Fanning Wash Stormwater Improvements

Proposal

CENE 476-EGR Design Capstone Prep

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List of Abbreviations

ADOT	Arizona Department of Transportation
FE	Fundamentals of Engineering Exam
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HEC-HMS	Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center's River Analysis System
NAU	Northern Arizona University

1.0 Project Understanding

1.1 Project Purpose

The purpose of this project is to design improvements to the current channel and culvert design in the fanning wash from Linda Vista to Route 66. The end goal of this project is to prevent the flooding that has been happening in the Siler Homes (E. Elder Drive).

1.2 Project Background

Fanning Wash is currently a functioning wash, but it cannot hold enough capacity. A few repairs have been made since the summer of 2021, as well as recent repairs were done by contractors in the segment between Lockett and Linda Vista.

1.2.1 Location

Fanning Wash is located in the city of Flagstaff, in Northern Arizona Figure1-1.

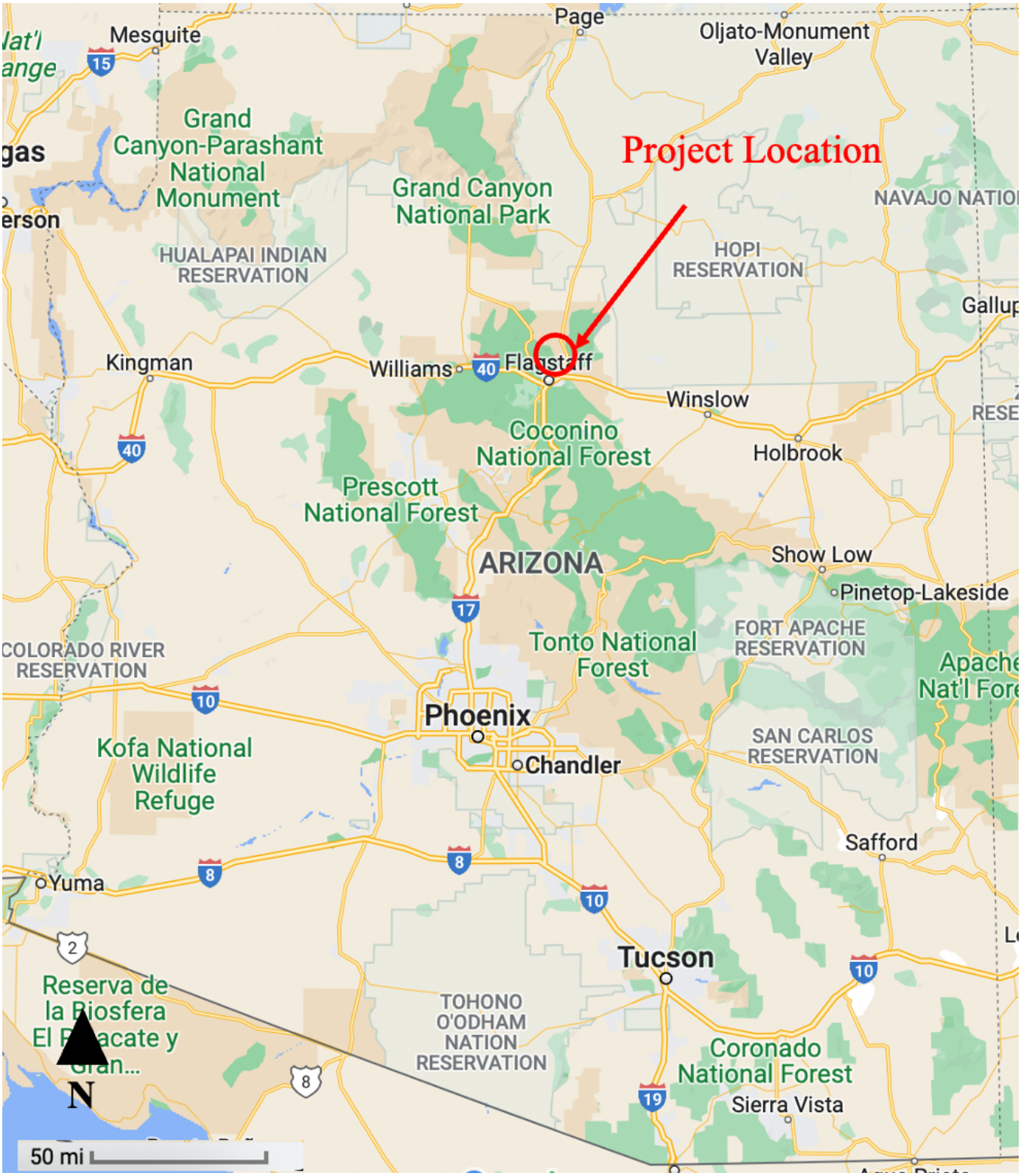

Figure 1-1: Project Location in Arizona [3]

Figure 1-2 shows Fanning Wash in respect to the city of Flagstaff. Figure 1-3 depicts the main focus point of the project.

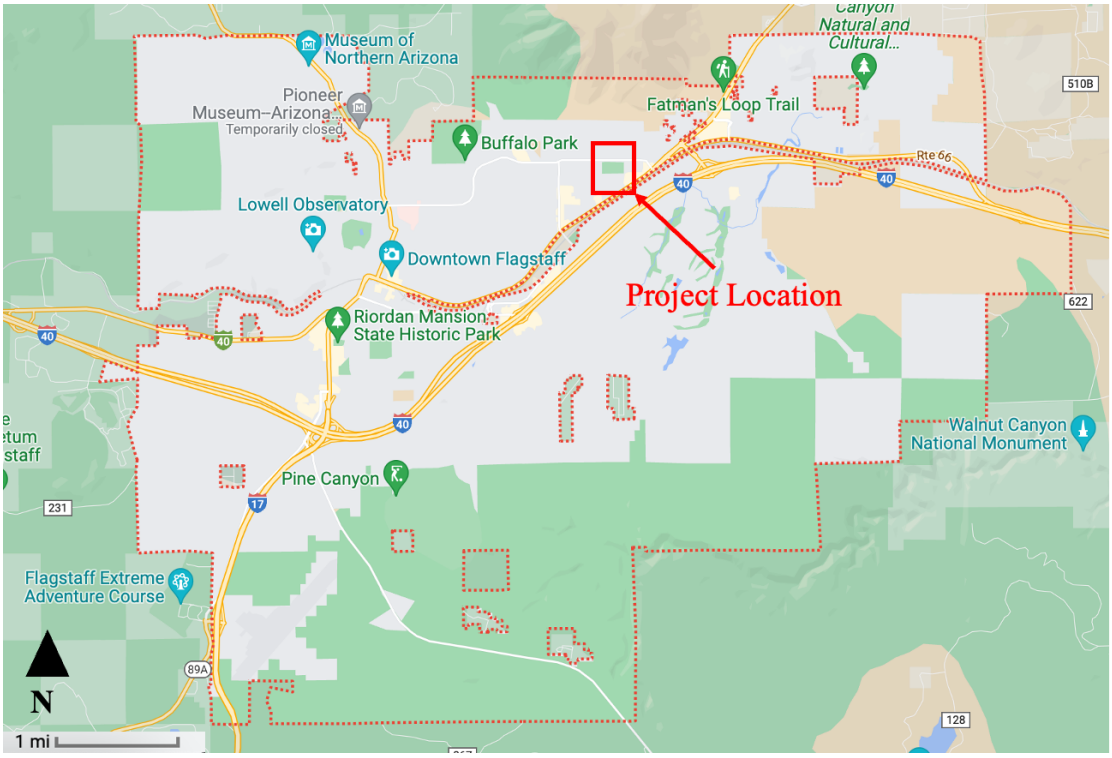

Figure 1-2: Project Location in Flagstaff[3]

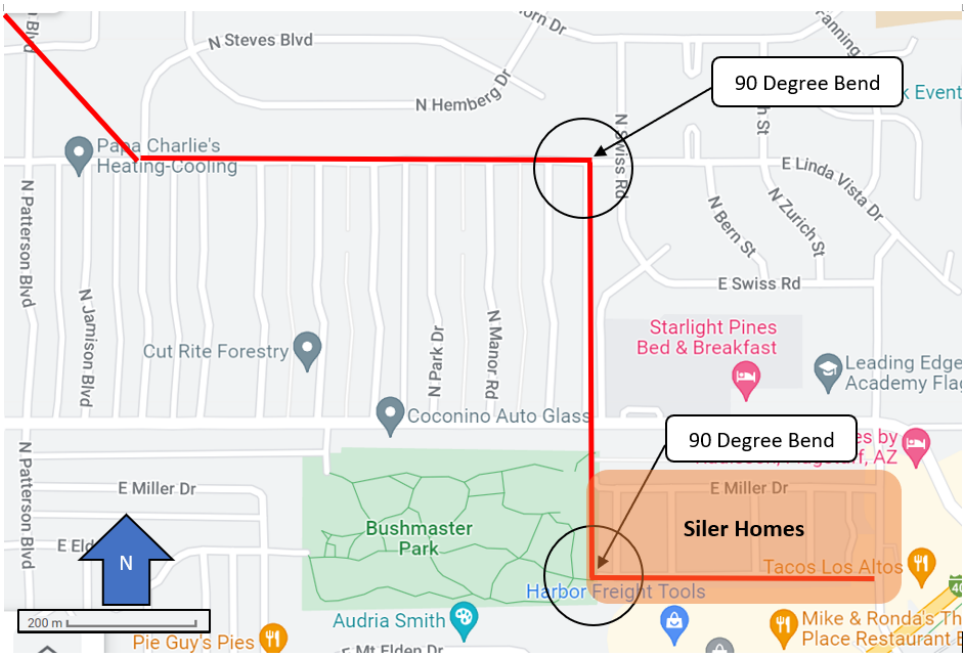

Figure 1-3: Fanning Wash and its problem points [4]

1.2.2 Fanning Wash Issues

Multiple cases of overtopping have occurred at various points on the wash due to the two 90-degree curves on the wash. There are two major problem points with the drainage system, one at Linda Vista before it goes under the road to Bushmaster Park and the other is at the south end of Bushmaster Park. Both problem points are at turns in the drainage system (Figure 1-3). These 90-degree curves (Figure 1-3) cause flooding in the Siler homes because of how the water hits the bend. In addition to flooding, the channel capacity in the south side of the Siler Homes area is insufficient and causes the channel to overflow along the west side of the Siler homes. Figure 1-4 show the channel running from Linda Vista to E. Elder Drive

Figure 1-4: Existing Channel at E, Elder Dr (Siler Homes)

1.3 Technical Considerations

The technical considerations discussed will be applied to carry out the design aspect of the project.

1.3.1 Surveying

An analysis of the culvert and the immediate area will be necessary for the design of the culvert improvements. Further surveying work might be necessary for more accurate topographical maps of the wash if other data is not sufficient for analyzing the area. The team will have to be aware of the area that is being surveyed since the design is constrained to be within the land owned by the city.

1.3.2 Hydrologic Analysis

Rainfall intensity and storm intensities will need to be analyzed for the given project watershed. This information will be used to determine the total storm runoff that must be conveyed by the wash.

1.3.3 Hydraulic Analysis

The existing culverts, channels, and basins that connect to Fanning Wash will be analyzed in order to create a new drainage plan. The upstream and downstream conditions are also necessary to analyze for the new drainage plan. The different designs will be developed and compared to existing designs using HEC-RAS and AutoCAD to make sure that the new design does not affect the wash.

1.4 Potential Challenges

One of the potential challenges to the project is the availability of surveying equipment. Surveying equipment could be in use by labs conducting surveys or other capstone projects using the equipment at the time needed. This would cause delays in time and would delay when the survey data is taken. Another possible challenge is the weather as Flagstaff weather is very unpredictable. This unpredictable weather could be consequential for a delay in surveying.

1.5 Stakeholders

Homeowners in the Fanning-Linda Vista area and Siler Homes area are the residents most affected by this project with flooding and construction. In addition to that users and visitors of Bushmaster Park are also affected by the stormwater drainage system.

The flooding in the roads can lead to accidents and road damage, making local drivers and the city of Flagstaff a stakeholder.

Local businesses and business owners could also be affected by the flooding in the roads since it can cause accessibility problems.

2.0 Scope of Services

2.1 Task 1 Research

Previous culvert designs and analysis will be looked at before any new improvements or modifications of the culvert are proposed. Federal, state, and local codes will be used for the analysis and design of the culvert.

2.1.1 Task 1.1 Code Research

Research city, county, and state codes for the analysis and design of waterways including Coconino County Drainage Design Manual, ADOT Hydrology Manual, and Flagstaff Stormwater Management Design Manual [1], [2], [5]. Building codes will also need to be analyzed for working with different land ownership.

2.1.2 Task 1.2 Research Existing Topography

Maps obtained from USGS will be used to observe the contours and landscape of the site. In addition, other survey data websites will also be used to better evaluate the alluvial fan topography. Maps of the land ownership will also need to be obtained so as not to exceed project boundaries.

2.1.3 Task 1.3 Review Existing Plans/Studies

Plans and proposals for the site will be requested from the City of Flagstaff or the client. The plans will be analyzed and evaluated to compare the data obtained through the survey to prevent any errors in the topography before starting the design.

2.1.4 Task 1.4 FEMA Floodplain Research

The data from FEMA and regulatory floodways will be examined in relevance to the project region and evaluated based on results.

2.2 Task 2 Site Investigation

Site investigations will be performed, and the existing conditions will be evaluated to have the necessary knowledge and data from the area to be able to proceed with the design.

2.2.1 Task 2.1 Site Visit

A site visit is required for documentation of conditions and data points of topography in a field survey.

2.2.1.1 Task 2.1.1 Documentation of Existing Conditions and Structures

An initial analysis of the site will be performed where initial problems mentioned by the client and identified by the team will be noted and recorded. The initial documentation of current conditions and problems will be written down and documented. A tour of the surrounding area and conditions will also be considered for future design possibilities and use of land for drainage.

2.2.1.2 Task 2.1.2 Land Surveying/ Site Assessment

Land Surveying will be conducted to get accurate contours of the site. This will help evaluate the elevation and distance of each culvert and channel for precise

design work. Approximate control points and areas will be selected to survey where the elevation will be measured in 1’ intervals.

2.2.2 Task 2.2 Topographic Map

The data collected from the site investigation will be used for an analysis of the initial conditions and will be input into a drawing on AutoCAD. The first drawing will give information about existing structures and the topography of the area.

2.3 Task 3 Hydrologic Analysis

2.3.1 Task 3.1 Watershed Delineation

An accurate map of the project watershed will need to be delineated and shown properly for hydrologic analysis.

2.3.2 Task 3.2 Time of Concentration

The time of concentration for the water flowing into the problem area will be determined in order to calculate other factors of analysis such as rainfall intensity and runoff.

2.3.3 Task 3.3 Determine Rainfall Intensity

NOAA Atlas 14 will be used to determine the intensity based on the time of concentration and design storm.

2.3.4 Task 3.4 Determine Runoff

Upon being given data for the discharge, the amount of volume that is going through the system will need to be determined and designs will need to take into account the volume identified.
Another way of determining the runoff would be using HEC-HMS: If the Rational Method tool is not applicable for the water delineation area per the Flagstaff Stormwater Management Design Manual, the HEC-HMS tool will be used to determine the flow and different patterns of flow and volume within the watershed and flow path.

2.4 Task 4 Hydraulic Analysis of Existing Structures

2.4.1 Task 4.1 Open Channel Analysis

The current open channel design will be analyzed using the plan obtained and thorough site investigation. The channel characteristics such as material, shape, and size will be analyzed to determine how it affects the capacity of the channel. Using the survey data, the cross-section analysis of the channel will be conducted.

Using software like FlowMaster or HEC-RAS the normal depth, velocity, and flow regime will be determined, and the values will be verified to ensure they are not in conflict with City of Flagstaff Stormwater Management Design Manual requirements [5]. The value of normal depth will be analyzed to make sure that it follows the accommodated freeboard.

2.4.2 Task 4.2 Culvert Analysis

The culvert material, shape, size (length and diameter), and slope will be determined using the images and observation from the site visit. After determining the culvert data, CulvertMaster software will be used to determine the peak discharge. After determining the peak discharge, the design flow and check flow will be evaluated. Design flow criteria are provided in the City of Flagstaff Stormwater Management Design Manual as a Roadway Culvert for Local Streets [5]. Design Flow is the 25-year flood design for a channel and the check flow is the 100-year flood design for a channel. Both conditions need to be analyzed when checking the flow within channels to make sure the channel is performing correctly.

2.5 Task 5 Design Analysis

2.5.1 Task 5.1 Identify Constraints and Criteria

The constraints and criteria will be determined before beginning the design part of the project. This information will further be used in the decision matrix to eliminate non applicable designs.

2.5.2 Task 5.2 Develop Design Alternative

Different designs will be drawn in AutoCAD while also identifying/analyzing their weaknesses and strengths to select the best design.

2.5.3 Task 5.3 Select Best Alternative

Using parameters like efficiency, cost, and materials, the selected designs will be analyzed. Using the decision matrix, scores will be given to each design and the design with the highest score will be chosen.

2.6 Task 6 Final Design Construction Plans

The best design chosen from the decision matrix will be a fully developed construction plan.

2.6.1 Task 6.1 Cover Sheet

Cover Sheet for the Auto-CAD design will be created. Plan View will be shown in its entirety covering the portions of the wash which the project covers.

2.6.2 Task 6.2 Profile Views

The elevation view of each portion of the wash will be covered and annotated in detail.

2.6.3 Task 6.3 Cross-Section Views

A cross-section drawing of the culvert will be created to show the internal structure of the design.

2.6.4 Task 6.4 Details Sheet and General Notes

A details page will be used discussing all the codes and justifications for design features within the drawing.

2.6.5 Task 6.5 Extra Sheets

Other sheets may be needed to accurately plan out the construction plans.

2.7 Task 7 Cost Estimate

Upon deciding the design, a cost estimate of the project construction cost will be performed. The cost will be based off materials, labor, and hours to complete the project.

2.8 Task 8 Impacts Analysis

An impacts analysis will be completed to determine the positive and negative environmental, economic, and social impacts of the design.

2.9 Task 9 Deliverables

There are certain deliverables that need to be completed for the class, where each major deliverable is further explained below.

2.9.1 Task 9.1 30% Submittal

The 30% submittal will include tasks 1 and 2 (research and site investigation) to include the surveying of the area and the research behind the project to give a full scope of what is to come. Within the 30% submittal will be a presentation, design report, and project plans.

2.9.2 Task 9.2 60% Submittal

In the 60% submittal, tasks 3, 4 and 5 (hydrologic and hydraulic analysis) will be done to understand the scope of the water analysis and water design. Everything that is required to be analyzed for the water properties/behaviors will be completed and included in the 60% report. Within this 60% submittal will be a presentation, design report, and project plans.

2.9.3 Task 9.3 90% Submittal

The 90% submittal will include tasks 6 and 7 (AutoCAD plans and impact analysis) within the report to show the design of the project and the impact the project has on the general public and wildlife. The submittal will include a plan set as well as the design report for client viewing. The project website will be mostly complete with documentation uploaded.

2.9.4 Task 9.4 Final Submittal

The final report, plans, and presentation will be presented to the board and to the client for consideration and any comments they may have. The website will also be complete for public viewing at the final submittal.

2.10 Task 10 Project Management

There are certain meetings that the team will have to conduct in the duration of the project while also making sure to manage the schedule and budget for the project.

2.10.1 Task 10.1 Meetings
These meetings will consist of Technical Advisor meetings, Grading Instructor Meetings, Client meetings, and Team meetings.

2.10.2 Task 10.2 Schedule Management
The schedule will be tracked and updated to ensure that the project will be completed on time.

2.10.3 Task 10.3 Resource Management
Staffing and Budgeting of the project will be managed to ensure the project is completed on budget.

2.11 Exclusions
Some tasks or steps will not have to be completed for the completion of the project.

2.119 Geotech Analysis
A geotechnical analysis of the project site will not be used as the current development has no exposed ground in the channel. Existing soil studies in the area will give the information needed for building and water resistance in the soil if that becomes part of the design choice. The current conditions are concrete ground and other impervious ground layers within the open channel and the post development design will assume ground is concrete. Geotechnical analysis is needed for construction on soils, but the task at hand is to design a channel that will work better in Fanning Wash.

2.11.2 Roadway and Traffic Analysis
Traffic analysis of the area will not be needed as the project site is in a residential area and does not experience excessive traffic.

2.11.3 Surveying on Streets or Private Property
The survey on Street and Private Property will not be conducted as permission from the landowner is required to access the properties around the project site which is not accessible. Additionally, the City of Flagstaff does not allow surveying on city streets for safety reasons.

3.0 Schedule
The project schedule can be seen in the Appendix. It includes all the major tasks, sub-tasks and the timing of the project.

3.1 Major Tasks
The major tasks in this project are research, site investigation, hydrologic analysis, hydrologic analysis, design analysis and final design which are highlighted in Appendix: Schedule/Gantt Chart. The project is scheduled to start on January 15, 2023, and end on May 2, 2023, giving the team a total of 107 days to complete the project. Milestones of

the project includes the 30%, 60%, 90%, and final submittal-all of which are in Task 9 “Deliverables”. These tasks are seen as milestones since they encompass not only deliverables that need to be completed but also the tasks that need to be done in that submittal.

3.2 Critical Path

The critical path is shown in red on the Gantt Chart in the appendix, it is the sequence of important tasks that need to be completed on time or the project will not be completed on time. Design Analysis and Final design are the tasks that fall into a critical path as delays to these tasks can impact the overall project. Staying on task is key on the critical path. In order to keep the schedule, working on weekends and on breaks may need to be done. Keeping each other in check and checking on progress of work will need to be done to keep each team member accountable and on time in the delivery of tasks.

4.0 Staffing Plan

This project will be completed by four employees with different roles and responsibilities throughout the project.

4.1 Staff Positions and Qualifications

Senior engineer is a professional engineer who is responsible for supervising and overseeing the entire project. They require a bachelor’s degree in their respective field as well as 10 + years' experience and are required to have a Professional Engineering License (PE).

Engineer is responsible for working on the technical aspect of the project. They also assign tasks to the intern and train them as well. Engineers are required to have a bachelor's degree and have passed the fundamentals of engineering (FE) exam.

Interns work on the task assigned by the engineers. They are usually students in an engineering major in their senior year or students that recently graduated.

Lab Technicians will be responsible for most of the software and lab activities like data analysis and surveying. They are required to have a bachelor's degree or associates degree in the field their lab work is for.

4.2 Estimated Personnel Hours

The table below shows the estimated number of hours each staff member will be putting in for each task.

Table 4-1: Estimated Personnel Hours

Task	*SENG Hours*	*ENG Hours*	*LAB Hours*	*INT Hours*
1.0 Research	**0**	**11**	**14**	**9**
1.1 Code Research		4		4
1.2 Research Existing Topography			5	5
1.3 Review Existing Plans/Studies		7		
1.4 FEMA Floodplain Research			9	
2.0 Site Investigation	**1**	**14**	**25**	**36**
2.1 Site Visit	0	5	17	23
2.1.1 Documentation of Existing Conditions and Structures	0	3	2	8
2.1.2 Land Surveying	0	2	15	15
2.2 Data Analysis	1	9	8	13
2.2.1 Topographic Map Documentation	1	5		6
2.2.2 Documentation of Survey Data	1	4	7	7
3.0 Hydrologic Analysis	**2**	**10**	**12**	**20**
3.1 Watershed Delineation	0	3	3	5
3.2 Time of Concentration	1	2	3	5
3.3 Determine Rainfall Intensity	0	3	3	5
3.4 Determine Runoff	1	2	3	5
4.0 Hydraulic Analysis of Existing Structures	**2**	**10**	**8**	**14**
4.1 Open Channel Analysis	1	5	4	7
4.2 Culvert Analysis	1	5	4	7
5.0 Design Analysis	**2**	**15**		**19**
5.1 Identify Constraints and Criteria		4		6

5.2 Develop Design Alternatives		8		9
5.3 Select Best Alternative	2	3		4
6.0 Final Design Construction Plan	**5**	**27**	**0**	**29**
6.1 Cover Sheet	1	3		4
6.2 Site Plan	1	5		6
6.3 Profile Views	1	5		5
6.4 Cross Section Views	1	5		5
6.5 Details Sheets and General Notes	1	6		6
6.6 Extra Sheets	0	3		3
7.0 Cost Estimate	**2**	**5**		**2**
8.0 Impact Analysis	**1**	**7**		**5**
9.0 Deliverables	**7**	**25**	**0**	**15**
9.1 30% Submittal	1	5		3
9.2 60% Submittal	1	5		3
9.3 90% Submittal	2	6		4
9.4 Final Submittal	3	9		5
10.0 Project Management	**20**	**46**	**20**	**25**
10.1 Meetings	15	20	20	25
10.2 Schedule Management	1	20		
10.3 Resource Management	4	6		
Total Task Hours	***42***	***170***	***79***	***174***
Total Person Hours	***465***			

4.3 Summary Table

The table below shows a condensed version of the table above giving a better overview of the hours the roles will take in each major task.

Major Task	*SENG Hours*	*ENG Hours*	*LAB Hours*	*INT Hours*
1.0 Research	**0**	**11**	**14**	**9**
2.0 Site Investigation	**1**	**14**	**25**	**36**
3.0 Hydrologic Analysis	**2**	**10**	**12**	**20**
4.0 Hydraulic Analysis of Existing Structures	**2**	**10**	**8**	**14**
5.0 Design Analysis	**2**	**15**	**0**	**19**
6.0 Final Design Construction Plan	**5**	**27**	**0**	**29**
7.0 Cost Estimate	**2**	**5**		**2**
8.0 Impact Analysis	**1**	**7**		**5**
9.0 Deliverables	**7**	**25**	**0**	**15**
10.0 Project Management	**20**	**46**	**20**	**25**
Total Person Hours	**42**	**170**	**79**	**174**

5.0 Cost of Engineering Services

Table 5.1 shown below shows the total cost of person-hours based on the personnel hours determined from table 4.1 shown above. The total cost of the engineering services required for the Fanning Wash project is estimated to be $ 76,079.

Table 5-1: Cost of Engineering Services

1.0 Personnel	***Classification***	***Hours***	***Rate ($/hr)***	***Cost***
	SENG	42	196	$8,231
	ENG	170	121	$20,577
	LAB	79	46	$3,666
	INT	174	30	$5,265
	Total Personnel			$37,740
2.0 Supplies	Surveying Equipment/Lab Rental	6 days	$100/day	$600
3.0 Total				$76,079

6.0 References

[1] ADOT. *Arizona Department of Transportation Highway Drainage Design Manual.* 2nd Edition. Phoenix, AZ, US. ADOT, 2014

[2] Coconino County Public Works. *Coconino County Drainage Design Manual.* Flagstaff, AZ, US. 2020.

[3] Google Maps [online] Available: https://www.google.com/maps/@35.2002321,-111.602334 3,12.32z

[4] Google Maps [online] Available: https://www.google.com/maps/@35.2194301,-111.6 029503,16z

[5] The City of Flagstaff Utilities Division. *CITY OF FLAGSTAFF STORMWATER MANAGEMENT DESIGN MANUAL.* Flagstaff, AZ, US. City of Flagstaff Engineering Division Stormwater Management Section. 2009.

7.0 Appendix: Schedule/Gantt Chart