CREATION OF AN OPEN SOURCE WEB-BASED GEOSPATIAL DECISION SUPPORT TOOL FOR ENVIRONMENTAL CEQA REVIEW

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by
Peter Hansen
Spring 2012
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DEDICATION

This project is dedicated to Dustin Granville, my favorite geographer. You are forever in my thoughts.
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This entire academic process would not have been possible without the support of my family, friends, and the Department of Geography at California State University, Chico. Most of all, I could not have completed this process without the unconditional love of my wonderful wife and best friend Rebecca. Your patience and support has enabled me to succeed.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedication................................................................. iii</td>
</tr>
<tr>
<td>Acknowledgments......................................................... iv</td>
</tr>
<tr>
<td>List of Tables............................................................... vii</td>
</tr>
<tr>
<td>List of Figures............................................................... viii</td>
</tr>
<tr>
<td>Abstract................................................................................. ix</td>
</tr>
<tr>
<td>CHAPTER</td>
</tr>
<tr>
<td>I. Introduction ........................................................................ 1</td>
</tr>
<tr>
<td>GIS, Interoperability and Planning Hurdles.......................... 2</td>
</tr>
<tr>
<td>GIS in Planning ............................................................... 6</td>
</tr>
<tr>
<td>Volunteered Geographic Information and Crowdsourcing ........ 8</td>
</tr>
<tr>
<td>GIS Shortcomings ................................................................ 9</td>
</tr>
<tr>
<td>Web-Based GIS and Usability of Online Systems .................. 10</td>
</tr>
<tr>
<td>Cost of Entry and Technical Shortcomings.......................... 11</td>
</tr>
<tr>
<td>Open Source and Proprietary GIS ...................................... 13</td>
</tr>
<tr>
<td>Open Source Promotion by Federal Government ................... 16</td>
</tr>
<tr>
<td>Purpose of the Project....................................................... 17</td>
</tr>
<tr>
<td>Scope of the Project.......................................................... 19</td>
</tr>
<tr>
<td>Significance of the Project................................................. 20</td>
</tr>
<tr>
<td>Limitations of the Project ................................................ 21</td>
</tr>
<tr>
<td>Definition of Terms ........................................................... 22</td>
</tr>
<tr>
<td>II. Methodology...................................................................... 25</td>
</tr>
<tr>
<td>Creating the Map Application............................................. 25</td>
</tr>
<tr>
<td>Building the Spatial Data Infrastructure............................. 26</td>
</tr>
<tr>
<td>Data Collection ............................................................... 30</td>
</tr>
<tr>
<td>Styling and Cartography..................................................... 33</td>
</tr>
<tr>
<td>Programming the Application............................................. 34</td>
</tr>
<tr>
<td>CHAPTER</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>III. Results</td>
</tr>
<tr>
<td>User Survey</td>
</tr>
<tr>
<td>IV. Conclusions</td>
</tr>
<tr>
<td>References</td>
</tr>
<tr>
<td>Appendices</td>
</tr>
<tr>
<td>A. Screenshots</td>
</tr>
<tr>
<td>B. CEQA Appendix G Environmental Checklist Form</td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Data Matrix of Data Contained in the PostgreSQL Database for Butte County</td>
<td>32</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>DESCRIPTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Derived Architecture of the Spatial Data Infrastructure Used in the Project</td>
<td>27</td>
</tr>
<tr>
<td>2.</td>
<td>Screen Snapshot of the Notepad++ Programming Environment Used for the Project Development</td>
<td>29</td>
</tr>
<tr>
<td>3.</td>
<td>CaliforniaOpenAtlas.com Home Page</td>
<td>35</td>
</tr>
<tr>
<td>4.</td>
<td>CaliforniaOpenAtlas</td>
<td>Butte Screenshot</td>
</tr>
<tr>
<td>5.</td>
<td>The Map Layer List Available to a User</td>
<td>40</td>
</tr>
<tr>
<td>6.</td>
<td>Quick Zooms of the Spatial Data and the APN Search Window</td>
<td>40</td>
</tr>
<tr>
<td>7.</td>
<td>Toolbar Available to a User</td>
<td>41</td>
</tr>
</tbody>
</table>
ABSTRACT

CREATION OF AN OPEN SOURCE WEB-BASED GEOSPATIAL DECISION SUPPORT TOOL FOR ENVIRONMENTAL CEQA REVIEW

by

Peter Hansen

Master of Arts in Geography

Environmental Policy and Planning Option

California State University, Chico

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Geographic information systems (GIS) and other geospatial support tools can be utilized by environmental planners during environmental impact review. However, these proprietary computer desktop tools are typically beyond the reach of environmental planners due to a high cost of entry, a steep learning curve, and disparate geospatial datasets. The CaliforniaOpenAtlas (COA) project aims to alleviate these issues by cataloging publicly available datasets from various government agencies into a streamlined and usable web-based decision support tool built with freely available open source geospatial software for use by environmental planners. Applicable datasets are determined using indicators from the CEQA’s Appendix G – a checklist that environmental
planners consult containing a broad range of potential environmental impacts that may result from a CEQA project.

This project write-up relays the importance of geographic data and maps in environmental planning, the issues restricting a higher level of use by potential and current users, and the push for increased usability and transparency of data and policy as dictated by state and federal governments. Additionally, this write-up documents the creation of the COA platform, highlighting the manipulation and coding process of the open source geospatial software utilized.
CHAPTER I

INTRODUCTION

Environmental planning is a decision-making process that relies heavily on the evaluation of existing environmental conditions while anticipating, predicting, and mitigating the potential political, societal, economic, and natural environmental impacts that occur as a byproduct from a proposed project (Marsh 2010). The process can be complex since there are so many variables at play. To help sort, quantify, research, and clarify information as it relates to the environmental review process, environmental planners can use geographic information systems (GIS), which are designed to store, edit, and analyze geographic data.

Since environmental planning is most concerned with the potential impact to the natural environment, the spatially-connected abiotic and biotic components cannot be ignored. The interconnectedness of the physical environment with biological patterns/processes necessitates a thorough interpretation and understanding of the various processes that occur and how human interaction can negatively affect the natural processes. In other words, geospatial understanding is crucial to the environmental review process. To ensure thorough and legally binding environmental review, planners defer to the statutes set forth in CEQA and NEPA protocol.

GIS can assist the planner in making an informed decision in the outcome of the environmental review process through the understanding of the natural environment
of the study area. It should be stressed that GIS is not a decision maker; rather, it should be used to inform the planner and support the process. At a minimum, it provides a starting point for initial research, especially in the case where the planner is not familiar with the study area.

GIS, Interoperability and Planning Hurdles

Advances in hardware and software have allowed for GIS to become a more powerful tool with the ability to leverage larger and more complex datasets, yet the technical ability needed to maintain a traditional GIS is often out of the grasp of a typical environmental planner (Gocmen and Ventura 2010). While there are exceptions to the norm, other hurdles such as cost, data availability, and data integrity, prohibit GIS from being as well utilized as it could be in a typical environmental planning undertaking. Additionally, as we collect larger datasets, we are met with challenges of interoperability, standards-compliance, linguistic, geosemantics and cataloging issues, and simply data overload.

Standardization and interoperability has long been a foundational pillar in the proliferation of open source geospatial software. Promoted by open source groups such as the Open Geospatial Consortium, recent gains in standardization practices have provided new opportunities for data collaboration. The semantics involved in data cataloging, however, are typically overlooked. Despite these new advances in interoperability, semantics-based issues, such as inconsistent naming conventions and contextual influences can inconspicuously cause problems. To date, much of the standardization of open source geospatial has been focused towards data interoperability and software
compatibility, while data classification is left up to the interpretation of the data collectors (Janowicz, et al. 2010).

Janowicz and Keßle (2008) breaks the classification of data into three sections, the name, the geographic extent, and the type (i.e., attribute description). All three of these classifications depend on a definition of sorts defined by the contextual influences that act upon the data collection process. It is important to be aware of the contextual differences at play during the creation of spatial data, as different jurisdictions may have different measuring or classifying (describing an attribute) techniques. For example, what may be a small lake to one culture or institutional authority (local or federal), could be classified as a large pond to another. Typing classifications leave the most room for variability amongst datasets and continue to be the biggest hurdle with respect to the “geosemantics” of database interoperability across the Internet.

Additionally, the matter of geographic extent is one that is dependent on the understanding of that entity at the time of measurement/definition. Geospatial data must be defined by a geometric type that the associated data can describe, be it a line, point, or area. The actual geometry of a shape can vary greatly depending on the chosen geometry type as well as the agreement over the actual extent or reach of the shape. Whereas geometric shapes have a starting and stopping point and hard lines, this is often not the case in the natural world, where transitions, gradients, and gray areas are commonplace. Determining an extent, as well as a consistent and cross-referenceable name and typing convention can quickly become problematic. There is the possibility to produce data that lacks meaning relative to other “standardized” datasets intended for interoperability. Increasingly, a geosemantic web standardization becomes necessary (Janowicz and
Keßler, 2008), especially in this era of big data sets and multiple producers of geospatial data.

There is a growing field of GIS developers, however, who are developing open source GIS tools that are intended to overcome some of those hurdles and compete with traditional proprietary (corporation-driven) solutions. Their efforts have enabled a legion of non-technically competent users to explore free GIS solutions to supplement their work tasks. Can these open source GIS tools assist in environmental review? Given the spatial connections of the environmental review process, the availability of pertinent data, and the increasing capability of open source GIS tools, surely there is possibility for improvement. Many environmental planners, however, are left with disparate data from multiple sources, and no skills to work with software that they may not even have due to expense or lack of understanding.

In the 1980s and 1990s, during the infancy of GIS, most operations were completed using a command line interface or through user created programs, often intimidating for planners to use. Further developments in software through the 1990s have allowed for greater ease of use, but planners still saw GIS as an impediment to work, rather than a benefit. Additional studies of usability through the 1990s and early 2000s concluded that technological, organizational, and institutional factors were barriers in the use of GIS in planning. A 2007 study of barriers for GIS in planning surveyed nearly 1,200 individuals from 256 public agencies in Wisconsin. The results indicated that lack of GIS training, lack of understanding of data structures, and funding were the top three barriers (Gocmen and Ventura (2010)).
Workable software, albeit important, is only one element of this process. Another is the determination of geographic data to be used. Since there is an ever-growing abundance of geospatial data, it is important to choose the correct data for this process. As application of this project is proposed or limited to Butte County, California, the scope will defer to California law to determine what datasets would be appropriate for assistance in environmental review. By California law, applicable projects must undergo initial environmental review called an ‘initial study’ to determine the potential impacts of the project. Environmental planners consult ‘Appendix G’ (see Appendix B) of the CEQA guidelines (1970), which includes a checklist of categories, designed to include all the possible environmental impacts that a proposed development project could inflict on the site as well as areas adjacent to the project site. Many of these categories have a geospatial component and could be answered by consulting a GIS database or other map product. The CEQA checklist of categories are (Bass, Herson, and Bogdan 1999):

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources
- Cultural Resources
- Geology/Soils
- Greenhouse Gas Emissions
- Hazards & Hazardous Materials
- Hydrology/Water Quality
Over the last ten years, increased computer literacy, the spread of the Internet, and the mainstream acceptance and use of commercial basic mapping enterprises like Google™ Maps and Google™ Earth by planners and public alike have benefited the GIS research community and industry. As technology continues to progress and systems are easier for non-technical users to grasp, GIS will become more useful and relevant, as planning technology and scientific knowledge have made great strides in recent years (Klosterman 2008; Drummond and French 2008). Daniels (2009), in his review of the evolution of American environmental planning since the latter half of the 19th century, states that with recent technological advances, planning no longer suffers from a lack of understanding of environmental sciences, but from a lack of political will. The tools and data are available for use. While Daniels (2009) point is well stated that
data and tools are available, other studies (Aime, Bonfati, and Monari 1999; Gocmen and Ventura, 2010) suggest that many GIS tools suffer from design shortcomings limiting their use. Their ease of use is key in adoption by planning staff.

Though GIS has increased in use and acceptance, the industry must cater to the new type of user, unfamiliar with traditional, full-fledged GIS systems. Many new systems are too complex and require technical training to remain cost-effective for many of the simple mapping exercises required by planners, such as locating a parcel on an aerial map, or measuring the distance from one object to another. As many basic GIS functions are becoming more available over the web, the demand for simple GIS requests will be met by that technology (Drummond and French 2008). Environmental planning has always struggled with the balance of conservation and development. The process has continually been criticized for being unable to balance the demands of stakeholders, both from planners and involved public individuals and entities, sometimes due to lack of equity or access. In this case, equity deals with the amount of participation in the process, while access addresses the ability to make input towards outcomes. Sometimes, those who have been affected by planning decisions did not have an adequate foray into the participation process. Planning has had to overcome traditional barriers to stakeholder participation, such as distance, competing views, and diverse motivation. Public participation GIS (PPGIS) in general and Web-based GIS specifically offers a publicly accessible and therefore potentially larger forum for all stakeholders to participate in the planning process (Dragicevic and Balram 2004).
Along with PPGIS, voluntary geographic information (VGI) can provide valuable insight in the form of crowdsourcing. Goodchild (2007) notes that Linus’ Law and Tobler’s Law are in effect with VGI. Linus’ Law stems from the development of Linux, the open source operating system, stating that the more people you have watching over and contributing to an idea, the better off it will be, as errors will be spotted and fixed more quickly. Additionally, Tobler’s Law states that everything is related, but nearer things are more related than distant things. Therefore, VGI and crowdsourcing can result in fresher data, from a large audience. Based on the successes of both Wikipedia and Twitter (as a source of breaking news), crowdsourcing and VGI provides immediate information from informed sources. While arguably valuable and useful (Batty et al., 2010), volunteered data is not necessarily an acceptable source in environmental review.

VGI has played a crucial role in crisis response. During the 2010 Haiti earthquake crisis, VGI based information sources such as OpenStreetMap gave first responders invaluable infrastructure information. Before the earthquake, there had not been a complete, valid, or thorough source of information about Port-au-Prince, Haiti, which saw extensive devastation from the earthquake. However, the combination of usable open source GIS tools as well as modules for data collection allowed contributors to create a wealth of information to assist in the relief effort. As geography and geographic information are dynamic, VGI and crowdsourcing will continue to grow as a viable source of information in the future (Zook et al. 2010)
GIS Shortcomings

Aime, Bonfati, and Monari (1999) says that the user and their potential lack of knowledge about the system and how it functions is an obstacle to usability. User tasks are separate from computer processes, and advances in data structures, modeling, and computations, must also be met with improvements at the system interface level, hiding computational tasks, and allowing the user to focus on the geographic data.

A study conducted over twenty years ago by the National Center for Geographic Information and Analysis (1991) stated that GIS being difficult to use is an interface problem rather than an engineering problem. Despite software advances, another survey in 1999 highlighted non user-friendly GIS software (Bernardo and Hipolito, 2000). Again in 2010, Lew, Zhang, and Olsina (2010) found that usability is paramount in GIS applications, often overshadowing data integrity and ability of the software to perform the desired task, under the premise that, if the system cannot be used, all else is moot.

Even the most seemingly simple GIS operations still use complex algorithms, data structures, networks, and numerous functions and subfunctions. Only the most advanced users can work knowing the technical structures going on behind the scenes. The novice and non-technical users do not interface in GIS in this manner. Rather, they operate on a more abstract level, and are given illusions in the form of graphical user interfaces (GUI) to comprehend and then facilitate what they would like to happen. More specifically, users expect to press buttons, select from options, give textual input, and browse graphically (Lanter and Essinger1991). All computer programs and Internet
applications are a complex collection of codes, connections, and algorithms, and usable interfaces are absolutely necessary for adoption and use by non-technical users.

Web-Based GIS and Usability of Online Systems

Increasing numbers of Human-Computer Interaction (HCI) studies have been performed, not only for desktop GIS, but also for many web-mapping applications (Blaser, Sester, and Egenhofer, 2000; Fonseca et al., 2000; Haklay and Tobón 2003; Haklay and Zafiri 2008; Hewett et al. 2002; Mark et al., 1999; Medyckyj-Scott, 1992).

With a widely varying and growing audience due to the increase in Internet users, user-interface must be considered. Unwin (2005) creates the ‘accidental geographers,’ potential users who may not be technically skilled enough to run a full-fledged GIS program, yet are able to access simple web-based GIS-like systems, like Google, Yahoo Maps, or Wikimapia (Unwin, 2005).

HCI is a study of many interconnected fields and disciplines, which ‘arose as a field from intertwined roots in computer graphics, operating systems, human factors, ergonomics, industrial engineering, cognitive psychology, and the systems part of computer science’ (Hewett et al. 2002). Haklay and Tobón (2003) states that literature has been concurrent with the prevalent technology of the time. Beginning in the 1980’s, with the explosion of personal computers, more HCI has been focused on many more non-technical users, rather than between a specialist and the computer. In the 1990’s, HCI within the GIS field began to be studied, as GIS developers began to be more concerned with user needs, rather than processing speeds and data storage solutions. It was found that GIS shortcomings were “more likely to fail on human and organizational grounds
than on technical ones” (Medyckyj-Scott, 1992, p. 106). However, there is limited study in how the common user, or ‘accidental geographer’ uses the system (Haklay and Zafiri 2008).

Cost of Entry and Technical Shortcomings

Current proprietary GIS vendors, specifically Environmental Systems Research Institute (ESRI), offer multiple levels of service ranging from a few thousand dollars for single computers providing limited GIS capabilities to fully enabled enterprise solutions, costing hundreds of thousands of dollars. Additionally, many vendors necessitate an annual maintenance contract or license in order to provide user support and software updates, further entrenching a financial commitment. As of 2011, ESRI maintains a 40.7% market share in the GIS software industry, which is more than any other vendor (Schutzberg 2011). Along with high software costs come high hardware costs, as ESRI programs typically require high-speed workstations with advanced processing capabilities. These potentially high entry costs prohibit many potential users of GIS. The current proprietary software in the GIS industry is ESRI, who produces the desktop GIS software known as ArcGIS (ESRI 2012). Beyond the financial hurdle, many GIS programs, specifically ESRIs ArcGIS platform, come bundled with a large amount of buttons and tools to perform multiple tasks, as their approach is more of a one size fits all. As stated before, many potential users, who could still benefit from GIS concepts, can be easily overwhelmed by a robust computer program, with functionality beyond them.

While companies who keep the source coding proprietary create most computer software, there is a growing amount of software created through an open source
approach. The Open Source Initiative provides a lengthy definition of open source software. There are numerous definitions of open source and its philosophy, but the general gist is that users are given access to the software’s source code and are free to manipulate and distribute it however they see fit to suit their needs, even for commercial purposes. Additionally, they must agree to redistribute back to the open source community. The proliferation of the Internet has provided a platform for an international network of code developers to work together to create robust software, often with the ability to compete with or outperform many proprietary alternatives. It is no different with GIS software as there are open source alternatives available that can stand in for almost any service that ESRI can provide. The World Wide Web (WWW) acts as a platform where open source GIS solutions can exist, and be modified to suit the needs of the end user. Alternatively, ESRI provides one platform, which may or may not be the most appropriate for the end user.

Just as the open source software movement has been gaining momentum, there has been a push for more government transparency. The Obama Administration has created a portal for citizens to scour a multitude of informational federal documents and datasets (www.data.gov). Many states and cities have followed suit, and are allowing citizens to have access to public records. If GIS is a suitable platform for viewing much of this data, then it should be used as such, but the aforementioned hurdles exist. Open source GIS software solutions provide the platform for spatial datasets to be published publicly, with concern given to the enhanced design and usability elements that often plague proprietary GIS software. Coupled with the growing number and strength of web-
based open source GIS applications, low cost of entry, data rich, easy to use GIS applications are attainable.

Throughout its 40-year development, GIS has mostly evolved as an isolated, stand-alone, monolithic, and proprietary system. Only recently has GIS technology shifted more into the mainstream. As systems evolve, they are becoming more streamlined, replaced by smaller applications, and are integrated more into the mainstream IT developments (Anderson and Moreno-Sanchez 2003). GIS, once mostly concerned with data and tools, is now evolving to a web services model that includes not only data, but some geo-processing tools, such as spatial queries (Dangermond 2002). As services move to the web, they must (1) maximize productivity and efficiency; (2) protect critical information and infrastructure; and (3) overcome problems related to data-sharing, security, and maintenance. Even though the web is an ideal platform for this sort of structure, many companies find that most commercial web-GIS products do not meet this demand. Specifically, (1) most products do not offer out-of-the-box functionality to meet the needs of their users; (2) it is expensive to purchase and maintain; (3) it has a steep learning curve; (4) requires a specialist to manage the software; and (5) is often difficult to integrate with existing data, applications, and services, both in-house, and on the web (Anderson and Moreno-Sanchez 2003).

Open Source and Proprietary GIS

It is generally accepted that computer software takes a lot of time, research, and effort from numerous people to develop. Proprietary companies develop software, which becomes the companies’ intellectual property and asset. Therefore, to gain access
to the software, consumers must purchase it. Additionally, consumers typically pay for updates and customer service. As the source code for proprietary software is kept secret, it can only be developed by the company that has rights to the code. Therefore, updates, code rewrites, custom requests, and any other change to the source code can only be developed by one company. Open source is able to overcome this instability by relying on a large international network of developers that are able to download, change, modify, and re-release code to the world. This type of infrastructure allows for high customization and modifiability, as well as a seemingly limitless life-span (Raju, 2007).

In Donnelly’s (2009) article, the author explores the usefulness of proprietary versus open source GIS solutions for academic libraries. The author concedes that ESRI’s ArcGIS is a powerful program, and, due to its widespread use, should probably be the tool of choice for advanced analysis within the desktop GIS realm. However, the author does note that open source tools also have a place in the GIS world, by pointing to the low cost of entry, and basic functionality that they provide (Donnelly 2009). It is important to note that not every GIS application has to have an advanced set of tools, but can be built to suit the needs of the most novice user.

Open source GIS options allow for out-of-the-box solutions capable of matching, and in many cases, exceeding the effectiveness of proprietary commercial products, not only in terms of cost, but also in terms of processing, start-up speed, and learning curve (Ramsey 2002). Additionally, open source GIS adheres to an internationally adopted standard for interoperability, defined as

the ability for a system or components of a system to provide information portability and inter-application cooperative process control. In the context of the OGC specifications this means software components operating reciprocally
(working with each other) to overcome tedious batch conversion tasks, import/export obstacles, and distributed resource access barriers imposed by heterogeneous processing environments and heterogeneous data. (The Open Geospatial Consortium, 2012)

Hecht (2002) best summarizes the desire for geospatial data interoperability in the Internet era as the following:

1) It allows for communication between information providers and end users without requiring that both have the same geo-processing software.

2) No single GIS, mapping tool, or database answers every need.

3) There are large numbers of database records with a description of location that have the potential to become geospatial data, and also, advances in mobile technologies (e.g., with integrated GPS) are increasing the amount of crowd-sourced or volunteered geographic information for analytical use.

4) The number of software companies offering components to deal with geospatial data is growing.

5) It is more efficient to collect data once and maintain them in one place (cost effective to maintain in one place online, in the cloud, rather than maintaining individual redundant databases that can be subject to operator input error and thus become different from the original).

6) The ability to seamlessly combine accurate, up-to-date data from multiple sources (i.e., data mashups) opens new possibilities for improved decision making and makes data more valuable.
the ability for multiple users, including non-GIS experts, to use a particular set of data (perhaps at different levels with different permissions) also makes the data more valuable.

Open Source Promotion by Federal Government

In an April 2006 report by the Digital Connection Council of the Committee for Economic Development, the authors found the tragedy of the commons had a much different meaning when applied to technological advancements and data collection. The paper states that open source solutions and ideology promote collaboration and innovation, allowing all people the opportunity to volunteer their genius. On an ethical level, the Council believes that no government should choose only proprietary software, because it may be difficult for all potential users to gain access (Committee for Economic Development, 2006).

After his election in 2008, President Obama vowed to regain the trust of Americans and the rest of the world, by promising to “create a transparent and connected democracy,” (Obama 2007) and to create “an unprecedented level of openness in Government” (Obama 2009a). He also favored “the use [of] cutting edge technologies to . . . creat[e] a new level of transparency, accountability, and participation for American citizens” (Obama 2007). Additionally, he pushed the Open Government Directive, urging all independent agencies to comply, noting that “Government should not keep information confidential merely because public officials might be embarrassed by disclosure, because errors or failures might be revealed, or because of speculative or abstract fears” (Obama 2009b).
citizens will need tools to utilize and examine it. Additionally, they will need to be prepared to share their information in a standardized format.

Purpose of the Project

As a GIS Analyst at an environmental consulting firm that conducts environmental CEQA review processes the following scenario is not uncommon. For example, one of the firm’s environmental planners will request that I make a map or retrieve data for them. To assist in this process, I created a tool so that the non-technical/non-GIS user (the planner) could retrieve some of the simple geographic data requests that are required per the CEQA process. Using Appendix G as the indicator of data, this tool would provide insight into geographic data in a manner that is usable to a non-technical clientele. Whereas GIS can perform complex analyses and modeling, the majority of the work an environmental planner requires of a GIS analyst is the retrieval, compilation, conductance of a few simple data queries, and the creation of a map. The following is the typical set of questions these maps might try to answer:

- What environmental resources or hazards are on or near my project site?
- What is next to it?
- How far away from a certain occurrence of a resource or hazard (e.g. sensitive species, flooding hazard, etc.) is the project site?

Simple requests for maps and questions about data are very commonplace for a GIS analyst. However, many planners do not utilize GIS data because they have limited access to it. Typically, in order to utilize said data, they make requests to a certain staff member, provided they have staff that have been properly trained, have the appropriate
data or know where to find it, and have the right software. The process is jumbled if not broken, and as such can create bottlenecks in analysis and production for a GIS analyst every time a planner (potential user) requests a simple map or simple query of a GIS database for their work. The use of a GIS analyst for these tasks is a waste of technical capacity especially when they are working on more involved difficult tasks for which now they must put on hold to help the planner’s request. In private consultancy planning (and many times at public planning institutions), GIS is seldom used for complex modeling and spatial analysis, rather, it is utilized most often for simple queries and inventories, and for simple mapping for reports and meetings (Gocmen and Ventura, 2010).

While very powerful, ESRI’s ArcGIS is designed in anticipation of any kind of user, ranging from novice to professional. This means that the user has hundreds of different options, tools, and menus available. For many users, let alone newcomers, this situation can be a bit overwhelming and is a deterrent for potential limited users. For more intense GIS analysis and modeling, this level of sophisticated software is warranted, but most potential and current GIS users do not require this level of sophistication. I thought that the process to utilize GIS for simple requests should be much easier and accessible for all users.

Since the environmental planner must consider so many variables during their review of a proposed project, the process can be cumbersome. Managing data, maps, legal documents, and previous studies from myriad sources can be overwhelming. This project aims to consolidate and streamline a portion of the environmental review process by cataloging geospatial data from disparate sources, grouping and sorting according to a
standard (Appendix G), and publishing the information onto a simple web-based map built with free open source software, which would be easily replicable for any jurisdiction.

Scope of the Project

The purpose of this project is to create a web-based GIS application for environmental planners to use in CEQA review. Although mostly subjective, the planner can utilize geographic data for help in determination of existing conditions and potential impacts. Many planners or other potential users do not have the means or technical ability to access such data (Gocmen and Ventura, 2010), and their environmental determination may not be as thorough as it could possibly be. Also, while based on a model for environmental review, I believe this would still be a useful tool for many other industries, such as civil engineering, agricultural management, or transportation planning, in both the public and private sectors.

My project aims to streamline their workflow, enabling more data access and usability at a lower cost. This will not be a tool to make decisions for the planner, rather, it will be a tool for environmental assessment to help the planner make a “first pass” determination of the project site. Although some data may dictate a black or white scenario, the planner conducting the environmental review process must always acknowledge the gray area, and remain speculative in their determination of the impact.

For my project, a web-based GIS map using free and readily available open source software components, and publicly available geospatial datasets was created. Butte county was the study area, and includes layers specific to the county extent. The
majority of the data was provided by Butte County Development Services (planning office). Additionally, other data specific to the county, the region, and the state, was sourced, as provided by state (i.e., Cal Fish and Game, Cal Forestry and Fire Protection) and federal (i.e., U.S. Geological Survey, National Resources Conservation Service) level entities. The project is entitled CaliforniaOpenAtlas (COA), with this iteration called COA|Butte, as Butte county is its focus jurisdiction.

Since it is available online, it is available to anyone with an internet connection and a browser. It should not be viewed as a complete catalog of data for review. It should be used for planning purposes only. All data integrity will be the dependent upon the data protocol set forth by the publishing agent. This project acts as the conduit, a base map and common ground for many varied types of geospatial data.

Significance of the Project

Although the appropriate data exists, the problem is that everything sits disconnected. The data has not been gathered in a common place for this particular set of users, i.e. planners working with CEQA. Datasets sit without the resources to find them, extract them, visualize them, or query them. Planners are tasked with reviewing a wide range of considerations without proper support tools in place. The aim of the project is not to produce new tools and datasets, but rather to connect those tools and datasets in a way that has not been done before—a way that maximizes accessibility and efficiency for a planner to conduct CEQA environmental review.

Resources do exist that allow for similar data collaboration and usability, but lack in crucial areas which may restrict potential users. For example, ESRI’s ArcGIS
Online has a very usable platform, but users cannot alter the GUI or change the tools that are available as ESRI maintains a closed software platform. While ArcGIS Online can consume volunteered data, its Terms of Use states that it can maintain access to that data thereon, which could result in privacy issues. Also, the other big geospatial provider in Web 2.0, Google, maintains a similar data policy. Additionally, ESRI can alter the application without notice or repercussion, while COA is maintained and updated by the jurisdiction.

Open source tools are gradually gaining momentum in the GIS industry as they become more powerful, intuitive, and utilized. I believe that all users could benefit from access to the data that they frequently inquire about and that there are inexpensive and simple ways to allow for this to happen, which could greatly increase the efficiency and equity within the planning process.

Limitations of the Project

Some of the software and website creation took some programming skills. I consider myself an above-average computer user, as far as technical skills go, but I do not have any formal training in the programming and web-site development process. I depended on available resources online that supported the tools that I used, in the form of tutorials, videos, developer forums, chat, and existing sites utilizing the tools.

This iteration does not include information about incorporated cities in the county. This was chosen in an effort to keep the complexity of the project to a manageable level. Additionally, confidence in the data could be somewhat ensured since the providers of the datasets are government agencies, rather than unknown contributor,
as you might see in a Web 2.0 mashup utilizing crowdsourced data. Also, too many jurisdictions would detract from the overall usability of the map. A more appropriate approach would be to create a similar application with that particular jurisdiction as the focus. e.g. COA|Chico, or COA|Plumas.

Some datasets that are technically available to the public are not compiled into a usable or downloadable format. Others are restricted by terms of use agreements and cannot be publically published. Sourcing all the desired and required data was challenging. In addition, there is no protocol in place for replacing datasets as they become antiquated, or as new datasets are released by the publisher.

Definition of Terms

In general, **open source** refers to any program whose source code is made available for use or modification as users or other developers see fit. Open source software is usually developed as a public collaboration and made freely available.

The **Spatial Data Infrastructure (SDI)** is the word I will use to describe the software architecture, which is broken into three components: a back end **database**, a **server** to talk to the database, retrieve queries, and render geographic shapes and data, and an Internet-enabled browser-based **front end interface**, where the user will interact with a map, layer list, and small set of tools all within most internet browsers.

**PostgreSQL** is an open source database similar to Microsoft’s MySQL, or Oracle’s 10G. It utilizes the **PostGIS** extension to give spatial capabilities to the database. The PostGIS database can perform spatial queries as well as execute standard attribute queries.
The **Geoserver** map/feature server can provide standardized web access to underlying GIS data sources. It is a Java-based server allowing the user to access the database and output the contents.

The **GeoWebCache** tile server can intelligently store and serve map tiles using standard web protocols for requests and responses. This will significantly help load times.

The **GeoExt/ExtJS** interface framework includes standard UI components and also specific bindings for spatial features. It is a JavaScript library, containing many tools to enrich the user experience, allowing them to control map layers/styles, access data, and interact with the front end map application.

**OpenLayers** is a front end application that can consume maps from multiple sources, and provides tools for data editing and capture. It is an open source JavaScript application that is similar in functionality to Google Maps or Yahoo! Maps, but without licensing restrictions, allowing multiple data and data sources to overlay on one front end map interface.

**CEQA** is an acronym for the California Environmental Quality Act, which was a statute passed in 1970, shortly after the United States federal government passed the National Environmental Policy Act (**NEPA**). CEQA is used to institute a statewide policy of environmental protection. CEQA requires state and local agencies within California to follow a protocol of analysis and public disclosure of environmental impacts of proposed projects and mitigation measures. To assist in the initial study process, a checklist called **Appendix G** acts as a guideline of potential environmental impacts. It is a list of considerations representing 18 categories ranging from geological conditions, to
land use considerations, to environmental constraints, and other areas of assessment which could result in an adverse environmental impact from approval of a proposed project.
CHAPTER II

METHODOLOGY

Creating the Map Application

The project’s goal was to use a fully open-source spatial data infrastructure so that all the tools used would be freely available for any potential user who would want to create their own map application. My employer, NorthStar Engineering allowed use of a relatively unused Dell PowerEdge running Windows Server 2003. I was given permission to utilize the server. All software would be downloaded and installed to the machine. This is also where all the geospatial data would be stored. The server would also act as a webservice, hosting the final website.

Operating System

Ubuntu is an open source operating system, based on the Linux distribution. Linux is a popular open source operating system that is heavily used for server administration, and in a broad range of hardware and applications. Ubuntu provides a Linux desktop environment similar to the Apple operating system. Wubi is an application that allows for dual booting of either Windows or Linux. Wubi stands for Windows-based Ubuntu Installer, and provides an easy alternative to try out the Linux operating system without having to reformat the existing Windows-based computer. Download and installation instructions can be found here: http://www.ubuntu.com/desktop/get-ubuntu/windows-installer (accessed 11/20/2010).
It was my intention to use Ubuntu as my operating system to make this build fully open-source. However, I was restricted against removal of the existing Windows Server as instructed by the IT department at my workplace, as the server hosted other services (i.e. FTP server). As a proof of concept, I did install Ubuntu (via Wubi) on my Windows-based personal laptop. I then mirrored the eventual build of the Stack on that system. That was just an effort to ensure that a fully open-source stack was possible. It is important to note that open-source tools can be placed on top of a Windows operating system. However, the final project (COA|Butte) is served from the Windows Server 2003 Dell PowerEdge, as it is more appropriate for hosting and serving web data than a personal laptop.

Building the Spatial Data Infrastructure

Software Architecture Overview

Simply put, the architecture of Spatial Data Infrastructure (SDI) is made up of three levels - the database, the server, and front end (Figure 1). The database is where all the data is stored and indexed. The server connects to the database and serves the data in various formats. The front end is a web page made up of HTML, CSS, PHP, and JavaScript files that can read, parse, and display the various formats from the server. A more thorough explanation of each follows.

Spatial Database

PostgreSQL is a highly-functional and powerful open source object-relational database that has spatial query capabilities when coupled with the PostGIS extension. It can be run in both Linux and Windows environments successfully. Many highly popular
and trafficked websites such as Yahoo! and MySpace use PostgreSQL as their backend database. For this build, I installed the Windows version of PostgreSQL 9.0 (http://www.postgresql.org/download/). Installation was completed using default parameters except for the inclusion of the PostGIS 1.5 extension. The administration tools `psql` and `pgAdmin` were utilized to interact with PostgreSQL. Psql is a command line tool, while pgAdmin uses a GUI for interaction. Initially, geospatial data was
uploaded using psql, but over the course of my development, a new release of pgAdmin debuted a brand-new GUI for geospatial data upload. Both methods have their own benefits - bulk upload capability with command line but an easier more straightforward approach with the GUI.

**Server**

GeoServer is an open source software server that allows geospatial data to be shared and displayed. It can publish many major spatial data types because of its adherence to open standards for interoperability, as promoted by the OpenGeospatialConsortium. GeoServer can read a variety of data formats including PostGIS, as well as shapefiles, ArcSDE, MySQL, GeoTIFF, MrSID, and Oracle Spatial. From these data sources, GeoServer is able to output a variety of formats such as KML, shapefile, GeoRSS, pdf, JPEG, PNG, as well as providing the geographic web services such as WMS, WFS, and WFS-T.

**Front End**

For the front end, a lightweight application called GeoExplorer was utilized, written using Open Layers and GeoExt libraries. It was heavily modified to automatically include preselected layers, a handful of additional tools, a custom banner, and additional tabs for ‘Help’ and ‘About’. All code editing to the application’s HTML, PHP, CSS and JavaScript files was completed using a program called Notepad ++ (Figure 2), a extended text editor that color codes text and justifies text allowing for easier coding interpretation. The editing process entailed making a single change to the source code, saving, and then refreshing the webpage to view the results and ensure that the coding was done correctly.
Figure 2. Screen snapshot of the Notepad++ programming environment used for the project development.
Building on trial and error, the front end evolved to include elements that are not included in the stripped down out of the box version of GeoExplorer.

**Web Hosting Protocol**

An Internet domain was registered and created as www.californiaopenatlas.com (as well as caopenatlas.com and calopenatlas.com), as this project, and future iterations of it would presumably be based in California. Each iteration is based on the jurisdiction (i.e., County) that it is focused on. Therefore, www.californiaopenatlas.com/butte became the pilot County for this project.

Domain registration was completed through godaddy.com and all hosting duties fall on the aforementioned webserver at NorthStar Engineering. GeoServer comes bundled with a web serving protocol that directs all outgoing services through a particular port that is defined both at the GeoServer and the GoDaddy levels so that they can interact with one another. Domain registration for two years represented a fifteen dollar investment.

**Data Collection**

**Finding Appropriate Data**

During the initial study process, environmental planners refer to Appendix G (Appendix B) as a guide of potential impact considerations. Many of the categories in Appendix G refer to an associated geospatial dataset. For example, to determine if a proposed project sits near an earthquake fault, or in a floodzone, a planner will typically refer to the appropriate map. Therefore, geospatial data can be used to help reveal information for a large proportion of the considerations listed in Table 1.
Determining Datasets and Data Collection

I consulted a coworker, an experienced environmental planner and GIS user who is familiar with Appendix G and its proclivity towards geospatial data. Together, we went through Appendix G, noting what categories could be explored with geospatial data or maps. Using the information from our brainstorming session, I browsed potential layers that we had in our existing GIS database repository. For those categories where we did not have existing pertinent data, I found the appropriate agency responsible for the maintenance and publication of that data. Some of those agencies included: United States Fish and Wildlife Service, CalTrans, Natural Resources Conservation Service, Cal-Atlas (the California geospatial clearinghouse of data, run by the California Natural Resources Agency), Department of Water Resources, and Butte County Development Services.

Data was collected through a variety of means, as each Agency has a different protocol for cataloging, storing, maintaining, and disseminating its data. Over 70 datasets were acquired and kept in a data matrix spreadsheet (Table 1).

Data Preparation

In order to display and layer datasets together in the eventual web application, each dataset had to be re-projected to the World Geodetic System 1984 (WGS84) datum that is commonly used in Internet mapping applications, as it is useful for datasets that span the whole globe. At this point, the data was ready to be loaded into the SDI via PostgreSQL.

Data Organization

All the data was loaded into PostgreSQL, and linked to a GeoServer datastore. A datastore is the name of the protocol used by GeoServer to access the PostgreSQL
Table 1. Data matrix of data contained in the PostgreSQL database for Butte County.

<table>
<thead>
<tr>
<th>Category</th>
<th>Layer</th>
<th>Geographic Extent</th>
<th>Data Source</th>
</tr>
</thead>
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<tr>
<td>Administrative Boundaries and Districts</td>
<td>School Districts</td>
<td>Butte</td>
<td>Butte County Development Services</td>
</tr>
<tr>
<td></td>
<td>Parks &amp; Recreation Districts</td>
<td>Butte</td>
<td>Butte County Development Services</td>
</tr>
<tr>
<td></td>
<td>Mosquito Abatement Districts</td>
<td>Butte</td>
<td>Butte County Development Services</td>
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<tr>
<td></td>
<td>Supervisor Districts</td>
<td>Butte</td>
<td>Butte County Development Services</td>
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<td></td>
<td>Community Service Areas</td>
<td>Butte</td>
<td>Butte County Development Services</td>
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<tr>
<td></td>
<td>Census Community Areas</td>
<td>Butte</td>
<td>Butte County Development Services</td>
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<tr>
<td></td>
<td>City Limits</td>
<td>Butte</td>
<td>Butte County Development Services</td>
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<td>Private Water Districts</td>
<td>California</td>
<td>CASIL</td>
</tr>
<tr>
<td></td>
<td>Air Districts</td>
<td>California</td>
<td>CASIL</td>
</tr>
<tr>
<td></td>
<td>Air Basins</td>
<td>California</td>
<td>CASIL</td>
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<tr>
<td></td>
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<td>California</td>
<td>CASIL</td>
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<td>Agricultural Parcels and Addresses</td>
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<td>Butte</td>
<td>FMMP</td>
</tr>
<tr>
<td></td>
<td>Parcel boundaries</td>
<td>Butte</td>
<td>Butte County Development Services</td>
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<td>USA</td>
<td>USFWS</td>
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<td>Critical Habitat Areas</td>
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<td>USFWS</td>
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<tr>
<td></td>
<td>Wild and Scenic Rivers</td>
<td>California</td>
<td>CaSIL</td>
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<tr>
<td>Hazards and Geology</td>
<td>Floodzones</td>
<td>Butte</td>
<td>FEMA</td>
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<tr>
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<td>Soils</td>
<td>Butte</td>
<td>NRCS</td>
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<tr>
<td></td>
<td>Geology</td>
<td>California</td>
<td>USGS</td>
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<td></td>
<td>Fault lines</td>
<td>California</td>
<td>USGS</td>
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<td>California</td>
<td>CDF</td>
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<td></td>
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<td>California</td>
<td>USGS</td>
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<tr>
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<td>Airport Runways</td>
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<td></td>
<td>Fire Stations</td>
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<td></td>
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<td>Schools</td>
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<td>Butte</td>
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<td></td>
<td>25 ft. contour</td>
<td>Butte</td>
<td>USGS</td>
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<td>Deer Herd Management Overlay</td>
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<td></td>
<td>General Plan (2030 draft)</td>
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<td>Zoning</td>
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<tr>
<td></td>
<td>Lakes</td>
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<td>Butte County Development Services</td>
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<tr>
<td></td>
<td>Parks</td>
<td>Butte</td>
<td>Butte County Development Services</td>
</tr>
<tr>
<td></td>
<td>Railroads</td>
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<td>Butte County Development Services</td>
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<tr>
<td></td>
<td>Streets</td>
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<td>Butte County Development Services</td>
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<tr>
<td></td>
<td>Bridges (CalTrans jurisdiction)</td>
<td>California</td>
<td>CalTrans</td>
</tr>
<tr>
<td></td>
<td>Bridges (Local jurisdiction)</td>
<td>California</td>
<td>CalTrans</td>
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<td></td>
<td>Google Streets, Hybrid, Aerial</td>
<td>Global</td>
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<td></td>
<td>Bing Streets, Hybrid, Aerial</td>
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<tr>
<td></td>
<td>USGS Quad Maps (7.5', 15', 30')</td>
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<td>OpenStreetMap Streets</td>
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<td>NAIP 1 meter imagery</td>
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<td>ESRI street basemap</td>
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<td></td>
<td>Shaded relief</td>
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</tbody>
</table>

Abbreviations

- **CaSIL**: California Spatial Information Library
- **FMMP**: Farmland Mapping and Monitoring Program
- **USFWS**: US Fish and Wildlife Service
- **FEMA**: Federal Emergency Management Agency
- **USGS**: US Geological Survey
- **USDA**: United States Department of Agriculture
- **USFWS**: United States Fish and Wildlife Service
- **ESRI**: Environmental Systems Research Institute
database. At this stage, layers were named in a manner that adhered to a standard convention for all datasets, which consisted of the geographic extent of the data followed by a general name of the dataset (e.g., California - Vernal Pool Critical Habitat, or Butte - Parcels). This convention allowed the user to see at a glance the geographic extent and theme of the dataset.

Styling and Cartography

GeoServer uses the Styled Layer Description (SLD) file to define the styling properties and characteristics of each layer. SLD can be read and created by a text editor. However, as the SLD is concerned with cartographical elements such as color, line thickness, transparency, labeling rules, and other classification concepts, it is difficult to completely write all styling rules in a text editor. For quick edits, such as quickly changing a color value or doubling the thickness of a line, a text editor works just fine. But, when starting from scratch, a visual SLD creator/editor would be much more useful. Unfortunately, at this stage, GeoServer lacks a robust SLD editor. I employed the use of another open source geospatial project called uDig (User-friendly Desktop Internet GIS) that had a symbology editor with an SLD editor running alongside. I was able to create SLD text from a GUI and save the SLD text back into GeoServer. By this point, the system was at a point where all the required data was loaded into the database, connected to GeoServer, and styled appropriately. With the SDI in place, the application itself could be built.
Programming the Application

Creating a Splash Page

Since the application itself resided at .com/butte, I didn’t want users to get lost if they had just gone to .com. Therefore, I felt that a simple HTML page would serve as a “splash page” for the COA concept. I located a Creative Commons HTML template and began replacing the content to suit my needs. The page would provide a link to the project at .com/butte, and would contain other small pages, such as an About, Contact Us, and some useful links to some of the resources utilized during the application build. Along with some minor styling adjustments and some new graphics, there was now an initial web page whose main intent was to funnel potential users to COA|Butte (Figure 3).

Code Interpretation

The first step to build COA|Butte was to unpack and change the code from OpenGeo’s GeoExplorer application. GeoExplorer is like a very stripped down version of COA|Butte, and acts as the main foundation of the project. GeoExplorer, like most applications, is a complex file and folder network of various types of file formats ranging from PHP, CSS, JavaScript, and HTML. To understand what each file represented, and furthermore, what each line of the file represented, I opened up each document in Notepad++ and began looking for clues and patterns in the code. Perhaps this meant certain text that I saw on the working GeoExplorer front end or even words that related to some element on the page. The process of familiarization was arduous, but paid off with knowledge of the working of the application.
Writing the Code

The process of development was iterative with exploration of the default code, changing single elements of that code, saving it, and viewing the changes in the web browser. If the application developed an error or the result was not what was anticipated, the code alteration was reversed. Therefore, if something broke the application, the development process was such that one could always revert back quickly without having to guess any number of possible issues inhibiting the code. Through this process, a handful of pertinent files were edited to include some additional tools, graphics, and to preload my data layers, and auto-center on Butte County.
To add the preloaded layers, I had to specify which layers I would need. GeoServer spits out a Web Mapping Service (WMS) feed that is accessible through a URL. Simply put, through the WMS, the front end can specify which layers it would like to receive from GeoServer. The code was edited to include the specific WMS URL, proper credentials, and layer specifications. Additionally, I was able to specify groups that each layer would fit into. Initially, the plan was to duplicate the categories as shown in Appendix G. It was found more appropriate to categorize even more generically than Appendix G did (Table 1). This was because there are 17 categories in Appendix G with many layers potentially significant in multiple categories. For example, it would be redundant to place the soils data in ‘geology’ as well as ‘natural hazards’. Additionally, with so many categories, it would be possible for users to be overwhelmed by too many options, or potentially underwhelmed if a category had too few layers. Therefore, it was decided to have categories that were derivative of the Appendix G categorizing, rather than an exact copy.
CHAPTER III

RESULTS

The final product can be seen at http://www.californiaopenatlas.com/butte (Figure 4). The layout of the site consists of a large main map screen, a table of contents containing a checklist of the layers as shown in Table 1 (Figure 5). The horizontal toolbar running below the banner includes a dropdown menu of spatial bookmarks called “Quick Zooms” that automatically zoom to the extent of a handful of selected extents, including Chico, Durham, Oroville, Biggs, and the Paradise-Magalia corridor. Next to the “Quick Zooms” menu is the Assessor Parcel Number (APN) search. This tool allows for the user to enter a 12 digit APN and zoom directly to it, allowing the planner to zero in on their project parcel. The APN is a unique identifier of each parcel, furnished by each county assessor office (Figure 6).

Also, the toolbar includes the following tools: zoom in, zoom in, zoom to previous extent, pan map, identify, measure (area and length), enable Google Earth in browser, print map, link map, save map, and clear parcel selection (Figure 7). There are tabs across the top of the map window labeled “Interactive Map”, “Data Center”, “Help”, and “About.” By default, the map loads centered on Butte County with the county boundary layer and Google Streets basemap enabled. The user can interact with the map by expanding layer categories and checking layer boxes to overlay the data on the map.
Multiple data sets can be overlayed at a time. Data can be queried by selecting the “Identify” tool and clicking on a geographic shape on the map.

User Survey

During the initial stages of development, I received informal feedback from colleagues and classmates. Those anecdotes were used to influence the direction of the application development to follow. Among the chief discoveries from this feedback was the need for clarity and ease of use in the application. Additionally, this survey helped to guide the layer classifications, as it was at this stage that it was determined that there could be redundancy by using every category as seen in Appendix G. Also, since many of the survey participants had limited exposure to environmental policy, it was a reminder that this application had to be streamlined with reduced complexity to allow for the wider base of potential users.

More recently, as the site has become more developed, I have incurred additional feedback speaking towards the usability, understandability, and intention of the site. From these anecdotal accounts, COA|Butte is considered sufficient in both content and ease of use to assist in environmental review.

COA|Butte excels at what it was intended to do. It is built completely with free components, giving all public the opportunity to view GIS data that could assist in environmental review by including datasets that are commonly referenced during environmental review. Despite its learning curve it does achieve its stated goal, and could be expanded to include other jurisdictions.
Figure 4. CaliforniaOpenAtlas|Butte screenshot.
Figure 5. The map layer list available to a user.

Figure 6. Quick zooms of the spatial data and the APN search window.
Figure 7. Toolbar available to a user.
CHAPTER IV

CONCLUSIONS

California has been considered to have some of the most stringent environmental laws in place (Frederiksson and Millimet 2002). With an increasing regulatory presence in the development process, efficient and thorough compliance is of utmost importance. Environmental planners are tasked with the duty of calculating, analyzing, and predicting potential impacts with ever changing processes, litigation, and jurisdictional hurdles. Given the amount of variability inherent in the environmental review process, tools that can help planners sort, query, and filter pertinent variables could surely increase efficiency.

With COA|Butte, environmental planners are able to view geospatial data from a variety of agencies concerning a variety of review topics. By building the application with open source software, we are overcoming the hurdle of cost that is typically associated with a similar program driven by proprietary GIS software. By making the application web-based, we allow accessibility through the most modest of means, allowing jurisdictions with limited technological reach or access issues the opportunity to browse spatial data that is normally unavailable. By stripping many of the excessive tools capabilities found in typical web and desktop based GIS applications and leaving the most used tools, we allow even the most technologically challenged users the ability to do tasks typically beyond their means.
The other intention of this project write-up was produce a rubric for reproducible open source GIS web applications. As the COA template is already built via COA|Butte, this could be replicated in other jurisdictions. Unfortunately, I still feel that it would be difficult for someone with little technical capability to reproduce a variation of application. Despite efforts to be accessible, all this software requires a fair amount of potentially complex setup and patches, with multiple levels of trial and error. Surely there are people far more capable than I at programming, and for that audience, open source GIS is a field ripe with opportunity. It is a fact that this is a rapidly developing field with plenty of room to grow, not only in the planning sector, but in many other industries as well. It will still take someone with computer programming capabilities to fully utilize what these open source packages can do. However, I believe what I accomplished shows what can be done with having limited programming proficiency.

There is a disclaimer at the entrance to the site that you must ‘Accept’ in order to load the application that caveats the integrity of the data (as COA is not the author of the data). It also states that the site should be used for exploratory purposes only. This is done to avoid repercussions of decisions that may stem from data collected from COA|Butte. Additionally, this is in place as a reminder to be aware of where your data comes from, since people would still readily accept most things published on the site, because it is on a map, and people typically tend to unquestionably trust maps (Monmonier 1991).

By getting this data into a database and linked to GeoServer, it can be fed to any number of digital mediums, including other web maps and even mobile devices, joining the ever growing amount of geospatial data online. I have not set up a data update
protocol. As data becomes antiquated, it is important to replace it with the newest data. Having the latest and greatest data would be crucial to COA|Butte succeeding as a viable and reliable data source. In addition to the WMS feed that GeoServer provides, it also broadcasts a handful of other data formats, one such being KML - the Google Earth format. The KML format allows users to view the same datasets as found in COA|Butte in Google Earth, rather than the COA|Butte web application. Additionally, users could create their own collection of KML output files from GeoServer rather than the full suite of layers that comes preloaded in the web application.

Despite my efforts to streamline the process, I believe that the CEQA process is far too complex to fit all the variables and components into one map application. While this effort brought together a tremendous amount of disparate data, I believe its purpose is better suited for something with a much simpler request. The effort to include so much data can be overwhelming and potentially reduce use from potential users. COA|Butte, however, does succeed at proving the viability and usability of a streamlined web based open source GIS, all while cataloging disparate geospatial datasets into one accessible location.

This process also sheds light on the emerging capabilities of open source software and geographic information in the Web 2.0 era. The more that GIS tools can become accessible, the more they can be utilized by a wider professional audience that is not necessarily required to be technically trained in GIS-based tools and systems.
REFERENCES
REFERENCES


Dangermond, J. (2002). Web services and GIS. Geospatial Solutions 7:56.


Goodchild, Malcolm. 2007. *Citizens as sensors: The world of volunteered geography*. National Center for Geographic Information and Analysis, and Department of Geography, University of California, Santa Barbara, CA


APPENDIX A
This is the “Home” page and can be found at http://www.californiaopenatlas.com

This is the “About” page. It gives a brief summary about CaliforniaOpenAtlas and can be found at http://www.californiaopenatlas.com/about.html
This is the “Atlases” page. It links to COA|Butte, and will be the place where future COA atlases will be linked from. It can be found at http://www.californiaopenatlas.com/atlases.html

This is the “Contact Us” page. It contains contact information. It can be found at http://www.californiaopenatlas.com/contact.html
This is the CaliforniaOpenAtlas|Butte project page. This is what you see when you first load the page and accept the disclaimer to enter the site.

This is a tab within the COA|Butte site called the Data Center. It contains a data matrix of all the geographic data on the site, and what layer category it resides in.
This is the second half of the data matrix table, found under the data center tab in COA|Butte.

This is the COA|Butte help pace. It contains a video hosted on YouTube of a tutorial of some of the basic functions of the site.
This is the “About” page on COA|Butte. It contains some background information about the site, as well as some contact information.

This is a screenshot showing the Spatial Bookmarks dropdown list. It is a list of common points within Butte County that allow the user to quickly zoom into the point specified.
This is a screenshot showing how the parcel number search works. The parcel search box can be found in the upper right corner of the page.

This is a screenshot showing the result of the parcel search. The search will automatically place you in the vicinity of the parcel that was searched.
This is a screenshot showing how the “Measuring Tool” works. The “Measuring Tool” can be found along the top toolbar.

This is a screenshot showing how the “Identify” works. The “Identify” can be found along the top toolbar. This
This is a screenshot showing an example of a layer getting activated and overlaying across the screen. The layers can be found in the layer categories to the left of the screen.

This is a screenshot showing the 3D capabilities that are built into the site. The 3D viewing can be activated by clicking the Google Earth icon on the top toolbar.
This is a screenshot showing what different basemaps can be selected to display under the data. In this instance, we are looking at a collection of USGS topographic quadrangles.

This is a screenshot showing another basemap and another data layer.
CEQA APPENDIX G:
ENVIRONMENTAL CHECKLIST FORM

NOTE: The following is a sample form and may be tailored to satisfy individual agencies’ needs and project circumstances. It may be used to meet the requirements for an initial study when the criteria set forth in CEQA Guidelines have been met. Substantial evidence of potential impacts that are not listed on this form must also be considered. The sample questions in this form are intended to encourage thoughtful assessment of impacts, and do not necessarily represent thresholds of significance.

1. Project title: _______________________________________________________________________
2. Lead agency name and address: ________________________________________________________
3. Contact person and phone number:______________________________________________________
4. Project location: _____________________________________________________________________
5. Project sponsor's name and address: _____________________________________________________
8. Description of project: (Describe the whole action involved, including but not limited to later phases of the project, and any secondary, support, or off-site features necessary for its implementation. Attach additional sheets if necessary.) _____________________________________________________________
9. Surrounding land uses and setting: Briefly describe the project's surroundings: 
   __________________________________________________________________________________
10. Other public agencies whose approval is required (e.g., permits, financing approval, or participation agreement.) ____________________________________________________________________________

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:
The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Potentially Significant Impact" as indicated by the checklist on the following pages.

- [ ] Aesthetics
- [ ] Agriculture and Forestry Resources
- [ ] Air Quality
- [ ] Biological Resources
- [ ] Cultural Resources
- [ ] Geology /Soils
- [ ] Greenhouse Gas Emissions
- [ ] Hazards & Hazardous Materials
- [ ] Hydrology / Water Quality
- [ ] Land Use / Planning
- [ ] Mineral Resources
- [ ] Noise
- [ ] Population / Housing
- [ ] Public Services
- [ ] Recreation
- [ ] Transportation/Traffic
- [ ] Utilities / Service Systems
- [ ] Mandatory Findings of Significance

DETERMINATION: (To be completed by the Lead Agency)

On the basis of this initial evaluation:
I find that the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A MITIGATED NEGATIVE DECLARATION will be prepared.

I find that the proposed project MAY have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

I find that the proposed project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.

I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (a) have been analyzed adequately in an earlier EIR or NEGATIVE DECLARATION pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier EIR or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed upon the proposed project, nothing further is required.

EVALUATION OF ENVIRONMENTAL IMPACTS:

1) A brief explanation is required for all answers except "No Impact" answers that are adequately supported by the information sources a lead agency cites in the parentheses following each question. A "No Impact" answer is adequately supported if the referenced information sources show that the impact simply does not apply to projects like the one involved (e.g., the project falls outside a fault rupture zone). A "No Impact" answer should be explained where it is based on project-specific factors as well as general standards (e.g., the project will not expose sensitive receptors to pollutants, based on a project-specific screening analysis).

2) All answers must take account of the whole action involved, including off-site as well as on-site, cumulative as well as project-level, indirect as well as direct, and construction as well as operational impacts.

3) Once the lead agency has determined that a particular physical impact may occur, then the checklist answers must indicate whether the impact is potentially significant, less than significant with mitigation, or less than significant. "Potentially Significant Impact" is appropriate if there is substantial evidence that an effect may be significant. If there are one or more "Potentially Significant Impact" entries when the determination is made, an EIR is required.

4) "Negative Declaration: Less Than Significant With Mitigation Incorporated" applies where the incorporation of mitigation measures has reduced an effect from "Potentially Significant Impact" to a "Less Than Significant Impact." The lead agency must describe the mitigation measures, and briefly explain how they reduce the effect to a less than significant level (mitigation measures from "Earlier Analyses," as described in (5) below, may be cross-referenced).

5) Earlier analyses may be used where, pursuant to the tiering, program EIR, or other CEQA process, an effect has been adequately analyzed in an earlier EIR or negative declaration. Section 15063(c)(3)(D). In this case, a brief discussion should identify the following:
a) Earlier Analysis Used. Identify and state where they are available for review.

b) Impacts Adequately Addressed. Identify which effects from the above checklist were within the scope of and adequately analyzed in an earlier document pursuant to applicable legal standards, and state whether such effects were addressed by mitigation measures based on the earlier analysis.

c) Mitigation Measures. For effects that are "Less than Significant with Mitigation Measures Incorporated," describe the mitigation measures which were incorporated or refined from the earlier document and the extent to which they address site-specific conditions for the project.

6) Lead agencies are encouraged to incorporate into the checklist references to information sources for potential impacts (e.g., general plans, zoning ordinances). Reference to a previously prepared or outside document should, where appropriate, include a reference to the page or pages where the statement is substantiated.

7) Supporting Information Sources: A source list should be attached, and other sources used or individuals contacted should be cited in the discussion.

8) This is only a suggested form, and lead agencies are free to use different formats; however, lead agencies should normally address the questions from this checklist that are relevant to a project’s environmental effects in whatever format is selected.

9) The explanation of each issue should identify:

a) the significance criteria or threshold, if any, used to evaluate each question; and

b) the mitigation measure identified, if any, to reduce the impact to less than significance

SAMPLE QUESTION

Issues:

<table>
<thead>
<tr>
<th>Potentially Significant Impact</th>
<th>Less Than Significant with Mitigation Measures Incorporated</th>
<th>Less Than Significant Impact</th>
<th>No Impact</th>
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</thead>
</table>

I. AESTHETICS. Would the project:

a) Have a substantial adverse effect on a scenic vista?

b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?

c) Substantially degrade the existing visual character or quality of the site and its surroundings?

d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

II. AGRICULTURE AND FORESTRY RESOURCES. In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state’s
inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board. Would the project:
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?

b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?

c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g))?  

d) Result in the loss of forest land or conversion of forest land to non-forest use?

e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?

III. AIR QUALITY. Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:

a) Conflict with or obstruct implementation of the applicable air quality plan?

b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?

c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?

d) Expose sensitive receptors to substantial pollutant concentrations?

e) Create objectionable odors affecting a substantial number of people?

IV. BIOLOGICAL RESOURCES:
Would the project:

a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or
regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?

b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?

c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?

d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?

e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?

f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?
<table>
<thead>
<tr>
<th>V. CULTURAL RESOURCES. Would the project:</th>
<th>Less Than Significant Impact</th>
<th>Less Than Significant Impact</th>
<th>No Impact</th>
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<tbody>
<tr>
<td>a) Cause a substantial adverse change in the significance of a historical resource as defined in § 15064.5?</td>
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<td>b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to § 15064.5?</td>
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<tr>
<td>c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?</td>
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<td>d) Disturb any human remains, including those interred outside of formal cemeteries?</td>
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<th>VI. GEOLOGY AND SOILS. Would the project:</th>
<th>Less Than Significant Impact</th>
<th>Less Than Significant Impact</th>
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<td>a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:</td>
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<td>i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.</td>
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<td>ii) Strong seismic ground shaking?</td>
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<td>iii) Seismic-related ground failure, including liquefaction?</td>
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<td>iv) Landslides?</td>
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<tr>
<td>b) Result in substantial soil erosion or the loss of topsoil?</td>
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<td>c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?</td>
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d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?

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<th>Category</th>
<th>Potentially Significant Impact</th>
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e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

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VII. GREENHOUSE GAS EMISSIONS. Would the project:

a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

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<th>Category</th>
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b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?

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<th>Category</th>
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VIII. HAZARDS AND HAZARDOUS MATERIALS. Would the project:

a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?

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<th>Category</th>
<th>Potentially Significant Impact</th>
<th>Less Than Significant with Mitigation Incorporated</th>
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b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?

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<th>Category</th>
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c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?

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<th>Category</th>
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d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?

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<th>Category</th>
<th>Potentially Significant Impact</th>
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</table>
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?

f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?

g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?

h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?

IX. HYDROLOGY AND WATER QUALITY. Would the project:

a) Violate any water quality standards or waste discharge requirements?

b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?

c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?

- Potentially Significant Impact
- Less Than Significant with Mitigation Incorporated
- Less Than Significant Impact
- No Impact

e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?

- Potentially Significant Impact
- Less Than Significant with Mitigation Incorporated
- Less Than Significant Impact
- No Impact

g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?

- Potentially Significant Impact
- Less Than Significant with Mitigation Incorporated
- Less Than Significant Impact
- No Impact

h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?

- Potentially Significant Impact
- Less Than Significant with Mitigation Incorporated
- Less Than Significant Impact
- No Impact

i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?

- Potentially Significant Impact
- Less Than Significant with Mitigation Incorporated
- Less Than Significant Impact
- No Impact

j) Inundation by seiche, tsunami, or mudflow?

- Potentially Significant Impact
- Less Than Significant with Mitigation Incorporated
- Less Than Significant Impact
- No Impact

X. LAND USE AND PLANNING. Would the project:

a) Physically divide an established community?

- Potentially Significant Impact
- Less Than Significant with Mitigation Incorporated
- Less Than Significant Impact
- No Impact

b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?

XI. MINERAL RESOURCES. Would the project:

a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?

b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?

XII. NOISE -- Would the project result in:

a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?

b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?

c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?

d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?

e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?

f) For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?
XIII. POPULATION AND HOUSING. Would the project:

a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?

b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?

c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?

XIV. PUBLIC SERVICES.

a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services:

- Fire protection?
- Police protection?
- Schools?
- Parks?
- Other public facilities?

XV. RECREATION.

a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?

XVI. TRANSPORTATION/TRAFFIC. Would the project:

a) Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?

b) Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?

c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?

d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?

e) Result in inadequate emergency access?

f) Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?
XVII. UTILITIES AND SERVICE SYSTEMS.
Would the project:

a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board? □ □ □ □

b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects? □ □ □ □

c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects? □ □ □ □

d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed? □ □ □ □

e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project’s projected demand in addition to the provider’s existing commitments? □ □ □ □

f) Be served by a landfill with sufficient permitted capacity to accommodate the project’s solid waste disposal needs? □ □ □ □

g) Comply with federal, state, and local statutes and regulations related to solid waste? □ □ □ □

XVIII. MANDATORY FINDINGS OF SIGNIFICANCE.

a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory? □ □ □ □

b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)? □ □ □ □

c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly? □ □ □ □

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