

## COMBATING IMPERMEABLE SURFACE

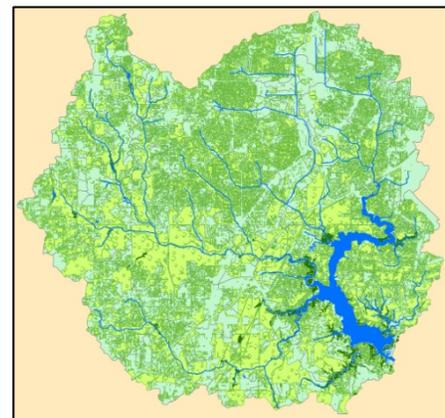
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Impermeable surfaces are a key factor when studying an urban watershed. These are surfaces that do not allow water to penetrate and saturate the ground. Impermeable surfaces also change the runoff characteristics of a watershed. In short they allow the water moving across them to accelerate, due to little resistance, causing higher transportation capacities, and intense erosion. In an existing urban area, there is little that can be done to combat these surfaces, but it is very helpful to know where they are located and concentrated. Using ESRI's ArcDesktop, I have created an impermeable surface layer set of the Dog River Watershed in Mobile, AL. The layer set was created using the City of Mobile's geodatabase, and its subsequent data files. The files used are buildings, roads, paved edge, parking, driveways, and sidewalks. These shape files combined show the spatial distribution of impermeable surfaces as well as their concentration. The higher areas of concentration lie closer to the city proper, and decrease as one moves out. The results of this project are useful for future watershed modification, new construction, and watershed retrofits.

Keyword: impermeable surface, runoff, urban sprawl.

### **Introduction**

Urban areas place a large amount of pressure on the watersheds they are built in and around. The Dog River Watershed has been feeling the pressure of Mobile since ground was first broken in its hills and valleys (fig1). Particularly there is one form of urban pressure that radically changes the dynamics of the watershed, impermeable surfaces (fig 2). Impermeable surfaces (i.e. asphalt, concrete, buildings, etc.) keep water from infiltrating into the ground, and provide little to no friction for moving water. This lack of absorption and increase in speed causes an increase in



**Figure 1: Dog River Watershed**

erosion and runoff (Thompson et al. 2007). In expanding areas, the amount of impermeable surface can be controlled and modified in order to best find a balance between urban and natural through the use of gabions and other modern conservation techniques (National Research Council 1999). Mobile is an expanding urban



**Figure 2: Impermeable Surface**

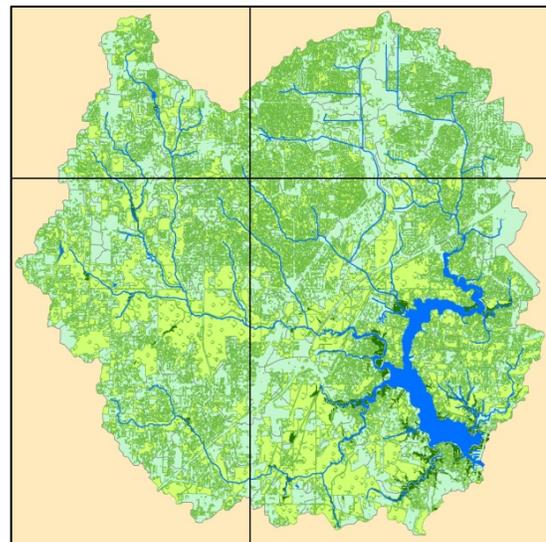
area, and it has already enveloped most of the Dog River Watershed (City of Mobile). That being, said there is still a way to reach balance. Through GIS we can compare the individual parts of the watershed from a distance, as well as view the watershed as a whole (Schowengerdt, 2007). At this distance we can examine each contributor of impermeable surface, and see its spatial distribution. This spatial distribution is a key aspect in determining how impermeable surfaces affect the health of the watershed, and which areas are the most affected.

### **Research Question**

Impermeable surfaces are an important factor in watershed health. They are an integral part of urban landscape, and are necessary for urban processes. These surfaces modify the runoff and ground water penetration characteristics of a watershed (USGS, 2009). The spatial distribution of impermeable surface will answer the questions, how much of the Dog River Watershed is covered in impermeable surface, and which sub-watershed contains the most?

## Methods

The project's two research questions have been answered using the City of Mobile's Geodatabase and ArcGIS. Shape files have been taken from the city's GIS and the 2006 planimetrics. The GIS provides the layer for roads and the Dog River Watershed. The planimetrics file provides the other impermeable layers parking, driveway, building, sidewalk, and paved edge. The files from planimetrics are not full layers like those of the GIS, they are broken down into quadrants (NW, NE, SE, SW) (fig3), so each layer is combination of four sub-layers. The GIS and planimetrics layers were clipped using the Dog River Watershed, eliminating all features outside of it. Next for all of the line features a standard width was assigned so that an area attribute could be created. The width differs for each layer, and in the case of roads it has three different values. The widths used were driveways 10ft, sidewalks 5 ft, and paved edge 4ft (Easa, 2000). The roads layer is broken down into three categories small, medium, and large, which represent the road type. Lane widths of 12 ft, inner shoulder 4ft, and outer shoulder 10ft, were used, and this produced small 24 ft, medium 48 ft, and large 76ft (ALDOT, 2009).



**Figure 3: Quadrants of Shape Files**

Adding the area attributes of the impermeable layer set produced the total area of impermeable surface, and when divided by the total area of the watershed, the percentage of it. This answers the first question. The second question requires that each sub-watershed be extracted from the Dog River Watershed layer. The extracted sub-watersheds were Alligator Bayou, Bolton Branch, Campground Creek, Dog River, Eslava Creek,

Halls Mill Creek, Milkhouse Creek, Montlimar Canal, Moore Creek, Perch Creek, Rabbit Creek, Robinson Bayou, Second Creek, and Spring Creek (Figure 4). Each impermeable layer was then clipped by every sub-watershed. This produced an impermeable layer set for each individual watershed. Adding the area attributes of the impermeable layer set then provides a total for that sub-watershed, and that value is used to determine which sub-watershed contains the most impermeable surface.

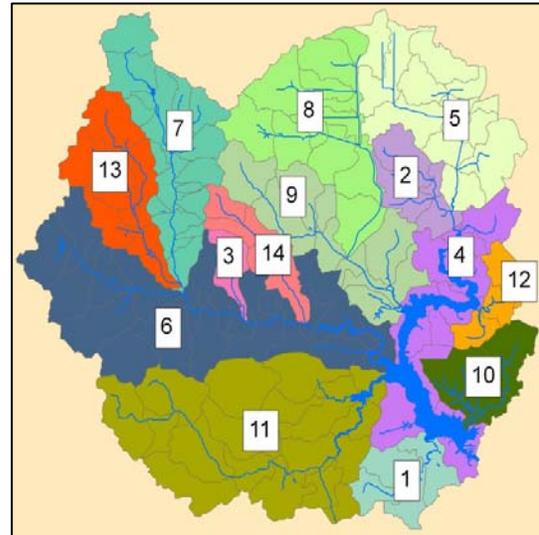


Figure 4: Divisions of Dog River Watershed

## **Results**

The results of my project are not only an impermeable surface layer set, but also an impermeable surface spread sheet. The layer set and spread sheet were used in answering the two research questions for my project. The Dog River Watershed contains a total area of 58125 acres, according to the City of Mobile's GIS. My impermeable layer set represents a total area of 15062 acres, and when divided by the total area of the watershed it is found that 26% is impermeable. Once the layer set was broken down into individual sub-watershed data sets, the second question was answered. The Eslava Creek sub-watershed contained the most impermeable surface with 2757 acres, 18% of the total for the watershed (fig 5).

In addition to answering the two research questions the created layer set and spread sheet also provides other interesting and important results. Campground Creek contains the lowest amount of impermeable surface for the watershed at 134 acres or 0.8% of the total impermeable area. Eslava Creek contains not only the largest concentration of impermeable surface for the watershed, but also the largest concentration when

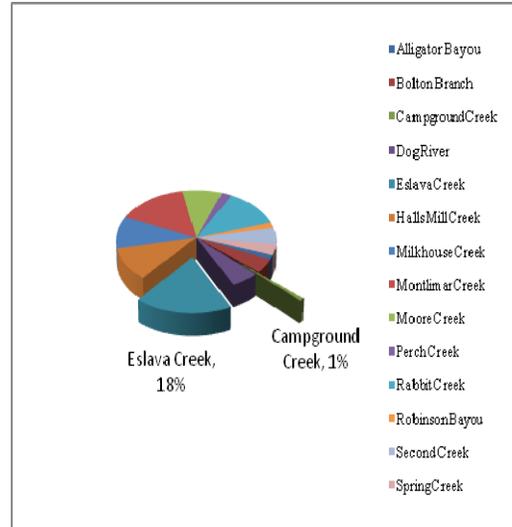


Figure 5: Distribution of Impermeable Surface

compared to its (Eslava Creek) area. Fifty percent of the surface in the Eslava Creek sub-watershed is impermeable. Alligator Bayou has the lowest concentration compared to its total area at 12% (fig 6). The individual contributions of each impermeable surface can also be extrapolated from the layer set and spread sheet.

Buildings are the largest contributor at 4268 acres or 28% of total impermeable surface, and sidewalks are the lowest contributor at 461 acres or 3% of total impermeable surface. These can also be broken down into the individual sub-watersheds and give values versus their total area. The layer set and spread sheet show the spatial distribution of impermeable surface in the Dog River Watershed.

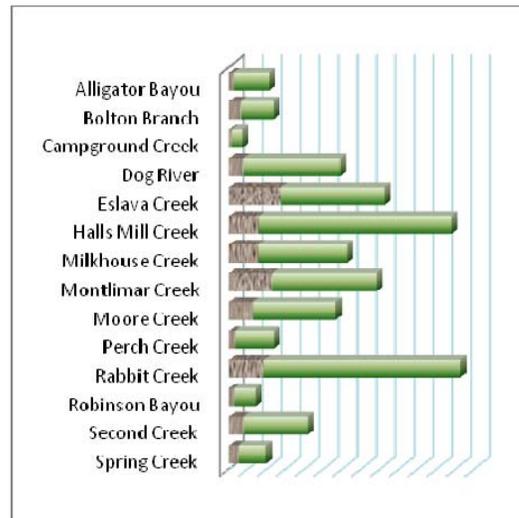


Figure 6: Percent Area Impermeable

## **Discussion and Conclusions**

Impermeable surfaces are a necessary evil in an urban area. They modify the runoff characteristics of a watershed, and can adversely affect the health of it. The first step in combating these surfaces is to know how they are distributed in the watershed. The Dog River Watershed is shown to have 15062 acres of impermeable surface, with the highest concentration in the Eslava Creek region at 2757 acres. This information is useful in improving the health of the watershed because of its adaptability to be correlated with other spatial data. Using other spatial variables such as slope and soil permeability a complete runoff model can be created for the watershed. When used on its own, it can show which areas of the watershed are subject to the largest change in health due to these surfaces.

As with any research project there are some limitations, and factors that affect the accuracy of the results. The first issue would be including the armored channels in with the impermeable layer set. There is a shape file in the City of Mobile's GIS for drainage, but upon investigation (Terraserver, 2009) even though all the channels are included, there is no distinction between armored and unarmored channels. The second issue is the lack of an area attribute for the roads, driveways, sidewalks, and paved edge. The assumption of standard widths creates a larger margin of error in the total surface. The final issue affecting accuracy is the lack of uniformity in the attributes for each shape file. If these files had uniform attributes then the separate layers could be combined, making the construction process simpler, and the resulting layer could be used in ArcGIS to perform several types of spatial analysis.

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