Planning and Mitigation for Emergency Situations and Natural Disasters in Hennepin County, Minnesota Utilizing GIS

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Abstract

Hennepin County is the most populous county in Minnesota with over 1.1 million inhabitants, which is one-fifth of the state's population. Hennepin County contains a large portion of the seven-county metropolitan area. The metropolitan or Twin Cities metro area accounts for 60 percent of Minnesota's population and is the sixteenth largest metropolitan area in the United States. The size and population of Hennepin County makes it vulnerable to a number of emergency situations. This study details the steps and methodologies needed to develop an efficient Geographic Information Systems (GIS) database, a risk suitability assessment map, and a model identifying vulnerable areas that could be utilized by Hennepin County in the event of a disaster.

Introduction

A disaster can strike with little to no warning or can be known well in advance but still impact thousands of lives (Givens, 2009). In the 1990s, it was estimated that 535,000 people were killed worldwide in natural disaster events with over $684 billion of losses as a result of direct damages (Cutter, 2003). A disaster is a "single large scale, high impact event" (Cutter, 2003). Due to the effects of disasters in the last two decades, emergency manager's training, preparation, and mitigation techniques have bloomed across the United States (Cutter, Mitchell and Scott, 2000).

To accommodate the needs of any disaster, emergency planners are making use of Geographic Information Systems (GIS) software (Newsom and Mitrani, 1993). GIS software can store multiple datasets, allowing emergency personnel to access data for any area in a fast and manageable manner (Cutter, 2003). In addition, Johnson (2000) states GIS software can store information for multiple emergency situations such as: human-caused, natural disasters, internal disturbances, energy and material shortages, and attacks. A GIS allows emergency planners to locate hazards and assess areas based upon their hazards and the potential of a disaster or emergency event (Johnson, 2000).

Hennepin County Emergency Preparedness

Hennepin County is the most populous county in Minnesota with more than 1.1 million inhabitants and one-fifth of the state's population (U.S. Census, 2006). Most importantly, Hennepin County

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contains a large portion of the seven-county metropolitan area. The Twin Cities metro area accounts for 60 percent of Minnesota's population and is the sixteenth largest metropolitan area in the United States (U.S. Census, 2000). The total land area of Hennepin County is 557 square miles with 2,004 persons per square mile (U.S. Census, 2000).

The mission of the Hennepin County Emergency Preparedness Division is to mitigate and plan for disasters to ensure personal and property safety in the event of an emergency (Rue, 2009). Hennepin County utilizes various mitigation techniques to ensure the safety of its citizens. Koxvold (2008) states the Emergency Preparedness Division takes part in the following emergency plans: the Business Community Plan, the Pandemic Flu Plan, and the Monticello Nuclear Facility Emergency Plan. Additionally, the Emergency Preparedness Division completes a mitigation plan detailing the hazards within Hennepin County every five years (Bovitz, 2009).

Until recently, the Hennepin County Emergency Preparedness Division did not have an efficient technology-based system in place despite having personnel and data available (Rue, 2009). The division had been using a large assortment of digital and paper maps containing information pertaining to emergency management and/or homeland security (Rue). The digital and paper maps provided mitigation techniques utilized by Hennepin County but were no longer useful in the event of a disaster (Rue).

In August, 2007, the Interstate 35-W bridge collapsed without warning leaving emergency planners in chaos (Givens, 2009). Givens cites communication and methodology techniques as the two largest issues after the bridge collapse, not personnel and data availability. After the bridge collapse, the Hennepin County Emergency Preparedness Division reassessed their emergency mitigation and preparation methodologies and techniques (Rue, 2009). During this time, GIS was considered as a tool to organize Hennepin County's mitigation and preparation methodologies in the event of a future disaster or emergency event (Rue).

Emergency Management Models

Gunes and Kovel (2000) convey the strength of GIS in that it can capture, store and manipulate data, and form data queries. Accessibility for the GIS user allows for ease of integration, storage, and processing needs (Gunes and Kovel). In addition, a GIS can assimilate large amounts of data from multiple sources and display the information uniformly (Gunes and Kovel). The combination of "GIS with a model makes both technologies more powerful than if used alone" (Newsome and Mitrani, 1993).

Emergency management models are commonly used to produce evacuation routes for cities in the event of a large-scale disaster (Pal, Graettinger and Triche, 2002). However, models can be used to accommodate any emergency situation or disaster for a wide array of locations (Newsome and Mitrani, 1993). For example, a model implemented by Cutter (1993) included a hazards model of vulnerability incorporating both biophysical and social vulnerabilities at the local level (Cutter et al., 2000).

Methods

Data Acquisition

Hennepin County has several GIS datasets that are properly maintained; however, they are not distributed to outside departments or divisions within the county. The data is stored in a departmental repository which may be sent to internal departments or external organizations upon request. To assist the Emergency Preparedness Division, several GIS datasets were requested to create an Emergency Preparedness data repository.

Some GIS datasets were acquired by the transferring of datasets from the Department of Environmental Services (DES) and the Human Services and Public Health Department (HSPHD) servers to the Emergency Preparedness server. To maintain the accuracy of the DES and HSPHD datasets, additional transferring between the servers will occur on a biannual basis. Other GIS datasets were acquired through a database connection to the GIS Division's server. The datasets acquired from the GIS Division are updated immediately after modification due to their distribution via a database connection. Other GIS datasets were acquired through the Metro Datafinder GIS Server (Figure 1).

To ensure each dataset was available in a disaster, the Emergency Preparedness GIS data server was backed up to a secondary server. The backup server serves as a secondary source to access GIS data in the event that the primary server is not available.

In addition to the acquisition of datasets, new datasets and address locators were created to better serve the needs of the Emergency Preparedness Division. One dataset vital to the Emergency Preparedness Division's business line was creating a dataset with the location of 302 facilities, otherwise known as hazardous materials facilities. The Minnesota Homeland Security and Emergency Management Division (HSEM) provided a list of addresses of 302 facilities within Hennepin County. The addresses were then geocoded in the 302 facilities address locator utilizing Hennepin County's street network dataset for its reference data (Figure 2).

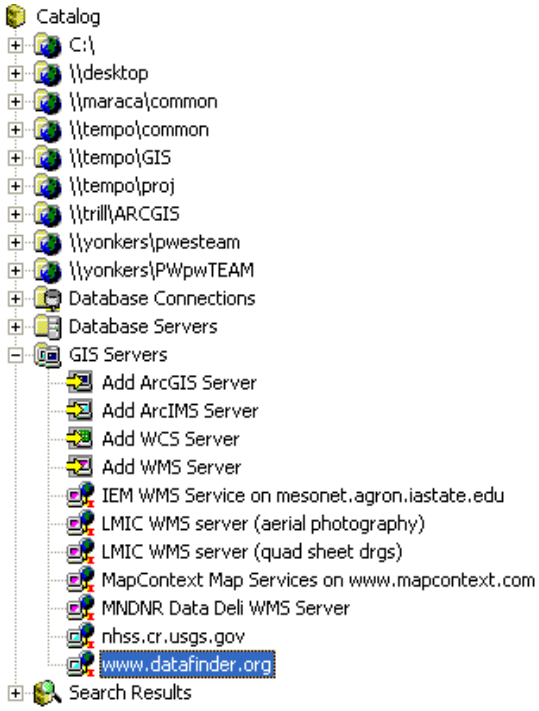

Figure 1. The Metro Datafinder GIS Server connected to the www.datafinder.org website.

After the datasets were located or created, data editing took place. Data editing consisted of moving points for each geocoded dataset from a location alongside a street to its appropriate parcel (Figure 3).

In the event of a disaster, metadata is essential in distributing or utilizing GIS datasets. Metadata can verify the dataset's accuracy and completeness. Most importantly, metadata stores information about the

dataset. After each dataset was acquired, created and/or maintained, metadata was properly documented. Metadata was compiled within the Minnesota Geographic Metadata Guidelines (MGMG) editor utilizing the MGMG standards.

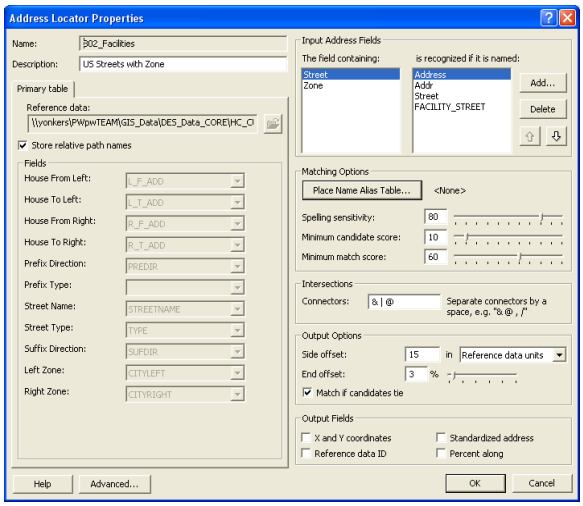

Figure 2. The address locator compiled for Hennepin County's 302 facilities utilized the Hennepin County street network for its reference data.

Figure 3. The editing process consisted of transferring offset points from a location along a street to a parcel.

Mitigation Plan

Once datasets were acquired, maps were created to spatially illustrate the boundary, demographic and hazard information for the 2010 mitigation plan. The 2004 mitigation plan included maps but they were located at the end of the plan and were irrelevant to the remainder of the document. The lack of spatial information, such as cartographic maps, in the 2004 mitigation plan made it rarely used by emergency managers after its creation. The plan contains mostly text and does not provide emergency planners with a rapid response in the event of an emergency. One of the objectives for the 2010 mitigation plan was to utilize the spatial information available to Hennepin County and incorporate it throughout the entire plan.

A second objective of the 2010 mitigation plan was to distribute a digital version of the plan on Hennepin County's external website instead of distributing in its normal binder form. A software program, Flippingbook PDF Publisher™, was utilized to imitate an electronic book, flipping pages of a PDF document electronically.

In previous mitigation plans optional sections such as hazard assessments were not conducted. For the 2010 mitigation plan, a flood hazard assessment was conducted that included key infrastructure for each municipality within the county.

To identify the vulnerable areas within Hennepin County's flood hazard assessment, key infrastructure datasets were located utilizing the ArcGIS™ Select by Location tool (Figure 4). Each infrastructure dataset located within the 100 and/or 500 year Federal Emergency Management Agency (FEMA) flood zone area had their spatial and tabular information recorded for distribution to each municipality.

Assessment Map

To assist the Emergency Preparedness Division in mitigation, a vulnerability assessment map was created. The assessment determines vulnerabilities for each parcel within Hennepin County.

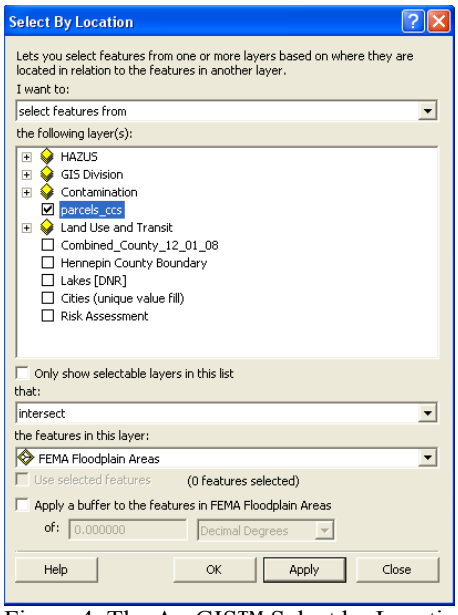

Figure 4. The ArcGIS™ Select by Location tool identifying parcels intersecting the FEMA flood zones.

To determine vulnerable areas within the county, 38 datasets were selected from the Emergency Preparedness data repository. Some of these datasets include 302 facilities, churches, hospitals, land use, schools, and shopping centers. Each dataset was given a weighted value depending upon its vulnerability if an emergency or natural disaster were to occur (Appendix A).

Next, the parcel dataset was copied remotely to the computer's desktop from the Hennepin County Survey Division's server. In the ArcGIS™ software, 39 fields were created: 38 short integer fields were created for each vulnerable dataset and 1 double field was created to calculate the 38 vulnerabilities into a final emergency rank.

Each dataset utilized the ArcGIS™ Select by Location tool with the Hennepin County parcel dataset. If the dataset intersected spatially with the parcel dataset, the weighted value was calculated into its individual field created within the parcels dataset. However, two datasets had a different spatial process.

A rate code was established determining a parcel's land use of agriculture, commercial retail, industrial, institutional, lodging, medical, office, recreational, and/or residential use. The land use dataset utilized the ArcGIS™ Select by Attribute tool to determine the rate codes containing lodging, institutional, industrial, office, and commercial/retail. Then, a Select by Location was conducted to determine the parcels that fell within the selected rate codes. All of the parcels containing the rate codes were given a weighted value of one and were added within the parcels attribute table. The same process was conducted to determine parcels containing residential and medical land use (Figure 5). All of the parcels intersecting the residential and medical uses were given a weighted value of two. The methodology was conducted in this order to ensure that residential and medical land use received the highest rank of two in the event a parcel had two or more land uses.

Emergency sirens are located throughout Hennepin County and in the event of severe weather in the area will sound to alert businesses and residents. The Select by Location tool within ArcGIS™ was used to identify parcels that fell within the siren zones. Then, the Switch Selection tool was utilized to determine which parcels did not fall within any of the emergency siren zones (Figure 6). The areas outside of the siren

zones cannot hear the emergency siren sound and are at high risk if the businesses or residents do not know of approaching severe weather. Therefore, parcels outside of the siren zones were given a weighted value of four.

"RATE_CODE" = 200 OR "RATE_CODE" = 201 OR "RATE_CODE" = 202 OR "RATE_CODE" = 203 OR "RATE_CODE" = 204 OR "RATE_CODE" = 206 OR "RATE_CODE" = 207 OR "RATE_CODE" = 208 OR "RATE_CODE" = 209 OR "RATE_CODE" = 600 OR "RATE_CODE" = 601 OR "RATE_CODE" = 602 OR "RATE_CODE" = 603 OR "RATE_CODE" = 604 OR "RATE_CODE" = 640 OR "RATE_CODE" = 642 OR "RATE_CODE" = 643 OR "RATE_CODE" = 645 OR "RATE_CODE" = 647 OR "2030_RATE" = 200 OR "2030_RATE" = 201 OR "2030_RATE" = 202 OR "2030_RATE" = 203 OR "2030_RATE" = 204 OR "2030_RATE" = 206 OR "2030_RATE" = 207 OR "2030_RATE" = 208 OR "2030_RATE" = 209 OR "2030_RATE" = 600 OR "2030_RATE" = 601 OR "2030_RATE" = 602 OR "2030_RATE" = 603 OR "2030_RATE" = 604 OR "2030_RATE" = 640 OR "2030_RATE" = 642 OR "2030_RATE" = 643 OR "2030_RATE" = 645 OR "2030_RATE" = 647

Figure 5. The land use rate codes determining the residential and medical parcels in Hennepin County.

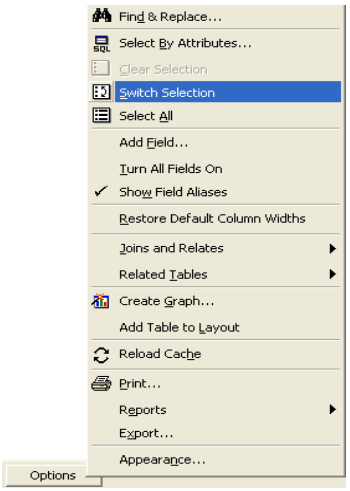

Figure 6. The ArcGIS™ Switch Selection tool was utilized to determine which parcels were located outside the emergency siren zones.

After each dataset was processed through the ArcGIS™ Select by Location and field calculation process, the double field named 'EM_RANK' was calculated. The 'EM_RANK' field summed each of the 38 vulnerable datasets together to determine the final emergency rank for each parcel (Figure 7).

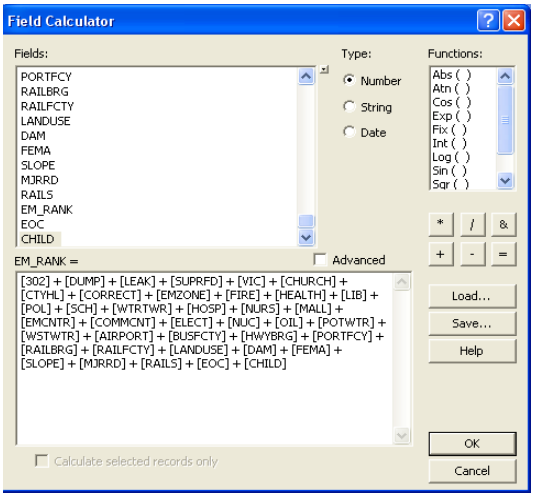

Figure 7. The ArcGIS™ field calculator calculating the 39 vulnerable datasets to determine the emergency ranking for each parcel within the 'EM_RANK' field.

Assessment Models

Due to the nature of mitigation procedures, the assessment map will alter over time. Datasets will be created and edited and some will no longer be vital in mitigation planning of the Emergency Preparedness Division.

To preserve the assessment and allow the GIS user to perform the assessment on a biannual basis, a model was created within the ArcGIS™ Modelbuilder program to serve the future needs of the Emergency Preparedness Division.

An Emergency Preparedness Toolbox was created and it contains two models carrying out the same methodology conducted to create the assessment map allowing a GIS specialist to conduct the same processes with relative ease in the future (Figure 8).

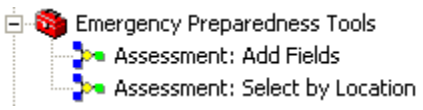

Figure 8. The Emergency Preparedness Toolbox.

The first model copies the parcel dataset from Hennepin County's Survey Division server remotely to the user's desktop and renames the shapefile Assessment_Parcels.shp. This procedure ensures the parcels are the most up-to-date parcel dataset available within Hennepin County.

Next, the model adds a field for each of the 38 vulnerable datasets including one for the final emergency ranking, giving each field a unique name. Of the 39 fields created, 38 were given short integer fields and one double field was created for the final emergency ranking named 'EM_RANK.'

The second model utilizes the ArcGIS™ Select by Location tool for each of the 38 datasets corresponding to the Hennepin County parcel dataset. Utilizing this tool, 36 of the datasets selects the parcels intersecting them. If the parcels contained the dataset their individual field receives a ranked score shown in Appendix A. Similar to the methodology of the assessment map, two of the datasets – land use and the emergency siren zones – underwent a different spatial process as indicated in the assessment map methodology.

Next, the double field, 'EM_RANK' calculates all 38 vulnerable datasets to determine the final emergency rank for each individual parcel within Hennepin County (Figure 7). Lastly, symbology is assigned to each parcel depending upon the score it receives in the 'EM_RANK' field (Figure 9). In future processes the range of values from low to high risk for the 'EM_RANK' field will need to be altered if weights or datasets are modified since the last assessment was conducted.

Results

Emergency Preparedness Data Repository

The Emergency Preparedness data repository contains 36 file geodatabases with 139 GIS datasets (Figure 10). The repository contains datasets that were utilized for the county-wide hazard assessment and the 2010 mitigation plan. Datasets will be continually added as they become available to the Emergency Preparedness Division.

Figure 9. Assigned symbology within the 'EM_RANK' field defined as either low (green), moderate (yellow), or high (red) risk parcels.

Mitigation Plan

The 2010 mitigation plan contains a series of boundary, demographic and hazard maps utilizing GIS datasets from the Emergency Preparedness data repository (Figures 11 and 12). The plan serves as a great visual and informative tool to emergency personnel.

The 2010 plan contains a community profile detailing boundary and demographic information pertaining to Hennepin County. The community profile also provides a brief description of each municipality within Hennepin County.

Additionally, the plan lists each hazard in detail and contains an identifying map showing the locations of each hazard. For instance, flood zones were mapped to identify the extent of Hennepin County that fell within the flood zone area (Figure 13). Other

hazards included in the mitigation plan include dams, droughts, earthquakes, extreme temperatures, hazardous materials, infectious diseases, radiological facilities, terrorism, thunderstorms, tornadoes and winter storms.

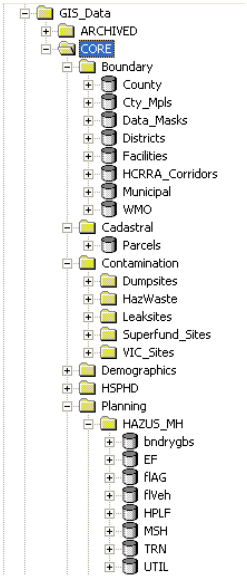

Figure 10. An excerpt of the Emergency Preparedness data repository containing 36 file geodatabases and 137 GIS datasets.

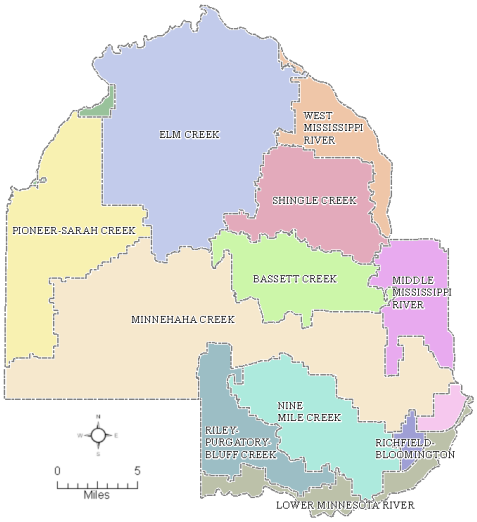

Figure 11. The watershed boundaries of Hennepin County.

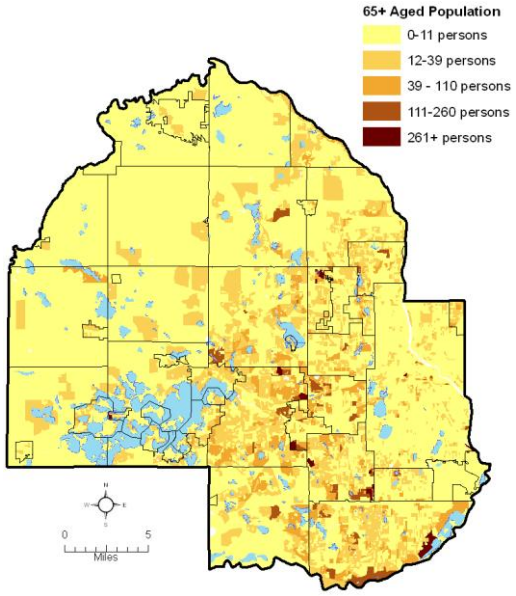

Figure 12. Demographic information pertaining to persons 65 and older residing in Hennepin County.

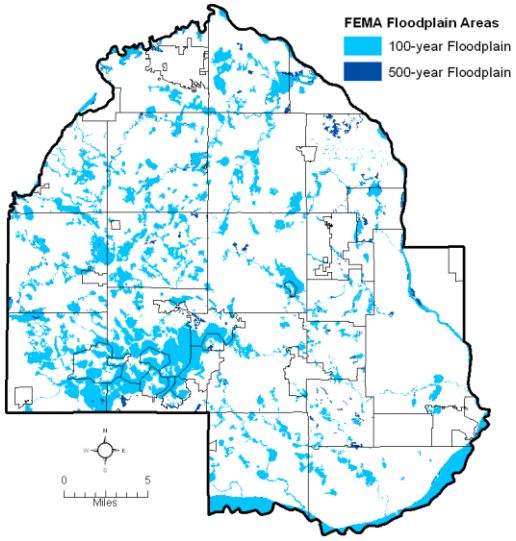

Figure 13. Hennepin County's flood zone hazard.

A floodplain assessment was implemented for the entire county as well as each individual municipality (Tables 1 and 2). Some of the infrastructure included in the assessment include airports, city halls, fire stations, nursing homes, police stations, and wastewater facilities.

Table 1. The unorganized territory of Fort Snelling's floodplain assessment.

Facility Type	Number of Structures		
	Total # in city	# in hazard area	% in hazard area
Airports	1	0	0.00%
Bus Facilities	0	0	0.00%
Child Care Facilities	1	0	0.00%
Churches	0	0	0.00%
City Halls	0	0	0.00%
Communication	0	0	0.00%
Correctional	0	0	0.00%
Dams	2	2	100.00%
EOC Facilities	0	0	0.00%
Electrical Power	0	0	0.00%
Emergency Sirens	2	0	0.00%
Fire Stations	0	0	0.00%
Healthcare Facilities	0	0	0.00%
Highway Tunnels	0	0	0.00%
Hospitals	0	0	0.00%
Libraries	0	0	0.00%
Nursing Homes	0	0	0.00%
Oil Facilities	0	0	0.00%
Police Stations	1	0	0.00%
Potable Water	0	0	0.00%
Railways (mi)	0	0	0.00%
Railway Facilites	0	0	0.00%
Roadways (Major) mi	18.32	1.58	8.62%
Schools	0	0	0.00%
Wastewater Facilities	0	0	0.00%
Total	25.32	3.58	14.14%

Upon its release, the 2010 mitigation plan will be distributed to each municipality through the Hennepin County website. The plan will utilize the Flippingbook PDF Publisher™ software enabling a PDF document containing the mitigation plan to imitate an electronic book. The electronic distribution will allow emergency personnel within the county to gather information more efficiently and effectively. Additionally, the electronic delivery of the mitigation plan will provide an environmentally friendly mode of distribution.

Assessment Map

A summary risk assessment map was created detailing the vulnerability in the event of a disaster for each parcel within Hennepin County (Figure 14). Each parcel was given a risk value depending on the value of the 'EM_RANK' field. Risks were defined as either: low risk (green), moderate risk (yellow) or high risk (red).

Table 2. Hennepin County's floodplain assessment.

Facility Type	Number of Structures		
	Total # in cnty	# in hazard area	% in hazard area
Airports	6	3	50.00%
Bus Facilities	12	1	8.33%
Child Care Facilities	379	1	0.26%
Churches	776	3	0.39%
City Halls	46	2	4.35%
Communication Facilities	15	6	40.00%
Correctional Facilities	3	0	0.00%
Dams	21	21	100.00%
EOC Facilities	32	1	3.13%
Electrical Power Facilities	4	0	0.00%
Emergency Sirens	236	2	0.85%
Fire Stations	82	0	0.00%
Healthcare Facilities	850	23	2.71%
Highway Tunnels	4	0	0.00%
Hospitals	10	0	0.00%
Libraries	41	0	0.00%
Nursing Homes	48	2	4.17%
Oil Facilities	1	0	0.00%
Police Stations	37	1	2.70%
Potable Water Facilities	5	0	0.00%
Railways (mi)	397.5	25.3	6.36%
Railway Facilities	10	1	10.00%
Roadways (Major) mi	1724.13	65.22	3.78%
Schools	371	8	2.16%
Wastewater Facilities	3	1	33.33%
Total	5113.63	166.52	3.26%

The lowest calculated vulnerability score for the assessment was zero, and the highest vulnerability score was 32. The risk ranges utilized for the assessment were as follows:

- Low Risk (green): 0–10,
- Moderate Risk (yellow): 11–16,
- High Risk (red): 17–32.

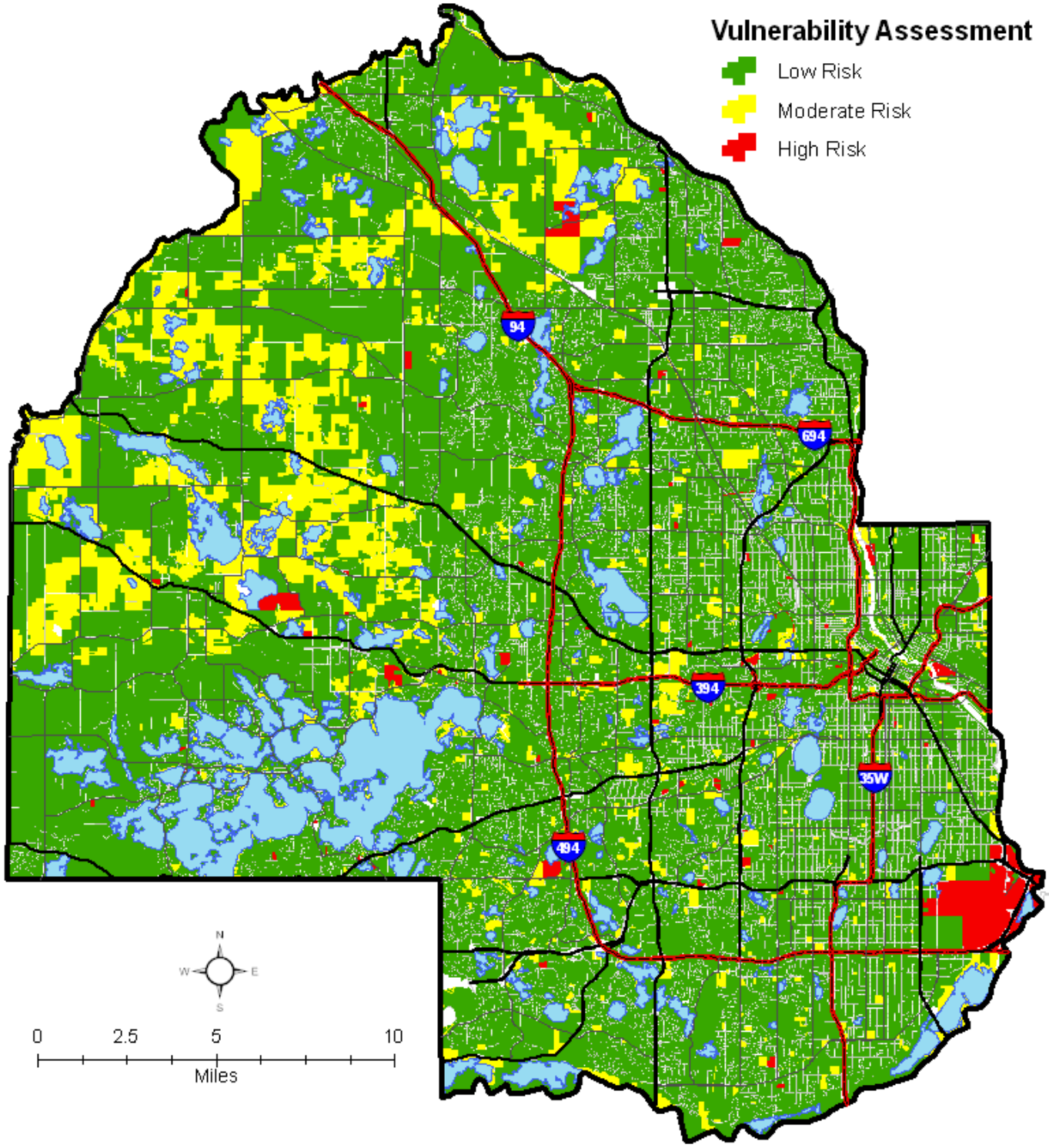

Figure 14. The summary disaster vulnerability map for Hennepin County shows the vulnerability for each parcel ranging from low (green) 0–10, moderate (yellow) 11–16, to a high risk (red) 17–32.

Each individual parcel contains information pertaining to the infrastructure within its spatial area (Figure 15). For example, as seen in Figure 15, this parcel falls into a high risk category with an 'EM_RANK' of 23 and is symbolized in red in the assessment map (Figure 16).

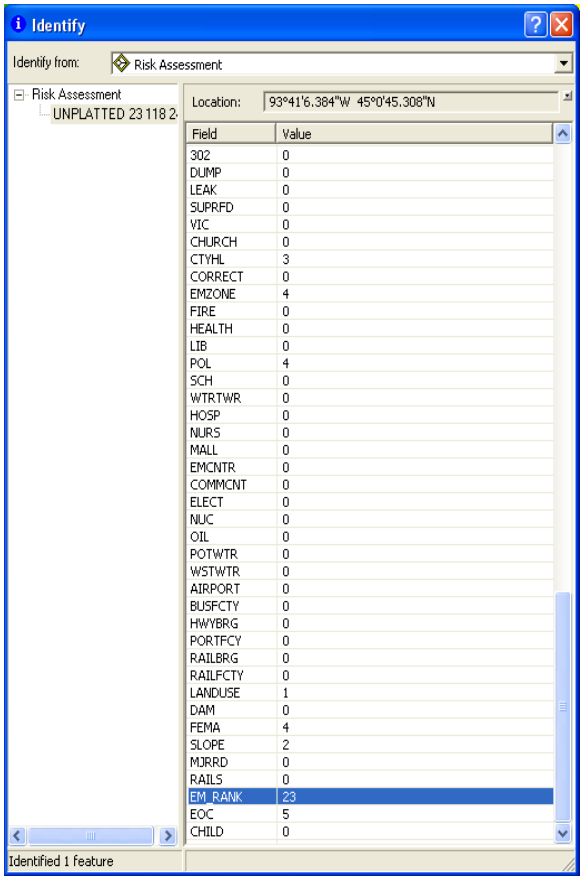

Figure 15. Detailed attribute information for each parcel, as seen by identifying one parcel.

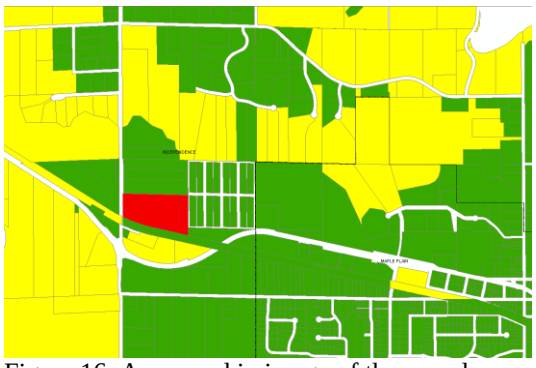
Figure 16. A zoomed in image of the parcel identified in Figure 15.

For future assessments, the risk ranges may change depending upon the modifications from the datasets, adding and/or removing datasets from the assessment. Each assessment will be monitored carefully to ensure risk ranges maintain integrity and validity.

Discussion

This application may not apply to all geographic areas. The relevance of this application is based upon the availability of data for each location within the selected study area and the functionality of its infrastructure. The key infrastructure within Hennepin County may differ from other states or counties depending upon the study area.

Data Limitations

Data is an important component of this research assessment. Although the datasets utilized are not 100 percent accurate, they are the most accurate and up-to-date datasets available to Hennepin County. However, the assessment output is only as accurate as the datasets that were utilized in the assessment.

Communication of datasets across departments within Hennepin County was another limitation within the constraints of this project. Datasets may be available at a departmental level but not available county-wide. Although access to all departmental datasets was not available for this assessment, this will be an option for future projects once the enterprise GIS has been established.

Each dataset was given a weighted value dependent upon its vulnerability within Hennepin County. Each weight was determined and approved by the Hennepin County

Emergency Preparedness Division. These ranks were appropriate for this study, but they may not be suitable for other areas and/or may change over time. For future or other analyses, the weighted scores must be reevaluated to determine their accuracies.

Continued Work

WebEOC™ Implementation

Hennepin County's Emergency Preparedness Division is implementing a software package named WebEOC™ Surface Transportation. A product within the WebEOC™ software package, Mapper, will allow Hennepin County's emergency managers without previous training of GIS to access GIS datasets.

The WebEOC™ product will aid in developing a virtual Emergency Operation Center (EOC) for the county and its municipalities. The virtual EOC will allow its users to access Hennepin County's EOC at any location in the world as long as the user has an internet connection and a secure identification with a password key.

Hazard Assessment

To complement the floodplain assessment, a Federal Emergency Management Agency (FEMA) Hazards U.S. Multi-Hazard (HAZUS-MH) assessment will be completed utilizing the FEMA model.

Emergency Management Models

Two models will be created to serve the needs of the Hennepin County Emergency Preparedness Division.

First, a flood model will be created. The user will place a graphic within the ArcGIS ArcMap™ application. With a click of a button, the user can select the infrastructure datasets desired thus identifying key infrastructure within the flood zone area. Then, a report will generate the infrastructure affected by the flood incident in a tabular format.

An emergency model will also be implemented. The emergency model will allow the user to place barriers for an incident. This will inform emergency personnel of barriers, such as the location of traffic cones to prevent traffic from entering a secure and/or unsafe area. Additionally, the model will create alternative routes around the user-defined area utilizing the ArcGIS Network Analyst™ toolbar.

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References

Bovitz, D. Hennepin County Emergency Preparedness Division. Personal Interview. Daniel.Bovitz@co.hennepin.mn.us on October 19, 2009.

Cutter, S. L., Mitchell, J. T., Scott M.S. 2000. Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. *Annals of the Association of American Geographers.* 90(4): 713-737.

Cutter, S.L. 2003. GI Science, Disasters, and Emergency Management. *Transactions in GIS.* 7(4): 439-445.

Givens, J. Minnesota Department of Transportation GIS Division. Personal Interview. Joella.Givens@dot.state.mn.us on January 27, 2009.

Gunes, A. E., and Kovel, J. P. 2000. Using GIS in Emergency Management Operations. *Journal of Urban Planning and Development*. 126(3): 136-148.

Johnson, R. 2000. GIS Technology for Disasters and Emergency Management. *ESRI White Paper*. pp.6. Retrieved January 6, 2009 from http://www.esri.com/library/whitepapers/pdfs/disastermgmt.pdf.

Koxvold, D. Hennepin County Department of Environmental Services. Personal Interview. Donovan.Koxvold@co.hennepin.mn.us on December 15, 2008.

Newsome, D. E., and Mitrani, J. E. 1993. Geographic Information System Applications in Emergency Management. *Journal of Contingencies and Crisis Management.* 1(4): 199-202.

Pal A., Graettinger A. J., Triche M. H. 2003. Emergency Evacuation Modeling Based On Geographical Information System Data. Retrieved January 6, 2009 from http://www.ltrc.lsu.edu/TRB_82/TRB2003-001689.pdf.

Rue, J. Hennepin County Emergency Preparedness Division. Personal Interview. Judith.A.Rue@co.hennepin.mn.us on January 5, 2009.

U.S. Census. 2000. Retrieved January 6, 2009 from http://factfinder.census.gov.

U.S. Census. 2006. Retrieved January 6, 2009 from http://factfinder.census.gov.

Appendix A. Weighted values of the 38 GIS datasets were determined by Hennepin County's Emergency Preparedness Division based upon each dataset's vulnerability.

Dataset Name	Weighted Score	Definition and Explanation of Rank	Future Analyses (Y/N)
302 Facilities	4	302 facilities are facilities that have extremely hazardous substances (EHS) that exceed the Threshold Planning Quantity (TPQ). The owner or operator must submit a notification to the state emergency response commission (SERC). Due to the hazard 302 facilities impose; a weight of four was assigned.	N
Dump Sites	1	A dump site is a site where waste is stored that may have potential health effects on the human population; however the risks of human health in relation to dump sites are extremely low even in the event of a flood. Thus, dump sites were given a rank of one.	N
Leak Sites	3	Leak sites are sites that have potential for soil and groundwater contamination. These sites are critical in the event of hazardous materials entering the site or potential redevelopment on the site. Thus, a moderate rank of three was granted for leak sites.	N
Superfund Sites	1	Superfund sites are sites where toxic wastes have been dumped and the Environmental Protection Agency (EPA) has designated them to be cleaned up. However, since Superfund sites are located in very small businesses or are unoccupied their rank does not need to be listed as higher than one.	N
Voluntary Investigation Cleanup (VIC) Sites	1	Sites that are being investigated and/or cleaned up may have hazardous materials. However, since VIC sites are unoccupied their rank does not need to be listed as higher than one.	N
65+ Aged Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 Census information. Additionally, the 65+ aged population dataset is situational dependent.	Y
African American Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 United States Census information. Additionally, the African American population dataset is situational dependent.	Y
Asian Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 United States Census information. Additionally, the Asian population dataset is situational dependent.	Y
Caucasian Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 United States Census information. Additionally, the Caucasian population dataset is situational dependent.	Y
Hispanic Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 United States Census information. Additionally, the Hispanic population dataset is situational dependent.	Y
Native American Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 United States Census information. Additionally, the Native American population dataset is situational dependent.	Y
Other Racial Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 United States Census information. Additionally, the other races population dataset is situational dependent.	Y

Pacific Islander Populations	N/A	The current Census dataset from 2000 is outdated information, Hennepin County is waiting on 2010 United States Census information. Additionally, the Pacific Islander population dataset is situational dependent.	Y
Airports	5	September 11th, 2001 is an example of the importance of air transit. If a terrorist attack were to occur on the ground, an airport may be the most likely target for a terrorist. Airports can be occupied by several thousands of travelers on a 24/7 basis. Thus, the airport dataset was given the highest ranked score of five.	N
Bus Facilities	2	Bus facilities illustrate the location of bus station facilities. The facilities are not of large risk but in the event of an emergency situation could be vital in deploying buses to locations throughout the County and/or metropolitan area. Thus, bus facilities were given a lower weighted value of two.	N
Communication Facilities	4	Communication facilities help responders communicate via microwave connection in the event of an emergency situation. Without these facilities communication via radio would be unfeasible. Thus, communication facilities were given the second highest ranking of four.	N
Electrical Power Facilities	4	Electrical power facilities provide electrical power to the residents and businesses within Hennepin County. If a facility were disabled dramatic problems could arise for both businesses and residents. Thus, a rank of four was given to the facilities.	N
Highway Bridges	4	The Interstate 35-W bridge is an example of the importance of transportation infrastructure. If a bridge were to fail, human lives could be in danger. Thus, highway bridges were given a rank of four.	N
Highway Tunnels	4	Highway tunnels are a vital asset to Hennepin County, specifically the city of Minneapolis. If the infrastructure were to fail naturally, environmental or by human means it could be catastrophic and effect human life. For this reason, highway tunnels were given the second highest rank of four.	N
Oil Facilities	2	Oil facilities consist of pipelines, refineries, control vaults, control stations and tank farms. The facilities are vital to the everyday necessity of businesses and residents however do not put humans at direct risk. Therefore, oil facilities were given a rank of two.	N
Portable Water Facilities	2	Portable water facilities include porting areas. These ports may be valuable in the event of a disaster along a river to identify known entrance/exit points. However are not necessarily in direct correspondence to human life, giving the dataset a rank of two.	N
Potable Water Facilities	2	Potable water facilities consist of pipelines, water treatment plans, control vaults, control stations, wells, storage tanks, and pumping stations. These facilities may be critical in the event of a flood after the disaster has occurred however they do not initially affect human life. Thus, the dataset was granted a rating of two.	N
Railway Bridges	2	Railway bridges include any bridge a train must pass over. If a railway bridge were to fail by way of natural causes or a terrorist attack, goods and services as well as human lives could be in danger. However, the risk of human life is far less probable than that of a highway bridge. Thus, railway bridges were given a weighted value of two.	N
Railway Facilities	2	Railway facilities illustrate the location of railway station facilities. The facilities are not of large risk but could be vital in the transfer of goods and services as well as minimal human life. Thus, railway facilities were given a lower weighted value of two.	N

Wastewater Treatment Facilities	2	Wastewater treatment facilities consist of pipelines, wastewater treatment plants, control vaults, control stations and lift stations. These facilities may be valuable in the event of a disaster, specifically to determine if the contamination needs to be contained. However are not necessarily in direct correspondence to human life, giving the dataset a rank of two.	N
Childcare Facilities	4	Childcare facilities are licensed childcare center providers as provided by the Minnesota Department of Human Services. Childcare facilities have the potential to have a large number of children present. If an emergency were to occur it could be catastrophic, therefore childcare facilities were given a ranked score of four.	N
Churches	3	The locations of churches can be vulnerable locations as they have the potential to host a large number of people. Additionally, churches could be a potential shelter location in an emergency. If an emergency were to occur it could impair human life, therefore churches were given a ranked score of three.	N
City Halls	3	The locations of city halls can be vulnerable locations as they have the potential to host a large number of people and provide services to the public. Additionally, city halls could be a potential shelter location in an emergency. If an emergency were to occur it could impair human life, therefore city halls were given a ranked score of three.	N
Correctional Facilities	3	The locations of correctional facilities can be vulnerable if an emergency were to occur and inmates must be moved to another location. Thus, correctional facilities were granted a ranked score of three.	N
Emergency Operation Centers (EOC's)	5	The locations of Emergency Operation Centers (EOC's) are one of the most vulnerable areas within Hennepin County. In that, if these areas are targeted, the center may no longer function. Due to the potential destruction of an imperative site, EOC's were granted a rank of five.	N
Emergency Siren Zones; not in range	4	Emergency siren zones are the ranges of emergency sirens that sound in the event of a weather emergency. Areas not in range of these zones are at high risk since they will not hear the sirens go off. Due to the potential risk, the areas where sirens are not heard received a ranked score of four.	N
Fire Stations	4	Fire stations include locations where fire fighters are stationed or based out of, or where equipment that such personnel use in carrying out their jobs is stored for ready use. Fire stations are critical in distributing resources in the event of an emergency. Due to the resources that are available on site, fire stations were given a rank of four.	N
Healthcare Facilities	4	Healthcare facilities include clinic facilities. Healthcare facilities are critical in distributing resources in the event of an emergency. Due to the resources that are available on site, healthcare facilities were given a rank of four.	N
Hospitals	5	Hospitals are critical and house hundreds to thousands of people everyday. They are critical in distributing resources and aiding in the well being of human lives. In the event of an emergency, hospitals would be critical in distributing resources as well as providing care to any potential victims. Due to their importance, hospitals were given the highest rank of five.	N
Libraries	3	Libraries are locations were documents and resources are stored for public information. Libraries have the potential to have a large number of people present. Additionally, libraries could be a potential shelter location in an emergency. If an emergency were to occur it could be vulnerable, therefore libraries were given a rank of three.	N

Malls	3	Malls, or major shopping centers, include centers with more than 26,000 gross square feet of retail space as of 1/1/1999 provided by Metropolitan Council. Malls have the potential to have a large number of people present. Additionally, malls could be a potential shelter location in an emergency. If an emergency were to occur it could be vulnerable, therefore malls were given a ranked score of three.	N
Nursing Homes	4	Nursing homes are licensed providers as provided by the Minnesota Department of Human Services. Nursing homes have a large number of senior residents on a 24/7 basis. If an emergency were to occur it could be catastrophic, therefore nursing homes were given a ranked score of four.	N
Police Stations	4	Police stations only include the main police station and not the substations. Police stations are critical in distributing resources in the event of an emergency. Due to the resources that are available on site, police stations were given a rank of four.	N
Schools; Private and Public	4	Schools include public, private and charter schools provided by the Minnesota Department of Human Services. Schools have the potential to host a large number of children. Additionally, schools could be a potential shelter location in an emergency. If an emergency were to occur it could be catastrophic, therefore schools were given a ranked score of four.	N
Water Towers	3	Water towers are vital in distributing pressurized water to businesses and residents. If a water tower were targeted, there would be many persons affected by the lack of running water. Thus, water towers were given a score of three.	N
2005 and 2030 Land Use	1	Land use defined as lodging, institutional, industrial, commercial/retail, or office received a rank of one because these usages can be susceptible in the event of an emergency. However, are not as critical as medical or residential uses.	N
2005 and 2030 Land Use	2	Land use defined as medical or residential uses received a rank of two because these usages can be very susceptible in the event of an emergency. Since medical facilities, such as healthcare facilities and hospitals have already received a high rank this ranking is only given a slightly heightened rank.	N
Dams	5	Dams, while located along rivers, can impact land features within Hennepin County. If a break were to occur, by natural means or by terrorism, damages could be catastrophic depending upon the season and recent rainfall or snowfall events. Thus, dams were given the highest rank of five.	N
FEMA Floodplain Zones	4	FEMA flood hazard delineations designated the special flood hazard areas. The flood hazard information includes both the 100 and 500 year floodplain zones. Flood zones can include businesses, homes, and critical infrastructure. With high risk and the likelihood of a flood in Hennepin County, flood zones were given a rank of four.	N
Natural Resource Inventory	N/A	The natural resources inventory, upheld by the Department of Environmental Services, will help in development of new businesses within the County and will be utilized in future analyses.	Y
Parks	N/A	Parks include areas that are defined as developed parks. The parks dataset is situational dependent, depending upon the season and the potential disaster or emergency. Thus, future analyses could utilize this dataset.	Y
Steep Slopes	2	Slopes include any area in Hennepin County that exceeds a twelve percent gradient. These areas may be susceptible to land slides, though not prevalent in Minnesota, could have dramatic effects on the population. Thus, areas with slopes exceeding twelve percent were given a weight of two.	N

Bottineau Bus Rapid Transit (BRT)	N/A	The Bottineau Bus Rapid Transit line is expected to be operational by 2020 however a line has not been fully determined. However, future analyses may utilize the Bottineau dataset.	Y
Central Corridor Bus Rapid Transit (BRT)	N/A	The Central Corridor Bus Rapid Transit line is expected to be operational by 2014 however a line has not been fully determined. However, future analyses may utilize the Central Corridor dataset.	Y
Hiawatha Light Rail Transit (LRT)	N/A	The Hiawatha Light Rail Transit line is currently in operation however due to the construction of the Northstar Light Rail Transit line, the line will undergo minor changes. Therefore, future analyses may utilize the Hiawatha dataset.	Y
Major Roadways	3	Major roadways include United States Interstates, United States Highways, Minnesota State Highways and County roadways. These roadways are utilized by commuters on a 24/7 basis. Due to their vulnerability and use, major roadways were given a rank of three.	N
Railways	2	Railways include the locations of railways. If a railway were to close, it is imperative to find other routes for other trains entering the area. The train collision near Winona, Minnesota in 2008 is an example of the effect one track can create. Thus, railways were given a rank of two.	N
Roadways	N/A	Roadways include all roadways that exist within the extent of Hennepin County including Interstates, Highways, and roadways. In an emergency, roadways would be utilized however are not pertinent to an assessment. Therefore, future analyses may utilize the roadways dataset.	Y
Southwest Corridor Light Rail Transit (LRT)	N/A	The Southwest Corridor Bus Rapid Transit line is expected to be operational by 2015 however a line has not been fully determined and until it has been developed the dataset will not be utilized for mitigation or planning purposes. Therefore, future analyses may utilize this dataset.	Y
Transit Ways 2030	N/A	Transit ways includes expected mass transit routes in 2030. While this dataset may be beneficial for emergencies, it is not useful in mitigation or planning because the routes may change before they become operational. Therefore, future analyses may utilize the transit ways dataset.	Y
Hail Diameter	N/A	Hail diameter detail is provided by the National Weather Service and includes data from weather stations between 1950 and 2008. Due to the random nature of thunderstorms, this dataset should be situational-based.	Y
Tornado Touchdowns	N/A	Tornado touchdowns detail is provided by the National Weather Service and Thomas Grazulis and includes data from weather stations between 1820 and 2009. Due to the random nature of tornados, this dataset should be situational-based.	Y
Wind Speed, in knots	N/A	Wind speed in knots is provided by the National Weather Service and includes data from weather stations between 1955 and 2006. Due to the random nature of thunderstorms, this dataset should be situational-based.	Y