NORTHERN ARIZONA UNIVERSITY

NAU TRAFFIC STUDY

Final Proposal

Louis Sisto, Michael Talamantez, Faris Alradhi, Mshary Alkhamees

CENE 476

Table of Contents

List of Tables

List of Figures

List of Acronyms

Acronym	Description
TSE	Transportation & Systems Engineering
NAU	Northern Arizona University
AOI	Area of Interest
ADOT	Arizona Department of Transportation
MUTCD	Manual on Uniform Traffic Control Devices
AASHTO	American Association of State Highway and Transportation Officials
CAD	Computer Aid Draft

1.0 Project Understanding

This section includes background research of what the project may entail and developed technical aspects to serve as a basis of the overall implications throughout the course of project. The understanding of this project will provide the overall purpose, background, technical considerations with potential challenges and consider who the primary stakeholders might be. The following sections will provide further details of these topics.

1.1 Project Purpose

The purpose of this project is to mitigate the heavy discharge of traffic and pedestrians on McConnell, Pine Knoll and Huffer Lane around class start/end times. Currently, Pine Knoll has two, one-way roads that divert traffic out to McConnell and Lone Tree. A second northbound lane is reserved for campus transportation vehicles until the intersection of Pine Knoll Drive and McConnell Drive. The team will perform a traffic impact analysis in order to make recommendations to best serve both vehicle and pedestrian traffic.

Figure 1. Traffic congestion from McConnell Drive onto Pine Knoll Drive [1].

1.2 Project Background

The current conditions of the Northern Arizona University's roadway network requires the need for maintenance and improvements. It is understood that based on the background research, the major roads along McConnell Drive, Pine Knoll Drive and minor street Huffer Lane contain limited lanes that are shared with the public and public transportation. In addition to the traffic, parking lots (P61, P62, P47, and P46) will be included as part of the study. The project site is located southwest of Northern Arizona University (NAU) south campus in Flagstaff, Arizona showing in Figure 2.

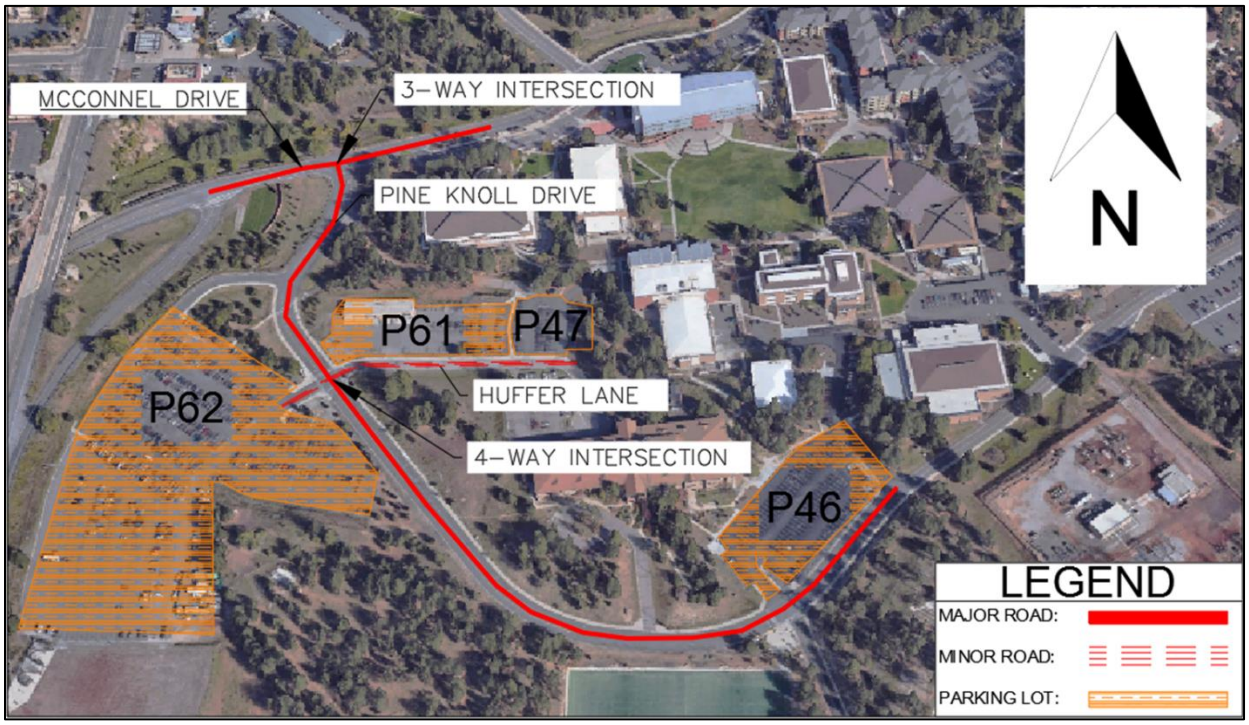

Figure 2. Project site location [12].

1.3 Technical Considerations

The technical components of this project include, but are not limited to surveying, occupancy data of the AOI (Area of Interest), volume analysis, and turning movement counts. The following sub-sections will provide a more detailed description of the technical considerations.

1.3.1 Occupancy Data

An Occupancy Analysis determines the number of vehicles that occupy the area of interest on an average day of the week. The data collected is used for initiatives regarding demand, availability

and average accumulation. The data is also be sued to determine the amount of traffic that the AOI adds to the main commuter traffic. In this case, the AOI are parking lots P62 and P62A.

Figure 3. Traffic congestion of parking lot P62 & P62A [1].

1.3.2 Volume Analysis – McConnell Exit Ramp 341

The amount of traffic that occupies an AOI is used to determine the solution most suited for existing conditions. For example, it would not be appropriate to install a traffic signal at an intersection that only experiences 12 cars an hour. This data affects the geometric design of any redesigns submitted by the team i.e. if the amount of trailers and heavy trucks is significant, the lane widths will need to be adjusted accordingly

1.3.3 Turning Movement Count

A Delay Analysis determines how long vehicles are stopped in a queue leading up to an intersection before they are permitted to pass through. The amount of time a vehicle is stopped, or delayed provides an indicator as to how well the intersection serves both vehicle and pedestrian traffic under current conditions. Currently, the intersection has students, and sometimes police officers that direct traffic. The traffic coordinators give preference to the major lines, which causes minor lanes to experience increased delay.

Figure 4. Huffer Lane, minor lane of AOI [1].

1.3.4 Surveying

Depending on the results of the previous forms of data collection, the team will perform the need to survey the AOI to gain a better understanding of current conditions of the geographic layout. This helps in the role of determining specific locations, planning, measuring and mapping property boundaries.

1.4 Potential Challenges

The traffic congestion occurs at specific times throughout the day that may or may not last more than an hour. Traffic congestion takes place within the 20-25 minutes intervals between classes. The potential challenges that may have an influence on the project improvement alternatives, is recognizing the exit ramp 341, located 280 feet west of the project area and integrates to the major road McConnell Drive. However, the challenge of the exit ramp will be addressed by taking the proper evaluations to accommodate the service and safety of the public.

Figure 5. McConnel exit ramp 143, onto McConnel Drive [1].

1.5 Stakeholders

The team's client is Greg Mace, who is the Facility Service: Engineer & Inspection Associate Director of the project. The stakeholders affected by the project are the city of Flagstaff residents, establishments along the vicinity, NAU students & faculty, users exiting the freeway ramp, Arizona Department of Transportation (ADOT), and NAU itself being that it is within their property line.

2.0 Scope of Services

Traffic & Systems Engineering (TSE) has been tasked with developing technical recommendations to best serve both vehicle and pedestrian traffic. The technical propositions will help mitigate the traffic congestion with an efficient transportation network, right of way

system, and provide safety to the public. The scope includes the tasks that TSE will complete to perform an impact assessment for each of the proposed designs. These designs will include a preliminary engineering assessment, technical reports and supporting drawings.

2.1 Task 1: Field Evaluation

2.1.1 Analysis of Existing Data

TSE will perform a site investigation of the AOI to gain a better understanding of existing conditions The sections below provide descriptions of the data and provided by Northern Arizona University Parking and Shuttle Services, NAU Police Department and the City of Flagstaff & Flagstaff Metropolitan Planning Organization.

2.1.1.1 Parking Lot Analysis

TSE will abide by the City of Flagstaff Division 10-50.80 Parking Standards during their evaluation of the Parking lots P61, P62, P47, and P46. According to the City of Flagstaff Zoning Code, these standards are to 'ensure that the parking needs of new land uses and development are met, while being designed and located in a manner consistent with the desired character and development patterns of the community and as outlined in the General Plan.

2.1.1.2 Analysis of Traffic Collisions

TSE will meet with the Police Records Coordinator, Bobbi J. Ortega and Corporal University Police, Joe Tritschler. The purpose of these meetings will be to collect traffic collision reports from 2013 to the present. The collisions involve the area of interest, collisions by month, by day and collision classification. TSE will evaluate the crash factors and incorporate with the geometric study.

2.1.1.3 2015 NAU Landscape Master Plan

TSE will review the NAU Landscape Master Plan in regards to their Principles, Standards, and Concept Design. The plans provide a guidance for TSE, pertaining to campus circulation, landscape, architectural design, sustainability, seasonal considerations, and accessibility to accommodate traffic users, pedestrians and bicyclists.

2.1.1.4 NAU Circulation Study

As part of the campus circulation analysis, TSE will consider NAU's Masterplan regarding Campus Circulation analysis and assessment for their understanding of NAU's campus

landscape functionality. According to the 2015 Landscape Masterplan, the primary concern of existing circulation routes is safety.

2.1.1.5 Signage

TSE will evaluate the signage around the area of interest, and consider whether the traffic signs provide explicit roadway safety to users and minimize uncertainties.

2.1.1.6 Striping/Curb and Pavement Markings

TSE will evaluate the existing striping conditions and pavement markings around the area of interest. TSE will determine if the project area requires additional markings to accommodate users, pedestrians and bicyclists.

2.2 Task 2: Mapping & Surveying

2.2.1 Establish Survey Control

In order to be of practical use in engineering design, a map's scale, orientation and height must be known and marked. In order to establish survey control, TSE will mark latitude, longitude and height of any features that can be seen on the map. These points will compared to the nearest benchmarks, or permanent points of reference, with known elevations.

The survey will cover the area including and surrounding the intersection of South Huffer Lane and East McConnell Drive. Since the survey will cover only a small area, the curvature of the Earth will not be taken into consideration. This method is known as plane surveying

2.2.2 Topographic Surveys

As mentioned in section 2.1, TSE will use the elevations of the closest benchmarks to the intersection for any survey work done in the area. This data will be collected utilizing surveying equipment, such as a total station and a TDS Recon Data Collector. The topographic information obtained will be operated, using both AutoCAD and SurveyPro. The maps generated in AutoCAD will help TSE measure the heights and areas of the landscape on either side of East Pine Knoll Drive. This data will help the team measure any cut/fill sections that will need to be accounted for in the event the team decides to redesign the existing roadway

2.3 Site Characterization

2.3.1 Traffic Impact Analysis

Since the traffic study project involves a limited degree of roadway configuration and technical recommendations, the following evaluations will be considered:

2.3.1.1 Occupancy Data

TSE will meet with the Director of Parking Services, Erin Stam, to determine occupancy data, or the number of cars that purchased passes for parking lots 61 and 62. Metrics will include the number of students that purchased passes for P61 and the number of students that purchase passes from the parking kiosks. This data will help determine the amount of cars that feed into the intersections of South Huffer Lane/East Pine Knoll Drive and East Pine Knoll Drive/East McConnell Drive. The lot by the Skydome, although affiliated with the "South Commuter" parking lot designation, is outside the Area of Interest (AOI), and will not be taken into consideration for Occupancy or redesign.

2.3.1.2 Volume Analysis

Currently, there is a high discharge of cars in the 20-25 minute intervals between classes. TSE will uses JAMAR boards to count the number and behavior of cars that pass through each of the intersections during these intervals. Traffic engineering studies dictate that studies must performed on either a Tuesday, Wednesday or Thursday. All other days of the week are subject to abnormal traffic patterns, so the team will perform these counts on an appropriate day of the week.

2.3.1.3 Delay Analysis

Under existing conditions, a traffic control director is used to waive traffic through the intersection. This creates a significant delay for minor lanes i.e. the parking lots on either side of East Pine Knoll. The team will measure the average delay experienced by traffic from all four corners of the intersection, including pedestrians.

2.3.1.4 Vehicle Classification Study

The purpose of this study is to identify the design vehicle for the AOI. The NAU campus transportation service frequently runs through the intersection. TSE will have to determine if the

frequency of busses is sufficient to render the NAU busses as the design vehicle for this intersection in place of a standard passenger vehicle

2.4 Design

TSE will determine the appropriate structure type for improving the traffic congestion, based on the recommendations provided from the field evaluation, traffic impact analysis, volume analysis, technical considerations, and impact assessment, as well as any other applicable information during the preliminary engineering study. As part of the technical recommendations, TSE has suggested a number of options below.

- Roundabout
- Roadway Extension
- Pedway with Bike Lane
- Pedestrian Footbridge

2.4.1 Geometric Study

TSE will develop a study plan and a geometric evaluation to develop an alignment of the current conditions that is suitable with impending improvements for the area of interest. The study will consider multiple alternatives and take into consideration:

- Manual on Uniform Traffic Control Devices (MUTCD)
- American Association of State Highway and Transportation Officials (AASHTO) Design Standards
- Right-Of-Way Requirements
- City of Flagstaff Transportation Engineering
- Arizona Department of Transportation
- Coconino County Planning & Zoning Ordinances

2.4.2 Environmental

TSE will verify if an environmental sustainability is to be determined, in protecting and enhancing the natural environment. The team will utilize their available resource agency information with the City of Flagstaff and ADOT within the project study area.

2.4.3 Economical

TSE will determine an economic feasibility analysis, considering the impending recommendation provide an economic benefit and development in regards to improving freight movement and congestion.

2.4.4 Social

2.5 Project Management

2.5.1 General Management and Meetings

Team will meet with client if necessary for any inquiries about the project. However, team will meet approximately on a weekly basis through the semester, and meet with the technical advisors as needed

2.5.2 Project Schedule

Scheduling is a big part of project management. The team will assign sub sections to each team member and set team due dates at least one day in advance of the actual due date. This way, the team can then review the material and submit to the grading instructor for initial feedback.

2.5.3 50% Design Report

Team will provide final aspects of the scope of services, project understanding, and background research for the final design on our 50% design report. The report will be submitted to the client for feedback on the final design.

2.5.4 Final Design Report

After the client, grading instructor, and technical advisor review our 50% report, the team will create the final draft of the project report. The Final Report will include all submittals of the design project including area of the project, new conditions of the design project, and computer aid draft (CAD) files.

2.5.5 Final Presentation

Final presentation slides will address all the deliverables and clearly explain the scope of the project. The audience of the presentation are professional Engineers, so the presentation must demonstrate a full understanding of the project, with respect to the needs of the client.

2.5.6 Website Production

TSE will provide a website for the design project that can be accessed through the NAU website. The design project can be found on NAU College of Engineering capstone projects website. The website page will include a brief biography of the team with pictures attached. It will also include pictures of the AOI and provide links to all Capstone submittals

2.6 List of Exclusions and Clarifications

1. The scope of this project is not subjected to change and accept any propositions into consideration.
2. Traffic & Systems Engineering will not consider any additional propositions to be incorporated given the timeframe of the project and will accommodate the needs of the client.
3. The appointed project manager will not determine approvals and correlate additional propositions subsequent to Spring 2017.
4. Traffic & Systems Engineering will not provide instructional manuals in regards to maintenance and repairs.
5. Traffic & Systems Engineering will not be liable for costs to operate and/or maintain the desired recommendations to best serve both vehicle and pedestrian traffic.
6. Traffic & Systems Engineering will not formulate a cost analysis for any construction designs or plan quantities.

3.0 Project Schedule

A descriptive project schedule is provided in the appendices (See Appendix A & B) following the arranged tasks and duration period for the given tasks provided. The schedule shows the approximate period to acquire each tasks within a given four months, from the time of anticipated award of contract through completion. However, TSE will continually monitor and update the schedule if there are any adjustments to the tasks, along with ensuring the milestones are met.

4.0 Cost of Engineering Services

The table below displays the tasks for each position: Senior Engineer, Project Engineer, Engineer In Training (E.I.T), and Intern.

Table 4.1. Illustrates positions and their respective responsibilities.

Positions	Qualifications
Senior Engineer	Transportation Specialty
Project Engineer	Traffic & Systems Specialty
Engineer In Training (E.I.T)	Traffic Systems Specialty
Intern	Traffic Data Collector Specialty

4.1 Projected Hours

The table below displays the number of hours for each position in accordance with the required project tasks. The total number of hours required to conduct the overall analysis is approximately 700 hours.

Table 4.1.1. Number of hours associated to position per tasks.

Task	Senior Engineer	Project Engineer	Engineer in Training	Intern	Total Hours
Task 1: Field Evaluation					
1.1 Analysis of Existing Data	10	20	35	35	100
Task 2: Mapping and Surveys					
2.1 Establish Survey Control	2	8	8	8	
2.2 Topographic Surveys	2	8	32	32	100
Task 3: Site Characterization					
3.1 Traffic Impact Analysis	Total Sum:	28	66	131	
3.1.1 Occupancy Data	3	8	25	35	
3.1.2 Volume Analysis	3	8	16	35	
3.1.3 Delay Analysis	2	8	15	35	
3.1.4 Vehicle Classification Study	1	4	10	26	234
Task 4: Design					
4.1 Geometric Study	3	5	20	20	
4.2 Environmental	2	8	15	16	
4.3 Social	2	6	15	16	
4.4 Economical	2	8	20	8	166
				Total	600

4.2 Staffing Plan

The cost of services includes the overall personnel and rental billing rates. The total cost of engineering services is approximately $80,900. The table below displays the number of hours for each classification along with their billing rates.

Table 4.2.1. Cost of engineering services.

Personnel	Classification	Hours	Base Pay Rate ($/Hour)	Benefits of Base Pay Rate ($)	Actual Pay ($/Hour)	Billing Rate ($/Hour)	Cost
	Senior Engineer	32	$ 120.00	50%	$ 185.00	$ 220.00	$ 7,040.00
	Project Engineer	91	$ 100.00	20.00%	$ 133.00	$ 160.00	$ 14,560.00
	Engineer In Training (E.I.T)	211	$ 50.00	25.00%	$ 95.00	$ 140.00	$ 29,540.00
	Intern	266	$ 25.00	30.00%	$ 83.00	$ 110.00	$ 29,260.00
Rental	Survey Equipment	100				$ 5.00	$ 500.00
Total:							$ 80,900.00

References

[1] L. Sisto, NAU Traffic Study. 2017.

[2] Northern Arizona University, CIVIL AND ENVIRONMENTAL ENGINEERING. 2017.

[3] United States Department of Transportation - Federal Highway Administration, "Chapter 4C - MUTCD 2009 Edition - FHWA", Mutcd.fhwa.dot.gov, 2017. [Online]. Available: http://mutcd.fhwa.dot.gov/htm/2009/part4/part4c.htm. [Accessed: 30- Jan- 2017].

[4] "FHWA - MUTCD - 2003 Edition Revision 1 Chapter 4C". Mutcd.fhwa.dot.gov. N.p., 2017. Web. 29 Jan. 2017.

[5] "Comparison of Turning Movement Count Data Collection Methods for a Signal Optimization Study," in Mio Vision, 2011. [Online]. Available: http://miovision.com/wp-content/uploads/URS_Whitepaper_May2011.pdf.

[6] M. Kyte and T. Urbanik, Traffic signal systems operations and design: An activity-based learning approach, First Edition ed. 2012.

[7] Manual on Uniform Traffic Studies, "Intersection Turning Movement Counts", http://mutcd.fhwa.dot.gov/, 2014. [Online]. Available: http://mutcd.fhwa.dot.gov/htm/2009r1r2/part4/part4_toc.htm. [Accessed: 31- Jan- 2017].

[8] U.S. Department of Transportation Federal Highway Administration, "Part 4 Highway Traffic Signals", 2009. [Online]. Available: http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/part4.pdf. [Accessed: 01- Feb- 2017].

[9] M. Mamlouk, Ph.D., P.E., "Effect of Traffic Roundabouts on Safety in Arizona", National Transportation Center at Maryland (NTC@Maryland), Maryland, 2016.

[10] Federal Highway Administration Office of Safety, "Intersection Safety Roundabouts - Safety | Federal Highway Administration", Safety.fhwa.dot.gov, 2017. [Online]. Available: http://safety.fhwa.dot.gov/intersection/innovative/roundabouts/fhwasa10006/. [Accessed: 01- Feb- 2017].

[11] Google Images, Aerial view of Northern Arizona University campus. 2017.

[12] 2017 Autodesk Inc., Civil 3D 2017 Imperial. 2017.

Appendices

Appendix A: Figure 6. Traffic congestion of parking lot P62 & P62A [1]

Appendix B: Figure 2. Project site location [12].

Appendix C: Figure 3. Traffic congestion of parking lot P62 & P62A [1].

Appendix D: Figure 4. Huffer Lane, minor lane of AOI [1].

Appendix E: Figure 5. McConnel exit ramp 143, onto McConnel Drive [1].

Appendix F: Table 4.1. Illustrates positions and their respective responsibilities.

Appendix G: Table 4.1.1. Number of hours associated to position per tasks.

Appendix H: Table 4.2.1. Cost of engineering services.

Appendix I: Figure 11. Project schedule Gantt Chart.

Appendix A

Figure 6. Traffic congestion from McConnell Drive onto Pine Knoll Drive [1].

Appendix B

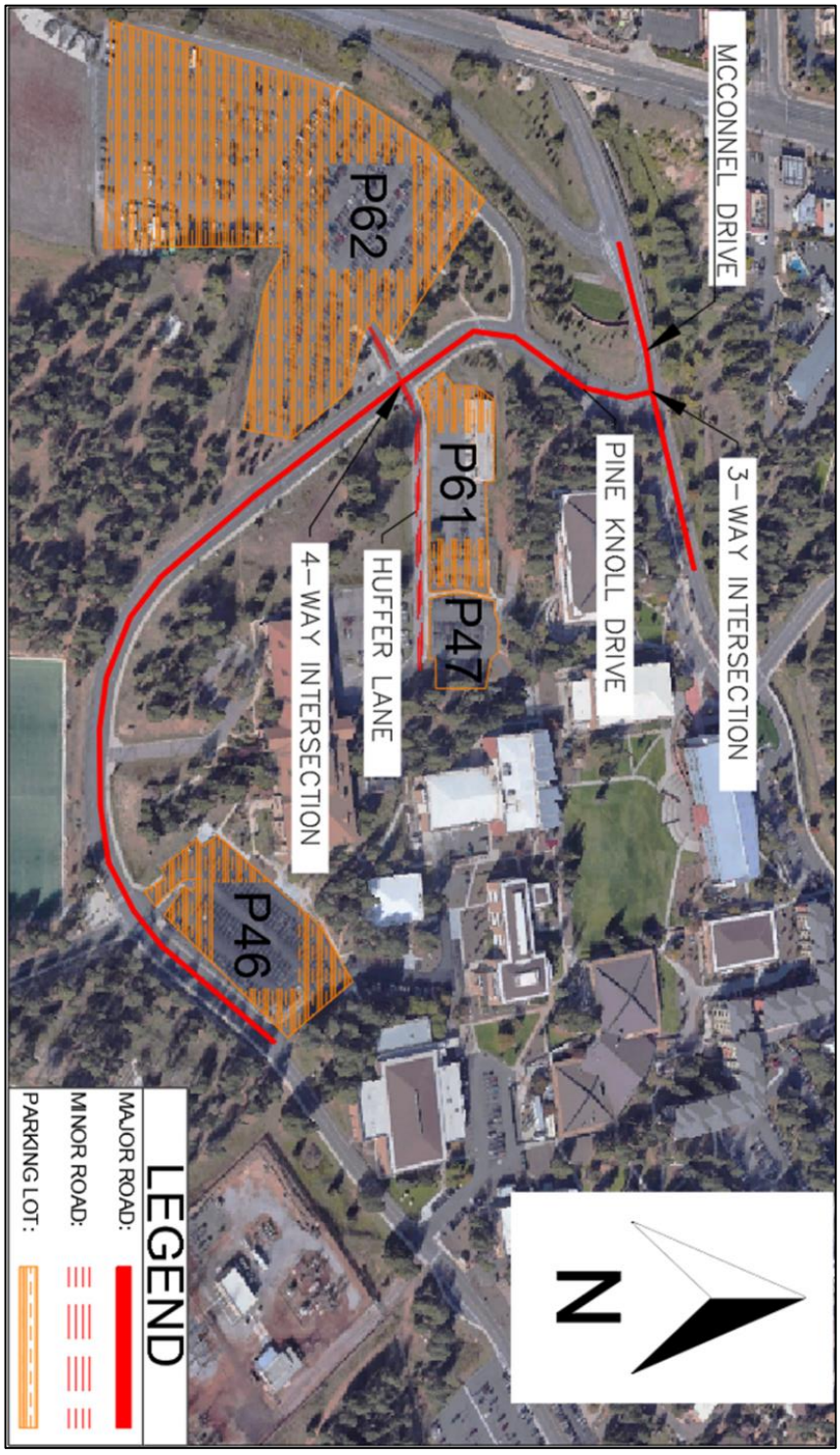

Figure 7. Project site location [12].

Appendix C

Figure 8. Traffic congestion of parking lot P62 & P62A [1].

Appendix D

Figure 9. Huffer Lane, minor lane of AOI [1].

Appendix E

Figure 10. McConnel exit ramp 143, onto McConnel Drive [1].

Appendix F

Table 0.1. Illustrates positions and their respective responsibilities.

Positions	Qualifications
Senior Engineer	Transportation Specialty
Project Engineer	Traffic & Systems Specialty
Engineer In Training (E.I.T)	Traffic Systems Specialty
Intern	Traffic Data Collector Specialty

Appendix G

Table 0.1. Number of hours associated to position per tasks.

Task	Senior Engineer	Project Engineer	Engineer in Training	Intern	Total Hours
Task 1: Field Evaluation					
1.1 Analysis of Existing Data	10	20	35	35	100
Task 2: Mapping and Surveys					
2.1 Establish Survey Control	2	8	8	8	
2.2 Topographic Surveys	2	8	32	32	100
Task 3: Site Characterization					
3.1 Traffic Impact Analysis	Total Sum:	28	66	131	
3.1.1 Occupancy Data	3	8	25	35	
3.1.2 Volume Analysis	3	8	16	35	
3.1.3 Delay Analysis	2	8	15	35	
3.1.4 Vehicle Classification Study	1	4	10	26	234
Task 4: Design					
4.1 Geometric Study	3	5	20	20	
4.2 Environmental	2	8	15	16	
4.3 Social	2	6	15	16	
4.4 Economical	2	8	20	8	166
				Total	600

Appendix H

Table 0.1. Cost of engineering services.

Personnel	Classification	Hours	Base Pay Rate ($/Hour)	Benefits of Base Pay Rate ($)	Actual Pay ($/Hour)	Billing Rate ($/Hour)	Cost
	Senior Engineer	32	$ 120.00	50%	$ 185.00	$ 220.00	$ 7,040.00
	Project Engineer	91	$ 100.00	20.00%	$ 133.00	$ 160.00	$ 14,560.00
	Engineer In Training (E.I.T)	211	$ 50.00	25.00%	$ 95.00	$ 140.00	$ 29,540.00
	Intern	266	$ 25.00	30.00%	$ 83.00	$ 110.00	$ 29,260.00
Rental	Survey Equipment	100				$ 5.00	$ 500.00
Total:							$ 80,900.00

Appendix I

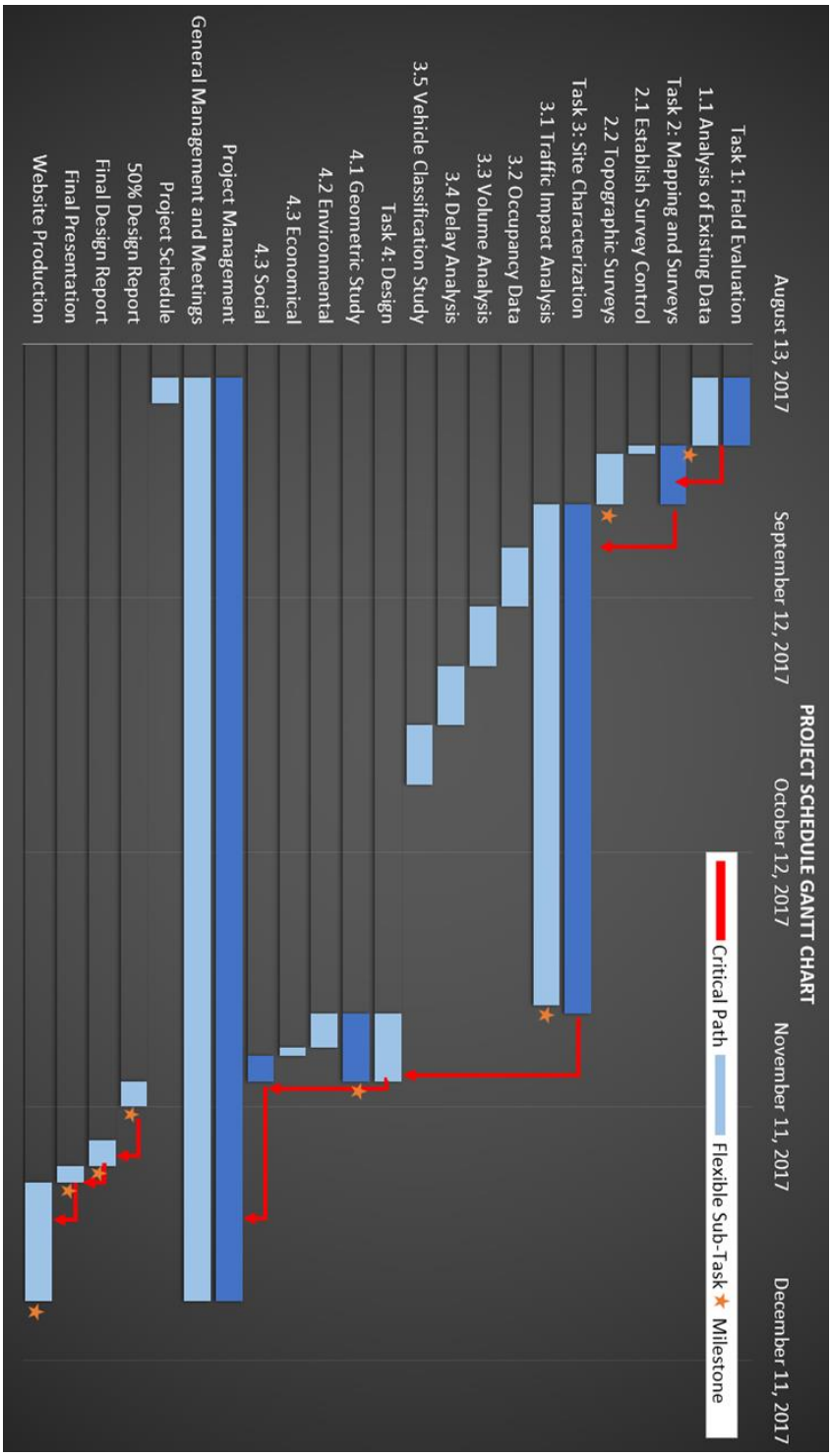

Figure 11. Project schedule Gantt Chart.

Appendix J