Rio de Flag Restoration

Artemis Designs

Team Members:

Emily Frazer | Destiny Gourley | Jenna McCaffrey | Daniel Segal

April 27th, 2021

Table of Contents

Table of Figures

Table of Tables

List of Abbreviations

ADWR	Arizona Department of Water Resources
ATV	All-Terrain Vehicle
COE	Corps of Engineers
COF	City of Flagstaff
EIT	Engineer In Training
FUTS	Flagstaff Urban Trail System
CWA	Clean Water Act
NOAA	National Oceanic and Atmospheric Administration
PM	Project Manager
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
SMDM	Stormwater Management Design Manual
USGS	United States Geological Survey
USFS	United States Forest Service
LID	Low Impact Development

1.0 Project Understanding

1.1 Project Purpose

The goal of this project is to the improve the channel conditions for the section of Rio de Flag flowing from Herold Ranch Rd. to Foxglenn Park, to provide a healthy riparian environment that can support local plants and offer an enjoyable shared public experience. The site is home to a variety of recreational activities and abuts many public and residential zones. Currently, the area suffers from poor stream conveyance, creating standing water pools in areas of heavy public use (this increases insect load, a potential health hazard) causing excessive erosion in these areas and reduces the flow available to downstream portions of the reach. This will require restoration of the channel and associated floodplains to improve the flow of water by creating a series of detention basins where it is most appropriate and reconstructing eroded and incised portions of the channel.

1.2 Project Background

The reach is located in the city of Flagstaff in Coconino County, Arizona between the upstream culvert at Herold Ranch Road, due East of the junction with S. River Valley Road, and the downstream culvert at Foxglenn park crossing under East Butler Ave.

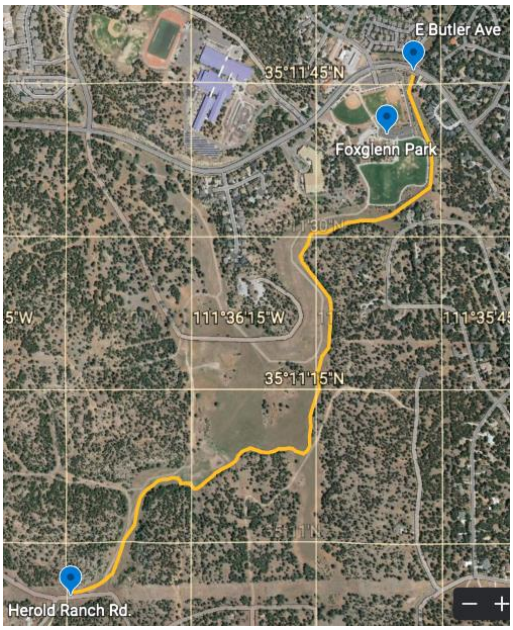

Figure 1: Overview of Reach [1]

Much of the reach runs along the FUTS, an organization of mixed-use, recreational trails that weave through and around the city of Flagstaff, which are owned and maintained by the City of Flagstaff. Picture below is a satellite image of the channel (right), the FUTS trail (center), and a rogue ATV trail (left), highlighting the issues related to the mixed-use nature of this section.

Figure 2: Example of Multi-use Section of Reach [1]

This section of reach currently acts as a part of the city storm sewer system, as such the City of Flagstaff Stormwater Project Manager provided the solicitation for this project and has described the current conditions of the reach as "a real mess." Aspects that need to be addressed include the proliferation of invasive plants, the buildup of public refuse from recreational and homeless use, and soil degradation caused by unrestricted off-roading and ATV usage.

1.3 Technical Considerations

To address the slate of issues proposed by the client, the team will need to reshape many sections of the channel and alter the current biological makeup of the channel and associated floodplains.

Many studies will need to be undertaken along every section of the reach, and possibly further upstream. It is imperative that the team gain a full understanding of the hydraulic conductivity of the channel beginning with a survey of the topography.

Once the dimensions of the reach are known, a pebble count must be conducted to determine the average diameter of the current substrate. These values will inform the hydraulic models created for the site in the form of various modeling software and hand calculation techniques.

Due to the Mobius nature of the land ownership, there will need to be a comprehensive study to determine jurisdictional control and regulations as presented in Section 404 of the CWA [2].

The soil itself will need a geotechnical analysis for water conductivity and shear strength to determine base values that will inform the final design. The soil will also require analysis of the nutrient content so that it can be determined what, if any, amendments are needed to support the endemic plants that are desired at the given sections of the reach.

Biological and ecological assessments will need to be made for the area to decide how these factors could affect the project and if any changes need to be made.

There will need to be a long-term hydrological study covering the precipitation intensity, duration, and frequency. All the available information from NOAA Atlas 14, the FEMA flood maps, and the City of Flagstaff will be utilized in this study.

The culverts and current structures will need to be assessed to decide what needs to be done to allow better flow through the area. More culverts may need to be inserted for better flow and/or for easier travel for the ATVs in this area.

A detailed construction plan will need to be devised once the engineering design process is completed, as such a thorough engineering plan set must be created and verified with accurate modeling and in situ measurements.

1.4 Potential Challenges

The constraints affecting the project stem primarily from the volume of interested parties, each with a separate target outcome, and from the overall cost of the restoration. For the project to be completed, there must be sufficient financial support from the city and other vested parties to achieve the desired outcomes. Artemis Designs will work to ensure a budget that is reasonable but still makes the project effective.

As a stakeholder in the outcome of this project, the local community must be in support of the work. To inform the community of the project and it is importance, effective signage could be posted with information about the restoration, how it will affect the community in a positive way, and the best methods to share the space with each other and the natural environment.

The project site passes through an unofficial ATV path that will be difficult to restrict access to. Such a restriction could also provoke public backlash aimed at the project. To reduce destructive ATV activity, signs could be made stating to avoid crossing the stream especially during the rainy season, as well as inform the riders of the harmful effects of disobeying these signs.

Due to the unpredictable weather patterns, it may be difficult to access the reach during surveying, planning, and construction. The team will mitigate weather related constraints by doing in situ tests and construction on days with low chance of storm along with using online resources of data already collected.

1.5 Stakeholders

The primary financial stakeholder of this project is the City of Flagstaff Stormwater Division, which is headed by the Project Manager Ed Schenk. There are currently three private organizations that maintain a vested interest in the reach as well. These are Little America Suites, a hotel and event center that abuts a large section of the upstream floodplain; Symmetry Homes, which holds a land trust account for a section of the reach; and Canyon Del Rio, a housing developer with properties abutting the reach. These ownership roles typically allow for the City of Flagstaff guidance to supersede any internal deliberations [3], and it is likely that the actual ownership of these properties will defer to the city of Flagstaff in the future. In addition, the area supports an array of recreational and wildlife activity and is therefore heavily utilized by the public at large, which should always be considered as the intended end-user whenever possible.

2.0 Scope of Services

2.1 Task 1: Project Due Diligence

To understand the current performance and condition of the site, multiple field visits and data assessments will be conducted. These will include studies of the topography, hydrology, infrastructure, vegetation, and soil composition, as well as any other pertinent studies required for the design. The team will also utilize all available documentation on the site including, but not limited to, topographic maps and hydrologic and geotechnical assessments.

2.1.1 Task 1.1: Site Investigation

The team will undertake a geomorphic survey of various sections of the reach to determine the most representative sites for the reach according to the shape, slope, and size of the section. This will include the use of auto level, total station, and other GIS data available; all of this will inform the creation of the models that will be developed in the hydraulic assessment.

2.1.1.1 Task 1.1.1: Soil Survey

An analysis of the current substrate will be conducted from samples taken at the site to determine makeup, Manning's roughness values, and shear strength. The team will take soil samples and then perform a sieve analysis and subsequent soil classification.

2.1.1.2 Task 1.1.2: Plant Survey

A thorough examination of the current floral composition of the site will be executed to determine the invasive and native species.

2.1.1.3 Task 1.1.3: Topographic Survey

A survey of the topography will be conducted using auto levels and/or total stations. These will serve as the basis for channel hydraulic models of the current flow regimes, normal depth, and critical depth.

2.1.2 Task 1.2: Previous Studies

A study of the status regarding federal, state, and local rules and regulations of such a proposed project will be completed to ensure all policies and laws are accounted for in the design.

2.1.2.1 Task 1.2.1: FEMA Floodway and FIS

Information from FEMA's Regulatory floodway data, the FEMA FIS will be reviewed. This will provide the team with the necessary information regarding restrictions and historical data for this section of the Rio De Flag. Using the FIS document will help denote the severity of the flood hazards that surround this section of the Rio De Flag.

2.1.2.2 Task 1.2.2: City of Flagstaff SMDM

The COF SMDM will provide information regarding different forms of open channel design, Flagstaff specific drainage requirements, and bridge and culvert design criteria.

2.1.3 Task 1.3: Representative Site Determination

From the information determined from the previously listed research tasks, the entirety of the site will be divided into four different areas. This will condense the entire reach into smaller representations allowing for reliable modeling. The four areas determined in this step will be used and referred to for the remainder of the proposal.

2.2 Task 2: Hydrologic Data

Hydrological studies performed in the past by USGS, and FEMA will be predominately used to describe normal to extreme flow conditions of Rio de Flag. Other study sources may be used by COE and ADWR. The data will be used to see flooding trends along with discharge frequencies and flow in determining channel conditions and culvert sizes.

2.2.1 Task 2.1: Sub-basin Delineation

USGS topographic maps and COF LIDAR will be used to delineate the Rio de Flag drainage basin to show stream distribution.

2.2.2 Task 2.2: Sub-basin Properties

The sub-basin will be assessed for area, perimeter, typical seasonal precipitation, and geomorphology. This will include general properties such as aquifer recharge rates, area and precipitation intensity values, and upstream characteristics. This will be used to inform the overall hydrological assessment.

2.2.3 Task 2.3: FEMA / City of Flagstaff

A study of the FEMA FIS results, and COF data will be conducted to reduce the amount of work for the team to achieve a complete understanding of the site. Where applicable, data will be used to inform the current models.

2.3 Task 3: Hydraulics

Pre-existing hydraulic data for the site will be reviewed and compiled with the measurements taken in previous steps to determine how the water flows through the site. This information will be incorporated into the design plans with the assistance of modeling software.

2.3.1 Task 3.1: Input Data Development

Existing data about this site will need to be gathered to ensure that hydraulic models are accurate. Information on the flow conditions, boundaries, linings, and obstructions will be obtained because this information could have changed since the existing data was gathered.

2.3.2 Task 3.2: NRCS Analyzer

NRCS Cross-Section Analyzer models will be created to analyze the selected cross sections for various flow properties.

2.3.3 Task 3.3: HEC-RAS Analysis

HEC-RAS will be used to model the current conditions to inform the final design.

2.4 Task 4: Design

A design will be created that addresses the current problems with the channel. This will be accomplished iteratively to ensure the outcomes are conducive to client's desires. The implementation of the final design will improve the channel so that it may convey flow properly, support local plants, and offer an enjoyable riparian area for public use.

2.4.1 Task 4.1: CAD Drafting

An accurate model of the site will be drafted using Civil 3D to utilize with the NRCS model and to aid in developing a plan set and determine the best physical layout of the finished design. This will reflect the geomorphic and plant survey data conducted previously to determine the current conditions and convey proposed changes. This step will be revisited as proposed changes are honed.

2.4.2 Task 4.2: Hydraulic Software

HEC-RAS and NRCS models will be created to assess the operation of the various design proposals. These proposed conditions will modify substrates, channel geometry, and flow conditions to determine what changes will result in ideal conditions to stabilize the channel. This step will be revisited as proposed changes are honed.

2.5 Task 5: Deliverables

2.5.1 Task 5.1: 30% Submittal

This submittal will consist of a report summarizing the up-to-date progress on the project. This will include an explanation of the milestones, an expository on the unexpected issues that have occurred, as well as the methods and changes undertaken to overcome these. This submittal will include all data collected from onsite research and previous studies. A 30% CAD drawing will provide a visual interpretation of the site and the proposed restoration. A 30% presentation will accompany the report to show the teams progress from analyses conducted and apprise the client of the progress. This will also include what is to be expected in the subsequent submission.

2.5.2 Task 5.2: 60% Submittal

The 60% submittal will include a discussion of what has been updated from the 30% submittal. This will present the data accrued during the HEC-RAS modeling steps and all current proposed changes informed by this. This will include a 60% presentation and updated plan sets. The report will contain the preliminary analysis of all the technical issues forgone through the project thus far.

2.5.3 Task 5.3: 90% Submittal

The 90% submittal will contain an almost complete report and a plan set representing the most desirable proposal in accordance with the selected outcomes arising from it. This will include what has been updated or changed from what was discussed in the 60% submittal. This report will include all the corrected and completed analysis, hydraulic assessments, improvement plans, impact assessments, and project costs, along with an updated plan sets and hydraulic models. This will include a thorough vegetation plan and construction drawings. The 90% present presentation will include what has been

discussed above as well as a general layout for how the final deliverables will be met before the final report.

2.5.4 Task 5.4: Final Report

The final report includes all the final corrections from the 90% submittal as well as the new additions made to the project. This report will help show the client the goal and final product of the project. New deliverables to this report will include finalized models, results, and the final feasibility analysis of the restorations of the sites as well as the final plan set for the project.

2.5.5 Task 5.5: Final Presentation

The final presentation explains the final deliverables while also providing all improvements made from the on-site investigations, hydraulic analysis, and impact interpretation. The final plan set includes finalized maps, details, and construction plans for each of the sites. This presentation will provide a visual representation of all completed work and design elements for this project. The results of analysis will also be included within this presentation.

2.5.6 Task 5.6: Meeting Memo Binder

Throughout the entirety of the project, meeting minutes have been taken at each meeting. The minutes show the participants, date and time, and the topics discussed. The minutes provide a detailed list of what was accomplished during the meeting and what will be accomplished post meeting. This binder will help keep track of meetings between team members, grading instructors, technical advisors, and clients. The binder will be divided into sections relating to each of the groups above for easy accessibility.

2.5.7 Task 5.7: Website

A website will be created to present the information and data gained from the project to any interested client or consumer. This will also serve as a portfolio to archive all the work completed during this project. The home page of the website will display the project title, group members, member, and client information. The project information page will contain information regarding project specific deliverables. The documents page will include all written and presentation documents as well as any other documents used to communicate the projects final design. The site will be created using provided resources from the client, grading instructor, or technical advisor.

2.6 Task 6: Project Management

To ensure that all deadlines are met and that the team performs to the fullest, there will be a cohesive plan designed that all parties agree and adhere to.

2.6.1 Task 6.1: Team Meetings

Team meetings are to be held every week on an agreed upon day, via Bblearn Collaborate, to discuss the current deliverables and coordinate for future ones. Additional meetings are to be scheduled on a circumstantial basis. ‘Meeting Minutes’ are to be recorded for each meeting in a specified document, showing the discussions, decisions,

and to-dos. The main point of the meeting is to work on the current deliverable or to form plans.

2.6.2 Task 6.2: Tech Advisor Meetings

When problems or unanswered questions arise, a meeting with the Technical Advisor will be scheduled. The Technical Advisor will also review the progress of the project and provide constructive feedback. Utilizing these meetings will help the quality and pace of the project.

2.6.3 Task 6.3: Client Meetings

Meetings with the client will entail reviewing the progress of planning to ensure client satisfaction. These meetings will be an opportunity for the client and team to ask any questions or make requests.

2.6.4 Task 6.4: Schedule Management

The team will create a plan to ensure all tasks are completed on time in the form of a Gantt chart. This will help team members to stay organized and on track by showing all tasks and subtasks along with submittal date.

2.6.5 Task 6.5: Resource Management

Due to limited resources, the team will delegate budgets, tasks, equipment, and supplies. Managing resources will involve open communication between team members to ensure no resources are wasted.

2.6.6 Task 6.6: Impacts

This section is used to inform stakeholders on the possible impacts the project can have. This also helps to explain the benefits of the project once completed.

2.7 Exclusions

The exclusions listed refer to projects or studies that the team will not be performing in-house, where appropriate, properly equipped professional organizations will be required to execute such tasks.

2.7.1 Construction

The actual construction of the design will be required for this project if it is approved. These services, however, will not be performed by this team as a team of professionals will be required to complete this work.

2.7.2 USACE 404 Jurisdiction

A study of the jurisdiction of the site in accordance with Section 404 of the CWA, will not be performed in-house due to a lack of time and expertise. This study indicates the set of federal rules and regulations regarding the use of and improvements made to the site.

2.7.3 FEMA LOMR

It is not withing the scope of this project, nor within the team’s ability to produce a Letter of Map Revision (LOMR) to amend the FEMA Flood Insurance Rate Map as described in Chapter 65 of the National Flood Insurance Program. This is a required when

altering the physical layout of a designated channel to inform insurers and municipalities of the likely effects of flooding to a region.

2.7.4 No Adverse Impact

A No Adverse Impact (NAI) determination is beyond the scope of this project as it requires oversight and liability not within the purview of this team. A NAI determination ensures that any modifications to a channel do not increase the likelihood of future property damages due to flood events.

3.0 Schedule

Scheduling is an integral part of any engineering project as it is necessary for the team, client, and contractors to be aware of all milestones and expectations. There are many ways to organize and display these tasks and correlated dates, but consistency is required throughout the project.

3.1 Gantt Chart

The figure in Appendix A displays the project schedule for the team, represented as a Gantt chart. The chart displays the working schedule for the entire project from time that the contract is awarded (08/20/21) to the end date (11/20/21). This schedule encompasses the ensuing 66 days and highlights the progression of tasks. Each of the major tasks is represented as a bracket over the multiple subtasks required to fulfill the goal of this heading. In “Task 4.0 Design” the bracket covers the two subtasks from the start of the earliest to the end of latest. Each basic task and subtask are colored in blue, whereas those associated with the critical path are colored red, and lines with arrows connect tasks that are dependent upon each other for completion.

If a task requires multiple separate meets, such as in subtask “1.1.1 Soil Survey”, the solid block is broken into multiple sections representing the date and length of occurrence; in this case the date of sampling and actual laboratory analysis occur two weeks apart. This is known as a “split” and is represented by small dots connecting boxes on the same task row. Similarly, for subtask “1.1.3 Topographical Survey” the team will be meeting at the site to take topographical measurements of the plain and channel in separate outings.

The team consists of 4 people and therefore can accomplish multiple tasks each day, which is why certain subtasks may overlap even if they are not necessarily dependent upon one another.

3.2 Critical Path

The chart displays each task and correlated subtask, when a given task requires the completion of a previous task to begin it is known as a dependency. When these dependent tasks are themselves required to be completed for the sequent task to begin, this is known as the critical path. This is the series of events required to be completed for the project to finish on time, therefore anything in the schedule that cannot be adjusted for timeliness lest the entire project suffer, is considered the critical path. In Figure 3, this series of dependent tasks is highlighted in red, where each milestone occurs, the critical path connects predecessors to their dependent tasks. For this project, the critical path begins with subtasks 1.1.1 and 1.1.3, this is because the models intended to assess the channel flow, and which will ultimately be the basis of the design require the

topographical and soil structure data used for the models. As such, the completion of each milestone deliverable is dependent on the timely completion of these tasks. Once these data are used to select the representative sites, the sub-basin can be delineated and assessed for hydrologic performance, from which the hydraulic data can be analyzed and used to create preliminary models. Following the completion of this, the corresponding report submittals can be populated and eventually, the design can be completed, and the final report published to include this.

4.0 Staffing Plan

A staffing plan is used to specifically identify the staff positions necessary for the project. It outlines the necessary qualifications each specific staff should have to have the best possible project outcome.

4.1 Staff Titles and Qualifications

Each staff member is selected based on applicable qualifications and expertise in the related field. Below are the positions and the determination of how the individual qualifies for a given position.

4.1.1 Project Manager (PM)

The project manager is the most experienced and qualified member of the group. They have a plethora of knowledge gained from the multiple years of experience with professional engineering license requires. They fill the role as the group leader. They supervise and manage the team while also providing guidance on tasks.

The project manager should have a professional engineering license, a bachelor's in civil/environmental engineering, experience with stormwater channel restoration and design, excellent knowledge of the City of Flagstaff stormwater design codes, and project management experience.

4.1.2 Lead Engineer (ENG)

The engineer will also have experience working as an engineer on many previous projects relating to channel restoration. As the head engineer, they will be knowledgeable about codes and regulations, and have experience using AutoCAD, HEC-RAS, and Bentley FlowMaster. They will help oversee the EIT.

The engineer will have a bachelor's degree in civil or environmental engineering, as well as professional engineering license.

4.1.4 Engineer in Training (EIT)

The engineer in training will collect site-specific data and implement into software for software analysis modeling. They will assist in technical research as well as aid in the organization of the overall completion of tasks throughout the project. Other tasks will be assigned to the EIT from the engineer, project manager, and/or the lab technician if they need more assistance. The EIT must have excellent writing skills as much of the work will be recording data and technical writing.

The engineer in training can be either a degree seeking student or a recent graduate with a Bachelor of Science in engineering: civil/environmental engineering degree. They should have experience with data analysis and very good problem-solving skills.

4.1.5 Lab Technician (TECH)

The lab technician will have experience analyzing soil, water, and plant samples in a professional laboratory. They will also have knowledge and experience using AutoCAD, HEC-RAS, and Bentley FlowMaster. They will help to oversee the EIT if needed.

The lab technician will have an associate's or bachelor's degree in a related field.

4.3 Estimated Hours

The following table enumerates the estimated number of hours required to complete each task and the appropriate staff member to whom it will be assigned.

Table 1: Billable Hours by Task and Staff Member

	Hours				
Task Name	(PM)	(ENG)	(EIT)	(TECH)	
1.0 Project Due Diligence	**7**	**34**	**96**	**10**	**146**
1.1 Surveying Data	2	29	80	10	
1.1.1 Soil Survey	0.5	4	4	10	
1.1.2 Plant Survey	0.5	0.5	4	0	
1.1.3 Topographic Survey	0.5	24	72	0	
1.2 Previous Studies	1	1	12	0	
1.2.1 FEMA Floodway and FIS	0.5	0.5	6	2	
1.2.2 City of Flagstaff SMDM	0.5	0.5	6	2	
1.3 Representative Site Determination	4	4	4	0	
2.0 Hydrologic Data	**3**	**6**	**12**	**4**	**25**
2.1 Sub-Basin Delineation	0.5	1	4	0	
2.2 Sub-Basin Properties	0.5	0.5	4	4	
2.3 FEMA/City of Flagstaff	2	4	4	0	
3.0 Hydraulic Data	**2**	**4**	**34**	**0**	**40**
3.1 Input Data Development	1	2	14	0	
3.2 NRCS Analyzer	1	2	20	0	
3.3 HEC-RAS Analysis	0.5	0.5	30		
4.0 Design	**8**	**60**	**120**	**4**	**192**
4.1 CAD Drafting	4	30	60	0	
4.2 Hydraulic Software	4	30	60	4	
5.0 Deliverables	**23**	**51**	**77**	**21**	**172**
5.1 30% Submittal	2	10	16	4	
5.2 60% Submittal	4	10	8	4	
5.3 90% Submittal	4	10	16	4	
5.4 Final Report	4	8	10	2	
5.5 Final Presentation	6	8	8	4	
5.6 Meeting Memo Binder	1	1	1	1	
5.7 Website	2	4	18	2	
6.0 Project Management	**52**	**42**	**37**	**28**	**159**
6.1 Team Meetings	16	16	16	16	
6.2 Tech Advisor Meetings	8	8	8	8	
6.3 Client Meetings	16	2	0	0	
6.4 Schedule Management	2	6	0	0	
6.5 Resource Management	8	4	1	0	
6.6 Impacts	4	6	12	4	
Total Hours:	**95**	**196**	**376**	**67**	**734**

As listed above, 95 hours are delegated to the Project Manager. This is because they will spend most of their time ensuring the work of the subordinate staff members is correct and pertinent to the project. They will also be communicating the project's progress with the client. The Lead Engineer is slated to conduct 196 hours of work directing the Lab Technician and Engineer in Training in their tasks and ensuring the accuracy of all the work conducted. The Lab Technician will spend 67 hours sampling, conducting tests, and meeting with the team, as well as ensuring the results of their work are communicated thoroughly in the reports. The Engineer in Training is likely to do the bulk of the work at 376 hours as they are well qualified, but much more affordable than the P.E.s on staff. The total estimated billable hours for this project is 734, taking place over the course of 66 days.

The following table summarizes the total estimated hours for each staff member along with the total number of hours designated for each task.

Table 2: Total Hours by Employee

	Hours by Employee				
	Project Manager	Engineer	Engineer in Training	Lab Technician	Total Hours
Task Name	(PM)	(ENG)	(EIT)	(TECH)	
1.0 Due Diligence	7	34	96	10	146
2.0 Hydrologic Data	3	6	12	4	25
3.0 Hydraulic Data	2	4	34	0	40
4.0 Design	8	60	120	4	192
5.0 Deliverables	23	51	77	21	172
6.0 Project Management	52	42	37	28	159
Total Hours:	**95**	**196**	**376**	**67**	**734**

Each staff member is assigned a specific number of hours per each task indicated above in the scope of services section. It is important to see the range of hours the staff members will work during this project when needing to refer to the personnel responsible for specific documents and/or items that were created during the specific task.

5.0 Cost of Engineering Services

Below, Table 3 contains the total estimated cost of engineering services this project would require if awarded to Artemis Designs.

Table 3: Personnel Cost Estimate to Complete Project

Category	Classification	Hours	Rate, $/hr	Cost
Personnel	PM	94.5	200	$18,900
	ENG	196	140	$27,440
	EIT	376	90	$33,840
	TECH	67	60	$4,020
Lab Fees		4	25	$100
Software Fees		Yearly	1300	$1,300
TOTAL		734		$84,300

This table breaks down how many hours each member of the project will need to contribute to properly complete the project along with the hourly rate each member will get paid. The total cost is $84,300 to complete the project. The justifications for pay rates can be found in the "Staff Titles and Qualifications" section above. This table does not include travel or supplies costs because the supplies will be provided by Northern Arizona University, and the cost of travel to and from the site has been included in the personnel cost.

6.0 References

[1] *Google Earth*. [Online]. Available: https://earth.google.com/web/@35.18457654,-111.60653655,2077.3789976a,9446.49157517d,30y,0h,0t,0r/data=MicKJQojCiExWktGdEFQUk1QV1ctb1RJaUktaktpRTlWSldWcjNmOXQ. [Accessed: 06-Feb-2021].

[2] "Home," *Portland District, US Army Corps of Engineers*. [Online]. Available: https://www.nwp.usace.army.mil/Missions/Regulatory/Jurisdiction.aspx. [Accessed: 06-Feb-2021].

[3] Cella Barr Associates, "Canyon De Rio Development Plan," *City of Flagstaff Official Website*, May-1984. [Online]. Available: https://www.flagstaff.az.gov/DocumentCenter. [Accessed: 08-Feb-2021].

[4] 2009. COF Low Impact Development. 1st ed. [eBook] Flagstaff: City of Flagstaff. Available at: [<https://www.flagstaff.az.gov/DocumentCenter/View/8401/COF-LID-Manual-1-09?bidId=> [Accessed 15 February 2021].

7.0 Appendix

Appendix A: Team Gantt Chart