NAU CENE 476

Fall 2017

Final Proposal for San Simon Basin Dam Evaluation

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Table of Contents

List of Tables

List of Figures

Abbreviations

- AA - Administrative Assistant
- ANSI - American National Standards Institute
- ANS - American Nuclear Society
- AO - Area of Operation
- BLM - Bureau of Land Management
- DBA - Dam Breach Analysis
- EIT - Engineer in Training
- GIS - Geographic Information System
- HEC-RAS - Hydrologic Engineering Center's River Analysis System
- ISC - Industrial Source Complex Model
- Lab - Lab Technician
- OST - On Screen Takeoff
- PE - Project Engineer
- SENG - Senior Engineer

1.0 Project Understanding

The San Simon Basin in southeast Arizona near the city of Safford is requesting a dam-breach study for failure. In this project, the main challenges include economic evaluation, community flood safety impact, and a dam breach failure evaluation. The team will need to consider the main function of the original dam structure, the water flow rates of the basin, and the downstream affected municipalities. If the dam fails, the reduced functionality of the system will negatively affect the local communities including ecology, the property of residents, and the impact on local agricultural cultivation.

Figure 1. Location of Safford, AZ on map of Arizona [1].

1.1 Project Background:

The San Simon Basin dam system is currently categorized as medium to low-hazard dam system. The design purpose includes flood control, sediment control, and to prevent damage to nearby infrastructure. The dam system needs to be reassessed to ensure that the medium to low-hazard rating is still accurate and that is doesn't need to be moved up to a high-hazard dam.

1.2 Stakeholders

The stakeholders involved in the San Simon Basin dam breach analysis are the Bureau of Land Management, the local town community, Northern Arizona University, and the student engineers involved in the project. Specific staff members at NAU include the Technical advisor Wilbert Odem, and Project advisor Mark Lamer. The Technical advisor agreement can be seen in Appendix #A. The local community involves the flood basin affected farmers, the residents of Safford, Arizona, and the motorists of the local highways and roadways. Northern Arizona University is helping to fund this project for the student engineers involved, so liability to complete the project as the Bureau of Land Management's request will affect both Northern Arizona University and the student engineers involved.

2.0 Scope of Work

BLM has contacted NAU to perform a DBA on the San Simon Barrier Dam in the dam system, and report the results. The final report back to BLM shall include a comprehensive presentation by the engineering team, an analytical report, and a website containing all needed information. The different portions of work to be done over the course of the project have been broken down into tasks and subtasks.

2.1 Task 1: Field Investigation

During the field assessment one of the major tasks is for the team to familiarize themselves with the area. To get a feel for the kinds of soils, terrain, and the conditions of the dam and channel. This step will result in various notes and pictures of the area to be referred to for future needs in the project. Another item of interest is the roughness of the surrounding terrain and the likely Manning's coefficient that can be attributed to that terrain. This will be used for HEC-RAS, but is also needed for overland flow, flood plain analysis, and infiltration rates. A small amount of surveying of the dam structure itself will also be conducted while on site.

2.2 Task 2: Hydrology

The hydrologic data shall include the expected rainfall depth and intensity for a 100-year storm in the area. It will also include expected infiltration data and expected time for water to travel from one end of the floodplain to the other, to find the duration of storm to be analyzed. The overland runoff flow determined from this step will be used to run the DBA in the HEC-RAS model later in the project.

2.3 Task 3: Hydraulic Analysis

The background data will be acquired and checked, reserving any data points or variables that may be needed to analyze the results or refine the conclusion that are not clear at this time. The modeling will result in multiple functioning one-dimensional HEC-RAS models that can be viewed in multiple stages of a large flow. This task will provide expected depth of flow for the DBA in the area downstream of the dam that can be used later to evaluate possible sources of property damage [2].

2.3.1 Geometric Parameters

The dam structure will be surveyed during the field visit down to the project site in order to determine the necessary dimensions of the structure. The channel and nearby agricultural fields will be determined using topographic data from the area.

2.3.2 Routing and Reservoir Effect

The initial phase of breaking down the survey and topographic data will be to look for locations where the flow of flood waters will most likely follow, and where pooling will occur. The areas

where pooling does occur or the flow of floodwaters seems to head in a different direction must be subtracted from the overall flood flow later on.

2.3.3 Dam Breach Failure Method and Parameters

The San Simon Barrier Dam is an earthen style sediment structure with an L-shaped earth structure surrounding a concrete baffle-block transition section. There are two possibilities for failure in an earthen style dam, overtopping and piping.

2.3.3.1 Piping Failure

Piping failure occurs in an earthen dam style dam when internal erosion of the dam structure begins to occur. This causes a ‘pipe’ to form in the dam structure causing the top of the dam to eventually slip down and be washed away.

2.3.3.2 Overtopping Failure

Overtopping failure occurs in an earthen dam structure when the headwater in front of the dam exceeds the overall lip height of the dam structure, resulting in the water overtopping the crest. This leads to the floodwaters rushing over the dam and eroding the back face of the dam, resulting in catastrophic failure.

2.3.4 Peak Flow Estimation

The peak flow estimation will be based off an assumed 100-year storm event which will be determined during the hydrologic portion of the analysis [2]. The peak flow will take into account the runoff and infiltration rates of the local area as well as natural friction sources from in the environment.

2.3.5 Steady Flow Analysis

The first test of the HEC-RAS model will be using a steady flow in order to verify that the model is operating correctly under normal conditions. This mode will be run several times to ensure the model is in working order for the simulated flood event flow.

2.3.6 Unsteady Flow Analysis

The unsteady flow analysis will be conducted as simulation of the flood event flow. The results from these models will be used for the economic analysis later in the project.

2.3.7 Sediment Transport Analysis

The San Simon Barrier Dam and the other local erosion controlling structures have been reported to be partially buried in loose sediment material. During the storm event the massive amounts of flood water will pick up loose sediment and spread it over the affected flood area, resulting in large damages.

2.3.8 Flood Map - Severity Index

A map of the total flood area will be created which will include all of the local land that has been affected by the flood waters. The map will later be overlaid with a depth of floodwater severity index that will easily identify the worst affected areas.

2.4 Task 4: Socio-Economic Impacts:

The dam basin system is located just outside the city limits of Safford, AZ leading to concerns about floods and resulting economic damage for the city and surrounding agricultural land, in the event of a dam failure. The team must determine if a flood and dam breach does occur and will the damage be contained to the farmlands outside of Safford, or will the water cause damage inside the city limits. This requires not only the results of the analysis previously discussed but also topographic and economic data about Safford and the buildings and land in the area.

2.4.1 Socio- Economic Impacts: Define Flood Concern Area

This task is heavily impacted by the floodplain analysis from the HEC-RAS model previously discussed. The flood area determined in the second step of the model will be used for this concern area. This area will be any place that is determined to have more than 1in of water above the soil surface. These areas will be laid over a map and formed for each flood situation. These will later be combined to predict the worst possible and most extensive area of concern.

2.4.2 Socio-Economic Impacts: Considered Loss sources

Within this area an inventory of all structures, sources of income, and pieces of infrastructure will be accounted for. These structures will the be examined and evaluated for their importance in the analysis as not all structures damaged or destroyed by the flood are to be evaluated and counted. The structures will only be assessed for water damage during this step, no other further damage assessment will be necessary. Then once all possible loss sources are identified for the area, they shall then be researched, and an expected damages cost will be associated with the structure.

2.4.3 Socio-Economic Impacts: Map of AO including Districts and types of Structures

For this task, a topographic map of the area is to be created. This will include all areas affected by the resulting DBA. While the topographic map is created, two more maps will be designed and evaluated. One will contain information about the percentage of loss sources within a section and the other map shall include the areas that will be affected by flow and the expected depth of the flow above ground at those areas. All three of these maps can be overlaid and compared to establish the total cost of damages and the areas to expect damage. The map will also provide relative depths in specific areas, allowing research into the extent of the injuries in those areas.

2.5 Task 5: Project Deliverables:

2.5.1 Project Deliverables: DBA report

The deliverables produced from this project will be a finished DBA report including damages and the damage impact area in Safford, AZ. This report will be grouped with a comprehensive website containing all of the project information and all useful research documents used on the project. This can help future teams continue the San Simon basin project and expand the scope of the project to meet more BLM requests. A final in-person presentation will be provided at the conclusion of the project that will include all resulting data and findings.

2.5.2 Project Deliverables: Presentations

A final presentation shall be performed in May of 2018 to showcase for the client the results of the analysis. This presentation shall be approximately fifteen minutes long and contain a question and answer section as well as a full explanation of the project and the methods used to analyze the data.

2.6 Task 6: Project Management:

Project management is throughout the project's life and it is to meet the needs of the project as they come up. Management includes holding meetings, organizing presentations, and other major tasks. Project management is the use of a variety of related skills, methods, and tools to meet or exceed the requirements of the project stakeholders [2].

2.6.1 Project Management: Meetings

Project meetings will be coordinated and performed by the engineering team, the teams grading instructor, the team's technical advisor, and BLM contacts. This continuous communication between multiple parties shall ensure a favorable product for all groups.

2.7 Project Limitations

The major limitations for this project stem from the condensed time frame of the project as well as the lack of experience of the engineering team. The lack of experience of the engineering team is because the engineers are still students and the relatively narrow field of specialties of the engineers. These limitations are part of the factors that dictate both the challenges and expected exclusions of the project scope.

2.7.1 Challenges

The challenges facing this project are mostly a result of lack of experience for the engineering team. These challenges include but are not limited to cost estimation and use of the analysis software. The software limitation will arise from most of the team learning the software as they progress and any limitation to the software available through NAU. The estimates made will be based on the resulting area analyzed below the flood and the average costs of similar structures in Arizona, they will not include or account for all possible details or any error in the data.

Another major challenge will be performing this project in the desired time frame while working around all involved groups schedules.

2.7.2 Exclusions

There shall be no analysis of contaminants of any kind analyzed for this project. There will also be no analysis of the structure of the dam or the likelihood of its failure, only the results of the said failure will be analyzed. There will be no dam removal costs considered for this project. The project will not compare the cost of dam repairs, dismantlement, or reconstruction. There shall be no surveying, or other forms of field data collection performed by the engineering team and all data shall be sourced secondhand. The engineering team maintains the right to exclude other project complications that may be unforeseen if the future exclusions are made on reasonable terms and are outside the experience of the engineering team.

3.0 Project Schedule

The San Simon DBA project began in the Fall 2017 semester and will continue into the end of the school year in the Spring of 2018. The overall schedule has been divided into four portions in order to ensure the engineering team stays on the project's critical path as well as to give short term deliverables for the team. The four sections of the project are divided into data collection, the HEC-RAS model, an economic analysis, and the final compilation. The project's critical path will follow the same breakdown starting with data collection which will be used for the HEC-RAS model. The HEC-RAS model as well as additional data will be used for the economic analysis portion and the results from all 4 sections will be compiled for the final deliverable in the Spring of 2018. A visual representation of the projects expected progression can be seen below in Figure 2, in the form of a Gantt Chart.

3.1 Data Collection

The first major task for the San Simon engineering team is to compile all of the necessary data in order to complete the analytical tasks. The first section of the project is completely dedicated to gathering all of the information needed and has been estimated to take 85 days, or from August 31st to late November. During this time the rainfall data, channel hydraulic data, channel assumptions, topographic data, and local flood prone areas for the basin must be collected and organized.

3.1.1 Project Synopsis

After the initial meeting with BLM, the engineering team began to break down the problem at hand and the local area involved in the project. This portion of data collection consisted of gathering basic project information such as the main scope of work to be completed by the engineering team, the stakeholders involved, and all other introductory necessities.

3.1.2 Hydrology Data

Local topographic areas as well as target basins are to be used along with local hydrologic data to approximate an average rainfall during a 100-year peak storm event. This rainfall approximation will be assessed by looking at the infiltration and runoff coefficients for the local

area, and assuming a very large runoff. This portion of the data collection task will take 5 days to complete and double check to ensure accurate results.

3.1.3 Hydraulic Data

The last data collection task for the engineering team will be the research real channel properties as well as come up with necessary analysis assumptions. These assumptions will need to be back checked by all stakeholders and engineers involved in the outcome of this project. These assumptions as well as real channel measurements will be used in further model steps in order to create a detailed model of the single dam structure being analyzed. This section of the data collection task will take 45 days to complete and ensure all results and assumptions are checked.

3.2 HEC-RAS Model

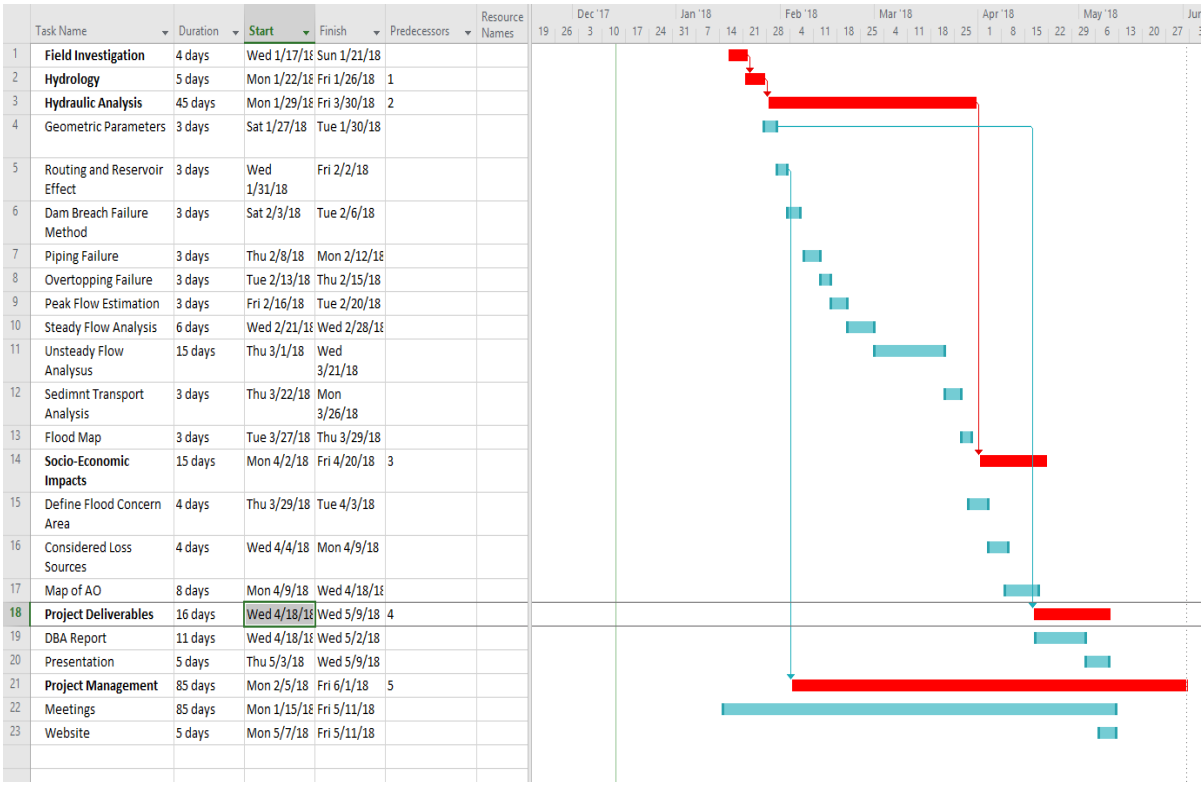
The second major task for the engineering team will be to compile all of the necessary channel data into a model representation of the basin and dam. The team will then need to run multiple simulations in order to determine the outcome of the DBA with multiple possibilities[3]. This task has been estimated to take 45 days, or from early December to mid March to model and complete all necessary simulations.

3.3 Economic Analysis

An economic analysis for the surrounding flood prone area is the next step for the engineering team. Data from the first portion of the project will be needed to determine affected flood areas as well as an estimated cost for different portions of land. However, additional research will likely need to be performed during this step of the project in order to determine a proper cost of damage if a catastrophic flooding event were to occur. This portion of the project has been estimated to take 15 days, or from mid March to mid April to complete and ensure an accurate economic model.

3.4 Final Submittal

The final portion of the project for the engineering team will be to compile all of the gathered data into a final submission document, an informational website, and a professional presentation. The final submission document is an ongoing process throughout the entire project life and will be complete along with a website containing all of the same information on the project. The professional presentation will be performed on midterm of Spring 2018 in front of professional engineers as well as engineering professors. The final portion of the project has been estimated to take 16 days, and will be worked on sporadically from now until final submission.



	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1	**Field Investigation**	4 days	Wed 1/17/18	Sun 1/21/18		
2	**Hydrology**	5 days	Mon 1/22/18	Fri 1/26/18	1	
3	**Hydraulic Analysis**	45 days	Mon 1/29/18	Fri 3/30/18	2	
4	Geometric Parameters	3 days	Sat 1/27/18	Tue 1/30/18		
5	Routing and Reservoir Effect	3 days	Wed 1/31/18	Fri 2/2/18		
6	Dam Breach Failure Method	3 days	Sat 2/3/18	Tue 2/6/18		
7	Piping Failure	3 days	Thu 2/8/18	Mon 2/12/18		
8	Overtopping Failure	3 days	Tue 2/13/18	Thu 2/15/18		
9	Peak Flow Estimation	3 days	Fri 2/16/18	Tue 2/20/18		
10	Steady Flow Analysis	6 days	Wed 2/21/18	Wed 2/28/18		
11	Unsteady Flow Analysus	15 days	Thu 3/1/18	Wed 3/21/18		
12	Sedimnt Transport Analysis	3 days	Thu 3/22/18	Mon 3/26/18		
13	Flood Map	3 days	Tue 3/27/18	Thu 3/29/18		
14	**Socio-Economic Impacts**	15 days	Mon 4/2/18	Fri 4/20/18	3	
15	Define Flood Concern Area	4 days	Thu 3/29/18	Tue 4/3/18		
16	Considered Loss Sources	4 days	Wed 4/4/18	Mon 4/9/18		
17	Map of AO	8 days	Mon 4/9/18	Wed 4/18/18		
18	**Project Deliverables**	16 days	Wed 4/18/18	Wed 5/9/18	4	
19	DBA Report	11 days	Wed 4/18/18	Wed 5/2/18		
20	Presentation	5 days	Thu 5/3/18	Wed 5/9/18		
21	**Project Management**	85 days	Mon 2/5/18	Fri 6/1/18	5	
22	Meetings	85 days	Mon 1/15/18	Fri 5/11/18		
23	Website	5 days	Mon 5/7/18	Fri 5/11/18		

Figure 2: Gantt Chart

4.0 Project Staffing

The staffing is based off of the overall expected needs of the project and the expected work required. The professionals necessary to complete this project have been selected to be a senior engineer, a project engineer, a lab technician, an engineer in training, and an administrative assistant. All five of the professions necessary will be represented by all of the NAU senior engineers at different points throughout the project life.

4.1 List of All Qualifications of All Senior Personnel

This project is being assessed by four senior level engineering students from NAU including two civil engineering students and two environmental engineering students. All of the engineers involved have experience with water related engineering projects and are capable of understanding the full scope of work to be completed. The engineers are going to fill every staff position needed by taking turns over the course of the project's life.

4.1.1 Bowei Zeng

Senior Engineering Student at NAU with an emphasis in Environmental Engineering. Experience in AutoCAD, Civil 3D, Excel, Gantt charts and total stations. Work experience includes Hainan Hongsheng Survey and Design Co., Ltd. as an assistant hydraulic engineer and Hainan Hengwei Supervision Co, Ltd. as an internship supervisor. Previous project experience consists of the

flood discharge project at Bo'ao Airport in Qionghai City and the reinforcement of Namu Reservoir in Haikou City.

4.1.2 Jinyang Lu

Senior Environmental Engineering student at NAU, with one semester of urban planning major experience as the exchange student, Chinese Bachelor Degree of Environmental Science. Skilled in basic engineering, surviving, AutoCAD, Civil 3D, HEC-RAS, Bentley FlowMaster, Bentley WaterGems, and basic environmental science knowledge. Internship in Henan provincial environmental protection department, responsible for monitoring air quality and the primary analysis.

4.1.3 Brendan Garrison

Senior engineering student at NAU with an emphasis in hydraulic engineering and project engineering. Experienced in HEC-RAS, AutoCAD, and HEC-HMS and some experience in Bentley FlowMaster, Bentley WaterGems, and NRCS Analyzer. Previous work experience includes Govis Structural Engineering in Newport Beach, California as a structural engineering intern as well as experience as a project engineering intern at Walsh Construction in Corona, California. Previous project experience includes a several hundred million dollar highway engineering project in Corona, California.

4.1.4 Mike Gallio

Senior Engineering Student at NAU with an emphasis in water transportation. Experience in HEC-RAS, AutoCAD Civil 3D, CulvertMaster, FlowMaster, Excel, and OST. Previous experience as a field surveyor at Hunsaker and Associates. Previous projects include analysis of Flint MI. water crisis, and site analysis and planning of proposed hotel water systems.

5.0 Project Services Costs

The San Simon DBA project cost will be estimated using the industry rates for professional positions. The total cost for the project has been estimated to be the sum total of the total personnel staffing costs and the total service costs. The total service costs and total personnel costs have been broken down in further sections.

5.1 Estimated Staffing Costs Break Down

The estimated cost of staffing for the project includes all of the necessary professionals including the senior engineer (SENG), the project engineer (PE), the lab technician (Lab), the engineer in training (EIT), and the administrative assistant (AA). The cost per hour for each of the professions needed is included in the second column of Table 1, with the estimated number of hours for each profession in the third column. These are both multiplied together in the fourth column and summed together at the bottom to give an estimated staffing cost of $25,887.00[3]. A break down of the hours attributed to each position by task can be seen in Appendix B.

Table 1. Personnel Hourly Break Down

	Cost Per Hour	Estimated #of Hours	Estimated Cost For Project
SENG	$194.00	38	$7,372.00
PE	$67.00	147	$9,849.00
Lab	$48.00	20	$960.00
EIT	$22.00	251	$5,522.00
AA	$56.00	39	$2,184.00
Sum			**$25,887.00**

5.2 Estimated Costs of Services

The costs of services for the project are mostly focused on the field visits needed in order to properly analyze the dam structure and local area. The field visit includes the cost of a van or similar vehicle for transport down to Safford, AZ from Flagstaff, AZ. The costs also includes all necessary equipment such as GIS units and surveying equipment and lodging costs for food and a hotel, resulting in a total services cost of $760.00. The costs of service are described in detail below with Table 2.

Table 2. Costs of Services Break Down

Item	Cost ($/unit)	Units	# Units	Cost ($)
Van Rental	80	Day	3	$240.00
Equipment	60	Day	2	$120.00
Lodging	40	Room/person/day	10	$400.00
Total				**$760.00**

5.3 Estimated Total Cost of Project

The team has estimated that for the foreseen circumstances the total project engineering costs is expected to be $26,647. In preparation for non-engineering costs that were not calculated in this proposal as well as possible unforeseen circumstances a multiplier of 1.5 was applied to this estimate leaving the final proposed cost to be $39,970.

6.0 References

[1] Best Places to Live in Safford, Arizona. [Online]. Available: http://www.bestplaces.net/city/arizona/safford. [Accessed:14-Dec-2017].

[2]P. Sharma, “Dam Break Analysis Using HEC-RAS and HEC-GeoRAS – A Case Study of Ajwa Reservoir,” Journal of Water Resources and Ocean Science, vol. 5, no. 6, p. 108, 2016.

[3] "Google Earth", Earth.google.com, 2017. [Online]. Available: https://earth.google.com/web/search/SOLOMON/@32.8141183,-109.6294831,906.067488a,2411305.53662667d,35y,0h,0t,0r/data=CnIaSBJCCiUweDg2ZDdmOTE2OTIwNmI2NzU6MHhjMTk5MmJjNTg2ZTNjOGI0GZ3JSAc1aEBAIZ_4e3NJaFvAKgdTb2xvbW9uGAIgASImCiQJ2q3xIhhWQkAR2a3xIhhWQsAZ-daj6YotO8Aha5v7I6rJYcA. [Accessed: 21- Sep- 2017].

Appendix:

Appendix A: Technical Advising Agreement:

Floater	Site visit research dam breach analysis Misc Deliverables
Data Collection	(Now - Mid/Late November) Rainfall Data for area Section 1 mile up/down stream Channel Shape analysis Topo Map of Stafford and Dam Area
Hecras	(Mid November - Mid March) Geometry Data Set Up Model 1Main Channel Set Up Model 2 Flood Plain Model Analysis
cost analysis	(Mid March -End) Define Flood concern Area Meetings to confirm how to Progress/plan List of Possible Considerations(HOuses/Buildings/Roads/?) Average Cost associated with lost (properties) Map of AO including districts and types of structures located within

Appendix B: Task and Subtask Time Breakdown:

	Staff (hrs.)					Task Total
Task	SENG	PE	Lab	EIT	AA	
Field Investigation	2	8	1	20	1	32
Hydrology	2	10	3	14	3	32
Hydraulic Analysis	3	12	3	12	3	33
Geometric Parameters	1	6	2	9	1	19
Routing/Reservoir Effect	2	10	1	14	2	29
Dam Breach Failure Methods Parameters	4	12	2	35	3	56
Peak Flow Estimation	1	8	2	12	3	26
Steady Flow Analysis	2	10	1	15	1	29
Unsteady Flow Analysis	6	20	3	40	5	74
Sediment Transport Analysis	4	10	1	15	3	33
Flood Map-Severity Index	4	15	1	20	6	46
Socio-Economic Impacts	3	10	0	18	3	34
Define Flood Concern Area	2	6	0	12	2	22
Considered Loss Sources	2	10	0	15	3	30
Map of AO With Districts and Structures	1	9	2	15	2	29
Project Deliverables	4	20	4	40	10	78
Project Management Meetings	10	10	10	10	10	50
Website	2	6	1	20	3	32
Totals	38	147	20	251	39	684