Proposal

McConnell Dr. and Pine Knoll Dr. Roundabout Design

May 05, 2020

BETR Engineering

Brian Carpenter
Emery Ellsworth
Tessa Huettl
Rose Voyles

College of Engineering, Informatics, and Applied Sciences
Northern Arizona University

Contents

Tables

Figures

Appendices

Abbreviations

ADOT	Arizona Department of Transportation
CAD	Computer Aided Drafting
COF	City of Flagstaff
FHWA	Federal Highway Administration
NAIPTA	Northern Arizona Intergovernmental Public Transportation Authority
NAU	Northern Arizona University
MUTCD	Manual on Uniform Traffic Control Devices
PE	Professional Engineering License
SWMDM	City of Flagstaff Stormwater Management Design Manual
USDOT	United States Department of Transportation

1 Project Understanding

1.1 Project Purpose

The intersection of McConnell Dr. and Pine Knoll Dr. is a heavily trafficked intersection on Northern Arizona University's Flagstaff Mountain campus. It is one of the major entrances/exits to/from the campus, and as currently has large volumes of vehicle, pedestrian, and bicycle traffic that must be safely and efficiently handled. The intersection currently has problems with vehicle congestion, which is exacerbated by the high volumes of pedestrian traffic. Based on these issues and a brief site investigation, it is proposed by the client that a roundabout be investigated as a potential solution to issues of this site.

1.2 Project Background

Currently, the proposed intersection for the project is a three-way stop. Eastbound McConnell Dr. consists of a through lane and a designated right turn lane. Northbound Pine Knoll Dr. consists of a left turn lane and a right turn lane. Westbound McConnell Dr. consists of a combination through and a left-turn lane. The intersection is approximately 150 feet east of the I-17 off-ramp and approximately 120 feet west of the bus pullout. The location of the project intersection within the Flagstaff network can be seen in Figure 1-1. A detailed aerial image of the intersection and the immediate area can be seen in Figure 1-2.

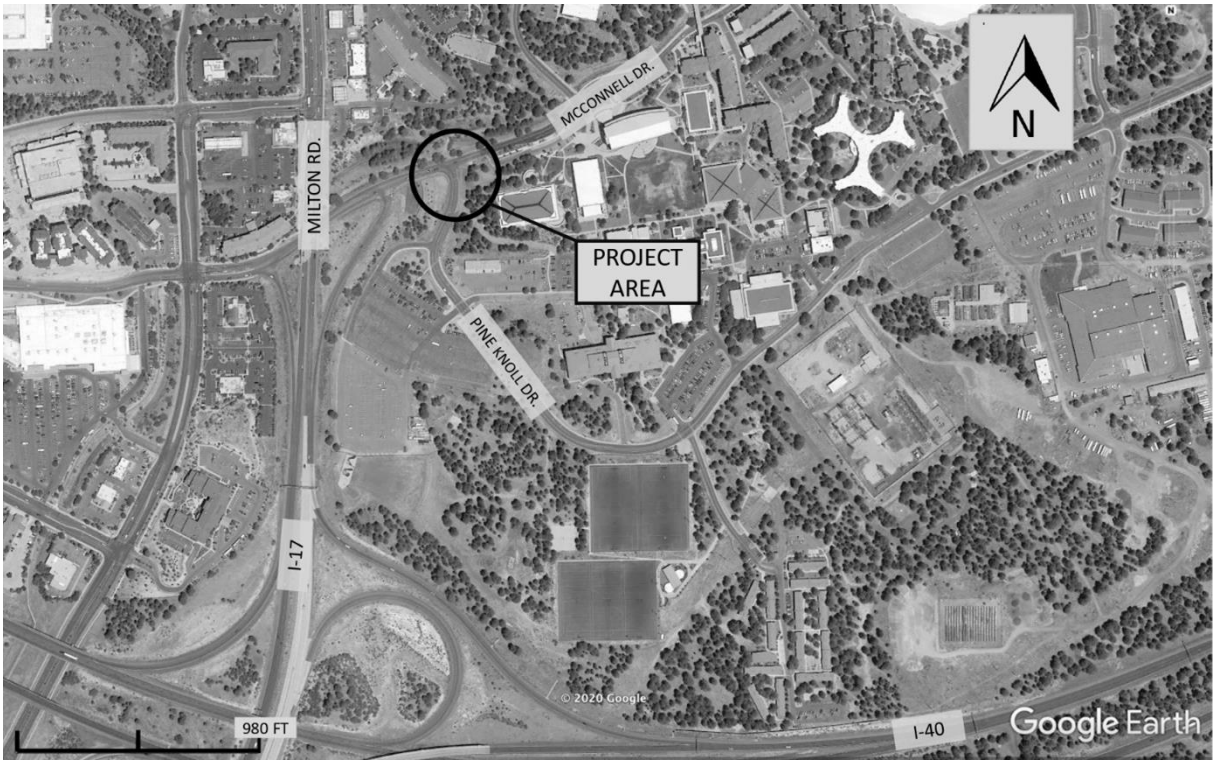


Figure 1-1: McConnell Dr. and Pine Knoll Dr. Roundabout Project Location Map

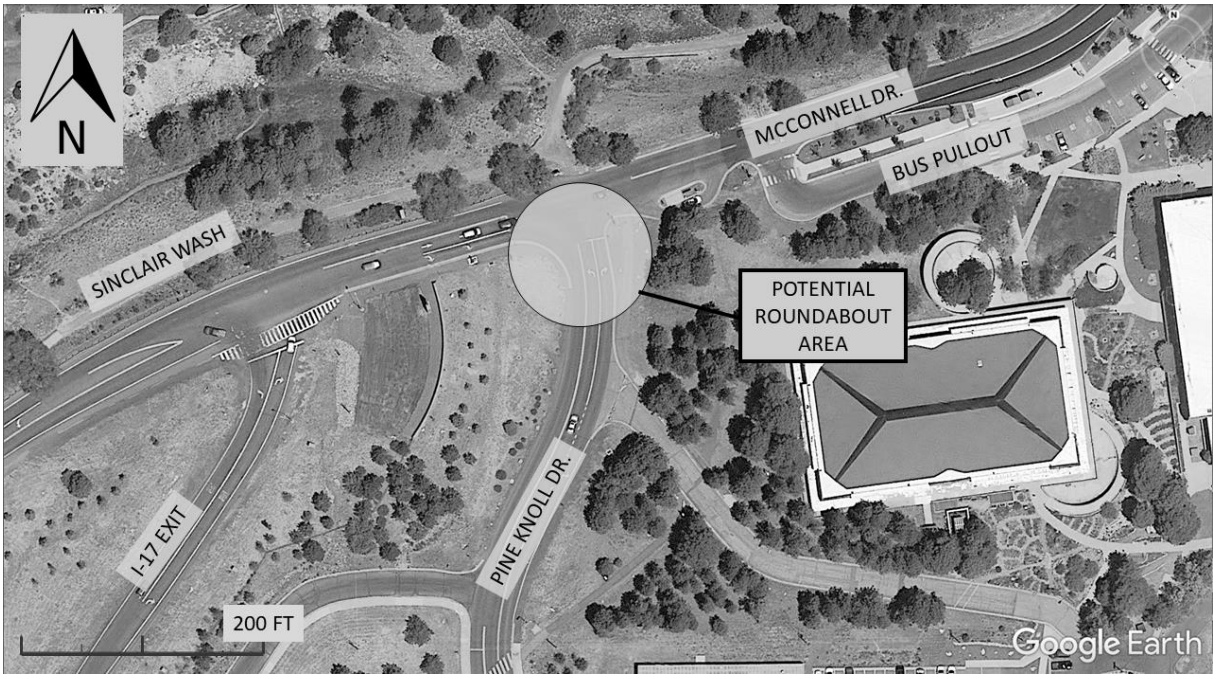


Figure 1-2: Project Vicinity Map Including Potential Roundabout Area

1.3 Technical Considerations

Technical work to be completed includes gathering of survey data. The survey data will be used to create a topographic map of the site and the surrounding area, along with an analysis of traffic volume and pedestrian volume data. Following survey, the assessment of the implementation of a roundabout can be completed. This assessment will include placement, determining the number of lanes, alignment of approaches, and inclusion of pedestrian and bicycle pathways. Safety analyses on the initial design must be completed to determine the feasibility of the design in terms of stakeholder goals. The design will likely need to be reevaluated, thus continuing the cycle of design, assessment, and reconfiguration. Once a roundabout design is selected, work will focus on drainage considerations, signing and striping, and lighting for the proposed intersection improvements.

1.4 Potential Challenges

One of the main challenges for this project includes the proximity of the proposed site to Sinclair Wash. This cannot be encroached on and is a potential source of flooding. Any improvements must be configured to the available space and topography of the land. This includes navigating the slope south of the current intersection. Additionally, concerns of all stakeholders must be addressed, meaning congestion and safety of on-campus traffic must be ensured as well as congestion and safety immediately off-campus, namely at the adjacent I-17 freeway exit ramp. Furthermore, the articulated busses frequently used by NAIPTA and routed directly through the intersection must be accommodated. Many of these challenges indicate the need to shift the intersection improvements south of the current intersection, which presents the challenge of re-aligning all approaches and assessing the grade of the south approach.

1.5 Stakeholders

The main stakeholders for this project include: NAU, ADOT, COF, and NAIPTA. NAU is considered the main stakeholder due to the site this project being located on the NAU campus, and because NAU will be paying for this complete design. Additionally, ADOT is the named client for this project. ADOT's main point of concern is the functionality of the I-17 exit ramp; ensuring that vehicles exiting the freeway at this location are served without major delay. Lastly, the other client to be considered is NAIPTA, as their Mountain Line bus route enters and exits campus through the intersection and any improvements must accommodate their busses. As the university and freeway exit are located within the city limits of the COF, they are another stakeholder interested in the reduction of congestion and increase in safety at the McConnell Dr. and Pine Knoll Dr. intersection and surrounding area.

2 Scope of Services

2.1 Task 1: Examine Existing Data

The existing data is information that was collected prior to the start of this project. This includes data provided by the client, traffic data, survey data, and right-of-way data. This existing data will be reviewed and utilized in the design of the proposed roundabout.

2.1.1 Task 1.1: Traffic Data

Existing traffic data includes pedestrian counts, vehicle turning counts, and peak hour volumes. This data is essential in determining the necessary number and type of lanes and the type of pedestrian crossings required. This existing traffic data will either be provided by COF or NAU or it will be collected prior to the start of design.

2.1.2 Task 1.2: Survey Data

Existing survey data consists of any recently collected topographic data of the project site. This data, if it exists, will reduce the amount of data needed to be collected and will be supplemental to any additional survey data collected for the completion of this project. If available, the existing survey data will be provided by NAU.

2.1.3 Task 1.3: Right-of-Ways

The right-of-ways present within the project area must be identified in their locations and ownership. This information must be determined so that encroachment can be avoided, if possible. If it is not possible, adjustments to the right-of-ways can be made, as needed. The location and ownership of existing right-of-ways will be determined through information provided by COF.

2.2 Task 2: Site Investigation

Site investigation is the process of cataloguing the physical properties of a project area. This is necessary in order to conceptualize the existing conditions, and challenges of a site as well as the extent of the project area. In order to accomplish this, a survey of the area will need to be completed and specific notes of the features of the site will need to be taken.

2.2.1 Task 2.1: Surveying

Surveying is the process of determining the three-dimensional locations of features of an area on a coherent surface. This is necessary in order to accurately map points and features of a site for use in design or the final element. The survey will be completed through use of a total station and data collector to manually take points of features such as curb faces, edge of the pavement, roadway lane markings, existing bike lanes, nearby crosswalks, environmental constraints, structures, drainage structures, and right of way constraints.

2.2.2 Task 2.2: Field Notes

Taking field notes involves the noting, describing, and recording of site features that have specific significance to or influence on the design of the site. This is necessary in order to determine the constraining features of the site are recorded for reference in the design of the roundabout and determination of work to be done. Fieldnotes will be completed by visiting the site and recording notes on possible constraining features of the site and accompanying each description with pictures of the feature.

2.3 Task 3: Existing Site Design

Existing site design is the process of converting the existing site survey into a workable drawing that showcases the extents of the site and the locations of all significant site features. This is essential for the design of the proposed project, as it informs the designers of all geographic constraints. The existing site design shall be completed by creating a topographic map and inserting into that map the existing structures, environmental features, and preliminary roadway alignments.

2.3.1 Task 3.1: Existing Topographic Map, Structures, and Environmental Features

Creating the map of the existing topography, structures, and environmental features involves importing survey data into Civil3D and converting the data into shapes and blocks. This map is necessary for determining the location of the proposed design and the amount of removals or additions will be needed. The map shall be completed by using the ground points from the survey to create a surface with contour lines, connecting the structure points to create outlines of the structures, and covering the environmental feature points (trees, bushes, boulders, etc.) with blocks.

2.3.2 Task 3.2: Existing Roadway Alignments

The existing roadway alignments depict the centerlines of all the roadways within the site extents. They are essential to this project as these roadway alignments will be used to determine the location and geometry of the roundabout. Existing roadway alignments can be determined by finding the middle point between the existing curb backs or edges of pavement.

2.4 Task 4: Roundabout Design and Check

Roundabout design and check is the process of creating a preliminary and very basic design of the roundabout off of the general requirements of the intersection. This is necessary in order to give a basis from which to begin the more in-depth design processes such as alignment of lanes, placement of splitter islands, and location of crosswalks. This will be done by determining preliminary requirements for the size of the roundabout, proper grading of the intersection, and drainage of the intersection so that more involved design can begin.

2.4.1 Task 4.1: Preliminary Roundabout Geometry

The team will reference the USDOT, FHWA Roundabout Design Guide, and COF intersection codes for preliminary roundabout geometry. This will include the number of legs, pedestrian crossing locations, circulatory roadway width, entrance and exit curves, vehicle considerations and bicycle previsions. The purpose of this is to ensure that when designing the roundabout, these basic standards are met and a general idea of the needs of the intersection is known for the purpose of beginning other elements of design such as grading and drainage.

2.4.1.1 Task 4.1.1: Radius of the Inscribed Circle

Determining the radius of the inscribed circle is the process of sizing the center island of the roundabout for the purpose of determining the general footprint of the intersection. This is necessary in order to begin the design process; for purposes of grading and assessment of potential design options, the general area needed will have to be obtained. The length of the radius for the island within the roundabout is determined by the ideal speed limit, limiting vehicle size, peak hourly volume, the width of the lanes, and the number of lanes.

2.4.1.2 Task 4.1.2: Assessment of Lanes

Assessment of lanes is the process of determining the number of lanes needed through the roundabout and the arrangement of lanes in consideration of the entirety of the intersection. This process is necessary as the number of lanes, type of lanes, and arrangement of lanes, especially for entry and exit of the roundabout or bypass of the roundabout, control the volumes and speeds of vehicles entering and exiting the intersection. This process will be completed through evaluation of the needed number of lanes to ensure that the capacity of the roundabout can meet the demands of expected traffic. An extension of this will be an evaluation of the need for and benefit of bypass lanes to allow certain turning movements to skip entering the roundabout to allow for control of demand of an approach where demand may exceed capacity. It will also include an evaluation of the necessary width of lanes through the roundabout which will be largely dependent on the design vehicle for the intersection and the number of lanes through the roundabout.

2.4.2 Task 4.2: Grading to Roundabout Requirements

Grading to the roundabout requirements means ensuring that the grades of the roadway legs approaching the roundabout do not exceed the allowable margin. This is necessary in order to meet code but, more specifically, to ensure the safety of users, with emphasis on the safety of pedestrians. Controlling the grade of the approaches aids in increasing sight distance and reducing vehicle speed. Grading to the roundabout requirements will be completed by determining the elevation of the roundabout, which needs to be relatively flat, determining the horizontal distance between the roundabout and points of preferred unchanged elevation and applying the minimum grade to determine the elevation of the end point. This process will require iterations in order to achieve appropriate grading and elevations of all points of interest.

2.4.3 Task 4.3: Hydrologic Analysis

The Hydrology Assessment is the process of determining the expected flow rates that the site must sufficiently manage. This is essential to the design of the hydraulic structures within this site. To accomplish this, the contributing area, storm duration, storm intensity, the weighted runoff coefficient, and design and check storm volumes will all be determined.

2.4.3.1 Task 4.3.1: Contributing Area and Weighted Runoff Coefficient

The contributing area is the area of land that contributes water to a specified concentration point. This is a value that is directly inputted into the Rational Method for calculating storm volume. The area is determined using a topographic map of the surrounding area and the process of watershed delineation. The weighted runoff coefficient is a dimensionless value that represents the percentage of rainfall that appears as surface runoff. This is a value that is directly inputted into the Rational Method for calculating storm volume. The runoff coefficient is determined either by surface type using Table 3-4 of the SWMDM or by land use, slope, and soil type using Table 3-5 of the SWMDM.

2.4.3.2 Task 4.3.2: Duration and Intensity

The duration is the length of time that the storm lasts. This is important as it is used to determine the intensity of the storm. The duration is determined by calculating the time it takes water to travel from the most hydraulically remote point of the drainage area to the point of concentration (i.e. time of concentration). The intensity is the amount of water generated per hour during the storm event. This is a value that is directly inputted into the Rational Method for calculating storm volume. The intensity is determined using the duration, storm event, and Table 3-2 in the SWMDM.

2.4.3.3 Task 4.3.5: Design and Check Storm Volumes

The design and check storm volumes are the volumes of water generated during specific storm events that must be adequately and safely contained within the curbs and right-of-way. These volumes are necessary for the design of the hydraulic structures at this site. The design and check storm volumes will be determined using the Rational Method.

2.4.4 Task 4.4: Hydraulic Assessment

Hydraulic assessment is the process of determining if the curb and gutter system at the site and the existing channel will be sufficient for the expected flows of water. This is necessary in order to ensure that the roadway and facilities near it are not flooded. In order to accomplish this flow criteria of the site, hydraulic structures, and existing channel will be analyzed.

2.4.4.1 Task 4.4.1: Assessment of Flow Criteria

Assessing flow criteria is the process of checking the characteristics of expected stormwater flow at the site for compliance with stormwater management code. This is required to ensure that the site meets city and county code for stormwater management and also for the purpose of increasing the longevity and safety of the roadway through proper drainage. This will be accomplished by assessing flow criteria such as the slopes of the roadways, flow velocity in the curb and gutter systems and the type of flow encountered using standards outlined in the SWMDM, and ensuring the values found are within the acceptable parameters.

2.4.4.2 Task 4.4.2: Hydraulic Structures

Determining the necessary hydraulic structures involves the previous assessment of flow criteria and, depending on the results of that assessment, ascertaining if additional means of stormwater management are necessary and deciding on those means. This is necessary to appropriately manage the flow that is greater than the capacity of the curb and gutter systems, in order to ensure the safety and long-term function of the roadway. This will be done using the determined characteristics of the flow present and, based off of those findings, choosing

an appropriate storm drain option. The chosen storm drain will then need to be assessed to determine if the flow velocity in the storm drain pipe is of an acceptable value. Then, the discharge location will need to be evaluated to determine if additional protection is needed to prevent erosion of the outlet location.

2.4.5 Task 4.5: Finalize Roundabout Geometry

The geometry of a roadway is the positioning of physical elements such as lanes, splitter islands, and crosswalks. These elements must be implemented following the standards and codes of ADOT and FHWA. The elements of roadway geometry can increase safety and provide direction for all users. This will be completed through an iterative design process that will result in the final shape and location of roundabout elements.

2.4.5.1 Task 4.5.1: Roadway Alignments

Roadway alignments are typically the centerline of a roadway as seen from above but can also include the edge of pavement lines. They allow for the stationing of roadway elements, aiding in the assignment of locations of design features along the progression of the roadway. Preliminary horizontal roadway alignments will be determined by finding the midpoint of the existing roadways, and connecting the points determined while proposed alignments will be taken as the centerline of the proposed roadways and determined through an iterative design process leading to the finished design.

2.4.5.2 Task 4.5.2: Splitter Islands and Crosswalk Locations

Splitter islands are raised or painted traffic islands that separate traffic going in different directions. They are implemented at a roundabout to separate traffic that is entering and exiting as well as to provide pedestrian refuges to increase safety by decreasing crossing distance. They are also used to separate designated right-hand turn lanes from the other lanes in a roundabout. The size, shape and location of these islands will be determined through an iterative design process. Crosswalks are the designated location where pedestrians and bicyclists can cross a roadway and will connect the splitter islands. When considering the location of crosswalks near a roundabout, there are certain guidelines from the FHWA that should be followed. Crosswalks closer to roundabouts are more dangerous for the pedestrians because vehicles feel less required to stop when going through the intersection. Crosswalk locations will be determined, following the FHWA guidelines, and safety checks will be performed to ensure that pedestrians and other crosswalk users will be safe.

2.4.5.3 Task 4.5.3: Safety and Code Checks

Safety and code checks are the processes of evaluating a preliminary roundabout design for adherence to city codes and for the safety of all potential users. This is necessary in order to ensure that a design is viable as a final option; that it follows all code requirements and provides a safety means of traversing the intersection for all expected users. For this design, the ADOT codes will need to be reviewed constantly to make sure the design iteration is meeting all applicable codes. The safety of the design will also need to be checked for each iteration, primarily through determination of the “fastest route,” assessment of length and location of pedestrian crossings, and sight distance. Additionally, each alternative will need to be assessed through input into a traffic analysis software. Problems encountered with safety will need to be addressed through redesign as needed until the roundabout is safe for all users.

2.4.5.4 Task 4.5.4: Redesign as Needed

Designing a roundabout is a highly iterative process and as such, many of the elements involved in the roadway geometry will need to be redesigned when implemented in conjunction with other design elements. This is necessary in order for the physical elements of the roundabout to be compatible with the needs of all users. This will be completed by evaluating all elements using the code and safety checks mentioned above and redesigning as needed to satisfy the needs of all users.

2.5 Task 5: Signage and Striping

Signage and striping is the process of determining the necessary signs and patterns of pavement markings needed to help users traverse the new infrastructure. This is necessary in order to give the proper direction, speed, right of way, and warnings to drivers, pedestrians, cyclists, and any other user that may be needed to ensure the safety and usability of the intersection. This will be done using the guidance of the MUTCD which details the necessary sign and pavement markings for roundabouts.

2.6 Task 6: Temporary Traffic Control

Temporary traffic control is the process of developing a plan to direct traffic during the implementation process of the roundabout. This is necessary in order to ensure sufficient access to all facilities in and around a site despite ongoing or impending construction activities. This will be done by assessing the construction that will be in action during all points of the implementation process and developing systems of road closures, signage, and temporary pavement markings necessary for guiding users through or around the construction site and to various destinations.

2.7 Task 7: Plan Set Production

Plan set production is the process of creating one cohesive document from the design drawings developed over the course of the project design. This is necessary in order to create an understandable representation of the design that has been developed and the work to be completed in order to implement the design. This will be done by developing templates of design and construction notes, drawing information (scales, drawn and checked by inputs, sheet focus), and sheet organization into which each layer of the design will be formatted in order to showcase the design and work necessary for that particular layer.

2.8 Task 8: Drainage Analysis

A drainage analysis is used to analyze the impact of the proposed design on stormwater discharges and to provide adequate data to ensure that the proposed design is protected from flooding and conforms to floodplain and stormwater management regulations. This analysis is necessary as it is submitted to the COF for review and approval. A drainage analysis will be completed by combining the information gathered during the hydrology and hydraulic assessments into a comprehensive format.

2.9 Task 9: Traffic Analysis

A traffic analysis is used to prove the functionality of the proposed design in regard to conveying the expected traffic flows. This analysis is necessary in order to ensure that the capacity of the

intersection is high enough for the traffic flow it will experience. This will be completed by combining the information gathered from the traffic analysis of the individual design alternatives with estimates of expected traffic flow, into a comprehensive format.

2.10 Task 10: Evaluate Project Impacts

The impacts this project will have on the future of this intersection and its surrounding area will need to be evaluated to ensure the design has minimal adverse effects. This will be done by determining the social, economic, and environmental impacts of the roundabout on the users and the location.

2.10.1 Task 10.1: Social Impacts

The impacts that the implementation of the intersection will have on the community will need to be assessed for the purposes of ensuring community buy-in. This will be done by determining the benefits and detriments that the roundabout, including its construction, will have on users.

2.10.2 Task 10.2: Economic Impacts

Economic impacts of the project will be determined in order to assess the cost-benefit relationship of the intersection improvements. This will be done by determining the monetary cost of designing and building the roundabout as well as any cost-savings expected due to its implementation.

2.10.3 Task 10.3: Environmental Impacts

The environmental impacts of the project will be determined to ensure that there is no undue harm to the environment as a result of the intersection improvements. This will be done by determining the benefits and detriments that the implementation of the roundabout will have on the local environment.

2.11 Task 11: Project Submittals

The project submittals are the major subdivisions of this design project. They are necessary as they ensure that the work is being completed in a timely and quality manner. These submittals will be completed by tracking and noting the completion of tasks that fall underneath each of the submittals.

2.11.1 Task 11.1: 30% Submittal

The 30% submittal is the first major milestone within the project design and will require that 30% of the design of the project is complete. This milestone will ensure that the project is progressing at an appropriate rate and is not falling behind schedule and that the work done up until this milestone is quality work. The milestone will be met by completing the collection and review of existing data, the site investigation, the existing site design, and an initial traffic report. These will be compiled into a presentation and report.

2.11.1.1 Task 11.1.1: 30% Report

The report will communicate information between the team and any other interested parties. This document will update users on what has been completed, relating toward the project.

The report will provide information regarding the existing site conditions, which include site investigation, existing data, and current site design.

2.11.1.2 Task 11.1.2: 30% Presentation

The presentation will be a visual display of the team's completed work. This will include current site conditions, such as existing soil conditions, traffic conditions, and physical constraints within the intersection. These existing site conditions are crucial factors to understand before an initial design can be designed.

2.11.2 Task 11.2: 60% Submittal

The milestone of 60% completion is the next major milestone within the project design and will require that 60% of the design of the project is complete. This milestone will ensure that the project is progressing at an appropriate rate and is not falling behind schedule and that the work done up until this milestone is quality work. The milestone will be met by revising the previously completed design elements and additionally completing the roundabout design and check. These will be compiled into a presentation and report.

2.11.2.1 Task 11.2.1: 60% Report

The report will convey information between the team and any other interested parties. This will provide updates from the 30% report until now and will additionally include an initial roundabout design and check.

2.11.2.2 Task 11.2.2: 60% Presentation

The presentation will review over all updated tasks completed previously for the 30% and will additionally include the initial design. The presentation will be presented to the various Grading Instructors, and any other interested parties.

2.11.3 Task 11.3: 90% Submittal

The milestone of 90% completion is the last major milestone before the project design is finalized and requires that all of the design of the project is complete. This milestone will ensure that the project is progressing at an appropriate rate and is not falling behind schedule and that the work done up until this milestone is quality work. The milestone will be met by revising the previously completed design elements and additionally completing the signage, the striping, a temporary traffic control plan, a drainage analysis, a final traffic analysis, and the final plan set. These will be compiled into a presentation and report.

2.11.3.1 Task 11.3.1: 90% Report

The report will provide updates regarding the design of the project. These updates will be based on previous content, and this report will also provide additional information on new design information added to the project.

2.11.3.2 Task 11.3.2: 90% Website

The website will be an online portfolio accessible to the public and will display all work completed regarding the project. This includes vital information regarding the project, such as team members, client, current congestion problem at the intersection, and what the proposed plan to relieve the congestion is. The website will be updated consistently throughout the Fall 2020 semester, to update users about initial and final designs.

2.11.4 Task 11.4: Final Submittal

The final report will be the compilation and description of all work completed for the project with the results or final product featured. This is the necessary means of presenting the completed work to the client and stakeholders for review. This will be completed by a drafting process that aims to relate the work done to reach each milestone and relate the final product in a technical narrative format.

2.11.4.1 Task 11.4.1: Final Report

The report will be a compilation of all the work completed to create upon the final design of the intersection. This will be completed by revising previous reports and adding the final results of the project. This is necessary in order to describe what the project was, how it was completed, and the final designs and recommendations.

2.11.4.2 Task 11.4.2: Final Presentation

The presentation will be a PowerPoint slideshow that the team will narrate to their audience at the completion of the project work. It is necessary in order to communicate the project parameters and work done by the team in an engaging and real-time manner. The presentation will be completed through a drafting and finalization process where relevant images and text will be implemented to compose an understandable and informative final product.

2.11.4.3 Task 11.4.3: Final Website

The project website will be an online portfolio of the team and project. It is necessary in order to provide the general public with a base knowledge of the team and project and provide the opportunity to reach out to the team to learn more. It will be completed through use of an html website template into which images, files, and other information specific to the team and project will be inputted.

2.11.5 Task 9.5: Website

The project website will be an online portfolio of the team and project. It is necessary in order to provide the general public with a base knowledge of the team and project and provide the opportunity to reach out to the team to learn more. It will be completed through use of an html website template into which images, files, and other information specific to the team and project will be inputted.

2.11.6 Task 9.6: Presentation

The presentation will be a PowerPoint slideshow that the team will narrate to their audience at the completion of the project work. It is necessary in order to communicate the project parameters and work done by the team in an engaging and real-time manner. The presentation will be completed through a drafting and finalization process where relevant images and text will be implemented to compose an understandable and informative final product.

2.12 Task 12: Project Management

Project management is the use of skills and techniques to ensure that the project is meeting required deadlines and requirements. This is necessary to ensure that the project does not fall behind schedule and that quality work is being completed. The goals of project management will be accomplished through meetings, schedule management, and budget management.

2.12.1 Task 12.1: Meetings

Meetings will consist of team meetings, grading instructor meetings, technical advisor meetings, and client meetings. These meetings will be used to ensure that the team stays on schedule and understands each element of the design process. Team meetings will occur weekly, grading instructor meetings will occur bi-weekly, and technical advisor and client meetings will occur on an as needed basis.

2.12.2 Task 12.2: Schedule Management

Schedule management is the process of ensuring that project tasks are completed in a timely and quality manner. This is necessary to ensure that project deadlines are met, and milestones are completed on time. Meetings, milestones, and other tasks necessary to the completion of the project will be scheduled in advance and should be completed according to the schedule.

2.12.3 Task 12.3: Budget Management

Budget management is the process of ensuring that all project tasks are completed efficiently and correctly in terms of cost to the client. This is necessary to ensure that the project is completed within the allowable range of resources. The distribution of tasks will be adjusted and time spent on each task will be recorded in order to stay within the allowable funds for the project.

2.13 Exclusions

This design project is limited to the creation of 30% design plans, as such many aspects of a full design will be excluded. Each of these excluded tasks is included below with a description of the task and why it shall be excluded.

2.13.1 Standard Details and Drawings

Standard details and drawings are documents provided by COF and ADOT that specify the requirements for, and methods of particular assemblies included in the project area, but not unique to the project. These details and drawings will be excluded because this project does not extend to the installation stage of project design.

2.13.2 Detour Plans

Detour plans are a form of temporary traffic control plans that outline the alternate routes users will use to bypass the construction site. These plans will be excluded because they were not requested by the client and as such shall be completed by another entity.

2.13.3 Construction Plans

Construction plans are a document that includes a construction completion schedule, construction staking plans, and construction fencing plans. These plans will be excluded because this project does not extend to the construction stage of project design.

2.13.4 Utility Assessment and Relocation

Utility assessment and relocation is the process of determining the existing locations of all utilities and determining if any of these utilities must be relocated to accommodate the proposed design. This assessment and relocation process will be excluded because this project does not extend to the utility management stage of project design.

2.13.5 Landscaping and Lighting Plans

Landscaping and lighting plans are documents that specify the types of all pieces of landscaping and lighting structures and indicate where they are located. These plans will be excluded because this project does not extend to the landscaping and lighting stage of project design.

2.13.6 Pavement Design

Pavement design is the process of determining the quantity, thickness, and composition of the asphalt and base layers of the pavements. This design element will be excluded because this project does not extend to the pavement design stage of project design.

2.13.7 Permitting

Permitting is the process of obtaining the requisite permits for construction and operation as per COF and ADOT code. This process will be excluded because this project does not extend to the construction or operation stages of project design.

2.13.8 Geotechnical Analysis

Geotechnical analysis is the process of analyzing the soil properties at the site. This design element will be excluded because it is not necessary as the new design will be tied into the existing pavement.

3 Schedule

The duration of this project is a period of 93 days which consists of a total of 65 working days. The longest duration tasks in the scope and schedule, in order of duration, are Task 4.5.4 Redesign as Needed, followed by Task 4.3.1 Contributing Area and Weighted Runoff Coefficient. For durations of these tasks, see the attached Roundabout Schedule. Deliverables included in the project schedule consist of 30% report and presentation, 60% report and presentation, 90% report, website, final report and presentation, and website, as well as a final plan set for the roundabout design.

3.1 Critical Path

Highlighted in red within the Roundabout Schedule is the critical path of work. The items that make up the critical path are those that cannot be started or completed without the completion of certain previous tasks. The critical path begins with collection of survey data, as this will be the basis of all further project work. Then the design elements will begin, followed by specific deliverable completion. This path is determined by the nature of the predecessor/dependencies relationships of each task which specify the order that each task needs to be completed in. Included in our scope and schedule are project management tasks. These include scheduled meetings, and continuous schedule and resource check requirements. Fulfillment of these tasks will ensure the maintenance of timing and duration of the critical path.

4 Staffing Plan

The duration of this project is a period of 93 days which consists of a total of 65 working days.

4.1 Staff Positions

The various staff positions that will be utilized in the completion of this project as well as their abbreviations are summarized in Table 4-1.

Table 4-1: Staffing Positions

Position	Abbreviation
Senior Engineer	SE
Project Manager	PM
Drafting Technician	DT
Engineer in Training	EIT
Survey Technician	ST

The following sections describe the training and qualifications needed for each position along with the tasks that the position is expected to perform.

4.1.1 Senior Engineer

The qualifications necessary for this position include: a bachelor's degree in engineering and several years of experience in a similar field [2]. A Senior Engineer must have a PE as well as skills in project management, time management, and leadership [2]. The Senior Engineer will perform tasks that include but are not limited to design, grading, hydrology, hydraulics, determination of final geometry, drainage analysis, and traffic analysis.

4.1.2 Project Manager

The qualifications necessary for this position include: a bachelor's degree in engineering, several years of experience in a similar field, and having very strong interpersonal and leadership skills, as they will work closely with and manage other team members [3]. The Project Manager will monitor the staff and determine training needs for individual team members. The Project Manager will be expected to manage the budget and schedule as well as perform quality assurance checks to ensure that the completed project is of high quality.

4.1.3 Drafting Technician

The qualifications necessary for this position include: at least an associate degree in engineering, valid CAD certification, a high level of knowledge of Civil 3D and AutoCAD, and attention to detail [4]. The Drafting Technician will be expected to create the topographic map of the site with the provided and collected survey data, draw the initial and final site designs, and create and compile the final plan sets.

4.1.4 Engineer in Training

The qualifications necessary for this position include: a bachelor's degree in engineering, valid certification from the State of Arizona, and knowledge of AutoCAD and Civil 3D [5]. The EIT will be expected to create the temporary traffic control and signage and striping plans, evaluate the impacts of the project, and create all reports, presentations, and website pages.

4.1.5 Survey Technician

The qualifications necessary for this position include: an associate degree in a surveying related field, knowledge of surveying equipment, understanding of advanced survey technology, and

strong knowledge of CAD drafting and design [6]. The Survey Technician will be expected to perform the site investigation, which includes performing surveys and recording field notes.

4.2 Qualifications of Senior Personnel

The following is a summary of relevant experience and qualifications of the BETR Engineering personnel.

4.2.1 Brian Carpenter

Brian Carpenter is a senior Civil Engineering student with the following qualifications and experience:

- 3+ years drafting experience
- Previous roadway design experience
- Previous pavement signing and striping design experience
- Traffic Study and Signal coursework
- Highway design coursework
- ArcMap/GIS work experience and coursework
- Water Resources I and II
- Geotechnical Engineering I and II
- Land Surveying
- Municipal Engineering
- Internships: WSP, QuakeWrap

4.2.2 Emery Ellsworth

Emery Ellsworth is a senior Civil Engineering student with the following qualifications and experience:

- HEC HMS experience
- AutoCAD experience
- ArcMap/GIS experience
- Land Surveying field and lab experience
- Geotechnical lab experience
- Traffic analysis experience
- Water Resources I and II
- Geotechnical Engineering I and II
- Internships: Land Surveying, Western Technologies

4.2.3 Tessa Huettl

Tessa Huettl is a senior Civil Engineering student with the following qualifications and experience:

- 3+ years of drafting experience
- Previous drainage design experience
- Previous pavement grading experience
- Traffic Study and Signal coursework
- ArcMap/GIS coursework

- Water Resources I and II
- Geotechnical Engineering I and II
- Land Surveying
- Municipal Engineering
- Internships: Jacobson Engineering

4.2.4 Rose Voyles

Rose Voyles is a senior Civil Engineering student with the following qualifications and experience:

- ArcMap/GIS coursework
- AutoCAD experience
- Water Resources I and II
- Geotechnical Engineering I and II
- Land Surveying
- Traffic Study and Signal coursework
- Municipal Engineering coursework
- Internships: Kimley-Horn Association

4.3 Task Staffing Matrix

The estimated number of hours that each staff position will spend on each task can be seen in Appendix A. Table 4-2 summarizes the total number of hours each staff position is estimated to contribute to the project.

Table 4-2: Staffing Positions

Position	Hours
Senior Engineer	299
Project Manager	144
Drafting Technician	131
Engineer in Training	337
Survey Technician	47
Total	958

From this table, it can be seen that a total of 958 hours is expected to be spent on this project. It can also be seen that the expected minimum number of hours needed to complete this project is 337 hours, which works out to be just over 42 business days of work. This is less than the scheduled 65 business day project duration to account for receival and processing of client review, receival of resources, and apprehension of lab time/space throughout the project.

5 Cost of Engineering Services

The estimated total cost of the engineering services to be provided by BETR Engineering to the client can be seen in Table 5-1, which includes a position and supplies breakdown. Included are the number of hours each staff member is expected to complete for the progression of the project, and each member's billing rate which, multiplied together produces the cost column. Incorporated within the billing rate are the expenses associated with business operation over this period,

including base pay for employees, benefit packages for employees, office overhead costs, and profit margin for the work to be completed. Supplies for this project consist of necessary survey equipment for creation of the topographical map of the project area, and computer lab access for utilization of necessary software for drafting and calculations of necessary design criteria.

Table 5-1: Cost Estimate for Engineering Services

	Classification	***Hours***	***Rate ($/hr)***	***Cost***
Personnel	SE	299	180	$53,820
	PM	144	160	$23,040
	DT	131	95	$12,445
	EIT	337	105	$35,385
	ST	47	110	$5,170
Supplies	***Classification***	***Days***	***Rate ($/day)***	***Cost***
	Survey equip.	3	100	$300
	Computers	56	100	$5,600
			Total	$135,760

6 References

[1] City of Flagstaff Engineering Division, “City of Flagstaff Stormwater Management Design Manual”, City of Flagstaff, 2009.

[2] “Senior Civil Engineer Job Description”, *JobHero*. [Online]. Available: https://www.jobhero.com/senior-civil-engineer-job-description/. [Accessed: 26-Mar-2020].

[3] “Civil Project Manager Job Description”, *JobHero*. [Online]. Available: https://www.jobhero.com/civil-project-manager-job-description/. [Accessed: 26-Mar-2020].

[4] “Civil Drafter Job Description”, *JobHero*. [Online]. Available: https://www.jobhero.com/civil-drafter-job-description/. [Accessed: 26-Mar-2020].

[5] “Civil Engineer Job Description”, *JobHero*. [Online]. Available: https://www.jobhero.com/civil-engineer-job-description/. [Accessed: 26-Mar-2020].

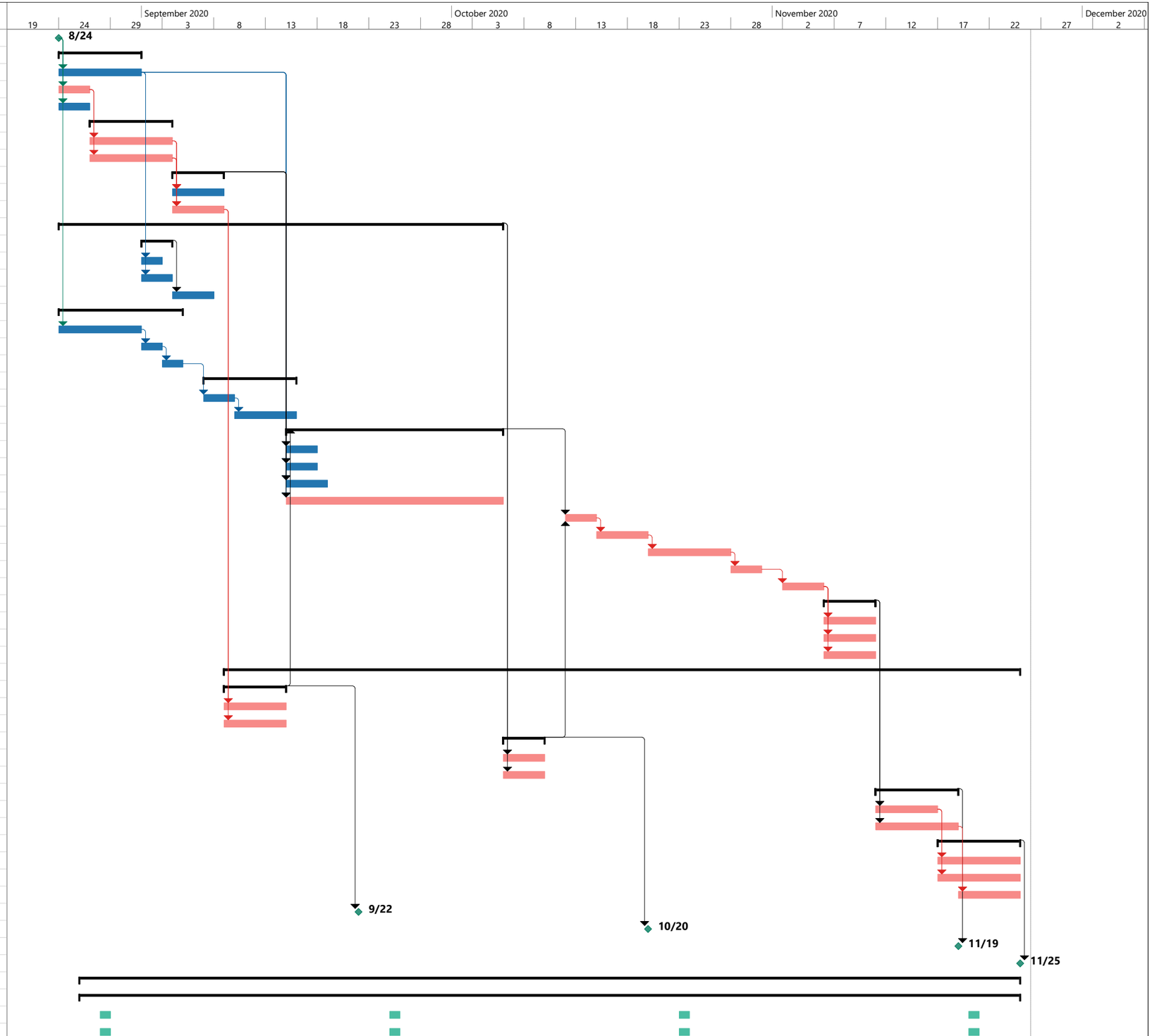
[6] “Survey Technician Job Description”, *JobHero*. [Online]. Available: https://www.jobhero.com/survey-technician-job-description/. [Accessed: 26-Mar-2020].

7 Appendices

Appendix A: Task Staffing Matrix

Task	Hours Per Position					Hours Per Task
	SE	*PM*	*DT*	*EIT*	*ST*	
TASK 1: Review Existing Data						
1.1 Traffic Data	16	12		10		38
1.2 Survey Data	8	8				16
1.3 Right-of-Ways	8	8				16
TASK 2: Site Investigation						
2.1 Surveying				8	32	40
2.2 Field Notes				32	4	36
TASK 3: Existing Site Conditions						
3.1 Existing Topographic Map, Structures, and Environmental Features			16	4		20
3.2 Existing Roadway Alignments			8	4		12
TASK 4: Roundabout Design and Check						0
4.1 Preliminary Roundabout Design						0
4.1.1 Radius of the Inscribed Circle	8					8
4.1.2 Assessment of Lanes	16					16
4.2 Grading to Roundabout Requirements	8			4		12
4.3 Hydrology Assessment						
4.3.1 Contributing Area and Weighted Runoff Coefficient	20	4		12		36
4.3.2 Duration and Intensity	6					6
4.3.3 Design and Check Storm Volumes	6					6
4.4 Hydraulic Assessment						
4.4.1 Assess Flow Criteria	8			12		20
4.4.2 Hydraulic Structures	24					24
4.5 Finalize Roundabout Geometry						
4.5.1 Roadway Alignments	8		12			20
4.5.2 Splitter Islands and Crosswalk Locations	8		12			20
4.5.3 Safety and Code Checks	16	4		8		28
4.5.4 Redesign as Needed	26	10	40	32		108
TASK 5: Signage and Striping	4		6	8		18
TASK 6: Temporary Traffic Control	8			12		20
TASK 7: Plan Set Production	8	4	26	10		48
TASK 8: Drainage Analysis	6	4		8		18
TASK 9: Traffic Analysis	8	4		10		22
TASK 10: Evaluate Project Impacts						
10.1 Social Impacts	2	2		8		12
10.2 Economic Impacts	2	2		8		12
10.3 Environmental Impacts	2	2		8		12
TASK 11: Project Deliverables						
11.1 30% Submittal						
11.1.1 30% Report	4	4		16		24
11.1.2 30% Presentation	4	4		12		20
11.2 60% Submittal						
11.2.1 60% Report	4	4		16		24
11.2.2 60% Presentation	4	4		12		20
11.3 90% Submittal						
11.3.1 90% Report	4	4		16		24
11.3.2 90% Website	10	12		16		38
11.4 Final Submittal						
11.4.1 Final Report	10	8		16		34
11.4.2 Final Presentation	10	8		16		34
11.4.3 Final Website	4	12		8		24
TASK 12: Project Management						
12.1 Meetings	11	12	11	11	11	56
12.2 Schedule Management	4	4				8
12.3 Budget Management	4	4				8
Total	299	144	131	337	47	958

ID	Task Name	Duration	Start	Finish
1	Project Start	0 days	Mon 8/24/20	Mon 8/24/20
2	**TASK 1: Review Existing Data**	**6 days**	**Mon 8/24/20**	**Mon 8/31/20**
3	1.1 Traffic Data	6 days	Mon 8/24/20	Mon 8/31/20
4	1.2 Survey Data	3 days	Mon 8/24/20	Wed 8/26/20
5	1.3 Right-of-Ways	3 days	Mon 8/24/20	Wed 8/26/20
6	**TASK 2: Site Investigation**	**6 days**	**Thu 8/27/20**	**Thu 9/3/20**
7	2.1 Surveying	6 days	Thu 8/27/20	Thu 9/3/20
8	2.2 Field Notes	6 days	Thu 8/27/20	Thu 9/3/20
9	**TASK 3: Existing Site Conditions**	**3 days**	**Fri 9/4/20**	**Tue 9/8/20**
10	3.1 Existing Topographic Map, Structures, and Environmental Features	3 days	Fri 9/4/20	Tue 9/8/20
11	3.2 Existing Roadway Alignments	3 days	Fri 9/4/20	Tue 9/8/20
12	**TASK 4: Roundabout Design and Check**	**31 days**	**Mon 8/24/20**	**Mon 10/5/20**
13	**4.1 Preliminary Roundabout Design**	**3 days**	**Tue 9/1/20**	**Thu 9/3/20**
14	4.1.1 Radius of the Inscribed Circle	2 days	Tue 9/1/20	Wed 9/2/20
15	4.1.2 Assessment of Lanes	3 days	Tue 9/1/20	Thu 9/3/20
16	**4.2 Grading to Roundabout Requirements**	**2 days**	**Fri 9/4/20**	**Mon 9/7/20**
17	**4.3 Hydrology Assessment**	**10 days**	**Mon 8/24/20**	**Fri 9/4/20**
18	4.3.1 Contributing Area and Weighted Runoff Coefficient	6 days	Mon 8/24/20	Mon 8/31/20
19	4.3.2 Duration and Intensity	2 days	Tue 9/1/20	Wed 9/2/20
20	4.3.3 Design and Check Storm Volumes	2 days	Thu 9/3/20	Fri 9/4/20
21	**4.4 Hydraulic Assessment**	**7 days**	**Mon 9/7/20**	**Tue 9/15/20**
22	4.4.1 Assess Flow Criteria	3 days	Mon 9/7/20	Wed 9/9/20
23	4.4.2 Hydraulic Structures	4 days	Thu 9/10/20	Tue 9/15/20
24	**4.5 Finalize Roundabout Geometry**	**15 days**	**Tue 9/15/20**	**Mon 10/5/20**
25	4.5.1 Roadway Alignments	3 days	Tue 9/15/20	Thu 9/17/20
26	4.5.2 Splitter Islands and Crosswalk Locations	3 days	Tue 9/15/20	Thu 9/17/20
27	4.5.3 Safety and Code Checks	4 days	Tue 9/15/20	Fri 9/18/20
28	4.5.4 Redesign As Needed	15 days	Tue 9/15/20	Mon 10/5/20
29	**TASK 5: Signage and Striping**	**3 days**	**Mon 10/12/20**	**Wed 10/14/20**
30	**TASK 6: Temporary Traffic Control**	**3 days**	**Thu 10/15/20**	**Mon 10/19/20**
31	**TASK 7: Plan Set Production**	**6 days**	**Tue 10/20/20**	**Tue 10/27/20**
32	**TASK 8: Drainage Analysis**	**3 days**	**Wed 10/28/20**	**Fri 10/30/20**
33	**TASK 9: Traffic Analysis**	**4 days**	**Mon 11/2/20**	**Thu 11/5/20**
34	**TASK 10: Evaluate Project Impacts**	**3 days**	**Fri 11/6/20**	**Tue 11/10/20**
35	10.1 Social Impacts	3 days	Fri 11/6/20	Tue 11/10/20
36	10.2 Economic Impacts	3 days	Fri 11/6/20	Tue 11/10/20
37	10.3 Environmental Impacts	3 days	Fri 11/6/20	Tue 11/10/20
38	**TASK 11: Project Deliverables**	**55 days**	**Wed 9/9/20**	**Tue 11/24/20**
39	**11.1 30% Submittal**	**4 days**	**Wed 9/9/20**	**Mon 9/14/20**
40	11.1.1 30% Report	4 days	Wed 9/9/20	Mon 9/14/20
41	11.1.2 30% Presentation	4 days	Wed 9/9/20	Mon 9/14/20
42	**11.2 60% Submittal**	**4 days**	**Tue 10/6/20**	**Fri 10/9/20**
43	11.2.1 60% Report	4 days	Tue 10/6/20	Fri 10/9/20
44	11.2.2 60% Presentation	4 days	Tue 10/6/20	Fri 10/9/20
45	**11.3 90% Submittal**	**6 days**	**Wed 11/11/20**	**Wed 11/18/20**
46	11.3.1 90% Report	4 days	Wed 11/11/20	Mon 11/16/20
47	11.3.2 90% Website	6 days	Wed 11/11/20	Wed 11/18/20
48	**11.4 Final Submittal**	**6 days**	**Tue 11/17/20**	**Tue 11/24/20**
49	11.4.1 Final Report	6 days	Tue 11/17/20	Tue 11/24/20
50	11.4.2 Final Presentation	6 days	Tue 11/17/20	Tue 11/24/20
51	11.4.3 Final Website	4 days	Thu 11/19/20	Tue 11/24/20
52	30% Completion	0 days	Tue 9/22/20	Tue 9/22/20
53	60% Completion	0 days	Tue 10/20/20	Tue 10/20/20
54	90% Completion	0 days	Thu 11/19/20	Thu 11/19/20
55	Full Completion	0 days	Wed 11/25/20	Wed 11/25/20
56	**TASK 12: Project Management**	**65 days**	**Wed 8/26/20**	**Tue 11/24/20**
57	**12.1 Meetings**	**65 days**	**Wed 8/26/20**	**Tue 11/24/20**
90	**12.2 Schedule Managment**	**61 days**	**Fri 8/28/20**	**Fri 11/20/20**
95	**12.3 Budget Management**	**61 days**	**Fri 8/28/20**	**Fri 11/20/20**



Project: Roundabout Schedule
Date: Wed 3/11/20

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Critical
Critical Split
Progress
Manual Progress