What's Up, (re)Dox? Hydrologic modeling of Arsenic contamination in Boca Raton, Florida

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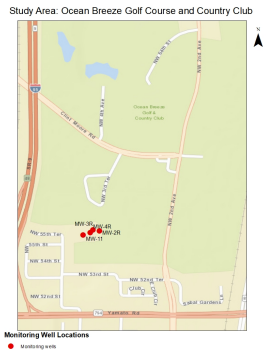
Abstract

Arsenic is a naturally-occurring metallic element that has been used by humans for thousands of years as a pesticide. It is the primary contaminant of concern at the Ocean Breeze Maintenance Area site, at the larger former Ocean Breeze Golf Club in Boca Raton, Florida. Initial sampling showed Arsenic in groundwater; however, though alleged, dumping by vandals was later shown to be unlikely based on the persistent, moderate concentrations and depth of impacted groundwater (8-12 feet below land surface), and without intervening soil impacts. Despite this, elevated concentrations of Arsenic have been detected in on-site monitor wells since 2011. Why did Arsenic concentrations increase after the onset of monitoring, despite the apparent absence of source material?



Methods

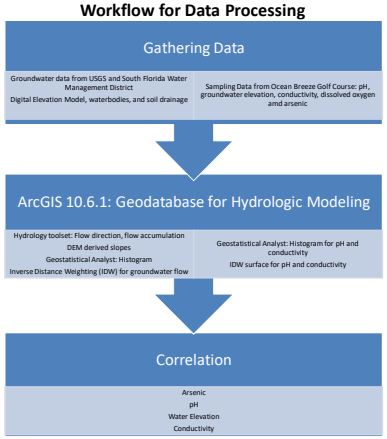
Based on previous research (Amini et al., 2008), we determined that there was a possibility of geogenic sources for the arsenic contamination at Ocean Breeze. Figure 1 below illustrates the likely characteristics for either reducing or high pH/oxidizing conditions. We decided to model these characteristics from data gathered from the monitoring wells at Ocean Breeze.

variable[a]	reducing	oxidizing
ET/P	<1	>1
drainage condition	imperfect to poor	imperfect to poor
hydrologic basin	deltas	closed
slope	flat	flat
organic carbon	high	
salinity	low	high
temperature	high	
pH		high
geology	young sediment	young sediment

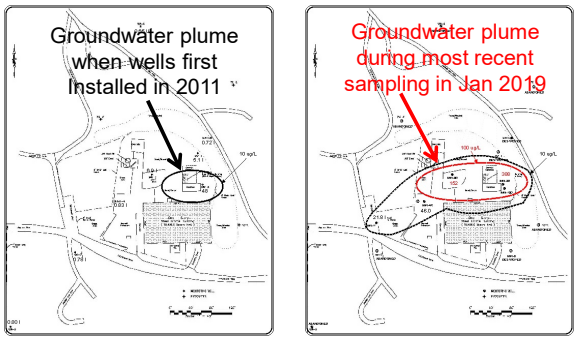
[a] ET = evaptranspiration, P = precipitation.

Figure 1 from Amini et al., 2008: Variables considered likely for geogenic arsenic contamination.

Workflow for Data Processing

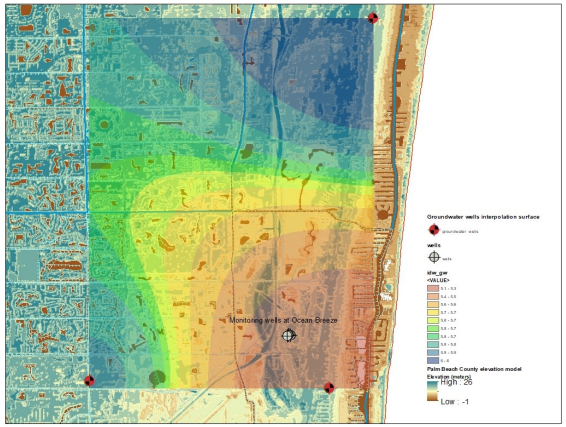


Results



Figures 2 and 3 (above): Site maps showing groundwater plume

Figure 4 (below): inverse distance weighted map of groundwater from monitor wells near study site



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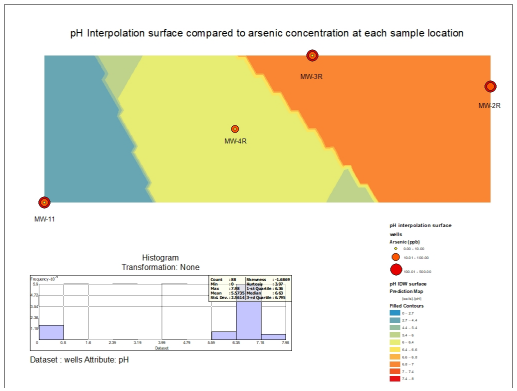
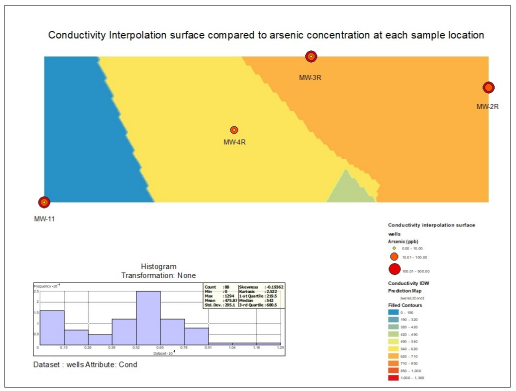
Information also derived from professional reports authored by D.S. Monty Watson for the Ocean Breeze Golf Club Maintenance Area site between 2011 and 2019.

Results





Discussion

Our results revealed a plume of Arsenic contaminated water in the direction of the natural groundwater flow, which is important as no upgradient source has been identified in another monitor well, or in surface water or sediment in a nearby pond. Flow Direction and Accumulation tools in ArcMap did not prove helpful to our analysis as our site is mostly flat, with elevations ranging from 5-7m above sea level, with little to no slope. This is actually consistent with conditions for a reducing or oxidizing environment.

When examining the nature of our data, it would appear that areas with the highest pH and the lowest water elevation have the highest arsenic concentration. We used a simple correlation between arsenic and water elevation and found that there is a moderately negative correlation between arsenic and water elevation, and a moderately positive correlation between pH and arsenic levels. However, more detailed statistics could not be determined given our small sample set.

This is an ongoing process of both sampling at the Ocean Breeze Golf Course and creating a hydrologic model for the site. This work represents only preliminary research into the task. We intend to continue to build our model to include more parameters as well as improve our statistical strength for our data set. Sampling and monitoring at this site has determined that contamination does not appear to be the result of golf course operations or illegal dumping. Further study is ongoing at this time, focusing on the potential for oxygenation of buried, native sediments to release the Arsenic observed in monitor well samples.