

Salty Water Trend and Sources of Salt in the Delaware River

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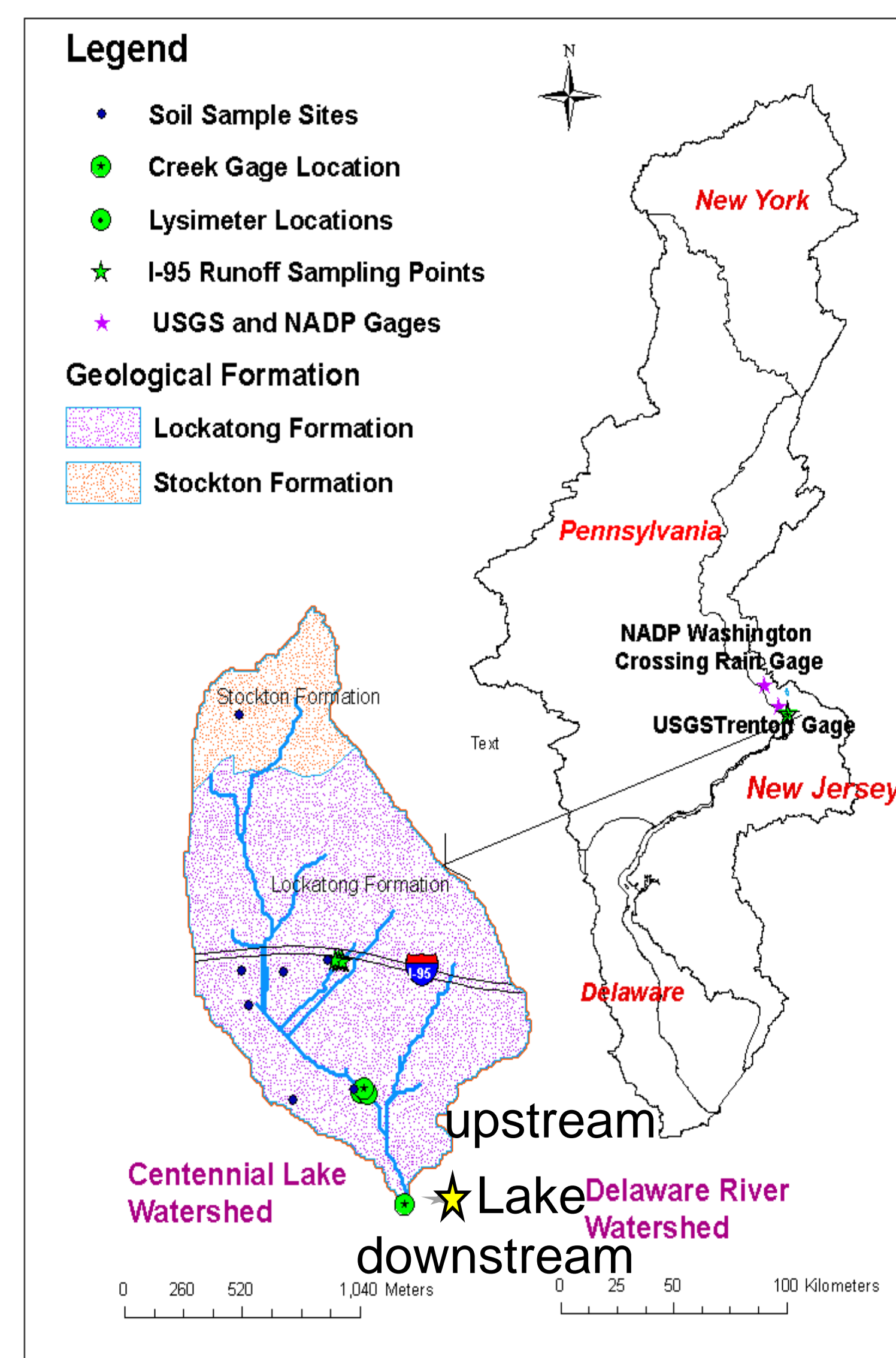
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Abstract

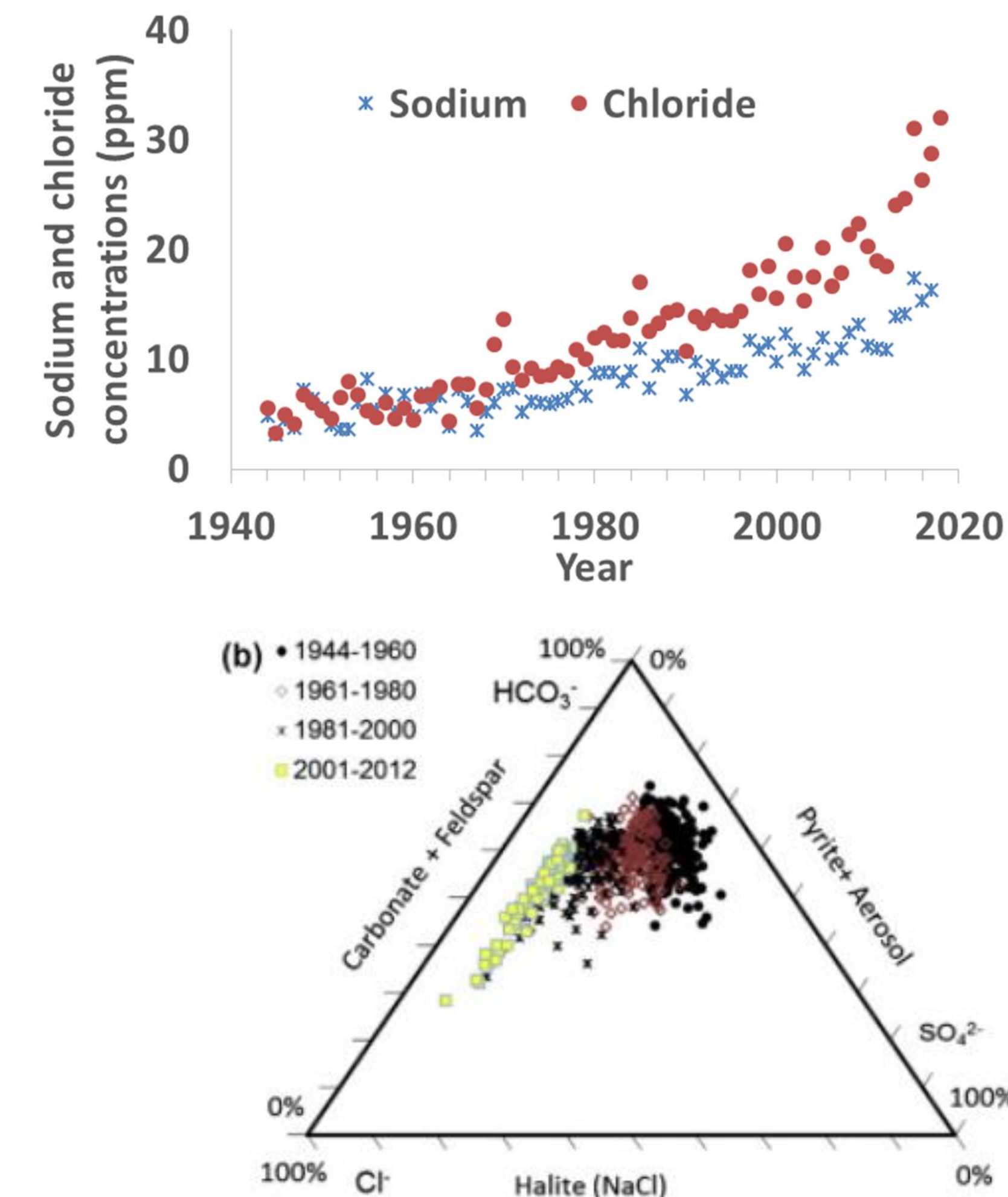
There were 13 recorded periods when sodium concentrations were above the 20 mg/l in drinking water recommended by US EPA and American Heart Association between 2009 and 2018 for the Delaware River at USGS Trenton gage station. If the current rising trend continues, the projection here is that by approximately year 2050 (or sooner), annual average sodium concentration in the Delaware River at Trenton station will reach this benchmark of 20 mg/l level. Among the five sources of sodium chloride (winter deicing road salt, weathering of rocks, agricultural fertilizer, sewage treatment plants and precipitation) deicing road salt contributes to about 2/3 of the total salt loading and the continuing increase in the Delaware River. Annual retention of sodium from the deicing salt is about 30 to 40% (or more depending on the annual precipitation) in the Delaware River based on past studies.

Locations of current and past sampling sites for salt studies

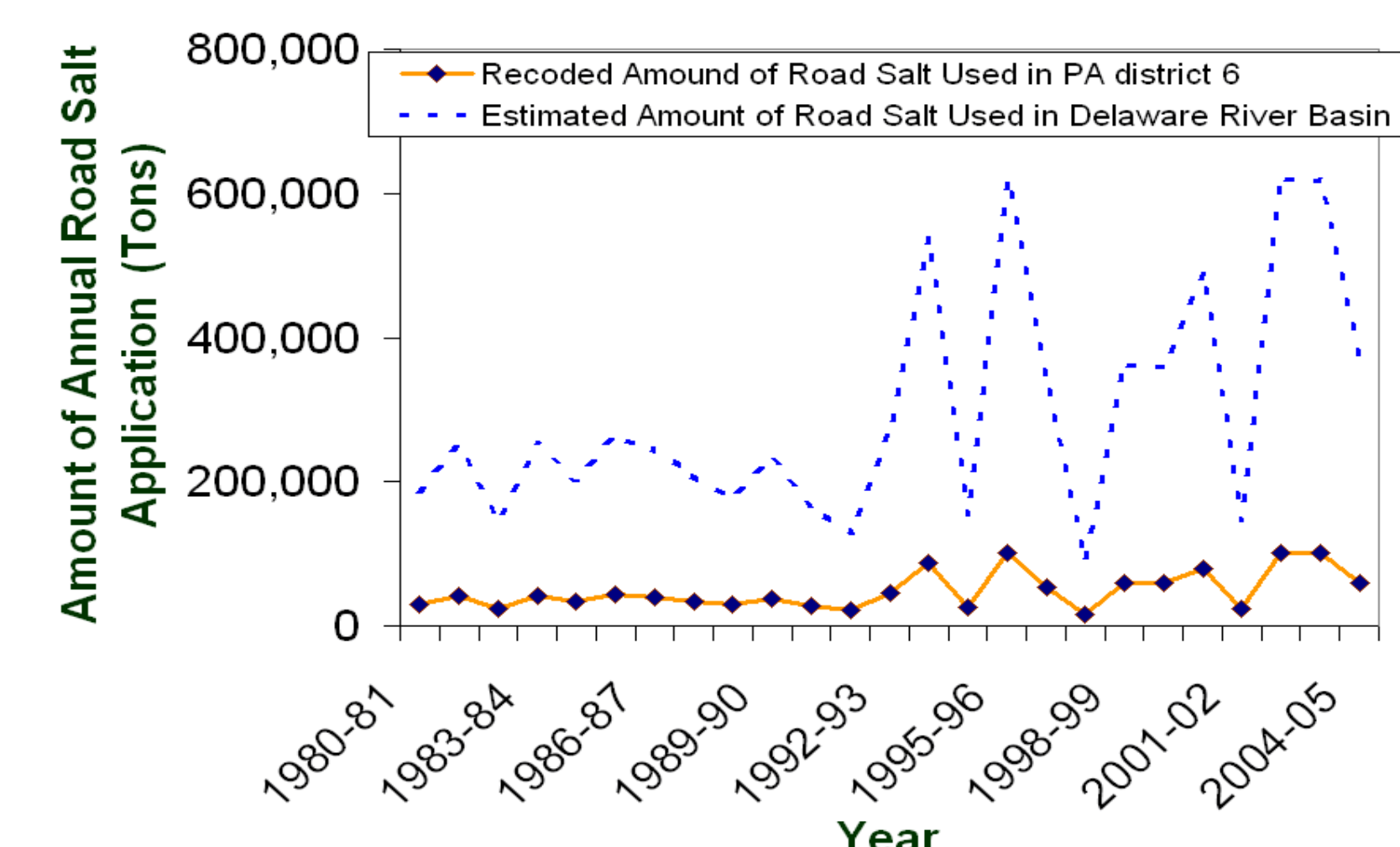


1. Trend of salt level in Delaware River Watershed

1) Average annual sodium and chloride concentrations in the Delaware River at Trenton
Na increased 4.5 times, chloride increased 7.6 times between 1945 and 2018

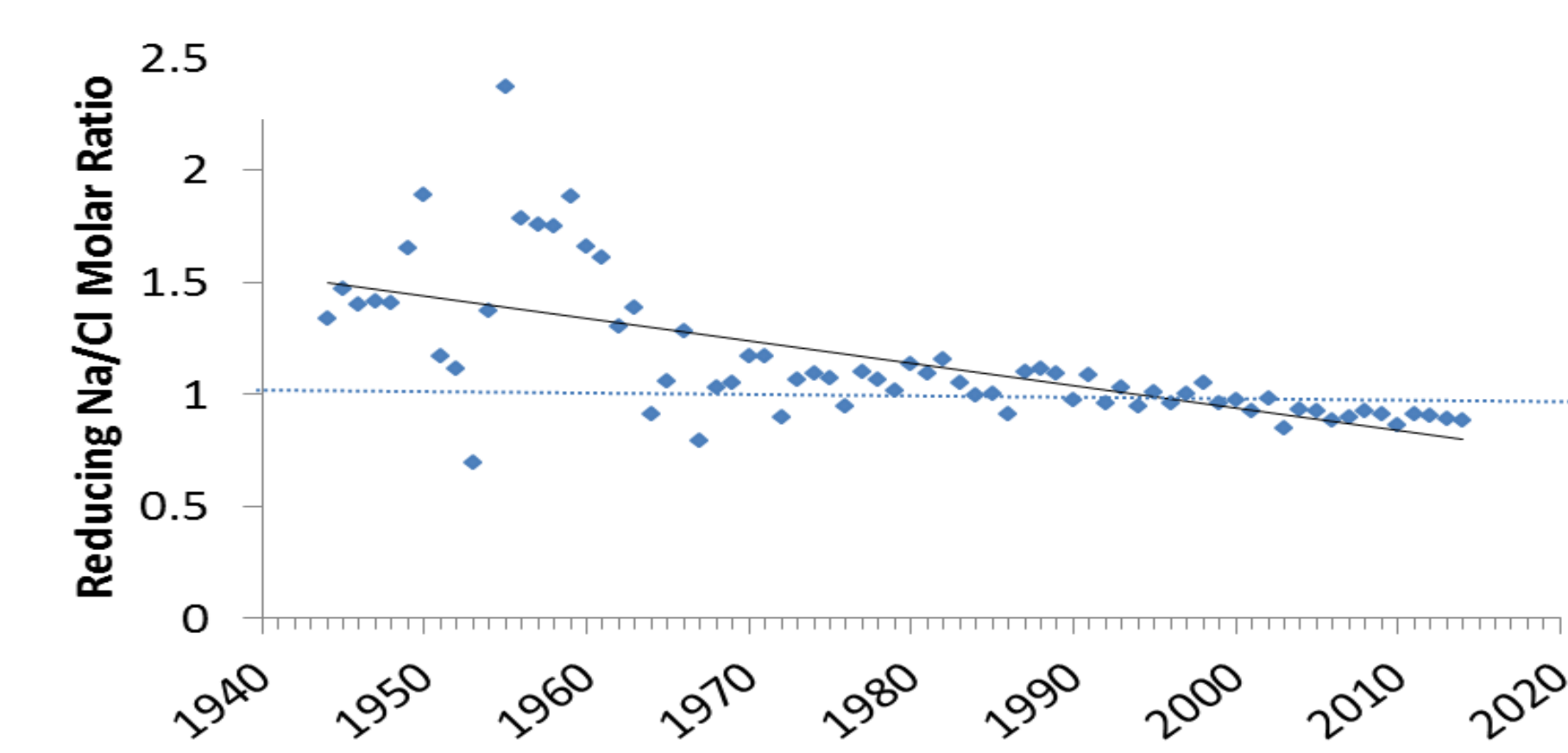


2) Amount of the deicing salt application in the Delaware River Watershed (DRW)



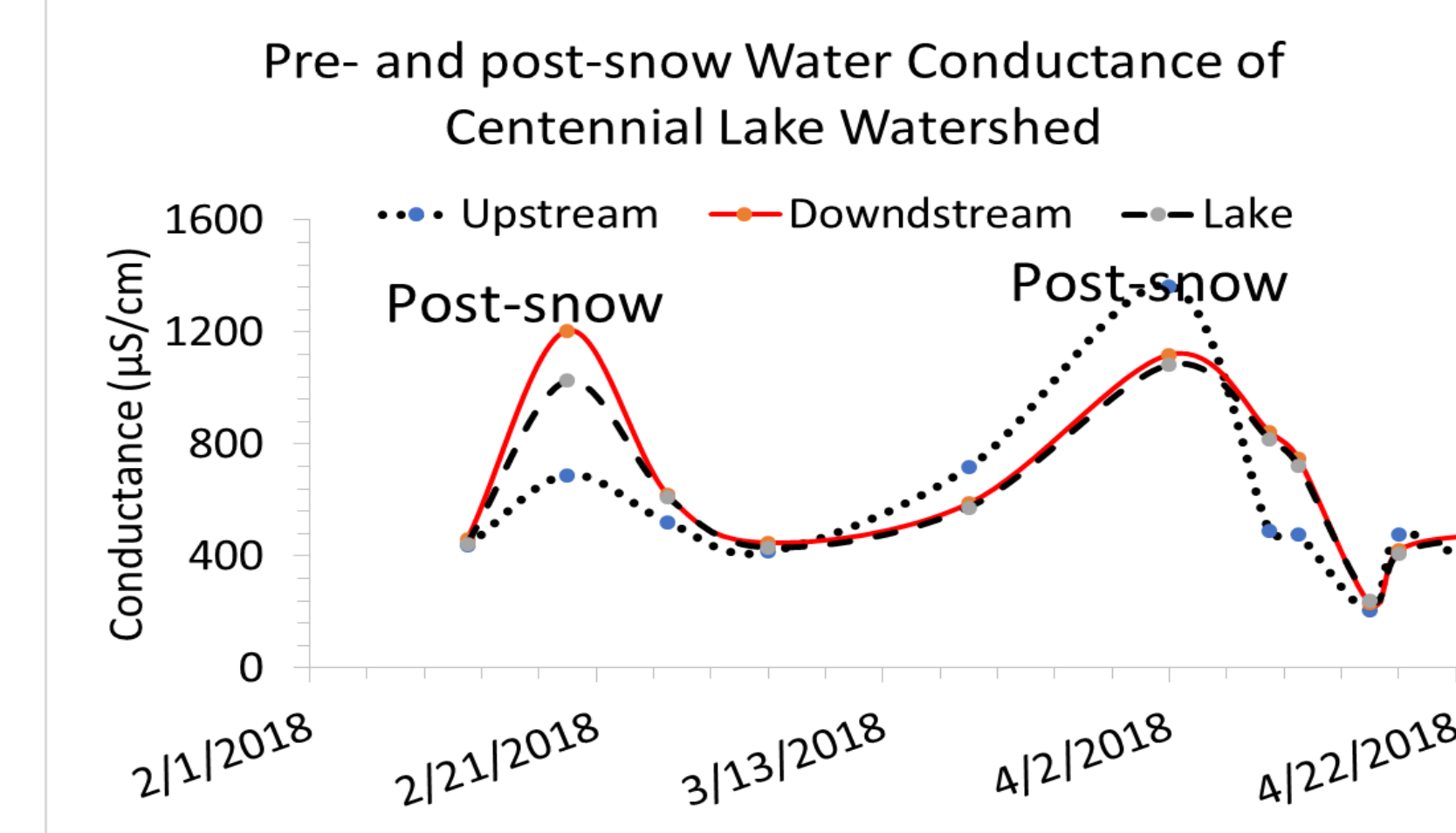
3) Reduced Na/Cl Molar Ratios in DRW and changed trend

Na used to come from weathering of albite and other salt minerals, now it is mainly from the road salt with a molar ratio of Na/Cl=1. Because Na is adsorbed more onto the soil particles by cation exchange than chloride, Na/Cl molar ratio declines when the proportion of sodium from natural supply declines. (data from Sun et al. 2012).

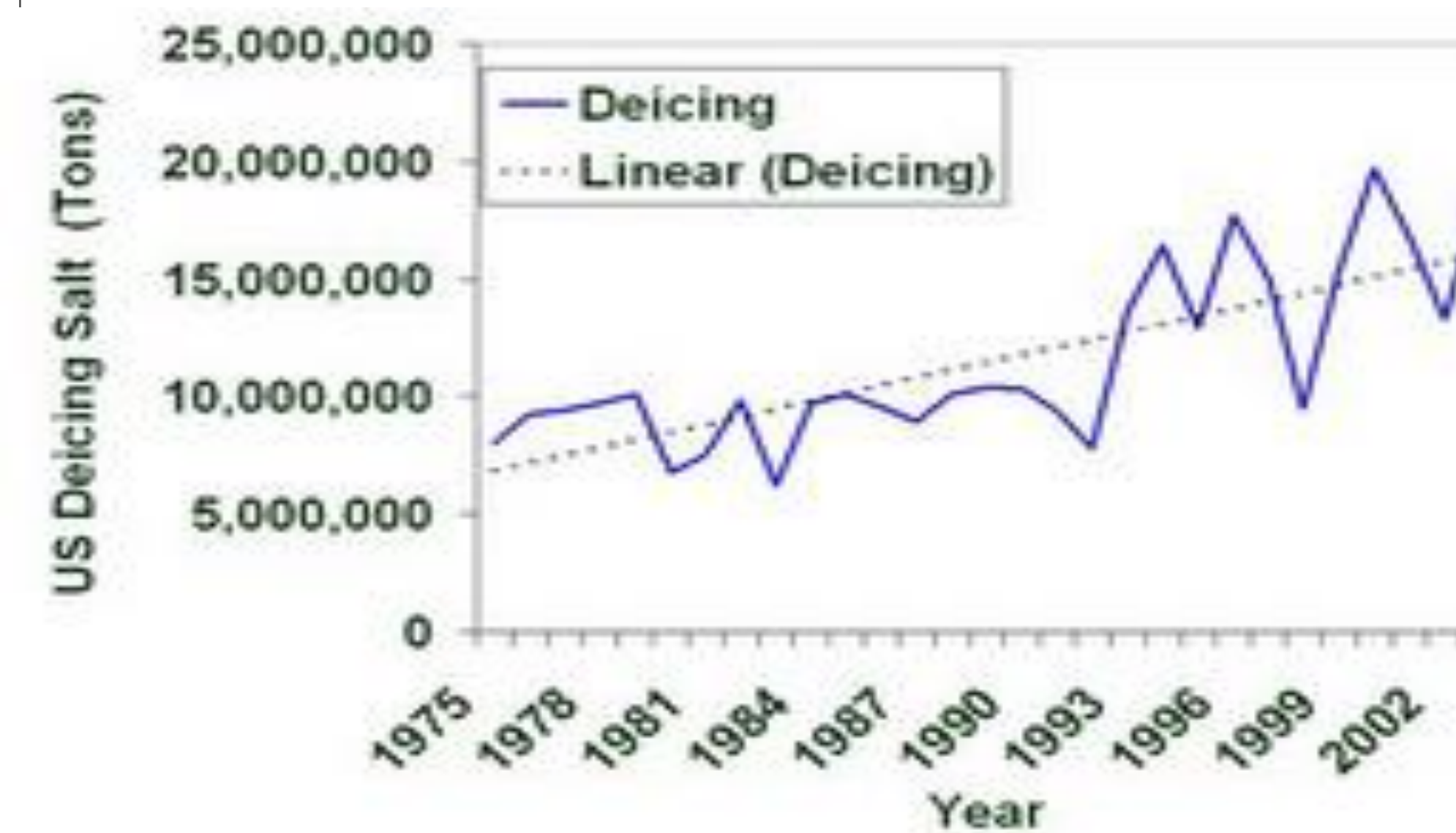


2. Salt sources of Delaware River watershed

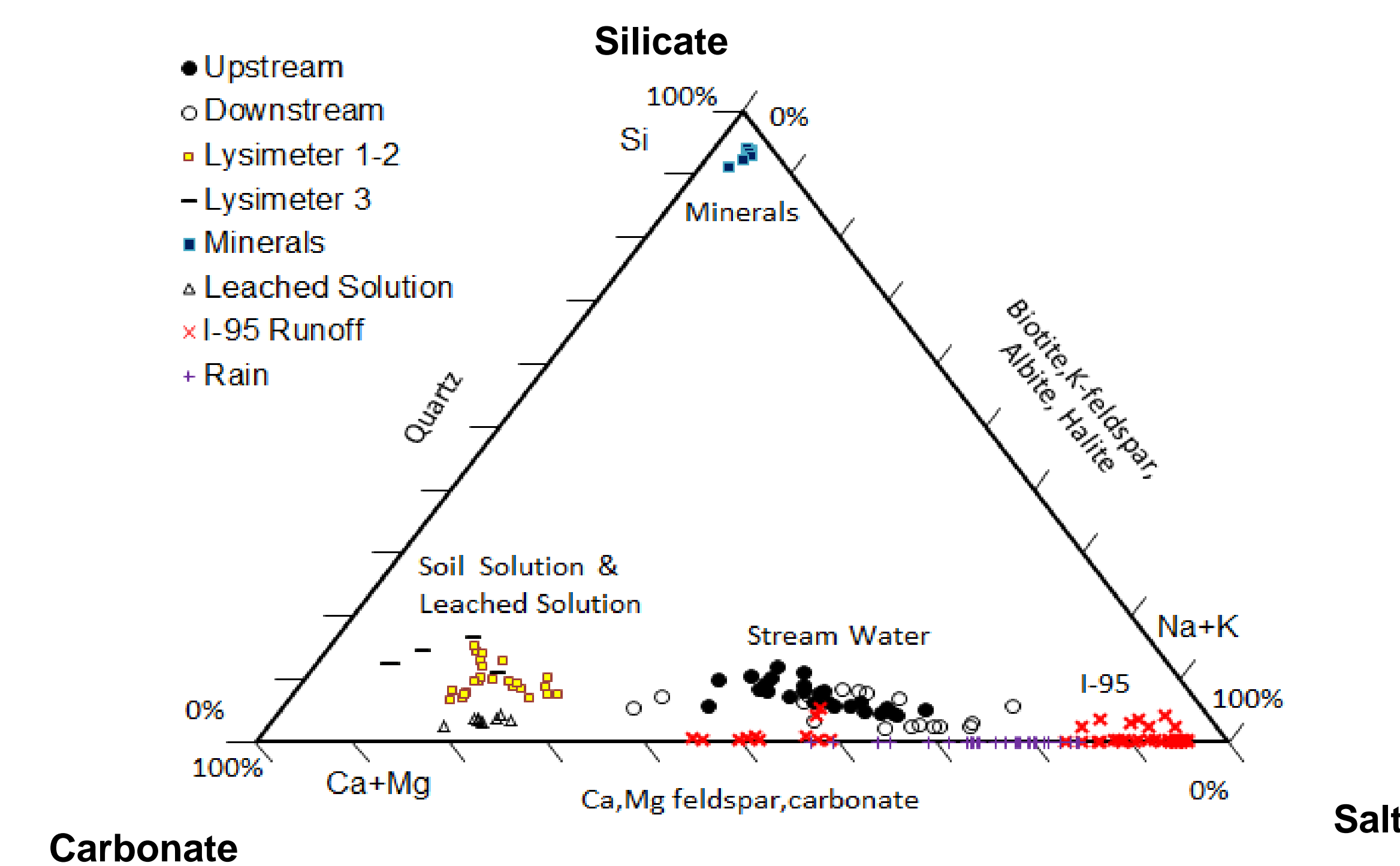
1). Road salt ---75% Centennial Lake Watershed
Water Data collected from 2/2/2018-4/25/2018. Increases of downstream salt is from Rider. Increase of upstream salt is mainly from highway I-95 runoff.



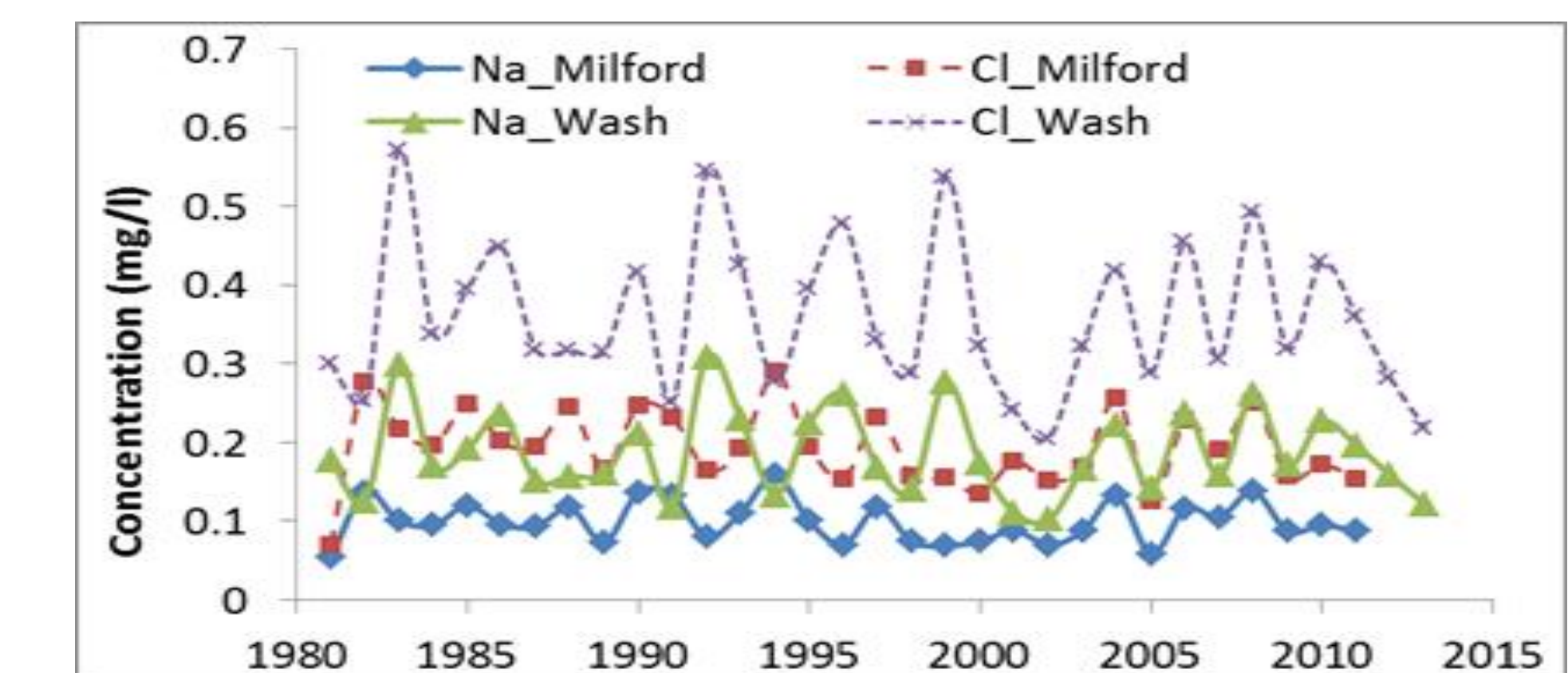
US Deicing Salt Application



Ternary diagrams of major cation and anion concentrations (mmol/l) for CWL stream and Soil Solutions.



2). Rain 2-3%. No increase for sodium and chloride concentrations in the precipitation at two stations in the DRW.



3). Weathering and others (water softeners, agricultural etc. ---20-22%)

Normalized 10-year average annual concentrations and regression trends of major ions, in the Delaware River at Trenton, NJ station, Units: Kg/hectare/year

	Na ⁺	HCO ₃ ⁻	SO ₄ ²⁻	Cl ⁻
1944-1950	31.5	245.7	149.3	31.7
1961-1970	25.7	166.8	107.3	35.8
1981-1990	50.8	125.6	125.6	75.1
2001-2011	84.8	366.7	108.1	143.1

Regression of Ion Concentrations between 1944 and 2012. For SO₄²⁻, between 1980-2012

Regress t-test	25.6	6.2	-12.6	34.3
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Data # used: 693, 536, 231, 694

Average Annual Ion Precipitation as Percentage of Delaware River Ion Discharge at Trenton				
2001-2010	2.0%	---	16.2%	2.3%

*Regression t-test: Any t value >1.97 or <-1.97 indicates a significant trend with 95% confidence.

Deicing Salt Choice: Sodium or Calcium Chloride?

Sodium Chloride (also halite, NaCl) Cost: \$7 to \$10 per 50lbs. Melt down to 5°F Less eco-friendly	Calcium Chloride (CaCl ₂). Cost: \$20 to \$25 per 50lbs Melt down to -25°F More eco-friendly
EPA recommended sodium level in drinking water: 20 mg/l.	EPA recommended calcium level in drinking water: none(?)
Our vote goes to calcium chloride for now.	

Conclusions

By year 2050, average annual Na concentration in the Delaware River at Trenton will reach the 20 mg/l EPA and AHA recommended limit. By the end of the century, the average annual Na concentration will be 24.2 mg/l.

At the intake points of Philadelphia Water Department, it will reach this 20 mg/l benchmark sooner than at the Trenton gauging station. Between now and 2050, there will be more periods in January and February in which sodium concentrations will be above 20 mg/l.