Assessing the Impact of a Web-Based GIS Application to Promote Earthquake Preparation on the University of Southern California University Park Campus

by

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Abstract

The Southern California region faces the constant threat of earthquakes due to the hundreds of faults that lie just beneath its surface. As earthquake prediction technology is limited, it is important that residents, including students at the University of Southern California, are prepared for an earthquake event. This project develops and assesses the impact of an interactive web-based Geographic Information Systems (GIS) application, titled USC Earthquake, as an educational tool for communicating information about earthquake preparedness on the University of Southern California University Park Campus.

This study will incorporate previously conducted research regarding the use of GIS as a tool for emergency preparation, the implementation and assessment of educational programs for emergency preparation, and the description of other earthquake-related mapping applications. The application created for this project will include data from USC Department of Fire Safety and Emergency Management and the Los Angeles County GIS Data Portal to communicate information about the location of emergency supplies and assembly areas on campus. The author will process this data using the ArcMap program as well as ArcGIS Server and will construct the application using ArcGIS Web AppBuilder. The study will assess the educational impact of this tool by surveying two groups of volunteer undergraduate student participants. The experimental group will be asked questions about their level of earthquake risk awareness and perceived level of preparation before and after using the USC Earthquake application. The control group will be asked the same questions before and after viewing a stationary mapping visualization. Once this data is collected, the author will analyze the survey data and compare the results in order to determine the educational impact of USC Earthquake application.

Chapter 1: Introduction

Geographic Information Science (GIS) has provided new ways to use available technology to visualize and analyze spatial data. In 1993, the Xerox Corporation developed the first web-based map viewer, an event that marked the beginnings of a new category of technology, which would come to be known as "web GIS" (Fu and Sun 2010). Since its invention, web GIS has become a commonly used technology for sharing and visualizing different types of spatial information. This project focuses on using web GIS to display information about disasters and emergency preparation, particularly as it relates to earthquakes. The goal of this project is to determine the impact of an interactive web GIS visualization on an individual's disaster awareness and sense of preparation.

Section 1.1 provides an overview of the project by introducing the research question and hypothesis of the study. The author reviews the motivations for this study in Section 1.2 and discusses an overview of the project methodology in Section 1.3. Finally, Section 1.4 provides an outline of the structure for the remainder of the proposal.

1.1 Project Overview

This project focuses on two main objectives in order to evaluate the educational impact of the interactive web GIS application, titled USC Earthquake. The first objective is to develop the USC Earthquake application, which meant to encourage earthquake awareness and preparation. This web-based mapping application will provide users with information that is unique to the University of Southern California (USC) regarding the location of emergency supplies and assembly areas on the university's main campus. The second objective is to survey a group of undergraduate student participants who have used the application in order to assess the impact of the interactive visualization on awareness and sense of preparedness. In order to complete this assessment, this project will ask the same survey questions of participants who have been given a stationary mapping visualization that will include the same base map and data as the application. The author will then compare the results between the two groups of survey participants in order to determine the impact of the USC Earthquake application. Due to the interactive nature of the application and the use of information that is specific to the USC community, the author hypothesizes that the interactive web GIS application will increase awareness about earthquake preparation.

1.2 Motivation

This study focuses on the visualization and communication of information regarding earthquake awareness and preparation on the USC campus. Earthquakes are one of the most common natural hazards in the Southern California area and, therefore, it is important for individuals who live in this area to be aware of how to prepare themselves and where to locate emergency supplies. The author chose to focus this study on the USC University Park Campus in order to create an application that was unique to a single community in this area. The remainder of this section provides an explanation of the earthquake risks in the USC University Park region and a description of the chosen study area.

1.2.1 Earthquake Risk

Earthquakes pose the greatest risks for natural disasters in the Southern California region. The state of California contains thousands of fault beneath its surface, but the largest and most well-known fault in the area is the San Andreas fault. The San Andreas fault begins east of San Diego and runs north through California, ending just south of Eureka. A map of the San Andreas Fault can be seen in Figure 1 (Lynch 2006). This fault has the capacity to produce very large earthquakes, as evidenced by the 1906 San Francisco Earthquake which ruptured with a magnitude of 7.9 on the moment magnitude scale (Mw). This scale measures the amount of energy released in an earthquake (United States Geological Survey 2012). As of 2016, the San Francisco earthquake occurred over 100 years ago and represents the last significant rupture on the San Andreas fault. According to Fumal et al., due to the earthquake recurrence rate on the San Andreas fault, it is likely that the next large earthquake on this fault will occur in the Southern California region. This recurrence pattern on the San Andreas fault means that the Los Angeles area may be vulnerable to an earthquake event in the near future.

Figure 1) Map of the San Andreas Fault

Seismological studies have assessed the risk of earthquakes in California by studying the faults throughout the state. In 2014, the Working Group on California Earthquake Probabilities

(WGCEP) along with the United States Geological Survey (USGS), created a long-term earthquake forecast model in order to quantify the rate of earthquake occurrence on the San Andreas Fault as well as all other known faults in the state of California. An image of this model displayed on a map of the state can be seen in Figure 2 (Field et. al 2014). This model, known as the Uniform California Earthquake Rupture Forecast Model Version 3 (UCERF3), demonstrates a significant likelihood of an earthquake with a magnitude greater than 6.7Mw occurring on the San Andreas fault before 2050 (WGCEP 2015). While the San Andreas fault poses the most risk for earthquakes larger than 6.0Mw, the many faults throughout the state are also capable of producing significant earthquakes.

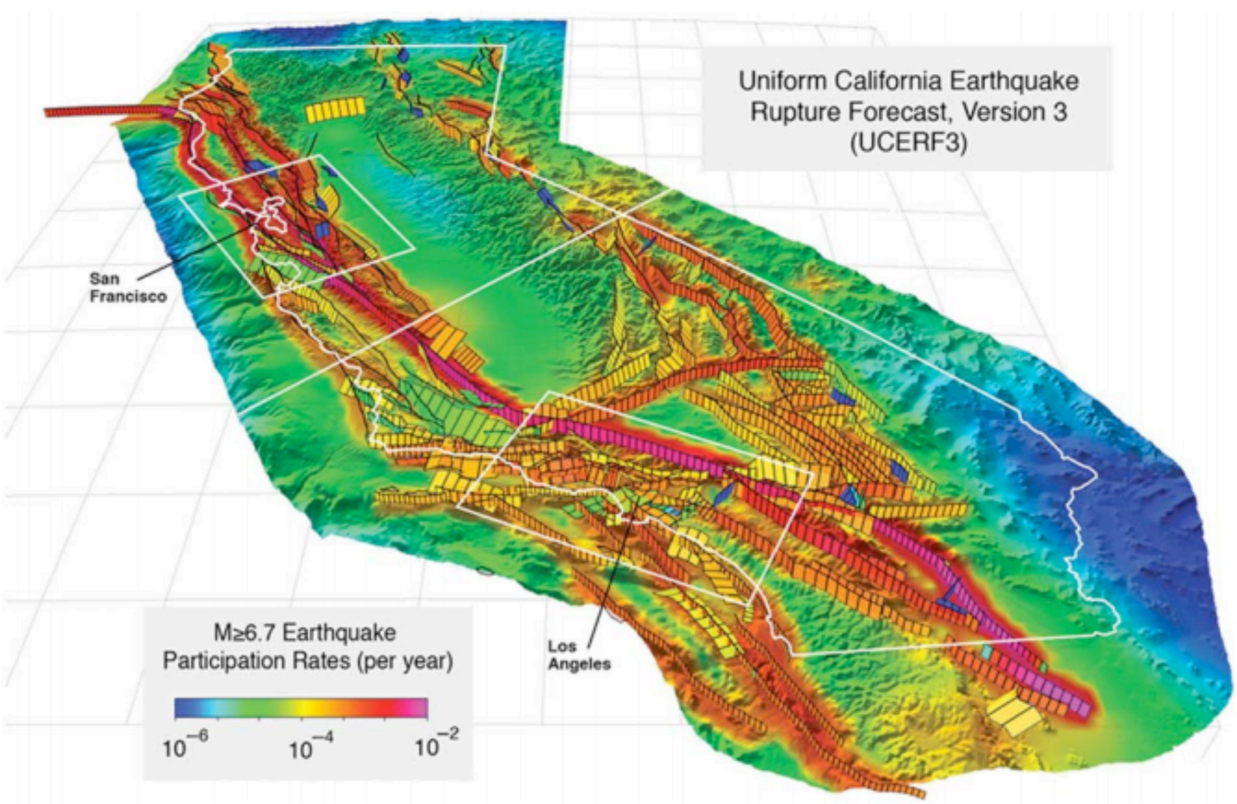

Figure 2) Image of the UCERF3 Model

While the Los Angeles area faces a significant risk for earthquakes due to the presence of many faults, the impacts of seismic ruptures in the region are amplified by its geological setting. This area lies on top of a sedimentary basin, known as the Los Angeles basin, which contains mostly soft soils (Hillhouse, Reichard and Ponti 2006). Soft soils amplify seismic waves, which means the Los Angeles region is susceptible to increased shaking in the event of an earthquake.

1.2.2 Study Area

The University of Southern California, whose main campus lies just 3 miles south of Downtown Los Angeles, is a privately-funded research university and was named the 23rd ranked university in the nation according to U.S. News & World Report (U.S. News & World Report 2016). As of the 2015-2016 academic year, USC hosted a combined undergraduate and graduate population of 43,000 students (University of Southern California 2015). A map of this region can be seen in Figure 3.

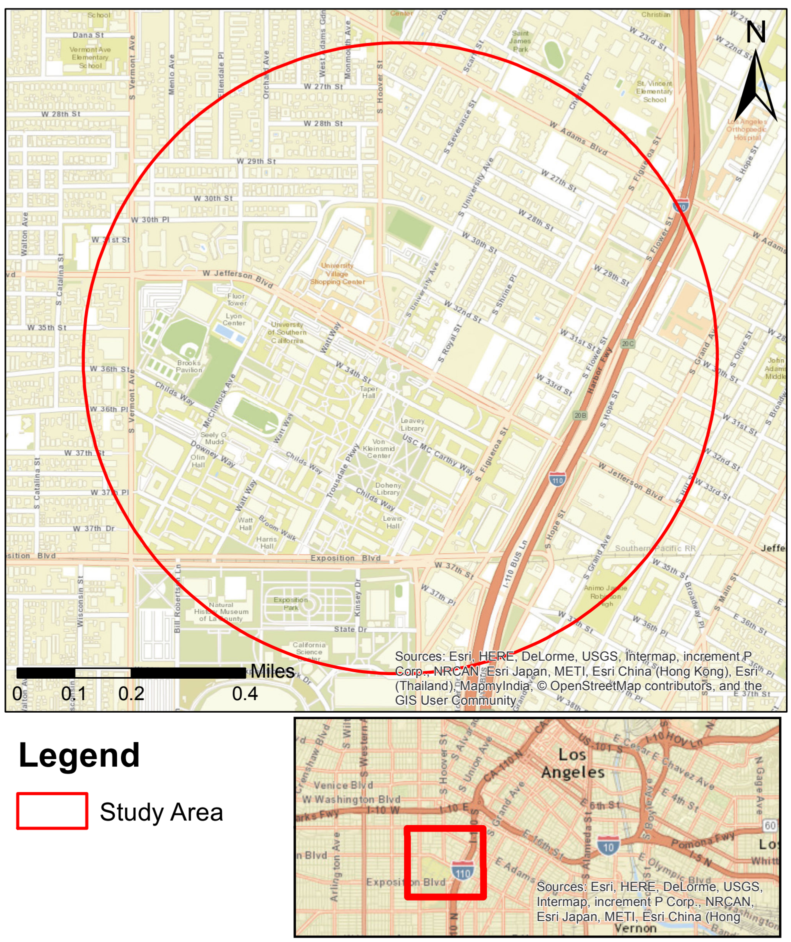

Figure 3) USC University Park Campus

The research described above has established that Los Angeles is a region of Southern California that is especially vulnerable to earthquake risks due to rupture patterns on the San Andreas Fault, the presence of many faults in the area, and the geological setting of the region. As a result of the increased risk at this location, it is important that Los Angeles residents have the resources to prepare themselves for an earthquake event. The population of Los Angeles, which has reached nearly 4 million people as of 2015, include the students of USC (United States Census Bureau 2015).

The student population at USC, as with the population at any university, is constantly changing. These students come from different locations all over the world and they may not have experience with earthquake events or earthquake preparation. It is important that these students be introduced to the idea of earthquake hazards and be given the resources and information they need to be prepared for an earthquake.

As this project seeks to create an interactive tool that could be used by the University of Southern California for educating current and incoming students, it is important that this tool is proven to be effective. For this reason, this project will develop a method to determine the educational impact of the application. The author will assess the impact of this tool by surveying volunteer participants. As students are the individuals who will benefit from the use of the application, this study will seek undergraduate students as survey participants.

1.3 Methodological Overview

The goal of this project is to assess the educational impact of a web-based mapping visualization that seeks to increase earthquake hazard awareness and encourage earthquake preparation. In order to make this assessment, this study will first create an interactive web-based mapping application that is meant to communicate information about the location of emergency supplies and assembly areas. The author will then survey experimental and control groups of participants about the use of the application in order to understand the impact on earthquake awareness and preparedness conceptions. The survey results will be compared in order to determine the educational impact of the USC Earthquake application.

1.3.1 Application Construction

This project seeks to create a web-based mapping application that will communicate information about the location of emergency supplies, emergency assembly areas, and disaster routes on the USC University Park Campus. Data for this application will be collected from the USC Department of Fire Safety and Emergency Management and the Los Angeles County Data Portal. This data will be processed for use in the application in the ArcMap program from ArcGIS for Desktop and shared using the ArcGIS for Server program. The application will be constructed in the ArcGIS Web AppBuilder program within the ArcGIS Online platform. Once the application is completed, a link to the application will be shared with survey participants in the experimental group in order to assess the educational impact of the tool.

1.3.2 Survey Participation

This project will seek to survey a pool of at least 60 undergraduate student participants in order to assess the impact of the interactive web-based application created for this study. The author will ask for volunteer participants from general education classes on the USC main campus. The goal of this method of requesting participants is intended to include students from diverse majors and disciplines. Half of the participants will be surveyed about their earthquake awareness and level preparedness before and after using the interactive web-based, while the other half will be given the same survey before and after viewing a stationary web mapping visualization. These results will be compared in order to assess the educational impact of the interactive web-based mapping application.

1.4 Thesis Structure

The remainder of this paper is divided in four chapters. Chapter 2 discusses previous studies and work that is related to disaster awareness, assessing educational disaster programs, and earthquake-related mapping applications. Chapter 3 provides a detailed explanation of the data sources and methodology employed in the completion of this project.

Chapter 2: Related Work

Earthquake hazards and disaster preparation are global issues that many researchers have worked to address. This chapter provides a detailed overview of scholarly work related to this study. Section 2.1 discusses previous studies that have utilized GIS and spatial data to analyze local earthquake hazards and promote disaster preparation. Section 2.2 addresses studies that discuss the implementation of disaster awareness programs around the world. Section 2.3 reviews studies that have assessed the impact of these education programs in various communities in order to determine effective methods of communicating this information. Finally, section 2.4 describes several web-based applications have been implemented to provide users with information about earthquake hazards and preparation. This study aims to utilize similar GIS techniques and educational assessment methods to the studies presented.

2.1 GIS for Emergency Preparation and Safety

GIS is a diverse technology that can be used to assess disaster safety and to create visualizations for emergency preparation. A 2009 study by Abbas, Srivastava, and Tiwari implemented a geodatabase with a collection of biological, meteorological, hydrological, and socio-economic spatial data that was meant to model flooding vulnerability in the Allahabad Sadar Sub-District in India (Abbas, Srivastava, and Tiwari 2009, 38). The study concluded that the implementation of a spatial database assisted in creating a comprehensive disaster management plan within the community. GIS and spatial data can also be used to create visualizations for the purpose of safety and emergency preparation.

The University of Southern California has also utilized spatial data visualization as a means of increasing risk awareness with the release of the Trojan Mobile Safety App. This application allows users to view recent incidents of crime with respect to the user's current location (USC Department of Public Safety 2015). It also allows users to report incidents of crime directly to the USC Department of Public Safety, providing a link between the users and the organization. The studies described have proven that spatial data can be a powerful tool for communicating information about emergency preparation. This project seeks to use spatial datasets in the same manner to provide user's with information about emergency supplies and assembly areas.

Several organizations and studies have applied GIS to hazard awareness and education. The Urban and Regional Information Systems Association (URISA) dedicates its efforts to providing educational programs that teach individuals how to utilize GIS tools to improve disaster planning within their organization (URISA 2015). While URISA focuses on using GIS analysis tools for preparation within an organization, the Earthquake Country Alliance works on providing GIS visualizations to a public audience in an effort to increase earthquake awareness. In 2013, the Earthquake Country Alliance released a series of videos, called Northridge Near You, which demonstrates earthquake scenarios from the UCERF3 Model, which has been discussed previously and can be seen in Figure 2 (Earthquake Country Alliance 2013). These videos display maps of potential causalities and monetary losses that have been calculated using an ArcGIS plug-in developed by the Federal Emergency Management Agency (FEMA). These visualizations are available to the public and are meant to increase awareness of local earthquake hazards in Southern California. As GIS tools and visualizations have been found to be effective in increasing awareness of safety hazards and managing disaster preparation, this project will incorporate similar visualization strategies in an effort to create a better understanding of earthquake hazards.

2.2 Emergency Preparation Education

Many researchers have conducted studies on disaster in communities throughout the world in order to determine the most effective method of educating individuals about disaster preparation. A study by Karanci, Aksit, and Dirik (2005) investigated the impact of a disaster awareness program in Istanbul, Turkey, which is a very seismically active region. The program consisted of an 8-hour training program and a 10-page brochure about earthquake preparation. The study then compared surveys from 400 program participants and 400 non-participants one year after the program and found that preparation behavior was significantly higher in participants who received this training and visual aid than in non-participants.

A similar natural hazard education study was conducted in Northern India, which is a seismically active region due to the presence of the India-Asia plate boundary. Researchers investigated the impact of an earthquake education program called the School Earthquake Laboratory Program (SELP) (Bansal and Verma 2012). This program included the implementation of seismic receptors that recorded seismic activity and allowed participants to visualize seismic data. This study concluded that giving the participant the ability to visualize the collection of was an important factor in increasing awareness about earthquake risks. In accordance with these studies, this project anticipates that utilizing data visualization and individual participation will help to increase an individual's understanding of seismic hazards and preparation.

Many organizations have implemented various applications and educational programs which attempt to encourage earthquake preparation. FEMA has released a mobile application that provides safety tips for multiple types of natural disasters, including earthquakes. The FEMA Mobile App, which is accessible through the organization's website, provides a list of recommended emergency supplies and explains what to do before, during, and after earthquake event (FEMA 2015). This application simply distributes written information, but other programs include visualization and interactive components. The Southern California Earthquake Center, which is headquartered on the USC University Park Campus, has implemented a program called The Great ShakeOut meant to encourage organizations and individuals across the country to participate in a national earthquake drill. Over 21 million individuals across the United States participated in the 2015 earthquake drill during October 2015 and SCEC provides additional resources to help families, businesses, and organizations prepare for a disaster (SCEC 2016). These resources include visualizations of a potential earthquake scenario on the southern section on the San Andreas fault, which they call the ShakeOut Scenario, seen in Figure 4. These programs provide an example of bringing awareness of earthquake risks to various communities in order to encourage preparation. This project will use similar GIS visualization techniques over written information in order to educate the USC community about earthquake and disaster preparation.

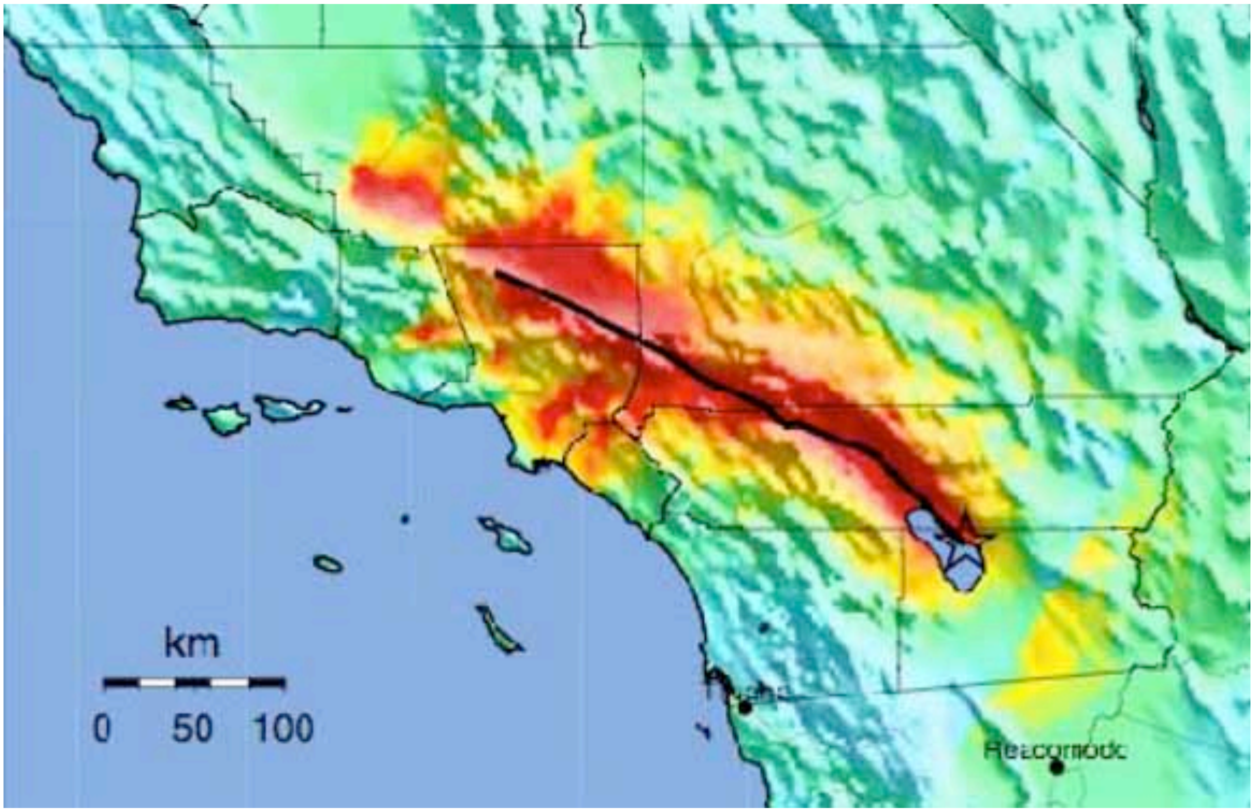

Figure 4) Visualization of the SCEC ShakeOut Scenario

2.3 Assessing Educational Impact

While institutional organizations have worked towards creating disaster preparation programs, researchers have conducted studies that assess the impact of their curriculum. Earthquake and general disaster awareness is an issue across the globe and many researchers have attempted to implement disaster education programs. Several studies have investigated the most effective ways to assess these programs it in various communities. A 2011 study by Tekeli-Yesil, et al., surveyed over 1,000 people in Istanbul, Turkey, where the study reports that there is a 62% chance of an earthquakes occurring by 2040 (Tekeli-Yesil, et al. 2011, 428). Participants were asked a series of questions regarding their perceptions of preparedness and asked to provide demographic information, including their educational and socio-economic level. These inquiries were determined by the study to indicate an individual's level of preparation and included questions about what an earthquake is as well as how prepared participants feel their homes are. Another study utilized a similar survey method in Japan, a region that is also susceptible to large earthquakes. The researchers polled 1,065 first grade students on their knowledge of earthquake risks, perception of risk, and willingness to take steps to prepare (Shaw et al. 2004). The study views willingness as an indication of how individuals are likely to respond to educational training. This project will include this survey method of self-reported perceptions of awareness and preparedness.

Additionally, Shaw et al. (2004) also investigated factors that impact earthquake awareness and preparation and found that these factors included education and community participation. Simpson (2008), who conducted a study in the Midwestern United States regarding disaster preparation, agrees with Shaw et al. that including many individuals from the community helps increase overall community preparedness (Simpson 2008). Simpson (2008) seeks to give the community a tool to assist in disaster preparation. Bourque et al. 2012 also assessed the factors that impact preparedness and found that, along with knowledge and education, an individual's perceived level of control in a disaster situation has an important influence on preparedness behaviors. These studies concur that personalized tools and community participation are effective methods for encouraging disaster awareness and preparation. The USC Earthquake project aims to give individuals the tools they need to learn about earthquake risk and prepare for an earthquake event. It will also personalize the tools for the USC community, in an effort to increase the level of earthquake awareness throughout the community.

2.4 Earthquake-related Mapping Applications

Several organizations have created earthquake-related mapping applications that are meant to help individuals become more aware of earthquake hazards and how to prepare for them. The American Red Cross has released a series of applications for various types of disasters, including an application intended for earthquake information. The Red Cross earthquake application provides users with advice for planning ahead and preparing for a disaster and allows them to add their location based on the user's location (American Red Cross 2016). The user can examine a zoomable global map that has points marked for each earthquake incident that has occurred in the past month, an image of which can be seen in Figure 5. Additionally, the application connects the user to the USGS website where they can report any seismic shaking they feel.

Another earthquake application, known as QuakeFeed, also incorporates location-based earthquake information. QuakeFeed is an application developed by Esri, the foremost creator of GIS software, and it provides users with a visualization of location and magnitude of seismic events all over a map of the globe that have occurred in the last seven days. The application allows users to set up notifications for seismic events based on location or magnitude of event (ESRI 2015).

The University of California Berkeley Seismological Laboratory developed an application very similar to QuakeFeed called My Quake. This application also considers the user's location and allows them to view a map of the location and magnitude recent earthquakes. My Quake does have a unique feature that allows the user to view maps of historic earthquakes near their specified location (UC Berkeley Seismological Laboratory 2016). These applications provide general visualizations of earthquake hazards, but do not necessarily create a personalized view of earthquake risk. The USC Earthquake application will seek to create a personalized tool that can be used practically by members of the USC community.

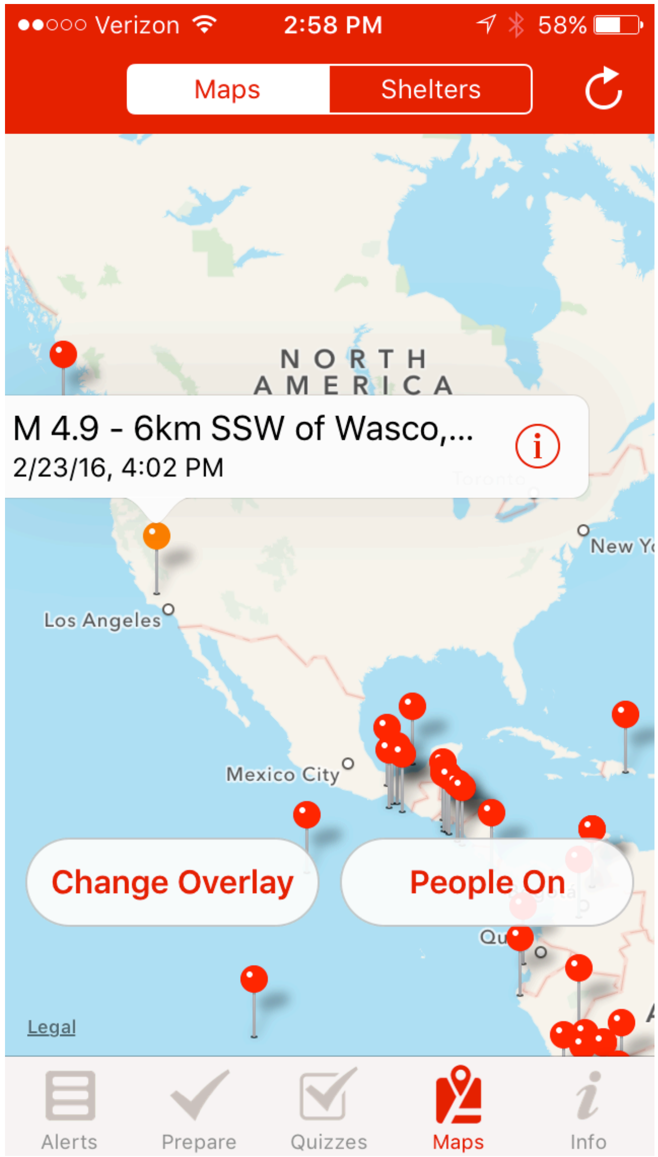

Figure 5) Image of Red Cross Earthquake Application

A few studies have explored the development of earthquake-related mapping applications for the use of earthquake hazard awareness. A 2014 study describes the creation of an application meant to educate users about earthquake hazards by allowing them to choose a location on a map and learn facts about the history of that location (Chatterjee 2014). The author built this application using “Map Objects Java Edition,” which was provided by Esri (Chatterjee 2014, 4). This type of application construction requires a high level of proficiency with the Java programming language. Another study produced an application meant to encourage building owners to seek seismic retrofit by allowing users to search for a building the in Los Angeles area and to view information about the likelihood of a structure to withstand an earthquake (Moffett 2015). This application was developed using ArcGIS Web AppBuilder, a platform that is also provided by Esri. This platform allows application builders to input their own data, to choose from a variety of themes, and to add and configure premade widgets. The methodology developed for the USC Earthquake application will be constructed using the Esri Web AppBuilder platform due to the ease of construction and customization.

The studies described in this section have each attempted to increase awareness of earthquake hazards and earthquake preparation in order to create safer communities. This project will incorporate the visualization of spatial data that is relevant to a specific community in an interactive environment. The conclusions of the above studies, support the hypothesis that this methodology will have an impact on the application user’s sense of earthquake preparedness.

Chapter 3: Data and Methodology

The following chapter provides a detailed description of the research methodology employed by the author to complete the application and educational assessment for this project. The goal of this project is to determine if an interactive web-based visualization is more effective at communicating information about earthquake preparedness than a stationary mapping visualization. Section 3.1 describes the sources of data for the USC Earthquake application and section 3.2 explains how each dataset was processed in ArcMap for the purposes of the application. Section 3.3 describes the construction of the application using the ArcGIS Web AppBuilder platform. Section 3.4 explains the process of selecting and surveying random participants and section 3.5 reviews the analysis of the survey results in order to assess the educational value of the USC Earthquake application in comparison to a stationary map visualization.

3.1 Application Construction

The first objective of this project involves building an interactive web-based application for the purposes of communicating information about the location of emergency supplies and assembly areas on the USC University Park Campus. This section describes the data sources and processing of the data for the application.

3.1.1 Data Sources

The author collected data for this project from two main sources, including the Los Angeles County GIS Data Portal and the USC Department of Fire Safety and Emergency Management. The Los Angeles County GIS Data Portal is the source of the Building Outlines and the Disaster Routes datasets. The USC Department of Fire Safety and Emergency Management provided data for the Emergency Supplies and Assembly Areas datasets.

3.1.1.1 Los Angeles County Data Portal

The Los Angeles County GIS Data Portal provides access to GIS data relevant to the administrative processes of Los Angeles County and makes datasets available for public download when possible. Available datasets include OpenStreetMap datasets, geologic maps, points of interest maps, and city boundary maps (Los Angeles County Data Portal 2015). For this project, I utilized the Los Angeles Region Imagery Acquisition Consortium Building Outlines dataset and the Los Angeles County Disaster Routes dataset.

The Los Angeles Imagery Acquisition Consortium (LARIAC) Building Outlines dataset utilizes satellite imagery to create a polygon dataset with outlines for the nearly 3 million buildings in Los Angeles County (LAC Data Portal). This dataset, which was updated in 2014, includes information about building height, building age, elevation, and building identification. For this project, the author has extracted the building outlines within the study area of the University of Southern California University Park Campus. These building outlines provide a means to create the most accurate spatial representation of the buildings in order to add information about the emergency supplies located in the buildings. This process will be explained in the description of the emergency supplies dataset. An image of the building outlines dataset can be seen in Figure 6.

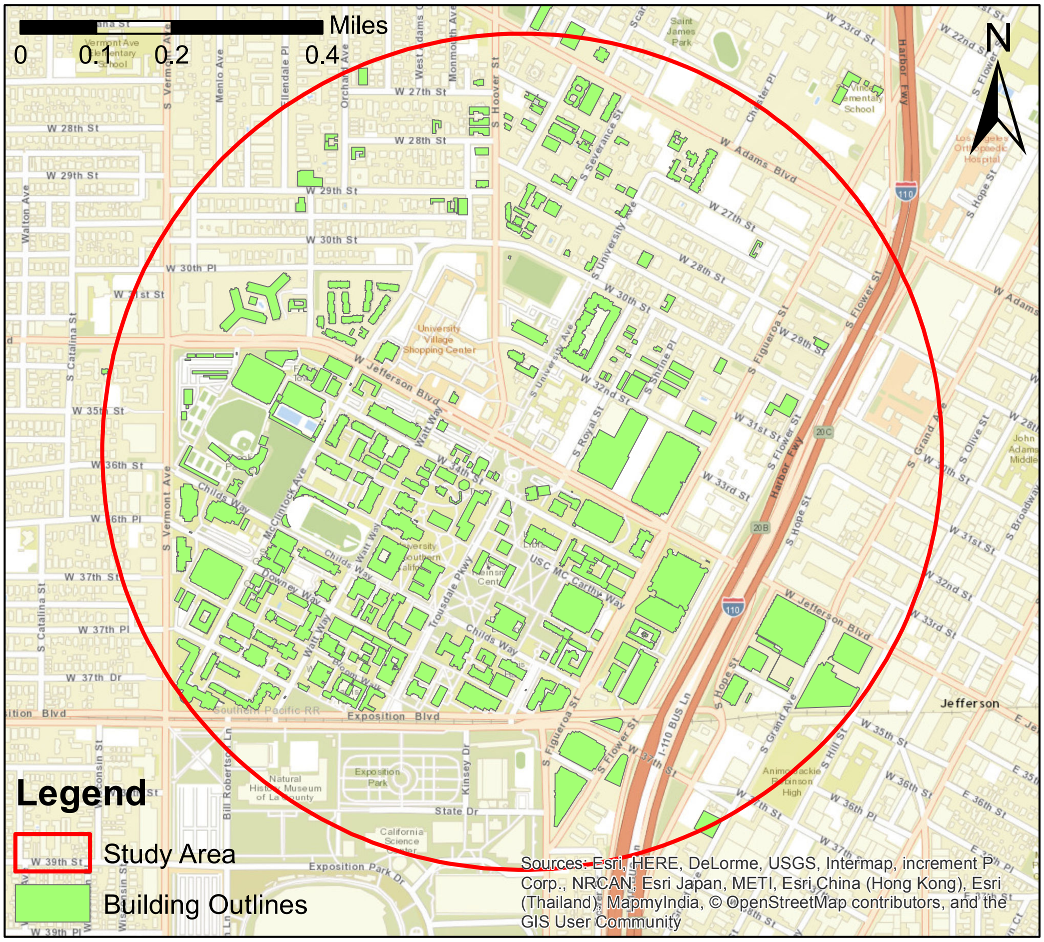

Figure 6) LAR-IAC Building Outlines Dataset

Another dataset provided by the Los Angeles County Data Portal is the Los Angeles County Disaster Routes, which was made available to the public in 2015. This dataset provides a visualization of roads and streets that are designated for transportation of emergency vehicles and for emergency evacuation. The Disaster Routes dataset includes information about the name of the road, road type, road surface, driving direction, and length of the road. This project uses this dataset in order to allow users to visualize potential evacuation routes that would be used in the event of a disaster. This data set can be seen on the map below in Figure 7.

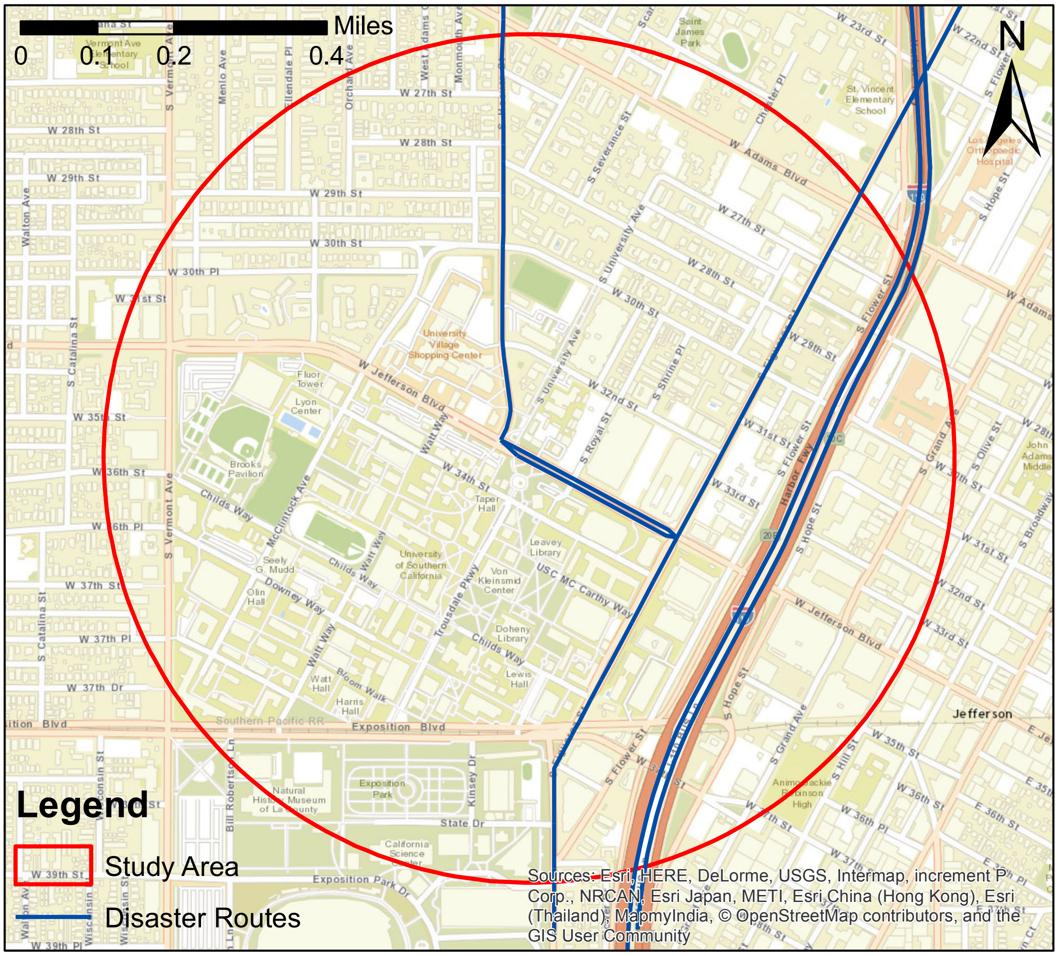

Figure 7) Los Angeles County Disaster Routes Dataset

3.1.1.2 USC Department of Fire Safety and Emergency Management

The USC Department of Fire Safety and Emergency Management supervises all emergency services operations on the USC campus, including disaster drills and safety operations. This organization's website provides what they call "Building Information Sheets" for each building on campus. These information sheets list the location of emergency supplies within each building as well as the name of the area where individuals in that building are meant to congregate in the event of an emergency. For this project, the author created two spatial datasets from this information and titled these datasets Emergency Supplies and Assembly Areas.

The Emergency Supplies dataset is a polygon dataset that was created in March 2016 using the Create Features tool in the ArcMap Editing Window. Each shape in the dataset represents a building on the USC University Park campus and is based off the LARIC dataset. The author used the USC Maps web application to identify the buildings listed on USC Department of Fire Safety and Emergency Management's building information sheets. The attribute table for this dataset includes the name of the building, the room where emergency supplies are located, the assembly area for that building, the address, and the three letter code used by the university to identify the building. This dataset can be seen below in Figure 8.

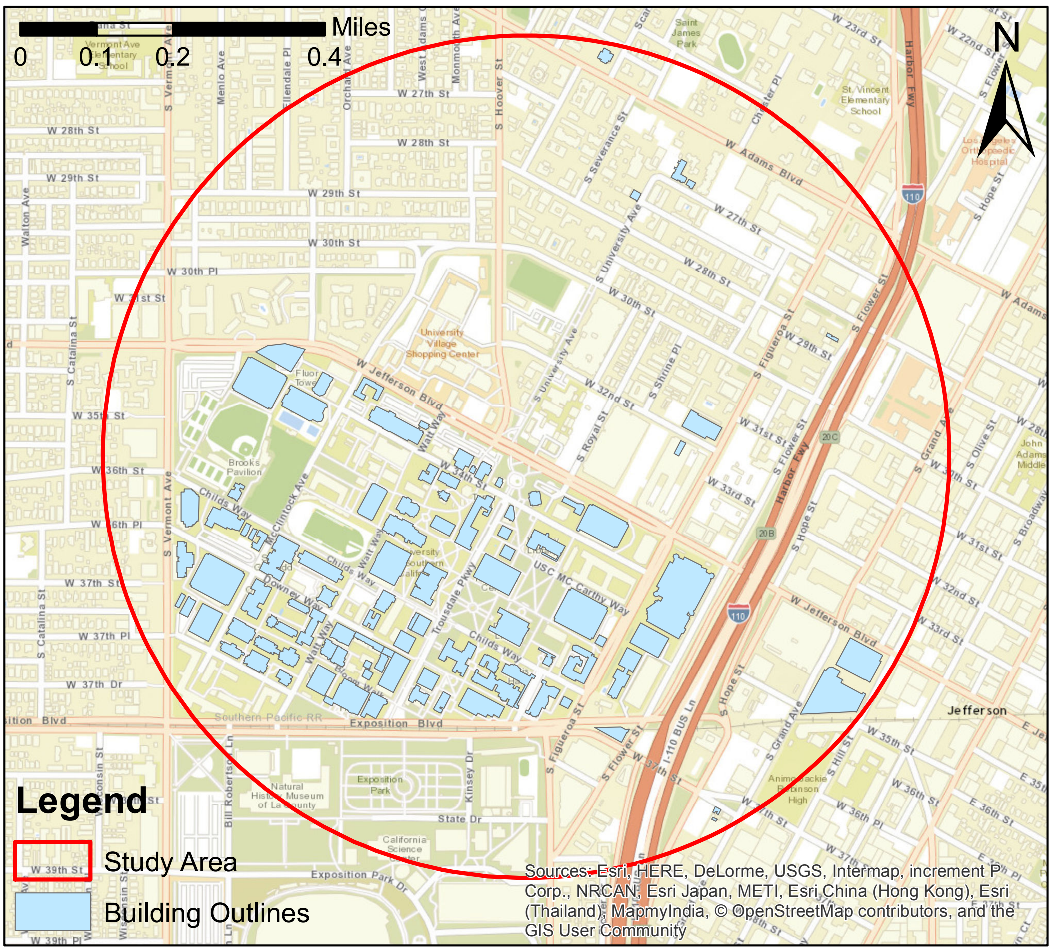

Figure 8) Emergency Supplies Outlines Dataset

The Assembly Areas dataset is a polygon dataset, created in November 2015, which represents the general location of the assembly areas on the USC campus as listed on the Building Information Sheets. This dataset was also constructed using the Create Features tool in the ArcMap Editing Window. The attribute table for this dataset includes the name of the assembly area and the list of names of each building whose inhabitants are meant to assembly in that location. This dataset can be seen below in Figure 9.

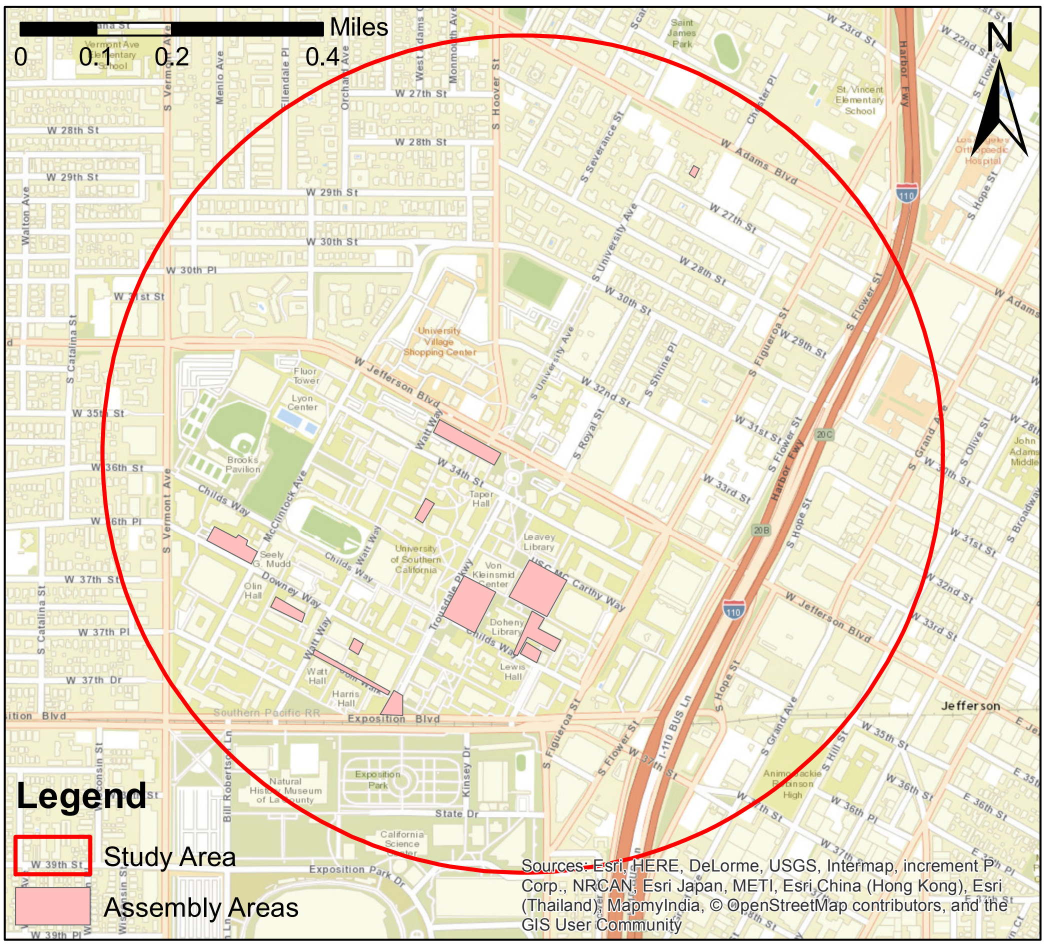

Figure 9) Assembly Areas Dataset

3.1.2 Data Processing

All data for this project was prepared using the ArcGIS suite of products. Two datasets were extracted and two were created using the ArcMap program. All data was shared using

ArcGIS Server in preparation to be displayed in a map within ArcGIS Online and to be incorporated into the ArcGIS Web AppBuilder platform. This section provides a detailed explanation of each step towards preparing the data to be implemented into the application constructed for this project.

3.1.2.1 Data Extraction

The Building Outlines and Disaster Routes were both downloaded from the Los Angeles County Data Portal in order to be processed in ArcMap. These datasets contain thousands of records that span the entire area of Los Angeles County, which is more than is necessary for this project. Both datasets were imported as shapefiles and displayed in ArcMap. The author then used the Clip tool in ArcMap and highlighted only the data present within the study area. The result of this process was two new feature classes that included only the data within this area and were ready to be exported to ArcGIS Server.

3.1.2.2 Data Creation

The information for the Emergency Supplies and Assembly Areas datasets were initially in the form of lists from the USC Department of Fire Safety and Emergency Management with no spatial component. Therefore, it was necessary to create new spatial datasets from the information provided. The author created two new feature classes before using the Editing Window in ArcMap to create polygon features and populate the attribute table with the relevant information. Polygons for the Emergency Supplies dataset were modeled off the polygon features from the Building Outlines dataset. The Assembly Areas dataset is meant to represent general areas on campus rather than clearly defined spaces and, therefore, the polygons for this dataset are based on areas found on the Esri World Streetmap available as a basemap in the

ArcMap program. Once these datasets were complete, they were ready to be exported to ArcGIS Server.

3.1.2.3 Data Export

In order for datasets to be displayed in ArcGIS Web AppBuilder, they first needed to be exported to ArcGIS Server. The author shared each dataset as an individual Map Service to a personal ArcGIS Server account. The author then created a new map in the My Content window of a personal ArcGIS Online account. Within the new map, the author chose the Add Data From Web button from the Add Data menu and added the REST Services URL from the ArcGIS Server account for each dataset. The author then saved the map and adjusted the sharing settings so that the map could be viewed publicly on ArcGIS Onlline. An image of the final map in ArcGIS Online is displayed below in Figure 10.

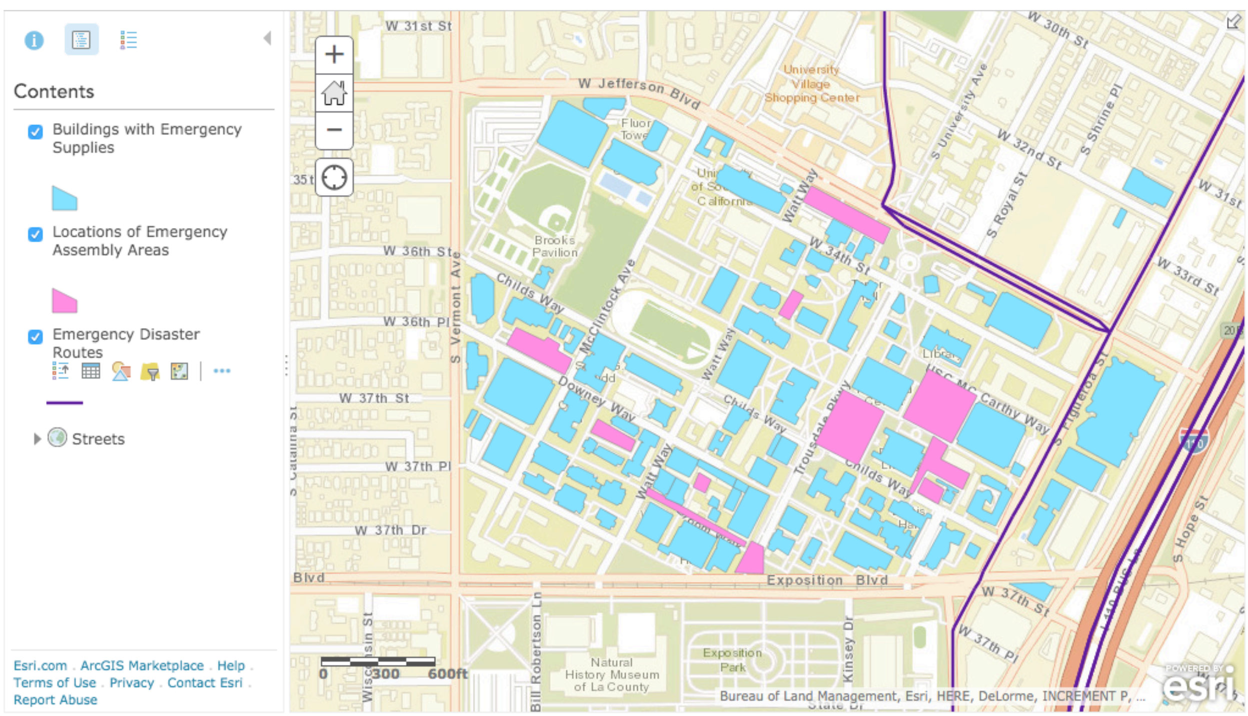

Figure 10) Image of Dataset in ArcGIS Online

3.1.3 Application Creation

This application, entitled USC Earthquake, was constructed using the ArcGIS Web AppBuilder platform in the ArcGIS Online environment. Using the personal ArcGIS Online account described above, the author selected the New Item button and then chose App and Using AppBuilder within the My Content window. Once Web AppBuilder was opened, the author chose to use the Dart Theme, which places all the functions of the application along the bottom of the application window. The author chose to theme the application with cardinal and gold colors, as those are the official colors of the University of Southern California. The application was then prepared to add the datasets describe above.

The datasets for this project have been aggregated into a single map in the ArcGIS Online platform. In the editing window of the application, the author selected the Map tab and added the map containing the Disaster Routes, Emergency Supplies, and Assembly Areas datasets. The author then changed the basemap to the Esri World Streetmap in order to give an improved visualization of the roads in the local area. An image of this map within the surface of the application can be seen in Figure 11.

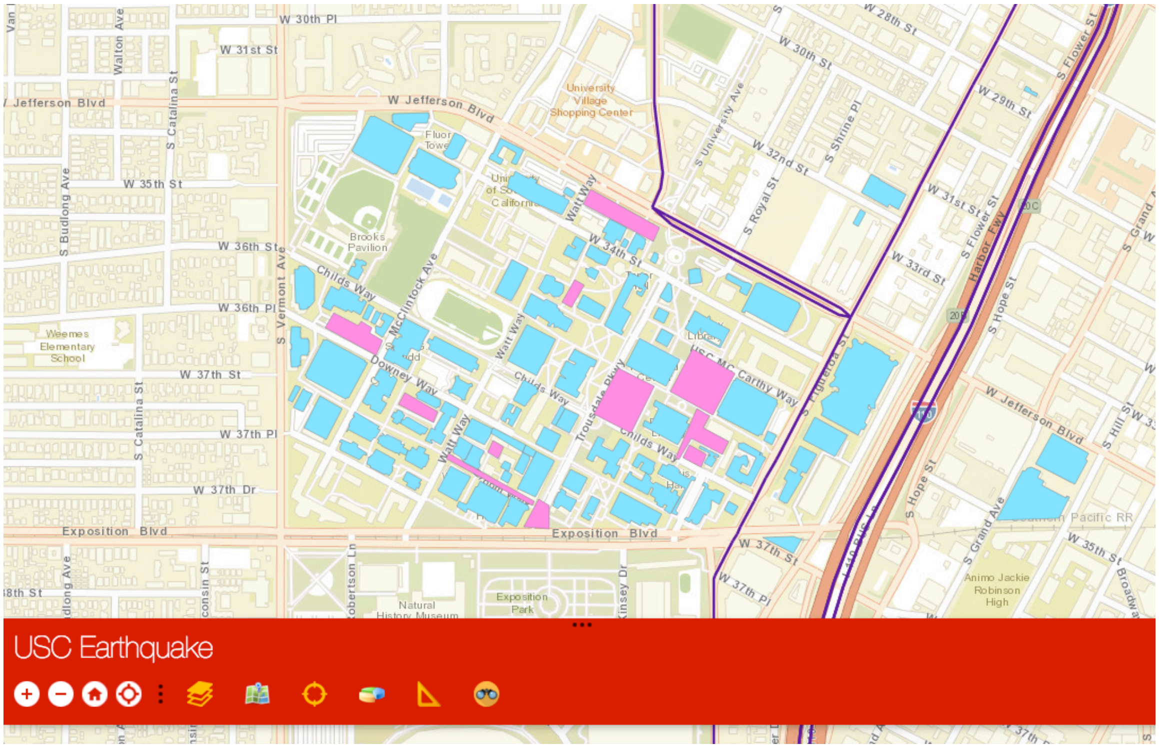

Figure 11) Application User Interface

3.1.2 Widget Configuration

The Web AppBuilder platform uses tools called widgets, which can be configured and customized by the creator of the application to allow the user to perform tasks within the application. The widgets that are standardized within the Dart theme include a Zoom Slider, which allows the user to zoom in and out on the map surface, a Home button, which allows the user to return to the default map extent set up the application creator, and a Location button, which indicates the user's location. These standard widgets are placed on the left side of the widget bar on the bottom of the application, seen in Figure 12 below.

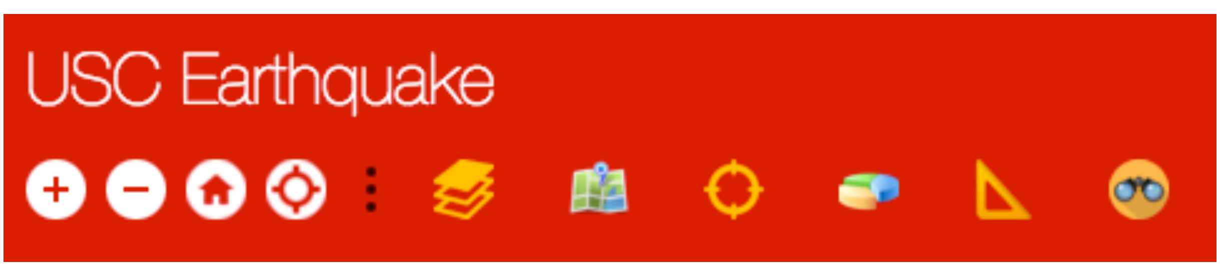

Figure 12) Image of Widget Toolbar

This application also contains widgets that needed very little configuration and customization. One of these was the Layers button, which allows the user to see the names and symbology of each layer, as seen in Figure 13. Another one of these simple widgets is the Basemap Gallery, which allows users to choose a new basemap from the ArcGIS Online gallery. Next is the Analysis widget, which includes Aggregate Points, Calculate Density, Find Nearest, and Summarize Nearby tasks and can be seen in Figure 14. Finally, the Measurement tool allows the user to measure polygons, straight line distances, and the longitude and latitude of a user defined point.

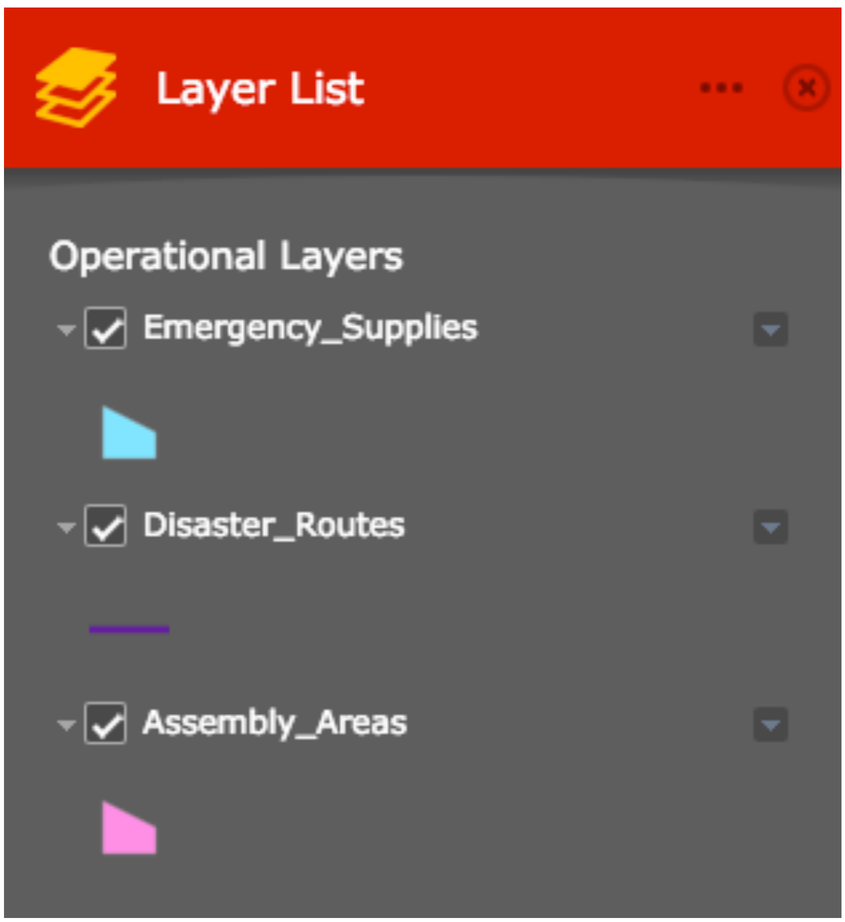

Figure 13) Image of Layer List Widget

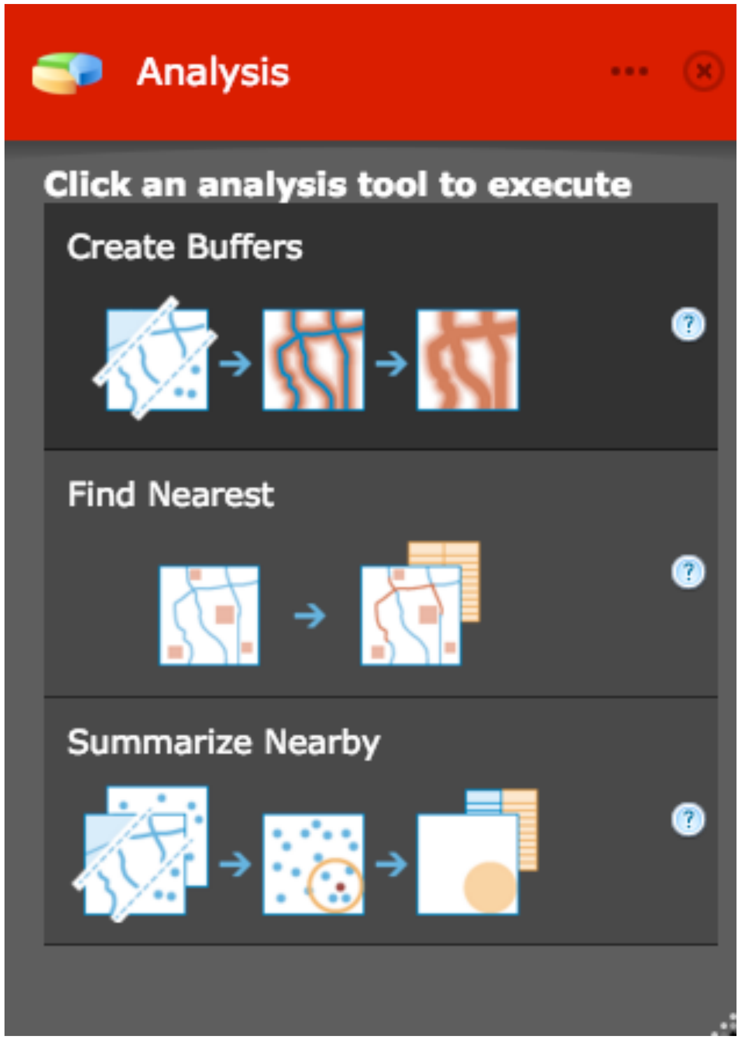

Figure 14) Image of the Analysis Widget

For the purpose of this project, a few widgets were customized to be uniquely used for this application. The Draw widget, which is intended to allow the user to add points, lines, and polygons on the map surface as operational layers, was renamed Add Location to make it clear that its purpose is to add a location of the user's choice. Next, the Incident Analysis widget was renamed as the Locate Nearest widget. This widget allows the user to input a location, define a buffer distance, and receive information about the location of emergency supplies, assembly areas, and disaster routes within that buffer. The result of this process can be seen in Figure 15.

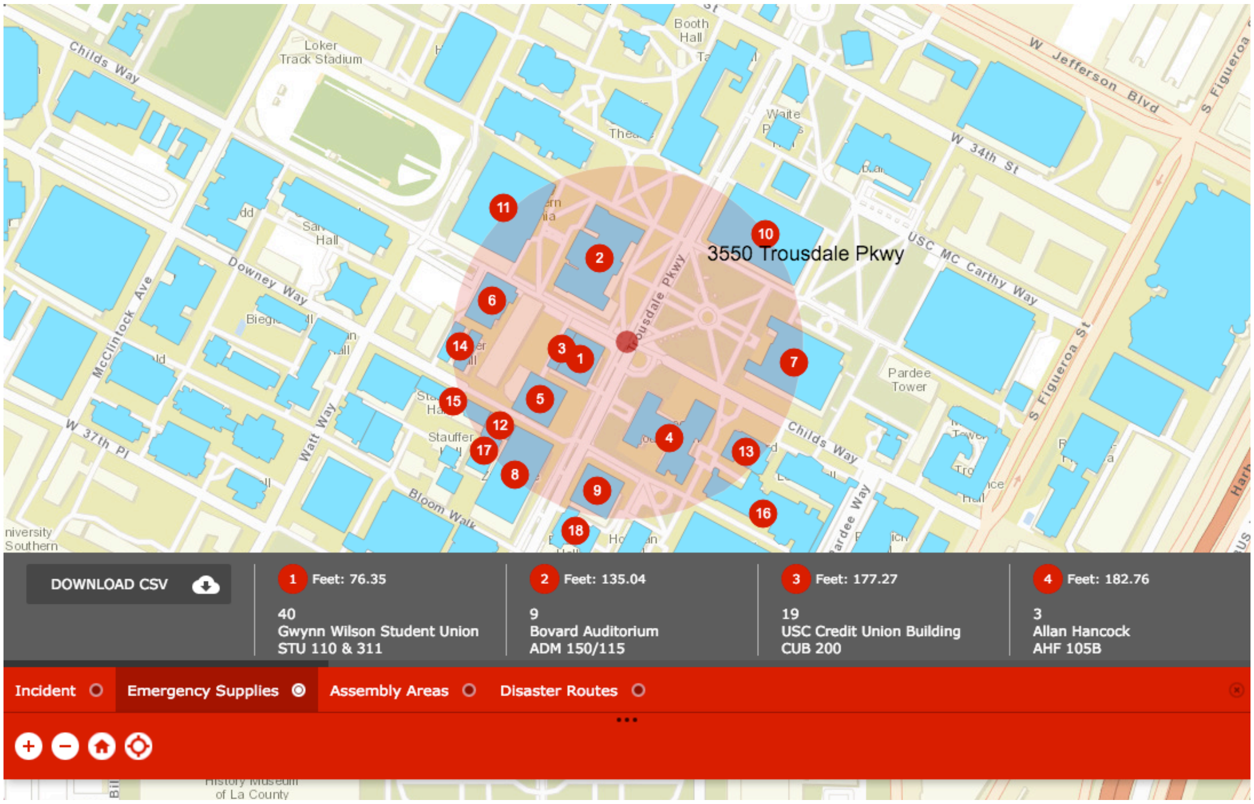

Figure 15) Locate Nearest Results

3.2 Participant Survey

This project seeks to understand how the use of the USC Earthquake application can impact the user's sense of earthquake preparedness in comparison to a stationary web map. In order to evaluate the educational impact of the web GIS application, this project will survey students in the USC community. The survey questions for this project will include demographic questions about the participant, their level of risk awareness, and their preparedness cognitions.

3.2.1 Visualization Comparison

This project seeks to compare two types of visualizations, comprised of the interactive application constructed for this project and a stationary web-based visualization. As described above, the application will be embedded into a website that will be distributed to survey participants. For the stationary visualization survey, the web GIS application will be replaced with the stationary visualization. This visualization will be an image of the map surface from the application without the widgets and tool of the application and can be seen in Figure 16.

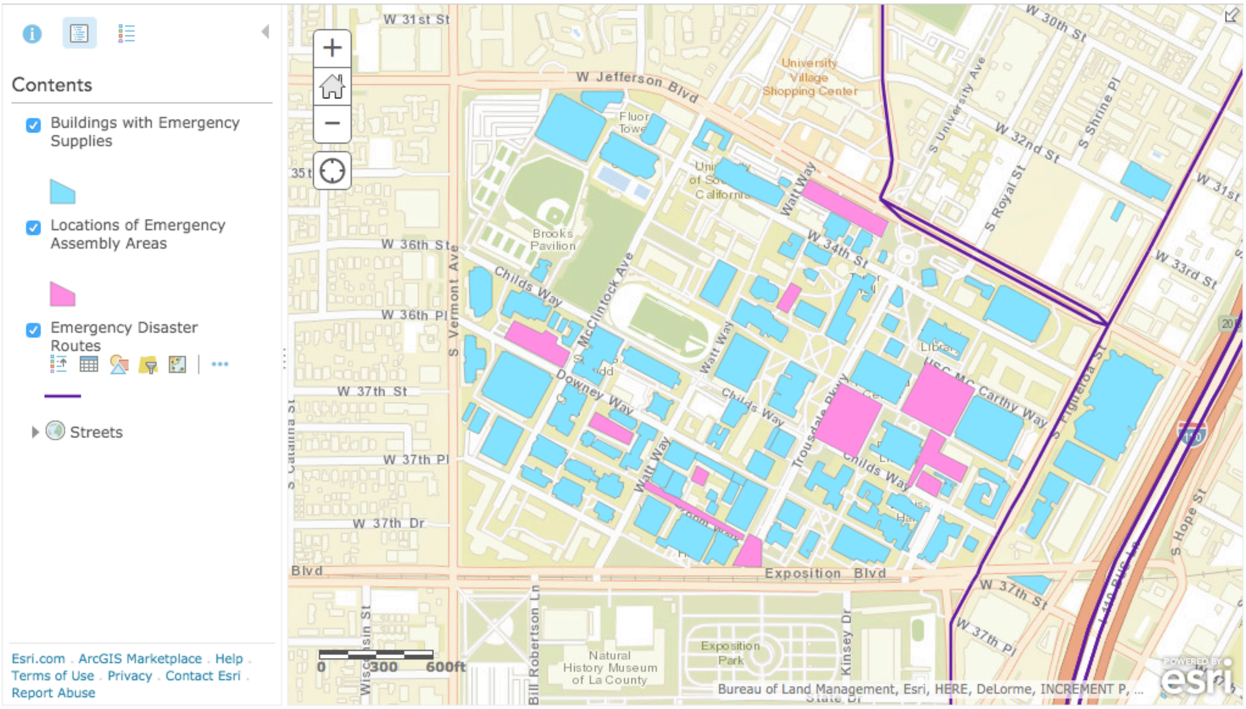

Figure 16) Stationary Visualization Used in Survey

3.2.2 Selection of Participants

In order to collect a sufficient amount of survey data, this project will aim to survey a total of 120 undergraduate student participants with 60 participants using the stationary visualization and 60 participants using the web GIS visualization. These participants will be asked to volunteer to test the visualizations and take the survey in several General Education courses on the University Park Campus. The purpose of asking for participants in General Education courses is to attempt to include survey participants from multiple different majors, backgrounds, and disciplines.

3.2.3 Survey Creation

This survey will be constructed on an online program, called Survey Monkey, so that the link can be distributed easily. Before the survey was distributed, a few individuals field tested the survey and gave suggestions about how to improve the survey.

Participants will be asked the same questions before and after the viewing the visualization. The first survey, named USC EQ 1, will contain an image of the stationary visualization and the second survey, named USC EQ 2, will contain a link to the USC Earthquake application. Questions that ask participants to rank their level of agreement will use the Likert scale, which uses the following phrases: Strongly Agree, Agree, Undecided, Disagree, and Strongly Disagree. Below is a sample of what the survey questions will be:

1) Demographic Questions
   (a) What is your major(s):
   (b) Year in School: (Freshman, Sophomore, Junior, Senior, Graduate)
   (c) Do you live on the USC campus? Yes or No
   (d) I am likely to experience an earthquake while attending USC: Rank Agreement
2) Risk Awareness- BEFORE Visualization
   (a) I would feel safe if an earthquake happened while I was on the USC campus: Rank Agreement
   (b) I would feel safe if an earthquake happened while I was in my place of residence: Rank Agreement
3) Preparedness Cognitions- BEFORE Visualization
   (a) I feel prepared for an earthquake: Rank Agreement

(b) I know where to go on campus in the event of an earthquake or emergency: Rank Agreement

(c) I know where to find emergency supplies on the USC Campus: Rank Agreement

4) Risk Awareness- AFTER Visualization

(a) I would feel safe if an earthquake happened while I was on the USC campus: Rank Agreement

(b) I would feel safe if an earthquake happened while I was in my place of residence: Rank Agreement

5) Preparedness Cognitions- AFTER Visualization

(a) I feel prepared for an earthquake: Rank Agreement

(b) I know where to go on campus in the event of an earthquake or emergency: Rank Agreement

(c) I know where to find emergency supplies on the USC Campus: Rank Agreement

After these surveys are received, the results will be analyzed to determine the overall impact of the web GIS visualization in comparison to the stationary visualization.

3.2.4 Analysis of Results

After the at least 60 participants have responded to the survey, the author will collect and compare the results. First, the author will establish if the respondents showed any increase in the level of risk awareness and sense of preparedness after either type of visualization. If there is proven to be an increase in these two factors, the author will compare the increase in risk awareness and sense of earthquake preparedness between the interactive visualization participants and the stationary visualization participants.

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