NORTHERN ARIZONA UNIVERSITY
College of Engineering, Forestry & Natural Sciences

Proposal for – Odell Dam Safety Analysis

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1. Project Understanding

The purpose of this project is to perform a safety analysis for the Odell Dam, and to provide information on whether the dam can support local flood conditions. This is due to potential changes of local rainfall conditions and the change in storm recurrence intervals for unlikely situations which may cause the dam to fail. Comprehensive geotechnical, hydraulic, structure, and hydrologic methods will be used to determine whether or not the dam is safe. All analyses performed will abide as close as possible by the Arizona Department of Water Resources (ADWR) regulations and procedures.

The team will also consider post-fire floods and debris floods as another alternative method for a cause of the dam failure. Due to the high fire hazards in the Northern Arizona region during the months prior to and after the monsoon season, accounting for post-fire floods and debris floods will be vital to the dam failure analyses.

1.1 Background and Existing Conditions

The dam in consideration is the Odell dam, located in Munds Park, Arizona. This is roughly 20 miles south of Flagstaff, Arizona.

The exact location of the Odell Dam is latitude N34°56’0.0666” longitude W111°38’0.5562” at center.

From Arizona Dams (1996), the Nation Inventory of Dams ID is AZ00156, and is considered to be of significant hazard. The dam is an earthen dam, gravity fed, and its primary purpose is the storage of water as a recreational lake. The dam’s construction was finished in 1978, and measured to be approximately 20 feet in height and 460 feet across. The dam has been deemed High Hazard Class by the 2013 State of Arizona Hazard Mitigation Plan Risk Assessment, and is defined by the “loss of life is probable and one or more is expected”, as well as economic and environmental impacts will occur if the dam fails. Thus the ADWR has determined the dam to be an “unsafe dam requiring rehabilitation or removal”.

The dam has a concrete spillway located at the south end. The spillway has rock and concrete debris larger than 1ft in diameter, thus giving a high roughness coefficient to slow down the discharge traveling through the spillway. Currently, the volume of water stored within the dam is lower than normal, which is indicated by waterlines at the shore.

1.2 Stakeholders

The client for this project is Professor Mark Lamer. However, the primary stakeholder has been determined to be the owner of the dam, Pinewood Country Club, INC. as well as anyone downstream from the dam that may be effected in the case of a dam failure.

1.3 Constraints

Some potential challenges the team might experience has been established to be the following:

- Weather Conditions inhibiting means of transportation and collecting data.
- Not all preexisting data could be found, or still exists.
    - Not all data needed is available.
    - Some data may be outdated.
- Limitations set forth by the owner

    Note: No limitations have been set by the owner, Pinewood Country Club.

1.4 Approach

Information that will be pertinent in a dam safety analysis may include; the existing conditions of the dam, dam purpose, engineering properties of the soil, analysis of current runoff and watershed conditions in the area, current structural properties of the dam, and identifying key safety deficiencies (embankment cracks, erosion, breaching, unusual/uncontrolled seepage, slope instability and/or inadequate spillway capacity).
The technical approach that has been initially established by the team and needs to be conducted, is a series of analysis and are as follows:

1. A soil analysis of the surrounding area that encompasses the dam.
2. A survey analysis to establish key features as height, length, width of the dam.

3. A geotechnical analysis of soil samples to help determine infiltration and structural components.
4. A structural analysis to determine integrity of the dam.
5. A hydraulic analysis for a dam breach, and overbanking.
6. A failure assessment to generate the most likely failure methods.

The team has been asked to provide qualitative answers for the following questions:

1. What failure method is most likely to fail the dam?
2. At what storm reoccurrence interval and discharge will cause the dam to fail?
3. What impacts on the area does a failure with the damn yield?

The team is also in the process of obtaining LIDAR data for Coconino County for the area of the dam. This information will help with the analyses specified above. The following image is an aerial view of the Odell Dam. The photo also shows the close proximity of residence to the dam.

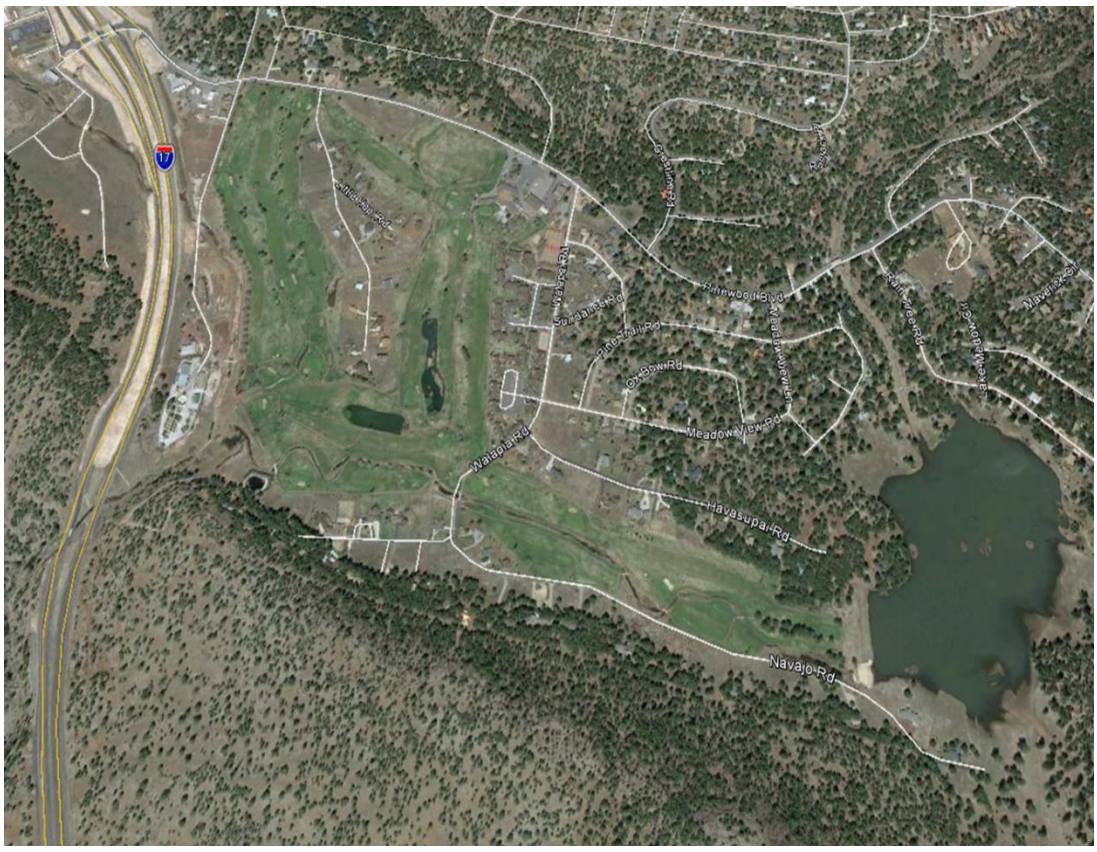

Figure 1. Aerial Photo of Project Location

2. Scope of Services

The team will perform the tasks mentioned below for the client in regards to the Odell Dam Safety Analysis (ODSA).

Task 1 – Project Management
Task 2 – SOTA Researching
Task 3 – Site Inventory
Task 4 – Geotechnical Analysis
Task 5 – Watershed Analysis
Task 6 – Dam Failure Analysis
Task 7 – Modeling - Dam Breach Inundation
Task 8 – Final Reporting

Task 1 – Project Management
The following tasks will be completed to organize the team and project:

- **Task 1.1 Odell Dam Team Meetings**
  Project meetings will be held weekly with the Odell Dam Team, and will serve as a time to review the work done, distribute and discuss new work, and resolve project issues.
- **Task 1.2 Technical Adviser Meetings and Communication**
  Meetings will be held with the technical advisers, when necessary, to overcome current obstacles, to ask for additional or alternative resources, and to ask for guidance on the project as a whole.
- **Task 1.3 Client Meetings and Communication**
  Meetings with the client will be held when necessary to discuss the current accomplished goals, unaccomplished goals, and completed work.
- **Task 1.4 Communication with the Owners of Pinewood Country Club**
  Communication between the project lead and the owner of the Odell Dam, Pinewood Country Club, will be continued to establish permission to conduct surveying and

geotechnical analysis on their property as well as coordinating with the surrounding residences to insure full disclosure of the project.

Task 2 – State of the Art Research (SOTA)

State of the art research is the use of scholarly articles and technical journals to conduct research and gather helpful resources to be used in the employment of this project. SOTA will help the team gain a comprehensive understanding of each analysis to be completed for the entire project.

- **Task 2.1 Light Detection and Ranging (LiDAR)**

  Our team use the aid of LiDAR surveying to create a 3D landscape of the area of interest. This will be used for surveying the area surrounding the Odell Dam as well as developing the watershed analysis and the hydraulic modeling software.
- **Task 2.2 Past Dam Failures**

  The team will research Arizona dams similar to the Odell Dam that have failed. This will help our team establish a baseline of most probable dam failure methods of the Odell Dam.
- **Task 2.3 State and Federal Dam Safety References**

  Research will be performed on state and federal dam risk analysis procedures. Listed below are different organizations that will be researched for current dam risk analysis procedures.
    - Federal Emergency Management Agency (FEMA)
    - Arizona Department of Water Resources (ADWR)
        - ADWR will be contacted to obtain any information the state has for the design and existing conditions of Odell Dam as well as any research that has been conducted on this dam.
    - United States Army Corp of Engineers (USACE)
    - United States Geological Survey (USGS)

  The team will examine government databases to determine all relevant data to the project, such as; soil properties, existing conditions, and background information on the Odell Dam.

Task 3 – Site Inventory

The Odell Dam team will take an inventory of all pertinent cross sections, identify key safety deficiencies, and gather all necassary geometric data of the Odell Dam site.

- **Task 3.1 Survey Existing Infrastructure**

  Surveying data will be collected through a site visit after the permission from the owner of the dam has been established. Basic cross sections and geometric data will be generated for this site as well as key safety deficiencies, such as embankment cracks, erosion, breaching, unusual or uncontrolled seepage, slope instability and/or inadequate spillway capacity. The LiDAR information will be used to generate the topographical and contour map of the area.

Task 4 – Geotechnical Analysis

Geotechnical analyses will be conducted on the project site to gain basic knowledge of the soil properties of the area. The properties to be determined will include but are not limited to the soils' water content, specific weight and angle of repose.

Task 5 – Watershed Analysis

Watershed analysis will be conducted on the project to attain an understanding of how and where the water flows around our project with the aid of LiDAR data.

- **Task 5.1 Use of LiDAR**

  As stated previously, LiDAR data will be used to generate a topographic map which will then be used to determine the watershed contributing to the Odell Dam.

- **Task 5.2 Determine Watershed**

  Determining the watershed will be pertinent to any analysis done for the dam risk analysis. The watershed will help determine the amount of water which needs to be contained by the dam. The watershed will help reveal different types of possible failures.

- **Task 5.3 Determine Storm Recurrence Intervals (5, 10, 50, 100, 500, 1000 year)**
  Storm recurrence intervals will help determine the type and frequency of storm that will contribute to the Odell Dam.

    - National Oceanic and Atmospheric Administration (NOAA)
      NOAA will be researched and its information implemented to help determine the different possible scenarios of storm duration and rainfall intensity. Many different situations will be accounted for in order to estimate possible storm conditions.

Task 6 – Dam Failure Analysis

Dam failure analysis is a primary objective of the Odell Dam Team. The failure analysis can help rectify the dam's current safety status and aid in future improvements of the dam.

- **Task 6.1 Geotechnical Failure Analysis**
  It is known that overtopping and seepage failures are forms of geotechnical failures of a dam that will be researched.
- **Task 6.2 Structural Failure Analysis**
  It is known that cracking, settlement, and slides of the embankment are common signs of structural failure, according to Ohio.gov, Department of Natural Resources. Therefore, these will be the main focuses for the structural failure methods for the Odell Dam.
- **Task 6.3 Hydraulic Failure Analysis**
  According to New Hampshire Department of Environmental Services, it is known that hydraulic failures include overtopping, wave erosion, top erosion and gullying, are the most common causes of dam failure and will be analyzed.
- **Task 6.4 Failure Probability**
  Failure probability will be conducted in order to determine the most likely cause of failure for the Odell Dam.

Task 7 – Modeling - Dam Breach Inundation

Modeling and inundating is the other primary objective of the Odell Dam Team. The modeling and inundating can help to show how the failure will effect areas downstream of the dam.

- **Task 7.1 Hydraulic Modeling Software**

  A hydraulic software, such as Flow 2D, will be used to show the dam breach inundation. The use of such software in compliance with LiDAR, will help to show the outcome of different dam failures.

- **Task 7.2 Determine Properties below water line**

  The client has asked the team to account for the different properties downstream from the dam that will be affected due to a dam failure. This will not be an economic analysis but rather an inventory.

Task 8 – Final Reporting

Final reporting of the ODSA project will be done to prepare a recommendation, presentation, and website for the client.

- **Task 8.1 Comprehensive Recommendation**

  A comprehensive recommendation will be developed once all the analysis for the dam risk assessment has been completed. This will serve as the final deliverable for the class.

- **Task 8.2 Client Presentation/UGrads.**

  After the final recommendation is completed, a PowerPoint presentation will be generated, followed by a UGRADs poster. The poster will give all pertinent information about the capstone project.

- **Task 8.3 Website**

  Through the course of the project, a website will be developed and maintained. The website will have all the information about the capstone project as well as a comprehensive listing of all team members and their contributions to the project.

3. Proposed Staffing Plan

Listed below is an outline of the staffing plan that will be used for the entirety of this project. The project has been broken down into primary tasks which have been broken down into subtasks. Each task and subtask has been assigned a leader who will make sure that their subtask is being completed by the scheduled due date. The subtasks, dates, and time allotted to each task are estimates. A table representation of the staffing plan is attached along with a Gantt Chart. The Gantt Chart is a graphical representation of the project schedule showing tasks and their time allotted.

Table 1. Staffing Plan for the ODSA Project

	Main Task	Task Lead	Student Engineers	Hours Per Person	Total Hours
1	Project Management	Braedan	Braedan, Sharlot, Ibrahim, Chandler, Yaowan	20	100
2	SOTA	Sharlot	Braedan, Sharlot, Ibrahim, Chandler, Yaowan	8	40
3	Site Inventory	Chandler	Braedan, Chandler, Ibrahim	53.33	160
4	Geotechnical Analysis	Braedan	Braedan, Sharlot	50	100
5	Watershed Analysis	Ibrahim	Ibrahim, Chandler	50	100
6	Dam Failure Analysis	Yaowan	Chandler, Yaowan	50	100
7	Hydraulic Modeling	Chandler	Chandler, Braedan	60	120
8	Final Reporting	Braedan	Braedan, Sharlot, Ibrahim, Chandler, Yaowan	30	150
Total Hours:					870

4. Proposed Budget

Listed below is a table for the total budget of the project based on job title. The budget includes overhead and a 20% profit to be made within the project. The total cost of the project is also listed within the table. Let it be noted that the total billable hours differ from the staffing plan hours due to the project management task. This was deemed not billable to the client.

Table 2. Budget per Job Title

Task	Total hours	Base pay	Benefits %	Actual Pay	Profit %	Billable Per Hour	Total
General Engineer	283.33	$ 45.00	50	$ 67.50	20	$ 81.00	$ 22,950.00
Geotechnical	183.33	$ 50.00	50	$ 75.00	20	$ 90.00	$ 16,500.00
Hydraulic	303.33	$ 50.00	50	$ 75.00	20	$ 90.00	$ 27,300.00
Total	770.00						$ 80,100.00

The following table is a budget for each of the task listings. Each task has been broken down into the amount of hours to be worked per task as well as the cost for completing that task.

Table 3. Budget per Task Listing

Task	Total hours	Group	Cost per task	Billable + 20% profit
SOTA	40	G. Engineer	$ 3,240.00	$ 3,888.00
Site Inventory	160	G. Engineer	$ 12,960.00	$ 15,552.00
Geotechnical	100	Geotechnical	$ 9,000.00	$ 10,800.00
Watershed	100	Hydraulic	$ 9,000.00	$ 10,800.00
Dam Failure	100	Geotech/Hydraulic/G. Engineer	$ 8,700.00	$ 10,440.00
Modeling	120	Hydraulic	$ 10,800.00	$ 12,960.00
Final Reporting	150	Geotech/Hydraulic/G. Engineer	$ 13,050.00	$ 15,660.00
Total	770			$ 80,100.00

5. Schedule

The following figure is a Gantt Chart that has been constructed in respect to the staffing plan.

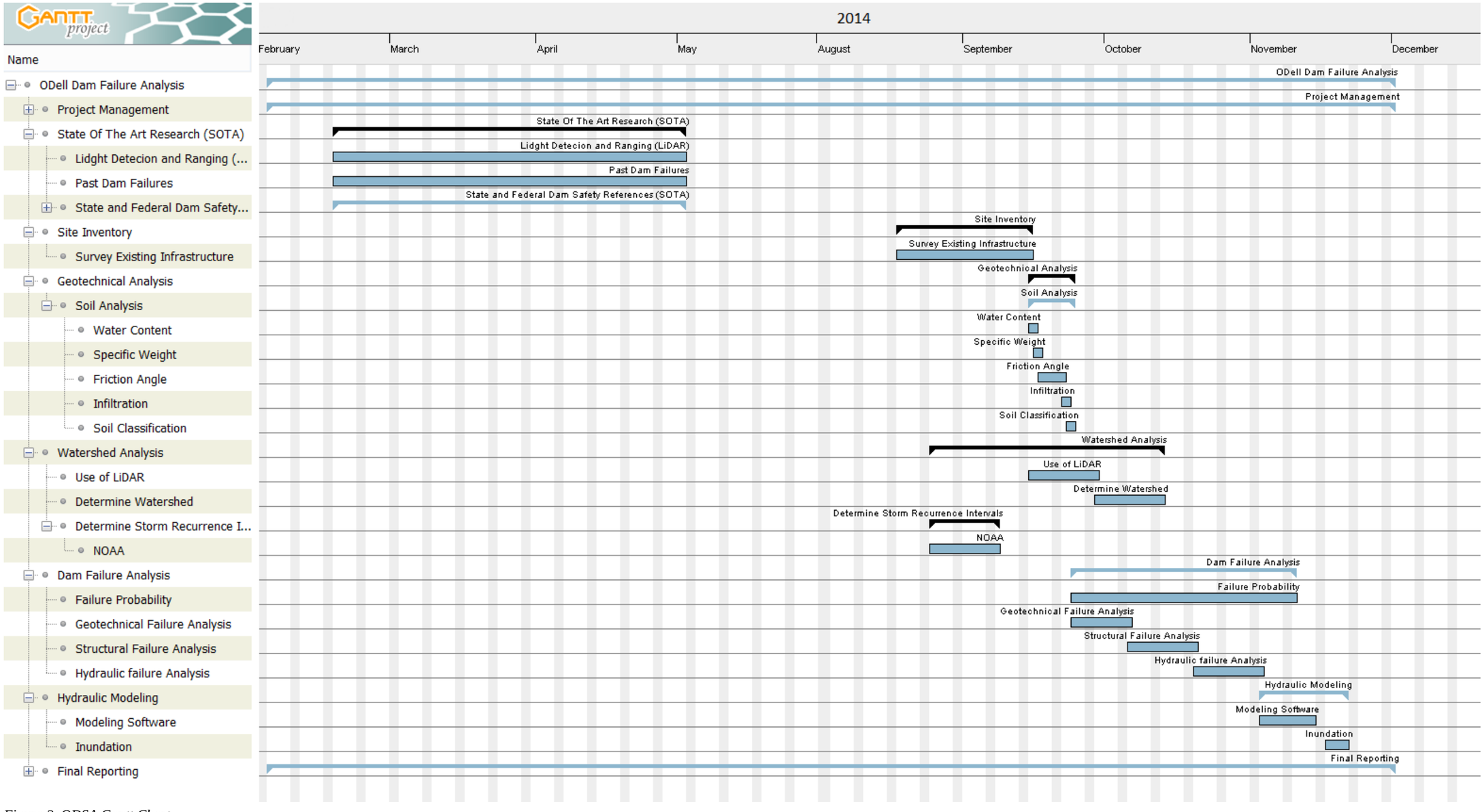

Figure 2. ODSA Gantt Chart