How Has Urbanization Impacted the Town of Brookfield, Massachusetts?

An Exploration of the Effect of Impervious Surfaces on the Risk of Flooding

Introduction

While urbanization is often linked to many environmental issues, its potential to increase flood risk is quickly becoming a concern in metropolitan areas across the world. Impervious surfaces such as parking lots, roads, and building footprints cause rainwater to runoff rather than infiltrate into the natural ground surface. Not only does this decrease the amount of recharge into watersheds, but it also causes precipitation on the surface to accumulate, sometimes flooding homes and making roads impassable.

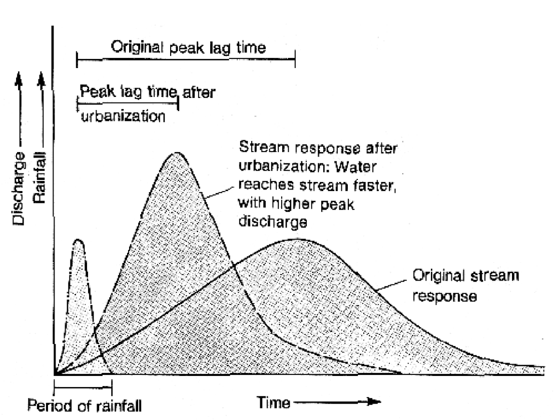

Figure 1. Hydrograph. *Wesleyan University Geology Department.*

The above figure represents the stream response to a given rainfall event before and after urbanization. The existence of impervious surfaces causes runoff to reach streams faster and in greater quantities. If rainfall finds land depressions in which it can accumulate, flooding will occur sooner and in more severely than if the rain were to fall on the natural ground surface.

Although much of the concern for flooding due to urbanization lies in highly urban areas, suburban areas can also be affected if there exists a very concentrated area of impervious surfaces at a location with little change in slope. This would cause for water to accumulate without infiltration. In our study, we will focus on the town of Brookline, Massachusetts - a suburb of the city of Boston.

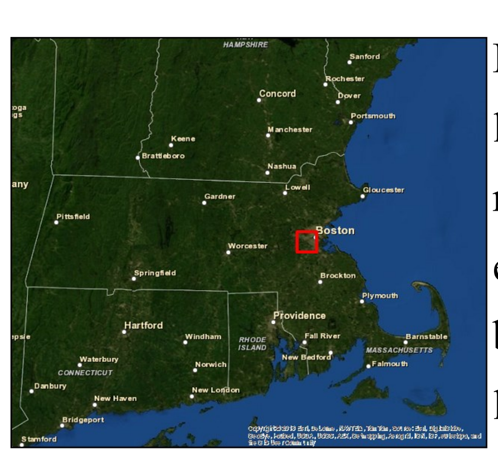

Figure 2. Context of Brookline, Massachusetts.

Brookline is of particular interest due to its rural end and more urban end, which happens to be located in a low-lying area on the banks of the Charles River.

Methodology

In order to analyze the town of Brookline for its flood risk potential, two layers must be created: an elevation raster and a permeability raster with values ranging from zero to one representing the relative permeability of the surface of the land. The elevation raster is a required input of the "Flow Direction" tool in GIS, which outputs a raster showing which direction water will flow in the event of a rainstorm.

The output raster of the "Flow Direction" tool then becomes an input of the "Flow Accumulation" tool. This tool has an added feature which allows for a single raster to be added as a weight factor. In the analysis, our weight factor is the permeability raster, with values ranging from zero representing a perfectly pervious surface to one representing a perfectly impervious surface. For the analysis, storm sewers were given a value of zero, roads and building footprints were given a value of one, and all other land (assumed to be soil or vegetation) was given a value of 0.5.

Figure 4. illustrates the TIN created from contour line data found for the town of Brookline, MA. Figure 5. represents the raster created from the TIN in Figure 4. Figures 6. and 7. illustrate the permeability raster created for the region.

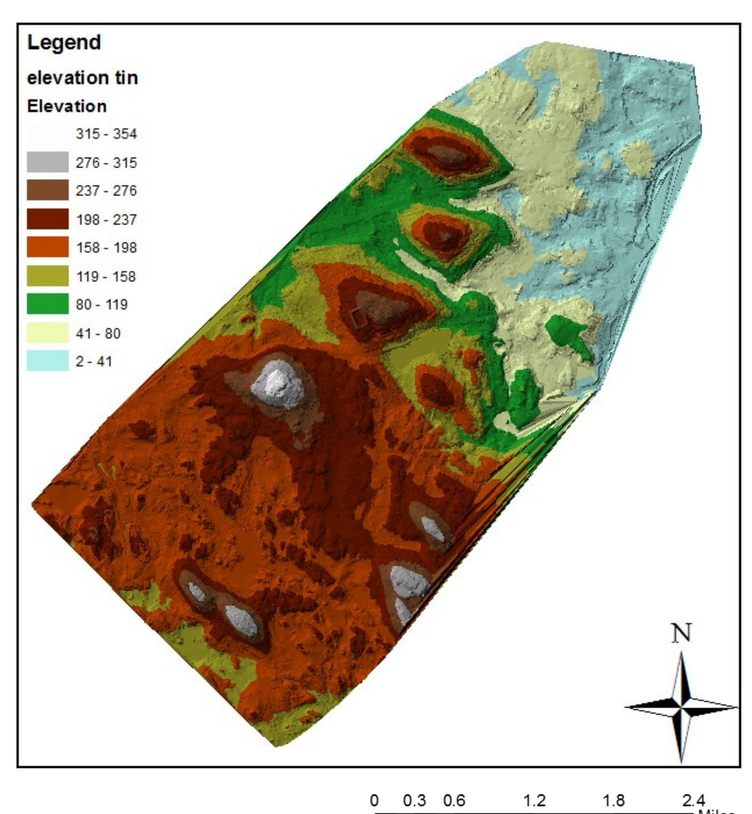

Figure 4. Elevation TIN of Brookline, MA

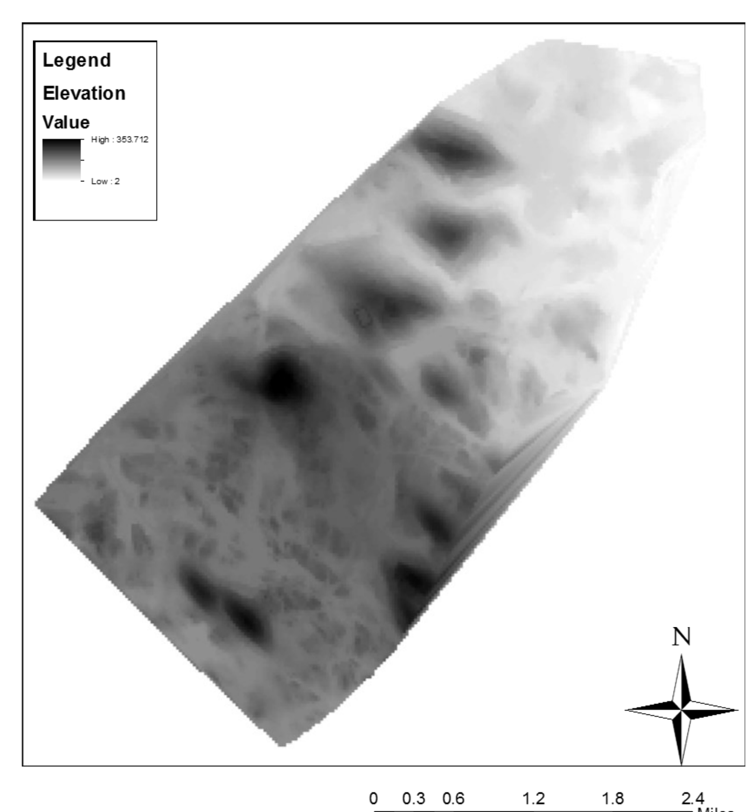

Figure 5. Elevation Raster of Brookline, MA

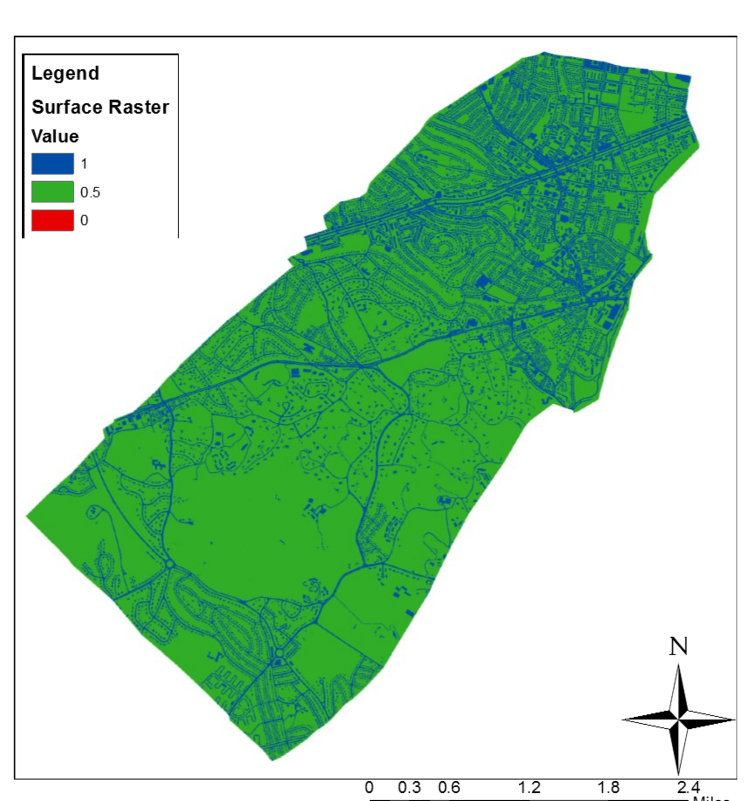

Figure 6. Permeability Raster of Brookline, MA

Figure 7. Close-Up of Permeability Raster of Brookline, MA

Results

Figure 8. shows the results of running the "Flow Direction" tool from the Spatial Analyst extension in GIS. The raster ranges from a value of 1 to a value of 255, with higher values implying a greater potential for flow due to a greater change in slope. By comparing the various colors of the raster to the elevation raster in Figure 5., we see a very clear connection between the peaks and red and orange colors.

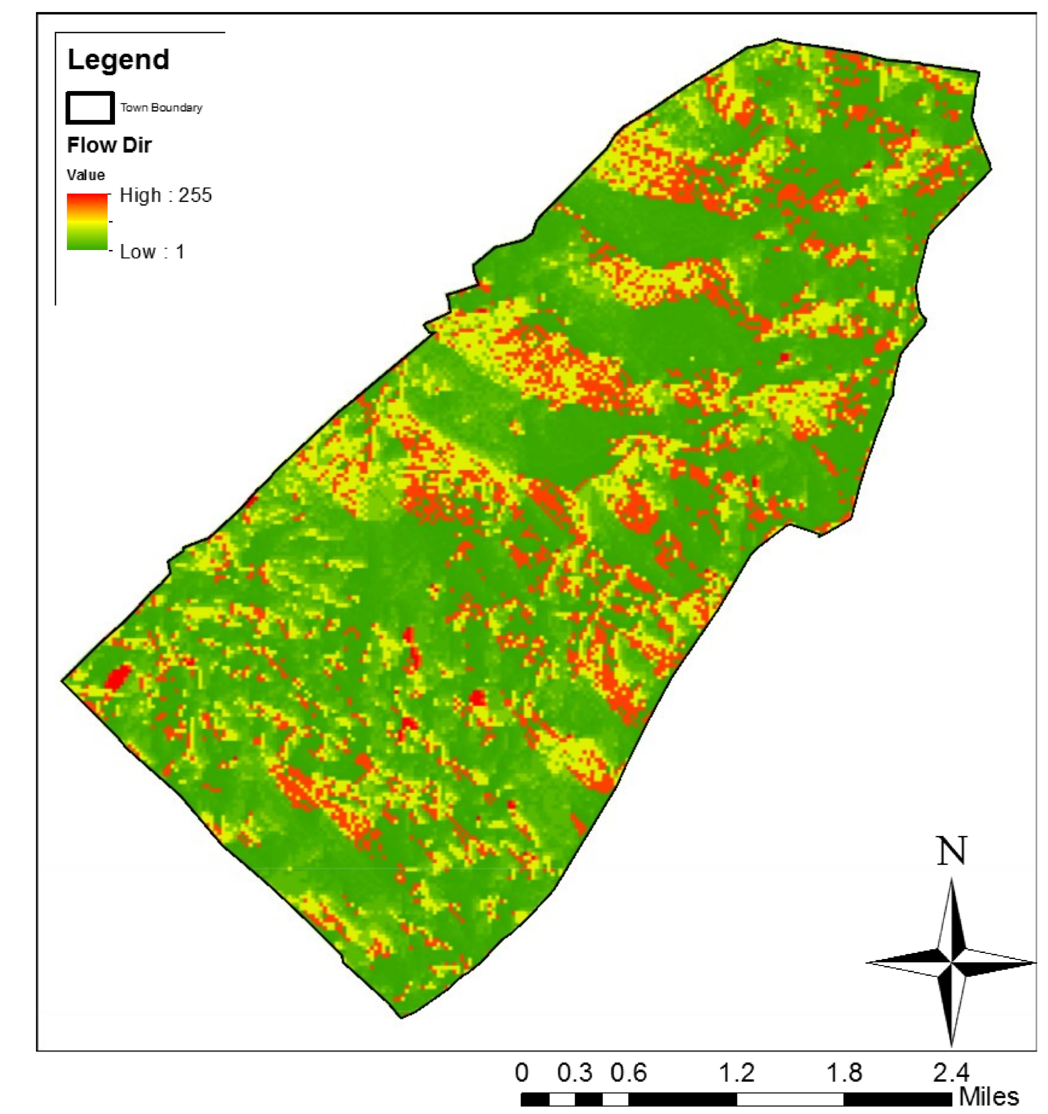

Figure 8. Flow Direction Results—Brookline, MA

Figure 9. illustrates the results of the "Flow Accumulation" tool from the Spatial Analyst extension in GIS. The raster ranges from 0 to 665.5 with higher values implying more potential for flow accumulation. A standard deviation stretch was used to show greater variety in the raster.

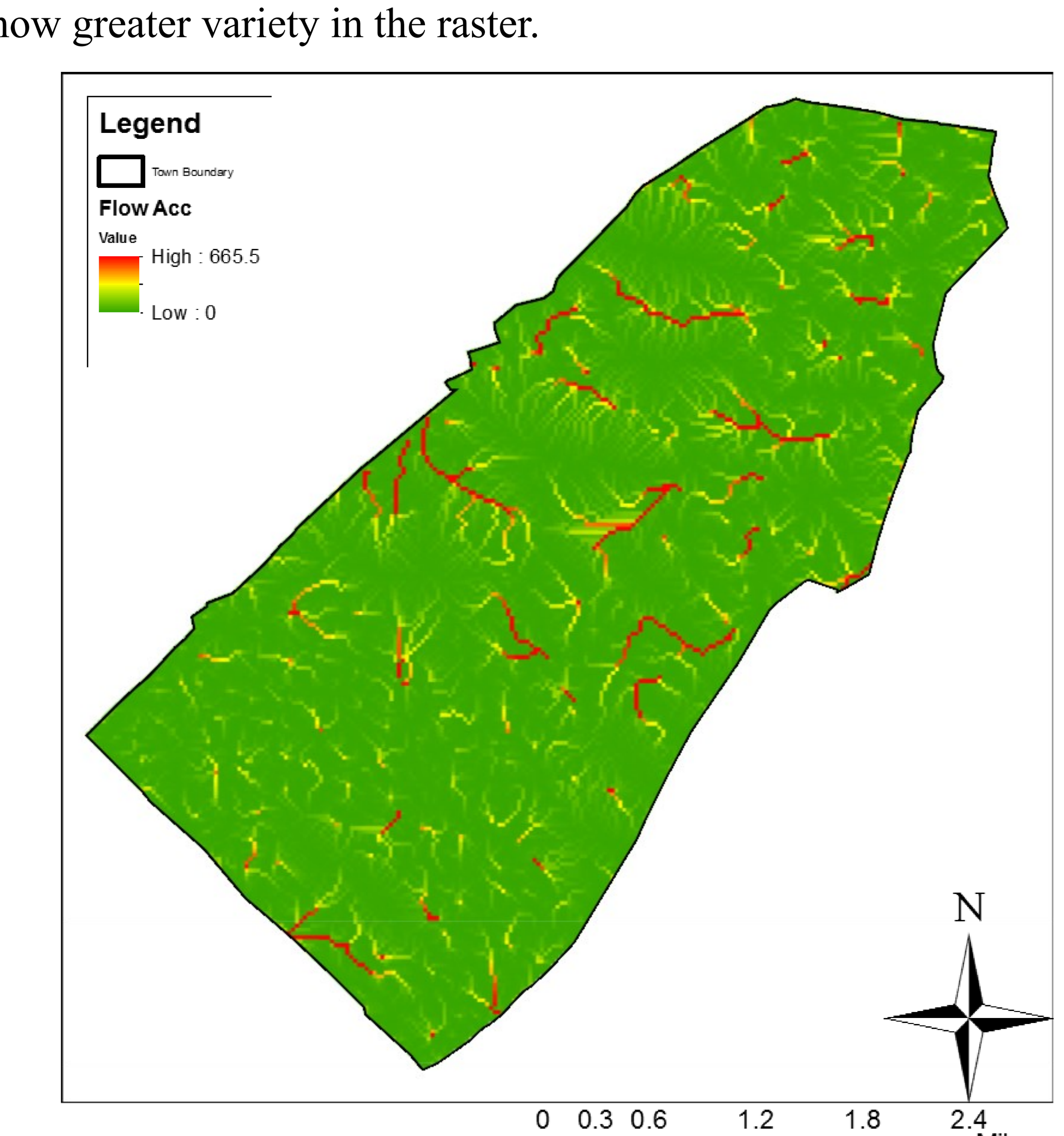

Figure 9. Flow Direction Results—Brookline, MA

Conclusion

Although the potential for flooding in Brookline, MA is likely much smaller than it would be in a more urban environment such as Boston, there are several areas that may want to be analyzed more closely if measures to prevent flooding were ever taken in the town. Many of these areas seem to correspond with low-lying areas on the elevation raster, although it is clear that the impervious surfaces are making an impact because not all of the low-lying areas are registering as locations where flow accumulation would be high.

This project provides an interesting snapshot of how flooding might occur in the town of Brookline, but it would be interesting to take the project a step further by also incorporating the varying permeability of the open spaces across the region. Estimating the permeability of the open space as 0.5 in the permeability raster was likely a very crude estimate, as the permeability will vary with soil type, vegetation cover, and the initial saturation of the soil. However, the analysis provides us with a fairly reasonable approximation of regions with high flood risk and a good basis for further analyses inside and outside of Brookline, MA.

References & Map Projection

All maps show use the following projection:

Coordinate System: NAD 1983 State Plane / Massachusetts Mainland (ft-US)

Projection: Lambert Conformal Conic

Datum: NAD 1983

Data was collected from the GeoData @ Tufts database, with sources including the Town of Brookline, the Brookline Planning Department, and MassGIS.

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Map Created by Kaitlyn Davis on December 12, 2013.