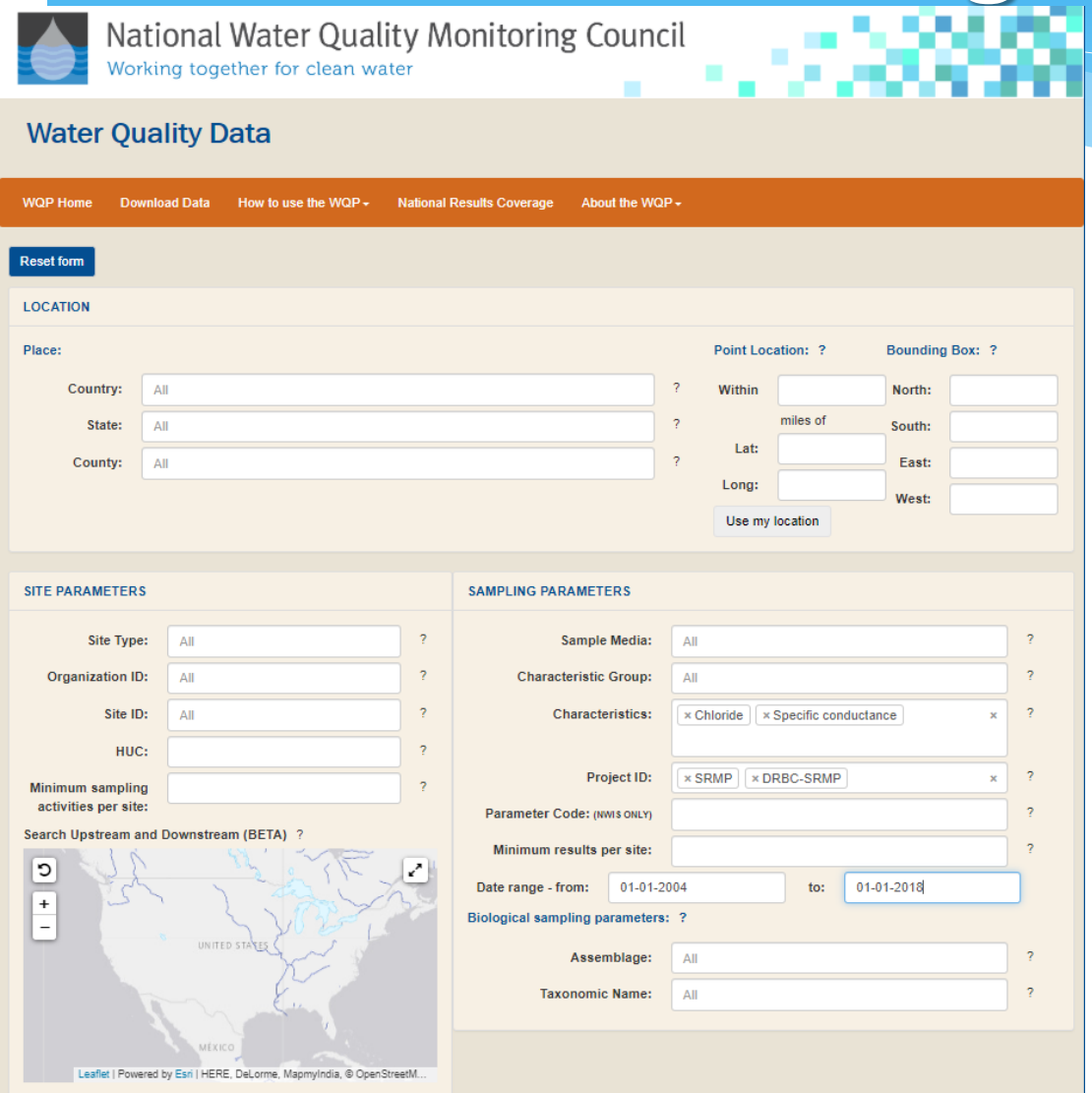


VS



https://elainepanuccio.shinyapps.io/specialprotectionwatersexplorer/

Special Protection Waters Monitoring Dataset



- Readily available via Water Quality Portal (2004-2017)
- National Park Service Upper Delaware and Middle Delaware as monitoring partners (May through September)
- 2,105 individual chloride observations downloaded for upcoming analysis
  - 1,580 chloride observations used for analysis from SPW Monitoring Program dataset (sites with sparse data [N < 10] were filled in with appropriate data from WQP)

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SPW Chloride Analysis

- Assessment of data and trends indicate chloride concentrations are increasing
  - Are there explanatory variables that can help predict chloride levels in a sub-watershed?
  - Do relatively high-chloride sites have similar characteristics vs. relatively low-chloride sites?

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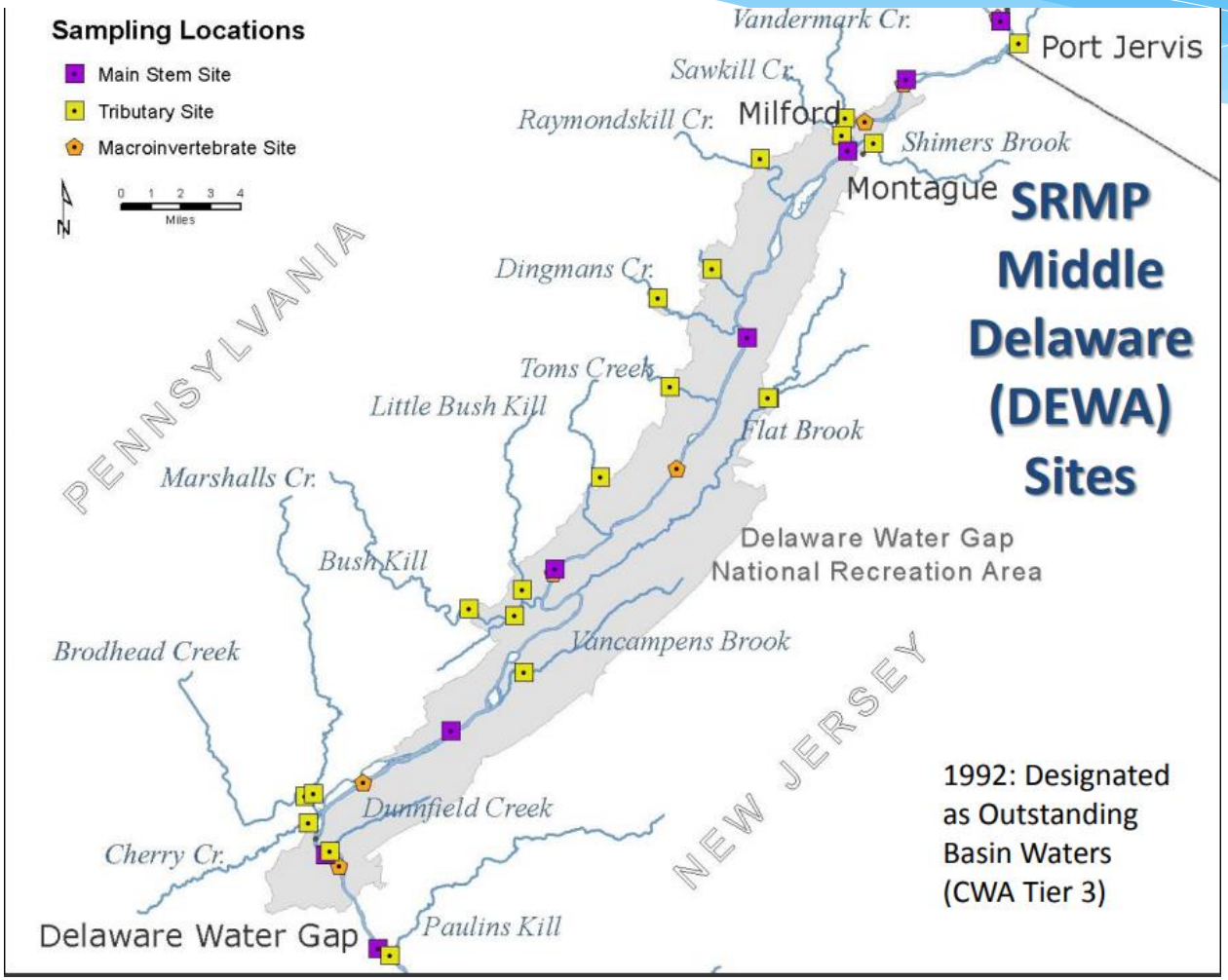
Boundary Control Points (Middle Delaware)



- Yellow (tributaries)
- Purple (mainstem)
- Tributaries in SPW at bottom of sub-watershed near confluence of mainstem Delaware River

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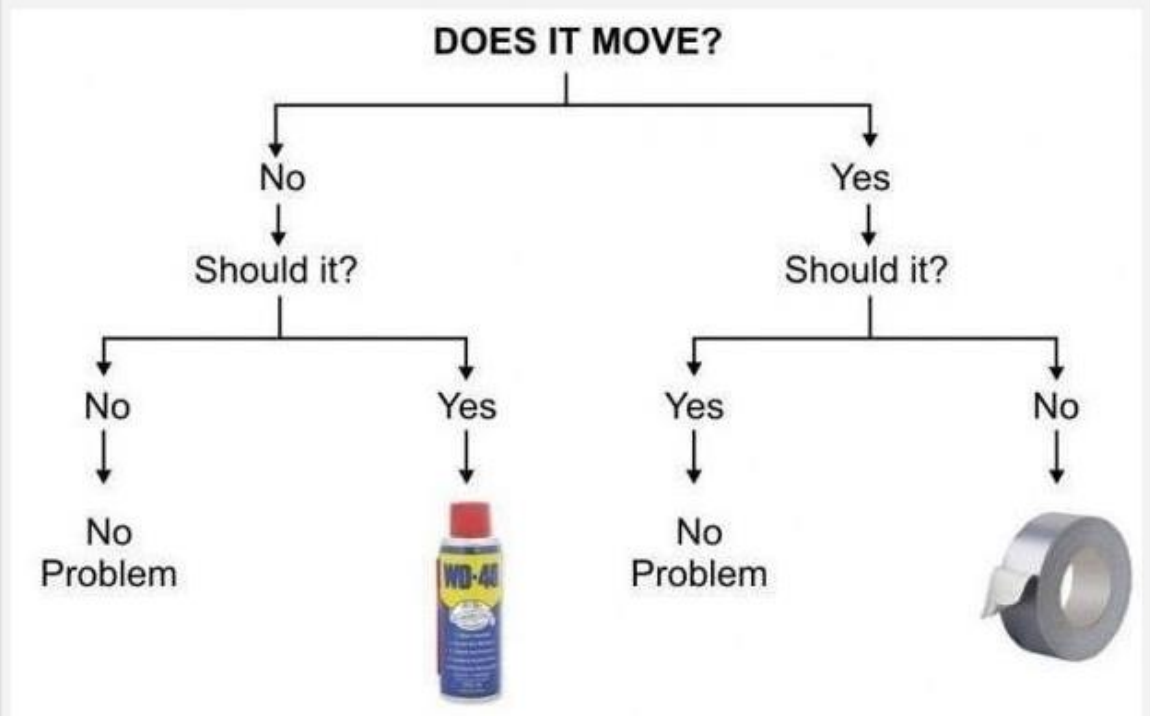
Method of SPW Chloride Analysis

- CART Analyses
  - **C**lassification **a**nd **R**egression **T**ree



https://eight2late.wordpress.com/2016/02/16/a-gentle-introduction-to-decision-trees-using-r/

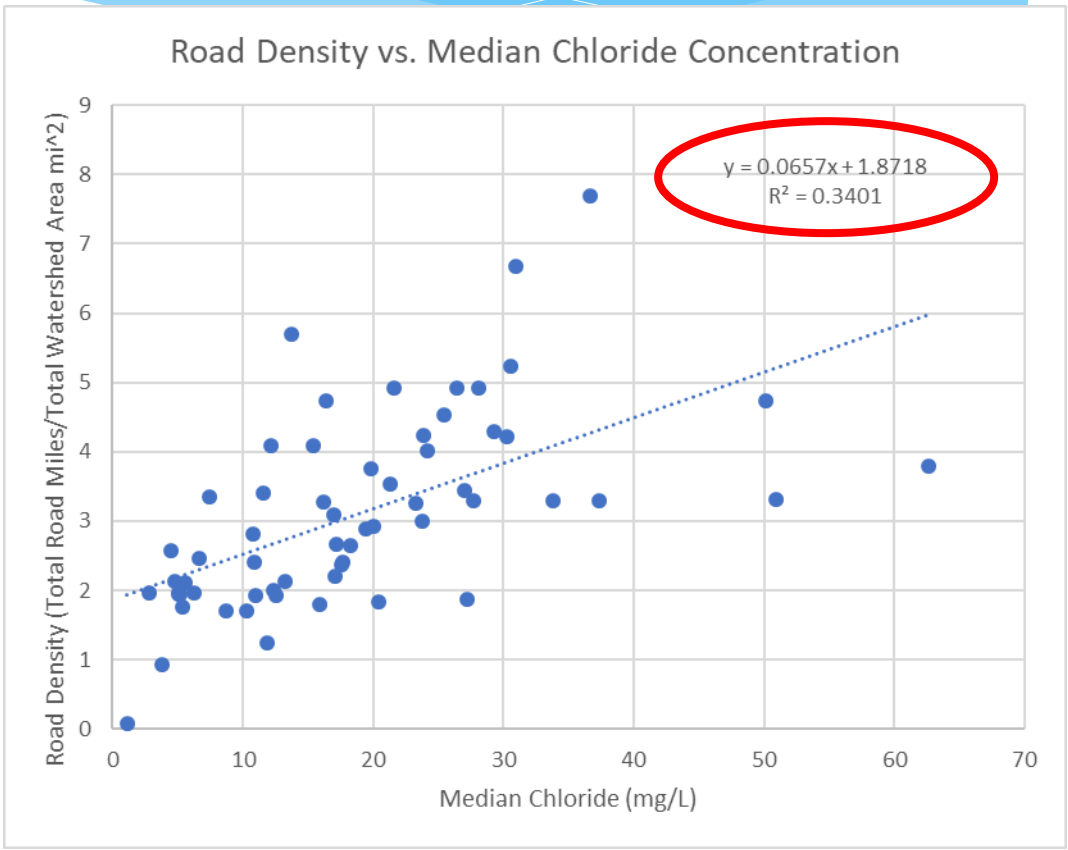
SPW Chloride CART Analysis

https://www.usatoday.com/story/news/nation/2019/12/24/winter-weather-road-salt-use-problems/2741286001/

- Use available land-use data to determine possible explanatory variables for differences in chloride levels among sub-watersheds within SPW watershed
- Road salt application largely unregulated by DOT, private contractors, and municipalities
  - Urban Area, Road Density, and Population data used as surrogates in lieu of road salt application data
- Utilized rpart data package in R Statistical Programming for CART (Classification and Regression Trees) analysis of chloride data
  - Classified chloride concentration data as a function of the above variables

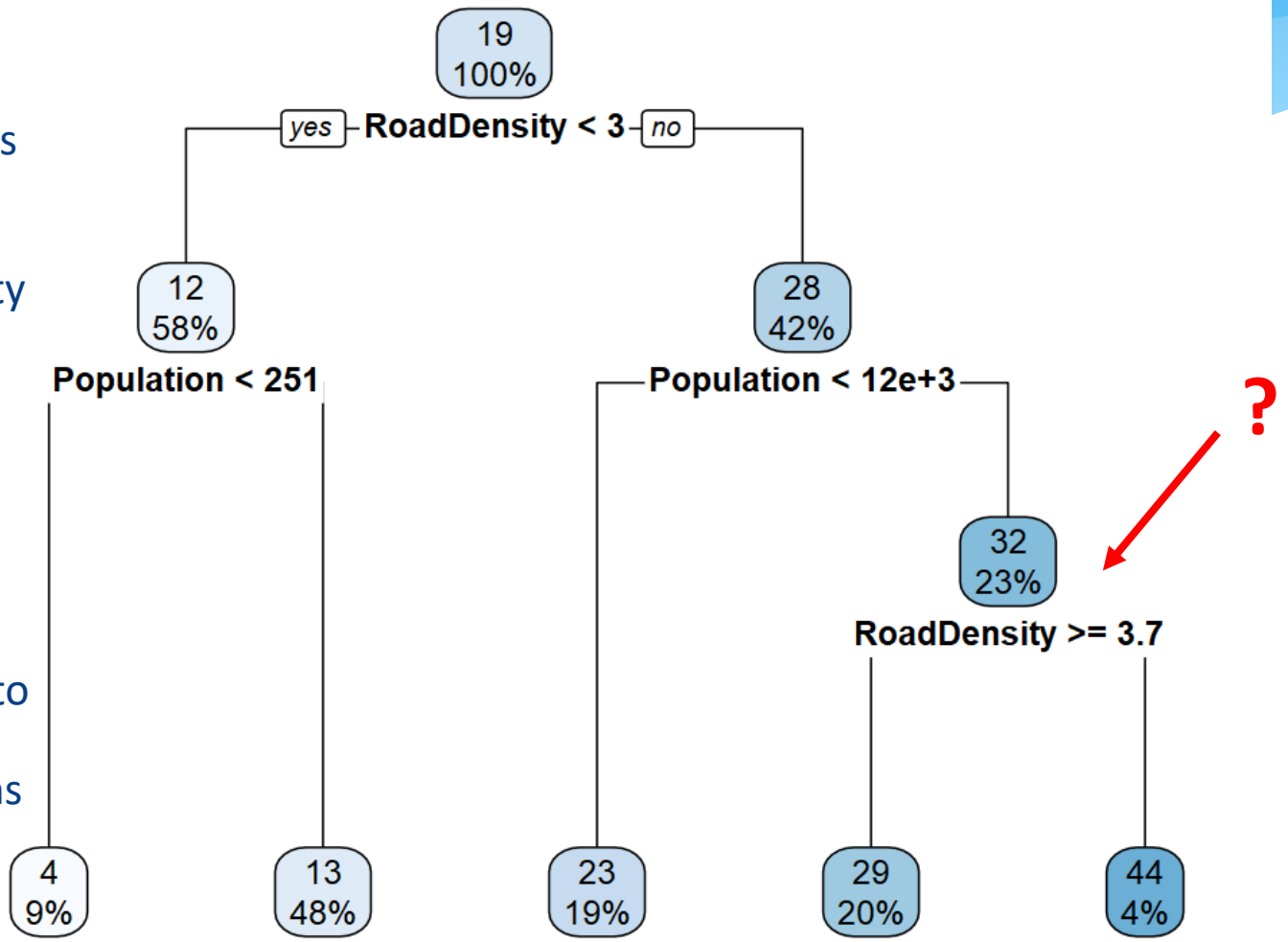
Road Density of Sub-watersheds in SPW Area vs. Median Chloride at BCPs

- Strongest R^2 with road density variable, but questions remain
  - Can sub-watersheds be categorized based on explanatory variables, and what other variables should be included? (Agricultural, forested area, point-discharge volume assessment, etc.)

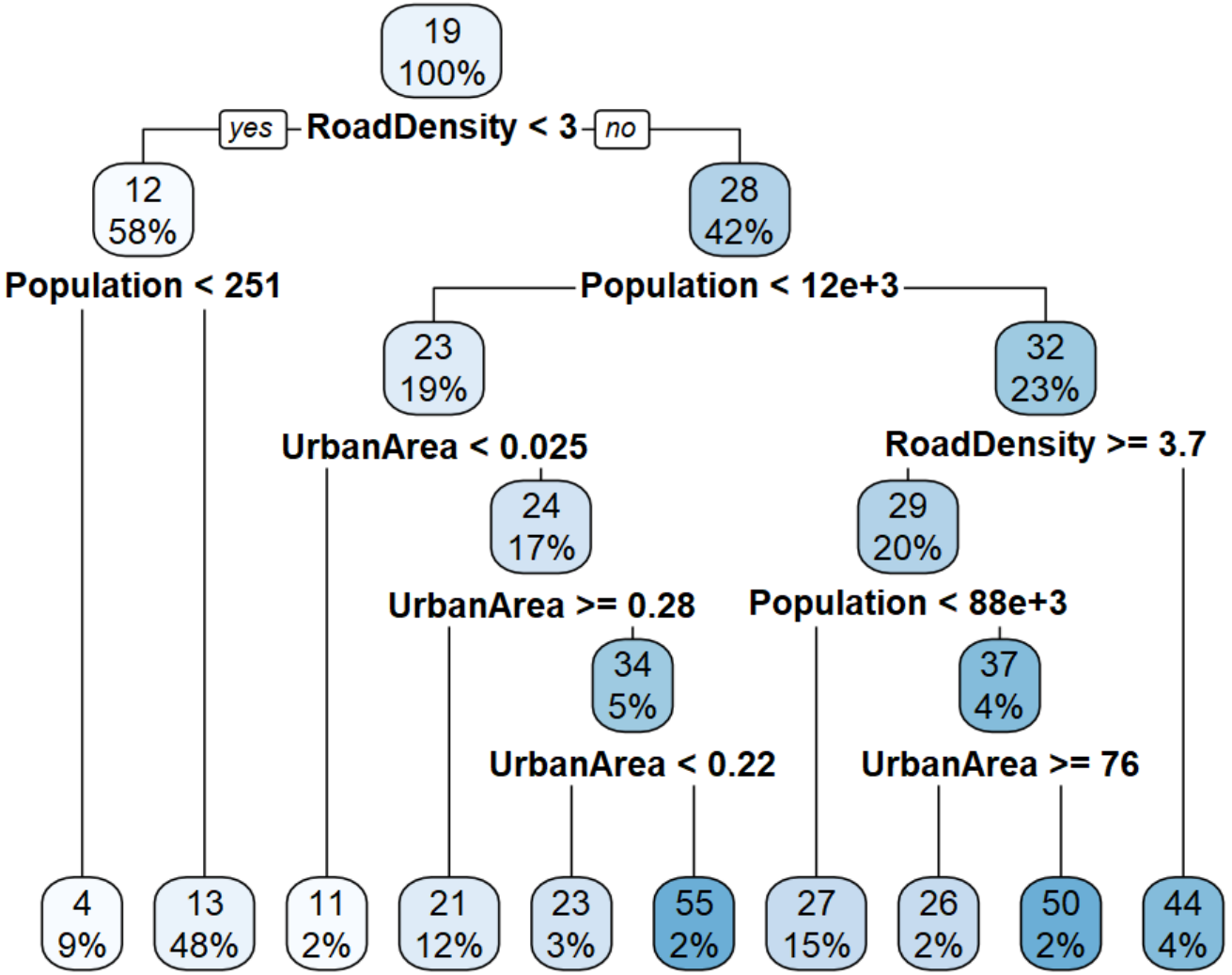


Results of CART Analyses

- Increasing chloride concentration averages seem to generally correspond with increase in road density and population
  - Urban area not incorporated in final tree
- Far-right split may indicate further investigation of other explanatory variables to include in predicting chloride concentrations in sub-watersheds



Greater number of splits (more complicated)



DRBC Next Steps

- Further SPW sub-watershed assessment:
  - forested area
  - agricultural land area
  - point-discharge volume per sub-watershed
  - precipitation (use percentile flows to analyze seasonal effects)
- Deploy continuous conductivity loggers in SPW tributary sites/BCPs for year-round data collection with concurrent sample collection for chloride

For WQAC Group:

- Looking for suggestions for potential explanatory variables to include in CART analysis of SPW sub-watershed sites to help predict chloride concentration
- Reminder that the SPW dataset exists
  - Interested in filling spatial and temporal data gaps within this area
  - Suggestions for monitoring data to utilize/other data not uploaded to WQP?
- What other types of analyses, monitoring programs, and/or plans are occurring or being initiated in regard to the growing chloride concern?

Potential Future Action to Mitigate Chloride

- Municipality & DOT improvement plans regarding road salt application
- Continued topic of water quality committees
- Alternatives to chloride-based deicers
- Site visits and strict BMPs implemented at salt storage facilities
- Other suggestions?

Thank you!

- About SPW Program with links to reports:
  - https://www.nj.gov/drbc/programs/quality/spw.html
- SPW Data Explorer
  - https://elainepanuccio.shinyapps.io/specialprotectionwatersexplorer/

- Please contact Elaine Panuccio with any questions, comments, and/or concerns at Elaine.Panuccio@drbc.gov