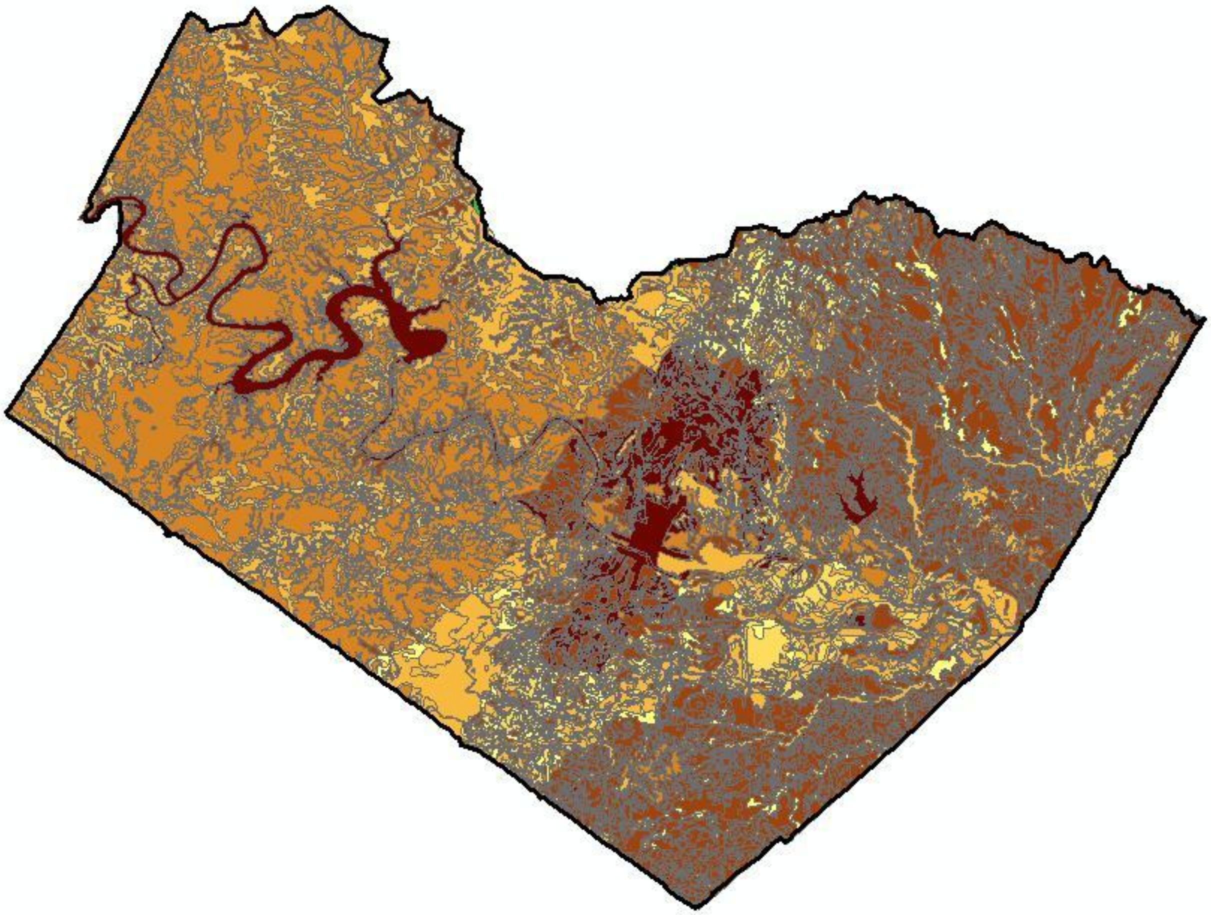


A DRASTIC Model of Travis County

Document Prepared for CE 394K: GIS in Water Resources

Brian Au

Introduction

DRASTIC, a model developed by the EPA in the mid 1980s, is still an incredibly useful tool to assess the potential pollution loading on an aquifer. DRASTIC stands for the parameters Depth to Ground Water, Net Recharge, Aquifer Media, Soil Media, Topography, Impact of Vadose Zone, and Hydraulic Conductivity. These parameters are combined into a single equation, which produces the total DRASTIC potential pollution index (DPPI).

$$DPPI = \sum_{i=1}^{7} (w_i \times r_i) \tag{1}$$

The variable w_i represents how important each parameter is with respect to other parameters, and the r_i variable shows how extreme each parameter is within its own subset. Note that a higher DPPI means a higher susceptibility to pollution.

As is apparent, this equation uses absolutely no data on water quality! This is the greatest asset and greatest downfall of the DRASTIC model. Historical data for most of the parameters can be found and made without premeditation and a huge budget for sampling.

Most documents written on this subject and most DRASTIC maps are from well over a decade ago. These maps took data from books and geological surveys and most data that, for the most part, has never been accessible online. In figure 1, a prime example of age-old map techniques, the author of this map digitized most of the data they used. As I found out, the only way to get some data is by digitizing it yourself.

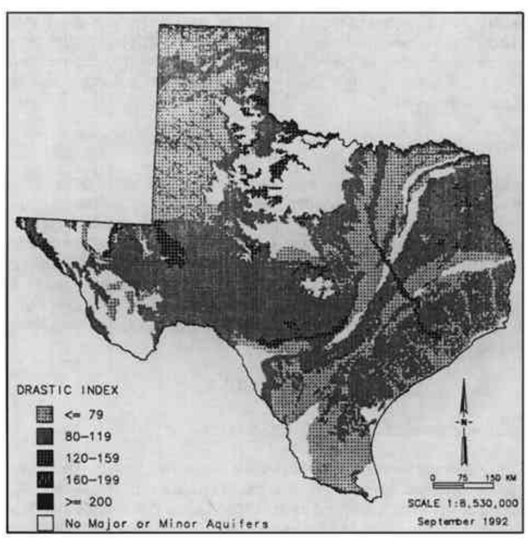


Figure 1. DRASTIC Ground Water Pollution Potential in Texas

Rating Parameter Tables and Parameter Weights

Table 1. Parameter Weights for DRASTIC

Parameter	DRASTIC Weight
Depth to Water Table	5
Net Recharge	4
Aquifer Media	3
Soil Media	2
Topography	1
Impact of Vadose Zone	5
Hydraulic Conductivity	3

Table 2. Range and Ratings for Depth to Water Table (feet)

Range	Rating
0-5	10
5-10	9
10-20	8
20-30	7
30-50	5
50-75	3
75-100	2
100+	1

Table 3. Range and Ratings for Net Recharge (inches per year)

Range	Rating
0-2	1
2-4	3
4-7	6
7-10	8
10+	9

Table 4. Range and Ratings for Aquifer Media

Range	Rating	Typical Rating
Shale	1-3	2
Igneous	2-4	3
Weather metamorphic	3-5	4
Sandstone, Limestone	5-9	7
Large Sandstone formations	4-9	6
Large Limestone formations	4-9	6
Sand/Gravel	6-9	8
Basalt	2-10	8
Small Limestone	9-10	10

Table 5. Range and Ratings for Topography (% slope)

Range	Rating
0-2	10
2-6	9
6-12	5
12-18	3
18+	1

Table 6. Range and Ratings for Soil Media

Range	Rating
Thin or Absent	10
Gravel	10
Sand	9
Shrinking/Aggregating Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clayey Loam	3
Non-shrinking/non-aggregating Clay	1

Table 7. Range and Ratings for Vadose Zone

Range	Rating	Typical Rating
Silt/Clay	1-2	1
Shale	2-5	3
Limestone	2-7	6
Sandstone	4-8	6
Thin-bedded Sandstone	5-9	6
Large Sandstone formations	4-9	6
Large Limestone formations	4-9	6
Basalt	2-10	9
Small Limestone	9-10	10

Table 8. Range and Ratings for Hydraulic Conductivity (GPD/ft^2)

Range	Rating
1-100	1
100-300	2
300-700	4
700-1000	6
1000-2000	8
2000+	10

Objectives

- Combine data from online sources to collect the necessary parameters
- Produce rasters for each parameter, then combine them to form a single DRASTIC map
- Assess the potential for pollution in Travis County as a result of the output

Data Sources

TCEQ – water depth to groundwater

CAPCOG – well data

Bureau of Economic Geology – net recharge

National Atlas – aquifer media

USGS – National Elevation Dataset

NRCS – SSURGO

Texas Tech University – Travis County Boundary

Methods/Results

Water Depth to Groundwater

Well location and depth to groundwater data were downloaded separately from the Texas Center for Environmental Quality for Travis County, since there a dataset with both of these components does not exist. After combining the two datasets and performing a Nearest Neighbor Interpolation on the data, data was available for 90% of the watershed.

Unfortunately, a raster of the data produced a rectangle that did not completely cover the entire Travis County. Another issue with the depth to water table raster is that it does not accurately represent the depth to the water table. Approximately 40% of the output raster is in the downdip region of the aquifer, which represents pieozometric head of the confined aquifer. This region can only be (at most) 1, the lowest rating for an aquifer. Before modifying this area, it also had the highest ratings for depth to water table, which made the correction a necessity for an accurate DRASTIC rating.

In figure 2, the final result can be seen with a Travis County boundary laid over it. The line through the middle of the raster is the boundary between the downdip and outcrop portions of the aquifer; to the east of the line is the Trinity downdip. The other lines drawn into the Travis County boundary are where values had to be manually entered to create a contiguous depth-to-groundwater surface.

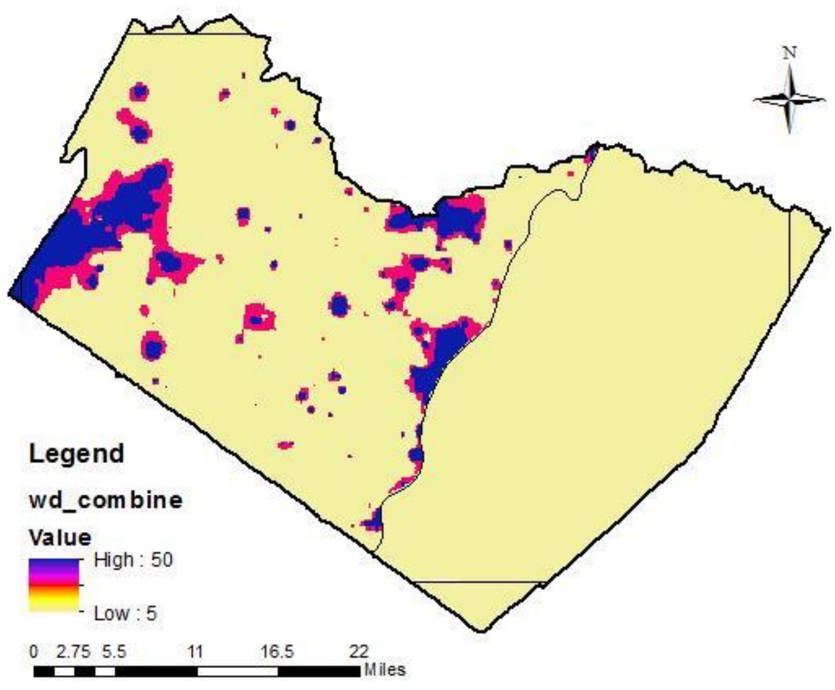
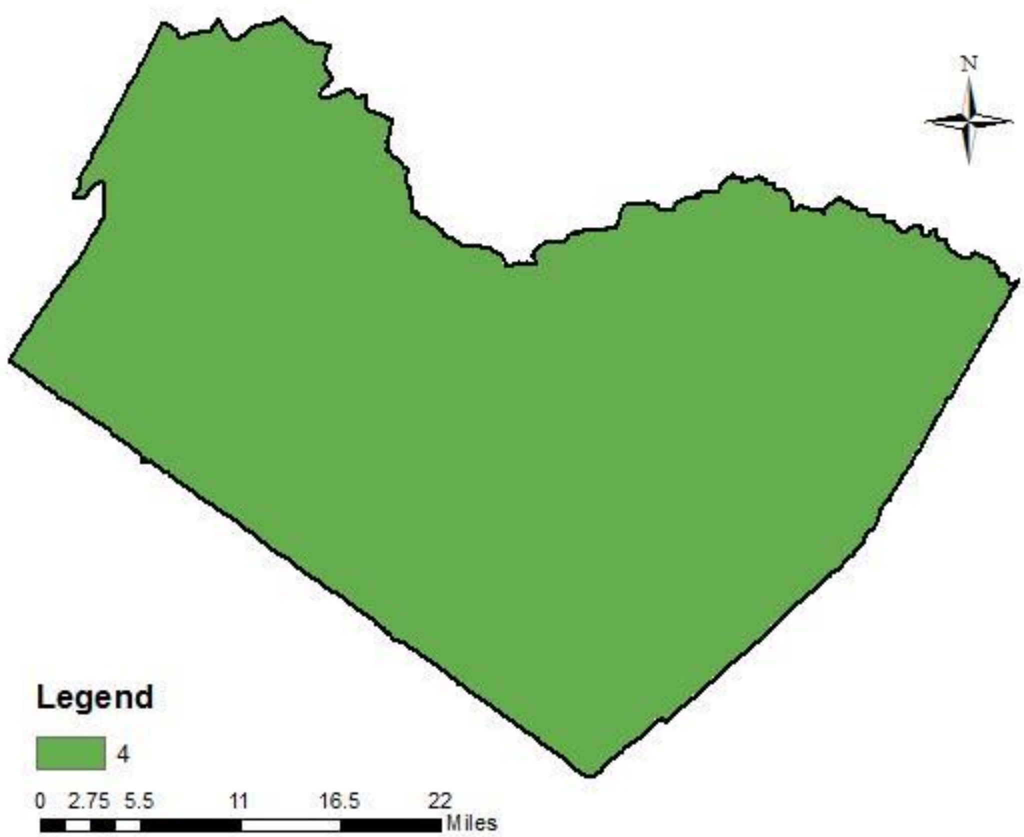


Figure 2. Depth to groundwater in units of DPPI.

Net Recharge

Net recharge ranges for Travis County were given by the Bureau of Economic Geology. All of the annual net recharge values, however, fell within the lowest range for net recharge in the DRASTIC scheme (less than two inches per year). Therefore, a raster comprised only of the single lowest rating value was used to represent the net recharge. At some times of the year, the net recharge rates might be high enough to contribute a few more DPPI points, but it is insignificant and would require a lot more processing time.

Figure 3. Net Recharge in units of DPPI.

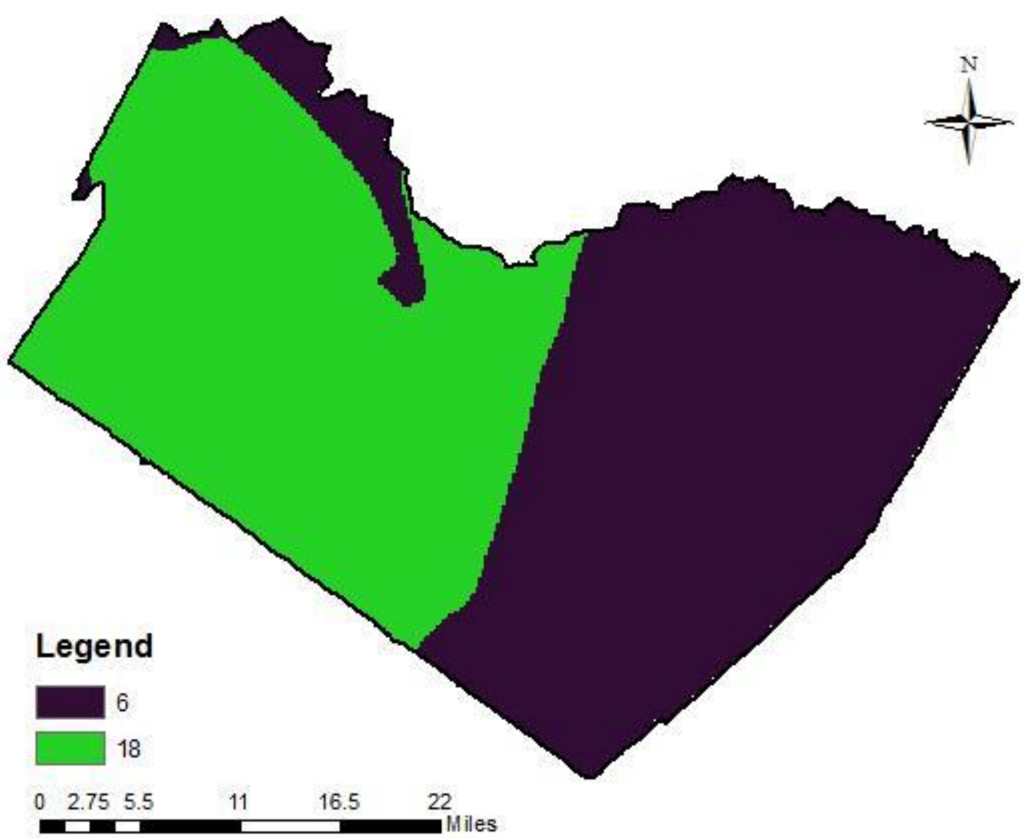


Aquifer Media

There was not much data online available for aquifer media. There is some very general data available from the Nationalatlas.gov website which gives rough composition for all of the aquifers in the conterminous United States. The aquifers in Texas are probably much more complicated than to be separated into just two different media, but it was the only data on aquifer media composition I could find. Another flaw in the given data is that it lumps all impermeable media into a single label. The data can be locally permeable, and some materials may be more permeable than others.

According to the data from National Atlas, the major component in the downdip is impermeable, which makes sense, and the major components of the Trinity and Edwards outcrop regions are limestone. Even though the strokes of the dataset are very broad, it probably is not a terrible assumption to use only these two classifications.

Figure 4. Aquifer Media in Units of DPPI.



Topography

The topography data was the easiest to acquire from the National Elevation Dataset (USGS). Two blocks of data (~300 MB each) were downloaded directly from the USGS website. The dataset was moved to the correct spatial reference, and then the ArcGIS slope tool was used to determine the percent slope of all points from the NED. This dataset, like a few of the datasets, required nested conditional statements in the raster calculator to compile the elevation data into more meaningful DPPI units. The nested conditional loops were incredibly useful because of the tiered ranking system defined by the DRASTIC rating parameters.

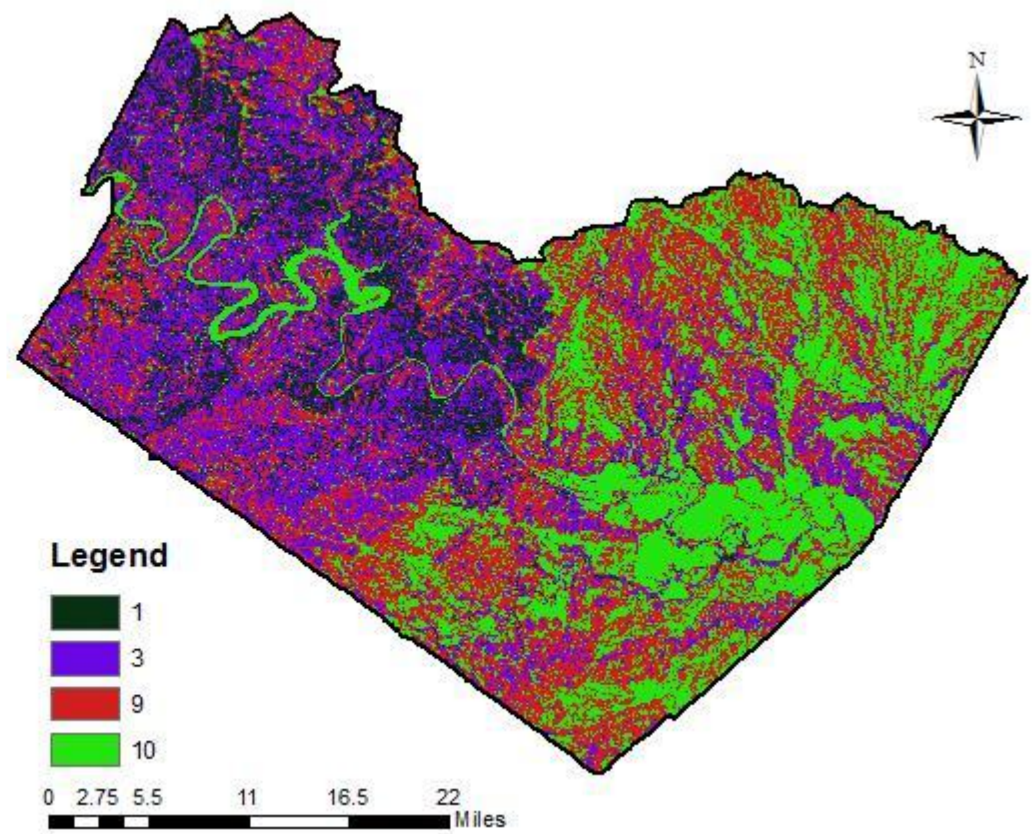


Figure 5. Topography in units of DPPI.

An interesting thing to note about the topography data is that it becomes much flatter towards the east. An almost immediate transition in percent slope occurs exactly at the line that marks a major composition change in the aquifers.

Soil Media

The soil media data was also relatively easy to access online (SSURGO from NRCS Soils). The soil classification system was the hardest part of this component of the soil media component. I searched for hours and hours for a table that I could use to decipher the classification system used by NRCS and most soil scientists. I was unable to find any such table or program that could help me. Therefore, I was relegated to searching then manually translating soil keys to DPPI values.

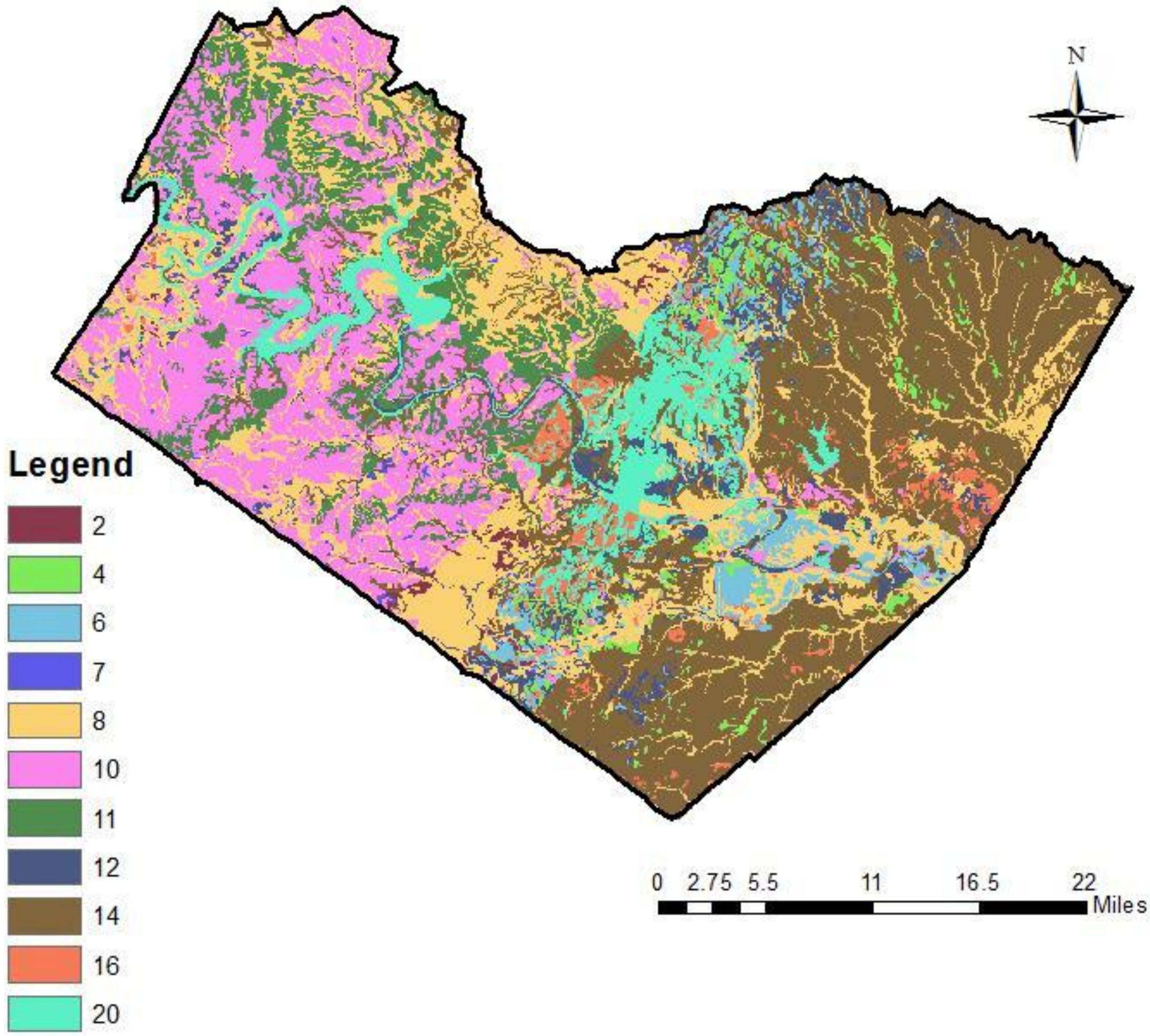


Figure 6. Soil Media in Units of DPPI

Downtown Austin shares the highest rating with other regions which have no soil (like Lake Travis). Unfortunately, I believe this is due to the composition scheme that NRCS uses. It classifies pavement and buildings as “no soil”, which is true, but in the DRASTIC classification scheme, “no soil” receives the highest rating.

Hydraulic Conductivity and Impact of the Vadose Zone

More than any others, these two components of the DRASTIC rating system were elusive. Hydraulic conductivity can be modeled in MODFLOW, which I am unfamiliar how to use; the vadose zone data, however, was completely absent from any online GIS database. A lot of experimental papers and DRASTIC studies were able to get values for the vadose zone, but each of these sources always listed a book or governmental agency as a source of its data, so I believe that this data exists, yet almost no one has a need for it, so it never became publicized. It is very unfortunate that this data is not readily available because both the hydraulic conductivity and vadose zone parameters are heavily weighted (4 and 5 weighting, respectively). The outcome could be almost 35-40% higher with extreme values for these two parameters.

Final DRASTIC Map

Neglecting Hydraulic Conductivity and the Vadose Zone

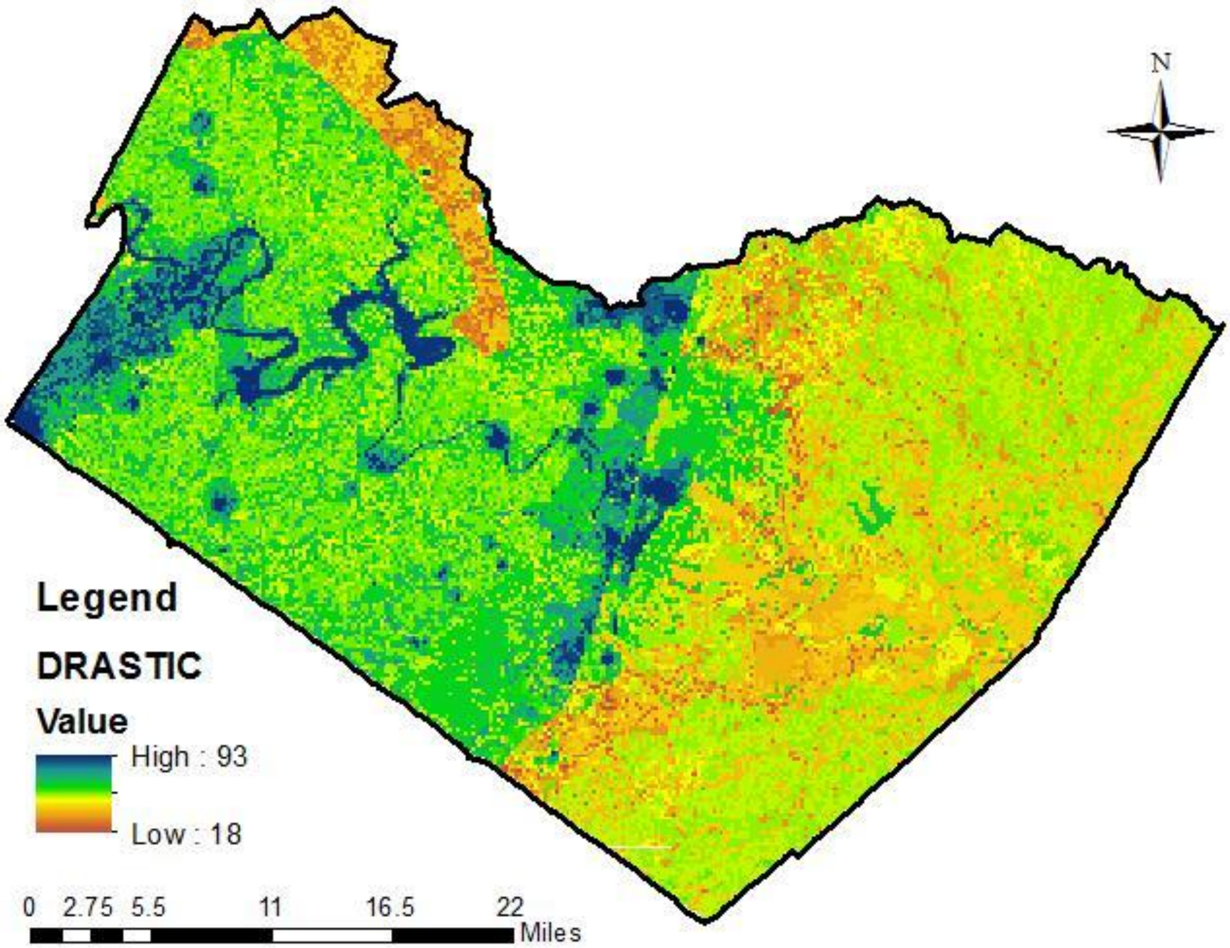


Figure 7. Combined DRASTIC Map

The maximum value that any point could have, with only the five parameters involved, is 150. Also, since the depth to the water table is the dominating factor in the absence of hydraulic conductivity and vadose zone data, the points that had very low depth to water table values are the points that have the highest DPPI. For the most part, almost all of Travis County is below half of the maximum possible DPPI.

Discussion and Future Work

Travis County, from a partial DRASTIC assessment, appears to have few regions that require attention. Of course, given more complete soil and aquifer data, this assessment could definitely find a drastically different result. For this reason, more data needs to be made available online in an easily accessible and useable format. Another key component of any model is comparing model outputs to laboratory procedures and sample results. If the DRASTIC output matches poorly with groundwater samples and contaminant concentrations, then the model simply is not capable of taking into account all of the critical physical parameters.

Another interesting application of this research is matching the amount of money spent over the county, and seeing if it matches well with the DRASTIC map. I think that DRASTIC maps have a large potential to improve how companies and the government allocate spending for remediation and mitigation.

References Listed

Ashworth, J., Hopkins, J. 1995. Report 345: Aquifers of Texas. Texas Water Development Board. Available from: < http://www.colorado.edu/geography/gcraft/warmup/aquifer/sources/R345.pdf >.

Atkinson, F. S., Thomlinson, J.R., 1997. An Examination of Ground Water Pollution Potential Through GIS Modeling.

CAPCOG. Data, Maps, and Reports. Available from: <http://www.capcog.org/data-maps-and-reports/geospatial-data/>.

Dutton, A., Scanlon, B. 2000. Groundwater Recharge in Texas. Bureau of Economic Geology. Available from: <http://www.beg.utexas.edu/environqlty/vadose/pdfs/webbio_pdfs/TWDBRechRept.pdf>.

EPA. 1987. DRASTIC. A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings. USEPA.

New Mexico State University. DRASTIC Informaton 2003. Available from: <http://rio.nmsu.edu/Website/nmda/nmda_website/drastic.html#Vadose>.

NRCS. Soil Legend.

US Dept. of Agriculture. 1981. Soil Survey of Washtenaw County, Michigan. Nat. Sci.