CENE 486C – NAU Graduation Traffic Circulation Capstone Team

10th December, 2019
Nate Reisner
ADOT NorthCentral District Development Engineer
Arizona Department of Transportation
Flagstaff, Arizona

Subject: Letter of Transmittal

Dear Mr. Reisner,

This Final Design Report contains the work completed for the NAU Graduation Traffic Study and Traffic Management Plan. The 30% milestone included the complete September 2019 baseline traffic study as well as the completed May 2019 NAU Graduation traffic study. The Team completed the baseline and graduation traffic studies using Jamar Boards for traffic volume and turning movements. The Team also utilized road tube counters at the ingress leg of the four study intersections to collect traffic volumes over both graduation weekend May 2019 and from the 19th to the 26th of September 2019.

The 60% milestone includes the complete VISSIM traffic model analysis of the four campus ingress intersections studied. Using the Jamar board data from graduation, the Team built VISSIM models for all four intersections using the current roadway geometry. The models analyzed the current and projected population growth performance of the intersections and guided traffic management solutions to both the Arizona Dept. of Transportation and the NAU Police Dept., which are included in this 90% Design Report. Also included are the societal, economic, and environmental impacts of the recommended traffic management solutions.

Sincerely,

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Northern Arizona University May 2019 Traffic Study and Circulation Recommendations to Improve Traffic Flow During Graduation Events

NAU Traffic Capstone Team

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CENE 486C EGR Design: Final Design Report– Fall 2019

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Clients: Nate Reisner, NAU PD, and NAU Parking Services

10th December, 2019

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ACKNOWLEDGMENTS

- Greatest appreciation to Dr. McDonnell, the grading instructor, for her constant supervision and guidance with the traffic capstone study progression.
- Special thanks to the technical advisors, Dr. Smaglik and Mr. Reisner P.E., for their constructive suggestions and insight in utilizing Vissim software and providing Jamar Boards for data collection.
- Many thanks to Grace Garwin with her Microsoft Project gantt chart scheduling help.
- Deepest gratitude to Ms. Stephanie Sarty, for providing and her assistance in collecting the data from the road tube counters, as well as providing raw ingress and egress volume count data.
- Special thanks to classmate Abdullah Alenezi for his devoted assistance with the Team's Capstone Project website.
- Last but not least, much appreciation to classmate David Lemcke for his assistance and guidance in utilizing Vissim software.

EXCLUSIONS

This project does not include notifications to the public about the condition of the university's environment pertaining to traffic. Site survey and analysis of the hydrological nature of the study area are also not included in the report. This project does not design any finalized roadway geometry changes, only recommendations for traffic routing and suggested geometry changes.

1. INTRODUCTION

1.1 Project Purpose

The Northern Arizona University (NAU) graduation traffic management plans aims to reduce event travel delay, congestion, fuel waste, and air pollution, as well as increase patron enjoyment of the ceremonies and enhance public safety. The May and September 2019 traffic studies, VISSIM traffic model analysis, projected growth of NAU's population, the recommended NAU special event traffic management plan of three provided alternatives with their cost estimations, and the project's impact analysis. The three management alternatives include low cost investment, moderate university investment, and high cost investment.

1.2 NAU Graduation Traffic Congestion

NAU's graduation ceremonies take place at the NAU Sky-Dome on South Campus on Friday and Saturday mornings and afternoons in Mid-May and Mid-December. The historic ingress point for patrons attending ceremonies prior to December 2018 was solely from Interstate 17 northbound onto the McConnell Drive East Exit in South Flagstaff. During the 2 hours leading up to the start of each graduation ceremony, patrons attempting to exit I-17 and park on NAU's South Commuter Parking Lot P62 would jam the local campus roadway network and back traffic up onto both I-17 northbound and I-40 westbound. Changes implemented for the December 2018 graduation ceremonies by NAU PD and ADOT rerouted traffic down two routes, McConnell and Lake Mary Road, to reduce the interstate and surface street congestion due to the McConnell Drive/I-17 Exit pinch-point. Figure 1 shows the study intersections on NAU campus and the areas of historic interstate graduation traffic congestion. Figure 2 shows the project location in Arizona, and the study intersections.

The design alternatives are based on Flagstaff population and the projected NAU student population guided recommendations. As established by the US Census Bureau, Appendix A1 shows the population and annual growth rates from 1900 to 2018 for the

City of Flagstaff [1]. Appendix A2 shows a graphical representation of historic annual population growth, which ranges from 1.5 to 2.5% over the same time period. An assumed rate of 2% annual city and campus population growth was considered to account for future traffic volumes up to 20 years out [1]. This percentage estimation helps in the traffic volume modeling analysis by determining how the intersections would perform with larger nearby city populations and larger campus populations. NAU's population is projected to cap out at 25,000 students at its Flagstaff Mountain Campus by 2020 [2]. The Flagstaff population is expected to reach 91,000 people by 2030, and the NAU Flagstaff Mountain Campus will remain at its cap of 25,000 students [1, 3]. However, NAU owns more undeveloped land south of I-40 and the 25,000 student enrollment cap at the Flagstaff Mountain Campus may be raised further and increase the size of graduation events.

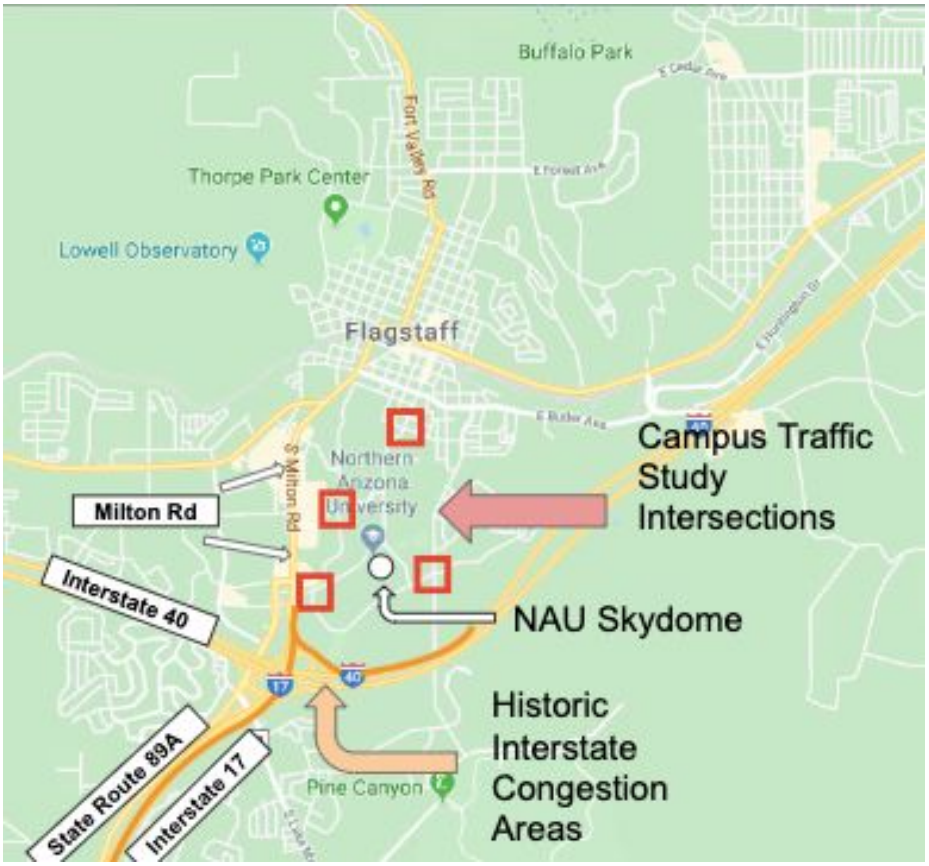


Figure 1: NAU Campus, Traffic study intersection locations on campus, and historic graduation traffic congestion areas on Interstates 17 and 40 [1].

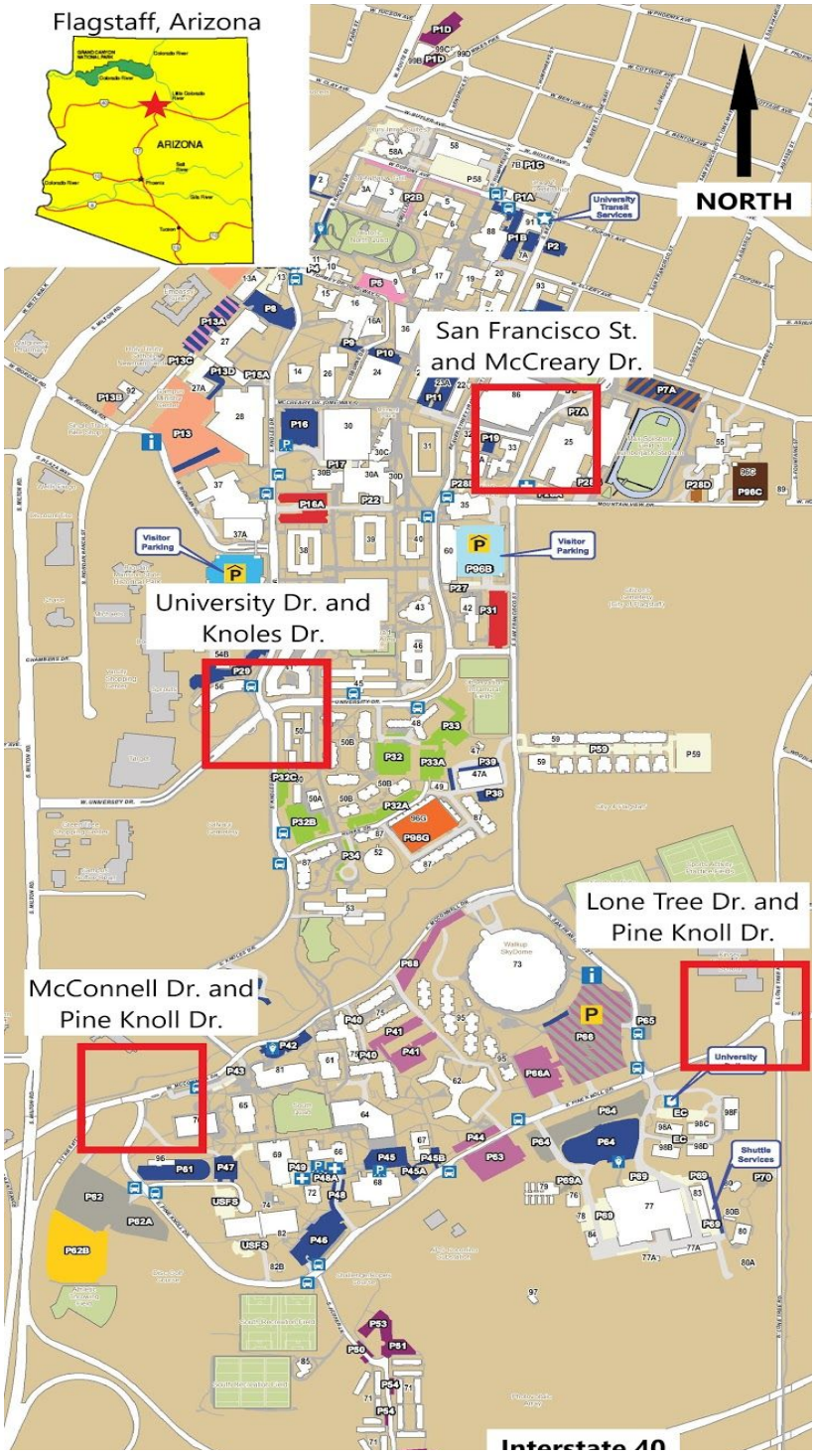


Figure 2: Included in top left above is a map of Arizona State that highlights Flagstaff AZ. To the right of the state map is a map of NAU's campus roadways, the four study intersections highlight in (red) [4].

The backed up traffic on interstates is dangerous for event-goers, law enforcement, and travelers near campus [5]. The backups concerned the officials at the Arizona Department of Transportation (ADOT) as well as the NAU Police Department. Mr. Nate Reisner, the North-Central District Development Engineer for ADOT, requested that traffic volumes for the May 2019 Graduation Ceremonies be collected and campus traffic management alternative plans be developed. Sergeant Joseph Tritschler, of NAU PD, also requested that traffic volumes be collected for the May 2019 Graduation Ceremony in order to better inform the NAU PD how to solve and improve traffic problems [5].

ADOT and NAU PD created an alternate ingress route for event-goers to take in December 2018 for the Fall Semester Graduation Ceremonies. It was established to reduce the McConnell Drive Exit backup and improve campus traffic flow by providing two routes onto south campus. The alternative route used the Lake Mary Road Exit to J.W. Powell Blvd to Lone Tree Road. From Lone Tree Road, traffic was directed to Pine Knoll Drive where motorists could park at either the Sky-Dome, San Francisco Parking Garage, or Lot P62. This alternative route proved successful during both the December 2018 and May 2019 Ceremonies. Traffic back-ups onto I-17 and I-40 were reduced significantly to the point of near elimination [5]. See Appendix B for the original McConnell Dr. Route via I-17 and new alternate Lake Mary Road/Lone Tree Road Route onto NAU South Campus.

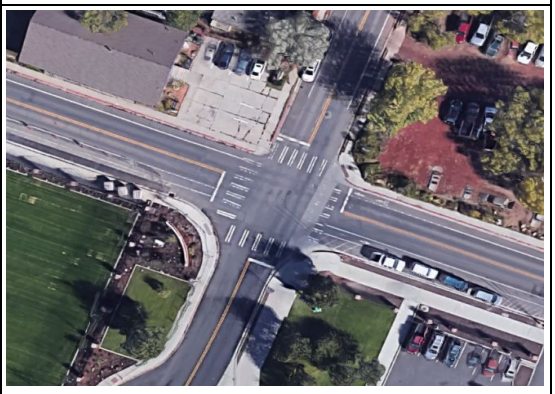
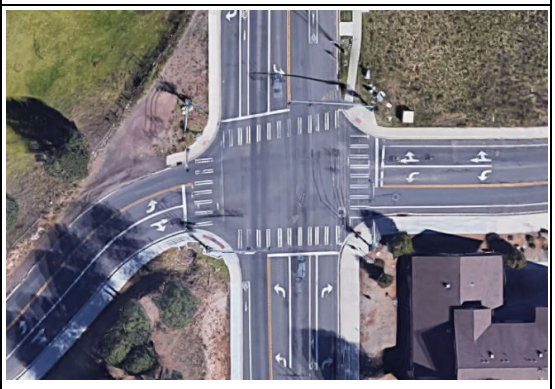
2. TRAFFIC MOVEMENT AND VOLUME COUNT

2.1 Overview

The graduation and baseline traffic count and turning movement data was collected at the four ingress intersections on the NAU campus border, shown in Figure 1. The ingress intersections were the only access points to NAU Campus and provided the ability to capture the majority of vehicular traffic attending the event. Table 1 summarizes the traffic issues affecting each study intersection. The turning movement

and traffic volume data were collected for four study intersections during May 2019 graduation event by utilizing the Jamar boards and road tube counters. Appendix C1-C4 show the turn-movement volume data collection from the Lone Tree Rd/Pine Knoll Dr. intersection, San Francisco St/Franklin Ave, University Dr/Knoles Dr, and McConnell Dr/Pine Knoll Dr Jamar Boards, respectively.

Table 1: NAU Study Intersections and Associated Traffic Issues during Heavy Congestion [6]

Int. No.	Location Name	Traffic Issue(s)	Geometry Illustration
1	University Dr & Knoles Dr	Bus route, pedestrian traffic, heavy vehicle traffic, and nearby trail crossing stop-light backing traffic into intersection from east	
2	San Francisco St & Franklin Ave	Pedestrian traffic, single-lane roadway geometry, bicycle traffic, and limited right-of-way	
3	Pine Knoll Dr & Lone Tree Rd	Pedestrian traffic and large NB left turning volume from Lone Tree	
4	McConnell Dr & Pine Knoll Dr	Very high vehicle volumes exiting from freeway, bus route, and restricted right-of-way	

A site assessment at all four intersections and nearby campus entrance segments of access roads to help define the site constraints. Since the jamar boards require manual operation, personnel were required to be present on site for the traffic study. A safety plan was developed to ensure the safety of Jamar board operators, bicyclists, pedestrians, and motorists. A singular point of observation was chosen for each intersection to maintain consistency in data collection and personnel/public safety.

The roadway geometry survey of the lane width and pavement design determined the most suitable road tube counter device to install. University Drive has a landscaped median that suits using two shorter road tube counters. The longer tube counters are in short supply from the City of Flagstaff. Utilizing the road tube counter setup helped to ensure adequate data collection at all four roadway segments across campus. The other three intersections used longer road tube counters.

The team adhered to the following safety procedures during the application and removal of road tube counters. Teams of two or three people would work together to place/remove the tube counter equipment. One or two people work on the equipment, and the remaining person stand as far from the road shoulder, about 5-10 feet, as team member(s) removing/placing the equipment. The remaining person was the flagger for oncoming traffic and stood up-road from the working crew. This person would signal/warn oncoming drivers of the people working in the road to protect motorists and workers.

2.2 Baseline Traffic Volume

A baseline road tube counter study was conducted September 19th to 26th, 2019 by NAU Traffic Capstone Team to collect NAU campus ingress and egress traffic volumes. The baseline study was conducted to determine the magnitude of graduation traffic compared to normal conditions. Appendix D displays the baseline AutoCAD flow map for both ingress and egress volumes, as well as the directional traffic flow. In addition, daily road tube counter traffic volumes pertaining to the study intersections are shown in Appendix E1-E3. The appendices made clear the following observations:

- The McConnell & Pine Knoll intersection is an area in NAU that has the highest traffic volume during both baseline and event traffic of the four study intersections.
- There is reduction of overall baseline traffic ingress on San Francisco St. due to the street's location on northeast campus. Baseline traffic chooses San Francisco St. for egress from campus and regularly about half of that baseline volume chooses the street for campus ingress.

2.3 Graduation Traffic Volume

A graduation traffic study was conducted during the May 2019 Commencement Ceremonies on Friday and Saturday May 10th and 11th, 2019. Jamar Boards were operated from 8 to 11am on Friday May 10th during the first commencement ceremony to collect traffic volumes and turning movements at the four study intersections. Road tube counters were placed at the ingress leg at each study intersection to collect traffic volumes from May 9th to the 13th. See Table 2 for the overall ingress and egress traffic at the study intersections. See Appendix F for the graduation flow map showing both ingress and egress volumes, as well as the directional traffic flow.

Daily road tube traffic study volumes are depicted by Appendix G1-G4. The graphs show data from May 9th through May 13th. It is noted that McConnell and Pine Knoll intersection has the highest amount of ingress traffic volume of all the intersections studied for both the Jamar Boards and road tube counters.

Table 2 summarizes the overall intersections' tube counter ingress and egress traffic volumes for the graduation and baseline studies from 8a-11am on May 10th and September 20th, 2019, respectively. The collected raw data from the road tube counters for baseline and graduation studies are shown in Appendix H1-H4 and Appendix H5-H, respectively. Table 3 summarizes the observed graduation parking lot volumes compared to respective lot capacities. Appendix I in Appendices section shows the locations on NAU Campus of the parking lots used for graduation traffic.

Table 2: Graduation and Baseline Traffic Study Road Tube Volumes

Intersection	Total Vehicles 8a-11a on Friday, September 20, 2019		Total Vehicles 8a-11a on Friday, May 10, 2019		Delta Graduation vs. Baseline	
	Ingress	Egress	Ingress	Egress	Ingress	Egress
1. University Dr and Knoles Dr	632	538	931	802	+ 299	+ 264
2. San Francisco St and Franklin Ave	13	120	843	637	+ 830	+ 517
3. Lone Tree Rd and Pine Knoll Dr	623	402	655	682	+ 32	+ 280
4. McConnell Dr and Pine Knoll Dr	941	671	1517	694	+ 576	+ 23

Table 3: May 2019 Observed Parking Lot Volumes vs. Lot Capacity

Parking Lot	Volume Observed	Capacity	Full? (Yes/No)
P64	392	392	Yes
P66	490	490	Yes
P63	161	161	Yes
P45	96	96	Yes
P62 (South Commuter Lot)	700	700	Yes
P96B (San Francisco Garage)	900	1200*	No

*Estimated capacity with garage ramp parking not allowed during graduation events.

3. VISSIM ROAD SIMULATIONS

Verkehr In Städten - SIMulations modell (German for Traffic in Cities Simulation model) (VISSIM) software modeled and simulated the studied intersections for both baseline and graduation traffic volumes, roadway and intersection geometry, traffic volumes, and pedestrian/bicyclist traffic in each intersection. The software was used for the existing roadway geometry to model the graduation and baseline traffic studies. Changes to the roadway geometry is costly, and the only portion of the project that features any possible geometry changes is the ideal (expensive) traffic management plan presented to NAU PD, NAU Parking, and ADOT, which conveys a roundabout construction.

Individual VISSIM models were built for each of the four study intersections using the existing roadway geometry. Signal timing, permitted movements through intersections, traffic

volumes, and pedestrian routing used in the model matched conditions present during the May 2019 Graduation ceremonies. The VISSIM models simulated the traffic conditions during graduation using the collected May 2019 data.

May 2019 traffic volumes were increased by 2% per year for 20 years to project future student and city population growth through the year 2040. This assumption is based off of the 2019 NAU Strategic Plan and the 2012 Flagstaff Regional Plan [7]. See Figure 3 below for the possible growth of the City of Flagstaff through the year 2040. The new traffic volumes were entered into the VISSIM models for each intersection to test the performance of current geometry, signal timing, and graduation traffic plan under future conditions. All four intersections performed well with no persistent vehicle queues forming on any legs of any intersection. The San Francisco St. and Franklin Ave. intersection experienced intermittent traffic backups, but congestion was short-lived and localized. See Figure 4 for the VISSIM models of the study intersections.

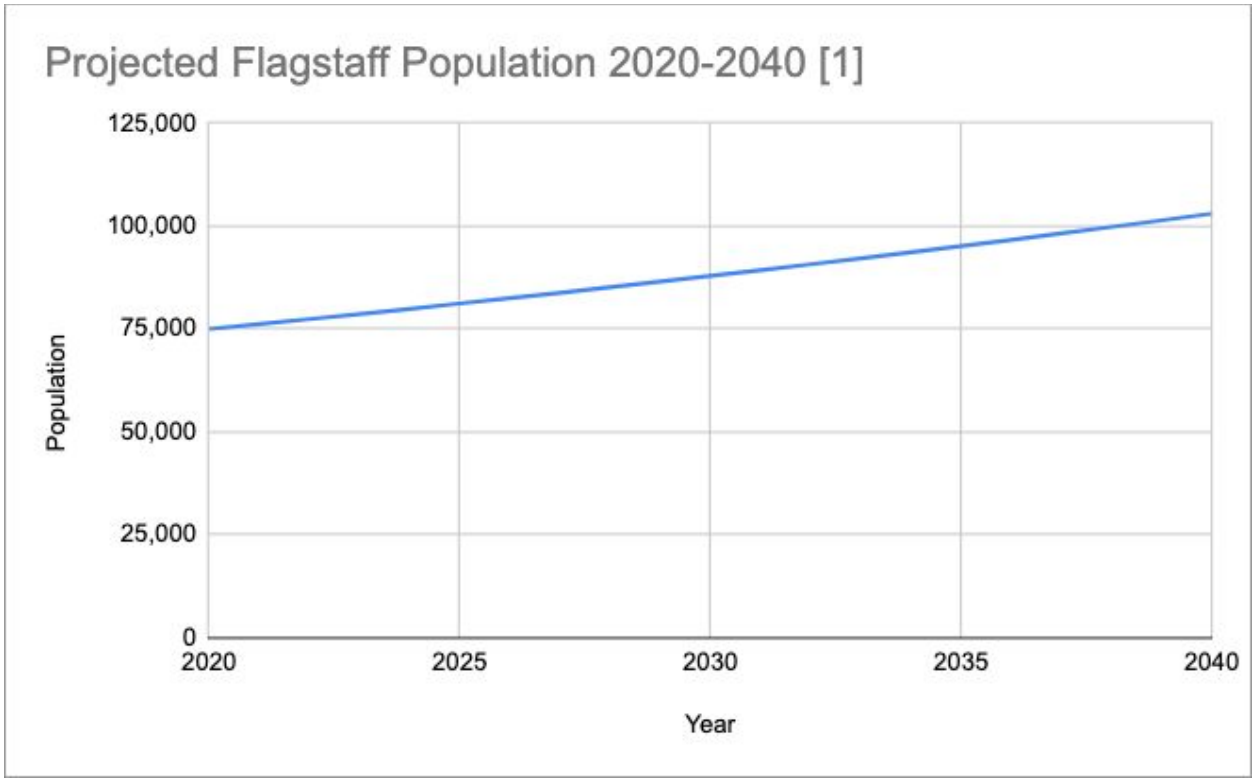
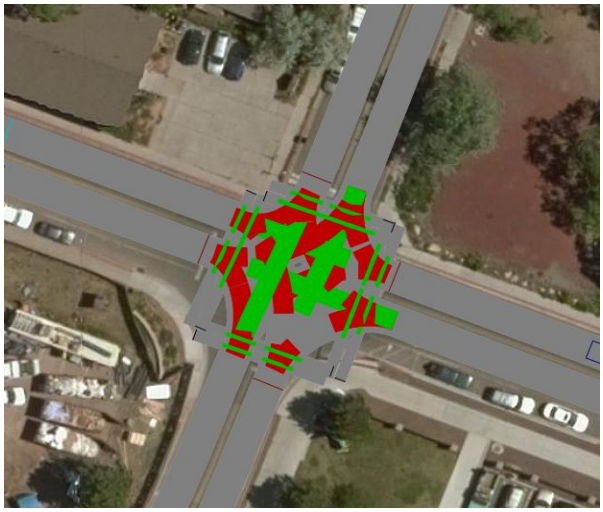


Figure 3: Projected Flagstaff city population from 2020 to 2040 [1].

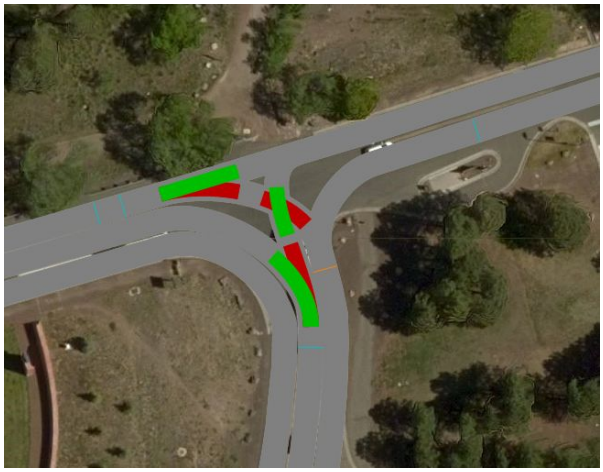
1. University Dr and Knowles Dr

2. San Francisco St and Franklin Ave



3. Lone Tree Rd and Pine Knoll Dr

4. McConnell Dr and Pine Knoll Dr



LEGEND

Right of Way (Major Road)
Yield/Stop (Minor Road)

Figure 4: VISSIM Models of Study Intersections

The green color indicates the main road (right-of-way) which means that the driver is allowed to cross first. Whereas the red color indicates the minor road (yield) which means that the driver would stop and observe that approaching vehicles first [8].

4. TRAFFIC MANAGEMENT RECOMMENDATIONS

4.1 Short-Term Alternative Plan

The short-term plan is based on traffic volume analysis and VISSIM roadway modeling for the year 2025. This plan requires minimal amounts of funding so that the University can focus its current resources more efficiently and effectively. Any additional costs recommended are relatively small (several thousand dollars) for additional road signs and traffic operators.

Short-term recommendations include a new traffic management plan that utilizes more staffing, more signage, and more traffic cones/barricades to help move traffic safely and efficiently. The goal is to improve efficiency and address observed problem areas of traffic backups and driver confusion from the May 2019 graduation. This solution also maintains very low additional investment, by utilizing staff provided by NAU PD or NAU Parking Services to direct traffic at the primary intersections. Additionally this short-term recommendation includes maintaining the current NAU PD plan of rerouting traffic down the Lake Mary Rd. route for event ingress to reduce traffic on the McConnell Dr./I-17 exit on south campus. Table 4 lists the short-term recommendations for all study intersections' roadway improvements and their cost estimates.

Table 4: Short-term Roadway Recommendations

Improvements	Cost Estimation [2020 Dollars]	Total Cost
● Rent electronic changing message highway signs for interstate and surface street traffic	~$750/week for each rental sign needed (10 signs recommended) [9]	$7,500
● Traffic operators (student workers or NAU Police Officers)	~$1,600/day for 14 student workers working 12 hour shifts [10]	$3,200
● Rent additional traffic safety cones	$10/cone/week [11]	$5,000

● Promote public transit (bus service) usage for in-town event-goers	$430 (each semester) [12]	$430
Total cost for one Graduation (Friday, Saturday)		$16,130

4.2 Mid-Term Alternative Plan

The mid-term period recommendation plan for 2025-2030 addresses more complex projects which require moderate investment on the University's part for new/more equipment and more personnel to satisfy future development needs as the campus and City of Flagstaff grow. Mid-term recommendations include utilizing more University transit shuttles to move pedestrians from one parking location to the main event at the Northern Arizona University Skydome. The main goal of utilizing shuttles is to reduce the volume of cars traveling on south campus where the main congestion occurs and to direct them to the San Francisco and Knoles Parking Garages. It should be noted that the mid-term recommendations also include the short-term recommendations provided, which include more staffing, more signage, more traffic cones/barricades.

Guests that utilize the parking garages on North Campus have the option to either walk to the event located on South Campus or the ability to arrive on the shuttle buses that pick up guests every 10 minutes from the parking garages on Central Campus. Uber and Lyft services also currently utilize the parking garages for guest drop off locations which forces the guests to either take a shuttle or walk from this location. The mid-term recommendations encourage using University shuttles and Mountain Line city busses before Uber and Lyft since more passengers per vehicle can be delivered with busses than taxis. The recommendation doesn't remove Uber/Lyft access to the Skydome, however. Table 5 lists the mid-term recommendations for the study intersections' roadway improvements and their cost estimates.

Table 5: Mid-term Roadway Recommendations

Improvements	Cost Estimation [2028 Dollars]	Total Cost
● Increase Shuttle Van Service to every 10 minutes on campus (from current 15 minute service)	$4,680/2 days for South Commuter and San Francisco Garage [13]	$4,680
● Promote public transit (bus service) usage for in-town event-goers	$300 for 3 A-Frame signs at the downtown bus connection center and mall connection center [12]	$470
● Rent electronic changing message highway signs for interstate and surface street traffic	~$930/week for each rental sign needed (10 signs recommended) [9]	$9,300
● Rent additional traffic safety cones	$12/cone/week [11]	$6,000
● Traffic operators (student workers or NAU Police Officers)	~$2,000/day for 14 student workers working 12 hour shifts [10]	$4,000
● Use Knoles Parking Garage as spillover if San Francisco Garage is full	$1,170/day [14]	$2,430
Total cost for one Graduation (Friday, Saturday)		$23,090

4.3 Long-Term Alternative Plan

The long term recommendations provided in this report address expensive projects that would be designed to accommodate a 20 year period at NAU and the City of Flagstaff. Therefore this long term recommendation included changes in roadway geometry as well as a roundabout for the intersection of McConnell Dr. and Pine Knoll. A roundabout is a type of intersection that requires traffic to rotate counter-clockwise around a center island in constant motion, only yielding to oncoming traffic [15]. The main goal of this roundabout is to provide free flow traffic movement at this intersection during normal peak hours as well as during the special event which would require additional time for funding and high capital investment by NAU as the project study progresses. Table 6 lists the long-term recommendations for the study intersections'

roadway improvements and their cost estimates. See Figures 5, 6, and 7 for the traffic circulation plan for routing traffic down JW Powell Blvd.

Table 6: Long-term Roadway Recommendations

Improvements	Cost Estimation [2040 Dollars]	Total Cost
● Roundabout Construction at McConnell and Pine Knoll	~$500,000 [16]	$500,000 (one time)
● Route traffic down a new alternate route on JW Powell	$6,600/ 2 days for 2 additional Police Officers [17]	$6,600
● Additional Park'N'Ride Bus shuttle from Knoles Parking Garage (Spillover)	$2,912/ 2 days for 2 additional shuttles [14]	$2,912
● Promote public transit (bus service) usage for in-town event-goers	$470 (each semester) [12]	$500
● Shuttle Van Service every 10 minutes on campus	$2,900/day for South Commuter and San Francisco Garage [14]	$5,800
● Rent electronic changing message highway signs for interstate and surface street traffic	~$1,100/week for each rental sign needed (10 signs recommended) [9]	$11,000
Total capital cost for one roundabout and Graduation (Friday, Saturday)		$528,112

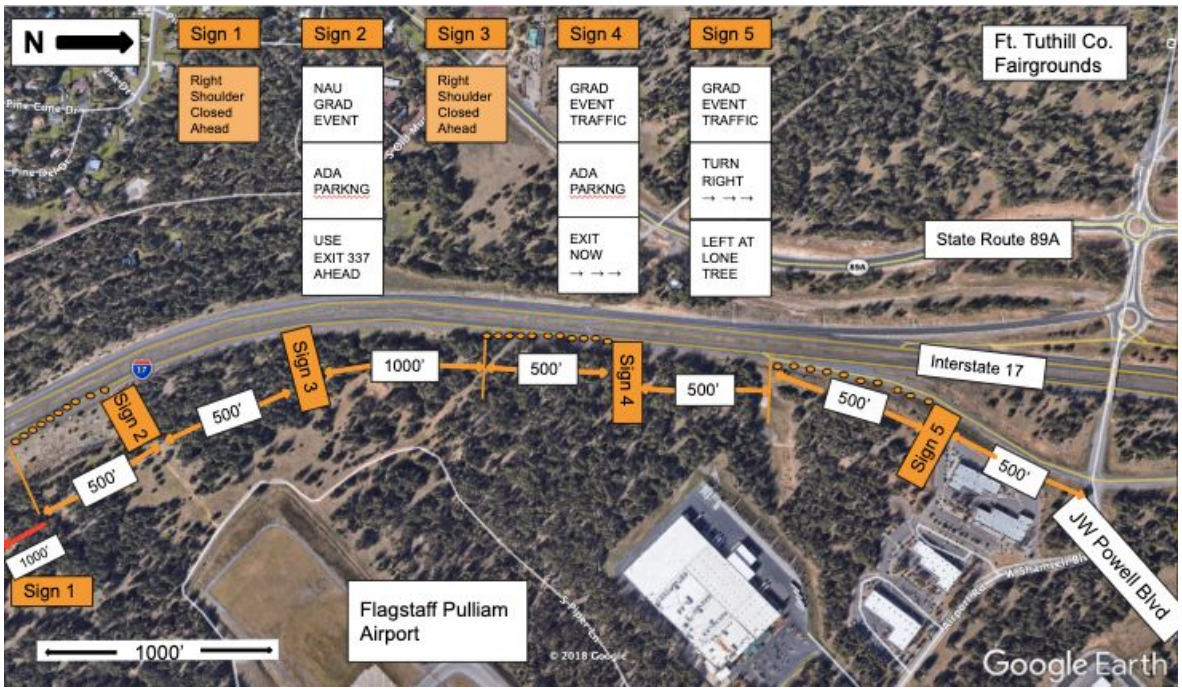


Figure 5: Southern Segment of Long-term Traffic Circulation Plan along I-17 near the Flagstaff Pulliam Airport [1].

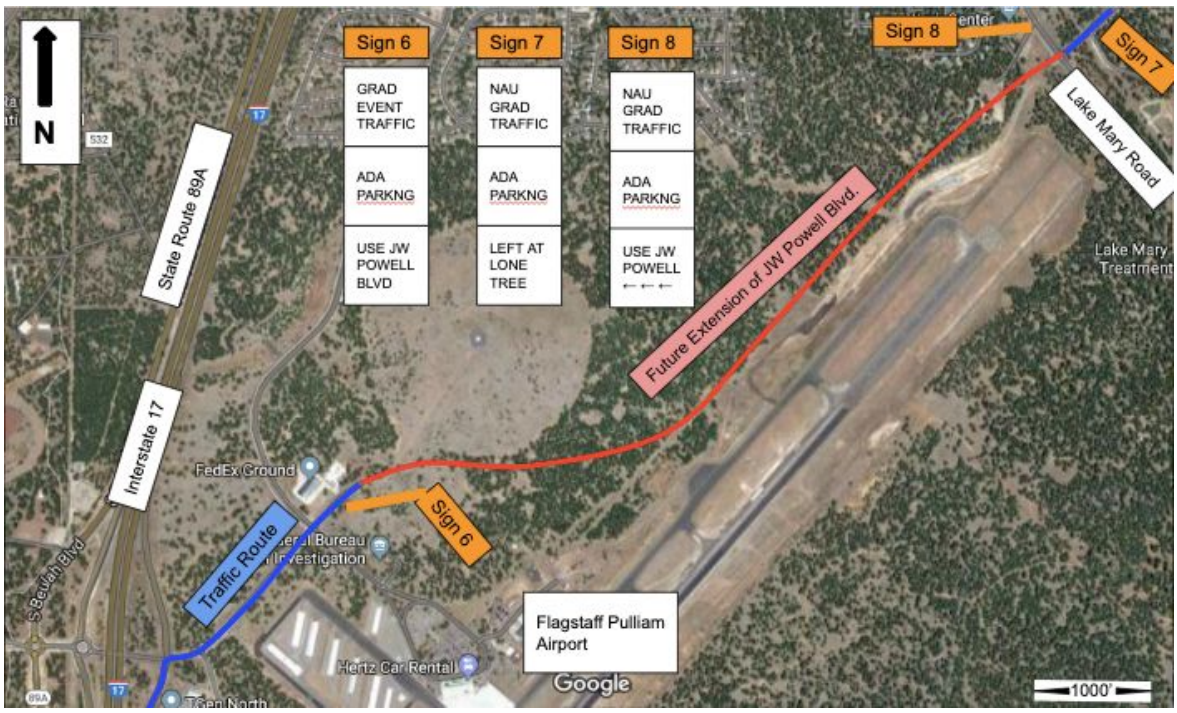


Figure 6: Long-term Traffic Circulation Plan along I-17 north of the Flagstaff Pulliam Airport [1].

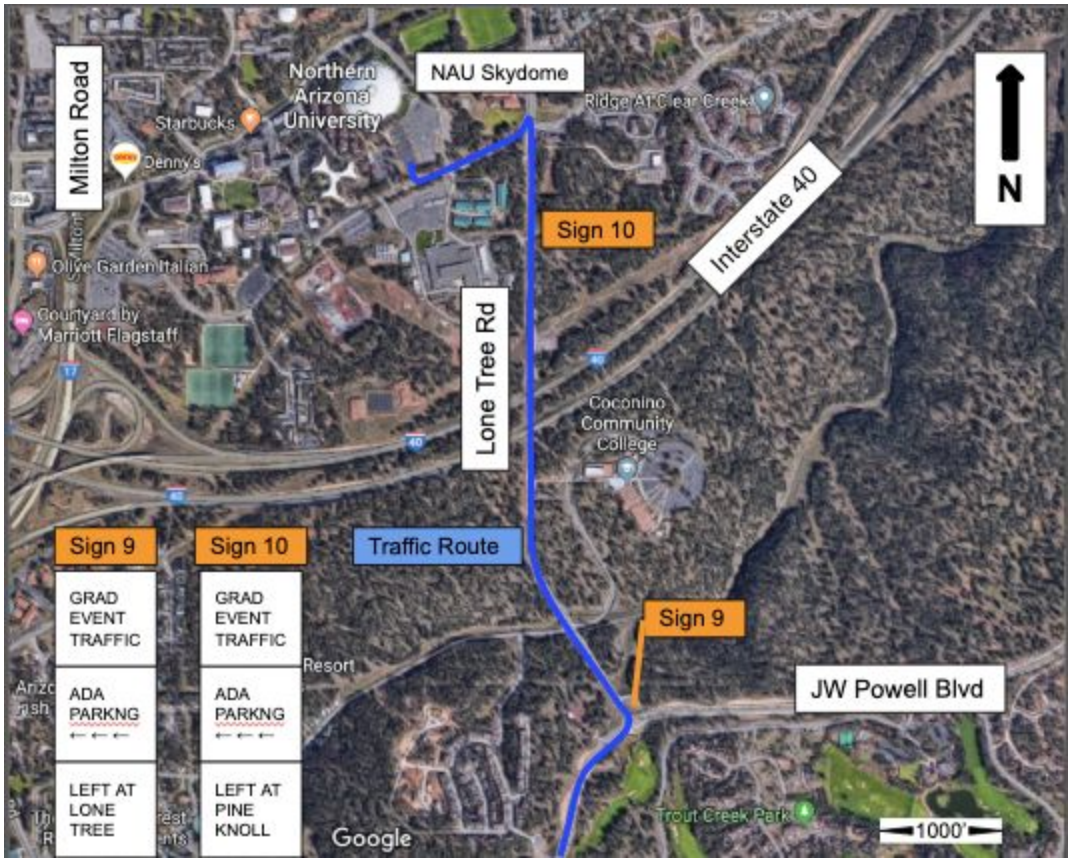


Figure 7: Long-term Traffic Circulation Plan along JW Powell Blvd and Lone Tree Road south of NAU Campus and the NAU Skydome [1].

4.4 Cost of Implementing 3 Circulation Plans

The feasibility of each traffic management and circulation plan ultimately depends on cost. University budgets are stringent with high competition for available funding. The cost, safety, and effectiveness of each plan helped determine the final traffic management plan recommendations. See Table 7 for a summary of the cost of implementation for each circulation plan. Please note that the long-term cost below includes the one-time cost of building a roundabout at McConnell and Pine Knoll Drives.

Table 7: Short, Mid, and Long-Term Circulation Plan Cost Estimates

Management Plan	Cost [2020 Dollars]
Short-Term (through 2025)	$16,130
Mid-Term (through 2030)	$23,090
Long-Term (through 2040)	$528,112

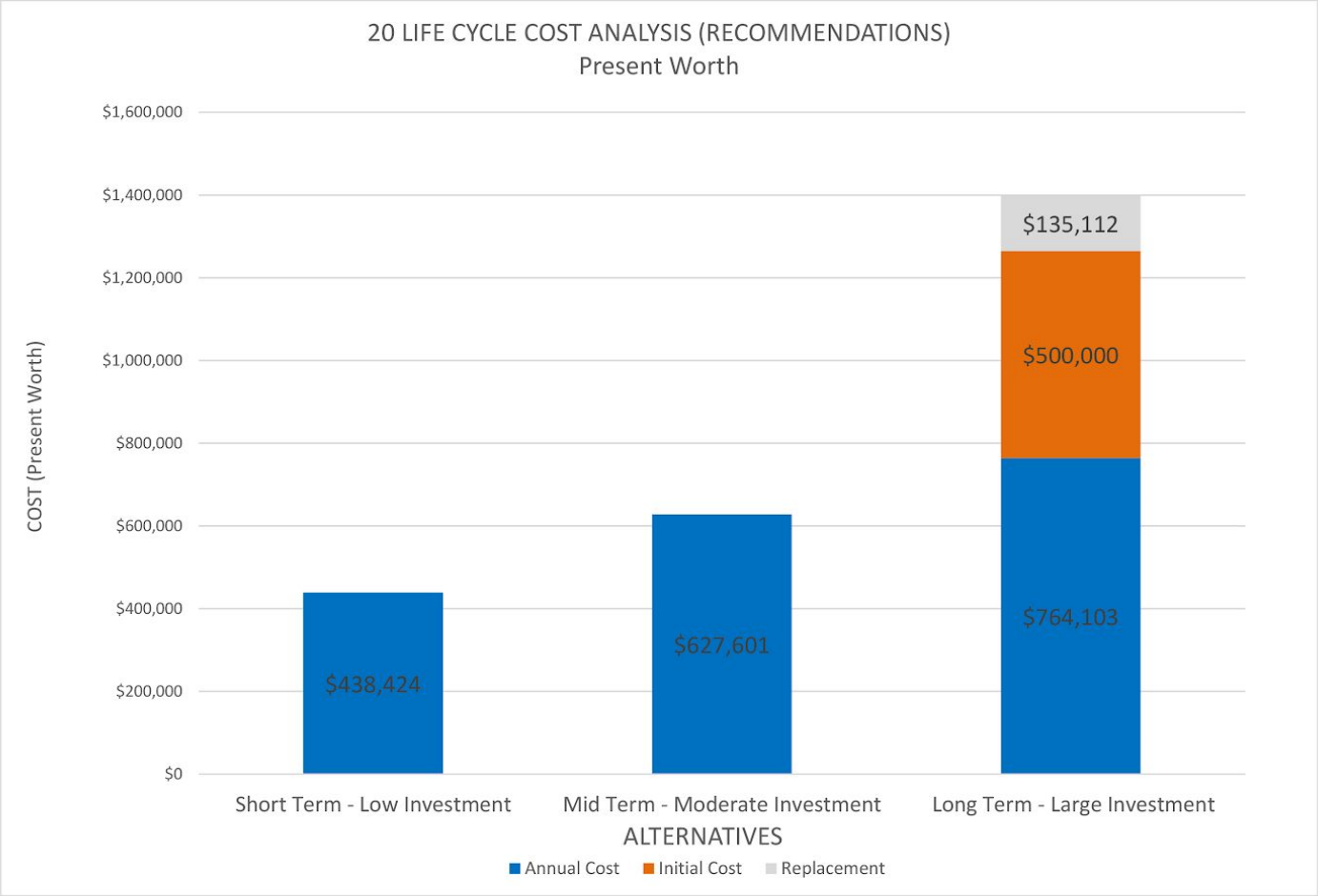


Figure 8: 20 Year Present Worth Bar Graph for short term-low cost, mid term- moderate cost, and long term-large cost alternatives, accounting for a 4% interest rate.

5. PROJECT IMPACTS

5.1 Socio-Economic Impacts

This section discusses the effective usage of the traffic control devices, and the effects of the traffic management plan action on social and economic considerations. This section also assesses the impacts to the university, public, and quality of life, as well as guidance for recognizing the socioeconomic effects and considerations through the project development process. Table 8 lists the economical positive and negative impacts identified for the graduation customized proposed solutions for individual places, depending on the objectives sought [18].

Table 8: Positive and Negative Socio-Economic Impacts of the Proposed Solutions

Proposed Solution	Positive Economic Impacts	Negative Economic Impacts
Safety Cones (Short/Mid-term)	● Low installation costs ● Re-usable	● University budget increase
Flaggers (Short/Mid-term)	● Provides jobs to community	● Possible worker injury and hospital bills leading to reduced workforce capacity of the community
Guide Signs (Mid-term)	● Low-moderate installation costs ● Re-usable	● University budget increase
Additional Bus Shuttle Services (Mid/Long-term)	● Affordable mobility ● Saves fuel usage	● N/A
Roundabout (Long-term)	● Decrease maintenance operations and electrical costs	● High installation cost

5.2 Environmental Impacts

Traffic management plans will have an environmental impact, whether positive or negative, which is dependant on the driver's behaviour. In this case, it would result in an impact on the vehicle's operation, resulting in exhaust emissions, noise and vibration. Upon reviewing the environmental conditions during the early stages of the traffic study process, several recommendation plans can be established in order to identify and minimize the negative environmental impacts and reduce congestion. Table 9 lists the environmental positive and negative impacts identified for the graduation proposed solutions [19].

Table 9: Positive and Negative Environmental Impacts of the Proposed Solutions

Proposed Solution	Positive Environmental Impacts	Negative Environmental Impacts
Safety Cones (Short/Mid-term)	● Does not affect vehicles, pedestrians, and cyclists	● Less effective in winter conditions
Flaggers (Short/Mid-term)	● Does not affect vehicles, pedestrians, and cyclists	● N/A
Guide Signs (Mid-term)	● Does not affect vehicles, pedestrians, and cyclists	● N/A
Additional Bus Shuttle Services (Mid/Long-term)	● Decrease vehicle emissions and improve air quality	● Traffic vehicle emissions ● High energy usage
Roundabout (Long-term)	● Decrease emissions as vehicles slow down instead of stopping	● Noise and vibrations from construction operation

5.3 Public Safety Impacts

This section discusses several intersections that would require potential safety enhancements to avoid pedestrian safety issues along the roadside area. The roadway improvement service consists of necessary actions, which addresses the public safety possible concerns from the temporary public safety impacts related to construction. The following Table 10 lists the public safety positive and conflict impacts identified for the graduation proposed solutions [19].

Table 10: Positive and Negative Public Safety Impacts of the Proposed Solutions

Proposed Solution	Positive Public Safety Impacts	Negative Public Safety Impacts
Safety Cones (Short/Mid-term)	● Slow down drivers	● Might interfere with snow-plow operations
Flaggers (Short/Mid-term)	● Improve work zone ingress and egress by directing traffic ● Traffic speed reduction and yield	● The flagger him/herself must hold responsibility of the public safety and might endanger themselves
Guide Signs (Mid-term)	● Traffic speed reduction and yield	● May be misleading for non-local drivers
Additional Bus Shuttle Services (Mid/Long-term)	● Decrease travel demand ● Encourage ride sharing instead of using individual cars	● May cause potential traffic jams due to stop-offs (or over)
Roundabout (Long-term)	● Vehicles must slow down to navigate the area, reducing traffic collisions and accidents	● Large vehicles might experience difficulty in navigating the area

6. SUMMARY OF ENGINEERING WORK

6.1 Traffic Study

Tasks 1 and 2, shown in the gantt chart in Figure 6, include the work performed for the traffic study. A site assessment was conducted for all four intersections as well as nearby campus entrance segments of access roads to help design an action plan for both traffic studies. Since the jamar boards required manual operation, personnel were required to be present on site for the traffic study. A safety plan was devised to ensure the safety of Jamar board operators, bicyclists, pedestrians, and motorists. A singular point of observation was chosen for each intersection to maintain consistency in data collection as well as personnel/public safety.

The roadway geometry was surveyed regarding the lane width and pavement design to determine which road tube counter device would be suitable to install. University Drive has a landscaped median that suits using two shorter road tube counters. The longer tube counters are in short supply from the City of Flagstaff, so utilizing this

setup helped to ensure adequate data collection at all four roadway segments across campus. The other three intersections used longer road tube counters.

Sunscreen, sunglasses, drinking water, and bright orange safety vests were necessary for Jamar board operators during the traffic study. Backup personnel familiar with the operation of the Jammar boards were also present to provide restroom breaks for the traffic study team about halfway through the 3-hour study period.

During the application and removal of road tube counters, bright orange safety vests were necessary for all people involved. Further, teams of two or three people would work together to place/remove the tube counter equipment. One or two people would work on the equipment, and the remaining person would stand as far out in the road as the other team members and up road. This person would signal/warn oncoming drivers of the people working in the road to protect motorists and workers.

6.2 Volume Data Analysis

Traffic and turning movement volume counts were collected for graduation event and baseline in May 2019 and September 2019 respectively, as part of the project's study per clients' request. The two traffic conditions were compared to account for the increase of tourists during the special events. Utilizing the volume data at several intersections, traffic management recommendations, their cost estimates, and impacts were identified and provided.

6.3 Vissim Analysis

The purpose of Vissim analysis is to simulate the existing roadway geometry and to determine future congestion levels due to the projected increase in Flagstaff population/NAU students. This helps in evaluating how the proposed solutions would perform if future improvements were made.

6.4 Traffic Management Alternative Plans

An updated work task plan (Gantt Chart) has been developed and displayed illustrating the project schedule. Some of the work tasks have been modified based on the technical advisor's feedback. However, alterations were required may be further identified and discussed in the later stages of the traffic plan study. Appendix J1 displays the updated gantt chart which presents an overview of the revised project tasks and standards activities for which the traffic circulation study would be accomplished. Appendix J2 displays the previous original gantt chart.

6.5 Impacts

The impacts are identified for all proposed solutions that was provided by the technical advisor to establish the roadway access management attributes in order to qualify for future construction eligibility.

7. SUMMARY OF ENGINEERING COSTS

7.1 Personnel

The goal for project hours was 450-600 hours total for the senior engineer, engineer, and intern positions. The total hours logged for the NAU traffic management plan project is 550 hours. Please see Appendix K for details on the hours logged for individual tasks.

7.1.1 Senior Engineer

The role of the senior engineer was to lead, arrange meeting activities, provide assistance in collecting data and analysis, track and meet the project deadlines and budgets, and to develop and maintain a professional relationship with the client.

7.1.2 Engineer

The engineer was to acquire useful information and learn the material's field industry codes and regulations. Their role was to provide technical expertise and consultation throughout the project study, assist in completing the work task management, and ensure/account for the accuracy and completion of the task time frame.

7.1.3 Intern

The intern is accountable in coordinating and working with the senior engineer and the engineer, and acquire decision making skills. Their role was to demonstrate effective communication skills and the ability to be team-oriented, and exhibit responsibility and strong motivation in accomplishing a common goal.

7.2 Travel

The travel expenses is not required for this project study.

7.3 Supplies

Table 11 provides the cost estimates for the traffic study, analysis, and traffic circulation recommendations. Four Jamar boards and three road tube counters were required to collect the traffic count data of travelling vehicle within the study area. These cost estimations should be used for study planning and project budgeting only. Estimates in this table does not include project risk costs.

Table 11: Cost of Engineering Services

	Classification	Rate, $/hr	Hours	Cost
1.0 Personnel	Senior Engineer	200	99	**$19,800**
	Engineer	70	261	**$18,270**
	Intern	25	190	**$4,750**
	Total Personnel			**$42,820**
2.0 Travel	N/A	N/A	N/A	0
3.0 Supplies	4 Jamar Boards and 3 Road Tubes	$45/hr	24	$4,320
4.0 Subcontract	N/A	N/A	N/A	0
5.0 Total				**$47,140**

8. SUMMARY

8.1 Objectives

The NAU traffic management circulation plan project aimed to reduce traffic congestion, reduce interstate and surface road gridlock, reduce air pollution, increase patron enjoyment of future ceremonies, maintain University financial solvency, and maintain/improve public safety. The solutions proposed encompass all of these goals, and time will be the test of their ultimate effectiveness and feasibility. The solutions proposed are subject to University and ADOT budget approval, so not every solution posed will likely be implemented.

8.2 Results

The VISSIM simulation software confirmed the viability of maintaining for the next twenty years the current traffic management plan at the intersections of Pine Knoll and Lone Tree Rd, San Francisco St & Franklin Ave, and University & Knoles Dr. VISSIM also confirmed the viability of constructing a roundabout at the intersection of McConnell & Pine Knoll Drives for projected twenty year Flagstaff and NAU population growth.

8.3 Traffic Management Plan and Recommendations

The driving factor for determining feasible traffic management solutions was capital cost to NAU. Short-term recommendations focused heavily on "fine-tuning" the traffic management plans already implemented by NAU PD and ADOT. The mid-term solutions were a little more costly since population growth of both NAU and the City of Flagstaff needed to be considered. The long-term solutions, namely the roundabout, were much more costly since higher population levels needed consideration and roadway geometry changes are expensive.

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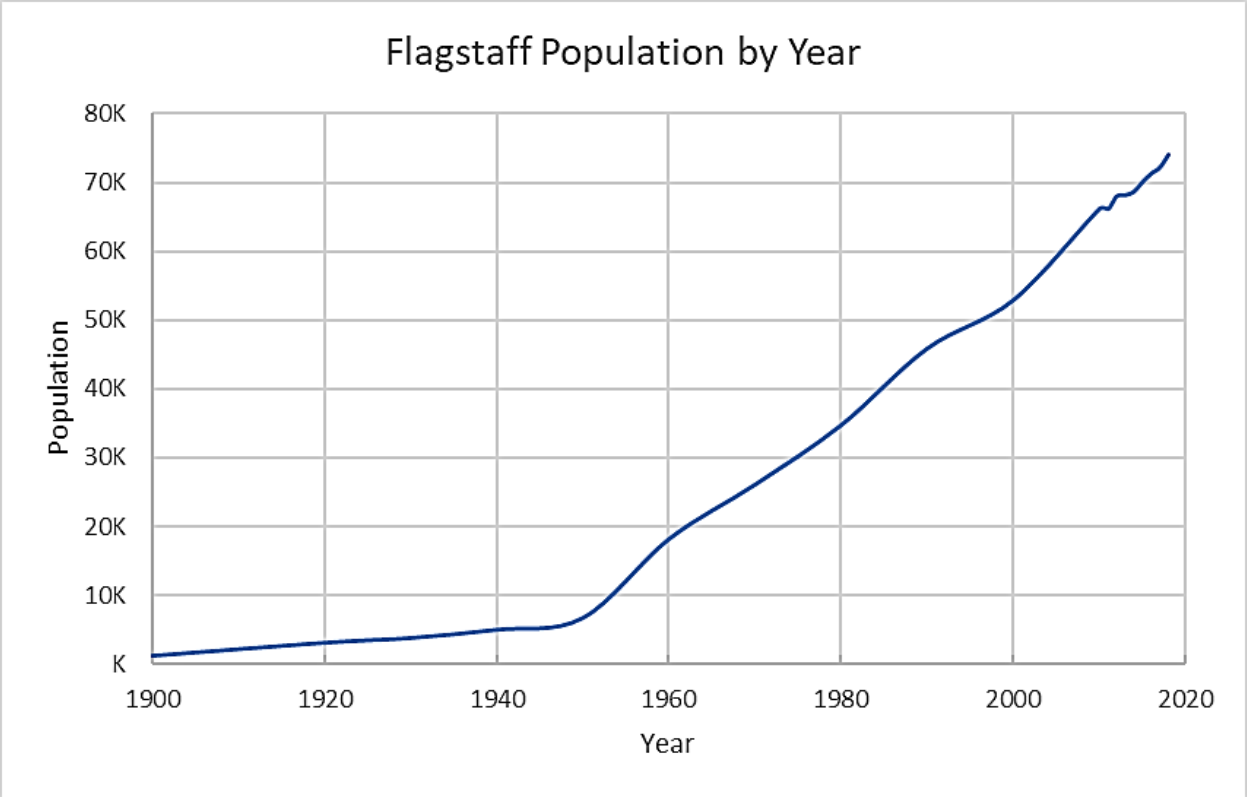
10. APPENDICES

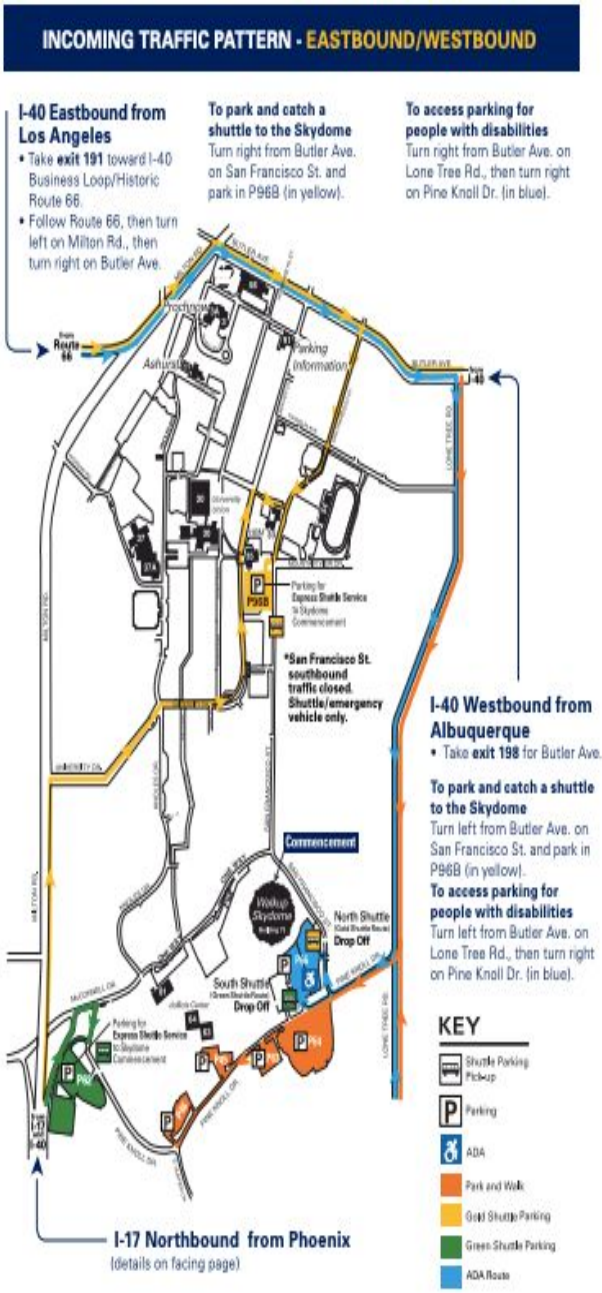
Appendix A1: U.S. Census data for Flagstaff total population per year starting in 1900 [1].

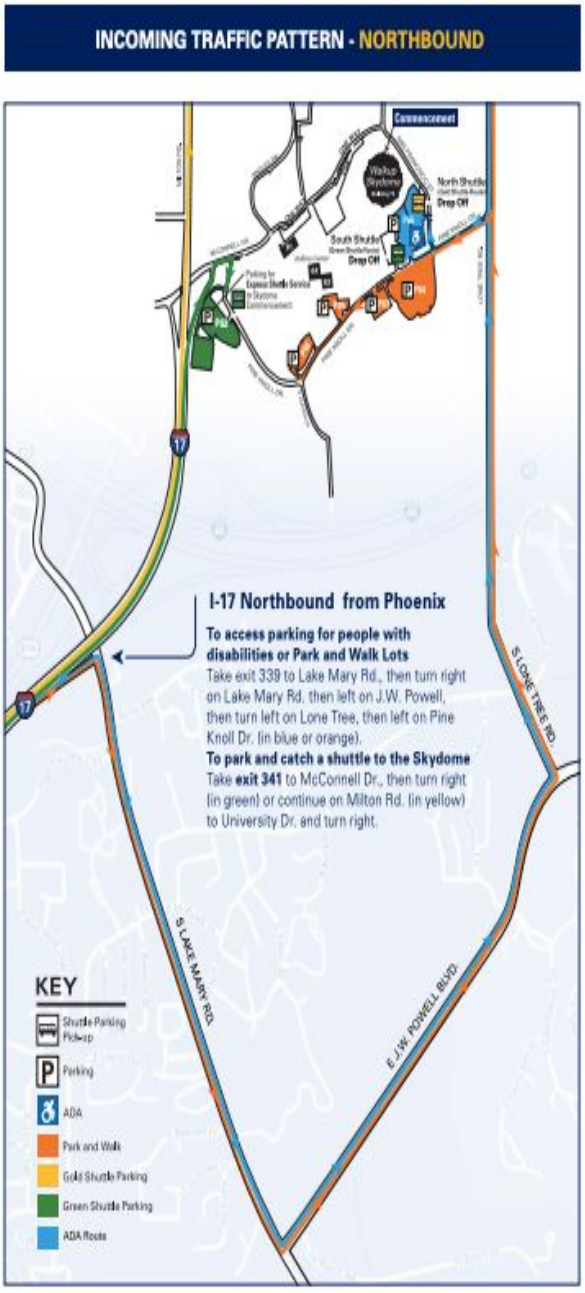
Year ▲	Population	Growth	Annual Growth Rate
1900	1,300		0.00%
1920	3,186	1,886	4.58%
1930	3,891	705	2.02%
1940	5,080	1,189	2.70%
1950	6,771	1,691	2.92%
1960	18,214	11,443	10.40%
1970	26,117	7,903	3.67%
1980	34,743	8,626	2.90%
1990	45,857	11,114	2.81%
2000	52,894	7,037	1.44%
2010	66,106	13,212	2.25%
2011	66,082	-24	-0.04%
2012	67,931	1,849	2.80%
2013	68,110	179	0.26%
2014	68,633	523	0.77%
2015	70,015	1,382	2.01%
2016	71,227	1,212	1.73%
2017	72,121	894	1.26%
2018	73,964	1,843	2.56%

Appendix A2: Flagstaff Total Population per Year [1].



Appendix B: NAU Police Department Traffic Management Plan put into place December 2018. The McConnell Drive Route is shown on the left, and the alternate route down Lake Mary Road is shown on the right [20].





Appendix C1: May 2019 Graduation of Lone Tree Road and Pine Knoll Drive Jamar Board traffic volume data.

Street Name	Lone Tree Road and Pine Knoll Drive 10-MAY-2019																			
	From North					From East					From South					From West				
Start Time	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total
9:00 AM	36	55	13	6	104	14	24	3	1	41	2	62	7	0	71	4	8	12	1	24
9:15 AM	34	46	14	0	94	13	19	4	0	36	4	78	7	4	89	11	8	17	0	36
9:30 AM	27	60	11	6	98	26	17	3	0	46	1	64	14	1	79	7	7	16	1	30
9:45 AM	34	64	23	2	121	21	17	9	1	47	0	43	20	1	63	5	5	27	1	37
10:00 AM	40	73	21	3	134	15	9	8	2	32	10	51	29	7	90	11	6	33	1	50
10:15 AM	65	71	23	2	159	15	14	7	6	36	5	44	35	1	84	7	7	38	0	52
10:30 AM	66	70	22	7	158	16	24	9	18	49	6	56	43	33	105	3	11	16	11	30
10:45 AM	53	31	8	21	92	26	26	9	12	61	3	36	44	16	83	7	12	24	3	43
11:00 AM	60	71	24	1	155	28	10	9	8	47	6	36	45	5	87	8	13	10	1	31
11:15 AM	63	41	16	0	120	25	13	5	2	43	8	63	49	8	120	7	14	32	4	53
11:30 AM	37	48	25	1	110	26	23	4	9	53	3	52	20	6	75	1	7	31	2	39
11:45 AM	34	54	22	4	110	17	24	4	10	45	3	48	13	11	64	4	2	16	4	22
	Ingress Total			Grand Total	1455		Ingress Total		Grand Total	536			Ingress Total	Grand Total	1010				Grand Total	447
	549			Ped. Total	53		220		Ped. Total	69			326	Ped. Total	93				Ped. Total	29

Appendix C2: May 2019 Graduation Data of University Dr. and Knoles Dr. intersection traffic volumes.

Street Name	San Francisco & Franklin																			
	SAN FRANFrom North					FRANKLINFrom East					SAN FRANFrom South					FRANKLINFrom West				
Start Time	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total
9:30 AM	0	22	4	6	26	11	7	19	6	37	11	24	5	9	40	17	15	2	5	34
9:45 AM	2	9	3	0	14	6	12	16	5	34	9	22	5	7	36	23	8	1	0	32
10:00 AM	1	39	5	1	45	9	15	15	0	39	16	24	12	1	52	23	14	3	6	40
10:15 AM	3	23	3	0	29	16	11	28	5	55	18	14	5	6	37	21	10	2	3	33
10:30 AM	0	32	5	2	37	10	15	26	3	51	21	17	5	7	43	22	16	2	3	40
10:45 AM	5	47	10	1	62	14	13	31	5	58	23	20	7	7	50	26	11	2	10	39
11:00 AM	2	48	8	2	58	11	12	23	9	46	19	19	4	7	42	51	29	5	7	85
11:15 AM	2	57	6	2	65	10	14	32	8	56	15	17	4	4	36	17	21	4	5	42
11:30 AM	6	28	2	2	36	19	16	29	2	64	23	25	0	2	48	32	16	3	3	51
11:45 AM	0	31	4	2	35	18	21	25	2	64	13	15	4	5	32	35	17	3	13	55
12:00 PM	2	21	8	1	31	14	12	18	2	44	20	29	9	6	58	15	14	5	3	34
		Ingress Total		Grand Tot.	438			Ingress Total	Grand Tot.	548				Grand Tot.	474	Ingress Total			Grand Tot.	485
		357		Ped. Total	19			262	Ped. Total	47				Ped. Total	61	282			Ped. Total	58

Appendix C3: May 2019 Graduation Data of University Dr. and Knoles Dr. intersection traffic volumes.

Street Name	University & Knoles																			
	From North					From East					From South					From West				
Start Time	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total
8:15 AM	13	29	14	4	56	11	26	22	2	59	3	15	11	4	29	13	31	21	0	65
8:30 AM	11	20	8	4	39	12	44	23	2	79	10	22	15	5	47	24	29	17	3	70
8:45 AM	17	12	4	8	33	11	35	23	6	69	8	24	9	7	41	21	22	13	3	56
9:00 AM	17	30	6	10	53	16	58	26	5	100	10	9	16	11	35	18	31	16	4	65
9:15 AM	31	20	7	7	58	12	54	23	1	89	7	14	23	4	44	20	54	8	0	82
9:30 AM	15	43	13	7	71	9	40	23	7	72	5	23	18	5	46	17	44	18	2	79
9:45 AM	19	39	16	9	74	6	34	17	9	57	9	22	11	19	42	40	59	11	1	110
10:00 AM	26	39	15	12	80	3	29	31	7	63	7	13	10	17	30	32	48	10	11	90
10:15 AM	14	29	11	5	54	7	40	18	5	65	11	17	14	3	42	26	40	10	3	76
10:30 AM	17	29	10	6	56	3	31	12	13	46	3	16	14	3	33	35	41	11	2	87
10:45 AM	13	15	11	11	39	7	24	20	5	51	5	17	19	4	41	26	35	7	3	68
11:00 AM	10	16	4	11	30	10	35	11	5	56	6	13	14	8	33	20	38	14	5	72
		Ingress Total	Ingress Total	Grand Total	643	Ingress Total		Ingress Total	Grand Total	806	Ingress Total	Ingress Total		Grand Total	463	Ingress Total	Ingress Total	Ingress Total	Grand Total	920
		321	119	Ped. Total	94	107		249	Ped. Total	67	84	205		Ped. Total	90	292	472	156	Ped. Total	37

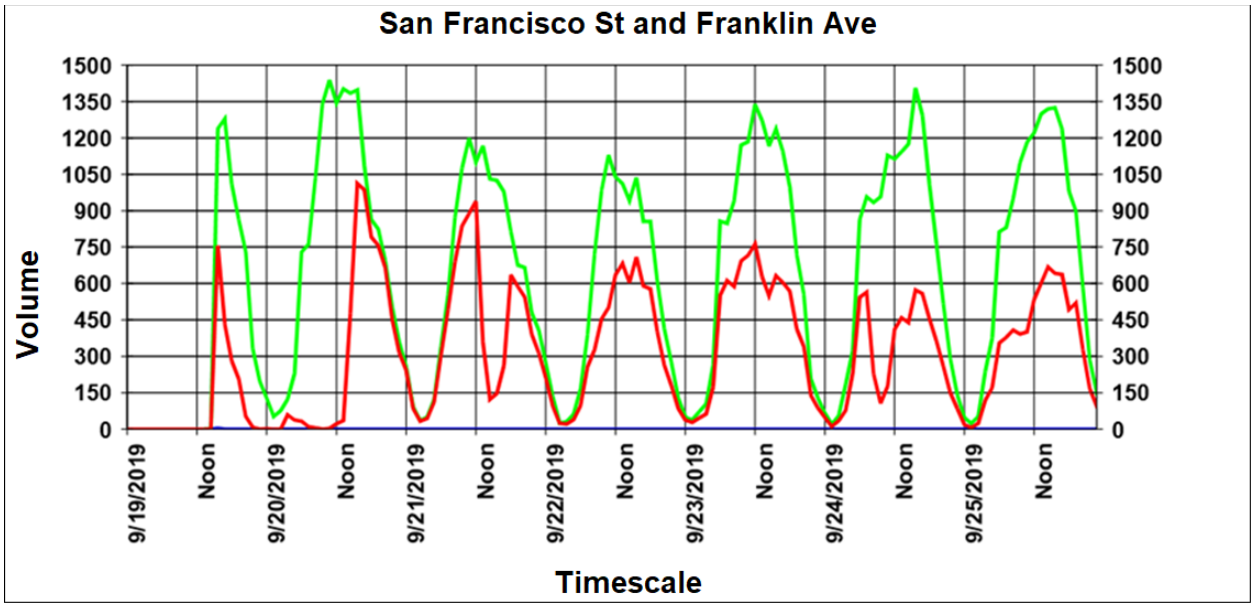
Appendix C4: May 2019 Graduation Data of McConnell Dr. and Pine Knoll Dr. intersection traffic volumes.

Street Name	McConnell & Pine Knoll																			
	From North					From East					From South					From West				
Start Time	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total	Right	Thru	Left	Peds	Total
8:15 AM	0	0	0	0	0	0	30	16	0	46	23	0	30	0	53	84	7	0	0	91
8:30 AM	0	0	0	0	0	0	21	15	0	36	17	0	38	0	55	86	1	0	0	87
8:45 AM	0	0	0	0	0	0	22	11	0	33	19	0	18	0	37	91	2	0	0	93
9:00 AM	0	0	0	0	0	0	22	25	0	47	16	0	24	0	40	119	9	0	0	128
9:15 AM	0	0	0	0	0	0	26	12	0	38	37	0	18	0	55	117	4	0	0	121
9:30 AM	0	0	0	0	0	0	30	8	0	38	21	0	21	0	42	173	2	0	0	175
9:45 AM	0	0	0	0	0	0	23	25	0	48	25	0	29	0	54	221	2	0	0	223
10:00 AM	0	0	0	0	0	0	12	19	0	31	12	0	21	0	33	257	3	0	0	260
10:15 AM	0	0	0	0	0	0	19	13	0	32	7	0	21	0	28	158	3	0	16	161
10:30 AM	0	0	0	0	0	0	15	14	0	29	6	0	34	0	40	142	5	0	0	147
10:45 AM	0	0	0	0	0	0	23	15	0	38	13	0	27	0	40	66	31	0	0	97
				Grand Total	0			Ingress Total	Grand Total	416	Ingress Total			Grand Total	477	Ingress Total	Ingress Total		Grand Total	1583
				Ped. Total	0			173	Ped. Total	0	196			Ped. Total	0	1514	69		Ped. Total	16

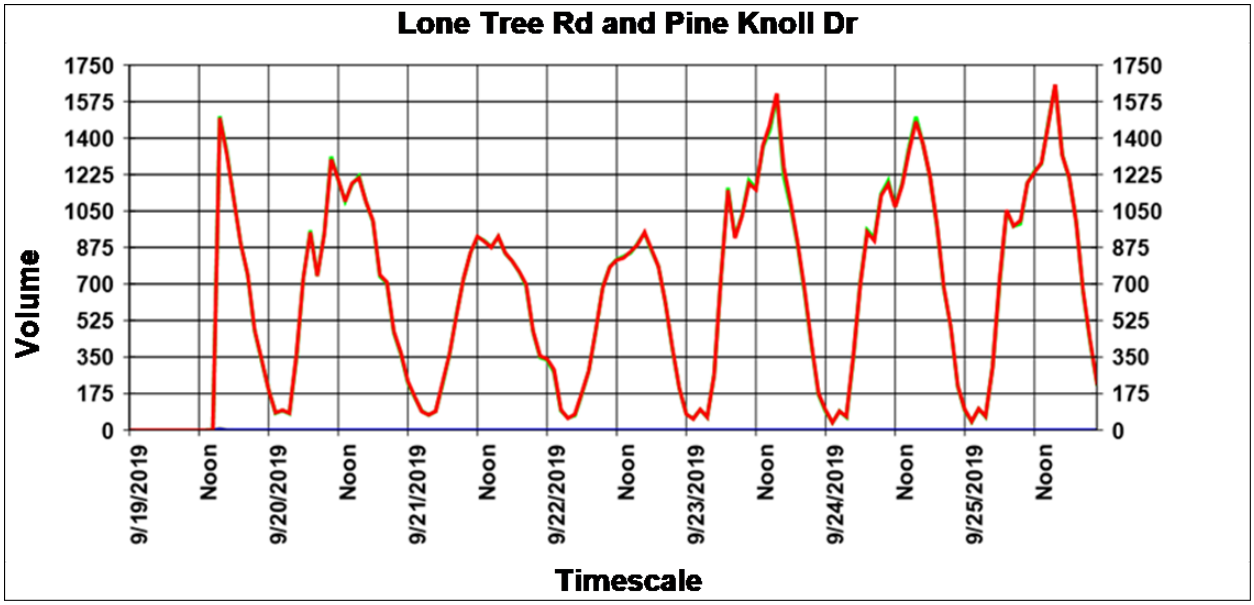
Appendix D: Baseline Condition AutoCAD Flow Map with study intersections shown in red boxes.

Appendix E: May 2019 Graduation AutoCAD Flow Map with study intersections shown in red boxes.

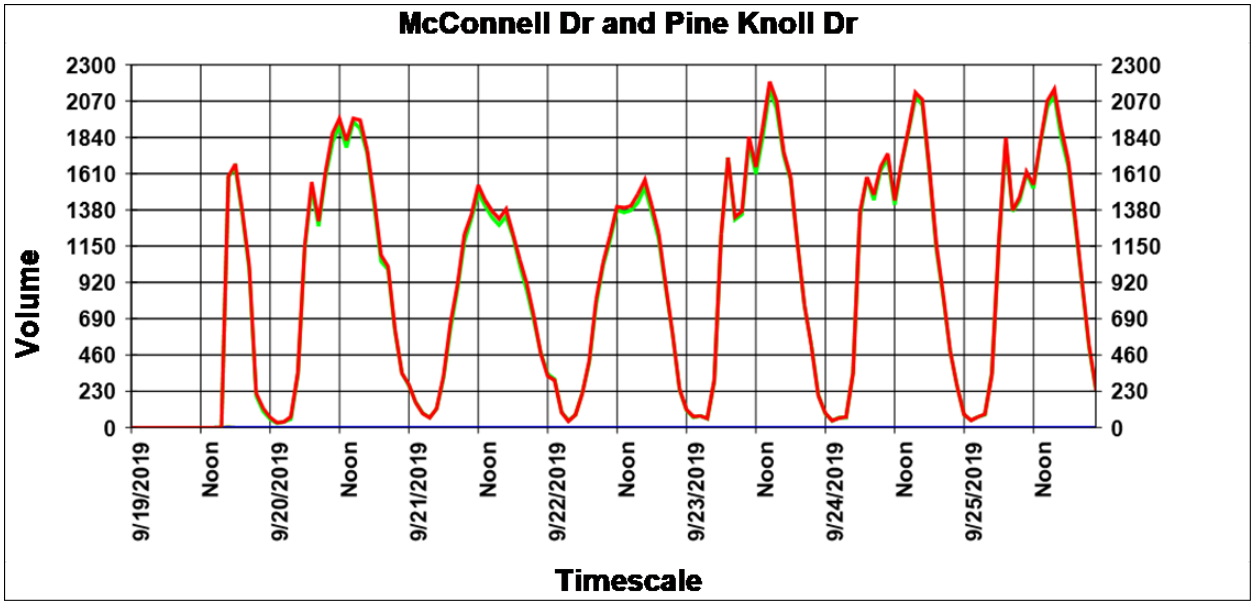
Appendix F1: San Francisco, Franklin Baseline Volumes - Ingress in (red) and Egress in (green)



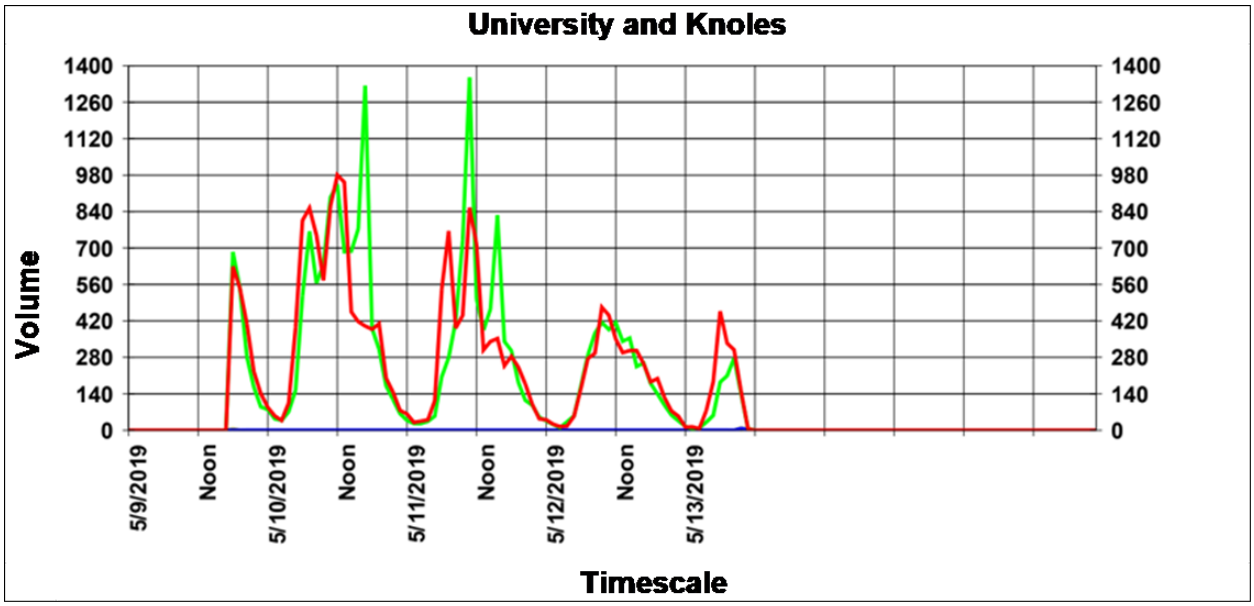
Appendix F2: Lone Tree, Pine Knoll Baseline Volumes - Ingress in (red) and Egress in (green)



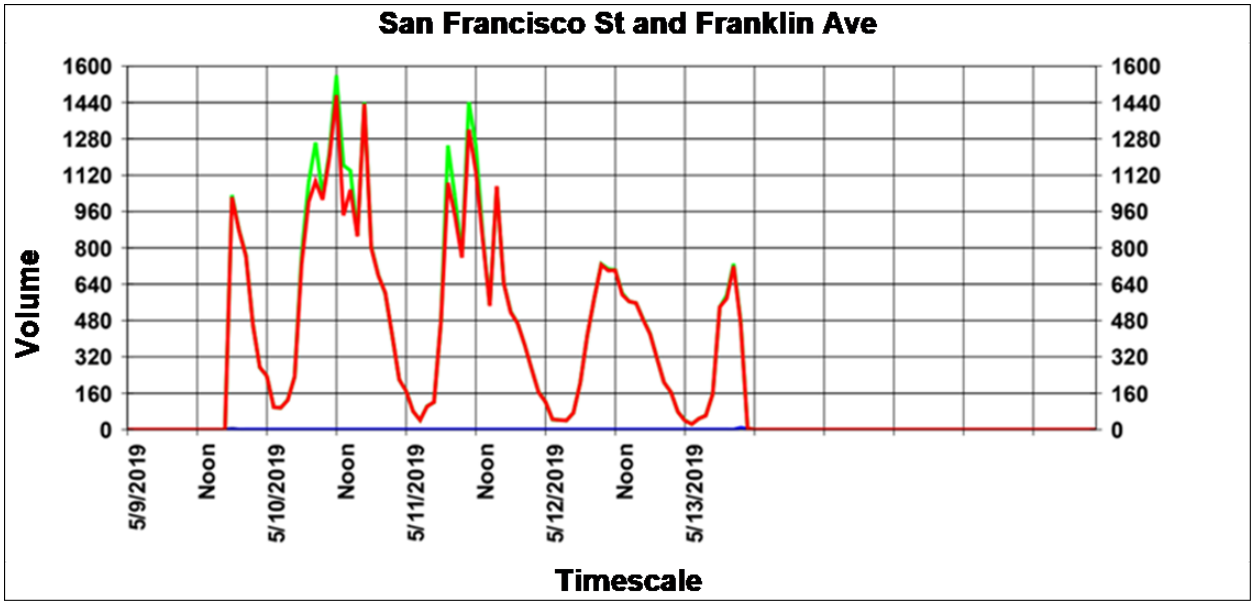
Appendix F3: McConnell, Pine Knoll Baseline Volumes - Ingress in (red) and Egress in (green)



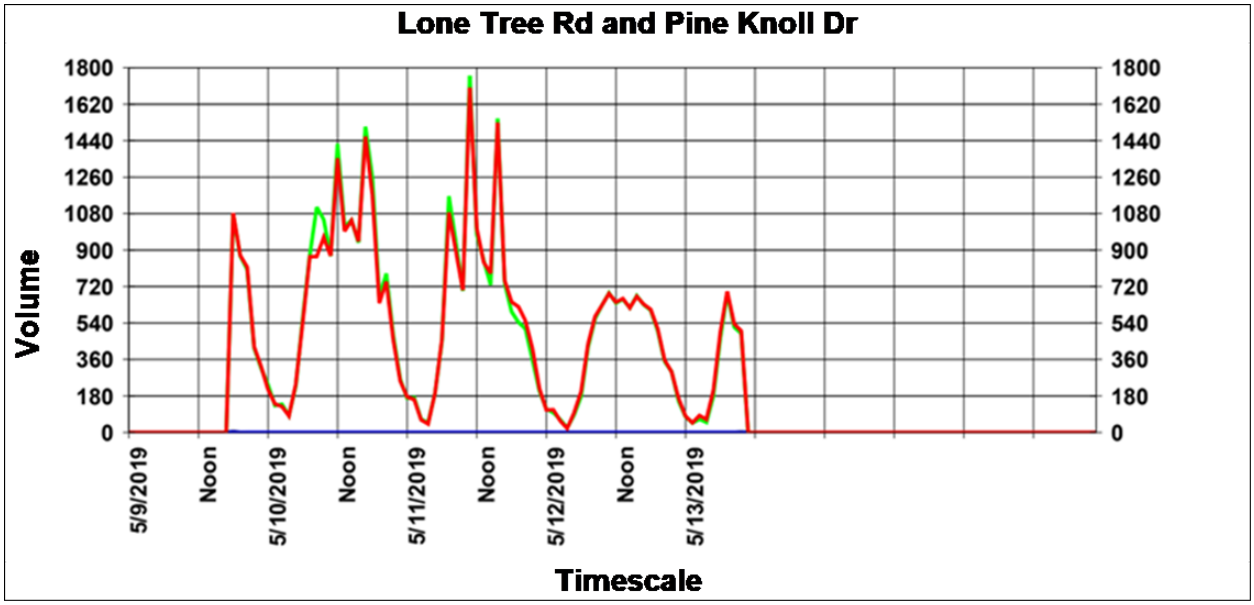
Appendix G1: University Dr, Knoles Graduation Volumes - Ingress in (red) and Egress in (green)



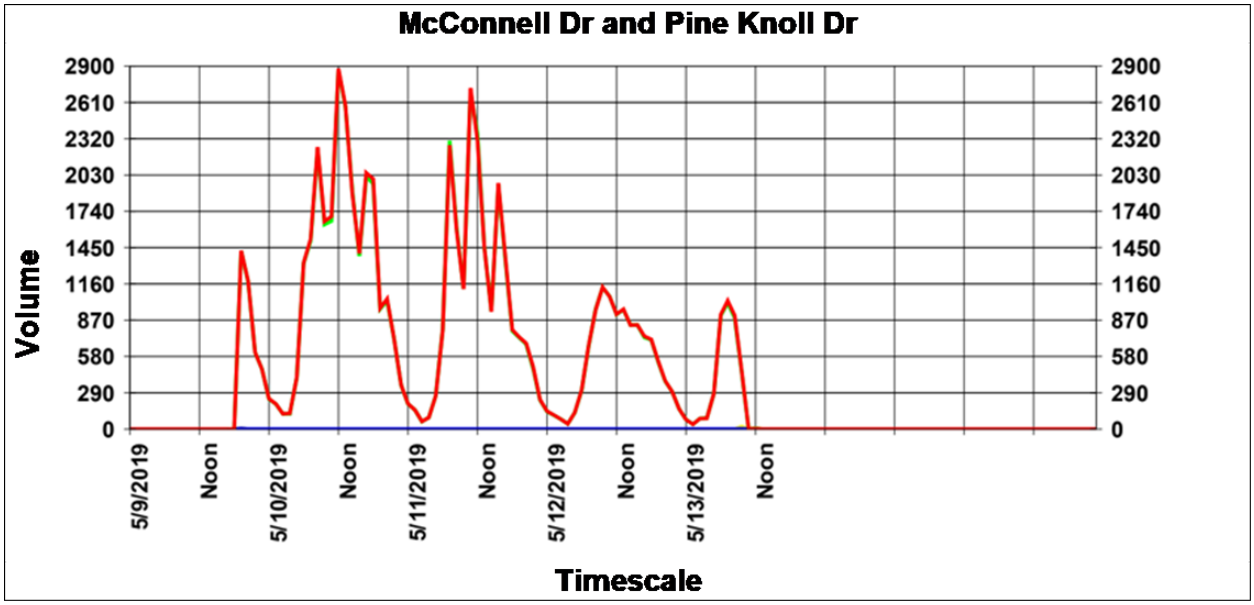
Appendix G2: San Francisco, Franklin Graduation Volumes - Ingress in (red) and Egress in (green)



Appendix G3: Lone Tree, Pine Knoll Graduation Volumes - Ingress in (red) and Egress in (green)



Appendix G4: McConnell, Pine Knoll Graduation Volumes - Ingress in (red) and Egress in (green)



Appendix H1: Baseline Road Tube Counter Raw Volume Data for Pine Knoll & Lone Tree

Start Date: 9/19/2019			
Start Time: 4:25:00 PM			
Site Code: 1			
Location: Pine Knoll & Lone Tree			
Date	Time	Ingress (A)	Egress (B)
9/20/2019	08:00 AM	25	14
9/20/2019	08:05 AM	11	12
9/20/2019	08:10 AM	18	9
9/20/2019	08:15 AM	24	5
9/20/2019	08:20 AM	21	6
9/20/2019	08:25 AM	18	11
9/20/2019	08:30 AM	17	8
9/20/2019	08:35 AM	21	8
9/20/2019	08:40 AM	30	10
9/20/2019	08:45 AM	22	10
9/20/2019	08:50 AM	24	14
9/20/2019	08:55 AM	23	13
9/20/2019	09:00 AM	25	16
9/20/2019	09:05 AM	19	15
9/20/2019	09:10 AM	16	13
9/20/2019	09:15 AM	15	9
9/20/2019	09:20 AM	12	5
9/20/2019	09:25 AM	10	6
9/20/2019	09:30 AM	9	10
9/20/2019	09:35 AM	14	4
9/20/2019	09:40 AM	8	10
9/20/2019	09:45 AM	19	6
9/20/2019	09:50 AM	29	13
9/20/2019	09:55 AM	21	4
9/20/2019	10:00 AM	27	14
9/20/2019	10:05 AM	10	8
9/20/2019	10:10 AM	20	20
9/20/2019	10:15 AM	14	13
9/20/2019	10:20 AM	5	13
9/20/2019	10:25 AM	9	6
9/20/2019	10:30 AM	13	15
9/20/2019	10:35 AM	7	18
9/20/2019	10:40 AM	17	16
9/20/2019	10:45 AM	15	16
9/20/2019	10:50 AM	24	5
9/20/2019	10:55 AM	11	27
9/20/2019	11:00 AM	19	16

Appendix H2: Baseline Road Tube Counter Raw Volume Data for San Fran & Franklin

Start Date: 9/19/2019			
Start Time: 5:00:00 PM			
Site Code: 2			
Location: San Fran & Franklin			
Date	Time	Ingress (A)	Egress (B)
9/20/2019	08:00 AM	25	14
9/20/2019	08:05 AM	11	12
9/20/2019	08:10 AM	18	9
9/20/2019	08:15 AM	24	5
9/20/2019	08:20 AM	21	6
9/20/2019	08:25 AM	18	11
9/20/2019	08:30 AM	17	8
9/20/2019	08:35 AM	21	8
9/20/2019	08:40 AM	30	10
9/20/2019	08:45 AM	22	10
9/20/2019	08:50 AM	24	14
9/20/2019	08:55 AM	23	13
9/20/2019	09:00 AM	25	16
9/20/2019	09:05 AM	19	15
9/20/2019	09:10 AM	16	13
9/20/2019	09:15 AM	15	9
9/20/2019	09:20 AM	12	5
9/20/2019	09:25 AM	10	6
9/20/2019	09:30 AM	9	10
9/20/2019	09:35 AM	14	4
9/20/2019	09:40 AM	8	10
9/20/2019	09:45 AM	19	6
9/20/2019	09:50 AM	29	13
9/20/2019	09:55 AM	21	4
9/20/2019	10:00 AM	27	14
9/20/2019	10:05 AM	10	8
9/20/2019	10:10 AM	20	20
9/20/2019	10:15 AM	14	13
9/20/2019	10:20 AM	5	13
9/20/2019	10:25 AM	9	6
9/20/2019	10:30 AM	13	15
9/20/2019	10:35 AM	7	18
9/20/2019	10:40 AM	17	16
9/20/2019	10:45 AM	15	16
9/20/2019	10:50 AM	24	5
9/20/2019	10:55 AM	11	27
9/20/2019	11:00 AM	19	16

Appendix H3: Baseline Road Tube Counter Raw Volume Data for University & Knoles

Start Date: 9/19/2019			
Start Time: 5:30:00 PM			
Site Code: 3			
Location: University & Knoles			
Date	Time	Ingress (A)	Egress (B)
9/20/2019	08:00 AM	46	32
9/20/2019	08:15 AM	33	24
9/20/2019	08:30 AM	45	29
9/20/2019	08:45 AM	80	18
9/20/2019	09:00 AM	48	50
9/20/2019	09:15 AM	42	34
9/20/2019	09:30 AM	45	31
9/20/2019	09:45 AM	59	55
9/20/2019	10:00 AM	77	74
9/20/2019	10:15 AM	51	66
9/20/2019	10:30 AM	52	57
9/20/2019	10:45 AM	54	68
9/20/2019	11:00 AM	68	70

Appendix H4: Baseline Road Tube Counter Raw Volume Data for McConnell & Pine Knoll

Start Date: 9/19/2019			
Start Time: 5:30:00 PM			
Site Code: 4			
Location: McConnell & Pine Knoll			
Date	Time	Ingress (A)	Egress (B)
9/20/2019	08:00 AM	33	15
9/20/2019	08:05 AM	32	12
9/20/2019	08:10 AM	20	10
9/20/2019	08:15 AM	19	11
9/20/2019	08:20 AM	27	17
9/20/2019	08:25 AM	28	14
9/20/2019	08:30 AM	38	18
9/20/2019	08:35 AM	39	10
9/20/2019	08:40 AM	35	16
9/20/2019	08:45 AM	46	10
9/20/2019	08:50 AM	46	11
9/20/2019	08:55 AM	34	25
9/20/2019	09:00 AM	23	29
9/20/2019	09:05 AM	26	27
9/20/2019	09:10 AM	16	20
9/20/2019	09:15 AM	20	15
9/20/2019	09:20 AM	16	12
9/20/2019	09:25 AM	15	8
9/20/2019	09:30 AM	14	12
9/20/2019	09:35 AM	22	15
9/20/2019	09:40 AM	23	11
9/20/2019	09:45 AM	33	16
9/20/2019	09:50 AM	28	8
9/20/2019	09:55 AM	17	18
9/20/2019	10:00 AM	29	16
9/20/2019	10:05 AM	35	30
9/20/2019	10:10 AM	30	36
9/20/2019	10:15 AM	26	26
9/20/2019	10:20 AM	16	36
9/20/2019	10:25 AM	17	34
9/20/2019	10:30 AM	18	13
9/20/2019	10:35 AM	18	22
9/20/2019	10:40 AM	25	17
9/20/2019	10:45 AM	31	23
9/20/2019	10:50 AM	25	23
9/20/2019	10:55 AM	21	35
9/20/2019	11:00 AM	32	30

Appendix H5: Graduation Road Tube Counter Raw Volume Data for Pine Knoll & Lone tree

Start Date: 5/9/2019			
Start Time: 6:50:00 PM			
Site Code: 1			
Location: Pine Knoll & Lone Tree			
Date	Time	Ingress (A)	Egress (B)
5/10/2019	08:00 AM	24	11
5/10/2019	08:05 AM	16	11
5/10/2019	08:10 AM	23	5
5/10/2019	08:15 AM	26	11
5/10/2019	08:20 AM	19	6
5/10/2019	08:25 AM	17	11
5/10/2019	08:30 AM	16	12
5/10/2019	08:35 AM	21	12
5/10/2019	08:40 AM	22	8
5/10/2019	08:45 AM	16	11
5/10/2019	08:50 AM	18	11
5/10/2019	08:55 AM	11	25
5/10/2019	09:00 AM	12	10
5/10/2019	09:05 AM	18	22
5/10/2019	09:10 AM	13	29
5/10/2019	09:15 AM	22	13
5/10/2019	09:20 AM	13	25
5/10/2019	09:25 AM	14	25
5/10/2019	09:30 AM	24	18
5/10/2019	09:35 AM	16	26
5/10/2019	09:40 AM	14	33
5/10/2019	09:45 AM	17	30
5/10/2019	09:50 AM	10	26
5/10/2019	09:55 AM	14	24
5/10/2019	10:00 AM	31	22
5/10/2019	10:05 AM	19	24
5/10/2019	10:10 AM	21	20
5/10/2019	10:15 AM	2	28
5/10/2019	10:20 AM	13	30
5/10/2019	10:25 AM	10	42
5/10/2019	10:30 AM	28	19
5/10/2019	10:35 AM	14	32
5/10/2019	10:40 AM	14	23
5/10/2019	10:45 AM	28	11
5/10/2019	10:50 AM	28	12
5/10/2019	10:55 AM	31	4
5/10/2019	11:00 AM	27	9

Appendix H6: Graduation Road Tube Counter Raw Volume Data for San Fran & Franklin

Start Date: 5/9/2019			
Start Time: 7:10:00 PM			
Site Code: 2			
Location: San Fran & Franklin			
Date	Time	Ingress (A)	Egress (B)
5/10/2019	08:00 AM	14	23
5/10/2019	08:05 AM	9	20
5/10/2019	08:10 AM	18	13
5/10/2019	08:15 AM	5	19
5/10/2019	08:20 AM	22	11
5/10/2019	08:25 AM	21	16
5/10/2019	08:30 AM	24	7
5/10/2019	08:35 AM	16	12
5/10/2019	08:40 AM	28	12
5/10/2019	08:45 AM	14	21
5/10/2019	08:50 AM	15	24
5/10/2019	08:55 AM	27	18
5/10/2019	09:00 AM	18	14
5/10/2019	09:05 AM	9	26
5/10/2019	09:10 AM	14	22
5/10/2019	09:15 AM	23	20
5/10/2019	09:20 AM	30	12
5/10/2019	09:25 AM	38	11
5/10/2019	09:30 AM	34	21
5/10/2019	09:35 AM	33	14
5/10/2019	09:40 AM	20	21
5/10/2019	09:45 AM	32	23
5/10/2019	09:50 AM	31	16
5/10/2019	09:55 AM	30	19
5/10/2019	10:00 AM	37	20
5/10/2019	10:05 AM	34	18
5/10/2019	10:10 AM	24	22
5/10/2019	10:15 AM	14	18
5/10/2019	10:20 AM	36	27
5/10/2019	10:25 AM	28	14
5/10/2019	10:30 AM	18	18
5/10/2019	10:35 AM	27	13
5/10/2019	10:40 AM	18	22
5/10/2019	10:45 AM	37	17
5/10/2019	10:50 AM	18	20
5/10/2019	10:55 AM	27	13
5/10/2019	11:00 AM	30	16

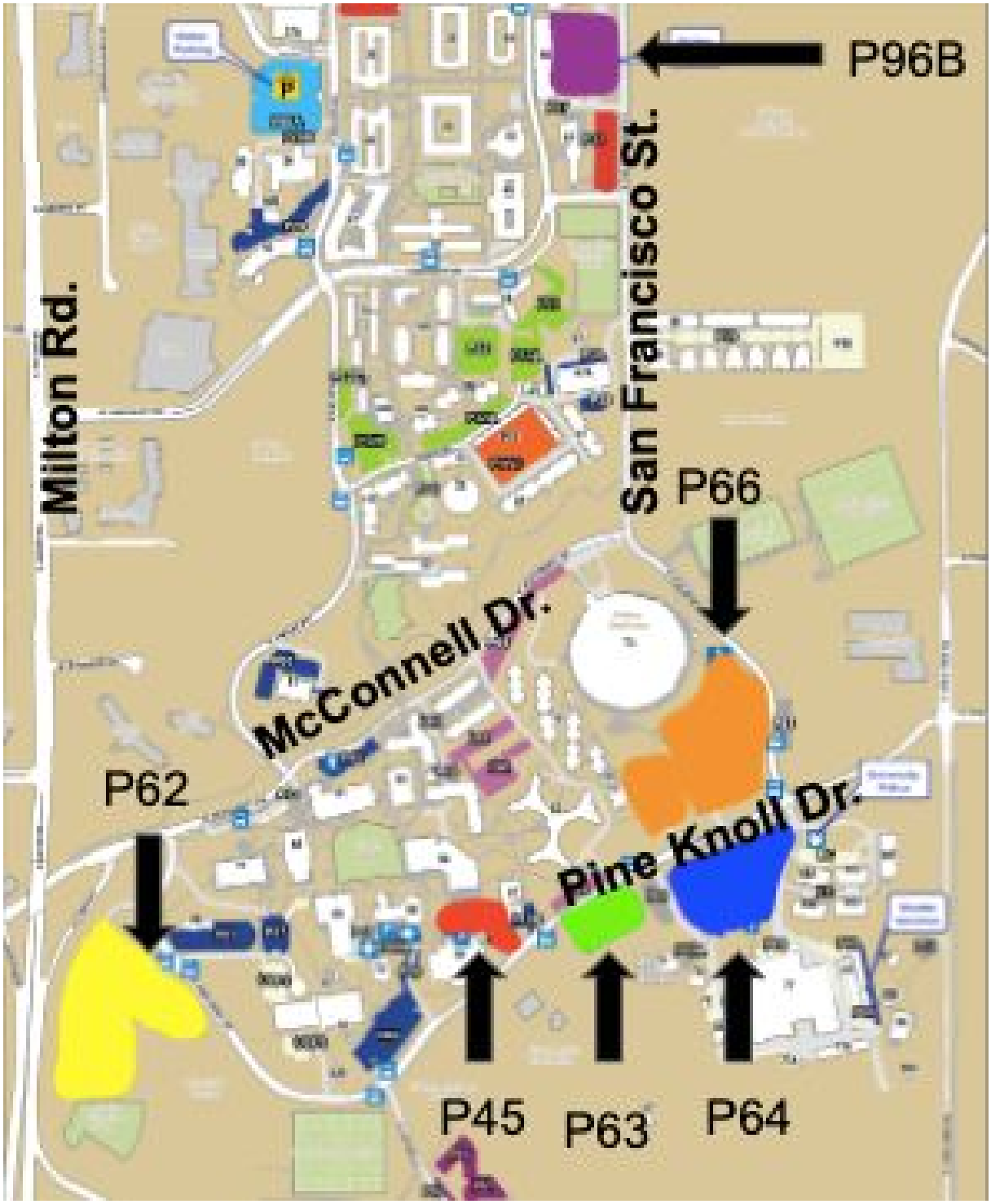
Appendix H7: Graduation Road Tube Counter Raw Volume Data for University and Knoles

Start Date: 5/9/2019			
Start Time: 7:40:00 PM			
Site Code: 3			
Location: University & Knoles			
Date	Time	Ingress (A)	Egress (B)
5/10/2019	08:00 AM	30	12
5/10/2019	08:05 AM	24	14
5/10/2019	08:10 AM	20	18
5/10/2019	08:15 AM	27	15
5/10/2019	08:20 AM	18	18
5/10/2019	08:25 AM	31	26
5/10/2019	08:30 AM	20	24
5/10/2019	08:35 AM	15	20
5/10/2019	08:40 AM	19	19
5/10/2019	08:45 AM	22	22
5/10/2019	08:50 AM	20	24
5/10/2019	08:55 AM	18	36
5/10/2019	09:00 AM	25	32
5/10/2019	09:05 AM	22	23
5/10/2019	09:10 AM	19	31
5/10/2019	09:15 AM	32	34
5/10/2019	09:20 AM	31	36
5/10/2019	09:25 AM	22	22
5/10/2019	09:30 AM	30	26
5/10/2019	09:35 AM	34	24
5/10/2019	09:40 AM	44	30
5/10/2019	09:45 AM	40	12
5/10/2019	09:50 AM	25	23
5/10/2019	09:55 AM	29	22
5/10/2019	10:00 AM	35	26
5/10/2019	10:05 AM	28	17
5/10/2019	10:10 AM	28	20
5/10/2019	10:15 AM	25	24
5/10/2019	10:20 AM	29	19
5/10/2019	10:25 AM	32	16
5/10/2019	10:30 AM	22	19
5/10/2019	10:35 AM	24	30
5/10/2019	10:40 AM	20	18
5/10/2019	10:45 AM	18	13
5/10/2019	10:50 AM	29	20
5/10/2019	10:55 AM	24	17
5/10/2019	11:00 AM	24	17

Appendix I8: Graduation Road Tube Counter Raw Volume Data for McConnell & Pine Knoll

Start Date: 5/9/2019			
Start Time: 8:05:00 PM			
Site Code: 4			
Location: McConnell & Pine Knoll			
Date	Time	Ingress (A)	Egress (B)
5/10/2019	08:00 AM	46	24
5/10/2019	08:05 AM	31	15
5/10/2019	08:10 AM	27	19
5/10/2019	08:15 AM	30	25
5/10/2019	08:20 AM	28	12
5/10/2019	08:25 AM	32	18
5/10/2019	08:30 AM	33	19
5/10/2019	08:35 AM	30	23
5/10/2019	08:40 AM	27	16
5/10/2019	08:45 AM	31	13
5/10/2019	08:50 AM	38	14
5/10/2019	08:55 AM	31	19
5/10/2019	09:00 AM	47	25
5/10/2019	09:05 AM	37	21
5/10/2019	09:10 AM	30	19
5/10/2019	09:15 AM	38	16
5/10/2019	09:20 AM	53	22
5/10/2019	09:25 AM	50	20
5/10/2019	09:30 AM	50	22
5/10/2019	09:35 AM	57	12
5/10/2019	09:40 AM	69	12
5/10/2019	09:45 AM	46	24
5/10/2019	09:50 AM	53	17
5/10/2019	09:55 AM	73	16
5/10/2019	10:00 AM	53	12
5/10/2019	10:05 AM	56	22
5/10/2019	10:10 AM	51	26
5/10/2019	10:15 AM	51	19
5/10/2019	10:20 AM	42	12
5/10/2019	10:25 AM	52	26
5/10/2019	10:30 AM	39	14
5/10/2019	10:35 AM	25	28
5/10/2019	10:40 AM	37	19
5/10/2019	10:45 AM	40	20
5/10/2019	10:50 AM	38	32
5/10/2019	10:55 AM	46	21
5/10/2019	11:00 AM	38	21

Appendix I: Graduation parking lot locations on NAU Central and South Campus [21].



Appendix J1: Graduation Traffic Management Project Updated Gantt Chart

Appendix J2: Graduation Traffic Management Project Original Gantt Chart

Appendix K: Project Work Hours Logged

Task	Staff (hrs)									Total Task (hrs)
	Senior Engineer			Engineer			Intern			
	Hia	Chris	Cyrus	Hia	Chris	Cyrus	Hia	Chris	Cyrus	
1.0 Study Area Assessment										0
1.1 Safety Plan	1	1	1	3	3	3				12
1.2 Virtual Data Collection	1	1	1				5	7	10	25
1.3 Equipment Acquisition	1	1	1	1	1	1	7	5	8	26
2.0 Traffic Study										0
2.1 Baseline Conditions Study				8	8	8				24
2.2 Baseline Flow Map	1	1	1	2	2	8	6	6	10	37
2.3 Graduation Traffic Study				7	7	7				21
2.4 Graduation Flow Map	1	1	1	2	2	8	5	5	8	33
3.0 Data Analysis										0
3.1 VISSIM Modeling	2	2	2	12	15	6	4	4	4	51
3.2 Traffic Volume Analysis										0
3.2.1 Baseline Volume Analysis	1	1	1	2	2	2	4	4	4	21
3.2.2 Graduation Volume Analysis	1	1	1	2	2	2	4	4	4	21
6.0 Deliverables										0
6.1 Traffic Study										0
6.1.1 30% Design Report	1	1	1	5	5	5	4	4	4	30
6.1.2 30% Design Presentation	2	2	2	3	3	3	2	2	2	21
6.2 Traffic Study Data Analysis										0
6.2.1 60% Design Report	1	1	1	5	5	5	4	4	4	30
6.2.2 60% Design Presentation	2	2	2	3	3	3	2	2	2	21
6.3 Report Compilation										0
6.3.1 90% Design Report	1	1	1	5	6	3				17
6.3.2 90% Website	1	1	1	1	8	1				13
6.4 Final Report and Presentation	1	1	1	6	6	6				6
7.0 Project Management										0
7.1 Coordination	6	6	6	6	6	6				36
7.2 Scheduling Meetings				3	3	3				9
7.3 Team Meetings	2	2	2	8	8	8	10	10	10	60
7.4 Resource Management				3	3	3	2	2	2	15
7.5 Project Tracking	2	2	2							6

								Total Project Hours	**550**