# There's Something in the Water: An Analysis of of the Chemical Composition of the Sagamore, Killbuck Creek, and Upper Floridan Aquifer

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## Abstract

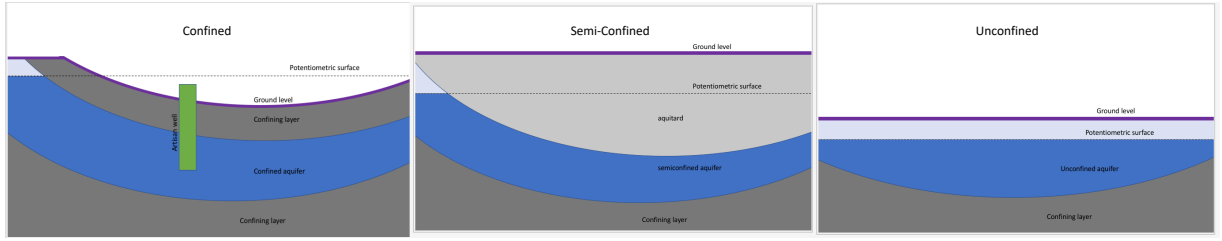
Aquifers are commonly used as sources of fresh water but are very susceptible to contamination. In order to track contamination, the chemical composition of an aquifer should be known. This research aims to supply background chemical compositions of three distinct aquifers, the Upper Floridan aquifer, the Sagamore aquifer, and the Killbuck Creek aquifer. The chemicals considered for this research are magnesium (Mg), sodium (Na), and sulfate ions ($SO_4$) which are compared against calcium (Ca). This research has found trends within the individual aquifers and distinctions when compared against each other. The Upper Floridan aquifer is located on the southeastern coast of the United States and is part of the larger Floridan aquifer system. It is uniquely large and has a combined structure of confined and unconfined, leading to varied levels for risk of contamination. Within this aquifer, the chemicals, Mg, Na, and $SO_4$, show a negative trend when compared with Ca. The Sagamore aquifer is located on the southeast coast of Massachusetts. Overall, chemical compositions of this aquifer are in higher concentrations near and in kettle ponds than in areas that are farther away from these features and has an overall positive trend. The Killbuck Creek aquifer is a buried valley aquifer located in northeast Ohio. This aquifer has no connections with any other groundwater, although it has connections with some surface water streams and rivers. Within this aquifer, the chemicals, Mg, Na, and $SO_4$, show a positive linear trend when compared with Ca. When aquifer chemicals are compiled together, the kettle ponds found within the Sagamore aquifer contain chemical concentrations that are distinctly grouped and separate from the concentrations found in other aquifers. The Upper Floridan aquifer has concentrations that are more random than the Killbuck Creek aquifer, allowing it to have concentrations that are both greater and less than those found within the Upper Floridan aquifer.


## Purpose

There has been significant contamination off military bases. One chemical causing contamination is per- and polyfluoroalkyl substances (PFAS). The Department of Defense is now investing in resources to help decontaminate aquifers. This study will be used to assist chemists in the creation of a sensor that will be able to sense where PFAS. Having an understanding of what chemicals are expected within aquifers will allow for the sensor to be tested against real world chemical compositions.

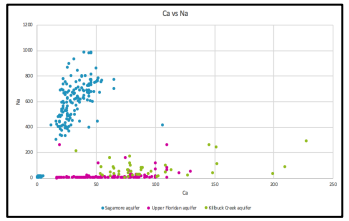
## What is an Aquifer?

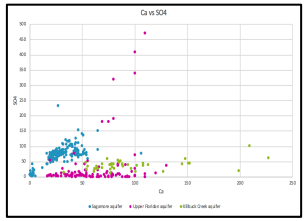
An aquifer is a formation, group of formations, or part of a formation that contains sufficient saturated, permeable material to yield significant quantities of water to wells and springs (USGS 2021). There are three main types; confined, semi-confined, and unconfined.

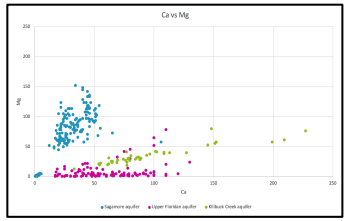



## Aquifer Chemistry and Analysis

The grouping of Sagamore's kettle ponds are presented in groupings that have higher concentrations of Na, $SO_4$, and Mg, than other aquifers. Killbuck Creek aquifer has the highest levels of Ca. The Upper Floridan aquifer reports contain the lowest concentration of Na, Mg, and $SO_4$ as well as the highest concentrations of $SO_4$. Killbuck Creek aquifer has the highest concentrations of Ca and Mg. The Sagamore aquifer has the highest concentrations of Na and the lowest concentrations of Ca.




| | Min (mg/L) | Max (mg/L) |
|---|---|---|
| Na | 1.4 | 989 |
| Mg | 0.5 | 381 |
| $SO_4$ | 0.1 | 1400 |
| Ca | 0.36 | 499 |

*Data from Eckstein (2011), Portnoy et al (2001), Bau et al. (2004), and Swancar and Hutchinson (1995).*

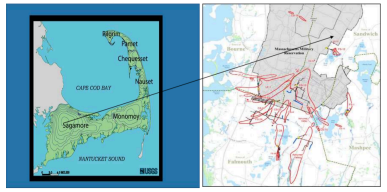
## PFAS

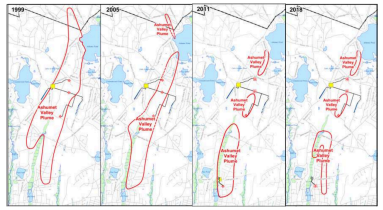
Per- and polyfluoroalkyl substances (PFAS) are used by the military in firefighting foams. When applied to the ground they are able to infiltrate into unconfined aquifers. At this point it is unknown exactly what PFAS does to organisms that consume it. PFAS is not only found in firefighting foams, it is also found within food packaging, commercial household products, workplaces such as facilities and industries, and within living organisms where PFAS is able to build up over time (EPA 2021).

## PFAS Within the Sagamore Aquifer

The groundwater mound of the Sagamore Lens is located under the northeast portion of Joint Base Cape Cod, a 22,000 acre military base located on Cape Cod, MA. Past military activities have contaminated the sole source drinking water aquifer with fuels, solvents, explosives, and PFAS. The Air Force Installation Restoration Program (IRP) began in 1984 to investigate and remediate the contamination. IRP source areas have been cleaned up and nine pump and treat systems were constructed to remediate the groundwater (Forbes 2021, personal communication).

The Ashumet Valley plume was caused by contamination from the former fire training area and the former sewage treatment plant. The legacy contaminants of concern, TCE and PCE, are mostly remediated; however, PFAS is now being investigated. The primary source of PFAS contamination was from the use of Aqueous Film Forming Foam (AFFF) in firefighter training activities. The PFAS plume extends from the source areas into Ashumet and Johns Ponds, which are kettle ponds, and downgradient into the Towns of Falmouth and Mashpee impacting drinking water supplies (Forbes 2021, personal communication).




Plume defined based on chlorinated solvents; PFOS/PFOA and DX detected above standards/health advisories

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