Northern Arizona University

Passing Lane Preliminary Design Proposal for Arizona Department Of Transportation On SR-64 Between Williams and the Grand Canyon

Benjamen Ruth

Mohammad Ali

Kyle MacPetrie

Christian Hillebrand

CENE 476 Capstone

Dr. McDonnell

December 12, 2018

Table of Contents

1.0 Project Understanding

1.1 Project Purpose

State Route 64 (SR 64) between mile markers 201-204 will be adding a passing lane for south bound traffic to help alleviate traffic congestion and provide adequate space for vehicles to pass. SR 64 is located between Williams, Arizona and the entrance to Grand Canyon National Park, in Coconino County in northern Arizona. A site map below in Figure 1 shows the site location in relevance to Arizona. A passing lane will allow traffic a chance to pass slower moving vehicles such as semi-trucks and recreational vehicles (RV's). These larger vehicles can be found along this route as the Grand Canyon is a national monument where tourists are more likely to visit in RV's and other larger vehicles that travel at slower speeds.

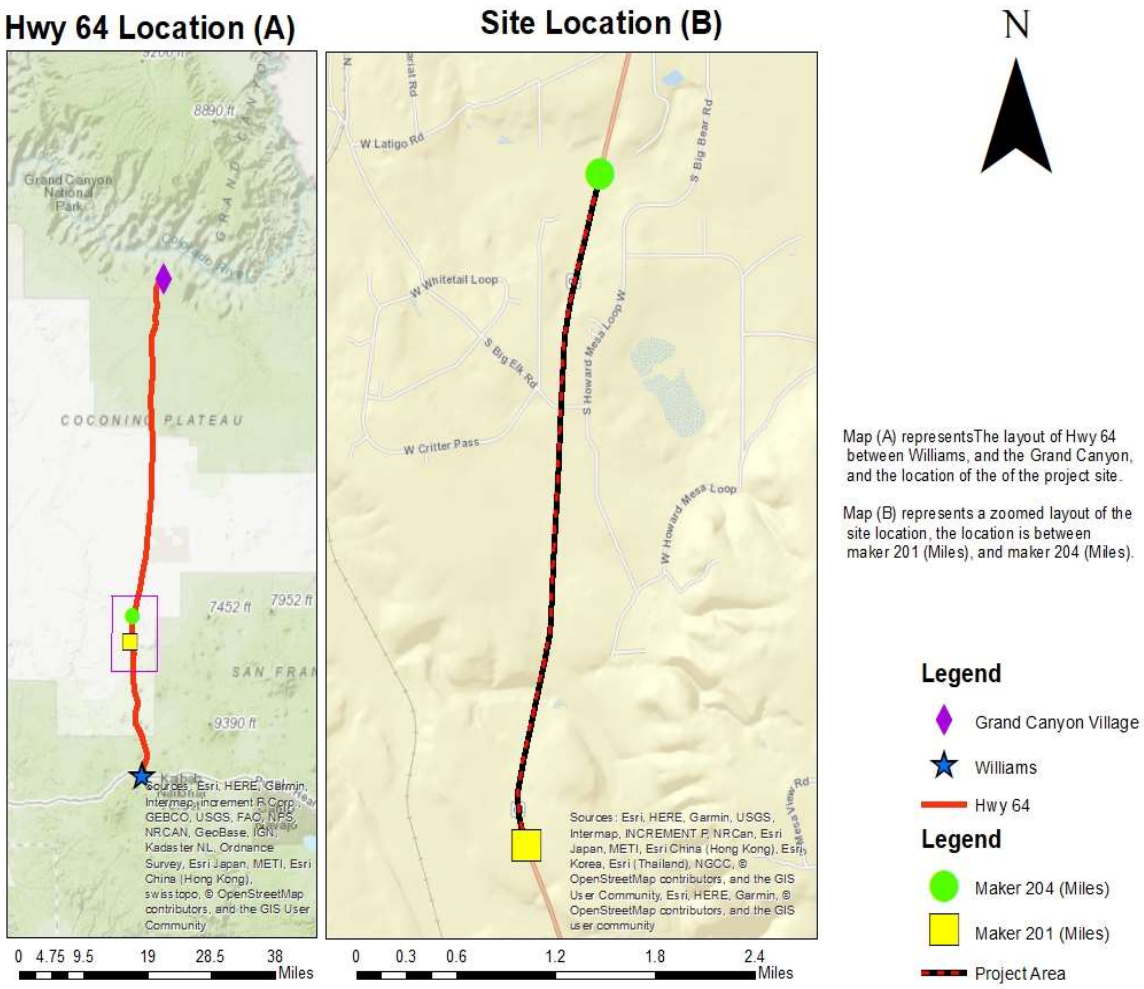

Figure 1: Site Map

1.2 Project Background

Arizona Department of Transportation (ADOT) has conducted initial studies and concluded that the areas along State Route 64 require the use of passing lanes or climbing lanes. The specific section this capstone group will be working on is between mile marker 201 and mile marker 204. State Route 64 connects Interstate-40 (I-40) outside of Williams, Arizona to the entrance of Grand Canyon National Park. The site in question is 15 miles north of I-40 going north to the Grand Canyon. The exact coordinates of the mileposts are as follows; Mile marker 201, 35.474070, -112176695, mile marker 204, 35.517694, -112.170398. Figure 1 below shows a statewide and site location of SR 64.

1.3 Technical Considerations

The Highway 64 project include an assessment of the existing roadway, hydrological assessment and analysis, geotechnical analysis, highway design, traffic control plan, and construction plans. These different technical portions will be broken up into different tasks with some tasks needing to be completed before another task can be started.

An assessment of the existing roadway is the first task that can be started. Within this the condition of the asphalt with any large cracks or sections of asphalt missing being noted, along with the condition of the shoulders of the roadway being noted. Rumble strips will also be noted with the width between the rumble strip and side of the lane being measured so that when a passing lane is added, this section of roadway will be taken out for the construction of the passing lane. If culverts or pipe networks under the roadway exist, then their locations should be noted along with the dimensions, structure type, and integrity including noting if, according to the team members, whether or not these culverts and pipe networks can be lengthened to accommodate the addition of the passing lane, or should be removed entirely and a new system put into place.

For the geotechnical analysis portion of the project, the soil cores will be analyzed using STP483 [2]. While, ASTM D6913 [3] will be used to determine the sieve analysis that is needed for the project. This includes using the correct number sieves, and how to properly get the proportions of the soils within the samples.

Highway design will be used for the design of the passing lane, while utilizing the standards roadway design though the use of the American Association of State Highway and Transportation Officials' (AASHTO) "A Policy on Geometric Design of Highways and Streets." [1] ADOT guidelines and references will also be used for the designing of highway related systems. These guidelines will be used when designing the passing lane along with the appropriate signing and striping needed for the addition.

The traffic control plan includes the plans needed to construct the highway. This includes how traffic is to pass through the area when construction is underway, striping for the construction process, and barriers, if any, are needed.

Construction plans include all documents that are needed to fully construct the additional passing lane. These documents include cut and fill reports, cross-sections, culvert extensions and any other document that may be needed. These will all be bundled within a final construction plan document at the end of the project.

1.4 Potential Challenges

Collecting survey data using Google Earth Pro could present some challenges due to the contour lines being spaced at 5 feet. This could create a potentially inaccurate situation for grading and drainage. The existing road conditions gained from Google Earth Pro may lack the necessary precision or accuracy, therefore a site visit will be made in order to determine the quality of the obtained data.

Other potential challenges will be safety for all people involved within the project, such as labor workers and engineers. Keeping everyone safe will be a major priority while completing the project.

Besides survey data and safety, weather could provide a challenge, due to the time of the yea, as this could bring in both rain and snow to the area, making it difficult to access at certain times, and making a site visit hard to achieve.

1.5 Stakeholders

Nearby towns and cities, the National Park Service (NPS), Arizona Department of Transportation (ADOT), and the public will need to be consulted during this project. The cities of Cameron, Tusayan and Williams are important stakeholders because State Route 64 is an access point to these cities and construction may hinder their accessibility. The National Park Service is considered a stakeholder due to the fact that State Route 64 leads to the Grand Canyon and is considered a pivotal way of getting access to the National Park. ADOT is a stakeholder in this project due to their direct involvement in maintaining and repairing Arizona's public roadways. The funding for this project is coming from taxpayers, the general public is considered a stakeholder, not only because of the money, but also because the route is considered a public route, meaning that the public will be affected by the construction of the roadway.

2.0 Project Scope

2.1 Task 1. Site Assessment

2.1.1 Road Condition Assessment

2.1.1.1 Asphalt Condition

The condition of the asphalt will be assessed to help in analyzing whether or not any repair work needs to be done before constructing the new passing lane.

2.1.1.2 Shoulder Condition

An initial site visit addresses all existing conditions that are present on the roadway and surrounding areas. The present party will make note of any obstructions that may be in the way on the side of the road, and any roadways that connect off of the route, including service roads and personal driveways.

2.1.2 Drainage Condition Assessment

2.1.2.1 Culvert Condition and Location

A culvert integrity assessment will assess whether the culverts currently at the site are in good shape and do not need to be renovated or have its capacity increased, and if they can continue to function well.

2.1.2.2 Wash Integrity

The current drainage that the roadway possess will be noted, which includes culverts that may pass under the roadway, curbs, trenches along the road that are used to either hold water or transport it to another locations.

2.1.3 Soil Sampling

Soil core samples are collected and analyzed in order to find the soil characteristics, and design the proper foundation for road based on the found information.

2.2 Task 2: Hydrology and Hydraulics Analysis

2.2.1 Map Culverts

The culvert inlet out outlet locations along the job site will be mapped and inputted into Civil3D.

2.2.2 Acquire Existing Contour Maps

Google Earth Pro provides the required contour lines and longitude/latitude locations to accurately map out culvert locations with figures.

2.2.3 Drainage Analysis

Using Culvert Master, a 25, 50, or 100 year design storm will be chosen for designing the proposed run-off from the roadway [4]. If a larger sized

culvert is determined to be the proposed solution, ADOT will perform all analysis, cost, etc.

2.3 Task 3. Geotechnical Analysis

2.3.1 Sieve Analysis

Sieve analysis test will be conducted in order to find the Particle Size Distribution of the soil. Particle Size is major to classify the soil type and understand its properties, and how to deal with it.

2.3.2 Plasticity Index Analysis

The plasticity of the soil along the proposed passing lane will need to be known for the complete geotechnical analysis. The plasticity index allows for the correct requirements to be known about the type of soil below the roadway.

2.3.3 Compaction Analysis

A compaction of the soil will be performed if the project site soil shows a noticeable number in its voids. The compaction will result in the increase of shear strength, and will also reduce the voids in the soil which will prevent the water from traveling in the soils.

2.4 Task 4. Highway Design

2.4.1 Cross Sections

Typical cross sections that will help analyze area within a certain amount of soil.

2.4.2 Extension of Existing Drainage Structures

The extensions of any existing infrastructure along with proper dimensions within AutoCAD software.

2.5 Task 5. Traffic Control Plan

2.5.1 Phasing

State Route 64 is the only major highway that connects the Grand Canyon to I-40 making it difficult to have the entire roadway closed for construction. To accommodate this, phasing will be introduced to so as to alleviate traffic travelling along the highway during the construction process.

2.5.2 Quantities

Within quantities, a certain amount of temporary signs and barriers will be need to be used to achieve safety for all cars and workers

2.5.3 Duration

The amount of time temporary signs and barriers will be used while construction is being done on the passing lane.

2.6 Task 6. Design Plan Sets

2.6.1 Face Sheet

A face sheet will include project title, project description, site location, standards and codes used, company name, and contact information.

2.6.2 Roadway Sections Plan Sheets

A typical cross-section will be provided along with cross-sections every given amount of length along the centerline of the main alignment of the roadway. These cross-sections should include the elevation at the centerline, elevations at the sides, and include any other details that are required in the sheet. Typical cross-sections include those of the roadway sections and if it applies to this section of roadway, a sidewalk cross-section will also be provided [5].

2.6.3 Existing Conditions Plan Sheets

Existing Conditions can include cross slopes, alignments and pavement types.

2.6.4 Structural Plan Sheets

Structural plans can include but are not limited to the structural analysis of the culverts and roadway.

2.6.5 Drainage Plan Sheets

Drainage plans for surface runoff and culvert design will be included in this section. The surface runoff should be calculated for a given storm event, and the culvert design should include the extensions, if any, that are done to already existing culverts along this section of the highway.

2.6.6 Storm Water Pollution Prevention Plan Sheets (SWPPP)

The team will design an adequate SWPPP that will avoid the pollution of surrounding areas with storm water runoff produced from rains.

2.6.7 Traffic Control Plan Sheets

Traffic Control Plans will detail how traffic will be controlled before the start of construction hours, during construction hours and after construction hours.

2.6.8 Cost Estimate Report Sheets To Implement

A report with the complete cost of the project will be made in order to create the final design for the project.

2.6.8.1 Scoping

2.6.8.1.1 Survey

Cost to survey the site and immediately surrounding areas.

2.6.8.1.2 Work Plan
Labor cost to implement a standing work plan for design, labor, etc.

2.6.8.2 Preliminary Engineering Design

2.6.8.2.1 Plan Sheets
The total amount of time and cost in order to design and assemble structural, drainage, traffic, and schedule plans.

2.6.8.2.2 Geotechnical Investigation
The total amount of time and cost to conduct a full geotechnical material and pavement design analysis/report.

2.6.8.2.3 Drainage Report
The total time and cost in order to conduct a full drainage analysis and feasibility report due to cost/time.

2.6.8.2.4 SWPPP
The total time and cost to conduct a full SWPPP analysis and design the appropriate plan sheets.

2.6.8.3 Construction Implementation

2.6.8.3.1 Site Obstruction Removal
The time and cost to removing any signs, asphalt, concrete, trees, shrubs, curbs, drainage, utilities, etc. that could be in the way of the construction path.

2.6.8.3.2 Excavation, Backfill, Embankment
The cost and time estimate to perform any excavation, structural backfill, and embankment for proper slopes on the passing lane.

2.6.8.3.3 Construction
The cost and time estimate in order to build culverts, pour asphalt or concrete, stripping, signage, topsoil, landscaping, etc.

2.6.8.4 Mobilization and Administration Costs

2.6.8.4.1 Contractor Mobilization
The cost and time estimate to mobilize the contractor and subcontractors to the job site and set up with equipment.

2.6.8.4.2 Traffic Control

The cost and time estimate to have flaggers, barriers, etc. to control the flow of traffic during construction.

2.6.8.4.3 Administrative

The cost and time that project engineers, managers, etc. will spend on the job site and/or working on the project.

2.7 Task 7: Project Management

2.7.1 Project Meetings

All meetings that take place involving the project should be documented and recorded. These meetings include team meetings, client meetings, technical advisor meetings, and grading instructor meetings.

2.7.2 Deliverables

All deliverables that will be submitted to either the grading instructor or to the client will be listed including both major and minor submittals. Examples of submittals may include a 30%, 60%, 90%, 100% plan sets, team website, construction drawings, and final documents.

2.7.3 Documentation

Document all deliverable drafts, team meetings, and design hours.

2.7.4 Manage Resources

2.7.4.1 Equipment

A list of all known equipment being used along with the amount of time that it is being used for should be listed and documented.

2.7.4.2 Materials

A list of all known materials that are going to be used should be listed and documented. The quantity of these materials should also be included in this section.

2.7.4.3 Transportation and Travel

Transportation of materials and workforce that are to be used at the site should be listed and documented for future use. If any travel is done for the project, the form of transportation, amount of time taken to travel, distance travelled, and estimated cost of travel should be documented and recorded.

3.0 Schedule

The schedule shows the tasks needed to insure the success of the highway 64 project for the CENE 486. The schedule is made based on the time the team thinks it will take to finish each task. Each task has its starting date, ending date, and how many days the team think it will take to complete the task. Please refer to the critical path, and the project schedule for more details about the tasks. Project Schedule is located as Attachment A.

4.0 Staffing Plan

The project staff will consist of a Project Manager (PM), Senior Engineer (SE), Engineer Step I (E), and a Drafter (D). To receive the title as Project Manager, the individual must have 10+ years in the engineering, accounting, or engineering related field, and possess a bachelor's degree from an accredited university/college. To receive the title of Senior Engineer, the individual must have 10+ years in the engineering or engineer related field, possess a bachelor's degree from an accredited university/college in engineering, and be a practicing professional engineer. To receive the title of Engineer Step I, the individual must possess a bachelor's degree from an accredited college/university in engineering. To receive the title of Drafter, the individual must possess a bachelor's degree from an accredited university/college in either engineering or architecture, and have at least 10 years of experience in the field. Shown below is the table of staffing hours, the majority of the hours fall onto the Engineer Step I, with the Senior Engineer and Drafter with about 15% less hours.

Table 1: Staffing Hours

	STAFF (hours)				
Task Name	Project Manager	Senior Engineer	Engineer Step I	Drafter	Task Total
1 Site Assessment	30	30	20	32	112
2 Hydrology and Hydraulics Analysis	0	12	18	24	54
3 Geotechnical Analysis	0	35	45	0	80
4.0 Highway Design	26	21	29	50	126
5 Traffic Control Plan	36	0	0	0	36
6 Design Plan Sets	102	106	88	88	384
6.1 Face Sheet	8	4	4	12	28
6.2 Roadway Sections Plan Sheets	0	10	10	10	30
6.3 Existing Conditions Plan Sheets	0	10	10	10	30
6.4 Roadway Construction Plan Sheets	0	10	10	10	30
6.5 Drainage Plan Sheets	0	10	20	20	50
6.6 SWPPP Sheet	0	10	0	10	20
6.7 Traffic Control Plan Sheets	2	12	6	16	36
6.8 Cost Estimate Report Sheet	92	40	28	0	160
7 Project Management	47	45	55	47	194
STAFF TOTAL	194	204	200	241	839

5.0 Cost of Engineering Services

The billing rates for each staff member are broken up as such, PM receives $100 an hour, SE receives $80 an hour, E receives $24 an hour, and D receive $26 an hour. [6] [7] [8] As seen in the table below, the benefits package for a state job are high, thus 30% of the salary was set as the benefit rate. Also shown is the 10% profit for each staff member to the company, coming out to a total of $322 per hour.

Table 2: Billing Rates

Billing Rates				
Staff	Cost per Hour	Benefits (%	Profit (%)	Cost Per Hour
Project Manager	$ 100	30	10	$ 140
Senior Engineer	$ 80	30	10	$ 112
Engineer Step I	$ 24	30	10	$ 34
Drafter	$ 26	30	10	$ 36

The final billing table is shown below for the entire project and for each staff member. The total hours and cost per hour are broken down for each staff member, detailing the cost of each staff member, and finally adding up the amount of hours, cost per hour, and job cost for the entire project as a whole.

Table 3: Billable Hours

Billable Services			
Staff	Hours	Cost per Hour	Cost Per Staff
Project Manager	194	$ 140	$ 27,160
Senior Engineer	204	$ 112	$ 22,848
Engineer Step I	200	$ 34	$ 6,800
Drafter	241	$ 36	$ 8,676
Totals	839	-----	$ 65,484

Any survey and gear will be borrowed from the lab and in which case, will not cost the job anything additional. Travel to and from the site is located in the table below, along with the final cost for all engineering services. Travel was estimated to be broken up between two trips to the site, $43 to rent a NAU van, and $0.22 per mile travelled.

Table 4: Cost of Travel

Cost of Travel					
	Van Cost per Day	Number of Days	Cost per Mile	Mileage	Total Cost
Staff	$ 43	2	$ 0.22	50	$ 136

6.0 References

[1] *A Policy on Geometric Design of Highways and Streets*. Washington: American Association of State Highway Officials, 2011.

[2] "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis," *ASTM International - Compass Login*. [Online]. Available: https://compass.astm.org/Standards/HISTORICAL/D6913-04.htm.

[3] B. B. Gordon, "Sampling of Soil and Rock," *ASTM International - Compass Login*. [Online]. Available: https://compass.astm.org/DIGITAL_LIBRARY/STP/SOURCE_PAGES/STP483.htm.

[4] B. Ruth, K. MacPetrie, M. Ali, C. Hillebrand, and N. Reisner, "State Route 64."

[5] Azdot.gov. (2018). [online] Available at: https://www.azdot.gov/docs/default-source/roadway-engineering-library/2014_adot_hydrology_manual.pdf?sfvrsn=6 [Accessed 25 Oct. 2018].

[6] "Project Management Manager," Salary.com, 2018. [Online]. Available: https://www1.salary.com/Project-Management-Manager-hourly-wages.html. [Accessed 6 November 2018].

[7] R. Thorne, "How Much Does a Civil Engineer Make Per Hour," Sapling, 10 January 2011. [Online] Available: hyyps://www.sapling.com/7750974/much-engineer-make-per-hour. [Accessed 6 November 2018].

[8] OWL GURU, "How Much Do Architectural Drafter Make?," OwlGuru, 2018. [Online]. Available: https://www/owlguru.com/career/architectural-drafters/salary/. [Accessed 6 November 2018].

Attachment A: SR-64 Capstone Proposed Passing Lane Schedule

ID	Task Name	Duration	Start	Finish
1	1 Site Assessment	2 days	Mon 1/14/19	Tue 1/15/19
2	1.1 Road Condition Assessment	2 days	Mon 1/14/19	Tue 1/15/19
3	1.1.1 Asphalt Condition	2 days	Mon 1/14/19	Tue 1/15/19
4	1.1.2 Shoulder Condition	2 days	Mon 1/14/19	Tue 1/15/19
5	1.2 Drainage Condition Assessment	2 days	Mon 1/14/19	Tue 1/15/19
6	1.2.1 Culvert Condition and Location	2 days	Mon 1/14/19	Tue 1/15/19
7	1.2.2 Wash Integrity	2 days	Mon 1/14/19	Tue 1/15/19
8	1.3 Soil Sampling	2 days	Mon 1/14/19	Tue 1/15/19
9	1.4 Right of Way Assessment	2 days	Mon 1/14/19	Tue 1/15/19
10	2 Hydrology and Hydraulics Analysis	30 days	Wed 1/16/19	Tue 2/26/19
11	2.1 Map Culverts	10 days	Wed 1/16/19	Tue 1/29/19
12	2.2 Hydrology	10 days	Wed 1/30/19	Tue 2/12/19
13	2.3 Hydraulics	10 days	Wed 2/13/19	Tue 2/26/19
14	3 Geotechnical Analysis	20 days	Wed 1/16/19	Tue 2/12/19
15	3.1 Sieve Analysis	6 days	Wed 1/16/19	Wed 1/23/19
16	3.2 Plasticity Index Analysis	6 days	Thu 1/24/19	Thu 1/31/19
17	3.3 Compaction Analysis	6 days	Fri 2/1/19	Fri 2/8/19
18	3.4 Soil Classification Report	2 days	Mon 2/11/19	Tue 2/12/19
19	4 Highway Design	13 days	Wed 2/27/19	Fri 3/15/19
20	4.1 Cross Sections	13 days	Wed 2/27/19	Fri 3/15/19
21	4.2 Plan View	8 days	Wed 2/27/19	Fri 3/8/19
22	4.3 Profile View	8 days	Wed 2/27/19	Fri 3/8/19
23	5 Traffic Control Plan	14 days	Wed 2/6/19	Mon 2/25/19
24	5.1 Phasing	8 days	Wed 2/6/19	Fri 2/15/19
25	5.2 Quantities	6 days	Mon 2/18/19	Mon 2/25/19
26	5.3 Duration	6 days	Mon 2/18/19	Mon 2/25/19
27	6 Design Plan Sets	83 days	Wed 1/16/19	Fri 5/10/19
28	6.1 Face Sheet	10 days	Wed 1/16/19	Tue 1/29/19
29	6.2 Roadway Sections Plan Sheets	15 days	Mon 3/18/19	Fri 4/5/19
30	6.3 Existing Conditions Plan Sheets	15 days	Wed 1/16/19	Tue 2/5/19
31	6.4 Structural Plan Sheets	15 days	Mon 3/18/19	Fri 4/5/19
32	6.5 Drainage Plan Sheets	15 days	Mon 4/8/19	Fri 4/26/19
33	6.6 SWPPP Sheet	15 days	Wed 2/27/19	Tue 3/19/19
34	6.7 Traffic Control Plan Sheets	10 days	Tue 2/26/19	Mon 3/11/19
35	6.8 Cost Estimate Report Sheet	83 days	Wed 1/16/19	Fri 5/10/19
36	6.8.1 Scoping	20 days	Wed 1/16/19	Tue 2/12/19
37	6.8.1.1 Survey	10 days	Wed 1/16/19	Tue 1/29/19
38	6.8.1.2 Work Plan	10 days	Wed 1/30/19	Tue 2/12/19
39	6.8.2 Preliminary Engineering Design	63 days	Wed 2/13/19	Fri 5/10/19
40	6.8.2.1 Plan Sheets	10 days	Mon 4/29/19	Fri 5/10/19
41	6.8.2.2 Geotechnical Investigation	10 days	Wed 2/13/19	Tue 2/26/19
42	6.8.2.3 Drainage Report	10 days	Mon 4/29/19	Fri 5/10/19
43	6.8.2.4 SWPPP	10 days	Wed 3/20/19	Tue 4/2/19
44	6.8.3 Construction Implementation	10 days	Wed 1/16/19	Tue 1/29/19
45	6.8.3.1 Site Obstruction Removal	10 days	Wed 1/16/19	Tue 1/29/19
46	6.8.3.2 Excavation, Backfill, Embankment	10 days	Wed 1/16/19	Tue 1/29/19
47	6.8.3.3 Construction	10 days	Wed 1/16/19	Tue 1/29/19
48	6.8.4 Mobilization and Administration Costs	44 days	Wed 1/16/19	Mon 3/18/19
49	6.8.4.1 Contractor Mobilization	5 days	Wed 1/16/19	Tue 1/22/19
50	6.8.4.2 Traffic Control	5 days	Tue 3/12/19	Mon 3/18/19
51	6.8.4.3 Administrative	5 days	Wed 1/16/19	Tue 1/22/19
52	7 Project Management	85 days	Mon 1/14/19	Fri 5/10/19
53	**7.1 Project Meetings**	**85 days**	**Mon 1/14/19**	**Fri 5/10/19**
54	7.1.1 Client Meetings	85 days	Mon 1/14/19	Fri 5/10/19
55	7.1.2 Team Meetings	85 days	Mon 1/14/19	Fri 5/10/19
56	7.2 Deliverables	85 days	Mon 1/14/19	Fri 5/10/19
57	**7.3 Documentation**	**85 days**	**Mon 1/14/19**	**Fri 5/10/19**
58	7.3.1 Meetings	85 days	Mon 1/14/19	Fri 5/10/19
59	7.3.2 Hours	85 days	Mon 1/14/19	Fri 5/10/19
60	**7.4 Manage Resources**	**85 days**	**Mon 1/14/19**	**Fri 5/10/19**
61	7.4.1 Equipment	85 days	Mon 1/14/19	Fri 5/10/19
62	7.4.2 Materials	85 days	Mon 1/14/19	Fri 5/10/19
63	7.4.3 Transportation	85 days	Mon 1/14/19	Fri 5/10/19