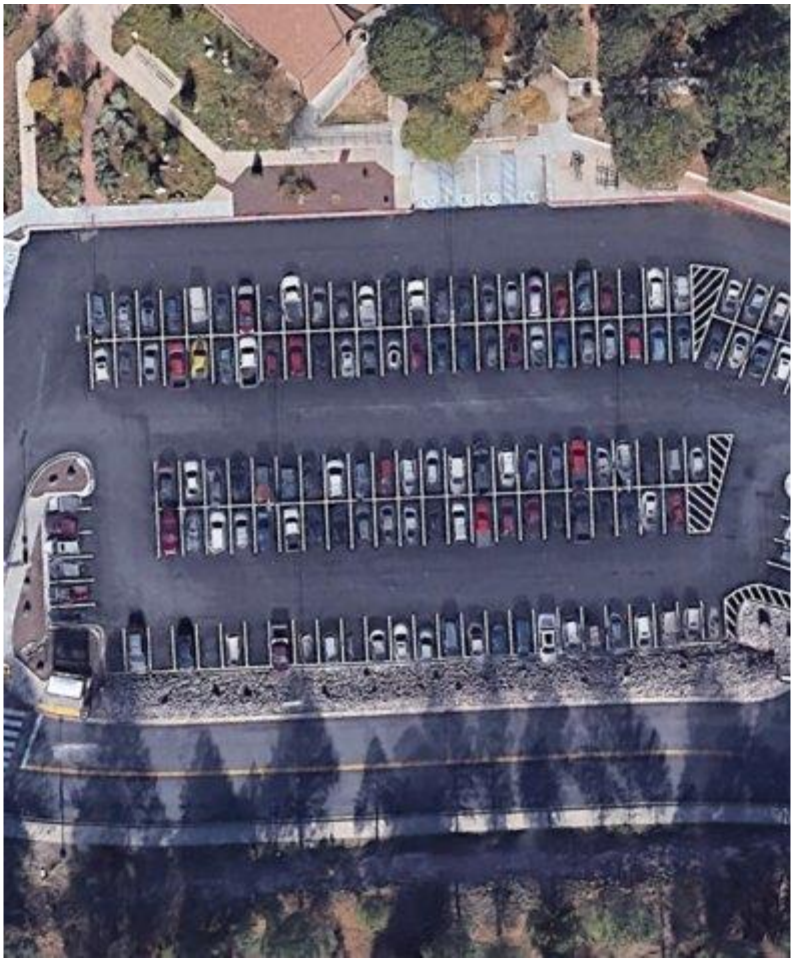


NAU PARKING LOT 46

April 26, 2021

NORTHERN ARIZONA UNIVERSITY
COLLEGE OF ENGINEERING

CAPSTONE PROJECT
FINAL PROPOSAL

Prepared for: Mark Lamer

Prepared by: Surf and Turf Engineering
Mariam Alqabandi, Sophia Fox, Donovan Stewart, and Saud Rumaih Alazmi

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF ABBREVIATIONS

Coconino County Drainage Design Manual..........CCDDM

National Resources Conservation Service..........NCRS

Low Impact Design..........LID

Northern Arizona University..........NAU

Americans with Disabilities Act..........ADA

Technical Advisor..........TA

Grading Instructor..........GI

1.0 PROJECT UNDERSTANDING

1.1 Project Purpose

The goal of the project is to improve the existing storm drainage system and pedestrian access for parking lot 46 on NAU's campus. Main objectives are to develop a storm drainage design plan set along with low impact design (LID), improving pedestrian access, by following Americans with Disabilities Act, 1990 (ADA), Universal Design Guidelines, and NAU Masterplan.

1.2 Project Background

The site is located off Pine Knoll Drive and South Hoffer Lane, between the Rolle Activity Center and the Southwest Forest Science Complex on Northern Arizona University's campus in Flagstaff, Arizona. In this area the basic problem was, storms drains were inadequate for peak storms in that area. If the peak storm hit the drainage because of inadequate outlet, the drainage spill into parking lot and surroundings. On the other hand, minor flooding occurs due to small parking lot size. Whereas lack of pedestrian access in the useful areas, and lack of signage for newcomers. Hence, new drainage designs with adequate capacity and pedestrian designs on useful areas proposed due to these basic problems.

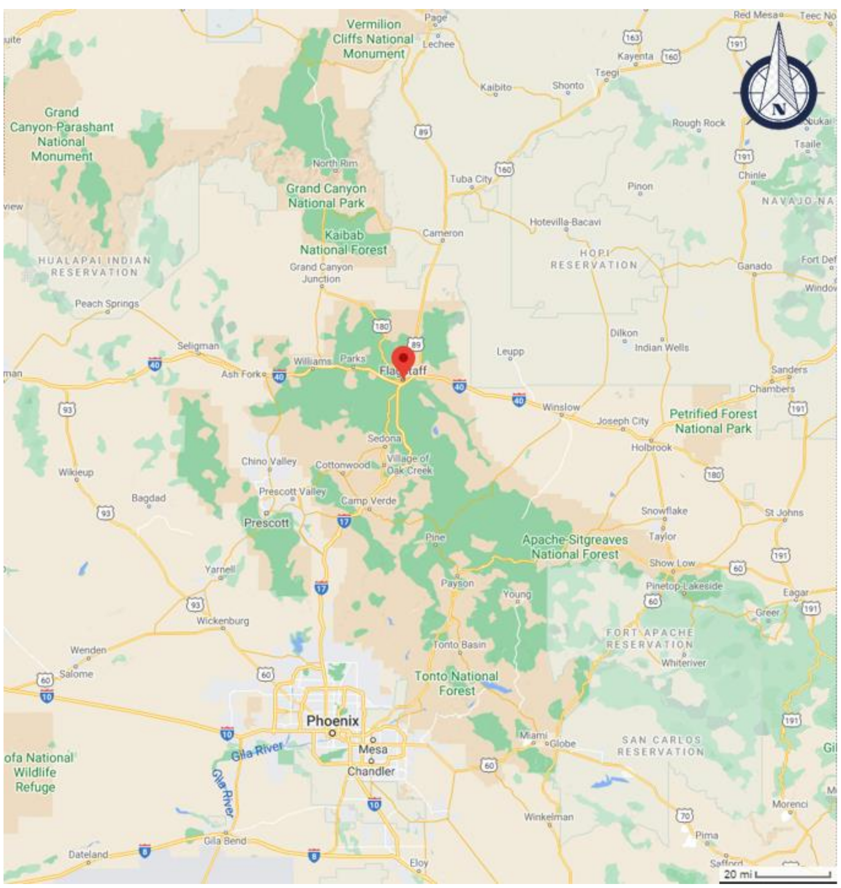


Figure 1-1: Location of project site in reference to Northern Arizona [1]

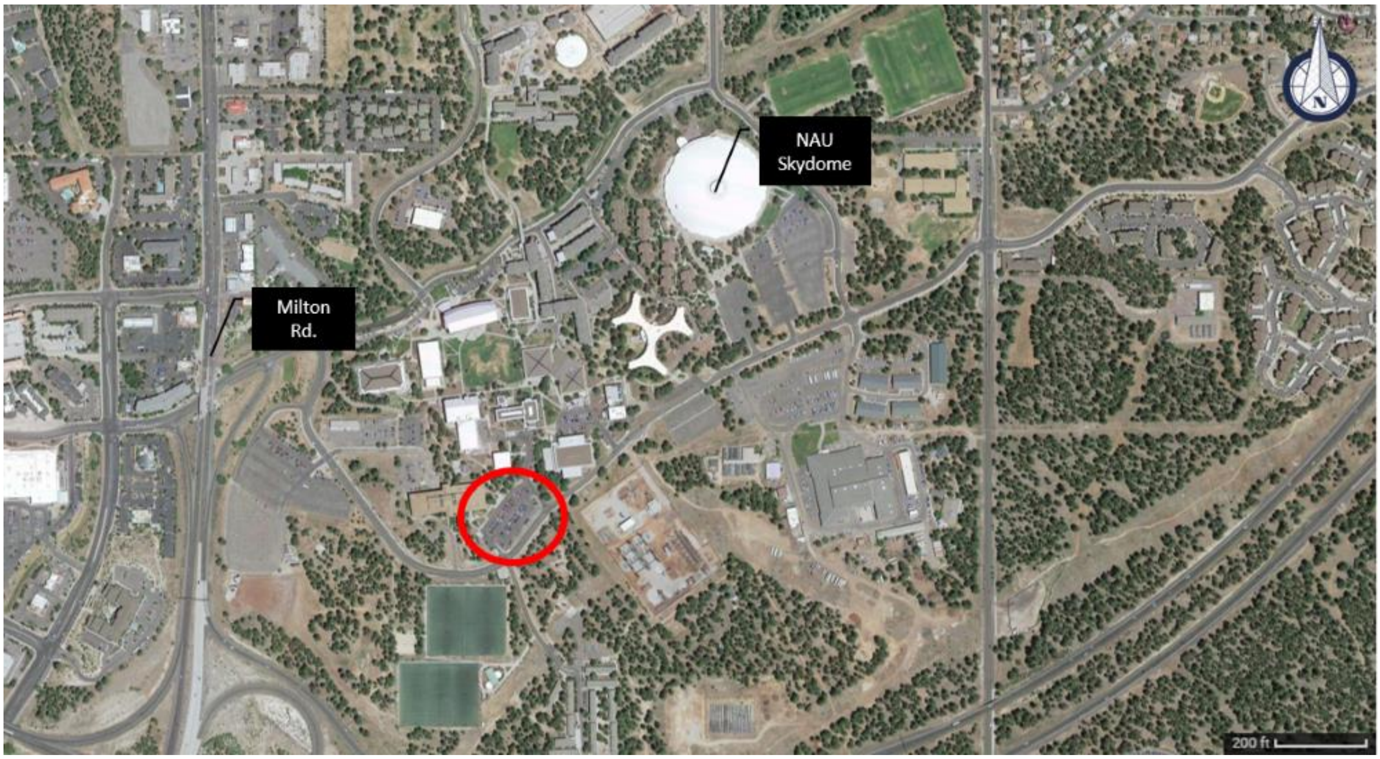


Figure 1-2: Project Site within NAU's Campus [1]

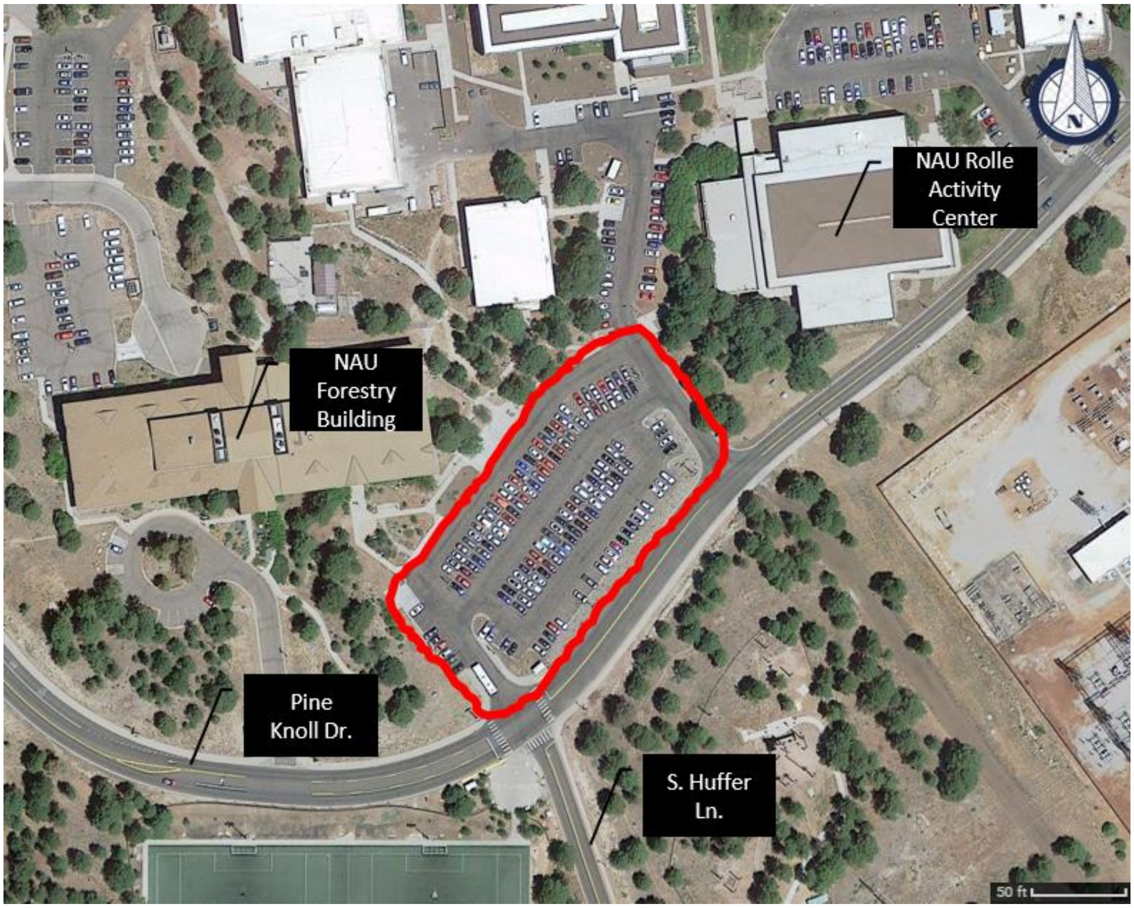


Figure 1-3: Project Site at NAU Parking Lot 46 [1]

1.3 Technical Considerations

Code research will be conducted to ensure the proposed design abides by statewide and local design criteria. The Arizona Department of Transportation Drainage Design Standards shall be taken into consideration as well as the City of Flagstaff Stormwater Drainage Design Manual of 2009. Specifically, the final proposed drainage design will follow direct guidance from the Northern Arizona University's 2015 Master Plan for all drainage concerns, sidewalk characteristics and pedestrian pathways.

a. NRCS Chapter 15 – Topographic Map Understanding / Comprehension and Watershed Basin Delineation
b. NOAA Atlas – Precipitation Frequency Calculator
c. Coconino Drainage Design Manual and Guide
d. City of Flagstaff Low Impact Development (LID) Codes and Manual Guide
e. ADA – Americans with Disabilities Act Guidelines

•Field/site investigation

The scopes are as listed below:

a. Terrain condition (surrounded by trees or bushes, or by building)
b. Urbanized or undeveloped area classification

Figure 1-4: Surrounding Terrain Conditions - 1

Figure 1-5: Surrounding Terrain Conditions - 2

Figure 1-6: Surrounding Terrain Conditions – 3

Figure 1-7: Surrounding Terrain Conditions – 4

Figure 1-8: Culvert outlet in NAU parking lot 46

Figure 1-9: Street storm drain

Figure 1-10: Culvert drainage outlet near Rolle Activity Center

Land surveying is a step in validating the land types shown in Google Earth with the actual condition of the basin/study area. Surveying will mainly identify the horizontal and vertical position of the basin area using the coordinates and elevation.

In executing the surveying, there is one crucial instrument called "Total Surveying Instrument."

A Topographic map is a two-dimensional illustration of earth's three-dimensional panorama. Those maps show an in-depth example of all manmade and natural geographical functions on the floor. Geographical features are clearly distinguished the use of a map scale, contour strains, colors and shading, and mapping symbols [2].

Interpolating information from a topographic map regularly done via a virtual line graph (DLG) or a virtual elevation version (DEM). DLG's are vector representations of most of the features and attributes proven in a USGS topographic map. DEM's are raster representations of a terrain floor. Elevation grids from the hypsography and hydrography layers of a DLG are interpolated to supply a DEM [3]. further analysis and calculations for the region of interest may be found the use of a DEM.

For this assignment, AutoCAD and Civil3D drafting could be used to decide flow paths and the kind of glide that occurs presently at the site. Accumulated go with the flow information, a topographic map, and an aerial image of the undertaking site can be uploaded into this software program and analyzed for large float patterns. Records from modern-day conditions can be manipulated to decide the nice-match drainage design for the region.

There are numerous techniques in modeling the hydrologic evaluation: HEC-RAS (River evaluation machine) and HEC-HMS (Hydrologic Modeling device). Each utilized in estimating the full runoff that happens inside the study vicinity the use of the empirical strategies. Both strategies wreck the basin/look at place into several smaller areas known as sub basin from which calculation that is extra special is derived. There could be several parameters calculated and plot in a graph called hydrograph. From this graph, peak discharge of the runoff that is maximum viable to show up because of positive returning duration will be capable of be identified as a result, making it possible for the responsible engineer to design a hydrologic infrastructure that could resist the peak discharge therefore, preventing any possibility in which flood ought to occur.

Hydraulic evaluation will consciousness on the water traits when it enters the open channel go with the flow. this could extraordinarily be related to culvert layout in addition to figuring out the culvert measurement + freeboard, inlet / outlet control in addition to figuring out the first-rate flumes bedding substances to sluggish down the water drift in minimizing the water strength that might finally put on off the natural bedding.

Storm drain design is a design at the slope of the hydraulic grade line with primary motive to acquire the storm water and optimizing the safe passage for the pedestrian and any visiting automobile across the location. Flagstaff codes limit the minimum slope of a storm drain to 0.5 percent and a minimum diameter of 18 inches.

With formula:

Equation 1: Slope of Hydraulic Grade Line

$$S = \frac{[(n * V^2)]}{\left[2.208 * R^{\frac{4}{3}}\right]}$$

Where

S= Slope of the hydraulic grade line
V= Flow velocity
n= Manning's roughness coefficient
R= Hydraulic radius

1.4 Potential Challenges

Challenges, which could arise at some stage in the length of this challenge, encompass public access in the course of creation. When you consider that this web page is positioned close to a university bus prevent, there must be a developed plan to detour students around the website at the same time as ensuring protection and efficient get right of entry to surrounding university buildings. The area of the opening of the drainage layout ought to expand accessibility issues for students if drainage flows into campus get admission to. To keep away from such issues the design have to take into account the fine possible placement for vast runoff and redirect scholar site visitors round the opening by means of implementing sufficient sidewalk placement and pedestrian pathway design.

1.5 Stakeholders

The principal stakeholder of this assignment is NAU engineer who has recommended for improvements to be achieved with the drainage and pedestrian troubles plaguing parking lot 46. NAU as in a whole institution is also a stakeholder of this challenge as they will be the ones to approve of any plans and pay the costs related to creating this undertaking occur. The final stakeholders will be the college students, school, and some other folks who use parking lot 46 on NAU's campus.

2.0 SCOPE OF SERVICES

2.1 Task 1: Existing Studies Review

The purpose of conducting an existing studies review is to research all necessary information regarding the project site characteristics, existing drainage features, and future drainage design plans. This will include collecting all the data that Northern Arizona University has for this site, data from any previously conducted work at the site, and local codes and regulations that are pertinent to drainage design and stormwater collection.

2.1.1 Task 1.1: Northern Arizona University Data

Blueprints of the current stormwater drainage facility will be requested from NAU to understand the layout of the current drainage system. The 2015 NAU Master Plan was created to guide development on campus and will be used to ensure this project is completed to the University's standards.

2.1.2 Task 1.2: Previously Conducted Work

A previous analysis of parking lot 46 was conducted in May of 2020. Documents from this analysis include survey data and a completed plan set. These documents will be requested from the team's technical advisor and used as the base line for future work.

2.1.3 Task 1.3: Codes and Regulations

A collection of codes, regulations, and standards that are relevant to implementing a drainage design on NAU's campus will be used to guide all work conducted on this project. The team will abide by the Coconino County Drainage Design Criteria Manual, Flagstaff Stormwater Management Design Manual, Flagstaff's Low Impact Development Guidance Manual for Site Design and Implementation, and the 2015 NAU Masterplan for all drainage design concerns.

The 2015 NAU Masterplan will also be used for all pedestrian pathway concerns along with the 2010 ADA Standards for Accessible Design.

2.2 Task 2: Analyze Existing Site

Information from the existing studies review will be compared to site visits to validate the current conditions of the project site. Existing site data will be generated into a topographic map of the project site that will be used for further drainage studies.

2.2.1 Task 2.1: Site Visit

A site visit involves a technical manner that ambitions at drawing all huge history data vital to resource within the kick starting of the design process. The initial site visit needs to include taking snap shots across the site for destiny reference. Area notes must be taken to report any intricate or extraordinary features on the site. Next site visits need to be made to file changes and development made during the length of the task. New site visits could be as compared to previous site visits to identify any progress or deterioration of the challenge.

2.2.2 Task 2.2: Survey

Previous survey data has been collected in May of 2020. This survey data will be used as the basis of analysis for this project. A review of the existing data will be conducted to validate the accuracy to current conditions. If any discrepancies arise between the existing survey data and the current conditions of the site, a supplemental survey will be conducted to obtain survey data as needed.

2.2.3 Task 2.3: Topographic Map

The topographical map provides the elevation data of the location which when combined with the levels data taken on site completes the data for the topology of the site. A site-specific topographic map will be created for this project using existing survey data. The project site's topographic map will further be used in hydrologic analysis and hydraulic modeling.

2.3 Task 3: Hydrologic Analysis

A hydrologic analysis will be performed to determine the volumetric flow rate of stormwater draining from the sub basin at the project site. This information will aid the team conducting a hydraulic analysis and designing a facility that can appropriately drain runoff at the site.

2.3.1 Task 3.1: Sub Basin Delineation

Delineating the existing sub-basins is done using the topographic map created for this specific site. First a circle is drawn on the topographic map indicating the outlet or downstream point of the wetland of focus. Next, the highpoints along both sides of the watercourse are marked with small x's working upstream from the outlet to the headwaters of the sub basin. Starting again at the outlet a line is drawn that connects all marked high points along both sides of the watercourse. This line connecting high points must pass through each contour line perpendicularly and return to the outlet to complete the delineation of the sub basin [4]. The delineated watershed will be used for further analysis of the stormwater runoff flow paths.

2.3.2 Task 3.2: Runoff Time of Concentration

Time of concentration, Tc, is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet [5]. The time of concentration varies depending on the watershed surface, slope and type of flow path. Time of concentration will later be used in this analysis to determine the average rainfall intensity and peak flow rate of the runoff at the project site. Flow paths within this site's sub-basin will be broken into segments where the type of flow changes. Time of concentration of each segment is calculated using specific formulas for sheet flow, shallow concentrated flow, street or gutter flow, and open channel flow. These formulas are obtained from the Coconino Drainage Design Manual and the NRCS National Engineering Handbook. The length and slope of each segment will be determined using the site-specific topographic map and AutoCAD computer software. All segment time of concentration are summed together to obtain the time of concentration for a whole flow path.

2.3.3 Task 3.3: Rational Runoff Method

The rational runoff method will be used to determine the maximum rate of runoff for the stormwater that occurs at the project site. Determining the peak discharge during a given time period will be used to size and design the appropriate drainage structure for parking lot 46. Equation 2 below shows the rational equation used to calculated peak discharge of runoff.

Equation 2: Rational Equation (CCDDM eq.3.1)

$$Q = C_f CIA$$

The antecedent precipitation factor, Cf, is used to account for less frequent high intensity storms. The value for the antecedent precipitation factor changes based upon the frequency of a storm event and can be found in table 3-1 of the Coconino Drainage Design Manual. The runoff coefficient, C, can be found in table 3-4 of the Coconino Drainage Design Manual based upon surface type and table 3-5 based upon soil texture, slope, and land use. The drainage area, A, will be determined by analyzing the topographic map of the site in AutoCAD software. Rainfall intensity will be found based on time of concentration through the NOAA Atlas 14-point precipitation frequency estimates data server found online.

2.4 Task 4: Hydraulic Drainage Analysis

A hydraulic analysis will be conducted to determine the flow depth, flow velocity, and other properties of stormwater runoff at the project site. Existing stormwater features are analyzed to understand their performance. After determining hydraulic properties of the stormwater, this data is modeled through software to understand current conditions and generate simulations of possible designs.

2.4.1 Task 4.1: Street Gutter

The pertinent data of stormwater flowing in the street gutters that lead to the storm drain inlets will need to be calculated for the required recurrence storm intervals. There will be no changes to the street gutters themselves, however, the pertinent data will be needed to analyze the needed changes to the storm drain inlet capacity.

2.4.2 Task 4.2: Storm Drain Line and inlets

The overall interactions between the storm drain inlets and the storm drain line is needed to be analyzed to reveal any design issues within the transfer of water between the two stormwater items. Getting data on the flow of the stormwater in the main line is also needed to make sure that the culvert outlet water velocity is meeting codes and standards and is not causing any safety issues.

2.4.3 Task 4.3: Culvert Inlet/Outlet

The culvert outlet which currently drains out into the entire parking lot is the main reason for taking on the project. The change that needs to be made is to take this outlet and move it, so the redirected stormwater is released into a detention basin area to the south west side of the NAU Rolle activity center. To accomplish this, the storm drain line will be put underground and extended to the detention basin. There is no culvert inlet, the storm drains are the inlet at this project site.

2.4.4 Task 4.4: Open Channel Outfall by Rolle Activity Center

Moving the culvert outlet to the detention basin on the southwest side of the NAU Rolle activity center is only part of the solution. The need to calculate how much water the detention basin can hold, and the outlet flow of the basin is necessary to make sure that the basin does not overflow during storm events. The main issue is that outfall stormwater flow leaving the basin is not going into a channel, more so a flow path that encounters different surfaces. Using the modified rational method, a flow time and speed can be calculated and accounted for when building the storm drain design.

2.4.5 Task 4.5: Culvert Inlet/Outlet Protection

To make sure that the longevity of the culvert outlet is maintained there will be culvert protective measures in place. These protections will be utilizing low impact design, which is in line with the NAU masterplan. The technologies for the protection chosen for the culvert outlet will be based on prior research and knowing the properties of the site.

2.4.6 Task 4.6: Low Impact Development (LID)

Low Impact Design (LID) is a strategy to preserve and mimic nature through the use of stormwater planning and management techniques [6]. LID will be used on this project to alleviate the downstream impacts of stormwater runoff to the surrounding areas of the University's campus. The LID approach aims to retain and reuse runoff at the source using rainwater collection and vegetation. Conveyance of stormwater includes pollution control using landscaping, swales, or gravel trenches. The city of Flagstaff's Low Impact Development Guidance Manual for Site design and Implementation will be used to assist the decisions made for this project.

2.4.7 Task 4.7: Stormwater Runoff Modeling

In order to design an appropriate drainage system that caters to the project site's needs, the existing behaviors of stormwater runoff must be understood. Stormwater runoff modeling will be conducted to gain an understanding of the quantity and quality of runoff that enters parking lot 46. Simulations will be created in modeling systems to achieve the best fit design for this site. Modeling software such as Bentley's Flow Master and Culvert master will be used.

2.4.7.1 Task 4.7.1: Flow Master

Using the software FlowMaster will allow the team to find the pertinent data about various aspects of the stormwater flow based on storm data and topographic data collected in earlier stages of the project. The data collected in FlowMaster will be crucial in making sure that the design of the storm drain can withstand the amount of stormwater that it is required to withstand. The flow type, velocity of the flow and volume of the flow are just a few out of many variables that need to be accounted for and will be found when using FlowMaster.

2.4.7.1 Task 4.7.1: Culvert Master

Culvert Master is a software that will be used to analyze the existing culvert hydraulics. This software can be used to solve for unknown hydraulic variables such as culvert size, peak discharge, and headwater elevation. Culvert master outputs detailed reports, rating tables of hydraulic properties, and performance curves [7]. This modeling system will be used to analyze the capabilities of the existing culverts and design an efficient culvert outlet that can appropriately manage the anticipated runoff from previous storm event data.

2.5 Task 5: Site Design

Understanding the existing site design will assist the design team in identifying current problem areas and what needs to be improved. Any demolition of existing stormwater feature will be detailed in the construction plan set for the proposed drainage design.

2.5.1 Task 5.1: Overall Site Layout

The overall site layout design includes laying out all the stormwater features and compiling the information of each in reference to the site and each other. In addition to the stormwater features, adding any pedestrian items to the site layout and the contours that were found through the site-specific topographic mapping will enable for a base site design to be made in plan view.

2.5.2 Task 5.2: Stormwater Feature Layout

The stormwater feature layout is building upon the overall site layout and adding the improved stormwater items in a featured layout that will include both plan and profile view.

2.5.3 Task 5.3: Pedestrian Pathways

The pedestrian pathways will be assessed by addressing what access does the pedestrian lack in and around the project site and how some pedestrian pathways can be included and added, adhering to the ADA and universal design standards found in the NAU masterplan.

2.5.4 Task 5.4: Plan Set Development

The plan set for this project will consist of construction plans. The plan set is a combination of construction documents and drawings that will include the site's grading, water retention, drainage, utilities, and erosion control [8]. These construction plans will be used as guidance for general contractors that provide valuable information on the project such as building codes, installation techniques, and quality standards. Once the project site has been thoroughly analyzed the team will create a construction plan set for the proposed design. All sheets within the plan set will contain a professional border developed in AutoCAD software detailing necessary information.

2.5.4.1 Task 5.4.1: Cover Sheet

The first sheet of the construction plan set will be a cover sheet
that clearly establishes the nature of work for the project, where it's at, and lists the contents of the plan set. The location of the project is provided with a vicinity and site map. The client's and engineering team's contact information are listed as well as standards used for the project.

2.5.4.2 Task 5.4.2: Project Notes

Any needed projects notes will be provided in the top left corner of a sheet within the plan set. All notes will consist of any relevant information regarding construction details or general comments that provide further explanation of the design.

2.5.4.3 Task 5.4.3: Results of Survey Sheet

The results of survey data will be provided on a single sheet within this plan set. This sheet will show the location of physical features such as existing structures, boundaries, catch basins, and measurements of the project site. This sheet will be used as a reference for future changes to the site.

2.5.4.4 Task 5.4.4: Drainage Details

Various sheets within this construction plan set will address all drainage details applicable to this design. There will be specific sheets for all used drainage regulations and codes, maps of the drainage area, hydraulic calculations, and culvert cross section layout. Plan and profile view of all stormwater feature layouts will be included.

2.5.5 Task 5.5: Engineers Opinion of Probable Cost to Construct

The probable cost to construct the proposed drainage facility will be evaluated once the general design needs have been determined. The factors that will influence the cost of construction include needed equipment and materials, contractors rate of pay, time duration of construction, and low impact design attributes.

2.6 Task 6: Project Management

Project management encompasses potential impacts caused by the proposed project, all deliverables required to meet the project deadline, professional meetings with advisors and stakeholders to stay on track, resource management and exclusions. All aspects of project management are concerned with how the team plans to produce a high-quality drainage design in an efficient manner.

2.6.1 Task 6.1: Project Impacts

The design team will assess any potential impacts the proposed project could have on the surrounding area and community to ensure there are no detrimental effects. The sectors of impacts to be evaluated are impacts to the environment, economy, and society.

2.6.1.1 Task 6.1.1: Environmental Impacts

During the progression of the project assessments will be made to understand the potential environmental impacts caused by implementing the new storm drain design and pedestrian pathways. However, it is our utmost desire to leave a positive impact on the environment with this project. full environmental impact assessment will be available once the project is completed.

2.6.1.2 Task 6.1.2: Economic Impacts

During the progression of the project assessments will be made to understand the potential economic impacts caused by implementing the new storm drain design and pedestrian pathways. However, it is our utmost desire to leave a positive impact on the economics with this project. The full economic impact assessment will be available once the project is completed.

2.6.1.3 Task 6.1.3: Social Impacts

During the progression of the project assessments will be made to understand the potential social impacts caused by implementing the new storm drain design and pedestrian pathways. However, it is our utmost desire to leave a positive impact on the social life with this project. The full social impact assessment will be available once the project is completed.

2.6.2 Task 6.2: Project Deliverables

The following submittals are scheduled to keep the project progression on track for a final submittal to the client. Each submittal will be reviewed by the team’s technical advisor (TA) and grading instructor (GI), the provided feedback will be used to improve the overall proposal prior to a subsequent submittal.

2.6.2.1 Task 6.2.1: 30% Submittals

The 30% submittal is the initial check of the team's progress on the proposed design. This submittal requires a report with the completion of the scope of services needed for the project as well as a presentation containing the work done up to this point. This report should also show an accurate project understanding and an outline of future work.

2.6.2.2 Task 6.2.2: 60% Submittals

The 60% submittal will implement feedback from the team’s technical advisor and grading instructor by including revised work from the previous submittal. This submittal requires a report, presentation, and plan set. The report for this submittal will provide a concise schedule for completion of the project. The plan set will demonstrate the determined design specifications up to this point.

2.6.2.3 Task:6.2.3 90% Submittals

The 90% submittal will implement newly provided feedback by including revised work from the previous submittal. This submittal requires an updated report, presentation, plan set, and the creation of a project website. This report will have the addition of sections detailing the staffing and cost of services for the project. The project website will have all professionally completed documents for the project up to this point.

2.6.2.4 Task 6.2.4: Final Submittal

The final submittal will provide a completed proposal report, presentation, plan set, and website. All feedback provided on previous submittals will be implemented into the final submittals. The final plan set will be ready for a contractor to use to aid in the construction phase of the project. The final report and presentation will be of top quality to ensure client satisfaction. The final website will include all updated documents for the project.

2.6.2.5 Task 6.2.5: Meeting Memo Binder

The meeting memo binder will hold all the meeting information during the progression of the project. Meeting agendas and meeting minutes will be compiled into one organized binder for easy reference if needed. It will be a record of team meetings and meetings held with the client, technical advisor, and grading instructor categorized accordingly.

2.6.2.6 Task 6.2.6: Website

The website will be made to present different areas of the project. This site will be accessible to the public so they can understand the work done during the progression of the project. The website presents the project description, all contact information of the design team and client, and all completed documents.

2.7 Task 7: Project Management

2.7.1 Task 7.1: Meetings

Throughout the course of the project there will be scheduled team meetings, client meetings, grading instructor meetings, and technical advisor meetings. These meetings are to help ensure the project is staying on schedule, to make decisions, and to keep all parties informed on the progression of the project.

2.7.1.1 Client Meetings

Client meetings will be scheduled to ensure the proposed design meets all the client's criteria and needs. These meetings will directly follow the planned agenda and provide time to answer the team's questions for the client and any questions the client has for the team. These meetings will be used to keep clear communication between the client and the project team.

2.7.1.2 Technical Advisor (TA) Meetings

There will be minimum of four scheduled meetings with the team's technical advisor throughout the semester. The purpose of these meetings is for clarifying questions and guidance on project submittals. The technical advisor will assist the team in understanding the expectations of the grading instructor.

2.7.1.3 Grading Instructor (GI) Meetings

Meetings with the grading instructor should be scheduled following the submittal of each major deliverable for direct critique of technical work. These meetings will be used to improve further submittals to expected professional standards.

2.7.1.4 Team Meetings

Team meetings will be conducted weekly to ensure all team members work as a cohesive unit. These meetings will be used to stay updated on the progress of each submittal and create plans of action to complete each step of the project. Additional team meetings may be scheduled as needed ensure the success of proposed drainage design.

2.7.2 Task 7.2: Resource Management

Resource management identifies all resources the project will need, how they will be acquired, and how they will be managed. Resources for a project include people, materials, equipment, knowledge, infrastructure, and software [9]. The project team will develop a concise resource management plan to organize acquiring and utilizing resources in an efficient manner to meet the design needs, budget, and schedule of the project successfully. Each team member will be assigned individual roles and responsibilities. Team meetings will include updates on the resource management plan to ensure the project stays efficient and on task.

2.7.2.1 Task 7.2.1: Schedule Management

An overall schedule for completion of the project will be produced to manage and execute all tasks efficiently. The team will hold weekly meetings to stay current with the progression of the project and correct any issues that may arise. Meetings with a technical advisor will be scheduled prior to each deliverable submittal. Meetings with a grading instructor will be scheduled following each deliverable submittal. These meetings will assist the team in keeping the project on schedule for the determined completion date.

2.7.2.2 Task 7.2.2: Budget Management

Budget management focuses on determining the cost for the team to design this drainage facility, also known as the design budget. First, the scope of the project must be completed to understand the needs and size of the project. The design budget will then depend on the hourly salary of all design team members, the time duration of the design, and any other additional training or equipment necessary to complete the design.

2.7.2.3 Task 7.2.3: Staff Management

All members of the design team will be assigned distinct roles and responsibilities to efficiently produce a drainage design. The time spent contributing to this project will be recorded for each staff member. Staff schedules must align with the design budget agreed upon with the client.

2.8 Exclusions

For this project, the team will not focus on other structures besides the storm drain and the needed signage, sidewalks and crosswalks needed for NAU parking lot 46. There will be no geotechnical work, floodplain mapping, structural work, paving/asphalt design, traffic or transportation design, environmental compliance, and no permitting. The main work for the project is strictly drainage design and nothing more. The other parts to be excluded from design will be analysis of geotechnical condition, structural designs of pavements and side walkways. For projects, traffic analysis is the basic concern so we will not exclude it from project means will discuss diversion paths and traffic in peak hours during construction time. Environmental impacts will take into consideration because we cannot exclude them from project because these are the major concerns.

3.0 SCHEDULE

A schedule for the completion of this project was generated to ensure a quality design is prepared in an efficient manner and all deliverables are met. All major tasks and sub tasks were outlined within the scope of this report. These tasks were inputted into a Gantt chart using Microsoft Project. The Gantt chart identifies the critical path of tasks and is used as a tool to assist the design team in making any necessary schedule changes prior to the start of work on the project.

3.1 Duration, Major Tasks, and Deliverables

The NAU parking lot 46 stormwater drainage design project will start on August 23rd, 2021. The project will be completed on November 26th, 2021 with a final report, presentation, and construction plan set. The duration of this project is 83 days. Major tasks include an existing studies review, analyze existing site, hydrologic and hydraulic analyses, site design, and project deliverables. Required deliverables for this design include submitting a 30%, 60%, 90% and final reports, presentations, plan set, and website.

3.2 Critical Path

A critical path for a project schedule outlines tasks that must be completed before subsequent tasks can begin. The critical path for this design process is shown in red on the Gantt chart provided in appendix A. The projects critical path begins with existing studies review, as this is where the team will collect all relevant data as the base line for the project, followed by analyzing the existing site. The next critical task is conducting the hydrologic analysis of the site, the stormwater runoff data obtained here is the basis for what the drainage facility will be designed for. The data obtained from the hydrologic analysis is used in the following critical task to perform a hydraulic analysis. The next critical task is stormwater runoff modeling. Modeling the existing runoff will allow the team to spend time predicting how different designs can manage the given flow. The final critical task for this project is site design where a construction plan set will be developed.

4.0 STAFFING PLAN

The following section includes all details regarding staffing for this project. A description of all necessary personnel, design team qualifications, and work plan are provided below.

4.1 Personnel Classification

The project requires services of the following personnel for completion of the project. The qualifications and the skills sets required have also been mentioned along with roles.

- **Senior Engineer (SR. ENG)**

  A qualified senior engineer must have a Bachelor of Science in civil engineering and be well versed with engineering related software. The engineer must be registered with the Arizona Engineering Department and have a working experience of 10-20 years in the field of hydraulic engineering. The primary role of a senior engineer is to oversee the design and building of construction projects [10]. The senior engineer will work closely with the project manager and be involved with planning process, scheduling, and management.

- **Project Manager (PM)**

  A qualified project manager must have a bachelor's degree in civil engineering, building science, or construction management. Core tasks for this position include completing the construction project planning process, oversee construction personnel, prepare progress reports and attend meetings [11].

- **Junior Engineer (JR. ENG)**

A qualified junior engineer must have a bachelor's degree in engineering. The engineer must be registered with the Arizona Engineering Department and have a working experience of 5-10 years in the field of hydraulic engineering. The individual must be well versed with structural engineering related software and should be capable of working as a team rather than as an individual.

- **Engineer in Training (EIT)**

A recent graduate holding a professional degree in the field of Civil Engineering from an ABET accredited university. The individual must be pursuing hydraulic engineering as his career and have 6 months of relevant experience. The individual must be well versed with structural engineering related software and should be capable of working as a team rather than as an individual.

- **Engineering Intern (I. ENG)**

A recent graduate or current student pursuing a license in the field of hydraulic engineering. The individual must have 6 months of relevant experience. The individual must be well versed with hydraulic engineering related software and should be capable of working as a team rather than as an individual.

4.2 Qualifications

The Surf and Turf Engineering team consists of four senior engineering students that bring a range of experience to this design. The qualifications of each team member are listed below.

Donovan Stewart

- Knowledgeable on various codes and regulations in the city of Flagstaff and Coconino County regarding storm drainage design.
- Experience using major hydrological and hydraulic software such as Flow Master, Culvert Master, and HEC-RAS.
- Experience in the leadership role with a focus on great communication and producing high quality work as a team.
- Technical knowledge on hydrology and hydraulics including modeling, complex analysis and computational data collecting.

Mariam Alqabandi

- **Qualification:** Bachelor's in environmental engineering (7th Semester), Northern Arizona University College of Engineering
- **Software's:** Gis, AutoCAD, MS Word, MS Project, MS PowerPoint, MS Excel, Flow Master, Culvert Master.
- **Attributes:** Team management skills, time management skills, project management skills, good analytical and problem-solving skills, good communications skills and creative thinker.

Saud Rumaih Alazmi

- Well versed with traffic engineering and water resources software's and have sufficient skill set required to carry out traffic engineering and water resources tasks.
- An experienced surveyor who is well familiar with the surveying equipment and conducting surveys.
- Relevant hand on experience having performed several hydrologic and hydraulic experiments.
- Experience in software's such as MS office, AutoCAD, Culvert and Flow Master.

Sophia Fox

- Experience in conducting surveys and using surveying equipment.
- Proficient in engineering software such as AutoCAD, Flow Master and Culvert Master
- Completion of Water Resources I and II courses at an ABET accredited University.
- Laboratory experience in modeling hydrologic and hydraulic parameters of sub basins, open channels, and culverts

4.3 Work Plan

A staffing matrix that provides a breakdown of hours contributed to each task by all personnel can be found in appendix B. A summary of the total hours contributed by all employees is shown below in table 1.

Table 1: Staffing Summary

Staffing Summary	
Position	Hours
Senior Engineer	84
Project Manager	41
Junior Engineer	213
Engineer in Training	178
Engineering Intern	141
Total	657

As shown in table 1, this project will require an estimated 657 total hours from all employees. The Junior Engineer will spend 213 hours completing tasks as directed by the Project Manager and Senior Engineer. The Senior Engineer is projected to spend 84 hours overseeing all tasks and confirming quality work is being done.

5.0 COST OF ENGINEERING SERVICES

The Surf and Turf Engineering team has assessed the cost of design services based on personnel cost and overall cost of supplies to complete this project. This assessment is broken down and explained below.

5.1 Personnel Cost

The personnel cost comprises of the costs to be paid to the individuals. The personnel cost comprises of the base pay of the individual, the rate per hour, benefits other than the base pay. The benefits are calculated according to a certain percentage (pre-decided) of the base pay. All the previously mentioned are then combined and constitute the pay of a personnel. The total personnel cost is $66,816 for all the personnel working on this project.

5.2 Total Cost

The total cost comprises of the supplies cost plus the cost of all the personnel. The total cost of the project is estimated to be around $ 66,816. Table 2 below shows a breakdown of the total cost.

Table 2: Project Costs

1.0 Personnel	Classification	Hours	Billing Rate (Dollars/hr)	Cost
	Sr. Eng.	84	$180.00	$15,120
	PM	41	$150.00	$6,150
	Jr. Eng.	213	$120.00	$25,560
	EIT	178	$90.00	$16,020
	I. Eng.	141	$26.00	$3,666
	Total Personnel			$66,516
2.0 Supplies	Classification	Days	Dollar/day	Cost
	Surveying	1	$300.00	$300.00
	Total Supplies			$300.00
3.0 Total				$66,816

6.0 REFERENCES

[1] "Google Maps", Google Maps, 2021. [Online]. Available: https://www.google.com/maps. [Accessed: 06- Feb- 2021].

[2] "US Topo: Maps for America", Usgs.gov, 2021. [Online]. Available: https://www.usgs.gov/core-science-systems/national-geospatial-program/us-topo-maps-america?qt-science_support_page_related_con=0#qt-science_support_page_related_con. [Accessed: 06- Feb- 2021].

[3] "6. Digital Line Graph (DLG) | The Nature of Geographic Information", E-education.psu.edu, 2021. [Online]. Available: https://www.e-education.psu.edu/natureofgeoinfo/c7_p7.html. [Accessed: 06- Feb- 2021].

[4] How to Read a Topographic Map and Delineate a Watershed. United States Department of Agriculture, p. 3.

[5] Chapter 15 NRCS National Engineering Handbook. United States Department of Agriculture, 2021.

[6] Low Impact Development Guidance Manual for Site Design and Implementation. Flagstaff, 2009.

[7] "CulvertMaster", Docs.bentley.com, 2021. [Online]. Available: https://docs.bentley.com/LiveContent/web/Bentley%20SewerCAD%20SS5-v1/en/GUID-963C828E64CB4B20AA4E246DCB64B222.html. [Accessed: 04- Mar- 2021].

[8] "How to Read Construction Plans - A Beginner's Guide - Construct-ed.com", Construct-Ed, 2021. [Online]. Available: https://www.construct-ed.com/beginners-guide-how-to-read-construction-plans/. [Accessed: 08- Feb- 2021].

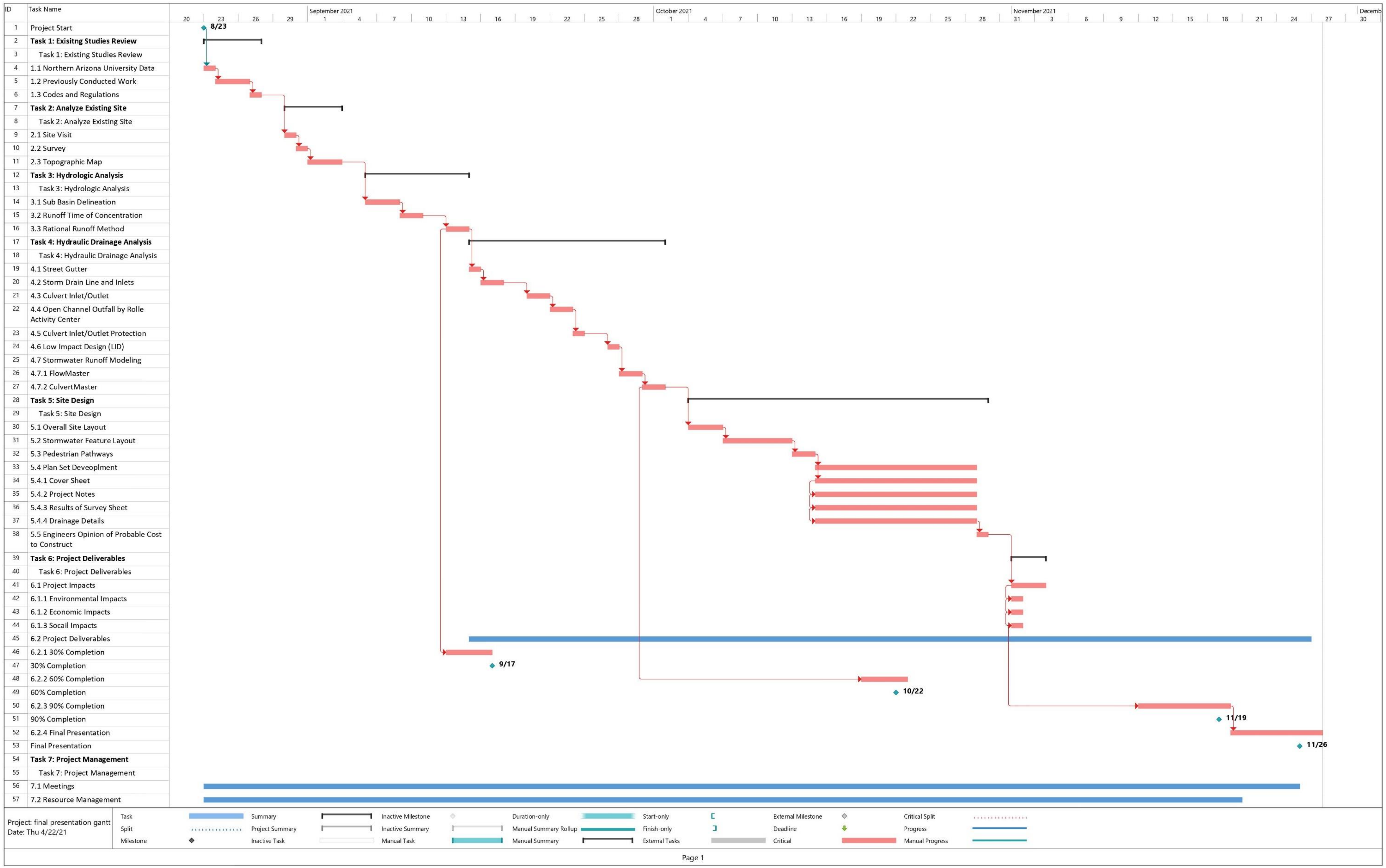
[9] P. Bernie Roseke, "Guide to Project Resource Management", ProjectEngineer, 2021. [Online]. Available: https://www.projectengineer.net/guide-to-project-resource-management/. [Accessed: 08- Feb- 2021].

[10] "Senior Project Engineer Job Description - Jobhero". Jobhero, 2021, https://www.jobhero.com/job-description/examples/engineering/project-engineer/senior. Accessed 20 Mar 2021.

[11] "Civil Project Manager Job Description - JobHero", JobHero, 2021. [Online]. Available: https://www.jobhero.com/job-description/examples/civil-engineering/project-manager. [Accessed: 20- Mar- 2021].

APPENDICIES

APPENDIX A: Gantt Chart



APPENDIX B: Staffing Matrix

Task	SR. ENG	PM	JR. ENG	EIT	I. ENG	Total Hours	Days Allotted
1.0 Existing Studies Review							
1.1 Northern Arizona University Data	1	0	3	2	2	**8**	1
1.2 Previously Conducted Work	3	0	9	6	6	**24**	3
1.3 Codes and Regulations	1	0	3	2	2	**8**	1
2.0 Analyze Existing Site							
2.1 Site Visit	0	0	3	3	3	**9**	1.125
2.2 Survey	0	0	3	3	3	**9**	1.125
2.3 Topographic Map	2	0	10	6	6	**24**	3
3.0 Hydrologic Analysis							
3.1 Sub Basin Delineation	0	0	10	8	6	**24**	3
3.2 Runoff Time of Concentration	0	0	8	4	4	**16**	2
3.3 Rational Runoff Method	0	0	8	4	4	**16**	2
4.0 Hydrualic Drainage Analysis							
4.1 Street Gutter	0	0	3	3	2	**8**	1
4.2 Storm Drain Line and Inlets	0	0	6	6	4	**16**	2
4.3 Culvert Inlet/Outlet	0	0	6	6	4	**16**	2
4.4 Open Channel Flow Outfall by Rolle Activity Center	0	0	6	6	4	**16**	2
4.5 Culvert Inlet/Outlet Protection	0	0	3	3	2	**8**	1
4.6 Low Impact Development (LID)	1	1	2	2	2	**8**	1
4.7 Stormwater Runoff Modeling	2	0	12	12	6	**32**	4
4.7.1 Flow Master	1	0	6	6	3	**16**	2
4.7.2 Culvert Master	1	0	6	6	3	**16**	2
5.0 Site Design							
5.1 Overall Site Design	4	0	8	8	4	**24**	3
5.2 Stormwater Feature Layout	4	0	12	12	4	**32**	4
5.3 Pedestrian Pathways	2	0	5	5	4	**16**	2
5.4 Plan Set Development	24	0	30	14	12	**80**	10
5.4.1 Cover Sheet	0	0	3	3	2	**8**	1
5.4.2 Project Notes	0	0	3	3	2	**8**	1
5.4.3 Results of Survey Sheet	12	0	12	4	4	**32**	4
5.4.4 Drainage Details	12	0	12	4	4	**32**	4
5.5 Engineering Opinion of probable Cos	2	1	0	0	0	**3**	0.375
6.0 Project Deliverables							
6.1 Project Impacts	3	0	6	6	3	**18**	2.25
6.1.1 Environmental Impacts	1	0	2	2	1	**6**	0.75
6.1.2 Economic Impacts	1	0	2	2	1	**6**	0.75
6.1.3 Social Impacts	1	0	2	2	1	**6**	0.75
6.2 Project Deliverables	21	10	43	43	40	**157**	19.625
6.2.1 30% Submittal	4	2	8	8	8	**30**	3.75
6.2.1.1 30% Report	2	1	3	3	3	**12**	1.5
6.2.1.2 30% Presentation	0	1	2	2	3	**8**	1
6.2.1.3 30% Plan Set	2	0	3	3	2	**10**	1.25
6.2.2 60% Submittal	4	2	8	8	8	**30**	3.75
6.2.2.1 60% Report	2	1	3	3	3	**12**	1.5
6.2.2.2 60% Presentation	0	1	2	2	3	**8**	1
6.2.2.3 60% Plan Set	2	0	3	3	2	**10**	1.25
6.2.3 90% Submittal	6	3	12	12	12	**45**	5.625
6.2.3.1 90% Report	2	1	3	3	3	**12**	1.5
6.2.3.2 90% Presentation	0	1	3	3	3	**10**	1.25
6.2.3.3 90% Plan Set	3	0	3	3	3	**12**	1.5
6.2.3.4 90% Website	1	1	3	3	3	**11**	1.375
6.2.4 Final Submittal	7	3	15	15	12	**52**	6.5
6.2.4.1 Final Report	2	1	4	4	3	**14**	1.75
6.2.4.2 Final Presentation	0	1	3	3	3	**10**	1.25
6.2.4.3 Final Plan Set	4	0	4	4	3	**15**	1.875
6.2.4.4 Final Website	1	1	4	4	3	**13**	1.625
7.0 Project Management							
7.1 Meetings	14	14	14	14	14	**70**	8.75
7.1.1 Client Meetings	1	1	1	1	1	**5**	0.625
7.1.2 Technical Advisor Meetings	4	4	4	4	4	**20**	2.5
7.1.3 Grading Instructor Meetings	2	2	2	2	2	**10**	1.25
7.1.4 Team Meetings	7	7	7	7	7	**35**	4.375
7.2 Resource Management	0	15	0	0	0	**15**	1.875
7.2.1 Schedule Management	0	7	0	0	0	**7**	0.875
7.2.2 Budget Mangagement (Design Budget)	0	1	0	0	0	**1**	0.125
7.2.3 Staff Management	0	7	0	0	0	**7**	0.875
					Total	**657**	**82.125**

Sr. Eng	PM	Jr. Eng	EIT	I. Eng
84	41	213	178	141