Shadow Mountain Drainage Design Proposal

AB Stormwater Management Co.

Northern Arizona University

Flagstaff, Arizona

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ABBREVIATIONS

ADOT Arizona Department of Transportation

ADEQ Arizona Department of Environmental Quality

Mt. Mountain

Ave. Avenue

HEC-HMS Hydrologic Modeling System

HEC-RAS Hydrologic Engineering Center River Analysis System

NOAA National Oceanic and Atmospheric Administration

LIDS Low Impact Developments

GIS Geographic Information System

1.0 PROJECT UNDERSTANDING

1.1 PROJECT PURPOSE

Runoff from the south slopes of Mt. Elden flows down into the Shadow Mountain residential area. Over the years this runoff has greatly increased, and the current stormwater infrastructure can no longer handle this runoff. As a result, this community is experiencing devastating flooding and sediment deposit. The purpose of this project is to reduce flow volume and velocities of flow before it reaches this neighborhood to prevent future flooding in the Shadow Mountain area.

1.2 PROJECT BACKGROUND

Shadow Mountain is an older neighborhood located on the east side of the City of Flagstaff. The community was built between the late 1970's to early 1980's. During the time of the construction, the need to construct stormwater infrastructure was not a necessity. Over the years, the increase in infrastructure and change in weather patterns have increased Mt. Elden's storm runoff on the eastside of Flagstaff. As a result, every year when the snow melts and the monsoon rains come to Flagstaff, the community is impacted by destructive floods. The existing stormwater infrastructure in the Shadow Mountain community includes limited storm drains and culverts. All these original stormwater infrastructures are outdated and are no longer large enough to withstand the annual rainstorm flow rates. Residents in this area are relying on sandbags and plywood built up to slow down the flood waters from impacting their property.

Figure 1-1 shows the site of the project in Flagstaff, Arizona, indicated by the red marker.

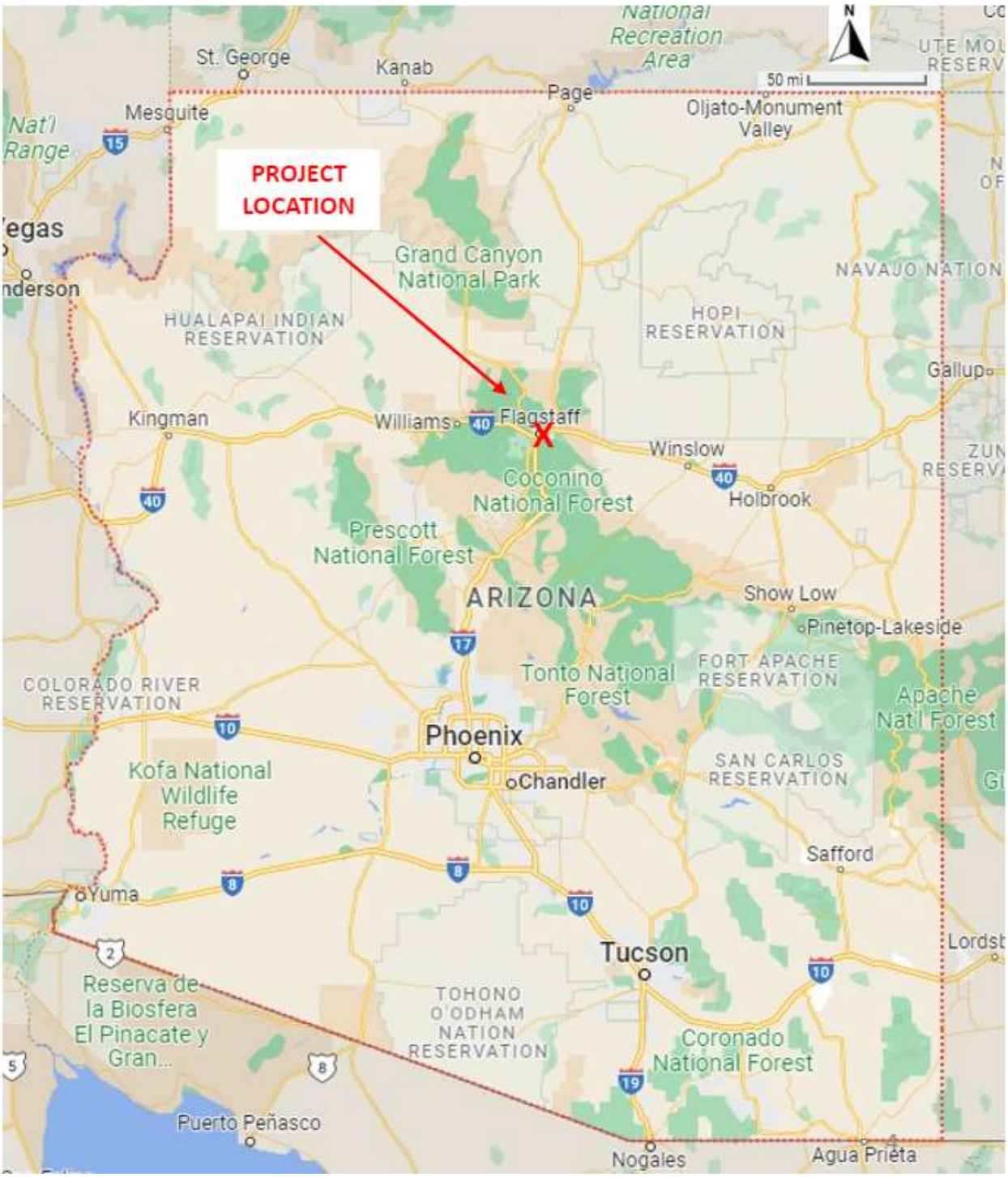

Figure 1-1 Map of the State of Arizona

Within the City of Flagstaff, the project is located on the east side of Flagstaff in a community called Shadow Mountain. It was built against the southwest base of Mt. Elden as seen in Figure 1-2 below and is indicated by the rectangle.

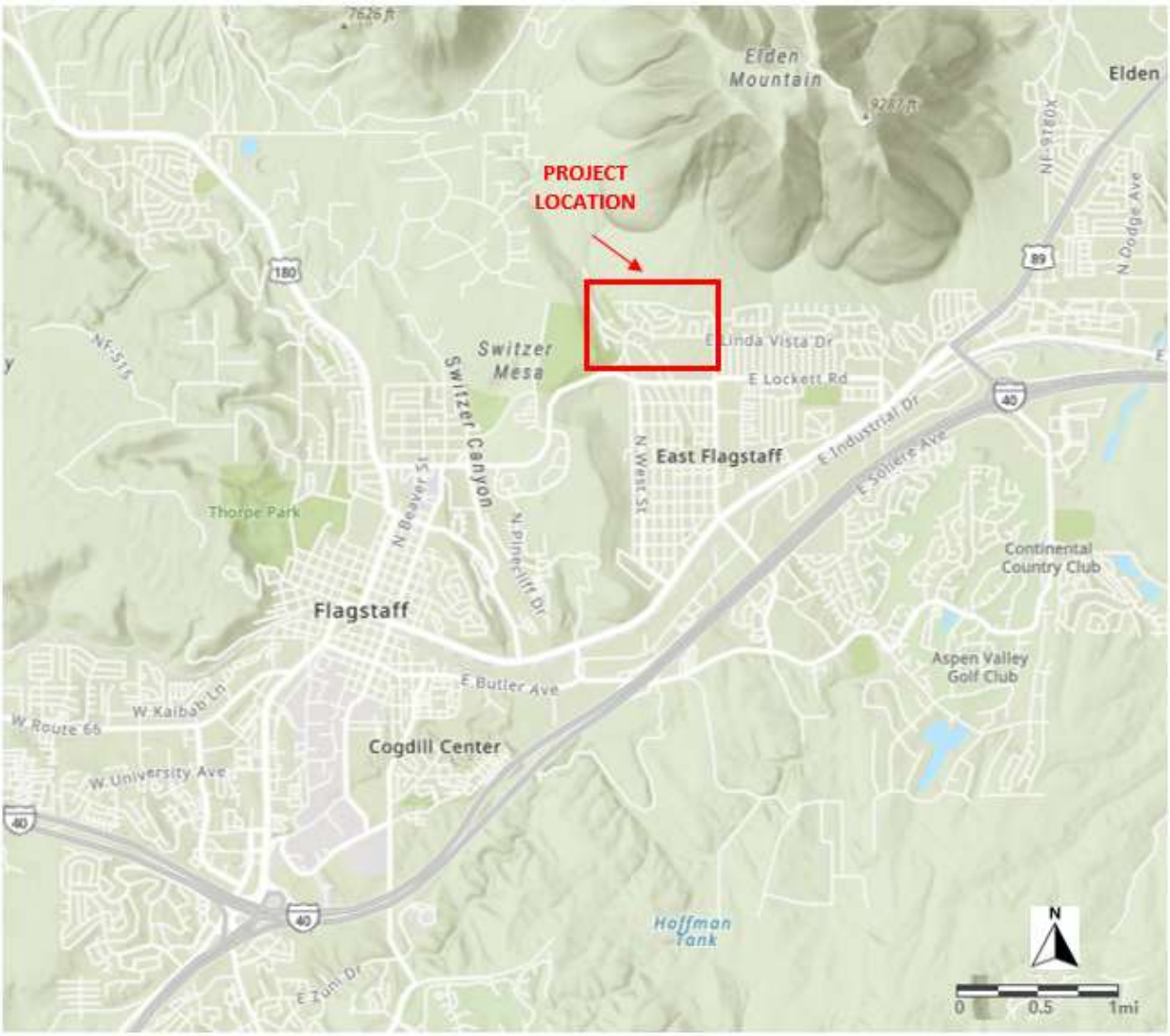

Figure 1-2 Map of the City of Flagstaff

Figure 1-3 below shows the community of Shadow Mountain with respect to the area of Mt Elden that impacts the community with its storm runoff.

Figure 1-3 Map of Shadow Mountain Community and Mt. Elden

Figure 1-4 below shows the community of Shadow Mountain in greater detail. The bounds of the project are Appalachian Road to the north and east, Linda Vista Drive to the south and Paradise Hill Park being the western boundary of the project site. This project will focus on reducing the flood waters that directly impact the cul-de-sac located in the northwest corner of the project site. This cul-de-sac is indicated by a red mark in Figure 4 below.

Figure 1- 1 Map of Project Location - Shadow Mountain

1.3 TECHNICAL CONSIDERATIONS

The technical consideration for this project includes the application of hydrological modeling, hydraulic analysis, design requirements, research into city and county drainage codes, and drafting software.

1.3.1 HYDROLOGICAL

Hydrological modeling is required to understand the predevelopment and post development effects of the area where Shadow Mountain is located. This analysis of the change to the hydrology in the area will help determine the amount of stormwater that is impacting the community to create an effective solution. A watershed delineation for computing a concentration point could be used along with a HEC-HMS or HEC-RAS to provide more information for each sub-basin that reaches this concentration point. This will be applied in the scope of work in determining the volume of water that needed to be retained by the constructed basin. Without this information, the project will not be able to create an appropriate design to retain the annual rainfall.

1.3.2 HYDRAULIC

A hydraulic analysis is needed to understand both the present and probable future channel, culverts, and basin designs. The focus will be on analyzing the flow capacity of existing and/or designing new hydraulic structures.

1.3.3 DESIGN CODES

Design requirements for channels, culverts, and basins will need to be evaluated using the information provided in the Stormwater Management Design Manual for the city of Flagstaff. Additionally, to create an effective solution, the team will need to understand what city and county codes apply to the project site. The codes will provide parameters for what the solution can be and how it could be implemented. Design codes will be applied to this project in determining the standard to design too. Without the correct codes identified, the project will be out of compliance with the City of Flagstaff and will fail.

1.3.4 SOFTWARE

The final solution will require a computer drafting software such as Civil 3D to draw the final design. This is an acceptable approach to creating a design because it is compatible with the software used by the project client, the City of Flagstaff Stormwater department. The use of software will be applied to the project to analyze the information into an easier form to understand and apply to the project. Without the use of properly learned software, the project will not have the necessary information to create informed decisions and the progress of the project will fall behind schedule.

1.3.5 LAND SURVEY

Land survey is required to understand land boundaries of this project site. Land surveying data collected for the project site will be used to analyze the Spruce Ave. Watershed characteristics. This will be the basis used in the hydrological scope of the drainage design project.

1.4 POTENTIAL CHALLENGES

Potential challenges and constraints that may influence the Shadow Mountain project include weather, equipment availability, COVID, and restricted access to private property. The weather can impact the site investigation in which there may be rain or snow during this time of monsoon and winter season. Therefore, monitoring the weather ahead of time is important to appropriately plan for the completion of the design as the weather does vary day to day. Another challenge is the equipment availability in which the tools that are needed to gather data may not be available during this time and could possibly delay the schedule that is set for performing surveys. This is something that will need to be planned ahead of time such as compiling a list of equipment required for desired survey objectives and making sure that this equipment is available beforehand to avoid any delay. In addition, given that COVID is still prevalent, there is a possibility that a teammate or the technical advisor could contract COVID during this project that would cause a change in schedule. This will require flexibility of team members to adjust to taking on additional tasks to meet required deadlines. Additionally, there are constraints associated with access to easements

and private property during this process that will have to be considered. It is imperative to understand how to gain legal access to these areas that are deemed necessary for the development of this project.

1.5 STAKEHOLDERS

Stakeholders associated with the Shadow Mountain Drainage Design Project includes the residents of the Shadow Mountain area and the surrounding areas, the City of Flagstaff, the Arizona Department of Environmental Quality (ADEQ), Flagstaff Gas Company, and the City of Flagstaff Stormwater Management. Those who reside in Shadow Mountain, specifically those who reside downstream of the Spruce Ave. Wash, are affected by Mt. Elden south slopes runoff that is flooding their homes; while residents South could be affected by any runoff that is not properly designed for. The City of Flagstaff is a major stakeholder as public lands within the project site such as the Spruce Ave. Wash and previous existing stormwater systems will be affected by this drainage design. In addition, the Arizona Department of Environmental Quality regulates the environmental laws that this project will need to adhere to. Improvements made should help reduce the sediment loading to Rio de Flag and should improve the Flagstaff's compliance with their municipal separate storm sewer system permit. Depending on the selection of land to be used for the drainage design, the Flagstaff Gas Company could be a stakeholder if the chosen design is placed on the gas company's land where the gas line resides. Amongst this, the City of Flagstaff Stormwater Management department is a direct stakeholder as the client for this project is employed by this department. The final proposed design will be used as a basis for the City of Flagstaff Stormwater Management Plan for the Shadow Mountain area.

2.0 SCOPE OF SERVICES

2.1 TASK 1 RESEARCH

The research done for the Shadow Mountain will help in the development of the drainage design as the project moves forward.

2.1.1 TASK 1.1 DOCUMENT EXISTING STRUCTURES/GIS

Although no previous documentation of existing structures was made available during the time of neighborhood construction with the thought of a stormwater infrastructure, there is a topographic and GIS map made available for public view of Shadow Mountain that will be used for establishing project boundaries.

2.1.2 TASK 1.2 RESEARCH RETENTION/DETENTION OPTIONS

The different types of basins include a dry and wet detention pond that can be referred to as a retention pond. As both are good for the protection against flooding, detention basins are a temporary pool of water as it usually remains dry between storms and are used for a large collection of water and then slowly drained through the outlet. Retention basins are constant pools of water used to treat and store water runoff as it captures and holds rainwater.

2.1.3 TASK 1.3 FEMA FLOODPLAIN INFORMATION

The Federal Emergency Management Agency (FEMA's) Regulatory Floodway data will be reviewed in connection with the project area.

2.1.4 TASK 1.4 IDENTIFY DESIGN REQUIREMENTS FOR CITY

The City of Flagstaff Stormwater Management Design Manual and the Drainage Design Criteria Manual of the Coconino County will be used during this project for reference upon; the drainage report requirements, floodplain studies and map revisions, grading and drainage plan, street and gutter drainage, and public improvement plans.

2.1.5 TASK 1.5 REVIEW EXISTING PLANS/STUDIES

Since there are no current existing plans for the Shadow Mountain area of drainage design, we have been given the flood hazard map provided by the City of Flagstaff that will be used to look at for this project area identifying peak discharges and max depth.

2.1.6 TASK 1.6 CREATE A PLAN FOR THE FIELD SITE INVESTIGATION

A site investigation shall be conducted to determine the desired survey locations that would be useful and relevant in cross-sectional data. This involves visiting the area within the potential boundary points and creating a plan before taking out any surveying tools and examining the land for the surveying process.

2.2 TASK 2 FIELD SITE INVESTIGATION

To conduct a thorough analysis of the Shadow Mountain area, the site will be evaluated with a field visit to the boundary points of the project area as the Shadow Mountain residents will be the focus.

2.2.1 TASK 2.1 FIELD SITE VISIT

The team will visit the Shadow Mountain Cul De Sac and the land north of the project site located on the Unisource property. During the site visits the team will take photos documenting the current conditions, observing drainage runoff pathways, and looking at existing stormwater drains. Prior to the site visits, a request for the client to attend will be made.

2.2.2 TASK 2.2 FIELD SITE VISIT ASSESSMENT

Information collected during the site visit will be used to analyze the current condition of the Shadow Mountain area such as the runoff characteristics, and land use, land use cover, and determine the area of land above the Cul de sac that will be used to create the detention/retention basin.

2.3 TASK 3 HYDROLOGIC ANALYSIS

Historical precipitation data for the Shadow Mountain area will be used to create models that delineate the Spruce Ave. Watershed and analyzed the natural runoff flow characteristics such as watershed area, runoff flow volumes, flow directions, and time of concentrations. As requested by the client, this analysis will be done for a 100-year storm with a 24-hour rainfall, per the SCS Type 2 Rainfall Distribution requested in the City of Flagstaff Stormwater Design Manual.

2.3.1 TASK 3.1 WATERSHED DELINEATION

Use topographic maps and preexisting precipitation data to delineate the Spruce Ave. Watershed to determine the watershed area, the location of the point of concentration, the ultimate time of concentration, the rate of flow, existing sub-basin storage, design storm intensities, and the peak runoff flow in the Shadow Mountain area.

2.3.2 TASK 3.2 DETERMINE TIME OF CONCENTRATION

To predict the volume of runoff that flows out of the Spruce Ave. Wash during a given storm event, the longest time it takes for the runoff to travel from the hydraulically most distant point of the watershed to the outlet (ultimate time of concentration) needs to be determined. This time of concentration will be determined by using data from the watershed delineation and topographic maps. Data calculated through this process will

help determine the flow that needs to be designed for based on the Coconino County Stormwater Design Codes.

2.3.3 TASK 3.3 DETERMINE WATERSHED ROUGHNESS COEFFICIENT

Surface characteristics of the Spruce Ave. Watershed will be considered to accurately predict the rates of runoff flow. The roughness coefficients (C) change based on the roughness of the surface. The watershed will be broken up into different sub-basin areas to calculate the types of surfaces that occupy the entire watershed.

2.3.4 TASK 3.4 DETERMINE DESIGN STORM INTENSITIES

To determine the design storm intensities, the time of concentration, the NOAA Atlas 14, and design storm frequencies specified by the City of Flagstaff will be used. The depth of precipitation will represent the amount of rainfall from a storm event while the intensity of precipitation will represent the ratio of rainfall depth over a given time period.

2.3.5 TASK 3.5 DETERMINE NATURAL RUNOFF

The peak runoff flow in the Spruce Ave. Wash will be calculated using the areas of the sub-basins, runoff coefficients, and historical precipitation data.

2.3.6 TASK 3.6 ANLAYZE EXISTING SUB-BASIN STORAGE

Analyze the existing impacts of pre-existing retention and detention basins in the Spruce Ave. Watershed to find the volume of water that is currently being accounted for. This volume can be subtracted from the total natural runoff that this proposed stormwater drainage is being designed for.

2.4 TASK 4 HYDRAULIC ANALYSIS OF EXISTING STRUCTURES

Assess the current stormwater infrastructure at Shadow Mountain through existing GIS data or refer to notes from the site visit to get a better understanding of the current conditions. The capacity of existing structures will be determined.

2.5 TASK 5 ANALYSIS OF ALTERNATIVES

The design process consists of determining what to design, what standards to design to, and comparing multiple design possibilities against each other to determine the best solution.

2.5.1 TASK 5.1 DETERMINE CONSTRAINTS AND CRITERIA OF DESIGN

The constraints will be determined by the physical capacity of the project site such as saturation capacity of soil, area of land available to build on, annual rainfall, time of construction, and budget. Criteria will be identified for the use of a systematic evaluations of alternative designs.

2.5.2 TASK 5.2 DEVELOP ALTERNATIVE DESIGNS TO REDUCE RUNOFF

Detention and retention basins require certain conditions to be effectively implemented. Characteristics such as an available area, existing surfaces, cost, and water quality requirements are all important considerations in determining which hydraulic structure will be the best option for the existing conditions. The pros and cons of a retention and detention basins will be analyzed to determine which structure will be best for the Shadow Mountain area. Another alternative could be a low impact development site design that uses natural and engineered infiltration to control storm water where it is generated, achieving a sustainable site design. The Maricopa Association of Governments (MAG) will be used to design structures.

2.5.3 TASK 5.3 SELECT BEST ALTERNATIVE

A decision matrix will be used to determine which design option(s) from the list of design alternatives is the best choice for the Shadow Mountain area.

2.6 TASK 6 FINAL DESIGN

Based on the detention/retention basin, and the low impact development site analysis, the proposed drainage design will be modified to represent the detention/retention basin determined as the best fit for the Shadow Mountain area. HEC-RAS will be used to find effective solutions for the storm events required by the Coconino County Drainage Design Manual. This will show where problems arise and how this can be improved to ultimately determine the solution used for the Shadow Mountain area

2.7 TASK 7 CONSTRUCTION PLANS

The construction plans will be created for decreasing the velocity of the runoff flow on Mt Elden to this area and a detention/retention basin. The plans will provide guidance on how to construct and include specific details to help clarify plan details. The construction plan set will include the following pages: cover page, existing topography/site, proposed topography, plan, and profile cross sections of the hydraulic structure.

2.7.1 TASK 7.1 EXISTING FLOODPLAIN MAP

A map of the existing floodplain will be created to identify the areas within Shadow Mountain that are most impacted by flooding. The map will describe the behavior of flooding in the area and show where it mainly drains to and the average depth of flooding based on the 2-yr, 10-yr, 25-yr, and 100-yr flooding required for design.

2.7.2 TASK 7.2 DESIGN OF RUNOFF CONTROL STRUCTURE SHEETS

The design of runoff control structures will exist on the downhill slope of Mt. Elden that directly impacts the Shadow Mountain community. The types of sheets needed will be a

complete plan of the runoff control structure. This control structure will help protect Mt. Elden and the community from erosion as well.

2.7.3 TASK 7.3 GENERAL PROJECT DETAILS

The details will be obtained from ADOT and Coconino County drainage design manuals. These details will be used to show the design of structures included in the design of the runoff control structures selected.

2.7.4 TASK 7.4 PROJECT NOTES AND SPECIFICATIONS

Any modifications of design changes made to original plans for the runoff control structure or detention/retention basin will be noted in this section of the construction plans.

2.8 TASK 8 CONSTRUCTION COST ESTIMATE

A budget for the cost of construction will be developed and included in the final report.

2.9 TASK 9 PROJECT IMPACTS EVALUATION

The stormwater drainage design chosen for the Shadow Mountain area will have impacts much greater than the immediate area. The proposed design will analyze the environmental, social, and economic impacts caused by the design placement.

2.10 TASK 10 PROJECT DELIVERABLES

This task will detail what is included in each submittal and the sub-task associated with completing each listed task.

2.10.1 TASK 10.1 30% SUBMITTAL

This submittal is the initial products of the design process. At this time, tasks 1-3.4 will be completed. The deliverables required are the 30% draft of the final design report, a 30% construction plan set, and a presentation of the team's progress. The final design report will have completed sections written of the project research, background information, site investigation visit, the site investigation assessment, and the initial hydrologic analysis of the watershed delineation. The 30% construction plan set will include the completed design plan minus annotations and details, a cover sheet, a vicinity map, and sheets cut for abbreviations, details, and cost estimate. The progress presentation will summarize all the information required above and a review of the construction plans.

2.10.2 TASK 10.2 60% SUBMITTAL

This submittal is a progress check that will begin work from where the 30% left off. It will address all comments made on the 30% to the report and construction plans. At this

time, tasks 3.5-5 will be completed. The deliverables included are 60% of the final design report, a 60% construction plan set, and a presentation of the team's progress. The final design report will have completed sections from the 30% submittal with the review comments addressed and include a completed written section for hydrological analysis, hydraulic analysis of existing structures and the completed design process written. The 60% construction plan set will include a completed title page, completed vicinity map, completed details sheet, draft cost estimate sheet, annotated and complete design, all sheets required for a complete plan set cut and accurate title blocks on all sheets. The progress presentation will summarize all the information required above and a review of the construction plans.

2.10.3 TASK 10.3 90% SUBMITTAL

This is a submittal of all the team's final work. At this time, tasks 6-9 will be completed. The deliverables required are the complete final report, a progress presentation, 90% construction plan set and website draft. The 90% construction plan set will include a title sheet, table of contents sheet, vicinity map, abbreviations sheet, general notes sheet, and completed design sheets for the detention/retention basin and runoff control structure. All comments made from the 60% submittal will be addressed. A draft of the project team's website including all reports, presentations, and important information pertaining to the site and project deliverables. The progress presentation will summarize all the information required above and a review of the final construction plans. This presentation will focus on showing the project site's proposed design versus its existing design.

2.10.4 TASK 10.4 FINAL SUBMITTAL

This will be the last submittal of all work with all comments addressed from the 90% review. At this time, task 10 will be completed the deliverables required are the complete final report, final construction plans, final website ready for publishing, and a final presentation. The final report, final construction plans, final website will have all previous comments addressed. The final presentation will contain all the information from previous presentations. This report will be given to a panel of practicing engineers from the Flagstaff community, client, GI and TA for grading and questions.

2.11 TASK 11 PROJECT MANAGEMENT

2.11.1 TASK 11.1 PROJECT MEETINGS

Throughout the duration of the project meetings will be held with the grading instructor (GI), technical advisor (TA), client, and the team. The purpose of the meetings is to make sure the project is progressing in the direction that it was intended. Each of these meetings allow an opportunity to discuss how to progress, clarify questions, receive a review of work and comments to make corrections.

2.11.2 TASK 11.2 SCHEDULE MANAGEMENT

The schedule will be tracked and updated to reflect the team's progress and ensure critical tasks are completed on time. Adjustments will be made to ensure all work is completed by the due date of the final submittals.

2.11.3 TASK 11.3 RESOURCE MANAGEMENT

This will consist of tracking staffing and budget throughout the duration of the project.

2.1.3.1.1 STAFFING

Staffing will track the number of hours each member of the team is spending on a given task to estimate the cost for engineering services throughout the project.

2.1.3.1.2 BUDGET

The expenses of the project will be tracked and compared to the cost of engineering services to ensure the project is within budget.

2.12 EXCLUSIONS

This section details portions of the project that will be excluded due to time and subject constraints.

2.12.1 SURVEY OF EXISTING ROADWAYS AND PRIVATE PROPERTY

The project site location and potential area of interest for construction have the potential to conflict with existing roadways and property lines. To prevent this from occurring, the project will use pre-collected surveying data of the area that shows property lines, neighborhood roads, access roads, and easements owned by the City of Flagstaff. This information will be available through public records and GIS data provided by the client.

2.12.2 PUBLIC MEETINGS

The project is essentially changing the natural landscape of Mt. Elden to reduce the impact of annual flooding impacting Shadow Mountain. Any changes made at this location will have a direct impact on the residence of Shadow Mountain and those who live downstream. The nature of these changes will require public approval and acceptance to make this project a success. Public meetings will occur with the client and the citizens who live in Shadow Mountain and potentially those who live downstream of the project site location.

2.12.3 GEOTECHNICAL ENGINEERING

The project will require additional information on the sites soil classification and behavior. This information is required to understand how to design the runoff control

structure and detention/retention basin. The capacity of the soil to hold water is essential in determining what to build and how to build it. This information is also needed to understand why the area floods in the way that it does.

3.0 SCHEDULE

The schedule for the project is in the Appendix, as the start date will begin January 15, 2023, through May 3, 2023, with a duration of 106 days.

3.1 MAJOR TECHNICAL TASKS

The major task indicated on the Gantt chart are research, field site investigation, hydrologic analysis, hydraulic analysis, analysis of alternatives, final design, construction plans, construction cost estimates, project impacts, project deliverables, and project management. These major tasks were chosen based on the requirements needed to complete the overall project. Each of the major tasks is required to determine which design is needed to retain the annual floodwaters that impact the Shadow Mountain community. Milestones are indicted in the Gantt chart with a diamond icon. The milestones selected for this project are the 30% deliverable, 60% deliverable, 90% deliverable, and final deliverable. These milestones were determined because they are the major deliverables that need to be submitted during the length of the project.

3.2 CRITICAL PATH

The critical path is the grouping of tasks that must be completed on time to ensure the project is completed by its expected date. In the Gantt chart, the critical path is indicated by the tasks in red. The team can ensure the project remains on schedule by having regulated team meetings, maintaining accountability, and completing task on time. Regular team meetings will ensure the team is on the same page and check on everyone's progress. The meetings will serve as a starting block every week to ensure everyone is heading in the right direction. Accountability as individuals and for the team is important to ensure tasks are completed to standard, on time, and have been reviewed for technical and grammatical error. The last approach the team will use to stay on schedule is completing task on time. This can be done by finishing the task early, setting aside additional time to complete a task, and begin the task earlier in case questions arise.

4.0 STAFFING PLAN

This project will be completed with a total of 4 employed engineers. Each role assigned holds specific qualifications to be met to meet requirements for a successful project.

4.1 LIST OF QUALIFICATIONS

The roles of the 4 employees will include the Senior Engineer (SENG), the Project Engineer (ENG), the Engineer in Training (EIT), and an Engineering Intern (INT).

The Senior Engineer will lead the design effort and must be a Professional Engineering with 10 years or more of professional and industrial experience and must obtain a four-year bachelor's degree in Civil or Environmental Engineering. The Senior Engineer must oversee design plans, manage the project budget and engineering process, as well as conduct in-depth research. Skills required of the Senior Engineer will include solving skills, communication skills, and organizational skills to review and revise the different stages of the project or designs for improvement.

The Project Engineer must be a Professional Environmental or Civil Engineer with 5 years of experience in a related industry. The Project Engineer must be able to perform field work, creating plans/designs and acquire communication and technical skills needed to mentor the Engineer In Training.

The Engineer In Training should be a recent graduate with a Bachelor of Science in Environment or Civil Engineering from an ABET accredited University. The EIT must have passed the Fundamentals of Engineering Exam with some experience in an industry, as they will assist the Project and Senior Engineer in performing multiple tasks. Required skill must include technical, communication, and software such as Civil 3D and HEC-RAS.

The Intern must be enrolled in a 4-year college studying Civil or Environmental Engineering and will assist with the planning and design of the project. The Intern must demonstrate excellent verbal and written communication skills, effectively work in a team environment, and must have working knowledge of Civil 3D and Microsoft Office. Applied knowledge of hydrologic and hydraulic analysis is desired.

4.2 PERSONNEL HOURS

The Senior Engineer will focus on project management tasks such as scheduling, staffing, budgeting, resource management, with some final design work but mainly reviewing and approving the team's design work. The Project Engineer will be tasked with the majority of the technical hydrologic and hydraulic analysis, design work, and construction plans. The Engineer in Training will be tasked with the technical research, assist in the hydrologic and hydraulic analysis, a portion of the alternative designs, and construction plan details. The Engineering Intern will assist in basic research and administrative duties.

Table 4-1 below shows the staffing plan broken down by task and roles for each of the 4 employees and their estimated hours.

Table 4-1: Personnel Hours Table

TASK	SENG (hrs)	ENG (hrs)	EIT (hrs)	INT (hrs)	TOTAL (hrs)
1.0 RESEARCH (Total hours)	**1**	**13**	**15**	**14**	**43**
1.1 DOCUMENTATION OF EXISTING STRUCTURES/TOPOGRAPHY/GIS	0	2	2	4	8
1.2 RESEARCH RETENTION/DETENTION OPTIONS	0	3	2	3	8
1.3 FEMA FLOODPLAIN INFORMATION	0	1	2	2	5
1.4 IDENTIFY DESIGN REQUIREMENTS FOR THE CITY OF FLAGSTAFF	0	1	1	2	4
1.5 REVIEW EXISTING PLANS/STUDIES	0	5	8	3	16
1.6 CREATE A PLAN FOR THE FIELD SITE INVESTIGATION	1	1	0	0	2
2.0 FIELD SITE INVESTIGATION (Person-Total Hours)	**1**	**4**	**4**	**2**	**11**
2.1 FIELD SITE VISIT	0	1	1	1	3
2.2 FIELD SITE VISIT ASSESSMENT	1	3	3	1	8
3.0 HYDROLOGIC ANALYSIS (Person-Total Hours)	**5**	**44**	**36**	**19**	**104**
3.1 WATERSHED DELINEATION	0	1	2	1	4
3.2 DETERMINING TIME OF CONCENTRATION	0	15	10	5	30
3.3 DETERMINING WATERSHED ROUGHNESS COEFFICIENT	0	1	2	2	5
3.4 DETERMING DESIGN STORM INTENSITIES	0	2	2	1	5
3.5 DETERMINING NATURAL RUNOFF	3	15	10	5	33
3.6 ANALYZING EXISTING SUB-BASIN STORAGE	2	10	10	5	27
4.0 HYDRAULIC ANALYSIS OF EXISTING STRUCTURES (Person-Total Hours)	**5**	**30**	**15**	**5**	**55**
5.0 ANALYSIS OF ALTERNATIVES (Person-Total Hours)	**22**	**45**	**25**	**5**	**97**
5.1 DETERMINE THE CONSTRAINTS AND CRITERIA OF THE DESIGN	2	10	10	5	27
5.2 DEVELOP ALTERNATIVE DESIGNS TO REDUCE OR MANAGE RUNOFF	10	30	15	0	55
5.3 SELECT BEST ALTERNATIVE	10	5	0	0	15
6.0 FINAL DESIGN (Person-Total Hours)	**10**	**10**	**5**	**0**	25
7.0 CONSTRUCTION PLAN (Person-Total Hours)	**4**	**36**	**40**	**5**	**85**
7.1 EXISTING FLOODPLAIN MAP	0	5	5	5	15
7.2 DESIGN OF RUNOFF CONTROL STRUCTURES SHEETS	2	15	10	0	27
7.3 GENERAL PROJECT DETAILS	1	8	10	0	19
7.4 PROJECT NOTES AND SPECIFICATIONS	1	8	15	0	24
8.0 CONSTRUCTION COST ESTIMATE (Person-Total Hours)	**10**	**5**	**0**	**0**	**15**
9.0 PROJECT IMPACTS EVALUATION (Person-Total Hours)	**0**	**10**	**5**	**2**	**17**
10.0 PROJECT DELIVERABLES (Person-Total Hours)	**8**	**55**	**55**	**15**	**133**
10.1 30% SUBMITTAL	2	10	10	5	27
10.2 60% SUBMITTAL	2	10	10	5	27
10.3 90% SUBMITTAL	2	15	15	5	37
10.4 FINAL SUBMITTAL	2	20	20	0	42
11.0 PROJECT MANAGEMENT (Person-Total Hours)	**50**	**30**	**20**	**5**	**105**
11.1 PROJECT MEETINGS	20	20	20	5	65
11.2 SCHEDULE MANAGEMENT	10	5	0	0	15
11.3 RESOURCE MANAGEMENT	10	5	0	0	15
11.3.1 STAFFING	5	0	0	0	5
11.3.2: BUDGET	5	0	0	0	5
TOTAL PERSONNEL HOURS	**94**	**237**	**195**	**67**	**593**

Table 4-2 below is the total summary of hours for each role of the Senior Engineer, the Project Engineer, the Engineer In Training, and the Intern with a total personnel hours concluding at 593 hours for this project.

Table 4-2: Total Personnel Hours

CLASSIFICATION	HOURS
SENG	94
ENG	237
EIT	195
INT	67
TOTAL PERSONNEL	593

5.0 COST OF ENGINEERING SERVICES

Table 5-1 below shows the cost of engineering services broken down into 3 categories and a total estimate cost. For the personnel category are four employees classified as the Senior Engineer, Project Engineer, Engineer In Training, and the Intern. We have our Senior Engineer at an hourly rate of $200/hr, the Project Engineer at $137/hr, the Engineer in Training at $90/hr, and the Intern at $25/hr as each of them possess different skills, education, and working hours. Secondly, for the duration of this project we will not be traveling given our project is in Flagstaff so the cost will be zero. For the last category we will be utilizing the computer lab for the duration of this project, costing about $200/day for about 100 days with a total cost of $20,000. As a completed total estimate cost of adding personnel and supplies is a total of $90,494.00 shown in table 5-1 for the completion of this project.

Table 5-1 Cost of Engineering Services

1.0 Personnel	Classification	Hours	Rate, $/Hr	Cost
	SENG	94	200	$18,800
	ENG	237	137	$34,469
	EIT	195	90	$17,550
	INT	67	25	$1,675
	Total Personnel			$70,494
2.0 Travel	Travel to/from Flagstaff Shadow Mountain Community	0	$0.40/mi	$0
3.0 Supplies	Computer Lab Use	100	$200/day	$20,000
4.0 Total				**$90,494**

6.0 REFERENCES

1] “City of Flagstaff GIS Portal,” *Gis.flagstaffaz.gov*. [Online]. Available: https://gis.flagstaffaz.gov/portal/home/webmap/viewer.html. [Accessed: 05-Sep-2022].

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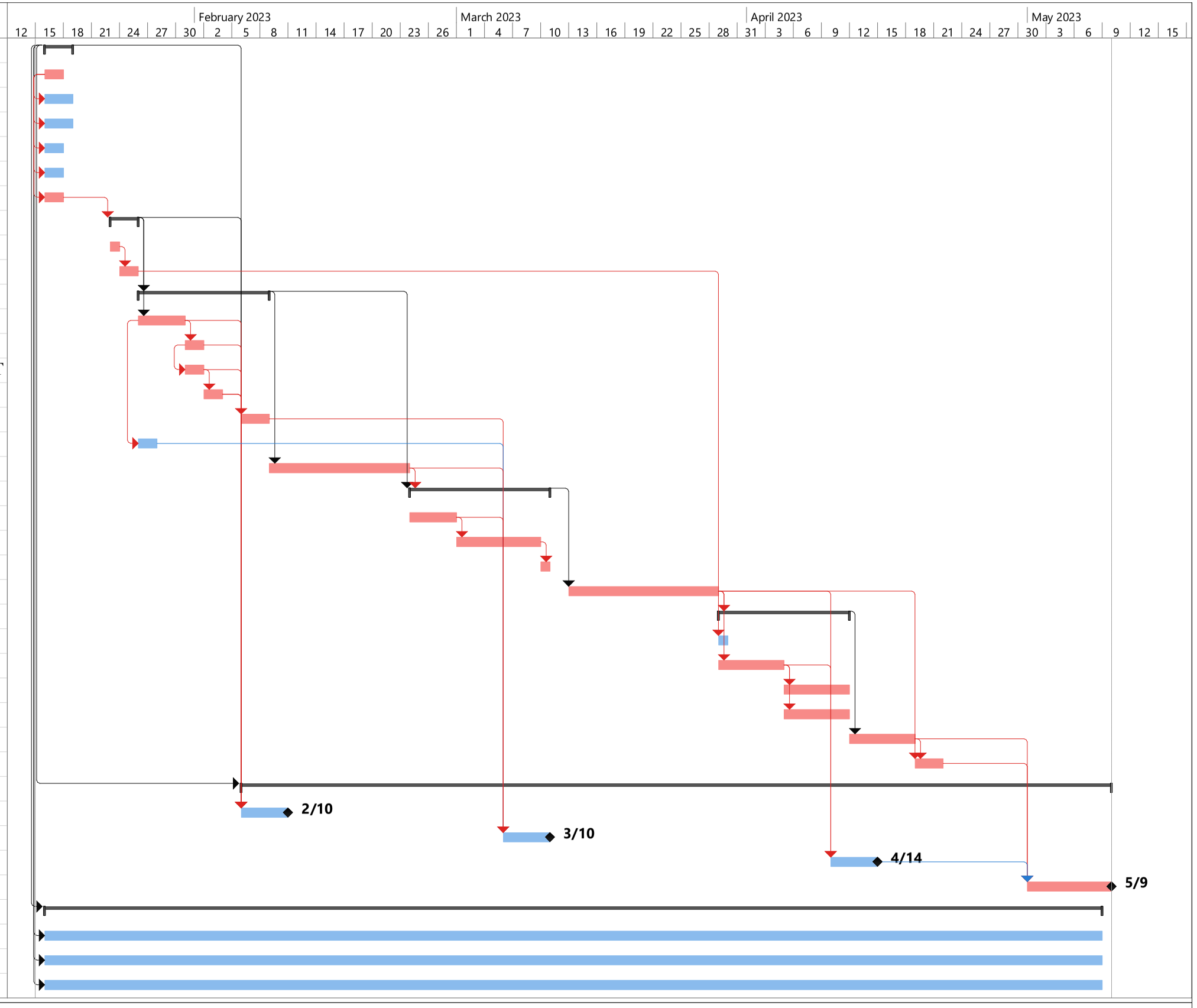
[5] “Hourly rate for industry: Engineering Services,” *PayScale*. [Online]. Available: https://www.payscale.com/research/US/Industry=Engineering_Services/Hourly_Rate .[Accessed: 01- Dec-2022].

7.0 APPENDIX

APPENDIX A: GRANT CHART

ID	Task Name
1	**TASK 1 RESEARCH**
2	**TASK 1.1 DOCUMENT EXISTING STRUCTURES/TOPOGRAPHY/GIS**
3	**TASK 1.2 RESEARCH RETENTION/DETENTION OPTIONS**
4	**TASK 1.3 FEMA FLOODPLAIN INFORMATION**
5	**TASK 1.4 IDENTIFY DESIGN REQUIREMENTS FOR CITY**
6	**TASK 1.5 REVIEW EXISTING PLANS/STUDIES**
7	**TASK 1.6 CREATE A PLAN FOR THE FIELD SITE INVESTIGATION**
8	**TASK 2 FIELD SITE INVESTIGATION**
9	**TASK 2.1 FIELD SITE VISIT**
10	**TASK 2.2 FIELD SITE VISIT ASSESSMENT**
11	**TASK 3 HYDROLOGIC ANALYSIS**
12	**TASK 3.1 WATERSHED DELINEATION**
13	**TASK 3.2 DETERMINING TIME OF CONCENTRATION**
14	**TASK 3.3 DETERMINING WATERSHED ROUGHNESS COEFFICIENT**
15	**TASK 3.4 DETERMINING DESIGN STORM INTENSITIES**
16	**TASK 3.5 DETERMING NATURAL RUNOFF**
17	**TASK 3.6 ANALYZING EXISTING SUB-BASIN STORAGE**
18	**TASK 4 HYDRAULIC ANALYSIS OF EXISTING STRUCTURES**
19	**TASK 5 ANALYSIS OF ALTERNATIVES**
20	**TASK 5.1 DETERMINE DESIGN CONSTRAINTS AND CRITERIA**
21	**TASK 5.2 DEVELOP ALTERNATIVE RUNOFF CONTROL DESIGNS**
22	**TASK 5.3 SELECT BEST ALTERNATIVE**
23	**TASK 6 FINAL DESIGN**
24	**TASK 7 CONSTRUCTION PLAN**
25	**TASK 7.1 EXISTING FLOODPLAIN MAP**
26	**TASK 7.2 DESIGN OF RUNOFF CONTROL STRUCTURES**
27	**TASK 7.3 GENERAL PROJECT DETAILS**
28	**TASK 7.4 PROJECT NOTES AND SPECIFICATIONS**
29	**TASK 8 CONSTRUCTION COST ESTIMATE**
30	**TASK 9 PROJECT IMPACTS**
31	**TASK 10 PROJECT DELIVERABLES**
32	**TASK 10.1 30% SUBMITTAL**
33	**TASK 10.2 60% SUBMITTAL**
34	**TASK 10.3 90% SUBMITTAL**
35	**TASK 10.4 FINAL SUBMITTAL**
36	**TASK 11 PROJECT MANAGEMENT**
37	**TASK 11.1 PROJECT MEETINGS**
38	**TASK 11.2 SCHEDULE MANAGEMENT**
39	**TASK 11.3 RESOURCE MANAGEMENT**



Project: schedule.mpp FINAL D
Date: Thu 12/8/22

Task	Project Summary	Manual Task	Start-only	Deadline	Manual Progress		
Split	Inactive Task	Duration-only	Finish-only	Critical			
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Critical Split			
Summary	Inactive Summary	Manual Summary	External Milestone	Progress			