Salt Management

An overview of sources, fate/transport and impacts

For EAC ♦ By Zach Neal

March 16, 2022

Salt isn't regulated. Why's it important?

- There are many types of salts. The best known is halite, or sodium chloride ($NaCl$). Other well-known salts include magnesium chloride ($MgCl_2$) and calcium chloride ($CaCl_2$).
  - Dissociation (separation when dissolving in water) splits the cation (e.g., sodium) from the anion (chloride). Chloride is a conservative ion in the environment; it does not break down or sorb to soil/rock and is difficult to remove from water.
- Human Health – Those on low sodium diets may be affected by drinking water with elevated concentrations. Chloride also gives water a salty taste over 250 mg/L.
- Infrastructure and Transportation – Elevated chloride concentrations can corrode plumbing and appliances. It's corrosive nature also decreases the lifespan of roadways, bridges and walkways, and damages vehicles, etc.
- Environment – Elevated salt concentrations in waterways can decrease biodiversity, stunt growth, interfere with osmoregulation, and/or kill flora and fauna, though some of these impacts are associated with other factors related to urbanization (not just salt).

Where's all this salt coming from?

- Natural Sources:
  - There are not any naturally occurring salt deposits or basin brines in Carroll County, MD
  - Naturally occurring sources are predominantly limited to atmospheric deposition and chemical weathering of soil and rock. These sources generally contribute very low concentrations of sodium and chloride to water.

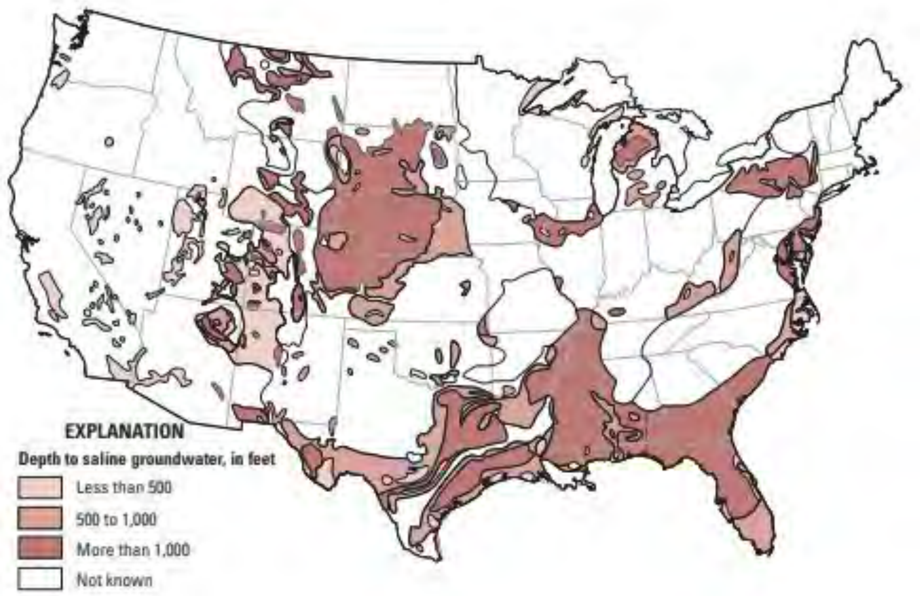
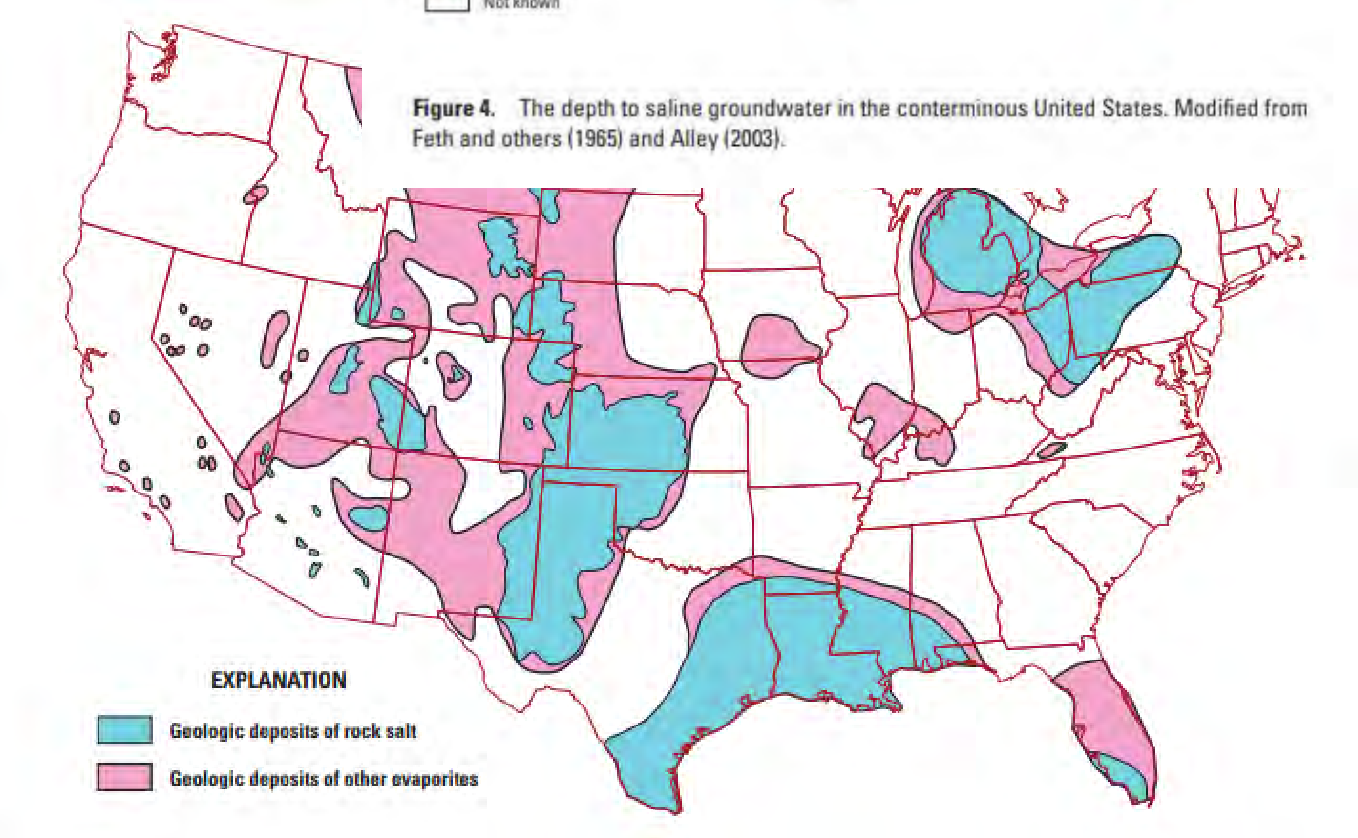


Figure 4. The depth to saline groundwater in the conterminous United States. Modified from Feth and others (1965) and Alley (2003).



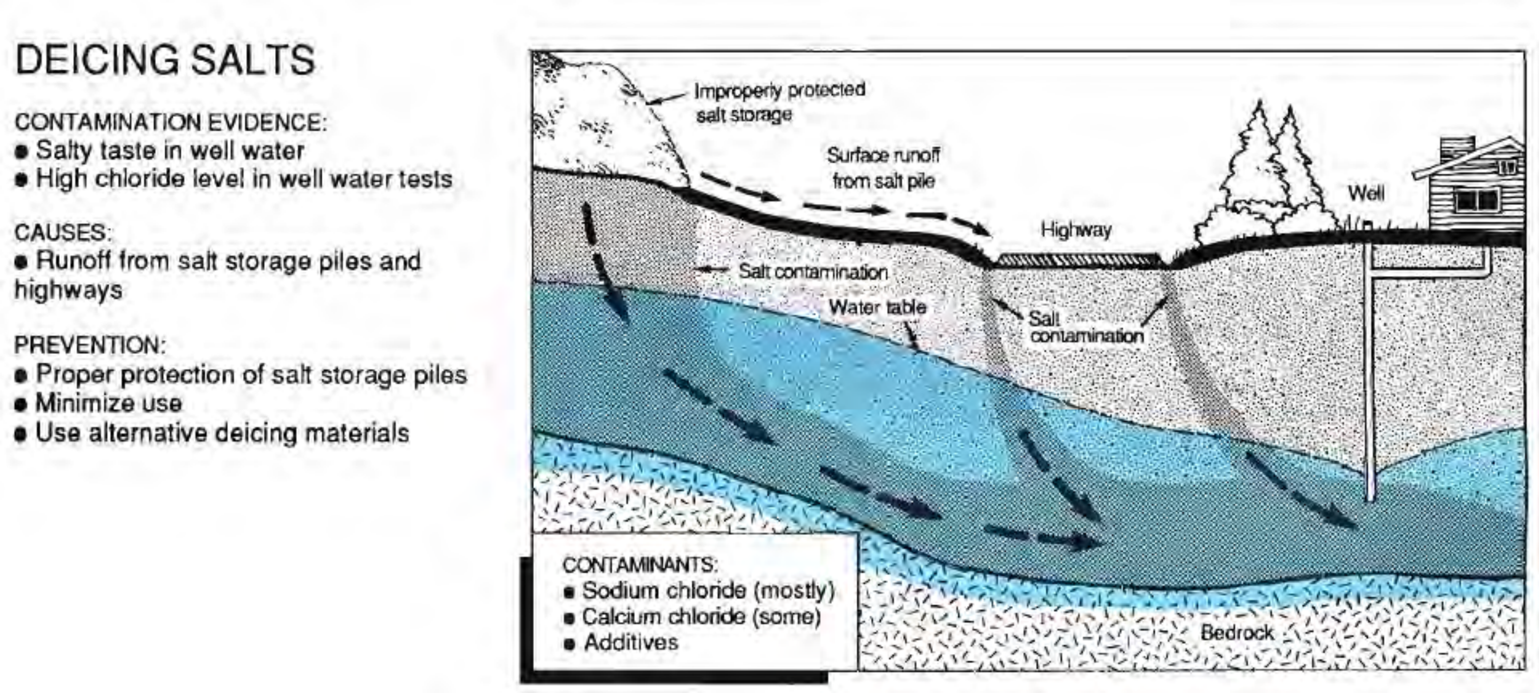
Anthropogenic Sources

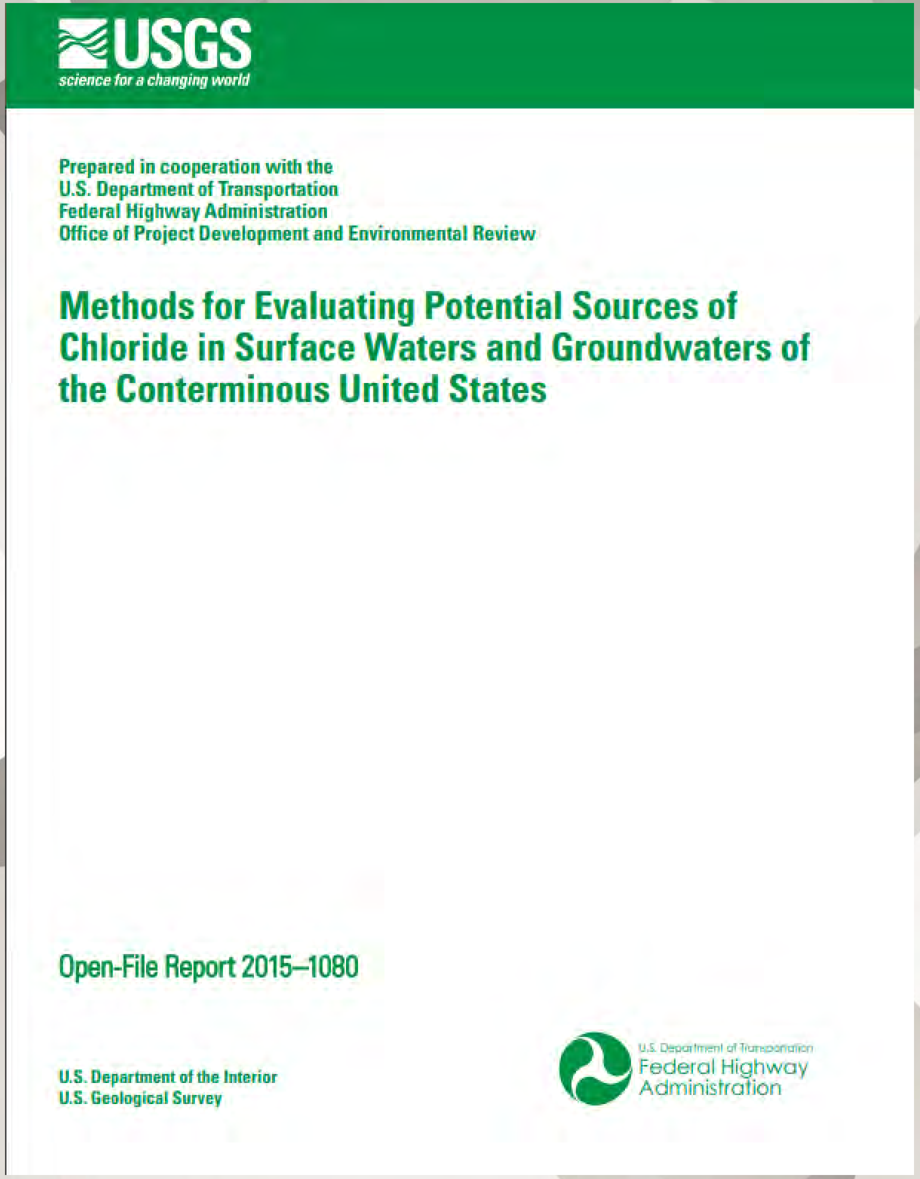
- Most salt in Carroll County is associated with man's activities.
- While many people tend to focus on "road salt" (a bit of a misnomer), there are many additional sources that contribute to overall chloride loads, including:
  - De-icing salts; the better representative term (highways, roads, parking lots, driveways, walkways)
  - Water treatment (water softening systems, disinfection)
  - Wastewater (from human diet, industrial processes, consumer products, disinfection, etc.)
  - Landfills (food wastes and consumer products)
  - Agriculture (animal waste and fertilizer)
- While these likely constitute many of the most frequent sources in the County, their method of introduction and control, along with hydrogeology, all influence fate, transport and potential impact.

Fate and Transport

- For groundwater:
  - Introduction via infiltration and percolation of salt-impacted water.
    - May originate from agricultural lands, run-off from impervious surfaces that infiltrates before reaching streams, septic disposal systems, leaky sewer lines, landfills and stormwater infrastructure that promotes infiltration
  - Receptors include domestic supply wells, municipal water wells and eventually streams (baseflow)
    - Much of the water in streams is sustained baseflow (groundwater discharge). As sodium and chloride concentrations increase in groundwater, they'll similarly increase in streams, especially during low flow.
  - Groundwater moves slower, and concentrations will have a lagged/sustained effect
  - Introduction via infiltration also allows for multiple overlapping sources along GW flow paths

- For streams:
  - Overland flow will directly contribute chloride near the land surface into waterways
  - Chloride may be directly discharged to streams via wastewater treatment plants that don't utilize spray irrigation.
  - Potential direct introduction at stream crossings, etc.




USGS
science for a changing world

Prepared in cooperation with the
U.S. Department of Transportation
Federal Highway Administration
Office of Project Development and Environmental Review

Methods for Evaluating Potential Sources of Chloride in Surface Waters and Groundwaters of the Conterminous United States

Open-File Report 2015–1080

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of Transportation
Federal Highway Administration

What do the data & studies say?

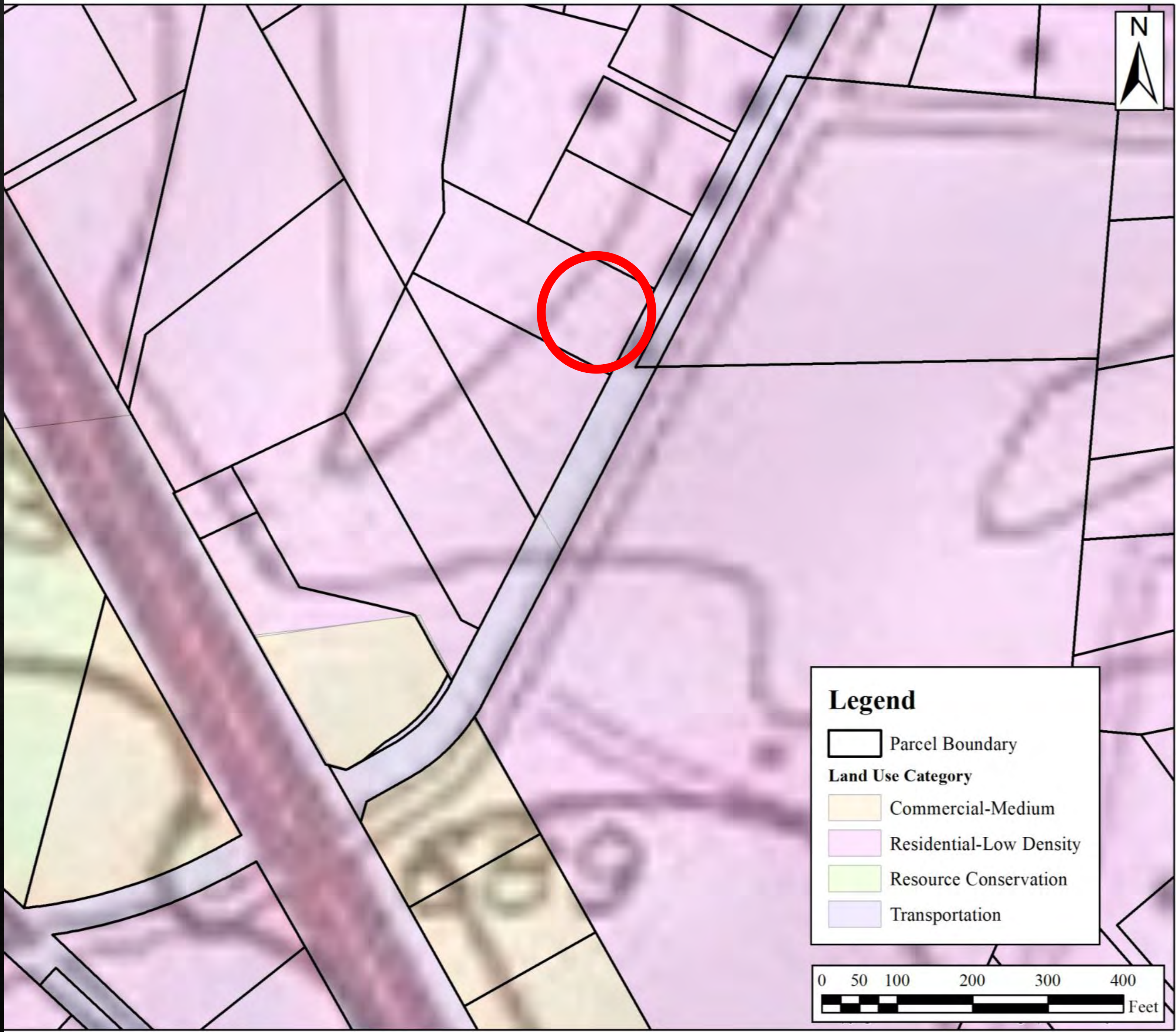
- Unfortunately, we don’t possess a robust sodium or chloride monitoring dataset across the County. Our knowledge comes from required monitoring, municipal and site-specific or project-specific testing and monitoring
  - Domestic well elevated chloride investigations
  - Municipal and other testing/monitoring
  - External studies
- Granato Et al. (OFR 2015-1080) indicate that anthropogenic chloride concentrations are rising even in southern states where deicing is minimal
  - Nationwide, only about 30% of salt consumed and released to environment is for deicing
  - Concentrations strongly correlated to imperviousness, road density and population density.

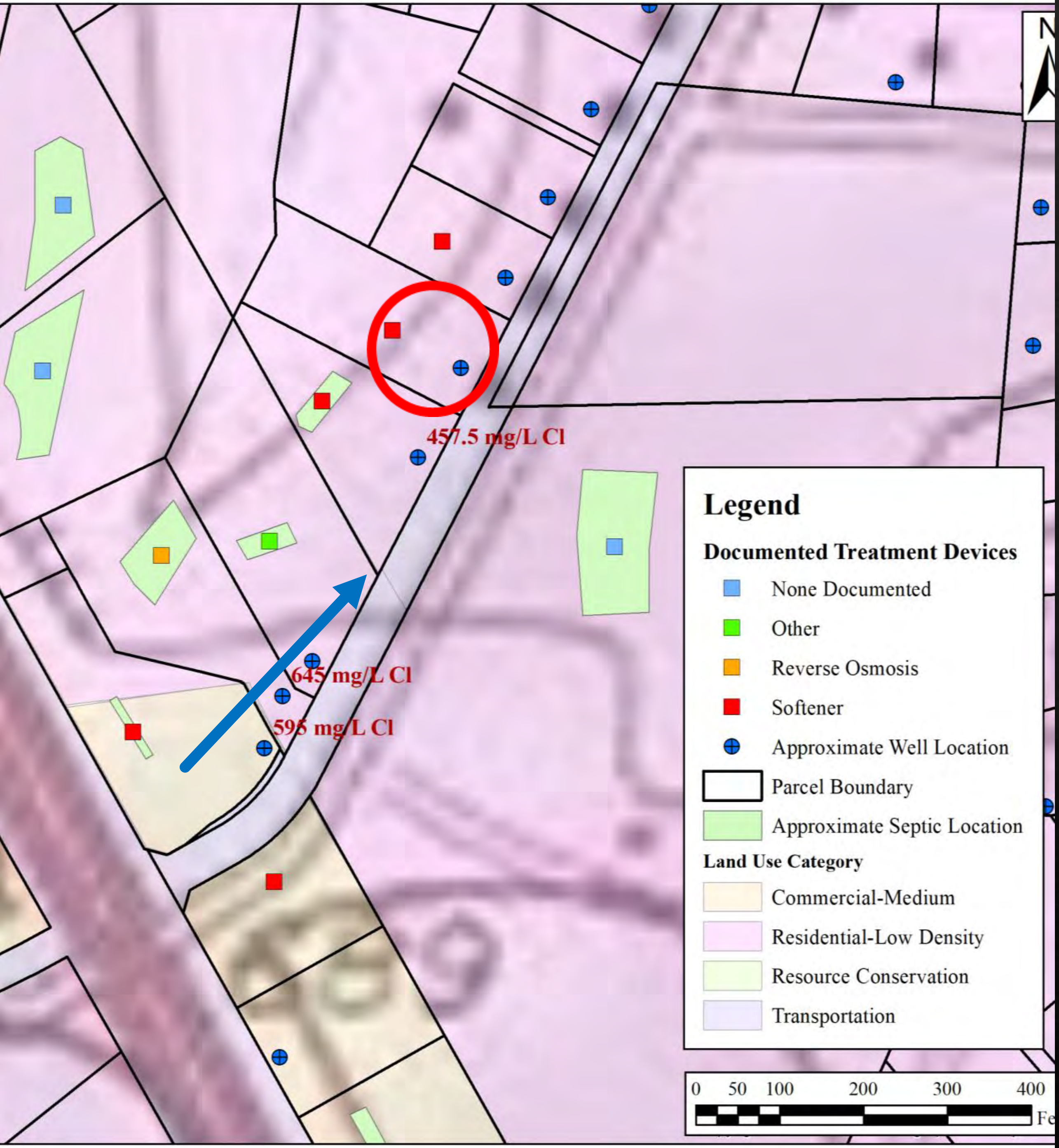
So, where and when do we see salt impacts?

- Given the numerous methods of introduction and fate/transport pathways, answers to that question are largely dependent on spatial and temporal scales of analyses.
- For streams, generally a long-term increase under baseflow conditions, especially in areas with increased urbanization. Stormflow can often dilute chloride concentrations, except during early impervious salt purge during storms (early rising limb on hydrographs)
- For groundwater, heavily dependent on proximity of receptor to sources
  - Groundwater serves as baseflow in streams, and we touched on that receptor above
  - Wells in proximity to and downgradient from vectors that serve as point sources of chloride can be significantly impaired.

Let's look at a brief example from an elevated chloride investigation here in the County

- Water treatment company serving a new homeowner at the location circled in red identified elevated chloride and sodium concentrations in on-site domestic supply well.
  - Treatment company suggested chloride attributable to County roadway de-icing practices
- October 2021 sampling by treatment company showed:
  - Chloride = 460 mg/L
  - Sodium = 55.7 mg/L (low relative to chloride concentration)
- County completed preliminary hydrogeologic investigation, which entails site visit and interview, compilation and review of hydrogeologic information, chloride source inventorying, and other available data.
  - Potential sources included state highway, County roadway, septic (w/softener discharge), commercial parking lots, residential de-icers.





What did we find?

- Commercial facility at intersection had monitoring wells on-site with documented groundwater flow direction to NE (nearly parallel County roadway)
- Past chloride data had been collected between commercial facility and homeowner from October 2021 inquiry. Elevated chloride concentrations identified in all sampled wells between the two.
- Commercial facility had an advanced water treatment system, including acid neutralizer, water softener, reverse osmosis, etc.
- Additional sampling at homeowners well identified other constituents associated with water treatment devices, including significantly elevated calcium and magnesium concentrations (acid neutralization) which were17-19 times higher than background concentrations in aquifer
- Takeaway: Point source water softener discharge likely culprit that created localized, impactful chloride plume.

Resources this group may find interesting/useful

USGS Open-File Report 2015-1080:

Methods for Evaluating Potential Chloride Sources in Surface Water and Groundwaters of the Conterminous United States

(Granato Et al., 2015)

https://pubs.usgs.gov/of/2015/1080/ofr20151080.pdf

USGS Scientific Investigations Report 2009-5086:

Chloride in Groundwater and Surface Water in Areas Underlain by the Glacial Aquifer System, Northern United States

(Mullaney Et al., 2009)

https://pubs.usgs.gov/sir/2009/5086/pdf/sir2009-5086.pdf