Final Project - Disaster Management

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**Statement of Problem**

**Discipline**

The problem chosen was the issue of disaster management in Maricopa County, Arizona, in case of a nuclear meltdown or other disaster at the Palo Verde nuclear station. In this case I made two maps: one to address the immediate need of medical evacuation to hospitals with both the equipment and capacity to treat victims of radiation poisoning, and one to allow the authorities to evaluate the potential contamination of water sources in the area. I chose this problem because as someone with an interest and background in politics and public policy, as well as an interest in climate change and therefore movement away from fossil fuels, I think nuclear energy is both important in this transition but is also a technology with a lot of potential hazards that I think are not examined critically enough, mostly out of complacency.

**Question**

This is an obvious problem to address with spatial data. In fact I’d argue that spatial data is the only logical way to address it. Here we used spatial data of several types (municipal boundaries, roads, buildings, bodies of water, geographic features like watersheds, etc.) to present actionable information in the form of maps. We use the point representation of buildings, color coded by hospital type, overlaid on the major roads and highways, to allow dispatchers to guide ambulances to appropriately equipped facilities, along the fastest routes. In the other map, the outlines of the water sheds as well as the significant flowing water sources and lakes will provide authorities with the required knowledge of hydrology to evaluate potential contamination of the water sources in Maricopa and surrounding areas.

**Data**

**Spatial Data**

There were several types of spatial data used here. The counties dataset was used for both maps, specifically to get the outline of Maricopa County. I also created and uploaded a CSV file with the coordinates of Palo Verde, which I used to put a pin in the map and base the 3-layer buffer around, which represents the contamination zones. Then for each map there was a different focus for the remainder of the data, as described above. In the Methodologies section I have a table describing each dataset. But generally, they were a mixture of points, lines and polygons designed to represent point features like buildings (specifically hospitals), linear features like roads, streams and rivers, and polygonal features representing things like the county, the watersheds (although this may appear more linear on the map due to how I chose to make it appear) and lakes.

I don’t know that it’s “different” from other types of spatial data; these are fairly standard sorts of datasets. However, they are specific to the problem being addressed, and fairly basic, in that they didn’t require much manipulation outside of some subsetting and SQL queries. But most of this data also seemed to be collected through government bodies like the USDA or the Census Bureau, as opposed to independent data collection, which is perhaps an important difference.

**Organization**

The organization of data on the map was important here, as the order of the data in the contents pane dictates how it’s written on the map. If something is placed above something else, it will physically cover it in the map. This was important when, for example, making sure that highways were visible as a separate layer on top of major roads, because highways were actually part of the major roads dataset, but needed to be distinguished separately. In this sense, the type of data affects the organizational technique when it comes to drawing order.

Also, the contents pane needed to have data elements clearly renamed, and unused features (i.e. main datasets after a subset was converted to a feature layer) removed, as such:

Graphical user interface, application, Teams

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Description automatically generated

The actual data in the project was organized in a geodatabase for the project, and the files were organized within a folder structure external to the geodatabase:

Graphical user interface, application

Description automatically generated with medium confidenceGraphical user interface, application

Description automatically generated with medium confidence

Unfortunately I was unable to find a way to organize this by folders within the geodatabase itself, which is strange to me, because given the number of clips and feature exports, it would have been useful to be able to categorize things by topic (hydrology, transportation, etc.) within the geodatabase similar to the way they are organized on the computer (right-side screenshot), but I’m actually not sure it’s possible. I spent a lot of time trying to figure this out and was unable to. However, in general, having your files organized and accessible is critical to having your project be organized and successful. Again here the type of data affects the organizational techniques to some extent; it should be organized in folders according to theme (“type” is kind of an ambiguous word) in order to make access easier.

**Quality**

The quality of the data was reliable, as most of it was given through SNHU. Other data that I got from other sources, specifically the location of Palo Verde and the watersheds dataset, were also from reliable sources. I got the latitude and longitude of the station from Google Maps, and the watersheds data was gotten through ArcGIS Online, and the metadata says it’s from the USDA, and a group called FracTracker, which is a non-profit specializing in geospatial data and data analysis related to fracking and the oil and gas industry. In a scenario like this, if this were a real project, reliable data would be absolutely critical. If lives could be at stake, you would want to be absolutely sure of your data source. Less existential but still important, large amounts of money being invested in a project of any kind would require quality data from a reputable source. Using the most current data possible, unless the problem statement specifies otherwise, is also an important consideration in any data science project.

**Methodologies**

**Outline**

Because the data did come from reputable sources, there wasn’t much cleaning that needed to be done. I did check the attribute table of each dataset for things that looked wrong, but as far as I could tell it was fine (I’m used to doing these things in Python so it’s possible I could have missed something). However they did all need to be changed to the same coordinate system and projection, which here was NAD 1983 StatePlane Arizona Central FIPS 0202 (US Feet). The watersheds dataset I got needed to be copied using the Copy Features geoprocessing tool to make a new feature layer before I was able to use it. I’m not sure why this was, but once I did that it worked fine. The CSV I made with the latitude and longitude of the station worked once I set the XY data. Other than this, no manipulation or setup of the raw data was required before being able to use it.

**Data Sets**

As described above, I had many data sets. A few were used for both maps, but most were for one or the other. Below is a table outlining them:

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Geometry Type** |
| **Both maps** |  |  |
| Counties/MaricopaBorders | A feature class subset from the larger Counties dataset | Polygon |
| Palo Verde Location | The latitude/longitude of the station, used as a center point for the multiple-ring buffer | Point |
| **Medical map** |  |  |
| Hospitals | Hospitals in Arizona, subset to the specific parameters required by the problem (capacity, etc.) | Point |
| Major Roads | Major roads including highways, secondary and local roads. | Line |
| Highways | Highways and interstates specifically | Line |
| **Water Map** |  |  |
| Major Rivers | Rivers | Line |
| Major Streams | Streams | Line |
| Major Water Bodies | Lakes | Polygon |
| Watershed Borders | Borders of all watersheds in the county | Polygon |

I did not use any joins here, because it wasn’t necessary. There was no useful data to be gathered by combining any two of these in a spatial join because I wasn’t doing any querying that would require both sets of data to be in the same table. Each was sufficient independently given the type of map being produced and the specific questions being answered.

**Geoprocessing Tools**

There were quite a few geoprocessing tools that I used. I will reuse the screenshots that I put in my previous milestone, as this part of the map was completed several weeks ago and I don’t have any new geoprocessing screenshots to share.

The principal ones used were clip and buffer. The buffer tool was used to make the three-layered rings representing the three contamination zones around the nuclear station. Each ring represents one of the specified zones:

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Diagram

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Once this feature was created I reused it in the other map, as the basic layout was the same and both required this feature.

The other tool I used a lot was clip, because each map had multiple features that extended beyond Maricopa County, which is the specified boundary of the map. Here is an example: in the top screenshot you can see Maricopa county with the Main Roads feature overlaid in brown. They clearly extend beyond the borders. So after using the clip tool you can see they’re confined to the boundary of Maricopa County. The topographical basemap conveniently has those major highways anyway.

Map

Description automatically generatedMap

Description automatically generated

Highways, roads, rivers, streams, and watersheds also required the use of this tool to fit within the constraints of the county borders.

I also used the select by attribute in a key way, and although that’s not technically a geoprocessing tool, it was a major tool in general and should probably be mentioned. I used this to narrow down which hospitals should be featured in the hospital map, based on capacity:

Graphical user interface, text, application, email

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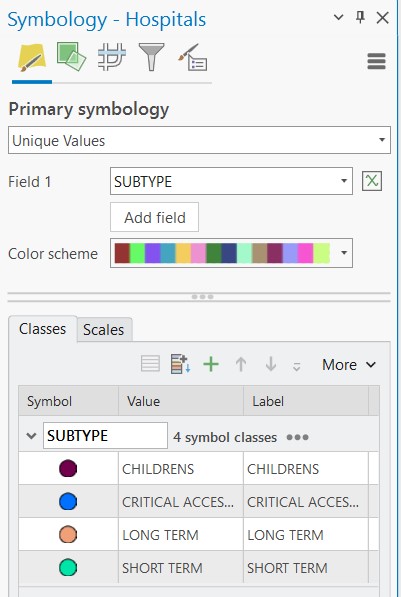
After this I filtered according to subtype, as I’ll show below in the symbology section. I made sure to only include types of hospitals that were actually medical hospitals, because things like rehab clinics and psychiatric hospitals were also part of this dataset, but these would not be equipped to treat medical patients. The project requirements stipulated that all of the hospitals had to be outside of the evacuation zones, but after doing this filtering there were none in the evacuation zones, and that parameter didn’t need to be filtered for.

I also used the select by location tool to select the major water bodies that were adjacent to the Maricopa county borders because those connect to the water sources within the county and are integral to the problem, but I excluded everything else outside the borders.

**Symbols**

The primary uses of symbology here were to differentiate the hospitals by type, and the graduated colors of the buffers. However before discussing the larger use cases, it’s worth mentioning that color choice in maps with this many features (which isn’t even that many, but it’s enough to require some consideration) was important even in contrasting roads versus highways, or the various water sources, and in general it was important to choose colors that could be visible under the buffer colors and wouldn’t get confused with them.

The symbology used to categorize the hospitals was as follows:



Which resulted in this:

Diagram

Description automatically generated

I chose a color palette that would stand out from the red/orange/yellow of the buffer, but also had decent contrast with the pink and brown of the road features. I used circles because I just like circles and thought it was a simple and effective shape to use for this, as opposed to triangles or something else.

With the buffer, I used the following:

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Description automatically generated

The color choice just seemed kind of obvious for the scenario. I made sure to overlay the features like roads, rivers etc., instead of allowing it to cover them, because the elements within the evacuation zones are obviously important as well.

With the water map, I used most of the same concepts, except in this case, as you can see in the map below in the following section, I chose to make the watershed borders dashed lines instead of filled polygons or solid lines, for the sake of aesthetics (filled polygons would be ugly) and readability (there are already two line features).

**Maps**

Medical Evacuation Map:   
 Diagram

Description automatically generated

Water contamination map:

Diagram

Description automatically generated

**Best Practices**

The best practices that I tried to pay attention to, other than making sure to include things like the legend, metadata, title, north arrow, etc., were readability, contrast and distinctness of features, and trying to keep it uncluttered.

I wanted obvious and eye-attracting colors for the contamination zones, but also distinct and contrasting colors for the similar-looking features like rivers, streams, and watershed borders. I also liked the design aspect (and practicality) of using the border of Maricopa County in bold as the basic outline of the map, although in a real-life project I would have argued in favor of extending the roads beyond the border of Maricopa County, due to the possibility of needing to take people elsewhere for any number of reasons. I also tried to minimize unused white space around the map. The north arrow, scale, and legend were not things that I knew how to do in ArcGIS at the time I submitted the previous milestone, but I know that these are key things on any professional map.

The clutter was a pretty important consideration, because I’d thought about adding some additional features because here it seemed kind of simplistic. However, the problem statements are pretty straightforward, and less is often more if you’re dealing with an emergency like this would be. The ability to just easily isolate where a hospital is, or where a highway is, or which rivers feed into which lakes, which are the problems at hand, is more important than just stuffing as much information as possible into the map. As someone who does python-based data analysis I tend to like doing feature engineering to get new insights that may not be there in the raw data, but that is a different environment than this and I had to remind myself of that.

**Conclusions**

**Observations**

I’m not sure exactly what’s being asked here – if I need to make observations about the literal maps, or observations about information that can be seen in the maps. I’ll assume the latter, so forgive me if that’s not right. With regard to the medical evacuation map, the interesting thing, which is a big relief, is that the main population cluster in Maricopa (based on the layout of the roads) is outside of the specified radiation zones, and that includes the hospitals. It’s also worth noting that all the hospitals are in one direction – east/northeast, with none to the north, south, or west. That means that keeping the roads open to the north and the east out of the evacuation zone will be critical. We can also see that the majority of the hospitals are short-term, which means they may lack some important equipment.

With the water map, I have no background in hydrology whatsoever (don’t tell Maricopa) so it’s harder for me to make meaningful observations and recommendations with it, but I take note of the Theodore Roosevelt Lake in the northeast of the county, which I assume would be an important fresh water source in a scenario like this. I had been looking for a better topographic map to use instead of the basemap to maybe be able to glean how water be flowing, but I couldn’t find one. We can also see that there are no major water bodies within the contamination zone, although the river does flow through it, and there are five watersheds that are partially within it, which is a significant number.

**Recommendations**

My recommendations in the medical evacuation scenario would begin with noting that the hospitals are all located in one direction, with routes out of the evacuation zone to the north and to the east. It will be important to have a contingency plan in place to make sure those routes stay open enough for ambulances to pass. Part of that may require having evacuation orders in place for the general population beforehand to utilize if possible to keep the roads clear. Since the majority of the hospitals in this area are short term, not long-term or critical, there should be a plan in place to make sure that equipment can be moved in that will help them sustain patients for at least the medium-term if need be, while arrangements are made to move patients elsewhere in the state.

In the water contamination scenario, again pardoning myself somewhat for lack of hydrology knowledge, I think the important things to note are the fact that the river that runs all the way through the state spends quite a bit of time running through the contamination zone. We should look at Theodore Roosevelt Lake, which is on the other side of the Mazatzal Mountains, as the best option for fresh water here. Additionally, knowing the properties of each watershed and how much of each is contained within the radiation zones will help them to determine the degree of contamination. There are several watersheds that are entirely outside the contamination zone, so these should be monitored as radiated water may flow through these areas.

Data Resources

FinalProjectData (2020). [Downloaded File] from *Mastering* *ArcGIS Pro* via SNHU. Price, M. McGraw Hill Education.

AZ\_Watershed (2014). [Downloaded File] USDA, US Census Bureau from ArcGIS Online. URL: <https://www.arcgis.com/home/item.html?id=65825bde5b154d03a790a0ed28029537>