Switzer Canyon Wash Proposal

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1.0 Project Understanding

1.1 Project Purpose

The upper reaches of the Switzer Canyon Wash (from the northern point of North San Francisco Street to Forest Avenue) floods serval homes in the Hospital Hill neighborhood from West Fir Avenue to West Forest Avenue. This flooding is due to insufficient channel capacity in the Switzer Canyon Wash along with a degrading culvert in the neighborhood. With new homes being built in the upper reaches of the floodplain, the City of Flagstaff is concerned with an increased flooding risk to residents in the area. This project seeks to decrease the frequency and severity of flooding in the Hospital Hill neighborhood by means of additional stormwater control.

1.2 Project Background

The Switzer Canyon watershed is in Coconino County within the city limits of Flagstaff, Arizona. It runs from just north of Elks Lodge, parallel to North San Francisco Street, and south into a part of the Hospital Hill neighborhood. The area consists of privately and publicly owned property as well as urban and rural land. Both sections are covered in tall vegetation and scattered boulders. In the upper reach of the channel man-made structures for different storm events are clearly visible and unobstructed. These include culverts, armored barriers, and berms. The conditions of this wash suggest decent flood control. Aerial photos of the site are provided for additional clarification.

Figure 1-2-1 below is a location map of the area in comparison to Flagstaff, Arizona.

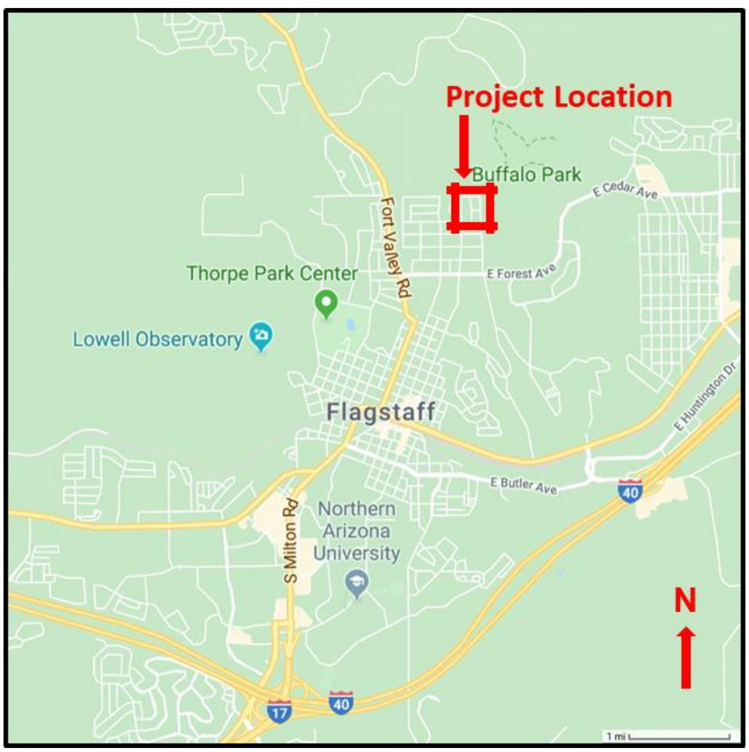

Figure 1-2-1: Project Location in Relation to Flagstaff, Arizona [1]

Figure 1-2-2 below represents the aerial map of the location from the inlet of the channel in the north down to the residential area part of the channel. Included in this figure is the floodplain according to the Federal Emergency Management Agency (FEMA).

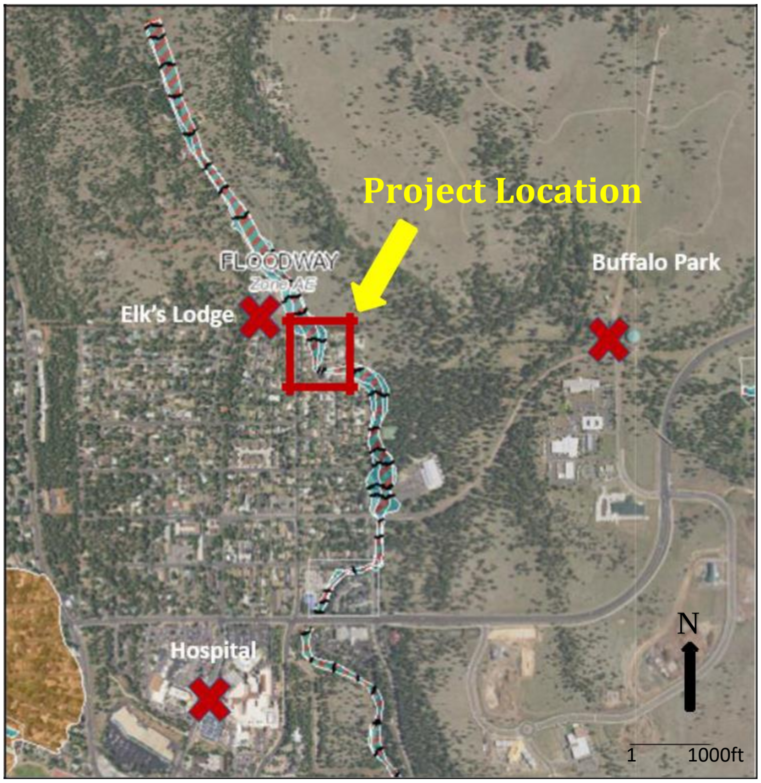

Figure 1-2-2: Aerial Map of Project Location and Floodplain ct. FEMA [2]

Figure 1-2-3 below represents the flooding of concern in the hospital neighborhood.

Figure 1-2-3: Aerial Map of Project Location and Area of Focus [2]

After visiting the site, it is known that the channel is intact, heavily vegetated, with berms and armoring in the area near Elks Lodge. Directly east of the upper reach of the wash is a large hill that is assumed to contribute greatly to the stormwater runoff in the wash. The hill is also well vegetated with grasses, bushes, and trees. Where the wash runs west to east in the neighborhood is where stormwater is carried under the houses via culvert.

1.3 Technical Considerations

1.3.1 Detention Basin Modeling

Detention basins are required as by the Coconino County Stormwater Design Manual for flood control via runoff management. To gauge the capacity of any natural detention basins, as well as any proposed basins, they will have to be modelled first using the parameters outlined in the manual. Modelling will likely occur in AutoCAD or Civil3D as both programs provide a digital to-scale space. The data compiled here can be used for verification of existing basins and how a proposed basin would manage this runoff water.

1.3.2 Storm Water Runoff

Storm water runoff is the assumed major contributor to flooding in the area and must be determined for all modelling endeavor. Typically, this is calculated using the rational equation, which combines rainfall intensity, area of interest, and surface run off coefficients. As the manual methods of determining rainfall intensity via rain gauge are time consuming and dependent on the weather for collection, the National Oceanic and

Atmospheric Administration rainfall intensity tool will be the source of this data. The area can be found by using an online watershed delineation tool called StreamStats, which is provided by the United States Geological Survey. Runoff coefficients are determined by surface type and can be found using the Coconino County Stormwater Design Manual. As this runoff flow is the crux of this entire project, these tools will be vital to accurately determining it.

1.3.3 Surveying

Surveying is another fundamental for CAD modeling to occur for this project. As it determines the elevations along the wash, it also determines where the water flows. The surveying data can be extracted from the online FEMA database or manually obtained on site. For the sake of accuracy, the elevation data will be taken manually and compared to existing values found from the City of Flagstaff 2008 topography data. The data obtained will then serve as the base elevation for modelling programs such as AutoCAD and HEC-RAS—both which are used with each other to determine flow and its direction.

1.3.4 Hydrologic Modeling

Hydrologic modeling is the compilation of raw elevation and feature data into various programs to determine the flow regime of the area. Ideally, HEC-RAS will be used as it models all components of a watershed rather than an individual. Still, the singular modelling can occur to verify that the HEC-RAS model is utilizing the data correctly. The results from this modelling will give the overall flow status of the channel during various storm events while noting where spill-over occurs. Additionally, these features (inlet control, outlet control, culvert specs) can be altered to see how flow would change under different conditions, simplifying the tasks of where storm water control should occur. Cost calculations can be derived from this as well.

1.4 Potential Challenges

The sub-basins of focus will be difficult to determine as there are several large areas of interest that may be affecting the draining. The sites being affected are known but what aspects of the watershed are hindering flow are unknown. A hydrograph simulation of the flow downhill will likely determine this unknown.

Given the large swath of private land, affected areas may not be accessible for development. To access these areas for development, parcel purchases may need to occur. This would increase the cost of the project considerably. Public land above the private watershed could also be considered for flood management.

The elevation of the site contains a mix of flat and sheet flow—the flat area being fields near residential area and the residential area itself, while the sheet flow occurs from hills towards the residential area. How to address this sheet flow may be difficult as it flows onto private property. A berm or additional vegetation could be added with permission from the residents or with purchase of the land.

Determining the budget will also prove challenging as the mix of private and public land along with urban and rural land brings a wide range of prices for development. These different land types also limit what structures are allowed on them. Careful review of the location of proposed structures must be considered to accurately budget this project.

1.5 Stakeholders

The stakeholders of this project are the City of Flagstaff, Coconino County, Elks Lodge, and the residents in the floodplain. This project is in conjunction with the City of Flagstaff who is also the client for this project. Much of the land is maintained by the City of Flagstaff who will ultimately maintain any additional infrastructure. A significant amount of the Elks Lodge falls in the floodplain. The floodplain also continues south through the nearby neighborhood. Many houses are along the channel which are exposed to potential flooding. The floodplain also has wildlife and natural habitats that is important to preserve, so the Stormwater Manager would be the stakeholder concerned with projects involving the floodplain [3].

2.0 Scope of Work

2.1 Task 1: Site Investigation

Site investigations will be performed through multiple site visits. The goal of these visits is to better understand the conditions of the site. These conditions are topography, existing infrastructure, vegetation, sediment build up, and soil types. This work will be done in order to accurately address the flooding in the hospital neighborhood area.

2.1.1 Task 1.1: Field Visit and Preliminary Assessment

A field visit will be performed on the Switzer Canyon Wash. The field visit will occur in the northern reach of the wash as well as a section of the hospital hill. The section of the hospital hill neighborhood visited will be between N Meadow Lark Dr. on the west, N Turquoise Dr. on the east, Silver Spruce Ave. to south, and W Fir Ave. to the north. During the field visit vegetation, soil types, and existing infrastructure will be identified.

2.1.2 Task 1.2: Field Surveying

2.1.2.1 Task 1.2.1: Land Surveying

If survey data is unavailable from past studies a land survey will be performed in the upper flood plain of the Switzer Canyon Wash. A robotic total station will be used to determine the area and elevations that could be used for a potential detention basin. A second land survey will occur in the channel that runs between N Meadow Lark Dr. on the west, N Turquoise Dr. on the east, south to Silver Spruce Ave., and north to W Fir Ave. This survey will be performed using an auto level to determine elevation cross section of the wash. This data will be inputted into cross-section analyzer NRCS and HEC-RAS modeling software to determine flow rates and the flooding elevation.

2.1.2.2 Task 1.2.2: Survey Data Processing

Data taken from the two land surveys will be inputted into their appropriate programs. The robotic total station data will be inputted as a point cloud into Civil 3D to create a topo map. The auto level data will be inputted into NRCS and HEC-RAS modeling software.

2.1.3 Task 1.3: Document Existing Infrastructure

The existing infrastructure in the Switzer wash will be assessed for its dimensions, material types, and its hydraulic condition. The hydraulic condition for the existing infrastructure will be assessed by measuring sediment build up and the structural integrity.

2.1.4 Task 1.4: Review As-Builts for Existing Infrastructure

The team will call the City of Flagstaff Development engineering office to start the process of obtaining as-builts for infrastructure identified in Task 1.3. Once documents have been obtained, the data will be processed. Flows, elevations, and dimensions will be noted and inputted into their appropriate modeling software. This data will determine the size of infrastructure, slopes, and other specifics about the existing infrastructure in the area. Additionally, the elevations, flows, and drainage studies for the area will be determined with this information.

2.2 Task 2: Hydrology

The hydrology of the site is crucial to understand and model before any hydraulic design can be created. To determine the hydrology of the site a mixed approach of research and analysis must be performed. The hydrology of the site will be determined using the methods identified in the City of Flagstaff Stormwater design manual [4].

2.2.1 Task 2.1: Research Previous Master Drainage Studies

Once as-builts have been found, a drainage study per the as built can be found. The team will work in conjunction with the City of Flagstaff stormwater division to find these drainage studies. The master drainage study will be taken from the City of Flagstaff website to determine past flow rates in the project area [5].

2.2.2 Task 2.2: Basin Delineation

2.2.2.1 Task 2.2.1: Major Basin Delineation

A major basin delineation will be done using topography data from the City of Flagstaff. High points surrounding the Switzer Canyon Wash will be marked. These high points will be used to determine the area that contributes storm runoff that will flow into the Switzer Canyon Wash.

2.2.2.2 Task 2.2.2: Sub-Basin Delineation

Sub-basins will be created for the area of interest. These are needed as there are areas on the site that will drain faster or slower during a storm event. This is due to different soil types I.e. paved verse unpaved, topography, detention facilities, and channels.

2.2.3 Task 2.3: Sub-Basin Variables

2.2.3.1 Task 2.3.1: Time of Concentration

The time of concentration is needed to determine how long it will take stormwater to enter the major/sub-basin then flow to the concentration point. The concentration point has been identified as the area of the wash immediately after the wash flows under Turquoise Dr.

2.2.3.2 Task 2.3.2: Flow Routing

Flow routing entails determining the route which water flows through the wash. This will be achieved with surveying data input into both AutoCad and HEC-RAS. Knowing the flow route of the Switzer wash aids with identifying areas of concern as well as the hydrology of the site. This will mainly be used to determine the kinds of flow the wash is experiencing. These include; sheet, paved, unpaved, and gutter flow. It should be noted that the wash may not exhibit all these flow types. The method shown in the City of Flagstaff Stormwater Design Manual [4] will be followed.

2.2.3.3 Task 2.3.3: Weighted Curve Number Determination

The weighted curve number is an average of various run off coefficients by surface type. The rational equation used to determine flow requires this coefficient, however, it does so without accounting for changes in terrain. This is problematic as the wash has no uniform terrain. Using coefficients by surface type found in the City of Flagstaff Stormwater Design Manual [4], they will be weighted into an average by area to have a singular coefficient for this calculation. The more impervious the surface, the higher the coefficient value as this coefficient is modifying flow by the amount a surface impedes flow. It will be one or less but always greater than zero for this reason.

2.2.4 Task 2.4: Hydrograph Development

A hydrograph will be created for the major basin flowing into the Switzer Canyon Wash. This will be done using data found in Task 2.2 and 2.3. The hydrograph will show the peak discharge for the drainage area. The method to determine the hydrograph has not been identified yet but will be chosen from one of the following methods, Rational method, SCS TR-55, or Tabular Hydrograph. Once the hydrograph has been created the storm event frequency can be determined. This frequency will be used in the sizing of downstream infrastructure as well as sizing of a potential detention basin.

2.3 Task 3: Develop Conceptual Stormwater Management Approaches

2.3.1 Task 3.1: Development of Conceptual Designs

The team will find alternative stormwater designs that could work in Switzer Canyon wash. Design plans for each alternative will be drawn and presented to the grading instructor and technical advisor/client in Task 3.2. These design alternatives will range from detention basin in the upper reach of the Switzer Canyon Wash, re-dredging the section of the wash that runs between homes in the hospital neighborhood, or resizing the downstream pipe underneath Turquoise Dr. Other options will be researched and proposed for this section

2.3.1.1 Task 3.1.1: Design Alternative 1

2.3.1.2 Task 3.1.2: Design Alternative 2

2.3.1.3 Task 3.1.3: Design Alternative 3

2.3.1.4 Task 3.1.4: Design Alternative 4

2.3.2 Task 3.2: Selection of Final Alternative

The team will meet with City of Flagstaff Stormwater Division for their technical and political expertise on which design would be the most realistic and effective to meet stormwater conveyance needs and City of Flagstaff codes. One design alternative will be chosen to move forward onto hydraulic modeling and final design plans.

2.4 Task 4: Hydraulics

Once the hydrology of the site has been assessed, the hydraulic design can start. The hydraulic analysis uses the flows found from the hydrology of the area to design structures able to convey the flow safely. The hydraulic design will follow City of Flagstaff stormwater design codes. As the Switzer Canyon wash is a FEMA designated water way, the designs must consider and identify what limitations FEMA has for design, however, the design will not be limited by FEMA codes.

2.4.1 Task 4.1: Proposed Open Channel Modeling

Several hydraulic models will be used to aid in the designing of the selected proposed design. They will accomplish this by modeling different storm events in the wash, outlet flow rates for proposed culverts or detention basins, predict velocities and headwater elevations as well as storage volumes. These parameters are crucial to the design functioning well and must meet City of Flagstaff codes. The hydraulic models listed below will ensure the design meets City of Flagstaff code and conveys the water efficiency preventing flooding.

2.4.1.1 Task 4.1.1: HEC-RAS Model

HEC-RAS is another hydraulic modeling program that allows the user to model the hydraulic principles of a channel or wash. This program will show if the wash will flood under different storm frequencies. This model is very important to this project as it will show if a potential design will prevent overtopping (flooding). This model will also be used to ensure the design meets the City of Flagstaff Stormwater codes.

2.4.1.2 Task 4.1.2: FlowMaster Modeling

FlowMaster is a hydraulic modeling program that will be used to design a (if selected) detention basin. The program will be used to determine storage, flow rates, and velocity out of the detention basin alongside other crucial variables needed for a detention basin. The program heavily relies on the Manning equation to determine flows and velocities.

2.4.1.3 Task: 4.1.3: CulvertMaster Modeling

Culvert master is a hydraulic modeling program specifically designed to model culverts. The program allows the user to create culverts of different sizes, material type, and culvert type while inputting stormwater data to determine run-off flows. The program will allow the user to ensure a design meets the City of Flagstaff Stormwater codes as well as determining the specs to prevent flooding in the area of interest.

2.4.1.4 Task 4.1.4: Proposed Erosion Protection Designs

The design selected has potential to cause downstream erosion damage i.e. increasing the velocity in the channel, then an erosion protection design must be implemented. The design would help reduce erosion of the natural channel. This is important for the longevity of the channel as well as reducing sediment build up downstream. As sediments build up it causes channels or culverts to convey less water. Armoring of the channel will help prevent this type of erosion ensuring the channel can function as designed for a much longer period of time.

2.4.1.5 Task 4.1.5: Proposed Design Inlet/Outlet Protection Designs

If the proposed design is a culvert, there could be a potential need to implement inlet or outlet protection. This is done to protect the culvert from undermining or head cut. Ramps, energy dissipaters, or large rocks are some examples of inlet/outlet protection. These may be implemented to resolve the flooding with respect to the City of Flagstaff Stormwater codes. Additionally, revegetation may occur to achieve the same effect.

2.4.2 Task 4.2: Proposed Stormwater Drain Design

If the proposed design involves a stormwater drain, a drain design will be found using City of Flagstaff Title 13 stormwater codes [7]. Modeling of the drain design will be performed in flow master. This modeling will allow the team to determine how well the drain design works regarding flow conveyance as well as meeting City of Flagstaff codes.

2.4.3 Task 4.3: Conceptual Final Design Plan

Design plans will be created for the design selected from Task 3.1. These plans will be created in accordance to the GI’s specifications. These plans will show the existing site and drainage then the proposed design and the changes the design will make to the area I.E flood zone, flow rates, new infrastructure.

2.5 Task 5: Impacts

2.5.1 Task 5.1: Environmental

Changing the water way will impact the environment. How the potential design will impact the channel will be determined so that they may be minimized. The City of Flagstaff sees natural channels as a resource to be preserved that also serve as wildlife corridors. The design will need to ensure historic flows are met for the downstream areas as plants and wildlife relay on the wash for water [6].

2.5.2 Task 5.2: Social

The impacts to the stakeholders will be assessed. How the community feels about the project will be discussed and evaluated.

2.5.3 Task 5.3: Economic

The economic impacts of the design will be assessed. The costs to the City of Flagstaff will be done. The economic impacts of the change to flood insurance rates will be performed. This will be done to help the city understand how the design will impact their budget. Economic impacts to the people in the neighborhood will be assessed such as the reduction of property damage.

2.6 Task 6: Deliverables

Task 6 consists of the course requirements that are needed to meet the criteria of the project and its solution.

2.6.1 Task 6.1: 30% Submittal

For the 30% submittal the team will have completed Tasks 1 and 2 and will have started inputting the hydrologic data into the hydraulic models (Task 4). A 30% report will be submitted at this time and a 30% presentation will be delivered on the progress of the project.

2.6.1.1 Task 6.1.1: 30% Report

2.6.1.2 Task 6.1.2: 30% Presentation

2.6.2 Task 6.2: 60% Submittal

For the 60% submittal, Tasks 3 and 4 will be completed. New information gathered will be added to the 30% report and submitted as the 60% report. A 60% presentation will also be delivered on the project progress.

2.6.2.1 Task 6.2.1: 60% Report

2.6.2.2 Task 6.2.2: 60% Presentation

2.6.3 Task 6.3: 90% Submittal to GI for Final Comments

All tasks will be completed, and the report will be updated based on redlines from Task 6.2. The report will be submitted to the GI for final comments before the final submittal.

2.6.4 Task 6.4: 90% Website

All required content will be on the website and will be ready for final comments by the GI.

2.6.5 Task 6.5: Final Design Plans

The design plans for the design alternative chosen in Task 3.2 will be completed.

2.6.6 Task 6.6: Final Presentation

At the end of the semester the team will present their analysis and final design plans.

2.6.7 Task 6.7: Final Website

The website will be completed with corrections based on the redlines from Task 6.4.

2.6.8 Task 6.8: Final Report

A finished report will be submitted with corrections based on the redlines from Task 6.3.

2.7 Task 7: Project Management

To ensure that all tasks get completed, they must be managed by the team.

2.7.1 Task 7.1: Meeting Binder

The team is required to meet with each other as well as the grading instructor, technical advisor, and client to make sure everyone’s needs are being met. The binder is proof that these meetings occurred. A meeting minutes template will be created and used for all subsequent meetings.

2.7.1.1 Task 7.1.1: Grading Instructor

Meeting minutes with the grading instructor will be documented in the binder.

2.7.1.2 Task 7.1.2: Technical Advisor/Client

Meeting minutes with the technical advisor and client will be documented in the binder.

2.7.1.3 Task 7.1.3: Team Minutes

Team meeting minutes will be documented in the binder.

2.7.2 Task 7.2: Schedule (Critical Path) Management

For time management and organization. The schedule will be reviewed and revised weekly.

2.7.3 Task 7.3: Resource Management

Time the team spends on the project will be documented as billable hours.

2.8 Exclusions

The exclusions address the scope items left out of the project due to a lack of proficiency or requirements.

2.8.1 Construction Management

Construction management would be a part of phase 3 which would be a part of a full project but due to time constraints, this project will focus on phases 1 and 2.

2.8.2 Constructions Plans

A full project would have construction plans, but this project is focused only on the general design and not actually implementing one.

2.8.3 Geotechnical Engineering

This project's end goal does not require soil analysis. Soil data can be found from the USGS website or the USDA web soil survey if needed.

2.8.4 Traffic Analysis

No traffic analysis will be performed for the hospital hill neighborhood. This is due to time and budget constraints. A third-party company would be required to perform this work.

2.8.5 Roadway Design

No roadway design will be performed for this project. This is due to budget and time restraints. The scope of this project is to design an engineer stormwater management design, no construction implementation of the design will be included in this project.

3.0 Project Schedule

In its entirety, the project is scheduled to take 80 days. This includes all major tasks: site investigations, hydrology, develop conceptual stormwater management approaches, hydraulics, impacts, deliverables, and project management. The deliverables and project management tasks occur throughout the whole project and serve as a way for the team to track progress.

3.1 Critical Path

The critical path of this project includes the site investigation, hydrology, design alternative 4, selection of final alternative, HEC-RAS modeling, proposed erosion protection designs, proposed design inlet/outlet protection design, the conceptual final design plan, final design plans, and the final report. These tasks are crucial to the progression of the project. Each must be completed for the following tasks to occur. If one task is late, the rest of the project gets delayed. It makes sense for the project to be so dependent on the site investigation and hydrology since the modeling is dependent on the surveying and hydrology data. To keep the project on track and minimize delays Microsoft Project will be used to track the team's progress. The team will manage the tasks by sticking to the schedule and documenting changes in the program. A Gantt chart has been created with all tasks to aid in scheduling (see Appendix A for schedule).

4.0 Staffing Plan

The staffing plan is used to identify the staff positions and cost associated with each position to complete the project.

4.1 Staff titles

The following staff will be needed for the project: senior engineer (SENG), engineer (ENG), engineer in training (EIT), and a lab technician (TECH).

4.2 List of qualifications

The qualifications needed for each position are listed below.

Senior Engineer: Professional engineering license, bachelor's in civil/environmental engineering, well experienced in stormwater design, proficient knowledge of City of Flagstaff stormwater and design codes, management experience

Engineer: Professional engineering license bachelor's in civil/environmental engineering, well experienced in stormwater design, proficient knowledge of City of Flagstaff stormwater and design codes, some management experience

Engineer in Training: Bachelor's in civil/environmental engineering, some experience in AutoCAD, surveying, and HEC-RAS modeling

Technician: Working knowledge of stormwater design, experience in AutoCAD, HEC-RAS, CulvertMaster, and FlowMaster, as well as surveying experience

The qualifications of each team member are listed below.

Celine Bannourah: Completed Water Resources 2 Lab, Hydrology, Hydraulics, Hydraulic Lab, Engineering in Natural Systems: Rivers and Streams

Kara Coffel: Completed Hydrology, Hydraulics, Hydraulic Lab

Gindiri Paul: Completed Water Resources 2 Lab, Hydrology, Hydraulics, Hydraulic Lab

Noah Tison: Completed Water Resources 2 Lab, Hydrology, Hydraulics, Hydraulic Lab

4.3 Estimated hours

Table 4-3-1 below list the scope of work and the time it will take each member of the team to complete each individual task.

Table 4-3-1: Billable Hours

	Hours				
Task	**SENG**	**ENG**	**EIT**	**TECH**	**Total**
1.0 Site Investigation	**1**	**2**	**22**	**22**	**47**
1.1 Field Visit and Preliminary Assessment	1	2	8	8	19
1.2 Field Surveying	0	0	6	6	12
1.2.1 Land Surveying	0	0	4	4	8
1.2.2 Survey Data Processing	0	0	2	2	4
1.3 Document Existing Infrastructure	0	0	4	4	8
1.4 Review As-Builts for Existing Infrastructure	0	0	4	4	8
2.0 Hydrology	**3**	**6**	**16**	**16**	**41**
2.1 Research Previous Master Drainage Studies	0	2	4	4	10
2.2 Basin Delineation	1	0	4	4	9
2.2.1 Major Basin Delineation	0.5	0	2	2	4.5
2.2.2 Sub-Basin Delineation	0.5	0	2	2	4.5
2.3 Sub-Basin Variables	0	3	6	6	15
2.3.1 Time of Concentration	0	1	2	2	5
2.3.2 Flow Routing	0	1	2	2	5
2.3.3 Weighted Curve Number Determination	0	1	2	2	5
2.4 Hydrograph Development	2	1	2	2	7
3.0 Develop Conceptual Stormwater Management Approaches	**10**	**18**	**18**	**10**	**56**
3.1 Development of Conceptual Designs	8	16	16	8	48
3.1.1 Design Alternative 1	2	4	4	2	12
3.1.2 Design Alternative 2	2	4	4	2	12
3.1.3 Design Alternative 3	2	4	4	2	12
3.1.4 Design Alternative 4	2	4	4	2	12
3.2 Selection of Final Alternative	2	2	2	2	8
4.0 Hydraulics	**5**	**13**	**28**	**28**	**74**
4.1 Proposed Open Channel Modeling	0	7	20	20	49
4.1.1 FlowMaster Modeling	0	1	4	4	9
4.1.2 Culvert Master Modeling	0	1	4	4	9
4.1.3 HEC-RAS Model	0	1	4	4	9
4.1.4 Proposed Erosion Protection Design	1	2	4	4	11

4.1.5 Proposed Design Inlet/Outlet Protection Designs	1	2	4	4	11
4.2 Proposed Stormwater Drain Design	1	2	4	4	11
4.3 Conceptual Final Design Plan	2	4	4	4	14
5.0 Impacts	**5**	**12**	**6**	**0**	**23**
5.1 Environmental	2	4	2	0	8
5.2 Social	1	4	2	0	7
5.3 Economic	2	4	2	0	8
6.0 Deliverables	**26**	**48**	**62**	**56**	**192**
6.1 30% Submittal	3	6	12	12	33
6.1.1 30% Report	1	4	8	8	21
6.1.2 30% Presentation	2	2	4	4	12
6.2 60% Submittal	3	8	12	12	35
6.2.1 60% Report	1	6	8	8	23
6.2.2 60% Presentation	2	2	4	4	12
6.3 90% Submittal to GI for Final Comments	2	8	12	12	34
6.4 90% Website	4	6	6	4	20
6.5 Final Design Plans	6	8	8	6	28
6.6 Final Presentation	4	4	4	4	16
6.7 Final Website	2	6	6	4	18
6.8 Final Report	2	2	2	2	8
7.0 Project Management	**48**	**48**	**48**	**48**	**192**
7.1 Meeting Binder	32	32	32	32	128
7.1.1 Grading Instructor	8	8	8	8	32
7.1.2 Technical Advisor/Client	8	8	8	8	32
7.1.3 Team Minutes	16	16	16	16	64
7.2 Schedule (Critical Path) Management	8	8	8	8	32
7.3 Resource Management	8	8	8	8	32
Total	**98**	**147**	**200**	**180**	**625**

4.4 Summary Table

Table 4-4-2 displays the total billable hours for each staff personnel. The EIT will be involved with every part of the project and will therefore have the most hours. This project will require a heavy amount of work in AutoCAD and hydrologic modeling software. The nature of this work requires a large amount of time and is thus given to the EIT and technician to keep project cost low.

Table 4-4-2: Summary of Billable Hours

Classification	Hours
SENG	98
ENG	147
EIT	200
TECH	180
Total Personnel	625

5.0 Cost of Engineering Services

The total cost of the engineering services is listed on the next page in Table 5-1-3. The total personnel cost was $66,245 to complete the project. The travel for the project includes a minimum of 8 meeting with the grading instructor and 4 meetings with the technical advisors for the project. The cost of driving to the site for surveying and visiting has been in included in personnel cost. The supplies for this project are renting a robotic total station and an auto level.

Table 5-1-3: Cost of Engineering Services Breakdown

	Classification	Hours	Rate, $/hr	Cost
Personnel	SENG	98	200	19600
	ENG	147	135	19845
	EIT	200	80	16000
	TECH	180	60	10800
	Total Personnel	625		66245
Travel	12 Meetings	100 Miles	0.58 $/Mile	58
Supplies	Surveying Equipment	8 Hours	100 $/hr	800
Cost of Engineering Services Total				**67103**

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Appendix:

Appendix A: Schedule