RESERVOIR MANAGEMENT
PROJECT ID: CEEN_2018CPST-DR-005

by

RBB Engineering
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A Capstone Project 30% Completion Report

Submitted to

Fidel Perez
INDHRI

Department of Civil and Environmental Engineering
Brigham Young University

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Executive Summary

PROJECT TITLE: RESERVOIR MANAGEMENT
PROJECT ID: CEEn_2018CPST_005
PROJECT SPONSOR: INDRHI
TEAM NAME: RBB Engineering

The goal of this project is to assist INDRHI with managing its reservoirs. Our clients will deploy our solutions to the employees that work at the dams, reservoirs or other relevant stations around the country. The people that will use these tools will need to make daily operation decisions for their water resources. Usually, the users will not be engineers or have similar technical training. Consequently, we have made understanding the jobs and needs of the end users a primary concern to guide our decision-making process. Based on prior work and assessments made with INDRHI, we will try to improve their management practices in three areas.

The first area centers on their data management system. The ability to collect, analyze, and share data is crucial to any management project. This will naturally be the first priority for the project since any other action will depend on the availability of data. The dams and other stations used by INDRHI record data about the reservoirs on a regular schedule. That data doesn't get shared in a way convenient for use in a tethys app. We will develop a way to facilitate this sharing.

The second area involves improvements to the existing app used to manage reservoirs called "Herramientas de Operaciones de los Embales." The primary goal of this section is to make the app compatible with the improved data management process from the first area. Ideally this is automated such that the user no longer needs to manually enter data. The app would always have access to the most available data so that the monitoring is close to real time. Additionally, the app needs improvements to the user controls and the display. The current app relies on the user to manually enter data for many time periods and variables. The improved user interface should automate that step to ensure accuracy, improve usability and streamline the interface. INDRHI has also requested that the improved app have better visual representations of the data rather than only primarily data tables. Some ways this may be accomplished include providing cross sectional views of reservoirs, adding graphs, or improving the map section of the app.

The third area is to design a tool to forecast changes in water level in each reservoir based fluctuating demands and forecasted inflows to the reservoir. This will most likely be handled by a spreadsheet to provide an additional method for managing reservoirs outside of a web app. A spreadsheet is ideal because it is easy to use, easier to edit than a web app, and doesn't require extra software and cost to use.

These project goals will evolve as our team better learns the needs of the end users and INDRHI officials. While we believe these areas are mostly likely to be beneficial and feasible, we anticipate revisions to these goals as the project unfolds. We will consider the project successfully complete upon implementation of our improvements to their reservoir management capabilities in these or other requested areas.

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Introduction

We have been assigned to improve the water management capabilities of the Instituto Nacional de Recursos Hidaulicos (INDRHI). Our initial project description included three primary areas. First, updates and improvements to an existing web app used for reservoir management, Herramientas de Operaciones de los Embalses (Management of Reservoir Operations). Second, developing a spreadsheet that performs similar functions to the app in a portable, offline format. Third, implementation of some system to facilitate regular data transfer between reservoir computer systems and the apps and spreadsheets we develop. During this semester our work consisted primarily of researching reservoir related concepts and previous work and correspondence with INDRHI. As our understanding of the project improved, the three areas of focus initially developed were modified as follows.

1. Our plans for the app were defined when we received a list of requests for changes to be made to the app and access to the source code for the app. The app needs to have functioning pages for each reservoir. There should be different levels of access to the app so that only some people can put in the newest reservoir information.
2. It was requested that the spreadsheet also generate reports with paragraphs, tables, and graphs of the information shown. These reports will be used by officials of INDRHI in national planning meetings over water resources.
3. The data needed for apps is already available online through web pages. We simply need to streamline the process of collection and make a list of where to get the data online.

Schedule

Our project has been divided into two main work periods, before and after the trip to the Dominican Republic. The trip in January 2018 will allow us to visit with INDRHI officials. There will be able to make presentations regarding all work we have completed up to that point. We will also receive guidance as to how are project/progress will directly meet the needs of INDRHI. To prepare for our trip, we have researched and developed initial concepts of our ideas for presentation and discussion.

Post trip will consist of the majority of our project work through its completion. We will take that time to create our final project meeting the proper specifications and instruction identified by INDRHI officials so that our project is most valuable to them.

Weekly Work Schedule:
It is anticipated that three hours per team member will be contributed on average per week during the Winter Semester. During Fall it is anticipated nine hours will be contributed by each team member.

Winter Semester Schedule:
1. Class: 3pm-4pm on Monday, Wednesday, Friday
    a. Most of this time will be devoted to group work and planning.
2. Individual work
    a. Approximately 6 hours of individual work are anticipated in addition to the hours of group work.
3. Study abroad trip dates
    a. Friday January 25 – Sunday February 3

Assumptions & Limitations

We have plans to develop a basic rule curve, in addition review other rule curve graphs already in use by INDRHI officials. At this stage we also understand a rule curve may not be necessary part of this project. However, if so the overarching goal of this rule curve is to designate the region which the water level should remain each month. This display will primarily be used on bulletins to be distributed amongst INDRHI and Dominican Republic governmental officials. The rule curve constructed shows the minimum and maximum levels to which the reservoir must be maintained and not exceed. For our inflow variable we are taking precipitation and stream runoff into consideration. For our outflow we are using demand data given to us by our sponsor over a specified period of time. These specific demands consist of irrigation and city needs downstream. We are disregarding evaporation in our outflow for simplicity, leaving the ability to add that in the future, or otherwise instructed to report it in this project. Demand outflow data will also be used to make a spread sheet for future predictions. The development of this rule curve is not all inclusive. It will not show specific demands separated by priority like more traditional rule curves provide. At this stage it will show all that has been described with potential to change as needs of the project change or asked for.

ACCRUACY of the streamflow prediction tool- estimates how much water is coming in
Sedimentation behind the dams could change accuracy of levels over time

Design, Analysis & Results

In the beginning of this project we began determining the variables our sponsor wanted to track, record, and predict. After our first initial meeting with our sponsor it was determined we should know maximum and minimum water levels for each reservoir. These values would help them compare their current water levels to max/min level. Having this data accessible is the first step in analyzing future outflow rates. It allows one to conserve sufficient water to meet demands during dry seasons, as well as not reach maximum levels causing flooding during rainy season.

Some important variables to our design include downstream demand and inflow values to each reservoir. These values would be used for future predictions. Currently these numbers have not been acquired from our sponsor. Additionally, we are using inflow data from a previous team in the past. We have been in communication with our sponsor and are working on a plan that will allow us to get this information more consistently with little effort on both ends. In project meetings with an INDHRI official it was discussed we could potentially have access to a link that projects reservoir data daily via Scada technology. We are in the process of making this resource a reality for us, and if not in this manner, obtain the data by another means. By completing this data step, we will be able to move on to the creation of our model and prediction tools. The tools include in app graphics displaying current water levels with the maximum and minimum water levels required for each reservoir. In addition, a spreadsheet that reports pertinent reservoir data information for Dominican Republic officials, as well as make future predictions according to future demand rates.

Figure 1.1 (below) is an example of what this spread sheet will look like.

Figure 1.1 (Reservoir Management Spreadsheet)

Lessons Learned

During the course of this project, our team has run into a few challenges. In the beginning, the scope of our project was almost non-existent. We had a general idea of what our project could potentially entail but there were no certainties and no guidance as to what we should prepare for. For the first few weeks we focused our time and effort on the Tethys program as well as the reservoir management app. Later as we gathered more information, we found that our efforts were to be focused on creating a spreadsheet to accurately display data and create a bulletin for essentials with non-technical backgrounds. This dilemma could be avoided in the future with a better communication process. Though it was difficult to get in touch with our project manager, seeing as he is stationed in another country, we could have done a better job at keeping in touch with our advisers here on campus. We could have let them be more involved in the planning process to make sure we were on the right track. This is a lesson learned and we will practice better methods of communication in the future.

The other challenge involved our planning process. In the initial weeks of our project, we planned times to meet together as a team with a text message only moments before we met. This proved to be difficult because at times one of us would be too busy to meet at that moment. So that left only two of our team members available to met and the other was to be filled in at a later time. During the fourth week of the semester, we set up a schedule on google docs. We planned out times and days that we could meet as a team for the coming week. Additionally, we kept track of what we talked about during each meeting. This was extremely helpful and time saving. We functioned better as a team and became more efficient with our time during those meetings. This is a lesson learned and we will continue to plan efficiently and keep records of the meetings we have.

Conclusions

Currently our team is stepping into the data gathering/design phase of our project. We have not drawn any specific conclusions. As we continue into the next phases of our project, the design phase, and complete our project we look forward to be able to make appropriate conclusions that will help INDHRI officials better manage their reservoirs.

Recommendations

At the current project stage, we make the following recommendations.

1. Being to collect the links generated daily so there is a database of available information. The apps and spreadsheets that will be in development next semester could be programmed to automatically retrieve information from these websites. Having a database of sample websites to attempt retrieval from would make the development of that feature simpler.
2. Collect a variety of additional reports showing multiple days, formats, and data types relevant for these reports. After the core functionality of the app or spreadsheet is available, many templates can be created for these programs to automatically generate. The better our team understands the purposes and formats of these reports, the better we can create templates that are automatically generated.
3. Provide rule curves, capacity information, and operating levels for each reservoir. In addition, provide any other information that would be helpful to INDRHI personal if it were available in the products in development e.g. construction year of a dam.

Appendix A

Briana Ihrke

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Education

Brigham Young University - Civil Engineering Estimated Graduation Date: April 2020

- GPA: 3.5
  - Minor in Mathematics

Work Experience

Kimley Horn and Associates – Analyst May 2018 – September 2018

- Assisted the Land Development Department with creating and editing grading plans
- Put together Erosion Control Plans and Demolition plans for onsite and offsite improvements
- Worked with over 10 cities to retain permits and applications for grading plans
  - Provided assistance on over 40 different projects ranging from small site to large site development

Anderson Engineering – Engineering Technician May 2017 – August 2017

- Assisted the Structural Engineering Department with dimensional analysis of towers
- Performed annual condition assessments of cell phone towers.
- Provided the Environmental Engineering Team with photo documentation and biological assessment of hazardous waste sites.
- Organized and digitized archived Utah Voluntary Cleanup Program documents.

Volunteer Experience

The Church of Jesus Christ of Latter-day Saints – Volunteer Representative July 2014 – Dec 2015

- Worked 12+ hour/day, 6 days a week).
- Learned how to set goals, and make and execute plans.
- Taught and created lesson plans for ESL class
- Positively represented an organization of over 16,000,000 members

Skills

- Comfortable with 3D LIDAR scanning
- Proficient in AutoCAD and Civil 3D
- Fluent in Spanish

Riley Hales

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rileyhales1@gmail.com Provo UT 84606

Education

Brigham Young University - Provo, Utah Graduation December 2019

- BS Civil and Environmental Engineering, **GPA 3.4**

Work Experience

BYU Hydroinformatics Lab – Research Assistant April 2018 – Present

- Computational, global scale **hydraulic modeling** using custom geospatial software (Tethys)
- Researched funded by **NASA, JPL, United Nations** Group on Earth Observations (UN GEO)
- Developed app to predict, track endemic disease across Africa, recommend solutions
- **Web App** development in **Python** and **Javascript** – some **HTML, CSS, Django, Visual Basic**

BYU Geomatics (GIS and Surveying) Teaching Assistant May 2017 – May 2018

- Personally **developed 13 lab assignments** and **Final Exam** to teach surveying and GIS skills
- Developed and presented in lab sections on GIS skills in **ESRI's ArcGIS** software package
- Responsible to grade assignments, input grades, teach review sessions

RCH Engineering PLLC – Founder January 2018 – Present

- **Consultant** for IT services, website management, technology to Arizona businesses
- Produced **CAD** models and renderings of proposed building interior, exterior renovations
- Independently seek jobs, quote prices, **manage business relationships** with professionals

Kevin Rose Professional Cleaning Services April-August 2014

- **Independent contracted** to clean homes, businesses, restaurants to professional standards
- Personally **represented the company** to business owner clients and managed their accounts
- Trusted with building keys, alarm codes, safe combinations, sensitive information

Volunteer/Service Experience

ASCE Officers- BYU Student Chapter (Networking Committee) April 2018-Present

- Plan, coordinate networking events with engineering companies, students, BYU
- Volunteer service to local K12 schools and after school programs promoting STEM
- Spent several hours per week planning and/or hosting events to serve other students

BYU Concrete Canoe Team August 2017-Present

- Participated in team that designed concrete mix to meet project standards and requirements
- Prepared, poured, cured concrete used in competition at regional and national ASCE competitions

Volunteer Missionary (Church of Jesus Christ of Latter-Day Saints) Jan-Dec 2015

- Unpaid, Full-time, representative of an international church and its practices in North Italy
- Responsible for daily interactions with diverse cultures, languages, religions, educations

Notable Achievements and Skills

- Computers: Python, Java, Microsoft Office, Visual Basic/VBA, Web Sites/Apps, Hardware Repair
- GIS and Geospatial modeling, especially ESRI products including ArcGIS, arcpy, modelbuilder
- Ethical, Dependable, Team Player, Self-Motivated, Organizational skills
- Boy Scouts of America- Eagle Scout, 3 palms, 2 years in local unit leadership while a scout
- Multilingual- English, Spanish, Italian

Benjamin Laddie Gray

(817) 550-7511 • benjaminlgray1@gmail.com

» Education

Bachelor of Science, Civil Engineering**,** *Brigham Young University* **December 2019**

Provo, UT

- GPA 3.42/4.00
- ASCE member - 2 years

» Professional Experience

Construction Intern, *Geneva Rock, Orem UT* **May 2017 – Present**

- Prepares bid estimates, attends pre-bid meetings, and assists project manager through project lifespan.
- Assists construction crews regularly to develop an understanding of horizontal construction projects. u.

Asset Management Intern, *Central Utah Water Conservancy District, Orem UT* **September 2017 – May 2017**

- Assisted in routine inspection documentation onsite at water treatment plants.
- Collaborated with 5 area/water treatment managers to update asset conditions in each managers' stewardship.

Intern, *Jones and Associates Consulting Engineers, Ogden UT* **May 2017 – September 2017**

- Site inspector for two new subdivision projects in the city of Perry and Wellsville.
- Surveyed, using GPS unit, all storm drains and sewer utilities in South Weber and Washington Terrace.
- Organized and reduced the entire GIS database for the city of Washington Terrace.

Teachers Assistant, *Sustainable Infrastructure, Provo UT* **December 2016 – May 2017**

- Responsible for maintaining 80 student grade calculations and updates using excel and school software.
- Developed student understanding of political, social, and economic factors regarding infrastructure projects.

Owner/Operator, *Laddie's Lawn Service***,** *Arlington, TX* **April 2015-December 2015**

- Built a client base from 0-50 by providing reliable and superior lawn services.
- Acted as CFO by preparing payroll, tax statements, and financial analysis of the company.
- Supervised, trained, and evaluated 3 employees.

» Leadership Experience

Volunteer Coordinator, *2016 National Student Steel Bridge Competition* **February 2016 – June 2016**

- Enlisted, trained, and managed 44 volunteers.
- Oversaw weekly committee meetings reviewing goals, deadlines, and address upcoming tasks.
- Delegated responsibilities amongst committee members and followed-up to ensure effective results.

Volunteer Representative, *LDS Church***,** *Denver CO* **April 2013- April 2015**

- Led groups of 28+ volunteers focused on reaching specific personal and team goals.
- Trained volunteers on problem solving, goal setting, planning, teamwork, and effective communication.

» Skills/Accomplishments

- Extensive experience using ArcMap, ArcCatalog, Excel VBA programming, and Trimble Business.
- Exposure to AutoCAD, Revit, EPAnet, and AutoCAD Storm Drain design.
- Experience in land surveying using a total station and GPS unit.
- 2nd Place - Mystery Design Competition Rocky Mountain Regional Conference 2016
- Fluent in Spanish
- Eagle Scout Award - 2010