Mapping Drainage and Surface Water Flow on Tufts Campus

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Class: Introduction to GIS, UEP 232
Coordinate System: NAD1983 StatePlane Massachusetts FIPS 2001 (Meters)

Background

As one of the largest landholders in the Medford/Somerville area, Tufts University is critical to the success or failure of new stormwater regulations as proposed by MassDEP. This is largely due to the fact that Tufts' campus alone is responsible for roughly 104.9 million gallons of runoff annually (Greene, 2011). Much of this remains untreated, and is potentially vulnerable to fines under Medford's stormwater bylaws. However, to ensure that these new regulations are met, it is first essential that we understand the stormwater runoff problem as it currently exists. As they are often forgotten in larger concerns of urban place-making, stormwater runoff and associated costs can balloon if not properly accounted for, especially in the face of these new regulations. In order to identify the areas most at risk for stormwater stresses, it is important to determine what the surface water flow over an area would look like. Fortunately, it is possible to develop a stormwater map of campus using hydrology tools within ArcGIS, which is what I will attempt here.

Ref: Greene, K. (2011) Bringing Low-Impact Development Features to Tufts University *Unpublished*

Data Sources

Name	Organization	Type	Data Source	Metadata
New England Digital Elevation Map	United States Geological Survey	Raster	http://ned.usgs.gov/	http://www.fgdc.gov/metadata/csdgm/
Tufts Buildings	Tufts	Shape	Tufts Database	N/A
Roads	MassGIS	Shape	Tufts MassGIS Database	N/A
Sewer Grates	N/A	Shape	Own	N/A
Tufts Pathways	Tufts	Shape	Tufts Database	N/A

Methodology

In order to develop a surface water map of Tufts campus, a number of steps must first be taken. To begin, we must first obtain a raster elevation map of the area. Unfortunately, the maps on offer by MassGIS are simply too precise to make use of on systems in place at Tufts (with raster cell sizes of around 5 meters). Working with them has proven difficult, as any analysis results in file sizes that are too large to properly use. Fortunately, the USGS has a Digital Elevation Map for New England that is easier to use, as the cells are larger (9+ meters), and allow for a better estimate of surface water flow patterns.

Once obtained, I focused on Tufts campus by creating a boundary around it and clipping the DEM to the boundary. I then was able to start using the Hydrology tools to develop a working surface water map of the campus. This process can be seen in the chevrons below.

In order to determine how effective Tufts stormwater management practices are, I also had to understand where all the surface water runoff went. In order to do so, I borrowed a GPS unit from the Tufts' GIS center, and proceed to walk around campus on three different occasions in order to identify and record the stormwater grates and drainage system locations. I imported this location dataset into ArcGIS, and was able to create a very accurate map of where storm drains are installed.

Using this data, we can then estimate how much water is being drained into these grates by using the Zonal Statistics as Table – Sum tool. After creating the table based on the Surface Flow Volume, I joined it to the sewer grates layer. This allows us to display – in graduated symbols - how much flow each sewer grate is receiving. From this, it becomes clear that those grates on the southern edge of campus are receiving the most flow – and we should focus our efforts at reducing stormwater runoff in those areas.

1. Download Digital Elevation Map (DEM)
2. Create a Flow Direction Raster
3. Create a Flow Accumulation Raster
4. Use the Sink Tool and Fill Tools to create a Depression-Less DEM
5. Repeat Steps 1 & 2
6. With the new Flow Accumulation Model, adjust classification to identify surface flow

Limitations

Unfortunately, there are a number of limitations with this study; first and foremost is window sizing problem. Because the hydrological tools only work with rasters, the size of the raster will affect your results. If it is too small, the edges can throw off calculations in those areas. As such, a viewer should only focus on the center of the surface flow maps, not the exteriors.

Secondly, the surface water maps only take into account the underlying topography, and not the built environment. While the surface flow will remain largely the same in the broader scheme of things, flow differences will arise due various impervious surfaces, and these differences can not be included here.

Conclusions

After running the different GIS hydrological tools, it became clear that Tufts' current drainage infrastructure is well sited to deal with much of the stormwater runoff that the university may have during the year. This can be seen in the many different sewer and storm grating located downstream of Tufts' hill, particularly along Powderhouse Boulevard. However, it is also clear that there are number of opportunities for investing in more stormwater infrastructure, especially along Winthrop Ave. and the South-Western edge of campus.