Water flow analysis over impervious and pervious surfaces

University of Minnesota, Twin Cities Campus

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Introduction:

Stormwater management is very crucial as it one of the public safety measures. The county and state puts a lot of money in this, however when it comes to University of Minnesota the Uservices department take care of all the management. One of the areas is Stormwater management. We decided to do this project hoping that we would help university in analyzing the water flow around the campus and to study the watersheds in university. Also by studying the impervious and pervious surfaces along with this would help the planners to plan the drainage and the water runoff and to decide the architectural aspect considering the impervious and pervious surfaces on the construction site and planning for the needs of Stormwater management.

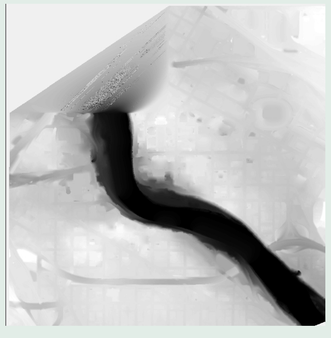
Objective:

The objective of this project is perform an analysis to the University of Minnesota stormwater management needs by using a watershed and image classification techniques. There would be two sections, the first would be the Water flow analysis in the East bank and West bank campus, and second would be an Image classification to understand the impervious and pervious surfaces in both West & East bank campus. Our aim is to bring these two studies together and see how and where there is need for the Storm water management planning.

Data Sources:

To calculate the watersheds around West & East Bank, we decided to use a DEM to obtain more accurate results. The DEM used in this project was obtained from MNGeo. Used for the image classification of the pervious and impervious areas around campus we used a RGB image from 2014.

Once we have the watersheds and the impervious and pervious surfaces we can find out the areas where storm water management is crucial.



Lidar data of Twin Cities from MNGeo.

Projected Coordinate System:
NAD_1983_UTM_Zone_15N

Linear Unit: Meter (1.000000)
LAS points: 52,861,770
ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/

RGB imagery from Uservices for 2014, from UServices, University of Minnesota

Projection:
NAD_1983_HARN_Adj_MN_Hennepin_Feet

Number of Bands: 4

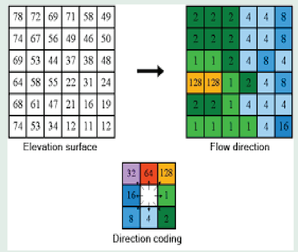
Resolution: 5 inch (approx)

Methods:

Watershed Delineation:

By using the LiDAR point cloud data, and created a DEM, we calculated the water flow around campus by using the Hydrology toolset from ArcGIS Desktop. This toolset provide the methods to describe the physical components of the surface and help us to identify sinks, flow direction, among others. The tools used in this project were Fill, Flow direction, Flow accumulation, Snap Pour point, and Watershed. Using the DEM as an input helped us to obtain the direction in which the water flows.

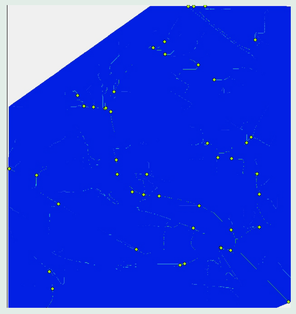
To determine the direction of flow from every cell in the DEM, was necessary to use the tool "Flow Direction", it is necessary to use a raster that represent the surface as input file, also is require to specifies if the edge of the cells will have always flow outward or normal flow rules, in this case we used the normal flow rules.



Flow Direction Tool

Using "Flow accumulation" tool we can calculate the accumulated flow, this creates a raster for each cell of the accumulated flow, which is based on the number of cells following each cell.

Flow Direction results



Flow Accumulation results

Now we created the pour points, which represent the points where the accumulation is highest, and are placed in way that it will create smaller watersheds to have fine detail. The Snap Pour Point tool is used to ensure the selection of points of high-accumulated flow when delineating drainage basins using the Watershed tool. Snap Pour Point will search within a snap distance around the specified pour points for the cell of highest accumulated flow and move the pour point to that location.

Watersheds are created for the particular flow stream where the pour Points were placed.

Watershed results

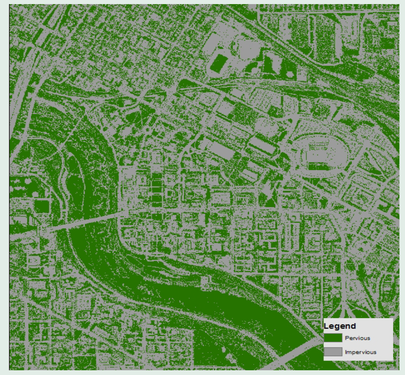
Image Classification:

Impervious/Pervious data classification: High resolution imagery available for year 2014. We classified the campus area in Impervious and Pervious surfaces. This would also help in storm water management, or also help the civil department of the university to deal with the land development.

The supervised classification was performed using the software Erdas Imagine, for the two classes (pervious and impervious) we generated around 250 signatures for the entire image. For the purpose of this classification we used as Google Maps as reference data and the parametric rule "Maximum Likelihood".

Validation:

To quantify the reliability of the supervised classification, the other member of team performed a validation (accuracy assessment) of the final classification. For this 70 points were used and the distribution parameter was "Stratified Random" ,with a minimum points of 10 per class. We decided to use a total of 70 points due to the number of classes and the study area.



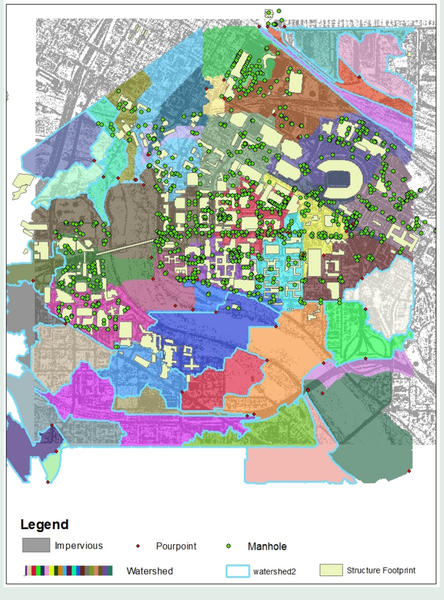
Supervised Classification

Map	Reference Data				
Class Name	Unclassified	Pervious	Impervious	Row Total	Producers Accuracy
Unclassified	0	0	0	0	0
Pervious	0	21	11	32	77.78%
Impervious	0	6	32	38	74.42%
Total	0	27	43	70	
User Accuracy	0	65.63%	84.21%		75.71%

Error Matrix

Results:

To analyze the "areas of concern" for stormwater management, we overlaid the classification, the watersheds, the pour points used for creating the watersheds and the manholes point feature class. The below image gives a visual understanding of the analysis. You can easily capture the areas of concern. You can notice the manholes are centered in the campus and at some places also overlapping with the pour points. The manholes are structured in a way that they cover all the watersheds. However there are some areas of campus where the manholes are not available and there are watershed with impervious surfaces.



To further analyze and get more information on the specific areas, we added the structure footprints of the campus and highlighted the "areas of concern" using the select by location tool. This results show that there is not much stormwater management on the west bank near the Fairview buildings.

Conclusions:

After overlapping the results of the watershed delineation, classification, manholes point feature class and the pour points, Our results show that there are some watershed which do not have man holes and are spots where stormwater management solutions needs to be implemented. This analysis will surely help Uservices to plan more efficiently for stormwater management.