DAMsel in Distress Engineering
April 14, 2014

Proposal for

West Cataract Creek Dam

I. Project Understanding

The following subsections outline the team's complete understanding of the West Cataract Creek Dam project as a whole.

1.1 Purpose of the Project

The purpose of this project is to analyze the safety of the West Cataract Creek Dam. y dams in history that have failed due to unforeseen circumstances. This increases the importance of analyzing existing dams to ensure that they aren't in danger of failing. Since West Cataract Creek Dam has been classified as a "significant" safety concern, it is important that this dam undergoes analysis.

1.2 Background Information & Existing Conditions

The West Cataract Creek Dam is a dam located in Coconino County, AZ at N35.25251° W112.21406° and at an elevation of 6,781 feet. The dam is also attached to Cataract Lake, which is located west of Interstate 40. According to the state of Arizona, this dam has been marked as being a "significant" safety concern, being recorded as having a "safety deficiency." This dam is a cause for concern because the City of Williams is located only two miles downstream from this dam. West Cataract Creek Dam is listed in the State Inventory Database (SID) as 3.10. It is also located in the National Inventory of Dams (NID) under the number AZ00039. A draft for an Emergency Action Plan (EAP) currently exists for immediate defensive action in case of a failure. At this time, no mapping has been created to determine the potential flood area in the event of a failure.

1.3 Key Stakeholders

The location of Cataract Lake and Cataract Creek is near Williams, Arizona making the City of Williams a key stakeholder for the project. If the dam is found to be unsafe, and a dam breach does occur at some time in the dam's life, the City of Williams could possibly take a big hit, and a potential flood could damage infrastructure in the town. The City of Williams built the dam in 1947 to create Cataract Lake, but they do not own the lake or the surrounding land. Due to this, other key stakeholders for this project are the land owners themselves. Cataract Lake is owned by the US Kaibab National Forest, but the western shoreline of the lake is owned by Coconino County. Another minor stakeholder in the project could be the Arizona Game and Fish Department, since the lake is stocked with trout throughout the summer.

1.4 Technical Requirements

The technical requirements for this dam safety analysis can be broken up into three categories. First, an evaluation and assessment of the dam's current conditions will need to be performed. Background information regarding the construction and design of the dam will need to be obtained through a reverse engineering process. This

process will most likely include surveying and research regarding flows through this area.
After all the information on the dam's current conditions is collected, likely failure methods will need to be analyzed. This analysis will include research on what types of failure methods are likely for this type of dam, and the calculations associated with them to determine whether or not the dam is up to code.
After an analysis of the failure methods is performed, a dam breach analysis will be necessary to determine the impacts that a failure would have on the surrounding area.

1.5 Potential Challenges

Potential challenges with this project include accessing the location due to adverse weather or road conditions in order to obtain soil samples for a geotechnical report, taking soil samples without compromising the integrity of the dam, and accessing information. Waiting until the weather is right will allow for easy access to obtain soil samples and using small sample sizes will be less likely to compromise the integrity of the dam.

II. Procedures/Scope of Work

The DAMsel in Distress Engineering team will perform the tasks laid out below in accordance with the West Cataract Creek Dam project. The tasks will be completed in order to achieve the overall dam safety analysis for the creek in question. The tasks that will be completed are:

- Task 1: Project management
- Task 2: Literature Review
- Task 3: Site Surveying/Inventory
- Task 4: Hydro Analysis
- Task 5: Geotechnical Analysis
- Task 6: Dam Failure Mode Analysis
- Task 7: Dam Breach Analysis
- Task 8: Final Reporting

2.1 Task 1: Project Management

DAMsel in Distress Engineering Team Meetings

Team meetings will be held on a weekly basis in order to review the work completed to date, to divide the work between the team, and to tackle any complications the team members encounter throughout the week.

Deliverables: Documentation of the topics covered during the meetings (minutes), and agendas laying out the scope of the meeting.

Communication and Meetings with Client

Meetings with the client will be scheduled as the team deems necessary. The team will be in contact with the client about any questions or concerns that come about during the lifetime of the project.

Deliverables: Meeting minutes and agendas for the client meetings documenting the meeting schedule as well as in depth notes taken from the meeting.

Communication and Meetings with Technical Advisors

Meetings with the technical advisor will be scheduled on a biweekly basis, or as help with analysis is needed. The team will be in contact with the technical advisor about any questions or concerns that come about during the lifetime of the project.

Deliverables: Meeting minutes and agendas for the technical advisor meetings documenting the meeting schedule as well as in depth notes taken from the meeting.

2.2 Task 2: Literature Review

Research on Dam Failures

The primary focus of our project is to determine the safety of the West Cataract Dam, so our first task in this analysis will be to research dam failure. This research will include a comprehensive look through the various types a dam can either break, or otherwise fail to perform its assigned task. In order to assist us with getting an idea of the different failure methods, we will also be looking at various dam failures in the past, particularly recent ones.

Deliverables: Summary of similar dam failures and relevant types of dam failure

Background Information

We will also do in-depth research of our dam's history. This will include the way it is categorized on the state level, as well as any notable situations or events that this dam may have experienced. This information may have something to tell us about the effectiveness of the dam. Specifically, during this task we will collect and review any information regarding any event in which the dam did not operate as specified. During this task, we will also determine who we will need to contact to get additional information about this dam.

Deliverables: Summary of the construction, maintenance, and operation of this dam

Relevant Document Procurement

Finally, a necessary step in our literature review would be to collect and take note of any documentation that was created about this dam, for this dam, or otherwise directly relevant to the dam.

Deliverables: Summary or references to any past studies done on this dam.

2.3 Task 3: Site Surveying/Inventory

Obtain Elevation Data

Obtaining elevation data will be among the first type of numerical data the team will procure. Our first means of attempting to collect this data will be to contact the party who would be in possession of elevation data for this area. If we are successful in this pursuit and the data is publicly accessible, then we will be able to use this data for the rest of our analysis. However, failing to collect the data in this manner will result in us taking surveying instruments out to the site of the dam and collecting the data ourselves.

Deliverables: Summary of elevations presented through a topographic map

Collect Soil Samples

Geotechnical data of the soils around the dam site will also need to be determined. To this end, we will be collecting adequate soil samples during a site visit, and take them with us for laboratory tests. This is how we will achieve numbers for various values needed for the geotechnical analysis. Because the West Cataract Dam is an earthen dam, the need for soil samples is crucial.

Deliverables: Extraneous notes on any unusual soil or geographical conditions

2.4 Task 4: Hydro Analysis

Upstream Hydrological Data

Using the data obtained from surveying, and the created topographic map, the surrounding watersheds can be evaluated. After evaluating the watershed areas, peak flows for the 5-, 25-, 50-, and 100-year storms can be evaluated and used for further analysis.

Deliverables: Watershed boundaries and areas, peak flows for each recurrence interval storm.

Hydrostatic Analysis on Dam

With the peak flows for each recurrence interval storm found, the lake levels should be able to be estimated. Using the estimation of the lake depth, hydrostatic analysis can be performed on the dam to find the pressure due to the water on the dam. This information will help with the failure method analysis.

Deliverables: The hydrostatic pressure on the dam for lake levels experienced for the 5-, 25-, 50-, and 100-year recurrence interval storms.

2.5 Task 5: Geotechnical Analysis

Obtain previous soil reports

Talk to the county, the city, and the state to obtain original geotechnical data of the earthen dam and the soils surrounding the lake/creek, as well as the soils found in the lake/creek.

Deliverables: Report conveying original geotechnical data

Collect soil samples

Collect current soil samples of the earthen dam, as well as the surrounding areas as well as the soils found in the lake/creek bed. Return the samples to the geotechnical engineering lab to complete current soils analysis.

Deliverables: Geotechnical Report of the current soil conditions

Analyze soil properties from collected samples

Compare and contrast the two soils reports to find any differences and changes to the soil profiles that might have occurred between the time that the dam was constructed and today.

Deliverables: Geotechnical Report comparing any similarities and differences (if any) of the original soil data and the current soil data found by the team themselves.

2.6 Task 6: Dam Failure Mode Analysis

Overtopping

Overtopping occurs where there is a spillway of insufficient size causing the water to flow over the dam and is a precursor to failure in most cases. Approximately 34% of all dam failures are due to overtopping.

Deliverables: Dam overtopping analysis report (If/when the dam be overtopped).

Sliding

Sliding occurs when the weight of the water built up behind the dam is greater than the weight of the dam itself and causes the dam to slide or move. This most often occurs in non-earthen dams.

Deliverables: Dam sliding analysis report (If/when the dam will fail due to sliding).

Bearing Capacity Failure

When the weight of the dam structure exceeds the bearing capacity of the soil, it shears, causing the dam to fail.

Deliverables: Dam bearing capacity analysis report (When the dam will fail due to soil shearing).

Earthquake failure

Earthquakes cause intense vibrations through the soil that, when sufficiently saturated, can cause liquefaction where the soil acts like a liquid. Earthquakes can also cause large faults to open up possible shifting the dam or collapsing it.

Deliverables: Dam earthquake failure analysis report (What earthquake will cause the dam to fail).

Internal Erosion

Internal erosion most often occurs in earthen dams and is also known as piping. The pressure of the water behind the dam forces water through the dam. If the pressure is too great the velocity of the water will be great enough that the water will remove soil as it passes through the dam. Particulate levels in the water downstream can be measured to analyze if piping is occurring. When the paths created by piping are sufficient the dam will collapse or break apart.

Deliverables: Dam internal erosion analysis report (If/when the dam will fail due to internal soil erosion, what will be taken into consideration to find what causes tunneling in the dam).

2.7 Task 7: Dam Breach Analysis

Hazard Analysis Downstream

In the event that the dam would fail due to one of the many failure methods that will be analyzed during this project as described above, an analysis would need to be performed to determine the downstream repercussions. This analysis will most likely be performed in the HEC-RAS software or a software with the same functions. This analysis will delineate the area that would potentially be impacted by the dam failure.

Deliverables: HEC-RAS report including the potential area of impact and dam classification

2.8 Task 8: Final Reporting

Proposal

At the end of the project a formal report will be created compiling all of the technical data and important information that the client requested. Any design suggestions made by the team will also be included in this proposal.

Deliverables: Final proposal and a compilation of all deliverables as listed above.

Website

A website will be created by the team to display all the information pertinent to the project to the public and the client for easy access.

Deliverables: Project Website

Presentation

A final presentation will be given at the end of the project in order to clearly display all found information and answer any questions that the client or the public may have.

Deliverables: Microsoft PowerPoint presentation with a question and answer portion

III. Project Schedule

Table 3.1 below highlights the main tasks that will be performed by the end of the project along with the personnel that will be contributing to each task. The team has allotted 520 hours to complete the project.

Table 3.1 – Engineer Task List

Task	Contributing Engineers	Hours per Person	Total Hours
Literature Review	Ethan, Dustin, Kallam, and Jaclyn	6	24
Website	Ethan, Dustin, Kallam, and Jaclyn	10	40
Site Surveying and Inventory	Kallam and Jaclyn	24	48
Geotechnical Analysis	Kallam and Jaclyn	32	64
Hydro Analysis	Dustin and Ethan	32	64
Dam Breach Analysis	Dustin and Ethan	32	64
Overtopping and Erosion Analysis	Dustin and Ethan	16	32
Sliding and Earthquake Analysis	Kallam and Jaclyn	16	32
Bearing Capacity Analysis	Ethan, Dustin, Kallam, and Jaclyn	8	32
Final Report	Ethan, Dustin, Kallam, and Jaclyn	30	120
		Total:	520

A Gantt chart was created to organize the tasks and subtasks as described in section 2, including start and end dates for each task. The Gantt chart can be found as an appendix to this memo. The following items are unique in that one depends on the completion of another.

- The majority of the geotechnical analysis will be initiated once all soil samples and data have been collected.
- The hydraulic analysis will be started once the upstream data is collected.

In addition, the final report will be completed in conjunction with the final stages of the analysis.

IV. Budget

Table 4.1 below shows how the total billed amount is broken up between the various tasks that the project requires. As shown at the bottom of the table, the billed total amounted to $30,240.

Table 4.1 – Cost per Task

Task	Total Hours	Total Cost per Task	Billable Rate (20% additional)
Site Surveying and Inventory	48	$3,600	$4,320
Geotechnical Analysis	64	$4,800	$5,760
Hydro Analysis	64	$4,800	$5,760
Dam Breach Analysis	64	$4,800	$5,760
Overtopping and Erosion Analysis	32	$2,400	$2,880
Sliding and Earthquake Analysis	32	$2,400	$2,880
Bearing Capacity Analysis	32	$2,400	$2,880
		Billed Total:	$30,240

The total costs per task as shown in Table 4.1, above, were obtained based on which DAMsel in Distress Engineering employee will be working on which task and for how many hours. The billing rates for each of the employees can be found in Table 4.2, below.

Table 4.2 – Employee Costs

Person	Base Pay, $/hour	Benefits, % Base Pay	Actual Pay $/hour	Profit, % Actual Pay	Billable Rate, $/hr
Geotechnical Engineer	50	50	75	20	90
Hydraulic Engineer	50	50	75	20	90

As outlined in Table 4.2, above, the geotechnical engineers and hydraulic engineers are billed at the same hourly rate. Of the four employees scheduled to work on this project, two are geotechnical engineers (Jaclyn Zibrat and Kallam Kruse), and two are hydraulic engineers (Ethan Shadley and Dustin Hailpern).