

FINDING YOUR BEST-FIT NEIGHBORHOOD:
A WEB GIS APPLICATION FOR ONLINE RESIDENTIAL PROPERTY SEARCHES
FOR ANCHORAGE, ALASKA

by

Jennifer Nicole Dowling

A Thesis Presented to the
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Jennifer Nicole Dowling

DEDICATION

To my ever-patient husband, Paul, who encouraged me to realize my potential.

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LIST OF ABBREVIATIONS

AMD	Asynchronous Module Definition
API	Application Program Interface
APD	Anchorage Police Department
ASD	Anchorage School District
CFS	Calls for Service
DPS	Alaska Department of Public Safety
ESRI	Environmental Systems Research Institute, Inc.
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GIST	Geographic Information Science and Technology
HTML5	HyperText Markup Language, revision 5
IIS	Internet Information Services
KML	Keyhole Markup Language
KMZ	Zipped Keyhole Markup Language
MLS	Multiple Listing Service
MOA	Municipality of Anchorage
MOA GIS	MOA, Information Technology Department - GIS Services
NAD83	North American Datum of 1983
REST	Representational State Transfer
USC	University of Southern California

ABSTRACT

Online geospatial data are evident in many websites, covering a variety of interests such as route planning, incident locations, and outdoor recreation searches. One type of geospatial website is the online real estate search. Many realty websites allow prospective residential property buyers to sort listed properties interactively based on desired elements. These elements typically address features wanted within a home, such as the dwelling's size, number of bedrooms and bathrooms, whether a garage or swimming pool is included, and other furnishings. Equally important in considering the ideal home is to find the ideal location. Length of the commute time, crime frequency, proximity to cultural and retail options, and the location of desired schools can provide for an overall "neighborliness" that is vital to ensure a comfortable life in the new home at the new location. While some websites are beginning to address this concern by including small overlays within a property's webpage, none overtly considers that the home buying process may not start with the selection of home features, but by first determining the "best-fit" neighborhood. The web application created for this thesis is unique in its premise to first introduce potential homebuyers to neighborhoods. Prospective homebuyers may select from several neighborhood factors to find locations that satisfy their search parameters. An overlay of available properties is then displayed for the web application user to show what offerings are available in those resulting areas.

CHAPTER 1: INTRODUCTION

This research project is designed to create a web application to allow prospective residential homebuyers to begin an online home search by first considering elements that make for a desirable neighborhood. The main goal of this project was first to understand the dynamic nature of geospatial website programming as it can be used to integrate neighborhood-based search features into existing residential real estate websites. The resulting web application is intended to provide a distinctive search for both the prospective buyer and his or her realtor by incorporating neighborhood-level geospatial data for the pilot study area of Anchorage, Alaska, in a unique approach that may be replicated in other municipalities.

1.1 Motivation

Home purchases are typically the largest expense one can make (Hoak 2010), and its selection is often an emotional one. Finding a home with the correct number of bedrooms and bathrooms is easy to do when researching real estate listings online, but it is unusual to incorporate an exploration of comfortable environments into the same general search. A good home in a less-than-ideal neighborhood can be disappointing.

One popular use for online geospatial data involves residential real estate, where prospective homebuyers can direct searches of available properties from a number of websites even before engaging a realtor (Trefethen 2013). According to the National Association of Realtors, 92 percent of homebuyers searched internet resources when searching for property and for 42 percent of buyers, examining online real estate websites was their first step (National Association of Realtors 2013). For the purposes of this thesis research, a property is defined as a residential dwelling, such as a single-family house or townhome that is available for purchase.

Real estate agents that present detailed information on available homes and land can realize increased interest in their properties and thus increased sales (Benjamin et al. 2005). This thesis web geographic information system (GIS) application was designed to assist two types of home shoppers: the recent transplant that may be unfamiliar with the town and is not acquainted with the various neighborhoods, and the long-time resident who wants to relocate but may not know the intricate social and environmental differences among the various sections of town. While an effective realtor can provide knowledgeable advice about the area, a comprehensive real estate website can also allow the buyer to research neighborhoods as simply as many websites currently allow general property research. Currently, most real estate websites pay little attention to these elements in the surrounding neighborhood. Are the schools good? Is the crime rate low? How far away from major roads, airports, or commercial properties is desired? Are there any natural hazards that would affect safety or make obtaining property insurance difficult? These additional elements must be considered at some point when looking for a home, and ideally, they should be considered early in the home search process.

1.2 Research Questions

This thesis answers several research questions. Is it possible to create a web application that contains the ability for users to filter neighborhoods by select criteria? Will such a web GIS application be easy to navigate and to understand? Herein, for the purposes of this thesis, a neighborhood is defined as a geographical subset of a municipal area that has characteristics distinct from surrounding areas. These characteristics may be as simple as major road boundaries or as complex as bounded social or ethnic associations. In this thesis, neighborhoods are smaller units that satisfy homebuyers' proximity desire for recreation, safety, or commerce.

According to real estate website site traffic numbers, current online real estate searches are a popular and practical means to shop for such large expenses. In February 2014, 316 million visitors went to an online real estate website from their desktop computer (Hagey 2014). Those numbers do not necessarily indicate a homebuyer or a unique visitor (they could be realtors, other home sellers, or real estate website developers), but they do suggest a viable business model. Online research is not confined to the desktop computer; the two largest websites, Zillow.com and Trulia.com, estimate that mobile device users account for almost half their website traffic (Hagey 2014).

1.3 Hypothesis

A unique web GIS application may be created that emphasizes neighborhood importance before home features. The application should be easy to navigate and intuitive, offer specialized neighborhood-related search functionality, and be simple to maintain. Finally, such an application can be constructed using select local knowledge rather than a more generic national-based assemblage of data, to fully inform the visitor at a local scale.

The web GIS application developed for this thesis project is unique in online home real estate searches compared to current online websites. This web GIS application offers the following local information and functionality, most of which are not currently found in exiting real estate websites:

- Trail routes with detailed use information
- Zoom and search within neighborhoods
- Political districts and current office holders
- Websites of all public schools

- Search by seismic layers
- Four prepackaged searches to assist in pinpointing optimal home search locations
- Ability to search by local address
- Share the resulting map via social media

CHAPTER 2: RELATED WORK

A web-based approach to offering real estate is neither unique nor rare, as shown by the number of real estate websites available. National real estate companies (e.g., Remax.com, Century21.com), local realtors, and businesses that display real estate offerings from multiple agencies or sellers (e.g. Zillow.com, Redfin.com, and Realtor.com) create these particular websites. All provide interactive maps that show available properties that the website visitor may filter based on their specific requests.

2.1 Web-Based Real Estate Sites

Figure 1 shows a filter on the website Homes.com. In this example, the user selects a 3-bedroom, 2-bathroom single-family home in Key West, Florida, priced between \$600,000 and \$800,000 and built sometime between 1900 and 1970. From those results, the visitor can click on any interesting properties for more information, photographs, and listing agent contact information, as seen in Figure 2.

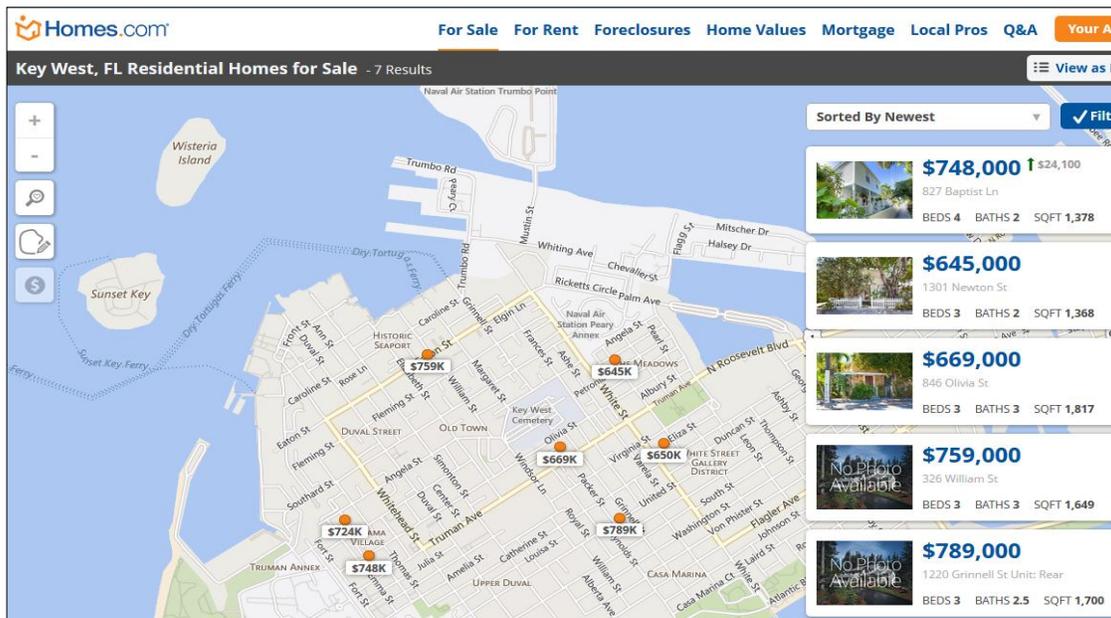


Figure 1 Results of the Interactive Filter from Homes.com

1214 Virginia St, Key West FL, 33040

Back to Results Search

For Sale > Florida > Key West > 1214 Virginia St

\$650,000 For Sale
\$3,360 Est. Payment

Get Prequalified with Wells Fargo

3 br, 2 ba 1 1/2 ba, 1,313 sq.ft.
 Price per sq.ft. \$495
 Check Your 2014 Credit Score

Save Email Share

Request Information

Name:

Email:

Phone:

I'd like more information about the listing that I found at Homes.com at 1214 Virginia St (MLS: 118812)

Get pre-approved from a local lender!

Send

Timothy Henshaw
 Key West Realty, LLC
 305-294-3064



Map View Street View

Property Record

Bedroom(s)	2	Monthly Est. Mortgage	\$2,481
Bathroom(s)	2	Monthly Est. Insurance	\$168*
Square Footage	950	Monthly Property Tax	\$338
Price Per SqFt	\$495*	Tax Year	--
Lot Size	0.05 acres	Tax Amount	--
Stories	2	Last Updated	05/28/2014
Property Type	Single Family	Last Sold Date	10/14/2004
Year Built	1928	Last Sold Price	\$811,000
MLS #	118812		

Public County Property Record information is provided by © SmartZip Analytics, Inc. and ©2011 Fast Forward, Inc. Information is deemed reliable, but not guaranteed.

Figure 2 Result of Homes.com Website Search Filter

Real estate web programming is often patented to secure intellectual ownership. Several processes in early real estate website programming were submitted to the US Patent Office to secure intellectual property rights for their authors (Choziak 2003); (Eraker, et al. 2005); (Florance, et al. 2007); (Hancock 2003); (Hoffman, Anzalone, and Cormack, 2003). The ideas presented in the patent applications suggest effective yet generic programming tactics. Eraker, et al., (2005) as one of the first developers submitted a patent application for the residential online real estate company Redfin.com that outlines a web-based program to include aerial image overlays and the ability to search various databases, including tax rolls, multiple listing service (MLS) listings (Multiple Listing Service 2012), and local government GIS datasets (Redfin 2012). These processes collect the available properties to create their databases and in turn build the website. Such early real estate websites served as examples for subsequent sites that use geospatial techniques to locate housing options.

Several national-level real estate websites including Realtor.com, Redfin.com, and Zillow.com also provide local demographic or financial data either as a general overview of a town or for user-selected properties. Realtor.com also displays limited local information when the user selects a property from the map (Figure 3). Zillow allows users to choose school boundaries as a neighborhood filter (Figure 4), and helpfully links school performance data from GreatSchools.com (GreatSchools 2013). Many other websites do not show any local information, at least not in map form or in otherwise readily searchable formats. Instead, Redfin uses a number of charts to describe the demographics, climate, and housing costs by zip code (Redfin 2012). Although this is useful information, it is not actionable when users want to quickly sort properties in a map (Figure 5).

One of the more innovative companies is Trulia.com. Their website employs a broad selection of local information (Figure 6). Users can view overlays of local amenities, school boundaries, floodplains, and earthquake zones, and via a simple interval map see travel times from a selected origin (Figure 7). Trulia has data for most of the United States; for locations where they do not have comprehensive coverage, users can at least view school boundary polygons and their associated GreatSchool.com ratings. Similar to the other websites, Trulia displays these data layers from the city overview page, or in limited form from a selected property's page rather than as an introduction to a neighborhood search (Figure 8) (Trulia 2012).

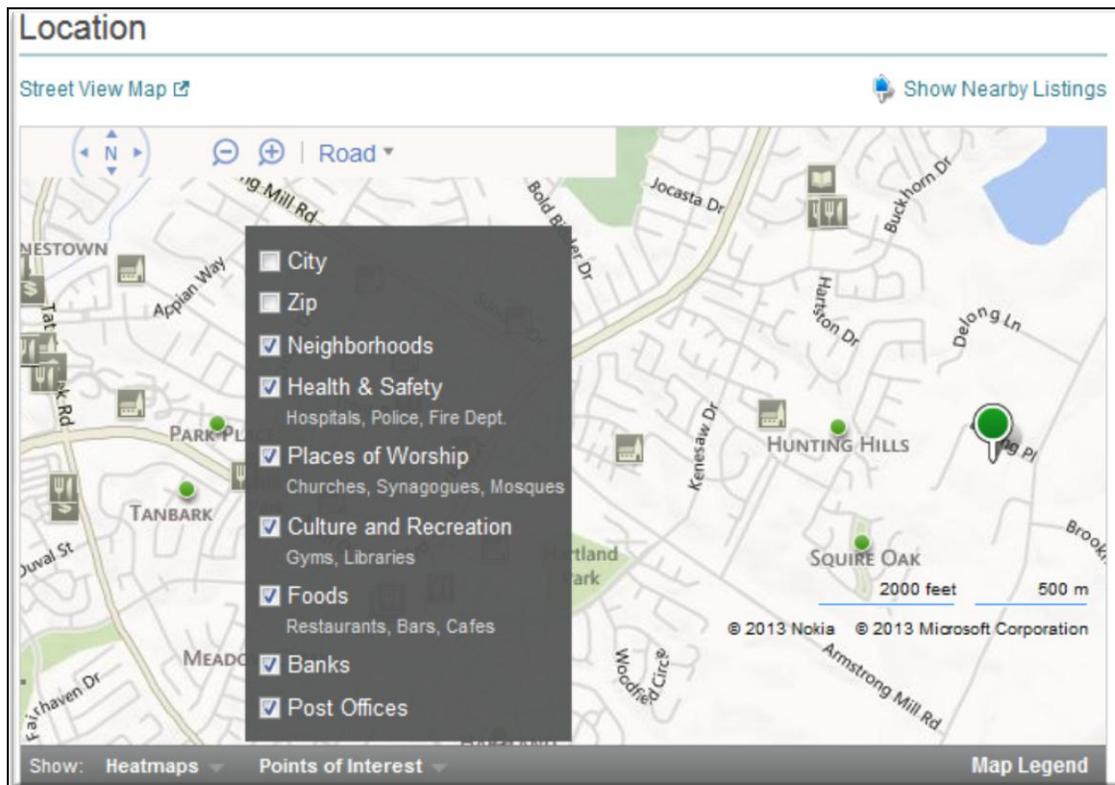


Figure 3 Realtor.com Amenties Legend Near a Property in Lexington, Kentucky

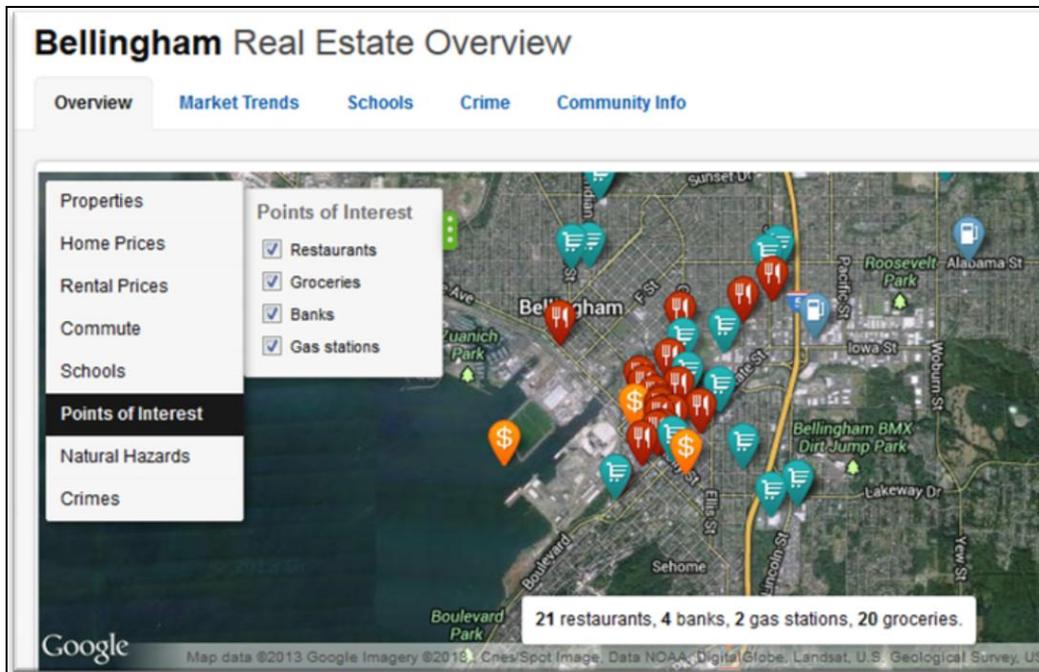


Figure 6 Trulia.com Selected Local Data for Bellingham, Washington

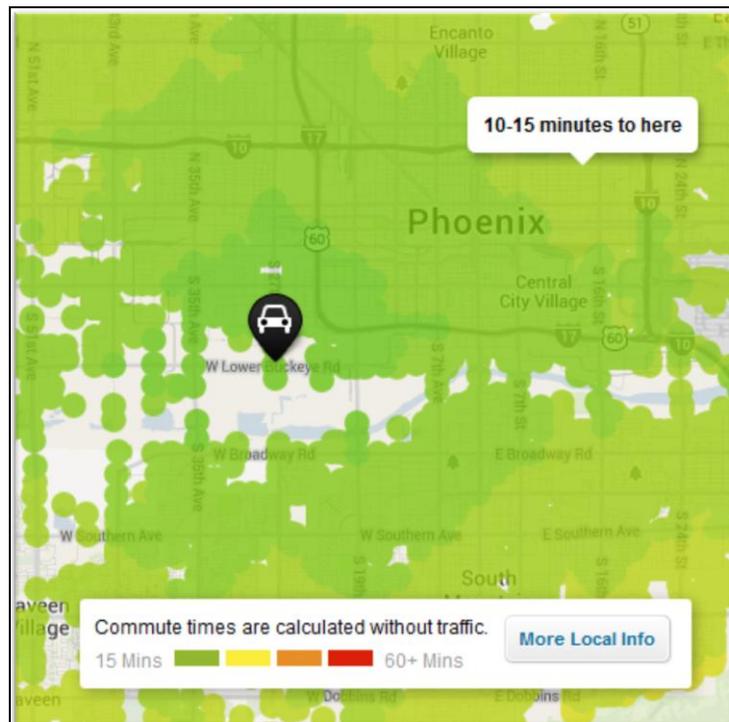


Figure 7 Trulia.com Display of Commute Times in Phoenix, Arizona

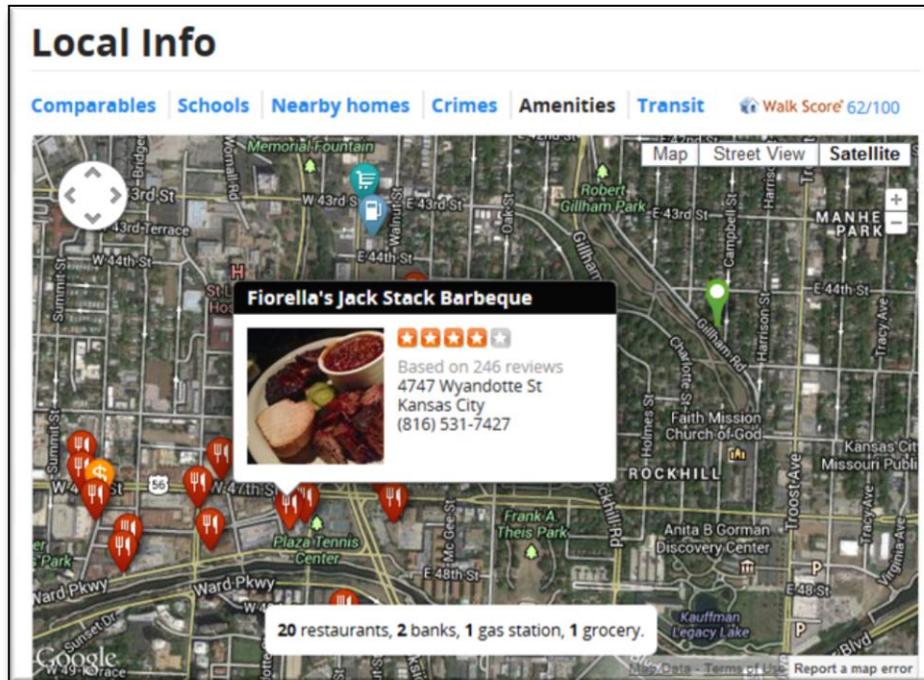


Figure 8 Local Amenities Near a Property in Kansas City, Missouri From Trulia.com

Crime information is also often considered in a home search and is addressed not only by the three big realty websites, but also by dedicated crime information websites such as Raidsonline.com (BAIR Analytics 2011). This site receives crime data from participating law enforcement agencies throughout the North America via automated feeds and populates the map with both point data and heat maps (Figure 9). This interface also allows users to choose crime types and buffer them around a location.

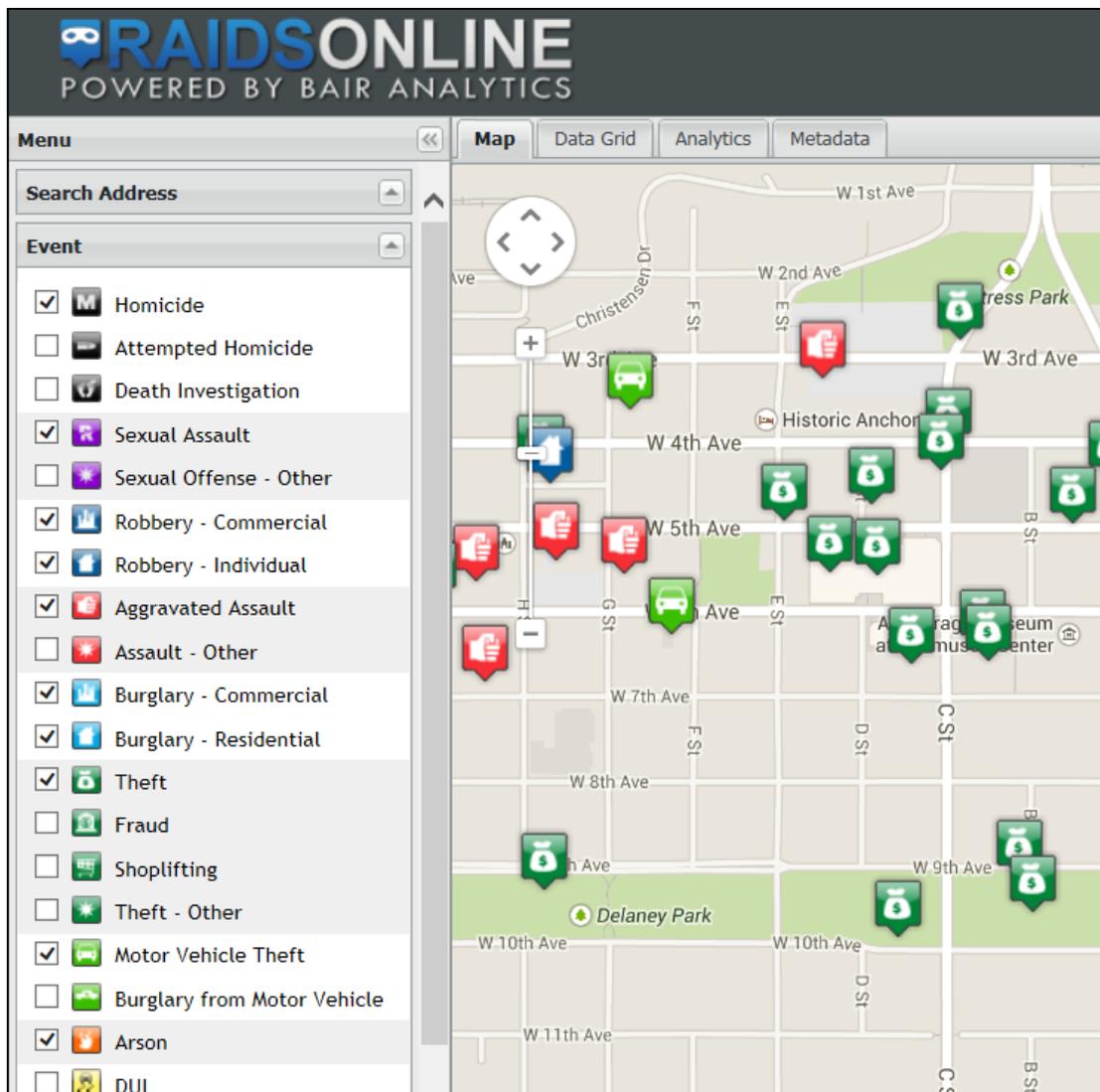


Figure 9 RaidsOnline.com Display of Anchorage, Alaska

The information in these websites is very useful to identify features of concern in an area, but they are not prominent (easily accessible) in the property-level (individual home) search, and they do not answer all the questions a prospective buyer may have, particularly about local political boundaries or other demographic data. Moreover, because they either reference a specific property or give a general overview of an area, the functionality of these real estate search applications as detailed above cannot help homebuyers sort a town into neighborhood

choices. Whereas the website application created for this thesis project is designed to first guide the user to search and find ideal neighborhoods based on a variety of layer selections, such as business or industry, major roads, schools and recreation. From within the resulting boundaries, users can then investigate available properties.

2.2 Online Web Real Estate Consumer

According to a study by the National Association of Realtors, ninety percent of homebuyers begin their search online (National Association of Realtors 2013). As more real estate websites come online and offer varied options to attract web traffic, home shoppers have responded. In March 2014, the top twenty online real estate websites showed 22.4 million unique visitors using either a desktop or mobile application, as shown in Figure 10. Of those, the top three most-visited websites include Realtor.com, Zillow, and Trulia. These websites claimed over half that amount (National Association of Realtors 2014). These numbers have increased steadily indicating that this method is viable for introducing properties to prospective buyers, perhaps regardless of buyer age. It is interesting to note that Zillow plans to purchase Trulia in 2015, and intends to operate both websites as independent businesses. (Light 2014).

As these real estate website flourish, specialized websites that provide various levels of in-depth details about neighborhoods, similar to this thesis, also appear. Such sites include NeighborhoodScout.com and Homefacts.com, where local information is prominent over property searches. NeighborhoodScout (NeighborhoodScout 2014) is a membership site that offers over 150 search parameters, most culled from US Census datasets, while Homefacts (Homefacts 2014) offer only neighborhood snapshots and limited filtering options. Both sites will link to local realtors, but neither provides home searches as its primary function.

Top Real Estate Vertical Matrix*							
Media	Unique Visitors (000)	Avg Views per Visitor	Avg Minutes per Visit	Avg Views per Visit	Total Visits (000)	Total Minutes (Millions)	Total Views (Millions)
Total Internet : Total Audience	249,513	3,776.0	21.8	34.0	27,675,138	1,135,499	942,230
Real Estate	91,620	54.0	6.3	8.6	569,432	4,207	4,906
ZILLOW.COM	42,817	25.0	4.6	4.8	227,940	1,361	1,083
REALTOR.COM	22,356	24.0	6.5	7.1	75,567	661	537
TRULIA.COM	21,397	17.0	5.0	5.0	72,711	362	364
Yahoo Homes.com	13,141	15.0	2.6	7.3	26,049	67	191
HOMES.COM	6,415	13.0	4.4	7.0	11,778	52	87
REDFIN.COM	5,421	11.0	5.1	3.9	15,520	87	61
HOTPADS.COM	3,682	15.0	3.7	6.5	8,282	31	54
CENTURY21 International	3,268	9.0	3.5	4.5	6,674	30	29
MOVOTO.COM	3,260	7.0	3.1	4.0	5,791	18	23
COLDWELLBANKER.COM	1,755	11.0	5.3	6.8	2,919	16	20
REMAX.COM	1,606	6.0	4.5	4.0	2,500	11	10
CURBED.COM	1,513	10.0	4.5	2.8	5,682	25	16
FORSALEBYOWNER.COM	1,176	6.0	2.6	3.8	1,705	4	7
HAR.COM	1,105	50.0	5.7	8.7	6,430	40	56
ZIPREALTY.COM	1,079	16.0	5.9	7.3	2,344	22	17
WEICHERT.COM	1,035	14.0	3.9	7.5	1,904	7	14
HOMEFINDER.COM	970	21.0	4.6	10.9	1,830	8	20
FRONTDOOR.COM	951	19.0	5.0	3.7	1,325	7	18
KW.COM	941	19.0	5.0	13.7	1,325	7	18
HUBZU.COM	722	66.0	15.2	30.2	1,573	24	48

Figure 10 Top Real Estate Vertical Matrix
Source: (National Association of Realtors 2014)

NeighborhoodScout delivers the results of a selection as a series of responses in paragraph form and as charts, as seen in Figure 11 and Figure 12. Homefacts lets users identify a variety of elements and a small selection of available properties within a given area (Figure 13). Once a property is selected, Homefacts will show a snapshot of "local area highlights" such as schools, crime rating, or natural hazards (Figure 14). Both websites offer the user a good choice of options to narrow a home search and explain their parameters. A cursory examination of Homefacts shows elements that may concern a homebuyer, such as placing Manhattan in the wrong county (indicating geocoding problems) and inflating the importance of a category (listing "Tanks and Spills" implies all the containers were hazards). Websites such as these are valuable, but because they are designed to apply to the entire US these websites end up being generic in their search functionality and resulting data descriptions, lowering the amount of detail on provided on a given topic. The homebuyer can benefit from a more local approach, which is attempted in this thesis project.

NOTABLE & UNIQUE NEIGHBORHOOD CHARACTERISTICS

The way a neighborhood looks and feels when you walk or drive around it, from its setting, its buildings, and its flavor, can make all the difference. This neighborhood has some really cool things about the way it looks and feels as revealed by NeighborhoodScout's exclusive research. This might include anything from the housing stock to the types of households living here to how people get around.

NOTABLE & UNIQUE: DIVERSITY

Did you know that the Connorville / Hillcrest neighborhood has more Finnish and Lithuanian ancestry people living in it than nearly any neighborhood in America? It's true! In fact, 23.5% of this neighborhood's residents have Finnish ancestry and 1.0% have Lithuanian ancestry.

Figure 11 Extract of Neighborhood Description of Ironwood, Michigan
Source: NeighborhoodScout.com

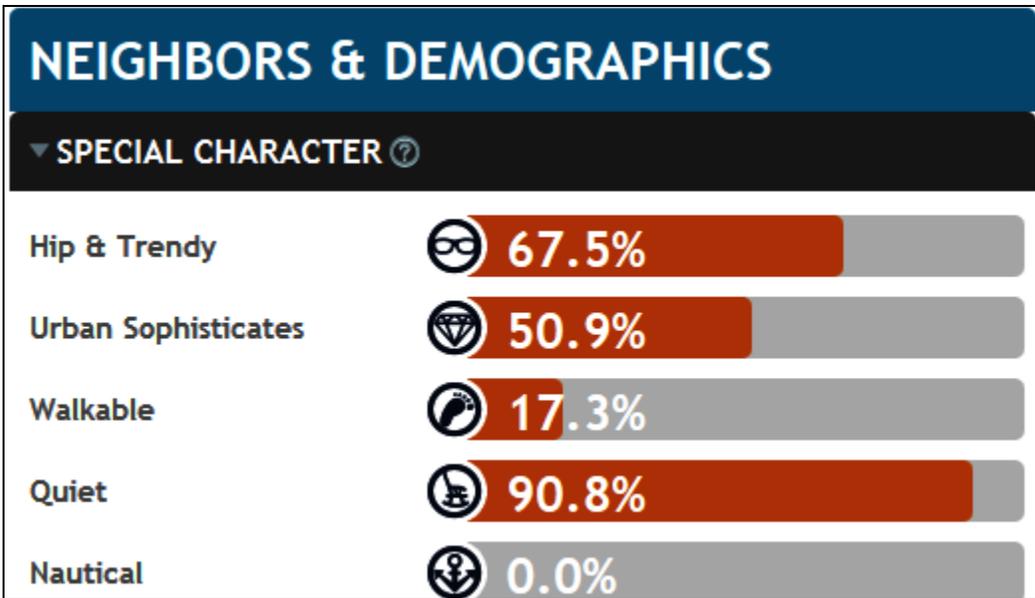


Figure 12 Graphic Demographic Representation of a Neighborhood in Ironwood, Michigan
Source: NeighborhoodScout.com

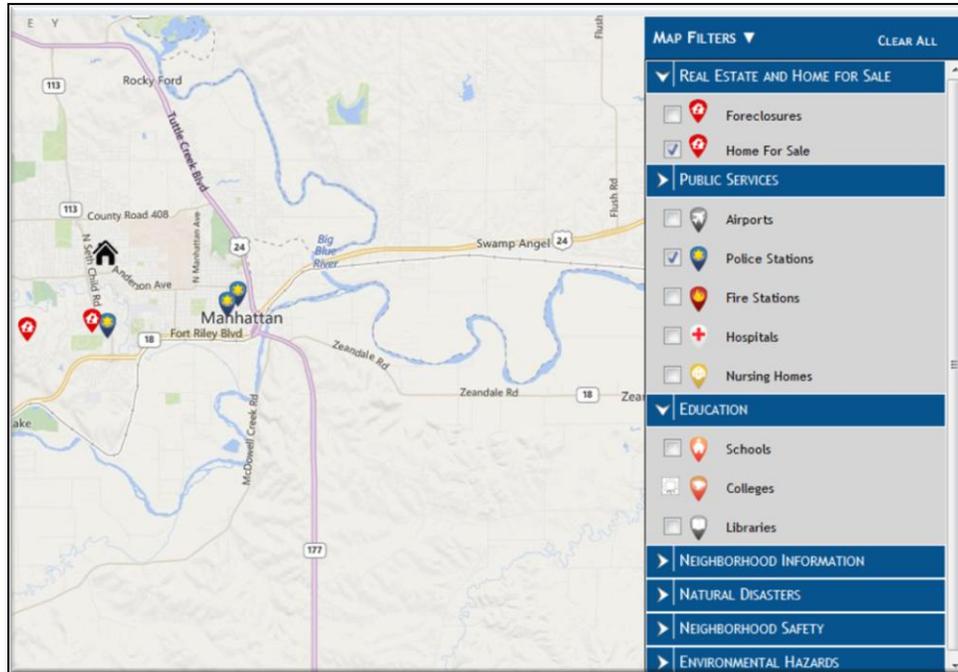


Figure 13 Filtering Options for Manhattan, Kansas
Source: Homefacts.com

2808 Arbor Dr., Manhattan, KS 66503

FOR SALE | **\$183,000** | **3** Beds | **3** Baths | **2,758** Sqft | Single Family
 Current Status | List Price | Beds | Baths | Sqft | Year Built: 1981

Photos | Map | [View interactive map](#)

Listing Details:
 MLS ID: REBRKS
 Listed: 03/13/2014 (3 months ago)

Local Area Highlights

- 5 Offenders** within 1 mile
- 2 Foreclosures** within 2 miles
- Nearby Schools: B-** Avg rating of 5 nearby schools
- Crime Rating: A+** Manhattan, KS
- Unemployment: 3.4%** Manhattan, KS
- 10 Tanks or Spills** within 2 miles
- 0 Drug Labs** within 1 mile
- Earthquakes: Very Low**
- Tornadoes: Low Risk**

Listing Description: 2808 Arbor Dr., Manhattan, KS 66503:
 Wonderful 3 bedroom, 3 bath ranch with finished basement, separate laundry on main level. All baths have been beautifully updated. There is a 2 car attached garage. The house is located on a Cul-de-Sac. The lot backs up to Warner Park, city's largest undeveloped space with beautiful native prairie grass and wooded valley. Located on the west side of town close to K18 for quick access to Ft. Riley... [Show More](#)

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Figure 14 Property Information from Homefacts.com

2.3 Caveats to Neighborhood Search Models

The number of options a shopper can integrate into a neighborhood search can be a double-edged sword in how the output data may be used by consumers. Searches that incorporate schools, commute times, and distances to services are simple, but adding granular information from census data such as ethnic makeup, income levels, and religious affiliation can be problematic. Such searches can be innocuous - families who want to live surrounded by other immigrants from the same country, or religious sects who commonly live in community settings - or they can appear more exclusionary and xenophobic. Real estate agents tend to avoid addressing such search requests for fear of conflicting with fair housing laws (Wiggin 2014). "Hyper local" data, while appealing to the more tech-savvy real estate shopper, can devolve a home search into a series of frustrating results that yield no successful neighborhoods, and therefore no properties of interest. In fact, while NeighborhoodScout uses over 100 search parameters culled from census data and local government websites, none can reliably inform a shopper whether the couple next-door keeps a team of howling sled dogs, the aspiring hockey star practices slap shots against the garage door, or that those families in the cul-de-sac insist on an "open door" policy and weekly potlucks.

As the well-informed internet shopper gleans data from websites, the role of the real estate agent may shift from a home finder to a home guider. Nearly all real estate websites appear to recognize the important role the realtor plays in the process and lists their names where possible in the property listing page (Figure 15). All real estate websites contain factual errors or suspect evaluations; competent realtors can therefore provide the additional, better source of local knowledge compared to a website.

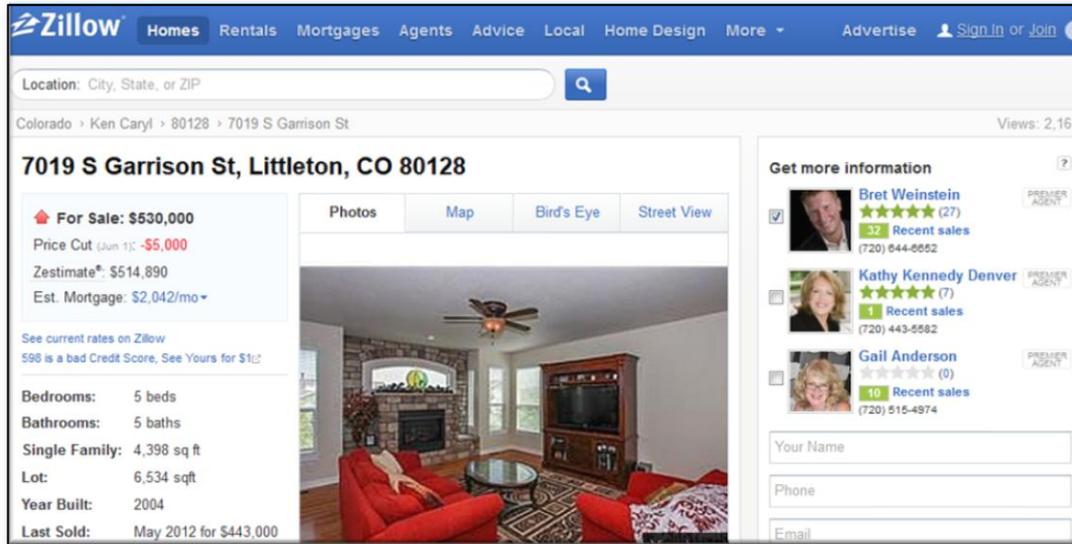


Figure 15 Realtor Links for a Zillow Listing

Given these numerous and varied data prompts homebuyers need to do to perform their own spatial analysis - what information is most important in the neighborhood search and how much credence should be given to the datasets themselves? As for the data quality and/or accuracy question, information that produce red flags for a property may not even be current or accurate, or can be misinterpreted. Crime data must be up to date and reflect trends, businesses close, and areas are rezoned for other purposes. Registered sex offenders move and new ones join the list (and not all offenders register). In examining a crime heat map, a reader may shy away from areas indicating high crime without realizing that those values are relative and temporal, and the types of crime included or not included in the map affect its display. For the prudent shopper, in real estate as in all other things, *caveat emptor*.

Lastly, the *Los Angeles Times* developed an online neighborhood map that displays census data including aggregated statistics for population, ethnicity, income, age, and some housing data such as rentals (Los Angeles Times 2014). The *Los Angeles Times* web map project differs from this thesis web GIS application in that it only provides data that defines and

describes neighborhoods, rather than supplying functionality associated with online real estate searches. The *Los Angeles Times* is using census tract-level information in an interactive map format to allow users to understand a fuller picture of a neighborhood in regards only to demographics.

CHAPTER 3: METHODS AND DATA SOURCES

The programming effort in this thesis resulted in a web GIS application that integrates existing real estate property data with related city and neighborhood data for Anchorage, Alaska into an interactive local mapping website. The study area was limited to a subset of Anchorage known as the Anchorage Bowl to minimize the processing time and storage size of the various large datasets. Anchorage was chosen for several reasons; it has a dedicated GIS user group within the municipality that creates and serves many appropriate and current datasets that the author has used before (Municipality of Anchorage 2013). The study area is located in a seismically active area, therefore, unique local seismic zone data have also been included in the web GIS application. Anchorage is the author's hometown and where she owns a home, so the author is familiar with the neighborhoods and issues homebuyers consider and can knowledgably evaluate the results of this thesis project.

3.1 Study Area

The study area was limited to a section of the Municipality of Anchorage (MOA) that excludes the surrounding bedroom communities. The city is bounded by ocean to the west and south, Joint Base Elmendorf-Richardson to the north, and Chugach State Park to the east (Figure 16). This roughly 112 square-mile area is called the Anchorage Bowl.

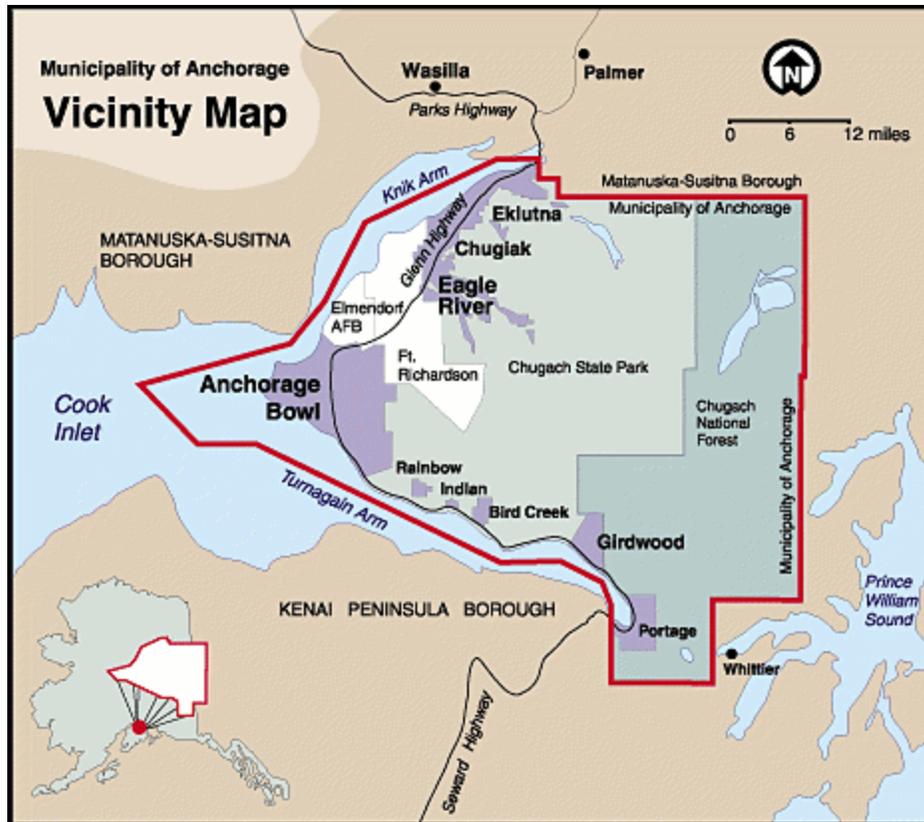


Figure 16 The Anchorage Bowl and Vicinity (Municipality of Anchorage 2013)

3.2 Web Application Development

The research conducted for this project centered on how to display residential areas that satisfy homebuyers' desired neighborhood features by creating a web GIS application that displays in a single webpage a detailed map of the study area (the Anchorage Bowl) flanked by a side panel where users may toggle various layers on and off for a custom display. These map layers are described Table 1 and Table 2, and consist of schools, trails, parks, seismic zones, business zones, industry zones, port and airports, major roads, and railroads. Four grouped selection layers, described in Table 3, are the result of intersections among multiple thematically-related layers. These resulting web mapping application user selection polygons illustrate the optimal areas to begin a home search.

Table 1 Source Material Information (Municipality of Anchorage 2013)

Layer	Theme	Source	Original Format	Date of Collection, Edit, or Metadata
Crime	Hazards	APD	shapefile	2012 data, layer created June 2013
Sex Offenders	Hazards	DPS	spreadsheet	June 2013
Seismically-Induced Ground Failure Susceptibility	Hazards	MOA GIS	shapefile	1979, edited 2005
Floodplain	Hazards	FEMA	Map Service	2014
School Boundaries	Education and Recreation	ASD	keyhole markup language	2013
Parks, Trails	Education and Recreation	MOA GIS	shapefile	2006, original, but updated "as needed"
Zoning	Transportation and Zoning	MOA GIS	shapefile	2008
Railroad	Transportation and Zoning	MOA GIS	shapefile	2008
Roads	Transportation and Zoning	MOA GIS	shapefile	1999
Political Boundaries for State Senate, State House, Anchorage Assembly Districts	Political	MOA GIS	shapefile	Updated after each election, current as of 2014
Neighborhoods	Political	MOA GIS	shapefile	2008
Anchorage Bowl	Political	MOA GIS	shapefile	2008
Properties	Housing	Gina Bergt, Realtor	spreadsheet	June 2013

Table 2 2012 "Calls For Service" Crimes By Type in the Anchorage Bowl (Morberg 2013)

Crime	Type	Count
Arson	Violent	74
Assault	Violent	3530
Burglary	Nonviolent	1096
Disorderly Conduct	Nonviolent	267
Disturbance	Nonviolent	15513
Drugs	Nonviolent	1574
Drunk Problem	Nonviolent	6296
Fraud	Nonviolent	258
Gambling/Prostitution	Nonviolent	162
Homicide	Violent	15
Liquor Law Violation	Nonviolent	470
Misconduct Involving Weapons	Nonviolent	1009
Robbery	Violent	380
Stolen Vehicle	Nonviolent	68
Theft	Nonviolent	2472
Vandalism	Nonviolent	765

Table 3 All Layers That May Be Viewed or Incorporated in a Search

Layer Name	Display	Included in Search
Trails	X	Outdoors, Great Outdoors
Parks	X	Outdoors, Great Outdoors
Neighborhoods	X	Neighborhoods
Anchorage Assembly District	X	Anchorage Assembly District
State Senate District	X	State Senate District
State House District	X	State House District
Anchorage Bowl	X	Anchorage Bowl
Alternative School	X	Alternative School
Charter School	X	Charter School
Elementary School	X	Elementary School
Elementary School Boundary	X	Elementary School Boundary
Middle School	X	Middle School
Middle School Boundary	X	Middle School Boundary
High School	X	High School
High School Boundary	X	High School Boundary
Crime Heat Map	X	Crime Heat Map
Seismic Zone	X	Quiet Zone
Sex Offender	X	Sex Offender
Flood Plain	X	Flood Plain
Available Housing	X	Available Housing
Major Road		Great Outdoors, Quiet Zone, Commerce
Railroad		Great Outdoors, Quiet Zone
Port		Great Outdoors, Quiet Zone
Industry		Great Outdoors, Quiet Zone
Business		Great Outdoors, Quiet Zone, Commerce

This thesis project was developed primarily using Esri ArcMap 10.2. Layers and data were initially processed using Esri ArcMap 10.1 and 10.2 to import shapefiles, to convert data to Google Maps' Keyhole Markup Language Zip (KMZ) layers, and to create datasets from

comma-delimited input data. The programming language was hypertext markup language, revision 5 (HTML 5), using a combination of Esri-created JavaScript v3.7 (3.8) modules (Esri 2013) and other-created JavaScript v3.7 (3.8) with Dojo (Dojo 2014), all using Asynchronous Module Development (AMD). Dojo acts as a shortcut to JavaScript modules, referencing third party libraries accessed over the internet, rather than stored on the development server. Dojo works with AMD to allow the webpage to load quickly, to avoid lag time by only running the modules as they are called.

All data were projected to NAD83, Alaska State Plane Zone 4. The final web GIS application was created using datasets published to ArcGIS.com by the author and added to an Esri Story Map template (Esri 2014) which was modified with programming written in JavaScript v3.9 and its associated Dojo toolkit (Dojo 2014). Notepad++ was used as the webpage editing program (Ho 2011). The full process of creating the web application is discussed in section 3.4.

The flowchart in Figure 17 outlines the process of collecting, editing, and publishing the data. A collection of relevant data was obtained through municipal and private sources and organized thematically for processing in ArcMap. The themes chosen cover *Hazards, Education and Recreation, Transportation and Zoning, and Political* - groups often-considered elements by homebuyers who wish to understand a town and its neighborhoods. *Hazards* includes floodplain zones, a crime heatmap, locations of registered sex offenders, and seismically induced ground failure susceptibility polygons. *Education and Recreation* shows all public schools and MOA trails and parks. *Transportation and Zoning* contains several layers including major roads, railroads, the port and airports, and business and industry zoned areas. *Political* is a set of boundaries for the Anchorage Assembly, Alaska Senate, Alaska State House, the names of

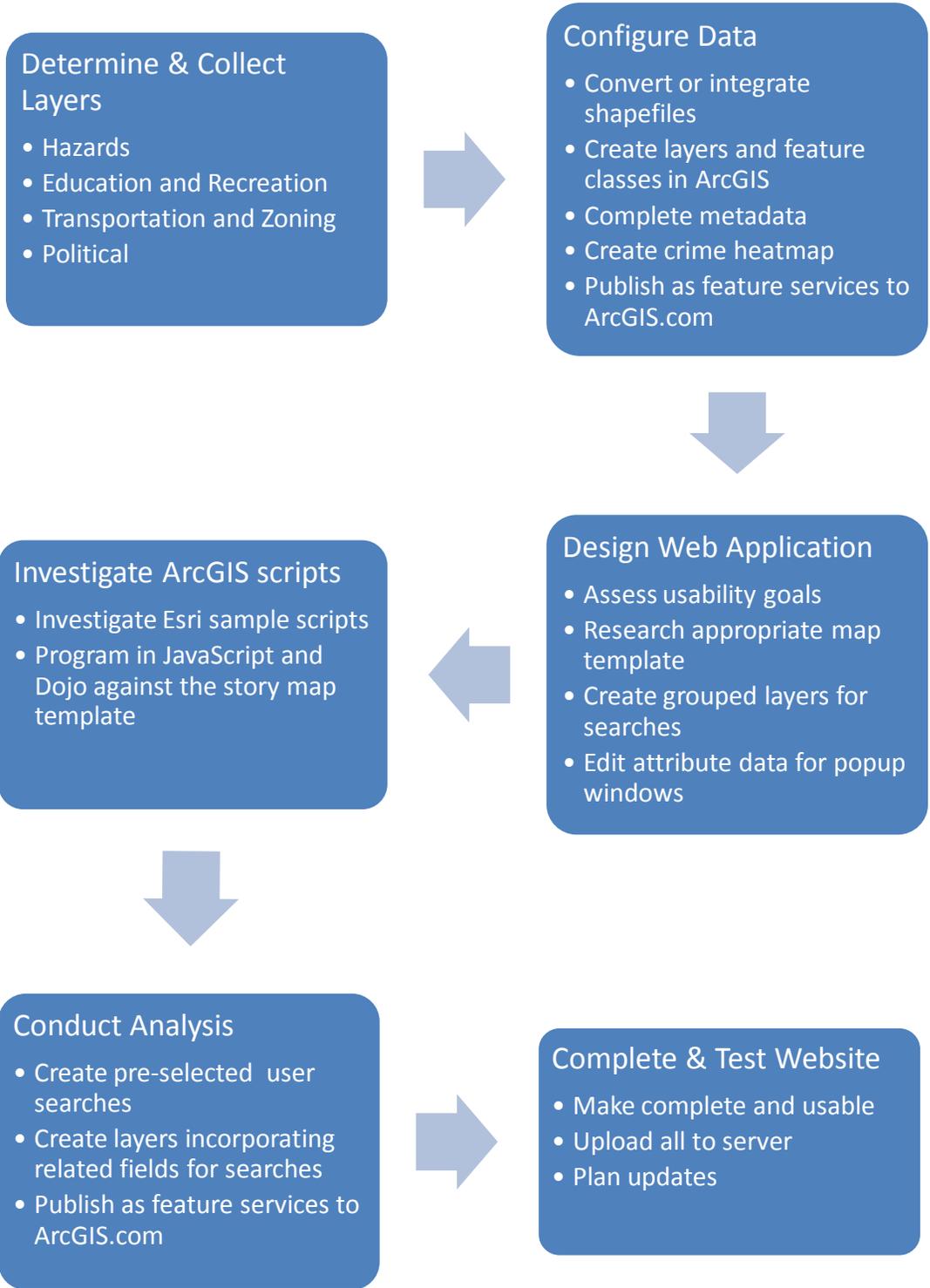


Figure 17 Flowchart Showing the Find Your Anchorage Neighborhood Creation Process

subdivisions in Anchorage, and the study area boundary, the Anchorage Bowl. A final layer called *Available Housing* is a sample of housing properties culled from the multiple listing service (MLS) (Bergt 2013). One of the main objectives of the web GIS application is for users to be able to toggle that layer on and off to view what properties are for sale in their newly chosen neighborhoods.

In regards to determining the most appropriate software to use in coding this thesis project, initial research suggested that Google Maps coded with Hypertext Markup Language 5 (HTML5) and JavaScript, Python, MySQL, or Google Fusion Tables (Google 2012) would be effective to create a simple website application. In contrast to a high level of programming skill, for example using Java, required to create the desired application using Google products, it was found that Esri's ArcGIS templates provide pre-coded web GIS applications that can be customized more easily using JavaScript, Dojo and HTML (Esri 2013). Esri has an active developers' website (Esri 2013) to assist web designers and other programmers, by posting samples of JavaScript and Dojo scripting that can be customized to perform many varied tasks.

Nearly twenty maps using various programming methodologies, scripting languages and various website examples were created and tested as part of this thesis project. Ultimately, the ability to create a fully functioning web application incorporating the desired datasets was successful using Esri's Story Map templates. The latter facilitate focusing on thesis-specific GIS-created data (Table 2) over detailed programming skills that would have been required to program the web GIS application from scratch, such as creating and integrating many different Java or JavaScript applets to allow for the a number of different search options and related map display.

3.3 Source Data

Table 1 identifies all the data created or incorporated for the project. Much of the data were provided as shapefiles from the Municipality of Anchorage, Information Technology Department GIS Services (MOA GIS), particularly the zoning, seismic, and political boundaries (Municipality of Anchorage 2013). The Anchorage School District (ASD) provided school locations and attendance boundaries in KMZ files (GreatSchools 2013). Crime data covering all calls for service received in 2012 came from Mr. Bryan Morberg, the GIS Analyst at the Anchorage Police Department (APD), while the sex offender list of all registered offenders as of June 2012 was obtained from Citydata.com culled from lists from the Alaska Department of Public Safety (DPS) (Alaska Department of Public Safety 2013). A random sample of properties on the market was obtained from Ms. Gina Bergt, a local Realtor with the Jack White Real Estate office in Anchorage (Jack White Real Estate 2014). The temporal coverage of this data is homes for sale in June 2013, as an example of a properties dataset that can be loaded directly into this application. With the exception of the real estate listings, all data covered the geographic extent of the Municipality of Anchorage rather than just the project limits of the Anchorage Bowl.

These data layers reflect typical homebuyer queries such as schools, crime rates, and recreation opportunities. Additional features unique to Anchorage were also included, specifically floodplain zones and seismic designations. Although these elements are also included in local searches with other online real estate websites, they may not be necessary in all parts of the country as they are in Anchorage. In some parts of the country, other hazards for tornadoes, hurricanes, and wildfires may be appropriate for inclusion instead.

3.3.1 Source Data for Hazards Theme

There are four datasets in the *Hazards* theme: crime, sex offenders, seismic areas, and 100-year flood data. Crime data include all reported calls for service (CFS) to the APD in 2012. These point data were delivered already geocoded in shapefile format and were added to the geodatabase. The types of crimes are sorted in Table 2 and investigated in the call_type field within the ArcMap layer attribute table (Figure 18, attribute Call_Type). One specific category is omitted from this list: sexual assaults (Morberg 2013), whose locations were adjusted by the data owner to APD headquarters in order to protect the victims. This readdressing would skew the distribution of crime shown on a heat map and therefore was deemed unsuitable for inclusion in this web GIS application. The remaining 33,949 (3,999 violent and 29,950 nonviolent) crime locations are plotted at the 100-level block rather than at their precise location (Figure 19) and used to create a heat map to show relative quantities of all other crime by location.

Call_No	100_Block_	Receive	Call_Type
121320078	10600 OLD SEWARD HW	5/11./2012	Disturbance
121320082	19500 WAR ADMIRAL RD	5/11./2012	Drunk Problem
121320087	900 W 27TH AV	5/11./2012	Disturbance
121320099	500 N BRAGAW ST	5/11./2012	Liquor Law Violation
121320102	3400 WYOMING DR	5/11./2012	Disturbance
121320110	3200 PENLAND PK	5/11./2012	Disturbance
121320158	3900 SPENARD RD	5/11./2012	Disturbance
121320186	1 APD CT	5/11./2012	Sexual Assault
121320238	2900 W 88TH AV	5/11./2012	Vandalism
121320248	6200 E 12TH AV	5/11./2012	Disturbance
121320249	1000 W 26TH AV	5/11./2012	Theft
121320252	200 N HOYT ST	5/11./2012	Drunk Problem
121320259	12600 BRECKENRIDGE DR	5/11./2012	Disturbance
121320266	4600 SPENARD RD	5/11./2012	Drunk Problem
121320272	4800 NORTHWOOD DR	5/11./2012	Theft
121320276	800 E TUDOR RD	5/11./2012	Theft
121320280	3600 MINNESOTA DR	5/11./2012	Fraud
121320295	800 L ST	5/11./2012	Theft
121320304	2200 NICHOLS ST	5/11./2012	Assault
121320318	1 APD CT	5/11./2012	Sexual Assault
121320322	4200 COPE ST	5/11./2012	Disturbance
121320340	300 N LANE ST	5/11./2012	Disturbance
121320344	1700 E 5TH AV	5/11./2012	Drugs
121320343	W 4TH AV/B ST	5/11./2012	Drunk Problem
121320356	9800 RELIANCE DR	5/11./2012	Drugs
121320362	E 12TH AV/HYDER ST	5/11./2012	Theft
121320385	900 E 45TH CT	5/11./2012	Disturbance
121320383	5500 ABBOTT RD	5/11./2012	Theft

Figure 18 Example of Crime Types by Date and Address in ArcMap. Note the Sexual Assault Addresses are Remapped to APD Headquarters.

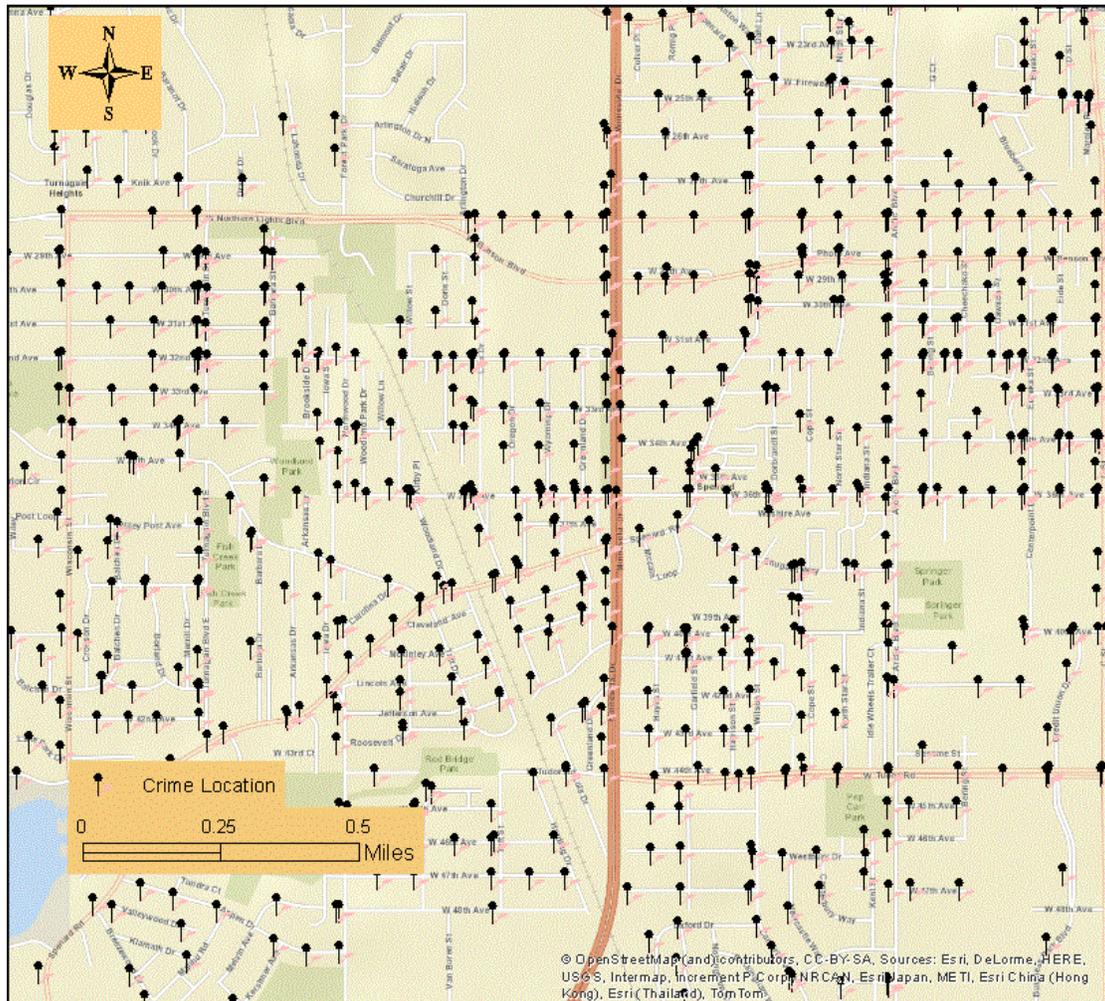


Figure 19 Crime Points Plotted at the 100-Block Level

In general, a heat map is a graduated density surface map created from interpolated individual points (Morais 2012). In this study, the crime heat map was created through several steps using ArcMap's Spatial Analyst tool, and provides a continuous surface showing the geospatial weighting in the number of crimes located throughout a given area. The crime points vector layer were converted into a raster grid surface via inverse distance weighting (IDW), where data points closer together are weighted more strongly than those further apart. These data points were next evaluated to check their statistical significance by attempting to answer this question: are the crime locations random? A spatial autocorrelation tool, Global Morans I was

used, incorporating factors of inverse distance squared and Manhattan distance to determine the dispersal characteristics of the crimes, depicted as z-scores (Esri 2014). Specifically, inverse distance squared calculates the influence of one point to another by their distances, in this case a Manhattan distance that measures along the Anchorage road network. This z-score varies throughout the Anchorage Bowl, which suggests that the distribution is clustered in the north and downtown areas where the z-scores are near 10 (indicating intense clustering of crime data), but dispersed outside those areas (where z-scores are less than 1). More crimes in close proximity to each other result in greater values in interpolated weighting and in higher z-scores, which display on the map as brighter and more focused clusters. The resulting heat map data were normalized into five geographic classes to show the percent of the values relative to the total value of each geographic class, then assigned a gradient color scheme; higher rated clusters of crime locations show as darker red while areas of lighter red illustrate lower rated clusters of crime locations (Figure 20).

A crime heat map is by nature subjective, because by altering the classification scheme or using different interpolation schemes for given point data different areas of the Anchorage Bowl would be manipulated to appear more crime-ridden than other areas. As a manual review of the resulting crime distribution, the published crime heat map was visually compared to the original point data locations, so that the classification scheme chosen provides the closest visual match between the cluster distribution of the heat map and the clustering of the original point data. It is important to consider that the level of both violent and nonviolent crime within the Anchorage Bowl is relative to other communities in Alaska and outside the state.

Violent and nonviolent crimes were compiled into a single layer in this analysis. The original consideration was to create separate heat maps to let homeowners weigh the risks of

living near nonviolent crime locations compared to locations of crimes involving injury to the person. On further consideration, by comparing the locations of violent and nonviolent crimes as shown in Figure 21, it appears that locations of infrequent violent crime are often surrounded by the locations of more common nonviolent crime. Segregating crime types into multiple heat maps would not offer significantly different results to warrant displaying more than one map, as shown in Figure 22.

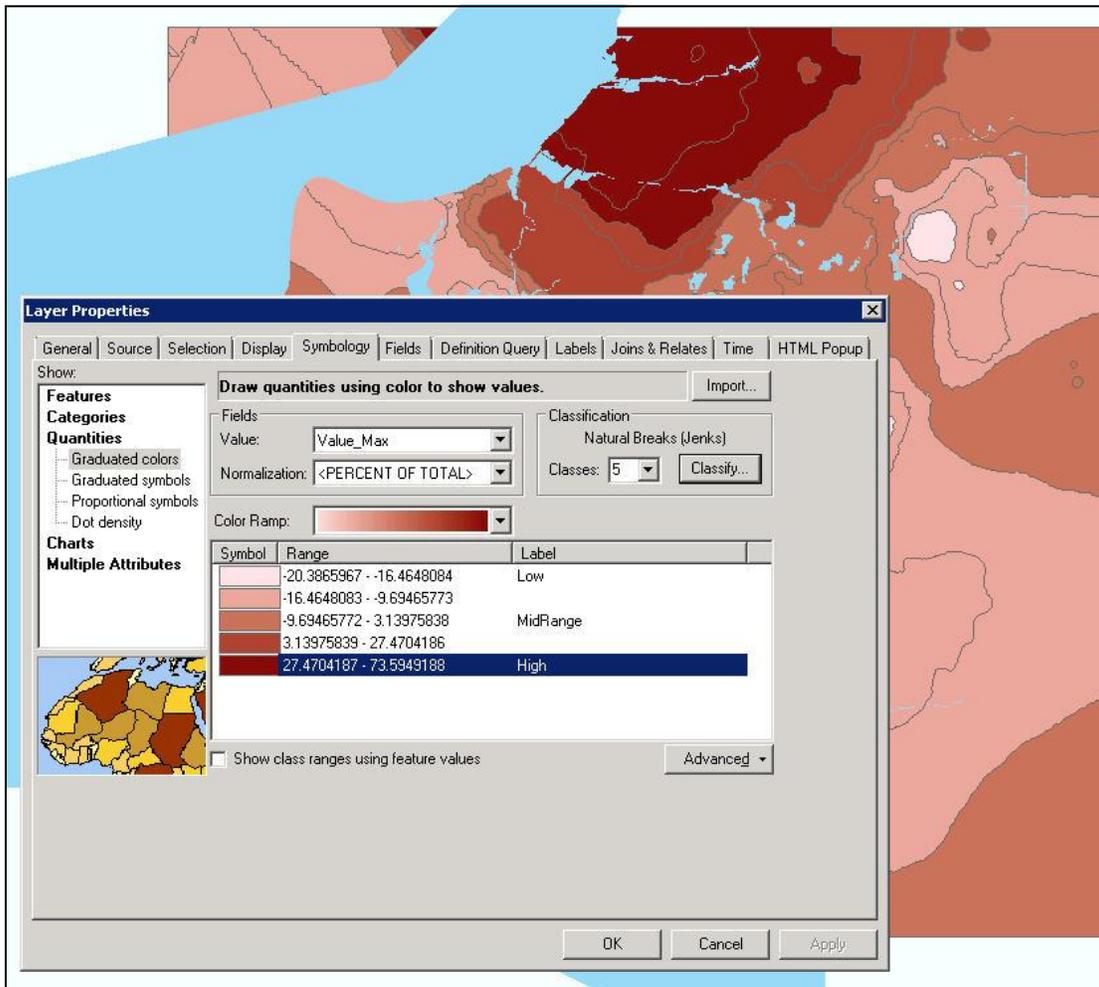


Figure 20 Classifying and Coloring the Heat Map

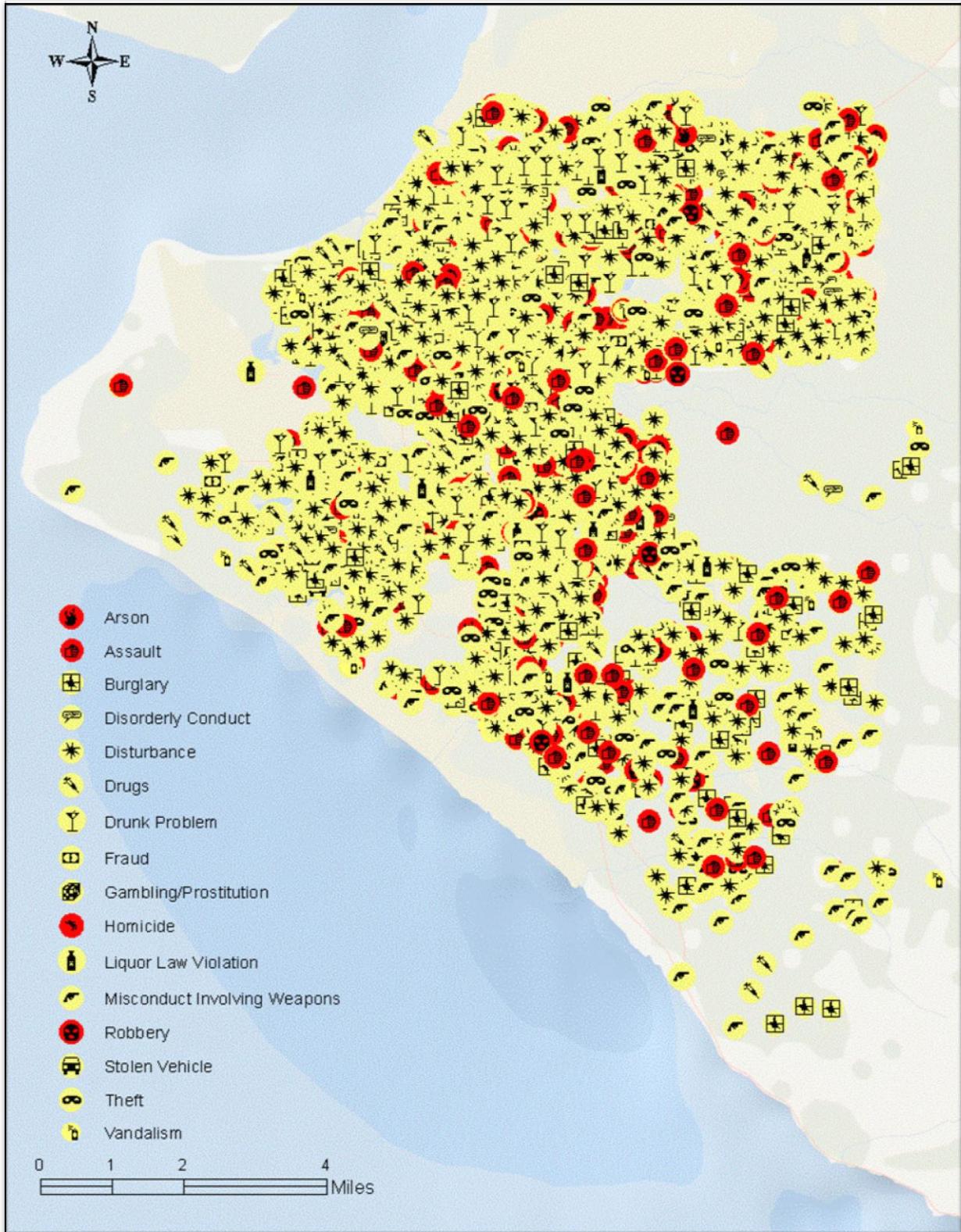


Figure 21 Anchorage Bowl Violent and Nonviolent Crime in 2012 (Morberg 2013)

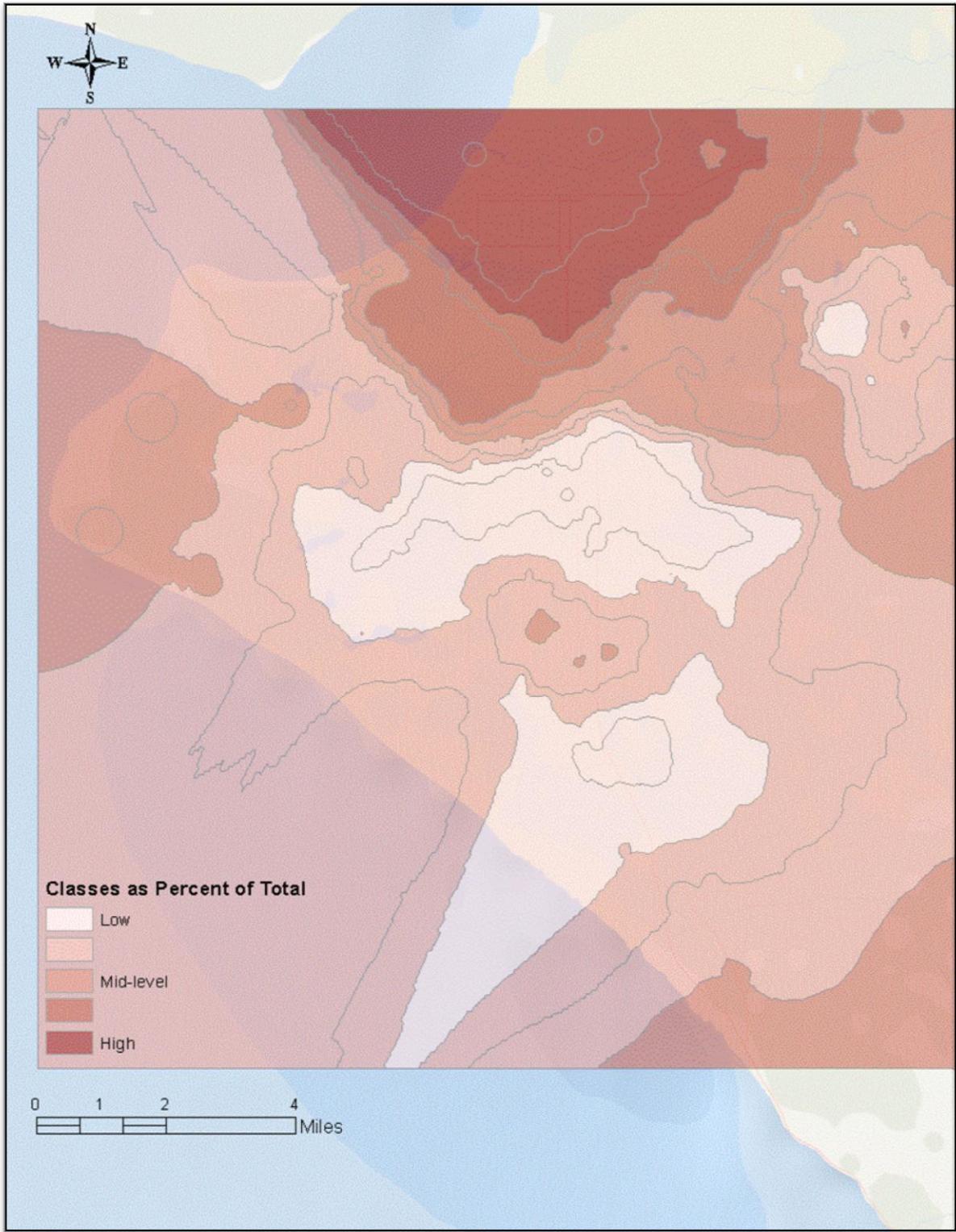


Figure 22 Anchorage Crime Heatmap

The sex offenders layer shows the domicile or employment locations of people convicted of crimes specified under Alaska Statute 12.63.100, in particular those convicted of sex offenses or child kidnapping, who are required to register with the state (Alaska Department of Public Safety 2014). The Anchorage Department of Public Safety maintains the list of registered sex offenders and provides updates each weekday. (Alaska Department of Public Safety 2013). A comma-delimited file of the data was obtained from the Anchorage forum of City-Data.com on June 20, 2013 (City-Data 2013) to provide an example of how this type of data can be integrated into this application. This original list of 696 names was edited in Microsoft Excel for clarity and organizational purposes, then imported into Esri ArcMap where 688 addresses were successfully geocoded using the 10.0 US Streets Geocode Service. The non-matched eight addresses had house numbers that did not fit any street segment and were thus excluded from this dataset. With few exceptions for halfway houses, group housing, or rehabilitation centers, the distribution of addresses extends throughout the Anchorage Bowl (Figure 23).

The sex offender layer was created in ArcMap 10.1 to show just the address, removing all offender names, crime type and other identifying information. The layer is not included in any "selection package" search in this project, as no answer may be correct for determining the buffer width that does not exclude all neighborhoods. This was done not to protect the offender, but rather to focus on providing only the basic geospatial information relevant to this project. Any prospective homebuyer will note that a hyperlink to the sex offender registry appears in the popup window in the web application should the web GIS application user wish to find more related information from the original data source.

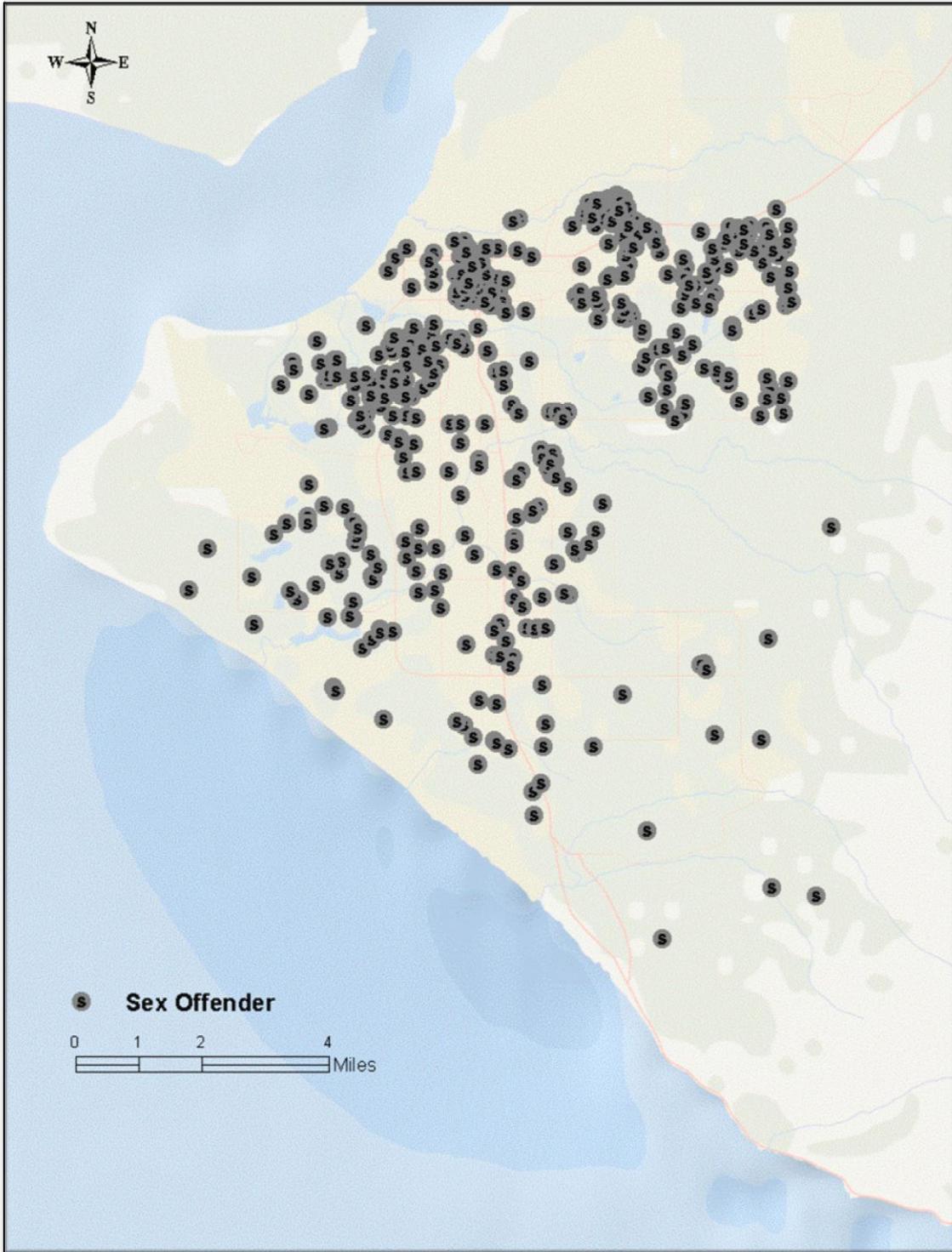


Figure 23 Home or Employment Locations of Registered Sex Offenders (Alaska Department of Public Safety 2013)

The Seismically-Induced Ground Failure Susceptibility data were originally created in 1979 and digitized in 2005 by the MOA (Municipality of Anchorage 2013). This layer shows the probable areas where the ground may slide in the event of a major earthquake. This original layer is categorized into five classes of ground failure, from "lowest" along the bedrock foothills to "very-high" near the bluffs and creek mouths. This layer was clipped to the extent of the Anchorage Bowl, as seen in Figure 24.

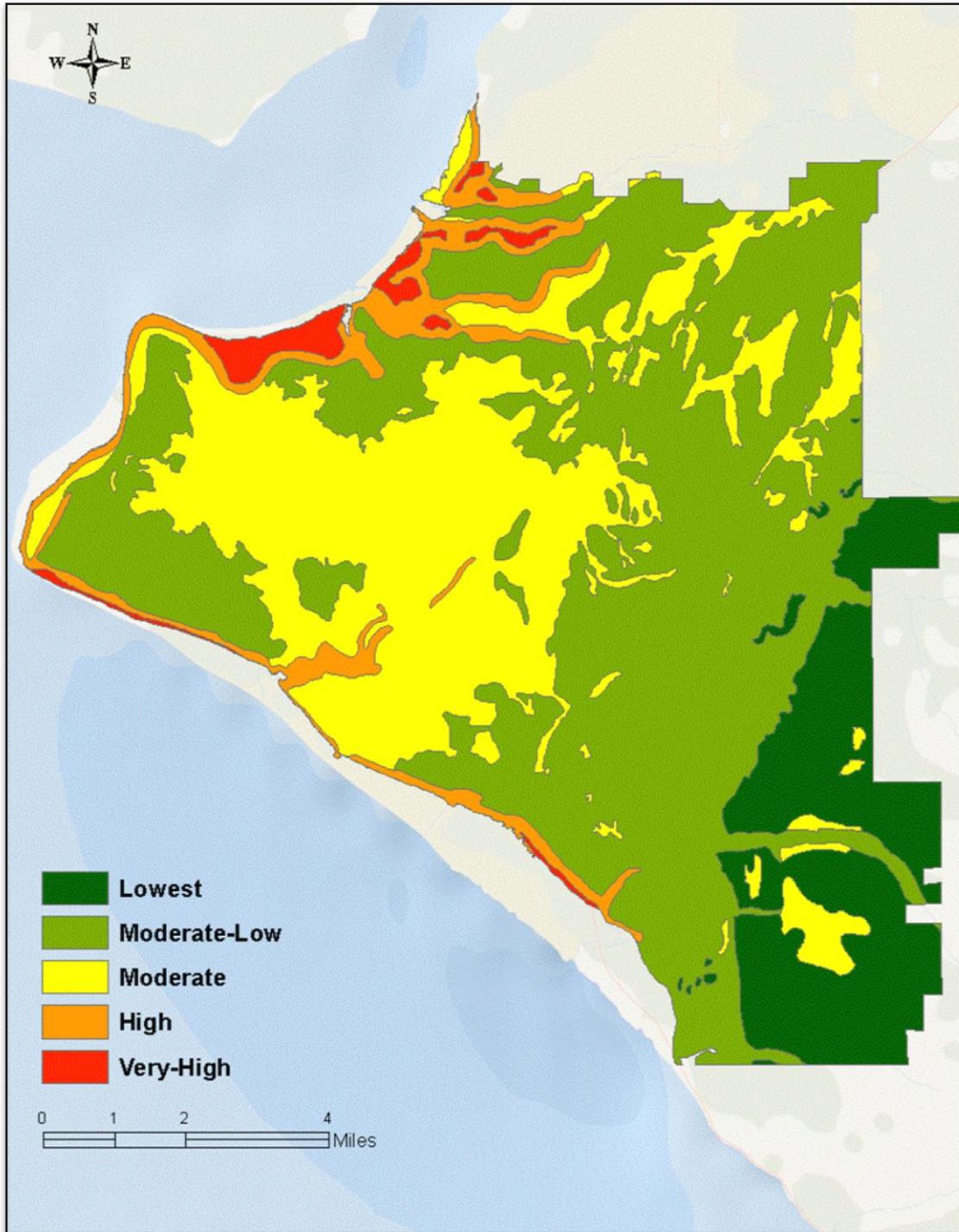


Figure 24 Seismic Layers in the Anchorage Bowl (Municipality of Anchorage 2013)

The FEMA floodplain dataset is an important layer to assess the probability of catastrophic flooding and used to calculate insurance costs for a property (Federal Emergency Management Agency 2013). A FEMA-published ArcGIS geoprocessing service (Federal Emergency Management Agency 2014) showing the 100-year flood zones for the US is incorporated in this web GIS application, cropped to the extent of the Anchorage Bowl in ArcMap using the "extract landscape source data" tool (Figure 25). This live geoprocessing tool was used to create a smaller subset layer for the project geodatabase. The information window identifies each area by floodplain zone of A, AE, or AH. These areas are all susceptible to a 1-percent-annual-chance flood and homeowners in those areas may be required to obtain flood insurance. Specifically, zone A is determined by "approximate methods of analysis", zone AE is determined by "detailed methods of analysis", and zone AH is in areas where there is "shallow flooding with constant water-surface elevation ... of 1-3 feet" (Federal Emergency Management Agency 2014).

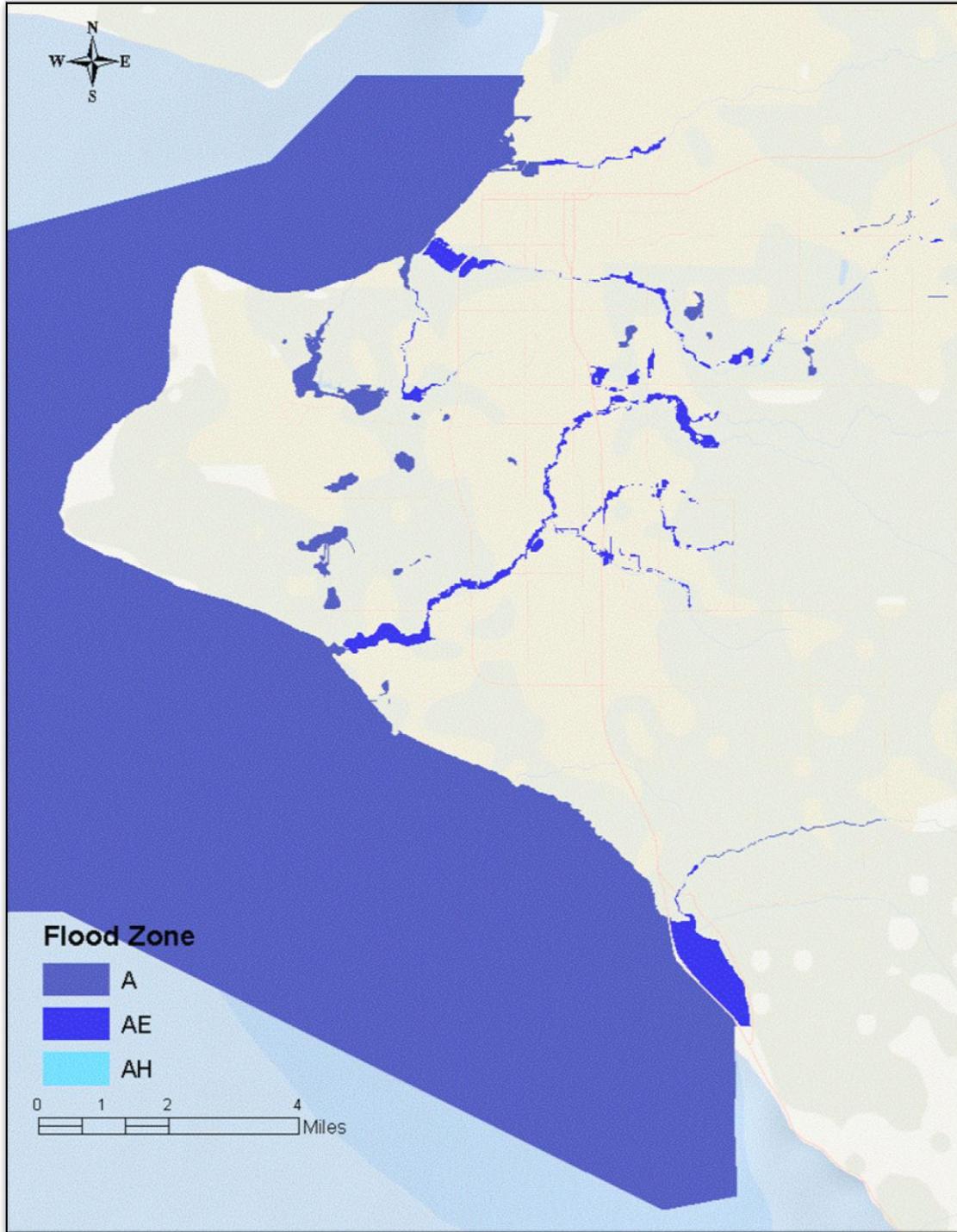


Figure 25 FEMA 100-Year Flood Plan (Federal Emergency Management Agency 2014)

3.3.2 Source Data for Education and Recreation Theme

All public school data were provided by ASD in a zipped KML or KMZ format to include point data for elementary, middle, and high schools and polygon layers for their attendance boundaries, plus point data for charter and alternative schools (Figure 26) (GreatSchools 2013). The data were imported to ArcMap, clipped to the Anchorage Bowl study area limits and color-coded to show the school levels. All schools and boundaries are displayed in the web application. No private schools were added nor were post-secondary or trade schools (GreatSchools 2013).

Also included in the *Education and Recreation* theme are two layers, city parks and city trails. These shapefiles were imported to ArcMap and clipped to the study area extent (Figure 27). These only show areas created and maintained by the MOA - no state or federal land is included.

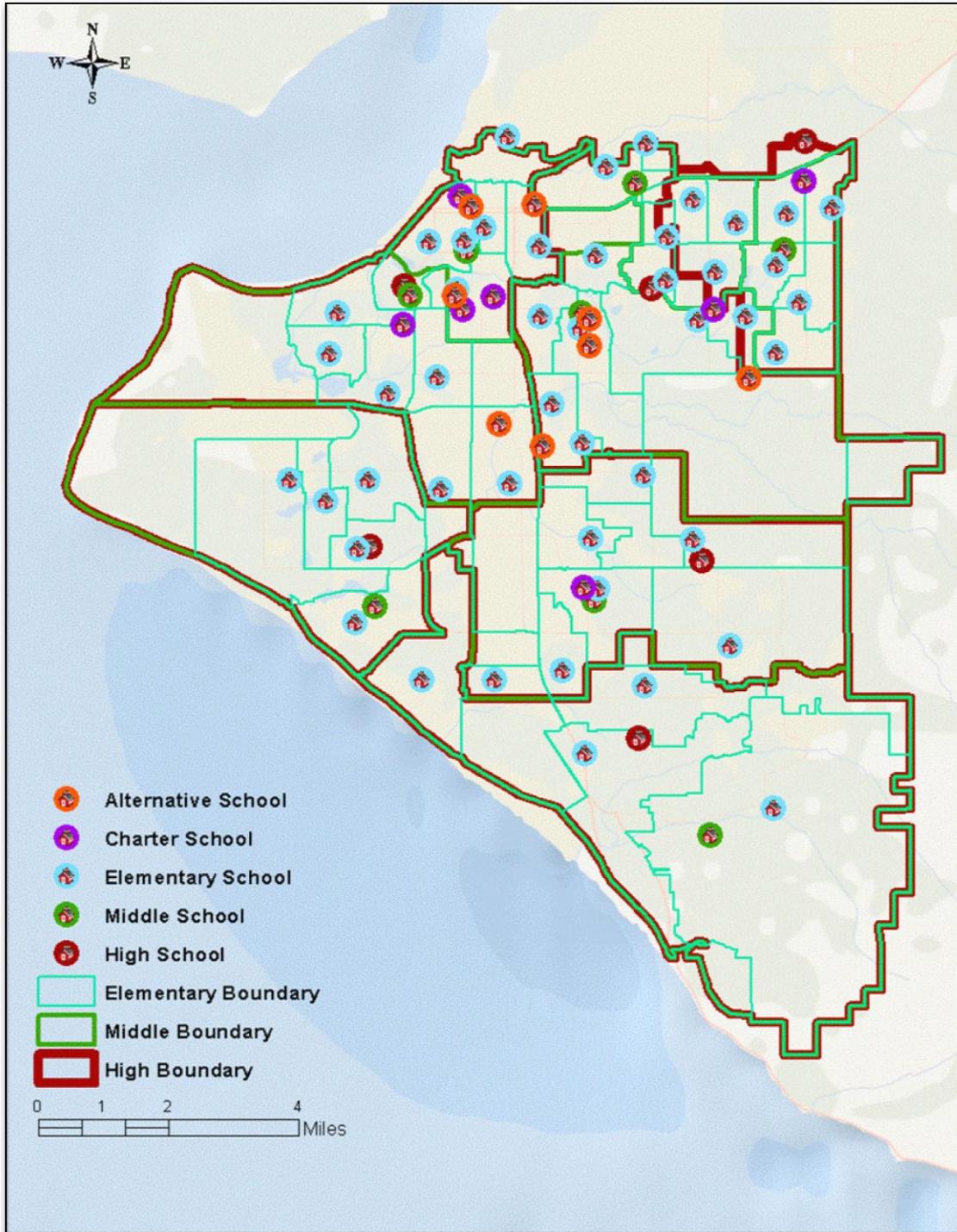


Figure 26 All Anchorage School District Schools and School District Boundaries (GreatSchools 2013)

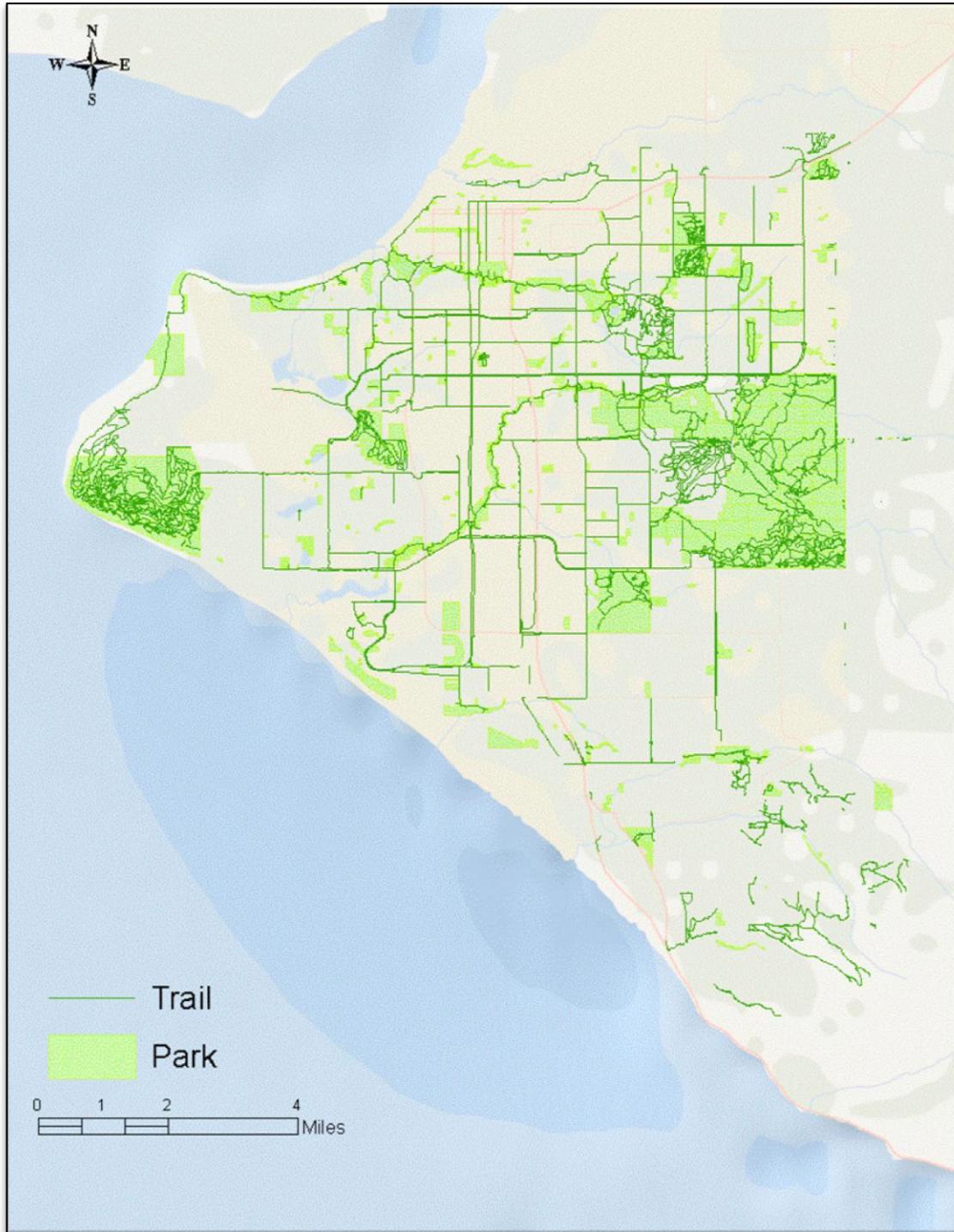


Figure 27 MOA Trails and Parks (Municipality of Anchorage 2013)

3.3.3 Source Data for Political Theme

The polygon boundaries for political districts, both at the municipal and state level are included in the *Political* theme along with a boundary polygon file for the Anchorage neighborhoods (Figure 28). The polygon outlining the Anchorage Bowl study area is also included in this frame. Popup windows in the web application show both the district identification and the current office holders as updated by the MOA GIS in the district polygons (Municipality of Anchorage 2013). Alaska has only one United States (US) Representative; therefore, a polygon outlining US House districts is unnecessary.

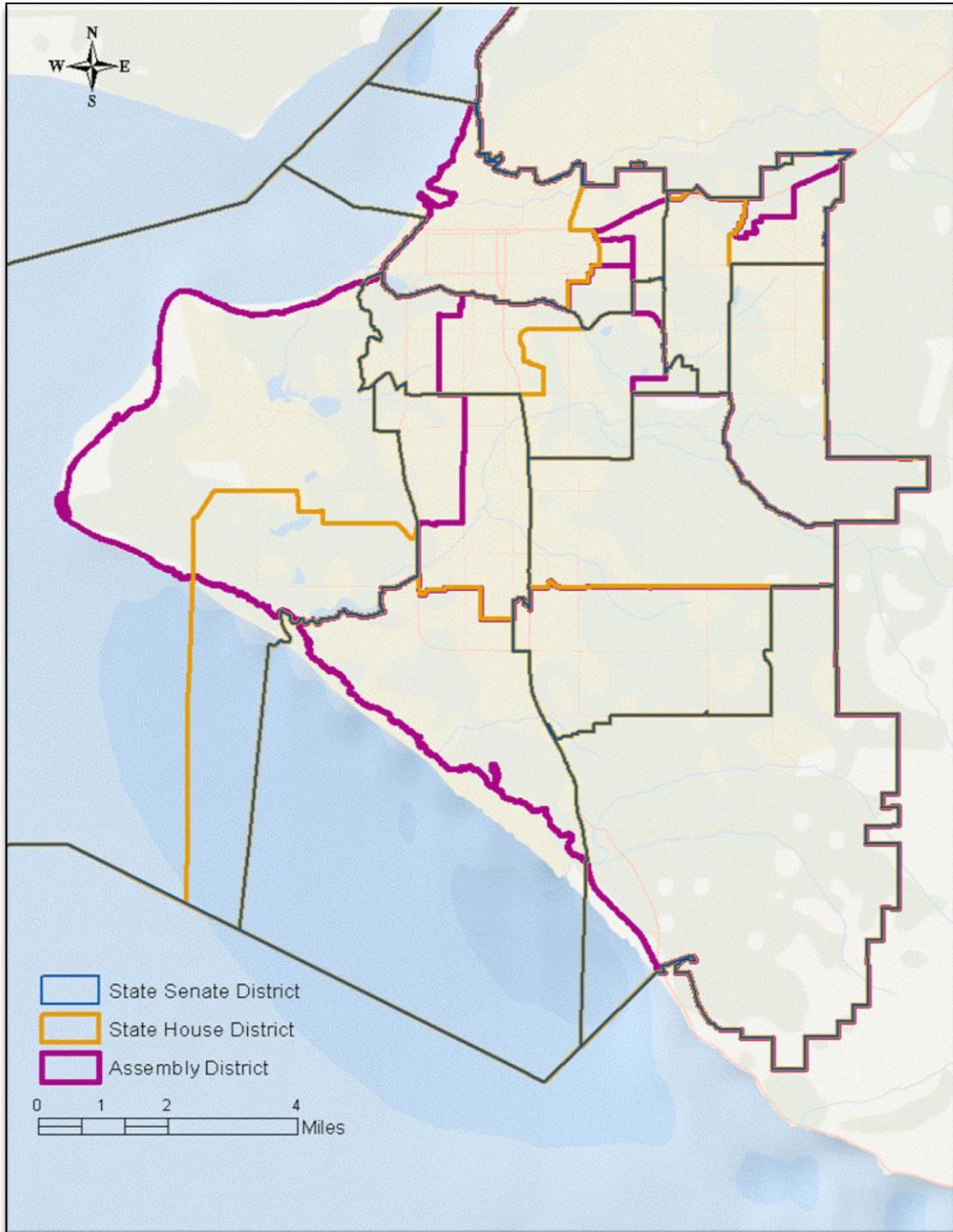


Figure 28 Political Theme (Municipality of Anchorage 2013)

3.3.4 Source Data for Transportation and Zoning Theme

The *Transportation and Zoning* theme contains shapefiles that are buffered and used to find residential polygons outside these buffered areas. The most manipulation required to prepare data for this project involved many of these zoning shapefiles. The railroad file was clipped to the Anchorage Bowl layer, and the major roads were identified from the street segments shapefile. The zoning shapefile was queried by zoning description (Municipality of Anchorage 2013) to derive several feature classes: business polygons, industry polygons, and the port and airports in Anchorage. A fourth feature class, called All Housing, was also created to show residential polygons that are stored in the *Housing* theme (Figure 29) Several of the zoning codes were generic and could refer to more than one district, for instance *R-11* and *PC* (Figure 30). Using local knowledge against Anchorage-area aerial and satellite images or by actually visiting the locations, the author investigated those polygons and individually assigned them to the zoning district that best fit their current use.

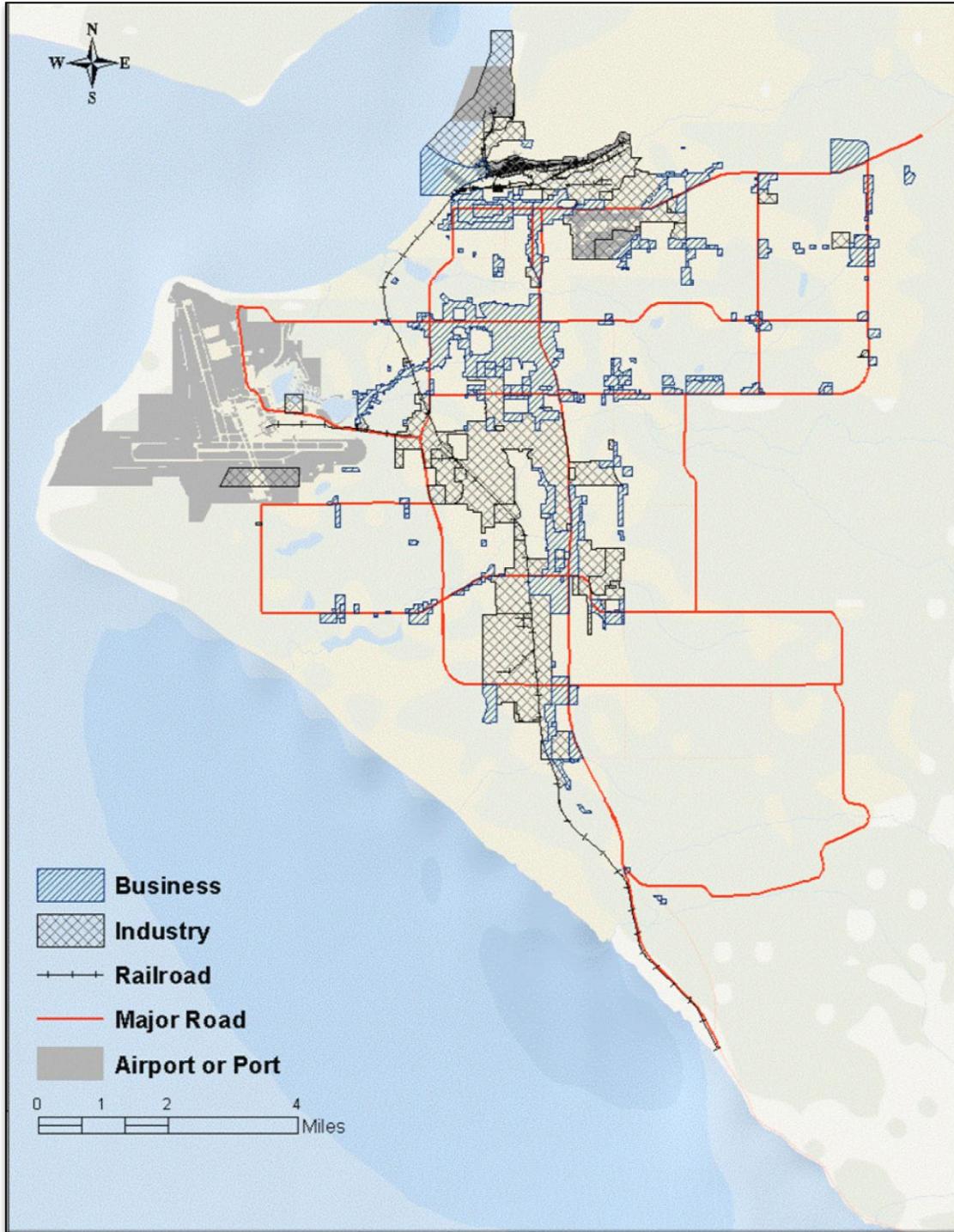


Figure 29 *Transportation and Zoning Theme* (adapted from (Municipality of Anchorage 2013))

<p>Residential Districts</p> <p>R-1, R-1A, R-2A, R-2D, R-2M, R-3, R-4, R-5, R-5A, R-6, R-7, R-8, R-9, R-10, R-11, R-O, PC, D-2, D-3</p> <p>Business Districts</p> <p>R-11, B-1A, B-1B, B-2A, B-2B, B-2C, B-3, B-4, R-O, MC</p> <p>Industrial Districts</p> <p>R-11, I-1, I-2, I-3, MI, PC</p>
--

Figure 30 MOA Zoning Codes By District Type from (Municipality of Anchorage 2013)

3.3.5 Source Data for Housing Theme

This housing theme is composed of two data layers: one showing available properties and the other the result of the zoning layer query by residential type (Figure 31). The available properties layer is a random sample of units on the market in the Anchorage Bowl as of June 2013; it is used solely as an example dataset to illustrate real estate availability after the neighborhood search has been completed. As previously stated, this layer was created from a query of the Anchorage MLS website conducted by a local Realtor (Bergt 2013). The properties of interest were saved and organized in Microsoft Excel. Fields were created for price, bedroom and bathroom quantities, address, square footage, lot size, garage or carport stall slots, and listing office. The MLS number supplied was reassigned to a simple sequential object ID value for consistency (Figure 32). The Excel file was imported into ArcMap and geocoded using the 10.0 US Streets Geocode Service (ArcGIS Online, 2013). Of the 140 properties, only seven did not match an address; these properties were on lots with new streets that had not yet been added to the service. Thus those properties had to be excluded from the resulting dataset.

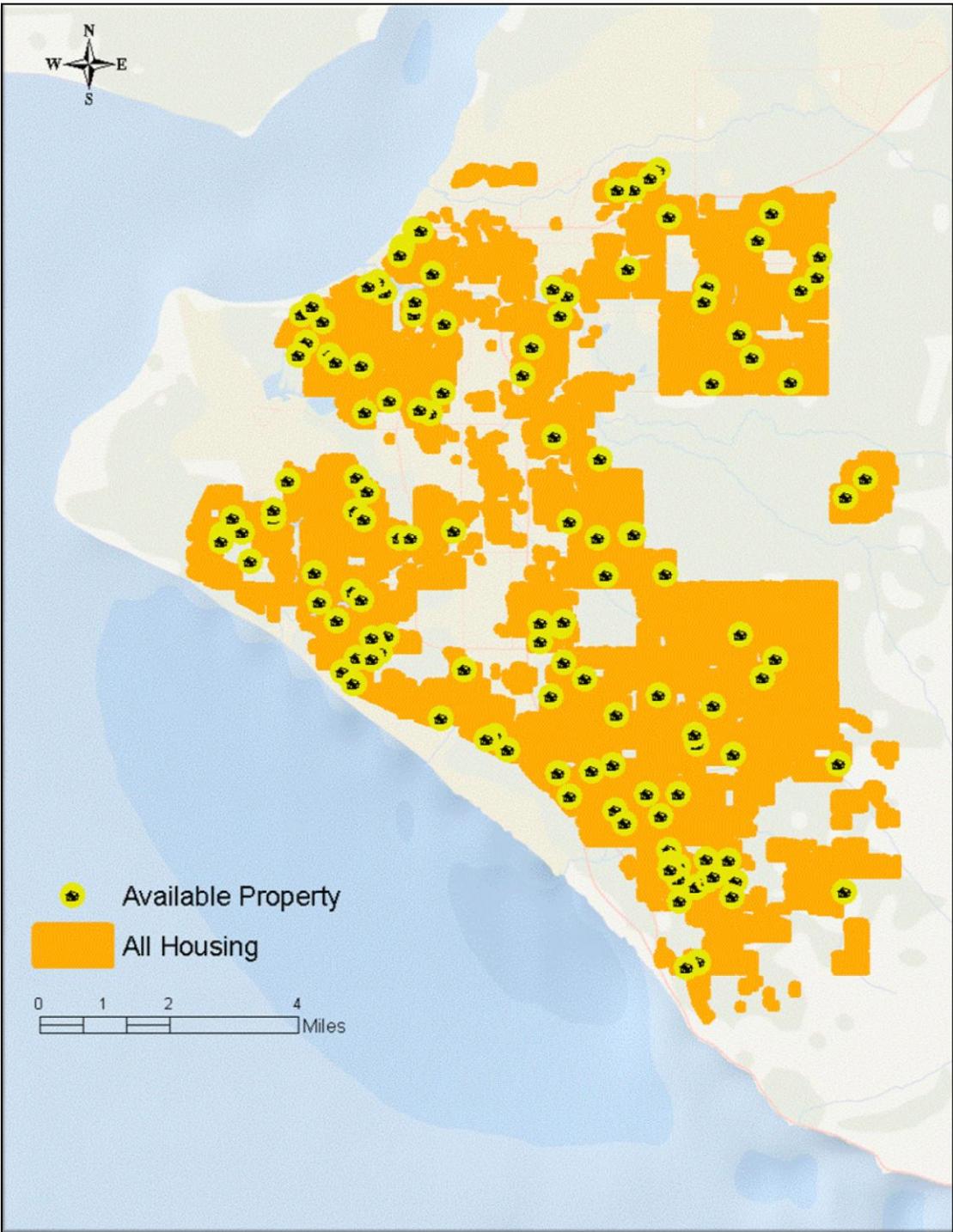


Figure 31 *Housing* Theme (Municipality of Anchorage 2013)

Available Housing										
	MLS	Price	Street	Zip	Beds	Baths	Unit	SF_Res	Acres	Garag
	13-040	295000	1209 Oxford Drive	99503	3	1.5		1552	0.18	1
	13-041	299000	11111 Forest Drive	99516	3	1		1984	0.44	2
	13-042	299900	1930 State Street	99504	3	2.5		2088	0.18	1
	13-043	302900	800 Hunt Circle	99504	4	3		2080	0.14	2
	13-044	309900	11015 Retreat Circle	99515	3	2		1868	0.08	2
	13-045	314000	3430 Kachemak Circle	99515	3	1.5		2000	0.2	2
	13-046	315000	7550 Trenton Lane	99502	3	2.5		2024	0.21	2
	13-047	319900	531 Bounty Drive	99515	3	2		1514	0.23	1
	13-048	325000	16844 Kenai Terrace Road	99516	2	2		1133	1.13	0
	13-049	325000	651 Highlander Circle	99518	3	2.5		2066	0.15	2
	13-050	325000	8029 Country Woods Drive	99502	3	2		1832	0.1	2
	13-051	329000	7900 Lucy Street	99502	3	2.5		1624	0.71	3
	13-052	335000	8011 Berry Patch Drive	99502	3	2		1906	0.18	2
	13-053	339900	9321 Noblewood Drive	99502	3	2		1829	0.22	2
	13-054	344900	2111 Tudor Hills Court	99507	3	2		1718	0.21	2
	13-055	347000	8956 Little Brook Street	99507	4	2.5		1916	0.15	2
	13-056	347000	10401 Constitution Street	99515	2	2.5		1903	0.18	2
	13-057	349000	14940 Longbow Drive	99516	3	2		2261	1.22	4
	13-058	349900	2221 Innes Circle	99515	3	3.5		2442	0.05	2
	13-059	349900	4170 Defiance Street	99504	5	3.5		2678	0.11	2
	13-060	349900	2431 W 89th Court	99502	3	2		2919	0.16	2
	13-061	360000	4701 Kershner Avenue	99517	4	2.5		2368	0.23	2
	13-062	369000	525 N Street	99501	1	1		594	0.16	0
	13-063	379000	2761 Pelican Court	99502	3	3		2487	0.24	2
	13-064	379000	3224 Cottonwood Street	99508	4	2		2080	0.2	2
	13-065	379900	7924 Mesquite Circle	99507	4	2		1828	0.15	2
	13-066	389000	4049 W 89th Court	99502	4	3		2568	0.25	2
	13-067	389000	11190 Via Appia	99515	5	3		2127	0.2	3

Figure 32 Excerpt from the Available Housing Attribute Table

The residential zoning layer was extracted from the zoning shapefile and saved to be used as a clip feature against the selectable layers. It is these resulting polygons that reflect the optimal neighborhoods for the subsequent residential search, while the residential zoning layer itself is not displayed in the map. Two other MOA shapefiles, neighborhoods and subdivisions derived from the MOA GIS landuse shapefile could be logical choices, but neither are good choices. The neighborhoods layer polygons are too large and user searches would not result in a very narrow or specific area. Conversely, selecting areas based on the small subdivision polygons would yield too many options (properties) for users as the polygons are much smaller

and successful searches would be widely scattered across the study area. A comparison of the two sizes is shown in Figure 33.

The best choice that reflects both the most up-to-date residential zoning and large polygons is found in the All Housing layer derived from the Zoning shapefile. While the neighborhoods layer was not used as a clip layer, it is still valuable to show on the map to aid realtors and homebuyers with the names of the local areas.

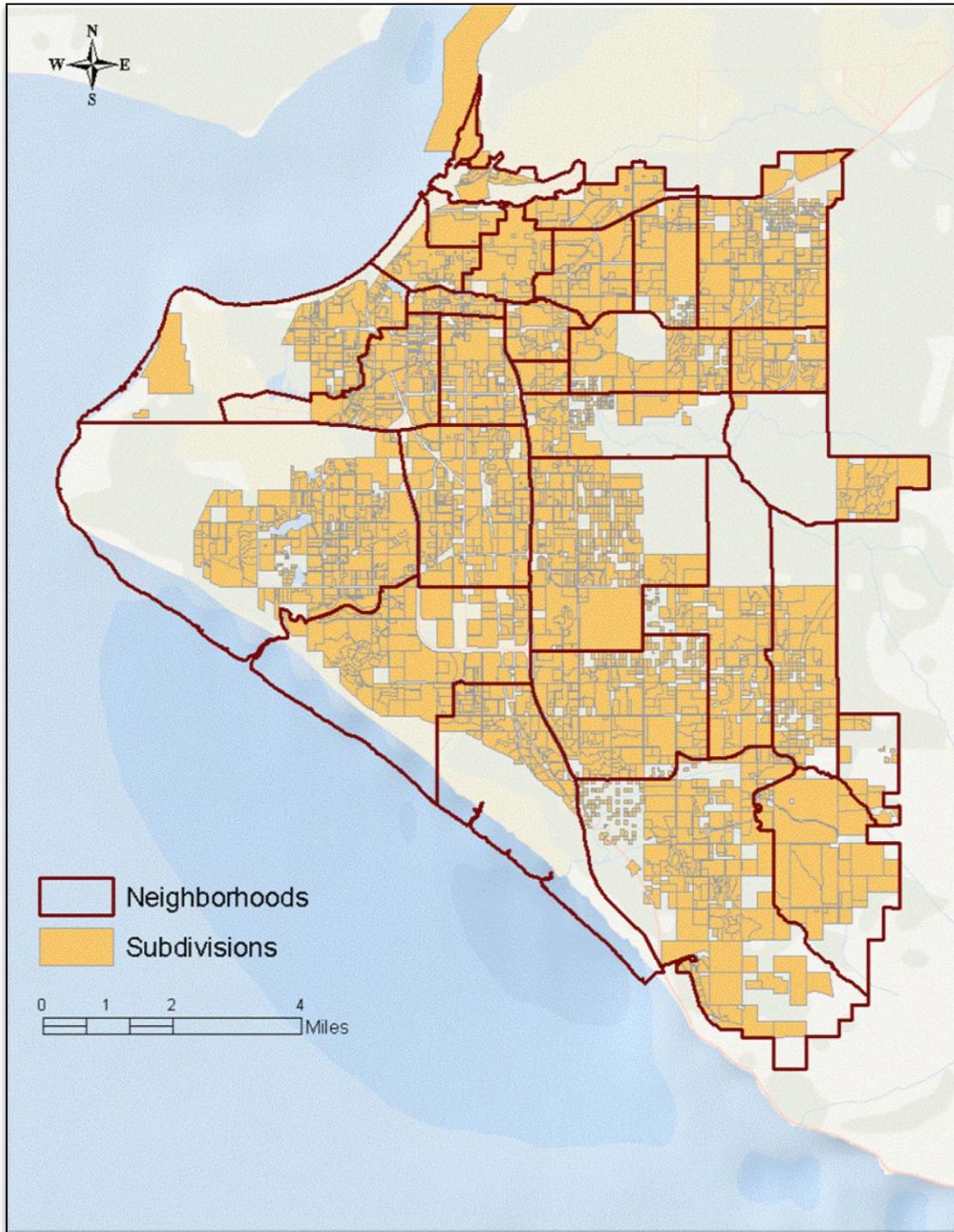


Figure 33 A Size Comparison of Neighborhood Versus Subdivision Layers

3.4 Data Configuration in the Find Your Anchorage Neighborhood Application

In the web GIS application the toggled (on or off) layers and the selected database query results are displayed as polygons: (business, industry, and port buffers at distances of 1/4-mile and 1/2-mile, parks, school attendance, seismic, political boundaries), points (schools, properties), lines (roads, railroads, and trails), or interval maps (crime heat maps). The layers are grouped by common themes in ArcMap as per the subsection headings in this chapter, and then published as Esri ArcMap feature services that are incorporated into the web GIS application coding.

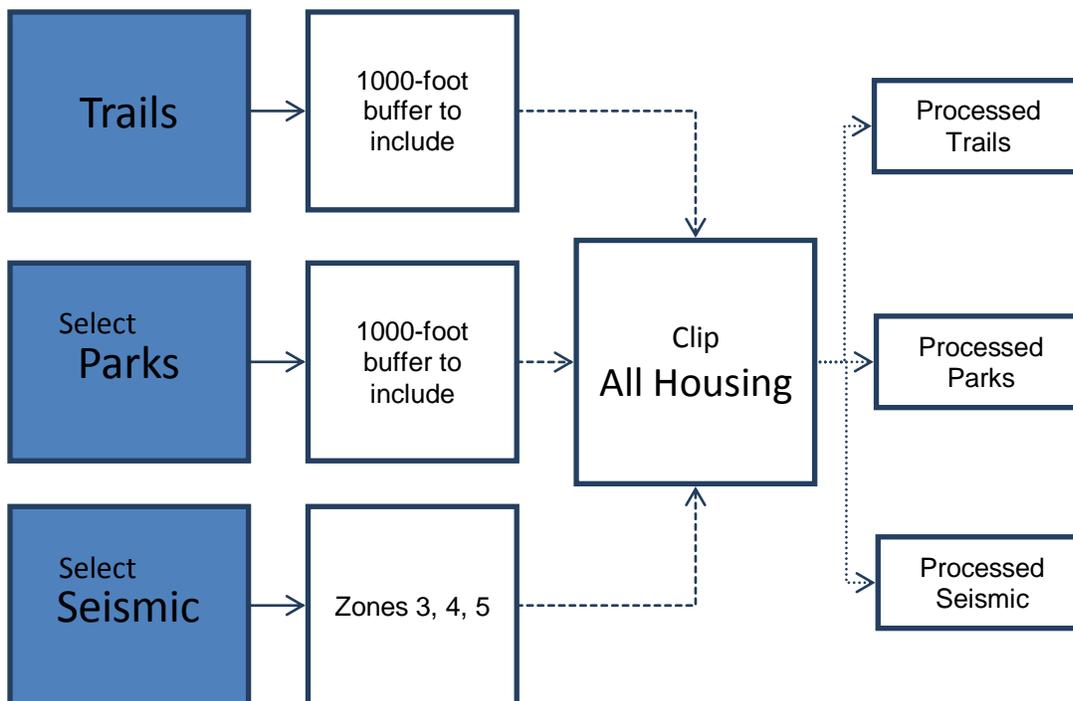


Figure 34 Data Preparation Tasks Performed on Trails, Parks, and Seismic Layers

All data were clipped to the extent of the project study area boundary using the Anchorage Bowl layer. Additional processing was required for layers used to intersect with the All Housing layer and used for one of four of the selections packages created in this project. The

flowcharts in Figure 34 and Figure 35 Layers Created From Zoning Layer illustrate the ArcMap query processes that created these selectable layers. Most of those searchable layers are derived buffered layers altered with regard to residential zoning parcels. For instance, homebuyers may want to be within walking distance of parks and trails and further from major roads and industrial areas; therefore the buffered layers were set to include housing options within 1000 feet of trails or parks, and exclude residential areas that fall within either a quarter-mile or half-mile of business parks and airports. All of these resulting parcels were then clipped against the residential polygons of the All Housing layer since homebuyers cannot purchase or build homes not zoned for residential use. Because these buffer distance decisions were pre-determined, the buffered layers could be generated server side and combined as static data layer options to be chosen by the homebuyer, rather than generated on-the-fly on the client side which would have greatly slowed map rendering. No buffered layer, however, can be displayed in the map except as part of a search. This helps to minimize clutter in the resulting web GIS map, and fits in with the established searches that have been created. Pertinent layers can be toggled on and off within the map display using code adapted from the original template coding. A complete list of all layers is in Table 2.

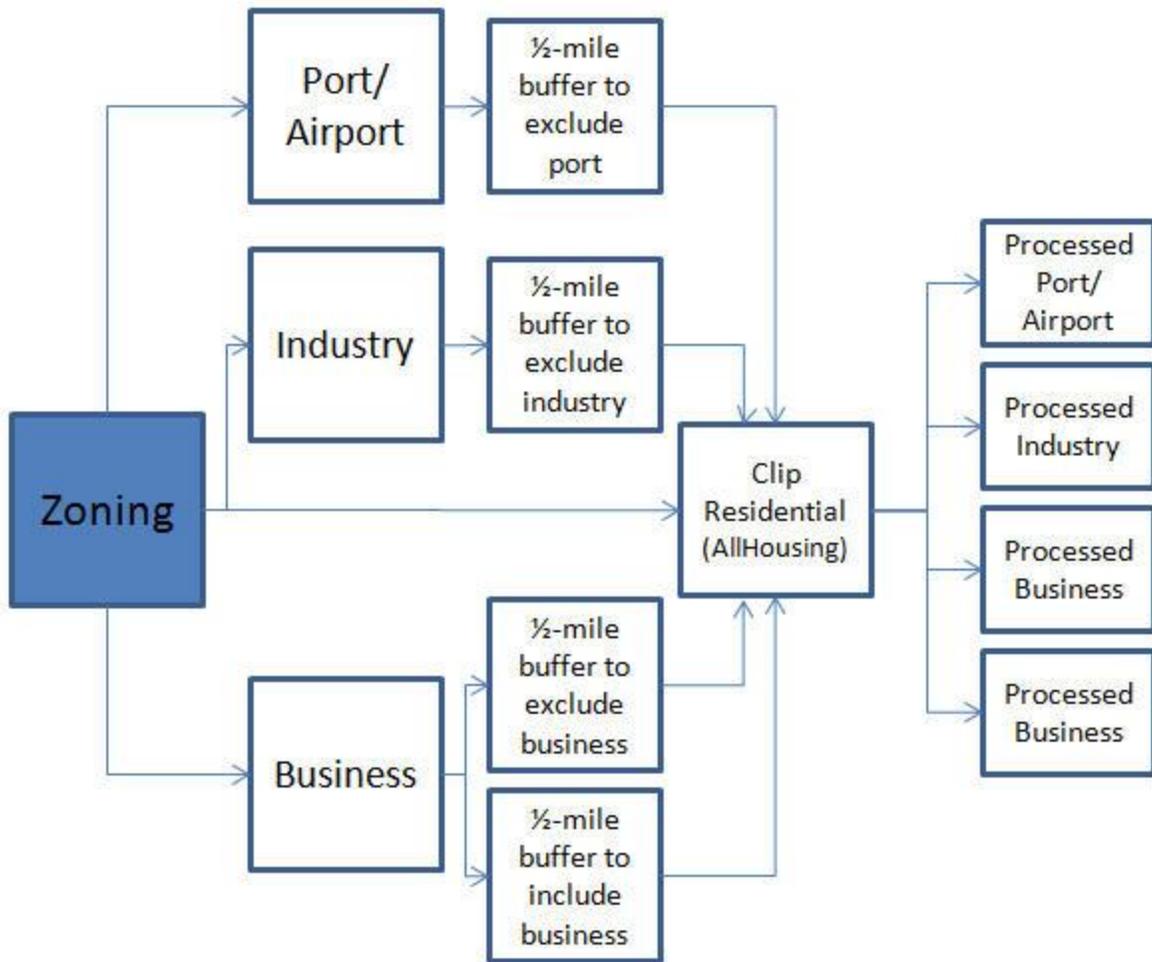


Figure 35 Layers Created From Zoning Layer

Once all the data layers are created and processed in ArcMap, selected layers can be integrated into a proper search function in the web GIS application. As previously mentioned, there are myriad options that users may want to consider when performing a search for potential homes: proximity to specific schools, are they within walking distance of offices, locations in "safe" (crime) areas, or combinations thereof. Due to complications discussed in Chapter 4, the author elected to make "selection package" searches using the processed layers created as illustrated in Figure 34 and Figure 35, plus the transportation layers or port/airport, rail, and major roads. Table 4 lists the four searches and the layers employed in the design of the web

map. *Outdoors* is for those homebuyers who want to be near the extensive trail or parks system, while *Great Outdoors* adds the exclusion zones of business, industry, roads, rail, and ports, for those who want to "get away from it all." For those who crave peace and quiet, the exclusion of business, industry, roads, rail, and ports is added to the more seismically-stable zones in the *Quiet Zone*. The fourth search assumes a homeowner who wants or needs to be closer to the city's amenities, for either work or commerce. *Commerce* includes commercial or business parcels (properties) within 1/2-mile of those zones and within 1/2-mile of major roads. All of these "selection packages" created for the user are Esri feature services published server-side, rather than client-based, which saves map-rendering time as previously mentioned.

Table 4 "Selection Package" Search Feature Services

Search Name	Includes Layers	Buffered Distance
Outdoors	Trails	1000 feet inclusion
	Parks	1000 feet inclusion
Great Outdoors	Trails	1000 feet inclusion
	Parks	1000 feet inclusion
	Port	1/2-mile exclusion
	Major Roads	1/4-mile exclusion
	Rail	1/2-mile exclusion
	Industry	1/2-mile exclusion
Quiet Zone	Business	1/2-mile exclusion
	Port	1/2-mile exclusion
	Major Roads	1/4-mile exclusion
	Rail	1/2-mile exclusion
	Industry	1/2-mile exclusion
	Business	1/2-mile exclusion
Commerce	Seismic	Zones 3, 4, 5
	Business	1/2-mile inclusion
	Major Road	1/2-mile inclusion

3.5 The Web-Based Design Application Development

The software and scripting samples most helpful in creating the website were readily available from Esri, specifically, ArcMap 10.1 and 10.2, Esri Story Maps templates, and ArcGIS.com. Notepad++, a free online editor with a clean and intuitive design, was relatively easy to use to edit the various web GIS application files (Ho 2011).

As previously mentioned, all data were edited using ArcMap 10.1 and 10.2. Common layers were grouped into themes and then published directly to ArcGIS.com, which provides unique URL addresses that are entered directly to a web GIS application. As all the layers within a given theme are published together, each layer has a unique value at the end of the frame's URL that allows each layer (representational state transfer, or REST endpoint) to be referenced in the web application, as shown in Figure 36. For example, the *Hazards* theme includes four layers, and the unique value representing Seismic is the number 0 at the end of the URL.

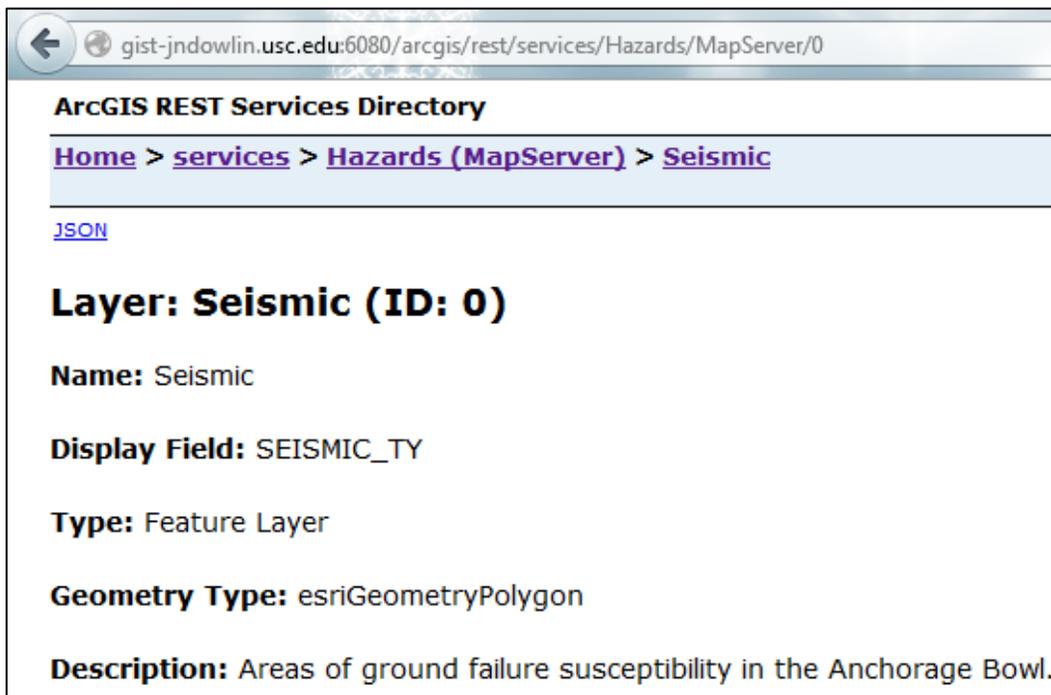


Figure 36 Seismic Layer URL

3.5.1 Web Application Planning

Using the data layers completed and published to ArcGIS.com, many iterations of the final map were attempted using Esri tools and JavaScripting code to find a method that successfully integrated all of the data, JavaScript modules and other scripts into a single working website. The original goal of the this project was to show a map of the Anchorage Bowl with additional interactive features flanking the map on either side of the web map, in a single web GIS application. This more complex design was later abandoned due to numerous coding difficulties integrating code snippets and modules in several scripting languages. The ArcGIS.com template model was ultimately adopted as described in subsequent sections of this thesis.

This section documents the design and testing of the first web application development plan. On one side would be a toggable list of all the created map layers so that the user could acquaint himself with the town. On the other side would be a subset of those layers from which the user could select items pertinent to a custom search. Those selected elements would only display where they intersected each other, the result being the user's optimal areas of town. An additional program element considered included network analyst, which can plot commute times between homes and work sites that ideally could be integrated into each search. Once the search was complete, the user could then toggle the AvailableHousing layer to see which properties were in those optimal areas. Popup windows would give information about the homes, including the realtor contact information.

The trial development website was served via the Internet Information Services (IIS) and accesses the data published on the ArcGIS.com server. A link to this thesis is also available in the About section of the final web application.

3.5.2 Web Application Development Efforts

According to Zed Shaw, "programmers are lazy" and will seek to use code programmed by others (Shaw 2010). This is not to suggest programmers are thieves but that many of the scripts used in numerous applications are not unique. The robust Esri Developers Forum (Esri 2013) and the user forum from Stack-Overflow (Stack-Overflow 2013) contain many scripting examples. The Esri ArcGIS API for JavaScript page contains many examples for developers to try out in a "sandbox" environment; successful edits can easily be copied to the web page programming (Esri 2013). While searches for web code to address specific problems may be hard to find, it was often not difficult to find someone to share code they have already created for an existing and usually published (publically available) application. The challenge then was to fully understand how to modify and incorporate the code into the existing program without adversely affecting other sections.

Many versions of the application were attempted, with each revision developing or abandoning a subset of the overall code while keeping the main goals in mind. Usually this meant establishing good coding habits by creating separate web pages to alter just the new code or manipulate sample programs; if that ran successfully, those changes could be introduced into the main webpage. Not all programming efforts successfully integrated, for example as stated previously, when trying to integrate code in different languages, different versions and from different sources, the customization was extremely difficult. As a result, significant revisions to the layout and coding had to be made, and the web application goals were altered to be more realistic for time and programming constraints.

While the web forums and conversations with Esri programmers were often beneficial in learning the processes of programming the map, particularly in how the scripts were constructed,

the author found the successful creation of a robust web application by modifying these numerous scripts a challenging task that eventually overshadowed the learned GIS processes. For that reason, the author abandoned the initial program and instead sought a published template from Esri's Story Maps collection (Esri 2014). These customizable templates allow the programmer to add created and published GIS maps and data. While there was still a significant amount of programming required to edit the template to satisfy the overall goal of this thesis, it was no longer as onerous a programming task. As a bonus, the template already included useful default design amenities such as an index map, a map/image toggle button, a return-to-extent button, and zoom levels.

3.6 Final Web Map Programming

Using the Story Map template meant altering some of the design elements of the web application, most notably the user's ability to create his or her own search parameters. Only a few template options closely matched the original design of the web application, but one from the repository of the website GitHub (GitHub 2014) proved to be the most useful. The flowchart shown in Figure 37 outlines the overall methodology for customizing the ArcGIS.com template to produce the final, successful web application.

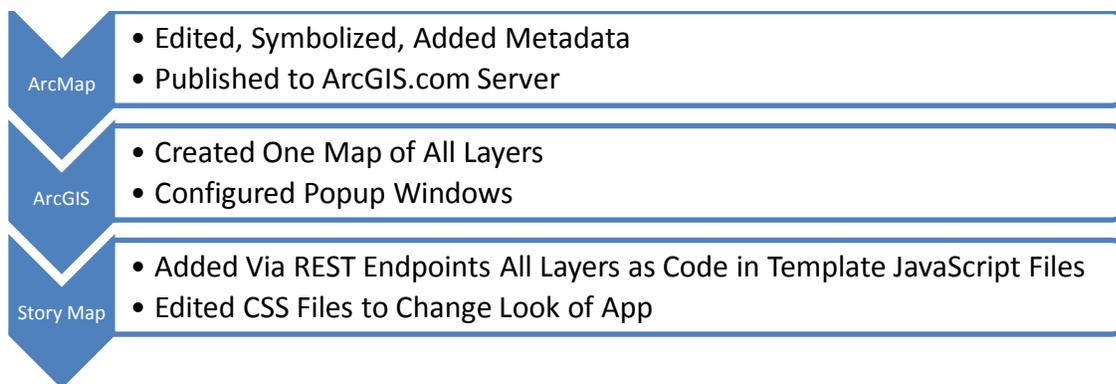


Figure 37 High Level Flowchart of Web GIS Application Creation Steps

The key elements desired are already included in the original GitHub-based template: a means to let the user select the layers to display, display a map legend, and interact with descriptive popup windows. As seen in the template sample in Figure 38, the map is uncluttered and easy for the user to understand and manipulate due to the inclusion of extensive programming libraries of associated style sheets, JavaScript files, and configuration codes.

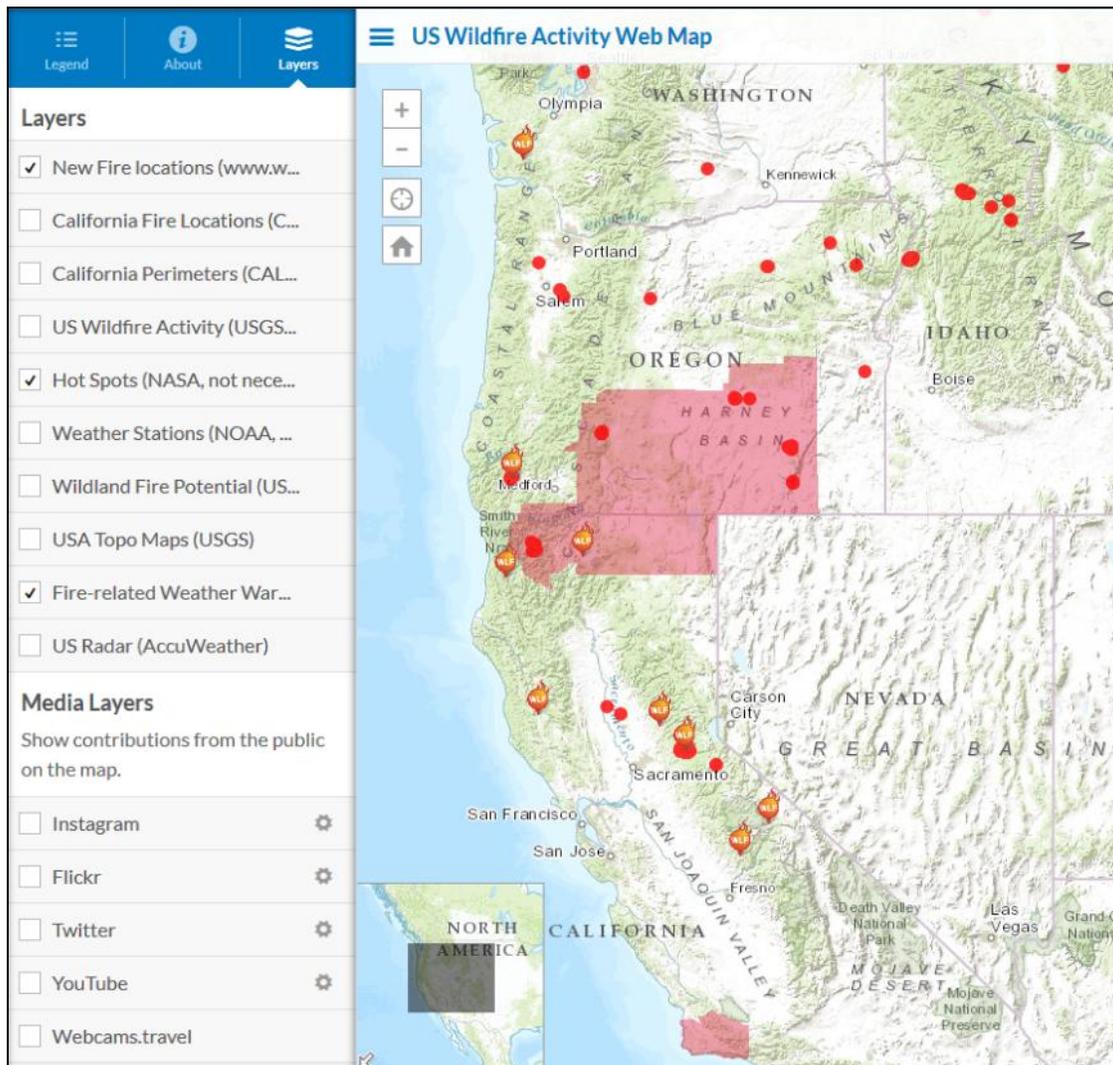


Figure 38 Public Information Template
Source: (GitHub 2014)

A benefit to using this particular template is that it allows the developer to directly insert a completed map published via ArcGIS.com by adding it to the web application using its unique webmap ID, as shown in Figure 39. Many tasks related to finalizing the map can also be completed using functionality provided in ArcGIS.com, when a developer is logged in and working on a web map or web GIS application. A side drawer, an expandable web page panel on the left side of the application including three separate tabs, lets users toggle layers to be displayed when opening the map and the basemap is chosen to suit the needs of the program. Bookmarks were created to pinpoint sectors in detail, and popup menus were configured for greater clarity. The layer displays were also altered to show only within a set zoom level or be made more transparent so they reduce visual clutter. Any modifications saved in the ArcGIS.com hosted web map automatically show up in the live web application that the user can access.

The main problem with hard coding the web GIS application was the inability to successfully create and display the results of searches. While no Esri Story Map template has been created yet that solves this problem, there is a viable work-around. Rather than attempt to set up a cumbersome search process for all layers, the author created four processes that can be called up by the user of the web GIS application. These searches as defined in Table 3 were added to the Story Map template where the user can toggle them on and off. An example of a Great Outdoors selection is shown in Figure 40, where popup windows provide descriptive information.

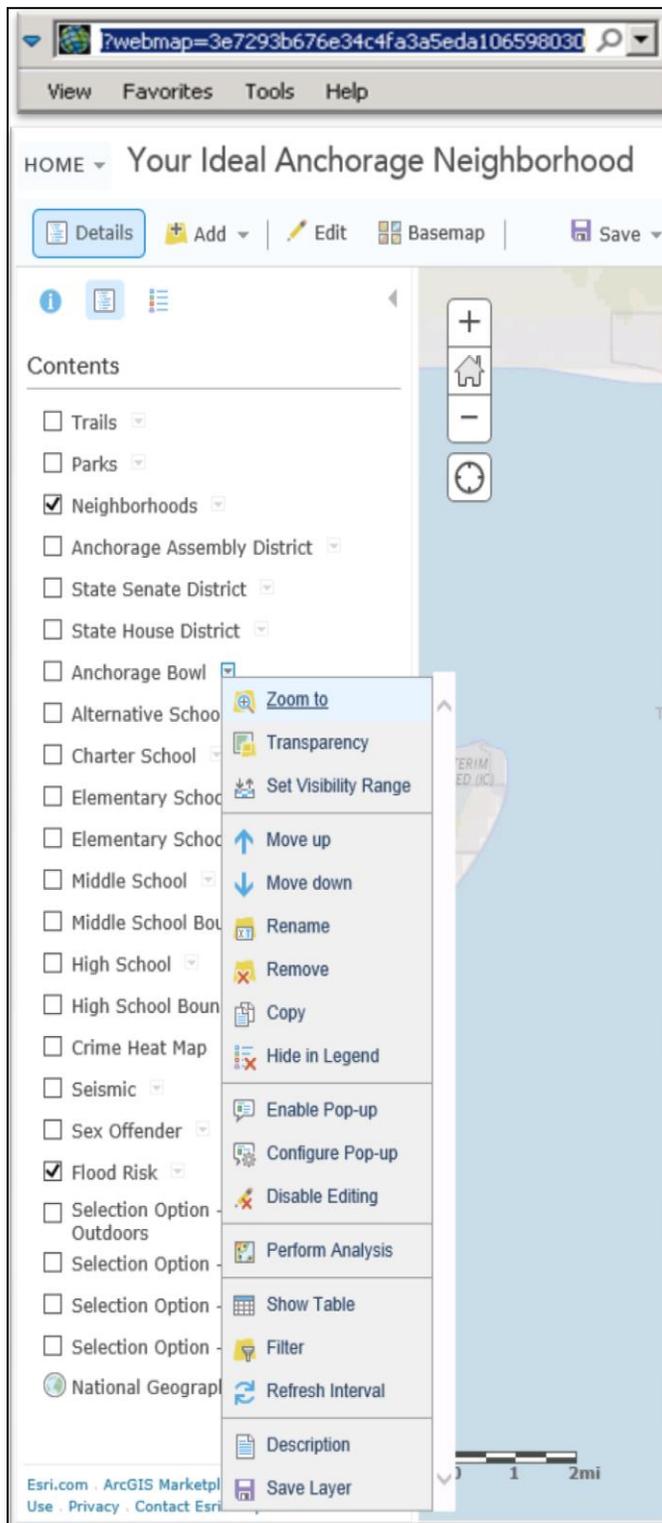


Figure 39 ArcGIS.com Map With Webmap ID



Figure 40 Great Outdoors Selection with Descriptive Popup Window

One additional feature in this template is a swipe function that displays a separate layer as the user scrolls a vertical line back and forth (horizontally) across the page. In the case of this web GIS application, the All Housing features are revealed using a vertical swipe bar as seen in Figure 41. Generally, a swipe bar is employed to show differences between map layers in image format, but in this application, the swipe function allows the user to quickly drag the All Housing layer features over an area to display properties in the user's neighborhood area of interest.

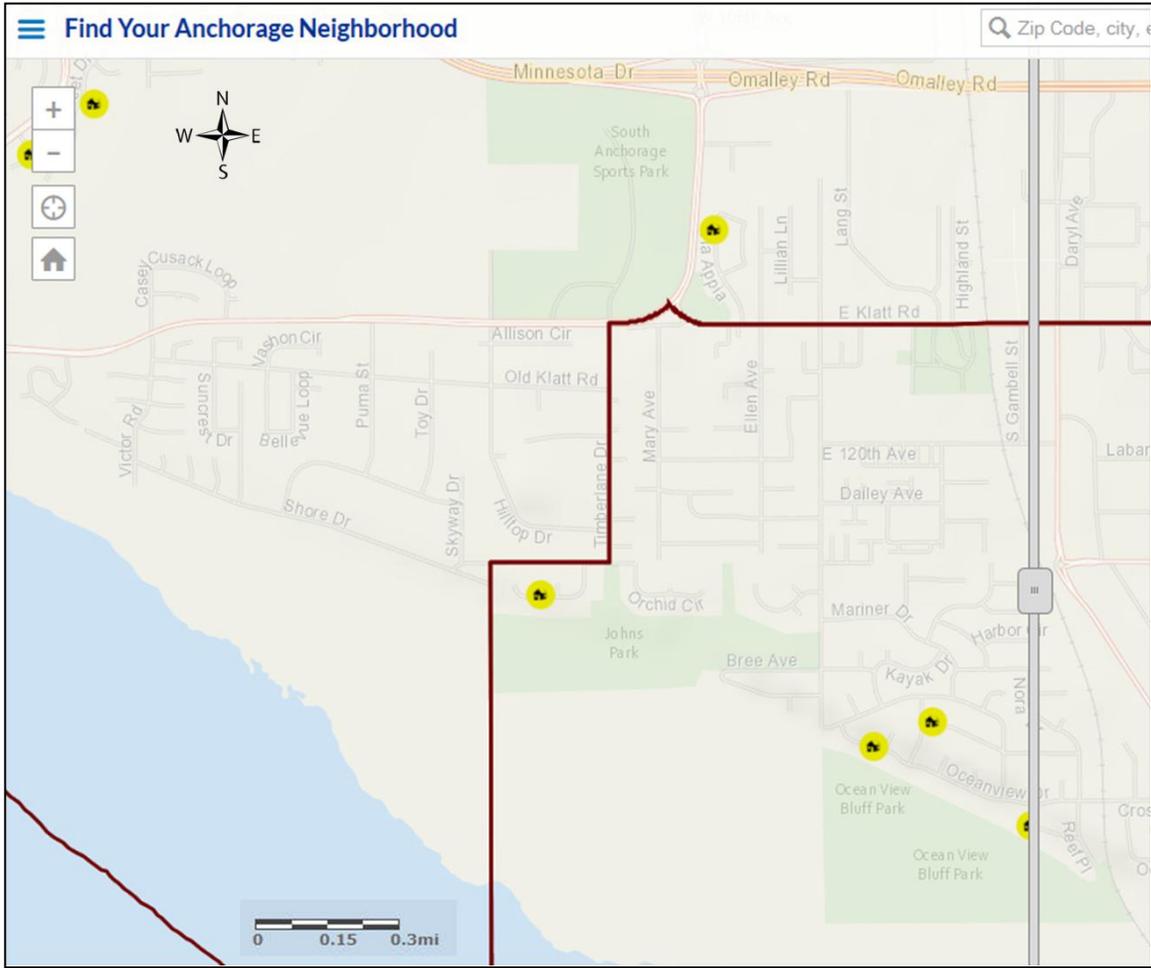


Figure 41 The Swipe Display Option in the Web Application

CHAPTER 4: RESULTS

The final web application developed as part of this thesis is available at <http://591-jndowlin.usc.edu/storymap/ThisTemplate/index.html>. This application provides the user an opportunity to view layers that help orient him or her within the city of Anchorage, and several search packages filter residential zones based on the user's need to either remove him or herself or include him or herself in the activities of the Anchorage Bowl. Once a user has identified his or her ideal neighborhoods, the user can display available properties by swiping that layer over the display to begin a home search.

4.1 A Tour of the Find Your Anchorage Neighborhood Application

The web GIS application usage is straightforward in its approach. An "About" screen appears first to explain the application and instruct the user how to select layers and choose one of the "selection packages." Three tabs in the left side drawer give the user flexibility to select layers to view, conduct searches in the map, visualize the layer symbology, and read metadata.

The first open tab is the "About" view (Figure 42) which links the user to the metadata and instructions page (Figure 43). This tab also houses the bookmarks that link to a selected neighborhood. This useful feature is important in displaying larger layers that cannot fully render in the map but will display completely at a larger zoom level. An unusual feature is the current date, useful indicate when the map was last edited. Few websites add the last edited date, but should do so to show that the website is not static.

The "Legend" tab shows the layers that have been toggled in the "Layers" tab and displays their icons and colors as created in ArcMap. By default, the Neighborhoods layer appears when the map is opened, as is the Available Housing that is visible only in the swipe function. All other layers are toggled as desired. All layers display at all zoom levels, except

those that approach or exceed the limit of 3000 rows that then render slowly or not at all. In this web GIS application, the large Trails layer and Commerce search layer may require the user to zoom in or select a large-scale bookmark to avoid long render times. As in ArcMap, layers at the top of the list may overlap those below them, including the selection layers at the very bottom. Therefore, these selection layers are best viewed with the other layers turned off.

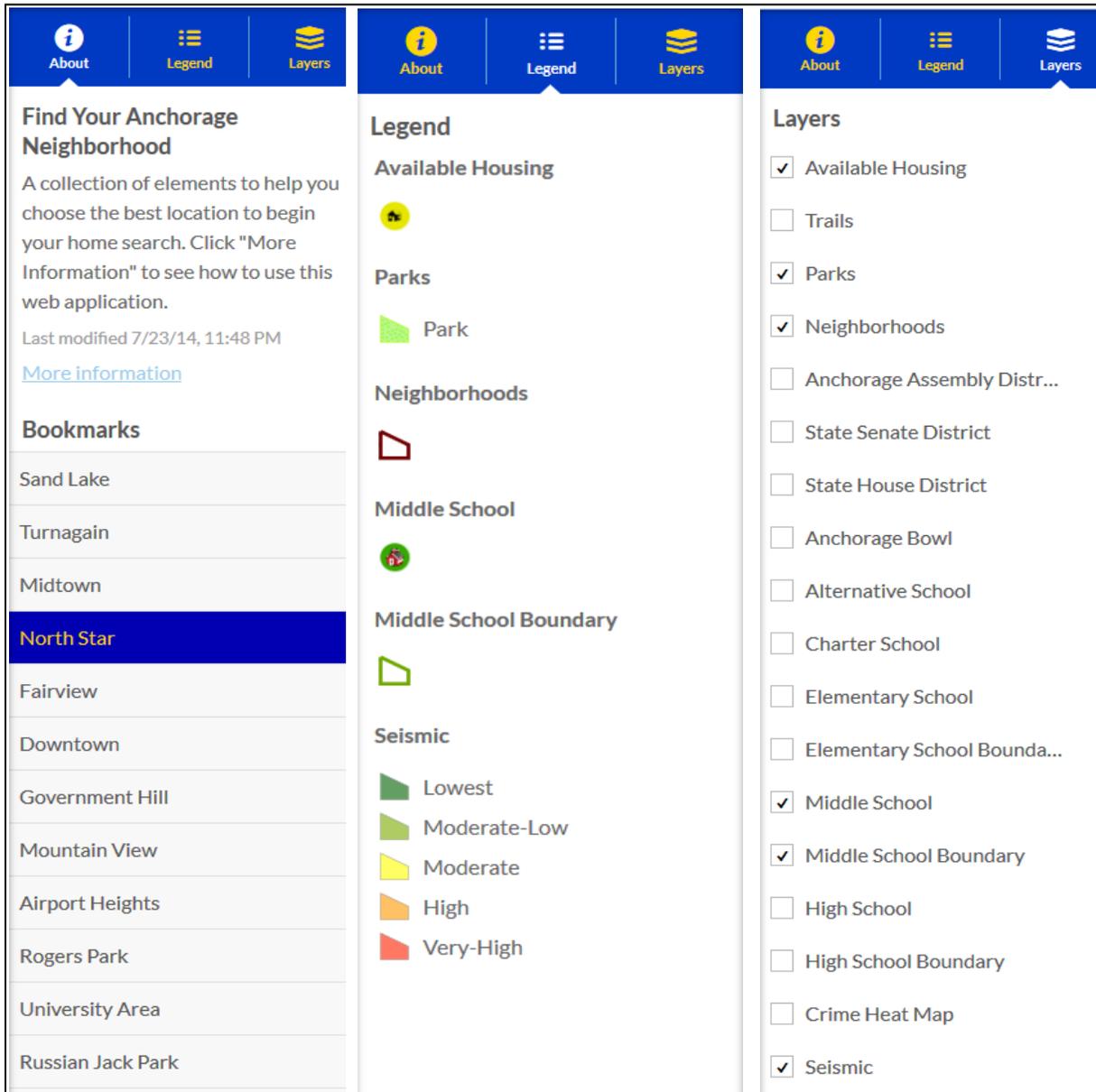


Figure 42 The Three Tabs in the Application Expanded

Find Your Anchorage Neighborhood

A collection of elements to help you choose the best location to begin your home search. Click "More Information" to see how to use this web application.

Web Map by jndowling_USCSSI
 Last Modified: September 12, 2014
 ★★★★★ (0 ratings, 380 views)
 Facebook Twitter

OPEN SHARE EDIT DELETE MOVE

Description

This web application is designed to help prospective home buyers determine which neighborhoods best display factors that are important to them. The resulting home search is then focused on these areas. This app uses data for Anchorage, Alaska.

There are four sections of related features:

- Education, showing the location of all public schools and their attendance boundaries within the Anchorage Bowl.
- Recreation, showing all municipally-owned parks and trails.
- Political, consisting of all boundaries for the municipal assembly, and state house and state senate. Larger neighborhoods are also listed and identified by their community councils.
- Hazards, specifically a crime heat map based on 2012 data, general locations of registered sex offenders, a seismic map showing potential subsidence, and flood map.

There are four selection options:

- Outdoors showing areas where the residential zoning is within 1000 feet of municipal trails and parks. These areas are beneficial for families and those who want quick access to green space and exercise areas.
- Great Outdoors that includes the Outdoors areas that are further than 1/2-mile from major roads, railroads, airports, ports, business and industry. These areas are away from the immediate bustle of city life.
- Quiet Area includes Great Outdoors areas that are in seismic zones 3 and 4 (low to very low ground subsidence probability). These areas are for those people who do not want to be in the middle of everything.

Figure 43 Partial Metadata for the Find Your Anchorage Neighborhood Web GIS Application

Two more interactive features are set in the original template. The website user can enter an address or business name into the search window to quickly find and zoom to that spot. That search function will allow the user to type in any street or business, even if it is not in Anchorage (Figure 44). Nearly all Story Map templates come with a way to broadcast via social media. Map users may embed the map with the provided HTML code, or share it through email or other media sites, as seen in Figure 45.

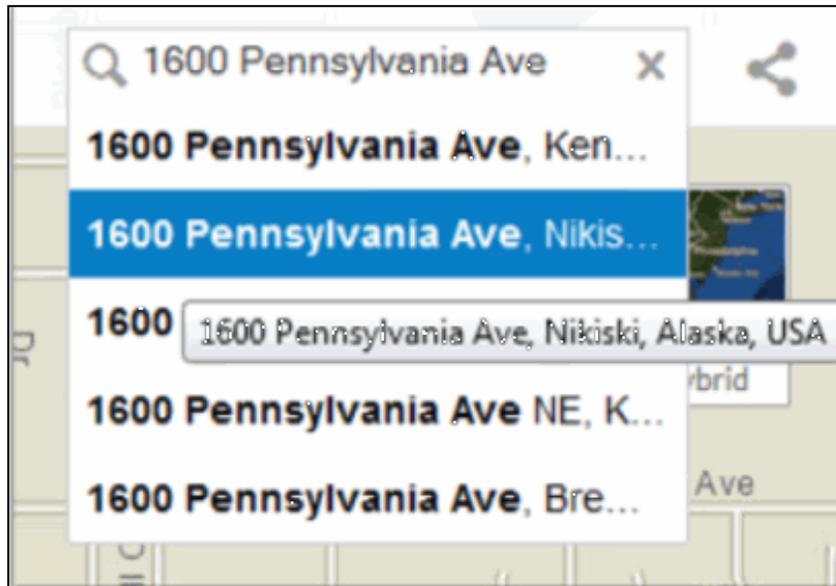


Figure 44 One of Several 1600 Pennsylvania Avenues

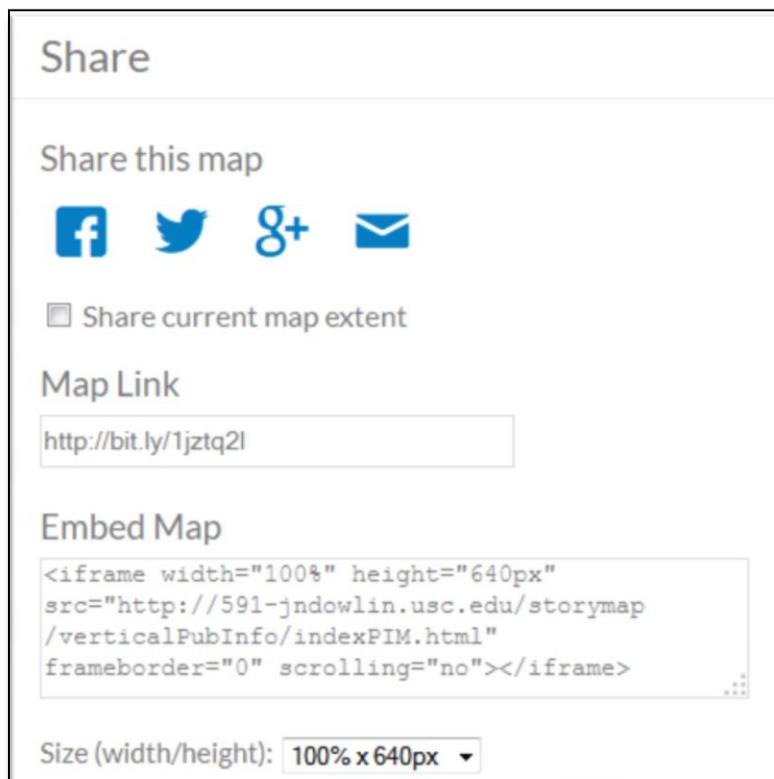


Figure 45 Social Media Options

4.2 Challenges Encountered

Several significant impediments affected the success of this project. These impediments are broken into issues concerning the Esri ArcGIS suite and how it is integrated with SQL Server, and the web programming using HTML and JavaScript. A great deal of database design and permissions handling is required to implement SQL Server as a backend for ArcGIS Server. The web page scripting was challenging primarily because the author's education and prior experience did not include additional computer science background outside of scripting learned in recent GIS programming coursework. It was these issues that took up most of the time and effort in the latter part of this project, as described below.

4.2.1 Esri ArcGIS and Microsoft SQL Server

Despite being a logical choice to use in this project due to increased familiarity and practice with robust software, Esri's ArcGIS suite is not a user-friendly product. A number of problems occurred with data permissions, delayed registering, enterprise geodatabases and publishing feature services necessary to create the web GIS application. Incredibly patient Esri technical support managed to straighten out the many issues, mostly by establishing SQL Server accounts and turning properties settings for "administrator" rather than "publisher" privileges. This corrected authentication errors that prevented accessing and saving data in geodatabases within ArcMap, and from publishing to the ArcGIS.com server.

An unexpected consequence was ownership of files within the geodatabase. Two authentication paths are available when using a database connection - the operating system authentication and the database authentication. Whenever a schema is established, the data are created and saved to a database; that process dictates the ownership of the data. The operating system does not require a password and therefore cannot be used when the data will be published

to another server. Many of the layers in the project were saved that way. Once the decision to publish the data was made, the permissions had to be changed and the database connection had to then use a password-enabled database authentication. Data saved to the geodatabase after that point were saved in that way and all other data were pointed to the database authentication scheme for publication. Any data files that required edits, however, had to point to the owner schema, before any changes could be made. This was both time-consuming and confusing. Any researcher who plans to create and publish datasets using SQL Server connections should be well versed in its theory and application, if only to avoid such an amalgamation of schema within the same database.

The project originally began in ArcMap 10.1, but the software became "buggy" in that it slowed processes and often prevented tools from working. Eventually, the project migrated from 10.1 to 10.2, and once the SQL Server connections were reestablished most of the problems with the program disappeared. One problem that plagued the project throughout was space limitations to the hard drive. Interestingly, that error manifested itself in different ways. Processes that worked perfectly previously were now unworkable, illustrated by permissions errors or locks to the data. After several failed attempts to complete a task, the program would flash a space limit screen (Figure 46). Deleting unneeded data files and programs from the virtual machine was the only way to eke out room to complete processes.

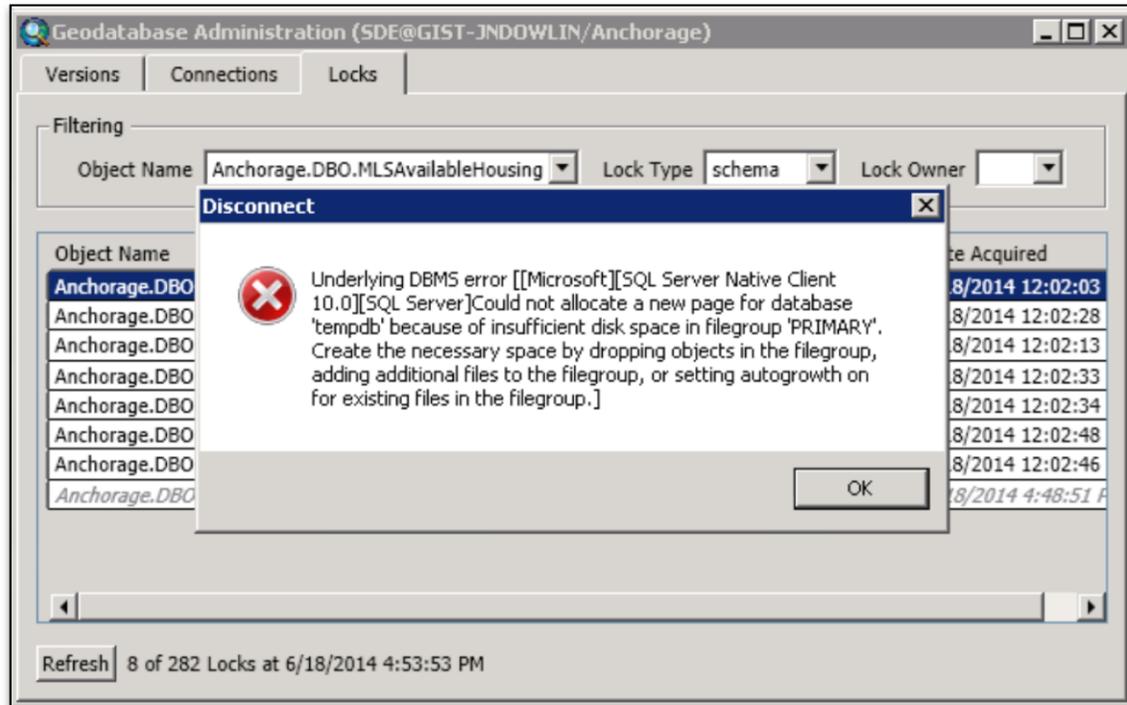


Figure 46 Insufficient Space Allocation Error in ArcMap

These challenges highlighted problems with the Esri Help file: while extensive and very current, it tends more toward the theory behind a task rather than the steps needed to accomplish it. The theory description relies heavily on jargon and detailed GIS concepts and by providing myriad links to help webpages that take hours to root through to a solution. In the instances listed above, only with the help of Esri Support could the problems be efficiently fixed.

4.2.2 HTML and JavaScript

Web programming is an intricate and time-consuming task, and combining HTML and JavaScripting with Esri-created geospatial data can overwhelm a novice programmer. Esri's Developers Forum for JavaScript applications has many small code samples for programmers to add to their own programs, and allows developers to use a "sandbox" to modify the scripts in

isolation from their main page (Esri 2013). A few of the scripts appeared useful enough in this thesis to warrant investigation, but none directly solved troubles that plagued the first iteration of the thesis web programming effort.

Many JavaScript and Dojo scripts from other websites were researched, especially those associated with geospatial programs or in help forums of StackOverflow (Stack-Overflow 2013). Curiously, because JavaScript versions changed often, certain compatibility issues required many hours of tinkering to correctly load the map and implement new elements. Map load functions, for instance, conflicted with instructions in other parts of the file, which meant the webpage would not render correctly. This problem most likely was a result of the author who did not fully understand the coding structure and how it related to other modules within the application. A simple workaround in these cases was to add additional lines in the JavaScript heading to recognize all JavaScript libraries.

A main conundrum in the web GIS application programming was the drop down menus from which the user could select multiple queries. Most existing real estate websites do allow the homebuyer to choose from drop down menus and display the results on the map (Figure 47). In many cases, these websites use Google maps and API functions to help produce their product (McConnathy 2013), citing customization ease. The Esri JavaScript code samples had no offerings for drop down menus and the samples for database queries did not provide a means to display the results in the map. This query does exist in ArcMap where users can select rows to display from a layer's attribute table, so it is confusing that it does not exist in other Esri code. New samples are created often, and such a process may yet be added to Esri templates, which when combined with the geospatial applications in ArcMap could be integrated to produce a more powerful web application.

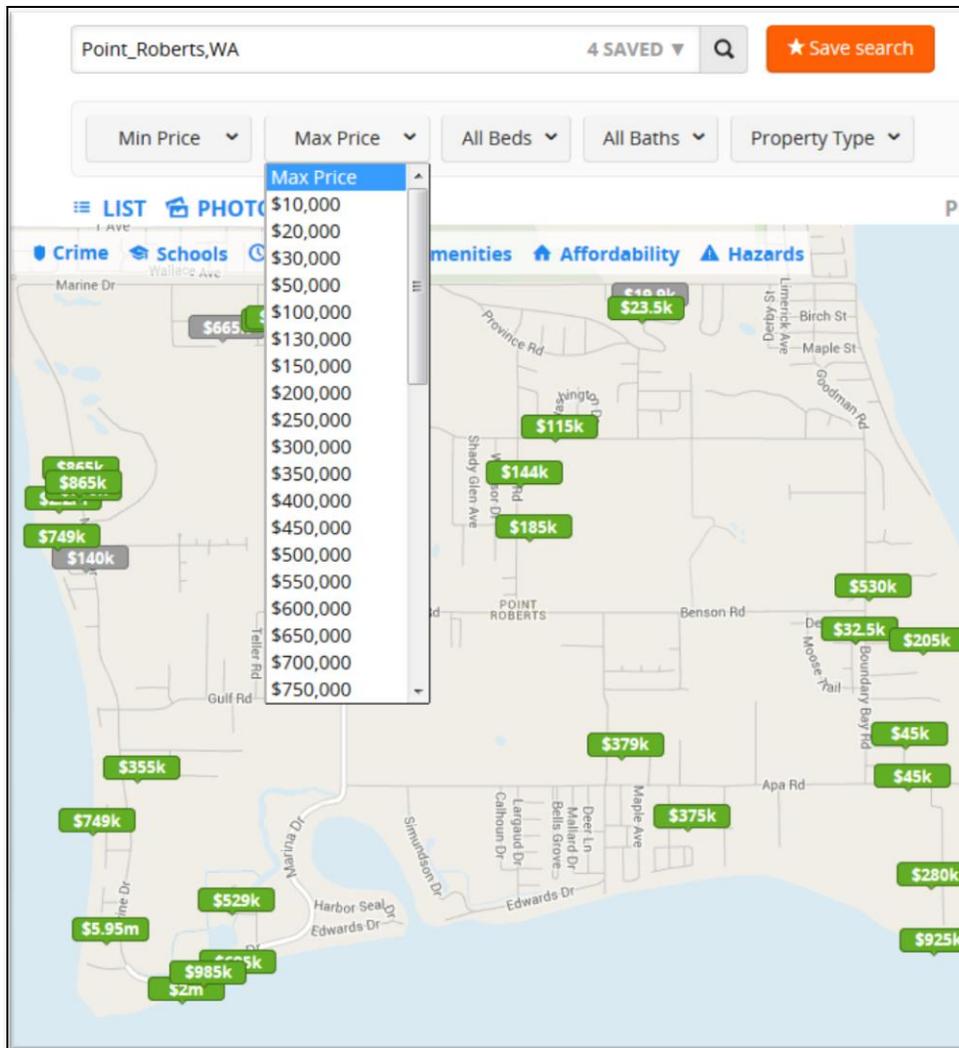


Figure 47 Drop Down Menu Option in Trulia.com

One of the final challenges in the coding scheme was to incorporate a swipe function in the Story Map template. The author studied the many JavaScript files included in the template to determine where to add the All Housing layer link. A series of email exchanges with the template author (Driscoll 2014) provided the answer. Each published layer is referenced by a unique text ID that is different from its ID in the REST services folder as shown in Figure 36. This ID may be found using developer debugging

CHAPTER 5: CONCLUSIONS

A web application that emphasizes neighborhood features before home amenities is a viable approach to home buying. While many real estate websites add this information after the user clicks on properties, other websites focus entirely on neighborhoods at the expense of property listings. The common factor for these websites is the ability to conduct realty research online, both with and without a realtor's aid. For this reason, both types of websites must be accurate and current and respond to evolving programming schemes. Future updates or additions to this dataset can be easily applied, as described in the future maintenance discussion in this chapter of this thesis.

5.1 The Future of Real Estate Search Websites

As more people use the internet to research tasks that previously were only performed by industry professionals, the proliferation of specific websites that show real estate listings will increase. Beyond showing an assortment of photographs and producing a checklist of home amenities, realtors and real estate web programmers will focus on providing a unique experiences for prospective homebuyers. They could potentially describe a neighborhood in full by incorporating census data, linking news reports, analyzing economic trends, and integrating social media posts. Greater search options will lead to detailed home and neighborhood descriptions to populate websites' search databases. Home searches will be more than paper flyers retrieved from a For Sale sign yard box, but instead be an invaluable tool for both realtor and homebuyer so that both parties can understand what aspects of a neighborhood and home are attainable. In many cases, real estate websites cannot supplant the expertise and experience of a realtor, but will instead enhance the process.

5.2 The Ever Expanding Future of Web GIS Map Programming

Esri's JavaScripting samples (Esri 2013) is an example of ever-expanding geo-programming interfaces. JavaScript and HTML code samples currently available are often edited by developers to incorporate recent programming improvements. Because of these advancements, someone who understands the changeable nature of web GIS map application programming should continuously monitor the relevant programming language to ensure that their own websites continue to display and function properly.

There are many elements incorporated in this web GIS application to provide the basic information required by a residential real estate client to search for a new home, plus some functions that improve the usability or display of the resulting maps. The great benefit of using templates provided by Esri's Story Maps and GitHub enable a more direct application of GIS-derived maps into a publicly available web application. Sites such as these add new scripting codes and templates frequently to aid less competent web programmers who deliver the results of GIS effort. For example, the template used in this project was created ten days before it was selected.

Esri is not unique in providing tools to help real estate web designers. Google APIs are integral to real estate websites such as Zillow and Trulia, and these larger companies employ many programmers to develop unique code in response their company's needs and even enter into partnerships with other companies to deliver real estate information (Zillow 2014). Many of these sites do not provide any neighborhood information, particularly the locally owned real estate offices, but as programming script become more prevalent or if homebuyers insist on a full picture of the area, this may change.

5.3 Future Work on the Find Your Anchorage Neighborhood Application

This web GIS application was designed as an interface to a dynamic real estate search page, therefore data maintenance is required. Crime and sex offender data are the most fluid and that information should be updated often. The lists of office holders in the municipal and state political offices may change after each election through the shapefiles presented by the MOA and should be updated in the database. Zoning and school shapefiles should also be periodically inspected for edits to location or classification. While it was only a secondary feature in this project, property lists from realtors and MLS databases should be complete and current, perhaps via live feeds from original database sources. Future work should investigate the constantly changing elements of web design and database management and add such to the website if it is deemed to improve the user experience. Because this application was created using Esri software, it is easiest to continue to host the map using ArcGIS.com, a solution that can be readily incorporated into a company's existing website. A national-based website would require data to be added to this application from many other communities, so the time frame to add all available data would be dependent on the amount of information that could be collected and integrated into the existing application.

The original design for this web GIS application was ambitious and was slowly scaled back in response to programming challenges or data acquisition issues. Some datasets that would have been good to include were unavailable from MOA, or only offered as printed maps, such as tax roles, municipal bus routes, private schools, and emergency service locations. Digitizing these layers, while very useful in a home search, would be time consuming, and except for the bus route data, would not have been applicable to any of the "selection packages" searches in this

project. Rather, these data could be included in later work to allow additional advanced queries within a more custom and specialized search tool.

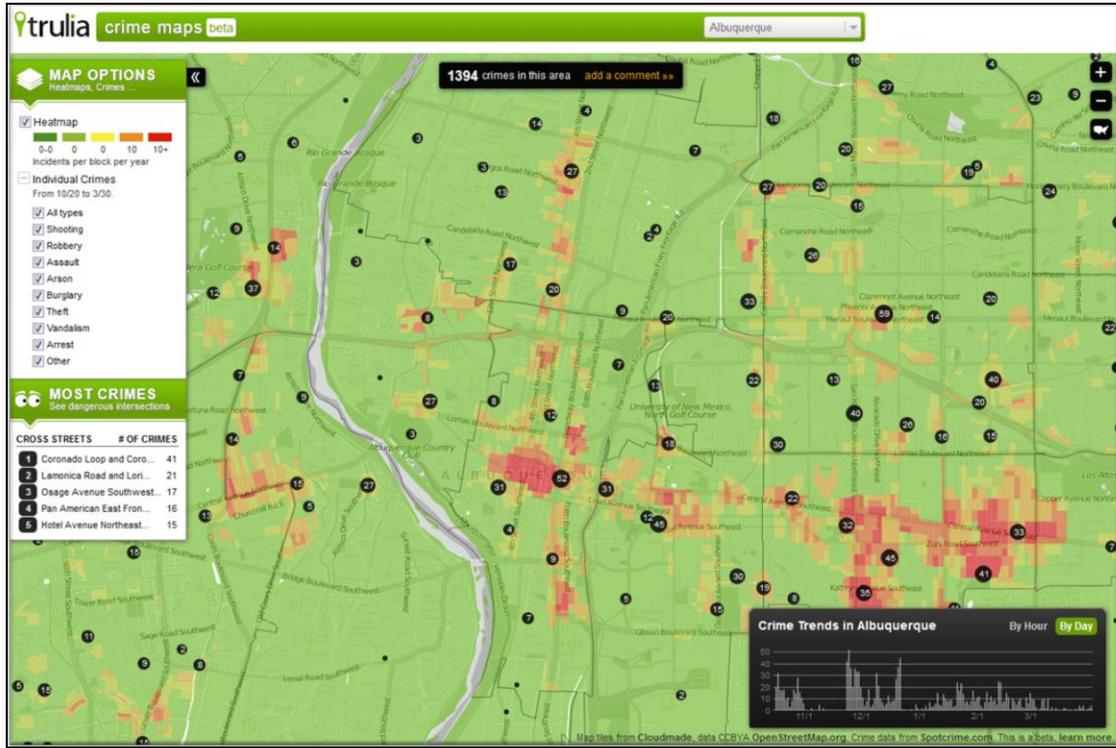


Figure 49 Crime Mapping Display From Trulia.com

Several data layers were added as information-only layers, namely the flood zone, crime, and schools layers. It would be very useful to allow homebuyers to conduct searches on school names or indicate "safer" areas of town. Currently, no real estate website offers all these search options. Figure 49 shows a robust crime layer from Trulia where users see recently reported crimes used to create updated heat maps, look at trends, and toggle various crime types. The homebuyer, however, cannot easily choose to see homes for sale only in the "green" areas. As discussed in chapter 3, heat map displays can be subjectively interpreted. Census data was not included in this project, but could be useful in future work if treated sensibly. The author

considered incorporating neighborhood information about age, income, ethnicity, and housing type. Such data would help paint a more vivid picture of a given neighborhood, but has a real potential to be misconstrued. Realtors are wary of or even prohibited from discussing sensitive Census data for fear of treading on Fair Housing Laws (Wiggin 2014). These concerns are outside the scope of the thesis and are not discussed further herein.

One final suggestion for future work is to create a mobile application handy for potential homebuyers as they travel to their optimal neighborhoods to begin directed home searches. The effort needed to develop a clean application for smaller devices may be significant, but as more users rely on mobile devices, its development is imperative for a real estate web site to maintain its competitive edge.

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