Proposal For West John Wesley Powell Blvd Extension Design

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Final Draft

Contents

List of Figures

List of Tables

List of Equations

List of Abbreviations

ADA	American Disabilities Act
ADOT	Arizona Department of Transportation
FHWA	Federal Highway Administration
FUTS	Flagstaff Urban Trail System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
JAMAR	Traffic Data Analysis & Reporting Software
JWP	John Wesley Powell
MUTCD	Manual on Uniform Traffic Control Devices
NOAA	National Oceanic and Atmospheric Administration
SWMDM	Storm Water Management Design Manual
WSS	Web Soil Survey

1.0 Project Understanding

1.1 Project Purpose

The John Wesley Powell Blvd Extension Design project aims to extend John Wesley Powell Boulevard (JWP) from South Pulliam Drive to Lake Mary Road, with the primary focus being able to enhance the accessibility to underserved areas. This project will include the design and construction of a one-mile road extension, with incorporating drainage systems, and redesigning the Lake Mary Rd. & JWP Blvd. intersection.

1.2 Project Background

The project focuses on a segment of JWP Blvd., in which it is situated between two intersections. JWP begins at the Interstate 17 (I-17) off-ramp and it continues approximately 4 miles eastward. This project centers on a 1.5-mile section between South Pulliam Dr. and Lake Mary Rd., where it is characterized by dense forests and rough terrain. It is important to note that this area lies just north of Flagstaff Pulliam Airport.

1.2.1 Project Location

The project is located in the west of Flagstaff, Arizona. This project site lies due East of I-17, see Figure 1-1 below:

Figure 1-1: Project location [1]

The City of Flagstaff, depicted in its entirety in the map below (Figure 1-2); various neighborhoods, local facilities, and key landmarks can also be seen surrounding the project location.

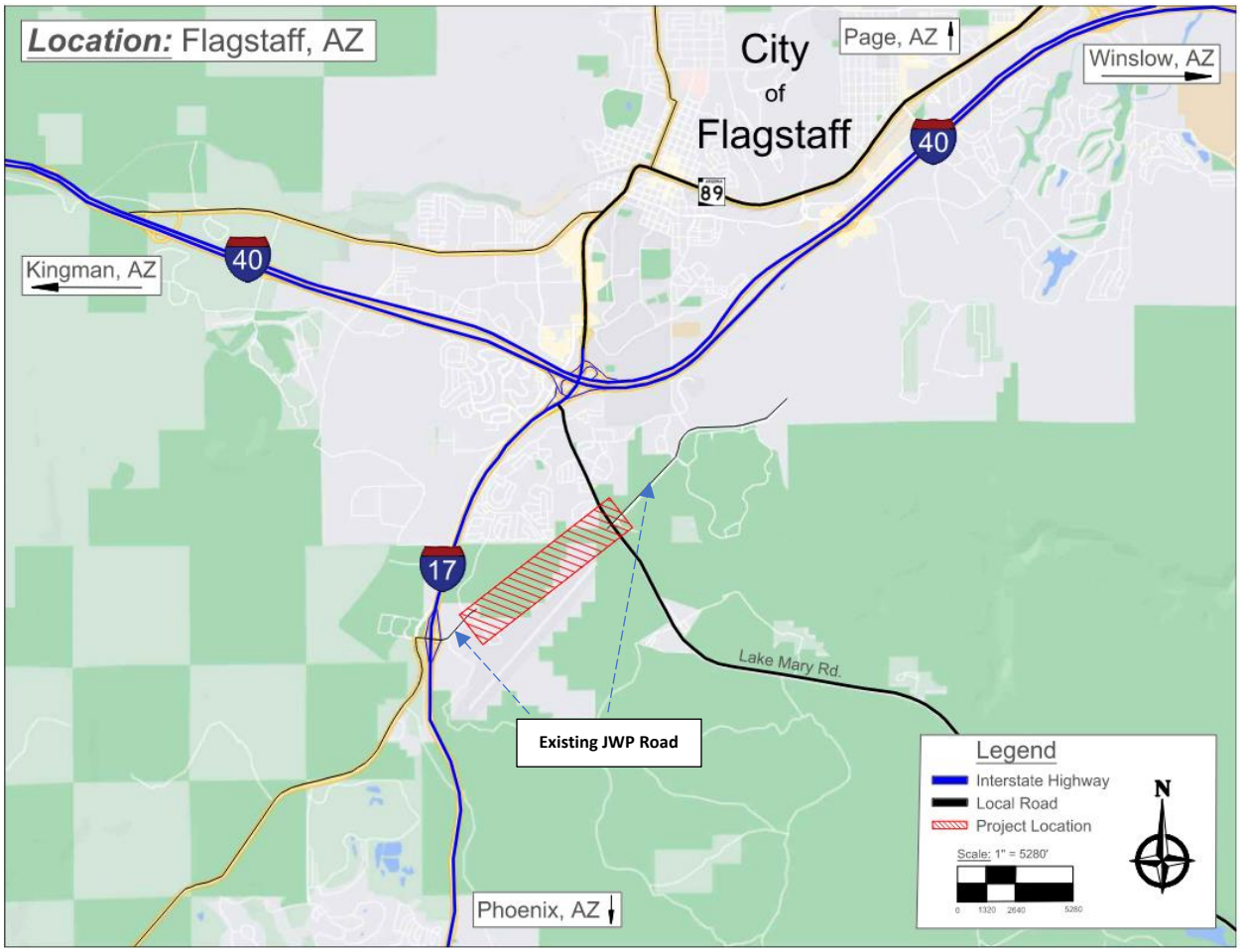


Figure 1-2: Vicinity map of project in Flagstaff, Arizona

The JWP Extension Project will aide in improving connectivity and accessibility within this portion of Flagstaff. Where it will offer benefits to both its residents and visitors. Figure 1-3 provides a satellite image of this location; this map is an overview of the project area, hatched in white.

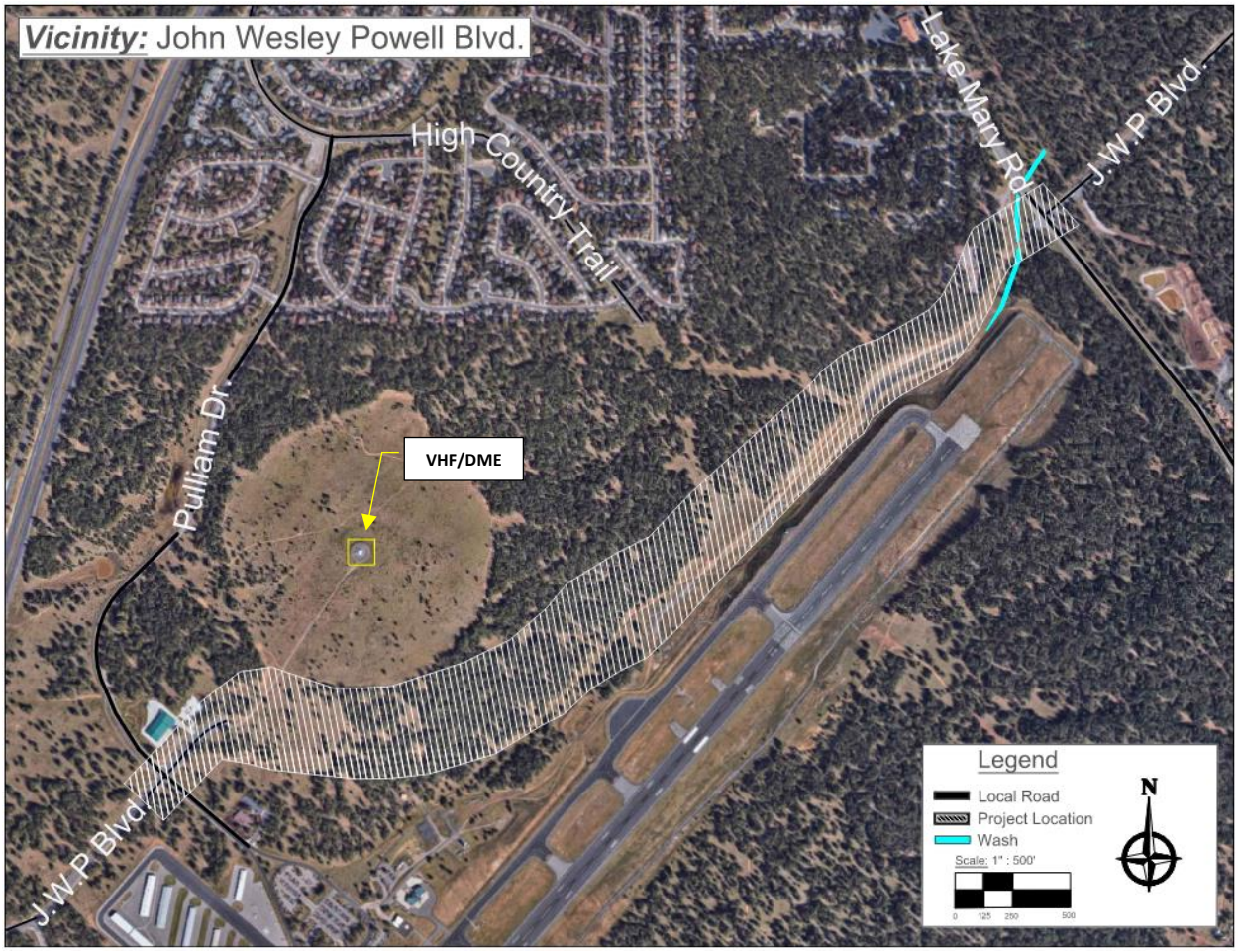


Figure 1-3: Project site

1.2.2 Existing Conditions

The existing conditions of the project area provides valuable insights into the challenges and opportunities that the project will seek to address. To assess the current state, we will refer to Figures 1-1, 1-2, and 1-3, where it offers a visual overview of the location.

Figure 1-3, the Vicinity Map of the Project Area, provides a detailed overview of the immediate surroundings; as it serves as a reference point for understanding the specific challenges imposed by the existing conditions.

Other factors that would need to be considered are: an ongoing housing development to the North, a significant wash located at the intersection of Lake Mary Rd. and JWP Blvd., an existing dirt road that traverses through forested areas, natural terrain, ridges, hills, and minor washes. Additionally, there is a permanent Very High-Frequency Omni-Directional Range (VHF Omnidirectional Range) with Distance Measuring Equipment (DME) situated in a cleared field nearby.

1.3 Technical Considerations

In preparation for the road extension design, this project will have to address technical considerations and emphasize environmental sustainability. The project will focus on enhancing intersections, prioritizing stormwater management, and traffic facilities. Extensive site survey data will be obtained through the City of Flagstaff to create a topographic map. Other inclusions will be offering safety and operational considerations when designing near an airport. Safety and clear zones will require avoiding structures and lighting elements that could interfere with aircraft navigation and safety.

Prior to any design consideration, a site investigation will be conducted to understand any existing conditions the project will encounter. This will ensure that additional parameters will be incorporated into the project; this includes existing topography, structures, soil properties, and channels. The geotechnical analysis portion of this project is as follows; soil property characterization, bearing capacity, and structural suitability are prioritized. FHWA provides a compendium of geotechnical manuals and guidelines, along with software tools to facilitate calculations for cut and fill reports, streamlining the design process.

A hydrological analysis will be conducted to examine the volume of stormwater runoff that must be managed at the project site. Such model will delineate the watershed, in which it estimates runoff within the project area using the Rational Method from ADOT's Hydrology Manual. Additionally, when such analysis is completed, a hydraulic analysis will be executed to determine the existing stormwater conveyances and its maximum capacity. Hydraulic modeling software, such as HEC-RAS, is employed to assess system performance under diverse conditions and ensure compliance with local regulations, particularly the City of Flagstaff Stormwater Management Design manual. These two analyses will form the basis of design improvements to relating stormwater structures.

And finally, roadway geometry and pavement design will be included into the project; based on these designs, determining traffic control devices, signage, and Level of Service assessments traffic analysis will require on-site data collection for traffic volume and conditions. This data informs an MUTCD intersection warrant analysis. In reference to City of Flagstaff and ADA requirements ensures road design compliance.

1.4 Potential Challenges

Challenges encompass factors beyond direct control that may impact a successful project completion, thus, makes it crucial to identify and plan for each challenge. Most challenges are related to budget constraints, limited land area, adverse weather conditions, site visits, environmental factors, and external circumstances. Budget constraints present a primary challenge, where it requires cost management and value engineering throughout the project's lifecycle to align with the client's maximum construction budget. While also considering working within confined land; this can tamper with innovative space utilization approaches.

Other challenges include when site visits cannot be conducted due to factors like inclement weather or client preferences, hindering on-site assessments and data collection essential for informed decision-making.

1.5 Stakeholders

The JWP West Road extension project involves a diverse array of stakeholders due to its substantial impact on the surrounding environment and communities, one being the nearby airport holds a critical stake in the project. Any alterations to the road system could potentially affect airport access and transportation for passengers, staff, and cargo. By ensuring smooth traffic flow and minimal disruption during construction, it will not disrupt the airport's operation.

In addition to the airport, users of the natural environment and forest trails surrounding the project area represent another group of stakeholders. This category encompasses various groups, including environmental organizations, hikers, and outdoor enthusiasts. The design of the road extension must prioritize the preservation of the local ecosystem and maintain access to the forest trails while minimizing environmental damage. Such an approach guarantees the continued enjoyment of nature while balancing the needs of the community.

Another stakeholder are the neighborhoods adjacent to the road extension project. Residents in these areas are directly impacted by changes in traffic patterns, noise levels, and property values. They hold an important interest in the project's outcome to ensure the maintenance or enhancement of their quality of life. Therefore, by addressing their concerns, in which that may be including traffic noise and other relevant factors, is essential for the successful implementation of the project.

Finally, the City of Flagstaff owners/maintainers and all of the City of Flagstaff's residents, whose taxes will fund the project, are crucial stakeholders. Their involvement and support play a pivotal role in the project's realization and its impact on the broader community.

2.0 Scope of Services

This section outlines the scope of work for the project. Each task addresses specific aspects of the project that will be performed to complete the project. Items that will not be performed are in the exclusions section.

2.1 Task 1: Research and Data Collection

This task involves research and data collection for an understanding of the existing conditions that the project site serves. It includes examination of local standards and regulations established by City of Flagstaff.

2.1.1 Task 1.1: Review Codes and Standards

Research local, state, and federal regulations that will guide the project. This involves a review of manuals and their standards that govern the specifications for the design process. These manuals and codes are sourced from the City of Flagstaff Website and higher-level governmental agencies such as Storm Water Management Design Manual (SWMDM), Manual on Uniform Traffic Control Devices (MUTCD), and Arizona Department of Transportation (ADOT).

2.1.2 Task 1.2: Identify Design Vehicle

Identify the types of vehicles that will utilize the proposed roadway. It involves assessing nearby infrastructure and analyzing the vehicles that currently use alternative routes.

2.1.3 Task 1.3: Collect Existing Geotechnical Data

Extract data from the USDA Web Soil Survey (WSS) to access soil information, maps, and reports specific to the project site within the city of Flagstaff.

2.2 Task 2: Site Investigation

This task involves an onsite investigation process to collect essential data for the project design.

2.2.1 Task 2.1: Site Visit Planning

Create a field safety checklist, outline activities to complete during the site visit, and identify equipment/tools to be used.

2.2.2 Task 2.2: Land Survey

Conduct a land survey to measure and document slopes and conditions of the project site.

2.2.3 Task 2.3: Traffic Counts

Collect raw data directly from the project site's intersections to assess the level of service. The traffic counts will be conducted with a JAMAR board and engineering-traffic software for data analysis.

2.2.4 Task 2.4: Photograph Site Features

Take photos of the existing intersections at each end of the corridor and along the proposed road alignment capturing unique features like wash crossings, rock outcroppings, and large trees.

2.2.5 Task 2.5: Collect Existing Hydraulic Structure Data

Obtain data of the dimensions, slopes, materials, and structural conditions of the current hydraulic structures in the project site. This data collection will be to analyze existing hydraulic infrastructure capacity.

2.2.6 Task 2.6: Geotech Analysis

Analyze the geotechnical information to assess the soil and subsurface conditions of the project site. Evaluate the collected information to understand soil properties, bearing capacity, and potential challenges to construction.

2.2.7 Task 2.7: Topographic Map

Process existing topographical data from the City of Flagstaff and results from the land survey to create a topographical map of the project site and the surrounding area with using engineering software.

2.3 Task 3: Hydrologic Analysis

Analyze hydrological conditions within the project site to establish rainfall, runoff, and drainage patterns. The analysis methodology is based on the Rational Method as the primary means of hydrologic analysis. It is important to note that during the design phase, the project remains flexible and open to adapting the methodology to comply with the City of Flagstaff guidelines. If site-specific conditions or regulatory requirements necessitate

an alternative method, the adjustments will be made to ensure alignment with the highest standards of practice.

2.3.1 Task 3.1: Watershed Delineation

Identify and map the boundaries of watersheds within the project site using topographic maps. It includes defining the contributing areas that feed into drainage systems for an understanding of stormwater flow patterns for effective management and analysis.

2.3.2 Task 3.2: Time of Concentration

Calculate the time of concentration for stormwater runoff within the project site (Equation 2-1). It determines the time it takes for precipitation to travel from the farthest point to the outlet point in the drainage system.

Equation 2-1: Time of concentration (sheet flow) [2]

$$T_t = [0.007(nL)^{0.8}/(2.0)^{0.5}S^{0.4}]$$

Where,
T_t: Sheet flow travel time (hr)
n: Mannings roughness coefficient
L: Flow length (ft)
S: Land slope (ft/ft)

2.3.3 Task 3.3: Storm Intensity

Determine the storm intensity, which refers to the rate at which precipitation falls during a storm event. The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 database will provide the precipitation frequency for return periods specified from SWMDM; the storm duration will equal the time of concentration to find the storm intensity.

2.3.4 Task 3.4: Calculate Peak Flow

Assess stormwater runoff using hydrological modeling software such as HEC-HMS. Considering watershed characteristics, land use, and rainfall data to estimate runoff. The results will guide the design of drainage control structures and stormwater management systems. For a quick estimation of the peak flow the Rational Method will still be used as shown in Equation 2-2.

Equation 2-2: Rational Method [2]

$$Q = C_f CIA$$

Where,
Q: Maximum rate of runoff (cfs)
C_f: Antecedent precipitation factor
C: Runoff coefficient
I: Rainfall intensity (in/hr)
A: Drainage area tributary to the design location (acres)

2.4 Task 4: Hydraulic Analysis

Analyze the hydraulic conditions for drainage and culvert systems through using the collected culvert/channel geometry. Hydraulic modeling tools, HEC-RAS, will provide

reports on existing culverts, channel geometry results, and compliance with regulatory requirements.

2.4.1 Task 4.1: Existing Culvert Analysis

Examine the current culvert systems within the project site through assessing the maximum capacity and velocities of the structures, as well as their condition and performance under various flow conditions.

2.4.2 Task 4.2: Existing Channel Analysis

Examine the current manmade channels within the project site through assessing the channel geometry, flow velocities, sediment transport, and the determination of max capacity and velocities.

2.4.3 Task 4.3: Post-Improvement Hydrologic Analysis

Determine the new peak flow, after the new road is built, that the hydraulic structures will need to carry.

2.4.4 Task 4.4: Proposed Culvert and Channel Design

Develop detailed designs for culverts and channels within the project site to ensure efficient water management, prevent flooding, and meet regulatory standards. This design phase optimizes the hydraulic efficiency, accommodates stormwater runoff, and minimizes erosion risk for the functionality and sustainability of the project.

2.4.4.1 Task 4.4.1: Determine Criteria

Establish requirements that proposed culvert and channel designs must meet to ensure effective stormwater management, flood control, and criteria for evaluating alternatives.

2.4.4.2 Task 4.4.2: Develop Alternatives

Develop various design alternatives for the culvert and channel improvements, considering factors such as size, shape, and materials.

2.4.4.3 Task 2.4.3: Analyze Alternatives and Select Best

Analyze design alternatives and use a decision matrix to determine the best alternative.

2.5 Task 5: Roadway Design

Design the roadway with all its physical aspects through considering projected traffic volumes and defined parameters.

2.5.1 Task 5.1: Roadway Geometry

Establish the geometry for the proposed roadway. The geometry design elements include lane widths, shoulder widths, bike lanes, and clear zones.

2.5.2 Task 5.2: Intersection Design

Select the appropriate intersection type for the proposed road, with consideration of key factors. These factors include traffic volume, the deployment of traffic control devices, the facilitation of turning movements, accommodation for bicycles and

pedestrians, and overall safety considerations. The objective is to design an intersection that prioritizes safety and efficiency for all categories of users.

2.5.2.1 Task 5.2.1: Determine Criteria

Establish requirements that the intersection design must meet to ensure effective traffic control.

2.5.2.2 Task 5.2.2: Develop Alternatives

Various design alternatives that will ensure various aspects to be addressed to meet the established criteria.

2.5.2.3 Task 5.2.3: Analyze Alternatives and Select Best

Analyze and compare the developed alternatives, taking into account performance, cost, and user impact to determine the most appropriate intersection design. The final choice will prioritize safety, traffic efficiency, and user experience.

2.5.3 Task 5.3: Pavement Design

Determine a pavement design for the proposed roadway, with consideration of external factors. These factors include type of design vehicle, material selection, and pavement geometry. The objective is to create a pavement design that can structurally withstand the anticipated load and usage while also optimizing cost-effectiveness.

2.5.3.1 Task 5.3.1: Determine Criteria

Establish requirements that the pavement design must meet to ensure state regulations.

2.5.3.2 Task 5.3.2: Develop Alternatives

Various pavement design alternatives, taking into account the identified criteria. These alternatives will explore multiple combinations of materials, thicknesses, and designs.

2.5.3.3 Task 5.3.3: Analyze Alternatives and Select Best

Analyze and evaluate the developed design alternatives, through assessing their structural integrity, cost-effectiveness, and overall suitability. The final selection will balance structural performance and cost-efficiency while adhering to established criteria and standards.

2.5.4 Task 5.4: Sidewalk Design

Design a safe and efficient sidewalk for pedestrians using the proposed road as their mode of travel by foot. It adheres to established standards, including compliance with ADA regulations, with a primary focus on ensuring the safety and comfort of sidewalk users.

2.5.5 Task 5.5: Signage and Striping

Identify appropriate signage and striping in accordance with established standards. The signage and striping plan will be designed with simplicity to ensure universal understanding by all users.

2.6 Task 6: Construction Plans

Create construction drawing plan set.

2.6.1 Task 6.1: Cover Sheet

Provides an overview of the entire set of construction plans, including project title, location, key contacts, and general project description.

2.6.2 Task 6.2: Existing Site Plan

Presents the current conditions of the project site, including topography, vegetation, and surrounding infrastructure.

2.6.3 Task 6.3: Plans and Profiles

Develop detailed drawings of the roadway, including alignments, cross sections, and profiles, for construction guidance and earthwork calculations.

2.6.4 Task 6.4: Details Sheets

Create design details for roadway elements, such as pavements, drainage systems, signage, and traffic control devices.

2.7 Task 7: Economic Analysis

Determine the total cost of the project and the cost to maintain its quality. Material, excavation, and maintenance costs will be determined using construction cost estimating software, RSMeans.

2.7.1 Task 7.1: Construction Cost

Construction cost will be calculated to include excavation, additional materials (subbase, subgrade, etc.), labor, equipment, and other project-specific expenses.

2.7.2 Task 7.2: Operation and Maintenance Cost

Operation and maintenance costs will be calculated for the expected lifespan of the roadway Possible expenses include improper visibility, pavement damages, etc.

2.8 Task 8: Impact Analysis

Potential societal, environmental, and economic impacts associated with the proposed road construction project will be analyzed. It aims to identify both positive and negative consequences to ensure alignment with sustainability goals, regulatory requirements, and community well-being. The analysis includes an examination of travel-related changes, economic effects, and environmental implications to provide a comprehensive impact assessment.

2.9 Task 9: Deliverables

Several deliverables will be required throughout the project. Each deliverable will include a distinct milestone, enhancing communication among team members and stakeholders. These deliverables will be used for quality control and increasing the project's chances of meeting its objectives on time and staying within budget.

2.9.1 Task 9.1: 30% Submittal

The submission for this milestone will include the Design Report, Presentation, and Construction Drawings (cover sheet and site plan). It will encompass completed

tasks related to research and data collection, site investigation, and hydrologic analysis.

2.9.2 Task 9.2: 60% Submittal

This milestone's submission will consist of the Design Report, Presentation, and Construction Drawings (plans and profiles). It will encompass completed tasks related to hydraulic analysis and roadway design.

2.9.3 Task 9.3: 90% Submittal

The submission for this milestone will include the Design Report, Draft Presentation, Draft Website, and Construction Drawings (details sheet). It will encompass completed tasks related to construction plans, economic analysis, and impacts analysis.

2.9.4 Task 9.4: Final Submittal

Submission will include the complete Design Report, Presentation, Website and Construction Drawings.

2.10 Task 10: Project Management

This task focuses on ensuring that tasks are well coordinated, risks are managed, and stakeholders are engaged. This will ensure a successful project within the scope.

2.10.1 Task 10.1: Meetings

Team meetings will be conducted on a weekly basis to discuss current project progress and to deliberate on project tasks that require attention. A total of 16 meetings with the technical advisors will be conducted over the course of the semester to obtain guidance and insights pertaining to the project's technical aspects. Meetings with the grading instructor will also be conducted to ensure project alignment, facilitate document submissions, and provide overall comprehensive project feedback.

2.10.2 Task 10.2: Schedule Management

The schedule will be maintained and updated to ensure project is completed on time.

2.10.3 Task 10.3: Resource Management

Staff and resources will be managed to ensure project is completed on budget.

2.11 Exclusions

The following items will not be included nor collected for the project, due to the amount of time allotted for this project; considerations such as geotechnical lab sampling/testing and utilities (sanitary sewer, water, storm, gas, electrical, etc.) will not be included in the final design. While the Flagstaff Urban Trail System (FUTS) will also not be included into the design process, it will be considered for further later development.

3.0 Schedule

This section outlines the project’s schedule and scope that will be followed next semester.

3.1 Summary of Schedule

The project is scheduled to commence on January 16, 2024 with a total task duration of 73 days, excluding weekends. Task 1: Research and Data Collection, Task 2: Site Investigation, and Task 3: Hydrologic Analysis, are planned for completion by February 16, 2024, reaching the 30% submittal milestone. Task 4: Hydraulic Analysis and Task 5: Roadway Design are targeted for completion by March 15, 2024, marking the 60% submittal milestone. Task 6: Construction Plans, Task 7: Economic Analysis, and Task 8: Impact Analysis are expected to be finished by April 19, 2024, reaching the 90% submittal milestone. The final presentation will need to be prepared by April 26, 2024, and will encompass the entirety of the project. The final submittal is slated for May 2, 2024, containing a fully detailed report. The Gantt Chart detailing this schedule can be found in Appendix A.

3.2 Critical Path

The tasks outlined in red on the Gantt chart delineate the project's critical path; the critical path represents the minimum length to complete the project. If necessary, additional work may be completed during the weekends and spring break to ensure all tasks are completed on time. Key critical tasks that must be completed on time include the following: 30% Submittal (Tasks 1-3), 60% Submittal (Tasks 1-5), 90% Submittal (Tasks 1-8), and the Final Submittal (Tasks 1-10).

4.0 Staffing Plan

The staffing plan provides an overview of the required personnel for the execution of engineering services. All staffing requirements and time allocations are calculated and assigned according to each staff member's respective qualifications and overall contribution to the project’s completion.

4.1 Positions

The project staff will consist of a Senior Engineer (SENG), Engineer (ENG), Engineer Technician (TECH), and an Engineering Intern (INT). Refer to table 4-1 for an overview of required staffing positions for the completion of the project.

Table 4-1: Staff Positions

Classification	Code
Senior Engineer	SENG
Engineer	ENG
Engineer Technician	TECH
Engineering Intern	INT

The Senior Engineer is responsible for the final review and approval of all documents and submittals. They must be an active licensed practicing engineer (PE) with 10+ years of successful project experience, and they must have attained a bachelor’s degree in Civil Engineering from an ABET accredited university. This individual is also responsible for overseeing the project and interacting with the client.

The Engineer is largely responsible for the planning and design aspects of the project, as well as handling all submittal revisions. They must have their Engineering - In - Training Certification (EIT) with 3+ years of practical experience under a licensed PE, and they must have attained a bachelor's degree in civil engineering from an ABET accredited university.

The Engineer Technician will primarily focus on conducting tests, analyzing data, and assisting in research related to traffic flow and pavement design. The lab technician must have 2+ years of prior field and data experience in transportation, geotechnical, and water resource engineering. This individual must be well qualified and have experience in surveying. Additionally, they must have attained an associate degree in civil engineering or environmental engineering from an accredited university.

The Engineering Intern will be responsible for a majority of the physical field surveying and soil sampling, uploading valuable data, and handling general note taking and document organization. The intern will professionally shadow the project's SENG, ENG, and Tech acquiring valuable insights and practical work experience. They must be a current senior studying civil or environmental engineering, have above a 3.0 GPA, and they must have completed relative coursework related to transportation, geotechnical, and water resource engineering.

4.2 Staffing Plan

Table 4-2 below provides a detailed breakdown of the amount of time that staff members will dedicate to each individual project task. A total of 736 hours is estimated to complete this project, with the SENG working 129 hours, the ENG working 346 hours, the TECH working 120 hours, and the INT working 141 hours. These hours are distributed over the entirety of the project duration of 77 days, excluding weekends.

Table 4-2: Staffing Plan

Task	SENG	ENG	TECH	INT	Total Hours
1.0 Research and Data Collection	0	4	3	2	9
2.0 Site Investigation	1	13	30	24	68
3.0 Hydrologic Analysis	0	12	3	3	18
4.0 Hydraulic Analysis	15	34	32	10	91
5.0 Roadway Design	30	124	26	31	211
6.0 Construction Plans	8	23	0	18	49
7.0 Economic Analysis	6	18	0	7	31
8.0 Impact Analysis	1	6	0	5	12
9.0 Deliverables	8	65	14	24	111
10.0 Project Management	60	47	12	17	136
Total	129	346	120	141	736

5.0 Cost of Engineering Services

The cost of engineering services is the management of project cost, involving estimating, cost control, cost forecasting, investment, and risk analysis.

5.1 Cost of Services

The total project cost is broken down into personnel, travel, and supplies. The personnel cost covers the billing rate for the SENG, ENG, TECH and INT, totaling $79,845. The travel cost covers the gas and vehicle maintenance required for 5 one day trips to and from the JWP site for field evaluations, sampling, and surveying, totaling $14. The supplies cost covers the surveying, traffic count, and computer lab equipment, totaling $2,000. Overall, the total cost of the engineering services is estimated to be about $82,409 A comprehensive breakdown of the total cost is shown in Table 5-1 below.

Table 5-1: Indirect Costs

Cost of Engineering Services				
1.0 Personnel	**Classification**	**Hours**	**Rate, $/hour**	**Cost**
	SENG	129	$ 200	$ 25,800
	ENG	346	$ 120	$ 41,520
	LAB	120	$ 75	$ 9,000
	INT	141	$ 25	$ 3,525
	Total	736		$ 79,845
2.0 Travel	**Classification**	**Miles/Trip**	**Rate, $/Mile**	**Cost**
	5 1-Day Trips	7	$ 0.40	$ 14
3.0 Supplies	**Classification**	**Days**	**Rate, $/Day**	**Cost**
	Surveying	3	$ 100	$ 300
	JAMAR Board	2	$ 75	$ 150
	Camera	2	$ 50	$ 100
	Computer Lab	20	$ 100	$ 2,000
Total				$ 82,409

6.0 References

[1] B. Jones, "Arizona US State PowerPoint Map," Maps for Design, 1 January 2023. [Online]. Available: https://www.mapsfordesign.com/product/arizona-us-state-powerpoint-map-highways-waterways-capital-and-major-cities/. [Accessed 26 September 2023].

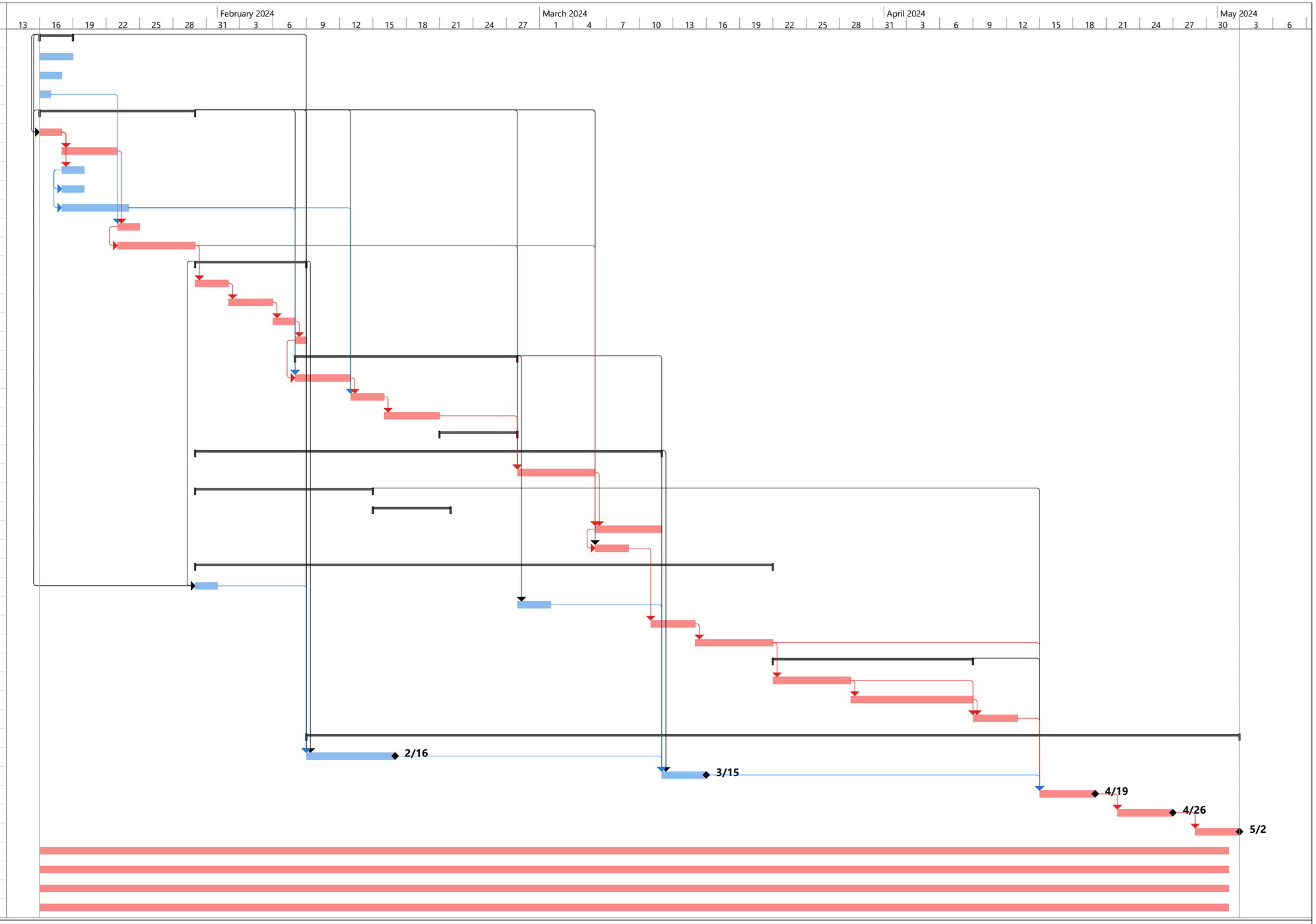
[2] City of Flagstaff Utilities Division, "City of Flagstaff Stormwater Management Design Manual," Stormwater Management Section, 1 March 2009. [Online]. Available: https://flagstaff.az.gov/DocumentCenter/View/58133/SWMgmtDesignManual-3-09?bidId=. [Accessed 20 October 2023].

7.0 Appendix

Appendix A: Gantt Chart

See Gantt Chart on the following page.

ID	Task Name
1	**TASK 1: Research and Data Collection**
2	1.1 Review Codes and Standards
3	1.2 Identify Design Vehicle
4	1.3 Collect Existing Geotechnical Data
5	**TASK 2: Site Investigation**
6	2.1 Site Visit Planning
7	2.2 Land Surveying
8	2.3 Traffic Counts
9	2.4 Photograph Site Features
10	2.5 Collect Existing Hydraulic Structure Data
11	2.6 Geotech Analysis
12	2.7 Topographic Map
13	**TASK 3: Hydrologic Analysis**
14	3.1 Watershed Delineation
15	3.2 Time of Concentration
16	3.3 Storm Intensity
17	3.4 Calculate Peak Flow
18	**TASK 4: Hydraulic Analysis**
19	4.1 Existing Culvert Analysis
20	4.2 Existing Channel Analysis
21	4.3 Post Improvement Hydrologic Analysis
22	**4.4 Proposed Culvert and Channel Design**
26	**TASK 5: Roadway Design**
27	5.1 Roadway Geometry
28	**5.2 Intersection Design**
32	**5.3 Pavement Design**
36	5.4 Sidewalk Design
37	5.5 Sinage and Striping
38	**TASK 6: Construction Plans**
39	6.1 Cover Sheet
40	6.2 Existing Site Plan
41	6.3 Plans and Profiles
42	6.4 Details Sheet
43	**TASK 7: Economic Analysis**
44	7.1 Construction Cost
45	7.2 Operation and Maintenance Cost
46	TASK 8: Impact Analysis
47	**TASK 9: Deliverables**
48	9.1 30% Submittal
49	9.2 60% Submittal
50	9.3 90% Submittal
51	9.4 Final Presentation
52	9.5 Final Submittal
53	**TASK 10: Project Management**
54	10.1 Meetings
55	10.2 Schedule Management
56	10.3 Resource Management



Project: Project Gantt 11-28
Date: Mon 12/11/23

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

Appendix B: Staffing plan

See Staffing Plan on the following page.

Task	SENG	ENG	TECH	INT	Total Hours
1.0 Research and Data Collection					**9**
1.1 Review Codes and Standards	0	3	0	1	4
1.2 Identify Design Vehicle	0	1	0	1	2
1.3 Collect Existing Geotechnical Data	0	0	3	0	3
2.0 Site Investigation					68
2.1 Site Visit Planning	1	2	1	0	4
2.2 Land Survey	0	2	6	6	14
2.3 Traffic Counts	0	2	6	6	14
2.4 Photographs of Site Features	0	0	0	3	3
2.5 Collect Existing Hydraulic Structure Data	0	3	5	6	14
2.6 Geotech Analysis	0	2	2	0	4
2.7 Topographic Map	0	2	10	3	15
3.0 Hydrologic Analysis					**18**
3.1 Watershed Delineation	0	3	2	1	6
3.2 Time of Concentration	0	4	0	1	5
3.3 Storm Intensity	0	2	1	1	4
3.4 Calculate Peak Flow	0	3	0	0	3
4.0 Hydraulic Analysis					**91**
4.1 Existing Culvert Analysis	1	5	12	2	20
4.2 Existing Channel Analysis	1	5	10	1	17
4.3 Post-Improvement Hydrologic Analysis	1	3	6	1	11
4.4 Proposed Culvert and Channel Design	6	10	2	3	21
4.4.1 Determine Criteria	1	4	0	1	6
4.4.2 Develop Alternatives	2	3	2	1	8
4.4.3 Analyze Alternatives and Select Best	3	4	0	1	8
5.0 Roadway Design					**211**
5.1 Roadway Geometry	4	15	2	8	29
5.2 Intersection Design	6	25	3	5	39
5.2.1 Determine Criteria	1	4	0	1	6
5.2.2 Develop Alternatives	2	15	2	3	22
5.2.3 Analyze Alternatives and Select Best	3	10	0	1	14
5.3 Pavement Design	5	20	2	5	32
5.3.1 Determine Criteria	1	2	0	1	4
5.3.2 Develop Alternatives	2	8	2	3	15
5.3.3 Analyze Alternatives and Select Best	2	10	0	1	13
5.4 Sidewalk Design	1	5	3	1	10
5.5 Signage and Striping	3	10	12	2	27
6.0 Construction Plans					**49**
6.1 Cover Sheet	2	3	0	3	8
6.2 Existing Site Plan	2	5	0	5	12
6.3 Plans and Profiles	2	10	0	7	19
6.4 Details Sheets	2	5	0	3	10
7.0 Economic Analysis					**31**
7.1 Construcion Cost	4	8	0	5	17
7.2 Operation and Maintenance Cost	2	10	0	2	14
8.0 Impact Analysis	1	6	0	5	**12**
9.0 Deliverables					**111**
9.1 30% Submittal	2	18	4	6	30
9.2 60% Submittal	2	20	5	6	33
9.3 90% Submittal	2	15	3	6	26
9.4 Final Submittal	2	12	2	6	22
10.0 Project Management					**136**
10.1 Meetings	30	40	10	10	90
10.2 Schedule Management	15	4	1	4	24
10.3 Resource Management	15	3	1	3	22
Summary					
Total Hours	129	346	120	141	**736**