Decision Support Systems for Water Management: Investigating Stakeholder Perceptions of System Use

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Decision Support Systems for Water Management: Investigating
Stakeholder Perceptions of System Use

by

Gabriella Balsam

A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science
School of Geosciences
College of Arts and Sciences
University of South Florida

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Date of Approval:
June 23, 2016

Keywords: Water Resources, Natural Resource Management, Water Quality

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Acknowledgements

This study was made possible by the generous participation of Water Atlas staff and stakeholders in both surveys and interviews. I would like to thank my major professor, Dr. Kamal Alsharif for the inspiration and direction on this study. I would also like to thank Dr. Shawn Landry for sharing his knowledge and making data collection possible. Furthermore, I would like to thank Dr. E. Christian Wells for his guidance on methodology and analysis.
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Abstract

Water resources are becoming increasingly important to protect, but doing so has proven challenging due to the complex nature of resource management. Many researchers have been trying to develop “usable science” to aid in this endeavor, and one method of this is the development of decision support systems. This has led to the employment of this method as a potential tool for decision makers, scientists, and the interested public to use; yet little literature is available on the success of their implementation. This study attempted to fill the gaps by gathering data through surveys and interviews from stakeholders who are part of institutions that fund the University of South Florida’s Water Atlas. The study found that the tool was used for both educational outreach and scientific research support. Decision making was mostly supported through the program’s use as a research tool. Stakeholders also expressed that conditions found in the literature to contribute to successful implementation were largely met through the Water Atlas development process and continued use.
Chapter 1. Introduction

The Earth’s water resources are a component in a finite closed system. Consequently, the rise of population will unavoidably result in per capita decreases of water availability. Additionally, growing economies also result in increased water consumption (Sullivan, 2010). Not only are populations limited by quantity of water resources, but are also affected by quality (Sullivan, 2010). A long history of water neglect has resulted in widespread pollution of this necessary resource, and pollution events continue to increase globally (Sullivan, 2010). Despite the growing importance of protecting water resources, effective management is difficult to achieve. First, water ecosystems are intrinsically complex. Complications are exacerbated when those ecosystems interact with evolving human activities. Second, as an environmental issue, management has to be worked around varied and regularly conflicting interests. As more of the general public becomes interested in environmental issues, there are even more concerns to address. Finally, information regarding water systems and their interactions with human systems is often fractured. Various stakeholders, policy-makers, and experts may hold pieces of information that prevent any one particular group from seeing the “big picture” (Giupponi and Sgobbi, 2013), which can prove exceptionally difficult when that picture includes technical, environmental, economic, legal, and cultural concerns (Zhang et al, 2014).

Consequently, it is imperative to develop tools that can synthesize various pieces of information to create a holistic understanding of water resources for resource managers,
One popular method employed to do this has been decision supports systems (DSS), a diverse collection of resources designed to aid in the management of complex problems by assisting in the comprehension of options and impacts (Eden, 2011; Pyke at al., 2007). As described in chapter 2, DSS can have expansive and varied definitions. Because DSS can be found in a variety of forms, from computer modeling programs to work processes, this study will follow the approach of authors such as Pyke et al. (2007) and take a comprehensive view of DSS, with terms such as decision support tools and resources being interchangeable.

The University of South Florida’s Water Atlas is one example of a DSS for water resources that aims to connect various stakeholders in order to inform about surface waters. Despite the popularity, little research has been conducted to assess implemented success of these systems.

The Water Atlas is a decision support tool created to fill the needs of local governments and other individual project sponsors through using technology that can link various stakeholders in water resource management. The program originally acted as a static website that presented information about the lakes in Hillsborough County, Florida, but has since expanded significantly. It currently acts as a dynamic water resource data warehouse, presenting comprehensive information through graphs, tables, maps and graphics. The intent of the site is to make the information accessible to both experts and laypersons so that citizens, scientists, professionals, and planners can make use of the data.

The program was created in 1997 by the University of South Florida, is managed by the USF Water Institute, and is funded through sponsoring organizations. These
include, but are not limited to, city, county, and regional government agencies, and amount to between $400,000 and $500,000 in total annual funding. These sponsorships have led to the creation of 11 separate atlases: Charlotte Harbor NEP Water Atlas, Florida Atlas of Lakes, Hillsborough County Water Atlas, Lake County Water Atlas, Manatee County Water Atlas, Orange County Water Atlas, Pinellas County Water Atlas, Polk County Water Atlas, Polk County Water Atlas, Sarasota County Water Atlas, Seminole County Water Atlas, and the Tampa Bay Estuary Atlas (Figure 1). As of April 2015, Hillsborough County has discontinued funding, choosing instead to create an independent website containing similar information (S. Landry, personal communication, Aug 17, 2015; “What is the Water Atlas?,” n.d.).

While the Water Atlas has no dedicated employees, several employees from the USF Water Institute contribute time to maintaining it. The Water Atlas is supported mainly by the director of the Water Institute, staff GIS manager, staff database developer, student database developer, two web application developers, and a staff content manager. The long-term development of the program is also guided by members of the Water Atlas Advisory Group, which includes individuals from the Water Institute as well as funding organizations (S. Landry, personal communication, Aug 17, 2015; “What is the Water Atlas?,” n.d.).
To create a new atlas, an initial agreement is developed to tailor it to the needs of a sponsor. This involves the selection of datasets, topics, and features that would be of special interest. Additionally, biennial or annual follow-on contracts allow for continued site maintenance, upgrades and content additions. Water Atlas faculty maintain regular communication with partners to address any concerns in addition to an annual partners meeting. This meeting brings together current and prospective partners for a discussion.
of site updates, progress briefing, plans for enhancement, and possible uses and marketing opportunities.

Water quality, hydrologic, and ecological data are gathered from federal and state agencies such as United States Geological Survey, the Florida Department of Environmental Protection, Florida Fish and Wildlife Research Institute and local water management districts. The data cover 7,700 water bodies from 36,000 sampling sites and over 300 sources (“What is the Water Atlas?,” n.d.). In addition to scientific data, the website also includes upcoming environmental events, ranging from technical workshops to leisure activities, relevant news stories, and educational materials.

The individual atlases are arranged by five sections: “Mapping,” “Analysis,” “Learn,” “Participate” and “About” (Figure 2). While content under each of these sections varies by editions, common features under the mapping section include an advanced mapping application, real-time data mapping, contour mapping, and rainfall estimates. The advanced mapping application is a GIS program powered by ESRI ArcGIS Server. Most atlases’ applications contain few layers aside from water bodies except for Sarasota County Water Atlas, which has a variety of layers including artificial reefs, storm surges, and environmentally sensitive lands. The real-time data mapping is a spatial presentation of monitoring station’s recently reported rainfall, water flow, water levels, water quality, and weather. Contour mapping visualizes several water quality criteria (e.g. nitrogen) on a monthly basis, allowing viewers to examine spatial distribution changes (Figure 3). Some of these features are repeated under the analysis section because they offer users the ability to download the data for their own analyses. This section also offers general data download, where users can select from a variety of
water quality, hydrology, meteorological, and real-time data. Metadata such as land use and impaired waters can also be downloaded for GIS use.

Figure 2. Example of Water Atlas Interface

Figure 3. Example of Contour Mapping Tool
The learn section contains a variety of educational pages that can include topics such as stormwater education, Tampa Bay restoration, and oysters depending on the focus of individual atlases. The section often contains reference documents from sponsoring institutions, and sometimes even picture galleries. Under participation, residents can find out about volunteer opportunities as well as report pollution. Finally, the about section includes funding organizations, partners, and information providers.

Little research has been focused on end-use of DSS that have been implemented. Instead, available articles largely focus on the development of software and prototypes. While many of the researchers who develop these prototypes declare it a successful tool for water resource management, the real test of success lies in how well it has been implemented and if it is having any impacts on water management. Thus, there is a gap present in the literature for the evaluation of DSS post-implementation, which according to available literature is one of the most crucial aspects of utilizing DSS. Failing to assess DSS that have been employed for real-world use could lead to resources unnecessarily being designated towards tools that may not be the best option because unsupported claims of usefulness are being perpetuated.

The purpose of the research is to acquire primary data through a study of employees from past and present funding organizations of USF’s Water Atlas. These data were used to evaluate why organizations choose to fund programs such as the Water Atlas and what the perceived uses and benefits are. The two research questions for this study are: in what ways and to what extent does the Water Atlas influence decision making and educational outreach? Do the implementation of the Water Atlas and user perceptions align with data from the literature regarding successful DSS use?
The working hypotheses for this research are: (1) The Water Atlas will influence public education efforts and decision-making through scientific support; (2) The Water Atlas and its development meet conditions indicated in the literature as important to successful implementation.
Chapter 2. Literature Review

2.1 DSS: An Overview

The USF Water Atlas can be regarded as a decision support system, a tool that has been applied to water resource management for decades, but whether or not it has had significant positive impacts is still debated. Despite a widespread embrace, characterizing exactly what a decision support system is proves challenging, as the definitions provided in literature are often broad and vary from author to author. Adding to that complexity is the interchangeability of terms used to describe these tools, including decision support tools and resources (Freeling, 1984; Gamble et al., 2004; Pyke, 2007). Generally, the systems employ human intelligence and experience with computer-based support (Zhang et al, 2014), though it is argued that DSS can take many forms such as documents and work processes (Brewer and Stern, 2005; Pyke, 2007).

As the name implies, decision support systems (DSS) were developed in the early 1970s to support decision making when solving complicated problems in order to improve the efficiency and effectiveness of those decisions (Shim et al, 2002). When used in a field such as water resource management, they are also meant to improve the scientific soundness of a decision (Giupponi & Sgobbi, 2013). Specifically, DSS was designed to provide support for problems that had both structured and unstructured components through the use of data and models. A computer system could then be
developed to solve the structured portion, while a person would act as a decision maker for the unstructured portion (Sprague and Carlson, 1982; Zhang et al, 2014). DSS can be used to aid analyses of current conditions or model predictions for future circumstances. In some cases, decision support tools combine both (Gourbesville, 2008; Junier and Mostert, 2014). In addition to supporting problem-solving, DSS have been noted to store data or models, encourage education, bolster discussion, foster participatory processes and support institutional capacity building (Bots et al., 2011; De Kok et al., 2009; Horlitz, 2001; Junier and Mostert, 2014; Welp, 2001).

Some authors suggest that there are three components integral to DSS, while others make a case for five components. In the case of three components, a DSS is comprised of three interactive features: a database management system, a model-based management system, and the user interface (Sprague and Carlson, 1982; Zhang et al, 2014). Some authors also include a knowledge engine and users in addition to the previously mentioned components as part of the general DSS architecture (Marakas, 1999; Zhang et al, 2014).

The technology emerged out of theoretical studies in organizational decision making at Carnegie Institute of Technology and the technical work done at MIT, and has since expanded significantly (Keen & Morton, 1978; Shim et al, 2002). Some of the most profound changes have been catalyzed by the arrival of the World Wide Web in 1990. Widespread use of the Internet and its ability to disperse information quickly has allowed for new applications of DSS that are easier to use and understand. Managers, staff, and stakeholders can use the same system despite being geographically scattered, and vendors can rapidly innovate and sell increasingly sophisticated DSS
technology (Shim et al 2002). Systems such as the Water Atlas are now capable of being hosted on websites that the public can access easily.

2.2 DSS in Water Resource Management

Since the early years of DSS development, these systems have been applied to problems associated with environmental decision making, including water resource management. Traditionally, the systems used for water resources had limited decision-making capacity and could only be understood by technically trained individuals. DSS were usually designed for very specific purposes such as reservoir and infrastructure operations as well as testing engineering designs. According to Serrat-Capdevila (2011) they utilized visualization tools like GIS, tools to indicate varying costs and effects of construction alternatives, tables and models that demonstrate actions to execute given alternate sets of constraints, and simulations to demonstrate effects of varying policies and management choices.

In addition, water resource DSS were historically focused on cost-benefit or other quantitative analysis, and planning was largely focused on the computer model to be used. To illustrate, at an international workshop on DSS for water resource management and research held in 1990, most of the workshop’s articles discussed software design and visualizations of the systems (Serrat-Capdevila, 2011). Only a small portion of the articles examined communication with end-users, and an even smaller number considered stakeholder communication. Models were created with little to no stakeholder input. Engineers and other technical experts thus developed DSS that could support the work of policy makers, planners, etc., but did not address the constraints these decision makers face in the planning process. As a consequence of
this oversight, decisions have customarily been difficult to implement, causing low model usefulness and low project success (Serrat-Capdevila, 2011; Van Delden et al., 2011). Since the abovementioned workshop, progress has been made to approach water management in a more interdisciplinary manner, which has been echoed in the creation of holistic DSS (Serrat-Capdevila, 2011).

In water resource management, DSSs have been widely accepted for several reasons. In a more general sense, the notion that government funding should be spent on science that bolsters public decision making, as opposed to funding independent and self-guided research, has been gaining popularity. There is a pressure to produce “usable science,” and one of that ways this has been attempted is through DSS (Eden, 2011). The dynamic and interactive nature of the technology can potentially streamline the complex work of water resource managers (Fernandes et al., 2014). Water resource management, as with most natural resource management, can be a difficult undertaking because of the challenges in the decision-making process. Some of the reasons authors (Brewer and Stern, 2005; Eden, 2011; Junier and Mostert, 2014; Pyke et al., 2007; Zhang et al, 2014) have discussed for water resource management difficulties include:

1) Disjointed knowledge: water resource management often requires considering knowledge from a variety of scientific disciplines, such as engineering, biology, geology and chemistry, which do not always lend to a holistic view of water systems; additionally, some processes—e.g. human/environment interactions—may not be fully understood; this often
discontinuous scientific understanding must then be effectively translated to policy.

2) Structural intricacies: management involves multiple decision makers and stakeholders operating on various scales with the possibility of being situated in multiple economic, political and natural realities

3) Busy schedules: many decision makers are often overextended in their duties.

4) Conflicting interests: managers must also juggle the demands from competing needs, such as irrigation, industry, public water supply, and the environment.

5) Time constraints: decisions often have to be made at a relatively faster pace than scientific consensus can be reached.

6) Significant consequences: implications for water management can have profound and long lasting repercussions on the environment and society.

DSS are seen as possible tools to aid this complexity, particularly by filling the knowledge gap between researchers, policy makers, and—in cases such as the Water Atlas—the public, and doing so in an efficient manner (Brewer and Stern, 2005). It is important to note that these same reasons are also why developing a useful and valued system proves challenging. Furthermore, these challenges make it difficult to evaluate the effects of implemented systems (Brewer and Stern, 2005). Another catalyst for increased DSS use is that the need for reliable water resource support is becoming timelier. DSS can be used to address the increasing problems of pollution events and strains on water supplies due to rising population and urbanization (Zhang et al, 2014). Because of this, DSS have been implemented globally to solve a range of water management issues.
Examples of DSS’s far-reaching nature can be found in the Aegean islands and Jordan Valley, where systems have been used to address water scarcity conflicts by optimizing resources (Fernandes et al., 2014; Hussein, 2005), while in Greece it has been invoked to simulate heavy rainfall in order to find a solution for frequent flooding (Fernandes et al., 2014). DSS has also been used to manage water quality in the Songhua River Basin in China and the Dublin Bay in Ireland (Zhang et al., 2010; Regan et al., 2013). In Uganda, DSS has been employed in water resources in order to increase synergy within a decentralized management system (Kizito et al., 2009). Additionally, DSS can be created to help scientists and managers plan for the future of particular water resources. Examples include a prototype to model climate change scenarios in the Tiber River Basin in Italy (Pierleoni et al., 2014) and another to assess sustainability of water distribution systems (Aydin et al., 2015). Sometimes multiple problems can be addressed with one DSS. In Vietnam, a system has been created to address issues of water distribution as well as water quality in a country that faces rapid population growth despite inadequate infrastructure (Jolk et al, 2010).

The use of DSS in water resources varies widely, but certain trends in these systems do emerge. Zhang et al. (2014) discussed several common features. One critical aspect of a DSS is modeling capabilities. In water resources, classical mathematical models such as contaminant fate and transport models, optimization models, and risk-based models are typically employed. GIS is also almost always integrated in water resource DSS in order to visually represent the spatial information affiliated with water systems. Employing GIS therefore allows for better storing, displaying, and manipulating these data, which is essential for decision making.
regarding the water systems. Multi-criteria analysis techniques can also be important in DSS for water resources because they allow for a multitude of varying situations, which is often the case in water management. Despite widespread embracing of the tools and effort to create more comprehensive plans, it still appears that some of the same problems remain (Eden, 2011; Giupponi and Sgobbi, 2013).

2.3 Implementation, Success, and Stakeholder Feedback

Analysis of the application of developed DSS proves challenging with the current availability of scientific literature and journals. These are generally limited to discussing methods and prototypes of DSS without examining their end-use, implementation, and efficacy (Giupponi and Sgobbi, 2013; Pyke et al., 2007). The consequences of this article availability are that there is little knowledge of what systems work and under what conditions they work in. It is possible that this knowledge gap leads to a perpetuation of beliefs about tool effectiveness and a continuous cycle of developers making the same mistakes (Eden, 2011).

Sources that are available note that DSS seem to be used very little outside of the research community, even if they are free and easily accessible. Policy and other decision makers typically do not utilize modeling tools that have been developed. The reasons for this include 1) policy makers often have busy schedules and will not use tools they are unfamiliar with and/or are not easy to use; 2) they do not know how the program was developed; 3) they do not know how the design will help them make better decisions; 4) they feel there is a lack of transparency; 5) they do not believe DSS addresses their needs and concerns; 6) their input was not solicited or assimilated into the system’s design; and 7) the technology has not been framed in the policy-maker’s
decision management practices (Giupponi and Sgobbi, 2013; Serrat-Capdevila, 2011; Junier and Mostert, 2014). It is suggested by Van Delden et al. (2011) that poor use can be contributed to a remaining emphasis on technical capacities, while actual planning frameworks remain relatively ignored. A mutual misunderstanding between technical developers typically within the research community and water managers remain. For greater success, developers need to improve upon current decision-making practices instead of supplanting them (Borowski and Hare, 2005; Van Delden et al., 2011).

Several authors discuss important elements for realization that often overlap and support each other, as well as reaffirm the barriers previously listed. Junier and Mostert (2014) suggest that there are three integral components of successful implementation: tool usefulness, including appropriateness for intended purpose and ease of use; accurate replication of reality (the knowledge base); and the availability of data that can be processed. The most discussed way to ensure tool usefulness and overall successful implementation is early stakeholder involvement in the development process, including discussion of how models will be used (e.g. Bots et al., 2011; Jakeman et al., 2006; McIntosh et al., 2011). Doing so can address many of the problems listed previously that prevent system use, such as establishing transparency and understanding. Less discussed is that there should also be a continued collaborative process between developers and stakeholders. McIntosh et al., (2011) add that a permanent and clearly organized point of contact for maintaining communications should be established to address unforeseen issues post-implementation.

To further reduce risks of system rejection, developers should provide solid scientific support with accurate, plentiful, and high quality data that can be displayed
spatially (Borowski and Hare, 2005; McNie, 2007). Borowski and Hare (2005) add that end-users prefer simple DSS over all-encompassing tools that aid in the decision-making process but do not provide an actual response. McIntosh (2011) echoed the need for simplicity, noting that users can become overwhelmed when too much context is provided. It was added that users should have expertise in the material of the DSS in order to appropriately use the system (Junier and Mostert, 2014). Real-world applications are also provided to expand on contributions and barriers to success that may have not been discussed in articles covering general environmental or water resource DSS use.

Notable learning lessons for project success can be found in a study of DSS in Africa. Field experts were contacted through telephone interviews and questionnaires to analyze experiences in DSS used for water resource management. A developer of the Nile River Decision Support Tool (Nile River DST), a project that had little impact, cited a lack of data as the primary shortcoming (Giupponi and Sgobbi, 2013). Furthermore, data accessibility and software and computer skills were also problematic, highlighting a need for user-friendly technology (Giupponi and Sgobbi, 2013). Another system, the Nile Basin DSS, was also developed closely after the Nile River DST. It is possible that this similar DSS led to decreased use of the first. Like the Nile River DST, the second program also faced similar data shortage issues, as well as uncertainty of continued financial and institutional backing (Giupponi and Sgobbi, 2013). Lack of data was a continued trend in DSS implemented for the Volta River Basin in West Africa and rainwater harvesting in South Africa. Successes in the Nile Region and West Africa were attributed to early end-user and stakeholder involvement and acceptance, while
the strengths of South Africa’s DSS were that it was GIS-based and customizable (Giupponi and Sgobbi, 2013).

Examples of more successful implementation of DSS due to stakeholder, end-user and public involvement can be found in New Mexico and Arizona (Passell et al., 2003; Serrat-Capdevila, 2011). In the former state, stakeholders from the Middle Rio Grande region volunteered to form the Middle Rio Grande Water Assembly (MRGWA) to work on the area’s water planning. After consulting with the public on possible management scenarios, they were entered into the Middle Rio Grande DSS model for quantitative comparison. Several scenarios were then selected and combined into a preferred management plan in partnership with the Middle Rio Grande Council of Governments (MRGCOG), a group of representatives from the local governments that would enforce the final plan in three counties (Passell et al., 2003; Serrat-Capdevila, 2011).

In Arizona, another group of stakeholders formed the Upper San Pedro Partnership (USPP) to address management challenges in the Upper San Pedro basin (Serrat-Capdevila, 2009; Serrat-Capdevila, 2011). The partnership consisted of three committees representing the decision-making body, the financers, and the technical and scientific team. The DSS was developed through monthly open meetings that the public could also participate in, and it featured updates by the technical committee for collaboration with the decision makers. This framework encouraged greater understanding for all participants. Decision makers gained an awareness of natural systems, while scientists acquired a more accurate perception of drivers and constraints of policy making. Though the USPP, like the MRGWA, did not have any regulatory
powers, it did have the ability to offer recommendations. One such policy created because of the DSS process’s influence was a limit on development density near the San Pedro River (Serrat-Capdevila, 2009; Serrat-Capdevila, 2011).

Success due to stakeholder involvement was echoed in the learning lessons from a case study of the Science and Technology Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) (Eden, 2011). Eden (2011) expanded on stakeholder involvement by also stressing the importance of developing an “end-to-end network” of nestled and networked projects in multiple organizations for the quick diffusion of research results to application. A network allows for projects to contribute ideas, draw on expertise, and learn from mistakes (Eden, 2011), which may have led to greater success in the implementation of DSS in Africa (Giupponi and Sgobbi, 2013). Additionally, research can take place independent of direct stakeholder involvement, but still impact decision tools that are consulted for decision-making. Finally, success can be more likely achieved by leaving room for adaptive learning. In the case of SAHRA, adaptive learning allowed for improving stakeholder involvement and information dissemination (Eden, 2011).

These three case studies indicate that DSS has the potential to help water managers choose scientifically sound plans for a variety of water resource issues; however, relatively few sources that attempted to discuss specific project successes in real-world application were found. From the available literature of specific project implementation, as opposed to generalized findings, it appears that projects tend to be most successful when there is easily accessible data to use and comprehensive simulation of basin behavior with simplified representations of its components. Projects
should also be developed with collaboration between scientists and stakeholders in a way that leads to mutual learning and agreement on a conceptual model, as well as collaboration and communication between multiple organizations. A comprehensive list of factors that the literature indicated have contributed to or hindered implementation success can be found in Table 1.

**Table 1. Contributing Conditions to Implementation Success**

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Difficulties</th>
</tr>
</thead>
<tbody>
<tr>
<td>appropriate for needs</td>
<td>stakeholders believe it addresses needs and concerns</td>
</tr>
<tr>
<td>accurate replication of reality</td>
<td>emphasis on technical capacities</td>
</tr>
<tr>
<td>satisfactory amount of reliable data</td>
<td>unfamiliar/difficult tools</td>
</tr>
<tr>
<td>spatial display of data</td>
<td>all-encompassing, overwhelming tools</td>
</tr>
<tr>
<td>early stakeholder involvement</td>
<td>lack of transparency</td>
</tr>
<tr>
<td>continued communication between developers and users</td>
<td>stakeholder input not solicited/included</td>
</tr>
<tr>
<td>tools do not provide actual decision</td>
<td>data shortage</td>
</tr>
<tr>
<td>user expertise</td>
<td>lack of software and computer skills</td>
</tr>
<tr>
<td>customizable</td>
<td>uncertain financial and/or institutional backing</td>
</tr>
<tr>
<td>cooperative learning</td>
<td></td>
</tr>
<tr>
<td>nested organizations</td>
<td></td>
</tr>
</tbody>
</table>
Overall, a review of the literature indicates that DSSs have been applied to a wide variety of water resource concerns, and likewise have a wide variety of intended end-use. A commonality among the varied DSS that exist seems to be a lack of evaluation post-implementation. My research attempts to fill this gap in literature by examining stakeholder perceptions of why stakeholders chose to use tools such as the Water Atlas, and if they feel it has had positive impacts.
Chapter 3. Methodology

3.1 Sample

The overall sample in this research included stakeholders that are individuals who are employed at organizations that fund the Water Atlas and Water Institute staff that contribute to the management of the Water Atlas. The sample initially only consisted of the former group for the survey portion of data collection, but was then expanded to Water Institute staff to gain more insight into the development and communication regarding the program.

The sample that was surveyed represent stakeholders that contribute funding to the Water Atlas (Table 2). The goal was to speak to informants that would be representative of the multiple distinct atlases within the program. All of the potential informants were Water Institute contacts, and have communicated with Water Institute staff regarding the atlases prior to this study. This sample group was selected because these individuals are involved with the implementation and everyday use of the program, and could thus provide feedback regarding these topics.
Table 2. Funding institutions by atlas.

<table>
<thead>
<tr>
<th>Atlas</th>
<th>Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charlotte Harbor</td>
<td>• Charlotte Harbor National Estuary Program</td>
</tr>
<tr>
<td></td>
<td>• Southwest Florida Water Management District</td>
</tr>
<tr>
<td>Florida Atlas of Lakes</td>
<td>• Florida Lake Management Society</td>
</tr>
<tr>
<td></td>
<td>• Florida LAKEWATCH</td>
</tr>
<tr>
<td>Hillsborough County (discontinued)</td>
<td>• Hillsborough County</td>
</tr>
<tr>
<td>Lake County</td>
<td>• Lake County Water Authority</td>
</tr>
<tr>
<td>Manatee County</td>
<td>• Manatee County</td>
</tr>
<tr>
<td></td>
<td>• City of Bradenton Beach</td>
</tr>
<tr>
<td></td>
<td>• City of Holmes Beach</td>
</tr>
<tr>
<td>Orange County</td>
<td>• Orange County Florida</td>
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<td>• City of Orlando</td>
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<tr>
<td>Pinellas County</td>
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<td>Polk County</td>
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<td></td>
<td>• City of Lakeland</td>
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<td></td>
<td>• City of Winter Haven</td>
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<td>Sarasota County</td>
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<td>• New College of Florida</td>
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<td>Seminole County</td>
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<td>• City of Altamonte Springs</td>
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<td>• City of Sanford</td>
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<td>• City of Winter Springs</td>
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<td>• Florida Department of Transportation</td>
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<tr>
<td>Tampa Bay</td>
<td>• Pinellas County</td>
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<td></td>
<td>• Manatee County</td>
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<td></td>
<td>• Tampa Bay Estuary Program</td>
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</tbody>
</table>
Additionally, the sample was broadened for the interview portion of the data collection to include staff of the Water Institute that are directly involved with the Water Atlas. Because the literature review indicated that communication between stakeholders and program developers was an important key to successful implementation, interviews further investigated this communication with both parties. Including Water Institute staff also provided greater insight into the initial development and continued development of the Water Atlas, as well as any factors for that are hindrances or strengths to implementation that may not be apparent to stakeholders.

3.2 Data Acquisition

Data for this project were collected in two phases: online survey administration and follow-up telephone interviews. The survey gathered data regarding general background information, system use and perceptions. This information was used to analyze general trends, and also serve as a gauge for interview questions.

3.2.1 Survey Administration

In order to assess stakeholder perceptions, surveys were used to investigate why Water Atlas and similar tools are invested in, perceptions of the system and the information it provides, and frequency of use. Data were gathered through Qualtrics.com (Appendix A). The survey was designed to maintain the anonymity of the participating informants. Committee members reviewed the questions used in the surveys prior to distribution in order to ensure appropriateness, comprehensiveness, and clarity. The questions were also submitted to Institutional Review Board (IRB) through USF’s Human Resource Protection Program (HRPP) to make certain that they do not violate the rights, safety, and welfare of participating informants (Appendix C).
Prior to beginning the survey, all potential participants were given an informed consent document that outlined the purpose of the study, the minimal risks involved, and the ability to withdrawal from the survey at any time (Appendix B). These measures ensured that those who completed the survey participated completely voluntarily, thus providing data free of information gathered through coercion. Selecting “continue” on the first question of the survey indicated that they had read and agreed to the document. The Director of the USF Water Institute provided each potential participant with a link to the survey via email on January 14, 2016. The informed consent document was attached in this email as well. The targeted participants were Water Institute contacts for each individual atlas. Out of 22 potential informants contacted, 13 submitted surveys. One survey was unable to be used in analysis because the participant had given consent by selecting “continue.”

The decision to end data collection was based on the small sample size and recruitment measures required to maintain the anonymity of informants. Because the group of individuals that serve as stakeholders in communication with Water Atlas staff or Water Atlas staff themselves is a small, limited number, additional informants could not be sought out. In order to remain in compliance with HRPP protocols, the investigator also could not initiate contact with the original participant set. Data collection ended when survey completion by informants ceased.

3.2.2 Survey Development and Study Measures

The method of data collection in this project had to allow for the understanding of the stakeholders’ behavior, beliefs, and conditions in order to answer the research questions. Because this research was being conducted by a single individual, surveys
were selected as the first method of data collection in order to quickly gather accurate data from stakeholders that represent multiple organizations located across central Florida. An online survey made it fast and easy to gather responses from multiple informants regardless of geographic location.

The survey topics largely focus on attitudes and behaviors. Questions were designed while keeping the three components of attitudes in mind: knowledge, feeling, and action (Alreck and Settle, 2004). Because people base their opinions and actions on what they know (Alreck and Settle, 2004), establishing the informants' knowledge and experience with water resource management and the Water Atlas was a component of survey development. The effects that knowledge has on feelings and actions regarding the system are analyzed. Since the purpose of this research was to investigate perceptions and uses of the Water Atlas, the feeling and action components were also included in the survey. Questions regarding feeling needed to be presented in a way that could capture both the position of the opinion (i.e. positive or negative) as well as the intensity levels of these feelings (Alreck and Settle, 2004). It was determined that Likert-type questions would be an appropriate way to address this. Addressing the action component usually includes inquiring about actions informants have taken in the past regarding the topic, current practices, and how they intend to act in the future (Alreck and Settle, 2004). The survey employed in this project focuses on the present, asking about how often informants’ access the site and what areas they are accessing.

The third component of attitudes, action, is similar to the second topic of behavior. Thus, some of the questions addressing attitude can also address behavior. This is important to include because the survey is meant to elicit not only what stakeholders
perceive of the system, but also how they are implementing the system within their organization. Questions were designed to address the four concepts of behavior measurement: what informants do, where they do it, when they do it, and how often they do it (Alreck and Settle, 2004).

3.2.3 Survey Questions and Coding

The survey is composed of free-response, multiple-choice, and Likert-type questions to gather categorical, ordinal, and ratio scale data. Questions on demographics included age, sex, residential zip code, and educational background. These were assessed as individual variables during analysis.

Open-ended questions were included to gather data on the professional background and current workplace of the respondent, particularly as it relates to the Water Atlas. This includes how long they have worked in water resources at their current organization and with the Water Atlas. It also includes how many of their coworkers use the Water Atlas. Data provided by answers to these questions were used to examine if various levels of experience, implementation time of the Water Atlas (i.e. before or after an informant began working there), and coworkers that use the system correlate with perceived effectiveness and frequency of use.

Multiple-choice questions served to categorize the role of the informant and the role of the Water Atlas within the organization. Four categories were provided to describe the role of the informant within the organization: division/organization management, project management, scientific/technical, and public outreach/education. Three categories were given to describe the purpose for funding the program and its actual use. These were education/outreach support, management support, and
technical/scientific support. Because these questions were designed to elicit primary roles, not all of the roles, the multiple-choice questions were single-response. Additionally, there was an option to type in a free-response if the informant felt that these categories did not best describe the roles.

Finally, Likert-type questions were created based on conditions found from the literature review that are linked to successful DSS implementation (e.g. early stakeholder involvement and transparency). Additional questions were added to this section to determine the level of influence DSS has in decision making and public outreach to establish not only the overall use of the system, but also the extent to which it is used.

3.2.4 Interview Administration

Stakeholder perceptions were further elicited through one-on-one interviews. After basic data regarding system uses and perceptions were gathered through surveys, interviews were employed to gather more specific information on the development and use of the Atlas. Interviews with those representing funding organizations focused on the work done at informants’ organizations and the role of the Water Atlas within that framework. They were also used to collect more detailed information on the benefits and drawbacks of the Atlas. Interviews with those representing the Water Institute focused on the development, upkeep and evolution of the Atlas. Data were collected over the phone, and recorded with the NoNotes.com Call Recording app after consent
was given. The interview guide was designed to maintain the anonymity of the participating informants.

Before moving forward, the IRB had to approve the additional interviews, making the study expedited instead of exempt (Appendix D). Once again, the Water Atlas director contacted each potential participant with via email on March 21st, 2016, with an IRB approved recruitment message (Appendix E). The email included instructions that those choosing to participate should contact the principal investigator at a provided email address. The targeted participants were Water Institute contacts for each individual atlas, both currently funded and previously funded, as well as relevant staff within the Water Institute. Once contact with the investigator had been initiated by informants via email, a time and date were selected for a one-time telephone interview that would last approximately 20 minutes. Prior to beginning the interview, all potential participants were read a verbal consent document that outlined the purpose of the study, the minimal risks involved, the knowledge that they would be recorded and the ability to withdrawal from the interview at any time (Appendix F). As with the survey, these measures again ensured that those who participated in the interviews did so completely voluntarily, thus providing data free of information gathered through coercion. Once informants verbally agreed to participate, the interview commenced.

For the interview portion of data collection, four current users and two past users emailed the investigator for participation. Additionally, three Water Institute staff members contributing to the Water Atlas were interviewed, making a total of nine informants. The decision to stop data collection was based on the small sample size and recruitment measures required to maintain the anonymity of informants. Because
the group of individuals that serve as stakeholders in communication with Water Atlas staff or Water Atlas staff themselves is a small, limited number, additional informants could not be sought out. In order to remain in compliance with HRPP protocols, the investigator also could not initiate contact with the original participant set. Data collection ended when contact via email had ceased to be commenced by the prospective participant set.

3.2.5 Interview Guide Development

Semi-structured interviews were chosen for this portion of data collection because they ensure comparable, related information will be drawn from the participating informants, yet will also allow for flexibility in the way questions are posed and in the ability to ask further questions that were not included on the guide (Dunn, 2005; Bernard, 2002). The ability to deviate from a set guide of questions is crucial because informants can have widely varying responses. These variations require modified follow-up questions that could not have been anticipated pre-interview. Another benefit to using semi-structured interviewing methods is that it is considered the best approach if an interviewer will only have one opportunity to interview an individual person (Bernard, 2000; Bernard, 2002). Considering the busy nature of natural resource managers, this seemed to be the most appropriate option.

Qualitative interviews elicit qualitative knowledge as expressed in everyday language, thus it does not intend to reveal quantitative data. Gathering data through this type of interview aims at collecting nuanced accounts of informants' perceptions, so assurance in quality data requires a different approach than quantitative methods. Instead of exactness in measurements, it is key to focus on description and
rigorousness in meaning interpretation (Kvale, 2007). While methods may differ from quantitative approaches, reliability and validity are important concepts for both qualitative and quantitative research in order to evaluate the data’s credibility and objectivity (Anderson, 2010). There is no standard method for qualitative interviews, but several common methods can be found.

Reliability refers to the consistency and reproducibility of the assessment (Anderson, 2010). Using standard interview guides for each group of informants ensures data gathered will be comparable because the same topics will be covered. Validity pertains to the accuracy of the data, as in the findings are an accurate representation of the subject matter being investigated (Anderson, 2010). Establishing validity for this study consists of structuring it as a ‘self-correcting interview’ with an opportunity for respondent validation in which I, as the interviewer, condense and interpret the informants’ response and my understanding of its meaning. I then feed it back to them during the interview in order for them to confirm or deny the accuracy of my understanding. This allows for a way to check for inconsistencies, investigate assumptions made by the investigator, and allow for the informants’ re-analyze their answers (Anderson, 2010).

Two interview guides were developed for the second and final phase of data collection (Appendix G). The first guide was designed for informants employed at funding organizations that used the Water Atlas. These questions were designed to build off of findings in the literature review as well as verify and supplement data from the survey. While the survey allowed for data acquisition on general attitudes (including knowledge, feeling, and action) and behaviors regarding the Atlas, more insight could
be gathered through one-on-one interviews. Through a guided interview, nuances, complexities, and examples could be acquired that would have otherwise been missed by different examinations (Anderson, 2010).

### 3.2.6 Interview Questions

The interview guides were developed to gather specifics regarding topics covered in the survey as well as collect qualitative information that may have been impossible to discover due to the survey design. Guides designed for informants representing funding organization consisted of questions regarding roles, uses, and perceptions. Half of the questions attempted to gather factual responses on activities within the organization to provide better context for the ways in which the Atlas is being used. The survey established general trends, and the interview questions were designed to add greater nuance and depth to the findings. For example, the survey asked informants to select the main purpose for using the Atlas from three umbrella choices (technical/scientific support, education/outreach support, and management support). While this provided data that would be useful to discover broad overall uses, it provides little insight into how the system is specifically being used within these three categories and if it is simultaneously supporting secondary uses. By revisiting how the Water Atlas is used in an interview, more information can be gathered on particular programs or activities that the Atlas is being used for, even if it does not fit into the “primary purpose.” Other questions asked to informants from funding organizations included revisiting the role and typical responsibilities of the informant, how and what is
discussed with Water Atlas staff, and how and what is discussed with other funding
organizations regarding the Atlas.

The other portion of the questions focused on discussing the informants’
perceptions. As with the previous portion, these questions also attempt to add greater
depth to the topic addressed in the survey. Additionally, they were used to verify trends
in perceptions gathered from the survey and select levels of importance. It was
anticipated that Likert-type questions regarding perceptions may be rated similarly,
making it difficult to analyze what is considered to be the most important aspects for
implementation. Some questions would aid in indicating whether or not factors believed
to facilitate successful DSS implementation were met, but would not indicate how
strongly informants felt this did or did not contribute to successful implementation.
Interview questions would also give informants the ability to list what they believed to be
important factors for continued system use that were not present in the academic
literature, and therefore not present in the survey. Questions regarding informants’
perceptions include what the perceived benefits of using the Atlas are, if discussions
with Water Atlas staff and other funding organizations contributed to improved system
use, if it aids in prioritizing actions, if it aids in selecting more scientifically sound actions,
what the perceived drawbacks are, what could be changed, and what are important
factors for successful implementation.

Guides designed for informants representing staff that works on the Water Atlas
focused on overall goals, communication with funding organizations, and the
development—both initial and ongoing—of the atlases. Though the perceptions of this
group are not the main focus of the research and they were not included in survey
administration, the literature review indicates that the communication between stakeholders that would be employing the DSS and the group that would be developing the DSS is one of the most important aspects of successful implementation. It will also be later discussed that the survey results indicated that all informants regularly communicated with this group. Because of this communication, interviews with Water Atlas representatives were conducted to provide a more encompassing picture of the communication process. Questions to investigate this process are similar to those directed towards stakeholders. The questions include what features organizations are looking for when atlases are created, if requests change over time, what is discussed during post-implementation communication, and how communication is initiated.

Further, this group has unique perspectives, influenced by their roles maintaining the atlases and communication with all stakeholder groups, that other informants would not be aware of. By including them in the interview process, a greater context for the Water Atlas can be provided. Questions include addressing program goals, factors for successful implementation, maintenance difficulties, and future improvement plans.

3.3 Data Analysis

3.3.1 Survey analysis

The survey data were analyzed using frequency and descriptive statistics, both by employing formulas within Microsoft Excel. The nonparametric Kruskal-Wallis test was also used to determine if there were any significant differences between types of informants, though little information could be drawn from this due to the small sample
size of the surveys and the three-by-three nature of the responses (e.g. technical/scientific support, education/outreach support, and management support).

Frequency statistics were used to determine the percentages of participants for gender, education level, primary role within their organization, frequency of communication with other parties, frequency of overall Water Atlas use, most used Water Atlas sections. Frequency statistics were also used to determine the percentage of participants indicating the primary purposes of Water Atlas (both funding and organization use), methods of advertising to the public, and agreement level with hypothesized factors for successful implementation.

Descriptive statistics were used to summarize, consolidate, and describe collected data in order to see if patterns emerge through range, mean, median, and standard deviation (Wienclaw, 2015). These statistics were applied to informants’ ages, experience (including as water resource managers, at current position, and as Water Atlas users), and levels of agreement with Likert-type statements regarding factors derived from the literature review. Because of the small sample size, median was used for age and experience to avoid outliers skewing the analysis. Otherwise, mean was used for ordinal data gathered through Likert-type responses.

3.3.2 Interview analysis

The analysis of the interview portion is presented in a similar manner as Giupponi and Sgobbi’s (2013) article, which also collected data through telephone interviews with a small sample. Because the sample size of those interviewed is very small, formal coding methods was not employed. Instead general trends in answers are discussed, particularly in relation to survey findings. When possible and appropriate,
responses are semi-quantified. For instance, it can be noted how many respondents discussed funding as a factor for successful implementation.

Results are also supported through providing select illustrative quotes that are insightful and/or most representative of overall findings (Anderson, 2010). Because quotes are considered raw data (Anderson, 2010), explanations for the selection are provided. Findings are grounded in the context of information found in the literature review.
Chapter 4. Results

4.1 Survey Data

4.1.1 User demographics and experience

In this study, the median age of participants was 46, with the youngest being 28 and the oldest being 63. Frequencies are presented in Table 3. There were a higher number of male participants (67%) compared to female participants (33%) (Table 4). All of them had completed at least some college, with most (58%) having master’s degrees (Table 5).

Table 3. Age Frequencies.

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29 years</td>
<td>1</td>
<td>8.33</td>
</tr>
<tr>
<td>30-39 years</td>
<td>5</td>
<td>41.67</td>
</tr>
<tr>
<td>40-49 years</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>50-59 years</td>
<td>4</td>
<td>33.33</td>
</tr>
<tr>
<td>60-69 years</td>
<td>2</td>
<td>16.67</td>
</tr>
</tbody>
</table>
Table 4. Gender Frequencies.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>8</td>
<td>66.67</td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
<td>33.33</td>
</tr>
</tbody>
</table>

Table 5. Highest Level of Education Frequencies.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Some college</td>
<td>1</td>
<td>8.33</td>
</tr>
<tr>
<td>Associate’s degree</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>3</td>
<td>25.00</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>7</td>
<td>58.33</td>
</tr>
<tr>
<td>Vocational degree</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Doctorate degree</td>
<td>1</td>
<td>8.33</td>
</tr>
</tbody>
</table>

Half of the informants had at least two decades of experience working in water resource management, with the median years of experience being 19.5 (Table 6). Most (75%) have been at their current position for at least a decade. The median years working their current position was 13, with the lowest being 3 and the highest at 29 (Table 7). The median number of years of experience using the Water Atlas was 10.5 years. The respondent using it the longest reported 16 years and the respondent using
it for the shortest amount of time reported 4 years (Table 8). These positions are largely managerial in nature. A majority (58%) of respondents indicated that their primary role at the organization they worked for was division/organization management, while 25% listed their role as primarily scientific/technical in nature. Only one respondent listed it as public outreach/education, and one respondent selected “other” with a write-in that his/her job functions consisted of all the above (division/organizational management, project management, scientific/technical, and education/public outreach) (Table 9).


<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 years</td>
<td>8.33</td>
</tr>
<tr>
<td>10-19 years</td>
<td>41.67</td>
</tr>
<tr>
<td>20-29 years</td>
<td>16.67</td>
</tr>
<tr>
<td>30-39 years</td>
<td>25.00</td>
</tr>
<tr>
<td>40-49 years</td>
<td>8.33</td>
</tr>
</tbody>
</table>

Table 7. Experience at Current Position.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9 years</td>
<td>33.33</td>
</tr>
<tr>
<td>10-19 years</td>
<td>41.67</td>
</tr>
<tr>
<td>20-29 years</td>
<td>25.00</td>
</tr>
</tbody>
</table>

Table 8. Experience Using Water Atlas.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
</table>

39
Table 9. Primary Role at Organization.

<table>
<thead>
<tr>
<th>Division/organization management</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project management</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Scientific/technical</td>
<td>3</td>
<td>25.00</td>
</tr>
<tr>
<td>Outreach/public education</td>
<td>1</td>
<td>8.33</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>8.33</td>
</tr>
</tbody>
</table>

4.1.2 Water Atlas use

Table 10. Years of Implementation.

<table>
<thead>
<tr>
<th>Years</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4 years</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>5-9 years</td>
<td>5</td>
<td>41.67</td>
</tr>
<tr>
<td>10-14 years</td>
<td>3</td>
<td>25.00</td>
</tr>
<tr>
<td>15-19 years</td>
<td>4</td>
<td>33.33</td>
</tr>
</tbody>
</table>
According to survey results, the Water Atlas has been implemented for at least 5 years at all organizations. The longest it has been in use was reported to be 17 years, with a median number of years at 11 (Table 10).

Responses to questions regarding informants' individual use of the Water Atlas indicate that almost all (83.33%) accessed it at least once a month, and are primarily using features under the mapping and analysis sections. One informant (8.33%) accessed the program more than once a week, while two informants (16.67%) accessed it less than once a month. The rest of the group fell somewhere between these two frequencies (Table 11). Aside from one informant who indicated “other” as the section they primarily use, the rest of the group was split between 50% primarily utilizing the mapping section and 41.67% primarily utilizing the analysis section (Table 12).

Table 11. Access Frequencies.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than once a week</td>
<td>8.33</td>
</tr>
<tr>
<td>Once a week</td>
<td>16.67</td>
</tr>
<tr>
<td>2-3 times a month</td>
<td>33.33</td>
</tr>
<tr>
<td>Once a month</td>
<td>25.00</td>
</tr>
<tr>
<td>Less than once a month</td>
<td>16.67</td>
</tr>
<tr>
<td>Never</td>
<td>0.00</td>
</tr>
</tbody>
</table>
In regards to the organization on a whole, the primary purpose for funding the Water Atlas was largely split between education/outreach support and technical/scientific support. 42% of participants indicated that the primary purpose was education/outreach support, while 50% listed scientific/technical support. One informant selected “other,” stating that the main reason it was funded was to serve as a warehouse for the organization’s data (Table 13). Responses to the question asking what the main purpose of using the Water Atlas in the organization is differs. In this case, only one respondent selected education/outreach support as the primary purpose of using the system, while 17% indicated it as management support and 67% as scientific/technical support. The same informant who had selected “other” as the purpose for funding also selected “other” for using the program, again citing the main purpose as a warehouse for the organization’s data (Table 14). The differences reported between the purpose of funding and using the Atlas was further explored in the interview portion of data collection.

### Table 12. Primary Section Used.

<table>
<thead>
<tr>
<th>Section</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping</td>
<td>6</td>
<td>50.00</td>
</tr>
<tr>
<td>Analysis</td>
<td>5</td>
<td>41.67</td>
</tr>
<tr>
<td>Learn</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Participate</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>8.33</td>
</tr>
</tbody>
</table>
Table 13. Primary Purpose for Funding Water Atlas.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education/outreach support</td>
<td>5</td>
<td>41.67</td>
</tr>
<tr>
<td>Management support</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Technical/scientific support</td>
<td>6</td>
<td>50.00</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>8.33</td>
</tr>
</tbody>
</table>

Table 14. Primary Purpose for Using Water Atlas.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education/outreach support</td>
<td>1</td>
<td>8.33</td>
</tr>
<tr>
<td>Management support</td>
<td>2</td>
<td>16.67</td>
</tr>
<tr>
<td>Technical/scientific support</td>
<td>8</td>
<td>66.67</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>8.33</td>
</tr>
</tbody>
</table>

Figure 4. Primary Purposes: Funding vs. Actual Use.
The number of coworkers reported to also use the program ranged from two to 10. The median number of other employees was four. The most reported number of coworkers was three, representing 33% of responses.

All organizations using the Water Atlas also communicate about the program with Water Atlas staff and other institutions that fund the Atlas. Informants were asked about the frequency of communication with Water Atlas staff because it was established these communications took place as part of follow-on contracts prior to distributing the survey. Nearly all (92%) respondents reported that the frequency of communication with Water Atlas staff was more than twice a year. One informant (8%) indicated that communications with staff took place twice a year (Table 15). Informants were then asked to answer either “yes or no” regarding communication with other organizations to determine if this should be further discussed in interviews. This was included because it was indicated in the literature review that programs are more successful when organizations are sharing information regarding the tool, in addition to regularly communicating with the technical individuals that design the tool. All respondents indicated that they did communicate with other funding organizations about the Water Atlas.

Additionally, to gain more insight on if and how the Water Atlas was being utilized for public outreach and education, respondents gave feedback on where the Water Atlas was advertised through their organizations websites. All of the organizations indicated that the individual atlases were linked for the public to access in some way.
81.81% were through the organization’s main page or through a department/division page (Table 16).

**Table 15.** Communication Frequencies.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every two years or more</td>
<td>0</td>
</tr>
<tr>
<td>Once a year</td>
<td>0</td>
</tr>
<tr>
<td>Twice a year</td>
<td>1</td>
</tr>
<tr>
<td>More than twice a year</td>
<td>11</td>
</tr>
<tr>
<td>Never</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 16.** Online Advertisement Frequencies.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main page</td>
<td>6</td>
</tr>
<tr>
<td>Department/division page</td>
<td>4</td>
</tr>
<tr>
<td>Nowhere</td>
<td>0</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
</tbody>
</table>
4.1.3 Water Atlas perceptions

Data from the Likert-type questions attempted to gather data relating to the informants’ perceptions on conditions thought to contribute to DSS project success, as well as its overall effectiveness as a decision-making and public outreach tool. When asked to express how strong they agreed or disagreed on statements relating to successful project implementation, all mean responses were over three (three being neutral). This indicated that respondents generally tended to agree that the conditions were met. Additionally, all conditions had a least one respondent that “strongly agreed” with the statement. The statement with the highest average level of agreement was “I understand how Water Atlas was developed,” with a mean of 4.33. This statement also had the smallest deviation in answers. It was followed by “I am satisfied with the amount of data available” at 4.25.

The four conditions that did not have averages reaching at least four (i.e. agree), from lowest to highest average, were “Water Atlas is easy to use,” “[it] addresses my needs and concerns,” “my input was assimilated into the design of [it],” and “[it] has a role in my decision making.” Though ease of use had the lowest mean at 3.33 and the second smallest amount of deviation in responses, the minimum score was only two (disagree). Three other conditions were given a minimum score of one (strongly disagree). These were “[it] addresses my needs and concerns,” “[its] data is reliable and accurate,” and “my input was assimilated into the design of [it]” (Table 17).
Table 17. Perceptions of Conditions

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiarity with features</td>
<td>3</td>
<td>5</td>
<td>4.17</td>
<td>0.84</td>
</tr>
<tr>
<td>Ease of use</td>
<td>2</td>
<td>5</td>
<td>3.33</td>
<td>0.78</td>
</tr>
<tr>
<td>Understanding of development</td>
<td>3</td>
<td>5</td>
<td>4.33</td>
<td>0.65</td>
</tr>
<tr>
<td>Reliability and accuracy of data</td>
<td>1</td>
<td>5</td>
<td>4.00</td>
<td>1.21</td>
</tr>
<tr>
<td>Satisfactory data amount</td>
<td>3</td>
<td>5</td>
<td>4.25</td>
<td>0.84</td>
</tr>
<tr>
<td>Addresses needs and concerns</td>
<td>1</td>
<td>5</td>
<td>3.75</td>
<td>1.14</td>
</tr>
<tr>
<td>Input solicited for design</td>
<td>2</td>
<td>5</td>
<td>4.17</td>
<td>1.03</td>
</tr>
<tr>
<td>Input assimilated into design</td>
<td>1</td>
<td>5</td>
<td>3.75</td>
<td>1.36</td>
</tr>
<tr>
<td>Has role in decision-making</td>
<td>3</td>
<td>5</td>
<td>3.91</td>
<td>0.90</td>
</tr>
</tbody>
</table>

* 1 representing strongly disagree; 5 representing strongly agree

Two statements attempted to gauge how the informants perceived the effectiveness of the Water Atlas as a decision support tool and public outreach/education tool. “The Water Atlas helps me make better decisions within my organization” received a mean score of 4.17 and “this technology is useful for educational outreach” received a mean of 4, meaning on average the informants agree. While the statement regarding helping make better decisions had a minimum score of three, indicating that no one disagreed with this statement, the statement regarding its usefulness as an educational outreach tool received a minimum score of two (Table 18).
However, both did receive a maximum score of five (strongly agree), though the decision-making statement received a higher number of five scores (Figure 5).

### Table 18. Perceptions of Decision Support and Public Outreach.

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helps make better decisions</td>
<td>3</td>
<td>5</td>
<td>4.17</td>
<td>0.84</td>
</tr>
<tr>
<td>Useful for educational outreach</td>
<td>2</td>
<td>5</td>
<td>4.00</td>
<td>0.95</td>
</tr>
</tbody>
</table>

* 1 representing strongly disagree; 5 representing strongly agree

![Decision-making v. Educational Outreach Scores](image)

**Figure 5.** Decision-making v. Educational Outreach Scores.
4.1.4 Differences

Attempts were made to employ the Kruskal-Wallis test to determine if there were statistically significant differences in responses from informants with different experience levels and roles within the organization. Because of the small sample size, none of the analyses produced statistically significant results so these were not included. Additionally, informants within categories of experiences and roles were not evenly represented. For instance, informants with a managerial role accounted for over half of all responses, while there was only one informant with a primarily outreach/education position.

4.2 Interview Data

Telephone interviews were scheduled with nine individuals. Four informants were stakeholders at organizations currently funding the program, two were stakeholders at organizations that had previously funded the program, and three were staff that work on the development and maintenance of the program. In order to maintain informant anonymity, all subjects will be referred to by their labels presented in Table 19. Interviews lasted an average of 15 minutes, with the longest being 26 minutes and the shortest at 10 minutes.
### Table 19. Interview Subject Labels

<table>
<thead>
<tr>
<th>Subject Label</th>
<th>Subject Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject A</td>
<td>Stakeholder at current funding organization</td>
</tr>
<tr>
<td>Subject B</td>
<td>Stakeholder at current funding organization</td>
</tr>
<tr>
<td>Subject C</td>
<td>Stakeholder at current funding organization</td>
</tr>
<tr>
<td>Subject D</td>
<td>Stakeholder at current funding organization</td>
</tr>
<tr>
<td>Subject E</td>
<td>Stakeholder at past funding organization</td>
</tr>
<tr>
<td>Subject F</td>
<td>Stakeholder at past funding organization</td>
</tr>
<tr>
<td>Subject G</td>
<td>Water Atlas staff member</td>
</tr>
<tr>
<td>Subject H</td>
<td>Water Atlas staff member</td>
</tr>
<tr>
<td>Subject I</td>
<td>Water Atlas staff member</td>
</tr>
</tbody>
</table>

#### 4.2.1 User Experience

All interviewed Water Atlas stakeholders, both past and present, worked for an organization, or division of an organization, that manage water quality. While not all informants listed scientific research, legislation, and public outreach as part of their main job functions on an individual level, every informant did indicate that their organizations’ purpose encompassed all three. As expected from the survey results, a majority of informants had management positions that required supervision of several different efforts, such as permitting, sampling and public outreach. Other informants mainly functioned as scientific and technical support.

Subjects B through F described job responsibilities as largely focusing on regulatory compliance in order to improve stormwater quality and conveyance, namely
through Total Maximum Daily Loads (TMDLs) and National Pollutant Discharge Elimination System (NPDES) permit program. Informants also listed conducting water quality studies, surface water sampling, and implementing stormwater best management practices as major job functions. Only one of these five, Subject D explicitly indicated communication with the public as part of the work done, stating “collecting and analyzing [water quality] information and getting that to the public is important to us.” While all other informants discussed public education, it was only brought up in answers to subsequent questions discussing the topic. Subject A, who did not focus on regulatory compliance, succinctly listed job responsibilities as managing “research, restoration, legislative action and public outreach.”

4.2.2 Water Atlas Use

A majority (66.67%) of survey respondents indicated that the main function of the Water Atlas within organizations was for scientific/technical support, and this was reflected in the interview answers, which described more specific uses. The interview, however, revealed that most past and present users utilized the Water Atlas for several functions. In addition to scientific/technical support, responses falling under the public outreach/educational support category were also frequently given. Out of a total of six responses, all answers indicated that Water Atlas was used for scientific/technical support and five indicated that it was used for educational outreach as well. Subject C did not include public outreach as a main purpose for funding. Water Atlas staff also indicated that the goal of the tool is for scientific support and educational outreach. Subject G indicated that the former has increased through the years as the Water Atlas began to offer more unique data.
4.2.3 Water Atlas Use – Scientific/Technical Decision Support

Out of the four current users of Water Atlas, Subjects B and C listed the first use as scientific/technical support, Subject A listed it as one of several main uses, and Subject D listed it as secondary to educational outreach. Likewise, both past users mentioned scientific/technical uses first and educational uses second. When the atlas is being used for scientific/technical support, all informants indicated it being utilized as a research tool for understanding water quality trends. Within that use, it can be used in determining problem areas, which can then influence future actions for appropriate, effective management. Management responses typically seem to fall under two categories: engineering solutions and policy solutions.

According to Subjects A, B and E, data can be analyzed to determine locations of problems such as nutrient loading hotspots, indicating where new engineering projects would be best suited. Analysis and subsequent response actions can both be performed within the same organization, as will Subject B. This informant indicated "All the projects that we do, whether it is a lakes restoration project or stormwater retrofit, we'll hire engineering consultants to help us...one of the first places they go is the Water Atlas." Sometimes one organization analyzes data and communicates findings with another organization that would be more capable of appropriate initiatives. Subject A stated, "We have also used [the contour mapping tool] to identify hotspots of different nutrient loads and have followed up with different management agencies to address those hotspots. For example, we found one near Burnt Store Marina and contacted FDEP and they have just implemented a clean marina program there....and since that time we have found a decrease in nutrients."
Additionally, as also indicated by Subject A’s former quote, it has been used to examine effectiveness of implemented projects, which can then support future legislative action. Subject A provided an additional example, stating "I've used the Water Atlas for research by downloading the water quality data and analyzing it. I investigated the effects of the fertilizer ordinances and have found that especially phosphorous but also nitrogen loads have been reduced as a result....I've given that information to people who are seeking adoption of local fertilizers ordinances elsewhere in the state." These findings would serve as support for potential effectiveness of new legislation. Subjects B and C also mentioned that it is a quick reference for estimating volumes of water as well as quality.

4.2.4 Water Atlas Use – Educational/Public Outreach

Three out of four current users (excluding Subject C) and both past users also identified using the atlas as an educational/public outreach tool. Subjects B, D, and F, indicated that this is or was done by directing residents to the Water Atlas website, either through advertising a link on the organization’s website or by providing the Water Atlas website information to citizens who contact them with questions and concerns. Two Water Atlas staff members also discussed that this was important to sponsors when discussing program use, explaining that stakeholders want the website to be a place that residents can go to get their questions answered on their own or after being informed about it, freeing up staff time for other uses.

Additionally, using the atlas as an educational tool also assists some organizations in meeting regulatory requirements. Subject B indicated that NPDES permitting necessitates that organizations have stormwater pollution prevention
education. The Water Atlas can be used to fulfill this, and website traffic can be used when filling out permits. Again, this was also mentioned by two of the Water Atlas staff, one of which added that these analytics can also be used by sponsors to justify continued funding. Subject D added that website traffic is also useful for gaging public awareness. Observing increased traffic on certain features can indicate a raised level of education regarding that topic. Subject A used it as a tool for outreach and education by creating contour mapping and providing them to the public so residents can visualize local water quality.

Subject B, the user that mentioned educational components of NPDES permitting, did so when asked about survey data regarding funding versus use. As mentioned in the survey data section, 41.67% of respondents indicated that education/outreach support was the main purpose for funding the atlas, while only 8.33% indicated this was the main purpose for using the atlas. This particular informant indicated that this discrepancy might be due to the fact that organizations may be more likely to seek funding in order to meet the educational NPDES requirements.

4.2.5 Water Atlas Communication

Survey data indicated that 91.67% of informants communicated with Water Atlas staff at least twice a year, meaning that communication usually takes place more frequently than the contract meetings. According to Subject I, sponsors and staff are in contact whenever a problem is found, when sponsors would like something added, when they are unsure of how to use an application, or when there are contractual obligations to add something new. Responses from three users indicate that the ways in which these are initiated typically vary, but are rather informal. Subjects A and B
indicated that when new additions or changes are needed, communication is handled through email. Sometimes this can be as simple as forwarding an email about an upcoming event to be advertised. Subject B indicated that this is sometimes followed up with a conference call to discuss update details. Another user indicated that the only communication outside of scheduled meetings is to send over new water quality data as it is generated.

Subject D, who noted that he had only been working with the Water Atlas for a relatively shorter period of time, solely discussed communication through annual meetings. This user described those meetings, which are initiated by Water Atlas and attended by representatives that provide funding, as largely revolving around balancing the funding that can be committed with the features that stakeholders would like to see added. According to this informant, a benefit to having several organizations take part in these discussions is that counties with more public interest in water quality can advocate for certain features which can then be made standard, allowing other organizations to take advantage of new components that they otherwise would not be able to fund. A Water Atlas staff member confirmed that funding is often a major concern during communications, particularly for certain sponsors that have more funding challenges. These organizations typically frame the discussion in terms of justification for continuing funding.

Subject D also mentioned that sponsors will discuss what can be added to support new programs within their organization. Subject A described these meetings as collaborative processes where tasks are created to accomplish their goals. This leads to the creation of deliverables that are presented for approval. A separate
developer substantiated that feedback is a large part of the development process. New software and features will be sent out to sponsors for beta testing to ensure it is working properly and meets their needs. He did note that sometimes there is a lack of response from stakeholders during this process.

In the survey, all respondents cited that they do communicate with other organizations about the Water Atlas. Users also indicated regularly communicating with other organizations during interviews, through both formal to informal means. As with communication with Water Atlas staff, communication with other organizations takes place at scheduled meetings where features and funding are discussed. Subject B indicated that they promote the Water Atlas to other organizations by letting them know it is a good tool, particularly for data storage, if the topic comes up. Word of mouth about the benefits of the Water Atlas was echoed by Subject A, who is employed at an institution that began using the atlas because of its proven track record with other groups. As previously mentioned, this user also communicates with other organizations in regards to research findings. If nutrient hotspots are identified, the results will be sent to the appropriate regulatory organization for follow-up.

4.2.6 De-funding

After speaking with past users about the use of a new in-house program that functions similarly to the Water Atlas, it seems as though the main purpose of the program has shifted away from decision-support and public education, and instead focuses on housing water quality information. Subject E noted that the new program can still be used for public education, as it does still store the organization’s documents and serve as a reference for staff to answer residents’ questions; however, upon browsing
the organization’s website, it can be noted that finding this information is not as apparent as organizations’ with a Water Atlas.

This shift reflects one of the reasons why the organization made the decision to discontinue funding the Water Atlas and design an in-house program instead. While collaboratively agreeing on development benefits some organizations, but has been detrimental for use by others. Subject E stated that when the organization initially funded Water Atlas, the program was much simpler but new additions through the years have made it a more cumbersome experience. An in-house program allowed them to stick more closely to their original goals. To sum up this point, the user explained, “Sometimes I compare it to a kitchen tool. We didn't need another slicer dicer chopper. We just needed a really good knife.” This was not the primary motivation for the switch, however. The major impetus for the move was a change in funding. The same user again explained, “We had been cooperatively funded by the Southwest Florida Water Management District and that ceased, so we had to make some drastic reductions.” It was decided that the atlas was rather expensive, and developing a new database would allow the organization to save money.

4.2.7 Water Atlas perceptions

Overall, current users found the Water Atlas to be a valuable tool within their organization, and past users also find benefits to employing similar tools. While the extent of use varied, a general trend in responses indicated that the main advantage of using these tools is the added convenience through technical as well as educational support. Five out of six past and present users indicated that this type of tool makes it easier to keep track of water quality information, though Subject D indicated that this
was a secondary benefit to the outreach component. While several informants mentioned that much of the data used could be found in other places, Subject B explained, "It saves a lot of time. You don't have to email someone and wait for them to email you back." The Water Atlas simplifies the process of quickly referencing data and performing analyses.

Time is also saved through serving as a resource for public education. As previously mentioned, the public can easily find information and answers to their questions by accessing the Water Atlas from home. Staff can also direct residents to the site to better answer questions when they are contacted. Subjects B and D indicated that this can save time by lessening the volume of questions they receive and/or reducing the response time to questions they do receive. Subject F, a past user, indicated that this kind of database can also reduce response time by having readily compiled resources for employees to refer to when they receive questions. A Water Atlas representative, Subject G, added greater context to why this would be of particular use to sponsors, explaining that the recession around 2008 led to reductions in staff members within these organizations that have yet to bounce back despite an improving economic environment. The respondent added that interactions with residents can also be streamlined by providing a clear place where they can submit pollution sightings.

Subject D had another unique response regarding the Water Atlas’s main benefits, which is that the outreach component provides transparency. He stated, "I think in government there is value in transparency, so if you're able to have that information available so that when elected officials come to you or residents come to
you, you can easily share [it]." The respondent noted that the public may not be widely accessing the information provided, but the fact that it is available is important.

Because decision support tools in water resource management typically are used to aid in the scientific soundness of decisions or the prioritization of actions, informants were asked if and how this took place in their organization. All users except for Subjects C and F indicated that the Water Atlas does or did aid in decision making in this manner, based on the previously discussed scientific/technical uses that allow for users to target vulnerable areas with appropriate responses and support expanding effective policies. Subject A also noted that through the years, more ways to improve decision making has been included in contracts. Continuous collaboration with Water Atlas staff has allowed for the development of a water clarity tool, and staff has also written algorithms to observe water quality trends. Subject D believed that staff looks at water data more frequently because the process to do so has become streamlined. Those that did not indicate that it aids decision-making through improving scientific soundness or prioritizing actions did indicate that it again was a more convenient process, however.

Users seemed overall content, but discussed several varying drawbacks and/or possible improvements to the Water Atlas. Two current users mentioned enhanced features may be beneficial. Subject C would like to see increased water quality graphing capabilities. The respondent also mentioned there could be several useful reference documents that could be included, but indicated that this was due to lack of impetus on his/her part. Subject D would like better representations of hydrology and an incorporation of aquatic vegetation in relation to water quality.
Subject A mentioned that a drawback is the time it takes for data to upload, though she believed there is little that could be done to improve this. Subject E expanded on this drawback, stating "There's a time lag on information. There's not real-time data. Somebody has to go out and sample [the water] and get a lab analysis, and then that information needs to get recorded and eventually loaded into the website… When you're looking at the website you don't have information from yesterday or last week or even last month, typically." This problem applied to both the respondent's experience with the Water Atlas and the new program. The respondent estimated that both required a three to six-month period for new data to be added, but the only way to reduce this time would be through an expensive system such as SCADA (Supervisory Control and Data Acquisition), which is a remote monitoring and control system that can relay data measurements in near real-time.

Feedback varied the most when informants were asked about what they consider to be the most important factors for successful implementation of a program such as the Water Atlas. Factors included: 1) having a good economic climate for funding, 2) having IT capabilities for smooth transfer of data, 3) focus-grouping with the public about the interface, 4) ease of use and accessibility of data, 5) early stakeholder involvement, and 6) early identification of purpose and goals. Water Atlas staff also felt ease of use and stakeholder involvement were important factors, but noted that these were both difficulties on the development side. One staff member also expanded on IT capabilities by emphasizing that these capabilities need to be guaranteed long-term in order to keep the program up-to-date and functioning. They also added that advertising in order to let people know what the tool is and how it can be used is critical.
Chapter 5. Discussion

As indicated by the Water Atlas website, survey results indicate that it can be considered an implemented system, as opposed to the myriad of prototypes available in the literature. Because the study found that the Water Atlas had been used at all organizations for at least five years, with users having a median of 10.5 years of experience using the program, it can be established that the system has had real-world application. This makes it an ideal tool to evaluate in order to determine how DSS is being used and if it supports the existing body of literature.

5.1 Water Atlas Use

The study indicates that the Water Atlas is used as both a scientific research platform and educational resource, with decision-making support mostly from the research uses. This supports Hypothesis 1, which states that the atlas will support education efforts and decision-making through scientific support. The most discussed way in which Water Atlas influences public education according to interview responses is through providing citizens with resources to independently learn about local water quality, policies, projects, and other pertinent information without having to rely on communication with organization staff to convey that knowledge to them. Enabling the public to access scientific data, documents, and more autonomously has added benefits for stakeholders, which is discussed further in the section. Another way interview responses indicated it influences public education is through stakeholders’ ability to
create their own informational material, e.g. maps, through the collection of scientific data available. Finally, public education is further influenced through the ability to track website visits. While the Water Atlas allows citizens to access water quality information, it also grants stakeholders the ability to monitor what kinds of information they are accessing. Website hits can therefore inform stakeholders of increased public awareness regarding certain topics. This also aids in regulatory compliance by meeting the educational component of the NPDES program.

Decision-making is influenced by using the Water Atlas as a research tool. Scientists within funding organizations access Water Atlas data to identify things such as changes in nutrient levels or concentrations of nutrient levels in order to enact fitting solutions. Depending on the use by organizations, decisions that are supported can be policy-based or engineering-based.

A surprising finding in the survey was the discrepancy in responses regarding the primary purpose for funding the program and using it. While purposes for funding were almost evenly split between education/outreach support and technical/scientific support, with one more person selecting the latter, a majority of respondents selected technical/scientific support as the main use. This was followed-up in the interview portion, where several stakeholders cited fulfilling educational requirements for regulatory compliance as the primary reason for funding.

Another surprising finding, was that when stakeholders were asked what the purpose of using the Water Atlas was in interviews, they spent a considerable portion of time on educational outreach application. While almost all users mentioned the technical/scientific uses first, all but one elaborated on outreach purposes as well,
indicating that this was another important use within the organizations. Further, one informant felt that this component was the most beneficial aspect of the program, and developers also felt this was a primary goal. The importance of the Water Atlas as an education tool within organizations was possibly obscured by the need to select primary uses in the survey.

While decision support is generally found on the scientific side of the website’s use, both the scientific and education support the atlas provide address several of the goals DSS have been utilized to achieve. First, the program facilitates the sharing of “usable science” (Eden, 2011). Not only can managers have access to local water quality data and supporting information, but the public can access the information as well. Results regarding the way in which the program is used and the benefits from program use indicate that it has also streamlined work. As mentioned in the literature review and further supported through interview feedback, water managers are often overextended and under time constraints (Eden, 2011; Pyke et al., 2007). Data collected from interviews illustrate that both the educational and scientific support components simplify processes and save time. One way this has been done is through addressing another problem found in the literature: disjointed knowledge (Brewer and Stern, 2005; Eden, 2011). Describes on the website says, the Water Atlas is a “one-stop data warehouse.” As such, informants expressed that the website is a place where a variety of information is collected and presented without the need to contact multiple sources, therefore saving time that would otherwise be spent locating data held by different institutions. Another way the educational component streamlines processes and saves time is through filling the knowledge gap between managers and the public.
The Water Atlas enables citizens to access local scientific knowledge on their own, freeing up staff time that would be spent communicating with the public for other purposes.

5.2 Implementation Conditions

I found that conditions for success as indicated by the literature, such as user expertise and early stakeholder involvement (summarized in Table 1, pg. 19), generally tended to be met in situations of continued atlas use, supporting Hypothesis 2. However, interviews with past users reflected that when those conditions were no longer present, it had led to ceased use. Results from both the survey and the interview demonstrated that stakeholders had considerable experience in the field of water resource management. Survey respondents had a median of 19.5 years of experience in the field, and two thirds of them had been at their current position for at least a decade. From the interviews, it can be gathered that many of these stakeholders have management positions where they are aware of the scientific/technical, public outreach/education, and managerial nature of their organizations. This seems to satisfy a need for expertise on the side of the users that authors believed contributed to use (Junier and Mostert, 2014).

The most emphasized condition for success—stakeholder involvement—was also a large part of the Water Atlas implementation process. Most literature indicated that early involvement was instrumental in success (e.g. Bots et al., 2011; Jakeman et al., 2006; McIntosh et al., 2011). Involvement allows for shared knowledge between developers and stakeholders, which aids in preventing the largest barrier in water management DSS history: creation of a product that is not grounded in the decision-
maker’s reality. Early stakeholder involvement is satisfied by the program’s development process, where stakeholders collaborate to determine features that are included. Survey results supported this, with most respondents agreeing or highly agreeing that their input was solicited for the design. Interview results also indicated that Water Atlas design takes place after communication between stakeholders and developers.

Further, the Water Atlas meets the suggestion presented by McIntosh et al. (2011), that communication between stakeholders and developers should continue post-implementation. Through the information presented on the Water Atlas sites and interview data, it was indicated that communication with staff continues at least every other year at contract meetings. However, survey responses indicated that exchanges take place more frequently than this. Interviews revealed that communication takes place through the formal meetings as well as informally. The communication allows for the program to stay updated with relevant information and, as one informant mentioned, continue to improve its decision-making capabilities. Continued stakeholder collaboration thus possibly needs to be considered more frequently if a tool is designed for long-term use. Interview responses from staff also mirrored responses given by users, further supporting that communication between the two had led to an understanding by the developers of users’ needs and product application.

An unexpected finding in the study was that a Water Atlas developer expressed receiving little feedback from stakeholders on new program updates. Literature (see Giupponi &amp; Sgobbi, 2013; Serrat-Capdevila, 2011) tended to discuss lack of stakeholder involvement as a lack of initial consideration on the end of developers. This
study indicates that the stakeholder group could also be responsible for inadequate communication. Interview data revealed that stakeholders often do not provide comments during beta-testing, making it difficult for developers to design a program best suited for them.

Shared information between stakeholders and developers also aid in satisfying other factors that contribute to successful system use (e.g. understanding of development) (Junier and Mostert, 2014). Because data indicates both early and continued stakeholder involvement in the Water Atlas development, it is unsurprising that users tended to agree that other conditions drawn from previous articles were met. Unlike decision makers who do not use designed DSS, stakeholders’ average scores on the Likert-type questions indicated that they felt familiar with the features of the atlas, understood how it was developed, believed data was reliable and accurate, believed there was enough data, and felt their input was solicited for the creation of the program. The average scores of other conditions fell between three and four, indicating an overall slight agreement that the program is easy to use, it addresses needs and concerns, it was designed with an assimilation of stakeholder input, and it has a role in decision making.

It is interesting that ease of use had the lowest score at 3.33 (with most selecting 3, neither agree nor disagree) because of information collected during the interviews that discussed program ease. While developers acknowledge designing an easy to use product was challenging, interview responses seemed to indicate that accessing data for review and analyses was a less complicated process than the alternative, which would require collected data from several sources. Further, an informant also discussed
that residents were directed to the Water Atlas for more information regarding water because it was a more accessible format for them to use compared to other options. It may be important to note that although the Water Atlas may not be considered easy to use on its own, it seems to be considered a relatively easy resource overall.

In addition to having one of the lower scores, input assimilated into design had the highest standard of deviation. A low level of agreement about assimilation of could be influenced by employees who were hired after the Water Atlas had been established within the organization. The two respondents that either disagreed or strongly disagreed with the statement both had started working at their current position after the Water Atlas had been implemented.

I found that the program seemed to satisfy the literature’s suggestions on data availability. Authors stressed the importance of providing an adequate amount of trustworthy data (Borowski and Hare, 2005; Junier and Mostert, 2014; McNie, 2007). As previously mentioned, average scores indicated that users largely agreed that data were reliable/accurate and that there is a satisfactory amount of data, with scores of 4.00 and 4.25 respectively. The literature (Junier and Mostert, 2014) also noted that in addition to having accurate, plentiful, and high quality data, it should also be presented spatially. As presented in chapter three, there are several provided methods of visually presenting data.

The Water Atlas also partially complies with Borin and Hare’s (2005) suggestions that the tool aids in the decision-making process, but does not actually make a decision. Interview responses indicate that it is employed as a reference tool to pinpoint vulnerable areas or observe changes, which informs and supports the decision-making
responses. It does not fully satisfy the following suggestions put forth in regards to DSS functions. While Borin and Hare (2005), as well as McIntosh (2011), note that tools should be kept simple rather than all-encompassing, the Water Atlas has a variety of uses. I found conflicting opinions regarding whether or not this hindered implementation. On one hand, the addition of several new features was linked to decreased ease of use and de-funding in favor of a simpler tool according to one past stakeholder. However, current stakeholders expressed additional features facilitated increased decision making, and would even like supplementary features added for a more comprehensive tool.

The study also found funding to be a considerable factor in successful continued use, echoing similar findings by Giupponi and Sgobbi’s (2013) case studies in Africa. Again, decreased funding ability was considered the main reason for past stakeholders to discontinue using the Water Atlas. Additionally, a current stakeholder considered a favorable economic climate for increased funding opportunities as the most important factor for implementation success.
Chapter 6. Conclusion

Overall, I found that the Water Atlas supports decision-making by providing a streamlined research tool that can be used to address water quality problems through appropriate means. The program also supports educational outreach by facilitating citizens to independently answering their own questions and saving time within institutions. Additionally, the educational component effectively satisfies regulatory compliance needs. I found many of the factors (e.g. early stakeholder involvement, understanding of development) found to be important to the success of a DSS within the literature are present in the Water Atlas development and continued use. When past stakeholders’ felt that these conditions were not met, sponsorship ceased.

Funding capabilities and sustained technical support between developers and stakeholders were perhaps underrepresented in the literature. Furthermore, developers should consider the environment stakeholders work within, not only to ensure the product will be useful, but also to understand what would make it more marketable as a justified expenditure. Both developers and stakeholders should also consider advertising in this context to establish a user base, which would aid in marketability. These factors could be further explored in additional studies. While many authors focused on technical abilities of DSS (e.g. Fernandes et al., 2014; Pierleoni et al., 2014), including a public outreach component to the program could aid in securing funding in addition to meeting goals of streamlining environmental resource managers’ work (Fernandes et al. 2014).
Though this study was able to provide information regarding the stakeholder perceptions of a DSS with long-term implementation in order to examine successful factors for success and realistic use, it did have limitations. One limitation was that the sample sizes of both the survey and interviews were very small. In regards to the survey, this makes it difficult to analyze correlations between conditions (e.g. familiarity with features and stakeholder input solicited to design) and perceived effectiveness, frequency of use, etc. Additionally, statistically significant differences between user groups based on experience, roles, etc. and their perceived effectiveness could not be determined.

Likewise, interview data has to be largely qualitative because there were not enough informants to justify coding in order to create quantitative datasets for analyses. Responses were also diverse and informants often had unique answers to interview questions, indicating that the broader population of stakeholder users may have experiences and perceptions that remain unknown. If a larger number of individuals could have been interviewed, trends may have been more apparent.

A final limitation was that another group of intended users, the public, could not be included. Because the Water Atlas is funded and used as a public outreach tool, perceptions from this group of users could be valuable. Results may be skewed towards an emphasis on scientific/technical uses because stakeholders within funding organizations would be more inclined to actively use the atlas in this way after initially making it available to residents. Future studies could include the public to gage their perceptions of system usefulness and factors that they value (e.g. transparency). In regards to water resource management education.
The Water Atlas is unique in that it serves as a decision aiding research tool as well as an educational resource. The research component of the atlas allows for staff to quickly access relevant information in one place and make appropriate decisions regarding the management of water quality. The educational component saves staff time, gauges public awareness, and contributes to transparency with the public. The most discussed benefit of the educational component was the reduced time spent answering residents’ questions. The educational outreach also aided in continued funding by satisfying regulatory compliance. The study adds to the literature by introducing new methods for aiding stakeholders in streamlining work and continuing funding for DSS by including an educational component.

The study also found that in instances of continued use, informants generally reported that conditions indicated by the literature to contribute to successful implementation and actual use were met. In instances of discontinued use, past stakeholders reported that two of these conditions were no longer met. These included funding abilities and ease of use. This study again adds to the literature by providing a real-world example of how a DSS in water resource management is used, and under what conditions it has worked in. It further supports present literature’s suggestions for successful DSS design and implementation as well as highlights additional conditions that may not have been considered due to the high level of literature on prototype DSS (e.g. Aydin et al., 2015; Jolk et al., 2010). Two conditions that were discussed minimally were a need for continued institutional funding and continued stakeholder/developer communication, which were both discussed in the interview portion. Additionally, literature focused on developers’ lack of communication with stakeholders (e.g. Serrat-
Capdevila, 2011), however this study revealed that stakeholders lack of communication with developers may also pose a potential barrier to success.
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Appendices
Appendix A: Survey

By clicking continue, you indicate that you have read the informed consent document and agree to participate in this study.

Continue
What is your age?

What is your sex?

Male
Female

What is the 5 digit zip code of your residence?

What is the highest level of education you have completed?

High school graduate
Some college (1-4 years, no degree)
Associate's degree (including occupational or academic degrees)
Bachelor's degree (BA, BS, AB, etc)
Master's degree (MA, MS, MENG, MSW, etc)
Professional school degree (MD, DDC, JD, etc)
Doctorate degree (PhD, EdD, etc)

What year was the Water Atlas implemented at the organization you work for?
How many years have you worked in water resource management?

How many years have you been working at your current job?

How many years have you been using the Water Atlas?

Which would best describe your primary role within the organization you work for?

- Division/Organization Management
- Project Management
- Scientific/Technical
- Outreach/Public Education
- Other

How often do you or other members of your organization communicate with Water Atlas staff about project tasks and website content?

a. Every two years or more
b. Once a year
c. Twice a year
d. More than twice a year
e. Never
f. Don’t know
Do you or other members of your organization communicate with other Water Atlas project sponsors about the Water Atlas project/contract?

Yes

No

About how many other co-workers besides you at your organization use Water Atlas?

Out of the following categories, which do you think is the primary purpose of using the Water Atlas within your organization fits under most?

a. Education/Outreach support

b. Management support

c. Technical/Scientific support

Other

Which primary section of the Water Atlas contains the features you use most?

a. Mapping

b. Analysis

c. Learn

d. Participate

Other
How often do you access the Water Atlas?

a. More than once a week
b. Once a week
c. 2-3 times a month
d. Once a month
e. Less than once a month
f. Never

How often do you access features under the mapping section?

a. More than once a week
b. Once a week
c. 2-3 times a month
d. Once a month
e. Less than once a month
f. Never
How often do you access features under the participate section?

- a. More than once a week
- b. Once a week
- c. 2-3 times a month
- d. Once a month
- e. Less than once a month
- f. Never

On your organization’s website, where do you refer visitors to the Water Atlas?

- a. On the main home page for the organization
- b. On a department/division page
- c. Nowhere
- d. I don’t know
- Other [ ]
Please respond to the following statements using the following scale: (1 strongly disagree
- 5 strongly agree, n/a)

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<thead>
<tr>
<th>Statement</th>
<th>1</th>
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<th>3</th>
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<th>5</th>
<th>n/a</th>
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<tbody>
<tr>
<td>1. I feel familiar with the features of Water Atlas</td>
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<td>2. The Water Atlas is easy to use</td>
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<td>3. I understand now Water Atlas was developed</td>
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<td>4. The Water Atlas data are reliable and accurate</td>
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<td>5. I am satisfied with the amount of data available on the Water Atlas</td>
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<td>6. The Water Atlas helps me make better decisions within my organization</td>
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<td>7. The Water Atlas addresses my needs and concerns</td>
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<td>8. My input was solicited for the design of the Water Atlas</td>
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<td>9. My input was assimilated into the design of the Water Atlas</td>
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<td>10. This technology has a role in my decision management practices</td>
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<td>11. This technology is useful for educational outreach</td>
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<td>12. It is important for the community to have access to the information provided by the Water Atlas</td>
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<td>13. Effective water resource management is a priority at my organization.</td>
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<td>14. Sharing and compiling data from multiple organizations is important in water resource management</td>
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15. Having access to other organizations' data through Water Atlas helps me make better decisions within my organization.
Appendix B: Informed Consent Document - Survey

Informed Consent to Participate in Research
Information to Consider Before Taking Part in this Research Study

Pro # 00024599

Researchers at the University of South Florida (USF) study many topics. To do this, we need the help of people who agree to take part in a research study. This form tells you about this research study. We are asking you to take part in a research study that is called: Decision Support Systems for water management: Investigating stakeholder perceptions of system use. The person who is in charge of this research study is Gabriella Balsam. This person is called the Principal Investigator.

Purpose of the Study
The purpose of this study is to gather information on the ways in which the Water Atlas facilitates decision-making and public outreach.

Why are you being asked to take part?
We are asking you to take part in this research study because you are a stakeholder in the Water Atlas. As part of an organization that funds the Water Atlas, the feedback you provide will serve as data for perceptions and uses of the Water Atlas.

Study Procedures
If you take part in this study, you will be asked to complete an online survey through the website Qualtrics. The data collected through the survey will remain anonymous.

Alternatives / Voluntary Participation / Withdrawal
You have the alternative to choose not to participate in this research study.

You should only take part in this study if you want to volunteer; you are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study.

Benefits and Risks
We are unsure if you will receive any benefits by taking part in this research study.
This research is considered to be minimal risk.

Compensation

Social Behavioral  Version 1  Version Date 12/28/2015
We will not pay you for the time you volunteer while being in this study.

Privacy and Confidentiality

We must keep your study records as confidential as possible. It is possible, although unlikely, that unauthorized individuals could gain access to your responses because you are responding online.

Certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are:

- Gabriella Balsam – Principal Investigator
- Kamal Alsharif – Advising Professor
- The University of South Florida Institutional Review Board (IRB).

It is possible, although unlikely, that unauthorized individuals could gain access to your responses. Confidentiality will be maintained to the degree permitted by the technology used. No guarantees can be made regarding the interception of data sent via the Internet. However, your participation in this online survey involves risks similar to a person’s everyday use of the Internet. If you complete and submit an anonymous survey and later request your data be withdrawn, this may or may not be possible as the researcher may be unable to extract anonymous data from the database.

Contact Information

If you have any questions about your rights as a research participant, please contact the USF IRB at 974-5638. If you have questions regarding the research, please contact the Principal Investigator at gbalsam@mail.usf.edu or (407)222-7025.

We may publish what we learn from this study. If we do, we will not let anyone know your name. We will not publish anything else that would let people know who you are. You can print a copy of this consent form for your records.

I freely give my consent to take part in this study. I understand that by proceeding with this survey that I am agreeing to take part in research and I am 18 years of age or older.

https://gtrial2015g4az1.az1.qualtrics.com/SE/?SID=SV_bjAho7cBk5TR6h
January 5, 2016

Gabriella Balsam
School of Geosciences
Tampa, FL  33612

RE: Exempt Certification
IRB#: Pro00024599
Title: Decision Support Systems for water management: Investigating stakeholder perceptions of system use

Dear Ms. Balsam:

On 1/5/2016, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45CFR46.101(b):

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Approved Items:

Protocol Version #1 12.28.2015

balsam-informed-consent-2.docx

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF HRPP policies and procedures.

Please note, as per USF HRPP Policy, once the Exempt determination is made, the application is closed in ARC. Any proposed or anticipated changes to the study design that was previously declared exempt from IRB review must be submitted to the IRB as a new study prior to initiation of the change. However, administrative changes, including changes in research personnel, do not warrant an amendment or new application.
Given the determination of exemption, this application is being closed in ARC. This does not limit your ability to conduct your research project.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[Signature]

John Schinka, Ph.D., Chairperson
USF Institutional Review Board
March 8, 2016

Gabriella Balsam
School of Geosciences
Tampa, FL 33612

RE: Expedited Approval for Initial Review
IRB#: Pro00025490
Title: Decision support systems for water resource management: Investigating stakeholder perceptions of system use

Study Approval Period: 3/8/2016 to 3/8/2017

Dear Ms. Balsam:

On 3/8/2016, the Institutional Review Board (IRB) reviewed and APPROVED the above application and all documents contained within, including those outlined below.

Approved Item(s):
Protocol Document(s):
Protocol Version #1 3.2.16

Consent/Assent Document(s)*: Granted a waiver of documentation
Balsam Verbal Informed Consent

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s). Coversheets are not stamped.

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110. The research proposed in this study is categorized under the following expedited review category:
(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your study qualifies for a waiver of the requirements for the documentation of informed consent as outlined in the federal regulations at 45CFR46.117(c) which states that an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either: (1) That the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting from a breach of confidentiality. Each subject will be asked whether the subject wants documentation linking the subject with the research, and the subject's wishes will govern; or (2) That the research presents no more than minimal risk of harm to subjects and involves no procedures for which written consent is normally required outside of the research context. (Consent form).

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[Signature]

Kristen Salomon, Ph.D., Vice Chairperson
USF Institutional Review Board
Hello,

My name is Gabriella Balsam. I am a graduate student in Environmental Science & Policy at the University of South Florida conducting a research study about the ways in which the Water Atlas facilitates decision-making and public outreach (eIRB#24599). Would you be willing to participate in a brief 20 minutes telephone interview with me in order to finish my thesis? We are asking you to take part in this research study because you are a stakeholder in the Water Atlas. The feedback you provide will serve as data for perceptions and uses of the Water Atlas. All data and quotes used in my research will be totally anonymous, and you may end the interview at any time.

If you have questions, please feel free to email me at gbalsam@mail.usf.edu or call at 407-222-7025. If you choose to participate, please email me at gbalsam@mail.usf.edu to select a date and time that would work best for you.

Thank you,
Gabriella Balsam
Appendix F: Verbal Interview Consent Document

Script for Obtaining Verbal Informed Consent

Researchers at the University of South Florida (USF) study many topics. To do this, we need the help of people who agree to take part in a research study. We are asking you to take part in a research study that is called: Decision Support Systems for water management: Investigating stakeholder perceptions of system use.

The person who is in charge of this research study is Gabriella Balsam. This person is called the Principal Investigator.

We are asking you to take part in this research study because you are a stakeholder in the Water Atlas. As part of an organization that funds the Water Atlas, the feedback you provide will serve as data for perceptions and uses of the Water Atlas. The purpose of this study is to gather information on the ways in which the Water Atlas facilitates decision-making and public outreach.

If you take part in this study, you will be asked to take part in a brief one-time phone interview about your thoughts on the Water Atlas. This interview will last approximately 20 to 30 minutes. With your permission, the interview will be recorded and stored on a secure computer accessed only by the principal investigator. These files will be kept for a 5-year period, after which they will be destroyed.

You have the alternative to choose not to participate in this research study.

You should only take part in this study if you want to volunteer and should not feel that there is any pressure to take part in the study. You are free to participate in this research or withdraw at any time. There will be no penalty or loss of benefits you are entitled to receive if you stop taking part in this study.

This research is considered to be minimal risk.

We do not know if there is any benefits to participating in this study.

We will not pay you for the time you volunteer while being in this study.

We must keep your study records as confidential as possible. We may publish what we learn from this study. If we do, we will not let anyone know your name. We will not publish anything else that would let people know who you are. However, certain people may need to see your study records. By law, anyone who looks at your records must keep them completely confidential. The only people who will be allowed to see these records are:
• The research team, including the Principal Investigator, the Advising Professor, and all other research staff.
• Certain government and university people who need to know more about the study. For example, individuals who provide oversight on this study may need to look at your records. This is done to make sure that we are doing the study in the right way. They also need to make sure that we are protecting your rights and your safety.) These include:
  • The University of South Florida Institutional Review Board (IRB) and the staff that work for the IRB. Other individuals who work for USF that provide other kinds of oversight may also need to look at your records.
  • The Department of Health and Human Services (DHHS).

If you have any questions about this study, you can contact the investigator Gabriella Balsam at 407-222-7025. If you have question about your rights as a research participant please contact the USF IRB at 813-974-5638.

Would you like to participate in this study?
Appendix G: Interview Guides

**Informants from funding organizations**
How would you describe the typical responsibilities of your job, and how do you implement the Water Atlas into the work you do?

What is the primary purpose of implementing Water Atlas in your organization, and has it changed since you started using it?

What are the benefits of using Water Atlas?

What do you discuss with other organizations and Water Atlas staff in regards to Water Atlas? How are these discussions typically initiated, and do they improve program use?

Do you think actions taken within your organization are more scientifically sound/accurate because of the Atlas? Does it help prioritize actions? If so, how?

What do you consider some of the drawbacks of using a program like Water Atlas?

Is there anything you would change to improve its functionality or better meet your needs? If so, what would it be?

What do you think is the most important factor for successful implementation of a program like the Atlas?

**Informants from Water Atlas staff**
What are the typical responsibilities of your job?

What do you consider to be the main goals of the Water Atlas? Have they changed over the years?

When developing a new Atlas, what are the typical features and/or expectations that organizations are looking for? Do these tend to change over time?

What types of things are discussed when communicating with funding organizations, and how are those discussions typically initiated?

What do you think is the most important factor for successful implementation of a program like the Atlas?

What are the most difficult aspects of running the Water Atlas?

Are there any plans right now to improve its functionality? Is there anything you would like to improve about it?