NORTHERN ARIZONA UNIVERSITY

Final Proposal

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To: Greenlee County Engineer, Phil Ronnerud, PE and Technical Advisor, Dr. Brendan Russo

C.C: Mark Lamer, PE, CENE 476 Grading Instructor

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Date: 5/9/2018

Re: Duncan, Arizona Floodplain Analysis- Highway and Levee Alignment Alternatives

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Attached is our team's Final Proposal for the project; Duncan, Arizona Floodplain Analysis- Highway and Levee Alignment Alternatives.

Final Proposal
Duncan, Arizona Floodplain Analysis- Highway and Levee Alignment Alternatives
CENE 476: Capstone-Prep

May 10, 2018
Term: Spring 2018
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1 Project Understanding

The 'Duncan, Arizona Highway and Levee Alignment Alternatives' project will be explained throughout the project purpose, project background, technical considerations, potential challenges, and stakeholders sections.

1.1 Project Purpose

The purpose of the project is to aid Duncan, Arizona by developing highway and levee alignment alternatives. The town of Duncan, Arizona has seen a fair share of floods in the past which caused a slowdown in both the town's economy and traffic. Duncan resides in a floodplain, which has made the town vulnerable to rain upstream. To prevent Duncan from flooding, building a levee would restrict the river from flowing into the town and keep the town safe during a heavy precipitation. By having an additional highway added to the levee would most likely result in a reduction in traffic along the main street, Railroad Ave and receiving funding to complete the project.

1.2 Project Background

The project location is in Duncan, along the Southeast border of Arizona (Figure 1). Duncan, AZ has been experiencing issues with flooding of the Gila River, which runs through the town, which is an issue during peak rainfall (Figure 2). Most of their rainfall occurs from the months of July to August [7]. Currently, there are dikes in place along the river, but they are not adequate enough to support the volumes of water they are experiencing (Figure 3) [9]. When they experience this much flooding, everyone is affected. This influx of water causes damage to people's homes and some are unable to work due to temporary closures of businesses. Along with this, the roads are shut down which impacts traffic passing through the town. The worst flooding they had resulted in the city to be underwater ranging from two to twelve feet deep [8].

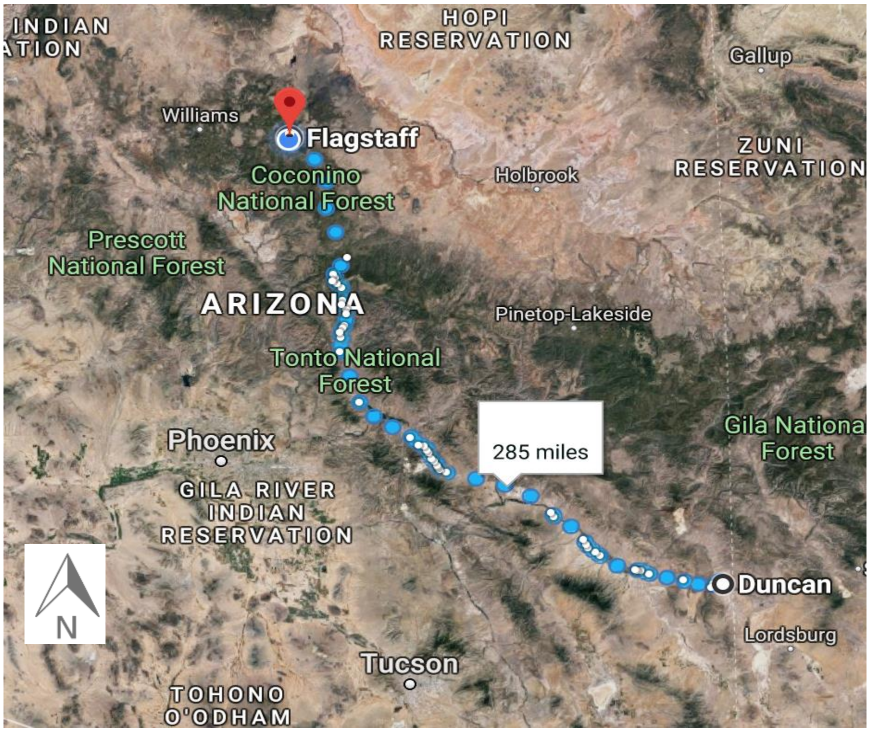


Figure 1: Project location: Duncan, Arizona [15]

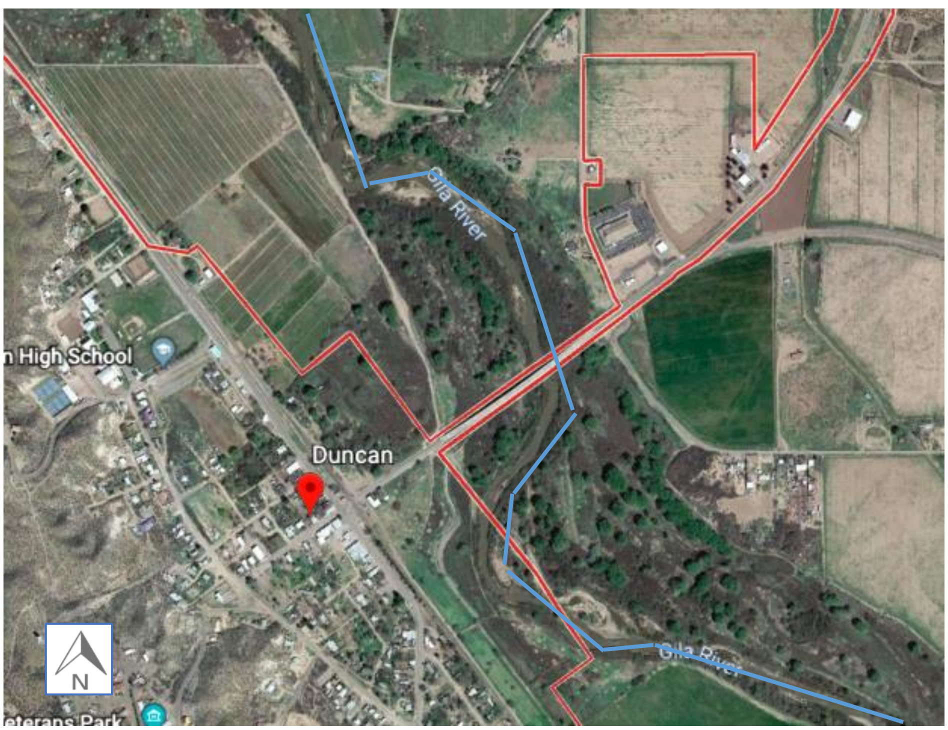


Figure 2: Gila River running through Duncan, Arizona [15]

Figure 3: Current pikes in place. [16]

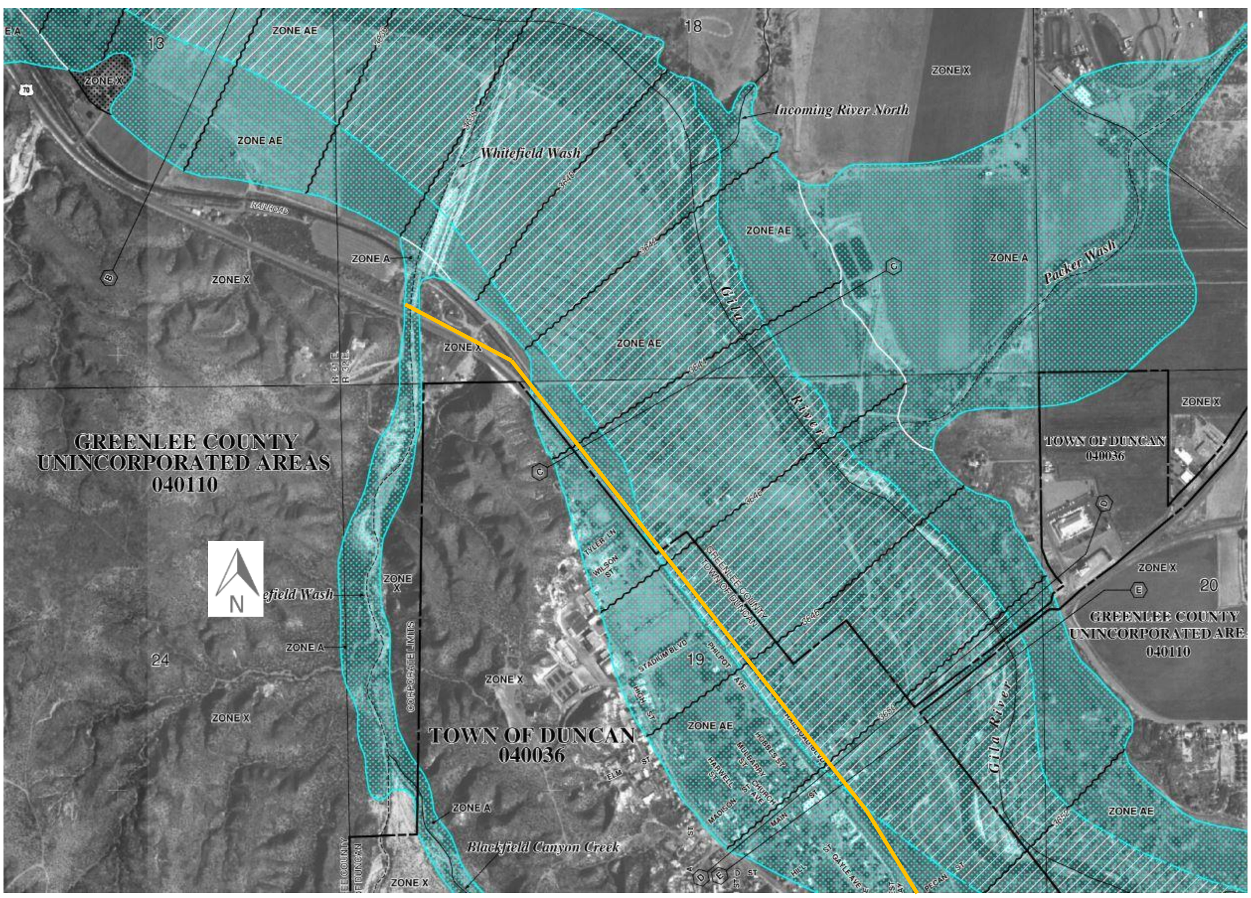


Figure 4: Map of Gila River Floodplain Zone. [18]

1.3 Technical Considerations

The technical considerations for this project are the addition of a levee and raising of intersections to meet the new highway levee height. The height of the elevated intersection will depend on the additional height of a levee, therefore, possibly affecting the proper location of the intersection. Per AASHTO requirements, a traffic study may be considered to determine if the intersection will be a signalized. Both the roadways and highways will have horizontal and vertical alignments of adjusted curves, alignments standards are given by AASHTO methods [1]. Alignments will include the levee design [4]. Due to needing an elevation addition to the project, surveying and topographic mapping of a location will be required. A maximum recorded depth of the flood will determine the height of the levee, a watershed analysis could be used if no data is available. Other possible considerations include riprap in design, to increase longevity of levee [5].

All highway and roadway design projects are required to follow set standards that will be followed to complete the technical considerations of the project. These standards include Arizona Department of Transportation Roadway Design Guidelines [17], AASHTO (American Association of State Highway and Transportation) [10], AASHTO Green Book [1], and HCM (Highway Capacity Manual) [2]. AASHTO are a set of standards set by specifications, test protocols, and guidelines, which are used in all highway design and construction throughout the United States [10]. AASHTO Green Book is a policy on geometric design of highways and streets [1]. HCM is a manual for engineers and planners use to assess the traffic of highway projects [2]. A redesign for the designed 25/50/100-year storm levee will be included for cost considerations.

1.4 Potential Challenges

Potential challenges for this project include acquisition of property, budget, and meeting elevation requirements. We will need to acquire property from Duncan in order to complete our project, which will be a challenge as residents may not want to give up their land. Another challenge will be keeping our design within the client's budget. Flood mitigation designs can be very costly, therefore, we will need to find the most cost-effective solution. Lastly, in order to prevent future flooding our levee may need to be at elevations level with rooftops. We will also need to ensure our elevations are not above American Disability Act (ADA) requirements in intersections.

1.5 Stakeholders

The primary stakeholders in this project include the technical advisor Brendan Russo, ADOT, and Greenlee County. Brendan Russo is a stakeholder because he is responsible for giving guidance for the team's success. How well the team does will reflect on his competence as an advisor. ADOT is also a stakeholder because their code will be used for the design of this highway. The final stakeholder is Greenlee County. The engineers on this project are putting their names on the design and taking accountability for any errors there may be. The citizens of Greenlee county are also stakeholders, their homes and businesses could be negatively affected if this project were to fail.

2 Scope of Services

2.1 Task 1: Field Investigation- Visiting Duncan, Arizona to complete the site investigation and traffic analysis.

2.1.1 Task 1.1: Site Investigation- Visually inspecting the site for any possible problems that may occur for the highways and intersections. This would include large trees, existing infrastructures, and other obstructions that may occur on the site. A walkthrough of the client's ideal location of the proposed roadway will be conducted.

2.1.2 Task 1.2: Traffic Analysis- This will include determining what type of traffic analysis will performed, such as turn counts at the intersection to get an estimate of the traffic count to be expected on the roadway. Also, which equipment is necessary to perform traffic analysis and as a result, determine the type of design vehicle. The average annual daily volume (AADT) will be obtained from ADOT (Arizona Department of Transportation).

2.1.2.1 Task 1.2.1: Crash Data Analysis: An evaluation of crash data will be performed in order to ensure that there will be no significant amount that will affect the alternatives. The data will be obtained from Arizona Department of Transportation. If there is a significant amount, the intersections will be evaluated with an Crash Modification Factor in order to make it safer for users.

2.2 Task 2: Traffic Conditions- Assess the traffic analysis using highway analysis software. This will provide the team the geometric designs of the highway, intersection, and roadway width.

2.2.1 Task 2.1: Traffic Characteristics- Determine the speed and other dimensions required to meet ADOT, AASHTO, and Greenbook requirements. Other characteristics of the roadway will include traffic volume, number of lanes, level of service, sight distance, and grades. To determine all of the characteristics, Highway Capacity Software will be used.

2.2.2 Task 2.2: Highway Capacity Software (HCS)- Using HCS to determine the number of lanes and level of service for a 20-year span.

2.3 Task 3: Preliminary Data- Design will be based on the AASHTO Greenbook, Arizona Design Standards, and the Highway Capacity Manual. This data will be used to outline the criteria of the new roadway.

2.3.1 Task 3.1: Elevation and LiDAR- Using the LiDAR the previous Capstone Team collected and in-putting it into Civil-3D to create a surface elevation in order to determine the possible elevation of the roadways.

2.3.2 Task 3.2: AASHTO Roadway Design Guidelines- Using the guidelines to insure the design is up to par and insuring that the side-slopes do not warrant guardrails.

2.4 Task 4: Alignment Design Alternatives- Multiple alternatives will need to be created to minimize cost, minimize conflict with the community, and satisfy the client.

2.4.1 Task 4.1: Alignment Design 1- Creating the first iteration of road realignment based on the client's request to utilize the new roadway as a levee. Creating an assembly and minimize the property interference.

2.4.1.1 Task 4.1.1: Horizontal Alignment- Having a brief idea where the road will be, adjustments can be made to minimize cost. This would require a surface in Civil-3D to input the roadway which does not interfere with existing infrastructures.

2.4.1.2 Task 4.1.2: Vertical Alignment- Elevate the roadway and create profile graph of roadway. Using Civil-3D to create the profile, and to meet the required height to double as a levee. This data, such as sight distance, will be used to meet ADOT guidelines.

2.4.1.3 Task 4.1.3: Property Investigation- Use the AcreValue website find how much property will be interfered with and who they belong to. This will provide an idea of how much land we may need from each owner.

2.4.1.4 Task 4.1.4: Quantities Takeoff- Determine how much material is needed to fulfill design needs. Default of 6” hot mix asphalt and 6’ aggregate base.

2.4.2 Task 4.2: Alignment Design 2-Developing second iteration of realignment.

2.4.2.1 Task 4.2.1: Horizontal Alignment- Having a brief idea where the road will be, adjustments can be made to minimize cost. This would require a surface in Civil-3D to input the roadway, which does not interfere with existing infrastructures.

2.4.2.2 Task 4.2.2: Vertical Alignment- Elevate the roadway and create profile graph of roadway. Using Civil-3D to create the profile, and to meet the required height to double as a levee. This data such as sight distance will be used to meet ADOT guidelines.

2.4.2.3 Task 4.2.3: Property Investigation- Use the AcreValue website to find how much property will be interfered with and who they belong to. This will provide an idea of how much land we may need from each owner.

2.4.2.4 Task 4.2.4: Quantities Takeoff- Determine how much material is needed to fulfill design needs.

2.4.3 Task 4.3: Alignment Design 3-Developing third iteration of realignment.

2.4.3.1 Task 4.3.1: Horizontal Alignment- Having a brief idea where the road will be, adjustments can be made to minimize cost. This would require a surface in Civil-3D to input the roadway which does not interfere with existing infrastructures.

2.4.3.2 Task 4.3.2: Vertical Alignment- Elevate the roadway and create a profile graph of the roadway. Using Civil-3D to create the profile, and to meet the required height to double as a levee. This data, such as sight distance, will be used to meet ADOT guidelines.

2.4.3.3 Task 4.3.3: Property Investigation- Use the AcreValue website to determine how much property will be interfered with and who they belong to. This will provide an idea of how much land we may need from each owner.

2.4.3.4 Task 4.3.4: Quantities Takeoff- Determine how much material is needed to fulfill design needs.

2.5 Task 5: Intersections- The intersections that are connecting on the highway will be redesigned. This will include incorporating a new number of lanes and the current number of lanes in the opposite direction of the highway.

2.5.1 Task 5.1: Intersection Impact Analysis- Highway Capacity Software (HCS) will be utilized again to find the best fit intersection and to ensure that all criteria per ADOT, AASHTO Greenbook and AASHTO will be met.

2.5.2 Task 5.2: Intersection Recommendations- This will be a recommendation for signage and if a stoplight will be required.

2.6 Task 6: Cost Analysis- Determine the overall cost of the new alignment designs.

2.6.1 Task 6.1: Land Value Assessment- Determine how much property will cost based on land value.

2.6.2 Task 6.2: Alternatives Total Cost- Overall costing including labor, materials, and land value.

2.7 Task 7 Deliverables- CENE 486 Deliverables

2.7.1 Task 7.1: 30% Report- This report will be completed by the due date, with the proper information included to the Grader.

2.7.2 Task 7.2: 60% Report- This report will be completed by the due date, with the proper information included to the Grader.

2.7.3 Task 7.3: Final Report- This report will include all tasks listed above and presented to the client.

2.7.4 Task 7.4: Website- Create and maintain a website that includes all major deliverables and pictures of the project from the beginning to completion.

2.7.5 Task 7.5: Impacts Report- A report on how the project impacts the town, environment, and others if needed.

2.7.6 Task 7.6: Status Updates- Updating the Grader and client about the project's current standing throughout the semester.

2.7.7 Task 7.7: Final Presentation- This will be given at NAU UGrads Symposium and will be based on the proposed alternatives.

2.8 Task 8: Project Management- This includes weekly team meetings and extra meetings as necessary. Phone meetings with our client, Phil Ronnerud, monthly and on an as needed basis. Technical advisor, Brendan Russo, meeting once a month and as needed to insure the team is performing all technical work correctly. As needed meetings with the Grader, Mark Lamer. This will include all the deliverables and following the schedule laid out by the team. Team members will keep each other accountable for the tasks and trade off being the team leader.

2.9 Project Limitations: The proposed flood mitigation measures will help reduce the impact on Duncan's urban structures. However, there will be limitations such as cost. During low rainfall seasons, the materials will be exposed resulting in higher maintenance costs. Determining a height for the levee will also be challenging as lower parts of the town are more susceptible to flooding. Also, the Federal Emergency Management Agency has set guidelines for designing and building levees. There will be challenges with following these guidelines to meet the minimum seepage due to Duncan's terrain and general slope. The team will have to follow these guidelines and gain permits in order to build a levee.

2.9.1 Challenges: Challenges with this project would include travel and scheduling. Duncan, Arizona is located approximately five hours South East of Flagstaff and could cause complications with finding a time that works with the team's schedule as well as a time that works with the client. Another challenge would be funding for the project. In order for this project to be successful, the project would need federal funding for the highway portion of the levee. Other challenges with this project would include meeting the allowable grade for pedestrians, bicycles, and American Disabilities Act (ADA) requirements. The introduction of an elevated highway could cause complications with meeting the maximum allowable grade. Along with this, Duncan High School is located near the floodplain, so the team would have to take into consideration whether the students would need a route for walking to school. Currently there is also a railroad that runs through the town, this will not be designed for reroute, but it will need to be taken into consideration for our final design.

2.9.2 Exclusions: For the project, the team will only be designing an elevated highway. A new floodplain analysis will not be conducted, as previous teams have already done so. Elevation determination will be based on previous floodplain analysis. A geotechnical analysis of the soils and materials under the highway and surrounding area will be excluded from the project. Detailed intersection design and a economical analysis will not be conducted. Other components that will be excluded are a formal EPA Environmental Impacts report and development permits for re-zoning of the new acquired land.

3 Project Schedule

3.1 Total Duration of Project

The total duration of the project will be approximately 81 days. The field investigation is proposed to take three weeks to complete. Followed by the analysis of traffic conditions which will take around 16 days. The preliminary data for the design alternatives will take roughly 21 days. After the completion of these tasks, the three design alternatives will take approximately one month. Cost assessment and intersection analysis will take two weeks. The team's deliverables will be completed on an ongoing basis throughout the project duration.

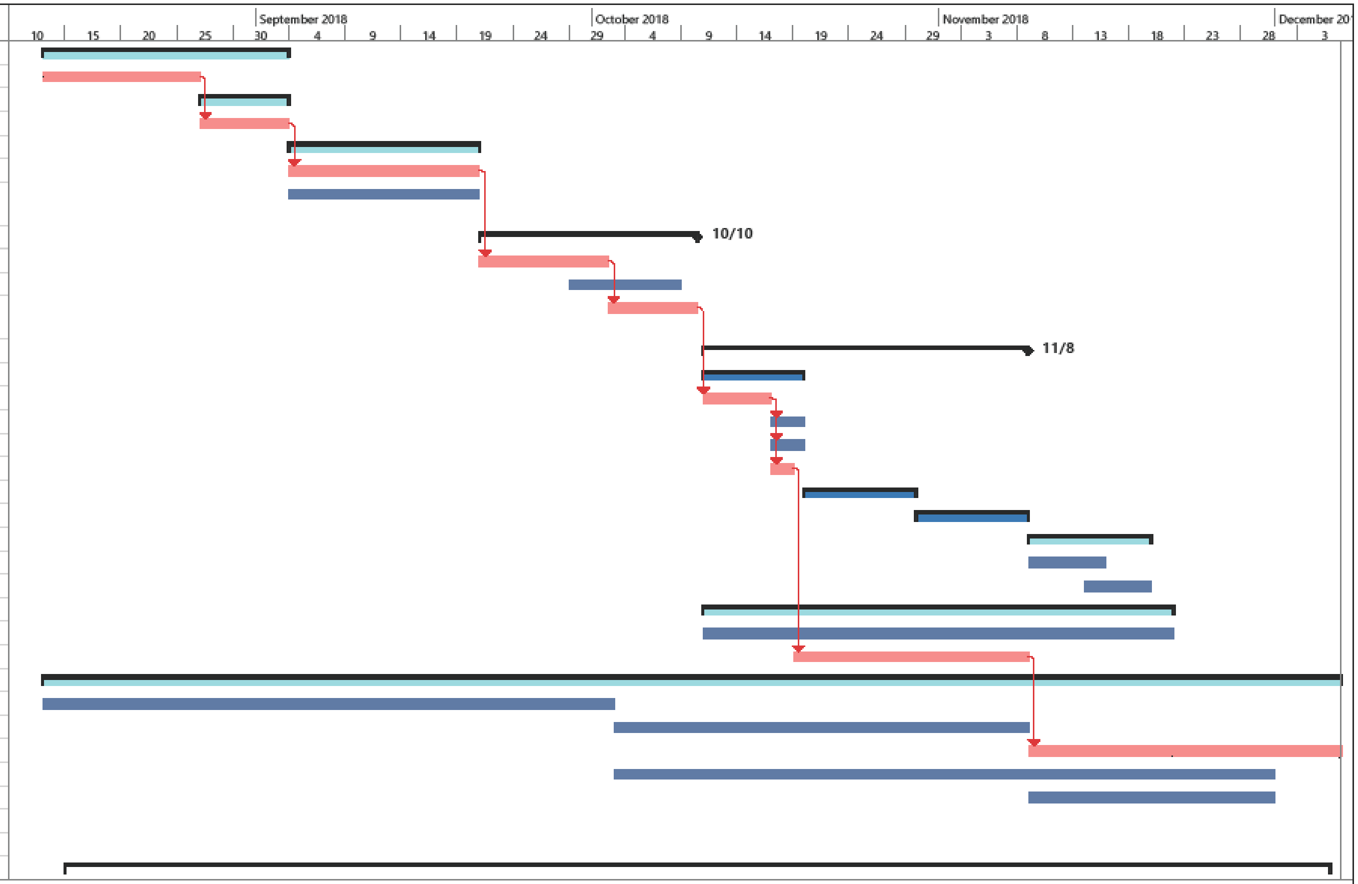
3.2 Major Tasks/ Deliverables

The major tasks of the project schedule include a field investigation. Also, traffic conditions, preliminary data, alignment design alternatives, and intersections. Lastly, the major tasks will also include cost assessment, deliverables, and project management. All eight of these major tasks will have sub tasks. The deliverables in the schedule include 30% report, 60% report, final report, status update, impacts report, website, and final presentation. These deliverables are due at various times and are major reports that will be done.

3.3 Critical Path

The critical path was determined by identifying what tasks needed to be completed in order to have a final product. This showed that the major tasks must be completed in order to have a final product. The timing will be maintained by the team leader who will help to keep everyone on task. The duration of the tasks will be based on what the individual team members have been assigned. It will be up to their discretion on whether to finish it ahead of time or when it needs to be completed by.

ID	Task Name
1	**1: Field Investigation**
2	1.1: Site Investigation
3	**1.2: Traffic Analysis**
4	1.2.1: Crash Data Analysis
5	**2: Traffic Conditions**
6	2.1: Determine Traffic Characteristics
7	2.2: Utilize Highway Capacity Software to determine characteristics
8	**3: Preliminary Data**
9	3.1: Existing Feature Limitations
10	3.2: Civil 3D Surface Creation
11	3.3: Schematic for Horizontal Alignment Alternatives
12	**4: Alignment Design Alternatives**
13	**4.1: Alternative Design 1**
14	4.1.1: Horizontal Alignment
15	4.1.2: Vertical Alignment
16	4.1.3: Property Investigation
17	4.1.4: Quantities Takeoff
18	**4.2: Alternative Design 2**
23	**4.3: Alternative Design 3**
28	**5: Intersection**
29	5.1: Intersection Impact Analysis
30	5.2: Intersection Recommendations
31	**6: Cost Assessment**
32	6.1: Land Value Assessment
33	6.2 Alternatives Total Cost
34	**7: Deliverables**
35	7.1: 30% Report
36	7.2: 60% Report
37	7.3: Final Report
38	7.4: Website
39	7.5: Final Presentation
40	7.6: Impacts Report
41	**7.7: Status Update**
46	**8: Project Management**



Project: Schedule with Mileston
Date: Wed 4/25/18

Task		Project Summary		Manual Summary		Critical	
Split		Manual Task		External Tasks		Critical Split	
Milestone	◆	Duration-only		External Milestone	◇	Progress	
Summary		Manual Summary Rollup		Deadline		Manual Progress	

4 Project Staffing

4.1 List of Staff Positions

Senior Engineer, Sr. Engineer, SE
Professional Engineer, Prof. Engineer, PE
Engineer-in-Training, EIT
Drafter/Technical Design, Drafter/Tech, D/T
Administrator, Admin., Ad
Arizona Department of Transportation Coordinator, ADOT Coordinator, ADOT Coord.

4.2 Qualifications of Senior Personnel

Abdullah Alhusaini- Qualifications include knowledge in ArcMap, AutoCAD, and Civil-3D. Experience with ADOT and AASHTO guidelines. Developing intersections and highway designs.

Ashley Charlton- Qualifications include Highway Capacity Software, AutoCAD, and Civil-3D. Experience with ADOT and AASHTO guidelines. Quality writing and communication skills. Experience in creating intersections and highway designs. Prior experience with highway and street safety.

Morty Jim- Qualifications include knowledge in AutoCAD, Civil-3D, and Highway Capacity Software. Understanding of basic function of AutoCAD and creating blocks for drafting. Able to utilize Civil-3D to develop both horizontal and vertical alignment for highway projects. Prior experience in developing a new highway with a four-lane highway, in compliance with ADOT and AASHTO guidelines.

Leslie Sorenson- Qualifications include knowledge in AutoCAD and Civil-3D. Familiarity with ADOT and AASHTO guidelines. Quality writing and communication skills. Knowledge of intersection design and safety guidelines.

4.3 Hour Matrix

Task Name	Sr. Engineer	Prof. Engineer	EIT (4 Combined)	Drafter /Tech	Administrator	Task Total
1: Field Investigation	4	24	80	0	0	108
2: Traffic Conditions	2	7	48	0	0	57
3: Preliminary Data	3	10	64	13	0	90
4: Alignment Design Alternatives	7	22	144	29	12	214
5: Intersection	2	5	32	7	2	48
6: Cost Assessment	2	5	32	0	8	47
7: Deliverables	7	22	144	0	20	193
8: Meetings	2	5	34	0	7	48
Total Hours	29	100	578	49	49	**805**

4.4 Staff Position Justification

In order to complete this project, the team will need a Senior Engineer, a Professional Engineer, an Engineer-in-Training (EIT), a Drafter, and an Administrator. The duties of the Senior Engineer will include overseeing all tasks to ensure operations are going smoothly. The team will only be required to be present at major site visits and milestone meetings. The Professional Engineer is responsible for developing plans and making sure everything is done correctly and promptly. The Professional Engineer will require more hours than a Senior Engineer due to having the responsibility of creating design plans and overseeing the EITs. The EITs will be performing the majority of legwork for the project. They will be completing analysis under the supervision of the Professional Engineer. Since EITs will be completing the majority of the analysis, they will be required to work more hours on this project. Both the Drafter and Administrator will only be utilized for specific tasks involved with this project.

5 Cost of Engineering Services

5.1 Matrix of Engineering Cost and Total Cost of Services

Rate Table					
Staff	**Pay Rate ($/hr.)**	**Multiplier**	**Billing Rate ($/hr.)**	**Hours**	**Cost ($)**
Sr. Engineer	60	3	180	29	$5,220.00
Prof. Engineer	40	2.5	100	100	$10,000.00
EIT	25	2.5	62.5	578	$36,125.00
Drafter/Tech	25	2	50	49	$2,450.00
Administrator	20	2	40	49	$1,960.00
ADOT Coordinator	30	2	60	20	$1,200.00
OTHER EXPENSES					
	cost ($/mi.)		**Trips**	**Miles**	
Travel	0.7		2	600	$840.00
	cost ($/night)			**Rooms**	
Hotel	150		-	6	$900.00
				Total Cost	$58,695.00

5.2 Discussion of Engineering Cost and Total Cost of Services

To maintain a safe overhead to keep the Engineering company, a Rate Table will be utilized to cover all others who are not completely involved in each individual project. There must be a steady stream of income, even when there are no clients. The Rate Table used above is based on a typical rate of the included staff members and a multiplier for additional overhead. Considering both the Senior Engineer and Professional Engineer will only be involved when approval is needed, their hours worked on the project will be minimal; therefore, they would have a higher rate such as three and two and half multiplier. The same can be applied to the EIT, Drafter, Admin, and ADOT Coordinator. The EITs will be generating the majority of the income, which can cover the overhead (such as Health Insurance, Fees, and other required benefits). In addition to the Rate Table, both Travel and Hotel will need to be included to gather proper information for the completion of the project.

5.3 Total Cost of Services Justification

These costs for each profession was determined through the analysis of average rates and multiplying them by a variable as discussed in section 5.2. Using the matrix, the engineering cost of services was multiplied by hours worked in order to find the total billing rate. The team is estimating to stay a total of two night over the course of the project, which will include around 600 miles of travel.

6 References

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