Coconino County Roadway Alignment Proposal

CENE 476 Engineering Design: Capstone Preparation

Prepared For

Nate Reisner, PE, PTOE

Coconino County Public Works County Engineer

Prepared By

ViaNova Engineering Team:

Spencer Huttenmeyer, Janelle Sanchez, Orlando Santoyo, Lauren Towner

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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AADT	Annual Average Daily Traffic
CCPW	Coconino County Public Works
FEMA	Federal Emergency Management Agency
IDF	Intensity Duration Frequency
NOAA	National Oceanic and Atmospheric Administration
USFS	United States Forest Service
USGS	United States Geological Survey
SENG	Senior Engineer
ENG	Project Engineer
TECH	Engineering Technician
INT	Engineering Intern

Appendices

1.0 Project Understanding

1.1 Project Purpose

Coconino County has identified a need to provide alternative access from Bellemont to prioritize resident safety, travel efficiency, and future development. In response, Coconino County has proposed an alternative access route through the Coconino National Forest with a 1.5-mile two-lane roadway from Shadow Mountain Dr to Forest Service Rd 171. The existing roadway alignment poses challenges during emergency situations as congestion and one-way access delay response times. Overall, the project will support improved ingress and egress for daily and emergency use, while opening access to land for residential development. By addressing geometric roadway deficiencies that account for proper drainage and soil parameters, the project will provide a design solution that is compliant with Coconino County standards and will support long-term planning and funding.

1.2 Project Background

The site, north of the I-40, is located in Bellemont, Arizona—approximately 15 miles to the west of Flagstaff. The site for the proposed alignment is currently undeveloped land. This land is generally cleared, flat grasslands with patches of tall trees. Part of the land is property of the Forest Service, and part of it is for sale by the Forest Service.

A location map of the site can be found below, in Figure 1, showing the project's location in reference to Flagstaff and I-40.

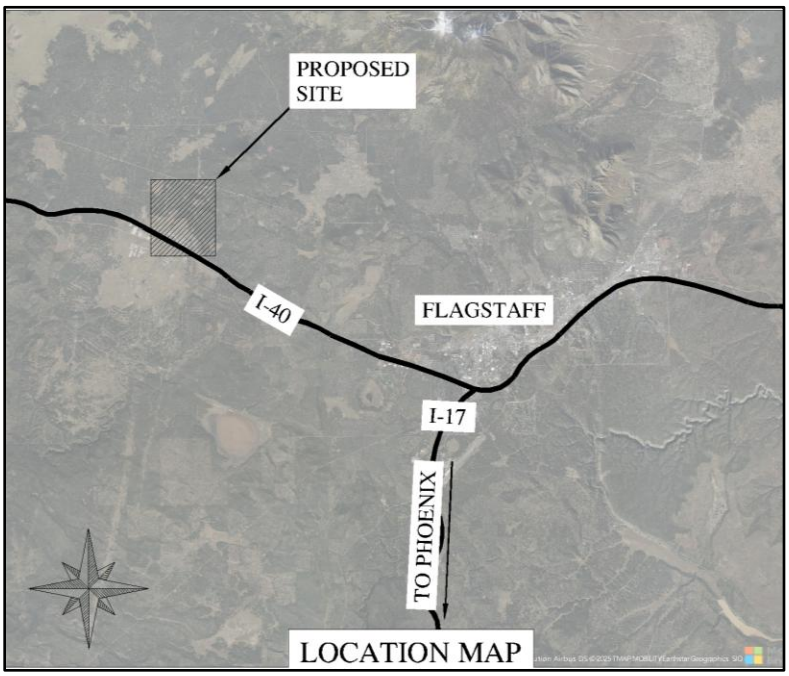

Figure 1: Location Map

The vicinity map, Figure 2, illustrates the project site's perimeter in closer proximity.

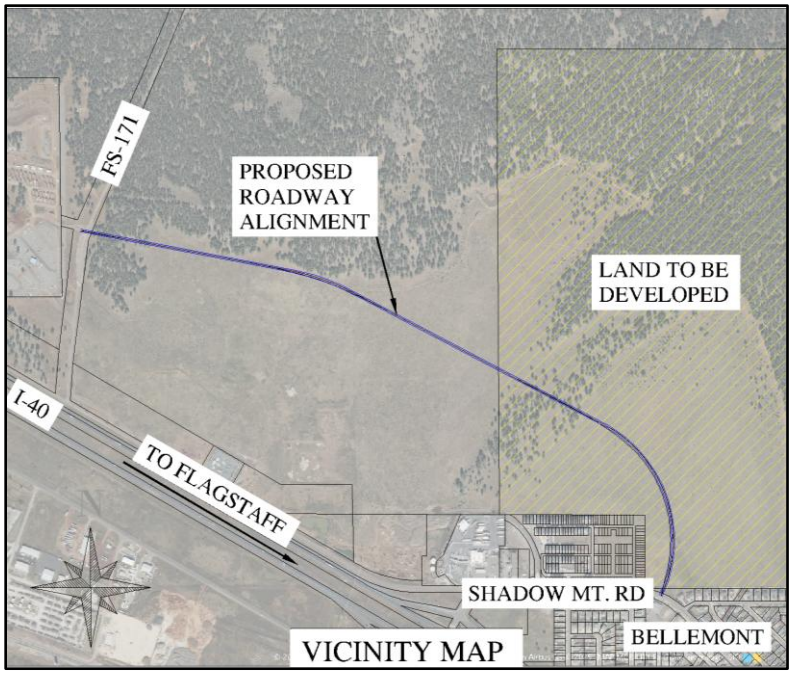

Figure 2: Vicinity Map

1.3 Technical Considerations

The roadway alignment requires several technical considerations. The roadway itself must meet the standards within the Coconino County Design and Construction Manual [1]. This includes considerations for geometric design such as the horizontal and vertical alignment, lane widths, and sight distances. The manual also contains minimum structural sections for new roads, which along with a native soil assessment, will be used to determine a structural section that will meet client needs. Along with roadway design, drainage must also be designed due to the alteration of existing stormwater drainage patterns. Hydrologic and hydraulic calculations will be used to properly size culverts and safely convey stormwater while mitigating flooding and erosion. This will be completed in accordance with the Coconino County Drainage Design Criteria Manual [2]. An additional technical element is traffic analysis. Traffic analysis is necessary to maintain safe and efficient movement of vehicles and pedestrians throughout the proposed and existing alignment's lifetime. Overall, geometric design, drainage, and traffic analysis will be the main technical considerations for this alignment project.

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1.4 Potential Challenges

Site Soil Conditions. There is limited information regarding soil conditions in the project location. Current web soil surveys do not provide sufficient data, and conducting soil borings along the alignment is not within the scope of this project. To address this issue, soil reports from recently completed projects in Bellemont will be used to estimate site soil conditions.

FEMA Flood Zone A: The proposed alignment crosses through a FEMA flood zone. This specific flood zone is identified as Zone A, meaning no formal FEMA study has established a flood elevation for this zone. The team will have to research flood insurance studies to determine a floodplain elevation.

Weather: Weather in Bellemont will make it difficult for the team to conduct a site investigation once snowfall begins. To avoid adverse conditions, the team will conduct the site investigation in mid-October.

1.5 Stakeholders

The primary stakeholder for this project is the residential community of Bellemont. This community currently have only one road for access to the interstate and their homes. Should anything inhibit the traffic on Shadow Mountain Drive, their access in and out of the neighborhood will be compromised. The project will provide an alternative access route for the community. It will also provide the opportunity for development along the proposed alignment, increasing the residential and commercial capacity for Bellemont. Other stakeholders include Coconino County Public Works, Federal Emergency Management Agency, United States Forest Service, Ponderosa Fire District, and Village Camp.

Coconino County Public Works (CCPW) will act as the client for this project, the Federal Emergency Management Agency (FEMA) has a floodplain within the alignment, and the United States Forest Service (USFS) owns and is selling land within the alignment. Ponderosa Fire District provides fire response for this community and will have stakes in the roadway design, ensuring that their engines can respond appropriately throughout the new alignment. Village Camp is a large RV park that can be accessed by the new alignment and will have stakes in ensuring that their customers can properly access their facility.

2.0 Scope of Services

This section outlines the project's scope of work. The tasks below outline varying elements needed to complete the project. Tasks 1.0 through 9.0 outline technical work required by the team, tasks 10.0 and 11.0 outline non-technical work that the team will complete. Additionally, section 2.12 summarizes the project's exclusions.

2.1 Task 1: Acquire Existing Site Information

This task includes gathering and researching information on the site's existing conditions. The objective is for the team to gain an understanding of the topography, flow, soil conditions, and traffic data in the area. It needs to be completed to have a general idea of the site before beginning other technical work.

2.1.1 Task 1.1: Lidar Data

Access Coconino County public data, download Bellemont 2' contours, and interface with Civil3D to create a surface. This is necessary to provide existing elevation data to begin analysis on.

2.1.2 Task 1.2: FEMA Flood Zone

Use aerial photos from FEMA resources and integrate FEMA flood zone limits into Civil3D. This will allow the design team to have clear and specific points of reference. FEMA needs to be considered as it impacts decisions regarding water flow.

2.1.3 Task 1.3: Geotechnical Reports of Similar/Relevant Projects

Request geotechnical reports from Coconino County Public Works for projects in the project area and compile them for analysis. This will allow the design team to have a general understanding of the soil conditions in the project area. This needs to be completed since there will be no geotechnical testing completed for the site.

2.1.4 Task 1.4: Geotechnical Analysis

Review geotechnical reports from past Coconino County project to assess soil characteristics. Data will be compiled into a digestible Excel spreadsheet for review and analysis. This will be applicable in later structural section design tasks.

2.1.5 Task 1.5: TCDS data

Access ADOT data online on surrounding highways and roads and compile for analysis. General traffic data, such as average daily traffic, will be compiled in an Excel spreadsheet. This data will be used for analysis in later traffic analysis tasks.

2.2 Task 2: Site Investigation

This task includes visiting Bellemont to gather information on the proposed location of the alignment and the tie-in areas. This is necessary for the team to get a feel for the project and to identify areas of concern and characteristics that may not be visible in available ariel imagery.

2.2.1 Task 2.1: Site Investigation Planning

Conduct team meetings to decide the site investigation objectives and tasks. Refer to the Field Safety Checklist Form and fill it out prior to the site investigation. This task will allow the project team to have a greater understanding of site conditions.

2.2.2 Task 2.2: Conduct Site Investigation

Travel to the project area, perform a site walk, take site photos, and return to NAU. A photo log will be assembled with figure numbers and descriptions to document the site investigation. It will be a valuable resource for the team to reference through the design process.

2.3 Task 3: Hydrologic Analysis

This task requires analysis of the surrounding areas that affect the proposed roadway and determining the effects the water flow may have. HEC-HMS will be used to model storm events, which will determine roadway elevations. This is to be completed so flooding is prevented.

2.3.1 Task 3.1: Delineate Watershed

Determine the contributing areas that affect the proposed project using USGS Streamstats. Interface this data with GoogleMaps to create a reference map. This area will be used to calculate the flow of runoff water in the project area.

2.3.2 Task 3.2: Determine Rainfall Intensity

Using data from the NOAA, analyze IDF curves to determine the rainfall intensity during a storm event. This data will be used with the watershed area to determine the flow of runoff water in the project area.

2.3.3 Task 3.3: Determine Peak Flow

Calculate the peak flow in the watershed area during multiple storm events using the calculated watershed area and rainfall intensity. This flow value will allow the project team to design proper conveyance infrastructure.

2.3.4 Task 3.4: Model Within HEC-HMS

Collect watershed area, rainfall intensity, time of concentration, and peak flow. Input all the data into HEC-HMS to create a model to determine how much water will affect the proposed roadway.

2.4 Task 4: Hydraulic Analysis

This task includes analysis of the flood zone conflicting with the proposed roadway and creating a solution to convey storm events underneath the roadway. Hydraulic structures will be in accordance with the Coconino County Drainage Design Manual [2]. The final design will be modeled in HEC-RAS and CulvertMaster to ensure requirements are met.

2.4.1 Task 4.1: Determine Floodplain Elevation

Access FEMA Floodplain Insurance Studies in the project area. Work with Professional Engineer(s) to determine floodplain elevation with data from FEMA FIS. This floodplain elevation will impact the drainage infrastructure on the project to ensure that existing floodplains are not negatively impacting the new roadway or surrounding areas.

2.4.2 Task 4.2: Analyze Potential Hydraulic Structures

Use floodplain elevation to determine where drainage infrastructure is necessary. Use the Coconino County Drainage Design Manual to determine the design of the proposed infrastructure [2]. This drainage design will ensure that the flood waters will not negatively impact the new roadway or surrounding areas.

2.4.3 Task 4.3: Model Hydraulic Structure

Use HEC-RAS and CulvertMaster software to model drainage design and ensure Coconino County standards are met. These hydraulic models will be integrated into the overall design to ensure that this project maintains proper drainage along the alignment.

2.5 Task 5: Traffic Analysis

The team will analyze present and future traffic patterns to determine traffic demand for the proposed roadway. Using the data collected in prior tasks, this task will ensure that the project meets the client's and stakeholder needs.

2.5.1 Task 5.1: Determine Future Traffic

Forecast 20-year AADT and peak flows using growth, land-use buildout, and trip assignment. Select functional classification and facility type (e.g., arterial/collector, divided/two-lane) based on context and demand. This is needed to determine the capacity and roadway characteristics that the alignment should be designed for.

2.5.2 Task 5.2: Determine Connections into Existing Roadway

Define tie-in locations and transitions where the project interfaces with existing streets and access points. Select the type of traffic control at roadway connections according to the MUTCD manual [3]. This will ensure that the new roadway does not negatively impact existing infrastructure.

2.5.3 Task 5.3: Determine Need for Turn Lanes

Check warrants and operations to size left/right turn lanes at intersections. This will provide insight into the possible changes to the roadway and ensure that all future development has proper access.

2.5.4 *Task 5.4: Determine Signage on Roadway*

Develop regulatory, warning, and guide sign plans per MUTCD for clarity and compliance [3]. Additionally, establish a statutory or study-based speed consistent with design speed, context, and safety.

2.6 Task 6: Roadway Design

The team will produce a roadway design from the geotechnical, hydrological, hydraulic, and traffic analysis completed. Referring to previous work is important to ensure the roadway design meets the Coconino County requirements.

2.6.1 *Task 6.1: Determine Design Vehicle and Design Speed*

Analyze the current and future traffic to determine the most common vehicle and design speed. This will be used to determine the loadings the roadway needs to handle. This will also ensure that the roadway meets all stakeholder needs.

2.6.2 *Task 6.2: Determine Horizontal Alignment*

Create a horizontal alignment that creates safe turns for drivers at the posted speed limit. This task will be completed with guidance from the AASHTO Green Book and Coconino County to ensure the roadway meets specifications [4, 1].

2.6.3 *Task 6.3: Determine Vertical Alignment*

Ensure there is proper visibility in any vertical alignment and create smooth transitions from grade changes. This task will be completed with guidance from the AASHTO Green Book and Coconino County to ensure the roadway meets specifications [4, 1].

2.6.4 *Task 6.4: Structural Section*

Research proper subgrade and base course for the proposed alignment and make sure it meets Coconino County design standards [1]. Determine the thickness of the aggregate base course, asphaltic concrete, and the thickness of each pavement lift. This will ensure that the roadway can operate for the design life span while serving all users.

2.6.5 *Task 6.5: Typical Cross Section*

Ensure the subgrade, base course, and pavement have sufficient strength to convey traffic for twenty years. This determination will be done in accordance with previous research. This cross section development is important so that the new roadway meets all the clients and stakeholders' needs.

2.6.6 *Task 6.6: Determine Roadway Drainage*

Ensure the roadway does not flood during storm events and drains water efficiently. With the results of prior hydraulic and hydrologic tasks, the roadway drainage will be designed to ensure that the new roadway meets all required Coconino County specifications [2].

2.6.7 *Task 6.7: Pavement Markings/Striping Layout*

Create a safe striping layout that allows cars to turn, stop, and flow safely and efficiently. Coconino County standards will be referenced to create this layout [1]. This will ensure that the new roadway does not impact existing infrastructure and serves all users equitably.

2.6.8 *Task 6.8: Select Horizontal and Vertical Alignment*

Establish multiple alternative horizontal and vertical alignments. Consider earthwork volumes, cost, and drainage infrastructure to create the best design. A weighted decision matrix will be created to analyze and choose the best option with input from the client. All alternatives will meet the criteria in the Coconino County Engineering Design Manual *[1]*.

2.7 Task 7: Site Design

This task involves calculating the cut and fill volumes for minimization, creating slopes, and incorporating utilities for the proposed roadway. This work will be done in Civil3D. This is important in estimating costs and making sure design is plausible in reference to the site and earthwork.

2.7.1 *Task 7.1: Determine Cut/Fill*

Analyze the existing terrain of the proposed alignment and determine how much soil needs to be excavated or filled. This will be designed with results from the prior vertical and horizontal alignment tasks to ensure that the client's needs are met and that the design is optimized.

2.7.2 *Task 7.2: Determine Site Grading*

Create proposed roadway elevations that allow for proper drainage. Design slopes next to the roadway that minimizes danger if drivers drive off the roadway. This prioritizes user safety for the lifetime of the roadway.

2.7.3 *Task 7.3: Utility Design*

The proposed roadway design will include a standard utility corridor. This will allow future development to have access to necessary utilities.

2.8 Task 8: Create a Plan Set

This task includes creating a construction/design plan set that establishes the new roadway alignment in correspondence to the existing conditions of the site. It will outline the team's design that considers Coconino standards for construction and drainage. This plan set is to be made in reference to the construction and improvement plan requirements of Coconino County's CADD Manual [5].

2.8.1 *Task 8.1: Plan Set Border/Template*

A template will be created for the team to use by making a .dwt file and a block with attributes. This is important to do so that there is consistency in submittals and page layouts can be set up quickly.

2.8.2 *Task 8.2: Cover Page*

The cover page will include the project name, coordinates, vicinity map, key design data, index of sheets, and a legend. This is the first page of the plan set and needs to be set up with the prior information so that the project is easily identifiable.

2.8.3 *Task 8.3: Estimated Quantities/EOPC*

Estimated quantities will be derived in AutoCAD through layer usage, hatching, and measuring. Major items with units will be determined by the team, and prices will be based on past County projects. This needs to be incorporated so that the client can plan for future budgets.

2.8.4 *Task 8.4: Note Sheet*

The general notes sheet will have the latest applicable County notes for the improvements proposed, including pavement and utility notes. This needs to be provided to establish compliance with codes, provide supplemental data, and clarify designs.

2.8.5 *Task 8.5: Proposed Cross-Section/Typical Cross-Section*

A cross-section sheet will be made outlining the roadway's characteristics, such as widths and horizontal slopes. This will establish a clear view of the roadway and its typical features.

2.8.6 *Task 8.6: Existing Site Conditions and Removals*

These sheets will lay out the existing topography and will call out removals that are needed on the site in plan view. This needs to be incorporated to show how the site is going to be altered.

2.8.6.1 *Task 8.6.1: Topographic Data*

Public data will be acquired from Coconino County for 2' contours. This will be brought into CAD to create a topographic map. Its important to have contours to have a clear idea on the topography of the existing landscape.

2.8.6.2 *Task 8.6.2: Existing Landmarks from Aerial Imagery*

An aerial will have to be used to roughly outline the location of important landmarks such as existing striping, signage, and infrastructure. Since surveying will not be done, the aerial imagery is important to design in accordance with existing infrastructure.

2.8.7 *Task 8.7: Proposed Improvements (Plan and Profile)*

These sheets will indicate the proposed design with call outs for improvements to be made in reference to standards and details. It will be a plan view of the alignment. Along with these improvements, profiles will be displayed beneath with matching stationing. A drainage plan and profile will also be made containing information regarding proposed culverts and other drainage infrastructure. These sheets are important to clearly illustrate the proposed improvements.

2.8.8 *Task 8.8: Plan Details*

This page will depict the pavement structural cross-section of the proposed alignment. It will also reference any other supplementary details that would be beneficial for clarity or are modified from Coconino or MAG details.

2.9 Task 9: Impact Analysis

The team will determine the future impacts the roadway will have, such as on roadway capacity and future development, in reference to its 20 year lifetime. It is important that the team develop an analysis to predict and mitigate potential consequences that the project may have. This will include social, environment, and economic factors to access holistic sustainability.

2.10 Task 10: Deliverables

This task involves creating quality and complete deliverables throughout the project schedule. They are valuable to effectively communicate the proposed design of the roadway.

2.10.1 Task 10.1: 30% Deliverables

The team will complete Tasks 1.0 - 3.0 completely and incorporate findings into the final report and 30% presentation.

2.10.2 Task 10.2: 60% Deliverables

The team will complete Tasks 4.0 - 6.0 entirely and include findings in the final report and 60% presentation. The team will also begin creating a plan set.

2.10.3 Task 10.3: 90% Deliverables

The team will complete Tasks 7.0, complete a conceptual plan set, and begin the creation of the project website. The team will also put together the first version of the final report.

2.10.4 Task 10.4: Final Deliverables

The team will finish the remaining tasks, Tasks 8.0 and 9.0, and finalize the report, presentation, and website. These final deliverables are important to communicate the design professionally and effectively.

2.11 Task 11: Project Management

This task involves managing meetings, schedules, and resources to deliver a quality project. This will ensure that the project team maintains proper communication and remains on schedule for project completion.

2.11.1 Task 11.1: Meetings

All meetings held with the client, technical advisor, and grading instructor will be included in this item. This includes meeting set-up, meeting agendas, and communication with the client, technical advisor, and grading instructor.

2.11.2 Task 11.2: Schedule Management

The team will ensure the project is delivered on time and will stick to the schedule as best as possible. If the schedule needs to be adjusted, it will be adjusted so that the project can be delivered at the original due date. It's important for the team to reference this schedule to make sure the project is completed with quality.

2.11.3 Task 11.3: Resource Management

The team will manage resources such as software, engineering reports, and information from the technical advisor. This will help the team to deliver a quality product and to allocate resources.

2.12 Exclusions

The team will exclude utility plans, traffic impact analysis, and existing tie-in elevations & coordinates. These tasks would be required for a fully usable plan set, but it is outside the scope of this project. The team will incorporate room in the roadway for utilities, but will not provide notes regarding utilities. Notes for installation and information would fall into the utility company's scope of work. The team will not be creating a traffic impact analysis since the team is focused on developing the design of the roadway. The team will not perform any surveying in the area. In later phases of this design, specific existing elevations and coordinates will be needed for the tie-in areas.

3.0 Project Schedule

The project schedule can be found in Appendix A. It establishes the duration assigned to the tasks outlined above so that the team can complete the project efficiently.

3.1 Schedule

The schedule for this project will take a total of 82 working days, beginning January 12th, 2025, and ending with the final submission on May 5th, 2025. Major tasks include traffic analysis, site design, and creation of a plan set. Deliverables for this project include 30-, 60-, and 90-percent submittals, and a final submittal.

3.2 Critical Path

The critical path outlines the major tasks that need to be completed on time for the project to finish by May 5th. The critical path encompasses the major tasks outlined above. To elaborate, the analysis portion will take 16 days and includes obtaining TCDC data, determining future traffic volumes, and calculating the design vehicle and speed. The design portion will take 39 days and includes designing the appropriate alignment and determining site grading. The plan set creation will take 27 days and includes creating a template for the plan set, generating proposed improvements, producing drainage plan sheets, creating plan set details, and conducting an impact analysis. This is the critical path because any delay in a critical task will directly impact the project's overall completion date. To ensure the critical path tasks are completed on or before schedule, the team will manage individual workloads and regularly check in with the team. If these tasks cannot be completed on time, the team will modify the schedule and re-evaluate other task lengths to ensure the project is completed on time.

4.0 Staffing

The staffing plan organizes the required positions for the engineering services pertinent to this project. The qualification and time requirements per position are established.

4.1 Staffing Positions

The team will have four staffing positions, including a senior engineer, a project engineer, an engineering technician, and an engineering intern. These positions shall be abbreviated as shown in Table 4-1 below.

Table 4-1: Staffing Codes

Title	Code
Senior Engineer	SENG
Project Engineer	ENG
Engineering Technician	TECH
Engineering Intern	INT

4.1.1 Senior Engineer

The senior engineer shall be responsible for the review and approval of each submittal prior to submission to the client. The SENG must be a licensed engineer with a minimum of 15 years of experience in civil design. The senior engineer will attend the site investigation, weigh in on major design choices, and organize and run meetings with the client.

4.1.2 Project Engineer

The project engineer shall be responsible for a majority of engineering tasks in regards to roadway and drainage design. The ENG must be a licensed engineer with a minimum of 5 years of experience in civil design. The project engineer will attend the site investigation, design major components of roadway and drainage scopes, and record notes at meetings with the client.

4.1.3 Engineering Technician

The tech shall be responsible for minor engineering tasks and major AutoCAD drafting tasks. The tech must be an engineer in training with a minimum of a bachelor's degree in civil engineering from an ABET-accredited institution. The tech will attend the site investigation, design minor components of roadway and drainage scopes, manage data collection and organization, and attend meetings with the client.

4.1.4 Engineering Intern

The engineering intern shall be responsible for the collection of existing data and minor AutoCAD drafting tasks. The intern must be pursuing a bachelor's degree in civil engineering from an ABET-accredited institution. The INT will attend the site investigation, download required data from online sources, and organize the plan set within Civil3D.

4.2 Team Qualifications

Spencer Huttenmeyer is a civil engineering student with experience in the following:

- Project Management
- Scheduling
- Bluebeam
- Field Inspections
- Microsoft Software

Lauren Towner is a civil engineering student with experience in the following:

- AutoCAD and Civil3D
- Drainage Design
- Traffic Analysis
- Wastewater Design
- Grading Design
- Project Management

Janelle Sanchez is a civil engineering student with experience in the following:

- AutoDesk/Microsoft Software
- Roadway Design
- Field Inspections
- Traffic Analysis
- Report Writing

Orlando Santoyo is a civil engineering student with experience in the following:

- Project Management
- AutoCAD
- Bluebeam
- Scheduling
- Field Inspections
- Microsoft Software

4.3 Staffing Matrix

The total hours per task and personnel are summarized below in Table 4-2. The projected total for this project is 660 hours. Reference Appendix B for the complete list that is subdivided into subtasks.

Table 4-2: Staffing Matrix Summary

Task #	Task Name	*SENG hours*	*ENG hours*	*TECH hours*	*INT hours*	*Subtotal*
1.0	**Acquire Existing Site Information**	4	0	12	40	56
2.0	**Site Investigation**	8	4	8	4	24
3.0	**Hydrologic Analysis**	3	5	22	8	38
4.0	**Hydraulic Analysis**	3	14	12	8	37
5.0	**Traffic Analysis**	3	18	22	14	57
6.0	**Roadway Design**	14	30	36	38	118
7.0	**Site Design**	3	20	22	34	79
8.0	**Create a Plan Set**	7	17	44	29	97
9.0	**Impact Analysis**	4	4	4	0	12
10.0	**Project Management**	24	15	9	6	54
11.0	**Deliverables**	32	24	16	16	88
Total Project Hours		**105**	**151**	**207**	**197**	**660**

5.0 Cost of Engineering Services

The total cost to complete the Bellemont Roadway Alignment design is shown in Table 5-1. The cost includes personnel that is subdivided based on classification, with projected hours and rates. These billing rates were compiled in reference to local Flagstaff engineering company rates. Additionally, software usage is included based on the tasks shown above that utilize software. The software was billed at a rate of $100 a day to cover a ratio of the team's yearly software expenditure. The cost excludes travel, as Bellemont is within a non-payable distance of travel. The total cost, based on personnel and software, is approximately $80,000.

Table 5-1: Engineering Services Cost

Category	Classification	Quantity	Unit	Rate, $/hr	Cost
1.0 Personnel	SENG	105	Hours	$162	$17,010
	ENG	151	Hours	$127	$19,166
	TECH	207	Hours	$110	$22,745
	INT	197	Hours	$84	$16,548
	Total Personnel				$75,332
2.0 Software	Software	30	Day	$100.00	$3,000
3.0 Total					**$78,332**

6.0 References

[1] Coconino County, Coconino County Design and Construction Manual, 2025.

[2] Coconino County, Coconino County Drainage Design Criteria Manual, 2025.

[3] U.S. Department of Transportation, Manual on Uniform Traffic Control Devices, 2023.

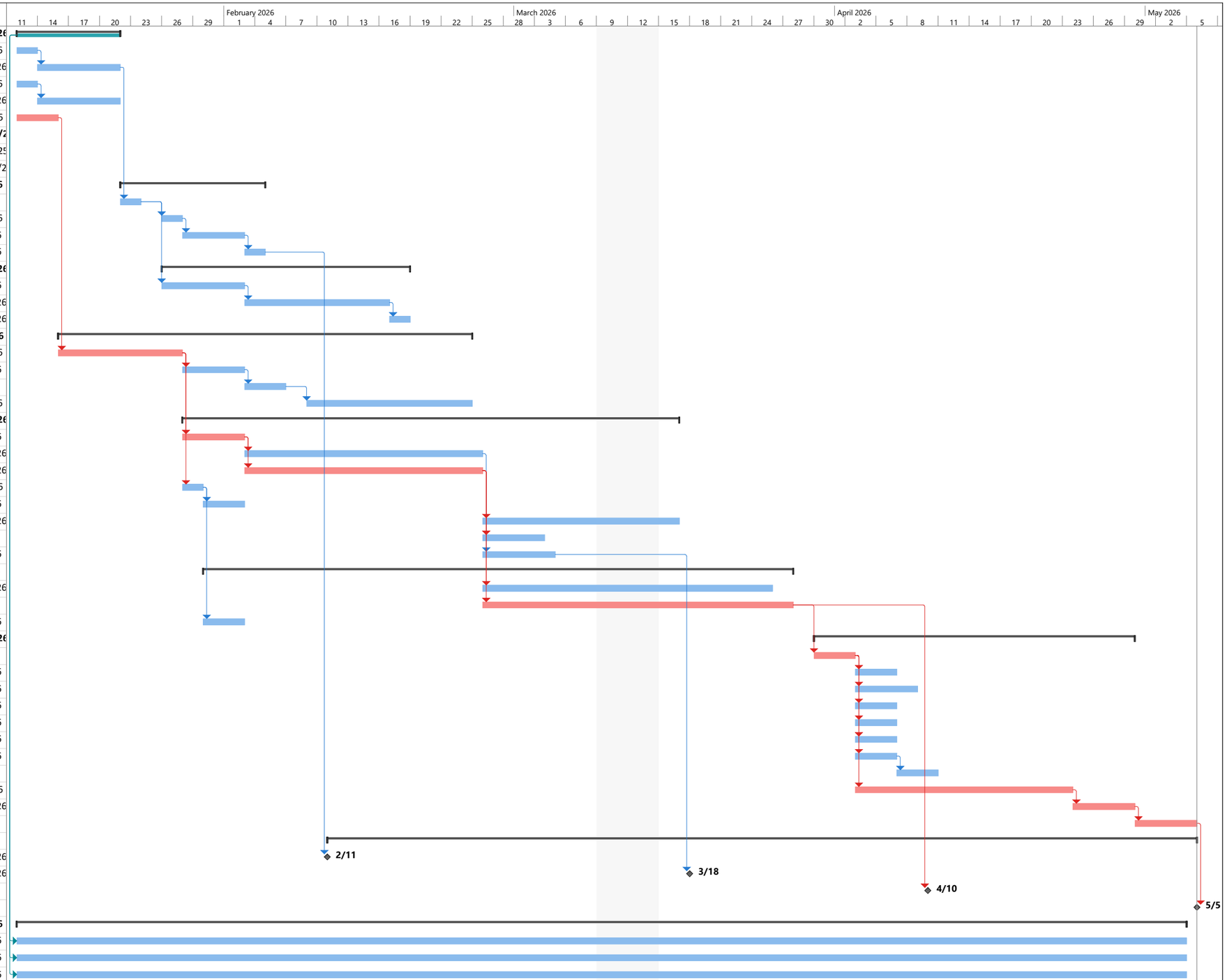
[4] AASHTO, A policy on Geometric Design of Highways and Streets, 2018.

[5] Coconino County, Coconino County Engineering & Survey CADD Manual, 2025.

[6] Federal Emergency Management Association, "FEMA Flood Map Service Center," June 2024. [Online]. Available: https://msc.fema.gov/portal/search?AddressQuery=flagstaff. [Accessed 18 September 2025].

Appendix A: Coconino County Roadway Alignment Schedule

ID	Task Name	Duration	Start	Finish
1	**Task 1 - Acquire Existing Site Information**	**8 days**	**Mon 1/12/26**	**Wed 1/21/26**
2	Task 1.1 - Lidar Data	2 days	Mon 1/12/26	Tue 1/13/26
3	Task 1.2 - FEMA Flood Zone	6 days	Wed 1/14/26	Wed 1/21/26
4	Task 1.3 Geotechnical Reports from Similar/Relevant Project	2 days	Mon 1/12/26	Tue 1/13/26
5	Task 1.4 - Geotechnical Analysis	6 days	Wed 1/14/26	Wed 1/21/26
6	Task 1.5 - TCDS Data	4 days	Mon 1/12/26	Thu 1/15/26
7	**Task 2 - Site Investigation**	**6 days**	**Wed 10/15/25**	**Wed 10/22/2**
8	Task 2.1 - Site Investigation Planning	2 days	Wed 10/15/25	Thu 10/16/25
9	Task 2.2 - Conduct Site Investigation	4 days	Fri 10/17/25	Wed 10/22/2
10	**Task 3 - Hydrological Analysis**	**10 days**	**Thu 1/22/26**	**Wed 2/4/26**
11	Task 3.1 - Delinate Watershed	2 days	Thu 1/22/26	Fri 1/23/26
12	Task 3.2 - Determine Rainfall Intensity	2 days	Mon 1/26/26	Tue 1/27/26
13	Task 3.3 - Determine Peak Flow	4 days	Wed 1/28/26	Mon 2/2/26
14	Task 3.4 - Model Within HEC-HMS	2 days	Tue 2/3/26	Wed 2/4/26
15	**Task 4 - Hydraulic Analysis**	**18 days**	**Mon 1/26/26**	**Wed 2/18/26**
16	Task 4.1 - Determine Floodplain Elevation	6 days	Mon 1/26/26	Mon 2/2/26
17	Task 4.2 - Analyze Potential Hydraulic Structures	10 days	Tue 2/3/26	Mon 2/16/26
18	Task 4.3 - Model Hydraulic Structure	2 days	Tue 2/17/26	Wed 2/18/26
19	**Task 5 - Traffic Analysis**	**28 days**	**Fri 1/16/26**	**Tue 2/24/26**
20	Task 5.1 - Determine Future Traffic	8 days	Fri 1/16/26	Tue 1/27/26
21	Task 5.2 - Determine Connections into Existing Roadway	4 days	Wed 1/28/26	Mon 2/2/26
22	Task 5.3 - Determine Need for Turn Lanes	4 days	Tue 2/3/26	Fri 2/6/26
23	Task 5.4 - Determine Signage on Roadway	12 days	Mon 2/9/26	Tue 2/24/26
24	**Task 6 - Roadway Design**	**29 days**	**Wed 1/28/26**	**Mon 3/16/26**
25	Task 6.1 - Determine Design Vehicle and Design Speed	4 days	Wed 1/28/26	Mon 2/2/26
26	Task 6.2 - Determine Horizontal Alignment	17 days	Tue 2/3/26	Wed 2/25/26
27	Task 6.3 - Determine Vertical Alignment	17 days	Tue 2/3/26	Wed 2/25/26
28	Task 6.4 - Structural Section	2 days	Wed 1/28/26	Thu 1/29/26
29	Task 6.5 - Typical Cross-Section	2 days	Fri 1/30/26	Mon 2/2/26
30	Task 6.6 - Determine Roadway Drainage	8 days	Thu 2/26/26	Mon 3/16/26
31	Task 6.7 - Pavement Markings/Striping Layout	4 days	Thu 2/26/26	Tue 3/3/26
32	Task 6.8 - Select Horizontal and Vertical Alignment	5 days	Thu 2/26/26	Wed 3/4/26
33	**Task 7 - Site Design**	**36 days**	**Fri 1/30/26**	**Fri 3/27/26**
34	Task 7.1 - Determine Cut/Fill	15 days	Thu 2/26/26	Wed 3/25/26
35	Task 7.2 - Determine Site Grading	17 days	Thu 2/26/26	Fri 3/27/26
36	Task 7.3 - Utility Corridor Design	2 days	Fri 1/30/26	Mon 2/2/26
37	**Task 8 - Create a Plan Set**	**23 days**	**Mon 3/30/26**	**Wed 4/29/26**
38	Task 8.1 - Plan Set Border/Template	4 days	Mon 3/30/26	Thu 4/2/26
39	Task 8.2 - Cover Page	2 days	Fri 4/3/26	Mon 4/6/26
40	Task 8.3 - Estimated Quantities/EOPC	4 days	Fri 4/3/26	Wed 4/8/26
41	Task 8.4 - Note Sheet	2 days	Fri 4/3/26	Mon 4/6/26
42	Task 8.5 - Proposed Cross-Section/Typical Cross-Section	2 days	Fri 4/3/26	Mon 4/6/26
43	Task 8.6 - Exisiting Site Conditions and Removals	2 days	Fri 4/3/26	Mon 4/6/26
44	Task 8.6.1 - Topographic Data	2 days	Fri 4/3/26	Mon 4/6/26
45	Task 8.6.2 - Existing Landmarks from Aerial Imagery	4 days	Tue 4/7/26	Fri 4/10/26
46	Task 8.7 - Proposed Improvements (Plan and Profile)	15 days	Fri 4/3/26	Thu 4/23/26
47	Task 8.8 - Plan Details	4 days	Fri 4/24/26	Wed 4/29/26
48	**Task 9 - Impact Analysis**	4 days	Thu 4/30/26	Tue 5/5/26
49	**Task 10 - Deliverables**	**55 days**	**Wed 2/11/26**	**Tue 5/5/26**
50	Task 10.1 - 30% Deliverables	0 days	Wed 2/11/26	Wed 2/11/26
51	Task 10.2 - 60% Deliverables	0 days	Wed 3/18/26	Wed 3/18/26
52	Task 10.3 - 90% Deliverables	0 days	Fri 4/10/26	Fri 4/10/26
53	Task 10.4 - Final Deliverables	0 days	Tue 5/5/26	Tue 5/5/26
54	**Task 11 - Project Management**	**76 days**	**Mon 1/12/26**	**Mon 5/4/26**
55	Task 11.1 - Meetings	76 days	Mon 1/12/26	Mon 5/4/26
56	Task 11.2 - Schedule Management	76 days	Mon 1/12/26	Mon 5/4/26
57	Task 11.3 - Resource Management	76 days	Mon 1/12/26	Mon 5/4/26



Project: Capstone Schedule Rev
Date: Tue 12/9/25

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: Full Staffing Matrix

Task #	Task Name	*SENG hours*	*ENG hours*	*TECH hours*	*INT hours*	Subtotal
1.0	**Acquire Existing Site Information**	**4**	**0**	**12**	**40**	**56**
1.1	Lidar Data	0.5		4	12	16.6
1.2	FEMA Flood Zone	0.5			4	4.5
1.3	Geotechnical Reports from Relevant Projects	0.5			12	12.5
1.4	Geotechnical Analysis	2		8		10
1.5	TCDS Data	0.5			12	12.5
2.0	**Site Investigation**	**8**	**4**	**8**	**4**	**24**
2.1	Site Investigation Planning	4	2	4	2	12
2.2	Conduct Site Investigation	4	2	4	2	12
3.0	**Hydrologic Analysis**	**3**	**5**	**22**	**8**	**38**
3.1	Delineate Watershed	0.5			8	8.5
3.2	Determine Rainfall Intensity	0.5		6		6.5
3.3	Determine Peak Flow	1	5	10		16
3.4	Model Within HEC-HMS	1		6		7
4.0	**Hydraulic Analysis**	**3**	**14**	**12**	**8**	**37**
4.1	Determine Floodplain Elevation	2	10			12
4.2	Analyze Potential Hydraulic Structures	0.5	4	8	8	20.5
4.3	Model Hydraulic Structure	0.5		4		4.5
5.0	**Traffic Analysis**	**3**	**18**	**22**	**14**	**57**
5.1	Determine Future Traffic		2	6	8	16
5.2	Determine Connections Into Existing Roadway	0.5	4	4		8.5
5.3	Determine Need for Turn Lanes	0.5	4	4		8.5
5.4	Determine Signage on Roadway	2	8	8	6	24
6.0	**Roadway Design**	**14**	**30**	**36**	**38**	**118**
6.1	Determine Design Vehicle and Design Speed	0.5		2	2	4.5
6.2	Determine Horizontal Alignment	4	10	10	10	34
6.3	Determine Vertical Alignment	4	10	10	10	34
6.4	Structural Section	0.5			4	4.5
6.5	Typical Cross-Section			4		4
6.6	Determine Roadway Drainage	0.5	4	4	8	16.5
6.7	Pavement Marking/Striping Layout	0.5	4	4		8.5

6.8	Select Horizontal/Vertical Alignment	4	2	2	4	12
7.0	**Site Design**	**3**	**20**	**22**	**34**	**79**
7.1	Determine Cut/Fill	2	8	10	10	30
7.2	Determine Site Grading	0.5	12	12	20	44.5
7.3	Utility Corridor Design	0.5			4	4.5
8.0	**Create a Plan Set**	**7**	**18**	**41**	**31**	**97**
8.1	Plan Set Border/Template	0.5	2	2		4.5
8.2	Cover Page			2	2	4
8.3	Estimated Quantities/EOPC	0.5	4	4		8.5
8.4	Note Sheet	0.5		2	2	4.5
8.5	Proposed/Typical Cross-Section	1		3		4
8.6	Existing Site Conditions and Removals	1	3	1		5
8.6.1	Topographic Data	0.5		4		4.5
8.6.2	Existing Landmarks from Aerial Imagery	0.5		2	6	8.5
8.7	Proposed Improvements (Plan and Profile)	2	8	20	15	45
8.8	Plan Details	0.5		4	4	8.5
9.0	**Impact Analysis**	**4**	**4**	**4**	**0**	**12**
10.0	**Project Management**	**24**	**15**	**9**	**6**	**54**
10.1	Meetings	8	5	3	2	18
10.2	Schedule Management	8	5	3	2	18
10.3	Resource Management	8	5	3	2	18
11.0	**Deliverables**	**32**	**24**	**16**	**16**	**88**
11.1	30% Deliverables	8	4	4	4	20
11.2	60% Deliverables	8	4	4	4	20
11.3	90% Deliverables	8	8	4	4	24
11.4	Final Deliverables	8	8	4	4	24
Total Project Hours		**105**	**151**	**207**	**197**	**660**