Tracing Contaminants in Cape Cod Drinking Water | A Vulnerability Analysis

Overview

Cape Cod is a peninsula in the southeast portion of Massachusetts. The sandy and highly permeable soils of the Barnstable aquifer make this popular vacation spot highly susceptible to groundwater contamination. Research suggests that a range of wastewater contaminants present even in minute concentrations in drinking water may have adverse health effects in both humans and wildlife (Swartz et al, 2006). Some pollutants have even been linked to certain cancers, including breast and lung cancer. Since the early 2000's, the incidence of breast cancer in multiple Cape Cod towns has been measured at rates at least 15% higher than the rest of Massachusetts, which suggests a possible relationship between decreases in drinking water quality and increases in cancer-related diseases (Silent Spring Institute, 2010).

This project aims to determine which areas of Cape Cod place its residents at the highest risk for contaminated drinking water. Specifically, 5 pollution sources associated with high amounts of wastewater were evaluated. These include proximity to hospitals, airports, unlined landfills, and roads, as well as the number of groundwater discharge permits in a given area. These discharge permits give a variety of small businesses authorization to release large amounts of effluent into groundwater systems.

Figure 1. Location of Cape Cod.

Methodology

To perform the vulnerability analysis, point data from hospital, airport, and unlined landfill locations were converted to raster data using the Euclidean distance tool. This process was also implemented with line data from road locations. These layers were then reclassified and ranked for their level of risk based on proximity to the source of pollution. The density of ground water discharge permits on Cape Cod was calculated using the Kernel density tool to convert point data to raster. This layer was also then reclassified and ranked for its level of risk.

After these 5 factors were analyzed, the raster calculator tool was used to perform a vulnerability analysis. Once an unweighted analysis was calculated, a new weighted analysis was created as well. This placed more emphasis on distance from unlined landfills and the density of ground water discharge permits, with distance from hospitals and distance from roads considered less important.

Figure 2. The acidic Barnstable aquifer is highly susceptible to groundwater contamination from several sources.

After the vulnerability analysis was performed, census data was reclassified and ranked. Regions with more than 3900 people were considered highly populated areas. Massachusetts
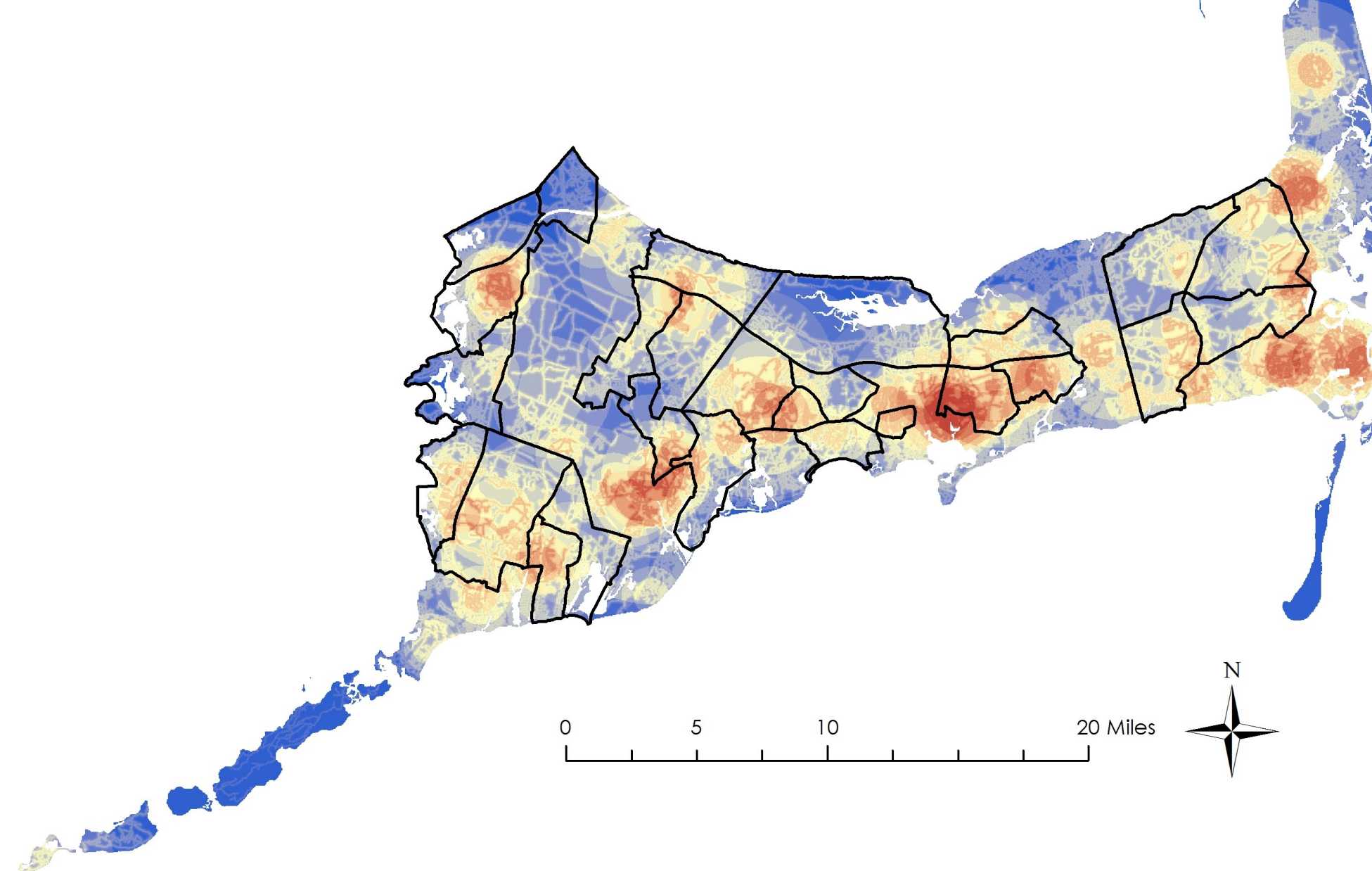
Vulnerability in Highly Populated Areas

Weighted Vulnerability
- High : 5 (Least Vulnerable)
- Low : 1.55 (Most Vulnerable)
- Highly Populated Areas

Cancer Registry statistics were manually added to a Cape Cod towns layer, mapped, reclassified, and ranked. Towns with more than 100 cases of breast cancer from 2005-2009 were considered areas with high incidences of breast cancer. For both population and cancer data, these overlay maps were displayed with the vulnerability analysis to show areas of overlap with high risk areas.

Results & Conclusions

As highlighted on the final maps, it appears that the areas most susceptible to groundwater contamination are all towards the ocean side of the peninsula, where there is typically more human activity. The spatial comparison between high risk areas and highly populated regions shows some overlap. Some highly populated areas exhibit a high risk for water pollution while some do not. The proximity of high risk areas to densely populated regions is something that researchers must take into account when designing new ways to decrease wastewater runoff and infiltration. Areas that have the highest risk and highest population should be considered more of a priority than those that do not.

The comparison between high risk areas and regions with high incidence rates of breast cancer also displays some similarities. There is a correlation between the two features in the towns of Yarmouth and Barnstable, two towns with some of the highest risk for contaminated groundwater, but there are no increased number of

Vulnerability and Breast Cancer Rates

Weighted Vulnerability
- High : 5 (Least Vulnerable)
- Low : 1.55 (Most Vulnerable)
- High Incidence of Breast Cancer

breast cancer cases in towns such as Mashpee and Chatham, where the model also predicted high risk for pollution.

However, the vulnerability model produced in this study was not an all-encompassing one. One limitation of this analysis was that it did not take into account individual household data. Home density could have been used to predict runoff rates of pharmaceuticals and personal care products. Future research on Cape Cod could look at the density of cranberry bogs and the potentially harmful effects of pesticide use at these farms. Future studies should perform analyses that take into account any and all sources that could contribute to groundwater pollution in order to protect the health of both the people and wildlife of Cape Cod.
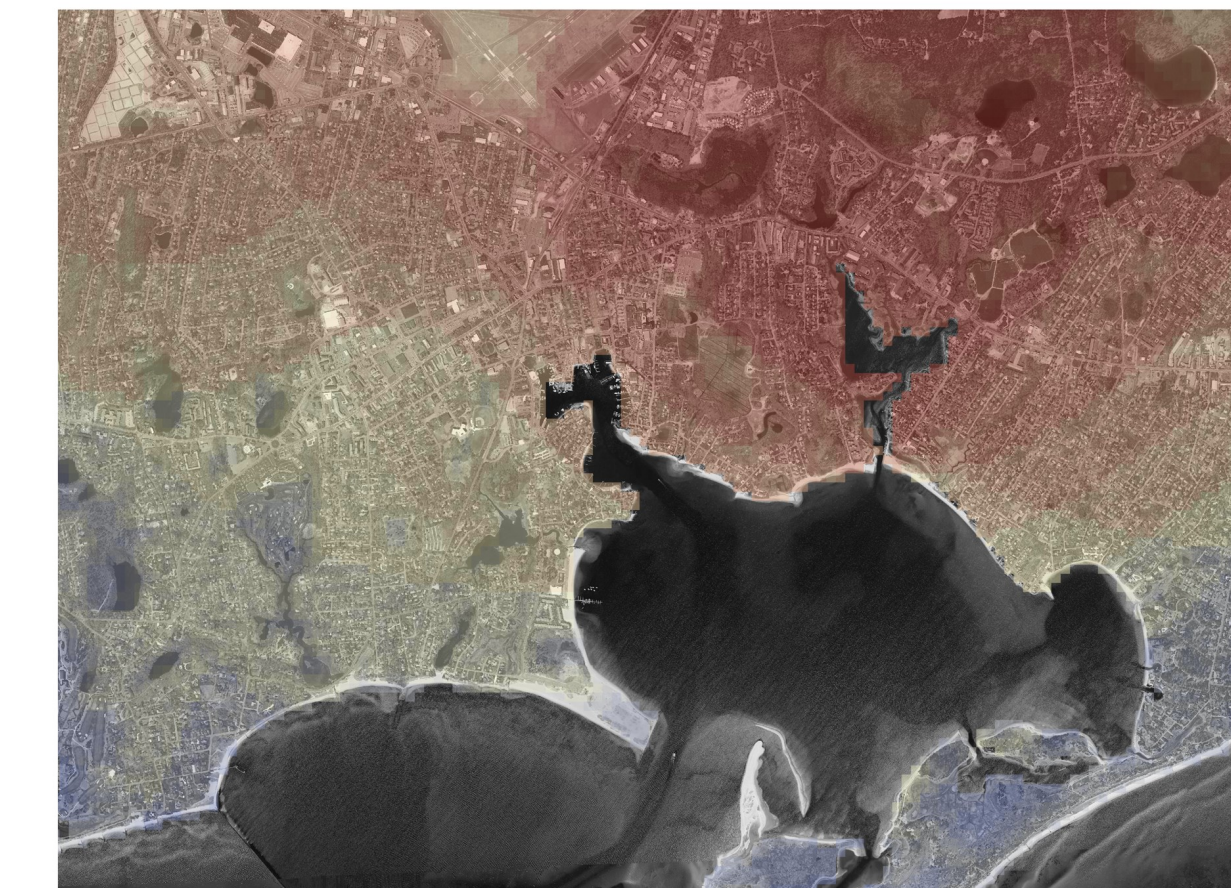

Figure 3. An orthophoto that displays a high risk area (shown in red) in Yarmouth, MA.
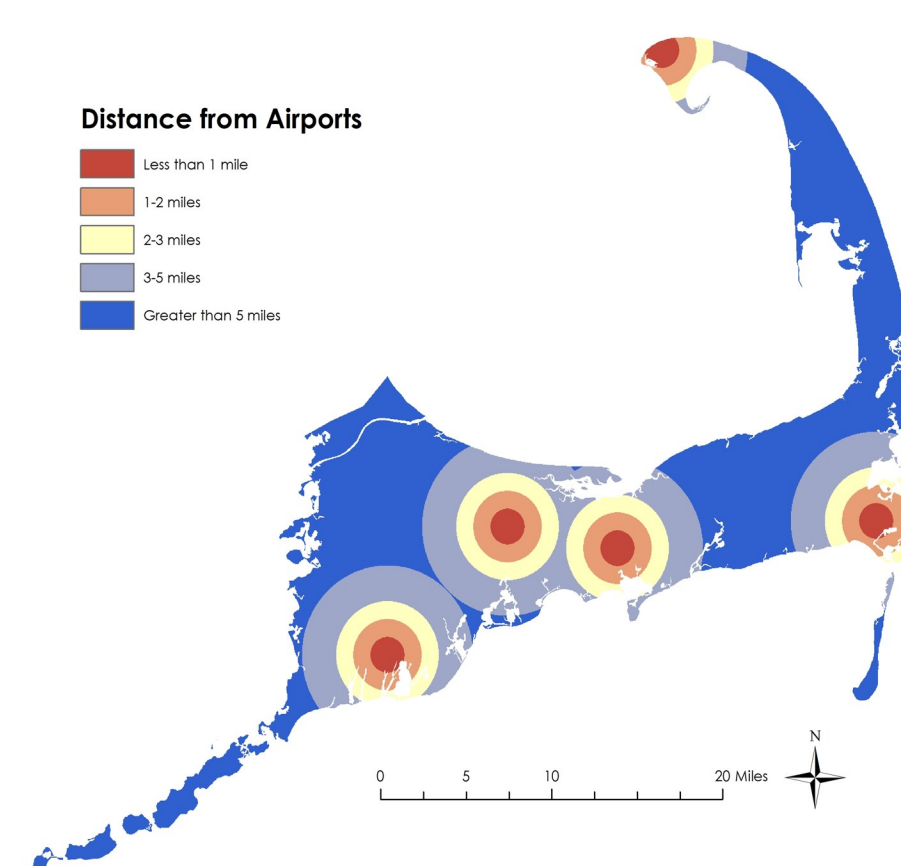
References

Schaider, L., Rudel, R., Dunagan, S., Ackerman, J., Perovich, L., & Brody, J. (2010). Emerging Contaminants in Cape Cod Drinking Water. *Silent Spring Institute*.

Swartz, C., Reddy, S., Benotti, M., Yin, H., Barber, L., Brownawell, B., & Rudel, R. (2006). Steroid estrogens, nonylphenol ethoxylate metabolites, and other wastewater contaminants in groundwater affected by a residential septic system on Cape Cod, MA. *Environ Sci Technol, 40*(16), 4894-4902.
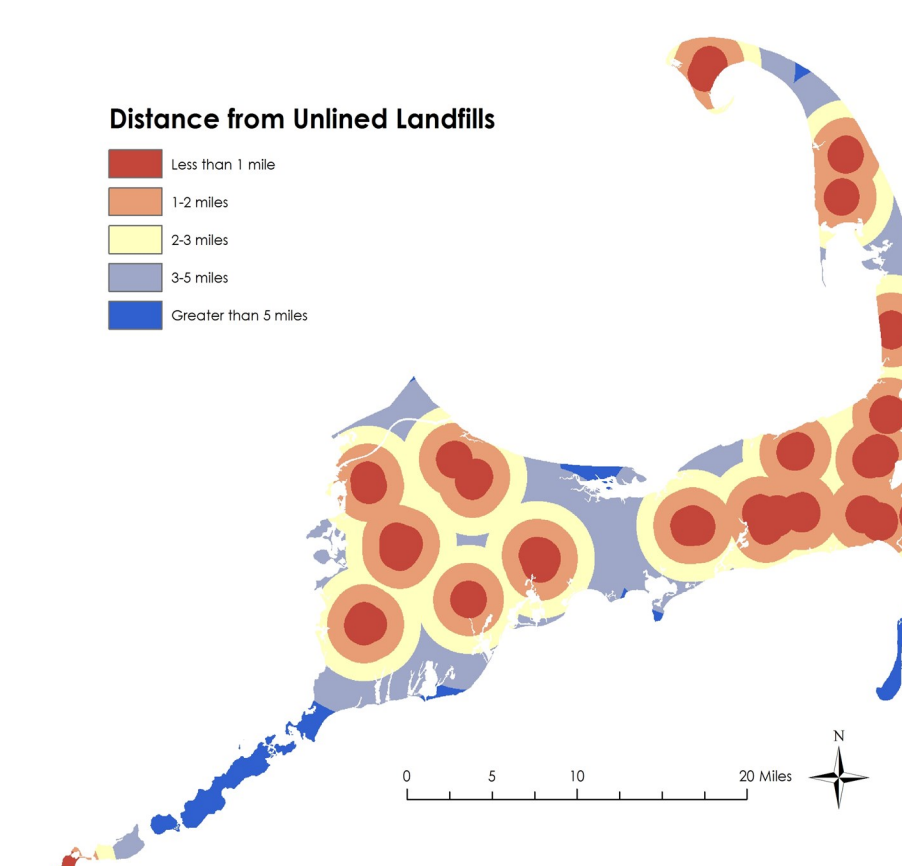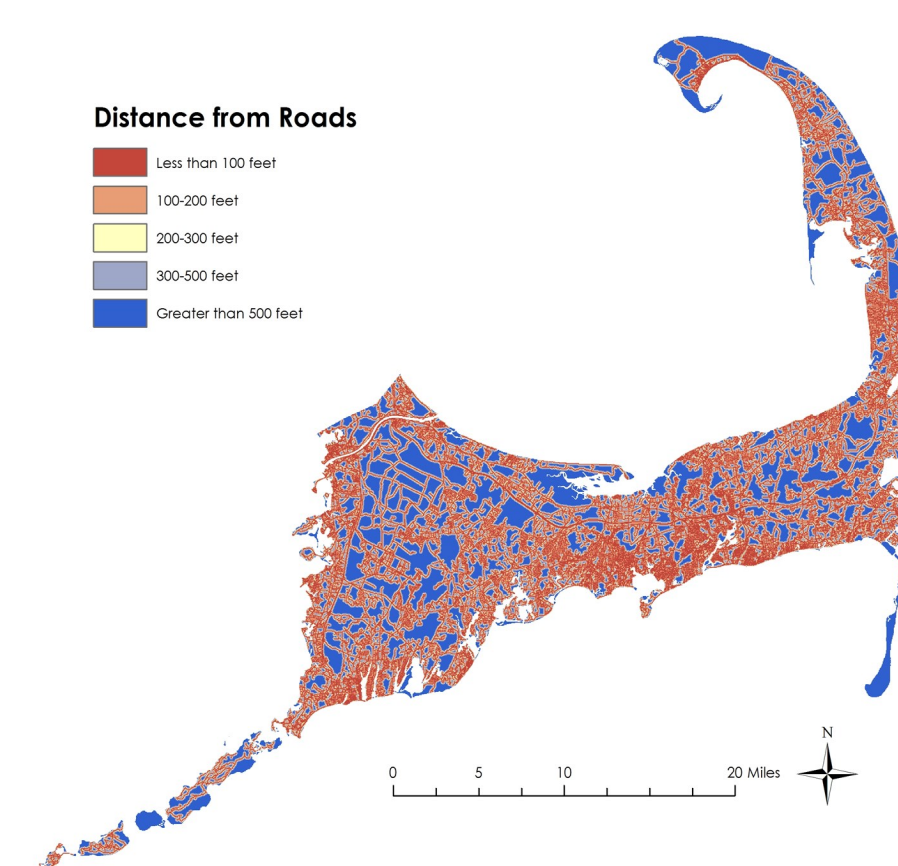
Distance from Hospitals

Distance from Hospitals
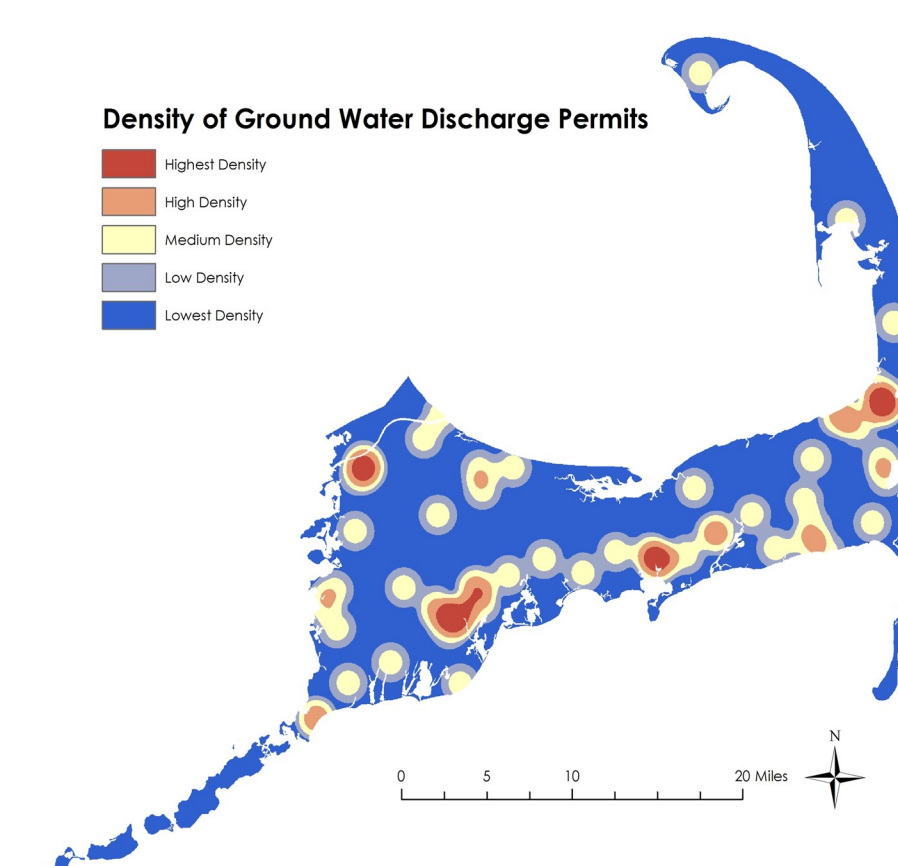- Less than 1 mile
- 1-2 miles
- 2-3 miles
- 3-5 miles
- Greater than 5 miles
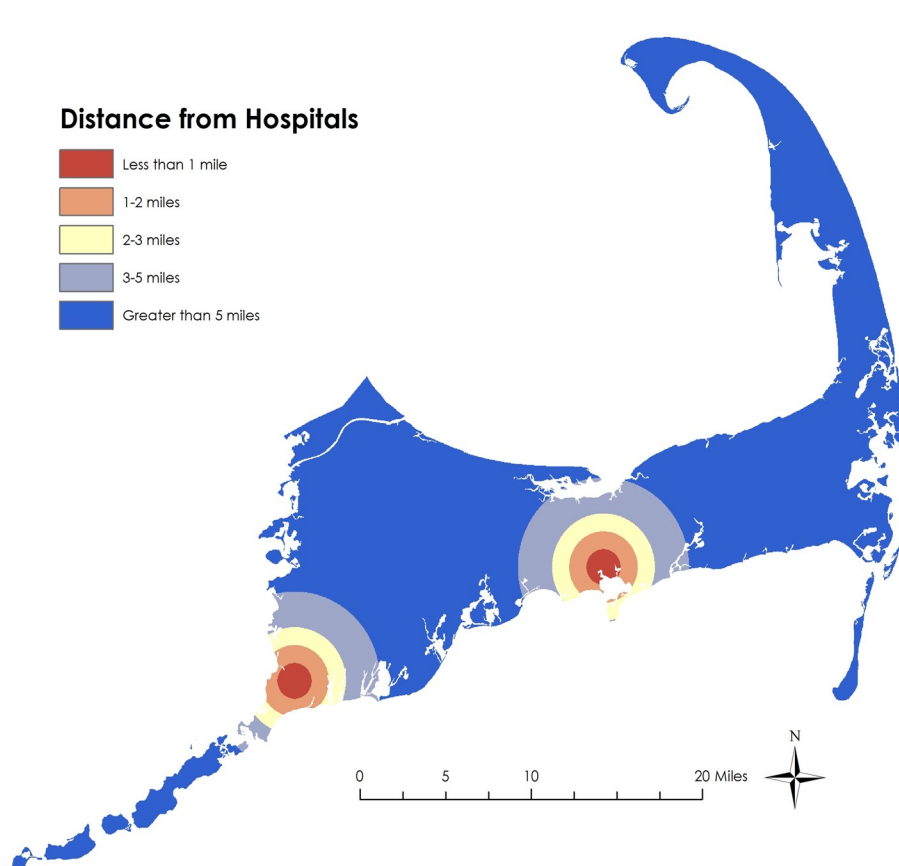
Distance from Airports

Distance from Airports
- Less than 1 mile
- 1-2 miles
- 2-3 miles
- 3-5 miles
- Greater than 5 miles

Distance from Unlined Landfills

Distance from Unlined Landfills
- Less than 1 mile
- 1-2 miles
- 2-3 miles
- 3-5 miles
- Greater than 5 miles

Distance from Roads

Distance from Roads
- Less than 100 feet
- 100-200 feet
- 200-300 feet
- 300-800 feet
- Greater than 800 feet

Ground Water Discharge Permits

Density of Ground Water Discharge Permits
- Highest Density
- High Density
- Medium Density
- Low Density
- Lowest Density

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Introduction to GIS
Projection: North American Datum 1983 State Plane Massachusetts, Mainland
Scale: 1:415,000
Data: MassGIS, U.S. Census Bureau, MA Department of Public Health & Cancer Registry

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