

# Sub-basin level Vulnerability Analysis, Massachusetts

To determine the impact of the new Water Management Act (WMA) Permitting requirements

## INTRODUCTION

The Sustainable Water Management Initiative (SWMI) framework can be used to assess impacts to aquatic resources, to natural and manmade conditions such as groundwater withdrawal. In 2012, the framework was used to outline the WMA permitting requirements for Massachusetts. The regulations are intended to manage water withdrawals to ensure a balance between competing water needs and the preservation of water resources. The WMA regulations state that Minimization requirements applies to applicants with August net groundwater depletion of 25% or more<sup>4</sup>.



To determine which sub-basins are most likely to fall under the WMA Minimization requirement, vulnerability analysis was performed. The vulnerability analysis will follow the source optimization technique, which is part of the minimization requirement for WMA permitting. For this study, the analysis includes sub-basin level source optimization along with population change over 13 years (2000—2013).

To perform the analysis the source optimization parameters used are: Coldwater Fisheries Resources (CFR), Aquifers, Groundwater permits, Outstanding Resource Waters (ORW), Surface Water Supply Watersheds and Surface Water Protection Zones. Population change data is also included to the parameters to better understand which sub-basins will be most vulnerable to water depletion and may need to follow WMA minimization requirements.

## METHODS

To determine the impact of optimization parameters on sub-basins, given the change in population over 13 year, a score card was prepared for the layers used. Vulnerability scoring attributed to each layer is given in the Table 1.

The optimization data layers were converted from shapefiles to rasters and reclassified on a 1-5 scale (Table 1). The population change data layer used was census tracts data for 2013 in Microsoft Excel format, which was joined to the Census\_2000 data. Query was created to calculate population change. The new field (population change) was selected and converted into a new shapefile and subsequently into a raster, which was reclassified on a 1-5 scale. For Groundwater Permits (point data), the shapefile was joined spatially to sub-basin layer for density analysis and reclassified according to the 1-5 scale.

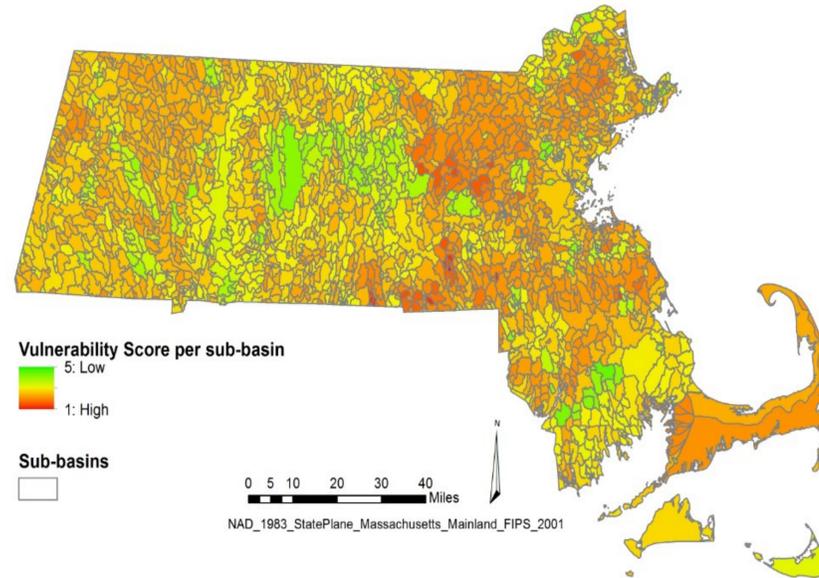
Raster calculator was used to sum the data layers and determine the statewide vulnerability which was reclassified. Zonal Statistics were used to determine the mean vulnerability score per sub-basin.

Math tool in Spatial Analyst tools was used to convert the vulnerability score per basin into integer to determine the number of cells attributed to each score. Cell size was previously set to 300 meters. Total area (km<sup>2</sup>) for each score was calculated in the attribute table. Microsoft Excel was used to determine the percentage of total area in Massachusetts which is most vulnerable.

**Table 1. Scoring Card: scoring attributed to each layer**

	Bad Score	1	2	3	4	Good Score
		1	2	3	4	5
1 Population Change	2060-3052	1000-2000	500-1000	0-500	-12051 - 0	
2 Groundwater discharge permit density	0.023699805 to 0.090200752	0.007074569 to 0.023699805	0.002829828 to 0.007074569	0.000353728 to 0.002829828	0 to 0.000353728	
3 Cold Water Fisheries Resources	Present				Absent	
4 Surface Water supply watersheds	Emergency Supply Watershed/ Rhode Island				Present	
5 Aquifers	Absent				Medium Yield	High Yield
6 Outstanding Water Resources	Restricted/ Protected/ Scenic / Retired water				Surface Water Supply Watershed	
7 Surface Water Protection Zones A, B, C	Present				Absent	

## Vulnerability Score per Sub-basin



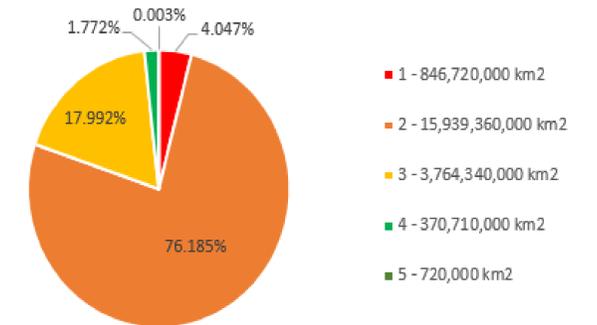
## RESULTS

The seven data layers used to do the vulnerability assessment show that the population change is most evident in the eastern part of the state. However there is some increase in the SW (yellow regions). Groundwater permits are present most in the NE and SE. CFRs are present in west Massachusetts. Few aquifers are available in the state, mostly in the SW. Surface water supply watersheds and available outstanding waters are in the same basins. However those basins are in the surface water protection zones and may not be used for water supply.

Vulnerability assessment per sub-basin shows that sub-basins in the center are least vulnerable and sub-basins present towards east Massachusetts have high vulnerability. Sub-basins in the west are also vulnerable due to presence of CFRs and absence of aquifers. But the vulnerability in the east is not as high as the vulnerability in western Massachusetts.

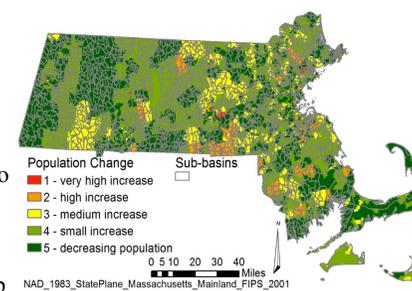
Most sub-basins in Massachusetts have a vulnerability score of 2 (~76.2% total MA area). This is followed by a medium vulnerability score of 3 (~18% total MA area). A high vulnerability score of 1 is given to only ~4.05% total MA area. A low score of 4 is given to only ~1.8% total MA area and a good score of 5 was given to least number of sub-basins (~0.003% total MA area).

**Vulnerability Score by State Area**

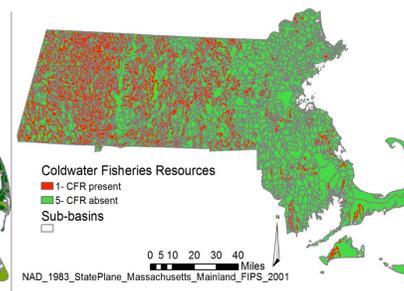


## Factor Inputs

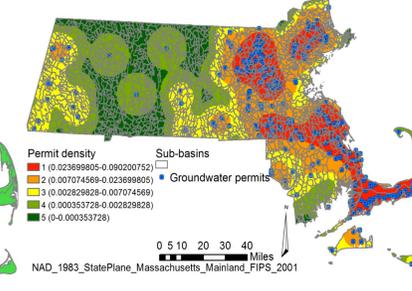
**Population Change 2000 – 2013**



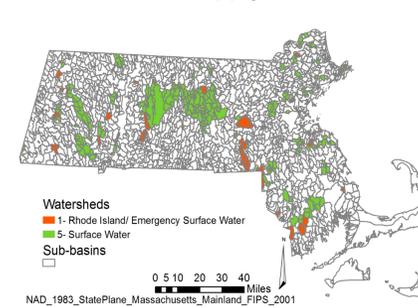
**Coldwater Fisheries Resources**



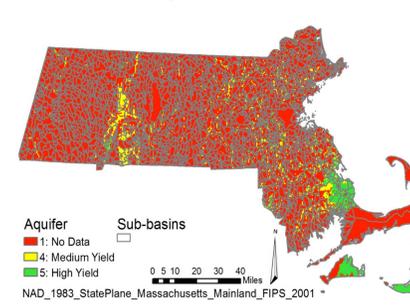
**Groundwater Permits**



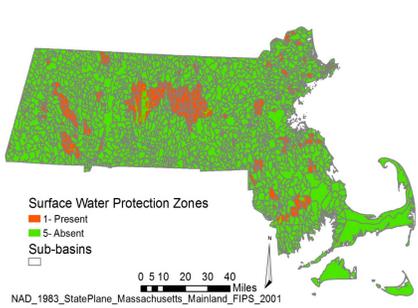
**Surface Water Supply Watersheds**



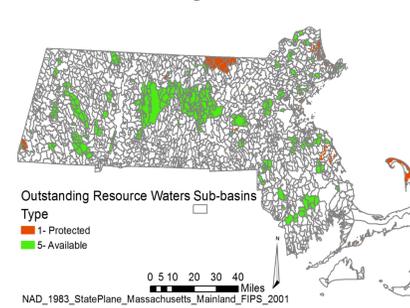
**Aquifers**



**Surface Water Protection**



**Outstanding Resource Waters**



## CONCLUSION

Data layers from the WMA source optimization were used as parameters to determine vulnerability to water depletion. Population change data was added as an additional layer to help predict sub-basins most likely to experience more stress on water sources. Since population change is most evident in the east and the SW part of the state. These areas will experience high vulnerability in the future. High density of groundwater water permits in the NE and SE further stress the available water sources. Surface water supplies are in the surface water protection zone and may not be used to overcome stress on groundwater.

Limitations: The vulnerability assessment is based on ~2200 minor or drainage sub-basins. However the SWMI framework is based on 1400 sub-basins. The definition of sub-basin is different for SWMI and could not be accessed for the project. This analysis may not be applicable for a sub-basin if its source of water lies in a different region. The degree to which each of the seven layers may contribute to vulnerability was not determined.

## REFERENCES

- Water Management Act Permit Guidance Nov 7, 2014 Massachusetts department of environmental protection: <http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/wmaguide14.doc>
- SWMI framework: <http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/wmafaq.pdf>
- Data layers: <http://www.mass.gov>
- Population 2000 data layer: <http://www.mass.gov>
- Population 2013 data: <http://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=#>

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